Clean Water Act §319(h) Nonpoint Source Grant Program

Development of the Watershed Protection Plan Modeling for Geronimo Creek
TSSWCB Project # 08-06

Quality Assurance Project Plan

Texas State Soil and Water Conservation Board
Revision 2

prepared by

Texas AgriLife Research
Texas Water Resources Institute

and the

Texas A&M University Department of Biological and Agricultural Engineering

Effective Period: April 2010 through July 2012

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

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Section A1 Approval Sheet

Quality Assurance Project Plan (QAPP) for the *Development of the Watershed Protection Plan Modeling for Geronimo Creek* project.

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Name: Curry Jones
Title: USEPA Chief State/Tribal Programs Section

Signature: ______________________________ Date:____________________

Name: Henry Brewer
Title: USEPA Texas Nonpoint Source Project Manager (PM)

Signature: ______________________________ Date:____________________

Texas State Soil and Water Conservation Board (TSSWCB)

Name: Loren Warrick
Title: TSSWCB Project Manager

Signature:__________________________________Date:____________________

Name: Aaron Wendt
Title: TSSWCB Quality Assurance Officer (QAO)

Signature:__________________________________Date:____________________

Guadalupe-Blanco River Authority (GBRA)

Name: Debbie Magin
Title: Director of Water Quality Services

Signature:__________________________________Date:____________________

Texas AgriLife Extension Service – Dept. of Soil and Crop Sciences (SCSC)

Name: Mark McFarland
Title: Professor and Extension Soil Fertility Specialist

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Texas AgriLife Research – Dept. of Biological and Agricultural Engineering (BAEN)

Name: R. Karthikeyan
Title: Assistant Professor

Signature:___________________________________Date:___________________

Texas AgriLife Research – Spatial Sciences Laboratory (SSL)

Name: R. Srinivasan
Title: Professor and SSL Director

Signature: R. Srinivasan Date:___________________

Espey Consultants Incorporated

Name: David Harkins, P.E.
Title: Vice President

Signature:___________________________________Date:___________________

Texas AgriLife Research – Texas Water Resources Institute (TWRI)

Name: Lucas Gregory
Title: TWRI QAO

Signature:___________________________________Date:___________________

Section A2: Table of Contents

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List of Acronyms and Abbreviations

BAEN	Department of Biological and Agricultural Engineering
BMP	best management practice
BSLC	Bacteria Source Load Calculator
CAR	corrective action report
CBMS	computer based mapping system
CWA	Clean Water Act
DQO	data quality objectives
ETJ	extra-territorial jurisdiction
FDC	flow duration curve
GBRA	Guadalupe-Blanco River Authority
GIS	geographic information system
LDC	load duration curve
LULC	landuse/landcover
NAIP	National Agricultural Imagery Program
NHD	National Hydrography Dataset
NLCD	national land cover data set
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
PM	Project Manager
QA	quality assurance
QAPP	quality assurance project plan
QAO	Quality Assurance Officer
QC	quality control
SCSC	Department of Soil and Crop Sciences
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSL	Spatial Sciences Laboratory
SSURGO	soil survey geographic
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
TAMU	Texas A&M University, College Station
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas AgriLife Research, Texas Water Resources Institute
USDA-ARS	United States Department of Agriculture-Agricultural Research Service
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WCSC	watershed coordination steering committee
WPP	watershed protection plan

Section A3: Distribution List

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

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Texas AgriLife Research - Texas Water Resources Institute

1500 Research Parkway, Suite 240
2118 TAMU
College Station, TX 77843-2118

Name: Lucas Gregory
Title: TWRI QAO

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 – Provides project oversight and funding at the federal level.

Henry Brewer, USEPA Texas Nonpoint Source PM
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 QAPP, project progress, and deliverables.

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

Loren Warrick, TSSWCB Project Manager
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. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB participants.

Donna Long; TSSWCB Quality Assurance Officer
Reviews and approves QAPP and any amendments or revisions. Responsible for verifying that the QAPP is followed by project participants. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures. Determines that the project meets the requirements for planning, quality assessment (QA), quality control (QC), and reporting under the TSSWCB Total Maximum Daily Load Program.

GBRA – Guadalupe-Blanco River Authority. Provides project coordination and administration, coordinates water quality monitoring, quality assurance and modeling.

Debbie Magin, Director of Water Quality Services, Guadalupe-Blanco River Authority
Responsible for ensuring the smooth operation of the project, timely delivery of quality deliverables and general project coordination and administration at the local level. Coordinates quality assurance, water quality monitoring and modeling activities. Closely coordinates with SCSC personnel to establish and facilitate the watershed steering committee and develop the watershed protection plan (WPP).

SCSC – Department of Soil and Crop Sciences, Texas A&M University, College Station, Texas. Responsible for stakeholder facilitation and WPP development.

Mark McFarland, Professor and State Water Quality Coordinator, Soil and Crop Sciences
Facilitates the development of the Geronimo Creek WPP and coordinates the inclusion of LDCs and SELECT modeling into the WPP.

BAEN – Department of Biological and Agricultural Engineering, Texas A&M University, College Station, Texas. Responsible for modeling activities associated with the Spatially Explicit Load Enrichment Calibration Tool (SELECT) and Load Duration Curve (LDC) development.

R. Karthikeyan, Assistant Professor, Biological and Agricultural Engineering

Responsible for performing LDC analysis and SELECT modeling utilizing water quality data from the Geronimo Creek watershed. Responsible for assisting in the development of a geographic information system (GIS) inventory of the selected project watersheds and designing the watershed source survey.

SSL – Texas AgriLife Research, Spatial Sciences Laboratory at Texas A&M University, College Station, Texas. Responsible for developing an updated landuse/landcover (LULC) map and estimating Geronimo Creek streamflow.

R. Srinivasan, Professor and Director of the Spatial Sciences Laboratory
Responsible for overseeing the development of updated land use and land cover maps for the Geronimo Creek watershed and ground-truthing data points to ensuring their accuracy. Also responsible for the development of flow duration curves (FDCs) at critical water quality monitoring locations throughout the watershed based upon simulated flow generated by SWAT modeling scenarios.

Espey Consultants Incorporated – Austin, TX. Responsible for assisting BAEN and SSL in on the SELECT modeling task.

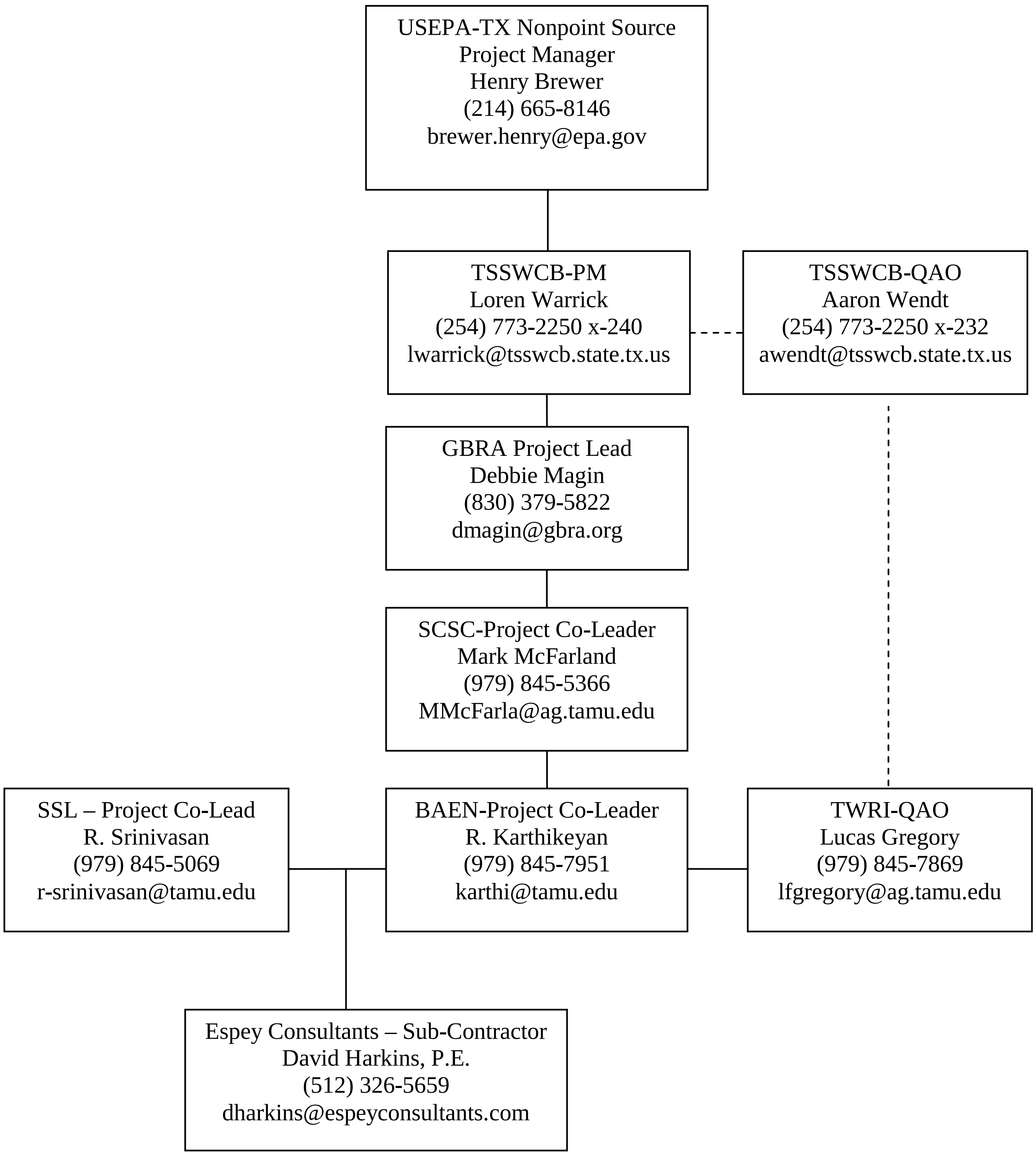
David Harkins, Vice President, Espey Consultants Inc.
Responsible for assisting BAEN and SSL in the development and automation of the SELECT model the Geronimo Creek watershed, running the SELECT model and assisting in the preparation of the final report that describes modeling results.

TWRI – Texas Water Resources Institute, College Station, Texas. Responsible for development of data quality objectives (DQOs) and a QAPP.

Lucas Gregory, Quality Assurance Officer

Responsible for determining that the QAPP meets the requirements for planning, QA and QC. Conducts audits of field and laboratory systems and procedures. Responsible for maintaining the official, approved QAPP, as well as conducting quality assurance audits in conjunction with TSSWCB personnel.

Figure A.4-1. Project Organization Chart



Section A5: Problem Definition/Background

State and federal water resource management and environmental protection agencies have embraced the watershed approach for managing water quality. The watershed approach involves assessing sources and causes of impairments and utilizing this information to develop and implement watershed management plans. This project will address the bacterial impairment and high and increasing nutrient concentrations in Geronimo Creek. The 2004 303(d) list indicated Geronimo Creek as impaired for *E. coli* bacteria (geometric mean = 162 organisms/100 milliliters). The GBRA has been sampling Geronimo Creek since 1996. The mean concentration for nitrate-nitrogen during that period is 11.0 milligrams per liter, well over the assessment screening concentration of 1.95 milligrams per liter and over the drinking water standard of 10.0 milligrams per liter. The only point source to the creek is within three-quarter mile of the confluence with the Guadalupe River, downstream of the historical monitoring locations. Hence, excess contributions of the bacteria and nutrient loads are most likely from non-point sources.

The land use in the area is primarily agricultural. The 44,152-acre watershed is made up of 45.5% cropland, including managed pasture, 31.6% rangeland, 9.8% forest and 11.5% developed land. Also located in the watershed is the New Braunfels airport and a commercial fish hatchery, neither of which has a point source discharge. The lower portion of the Geronimo Creek watershed is in the extra-territorial jurisdiction (ETJ) of the city of Seguin. The upper portion of the Alligator Creek watershed lies in the ETJ of the city of New Braunfels. Alligator Creek begins on the west side of IH 35 and travels southeast, crossing IH 35 and travelling through a rapidly developing area of the IH35 corridor. The city of Seguin is in the process of developing a master plan for the city which includes a component that is looking at projected growth in its ETJ and environmental impacts from the projected growth. Also, Guadalupe County is applying for a grant to look at flood control and stormwater management in the Geronimo Creek watershed. The timing for this WPP effort is good as the project will work in concert with both of the other governmental entities' efforts.

The TSSWCB Regional Watershed Coordination Steering Committee (WCSC) was formed in 2005 with the charge to develop a system to evaluate and rate watersheds for WPP development. Using a set of established criteria, the system prioritizes watersheds in southeast and south central Texas for WPP development. After a very successful WPP project on the Plum Creek in the Guadalupe River Basin, the committee was asked to nominate candidate watersheds for the next WPP development project. Using the criteria that included stream impairment and the watershed's status on the 303(d) list, land use, potential for success and stakeholder involvement, Geronimo Creek ranked in the top two. After significant discussions the WCSC selected a different watershed to pursue funding for. However, after considering on-going activities and the high interest level of stakeholders in the watershed GBRA believes a WPP effort was warranted.

The project will result in the production of a WPP that has been developed with buy-in from local stakeholders and governmental entities. The WPP will identify implementable best management practices that are based on the goals of water quality improvement and watershed protection. A comprehensive watershed approach will be a strong focus with concentrations on the most significant sources of agricultural nonpoint source pollution contributing to the current impairments, at the same time looking ahead at potential sources of pollution from urban and suburban growth. The outcomes of the project, which include data in the form of identification and estimation of sources and in partnerships with local stakeholders, would benefit the local governmental entities as they look at developing master plan and stormwater management strategies. Recommended best management practices that are identified by the steering committee, work groups and partner agencies will be evaluated for their relative impact on water quality. An important benefit or outcome of the project would be the identification of implementation strategies that get ahead of growth so that it can be directed in an environmentally-safe and community-accepted direction. A holistic look at impacts to water quality is critical because it would be unfortunate to implement best management practices aimed to correct an impairment caused by the existing agricultural activities, only to have the impairment replaced by land use activities associated with urban development, i.e. pet waste and stormwater, that is only in the planning stages.

Section A6: Project Goals and Task Description

The project will include historical data collection on the Geronimo Creek and Alligator Creek watersheds. The data will be used to address pollutant sources and gather basic information. Using a spatially specific geographic information system and the appropriate model, estimates will be made concerning the fate and transport of pollutants and E. coli within the watershed. The project will result in the production of a WPP that has been developed with buy-in from local stakeholders and governmental entities. The WPP will identify implementable best management practices that are based on the goals of water quality improvement and watershed protection. A comprehensive watershed approach will be a strong focus with concentrations on the most significant sources of agricultural nonpoint source pollution contributing to the current impairments, at the same time looking ahead at potential sources of pollution from urban and suburban growth. The outcomes of the project, which include data in the form of identification and estimation of sources and in partnerships with local stakeholders, would benefit the local governmental entities as they look at developing master plan and stormwater management strategies. Recommended best management practices that are identified by the steering committee, work groups and partner agencies will be evaluated for their relative impact on water quality. An important benefit or outcome of the project would be the identification of implementation strategies that get ahead of growth so that it can be directed in an environmentally-safe and community-accepted direction. A holistic look at impacts to water quality is critical because it would be unfortunate to implement best management practices aimed to correct an impairment caused by the existing agricultural activities, only to have the impairment replaced by land use activities associated with urban development, i.e. pet waste and stormwater, that is only in the planning stages. The WPP could be utilized by the city and county as they develop master plans, stormwater management plans and developmental ordinances.

Specifically, this QAPP is intended to only cover a portion of the overall project described above. GBRA sub-contracted a historical data assimilation and analysis, spatially explicit modeling, load duration curve development and stakeholder facilitation to Texas A&M University. Subtasks of the TSSWCB project #08-06 included in this QAPP are: subtasks 3.1, 4.1, 4.2, 4.3 and 4.4. Subtask 3.2 is covered under a QAPP developed by GBRA and it will be referred to in this QAPP. As a result, task descriptions for tasks and subtasks not included under this QAPP are not provided; for further information on those tasks, see the GBRA QAPP for this project.

The results of the modeling effort will be included in a technical report submitted to TSSWCB and Texas AgriLife Extension Service for inclusion in the Geronimo Creek WPP (TSSWCB Project 08-06).

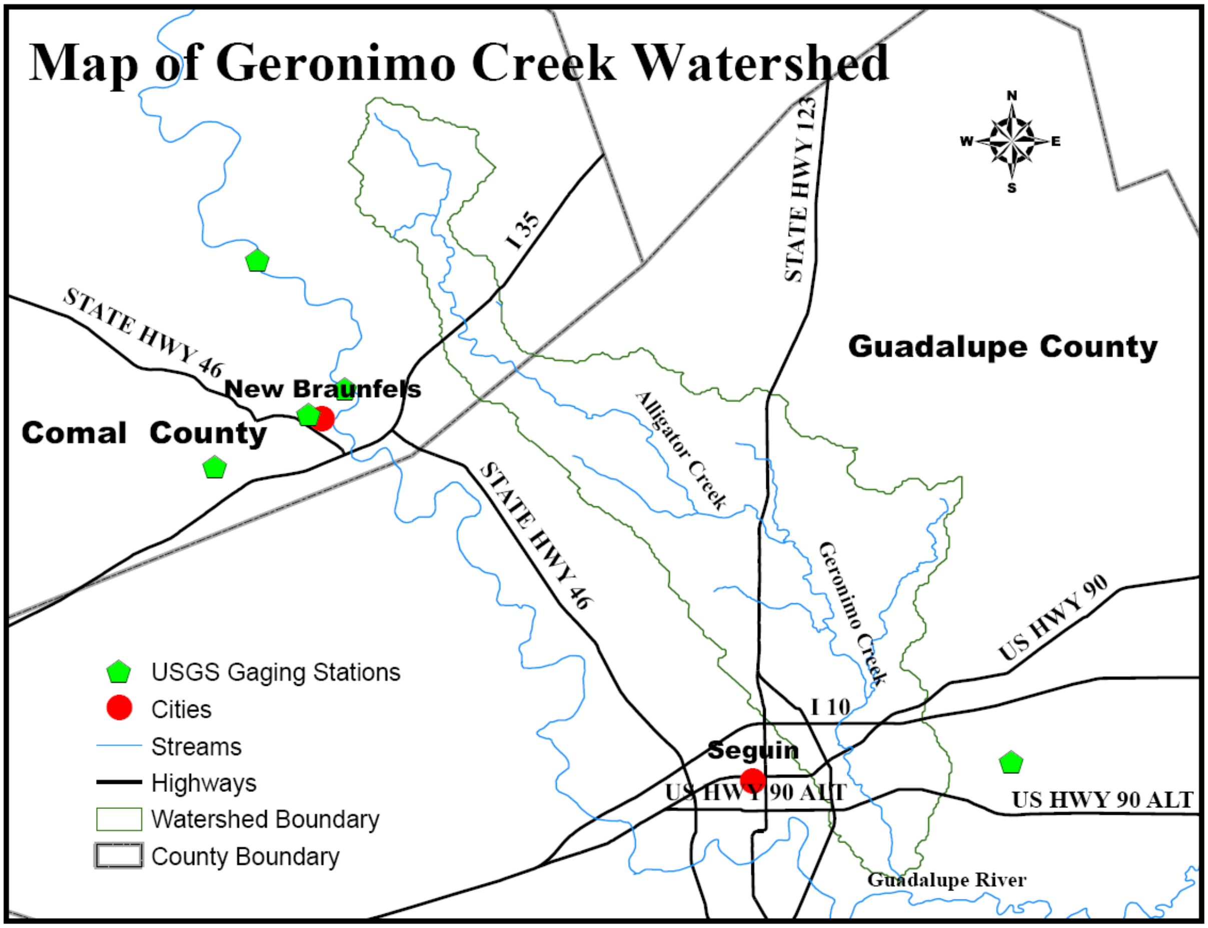


Figure A.6-1. The Geronimo Creek Watershed

Task 3: Collect Data

Objective: Review historical data and identify data gaps to support the development of the WPP.

Subtask 3.1: Compile historical and baseline data on the Geronimo Creek watershed, including water quality data, flows, land use, topography, soil types and vegetation to determine the most appropriate water quality monitoring locations. (Start Date: Month 9; Completion Date: Month 13)

Deliverables:

- Historical baseline data report, including digital sub-watershed maps

Task 4: Modeling and Analysis

Objective: BAEN and SSL, with assistance from Espey Consultants Incorporated, will conduct data analysis and develop analytical tools that support the development of a WPP by producing geographical information including gathering or verifying land use data appropriate for SELECT; Flow data for Flow Duration Curve development using Soil Water Assessment Tool (SWAT) model; Load Duration Curve data analysis for bacteria; SELECT data analysis to rank sources of the impairments due to bacteria; provide this data analysis to develop a final technical report.

Subtask 4.1: BAEN and SSL will gather necessary data and information to develop land use/land cover data and maps appropriate for potential source characterization using SELECT

Subtask 4.2: BAEN and SSL will model flows appropriate for Flow and Load Duration Curve Development in the watershed and estimate Pollutant Load Reductions required for each site.

Deliverables

- Technical data including graphs and maps for use in stakeholder meetings and WPP
- Technical report detailing modeling results

The purpose of this QAPP is to clearly delineate the QA policy, management structure, and procedures, which will be used to implement the QA requirements necessary to analyzing data using Load Duration Curves and spatially explicit modeling under subtasks 3.1 and Task 4.

Table A6-1. Project Plan Milestones

Task	Project Milestones	Agency	Start	End
3.1	Compile historical and baseline data on the Geronimo Creek watershed, including water quality data, flows, land use, topography, soil types and vegetation to determine the most appropriate WQ monitoring locations.	BAEN, SSL	June 09	July 12
4.1	BAEN and SSL will gather necessary data and information to develop land use/land cover data and maps appropriate for potential source characterization using SELECT	BAEN, SSL	Aug 09	July 12
4.2	BAEN and SSL will model flows appropriate for Flow and Load Duration Curve Development in the watershed and estimate Pollutant Load Reductions required for each site.	BAEN, SSL	Aug 09	July 12

Model descriptions

Spatially Explicit Load Enrichment Calculation Tool (SELECT)

The Center for Total Maximum Daily Load (TMDL) and Watershed Studies at Virginia Tech has been involved in TMDL development for bacteria impairments. The Center personnel developed a systematic process for source characterization that includes the following steps:

- inventorying bacterial sources (including livestock, wildlife, humans, and pets);
- distributing estimated loads to the land as a function of land use and source type; and
- generating bacterial load input parameters for watershed-scale simulation models.

This process provides a consistent approach that is necessary to develop comprehensive bacteria TMDLs. The Center personnel developed a software tool, the Bacteria Source Load Calculator (BSLC), to assist with the bacterial source characterization process and to automate the creation of input files for water quality modeling (Zeckoski, et al., 2005). But BSLC does not spatially reference the sources. A spatially-explicit tool, SELECT is being developed by the SSL and BAEN Department at Texas A&M University to calculate contaminant-loads resulting from various sources within a watershed. SELECT spatially references the sources, and is being developed under ArcGIS 9 environment. SELECT will calculate and allocate pathogen loading to a stream from various sources within a watershed. All loads will be spatially referenced. In order to allocate the *E. coli* load throughout the Geronimo Creek watershed, estimations of the source contributions will be made. This in turn allows the sources and locations to be ranked according to their potential contribution for each sub-watershed. The populations of agricultural animals, wildlife, and domestic pets will be calculated and distributed throughout each watershed according to appropriate land use. Septic system contribution will also be estimated based on criteria including distance to a stream, soil type, failure rate, and age of system. Once the watershed profile is developed for each potential source, the information can be aggregated to the sub-watershed level to identify the top contributing areas in the watershed.

Load duration Curve (LDC)

This is a simple and an effective first-step methodology to obtain data-based TMDLs (Cleland, 2003; Stiles, 2001). A duration curve is a graph that illustrates the percentage of time during which a given parameter's value is equaled or exceeded. For example, a flow duration curve (FDC) (Figure A6-1) uses the hydrograph of the observed stream flows to calculate and depict the percentage of time the flows are equaled or exceeded.

A LDC (Figure A6-2), which is related to the FDC, shows the corresponding relationship between the contaminant loadings and stream flow conditions at the monitoring site. In this manner, it assists in determining patterns in pollution loading (point sources, nonpoint sources, erosion, etc.) depending on the streamflow conditions. Based on the observed patterns, specific restoration plans can be implemented that target a particular kind of pollutant source. For example, if the pollutant loads exceed the allowable loads (see Figure A6-2) for low stream flow regimes, then the point sources such as waste water treatment plants and direct deposition sources (wildlife, livestock) should be targeted for the restoration plans. Another main advantage of the LDC method is that it can also be used to evaluate the current impairment as some percent of samples which exceed the standard, and therefore it allows for the rapid development of TMDLs (Stiles, 2001).

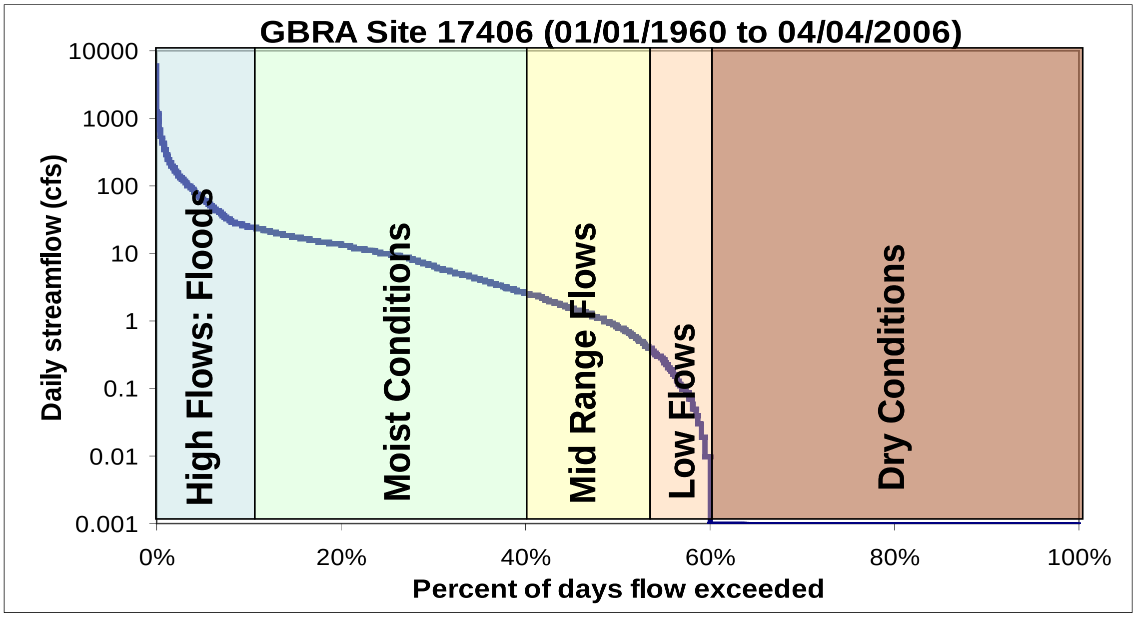


Figure A6-2 Flow Duration Curve (FDC) for streamflow conditions at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX. The flow data at 17406 was obtained from the nearest USGS gage station 8172400, after adjusting for subwatershed aerial contribution during runoff events.

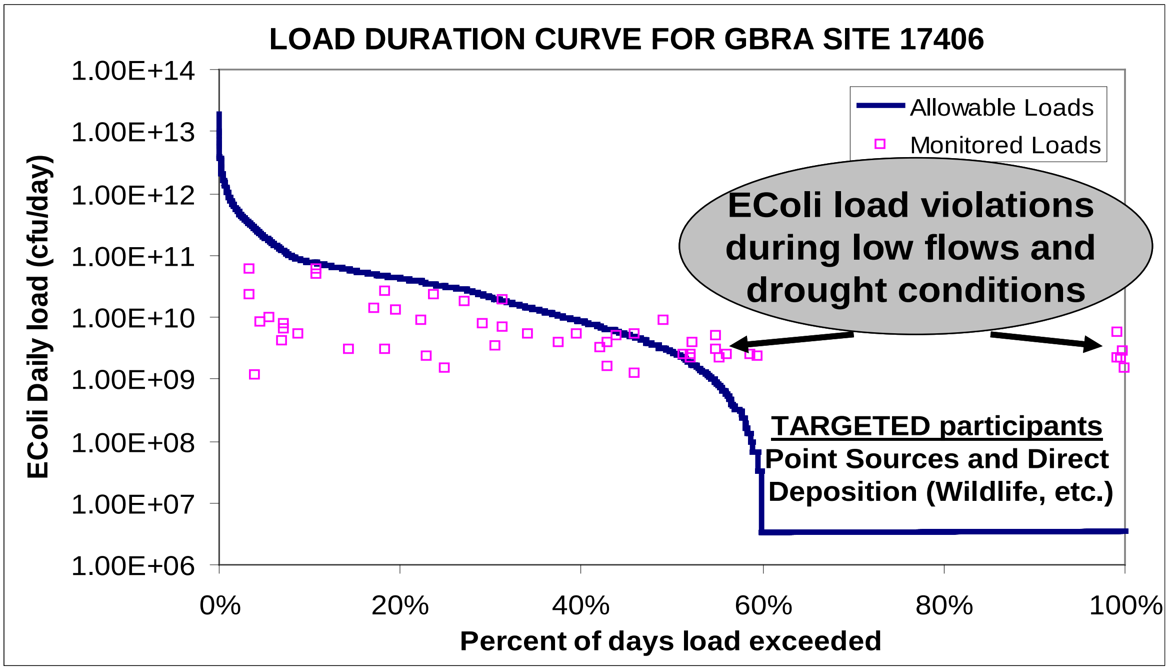


Figure A6-3 Load Duration Curve for *E. coli* at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX. The flow data at 17406 was obtained from the nearest USGS gage station 8172400, after adjusting for subwatershed aerial contribution during runoff events.

Soil and Water Assessment Tool (SWAT)

SWAT is a physically-based watershed and landscape simulation model developed by the USDA-ARS. Major components of the model include hydrology, weather, erosion, soil temperature, crop growth, nutrients, pesticides and agricultural management. SWAT has the ability to predict changes in sediment, nutrients (i.e. organic and inorganic nitrogen and organic and soluble phosphorus), pesticides, dissolved oxygen, bacteria and algae loadings from different management conditions in large un-gauged basins. SWAT operates on a daily time step and can be used for long-term simulations. The model output is available in daily, monthly and annual time scales. SWAT coding and subroutines are modular, allowing for addition of new subroutines when necessary. SWAT has been successfully applied to model flow and water quality issues including sediments, nutrients and pesticides in watersheds. SWAT will be used in this study to generate flow data for Alligator and Geronimo Creeks due to the lack of available flow data for these water bodies. This flow data will be used to develop LDCs and incorporated into the SELECT model analysis of the watershed.

Landuse and Land Cover Classification

A Land Use/Land Cover dataset for Geronimo Creek watershed will be developed using a prior Texas Parks and Wildlife Department classification and 2008 National Agricultural Imagery Program (NAIP), 1-meter resolution imagery. The classification is intended to provide a rough classification of several types of cover. The land use classification scheme to be used in this delineation will include:

Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil

Developed Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.

Developed Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.

Developed High Intensity- Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100% of the total cover.

Barren Land - (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover and includes transitional areas.

Forested Land - Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover.

Near Riparian Forested Land - Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover. These areas are found following in near proximity to streams, creeks and/or rivers.

Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% but less than 50% of total vegetation cover.

Rangeland - Areas of unmanaged shrubs, grasses, or shrub-grass mixtures

Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

Section A7: Quality Objectives and Criteria for Model Inputs / Outputs

Faculty in BAEN and SSL at TAMU, with assistance from Espey Consultants, will conduct a phased modeling effort to develop pollutant source and loading information and estimates of needed bacteria and nitrate reductions. The objectives of the water quality modeling for this project are as follows:

1) Develop and obtain approval for a QAPP
2) Spatially characterize and rank sources of bacteria and within the watershed using SELECT, a spatially-explicit GIS methodology. Divide the area into sub-watersheds and identify, quantify and rank pollutant loads from various sources, i.e. agriculture, urban/human, wildlife, and other sources in the study area.
3) Utilize SWAT to develop flow estimations for the Geronimo and Alligator Creek watershed by modeling flow in a larger portion of the Guadalupe River watershed (including Geronimo and Alligator Creeks) and comparing model outputs to historic flow data from U.S. Geological Survey (USGS) gages 08169500 and 08169792.
4) Develop LDCs to analyze the temporal trends in the observed water quantity and quality data for the watershed. The LDCs will be developed using currently existing water quality and flow data available from GBRA collected under TSSWCB project 08-06 and data previously collected by GBRA under their CRP QAPP. Obtain an interpolated model to simulate the trends of the monitored data. Evaluate the violations and the required load-reductions of bacteria and nitrates for different flow-rate regimes (low, medium, and high flow) using LDC and interpolated model.

SELECT – this approach is being developed by the Spatial Sciences Laboratory (SSL) at TAMU and BAEN. It is similar to BSCL (Zeckoski, et al. 2005) in TMDL development. High quality spatial data (most recently available land use and land cover data, SSURGO soils data, NHD, etc) will be processed and utilized in SELECT approach. Distributions for input parameters for SELECT will be created based on literature values and expert knowledge.

SWAT – this model will be used solely as a tool to predict flow for Geronimo and Alligator Creeks. These creeks have no long-term flow data available thus causing significant uncertainty in LDC and SELECT analyses. SWAT will predict flow by modeling a portion of the Guadalupe River watershed that includes Geronimo and Alligator Creeks and will utilize long-term stream flow data available from GBRA and USGS stream gages upstream and downstream of the Geronimo Creek and Guadalupe River confluence. The same spatial data sets utilized in the SELECT model will be used as inputs or initial conditions for the SWAT model simulations. Annual flow for the modeled watershed will be calibrated to be within 15% of recorded annual flow at the downstream USGS gage. Partitioning of stream flow between surface and baseflow will also be calibrated according to the base flow filter to be within 15% of measured values. Outputs from the calibrated SWAT model will predict incremental flow at designated points in Geronimo and Alligator Creeks. This generated flow data will be incorporated into SELECT and LDC analyses.

LDC – this approach has been utilized in several TMDL projects as an initial screening-tool to evaluate the actual temporal load trends in streams (Cleland, 2003; Stiles, 2001). In cases of violations, it is necessary to determine the required load-reduction in that region near the monitoring station. Load-reductions should be calculated for all flow-regimes of the stream. In order to do this continuous monitoring data will be simulated using the actual monitoring data by regression methods. Uncertainty of the model will be estimated via residual error analysis. The straight line passing through residual error plot should have a slope of zero.

LULC - this methodology will be used to develop accurate coverages of land use and land cover layers specific to the Geronimo and Alligator Creek watersheds that will serve as an input to the SELECT model. Two sets of aerial imagery will be used to classify and accurately describe land use types in the watershed.

Section A8: Special Training Requirements/Certification

Watershed Modeling

All personnel involved in model calibration, validation, and development will have the appropriate education and training required to adequately perform their duties. No special certifications are required.

Landuse and Land Cover Classification

No special certifications are required. However, all personnel involved in classification of land use and land cover will have the appropriate education and training required to adequately perform their duties.

Section A9: Documentation and Records

All records, including modeler's notebooks and electronic files, will be archived by BAEN for at least five years. These records will document model testing, calibration, and evaluation and will include documentation of written rationale for selection of models, record of code verification (hand-calculation checks, comparison to other models), source of historical data, and source of new theory, calibration and sensitivity analyses results, and documentation of adjustments to parameter values due to calibration. Electronic data on the project computers and the network server are backed up daily to the network drive and weekly to an external hard drive and the PI's computer. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Quarterly progress reports disseminated to the individuals listed in section A3 will note activities conducted in connection with the water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP. Final reports on the SELECT modeling analysis and the LDC analysis will be developed. Outcomes will be submitted to the established stakeholder group and utilized in future TMDL development.

Corrective Action Reports (CARs) will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference at TWRI and will be disseminated to the individuals listed in section A3. CARs resulting in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in updates or amendments to the QAPP.

Table A9-1 Project Documents and Records

Document/Record	Location	Retention	Form
QAPP, amendments, and appendices	TWRI	5 years	Paper/Electronic
QAPP distribution documentation	TWRI	5 years	Paper/Electronic
Corrective Action Reports (CARs)	TWRI	5 years	Paper/Electronic
Modeler Notebooks	BAEN/SSL/Espey	5 years	Paper
Model Input Data Files	BAEN/SSL/Espey	5 years	Electronic
Model Calibration Documentation	BAEN/SSL/Espey	5 years	Paper/Electronic
Model Validation Documentation	BAEN/SSL/Espey	5 years	Paper/Electronic
Model Output	BAEN/SSL/Espey	5 years	Paper/Electronic
Progress reports/ Final Reports	Extension/TSSWCB	3 years	Paper/Electronic

Digital files of land cover data for each watershed will be produced in shapefile or ArcGIS grid format and stored on CD-ROM disks. Multi-color hard copy maps of land cover can be produced at various geographic scales from these digital files.

QAPP Revision

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 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 can be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and non-conformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests or amendments are directed from the TWRI Project Lead to the TSSWCB Project Manager in writing. The changes are effective immediately upon approval by the TSSWCB Project manager and Quality Assurance Officer, or their designees, and the EPA Project Officer. Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved QAPP Expedited Amendment form will be 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.

Section B1: Sampling Process Design (Experimental Design)

Not relevant.

Section B2: Data Collection Methods

Watershed Modeling
Not relevant.

Landuse and Land Cover Classification
Ancillary data will be used to classify the satellite based images into classes. The SSL is using existing aerial photos, topo maps and field data from the Texas Parks and Wildlife (TPWD) as sources to define LULC polygons. The geographic location of the polygons is known and is matched to the same location on the imagery.

Ancillary data used will include NAIP images: Comal County 2008 and Guadalupe County 2008. These images have a spatial resolution of 1 meter. TPWD classifications of Geronimo and Alligator Creek will be used to aid in classification of NAIP images. This is a highly accurate classification that consists of polygons representing numerous classes.

Section B3: Sample Handling and Custody Requirements

Watershed Modeling

Not relevant.

Landuse and Land Cover Classification

All ancillary data sources are filed by watershed in the SSL Lab. When hardcopy data is digitized or otherwise entered into the computer, backups of the digital files to removable media will be made to ensure no loss of data due to machine failure.

Section B4: Analytical Methods

Watershed Modeling
Not relevant.

Landuse and Land Cover Classification
The Comal and Guadalupe county NAIP images were mosaiced and clipped to the watershed boundary in order to create a complete coverage. The watershed was classified using two supervised, pixel-based classification algorithms; Mahalanobis Distance and Maximum Likelihood. Theses classification methods were performed using ENVI geospatial imagery processing and analysis software.

A mosaic of the 2008 NAIP imagery from Comal and Guadalupe counties was used to classify the watershed. The following classes were identified using regions of interest: Open Water, Barren, Urban, Forest, Pasture, and Cultivated Crops. Regions of interest were selected in across the watershed in the form of points. The larger portion of the image was classified using Maximum Likelihood. Due to the similarity between barren land and urban, two subsets were made for areas with large areas of barren land to accurately classify each region without overestimated barren land throughout the study area. Each subset was classified individually using Mahalanobis Distance. The subsets were then reclassified to remove everything but barren land. In other areas, pastures and crops were difficult to differentiate so a class called pasture/crops was created to account for this. Also, the crops class was split into red and green classes due to variability throughout the image. The TPWD classifications were compared to the NAIP images to determine land uses but the classification was 2-4 years older than the images and some areas had changed. In addition, TPWD image forest and riparian lands were used as these classes do not tend to change much in a short period and TPWD has most detail information on these classifications. The most accurate classifications for the two subsets and the main image were selected and converted to an Erdas Imagine file. The barren subsets and the complete classification were then merged together using spatial analyst.

Section B5: Quality Control Requirements

Watershed Modeling
Not relevant.

Landuse and Land Cover Classification
Cross referencing NAIP 2008 images for Comal and Guadalupe Counties with the highly accurate 2004 TPWD Geronimo and Alligator Creek Classifications served as a QC check. The TPWD data was ground-truthed and verified using field based methods.

Section B6: Equipment Testing, Inspection, & Maintenance Requirements

Not relevant.

Section B7: Instrument Calibration and Frequency

Not relevant for LDC and SELECT analyses or LULC classification.

SWAT

Calibration is the process where the model input parameters are adjusted until the simulated data from the model match with observed data. Model calibration, in this setting, is defined as how well the model is able to reproduce current observed flow rates as measured from multiple field surveys and stored in the respective monitoring databases. Model parameters related to watershed/landscape processes will be adjusted to match the measured and simulated flow at key locations in the watershed. During the calibration process, all model parameters will be adjusted within literature recommended ranges. Calibration will be done to represent normal, wet and dry years. Time series plots (between simulated and observed data) and statistical measures such as mean, standard deviation, coefficient of determination and Nash-Suttcliffe simulation efficiency will be used to evaluate the prediction (performance) of the model during calibration. Calibration is done systematically, first for flow, then for sediment and followed by organic and mineral nutrients if those components are being modeled. In this case, they are not.

Annual flow will be calibrated so that predicted values agree to measured values within 15%. Partitioning of stream flow between surface and subsurface flows (as defined by base flow filter) will be calibrated so that predicted values agree to measured values within 15%.

If calibration standards are not obtained (±15% of measured output), BAEN/SSL will check input data for deficiencies and correct identified errors. Model algorithms will be checked for deficiencies and corrected, and the model will be recalibrated. If at that time, predictive values do not fall within the established standards, a corrective action report will be submitted to TSSWCB with the following quarterly report. If these steps do not bring predicted values within calibration standards, the TWRI Quality Assurance Officer will work with TSSWCB and EPA to arrive at an agreeable compromise.

GIS data required for SWAT modeling (i.e., topography, land use, soils and river segments) will be collected for the Guadalupe River watershed between available USGS flow gages up and downstream of the confluence of Geronimo Creek and the Guadalupe River. Data collected for the watershed will be processed and run for the watershed to develop model inputs. Qualitative assessments will be done when evaluating the outcome of model calibration by evaluating how well the outputs of the fitted model are able to match the overall trend in prediction over time and over the entire watershed area.

Calibration of a SWAT model for the watershed will begin after QAPP approval. After collecting all available data for the watershed, the SWAT model will be calibrated to measured stream flow. All model parameters will be adjusted within ranges recommended in published literature. Then the model will be validated without adjusting any parameters. The calibration period will be from 2000-2005 (with 2000 as preparation period) and the validation period will be from 2006-2008. Time series plots and standard statistical measures will be used to evaluate the performance of modeling during calibration and validation. After calibration, the existing condition will be simulated for a 30-year period to determine time series of average daily flow at key sampling locations in the Geronimo Creek watershed.

Section B8: Inspection/Acceptance Requirements for Supplies and Consumables

Not relevant.

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

SELECT and LDC Analyses

Water quality data collected by the GBRA, specifically *E. coli*, nitrates and flow, will be used along with data from two other projects to conduct the SELECT (*E. coli* only) and LDC (*E. coli* and nitrates) analyses. The GBRA is a partner in the Clean Rivers Program for the state of Texas. As such, they collect data on a regular basis for routine water quality assessment as part of the state's mandate for CWA §305(b) – Water Quality Inventory Report. These data also are used by Texas for consideration of water bodies to be added to their list of impaired water body segments, as described in CWA §303(d). Additional data obtained from the Texas Commission Environmental Quality (TCEQ) are from the TRACS database.

Data collected under the *Surface Water Quality Monitoring to Support the Development of a Watershed Protection Plan for Geronimo Creek* project (TSSWCB Project 08-06) will also be used to develop SELECT and LDC analyses. These data will be collected in accordance with the approved QAPP for the project and will be collected by GBRA as well. Data that may be used from this project include water quality, rainfall and streamflow information.

All data used in the modeling procedures for this project are collected in accordance with approved quality assurance measures under the state's Clean Rivers Program, TCEQ, Texas Water Development Board, USDA, National Weather Service, or USGS.

GIS data to be used are 2008 NAIP and 2004 TPWD imagery, SSURGO and Computer Based Mapping System (CBMS) soils, USGS National Land Cover Dataset (NLCD) landuse, National Hydrography Dataset (NHD), Census data (2000), Agricultural Census data from USDA-National Agriculture Statistics Service (2002), and the USGS 30-meter resolution digital elevation model. Depending on the availability of the GIS layers from different data sources, efforts will be made to update the spatial data to the most recent year.

Because most historical data is of known and acceptable quality and were collected and analyzed in a manner comparable and consistent with needs for this project, no limitations will be placed on their use, except where known deviations have occurred.

SWAT Modeling

Various data such as land use (current and historical), soil, best management practice (BMP) implementation locations, topography, sub-watershed delineation (matching previously delineated sub-watersheds if available), long-term weather data, crop management practices and stream flow for the Guadalupe River watershed segment including the Geronimo Creek watershed will be compiled for the period of 2000-2008 from sources such as USGS, TCEQ, Texas Water Development Board, the Texas Parks and Wildlife Department, GBRA, Texas AgriLife Extension Service, Texas AgriLife Research, and the Natural Resource Conservation Service (NRCS).

Meteorological, in-stream flow and wastewater flow data will be compiled along with information on the type and extent of management measures implemented for both agricultural and urban areas in the watershed. GIS data that will be used are SSURGO and CBMS soils, USGS NLCD landuse, and the USGS 30-meter resolution digital elevation model. Measured precipitation will be collected from National Weather Service climate stations in and near the modeled area for input to SWAT. Measured stream flow will be collected from USGS, GBRA and other stream gage stations.

Information on typical crops and management practices (e.g. tillage practices, irrigation management, and nutrient application rate and timing) will be obtained from Texas AgriLife Extension Service, Texas AgriLife Research, TSSWCB, and local NRCS and Soil and Water Conservation District (SWCD) field offices. Existing BMPs (e.g. land leveling, irrigation management, nutrient management methods) will be obtained through the NRCS, TSSWCB, and SWCD field offices. SWAT inputs will be prepared to accurately represent existing conditions and management.

All data used in the modeling procedures for this project are collected in accordance with an approved QAPP under the state's Clean Rivers Program, the TSSWCB NPS Program, TCEQ's targeting monitoring approach, the Texas Water Development Board, or the USGS.

Landuse and Land Cover Classification

NAIP images for Comal County 2008 and Guadalupe County 2008 with a spatial resolution of 1 meter will be used in conjunction with 2004 TPWD classification of Geronimo and Alligator Creek.

Both datasets are of known and acceptable quality and were collected/conducted in accordance with relevant QA/QC guidance.

NAIP imagery is acquired at a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within six meters of photo-identifiable ground control points, which are used during image inspection. The spectral resolution is a four band format; natural color (Red, Green and Blue, or RGB) plus Near Infrared.

NAIP imagery products are available either as digital ortho quarter quad tiles with individual image tiles within the mosaic covers a 3.75 x 3.75 minute quarter quadrangle plus a 300 meter buffer on all four sides. The DOQQs are geotiffs, and the area corresponds to the USGS topographic quadrangles. All individual tile images and the resulting mosaic were rectified in the UTM coordinate system, NAD 83, and cast into a single predetermined UTM zone.

Section B10: Data Management

Systems Design

BAEN, SSL and Espey Consultants use laptop personal computers and desktop personal computers. The computers run Windows XP or Vista operating system. Software includes Microsoft® Word, Microsoft® Excel, Microsoft® Access, and a Statistical Analysis System database management system run through Windows XP operating system. All GIS analysis will be performed using ArcGIS 9x.

Backup and Disaster Recovery

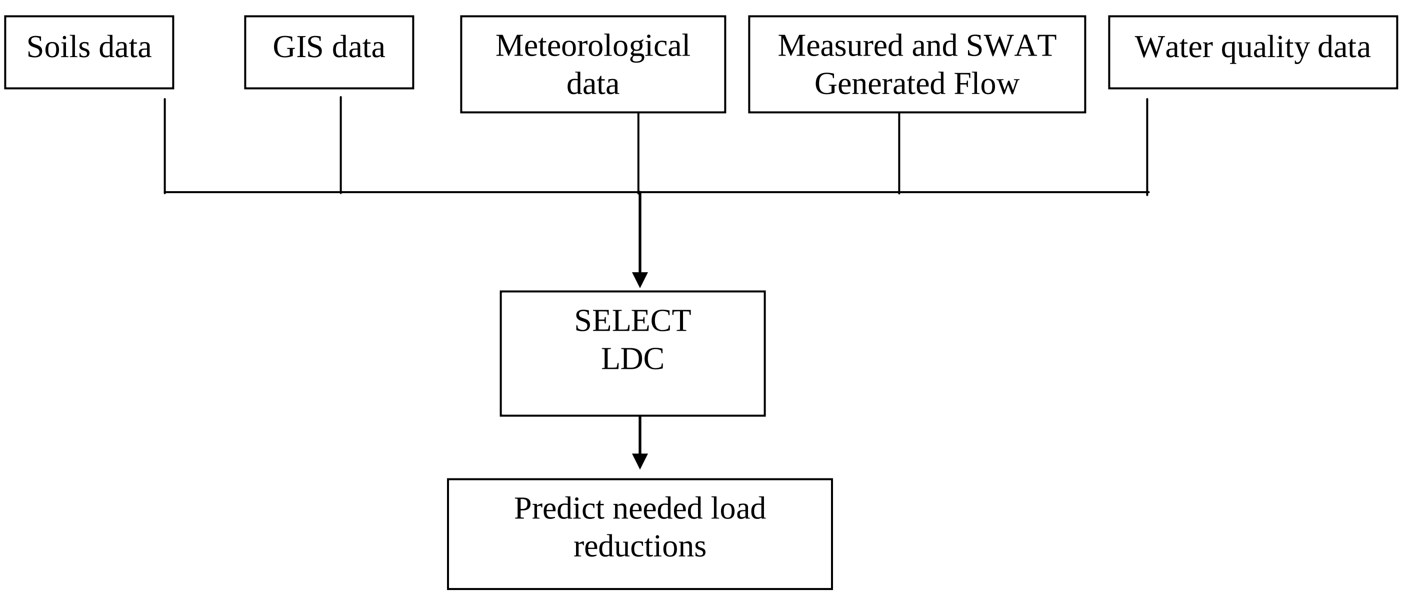
The personal computer drives are backed up daily on the network server and on a weekly basis to an external hard drive. Data are also backed up weekly to the PI's computer. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Archives and Data Retention

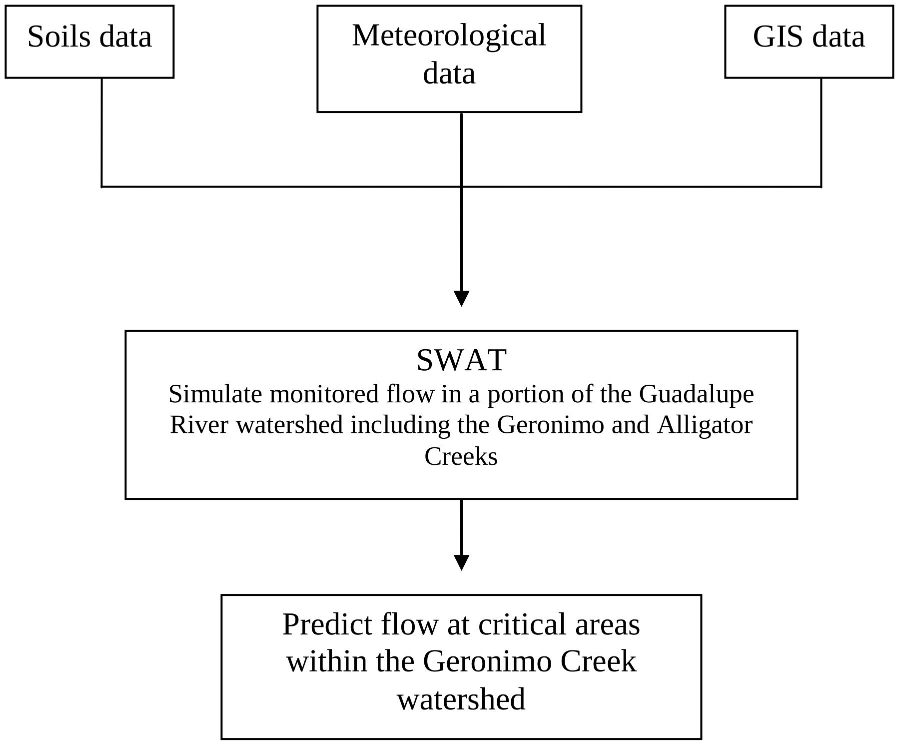
Original data recorded on paper files are stored for at least five years. Data in electronic format are stored on tape drives in a climate controlled, fire-resistant storage area on the TAMU campus.

Figure B10-1. Information Dissemination Diagrams

SELECT



SWAT



Landuse and Land Cover Classification

A combination of IBM compatible microcomputers with a Windows XP Operating System will be used to process the data. An effort was made to purchase machines with the most memory, largest hard drives and fastest processing speeds that were available at the time. Additional hard drive space and random access memory will be purchased as project needs require. A suite of software will be used to process the data. All software packages are industry standard and represent the best application available for each processing function.

All GIS and LULC data will be backed up on r/w CD's weekly and stored in separate area away from the computer. At least 10% of all data manually entered in the database will be reviewed for accuracy by the Project Manager to ensure that there are no transcription errors. Hard copies of data will be printed and housed in the Spatial Sciences Laboratory for a period of five years.

Section C1: Assessments and Response Actions

Table C1.1 presents the types of assessments and response actions for activities applicable to the QAPP.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party(ies)	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TWRI, SCSC, BAEN	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of performance and data quality.	Report to project lead in Quarterly Report
Technical 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. Facility review and data management as they relate to the project.	30 days to respond in writing to the TSSWCB QAO to address corrective actions

In addition to those listed above, the following assessment and response actions will be applied to modeling activities. As described in Section B9 (Non-direct Measurements), modeling staff will evaluate data to be used in calibration and as model input according to criteria discussed in Section A7 (Quality Objectives and Criteria for Model Inputs/Outputs Data) and will follow-up with the various data sources on any concerns that may arise.

The model calibration procedure is discussed in Section D2 (Validation and Verification Methods), and criteria for acceptable outcomes are provided in Section A7 (Quality Objectives and Criteria for Model Inputs/Outputs).

Results will be reported to the project QAO in the format provided in Section A9. If agreement is not achieved between the calibration standards and the predictive values, corrective action will be taken by the Project Manager to assure that the correct files are read appropriately and the test is repeated to document compliance. 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 and will be documented utilizing corrective action reports (CARs). CARs (Appendix A) will be filled out to document the problems and the remedial action taken. Copies of CARs will be included in QPRs and will discuss any problems encountered and solutions made. These CARs are the responsibility of the QAO and the Project Manager and will be disseminated to individuals listed in section A3. If the predicted value cannot be brought within calibration standards, the QAO will work with TSSWCB to arrive at an agreeable compromise.

Software requirements, software design, or code are examined 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 its 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.

Landuse and Land Cover Classification

The SSL Project Manager will conduct in-house audits of data quality and staff performance to assure that work is being performed according to standards. Audits will be documented in a written laboratory journal and initialed by the SSL PM. If audits show that the work is not being performed according to standards, immediate corrective action will be implemented and documented in the laboratory journal.

The TSSWCB QAO (or designee) may conduct an audit of the field or technical systems activities for this project as needed. The SSL Project Manager will have the responsibility for initiating and implementing response actions associated with findings identified during the on-site audit. Once the response actions have been implemented, the TSSWCB QAO (or designee) may perform a follow-up audit to verify and document that the response actions were implemented effectively. Records of audit findings and corrective actions are maintained by the TSSWCB Project Manager and TWRI QAO. Corrective action documentation will be submitted to the TSSWCB Project Manager with the 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.

Section C2: Reports to Management

Quarterly progress reports developed by the Project Manager and Project Co-Leaders will note activities conducted in connection with the water quality modeling project and LULC updates, items or areas identified as potential problems, and any variations or supplements to the QAPP. CAR forms will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference by the Technical Consultants and at TWRI and disseminated to individuals listed in section A3. 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.

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. CARs will be filled out to document the problems and the remedial action taken. Copies of CARs will be included in quarterly progress reports.

The final report for this project will be a technical report detailing the results of LDC and SELECT work conducted under this QAPP. Items in this report will include a very brief description of methodologies utilized and assumed initial conditions, a detailed narrative regarding specific LDC and SELECT findings and a discussion/conclusions section that highlights the implications of these findings.

Section D1: Data Review, Validation and Verification

All data obtained will be reviewed, validated, and verified against the data quality objects outlined in Section A7, "Quality Objectives and Criteria for Model Inputs / Outputs." Only those data that are supported by appropriate QC will be considered acceptable for use.

The procedures for verification and validation are described in Section D2, below. The Technical Consultants are responsible for ensuring that data are properly reviewed, verified, and submitted in the required format for the project database. Finally, the TWRI QAO is responsible for validating that all data collected meet the DQOs of the project and are suitable for reporting.

Section D2: Validation Methods

SELECT and LDC

There is no validation and calibration for the SELECT model or LDC as they are data processors.

SWAT

In the validation process for SWAT, the model is operated with input parameters set during the calibration process, as described in Section B7, without any change and the results are compared to the measured for the period of 2000-2008 to evaluate the model prediction. The same evaluation measures will be used for assessing the performance of the model during validation. In case the matching between simulated and observed data is not to the standard, the calibration process will be revisited until a best fit between simulated and observed data is obtained. The validation and verification process will be conducted by the Technical Consultants.

SWAT is built with state-of-the-art components with an attempt to simulate the processes physically and realistically. Most of the model inputs are physically based (that is, based on readily available information). It is important to understand that SWAT is not a parametric model with a formal optimization procedure (as part of the calibration process) to fit any data. Instead, a few input variables that are not well defined physically such as runoff curve number and Universal Soil Loss Equation's cover and management factor (C factor) may be adjusted to provide a better fit. Moreover, these model parameters are adjusted within literature recommended values so that the results are scientifically valid and defensible. In addition, statistical measures used for evaluating the model's predicted data using the observed data during calibration and validation help to maintain the quality of the model simulation processes and the model results reliable.

Landuse and Land Cover Classification

Verification, validation and integrity review of LULC data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the SSL Project Manager. The LULC data generated are evaluated against ground control points and project specifications and are checked for errors. Potential outliers are identified by examination for unreasonable data. If a question arises or an error or potential outlier is identified, then issues will be resolved through mutual consultation between the SSL Project Manager, TWRI QAO, and TSSWCB Project Manager. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork.

The final element of the validation process is consideration of any findings identified during assessments or audits conducted by the TWRI or TSSWCB QAO. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the SSL Project Manager in coordination with the TWRI QAO validates that the data meet the data quality objectives of the project and are suitable for reporting to the TSSWCB.

Section D3: Reconciliation with User Requirements

SELECT and LDC

The SELECT modeling framework developed for this project will be used to evaluate bacteria loading in the Geronimo Creek watershed. It will provide information pertaining to watershed characteristics and to the prediction of possible pollution, the sources of this pollution and will provide critical information to assist in identifying management practices to prevent pollution loading in area streams. This, in turn, will be useful for incorporation in the WPP being developed under TSSWCB Project 08-06.

The LDC framework utilized for this project will be used to evaluate bacteria and nitrate loading in relation to flow regimes in Geronimo Creek. This approach will utilize flow predictions generated by SWAT and pair them with real bacteria and nitrate water quality data to illustrate times when loadings exceeds standards. These analyses will aid in targeting water quality best management practices recommendations to the most likely areas of bacteria and nitrate impairment.

SWAT

The SWAT modeling framework developed for this project will be used to evaluate flow contributions from Geronimo Creek into the Guadalupe River. Model results will be incorporated into SELECT and LDC analyses conducted by BAEN, SSL and Espey Consultants. This input data developed by the SWAT model is a critical component of the SELECT and LDC tasks. Statistical measures such as means, standard deviation, coefficient of determination (r^2), and Nash-Suttcliffe simulation efficiency to show the model's prediction with respect to observed data at several locations in the watershed will also be provided.

The final data will be reviewed to ensure that it meets the requirements as described in this QAPP. CARs 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 water quality agency decision-makers. These summaries, along with a description of any limitations on data use, will be included in the final report.

Landuse and Land Cover Classification

Once the final version of each Land Use / Land Cover Map is produced, the TSSWCB Project Manager will review the product and the accuracy assessment report to determine if they fall within the acceptance limits as defined in this QAPP. Completeness will also be evaluated to determine if the completeness goal for this project has been met. If data quality indicators do not meet the project's requirements as outlined in this QAPP the data may be returned for revisions.

These data, and data collected by other organizations, will subsequently be analyzed and used for watershed assessment, watershed plan development, and modeling activities. Thus, data which do not meet requirements will not be submitted to the TSSWCB nor will be considered appropriate for any of the uses noted above.

References

Cleland, B. 2003. TMDL Development from the "bottom up" – Part III: Duration Curves and wet-weather assessments. America's Clean Water Foundation, Washington, DC.

Stiles, T.C., 2001. A simple method to define bacteria TMDLs in Kansas. KS Dept. of Health and Environment. Topeka, KS. http://www.wef.org/pdffiles/TMDL/Stiles.pdf (last accessed, 9/12/2006).

Zeckoski, R.W., B.L. Benham, S.B. Shan, M.L. Wolfe, K.M. Brannan, M. Al-Smadi, T.A. Dillaha, S. Mostaghimi, and C.D. Heatwole, 2005. BSLC: A tool for bacteria source characterization for watershed management. Transactions of ASAE, 21(5): 879-889.

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Corrective Action Report
SOP-QA-001
CAR #:______________

Date:____________________ Area/Location:_____________________

Reported by:____________________ Activity:__________________________

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

Possible causes:
____
____
____

Recommended Corrective Actions:
____
____
____

CAR routed to:________________________________
Received by:_________________________________

Corrective Actions taken:
____
____
____
____

Has problem been corrected?: YES NO

Immediate Supervisor:_______________________________

Program Manager:__________________________________

TWRI Quality Assurance Officer:_____________________________

TSSWCB Quality Assurance Officer:___________________________