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

Seymour Aquifer Water Quality Improvement Project
TSSWCB Project FY04-9

Quality Assurance Project Plan

Texas State Soil and Water Conservation Board

prepared by

Texas Water Resources Institute
Texas A&M University
Effective Period: August 2007 to August 2008

Questions concerning this quality assurance project plan should be directed to:

Dr. B.L. Harris; Associate Director
Texas Water Resources Institute
Texas A&M University
1500 Research Parkway, Suite 240
2118 TAMU
College Station, TX 77843-2118
bl-harris@tamu.edu
(979) 845-1851

Section A1: Approval Sheet

Seymour Aquifer Water Quality Improvement Project

United States Environmental Protection Agency (USEPA), Region VI

Name: Donna Miller
Title: USEPA Chief; Assistance Programs Branch

Signature: Donna R. Miller Date: 5/20/08

Name: Ellen Caldwell
Title: USEPA Texas Nonpoint Source Project Manager

Signature: Ellen Caldwell Date: 5-21-08

Texas State Soil and Water Conservation Board (TSSWCB)

Name: Lee Munz
Title: TSSWCB Project Leader

Signature: Lee Munz Date: 4-23-08

Name: Donna Long
Title: TSSWCB Quality Assurance (QA) Officer

Signature: Donna K. Rathbone Date: 4/23/08

Texas A&M AgriLife - Texas Water Resources Institute (TWRI)

Name: B.L. Harris, Ph.D.
Title: TWRI Associate Director; Project Coordinator

Signature: B.L. Harris Date: 04/01/08

Name: Kevin Wagner
Title: TWRI Quality Assurance (QA) Officer
Signature: Kevin Wagner Date: 4/1/08

Texas A&M University-Soil and Crop Sciences Department (Texas AgriLife Research, TAMU)

Name: Cristine Morgan, Ph.D.
Title: Assistant Professor; Data Supervision; Field Supervision; Project Modeler

Signature: Cristine Morgan Date: 3/26/08

Texas AgriLife Research and Extension Center (Texas AgriLife Research at Vernon)

Name: John W. Sij, Ph.D.
Title: Professor, Field Supervision

Signature: John W. Sij Date: 3/24/08

Louisiana State University, School of Plant, Environmental and Soil Sciences

Name: Rodney Henderson, Instructor
Title: Laboratory Director

Signature: Rodney Henderson Date: 3/28/08

Section A2: Table of Contents

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List of Acronyms and Abbreviations

ACS	American Chemical Society
AREC	Vernon Agricultural Research and Extension Center
ASTM	American Society for Testing and Materials
ATV	all-terrain vehicle
BMP	best management practices
CAL	Compost Analysis Laboratory
CAR	corrective action report
COC	chain of custody
CWA	Clean Water Act
DQI	data quality indicators
DQO	data quality objectives
ENWATBAL	ENergy and WATer BALance model
EPA	Environmental Protection Agency
GCD	groundwater conservation district
GM	general maintenance
GPS	geographic positioning system
HCl	hydrochloric acid
HDPE	high density polyethylene
H_2O	water
H_2SO_4	concentrated sulfuric acid
ID	identification
KCl	potassium chloride
LAI	leaf area index (a plant transpiration measurement tool)
MDL	method detection limit
NIST	National Institute for Standards and Technology
NO_3-N	nitrate-nitrogen
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
PET	potential evapotranspiration
PM	project manager
QA	quality assurance
QAM	quality assurance manual
QAO	quality assurance officer
QAPP	quality assurance project plan
QC	quality control
QMP	quality management plan
RPD	relative percent deviation
SPLUS	statistical analysis software
SOP	standard operating procedures
SWCD	soil and water conservation district
SWQM	surface water quality monitoring
TAES	Texas Agricultural Experiment Station
TAMU	Texas A&M University
TCE	Texas Cooperative Extension
TCEQ	Texas Commission on Environmental Quality
TSSWCB	Texas State Soil and Water Conservation Board
TSU	Tarleton State University
TWRI	Texas Water Resources Institute
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WQMP	water quality management plan

Section A3: Distribution List

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

United States Environmental Protection Agency, Region VI
6WQ-AT
1445 Ross Avenue
Suite 1200
Dallas, Texas 75202-2733

Name: Donna Miller
Title: USEPA Chief; Assistance Programs Branch

Name: Ellen Caldwell
Title: USEPA Texas Nonpoint Source Project Manager

Texas State Soil and Water Conservation Board
P.O. Box 658
Temple, TX 76503

Name: Donna Long
Title: TSSWCB Quality Assurance Officer

Name: Lee Munz
Title: TSSWCB Project Leader

Texas Water Resources Institute
1500 Research Parkway, Suite 240
2118 TAMU
College Station, TX 77843-2118

Name: B. L. Harris, Ph.D.
Title: TWRI Associate Director; Project Coordinator

Name: Kevin Wagner
Title: TWRI Quality Assurance (QA) Officer

Texas A&M University—Soil and Crop Sciences
545 Heep Center
Soil and Crop Sciences
College Station, TX 77843-2474

Name: Cristine Morgan, Ph.D.
Title: Assistant Professor, Soil Scientist; Data Supervision; Field Supervision; Project Modeler

Name: Omar Harvey, M.S.
Title: Graduate Student; Field, Lab, and Modeling Technician

Texas A&M Vernon Agricultural Research and Extension Center
Box 1658
Vernon, TX 76385

Name John Sij, Ph.D.
Title: Professor; Research and Extension Agronomist; Field Supervision

Name Phyllis Dyer
Title: Research Assistant; Field Technician

Louisana State University, School of Plant, Environmental and Soil Sciences
125 Sturgis Hall
Louisana State University
Baton Rouge, LA 70803

Name: Rodney Henderson
Title: Laboratory Director

Section A4: Project/Task Organization

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

USEPA – United States Environmental Protection Agency (USEPA), Region VI, Dallas. Provides project overview at the Federal level.

Ellen Caldwell, USEPA Texas Nonpoint Source Project Manager

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

TSSWCB –Texas State Soil and Water Conservation Board (TSSWCB), Temple, Texas. Provides project overview at the State level.

Lee Munz, TSSWCB Project Leader

Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified.

Donna Long, TSSWCB Quality Assurance Officer

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 assessment (QA), quality control (QC), and reporting under the CWA Section 319 program. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures.

TWRI – Texas Water Resources Institute (TWRI), College Station, Texas. Project Facilitator. Provides the primary point of contact between the Texas State Soil and Water Conservation Board (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 reports and the final project report.

Dr. B. L. Harris, TWRI Associate Director; Project Coordinator

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 Project Leader; and coordinating attendance at conference calls, meetings, and related project activities.

Kevin Wagner, TWRI Quality Assurance (QA) Officer

Responsible for determining that the Quality Assurance Project Plan (QAPP) meets the requirements for planning, quality control, quality assessment, and reporting for activities conducted by TWRI. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques.

TAMU-Soil and Crop Sciences Department – Texas A&M University (TAMU), College Station, Texas. Data Supervision, Field Supervision, Project Modeling. Responsible for the data analysis and interpretation in field and laboratory samples. TAMU – Soil and Crop Sciences Dept. will contribute to the development of quarterly reports and the final project report.

Dr. Cristine Morgan, Assistant Professor, Soil Scientist; Data Supervision; Field Supervision; Project Modeler

Responsible for coordinating field sampling activities. Responsible for ensuring that scheduled tasks and other requirements in the contract are executed on time and in accordance with the QA/QC requirements in the system as defined by the contract 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 the facilitation of audits and the implementation, documentation, verification, and reporting of corrective actions. Performs validation and verification of data before the report is sent to the primary contractor. Responsible for submitting accurate and timely data analyses and other materials, for progress and final reports, to TWRI.

Vernon AREC –Agricultural Research and Extension Center, Vernon, Texas. Field Support. Responsible for field analysis, collection and shipment of water, soil and/or forage samples for the project.

Dr. John Sij, Professor, Research and Extension Agronomist; Field Supervision

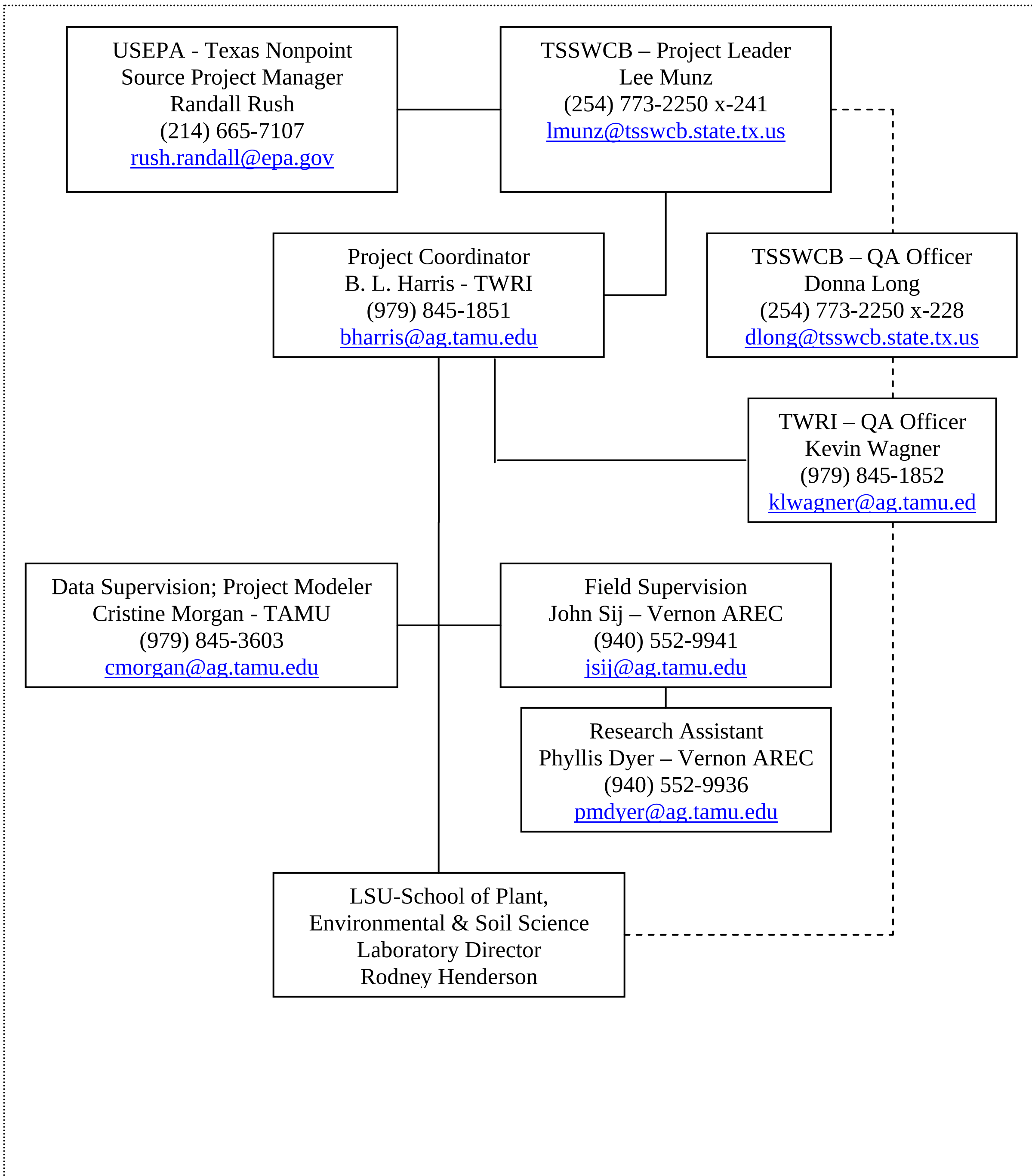
Responsible for coordinating and supervising field sampling activities. Responsible for ensuring that field personnel have adequate training and a thorough knowledge of standard operating procedures (SOPs) specific to the field analysis or task performed. Ensures that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the contract work plan and in the QAPP. Responsible for the facilitation of audits and the implementation, documentation, verification, and reporting of corrective actions. Responsible for submitting accurate and timely data analyses and other materials for progress and final reports to TWRI.

Louisana State University – School of Plant, Environmental and Soil Sciences Laboratory Support. Responsible for data analysis and reporting tasks for the project

Rodney Henderson, Instructor; LSU School of Plant, Environmental and Soil Sciences

Responsible for oversight of laboratory operations and ensuring that quality-assurance control requirements are met regarding the Dumas procedure on soil samples. Responsible for documentation related to laboratory analyses to include, ensuring adequate training and supervision of all activities involved in generating analytical data, the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions. Enforces corrective action, as required. Conducts in-house audits in conjunction with the TWRI QAO to ensure compliance with written SOPs and to identify potential problems.

Figure A4-1. Project Organization Chart
Dashed lines indicate communication only



Section A5: Problem Definition/Background

The Seymour Aquifer is a shallow aquifer in Northwest Central Texas and the only major source of groundwater in Haskell, Jones, and Knox Counties. The aquifer underlies over 300,000 acres and furnishes drinking and domestic water for many rural families. In addition, over 3,000 wells furnish water for irrigation and livestock use. The State of Texas has identified elevated nitrate levels as a concern in Haskell, Knox, and Jones Counties. In over 75% of the wells tested, nitrate levels exceed the federal safe drinking water standard of 10 mg/L NO3-N. Nitrate levels have been documented in some wells as high as 35 mg/L NO3-N. To remove this threat, the Texas State Soil and Water Conservation Board (TSSWCB) will work cooperatively with the Haskell, Wichita Brazos, and California Creek Soil and Water Conservation Districts (SWCDs), Natural Resources Conservation Service (NRCS), Texas Cooperative Extension (TCE), local Groundwater Conservation Districts, and Texas Agricultural Experiment Station (TAES) to provide water quality education, technical assistance, and financial assistance to irrigators for BMP implementation in order to reduce nitrate concentrations in the Seymour Aquifer.

Section A6: Project/Task Description

This project will serve as a catalyst to encourage the installation of Trickle (Drip) Irrigation Systems as a best management practice (BMP) to improve water quality and increase water quantity in the Seymour Aquifer Region (Figure A6-1). The project provides cost-share to replace existing center pivot, sprinkler, or row-water irrigation systems with drip irrigation systems at a cost-share rate of 60 percent. The project area will include the irrigated portions of Haskell, Knox, and Jones counties.

The installation of drip irrigation systems may have a direct impact on the area groundwater by, first, reducing the potential for return flow of irrigation water into the aquifer (Return irrigation water flow has the potential to transport nutrients and pesticides into groundwater). Secondarily, drip irrigation has the potential to increase irrigation efficiency; therefore potentially increasing water quantity (Evett et al., 1991).

A number of other BMPs to reduce nitrate levels may be implemented through the development of WQMPs. However, only implementation of Trickle (Drip) Irrigation Systems will receive cost-share in this project.

Highest priority is given to the replacement of the least efficient irrigation systems. Feasibility of successful installation will also be considered. The Haskell, Wichita Brazos, and California Creek SWCDs, with assistance from the TSSWCB and NRCS, will prioritize the applications received and determine which landowners in their respective SWCDs will receive technical assistance for the development and implementation of WQMPs.

The TAES, in coordination with local Groundwater Conservation Districts will evaluate the effectiveness of BMP implementation in reducing nitrate levels within the aquifer by monitoring the field nitrogen balance and using ENWATBAL.

Subtasks are outlined in Table A6-1 along with a listing of the responsible agency or agencies and an activity schedule.

Table A6-1. Project Plan Milestones

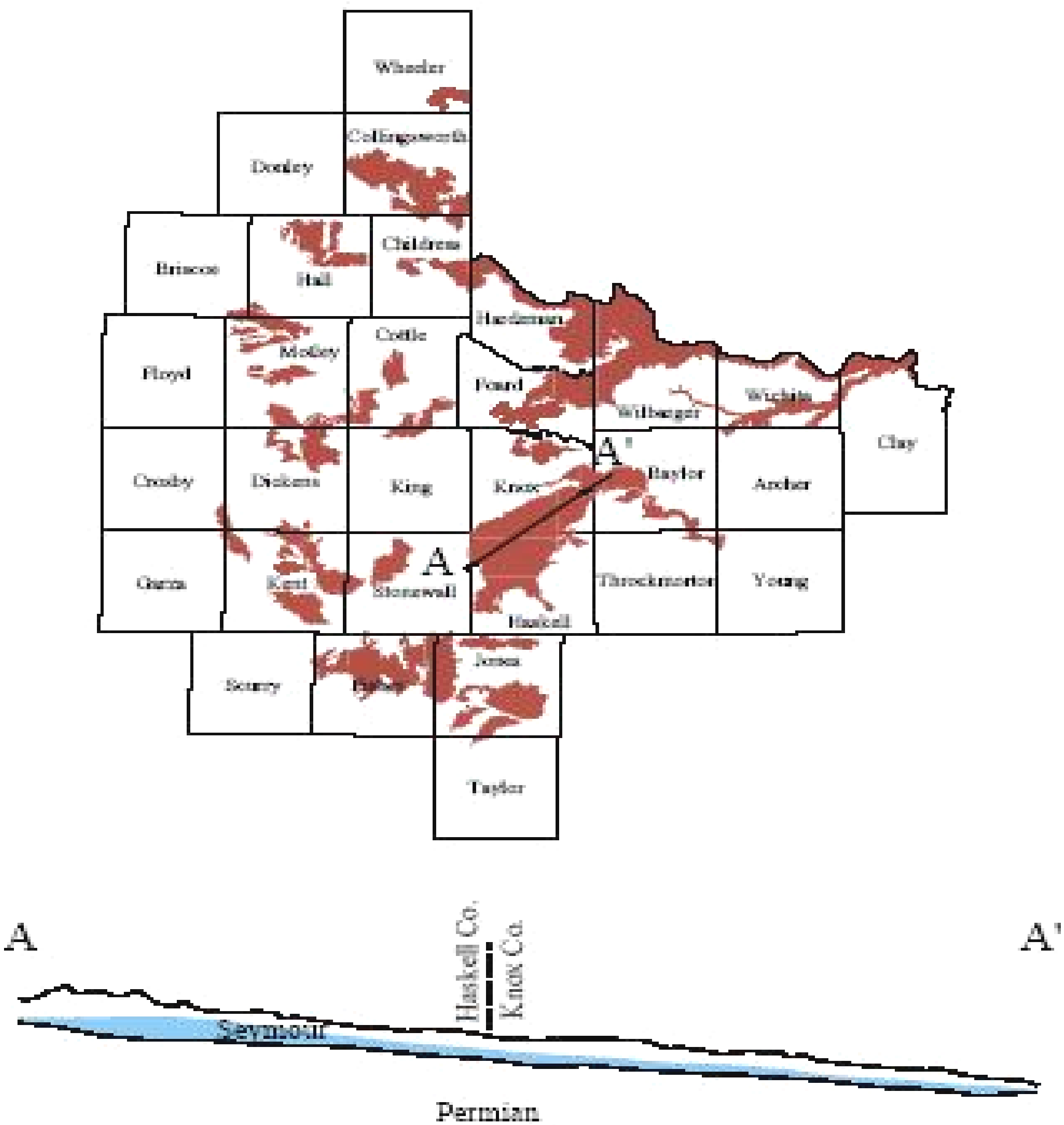
PROJECT MILESTONES	AGENCY	START	END
Install a subsurface drip irrigation system on the 14-acre site at the Chillicothe Research Station	TAES	June05	Nov08
Establish 72 individually controlled plots to evaluate various BMPs, cropping systems, management techniques for education purposes to protect aquifer water quality	TAES	June05	Nov08
Host on-site educational events at the Chillicothe site	TAES, TCE	Nov05	Nov08
Assess and compile existing data on the Seymour Aquifer and the effects of farming practices on aquifer water quality	TAES, SWCD	Nov04	Nov07
Assess impacts of conversion from pivot irrigation to drip irrigation through monitoring of nitrate concentration.	TAES, TAMU	May05	May07
Model water and nitrate balance on fields implemented with BMPs and drip irrigation.	TAES, TAMU	Nov 05	Nov07
Confer with project participants to validate modeling calibrations.	TAES, TAMU	Nov 06	Nov08
Forecast amount of irrigation conversion necessary to meet water quality standards and BMP system efficacy.	TAES, TAMU	Nov 07	Nov08
Develop DQOs and a QAPP to be approved by the TSSWCB and USEPA	TWRI, TAES	Nov 04	June 05

Model description

The ENWATBAL model

ENWATBAL.BAS is a mechanistic one-dimensional computer program written in Microsoft compiled BASIC which separately computes evaporation from the soil and plant canopy. It has been used successfully to simulate evaporation from bare soil as well as evaporation and transpiration for corn, sorghum, wheat and cotton; and has been used to estimate the reduction in evaporation loss due to using subsurface as opposed to surface drip irrigation. Soil water and heat flux are calculated using Darcy’s and Fourier’s laws, respectively. ENWATBAL is not a crop growth model; hence, transpiration is calculated assuming a single layer canopy (the big leaf model). Measurements of the crop leaf area index (LAI) are used as crop growth input. ENWATBAL can accept data for up to 9 soil horizons and any reasonable number of soil layers (i.e. finite difference nodes). ENWATBAL.BAS was derived from the program ENWATBAL published by van Bavel and Lascano. The paper titled, "ENWATBAL.BAS: A mechanistic evapo-transpiration model written in compiled BASIC" (Evett and Lascano, 1993) contains a list of references to ENWATBAL and precursor models such as WATBAL and CONSERVB. The computer source code is heavily commented so that variables and their units are identified and explanations of each significant section of code are given (http://www.cprl.ars.usda.gov/wmru/srevett/enwatbal.htm).

Figure A6-1. Seymour Aquifer Region.



Section A7: Data Quality Objectives (DQO) for Measurement Data

The primary objective of the monitoring and modeling implemented for this project is to assess the impacts of conversion from sprinkler pivot irrigation to drip irrigation on nitrate concentration and water quantity at the field scale. Modeling will verify assumptions made to scaling information from plot to field to aquifer scale.

Six fields will be chosen from the list of land owners agreeing to convert agricultural fields from pivot to drip irrigation. Three fields will be pivot irrigated and three will be drip-irrigated. All fields will be under BMPs according to the nutrient and water quality management plans created by the TSSWCB.

Field selection priorities for this experiment are the following:

1. Pivot and drip irrigated fields next to each other with similar soils and same field manager. Creates a paired test.
2. Three sets of fields with soils representative of the Seymour Aquifer agricultural lands.
3. Location of all fields in close geographical proximity to minimize driving and sample collection times.

The 6 selected fields will be surveyed using GPS and an EM38. The EM38 noninvasively measures soil bulk electrical conductivity. A GPS and an EM38 mounted onto an ATV will be used to non-invasively collect continuous soil electrical conductivity measurements on 20 m transects. The EM38 survey will be used to identify soil heterogeneity and sampling areas. In each field, 5-6 areas will be selected for individual nitrogen and water balance. The 5-6 sampling areas (experimental units) in each of the 6 fields will be identified using the EM38 map. These field areas will be where the nitrogen information is collected. Experimental units will be 3 x 4 m, and sub sampled. Initial soil samples will include textural and organic carbon analysis. For the 3 drip irrigation fields, drip irrigation will be installed late winter 2005 before the 2005 planting season.

Because bromide movement through soil emulates that of nitrogen, a bromide study will be conducted during the 2006 growing season to further assess the movement of nitrogen through the soil profile. The bromide study will be conducted in two of the selected fields, one under drip irrigation and one under pivot irrigation.

Water balance determinations will be made using specific irrigation, irrigation management, rain, evaporation, transpiration and drainage measurement procedures. The nitrogen balance will be calculated using data derived from a series of soil, water, and plant samples.

The measurement performance specifications to support the project objectives for a minimum data set are detailed in Table A7-1 and in the text following.

Table A7-1. Estimated Accuracy and Precision Limits of Measured Parameters

NA = Not applicable; mg/L = milligrams per liter; mg/Kg = milligrams per kilogram;

PARAMETER	UNITS	METHOD	PRECISION LIMITS[1] (RPD)	ACCURACY LIMITS	METHOD DETECTION LIMITS (MDL)
SOIL					
Total Carbon (organic)	mg/Kg	Dumas dry oxidation/ combustion LSU-SPESS SOP	25%	75-125%	0.002 mg/Kg
Total Nitrogen (organic)	mg/Kg	Dumas dry oxidation/ combustion LSU-SPESS SOP	25%	75-125%	0.004 mg/Kg
Nitrogen (inorganic)	mg/Kg	KCl extraction Auto analyzer/ Colorimetric TAES SOP	25%	75-125%	0.020 mg/Kg
Bromide	mg/Kg	Ion selective electrode	25%	75-125%	1.0 mg/Kg
Particle size analysis	%, by volume	Pipette method TAES SOP	25%	75-125%	2% by volume
PLANT					
Total Nitrogen	mg/Kg	Dry oxidation	25%	75-125%	0.15 mg/Kg
WATER					
Nitrate/nitrite-N, dissolved	mg/L	Auto analyzer/ Colorimetric TAES SOP	20%	80-120%	0.020 mg/L

[1] RPD = relative percent deviation

Data Quality Indicators (DQIs) are a simplistic way of referring to data characteristics by consideration of commonly used measures of environmental quality. The principal DQIs are precision, representativeness, comparability, and completeness and although discussed as separate items are actually inter-related. For instance, lack of representativeness could lead to bias and lack of completeness. These DQIs are individually defined below:

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.

The laboratory will determine precision of its analyses by completing the entire analysis of a duplicate sample once per batch. Relative percent deviation (RPD) of duplicate analyses (X_1 and X_2) will be calculated with the formula with the precision limits indicated in Table A7-1:

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

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. Accuracy of each measurement will be recorded by reporting the measurements of know quantities with each batch. Accuracy will be calculated utilizing percent recovery.

Representativeness
Site selection and sampling of all pertinent media (water, soil and plant material), and use of only approved analytical methods, will assure that the measurement data represents the conditions at the site. Representativeness also depends on the number of samples taken to accurately reflect the technological effectiveness at a given site. The goal for meeting total representation for effectiveness of each technology is tempered by the potential funding for complete representativeness.

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 approved sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP and project SOPs. 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.

Completeness
The completeness of the data is basically a relationship of how much of the data is available for use compared to the total potential data. Ideally, 100% of the data should be available. However, the possibility of unavailable data due to accidents, insufficient sample volume, broken or lost samples, etc. is to be expected. Therefore, it will be a general goal of this project that 90% data completion is achieved. If there is less than 90 percent data completeness, the Data Supervisor will initiate corrective action. Data completeness will be calculated as a percent value:

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

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

Section A8: Special Training Requirements/Certification

There are no special requirements for staff training or certification for this project, however; field technicians and laboratory analysts for this project have a combination of experience, education, and training to demonstrate sufficient knowledge of their function. Experience, education and training are retained in the respective agency personnel files and can be made available during a monitoring systems audit.

Section A9: Documentation and Records

Hard copies of all field data sheets, general maintenance (GM) records for field equipment, QAPPS, amendments, appendices, and distribution documentation, will be archived by TAES for at least five years. Electronic copies and/or hard copies of all general maintenance (GM) records for laboratory equipment, chain of custody forms (COCs), laboratory data entry sheets, calibration logs, and laboratory corrective action reports (CARs) will be archived by TAES for at least five years. In addition, TAMU will archive electronic forms of all project data for at least five years. All electronic files and data will be written onto on recordable CD's monthly. Every 6 months a back-up copy of the CD's will be taken off-site as additional back-up. The off-site location is climate controlled and secure. A CAR form is presented in Appendix A, a copy of the COC is presented in Appendix B, and a copy of the field data sheet is presented in Appendix C.

Quarterly progress reports will be generated by the TWRI and will note activities conducted in connection with the water quality monitoring program, items or areas identified as potential problems, and any variations or supplements to the QAPP. CARs will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference at TWRI. 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 by the TWRI. TWRI will be responsible for submitting an evaluation report for this project.

The TSSWCB may elect to take possession of records (or copies thereof) at the conclusion of the specified retention period.

Section B1: Sampling Process Design (Experimental Design)

Experimental design for nitrogen and water balance on fields

Six fields will be chosen from the list of land owners agreeing to convert agricultural fields from pivot to drip irrigation. Three fields will be pivot irrigated and three will be drip-irrigated. All fields will be implemented with BMPs according to the nutrient and water management plans created by the TSSWCB. These six fields will be monitored for three growing seasons.

Field selection priorities for this experiment are the following:

- Pivot and drip irrigated fields next to each other with similar soils and same field manager. Creates a paired test.
- Three sets of fields with soils representative of the Seymour Aquifer agricultural lands.
- Location of all fields in close geographical proximity to minimize driving and sample collection times.

The six selected fields will be surveyed using GPS and bulk electrical conductivity. A GPS and an EM38 mounted onto an ATV will be used to non-invasively collect continuous soil electrical conductivity measurements on 10 m transects. The EM38 survey will be used to identify soil heterogeneity and sampling areas. In each field, 5-6 areas will be selected for individual nitrogen and water balance.

The 5-6 sampling areas (experimental units) in each of the six fields will be identified using the EM38 map. These field areas will be where the nitrogen information is collected. Experimental units will be 3 x 4 m, and sub sampled. Initial soil samples will include textural and organic carbon analysis. For the 3 drip irrigation fields, drip irrigation will be installed late winter 2005 before the 2005 planting season.

Water balance determinations will be made using the following procedures:

- Irrigation: Inline flow gauges installed in drip irrigation systems. Logging charts in the well house of the pivot irrigation systems.

- Irrigation Management: scheduling will follow the water conservation plan, which will be about 75% PET as recommended by weather stations located nearest to the sites.

- Rain: Hobo tipping bucket rain gauges will be installed at each field site and rainfall will be collected in sealed plastic containers (a funnel will connect the tipping bucket and plastic collection container) to estimate inorganic nitrogen in the rain.

- Evaporation: Daily/Hourly meteorological data will be collected at weather stations.

- Transpiration: After emergence, plant LAI will be measured every two weeks using a Licor LAI2000, estimates of green LAI will be made as the plant senesces.

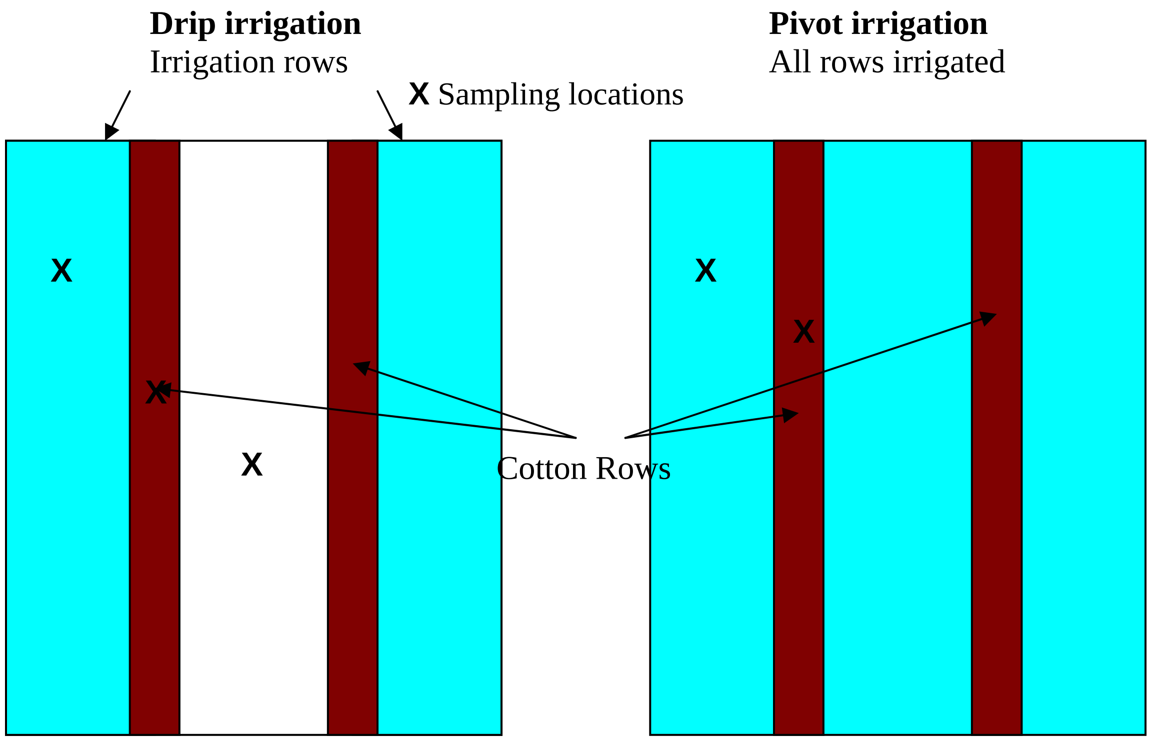
- Drainage: Total drainage for each field will be estimated by using ENWATBAL.

Nitrogen Balance will be determined using data derived from a series of soil, water, and plant samples.

Soil Samples will be:
- collected over three full growing seasons (3 years)
- collected before and after harvest at each of the sampling locations, to a depth of 150 cm (over 90% of the rooting depth of cotton).
- collected using a 2 inch diameter Giddings soil probe.
- estimated for soil bulk density by measuring the depth of the sampling hole at each sampling interval (0-15, 15-30, 30-70, 70-110 cm).
- air dried (60°C) before being analyzed for total organic nitrogen and carbon (Dumas method) and for total inorganic nitrogen (KCl extraction—1:7). See table B4.1.

Geometric design of the samples is shown in Figure B1-1, below. The cotton will be planted on 40-inch or 32 inch rows. The sampling locations are noted with an "X". No soil cores will be composited.

Figure B1-1 Sampling Locations



Water Samples:

- Rain and irrigation water will be collected after rainfall and once weekly during irrigation, respectively
- Irrigation samples will be pulled from the irrigation pipes, after the water has passed through the irrigation filtration system
- The water samples will be frozen immediately after collection and remain frozen until analyzed.
- The samples will be analyzed for total inorganic nitrogen (KCL extraction—1:7) on a 28-day basis (see Table B4.1).

Plant Samples: (At each sampling location in each field)

- will be harvested at an interval of 2 rows by 1 meter of cotton plants before the plants are defoliated for mechanical harvest.
- will be separated into leaf, stem and fruit, ***air-dried*** and weighed.
- (***air-dry*** sub samples) will be analyzed for Total N, dry combustion.
- remaining plant tissue will be ***oven-dried*** and weighed for total dry biomass.

Bromide Study

A bromide study will be conducted during the 2006 growing season to further assess the movement of nitrogen through the soil profile. The bromide study will be conducted in two of the selected fields, one under drip irrigation and one under pivot irrigation. At the beginning of the growing season, a solution of sodium bromide (NaBr) will be applied at a rate of 150 pounds per acre to five 10 x 10 m plots in the drip irrigation field and five 10 x 10 m plots in the pivot irrigation field. Soil samples will be collected immediately following application of the NaBr and thereafter following each major rainfall or irrigation event (or monthly if no major events) throughout the 2006 growing season until the termination of irrigation. Cores will be collected to a depth of 150 cm (over 90% of the rooting depth of cotton) using a 2 inch diameter Giddings soil probe. The cores will be dissected at 5 cm depth intervals. A 1:2 soil:water extraction followed by 1 hour of shaking will be used to extract the bromide from each depth interval. Once the shaking is complete, the water will be decanted, $NaNO_3$ added, and bromide measured using a Cole-Parmer Ion Selective Electrode.

Section B2: Sampling Method Requirements

Field sampling activities are documented on field data reporting forms as presented in Appendix C. All sample information will be logged into a field log. The following will be recorded for all sampling events:

- station ID / location
- sampling time
- date
- sample collector's name/signature
- COC number

Detailed observational data are recorded including weather, specific sample information, and days since last significant rainfall. Upon collection, all water, soil and plant material will be secured in proper sample containers for transport and all water samples will be transported in an iced container for analysis. All filtration and preservation, other than temperature reduction by ice, will be performed in the laboratory within 48 hours of the collection time.

Recording Data

For the purposes of this section and subsequent sections, all field and laboratory personnel follow the basic rules for recording information as documented below:

- Legible writing with no modifications, write-overs or cross-outs;
- Correction of errors with a single line followed by an initial and date;
- Close-outs on incomplete pages with an initialed and dated diagonal line.

Failures in Sampling Methods Requirements and/or Deviations from Sample Design and Corrective Action

Examples of failures in sampling methods and/or deviations from sample design requirements include but are not limited to such things as sample container problems such as inadequate sample volume due to spillage or container leaks, contamination of a sample bottle during collection, failure to preserve samples appropriately, storage temperature and holding time exceedance, sampling at the wrong site, etc. Any deviations may require corrective action. Corrective action may include for samples to be discarded and re-collected. It is the responsibility of the Field and Data Supervisors, in consultation with the TWRI QAO, to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP. The Field and Data Supervisors will determine if the deviation from the QAPP compromises the validity of the resulting data. The Field and Data Supervisors, in consultation with the TWRI QAO, TWRI Project Leader, and TSSWCB QAO will decide to accept or reject data associated with the sampling event, based on best professional judgment. Resolution of the situation will be reported to the TSSWCB in the quarterly report.

Section B3: Sample Handling and Custody Requirements

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 COC form is used to document sample handling during transfer from the field to the laboratory, and among subcontract laboratories. 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. At TSU/TAES CAL, sample numbers will then be recorded into a laboratory sample log, where the laboratory staff member who receives the sample will sign it. A copy of the COC form is located in Appendix B.

Sample Labeling

Samples are labeled on the container with an indelible, waterproof marker. Label information includes the site identification / location, date, sampler's initials, time of sampling, sample type, and preservative added, if applicable. A COC form will accompany all sets of sample containers.

Sample Handling

Following collection, water samples are placed on ice in an insulated cooler and soil and plant samples are placed in proper sample containers (i.e. clean, unused Ziploc baggies or standard brown bags for air-drying) for transport to the laboratory. The water samples will be collected at the field location and frozen until they can be transported (in ice) to the laboratory. At the laboratory, water samples are kept frozen in a freezer dedicated for sample storage until thawed for analysis. Freezing is an effective method for preserving the inorganic nitrogen in water samples (Avanzino and Kennedy 1993). Freezing is generally a better form of preservation than sterilization and acidification. Sterilization using $HgCl_2$ presents human health hazards and strong acidification requires neutralization before analysis, thereby increasing the chance for contamination. Freezing has been shown to effectively preserve water samples for inorganic nitrogen analysis for up to eight years (Avanzino and Kennedy 1993). In the event that soil samples cannot be dried within 48 hours of being removed from the field, they will be frozen until they can be processed. The TAMU Research Assistant and the Data Supervisor have the responsibility to ensure that holding times are met with samples. The holding time for all sample media is documented on the COC. Any problems will be documented with a corrective action report.

After samples are received at the laboratory, they will be inventoried against the accompanying COC. Any discrepancies will be noted at that time and the COC will be signed for acceptance of custody. Sample numbers will then be recorded into a laboratory sample log and samples will be checked for preservation (as allowed by the specific analytical procedure). Table B3-1 delineates the method, sample container, and holding time information for parameters of interest in this project.

Table B3-1. Sample Procedures and Handling Methods

PARAMETER	UNITS	METHOD	CONTAINER	HOLDING TIME	SAMPLE VOLUME	FIELD PRESERVATION
SOIL						
Total Carbon (organic)	mg/Kg	Dumas dry oxidation/ combustion LSU-SPESS	Zipper storage bags	6 months	100 g	Air dry
Total Nitrogen (organic)	mg/Kg	Dumas dry oxidation/ combustion LSU-SPESS	Zipper storage bags	6 months	100 g	Air dry
Nitrogen (inorganic)	mg/Kg	KCl extraction TAES SOP	Zipper storage bags	6 months	100 g	Air dry
Bromide	mg/Kg	Ion selective electrode	Zipper storage bags	6 months	50 g	N/A
Particle size analysis		Pipette method TAES SOP	Zipper storage bags	6 months	50 g	N/A
PLANT						
Total Nitrogen	mg/Kg	Dry oxidation	Brown bag	6 months	100 g	Air dry
WATER						
Nitrate/nitrite-N, dissolved	mg/L	Auto analyzer/ Colorimetric TAES SOP	HDPE	28 days	200 mL	4^{o}C dark, freeze until analysis

HDPE = High Density Polyethylene bottles
H_2SO_4 = Sulfuric acid
N/A = not applicable

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 Field and Data Supervisors. 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 Field and Data Supervisors in conjunction with the TWRI Project Leader and TWRI QAO will determine if the procedural violation may have compromised the validity of the resulting data. Any failures that potentially 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. Corrective action reports will be maintained by the Data Supervisor.

Section B4: Analytical Methods Requirements

The parameters listed in Table B4-1 will be analyzed by LSU-SPESS or TAMU at Texas A&M University in College Station, Texas. Standard operating procedures have been established for all procedures undertaken by staff that concerns sample monitoring and analysis, and copies of the SOPs are available upon request.

Failures in Measurement Systems and Corrective Actions

In the event of a failure in the analytical system, the TWRI QAO will be notified. Failures in 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, lab analyst will be able to correct the problem. If the problem is resolvable by the laboratory director or lab analyst, then they will document the problem on the laboratory record, or corrective action report (CAR) and complete the analysis. If the problem is not resolvable, then the Laboratory Director (and their QAO, if applicable) of the affected Lab, in conjunction with the Field and Data Supervisors, TWRI Quality Assurance Officer, and TWRI Project Leader will then determine if the existing sample integrity is intact, if re-sampling can and should be done, or if the data should be omitted. The situation and agreed resolution will be reported to the TSSWCB in the quarterly progress report.

Table B4-1 Laboratory Analytical Method

PARAMETER	METHOD	EQUIPMENT USED
SOIL		
Total Carbon (organic)	Dumas dry oxidation/ combustion LSU-SPESS SOP	LECO TruSpec C:N Analyzer
Total Nitrogen (organic)	Dumas dry oxidation/ combustion LSU-SPESS SOP	LECO TruSpec C:N Analyzer
Nitrogen (inorganic)	KCl extraction Auto analyzer/ Colorimetric TAES SOP	Technicon autoanalyzer II
Bromide	1:2 soil:water extraction Ion Selective Electrode	Cole-Parmer Ion Selective Electrode
Particle size analysis	Pipette method TAES SOP	Glassware
PLANT		
Total Nitrogen	Dry oxidation	Elementar Vario Macro C:N Analyzer
WATER		
Nitrate/nitrite-N, dissolved	Auto analyzer/ Colorimetric TAES SOP	Technicon autoanalyzer II

Section B5: Quality Control Requirements

The use of approved sampling and analytical methods will ensure that measured data accurately represent conditions at each monitoring site. Table A7-1 in Section A7 "Data Quality Objectives" lists the required accuracy limits for the parameters of interest. The completeness of the data will be affected by the reliability of the equipment, frequency of field and laboratory errors or accidents, and unexpected events; however, the general goal requires 90 percent data completion.

Project site audits and quality assurance of field sampling methods will be conducted by the TWRI QA officer. In addition, laboratory audits, sampling site audits, and quality assurance of field sampling methods will be conducted by the TSSWCB QAO or their designee.

It is the responsibility of the Data Supervisor to verify that the data are representative. The chemistry data's precision, accuracy, and comparability will be the responsibility of the Laboratory Director. The Field and Data Supervisors have the responsibility of determining that the 90 percent completeness criteria is met, or will justify acceptance of a lesser percentage. All incidents requiring corrective action will be documented through use of Corrective Action Reports (Appendix A). Corrective action reports will be maintained by the Project Leader, Field and Data Supervisors, and the TSSWCB PM.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria

Detailed laboratory QC requirements are contained within each individual method and laboratory quality assurance manuals (QAMs). Lab QC sample results are reported with the laboratory data report.

When daily calibration is not required or a method does not use a calibration curve to calculate results, the laboratory will analyze a check standard at the reporting limit on each day samples are analyzed. The check standard does not have to be taken through sample preparation, but must be recovered within 75-125% of the reference concentration for the standard. The percent recovery of the check standard is calculated using the following equation in which %R is percent recovery, SR is the sample result, and SA is the reference concentration for the check standard:

$$\%R = SR/SA * 100$$

If the calibration (when applicable) or the recovery of the calibration or control standard is not acceptable, corrective actions (e.g., re-calibration) will be taken to meet the specifications before proceeding with analyses of samples.

<u>Laboratory duplicate</u> - Laboratory duplicates are used to assess precision. A laboratory duplicate is prepared by splitting aliquots of a single sample (or a matrix spike or a laboratory control standard) in the laboratory. Both samples are carried through the entire preparation and analytical process. Laboratory duplicates are performed at a rate of one per batch. They are used to assess precision.

Precision is calculated by the relative percent deviation (RPD) of duplicate results as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, X_1 and X_2, the RPD is calculated from the following equation:

$$\mathbf{RPD = \{ (X_1 - X_2) / (X_1+X_2)/ 2 \}* 100}$$

Method Blank- A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing and analyzed with each batch. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination from the analytical process. A CAR will be completed to document the exceedence and corrective actions. The CAR information, conclusions, corrective actions, and affected tag numbers will be included with data submittal to TSSWCB. For very high level analyses, blank value should be less then 5% of the lowest value of the batch or corrective action will be implemented.

Additional method specific QC requirements - Additional QC samples are run (e.g., surrogates, internal standards, continuing calibration samples, interference check samples) as specified in the methods. The requirements for these samples, their acceptance criteria, and corrective action are method-specific.

Deficiencies, Nonconformances and Corrective Action Related to Quality Control

Deficiencies are defined as unauthorized deviations from procedures documented in the QAPP. Nonconformances are deficiencies, which affect quality and render the data unacceptable or indeterminate. Deficiencies related to quality control include but are not limited to field and laboratory quality control sample failures.

The Field and Data Supervisors, in consultation with the TWRI QAO and Project Leader, will determine if the deficiency constitutes a nonconformance of the QAPP. If it is determined the activity or item in question does not affect data quality and therefore, is not a valid nonconformance, it will be added as part of the normal quarterly reporting requirement with no other documentation needed. If it is determined a nonconformance does exist, Field and Data Supervisors, in consultation with the TWRI QAO and Project Leader, will determine the disposition of the nonconforming activity or item and necessary corrective action(s). Results will be documented by the TWRI QAO, Field and Data Supervisors, or the LSU-SPESS Laboratory Director, as appropriate, by completion of a Corrective Action Report.

Corrective Action Reports (CARs) document: root cause(s); impact(s); specific corrective action(s) to address the deficiency; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and, the means by which completion of each corrective action will be documented. CARs will be included with quarterly 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.

Section B6: Equipment Testing, Inspection, & Maintenance Requirements

Manufacturers’ recommendations for scheduling testing, inspection, and maintenance of each piece of equipment (see Table B4-1) will be followed or exceeded. All laboratory tool, gauge, instrument, and equipment testing and maintenance requirements are contained within laboratory SOPs. Records of all tests, inspections, and maintenance will be maintained and log sheets kept showing time, date, and analyst signature. These records will be available for inspection by the TSSWCB. The field equipment will be tested, inspected, and maintained by the field supervisors. The laboratory equipment at Texas A&M University and Louisiana State University will be tested, inspected, and maintained by TAMU/TAES data supervisor and LSU-SPESS laboratory director

To minimize downtime of all measurement systems, all field measurement and sampling equipment, in addition to all laboratory equipment, must be maintained in a working condition. Also, backup equipment or common spare parts will be made available, where possible, in the case that a piece of equipment fails during use, so measurement tasks may be resumed. Batteries for field equipment (rain gauges and Licor, LAI 2000) will be replaced annually. No other maintenance is needed for these field equipment. All staff who use chemicals, reagents, 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. Maintenance and inspection logs will be kept on each piece of laboratory equipment.

Failures in any testing, inspections, or calibration of equipment will result in a CAR and resolution of the situation will be reported to the TSSWCB in the quarterly report. Copies of corrective action reports will be maintained by the Project Leader.

Section B7: Instrument Calibration and Frequency

All instruments or devices used in obtaining environmental measurement data will be used according to appropriate laboratory or field practices. Written copies of project standard operating procedures will be available for review upon request.

Standards 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 standards will be recorded in the standards log book and given unique identification numbers. The date, analyst initials, stock sources with lot number and manufacturer, and dilution concentrations will also be recorded in the standards log book.

Normally calibrations are performed with a minimum of four standards of increasing concentrations and a calibration blank. Standards shall not exceed the linear range of the instrument or method. Calibration shall be verified immediately after a set of standards is analyzed and continuously throughout an analytical run, after every sample batch, and at the end of an analysis to verify that the instrument or method has not drifted or changed since calibration. The initial calibration verification and continuing calibration verification will be matched to the generated standard curve and screened for acceptability. Laboratory equipment and devices needing calibration and recalibration are numerous and varied. All equipment will have verifiable calibration documentation maintained and available for inspection in the laboratory. Laboratory standards will be checked to verify that the concentrations are those which are prescribed for the analytical method.

All instruments or devices used in obtaining environmental measurement 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. The frequency of calibration recommended by the equipment manufacturer, as well as any instructions specified by applicable analytical methods, will be followed. All information concerning calibration will be recorded by the person performing the calibration and will be accessible for verification during either a laboratory or a field audit.

Failures in any instrument calibration will result in a CAR and resolution of the situation will be reported to the TSSWCB in the quarterly report. Copies of corrective action reports will be maintained by the TWRI Project Leader.

Model Calibration

Performance calibration

Model calibration is the process where the model input parameters are adjusted until the simulated data from the model match with observed data. The ENWATBAL model is physically based and will not be calibrated to fit field measurements of water hydrology. ENWATBAL will be used to estimate the water balance using water inputs, weather variables, and crop information in the fields. ENWATBAL will be used to further understand the processes of a complex biophysical system and will not be used to make absolute determinations.

Model calibration

Simulation models such as ENWATBAL are useful for investigating complex biophysical processes that are difficult to examine through field studies. ENWATBAL was designed to predict cotton and sorghum evapotranspiration in production irrigated and dry land production fields. Simulated evapotranspiration and soil moisture profiles will be used to enhance the understanding gained with field measurements. ENWATBAL is a processed base mechanistic model that bases calculations on meteorological data, plant growth data and soil physical properties.

Because meteorological and plant growth information will be directly measured and the soil physical properties will be simulated using pedotransfer functions based on measurements of soil texture, ENWATBAL will not be calibrated. ENWATBAL as been extensively tested for accuracy and has been proven valid in the scientific literature (Lascano et al., 1987; VanBavel et al., 1987; Evett and Lascano 1993). Ritchie and Johnson (1990) compared ENWATBAL to the CERES-Maize model to predict cotton evapotranspiration. Krieg and Lascano (1990) used ENWATBAL to predict sorghum evapotranspiration at Brownfield, TX, and Lascano (1991) used the model to predict the effects of nitrogen on the water use of irrigated and dry land sorghum at Lubbock, TX. ENWATBAL is proven to match daily evapotranspiration (r2 = 0.85 to 0.96) and net radiation (r2 = 0.97) over a full season at a study site (Evett et al., 1991).

Section B8: Inspection/Acceptance Requirements for Supplies and Consumables

All supplies and consumables received by the TAES and TSU/TAES CAL laboratories 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. Volumetric glassware is inspected to ensure class "A" classification, where required. All supplies will be stored as per manufacturer labeling and discarded past expiration date.

Glassware and high density polyethylene containers used for chemical analyses and to obtain water samples are cleaned in soapy water, rinsed in tap water then rinsed at least three times in water with conductivity of less than 2 microsiemens per centimeter. Glassware is never rinsed with compounds of the constituent being analyzed.

Individuals responsible for inspection and acceptance of supplies and consumables include the LSU-SPESS laboratory manager and the TAES/TAMU data supervisor.

Section B9: Data Acquisition Requirements (Non-direct Measurements)

Water quality determinations at sampling sites will be based upon data collected during the time frame of this project. However, data collected within the Seymour Aquifer Region, under approved QAPPs, from other state or federal projects will be used as supplemental information to meet data quality objectives (see Section A7). The data collected under approved QAPPs from other projects will be referred to as historical data.

The weather data collected for calculating the water balance in ENWATBAL and analyzing soil nitrogen results will be obtained from the Texas North Plains ET (evapotranspiration network). The data can be downloaded from a Web site located at http://amarillo2.tamu.edu/nppet/station.htm. The ET network is developed and operated by Texas A&M Agricultural Research and Extension Center in Amarillo Texas. The weather station collecting the required weather information is located 3 miles from Munday, Texas. The weather information collected includes daily, maximum and minimum temperature, relative humidity, and solar radiation. To ensure data quality, the downloaded weather data will be evaluated for consistency and logging failures. Any missing weather data will be obtained from the nearest weather station on the ET network.

The soil physical properties used for ENWATBAL will be obtained from pedotransfer functions that link soil texture to national averages of saturated hydraulic conductivity, and the soil moisture release curve (Rawls et al., 1992).

Section B10: Data Management

Field Collection and Management of Routine Samples

Field staff will visit sampling sites on a weekly or bi-weekly basis (dependent on individual irrigation schedules) to collect samples. Site identification, date and time, personnel, and any comments concerning weather or conditions at the site are noted on a field data sheet. One field data sheet is filled out in the field for each site visited.

Grab samples are then collected at the site, and an identification number (either a sample identification number or a site code) is written in marker on the outside of the HDPE sample bottles. The samples are then placed in an iced chest for transportation to the laboratory.

Unique sample identification numbers are obtained from a book of numbers located at the laboratory. After sample ID numbers are obtained, each sample bottle is labeled with the appropriate ID number by marking the number on each bottle.

Sample ID numbers are recorded on the COC forms. Sample bottles being processed are typically placed in order of collection time, so the order of the sample bottles matches the order of the field data and the COC sample ID numbers, reducing transcription errors. Site name, time of collection, comments, and other pertinent data are copied from the field data sheets to the COC. The COC and accompanying sample bottles are submitted to laboratory analysts, with relinquishing and receiving personnel both signing and dating the COC. A copy of a blank COC form used on this project is included as Appendix B.

Chain of Custody Forms

A chain of custody (COC) form is used to record water sample identification parameters and to document the submission of samples from the field staff to the analytical laboratory staff or from the initiating laboratory to a sub-contracted laboratory. Each COC has space to record data for at least 12 separate samples. All entries onto the COC forms will be completed in ink, with any changes made by crossing out the original entry, which should still be legible, and initialing and dating the new entry. COCs will be kept in three-ring binders in the TAMU Soil and Crop Sciences office of the Data Supervisor. The Project leader will also keep a copy of the COCs at TWRI for at least five years.

Laboratory Analysis and Data Collection

Aliquots of each sample are used by the laboratory staff in running the various analytical procedures. The sample number is marked on all containers to which aliquots are transferred. Aliquots are analyzed as per standard operating procedures. Data pertaining to analyte measurements are recorded in bound personal logbooks, which are specific to each procedure and analyst. Measurement data are entered into the project database from the laboratory data sheets produced by laboratory personnel.

Water Quality Data Entry

All COC, field, and laboratory information will be entered into a Microsoft® Excel data entry table. Field data and COC information will be verified by the Field and Data Supervisors. The Field and Data Supervisors will review site names, appropriateness of data values, completeness of data, dates and times, bottle numbers, comments and all other data within the Excel data table. Any questions or abnormalities will be investigated, relying largely on field data and general maintenance records, field technicians, laboratory notebooks, and laboratory personnel. As appropriate, corrections will be made to the Excel data table with appropriate documentation maintained.

Model Data Entry

All input data (measured and obtained) will be compiled into the appropriate file format for ENWATBAL.

Systems Design

TAMU- Soil and Crop Sciences, Vernon-AREC, TWRI, and TSU/TAES CAL use laptop personal computers and desktop personal computers. The computers run Windows operating system and databases include Microsoft® Excel. The TSU/TAES CAL analytical laboratory collects data using a variety of automated equipment with instrument-specific software.

Backup and Disaster Recovery

Laptop and desktop personal computers will be backed up monthly on writable CD ROMs. Every 6 months a back-up copy of the CD's will be taken off-site as additional back-up. This off-site facility is climatic controlled and secure.

Archives and Data Retention

Original data recorded on paper files are stored for at least five years. Data in electronic format are stored on CD ROMs and kept at the Texas A&M University campus.

Information Dissemination

All data for this project will be sent to the Data Supervisor at TAMU-Soil and Crop Sciences Department. Summaries of the data will be presented to TSSWCB in the final project report.

Section C1: Assessments and Response Actions

Laboratory and Field

The commitment to use approved equipment and approved methods when obtaining environmental samples and when producing field or laboratory measurements requires periodic verification that the equipment and methods are, in fact, being employed and being employed properly. This verification will be provided through a field and laboratory performance audit performed by the TSSWCB QAO or designee. Individual field personnel will be observed during the actual field investigation to verify that equipment and procedures are properly applied. Any problems that are discovered in the monitoring procedures that would affect the quality of data collected at the demonstration sites will be addressed by the project participants and followed up with a CAR. Follow-up observations will occur within three months of when discrepancies are noted.

Table C.1-1. Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party(ies)	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TWRI, Field and Data Supervisors	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of contract laboratory performance and data quality	Field and Data Supervisors and TWRI will report to TSSWCB PM via quarterly report.
Laboratory Inspections	Minimum of one during the course of this project.	TWRI-QAO and TSSWCB QAO	Analytical and QC procedures employed at the laboratory and in the field.	Field and Data Supervisors have 30 days to respond in writing to the TSSWCB QAO to address corrective actions
Monitoring Systems Audit	Minimum of one during the course of this project.	TSSWCB QAO	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Field sampling, handling and measurement; facility review; and data management as they relate to the project	Field and Data Supervisors have 30 days to respond in writing to the TSSWCB QAO to address corrective actions

All laboratory analyses will have the precision and accuracy of data determined on the particular day that the data were generated. The specific requirements are presented in Section B5 of the QAPP.

To minimize downtime of all measurement systems, all field measurement and sampling equipment, in addition to all laboratory equipment, must be maintained in a working condition. Also, backup equipment or common spare parts will be made available, where possible, in the case that a piece of equipment fails during use, so measurement tasks may be resumed.

Modeling

Software requirements, software design, or code are examined by the team to detect faults, programming errors, violations of development standards, or other problems. All errors found are recorded at the time of inspection, with later verification that all errors found have been successfully corrected. Software used to compute model predictions are tested to assess performance relative to specific response times, computer processing usage, run time, convergence to solution, stability of the solution algorithms, the absence of terminal failures, and other quantitative aspects of computer operation.

Checks are made to ensure that the computer code for each module is computing module outputs accurately and within any specific time constraints. The full model framework is tested as the ultimate level of integration testing to verify that all project-specific requirements have been implemented as intended. All testing performed on the original version of the module, or linked modules, is repeated to detect new “bugs” introduced by changes made in the code to correct a model.

Audits

The TWRI Project Leader and the Field and Data Supervisors 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 Project Leader, Field and Data Supervisors and the TSSWCB QAO.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in the TSSWCB QMP and in agreements or contracts between participating organizations.

Section 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 variations or supplements to the QAPP. Corrective action report forms will be utilized when necessary (Appendix A). CARs that concern field operations will be maintained in an accessible location for reference at Vernon-AREC. CARs that concern laboratory operations will be maintained in an accessible location for reference at TAMU-Soil and Crop Sciences Department. CARs that result in any 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.

The field and laboratory 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 are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. Corrective Action Reports will be filled out to document the problems and the remedial action taken.

Copies of all Corrective action reports for this project will also be included with the project final report. The final report will contain a quality assurance section to address accuracy, precision and completeness of the measurement data. The final report will also discuss any problems encountered and solutions made. The final report is the responsibility of the Project Leader, Field and Data Supervisors, and TWRI Quality Assurance Officer.

Section D1: Data Review, Validation and Verification

For the purposes of this document, verification means the processes taken to determine compliance of data with project requirements, including documentation and technical criteria. Validation means those processes taken independently of the data-generation processes to determine the usability of data for its intended use(s). Integrity means the processes taken to assure that no falsified data will be reported.

All data obtained from field and laboratory measurements will be reviewed and verified for integrity and continuity, reasonableness, and conformance to project requirements, and then validated against the data quality objects outlined in Section A7, “Data Quality Objectives for Measurement Data.” Only those data that are supported by appropriate QC data and meet the DQOs defined for this project will be considered acceptable for use.

The procedures for verification and validation of data are described in Section D2, below. The Field Supervisor is responsible for ensuring that any pertinent field data is properly reviewed, verified, and submitted in the required format for the project database. The Laboratory Director is responsible for ensuring that laboratory data are scientifically valid, defensible, of acceptable precision and accuracy, and reviewed for integrity. The data is then submitted to the Data Supervisor in the required format for the project database.

Section D2: Validation and Verification Methods

Field and Laboratory data validation

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. A *Data Review Checklist* is included in Appendix D. The staff and management of the respective field, laboratory, and data management tasks, as listed in this project, 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.

Microsoft Excel will be used for general spreadsheet computation and laboratory control charting of quality control parameters. The TSU/TAES CAL, Vernon AREC, and TAES laboratories will employ various data handling software on IBM compatible personal computer stations for data on the analyzed parameters. Specific software and/or hardware handle data for other parameters

The Data Supervisor is responsible for review of calculations and charts made by these programs. Statistical analyses are performed with Minitab and SPlus programs. The Project Leader, Data Supervisor, Field Supervisor and TWRI QAO, as appropriate, are responsible for validating that the verified data are scientifically valid, defensible, of known precision, accuracy, integrity, meet the data quality objectives of the project, and are reportable to the TSSWCB.

The TAES/TAMU Data Supervisor will review the final data to ensure that it meets the requirements as described in this QAPP. Data that have been reviewed, verified, and validated will be summarized for each site individually, as well as all sites collectively, for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. Statistical analysis and calculations will also be reviewed and verified as accurate. These summaries will be included in the final report.

Model validation

The process based model, ENergy and WATer BALance (ENWATBAL) Model proposed for this study was built with an attempt to simulate water balance processes physically and realistically. Most of the model inputs are physically based (that is, based on physical characteristics of the soil, atmosphere, and plant). It is important to understand that ENWATBAL is not a ‘parametric model’ with a formal optimization procedure (as part of the calibration process) to fit any data.

Because meteorological and plant growth information will be directly measured and the soil physical properties will be simulated using pedotransfer functions based on measurements of soil texture, ENWATBAL will not be calibrated. ENWATBAL as been extensively tested for accuracy and has been proven valid in the scientific literature (Lascano et al., 1987; VanBavel et al., 1987; Ritchie and Johnson 1990; Kreig and Lascano, 1990; Evett and Lascano 1993); hence, the scope of the study will not include data collection to extensively validate ENWATBAL.

Section D3: Reconciliation with Data Quality Objectives

The Laboratory Director shall be responsible for reviewing raw data produced by the LSU-SPESS. The Data Supervisor shall be responsible for reviewing raw data produced by the TAES laboratory. The Data Supervisor shall check calculations to verify that data are entered into the database correctly and be responsible for internal lab error corrections. Corrective Action Reports will be initiated in cases where invalid or incorrect data have been detected.

Representativeness and comparability of data, while unique to each individual collection site, is the responsibility of the Data Supervisor. By following the guidelines described in this QAPP, and through careful sampling design, the data collected in this project will be representative of the actual field conditions and comparable to similar applications. Representativeness and comparability of laboratory analyses will be the responsibility of the Laboratory Director.

The Data Supervisor will review the final data to ensure that it meets the requirements as described in this QAPP. Data that have been reviewed, verified, and validated will be summarized for each site individually, as well as all sites collectively, for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. These summaries will be included in the final report.

References

Avanzino RJ and Kennedy VC. Long-term frozen storage of stream water samples for dissolved orthophosphate, nitrate plus nitrite and ammonia analysis. Water Resources Research 1993; 29: 3357 -3362.

APHA, American Public Health Association, American Water Works Association, and Water Environment Federation. 1992 & 1999. Standard Methods for the Examination of Water and Wastewater, 18th & 20th editions.

EPA, 2002. Guidance for Quality Assurance Project Plans for Modeling. EPA 240-R-02-007. US EPA Office of Environmental Information, Washington D.C.

Evett, S.R., T.A. Howell, J.L. Steiner, and J.A. Tolk. 1991. Measured and modeled soil and plant evaporation. Agronomy Abstracts, p. 16.

Evett, S.R. and R.J. Lascano. 1993. ENWATBAL.BAS: A mechanistic evapo-transpiration model written in compiled BASIC. Agron. J. 85(3):763-772.

Krieg, D.R. and R.J. Lascano. 1990. Sorghum. p. 719-740. In B.A. Stewart and D.R. Nielsen (ed.) Irrigation of agricultural crops. Amer. Soc. Agron., Madison, WI.

Lascano, R.J., C.H.M. van Bavel, J.L. Hatfield, and D.R. Upchurch. 1987. Energy and water balance of a sparse crop: simulated and measured soil and crop evaporation. Soil Sci.Soc. Am. J. 51:1113-1121.

Ott, L. 1984. An Introduction to Statistical Methods and Data Analysis, 2nd Edition. Duxbury Press, Boston., Massachusetts.

Rawls, W.J., L.R. Ahuja, and D.L. Brakensick. 1992. Estimating soil hydraulic properties from soil data. *In* M.Th. Van Genuchten, F.J. Leij, and L.J. Lund (eds.) Indirect methods for estimating hydraulic properties of unsaturated soils. U.C. Riverside Press, Riverside, CA.

Ritchie, J.T., and B.S. Johnson. 1990. Soil and plant factors affecting evaporation. p. 363-390. In B.A. Stewart and D.R. Nielsen (ed.), Irrigation of agricultural crops. Amer. Soc. Agron., Madison, WI.

Soil and Plant Analysis Council, Inc. 1992. Handbook on Reference Methods for Soil Analysis. Council on Soil Testing and Plant Analysis, Athens, Georgia.

Spooner, J., R.P. Maas, S.A. Dressing, M.D. Smolen, and F.J. Humenik. 1985. Appropriate Designs for Documenting Water Quality Improvements from Agricultural NPS Control Programs, pp. 30-34. In: Perspectives on Nonpoint Source Pollution. EPA 440/5-85-001.

SCS, United States Department of Agriculture Soil Conservation Service. 1985. National Engineering Handbook, Section 4 - Hydrology. Engineering Division. Washington, D.C. Report No. SCS/ENG/NEH-4-2.

TCEQ (Texas Commission on Environmental Quality). September 2003. *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue.* Austin, Texas.

TCEQ (Texas Commission on Environmental Quality). September 2003. Clean Rivers Program (CRP) Quality Assurance Project Plan (QAPP) Shell for 2004-2005. Austin, Texas.

TIAER, Texas Institute for Applied Environmental Research. 2002. Quality assurance project plan for Technical and Financial Assistance to Dairy Producers and Landowners of the North Bosque River Watershed within the Cross Timbers Soil and Water Conservation District and the Upper Leon Soil and Water Conservation District. Tarleton State University, Stephenville, Texas.

Van Bavel, C.H.M., and R.J. Lascano. 1987. ENWATBAL: A numerical method to compute the water loss from a crop by transpiration and evaporation. Texas Agricultural Experiment Station, Texas A&M Univ., College Station, TX 77843-2474, 75 pp. plus 3 appended articles.

Ward, R.C., J.C. Loftis, H.P. DeLong, and H.F. Bell. 1988. Groundwater quality: A data analysis protocol. Journal of the Water Pollution Control Federation 60:1938-1945.

Appendix A
Corrective Action Report

CAR #: ______________________________

Report Initiation Date: ___________________ Area/Site: ____

Reported by: ___________________________Analyte/Activity: __________________________________

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

____

____

____

Affected sample #s / date(s) of sample collection:

____

Project: ______________________________ Attached documentation: (NA, COC, etc.)_____________________

Possible Causes and Corrective Actions Taken / Recommended:

____

____

____

CAR routed to: ______________________________ Date: ____________________________________

Supervisor: ____

Circle one: **Tier 1** (does not affect final data integrity) **Tier 2** (possibly affects final data integrity)

Corrective Actions (If actions are to be taken, include Responsible Party[1] and proposed completion date, where appropriate)

For specific incident: Taken To be taken ____

____

____

To prevent recurrences: Taken To be taken ____

____

____

Effect on data quality: ____

Responsible Supervisor: ____ Date: _________________________

<u>Concurrence</u>: ____

Program/Project Manager: ____ Date: _________________________

Quality Assurance Officer: ____Date:_____________________

[1] Party responsible for implementing corrective action is also responsible for notifying QAO of completion and outcome of corrective action

Appendix B

CHAIN OF CUSTODY

COC Number:________

Page _____ of _____

Seymour Aquifer Water Quality Project

Sampler Name(s):

Sample No.	**Date**	**Time**	**Site ID**	**Preservative** (water only)	**Sample Type**	**Comments:** (if applicable)	**Disposed** (no, or yes-with a date)
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	
					soil H_2O plant:	end time:	

Relinquished by:	Date/ Time:	Received by:	Date/Time:	
Relinquished by:	Date/ Time:	Received by:	Date/Time:	

Appendix C

Seymour Aquifer Water Quality Project

Field Data Reporting Form

Station ID **Date** **Time**

Sample ID **COC Number**

Sample Matrix:

Soil ☐ Water ☐ Plant ☐

Collector Name(s)

Vernon-AREC TAES-College Station

Collecting Agency(ies)

Days since last significant rainfall:

Weather Observations:

Other Observations:

Appendix D

Data Review Checklist

Y, **N**, or **N/A**
(Y =yes **N** =no
N/A=not applicable**)**

Field Data Review

A. Field documentation includes the following: __________
   (1) Identification of individual collecting samples(s)? __________
   (2) Sample ID number and site location? __________
   (3) Sample collection date and time? __________
   (4) Site observations (i.e. weather, etc.)? __________
   (5) Unusual occurrences that may affect sample? __________
   (6) Sample collection problems?
B. Chain of custody record properly filled out and available for review? __________

Data Format and Structure

A. Are there any duplicate sample ID numbers? __________
B. Are station location numbers assigned? __________
C. Are sampling dates in the correct format, DD/MM/YY? __________
D. Are samples listed in the correct units? __________
E. Is the sampling time entered? __________

Data Quality Review

A. Appropriate holding times confirmed? __________
B. MDLs consistent with those in the QAPP? __________
C. Outliers confirmed and documented? __________
D. Documentation (verified error log) provided to TSSWCB? __________
E. Checks on correctness of analysis or data reasonableness performed? (i.e. - Is ortho-phosphorus greater that total phosphorus?) __________
F. Have at least 10% of the data in the database been reviewed against the data sheets? __________

Explain any answers that may indicate a problem with the data (attach another page if necessary):____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
_

Data Range: _______________________________

Data Source: _______________________________

Field Supervisor Signature:__________________________________Date:_______________

Data Supervisor Signature:__________________________________Date:_______________

Project Leader Signature: __________________________________Date:_______________