Clean Water Act Section 319(h) Nonpoint Source Pollution Control Program

Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions

TSSWCB Project Number 09-03
Revision #0

Quality Assurance Project Plan

Texas State Soil and Water Conservation Board

prepared by

Texas AgriLife Research
Texas Water Resources Institute

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(with annual updates required)

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A1 APPROVAL PAGE

Quality Assurance Project Plan for the *Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions* project.

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A3 DISTRIBUTION LIST

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

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List of Acronyms

ACS	American Chemical Society
ARS	U.S. Department of Agriculture – Agricultural Research Service
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CAR	Corrective Action Report
CD	Compact Disk
COC	Chain of Custody
CPRL	Conservation and Production Laboratory
CRP	Conservation Reserve Program
CWA	Clean Water Act
DQO	Data Quality Objectives
DVD	Digital Video Disk
ESSL	Environmental Soil Science Lab – Vernon
ESSM	Ecosystem Science and Management
GSWRL	Grassland, Soil and Water Research Lab
N	Nitrogen
NH_4-N	Ammonium - Nitrogen
NIST	National Institute of Standards and Technology
NO_3-N	Nitrate – Nitrogen
NPS	Nonpoint Source
P	Phosphorous
PM	Project Manager
QA	Quality Assurance
QC	Quality Control
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QPR	Quarterly Progress Report
RPD	Relative Percent Difference
SD	Standard Deviation
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SOPs	Standard Operating Procedures
TAMU	Texas A&M University
TC	Total Carbon
TN	Total Nitrogen
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UT-BEG	University of Texas Bureau of Economic Geology

A4 PROJECT/TASK ORGANIZATION

The following is a list of individuals and organizations participating in the project with their specific roles and responsibilities:

USEPA Region 6 – Provides project oversight and funding at the federal level.

Henry Brewer, Texas NPS Project Officer

Responsible for overall performance and direction of the project at the federal level. Ensures that the project assists in achieving the goals of the clean water act (CWA). Reviews and approves the quality assurance project plan (QAPP), project progress, and deliverables.

TSSWCB – Provides project oversight and funding at the state level.

Pamela Casebolt, TSSWCB PM

Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between TWRI and the TSSWCB. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified in the contract. Notifies the TSSWCB QAO of significant project nonconformances and corrective actions taken as documented in quarterly progress reports from the TWRI Project Manager.

Donna Long, TSSWCB QAO

Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB and USEPA participants. Responsible for verifying that the QAPP is followed by project participants. Determines that the project meets the requirements for planning, quality assurance/quality control (QA/QC), and reporting. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures.

TWRI - Provides the primary point of contact between the TSSWCB and the project contractors. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified. Responsible for coordination, review, and delivery of quarterly progress reports (QPRs) and educational materials. Responsible for maintaining and updating the project website.

B. L. Harris, TWRI Acting Director; Project Lead

Responsible for ensuring that tasks and other requirements in the contract are executed on time and as defined by the grant work plan; assessing the quality of work by participants; submitting accurate and timely deliverables and costs to the TSSWCB; and coordinating attendance at conference calls, meetings, and related project activities.

Lucas Gregory, TWRI QAO

Responsible for determining that the QAPP meets the requirements for planning, QA/QC, and reporting activities conducted by TWRI. TWRI and AgriLife Research will conduct annual Project Coordination Meetings to discuss the QAPP and other guidance documents necessary for the project.

AgriLife Vernon – Responsible for demonstrating the ability to mine nitrogen from irrigation waters (N crediting) and developing and delivering educational programming to convey project findings.

Dr. Paul DeLaune, Assistant Professor, Project Co-Lead

Responsible for demonstrating that available N in groundwater is plant available; develop and deliver educational materials and programming. Responsible for ensuring that field personnel have adequate training, equipment, and a thorough knowledge of the QAPP and its requirements specific to the analysis or task performed and/or supervised. Responsible for ensuring that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the work plan and in the QAPP. Responsible for verifying that the data produced are of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data for this project. Responsible for submitting accurate and timely data analyses and other materials for QPRs and final reports to TWRI.

UT-BEG – Responsible for evaluating the relationships between land use and N loading to underlying aquifers and between natural sources of N versus fertilizer N.

Dr. Bridget Scanlon, Senior Research Scientist, Project Co-Lead

Responsible for conducting demonstrations that identify the relationships between land use and N loading in the Texas Rolling Plains' Seymour aquifer and to assess the relative importance of natural and anthropogenic N inputs in the Texas High Plains' Ogallala aquifer. Responsible for ensuring that field personnel have adequate training, equipment, and a thorough knowledge of the QAPP and its requirements specific to the analysis or task performed and/or supervised. Responsible for ensuring that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the work plan and in the QAPP. Responsible for verifying that the data produced are of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data for this project. Responsible for submitting accurate and timely data analyses and other materials for QPRs and final reports to TWRI.

ESSM – Responsible for conducting isotope analysis.

Dr. Tom Boutton, Regents Professor and Faculty Fellow

Responsible for measuring isotopes and analyze results related to soil nitrate and carbon and ensuring that analysis is conducted in accordance with the QA/QC requirements in the system as defined by the work plan and in the QAPP. Responsible for verifying that the data produced are of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data for this project.

ARS – Responsible for measuring nutrient parameters.

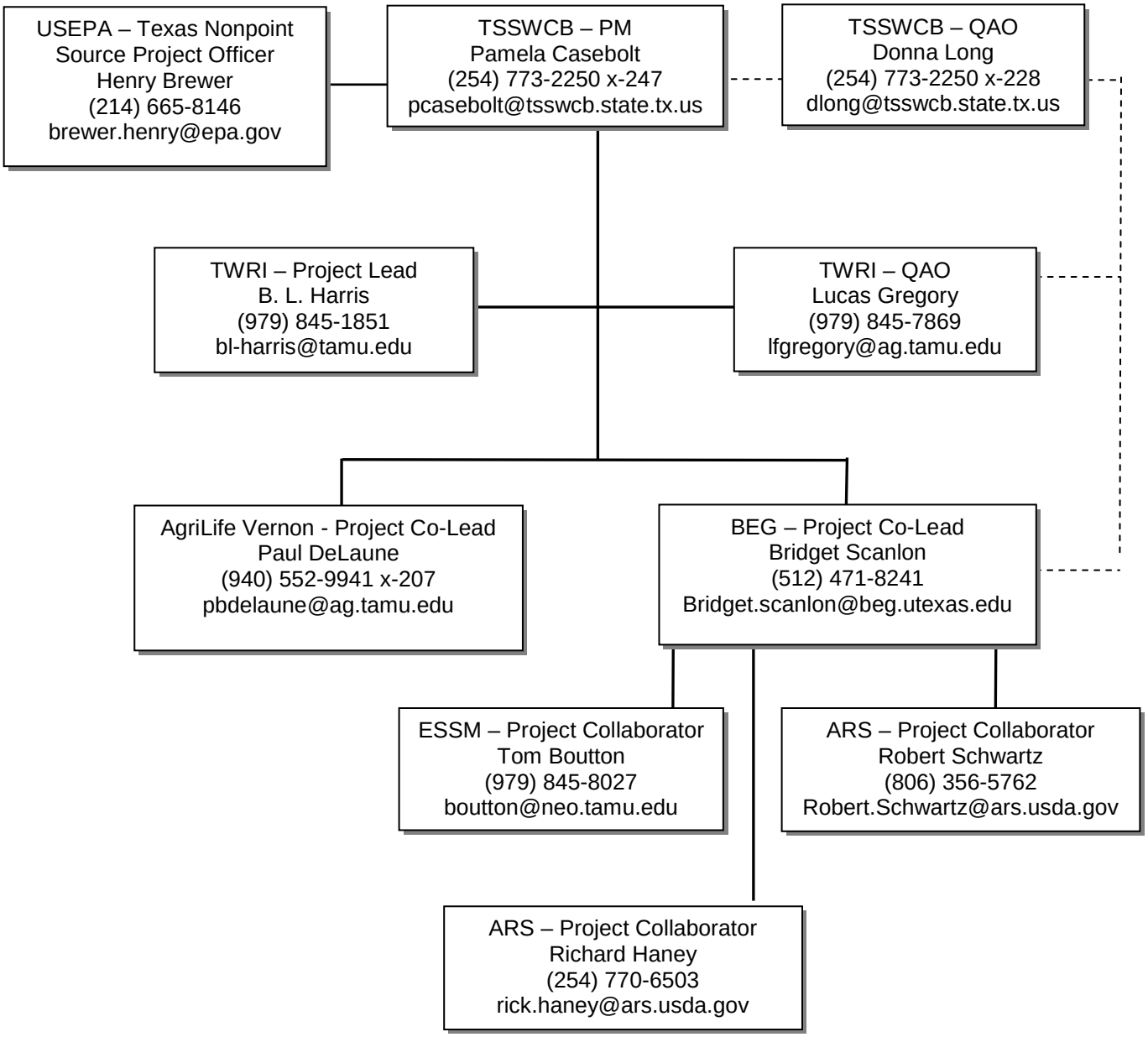
Dr. Robert Schwartz, Soil Scientist

Responsible for conducting field measurements on nutrient levels and utilizing collected data to ensure that analysis is conducted in accordance with the QA/QC requirements in the system as defined by the work plan and in the QAPP. Responsible for verifying that the data produced are of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data for this project.

Dr. Richard Haney, Soil Scientist

Responsible for analyzing soil samples to assess potentially mineralizable nitrogen in the soils. This information is important for assessing the natural source of high nitrates in the system from mineralization of soil organic nitrogen.

Figure A4.1 Organization Chart



A5 Problem Definition/Background

The Seymour Aquifer is a shallow aquifer underlying over 300,000 acres in 20 counties in northwest central Texas. According to Table D.1 of the Texas NPS Management Program, the Seymour Aquifer has the highest aquifer vulnerability rating of all the major aquifers in Texas. This indicates the aquifer's high susceptibility to impacts from surface activities. High nitrate concentrations are widespread in the Seymour Aquifer. Ambient Monitoring Groundwater Quality Data from the Seymour Aquifer from 1999-2006 shows that of the 91 wells sampled, 83 exceeded the maximum contaminant limit of 10 mg/l. All 91 wells had detectable levels of nitrate. Median nitrate levels in Knox, Haskell, Baylor, Hall, Wichita, Wilbarger, and Fisher counties exceeded the federal safe drinking water standard (10 mg/L NO3-N), with some exceeding 40 mg/L. The Groundwater Contamination Summary for the Seymour Aquifer Outcrop (2006) indicates that 15 sites had confirmed groundwater contamination with atrazine, dicamba, prometon, and propazine due to nonpoint sources. A study by the UT-BEG found that nitrate accumulations beneath irrigated agriculture are generally high.

High levels of nitrate in groundwater prior to fertilization and irrigation in the Seymour aquifer, low to moderate fertilizer application rates, and low to moderate unsaturated zone nitrate accumulations indicate that high groundwater contamination may be related to natural nitrate sources prior to irrigation and to irrigation recycling. These high concentrations are a concern because, although 90% of the water from the aquifer is used for irrigation, it is used as a municipal water source for Vernon, Burkburnett, and Electra and rural families in the region.

In addition to the use of groundwater from the Seymour Aquifer for irrigation and municipal purposes, the aquifer also naturally discharges through seeps and springs. This natural discharge contributes to the baseflow of many streams throughout the region. Groundwater flows toward the east-southeast, heading to the perimeter of the Seymour deposits. Stream flow increases towards the perimeter because stream stage is at a lower elevation than groundwater in the Seymour aquifer. Nitrate is a concern in a number of waterbodies in the region including South Groesbeck Creek, Wichita River Below Diversion Lake Dam, and Paradise Creek. Activities designed to reduce nitrate levels in the aquifer may also benefit area streams receiving baseflow from the Seymour Aquifer.

Currently, producers do not account for the high nitrate levels in the irrigation water they apply from the Seymour Aquifer. Underutilization of water testing, historical low cost of fertilizer, and speculation regarding the amounts of nitrate in the irrigation water that is actually available to crops prevent widespread accounting of this nitrate source. As a result, this lack of crediting has in many cases led to over-application and build-up of soil nitrate which increases the potential for N transport to surface and groundwater water supplies. With the recent increases in fuel and fertilizer costs, farmers are searching for ways to better manage their nutrients and make their operations more efficient and profitable. Thus, the stage is set for positive changes in nutrient management. This project will work to build on this momentum and encourage nutrient management through demonstration of N remediation strategies. In the Seymour Aquifer Water Quality Improvement Project Final Report (TWRI Technical Report – 332), it was recommended

that educational programs on irrigation management and nutrient management be provided to encourage regular soil testing, better manage irrigation systems, and account for nitrate levels in irrigation water when determining N fertilization needs. The report suggested that if nitrate in the aquifer could be "mined" using irrigation, then substantial cost savings could be realized by producers as a result of reduced nitrogen fertilization. It is estimated that irrigation water from some wells could supply the entire N requirement of a cotton crop (TWRI Technical Report – 332). This in turn could potentially improve the quality of the water in the aquifer. The goal of this project is to begin implementing these recommendations.

Groundwater nitrate contamination is also very important in the Texas High Plains Ogallala Aquifer. Groundwater contamination is most widespread in the southern half of the Southern High Plains where 25% of all wells exceed the Maximum Contaminant Level of 10 mg/L nitrate-N (Scanlon BR, Reedy RC, Bronson KF (2008) Impacts of land use change on nitrogen cycling archived in semiarid unsaturated zone nitrate profiles, southern High Plains, Texas. Env Sci & Tech 42: 7566-7572 DOI 10.1021/es800792w).

Understanding the source of nitrate in the aquifers is essential for mitigating the problem. There are a variety of potential sources of high groundwater nitrate concentrations in the Texas High Plains Ogallala and Rolling Plains Seymour Aquifers. High nitrate concentrations are generally attributed to a surface source because of high correlations with water table depth and negative correlation with aquifer saturated thickness as a result of reduced assimilative capacity. Potential sources of nitrate in groundwater include atmospheric deposition, natural sources, inorganic fertilizer, organic fertilizer (manure), concentrated animal feeding operations (CAFOs), barnyards, septic tanks, and leaking sewer systems.

In the High Plains and Rolling Plains, the most widespread source of nitrate is from fertilizer application. However, preliminary results from a recent study suggest that much of the nitrate in the southern High Plains could be natural, originating from mineralization of soil organic matter (SOM) associated with initial soil cultivation (Scanlon et al., 2008). These data include high nitrate concentrations that extend into zones of high chloride concentrations in the unsaturated zone, indicating old soil water that pre-dated cultivation. The mechanism for release of nitrate from SOM is attributed to increased aeration and increased moisture content associated with cultivation and is shown by soil moisture data. Nitrogen isotope data from soil water could not be used to distinguish natural sources from fertilizer sources because fertilizer nitrogen is derived primarily from ammonium-based fertilizers that undergo similar processes to natural mineralization of SOM. If the high nitrate concentration is related primarily to natural sources, then this source should eventually move through the system and groundwater quality should improve with time.

Reservoirs of Nitrate in the Soil

It is difficult for farmers to determine if they are over applying nitrogen to their fields. However, drilling and sampling soil profiles provides excellent information on long-term nitrogen transport in the subsurface. Preliminary results from drilling in areas of different land management indicate that the largest nitrate-N reservoirs are restricted to irrigated agriculture with maximum

concentrations ranging from 93 to 430 mg/L. Large concentrations of nitrate are accumulating under irrigated settings because of over application and inappropriate timing of application (50% applied pre-plant). Educational materials need to be developed for agricultural and water resource managers to show that nitrate is currently being over-applied and is being leached below the root zone, particularly in irrigated areas. With increasing costs of fertilizers, such information would be extremely valuable to producers and should result in large scale reductions of nitrogen fertilizer applications.

A6 PROJECT/TASK DESCRIPTION

In order to implement the recommendations described above, this project will (1) evaluate relative inputs of natural and fertilizer N in the Texas High Plains and Rolling Plains, (2) quantify nitrogen inventories under different agricultural land use management schemes, (3) identify and demonstrate strategies for reducing groundwater nitrogen levels (e.g. N crediting), and (4) transfer the results to farmers and others throughout the region through field days, workshops, and other venues.

Quantify Relative Inputs of Natural and Fertilizer Nitrogen in the Texas High Plains (Task 3)

Preliminary work in the Texas High Plains indicated that 74% (median) of total nitrate inventories in soil profiles is from mineralization of natural SOM in the soil profile that developed during initial cultivation. Support for the attribution of nitrate to mineralization of SOM during initial cultivation was provided by increased nitrate levels in the deeper part of the profiles that extended into old soil water (pre-cultivation) and were dated using chloride concentration analyses. These results were preliminary and need more support and justification. Since suitable native rangeland sites were not available in the southern High Plains during the study, UT-BEG was unable to compare native rangeland sites with nearby cultivated sites to quantify changes in organic carbon and nitrogen in order to support these results.

This project will quantify the changes between native rangeland sites and cultivated sites that are in close proximity to each other. UT-BEG will use data from the ARS Bushland site near Amarillo where an area of the research station has been maintained under rangeland management and is adjacent to cropland. Previous drilling has shown that there is very low nitrate under native rangeland at this site and there are pockets of nitrate in elevated concentration that extend into old soil water under cropland, similar to results from the southern High Plains.

UT-BEG will measure organic carbon and total nitrogen in the native and cropland profiles to quantify the reduction in organic carbon from the native to the cropland site. These data will be used to determine if changes in organic carbon and nitrogen can account for the increased nitrate found in profiles under cropland. This is an ideal system to conduct this comparison because of the close proximity of the native and cropland systems and the similarity in soil types between the two settings. UT-BEG will also examine carbon-13 isotopes on the organic carbon which may provide insights on the impact of the shift from native vegetation to cropland on the relative proportions of soil organic carbon derived from the native system versus the cultivated system. Soil and plant N will also be determined from long-term Conservation Reserve Program (CRP) fields to provide proof of concept that SOM may be a potential source of nitrate. Mass balance studies will also be conducted to evaluate the relative inputs of nitrogen from different sources.

These results should be applicable to the entire Texas High Plains and much of the Rolling Plains Seymour aquifer regions where up to 70% of wells exceed the 10 mg/L NO3-N maximum contaminant level. Unfortunately there are no appropriate rangeland sites in the Seymour aquifer region to apply this approach, but perhaps long-term CRP fields could serve as a substitute.

Nitrate derived from mineralization of native SOM does not constitute a continuous input to the system and should move through the groundwater system as a pulse of high nitrate concentration. UT-BEG will evaluate this process through mass balance analyses.

Quantify Nitrogen Inventories under Different Agricultural Land Use Management Schemes (Task 4)

Previous drilling and analyses have shown different nitrate inventories under various agricultural management scenarios. This drilling has been conducted at many sites in the Texas High Plains and Rolling Plains, including research farms associated with Texas Tech, such as La Mesa Research Farm in Dawson County, AgCares Farm, and Halfway Farm. Historical data of water and nutrient applications have been recorded at these sites. The drilling and sampling at these sites will be used to connect agricultural management practices and accumulation and/or leaching of nitrates in the subsurface. Historical records of agricultural practices will be examined for dryland and irrigated sites. The above farms offer ideal locations for conducting this work because of the detailed records on water and nutrient applications. The quality of the irrigation water has also been analyzed. Highest nitrate-N inventories were found under irrigated agriculture, moderate levels of nitrate were found under dryland agriculture, and very low levels of nitrate were found under rangeland settings.

UT-BEG will examine these data to determine relationships between nitrogen application rates and subsurface inventories. Based on these data and findings from UT-BEG, Texas AgriLife Research will develop recommendations on nitrogen application rates for farmers. In addition to the amount of nitrogen applied, the timing of the application process is also critical. Previous studies indicate that ~50% of the nitrogen is applied pre-plant (Bronson et al., 2006) and this nitrate may be much more vulnerable to leaching because the crop has not developed to utilize the applied N. These data are an important indicator that may contribute to facilitating the implementation of best management practices (BMPs), thereby minimizing future groundwater nitrate contamination. Texas AgriLife Research- Vernon will work with UT-BEG to determine BMPs related to nitrogen fertilizer applications for producers. UT-BEG will also evaluate nitrate input from mineralization of SOM. This mechanism may contribute substantial amounts of nitrate to the system. UT-BEG will supplement existing data by drilling additional boreholes in Lynn County where extremely high groundwater nitrate contamination is found, provided site access can be obtained.

One promising BMP is the practice of accounting for existing nitrogen in the irrigation water and reducing subsequent fertilizer N applications. Aquifers, such as the Seymour Aquifer, with high concentrations of nitrate can contribute a significant amount of N during the growing season. For example, an application of 12 inches of water/ac with a nitrate concentration of 20 mg/L will contribute approximately 55 lb N/ac. This practice will be termed as nitrogen crediting. This practice will be demonstrated and verified by Texas AgriLife Research-Vernon. Side-by-side plots of N crediting and conventional fertilization practices will be demonstrated to farmers in the region and benefits of N crediting documented, both economically and environmentally. This is greatly needed to provide assurance to farmers in the region that the nitrogen in the irrigation water (which in some soils leaches quickly through the root zone) is truly available for crop

uptake and that reductions in fertilizer applications will not adversely impact crop yields and their livelihoods.

Due to the quick leaching alone, it is likely that a one to one accounting of the nitrogen in the irrigation water is not possible. This will also vary depending on the irrigation method used. These impacts must be quantified and demonstrated to area farmers to obtain widespread adoption. Primary crops in the region include cotton, bermudagrass hay, wheat, and peanuts. Demonstrations at the Chillicothe Experiment Station will target three different irrigation systems cropped to cotton: subsurface drip, furrow, and overhead irrigation. Nutrient management strategies will be based on the crop's agronomic: 1) N requirements; 2) N and phosphorous (P) requirements; 3) N requirements minus irrigation N credit; 4) N and P requirements minus irrigation N credit and 5) the control (N supplied through irrigation water only). Soil samples will be taken to a depth of 36 inches following each growing season. Samples will be segmented (0-6, 6-12, 12-18, 18-24, and 24-36 inches) and analyzed for nitrate, ammonium, total N, and phosphorus. Irrigation water samples will also be taken weekly throughout the irrigation season and analyzed for nitrate. One irrigation treatment based on a pre-selected evapotranspiration replacement level will be used among the three irrigation systems.

To transfer the results and recommendations of the project to farmers directly and via project partners, Texas AgriLife Research- Vernon will work with TWRI and UT-BEG to develop and distribute a fact sheet, technical report, handouts, presentations, and refereed journal publications and posters (as appropriate). (Subtask 4.4, 4.5, 4.6) This information will be presented at a minimum of 1 field day at the demonstration site, 2 national meetings, 2 regional meetings, and 3 workshops/stakeholder meetings held to discuss nitrate and irrigation strategies. These educational materials will primarily target the Texas High Plains and Rolling Plains regions but will have applicability to similar systems both regionally and nationally. To ensure the long-term delivery of these materials, findings, and recommendations, the educational materials will subsequently be made available to AgriLife Extension and other project partners for use at other venues in the region.

In order to produce results in a timely manner, the project will follow the timeline described in Table A6.1.

Table A6.1. Project Plan Milestones

Task	Project Milestones	Agency	Start	End
1.1	Prepare & submit quarterly reports to TSSWCB & participants	TWRI	M 1	M 36
1.2	Perform accounting functions	TWRI	M 1	M 36
1.3	Participate in meetings with TSSWCB & partners	TWRI	M 1	M 36
1.4	Develop project final report	TWRI	M 30	M 36
2.1	Develop QAPP	TWRI	M 1	M 6
2.2	Submit revisions and amendments to QAPP	TWRI	M 6	M 36
3.1	Quantify changes between native and cultivated sites	UT-BEG	M 6	M 24
3.2	Quantify organic carbon and total nitrogen in the native and cropland profiles	UT-BEG	M 6	M 30
3.3	Examine carbon-13 isotopes on organic carbon	UT-BEG/ESSM	M 12	M 30
3.4	Mass balance analyses to evaluate nitrogen inputs	UT-BEG/ARS	M 1	M 24
3.5	Evaluate nitrate mineralization through mass balance analyses	UT-BEG	M 6	M 30
3.6	Examine historical records of agricultural practices for dryland and irrigated sites	UT-BEG	M 1	M 24
3.7	Determine BMPs related to nitrogen fertilizer applications	AgriLife Vernon/ UT-BEG	M 1	M 18
3.8	Evaluate nitrate input from mineralization of SOM	UT-BEG	M 12	M 24
4.1	Establish a 2.5 acre block under subsurface drip irrigation to cotton	AgriLife Vernon	M 6	M 30
4.2	Demonstrate nutrient management strategies	AgriLife Vernon	M 6	M 30
4.3	Collect and analyze soil samples following each growing season	AgriLife Vernon	M 6	M 30
4.4	Develop recommendations on nitrogen application rates	AgriLife Vernon	M 24	M 36
4.5	Host a minimum of 1 field day at the demonstration site	AgriLife Vernon	M 6	M 30
4.6	Develop a technical report and refereed journal publication summarizing results	AgriLife Vernon	M 6	M 30

A7 QUALITY OBJECTIVES AND CRITERIA

The primary project objectives are to (1) evaluate relative inputs of natural and fertilizer N in the Texas High Plains and Rolling Plains, (2) quantify nitrogen inventories under different agricultural land use management schemes, (3) identify and demonstrate strategies for reducing groundwater nitrogen levels (e.g. N crediting). Measurement performance specifications to support the project objective are specified in Table A7.1. Laboratory measurement QC requirements and acceptability criteria are provided in Section B5.

Precision

The precision of data is a measure of the reproducibility of a measurement when an analysis is repeated. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. All chemical analyses will be checked for precision by the analysis of duplicate laboratory samples. The frequency of duplicate analysis will be approximately one in thirty samples. The laboratory check sample will be subjected to analytical steps subjected to the unknown samples. Relative percent difference (RPD) of duplicate analyses (X_1 and X_2) will be calculated with the formula with the precision limits indicated in Table A7.1:

$$\text{Relative Percent Difference} = \frac{(X_1 - X_2)}{(X_1 + X_2)/2} \times 100\%$$

Accuracy

Accuracy is the degree of conformity with a standard. Accuracy relates to the quality of a result, and is distinguished from precision, which relates to the quality of the operation by which the result is obtained. The relative accuracy of the analytical process will be monitored via comparison of the laboratory check sample(s) data. This differs from traditional accuracy assessments since there is no proper procedure for spiking soil to add a known to the sample. Due to the inherent heterogeneity of soil, a variety of reactions can occur, making accuracy difficult to determine. These reactions may include precipitation, anion exchange, and cation exchange. Instead, reproducibility will be used. In addition, after every thirty samples, a laboratory standard and an EPA certified standard will be run to check accuracy.

Reproducibility

Reproducibility will be determined by evaluation of a laboratory soil check sample within each sub-batch of 30 samples. Recovery of critical data for each check sample will be compared to the historic project data associated with the laboratory soil check sample. Values with greater than one standard deviation of the mean will be determined to be substandard and all extracted solutions between the previous acceptable laboratory soil check sample and the next acceptable laboratory soil check sample will be re-analyzed.

Table A7.1. Measurement Performance Specifications

Parameter	Units	Extractant	Analysis Method	Method Reference	Reproductibility Limits	Precision Limits	Percent Complete
Texas AgriLife Research: Vernon							
Nitrate (NO3)	mg/kg	KCL	EPA 353.2	Keeney and Nelson. 1982	1 S.D.	10%	90
Mehlich III P	mg/kg	Melich III	EPA 365.1	Ziadi and Tran. 2008	1 S.D.	10%	90
Ammonium (NH4)	mg/kg	KCL	EPA 350.1	Keeny and Nelson. 1982	1 S.D.	10%	90
Nitrate (water)	mg/L	N/A	EPA 353.2	APHA, 2005	1 S.D.	10%	90
Total N	mg/kg	plant	EPA 440.0	Rutherford et al. 2008	1 S.D.	10%	90
UT Bureau of Economic Geology							
Nitrate (NO3)	mg/kg	soil/water	EPA 300.0	Keeney and Nelson. 1982	1 S.D.	10%	90
Total Organic C	mg/kg	soil	Combustion	Nelson and Summers. 1982	1 S.D.	RPD<5%	90
Total N	mg/kg	soil	Combustion	Nelson and Summers. 1982	1 S.D.	RPD<5%	90
Anions (F-, Cl-, Br-, SO4^2-)	mg/L	soil/water	EPA 300.0	Keeney and Nelson. 1982	1 S.D.	10%	90
Cations (Ca2+, Mg2+, Na+, K+)	mg/L	soil/water	ASTM D6919-03	Knudsen et al. 1982; Lanyon and Heald, 1982	1 S.D.	10%	90
Conductivity, field	mS/cm	water	EPA 120.1	Eaton et al. 2005	1 S.D.	10%	90
Dissolved Oxygen, field	mg/L	water	EPA 360.1	Eaton et al. 2005	1 S.D.	10%	90
pH, field		water	EPA 150.1	Eaton et al. 2005	1 S.D.	10%	90
Temperature, field	°C	water	EPA 170.1	Eaton et al. 2005	1 S.D.	10%	90
Alkalinity, field	mg/L	water	EPA 310.1	Eaton et al. 2005	1 S.D.	10%	90
USDA Agricultural Research Service - Conservation and Production Research Lab							
Total C	mg/kg	soil	Dry Combustion	Nelson and Summers. 1982	1 S.D.	RPD<5%	90
Total N	mg/kg	soil	Dry Combustion	Nelson and Summers. 1982	1 S.D.	RPD<5%	90
Soil Extractable NO3	mg/kg	soil	EPA 353.2	Keeney and Nelson. 1982	1 S.D.	RPD<10%	90
Soil Extractable NH4	mg/kg	soil	EPA 350.1	Keeney and Nelson. 1982	1 S.D.	RPD<10%	90
USDA Agricultural Research Service - Grassland, Soil and Water Research Lab							
Total N	mg/kg	soil	Mineralizable N + Total Inorganic N	Haney et al. 2004	1 S.D.	RPD<10%	90
Total Inorganic N (NO3-N + NH4-N)	mg/kg	soil	RFA	Haney et al. 2006	1 S.D.	RPD<10%	90
Mineralizable C	mg/kg	soil	Solvita	Haney et al. 2008	1 S.D.	RPD<10%	90
Mineralizable N	mg/kg	soil	0.5 x 1-day CO2-C	Haney et al. 2001	1 S.D.	RPD<10%	90
Texas AgriLife Research - Ecosystem Science and Management							
Soil Organic C	mg/kg	soil	Combustion	Nelson and Summers. 1982	1 S.D.	RPD<10%	90
Total N	mg/kg	soil	Combustion	Bremner and Mulvaney. 1982	1 S.D.	RPD<10%	90
$\delta^{13}C$	mg/kg	soil	Combustion / IRMS	Hut. 1987; Coplen. 1995 & 1996	1 S.D.	<0.1 ‰	90

Database checks for validity will be performed on an on-going basis by the AgriLife Vernon / ARS / ESSM / UT-BEG Project Co-Leads / Lab Managers. Data will be reviewed for abnormalities or any unusual results. Any unusual results will be traced for error sources. In the event no error is found, the data will be assumed normal and appropriate for decision determinations. If an error is found and cannot be resolved, the raw samples will be prepared again and reanalyzed. If there is not sufficient raw sample for preparation, the data will be discarded based upon the decisions of the AgriLife Vernon / UT-BEG Project Co-Leads and TWRI QAO.

Comparability

Confidence in the comparability of data sets from this project to those for similar uses is based on the commitment of project staff to use only accepted sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP and referenced method documents. Comparability is also guaranteed by reporting data in standard units, by using accepted rules for rounding figures, and by reporting data in a standard format. The Project Co-Leads will closely coordinate activities to ensure that proper protocols are utilized.

Completeness

Although 100 percent of collected data should be available, accidents, insufficient sample volume, or other problems must be expected. A goal of 90 percent data completeness will be required for data usage. Should less than 90 percent data completeness occur, the Project Co-Leads will initiate corrective action. Data completeness will be calculated as a percent value and evaluated with the following formula:

$$\% \text{ completeness} = \frac{SV}{ST} \times 100$$

where: SV = number of samples with a valid analytical report
ST = total number of samples collected

A8 SPECIAL TRAINING/CERTIFICATION

Laboratory analysts have a combination of experience, education, and training to demonstrate knowledge of their function. In addition, all personnel involved in sampling, sample analyses, and statistical analyses have received the appropriate education and training required to adequately perform their duties.

A9 DOCUMENTS AND RECORDS

Hard copies of all field data sheets, chain of custody forms (COCs), laboratory data files, field data entry sheets, and corrective action reports (CARs) will be archived by the AgriLife Vernon / ARS/ ESSM/ UT-BEG Project Co-Leads or collaborators for at least five years from the end of the project. Instrument (general maintenance records) logs will be maintained by the AgriLife Vernon / ARS / ESSM / UT-BEG Project Co-Leads / Lab Managers. All electronic data are backed up on a CD or DVD monthly and are simultaneously saved in an external network folder and the computer's hard drive. In addition, the AgriLife Vernon / ARS / ESSM / UT-BEG Project Co-Leads / Lab Managers will archive electronic forms of all project data for at least five years from the end of the project. A CAR form is presented in Appendix A and a copy of a COC is presented in Appendix B.

Quarterly progress reports will note activities conducted in connection with the project's soil analyses, items or areas identified as potential problems, and any variations or supplements to the QAPP. CARs will be utilized when necessary. CARs will be maintained in an accessible location for reference at AgriLife Vernon and UT-BEG. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP. All quarterly progress reports and QAPP revisions will be distributed to personnel listed in Section A3. Finally, the TSSWCB may elect to take possession of records at the conclusion of the specified retention period.

QAPP Revision and Amendments

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The last approved versions of QAPPs shall remain in effect until revised versions have been fully approved; the revision must be submitted to the TSSWCB for approval at least 60 days before the last approved version has expired. If the entire QAPP is current, valid, and accurately reflects the project goals and the organization's policy, the annual re-issuance may be done by a certification that the plan is current. This will be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

QAPP amendments may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Written requests for amendments are directed from the TWRI QAO to the TSSWCB PM and are effective immediately upon approval by the TSSWCB PM, QAO and EPA Project Officer. Amendments to the QAPP and the reasons for the changes will be documented and distributed to all individuals on the QAPP distribution list by the TWRI QAO. Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process.

B1 SAMPLING PROCESS DESIGN

The primary project objectives are to (1) evaluate relative inputs of natural and fertilizer N in the Texas High Plains and Rolling Plains, (2) quantify nitrogen inventories under different agricultural land use management schemes, (3) identify and demonstrate strategies for reducing groundwater nitrogen levels (e.g. N crediting). All parameters are considered "critical" to achieving the objectives of the project.

UT-BEG will seek to quantify the changes between native rangeland sites and cultivated sites that are in close proximity to each other, UT-BEG will use data from the ARS Bushland site near Amarillo where an area of the research station has been maintained under rangeland management and is adjacent to cropland. Table B1.1 presents the sampling scheme including the general location, sampling site type, sample type, the number of boreholes that will be drilled, an estimation of the number of samples that will be collected from each borehole and the laboratory that will be analyzing the respective samples. The total number of samples per sampling event and total samples will depend on how deep soil cores can physically be taken. Typically, 80 feet is the maximum depth that the soil corer being used can achieve. Sample planning was based on the maximum number of samples typically possible; as such, sample numbers anticipated are likely overestimates.

Sample Sites: One soil sample will be collected by UT-BEG per borehole; field splits will be derived from each sample to allow for each lab to conduct the respective analysis illustrated in Table A7.1. UT-BEG will target the Texas Tech University rangeland site near Lubbock (NAD 1983, GEOID99 Conus; N33°36'11"; W101°54'26") for drilling a deep profile and collect shallow samples from nearby dryland and irrigated sites. UT-BEG will also drill profiles in Lynn County in rangeland, rainfed and irrigated sites (NAD 1983, GEOID99 Conus: rangeland: N32^{0}57'39''; W101^{0}43'28''; rainfed: N32^{0}58'25''; W101^{0}43'24''; rainfed: N33^{0}0'40''; W101^{0}57'3''; and irrigated: N33^{0}1'5''; W101^{0}57'3''; Figure B1.2). UT-BEG will drill profiles at the Agricultural Demonstration Project in Hale and Floyd Counties as illustrated in figure B1.1 in irrigated and dryland settings (N34^{0}13'1''; W101^{0}36'47''; N34^{0}1'7''; W101^{0}29'47''; rainfed: N34^{0}1'4''; W101^{0}29'40'' (Figure B1.3). UT-BEG will collect shallow soil samples for TOC and TN analyses adjacent to the locations where previous boreholes have been drilled at the Bushland site (Table B1.2). For all irrigated sampling sites, irrigation water from the irrigation well used for the respective sites will be sampled as well. In the event that a sample cannot be obtained, historical records from local groundwater conservation districts or the Texas Water Development Board will be utilized to determine irrigation water constituents.

Texas AgriLife Research- Vernon will establish a 2.5 acre block under subsurface drip irrigation cropped to cotton at the Chillicothe Research Station (Figure B1.1) to demonstrate and document benefits of irrigation water N crediting to area farmers. At Chillicothe, Texas AgriLife Research- Vernon will demonstrate nutrient management strategies based on the crop's agronomic (1) N requirements, (2) N and P requirements, (3) N requirement minus irrigation N credit, (4) N and P requirement minus irrigation N credit, and (5) control (N from irrigation water only) on plots cropped to cotton under subsurface drip, furrow, and overhead irrigation. Texas AgriLife Research- Vernon will collect and analyze soil samples from a depth of 36

inches following each growing season. Soil samples will be analyzed by Texas AgriLife Research- Vernon for nitrate, ammonium and P. Irrigation water samples will also be collected bi-weekly throughout the irrigation season at demonstration sites as irrigation water is applied and will be analyzed for nitrate. Irrigation at Chillicothe is conducted based on the evapotrasnpirative requirements of the plant, thus sufficient rainfall circumvents irrigation.

Table B1.1 Soil sampling schedule and sample count

Groundwater Nitrogen Project Soil Sampling Schedule

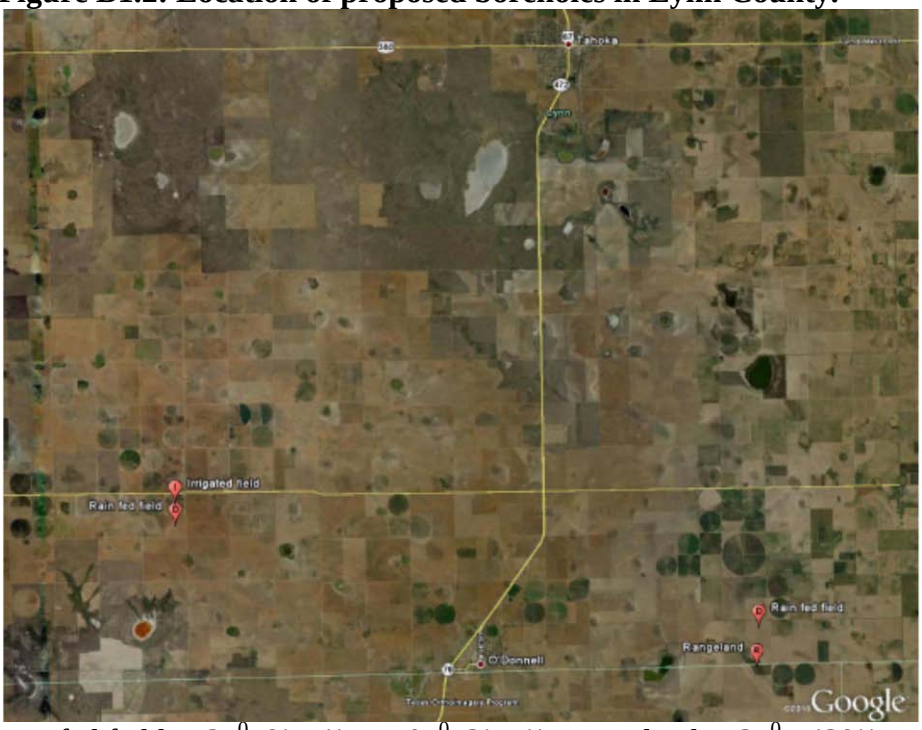
Task	Location	Sample Site Type	Sample Type	# of Sampling Events (Boreholes drilled)	Max. # of Samples per Event	Max. Total # of Samples	Analyzing Laboratory†
3	Ag Demo Farm	Dryland	Deep	3	27	81	UT-BEG/GSWRL
	Ag Demo Farm	Irrigated	Deep	3	27	81	UT-BEG/GSWRL
	Lynn County	Dryland	Deep	2	27	54	UT-BEG/GSWRL
	Lynn County	Irrigated	Deep	2	27	54	UT-BEG/GSWRL
	TTU	Rangeland	Deep	1	27	27	UT-BEG/GSWRL
	*Seymour	Rangeland	Deep	1	27	27	UT-BEG/GSWRL
	Bushland	Rangeland	Deep	2	27	54	UT-BEG/GSWRL
	Bushland	Dryland	Deep	2	27	54	UT-BEG/GSWRL
	Bushland	Irrigated	Deep	2	27	54	UT-BEG/GSWRL
3	Ag Demo Farm	Dryland	Shallow	3	5	15	CPRL
	Ag Demo Farm	Irrigated	Shallow	3	5	15	CPRL
	Lynn County	Dryland	Shallow	2	5	10	CPRL
	Lynn County	Irrigated	Shallow	2	5	10	CPRL
	TTU	Rangeland	Shallow	1	5	5	CPRL
	Bushland	Rangeland	Shallow	2	5	10	CPRL
	Bushland	Dryland	Shallow	2	5	10	CPRL
	Bushland	Irrigated	Shallow	2	5	10	CPRL
	*Seymour	Rangeland	Shallow	1	5	5	CPRL
Totals from all Task 3 deep and shallow sampling events				**36**	**288**	**576**	
4	Chillicothe	Drip Irrigated	Composite	4	8	32	ESSL
	Chillicothe	Pivot Irrigated	Composite	4	8	32	ESSL
	Chillicothe	Furrow Irrigated	Composite	4	3	12	ESSL
Totals from all Task 4 sampling events				**12**	**19**	**76**	

† isotope analysis conducted by ESSM under task 3 will be determined based on results of other analyses; as such, not all samples will be analyzed by ESSM

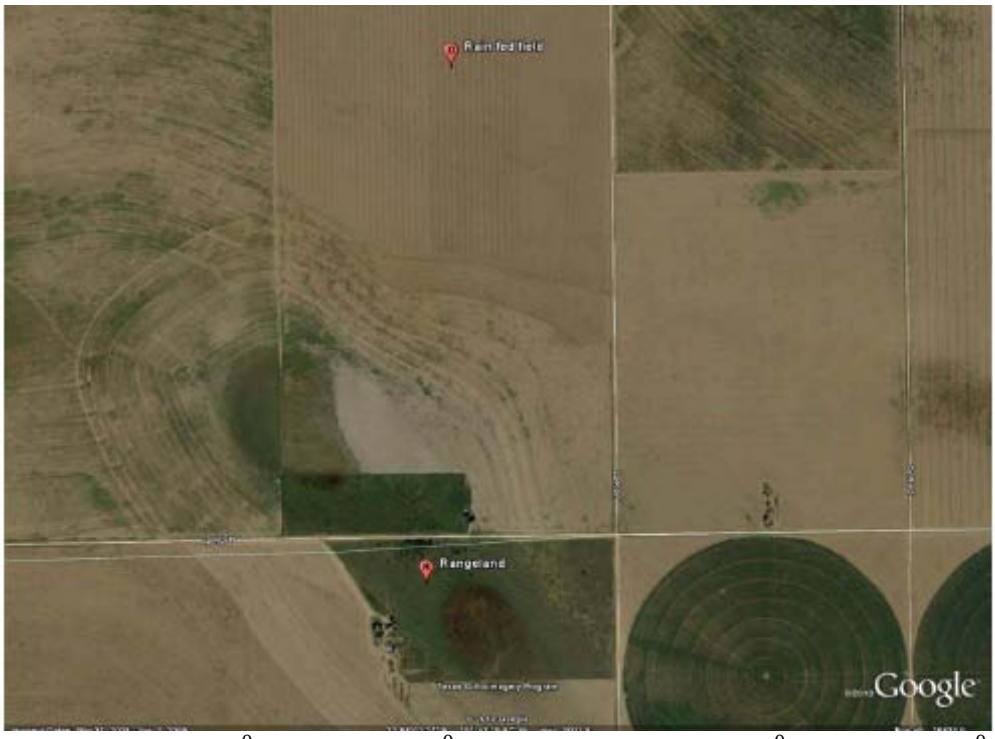
*It is unknown if a true rangeland sight can be identified in the Seymour aquifer area

Figure B1.1 Locations of Demonstration/Sampling Sites at Chillicothe Farm

Figure B1.2: Location of proposed boreholes in Lynn County.



Rainfed field: N32^{0}58’25’’ W101^{0}43’24’’ Rangeland: N32^{0}57’39’’ W101^{0}43’28’’



Rainfed field: N32^{0}58’25’’ W101^{0}43’24’’ Rangeland: N32^{0}57’39’’ W101^{0}43’28’’

Rainfed field: N33^{0}0’40’’ W101^{0}57’3’’Irrigated: N33^{0}1’5’’ W101^{0}57’3’’

Figure B1.3: Location of proposed boreholes in Hale and Floyd Counties.

Irrigated: N34^{0}13’1’’ W101^{0}36’47’’

Irrigated: N34^{0}1’7’’ W101^{0}29’47’’ Rainfed: N34^{0}1’4’’ W101^{0}29’40’’

Table B1.2: Location of sampling sites for shallow sampling at Bushland, Texas.

Borehole	Setting	Latitude	Longitude
POT07-04	Natural	35.17460	-102.09348
Pot06-01	Rainfed	35.18210	-102.09287
POT06-02	Rainfed	35.18185	-102.09235
POT07-01	Rainfed	35.18550	-102.09065
POT07-02	Rainfed	35.18633	-102.09160
POT07-05	Rainfed	35.18497	-102.09300
POT07-06	Rainfed	35.18567	-102.09224
Pot08-04	Rainfed	35.18150	-102.09147
Pot08-05	Rainfed	35.18167	-102.09188
Pot08-06	Rainfed	35.18238	-102.09340
Pot08-07	Rainfed	35.18258	-102.09393
Pot08-08	Rainfed	35.18427	-102.09193
Pot07-03	Irrigated	35.18575	-102.09643
Pot08-02	Irrigated	35.17338	-102.09727
Pot08-03	Irrigated	35.17302	-102.09727
Pot08-09	Irrigated	35.17323	-102.09733

B2 SAMPLING METHODS

Soil Sampling

Task 3. Soil samples will be collected by UT-BEG / CPRL in the shallow subsurface (upper 1.0 to 1.5 ft) using a core sampler or Giddings soil probe at 0.3 ft depth intervals during the non-growing season portion of the year (January to April). This sampling scheme will result in a maximum of 10 shallow soil samples per sample event. These samples will be stored in plastic containers for later analysis at GSWRL. Deeper soil profiles will be sampled using a direct push drill rig (Model 6620 DT, Geoprobe, Salina, KS) (Geoprobe SOP, Appendix C). Continuous soil cores will be collected in the field and put in ice chests for laboratory analyses. The cores will be sectioned in the laboratory for analysis of water extractable NO_3-N at varying depth intervals from 1 ft depth intervals to 6 ft, 2 ft depth intervals to 16 ft and 4 ft depth intervals to total depth for a maximum of 27 total potential samples per deep borehole. Drilling and sampling will be coordinated with producers, taking crop harvest times and weather into account. All soil samples/cores will be stored at the laboratory either refrigerated at 4°C or frozen. Extracts for all analytical methods excluding EPA 300.0 (NO_3-N by ion chromatrography) that cannot be analyzed within 24 hours will be acidified with H_2SO_4 to pH <2 and frozen. Such frozen samples will be analyzed within 2 weeks. All water-extractable NO_3-N analyses following EPA Method 300.0 will be performed within 48 hours of extraction.

Well Water Samples

Water samples will be collected from irrigated plots only identified in Section B1. The well head used to irrigate the sampled field will be sampled when parameters have stabilized, as determined when the relative variations between 3 consecutive 5-minute interval measurements of temperature, pH, and conductivity do not exceed 10%. Water samples for NO_3-N analysis using EPA Method 300.0 will be filtered through a 0.45 μm filter, stored in a bottle, refrigerated at 4°C, and analyzed within 48 hours. Water samples for NO_3-N analysis that cannot be analyzed within 48 hours will be filtered through a 0.45 μm filter, acidified to pH <2, stored in a bottle, refrigerated at 4°C, and analyzed within 28 days using EPA Method 353.2. Water samples for other anion analyses will be filtered through 0.45 μm filter, stored in a bottle, refrigerated at 4°C, and analyzed within 28 days. Water samples for cation analyses will be filtered through a 0.45 μm filter, acidified to pH <2, stored in a bottle, and analyzed within 28 days.

Ground Water Sample Handling Protocols

Parameter	Medium	Container	Volume	Preservative
Nitrate	Water	Sterile polyethylene container with lid	60 ml	Sub-sample and filter immediately (.45 micron filter) and refrigerate (4 ^{o}C); H_2SO_4, pH<2
Anions (F, Cl, Br, SO4)	Water	Polyethylene container w/ lid	60 ml	Sub-sample and filter immediately (.45 micron filter) and refrigerate (4°C)
Cations (Ca, Mg, Na, K)	Water	Polyethylene container w/ lid	60 ml	Sub-sample and filter immediately (.45 micron filter) and refrigerate (4°C); HNO-3, pH<2

Task 4. Soil samples will be collected using a Giddings soil probe. Soil samples will be collected in paper boxes or bags with at least 1 pint of sample. At least two cores will be sampled from each demonstration plot and thoroughly composited. Samples can be held indefinitely. Sampling will occur once annually, with four replications during the non-growing season portion of the year (January to April) and will be processed and analyzed at the Environmental Soil Science Laboratory (ESSL) located at the Texas AgriLife Research- Vernon. Sampling once per year will be done to minimized intra-annual variations in soil constituencies under varying stages of plant growth. The goal of this assessment is to identify N uptake and N leaching on an annual basis; therefore, annual sampling is best suited for this analysis. Sample analysis will include ammonium, nitrate, and Mehlich III P. Analysis will be completed within 28 days.

Soil Sample Handling Protocols

Parameter	Medium	Container	Volume	Preservative
Ammonium, Nitrate, Mehlich III P	Soil	Paper box/bag	1 Pint	Oven dry within 2 days and store at room temperature

Plant Sampling

Plant sampling consists of randomly selecting 5 plants from the 2nd row and 5 plants form the 7th row in each treatment. Demonstrations on furrow, center-pivot and drip irrigation are being conducted with each containing 5 treatments of 8 rows. The furrow demonstration contains 3 reps while the center-pivot and drip demonstrations contain 4 reps. In total, a maximum of 550 individual plants will be sampled and analyzed for Total N content. Samples will be collected at the peak of their maturity; cotton will be collected upon the opening of the first boll and sorghum would be collected upon maturity of the head (sorghum will only be planted and sampled if the cotton crop is destroyed by nature and it is too late to replant cotton). Plant material will be collected by clipping the plant at ground level, drying the portions of the plant individually dried and later ground in a Wiley mill (2mm). The ground plant samples will be placed in labeled plastic containers (same labels that were on each collection brown paper bag). The samples will be delivered to the ESSL where they will be analyzed for total N. Analysis will occur within 28 days.

Forage Sample Handling Protocols

Parameter	Medium	Container	Volume	Preservative
Total N	Plant	Plastic container with lid	Approx 100-200 g dry weight	Oven dry within 2 days and store at room temperature

Well Water Samples

Water samples will be collected from the well head only after the pump has been running for at least 1 hr. Water will be collected in a syringe and immediately filtered through a 0.45 µm membrane and acidified to pH 2 with H_2SO_4. Samples will be transported to the ESSL and stored in a refrigerator at 4°C. Analysis will be completed within 28 days.

Ground Water Sample Handling Protocols

Parameter	Medium	Container	Volume	Preservative
Nitrate	Water	Sterile polyethylene container with lid	60 ml	Sub-sample and filter immediately (.45 micron filter) and refrigerate (4 ^{o}C); H_2SO_4, pH<2

Recording Data

For the purposes of this section and subsequent sections, all field and laboratory personnel will: (1) write legibly in indelible, waterproof ink with no modifications, write-overs or cross-outs; (2) correct errors with a single line followed by an initial and date; and (3) close-out incomplete pages with an initialed and dated diagonal line.

Deviations from Sampling Method Requirements or Sample Design, and Corrective Action

Examples of deviations from sampling method requirements include inadequate sample volume collected, failure to preserve samples appropriately, contamination of sample bottle during collection, storage temperature and holding time exceedance, and sampling at the wrong site. Deviations invalidate resulting data and may require corrective action including samples being discarded and re-collected. It is the responsibility of the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads and TWRI QAO to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP. In addition, these actions and resolutions will be conveyed to the TSSWCB PM both verbally and in writing in progress reports and by completion of a corrective action report (CAR) as shown in Appendix A. CARs will be included with project progress reports. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TSSWCB immediately both verbally and in writing.

B3 SAMPLE HANDLING AND CUSTODY

Chain-of-Custody

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis. The chain-of-custody (COC) form is used to document sample handling during transfer from the field to the laboratory. The sample number, location, date, changes in possession and other pertinent data will be recorded in indelible ink on the COC. The sample collector will sign the COC and transport it with the sample to the laboratory. At the laboratory, samples are inventoried against the accompanying COC. Any discrepancies will be noted at that time and the COC will be signed for acceptance of custody. A copy of a blank COC form used on this project is included in Appendix B.

Sample Labeling

Samples will be labeled on the container with an indelible, waterproof marker. Label information will include site identification, date, sampler's initials, and time of sampling. The COC form will accompany all sets of sample containers.

Sample Handling

Following collection, samples will be transported to the laboratory and stored at appropriate temperature designated by the method handling criteria as listed in section B2 until analysis. The Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG Project Co-Leads / Lab Managers have the responsibility to ensure that holding times are met with all samples. Any problem will be documented with a CAR.

Failures in Chain-of-Custody and Corrective Action

All failures associated with chain-of-custody procedures as described in this QAPP are immediately reported to the TWRI QAO and Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads. These include such items as delays in transfer, resulting in holding time violations; violations of sample preservation requirements; incomplete documentation, including signatures; possible tampering of samples; broken or spilled samples, etc. The TWRI QAO and Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads will determine if the procedural violation may have compromised the validity of the resulting data. Any failures that have reasonable potential to compromise data validity will invalidate data and the sampling event should be repeated. The resolution of the situation will be reported to the TSSWCB PM in the project progress report. Corrective action reports will be prepared by the TWRI QAO and submitted to the TSSWCB PM along with project quarterly progress report.

B4 ANALYTICAL METHODS

UT-BEG will measure water extractable NO_3 using ion chromatography (Dionex ICS 2000) (EPA Method 300). UT-BEG will also measure TOC and TN using a TOC/TN analyzer (Model Apollo 9000, Dohrman Series, Teledyne Tekmar, Mason, OH).

ARS CPRL will measure total elemental C (Nelson and Sommers, 1982) and N (Bremner and Mulvaney, 1982) in soils by dry combustion at 900ºC and subsequent thermal conductivity analyses of evolved gases using an Elementar vario Max CN analyzer (Elementar Americas Inc., Mt. Laurel, NJ). Total C and N will be determined air dried soil samples passed through a 2 mm sieve. For soils containing carbonates, ground samples will be pretreated with 2 *M* HCl, leached with deionized water, and air-dried prior to analysis. Two blanks, two glutamic acid standards and two soil standards will be analyzed every 20 samples. Samples will be reanalyzed if check standard concentrations exceed a relative percent difference of 5% from the known concentration.

Soil extractable NO_3–N and NH_4–N will be determined using a 2.0-M KCl extracting solution (Keeney and Nelson 1982; 2 g of soil in 20 mL, shaken end over end for 10 minutes, and filtered through Whatman No. 2 filter paper). The Lachat QuikChem 8000 flow-injection analyzer (Hach Company, Loveland, CO) will be used for the automated determination of both NO_3–N and NH_4–N in soil extracts. Nitrate–nitrogen will be determined in soil extracts using the automated cadmium reduction procedure (US EPA, 1983). Ammonium–nitrogen in soil extracts will be determined using the automated salicylic analog of the indophenol blue method (US EPA, 1983). Duplicate samples will be analyzed in separate runs. Reagent blanks and check standards will be run every thirty samples to check for repeatability. Samples will be reanalyzed if check standard results exceed a relative percent difference of 10% from the known concentration.

ARS GSWRL will measure potentially mineralizable C and N using a new method for determination of soil microbial activity with a digital array diode reader to quantify CO_2-C release from soil microbes 24 hr after drying (40 - 50°C)/wetting the soil. Mineralizable C will be measured using the Solvita analytical method according to Haney et al., 2008 with a reproducibility limit of 1 SD from the mean and a precision limit of ≤10%. Mineralizable N will be measured according to Haney et al. (2001) with a reproducibility limit of 1 SD from the mean and a precision limit of ≤10%. Total inorganic N (NO_3 + NH_4) will be measured using RFA according to Haney et al. (2006) with a reproducibility limit of 1 SD from the mean and a precision limit of ≤10%.

Texas AgriLife Research- Vernon, ESSM will measure SOC (Nelson and Sommers, 1982), TN (Bremner and Mulvaney, 1982), and Soils $\delta^{13}C$ of SOC will then be determined using a Carlo Erba EA-1108 (CE Elantech, Lakewood, NJ) elemental analyzer interfaced with a Delta Plus isotope ratio mass spectrometer operating in continuous flow mode (ThermoElectron Corp., Woburn, MA). Carbon isotope ratios will be presented in δ-notation:

$$\delta^{13}C = [(R_{SAMPLE} - R_{STD})/R_{STD}] \times 10^3$$

where R_{SAMPLE} is the $^{13}C/^{12}C$ ratio of the sample, and R_{STD} is the $^{13}C/^{12}C$ ratio of the international V-PDB standard (Coplen, 1996). $\delta^{13}C$ values will be reported relative to the international V-PDB standard by calibration through NBS-19 (Hut, 1987; Coplen, 1995). The elemental analyzer will be standardized for detection of carbon and nitrogen concentrations using an acetanilide standard.

Soil NO_3 and NH_4 will be extracted with 1M KCl (20 ml extractant/2 g soil; shaken for 1 hr, filtered through Whatman no. 42 filter paper) (Keeney and Nelson, 1982). Soil extractable NO_3 and NH_4 will then be analyzed using an auto-analyzer similar to EPA methods 353.2 and 350.1. Soil P will be extracted using Mehlich III solution (20 ml extractant/2 g soil; shaken for 5 min; filtered through qualitative filter paper) (Ziadi and Tran, 2008). Mehlich III P will be analyzed using an auto-analyzer similar to EPA method 365.1.

Failures in Measurement Systems and Corrective Actions

Failures in field and laboratory measurement systems involve, but are not limited to such things as instrument malfunctions, failures in calibration, blank contamination, quality control samples outside QAPP defined limits, etc. In many cases, the field technician or lab analyst will be able to correct the problem. If the problem is resolvable by the field technician or lab analyst, then they will document the problem on the field data sheet or laboratory record and complete the analysis. If the problem is not resolvable, then it is conveyed to the Texas AgriLife Research-Vernon / UT-BEG Project Co-Leads, who will make the determination in coordination with the TWRI QAO. If the analytical system failure may compromise the sample results, the resulting data will not be reported to the TSSWCB as part of this project. The nature and disposition of the problem is reported on the data report. The TWRI QAO will include this information in the CAR and the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads / Project Managers will submit it with the Quarterly Progress Report which is sent to the TSSWCB Project Manager.

Table B4.1: Laboratory & Field Analytical Methods

Parameter Measured	Method	Equipment Used
Texas AgriLife Research Vernon		
Nitrate (NO3) (soil and water)	EPA 353.2	Skalar SAN++Analyzer
Mehlich III P	EPA 365.1	Skalar SAN++Analyzer
Ammonium (NH4)	EPA 350.1	Skalar SAN++Analyzer
Total N	EPA 440.0	Elementar Vario Max
UT Bureau of Economic Geology		
Nitrate (NO3)	EPA 300.0	Dionex ICS 2000
Total Organic C	Combustion	Apollo 9000, Dohrman
Total N	Combustion	Apollo 9000, Dohrman
Anions (F, Cl, Br, SO4)	EPA 300.0	Dionex ICS 2000
Cations (Ca, Mg, Na, K)	ASTM D6919-03	Dionex ICS 2000
Conductivity, field	EPA 120.1	Hanna HI9828
Dissolved Oxygen, field	EPA 360.1	Hanna HI9828
pH, field	EPA 150.1	Hanna HI9828
Temperature, field	EPA 170.1	Hanna HI9828
Alkalinity, field	EPA 310.1	Hach Digital Titrator
USDA Agricultural Research Service - Conservation and Production Research Lab		
Total C	Dry Combustion	Elementar Vario Max
Total N	Dry Combustion	Elementar Vario Max
Soil Extractable NO3	EPA 353.2	Lachat QuikChem 8000
Soil Extractable NH4	EPA 350.1	Lachat QuikChem 8000
USDA Agricultural Research Service - Grassland, Soil, and Water Research Lab		
Total N	Mineralizable N + Total Inorganic N	calculated
Total Inorganic N	RFA	OI Analytical Flow IV
Mineralizable C	Solvita	Solvita DAD
Mineralizable N	0.5 x 1-day CO2-C	calculated
AgriLife Research - Ecosystem Science and Management		
Soil Organic C	Combustion	Carlo Erba EA-1108
Total N	Combustion	Carlo Erba EA-1108
$\delta^{13}C$	Combustion / IRMS	Carlo Erba EA-1108

B5 QUALITY CONTROL

The Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG labs will determine the precision of their analyses. Laboratory audits, sampling site audits, and quality assurance of field sampling methods will be conducted by the TSSWCB or their designee. No spiked sample analyses will be performed in the course of this project due to the varied adsorptive capacities of different soil types in relation to the majority of elements being evaluated. Adding elements to soils would always yield varying returns due to the chemical properties of the soils. The spiking of soil samples risks precipitation of those parameters. Matrix blanks, and known standards not used in the calibration of the instrument, will be employed in place of spiked samples to insure accurate and proper recovery of each parameter. All standards with added concentrations of elements or compounds to be analyzed will be comprised of purchased NIST solutions whenever possible and practical. These matrix blanks and/or standards will be included in each batch of samples analyzed. Recovery of each parameter in the non-calibration standards must be within 10% of known value.

In the database, missing values will be left as blanks. The UT-BEG/ Texas AgriLife Research-Vernon Project Co-Leads will graphically screen data to highlight questionable data points. Questionable data will be traced through the COC forms, CARs, and, as necessary, through research laboratory notebooks and field data sheets to ensure that data are properly entered. Changes will be made only if an error is found in transcription into the database. Values determined to be below the laboratory method detection limit will be noted as such in the comment column of the database and used in statistical analyses as one-half the method detection limit, as recommended by Gilliom and Helsel (1968) and Ward et al. (1988). Values that are greater than the upper method detection limit will be diluted and reanalyzed.

It is the responsibility of the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads to verify that the data are representative. The use of peer reviewed sampling and analytical methods will ensure that measured data accurately represent field conditions. The data's precision, accuracy, and comparability generated in the Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG Project Labs will be the responsibility of the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads / Lab Managers. The Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads also have the responsibility of determining that the 90 percent completeness criteria is met, or will justify acceptance of a lesser percentage.

Failures in Quality Control and Corrective Action

Corrective action will involve identification of the possible cause (where possible) of the contamination failure. Any failure that has potential to compromise data validity will invalidate data, and the sampling event should be repeated. The resolution of the situation will be reported to the TSSWCB in the quarterly progress report. The CAR's will be maintained by the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads and the TWRI QAO.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Manufacturers' recommendations for scheduling testing, inspection, and maintenance of each piece of equipment will be followed or exceeded. Maintenance and inspection logs will be kept on each piece of laboratory equipment. The Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG Project Co-Leads / Lab Managers will routinely review laboratory instrument logbooks for maintenance and operational irregularities.

To minimize downtime of all measurement systems, all field sampling equipment and laboratory equipment, must be maintained in a working condition. Also, backup equipment or common spare parts will be made available if any piece of equipment fails during use. This will ensure that repairs or replacements can be made quickly, allowing measurement tasks to be resumed. All staff who use chemicals, reagents, or equipment whose parts require periodic replacement and other consumable supplies receive instruction concerning the remaining quantity (unique for each supply) which should prompt a request to order additional supplies.

UT-BEG has a maintenance contract for the Dionex ICS 2000 for preventive maintenance and to repair the instrument if it is not functioning properly. The machine is kept running constantly and deionized water is continuously pumped through the system.

UT-BEG follows the preventative maintenance schedule as recommended by the manufacturer for the Dohrman Series Apollo 9000 CN analyzer.

B7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All instruments or devices used in obtaining data will be used according to appropriate laboratory or field practices. Standards and purchased solutions used for instrument or method calibrations shall be of known purity and be National Institute for Standards and Testing (NIST) traceable whenever possible. When NIST traceability is not available, standards shall be of American Chemical Society (ACS) or reagent grade quality, or of the best attainable grade. All certified standards will be maintained traceable with certificates on file in the laboratory. Dilutions from all primary standards will be recorded in the standards log book and given unique identification numbers. The date, analyst initials, stock standards sources with lot number and manufacturer, and the dilution concentrations/ratios will also be recorded in the standards log book and be identified by a unique standards number which will also be placed on the standards bottle.

All instruments or devices used in obtaining data will be calibrated prior to use. Each instrument has a specialized procedure for calibration and a specific type of standard used to verify calibration. All calibration procedures will meet the requirements that are specified by the equipment manufacturer, as well as any instructions specified by applicable analytical methods. All information concerning required data calibration will be recorded in the project laboratory book by the person performing the calibration and will be accessible for verification during either a laboratory or field audit.

All calibration procedures used in the field or laboratory will meet or exceed the calibration frequencies published in the test methods used for this project. Additional calibration procedures may be conducted if laboratory personnel determine additional calibration is warranted as beneficial to this project. Instruments and laboratory equipment used in the analyses of these that require calibration prior to use will be calibrated before each day’s analyses.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All standards, reagents, media, plates, filters, and other consumable supplies are purchased from manufacturers with performance guarantees, and are inspected upon receipt for damage, missing parts, expiration date, and storage and handling requirements. Labels on reagents, chemicals, and standards are examined to ensure they are of appropriate quality, initialed by staff member and marked with receipt date and the in-use date when they are placed on the bench for use. Volumetric glassware is inspected to ensure class "A" classification, where required. Media will be checked as described in quality control procedures. All supplies will be stored as per manufacturer labeling and discarded past expiration date.

B9 NON-DIRECT MEASUREMENTS

Existing archival data on historical meteorological conditions, atmospheric wet deposition rates, groundwater levels, and groundwater chemistry may be incorporated into the analysis and interpretation of results obtained by direct measurements for this project. Meteorological information will be obtained from the U.S. National Climate Data Center and/or from the Oregon State University Prism Climate Group. Atmospheric wet deposition rates will be obtained from the U.S. National Atmospheric Deposition Program. Groundwater levels and groundwater quality data will be obtained from the Texas Water Development Board and/or the U.S. Geological Survey. Each of these agencies collects and archives data following published QA/QC procedures and protocols. Additionally, other sources and types of information may also be incorporated, including the results of previously published studies relevant to the interpretation of project results. The professional judgment of the investigators will be applied in determining the accuracy and relevance of data utilized from these sources as they relate to the interpretation of project results.

Data sample analysis previously conducted on samples collected at the USDA ARS Bushland site will also be used by UT-BEG as a means to prevent duplication of previous efforts. This sampling has been conducted by Dr. Robert Schwartz of USDA ARS and was collected and analyzed using the same protocol and methodologies as employed in this project.

AgriLife Vernon will utilize data from previously collected samples in their analysis of the N budget for year 1 of the project. These data were collected utilizing the methodologies described in Table A7.1 that will be employed under this project.

Sub-task 3.4 will utilize National Agriculture Statistics Service data for N inputs obtained by surveying landowners about their nitrogen usage. This data will be used in completing the mass balance assessment for N use in the study area.

B10 DATA MANAGEMENT

Field Collection and Management of Routine Samples

All field collection will be completed as described in Section B2 of the QAPP. A field notebook is filled out in the field for each site visit. Samples collected will be labeled and transported to the laboratory. A COC form will be used. Site name, time of collection, comments, and other pertinent data are copied from the field notebook to the COC.

Laboratory Data

Once the samples are received at the Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG labs, samples are logged and stored at appropriate temperature designated by the method handling criteria as listed in section B2 until processed. The COC will be checked for number of samples, proper and exact I.D. number, signatures, dates, and type of analysis specified. If any discrepancy is found, proper corrections will be made. The COC and accompanying sample bags/bottles are submitted to the Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG laboratory analysts, with relinquishing and receiving personnel both signing and dating the COC. All COC and soils data will be manually entered into an electronic spreadsheet. The electronic spreadsheet will be created in Microsoft Excel software on an IBM-compatible microcomputer with a Windows Operating System. The project spreadsheet will be maintained on the computer's hard drive, which is also simultaneously saved in a network folder. Data manually entered in the database will be reviewed for accuracy by the Texas AgriLife Research- Vernon / ARS / ESSM / UT-BEG labs to ensure that there are no transcription errors. Hard copies of data will be printed and housed in the laboratory for a period of five years. Any COC's and analysis records related to QA/QC of lab procedures will be housed at the Texas AgriLife Research-Vernon / ARS / ESSM / UT-BEG Labs. All pertinent data files will be backed up monthly on an external hard drive. Current data files will be backed up on an external hard drive monthly and stored in separate area away from the computer. Original data recorded on paper files will be stored for at least five years. Electronic data files will be archived to CD after the end of the project, and then stored with the paper files for the remaining 4 years.

Data Validation

Following review of laboratory data, any data entry that is not representative of environmental conditions, because it was generated through poor field or laboratory practices, will not be submitted to the TSSWCB. This determination will be made by the Texas AgriLife Research-Vernon / UT-BEG Project Co-Leads, TWRI QAO, TSSWCB QAO, and other personnel having direct experience with the data collection effort. This coordination is essential for the identification of valid data and the proper evaluation of that data. The validation will include the checks specified in Table D2.1.

Data Dissemination

At the conclusion of the project, the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads will provide a copy of the complete project electronic spreadsheet via recordable CD to the TSSWCB PM, along with the final report. The TSSWCB may elect to take possession of all project records. However, summaries of the data will be presented in the final project report.

C1 ASSESSMENTS AND RESPONSE ACTIONS

The following table presents types of assessments and response actions for data collection activities applicable to the QAPP.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	AgriLife Vernon / ARS / ESSM / UT-BEG Project Co-Lead / Project Collaborator	Monitoring of project status and records to ensure requirements are being fulfilled. Monitoring and review of laboratory performance and data quality	Report to TSSWCB in Quarterly Progress Report. Ensure project requirements are being fulfilled.
Laboratory Inspections	Dates to be determined by TSSWCB QAO	TSSWCB QAO	Analytical and quality control procedures employed at laboratory	45 days to respond in writing to TSSWCB to address corrective actions
Monitoring Systems Audit	Dates to be determined by TSSWCB	TSSWCB QAO	Field sampling, handling and measurement; facility review; and data management as they relate to project	45 days to respond in writing to TSSWCB to address corrective actions

Corrective Action

The TWRI QAO and Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads are responsible for implementing and tracking corrective action procedures as a result of audit findings. Records of audit findings and corrective actions are maintained by the TSSWCB PM and TWRI QAO. Corrective action documentation will be submitted to the TSSWCB PM with the quarterly progress report. If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in agreements or contracts between participating organizations.

C2 REPORTS TO MANAGEMENT

Quarterly progress reports will be generated by TWRI personnel and will note activities conducted in connection with the water quality monitoring program, items or areas identified as potential problems, and any variation or supplement to the QAPP. The CARs forms will be utilized when necessary and will be maintained in an accessible location for reference at Texas AgriLife Research- Vernon / UT-BEG and TWRI. The CARs that result in changes or variations from the QAPP will be made known to pertinent project personnel, documented in an update or amendment to the QAPP and distributed to personnel listed in Section A3. Following any audit performed by the TWRI or TSSWCB, a report of findings, recommendations and responses are sent to the TSSWCB PM in the quarterly progress report.

Field measurements and all sampling for the project will be done according to the QAPP. However, if the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data will be identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problems. The CARs will be filled out to document the problems and the remedial action taken.

Laboratory data reports contain the results of all analyses, as well as specified QC measures listed in section B5. This information is reviewed by the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads and compared to the pre-specified acceptance criteria to determine acceptability of data. This information is available for inspection by the TSSWCB.

D1 DATA REVIEW, VERIFICATION AND VALIDATION

All data obtained from field and laboratory measurements will be reviewed and verified for conformance to project requirements, and then validated against the data quality objectives (DQOs) which are listed in Section A7. Only those data which are supported by appropriate quality control data and meet the DQOs defined for this project will be considered acceptable. This data will be submitted to the TSSWCB.

The procedures for verification and validation of data are described in Section D2, below. The Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads are responsible for ensuring that field data are properly reviewed and verified for integrity. The Texas AgriLife Research- Vernon / UT-BEG Project Co-Lead / Lab Manager is responsible for ensuring that laboratory data are scientifically valid, defensible, of acceptable precision and accuracy, and reviewed for integrity. The Texas AgriLife Research- Vernon / UT-BEG Project Co-Lead / Project Manager will be responsible for ensuring that all data are properly reviewed and verified, validated, and submitted in the required format as described by the TSSWCB PM. Finally, the TWRI QAO is responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting to TSSWCB.

D2 Verification and Validation Methods

All field and laboratory data will be reviewed, verified and validated to ensure they conform to project specifications and meet the conditions of end use as described in Section A7. The staff and management of the respective field, laboratory, and data management tasks are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process. The field and laboratory tasks ensure the verification of raw data, electronically generated data, and data on chain-of-custody forms and hard copy output from instruments.

Verification, validation and integrity review of data will be performed using self-assessments and peer review, as appropriate, followed by technical review by the Texas AgriLife Research-Vernon / UT-BEG Project Co-Leads. The data to be verified (listed by task in Table D2.1) are evaluated against project specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. Potential outliers are identified by examination for unreasonable data. If a question arises or an error or potential outlier is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads consult with the TWRI QAO and TSSWCB PM to establish the appropriate course of action, or the data associated with the issue are rejected.

The Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads, with assistance from the TWRI QAO, are responsible for validating that the verified data are scientifically valid, legally defensible, of known precision, accuracy, integrity, meet the DQOs of the project, and are reportable to TSSWCB. One element of the validation process involves evaluating the data for anomalies. The Texas AgriLife Research- Vernon / UT-BEG Project Co-Leads may designate other experienced experts to perform this evaluation. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data, before data validation can be completed.

A second element of the validation process is consideration of any findings identified during the monitoring systems audit conducted by the TWRI QAO or TSSWCB QAO assigned to the project. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the Texas AgriLife Research-Vernon / UT-BEG Project Co-Leads validate that the data meet the DQOs of the project and are suitable for reporting to the TSSWCB.

Table D2.1. Data Verification Procedures

Data to be Verified	**TWRI QAO**	**AgriLife Vernon / UT-BEG Project Co-Leads**	**ARS**	**TSSWCB PM/QAO**
Analysis techniques consistent with QAPP	X	X	X	X
Instrument calibration data complete		X	X	X
Sample documentation complete		X	X	X
Chain of custody complete/acceptable	X	X	X	X
Sample preservation and handling	X	X	X	
Holding times met		X	X	
QC samples analyzed at required frequencies		X	X	X
QC samples within acceptance limits		X	X	X
Laboratory data verification for integrity, precision, accuracy, and validation		X	X	
Laboratory data reports		X	X	X
Nonconforming activities documented and corrected	X	X	X	X
Absence of transcription error verified		X	X	
Reasonableness of data verified		X	X	
Electronic submittal errors corrected		X	X	

D3 RECONCILIATION WITH USER REQUIREMENTS

Data produced by this project will be evaluated against the established DQOs and user requirements to determine if any reconciliation is needed. Reconciliation concerning the quality, quantity or usability of the data will be reconciled with the user during the data acceptance process. Corrective Action Reports will be initiated in cases where invalid or incorrect data have been detected. Data that have been reviewed, verified, and validated will be summarized for their ability to meet the DQOs of the project and the informational needs of decision-makers and cooperators.

The final data for the project will be reviewed to ensure that it meets the requirements as described in this QAPP. Data summaries along with descriptions of any limitations on data use will be included in the final report. Only data that has met the DQOs described in this QAPP will be reported and included in the final project report. Data and information produced thru this project will be used to (1) evaluate relative inputs of natural and fertilizer N in the Texas High Plains and Rolling Plains, (2) quantify nitrogen inventories under different agricultural land use management schemes, (3) identify and demonstrate strategies for reducing groundwater nitrogen levels (e.g. N crediting). Using this data, a fact sheet, technical report, handouts, presentations, and/or posters describing results and recommendations will be developed and delivered to project partners and producers in the Texas High Plains and Rolling Plains regions at the field day, regional and national meetings, and workshop/stakeholder meetings. Through these activities, producers and farm managers will have the information needed and be better positioned to modify their nutrient management strategies, adopt the practice of N crediting, and achieve water quality improvements.

APPENDIX A. CORRECTIVE ACTION REPORT

Corrective Action Report

CAR #:_____

Date:_____ Area/Location:_____

Reported by:_____ Activity:_____

State the nature of the problem, nonconformance, or out-of-control situation:

_____
_____
_____
_____
_____

Possible causes:

_____
_____
_____

Recommended corrective action:

_____
_____
_____

CAR routed to:_____

Received by:_____

Corrective Actions taken:

_____
_____
_____
_____

Has problem been corrected? YES NO

ARS Project Co-Lead / Lab Manager:_____

ARS Project Co-Lead / Project Manager:_____

TWRI Quality Assurance Officer:_____

APPENDIX B. CHAIN-OF-CUSTODY FORMS

Environmental Soil Science Laboratory AgriLife Vernon
CHAIN OF CUSTODY RECORD

Project Name: **Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions**					# of containers	Analyses Required											
Station ID	Date	Time (24hr)	Matrix	Description													Sample ID

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Laboratory remarks:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Lab log #
Relinquished by: (Signature)	**Date:**	**Time:**	**Received for lab by: (Signature)**	**Date:**	**Time:**	**Laboratory Name:**

UT-BEG
CHAIN OF CUSTODY RECORD

Project Name: **Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions**					# of containers	Analyses Required											
Station ID	Date	Time (24hr)	Matrix	Description													Sample ID

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Laboratory remarks:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Lab log #
Relinquished by: (Signature)	**Date:**	**Time:**	**Received for lab by: (Signature)**	**Date:**	**Time:**	**Laboratory Name:**

APPENDIX C. STANDARD OPERATING PROCEDURES

UT-BEG Geoprobe Soil Sampling SOP

UT-BEG Geoprobe Soil Sampling SOP

This standard operating procedure describes in general terms site selection criteria, procedures, and methods for soil core sampling and for sample handling using the Geoprobe Model 6620DT. General information for each borehole location is recorded on a Geoprobe Field Core Log form, including project name, borehole designation, borehole total depth, date and time of completion, borehole GPS location information, landowner/coordinator contact information, and field personnel information. Available land use history is also recorded.

Effective use of the system requires a trained and experienced operator and crew. Three personnel are typically required for efficient field operations, with two operating the Geoprobe and one processing the core samples.

Sample Location Selection

Sample site locations should be selected to obtain samples representative of the area(s) under study. Site location selection should consider trade-offs between 1) boundaries between dissimilar surface conditions (i.e., land use or experimental treatments) and 2) targeted maximum depth of sampling. As a general guideline and wherever possible, sampling sites should be located a minimum lateral distance from such boundaries of at least 2 to 3 times the target maximum sampling depth. As a general guideline and where access and boundary conditions permit, sites should be located at least 100 (30 m) within areas of uniform surface conditions when targeting depths greater than 30 ft.

Core Sample Systems and Procedures

The Geoprobe is equipped to sample continuous cores using two versions of a dual tube sampling system. The difference between the two systems is the diameter of the core produced, either 1-in or 2.5-in core. Coring procedures are identical for both versions.

The dual tube sampling system consists of an outer casing string and an inner sampling string terminated with a clear PVC sample liner that receives the core sample. This design prevents cross-contamination of samples, provides contained samples, and virtually eliminates sample moisture exchange with the atmosphere. Sections are 4-ft in length. Sections are advanced into the soil and the inner string and sample liner are retrieved. A new liner is attached, the inner string is lowered into the open outer casing pipe, and a new section is installed. The entire string is then advanced into the soil and the process is repeated until either the target depth is reached or advancement of the string is refused due to geologic conditions at depth. Driller observations and notes concerning difficulties encountered during the coring process are recorded on the Geoprobe Field Core Log form.

The smaller diameter system is typically used to core sample a single deep profile to depth of refusal. This is followed by a second core sample profile using the larger diameter system to a depth of 8 ft and located a lateral distance of 2 – 3 ft from the deep profile. The second shallow profile is not assigned a new borehole designation. The second core sample provides addition sample volume in the near-subsurface, where sample depth intervals are typically more closely spaced.

Sampled depth intervals per advancement are typically 2, 3, or 4 ft in length. Each advancement and core-recovery cycle is termed a “throw”. Throws shorter than 4 ft are used when expansive soil horizons are encountered in order to prevent over-filling of the sample liner.

Field Sample Handling

Core sample information is recorded for each throw on the Geoprobe Field Core Log form, including the top and bottom depths, the length of core recovered, and the coring system used (22 for the 1-in core, 32 for the 2.5-in core).

Core samples from the borehole in 4-ft length clear PVC sample liners. Both ends of the sample liner are immediately capped upon retrieval to limit moisture exchange between the sample and the atmosphere. Color-coded caps are used, with a black cap installed on the deep-depth end and a red cap installed on the shallow-depth end of the liner. The core sample is transferred to the core processor.

Any empty head-space interval above the recovered core at the shallow-depth end of the sample liner is cut off and the exposed core end is immediately capped. The core sample is labeled in indelible ink directly on the liner with the borehole designation, throw number, and depth interval. If the recovered core length exceeds 2 ft, each end of the core section is labeled, the core is cut in half, and the exposed ends are immediately capped with the appropriate color cap. Caps are secured by electrical tape and the core sections are stored on ice in double-nested heavy duty plastic bags for transport to the laboratory.

Geoprobe Field Core Log

Project_____Page_____of_____

Borehole_____Total Depth (ft)_____

Date/Time_____County_____

Latitude_____Longitude_____

Elevation_____Land Use_____

Land Owner/Contact_____

Coordinator/Contact_____

Drill Team Personnel_____

Throw Number	Depth Top (ft)	Depth Bottom (ft)	Recovery (in)	System (22, 32)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Land Use History Information

Cultivation date_____Irrigation date_____

Crops/rotations history_____

Irrigation methods/history_____

Irrigation source/depth_____

Irrigation water quality available?_____

Fertilizers (inorganic/organic/manure)_____

Fertilizer rates_____

Fertilizer application method_____

Drillers Notes