Alberta Offset System
Offset Project Plan for XYZ Inc.'s Nitrous Oxide Emission Reductions (NERP) Aggregation Project - Protocol Validation Study
(June 2014)

Disclaimers

This document has been produced independently by The Prasino Group at the request of the Climate Change Emissions Management (CCEMC) Corporation as specified under contract for the Protocol Validation Studies. It was produced according to the requirements in the Alberta Offset System's Nitrous Oxide Emissions Reduction in Agriculture Quantification Protocol v 1.0 October 20131. The views expressed in this report are not necessarily the views of the Climate Change Emissions Management (CCEMC) Corporation.

Note to Reader:

This document is a sample Offset Project Plan (OPP) produced as part of the larger Protocol Validation Study. It is meant to provide guidance to project developers on applying the OPP template (http://environment.gov.ab.ca/info/library/8524.pdf) to a Nitrous Oxide Emission Reductions Offset Project under the Alberta Offset System. Any reference to farm information, or offset credit information contained within this document is fictitious and intended for illustrative purposes only.

[1] See http://environment.gov.ab.ca/info/library/8294.pdf

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1 Project Scope and Site Description

1.1 Project Scope

Table 1 below provides details on the projects scope, ownership, reporting plans, verification details and registration.

Table 1: Project Details	
Project Title:	Offset Project Plan for XYZ Inc.'s Nitrous Oxide Emission Reductions (NERP) Aggregation Project - Protocol Validation Study
Project Purpose and Objective(s):	The purpose of this project is to reduce emissions of nitrous oxide (N_2O) related to direct losses (nitrification/ denitrification losses), indirect losses (through nitrate leaching), and/or volatilization and redeposition of ammonia gas. Specifically, N_2O emissions will be reduced through the use of beneficial management practices (BMPs) called the 4R's – right rate, right place, right time and right source. These practices are defined under a 4R Nitrogen Stewardship Plan. Five farms, representing approximately 15,000 cultivated hectares, will be aggregated for this project by XYZ Inc. The broader goal of the Protocol Validation Study is to identify barriers that currently exist in implementing projects under the NERP protocol and design scalable approaches to adopting this protocol.
Project Start Date:	e.g. January 1, 2011
Credit Start Date:	N/A – the NERP Protocol Validation Study is a non-commercial exercise (e.g. January 1, 2011)
Credit Duration Period:	N/A - The NERP Protocol Validation Study is a non-commercial exercise. The Alberta offset system allows eligibility for 8 years, (e.g. January 1, 2011 to December 31, 2019), with the potential for an additional five years upon government approval.
Expected Lifetime of the Project:	N/A - The NERP Protocol Validation Study is a non-commercial exercise. Commercial offset projects may have a lifetime of up to 13 years for all participating farms as per the

Table 1: Project Details	
	protocol, although the activity itself can be continued indefinitely.
Estimated Emission Reductions/Removals:	Up to 2,500 t CO_2e/year (note – this is not a commercial exercise so tonnage is small and based on five fictitious farms)
Applicable Quantification Protocol(s):	Government of Alberta Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions, Version 1.0, October 2010
Protocol(s) Justification:	All participating project sites are based in Alberta and have implemented a 4R Plan. The 4R plan includes an integrated set of BMPs for either annual or perennial cropping. It has been designed and implemented in consultation with an Accredited Professional Advisor, at the basic performance level. The practices employed in this project are not required by law and go beyond business as usual practices. As a result, the project is additional. The Project and all aggregated sites also align with all applicability requirements stated in the Protocol. Refer to Section 3.3 for Project Eligibility Criteria.
Other Environmental Attributes:	This project will not generate any other environmental credits/benefits. However, more efficient crop production will result in less nitrogen being used and as a result lower associated impacts to water quality, etc.
Legal Land Description of the Project and/or Other Unique Site Descriptions:	Farm #1: 01-01-010-01W4 Farm #2: 02-01-010-01W4 Farm #3: 03-01-010-01W4 Farm #4: 04-01-010-01W4 Farm #5: 05-01-010-01W4
Ownership:	As described in the Protocol, ownership of offset credits generated under this protocol is assigned to the land manager/farmer. Since this is an emission reduction protocol, no accumulation of soil organic carbon is accounted for, and no carbon sink is attributed. As such, the land manager/farmer creates the reduction through implementing the improved nitrogen management practices prescribed through the 4R Nitrogen Stewardship Plan.

Table 1: Project Details	
	Proof of ownership over emission reductions is provided in the form of land title certificates for each field, in addition to agreements between the participating farmers and XYZ Inc. XYZ Inc. is the aggregator of all offsets arising from this project. XYZ Inc. must negotiate contractual agreements for the purchase of carbon offset credits with each of the land managers/farmers.
Reporting and Verification Details:	N/A – this document is an example of an Offset Project Plan for the Protocol Validation Study. This is the first mock-verification for this project. A second mock-verification will be completed by a qualified third party validator in Late Fall 2014. The verifier has no actual or perceived conflicts of interest associated with this project. This is the first project plan for this project. Verification is expected to occur on an annual basis, although the verification of smaller tonnes may occur every second year.
Project Registration:	N/A – the NERP Protocol Validation Study is a non-commercial exercise. Therefore, the project will not be registered in Alberta or in any other jurisdiction. However, it will be implemented according to ministerial guidelines.

1.2 Site Description - Legal Land Description of the Project and/or Other Unique Site Descriptions

This project is an aggregation of emission reductions across five farms in Alberta. The location of these farms is provided below[1]:

Table 2: Farm Coordinates			
Farm	Legal Land Description	Latitude	Longitude
Farm #1	01-01-010-01W4	53.521479	-112.015915
Farm #2	02-01-010-01W4	53.447117	-111.923904
Farm #3	03-01-010-01W4	49.387617	-112.438202
Farm #4	04-01-010-01W4	49.301725	-111.471405
Farm #5	05-01-010-01W4	49.214875	-111.631052

Note: the above coordinates are fictitious

1.3 Project Activity and Eligibility

This project activity meets all the eligibility criteria for the Alberta Offset System and has been completed in accordance with the most recent version of the Technical Guidance for Offset Project Developers (Version 4.0, February 2013)[2]. The Project complies with the Specified Gas Emitters Regulation Quantification Protocol for Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions, Version 1.0, October 2010.

Table 3: Alberta Offset System Eligibility

Criteria	How this Project Meets the Requirement
Start Date after Jan 1, 2002	The 4R Plans were implemented in January 2011.
Real, Demonstrable, and Quantifiable	The project offset credits were generated from activities that go beyond business as usual practices, producing quantifiable emission reductions under the Nitrous Oxide Emission Reductions Protocol.
Not Required By Law	The changes in practices were not required by law or regulation.
Clearly Established Ownership	Legal contracts between the land manager and XYZ Inc. exist. Within the contract, XYZ Inc. and the land manager have an agreement clearly establishing the XYZ Inc. as the owner of the credits.
Counted Once for Compliance Purposes	Any carbon offset credits generated in this project will be serialized on the registry for use in the Alberta Offset System only and will not be used or counted in any other jurisdiction. Note: The offsets generated from this project plan are not intended for use.
Verified by a Third Party	This project will be verified by a verifier meeting the requirements of the Alberta Specified Gas Emitters Regulation.
Have occurred in Alberta	All aspects of the Project occur in Alberta.
Be implemented according to a government approved quantification protocol.	The activities are implemented under the Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions Protocol V1.0, October 2010.
Be registered on the registry.	This document supports the registration of tonnes serialized by XYZ Inc. on the registry.

[2] http://environment.gov.ab.ca/info/library/8525.pdf

2 Contact Information

Project Developer Contact Information	XYZ Inc. John Abbott; President 1234 Main Street Red Deer, Alberta T4N 3T2 Canada 403-747-1234 403-747-5678 jabbott@xyzinc.com www.xyzinc.com	XYZ Inc. Michelle Abbott; Project Manager 1234 Main Street Red Deer, Alberta T4N 3T2 Canada 403-747-1234 403-747-5678 mabbott@xyzinc.com www.xyzinc.com
Authorized Project Contact	Optional depending on commercial arrangement.	

3 Other Project Information

3.1 Conditions Prior to Project Initiation

Each of the participating sections of land had been in operation for a minimum of three years prior to the implementation of the project. Furthermore, prior to the implementation of the project, a 4R Nutrient Stewardship Plan (built according to the NERP Protocol) had not been exercised for the sections of land and associated crops aggregated under this project. The NERP Protocol Validation Study will run until Fall 2015.

3.2 Description of How the Project Will Achieve Greenhouse Gas Emission Reductions/Removals

According to the Government of Alberta Quantification Protocol for Agricultural Nitrous Oxide Emission Reductions, the opportunity for generating direct and indirect emission reductions from this project is related to the implementation of a 4R Nitrogen Stewardship Plan at a basic, intermediate or advanced level of performance, relative to the baseline conditions.

Application of nitrogen (from manure, biological fixation, fertilizer, etc.) is an important component of agricultural production. Such applications, however, can lead to emissions of N_2O. Beneficial practices for nitrogen management, which synchronize the availability of nitrogen (N) with the requirements of the crop, minimize the emissions of N_2O per unit of crop production.

The protocol quantifies carbon offsets from projects which implement BMPs in the context of a comprehensive 4R (Right Source, Right Rate, Right Time and Right Place™) nitrogen

stewardship plan (hereinafter called the 4R plan) for their farms. The implementation of a 4R plan, including the BMPs specified in the 4R plan, reduces the N_2O emitted per kg of crop grown.

Emissions reductions are compared using a functionally equivalent unit of emissions reductions per kilogram of crop produced.

3.3 Project Eligibility

The project meets the requirements of the Nitrous Oxide Emission Reductions Protocol. The applicability criteria, sources and sinks, and quantification methodologies for the NERP Validation Study have been determined in accordance with the Government of Alberta Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions (October 2010, Version 1.0) and the most recent version of the Technical Guidance for Offset Project Developers (Version 4.0, February 2013). As described in the protocol, the project must conform to or meet certain criteria. Table 4 describes how the protocol criteria are met and the relevant section of the Offset Project Plan.

Table 4: Protocol Applicability Criteria

Applicability Criterion as per the Protocol[3]	How Criteria Are Met
The 4R Consistent Plan, including clear identification of the baseline and project condition has been accredited and signed by an Accredited Professional Advisor.	The 4R Consistent Plan for each farm has been signed by an Accredited Professional Advisor and is available at verification.
All farms being included in the project are being implemented according to the 4R Consistent Plan and have received annual sign-off by the Accredited Professional Advisor.	The Accredited Professional Advisor has confirmed that the 4R Consistent Plan is being implemented on an annual basis. Annual reports from each farm are available at verification.
New crops being added to the participating farms have correctly established three years of baseline data on crop events prior to including the crop in the farm/project.	Baselines have been correctly established for each crop included in the project.
Contracts are done through bilateral agreements between parties and should consider contracting guidance provided in the *Technical Guidance for Offset Project Developers*.	Contracts have been written considering the *Technical Guidance for Offset Project Developers*, and are available at verification.
The quantification of reductions achieved by the project is based on actual	Calculations of reductions achieved by the project are based on measurement and monitoring; and provided in the Offset

[3] Alberta Environment Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions (October 2010, Version: 1.0)

Table 4: Protocol Applicability Criteria	
Applicability Criterion as per the Protocol[3]	**How Criteria Are Met**
measurement and monitoring as required in this protocol.	Project Report. Sample calculations are provided below.
The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.	The Project meets the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System (See Table 3 above).

3.4 Flexibility Mechanisms

The Protocol identifies three (3) flexibility mechanisms for Project developers in quantifying offsets. Table 5 below identifies which of these flexibility mechanisms has been applied in quantifying offsets from the project. A justification of why the flexibility mechanism has been exercised is also provided. In addition, this project plan has applied two other flexibility mechanisms as an appropriate solution to address project-specific issues.

Table 5: Summary of Flexibility Mechanisms Applied		
Flexibility Mechanism as per the Protocol[4]	**Exercised (Yes/No)**	**Justification**
A Project Developer may choose to select non-consecutive years for crop events to set the baseline to match with data availability and to account for any extra-ordinary growing seasons. However, any gaps between baseline seasons or gaps between the baseline period and project implementation period must be justified such that they are not contributing to an over-estimate of greenhouse gas emission reductions. The verifier must provide a written statement of agreement with the approach selected by the Project Developer.	No	N/A
The Project Developer may exclude On-Site Fertilizer and Lime Distribution (Table 6 in the protocol - SS P7) from quantification where it can be demonstrated that no increased fuel use has occurred as a result of implementing	Yes	Emissions from fuel use in the project will not increase as a result of implementing the 4R Plan. The 4R Plan does not include an in-crop application of nitrogen fertilizer and thus

[4] Ibid

Table 5: Summary of Flexibility Mechanisms Applied		
Flexibility Mechanism as per the Protocol[4]	**Exercised (Yes/No)**	**Justification**
the 4R Plan (i.e. additional N applications during cropping).		fuel emissions will not be increased over baseline conditions. The APA has overseen the development and implementation of the 4R plan and has signed off that no extra crop nitrogen application occurred.
The protocol applies to a single component (nitrogen management) of farm operations. As such, this protocol can be combined with other protocols where multiple projects are undertaken to lower overall greenhouse gas emissions from farm operations.	No	N/A
Justification for exclusion of fields/acres due to catastrophic events in baseline or project (as per Saskatchewan version of NERP).	XYZ Inc.'s flexibility	In this event, where yields are devastated, trend data from AFSC's Alberta Management Insights or other yield trend data (http://www.agric.gov.ab.ca/app96/loadrptinput) is used to justify the exclusion.
In the case that a field is bisected by an ecodistrict boundary the project developer can use the ecodistrict with the most conservative emissions reduction estimate for the entire field.	XYZ Inc.'s flexibility	This approach is conservative.

3.5 Project Technologies, Products, Services and the Expected Level of Activity

The 4R Plan and BMP Performance Levels for Drier Soils (P/PE Ratio of <1) are provided in Table 6 below. The performance level implemented in this project is the basic level.

Table 6: The 4R Plan and BMP Performance Levels for Drier Soils

Performance Level	Right Source	Right Rate	Right Time	Right Place	Reduction Modifier
Basic	• Ammonium -based formulation;	• Apply N according to recommendation of 4R N stewardship plan*, using annual soil testing and/or N balance to determine application rate.	• Apply in spring; or • Split apply; or • Apply after soil cools in fall	Apply in bands / Injection	0.85
Intermediate	• Ammonium -based formulation; and/or • Use slow / controlled release fertilizers; or • Inhibitors; or • Stabilized N	• Apply N according to qualitative estimates of field variability (landscape position, soil variability)	• Apply fertilizer in spring; or • Split apply; or • Apply after soil cools in fall if using slow / controlled release fertilizer or inhibitors / stabilized N	Apply in bands / Injection	0.75
Advanced	• Ammonium -based formulation; and/or • Use slow / controlled release fertilizers; or • Inhibitors; or • Stabilized N	• Apply N according to quantified field variability (e.g. digitized soil maps, grid sampling, satellite imagery, real time crop sensors) and complemented by in season crop monitoring	• Apply fertilizer in spring; or • Split apply; or • Apply after soil cools in fall if using slow / controlled release fertilizer or inhibitors / stabilized N	Apply in bands / Injection	0.75

3.6 Identification of Risks

There are a number of issues associated with offset credits and the evidence that is required to support assurance. In their report titled "Scoping Study of Assurance Standards to Verify Agricultural Greenhouse Gas Offset Projects" (2011), KPMG identified a number of these risks and ways to mitigate them. Table 7 below was taken directly from KPMG's report and represents risks that are applicable to all agricultural offset credits. Table 8 presents' additional risks and control measures that are specific to the Nitrous Oxide Emissions Reductions Protocol. All of these control measures have been applied to this project.

Table 7: Risks Associated with Agricultural Offset Credits (Source: KPMG, 2011)

Risk	Evidence to provide a reasonable level of assurance	Recommended control to mitigate risk	Action taken to mitigate risk
Project developer does not have ownership of emission reductions.	Signed offset credit agreement between project developer and land manager laying out terms for transfer of offset credits.	Management review[5] and approval of offset credit agreements.	Management review of agreements completed.
Land manager does not have the right to assign emission reductions to project developer.	Signed offset credit agreement between project developer and land manager laying out terms for transfer of offset credits.	Management review of offset credit files for completeness of information regarding ownership and leasing arrangements.	Management review of offset credit files completed.
Land manager has already sold emission reduction rights on another registry to another project developer.	Signed offset credit agreement between project developer and land manager that clearly states the land manager has not sold offset credits previously under the protocol.	Management review of current NERP projects listed on the Alberta Registry.	Management review of projects on registry completed.
Fields claimed that do not exist in province of Alberta.	Checks on the legal land location to ensure it exists in Alberta through web-	Management review of offset credit files for	Management review of offset credit files completed.

[5] Defined as the analysis and evaluation of information prepared by one individual and reviewed by a second independent manager.

Table 7: Risks Associated with Agricultural Offset Credits (Source: KPMG, 2011)			
Risk	**Evidence to provide a reasonable level of assurance**	**Recommended control to mitigate risk**	**Action taken to mitigate risk**
	based mapping provided by the Government of Alberta (e.g. provincial base map or AGRISID*).	completeness of information.	
Data management system does not track required ownership, farming practices, etc.	Detailed listing of all fields/farms included in offset claim by year that links to information required to establish ownership, eligibility, 4R Plans and offset credit claimed.	Management review of data transparency (i.e. Linkages are maintained both ways between base data and field specific offset claims).	Management review of data completed.
Insufficient controls over stored data.	Process documentation relating to data management and record keeping for offset credits.	Restricted user access to offset claim calculations and data.	User access to database and credit calculations restricted by program security settings.
Incorrect formulae for calculating sequestered amounts.	Process documentation relating to data management and record keeping for offset credits.	Exception reports to identify duplicate records, incorrect emission factors records with values outside of expected parameters.	Exception reports generated.
Discrepancies between reported amounts of offsets and data management system.	Process documentation relating to data management and record keeping for offset credits.	Management review of reported data to ensure it is consistent with underlying offset credit data.	Management review of data completed.

* http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag3254#f4

Table 8: Additional Risks Associated with the Nitrous Oxide Emissions Reductions Protocol (Source: KPMG, 2011)			
Risk	**Evidence to provide a reasonable level of assurance**	**Recommended control to mitigate risk**	**Action taken to mitigate risk**
Accredited Professional Advisor (APA) is not accredited.	Review of Professional Advisor's credentials/certificate to ensure they meet the requirements noted in Appendix C of the protocol.	Management check of Professional Advisor credentials against professional association records and Canadian Fertilizer Institute's training program.*	Management cross check with professional association records completed.
Field size claimed is larger than actual field size, including parts of field physically unsuitable for crops.	Supporting documentation for field size (e.g. GPS track files from specific farm equipment, GPS shape files derived from field inspection, re-measurement of field size using Google earth, satellite data) showing deductions for unfarmed areas (roads, dwellings, gullies, wooded areas, etc.).	Management review to check records of field size calculations are complete AND Exception report to identify fields sized outside of expected ranges (e.g.> 160 acres).	Management review of calculation records.
Field practices claimed differ from those that occurred or are not fully substantiated.	Inspection records completed by field agent and APA that confirms that the 4R practices in the Plan were implemented. Includes the post-harvest assessment.	Management review of 4R practices data to ensure protocol requirements are met. AND Management review of offset credit files for completeness of 4R Plan/practices.	Management review of data and offset credit files for completeness.
Performance level implemented differs from performance level claimed.	4R Plan signed off by Accredited Professional Advisor.	Management review of 4R Plan to ensure it is signed off by Accredited Professional Advisor.	Management review of 4R plan.

* http://growzone.cfi.ca - The Accredited Professional Advisor certification training program link.

4 Inventory of Sources and Sinks

Table 9 below identifies all the sources, sinks and reservoirs (SSRs) as listed in the Government of Alberta Quantification Protocol for Agricultural Nitrous Oxide Emission Reductions (Version 1.0, October 2010). Specifically, the table states whether each source and sink is related, controlled, or affected by the project, whether they are included or not for quantification and whether they are included or not for the NERP Validation Study Project, with justification as to why.

Table 9: Baseline & Project Sources, Sinks and Reservoirs			
GHG Source, Sink, or Reservoir	Controlled, Related, Affected	Incl. / Excl. in Protocol	Included / Excluded in Project (with justification)
Baseline Condition:			
Upstream Sources and Sinks During Baseline Operation			
B1 Seed Production	Related	Exclude	Excluded as per protocol
B2 Seed Transportation (Off-Site)	Related	Exclude	Excluded as per protocol
B5 Fertilizer and Lime Production	Related	Exclude	Excluded as per protocol
B6 Fertilizer and Lime Distribution (Off-Site)	Related	Exclude	Excluded as per protocol
B9 Pesticide Production	Related	Exclude	Excluded as per protocol
B10 Pesticide Distribution (Off-Site)	Related	Exclude	Excluded as per protocol
B17 Fuel Extraction and Processing	Related	Exclude	Excluded as per protocol
B18 Fuel Delivery	Related	Exclude	Excluded as per protocol
Onsite Sources and Sinks During Baseline Operation			
B3 Seed Distribution (On-Site)	Controlled	Exclude	Excluded as per protocol
B4 Seed Use	Controlled	Exclude	Excluded as per protocol
B7 Fertilizer and Lime Distribution (On-Site)	Controlled	**Conditional Inclusion in Protocol**	**Excluded** as per protocol flexibility mechanism
B8 Fertilizer and Lime Use	Controlled	Include	Included as per protocol

Table 9: Baseline & Project Sources, Sinks and Reservoirs			
GHG Source, Sink, or Reservoir	Controlled, Related, Affected	Incl. / Excl. in Protocol	Included / Excluded in Project (with justification)
B11 Pesticide Distribution	Controlled	Exclude	Excluded as per protocol
B12 Pesticide Use	Controlled	Exclude	Excluded as per protocol
B13 Soil Crop Dynamics	Controlled	Include	Included as per protocol
B14 Farm Operations	Controlled	Exclude	Excluded as per protocol
B15 Crop Product Transportation (On-Site)	Controlled	Exclude	Excluded as per protocol
Downstream Sources and Sinks During Baseline Operation			
B16 Crop Product Transportation	Related	Exclude	Excluded as per protocol
B17 Crop Product Processing	Related	Exclude	Excluded as per protocol
Other Sources and Sinks			
B20 Building Equipment	Related	Exclude	Excluded as per protocol
B21 Transportation of Equipment	Related	Exclude	Excluded as per protocol
B22 Testing of Equipment	Related	Exclude	Excluded as per protocol
Project Condition:			
Upstream Sources and Sinks During Project Operation			
P1 Seed Production	Related	Exclude	Excluded as per protocol
P2 Seed Transportation (Off-Site)	Related	Exclude	Excluded as per protocol
P5 Fertilizer and Lime Production	Related	Exclude	Excluded as per protocol
P6 Fertilizer and Lime Distribution (Off-Site)	Related	Exclude	Excluded as per protocol
P9 Pesticide Production	Related	Exclude	Excluded as per protocol
P10 Pesticide Distribution (Off-Site)	Related	Exclude	Excluded as per protocol
P17 Fuel Extraction and Processing	Related	Exclude	Excluded as per protocol

Table 9: Baseline & Project Sources, Sinks and Reservoirs			
GHG Source, Sink, or Reservoir	Controlled, Related, Affected	Incl. / Excl. in Protocol	Included / Excluded in Project (with justification)
P18 Fuel Delivery	Related	Exclude	Excluded as per protocol
Onsite Sources and Sinks during Project Operation			
P3 Seed Distribution (On-Site)	Controlled	Exclude	Excluded as per protocol
P4 Seed Use	Controlled	Exclude	Excluded as per protocol
P7 Fertilizer and Lime Distribution (On-Site)	Controlled	**Conditional Inclusion in Protocol**	**Excluded** as per protocol flexibility mechanism
P8 Fertilizer and Lime Use	Controlled	Include	Included as per protocol
P11 Pesticide Distribution	Controlled	Exclude	Excluded as per protocol
P12 Pesticide Use	Controlled	Exclude	Excluded as per protocol
P13 Soil Crop Dynamics	Controlled	Include	Included as per protocol
P14 Farm Operations	Controlled	Exclude	Excluded as per protocol
P15 Crop Product Transportation (On-Site)	Controlled	Exclude	Excluded as per protocol
Downstream Sources and Sinks During Project Operation			
P16 Crop Product Transportation (Off-Site)	Related	Exclude	Excluded as per protocol
P17 Crop Product Processing	Related	Exclude	Excluded as per protocol
Other Sources and Sinks			
P20 Building Equipment	Related	Exclude	Excluded as per protocol
P21 Transportation of Equipment	Related	Exclude	Excluded as per protocol
P22 Testing of Equipment	Related	Exclude	Excluded as per protocol

Figure 1 and Figure 2 below are process flow diagrams representing the project and baseline conditions respectively.

Figure 1: Process Flow Diagram for the Project Condition

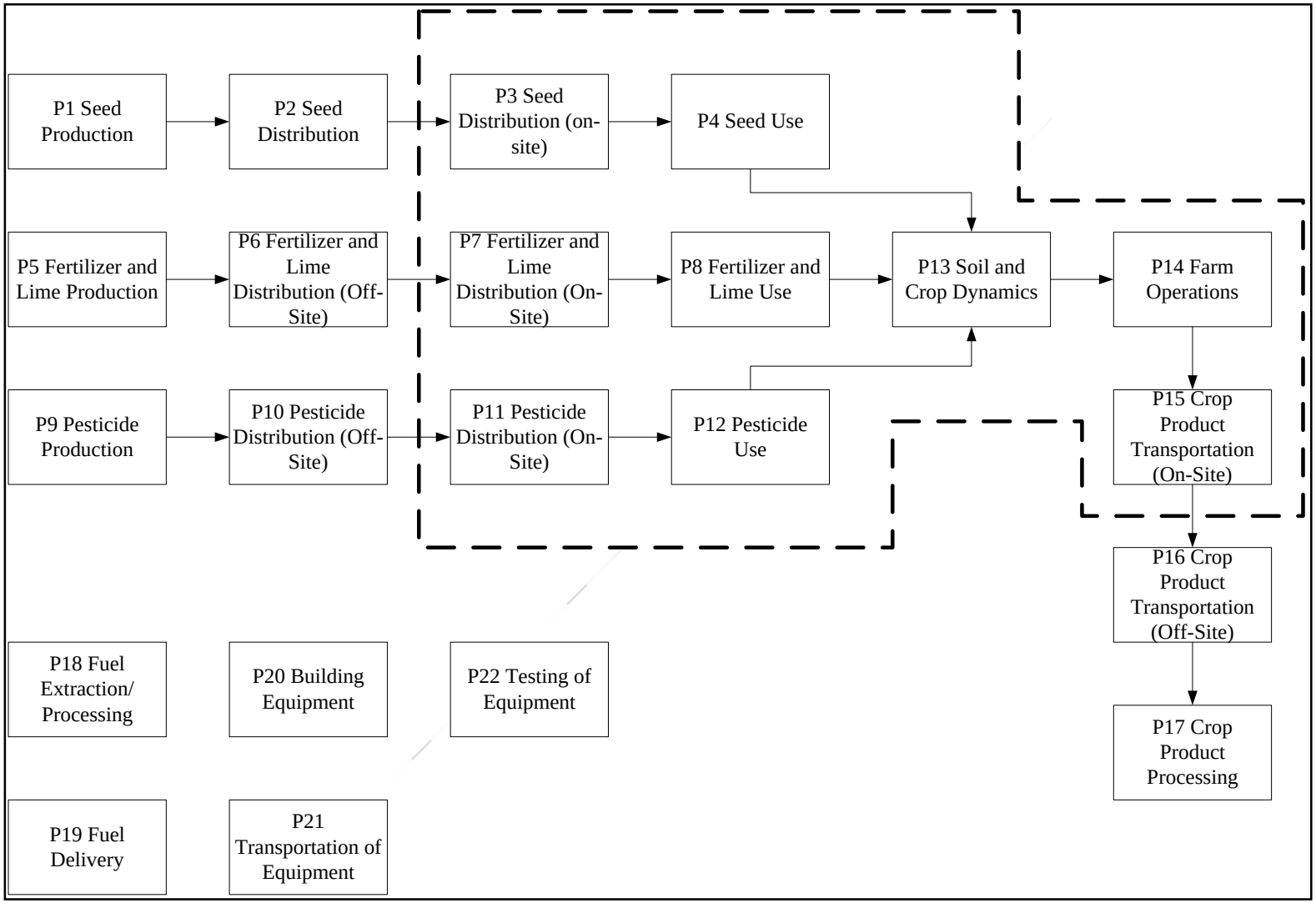
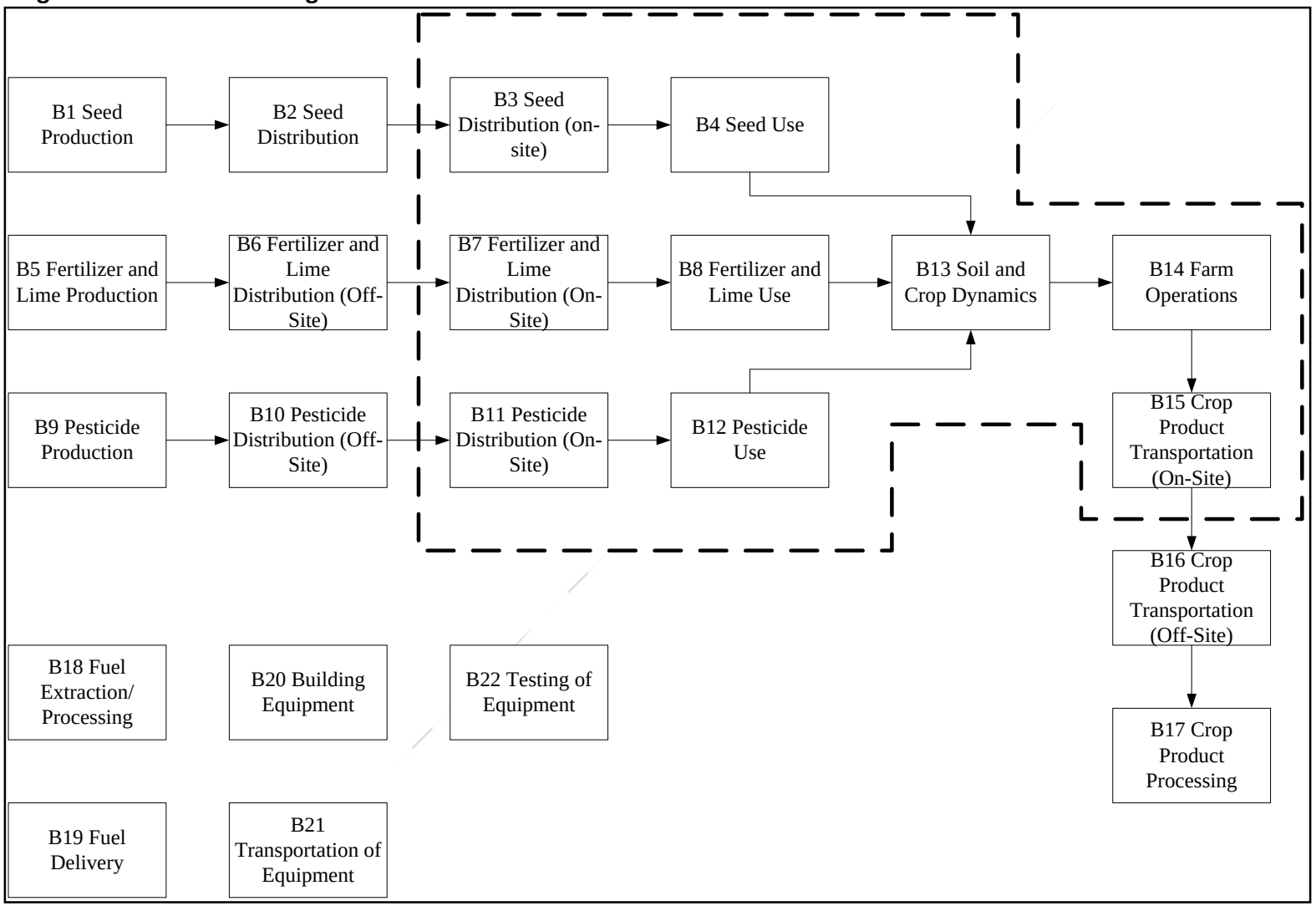


Figure 2: Process Flow Diagram for the Baseline Condition



5 Identification of the Baseline and Project

5.1 The Baseline Condition

The Baseline Condition represents the nitrogen fertilizer application rates for each crop produced, and the GHG emissions per kg crop associated with these rates of amendment, in place before the beginning of the project.

The Protocol implements a historic benchmark approach which estimates the baseline GHG emissions based on three years of site-specific data from crop events on farm operations prior to the implementation of a 4R plan. Comparable metrics are maintained between the baseline scenario and the project condition by calculating emissions per kg of crop produced. The baseline years for this project are 2008, 2009 and 2010.

For those growers with sophisticated nitrogen practices during baseline period, such as annual testing or variable rate application, incremental N_2O emission reductions are achieved through the application of a 4R Plan.

Table 10 below summarizes the baseline periods for each of the project sites aggregated under the NERP Validation Study.

Table 10: Baseline Period (Years) for Each of the Project Sites Aggregated

Farm:	Baseline Period:
Farm #1	2008-2010
Farm #2	2008-2010
Farm #3	2008-2010
Farm #4	2008-2010
Farm #5	2008-2010

5.2 The Project Condition

The project condition is defined by implementation of a 4R Plan. Quantifying N_2O in the project involves nitrogen inputs, time, placement, and the form of fertilizer, in addition to rate of fertilizer application.

To account for emission reductions achieved by project innovations (i.e. better nitrogen management), a reduction modifier is multiplied against the emissions calculated according to a method defined in the protocol, which is based on the National Emissions Inventory methodology for N_2O emissions from farmland.

The 4R Plan, with the associated BMPs required for each performance level, are implemented to achieve a reduction of N_2O emissions in the project as compared to the baseline scenario. As the performance level increases from basic to intermediate/advanced, the 4R Plan addresses more precisely field variability through the development of more

sophisticated BMPs. The greater the performance level, the more potential there is for emission reductions as shown by a smaller reduction modifier. Emissions in the baseline and project conditions are calculated using functionally equivalent units of kilograms (kg) CO_2e per kg of crop produced on a dry matter basis.

6 Quantification Plan

Section 4 of the Alberta Quantification Protocol for Nitrous Oxide Emission Reductions defines the appropriate methodology in quantifying emission reductions from related projects.

6.1 Quantification Methodology

Total emission reductions associated with the project are the sum of the emissions reductions calculated for each crop event for each crop grown on the farms. The sequence of calculations for each crop event is as follows:

1. The CO_2e emissions in the baseline and project conditions are calculated using functional units of kilograms (kg) CO_2e per kg of crop produced on a dry matter basis[6]. In the equations, the crop event will be referred to as 'crop i, zone j', representing the understanding that each project (farm) will consist of a number of crops, and each crop will be grown in a number of management zones.
2. The baseline condition is expressed for each crop event as the three year average kg CO_2e per kg of crop produced.
3. The project condition is calculated for each crop event on an annual basis using the same functional units.
4. The sum (kg CO_2e per kg crop produced) is multiplied by the appropriate reduction modifier for the selected 4R performance level to get the emission levels by project crop event;
5. The CO_2e reduction for each project crop event is calculated as the difference between the baseline emissions and project emissions (kg CO_2e per kg crop produced).
6. To get the total emission reductions (kg CO_2e) for crop events, multiply the reduction in number five above by the total kg of dry matter production for the crop and the total area (ha) of the crop fields and sub-fields (i.e. management zones) in the project.

[6] Dry matter weight = (actual weight) x (100 - actual moisture content) / (100 - standard moisture content); for example, grain has standard bushel masses and moisture content. ie: barley = 48lb/bu and 15.5% moisture, wheat = 60lbs and 14.5% etc. For standard moisture contents, refer to http://www.munros.com/grain_calc.html (US units) or http://www.hgca.com/tools.output/114/114/Tools/Agronomy%20Calculators/Grain%20Moisture.mspx?fn=grainMoisture (Metric Units).

This procedure is repeated for each crop event being included in the project condition to obtain the aggregate CO_2e emission reductions achieved through the implementation of the 4R Plan. See Appendix A for a sample calculation that walks through the steps above.

In certain project configurations, the implementation of the 4R Plan may result in additional fossil fuel consumption to spread fertilizer (e.g. split application) compared to management in the baseline scenario. If this occurs, the incremental project emissions from the distribution of fertilizer (Fert Dist P7) must be subtracted from the previously calculated CO_2e reductions that have been summed for all crop events. This will not be applicable in this project.

6.1.1 Summary of Equations

$$Emission\ Reduction_{Crop\ i} = \sum [Emissions\ Baseline_{Crop\ i} - (Emissions\ Project_{Crop\ i,\ Zone\ j} * RM_{PL}) * Area_{Crop\ i,\ Zone\ j} * Crop\ Production_{Crop\ i,\ Zone\ j}] - Emissions_{Project,\ Fert\ Dist}$$

$$Emissions\ Baseline_{Crop\ i} = CO_2e \text{ Baseline Intensity}_{\text{Crop i}}$$

$$Emissions\ Project_{Crop\ i} = \sum CO_2e \text{ Baseline Intensity}_{\text{Crop i}}$$

Where:

- $Emissions\ Baseline_{Crop\ i}$ = Average emissions over the three year baseline condition for crop$_i$ (kg CO_2e kg^{-1} of crop produced)
- $N_2O\ Baseline_{Crop\ i}$ = Component of emissions under SS B8 Fertilizer and Lime Use & B13 Soil Crop Dynamics for crop event$_i$ (kg N_2O kg^{-1} of crop produced)
- $Emission\ Project_{Crop\ i}$ = Sum of the emissions under the project condition for crop I from zones 1 through j (kg CO_2e kg^{-1} of crop produced)
- $N_2O\ Project_{Crop\ i}$ = Component of emissions under SS P8 Fertilizer and Lime Use & P13 Soil Crop Dynamics for crop event$_i$ (kg N_2O kg^{-1} of crop produced)
- $Area_{Crop\ i,\ zone\ j}$ = The area of the crop management zone in the project condition for crop event I as defined in Table 4.2 of the protocol (ha).
- $Crop\ Production_{Crop\ i,\ Zone\ j}$ = The production from the crop in the project condition for crop I in management zone j, expressed as dry matter, as defined in Table 4.2 of the protocol (kg).
- RM_{PL}= The emission reduction modifier as defined in Table 4.2 of the protocol, associated with the selected performance level.

- $Emissions_{Project,Fertilizer\ Dist}$ = Sum of the emissions under the project condition SS P7 Fertilizer and Lime Distribution

Table 11 below provides project specific details on how the protocol has been implemented in quantifying emission reductions from each project site included under this aggregation project. The table is based on the methodology defined in the protocol, and discusses the parameters introduced in the above equations.

Table 11: Measurement and Estimation Procedures for Each Quantification Parameter				
Protocol Parameter / Variable	Project-Specific Data	Measurement or Estimation Procedure	Measurement Frequency	Measurement Specifications and Estimation Justifications
B8/P8 Fertilizer and Lime Use & B13/P13 Soil Crop Dynamics				
Calculating Nitrous Oxide Emissions (kg N_2O /kg crop)				
Area of Crop Management Zone at Project Site Under Consideration	Dependent on performance level applied	Measured – direct through GPS shape or track files. See Section 6.4	Annually, if field dimensions or management zone dimensions have changed	The performance level applied to a specific field or management zone will impact the type of data referenced in determining the area under management. This project uses a 'basic' level of implementation so the field is the management zone (i.e. no subfield zones).
The Production or Yield of the Crop Management Zone	kg of dry matter	Direct measurement through yield monitors or load cells on grain carts. See Section 6.7	Continuous	The performance level applied to a specific field or management zone will impact the type of data referenced in determining the crop yield. This project uses a 'basic' level of implementation so the yield is measured on a field basis (i.e. no subfield zones).
Emission Reduction Modifier — RM_{PL}	Dependent on performance level applied	Protocol Table 1	Annually in calculation	Emissions modifier based on the 4R Plan undertaken by the project. Values are 0.85 or 0.75 which correspond to the implementation of basic or intermediate / advanced 4R Plans, respectively. This project will use the 0.85 value since basic 4R Plans will be applied to participating fields.

Table 11: Measurement and Estimation Procedures for Each Quantification Parameter				
Protocol Parameter / Variable	Project-Specific Data	Measurement or Estimation Procedure	Measurement Frequency	Measurement Specifications and Estimation Justifications
Direct Emissions of Nitrous Oxide from Crop Residue Decomposition				
Nitrogen Fertilizer Consumption per Crop Management Zone	kg of actual N / ha	Direct Measurement See Section 6.8	Continuous	Direct measurement is the most accurate method.
Emission Factor Related to Local Soil and Climatic Conditions	kg N_2O - N / kg N	Calculated using 0.022*P/PE-0.0048, where P/PE is the ratio of precipitation and irrigation to potential evapotranspiration for the area. Also integrates influence of texture, tillage, and topography.	Calculated annually	Protocol Appendix B, according to the ecodistrict in which the participating crops/acres reside – will include summing all N sources applied to soils (see manure N and residue N below).
Manure Nitrogen per Crop Management Zone	kg of actual N / ha	Measured or in some cases book values according to the Ag Operations Practices Act. See Section 6.10	Continuous	Direct measurement is the most accurate method. No manure is applied in this Project. But, manure N is accounted for in the total N applied and then uses Protocol Appendix B emission factors.

Table 11: Measurement and Estimation Procedures for Each Quantification Parameter				
Protocol Parameter / Variable	Project-Specific Data	Measurement or Estimation Procedure	Measurement Frequency	Measurement Specifications and Estimation Justifications
Total Amount of Crop Nitrogen that is Returned to the Cropland Annually	kg of actual N / ha	The crop N residue factors are estimated depending on the crop grown. See Section 6.9	Continuous	Estimated values as per Canada's National Emissions Inventory quantification process; as per Section 4.1.2.2 of the NERP and Appendix E, Table E.1.
Amount of Crop Nitrogen that is Returned to the Cropland Annually per crop				
Fraction of Total Area Under Crop that is Renewed Annually	Estimated for each field/management zone	For annual crops $FRAC_{renew} = 1$. In cases which crops are renewed on average every X years, $Frac_{renew} = 1/X$.	Annually	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies. (As stated in Protocol)
Ratio of Above-Ground Residues Dry Matter to Harvested Production for Crop	Estimated for each crop in each field/management zone	This value is determined using the Table E.1 in Appendix E of the protocol (6^{th} column)	Annually	Values are attained from Holos 2008 methodology (produced by agriculture and agri-food Canada) which is based on IPCC methodology but has been modified to account for Canadian specific conditions.
Nitrogen Content of Above-Ground Residues for Crop	kg nitrogen / kg dry matter Estimated for each crop in each field/management zone	This value is determined using the Table E.1 in Appendix E of the protocol (3rd column)	Annually	Values are attained from Holos 2008 methodology (produced by agriculture and agri-food Canada) which is based on IPCC methodology but has been modified to account for Canadian specific conditions.

Table 11: Measurement and Estimation Procedures for Each Quantification Parameter				
Protocol Parameter / Variable	Project-Specific Data	Measurement or Estimation Procedure	Measurement Frequency	Measurement Specifications and Estimation Justifications
Ratio of Below-Ground Residues to Harvested Production for Crop	Estimated for each crop in each field/management zone	This value is determined using the Table E.1 in Appendix E of the protocol (7th column)	Annually	Values are attained from Holos 2008 methodology (produced by agriculture and agri-food Canada) which is based on IPCC methodology but has been modified to account for Canadian specific conditions.
Nitrogen Content of Below-Ground Residues for Crop	kg nitrogen / kg dry matter	This value is determined using the Table E.1 in Appendix E of the protocol (4th column)	Annually	Values are attained from Holos 2008 methodology (produced by agriculture and agri-food Canada) which is based on IPCC methodology but has been modified to account for Canadian specific conditions.
Indirect Emissions of Nitrous Oxide from Volatilization and Re-deposition				
Fraction of Synthetic Fertilizer N Applied to Soils that Volatizes as NH_3^- and NO_x-N	(NH_3-N + NO_x-N) / kg	Default factor set at 0.1 for commercial fertilizer.	Annually	As per Canada's National Inventory Report Quantification process as stated in Protocol; based on fertilizer consumption per crop management zone above.
Fraction of Manure N Applied to Soils that Volatizes as NH_3-N and NO_x-N	(NH_3-N + NO_x-N) / kg	Default factor set at 0.2 for commercial fertilizer.	Annually	As per Canada's National Inventory Report Quantification process as stated in Protocol; based on manure applied per crop management zone above.
Emission Factor for N_2O from Nitrogen Redeposited after Volatilization	kg N_20 - N / kg N	Default factor set at 0.01 kg	Annually	As per Canada's National Inventory Report Quantification process as stated in Protocol; based on manure applied per crop management zone above.

Table 11: Measurement and Estimation Procedures for Each Quantification Parameter				
Protocol Parameter / Variable	Project-Specific Data	Measurement or Estimation Procedure	Measurement Frequency	Measurement Specifications and Estimation Justifications
Indirect Emissions of Nitrous Oxide from Leaching per Crop				
Fraction of Nitrogen Lost in Leachate	Estimated for each crop in each field/management zone	Calculated using 0.3247*P/PE-0.00247, where P/PE is the ratio of precipitation and irrigation to potential evapotranspiration for the area.	Annually	The $FRAC_{LEACH}$ value for each ecodistrict within Alberta is listed in Appendix B of the protocol. As per Canada's National Inventory Report quantification method. Irrigated fields use a $FRAC_{LEACH}$ = 0.3. The amount of nitrogen to which the FRAC value is applied, is the sum of the N fertilizer consumption, manure nitrogen and crop residue nitrogen per crop management zone in the equations above.
Emission Factor for N_2O from Leachate	kg N_20 - N / kg N	Default factor set at 0.025	Annually	As per Canada's National Inventory Report quantification process.

See Section 7 and Section 8 for further details on the project monitoring plan and the data management system and records, including data process flow diagrams, QA/QC procedures, data security and other information management procedures.

6.2 Approved Methodological Deviations from the Quantification Protocol

In those cases where a field was bisected by an ecodistrict boundary, the ecodistrict that has the most conservative emission reductions estimate was applied for the entire field. Otherwise, no modifications to the procedures outlined in the protocol were applied to this project.

6.3 Identification of Level of Management

Accurate assessment of the area of the field or management zones is essential in quantifying associated N_2O emission reductions. For the purposes of this aggregated project, each field, sub-field, crop, and/or sub-field management zone depending on the related performance level is identified. In addition, fallowed lands are also specifically identified to ensure the correct quantification methodology is applied. The associated data and quantification requirements will vary depending on the specific performance level applied and whether the specific area of land is fallow.

6.4 Calculating Area of Fields

Table 12 below states the data and supporting documentation needed to calculate area of fields under each of the three performance levels. This project collected documentation to meet the requirements of the basic performance level.

Table 12: Data and Documentation for Calculating Area of Fields

	Baseline	Basic Level	Intermediate Level	Advanced Level
Data Required	Total number of hectares seeded to each crop type by year for the three years used to establish the baseline	Number of hectares seeded to each crop type for each field included in the project	Number of hectares seeded to each crop type for each sub-field included in the project	Number of hectares seeded to each crop type for each sub-field, by slope and aspect, included in the project
Farm Sources (any combination of the data sources listed, depending on the section of land)	Farm records, GPS data, readings from seeding equipment	GPS data, readings from seeding equipment, legal land descriptions	GPS data	GPS data and digital maps
Supporting Documentation (any combination of the data sources listed, depending on the section of land)	AFSC records, CWB records, crop advisor records	AFSC records, crop advisor and/or APA records	Crop advisor and/or APA records	Crop advisor and/or APA records
Other sources	Aerial or satellite photos	Aerial or satellite photos	Aerial or satellite photos	Aerial or satellite photos

6.5 Testing of Soil and/or Tissue

In order to enact a 4R Nitrogen Stewardship Plan, soil tests are required. The specific data provided, based on the performance level of each field or management zone, are defined below. This project collected documentation to meet the requirements of the basic performance level.

Table 13: Data and Documentation for Testing of Soil and/or Tissue

	Basic Level	Intermediate Level	Advanced Level
Data Required	Field scale sampling and testing of soil to derive fertilizer rate requirements	Sub-field scale sampling and testing of soil to derive fertilizer rate requirements	Sub-field scale sampling and testing of soil to derive fertilizer variable rate requirements
Farm Sources (any combination of the data sources listed, depending on the section of land)	Lab reports, recommendations from crop advisors, reviewed by APA	Lab reports, field maps, recommendations from crop advisors, reviewed by APA	Lab reports, field maps, recommendations from crop advisors, reviewed by APA
Supporting Documentation (any combination of the data sources listed)	Lab reports, crop advisors and/or APA records	Lab reports, crop advisors, reviewed by APA and/or APA records	Lab reports, crop advisors, reviewed by APA and/or APA records

6.6 Crop Seeded

In order to calculate the nitrogen requirements and the nutrient uptake over the growing season, it is necessary to document the type of crop seeded. The data sources available for the baseline and the various project levels are noted in the chart below. This project collected documentation to meet the requirements of the basic performance level.

Table 14: Data and Documentation for Determining Crop Seeded

	Baseline	Basic Level	Intermediate Level	Advanced Level
Data Required	Types of crops grown in the three years used to establish the baseline	Crop grown for each field included in the project	Crop grown for each sub-field included in the project	Crop grown for each sub-field, by slope and aspect, included in the project
Farm Sources (any combination of the data sources listed, depending on the section of land)	Farm records, GPS data, readings from seeding equipment	GPS data, readings from seeding equipment	GPS data from seeding equipment settings	GPS data and digital maps based on seeding equipment
Supporting Documentation (any combination of the data sources listed)	Records from AFSC crop advisor, CWB	AFSC records, crop advisor and/or APA records	Crop advisor and/or APA records, including field visits	Crop advisor and/or APA records, including field visits
Other sources	Seed purchase receipts	Seed purchase receipts	Seed purchase receipts	Seed purchase receipts

6.7 Crop Yield

The collection of yield data for each crop event of each crop is key to the implementation of the protocol. To calculate dry matter, use the water content of the crop at time of sale[7].

Data is needed from field area measurements and total crop produced, but the means of obtaining this data are dependent on the performance level for which the 4R nitrogen management plan is designed. This project used the Basic performance level.

Table 15: Data and Documentation for Determining Crop Yield

	Baseline	Basic Level	Intermediate Level	Advanced Level
Data Required	Yield by crop grown for each of the three years used to establish the baseline	Yield by crop for each field included in the project	Yield by crop for each sub-field included in the project	Yield by crop for each sub-field, by slope and aspect, included in the project
Farm Sources (any combination of the data sources listed, depending on the section of land)	Farm records, GPS data, yield monitors, weigh wagon records	Farm records, GPS data, yield monitors, weigh wagon records	GPS data generated from yield monitors, weigh wagon records	GPS data and digital maps generated from yield monitors
Supporting Documentation (any combination of the data sources listed)	AFSC records, crop advisor records, bin counts	AFSC records, crop advisor and/or APA records	Crop advisor and/or APA records	Crop advisor and/or APA records
Other sources	Sales receipts	Sales receipts	Sales receipts	Sales receipts

[7] Dry Matter weight = (actual weight) x (100 - actual moisture content) / (100 - standard moisture content); for example, grain has standard bushel masses and moisture content. ie: barley=48lb/bu and 15.5% moisture, wheat =60lbs and 14.5% etc. For standard moisture contents, refer to http://www.munros.com/grain_calc.html (US units) or http://www.hgca.com/tools.output/114/114/Tools/Agronomy%20Calculators/Grain%20Moisture.mspx?fn=grainMoisture (Metric Units).

6.8 Fertilizer Input

The amount of fertilizer nitrogen applied for each crop management zone for each crop is required. The pattern of distribution for fertilizer (i.e. the distribution for each crop management zone), and the resolution of the documentation, will vary with the selected performance level. This project used the Basic performance level.

Table 16: Data and Documentation for Determining Fertilizer Input

	Baseline	Basic Level	Intermediate Level	Advanced Level
Data Required	Amount of nitrogen fertilizer applied per hectare by crop type across the full farm in each of the three years used for the baseline	Amount of nitrogen fertilizer applied per hectare by crop type for each field included in the project	Amount of nitrogen fertilizer applied per hectare by crop type for each sub-field included in the project	Amount of nitrogen fertilizer applied per hectare by crop type for each sub-field, by slope and aspect, included in the project
Farm Sources (any combination of the data sources listed, depending on the section of land)	Farm records, GPS data, readings from application equipment printouts/ electronic data	Farm records, GPS data, readings from application equipment printouts/electronic data	GPS data from application equipment	GPS data and digital maps generated from application equipment
Supporting Documentation (any combination of the data sources listed)	AFSC records, crop advisor records	AFSC records, crop advisor and/or APA records	Crop advisor and/or APA records	Crop advisor and/or APA records
Other sources	Fertilizer purchase receipts, custom application records	Fertilizer purchase receipts, custom application records	Fertilizer purchase receipts, custom application records	Fertilizer purchase receipts, custom application records

6.9 Crop Residues

For calculating the amount of crop residue nitrogen, above ground and below ground, accumulated in the year of interest per hectare for each crop. This estimate is made on the basis of yield, so the residue calculations are delineated on the fields according to the selected performance level in the same way as yield data is collected and reported.

In some instances, crop residue management may be complicated by events such as baling, burning, cattle turned into the field after harvest, etc. The implications of these events for nitrogen input calculations will need to be addressed in the 4R plan. For example, the amount of nitrogen removed in these events should be treated as crop yield and should be included in the post-harvest assessment of nitrogen uptake, using default or measured nitrogen values (including nitrogen retained in weight gain of grazing livestock) as appropriate for each performance level.

Table 17: Data and Documentation for Determining Crop Residues

Parameter	Units	Source
Annual average crop yield (dry matter)	Kg dry matter / ha	Yield is recorded by crop event, delineated by field, by sub-field, or according to GPS-based monitors.
Crop-specific factors	Kg N / kg	AGresidue_ratio, AGresidue_n_conc, BGresidue_ratio, BGresidue_N_conc from table F1 (Appendix F, Protocol)

6.10 Manure Application

If manure is used on the farm, the N_2O quantification method of Canada's National Inventory Report assumes that all manure nitrogen is available in the year of application. The specific data used to determine manure application, appropriate for each performance level, are listed below. This project collected documentation to meet the requirements of the basic performance level.

Table 18: Data and Documentation for Determining Manure Application				
	Baseline	**Basic Level**	**Intermediate Level**	**Advanced Level**
Data Required	Amount of nitrogen contained in manure applied per hectare by crop type across the full farm in each of the three years used for the baseline	Amount of nitrogen contained in manure applied per hectare by crop type for each field included in the project	Amount of nitrogen contained in manure applied per hectare by crop type for each sub-field included in the project	Amount of nitrogen contained in manure applied per hectare by crop type for each sub-field, by slope and aspect, included in the project
Farm Sources (any combination of the data sources listed, depending on the section of land)	Farm records, GPS data, readings from equipment	Farm records, GPS data, readings from equipment	Farm records, GPS data, readings from equipment	Farm records, GPS data, readings from equipment
Supporting Documentation (any combination of the data sources listed)	Lab reports, recommendations from crop advisors	Lab reports, recommendations from crop advisors and/or APA records	Lab reports, recommendations from crop advisors and/or APA records	Lab reports, recommendations from crop advisors and/or APA records
Other Sources	Livestock operation records, custom application records	Livestock operation records, custom application records	Livestock operation records, custom application records	Livestock operation records, custom application records

7 Monitoring Plan

XYZ Inc. has established and applied quality management procedures to manage data and information, including the assessment of uncertainty, relevant to the project and baseline scenario. Using transparency and accounting, XYZ Inc. has reduced as many uncertainties as possible that may be related to the quantification of GHG emission reductions or removal enhancements.

Those at XYZ Inc. who are responsible for the measurement work have been fully trained in all aspects of the field data collection, farmer interviews, and data analysis procedures. XYZ Inc. has developed Standard Operating Procedures (SOPs) for each step of the field measurements. These SOPs detail all phases of the field measurements and contain provisions for documentation, for verification purposes and so that field personnel can check previous results and repeat the measures in a consistent fashion. All of these procedures are included in XYZ Inc.'s process manual and associated documentation.

Copies (electronic and/or paper) of all field data, data analyses, and collected record/documentation; are uploaded into XYZ Inc.'s data management system. Copies of the measuring and monitoring reports are stored in a dedicated and safe place at XYZ Inc.'s office as well as on an offsite server.

The quantification plan used by XYZ Inc. involves collaboration of in-house agricultural expertise (APAs) as well as an IT team skilled in data management organization. The general approach to monitoring and data management is as follows: XYZ Inc.'s staff interview and collect data from farm operators who wish to claim offset credits generated through implementation of a 4R Plan, prepared cooperatively with an Accredited Professional Advisor – either an external party sourced by the farm operator, or XYZ Inc.'s APA staff. The collected data is then input into the agricultural data management organization's proprietary analytical database software, which stores and assesses a wide variety of farm, soil and cropping information. The analytical database is configured to collect and assess data specific to soil nitrogen management practices and 4R fertilizer systems, along with required records and documentation to support the assurance process. Details of the data collection and storage methodology are provided in the following sections.

7.1 Farm-Level Data Collection

In order to begin the offset project at a particular farm, XYZ Inc.'s field staff will initially conduct an on-site meeting with the farm operator. During this meeting, the field staff will:

a) Obtain the consent of the farm operator, through a producer contract, to quantify and claim the emissions reductions generated by NERP 4R practices and plan developed at the farm.

b) The agreement with the farm operator confirms the farm operator's legal status as owner of the offsets. A copy of the documentation will be retained in the farm file. The documentation may be in the form of:
    a. Land title documents
    b. Power of Attorney
    c. Lease agreements
    d. A signed Landlord Agreement
    e. Other documentation of similar quality
c) Obtain the consent of the farm operator to access crop insurance information through Agricultural Financial Services Corporation (AFSC), if applicable, and record the policy number.
d) Arrange for an APA to work with the farm operator to develop the 4R Plan in accordance with the NERP.
e) If possible at this point, obtain a signed document by the farm operator that he/she is following NERP 4R plans (i.e. the farm operator has already engaged an APA to get ready for the project).

7.2 Field-Level Data Collection

For each crop event that is managed using 4R plans and practices in a given year, XYZ Inc.'s staff will collect the following information:

1. The legal land description of each field to be included in the project.

2. The area of each field to be included in the project. Documentation supporting the method of area calculation will be maintained in the field file. The field area will be determined using one of the following methods, with a secondary corroborating piece of information as per Section 6 of this Plan:
    a. Calculation using GPS data
    b. Calculation from a legal survey
    c. Calculation based on aerial photographs
    d. Determination based on land title information
    e. Estimation based on the farm operator's knowledge and confirmed by a signed affirmation from the farm operator.

3. Determine the soil ecodistricts that the field is located in, as outlined in Appendix B of the protocol.

4. Obtain APA signed-off copies of the 4R Plan and practices used on each field, including the certificate in Appendix D of the Protocol, filled out by the APA. The XYZ Inc. field staff will conduct field investigations and collect supporting documentation and records from the farm operator regarding the crop, equipment and operating parameters for each field, according to Section 6 of this Plan.

5. Collect the post-harvest assessment performed by the APA to keep on the farm file in XYZ Inc.'s database.

XYZ Inc.'s field staff has the ability, if requested, to obtain crop insurance data on an annual basis from AFSC, based on the policy numbers provided by the land manager or farm operator. The information provided by AFSC includes:

a) Legal land descriptions
b) Number of acres insured
c) Crop type
d) Information on crop management practices including irrigation and tillage system.
e) Yield data

Tables 19 through 22 below outline the full monitoring plan.

Table 19: Monitoring Plan for Fields and Crops – Seeded Acres	
Source / Sink Identifier or Name	B8/P8 – Fertilizer and Lime Use - seeded acres included in these SS's.
Data parameters	1. Number of hectares seeded to each crop type for each field (basic level), sub-field (intermediate level) or sub-field by slope and aspect (advanced level) included in the project. 2. Number of hectares seeded to each crop type by year for three years to establish the baseline 3. Types of crops grown in the years used to establish the baseline. 4. Crops grown for each field (basic level), sub-field (intermediate level) or sub-field by slope and aspect (advanced level) included in the project.
Estimation, Modeling, Measurement or Calculation approaches	Measured using GPS data, readings from seeding equipment and/or maps/aerial photos/satellite photos. Measurements supported by AFSC records, hail insurance records, CWB records, crop advisor records, APA records, field visits and/or seed purchase receipts.
Data Unit	1. Hectares 2. Crop Type
Sources / Origin	Measured and recorded for each farm.
Monitoring Frequency	See Table 11 above for description - Annual
Description and Justification of Monitoring Method	This is the most accurate and practical method of measuring this parameter. Furthermore, the data is supported by appropriate evidence to verify its accuracy.
Uncertainty	There is a low level of uncertainty associated with the above parameters (hectares seeded and crop type) due to the possibility of data collection error or mis-representation of the data/information. However, this uncertainty is greatly reduced by cross-comparison with the information found in the required supporting documentation.
Provide the Details for any deviations from protocol including the justification and rationale	This method complies with the guidelines outlined in Section 5 of the protocol.

Table 20: Monitoring Plan for Soil and Tissue Testing	
Source / Sink Identifier or Name	B8/P8 – Fertilizer and Lime Use
Data parameter	1. Fertilizer rate requirements derived from field (basic level) or sub-field (intermediate/advanced level) soil sampling and testing
Estimation, Modeling, Measurement or Calculation approaches	Measured under the project condition – testing will be conducted at an accredited lab with a quality control/quality assurance program. Nutrient recommendations will be made.
Data Unit	Kg of N/ha
Sources / Origin	Measured and recorded for each farm.
Monitoring Frequency	See Table 11 above for description - continuous
Description and Justification of Monitoring Method	This is the most accurate method of measuring this parameter assuming that staff are correctly trained and equipment is correctly maintained.
Uncertainty	There is a low level of uncertainty associated with the above parameters due to the APA developing the soil testing and tissue testing sampling plan. Accredited labs are used to analyse the soil and tissue samples with reported uncertainties in the 0.001% range.
Provide the Details for any deviations from protocol including the justification and rationale	This method complies with the guidelines outlined in Section 5 of the protocol.

Table 21: Monitoring Plan for Timing and Form of Nitrogen Inputs	
Source / Sink Identifier or Name	B8/P8 – Fertilizer and Lime Use
Data parameters	1. Amount of nitrogen fertilizer applied per hectare by crop type across the full farm for each of the three baseline years. 2. Amount of nitrogen fertilizer applied per hectare by crop type for each field (basic level), sub-field (intermediate level) or sub-field by slope and aspect (advanced level) including: • The type of ammonium-based fertilizer applied; and • Timing of application 3. Amount of nitrogen contained in manure applied in the baseline and in the project. 4. Amount of manure applied per hectare by crop type across the full farm in each of the three baseline years. 5. Amount of manure applied per hectare by crop type for each field (basic level), sub-field (intermediate level) or sub-field by slope and aspect (advanced level). 6. Timing of manure spreading. 7. Results of soil tests tracking nutrient status of the soil. 8. Fertilizer nitrogen placement – place in bands either through injection or in concentrated sub-surface rows. The band must have a fertilizer spread that is not more than 30 per cent of the row laterally. 9. Amount of crop residue nitrogen.
Estimation, Modeling, Measurement or Calculation approaches	**Nitrogen Fertilizer** - Measured using GPS data or readings from application equipment. **Manure** – Measured and recorded in farm records which are supported by manure management plans, crop advisor records, feedlot records or custom application records. Crop available nitrogen for each year of manure application will be calculated following the steps outlined in the Alberta Nutrient Management Planning Guide. **Fertilizer Nitrogen Placement** – Percent band concentration will be calculated as follows:

	% Band Concentration = Width of Spread/Row Spacing* 100 where, *Width of spread* is determined by the type of opener; and *Row Spacing* is the distance between seed rows. Correct placement is supported by date stamped photos of spreading equipment, openers and row spacing of fields. **Crop Residue Nitrogen** – Estimated in the default values outlined in Appendix E of the protocol. See Table 11 above for a more in-depth description
Data Units	• Kg of N/ha • Kg of manure N/ha • % band concentration
Sources / Origin	Measured and recorded for each farm.
Monitoring Frequency	See Table 11 above for description - continuous
Description and Justification of Monitoring Method	**Nitrogen Fertilizer** - This is the most accurate method of measuring this parameter assuming that equipment is correctly maintained. Fertilizer amount, timing and type is supported by AFSC records, hail insurance records, purchase receipts, custom application records, crop advisor records or APA records. **Manure** –Manure management plans are a requirement for larger operations in Alberta under the Agricultural Operation Practices Act. The plans need to record where manure is sold to or given to and where it's being applied and at what rate. Nutrient content of the manure is also recorded in the plans. **Fertilizer Nitrogen Placement –** The method used follows the approach outlined in the protocol.

Uncertainty	Fertilizer and manure application equipment are calibrated to deliver the appropriate amount of fertilizer per hectare. Calibration records, cross-references with the above data sources provide corroborating evidence to ensure uncertainties are reasonable. The seed bed utilization check confirms the placement of the fertilizer is appropriate.
Provide the Details for any deviations from protocol including the justification and rationale	The above methods comply with the guidelines outlined in Section 5 of the protocol.

Table 22: Monitoring Plan for Yields	
Source / Sink Identifier or Name	B13/P13 – Soil Crop Dynamics
Data parameters	1. Yield of each crop for each of the three years used for the baseline. 2. Yield of each crop for each field (basic level), sub-field (intermediate level) or sub-field by slope and aspect (advanced level) on a dry matter basis.
Estimation, Modeling, Measurement or Calculation approaches	Measured and calculated using: • Field area • Water content of the crop at time of sale • Total volume of crop produced Supported by farm records, GPS data, yield monitors, weigh wagon records, AFSC records, hail insurance records, crop advisor records, APA records and/or bin counts.
Data Unit	Kg DM/ha
Sources / Origin	Measured and recorded for each farm.
Monitoring Frequency	See Table 11 above for description - continuous
Description and Justification of Monitoring Method	This is the most accurate method of measuring this parameter assuming that staff are correctly trained and equipment is correctly calibrated.
Uncertainty	Uncertainty in yield estimates is managed by cross referencing yield monitor, weight wagon records at a calibrated scale, and grain cart load cells to calculate the lower 95% confidence interval in the gathered estimates.
Provide the Details for any deviations from protocol including the justification and rationale	This method complies with the guidelines outlined in Section 5 of the protocol.

8 Data Management System and Records

The following sections describe the data management system and data controls that XYZ Inc. applied in the Project. The data management system employed by XYZ Inc. ensures that all information collected is complete, accurate, valid and secure. Relevant landbase and cropping information collected by XYZ Inc. is entered into the analytical database for the calculation of the GHG offset assertion. If applicable, the XYZ Inc. database staff will input the AFSC policy number for the farm operation. Once the details of a farm operation have been added to the database, the system generates a unique identifier for each field. Information is stored according to the name of the farm operation and the unique field identifier created for each field. The unique identifier will be linked to the farm identifier, and will be used to file all documentation associated with offset credits for that field. Documentation collected by the XYZ Inc. field agent will be maintained on file at XYZ Inc.'s office for a minimum of seven years from the date of the annual reductions/removals report in which the offsets are claimed, and up to seven years after the end of a project's crediting period.

8.1 Emission Reductions

The emission reductions generated on an annual basis under the project condition will be calculated using the methodology outlined in the Nitrous Oxide Emissions Reduction Quantification Protocol. The database has been designed to calculate the emission reductions based on the area, ecodistrict and 4R practices entered for each field. The appropriate ecodistrict emission factors, as well as indirect and direct emission coefficients and reduction modifiers, for each field are automatically selected based on the values provided in the NERP Protocol. Database reports will provide the calculated emission reductions per farm operation, per field and for the portion of the project managed by XYZ Inc.

8.2 Data Controls

The data monitoring and control plan utilized by XYZ Inc. was developed to address the following potential sources of error in the quantification process:

- Inaccurate details from farm operators
- Transcription error during data input into the databases
- Double-counting acres
- Changes to data in the system after it has been entered
- Calculation error due to database programming

The flow of data through the project, from collection to reporting is presented in Figure 3 below. The monitoring and controls for each of the six different data segments is outlined below.

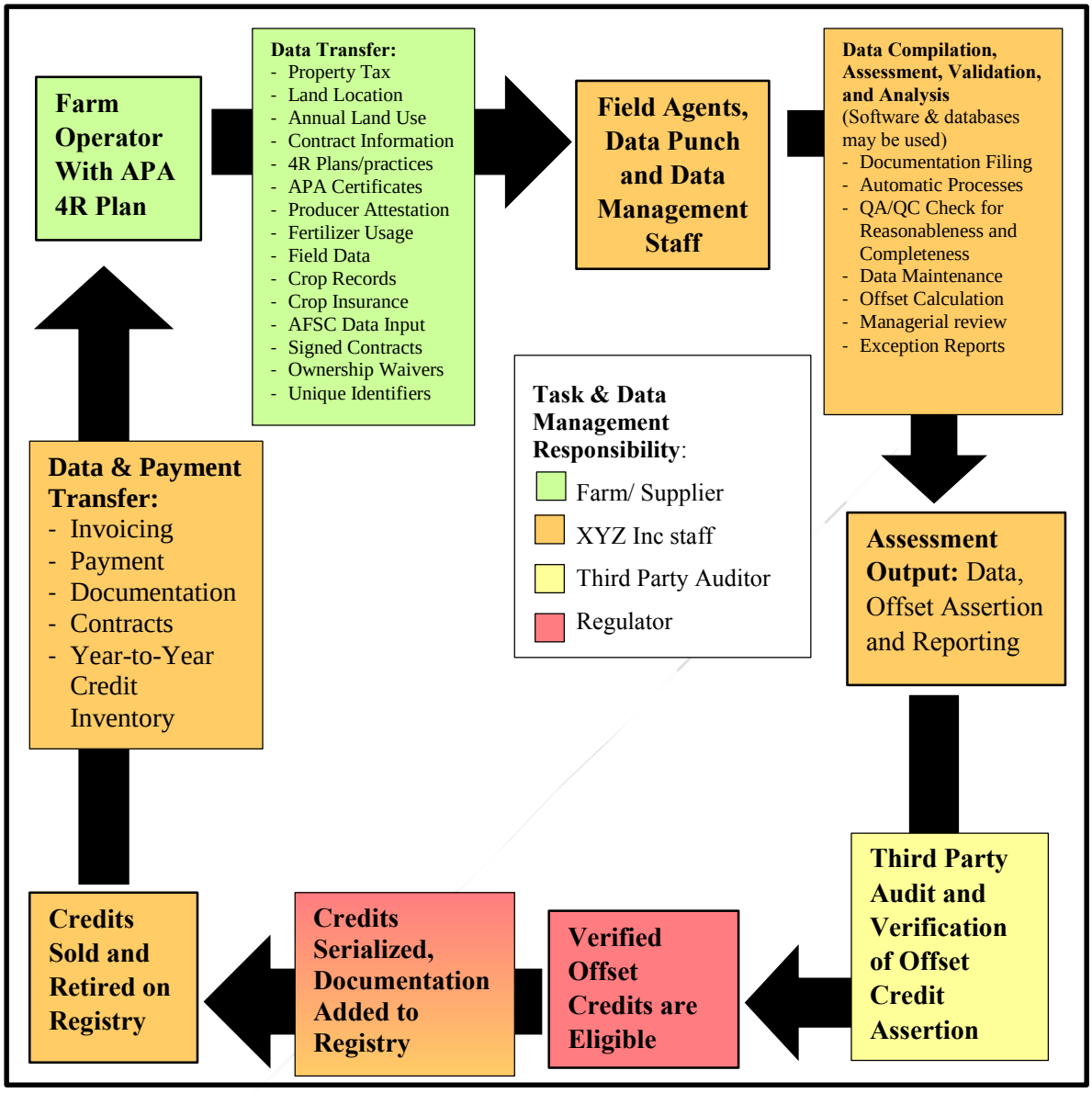


Figure 3: Data Management Process Flow for NERP 4R Offset Assessment, Assertion and Reporting

8.2.1 Data Collection from Farm Operators (Data Transfer)

The primary component of both the monitoring and control plan during collection of data from the farm operator is the experience of XYZ Inc.'s staff. The staff are a combination of trained field agents who are Certified Crop Advisors or Professional Agrologists or agricultural specialists with numerous years of experience in the agricultural sector. They are familiar with the geographical areas in which they are working and collecting data. During data collection, the field staff check the data provided by the farm operator for reasonableness based on their expertise and knowledge of the individual farm. The one-on-one interview with the farm operator also provides the field staff an opportunity to observe the farm's operating practices and ask questions if necessary.

For the purpose of this project, farm records are supported by the records and practices of the 4R Plan, which has been signed off by the APA. Implementation is assessed by either the farmer's selected APA, or a member of XYZ Inc.'s staff. The 4R plan is designed to manage uncertainty and risk to insure business success by forecasting crop returns and prices based on:

- Analysis of past planting practice records and experience;
- Crop acreage; and
- Crop input management (to balance strong crop growth with minimization of over-usage and waste of applied nitrogen sources).

In addition, XYZ Inc.'s staff ensures that the data provided is accurate by requiring the land manager or farm operator to sign affirming that the data is correct to the best of his or her knowledge.

8.2.2 Data Input into Database (Data Compilation, Assessment, Validation and Analysis)

Data entry into the agricultural management database is performed by XYZ Inc. using the notes they collected during interviews with the farm operator. During the data input stage, the database generates a unique identifier for each field in the project. The unique identifier is used to link the electronic data with hard-copy documentation, and provides a method of monitoring the data to prevent double-counting of acres. For example, the database administrator can search the database for a legal land description and ensure that there is only one unique identifier associated with that location.

To ensure data accuracy, multiple procedures and controls are built into XYZ Inc.'s aggregation database. The first control is the generation of a summary report at the land manager or farm operator level, which highlights any errors in the data in red and informs the aggregators of the errors that need to be fixed. When the system administrator runs a procedure to move the data into an aggregation pool, only fields without errors will be added to the pool.

The actual data entry stage allows a second opportunity for the XYZ Inc.'s aggregators to check the reasonableness of the data and to follow up with the land manger or farm operator to resolve any problems. The risk of transcription error at the data entry stage is mitigated by the use of trained personnel to enter the data and the user interface has been designed to guide the user during data entry by providing dropdown lists, etc. as much as possible. In addition, data that is missing or incorrect on the data entry screen is highlighted alerting the aggregator of an error. The purpose of this control is to give the user immediate feedback at data entry that they may have made a mistake or they are missing information.

The database only accepts annual seeded crops that have been identified in the 4R Plan as acceptable through a white list (approved crop) check that flags any non-approved crop as

an error in the system. Finally, the system has also been designed to not accept acreages larger than allowed by the legal land descriptor ensuring further quality assurance.

Also, once the data is moved into an aggregation pool it is locked and cannot be changed by anyone. To change data for a field that is in a pool, it must been removed from the pool, edited and then moved back into the Pool. This can only be done by a system administrator. Lastly, the user entering data must confirm that the backup documentation (contracts, proof of offset ownership, etc.) is in place.

8.2.3 Data Maintenance

Documentation collected by the aggregator will be maintained on file at XYZ Inc.'s office for a minimum of seven years from the end of the crediting period for this project. Documentation is filed according to the individual farm operation and field, using the unique field identifier generated by the database system.

Maintenance of electronic data integrity is accomplished by controlling access to the database. The electronic data associated with a farm or field can be edited by the aggregator or a database administrator until verification begins. Access to the data is controlled by a username and password. Subsequent to the start of a verification, no one but the system administrator can access the data.

8.2.4 Offset Calculation and Assertion

Offset calculations are performed automatically by the database using the methodology outlined in the NERP Quantification Protocol. The plan for monitoring the accuracy of the offsets calculated by the database is to have a manual check performed by XYZ Inc. personnel, and then management review and sign off. The manual check includes:

- Confirming that land being claimed is in the appropriate ecodistrict by using the ecodistrict look-up table provided by Alberta Agriculture and Rural Development.
    - Within the database, GIS latitude/longitude coordinates have been added to every quarter section in Alberta allowing the system to cross-reference the latitude/longitude for each quarter section to identify the appropriate ecodistrict.
        - All (100%) of the current pool's legal land descriptions submitted for aggregation are accounted for in the report.
    - XYZ Inc. pre-verifies four items on the document to match the aggregated pool database report:
        - Legal land description matches.
        - Acres on the land title are greater-than or equal to the acres.

  - If a discrepancy appears to exist between farm records and any other data, cross-referencing is performed. Below is an example of how data is cross referenced for certain data points of NERP.

- Cross-referencing AFSC data (where available) with the legal land description, area and crop yields.
- Cross-referencing other sources on certain data points with the claimed performance level (e.g. Alberta Management Insights for yields).
- Contacting the field agent or farm operator, referring to the backup documentation to resolve any discrepancies between AFSC data and the project data.
- Performing manual re-calculation of offsets for selected fields to ensure that the database programming uses the correct methodology.
- Identifying fields that have been confirmed to be correct for inclusion in the annual reductions/removals report using a checkbox built into the database.
- XYZ Inc. performs random manual re-calculation of offsets to ensure that the database programming uses the correct methodology.

The use of a manual check provides monitoring and quality control of the data at all stages of the project, and allows for feedback to improve the monitoring and control systems if necessary.

8.2.5 Reporting

The annual reductions/removals report consists of a summary table generated from the database which lists the offsets claimed by field. Only those fields which have been confirmed during the manual check will be included in the summary table.

8.2.6 Record Keeping

The record keeping practices of this project consist of:

- Electronic recording of values of logged primary parameters for each measurement interval;
- Printing of monthly back-up hard copies of all logged data;
- Retention of copies of logs and all logged data for a period of seven years; and
- Keeping all records available for review by a verification body for a period of seven years after the end of the crediting claims for the project.

8.3 Quality Control and Assurance

XYZ Inc. has employed a number of quality assurance/quality control (QA/QC) procedures to add confidence that all measurements and calculations have been made correctly. XYZ Inc.'s QA/QC methodology is largely incorporated into its analytical database program. This program has internal checks and balances to safeguard against human error and data entry mistakes. These procedures are summarized in Table 23 below.

Table 23: Quality Assurance/Quality Control Procedures and Plan

Area	XYZ Inc.'s Quality Assurance/Quality Control Procedure
Ensuring that changes to operational procedures continue to function as planned	Field agents visit the farm operation at least two or three times per year. At the field site visits they punch data into their tablets and upload to the main database information system. This information is checked by the database manager and flagged if deviations from the 4R Plan occur. The database manager alerts XYZ Inc. program manager and corrective actions are discussed with the farm operator and APA. If corrective actions cannot be implemented, then the program manager will decide if that field/operation will continue to participate in the project.
Ensuring the measurement and calculation system for GHG reporting remains in place and accurate	XYZ Inc.'s data management platform houses all coefficients and formulae needed for the calculations and has been programmed to perform the calculations based on Table 8 in the protocol.
Checking data validity	All acquired data undergoes a data filtering process prior to being processed (see Section 8.2). Emission factors and static factors have been programmed into XYZ Inc.'s data management platform and were checked at the time of development and reviewed by a technical expert.
Documenting errors and associated changes/updates in records and raw data	If duplicate records, incorrect emission factors or records with values outside of expected ranges are identified, they are updated or removed accordingly and the changes documented in an exception report. Likewise, any adjustments made to the raw data are recorded and explained.
Performing recalculations of quantification procedures to reduce the possibility of error	XYZ Inc.'s data management platform stores all coefficients and formulae needed for the quantification of emissions. The platform has been programmed to perform the calculations based on Table 8 in the protocol. When the platform was being created it was checked several times to ensure it was calculating emissions correctly and reviewed by a technical expert.
Data storage	All logged data, copies of logs and records are kept in their raw form so they are available for review by a verification

Table 23: Quality Assurance/Quality Control Procedures and Plan	
Area	XYZ Inc.'s Quality Assurance/Quality Control Procedure
	body for a period of seven years after the end of the crediting claims for the project.
Data and documentation record protection	All supporting evidence is scanned and uploaded into the carbon data analysis program. Likewise, back-up hard copies of all logged data are printed monthly.
Contingency plan for potential data loss	XYZ Inc. has taken several steps to avoid potential data loss, including backing up its electronic records on an offsite server and web-based cloud; as well as printing hard copies of all logged data. As a result, XYZ Inc. does not anticipate any data loss with a triple fail-safe mechanism.
Back-end controls	Management reviews and approves all agreements and records; and ensures completeness of farming activity information.

9 Project Developer Signature

I am a duly authorized corporate officer of the project developer mentioned above and have personally examined and am familiar with the information submitted in this offset project plan including the accompanying greenhouse gas assertion on which it is based. Based upon reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, I hereby warrant that the submitted information is true, accurate and complete to the best of my knowledge and belief, and that all matters affecting the validity of the emission reduction claim or the protocol(s) upon which it is based have been fully disclosed. I understand that any false statement made in the submitted information may result in de-registration of credits and may be punishable as a criminal offence in accordance with provincial or federal statutes.

The project developer has executed this offset project plan as of the _____ day of _____, 20_____.

Project Title: Enter name of project

Signature: _____

Date: Enter date
Name: Enter Name
Title: Enter title

Appendix A – Sample Calculation

An example calculation for spring wheat grown on Farm #4 is provided below. In this example the farm has implemented the basic performance level, involving (1) design and use of the 4R Plan; and (2) use of spring-banded instead of fall broadcast application of fertilizer. The farm is located in ecodistrict 737.

In the 2011 project year, 500 ha of spring wheat were grown using 55 kg of fertilizer N/ha to produce a yield of 3550 kg DM/ha. The dry matter crop yield was calculated using the water content of the crop at the time of sale. No manure or other sources of nitrogen were applied and the crop was not irrigated. Furthermore, no summerfallow was used on this farm in the baseline or in the project.

Baseline emissions were found to be an average of 0.229 kg CO_2/kg crop from 2008 to 2010.

The step by step procedure for estimating emissions from spring wheat for Farm #4 is provided below.

1. Calculating Nitrogen Inputs

In addition to the 55 kg of fertilizer N/ha applied, above and below ground crop residue N was calculated on a per hectare basis using the following formulas:

$N_{AG,wheat}$ = $Yield_{Wheat}$ * 1/Yield_ratio * AGresidue_ratio *AGresidue_N_conc

= 3550 kg DM ha^{-1} * 1/0.34 * 0.51 * 0.006 kg N kg^{-1}DM

= **31.950 kg N ha^{-1}**

$N_{BG,wheat}$ = $Yield_{Wheat}$ * Yield_ratio * BGresidue_ratio * BGresidue_N_conc

= 3550 kg DM ha^{-1} * 1/0.34 * 0.15 * 0.01 kg N kg^{-1}DM

= **15.662 kg N ha^{-1}**

$N_{res,\ wheat}$ = $N_{AG,wheat} + N_{BG,wheat}$

= 31.950 kg N ha^{-1} + 15.662 kg N ha^{-1}

= **47.612 kg N ha^{-1}**

2. Calculating Direct N_2O Emissions for Each Crop on an Area Basis

a. Direct Emissions from Fertilizer

The amount of fertilizer N applied to the crop was multiplied by the emission factor for the soil (EF_{ECO}). EF_{ECO} is an ecodistrict-specific factor which integrates the average F_{TOPO}, F_{TILL}, F_{IRRI}, and F_{TEXT} for the ecodistrict.

$N_2O_{FN,wheat}$ = $N_{Wheat} * EF_{ECO} * 44/28$

= 55 kg N ha^{-1} wheat* 0.009 kg N_2O-N kg N * 44/28

= **0.778 kg N_2O ha^{-1} wheat**

b. Direct Emissions from Crop Residue

The amount of crop residue N accumulated from the crop was multiplied by the emission factor for the soil (EF_{ECO}).

$N_2O_{res,wheat}$ = $N_{res,Wheat} * EF_{SOIL} * 44/28$

= 47.612 kg N ha^{-1} wheat* 0.009 kg N_2O-N kg N * 44/28

= **0.673 kg N_2O ha^{-1} wheat**

c. Direct Emissions from Manure

No manure was used on the farm and therefore there were no direct emissions from manure.

d. Total Direct Emissions from Spring Wheat

The direct emissions from fertilizer, crop residues and manure were then summed to get total direct emissions.

$N_2O_{D,wheat}$ = $N_2O_{FN,wheat} + N_2O_{res,wheat}$

= 0.778 kg N_2O ha^{-1} wheat + 0.673 kg N_2O ha^{-1} wheat

= **1.451 kg N_2O ha^{-1} wheat**

3. Calculating Indirect N_2O Emissions from Volatilization for Each Crop on an Area Basis

a. Volatilization Emissions from Fertilizer

The amount of fertilizer N applied to the crop was multiplied by the appropriate coefficient of volatilization ($FRAC_f$ for fertilizer and $FRAC_m$ for manure) and the emission factor for volatilized N (EF_{VD}). The values for $FRAC_f$ and EF_{VD} are constant across Canada.

$N_2O_{VD,wheat}$ = $N_{Wheat} * FRAC_f * EF_{VD} * 44/28$

= ((55 kg N ha^{-1} wheat* 0.1) + (0.00*0.2)) * 0.01 kg N_2O-N kg N * 44/28

= **0.086 kg N_2O ha^{-1} wheat**

b. Volatilization Emissions from Crop Residue

Not included in the calculation of indirect N_2O emissions as per IPCC convention.

c. Volatilization Emissions from Manure

No manure was used on the farm and therefore there were no volatilization emissions from manure.

d. Total Volatilization Emissions from Crop

The volatilization emissions from fertilizer and manure were then summed to get total direct emissions.

$N_2O_{VD,wheat}$ = 0.086 kg N_2O ha^{-1} wheat + 0 kg N_2O ha^{-1} wheat
= **0.086 kg N_2O ha^{-1} wheat**

4. Calculating Indirect N_2O Emissions from Leaching for Each Crop on an Area Basis

a. Leaching Emissions from Fertilizer

The amount of fertilizer N applied to the crop was multiplied by the appropriate coefficient of leaching ($FRAC_L$) and the emission factor for volatilized N (EF_L). The values for $FRAC_L$ are calculated for each ecodistrict in Canada, and are provided in Appendix B of the protocol. The value for EF_L is a constant of 0.025 kg N_2O-N kg N.

$N_2O_{L,F,wheat}$ = $N_{F,Wheat}$ * $FRAC_L$ * EF_L * 44/28
= 55 kg N ha^{-1} wheat* 0.190 * 0.025 kg N_2O-N kg N * 44/28
= **0.411 kg N_2O ha^{-1} wheat**

b. Leaching Emissions from Crop Residue

$N_2O_{L,Res\ wheat}$ = $N_{res,Wheat}$ * $FRAC_L$ * EF_L * 44/28
= 47.612 kg N ha^{-1} wheat* 0.190 * 0.025 kg N_2O-N kg N * 44/28
= **0.355 kg N_2O ha^{-1} wheat**

c. Leaching Emissions from Manure

No manure was used on the farm and therefore there were no leaching emissions.

d. Total Leaching Emissions from Crop

The leaching emissions from fertilizer and manure were then summed to get total leaching emissions.

$N_2O_{L,wheat}$ = $N_2O_{L,F,wheat}$ + $N_2O_{LF,manure}$
= 0.411 kg N_2O ha^{-1} wheat + 0.355 kg N_2O ha^{-1} wheat
= **0.766 kg N_2O ha^{-1} wheat**

5. Calculating Total CO_2e Emissions for Each Crop on an Area Basis

a. Total N_2O Emissions from Crop

The direct and indirect N_2O emissions from fertilizer, crop residues and manure were then summed to get total N_2O emissions from the crop.

N_2O_{wheat} = $N_2O_{D,wheat} + N_2O_{VD,wheat} + N_2O_{L,wheat}$

= 1.451 kg N_2O ha^{-1} + 0.086 kg N_2O ha^{-1} + 0.766 kg N_2O ha^{-1}

= **2.303 kg N_2O ha^{-1} wheat**

b. Convert to Total N_2O Emissions per Kilogram of Crop

The total emissions for the crop were divided by yield.

$N_2O_{wheat/crop}$ = (2.303 kg N_2O ha^{-1} wheat) / (3550 kg DM ha^{-1})

= **0.00064 kg N_2O kg^{-1} crop**

c. Convert to CO_2e Emissions per Kilogram of Crop

Emissions for the crop were multiplied by the global warming potential of N_2O.

$CO_2e_{wheat/crop}$ = 0.00064 kg N_2O kg^{-1} crop x 310 kg CO_2e kg^{-1} N_2O

= **0.198 kg CO_2e kg^{-1} crop**

d. Multiply by the Reduction Modifier and Calculate the Emission Reduction on a Kilogram of Crop Basis

The emissions were multiplied by the reduction modifier for the basic performance level (0.85). This value was then subtracted this from the baseline emissions* (on a crop basis).

Emission Reduction = 0.226 kg CO_2e kg^{-1} crop* - (0.198 kg CO_2e kg^{-1} crop x 0.85)

= **0.058 kg CO_2e kg^{-1} crop**

***Note:** Baseline emissions were calculated using the same general process, except the reduction modifier is not applied. For this project 2008-2010 data were used for the baseline.

e. Determine Total Credits in CO_2e

Finally, total credits were calculated by multiplying by the yield and crop area and then converting to tonnes.

Credits = 0.058 kg CO_2e kg^{-1} crop x 3550 kg DM ha^{-1} x 0.001 t/kg x 500 ha

= **102 t CO_2e**

The same method was used across all fields and farms in the aggregated project. In those cases where a field was bi-sected by an ecodistrict boundary, the ecodistrict that had the most conservative emissions reduction estimate was applied for the entire field.

10 References

KPMG – Advisory. (2011). Scoping Study of Assurance Standards to Verify Agricultural Greenhouse Gas Offset Projects