CLIMATE ACTION RESERVE

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Nitrogen Management

Project Protocol

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Abbreviations and Acronyms

BMP	Best management practices
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CH_4	Methane
CRT	Climate Reserve Tonne
CSNT	Corn Stalk Nitrate Test
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GHG	Greenhouse gas
Mg	Megagram
MSU-EPRI	Michigan State University and Electric Power Research Institute
N_2O	Nitrous oxide
N	Nitrogen
NCR	North Central Region of the United States
NH_3	Ammonia
NH_4^+	Ammonium
NMP	Nutrient or Nitrogen Management Plan
NO_3^-	Nitrate
NO_x	Nitrogen oxides
NRCS	Natural Resource Conservation Service of the USDA
NPS	Non-point source
NUE	Nitrogen use efficiency
Reserve	Climate Action Reserve
RTA	Ratio of removed to applied nitrogen
SSR	Source, sink, and reservoir
USDA	United States Department of Agriculture

1 Introduction

The Climate Action Reserve (Reserve) Nitrogen Management Project Protocol (NMPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with improvements in nitrogen use efficiency (NUE) in crop production. The NMPP is intended to be a modular protocol, which will expand to include additional activities that improve NUE, as more data becomes available.

The Reserve is a national offsets program working to ensure integrity, transparency, and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification, and verification of GHG emission reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of the U.S. carbon market.

Project developers and aggregators that initiate nitrogen management projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a nitrogen management project.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Nitrous oxide (N_2O), a potent agricultural greenhouse gas, is emitted as a product or by-product of the naturally occurring microbial processes of nitrification and denitrification. Nitrous oxide emissions from agricultural lands are generally related to the application of inorganic and organic nitrogen (N) fertilizer, or legume-derived N. Any factor or action that impacts N availability in the soil may impact N_2O emissions, due to the fact that higher levels of available mineral N increase the amount of N available for transformation through the nitrification-denitrification cycle.

Nitrous oxide emissions from agricultural lands in the U.S. are estimated at 204.6 Mt CO_2e, which make up 69.2 percent of total U.S. N_2O emissions, or 3.1 percent of total U.S. emissions. Although annual N_2O emissions from agricultural lands in the U.S. have fluctuated somewhat over the years, they were 3.4 percent higher in 2009 than they were in 1990.[2]

Nitrogen is an essential nutrient for plants, and agricultural producers have long supplied additional N soil amendments to their crops. During much of history, N was supplied to crops primarily in organic form such as through manure application and N-fixing legumes. However, during the latter part of the 19th century, inorganic N (typically synthetic fertilizer) replaced organic N as the main source of this nutrient, and today, inorganic N has become essential to world food production, contributing significantly to the 18 percent increase in global atmospheric concentrations of N_2O since 1750.[3] In addition to increased N_2O emissions, the increased use of inorganic N in agriculture has proliferated the N-losses to the environment in the forms of ammonia (NH_3), ammonium (NH_4^+), nitrogen oxides (NO_x), and nitrate (NO_3^-), which affect air and water quality and lead to significant disruptions to natural ecosystem functions.

Because N available to microbes drives N_2O emissions, any agricultural management practice that reduces the presence of excess mineral N in the soil is a good candidate N_2O emission reduction strategy. Specifically, N_2O emissions can be reduced with the implementation of nitrogen management practices that focus on improving the nitrogen use efficiency (NUE)[4] by matching nitrogen supply as exactly as possible with plant nutrient uptake to avoid the presence of excess N in the soil (i.e. less N applied for the same crop productivity). Determining the proper rate and timing of N applications during the year are important management decisions for agricultural producers. Using too little N may result in lower yields, poorer crop quality, and hence, reduced profits. When too much N is applied, yields and quality are generally not compromised (for most crops), but profit may be reduced and negative environmental effects can occur related to N leaching and nitrous oxide (N_2O) emissions.

The objective of a nitrogen management project under this protocol is to reduce N_2O emissions by adopting practices that further improve nitrogen use efficiency beyond what is projected to happen in the future, absent a carbon market.

[2] U.S. EPA. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C. Available at http://www.epa.gov/climatechange/emissions/usgginv_archive.html

[3] IPCC Fourth Assessment Report: Climate Change 2007. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

[4] The N Use Efficiency (NUE) is typically defined as "the proportion of all nitrogen inputs that are removed in harvested crop biomass" (Ribaudo et al., 2011).

This protocol provides eligibility criteria for approved nitrogen management practices and approaches for quantifying N_2O emission reductions that occur as a result of adopting the approved practices.

N_2O emissions are positively correlated with low soil pH, higher ambient temperatures, high water-filled pore space, soil compaction, available carbon substrate in soils, and available mineral N in soils.[5] These relationships result in significant variability in expected N_2O emissions and reduction potentials associated with different regions and crops across the U.S. They are also responsible for significant differences in the feasibility and efficacy of various nitrogen management practices for reducing N_2O emissions while maintaining or improving crop yield. As a result, this protocol contains region- and crop-specific eligibility criteria, as noted below, and employs system-specific GHG quantification approaches that are applicable to specific circumstances.

2.1.1 Nitrogen Management Practices Considered for this Protocol

The Reserve's Science Advisory Committee recommended certain practices that are likely to reduce N_2O emissions and have shown consistent results in scientific peer-reviewed literature, and those practices were prioritized for consideration as project activities. These candidate activities are summarized in Appendix B and listed below in Table 2.1, along with the Reserve's current assessment of data availability and existing quantification methods for these activities. Appendix A addresses the steps required for developing performance standards, particularly data needs for common nitrogen management practices, and Appendix D describes the criteria necessary to ensure that quantification methods are sufficiently rigorous and vetted in order to be included as a project activity in this protocol. The Reserve may add additional eligible project activities in future versions of the protocol if data and analyses support their inclusion and if robust quantification methods can be developed.

This version of the Nitrogen Management Project Protocol includes only one method for quantifying N_2O emission reductions from reducing N application rates, which is applicable only to N rate reductions for corn in the Corn Belt, or the North Central Region, as it is called in this protocol.[6] Section 5 provides further information on regions where the currently approved project activity is applicable. Additional quantification methods for N application rate reductions may be added in future versions of the protocol, covering additional regions and crop systems.

[5] Chantigny et al., 2010; Farahbakhshazad et al., 2008; Venterea and Rolston, 2000.
[6] See Table 2.2 below for applicability of the approved quantification methodology and for a list of states included in the North Central Region.

Table 2.1. Priority List of Nitrogen Management Practices

Potential Nitrogen Management Practice	Are comprehensive national data available to develop a performance standard?[a]	Is a standardized quantification methodology for N_2O emissions currently available that meets Reserve criteria?[b]
Reduce N Applied	Yes	Yes
Use of Nitrification and Urease Inhibitors[c]	Yes	No
Use of Nitrification Inhibitors (only)[c]	Yes	No
Switch from anhydrous to urea	No	No
Switch from Fall to Spring Application	Yes	No
Change to Slow Release Fertilizer	No	No
Change to Fertigation	No	No
Apply N Closer to Roots	No[d]	No
Add N Scavenging Cover Crops	No	No

a) This column represents whether or not data is available specifically through the USDA ARMS dataset, which the Reserve identified as the best available to develop performance standards for nitrogen management. Appendix A provides more detail on how the Reserve made this determination.
b) The Reserve shall only adopt quantification methodologies that are standardized, scientifically vetted, and conservative. Appendix D outlines general criteria that the Reserve considered when determining which quantification methodologies were sufficiently evaluated to include in this protocol.
c) Note that while the use of nitrification inhibitors was recommended both with urease inhibitors and on their own, the use of urease inhibitors (without nitrification inhibitors) is not a priority practice.
d) Although some N application method data is available, the Reserve does not believe the data is sufficient to develop a performance standard for changing N placement to apply N closer to the roots.

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project ("project") is defined as the adoption and maintenance of an approved project activity[7] that reduces nitrous oxide (N_2O) emissions.

The approved project activity may be implemented on a single field, known as a "single-field project," or may be implemented on two or more individual fields combined into a single project area, also known as an "aggregate." Specific requirements for aggregates are outlined in Section 2.4. Physical boundaries for individual fields must be defined according to the requirements in Section 2.2.1.

At present, only project activities listed in Table 2.2 below are considered approved project activities. However, implementation of additional best management practices and adaptive management practices are encouraged under this protocol, as discussed in Section 2.2.3, below.

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[7] Note that a project is defined by the adoption of practices; however, GHG reductions are quantified based on actual project performance in terms of reduced N_2O emissions.

Table 2.2. Definitions for Approved Project Activities

Approved Project Activity	Description	Applicable Crop	Applicable Region
Reduce N Applied	Reduction in the annual nitrogen application rate compared to recent historic application rates[8] at the site, without going below N demand[9]	Corn[10]	North Central Region[11]

2.2.1 Defining Field Boundaries

For the purposes of this protocol, an individual field must be defined by the following criteria:

1. The field must be under the direct management control of a single entity.
2. The field area must be continuous.
3. Management practices within the field boundary must be homogeneous, within a reporting period.[12] More specifically, in a reporting period, the same crop must be grown throughout the field and N fertilization dates must be the same (within fourteen days); N fertilization composition, placement, and cover crops must be implemented consistently throughout the field.N-application rate may vary across the field, so long as the total N applied is used as the input for all equations in Section 5. This protocol also explicitly encourages use of variable rate technology and other adaptive management strategies, as they may help enable the project activity while maintaining or increasing yields (see Section 2.2.3, below).

The field boundary, as defined by this protocol, should generally be similar, if not exactly the same, as the field boundaries that have been historically observed by the farmer for other BAU management purposes (e.g. tracking yield per field over time, but particularly during the baseline), and/or the field boundaries referenced in legal documents pertaining to all, or part of a parcel, of the property (e.g. contracts and other documentation of property sales). Fields should only be sub-divided beyond the traditional or legal boundaries if doing so is required to meet all three of the above criteria.

2.2.2 Defining the Cultivation Cycle

For the purposes of this protocol, a cultivation cycle is generally defined as the period starting immediately after harvest of one primary crop and ending after the next primary planted crop is harvested the following calendar year. A primary crop is defined as the main production crop grown on a field in a given year (e.g. corn is a primary crop and may be grown on its own or with

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[8] Nitrogen application rates in the project description are meant to include total N rate (e.g. the total of all synthetic and organic sources of N).
[9] The NMPP Science Advisory Committee recommended that "without going below N demand" be included in the project definition to ensure that this project activity should not be implemented such that yields are significantly affected. To prevent going below N demand, this protocol includes a performance standard based on a nitrogen use efficiency metric (see Section 3.5.1), encourages implementation of additional enabling practices (Section 2.2.3), and accounts for any leakage effects if yield is affected (see Section 5.4.2).
[10] Multi-year rotations that include other crops (e.g. soy, wheat) are eligible under this protocol; however, only emission reductions related to the corn cultivation cycle shall be credited.
[11] Defined in Section 3.1.
[12] Changes in management practices may be made from year to year (e.g. in different reporting periods), so long as management within a given field is homogenous for the purposes of defining the field's spatial boundary.

a cover crop). If there are multiple primary crops in rotation, each type of crop (e.g. corn in a corn-soybean rotation) has a distinct cultivation cycle. As Version 1.0 of this protocol is only applicable to annual corn crops, the cultivation cycle in Version 1.0 is further defined as approximately 365 days.[13] One complete cultivation cycle for corn in a corn-soy rotation, for example, begins with post-harvest residue management for the soy crop harvested in the fall of year one, continues with field preparation, seeding, and cultivation of the corn crop, and culminates upon completion of the corn harvest in the fall of year two.

2.2.3 Implementation of Enabling Practices

As noted in the project definition (Table 2.2), implementation of the project activity (reducing N application rate) should not result in such a significant N rate reduction that the N applied falls below N demand of the crop, resulting in yield loss. Though reducing one's N rate is the only creditable activity at this time, the NMPP recognizes that improved nitrogen use efficiency can be achieved through a variety of nitrogen best management practices that minimize the risk of yield losses.

This protocol encourages the adoption of additional best management practices as a way to enable N rate reductions, while maintaining or increasing yield. These enabling practices include, but are not limited to: practices listed in Table 2.1, practices listed in NRCS Conservation Practice Standard (CPS) 590, precision agriculture practices (particularly variable rate technology and yield monitors), and adaptive management tools (such as corn stalk nitrate tests,[14] pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials). In some cases, these practices may result in additional N_2O reductions beyond those quantified in this protocol; such reductions may be creditable under future versions of the protocol.

2.3 Project Developer

The project developer is an entity that has an active account in good standing on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Under this protocol, project developers may act as aggregators, who represent one or more fields participating in a project, or as developers of single-field projects. Project developers/aggregators may be a corporation or other legally constituted entity, city, county, state agency, agricultural producer, or a combination thereof. An individual farmer may serve as a project developer of a single-field project, as an aggregator for their own fields, or as an aggregator for a group of fields under different ownership or management. Farmers who elect to enroll in an aggregate and not serve as a project developer are referred to as "project participants." Project participants must have authority to make cultivation management decisions on their fields that are enrolled in the aggregate.

Project developers/aggregators act as official agents to the Reserve on behalf of project participants and are ultimately responsible for submitting all required forms and complying with the terms of this protocol. Project developers/aggregators manage the flow of ongoing monitoring and verification reports to the Reserve and may engage in other project development

[13] As the protocol expands in future versions, primary crops with cultivation cycles of less than a year (e.g. lettuce) or more than a year (e.g. perennials) may be included, which would likely necessitate changes in the definition of "cultivation cycle" as approximately 365 days.
[14] Corn Stalk Nitrate Tests (CSNTs) are required by this protocol for monitoring and verification of the project activity, at a frequency of one CSNT per field or one CSNT per 100 acres, whichever is lower. However, it is up to each individual project participant to use the CSNT results as an adaptive management tool.

activities such as developing monitoring plans, modeling emission reductions, managing data collection and retention etc., or may hire technical contractors to perform these services on their behalf. The scope of project developer/aggregator services is negotiated between the project participants and the project developer/aggregator and should be reflected in contracts between the project participants and the project developer/aggregator.

Project aggregators have the authority to develop their own internal monitoring, reporting, and other participation requirements for individual fields as they deem necessary, as long as these internal requirements do not conflict with any requirements outlined in this protocol.

Aggregators also have the discretion to exclude individual fields enrolled in their aggregate from participating in verification activities for any given reporting period; however, in such cases, there can be no CRTs issued for those fields in the aggregate total.

In all cases, the project developer/aggregator must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from all fields in the project. The project developer/aggregator must attest to this requirement by submitting a signed Attestation of Title form for single-field projects or Aggregator Attestation of Title[15] form for aggregates, prior to the commencement of verification activities each time the project is verified (see Section 8).

Although the aggregator must have exclusive claim to CRTs for the project to complete verification, this protocol does not dictate the terms for how that exclusive title will be established; allowing the aggregator, project participant, and land owner (if separate from the project participant) maximum flexibility for the terms of contracts between the respective parties. In the case of project activities taking place on leased fields (e.g. the project participant is not the land owner, but rather a lessee), the aggregator must notify the land owner with a Letter of Notification of the Intent to Implement a GHG Mitigation Project on the respective field.

As part of verification activities, verification bodies shall review contracts and letters of notification as a means of confirming exclusive title to the CRTs. The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the aggregator.

2.4 Project Aggregates

As noted above, incorporated into the NMPP is an option for project aggregation, with clear rules for how aggregation must be undertaken. Aggregators may provide appropriate technical expertise and fulfill protocol requirements on behalf of farmers in addition to providing other technical consulting services. In addition, aggregation allows for “economies of scale” within the methodology, allowing streamlined requirements for individual farmers while upholding rigorous quantification and verification standards at an aggregate level. This is primarily accomplished through pooling uncertainty and by sampling fields for verification activities.

2.4.1 Field Size Limits

The aggregate does not need to be comprised of contiguous fields, and can encompass numerous fields located on one farming operation or distributed amongst different farms and/or producers.

[15] The Reserve Aggregator Attestation of Title form is available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

There is no limit on the total number of acres enrolled in an aggregate, assuming each individual field meets the requirements of Section 2.2.1. There are, however, limits on how large a single field may be, in relation to the total combined acreage in an aggregate, as defined by Table 2.3 below. Field size limitations are in place to minimize the influence that a single large field may have on an aggregate's total emission reduction calculations, due to the random sampling used to verify aggregates.

Table 2.3. Maximum Field Size as a Percent of Aggregate Acreage

Number of Fields in Aggregate	Maximum Acreage of a Single Field (% of Aggregate Acreage)
2	70%
3	50%
4	33%
5 or more	25%

2.4.2 Entering an Aggregate

Individual fields may join an aggregate by being added to the aggregate's Project Submittal Form (if joining an aggregate at initiation) or by being added through the New Field Enrollment Form (if joining once the aggregate is underway).

Single-field projects that have already been submitted to the Reserve may choose to join an existing aggregate by submitting an Aggregate Transfer Form to the Reserve. The project aggregator will also need to submit a New Field Enrollment Form, listing that field. Emission reductions occurring on single fields or new fields entering an aggregate will start counting toward the aggregate CRTs in the reporting period immediately following the transfer. Because project start dates and reporting periods are tied to annual cultivation cycles, fields are encouraged to begin the process of entering an aggregate prior to completion of the cultivation cycle (e.g. prior to harvest) of the year immediately preceding that in which emission reductions will be registered as part of the aggregate.

2.4.3 Leaving an Aggregate

Fields must meet the requirements in this section in order to leave or change aggregates and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be attributed to one project for a complete reporting period, as defined in Section 3.3, and no CRTs may be claimed by a project for a field that does not participate and report data for a full reporting period.

Project activities on an individual field may be terminated and the field may elect to leave the aggregate at any time.

Individual fields may elect to leave an aggregate and participate as a single-field project for the duration of their crediting period. To leave an aggregate and become a single-field project, the project participant must open a project developer account on the Reserve and submit a Project Submittal Form to the Reserve, noting that it is a "transfer project" and identifying the aggregate from where it transferred.

Fields can switch their participation to another aggregate during a crediting period if, and only if:

1. The field changes ownership, tenant occupancy or management control during the crediting period and the new owner, tenant or manager has other fields already enrolled with a different aggregator.
2. The original aggregate is terminated (e.g. goes out of business).
3. The aggregator breaches its contract with the project participant and the contract is terminated.

Fields seeking to change aggregates during a crediting period under one of the above allowed circumstances must submit an Aggregate Transfer Form to the Reserve prior to enrolling in the new aggregate.

2.4.4 Changes in Land Ownership, Management or Tenant Occupancy

A field in an aggregate can change ownership, tenant occupancy or management control during a crediting period, and remain in the aggregate with uninterrupted crediting if, and only if, the following criteria are met:

1. The contract with the aggregator is transferred from the old to the new project participant.
2. The new project participant submits a Field Management Transfer Form to the Reserve via their aggregator prior to the beginning of the subsequent reporting period.
3. Implementation of the approved project activity continues without change until the end of the current reporting period.[16]

Where any of these criteria are not met, a field will forfeit the opportunity to generate CRTs for the reporting period during which the ownership, tenant occupancy or management control change occurs. The field may re-enter the aggregate at any time during the remainder of the 5-year crediting period by fulfilling the three requirements above.

[16] See Sections 3.3 and 7.4 for a description of reporting periods.

3 Eligibility Rules

Projects must fully satisfy all eligibility rules in order to register with the Reserve. All fields participating in a project must meet the following criteria, as well as the definition of a GHG reduction project (Section 2.2), in order for the project to be eligible.

Eligibility Rule I:	Location and Crop System	→	*U.S. and U.S. tribal areas, in areas corresponding to approved quantification approaches (see Table 3.1)*
Eligibility Rule II:	Start Date	→	*No more than six months prior to submission**
Eligibility Rule III:	Additionality	→	*Meet performance standard*
Eligibility Rule IV:	Regulatory Compliance	→	*Exceed regulatory requirements*
		→	*Compliance with all applicable laws*

* Except as otherwise permitted in Section 3.2.

3.1 Location and Crop System

Only projects located in the United States and on U.S. tribal lands are eligible to register reductions with the Reserve under this protocol. Project fields must be located in regions and employ crop systems for which there is an applicable quantification approach in this protocol. Table 3.1 lists the quantification approaches currently contained in this protocol along with their applicable geographic regions and crop systems. Not all fields within a project are required to be located in the same region.

Please also refer to the additional applicability criteria included in Section 5.1, which may further restrict eligibility in some of the states included in Table 3.1.

Table 3.1. Eligible Practice: State-Crop Combinations

Approved Practice	Eligible State-Crop Combinations[17]	
Reducing Amount of N Applied	Illinois	Corn
	Indiana	Corn
	Iowa	Corn
	Kansas	Corn
	Michigan	Corn
	Minnesota	Corn
	Missouri	Corn
	Nebraska	Corn
	North Dakota	Corn
	Ohio	Corn
	South Dakota	Corn
	Wisconsin	Corn

[17] Multi-year rotations that include other crops than those listed in Table 3.1 are eligible under this protocol; however, only emission reductions related to the corn cultivation cycle shall be credited. Both corn grown for grain and corn for silage are eligible.

3.2 Start Date

Each field has a unique start date, defined as the first day of a new cultivation cycle during which an approved project activity is implemented. The first day of a new cultivation cycle is defined as the first day after the field's previous harvest was completed for that field. The start date may be chosen as any date that coincides with the start of a cultivation cycle during which a project activity is implemented. Further, fields under the same management control or even within the same aggregate may have different start dates within the same year and/or may have start dates in different years, depending on when the project activity is first implemented on a given field. It is important to note, however, for fields that are part of an aggregate, the aggregate's reporting start date might differ from the field's start date (see Section 7.3.3).

To be eligible, a field must be submitted as a single-field project or join an aggregate before the end of the first cultivation cycle after the start date, unless the field is submitted during the first 12 months following the date of adoption of this protocol by the Reserve Board (the Effective Date, i.e. June 27, 2012).

For a period of 12 months from the Effective Date of this protocol (Version 1.0), fields with start dates on or after June 27, 2010 are eligible to register with the Reserve if submitted by June 27, 2013. Fields with start dates prior to June 27, 2010 are not eligible under this protocol. Fields may always be submitted for listing by the Reserve prior to their start date.

3.3 Crediting Period

The crediting period for fields under this protocol is defined as five eligible crop years, which may occur over a period of up to ten years. [18] An eligible crop year is defined as a year in which an eligible crop (see Table 3.1) is grown on the field. Eligible crop years do not have to be consecutive, but project reporting for each field must be continuous during a crediting period, with no gaps between reporting periods. This means that multi-year rotations that alternate between eligible and non-eligible crops must report project data for all time periods, including ineligible crop years, to maintain continuous reporting throughout the crediting period (see Section 6.4 for reporting requirements).

Crediting periods may be renewed one time (for a potential of ten eligible crop years of crediting). During the last six months of a field's first crediting period, project developers/aggregators may apply for a field's eligibility under a second crediting period. The project must meet the eligibility requirements of the most recent version of this protocol, including any updates to the Performance Standard Test (Section 3.5.1.1). The historic baseline established in the first crediting period of the project shall be used for the project's second crediting period.

The reporting period under this protocol is one complete cultivation cycle of an annual crop, approximately 365 days. Reporting periods in which a field does not meet the performance

[18] The time period over which a crediting period of five eligible crop years must be completed is based on a variable period of time (five to ten years), depending on how many eligible crop years are planted. For example, in the case of a corn-corn monoculture, the crediting period must be five consecutive years, while a corn-soy rotation may have a five year crediting period that extends over ten years, if corn is planted every other year. A more complex multi-crop rotation, however, in which the eligible crop is grown only every fourth year will likely be limited specifically by the ten year maximum crediting period, as opposed to limited by the five eligible crop years.

standard (see Section 3.5.1.1), or a field is withdrawn from participation in verification activities, still count as one of the five eligible crop years in the crediting period. Similarly, the field must continue to meet monitoring and continuous reporting requirements, even if not eligible to generate CRTs in a given year.

Crediting periods do not apply to aggregates, only to individual fields within an aggregate and to single-field projects.

The Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two five-year crediting periods after the field's start date, as defined above. If, at any point in the future, the approved project activity adopted on a field becomes legally required, emission reductions may be reported to the Reserve for that field up until the date that the practice is required by law to be adopted. Upon the effective date of the new legal requirement, the Reserve will cease to issue CRTs for GHG reductions for the legally required N rate reduction for that field (see Section 3.5.2 for further guidance).

3.4 Other Criteria

Section 5.1 specifies additional "applicability conditions," specific to each approved project activity, that must be met by each field implementing that respective project activity. Currently, Section 5.1 includes applicability conditions for implementing the only approved project activity: reducing N application rate.

Lands that have no cropping history prior to the earliest eligible start date under this protocol (June 27, 2010) are not eligible under this protocol. Further, project fields may not be located on lands that are classified as either highly erodible land (HEL) or wetlands, as classified by USDA NRCS's sodbuster and swampbuster provisions, respectively. In other words, to be eligible, project fields must meet the 1985 and subsequent Farm Bills' basic conservation compliance standards.[19]

Management records and/or data must be available on the history of crop production practices for at least the past five years prior to the field's start date. In case less than three eligible crop years were planted in the five years prior to the field's start date, the period shall be extended so that at least three eligible crop years are included. Further, the crop production system on a project field must be consistent with the past five years of management data (or extended years including the three eligible crop years) for that field. More specifically, the frequency of eligible crops grown in a multi-crop rotation must not increase due to the project (e.g. a multi-crop rotation shall not be replaced during the project with a corn-corn rotation nor with any other rotation that increases the frequency of corn crops while decreasing the frequency of others and/or the decreasing the diversity of a multi-crop rotation. However, the frequency of eligible crops grown may decrease (e.g. a corn-corn rotation may be changed to corn-soy or other multi-crop rotation).

[19] Please refer to the classifications for the HEL (sodbuster) and wetlands (swampbuster) as defined in the U.S. Code, Title 16, Chapter 58, Subchapter I-III. These classifications were established in the 1985 Food Security Act and were amended in 1990, 1996 and 2002. In general, the term "highly erodible land" includes land classified by the NRCS as class IV, VI, VII, or VIII, while "wetlands" have a predominance of hydric soil and are inundated or saturated by surface or groundwater for various durations over the year.

Increases or decreases in yields compared to pre-project yields are allowable. However, yield reductions may result in leakage effects that must be estimated and accounted for (see Section 5.4.2 for further guidance on accounting for leakage). The Reserve also encourages implementation of the additional best management practices listed in Section 2.2.3 as a way to mitigate the risk of perceived yield loss and to help ensure that yields are maintained (or increased) while the N rate decreases.

3.5 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all nitrogen management projects, established by this protocol. Performance standards are specified below according to the type of project activity being implemented.

The performance standard research and rationale for the specific performance standards outlined below are summarized in Appendix A.

3.5.1.1 Performance Standard for Reducing Nitrogen Application Rate

The performance standard for this project activity is based on a nitrogen use efficiency metric, calculated as a ratio of the amount of N removed by crop biomass to the amount of N available to the crop as a function of how much total nitrogen was applied to the crop. This ratio is referred to as the ratio of **r**emoved **t**o **a**pplied nitrogen (RTA). The RTA can be interpreted as a general measure of the nitrogen use efficiency.

A field passes the Performance Standard Test when its annual RTA, calculated for each eligible crop year of the project,[20] exceeds the applicable performance standard RTA threshold in Table A.7, which represents the calculated state average RTA.[21]

A field's RTA is calculated using Equation 3.1 below.[22] The calculation to determine a field's RTA and to demonstrate that a field passes the Performance Standard Test occurs *ex post* (e.g. after completion of the reporting period). However, the field's RTA is calculated using average historic yield, so a farmer can estimate *ex ante* the maximum N rate that will allow a given field to pass the Performance Standard Test.

[20] Fields are not excluded from program participation based on their pre-project RTA levels.
[21] The Reserve calls this the "calculated state average RTA" because this value it calculated based on mean N rate application and mean yield for each state. Data for calculating the true mean RTA of each state is not available.
[22] Equation 3.1 mirrors the equation used to calculate the state average RTA, with the exception that the yield and N rate values are state average values from a given survey year.

Equation 3.1. Annual RTA

$$RTA_f = \frac{(Y_f \times NC)}{NR_f}$$

Where, Units

RTA_f	=	RTA calculated for field *f*	
Y_f	=	Average historical yield for field *f* (over the time period defined below)	unit*/ha
NC	=	Default N concentration [0.36 kg N/bushel for corn grain and 3.22 kg N/US ton for silage]	kg N/unit
NR_f	=	Annual N application rate (including organic and synthetic forms of N) for field *f*	kg N/ha

* Unit may be bushels (in the case of corn grain) or short tons (in the case of corn for silage). To convert from unit/acre to unit/ha, divide by 0.405. Additional guidance on determining this equation's input parameters is provided in Section 5.1.

Average historical yield (Y_f) is defined as the average yield (per hectare per year) of the eligible crop (corn) over the five years prior to the field's start date. If less than three eligible crop years were planted in the five years prior to the field's start date, the average yield is calculated from at least three (and up to five) consecutive eligible crop years prior to the start date. If a catastrophic yield loss occurred due to anomalous weather during a historic eligible crop year, yield data for that year may be excluded from the calculation of average historical yield; however, if those yield data are excluded, the historic period over which the average historical yield is calculated must be extended to include the another historic eligible year (i.e. so that the same number of valid eligible crop years is used to determine the average historical yield). Verifiers will use their professional judgment to determine whether it was appropriate to exclude an anomalous yield for calculating Y_f. The average historical yield value will be fixed for the duration of a field's crediting period, but shall be (re)calculated at the start of each crediting period.

A field must pass the Performance Standard Test in a reporting period (i.e. annually) in order to be awarded CRTs for that reporting period. However, if a field does not pass the performance standard in an eligible crop year, it does not necessarily forfeit eligibility for the remainder of the crediting period. Rather, the field loses one of the five eligible crop years of its crediting period but maintains eligibility for the remainder of the crediting period, so long as the field maintains continuous reporting to the Reserve and is able to pass the performance standard in a future reporting period.

A field growing both eligible and non-eligible crops does not need to pass the performance standard in its non-eligible crop years to maintain eligibility, so long as N use does not increase significantly in the non-eligible crop years. Specifically, the N application rate in a non-eligible crop year of the project must be within 15 percent of the average N rate from the past five planting seasons for the non-eligible crop.[23] If the N rate for the non-eligible crop year is greater

[23] In the case that five previous seasons of data are not available for the non-eligible crop on a field, the average of the number of years available shall be used. If no data is available for a field, N rates for the same non-eligible crop applied to other fields managed by the project participant *or* N rate recommendations from Extension Service representatives for those non-eligible crops shall be used, whichever is lower.

than 15 percent of the historic average, the field will forfeit eligibility for the subsequent eligible crop year.[24] Verifiers shall review non-eligible crop year reporting data as part of their eligibility assessment for the next eligible crop year. See Section 6.3.3.2 for reporting requirements in non-eligible crop years.

3.5.1.1.1 Grace Period

At the beginning of a field's first crediting period, each field shall be given a grace period for the first two eligible crop years to meet or exceed the applicable RTA performance threshold in Table A.7. During the grace period, a modified performance standard shall be applied, in which the field passes the performance standard so long as the field's RTA increases each reporting period. Implementation of the approved project activity shall be fully creditable during this grace period. However, CRT issuance will be delayed for all CRTs generated by a field during its grace period, until such time as the field's RTA meets or exceeds the RTA threshold established in Table A.7. Once a field has completed verification for the reporting period in which it meets or exceeds the RTA threshold, CRTs shall be issued for all emission reductions achieved during the grace period. Fields must pass the performance standard in the reporting period associated with the third eligible crop year to receive any credits for the grace period; if the field does not pass the performance standard in the third eligible crop year, CRTs generated, but not issued, during the grace period will be forfeited.

3.5.2 The Legal Requirement Test

All fields enrolled in a project or aggregate are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by approved project activities on those fields would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A field passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, binding contractual obligations,[25] or other legally binding mandates (including, but not limited to, legally mandated nutrient management plans,[26] conservation management plans, and deed restrictions) that require adoption or continued use of approved nitrogen management project activities on the field.

To satisfy the Legal Requirement Test, project developers of single-field projects must submit a signed Attestation of Voluntary Implementation form, while aggregators must submit a signed Attestation of Voluntary Implementation form on behalf of all project participants in the aggregate.[27] Attestations of Voluntary Implementation must be signed and submitted to the Reserve prior to the commencement of verification activities each time the project or aggregate is verified (see Section 8). Individual project participants who are part of an aggregate will not be required to attest to the voluntary nature of project activities to the Reserve. However,

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[24] This percent threshold prevents the project participant from increasing the non-eligible crop's N use to intentionally build residual N on the field, which would result in N reductions in subsequent eligible years that may be larger than would have otherwise been possible without risk of yield loss.

[25] Contracts with NRCS that must be signed by a grower in order to receive EQIP funds are not considered "legally binding mandates" for the purposes of this Legal Requirement Test, if the only repercussion of violating the contract is not receiving the aforementioned financial incentive (e.g. there is no fine, notice of violation, or other legal penalty levied).

[26] If Nutrient Management Plans are legally required, but do not require N rate reductions or specify N rate targets that would require reductions, the field passes the Legal Requirement Test because the project activity (reduce N rate) is not specifically required. Verification bodies shall evaluate such plans and use their professional judgment to make a determination.

[27] Form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

supporting documentation should be made available to the verification body during verification, if requested. In addition, the Single-Field Monitoring Plan (Section 6.1) must include procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test, while the Aggregate Monitoring Plan (Section 6.2) must similarly include procedures that the aggregator will follow to ascertain and demonstrate that all fields in the aggregate at all times pass the Legal Requirement Test.

A summary of research performed on federal and state requirements is provided in Appendix C. This summary includes extensive background on the Clean Water Act (CWA) and other important water quality laws, as well as other regulations related to synthetic N fertilizer, manure N, and their uses.

As of the Effective Date of this protocol, the Reserve could identify no existing federal regulations that explicitly obligate agricultural producers to adopt the nitrogen management practices approved under this protocol. When watersheds are successfully meeting the CWA water quality standards, agriculture sources are generally unregulated. However, the Reserve has identified circumstances, particularly where watersheds are not in compliance with CWA water quality standards, in which state- and local-level regulations enacted to implement the federal CWA may require nutrient management plans (NMPs) and/or require implementation of some of the nitrogen management practices approved as project activities. More specifically, once a watershed is identified as "impaired,"[28] if any agricultural non-point source[29] is identified as contributing to a watershed's impairment, agricultural non-point sources in that watershed may become limited by a non-point source pollution obligation (e.g. a field- or region-specific obligation to help meet a total maximum daily load (TMDL)[30] or other policy mechanism chosen to meet that obligation).

Due to localized implementation of the CWA and TMDL strategies, the extent to which nutrient management plans become effectively required by law may vary greatly in terms of flexibility and what is explicitly required (e.g. a project participant may be allowed to self-select practices to include in an NMP for their field, while elsewhere an explicit N rate reduction may be required). Once a practice is required or is self-selected by a project participant for CWA compliance, the Reserve considers that practice a non-voluntary legally binding mandate, as continued implementation of that practice is required by law, and that practice will not be considered an eligible project activity for that farm.

Further, fields that are located in impaired watersheds with established TMDLs for nitrogen that identify agriculture as a source of impairment shall not pass the Legal Requirement Test *unless*

[28] A watershed is identified as impaired when it is not in compliance with Clean Water Act water quality standards. Once identified as "impaired," a watershed is added the "Impaired or Threatened Waters List," also known as the CWA's "303(d) List." As this list is updated frequently, project developers and verification bodies should refer to the U.S. EPA website for the most current list of impaired watersheds: http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T

[29] A "non-point source" is defined by the Clean Water Act as any source of water pollution not meeting the legal CWA definition of "point source." The term "point source" is defined by the CWA Section 502(14) as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged." The CWA point source definition goes on to explicitly state that agricultural storm water discharges and return flows from irrigated agriculture are not considered point sources.

[30] The maximum contaminant level for Nitrate-N (concentration of 10 mg/L) according to the Safe Drinking Water Act (e.g. the highest level of a contaminant allowable in drinking water). is often referenced when developing total maximum daily loads (TMDL) and can serve as a minimal target, and is included here for reference.

the field (and/or appropriate non-point source under which discharges from the field would be categorized) has been specifically identified as *not* contributing to the watershed's impairment.

If the approved project activity (N rate reduction) of an eligible field later becomes legally required, emission reductions may be reported to the Reserve for that field up until the date that the practice is required by law to be adopted. Upon the effective date of the new legal requirement, a field may no longer report emission reductions to the Reserve.

The Legal Requirement Test is applied to each field, so if one field in an aggregate becomes legally required, it shall not affect the other fields in the aggregate.

3.5.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single field, it is referred to as "credit stacking" or "payment stacking," respectively.[31] Under this protocol, credit stacking is defined as receiving more than one mitigation credit for the same activity on spatially overlapping areas (i.e. in the same acre). Payment stacking is defined as issuing mitigation credits for a best management or conservation practice that is funded by the government or other parties via grants, subsidies, payment, etc. Mitigation credits are used to offset the environmental impacts of another entity such as emissions of GHGs, removal of wetlands or discharge of pollutants into waterways, to name a few.

3.5.3.1 Credit Stacking

Based on a review of mitigation credit markets in the U.S., water quality trading is the only ecosystem services market that would credit nutrient-reducing activities. Water quality trading programs (WQTP) are being developed across the country as an optional tool for compliance with the Clean Water Act. While there are many water quality trading programs under development, as of the effective date of this protocol, there were no active WQT markets identified that had issued nutrient reduction credits to agricultural sources for the approved practice (N rate reduction) in eligible project locations under this protocol (see Table 3.1).[32] As such, credit stacking is not addressed by the protocol at this time.

Research on WQTP to date suggests that these programs are highly variable due to the localized nature of program development and enforcement as allowed under the Clean Water Act. The Reserve will continue to track the development of relevant WQTP and will update this section as programs are implemented. This section will also be updated as the protocol is revised to include additional approved practices and/or geographic regions.

3.5.3.2 Payment Stacking

The Reserve has identified three USDA Natural Resource Conservation Service (NRCS) programs that provide payments nationwide to support the implementation of agricultural best management practices (BMPs). Authorized by the 2008 Farm Bill, the Environmental Quality Incentives Program (EQIP), the Agricultural Water Enhancement Program (AWEP), and the Conservation Stewardship Program (CSP) are national programs that are implemented at the

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[31] Cooley, D., & Olander, L., September 2011.

[32] The following WQTP that allow nutrient trading between point sources and agricultural non-point sources were assessed: The Great Miami River Watershed Water Quality Credit Trading Pilot (OH), Red Cedar River Nutrient Trading Pilot Program (WI), Southern Minnesota Beet Sugar Cooperative Program, Alpine Cheese Phosphorus Nutrient Trading Plan (OH), Kalamazoo River Demonstration (MI), and Rahr Malting Company NPDES Permit (MN). None of these programs have issued water quality credits to cropland for fertilizer reduction activities.

state- and county-level. NRCS expressly allows the sale of environmental credits from enrolled lands,[33] but does not provide any additional guidance on ensuring the environmental benefit of any payment for ecosystem service stacked with an NRCS payment.

All NRCS programs share a common set of conservation practice standards that contain information on why and where the practice is to be applied, and set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

NRCS Conservation Practice Standard 590 – *Nutrient Management* (CPS 590) provides assistance to farmers to manage the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments on lands where plant nutrients and soil amendments are applied.[34]

Data obtained from NRCS show that no state eligible under this protocol has more than two percent of cropland acres receiving NRCS funding under CPS 590, suggesting that existing payments are not adequate to further incentivize nitrogen application reductions.[35] Analyses also show that farmers base their fertilizer application rate decisions on routine practice and there is significant opportunity for farmers to reduce fertilizer application without affecting yields (see Appendix A).

Therefore, the use of NRCS payments to help support reductions in nitrogen application under this protocol is allowed, except as specified below. Fields seeking to stack payments must also meet all other eligibility requirements in this protocol, including the start date requirement in Section 3.2.

Stacking NRCS payments under CPS 590 with CRTs under this protocol is not allowed if the nutrient management plan required by CPS 590 was under a signed agreement with NRCS prior to the project field's start date or prior to the field's submittal to the Reserve, whichever is earlier, and the plan included a reduction in fertilizer application. For a period of 12 months from the Effective Date of this protocol (Version 1.0), fields with start dates on or after June 27, 2010 are allowed to stack, so long as no agreement with NRCS to implement CPS 590 with a nutrient management plan including N rate reductions was signed prior to the field's start date.

Note that if a field is under an agreement with NRCS to receive payments for activities that do not include reduced fertilizer application under CPS 590 (or NRCS payments under any other CPS), those payments do not affect field eligibility since the payments were awarded for different activities than those credited by this protocol and are therefore not considered "stacked."

Furthermore, other fields owned by the farmer are eligible if they are not under agreement to receive NRCS funding for CPS 590 activities that include reduced fertilizer application. Fields

[33] EQIP, 7 CFR §1466.36; CSP, 7 CFR §1470.37.
[34] Natural Resources Conservation Service. (December 2011). Conservation Practice Standard, Nutrient Management, Code 590. State-specific conservation practice standards can be downloaded from http://efotg.sc.egov.usda.gov//efotg_locator.aspx.
[35] Based on data obtained from NRCS Performance Results System Database. FY 2010 data updated as of March 30, 2011; FY 2011 data updated as of October 1, 2011. Retrieved April 2012 from http://ias.sc.egov.usda.gov/prshome/.

that have received CPS 590 payments in the past (e.g. prior to the field's start date) but have not received payments for at least one year are also eligible.

To be conservative, fields stacking NRCS CPS 590 payments are only eligible to receive CRTs for the portion of the project not funded by public dollars. For example, EQIP payment rates are estimated to provide 50 percent, 75 percent or 90 percent of the cost of practice implementation, with higher percentages awarded if the farmer qualifies as "historically underserved" or as a "limited resource farmer," respectively. If a farmer receives an EQIP payment for CPS 590 at the 50 percent level, the number of CRTs issued is to be reduced by 50 percent. This is to support the additionality of the project and to protect against public funds for voluntary natural resource protection and/or restoration being used to finance mitigation projects undertaken to satisfy regulatory requirements (i.e. offset a regulated entity's CO_2 emissions in a cap-and-trade system).

For informational purposes, any other type of ecosystem service payment or credit received for activities on a project field must be disclosed by the project developer/aggregator to the verification body and the Reserve.

This section will also be updated as the protocol is revised to include additional approved practices.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project is in material compliance with all applicable laws relevant to the project activity (e.g. air, water quality, water discharge,[36] safety, labor, endangered species protection, etc.) prior to verification activities commencing each time a project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a field is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred on the field during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting.

Additional information on legal requirements potentially relevant to a project's status of regulatory compliance is included in Appendix C.

[36] See Appendix C for an overview of water quality rules and regulations that may impact a farm's legal requirements or regulatory compliance.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a nitrogen management project.[37]

The GHG Assessment Boundary encompasses all the GHG SSRs that may be significantly affected by project activities, including sources of N_2O and CH_4 emissions from the soil, biological CO_2 emissions and soil carbon sinks, and fossil fuel combustion GHG emissions. For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with a nitrogen management project's "primary effect" (i.e. the project's intended N_2O reduction), or its "secondary effects" (i.e. unintended changes in carbon stocks, CH_4 emissions, or other GHG emissions).[38] Secondary effects may include increases in mobile combustion CO_2 emissions associated with site preparation, as well as increased GHG emissions caused by the shifting of cultivation activities from the project area to other agricultural lands (often referred to as "leakage"). Projects are required to account for all SSRs that are included in the GHG Assessment Boundary regardless of whether the particular SSR is designated as a primary or secondary effect.

Table 4.1 provides a comprehensive list of the GHG SSRs that may be affected by a nitrogen management project, and indicates which SSRs must be included in the GHG Assessment Boundary.

[37] The definition and assessment of sources, sinks, and reservoirs is consistent with ISO 14064-2 guidance.
[38] The terms "primary effect" and "secondary effects" come from World Business Council on Sustainable Development / World Resources Institute. (2005). The Greenhouse Gas Protocol for Project Accounting, *World Resources Institute*, Washington, DC. Available at http://www.ghgprotocol.org.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1. Soil Dynamics	Biogeochemical interactions occurring in the soil that produce emissions of nitrous oxide, as well as carbon dioxide (biogenic), and possibly methane.	N_2O	I	A method for quantifying direct N_2O emissions from an approved project activity, as provided in Section 5.3.1	The primary effect of a nitrogen management project is a reduction in nitrous oxide emissions from soil. [39]
		CO_2	E	N/A	Changes in soil carbon stocks may result from implementation of a nitrogen management project activity; however, the effect is negligible since it is unlikely that growers will reduce N application rates such that crop yields are significantly reduced. It is conservative to not account for increases in soil carbon from increases in organic fertilizer (i.e. manure) application rates. The impact of project-related reductions in organic fertilizer application rates on stable soil organic carbon pools[40] are likely going to be insignificant due to the small size of the expected change in organic N fertilization rate.
		CH_4	E	N/A	Methane production and oxidation is insignificant for non-flooded soils.

[39] These N_2O emissions are referred to as "direct N_2O emissions from soils" by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
[40] Changes in organic fertilizer may significantly impact total soil organic carbon. However, due to aerobic carbon decomposition, only a small fraction of the added organic fertilizer is transformed into a carbon pool that is stable during the permanence period (100 years).

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
2. Leaching, Volatilization, and Runoff	Leaching, volatilization, and runoff of applied nitrogen, followed by denitrification into N_2O.[41]	N_2O	I	IPCC emission factor methodology, as provided in Section 5.3.2	Also a primary effect of nitrogen management projects, this may be a significant portion of overall N_2O emission reductions, due to the project's reduction in losses of total N from the project field.
Secondary Effect Sources, Sinks, and Reservoirs					
3. GHG Emissions from Cultivation Equipment	Fossil fuel emissions from equipment used for field preparation, seeding, fertilizer/pesticide/herbicide application, and harvest.	CO_2	I	Method in Section 5.4.1	Emissions may be significant if management requires an increase in the use of cultivation equipment or a change in the type of equipment required (e.g. increased number of fertilizer applications). Increased emissions due to project activity must be accounted for. Decreased emissions due to project activity are not accounted for, to be conservative and to avoid double counting under a cap (e.g. in regions such as California where emissions from transportation fuels will be capped).
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
4. GHG Emissions from Irrigation	Changes to nitrogen management practices may require changes to the field's irrigation system. As irrigation water pumping and transport requires energy, certain nitrogen management changes may increase energy use for irrigation and lead to energy-related GHG emissions.	CO_2	E	N/A	Excluded, as currently approved project activities are not allowed to use irrigation, except in emergencies, and as such any increase in water usage or changes to the irrigation system are not likely to be due to the project.
		N_2O	E		
		CH_4	E		

[41]The IPCC Guidelines for National Greenhouse Gas Inventories (2006) refer to the N_2O emissions from leaching, volatilization, and runoff (LVRO) as "indirect N_2O emissions" because these emissions typically occur offsite due to denitrification of the N lost from the project site due to LVRO. Reductions in "indirect N_2O emissions" are still considered reductions in primary effect emissions because reducing N losses from the project site is one of the primary goals of the approved project activity (reducing N rate). Reductions of these "indirect N_2O emissions" are not to be confused with "indirect emission reductions" or "secondary effect emission reductions," (e.g. emission reductions occurring outside the control of the project participant). To avoid confusion, this protocol refers to emissions from leaching, volatilization, and runoff as emissions from "LVRO," instead of "indirect N_2O emissions."

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5. GHG Emissions from Offsite Storage of Manure	Indirect emissions from changes in storage of manure at the facilities from which the manure originates.	N_2O	E	N/A	As a waste product, the supply of manure is relatively inelastic. A reduction of total organic N applied to land will not result in any less organic N produced, but rather, may lead to the shifting of the end-of-life fate of manure across the landscape. The most likely end-of-life fate for manure is to be land-applied elsewhere, resulting in no real reductions in organic N applied, due to the project, or in a worst-case scenario, manure may spend more time in storage before being land-applied. The reverse is also true; an increase in organic N application is likely to result in a reduction in organic N applied elsewhere (or a reduction in storage), leading to little or no net change in N_2O emissions. Changes in organic N application therefore do not need to be included in project accounting.
		CH_4	E	N/A	
		CO_2	E	N/A	
6. GHG Emissions from Fertilizer Transportation	Changes to nitrogen management practices may include increasing proportions of organic to synthetic N applied. An increase in the amount of organic N applied may increase emissions from transporting that fertilizer.[42]	CO_2	E	N/A	Because organic N fertilizers have a greater weight per unit N compared to synthetic fertilizers, emissions from organic N transportation are higher compared to emissions from synthetic N transportation when organic N transportation distances exceed about 5 miles. However, GHG emissions from organic N transportation are not included because any increases in organic N inputs will not likely be due to the project. Furthermore, since the supply of organic N is mostly inelastic, organic N will be transported regardless of absence or presence of the project.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.

[42] Organic N weighs more per unit of N than synthetic N, resulting in more GHG emissions per unit of N applied, and it is distributed less efficiently than commercial synthetic fertilizer.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
7. GHG Emissions from Shifted Production (Leakage)	Increases in production outside the project area, sometimes referred to as "indirect land use change," may occur if yields are significantly and negatively affected by a project activity.	CO_2	I	Method in Section 5.4.2	If aggregate level yields are found to have statistically decreased due to project activities, there is an assumed increase in GHG emissions from shifted production that must be estimated and included.
		CH_4	I		
		N_2O	I		
8. GHG Emissions from Synthetic Fertilizer Production	Decreases in use of synthetic N fertilizer on fields may affect the amount of synthetic fertilizer produced and indirectly cause reduction of GHGs associated with fertilizer production.	CO_2	E	N/A	It is conservative to exclude this category because, in all cases, emissions from this SSR will decrease. Also, the source is "indirect," meaning that reductions take place offsite, and are difficult to link directly to project activities of a single field. Finally, in some regions, emissions from fertilizer production will be directly regulated under a capped industry and including this source would lead to double counting.
		N_2O	E	N/A	
		CH_4	E	N/A	
9. GHG Emissions from Production and Use of Chemical Inputs	Changes in nutrient management practices may impact how much lime or herbicides are used on fields	CO_2	E	N/A	Excluded, as approved project activities are unlikely to materially increase the use of lime or herbicides used on fields. The very small changes in herbicide and/or lime demand due to nitrogen management projects are unlikely to have an effect on herbicide and/or lime production.
		N_2O	E		
		CH_4	E		

5 Quantifying GHG Emission Reductions

GHG emission reductions from a nitrogen management project are quantified by comparing actual project emissions to baseline emissions related to nitrogen management. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the nitrogen management project. Project emissions are actual GHG emissions that occur from sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions. GHG emission reductions are calculated separately for each individual field and, in the case of an aggregate, summed together over the entire aggregate. The calculation approach in this section is applicable to single-field projects and aggregates.

Project emission reductions must be quantified and verified on an annual basis, reflecting a reduction in annual N rate over a complete cultivation cycle. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." For reporting purposes, the reporting period must be uniformly defined for the aggregate, with a start date chosen by the aggregator (i.e. an aggregator may choose for the reporting period to start on any date during the year, with all subsequent reporting periods following the same annual cycle). Individual fields within an aggregate may have cultivation cycles that start on different dates; however, the cultivation cycles for all fields within an aggregate must be complete before the aggregate is able to undergo verification. To ensure that only emission reductions occurring during an aggregate's fixed reporting period is credited during that reporting period, emission reductions from each field shall be prorated, according to the methodology in Section 7.3.3. For single-field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

The primary effect of a nitrogen management project is the total reduction in direct N_2O emissions from soil (SSR 1) and in N_2O emissions from leaching, volatilization, and runoff (SSR 2), due to implementation of an approved project activity (a reduction in N application rate).

In addition to the primary effect (SSR 1 and 2), nitrogen management projects may result in unintended increases of GHG emissions from other SSRs. Section 5.4 provides requirements for calculating these secondary effect GHG emissions resulting from the project activity.

Total emission reductions from a project are equal to the combined primary emission reductions from SSR 1 and 2 for all fields in the project area, minus the increase in emissions from all other SSRs due to the project activity (secondary effects). Total net GHG reductions for a reporting period are calculated by subtracting actual project emissions from baseline emissions for all SSRs over the reporting period, as prescribed in Sections 5.2 to 5.4. Equation 5.1 below provides the general GHG reduction calculation.

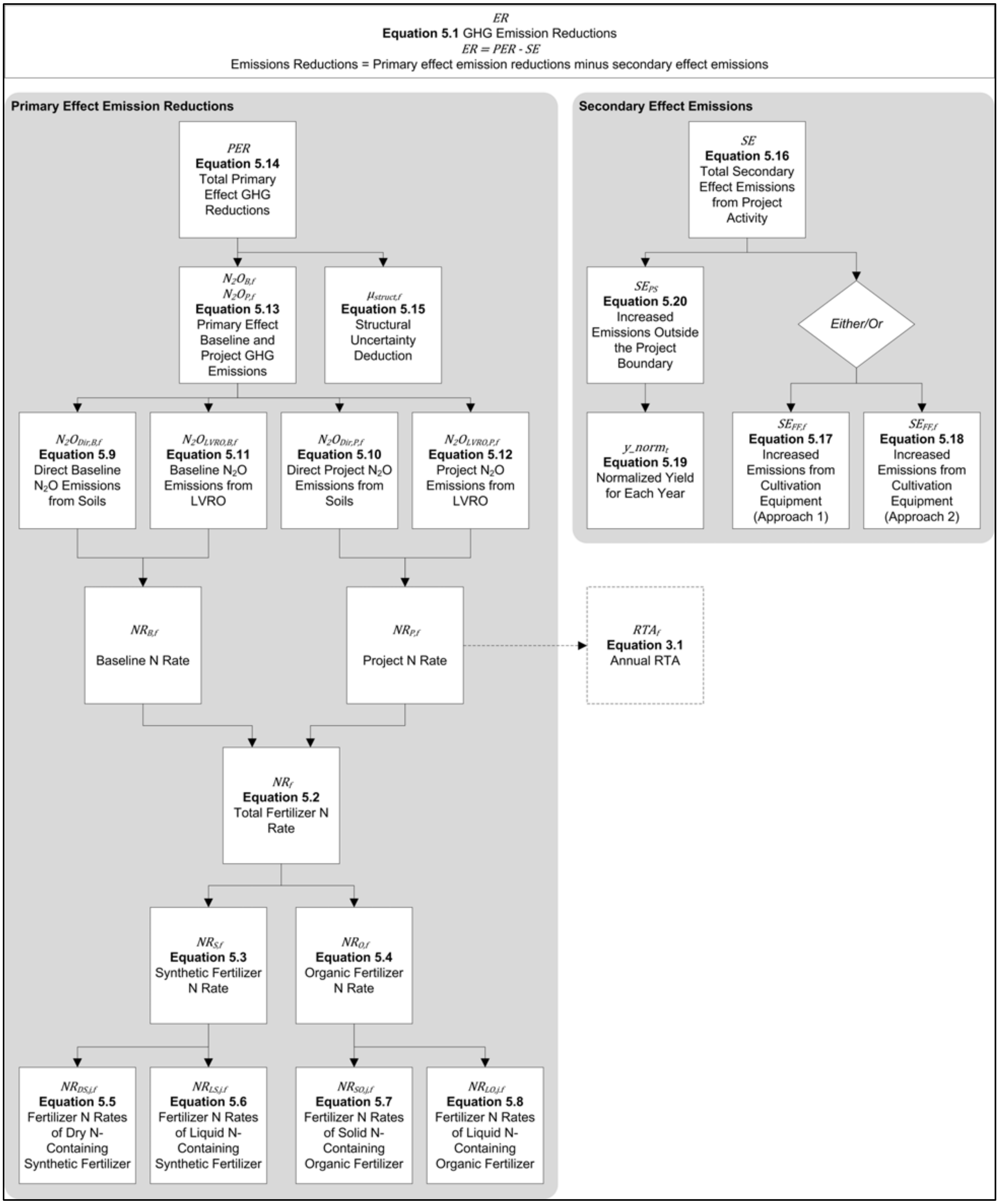

Figure 5.1. Equation Organizational Chart

Equation 5.1. GHG Emission Reductions

$$ER = PER - SE$$

Where,

			Units
ER	=	Total emission reductions from the project area for the reporting period	Mg CO_2e
PER	=	Total primary effect GHG emission reductions over the entire project area, see Section 5.3	Mg CO_2e
SE	=	Total secondary effect GHG emissions caused by project activity during the reporting period for the entire project aggregate,[43] see Section 5.4	Mg CO_2e

5.1 Applicability Conditions for N Rate Reduction Projects

The following applicability conditions must be met for all fields implementing the approved project activity: reducing N rate in corn cropping systems in the NCR.[44]

1. The project area shall not contain any organic soils (e.g. histosols).[45]

2. The mean annual precipitation on all fields in the project area must be between 600 mm and 1200 mm (see Figure 5.2 below).[46]

3. The project area shall not include irrigated corn cropping systems. However, emergency irrigation to prevent crop failure in years of severe drought will be allowed in systems that are typically not irrigated.[47]

4. The project area shall not include tile-drained fields.

5. Both synthetic as well as organic fertilizer may be applied to project fields. However, only N_2O emission reductions from reductions in the synthetic N rate shall be credited. . Synthetic fertilizers[48] may be applied in dry form (e.g. granular urea, ammonium nitrate) or liquid form (e.g. urea ammonium nitrate, UAN). Organic fertilizers may be liquid or solid, and may include unprocessed manure (e.g. beef cattle manure, hog manure, digester effluent and/or solids), other unprocessed organics (e.g. compost) and processed commercial organic fertilizers. On any particular field, a number of different fertilizer types can be applied.

6. Total organic N applied may increase or decrease in the project area. However, total annual N applied (synthetic and organic) must decrease below baseline levels. Only

[43] Throughout Section 5, equations will distinguish between calculations which must be performed at the field versus aggregate level. For a single-field project, the entire project area is comprised of only the single field. As such, in this section, when guidance is provided for the aggregate, but not the single-field project, the guidance should be assumed to apply to both.
[44] "Corn cropping systems" includes both corn grown for grain and corn grown for silage.
[45] See USDA-NRCS, Keys to Soil Taxonomy. Available at http://soils.usda.gov/technical/classification/tax_keys/.
[46] This precipitation range was constrained by a sensitivity analysis.
[47] Verifiers (e.g. the agronomist on the verification team) shall use professional judgment to assess whether the local weather in the reporting year was dry enough to consider emergency irrigation necessary.
[48] Even though urea is technically an "organic" fertilizer, it is considered a "synthetic" fertilizer for the purposes of this protocol.

reductions in synthetic N rate shall generate creditable emission reductions under this protocol.

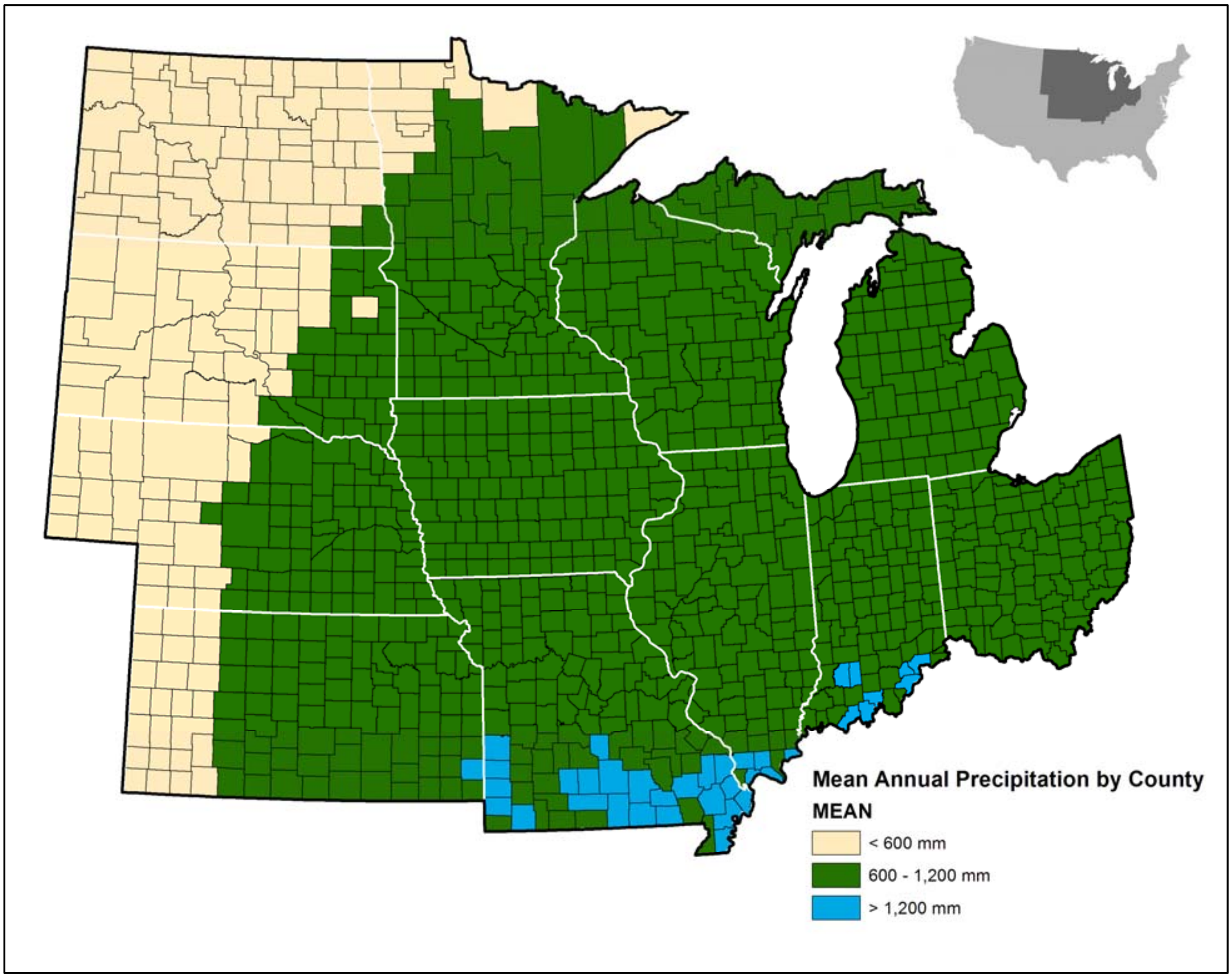

Figure 5.2. Map of Mean Annual Precipitation per County in the North Central Region
Green denotes eligible counties. Developed based on data from the NOAA Climate Prediction Center. The area-weighted average of mean annual precipitation was determined for each county in the NCR.[49]

5.2 Determining Baseline and Project N Rates

A baseline N rate ($NR_{B,f}$) and project N rate ($NR_{B,f}$), used to calculate baseline and project N_2O emissions for N rate reduction projects shall be calculated separately for each individual field. The process for calculating the total annual N rate, and total annual synthetic and organic N rates respectively, is the same for any given year, whether that year is one of the eligible crop years in the baseline look-back period or a reporting period during the crediting period of the project. Section 5.2.3 provides equations to determine a field's N rate in terms of kg N per hectare for each different type of fertilizer, based on information typically more readily available to the project participant (such as fertilizer mass and volume). The parameters calculated in Section 5.2.3, combined with the guidance below, are then used in the equations in Section 5.3.

[49] CPC U.S. Unified Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado. Retrieved from http://www.esrl.noaa.gov/psd/.

5.2.1 Determining the Baseline N Rate

The baseline N rate ($NR_{B,f}$) is calculated using the equations in Section 5.2.3 below, and is used in Equation 5.9 and Equation 5.11. The baseline N rate shall be based on a historic average N rate value calculated using N rate data from all eligible crop years within at least the five years prior to a field's start date. If less than three eligible crop years were planted in the five years prior to the field's start date, the historical look-back period shall be extended until at least three eligible crop years are included.[50] Once the appropriate baseline look-back period is identified, the respective annual N rates for both synthetic and organic N sources for each eligible crop year must be calculated using Equation 5.3 through Equation 5.8, in Section 5.2.3.

5.2.2 Determining the Project N Rate

For each reporting period, the project N rate ($NR_{P,f}$) is calculated using Equation 5.3 through Equation 5.8, in Section 5.2.3 below. The project N rate is subsequently used in Equation 5.10 and Equation 5.12. The respective annual N rates for both synthetic and organic N sources for each eligible crop year must be calculated according to Section 5.2.3.

If the project organic N rate ($NR_{P,O,f}$) is equal to or greater than the baseline organic N rate ($NR_{B,O,f}$), the total project N rate ($NR_{P,f}$) must be calculated as the sum of project synthetic and project organic N rates ($NR_{P,S,f}$ and $NR_{P,O,f}$) in Equation 5.12.[51]

If the project organic N rate ($NR_{P,O,f}$) is less than the baseline organic N rate ($NR_{B,O,f}$), the baseline organic N rate ($NR_{B,O,f}$) must be used instead of the project organic N rate ($NR_{P,O,f}$) in Equation 5.12.

5.2.3 Determining N Content of Fertilizer Application

This section provides equations to determine each field's respective N rate in terms of kg N per hectare for each different type of fertilizer, using information more readily available to the project participant (such as fertilizer mass and volume). These equations shall be used for both the baseline and project, as necessary, to calculate necessary values in Equations 5.3 and 5.4, which in turn produce values necessary for use in Equations 5.9 to 5.12 below.

Regardless of whether baseline ($NR_{B,f}$) or project ($NR_{P,f}$) N rates are being calculated, the total N rate for a field *f* is calculated as the sum of N rates of synthetic and organic fertilizer N, as indicated in the general Equation 5.2 below.

[50] For example, if the cropping sequence prior to the project start is corn-soybean-corn-soybean-corn, and all corn cropping years are eligible, a look-back period of five years suffices. However, if the cropping sequence prior to the project start is soybean-corn-soybean-corn-soybean, the look-back period shall be extended until one more corn cropping year is included.

[51] This approach conservatively disallows the quantification of N_2O emission reductions from reducing organic N rate, while ensuring the largest N_2O emission reductions from reducing synthetic N rate, by taking full advantage of the exponential N_2O response at higher total N rates.

Equation 5.2. Total Fertilizer N Rate for Field *f*

$$NR_f = NR_{S,f} + NR_{O,f}$$

Where,			Units
NR_f	=	Total fertilizer N rate for field *f*	kg N/ha
$NR_{S,f}$	=	N rate of total synthetic fertilizer for field *f,* see Equation 5.3	kg N/ha
$NR_{O,f}$	=	N rate of total organic fertilizer for field *f,* see Equation 5.4	kg N/ha

The total synthetic fertilizer N rate for a particular field is calculated as the sum of N rates of all dry and liquid synthetic N sources and calculated in Equation 5.3 below.

Equation 5.3. Synthetic Fertilizer N Rate for Field *f*

$$NR_{S,f} = \sum_j NR_{DS,j,f} + \sum_j NR_{LS,j,f}$$

Where,			Units
$NR_{S,f}$	=	N rate of total synthetic fertilizer for field *f*	kg N/ha
$NR_{DS,,j,f}$	=	N rate of dry synthetic fertilizer type *j* on field *f,* see Equation 5.5	kg N/ha
$NR_{LS,j,f}$	=	N rate of liquid synthetic fertilizer type *j* on field *f,* see Equation 5.6	kg N/ha

The total organic fertilizer N rate for a particular field is calculated as the sum of N rates of all solid and liquid (slurry) organic N sources and calculated in Equation 5.4 below.

Equation 5.4. Organic Fertilizer N Rate for Field *f*

$$NR_{O,f} = \sum_j NR_{SO,j,f} + \sum_j NR_{LO,j,f}$$

Where,			Units
$NR_{O,f}$	=	N rate of total organic fertilizer for field *f*	kg N/ha
$NR_{SO,,j,f}$	=	N rate of solid organic fertilizer type *j* on field *f,* see Equation 5.7	kg N/ha
$NR_{LO,j,f}$	=	N rate of liquid organic fertilizer type *j* on field *f,* see Equation 5.8	kg N/ha

Fertilizer N rates used in the equations throughout this protocol are in [kg N/ha]. Use the following guidance to determine how to convert project participants' reported synthetic and organic fertilizer N rates to kg N/ha, yielding values for $NR_{DS,j,f}$, $NR_{LS,j,f}$, $NR_{SO,f}$ and $NR_{LO,f}$.

In general, the amount of N-containing fertilizer is multiplied by the N concentration (NC_j) of the fertilizer, and relevant conversions to SI units are applied. Equation 5.5 and Equation 5.6 show calculations for fertilizer N rates for dry N-containing synthetic fertilizers and liquid N-containing synthetic fertilizers, respectively, which are used in Equation 5.3, above, while Equation 5.7 and Equation 5.8 show calculations for fertilizer N rates for solid N-containing organic fertilizers and liquid N-containing organic fertilizers, respectively, which are used in Equation 5.4, above. Default information on N concentrations and weights of various N-containing fertilizers is provided in Table A.2, although farm management records, commercial fertilizer labels, and/or laboratory tests on the N content of organic sources are preferable, when available, as discussed further in Section 6.

Equation 5.5. Fertilizer N Rates of Dry N-Containing Synthetic Fertilizer *j*

$$NR_{DS,j,f} = \frac{MF_{DS,j,f} \times NC_{DS,j} \times 0.454}{0.405}$$

Where, Units

$NR_{DS,j,f}$	=	N rate of dry synthetic fertilizer *j* for field *f*	kg N/ha
$MF_{DS,j,f}$	=	Mass of dry synthetic N-containing fertilizer *j* applied to field *f*	lbs fertilizer/acre
$NC_{DS,j}$	=	N concentration of dry synthetic fertilizer *j*, see Table A.2	lbs N/lbs fertilizer
0.454	=	Factor to convert lbs to kg	
0.405	=	Factor to convert acre to ha	

Equation 5.6. Fertilizer N Rates for Liquid N-Containing Synthetic Fertilizer *j*

$$NR_{LS,j,f} = \frac{VF_{LS,j,f} \times MF_{LS,j} \times NC_{LS,j} \times 0.454}{0.405}$$

Where, Units

$NR_{LS,j,f}$	=	N rate of liquid synthetic fertilizer *j* for field *f*	kg N/ha
$VF_{LS,j,f}$	=	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f*	gallons/acre
$MF_{LS,j}$	=	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer	lbs fertilizer/gallon
$NC_{LS,j}$	=	N concentration of liquid synthetic fertilizer *j*, see Table A.2	lbs N/lbs fertilizer
0.454	=	Factor to convert lbs to kg	
0.405	=	Factor to convert acre to ha	

Similarly, the solid and liquid organic fertilizer N rate for a particular field is calculated as the sum of N rates of all organic N sources and calculated using the equation below.

Equation 5.7. Fertilizer N Rates for Solid N-Containing Organic Fertilizer *j*

$$NR_{SO,j,f} = \frac{MF_{SO,j,f} \times NC_{SO,j} \times 0.454}{0.405}$$

Where, Units

$NR_{SO,j,f}$	=	N rate of solid organic fertilizer *j* for field *f*	kg N/ha
$MF_{SO,j,f}$	=	Mass of solid organic N-containing fertilizer *j* applied to field *f*	lbs fertilizer/acre
$NC_{SO,j}$	=	N concentration of solid organic fertilizer *j*, see Table A.2[52]	lbs N/lbs fertilizer
0.454	=	Factor to convert lbs to kg	
0.405	=	Factor to convert acre to ha	

[52] For processed commercial organic fertilizer, N contents following manufacturers' specification can be used. For unprocessed manure, default manure N contents are shown in Table A.2 in Appendix A.

Equation 5.8. Fertilizer N Rates for Liquid N-Containing Organic Fertilizer *j*

$$NR_{LO,j,f} = \frac{VF_{LO,j,f} \times MF_{LO,j,f} \times NC_{LO,j} \times 0.454}{0.405}$$

Where,			Units
$NR_{LO,j,f}$	=	N rate of liquid organic fertilizer *j* for field *f*	kg N/ha
$VF_{LO,j,f}$	=	Volume of liquid organic N-containing fertilizer *j* applied to field *f*	gallons/acre
$MF_{LO,j,f}$	=	Mass of liquid organic N-containing fertilizer *j* applied to field *f*	lbs fertilizer/gallon
$NC_{LO,j}$	=	N content of liquid organic fertilizer *j*, see Table A.2[53]	lbs N/lbs fertilizer
0.454	=	Factor to convert lbs to kg	
0.405	=	Factor to convert acre to ha	

5.3 Determining Primary Effect N_2O Emission Reductions

This section provides the calculation method for primary effect N_2O emission reductions for N rate reduction projects in corn crops in the North Central Region of the United States.

5.3.1 Baseline and Project Direct N_2O Emissions from Soils[54] (SSR 1)

The baseline direct N_2O emissions are calculated using the baseline N rate and the MSU-EPRI Tier 2 emission factor developed for the project activity (N rate reduction) in corn cropping systems in the North Central Region of the U.S.[55] See Equation 5.9 below.

Equation 5.9. Direct Baseline N_2O Emissions from Soils for Field *f*

$$N_2O_{Dir,B,f} = NR_{B,f} \times EF_{Dir,B,f} \times \frac{44}{28} \times \frac{310}{1000}$$

$$EF_{Dir,B,f} = \frac{0.67 \times \left(e^{(0.0067 \times NR_{B,f})} - 1\right)}{NR_{B,f}}$$

Where,			Units
$N_2O_{Dir,B,f}$	=	Annual baseline direct N_2O emissions from field *f*	Mg CO_2e/ha
$NR_{B,f}$	=	Total baseline N rate for field *f*	kg N/ha
$EF_{Dir,B,f}$	=	Emission factor for baseline direct N_2O emissions from baseline N inputs	kg N_2O-N/kg N input
44/28	=	Unit conversion from kg N_2O-N to kg N_2O, where 44 is the molecular weight of N_2O and 28 is twice the atomic weight of N	
310	=	Global warming potential of N_2O	
1000	=	Conversion of kg CO_2e/ha to Mg CO_2e/ha	

[53] For processed commercial organic fertilizer, N contents following manufacturer's specifications can be used. For unprocessed manure, default manure N contents are shown in Table A.2 in Appendix A and are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C.

[54] As noted in Section 4, SSR 1 refers to the N_2O emissions from soil dynamics or, to follow IPCC nomenclature, refers to the "direct N_2O emissions from soils."

[55] Millar et al. (2012). Quantifying N_2O Emissions Reductions in U.S. Agricultural Crops through Nitrogen Fertilizer Rate Reduction. Version 1.4.6, 25 Jan 2012. *Michigan State University and Electric Power Research Institute*, Undergoing 2nd Assessment with Verified Carbon Standard.

Similarly, the project direct N_2O emissions are calculated based on the project total N rate applied during the cultivation cycle and the MSU-EPRI Tier 2 emission factor. See Equation 5.10 below.

Equation 5.10. Direct Project N_2O Emissions from Soils for Field *f*

$$N_2O_{Dir,P,f} = \left(NR_{P,S,f} + NR_{P,O,f}\right) \times EF_{Dir,P,f} \times \frac{44}{28} \times \frac{310}{1000}$$

$$EF_{Dir,P,f} = \frac{0.67 \times \left(e^{\left(NR_{P,S,f} + NR_{P,O,f}\right)} - 1\right)}{\left(NR_{P,S,f} + NR_{P,O,f}\right)}$$

Where,

			Units
$N_2O_{Dir,P,f}$	=	Annual project direct N_2O emissions from field *f*	Mg CO_2e/ha
$NR_{P,S,f}$	=	Total project synthetic N rate for field *f*	kg N/ha
$NR_{P,O,f}$	=	Total project organic N rate for field *f.* (If the project organic N rate is smaller than the baseline organic N rate, use $NR_{B,o,f}$ instead of $NR_{P,o,f}$ in this equation.)	kg N/ha
$EF_{Dir,P,f}$	=	Emission factor for project direct N_2O emissions from project N inputs	kg N_2O-N/kg N input
44/28	=	Unit conversion from kg N_2O-N to kg N_2O	
310	=	Global warming potential of N_2O	
1000	=	Conversion of kg CO_2e/ha to Mg CO_2e/ha	

5.3.2 Baseline and Project N_2O Emissions from Leaching, Volatilization, and Runoff (SSR 2)

N_2O emissions from leaching, volatilization, and runoff (LVRO)[56] of N must be accounted for in determining primary effect GHG reductions. Baseline N_2O emissions from LVRO are determined according to Equation 5.11 below.

[56] As noted in Section 4, the IPCC refers to these emissions as "indirect N_2O emissions."

Equation 5.11. Baseline N_2O Emissions from LVRO for Field *f* [57]

$$N_2O_{LVRO,B,f} = \left(\left(\left(NR_{B,S,f} \times 0.10 + NR_{B,O,f} \times 0.20\right) \times 0.01\right) + \left(NR_{B,f} \times Frac_{LEACH} \times 0.0075\right)\right) \times \frac{44}{28} \times 310 \div 1000$$

Where,

			Units
$N_2O_{LVRO,B,f}$	=	Annual baseline N_2O emissions from LVRO from field *f*	Mg CO_2e/ha
$NR_{B,S,f}$	=	Baseline N rate of total synthetic fertilizer for field *f*	kg N/ha
0.10	=	$Frac_{GASF}$, IPCC default factor for the fraction of all synthetic fertilizer N inputs that volatilizes as NH_3 and NO_x	
$NR_{B,O,f}$	=	Baseline N rate of total organic fertilizer for field *f*	kg N/ha
0.20	=	$Frac_{GASM}$, IPCC default factor for the fraction of all organic fertilizer N inputs that volatilizes as NH_3 and NO_x	
0.01	=	EF_4, IPCC default emission factor for N_2O emissions from atmospheric deposition of N on soil and water surfaces and subsequent volatilization	kg N_2O-N/(kg NH_3-N + kg NO_x-N)
$NR_{B,f}$	=	Baseline total N rate determined for field *f*, using Eq. 5.2 to 5.8.	kg N/ha
$Frac_{LEACH}$	=	Fraction of N inputs that is lost through leaching and runoff, see map for $Frac_{LEACH}$ values for specific geographic locations and reporting periods on the NMPP website[58]	
0.0075	=	EF_5, IPCC default emission factor for N_2O emissions from N leaching and runoff	kg N_2O-N/kg NO_3-N
44/28	=	Unit conversion from kg N_2O-N to kg N_2O	
310	=	Global warming potential of N_2O	
1000	=	Conversion of kg CO_2e/ha to Mg CO_2e/ha	

Project N_2O emissions during the cultivation cycle from leached and volatilized N must be accounted for according to Equation 5.12 below.

[57] The methodology to calculate LVRO emissions reflects the MSU-EPRI methodology's adaptation of the IPCC Guidelines for National Greenhouse Gas Inventories (2006) for calculating LVRO emissions (Vol. 4 Ch. 11 Table 11.3). MSU-EPRI's adaptation excluded N_2O emissions from crop residue management from Equation 5.11 and 5.12, as those emission reductions are not eligible for crediting. The IPCC methodology accounts for differences in LVRO emissions from organic and synthetic fertilizers, so no correction factor is needed to account for potential increases in N_2O emissions from N volatilization in cases where the organic fertilizer increases as a project activity. IPCC default factors are used for $Frac_{GASF}$, EF_4, $Frac_{LEACH}$, and EF_5.

[58] If (precipitation in the growing season)/(Potential evapotranspiration) ≥ 1.00, then $Frac_{LEACH}$ = 0.3; Else, $Frac_{LEACH}$ = 0. The determination of the values for $Frac_{LEACH}$ is consistent with MSU-EPRI Methodology protocol Version 1.4.6. The Reserve publishes a map with $Frac_{LEACH}$ values for the counties in the geographic applicability region annually, based on weather data from http://www.cpc.ncep.noaa.gov and factors to convert evaporation to evapotranspiration are based on Shaw, R.H. (1982), available at http://www.ipm.iastate.edu/ipm/icm/2000/5-29-2000/wateruse.html. The map with $Frac_{LEACH}$ values is available at http://www.climateactionreserve.org/how/protocols/nitrogen-management/.

Equation 5.12. Project N_2O Emissions from LVRO for Field *f* [59]

$$N_2O_{LVRO,P,f} = \left(\left(\left(NR_{P,S,f} \times 0.10 + NR_{P,O,f} \times 0.20\right) \times 0.01\right) + \left(\left(NR_{P,S,f} + NR_{P,O,f}\right) \times Frac_{LEACH} \times 0.0075\right)\right) \times \frac{44}{28} \times 310 \div 1000$$

Where, Units

$N_2O_{LVRO,P,f}$	=	Annual project indirect N_2O emissions from field *f*	Mg CO_2e/ha
$NR_{P,S,f}$	=	Project N rate for total synthetic fertilizer for field *f*	kg N/ha
$NR_{P,O,f}$	=	Project N rate for total organic fertilizer for field *f*. (If the project organic N rate is less than the baseline organic N rate, use $NR_{B,o,f}$ instead of $NR_{P,o,f}$ in this equation.)	kg N/ha
$NR_{P,f}$	=	Project total N rate determined for field *f*	kg N/ha

* 0.10, 0.20, 0.01 and 0.0075 are IPCC defaults, as defined in Equation 5.11.

5.3.3 Primary Effect Baseline and Project N_2O Emissions

Based on direct N_2O emissions from soil and N_2O emissions from LVRO from the baseline and the project, primary effect baseline and project GHG emissions for each field are calculated using Equation 5.13.

Equation 5.13. Primary Effect Baseline and Project GHG Emissions

$$N_2O_{B,f} = N_2O_{Dir,B,f} + N_2O_{LVRO,B,f}$$

$$N_2O_{P,f} = N_2O_{Dir,P,f} + N_2O_{LVRO,P,f}$$

Where, Units

$N_2O_{B,f}$	=	Total annual baseline N_2O for field *f*	Mg CO_2e/ha
$N_2O_{Dir,B,f}$	=	Annual baseline direct N_2O emissions from field *f*	Mg CO_2e/ha
$N_2O_{LVRO,B,f}$	=	Annual baseline N_2O emissions from leaching, volatilization and runoff from field *f*	Mg CO_2e/ha
$N_2O_{P,f}$	=	Total annual project N_2O for field *f*	Mg CO_2e/ha
$N_2O_{Dir,P,f}$	=	Annual project direct N_2O emissions from field *f*	Mg CO_2e/ha
$N_2O_{LVRO,P,f}$	=	Annual project N_2O emissions from leaching, volatilization and runoff from field *f*	Mg CO_2e/ha

5.3.4 Adjusting Primary Effect GHG Reductions for Uncertainty

The total primary effect GHG reductions (Mg CO_2e) for the entire project area are calculated and adjusted for uncertainty in Equation 5.14. Equation 5.14 shall be applied in the same way to both single-field projects and aggregates, with the exception that the aggregate must sum the entire project area's GHG reductions (e.g. sum the GHG reductions from all fields).

[59] Ibid.

Equation 5.14. Total Primary Effect GHG Reductions for the Project

$$PER = \sum_{f=1}^{nrFields} \mu_{struct,f} \times [(N_2O_{B,f} - N_2O_{P,f}) \times A_f]$$

Where, Units

PER	=	Primary effect GHG reductions over the entire project area	Mg CO_2e
nrFields	=	Number of fields included in the project area	
$\mu_{struct,f}$	=	Accuracy deduction for structural uncertainty for field *f* (as determined in Equation 5.15)	
$N_2O_{B,f}$	=	Total annual baseline N_2O for field *f*	Mg CO_2e/ha
$N_2O_{P,f}$	=	Total annual project N_2O for field *f*	Mg CO_2e/ha
A_f	=	Size of field *f*	ha

The value of $\mu_{struct,f}$ is calculated in two steps, so as to adjust for structural uncertainty, including measurement uncertainty of emission reductions. First, the uncertainty in emission reductions, $UNC_{PER,f}$, is calculated. Then, based on the value of $UNC_{PER,f}$ the accuracy deduction for structural uncertainty $\mu_{struct,f}$ can be determined. The two-step calculation is included in Equation 5.15.

Equation 5.15. Structural Uncertainty Deduction

Step 1:

In case the project is located in Michigan:

$$UNC_{PER,f} = \left(1 + \frac{32}{\sqrt{nrFields}}\right)\left(100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}{}^2}\right)$$

In case the project is not located in Michigan:

$$UNC_{PER,f} = \left(1 + \frac{32}{\sqrt{nrFields}}\right)\left(100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}{}^2} + 15\right)$$

Step 2:

In case $UNC_{PER,f} < 15$: $\mu_{struct,f} = 1$

In case $UNC_{PER,f} \geq 15$: $\mu_{struct,f} = e^{-UNC_{PER,f}/300}$

Where, Units

$UNC_{PER,f}$	=	Uncertainty in N_2O emissions reductions associated with a reduction in N rate for field *f* relative to the average emission reduction value	%
nrFields	=	Number of fields included in the project area (e.g. the number of fields in the aggregate, or equal to one for a single-field project)[60]	
$NR_{P,f}$	=	Project total N rate determined for field *f*. (If the project organic N rate is smaller than the baseline organic N rate, use $NR_{B,o,f}$ instead of $NR_{P,o,f}$, summed with $NR_{P,S,f}$, to calculate $NR_{P,f}$ for use in this equation)	kg N/ha
15	=	Additional uncertainty deduction for states other than MI (i.e. outside the area where field measurements occurred)	%
$\mu_{struct,f}$	=	Accuracy deduction for structural uncertainty for field *f*	

[60] The [1/√(nrFields)] factor ensures that the uncertainty decreases with an increase in the number of fields in the aggregate. This factor accounts for the smoothing effect on emissions (calculated by the quantification approach) from having more fields in an aggregate. This factor was not included in the MSU-EPRI protocol.

Box 5.1 below provides additional background information pertaining to the development of uncertainty methods in this protocol.

Box 5.1. Uncertainty in the NMPP

According to C-AGG's white paper on uncertainty, "When models are used, analyses of both structural and input uncertainty related to their use must be completed."[61] For the NMPP, the Reserve intends to apply an uncertainty deduction methodology that is similar to that used in the Reserve's Rice Cultivation Project Protocol (RCPP). Input uncertainty for an empirical model (such as the MSU-EPRI model adapted for use in this version of the NMPP) is subject to less uncertainty than a biogeochemical model (such as the DNDC model used by the RCPP), simply because there are significantly fewer critical inputs. However, no additional field emissions measurement datasets for N rate trials are available at this time for the North Central Region, other than the robust dataset used to develop the MSU-EPRI methodology. With no independent field data, the Reserve cannot explicitly quantify the structural uncertainty of the quantification approach included in the NMPP at this time. The Reserve and proposes to increase the uncertainty deduction used in the MSU-EPRI methodology, calculated using dependent data, by 25 percent to account for having no independent field data to evaluate the quantification approach. It is expected, however, that in the future independent data will become available to quantify the structural uncertainty explicitly, at which time the Reserve expects to adjust the NMPP's structural uncertainty deduction.

5.4 Determining Secondary Effect GHG Emissions

Secondary effect emissions are unintentional changes in GHG emissions from the secondary SSRs within the GHG Assessment Boundary. Secondary effect emissions may increase, decrease or go unchanged as a result of the project activity. If emissions from secondary SSRs increase as a result of the project, these emissions must be subtracted from the total calculated primary effect GHG reductions for each reporting period. Equation 5.16, below, summarizes the changes in secondary effect GHG emissions.

Equation 5.16 also accounts for any increased CO_2 emissions from increased combustion of fossil fuels associated with the operation of cultivation equipment (SSR 5), as well as increased GHG emissions due to shifted crop production outside the project boundary (SSR 6).

Equation 5.16. Total Secondary Effect Emissions from Project Activity for the Project Aggregate

$$SE = \sum_{f}\left(SE_{FF,f}\right) + SE_{PS}$$

Where,

			Units
SE	=	Net secondary effect GHG emissions for project aggregate due to project activities	Mg CO_2e
$SE_{FF,f}$	=	Net secondary effect GHG emissions from increased cultivation equipment emissions due to fossil fuel combustion for field *f* (SSR 3), as calculated in Section 5.4.1, using either Equation 5.17 or 5.18	Mg CO_2e
SE_{PS}	=	Secondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary (SSR 6), as calculated in Section 5.4.2	Mg CO_2e

[61] C-AGG (Discussion Draft, February 2012). Executive Summary: Uncertainty in Models and Agricultural Offset Protocols.

5.4.1 GHG Emissions from Cultivation Equipment (SSR 3)

Included in the GHG Assessment Boundary are CO_2 emissions resulting from increased fossil fuel combustion associated with increased use of onsite equipment for performing nitrogen management activities due to the project activity. Specifically, secondary emissions from cultivation equipment must be quantified if the number of field operations for N application increases (e.g. a switch from single to split application) or if the equipment for N application changes (e.g. from a gasoline- to diesel-powered tractor). Secondary emissions from cultivation equipment need not be quantified if there is no change in cultivation equipment due to implementation of the project (e.g. there is no change to the equipment used for N application and/or the number of field operations associated with N application).

Two approaches are provided to calculate secondary emissions from cultivation equipment. Approach 1 calculates emissions based on the time needed for each nitrogen management related field operation, the horsepower required for this field operation, and a default emission factor for GHG emissions per horsepower-hours. Approach 2 calculates emissions based on the fuel consumption for field operations related to nitrogen management and a default emission factor for GHG emissions per unit of fuel consumed.

Approach 1 is designed to require minimal documentation. The project participant must provide manufacturers' specifications on the horsepower requirements for the N application equipment used, and the time needed per hectare for N application. The time needed for N application should be reported based on work-hour records. However, lacking those records, they may be derived based on the average operation or ground speed of the equipment and the application width per pass (e.g. width of boom). Secondary emissions from cultivation equipment, following Approach 1, are determined in Equation 5.17.

Equation 5.17. Increased Emissions from Cultivation Equipment (Approach 1)

$$\boldsymbol{SE_{FF,f}} = \left(\sum_{i}\left(\boldsymbol{EF_{HP-hr,P,i,f}} \times \boldsymbol{HP_{P,i,f}} \times \boldsymbol{t_{P,i,f}}\right) - \sum_{k}\left(\boldsymbol{EF_{HP-hr,B,k,f}} \times \boldsymbol{HP_{B,k,f}} \times \boldsymbol{t_{B,k,f}}\right)\right) \times \mathbf{10^{-6}}$$

If $\boldsymbol{SE_{FF,f}} < 0$, set $\boldsymbol{SE_{FF,f}}$ to 0.

Where,

			Units
$SE_{FF,f}$	=	Increase in secondary emissions from a change in cultivation equipment on field *f*	Mg CO_2-e/ha
$EF_{HP\text{-}hr,P,i,f}$	=	Emission factor for project operation *i* on field *f*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[62]	g CO_2-e/HP-hr
$HP_{P,i,f}$	=	Horsepower requirement for project operation *i* on field *f*	HP
$t_{P,i,f}$	=	Time required to perform project operation *i* on field *f*	hr/field
$EF_{HP\text{-}hr,B,k,f}$	=	Default emission factor for baseline operation *k* on field *f*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[63]	g CO_2-e/HP-hr
$HP_{B,k,f}$	=	Horsepower requirement for baseline operation *k* on field *f*	HP
$t_{B,k,f}$	=	Time required to perform baseline operation *k* on field *f*	hr/field
10^{-6}	=	Converting g CO_2e to Mg CO_2e	

[62] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[63] Ibid.

<u>Optional Method</u> (Equation 5.17, determination of *t*)
If time records are not available, use the method below in both baseline and project estimates.

$$t = \frac{10000}{(width \times speed \times 1000)} \times A_f$$

Where, <u>Units</u>

t	=	Time requirement for field operation	hr
10000	=	Area unit conversion	m^2/ha
width	=	Application width covered by equipment	m
speed	=	Average ground speed of the operation equipment	km/hr
1000	=	Length unit conversion	m/km
A_f	=	Size of field *f*	ha

As an alternative to Approach 1, project participants may choose to quantify secondary emissions from changes in the use of cultivation equipment based on their fuel consumption records (see Equation 5.18, Approach 2, below). If insufficient fuel consumption records are available, Approach 1 must be used.

Equation 5.18. Increased Emissions from Cultivation Equipment (Approach 2)

$$SE_{FF,f} = \frac{\sum_j (FF_{PR,j} \times EF_{FF,j})}{1000}$$

If $SE_{FF,f} < 0$, set $SE_{FF,f}$ to 0.

Where, <u>Units</u>

$FF_{PR,j}$	=	Total change in fossil fuel combustion for field *f* during the reporting period, by fuel type *j*	gallons
$EF_{FF,j}$	=	Fuel-specific emission factor. Default values are 17.4 for gasoline and 13.7 for diesel[64]	kg CO_2/gallon fossil fuel
1000	=	Kilograms per megagram	kg CO_2/ Mg CO_2

5.4.2 GHG Emissions from Shifting Crop Production Outside Project Boundaries (Leakage) (SSR 7)

Econometric studies have reported considerable price elasticity for corn.[65] Therefore, it is assumed in this protocol that a statistically significant decrease in corn yields due to project activities would result in an increase of production outside of the project area. The increased emissions associated with this shift in production must be estimated if project related yield losses are statistically significant compared to historic and average yields.

In order to determine if crop yields have decreased across the project area during the cultivation cycle as a result of project activity, the annual yield from the project area must be compared to historical yields over the past five years from the same project area. Because yields fluctuate

[64] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[65] Huang, H., & Khanna, M., 2010.

annually depending on numerous climatic drivers, for this evaluation, yields are normalized to average annual county yields using USDA NASS statistics,[66] according to the procedure below.

This normalization procedure must be followed for each cultivation cycle to demonstrate that the yields from the project area have not declined due to project activity. The following procedure is applicable for a single-field project. All aggregates must apply the following procedure to the entire project area, defined as the sum of individual fields included in verification activities.

1. For each year *t* in the historical look-back period (see Section 5.2), normalize the yield of the field by the county average for that year, y_norm_t. If the project is an aggregate, calculate y_norm_t for each of the historical years as the weighted average (by percent of field area) of all fields in the aggregate following Equation 5.19. The distribution of y_norm_t will have the same number data points as the number of eligible crop years in the historical look-back period (between three and five years).

Equation 5.19. Normalized Yield for Each Year *t*

For single-field projects: $$y\_norm_t = \frac{Y_{f,t}}{Y_{county,t}}$$

For aggregate projects: $$y\_norm_t = \sum_f \left(A_f \times \frac{Y_{f,t}}{Y_{county,t}} \right) / \sum_f A_f$$

Where,

			Units
A_f	=	Size of field *f*	ha
$Y_{f,t}$	=	Yield of field *f* in year *t*	Mg/ha
$Y_{county,t}$	=	County average yield in year *t*	Mg/ha

If aggregates span multiple counties, $Y_{county,t}$ must correspond with the county in which field *f* is located.

2. For the cultivation cycle for the present reporting period, normalize the yield of each field by the county average for the growing season for the year and, if the project is an aggregate, calculate the weighted average for all fields in the aggregate to get y_norm_{t0} using Equation 5.19 above and replacing *t* with t_0, i.e. the year of the present reporting period.

3. Take the standard deviation, *s*, and mean of the y_norm_t distribution:

$$s = stdev(y\_norm_t)$$

$$\overline{y\_norm_t} = average(y\_norm_t)$$

4. Calculate the minimum yield threshold below which normalized yields are significantly smaller than the historical average. This shall be done as follows:

$$y\_\min = \overline{y\_norm_t} - 2.132 \times s$$

[66] Available at http://quickstats.nass.usda.gov.

Where 2.132 is the t-distribution value with 95 percent confidence for a one-tailed test with four degrees of freedom (i.e. n is 5),[67] and *s* is the standard deviation of the y_norm_t distribution, as calculated in Step 3.

5. For every year of the crediting period, calculate y_norm_{t0} and compare this value to *y_min*. If y_norm_{t0} is smaller than *y_min*, it must be assumed that leakage occurred and emissions increased outside of the project area. The project must account for increased emissions as specified in Equation 5.20 below.

Equation 5.20. Increased Emissions Outside the Project Boundary

$$\boldsymbol{SE_{PS}} = \left(1 - \frac{y\_norm_{t0}}{y\_min}\right) \times \sum_i [\, N_2O_{B,f} \times A_f \,]$$

Where,

			Units
SE_{PS}	=	Total secondary effect GHG emissions from production shifting outside of the project boundary	Mg CO_2e/ha
y_norm_{t0}	=	Normalized project yield for field *f*	Mg/ha
y_min	=	Minimum yield threshold below which normalized yields are significantly smaller than the historical average for field *f*	Mg/ha*
$N_2O_{B,f}$	=	Total annual baseline N_2O for field *f*, see Equation 5.13	Mg CO_2e/ha
A_f	=	Size of field *f*	ha

* Mg/ha is indicated as required units for crop yield. Note, however, that units of $y\_norm_{t0,i}$ and $y\_min_{t0,i}$ cancel each other out. Therefore, other units can be used, as long as the units for $y\_norm_{t0,i}$ are the same as the units for $y\_min_{t0,I}$.

[67] The t-distribution value of 2.132 = t(0.05, n – 1), where n is 5, and n-1 degrees of freedom is 4. If there are less than five data points (e.g. less than five eligible crop years in the historic look-back period), a different t-distribution value must be substituted for 2.132. Specifically, where n=4, t-value=2.353, and where n=3, t-value=2.920.

6 Project Monitoring

The Reserve requires that Monitoring Plans and Reports be established for all monitoring and reporting activities associated with the project. Single-field projects must develop a monitoring plan in accordance with the guidance in Section 6.1. Aggregate projects must develop monitoring plans both at an aggregate-level and field-level in accordance with the guidance in Section 6.2.

6.1 Single-Field Project Monitoring Plan

Single-field projects must establish a Single-Field Monitoring Plan (SFMP). The SFMP, together with the Single-Field Report (SFR) outlined in Section 7.2.1, will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and 7 are met for single-field projects, and that consistent, rigorous monitoring and recordkeeping is ongoing at the project field. The SFMP must be developed and maintained by the project developer. The SFMP must specify how required field data (Section 6.3) are collected, recorded, and managed at each field. The SFMP must also outline procedures for developing and submitting a complete SFR in accordance with Section 7.2.1. It is the responsibility of the project developer to ensure that the SFMP meets all requirements specified, and is kept on file and up-to-date for verification.

The SFMP will outline the following:

- Procedures describing how the field perimeter GIS shape file and/or *.kml file will be created
- Procedures describing how the crediting period, verification schedule, and quantification results will be tracked for that field
- Procedures or methods for ensuring that the project developer holds title to the GHG emission reductions as required in Section 2.3
- Procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test and Regulatory Compliance (Sections 3.5.2 and 3.6 respectively)
- A plan for monitoring the field data outlined in Section 6.3, which includes a plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.1
- The frequency of data acquisition
- The role of individuals performing each specific activity, particularly N application, monitoring, and corn stalk sampling
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.2 Monitoring Plans for Aggregates and Participating Fields

Aggregate projects must establish an Aggregate Monitoring Plan (AMP), according to the requirements of Section 6.2.1 below. It is also the responsibility of the aggregator to ensure that each of the project participants with fields enrolled in the aggregate develops a Field Monitoring Plan (FMP) that meets at minimum the requirements specified in Section 6.2.2, and to ensure that an up-to-date copy of each FMP is kept on file by the aggregator and for verification.

6.2.1 Aggregate Monitoring Plan

Aggregate projects must establish an AMP, which will serve, together with the Aggregate Report outlined in Section 7.2.2, as the basis for verifiers to confirm that the aggregate tracking requirements have been and will continue to be met for each reporting period. The AMP must be developed and maintained by the aggregator. The AMP must outline procedures on how all of the data included in the annual Aggregate Report, the requirements of which are specified in Section 7.2.2, will be collected and managed, and must outline procedures for developing and submitting a complete Aggregate Report.

The AMP will outline the following:

- Procedures describing how the field perimeter GIS shape file and/or *.kml files will be created for each field
- Procedures describing how the crediting period, verification schedule, and quantification results will be tracked for each field included in the aggregate
- Procedures and methods for ensuring that the title to the GHG emission reductions has been conferred to the aggregator as required in Section 2.3 for each field in the aggregate
- Procedures that the aggregator will follow to ascertain and demonstrate that all fields in the aggregate at all times pass the Legal Requirement Test and Regulatory Compliance (Sections 3.5.2 and 3.6 respectively); process should include review of permits (e.g. air, water, and land use permits), Notices of Violations (NOVs), and any administrative or legal consent orders relevant to project activities
- Procedures the aggregator will follow to track which fields have passed the performance standard and which are in a Grace Period with delayed crediting (see Section 3.5.1.1.1).
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.2
- The role of individuals performing each specific activity, particularly N application, monitoring, and corn stalk sampling
- QA/QC provisions to ensure that data collected from the field level, according to data acquisition requirements outlined in the Field Monitoring Plan (FMP) described below, is carried out consistently and with precision

6.2.2 Field Monitoring Plan for Project Participants in an Aggregate

The Field Monitoring Plan (FMP) will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in Sections 6 and 7 are met at each field in an aggregate, and that consistent, rigorous monitoring and record keeping is ongoing at each field. The FMP must specify how required field data (Section 6.3) are collected, recorded and managed at each field.

One FMP must be developed for each project participant. If a project participant has multiple fields enrolled in the aggregate, only one FMP is required as long as it addresses the distinct monitoring requirements at each field. The FMP can be developed by the project participant or the aggregator, depending on the arrangement specified in contractual agreements. It is the responsibility of the aggregator to ensure that the FMP meets all requirements specified, and that an up-to-date copy of each FMP is kept on file by the aggregator and for verification.

At a minimum the FMP shall stipulate:

- The frequency of data acquisition
- The role of individuals performing each specific activity, particularly N application, monitoring, and corn stalk sampling

- A plan for monitoring the field data outlined in Section 6.3, including a detailed record keeping plan meeting the minimum record keeping requirements of Sections 7.3.2.2 and 7.3.2.3
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.3 Mandatory Field Data Monitoring Requirements

All field-level data and information specified in this Section must be collected and retained for verification purposes. Section 7.3 provides further guidance on specific record-keeping requirements.

6.3.1 General Field Tracking Data

- Either a GIS shape file or a *.kml file clearly defining the field perimeter
- The coordinates of the most north-westerly point of the field, reported in degrees to four decimal places[68] (to be used for creating field serial numbers)
- The serial number of the field, constructed as specified in Section 7.1.1.
- The start date of the field
- Disclosure of any material and immaterial regulatory violations, with copies of all Notices of Violations (NOVs) included in the report
- Field crop yield during the reporting period and for five years (or at least three eligible crop years) prior to the field start date for the eligible crop(s)

6.3.2 Field Management Data

The following management data must be collected and retained at each field for each cultivation cycle over the life of the project (e.g. both for eligible and ineligible crop years):

- Planting date
- Begin and end date of harvesting on the field
- Dates when emergency irrigation is used, type of system, justification for use

6.3.3 Project Activity Data and Documentation

6.3.3.1 Project Activity Data and Documentation: Eligible Crop Years

To corroborate field management assertions, each field must collect and retain the following documentation for all eligible crop years:

- Planting date
- Begin and end date of harvesting on the field
- Crop yield
- Fertilizer types, amounts (e.g. rates), and application dates, disaggregated by type for all sources of N (both synthetic and organic). including purchasing records and information on each type's N concentration[69]
- All field monitoring parameters, as listed in Table 6.1
- Fertilizer application method and placement
- Type of equipment used for fertilizer application

[68] Longitude reported in degrees to four decimal places provides a spatial resolution of about 11 meters, the resolution of the latitude is slightly less than that.
[69] Blackmer, A.M., & Mallarino, A.P., 1996. Available at http://www.extension.iastate.edu/Publications/PM1584.pdf.

- Whether irrigation was used, and if so, the type of irrigation system used, justification of why it was necessary, irrigation dates and volumes (during the growing season and during post-harvest period). (It should be noted that irrigation is only permissible in eligible crop years in case of emergency irrigation needs)

6.3.3.1.1 Implementation of a Corn Stalk Nitrate Test

As a monitoring requirement to help corroborate field management assertions, each field must implement at least one Corn Stalk Nitrate Test (CSNT) for each eligible corn crop toward the end of the reporting period, according to the sampling methodology developed by Iowa State University (ISU).[70]

One CSNT sample is comprised of 15 segments taken from corn stalks across the field. If the project participant intends to use CSNT results as an adaptive management technique, each CSNT sample should cover no more than 20 acres. However, for the purposes of this protocol, one CSNT sample per 100 acres is allowable.

Sampling for the CSNT must follow the recommended methodology from ISU:

1. Sampling shall take place between one and three weeks after black layers have formed on about 80 percent of the kernels of most ears of corn.
2. The portion of each plant sampled is the 8-inch segment of stalk found between 6 and 14 inches above the soil.
3. Leaf sheaths should be removed from the segments.
4. Stalks severely damaged by disease or insects should not be used.
5. Fifteen 8-inch segments should be collected to form a single sample to be sent for analysis.

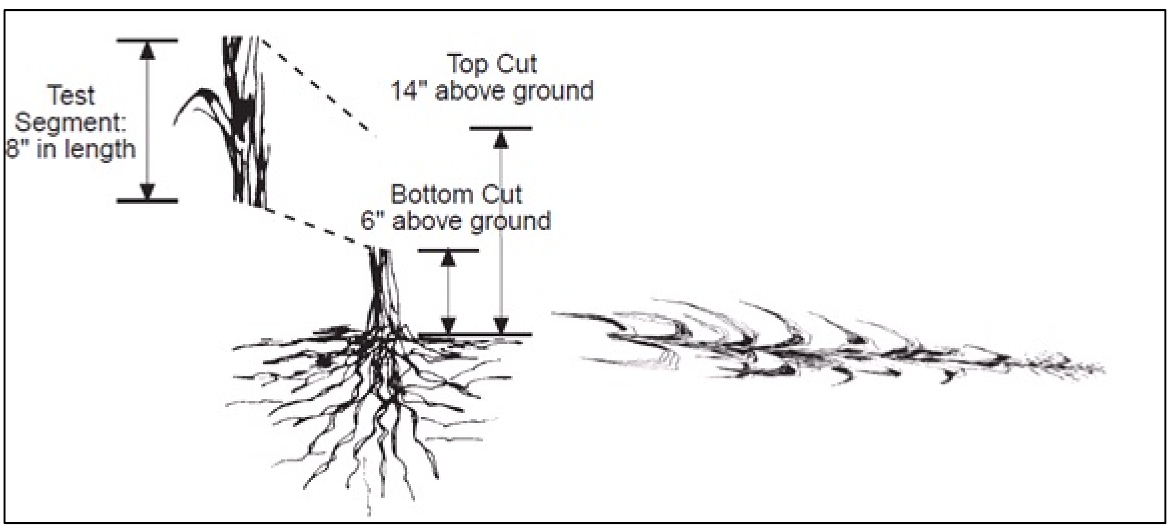

Figure 6.1. Diagram of How to Sample for Crop Stalk Nitrate Tests[71]

Once CSNT samples are collected, they must be sent to a university extension service or other qualified laboratory for analysis as soon as possible after collection. Samples should be placed

[70] Ibid.
[71] Ibid.

in paper (not plastic) bags to enable some drying and minimize growth of mold, and samples should be refrigerated (but not frozen) if stored for more than one day before mailing. The time required to mail samples to a laboratory should not be an issue.

Documentation of the lab results should be kept on file by both the project participant and aggregator. Verification bodies will use CSNT lab results to inform their verification site visit sampling for aggregates, as discussed in Section 8.3.1.

6.3.3.2 Project Activity Data and Documentation: Non-Eligible Crop Years

If the crop rotation on the project field includes ineligible crops (e.g. soy in a corn/soy rotation), the project field must report continuously on the field's management practices, even though the project field shall only receive credit for project activities implemented on eligible crops.

To corroborate field management assertions, each field must collect and retain the following documentation for all non-eligible crop years:

- Planting date
- Begin and end date of harvesting on the field
- Total N applied for the non-eligible crop year, and total N applied in each of the previous five crop years for the same non-eligible crop grown on that field

Though not required, the Reserve encourages project participants to keep detailed monitoring records for non-eligible crop years comparable to the records which must be kept for eligible crop years (e.g. Section 6.3.3.1).[72]

6.3.4 Field Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1 below. Field monitoring parameters must be determined according to the data source and frequency specified, for all eligible crop years. Table 6.1 specifies monitoring requirements for field monitoring parameters required of all project fields.

[72] Monitoring additional variables for the non-eligible crop year will ensure proper records have been kept in order to set an appropriate baseline and in the event that non-eligible crops are included in the NMPP in the future. See Section 6.4 for more information.

Table 6.1. Field Monitoring Parameters

Equation	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
3.1, 5.2	NR_f	Annual total nitrogen application rate (including organic and synthetic forms of N) on field *f*	kg N/ha	o, c	annual	Farmer records; calculated in Equation 5.2
3.1	RTA_f	RTA calculated for field *f* for purposes of the performance standard	ratio	c, o	annual	Calculated from farmer records
3.1, 5.19	$Y_{f,}$	Annual yield on field *f*	unit/ha	o	annual	Farmer records (historic and project)
3.1	NC	Default N concentration for corn	kg N/unit	r	annual (unless unchanged)	Equation 3.1 lists the default values [0.36 kg N/bushel for corn grain and 3.22 kg N/US ton for silage]
5.2, 5.3,	$NR_{S,f}$	Annual total synthetic nitrogen application rate for field *f*	kg N/ha	o, c	annual	Farmer records
5.2, 5.4	$NR_{O,f}$	Annual total organic nitrogen application rate for field *f*	kg N/ha	o, c	annual	Farmer records
5.3, 5.5	$NR_{DS,j,f}$	Annual N application rate of dry synthetic fertilizer type *j* on field *f*	kg N/ha	o, c	annual	Farmer records
5.3, 5.6	$NR_{LS,j,f}$	Annual N application rate of liquid synthetic fertilizer type *j* on field *f*	kg N/ha	o, c	annual	Farmer records
5.4, 5.7	$NR_{SO,j,f}$	Annual N application rate of solid organic fertilizer type *j* on field *f*	kg N/ha	o, c	annual	Farmer records
5.4, 5.8	$NR_{LO,j,f}$	Annual N application rate of liquid organic fertilizer type *j* on field *f*	kg N/ha	o, c	annual	Farmer records
5.5	$MF_{DS,j,f}$	Mass of dry synthetic N-containing fertilizer *j* applied to field *f*	lbs fertilizer/acre	o, m	annual	Farmer records
5.5	$NC_{DS,j}$	Nitrogen concentration of dry synthetic fertilizer *j*	lbs N/(lbs fertilizer)	o, m, r	annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Table A.2)

5.6	$VF_{LS,j,f}$	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f*	gallons/acre	o, m	annual	Farmer records
5.6	$MF_{LS,j}$	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer	lbs fertilizer/gallon	o, m	annual	Farmer records
5.6	$NC_{LS,j}$	Nitrogen concentration of liquid synthetic fertilizer *j*	gallons N/(gallons fertilizer)	o, m, r	annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Table A.2)
5.7	$MF_{SO,j,f}$	Mass of solid organic N-containing fertilizer *j* applied to field *f*	tons fertilizer/acre	o, m	annual	Farmer records
5.7	$NC_{SO,j}$	Nitrogen concentration of solid organic fertilizer *j*	lbs N/(lbs fertilizer)	o, m, r	annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Table A.2)
5.8	$VF_{LS,j,f}$	Volume of liquid organic N-containing fertilizer *j* applied to field *f*	gallons/acre	o, m	annual	Farmer records
5.8	$MF_{LO,j,f}$	Mass of liquid organic N-containing fertilizer *j* applied to field *f*	tons fertilizer/acre	o, m	annual	Farmer records
5.8	$NC_{LO,j}$	Nitrogen concentration of liquid organic fertilizer *j*	lbs N/(lbs fertilizer)	o, m, r	annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Table A.2)
5.9, 5.11	$NR_{B,f}$	Baseline total N rate determined for field *f*	kg N/ha	o, c	annual	Farmer records (calculated using Equations 5.2 to 5.8, as appropriate)
5.9	$EF_{Dir,B,f}$	Emission factor for baseline direct N_2O emissions from baseline N inputs	kg N_2O-N/(kg N input)	c		Calculated and used in Equation 5.9
5.9, 5.13	$N_2O_{Dir,B,f}$	Baseline direct N_2O emissions from field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.9

5.15	$NR_{P,f}$	Project total N rate for field *f*	kg N/ha	o, c	annual	Farmer records (calculated using Equations 5.2 to 5.8, as appropriate)
5.10, 5.12, 5.15	$NR_{P,S,f}$	Project N rate of total synthetic fertilizer for field *f*	kg N/ha	o, c	annual	Farmer records (calculated using Equations 5.3, 5.5, and 5.6, as appropriate)
5.10, 5.12, 5.15	$NR_{P,O,f}$	Project N rate of total organic fertilizer for field *f*	kg N/ha	o, c	annual	Farmer records (calculated using Equations 5.4, 5.7, and 5.8, as appropriate)
5.10, 5.11, 5.12, 5.15	$NR_{B,O,f}$	Baseline N rate of total organic fertilizer for field *f*	kg N/ha	o, c	annual	Farmer records (calculated using Equations 5.4, 5.7, and 5.8, as appropriate)
5.10	$EF_{Dir,P}$	Emission factor for project direct N_2O emissions from project N inputs	kg N_2O-N/(kg N input)	c	annual	Calculated and used in Equation 5.10
5.10, 5.13	$N_2O_{Dir,P,f}$	Project direct N_2O emissions from field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.10
5.11	$NR_{B,S,f}$	Baseline N rate of total synthetic fertilizer for field *f*	kg N/ha	o, c	annual	Farmer records
5.11, 5.13	$N_2O_{LVRO,B,f}$	Baseline N_2O emissions from leaching, volatilization and runoff from field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.11
5.12, 5.13	$N_2O_{LVRO,P,f}$	Project N_2O emissions from leaching, volatilization and runoff from field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.12
5.14, 5.17, 5.19, 5.20	A_f	Size of field *f*	ha	o	annual	Farmer records
5.13, 5.14, 5.20	$N_2O_{B,f}$	Total annual baseline N_2O for field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.13
5.13, 5.14	$N_2O_{P,f}$	Total annual project N_2O for field *f*	Mg CO_2e/ha	c	annual	Calculated in Equation 5.13
5.1, 5.14	PER	Primary effect GHG reductions over the entire project area	Mg CO_2e	c	annual	
5.14, 5.15	$\mu_{struct,f}$	Accuracy deduction for structural uncertainty for field *f*	value	c		
5.14, 5.15	nrFields	Number of fields included in the project area	No units	o	annual	Farmer records

5.15	$UNC_{PER,f}$	Uncertainty in N_2O emissions reductions associated with a reduction in N rate for field *f* relative to the average emission reduction value	%	c	annual	
5.1, 5.16	SE	Net secondary effect GHG emissions for project aggregate due to project activities	Mg CO_2e	c	annual	
5.16 and *either* 5.17 or 5.18	$SE_{FF,f}$	Secondary effect of GHG emissions from increased cultivation equipment emissions due to fossil fuel combustion for field *f*	Mg CO_2e	c	annual	
5.16, 5.20	SE_{PS}	Secondary effect of GHG emissions for the project aggregate from production shifting outside of the project boundary	Mg CO_2e	c	annual	
5.17	$EF_{HP\text{-}hr,P,i,f}$	Emission factor for project operation *i* on field *f*	g CO_2e/ HP-hr	r	annual	Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations
5.17	$EF_{HP\text{-}hr,B,k,f}$	Default emission factor for baseline operation *k* on field *f*	g CO_2e/ HP-hr	r	annual	Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations
5.17	$HP_{P,i,f}$	Horsepower requirement for project operation *i* on field *f*	HP	o, r	annual	
5.17	$HP_{B,k,f}$	Horsepower requirement for baseline operation *k* on field *f*	HP	o, r	annual	
5.17	$t_{P,i,f}$	Time required to perform project operation *i* on field *f*	hr/field	o, c	annual	Farmer records or calculated using optional method in Equation 5.17
5.17	$t_{B,k,f}$	Time required to perform baseline operation *k* on field *f*	hr/field	o, c	annual	Farmer records or calculated using optional method in Equation 5.17
5.17	t	Time requirement for field operation	hr	c	annual	Only calculated for Equation 5.17 if farm records for $t_{P,i,f}$ and $t_{B,k,f}$ are not available

5.17	width	Application width covered by equipment	m	o	annual	Only used to calculate $t_{P,i,f}$ and $t_{B,k,f}$ for Equation 5.17 if farm records are not available
5.17	speed	Average ground speed of the operation equipment	km/hr	o	annual	Only used to calculate $t_{P,i,f}$ and $t_{B,k,f}$ for Equation 5.17 if farm records are not available
5.18	$FF_{PR,j}$	Total increase in fossil fuel combustion for field *f* during the reporting period, by fuel type *j*	gallons	o	annual	Farmer records, fuel sales receipts
5.18	$EF_{FF,j}$	Fuel-specific emission factor	kg CO_2/gallon fossil fuel	r	annual	Default values are 17.4 for gasoline and 13.7 for diesel
5.19	$Y_{county,t}$	County average yield in year *t*	Mg/ha	r	annual	Reference data from USDA NASS county yield statistics
5.20	y_norm_{t0}	Normalized project yield for field *f*	Mg/ha	c	annual	
5.20	y_min	Minimum yield threshold below which normalized yields are significantly smaller than the historical average for field *f*	Mg/ha	c	annual	

6.4 Supplemental Field Data Monitoring

In addition to the required field-level data and information specified in Section 6.3, project participants may choose to monitor and keep records of additional field data. Project participants are encouraged to monitor and retain supplemental records for *all* nitrogen management activities and *all* crops once a project is underway, including practices and crops not currently eligible for crediting at this time. Additional records may be of use in the event that quantification methodologies become available for currently ineligible practices and crops in future versions of this protocol. Further, while not required, supplemental data collected for eligible crop years may further assist project participants in successfully completing verification by providing verification bodies with additional information to corroborate project implementation activities and emission reductions from the project.

Supplemental monitoring parameters could include:

- A list of “enabling practices” (defined in Section 2.2.3) implemented on the field during the reporting period, as well as detailed records of dates and other aspects of management
- Additional data collected and/or test results from the implementation of any enabling or adaptive management practices (e.g. variable rate technology and the results of supplemental pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials)

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers.

7.1 Project Submittal Documentation

For each nitrogen management project, project developers/aggregators must provide the following documentation to the Reserve in order to submit a nitrogen management project for listing on the Reserve.

- Project Submittal form
- Project Submittal *.csv file

The Project Submittal form will be the same for both single-field projects and aggregates. Both single-field and aggregate projects will also be required to submit a project submittal *.csv file, which shall include the initial "List of Enrolled Fields"; each field's serial number (according to Section 7.1.1 below), county and state; and the names of project participants for each field. In the case of a single-field project, the List of Enrolled Fields will include only the single field. The List of Enrolled fields for aggregate projects shall include all fields enrolled in the aggregate at the time of submittal. Once verification commences (i.e. at the NOVA/COI stage),, aggregate projects will be required to update the list to include all fields actually enrolled in the aggregate at that point (e.g. if fields have been added or removed from the aggregate between submittal and contracting a verifier [73]). The list must also be updated prior to each subsequent annual verification.

Project submittal forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.1.1 Determining Field Serial Numbers

The field serial number, which must be included in the List of Enrolled Fields, shall be determined by the following algorithm, with each element separated by a dash (-):

First state postal abbreviation, followed by the first letter of the County, followed by degrees of the most north-western point of the field (latitude then longitude, both reported to four decimal places), followed by the acreage of the field.[74] (Example: CA-*B-39.6123-121.5332-76* would be a 76 acre field in Butte County, CA)

[73] See the Reserve Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

[74] Because all fields will be located in the United States, the latitude will always be positive (i.e. degrees north of the equator), and longitude will always be negative (i.e. degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at *+39.6123º latitude, and -121.5332º longitude.*

7.2 Annual Reports and Documentation

Once a project has been listed on the Reserve, project developers must provide the following documentation to the Reserve in order to register a nitrogen management project with the Reserve. This documentation must be submitted to the Reserve within 12 months of the end of each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

The following documentation is required of both single-field projects and aggregates:

- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Signed (Aggregator) Attestation of Title form [75]
- Annual Reports (as outlined in Sections 7.2.1 and 7.2.2)
- Verification Report
- Verification Statement

With the exception of the Annual Reports, outlined in Sections 7.2.1 and 7.2.2, all of the above project documentation will be available to the public via the Reserve's online registry. Further disclosure (e.g. of the Annual Reports) and other documentation may be made available on a voluntary basis through the Reserve, at the request of the project developer.

In the event that a project participant transfers from one aggregate to a different aggregate, the new aggregator is responsible for submitting a Field Management Transfer form, which will require the project participant's signature, to the Reserve prior to the beginning of the subsequent reporting period.

Project forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.2.1 Single-Field Report (Single-Field Projects Only)

For each cultivation cycle, the following information must be included in an annual report that will be submitted to the Reserve as a *.csv file:

- The field serial number (according to Section 7.1.1)
- The acreage of the field (acres)
- Start date of the field
- Whether the field had previously been enrolled in an aggregate
    - If so, include the name of the aggregate, dates of enrollment, and a brief description of the circumstances for leaving the previous aggregate.
- The field's emission reduction calculation results for the current verified cultivation cycle (corrected for structural uncertainty) *OR* a statement indicating that the field is in a non-eligible crop year.[76]
- Lab results of the Corn Stalk Nitrate Test

[75] Although the single-field project will submit the general Attestation of Title form, aggregators will be required to submit an Aggregator Attestation of Title form, which will include language attesting to the fact that the aggregator has not and will not knowingly allow a third party (e.g. project participant) to provide false, fraudulent, or misleading data or statements.
[76] Note that a single-field project must report continuously (e.g. submit a single-field report annually) even if that field is in a non-eligible crop year.

7.2.2 Aggregate Report

For each cultivation cycle, all aggregate-level monitoring information must be included in an annual Aggregate Report that will be submitted to the Reserve as a *.csv file, with accompanying documentation, at verification. The Aggregate Report must contain a list of all fields and the following information <u>for each field</u>:

- The field serial number (according to Section 7.1.1)
- The acreage of the field (acres)
- Start date of the field
- Date field enrolled in the aggregate, including a flag specifying whether the field is a new addition to the aggregate for this reporting period
- Current status of field (active, active but not in an eligible crop year, terminated, transferred to a different aggregate)
- Name of project participant associated with the field
- A flag indicating whether the field had a site visit or desktop verification, or was unverified during the reporting period
- The emission reduction calculation results for the field (uncorrected for structural uncertainty)
- Lab results of the Corn Stalk Nitrate Test

In addition to the above information, collected at the field-level, the Aggregate Report must include the total verified emission reductions for the aggregate, corrected for structural uncertainty and any deductions due to errors or misrepresentations at the verified fields.

7.2.3 Field Report

For each cultivation cycle, including those in which a non-eligible crop is grown, all fields within an aggregate must submit an annual Field Report to the aggregator. This report will not be submitted to the Reserve. Although the Reserve encourages participants to submit Field Reports in the form of a *.csv file, the format of the report will be at the discretion of the aggregator.

At a minimum, Field Reports will be required to include the following:

- A signed statement by the project participant attesting to the fact that all statements and data contained therein are true and accurate
- Current status of field (active, active but not in an eligible crop year), as well as a description of any notable changes in management control and/or management practices
- Field management data (as specified in Section 6.3.2)
- Project activity data (as specified in Section 6.3.3),

All fields must report continuously (e.g. submit a Field Report annually) even if that field is in a non-eligible crop. In a non-eligible crop year, the Field Report should include a statement indicating that the field is in a non-eligible crop year, as well as the information required by Section 6.3.3.2.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or seven years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

7.3.1 Record Keeping for Single-Field Projects

The project developer should retain the following records and documentation, as well as documentation to substantiate the information in the annual Single-Field Report and all field-level data and calculations. These records include:

- Contractual arrangements with project developer, project participant and/or land owner (if applicable, e.g. if the project developer is not the field manager)
- Copies of letter of notification sent to land owner, including the date letter was sent
- GIS shape file or *.kml file
- North-western latitude/longitude coordinates of field (to four decimal places)
- Serial number of field (according to the guidance in Section 7.1.1)
- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Lab results of the Corn Stalk Nitrate Test
- Fertilizer purchase records
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records, manufacturer's HP specifications, hours spent on N application)[77]
- Data inputs for the calculation of the project emission reductions
- Field management data (as specified in Section 6.3.2)
- Project activity data (as specified in Section 6.3.3), including:
    - Farm management records pertaining to nitrogen management and crop yields[78]
    - Records relevant to the equipment used for N-application and/or N-monitoring (e.g. nutrient applicator, nutrient sprayer, chlorophyll meter, variable rate technologies)
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2 Record Keeping for Aggregate Projects

7.3.2.1 Aggregate-Level Record Keeping

The aggregator should retain the following records and documentation, as well as documentation required by Sections 6.2 to substantiate the information in the annual Aggregate Report. System information must be retained for each field, yet collected and managed at the aggregate level. These records include all:

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[77] Records are required for both approaches to quantifying SSR 3. Fossil fuel-use records, broken down by field, are required for implementing Approach 2 (see Section 5.4.1). If the standard default is used (Approach 1), less extensive records are required, as equipment horsepower requirements may be looked up based on manufacturer specifications and operating hours spent on N-application may be estimated, but basic documentation corroborating the choice of default (e.g. proof the equipment or hours claimed are the equipment or hours used/spent) are still necessary.

[78] Project participants are encouraged to retain excellent records for all nitrogen management activities and crops once the project is underway, even those not currently eligible for crediting at this time, in the event that quantification methodologies become available at some point in the future and considered for inclusion in this protocol.

- Contractual arrangements with project developer, each project participant and/or land owner
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS shape file or *.kml file for all fields in the aggregate
- North-western latitude/longitude coordinates for each field (to four decimal places)
- Serial numbers for each field (according to the guidance in Section 7.1.1)
- Executed Aggregator Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Data inputs for the calculation of the project emission reductions
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2.2 Aggregate Field-Level Record Keeping

The aggregator should retain the following records and documentation, as well as documentation required in Section 6.3 for each field.

At each field, the following records should be retained for verification purposes:

- Field management data (as specified in Section 6.3.2)
- Lab results of the Corn Stalk Nitrate Test
- Fertilizer purchase records
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records, manufacturer's HP specifications, hours spent on N application).[79]
- Project activity data (as specified in Section 6.3.3), including:
  - Farm management records pertaining to nitrogen management and crop yield.[78]
  - All records relevant to the equipment used for N-application and/or N-monitoring (e.g. chlorophyll meter, variable rate technologies)

7.3.2.3 Participant Field-Level Record Keeping

Project participants must retain the following documentation and be prepared to provide this documentation when requested by the aggregator and/or a verification body:

- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records)

7.3.3 Supplemental Record Keeping

As noted in Section 6.4, project developers (of single-field projects) and project participants (who are part of an aggregate) are encouraged – but not required – to monitor and retain

[79] Records are required for both approaches to quantifying SSR 3. Fossil fuel-use records, broken down by field, are required for implementing Approach 2 (see Section 5.4.1). If the standard default is used (Approach 1), less extensive records are required, as equipment horsepower requirements may be looked up based on manufacturer specifications and operating hours spent on N-application may be estimated, but basic documentation corroborating the choice of default (e.g. proof the equipment or hours claimed are the equipment or hours used/spent) are still necessary.

additional supplemental records for all nitrogen management activities and crops on their field once the project is underway, including nitrogen management activities and crops that are not eligible for crediting in the current protocol. Though this supplemental recordkeeping is not required, these additional records may help streamline verification activities and will be helpful for establishing a baseline in the event that additional quantification methodologies related to these practices and crops are included in future versions of the protocol. Supplemental records could include:

- A list of the "enabling practices" (see Section 2.2.3) implemented on the field during the reporting period
    - Additional data collected, due to enabling practices (e.g. variable rate technology and the results of supplemental pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials)
- Time-stamped digital photographs of fertilizer management activities
- Aerial images (demonstrating homogenous management and/or field boundaries)

7.4 Reporting Period and Verification Cycle

Project emission reductions must be quantified and verified on an annual basis, reflecting a reduction in annual N rate over a complete cultivation cycle. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." The reporting period must be uniformly defined for the aggregate, and shall be determined by the aggregator as an annual period most appropriate for aggregate, based on the cultivation cycles and respective start dates of fields within the aggregate. Individual fields within an aggregate may have cultivation cycles that start on different dates; however the cultivation cycles for all fields within an aggregate must be complete before the aggregate is able to undergo verification. To ensure that only emission reductions occurring during an aggregate's fixed reporting period is credited during that reporting period, emission reductions from each field shall be prorated as discussed further below. For single-field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

Both reporting periods and cultivation cycles must be contiguous; there can be no time gaps in reporting during the crediting period of an aggregate once the initial reporting period has commenced.[80] If the crop rotation on the project field includes ineligible crops (e.g. soy in a corn/soy rotation), the project field must report continuously on the field's management practices, even though the project field shall only receive credit for project activities implemented on eligible crops.

Because a single reporting period must be uniformly defined for the aggregate, the aggregator must prorate the emissions reductions from each field in the aggregate, after the field has completed its respective cultivation cycle and total emission reductions for that field have been calculated. All emission reductions from a complete cultivation cycle should be verified at one time. However, the aggregator shall divide total emission reductions from the reporting period by 365 days to calculate the average daily emission reductions associated with a given field, and multiply by the total days of the cultivation cycle falling within the aggregate's uniform reporting period currently undergoing verification. The remaining emission reductions from the complete cultivation cycle (applicable to the subsequent reporting period), should be verified along with

[80] An entire aggregate can willingly forfeit CRTs for an entire cultivation cycle in accordance with the zero-credit reporting period policy in Section 3.3.3 of the Reserve Program Manual.

the field's total emission reductions from this cultivation cycle, but shall be credited under the subsequent aggregate reporting period.

For aggregates, no more than one reporting period can be verified at once, except during an aggregate's first verification, which may include historical emission reductions from prior years.

7.4.1 Additional Reporting and Verification Options for Single-Field Projects

For single-field projects, there are three verification options to choose from, which provide the project developer more flexibility and help manage verification costs associated with nitrogen management projects. The project developer may choose from these additional options after a project has completed its initial verification and registration.

A project developer may choose to use one option for the duration of a project's crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced. Project participants must continue reporting during non-eligible crop years (see Section 6.3.3.2 for requirements). Non-eligible crop years do not require verification, and as such, do not count against the number of months included in a given verification period (see options below). Verifiers shall review N rate records for any interim non-eligible year(s) as a component of verifying eligibility in the subsequent eligible crop year (see Section 3.5.1.1).

If a single-field project joins an aggregate, that field will immediately be subject to the verification schedule of the aggregate moving forward (e.g. for the first reporting period that field is enrolled in the new aggregate).

If a field exits an aggregate to become a single-field project, that project is subject to the reporting and verification requirements of an initial reporting and verification period. In other words, that single-field project's first verification as a single-field project may not take advantage of Options 2 or 3, below.

7.4.1.1 Initial Reporting and Verification Period

The reporting period for projects undergoing their initial verification and registration cannot exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. The one exception is for historic projects (e.g. fields with start dates on or after June 27, 2010), which are eligible to include multiple cultivation cycles in their first reporting period, so long as the project is submitted to the Reserve by June 27, 2013 (see Section 3.2 for additional guidance). Once a project is registered and has had at least one complete cultivation cycle of emission reductions verified, the project developer may choose one of the verification options below.

7.4.1.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. Verification with a site visit is required for CRT issuance.

7.4.1.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed one complete cultivation cycle. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) Site visit verifications occur at two-year intervals (e.g. every second eligible crop year), with a maximum of three non-eligible crop years between corn crops; and (2) The verification body has confirmed that there have been no significant changes in selected project activities, field management or ownership and/or management control of the field since the previous site visit. Desktop verifications must cover all other required verification activities (i.e. a full desktop verification of the Single-Field Report).

Desktop verifications are allowed only for a single 12-month verification period in between 12-month verification periods that are verified by a site visit.

7.4.1.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed two complete cultivation cycles of eligible crops (approximately 730 days or 24 months) and the project monitoring plan and Single-Field Report must be submitted to the Reserve for the interim eligible crop's cultivation cycle's reporting period. The project monitoring plan and report must be submitted for projects that choose Option 3 in order to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on project operations and performance. They also demonstrate how the project monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve online registry, but are not publicly available documents. The monitoring plan and report shall be submitted within 30 days of the end of the reporting period. In the case of a multi-crop rotation, a 24-month verification period that consists of two non-consecutive corn crop years is allowable, with no more than one interim non-eligible crop year (e.g. verification could cover 24 months of data within a 36-month timeframe).

Under this option, CRTs may be issued upon successful completion of a site visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans or reports. Project developers may choose to have a verification period shorter than 24 months.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to nitrogen management projects.

Verification bodies trained to verify nitrogen management projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Nitrogen Management Project Protocol (NMPP)

The Reserve Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ISO-accredited verification bodies with lead verifiers trained by the Reserve for this project type are eligible to verify nitrogen management project reports. Verification bodies approved under other project protocol types are not permitted to verify nitrogen management projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

In addition, all verification bodies must have a Certified Professional Agronomist or Certified Crop Advisor[81] on the verification team in order to verify nitrogen management projects. The agronomist or crop advisor must be present for all verification site visits, and will provide additional support and expertise with interpreting information, assessing field conditions, reviewing CSNT collection procedures and results, and interviewing project participants and any relevant staff onsite.

8.1 Preparing for Verification

The project developer is responsible for coordinating all aspects of the verification process, coordinating with the verification body, project participants (in the case of an aggregate), and the Reserve, and submitting all necessary documentation to the verification body and the Reserve.

The project developer is responsible for selecting a single verification body for the entire project or aggregate for each reporting period. The same verification body may be used up to six consecutive years (the number of consecutive years allowed, according to the Reserve Verification Program Manual[82]). Verification bodies, including the agronomist, must pass a conflict of interest review against the project developer, and in the case of aggregate projects, all project participants and the aggregator. Consequently, the submitted List of Enrolled Fields must be updated by the aggregator prior to the conflict of interest review.

[81] Certification of agronomists and crop advisors should be administered by the American Society of Agronomy (https://www.agronomy.org), or other comparable program.
[82] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

Each year, project developers of single-field projects must make the Single-Field Report, which is submitted to the Reserve annually, and the Single-Field Monitoring Plan available to the verification body. These documents must meet the requirements in Sections 6 and 7.

In aggregate projects, project participants must annually submit a Field Report, all field data, and any reporting data from non-eligible crop years (where applicable, for fields completing an eligible crop year) to the aggregator according to the guidelines in Sections 6 and 7. Aggregators must make all Field Monitoring Plans (FMPs), Field Reports, reporting data from non-eligible crop years (for fields completing an eligible crop year), the Aggregate Monitoring Plan (AMP), and the Aggregate Report available to the verification body.

In all cases, the above documentation should be made available to the verification body after the NOVA/COI process is complete.

Aggregators may assist project participants in preparing documents for verification and in facilitating the verification process. The scope of these services is determined by the specific contract between project participants and the aggregator. However, the ultimate responsibility for monitoring reports and verification compliance is assigned to the aggregator.

For aggregates, a field is considered verified if it is in the pool of fields for which site visits or desktop verifications are conducted, even if not selected for either a site visit or desktop verification (see Section 8.3 for details on sampling for verification).

As a preliminary step in preparing for verification, the aggregator may choose to exclude fields from the pool of fields that may be selected for verification activities. Aggregators must report to the verification body all instances of field exclusion. The excluded fields shall be removed from the acreage totals and from field numbers used to determine field eligibility and verification sampling methodologies (in Section 8.3) and are therefore not considered verified.

8.2 Verification Schedule for Single-Field Projects

Single-field projects are comprised of exactly one field, and as such, there is no sampling methodology to select the fields undergoing verification. The single-field project shall be verified according to the verification schedule outlined below.

This protocol provides project developers three verification options, Sections 8.2.1 to 8.2.3, for a single-field project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with nitrogen management projects. For each option, verification bodies may need to confirm additional requirements specific to this protocol, and in some instances, utilize professional judgment on the appropriateness of the option selected.

All fields are required to perform a Corn Stalk Nitrate Test (CSNT) prior to the end of the reporting period for each eligible corn crop and provide the test results to the verification body, in preparation for verification. Unlike the case with aggregates, where CSNT results will directly inform risk-based sampling for verification site visits, the CSNT results for single-field projects are used to assess risk of whether the project activity has occurred. CSNT results that indicate “excessive” N use (e.g. greater than 2000 ppm nitrate-N)[83] or other anomalous results (e.g. a large increase in ppm nitrate-N from previous), should be interpreted as having a higher risk of

[83] Blackmer, A.M., & Mallarino, A.P., 1996.

not having reduced their N rate over the reporting period.[84] Therefore fields with "excessive" CSNT results shall receive further follow up, in the form of site visits, interviews, additional information requests, etc, as necessary.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.2.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol (see Section 7.4.1.2 for requirements).

8.2.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.4.1.3 in order to determine if a desktop verification is appropriate. The verifier shall use their professional judgment to assess any changes that have occurred related to project data management systems, equipment or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project verification. The documentation shall be reviewed prior to the NOVA/COI renewal submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the NOVA/COI renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.2.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.4.1.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12-month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.3 Verification Sampling and Schedule for Aggregates

Guidelines for verification sampling of the aggregate and the aggregate's verification schedule are different for "small aggregates," "large single-participant aggregates," and "large multi-participant aggregates." This approach allows a consistent application of verification requirements across all aggregates regardless of size or number of participants.

In all cases, the verification schedule shall be established by the verification body using a combination of risk-based and random sampling, according to the verification schedule and

[84] It is important to note that many factors influence N availability and a field's corn stalks may vary in their nitrate-N concentration from year to year. Consequently, an "excessive" result by the CSNT does not necessarily mean that a field has not reduced its N rate against its baseline, but it is a good indication of which fields have the highest probability of application above the N demand for the crop, and therefore are at highest risk of not having reduced their N rate over the reporting period.

sampling methodologies outlined in Sections 8.3.2, 8.3.3, and 8.3.4. These sampling methodologies establish a minimum and a range of verification frequencies, as well as guidance on circumstances in which the verification body is encouraged to add fields beyond the minimum percentage of fields required for site visit and/or desktop verification. The verifier may use professional judgment to determine the number of additional fields and method for selecting fields if a risk-based review indicates a high probability of non-compliance. The verification sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the aggregate.

The initial site visit verification schedule for a given year shall be established after the completion of the NOVA/COI process. The schedule should be established as soon as possible after the commencement of verification activities, once the verifier has received CSNT results and the Aggregate Report, at a minimum, so as to include both risk-based and random sampling for the selection of site visited fields. This is meant to allow for the aggregator and verification body to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list of project participants and fields receiving a visit to the aggregator and the Reserve. The aggregator shall be responsible for informing project participants of their selection for a planned site visit. Following this notification, the aggregator shall supply the verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary, due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Though significant advance notice of a field’s selection for a site visit is required, aggregators and project participants shall not be given advance notice of which fields’ data will be subject to desktop verification in a given year. A field shall be prepared for desktop verification during every reporting period, so long as the field’s FMP is implemented and up-to-date, the Field Report submitted to the aggregator, and all record-keeping requirements of this protocol are followed.

Regardless of the size of an aggregate, if the aggregate contains any fields that did not pass site visit verification the year before and wish to re-enter the aggregate, those fields must have a full verification with site visit for the subsequent reporting period. These fields must be site visited *in addition* to the verification sampling methodology and requirements outlined below in Sections 8.3.2, 8.3.3, and 8.3.4.

For the purposes of verification, a “small aggregate” is defined as an aggregate comprised of 20 or fewer fields, regardless of the number of project participants. Small aggregates will meet fixed site visit and desktop verification frequency requirements based on a verification schedule determined by the verifier, in compliance with Section 8.3.2 of this protocol.

A “large single-participant aggregate” is defined as an aggregate comprised of more than 20 distinct fields all managed by one single project participant. For large single-participant aggregates, fields will be randomly selected for site visit and desktop verification, according to the sampling method in Section 8.3.3, which is based on a non-linear scale where the relative fraction of fields undergoing verification activities gets smaller as the aggregate size gets larger.

A “large multi-participant aggregate” is defined as an aggregate comprised of more than 20 fields and more than one project participant. For large multi-participant aggregates, participants and their fields will be selected for site visit and desktop verification, according to the risk-based and random sampling method in Section 8.3.4, which is based on a non-linear scale where the relative fraction of fields undergoing verification activities gets smaller as the aggregate size gets larger.

In all cases, when determining the sample size for site visits and desktop verifications, the verification body shall round up to the nearest whole number.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.3.1 Informing Site Visit Sampling with Corn Stalk Nitrate Test Results

All fields are required to perform a Corn Stalk Nitrate Test (CSNT) prior to the end of the reporting period for each eligible corn crop and provide the test results to the verification body, in preparation for verification. Verifiers must review the results of the CSNTs for all fields to inform their risk-based sampling. Verifiers shall prioritize selection of fields for site visits, based on CSNT results that indicate “excessive” N use (e.g. greater than 2000 ppm nitrate-N)[85] or other anomalous results for site visit verification by sampling (e.g. a large increase in ppm nitrate-N from previous CSNT results, even if not excessive).

It is important to note that many factors influence N availability and a field’s corn stalks may vary in their nitrate-N concentration from year to year. Consequently, an “excessive” result by the CSNT does not necessarily mean that a field has not reduced its N rate against its baseline, but it is a good indication of which fields within the aggregate have the highest probability of application above the N demand for the crop, and therefore are at highest risk of <u>not</u> having reduced their N rate over the reporting period. As such, fields with “excessive” CSNT results shall receive further follow up, in the form of site visits, interviews, additional information requests, etc, as necessary.

Category	Nitrate-N Concentration	Interpretation
Excessive	>2000 ppm	High probability that N availability was greater than N demand
Optimal	700-2000 ppm	High probability that N availability was within the optimal range needed to maximize profitability for the producer
Marginal	250 – 700 ppm	Indicated that N availability was very close to the minimal crop demand
Low	<250 ppm	High probability that greater N availability would have resulted in increased yields

Source: Iowa State University Extension Service.[85]

8.3.2 Verification Schedule for Small Aggregates

8.3.2.1 Site Visit Verification Schedule for Small Aggregates

Site visit verifications must be conducted on a schedule such that:

[85] Blackmer, A.M., & Mallarino, A.P., 1996.

1. Each field in the aggregate must successfully complete a minimum of one site visit verification per crediting period.
2. A minimum of 20 percent of the fields in the aggregate shall be site verified in any given year, selected first by a risk-based approach informed by CSNT results, and then selected at random, until 20 percent has been reached.

8.3.2.2 Desktop Verification Schedule for Small Aggregates

In any given year, a number of desktop verifications of field data must be conducted, with the number inversely related to the number of fields undergoing a site visit that year. Specifically, the number of desktop verifications, *D*, shall equal 50 percent of the number of fields, *n*, in the aggregate that will not receive a site visit that year, rounding up in the case of an uneven number of fields. In other words,

$$\boldsymbol{D} = \frac{(\boldsymbol{n} - \boldsymbol{S})}{\mathbf{2}}$$

Where,

n	=	Number of fields in the aggregate
S	=	Number of site visits
D	=	Number of desktop verifications

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the value of *D* per the equation above.

8.3.3 Verification Schedule for Large Single-Participant Aggregates

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, a combination of risk-based and random sampling is a particularly important component of enforcement.

8.3.3.1 Sampling for Site Visit Verification for Large Single-Participant Aggregates

The verification body determines the number of enrolled fields that must be selected for site visit verification in a given year. The required number of site visits, *S*, shall equal the square root of the total number of eligible fields, *n* (e.g. those growing an eligible crop over the reporting period), enrolled in the large single-participant aggregate that year (i.e. $\boldsymbol{S} = \sqrt{\boldsymbol{n}}$ rounded up to the nearest whole number). Verifiers shall select fields for site visits first through the risk-based approach informed by CSNT results, and then by selecting additional fields at random, until the required number of site visits, *S*, has been reached.

8.3.3.2 Sampling for Desktop Verification for Large Single-Participant Aggregates

In addition to site visit verifications, verification bodies shall randomly select a sample of fields to undergo a desktop verification, *D*, equal to two times the square root of the total number of fields in the aggregate.

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.3.4 Verification Schedule for Large Multi-Participant Aggregates

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, a combination of risk-based and random sampling is a particularly important component of the enforcement mechanism. The sampling methodology for large multi-participant aggregates shall take place in three steps. Site visit sampling shall be informed in step one by a risk-based sampling approach and in step two by random sampling. The third step shall inform desktop verification based on random sampling.

A minimum of five percent of the total number of eligible fields in the aggregate (e.g. only fields growing eligible crops in the reporting period to be verified) must be site visited. The verification body shall be allowed to vary the number of site visits performed, based on levels of perceived risk identified during verification, up to a maximum of fifteen percent of eligible fields in a given year. Specific risks identified during the verification could include: the incidence of CSNT results within the “excessive” range, fields generating large proportions of the emission reductions of the aggregate, and/or demonstrated poor communication of N-reduction strategies and implementation between aggregators and participants

Each verification report must contain a description of the sampling methodology, number of site visits, and justification for higher levels of sampling (e.g. due to higher levels of risk)

8.3.4.1 Sampling for Site Visit Verification for Large Multi-Participant Aggregates

1. First, verifiers shall select fields for site visits first through a risk-based approach informed by CSNT results
2. Once the verifier has selected fields for site visits through the risk-based approach, additional fields shall by selected at random. The verification body shall randomly select additional fields until the number of site visits meets this minimum requirement of at least five percent (or the verifier’s chosen percentage, based on higher risk)

8.3.4.2 Sampling for Desktop Verification for Large Multi-Participant Aggregates

In addition to site visit verifications, each year verification bodies shall also randomly select fields to undergo a desktop verification of their field data. Verification bodies shall randomly select a sample of fields to undergo a desktop verification equal to two times the square root of the total number of fields in the aggregate (rounded up to the next whole number).

Fields shall not be selected for a desk-audit in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.4 Standard of Verification

The Reserve's standard of verification for nitrogen management projects is the Nitrogen Management Project Protocol (this document) and the Reserve Program Manual and Verification Program Manual. To verify a nitrogen management aggregate, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.5 Monitoring Plan

The Aggregate Monitoring Plan (AMP) and Field Monitoring Plan (FMP) serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and recordkeeping is ongoing by the aggregator and all enrolled fields. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.5.1 Annual Reports

The single-field project's project developer must annually submit field data for single-field projects to the Reserve. The Single-Field Report will consist of a *.csv file and attachments, as described in Section 7.2.1. Verification bodies must review the Single-Field Report to confirm project information and data collected according to the SFMP.

The aggregate must annually submit an Aggregate Report to the Reserve. The report will consist of a *.csv file and attachments, as described in Section 7.2.2. Verification bodies must review the Aggregate Report to confirm project information and data collected according to the AMP.

The verification body will need to review field data during desktop verifications of randomly selected fields in an aggregate. The field data must be made available to the verification body in order to confirm field-level information collected according to the FMP.

8.6 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field's eligibility during site visit and/or desktop verifications according to the rules described in this protocol. The table below outlines the eligibility criteria for each project field. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.3.

Table 8.1. Summary of Eligibility Criteria for a Nitrogen Management Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	The first day of the cultivation cycle, which begins immediately after completion of the previous crop's harvest, in which the approved project activity is adopted at the field. For 12 months following the Effective Date of this protocol, a pre-existing field with a start date on or after June 27, 2010 may be submitted for listing; after this 12 month period, projects must be submitted for listing within six months of the project start date	Once during first verification
Location and Crop Type	The field is located in an approved area of the U.S. and U.S. tribal areas and contains a corresponding eligible crop, according to Table 3.1	Every verification
Performance Standard	The field passes the Performance Standard Test for its respective state-crop combination according to Section 3.5.1.1). (Fields previously in a non-eligible year must also demonstrate that N loading has not occurred since the last verification to pass the Performance Standard Test)	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Legal Title to CRTs	Signed Aggregator Attestation of Title or Attestation of Title and monitoring procedures for ascertaining and demonstrating legal title to the CRTs	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verification body; project must be in material compliance with all applicable laws. In particular, no violations to the Safe Drinking Water Act or Clean Water Act, due to agricultural discharges	Every verification
Applicability Conditions	Verify that all applicability conditions to Section 5.1 have been met	Every verification

8.7 Core Verification Activities

The NMPP provides explicit requirements and guidance for quantifying the GHG reductions associated with the implementation of approved nitrogen management practice changes on project fields. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a nitrogen management project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies

3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs for each field
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a single-field project or aggregate, ensuring that all relevant secondary effect SSRs for each field are identified.

Reviewing GHG management systems and estimation methodologies at the field level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that are used to gather data and calculate baseline and project emissions for each field.

Reviewing GHG management systems and estimation methodologies at the aggregate level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the project aggregator uses to gather data and calculate baseline and project emissions on the aggregate level.

Verifying emission reduction estimates at the field level
The verification body further investigates areas that have the greatest potential for material misstatements and confirms whether or not material misstatements have occurred for all fields undergoing verification. This involves site visits to a random sample of project fields, according to the sampling methodology outlined in Section 8.3.3.1, to ensure systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desktop verifications of remaining project fields according to Section 8.3.3.2. In addition, the verification body recalculates a representative sample of the performance or emissions data from fields for comparison with data reported by the project aggregator in order to confirm calculations of GHG emission reductions.

Verifying emission reduction estimates at the aggregate level
The verification body further investigates areas that have the greatest potential for material misstatements at the aggregate level, including whether the appropriate structural uncertainty factors (Section 5.3.4) and yield-loss statistical tests (Section 5.4.2) have been performed for the aggregate.

8.8 Project Type Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a nitrogen management project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. Supplemental monitoring data and records (noted in Sections 6.4 and 7.3.3) are not included in the tables below. However, any supplemental information made available to the verifier by the project participant may be used to raise the verifier's level of assurance that the project activity occurred.

For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to nitrogen management projects that must be addressed during verification.

8.8.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for nitrogen management aggregates. These requirements determine if the aggregate is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either for one or more fields, then the entire aggregate may be determined ineligible or the GHG reductions from the reporting period may be ineligible for issuance of CRTs, as specified in Section 3.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that all verified fields meet the definition of a nitrogen management project	No
2.2.1	Verify that all verified fields meet the field boundary definition	Yes
2.2.2	Verify that all verified fields meet the definition of cultivation cycle	No
2.3	Verify ownership of the reductions by reviewing Aggregator Attestation of Title	No
2.3	Verify ownership of the reductions by reviewing Letters of Notification and contracts between aggregators, project participants, and land owners	No
2.4	Verify that no fields within the aggregate are simultaneously enrolled in another aggregate	No
2.4	Verify that any fields previously enrolled in another aggregate have followed the proper procedures to enter the new aggregate and leave the old aggregate	Yes
2.4.1	Verify that all fields within a project aggregate are within individual size limits	No
3.1	Verify that all fields are comprised of eligible state-crop combinations	No
3.2	Verify the project start date for all fields	No
3.2	Verify accuracy of project start date for all verified fields based on operational records	Yes
3.3	Verify that each field is within the 10-year crediting period and five eligible crop years within that crediting period	No
3.4	Verify that project is not located on fields that were not cropped prior to June 27, 2010	No
3.4	Verify that the project is not located on fields that are classified as Highly Erodible Land or wetlands	No
3.4	Verify that sufficient management records of historical practices are available	No
3.5.1	Verify that each field meets the Performance Standard Test	No
3.5.1	Verify that each field previously in a non-eligible year applied no more than the permissible N rate range over the non-eligible crop year	Yes
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to support demonstration of eligibility under the Legal Requirement Test	No
3.5.3	Verify that any ecosystem service payment or credit received for activities on a project field has been disclosed and is allowed to be stacked	No
3.6	Verify that the project activities at all verified fields comply with applicable	Yes

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	laws, particularly water quality laws, by reviewing any instances of non-compliance provided by the aggregator and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	
5.1	Verify that the project area does not contain any organic soils and/or histosols	No
5.1	Verify that the project area is located within the region in Figure 5.2 with mean annual precipitation between 600 mm and 1200 mm	No
5.1	Verify that the project does include irrigated corn cropping systems. If irrigation was used, verify that emergency irrigation was justifiable	Yes
5.1	Verify that the project does not include tile-drained fields	No
5.1	Verify that the total annual N rate decreased below baseline levels	No
6.1, 6.2, 6.2.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the Legal Requirement Test at all times	No
6.1, 6.2.2, 6.3	Verify that field-level and aggregate-level monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.8.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the aggregate GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5.2	For each field, ensure that the baseline and project N rate have been determined correctly	No
5.3, 5.4	For each field, verify that input parameters for both the baseline and the project are represented by the appropriate data and the calculations are accurate for the baseline and the project emissions calculations	Yes
5.3	For each field, verify that N rate has been properly quantified, particularly that any changes in organic N rate are properly accounted for	No
5.3.4	For the aggregate, verify that all field emission reductions are summed correctly, and that the structural uncertainty factor is properly applied	No
5.4.1	For the aggregate, verify that the project developer correctly monitored, quantified and aggregated fossil fuel use changes	Yes
5.4.2	For the aggregate, verify that the statistical test for reduced yield is properly performed, and that increased emissions outside the project boundary are properly quantified for significant yield losses	No

8.8.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that all contractors are qualified to perform the duties expected. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.1, 6.2	Verify that the project has documented and implemented the Single-Field Monitoring Plan or Aggregate Monitoring Plan, and all necessary Field Monitoring Plans	No
6.1, 6.2	Verify that the project monitoring plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.3	Verify that appropriate monitoring data is measured or referenced accurately	No
6, 7	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6,7,8	Verify CSNT results of all fields and use these results to inform risk-based sampling for site visit selection	Yes
6, 7	Verify that onsite personnel performing CSNT sampling are appropriately trained to perform such activities, and that sampling has been properly performed	Yes
6, 7	Verify that appropriate training was provided to personnel assigned to GHG reporting duties	Yes
7.2	Verify that the Single-Field Report or Aggregate Report was uploaded to the Reserve software	No
7.2, 7.3	Verify that field data has been gathered by project participants and made available to the aggregator	No
7.3	Verify that all required records have been retained by the project developer	No

8.9 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desktop verifications results in the crediting of all fields participating in the entire aggregate, as calculated by the aggregator according to the quantification methodology in Section 5.

Verification may uncover any number of material and immaterial errors at the field, project participant or aggregate level, and the extent to which an error was propagated through the aggregate can affect whether a verification is determined to be "unsuccessful."

8.9.1 Field-Level and Project Participant-Level Errors

If material issues arise during verification of a participating field, verification bodies shall issue Corrective Action Requests, as needed. The aggregator will need to work with the project participant to independently address the issues and required corrective actions using the same process taken with standalone projects. These are described in the verification guidance of this protocol and the Reserve Verification Program Manual. If the error can be corrected at the field level and is the type of error which will not be propagated across an individual participant's fields or the entire aggregate, then the error shall be corrected and the field verification shall be considered successful. Errors shall be considered immaterial at the field level if they result in a discrepancy that is less than five percent of the total emission reductions quantified for that field.

If verification of a field reveals material non-compliance with the protocol, and no corrective action is possible, that field shall receive a negative verification and no CRTs shall be issued for that field, effectively removing the field from the aggregate for that year. When verification is unsuccessful for a participating field, the verification body must verify additional fields until the total number of successful verifications reaches the required number (as described in Section 8.2), starting with fields managed by the same participant, as follows. If the project participant managing the unsuccessfully verified field also manages other fields enrolled in the aggregate, the verification body shall site visit a minimum of two additional fields or 50 percent of the remaining unverified fields, whichever is larger, that are managed by that project participant. If the verification of the additional fields is also unsuccessful, no CRTs shall be issued for any of the fields managed by the project participant.

Deliberate non-compliance may result in disqualification of the project participant including all of their enrolled fields. Additionally, if the project participant failing verification and their negatively verified fields re-enter the aggregate the following year, each of the fields that failed verification the previous year shall be required to undergo a site visit, in addition to the minimum sampling requirements in Section 8.2.

Whenever a project participant receives a negative verification for all of their enrolled fields, the verification body shall use their professional judgment and a risk-based assessment to determine whether sampling additional project participants for site visit verification, beyond the minimum requirements of this protocol, is necessary to verify the entire aggregate to a reasonable level of assurance.

8.9.1.1 Cumulative Field-Level Error of Sampled Fields

Total errors and/or non-compliance shall be determined for the sampled fields and the offset issuance for those fields corrected, as required, by the Verification Program Manual. Should the aggregated error and/or non-compliance rate for the sampled fields be less than five percent, CRT issuance for fields not subjected to site visit or desktop verification shall be equal to the amount reported by the aggregator. However, if the aggregated percent error and/or non-compliance rate (i.e. the percentage of verified fields failing verification) for sampled fields is greater than five percent, CRT issuance for fields not subjected to site visit or desktop verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.9.2 Aggregate-Level Errors

If verification reveals a potential systemic error, which may be propagated out to the aggregate level (e.g. a qualitative error with regard to the input parameters or a quantitative error repeated in multiple field-level calculations), the verification body shall use their professional judgment to sample additional fields, as necessary, to determine whether the error is truly systemic. Systemic errors must be corrected at the aggregate level.

8.10 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Project activities that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Aggregate	A project comprised of two or more fields. An aggregate does not need to be comprised of contiguous fields, and can encompass fields located on one farming operation or distributed amongst different farms and/or producers. See Section 2.4 for further definition.
Aggregator	A project developer who represents one or more fields participating in a project (e.g. an aggregate). See Sections 2.3 and 2.4 for further definition.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, deforestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Cultivation cycle	The period starting immediately after harvest of one primary crop and ending after the next primary planted crop is harvested the following calendar year (e.g. 365 days). See Section 2.2.2 for further definition.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the Reserve Board.
Eligible crop year	A creditable year of the crediting period, in which an eligible crop (see Table 3.1) is grown. Eligible crop years are not required to be consecutive.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).

Field	The project site, upon which the project activity is implemented. The field must be under the direct management control of a single entity, continuous, with homogenous management within the field boundary. See Section 2.2.1 for additional specifications.
Fossil fuel	A fuel such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Megagram (Mg)	One megagram is equal to one metric ton (MT, or tonne). Metric ton is a common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Primary crop	Defined as the main production crop grown on a field in a given year (e.g. corn is a primary crop and may be grown on its own or with a cover crop).
Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project, as identified in this protocol, Section 2.3.

Project participant	An individual (e.g. a farmer) who has the authority to make cultivation management decisions on their fields and enrolls in an aggregate.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification statement and provide verification services for operators subject to reporting under this protocol.

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Appendix A Summary of Performance Standard Development

This appendix summarizes performance standard development and research into industry trends in nitrogen management practices in crop cultivation that have the potential to reduce nitrous oxide emissions. This appendix primarily lays out the background and rationale for the Performance Standard Test for the approved project activity of reducing nitrogen application rate (N rate), which was identified in other methodologies[86] and by the Reserve's Science Advisory Committee (SAC, see Appendix B) as a practice with consistent N_2O emission reduction potential.

A.1 Practices and Data Availability

While nine N_2O mitigation practices were prioritized for consideration in the NMPP, the lack of comprehensive datasets on "business as usual" nitrogen management practices hindered the development of performance standards for a number of these practices, as shown in Table A.1.[87]

USDA ARMS datasets, discussed further below, were used to analyze common practice nitrogen management, and where sufficient data were available, research outcomes informed development of a performance standard. The only complete performance standard currently included in the NMPP is for N rate reduction projects for corn in the North Central Region; this appendix primarily addresses that performance standard and its development.

Section A.7 summarizes the preliminary performance standard research done on other priority nitrogen management practices for which data were available, namely switching from fall to spring application and using nitrification inhibitors (or using both nitrification and urease inhibitors), which may be included as approved project activities under a future version of this protocol. Section A.6 summarizes the preliminary performance standard research done on N rate reduction projects for other crops and regions, which also may be included under a future version of this protocol.

[86] Millar et al., 2010.
[87] The Background Paper on Quantification of N_2O Mitigation Options, prepared by Terra Global Capital for the Reserve provides an extensive review of datasets considered for use in developing the performance standard (available at http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/). Only the most promising and comprehensive of datasets are discussed here.

Table A.1. Priority List of Practices and Data Availability

Priority List of Practices to Include in NMPP (Based on SAC Report)	Are comprehensive data available to develop performance standard (USDA ARMS)?
Reduce N Applied w/out Going Below N Demand	Yes
Use of Nitrification and Urease Inhibitors	Yes[88]
Use of Nitrification Inhibitors (only)	Yes
Switch from Anhydrous Ammonia to Urea	No
Switch from Fall to Spring Application	Yes
Change to Slow Release Fertilizer	No
Change to Fertigation	No
Apply N Closer to Roots	No[89]
Add N Scavenging Cover Crops	No

A.2 Nitrogen Cycling and Nitrogen Use Efficiency

Metrics to set a performance standard threshold must be simple and consistent. Though the annual N fertilization rate may seem like a straightforward metric for setting a performance threshold, particularly for practices that reduce nitrogen rates, it is not a consistent metric. More specifically, fields that receive an equal amount of N fertilizer can vary drastically in terms of yield, how much N crops take up, how much N is lost, and how much residual N remains after crop uptake, all of which influence the quantity of N available for processes that lead to N_2O emissions. This difference in efficiency across sites can be understood if one considers the nitrogen cycle.

Nitrogen cycles through cropland systems in a way that is influenced by a wide range of site-specific variables such as soil type, climate, cropping system and previous and current nitrogen management. A simplified diagram of the N cycle is depicted in Figure A.1 below.

N inputs in most agricultural systems consist of synthetic N fertilizer (e.g. anhydrous ammonia or urea), organic fertilizer (e.g. manure, compost, or sewage sludge), or carryover from legumes in the rotation. N can also become available through mineralization of organic matter or residual soil N carried over from one season to the next. Major N losses include leaching, NH_3 volatilization or emission of NO, N_2O or N_2. Finally, N is also removed from the system through harvest, with the amount of N removed by harvest depending on the crop type and crop usage (e.g. corn for grain versus silage). As a consequence, the most appropriate N rate for a given field will vary drastically across and within cropping systems and regions, due to differences in climates, soil types and crop physiologies.

[88] The USDA ARMS data includes only penetration data for nitrification inhibitors, not urease inhibitors. This data set may still potentially be used to inform penetration rates for this practice, as the subset of farmers using both types of inhibitors will be smaller than those using just nitrification inhibitors, and as such, the penetration rate will also be lower.

[89] Though some N placement data is available through ARMS, the Reserve does not believe this data is sufficient to develop a performance standard for changing N placement, at this time.

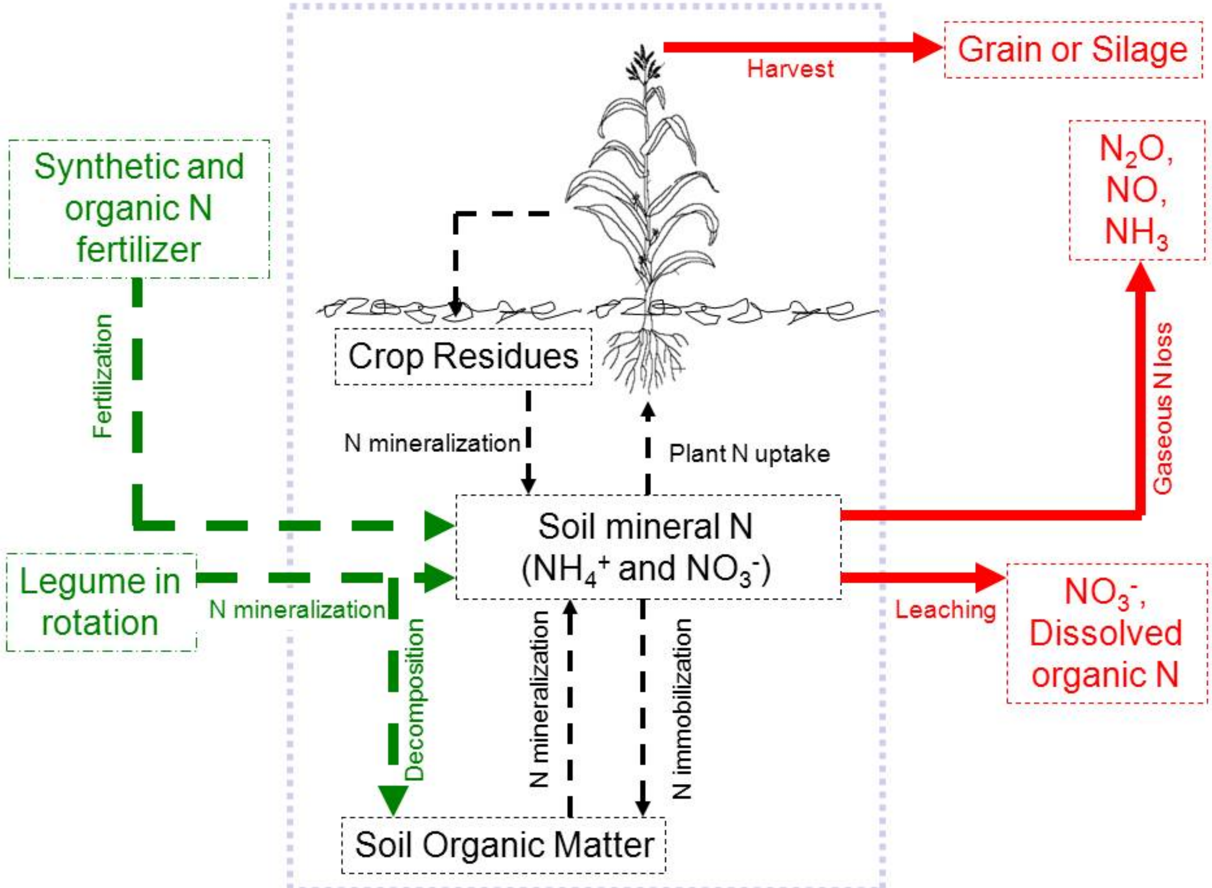

Figure A.1. Nitrogen Sources, Cycling, and Losses in Agricultural Systems[90]

Wide red arrows represent losses from the system, wide dashed green arrows external inputs and narrow dashed arrows internal recycling. The purple dotted line marks the accounting boundary.

The most comprehensive evaluations of N budgets and N cycling in the system take into account all N inputs, losses and internal N cycling. A commonly used metric in the industry to characterize N budgets of cropland systems is nitrogen use efficiency (NUE). The NUE takes the form of a ratio that considers an output (e.g. crop biomass at harvest or economic yield) as the numerator and input (N supply) as the denominator.[91] The crop biomass at harvest (i.e. the "biological yield") can include either total aboveground plant dry matter or total plant N, whereas the economic yield includes either grain yield or total grain N.[92] The N supply can be from soil (N mineralization, carryover of residual N, N credit from legumes), fertilizer (organic or inorganic), or soil plus fertilizer.[93] Consequently, various working definitions and methodologies to measure and calculate NUE are in circulation, each of which find their use in answering particular agronomic, ecological or economic questions. NUE can be used at various geographic scales, from studying and fine-tuning the N budget of a single field to evaluating nitrogen balances at a

[90] Drawing of corn plant was obtained from www.inra.fr with N Cycle added.
[91] Ladha, J.K., Pathak, H., Krupnik, T.J., et al., 2005.
[92] Ibid.
[93] Ibid.

watershed or landscape scale. In a recent USDA report on N use,[94] BMP N rates for a particular field were defined as N rates applied at less than 40 percent excess of N removed by harvest. At a landscape scale, NUE has been used by the International Plant Nutrition Institute (IPNI),[95] the Agricultural Sustainability Institute (ASI) at UC Davis, and other entities as an important indicator to evaluate the sustainability and performance of various agricultural regions and cropping systems.[96] Regardless of the definition used for NUE, higher values for NUE generally reflect improved utilization of N by the crop, often decreasing the risk for harmful loss of N to the environment, such as N_2O emissions.

A performance standard threshold that is solely based on N fertilizer rates will be insufficient to deduce performance consistently across sites, due to the inability to account for site-specific factors. A high N rate threshold may be appropriate for high-yielding fields, but not for marginal fields within the same geographic region. A performance metric based on nitrogen use efficiency rather than absolute N rate can overcome this issue. NUE-based performance metrics reflect nitrogen management that limits N losses and maximizes N use by crops.

A.3 Ratio of Removed to Available Nitrogen (RTA) as Performance Standard Threshold

In the previous section, it was explained how a performance threshold for reducing N rates shall be based on some measure of NUE. Ideally, all inputs, losses (including N removed by harvest), and internal recycling should be considered when characterizing cropland NUE. However, in practice, such data is lacking, both in terms of regional data sets needed to set a threshold, as well as site-specific data that would be needed to compare a field’s performance against the threshold. The only data readily available to assess these respective NUE values and set NUE thresholds is limited to synthetic and organic fertilizer N inputs and cropping yields, which can be used to calculate the N removed by harvest. Though more comprehensive NUE metrics, which include many additional variables, may approximate NUE more accurately in theory, these more comprehensive metrics can become rather complicated and opaque, making their use less desirable in the context of an offset protocol. For testing additionality, the focus should be on metrics for which sufficient data is available to define the common practice and that can be calculated for individual fields using historic data that is readily available to the grower. Metrics that reflect the system’s N budget to its fullest extent will require additional data gathering and field sampling that are likely prohibitive to conduct at a field scale due to practical and financial constraints.

This protocol uses a simplified NUE metric, defined as the “ratio of removed to applied N” (RTA). The terminology “RTA” rather than “NUE” was selected to avoid confusion with more complicated definitions of NUE used in the industry and to acknowledge that RTA as it is used in the protocol does not necessarily provide the most precise quantification of the cropping system’s N balance. The RTA metric is calculated in Equation 3.1 as the ratio of N removed by harvest to N applied, where N removed by harvest is determined by multiplying yield by a crop-specific default factor for N concentration.[97] Therefore, RTA values increase when yield increases or N rate decreases. If a large number of producers in a specific state apply relatively low N rates because they account for potential residual N at the beginning of the growing season or legume N credits, the state-average RTA will be relatively large. Vice versa, if the

[94] Ribaudo et al., 2011.
[95] NuGIS, Fixen, 2010.
[96] Fixen, 2010; Ladha et al., 2005; Rosenstock et al., In Review.
[97] Default N concentrations for corn are derived from Ribaudo et al., 2011.

selection of an appropriate N rate is not commonly discounted for residual N or N credit from legumes, the state-average RTA will be relatively large. Therefore, simple state-average RTA values implicitly take into account the adoption of best management practices with respect to N rate, and state-specific threshold values can be used to ensure additionality and promote environmental integrity.

It should be noted that the RTA is a kind of intensity-based metric that normalizes N rates by using cropping yields. However, it is important to note that while the performance standard is based on an intensity-based approach, quantification of N_2O emission reductions in the NMPP is not intensity-based, but rather based on total reductions quantified for a given project area.

The RTA equation[98] is used to calculate average state-level RTAs for developing performance standard thresholds (see Section A.5), as well as used to determine baseline and project RTAs, based on project participants' crop production management records as described in Section 3.5.1.1.

Calculation of the RTA, both at the project-level and for the regional threshold, relies on the use of default values for N concentration of crops, as included in Equation 3.1, which are adopted from the USDA N use report.[99] Default values for N concentration are used to allow for a more straightforward comparison of state-specific and field-specific RTAs, particularly because data on field-specific crop N concentrations are not typically collected and doing so can be somewhat cost-prohibitive. The average N concentration in corn grain may decrease in future years as more N-efficient corn hybrids are developed. The Reserve will monitor changes in average N concentration of crops over time and plans to update default values as appropriate.

In theory, the ratio of N removed by harvest to available N is expected to be close to one if a system is in balance. However, because the simplified RTA calculated in this protocol only considers applied N and does not take into account all available N sources, RTAs above one may be observed. Specifically, in cases where an N credit from leguminous crops in the rotation or from residual soil N contribute to the total plant N requirements and are taken into account by the growers, RTA values will likely be higher than one. In addition, RTA as defined in this protocol is sensitive to uncertainty around crop N concentration as well as the uncertainty around manure N concentration. Actual crop N concentration can be affected by various variables including weather, agronomic practices and crop hybrid, and overestimation of crop N concentration will lead to overestimation of the RTA. Likewise, while standard N concentrations for different sources of manure were used to calculate N application rates from manure, actual manure N concentrations can vary significantly even within a specific manure source. Given these assumptions and limitations associated with RTA calculations, RTA values larger than one do not necessarily indicate soil N mining. Moreover, while it is possible that some corn cropping systems in the NCR mine soil N, it is unlikely that reducing N rate will cause a drastic increase in N mining if yields are maintained. Significant N mining would have a strong impact on yields.

[98] The equation used to calculate the state average RTAs included in Table A.7 is identical to Equation 3.1, with the exception that the yield and N rate values are state average values from a given survey year.
[99] Ribaudo et al., 2011.

Table A.2. Default Values for Average Fertilizer N Concentration and Fertilizer Weights

Synthetic Fertilizer N Contents and Weights			
Fertilizer Type	**Form**	**N** (%)	**Weight** (lbs/gallon)
Ammonia	dry/liquid	80	NA
Ammonium superphosphate	dry	12-17	--
Ammonium metaphosphate	dry	12	--
Ammonium nitrate	dry	32-34	--
Ammonium phosphate	dry	11-18	--
Ammonium phosphate nitrate	dry	27-30	--
Ammonium phosphate sulfate (APS)	dry	13-16	--
Ammonium polyphosphate (APP)	liquid	10-11	11.65
Ammonium polysulfide (Ammonium sulfate)	liquid	20-21	NA
Ammonium sulfate nitrate	dry	20-30	
Ammonium thiosulfate solution	liquid	12	11.00
Anhydrous ammonia	liquid/gas	82	NA
Aqua ammonia (ammonium hydroixde)	liquid	16-25	NA
Bone meal	dry	0-2	--
Calcium nitrate	dry	15-16	--
Diammonium phosphate sulfur	dry	15-16	--
Diammonium phosphate (DAP)	dry	16-21	--
Monoammonium phosphate (MAP)	dry	11-13	--
Natralene	dry/liquid	40	NA
Nitrogen solutions	liquid	7-58	7-21-7: 11.00 9-18-9: 11.11 12-0-0: 11.00
Nitric phosphate	dry	12-17	--
Potassium nitrate	dry	13	--
Potassium sodium nitrate	dry	15	--
Sodium nitrate (nitrate of soda)	dry	15-16	--
Urea	dry	45-46	--
Urea, sulfur coated	dry	36-38	--
Urea ammonium phosphate	dry	25-58	--
Urea ammonium nitrate (UAN)	liquid	28-32	28%: 11.66 32%: 11.06
Urea phosphate	dry	17	--

Organic Fertilizer N Contents and Weights		
Manure Type	**NC** (lbs N/ton)	**Weight** (ton/gallon)
Beef cattle	8.5	8.5
Dairy cattle	6.1	8.4
Hog	11.3	8.4
Poultry	26.9	8.3

Source: Synthetic fertilizer N contents, fertilizer weights, and unit conversion factors are adopted from USDA NRCS Minnesota, Planning – Nutrient Management, Conversion Factors and Tables, Factors and Tables Useful When Planning. Available at http://www.mn.nrcs.usda.gov/technical/ecs/nutrient/planning/planning.htm. Organic fertilizer weights per unit of volume are adopted from: Lorimor, J.,A. Sutton, & Powers, W. (2004). Manure Characteristics. *MWPS-18*. Section 1. Second Edition. Ames, IA: Midwest Plan Service. Default manure N contents are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C.

A.4 Analysis of Grower Decision-Making to Determine N Rates

This section summarizes research into how farmers decide on the N application rate, as further background to the performance standard threshold. In particular, the use of recommended N rates as a proxy for common practice was investigated for corn cropping systems in selected states in the North Central Region. More information is available in a background paper prepared for the Reserve by Terra Global Capital,[100] which evaluated a regional N rate calculator using the "maximum return to N" (MRTN) approach and N application rates based on N use surveys; the analysis of those methods will be discussed further below.

In the Background Paper analysis, recommended N rates were determined using the Iowa State University Corn Nitrogen Rate Calculator.[101] This calculator provides a regional (corn belt) approach to N rate guidelines and finds the MRTN, which is the N rate where the economic net return to N application is greatest given current prices for fertilizer N and projected corn grain prices. The calculator was calibrated for several states and for specific regions within some of the states, using corn yield data from N response trials.[102] The MRTN approach to decide on N fertilizer rate is more commonly used today than the yield-goal approach,[103] which was the dominant approach to determine N rates for corn throughout the last four decades. MRTN-based recommended N rates are often lower than yield-goal based N rates. To assess the suitability of MRTN as a proxy for common practice, MRTN-based recommended N rates for selected N-to-corn grain price ratios were compared with state-average N rates from USDA ARMS (Table A.3). Price ratios were selected assuming that 50 percent of fertilizer use consists of urea and 50 percent consists of anhydrous ammonia, and based on the observation that price ratios fluctuated between 0.07 and 0.14 with an average of 0.10 over the period 1999-2011.[104]

[100] Background Paper: Quantification of Emission Reductions (December 22, 2011). Available on the Reserve website at http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/.
[101] Sawyer et al., 2006. Available at http://extension.agron.iastate.edu/soilfertility/nrate.aspx.
[102] Ibid.
[103] The yield-goal approach recommends that N rates be determined by multiplying the expected yield by a factor that expresses N requirements in function of expected yields.
[104] See NMPP background paper for more details at http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/.

Table A.3. Actual and Recommended N Rates for Corn in Selected States in the North Central Region

States	Actual Corn N Fertilization Rate [lbs N/acre]		Region Within State	Recommended N Rate - MRTNs at Different Price Ratios [lbs N/acre]					
				Average Price Ratio (0.10)		Low Price Ratio ~2010 (0.07)		High Price Ratio ~2005 (0.14)	
	2005	2010		SC	CC	SC	CC	SC	CC
Illinois	146	167	North	145	185	157	201	132	167
			Central	168	185	183	200	152	169
			South	172	188	190	205	155	171
Indiana	147	178	West & Northwest	169	NA	177	NA	156	NA
			East and Central	202	NA	214	NA	191	NA
			Remainder	176	NA	189	NA	161	NA
Iowa	141	142	State	133	190	145	199	120	176
Michigan	128	122	State	131	NA	141	NA	122	NA
Minnesota	139	125	State	109	148	120	154	103	144
Ohio	161	141	State	175	197	190	214	158	182
Wisconsin	107	92	VH/HYP	125	151	131	160	107	139
			M/LYP	94	109	107	118	89	94
			Irr. Sands	209	209	209	209	197	197
			Non-Irr. Sands	130	130	130	130	122	122

Red cells indicate MRTN N rates that are greater than the actual corn N fertilization rate at a specific year. Green cells indicate MRTN N rates that are less than the actual corn fertilization rate at a specific year. SC = Soy-corn rotation, CC = Continuous corn, NA = not available, VH/HYP = very high and high yield potential, M/LYP = medium to low yield potential, Irr. = irrigate, Non-Irr. = non-irrigated.

For continuous corn systems, the recommended MRTN rates were generally greater than the actual corn N fertilization rates at average and low price ratios. However, the N rate did fluctuate somewhat based on the price ratio. When the price ratio was small, as in 2010, the actual N fertilization rate tended to be lower than the recommended rates for soybean-corn systems in more states compared to when the price ratio was large, as in 2005. Consequently, whether the actual N rate is above or below the recommended N rate depends greatly on the crop rotation and price ratio. In agreement with Snyder et al. (2011), the outcomes of the comparison suggest that the average farmer in leading corn-producing states does not commonly apply more N than the recommended N rate based on the corn N rate calculator. Because the recommended N rate does not always compare well with the state-averaged N rates and does not capture potential variability in N rates between farmers within a state or geographic region, the Reserve deemed recommended N rates unsuitable as a proxy for common practice in this protocol. This is further supported by the low percentage of farmers (17.3 percent in 2005) reporting that the cost of nitrogen and/or expected commodity price was the driving factor in determining their N rates, as reported in a recent USDA N use report by Ribaudo et al. (2011) and presented in Table A.4, below.

Lastly, the suitability of historic or "routine practice" N rates (e.g. simply basing this year's N rate decision on previous years' historic N rates) as a proxy for common practice was investigated. A historic N rate has the advantage of taking into account site-specific variables that influence growers' management decisions, including soil fertility, soil N retention and previous management. Furthermore, survey data presented by Ribaudo et al. (2011) indicate that over 70 percent of growers base N rates on their routine practice (Table A.4). Consequently, historic or routine practice N rate is likely a sensible proxy for common practice on a particular site. As such, the Reserve determined that historic N rate shall be used to set the project's baseline under this protocol.

Table A.4. Factors Influencing Farmers' N Rate Decision

Application Used	2001	2005
	Percent of Farmers	
Soil or tissue test	18.8	27.0*
Crop consultant recommendation	13	17.6*
Fertilizer dealer recommendation	28.7	41.2*
Extension service recommendation	3.2	4.6*
Cost of nitrogen and/or expected commodity price	11.4	17.3*
Routine practice	70.9	71.7*
	Number	
Observations	1,646	1,344

* Statistically different from 2001 at the one percent level, based on pairwise two-tailed delete-a-group Jackknife t-test (Dubman, 2000). Source: Adapted from Ribaudo et al., 2011.

In most cases, recommended N rates are underpinned by results from N response trials, where the relationship between N rate and yield is assessed. Recommended N rates are designed to maximize yield or profit, but are not specifically optimized to minimize harmful N losses.[105] Similarly, an N rate survey in Minnesota indicated that average N fertilizer use by Minnesota corn farmers was generally consistent with University of Minnesota Extension nitrogen management guidelines.[106]

A.5 Setting the Performance Standard RTA Threshold

This section examines the current and historic trends of state RTAs and justifies the setting of an RTA threshold above which fields implementing N rate reduction projects are additional. The RTA metric is used as a proxy for nitrogen use efficiency. The nitrogen use efficiency is different per crop and state, and consequently the calculated average RTA, both in a given year and over time, varies across crops and states, as well. Ideally, the average state RTA would be calculated by calculating the RTA across a large number of individual fields within a state and cropping system and averaging these field-specific RTAs. Unfortunately, insufficient data are publically available to calculate the RTA values of individual fields, and, hence, the true distribution of RTAs within a state and cropping system in a robust manner. Therefore, the average RTA per state were calculated using readily available data in USDA datasets. More specifically, statewide crop-specific average yields are available from survey and census data from the NASS/USDA. Statewide average N rates from processed fertilizers (e.g. synthetic N, as well as some processed organics) for selected crops and states are available from ARMS/USDA. Note that the calculation of the RTA requires total N rates, including synthetic and all organic N. Therefore, the N input from unprocessed organics, such as manure, must be added to the synthetic N rates. Quantities of unprocessed manure inputs are available from ARMS/USDA. Estimates of the manure N inputs were based on quantities of unprocessed manure applied per treated acre, the percentage of corn acres treated with manure, the total number of acres planted with corn, and the animal source of the manure, consistent with the USDA N use report.[107]

[105] Ribaudo et al., 2011.
[106] Bierman et al., 2011.
[107] Ribaudo et al., 2011.

After collecting the state average yields and N rates for a number of years, average state RTA values were computed and trends in average state RTA values over time were assessed. In case RTA values would be upward trending, it is assumed likely that increasing nitrogen use efficiency will occur to some extent in the future in the absence of a carbon market. Conversely, if no significant trend in RTA over time exists, the rationale is that because NUE has remained constant over time, the chances are that it will remain constant into the future. As a consequence, the presence of strong trends of the RTA would justify setting the RTA at a different value than the current average to reflect future values of RTA values. A summary of the historic RTA and N rate trends for each NCR state is included in Table A.5 and Table A.6, respectively, below. Notably, only Missouri had a significant increasing trend for RTA, and only Missouri and Kansas had significant decreasing trends for N rate. In all of these cases, the trend, albeit significant, was either minor or caused by spikes in yields and N rates during a specific year, and hence not robust (Figure A.2). As a consequence, it was decided to set the RTA threshold for all states at the state-average RTA.

Table A.7 below summarizes state N rate averages and RTAs for a number of variations of corn rotations in the NCR. The table shows more complete state RTA and N rate averages for a number of variations of corn rotations in all states for which ARMS data is available and shall serve as the look-up table for the RTA performance threshold (Section 3.5.1.1).

Table A.5. Summary of State RTA Trends Over Time Based on USDA-ARMS Data

	Trends in RTA Over Time	
State	**Corn Grain**	**Corn Silage**
Illinois	no significant trend over time	no significant trend over time
Indiana	no significant trend over time	no significant trend over time
Iowa	no significant trend over time	no significant trend over time
Kansas	no significant trend over time	no significant trend over time
Michigan	no significant trend over time	no significant trend over time
Minnesota	no significant trend over time	no significant trend over time
Missouri	significant increase over time	significant increase over time
Nebraska	no significant trend over time	no significant trend over time
North Dakota	no significant trend over time	no significant trend over time
Ohio	no significant trend over time	no significant trend over time
South Dakota	no significant trend over time	no significant trend over time
Wisconsin	no significant trend over time	no significant trend over time

Table A.6. Summary of State N Rate Trends Over Time Based on USDA-ARMS Data

	Trends in N Rate Over Time	
State	Corn Grain	Corn Silage
Illinois	no significant trend over time	no significant trend over time
Indiana	no significant trend over time	no significant trend over time
Iowa	no significant trend over time	no significant trend over time
Kansas	significant decrease over time	significant decrease over time
Michigan	no significant trend over time	no significant trend over time
Minnesota	significant increase over time	significant increase over time
Missouri	significant decrease over time	significant decrease over time
Nebraska	no significant trend over time	no significant trend over time
North Dakota	no significant trend over time	no significant trend over time
Ohio	no significant trend over time	no significant trend over time
South Dakota	no significant trend over time	no significant trend over time
Wisconsin	significant increase over time	significant increase over time

The trends in RTA over time for corn following corn is also shown in the graph in Figure A.2 below.

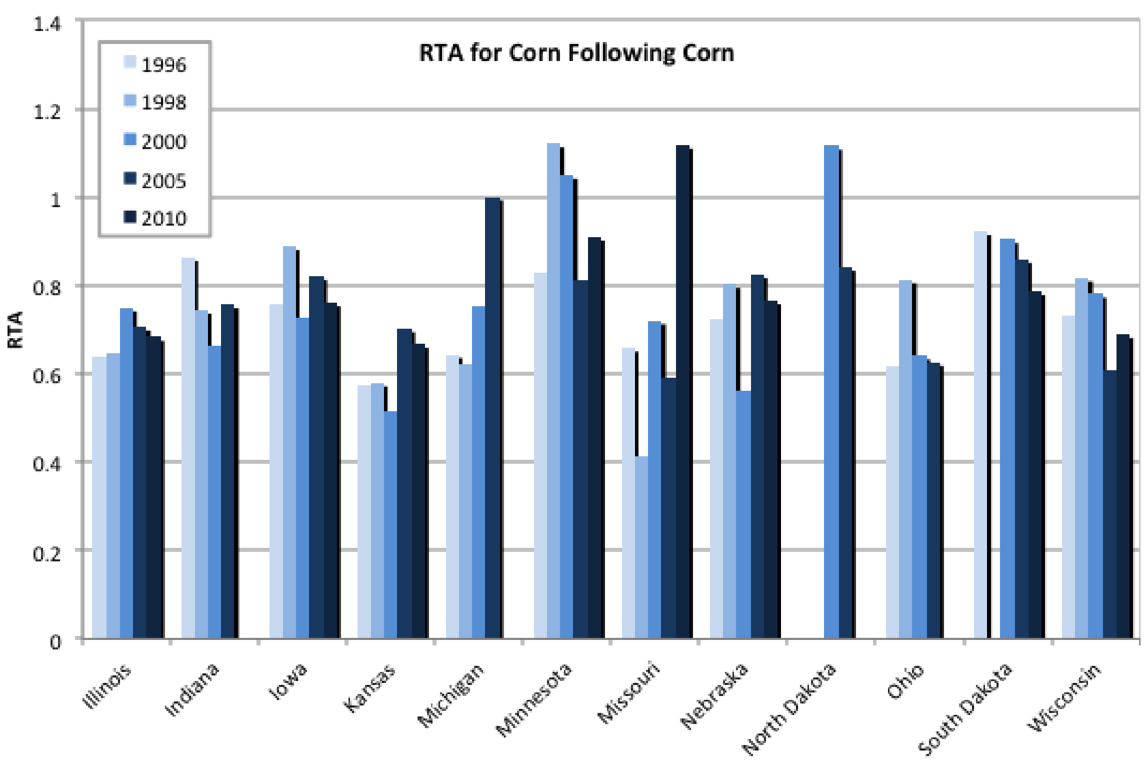

Figure A.2. RTA for Corn Following Corn in the North Central Region Based on USDA-ARMS Data

Table A.7. State N Rate and RTA Data for Corn in the North Central Region Based on USDA-ARMS Data and Yield Data from USDA-NASS[108]

State	Crop	Previous Crop	Most Recent Survey Year	Average N Rate (lbs/acre)	Average Yield (bushels/acre for grain; tons/acre for silage)	Average RTA
Illinois	corn grain	corn	2010	184	157	0.68
		soybean	2010	179		0.7
	corn silage	corn	2010	184	18	0.69
		soybean	2010	179		0.71
Indiana	corn grain	corn	2005	163	154 (for 2005) 157 (for 2010)	0.75
		soybean	2010	165		0.76
	corn silage	corn	2005	163	20 (for 2005) 21 (for 2010)	0.87
		soybean	2010	165		0.9
Iowa	corn grain	corn	2010	173	165	0.76
		soybean	2010	162		0.82
	corn silage	corn	2010	173	21.5	0.88
		soybean	2010	162		0.94
Kansas	corn grain	corn	2010	150	125	0.67
		soybean	2010	136		0.74
	corn silage	corn	2010	150	14	0.66
		soybean	2010	136		0.73
Michigan	corn grain	corn	2005	114	143 (for 2005) 150 (for 2010)	1
		soybean	2010	148		0.81
	corn silage	corn	2005	114	17.5 (for 2005) 18.5 (for 2010)	1.09
		soybean	2010	148		0.89
Minnesota	corn grain	corn	2010	156	177	0.91
		soybean	2010	155		0.91
	corn silage	corn	2010	156	20	0.91
		soybean	2010	155		0.91
Missouri	corn grain	corn	2010	88	123	1.12
		soybean	2010	130		0.76
	corn silage	corn	2010	88	15	1.21
		soybean	2010	130		0.82
Nebraska	corn grain	corn	2010	173	166	0.77
		soybean	2010	156		0.85
	corn silage	corn	2010	173	18.5	0.76
		soybean	2010	156		0.84
North Dakota	corn grain	corn	2005	123	129 (for 2005) 132 (for 2010)	0.84
		soybean	2010	142		0.74
	corn silage	corn	2005	123	11 (for 2005) 14 (for 2010)	0.63
		soybean	2010	142		0.7
Ohio	corn grain	corn	2005	183	143 (for 2005) 163 (for 2010)	0.62
		soybean	2010	158		0.82
	corn silage	corn	2005	183	17	0.66
		soybean	2010	158		0.76
South Dakota	corn grain	corn	2010	137	135	0.79
		soybean	2010	143		0.75
	corn silage	corn	2010	137	13.5	0.7
		soybean	2010	143		0.67
Wisconsin	corn grain	corn	2010	188	162	0.69
		soybean	2010	202		0.64
	corn silage	corn	2010	188	19	0.72
		soybean	2010	202		0.67

[108] No yield data were available from USDA NASS to distinguish yields between corn systems following cultivation of corn, and corn systems following cultivation of soybeans. In case the survey year for N rates for corn systems following cultivation of corn was different from the survey year for N rates for corn systems following cultivation of soybeans, yields for both survey years were included.

A.6 Discussion of Performance Standard Research for N Rate Reductions in Other Regions

A.6.1 Preliminary Work on RTAs for Other Crops and Regions

Average RTA values have been developed for corn cropping systems outside of the North Central Region where USDA-ARMS data on N rates for synthetic fertilizer and manure were available. Note that data distributions for N rate are not available. Therefore, only state-average RTA values could be investigated for performance standard tests. For calculating RTAs, crop yield data are required in addition to N rates. Crop yield data are not available from the USDA ARMS survey, but can be downloaded from USDA/NASS Quickstats.[109] Yield data for a large variety of crops are available at the state level. Within some state, agricultural district or county-averaged crop yields are available. No standard errors or distributions are available for yield data.

Table A.8. State N Rate and RTA Data for Corn *outside* the North Central Region Based on USDA-ARMS Data[110]

<table>
<tr><th>State</th><th>Crop</th><th>Previous Crop</th><th>Most Recent Survey Year</th><th>Average N Rate[111] (lbs/acre)</th><th>Average Yield (bushels/acre for grain; tons/acre for silage)</th><th>Average RTA</th></tr>
<tr><td rowspan="4">Colorado</td><td rowspan="2">corn grain</td><td>corn</td><td>2010</td><td>378</td><td rowspan="2">151</td><td>0.32</td></tr>
<tr><td>soybean</td><td>2010</td><td>NA</td><td>NA</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2010</td><td>378</td><td rowspan="2">24.5</td><td>0.46</td></tr>
<tr><td>soybean</td><td>2010</td><td>NA</td><td>NA</td></tr>
<tr><td rowspan="4">Georgia</td><td rowspan="2">corn grain</td><td>corn</td><td>2005</td><td>166</td><td rowspan="2">128</td><td>0.62</td></tr>
<tr><td>soybean</td><td>2005</td><td>115</td><td>0.89</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2005</td><td>166</td><td rowspan="2">19</td><td>0.81</td></tr>
<tr><td>soybean</td><td>2005</td><td>115</td><td>1.17</td></tr>
<tr><td rowspan="4">Kentucky</td><td rowspan="2">corn grain</td><td>corn</td><td>2005</td><td>182</td><td rowspan="2">132 (for 2005)
124 (for 2010)</td><td>0.58</td></tr>
<tr><td>soybean</td><td>2010</td><td>159</td><td>0.63</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2005</td><td>182</td><td rowspan="2">15 (for 2005)
18.5 (for 2010)</td><td>0.58</td></tr>
<tr><td>soybean</td><td>2010</td><td>159</td><td>0.83</td></tr>
<tr><td rowspan="4">New York</td><td rowspan="2">corn grain</td><td>corn</td><td>2010</td><td>151</td><td rowspan="2">150</td><td>0.79</td></tr>
<tr><td>soybean</td><td>2010</td><td>154</td><td>0.78</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2010</td><td>151</td><td rowspan="2">19</td><td>0.89</td></tr>
<tr><td>soybean</td><td>2010</td><td>154</td><td>0.87</td></tr>
<tr><td rowspan="4">North Carolina</td><td rowspan="2">corn grain</td><td>corn</td><td>2010</td><td>117</td><td rowspan="2">91</td><td>0.62</td></tr>
<tr><td>soybean</td><td>2010</td><td>149</td><td>0.49</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2010</td><td>117</td><td rowspan="2">13</td><td>0.79</td></tr>
<tr><td>soybean</td><td>2010</td><td>149</td><td>0.62</td></tr>
<tr><td rowspan="4">Pennsylvania</td><td rowspan="2">corn grain</td><td>corn</td><td>2010</td><td>186</td><td rowspan="2">128 (for 2005)
122 (for 2010)</td><td>0.55</td></tr>
<tr><td>soybean</td><td>2005</td><td>181</td><td>0.54</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2010</td><td>186</td><td rowspan="2">18</td><td>0.68</td></tr>
<tr><td>soybean</td><td>2005</td><td>181</td><td>0.70</td></tr>
<tr><td rowspan="4">South Carolina</td><td rowspan="2">corn grain</td><td>corn</td><td>1996</td><td>107</td><td rowspan="2">79</td><td>0.59</td></tr>
<tr><td>soybean</td><td>1996</td><td>122</td><td>0.52</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>1996</td><td>107</td><td rowspan="2">12.5</td><td>0.83</td></tr>
<tr><td>soybean</td><td>1996</td><td>122</td><td>0.73</td></tr>
<tr><td rowspan="4">Texas</td><td rowspan="2">corn grain</td><td>corn</td><td>2010</td><td>132</td><td rowspan="2">145 (for 2005)
100 (for 2010)</td><td>0.88</td></tr>
<tr><td>soybean</td><td>1998</td><td>103</td><td>0.78</td></tr>
<tr><td rowspan="2">corn silage</td><td>corn</td><td>2010</td><td>132</td><td rowspan="2">18 (for 2005)
19 (for 2010)</td><td>0.97</td></tr>
<tr><td>soybean</td><td>1998</td><td>103</td><td>1.31</td></tr>
</table>

[109] http://quickstats.nass.usda.gov/

[110] No data was available to distinguish yields between corn systems following cultivation of corn, and corn systems following cultivation of soybeans. In case the survey year for N rates for corn systems following cultivation of corn was different from the survey year for N rates for corn systems following cultivation of soybeans, yields for both survey years were included.

[111] Includes synthetic and manure N. N rates are based on USDA ARMS data on synthetic N application per acre, manure N applied per treated acre, total corn acreage and the percentage of corn acreage receiving manure inputs.

Average RTA values will be determined for other crops as well. Table A.9 summarizes states and crops for which N rate data is available with the most recent data collection in 2000 or later.

Table A.9. States and Crops for which USDA-ARMS Data on N Rate are Available with Data Collected in 2000 or More Recent

	Apples	Cotton	Soybeans	Durum wheat	Spring wheat	Winter wheat	Peanuts	Sugarbeets	Oats	Barley	Sorghum
Alabama		✔					✔				
Arizona		✔									
Arkansas		✔	✔			✔					
California	✔	✔						✔		✔	
Colorado					✔	✔		✔			✔
Florida							✔				
Georgia		✔					✔				
Idaho				✔	✔	✔		✔		✔	
Illinois			✔			✔			✔		
Indiana			✔								
Iowa			✔						✔		
Kansas			✔			✔			✔		✔
Kentucky			✔			✔					
Louisiana		✔	✔								
Maryland			✔								
Michigan	✔		✔			✔		✔	✔		
Minnesota			✔		✔	✔		✔	✔	✔	
Mississippi		✔	✔								
New York	✔								✔		
Missouri		✔	✔			✔					✔
Montana				✔	✔	✔		✔		✔	
Nebraska			✔			✔		✔	✔		✔
North Carolina	✔	✔	✔			✔	✔				
North Dakota			✔	✔	✔	✔		✔	✔	✔	
Ohio			✔			✔					
Oklahoma						✔					✔
Oregon	✔				✔	✔		✔			
Pennsylvania	✔								✔	✔	
South Carolina		✔									
South Dakota			✔	✔	✔	✔			✔	✔	✔
Tennessee		✔	✔						✔		✔

Texas		✔				✔	✔				
Virginia			✔								
Washington	✔				✔	✔		✔		✔	
Wisconsin			✔						✔	✔	
Wyoming								✔		✔	

A.6.2 Preliminary Work on California RTAs

The state of California is included in the ARMS data survey for some crops, such as wheat. However, due to the large variety of crops grown in California, most of which are specialty crops, the ARMS data are not particularly helpful. However, N rates and yields for various cropping systems in California can be found in the forthcoming California Nitrogen Assessment (CNA) performed by the Agricultural Sustainability Institute at UC Davis. This is likely the most comprehensive resource on nitrogen management in California. N rates reported in the CNA are derived from expert opinions taken from the most recent UC Davis ARE Current Cost and Return Studies (2000 to present)[112] and from growers surveys included in the USDA Chemical Usage Reports between 1999 and 2009. Grower survey data is the preferred data source for developing performance standard tests, especially given that experts likely overestimate N application rates.[113] However, some crops are not included in the USDA Chemical Usage Reports.[114] Adoption rates for other nitrogen management practices are currently not publicly available. Surveys of extension specialists could be considered for developing performance standard test for eligible project activities.

Table A.10. N Rates for Selected Crops in California

Crop	Average N Rate (lbs/acre)[115]	Average Yield (lbs/acre)	Moisture (%)	N content (%)	Average RTA[116]
Almond	NA	1882	4.42	3.34	NA
Avocado	116	6592	72.56	1.23	0.19
Broccoli	216	14900	89.7	5.65	0.40
Carrot	180	32040	88	1.51	0.32
Celery	344	71300	94.55	2.42	0.27
Corn-grain	NA	9544	13.52	1.64	NA
Cotton	123	1397	9	0.2	0.02
Grapes-wine	33	13388	80.28	0.57	0.46
Lemons	152	34772	87.2	1.51	0.44

[112] Available at http://coststudies.ucdavis.edu/current.php.
[113] Rosenstock et al., In Review.
[114] USDA, NASS, Agricultural Chemical Usage. Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1561.
[115] Survey data from USDA Chemical Usage Reports. Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1561.
[116] RTA is calculated as in Equation 3.1. Because available N content data for crops in Table A.10 is expressed on a dry matter basis, yield needs to be corrected for moisture content before multiplying with the N content: RTA = (yield x (100 - %moisture)/100 x %N/100) / N_rate.

Lettuce-head	200	37000	94.8	3.81	0.37
Melons-honeydew	58	20900	88.33	0.91	0.38
Oranges	85	23238	86.81	1.25	0.45
Peach-freestone	122	22364	87.83	0.98	0.22
Pepper-bell	283	36500	92.5	2.18	0.21
Plums-dried	130	3596	85.2	0.85	0.03
Potato	NA	35720	77.2	1.61	NA
Rice	124	7912	11.33	1.39	0.79
Strawberry	215	60600	91.28	1.24	0.30
Tomato-processing	188	75328	94	2.56	0.62
Walnut	NA	3116	3.65	2.37	NA

Source: California Nitrogen Assessment (http://asi.ucdavis.edu/research/nitrogen/n-science/nitrogen-use-efficiency).

A.7 Discussion of Performance Standard Research for Other Practices

Preliminary performance standard research for other practices has been undertaken by the Reserve, with the aim of eventually developing practice-based positive lists. The Reserve is looking at both absolute levels of and temporal trends in penetration rates of project activities as a decision criterion for including project activities on a positive list (i.e. activities on the positive list are automatically considered additional). Preliminary data for the project activities “changing N timing” and “use of N inhibitors,” the only two priority practices for which USDA ARMS datasets are available, are presented in Sections A.7.2 and A.7.3 of this appendix, respectively. If quantification methodologies for these practices become available, the Reserve will complete work on the positive list, with the hopes of expanding the protocol to include these new practices. The Reserve will also continue to evaluate, on an ongoing basis, additional datasets for the other priority practices, to determine whether there may be enough data for those practices to develop a performance standard, as discussed further below.

A.7.1 Data Available Using the USDA ARMS Dataset

Crop practice categories and crops for which data is readily downloadable from the USDA ARMS dataset are listed in Table A.11. Note that only a selected subset of the survey data is available to download.

Table A.11. Crops and Crop Practices Available from USDA ARMS Data[117]

Crops	Subgroups	Manure Table
corn	farm production region	manure type
soybean	irrigation system	manure application method
cotton	highly erodible land	manure application timing
rice	previous crop harvested	distance to manure production site
spring wheat	tillage system	tillage system
sorghum	ownership status	ownership status
oats		
peanuts		
barley feed		
barley malt		
Nutrient Use and Management	**Nutrient Use by Application Method**	**Synthetic N Application Timing**
N rate	no N broadcast	N in fall before planting
manure applied	all N broadcast with incorporation	N in spring before planting
compost applied	all N broadcast without incorporation	N at planting
soil and/or plant tissue N test	mixed N application method, with incorporation	N after planting
nitrification inhibitor used	mixed N application method, without incorporation	

A.7.2 Preliminary Analysis for N Timing (Switching from Fall to Spring Application)

Survey data on rates for those who already do *not* apply N in fall in corn cropping systems was obtained from USDA ARMS to evaluate the trends in switching from Fall to Spring. Both penetration rates and trends in penetration rate over time differ across states (Figure A.3, Table A.12). For a large number of states, not enough data are available for trend analysis. In states where enough data were available, no trends over time were observed. Across all states and years, the greatest observed penetration rate was 98 percent (Kentucky 2010) and the lowest 36 percent (Iowa 2010).

[117] The state and year combinations for which the data is available can be found at http://www.ers.usda.gov/Data/ARMS/GlobalDocumentation.htm

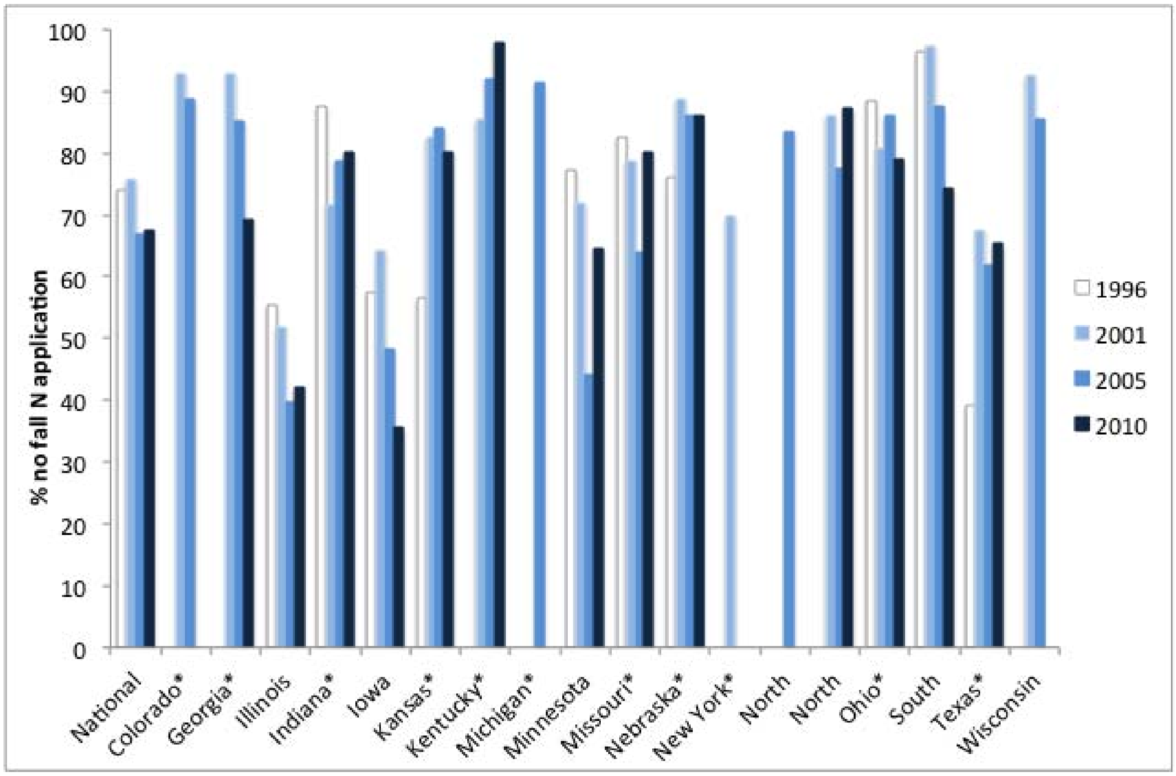

Figure A.3. Penetration Rate of those Not Applying N in Fall for Corn

Table A.12. Trends in Penetration Rate of those Not Applying N in Fall Over Time

State	Trend
Colorado	Insufficient data and no recent data
Georgia	Insufficient data but recent data is available
Georgia	Insufficient data but recent data is available
Illinois	no significant trend over time
Indiana	no significant trend over time
Iowa	no significant trend over time
Kansas	no significant trend over time
Kentucky	Insufficient data and no recent data
Michigan	Insufficient data and no recent data
Minnesota	no significant trend over time
Missouri	Insufficient data and no recent data
Nebraska	Insufficient data and no recent data
North Carolina	Insufficient data and no recent data
North Dakota	Insufficient data and no recent data
Ohio	Insufficient data and no recent data
Pennsylvania	Insufficient data and no recent data
South Dakota	Insufficient data and no recent data
Texas	no significant trend over time
Wisconsin	Insufficient data and no recent data
New York	Insufficient data and no recent data

A.7.3 Preliminary Results for the Use of N Inhibitors

Data on adoption of N inhibitors in corn cropping systems was also obtained from USDA ARMS. It should be noted that 'N inhibitor' as defined in the USDA ARMS survey includes nitrification inhibitors, urease inhibitors and chemical coated (controlled release) fertilizers. Only aggregated data on penetration rates for N inhibitors are publicly available. However, the survey question was phrased in a manner that disaggregation per N inhibitor type should theoretically be possible. Because of the aggregation, penetration rates presented in Figure A.4 should be interpreted with caution. Both penetration rates and trends in penetration rate of N inhibitors over time differ across states (Figure A.4 and Table A.13). For a large number of states, not enough data are available for trend analysis. In states where enough data were available, no trends over time were observed. Across all states and years, the smallest observed penetration rate was two percent (Missouri and Nebraska 2001) and the largest rate 44 percent (Indiana 2010). Penetration rates in 2010 were lower than 10 percent in Minnesota, Nebraska and Ohio.

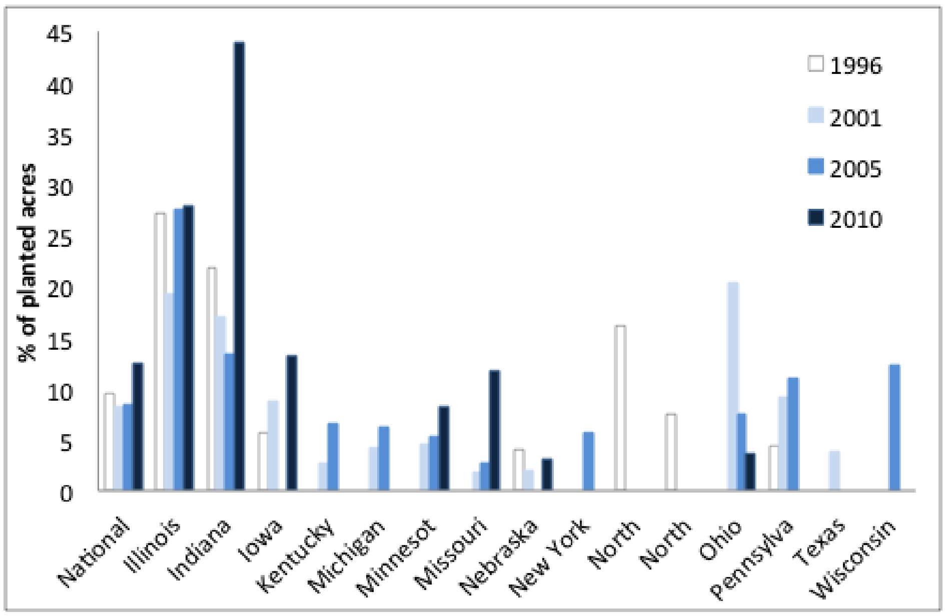

Figure A.4. Penetration Rate of Use of N Inhibitors for Corn

Table A.13. Trends in Penetration Rate of Use of N Inhibitors Over Time

State	Trend
Iowa	no significant trend over time
Illinois	no significant trend over time
Indiana	no significant trend over time
Kentucky	no significant trend over time
Michigan	Insufficient data and no recent data
Minnesota	no significant trend over time
Missouri	no significant trend over time
Nebraska	no significant trend over time
New York	Insufficient data and no recent data
Ohio	no significant trend over time
Pennsylvania	no significant trend over time
South Dakota	Insufficient data and no recent data
Texas	Insufficient data and no recent data
Wisconsin	no significant trend over time

Appendix B Science Advisory Committee Process and Recommendations for Nitrogen Management Practices

B.1 Committee Background

The Reserve together with the Nicholas Institute of Duke University assembled a group of leading scientific experts on agricultural N_2O emissions to form a Science Advisory Committee (SAC). The purpose of the SAC was to help the Reserve interpret and apply the best available science into the Nitrogen Management Project Protocol.

Committee membership was by invitation from the Reserve and the Nicholas Institute. SAC members were invited based on their involvement in the Technical Working Group on Agricultural Greenhouse Gases (T-AGG), a respected and well-established working group of agricultural scientists led by the Nicholas Institute, with relevant scientific expertise, knowledge of GHG offset protocol development issues, and an explicit interest in translating research into GHG mitigation policy applications for agriculture. In addition, scientists must have met the following criteria to be eligible to participate in the committee: a PhD in soil science or related field, 10+ years of experience in research, with a research emphasis directly relevant to agricultural nitrogen management and N_2O emissions, and multiple publications in soil science, ecosystem science, agronomy or related fields. A list of SAC members is available in the Acknowledgements section of this protocol.

The SAC has provided invaluable guidance on interpreting the most up-to-date science and has provided input throughout the protocol development process. Most importantly, the SAC provided recommendations on which nitrogen management practices were well studied with consistent results that should be prioritized for development, informed on boundaries for accurate and conservative GHG accounting, and weighed considerations of scientifically valid and economically practical quantification methods (e.g. comparing Tier 1, 2, and 3 methods). A summary of the SAC effort is presented in this appendix.

B.2 Potential Nitrogen Management Practices

The SAC evaluated a list of nitrogen management practices identified by T-AGG that result in significant N_2O emission reduction potential. The SAC assessed the practices based on criteria such as the available number of field studies (particularly side-by-side comparisons) showing measured N_2O emission reductions in the field, whether these studies consistently showed emission reductions across a range of variables (including precipitation, temperature, soil texture, SOC), and whether N_2O emission reductions were direct or indirect. SAC members rated the practices and made a recommendation on which practices should be prioritized for development, i.e. which had the highest potential of being incorporated into a project protocol based on best available science. Summaries of the priority list of practices recommended by the SAC are provided below.

B.2.1 Reducing the Amount of Nitrogen Applied

This practice involves reducing the total amount of nitrogen applied to a field (i.e. reducing the "N application rate"). The SAC recommended this practice for inclusion in an offset protocol on the condition that N rate reductions are not implemented at the expense of crop yield. Consequently, the Reserve has defined the project activity so that N rate reductions must occur without going below the nitrogen uptake demand of crops. This practice is the most well studied of the practices considered, with the most consistent N_2O reductions (e.g. most directional certainty). The SAC recommended that there should be a focus on improved nitrogen use efficiency rather than nitrogen application rate reductions because site variably and different management systems have different agronomic optimum nitrogen application rates, which affect how much nitrogen can be reduced on a given field before exhibiting yield effects.

The relationship between N_2O emissions and nitrogen application rate can be linear or non-linear depending on characteristics of specific crops and regions. However, these relationships can be described with the development of system-specific (as opposed to generic) emission factors. This practice was recommended for consideration in all regions of the U.S.

B.2.2 Using Nitrification Inhibitors and/or Urease Inhibitors

The SAC recommended applying nitrification inhibitors, as well as applying nitrification inhibitors with urease inhibitors, as practices that demonstrated promise for inclusion in the NMPP because they have been well studied and showed consistent emission reductions in certain U.S. regions; however, more research is needed to quantify emission reduction potential.

An extensive and recent literature review by Akiyama et al. (2010)[118] showed emission reduction potential for the use of nitrification inhibitors and nitrification inhibitors combined with urease inhibitors in certain regions. However, Akiyama et al. (2010) include relatively few North American sites, and other studies on U.S. sites show no effects or inconsistent effects; therefore, more studies are needed to develop a quantification methodology for this practice. Nevertheless, the practice could enable lower N rates, which would be eligible under the current NMPP but, in some studies, and particularly if not used properly by growers, nitrification inhibitors could have the adverse effect of decreasing yield potential and increasing residual soil nitrogen by maintaining immobile ammonia (NH_3) in the soil during the critical crop development stage.

The SAC was also concerned about regional variability in the effect of this practice on N_2O emissions, particularly due to the lack of U.S. studies in the Akiyama meta-analysis. The practice consistently reduces emissions in drier climates, where water is intensively managed, such as the western U.S. Results in rain fed regions are inconsistent, however, particularly for nitrification inhibitors by themselves. In the mid-southern U.S., due to the types of soils, the activity could potentially increase nitrogen losses, including N_2O emissions. As well, the SAC did not recommend the use of urease inhibitors on their own, due to inconsistent results and emission increases in some studies.

B.2.3 Using Slow-Release Fertilizer

The SAC believed that using slow-release fertilizer was a practice with promise for inclusion in the NMPP, but noted that more research is needed.

High N_2O emissions may occur when slow-release fertilizer application is followed by significant precipitation events. However, GHG reductions are assessed relative to a project's "business as usual" baseline in which the precipitation event also would have happened. Therefore, if the precipitation effect can be factored into the baseline *and* project emission estimates, a net N_2O reduction is possible when slow-release fertilizer is applied.

[118] Akiyama, H., Yan, X.Y., & Yagi, K., 2010.

It should be noted that the use of slow-release fertilizer could have an adverse effect of decreasing yield potential and increasing residual soil nitrogen, if the activity limits available nitrogen in the soil during the critical crop development stage.

This practice results in less consistent emission reductions in wetter regions due to greater volatilization. Slow-release fertilizers are more consistent at reducing emissions in a no till system compared to a conventional till system.

B.2.4 Changing Fertilizer Composition

This practice shows potential for certain fertilizer sources, particularly switching from anhydrous ammonia to urea. The effects are mostly consistent, but depend on the application rate (before and after switch). The practice change will have less N_2O emission reduction effect at lower nitrogen rates than at higher nitrogen rates.

Production of urea fertilizer results in significantly more emissions than production of anhydrous ammonia, so the difference in production emissions may need to be considered for conservativeness. Switching to urea from anhydrous ammonia may also increase nitric oxide emissions, an issue that would need to be addressed from an environmental impact perspective.

There was consistent directional certainty (e.g. that a switch in fertilizer would consistently reduce N_2O emissions) regardless of region. However, results from Canada showed no difference in N_2O emissions between Aqua Ammonia and urea, demonstrating potential regional differences.

Other fertilizer source switching may have potential, but were not directly addressed by the SAC.

B.2.5 Synchronizing Plant Nitrogen Uptake with Nitrogen Application

B.2.5.1 Increasing the Number of Applications

This practice showed possible potential for fertigation only. There are not enough studies that show consistent direct N_2O emission reductions; some studies have yielded conflicting results and may have simultaneously tested other management changes. The results of this practice are highly dependent on water management, placement of the increased number of applications, and how the applications are delivered. In some cases, the practice could increase emissions as a result of a pulsing response (i.e. bursts of N_2O emissions associated with the application). However, more applications over a season with fertigation (i.e. applying nitrogen through sprinkler and drip irrigation systems) generally would be expected to reduce nitrogen losses and N_2O emissions; though, it is not entirely known whether fertigation alone or the change in irrigation cause the effects.

Also, by providing nitrogen to crops in a manner more synchronous to crop nitrogen uptake, it helps to limit the pool of nitrogen available at any given time. Generally, this will reduce nitrate runoff and leaching, leading to indirect emission reductions. In regions with a deep water table, the amount of nitrogen leached is generally less.

There may be potential for N_2O emission reductions from increasing the number of nitrogen applications delivered via fertigation in irrigated western regions. However, rain fed systems would require further study, as results are unpredictable.

B.2.5.2 Switching from Fall to Spring Application

This practice could have significant potential, particularly in regions with winter freeze or spring thaw but the number of studies is limited, with some conflicting results. Additional research is needed for spring-planted crops before strong conclusions can be drawn.

This practice generally results in reduced nitrate leaching, leading to indirect emission reductions. In regions with a deep water table, there is usually less leached nitrogen. There is likely to be regional variability in potential for this practice with the largest consistent reductions in northern and Corn Belt regions of the U.S. where there is typically a spring thaw.

B.2.6 Applying Nitrogen Closer to the Root System

This practice showed possible potential when changing the placement of fertilizer. There are conflicting results from studies in different regions, but there may be limited potential in dry regions with irrigated systems, where reductions have been observed. The potential of this practice in rain fed systems in humid climates (i.e. defined as greater than 500 mm growing season precipitation) is less predictable. However, some studies have also shown that banding applications will increase N_2O emissions.

B.2.7 Adding Nitrogen Scavenging Cover Crops

Emission reduction potential of this practice is highly dependent on cover crop mixture and fertilizer management. However, if managed properly, there is potential to reduce N_2O emissions and increase yield, although studies show no or small reductions in indirect N_2O emissions. The practice may enable a nitrogen rate reduction and reduce nitrate leaching.

B.3 Practices Not Currently Eligible for Nitrogen Management

The following table outlines nitrogen management practices that were considered by the SAC but deemed not eligible for inclusion in the protocol due to lack of scientific data and/or consistent and reliable reductions in N_2O. See the table below for assessments of the specific practices.

Practice	Assessment
Variable Rate (VR) technologies and precision farming	VR technology may result in N rate reductions. However, no studies in North America quantify specifically how implementation of VR affects N_2O. May consider this as a technology that enables N rate reductions, but not necessarily an N_2O-reduction practice in and of itself.
Use of urease inhibitors (stand alone)	Akiyama et al. (2010) showed no significant effect of urease inhibitors, except for one (hydroquinone) that reduced N_2O emissions. The article did not show a significant increase in N_2O emissions with other urease inhibitors, but a high degree of variability in data used.
Supplying N in organic form through manure application	Most studies show an increase or no change in N_2O emissions with manure application. However, direct N_2O emissions are highly dependent on manure type and application method. If soil carbon storage were the primary intended GHG effect, then manure application could lead to a net GHG benefit.

	The net or landscape scale GHG effects should be considered, to ensure that emissions and sequestration are not simply being moved from one part of the landscape to another. Net reductions from soil carbon stock changes would occur when readily oxidized organic matter under “business as usual” is converted to or replaced by resistant organic matter through the project activity. By providing N in the form of organic material (manure) instead of fertilizer, residual mineral N in the soil can be reduced, thus having potential to reduce indirect N_2O emissions. However, available N during critical crop development stage may also be lowered (and insufficient), reducing yield and making such systems less desirable.
Supplying N in organic form through legume incorporation	Leguminous cover crops may reduce N_2O, but only if properly managed with cover crop varieties and changes in irrigation. Over time, these practices can increase soil fertility, which may enable an N rate reduction. However, leguminous cover crops can also potentially result in no change or an increase in emissions. Emissions also depend on how far cover crops are allowed to mature. Not enough research or consistent results are available to include the practice at this time.
Supplying N in organic form through composting	Not enough studies are available at this time to indicate that consistent N_2O reductions occur. According to available studies, the practice could potentially reduce or increase emissions, depending on soil type, management methods, and the composition of composted materials. However, even in cases where N_2O may increase, if soil carbon sequestration is the intended primary GHG effect, there could be net GHG reductions due to increased soil carbon sequestration. As with manure, a life cycle or landscape-scale analysis of the net GHG emissions from the compost may be necessary. Studies are underway for this practice and should be reexamined once more research results are published.
Adding deep rooting plants to the rotation	Effects of this practice are currently unknown and there is not enough data available. Indirect N_2O emissions are likely to be consistently reduced, but baseline management is hard to establish as well as the potential leakage implications.

B.4 GHG Assessment Boundary for Nitrogen Management

The SAC briefly discussed which GHG sources, sinks, and reservoirs (SSRs) must be quantified to accurately and conservatively assess the net effect of a change in nitrogen management.

Direct N_2O emissions from soil are the primary GHG source intended for quantifying GHG reductions. Some practices may also incidentally reduce indirect N_2O emissions from leaching, runoff, and volatilization (LVRO), which the SAC recommended for consideration as a primary GHG source, although more uncertainty is associated with its quantification (see below). While there may be soil carbon benefit from some practices, all of the practices recommended for inclusion in the protocol should primarily have the potential to reduce direct N_2O emissions. Soil carbon impacts would need to be included in the GHG accounting boundary, but only for practices that decrease soil carbon stocks and generate higher CO_2 emissions.[119]

Notwithstanding the potential of some practices to increase soil carbon sequestration, it is conservative to exclude the soil carbon pool from the quantification methodology. While some practices (e.g. cover crops) have the potential to both decrease N_2O emissions and increase soil carbon sequestration, none of the practices are likely to substantially *decrease* soil carbon stocks or sequestration rates as a result of project activities.[120]

The majority of SAC members agreed that it is important to include indirect N_2O emissions from volatilization, leaching, and runoff in the GHG accounting boundary for completeness. Further, SAC members recommended it should be a source directly targeted by the project activity (e.g. primary source). Indirect N_2O emissions result from the transport of nitrogen away from the project site via air or water (surface and groundwater) and eventual conversion to N_2O elsewhere. The ability to directly monitor the movement of nitrogen and the eventual indirect N_2O emissions is fairly limited. Therefore, the SAC felt the IPCC methodology for estimating indirect N_2O emissions for national GHG inventory reporting purposes was sufficient and is the best available option for capturing these effects.

B.5 Quantification Approach by Tier

Nitrogen management quantification approaches considered for this protocol were divided into tiers based on the IPCC Tier 1, Tier 2, and Tier 3 method definitions. The table below provides a brief summary of the tiered approach referenced in this protocol.

	Definition and Examples
Tier 1	A general emission factor developed for broad scales. For example, an emission factor recommended on a national scale for GHG inventories, such the IPCC emission factors.
Tier 2	A regionally specific emission factor or simplified multivariate statistical model, derived from field data or biogeochemical process model runs based on changes in project activities. For example, a model to quantify N_2O emissions from N rate reduction derived from field studies in one state and potentially applicable to crop rotations throughout an entire region of the U.S.
Tier 3	A biogeochemical process model with site-specific inputs or site-specific measurement of emissions. For example, the use of the DNDC model with field-level quantification of N_2O emission reductions.
Combination of Tiers	The MSU-EPRI protocol, referenced throughout the NMPP, uses a Tier 2 methodology for corn systems in the North Central Region, derived from empirical field measurements in Michigan, and a Tier 1 (IPCC emission factor) methodology for all other crops and regions in the US.

[119] The effect on soil carbon stocks and CO_2 emissions was a concern when assessing the application of manure in reducing N_2O emissions (see Section B.3) and contributed to the decision to exclude the practice at this time.
[120] Studies show inconsistent results for N_2O impacts of cover crops and leguminous cover crops may actually increase N_2O emissions.

B.6 Quantifying GHG Reductions from Nitrogen Management Practices

The SAC discussed scientifically valid, economically practical, and verifiable approaches to quantifying GHG reductions from nitrogen management projects. This section summarizes their conclusions about prioritizing quantification approaches.

1. It is advisable to use the most accurate quantification methods possible that meet a minimum data standard. Ideally, additional costs of using more accurate methodologies are balanced by the value of being able to more accurately estimate reductions.

2. It is believed that not enough practice-based trials have been conducted to develop biogeochemical process models (Tier 3), such as DNDC, with site-specific inputs or site-specific measurement of N_2O emissions (the latter of which is too costly given current technology and too time consuming, and therefore impractical for offset projects) into a comprehensive protocol methodology at this point in protocol development. However, there may be potential for using DNDC to develop regionally-specific emission factors (Tier 2) based on biogeochemical process model results, in circumstances where the model is known to perform well.

3. Regionally-specific emission factors (Tier 2) or simplified multivariate statistical models (Tier 2), derived from field data or biogeochemical process model runs, are ideal as a quantification method at this point in time. Data are available to develop models for nitrogen rate reduction accounting for soils and climate as well as other practices like inhibitors, fall to spring, and formulation.

4. General emission factors (Tier 1) may be appropriate, especially at regional and national scales and when regionally-specific emission factors (Tier 2) are not available (e.g. for indirect emission quantification). However, they should be used with care and it is preferable to work towards developing regionally-specific approaches.

B.6.1 Quantifying Aggregated Projects

The SAC established that allowing for unlimited numbers of fields to join together in an aggregate and act as a single project would generate improved accuracy of GHG reduction estimates at the aggregate scale. They noted that a key consideration is making sure the fields within the aggregate represent a diversity of situations so as to avoid propagating systematic biases in estimation methods, which would skew the aggregate total. It was suggested that if aggregates were made up of a variety of climates and practices, this particular risk could be addressed. The SAC discussed how a minimum aggregate size could be constructed from rough estimates of what is an economically viable quantity of GHG emission reduction credits for a project.

Appendix C Overview of Water Quality Regulations: Impacts on Legal Requirements and Regulatory Compliance

No federal laws exist that regulate the composition or efficacy of fertilizers. State-level laws addressing composition and/or efficacy are discussed further below. Numerous regulations exist, including at the federal level, concerning the production of fertilizer. However, as fertilizer production is outside the GHG project boundary of this protocol, regulations on fertilizer production are not addressed here. Regulations concerning the use and disposal of hazardous materials, such as fertilizer, and regulations protecting against the contamination of drinking and surface water and air pollution (related indirectly to the land application of fertilizers) are addressed further discussed below.

C.1 Clean Water Act

Though the Reserve could identify no existing federal regulation that explicitly requires implementation of the approved project activity, state or local implementation of the federal Clean Water Act may result in direct and indirect requirements for nutrient management.

The Clean Water Act (CWA) is the federal law regulating water quality for surface waters in the United States. It establishes a comprehensive federal system for regulating the discharge of pollutants into navigable water bodies, while restoring and maintaining the health of the nation's surface waters.[121] The CWA meets these objectives by authorizing water quality standards, requiring and issuing permits for point source discharges (the National Pollution Discharge Elimination System, NPDES),[122] assisting with the funding of municipal sewage treatment plant construction, and helping with planning to manage nonpoint source pollution. The CWA authorizes EPA as the primary agency tasked with implementation and enforcement, but in practice, most implementation is through state environmental agencies and state-level regulations, and as such state-level implementation can be highly variable. States have the authority to set their own water quality standards, so long as they meet or exceed EPA's minimum requirements.

Though the CWA explicitly defines "point sources" (e.g. industrial or sewage treatment plants, CAFOs), it defines nonpoint sources (e.g. agricultural runoff, urban runoff)as anything not considered a point source by the CWA or EPA regulation. The CWA makes it unlawful for point sources to discharge any pollutant into navigable waters without a permit (specifically an NPDES permit). Nonpoint source (NPS) pollution, however, comes from many diffuse sources and is caused by runoff from rainfall or snowmelt moving over and through the ground, picking up pollutants and eventually depositing them in water bodies. When watersheds are successfully meeting the CWA's water quality standards, nonpoint sources are generally unregulated, and in fact agricultural stormwater discharges and return flows from irrigated

[121] The Clean Water Act (CWA) was formerly known as the Federal Water Pollution Control Act (FWPCA), which was first enacted in 1948. Following its significant reorganization and amendments in 1972 and 1977, the FWPCA came to be known by its current name, the CWA. The FWPA / CWA can be found in 33 U.S.C. §§ 1251-1387.
[122] Legal requirements of NPDES permits, as they pertain to CAFOs, will be addressed in Section C.6 of this Appendix.

agriculture are specifically exempt under the CWA.[123] However, in polluted watersheds that are not attaining the proper water quality standards (i.e. "impaired" waters), nonpoint sources may come under regulation as part of efforts to restore water quality.

States are responsible for monitoring water quality of surface waters within their jurisdiction, and biennially, states are required to provide an inventory of the condition of state water bodies and progress toward CWA goals (305(b)) as well as to identify which waters are "impaired" (i.e. not currently meeting water quality standards) or "threatened" (i.e. believed likely to become "impaired" by the time the next "303(d) List" is due).[124] Subsequent to listing waters on the 303(d) List, states are required to prioritize restoration of these waters based on the severity of pollution and begin developing Total Maximum Daily Loads (TMDLs)[125] for these waters. In practice, once a TMDL is established, the state implements a concrete plan to reach this limit through a combination of regulations and voluntary incentives that reduce NPS pollution. EPA funding is typically available to help states implement their non-point source management programs.[126] If runoff from agricultural sources is determined to be contributing to the impairment, the TMDL implementation plan typically will include some degree of agricultural best management practices (BMPs). Typically, voluntary incentive payments are the preferred policy mechanism for agricultural sources, as has been the strategy for Maryland, where the state is working towards its Chesapeake Bay TMDL goals through incentive payments which have significantly increased the acres of farmland voluntarily planting cover crops. However, states may also chose to legally require conservation or nutrient management plans, as has recently become the case in California, where the Central Coast Water Board adopted new stringent regulations on March 15, 2012.[127] Particularly relevant to the NMPP, if agriculture is determined to be the source of impairment, and the water body is impaired by high levels of nitrogen (in any of its forms, e.g. nitrate, nitrite, etc.), agricultural BMPs related to nitrogen management are likely to become part of the TMDL.

Circumstances exist where the agricultural producer has significant flexibility for meeting its TMDL obligations. Producers often self-select what best management practices will become part of their legally required pollution reduction strategy, typically in the form of Conservation Management Plans (CMPs), which address a variety of conservation management practices, or in the form of Nutrient Management Plans (NMPs), which focus more nutrient management practices. As noted in Section 3.5.2, once a practice is self-selected as part of an NPS pollution

[123] King, Ephraim, "Nutrients: A National Overview Need for Strong Partnerships & Joint Accountability," U.S. EPA, Office of Science and Technology, Presented at "Nutrient Summit" Springfield, Illinois, 13 September 2010. Available at: http://www.epa.state.il.us/water/nutrient/presentations/ephraim_king.pdf.

[124] These reports contribute to the "National Water Quality Inventory" (Part 305(b) of CWA) and the "Impaired or Threatened Waters List" or the "303(d) List" (Part 303(d) of the CWA), respectively. Once identified as impaired or threatened, these waters will appear on the "303(d) List." As this list is updated frequently, project developers and verifiers should refer to the U.S. EPA website for the most up-to-date list of impaired watersheds: http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T.

[125] Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant, such as nitrate, that a given water body can receive without violating water quality standards. The term TMDL, however, is often used to refer to the whole process of establishing a TMDL, including all aspects of TMDL implementation and monitoring.

[126] Specifically, EPA funding is available through CWA Section 319(h) grants specifically for nonpoint source management, while states can also participate in the Clean Water State Revolving Fund (CWSRF) program, in which EPA to provide grants to states to establish loan funds which then provides low-cost financing to third parties (municipalities, non-profits, businesses) to implement water quality infrastructure projects.

[127] Additional information can be found on California's State Water Resources Control Board's Irrigated Lands Regulatory Program website (http://www.waterboards.ca.gov/water_issues/programs/agriculture/), as well as the Central Coast Regional Water Quality Control Board's respective program website (http://www.waterboards.ca.gov/centralcoast/water_issues/programs/ag_waivers/).

obligation, the Reserve considers that practice non-voluntary, as continued implementation of that practice is required by law, and that practice is no longer considered an eligible project activity for that farm.

C.4 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) encourages states/tribes to preserve, protect, restore or enhance natural coastal areas, including wetlands, floodplains, estuaries, beaches, and dunes. Eligible areas border the Atlantic, Pacific, and Arctic Oceans, Gulf of Mexico, Long Island Sound, and Great Lakes. Participation is completely voluntary. To encourage states/tribes to participate, the act makes federal financial assistance available to develop and implement a comprehensive coastal management program. Most eligible states/tribes participate in the program. Section 6217 of the CZMA, administered jointly by EPA and the National Oceanic and Atmospheric Agency (NOAA), specifically supports states to develop and implement nonpoint pollution control programs for coastal areas.[128] Within a guiding document specifying typical measures to control nonpoint source pollution published by the EPA[129] in 1993, commercial N fertilizer is identified as a pollutant to coastal areas. Management measures to reduce pollution include development and implementation of a nutrient management plan focusing on (1) applying nutrients at rates necessary to achieve realistic crop yields, (2) improving the timing of nutrient application, and (3) using agronomic crop production technology to increase nutrient use efficiency. In 2003, EPA updated and expanded the 1993 coastal nonpoint source manual to address the control of agricultural nonpoint source pollution for the entire United States.[130] *National Management Measures to Control Nonpoint Source Pollution from Agriculture* highlights best available, economically achievable means of combating nonpoint source pollution, and discusses monitoring techniques, load estimation techniques, and watershed approaches.

As participation is voluntary, assistance received through CZMA does not affect field eligibility. Any financial assistance received by project participants shall be disclosed to the project verifier and Reserve per Section 3.5.3.

C.5 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), the main federal law to ensure drinking water quality, requires actions to prevent the contamination of surface and ground sources of drinking water (e.g. rivers, lakes, reservoirs, springs, ground water wells, but not private wells, serving less than 25 people). Although EPA is primarily responsible for enforcement of the federal SDWA, states may apply to EPA for the authority to implement the SDWA and its enforcement within their jurisdictions (e.g. "primacy"), so long as they can demonstrate that state standards will be at least as stringent as the national standards and that state water systems meet these standards.

The SDWA authorizes EPA to set national health-based standards limiting the amount of contaminants, such as nitrates and nitrites, in drinking water. In practice, these health-based standards are legally enforceable limits, called maximum contaminant levels (MCLs). The SDWA includes MCLs for both nitrates and nitrites, for which fertilizer runoff and leaching from

[128] See http://coastalmanagement.noaa.gov/nonpoint/welcome.html
[129] Available at http://water.epa.gov/polwaste/nps/czara/MMGI_index.cfm
[130] Available at http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm

agriculture is the major source in drinking water. The MCL for nitrate is set at 10 mg/L or 10 ppm, while the MCL for nitrite is set at 1 mg/L or 1 ppm, both of which are measured in nitrogen.

The SDWA requires states and water suppliers to conduct assessments of potential contamination of water sources, and states are required to implement measures to protect water sources through voluntary incentive programs (to encourage agricultural BMPs) or legal enforcement actions, such as notices of violation (NOVs). Any individual discharger could, in theory, be found to be causing levels of nitrate or nitrite to exceed the MCL and receive a notice of violation. However, due to the nonpoint source nature of agricultural discharges, it is relatively difficult to identify one agricultural discharger as the source of an impairment and, as such, NOVs are typically only issued against agricultural discharges when the discharge is particularly egregious.

Though one of the main tools to limit agriculture's effect on drinking water quality are agricultural BMPs, to our knowledge, there is no legal requirement within the context of the SDWA to require best nitrogen management practices. However, any case of regulatory non-compliance, such as a NOV due to a violation of the SDWA, must be reported to the verifier, who will determine if the violation is material to the project.

C.7 Fertilizer Content Labeling Laws

There are no federal laws regulating the composition or efficacy of fertilizer in the U.S., but most states have developed their own fertilizer regulatory programs, which are generally administered by their respective departments of agriculture. These regulatory programs typically address efficacy claims and composition statements of the active ingredients displayed on labels for commercially available fertilizer.

The Association of American Plant Food Control Officials, tasked with making regulation among states uniform, stated that metals in N fertilizer generally do not pose harm to the environment as long as the metal concentration in fertilizer is below a specific threshold.[131] In addition to trace metal composition testing, state fertilizer laws generally require product registration, licensing and efficacy testing to assure that statements made on the label are correct. Also, at the state level, fertilizer is primarily regulated for quality, as for any manufactured good. These regulations are usually administered through the state's department of agriculture.

None of these laws should impact additionality or the eligibility of particular fertilizers.

[131] See http://www.aapfco.org/rules.html for the specific heavy metal threshold concentrations.

Appendix D Minimum Data Standard for Consideration in Quantification Methodology Development

D.1 Introduction

As noted throughout the NMPP, the Reserve plans to expand the list of project activities under this protocol as new data and quantification methodologies become available. The lack of field data on N_2O emissions for different regions, crops, and nitrogen management practices has been a significant limitation in the development of further quantification approaches, particularly a lack of data from “pairwise” or “side-by-side” comparisons (e.g. comparisons of baseline and project treatments on the same field in a given year). As such, this appendix provides general guidelines for establishing field experiments to develop reference data sets which can be used to develop and/or calibrate and validate standardized quantification methodologies. These guidelines are referred to throughout the protocol as “minimum data standards.”

D.1.1 Methodologies and Priorities for Future Protocol Expansion

The Reserve encourages field experiments and the development of reference data sets to support a variety of quantification approaches. Though the NMPP includes a Tier 2 quantification methodology (e.g. using standardized region-specific emission factors to quantify emission reductions from the project activity[132]), the NMPP’s current Tier 2 approach does not necessarily set precedent for future expansions of the NMPP. The Reserve has not made a determination of preference between Tier 2 and Tier 3 methods (e.g. higher order quantification methods, such as validated biogeochemical models or comprehensive field sampling[132]). Robust yet simple regional Tier 2 emission factors may be better suited for cropping systems that cover large areas, have management practices that are fairly homogenous, and that are grown in relatively simple rotations. Examples of such cropping systems are rainfed corn systems (included in Version 1.0 of the NMPP), irrigated corn systems, or wheat cropping systems. Tier 3 approaches, including validated biogeochemical models, may be preferred for specialty crops for which the management is often varying and that are grown in more complex rotations. Examples of such cropping systems are vegetable or fruit cropping systems.

Reference data sets will be reviewed by the Reserve to determine whether the data is appropriate for developing a Tier 2 methodology, for calibrating and validating a Tier 3 methodology (e.g. DNDC), or for further validating a previously accepted NMPP methodology. In addition to the data sets themselves, stakeholders are encouraged to develop and submit new Tier 2 or Tier 3 quantification methodologies, developed from these reference data sets, including justification of why the selected methodology is most appropriate for that specific crop/state/practice combination.

D.1.2 Process for Future Protocol Expansion

The minimum data standards presented in this appendix will serve as internal guidance for the Reserve in determining whether reference data are sufficiently robust. The Reserve will also maintain a Nitrogen Management Science Advisory Committee (SAC) into the future, and the Reserve will consult the SAC, as needed, when making determinations about the quality of proposed methodologies, their underlying reference datasets, and independent reference datasets.

[132] As defined by the Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Stakeholders are encouraged to submit new reference datasets and quantification methodologies to the Reserve at any time. Information on this submittal process is available on the Nitrogen Management Project Protocol webpage. Stakeholders should complete an NMPP New Data Submittal Form, which will be used to assess whether the dataset meets the minimum data standards included in this appendix. The stakeholder submitting data is also asked to provide recommendations for data sources on adoption rates of a given practice to be used for performance standard development. The Reserve will review new data submittals on an ongoing basis. The Reserve will periodically consult the SAC to determine whether a given data set or proposed quantification methodology should be prioritized for further development and inclusion in the protocol. Criteria to be considered include:

a) The existence of baseline N_2O emission measurements for the practice, region, and/or cropping system considered;
b) The total acreage and intensity of use of nitrogen fertilizer for the cropping system in question;
c) Whether sufficient data exists to develop a performance standard and preliminary assessments show a project activity is likely to be additional; and
d) The economic and technical feasibility, as well as the mitigation potential, of the management practice that reduces N_2O emission under consideration.

Once the Reserve identifies specific protocol expansions, the Reserve may decide to contract for additional expertise and/or reconvene a stakeholder workgroup to support the protocol revision. As with any new project type, once the new project type has been developed and included in the protocol, the protocol will be released for a 30-day public comment period before the revision is considered for adoption by the Reserve Board.

D.2 Minimum Data Standards for Field Experiments

The minimum data standards apply to the reference data collected in field experiments and used for developing and/or validating new N_2O quantification approaches, and/or validating existing N_2O quantification approaches using independent data.[133] Reference data can be new source data generated during new measuring campaigns or existing data from, *inter alia*, the following sources, so long as the data requirements included in this appendix are met: scientific and technical articles in books, journals and reports; universities and extension services; United States Department of Agriculture (USDA); sectoral experts, commodity and stakeholder organizations, and industry groups. A reference to the source of the data must be provided for existing data. For the Reserve to approve reference data for use in a new quantification method, it should comply with the minimum data standards described below.

D.2.1 Method of Data Collection

Reference data should be collected using either chamber-based or tower-based (micrometeorological) methods.[134] Chamber-based methods are currently the least expensive option for measuring N_2O emissions from agricultural fields, as the materials required for

[133] The minimum data standard applies for reference data used for the development of statistical models as well as for the calibration and validation of process-based biogeochemical models proposed for the quantification of N_2O emission reductions.
[134] Tower-based methods (micrometeorological techniques) to measure N_2O emissions have been developed and have the advantage of being non-intrusive while providing continuous time series. Nevertheless, high investment costs make their use in replicated experiments currently less attractive.

building the chambers are very affordable, and analytical tools used for N_2O concentration measurements, such as gas chromatography, have become omnipresent in analytical laboratories.

Since methodologies to measure N_2O emissions are continuously improving, specific guidelines for sampling methods are not listed in this protocol. The Reserve will only review datasets for which sample collection methods comply with the most recent peer-reviewed guidelines available for the adopted method at the start of the experiments that yielded the reference data. A brief description of the chamber design, sample collection and handling, gas analysis and data analysis should be provided. For chamber-based measurements, the Reserve recommends following guidelines from the USDA ARS GRACEnet Chamber-based Trace Gas Flux Measurement Protocol.[135] Measurements taken through tower-based methods should be consistent with methodologies currently in use in peer-reviewed scientific literature.

D.2.2 Intensity of Data Collection

Due to the high spatial and temporal variability of N_2O emissions, accurate N_2O quantification necessitates a minimum temporal and spatial intensity of data collection.

D.2.2.1 Temporal Frequency and Scale of Data Collection

Flux measurements should take place at least once per week (every seven days). However, it is strongly advised to increase the measurement frequency following agronomic or environmental events known to be associated with major N_2O fluxes (i.e. tillage, fertilization, irrigation, rain, or harvest). Daily flux measurements after such events should continue until N_2O emissions return to pre-event levels. Note that N_2O responses to such events may not appear until several weeks after the event. This lag effect should be incorporated in the sampling design. It is recognized that due to unforeseeable weather conditions, issues with measurement devices, and other challenges, some gaps in the data set are unavoidable. Guidelines on how to handle outlying values are included in Section D.2.3.

Measurements also should represent the daily variations in N_2O fluxes. Multiple flux measurements could be made during one day. However, one flux measurement taken per day is acceptable, so long as it is taken at a time that corresponds to the daily average temperature (e.g. mid-morning or early evening).

Flux measurements should be taken at a minimum over the complete growing season, but year round flux data is preferable. Reference data should extend over at least two consecutive growing seasons. Flux measurements over additional growing seasons may be necessary if the two consecutive growing seasons for which measurements were taken exhibited anomalous weather conditions, with respect to that region.

D.2.2.2 Spatial Frequency and Scale of Data Collection

N_2O emissions are not only variable over time, but are also subject to high spatial variability. This spatial variability reveals itself at multiple geographic scales, including variability within a field, variability across fields within the same landscape, and across landscapes (e.g. a LRR, Land Resource Region, or a MLRA, a Major Land Resource Area). In this section, guidelines are provided to ensure that the reference data accounts for spatial variability at those different scales. Note that the terminology for “field” in the NMPP, as defined in Section 2.2.1, is different

[135] Parkin, T.B., & Venterea, R.T., 2010. Available at www.ars.usda.gov/research/GRACEnet.

from the terminology used in the design of agricultural experiments, in which a field represents a random variable and may encompass multiple plots with different treatments. In these guidelines, the Reserve uses “replicate plot” to refer to the smallest experimental unit and “field” to designate a greater unit with multiple replicate plots. In other words, a replicate plot corresponds to a field as defined in the NMPP.

The spatial frequency and scale of data collection should adhere to the following guidelines:

1. **The dimensions of the flux chambers**: The surface area covered by the flux chamber should be large enough to capture small-scale variability in N_2O fluxes (e.g. due to the number of fertilizer granules present in the chamber, the presence of decomposing crop residues, etc.). Chamber surface areas typically cover between ~300 and ~3000 cm^2.

2. **The number of flux chambers per functional locations within a replicate plot**: In many cropland systems, multiple functional locations with different soil moisture conditions, soil temperature and N concentration can be identified within a replicate plot (For example: middle of the berm, side of the berm, the furrow in annual row crops, tree row versus tractor row in orchards, etc.). It is recommended that flux chambers be strategically placed in multiple functional locations so as to represent the variety within the field appropriately. A minimum of two flux chambers per functional location within a replicate plot is recommended.

3. **The number of replicate plots per field**: The reference data should cover a minimum of 3 replicate plots per treatment (i.e. management practice) and per field. Usually, for a side-by-side (“pairwise”) comparison, there will be at least two treatments, with one treatment representing the baseline scenario and one treatment representing the project scenario. However, implementing and monitoring more than one potential project treatment is encouraged, so as to collect data on a wider variety of project activities. Any number of potential project activities could be implemented together as the “project treatment” on a given field (e.g. add nitrogen inhibitors, add a cover crop, trial of different N rates, or N rate reduction with the addition of cover crops).

4. **The number of fields**: The field(s) should be representative for the conditions within the area in which the reference data sets will be used. Therefore, multiple fields are to be used that are located at different sites and geographic locations (e.g. different counties, different states). Ideally, the fields (and replicate plots within fields) are also chosen to represent some of the most commonly occurring soil types in a region. However, it is recognized that having multiple fields may be challenging.

D.2.3 Outliers

When experimental data are collected, it is very likely that some samples will have values that are considerably larger or smaller compared to replicate samples. Such samples are often referred to as outliers, and can be spatial, temporal or analytical in nature. Analytical outliers can be caused by inadequate closure of flux chambers, leaky sampling vials, errors in sample collection or analysis, etc. and labs can remove analytical outliers in a routine and standardized fashion. However, as N_2O fluxes are known to be very variable in space and time, spatial and temporal outliers are often merely a reflection of the variable nature of the process and should be handled as real data. As such, removal of temporal and spatial outliers is strongly discouraged; the Reserve prefers that submitted reference data include any observed temporal or spatial outliers, with notations as to which outliers were flagged for removal by lab analysis. In some cases, there is a real reason for removing temporally or spatially anomalous data. Examples include local flooding due to a leak in a drip line, enhanced N_2O fluxes due to undesired animal excretions in the flux chamber, etc. Under such situations, temporal and spatial outliers may be removed by the Reserve prior to methodology development, if the outliers were properly identified and a justification is provided with the data set submittal. The extent to which inclusion/exclusion of this value affects the mean should be discussed in this justification.

D.3 Applicability of Field Experiment to a Region

Stakeholders will be asked to propose and justify a geographic applicability region over which a data set (or the subsequently developed quantification methodology) may be extrapolated. It is recommended that the justification includes a comparison of weather and climate, soil characteristics, and management practices between the study sites and the geographic applicability region.

Summaries of growing season and experimental conditions during the field trials should be included along with a discussion of whether representative conditions (e.g. temperature, precipitation, etc.) were “typical” or “average” for that region. For example, a comparison of the experimental growing season(s)’s mean annual temperature and precipitation data to data collected over the preceding ten year period could indicate whether N_2O emissions measured for the period are representative of a “typical” year, or rather a cold, hot, wet or dry year.

Further, “typical” soil type, soil texture, soil water holding capacity, soil organic carbon (SOC) levels, etc., for a given region should be considered when selecting replicate plots and fields for inclusion in an experiment. Sites should be chosen for their widest applicability to multiple soil types, etc., within the region. Likewise, the management practices executed on the field trials should be selected so that they represent the overall management within the region.

D.4 Independent Validation and Quantifying Uncertainty

Large uncertainty around field measurements leads to uncertainty around predicted emission reductions for any quantification approach. Therefore, the quantification approach must be robust in situations with high uncertainty. Even though a quantification methodology may ensure that projects meet minimum standards through eligibility and applicability conditions (e.g. conditions for which the model was calibrated), a significant amount of uncertainty may remain, which must be accounted for through an uncertainty deduction mechanism.

According to C-AGG’s white paper on uncertainty, analyses of both structural and input uncertainty related to their use must be completed so as to use and apply models appropriately.[136] Input uncertainty for an empirical model is subject to less uncertainty than a biogeochemical model, simply because there are significantly fewer critical inputs. Quantification approaches based on biogeochemical models, and quantification approaches for which the input variables are associated with a significant amount of uncertainty, require a Monte Carlo simulation to assess the effect of uncertainty around input variables on projects’ N_2O emissions reduction estimates, as is done in the Reserve’s Rice Cultivation Project Protocol (RCPP). In addition, all quantification approaches that are using a biogeochemical process model must include how to parameterize every input parameter to the model. More specifically, for every input parameter, it must be explained if the parameter has to be set using

[136] C-AGG, Executive Summary: Uncertainty in Models and Agricultural Offset Protocols. Discussion draft, 2012.

field measurements, look-up tables, default values, or internal calibration. If internal calibration is used to set certain parameters, the procedures for calibration must be clearly explained, as is done in the RCPP.

Structural uncertainty (termed $\mu_{struct,f}$ in the RCPP and NMPP) represents how well the model performs against measured emissions, regardless of whether that model is an empirical model or a biogeochemical model. To estimate structural uncertainty in the RCPP, for example, independent emissions measurement data (e.g. data that were not used to build the model) for California rice fields were used to "validate" the DNDC model by comparing measured and modeled data.

In the case of this protocol, in which an adaptation of the MSU-EPRI methodology is included (see Section 5), no additional field emissions measurement datasets for N rate trials are currently available for the North Central Region, other than MSU-EPRI's robust data set. This makes it more challenging to validate the methodology and estimate structural uncertainty. However, the developers of the original MSU-EPRI methodology performed a "leave-one-out" cross-validation analysis[137] to approximate the structural uncertainty and found that the uncertainty increased about two to four percent compared to an uncertainty analysis using non-independent data. The uncertainty quantified using a leave-one-out cross-validation is certainly applicable for areas similar in characteristics to the study sites. However, the uncertainty is likely greater for areas far away from the study sites. As a consequence, the "leave-one-out" approach's two to four percent increase in uncertainty was considered acceptable by the Reserve for the state of Michigan, where all of the study sites used to develop the MSU-EPRI quantification approach are located. However, an additional 15 percent uncertainty deduction is taken for other states in the NCR to avoid underestimating the structural uncertainty on sites that are far away from the field measurement locations.

When independent data becomes available to validate the model and quantify the structural uncertainty explicitly for the various NCR states, the Reserve plans to adjust the structural uncertainty deduction currently included in the NMPP.[138] This independent reference data should be gathered from a sufficient number of different data points so that the reference data can be divided into separate calibration and validation data sets. If calibration data are taken primarily from one area within a larger region (such as a Land Resource Region, LRR), an extensive validation data set, including data points from other areas within the region collected from a number of sources, might allow validation of the model for a much larger geographic area than the model was otherwise developed and calibrated for. It is worth noting that while the MSU-EPRI methodology was adapted and included in the NMPP before independent data was available, this decision is not precedent-setting. The Reserve prefers a full structural uncertainty assessment using validation data that is representative for the geographic applicability region over the leave-one-out approach.

[137] Generally, the goal of a cross-validation analysis is to evaluate the fit of a model to a data set that is independent of the data that were used to train the model. A leave-one-out cross-validation analysis estimates the structural uncertainty by comparing a single observation from the original sample to the outcome predicted by a model that was calibrated using the remaining observations.

[138] The Reserve anticipates that market drivers will try and reduce this uncertainty deduction as soon as possible, hopefully within the next five years.