Texas Nonpoint Source Grant Program

Phase 1: Data Collection and Development of Essential Components for the Mill Creek Watershed Protection Plan

TSSWCB Project # 14-57

Quality Assurance Project Plan

Texas State Soil and Water Conservation Board

Revision #0

prepared by

Texas AgriLife Research
Texas Water Resources Institute

and the

Texas A&M University Department of Biological and Agricultural Engineering

Effective Period: upon signature through May 31, 2016

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

Lucas Gregory, TWRI Quality Assurance Officer
lfgregory@ag.tamu.edu

-or-

Dr. R. Karthikeyan, Assistant Professor, Department of Biological and Agricultural Engineering
Texas A&M University
306A Scoates Hall
2117 TAMU
College Station, TX 77843-2117

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Section A1 Approval Sheet

Quality Assurance Project Plan (QAPP) for the *Phase 1: Data Collection and Development of Essential Components for the Mill Creek Watershed Protection Plan* project.

Texas State Soil and Water Conservation Board (TSSWCB)

Name: Jana Lloyd
Title: TSSWCB Project Manager (PM)

Signature:________________________________Date:__________________

Name: Mitch Conine
Title: TSSWCB Quality Assurance Officer (QAO)

Signature:________________________________Date:__________________

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

Name: Mark McFarland
Title: Project Leader

Signature:________________________________Date:_________________

Name: Galen Roberts
Title: Project Co-Leader

Signature:________________________________Date:_________________

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:________________________________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
CDL	Cropland Data Layer
CWA	Clean Water Act
DQO	data quality objectives
ETJ	extra-territorial jurisdiction
FDC	flow duration curve
GIS	geographic information system
gSSURGO	gridded soil survey geographic
H-GAC	Houston-Galveston Area Council
LDC	load duration curve
LULC	landuse/landcover
NAIP	National Agricultural Imagery Program
NDVI	Normalized Difference Vegetation Index
NED	National Elevation Dataset
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
OLI	Operational Land Imager
SCSC	Department of Soil and Crop Sciences
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSL	Spatial Sciences Laboratory
SSURGO	soil survey geographic
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:

Texas State Soil and Water Conservation Board

PO Box 658
Temple, TX 76503

Name: Jana Lloyd
Title: TSSWCB PM

Name: Mitch Conine
Title: TSSWCB QAO

Texas AgriLife Extension Service - Department of Soil and Crop Sciences

370 Olsen Blvd.
2474 TAMU
College Station, TX 77843-2474

Name: Mark McFarland
Title: Project Co-Leader

Name: Galen Roberts
Title: Project Co-Leader

Texas AgriLife Research - Department of Biological and Agricultural Engineering

306A Scoates
2117 TAMU
College Station, TX 77843-2117

Name: R. Karthikeyan
Title: Associate Professor; Project Co-Leader

Texas AgriLife Research – Spatial Sciences Laboratory

2118 TAMU
College Station, TX 77843-2118

Name: R. Srinivasan

Title: Professor and Director, Spatial Sciences Laboratory

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:

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

Jana Lloyd, TSSWCB PM

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.

Mitch Conine; TSSWCB QAO

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.

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

Mark McFarland, Project Leader

Facilitates the development of the Mill Creek WPP and coordinates the inclusion of LDCs and SELECT modeling into the WPP.

Galen Roberts, Project Co-Leader

Responsible for implementing Mill Creek WPP requirements in the contract and the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Coordinates project planning activities and work of project partners. Ensures QAPP is followed by project participants and that project is producing data of known quality. Ensures that subcontractors are qualified to perform contracted work.

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, Associate Professor, Biological and Agricultural Engineering

Responsible for performing LDC analysis and SELECT modeling utilizing water quality data from the Mill 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 Mill Creek streamflow.

R. Srinivasan, Professor and Director of the Spatial Sciences Laboratory

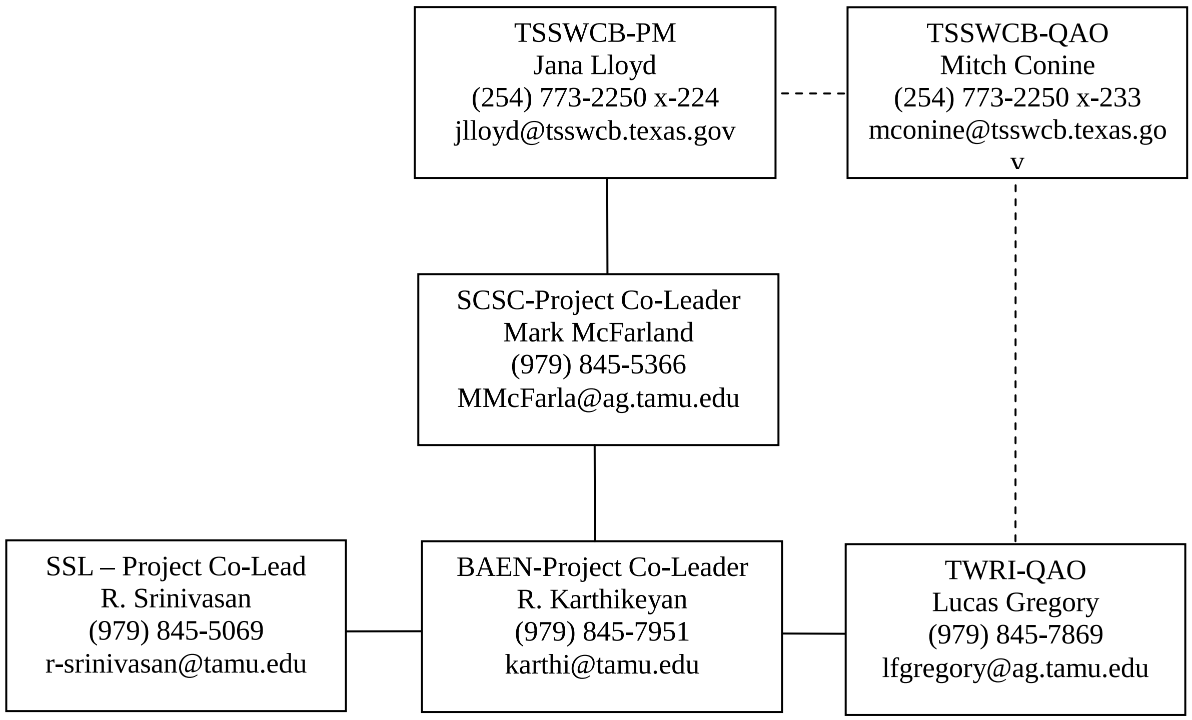
Responsible for overseeing the development of updated land use and land cover maps for the Mill Creek watershed and ground-truthing data points to ensuring their accuracy. Also responsible for the development of flow duration curves (FDCs) at critical water quality monitoring locations throughout the watershed.

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

Mill Creek (Segment 1202K) is a 256,000-acre watershed in the Brazos River Basin. From the headwaters located in western Washington County, the creek flows 14 miles southeast through Austin County to its confluence with the Brazos River 3.9 miles north of FM1458 in the City of San Felipe, Texas. The City of Bellville, with a population slightly more than 4,100 is located in the lower reach of the watershed. While the city covers an area of 2.664 square miles, not all of the city limits are within the Mill Creek watershed. The City of Industry, covering only 1.1 square miles and having a population of approximately 300, is situated midway up the western fork of Mill Creek. The unincorporated town of Burton, covering 1.2 square miles and having a population of 300, is located near the headwaters of the east fork of Mill Creek.

Mill Creek was identified as impaired on the 2012 303(d) list due to bacterial contamination. Data used for the 2012 Integrated Report were 25 samples taken during the 7-year period between December 2003 and November 2010. The geometric mean of these data for *E. coli* bacteria was 177 colony forming units per 100 milliliters (cfu/100 mL), which exceeds the state standard of 126 cfu/100 mL.

The 2012 Texas Integrated Report lists the source of the bacteria impairment for Mill Creek as unknown. Watershed reconnaissance performed on Mill Creek as part of the Recreational Use Attainability Analysis (RUAA) pilot project conducted in 2007 noted that land in the watershed is used predominantly for agricultural purposes with over 56% under some form of production. The RUAA also noted the presence of only two wastewater treatment plants in the watershed leaving all other commercial and residential structures being serviced by on-site sewer facilities (OSSFs) for wastewater treatment and disposal.

The 2010 Brazos River Authority's (BRA) Basin Highlights Report indicated concerns for bacteria and an impaired fish community; suggesting that Mill Creek had poor habitat to support a large and diverse fish population. Also mentioned were likely concerns for DO, nutrients, and chlorophyll a. The 2012 and 2013 BRA Basin Highlights Reports identify Mill Creek as not supporting its designated contact recreation use due to bacteria impairment. The Houston-Galveston Area Council (H-GAC) conducts surface water quality monitoring under the auspices of the Texas Clean Rivers Program (CRP). Currently, H-GAC and other local CRP partners collect valid, representative environmental data to accurately assess water quality conditions in the region and to support effective water quality decision making.

The land use and land cover (LULC) estimate presented in the RUAA is now quite dated and with the exponentially growing population of Texas, the actual land uses have likely changed. Updating available LULC information to reflect more recent conditions will be critical in the modeling process for determining estimated pollutant loads and needed loading reductions. Available and future water quality data also needs to be assessed and processed to aid landowners in the decision making process. Load duration curves (LDCs) are one such method of analysis that is useful in the decision making process. BAEN will utilize water quality data collected by H-GAC to develop these curves for each location sampled where a sufficient number of data points are present.

The purpose of this Quality Assurance Project Plan (QAPP) is to clearly delineate BAEN and SSL's Quality Assurance (QA) policy, management structure, and procedures which will be used to implement the QA requirements necessary to verify and validate the surface water quality data collected. The QAPP is reviewed by TSSWCB to help ensure that data generated and assessed for the purposes described above are scientifically valid and legally defensible.

Section A6: Project Goals and Task Description

This project will provide critical supporting data and information necessary for development of a stakeholder-driven watershed protection plan for Mill Creek that satisfies EPA's nine elements for acceptance, with the fundamental purpose being to promote enhanced stakeholder participation throughout the process and into the implementation phase. Baseline data collection, including land use and land cover, Spatially Explicit Load Enrichment Calculation Tool (SELECT) analysis, flow and load duration curve development, load reduction determination(s), and targeted water quality monitoring will be conducted as part of this project and in advance of the plan development process with stakeholders. This will allow all major components of essential data to be preemptively collected, analyzed, and prepared for delivery to stakeholders in an organized and efficient manner that maintains continuity of process and enables expedited plan preparation and approval. By shortening the development process, stakeholders will remain focused and engaged, and will actively transition and move forward into the implementation phase enhancing the potential for water quality improvement.

A key goal of this project is to complete the stakeholder component of plan development within 6 months. A "Local Advisory Group" will be created to support preemptive data collection and analysis efforts. The Local Advisory Group will consist of four to six selected stakeholders (landowners, agricultural producers, and city/county officials with historical knowledge and/or experience in the watershed), and local Extension, NRCS, and SWCD personnel. The purpose of the Local Advisory Group will be to offer insight and guidance on local issues of importance to the preemptive data collection and analysis process. Utilizing data and information gathered through this project, Extension will facilitate the stakeholder-driven plan development process with support from the Texas State Soil and Water Conservation Board (TSSWCB), Houston Galveston Area Council (H-GAC), and the Brazos River Authority (BRA).

The H-GAC will collect supplemental water quality data through targeted monitoring at selected locations in the watershed for eight to nine months. Sites will be selected based on watershed characteristics and input from the Local Advisory Group. These data will better enable selection, design, and targeted application of implementation measures. The TAMU SSL will conduct land use/land cover analysis with field validation. Texas A&M Research/BAEN will develop LDCs and load reduction estimates. In addition, BAEN will use SELECT analysis to distribute potential loads by source across subwatersheds to facilitate targeted implementation planning. The project will directly support the development of a comprehensive WPP that addresses all potential sources of pollution.

This QAPP is intended to only cover a portion of the overall project described above.
Subtasks of the TSSWCB Project #14-57 included in this QAPP are: 3.2 and 3.3.

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 Mills Creek WPP (TSSWCB Project 14-57).

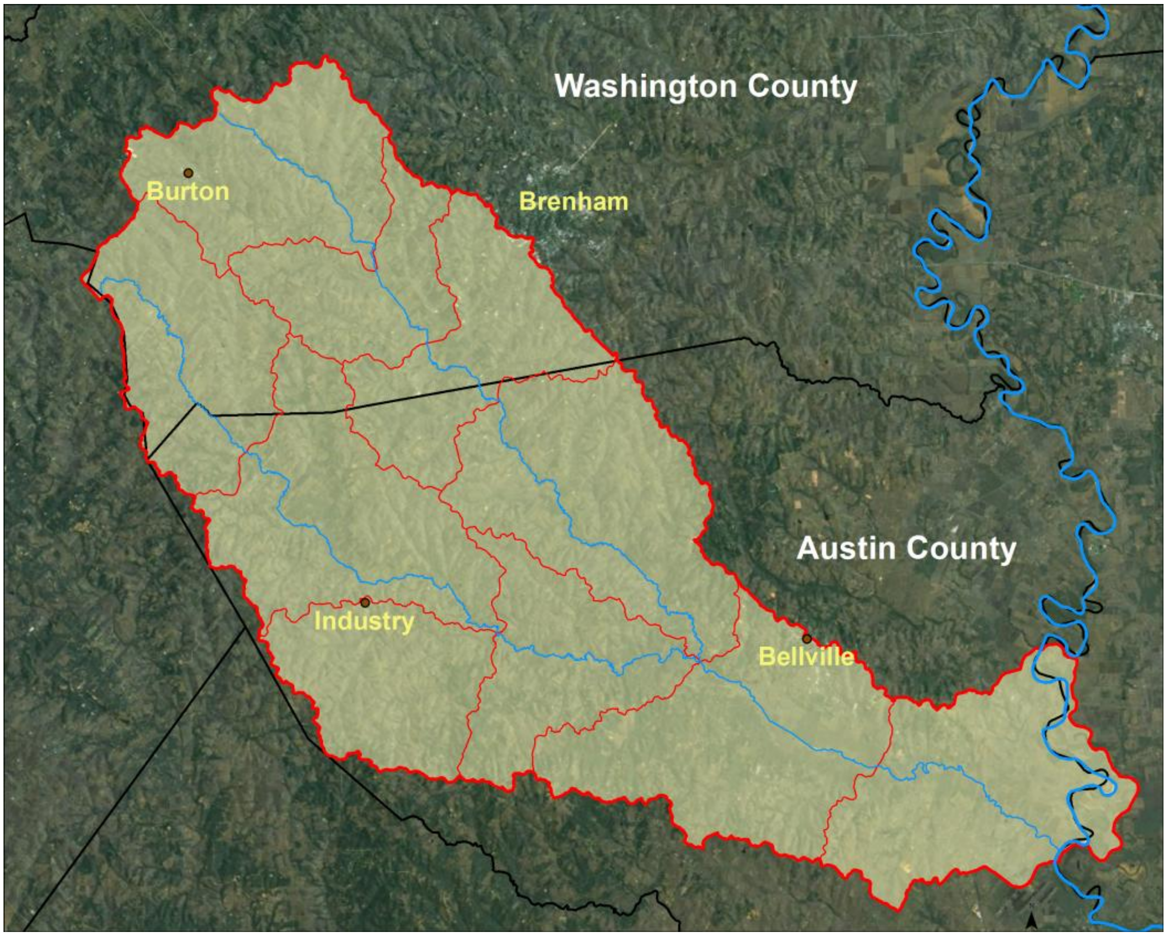


Figure A.6-1. The Mill Creek Watershed

Task 3: Conduct water quality monitoring, modeling, and data analysis to support development of a watershed protection plan.

Objective: Conduct water quality monitoring, data analysis, and resource development to support development of a watershed protection plan, including evaluation and prioritization of best management practices that if implemented in the watershed have a high potential to improve water quality.

Subtask 3.2: The SSL at TAMU will develop land use/land cover data at the subwatershed level appropriate for SELECT analysis and provide a detailed report of procedures and results for inclusion in the WPP. (Start Date: Month 3; Completion Date: Month 18)

Subtask 3.3: The BAEN at TAMU will prepare flow and load duration curves, conduct SELECT analysis for bacteria, and provide a detailed report of the procedures and results for inclusion in the WPP. (Start Date: Month 3; Completion Date: Month 18)

Deliverables

- Updated LU/LC map
- Load Duration Curves
- SELECT Model Outputs
- Technical reports detailing land use/land cover, load duration curves and 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 update the LU/LC map and analyze data using LDCs and the SELECT model under subtasks 3.2 and 3.3

Table A6-1. Project Plan Milestones

Task	Project Milestones	Agency	Start	End
3.2	The SSL at TAMU will develop land use/land cover data at the subwatershed level appropriate for SELECT analysis and provide a detailed report of procedures and results for inclusion in the WPP.	BAEN, SSL	Aug 14	Nov 15
3.3	The BAEN at TAMU will prepare flow and load duration curves, conduct SELECT analysis for bacteria, and provide a detailed report of the procedures and results for inclusion in the WPP.	BAEN, SSL	Aug 14	Nov 15

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, calculates and allocates 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 Mill 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).

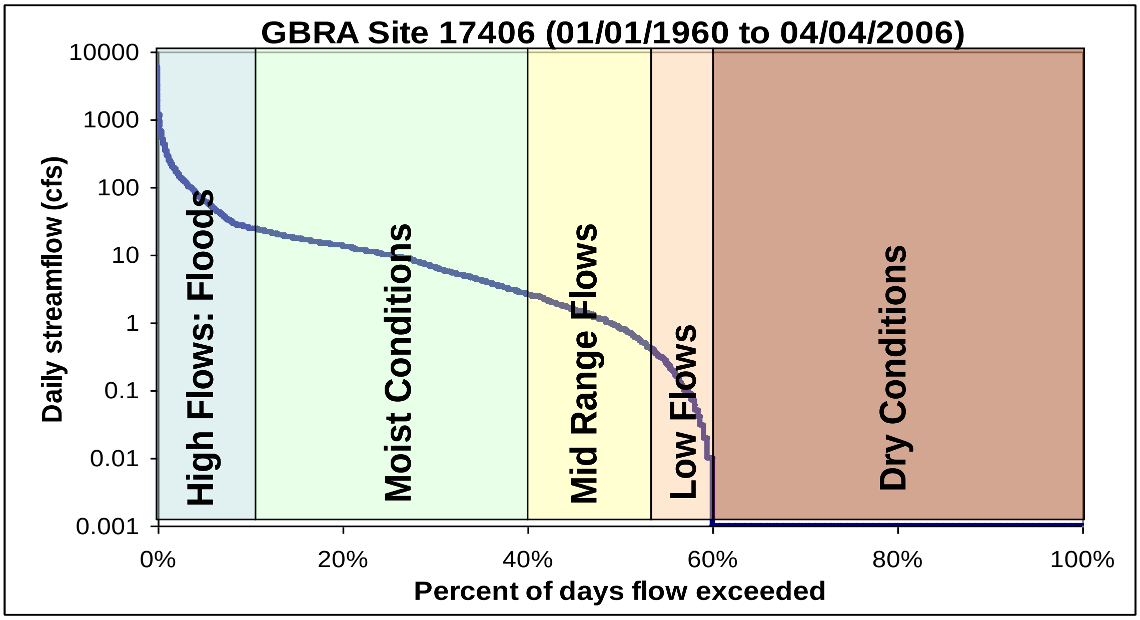


Figure 16-2 Flow Duration Curve (FDC) for streamflow conditions at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX. The flow data at 17406 was obtained from the nearest USGS gage station 8172400, after adjusting for subwatershed aerial contribution during runoff events.

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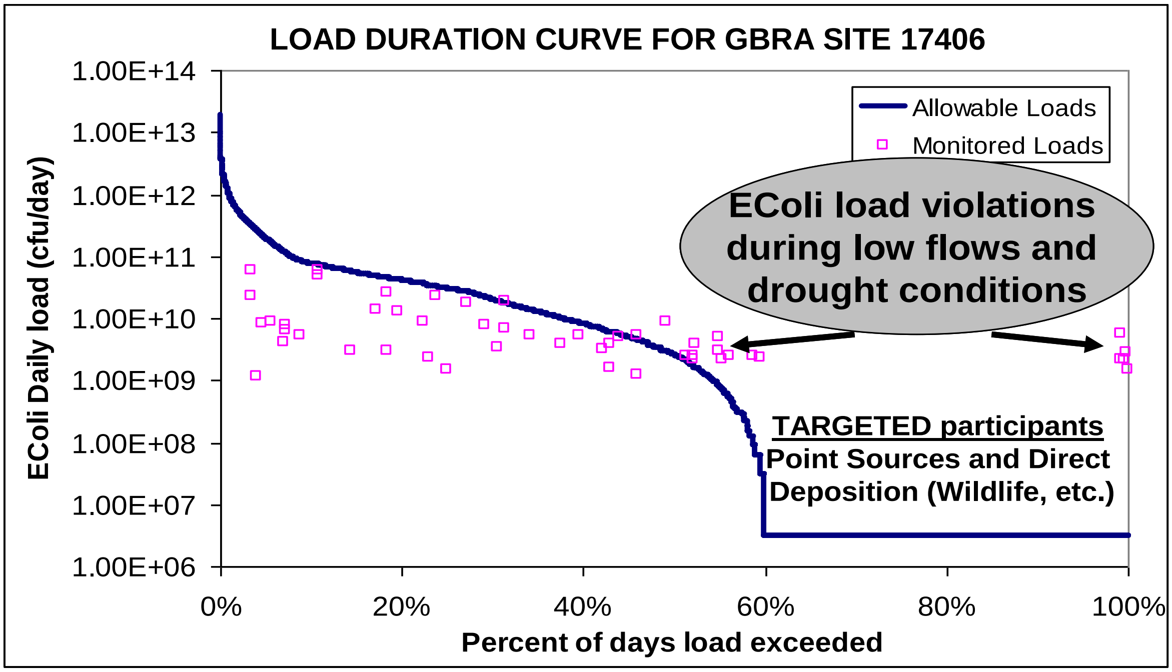


Figure A6-3 Load Duration Curve for *E. coli* at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX. The flow data at 17406 was obtained from the nearest USGS gage station 8172400, after adjusting for subwatershed aerial contribution during runoff events.

Landuse and Land Cover Classification

A Land Use/Land Cover (LULC) dataset for Mill Creek watershed will be developed using 2013 and 2014 Landsat 8 images, 2012 National Agricultural Imagery Program (NAIP) images, the 2011 National Landcover Database (NLCD), and additional ancillary datasets. 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 the following classes from a modified 2011 NLCD classification scheme:

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.

Deciduous Forest- Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.

Evergreen Forest- Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.

Near Riparian Forested Land - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% 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% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.

Shrubland- Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in early successional stage, and trees stunted from environmental conditions.

Grassland- Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management, but can be utilized for grazing.

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 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) 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 H-GAC. 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.

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 Mill Creek watershed that will serve as an input to the SELECT model. Multi-season satellite images as well as aerial photos 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	Electronic
QAPP distribution documentation	TWRI	5 years	Electronic
Corrective Action Reports (CARs)	TWRI	5 years	Electronic
Modeler Notebooks	BAEN/SSL	5 years	Paper
Model Input Data Files	BAEN/SSL	5 years	Electronic
Model Calibration Documentation	BAEN/SSL	5 years	Electronic
Model Validation Documentation	BAEN/SSL	5 years	Electronic
Model Output	BAEN/SSL	5 years	Electronic
Progress reports/ Final Reports	Extension/TSSWCB	3 years	Electronic

Digital files of land cover data for each watershed will be produced in shapefile or ArcGIS grid format and stored on digital media. 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. 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

Ground control points and existing ancillary data will be used to classify satellite images into LULC classes. Ground control points will be collected in the field for each class based on the definitions in the classification scheme. These points will then be verified for positional accuracy and overall usefulness by overlaying the points on the digital aerial photos and satellite images. Additional control points may be selected as necessary using the most current (2012-2014) high resolution satellite images and aerial photos published though online sources such as Google Maps.

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

Satellite images and additional inputs will be iteratively classified using a pixel-based decision tree classification method. The decision tree method assigns pixels to each class by applying a series of thresholds to each input. Decision trees can be produced either automatically by a software package or manually through trial and error. The See5 software package will be used to produce the decision tree based on a variety of inputs derived from satellite images and ancillary data. The decision tree will then be applied to the datasets using ENVI geospatial imagery processing and analysis software version 5.1.

Landsat 8 scenes which have been radiometrically calibrated to top-of-atmosphere reflectance in ENVI are extracted using the Mill Creek watershed boundary with an additional 1 mile buffer. These images are then used to produce several band indices such as the Normalized Difference Vegetation Index (NDVI). NDVI and other indices can be evaluated for identifying value thresholds for certain classes or as training inputs in later steps.

The Landsat 8 images and indices as well as ancillary data are used as inputs in the decision tree classification. Input values are identified by selecting 50% of ground control points from each desired output class and extracting values from selected input rasters at each point. The decision tree constructed by See5 is then reconstructed in ENVI and evaluated for accuracy. The ouput pixel-based classification is smoother to reduce speckling in the output. Finally, an accuracy assessment is performed to determine if the classification meets requirements.

Section B5: Quality Control Requirements

Watershed Modeling

Not relevant.

Landuse and Land Cover Classification

The LULC classification's overall accuracy will be assessed using the remaining 50% of ground control points. Control points may again be supplemented as necessary using current imagery. Additionally, ancillary datasets such as the 2013 Cropland Data Layer (CDL) and 2011 NLCD may be used to aide any visual assessment of the classification. Overall and class accuracy will be reported in a confusion matrix.

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.

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 H-GAC, 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. H-GAC 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 SWQMIS database.

Data collected under the *Phase 1: Data Collection and Development of Essential Components for the Mill Creek Watershed Protection Plan* project (TSSWCB Project 14-57) 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 H-GAC. 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 the LULC layer updated through Subtask 3.2 of this project, SSURGO and Computer Based Mapping System (CBMS) soils, National Hydrography Dataset (NHD), Census data (2010), Agricultural Census data from USDA-National Agriculture Statistics Service (2012), 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.

Landuse and Land Cover Classification

The new classification will be based on satellite images and aerial photos from the period of 2012 through mid-2014 as well other ancillary datasets. Existing LULC classifications will be used as a guide for evaluation and comparison. The following data types and datasets will be the primary data used in producing the classification:

Landsat 8 Operational Land Imager (OLI): Images collected by the USGS Landsat 8 Operational Land Imager (OLI) will be the primary data source for producing the LULC classification. USGS began publishing Landsat 8 images soon after its launch in early 2013. Images of each scene are captured every 16 days at 30 meter spatial resolution for visible and infrared bands and 15 meter resolution for the panchromatic band. Five cloud free images of the watershed have been collected through the USGS's EarthExplorer web interface. Image acquisition dates span from May 2013 to April 2014, including 2 leaf-off scenes, 2 leaf-on scenes, and 1 transition scene.

National Agricultural Imagery Program (NAIP): Aerial photos collected for the USDA NAIP program in 2012 are the secondary data source for the LULC classification. NAIP images currently collected at a resolution of 1 meter for the state of Texas every two years during growing season. The data is distributed as digital ortho quarter quad tiles (DOQQs) or county mosaics. DOQQ's from 2012 were collected for the area covered by the Mill Creek watershed boundary.

National Land Cover Database (NLCD): New versions of the NLCD are released through the USGS every 5 years with a resolution of 30 meters. NLCD classifications are now produced using a decision tree method to identify 20 unique classes. The most recent NLCD is the 2011 version, released in 2014, was acquired for use in this project. The accuracy of the current release has not yet been published, but based on previous versions it is expected to be of acceptable quality.

Cropland Data Layer (CDL): The CDL is a LULC produced by the USDA and is similar to the NLCD with the addition of specific crop classes which can be useful in identifying typical crops or crop rotations in an area. Currently, the CDL is released annually at a resolution of 30 meters. The 2013 CDL was acquired from CropScape, a web application specifically created for the distribution of the CDL.

Gridded Soil Survey Geographic Database (gSSURGO): gSSURGO is a gridded version of the SSURGO database which is distributed in shapefile format. gSSURGO grid cells are 10m x 10m in size. The database is distributed by state with a variety of tabular data associated with gridded values. The Texas gSSURGO database was acquired from the NRCS Geospatial Data Gateway.

National Elevation Dataset (NED): The NED is produced by the USGS at three different scales: 3 meters, 10 meters, and 30 meters. The 10 meter NED was collected from the NRCS Geospatial Date Gateway. Elevation data can be used directly or in the form of slope, aspect, or some other derivative.

Section B10: Data Management

Systems Design

BAEN and SSL use laptop personal computers and desktop personal computers. The computers run Windows 7 or 8 operating systems. Software includes Microsoft® Word, Microsoft® Excel, Microsoft® Access, and a Statistical Analysis System database management system run through the Windows operating system. All GIS analysis will be performed using ArcGIS 10.x.

Backup and Disaster Recovery

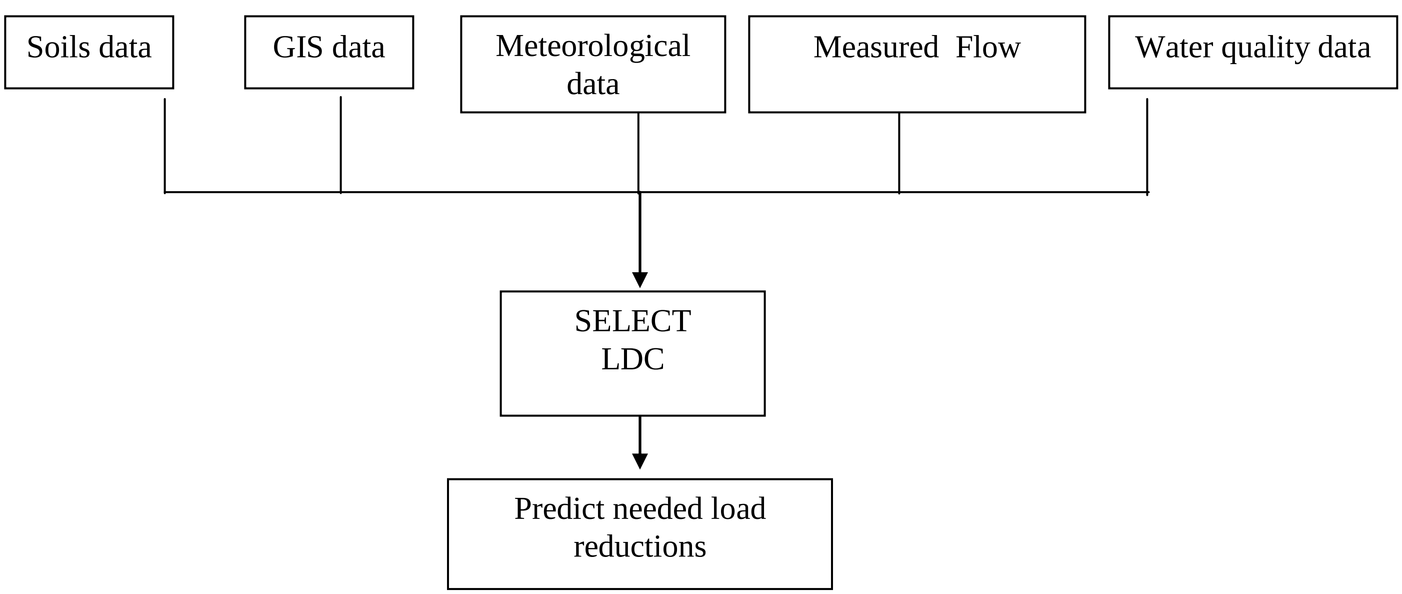
The personal computer drives are backed up daily on the network server and on a weekly basis to an external hard drive. Data are also backed up weekly to the PI's computer. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated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



Landuse and Land Cover Classification

A combination of IBM compatible microcomputers with a Windows 7 Operating System will be used to process the data. 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 digital media 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. Electronic copies of the data will 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.

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 Mill 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 for Mill Creek.

The LDC framework utilized for this project will be used to evaluate bacteria and nitrate loading in relation to flow regimes in Mill Creek. These analyses will aid in targeting water quality best management practices recommendations to the most likely areas of bacteria and nitrate impairment.

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:___________________________