The prasino Group

Bovine Innovative Greenhouse Gas Solutions (BIGGS)

Final Project Report

October 31, 2015

Cover Page

Title of the Grant or Project:	Piloting Innovative Beef and Dairy GHG Emission Reduction Strategies in U.S. Feedlots and Dairies (Bovine Innovative Greenhouse Gas Solutions -BIGGS)
Name of the Principal Investigator or Project Manager:	Matt Sutton-Vermeulen
Timeframe Covered by the Report:	8/1/2011 to 7/31/2015
Grant Number:	69-3A75-11-134
Date of Submission:	October 31, 2015
Deliverables Identified on the Grant Agreement:	1. Project Initiation: • Beef Protocol Adaptation Workshop at UC Davis 2. Protocol Adaptation and Acceptance: • Discussion Paper on protocol adaptation to meet ACR guidelines • Finalized methodologies incorporated into ACR process • White paper presentation 3. Program Design/Development: • Scoping process (no physical deliverable) • Financial and baseline modeling analysis • Secured project engagement of cooperators 4. Project Operation: • Common data management system for aggregating producer data • Quarterly project monitoring and measurement reports • Register projects with ACR 5. Communication/Tech Transfer: • Program website for on-going communication and reporting efforts • Development of storylines to document the process, linking the science to the farm operation and to the markets • Tech transfer workshops in conjunction with major supply chain conferences and events 6. Market Transactions: • Secure buyers for carbon credits; sales of carbon credits 7. Program Evaluation: • Web-based cooperator survey to determine cooperator's baseline understanding of the concept; perceptions associated with it; and how they are influenced from

	beginning to end of the project • Cost-benefit report for use by producers looking to enter into the markets • Final report identifying the successes and failures of the program

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Executive Summary

The objective of the BIGGS project was to demonstrate that beef and dairy operators can be incentivized by the sale of carbon credits to adopt innovative feeding and manure management practices that reduce methane and nitrous oxide emissions. In order to accomplish this objective the BIGGS project initially planned to adopt and pilot test five carbon offset protocols from Alberta into the USA. These protocols were as follows:

1. Reduced Carbon Intensity of Milk
2. Reduced Age at Harvest of Beef Cattle
3. Low Residual Feed Intake
4. Reduced Days on Feed of Beef Cattle; and
5. Adding Edible Oils to Beef Cattle Diets

However, after further consideration the Protocol Scientific Adaptation Team (PSAT) decided that the edible oils, reduced days on feed and low residual feed intake protocols could be combined into one protocol. As a result, the scope of the project was modified to three protocols: Reduced Carbon Intensity of Milk, Reduced Carbon Intensity of Beef and Reduced Age at Harvest of Beef Cattle.

Although the project did not progress exactly as planned due to problems linking the revised protocols to an existing carbon registry (part of the CIG requirements), it was successful in a number of ways. For example, some of the research conducted by the Protocol Scientific Advisory Team (PSAT) to adapt the protocols was referenced in an FAO report called *Mitigation of Greenhouse Gas Emissions in Livestock Production*. Five innovative pieces of science that advance the methodologies beyond the Alberta protocol approaches were stimulated by the BIGGS project. The FAO report collates all the literature to date (900 publications) on greenhouse gas mitigation for manure management and enteric fermentation. It is considered a "state-of-the-art review" that "provides critical information needed to conduct more specific and quantitative analyses on mitigation practice…".[1] Another significant accomplishment of the project is the completion and submission of two beef protocols to the American Carbon Registry (ACR). Additional protocol specific accomplishments of the project are described in Table 1 below.

Table 1: Project Accomplishments

Protocol	Accomplishments
Reduced Carbon Intensity of Fed Cattle	• CSU's inventory scientists established a performance standard baseline for the protocol. This baseline allows project proponents to get credits from 2003 onwards (retro-active crediting), which is allowed under the American Carbon Registry's Voluntary Standard. The performance standard baseline will be updated each year to allow for future crediting. • The protocol went through a public comment review period and no substantive changes were made to the protocol.

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[1] FAO (Food and Agriculture Organization). 2013. *Mitigation of Greenhouse Gas Emissions in Livestock Production. A review of technical options for non-CO_2 emissions.* Rome: FAO. (also available at http://www.fao.org/docrep/018/i3288e/i3288e.pdf)

Protocol	Accomplishments
	- The Protocol is in its final stage of review by ACR.
Reduced Carbon Intensity of Milk Production	- A carbon footprint for the potential feedstuffs used to feed dairy cattle in the major regions of the United States, based on DMI's LCA Report, was created by CSU's inventory scientists to support the adaptation of the Milk Carbon Intensity Protocol. - A cross-border committee was formed to share best practices in rolling out separate pilot projects in the United States and Canada. The committee consists of the Canadian-Atlantic Dairy Forage Institute, diary scientists at UC Davis and the BIGGS group. - Guidance was given to incorporate dairy manure as a source of N for carbon footprint of feedstuffs. - New science pieces were incorporated into the protocol to improve accounting and implementation: o A table that defines the methane conversion factors to be used when accounting for changes in ration formulation practices; o A new flexibility mechanism that states that project developers can exclude the quantification of emissions from heifer animal groupings on a farm if it can be demonstrated that the project heifer inventory did not increase by more than 2.5% on average over the baseline in a given year.
Reducing the Age at Harvest of Beef Cattle	- A dataset was identified that could be used to test the veracity of whether annualizing emissions (per kilogram of hot carcass weight) over a 10 year period is acceptable. - The protocol was completed and submitted to ACR.

The PSAT formed for the BIGGS project was made up of arguably the best pool of talent in ruminant GHG emissions science in the US and Canada, and chaired by Dr. Ermias Kebreab, Sesnow Endowed Chair for Sustainable Animal Agriculture, UCDavis. As a result of the PSAT efforts, meta-analyses that had never been done before, were conducted and incorporated into the protocols. The subject of these meta-analyses included:

1. Development of fat content in the diet and suppressed enteric methane relationships;
2. Development between forage quality and the relationship on Ym (enteric methane emission factor);
3. The effect of rumensin/monensin on enteric methane emissions; and
4. A new relationships on N retention in beef and dairy cattle that are an improvement over the current IPCC approach.

Although the project team engaged beef and dairy cooperators to assess data needs, data availability and feasibility of participation, the project never reached the pilot stage. Although the beef and dairy cooperators were supportive, they recognized the low value offered by the voluntary carbon market in the US would be a hindrance to adoption. Nevertheless, they were ready to give the protocols a go when they were approved by a carbon registry. Unfortunately, the process of adapting the protocols to the US took significantly longer than anticipated as did the American Carbon Registries (ACR) protocol review process. For the Fed Cattle protocol, what was intended to be a 4 month process of review, turned into an 18 month process due to staff turnovers and availability of qualified internal review staff. Further, in the case of the Beef Reduced Age at Harvest Protocol, the project team initially hoped to submit the protocol in November 2012. However, in the process of adapting the protocol an issue associated with the protocol's quantification approach was identified. In order to address this issue, the BIGGS team engaged Dr. Ermias Kebreab. The updated quantification approach (which was also vetted by Dr. John Basarab and the BIGGS team) is significantly more conservative and results in half the volume of emission reductions as that of the original protocol.[2] The process of resolving this issue took a significant amount of time, delaying the projects progression. Given the above and similar delays, all subsequent tasks (e.g. stakeholder engagement, program design and development, cooperator surveys, financial analysis, development of a common data management system, etc.) that depend on the approval of the protocols could not take place (See Table 2 below for a summary of challenges associated with each protocol). Consequently, in July 2014 a one year no-cost extension was requested and approved.

Table 2: Project Challenges

Protocol	Challenges
Reduced Carbon Intensity of Fed Cattle	• As part of the ACR review process, the BIGGS team needed to address leakage in the protocol. The team was able to show that leakage was not an issue through cattle inventory numbers over the last decade. • A 4 month review process extended into an 18 month review process due to staffing issues within ACR, and ongoing blinded review process with the 4 external scientists engaged in the review.
Reduced Carbon Intensity of Milk Production	• Emission factors for feedstuffs were generated for crops; however, feedstuffs that are by-products of a crop need to be further discounted through an economic allocation process. Finding appropriate economic allocation factors proved to be a challenge. • Through the protocol analysis it was determined that it may be difficult to find dairy producers that have not taken up practices years ago that would allow for carbon credit generation. In general, other than the introduction of rBST, there have not been any significant technological or management related practices that have dramatically improved dairy production efficiency in the last ten years. • The biggest opportunity for dairy producers is to switch out emptying the manure storage from a fall to a spring emptying. In the US, this limited the opportunity to catch basins and not anaerobic lagoons. The number of catch basins is small and limited to the upper US states; and asking dairymen to apply manure in the spring is challenging for them due to the timing and wet soils from snow melt.

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[2] In particular, it took a significant amount of time to find datasets that could be used to test the veracity of whether annualizing emissions (per kilogram of hot carcass weight) over a 10-year period is appropriate. Finally, the BIGGS team was able to secure a robust database from Feedlot Health Management Services.

Protocol	Challenges
Reduced Age at Harvest of Beef Cattle	• The BIGGS team found it difficult to find datasets that could be used to test the veracity of whether annualizing emissions (per kilogram of hot carcass weight) over a 10-year period is appropriate. • Preliminary results of the annualization of emissions test (mentioned above) indicate that there is no difference in final carcass weight based on days on feed. These results indicate that further work may need to be done which could delay the protocol development more.

In year three, quarter three it was decided that work on the dairy protocol should be ceased. This decision was made based on the following learnings:

- The potential for emission reductions is small. Therefore, uptake is likely to be minimal.
- Over the last 15 years, the dairy industry has already adopted the majority of the practice changes presented in the protocol (non-manure management practices). Given this the opportunity is small.
- There have not been any major breakthroughs in the dairy industry in the last decade that would reduce emissions other than the use of rBST. However, rBST's use as a production tool has proven controversial.
- The possibility of feeding Rumensin to improve feed efficiency and reduce emissions was explored; however, a PSAT scientist (Dr. Ermias Kebreab) found that newly prescribed doses of Rumensin did not have as a great of an effect in dairy cattle (only in beef cattle).
- The possibility of reducing emissions by changing the emptying of manure storage units from fall to spring (to avoid methane emissions released in the summer months) was explored; however, in the Southern states dairies use lagoons and in the north this practice would be unlikely to be adopted due high soil moisture in the spring, soil compaction and the lack of financial incentives to make this change.

A separate more detailed document explaining the reasons for not proceeding with the dairy protocol was sent on March 20, 2014 along with associated budget implications.

In regards to the budget, the BIGGS project used its complete budget exclusive of the reductions that were made as a result of removing the dairy protocol from the project and some of the travel funds. A copy of the final Federal Financial Report submitted at the end of the project is included for reference in Appendix A.

The purpose of the Conservation Innovation Grant that The Prasino Group received was to stimulate the application of greenhouse gas benefitting practices on agricultural land and to "get more conservation on the ground" – NRCS's core mission. As discussed above, the BIGGS project was successful in preparing and advancing the science in two agricultural protocols, that if approved, would allow agricultural producers to generate GHG benefits; however, due to delays in project progression to date no producers have been able to implement either of the protocols. Therefore, to date the project has been unsuccessful in "getting more conservation on the ground". Other beneficiaries of this grant include the larger scientific community working on emission reductions from beef cattle projects. The BIGGS project was the first of its kind in the US and although it did not progress as planned, significant learnings were made along the way (Please see the section on findings below for additional information).

1.1 Looking Towards the Future:

It is hoped that in the future the two beef protocols submitted to ACR will be approved so that the beef industry will be able to benefit from this grant through their use. Also, the dairy protocol could be resurrected due to the development of an exciting new technology known as 'Clean Cow' by DSM Nutritional Products. DSM has been working on the development of a compound that inhibits methanogenesis in the rumen for about 7 years. Since the structural elucidation of the last enzyme in a 7 step metabolic pathway converting the hydrogen from feed fermentation and CO_2 into methane in the rumen (published 1997 in Science, known as Methyl Co-Reductase) DSM has envisioned that a compound may be able to be found to block the active site of this particular enzyme. By taking a structural biology research approach, combined with the power of state of the art computational chemistry methods and available databases of possible compounds, they have developed a compound that is a highly specific enzyme inhibitor that works at the molecular level, known as 3-Nitrooxypropanol (3-NOP). Good results from independent researchers in Spain (sheep); Canada (beef and dairy cattle); New Zealand (ruminants); US (dairy) and the UK (dairy) have found effective reductions in enteric methane with the use of 3NOP.

The research on the compound in North America, when fed as a feed additive, is very promising as based on results from scientists who were part of the BIGGS PSAT group. Work done by Agriculture and Agri-Food Canada (Dr Karen Beauchemin - Beef), University of Alberta (Dr. Masahito Oba - Dairy) and Penn State (Dr. Alex Hristov, Dairy) is showing methane reductions of between 30 and 60%, with improved performance of the animal. Dosing is still being worked out, but Dr. Beauchemin is starting a 258 day trial with backgrounders and finishing cattle to determine optimal dosing by assessing the impact on performance of the finishing cattle. What these scientists are finding is:

- The compound always works at suppressing methanogenesis (regardless of ruminant species);
- The effect is lasting / no development of resistance - rumen microbes don't adapt to the compound (unlike ionophores such as monensin or rumensin where methane production resumes after a period of time);
- A reduction in dry matter intake by about 10% in backgrounding phases (higher forage based diets) and about a 10% increase in feed efficiency with no effect on average daily gain or digestibility of the diet;
- An increase in milk production in early lactation cycles, combined with weight gain in the milking cows (which may lead to improved health and reproduction).
- Milk and meat quality are not affected; full toxicology studies are underway to determine the animal and human safety of the compound.

The mode of action report will soon be published. It will show that 3-NOP specifically inhibits methanogenesis but does not affect non-methanogenic bacteria in the rumen (high specificity) and in addition will explain the reversible effect of this type of inhibition. The compound has been shown to have a short half-life in the rumen. Registration of the compound will begin this winter, with an expectation that if all goes well, the product could be registered within a three year timeframe.

To conclude, the following report recommends that USDA and EPA cooperate to create a regional or national GHG offset market in the US that encourages reductions from agricultural opportunities. Without a regional or national regulated market, the potential revenue from carbon offsets will not be high enough to encourage producers to adopt new practices that reduce GHG emissions. Presently, the price of credits in the voluntary market is too low for most producers to be willing to implement practice changes.

Introduction

The BIGGS project was conducted by a diverse team with a wealth of experience in all aspects of cattle project development – science, management, policy and markets/market linkages. The project was co-led by Dr. Garth Boyd[3]), Karen Haugen-Kozyra (M.Sc., P. Ag[4]) and Matt Sutton-Vermeulen (BSc)[5]. Later, these three principals became part of The Prasino Group.

The goals of the project were to adapt and apply innovative mitigation strategies and monetization of carbon reductions in U.S.-based beef and dairy operations, at scale, through (i) stimulating feed use efficiency, reducing manure output and/or improved manure management; (ii) streamlining of complex data management through statistically valid sampling procedures and aggregation methods; (iii) creation of flexible systems that beef and dairy producers can use to generate GHG reductions, (iv) monetization of verifiable carbon credits; (v) creation of carbon market linkages and protocol acceptance between Canada and the United States and across voluntary domestic carbon market standards (e.g. American Carbon Registry and the Climate Action Reserve), (vi) enhanced economic viability of feedlots/dairy farms; and (vii) design of scalable approaches to large GHG reduction tonnage. In addition, the activities proposed aim to close gaps in knowledge, hone best management practices, and transfer findings.

In order to achieve the above goals the project was organized in a phased structure as follows:

1) Protocol adaptation: Adapting the four Canadian protocols to fit the U.S. production systems.
2) Program design and development: Producer outreach to enroll them in the process while engaging key supply chain stakeholders to develop a unified and aligned solution-oriented approach.
3) Program Implementation: Harvesting and analyzing applicable data from individual feed yards/dairies, and 3rd party managed data information systems to road test protocols. Applying statistical sampling protocols to harvest the applicable data. Assessing the baseline GHG emissions from the project (feed yard or dairy) and qualifying carbon by calculating the difference (reduction) between baseline emissions and project emissions after practice was implemented.
4) Project Operations: Setting up data management systems; assembling all qualified project reductions together through aggregation; developing project documentation; proceeding with project monitoring, measuring and reporting; registering, verifying and monitoring projects with a credible Carbon Registry for continued carbon credit generation.
5) Market demonstration: Sale of high quality carbon credits to the voluntary market, with an emphasis on supply chain stakeholders.
6) Program evaluation: Debriefing the key accomplishments, discoveries and gaps identified through the pilot project.

Given the above, the main tasks of the project were to:

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[3] President and Founder of Global Sustainable Solutions (GGS)

[4] Principal of KHK Consulting Ltd (KHK)

[5] President of Unison Resource Company

- Adapt already approved Alberta GHG carbon offset protocols to meet U.S. science and carbon market standards, working with key experienced U.S. beef and dairy nutritional experts and carbon finance specialists
- Secure beef/dairy producer participation in key U.S. states that have the required data and are willing to innovate with new mitigation practices (e.g. ideally targeting four states; with beef/dairy producers that have a minimum of 500,000 head of beef cattle and/or; 25,000 head of dairy cattle)
- Work with NRCS state offices to identify the innovative practices as 'interim practices' for the Field Office Technical Guide (FOTG); and develop EQIP incentives
- Determine the baseline emissions of the cooperating operations, according to the adapted protocols
- Determine the project emissions from implementation of practices over the three year life of the pilot; and set up data management systems for monitoring, measuring and reporting of project emissions;
- Quantify the carbon credits according to the adapted protocols; and have them third party verified by qualified verification firms
- Register the verified carbon credits with an existing Registry (e.g. American Carbon Registry or Climate Action Reserve) and prepare the project documentation that is required for registration
- Evaluation and analysis – assess cooperating producer acceptance and views of the pilot; collect additional economic data from cooperating producers for cost-benefit analysis of the pilot within the context of their operations; including qualitative assessments of any additional environmental benefits arising from the project (this will require a willingness to continue to participate in the longer term program) report and transfer of findings.

The BIGGS project was funded by a USDA Conservation Innovation Grant and support from various project contributors including Camco, WWF and Climate Check.

Background

In 2011, the US agricultural sector was responsible for 461.5 million metric tons of CO_2e in greenhouse gas emissions (GHG) (6.9% of total US GHG emissions). Enteric and manure management emissions made up 20.4% and 7.2% of methane emissions from anthropogenic activities, respectively.[6] In the US there are approximately 87.7 million head of cattle (USDA NAS, 2014). Given this, small reductions in emissions from each individual animal can lead to significant reductions in total GHG emissions.

Numerous studies have demonstrated that enteric methane reductions in cattle can be achieved through a number of innovative production efficiency strategies such as the use of alternate electron acceptors (e.g. added oils to the diet, dried distillers grains), ionophores and betagonists, ration formulations, selecting for more genetically efficient cattle, managing the production chain to shorten cattle lifecycles, among others. In addition to reductions in the

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[6] USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011 (April 2013). See http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.

enteric emissions of methane, reductions can also be achieved through ancillary benefits such as reduced manure production from the above strategies and altering manure management practices. The scientific community agrees that anthropogenic sources of greenhouse gas emissions are causing the earth's climate to warm. Climate Change is expected to have negative impacts on agriculture in many regions of the U.S. These impacts may include declines in crop and livestock production from increased stress due to weeds, diseases, insect pests, and other climate change induced stresses.[7] Given this, climate change not only threatens natural resources, but also producer livelihoods which depend on those resources. If producers were able to generate emission reductions on their farms using an approved quantification protocol they could reduce GHG emissions, while simultaneously generating additional revenue from their operation. Presently, there are no beef cattle protocols in the US under which U.S feedlots can generate carbon credits. Given this, there is limited incentive for farmers to adopt practices that lower GHG emissions.

Review of Methods

This project initiated by seeking the support and engagement of thought leaders in the beef and dairy industry like Ross Wilson, CEO of Texas Cattle Feeders Association and Dr. Mike McCloskey, Chairman of the Sustainability Council of the Innovation Center for US Dairy and CEO of Select Milk Producers Cooperative. There were numerous others in both industries who we engaged with. Their feedback guided us as we sought to move forward with the adaptation of the five Alberta Offset System protocols for use in the US voluntary carbon market.

To initiate the process, we created the Protocol Scientific Advisory Team (PSAT) by enlisting the participation of leading ruminant GHG emission scientists from the US and Canada:

- **Chair — Ermias Kebreab**, Ph.D., *University of California-Davis*
- **Gustavo Cruz**, Ph.D., *University of California-Davis*
- **James Fadel**, Ph.D., *University of California-Davis*
- **Jim Oltjen**, Ph.D., *University of California-Davis*
- **Shawn Archibeque**, Ph.D., *Colorado State University*
- **Stephen Ogle**, Ph.D., *Colorado State University*
- **John Basarab**, Ph.D., *Alberta Agriculture and Rural Development*
- **Karen Beauchemin**, Ph.D., *Agriculture and AgriFood Canada*
- **Tim McAllister**, Ph.D., *Agriculture and AgriFood Canada*
- **Jude Capper**, Ph.D., *Washington State University*
- **Kris Johnson**, Ph.D., *Washington State University*
- **Andy Cole**, Ph.D., *USDA/ARS*
- **Alex Hristov**, Ph.D., *Penn State*
- **Rob Janzen**, Ph.D., *ClimateCHECK*
- **Nick Martin**, *American Carbon Registry*
- **Erasmus Okine**, Ph.D., *University of Alberta*
- **Harvey Freetly**, Ph.D., *USDA Meat Animal Research Center*

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[7] http://nca2014.globalchange.gov/report/sectors/agriculture#intro-section-2

- **Ben Weinhemer**, *Texas Cattle Feeders Association*
- **Juan Tricarico**, Ph.D., *Dairy Management Inc.*

A two-day meeting was held on the UC Davis campus on Dec. 11th and 12th, 2011. The outcomes from this meeting can be found in the Appendix.

Once we had agreement from the PSAT on how to proceed with protocol adaptation, we worked for many months to change the protocol methodology. To the best of our knowledge, this is the first time that a protocol was ever created in the US for capturing the reduced GHG emissions that occur from innovative beef production practices.

Upon completion, we chose to engage with the American Carbon Registry (ACR) to go through the protocol scientific review and approval process. ACR has a strong reputation for developing scientifically credible carbon protocols. In addition, ACR has fostered a relationship with the California Air Resources Board (CARB) that increased the chances that should the protocols be approved by ACR, someday, they may be also approved by CARB for carbon credit generation and sale into the California cap and trade program known as AB 32. This potential outcome would result in much higher prices for carbon credits and this market signal would incentivize beef producers to adopt these innovative practices resulting in lower emissions associated with beef cattle production.

As stated earlier, although the project team engaged beef and dairy cooperators to assess data needs, data availability and feasibility of participation, the project never reached the pilot stage. Unfortunately, the process of adapting the protocols to the US took significantly longer than anticipated as did ACRs protocol review process.

Discussion of Quality Assurance

The Alberta Offset Protocols that the BIGGS team chose to adapt, had already gone through an ISO 14064:2 process standard-based, rigorous and scientifically robust process to determine applicability of the practices and methodology to offset policy criteria fit before going through another round of stakeholder review, and then finally through a 30 day public comment process and ultimate approval by Alberta Environment.

In the BIGGS project, these protocols were presented to the group of PSAT scientists at a workshop December 2011 at UC Davis. The PSAT team carefully discussed and reviewed the methodological approaches used in the protocols and assessed their suitability for adapting to US conditions. A list of consensus-based decisions for adapting the science were generated by the PSAT and further work packages developed for the new science pieces identified through the process. As work moved forward, the PSAT scientists were engaged in the review and new revisions through the use of an on-line review tool known as Collaborase. Eighty percent agreement on the final adapted protocol methods was sought and achieved through the review process. An on-line webinar was conducted with the PSAT team in July 2012 for feedback on progress thus far. Further agreement and work was identified.

Findings

This initial protocol development and review process in Alberta was unique to Alberta and Canadian conditions, however, the quantification methodology used was based on the globally recognized IPCC 2006 guidelines so many of the parameters applied to US conditions as well. Further, the US national emissions inventory approaches, like Canada's, is based on IPCC Tier 2 to Tier 3 methodologies so the methodological approaches were quite similar and based on best available science (see Appendix B, C and D for the final protocols; the Fed Cattle and Reduced Age to Harvest were submitted to ACR). In general, the PSAT review of the protocols did not result in major discrepancies in the methodological approaches used in the Alberta protocols. Suggestions for appropriate factors to use and further work packages were determined at the December workshop (see Appendix D), but overall the science was relatively consistent.

The improvements in the science pieces are embedded throughout the 3 protocols in the appendices. All were approved by the PSAT with an 80% definition of consensus (these pieces are available on request). The protocol was submitted to ACR in the fall of 2012, and after conducting their internal review, with the BIGGS team providing revisions back and forth, the protocol was ready to proceed to public webinar a year later.

In the case of the Dairy protocol, the cross-border committee directed the BIGGS team, with the help of ClimateCHECK's in-kind contribution to conduct a heifer sensitivity analysis to determine the significance of the replacement herd on the overall emission reduction and whether it could be conservative to exclude the heifer quantification, and if so, at what level. This analysis is shown in Appendix G). The findings were that the project developer can conservatively exclude quantifying emissions from heifer animal groupings/herd components on a given farm, if the project developer can demonstrate that the project heifer inventory did not increase by more than 2.5% on average over the baseline numbers in any given year. Sufficient records documenting this flexibility option must be available, and signed off by a professional nutritionist, proving the monthly number of heifers on the farm for baseline and project years stayed within this variance. It was hoped this could significantly reduce the burden of gathering data for the heifer herd components on the dairy farm.

In September 2013, ACR hosted a webinar for public input to the Fed Cattle Protocol (see http://americancarbonregistry.org/news-events/events/acr-invites-stakeholder-feedback-on-a-methodology-for-reduced-carbon-intensity-of-fed-cattle). It was widely attended, but no major issues arose. Then, as part of ACR's third party scientific review, the BIGGS team was engaged over the course of the next year, along with key members of the PSAT to address the blinded scientist panel's questions regarding the Fed Cattle Protocol.

It was during this time period that the BIGGS team, as well as other PSAT members, could not resolve the issues to the satisfaction of two out of the four scientific reviewers. There is potential to still continue on with addressing the scientific concerns, but the BIGGS team had exhausted their resources in continuing on with this process.

Conclusions and Recommendations

The intent of the CIG Grant was to identify innovative practices that would reduce carbon and link those to an active voluntary carbon registry to test the ability to generate carbon offsets from U.S beef and dairy operations. While we accomplished significant results in adapting the Alberta protocols to U.S conditions along with innovative scientific improvements and beef and dairy cooperative engagement, it was difficult to deliver the outcomes the CIG Grant was looking for. Much of this was due to the ongoing formulation of voluntary and compliance based registries on what would count towards rigorous agricultural carbon offsets and methodologies.

The project team thanks the USDA for allowing a CIG grant process to focus on GHG reductions. Similar to C-AGG recommendations to the USDA (August 2013), the USDA GHG CIG projects have provided a critical path to enabling viable agricultural offset protocols to be developed for compliance-based and voluntary carbon markets. Additionally, USDA's investments have leveraged private sector and Canadian government investments in agricultural offset protocol and methodology development and related activities that are critical to further progress in this important area. Through our efforts, significant cross-border (Canada-US) collaboration between scientists on adapting protocols within the USDA GHG CIG projects has led to synergistic progress on pathways to quantifying and reducing greenhouse gas emissions in agricultural operations.

As C-AGG points out in their August 2013 report, the timelines for project development are longer than the USDA GHG CIG project cycle an, particularly for these first-of-a-kind projects in Beef and Dairy. Protocol development, farmer recruitment, project implementation, and credit delivery can take five or more years to complete. Further, the financial restrictions on EQIP funding for larger feedyard and dairy operations, made it difficult for the project team to link carbon offset opportunities with EQIP funding, as another value-add to make the financial return more attractive for these co-operators, and getting over the 'why bother' factor.

Finally, practice changes of any kind require decision support systems, and the bigger the practice change, the more important the support system is to inducing the desired change. This is particularly true for practice changes that involve long-term management investments (e.g. capital investments, infrastructure, and equipment). These changes are viewed largely as business decisions, and without the decision support systems, including business case scenarios showing adequate return on investment, even smaller practice changes that might reduce yield or income are viewed as risky – particularly if the financial benefits of participating are uncertain or delayed.

Going forward, the business case and value proposition uncertainties need to be resolved as carbon market's mature and the role of agricultural offset opportunities within them, as well as the resulting difficulty in estimating credits or the value of credits from any given agricultural offsets project. These uncertainties have limited or stifled full-blown investor, developer (project or protocol), and producer engagement– which makes ongoing GHG CIG project investments all the more critical to developing the business case and the certainty needed to develop these opportunities. As C-AGG points out, further programmatic and protocol design investments are necessary to apply the learnings of this project and complete the success of the significant investments made in all the CIG projects to date (note - the BIGGS project team was a significant contributor to the August 2013 C-AGG report).

The project team recommends the following:

1. USDA and EPA cooperate to create a process to develop compliance quality offsets for sub-national regulated markets in the U.S that encourage reductions from agricultural opportunities. This would include sharing the datasets needed to develop standardized baselines.
2. USDA and EPA build upon the draft methodologies developed under this project since significant effort and resources have been invested into these quality methodologies.
3. USDA and EPA recognize that breakthrough technologies (i.e. Clean Cow Compound) will soon become available, enhancing the opportunity for U.S beef and dairy producers. Anything that USDA and EPA can do to support this innovative technology will help enhance methane reduction opportunities for the U.S.

In addition, we fully support the C-AGG recommendations previously submitted to USDA in August 2013 (see http://c-agg.org/resources/ report entitled USDA GHG CIG Projects: C-AGG Recommendations and Feedback to USDA.

Appendices

Appendix A: Final Federal Financial Report

FEDERAL FINANCIAL REPORT

(Follow form instructions)

1. Federal Agency and Organizational Element to Which Report is Submitted	2. Federal Grant or Other Identifying Number Assigned by Federal Agency (To report multiple grants, use FFR Attachment)	Page	of
USDA NRCS	69-3A75-11-134	1	pages

3. Recipient Organization (Name and complete address including Zip code)

Name: The Prasino Group USA, LLC
Address: 1121 Military Cutoff Road, Suite C-320, Wilmington, NC 28405

4a. DUNS Number	4b. EIN	5. Recipient Account Number or Identifying Number (To report multiple grants, use FFR Attachment)	6. Report Type	7. Basis of Accounting
0-78583789	45-3273676	Y3-Q4	☑ Quarterly ☐ Semi-Annual ☐ Annual ☐ Final	☑ Cash ☐ Accrual

8. Project/Grant Period (Month, Day, Year)				9. Reporting Period End Date (Month, Day, Year)
From:	August 1, 2011	To:	July 31, 2014	June 30, 2014

10. **Transactions**	Cumulative
(Use lines a-c for single or combined multiple grant reporting)	
Federal Cash (To report multiple grants separately, also use FFR Attachment):	
a. Cash Receipts	$0
b. Cash Disbursements	$0
c. Cash on Hand (line a minus b)	$0
(Use lines d-o for single grant reporting)	
Federal Expenditures and Unobligated Balance:	
d. Total Federal funds authorized	$1,055,996
e. Federal share of expenditures	$927,990
f. Federal share of unliquidated obligations	$0
g. Total Federal share (sum of lines e and f)	$927,990
h. Unobligated balance of Federal funds (line d minus g)	$128,006
Recipient Share:	
i. Total recipient share required	$1,568,368
j. Recipient share of expenditures	$1,438,854
k. Remaining recipient share to be provided (line i minus j)	$129,514
Program Income:	
l. Total Federal share of program income earned	$0
m. Program income expended in accordance with the deduction alternative	$0
n. Program income expended in accordance with the addition alternative	$0
o. Unexpended program income (line l minus line m or line n)	$0

11. Indirect Expense	a. Type	b. Rate	c. Period From	Period To	d. Base	e. Amount Charged	f. Federal Share
	n/a						
				g. Totals:	0	0	0

12. Remarks: Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation:

13. Certification: By signing this report, I certify to the best of my knowledge and belief that the report is true, complete, and accurate, and the expenditures, disbursements and cash receipts are for the purposes and intent set forth in the award documents. I am aware that any false, fictitious, or fraudulent information may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

a. Typed or Printed Name and Title of Authorized Certifying Official	c. Telephone (Area code, number, and extension)
Matt Sutton-Vermeulen	515-371-7914
	d. Email Address
	mattsv@prasinogroup.com
b. Signature of Authorized Certifying Official	e. Date Report Submitted (Month, Day, Year)
	03/31/2014
	14. Agency use only:

Standard Form 425 - Revised 10/11/2011
OMB Approval Number: 0348-0061
Expiration Date: 2/28/2015

Appendix B – Reduced Carbon Intensity of Fed Cattle Methodology

American
Carbon
Registry

The American Carbon Registry™

July 2013

Quantification Methodology for Reduced Carbon Intensity of Fed

Prepared by the Protocol Scientific Adaptation Team, of the USDA Conservation Innovation Grant GHG Pilot called Bovine Innovative Greenhouse Gas Solutions (BIGGS).

Acronym List

The following acronyms are used in this methodology:

ACR	American Carbon Registry
AMS	Agricultural Marketing Service
BIGGS	Bovine Innovative Greenhouse Gas Solutions
Bo	Methane Producing Capacity
CF	Conversion Factor
$CF_{protein}$	Protein Conversion Factor
CH_4	Methane
CP	Crude Protein
$\rho_{Methane}$	Density of Methane
DOF	Days on Feed
DM	Dry Matter
DMI	Dry Matter Intake
EC Methane	Methane Energy Content
ED	Elasticity of Demand
ERTs	Emission Reduction Tons
EF	Storage Emissions Factor
EF Enteric	Enteric Emissions Factor
ES	Elasticity of Supply
GE Diet	Gross Energy Content of Diet
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
MCF	Methane Conversion Factor
MS	Management System
NE	Nitrogen Excreted
NR	Nitrogen Retention
N_2O	Nitrous Oxide
PAS	Professional Animal Scientist
TDN	Total Digestible Nutrients
UE	Urinary Energy
VS	Volatile Solids

Acknowledgements

This methodology was adapted from three Alberta Offset System Quantification Protocols: 'Reducing Days on Feed in Beef Cattle', 'Including Edible Oils in Beef Feeding Regimes' and 'Selecting for Low Residual Feed Intake in Beef Cattle', by the Bovine Innovative Greenhouse Gas Solutions (BIGGS) Protocol Scientific Adaptation Team, and submitted to the American Carbon Registry (ACR) for approval through the public consultation and scientific peer review process.

This methodology was developed with financial support from the United States Department of Agriculture Natural Resources Conservation Service under the Conservation Innovation Grants Program.

ACR extends its appreciation in particular to Ermias Kebreab and members of the Protocol Scientific Adaptation Team as part of the BIGGS adaptation process:

- **Chair — Ermias Kebreab**, Ph.D., *University of California-Davis*
- **Gustavo Cruz**, Ph.D., *University of California-Davis*
- **James Fadel**, Ph.D., *University of California-Davis*
- **Jim Oltjen**, Ph.D., *University of California-Davis*
- **Shawn Archibeque**, Ph.D., *Colorado State University*
- **Stephen Ogle**, Ph.D*., Colorado State University*
- **John Basarab**, Ph.D., *Alberta Agriculture and Rural Development*
- **Karen Beauchemin**, Ph.D*., Agriculture and AgriFood Canada*
- **Tim McAllister**, Ph.D*., Agriculture and AgriFood Canada*
- **Jude Capper**, Ph.D*., Washington State University*
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- **Andy Cole**, Ph.D., *USDA/ARS*
- **Alex Hristov**, Ph.D., *Penn State*
- **Rob Janzen**, Ph.D*., ClimateCHECK*
- **Nick Martin**, *American Carbon Registry*
- **Erasmus Okine**, Ph.D*., University of Alberta*
- **Harvey Freetly**, Ph.D., *USDA Meat Animal Research Center*
- **Ben Weinhemer**, *Texas Cattle Feeders Association*
- **Juan Tricarico**, Ph.D., *Dairy Management Inc.*

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1. Introduction

In 2011, the agricultural sector in the US was responsible for greenhouse gas (GHG) emissions of 461.5 million metric tons of CO_2e (6.9% of total US GHG emissions), with enteric and manure management emissions making up 20.4 and 7.2% of total methane emission from anthropogenic activities, respectively.[8] In the US, cattle and dairy production systems feature a combination of extensive grazing and intensive stages of production (e.g. feedlots and confined feeding). With an inventory of approximately 94 million head of cattle, small reductions in emissions associated with each animal can lead to significant reductions overall for U.S. animal agriculture.

Quantifying methane and nitrous oxide emissions from enteric fermentation and manure storage and handling is well characterized by the Intergovernmental Panel on Climate Change (IPCC 2006) best practice guidance. The science laid out in the IPCC guidance is applied in the U.S. to quantify enteric and manure-based emissions at a Tier 2 level. This methodology relies heavily on these quantification methods. When applied in project-based accounting, GHG emissions for *baseline* and *project* are calculated within cattle category and feeding period, known as animal groupings, using US-customized IPCC Tier 2 equations and the best available feedlot activity data.

1.2 Purpose

Agricultural activities, including the production of livestock, result in greenhouse gas emissions to the atmosphere. Beef cattle, in particular, release methane (CH_4) as a result of the digestion of feed materials in the rumen. These emissions are called enteric emissions and are a significant contributor to greenhouse gas emissions from agricultural activities. Other emission sources from cattle include methane and nitrous oxide (N_2O), generated from manure storage and handling within beef cattle operations.

This methodology addresses greenhouse gas emission sources for both enteric fermentation and manure storage/handling for beef cattle operations. Within the scope of this methodology, reductions in upstream emissions from lower carbon intensity feed production (e.g. renewable fuels for crop production, or less synthetic N fertilizer use) is not included. This methodology allows users to quantify greenhouse gas reductions using scientifically valid equations and emission factors. The American Carbon Registry *Quantification Methodology for Reduced Carbon Intensity of Fed Cattle* was developed to provide a standardized quantification methodology for calculating these greenhouse gas reductions. The reductions arise from alterations in feeding strategies and other technologies that reduce the carbon intensity, per kg of fed cattle at feedyards in the United States, compared to baseline conditions.

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[8] USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011
(April 2013). See http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.

2. Scope, Definitions, Applicability and Methodology Flexibility

2.1 Scope

Industry experts and agricultural scientists have developed methods, based on the Intergovernmental Panel on Climate Change (IPCC 2006) Tier 2 accounting procedures, and the United States' national emissions inventory, to calculate enteric and manure emissions generated by different cattle classes in the U.S. This science forms the basis for the quantification methods used in this methodology.

The scope of this methodology includes a number of innovative feeding practices and management strategies that can be implemented to decrease the carbon intensity in producing beef cattle. The metrics for emissions reductions applied in this methodology are compared in the baseline and project conditions, using a functionally equivalent unit of tonnes emissions reductions per kg of carcass weight. This methodology does not prescribe any particular feeding practice because it is recognized that different feedyard operators will use different techniques and several techniques may be used at once and may vary over time.

The kinds of innovative strategies that could decrease the carbon intensity of fed cattle include, but are not limited to the following:

1. Performance Tracking and Cattle Sorting Improvements – implementing individual animal performance management tracking and improved sorting for customized feeding by animal grouping;
2. Feeding Strategies – addition of feed components to the diet that inhibit uptake of electrons and hydrogen by rumen methanogenic bacteria, suppressing enteric methane emissions. Such feed additives include fats, oils[9], and others (e.g. fumarate, malate, oxaloacetic, beta hydroxybutyric acid, propyonic acid, and butynoic acid);
3. Feeding Technologies - beta-agonists and growth promoters which improve lean tissue growth and feed-to-gain; use of ionophores at newly prescribed dosage increases (40 g/ton of feed, etc.);
4. Genetic improvements – breeding for those animals which have naturally better feed conversion efficiencies;
5. Other innovative techniques being employed or that will be employed in the future, with justification as to how they impact feed-to-gain ratio, reduced days on feed, or decreased carbon intensity of beef production.

In all cases, the Project Proponent[10] must demonstrate through feedyard documentation and records that cattle in the project condition are showing decreased carbon intensity (tonnes of greenhouse gas emissions/kg hot carcass weight) relative to the cattle in the baseline condition. This methodology outlines the necessary measurements and monitoring parameters to quantify resulting emission reductions.

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[9] Feeding of edible oils at concentrations greater than 6% on a dry matter basis will not yield any incremental greenhouse gas reductions and may result in compromising the health of the animal.

[10] Note – this may be a feedlot operator if the feedyard is large enough to bring forward a commercially viable project, or could be an entity that enters into agreements with a number of feedyards to aggregate reductions for commercial purposes.

The baseline condition describes typical feeding and management strategies that represent average business operations for feedyards across the United States. The strategies include feeding regimes and other information typically found in feedyard close-out data, such as average dry matter intake of the cattle groups, average number of days required to complete a finishing diet, average carcass weight of the cattle sent to market, etc. This methodology uses a static historic performance-standard baseline that is developed from national level data to determine the baseline level of emissions intensity for beef cattle in the United States**.** This means that the baseline emissions are held constant and compared to the annual, actual feedyard-calculated project emissions intensity over the course of the project's Crediting Period. The baseline quantification approach is explained further in section 3.

The project condition defines the feeding and management strategies that reduce carbon intensity of beef production on a net basis[11], for the project year. As in the baseline condition, this includes data on the feeding regime, feedyard close-out data, such as average dry matter intake of the cattle groups, average number of days required to complete a finishing diet, average carcass weight of the cattle sent to market, but also the documented use of any strategies/technologies/additives that are employed in the feedyard. In general, the feeding and management strategies must be new to the feedyard operations after 2003.

More information on project emissions quantification is available in section 4.

The quantification approach and requirements are explained further in section 5.

Table 3: Relevant Greenhouse Gases Applicable for Reducing the Carbon Intensity of Fed Cattle in the US

Specified Gas	Formula	100-year GWP	Applicable to Project
Carbon Dioxide	CO_2	1	N
Methane	CH_4	21	Y
Nitrous Oxide	N_2O	310	Y

2.2 Definitions

Animal groupings	Specific groupings of cattle in the feedyard as they move through to the finishing stage. Groupings are typically based on production system and may be classified according to calf-fed, yearling-fed, gender (heifer, steers, bulls), weight and marketing program (e.g., a quality grid program like Rancher's Beef). Note: A feedyard may contain more than one pen

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[11] Project proponents/feedyard operators will need to quantify emissions reductions according to the methodology procedures to determine whether there is a net reduction in the feedlot (across all animal groupings) due to changes in feeding practices. It is the net reduction, summed across all relevant animal groupings in the project year that determines whether the Project Proponent has a claim to carbon credits.

	within the same animal grouping[12].
Animal head days	A basic unit used to account for the number of days animals were on feed in a specific animal grouping, calculated as the sum of the number of days each animal spent on a specific diet as it moved through the feedyard pens for that animal grouping. This is a weighted average approach to derive the average number of head, average daily dry matter intake, and average days on feed for each animal grouping that accounts for the disaggregation of lots into smaller units in the feedlot (i.e. pens for feeding).
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 the hide, head, tail, forelegs, internal organs, digestive complex and kidney knob and channel fat.
Concentrates	A broad classification of feedstuffs which are high in energy and low in crude fibre (<18% crude fibre). Concentrates can include grains and protein supplements, but exclude feedstuffs like hay, corn stover, silage or other roughage.
Custom feeding lot records	The records kept on a group of cattle by the feedyard operator for cattle owned by someone else.
Diet (ration)	Feed ingredients or mixture of ingredients, including water, consumed by beef cattle (Ensminger and Olentine (1980). Diet includes the amount of and composition for feed supplied to an animal for a defined period of time.
Fats and oils[13]:	This includes animal derived fats and fat blends including but not limited to white and yellow grease, tallow, lard and vegetable oils. Whole plant seeds and by-products such as corn/sorghum distiller grains/solubles (dry or wet) may also be applied as a feed ingredient so long as the oil content is

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[12] Animals shall be grouped for calculations with incoming weights in 45.4 kg (100 lb) increments. 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 feedyard for slaughter between 601.0 (1325 lb) and 635.0 kg (1400 lb) may be an animal grouping while another part of the project may use yearling-fed heifers on a quality grid program coming on feed between 340.2 kg (750 lb) and 385.6 kg (850 lb) and leaving the feedyard for slaughter between 657.7 kg (1450 lb) and 703.1 kg (1550 lb). Groupings of cattle will typically have a series of rations for a specified number of days on feed; this is termed *feeding periods* in this protocol.

[13] Note there are other edible oil-containing products such as unstabilized rice bran, or walnut oils, extracted oil from Dried Distillers Grains, or even beef tallow where available. The onus is on the Project Proponent to work with their nutritional specialist to ensure the ration formulation fits the requirements of this methodology.

	calculated on a dry matter basis to achieve the 4 to 6% content in the diet to suppress methanogenesis by 20% and not compromise the health of the animal.
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 beef cattle over a set period of time. This is then repeated for similar groupings of cattle.
Feeding periods	Animal groupings typically have a series of diets for a specified number of days on feed.
Feeding regimes	The whole system of diets fed to animals over the baseline/project period.
Land application	The beneficial use of agricultural manures and/or digestate applied to cropland based upon crop needs as a source of soil amendment and/or fertility.
Project Start Date	The date the feedyard or group of feedyards began to reduce GHG emissions against the performance standard baseline in this methodology. The Start Date is typically determined by the Project Proponent through their cooperative work with the feedyard to identify the date where a measurable impact on carbon intensity is being achieved as a result of adoption of reduction strategies.
Project Crediting Period	Ten years from the Start Date.
Project proponent	As defined in *ACR Standard*, "an individual or entity that undertakes, develops, and/or owns a project. This may include the project investor, designer, and/or owner of the lands/facilities on which project activities are conducted. The Project Proponent and landowner/facility owner may be different entities." For the purposes of this methodology, the Project Proponent may be a feedlot operator if the feedyard is large enough to bring forward a commercially viable project, or could be an entity that enters into agreements with a feedyard or a number of feedyards to aggregate reductions for commercial purposes.
Nutritionist	A practicing professional ruminant nutritionist responsible for formulating feedyard and dairy rations.

Quality grid program	A set of quality attributes (carcass weight, marbling, back fat thickness) for which a packing plant or a food processor is willing to pay a premium or give a discount to the feedyard operator.
Yardage	Overhead, or the cost of depreciation on original capital investment and interest, upkeep of pens, water, electricity, fuel, manure handling, equipment repairs, hired labor, and operator labor.

2.3 Applicability

To apply this methodology, the Project Proponent must meet the following requirements:

1. Diets fed to animals have sufficient documentation to quantify a reduction in enteric/manure-based emissions according to the quantification procedures outlined in Section 5. Specifically, the Project Proponent must have sufficient data and project level documentation detailing the content and quantity of feed fed per animal grouping in order to quantify enteric and manure emissions.

2. Animal grouping criteria must be shown to be similar between the baseline and project calculations, based on feeding practices and diets. Emission reductions must represent a reduction in emissions based on a common metric of emissions per kg carcass weight to ensure emissions reductions being quantified represent real reductions in carbon intensity when compared against the performance standard baseline.

3. Manure must be managed according to a Manure Management Plan, as required for confined animal feeding operations for the particular state where the feedyard is located. The intent is to verify that a permit is in place and is current and no major changes in manure handling have occurred over the life of the project. A major change is a signal to contact the American Carbon Registry for more clarification on how to proceed.

4. Sampling of project animals is allowed under this methodology and must be done according to the statistical sampling methodology outlined in Appendix B.

5. The quantification of reductions achieved by the project is based on measurement/estimation and monitoring as indicated by the proper application of this methodology.

6. For this methodology, emission reductions qualify if they occur in the United States.

7. The project meets the eligibility criteria stated in the American Carbon Registry Standard. In order to qualify, emissions reductions must:
    - Result from actions not otherwise required by law;
    - Result from actions taken on or after January 1, 2003;
    - Be real, demonstrable, additional, permanent and quantifiable; and

- Have clearly established ownership.

The general data requirements for this methodology are shown in Table 2 below. Additional details are provided in sections 5.0 and 6.0.

Table 4: General Overview of Data Requirements for the Project

Data Requirements:	What is needed:	Why it is needed:
Animal identifier	Animal identification (either by lot or by individual)	To track animals as they move through the feedyard.
Alignment of the animal groupings to the performance standard baseline, for quantification procedures in the project years; Average number of animals per grouping/lot	Documented feedyard records of animal grouping/lot entry and exit records that show: • Average weights of the group in and out, • Average date of entry (by production system, quality grid program, sex, breed or custom feedyard records); • Average number of animals in each grouping/lot; • Average daily dry matter intake for the animal groupings.	The methods used to define an animal grouping (e.g. sex, age, weight, breed, etc.) must be the same between project and baseline to ensure like groupings are compared for the offset calculations.
Documented proof of: • What was being fed to the cattle per grouping/lot in the feedyard; • Days on feed for each lot; • Diet composition; • Feed additives or strategies employed by the feedyard	Records include: • Feed purchase receipts or scale tickets, weights, etc. • Delivery records for a pen; • Diet formulations signed off by a qualified nutritionist; • Diet ingredients must include % Ether Extract, %Total Digestible Nutrients (TDN), % Concentrates; % Crude Protein and any additive or edible oil (4 to 6%) content on a dry matter basis in the diet; • Proof the diet was fed to the animals as indicated from feedyard or dairy record keeping systems or third party record keeping when appropriate.	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 project condition.
Incoming and outgoing average	Documented feedyard records of animal pen/lot entry and	To determine the animal groupings for

Table 4: General Overview of Data Requirements for the Project		
Data Requirements:	**What is needed:**	**Why it is needed:**
weight of each grouping of animals being included in the baseline and project	exit records that show: - Average weights of the group in and out, - Average date of entry and exit - Average number of animals in each pen/lot - Average carcass weights of harvested animals	calculations and the outgoing animal weights for carcass adjustments.
Legal land location of the feedyard operation, and feeding agreements for the animals in the project	- Legal land description will match ACR requirements - Proof that the animals fed in the project were under control of the feedyard operator in question (see section 6.2)	Required for registration of the project.

This methodology is only applicable to emission reductions generated through the implementation of innovative feeding strategies that result in a lower carbon intensity, on a net basis for the feedyard (i.e. across all animal groupings) in the project versus the performance standard baseline.

1.3 2.4 Flexibility

This methodology provides the following flexibility mechanisms in recognition of differences in management, feeding strategies and data collection across feedyards:

1. Where the required data for this methodology vary across animal groupings (i.e. weight class, age, sex, breed, diets) in a feedlot, the animals can be grouped in discrete units for the purposes of calculating greenhouse gas emissions in this methodology rather than in groupings that occur in the feedlot. It is important to note that exercising this flexibility option will require justification to the verifier that similar groupings between baseline and project were used for the calculations.[14]

2. Greenhouse gas reductions may be calculated on a ‘kilogram of live animal weight’ unit of production, rather than a kg of carcass weight. Emission reductions may be calculated based on dressing percentages (kilograms of carcass weight/kg of live weight) as long as

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[14] If using the flexibility option of defining discrete cattle groupings for calculation purposes, the Project Proponent must use a range of incoming weights of 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 while another part of the project may use yearling-fed heifers on a quality grid program coming on feed between 340.2 kg (750 lb) and 385.6 kg (850 lb) and leaving the feedlot for slaughter between 657.7 kg (1450 lb) and 703.1 kg (1550 lb).

the same unit is applied to the baseline and project conditions and the data can be substantiated (i.e. packing plant receipts).

3. Distillers grains and solubles have been identified as an acceptable source of dietary fat that will suppress methanogenesis in the rumen. These rations need to have nitrogen levels balanced so that excess excretion of nitrogen does not occur.

4. To streamline implementation and ensure conservativeness in the offset calculations, the Project Proponent can treat the entire time the cattle are in the feedyard as though they were on a >85% concentrate diet. To use this approach would be conservative for both baseline and project, because the IPCC 3% emission factor, and not the 6.5% emission factor for methane loss from the digestion of feedstuffs, is required to be applied to both conditions.

5. Monensin has been identified as an acceptable additive to minimize methane (CH_4) emissions from cattle. Monensin has traditionally been used in beef cattle as a feed additive at a dose of 32.4 mg/kg Dry Matter (DM) of feed. However, it has recently been approved by the Food and Drug Administration Center for Veterinary Medicine (FDA CVM) for use at 40 mg/kg DM of feed - an additional opportunity for this methodology. According to a meta-analysis prepared by Dr. Ermias Kebreab and his team at UC Davis (Appuhamy *et. al* 2013), for 1 mg/kg DM increase in monensin dose, the expected reduction is about 0.1% of the Enteric Emissions Factor for methane (EF Enteric; see Table 9). For those feed yard operations applying the new dosage, the incremental reduction in EF can be substituted for the standard 3% EF Enteric for diets equal to or greater than 85% concentrates, and the standard EF Enteric of 6.5% for those diets less than 85% concentrates. NOTE – due to the habituation of methanogens in the rumen to ionophores, this effect can only be claimed for the first 10 weeks the animal is in the feedyard and being fed the higher dose. The EF Enteric factors would also need to take into account the fat content of the diet and be adjusted accordingly (see Table 9).

3. Baseline Methodology Procedure

3.1 Project Boundary

The boundary of this methodology encompasses the feedyard operation where the cattle are raised and fed as well as the facility/sites where manure is stored and handled (see Figure 1). The project may include a number of feedyards, and a variety of enterprises, but all project farms will address the activities within the boundary of the project as outlined in this methodology. Credits are generated by demonstrating a reduction in carbon intensity of fed cattle in the project condition, compared to the baseline condition. A performance standard baseline is applied in this project (see Section 3.4). The project temporal boundaries are given in the Definitions (Section 2.2), The Project Start Date is defined as the date the feedyard or group of feedyards began to reduce GHG emissions against the performance standard baseline in this methodology. The Crediting Period spans 10 years from the Project Start Date.

3.2 Demonstrating Additionality

In order to evaluate the additionality of project activities, i.e. that the project activity is additional to any regulatory requirements and reduces emissions below the level associated with a conservative business-as-usual scenario, the Protocol Scientific Adaptation Team took into account current laws and regulations as well as assessed data for 2000 to 2011 from a number of regional and national sector-level practices (see section 3.4). This methodology adopts a performance standard approach to additionality. Project Proponents must evaluate applicable regulations applying to the project activity and demonstrate in the GHG Project Plan that the project activity is not required by any regulation; this demonstration is subject to third-party verification. However, Project Proponents are not required to make any project-specific demonstration of implementation barriers; rather, any project activity that reduces carbon intensity below the static historic performance-standard baseline carbon intensity, established on the basis of data summarized in section 3.4, is automatically considered to be additional provided it has passed the regulatory surplus test.

3.3 Baseline Condition

The methodology uses a static historic performance-standard baseline condition. Under this scenario, a baseline greenhouse gas emissions intensity per kg of carcass weight (kg CO_2e per kg carcass weight) is quantified for each animal grouping and averaged over a period of three years using a combination of representative, statistically valid industry and national USDA databases (see Appendix B). This methodology allows the Project Proponent to maintain a static baseline over the project Crediting Period that is representative of the baseline practices for the beef feeding sector in the United States. In essence, the methodology asks Project Proponents to compare monitored project-specific performance to “typical” feedyard performance animal groupings (weight by gender class) as characterized by a static performance standard baseline based on national datasets.

The sources and sinks identified in the following process flow diagrams cover the full scope of eligible baseline activities under the methodology (Figure 1). Note that the dotted line in Figure 1 indicates the sources and sinks that occur on site in the baseline condition.

3.4 The Performance Standard Baseline

The Colorado State University emissions inventory group, under guidance from the BIGGS USDA-CIG Grant Protocol Science Adaptation Team, developed the performance standard baseline calculations. Data to assess the baseline were derived from published, nationally relevant and/or national level datasets for cattle performance and for cattle feed information from 2000 to 2011[15] (see method description in Appendix B). An average of the 3 years prior to the start of the project is used to obtain the performance standard baseline intensity, held static, and used to compare to the project scenario for the duration of the Crediting Period. For example if the project starts in 2007 then the performance standard baseline is calculated as the average intensity of 2004, 2005, and 2006, and would be used to compare to all project years in the Crediting Period. Note that because data is not available prior to 2000, the earliest project Start

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[15] The Performance Standard Baseline will be updated every year and made available at (www.acr.drop link in here).

Date is 2003 which would use a performance standard baseline that uses the average of 2000, 2001, and 2002. Table 3 below presents the results of the baseline methodology assessment by animal grouping as of publication date of this protocol. Use the baseline from the most recent 3 years in the table for projects involving subsequent years (i.e., 2012 and 2013) until a new updated table is made available.

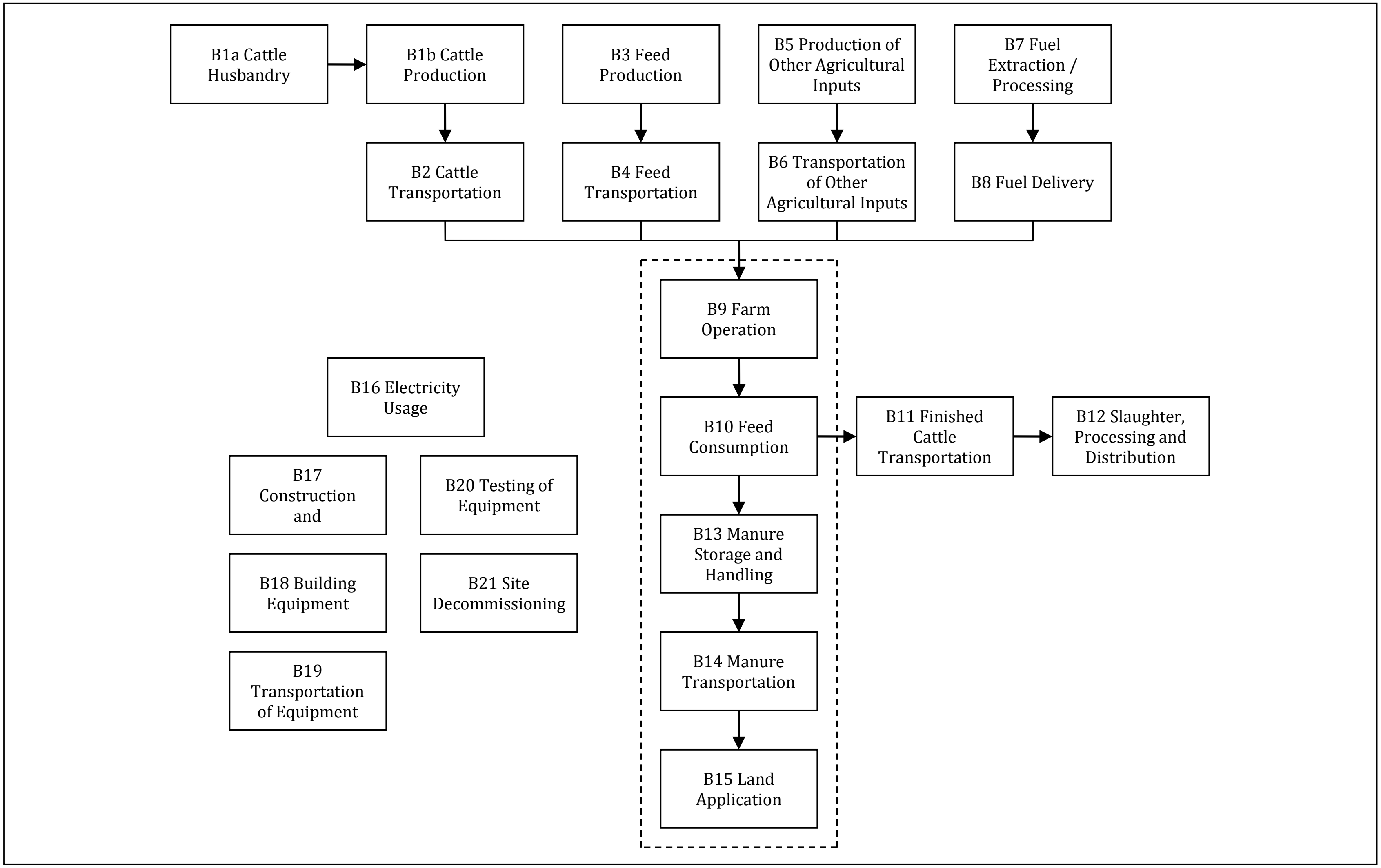
Table 5: Performance Standards for US Cattle (2000 – 2011)

	kg CO$_2$e/kg carcass weight												
	Steers							Heifers					
	Groupings (In Weights - 100 lb Increments)												
Year	**500-599**	**600-699**	**700-799**	**800-899**	**900-999**	**1000+**		**500-599**	**600-699**	**700-799**	**800-899**	**900-999**	**1000+**
2000	1.40	1.20	1.00	0.80	0.61	0.51		1.12	1.12	0.89	0.66	0.44	0.32
2001	1.42	1.21	1.01	0.81	0.61	0.51		1.15	1.15	0.92	0.69	0.46	0.34
2002	1.40	1.21	1.02	0.83	0.64	0.55		1.13	1.13	0.91	0.69	0.47	0.37
2003	1.39	1.20	1.00	0.81	0.62	0.52		1.10	1.10	0.88	0.66	0.45	0.34
2004	1.42	1.22	1.03	0.83	0.64	0.54		1.14	1.14	0.91	0.69	0.46	0.35
2005	1.42	1.23	1.04	0.84	0.65	0.56		1.13	1.13	0.91	0.69	0.47	0.36
2006	1.38	1.20	1.02	0.84	0.66	0.57		1.14	1.14	0.93	0.72	0.51	0.40
2007	1.44	1.25	1.06	0.88	0.69	0.60		1.18	1.18	0.96	0.74	0.53	0.42
2008	1.44	1.26	1.08	0.89	0.71	0.62		1.22	1.22	1.00	0.79	0.58	0.47
2009	1.41	1.24	1.06	0.88	0.71	0.62		1.17	1.17	0.97	0.77	0.56	0.46
2010	1.42	1.24	1.06	0.88	0.69	0.60		1.15	1.15	0.94	0.73	0.52	0.42
2011	1.40	1.22	1.04	0.87	0.69	0.60		1.16	1.16	0.96	0.75	0.55	0.45

The Performance Standard Baseline can be calculated using the following equation, where Year 1, 2, and 3 represent the three years prior to the Project Start Date.

$$Performance\ Standard\ Baseline = \frac{Year_1 + Year_2 + \ Year_3}{3}$$

Figure 1: Process Flow Diagram for the Baseline Condition



3.5 Identification of Baseline Sources and Sinks

Sources and sinks for an activity are assessed based on guidance provided by the ISO 14064:2 Standard and are classified as follows:

Controlled:	A source or sink where the source or sink's behavior or operation is under the direction and influence of a Project Proponent through financial, policy, management, or other instruments.
Related:	A source or sink that has material and/or energy flows into, out of, or within a project but is not under the reasonable control of the Project Proponent.
Affected:	A source or sink influenced by the project activity through changes in market demand or supply for products or services associated with the project.

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

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

Figure 2: Baseline Condition Sources and Sinks for Reducing Carbon Intensity of Fed Cattle

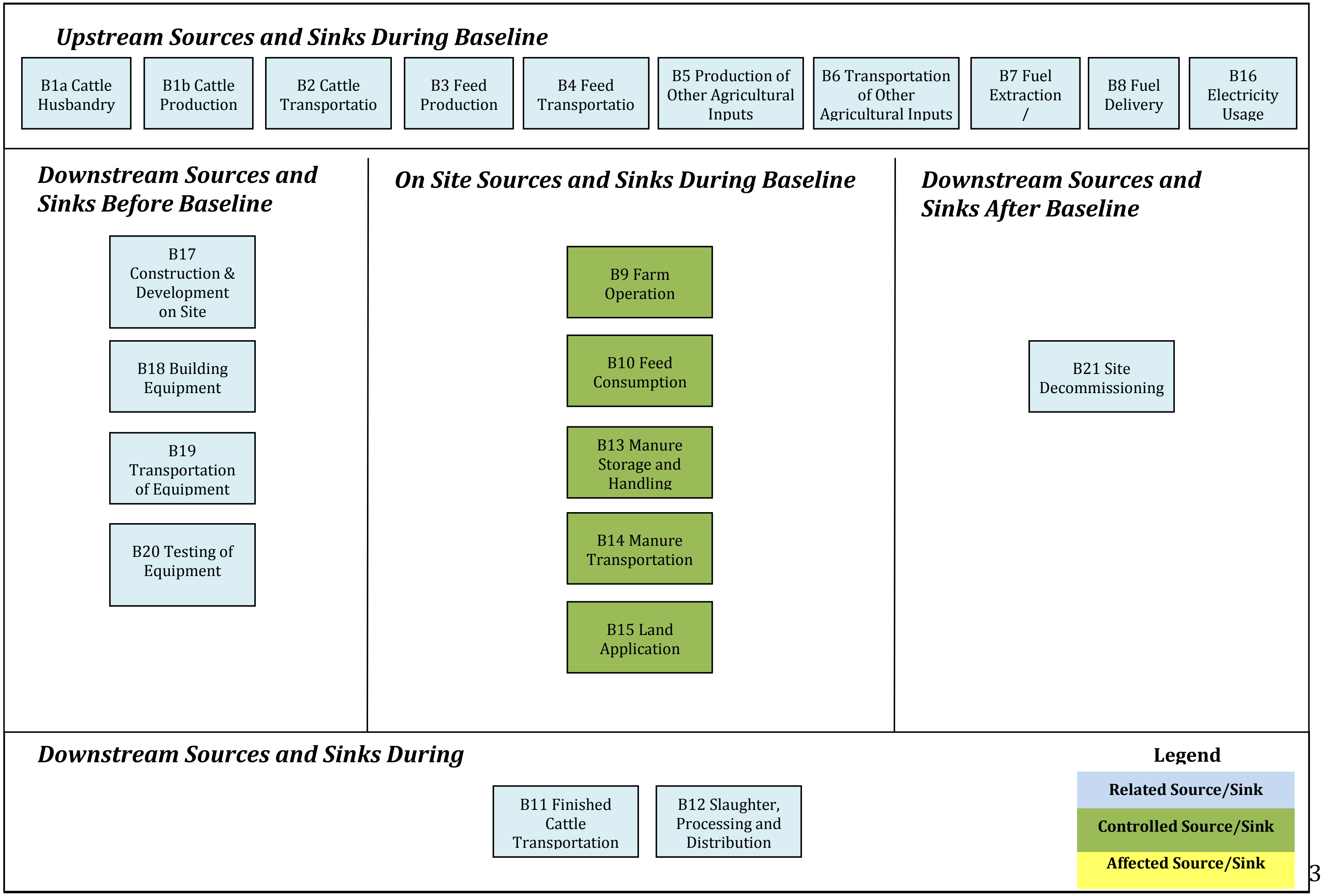


Table 6: Baseline Condition Sources and Sinks		
1. Source/Sink	**2. Description**	**3. Controlled, Related or Affected**
Upstream Sources and Sinks During Baseline Operation		
B1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities 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 fueling 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 fueling 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
B6 Transportation of Other Agricultural Inputs	Feed and other agricultural inputs may be transported to the project site by truck, barge and/or train. The related energy inputs for fueling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B7 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of	Related

Table 6: Baseline Condition Sources and Sinks		
1. Source/Sink	**2. Description**	**3. Controlled, Related or Affected**
	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.	
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 fueling 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 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 emissions of methane and nitrous oxide from the manure being stored and processed. Manure management storage and handling systems need to be accounted for.	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 be land applied. This may require the use of heavy equipment and mechanical systems. This could include emissions from energy use, and 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		

Table 6: Baseline Condition Sources and Sinks		
1. Source/Sink	**2. Description**	**3. Controlled, Related or Affected**
B11 Finished Cattle Transportation	Finished cattle may be transported from the project site by truck, barge and/or train. The related energy inputs for fueling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
B12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other Sources and Sinks		
B17 Construction and Development on 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 result primarily from 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 need to be delivered to the site. Transportation may be by train, truck, by some combination, or even by courier. Greenhouse gas emissions would result from to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B20 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 from the combustion of fossil fuels and the use of electricity.	Related
B21 Site	Once the facility is no longer operational, the site may need to be decommissioned. This may	Related

Table 6: Baseline Condition Sources and Sinks		
1. Source/Sink	**2. Description**	**3. Controlled, Related or Affected**
Decommissioning	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 result from the use of fossil fuels and electricity used to power equipment required to decommission the site.	

4. Project Methodology Procedure

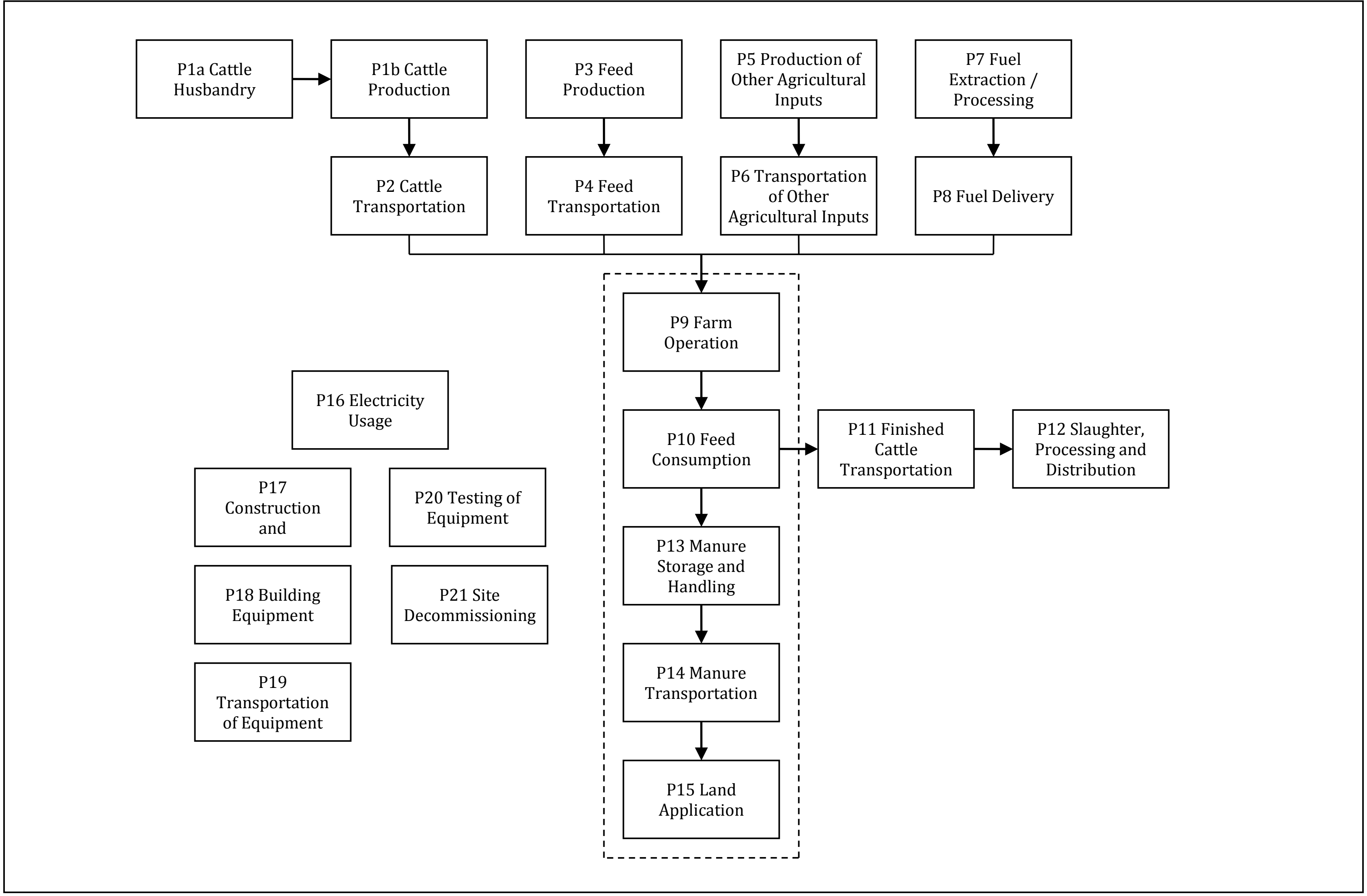
4.1 Project Condition

The project condition is defined by employing feeding and management strategies to decrease the feed-to-gain ratio of beef cattle fed in U.S. feedyards. Specifically, these practices include but are not limited to: (1) Individual animal performance management tracking; (2) Feed strategies that suppress enteric methane and inhibit uptake of electrons and hydrogen by ruminal methanogens; (3) Feeding technologies such as beta-agonists and growth promoters which improve lean tissue growth, or ionophores at newly prescribed dosages; (4) Genetic improvement breeding methods; and (5) Other innovative feeding strategies that decrease feed-to-gain ratios.

Although cattle produce enteric and manure-based emissions during the project condition as in the baseline condition, use of the above strategies will result in a lower quantity of greenhouse gases emitted per kg of carcass weight. The total amount of emission reductions generated by the project is equal to the difference in emissions between the project and performance standard baseline, after adjustment for production equivalency, as a result of incorporating one or more feeding strategies that decrease the carbon intensity of fed cattle.

Project sources and/or sinks were identified by reviewing the relevant process flow diagrams, consulting with technical experts on the Protocol Scientific Adaptation Team, national greenhouse gas inventory scientists and reviewing good practice guidance. The process flow diagram for the project condition is given in Figure 3. Note that the dotted line in Figure 3 indicates the sources and sinks that occur on site during a project.

Figure 3: Process Flow Diagram for the Project Condition



4.2 Identification of Project Sources and Sinks

Sources and sinks for reducing carbon intensity of beef production were identified based on a scientific review. This process confirmed that sources and sinks in the process flow diagram covered the full scope of eligible project activities under this methodology. The boundary for the project condition includes the feedyard(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 grouping characteristics, animal diets, feed additives, average daily dry matter intake, average days on feed and average entry/exit weights for groupings 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 6 below.

Figure 4: Project Condition Sources and Sinks for Reduced Carbon Intensity of Fed Cattle

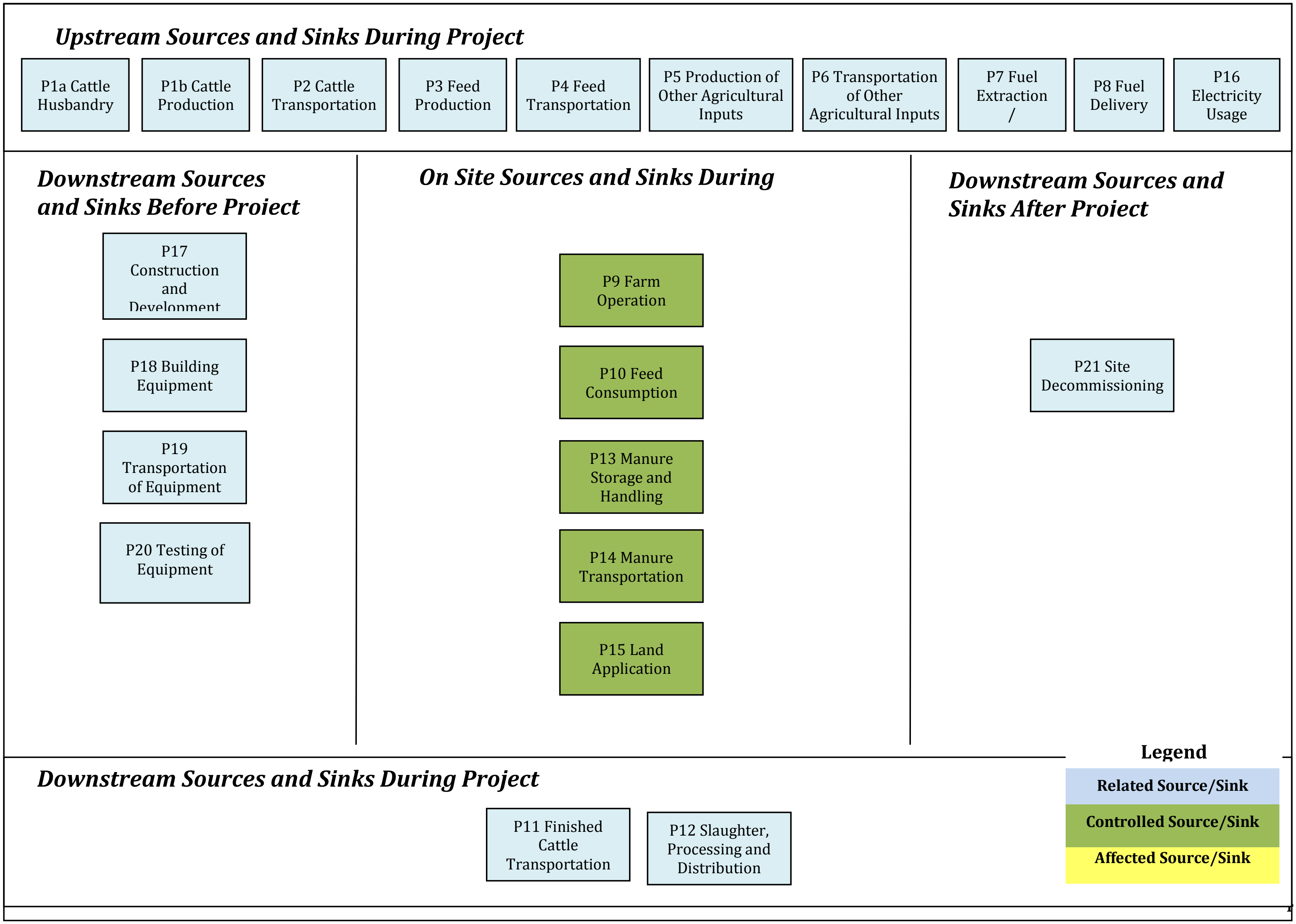


Table 7: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
Upstream Sources and Sinks During Project Operation		
P1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities and types for each of the energy inputs shall 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 fueling 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 fueling 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 and other agricultural inputs may be transported to the project site by truck, barge and/or train. The related energy inputs for fueling 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	Related

Table 7: Project Condition Sources and Sinks

1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
	condition.	
P7 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site sources/sinks are considered under this source/sink. Volumes and types of fuels shall be tracked.	Related
P8 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fueling 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 shall 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 emissions of methane and nitrous oxide from the manure being stored and processed. Manure management storage and handling systems need to be accounted for.	Controlled

Table 7: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
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 be land applied. This may require the use of heavy equipment and mechanical systems. This could include emissions from energy use, and 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 fueling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
P12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility operations. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other Sources and Sinks		
P17 Construction and Development on 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 result from 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 result from the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related

Table 7: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
P19 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will need to be delivered to the site. Transportation may be by truck, barge and/or train. Greenhouse gas emissions would result from the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P20 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 from the combustion of fossil fuels and the use of electricity.	Related
P21 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 result from the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

5. Quantification

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

Emissions that increase 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 8: Comparison of Sources and Sinks

1. Identified Source/Sink	2. Baseline (A, C, R)*	3. Project (A, C, R)*	4. Include or Exclude from Quantification	5. Justification
Upstream Sources/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 feedyard 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 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 methodology is based on increased feed efficiencies which result in decreased feed per same amount of gain or same amount of feed per increased gain in the project condition.
B4 Feed Transportation	R	N/A	Exclude	
P5 Production of Other Agricultural Inputs	N/A	R	Exclude	Excluded as upstream production of other agricultural inputs are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B5 Production of Other Agricultural Inputs	R	N/A	Exclude	
P6 Transportation of Other Agricultural Inputs	N/A	R	Exclude	Excluded as the methodology is based on increased feed efficiencies which result in decreased feed per same amount of gain or same amount of feed per increased gain in the project condition.
B6 Transportation of Other Agricultural Inputs	R	N/A	Exclude	

Table 8: Comparison of Sources and Sinks

1. Identified Source/Sink	2. Baseline (A, C, R)*	3. Project (A, C, R)*	4. Include or Exclude from Quantification	5. Justification
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/Sinks				
P9 Farm Operation	N/A	C	Exclude	Excluded as farm operation for beef production is not materially impacted 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.
B9 Farm Operation	C	N/A	Exclude	
P10 Feed Consumption	N/A	C	**Include**	Included because emissions from the baseline to project are materially different.
B10 Feed Consumption	C	N/A	**Include**	
P13 Manure Storage and Handling	N/A	C	**Include**	Included because emissions from the baseline to project are materially different.
B13 Manure Storage and Handling	C	N/A	**Include**	
P14 Manure Transportation	N/A	C	Exclude	Excluded as the emissions from transportation will be lower in the project than the baseline scenario because improved feed efficiencies result in decreased manure excretion per kg of production (so conservative to exclude).
B14 Manure Transportation	C	N/	Exclude	

Table 8: Comparison of Sources and Sinks				
1. Identified Source/Sink	**2. Baseline (A, C, R)***	**3. Project (A, C, R)***	**4. Include or Exclude from Quantification**	**5. Justification**
P15 Land Application	N/A	C	**Include**	Included because emissions from the baseline to project are materially different.
B15 Land Application	C	N/A	**Include**	
Downstream Sources/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/Sinks				
P17 Construction and Development on Site	N/A	R	Exclude	Excluded as the emissions from site development are not material given the long project life, and the minimal site development typically required.
B17 Construction and Development on Site	R	N/A	Exclude	Excluded as the 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	Excluded as the emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B18 Building Equipment	R	N/A	Exclude	
P19 Transportation of Equipment	N/A	R	Exclude	Excluded as the emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B19 Transportation of Equipment	R	N/A	Exclude	
P20 Testing of Equipment	N/A	R	Exclude	Excluded as emissions from testing of equipment are not

Table 8: Comparison of Sources and Sinks				
1. Identified Source/Sink	**2. Baseline (A, C, R)***	**3. Project (A, C, R)***	**4. Include or Exclude from Quantification**	**5. Justification**
B20 Testing of Equipment	R	N/A	Exclude	material given the long project life, and the minimal testing of equipment typically required.
P21 Site Decommissioning	N/A	R	Exclude	Excluded as the emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B21 Site Decommissioning	R	N/A	Exclude	

*Sources and sinks where C is Controlled, R is Related, A is Affected, and N/A is Not Applicable.

5.1 Quantification Methodology

Quantification of the reductions and removals of relevant sources and sinks for each of the greenhouse gases will be completed using the methods below. These quantification methods serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

Equation 1:

$$Emission_{Reduction} = Emissions_{Baseline} - Emissions_{Project} - Emissions_{Market\ Effect}$$

Equation 2:

$$Emissions_{Baseline} = Emissions_{Cattle} + Emissions_{Manure}$$

Equation 3:

$$Emissions_{Project} = Emissions_{Cattle} + Emissions_{Manure}$$

Where:

$Emission_{Baseline}$	Sum of the emissions under the baseline condition
$Emissions_{Cattle}$	Emissions under B10 Feed Consumption
$Emissions_{Manure}$	Emissions under B13 Manure Storage and Handling and B15 Land Application

Calculated in a performance standard carbon intensity baseline with regional and national data, by animal grouping.

$Emission_{Project}$	Sum of the emissions under the baseline condition
$Emissions_{Cattle}$	Emissions under P10 Feed Consumption
$Emissions_{Manure}$	Emissions under P13 Manure Storage and Handling and P15 Land Application

Calculated with actual annual feedyard carbon intensity data, by animal grouping.

$Emissions_{Market\ Effect}$	Net greenhouse gas emissions due to market-effects leakage (t CO_2-e) **As calculated in Equation 19*

5.2 The Project Standardized Quantification

Quantification of emission reductions of relevant sources and sinks for each of the greenhouse gases in the Project Condition will be completed using feedyard data and the methods in Table 7. These calculation methods serve to complete the following equations for calculating the emission reductions by comparing the project to the performance standard baseline.

As in the performance standard baseline, the greenhouse gases are calculated for each animal grouping (weight class by gender), using averages for the group.

Enteric Methane Emissions in Cattle by Cattle Grouping i:

Equation 4: Calculating Enteric Methane Emissions

$$Cattle\ Enteric\ Methane\ (kgCH_4) = \sum Number\ Production_i * DOF * DDMI_i * GE_{Diet} * (EF\ Enteric_i/100\%)/EC_{Methane}$$

Where:

$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
$DOF\ (Days\ on\ Feed)$	The average number of days that the animal grouping is being fed a specific diet. It can be estimated using the animal head.days factor.
$DDMI_i\ (Dry\ Matter\ Intake)$	Calculated 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.
$GE_{Diet}(Gross\ Energy\ Content\ of\ Diet)$	A default factor, depending on the concentration of edible oils/fats: o Use 19.10 MJ per kg of dry matter feed if the edible oil concentration is between 4.0% and 6.0% of the diet on a DM basis o Use 18.45 MJ per kg of dry matter fed to each head if the edible oil/fat concentration is less than 4% (IPCC 2006, Pg.10.21)
$EF\ Enteric_i(Enteric\ Emissions\ Factor)$	A default factor, depending on level of concentrates in the diet and edible oil/fat content: o Use 3.0% for diets with greater than or equal to 85% concentrates; and,

	o Use 6.5% for diets with less than 85% concentrates (IPCC 2006, pg.10.30) For diets with edible oils/fats in the 4% to 6% range: o 2.4% for diets with greater than or equal to 85% concentrates o 5.2% for diets with less than 85% concentrates
$EC_{Methane}(Methane\ Energy\ Content)$	The conversion factor of energy to methane. This is a default factor of 55.65 MJ per kg of methane (IPCC 2006, pg. 10.31)

Manure-Based Methane Emissions from Cattle by Cattle Grouping i:

Equation 5: Calculating Daily Volatile Solids Excreted in Manure

$$VS_i\ (Kg\ volatile\ solids/animal/day) = [(DDMI_i *\ GE_{Diet} * (1 - (TDN_i/100\%)) + (UE *\ DDMI_i * GE_{Diet})] * (1 - (Ash/100\%)/GE_{Diet})$$

Where:

$VS\ (Volatile\ Solids)$	The calculated daily volatile solid excreted for each head of cattle for each of the feeding periods in each animal grouping.
$DDMI_i\ (Daily\ Dry\ Matter\ Intake)$	Calculated 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.
$GE_{Diet}(Gross\ Energy\ Content\ of\ Diet)$	A default factor, depending on level of concentrates in the diet and edible oil/fat content: o Use 19.10 MJ per kg of dry matter feed if the edible oil concentration is between 4.0% and 6.0% of the diet on a DM basis o Use 18.45 MJ per kg of dry matter fed to each head if the edible oil/fat concentration is less than 4%
$TDN_i\ (Total\ Digestible\ Nutrients)$	The total digestible nutrients for the diet provided to each grouping of cattle must be

	recorded as a percentage (%) and is used in calculating the daily volatile solids excreted in cattle manure.
$UE\ (Urinary\ Energy)$	Used in calculating the daily volatile solids excreted per animal in each weight grouping. Use the default factors of 0.04 for diets with less than 85% concentrates and 0.02 for diets with greater than 85% concentrates.
Ash	A default factor extracted from international guidance and is used in estimating daily excretion of volatile solids. Use 8% for forage based diets and 2% for grain based (high concentrate) diets (IPCC 2006, Pg.10.42)

Equation 6: Calculating Manure Methane Emissions for the Project (Handling, Storage, and Application)

$$\boldsymbol{M}anure\ CH_4\ (kg\ CH_4) = \sum Number\ Production_i * DOF_i * VS_i * Bo * \rho_{Methane} * (MCF/100\%)$$

Where:

$Manure\ CH_4$	The sum of methane emissions from manure handling, storage and land application for each cattle grouping, expressed as kg CH₄ per head.
$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
$DOF\ (Days\ on\ Feed)$	The average number of days that the animal grouping is being fed a specific diet. It must be estimated using the animal head.days factor.
$VS_i\ (Volatile\ Solids)$	The calculated daily volatile solid excreted for each head of cattle for each of the feeding periods in each animal grouping

$Bo\ (Methane\ Producing\ Capacity)$	The maximum methane producing capacity for manure. It is a constant of $0.19m^3$ CH4/kg VS_i excreted (IPCC 2006, pg. 10.78)
$\rho_{Methane}(Density\ of\ Methane)$	The density of methane at normal temperature (20^0C) and pressure (1 Atm), which is $0.67\ kg/m^3$ (IPCC 2006, pg.10.42)
$MCF\ (Methane\ Conversion\ Factor)$	A factor specific for solid storage systems and dry lots, set at 2%. In the case of pasture, range, and/or paddock systems, set at 1%.

Manure-Based Nitrous Oxide Emissions from Cattle by Cattle Grouping i:

Equation 7 Calculating Daily Nitrogen Excreted in Manure

$$\boldsymbol{NE_i}\ (kg\ nitrogen\ excreted/animal/day) = [-38.9 + 0.71 * NI_i + 1.8 * GE_{Diet} + 0.054 * BW] * 1000$$

Where:

$NI\ (Nitrogen\ Intate)$	The total nitrogen consumed by each grouping by diet. It is calculated as crude protein content of diet times total dry matter intake divided by 6.25 expressed as nitrogen per head per day.
$GE_{Diet}(Gross\ Energy\ Content\ of\ Diet)$	A default factor, depending on the concentration of edible oils/fats: o Use 19.10 MJ per kg of dry matter feed if the edible oil concentration is between 4.0% and 6.0% of the diet on a DM basis o Use 18.45 MJ per kg of dry matter fed to each head if the edible oil/fat concentration is less than 4% (IPCC 2006, Pg.10.30)
BW	The average body weight in each grouping of animals.

Equation 8: Calculating Daily Nitrogen Intake

NI_i **(kg nitrogen intake/animal/day)** $=[DDMI_i * (CP_i / 100\%)] / CF_{protein}$

Where:

$NI\ (Nitrogen\ Intate)$	The total nitrogen consumed by each grouping by diet. It is calculated as crude protein content of diet times total dry matter intake divided by 6.25 expressed as nitrogen per head per day.
$DDMI_i\ (Daily\ Dry\ Matter\ Intake)$	The daily dry matter intake is calculated 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.
$CP\ (Crude\ Protein)$	A required component in the diet fed to each grouping of cattle that is expressed as a percentage (%).
$CP_{Protein}\ (Protein\ Conversion\ Factor)$	A default coefficient which represents the mass of dietary protein which is converted to dietary nitrogen and is equal to 6.25 kg of protein per kg of dietary nitrogen.

Equation 9: Calculating Direct Nitrous Oxide (N_2O) Emissions from Manure

$$Manure\ N_2O_{Direct}(kg\ N_2O) = \sum Number\ Production_i * DOF_i * NE_i * CF_{Manure} * (44/28)$$

Where:

$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
$DOF\ (Days\ on\ Feed)$	The average number of days that the animal

	grouping is being fed a specific diet. It must be estimated using the animal head.days factor.
NE_i $(Nitrogen\ Excreted)$	The nitrogen excreted by each head in each specific weight grouping of animals is expressed as kg of nitrogen per head per day. It is used in calculating direct and indirect nitrous oxide emissions.
$CF_{\ Manure}$ $(Manure\ Conversion\ Factor)$	Use 0.02 kg N_2O-N per kilogram of nitrogen excreted.
$44/28$ $(Conversion\ Factor)$	A quotient used to convert $N_2O\text{-}N_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

Equation 10: Calculating Direct Nitrous Oxide (N_2O) Emissions from Manure Decomposition

$$Manure\ N_2O_{Direct\ Storage}(kg\ N_2O) = \sum Number\ Production_i * DOF_i * NE_i * Frac_{Storage} * EF_{Storage} * (44/28)$$

Where:

$Manure\ N_2O_{\ direct\ storage}$	The sum of direct emissions of nitrous oxide from manure storage for each grouping of cattle and is expressed as kg N_2O per head of cattle.
$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
DOF $(Days\ on\ Feed)$	The average number of days that the animal grouping is being fed a specific diet. It must be estimated using the animal head.days factor.
NE_i $(Nitrogen\ Excreted)$	The nitrogen excreted by each head in each specific weight grouping of animals is expressed as kg of nitrogen per head per day. It is used in calculating direct and indirect nitrous oxide emissions.

$Frac_{Storage}$	The fraction of total nitrogen excreted for each animal grouping that is managed in a particular manure management system and is set at 0.8.
$EF_{Storage}(Storage\ Emissions\ Factor)$	An emission factor related to the direct N_2O emissions from a manure management system and set at 0.007 kg N_2O-N/kg nitrogen excreted.
$44/28\ (Conversion\ Factor)$	A quotient used to convert $N_2O\text{-}N_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

Equation 11: Calculating Indirect Nitrous Oxide (N_2O) Emissions from Volatilization of Manure

$$Manure\ N_2O_{Indirect\ Volatilization}(kg\ N_2O) = \sum Number\ Production_i * DOF_i * NE_i * Frac_{Volatilization} * EF_{Volatilization} * (44/28)$$

Where:

$Manure\ N_2O_{indirect\ volatilization}$	The sum of indirect emissions of nitrous oxide from manure volatilization for each grouping of cattle and expressed as kg N_2O per head of cattle.
$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
$DOF\ (Days\ on\ Feed)$	The average number of days that the animal grouping is being fed a specific diet. It must be estimated using the animal head.days factor.
$NE_i\ (Nitrogen\ Excreted)$	The nitrogen excreted by each head in each specific weight grouping of animals is expressed as kg of nitrogen per head per day. It is used in calculating direct and indirect nitrous oxide emissions.

$Frac_{Volatilization}$	The fraction of manure N that is lost as volatilized NO_x and NH_3 and is set at 0.2.
$EF_{Volatilization}$	An emission factor related to the indirect N_2O emissions from atmospheric deposition of nitrogen in soils/water surfaces and is set at 0.01 kg N_2O-N/kg N deposited.
$44/28\ (Conversion\ Factor)$	A quotient used to convert N_2O-$N_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

Equation 12: Calculating Indirect Nitrous Oxide (N_2O) Emissions from Manure N Leached in the Soil Profile

$$Manure\ N_2O_{Indirect\ Leaching}(kg\ N_2O) = \sum Number\ Production_i * DOF_i * NE_i * Frac_{Leaching} * EF_{Leaching} * (44/28)$$

Where:

$Manure\ N_2O_{indirect\ leached}$	The sum of indirect emissions of nitrous oxide for each grouping of cattle and is expressed as kg N_2O per head of cattle.
$Number\ Production_i$	The weighted average for the number of head in each animal grouping/pen. Can be estimated using the animal head-days factor in Section 5.3 below.
$DOF\ (Days\ on\ Feed)$	The average number of days that the animal grouping is being fed a specific diet. It must be estimated using the animal head.days factor.
$NE_i\ (Nitrogen\ Excreted)$	The average amount of nitrogen excreted by each animal grouping expressed as kg of nitrogen/head/day from Equation 7 above.
$Frac_{Leaching}$	The fraction of manure N that is added to soils in regions where leaching and runoff occurs that is lost as leaching and runoff and is set at 0.1.

$EF_{Leaching}$	An emission factor for N_2O emissions from N leaching and runoff and is set at 0.025 kg N_2O-N/kg N leached.
$44/28\ (Conversion\ Factor)$	A quotient used to convert $N_2O\text{-}N_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

5.3 Cattle Inventories and Data Collection

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

Transparent and accurate data are needed to support project implementation and facilitate third party verification of the emission reductions. How animals are tracked for offset quantification is critical to this methodology and must be consistent between the baseline and project conditions. The weight groupings applied in the performance standard baseline must align with the groupings of the data collected at the feedyard for project quantification. Any deaths that occur as cattle progress, or if animals are removed from a weight grouping due to sickness, must be accounted for in the animal head.day calculations (see below).

The data points to be collected for cattle inventory under the project condition include:

- The average number of head of cattle within each animal grouping (or individually)
- The average weight of cattle entering the grouping (or individually)
- The average weight of cattle exiting the grouping (or individually)
- The average weight in kilograms of dry matter feed provided to each group (for the animal grouping)
- The number of days the group of cattle are fed a specific type of diet.

Cattle inventory data must be derived by using a yardage matrix commonly applied by feedyard operators and referred to as animal head-days. Many feedyards use this approach to calculate their yardage where animal head-days is a basic unit used to account for the number of days cattle were on feed in a specific animal grouping, calculated as the average number of days each animal spent on a specific diet as it moved through the feedyard for that animal grouping. This is demonstrated in Table 7.

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

Pen	Diet Type	Days on Feed	No. of Head	Head-days	DMI (kg)*
A		1	119	119	1190
A		1	126	245	1260
A		1	126	371	1260
A		1	125	496	1250
A		1	125	621	1250
A		1	124	745	1250
A		1	124	869	1240
A		1	124	993	1240
A		1	124	1117	1240
A		1	124	1241	1240
A		1	124	1365	1240
A		1	124	1489	1240
A		1	124	1613	1240
A		1	124	1737	1240
Total		**14**	**124 (average)**	**1,737(sum)**	**17,380 (sum)**

*Note-this table could be recorded in pounds (lbs) or metric units, so long as the calculation steps are consistent with the metric units throughout, and converted to metric at the end.

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

a) **Days on feed**: must be extrapolated from animal head-days if the average number of animals in a pen under a specific diet and the animal head-days are known.

Equation 13:

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

Referencing Table 7 above, days on feed would be extrapolated by taking the quotient of 1,737 animal head-days / 124 animals, with a result of 14 days on feed.

b) **Number in production**: must be extrapolated from animal head-days if the days on feed (feeding periods) are known.

Equation 14:

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

Referencing Table 7 above, number in production for diet 1 would be extrapolated by taking the quotient of 1,737 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. Must be extrapolated from animal head-days if the total quantity of feed diets provided to a grouping of animals over the feeding periods are known.

Feed is provided to cattle on an as-fed basis[16] 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 must be obtained from a feed analysis of the total mixed diet, from a feed analysis of the total mixed diet, or from a diet-balancing program used by the feedyard.

Equation 15:

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

Statistical Sampling Approach Allowed under this Methodology

Appendix A describes a statistical sampling method that must 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 feedyard for a statistically valid sample, the feedyard 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/lots in the feedyard for greenhouse gas estimation involves taking measurements of the desired data in a number of pens/lots. 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%. If the interval is small, then the estimation is more precise.

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[16] As fed basis – the weight of the feed or ingredient including moisture (water content)

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
Project Sources and Sinks						
P10 Feed Consumption	$\text{Emissions}_{\text{Cattle}} = \Sigma (\text{Number}_{\text{Production i}} * \text{DOF}_{\text{i}} * \text{DDMI}_{\text{i}} * \text{GE}_{\text{Diet}} * (\text{EF}_{\text{Enteric i}} / 100\%) / \text{EC}_{\text{Methane}})$					
	Enteric emissions from cattle for each feeding period within each weight grouping ($\text{Emissions}_{\text{Cattle}}$)	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Number of cattle in grouping i ($\text{Number}_{\text{Production i}}$)	Head	Measured	Direct measurement of number of head sent to slaughter within each grouping of animals. This value must also be extrapolated from animal head-days if the days on feed (otherwise termed feeding periods) are known. Number in Production (heads) = animal head-days/days on feed	Continuous	Direct measurement is the highest level possible.

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Days on feed for each feeding period for cattle in Grouping i (DOF_i)	Days	Measured	Average for cattle in specific animal grouping for the project year. This value must 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	Direct measurement is the highest level possible.
	Average daily dry matter intake for each feeding period for cattle in Grouping i (DMI_i)	kg dry matter / head / day	Estimated	Estimated based on average mass of feed provided to cattle during period on diet. The amount of feed provided to a pen of animals under a particular diet regimen, expressed as kilograms of feed per animal per day, must be extrapolated from animal head-days if the total quantity of feed diets provided to a grouping of animals over the feeding periods is known. Dry Matter Intake (kg/head/day) = (Total quantity of feed for a specific diet) x (dry matter content of diet) / animal head-days	Continuous	Based on actual feed delivery records to each pen.

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Default value gross energy content (GE) of the diet GE_{Diet}	MJ / kg dry matter	Default	• 19.10 MJ / kg dry matter for diets including edible oils in the range of 4 to 6%. • 18.45 MJ / kg dry matter for diets with edible oils below the range of 4 to 6%	Annual	Default value taken from IPCC, 2006 guidance (Section 10.4.2).
	Emission factor for enteric emissions for each feeding period in Grouping i ($EF_{Enteric\ i}$)	%	Default	For diets with less than 4% edible oils/fat (DM basis): • 3.0% for diets with greater than or equal to 85% concentrates • 6.5% for diets with less than 85% concentrates For diets with edible oils/fats in the 4 to 6% range: • 2.4% for diets with greater than or equal to 85% concentrates • 5.2% 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 methane	Default	55.65 MJ / kg methane	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.3.2).
	$VS_i = [(DMI_i * GE_{Diet} * (1 – (TDN_i / 100\%))) + (UE * DDMI_I * GE_{Diet})] * ((1 – (Ash / 100\%)) / GE_{Diet})$					

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
P13 Manure Storage and P15 Land Application	Average daily volatile solid excreted for livestock in grouping i and each feeding period (VS_i)	kg / head / day	N/A	N/A	N/A	Quantity being calculated.
	Average dry matter intake for each feeding period for cattle in grouping i (DMI_i)	kg dry matter / head / day	Estimated	Estimated based on average mass of feed provided to cattle during period on diet. The amount of feed provided to a pen of animals under a particular diet regimen, expressed as kilograms of feed per animal per day, must be extrapolated from animal head-days if the total quantity of feed diets provided to a grouping of animals over the feeding periods is known. Dry Matter Intake (kg/head/day) = (Total quantity of feed for a specific diet) x (dry matter content of diet) / animal head-days	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	Default	19.10 MJ / kg dry matter for diets including edible oils in the range of 4 to 6%. 18.45 MJ / kg dry matter for diets with edible oils below the range of 4 to 6%	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.4.2).

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated/ Default**	**5. Method**	**6. Frequency**	**7. Justification / Additional Comments**
	Total digestible nutrients for each feeding period for cattle in grouping i (TDN_i)	%	Estimated	Estimated based on composition of feed provided to cattle during period on diet.	Continuous	Estimation based on diet composition and/or from direct analysis of the total mixed diet.
	Urinary energy (UE)	-	Default	0.04 for diets with less than 85% concentrates. 0.02 for diets with greater than 85% concentrates.	Annual	Set based on best available science and in reference to the IPCC, 2006 guidance (Section 10.4.2).
	Ash content of manure calculated as a fraction of the dry matter feed intake for cattle (Ash)	%	Estimated	2%	Annual	Set based on best available science and in reference to the IPCC, 2006 guidance.
	$Emissions_{Manure\ CH4} = \Sigma (Number_{Production\ i} * DOF_i * VS_i * Bo * \rho_{Methane} * (MCF / 100\%))$					
	Methane emissions from manure handling, storage and land application for each feeding period within each animal grouping ($Emissions_{Manure\ CH4}$)	kg CH_4	N/A	N/A	N/A	Quantity being calculated.

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Number of cattle in grouping i ($Number_{Production\ i}$)	Head	Measured	Direct measurement of number of head sent to slaughter within each grouping of animals.	Continuous	Direct measurement is the highest level possible.
	Days on feed for each feeding period for cattle in grouping i (DOF_i)	Days	Measured	Direct measurement of days at the feed lot.	Continuous	Direct measurement is the highest level possible.
	Maximum methane producing capacity for manure produced (Bo)	m^3 CH_4 / kg VS Excreted	Default	0.19 m^3 CH_4 / kg VS Excreted	Annual	Conversion factor taken from IPCC, 2006 guidance (Table 10A-5).
	Density of methane ($\rho_{Methane}$)	kg/m^3	Default	0.67 kg/m^3	Annual	Physical property of methane at standard temperature and pressure.
	Methane conversion factor (MCF)	%	Default	1.6 %	Annual	Set based on best available science and in reference to the IPCC, 2006 guidance.
	$Nitrogen_{Intake\ i} = DDMI_i * (CP_i / 100\%) / CF_{Protein}$					
	Nitrogen Intake for cattle grouping i ($Nitrogen_{Intake\ i}$)	kg / head / day	N/A	N/A	N/A	Quantity being calculated.

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Average daily dry matter intake for each feeding period for cattle in grouping i ($DDMI_i$)	kg dry matter / head / day	Estimated	Estimated based on average mass of feed provided to cattle during feeding period. The amount of feed provided to a group animals under a particular feeding period, expressed as kilograms of feed per animal per day, must be extrapolated from animal head-days if the total quantity of feed diets provided to a grouping of animals over the feeding periods is known. Daily Dry Matter Intake (kg/head/day) = (Total quantity of feed for a feeding period) x (dry matter content of diet) / animal head-days	Continuous	Based on actual feed delivery records to each pen.
	Percent crude protein in diet for each feeding period in cattle in Grouping i (CP_i)	%	Estimated	Estimated based on composition of feed provided to cattle during feeding period	Continuous	Estimation based on diet composition and/or from direct analysis of the total mixed diet.
	Conversion from mass of dietary protein to mass of dietary nitrogen	kg feed protein / kg nitrogen	Default	6.25 kg feed protein / kg nitrogen	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.5.2).
	$Nitrogen_{Excreted\ i} = (-38.9 + 0.71 * NI_i + 1.8 * GE_{Diet} + 0.054 * BW_i) * 1000$					

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Nitrogen Excreted by the Cattle in Grouping i (Nitrogen $_{\text{Excreted i}}$)	kg / head / day	N/A	N/A	N/A	Quantity being calculated.
	Default value gross energy content (GE) of the diet (GE$_{\text{Diet}}$)	MJ / kg dry matter	Default	19.10 MJ / kg dry matter for diets including edible oils in the range of 4 to 6%. 18.45 MJ / kg dry matter for diets with edible oils below the range of 4 to 6%	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.4.2).
	Body Weight for the Cattle in Grouping i (BW $_{\text{i}}$)	kg	Estimated	Average body weight for cattle grouping i	Annual	Estimation based on Feedyard Close-Out sheets
	$\text{Emissions}_{\text{Direct Nitrous Oxide}} = \Sigma\,(\text{Number}_{\text{Production i}} * \text{DOF}_{\text{i}} * \text{Nitrogen}_{\text{Excreted I}} * \text{CF}_{\text{Manure}}) * 44 / 28$					
	Direct emissions of nitrous oxide from manure for each feeding period within each animal grouping (Emissions $_{\text{Direct Nitrous Oxide}}$)	kg N_2O	N/A	N/A	N/A	Quantity being calculated.
	CF $_{\text{Manure}}$	kg N_2O-N / kg Nitrogen Excreted	Default	0.02 kg N_2O-N / kg Nitrogen Excreted	Annual	Set based on scientific peer review and in reference to the IPCC.
	$\text{Emissions}_{\text{Direct Storage}} = \Sigma\,(\text{Number}_{\text{Production i}} * \text{DOF}_{\text{i}} * \text{Nitrogen}_{\text{Excreted i}} * \text{Frac}_{\text{Storage}} * \text{EF}_{\text{Storage}}) * 44 / 28$					

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	Direct emissions of nitrous oxide from manure storage ($\text{Emissions}_{\text{Direct Storage}}$)	kg N_2O	N/A	N/A	N/A	Quantity being calculated.
	$\text{Frac}_{\text{Storage}}$	-	Default	0.8	Annual	Set based on best available science and in reference to the IPCC
	$\text{EF}_{\text{Storage}}$	kg N_2O-N / kg Nitrogen Excreted	Default	0.007 kg N_2O-N / kg Nitrogen Excreted	Annual	Set based on best available science and in reference to the IPCC
	$\text{Emissions}_{\text{Indirect Volatilization}} = \Sigma (\text{Number}_{\text{Production } i} * \text{DOF}_{i} * \text{Nitrogen}_{\text{Excreted } i} * \text{Frac}_{\text{Volatilization}} * \text{EF}_{\text{Volatilization}}) * 44 / 28$					
	Indirect emissions of nitrous oxide from volatilization for each feeding period within each animal grouping ($\text{Emissions}_{\text{Indirect Volatilization}}$)	kg N_2O	N/A	N/A	N/Al	Quantity being calculated.
	$\text{Frac}_{\text{Volatilization}}$	-	Default	0.2	Annual	Set based on best available science and in reference to the IPCC

Table 10: Quantification Methodology for Project Condition

1.0 Project Sources/ Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated/ Default	5. Method	6. Frequency	7. Justification / Additional Comments
	$EF_{Volatilization}$	kg N_2O-N / kg Nitrogen Deposited	Default	0.01 kg N_2O-N / kg Nitrogen Deposited	Annual	Set based on best available science and in reference to the IPCC
	$Emissions_{Indirect\ Leaching} = \Sigma (Number_{Production\ i} * DOF_i * Nitrogen_{Excreted\ i} * Frac_{Leach} * EF_{Leach}) * 44 / 28$					
	Indirect emissions of nitrous oxide from leaching for each feeding period within each animal grouping ($Emissions_{Indirect\ Leach}$)	kg N_2O	N/A	N/A	N/A	Quantity being calculated
	$Frac_{Leach}$	-	Default	0.1	Annual	Set based on best available science and in reference to the IPCC
	EF_{Leach}	kg N_2O-N / kg Nitrogen Leached	Default	0.0125 kg N_2O-N / kg Nitrogen Leached	Annual	Set based on best available science and in reference to the IPCC

5.4 Ensuring Functional Equivalence between Baseline and Project

The principle of functional equivalence is based on comparing a project's baseline and project emissions using the same metric, normalized to the same level of products and services (for example, CO_2e per kg of beef produced.).

Emissions related to the baseline and project conditions are calculated in a similar manner per animal grouping to account for reductions in enteric and manure-based emissions. In order to maintain functional equivalence, both baseline and project emissions need to be adjusted for production equivalency of the cattle and expressed on an intensity basis (tCO_2e / kg carcass weight). The performance standard baseline is already expressed on this basis by animal grouping (weight class by gender).

For the project condition, this is determined for each grouping by dividing the total emissions for each gas (summed for enteric and manure CH_4 and then N_2O) by the total number of animals in production multiplied by the average carcass weight of the animals for that grouping when they are sent to harvest:

Equation 16:

Project CH_4 Emissions Intensity (kg CH_4 /kg carcass weight during the Project Condition, animal grouping i) =

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

Equation 17:

Project N_2O Emissions Intensity (kg N_2O /kg carcass weight during the Project Condition, animal grouping i) =

$$\Sigma \left[(N_2O \text{ Emissions}) / (\text{Total Number in Production}_i * \text{Average carcass weight of Cattle}_i \text{ sent to market (kg)}) \right]$$

5.5 Leakage

This methodology follows the ISO 14064:2 Standard which applies a systematic approach to identifying sources, sinks and reservoirs (SSRs) associated with the project and baseline activities. First, a streamlined life cycle assessment, typically based on material and energy flows, is applied to identify those SSRs that are in three scope categories: controlled, related or affected by the project activity. Typically, those that are in the related type are from activities either upstream or downstream of the project, and are related to material and energy flows. Those that are affected are typically a result of leakage -- activity shifting or market impacts. The GHG impacts of the three types of SSRs are then assessed to identify the relevant sources, sinks or reservoirs in all three scope categories (shown in Table 6). Using this approach, the project boundary is defined by the sources and sinks that are deemed relevant to quantify, and the project will have to account for any emissions generated by a relevant related or affected source. This is different from the usual method of pre-defining boundaries and quantifying the SSRs within, and collectively estimating emissions impacts of sources outside the boundary.

Secondly, the ISO 14064:2 standard applies functional equivalence as a key requirement for quantifying GHG differences between baseline and project. For a project-baseline comparison to be meaningful, the service provided by the project must compare in quantity and quality to the baseline (e.g. per kg beef, per bushel of wheat, GJ of energy consumed or produced). This avoids the pitfalls of interpreting an emission reduction based on a full feedlot in a baseline situation, with a half full feedlot in a particular project year, or, comparing volumetric usage of fuels of varying carbon intensity in fuel switching projects. The application of functional equivalence with the systematic assessment of relevant Controlled, Related and Affected SSRs, informed by analysis of material and energy flows in baseline and project, minimizes the risk of activity-shifting leakage occurring in project types covered by the methodology. Further, the risk of activity shifting having an impact on emissions downstream in the beef feeding sector is low due to the majority of the beef feedyards being concentrated in four or five US States, all with similar environmental and economic conditions (See Appendix C).

5.5.1 Market-Effects Leakage

To address market-effects leakage, this methodology employs the theory developed by Murray *et al.* (2004) describing how market-effects leakage due to an increase or decrease in outputs from this project (i.e. kg hot carcass weight) can be quantified using published estimates of price elasticities of supply and demand.[17]

Project Proponents shall assess the potential for market-effects leakage by the following steps:

- Estimate and justify output in the baseline case and monitor output in the project case;
- Where baseline output exceeds project output by >3% or project output exceeds baseline output by 3%, market-effects leakage shall be determined according to the following section.

5.5.2 Accounting for Market-Effects Leakage

The default market-effects leakage factor applicable to any project using this methodology is determined using the following series of steps derived from Murray *et al.* (2004), Vohringer *et al.* (2004), and Murray and Baker (2011). Note that the elasticity of demand (E_D) is generally a negative number (demand goes down as price goes up) and the elasticity of supply (E_S) is generally a positive number (supply goes up as price goes up), so $LE_{M,t}$ will be a negative proportion that ranges from 0 to -1. For this methodology, Project Proponents shall use a value of 0.91 for E_S and -0.61 for E_D.[18]

Equation 18:

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[17] Price elasticities describe how a change in price affects quantity supplied or demanded. For example, a price elasticity of supply of 0.4 indicates that a 1% increase (decrease) in price results in a 0.4% increase (decrease) in the quantity supplied. Price elasticities of supply and demand for the dairy and beef sectors have been derived and published in several peer-reviewed economic studies (e.g., Tvedt *et al.* 1991). In the long-term, this may be the case for agriculture, as the price elasticity of supply is generally high and the price elasticity of demand for staple foods tends to be very low.

[18] Value of E_S based on *Elasticities in World Meat Markets* as referenced in http://www.farmdoc.illinois.edu/nccc134/conf_2000/pdf/confp23-00.pdf. Value of E_D based on http://www.agecon.ksu.edu/livestock/Extension%20Bulletins/BeefDemandDeterminants.pdf.

$$LE_{M,t} = \frac{E_S}{E_D - E_S}$$

Where:

$LE_{M,t}$	Market leakage factor at time t
E_S	Elasticity of supply with respect to price; set to 0.91
E_D	Elasticity of demand with respect to price; set to -0.61

The net greenhouse gas emissions due to market-effects leakage are derived from the difference in output (i.e. total kg of hot carcass weight beef produced) between the baseline and project at time **t**, any additional output from production shifted to non-project areas (activity shifting – assume this effect is zero[19]), the market leakage factor from Equation 18, and the baseline GHG emissions per unit output.

Equation 19:

$$E\_ME = \left[\left(\frac{(Y_{P,t} + Y_{AS,t}) - Y_{BSL,t}}{Y_{BSL,t}} \right) * LE_{M,t} * e_{BSL,t} \right]$$

Where:

E_ME	Net greenhouse gas emissions due to market-effects leakage (t CO_2-e)
$Y_{P,t}$	Project output at time t; total kg of hot carcass weight produced
$Y_{AS,t}$	Output from production shifted to non-project areas. Set at zero for this methodology.
$Y_{BSL,t}$	Baseline output at time t; kg hot carcass wt averaged over 3 years
$LE_{M,t}$	Market leakage factor at time t from Equation 18
$e_{BSL,t}$	Baseline emissions per unit output (t CO2e/kg of hot carcass weight) taken from the 3 yr average of applicable performance standard baseline in Section 3.4.

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[19] This method is adapted from ACR's Leakage Module for the Grazing Land and Livestock Management Greenhouse Gas Mitigation Methodology (GLLM). See the L-GLLM module, at http://americancarbonregistry.org/carbon-accounting/grazing-land-and-livestock-management-methodology.

Note that in theory it is possible that project output is greater than baseline output. In that case "positive leakage" may optionally be calculated. In Equation 19, *E_ME* will be a negative number, and in effect there will be positive market-effects leakage, since increased output from the project means that less output needs to be produced elsewhere, as compared to the baseline case. Further, since the four or five beef feeding states in the US all have similar conditions, activity-shifting impacts are deemed to be minimal (see Appendix C).

5.6 Final Quantification Steps

The final quantification steps include a calculation of the emission reductions across animal groupings. The steps include:

- For each animal grouping in the project, calculate the emissions intensity in total carbon dioxide equivalent/kg of carcass gain (kg) for both CH_4 and N_2O, using the global warming potential (GWP)[20] of CH_4 (21) and GWP for N_2O (310):
- For each animal grouping subtract the project CO_2e/kg carcass weight emissions intensity from the performance standard baseline intensity to obtain the functional unit difference in emissions intensity.
- For each animal grouping, multiply the functional unit difference by the total kg of carcass weight gain for that project animal grouping to obtain the GHG emission difference per kg of carcass weight gain in the project.

Sum the differences across all animal groupings to obtain the net GHG reduction, if any, for that project year(s).[21]

Once the emission reductions have been calculated across animal groupings, the final emission reductions can be calculated using Equations 1, 2, and 3. The Project Proponent calculates the total emissions from the project using Equation 3, and calculates the total emissions for the baseline using Equation 2. Lastly, the Project Proponent calculates the final emission reductions found in Equation 1 by subtracting the emissions reductions from the project (Equation 3) and the emissions from the market leakage-effect (Equation 19)[22] from the baseline emissions (Equation 2).

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[20] Global Warming Potential is a measure of a greenhouse gas' relative warming effect on Earth's atmosphere compared to carbon dioxide, expressed as a 100-year average. Per the ACR Standard, this methodology uses the IPCC 2nd Assessment Report 100-year GWP values.

[21] The feeding efficiencies of animals in a feedlot are based on a number of factors – weather, animal health, condition, frame, animal diets, feeding strategies, additives and animal husbandry. Therefore, it is the net reduction, summed across of all relevant animal groupings in the project year that determines whether a feedlot can claim carbon credits.

[22] Note that if the emission reductions from the effects of market leakage (e.g. Equation 19) is negative (because the project output exceeds the baseline output), then the subtraction of negative market effects from the project emissions (in Equation 3) would become a positive number and consequently increase credits to the project.

6. Data Management

Data collection, records and data quality management need to be of sufficient quality to support quantification of greenhouse gas emissions and reductions. **In all cases, greenhouse gas emission reductions must be substantiated with records and must meet minimum data requirements specified in Table 9. The American Carbon Registry cannot accept offset credits that are not supported by actual records.**

Individual farm operators participating in Reduced Carbon Intensity of Fed Cattle projects must collect and maintain records and proof of practice consistent with the requirements stated in Table 9. To facilitate quantification and verification of emission reductions, cattle inventory data must be tracked for each pen/lot grouping within a feedyard. Feedyards must track number of head-days and the dry matter intake for each of the feeding periods and each pen/lot in their close-out sheets to facilitate the calculations and justification for verification of a GHG assertion.

Additional evidence other than those collected for business reasons may be required to substantiate claims of greenhouse gas emission reductions and to provide positive proof of feeding and management strategies to a reasonable level of assurance. Each type of data requirement listed in Table 9 must be supported for each feedyard operation for each year of the project or a claim of GHG reductions cannot be made.

Project Proponents/feedyard operators are required to retain copies of the farm operator's records and any additional records needed to support greenhouse gas assertions consistent with the requirements stated in Table 9 of this methodology.

The Project Proponent/feedyard operator must also establish and apply data management procedures to manage data and information within the project. Written procedures must be established for each management task outlining responsibility, timing, quality control and quality assurance checks, records and record location requirements. These procedures must be documented in a procedures manual, and must be made available to third party verifiers and to ACR upon request. More rigorous data management systems can facilitate third party verification, and help to reduce overall transaction costs for the project.

Third party verifiers are required to assess the data management system, the internal procedures manual, quantification and project records as part of the third party verification.

Note: Attestations are not considered sufficient proof that an activity occurred.

6.1 Role of Professional Animal Scientist/ Nutritionists

Professional Animal Scientists (PAS) are third party professionals with technical knowledge in feedyard operations. PAS may work directly for the participating feedyard, the Project Proponent, or be an independent third party that is consulted during project implementation. PAS may have familiarity with a farm enterprise and must have specific knowledge on farm beef feeding systems. They can provide additional support for project implementation; however **sign-off by a qualified professional cannot be used as a substitute for farm records or third party verification.**

Project Proponents/feedyard operators may elect to have a qualified professional sign off on their opinion regarding practices being claimed in the project. This sign-off provides a secondary source of corroborating evidence of the beef feedyard practices.

Sign-off by a qualified professional does not replace record keeping requirements, but rather, can provide an added level of due diligence on the emission reduction claims. All parties (qualified professional, feedyard operator/Project Proponent) are required to maintain copies of records needed to support the greenhouse gas assertion. Minimum records are provided in Table 9.

Note: The Professional Animal Scientist/Nutritionist must collect and keep copies of the records needed to support his/her professional opinion presented in the sign-off statement.

6.2 Project Documentation and Evidence

Minimum data management requirements and examples of acceptable records needed to support a Reduced Carbon Intensity of Fed Cattle project are outlined in Table 9 below. The Project Proponent/feedyard operator is required to obtain and retain copies of records for each feedyard for each year of the project in their data management system and must disclose records to a third party verifier and to ACR upon request. Feedyard operators must retain records for their files and may be asked to produce records during a site visit conducted by a third party verifier. Data collection and retention responsibilities by party are outlined in Table 10.

The American Carbon Registry will not accept offset credits that do not have sufficient evidence to support the greenhouse gas reductions being claimed. **Records are needed to support each type of data requirement listed for each feedyard for each project year. These documents may be requested to support verification. See Table 10 for details of data collection responsibilities.**

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
Animal Inventory		
Animal Identifier Tags	▪ Feedyard records or third party records showing unique tag numbers for each animal recorded in animal inventory databases. AND ▪ Feedyard records showing animals with lost tags were either removed from the project or the lost tag was retired and a replacement tag registered with that individual animal.	To ensure the animals in the feeding/commercial agreements are fed in the feedyard in question and can be tracked, if necessary, in and out of the feedyard. Also to confirm that dead animals are confirmed as removed from the project.
Animal Groupings	▪ Documented procedures by the feedyard for methods used to sort and group animals to manage their production and performance. AND ▪ Documentation to prove that these procedures are the same for both baseline and project cases AND ▪ Documented procedures by the feedyard or third party agency that show the GHG calculations are performed by animal grouping, comparing similar groups of animals in the baseline and project OR, the following may be substituted for the second bullet above: ▪ Sign-Off by a PAS or Nutritionist who reviewed and collected calculations that confirm the grouping procedures are the same between baseline and project.	The methods used to define an animal grouping (e.g. lots or pens based on sex, age, weight, breed, or quality grid programs) must be the same between project and baseline to ensure the offset calculations are valid and functionally equivalent
Number in Production - for animal groupings – entry and exit numbers	▪ Feedyard inventory records (e.g. close out data) that show the average number of animals in each grouping, taking into account animal entry and exit movements from the grouping. This is a weighted average	To ensure an accurate average number of head per animal grouping for offset calculation purposes

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
	approach using the animal head-days factor. AND ▪ Feedyard records and shipping manifests or packing plant receipts that show animals in a grouping (by tag numbers) exited the feedyard destined for a packing plant. OR ▪ Third party managed data for production and performance, documenting weighted averages per animal grouping and shipping manifests to a packing plant or receipts from a packing plant; with sign-off by an authorized signatory of the third party agency.	and as evidence that animals were being finished for market purposes and being shipped to packing plants (i.e. not backgrounded in the feedyard).
Incoming and Outgoing Weights	▪ Feedyard records, date stamped, showing average incoming and outgoing weights for animal groupings. AND • Associated weigh scale tickets from a licensed scale at the feedyard per animal grouping. If using carcass weights (i.e. adjusting animal weights by dressing percentages): • Feedyard records showing a direct connection between the animal groupings and packing receipts.	Animal groupings will be sorted by weight classes within gender and animal type (e.g. fall calves, yearlings, winter calves, etc) thus the weights will need to be known. GHG reductions are calculated according to animal groupings and kilogram of live weight or kilogram of carcass weight basis, so an adjustment for production equivalency between baseline and project will need to be made in accordance with the methodology.
Feeding Management		
Number of Days on Feed	• Feedyard records or third party managed data, date stamped, that show the average number of days a group of animals spent on each diet while in the feedyard. This must be estimated using the animal.head days	Required to calculate the enteric and manure-based GHG emissions from feed intake of a particular

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
	approach. OR - Sign-Off by a PAS or Nutritionist who reviewed and collected supporting farm records that confirm the number of days on feed for each diet for baseline and project conditions.[23]	diet for a particular period of time.
Composition of each Diet or Classes of Diet	- Feedyard ration and nutrient analysis sheets, date stamped, that show the diet ingredients on a dry matter basis, including - Level of concentrates in the diet (%) - Total digestible nutrients (%) - Crude protein content (%) - Fat/Edible Oil content (% ether extract) - Incidence and inclusion of feed additives or supplements that will reduce days on feed (e.g. beta-agonists) as part of the project activity OR - Third party-managed data that includes all of the above, with sign-off by an authorized signatory of the third party agency. AND, in either case: - Sign off by a PAS or Nutritionist confirming the diet composition in the ration and nutrient analysis sheets; If diets are being grouped into two general categories for streamlining calculations (i.e. diets > or = 85% concentrates and those diets < 85% concentrates) for each animal grouping in the feedyard, then: - Documented procedures by the PAS or Nutritionist on how the average diets for use	Two key diet ingredients are required for GHG emissions to ensure that calculations have taken into account: - The right enteric emission factor (EF – percent of gross energy intake lost as methane in the rumen) is being used depending on the concentrate level of the diet (i.e. an EF of 3% for diets > or = 85% concentrates and an EF of 6.5% for < 85% if fat content of the diet is below 4% D.M.) - The right gross energy (GE) content of the diets is being used depending on the fat level of the diets (i.e. 19.10 MJ per kg of DM fed if

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[23] Note – it is acceptable to streamline implementation of the methodology by separating the diet requirements into two feeding periods – days on diets greater than or equal to 85% concentrates, and days on diets less than 85% concentrates. The project developer must justify to the verifier how the required diet ingredients are statistically representative of the two feeding periods for the feedyard in question, for both baseline and project.

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
	in the two diet groupings were derived. AND - Justification by the PAS or Nutritionist on the representativeness of the average diets for the particular animal grouping, and how they are tracked to the animal grouping for the year in question. AND - Sign-off by the PAS or Nutritionist on the derived diet groupings	between 4 and 6%, or 18.5 MJ per kg of DM fed if less than 4%) If the fat content of the diet is in the 4 to 6% range, the right enteric emission factor (EF) is being used according to the concentrate level of the diet (i.e. > or = 85% concentrates uses 2.4% EF while < 85% uses 5.2%)
Dry Matter Intake	▪ Feedyard records or third party managed data, date stamped, that document the average daily dry matter intake by animal grouping in the project; this includes: - Records showing kg of feed delivered to each animal grouping in the project for each diet/diet grouping. - Records/procedures showing the dry matter conversion of wet feed to dry. OR - Sign-Off by a PAS or Nutritionist who reviewed and collected supporting farm records that confirm the daily dry matter intake for each animal grouping in the baseline and project;[24]	Average Daily Dry Matter intake must be derived from these records by: - Dry Matter Intake (kg / head / day) = (Total quantity of feed for a specific diet x dry matter content of diet) / animal head/days
Manure Management		
Manure Managed according to a Manure Management Plan	- Feedyard documentation to show that a State required nutrient management plan is in place including: - Manure Handling Plans or Nutrient Management Plans and record keeping systems are in place;	Needed to demonstrate that no major changes in how manure is managed have occurred (since the pre-project time period). Major

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[24] Note – it is acceptable to streamline implementation of the methodology by separating the diet requirements into two feeding periods – days on diets greater than or equal to 85% concentrates, and days on diets less than 85% concentrates. The Project Proponent must justify to the verifier how the required diet ingredients are statistically representative of the two feeding periods for the feedyard in question, for both baseline and project.

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
	OR ▪ Sign-Off by a PAS or Nutritionist who reviewed and collected supporting farm records that confirm the manure management conforms to State requirements in both baseline and project and no major changes in manure management have occurred since the pre-project time period.	changes include: • switching storage types • instituting a composting system • installing an anaerobic digester The intent is to verify that a permit is in place and is current and no major changes in manure handling have occurred. A major change is a signal to contact the American Carbon Registry for more clarification on how to proceed.
Legal Claim to the Offsets		
Location of the Feedyard Operation(s)	• Legal land description for the land parcel(s) upon which the feedyard(s) are located	For registration and serialization of greenhouse gas reductions when the project is registered on the American Carbon Registry.
Commercial Feeding Agreements	• Feedyard agreements/purchase receipts demonstrating that the animals in the project are under control of the feedyard operator and were being fed at the feedyard in question. AND • Feedyard records or third party managed data that show the tag identifiers for each feeding agreement/purchase receipts. If the feedyard operator is a corporation: • The seal of the corporation will be affixed to	To prove that the animals being fed in the project were at the feedyard in question, and being finished for market.

Table 11: Evidence Required for this Methodology		
Data Requirement	**Records Needed**	**Why it is Required**
	the documentation.	

Copies of records must be retained by the feedyard operator, the PAS or Nutritionist (if applicable), and the Project Proponent for **7 years after** the end of the Crediting Period.

Table 10 below provides clarity on the roles and responsibilities of each party.

Table 12: Responsibilities for Data Collection and Retention

Entity	**Data Collection and Retention Responsibilities**
Feedyard Operator	If the sole Project Proponent, the feedyard operator has primary responsibility for record keeping and record coordination to support project implementation and due diligence, and will be the primary information source for third party verification. If part of a larger project (see below), will provide copies of farm records and documentation to the Project Proponent. The feedyard operator must retain original records for their files.
Project Proponent (if different than the above)	The Project Proponent has primary responsibility for collection of records from the feedyard to support project implementation and due diligence, and will be the primary information source for third party verification. The Project Proponent is required to collect and manage copies of feedyard records and supporting documentation outlined in Table 9 above.
Nutritionist	The Nutritionist can provide a third party opinion on the project based on project records. Records must be collected and maintained consistent with this methodology, and to support his/her professional opinion of the farm management practices.

6.3 Record Keeping

The American Carbon Registry requires that Project Proponents 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 Crediting Period. Where the Project Proponent is different from the entity implementing the activity, as in the case of an aggregated project, the individual feedyard operator and the Project Proponent must both maintain sufficient records to support the offset project. The Project Proponent and/or the feedyard operator must keep the information listed below and disclose all information to the verifier and/or ACR upon request.

Record Keeping Requirements:

- Records stated in Table 9 above for all applicable years in which offset credits are being claimed;
- A record of all adjustments made to the project data with justifications;

- List of equipment included and any changes that occurred during the Crediting Period;
- Common practices relating to possible greenhouse gas reduction scenarios discussed in this methodology (feedyard management practices);
- All calculations applying the greenhouse gas assertion and emission factors listed in this methodology; and
- Initial and annual verification records and audit results.

In order to support the third party verification, the Project Proponent 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 seven years after the project Crediting Period has ended;
- Project developers must maintain electronic records; while feedyard operators must maintain original records, which may include hardcopy records; and
- Copies of records shall be stored in two locations to prevent loss of data.

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

6.4 Quality Assurance/Quality Control Considerations

Project Proponents are required to ensure sufficient and appropriate quality assurance/quality control procedures are implemented to support the project implementation. 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:

- Outlining the process related to data management and record keeping for offset credits, including:
    - Data process flow charts for each feedyard describing data collection systems and input systems for animal grouping close out data, production performance databases, ration/nutrient tracking and animal identifier tag systems; validation points in the data flow (data oversight; second party checks; supervisor sign-off);
    - Data process flow charts for the overall project, describing how data collected from each feedyard is being inputted into the data management systems, with same data flow and controls as in above;
- Restriction of user access to offset claim calculations and data;
- Filtering procedures on production and performance data, close-out data for animal groupings; descriptions of techniques used to scrub the raw data to remove erroneous values/outliers;
- Ensuring that no major changes have occurred in manure management so that the quantification of project emissions relative to the static historic baseline are quantified appropriately;

- Ensuring that the measurement and calculation system and greenhouse gas reduction reporting remains in place and accurate;
- Any statistical sampling procedures are applied as per the methodology with a description of the procedure ensuring the guidance is met;
- Checking the validity of all data before it is processed, including emission factors, static factors, and acquired data;
- Exception reports for identification of duplicate records, incorrect emission factors, or records with values outside of expected ranges;
- 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 electronic 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; and,
- Management review and approval of agreements, records, completeness of feedyard activity information, consistency with underlying data, as well as linkage between base data and claims.

7. Registration and Claim to Offsets

It is important to note that the emission reductions associated with reducing carbon intensity in beef cattle production occur specifically at feedyards, where the activity takes place. There must be clear and uncontested legal claim to the greenhouse gas reductions achieved from the project in order to have the offsets verified and registered. Emission reductions are tracked through the American Carbon Registry. The registry relates the reduction to a specific land location. Project Proponents shall provide land ownership documentation and attestation of clear, unique, and uncontested land title.

Project Proponents must 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. Emission reductions cannot be consolidated to the parcel where the business entity is legally located.

Figure 5: One Feedyard, 2 Registry Parcels Example

Ownership of offset credits generated under this methodology is assigned to the Project Proponent.

The Project Proponent will need to ensure that they can justify the claim to the offsets to the satisfaction of the third party verifier. This will include the ability to provide feeding agreements for the animals in the project, to substantiate the Project Proponent fed the cattle in question, for the purposes of verification.

Data quality management must be of sufficient quality to support quantification requirements and must be substantiated by company records.

The Project Proponent 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.

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Appendix B1: Statistical Sampling Method for Reduced Carbon Intensity of Fed Cattle Projects

Sampling involves analyzing a subset of a population in order to make generalizations about the whole population. For example, values attained from measuring a sampling of groupings in a feedyard may be used to estimate the true value (known as the parameter) for the entire population of cattle in the yard or for a specific animal grouping (e.g. 600-700 lb fall-placed steers). In order to determine how close the estimation is to the parameter, statistics are needed.

Sampling a subset of pens in the feedyard for greenhouse gas estimation involves taking measurements of the desired data in a number of discrete pens. The average values of the desired data, when all the pens are combined, represent the larger population parameter. The confidence interval is used to determine how representative the sample is of the larger population. For example, a 95% confidence interval indicates that 95 times out of 100, the true greenhouse gas emissions lie within the sample interval. If the confidence interval is numerically small, the estimation is more precise.

To facilitate Reduced Carbon Intensity of Fed Cattle project development and increase the accuracy and precision of estimating GHG reductions, cattle in the feedyard shall divide their animal groupings or "strata" (typically organized in feedyard pens according to specific groupings) to form relatively homogenous sampling units. In general, stratified sampling also decreases the costs of monitoring since it typically lessens the sampling efforts necessary, while maintaining the same level of confidence due to the decreased variability in data that drive the greenhouse gas reductions of each animal grouping. The more variable the data, the more pens are needed to attain targeted precision levels.

To apply the above method, an indication of the variability of the data within the sampled strata is needed. This is calculated using the coefficient of variation of the data from each sampled animal grouping. The following key statistics must be calculated for each set of measured data in each animal grouping:

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

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

- Standard deviation: a measure of dispersion, calculated by using:

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

- Coefficient of variation (CV), calculated by:

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

It is necessary to determine an appropriate sample size to achieve the required precision. Taking a sample that is too small or too large, with under- or over-accuracy, respectively, shall be avoided. Therefore, a balance must be obtained by expressing the allowable error in terms of confidence limits.

- The 95% confidence limits are given by:

  $\bar{x} \pm 2s_x/\sqrt{n}$.
- L is the allowable error (for GHG projects it is set at 5% of the mean):

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

In other words, there is a 95% chance that the actual error will not exceed ±*L* or a 5% risk that the actual error will be below –*L* or above +*L*.

Applying the Sampling Approach

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

The biostatisticians and scientists involved in developing this methodology have tested this method with robust feedyard datasets[25]. 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 feedyard:

- 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 by Alberta Agriculture and Rural Development and explained below in the example, the initial sample shall contain 30 to 40 pens (i.e. n = 30 or 40 initially) in each of the above animal groupings. The data to be collected include[26]:

  - Number of animals per pen
  - 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)

---

[25] There are over 80,000 head of cattle in Alberta that have been used in these datasets.

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

- Average slaughter weight per pen
- Average Daily Gain per pen

Note: the sampling plan must 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 being set for the sampling method dictates a 95% certainty that the actual error will not exceed ±*L,* or a 5% risk that the actual error will be below –*L* or above +*L*, the desired sample size is calculated as:

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

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

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

This procedure will need to be concisely documented 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. Means, standard deviations and coefficients of variation were analyzed for the data outlined in Step 2 of the above procedure.

The analysis indicates that, for the key trait of daily dry matter intake, the coefficients of variation ranged from 4 to 32%.

The required sample size was then calculated to determine how many pens would be required to produce a mean or an average that is repeatable 95 times out of 100 or have a 5% error. For all animal groupings except yearling heifers (which tends to be a less homogenous group than others), the number of pens, required or 'n' is shown in **Table A1.**

Table A1: Required sample 'n' within the Allowable Error (+/- 5 %) with a 5% risk that the error will fall outside of the desired range (derived from Table 1 analysis) based on the example shown here.

Animal Grouping	Daily Dry Matter Intake (lbs/head/day) No. of Pens	Slaughter Weight (lbs) No. of Pens
Cows	34	4
Fall Heifer Calves	66	41

Fall Steer Calves	31	28
Mixed Steers/Heifers	2	0
Winter Heifer Calves	13	9
Winter Steer Calves	34	18
Yearling Heifers	167	26
Yearling Steers	48	8

As a conservative starting point, it is recommended that initial sampling occur 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 accounts for this by requiring an increased sample size until the Project Proponent can obtain a 5% error in the estimated mean. Once this iterative process is finished, the Project Proponent may find that fewer pens are required for some animal groupings, as shown in the example above.

Note: the Project Proponent may need to consult with a statistician to correctly implement this methodology.

Appendix B2: Development of the Performance Standard Baseline for the Reduced Carbon Intensity of Fed Cattle Methodology

This Appendix describes a performance standard baseline assessment for fed cattle in the U.S. feedyard system, from data analyzed for the 2000 to 2011 period. Dr. Shawn Archibeque, under guidance of the Protocol Scientific Adaptation Team of the BIGGS USDA-CIG Grant Project made every effort to use all known and available data sets to create an aggregate baseline. The method involved assessing published, nationally relevant and/or national level datasets for cattle performance and for cattle feed information.

Feedyard Performance Data:
For the purposes of feedyard performance, three data sets were used to gather and amalgamate the necessary cattle performance data for animal groupings (in 100 lb increments, by sex) in this protocol:

1. Kansas State University "Focus on Feedlots" – a representative data source for fed cattle in the United States – broken out by sex but not placement;
2. Previously acquired data from Cattle Fax; and,
3. Data obtained from Professional Cattle Consultants.

While the Kansas State data set had separated the performance of steers and heifers in the feedyard, the other two data sets only had average performance data available. Therefore, the steer and heifer data was averaged, using appropriate USDA National Agricultural Statistics Service data on the appropriate placement of steers and heifers into the U.S. feedyard system.

Additionally, the deviation from the mean performance of steers and heifers from the final average of the Kansas State University data was obtained to determine the proportionate performance of steers and heifers either above or below the mean for the various response variables. Once this average was acquired, all appropriate averages were made for the three data sets.

After a final average performance of cattle was obtained, the same proportional deviations from the mean obtained using the Kansas State University data set for steers and heifers were used to create a final average performance for both steers and heifers. Lastly, carcass data and final slaughter weights of steers and heifers were obtained from the USDA Agricultural Marketing Service (AMS) Annual Meat Trade Reviews for 2000 through 2011. These data provided a subsequent verification of the previous data set where a comparison was made between the average finished weight of cattle based on the average of the Kansas State University, Cattle Fax and Professional Cattle Consultants for both steers and heifers and the slaughter weight of cattle indicated by the Annual Meat Trade Reviews. This comparison indicates that there was an average deviation between the two estimates of final live weight of 0.86% across the 12 year time span, which allows for an assessment that the estimate of feedyard performance is acceptably accurate. It is also worth noting that with the exception of the year 2000, the AMS slaughter weight was less than the projected finished weight, which is likely an indication of shipping shrink, where the cattle lose weight as they are placed into transport to the slaughter facility from the feedyard. It is unknown why there is a discrepancy in the year 2000.

Cattle Feed Data:

The calculation of greenhouse gas emissions was performed using several modifications of the standard IPCC equations based on unique information available regarding the U.S. feedyard industry. For the calculation of enteric methane production the standard IPCC Ym conversion factor of 3% was used for the years 2006 and previous and a Ym of 2.8% was used for 2007 and subsequent years based on the surveys of Vasconcelos and Galyean (2007) and Galyean and Gleghorn (2001), which indicated that the mean total fat in feedyard rations in 2007 was 7.6% of DM, and 3.68% in 2000.

Without further delineation in the interim years, the conservative approach of maintaining the greater Ym value for years prior to 2007 was used. Additionally, it was assumed that with the greater inclusion of fat in 2007 and following years,that a dietary GE value of 19.1 MJ/kg dry matter intake was appropriate, while the concentration of 18.5 MJ/kg dry matter intake was maintained for the preceding years. Similarly, based on these surveys, it was assumed that the mean concentration of crude protein in the ration was 13.31 for the years prior to 2007 and 13.5 for 2007 and subsequent years.

These dietary crude protein concentrations were used to estimate the daily N intake, which was used to calculate N excretion and subsequent N_2O formation using the standard IPCC equations. Given that there was a lack of data to suggest variation in volatile solid excretion, it was assumed that these remained relatively constant and thus the standard IPCC tier 2 assumptions were maintained for the calculations. Finally, all emissions were totaled using the standard CO_2 equivalents of 21 for methane and 310 for N_2O, and were expressed as total emissions per final kg of carcass harvested.

In order to provide categorical separation of the data for varying entry weights, the mean value for each categorical sequence was used to establish a mean entry weight for that class (i.e. 650 pounds for a 600-699 lb class). The average days on feed or feed to gain ratio was calculated by dividing the starting weight and the final finished weights and all other assumptions remained constant.

Results:

Within these final statistics, the following data are present for both steers and heifers in the U.S. feedyard system during the years of 2000 through 2011:

- Initial Weight (The average weight of cattle entering into feedyards.)
- Final Weight (The average weight of cattle when exiting feedyards for slaughter.)
- Average Days on Feed (The average days cattle were within a feedyard.)
- Average Daily Gain (The average daily weight gain of cattle while within the feedyard.)
- Feed/Gain (The average amount of feed dry matter consumed to accumulate a defined amount of gain. In this case pounds of feed dry matter per pound of live gain, or kilograms of feed dry matter per kg of live gain.) Formula: DMI/Avg. Daily Gain

- DMI (Dry matter intake, an estimate of the feed consumed without water on a daily basis while in the feedyard.)

- % Death Loss (The percent of cattle that entered the feedyard that died before they were able to be sent to slaughter. This includes natural deaths and on-site euthanasia.)

- AMS Slaughter weight (The average weight of cattle when slaughtered, based on USDA AMS Annual Meat Trade Review data.)

- Carcass weight (The average weight of carcasses, based on USDA AMS Annual Meat Trade Review data.)

- Dressing percent (The percent of live weight that is present as the finished carcass once the hide and offal are removed, using the finished live weight calculated from the average of the Kansas State University, Cattle Fax and Professional Cattle Consultants data and the USDA AMS Annual Meat Trade Review carcass data.)
  - Formula: (Carcass Weight/Final Weight)*100

- AMS Dressing Percent (The percent of live weight that is present as the finished carcass once the hide and offal are removed, using the USDA AMS Annual Meat Trade Review slaughter weight and the carcass data.)
  - Formula: (Carcass Weight/AMS SlaughterWeight)*100

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Appendix B3: Supplemental Information Regarding Leakage

This Appendix demonstrates the contraction of both the cattle inventory and beef consumption over the last 10 years which supports the claim that the potential for leakage as a result of project activity is low.

The USDA Economic Research Service website (See: http://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx#.UdbQPfnCaM4) demonstrates that beef consumption has gone down since 2007 and cattle inventory has also contracted because of decreased demand and other factors like multi-year droughts in major cow-calf production states like Texas and other high plains states driving cow herd liquidation.

- Total U.S. beef consumption:
  - 2002: 27.9 billion pounds
  - 2003: 27.0 billion pounds
  - 2004: 27.8 billion pounds
  - 2005: 27.8 billion pounds
  - 2006: 28.1 billion pounds
  - 2007: 28.1 billion pounds
  - 2008: 27.3 billion pounds
  - 2009: 26.8 billion pounds
  - 2010: 26.4 billion pounds
  - 2011: 25.6 billion pounds

Cattle inventory

- January 1, 2003:
  - U.S.--96.1 million, down from 1996 peak of 103.5 million
  - Canada--13.5 million head
- January 1, 2004
  - U.S.--94.4 million head (cyclical low)
  - Canada--14.6 million head
- January 1, 2005
  - U.S.--94.0 million head
  - Canada--14.9 million head
- January 1, 2006
  - U.S.--96.3 million head
  - Canada--14.7 million head
- January 1, 2007
  - U.S.--96.6 million head
  - Canada--14.2 million head
- January 1, 2008
  - U.S.--96.0 million head

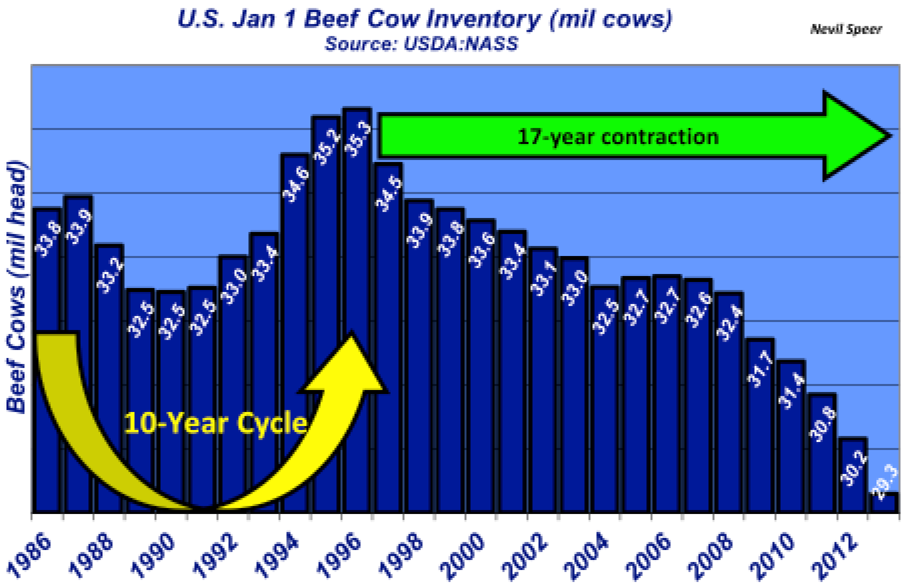
    - Canada--13.9 million head
- January 1, 2009
    - U.S.--94.5 million head
    - Canada--13.2 million head
- January 1, 2010
    - U.S.--93.9 million head
    - Canada--12.9 million head
- January 1, 2011
    - U.S.--92.7 million head
    - Canada--12.5 million head
- January 1, 2012
    - U.S.--90.8 million head
    - Canada--12.5 million head

Further evidence is provided by the following reference:

http://beefmagazine.com/cow-calf/industry-glance-us-cowherd-liquidation

Feb. 7, 2013

USDA's Jan. 1 cattle inventory report came in as expected: 2013's beef cow starting number was pegged at 29.3 million cows. That level marks a selloff of six-million cows during the past 17 years – the equivalent of approximately 350,000 head/year. Perhaps more importantly, given the upward adjustment to last year's inventory, 2012 now marks the largest year-over-year decline during that 17-year contraction period. See figure below.



The potential for leakage to occur outside the major cattle feeding area is very low given the concentration of the cattle feeding sector in the four high plains states of Texas, Kansas, Colorado and Nebraska. These four states accounted for 74% of the fed cattle production in 2013. From USDA-NASS Cattle on Feed June 2013 report http://usda01.library.cornell.edu/usda/current/CattOnFe/CattOnFe-06-21-2013.pdf

State	**1,000's of Head**
Arizona	275
California	490
Colorado	960
Idaho	210
Iowa	620
Kansas	2,060
Nebraska	2,390
Oklahoma	295
South Dakota	225
Texas	2,540
Washington	220
Other States	450
United States	10,735

Further, there is little variability in enteric emissions of cattle based on the regions where they are fed because of the overall similarity in the diets fed to cattle and hence methane emissions from cattle in the major cattle feeding states. A paper by Kebreab *et al.* (2008) entitled "Model for estimating enteric methane emissions from United States dairy and feedlot cattle" found that mean methane emissions from feedlot cattle fed 30 different typical diets that cover all feedlot states, was 5.03 MJ/day (SD = 0.10, CV = 0.02%). Emissions calculated using mechanistic models (average Ym 3.88%) was close to IPCC equations and Ym of 3.5% for all diets in the database (Table 6 below – last line).

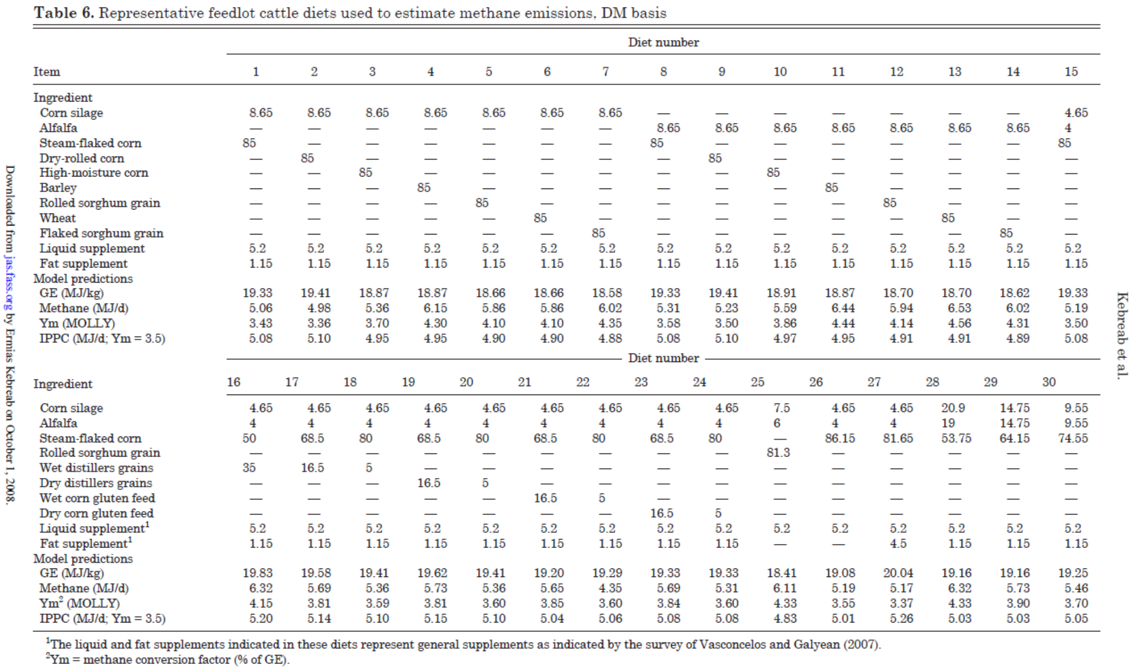


Table 6. Representative feedlot cattle diets used to estimate methane emissions, DM basis

	Diet number														
Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ingredient															
Corn silage	8.65	8.65	8.65	8.65	8.65	8.65	8.65	—	—	—	—	—	—	—	4.65
Alfalfa	—	—	—	—	—	—	—	8.65	8.65	8.65	8.65	8.65	8.65	8.65	4
Steam-flaked corn	85	—	—	—	—	—	—	85	—	—	—	—	—	—	85
Dry-rolled corn	—	85	—	—	—	—	—	—	85	—	—	—	—	—	—
High-moisture corn	—	—	85	—	—	—	—	—	—	85	—	—	—	—	—
Barley	—	—	—	85	—	—	—	—	—	—	85	—	—	—	—
Rolled sorghum grain	—	—	—	—	85	—	—	—	—	—	—	85	—	—	—
Wheat	—	—	—	—	—	85	—	—	—	—	—	—	85	—	—
Flaked sorghum grain	—	—	—	—	—	—	85	—	—	—	—	—	—	85	—
Liquid supplement	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Fat supplement	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Model predictions															
GE (MJ/kg)	19.33	19.41	18.87	18.87	18.66	18.66	18.58	19.33	19.41	18.91	18.87	18.70	18.70	18.62	19.33
Methane (MJ/d)	5.06	4.98	5.36	6.15	5.86	5.86	6.02	5.31	5.23	5.59	6.44	5.94	6.53	6.02	5.19
Ym (MOLLY)	3.43	3.36	3.70	4.30	4.10	4.10	4.35	3.58	3.50	3.86	4.44	4.14	4.56	4.31	3.50
IPPC (MJ/d; Ym = 3.5)	5.08	5.10	4.95	4.95	4.90	4.90	4.88	5.08	5.10	4.97	4.95	4.91	4.91	4.89	5.08

	Diet number														
Ingredient	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Corn silage	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	7.5	4.65	4.65	20.9	14.75	9.55
Alfalfa	4	4	4	4	4	4	4	4	4	6	4	4	19	14.75	9.55
Steam-flaked corn	50	68.5	80	68.5	80	68.5	80	68.5	80	—	86.15	81.65	53.75	64.15	74.55
Rolled sorghum grain	—	—	—	—	—	—	—	—	—	81.3	—	—	—	—	—
Wet distillers grains	35	16.5	5	—	—	—	—	—	—	—	—	—	—	—	—
Dry distillers grains	—	—	—	16.5	5	—	—	—	—	—	—	—	—	—	—
Wet corn gluten feed	—	—	—	—	—	16.5	5	—	—	—	—	—	—	—	—
Dry corn gluten feed	—	—	—	—	—	—	—	16.5	5	—	—	—	—	—	—
Liquid supplement[1]	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Fat supplement[1]	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	—	—	4.5	1.15	1.15	1.15
Model predictions															
GE (MJ/kg)	19.83	19.58	19.41	19.62	19.41	19.20	19.29	19.33	19.33	18.41	19.08	20.04	19.16	19.16	19.25
Methane (MJ/d)	6.32	5.69	5.36	5.73	5.36	5.65	4.35	5.69	5.31	6.11	5.19	5.17	6.32	5.73	5.46
Ym[2] (MOLLY)	4.15	3.81	3.59	3.81	3.60	3.85	3.60	3.84	3.60	4.33	3.55	3.37	4.33	3.90	3.70
IPPC (MJ/d; Ym = 3.5)	5.20	5.14	5.10	5.15	5.10	5.04	5.06	5.08	5.08	4.83	5.01	5.26	5.03	5.03	5.05

[1] The liquid and fat supplements indicated in these diets represent general supplements as indicated by the survey of Vasconcelos and Galyean (2007).

[2] Ym = methane conversion factor (% of GE).

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Appendix C – Reduced Age at Harvest Methodology

The American Carbon Registry™

October 2014

Quantification Methodology for Reducing the Age at Harvest of Beef Cattle

Prepared by the Protocol Scientific Adaptation Team, of the USDA Conservation Innovation Grant GHG Pilot called Bovine Innovative Greenhouse Gas Solutions (BIGGS).

Acronym List

The following acronyms are used in this methodology:

ACR	American Carbon Registry
AF	Annualization Factor
BIGGS	Bovine Innovative Greenhouse Gas Solutions
CH_4	Methane
CO_{2e}	Carbon Dioxide Equivalent
CV	Coefficient of Variation
ERTs	Emission Reduction Tons
GHG	Greenhouse Gas
GJ	Gigajoule
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
LCA	Life Cycle Assessment
N_2O	Nitrous Oxide
NGP	Northern Great Plains
SS	Sources and Sinks
TDN	Total Digestible Nutrients

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1.0 Introduction

The American Carbon Registry® (ACR) is a voluntary, online greenhouse gas (GHG) registration and emissions tracking system used by members to transparently register verified, project-based emissions reductions and removals as serialized offsets; record the purchase, sale, banking and retirement of verified offsets, branded as Emission Reduction Tons ("ERTs"); and optionally report, in a separate account, verified GHG inventories.

ACR was founded in 1996 by the Environmental Defense Fund and Environmental Resources Trust, and joined Winrock International in 2007. As the first private voluntary GHG registry in the United States, ACR has set the bar for transparency and integrity that is the market standard today.

Winrock International, a non-profit public benefit corporation founded in 1984, works with people in the U.S. and around the world to empower the disadvantaged, increase economic opportunity, and sustain natural resources. Central to Winrock's mission since its founding has been agricultural and livestock improvement, linking farmers to new markets, and enhancing food security – complemented in recent years by an objective to address potential impacts of climate change on agriculture and reduce the GHG intensity of agricultural production. Since the 1990s, Winrock has been a leader in developing science-based GHG measurement and monitoring methodologies.

1.4 Purpose

Agricultural activities, including the production of livestock, result in greenhouse gas emissions to the atmosphere. Beef cattle release methane (CH_4) as a result of the digestion of feed materials in the rumen. These emissions are called "enteric emissions" and are a significant contributor to greenhouse gas emissions from agricultural activities. Methane and nitrous oxide (N_2O) emissions are also generated from manure storage and handling within beef cattle operations. These emissions are called "manure emissions"

This methodology quantifies decreases in greenhouse gas emissions associated with the raising of beef cattle by reducing the number of days required to get youthful cattle (under 30 months) from birth to harvest. The methodology includes calf-fed and yearling-fed as well as feeder cattle.[27] Under the Reducing Age at Harvest Methodology, these cattle spend less time in background lots, on pasture, and in the feedlot, resulting in decreased greenhouse gas emissions from:

- **Enteric Fermentation**: less methane is produced from the cattle as a result of taking fewer days on lower quality diets and fewer days to reach harvest, and
- **Manure Production:** less manure is produced, stored and handled as a result of the cattle taking fewer days on lower quality diets and fewer days to get to harvest, thereby generating less methane and nitrous oxide.

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[27] Calf-fed animals are calves (steers or heifers) under 12 months old, yearling-fed animals (steers or heifers) are between 12 and 24 months or older and feeder cattle are steers or heifers over 24 months and under 30 months of age.

2.0 Scope, Definitions, Applicability and Methodology Flexibility

Agricultural activities, including the production of livestock, result in greenhouse gas emissions into the atmosphere. The scope of sources included in this methodology are derived from life cycle assessments (LCA) of feeding regimes/beef production systems. Emissions arise from four sources - (1) enteric methane from the digestion of feed; (2) manure methane and nitrous oxide; (3) cropping nitrous oxide (feed production); and (4) fossil fuel carbon dioxide (from farm operations).

This methodology quantifies decreases in greenhouse gas emissions associated with reducing the time required to produce a beef animal for market. Under the Reducing Age at Harvest Methodology, these cattle spend less time in background lots, on pasture, and in the feedlot on a per unit of production basis, resulting in decreased greenhouse gas emissions.

2.1 Scope

Through the Intergovernmental Panel on Climate Change (IPCC 2006), industry experts and agricultural scientists have developed Tier 2 accounting procedures for enteric and manure emissions generated by different cattle classes in the U.S.

The reducing age to harvest methodology quantifies emissions reductions on the basis of the mass of beef produced. That is, emission reductions are measured on a common metric of emissions per kilogram of carcass weight for both the baseline and project condition. The starting point for all quantification is the birth date, number of registered cattle, weights of cattle in and out of the feedlot, and the mass of registered cattle produced in the baseline and project conditions. This methodology does not prescribe the harvest age or production practices for raising cattle in a project. Rather, it guides Project Proponent in meeting the measurement, monitoring and greenhouse gas quantification requirements for calculating the offset credits[28] being generated for use in the American Carbon Registry.

2.1.0 Baseline Condition for Reducing Age at Harvest

The baseline condition is a reference case against which the performance of an offset project is measured. The baseline condition for a reducing age at harvest project is the average emissions for the year prior to project implementation on a per kg of carcass weight basis.

The Reducing Age at Harvest Methodology uses a **static performance standard baseline** to determine the baseline condition. This means that, once determined, the baseline emissions are held constant and compared to the annual project emissions, as feedlot operators source cattle at a younger age for finishing. More information on establishing and quantifying the baseline condition is provided in Sections 3.0 and 5.0.

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[28] An offset credit is a tradable credit issued per tonne of greenhouse gas emission reductions expressed as CO_2e.

2.1.1 Project Condition for Reducing Age at Harvest

Generically, project condition is defined as an action targeted at reducing, removing or storing greenhouse gas emissions at a project. Specific to a reducing age at harvest project, the project condition is defined as a change in the age at which cattle enter the feedlot, to shift beef cattle production systems compared to the baseline condition.

Approximately 60 per cent of fed cattle currently spend intermediary time in a backgrounding lot or on grass or wheat pasture before entering a feedlot. These animals are typically harvested at over 22 months of age. This segment of the beef cattle sector has the greatest potential for achieving greenhouse gas reductions through reducing their age at harvest, thereby avoiding months of enteric fermentation and manure-based emissions when compared to baseline conditions.

Table 1 below provides an overview of the relevant greenhouse gases applicable in this methodology and their related global warming potential.

Table 13: Relevant Greenhouse Gases Applicable to the Reducing Age at Harvest Methodology

Specified Gas	Formula	100-year GWP*	Applicable to Project
Carbon Dioxide	CO_2	1	N
Methane	CH_4	21	Y
Nitrous Oxide	N_2O	310	Y

* Global Warming Potential (GWP) is a measure of a greenhouse gas's relative warming effect on Earth's atmosphere compared to carbon dioxide expressed as a 100-year average.
More information on establishing and quantifying the project condition is provided in Sections 4.0 and 5.0.

2.2 Definitions

Lot	Feedlots manage and track cattle according to Lots, which are a group of incoming cattle entering the feedyard. Cattle are sorted into pens for performance-based feeding. Animal inventory and performance data (average gain; average dry matter intake; average daily gain, etc) are calculated and tracked by Lot, as well as the yardage data for the feedlot. The summaries are produced electronically in close-out sheets for each Lot as the cattle are sent to harvest.
Animal Calf.Days	A basic unit used in this methodology to calculate a weighted average age of animals for Lots on a monthly basis to calculate emissions in the standardized quantification methodology.

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 the hide, head, tail, forelegs, internal organs, digestive complex, kidney knob and channel fat.
Concentrates	A broad classification of feedstuffs which are high in energy and low in crude fibre (<18% crude fibre). Concentrates can include grains and protein supplements, but exclude feedstuffs like hay, silage or other roughage.
Custom Feedlot Records	The records kept on a group of cattle by a feedlot. These cattle are owned by someone other than the feedlot.
Diet	Feed ingredients or mixture of ingredients including water consumed by beef cattle (Ensminger and Olentine (1980)). Diet includes the amount of and composition for feed supplied to an animal for a defined period of time.
Enteric Emissions	Emissions of methane (CH_4) from cattle as part of the digestive process of feed materials.
Feeding Cycle	The combination of diets fed to beef cattle over a set period of time.
Feeding Regime	The whole system of diets or diets fed to beef cattle in a project over the baseline/project period**.**

2.3 Applicability

To apply this methodology, the Project Proponent must meet the following requirements:

8. Diets fed to animals have sufficient documentation to quantify a reduction in enteric/manure-based emissions according to the quantification procedures outlined in Section 5. Specifically, the Project Proponent must have sufficient data and project level documentation detailing the content and quantity of feed fed per animal grouping in order to quantify enteric and manure emissions.

9. Animal grouping criteria must be shown to be similar between the baseline and project calculations, based on feeding practices and diets. Emission reductions must represent a reduction in emissions based on a common metric of emissions per kg carcass weight to ensure emissions reductions being quantified represent real reductions in carbon intensity when compared against the performance standard baseline.

10. Manure must be managed according to a Manure Management Plan, as required for confined animal feeding operations for the particular state where the feedyard is located. The intent is to verify that a permit is in place and is current and no major changes in manure handling have occurred over the life of the project. A major change

is a signal to contact the American Carbon Registry for more clarification on how to proceed.

11. Sampling of project animals is allowed under this methodology and must be done according to the statistical sampling methodology outlined in Appendix F.

12. The quantification of reductions achieved by the project is based on measurement/estimation and monitoring as indicated by the proper application of this methodology.

13. For this methodology, emission reductions qualify if they occur in the United States.

14. The project meets the eligibility criteria stated in the American Carbon Registry Standard. In order to qualify, emissions reductions must:
    - Result from actions not otherwise required by law;
    - Result from actions taken on or after January 1, 2003;
    - Be real, demonstrable, additional, permanent and quantifiable; and
    - Have clearly established ownership.

The general data requirements for this methodology are shown in Table 2 below. Additional details are provided in sections 5.0 and 6.0.

Table 14: General Overview of Data Requirements for the Project

Data Requirements:	**What is needed:**	**Why it is needed:**
Animal identifier	Animal identification (either by lot or by individual)	To track animals as they move through the feedyard.
Alignment of the animal groupings to the performance standard baseline, for quantification procedures in the project years; Average number of animals per grouping/lot	Documented feedyard records of animal grouping/lot entry and exit records that show: • Average weights of the group in and out, • Average date of entry (by production system, quality grid program, sex, breed or custom feedyard records); • Average number of animals in each grouping/lot; • Average daily dry matter intake for the animal groupings.	The methods used to define an animal grouping (e.g. sex, age, weight, breed, etc.) must be the same between project and baseline to ensure like groupings are compared for the offset calculations.
Documented proof of: • What was being fed to the cattle per	Records include: • Feed purchase receipts or scale tickets, weights, etc. • Delivery records for a pen; • Diet formulations signed	To support calculations of the offset claim and for third party verification. Note, a

Table 14: General Overview of Data Requirements for the Project

Data Requirements:	What is needed:	Why it is needed:
grouping/lot in the feedyard; - Days on feed for each lot; - Diet composition; - Feed additives or strategies employed by the feedyard	off by a qualified nutritionist; - Diet ingredients must include % Ether Extract, %Total Digestible Nutrients (TDN), % Concentrates; % Crude Protein and any additive or edible oil (4 to 6%) content on a dry matter basis in the diet; - Proof the diet was fed to the animals as indicated from feedyard or dairy record keeping systems or third party record keeping when appropriate.	verifier will need evidence of diets and total mixed diets fed to cattle groupings for the project condition.
Incoming and outgoing average weight of each grouping of animals being included in the baseline and project	Documented feedyard records of animal pen/lot entry and exit records that show: - Average weights of the group in and out, - Average date of entry and exit - Average number of animals in each pen/lot - Average carcass weights of harvested animals	To determine the animal groupings for calculations and the outgoing animal weights for carcass adjustments.
Legal land location of the feedyard operation, and feeding agreements for the animals in the project	- Legal land description will match ACR requirements - Proof that the animals fed in the project were under control of the feedyard operator in question (see section 6.1)	Required for registration of the project.

2.4 Flexibility

1. The Project Proponent may choose to quantify age at harvest on an individual animal basis. In this case, the baseline condition would need to be calculated on an individual animal basis as well.

2. Operations using feeding cycles materially different from those outlined in the methodology may calculate custom emission factors based on their particular feeding cycles using a relevant method, such as the IPCC (Tier 2); or CowBytes$^{TM.}$. Justification and rational for the method chosen must be provided in the offset project plan.

3.0 Baseline Methodology Procedure

3.1 Project Boundary

The boundary[29] of the Reducing Age at Harvest methodology encompasses the pasture, background lot and feedlot where the cattle are raised and fed as well as the facilities/sites where manure is stored and handled. The project can include a number of sites and a variety of enterprises. However, each site/enterprise must address the activities within the boundary of the project as outlined in this methodology. The Project Start Date is defined as the date the feedyard or group of feedyards began to reduce GHG emissions against the performance standard baseline in this methodology. The Crediting Period spans eight years from the Project Start Date.

Offset credits are generated by demonstrating a decrease in the average age at harvest of the cattle involved in the project.

3.2 Demonstrating Additionality

Project Proponents shall demonstrate realistic and credible scenarios that would have occurred on the pasture background and feedlot operation in the absence of the project activity. These scenarios should take into account current laws and regulations as well as current industry practices. The GHG emission reductions and removals from the offset project must be additional or beyond the "business as usual" scenarios identified. Project proponents must demonstrate additionality using the "three-pronged" approach described in The American Carbon Registry® Standard Version 3.0.

In order to pass the ACR's three-prong additionality test Project Proponents must show

1. Regulatory Surplus - that there is no existing law, regulation, statute, legal ruling or other regulatory framework in effect mandating the project activity or requiring the GHG emissions reductions;
2. Common Practice - that the project activity is not widespread in the industry/sector in the geographic are; and

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[29] A project boundary is a conceptual line drawn around a project which defines the greenhouse gas sources and sinks that will be included in the project for emission reduction calculations.

3. Implementation Barriers – there are financial, technological or institutional [30]barriers to implementing the project (Note: In order to pass, a barrier is only needed in one of these areas).

3.3 Baseline Condition

A baseline condition is a reference case against which the performance of a project is measured. The Reducing Age at Harvest uses a **static historic benchmark** baseline condition. Under this scenario, a baseline condition using greenhouse gas emissions per kg of carcass weight (kg CO_2e per kg carcass weight) is quantified for registered cattle on a monthly basis, for a one-year period. This allows the Project Proponent to maintain a static baseline over the life of their projects that is representative of the baseline practices for their specific operation(s).

The Reducing Age at Harvest Methodology differs from other beef quantification methodologies in that it utilizes a **standardized quantification approach**. Regression curves for a range of typical feeding regimes over the life of cattle were constructed to derive greenhouse gas emissions on a per kg carcass weight basis**.** In the calculations, the final numbers are adjusted for the beef production differences between the baseline and project condition emissions to ensure consistency or functional equivalence.

The sources and sinks identified in the following process flow diagrams cover the full scope of eligible baseline activities under the methodology (Figure 1). Note that the dotted line in Figure 1 indicates the sources and sinks that occur on site in the baseline condition.

3.4 The Performance Standard Baseline

A baseline condition is a reference case against which the performance of a project is measured. The Reducing Age at Harvest Methodology uses a **static performance standard** baseline condition. Under this scenario, a performance standard baseline condition using greenhouse gas emissions per kg of carcass weight (kg CO_2e per kg carcass weight) is quantified for registered cattle on a monthly basis, for a one-year period. This allows project proponents to maintain a static baseline over the life of their projects that is representative of the baseline practices for their specific operation(s).

The Reducing Age at Harvest Methodology uses a **standardized quantification approach**. Regression curves for a range of typical feeding regimes over the life of cattle in the U.S. were constructed to derive greenhouse gas emissions on a per kg carcass weight basis**.** In the calculations, the final numbers are adjusted for the beef production differences between the baseline and project condition emissions to ensure consistency or functional equivalence.

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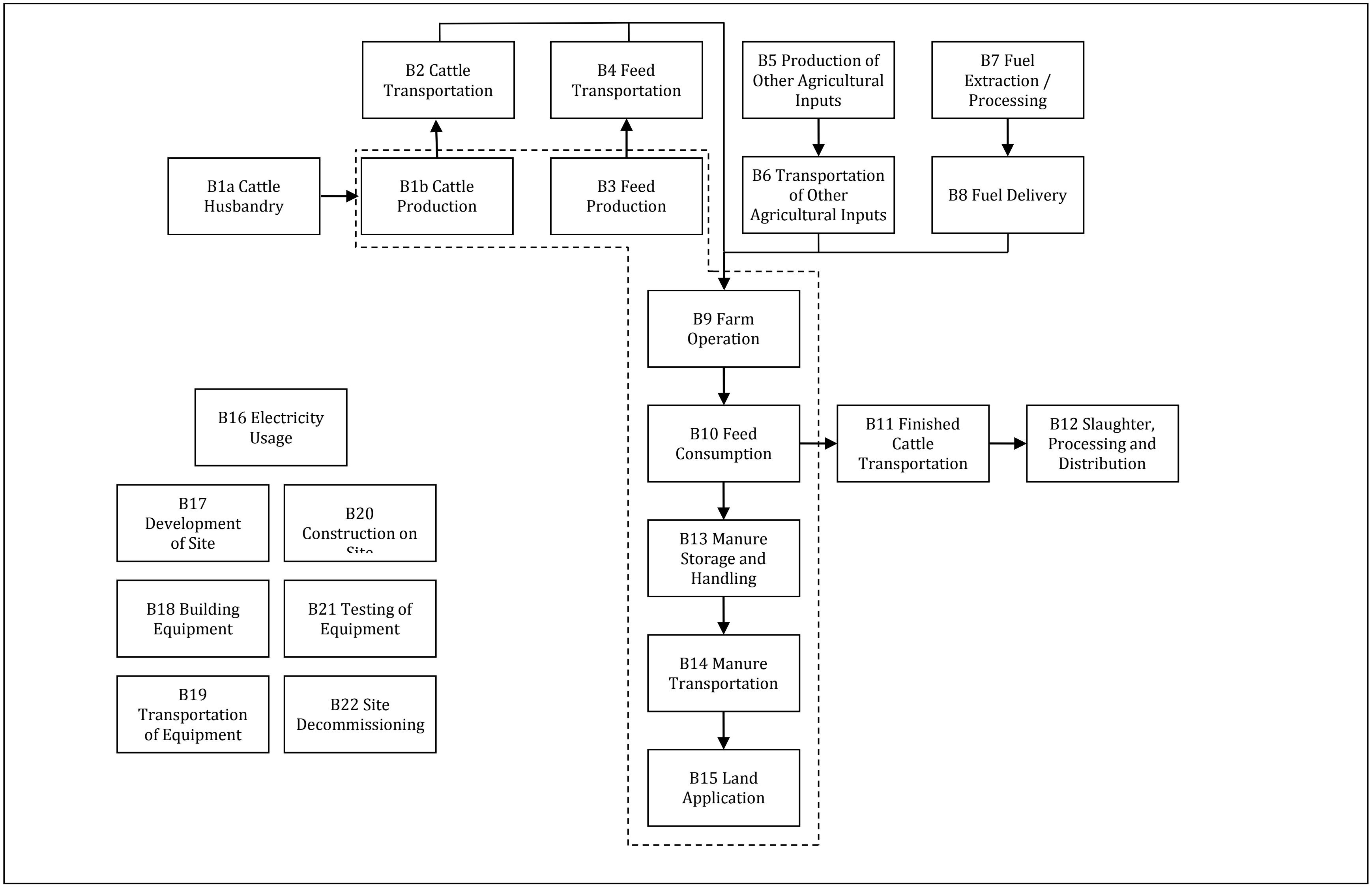
[30] Registered cattle with a livestock identification and registration agency; birth dates must be part of the registration information.

Figure 6: Process Flow Diagram for the Baseline Condition



3.5 Identification of Baseline Condition Sources and Sinks

Sources and sinks for an activity are assessed based on guidance provided by the ISO 14064:2 Standard and are classified as follows:

Controlled	A source or sink where the source or sink's behavior or operation is under the direction and influence of a Project Proponent through financial, policy, management, or other instruments.
Related	A source or sink that 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	A source or sink influenced by project activity through changes in market demand or supply for products or services associated with the project.

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

Based on the process flow diagram provided in Figure 1, Section 3.4, the baseline sources and sinks were organized into life cycle categories in Figure 2. Descriptions of each of the sources and/or sinks and their classification as controlled, related or affected are provided in Table 3.

Figure 7: Baseline Sources and Sinks for Reducing the Age at Harvest of Beef Cattle

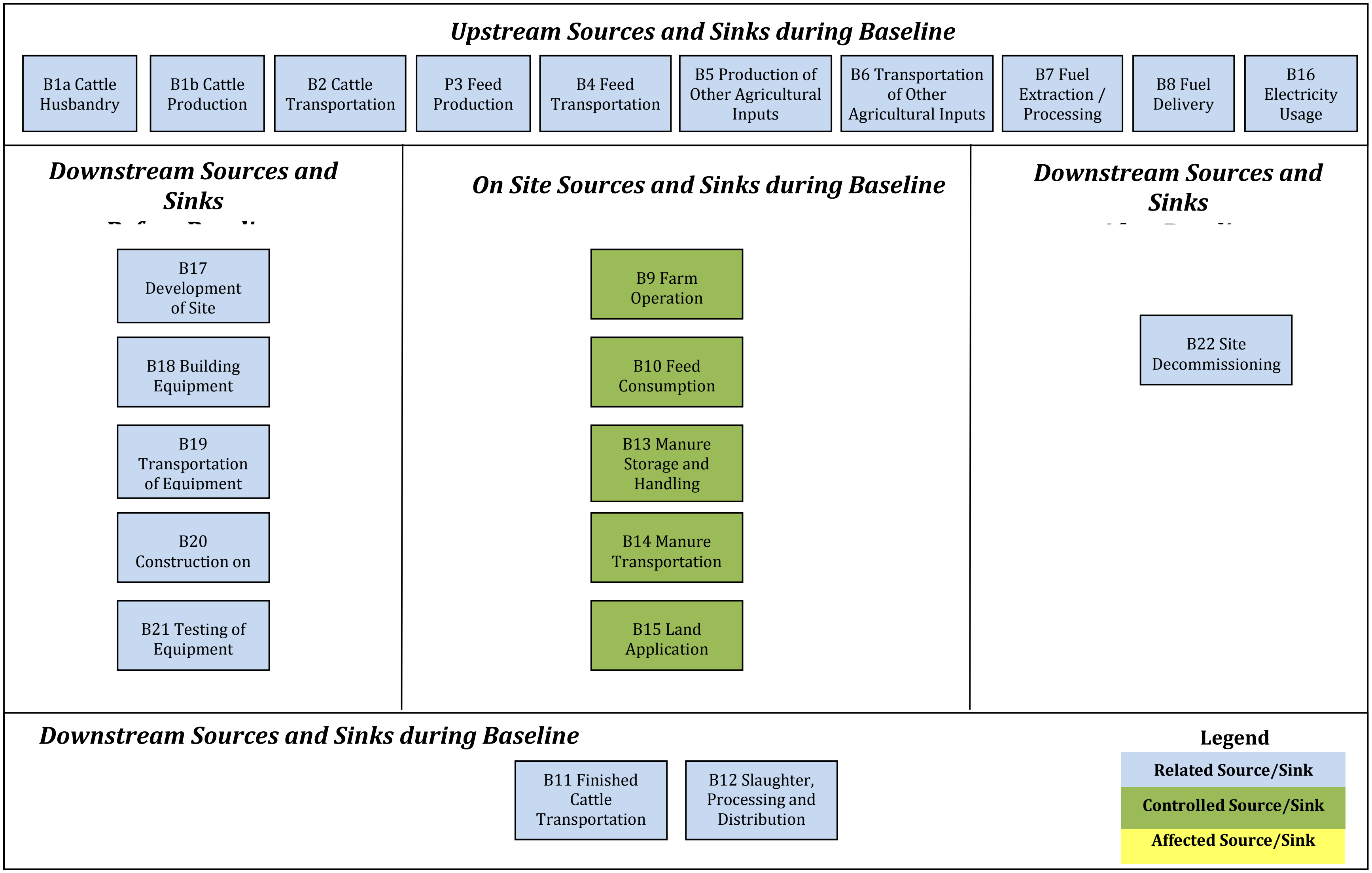


Table 15: Baseline Sources and Sinks

1. Source and Sink	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

Table 15: Baseline Sources and Sinks

1. Source and Sink	**2. Description**	**3. Controlled, Related or Affected**
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 volume of fuel for each on-site source/sink are considered under this source/sink. Volumes and types of fuels are the important characteristics to be tracked.	Related
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 emission 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 in this table and there is no other delivery.	Related
B16 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
Onsite Sources and Sinks During Baseline Operations		
B9 Farm Operation	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the beef production facility operations. This may include running vehicles and facilities at the project site for the distribution of the various inputs. Quantities and types for each of the energy inputs would be tracked.	Controlled
B10 Feed Consumption	Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the project condition. Length of feeding cycle would need to be tracked.	Controlled

Table 15: Baseline Sources and Sinks

1. Source and Sink	2. Description	3. Controlled, Related or Affected
B13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This will include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Quantities and types for each of the energy inputs would be tracked. Quantities, duration and conditions would also need to be tracked.	Controlled
B14 Manure Transportation	Manure may need to be transported to the field for land application from storage. Transportation equipment would be fuelled by diesel, gas or natural gas. Quantities for each of the energy inputs would be tracked to evaluate functional equivalence with the project condition.	Controlled
B15 Land Application	Manure may then be land applied. This may require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, or natural gas, resulting in greenhouse gas emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be tracked to evaluate functional equivalence with the project condition.	Controlled
Downstream Sources and Sinks During Baseline Operations		
B11 Finished Cattle Transportation	Finished cattle may be transported from the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
B12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility operations. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other Sources and Sinks		
B17 Development of Site	The site of the facility may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer, etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the	Related

Table 15: Baseline Sources and Sinks

1. Source and Sink	2. Description	3. Controlled, Related or Affected
	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.	
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 emissions 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

4.0 Project Methodology Procedure

4.1 Project Condition

A project condition is an action or actions targeted at reducing, removing or storing greenhouse gas emissions at a project. It can consist of one or more related activities developed according to a government-approved protocol. In the context of the Reducing Age at Harvest Methodology, project condition is defined as the reduction in age of beef cattle at harvest relative to the baseline condition. This methodology does not prescribe a method the Project Proponent must follow to progress animals through the typical stages in beef production. Rather, it provides a standardized quantification approach based on beef sector production standards to calculate the change in emissions of age-verified registered cattle between the project and baseline conditions.

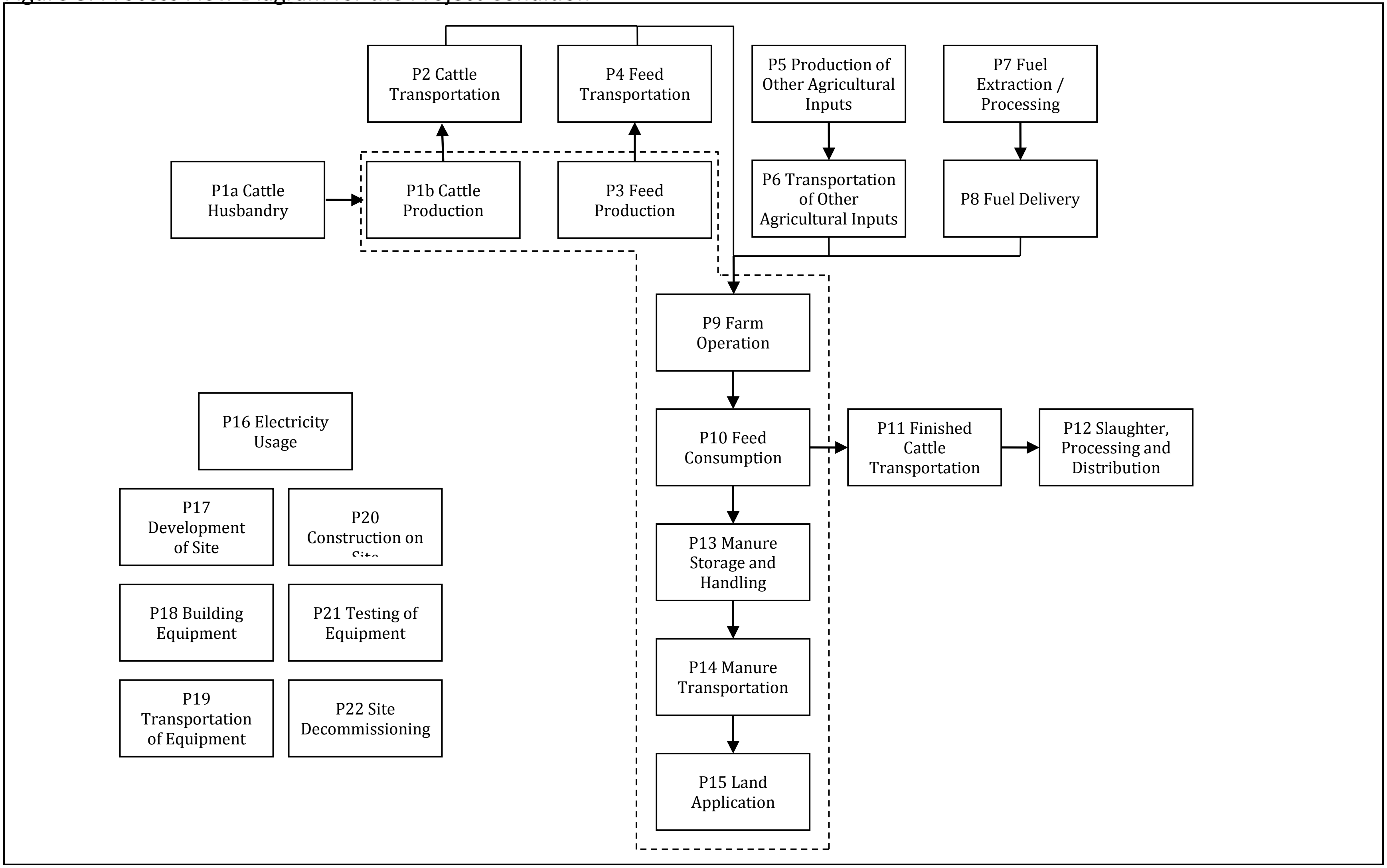
The reduction in the days at harvest results in a lower than conventional quantity of greenhouse gas emissions emitted over the lifespan of the identified and registered cattle in a project. The shortened lifespan also results in the reduction of manure produced and volatile solids and nitrogen excreted by the animals, as well as associated emissions from feed production and on-farm fossil fuel use. These elements can be quantified to calculate reduced greenhouse gas emissions under the project condition. The difference in emissions between the project and baseline conditions represents the total emission reductions generated.

As with the baseline condition calculations, regression curves for a range of typical feeding regimes over the life of cattle in various production systems were constructed to derive emission factors for the total amount of greenhouse gas sources, based on age of cattle at harvest.

The Project Proponent uses these regression equations to calculate an annual emission intensity per kilogram registered cattle produced (kg CO_2e/kg carcass weight) by weighted average by month, for Lots of animals using the Animal Calf.day approach. The total number of registered animals in production is used to calculate the total annual project emissions.

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

Figure 8: Process Flow Diagram for the Project Condition



4.2 Identification of Project Sources and Sinks

Sources and sinks for reducing age at harvest of beef cattle were identified through scientific review. The review confirmed that sources and sinks in the process flow diagram covered the full scope of eligible project activities under this methodology. The boundary for a project condition includes the pastures, background lots and feedlots where the cattle are raised and fed, the facilities/sites where manure is stored and handled, as well as feed production and fossil fuel emissions in beef operations.

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

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

Figure 9: Project Conditions Sources and Sinks for Reducing the Age at Harvest for Beef Cattle

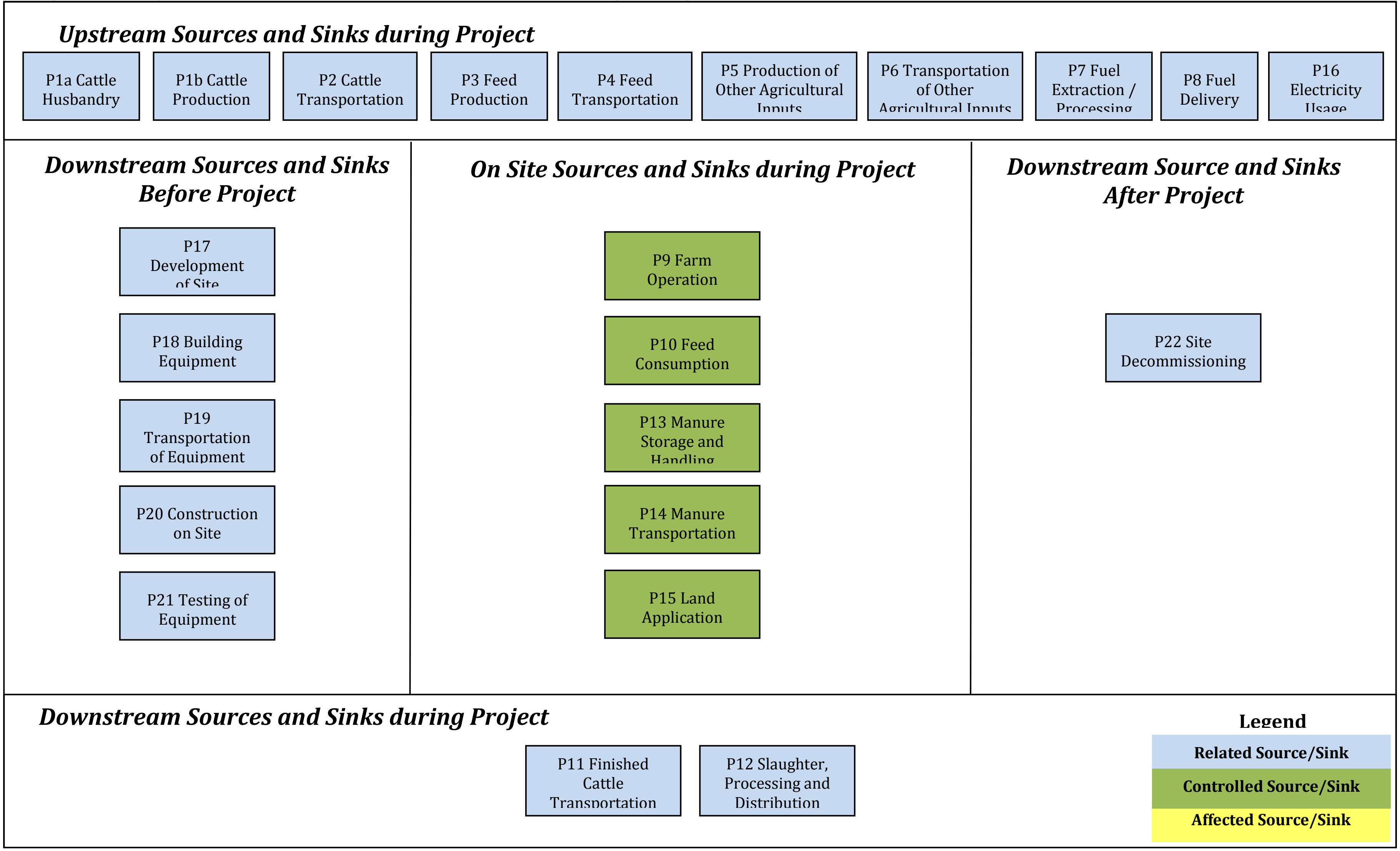


Table 16: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
Upstream Sources and Sinks During Project Operation		
P1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of a calf. Quantities 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 inputs to the project**.** 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 purpose 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

Table 16: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
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
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 in this table and there is no other delivery.	Related
P16 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced 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	Related

Table 16: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
	relate to the quantity of greenhouse gas emissions generated.	
On-site SS's during Project Operation		
P9 Farm Operation	Greenhouse gas emissions may occur that are associated with the operation and maintenance of a cattle feeding facility operation. This may include running vehicles and facilities at the project site for the distribution of the various inputs. Quantities and types for each of the energy inputs would be tracked.	Controlled
P10 Feed Consumption	Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the baseline condition. Length of each type of feeding cycle would need to be tracked.	Controlled
P13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This will include emissions from energy use and from the emissions of methane and nitrous oxide from the manure being stored and processed. Quantities and types for each of the energy inputs would be tracked. Quantities, duration and conditions would also need to be tracked.	Controlled
P14 Manure Transportation	Manure may need to be transported from storage to the field for land application. 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 be land applied. This may require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, or natural gas resulting in greenhouse gas emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Controlled

Table 16: Project Condition Sources and Sinks

1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
Downstream Sources and Sinks During Project Operation		
P11 Finished Cattle Transportation	Finished cattle may be transported from the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
P12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other		
P17 Development of Site	The site of the facility may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer, etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P18 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
P19 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to	Related

Table 16: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
	power the equipment delivering the equipment to the site.	
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 emissions 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 to ensure it 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 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

5.0 Quantification

In creating the Reducing Age at Harvest Methodology, baseline and project conditions were assessed against each other to determine the scope for reductions quantified under the methodology. Sources and sinks were either included or excluded, depending on how they were impacted by the project condition. Sources that were not expected to change between the baseline and project condition were excluded from the project quantification. It was assumed that excluded activities would occur at the same magnitude and emission rate during the baseline and project and so would not be impacted by the project.

Emissions that increase or decrease as a result of a 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 3 in Section 3.5 and Table 4 in Section 4.2 are listed in Table 5 below. Each source and sink is listed as included or excluded. Justification for these ratings is provided.

Table 17: Comparison of Sources/Sinks for Baseline (B) and Project (P) Conditions

Identified Sources and Sinks	**Baseline (C, R, A)****	**Project (C, R, A)****	**Include or Exclude from Quantification**	**Justification for Inclusion or Exclusion**
Upstream Sources and Sinks				
P1a Cattle Husbandry	N/A	R	Exclude	Excluded as animal husbandry is functionally equivalent to the baseline scenario.
B1a Cattle Husbandry	R	N/A	Exclude	
P1b Cattle Production	N/A	R	**Include**	Included because emissions from baseline to project are materially[31] different.
B1b Cattle Production	R	N/A	**Include**	
P2 Cattle Transportation	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B2 Cattle Transportation	R	N/A	Exclude	
P3 Feed Production	N/A	R	**Include**	Included because emissions from baseline to project are materially different.
B3 Feed Production	R	N/A	**Include**	
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 is not impacted by the implementation of the project and, as such, the baseline and project conditions will be functionally equivalent.
B5 Production of Other Agricultural Inputs	R	N/A	Exclude	
P6 Transportation of Other Agricultural Inputs	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B6 Transportation of Other Agricultural Inputs	R	N/A	Exclude	
P7 Fuel Extraction and Processing	N/A	R	Exclude	Excluded as these sources/sinks are not impacted by implementation of

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[31] Materially, Material, and Materiality refer to a measure of the estimated effect that an error, omission, or misrepresentation of project data and information may have on the accuracy or validity of a project's Greenhouse Gas Assertion.

Table 17: Comparison of Sources/Sinks for Baseline (B) and Project (P) Conditions

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion or Exclusion
B7 Fuel Extraction and Processing	R	N/A	Exclude	the project and, as such, the baseline and project conditions will be functionally equivalent.
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	**Include**	Included because whole-farm life cycle assessment incorporates all cradle-to-grave GHG emissions.
B9 Farm Operation	C	N/A	**Include**	
P10 Feed Consumption	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B10 Feed Consumption	C	N/A	**Include**	
P13 Manure Storage and Handling	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B13 Manure Storage and Handling	C	N/A	**Include**	
P14 Manure Transportation	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B14 Manure Transportation	C	N/A	**Include**	
P15 Land Application	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B15 Land Application	C	N/A	**Include**	
Downstream Sources and Sinks				
P11 Finished Cattle Transportation	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B11 Finished Cattle Transportation	R	N/A	Exclude	

Table 17: Comparison of Sources/Sinks for Baseline (B) and Project (P) Conditions

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

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

5.1 Quantification Methodology

Quantifying emission reductions for relevant sources/sinks for each of the greenhouse gases are completed using the methodologies outlined in Section 5.2 and Table 7 below. The scope of sources included in the quantification are derived from life cycle assessments of typical feeding regimes/beef production systems representative of current conditions (see Appendix C). Baseline and project emissions arise from four sources – (1) enteric methane; (2) manure methane and nitrous oxide; (3) cropping nitrous oxide (feed production); and (4) fossil fuel CO_2. According to Lupo et al (2013), in U.S Northern Great Plans (NPG) beef production systems the total greenhouse gas emissions on a life cycle basis can be broken down as follows: enteric emissions (46%); manure emissions and handling (32%); feed production (12%) and mineral and supplement production (6%).

These formulae below serve to complete the following three equations for calculating emission reductions through comparison of the baseline and project conditions.

Equation 1:

$$\text{Emissions}_{\text{Reductions}} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}} - \mathit{Emissions}_{\mathit{Market\ Effect}}$$

Equation 2:

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

Equation 3:

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

Where:

$\text{Emissions}_{\text{Baseline}}$	Sum of the emissions under the baseline condition
$\text{Emissions}_{\text{Feed}}$	Emissions under the B3 Feed Production
$\text{Emissions}_{\text{Energy}}$	Emissions under B9 Farm Operation and B14 Manure Transportation
$\text{Emissions}_{\text{Cattle}}$	Emissions under B1b Feed Consumption
$\text{Emissions}_{\text{Manure}}$	Emissions under B13 Manure Storage and Handling and B15 Land Application

Calculated in a performance standard carbon intensity baseline with regional and national data.

$\text{Emissions}_{\text{Project}}$	Sum of the emissions under the baseline condition
$\text{Emissions}_{\text{Feed}}$	Emissions under P3 Feed Production

Emissions $_{Energy}$	Emissions under P9 Farm Operation and P14 Manure Transportation
Emissions $_{Cattle}$	Emissions under P1b Feed Consumption
Emissions $_{Manure}$	Emissions under P13 Manure Storage and Handling and P15 Land Application

Calculated with actual annual feed yard carbon intensity data.

Emissions$_{Market\ Effect}$	Net greenhouse gas emissions due to market-effects leakage (t CO_2-e) **As calculated in Equation 14*

5.2 The Project Standardized Quantification

Regression curves for a range of data points including category of animal, birth date, growth stages of the animal, age entering the feedlot, gross energy intake; age and average carcass weight upon harvest over the life of cattle were constructed to calculate the emissions intensity for enteric methane based on age of cattle at harvest (Kebreab et al; see Appendix A for more information). Using the enteric methane intensity, the total greenhouse gas emissions, referred to as **Basic Emissions Intensity** in this methodology, can be derived from the fraction of total emissions attributable to enteric methane, and then annualized and adjusted for production equivalency.

The standardized equation for the enteric emissions intensity for age of cattle at harvest in a given year is: (as shown in Appendix A):

Equation 4: Calculating Enteric Emissions Intensity for Age of Cattle at Harvest

$$Emissions_{Enteric,CH4} = (0.0086 * (AAH)) + 0.27$$

Where:

Emissions $_{Enteric,\ CH4}$	(kg CH_4/kg of carcass weight)
AAH	The average age of registered cattle sent to harvest, in months

Deriving the **Basic Emissions Intensity** relies on a life cycle assessment of calf-fed and yearling-fed systems in the U.S Northern Great Plains (NPG), conducted by Lupo et al. (2013). The study concluded that enteric emissions consistently constitute 46% of whole-farm greenhouse gas emissions (i.e. included sources within the scope of this methodology) for U.S Northern Great Plains beef operations. The remainder of greenhouse gas emissions result from the following sources (in order of relative magnitude):

1. Manure (CH_4, NO_2)
2. Cropping (N_2O)
3. Energy (CO_2)

Using the upper bound of this estimate, 46%, is conservative since the global warming potential of methane is lower than the weighted average global warming potential of these constituents.

Therefore, the standardized quantification approach estimates non-enteric emissions using the factor (1-0.46)/0.46 ≈ 1.174, and then combines both to derive the **Basic Emissions Intensity** for use in the quantification method in this methodology (see Appendix B).

5.2.0 Annualizing Emissions for Standardized Comparisons

In order to standardize emissions to a functionally equivalent time period of one year for greenhouse gas accounting purposes[32], a method to derive annual standardization factors (AF) was developed. The annual factors were developed based on eight crops of cattle moving from birth to harvest for the different life span of cattle in representative beef production systems (see Appendix D). Eight crops of cattle were selected as a reasonable physiological end-point to standardize the calculations and be reasonably close to the project length of eight years.

The following equation is the result of plotting annualization factors for every comparison of baseline and project conditions (i.e. difference in average age of animals within the range of 12 to 30 months for average age at harvest. This equation is used to derive annually equivalent emission reductions for the project.

Equation 5: Calculating Annual Equivalent Emission Reduction for the Project

$$AF = 0.009542 * (\Delta AAH) + 0.9982$$

$$R^2 = 0.9982$$

Where:

AF	The annualization factor for the baseline and project comparison
ΔAAH	Difference in the average age at harvest (in months) for the given year

As mentioned, the annualization factor standardizes the **Basic Emission Reduction** to an **Annualized Emission Reduction** for both baseline and project according to the following equation:

Equation 6: Annualized Emissions Reduction

$$\text{Annualized Emissions Reductions} = AF * \sum \text{Basic Emissions Reduction}_{\text{month } i}$$

Where:

Basic Emission	Production Total $_{\text{month } i}$ * Basic Emission Intensity Reduction

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[32] Functional equivalence is the comparison of a project's baseline and project emissions using the same metric, normalized to the same level of products or services (for example, per GJ of energy, tonne of wheat produced, acres of carbon stored, etc.)

Reduction $_{\text{month i}}$	$_{\text{month i}}$
Production Total $_{\text{month i}}$	# Head Harvested $_{\text{month i}}$ * Average Carcass Weight $_{\text{month i}}$ (of registered cattle across all lots)
Basic Emission Intensity Reduction $_{\text{Project month i}}$	Basic Emission Intensity $_{\text{Baseline month i}}$ – Basic Emission Intensity $_{\text{Project month i}}$ (of registered cattle across all lots)

Note that the **Basic Emission Intensity Reduction** is scaled to the total mass of cattle produced to determine the amount of production-equivalent annual emission reductions for the project.

5.3 Quantification Approach

Equation 4: Calculating Enteric Emissions Intensity for Age of Cattle at Harvest

Enteric Emissions Intensity (kg CO_2e/ kg Carcass Weight) per Month

$$Emissions_{Enteric,\ month\ i} = GWP_{CH4} * (0.0086 * AAH_{month\ i} + 0.27)$$

Where:

Emissions $_{\text{Enteric, CH4}}$	(kg CH_4/kg of carcass weight)
AAH	The average age of registered cattle sent to harvest, in months

Substitute average age at harvest (in months) for registered cattle Equation 4 as ‘AAH’ and multiply by 0.0086 and add 0.27 to derive enteric methane emissions/kg carcass weight for the month in question. Convert units to CO_2e by multiplying the result by the appropriate global warming potential for methane (GWP_{CH4}) from Table 1. This unit provides the common reference point for the baseline and project conditions to ensure carbon equivalence on the rest of the quantification steps.

Step 1 is to calculate the average age at harvest for the year, for both baseline and project. To do this, take the weighted average age in days for a given month derived in Section 5.4 below, and divide by the number of days in the month. In the example above for the January baseline month (Table 8), this would equal 14.74 months (457 days divided by 31 days). Repeat this step for each month in the baseline and each month in the project year, then add the monthly averages and divide by 12, to derive the Average Age at Harvest on an annual basis.

Step 2 is to determine the weighted-average for carcass weights according to the method in Section 5.4, after finishing is complete for registered cattle in each month for both the baseline and project conditions (see Appendix E for an example).

Once the data requirements for each month have been tracked and the average age at harvest and kg carcass weight for both baseline and project is determined, emissions related to the baseline and project conditions are calculated in a similar manner. That is, they are calculated in two parts and summed for each month, the first part being enteric emissions and the second, non-enteric, including whole-farm operations (see Equation 6). Again, both sources of emissions (enteric and non-enteric) must be expressed on the basis of carbon equivalence and must be functionally equivalent.[33]

The final steps, annualizing and scaling for production equivalency are shown below. These calculations will be performed for each month in the baseline and project to derive a monthly emission reduction (see Appendix E for example).

Equation 5: Calculating Annual Equivalent Emission Reduction for the Project

Annualization Factor (AF)

$$AF = 0.009542 * (\Delta AAH) + 0.9982$$

Where:

AF	The annualization factor for the baseline and project comparison
ΔAAH	Difference in the average age at harvest (in months)

In order to standardize emissions to a functionally equivalent time period of one year for greenhouse gas accounting purposes[34], a method to derive annual standardization factors (AF) was developed. The annual factors were developed based on eight crops of cattle moving from birth to harvest for the different life span of cattle in representative beef production systems (see Appendix C). Eight crops of cattle were selected as a reasonable physiological end-point to standardize the calculations and be reasonably close to the project length of 8 years.

The previous equation is the result of plotting annualization factors for every comparison of baseline and project conditions (i.e. difference in average age of animals within the range of 12 to 30 months for average age at harvest. This equation is used to derive annually equivalent emission reductions for the project.

As mentioned, the annualization factor standardizes the **Basic Emission Reduction** to an **Annualized Emission Reduction** for both baseline and project according to the following equation:

Equation 6: Calculating Non-Enteric Emissions Intensity in the Project and Baseline Conditions

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[33] Functional equivalence is the comparison of a project's baseline and project emissions using the same metric, normalized to the same level of products or services (for example, per GJ of energy, tonne of wheat produced, acre of carbon stored, etc.)

[35] Price elasticity's describe how a change in price affects quantity supplied or demanded. For example, a price elasticity of supply of 0.4 indicates that a 1% increase (decrease) in price results in a 0.4% increase (decrease) in the quantity supplied. Price elasticity's of supply and demand for the dairy and beef sectors have been derived and published in several peer-reviewed economic studies (e.g., Tvedt *et al.* 1991). In the long-term, this may be the case for agriculture, as the price elasticity of supply is generally high and the price elasticity of demand for staple foods tends to be very low.

Non-Enteric Emissions Intensity (kg CO_2e/ kg Carcass Weight) per Month

$$Emissions_{Non\text{-}Enteric,\ month\ i} = Emissions_{Enteric,\ month\ i} * 1.174$$

Using the equation above, substitute Enteric Emissions Intensity from Equation 4 and multiply it by the above factor and use the product of these to derive non-enteric emissions/kg carcass weight the month in question. Repeat for all months in the project and baseline.

The **Basic Emissions Intensity** can then be calculated for the project and baseline conditions; note that this figure has not been annualized or adjusted for production equivalency.

Equation 7: Calculating Basic Emissions Intensity for the Project and Baseline Conditions

Basic Emissions Intensity (kg CO_2e/ kg Carcass Weight) per Month

$$Basic\ Emissions\ Intensity_{month\ i} = Emissions_{Enteric,\ month\ i} + Emissions_{Non\text{-}Enteric,\ month\ i}$$

Using the equation above, sum the Enteric Emissions Intensity from Equation 4 and the Non-Enteric Emissions Intensity from Equation 6 to derive the Basic Emissions Intensity for the month in question in the baseline condition. Repeat the step above for all months in the project and baseline.

Equation 8: Calculating Monthly Production Total for Project Condition

Production Total (kg Carcass Weight) per Month

$$Production\ Total_{month\ i} = Avg\ Carcass\ Weight_{month\ i} * Head\ Harvested_{month\ i}$$

For each month in the project, using the equation above, substitute the registered animal average carcass weight at harvest calculated in **Step 2** (in kg) and the number of head that were harvested each month, to derive the Production Total.

The Production Total is then used with the Basic Emission Intensities under baseline and project condition to calculate the Basic Emissions Reduction for each month (i.e. non-annualized emission reductions).

Equation 9: Calculating Basic Emissions Reduced in the Month

Basic Emissions Reduction (kg CO_2e) on a Monthly Basis

$$Basic\ Emissions\ Reduction_{month\ i} = (Basic\ Emissions\ Intensity_{Baseline,\ month\ i} - Basic\ Emissions\ Intensity_{Project,\ month\ i}) * Production\ Total_{month\ i}$$

Using the equation above, substitute the Basic Emissions Intensities for the baseline and project conditions to derive the basic emissions reduced on an intensity basis. Then multiply this result by the monthly Production Total in the Project, calculated by Equation 8 to derive the Basic Emissions Reduction for the month.

The annualization factor (AF) is used to adjust the Basic Emissions Reduction to an annual basis for both the project and baseline conditions, to ensure functional equivalence.

Equation 10: Calculating the Annualization Factor for the Project and Baseline Conditions

Annualization Factor (AF)

$$AF = 0.009542 * \Delta AAH_{Annual\ average} + 0.9982$$

Using the weighted annual average age at harvest for the year (calculated in **Step 1**) for both baseline and project conditions, substitute the difference in months between the reduced Age at Harvest ($\Delta AAH_{Annual\ average}$) in baseline and project conditions. Multiply by 0.00952, then add 0.9982 to derive the Annualization Factor (AF) for the project year.

The Annualization Factor and Basic Emissions Reduction are then used to calculate the Annualized Emissions Reduction for the project and baseline conditions.

Equation 11: Annualized Emissions Reduction for the Project

$$\text{Annualized Emissions Reductions} = AF * \sum \text{Basic Emissions Reduction}_{\text{month } i}$$

Where:

Basic Emission Reduction $_{\text{month } i}$	Production Total $_{\text{month } i}$ * Basic Emission Intensity Reduction $_{\text{month } i}$
Production Total $_{\text{month } i}$	# Head Harvested $_{\text{month } i}$ * Average Carcass Weight $_{\text{month } i}$ (of registered cattle across all lots)
Basic Emission Intensity Reduction $_{\text{Project month } i}$	Basic Emission Intensity $_{\text{Baseline month } i}$ – Basic Emission Intensity $_{\text{Project month } i}$ (of registered cattle across all lots)

Note that the **Basic Emission Intensity Reduction** is scaled to the total mass of cattle produced to determine the amount of production-equivalent annual emission reductions for the project.

Sum the monthly Basic Emissions Reductions for each month (from Equation 9) and substitute for $\sum$ *Basic Emissions Reduction*$_{month\ i}$ in the equation above. Then multiply by AF from Equation 10 to derive the Annualized Emissions Reduction for the project year.

Production quantification ensures functional equivalency between baseline and project conditions.

Table 7 below provides further detail on the quantification methodology for calculating emission reductions from reducing age at harvest.

5.4 Tracking Cattle for Accounting Purposes

Registered animals must be tracked consistently and appropriately between baseline and project conditions. The age to harvest of registered cattle between project and baseline will be compared on a monthly time step in order to capture emission reductions that result from the shift in reduced age to harvest in the project year (e.g. the January average for baseline will be compared to the January average for the project year, and so on for the rest of the months in that year). Feedlot close-out records track and summarize performance and economic data by Lots of incoming animals as they move through the feedlot to harvest. Lots will vary in the number of head and the number of Lots can vary between the baseline and project year for a given month. Thus, a weighted average age will need to be applied. To derive a weighted average age at harvest for a given month, the Animal Calf.days approach can be used (see below). To classify Lots to a given month, for consistent comparisons, baseline to project, the registered animals within a lot must be sorted on the average age at the 'out date' or the date the Lot leaves the feedlot for harvest. The starting month for data compilation is up to the discretion of the project developer, however it must be consistent baseline to project.

Animal Calf.days is a basic unit used to account for the number of days cattle were alive until they were harvested. It can be derived from the close-out data for a feedlot and for registered animals, the ages of animals as they enter and exit the feedlot. The age of the animals entering the feedlot can be derived from the birth certificate and the time spent in the feedlot can be used to obtain the average age in days when the registered cattle left the feedlot (i.e. average days out). The example shown in Table 6 shows Animal Calf.days, calculated for each lot in the month of January (Lots classified as 'January Lots' if the 'Average Out Date' in the close-out sheets occurred in January).

Table 18: Deriving the weighted average days to harvest by Month in the Baseline Condition

Baseline	**Lot No.**	**No. of Head Out**	**Average Days Out**	**Calf.days at Harvest**
January	101	72	390	28,080
	102	95	420	39,900
	103	190	500	95,000
Total:		**357**	-	**162,980**

Weighted average age to harvest for January: =162,980/357
= 457 days

Animal Calf.days at harvest for each Lot are calculated by multiplying the number of head (with the deads removed) by the average days at harvest or 'Average Days Out'. The weighted average age for the month of January in the baseline is derived from taking the total calf days (162,980) and dividing the total number of head out (357) for an average of 457 days.

The same procedure is repeated for each month in the baseline and the project to derive the average age for each month for registered cattle. Using this same approach, the average carcass weight can be calculated on a weighted average basis by substituting average carcass weight for the average days out in the above table and calculating a total production (kg) for each lot.

5.5 Establishing Birth Dates

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

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

5.5.0 Default Birth Date Approach

In the default approach, it is assumed that the Birth Certificate issued by a livestock identification and registration agency is the date of the first calf born. This assumption applies here due to the various methods used by cow-calf producers to establish their birth dates for identification and registration agencies. If a default birth date is used, 28 days must be added to the Birth Certificate date to estimate the average calving date and address the average known variance for calving patterns. This is a conservative approach to quantifying the age of cattle at harvest.

5.5.1 Documented Birth Date Approach

Alternately, project proponents' can record actual birth dates for calves in both the project and baseline condition. This method requires that animals be registered with actual birth dates supported by evidence from calving record books from cow-calf operations. If actual birth dates are used, the 28-day adjustment factor is not applied to calculations. This method requires more detailed records and is more accurate than default birth dates.

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

Table 19: Quantification Methodology for Calculating Emission Reductions – Registered Cattle

Project/ Baseline Sources and Sinks	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justify Measurement or Estimation and Frequency**
Project Sources and Sinks						
P1b Cattle Production and P10 Feed Consumption	$\text{Emissions}_{\text{Enteric, month i}} = \sum (\text{GWP}_{\text{CH4}})*(0.0086*\text{AAH}_{\text{month i}} + 0.27)$					
	Enteric Emissions from Cattle / $\text{Emissions}_{\text{Enteric}}$	kg CO_2e / kg Carcass Weight	N/A	N/A	N/A	Quantity being calculated.
	Methane GWP (GWP_{CH4})	kg CO_2e / kg CH_4	Estimated	Reference applicable source	N/A	IPCC values (Table 1) may be adjusted periodically based on most recent updated data.
	Age at Harvest for Month i ($\text{AAH}_{\text{month i}}$)	Months	Measured/ Estimated	Calculated using either the documented or default birth date for registered cattle and the average days out (harvest dates).	Monthly	If a default birth date is used, adding 28 days to the Birth Certificate date to estimate the average calving date addresses the average known variance for calving patterns.
P9 Farm Operation, P10 Feed Consumption, P13 Manure Storage and Handling, P14 Manure Transport and P15 Land Application	$\text{Emissions}_{\text{Non-Enteric, month i}} = \sum (\text{Emissions}_{\text{Enteric, month i}}) * (0.\overline{851})$					
	Whole-farm, Non-Enteric Emissions / $\text{Emissions}_{\text{Non-Enteric}}$	kg CO_2e / kg Carcass Weight	N/A	N/A	N/A	Quantity being calculated.
	$\text{Emissions}_{\text{Non Enteric, month i}}$	kg CO_2e / kg Carcass Weight	N/A	Equation 1 (P1b and P10)	N/A	Calculated in Equation 1
Baseline Sources and Sinks						
B1b Cattle	$\text{Emissions}_{\text{Enteric, month i}} = \sum (\text{GWP}_{\text{CH4}})*(0.0086*\text{AAH}_{\text{month i}} + 0.27)$					

Table 19: Quantification Methodology for Calculating Emission Reductions – Registered Cattle

Project/ Baseline Sources and Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify Measurement or Estimation and Frequency
Production and B10 Feed Consumption	Enteric Emissions from Cattle / Emissions $_{\text{Enteric}}$	kg CO_2e / kg Carcass Weight	Enteric Emissions from Cattle / Emissions $_{\text{Enteric}}$	N/A	N/A	Quantity being calculated.
	Methane GWP (GWP_{CH4})	kg CO_2e / kg CH_4	Methane GWP (EF_{CH4})	Reference applicable source	N/A	IPCC values (Table 1) may be adjusted periodically based on most recent updated data.
	Age at Harvest for month i ($AAH_{\text{month } i}$)	Months	Age at Harvest (AAH)	Calculated using either the documented or default birth date for registered cattle and the average days out (harvest dates).	Monthly	If a default birth date is used, adding 28 days to the Birth Certificate date to estimate the average calving date addresses the average known variance for calving patterns.
B9 Farm Operation, B10 Feed Consumption, B13 Manure Storage and Handling, B14 Manure Transport and B15 Land Application	$\text{Emissions}_{\text{Non-Enteric, month } i} = \sum(\text{Emissions}_{\text{Enteric, month } i}) * (0.\overline{851}))$					
	Whole-farm, Non-Enteric Emissions / Emissions $_{\text{Non-Enteric}}$	kg N_2O; kg CH_4	Whole-farm, Non-Enteric Emissions / Emissions $_{\text{Non-Enteric}}$	N/A	Whole-farm, Non-Enteric Emissions / Emissions $_{\text{Non-Enteric}}$	Quantity being calculated.
	$\text{Emissions}_{\text{Non Enteric, month } i}$	kg beef	Emissions $_{\text{Enteric}}$	Direct measurement of kg of beef produced within each animal grouping.	Emissions $_{\text{Enteric}}$	Direct measurement is the highest level possible.

5.6 Ensuring Functional Equivalence between Baseline and Project

Emissions related to the baseline and project conditions must be calculated in a similar manner to account for them properly. Thus, emissions must be expressed as an annualized carbon equivalence per kg of carcass weight.

Carbon equivalence is determined by employing emissions intensity, hence the units kg CO_2e / kg Carcass Weight. Functional equivalence is determined by multiplying the reduction in emissions intensity by the production total for each month. Annualization is accomplished through the following equation

Equation 12: Annualizing Emission Reductions

$$\text{Annualized Emissions Reduction}_{\text{year}} = \text{AF} * \sum \text{Basic Emissions Reduction}_{\text{month i}}$$

Where:

Annualization Factor (AF) = 0.009542 * (ΔAAH) + 0.9982

Basic Emission Reduction $_{\text{month i}}$ = Production Total $_{\text{month i}}$ * Basic Emissions Intensity Reduction $_{\text{month i}}$

Production Total $_{\text{month i}}$ = # Head Harvest $_{\text{month i}}$ * Average Carcass Weight $_{\text{month i}}$ **(across all lots)**

Basic Emissions Intensity Reduction $_{\text{month i}}$ = Basic Emission Intensity $_{\text{Baseline month i}}$ – Basic Emission Intensity $_{\text{Project month i}}$ **(across all lots)**

5.7 Leakage

This methodology follows the ISO 14064:2 Standard which applies a systematic approach to identifying sources, sinks and reservoirs (SSRs) associated with the project and baseline activities. First, a streamlined life cycle assessment, typically based on material and energy flows, is applied to identify those SSRs that are in three scope categories: controlled, related or affected by the project activity. Typically, those that are in the related type are from activities either upstream or downstream of the project, and are related to material and energy flows. Those that are affected are typically a result of leakage -- activity shifting or market impacts. The GHG impacts of the three types of SSRs are then assessed to identify the relevant sources, sinks or reservoirs in all three scope categories (shown in Table 5). Using this approach, the project boundary is defined by the sources and sinks that are deemed relevant to quantify, and the project will have to account for any emissions generated by a relevant related or affected source. This is different from the usual method of pre-defining boundaries and quantifying the SSRs within, and collectively estimating emissions impacts of sources outside the boundary.

Secondly, the ISO 14064:2 standard applies functional equivalence as a key requirement for quantifying GHG differences between baseline and project. For a project-baseline comparison to be meaningful, the service provided by the project must compare in quantity and quality to the baseline (e.g. per kg beef, per bushel of wheat, GJ of energy consumed or produced). This avoids the pitfalls of interpreting an emission reduction based on a full feedlot in a baseline situation, with a half full feedlot in a particular project year, or, comparing volumetric usage of fuels of varying carbon intensity in fuel switching projects. The application of functional equivalence with the systematic assessment of relevant Controlled, Related and Affected SSRs, informed by analysis of material and energy flows in baseline and project, minimizes the risk of activity-shifting leakage occurring in project types covered by the methodology. Further, the risk of activity shifting having an impact on emissions downstream in the beef feeding sector is low due to the majority of the beef feedyards being concentrated in four or five US States, all with similar environmental and economic conditions (See Appendix H).

5.7.0 Market-Effects Leakage

To address market-effects leakage, this methodology employs the theory developed by Murray *et al.* (2004) describing how market-effects leakage due to an increase or decrease in outputs from this project (i.e. kg hot carcass weight) can be quantified using published estimates of price elasticities of supply and demand.[35]

Project Proponents shall assess the potential for market-effects leakage by the following steps:

- Estimate and justify output in the baseline case and monitor output in the project case;
- Where baseline output exceeds project output by >3% or project output exceeds baseline output by 3%, market-effects leakage shall be determined according to the following section.

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[35] Price elasticity's describe how a change in price affects quantity supplied or demanded. For example, a price elasticity of supply of 0.4 indicates that a 1% increase (decrease) in price results in a 0.4% increase (decrease) in the quantity supplied. Price elasticity's of supply and demand for the dairy and beef sectors have been derived and published in several peer-reviewed economic studies (e.g., Tvedt *et al.* 1991). In the long-term, this may be the case for agriculture, as the price elasticity of supply is generally high and the price elasticity of demand for staple foods tends to be very low.

5.7.1 Accounting for Market-Effects Leakage

The default market-effects leakage factor applicable to any project using this methodology is determined using the following series of steps derived from Murray *et al.* (2004), Vohringer *et al.* (2004), and Murray and Baker (2011). Note that the elasticity of demand (E_D) is generally a negative number (demand goes down as price goes up) and the elasticity of supply (E_S) is generally a positive number (supply goes up as price goes up), so $LE_{M,t}$ will be a negative proportion that ranges from 0 to -1. For this methodology, Project Proponents shall use a value of 0.91 for E_S and -0.61 for E_D.[36]

Equation 13:

$$LE_{M,t} = \frac{E_S}{E_D - E_S}$$

Where:

$LE_{M,t}$	Market leakage factor at time t
E_S	Elasticity of supply with respect to price; set to 0.91
E_D	Elasticity of demand with respect to price; set to -0.61

The net greenhouse gas emissions due to market-effects leakage are derived from the difference in output (i.e. total kg of hot carcass weight beef produced) between the baseline and project at time **t**, any additional output from production shifted to non-project areas (activity shifting – assume this effect is zero[37]), the market leakage factor from Equation 18, and the baseline GHG emissions per unit output.

Equation 14:

$$E\_ME = \left[\left(\frac{(Y_{P,t} + Y_{AS,t}) - Y_{BSL,t}}{Y_{BSL,t}} \right) * LE_{M,t} * e_{BSL,t} \right]$$

Where:

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[36] Value of E_S based on *Elasticities in World Meat Markets* as referenced in Van Eenoo et al. (2000) (http://www.farmdoc.illinois.edu/nccc134/conf_2000/pdf/confp23-00.pdf). Value of E_D based on Schroeder et al. (2000). (http://www.agecon.ksu.edu/livestock/Extension%20Bulletins/BeefDemandDeterminants.pdf).

[37] This method is adapted from ACR's Leakage Module for the Grazing Land and Livestock Management Greenhouse Gas Mitigation Methodology (GLLM). See the L-GLLM module, at http://americancarbonregistry.org/carbon-accounting/standards-methodologies/grazing-land-and-livestock-management-gllm-ghg-methodology.

E_ME	Net greenhouse gas emissions due to market-effects leakage (t CO_2-e)
$Y_{P,t}$	Project output at time t; total kg of hot carcass weight produced
$\underline{Y_{AS,t}}$	Output from production shifted to non-project areas. Set at zero for this methodology.
$Y_{BSL,t}$	Baseline output at time t; kg hot carcass wt averaged over 3 years
$LE_{M,t}$	Market leakage factor at time t from Equation 18
$e_{BSL,t}$	Baseline emissions per unit output (t CO_2e/kg of hot carcass weight) taken from the 3 yr average of applicable performance standard baseline in Section 3.4.

Note that in theory it is possible that project output is greater than baseline output. In that case "positive leakage" may optionally be calculated. In Equation 14, *E_ME* will be a negative number, and in effect there will be positive market-effects leakage, since increased output from the project means that less output needs to be produced elsewhere, as compared to the baseline case. Further, since the four or five beef feeding states in the US all have similar conditions, activity-shifting impacts are deemed to be minimal (see Appendix C).

5.8 Final Quantification Steps

The final quantification steps include a calculation of the emission reductions across animal groupings. The steps include:

- For each animal grouping in the project, calculate the emissions intensity in total carbon dioxide equivalent/kg of carcass gain (kg) for both CH_4 and N_2O, using the global warming potential (GWP) of CH_4 (25) and GWP for N_2O (298):
- For each animal grouping subtract the project CO_2e/kg carcass weight emissions intensity from the performance standard baseline intensity to obtain the functional unit difference in emissions intensity.
- For each animal grouping, multiply the functional unit difference by the total kg of carcass weight gain for that project animal grouping to obtain the GHG emission difference per kg of carcass weight gain in the project.
- Sum the differences across all animal groupings to obtain the net GHG reduction, if any, for that project year(s).

Once the emission reductions have been calculated across animal groupings, the final emission reductions can be calculated using Equations 1, 2, and 3. The Project Proponent calculates the total emissions under the project condition using Equation 3, and calculates the total emissions under the baseline condition using Equation 2. Lastly, the Project Proponent calculates the final emission reductions in Equation 1 by subtracting from baseline emissions the emissions under the project condition (Equation 3) and the emissions from market effects leakage (Equation 13).

6.0 Data Management

Data collection, records and data quality management need to be of sufficient quality to support quantification of greenhouse gas emissions and reductions. **In all cases, greenhouse gas emission reductions must be substantiated with records and must meet minimum data requirements specified in Table 8. The American Carbon Registry cannot accept offset credits that are not supported by actual records.**

Project Proponents participating in reducing age at harvest projects must collect and maintain records and proof of practice consistent with the requirements stated in Table 9. Cattle data must be tracked for registered cattle on a Lot basis in the feedlot close-out data (see Section 6.1) for baseline and project conditions to support the quantification and verification[38] of emission reductions being claimed. This level of detail facilitates the calculations and verification of a project's Greenhouse Gas Assertion.[39]

Guidance for determining the required documentation to substantiate the Greenhouse Gas Assertion is given in Table 9. Additional evidence other than that collected for business reasons may be required to substantiate claims of greenhouse gas emission reductions and to provide positive proof to a reasonable level of assurance. Each type of data requirement listed in Table 9 must be supported for each operation in the project or the claim cannot be made. **Operations with incomplete records cannot be included in the reduced age at harvest project.**

Project Proponents, including aggregators,[40] are required to retain copies of the operator's records and any additional records needed to support greenhouse gas assertions consistent with the requirements stated in Table 9.

The Project Proponent must also establish and apply data management procedures to manage data and information within the project. Written procedures must be established for each management task outlining responsibility, timing, quality control and quality assurance checks, records and record location requirements. These procedures must be documented in a procedures manual, and must be made available to the Third Party Verifier[41] and government auditors upon request. More rigorous data management systems can facilitate third party verification and government audit and help to reduce overall transaction costs for the project.

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[38] Verification is an independent third party review of a project to assess project operating conditions against the baseline condition to confirm the Offset Credits being claimed in the project's Greenhouse Gas Assertion.

[39] A Greenhouse Gas Assertion is a document that identifies the greenhouse gas emission reductions/removals and offset credits being claimed by a project over a defined period of time.

[40] An aggregator is an entity acting as the Project Proponent of an aggregated project.

[41] A Third Party Verifier is a person or organization that meets the requirements of a third party auditor as stated in Section 18 of the *Specified Gas Emitters Regulation*.

The Third Party Verifier is required to assess the data management system, the internal procedures manual, quantification and project records as part of the project verification. A Third Party Verifier cannot sign off on a project with incomplete or missing data and/or records.

Note: Attestations are not considered sufficient proof that an activity occurred

6.0.1 Role of Professional Animal Scientist/ Nutritionists

Professional Animal Scientists (PAS) are third party professionals with technical knowledge in feedyard operations. PAS may work directly for the participating feedyard, the Project Proponent, or be an independent third party that is consulted during project implementation. PAS may have familiarity with a farm enterprise and must have specific knowledge on farm beef feeding systems. They can provide additional support for project implementation; however **sign-off by a qualified professional cannot be used as a substitute for farm records or third party verification.**

Project Proponents/feedyard operators may elect to have a qualified professional sign off on their opinion regarding practices being claimed in the project. This sign-off provides a secondary source of corroborating evidence of the beef feedyard practices.

Sign-off by a qualified professional does not replace record keeping requirements, but rather, can provide an added level of due diligence on the emission reduction claims. All parties (qualified professional, feedyard operator/Project Proponent) are required to
maintain copies of records needed to support the greenhouse gas assertion Responsibilities for the professionals involved in sign-off are given in Table 9.

Note: The Professional Animal Scientist/Nutritionist must collect and keep copies of the records needed to support his/her professional opinion presented in the sign-off statement.

5.9 6.1 Project Documentation and Evidence

Minimum data management requirements and examples of acceptable records needed to support each data requirement for a reduced age at harvest project are outlined in Table 8 below. The project developer/feedlot operator is required to obtain and retain copies of records for each year of the project in their data management system and must disclose records to a Third Party Verifier and government auditor upon request. They may be asked to produce records during a site visit conducted by a Third Party Verifier or government auditor. Data collection and retention responsibilities by party are outlined in Table 8.

The American Carbon Registry will not accept offset credits that do not have sufficient evidence to support the greenhouse gas reductions being claimed. **Records are needed to support each type of data requirement listed for each feedlot for each project year. These documents may be requested to support verification or government audit. See Table 9 for details of data collection responsibilities.**

Table 20: Evidence Source for Reducing Days at Harvest of Beef Cattle Projects

Data Requirement	Examples of Records	Why the Data are Required
Animal Inventory		
Animal Identifier Tags	▪ Feedlot records (close-out sheets) or third party records showing animals entering the project are registered with an identification and registration agency and have a tag number. The unique tag numbers for each animal recorded in animal inventory databases. AND ▪ Feedlot records or third party records showing animals with lost tags were either removed from the project or the lost tag was retired and a replacement tag registered with the a livestock identification and registration agency for that individual animal.	To ensure the animals in the feeding/commercial agreements are fed in the feedyard in question and can be tracked, if necessary, in and out of the feedyard. Also to confirm that dead animals are confirmed as removed from the project.
Birth and confirmation animals shipped to be harvested.	▪ If the Default Birth Date Method is being used, feedlot or third party records showing Birth Certificates on file for each animal in the project; AND ▪ Feedlot or third party procedures showing that 28 days is added to the Birth Certificate according to the Methodology requirements; OR If the Actual Birth Date Method is being used, collected records from the owner of the animal at the time of calving, matching the registered tag number of each animal to any tag inventory control system used by the cow-calf operator, to match individual calving records. AND, for all of the above: ▪ Documented procedures that show the same Birth Date Method is applied in both baseline and project animals; AND ▪ Feedlot records (close-out sheets) and shipping manifests that show the Lots where registered cattle were sent to the packing plant for harvest. AND ▪ Where cattle in the project have been exported for harvest documentation must be provided that shows all exported registered cattle leaving have an additional 0.25 months added to their harvest	To establish the birth and death dates of the registered animal to determine the age of the animal at harvest by either the default or actual birth date methods; and confirm Lots containing the registered cattle have been harvested.

Table 20: Evidence Source for Reducing Days at Harvest of Beef Cattle Projects

Data Requirement	Examples of Records	Why the Data are Required
	age as a result.	
Entry and Exit Dates and Age of Animals Entering the feedlot, by Lot	▪ Feedlot close out data and accompanying animal inventory databases listing registered cattle, showing the date and average age of animals exiting the feedlot.	Needed to establish the weighted-average age of the animals at harvest using Animal.Calf days.
Exit Weights of Animals leaving the feedlot by Lot	▪ Feedlot close out data and accompanying animal inventory databases listing registered cattle, showing the average weight of cattle leaving the feedlot.	Needed to establish the weighted-average age of the animals at harvest using Animal.Calf days.
Number in Production by Lot	▪ Feedlot close out data and accompanying animal inventory databases listing registered cattle, showing the number of head entering and exiting the Lots to calculate the weighted average of the number of registered head in a Lot destined for the packing plant.	To ensure an accurate count of cattle for offset calculation purposes and that animals were being shipped to packing plants upon exit (i.e. not backgrounded in the feedlot).
Characterization of the methods used to calculate the weighted average age and carcass weight and also the number of registered cattle in production for each month in the project.	Using the Feedlot close-out data, and birth certificates of registered cattle - documented procedures showing how the following are calculated for baseline and project conditions: • Monthly weighted-averages for age and carcass weight for baseline and project conditions • Number in production of registered cattle produced by Lot under baseline and project conditions	The methods used to calculate Animal.Calf days by Lot by month, and carcass weight at harvest, are similar between the project and baseline to ensure functionally equivalent comparisons for offset emissions
Manure Management		
Manure Managed according to a Manure Management Plan	• Feedyard documentation to show that a State required nutrient management plan is in place including: • Manure Handling Plans or Nutrient Management Plans and record keeping systems are in place; OR • Sign-Off by a PAS or Nutritionist who reviewed and collected supporting farm records that confirm the manure management conforms to State requirements in both baseline and project and no major changes in manure management have occurred since the pre-project time period.	Needed to demonstrate that no major changes in how manure is managed have occurred (since the pre-project time period). Major changes include: • switching storage types • instituting a composting system • installing an anaerobic digester The intent is to verify that a permit is in place and is current and no major changes in manure handling have occurred.

Table 20: Evidence Source for Reducing Days at Harvest of Beef Cattle Projects

Data Requirement	Examples of Records	Why the Data are Required
		A major change is a signal to contact the American Carbon Registry for more clarification on how to proceed.
Legal Claim to the Offsets		
Location of the Feedlot Operation(s)	▪ Legal land description for the land parcel(s) upon which the feedlot(s) are located.	For registration and serialization of greenhouse gas reductions when the project is registered on the American Carbon Registry.
Commercial Feeding Agreements or other proof animals existed at the feedlot in question for the project years	• Feedlot agreements/purchase receipts demonstrating that the animals in the project are under the control of the feedlot operator and were being fed at the feedlot in question. AND • Feedyard records or third party managed data that show the tag identifiers for each feeding agreement/purchase receipts If the feedlot operator is a corporation: • The seal of the corporation needs to be affixed to the documentation	To prove that the animals being fed in the project were at the feedlot in question and being finished for market.

Note: Copies of records must be retained by the feedlot operator, the PAS or Nutritionist (if applicable), and the Project Proponent for seven years after the end of the crediting period.

Table 9 below provides clarity on the roles and responsibilities of each party

Table 21: Responsibilities for Data Collection and Retention

Entity	Data Collection and Retention Responsibilities
Feedlot Operator	If the sole project developer, the feedlot operator, has primary responsibility for record keeping and record coordination to support project implementation and due diligence, and will be the primary information source for third party verification; If part of a larger project (see below), provides copies of farm records and documentation to the project developer. The feedlot operator must retain original records for his/her files.

Project Proponent (if different than above)	The Project Proponent has primary responsibility for record keeping and record coordination to support project implementation and due diligence, and will as being the primary information source for third party verification. The Project Proponent is required to collect and manage copies of feedlot records and supporting documentation outlined in Table 8.
Nutritionist	The Nutritionist can provide a third party opinion on the project based on project records. Records must be collected and maintained consistent with this methodology, and to support his/her professional opinion of the farm management practices

5.10 6.2 Record Keeping

The American Carbon Registry requires that the Project Proponent maintain appropriate supporting information for the project, including all raw data for the project in a secure and retrievable manner for at least seven years after the end of the relevant project crediting period, even if it does not carry out verification throughout the project crediting period. Where the Project Proponent is different from the person implementing the activity, as in the case of an aggregated project, the individual feedlot operator and the Project Proponent must both maintain sufficient records to support the offset project. The Project Proponent and/or the feedlot operator must keep the information listed below and disclose all information to the verifier and/or ACR upon request.

Record Keeping Requirements:

- Records stated in Table 8 above for all applicable years in which offset credits are being claimed;
- A record of all adjustments made to the project data with justifications;
- List of equipment included and any changes that occurred during the crediting period;
- Common practices relating to possible greenhouse gas reduction scenarios discussed in this methodology (feedlot management practices);
- All calculations applying the greenhouse gas assertion and emission factors listed in this methodology; and
- Initial and annual verification records and audit results.

In order to support the third party verification and the potential supplemental government audit, the Project Proponent 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 seven years after the project’s credit period has ended;
- The Project Proponent must maintain electronic records while feedlot operators must maintain original records, which may include hardcopy records; and
- Copies of records should be stored in two locations to prevent loss of data.

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

5.11

5.12 6.3 Quality Assurance/Quality Control Considerations

Project Proponents are required to ensure sufficient and appropriate Quality Assurance/Quality Control (QA/QC) procedures are implemented to support project implementation. QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- Outlining the process related to data management and record keeping for offset credits, including:
  - Data process flow charts for each feedlot operation describing: data collection systems and input systems for animal grouping close out data, production performance databases, ration/nutrient tracking and animal identifier tag systems, validation points in the data flow (data oversight, second party checks, supervisor sign-off);
  - Data process flow charts for the overall project describing: how data collected from each feedlot are being inputted into the data management systems, with same data flow and controls as in above.
- Restriction of user access to offset claim calculations and data.
- Filtering procedures on production and performance data, close-out data for animal groupings and descriptions of techniques used to scrub the raw data to remove erroneous values/outliers.
- Ensuring that the changes to operational procedures (including 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.
- Any statistical sampling procedures are applied as per the methodology with a description of the procedure ensuring the guidance is met.
- Checking the validity of all data before it is processed, including emission factors, static factors, and acquired data.
- Exception reports for identification of duplicate records, incorrect emission factors, or records with values outside of expected ranges.
- 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.
- Management review and approval of agreements, records, completeness of feedlot activity information, consistency with underlying data, as well as linkage between base data and claims.

5.13 6.4 Liability

Offset projects must be implemented according to the approved methodology and in accordance with American Carbon Registry regulations.

Notwithstanding any agreement between a Project Proponent and the feedlot operator (where applicable) the Project Proponent shall not and cannot pass on any regulatory liability for errors in design and/or errors in the project developer's data management system.

5.14 6.5 Registration and Claim to Offsets

It is important to note that the emission reductions associated with reducing age at harvest in beef cattle occur specifically at feedlot operations. This is where the majority of the data for documenting 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. As such, the Project Proponent is designated in this methodology as the owner-operator of the operation where feeder cattle spend their final stage of feeding prior to harvest. Project Proponent /feedlot operators will need to ensure that they can justify the claim to the offsets to the satisfaction of the Third Party Verifier. This includes contractual arrangements regarding the acknowledgement of who owns the carbon offset, or a portion thereof. For U.S projects, project proponents shall provide land ownership documentation and attestation of clear, unique, and uncontested land title.

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

The Project Proponent must ensure the parcel used to create the reduction (i.e. where the animal is finished or achieves an acceptable marketable weight prior to harvest) is the actual parcel registered with the Registry. Emission reductions will not be consolidated to the parcel where the business entity is legally located.

Figure 5: One Feedlot, Two Registry Parcels Example

The owner of the offset credits under this methodology is the feedlot operator, where the animals in the project spend the final stage prior to harvest. As pointed out in Table 9, feedlot operators can be a Project Proponent themselves if they have enough animals to be economically viable in the carbon market or, they can be aggregated under a Project Proponent in order to bring offset credits to market.

The project developer/feedlot operator needs to ensure that they can justify the claim to the offsets to the satisfaction of the Third Party Verifier. For purposes of verification, this includes the ability to provide feeding agreements for the animals in the project, to substantiate the Project Proponent fed the cattle in question.

7.0 References

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8.0 Appendices

Appendix C1: Generating the Enteric Emissions Intensity

Dr. Ermias Kebreab[42] developed the following methodology to calculate the enteric methane emission expected at different ages at harvest using representative data and the beef production systems outlined in this methodology. The analysis was conducted using the statistical software R (http://www.r-project.org/).

The following assumptions were made starting with 100 brood cows:

- The average pregnancy rate was assumed to be 86.3%
- Pregnancy loss was estimated to be 0.8%; i.e. 85.6 cows calving
- Calf death loss was estimated to be 5.2%. Assuming death occurs during the first 3 months, no methane is expected to be produced. Therefore 81.2 calves are weaned.
- Transportation death loss is estimated to be 0.05%. Assuming this occurs during the first 3 months, no methane is expected to be produced.
- Backgrounding death loss is estimated at 2.5%. This loss is expected to occur 2 months before slaughter.
- Feedlot death loss is estimated to be 1.0%.
- 2% replacements for cows culled when open during calving. Assuming one cow leaves and another cow takes her place, there is no impact on methane emissions.

Equation 1:

Calculates calves that contribute to enteric methane emissions (CCH4) after accounting for pregnancy rate, pregnancy loss, calf death loss, transportation death loss, backgrounding death loss, and feedlot death loss.

$$\text{CCH4} = 0.863 \times (1-0.008) \times (1-0.052) \times (1-0.0005) \times (1-0.025) \times (1-0.01) \quad [1]$$

The assumption for CCH4 is that all these events happen in the first 3 months of life, except for backgrounding death loss and feedlot death loss which are accounted for later using Equation 3 and Equation 4 for example.

CCH4 is also the correction for the number of cows needed to bring one calf to slaughter and it is also used for bulls. The amount of methane emitted by cows (CowsCH4) and bulls (BullsCH4) used to produce calves can then be calculated. Cows consuming a typical diet will emit 82.4 kg methane/year assuming an IPCC recommended emission factor of 6% of gross energy (GE). Applying the correction factor:

$$\text{CowsCH4} = 82.4/\text{CCH4} = 105.3 \text{ kg}$$

---

[42] Dr. Kebreab is a Professor of Animal Science and the Sesnon Endowed Chair in Sustainable Agriculture at the University of California, Davis. Dr. Kebreab developed the methane emissions intensity equations on typical industry data (7,000 data points) and the information in this methodology, as part of the USDA-Bovine Innovation Greenhouse Gas Solutions Conservation Innovation Grant Pilot Project, and they are applied in this methodology.

Considering that one bull is used for 27 cows but only 23 are weaned, BullsCH4 can be calculated as:

BullsCH4 = 122.72/(CCH4×27) = 5.81 kg

To estimate the amount of enteric methane emitted by cows harvested at 12 months (CalvesCH4.12), the following assumptions were made:

- The age to harvest is divided into four stages: First three months (stage 1), fourth month (stage 2), fifth month (stage 3) and last 4 months at the feed lot (stage 4).
- No emissions in stage 1 but for the stages 2 to 4, calculation of emissions depend on GE intake. The average daily GE intake for stages 2 to 4 is assumed to be 55.35, 99.08 and 166.60 MJ, respectively.
- IPCC recommended emission factor of 4% of GEI in stage 2, 6% in stage 3 and 4% in stage 4 are used to calculate total emissions. Assuming dry matter intake (per day) of 3.00, 5.37 and 9.03 kg, for stages 2 to 4 respectively, the following calculations (all in kg of methane/calf) were made:

CalvesCH4.12 = 0.00 + 1.24 + 3.32 + 25.43 for stages 1 to 4, respectively [2]

Accounting for 1% feedlot loss (FL) 2 months before slaughter:

CalvesCH4.12FL = (0.00 +1.24 + 3.32 + (3/5) ×25.43) ×0.01 [3]

Accounting for the 2.5% background lost (BL) 3 months before slaughter:

CalvesCH4.12BL = (0.00 +1.24 + 3.32 + (2/5) ×25.43) × 0.025 [4]

Following similar approach, calculations for age of harvest at 14, 18 and 21 months were made as follows:

CalvesCH4.14 = 37.03 kg
CalvesCH4.14FL = 0.29 kg
CalvesCH4.14BL = 0.62 kg
CalvesCH4.18 = 55.78 kg
CalvesCH4.18FL = 0.47 kg
CalvesCH4.18BL = 1.06 kg
CalvesCH4.21 = 72.2 kg
CalvesCH4.21FL = 0.63 kg
CalvesCH4.21BL = 1.46 kg

The annualized total methane emitted by a calf harvested at age of 12 months (TCH4.12) can be calculated as:

TCH4.12 = CalvesCH4.12 + CalvesCH4.12FL + CalvesCH4.12BL + CowsCH4 + BullsCH4 [5]

Total emissions per kg of carcass weight (TCH4.12.Car) are calculated as:

TCH4.12.Car = TCH4.12/Carcass.12 [6]

Where: Carcass.12 is the carcass weight (kg) at 12 months of age

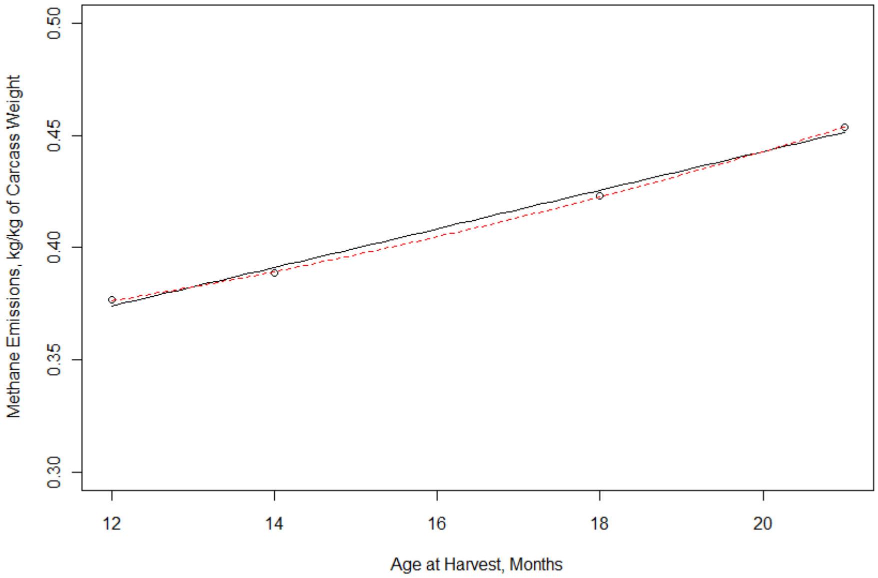
Similar calculations were also made for calves harvested at ages 14, 18 and 21 months.

A total of 3710 data points containing information on category of animal, birth date, days entering on feedlot, days on feed in the feedlot and carcass weight upon slaughter was used to determine the carcass weight at different ages of harvest. Although a positive trend was observed, there was no significant difference (P=0.20) in the weight of animals at harvest. We used the average weights at harvest for each age group to calculate emissions per kg of carcass weight. The weights used were as follows:

For 12, 14, 18 and 21 months the weights were 376.1, 383.4, 397.9 and 408.8 respectively.

A regression analysis (in R statistical software described above) was conducted to quantify the reduction of methane at reduced age of harvest (Figure A1). Linear and non-linear models were fitted to the data. The non-linear model did not significantly improve the fit, therefore, the linear model was accepted.

Figure 10: The relationship between age at harvest (months) and enteric methane emissions (kg/kg of carcass weight). The solid line is a linear fit and the broken line is an exponential fit.



Result:

The total enteric methane emissions at ages of harvest between 12 and 21 can be calculated as follows:

Total enteric methane emissions (kg CH_4/kg carcass) = 0.27 (SE= 0.008) + 0.0086 (SE=0.0005)× Age at Harvest (months)

Appendix C2: Generating the Basic Emissions Intensity

The study by Lupo et al., (2013) concluded that enteric emissions consistently constitute 46% of whole-farm greenhouse gas emissions (i.e. included sources within the scope of this methodology) for beef operations. The remainder of greenhouse gas emissions result from the following sources (in order of relative magnitude):

1. Manure (CH_4, NO_2)
2. Cropping (N_2O)
3. Energy (CO_2)

Using the above figures, the standardized quantification approach estimates non-enteric emissions using the factor (1-0.46)/0.46 ≈ 1.174, and then combines both to derive the **Basic Emissions Intensity** for use in the quantification methodology.

The Basic Emissions Intensity is derived by multiplying the enteric methane intensity by 1.174 to calculate the non-enteric greenhouse gas emissions, and then summing the enteric and non-enteric emissions intensities to derive the total greenhouse emissions included in this methodology. Table 10 shows the method for different Age at Harvest of youthful cattle.

Table 22: Emission Intensity of Greenhouse Gas Emissions Based on Age at Harvest in Youthful Cattle

Emissions Type (Source)	**Equation**[A]	**Age at Harvest (AAH**[B]**) (kg CO_2e / kg Carcass Weight)**				
		14	**18**	**21**	**24**	**27**
Enteric$_{CH4}$	$= \mathrm{GWP}_{\mathrm{CH4}} * (0.0086 * (AAH^{B}) + 0.27)$	9.76	10.62	11.27	11.91	12.56
Non-Enteric$_{CH4, N2O, CO2}$ (Basarab et al., 2012)	$= Enteric_{CH4} * (0.\overline{1.174^{C}})$	11.46	12.47	13.22	13.98	14.74
Basic Emissions Intensity (IPCC, Basarab et al., 2012)	$= (\mathrm{Enteric}_{\mathrm{CH4}} + \mathrm{NonEnteric}_{\mathrm{CH4,N2O,CO2}})$	21.22	23.09	24.49	25.89	27.29

[A] Equations represent best fits with the data, ensuring that the interpolation by the use of equations represent a conservative approach and reflect the likely variances around the data points. Linear and non-linear models were fitted to the data and the non-linear model did not significantly improve the fit, therefore the linear model was accepted.

[B] "AAH" represents the average age of cattle under 30 months (youthful cattle) sent to harvest, in months.

[C] Average proportion of whole-farm greenhouse gas emissions not attributable to Enteric Emissions, from life cycle assessment and actual daily and/or monthly farm inputs and outputs (based on Lupo et al 2013)

Appendix C3: Annualizing Emissions for Functional Equivalence

The reduced lifespan registered cattle in the project condition results in less manure being produced on an annual basis and a lower volume of greenhouse gases being emitted on a per animal basis. Table 11 below shows general feeding regimes and animal stages based on a typical range of diets in California beef operations, across a number of beef production systems. Slight variations will occur across California beef cattle operations; however, these numbers are representative of the stages of feeding during a beef animal's lifespan.

Note: It is not necessary to gather feed data for animals in baseline and project in this methodology. It is, however, important to document the age of an animal as it enters and exits the feedlot. Animal stages and feeding regimes for typical production systems are given in Table 11.

Table 23: Typical Feeding Regimes for Beef Cattle

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

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

The annual standardization factors were developed based on eight crops of cattle moving from birth to harvest for the different life span of cattle in the production systems represented above in Table 11 (see Appendix D for a visual representation of this process). This method was used to provide the input data and plotted to determine the best fit. The resulting equation[43] (with R^2 = 0.997) was then used to calculate the number of years to harvest eight crops of cattle across every age at harvest between 12 and 30 months.

The calculated years to harvest eight crops of cattle for the various life spans in production systems of cattle were used to derive the annualization factors (AF):

$$AF = Harvest_{Grp\ 8,Baseline}(yrs)/Harvest_{Grp\ 8,Project}(yrs)$$

---

[43] $Harvest_{Grp\ 8}(yrs) = 0.08423 * (AAH) + 7.719$

The following equation is the result of plotting annualization factors for every comparison of baseline and project conditions (i.e. difference in average age of animals within the range of 12 to 30 months for average age at harvest:

$$AF = 0.009542 * (\Delta AAH) + 0.9982$$

$R^2 = 0.998$

Where,

AF = the annualization factor for the baseline and project comparison
ΔAAH = difference in the average age at harvest (in months)

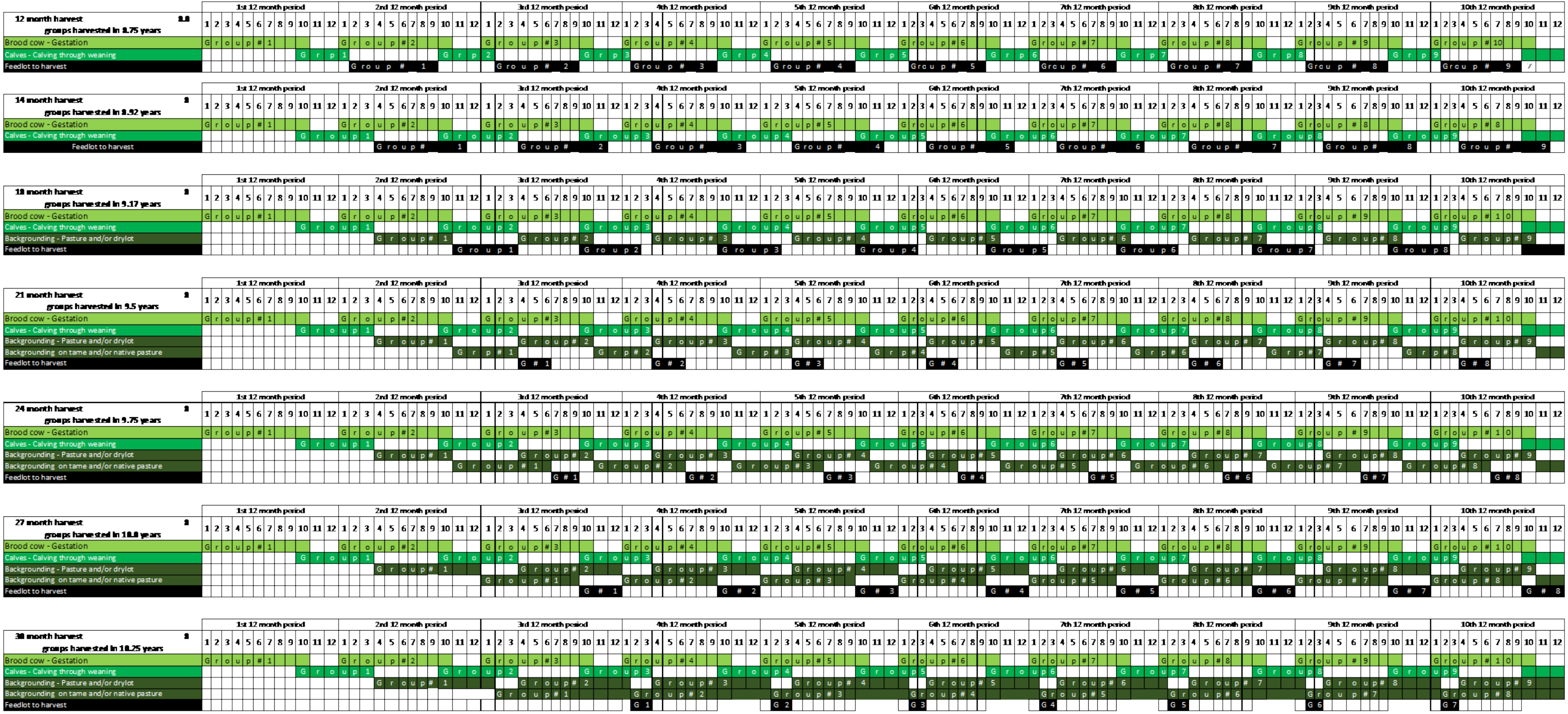
Appendix C4: Charts for Calculating Annualization Factors from Eight Crops of Cattle

BIGGS Reduced age at harvest protocol

Age at harvest comparison chart for rough visual estimation only

Assumptions

1. Gestation is 285 days (9.5 months)
2. All calves are not born at 285 days of gestation. The average calf birth date is about 30 days from the first calf born.
3. All calves are moved as a unified group after weaning



5.15 Appendix C5: Supplemental Information Regarding Leakage

This Appendix demonstrates the contraction of both the cattle inventory and beef consumption over the last 10 years which supports the claim that the potential for leakage as a result of project activity is low.

The USDA Economic Research Service website (See: http://www.ers.usda.gov/topics/animal-products/cattle beef/statistics-information.aspx#.UdbQPfnCaM4) demonstrates that beef consumption has gone down since 2007 and cattle inventory has also contracted because of decreased demand and other factors like multi-year droughts in major cow-calf production states like Texas and other high plains states driving cow herd liquidation.

- Total U.S. beef consumption:
  2002: 27.9 billion pounds
  2003: 27.0 billion pounds
  2004: 27.8 billion pounds
  2005: 27.8 billion pounds
  2006: 28.1 billion pounds
  2007: 28.1 billion pounds
  2008: 27.3 billion pounds
  2009: 26.8 billion pounds
  2010: 26.4 billion pounds
  2011: 25.6 billion pounds

Cattle inventory

- January 1, 2003:
    - U.S.--96.1 million, down from 1996 peak of 103.5 million
    - Canada--13.5 million head
- January 1, 2004
    - U.S.--94.4 million head (cyclical low)
    - Canada--14.6 million head
- January 1, 2005
    - U.S.--94.0 million head
    - Canada--14.9 million head
- January 1, 2006
    - U.S.--96.3 million head
    - Canada--14.7 million head
- January 1, 2007
    - U.S.--96.6 million head
    - Canada--14.2 million head
- January 1, 2008
    - U.S.--96.0 million head
    - Canada--13.9 million head
- January 1, 2009
    - U.S.--94.5 million head
    - Canada--13.2 million head
- January 1, 2010

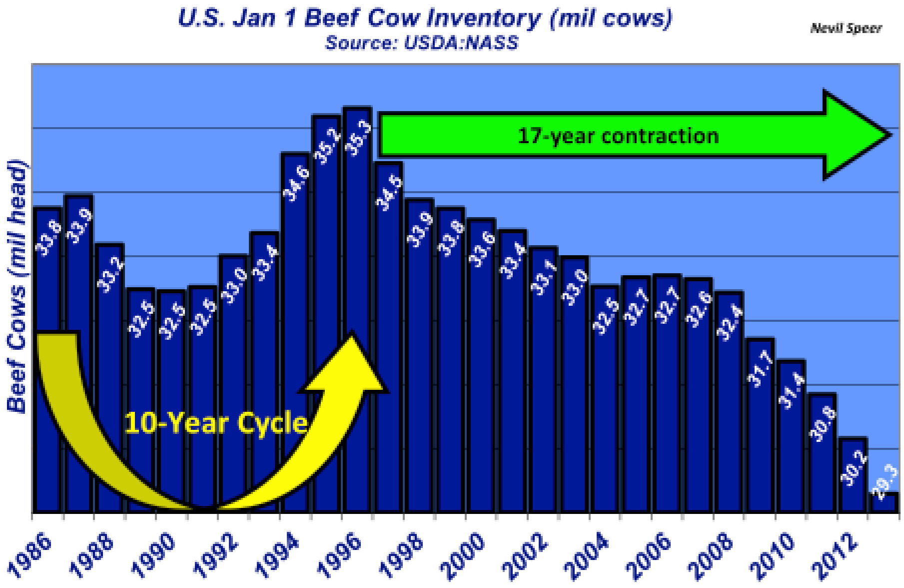
    - U.S.--93.9 million head
    - Canada--12.9 million head
- January 1, 2011
    - U.S.--92.7 million head
    - Canada--12.5 million head
- January 1, 2012
    - U.S.--90.8 million head
    - Canada--12.5 million head

Further evidence is provided by the following reference:

http://beefmagazine.com/cow-calf/industry-glance-us-cowherd-liquidation
Feb. 7, 2013

USDA's Jan. 1 cattle inventory report came in as expected: 2013's beef cow starting number was pegged at 29.3 million cows. That level marks a selloff of six-million cows during the past 17 years – the equivalent of approximately 350,000 head/year. Perhaps more importantly, given the upward adjustment to last year's inventory, 2012 now marks the largest year-over-year decline during that 17-year contraction period. See figure below.

Figure H1: U.S. Jan 1 Beef Cow Inventory (Source: USDA: NASS)



The potential for leakage to occur outside the major cattle feeding area is very low given the concentration of the cattle feeding sector in the four high plains states of Texas, Kansas, Colorado and Nebraska. These four states accounted for 74% of the fed cattle production in 2013. From USDA-NASS Cattle on Feed June 2013 report http://usda01.library.cornell.edu/usda/current/CattOnFe/CattOnFe-06-21-2013.pdf

State	1000's of Head
Arizona	275
California	490
Colorado	960
Idaho	210
Iowa	620
Kansas	2,060
Nebraska	2,390
Oklahoma	295
South Dakota	225
Texas	2,540
Washington	220
Other States	450
United States	10,735

Further, there is little variability in enteric emissions of cattle based on the regions where they are fed because of the overall similarity in the diets fed to cattle and hence methane emissions from cattle in the major cattle feeding states. A paper by Kebreab *et al.* (2008) entitled "Model for estimating enteric methane emissions from United States dairy and feedlot cattle" found that mean methane emissions from feedlot cattle fed 30 different typical diets that cover all feedlot states, was 5.03 MJ/day (SD = 0.10, CV = 0.02%).

Emissions calculated using mechanistic models (average Ym 3.88%) was close to IPCC equations and Ym of 3.5% for all diets in the database (Table 12 below – last line).

Table 24: Representative Feedlot Cattle Diets Used to Estimate Methane Emissions (Source: IPCC)

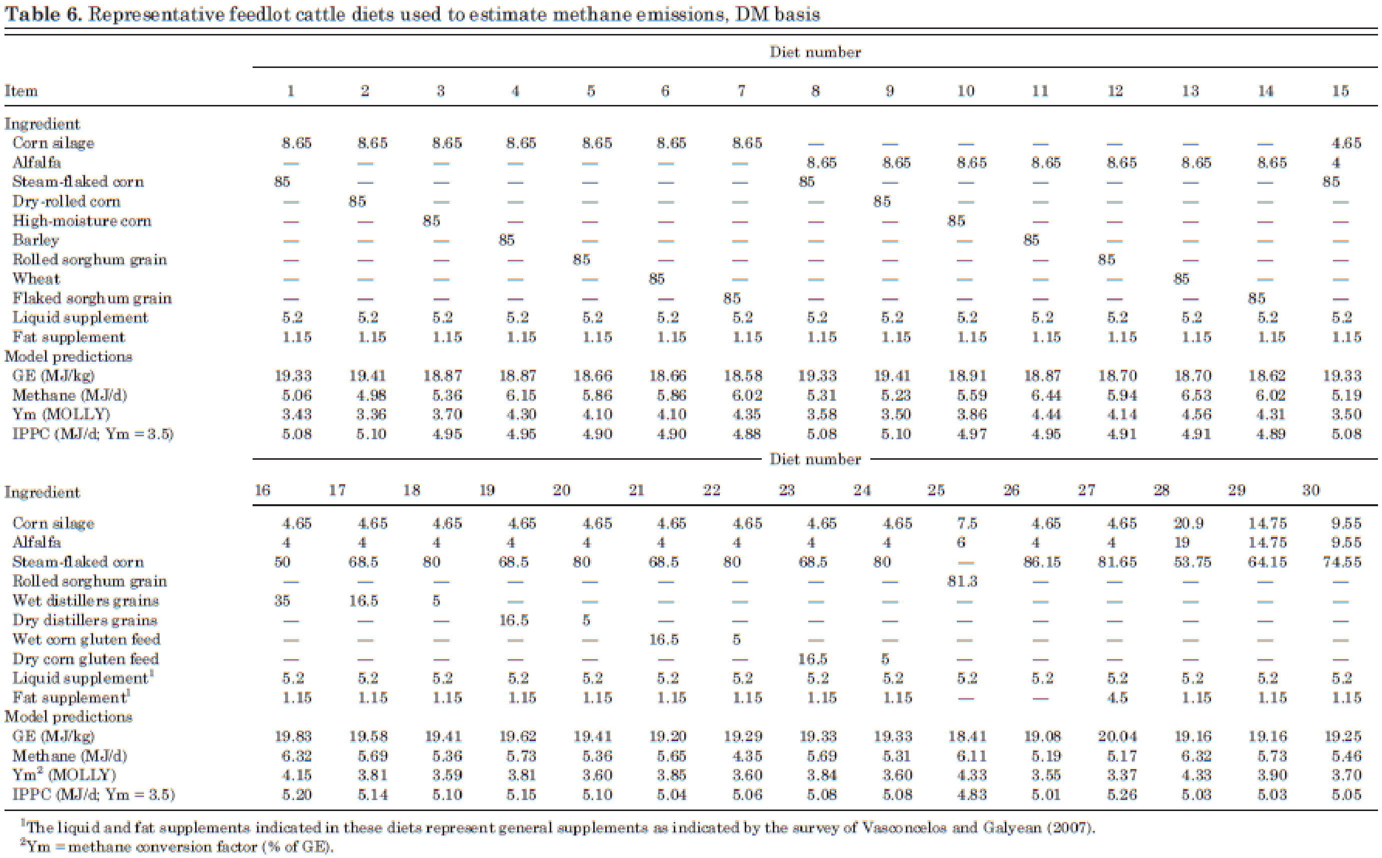


Table 6. Representative feedlot cattle diets used to estimate methane emissions, DM basis

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ingredient															
Corn silage	8.65	8.65	8.65	8.65	8.65	8.65	8.65	—	—	—	—	—	—	—	4.65
Alfalfa	—	—	—	—	—	—	—	8.65	8.65	8.65	8.65	8.65	8.65	8.65	4
Steam-flaked corn	85	—	—	—	—	—	—	85	—	—	—	—	—	—	85
Dry-rolled corn	—	85	—	—	—	—	—	—	85	—	—	—	—	—	—
High-moisture corn	—	—	85	—	—	—	—	—	—	85	—	—	—	—	—
Barley	—	—	—	85	—	—	—	—	—	—	85	—	—	—	—
Rolled sorghum grain	—	—	—	—	85	—	—	—	—	—	—	85	—	—	—
Wheat	—	—	—	—	—	85	—	—	—	—	—	—	85	—	—
Flaked sorghum grain	—	—	—	—	—	—	85	—	—	—	—	—	—	85	—
Liquid supplement	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Fat supplement	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Model predictions															
GE (MJ/kg)	19.33	19.41	18.87	18.87	18.66	18.66	18.58	19.33	19.41	18.91	18.87	18.70	18.70	18.62	19.33
Methane (MJ/d)	5.06	4.98	5.36	6.15	5.86	5.86	6.02	5.31	5.23	5.59	6.44	5.94	6.53	6.02	5.19
Ym (MOLLY)	3.43	3.36	3.70	4.30	4.10	4.10	4.35	3.58	3.50	3.86	4.44	4.14	4.56	4.31	3.50
IPPC (MJ/d; Ym = 3.5)	5.08	5.10	4.95	4.95	4.90	4.90	4.88	5.08	5.10	4.97	4.95	4.91	4.91	4.89	5.08

Ingredient	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Corn silage	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	7.5	4.65	4.65	20.9	14.75	9.55
Alfalfa	4	4	4	4	4	4	4	4	4	6	4	4	19	14.75	9.55
Steam-flaked corn	50	68.5	80	68.5	80	68.5	80	68.5	80	—	86.15	81.65	53.75	64.15	74.55
Rolled sorghum grain	—	—	—	—	—	—	—	—	—	81.3	—	—	—	—	—
Wet distillers grains	35	16.5	5	—	—	—	—	—	—	—	—	—	—	—	—
Dry distillers grains	—	—	—	16.5	5	—	—	—	—	—	—	—	—	—	—
Wet corn gluten feed	—	—	—	—	—	16.5	5	—	—	—	—	—	—	—	—
Dry corn gluten feed	—	—	—	—	—	—	—	16.5	5	—	—	—	—	—	—
Liquid supplement[1]	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Fat supplement[1]	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	—	—	4.5	1.15	1.15	1.15
Model predictions															
GE (MJ/kg)	19.83	19.58	19.41	19.62	19.41	19.20	19.29	19.33	19.33	18.41	19.08	20.04	19.16	19.16	19.25
Methane (MJ/d)	6.32	5.69	5.36	5.73	5.36	5.65	4.35	5.69	5.31	6.11	5.19	5.17	6.32	5.73	5.46
Ym[2] (MOLLY)	4.15	3.81	3.59	3.81	3.60	3.85	3.60	3.84	3.60	4.33	3.55	3.37	4.33	3.90	3.70
IPPC (MJ/d; Ym = 3.5)	5.20	5.14	5.10	5.15	5.10	5.04	5.06	5.08	5.08	4.83	5.01	5.26	5.03	5.03	5.05

[1] The liquid and fat supplements indicated in these diets represent general supplements as indicated by the survey of Vasconcelos and Galyean (2007).

[2] Ym = methane conversion factor (% of GE).

References for Appendix C5:

Kebreab, E., Johnson, K.A., Archibeque, S., Pape, D. and Wirth, T. "Model for estimating enteric methane emissions from United States diary and feedlot cattle". J Anim Sci 2008 86:2738-274

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Appendix D – Terminated ACR Dairy Protocol

American
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The American Carbon Registry™

May 2013

Quantification Methodology for Reduced Carbon Intensity of Milk Production

ACRONYM LIST

The following acronyms are used in this methodology:

ACR	American Carbon Registry
ADF	Acid Detergent Fibre
BIGGS	Bovine Innovative Greenhouse Gas Solutions
CH_4	Methane
CO_2	Carbon Dioxide
CP	Crude Protein
DE	Digestible Energy
DDGS	Corn Distillers Dried Grain with Solubles
DM	Dry Matter
DMI	Dry Matter Intake
ERTs	Emission Reduction Tons
FPCM	Fat and Protein Corrected Milk
GE	Gross Energy Intake
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
MCF	Methane Conversion Factor
NDF	Neutral Detergent Fibre
N_2O	Nitrous Oxide
SS’s	Sources and Sinks
TMR	Total Mixed Ration
VS	Volatile Solids

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9. Introduction

In 2009, the agricultural sector in the US was responsible for greenhouse gas (GHG) emissions of 419 Mt of CO_2e (6.3% of total US GHG emissions), with enteric and manure management emissions making up 20.4 and 7.2% of total methane emission from anthropogenic activities, respectively[44] In the US, cattle and dairy production systems feature a combination of extensive grazing and intensive stages of production (e.g. drylots and confined feeding). With an inventory of approximately 13 million dairy cattle in the United States[45], small reductions in emissions associated with each animal can lead to significant reductions overall for U.S. animal agriculture.

Quantifying methane and nitrous oxide emissions from enteric fermentation and manure storage and handling is well characterized by the Intergovernmental Panel on Climate Change (IPCC 2006) best practice guidance. The science laid out in the IPCC guidance is applied in the U.S. to quantify enteric and manure-based emissions at a Tier 2 level. This methodology relies heavily on these quantification methods. When applied in project-based accounting, GHG emissions for *baseline* and *project* are calculated within dairy cattle category and feeding period, known as animal groupings, using US-customized IPCC Tier 2 equations and the best available dairy activity data.

1.1 Purpose

This quantification Methodology has been developed with the purpose of quantifying greenhouse gas (GHG) emissions and emission reductions from Dairy Farms in the U.S. GHG emissions are normalized to unit of “GHG emissions per unit of fat and protein corrected milk (FCPM) produced”.

This methodology is intended to quantify emissions and emission reductions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) for dairy farms in the U.S. The main sources of GHG emissions from dairy farms include CH_4 emissions from enteric fermentation and manure, N_2O emissions from manure, and CO_2 and N_2O emissions from feed production. Although the type of GHG emissions reduced under this methodology will be dependent on the specific project(s) undertaken, the majority of projects will result in emission reductions of CO_2, CH_4, and N_2O.

2. Scope, Definitions, Applicability and Methodology Flexibility

2.1 Scope

The scope of the Methodology encompasses the animals, buildings, and land which constitute the biophysical system of a dairy farm. However, because of the complexity of the system, and because of on-going development of other GHG quantification methodologys in the U.S, some aspects of the animal/building/land system are simplified or excluded**.**

FIGURE 1.1 offers a typical process flow diagram for a typical project.

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[44] http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf

[45] Released July 23, 2010, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board, U.S. Department of Agriculture. http://www.nass.usda.gov

All projects are required to take place on U.S dairy farms. For the purpose of this methodology, a "dairy farm" is described as any farm which produces milk for eventual retail sale. For this Methodology, a "dairy farm" may conduct other farming practices such as beef or veal farming, while maintaining its status as a "dairy farm" provided that it continues to produce milk for retail sale.

A variety of project scenarios may be undertaken at the farm-level to reduce GHG emissions – a detailed description of typical project scenarios is described in **TABLE 1.1**.

TABLE 1.1 – Detailed Description of Typical Project Scenarios

Potential Scenarios	**Description**
1	Annual milk productivity per cow is increased, thus reducing GHG emissions per unit of milk produced from all SSRs.
2	Diet is modified to reduce the proportion of gross energy converted to methane (enteric emissions factor or Ym)
3	Fewer heifers are retained as replacements to reduce emissions derived from replacement animals
4	Timing of manure storage emptying (catch basins) is modified to reduce methane emissions from the storage unit

2.2 Definitions

Acid Detergent Fibre (ADF)	Comprises the fibrous, least-digestible portion of roughage. ADF consists of the highly indigestible parts of the forage, including lignin, cellulose, silica and insoluble forms of nitrogen. Roughages high in ADF are lower in digestible energy than roughages that contain low levels of ADF. As ADF levels increase, digestible energy levels decrease.†
As fed	Represents the actual weight of feed fed to animals, including the water contained in the feed.
Attestation	This formal document, with signature of the professional nutritionist, is required in some instances in the Methodology to serve as evidence concerning data quality or practice change. This dated and signed document will attest (1) to the accuracy of data regarding animal inventory, diet composition, feed quality, feed consumption, etc., or, (2) to the correctness of implementation of GHG reduction practices (ionophore feeding regime, etc.).

Concentrates	A broad classification of feedstuffs which are high in energy and low in crude fibre (<18% crude fibre). Concentrates can include grains and protein supplements, but exclude feedstuffs like hay, corn stover, silage or other roughage.
Dry Cows	Represents cows that are not producing milk (not lactating).
Dry Matter	Represents total weight of feed minus the weight of water in the feed, expressed as a percentage. May also be referred to as: dry, dry basis, dry result, or moisture-free basis. To convert between As-fed basis and dry matter basis, the following formulas are used: DM basis = As-fed basis x (Dry Matter %/100) or As-fed basis = DM basis x (Dry Matter %/100).†
Dry Matter Intake (DMI)	Consists of all the nutrients contained in the dry portion of the feed consumed by animals.†
Edible Oils	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% content in the diet. †
Enteric Emission	Emissions of methane (CH_4) from the cattle as part of the digestion of the feed materials.
Fat and Protein Corrected Milk (FPCM)	Quantity of milk, normalized to a common energy and fat basis. For the purposes of this protocol, the standard unit for calculating GHG emissions is 3.5% fat and 3.2% protein. The equation is: • kg 3.5% and 3.2% FPCM = [((kg milk production * (3.5 / actual fat%)) + ((kg milk production * (3.3 / actual protein%))] / 2.
Forage	High fibre feed, produced from grasses and legumes. Examples of forages include hay, pasture or silage. Forage is often referred to as roughages.
Gestation	The carrying of an embryo or fetus.
Gross Energy:	The total energy contained in feed; measured by calorimetry.
Hay	Dried forage used for feed.

Heifer	A young, female cow that has not given birth to a calf.
Ionophores	Antimicrobial compounds fed to animals to improve feed efficiency.
Lactation/Lactating	Process of producing and/or secreting milk.
Liquid Manure	Manure with water added to it during the collection, storage, or treatment process.
Methane (CH_4)	A greenhouse gas with a global warming potential (GWP) of 21.
Neutral Detergent Fibre (NDF)	A component of feedstuffs, commonly called "cell walls." NDF give a close estimate of fibre constituents of feedstuffs as they measure cellulose, hemi-cellulose, lignin, silica, tannins and cutins. Neutral detergent fibre has been shown to be negatively correlated with dry matter intake. As the NDF in forages increases, animals will be able to consume less forage. Thus, NDF content of feeds is used in formulas to predict the dry matter intake of cattle.
Nitrous Oxide (N_2O)	A greenhouse gas with a GWP of 310.
Nutritionist	A practicing professional ruminant nutritionist responsible for formulating feedyard and dairy rations
Pasture	Land with vegetation used for grazing of cows and other livestock.
Project start date	Defined in this protocol as the date the dairy or group of dairies established their 3 year average baseline and began to reduce GHG emissions according to this methodology.

Project crediting period	Defined in this methodology as 10 years from the start date.
Protein	Complex compounds containing carbon, hydrogen, oxygen, nitrogen and usually sulphur - composed of one or more chains of amino acids. Proteins are essential in the diet of animals for growth, lactation and reproduction. In ruminants (for example, cattle), the rumen microbes break down about 80 per cent of the protein in the feed to ammonia, carbon dioxide, volatile fatty acids and other carbon compounds. The microbes then use the ammonia to synthesize their own body protein. As feed is passed through the rumen into the rest of the digestive tract, the micro-organisms containing about 65 per cent of the high quality protein are washed along too. The ruminant obtains most of its required protein by digesting these micro-organisms.†
Replacement Cattle	Young cattle (calves, heifers, bulls) raised on a farm to replace milk cows removed from the herd.
Silage	High-moisture fodder that is compressed and fermented (used as feed).
Solid Manure	Manure that has not undergone any treatment process involving the addition of water.
Total Mixed Ration (TMR)	Consists of all the feed ingredients — concentrates, forage, minerals and vitamins — mixed together to form the ration allowance for the animal.†

2.3 Applicability

This Methodology provides flexibility for the user by introducing Basic and Advanced approaches to GHG emission quantification for specific sources. The basic approach for quantification will use accepted emission factors or default assessments of feed quality/GHG emissions, while the Advanced approach will require on-site measurement (with proper calibrations and QA/QC procedures, including attestation by the consulting nutritionist). Basic and Advanced approaches are not available in all quantifications; wherever flexibility is an option, the requirements and result of each approach will be stated.

Methodology participants using the Basic approach will use a discount factor to decrease the number of GHG reductions created. To be eligible for “Advanced approach” benefits, participants in the

Methodology must follow the Advanced approach for all quantification calculations which offer such flexibility (no Basic approaches may be followed). The discount factor scheme is outlined in **TABLE 1.2**.

TABLE 1.2 - Discount Factors for Basic and Advanced Approaches

Advanced Approaches Only Used in Dairy Methodology	Basic Approaches Used in Dairy Methodology	% of GHG Credits to be Received under this Methodology
YES	NO	100
NO	YES	80

3. Baseline Methodology Procedure

3.1 Project Boundary

(XXX)

3.2 Demonstrating Additionality

Project Proponents shall demonstrate realistic and credible scenarios that would have occurred on the dairy operations in the absence of the project activity. These scenarios should take into account current laws and regulations as well as current industry practices. The GHG emission reductions and removals from the offset project must be additional or beyond the "business as usual" scenarios identified. Project proponents must demonstrate additionality using the "three-pronged" approach described in The American Carbon Registry® Standard Version 2.1.

In order to pass the ACR's three-prong additionality test Project Proponents must show

1. Regulatory Surplus - that there is no existing law, regulation, statute, legal ruling or other regulatory framework in effect mandating the project activity or requiring the GHG emissions reductions;
2. Common Practice - that the project activity is not widespread in the industry/sector in the geographic area; and
3. Implementation Barriers – there are financial, technological or institutional barriers to implementing the project (Note: In order to pass, a barrier is only needed in one of these areas).

3.3 Baseline Condition

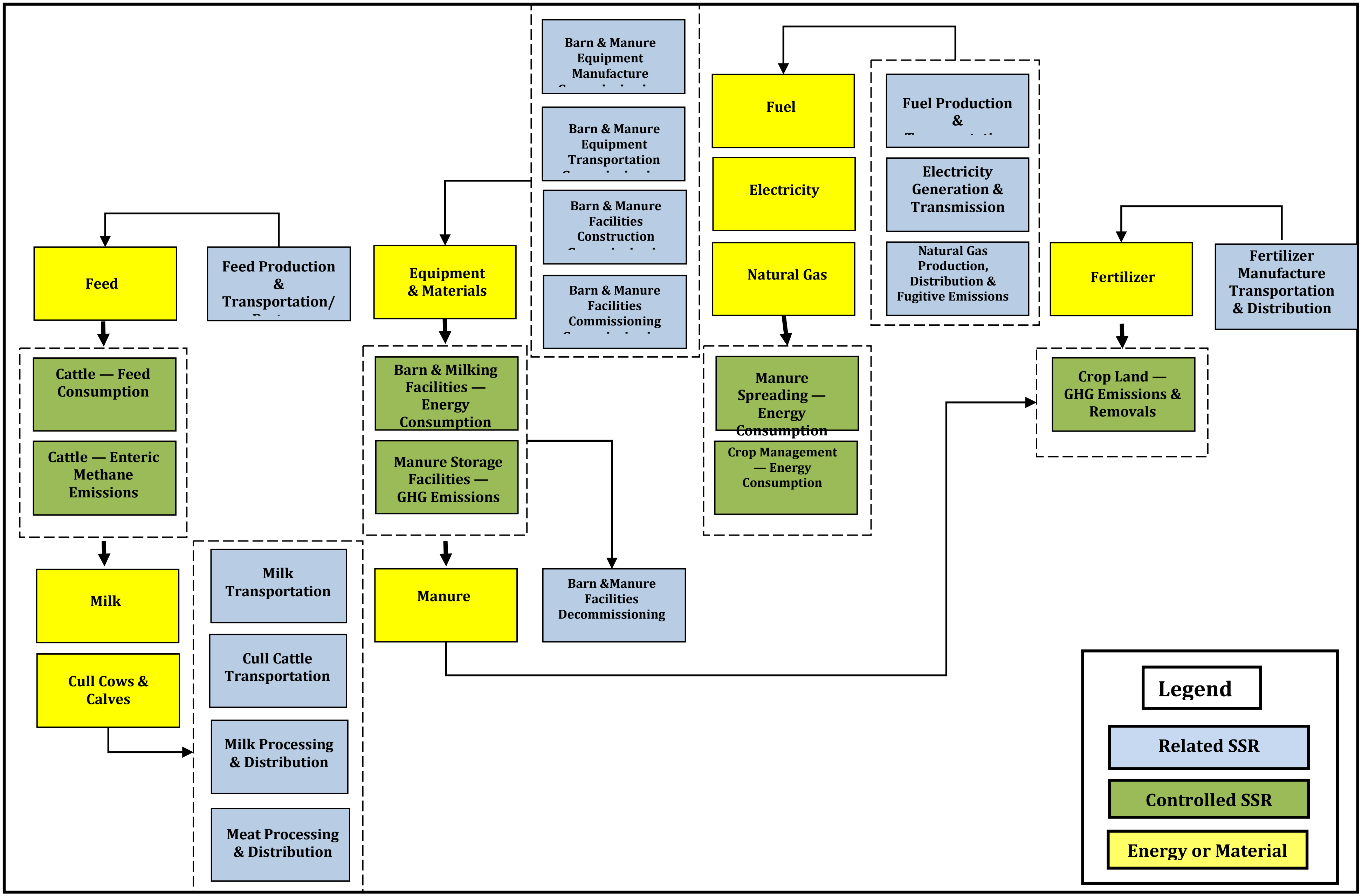
The baseline scenario is the most appropriate and best estimate of GHG emissions and removals that would have occurred in the absence of any project(s). With respect to developing the baseline scenario for the Methodology and calculations, two sets of circumstances must be considered to determine a baseline scenario. First, dairy farms across the U.S. can vary widely in their GHG emissions per kg of milk produced. Second, according to U.S. Census data, the number of dairy cows and dairy farms is steadily declining, but total milk production continues to increase to meet the demand of increasing population. These same data, however, also point out that the rate of decline in GHG emissions per unit milk production has slowed such that further decrease in emissions will require incremental practice change.

The approach to quantifying the baseline will be primarily a **Project-Specific Historic Benchmark**. This approach requires individual farms to calculate a baseline for each farm in the project for the 3-year period prior to project registration. Thus, each participating farm will use its own data (animal inventory, feed quality, feed quantity, milk production, manure spreading) to calculate baseline emissions per unit of milk on a 3.5% fat and 3.2% protein corrected basis. The method is described in Section 2.5 to calculate GHG emissions per unit milk, with data needed outlined in Table 2.5.

Baseline Scenario Adjustments

The baseline scenario identified for the projects eligible under this quantification methodology may require adjustments to ensure functional equivalence with the project. These adjustments are usually performed when the GHG reductions are quantified. In many cases, the quantification and claims of GHG emission reductions will occur on a yearly basis, therefore these adjustments will need to be performed according to that same schedule.

FIGURE 1.2 - Process Flow Diagram for the Baseline Condition



3.4. Identification of Baseline Sources and Sinks

Sources and sinks for an activity are assessed based on Guidance provided by the ISO 14064:2 Standard and are classified as follows:

Controlled:	A source or sink where the source or sink's behavior or operation is under the direction and influence of a project proponent through financial, policy, management, or other instruments.
Related:	A source or sink that has material and/or energy flows into, out of, or within a project but is not under the reasonable control of the project proponent.
Affected:	A source or sink influenced by the project activity through changes in market demand or supply for products or services associated with the project.

Baseline sources and/or sinks were identified by reviewing the relevant process flow diagrams, consulting with technical experts on the Protocol Scientific Adaptation Team, 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 methodology.

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

All SSs relevant to the baseline scenario selected must be identified. In addition to on-site SSs, SSs upstream and downstream of the facility must also be identified.

FIGURE 2.2 – Baseline Element Life Cycle Chart

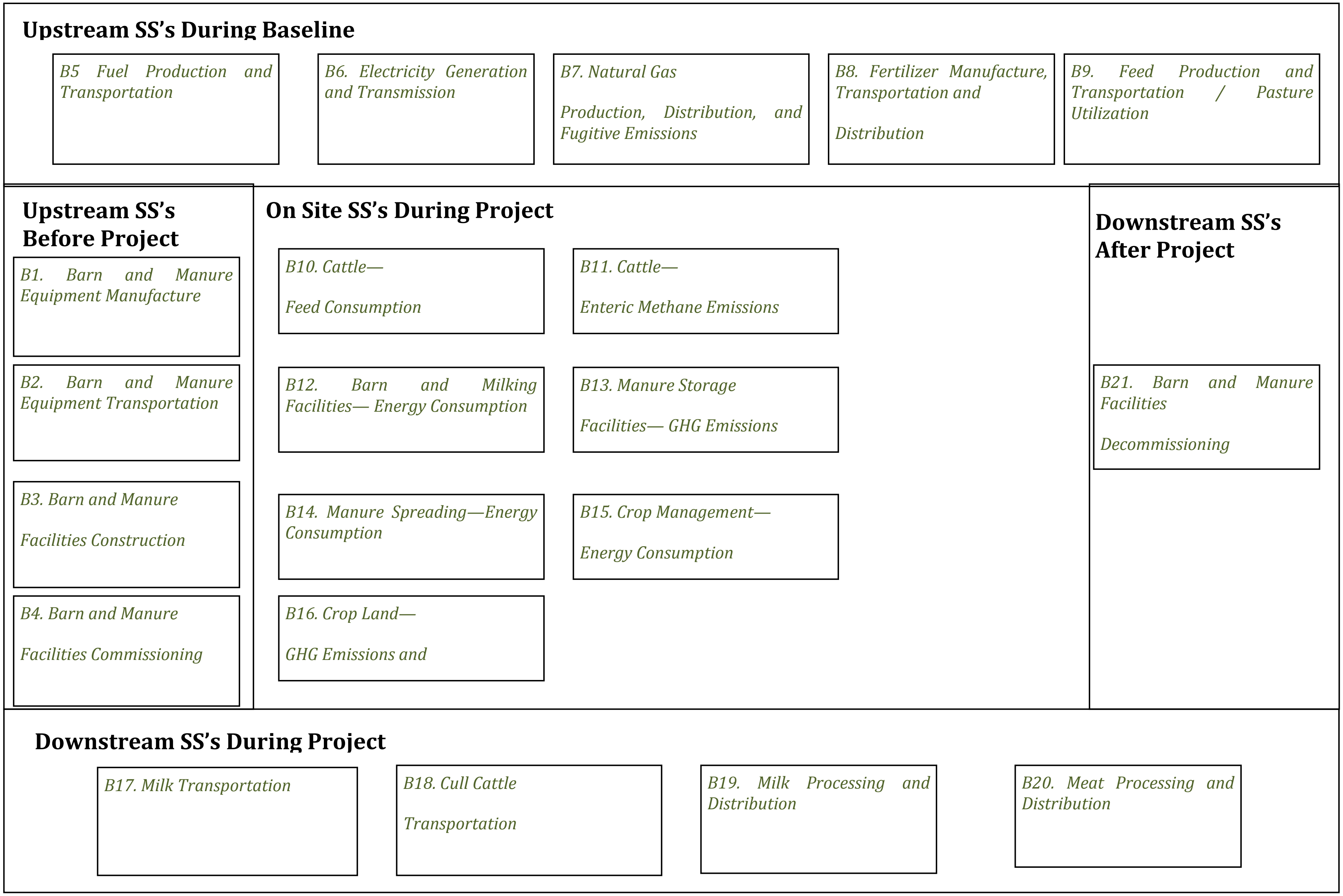


TABLE 2.1 – Baseline SS's

SSR	Description	Controlled, Affected, Related
Upstream SSs Before Project		
B1. Barn & Manure Equipment Manufacture	All activities (inputs of materials and energy) required to manufacture equipment used for barn and manure systems.	Related
B2. Barn & Manure Equipment Transportation	All activities (inputs of materials and energy) required to transport equipment used for barn and manure systems from the manufacturing location to the project location (farm).	Related
B3. Barn & Manure Facilities Construction	All activities (inputs of materials and energy) involved in the construction of the barn and manure systems.	Related
B4. Barn & Manure Facilities Commissioning	All activities (inputs of materials and energy) involved in the commissioning of the barn and manure systems.	Related
Upstream SSs During Project		
B5. Fuel Production and Transportation	All activities (inputs of materials and energy) involved in the production and transportation of diesel fuel.	Related
B6. Electricity Generation and Transmission	All activities (inputs of materials and energy) involved in the generation of electricity.	Related
B7. Natural Gas Production, Distribution, and Fugitive Emissions	All activities (inputs of materials and energy) involved in the discovery and production of natural gas. Because natural gas is a GHG (primarily composed of CH_4), fugitive emissions during production are included in this element.	Related
B8. Fertilizer Manufacture, Transportation and Distribution	All activities (inputs of materials and energy) involved in production, transportation, and distribution of fertilizer.	Related
B9. Feed Production and Transportation / Pasture Utilization	All activities (inputs of materials and energy) involved in the production (crop growing & harvesting) and transportation of feed.	Related
Onsite SSs During Project		
B10. Cattle – Feed Consumption	All activities (inputs of materials and energy) involved in the use of feed. Feed or dairy farm is both raised on farm and purchased from off-farm sources.	Controlled
B11. Cattle – Enteric Methane Emissions	Emissions produced as a result of digestion of feed by cattle, released through exhalation. Also refers to practices to manage feed composition to control enteric emissions.	Controlled

B12. Barn & Milking Facilities – Energy Consumption	Fuel and electricity used to operate the barn and milking facilities, including on-farm handling of feed and bedding.	Controlled
B13. Manure Storage Facilities – GHG Emissions	Fuel and electricity used to operate the manure storage facilities. Also refers to practices to reduce emissions of GHGs from the stored manure.	Controlled
B14. Manure Spreading – Energy Consumption	All activities (inputs of materials and energy) involved in the spreading of manure, with the exception of fuel use. Also refers to practices to reduce GHGs from the spread manure.	Controlled
B15. Crop Management – Energy Consumption	Fuel used to maintain till soil, and to raise and harvest crops.	Controlled
B16. Crop Land – GHG Emissions & Removals	GHG emissions and removals associated with typical land use, including emissions from fertilizer and decomposing crop residues.	Controlled
Downstream SSs During Project		
B17. Milk Transportation	All activities (inputs of materials and energy) involved in the transport of milk that is an output of the project farm.	Related
B18. Cull Cattle Transportation	All activities (inputs of materials and energy) involved in the transport of cull cattle from the project farm.	Related
B19. Milk Processing & Distribution	All activities (inputs of materials and energy) involved in processing and distributing milk from the project farm for retail sale.	Related
B20. Meat Processing & Distribution	All activities (inputs of materials and energy) involved in the processing and distribution of meat from the project farm for retail sale.	Related
Downstream SSs After Project		
B21. Barn & Manure Facilities Decommissioning	All activities (inputs of materials and energy) required to shut down the barn(s) and manure storage facility.	Related

4. Project Methodology Procedure

4.1 Project Condition

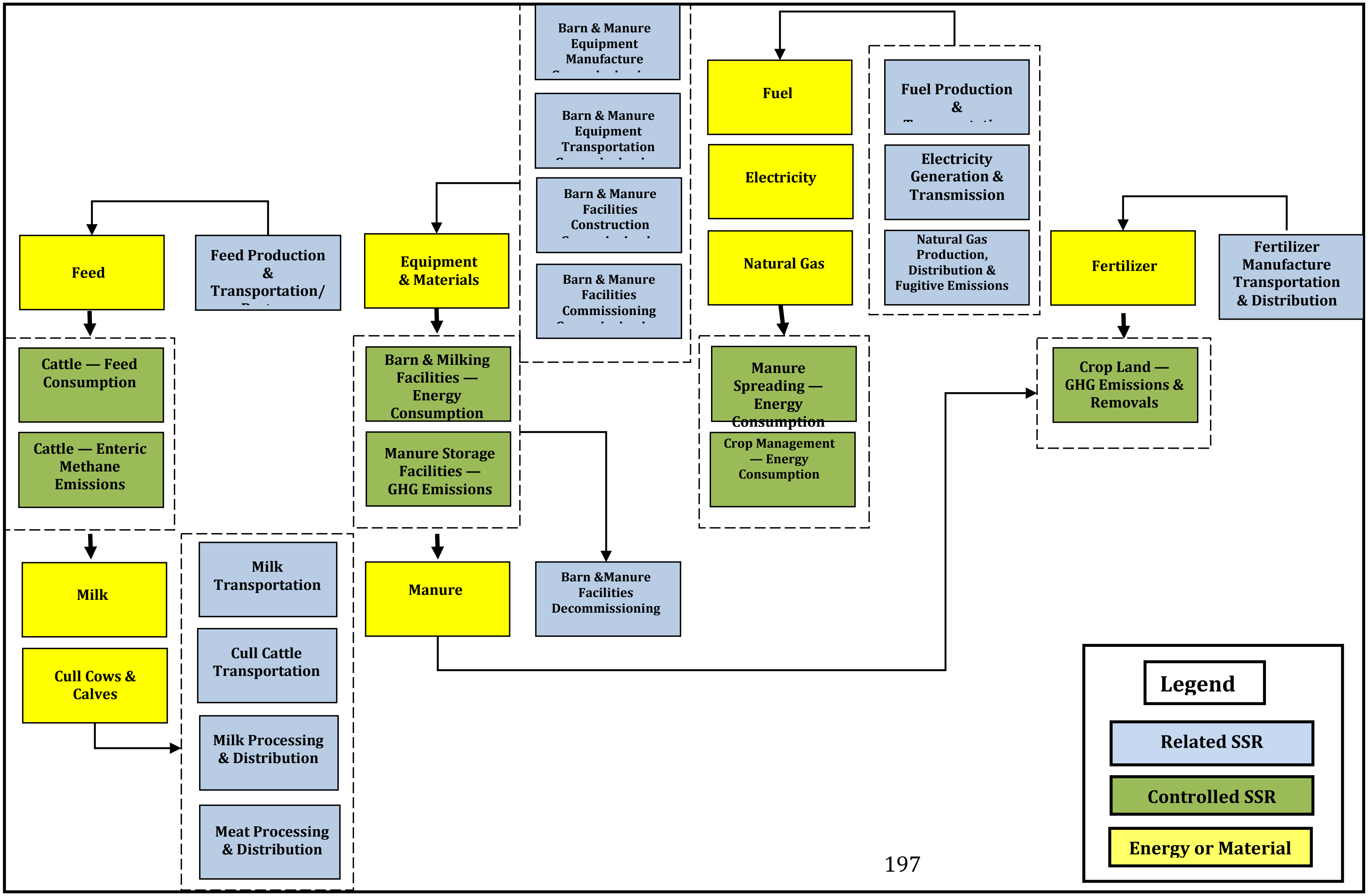
In the project condition, reductions in GHG emissions result from practice changes that decrease CO_2, CH_4, N_2O emissions per unit of FPCM. These include practices that increase milk productivity, modify the diets, lower the replacement rates, and avoid methane emissions from manure storage through spreading of manure in spring rather than fall, where the manure storage would normally be fermenting and emitting methane throughout the hot summer months. The project boundary is the whole farm - barn, cattle, manure storage and feed production.

The basis for the emission reductions in the project condition include but are not limited to the following practices:

- Milk productivity — better genetics or husbandry to achieve equal milk with less feed
- Diet modification — higher quality feed or supplements (edible oils or distillers grains) to decrease enteric methane per unit feed
- Altered replacement rate — fewer non-productive cows
- Season of spreading — avoid storing manure in warm months where methane emissions can be higher.
- Other practices that increase the efficiency of milk production (heifer herd management, health management programs, longer lactation cycles, better genetics, among others).

The common reporting metric of GHG emissions between the baseline practices and the project conditions identified in the protocol are normalized to the unit of “GHG emissions per unit of fat (normalized to 3.5%) and protein (normalized to 3.2%) corrected milk (FPCM) produced”. Dairy farms under this protocol are described as any farm that produces milk for eventual retail sale. A “dairy farm” may conduct other farming practices such as beef or veal farming, while maintaining its status as a “dairy farm” provided that it continues to produce milk for retail sale.

FIGURE 1.1 - Process Flow Diagram for Project Condition



QUANTIFICATION DEVELOPMENT AND JUSTIFICATION

1. Identification of Project Sources and Sinks

SS’s were identified for the project by reviewing the seed methodology document and relevant process flow diagram. This process confirmed that SS’s in the process flow diagrams covered the full scope of eligible project activities under the methodology.

Sources and sinks were identified for the project based on a scientific review and presented in a process flow diagram provided in **FIGURE 1.1**. This process confirmed that sources and sinks in the process flow diagram covered the full scope of eligible project activities under this methodology.

These sources and sinks have been further refined according to the life cycle categories identified in **FIGURE 2.1**. The approach to quantifying emissions in the project does not differ from the baseline. Descriptions of each of the SS’s and their classification as controlled, related, or affected are provided in **TABLE 2.2**.

FIGURE 2.1 – Project Element Life Cycle Chart

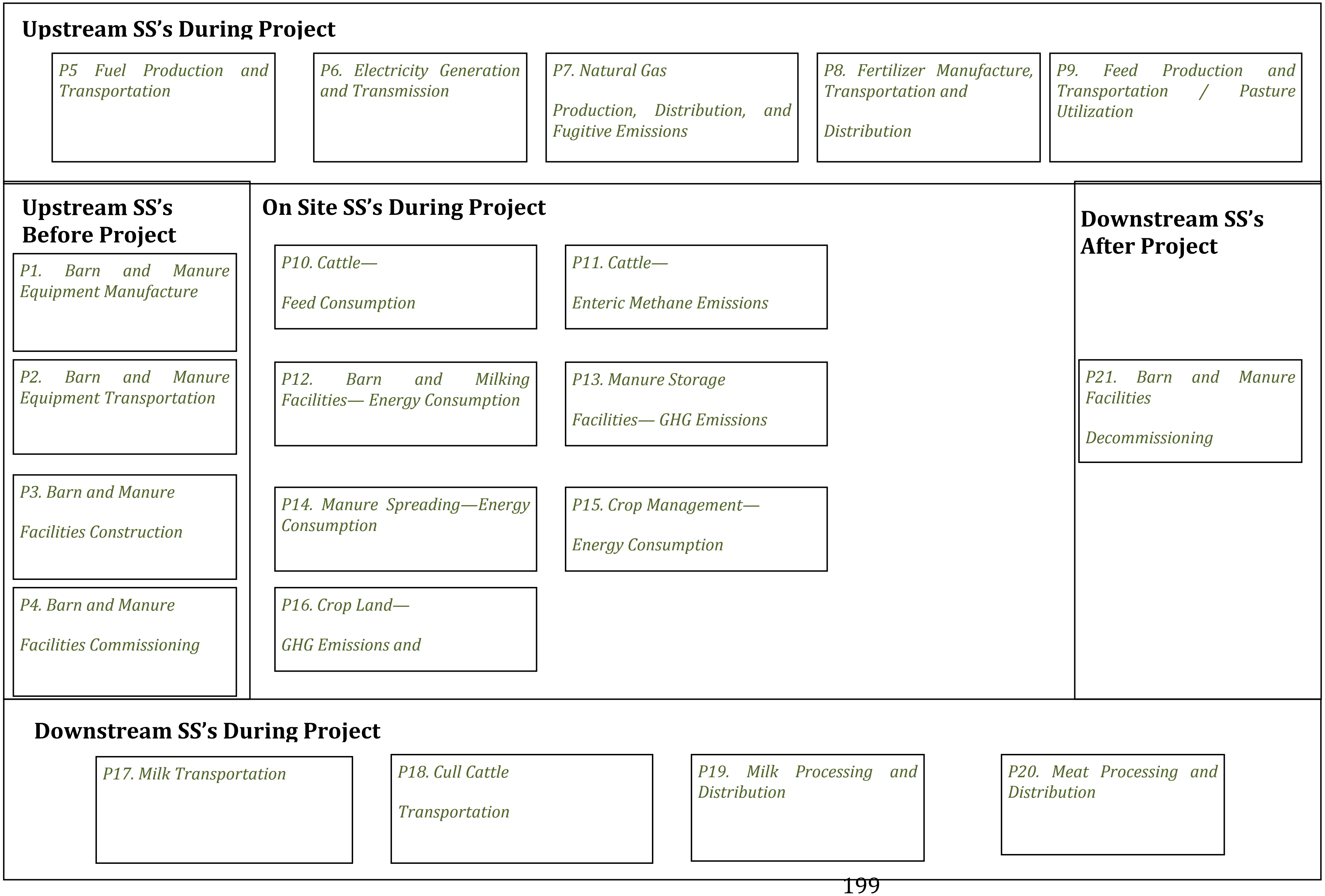


TABLE 2.2 –Project SS’s

SS	Description	Controlled, Affected, Related
Upstream SSs Before Project		
P1. Barn & Manure Equipment Manufacture	All activities (inputs of materials and energy) required to manufacture equipment used for barn and manure systems.	Related
P2. Barn & Manure Equipment Transportation	All activities (inputs of materials and energy) required to transport equipment used for barn and manure systems from the manufacturing location to the project location (farm).	Related
P3. Barn & Manure Facilities Construction	All activities (inputs of materials and energy) involved in the construction of the barn and manure systems.	Related
P4. Barn & Manure Facilities Commissioning	All activities (inputs of materials and energy) involved in the commissioning of the barn and manure systems.	Related
Upstream SSs During Project		
P5. Fuel Production and Transportation	All activities (inputs of materials and energy) involved in the production and transportation of diesel fuel.	Related
P6. Electricity Generation and Transmission	All activities (inputs of materials and energy) involved in the generation of electricity.	Related
P7. Natural Gas Production, Distribution, and Fugitive Emissions	All activities (inputs of materials and energy) involved in the discovery and production of natural gas. Because natural gas is a GHG (primarily composed of CH_4), fugitive emissions during production are included in this element.	Related
P8. Fertilizer Manufacture, Transportation and Distribution	All activities (inputs of materials and energy) involved in production, transportation, and distribution of fertilizer.	Related
P9. Feed Production and Transportation / Pasture Utilization	All activities (inputs of materials and energy) involved in the production (crop growing & harvesting) and transportation of feed.	Related
Onsite SSs During Project		
P10. Cattle – Feed Consumption	All activities (inputs of materials and energy) involved in the use of feed. Feed or dairy farm is both raised on farm and purchased from off-farm sources.	Controlled
P11. Cattle – Enteric Methane Emissions	Emissions produced as a result of digestion of feed by cattle, released through exhalation. Also refers to practices to manage feed composition to control enteric emissions.	Controlled

P12. Barn & Milking Facilities – Energy Consumption	Fuel and electricity used to operate the barn and milking facilities, including on-farm handling of feed and bedding.	Controlled
P13. Manure Storage Facilities – GHG Emissions	Fuel and electricity used to operate the manure storage facilities. Also refers to practices to reduce emissions of GHGs from the stored manure.	Controlled
P14. Manure Spreading – Energy Consumption	All activities (inputs of materials and energy) involved in the spreading of manure, with the exception of fuel use. Also refers to practices to reduce GHGs from the spread manure.	Controlled
P15. Crop Management – Energy Consumption	Fuel used to maintain till soil, and to raise and harvest crops.	Controlled
P16. Crop Land – GHG Emissions & Removals	GHG emissions and removals associated with typical land use, including emissions from fertilizer and decomposing crop residues.	Controlled
Downstream SSs During Project		
P17. Milk Transportation	All activities (inputs of materials and energy) involved in the transport of milk that is an output of the project farm.	Related
P18. Cull Cattle Transportation	All activities (inputs of materials and energy) involved in the transport of cull cattle from the project farm.	Related
P19. Milk Processing & Distribution	All activities (inputs of materials and energy) involved in processing and distributing milk from the project farm for retail sale.	Related
P20. Meat Processing & Distribution	All activities (inputs of materials and energy) involved in the processing and distribution of meat from the project farm for retail sale.	Related
Downstream SSs After Project		
P21. Barn & Manure Facilities Decommissioning	All activities (inputs of materials and energy) required to shut down the barn(s) and manure storage facility.	Related

III. Quantification

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

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 2.1 and Table 2.2 above are listed in Table 2.3 below. Each source and sink is listed as included or excluded. Justification for these choices is provided.

TABLE 2.3 – Comparison of SS's

Identified SSs	Baseline (C, R, A)	Project (C, R, A)	Include or Exclude from Quantification	Justification for Exclusion
Upstream SSs				
B1/P1. Barn & Manure Equipment Manufacture	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B2/P2. Barn & Manure Equipment Transportation	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B3/P3. Barn & Manure Facilities Construction	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B4/P4. Barn & Manure Facilities Commissioning	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B5/P5. Fuel Production and Transportation	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B6/P6. Electricity Generation and Transmission	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B7/P7. Natural Gas Production, Distribution, and Fugitive Emissions	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B8/P8. Fertilizer	Related	Related	Exclude	The emissions from this

Manufacture, Transportation and Distribution				element are expected to be equal or lower in the project as compared to the baseline scenario.
B9/P9. Feed Production and Transportation / Pasture Utilization	Related	Related	Include	This element comprises some of the practices for GHG reduction included in the methodology. To accommodate on- and off-farm sources of feed, standardized assessment of 'embedded emissions' are used to account for GHG intensity of feedstuffs.
Onsite SSs				
B10/P10. Cattle – Feed Consumption	Controlled	Controlled	Include	This element comprises some of the practices for GHG reduction included in the methodology.
B11/P11. Cattle – Enteric Methane Emissions	Controlled	Controlled	Include	This element comprises some of the practices for GHG reduction included in the methodology.
B12/P12. Barn & Milking Facilities – Energy Consumption	Controlled	Controlled	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario. Exclusion of this SS represents conservativeness concerning quantification of reductions. Also, this Methodology encourages participants to enrol in an Energy Efficiency Methodology to capture potential reductions from decreased use of energy.
B13/P13. Manure Storage Facilities – GHG Emissions	Controlled	Controlled	Include	This element comprises some of the practices for GHG reduction included in the methodology.
B14/P14. Manure Spreading – Energy Consumption	Controlled	Controlled	Exclude	The emissions from this element are expected to be equal or lower in the

				project as compared to the baseline scenario. Exclusion of this SS represents conservativeness concerning quantification of reductions.
B15/P15. Crop Management – Energy Consumption	Controlled	Controlled	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario. Exclusion of this SS represents conservativeness concerning quantification of reductions.
B16/P16. Crop Land – GHG Emissions & Removals	Controlled	Controlled	Include	These emissions and removals are addressed in the standard GHG intensity of feedstuffs.
Downstream SSs				
B17/P17. Milk Transportation	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B18/P18. Cull Cattle Transportation	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B19/P19. Milk Processing & Distribution	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B20/P20. Meat Processing & Distribution	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.
B21/P21. Barn & Manure Facilities Decommissioning	Related	Related	Exclude	The emissions from this element are expected to be equal or lower in the project as compared to the baseline scenario.

1. Quantification of Reductions, Removals and Reversals of Relevant SS's

1.1 Quantification Methodology

Quantification of the reductions, removals, and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.5**. These calculation methodologies serve to complete the following equations for calculating the emission reductions from the comparison of the baseline and project conditions.

GHG emission reductions are calculated using Equation 1, below.

*GHG Emission Reductions = (Baseline Emissions – Project Emissions) * Milk [1]*

Where:

Baseline GHG Emissions and **Project GHG Emissions** are the GHG emissions quantified per kg FPCM for the baseline and project scenarios, respectively; and

Milk is the total milk production in the Project, expressed as Fat and Protein Corrected Milk (FPCM).

GHG emissions for both the project and baseline scenario are calculated using Equation 2. Various multiplication factors are used for the quantification of each SSR and are described in their respective sections of this methodology.

GHG Emissions = Activity Level × Multiplication Factors [2]

Where:

Activity Level represents the "quantity" of a particular input, dependent on SSR

Multiplication Factors represents the various factors used to convert the activity level to an appropriate unit of GHGs

Activity levels will be either measured or estimated, depending on the SSR while multiplication factors will be acquired from current published documentation.

Application of Discount Factor

Once all GHG emission reductions have been properly calculated, the appropriate discount factor must be applied. The discount factor used to determine eligible GHG reductions depends on the quantification approach, Basic or Advanced[46], used to determine GHG emissions and reductions.

The discount factor is to be applied by multiplying the total GHG emissions from all SSRs by the discount factor, yielding total eligible GHG emission reductions.

Manure Storage Facilities – GHG Emissions

Basic Approach — CH_4 Emissions - Method 1: Annually

Methane emissions from manure storage are calculated using Equation 3.

$$E_{SSR13,\,CH4} = \sum_{S,G} VS_G * N_G * 365 * 0.24 * 0.67 * MCF_S * MS_{S,G} * 21/1000 \quad \textbf{[3]}$$

Where:

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[46] In instances where the calculations in the Advanced approach are based on data concerning the quantity and quality of feed used on the farm, these data will be attested by the nutritionist retained by the farm.

$E_{SSR13,CH4}$ = Methane emissions from manure management, tonnes CO_{2e} yr^{-1}
S = Manure management system (liquid, solid or pasture)
G = Animal group
VS_G = Average daily volatile solids excreted by a specific animal group, kg DM $head^{-1}$ day^{-1}
N_G = Number of animals in a specific animal group
365 = Number of days per year
0.24 = Maximum methane-producing capacity from dairy manure (m^3 CH_4 kg^{-1} of VS excreted)
0.67 = Coefficient to convert m^3 to kg for methane, kg CH_4 m^{-3} CH_4
MCF_S = Methane conversion factor: percent of VS converted to methane for the defined manure management system
$MS_{S,G}$ = Fraction of animal group G's manure handled by the defined manure management system
21 = Global warming potential of methane
1000 = kg per tonne

The average "daily volatile solids excreted by a specific animal group", VS_G, in Equation 3 is calculated using Equation 4, below.

$$VS = (GE * (1-DE/100) + 0.04 * GE) * 0.92 / 18.45 \qquad \textbf{[4]}$$

Where:
VS = Average daily volatile solids excreted per day on a dry matter basis, kg $head^{-1}$ day^{-1}
GE = Gross energy intake, MJ $head^{-1}$ day^{-1}
DE = Digestible energy expressed as a percentage of gross energy
0.04 = Urinary energy excretion expressed as a fraction of GE
0.92 = Fraction ash-free content of manure
18.45 = Average energy content of dry matter (MJ kg^{-1})

The "methane conversion factor", MCF_S, in Equation 3 is listed by manure system and region (**Table 2.4.1**).

Table 2.4.1 - Methane Conversion Factors (MCF_S)

Manure System		**MCF (%)**
Solid Storage		4.0
Pasture/DryLot		1.5
Liquid		
Mean Annual Temp (°C)	Natural Crust Cover	**MCF (%)**
15	Yes	17
	No	27
16	Yes	18
	No	29
17	Yes	20
	No	32
18	Yes	22
	No	35
19	Yes	24
	No	39
20	Yes	26

	No	42
21	Yes	29
	No	46
22	Yes	31
	No	50
23	Yes	34
	No	55
24	Yes	37
	No	60
25	Yes	41
	No	65

Advanced Approach — CH_4 Emissions - Method 2: Monthly
To account for the influence of temperature and timing of manure removal on methane emissions from liquid manure storage units, methane emissions can also be calculated monthly, following Equation 5.

$$E_{SSR13,CH4,L} = \sum_{m} (VS_{avail,m} * f_m) * 0.24 * 0.67 * 21 * 1000 \quad \textbf{[5]}$$

Where:

$\mathbf{E_{SSR13,CH4,,L}}$ = Methane emissions from a liquid manure storage unit, kilogram CO_{2e} yr^{-1}
m = Month (for a one year period)
$\mathbf{VS_{prod,m}}$ = Volatile solids added to manure storage unit during month (tonnes) (calculated for all animal groups contributing to unit)
$\mathbf{VS_{avail,m-1}}$ = Volatile solids in the storage unit at the end of the previous month available to be consumed by decomposer microorganisms
$\mathbf{f_m}$ = Fraction of available volatile solids consumed during month, Vant Hoff Arhenius factor.

$\mathbf{VS_{avail,m-1}}$, above, is calculated using Equation 6;

$$VS_{avail,m} = VS_{avail,\ m-1} + VS_{prod,m} - VS_{consumed,m-1} - VS_{stabilized,m} - VS_{removed} \quad \textbf{[6]}$$

Where:

$\mathbf{VS_{avail,m}}$ = Volatile solids available to be decomposed at end of current month (tonnes)
$\mathbf{VS_{avail,\ m-1}}$ = Volatile solids available to be decomposed at end of previous month (tonnes)
$\mathbf{VS_{prod,m}}$ = Volatile solids added to manure storage unit during month (tonnes)
$\mathbf{VS_{consumed\ m}}$ = Volatile solids consumed during month (tonnes)
= $VS_{avail,m} * f_m$
$\mathbf{VS_{stabilized}}$ = Volatile solids stabilized into non-available forms (tonnes)
= $VS_{prod,m} * 0.55$
$\mathbf{VS_{removed}}$ = Volatile solids removed from manure storage during month (tonnes)

The "fraction of available volatile solids consumed during month", f, in Equation 5 is calculated using Equation 7, below.

$$f = \exp[E(T_2-T_1)/(RT_1T_2)] \quad \textbf{[7]}$$

Where:

E = activation energy constant (63,515 J mol^{-1})
$\mathbf{T_2}$ = average monthly temperature (ºK = ºC + 273, $T_2 \geq 5$ ºC)
$\mathbf{T_1}$ = 303 ºK
R = ideal gas constant (8.317 J K^{-1} mol^{-1})

N_2O Emissions from Manure Storage

Nitrous oxide emissions from manure storage can be calculated using Equation 8. The assessment of the protein content of the diet and the intake of feed is provided by the nutritionist formulating the rations for the dairy cows, and this professional will attest to the accuracy of the monitoring procedures used.

$$E_{SSR13,N2O} = \sum_{G}(FeedN_G - MilkN_G - LWgainN_G) * 365 * N_G * E_{N2O,G} * 310/1000 \qquad \textbf{[8]}$$

Where:

$E_{SSR13,N2O}$ = N_2O emissions from manure storage, tonnes CO_{2e} yr^{-1}

G = Animal group

$FeedN_G$ = Feed N intake for a specific animal group, kg N $head^{-1}$ day^{-1}
= DMI * CP/100 * 0.16
Where:
DMI = daily dry matter intake, kg head day^{-1}
CP = crude protein content of diet, % of DMI
0.16 = fraction N in feed protein

$MilkN_G$ = N retained in milk N for a specific animal group, kg N $head^{-1}$ day^{-1}
= Milk * Milk protein/100 * 0.157
Where:
Milk = daily milk production, kg head day^{-1}
Milk protein = protein content of milk, % on weight basis
0.157 = fraction N in milk protein

$LWgainN_G$ = N retained in liveweight gain for a specific animal group, kg N $head^{-1}$ day^{-1}
= LWgain * 0.027
Where:
LWgain = daily liveweight gain, kg head day^{-1}
0.027 = fraction N in liveweight gain

365 = Number of days per year

N_G = Number of animals in a specific animal group

$E_{N2O,G}$ = N_2O emitted per kg of N excreted for a specific animal group, g N_2O kg^{-1} excreted N
= $F_{G,S}$ * $E_{N2O,S}$
Where:
$F_{G,S}$ = Fraction of excreted N handled by manure management system for a specific animal group
$E_{N2O,S}$ = N_2O emitted per kg of N excreted in a specific manure management system (**Table 2.4.2**), g N_2O kg^{-1} excreted N

310 = Global warming potential of N_2O

1000 = kg per tone

Table 2.4.2 - Direct and Indirect N_2O Losses from Manure Storage Units for Different Manure Management Systems

Variable	Solid	Liquid	Pasture
Direct N_2O losses, g N kg^{-1} excreted N	7.9	7.9‡	0
Indirect N_2O losses†, g N kg^{-1} excreted N	4.7	6.3	0
N_2O losses, g N kg^{-1} excreted N	12.6	14.1	0

†Assumed no N losses due to leaching

‡Assumed liquid storage units had natural crust covers

Manure-Based Nitrous Oxide Emissions

Manure based nitrous oxide emissions are calculated using equations 9, 10 and 11 below.

Calculating Daily Nitrogen Excreted in Manure

$$NE_i \text{ (kg nitrogen excreted/animal/d)} = -58.7 + 0.63\, N_i(g/d) + 0.79\, NDF(\%) + 0.10\, BW(kg) \quad \textbf{[9]}$$

Calculating Daily Nitrogen Intake

$$\mathbf{NI_i \text{ (kg nitrogen intake/animal/day)}} = [DDMI_i * (CP_i / 100\%)] / CF_{protein} \quad \textbf{[10]}$$

Calculating Daily Nitrogen Retained by the Animal

$$\mathbf{NR_i \text{ (kg nitrogen excreted/animal/day)}} = NI_i - NE_i \quad \textbf{[11]}$$

Where:
NE_i = Kilograms of nitrogen excreted/animal/day
NI_i = Kilograms of nitrogen intake/animal/day
NDF = Neutral detergent fibre
BW = Body weight
$DDMI_i$ = Daily dry matter intake, calculated 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.
CP_i = Crude protein, expressed as a percentage (%)
$CF_{protein}$ = A default coefficient which represents the mass of dietary protein which is converted to dietary nitrogen and is equal to 6.25 kg of protein per kg of dietary nitrogen

Cattle – Enteric Methane Emissions

Methane emissions from enteric fermentation can be calculated using Equation 9, below.

$$E_{SSR11} = \sum_{G} GE_G * (Y_{mG} / 100) * N_G * 365 / 55.65 * 21 / 1000 \qquad \textbf{[12]}$$

Where:

E_{SSR11} = Methane emissions from enteric fermentation, tonnes $CO_2e\ yr^{-1}$
G = Animal group
GE_G = Gross energy intake for a specific animal group (based on measured dry matter intake, MJ $head^{-1}\ day^{-1}$
Y_{MG} = Percent of gross energy in feed converted to methane for a specific animal group
N_G = Number of animals in a specific animal group

365 = Number of days per year
55.65 = Energy content of methane, MJ per kg methane
21 = Global warming potential of methane
1000 = kg per tonne

Dairy animals are generally grouped into milking cows (one to three groups), dry cows and replacement heifers (grouped by age). Male animals are excluded from calculations because adult bulls are rarely kept and bull calves are generally sold at a young age.

Replacement heifers are handled as one group, starting after weaning (assumed at end of two months) and extending until first calving (input variable). Weight gain is assumed to be constant over the growth period. GHG emissions are calculated for each month, based on calculated weights. Heifer ages are assumed to be distributed uniformly over the growth period. Pasture use and manure handling systems can be set differently for older heifers and younger heifers.

The Y_M value is defined as the percentage of gross energy intake by the dairy cow that is converted to methane in the rumen. The IPCC (2006) uses Y_M of 6.5 (± 1)% for ruminants, including dairy cows. In other words, 6.5% of the gross energy consumed is converted in the rumen to methane energy. The associated uncertainty estimation of ± 1% reflects the fact that diets can alter the proportion of feed energy emitted as enteric methane.

Basic Approach

"Gross energy intake", GE_G, in Equation 9 may be estimated using the energy required for a representative animal in each group using the approach outlined by the IPCC (2006) (**Table2.4.3**). The equations pertinent to enteric emissions from dairy cows are fully described in Chapter 10: Emissions from Livestock and Manure Management, of Volume 4: Agriculture, Forestry, and other Land Use, of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The IPCC equation number is listed in bold text in parentheses.

Table 2.4.3 - Calculations of Net Energy Requirements Using IPCC Equations.

$NE_m = Cf_1 * LW^{0.75}$ **(10.3)**

Where:
NE_m = Net energy for maintenance, MJ $head^{-1}$ day^{-1}
Cf_1 = Maintenance energy coefficient, MJ day^{-1} kg^{-1}
(0.386 for cows in lactation, 0.322 for heifers and dry cows)
LW = Average liveweight (kg)

$NE_a = 0.17 * F_{pstr} * NE_m$ **(10.4)**

Where:
NE_a = Net energy for activity, MJ $head^{-1}$ day^{-1}
0.17 = Coefficient for animals on pasture with sufficient forage for modest energy expense of feed acquisition
F_{pstr} = Fraction of time spent on pasture

$NE_g = 22.02 * (BW/0.8/MW)^{0.75} * WG^{1.097}$ **(10.6)**

Where:
NE_g = Net energy for growth, MJ $head^{-1}$ day^{-1}
BW = Average live body weight for animals in group, kg

MW = Mature live body weight of an adult cow, kg
WG = Average daily weight gain, kg day^{-1}

$$NE_l = Milk * (1.47 + 0.40 * Fat) \quad \textbf{(10.8)}$$

Where:
NE_l = Net energy for lactation, MJ $head^{-1}$ day^{-1}
Milk = Amount of milk produced, kg $head^{-1}$ day^{-1}
Fat = Fat content of milk, % by weight

$$NE_p = 0.1 * F_{preg} * NE_m \quad \textbf{(10.13)}$$

Where:
NEp = Net energy for pregnancy, MJ $head^{-1}$ day^{-1}
F_{preg} = Fraction of animal group that are pregnant

$$REM = 1.123 – 0.004092*DE + 0.00001126*DE^2 – 25.4/DE \quad \textbf{(10.14)}$$

Where:
REM = Ratio of net energy available for maintenance to digestible energy consumed
DE = Digestible energy expressed as a percentage of gross energy

$$REG = 1.164 – 0.005160*DE + 0.00001308*DE^2 – 37.4/DE \quad \textbf{(10.15)}$$

Where:
REM = Ratio of net energy available for growth to digestible energy consumed
DE = Digestible energy expressed as a percentage of gross energy

$$GE = [(NE_m + NE_a + NE_l + NE_p)/REM + NE_g/REG]/(DE/100) \quad \textbf{(10.16)}$$

Where:
GE = Gross energy, MJ $head^{-1}$ day^{-1}

Advanced Approach

Methane emissions from enteric fermentation may also be calculated more accurately by measuring the dry matter intake, DMI, on a daily basis using Equation 10.

$$GE_G = DMI/18.45 \qquad \textbf{[10]}$$

Where:
DMI = Dry matter intake, kg $head^{-1}$ day^{-1}
18.45 = Average energy content of dry matter (MJ kg^{-1})

The DMI value will be determined as the sum of all ration ingredients, but monitoring of individual ration ingredients is needed in the Advanced approach to determine the Y_M value.

The default Y_M value of IPCC was refined by Drs. Karen Beauchemin and Ermias Kebreab to account for changes in ration formulation practices - to modify the proportion of gross energy converted to enteric CH_4 (**Table 2.4.4**). Thus, the Advanced approach of the Dairy Methodology allows farmers to modify diets to manipulate Y_M within the range of variability of the IPCC default value. The assessment of the quality of forages is provided by the nutritionist formulating the rations for the dairy cows, and this professional must attest to the accuracy of the monitoring procedures used. This methodology will use the following rules for the Y_M for dairy cows:

Table 2.4.4 - Estimates of the Percentage of Gross Energy Converted to Methane (Y_M) for Various Diets

Diet Description	**Y_M (% of GE)**
Default (unknown diet composition)	6.5
Diet with < 25% NDF	5.5
Diet with 25-30% NDF	6.25
Diet with 30-50% NDF	6.5
Diet with >50% NDF	7.0
Situations in which adjustments apply to Y_M values above*	
Feeding fats*	
Calcium salts of palm oil (or similar bypass fats)	No reduction
Other Fat Sources*, not to exceed 80 g fat/kg DM	3.4% reduction in CH4 for each 10g increase in fat content of the diet on a dry matter basis (g fat/kg DM)
*Corn DDGS cannot exceed 20% of dry matter of ration, and the higher protein content of the DDGS must be addressed in the ration formulation to prevent excess nitrogen excretion. The procedures to implement proper use of lipids and corn DDGS must be documented by the nutritionist	

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GHG Emissions from Feed Production

Emission factors applied in this methodology are expressed in CO_2 equivalents (CO_2e) and combine N_2O and CO_2 emissions. CH_4 has been excluded because emissions of this gas are not considered to be significant in U.S. cropping systems.

- Nitrous oxide sources are from N-fertilizer application (chemical or organic), crop residues, leaching and volatilization. IPCC equations adapted for Canada by Rochette *et al*. (2008) were used.
- Carbon dioxide sources are from fossil fuel use for field work, electricity, crop drying and fertilizer and machinery supply. The F4E2 model was used (Dyer and Desjardins, 2003, 2005).

Feedstuffs for cattle are divided into 10 categories, each with its own emission factor. The 10 categories are presented below while emission factors are presented in Table 2.4.5:

- Four Grains:
  - Corn grains
  - Other small grains
  - Soybeans (and other legumes)
  - Canola meal and other protein supplements

- Four Forages:
    - Legume hay/silage
    - Non-legume hay/silage
    - Corn silage
    - Small grain silage
- Pasture
- “Other” – including DDGS – with estimates averaged

Processed Feed

Emissions arising from the production of feed can be calculated using specific emission factors for various regions and types of feed. Equation 11, below, is the basic equation and is used along with data found in Table to determine offsets from feed production.

$$E_{SSR9} = \sum_{G,F} \mathrm{FeedDM}_{G,F} * \mathrm{FeedCO_2e}_F \qquad \textbf{[11]}$$

Where:

E_{SSR9} = GHG emissions from feed production (excluding pasture), tonnes CO_2e yr^{-1}
G = Animal group
F = Feed type
$FeedDM_{G,F}$ = Amount of feed of a specific type consumed by a specific animal group, tonnes DM yr^{-1}
$FeedCO_2e_F$ = GHG emitted per tonne of feed, tonnes CO_2e $tonne^{-1}$ feed DM

Feed CO_2e were calculated for each province, combining both N_2O and CO_2
The feed category “Others” refers to dried distillers grains with solubles (DDGS). Calculated emissions consider only DDGS from grain corn and wheat. The calculations is as follows: assuming that 1t corn produces 309kg DDGS and 1t wheat produces 295kg DDGS, the emission factor for these two crops shall be inflated by 3.24 (i.e. 1/0.309) for corn and 3.39 (i.e. 1/0.295) for wheat.

Table 2.4.5 - Emission factors (tCO_2e / tonne of feed) for different crop category

	Crop category									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(tCO_2e/t.feed)									
NF	n.a.	n.a.	n.a.	n.a.	0.06	0.26	n.a.	n.a.	**See Table 2.4.6**	n.a.
PE	n.a.	0.55	0.31	n.a.	0.07	0.21	n.a.	0.24		1.73
NS	0.46	0.67	n.a.	n.a.	0.06	0.24	0.12	0.27		1.69
NB	n.a.	0.65	n.a.	n.a.	0.05	0.23	0.10	0.27		1.74
PQ	0.46	0.77	0.36	1.30	0.06	0.18	0.10	0.30		1.85
ON	0.41	0.58	0.34	1.21	0.05	0.18	0.10	0.21		1.52
MB	0.36	0.43	0.20	0.82	0.04	0.22	0.07	0.20		1.21
SK	n.a.	0.29	n.a.	0.78	0.05	0.21	n.a.	0.14		0.87
AB	0.29	0.35	n.a.	0.83	0.04	0.21	0.05	0.15		1.00
BC	n.a.	0.48	n.a.	1.30	0.05	0.22	0.05	0.18		1.49

n.a. = not available (meaning that, according to the agricultural census, these specific crops are not cultivated in the province)

(1) Corn grains
(2) Other small grains
(3) Soybeans
(4) Canola
(5) Legume hay/silage
(6) Non-legume hay/silage
(7) Corn silage
(8) Small grain silage
(9) Unimproved Pasture
(10) “Other” (DDGs – from corn and wheat)

Pasture Feed

Practice change with respect to use of pasture is not included as a GHG reduction strategy in the Methodology. However, to accurately quantify reductions on dairy farms, the emissions associated with use of pasture must be quantified in both Baseline and Project.

For pasture, the ninth category, results are given per animal and per year because animal weight varies. Hence, emission factors are presented for an equivalent of 1000kg of live weight (LW) per year (kgCO_2e./(tLW.yr)). As an example, for a cow which weighs 600kg the emission factor must be multiplied by 0.6.

In this methodology pasture refers to "unimproved pasture". As a result, N_2O emissions are only due to deposited manure. Direct N_2O emissions from manure decomposition and indirect emissions such as volatilization and leaching are included, but N_2O from N-chemical fertilizers and crop residues is excluded, as is CO_2 from fossil energy. Methane emissions from enteric fermentation and manure are not included for the following reasons:

1) Enteric fermentation emissions do not apply to crops;
2) CH_4 emissions from manure deposited on pasture are considered negligible.

GHG emissions from pasture feed can be calculated using Equation 12:

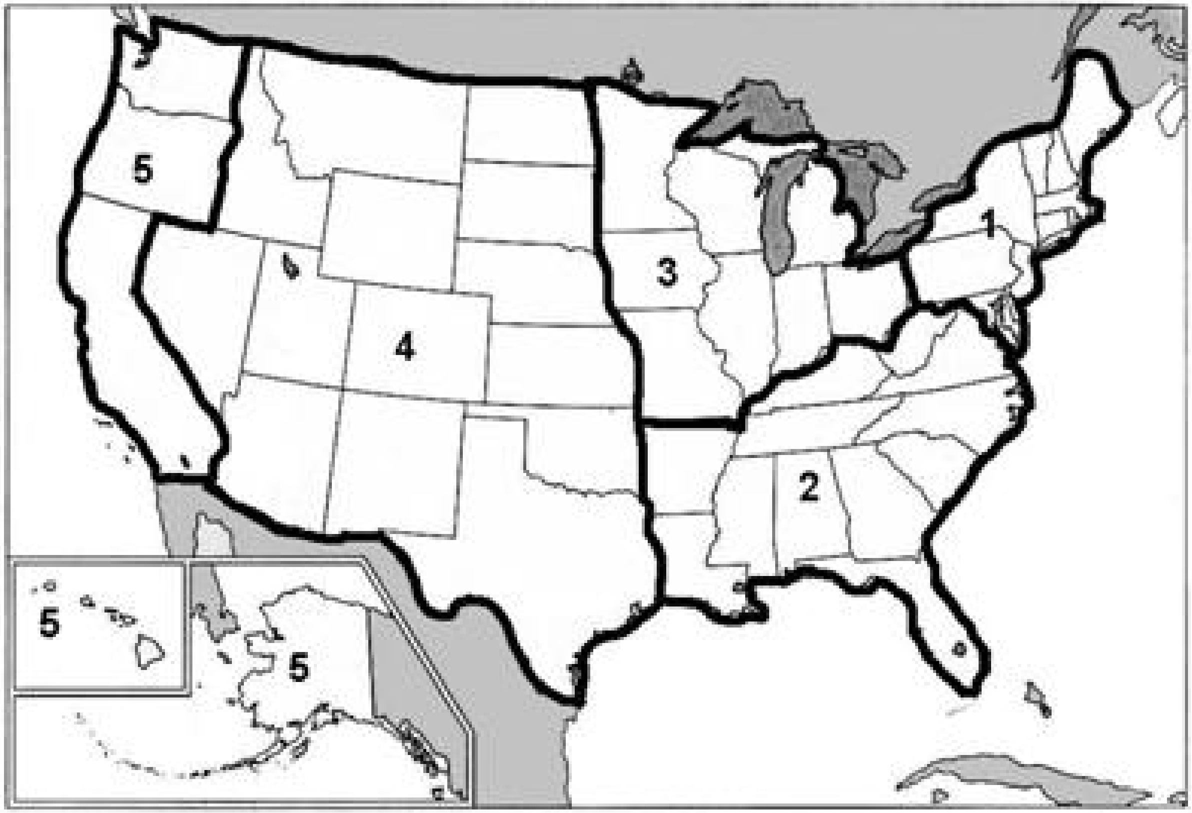
$$E_{SSR9,\,pstr} = \sum_{G} PstrCO_2e_G * LW_G * F_{pstr,G} * N_G \qquad \textbf{[12]}$$

Where:

$\mathbf{E_{SSR9,pstr}}$ = GHG emissions from pasture feed utilization, tonnes CO_2e yr^{-1} (**Table 2.4.6**)
G = Animal group
$\mathbf{PstrCO_2e_G}$ = GHG emissions from unimproved pasture per tonne liveweight per year for a specific animal group, tonnes CO_2e $tonne^{-1}$ LW yr^{-1}
$\mathbf{LW_G}$ = Average liveweight for a specific animal group, tonne
$\mathbf{F_{pstr,G}}$ = Fraction of annual dry matter intake obtained from pasture
$\mathbf{N_G}$ = Number of animals

NOTE: Use of pasture is a factor in quantification of the GHG emissions from dairy farms. Increased use of pasture can decrease the energy embedded in feed, resulting in decreased emission of CO_2 from feed production and processing. Decreased use of pasture can increase collection and storage of liquid manure, resulting in greater emission of methane from manure. However, uncertainty remains concerning the assessment of the quantity and quality of feed consumed by pastured cows, resulting in uncertainty concerning enteric emissions of methane. To conform to ISO 14064-2 principle of completeness, Methodology projects are required to use the Methodology quantification approach to account for GHG emissions associated with use of pasture to account for potential increase of GHG emissions in the Project compared to the Baseline. But, to address the remaining uncertainty concerning GHG emission reductions, and to conform to the ISO 14064-2 principle of conservativeness, Methodology projects must demonstrate that any estimated decreases in GHG emissions associated with the increased use of pasture are ***not included*** in the calculation of offset credits.

(Regions defined)


5
4
3
2
1
5
5

(N2O and CO2 emissions combined)

	Region1		Region 2		Region 3		Region 4		Region 5	
Feed Stock	**Emissions (mt CO$_2$eq ha^{-1})**	**SD**	**Emissions (mt CO$_2$eq ha^{-1})**	**SD**	**Emissions (mt CO$_2$eq ha^{-1})**	**SD**	**Emissions (mt CO$_2$eq ha^{-1})**	**SD**	**Emissions (mt CO$_2$eq ha^{-1})**	**SD**
Mixed Pasture (Irrigated)	0.82	0.17	1.08	0.28	0.92	0.04	0.79	0.22	0.98	0.29
Mixed Pasture (Rain Fed)	0.82	0.17	0.83	0.22	0.92	0.04	0.57	0.08	0.55	0.11
Grass Pasture (Irrigated)	0.9	0.17	0.99	0.22	0.93	0.05	0.88	0.24	1.16	0.35
Grass Pasture (Rain Fed)	0.91	0.2	0.87	0.23	0.93	0.05	0.6	0.07	0.57	0.09
Alfalfa Hay**	0.74	0.15	0.63	0.13	0.54	0.19	0.78	0.3	0.8	0.16
Alfalfa Silage**	0.74	0.15	0	0	0.54	0.19	0.78	0.3	0	0
Almond Hulls	0	0	0	0	0	0	0	0	0	0
Barley	0	0	0	0	0	0	0.72	0.14	0	0
Canola Meal	0	0	0	0	0	0	0	0	0	0
Citrus Pulp	0	0	0	0	0	0	0	0	0	0
Corn Gluten Feed*	0	0	0	0	1.06	0.3	0	0	0	0

Corn Grain	0.98	0.187	0.97	0.13	1.06	0.3	1	0.21	1.08	0.14
Corn, High Moisture*	0.98	0.187	0	0	1.06	0.3	0	0	0	0
Corn Silage	0.59	0.06	0.98	0.22	0.97	0.06	1.05	0.29	0.97	0.15
Cottonseed‡	0	0	0.83	0.13	0	0	0	0	0	0
DDG, dry*	0	0	0.97	0.13	1.06	0.3	1	0.21	1.08	0.14
Grain Mix*	0.98	0.187	0	0	0	0	0	0	1.08	0.14
Grass Hay	0.82	0.13	0	0	0	0	0.89	0.19	0	0
Grass Haylage†	0	0	0.78	0.1	0	0	0	0	0	0
PMR	0	0	0	0	0	0	0	0	0	0
Protein Mix*	0.98	0.187	0	0	1.06	0.3	0	0	1.08	0.14
Sorghum Silage	0	0	0	0	0	0	0.63	0.14	0	0
Soy Hulls§	0	0	0.56	0.17	0	0	0	0	0	0
Soybean Meal§	0	0	0.56	0.17	0.74	0.27	0	0	0	0
Supplement*	0.98	0.187	0	0	1.06	0.3	1	0.21	0	0
Wheat Straw[α]	0	0	0	0	0.68	0.1	0	0	0	0

*Values reported were calculated using model for Corn Grain, if corn grain is not the principal component of a regional mix, this estimate is not valid.
**Values reported were calculated using model for Legume Hay
‡Values reported were calculated using model for Cotton
†Values reported were calculated using model for Grass Hay
§Values reported were calculated using model for Soybeans
α Values reported were calculated using model for Wheat
ND means that no data are available for emission estimation.

For N2O emissions:
Each emission estimate is reported in metric tonnes of CO_2 equivalent on a per hectare basis.
These estimates include both direct and indirect N_2O emissions.
Estimates and standard deviations are based on a random sample of 2-5 counties for each state in the region.
Estimates were made using the DAYCENT biogeochemical model.

For CO2 Fuel emissions:
Each emission estimate is reported in metric tonnes of CO_2 equivalent on a per hectare basis.
Each emission estimate is based on diesel fuel usage. If other types of fuel are used, these estimates are not valid.
Estimates and standard deviations are based on the top 5 producing counties in high dairy production states in each region. All high production dairy states in each region were included. In regions where there were not at least 3 high dairy production states, states with high production of the crop of interest were added to the sample to attain a minimum of three states for each region.
Estimates were made using Comet 2.0 http://www.comet2.colostate.edu/

Feed Transportation

Practices and GHG emissions associated with the transportation of produced feed are not expected to change from baseline to project and, as a result, do not need to be quantified.

TABLE 2.5 – Quantification Procedures

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
Enteric Fermentation									
Enteric Methane - 1	Gross energy intake for a specific animal group	GE_G	MJ $head^{-1}$ day^{-1}	m (advanced) e (basic)	Daily (advanced) Monthly (simple)	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 2	Percent of gross energy in feed converted to methane for a specific animal group	Y_{mG}	%	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 3	Number of animals in a specific animal group	N_G	Head $year^{-1}$	c	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 4 (Basic)	Net energy for maintenance	NE_m	MJ $head^{-1}$ day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 5 (Basic)	Maintenance energy coefficient	Cf_1	MJ $head^{-1}$ kg^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
								issuance of carbon credit	
Enteric Methane – 6 (Basic)	Average live weight of cows	LW	kg	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 7 (Basic)	Net enegy for activity	NE_a	MJ $head^{-1}$ day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 8 (Basic)	Fraction of time spent on pasture	F_{pstr}	%	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 9 (Basic)	Net energy for pregnancy	NE_p	MJ $head^{-1}$ day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 10 (Basic)	Fraction of animal group that are pregnant	F_{pregp}	%	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
Enteric Methane – 11 (Basic)	Net energy for lactation	NE_l	MJ head^{-1} day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 12 (Basic)	Amount of milk produced	Milk	Kg head^{-1} day^{-1}	m	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 13 (Basic)	Fat content of milk	Fat	% by weight	m	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 14 (Basic)	Net energy for growth	NE_g	MJ head^{-1} day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 15 (Basic)	Average live body weight for animals in group	BW	kg	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane –	Mature live body weight for	MW	kg	e	Monthly	100%	Electronic	Minimum of two years	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
16 (Basic)	an adult kow							after last issuance of carbon credit	
Enteric Methane – 17 (Basic)	Average daily weight gain	WG	Kg day^{-1}	e	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 18 (Basic)	Ratio of net energy available for maintenance to digestible energy consumed	REM		c	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 19 (Basic)	Digestible energy expressed as a percentage of gross energy	DE	% of gross energy (GE)	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane – 20 (Basic)	Ratio of net energy available for growth to digestible energy consumed	REG		c	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Enteric Methane –	Dry matter intake for each	DMI	Kg head^{-1} day^{-1}	m	Daily	100%	Electronic	Minimum of two years	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
21 (Advanced)	ration ingredient (including edible oils, ionophores, etc.)							after last issuance of carbon credit	
Enteric Methane – 22 (Advanced)	Measure of quality of forage (NDF)	NDF		m	Monthly	100	Electronic	Minimum of two years after last issuance of carbon credit	This data could be provided by nutritionist judgment for diet formulation.
Manure Storage									
Manure Storage – 1 (Basic)	Daily volatile solids excreted by a specific animal group	VS_G	kg DM head^{-1} day^{-1}	m	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 2 (Basic)	Number of animals in a specific animal group	N_G	Head year^{-1}	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 3	Methane conversion	MCF_S	%	e	Monthly	100%	Electronic	Minimum of two years	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
(Basic)	factor							after last issuance of carbon credit	
Manure Storage – 4 (Basic)	Fraction of animal group G's manure handled by the defined manure management system	$MS_{S,G}$	%	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 5 (Basic)	Daily volatile solids excreted per day on a dry matter basis	VS	kg head^{-1} day^{-1}	e	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 6 (Basic)	Gross energy intake	GE	MJ head^{-1} day^{-1}	e	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 7 (Basic)	Digestible energy	DE	%	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure	Volatile solids	$VS_{prod,m}$	tonnes	m	Monthly	100%	Electronic	Minimum of	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
Storage – 8 (Advanced)	added to manure storage unit during month for all animal groups contributing to unit							two years after last issuance of carbon credit	
Manure Storage – 9 (Advanced)	Volatile solids in the storage unit at the end of the previous month available to be	$VS_{avail,m-1}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 10 (Advanced)	Fraction of available volatile solids consumed during month	f		c	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 11 (Advanced)	Volatile solids available to be decomposed at end of current month	$VS_{avail,m}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 12 (Advanced)	Volatile solids available to be decomposed at	$VS_{avail,m-1}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
	end of previous month							issuance of carbon credit	
Manure Storage – 13 (Advanced)	Volatile solids added to manure storage unit during month	$VS_{prod,m}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 14 (Advanced)	Volatile solids consumed during month	$VS_{consumed}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 15 (Advanced)	Volatile solids stabilized into non-available forms	$VS_{stabilized}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 16 (Advanced)	Volatile solids removed from manure storage during month	$VS_{removed}$	tonnes	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Manure Storage – 17 (Advanced)	Average monthly temperature	T_2	°C	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
N_2O Emissions									
N_2O Emissions - 1	Feed N intake for a specific animal group	$FeedN_G$	Kg N $head^{-1}$ day^{-1}	m	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 2	Dry matter intake	DMI	Kg $head^{-1}$ day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 3	Crude protein content of diet	CP	% of DMI	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 4	Nitrogen retained in milk for a specific animal group	$MilkN_G$	Kg N $head^{-1}$ day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N2O Emissions – 5	Daily milk production	Milk	Kg $head^{-1}$ day^{-1}	m	Daily	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O	Protein content	Milk	% on	e	Monthly	100%	Electronic	Minimum of	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
Emissions - 6	of milk	protein	weight basis					two years after last issuance of carbon credit	
N_2O Emissions - 7	Nitrogen retained in liveweight gain for a specific animal group	LWgain N_G	Kg N head^{-1} day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 8	Daily liveweight gain	LWgain	Kg head^{-1} day^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 9	Number of animals in a specific animal group	N_G	Head year^{-1}	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 10	N_2O emitted per kgof N excreted for a specific animal group	$E_{N2O,G}$	kg N_2O kg^{-1} excreted N	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
N_2O Emissions - 11	Fraction of excreted N handled by	$F_{G,S}$	%	e	Monthly	100%	Electronic	Minimum of two years after last	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
	manure management system for a specific animal group							issuance of carbon credit	
N_2O Emissions - 12	N2O emitted per kg of N excreted in a specific manure management system	$E_{N2O,S}$	Kg N_2O kg excreted N^{-1}	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Feed									
Processed Feed - 1	Amount of feed of a specific type consumed by a specific animal group	$FeedDM_{G,F}$	tonnes DM yr^{-1}	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Processed Feed - 2	GHG emitted per tonne of feed	$FeedCO_2e_F$	Tonne CO_2e $tonne^{-1}$ feed DM	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Pasture Feed – 1	GHG emissions from unimproved pasture per tonne	$PstrCO_2e_G$	tonnes CO_2e $tonne^{-1}$ LW yr^{-1}	c	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	

ID number (SS)	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording Frequency	Proportion of data monitored	How will data be archived? (electronic paper)	For how long is archived data kept?	Comments
	liveweight per year for a specific animal group								
Pasture Feed – 2	Average liveweight for a specific animal group	LW_G	tonne	e	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	
Pasture Feed - 3	Fraction of annual dry matter intake obtained from pasture	$F_{pstr,G}$	%	e	Monthly	100%	Electronic	Minimum of two years after last Pasture Feed - 4issuance of carbon credit	
Pasture Feed - 4	Number of animals in a specific group	N_G	Head year^{-1}	m	Monthly	100%	Electronic	Minimum of two years after last issuance of carbon credit	

IV. Data Management

1. Contingent Data Approaches

Not applicable in this Methodology.

2. Management of Data Quality

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

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

3. Record Keeping

The project proponent shall keep the information listed below for the time period stated **TABLE 2.6**. All information must be available to the verifier upon request.

TABLE 2.6 ***– Record Keeping Requirements***

Kept for Duration of Project's GHG Credit-Production
Raw baseline period energy, feed, milk production, livestock, and manure management data, independent variable data, and static factors within the measurement boundary
A record of all adjustments made to raw baseline data with justifications
All analysis of baseline data used to create mathematical model(s)
All data and analysis used to support estimates and factors used for quantification
Expected end of life date of equipment removed or renovated under the project
Common practices relating to possible GHG reduction scenarios discussed in this methodology (such as manure management practices)
Metering equipment specifications (model number, serial number, manufacturer's calibration procedures)
Kept for 2 Years After Generation
Raw reporting period energy, feed, milk production, livestock, and manure management data, independent variables, and static factors within the measurement boundary
A record of changes in static factors along with all calculations for non-routine adjustments
All calculations of GHG emissions/reductions and emission factors
Measurement equipment maintenance activity logs
Measurement equipment calibration records
Initial and annual verification records and audit results

The project proponent 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 should be maintained in an orderly manner;
- All documents must be retained for the life of the project;
- Electronic and paper documentation are both satisfactory; and
- Copies of records should be stored in two locations to prevent loss of data.

4. Quality Assurance/Quality Control (QA/QC)

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

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

V. References

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Appendix E – PSAT Meeting Report (December 13 to 14th, 2011)

PSAT Action and Decision Items
Dec 13-14, 2011 UCDavis Workshop

Overall Decisions and Action Items:

- **Decision Item No. 1 –** Use GWPs of 21 for CH_4 and 310 for N_20; consistency with USEPA and ACR
- **Decision Item No. 2 –** For N Balance in both Dairy and Beef animals, use the NRC approach (as opposed to IPCC 7% N retention across the board);

Action Item 1: Develop a Calculator based on NRC equations for ease of computation

- **Decision Item No. 3 -** Concentrate Levels – Ym for use in US **–** Apply the ≥ 85% concentrate for lower Ym, and < 85% concentrates for higher Ym

Action Item 2: A better definition of Concentrates is needed in the protocols (particularly for Almond husks

- **Decision Item No. 4 –** Reduced Age to Harvest (47% agreement) and Reduced Days on Feed (43% agreement) are the Beef Protocols with the highest chance of success (doesn't exclude Oils)
- **Decision Item No. 5 -** Expand the Edible Oils protocol scope to include direct and indirect emissions from manure excretion to allow project developers to assess trade-offs of certain fat sources with increased manure emissions – and include it in the Pilot

Action Item 3: PSAT to re-draft Edible Oils protocol to increase scope beyond enteric fermentation; allowing the user to consider and account for both Ether Extract and Crude Protein effects on GHG emissions

- **Decision Item No. 6 –** Low RFI in Beef to be set aside until more research is published.

Action Item 4: BIGGS partners to talk to USDA-NRCS about feasibility of expanding into cow-calf as a stand alone

Action Item 5: BIGGS partners (in this case Matt) to address contracting flexibility and add it into the FAQ for the BIGGs Project

Protocol-Level Decisions and Action Items:

Dairy

- **Alex H, Ermias K, Jim F, Karen B, Rob J, Sarah,**

1. In a high lactating animal, what are the N requirements of the animal? Are they high enough to offset the higher N_20 emission of a 22 to 25% blend of Corn DDGS in the diet (16% CP of the diet)?
   - **Decision Item No. 6** – Allow the project developer to account for both the Ether Extract and Crude Protein of the diet, to weigh the net effect of a fat source and it's impact on the GHG emissions
2. What % of fat corrected milk makes sense for the US? 3.7%, 4.0% or some thing other

   - **Decision Item No. 7 –** Use both fat and protein corrected milk as the denominator: 3.5% Fat and 3.2% Protein
3. Range of Ym for cows – 4.85% to 7.95% of GEI. Ym average from 2 different studies is 5.63% to 5.64% (mix of diets, including fats). (Uncertainty for Ym is 5.2%). Not that different from IPCC, but according to qualifying factors presented, the following is suggested:
   - **Decision Item No. 8** – Use the initial Ym of 6%; and then assess Ym for medium and high quality forage as well as grain to determine variation in Ym

Action Item 6: Ermias to examine the DMIs and USEPA data by State and provide a recommendation back to the group, using Collaborase, or a Webinar for decision making – mode TBD.

4. From the Monensin Meta-Analysis (non-recycled) - If EE greater than 40 g/kg at 22 DMI and study …then see reduced methane (higher dose).
   - **Decision Item No. 9** – Two ways of dealing with this….adjust the Ym or examine the Meta-Analysis to determine whether to adjust the GEI/DMI or milk output

Action Item 7: Ermias to examine the Meta-Analysis to determine best approach, recommendations will be presented using Collaborase, or a Webinar for decision making – mode TBD

5. Dairy Feed Production Side:
   - Does it make sense to base typology of dairy feeding regimes from the DMI LCA Study? The country is divided into 5 regions, with feed inputs for dairy operations and animals (see handout)
   - Do we use one number/carbon footprint for concentrates (commodity at national level) and capture variability for by-products and/or forages? What does this do to our 'Tier' choices?
   - Do we account for only added N for feedstocks, or for all N sources from the land used to grow the crop?
   - Should we use Tier 1, CometFARM/VR Tier 3 or NIR Tier 3 (8 to 10 crops and pasture)?
   - Do we want flexibility for management of these crops upstream from the dairy operations? It will mean collecting the farm activity data and farm documentation from the cropping side to base the calculations on – this increases the complexity of the implementation of the protocol.

Action Item 8: Since this Item was deferred, Karen and Ermias to work with Juan Tricarico (DMI) and Stephen Ogle to determine best approach; Anticipate Webinar in the New Year

6. Regional data for conservation districts – USDA fuel calculator/Comet VR?
   - **Decision deferred.**
7. How do we reconcile the approach in the Dairy protocol (stepwise adjustments to Ym with increasing fat content) vs. a threshold approach of between 4 to 6% fat content of the diet in the Beef Edible Oils protocol? Or do we?

- **Decision Item No. 10 –** For Lipid supplementation in Dairy, Ym should be adjusted on a sliding scale basis for EE levels.

Action Item 9: Karen Beauchemin and Ermias to examine regional dietary data (DMI LCA study - Appendix C; recent Meta Analysis (Grainger, Beauchemin) – to determine appropriate sliding scale; bring recommendations back to the group.

Beef 1 – Edible Oils, Days on Feed

- **Andy C, Ben W, Kris J, Gustavo C, Tim M, Jim O, Nick M**

1. How can we get CP content of Corn DDGS/mixed Corn - sorghum DDGS reduced to include it as a mitigation strategy under the Edible Oils Protocol? If we can get the CP to 12 or 12.5-13% of the diet then N20 would not eclipse the reduced enteric methane emissions.
    - **Decision Item No. 11** – Not feasible at this time.
2. Are there other byproducts containing fats that are economical to feed that aren't high protein?
    - **Decision Item No. 12. –** Not at this time.
3. Do we use the USEPA State by State MCFs for manure?
    - **Not addressed by the group**
4. Do we know enough about the effect of N balance and it's impact on N excretion? Should we adopt the NRC approach to refine the N balance of the animals?
    - **See above overall decisions/action items**
5. Should we use a Ym of 3% for >85% corn-based diets? What about <85% - 6.5%
    - **Decision Item No. 13** – for use in US **–** Apply the ≥ 85% concentrate for Ym of 3% for grain-based diets and < 85% concentrates for Ym of 6.5% -stick to IPCC 2006
6. What is the impact of oil on these?
    - **Not addressed by the group**
7. EPA Manure Calculator – 1% for Direct N20 emissions for % to N20 of excreted N – not 0.7%. Do we adopt this?
    - **Decision Item No. 14** – Insert IPCC Table 10.2.7 into the Beef Protocols for use across the Board.
8. Standardized finished carcass weight of 345 kg makes sense for the US?
    - **Decision Item No. 15** - Use 1350 lbs at 62% dressing percentage – so between 380 to 390 kg carcass weight
9. What are unintended consequences of feeding Ractopamine or Zilmax?
    - **Not addressed by the group**
10. Are there other strategies we should incorporate?
11. Manure Methane (methane conversion factors):
    - 1.0% for pasture, range, and/or paddock systems
    - 2.0% for solid storage systems
    - 17% for deep bedding manure – appropriate?
    - **Decision Item No. 16** – generally correct; apply in protocols.
12. Direct Manure N_20 from Storage:
    - Mgmt System factor - 0.8 – fraction of excreted N managed in the storage

- Emissions Factor – 0.7% of N excreted in system -Appropriate?
- **Decision Item No. 17** – 0.7% is appropriate for the US.

13. Indirect $N_2 0$ from Leaching
    - Management System –10% of excreted N in the solid manure storage system
    - Emission Factor – Canada recently doubled it from 1.25% of excreted N to 2.50% of excreted N – US numbers?
    - **Not addressed by the group**
14. Potential Strategies:
    - Beta-agonists - Optiflexx and Zilmax (0.04 tonnes GHG/head reduction for 7.7 days less)
    - Adoption of recently approved increased label dose for Rumensin - US based science to support?
    - Better animal sorting/individual performance mgmt
    - Improved animal husbandry – better genetics, animal health improvements
    - Any thing that increases the denominator (beef production) while not increasing emissions
    - Antibiotics?
    - Implants(96.1% in 1999 NAHMS)
    - Beta agonists
    - Feed processing (steam flaked vs. cracked, etc.)
    - Others
    - New 2011 NAHMS survey
    - **Not addressed by the group**

Action Item 10: PSAT writing team to develop method/approach for developing regional or national performance standard baselines for animal categories for selected states; will be an emission factor based on data from 2000-2001-2002 era NIR data and supporting information for animal category by weight class for feedlot fed animal.

Beef 2 – Reduced Age to Harvest/Low RFI

- **Harvey F, Jon W, Karen H-K, Garth B, Shawn A, John B**

General Comments – the Group focused on the top 2 priorities as instructed and selected No. 4 and No. 5 below. Recommendations are presented up-front right here:

- **Decision Item No. 18 –** Develop a grid that has a carbon footprint for each animal category (per carcass weight/yr) that has Incoming weight vs Age of the animal; the carbon footprint will have all embedded emissions, and will apply to baseline and project animals to determine the delta C.

Action Item 11: PSAT writing team to assess whether these Grids need to be regional or can be national in scope

Action Item 12: PSAT writing team to determine whether a Grid needs to be developed for the Baseline Period – 2000-2001-2002 and then a separate one for the most recent *data? Will need to determine how to adjust for production endpoints over time.*

Action Item 13: PSAT writing team to determine default birth date method (1st calf born; derived from calving percentages by region (if necessary). Karen to circulate the method used to derive the default in Alberta.

1. Shift to yearlings placement in the feedlots since 2005 – driven by corn prices/markets? How do we consider this in the protocols?
2. Are there going to be unintended consequences on animal morbidity?
3. Impacts on quality from the protocol? Will it be improved or decreased with more calf fed placements?
4. Should we annualize the GHG emissions/kg carcass weight or live weight, to reflect production efficiency of the system (time is a factor)?
5. How would we go about developing typologies of production systems across the United States? Should we go by the regions laid out in the Inventory CFEM model?
6. Should we just have the protocol allow the user to run the 8 to 12 equations to develop their own calculations rather than standardized approaches?
7. If we do decide to go with standardized approaches, t's been suggested we typify these production systems similar to the following:

        - Explanation as to how the RAH regression curves were developed was listed here, but taken out for brevity's sake.

8. **Residual Feed Intake**
    - Is selecting Low RFI a valid protocol approach for the U.S.?
    - What needs to be considered for this? Do we need to do more cross-ranking and indexing for this approach?
    - **Decision was made to shelve RFI for the time being.**

Appendix F – Heifer Sensitivity Analysis for the Dairy Protocol

Dairy Protocol

Heifer Sensitivity Analysis

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Business Confidential

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Context

ClimateCHECK was contracted by the Atlantic Dairy and Forage Institute (ADFI) to provide subject matter expertise, project management and software solutions for the Dairy Greenhouse Gas (GHG) Pilot Project on New Brunswick and Alberta Diary Farms. The objective of the ADFI pilot project was to field test the current Alberta Quantification Protocol for Greenhouse Gas Emissions Reductions from Dairy Cattle (version 1). By engaging producers in Alberta and New Brunswick the project team was able to assess the current on-farm and third party data collection against the data requirements of the Protocol.

Participating producers and third parties (including Valacta, nutritionist, CanWest DHI, Alberta Milk and others) supplied a wide range of documentation including feed data, manure, DHI and milk reporting records. After assessing the documentation collected it became clear that currently most producers (and some third parties) in practice don't collect all of the records needed to fulfill the requirements of the Protocol. Moreover, the pilot project also demonstrated that the current Protocol is too stringent in regards to the data requirements.

Under the auspices of a USDA-NRCS Conservation Innovation Grant, the Bovine Innovative Greenhouse Gas Solutions (BIGGS) team is adapting the Alberta Dairy Protocol to the US for purposes of piloting the revised version. A cross-border Dairy Pilot committee was struck[47]. Meetings occurred in April of 2012 to share best practices, identify issues and seek resolutions. At these meetings, the committee suggested undertaking a Sensitivity analysis, particularly on the heifer herds since data gaps were largest with these groups, and it is unlikely dairy producers will collect the needed data in the near term.

Thus, a sensitivity analysis was conducted on the replacement heifers to determine if certain data requirements can be excluded on the basis for de minimus exclusion.

Sensitivity Approach

The purpose of this sensitivity analysis was to assess the variance in heifer inventories that creates change of more than 5% of the potential emission reductions from a reduction scenario that is based on real data from a dairy operation (van Diemen farms in S. Alberta for milk and production data; Beaudry farms in Quebec for ration and feed data).

Throughout the course of the ADFI dairy pilot (intent was 50 farms in Alberta and 50 farms in New Brunswick) no complete dataset for a dairy operation could be gathered. The largest data gaps were heifer feed intake; feed quality and mid-weights for protocol calculations. Thus, in order to run the sensitivity analysis, adequate data sources had to be found. Valacta generously provided the full herd component diets and feed intake for the Beaudry farms.

The replacement heifers were selected for this analysis because the ADFI pilot demonstrated protocol data could be obtained for dry cows and lactating cows, but data gaps existed for the heiferes. The

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[47] The Cross Border Dairy Pilot Committee comprises Jim Oltjen, Ermias Kebreab from UCDavis, Claudia Wagner-Riddle, Uof Guelph; Cedric MacLeod, Josh Lamont, ADFI Dairy Pilot; Juan Tricarico, DMI; Karen Clark, DFC.

revised protocol also includes a flexibility mechanism for excluding bulls and calves from the quantification. The heifer inventory was initially altered by 10% increments to determine the impact on the modeled emission reduction. Based on this initial assessment, the increments were refined to =+/-1% up to a maximum change of +/- 10% to determine the effect on overall emissions for each scenario. For results see Table 5-10 and Figure 1-5.

Sensitivity Assumptions

5.16 Reduction Scenarios

For use in the BIGGS pilot, the van Diemen herd was scaled to a lactating herd of 1000 to reflect an medium sized dairy in the US. The van Diemen farm was included in the ADFI dairy pilot study, as well as the ARD Dairy protocol case study work. Data was collected over the course of the ADFI pilot. The reduction scenarios modeled on the van Diemen farm for purposes of the ADFI Pilot, scaled to 1000 are shown below.

Table 25: Reduction Scenarios

Scenario	Scenario Outline	Emissions T CO_2e	Emissions Reductions T CO_2e	Scenario Details
	Baseline (Fall manure application, No ionophore, 69 lbs milk/cow)	12,478	-	Van Diemen Farms, Picture Butte, Alberta
	10% increase in milk production in baseline for scenario #5	13,868	-	Modeled increase.
1	Fall vs Spring Manure Application	11,645	833	Van Diemen Farms, Picture Butte Alberta
2	Spring and Summer Manure Application	11,304	1,174	High quality rations offered all herds
3	Ionophores feeding	10,875	1,603	Replacement heifers raised on site, and the herd size is roughly 82% of the lactation herd.
4	30% Heifer herd size reduction	10,396	2,083	Manure stored in earthen manure storage and spread twice per year currently. This base case will be similar to what would likely occur in the northern mid-western US States. Baseline case was theoretically

Scenario	Scenario Outline	Emissions T CO_2e	Emissions Reductions T CO_2e	Scenario Details
				established based on fall application only to give an idea of the GHG reductions that can be achieved with spring and/or spring and fall application. Manure is currently spread twice annually, spring and fall, on the van Diemen Dairy Farm.
5	10% increase in milk production	10,993	2,875	Milk production - 69.5 lbs/hd/day (31.5-kg), 4.06% butterfat, 3.34% protein

5.17 Animal Herd Inventory Data (Source: ADFI Pilot Project)

In the scale up exercise, the following inventory splits were used to determine total emission reductions per herd. Heifers were assumed to be 30% of the lactating herd, based on typical industry percentages.

Table 26: Herd Inventory

Variable	Units	Lactation Herd #1	Lactation Herd #2	Dry Herd	Heifers[48]
# of Cattle	# of animals	500	500	170	300

5.18 Animal Herd Ration Data & Milk Data (Source: Valacta)

The data outlined in the following table was populated using on-farm feed records for Robert Beaudry Farms, a commercial dairy located in the province of Quebec. This data was used in the sensitively analysis due to its completeness, which was ensured by collection support from the farm's Valacta technician. The dataset was also chosen due to the detail provided for all herds on the farm (lactation, dry and replacement heifers) and the commercial reality of the feed mixes, which are widely adopted for use across Canada. These case study data provided both the data quantity and quality required to complete a full sensitivity analysis. Thanks to Valacta field and head office staff for their support in obtaining this information.

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[48] Representing 30% of the lactation herd

Table 27: Animal Herd Dietary Inputs and Milk Production Data

Variable	Units	Lactation Herd #1	Lactation Herd #2	Dry Herd	Heifers
Crude Protein	%DM	19	18	16	16
Digestible Energy	%DM	61	55	34	34
ADF	%DM	18	29	25	34
NDF	%DM	28	45	39	39
Average Live Weight	kg	647	647	647	409
Average Daily Weight Gain	kg day^{-1}	0.07	0.07	0.07	1
Dry Matter Intake	kg $head^{-1}$ day^{-1}	23.96	22.34	11.80	7
Daily Milk Production	kg $head^{-1}$ day^{-1}	34			
Fat Content of Milk	%	3.710			
Protein Content of Milk	%	3.320			

Table 28: Animal Herd Breakdown of Total Mixed Rations

Tonnes DM yr^{-1} for the each herd					
Type	**Feed Type**	**Lactation Herd #1**	**Lactation Herd #2**	**Dry Herd**	**Heifers**
Concentrate	**Grain corn**	739.13	684.38	47.78	10.68
	Barley & other small grains				
	DDGS	753.73	357.70	94.94	18.89
	Soybean meal	49.28	279.23		74.73
	Canola meal				
	Canola seed (for fat)				
Roughage	**Corn silage**	1456.35	1533.00	208.49	123.60
	Small grain silage				
	Legume hay or silage	1290.28	1136.98	276.74	245.28
	Non-legume hay or silage	83.95	83.95	104.24	
	Pasture[49]	0	0	0	0
Total		**4372.70**	**4075.23**	**732.19**	**467.84**

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[49] Assuming no time was spent on pasture for all herds.

Heifer Herd Sensitivity Results

The results presented here are the refined runs that vary the replacement heifers by +/- 1 % increments up to a maximum of 10% change. The project team selected reduction scenario No. 5 to determine the de minimus threshold for excluding the heifer herds Table 5 (see appendix A for Scenario 1 to 4 runs and accompanying spreadsheet for the full analysis). The results show that within the range of +/- 2.5% variance in heifer numbers, the impact on emissions reductions stays within the 5% materiality threshold (shaded area).

Table 5: Scenario #5 - Variance in the Heifer Inventory

Scenario 5

# of Heifers	% change in Heifer Inventory	Solid Manure Management		Liquid Manure Management	
		Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline	Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline
270	-10%	0.19	-2.11%	1.91	-21.24%
273	-9%	0.19	-1.90%	1.93	-19.11%
276	-8%	0.19	-1.69%	1.95	-16.99%
279	-7%	0.20	-1.48%	1.97	-14.86%
282	-6%	0.20	-1.27%	2.00	-12.74%
285	-5%	0.20	-1.05%	2.02	-10.62%
288	-4%	0.20	-0.84%	2.04	-8.49%
291	-3%	0.20	-0.63%	2.06	-6.37%
294	-2%	0.21	-0.42%	2.08	-4.25%
297	-1%	0.21	-0.21%	2.10	-2.12%
300	0%	0.21	0.00%	2.12	0.00%
303	1%	0.21	0.21%	2.14	2.12%
306	2%	0.22	0.42%	2.17	4.25%
309	3%	0.22	0.63%	2.19	6.37%
312	4%	0.22	0.84%	2.21	8.49%
315	5%	0.22	1.05%	2.23	10.62%
318	6%	0.22	1.27%	2.25	12.74%
321	7%	0.23	1.48%	2.27	14.86%
324	8%	0.23	1.69%	2.29	16.99%
327	9%	0.23	1.90%	2.31	19.11%
330	10%	0.23	2.11%	2.34	21.24%

Conclusion & Results

The results from the herd inventory analysis led to the development of a flexibility mechanism created in the second Version of the dairy protocol which states that, “The project developer can conservatively exclude quantifying emissions from heifer animal groupings/herd components on a given farm, if the project developer can demonstrate that the project heifer inventory did not increase by more than 2.5% on average over the baseline numbers in any given year. Sufficient records documenting this flexibility option must be available, and signed off by a professional nutritionist, proving the monthly number of heifers on the farm for baseline and project years stayed within this variance”

Appendix F1 – Scenario 1 to 4 Sensitivity Analysis

Table 29: Scenario #1 - Variance in the Heifer Inventory

Scenario 1

# of Heifers	% change in Heifer Inventory	Solid Manure Management		Liquid Manure Management	
		Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline	Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline
270	-10%	0.65	-7.28%	6.59	-73.20%
273	-9%	0.66	-6.55%	6.66	-65.88%
276	-8%	0.67	-5.82%	6.73	-58.56%
279	-7%	0.68	-5.09%	6.81	-51.24%
282	-6%	0.68	-4.37%	6.88	-43.92%
285	-5%	0.69	-3.64%	6.95	-36.60%
288	-4%	0.70	-2.91%	7.03	-29.28%
291	-3%	0.71	-2.18%	7.10	-21.96%
294	-2%	0.71	-1.46%	7.17	-14.64%
297	-1%	0.72	-0.73%	7.25	-7.32%
300	0%	0.73	0.00%	7.32	0.00%
303	1%	0.73	0.73%	7.39	7.32%
306	2%	0.74	1.46%	7.47	14.64%
309	3%	0.75	2.18%	7.54	21.96%
312	4%	0.76	2.91%	7.61	29.28%
315	5%	0.76	3.64%	7.69	36.60%
318	6%	0.77	4.37%	7.76	43.92%
321	7%	0.78	5.09%	7.83	51.24%
324	8%	0.79	5.82%	7.91	58.56%
327	9%	0.79	6.55%	7.98	65.88%
330	10%	0.80	7.28%	8.05	73.20%

Table 30: Scenario #2 - Variance in the Heifer Inventory

Scenario 2

# of Heifers	% change in Heifer Inventory	Liquid Manure Management		Solid Manure Management	
		Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline	Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline
270	-10%	0.46	-5.16%	4.68	-51.97%
273	-9%	0.47	-4.65%	4.73	-46.77%
276	-8%	0.48	-4.13%	4.78	-41.58%
279	-7%	0.48	-3.61%	4.83	-36.38%
282	-6%	0.49	-3.10%	4.89	-31.18%
285	-5%	0.49	-2.58%	4.94	-25.98%
288	-4%	0.50	-2.07%	4.99	-20.79%
291	-3%	0.50	-1.55%	5.04	-15.59%
294	-2%	0.51	-1.03%	5.09	-10.39%
297	-1%	0.51	-0.52%	5.15	-5.20%
300	0%	0.52	0.00%	5.20	0.00%
303	1%	0.52	0.52%	5.25	5.20%
306	2%	0.53	1.03%	5.30	10.39%
309	3%	0.53	1.55%	5.35	15.59%
312	4%	0.54	2.07%	5.40	20.79%
315	5%	0.54	2.58%	5.46	25.98%
318	6%	0.55	3.10%	5.51	31.18%
321	7%	0.55	3.61%	5.56	36.38%
324	8%	0.56	4.13%	5.61	41.58%
327	9%	0.56	4.65%	5.66	46.77%
330	10%	0.57	5.16%	5.72	51.97%

Table 31: Scenario #3 - Variance in the Heifer Inventory

Scenario 3

# of Heifers	% change in Heifer Inventory	Solid Manure Management		Liquid Manure Management	
		Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline	Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline
270	-10%	0.34	-3.78%	3.43	-38.08%
273	-9%	0.34	-3.40%	3.47	-34.27%
276	-8%	0.35	-3.03%	3.50	-30.46%
279	-7%	0.35	-2.65%	3.54	-26.66%
282	-6%	0.36	-2.27%	3.58	-22.85%
285	-5%	0.36	-1.89%	3.62	-19.04%
288	-4%	0.36	-1.51%	3.66	-15.23%
291	-3%	0.37	-1.13%	3.69	-11.42%
294	-2%	0.37	-0.76%	3.73	-7.62%
297	-1%	0.37	-0.38%	3.77	-3.81%
300	0%	0.38	0.00%	3.81	0.00%
303	1%	0.38	0.38%	3.85	3.81%
306	2%	0.39	0.76%	3.88	7.62%
309	3%	0.39	1.13%	3.92	11.42%
312	4%	0.39	1.51%	3.96	15.23%
315	5%	0.40	1.89%	4.00	19.04%
318	6%	0.40	2.27%	4.04	22.85%
321	7%	0.40	2.65%	4.07	26.66%
324	8%	0.41	3.03%	4.11	30.46%
327	9%	0.41	3.40%	4.15	34.27%
330	10%	0.42	3.78%	4.19	38.08%

Scenario 4

# of Heifers	% change in Heifer Inventory	Solid Manure Management		Liquid Manure Management	
		Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline	Total Difference in Reductions (%/Heifer Herd)	Difference in Emission Reductions from the Baseline
270	-10%	0.26	-2.91%	2.64	-29.31%
273	-9%	0.26	-2.62%	2.67	-26.38%
276	-8%	0.27	-2.33%	2.70	-23.45%
279	-7%	0.27	-2.04%	2.73	-20.52%
282	-6%	0.27	-1.75%	2.75	-17.58%
285	-5%	0.28	-1.46%	2.78	-14.65%
288	-4%	0.28	-1.16%	2.81	-11.72%
291	-3%	0.28	-0.87%	2.84	-8.79%
294	-2%	0.29	-0.58%	2.87	-5.86%
297	-1%	0.29	-0.29%	2.90	-2.93%
300	0%	0.29	0.00%	2.93	0.00%
303	1%	0.29	0.29%	2.96	2.93%
306	2%	0.30	0.58%	2.99	5.86%
309	3%	0.30	0.87%	3.02	8.79%
312	4%	0.30	1.16%	3.05	11.72%
315	5%	0.31	1.46%	3.08	14.65%
318	6%	0.31	1.75%	3.11	17.58%
321	7%	0.31	2.04%	3.14	20.52%
324	8%	0.31	2.33%	3.17	23.45%
327	9%	0.32	2.62%	3.19	26.38%
330	10%	0.32	2.91%	3.22	29.31%