TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 2, 2011

Ryan Bass
City of Boerne
402 E. Blanco
Boerne, Texas 78006

Re: Watershed Protection Plan Development for Upper Cibolo Creek Quality Assurance Project Plan (QAPP) for Modeling

Approved: December 2, 2011 (Update due December 2, 2012)

Dear Mr. Bass:

The above named QAPP has been approved. The original QAPP and signature page is enclosed as documentation of approval.

In accordance with the terms of the QAPP, **please ensure that copies of this document and any subsequent amendments are distributed to each sub-tier participant as noted in Section A3 of the QAPP.** This approval letter must be available for review during a monitoring systems audit.

Should you have questions, please contact me at (512) 239-0425.

Sincerely,

Kyle Girten
Quality Assurance Specialist

enclosure

cc: Sharon Coleman, Senior Quality Assurance Specialist, MC 165
Lauren Bilbe, Project Manager, MC 203

Watershed Protection Plan Development for Upper Cibolo Creek
Quality Assurance Project Plan for Modeling
Revision 0

Type of Model: Soil and Water Assessment Tool (SWAT)

Segment 1908

Date submitted to TCEQ: 11/18/2011

Funding source: Nonpoint Source Program CWA §319(h)
Federal Grant #99614613

City of Boerne
Ryan Bass
Watershed Coordinator
402 E. Blanco
Boerne, Texas 78006
(830) 248-9511 ext 61175
rbass@ci.boerne.tx.us

Nonpoint Source Management Program
Office of Water, Planning & Implementation Section
Texas Commission on Environmental Quality
P.O. Box 13087, MC - 203
Austin, Texas 78711-3087

This QAPP is effective for a period of one year from approval date.

Questions concerning this QAPP should be directed to:
Ryan Bass

SECTION A: PROJECT MANAGEMENT

A1 Approval Page

Texas Commission on Environmental Quality

Field Operations Support Division

12.2.11

Stephen Stubbs, TCEQ QA Manager — Date

12/1/11

Kyle Girten, Lead NPS QA Specialist — Date
Quality Assurance Team

Water Quality Planning Division

11/28/11

Monica Harris, Section Manager — Date
Water Quality Planning and Implementation Section

11/28/2011

Kerry Niemann, Team Leader — Date
Nonpoint Source Program

11/28/2011

Anju Chalise, NPS QA Specialist — Date

11/28/11

Lauren Bilbe, TCEQ NPS Project Manager — Date
Project Manager, Nonpoint Source Program

City of Boerne

11-18-11

Don Burger, P.E. City of Boerne
Deputy Public Works Director

Date

11/18/11

Ryan Bass, QA Officer

Date

PARSONS

Mel Vargas, Project Manager — Date: 11/18/2011

Monica Suarez, QA Officer — Date: 11/18/2011

The City of Boerne will secure written documentation from additional project participants (e.g., subcontractors, laboratories) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The City of Boerne will maintain this documentation as part of the project's quality assurance records. This documentation will be available for review. Copies of this documentation will also be submitted as deliverables to the TCEQ NPS Project Manager within 30 days of final TCEQ approval of the QAPP. (See sample letter in Appendix A of this document.)

A2 TABLE OF CONTENTS

A3 DISTRIBUTION LIST

The lead Nonpoint Source (NPS) Quality Assurance Specialist (QAS) will provide original versions of this project plan and any amendments or revisions of this plan to the Texas Commission on Environmental Quality (TCEQ) NPS Project Manager and the City of Boerne Project Manager. The TCEQ NPS Project Manager will provide copies to the EPA Project Officer within two weeks of approval. The TCEQ NPS Project Manager will document receipt of the plan and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

U.S. Environmental Protection Agency Region 6
State/Tribal Section
1445 Ross Avenue
Suite # 1200
Dallas, TX 75202-2733
Leslie Rauscher, Project Officer
(214) 665-2773

The City of Boerne will provide copies of this project plan and any amendments or revisions of this plan to each project participant defined in the list below. The City of Boerne will document receipt of the plan by each participant and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

City of Boerne
402 E. Blanco
Boerne, Texas 78006

Don Burger, Project Manager
(830) 249-9511 ext. 61148

Ryan Bass, Quality Assurance Officer
(830) 249-9511 ext. 61175

PARSONS
8000 Centre Park Drive, Suite 200
Austin, Texas 78754

Mel Vargas, Project Manager
(512) 719-6821

Monica Suarez, Quality Assurance Officer
(512) 719-6034

Kirk Dean, Lead Modeler
(512) 719-6016

List of Acronyms

ASCII	American Standard Code for Information Interchange
BMP	Best Management Practice
CAR	Corrective Action Report
CD-ROM	Compact Disc – Read Only Memory
CWA	Clean Water Act
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DSS	Decision Support System
DVD-ROM	Digital Versatile Disk – Read Only Memory
EC	*Escherichia coli*
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FC	Fecal Coliform
FTP	File Transfer Protocol
GIS	Geographic Information System
HRU	Hydrologic Response Unit
HSPF	Hydrologic Simulation Program-Fortran
HTTP	Hypertext Transfer Protocol
L	Liter
LAN	Local Area Network
m	Meter
mg	Milligram
mm	Millimeter
Mbps	Megabit Per Second
MAE	Mean Absolute Error
ME	Mean Error
NCDC	National Climatic Data Center
NHD	National Hydrography Dataset
NH_3-N	Ammonia Nitrogen
NLCD	National Land Cover Dataset
NOx-N	Nitrate + Nitrite Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service of the USDA
NSE	Nash-Sutcliffe Modeling Efficiency
NWS	National Weather Service
PDF	Portable Document Format (Adobe Acrobat)
PO_4-P	Orthophosphorus
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan

QAS	Quality Assurance Specialist
r^2	Coefficient of Determination
RAID	Redundant Array of Inexpensive Devices
RMSE	Root Mean Square Error
SWAT	Soil and Water Assessment Tool
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TPDES	Texas Pollutant Discharge Elimination System
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WPP	Watershed Protection Plan

A4 PROJECT/TASK ORGANIZATION

TCEQ

Field Operations Support Division

Kyle Girten
Lead NPS QA Specialist
Assists the TCEQ Project Manager in QA related issues. Serves on planning team for NPS projects. Participates in the planning, development, approval, implementation, and maintenance of the quality assurance project plan (QAPP). Determines conformance with program quality system requirements. Coordinates or performs audits, as deemed necessary and using a wide variety of assessment guidelines and tools. Concurs with proposed corrective actions and verifications. Monitors corrective action. Provides technical expertise and/or consultation on quality services. Provides a point of contact at the TCEQ to resolve QA issues. Recommends to TCEQ management that work be stopped in order to safe guard project and programmatic objectives, worker safety, public health, or environmental protection.

Water Quality Planning Division

Kerry Niemann, Team Leader
NPS Program
Responsible for management and oversight of the TCEQ NPS Program. Oversees the development of QA guidance for the NPS program to be sure it is within pertinent frameworks of the TCEQ. Monitors the effectiveness of the program quality system. Reviews and approves all NPS projects, internal QA audits, corrective actions, reports, work plans, and contracts. Enforces corrective action, as required. Ensures NPS personnel are fully trained and adequately staffed.

Lauren Bilbe
TCEQ NPS Project Manager
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with projects. Develops lines of communication and working relationships between the City of Boerne, the TCEQ, and the U.S. Environmental Protection Agency (EPA). Tracks deliverables to ensure that tasks are completed as specified in the contract. Responsible for ensuring that the project deliverables are submitted on time and are of acceptable quality and quantity to achieve project objectives. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP. Assists the TCEQ QAS in technical review of the QAPP. Responsible for verifying that the QAPP is followed by the City of Boerne. Notifies the TCEQ QAS of particular circumstances which may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action.

Anju Chalise
NPS QA Specialist
Assists Lead QAS with NPS QA management. Serves as liaison between NPS management and Agency QA management. Responsible for NPS guidance development related to program quality assurance. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP.

City of Boerne

Don Burger
City of Boerne Project Manager
Responsible for ensuring tasks and other requirements in the contract are executed on time and are of acceptable quality.. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with the TCEQ. Complies with corrective action requirements.

Ryan Bass
City of Boerne, Quality Assurance Officer (QAO)
Responsible for coordinating development and implementation of the QA program. Responsible for reviewing 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. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for coordinating with the TCEQ QAS to resolve QA- related issues. Notifies the City of Boerne Project Manager and TCEQ Project Manager of particular circumstances which may adversely affect the quality of data. Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques

PARSONS
Mel Vargas
Parsons Project Manager
Responsible for ensuring tasks and other requirements in Parsons contract with the City of Boerne are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with the City of Boerne. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Ensures adequate training and supervision of all modeling activities. Complies with corrective action requirements.

Monica Suarez
Parsons QAO
Responsible for coordinating development and implementation of the QA program at Parsons. Responsible for writing and maintaining the QAPP. Responsible for maintaining records of QAPP distribution within Parsons, including appendices and amendments. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for

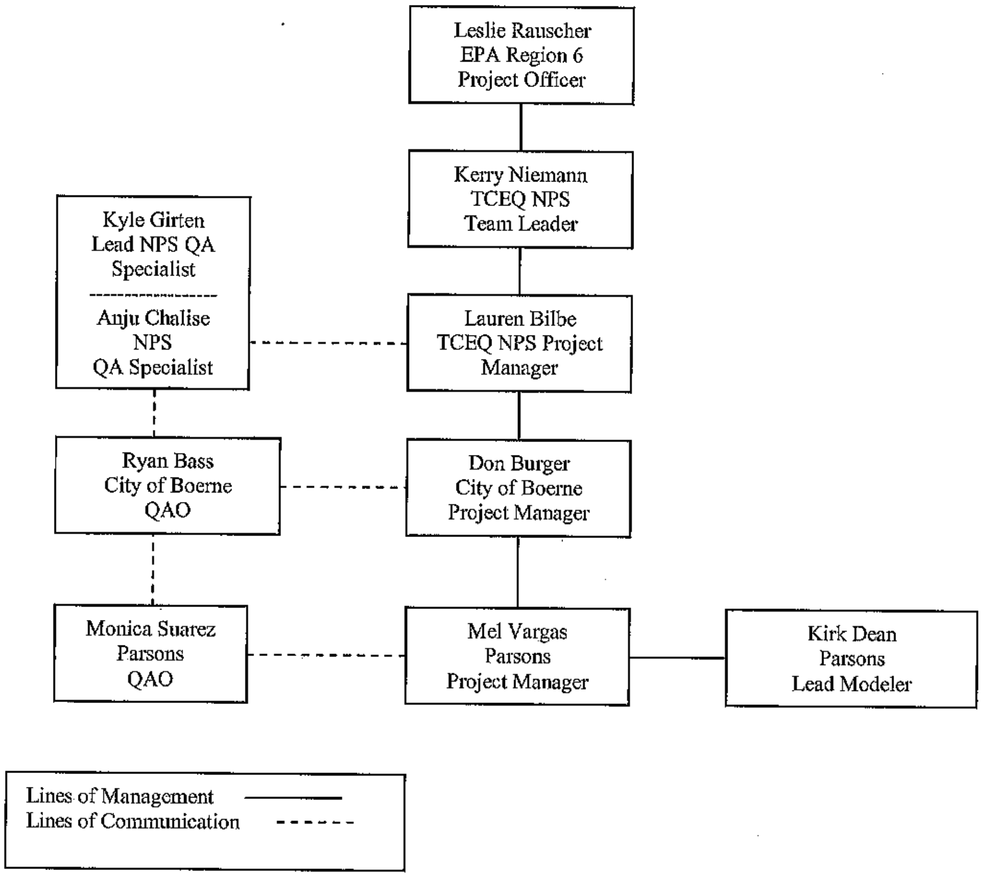
coordinating with the TCEQ QAS and City of Boerne QAO to resolve QA- related issues. Notifies the Parsons project manager, City of Boerne project manager, and TCEQ project manager of particular circumstances which may adversely affect the quality of data. Responsible for validation and verification of acquired data procedures after each task is performed. Coordinates the research and review of technical QA material and data related to water quality modeling.

Kirk Dean
Parsons Lead Modeler
Responsible for the development, calibration, operation, and documentation of computer models. Responsible for acquisition, inspection, and documentation of data of known and acceptable quality as model inputs and calibration datasets. Manages model input and output datasets. Responsible for transferring model and datasets to the City of Boerne in an acceptable format. Notifies the Parsons QAO and project manager of particular circumstances which may adversely affect the quality of results.

EPA Region 6

Leslie Rauscher
EPA Project Officer
Responsible for managing the CWA Section 319 funded grant on the behalf on EPA. Assists the TCEQ in approving projects that are consistent with the management goals designated under the State's NPS management plan and meet federal guidance. Coordinates the review of project workplans, draft deliverables, and works with the State in making these items approvable. Meets with the State at least semi-annually to evaluate the progress of each project and when conditions permit, participate in a site visit on the project. Fosters communication within EPA by updating management and others, both verbally and in writing, on the progress of the State's program and on other issues as they arise. Assists the regional NPS coordinator in tracking a State's annual progress in its management of the NPS program. Assists in grant close-out procedures ensuring all deliverables have been satisfied prior to closing a grant.

Figure A4.1. Organization Chart



A5 PROBLEM DEFINITION/BACKGROUND

Upper Cibolo Creek drains a 64-square mile watershed completely contained within Kendall County, Texas. The creek is central to the development of the City of Boerne and the surrounding community. The sensitive nature of the Upper Cibolo Creek watershed, its abundant aquatic life and the riparian zone habitat make it vulnerable to a variety of changes occurring in the watershed.

Upper Cibolo Creek was listed on the 1999 through 2004 Texas 303(d) Lists of impaired water bodies for depressed dissolved oxygen (DO). Studies conducted from 2002 to 2004 determined that the segment was supporting its uses, and the segment was removed from the §303(d) List for DO. Recent sampling has shown excessive bacteria counts, and the segment has returned to the 2006 §303(d) List of impaired water bodies because of elevated bacteria levels. A primary concern is the potential for an increase in nonpoint source pollution (NPS) from a rapidly growing population and the concurrent changes in land use. Land use in the Upper Cibolo Creek watershed is mostly rural with light ranch use and deer hunting. However, the urban area is expanding and a further increase in NPS pollution is expected.

The City of Boerne obtained funding from the TCEQ through the EPA under authorization of §319(h) of the federal Clean Water Act (CWA) to develop a Watershed Protection Plan (WPP) for Upper Cibolo Creek. One major component of the WPP for Upper Cibolo Creek is the development of a water quality model to estimate assimilative capacity and pollutant load reductions necessary to achieve a water quality goal established for bacteria levels. To accomplish this, the City of Boerne selected Parsons Water & Infrastructure Inc. (Parsons) to provide technical support for the development of a watershed/water quality model. The outcomes of this water quality modeling will be integrated into the WPP by the City.

The goal of this project is to develop a watershed/water quality model addressing fecal bacteria, nutrients, and dissolved oxygen to support the preparation of a WPP for Upper Cibolo Creek watershed. The project will model a select list of management strategies that are conducive to restoring and maintaining the designated uses of Upper Cibolo Creek (Segment 1908). A key objective of this project will be to provide outcomes that assist the City of Boerne and TCEQ in providing the technical information necessary to address three of the EPA's nine key elements of WPPs:

a. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

The modeling approach will address these technical challenges and aim to estimate load reductions at the same spatial scale and level of detail that was used for identifying causes and sources of pollutant loads.

The water quality model selected to be applied will be the Soil and Water Assessment Tool (SWAT). SWAT is a basin-scale, continuous time watershed model that currently operates on a daily timestep. The model is designed to predict the impact of management on water, sediment, agricultural chemical, bacteria, and nutrient yields, and also simulates the in-stream processes controlling dissolved oxygen (Neitsh et al., 2011). SWAT is a public-domain model widely used by agencies such as the NRCS, EPA, and National Oceanic and Atmospheric Administration. SWAT is an accepted tool to define the relationship between land use practices and the resulting export of nutrients from a watershed. SWAT has a long history of application (see Gassman et. al [2007] for a summary of applications). The model is currently employed in a large number of water quality projects throughout the State of Texas.

Other approaches which are less computationally intensive include load duration curves (Cleland 2002) and statistical regression-based approaches such as LOADEST (Runkel et al 2004) and SPARROW (Smith et al. 1997). These approaches were not considered adequate to link observed water quality to sources, and to evaluate the impacts of management measures.

Another model considered was the Hydrologic Simulation Program-Fortran (HSPF). Both SWAT and HSPF are full-featured, mechanistic models that have been extensively applied both in Texas and worldwide. Both models are in the public domain so the source code is freely available. Parsons has extensive experience in the application of both models in a variety of Texas watersheds. Parsons also developed tools to assist in the interface with these models. SWAT was selected over HSPF in part because it was considered the easier model to develop using existing spatial datasets and its graphical interface with ArcGIS. Also, several comparisons (i.e., Saleh and Du, 2004; Nasr et al., 2003) imply that SWAT often performs better than HSPF in simulating nutrient loading, particularly from rural watersheds. Finally, SWAT facilitates evaluation of the impacts of watershed management practices.

Most WPP and Total Maximum Daily Load projects focus only on quantifying the extent or severity of the pollution problem in relation to water quality standards. The stakeholders and managers of the Upper Cibolo Creek WPP process are interested in going beyond this evaluation and seek tools which will allow them to look at multiple options that integrate information on cost, willingness to implement, and effectiveness of pollutant reduction capability. Similarly, water resource managers and stakeholders need methods to allow them to use complex science to make decisions on cost, environmental benefit and social acceptance/value to move forward despite uncertainty. Accordingly, Parsons will use an innovative distributed decision support system (DSS) to provide decision makers (watershed stakeholders, government agencies, and experts) greater access to and more influence over the SWAT watershed simulation model developed for this project.

The DSS is not a model, but rather an interface for the calibrated SWAT water quality model that will serves as a communication front-end for non-modelers. The DSS interface was developed using a video game analogy to provide a more familiar format for non-modelers to operate some of the model options and parameters. The conceptual construct of the DSS is similar to a commercial simulation games such as "Sim City" that allow users to make managerial choices and then display the costs and consequences of which are simulated over time. In a similar fashion, the DSS allows the user to track cost and environmental consequences of managerial decisions to achieve regulatory environmental goals without intimate knowledge of the underlying water quality model. The DSS is simply a display tool that uses the SWAT model outputs to support more transparent public process where the outcome better integrates environmental benefit (pollutant load reduction), cost of management strategies, and social science (local input and support) to derive sound, legitimate decisions based on science that can be sustainably implemented.

The purpose of the QAPP is to clearly delineate Parsons' QA policy, management structure and procedures to implement the QA requirements necessary to verify, calibrate, and validate the output of the modeling process associated with this project. This QAPP is reviewed by the TCEQ to help ensure that the outputs and data generated for the purposes described within are scientifically valid and legally defensible. This process will facilitate the use of project outputs and data for the Upper Cibolo Creek WPP and other programs deemed appropriate by the TCEQ.

A6 PROJECT/TASK DESCRIPTION AND SCHEDULE

To achieve project outcomes the following four tasks and associated deliverables will be completed by Parsons.

Task 1. Project Management and Coordination: This task will be a collaborative effort between the City of Boerne (City) and Parsons to facilitate: effective coordination and communication among project team members; meeting project deadlines; and conducting the project in the most cost-efficient manner. Coordination and communication throughout the project will be aided by email correspondence, conference calls, and meetings and presentations described in subsequent tasks. This task includes project management labor costs and other direct costs necessary over the course of the project. The management activities consist of project coordination and oversight, budget tracking and schedule management, preparation of monthly progress reports and project accounting and billing. The format and information provided in progress reports and invoices shall adhere to requirements defined by the City to expedite concise information transfer to TCEQ for grant reporting needs. Cost information will be included as agreed upon by the City and Parsons.

Project Meetings: Parsons shall attend key project meetings over the course of the project. These meetings are anticipated to involve:

- a project kick-off meeting with the City and TCEQ;
- a technical meeting with the City and other appropriate entities to preview preliminary modeling results;
- up to three meetings with watershed stakeholders at key stages of the modeling process; and
- conference calls with the City as appropriate.

The City will coordinate and arrange all meetings and Parsons will attend the meetings to provide technical support and make technical presentations related to modeling tasks and outcomes. Parsons anticipates that the majority of the meetings will occur at various locations in the Upper Cibolo Creek watershed. Most meetings will be attended by two individuals from Parsons.

Task 2. Data Compilation and Quality Assurance Project Plan for SWAT Model: This task will begin with a project kick-off meeting at which the City and Parsons will discuss the scope of work and project schedule in more detail and review the list of data needs identified by Parsons. Prior to the kick-off meeting Parsons will submit a list of data needs and requirements to the City and collaborate to determine the most time efficient manner to acquire this data. This task will involve extensive collaboration between Parsons and the City to complete steps necessary to transfer all available data necessary to support model set-up and calibration to Parsons. To the extent possible data will be provided to Parsons in an electronic editable format. The primary data that will be compiled include existing watershed data in GIS shape files, Texas Pollutant Discharge Elimination System (TPDES) permitted facilities, water quality, flow, septic system, census, agricultural census, soil nutrient concentration, precipitation and household pet populations.

Parsons shall commence development of the modeling QAPP upon receiving a Notice to Proceed from the City. Parsons will prepare a QAPP to document the type and quantity of data needed for environmental decisions and to describe the methods for collecting and assessing the data used to support the SWAT model. The QAPP will address the required elements for secondary data and geospatial data by providing a blueprint for obtaining and evaluating geospatial and other secondary data from external sources used to support modeling. The QAPP will identify the specific data sources that will be used. Parsons will prepare a draft QAPP to address data inputs and the technical approach for modeling within 30 days of receiving a Notice to Proceed from the City. The draft QAPP will be submitted to the City and TCEQ project managers concurrently for review and comment. Upon receipt of written comments from TCEQ, Parsons will revise the draft QAPP and submit a final QAPP to TCEQ for review and approval. Parsons shall use a standard template for the QAPP that has been used and approved by EPA Region 6 for a similar SWAT modeling project.

Task 3. Watershed/Water Quality Modeling: Parsons shall develop a model of the Upper Cibolo Creek watershed using the Soil and Water Assessment Tool (SWAT). The SWAT model will be set up to be consistent with the subwatersheds established by the City in the Upper Cibolo Creek Watershed Characterization report (January 2011), unless otherwise agreed by the City (Figure A6.1.). Existing and potential future point source dischargers will be included in the SWAT model. The model will be calibrated for flow, nutrients, dissolved oxygen, and bacteria to the extent permitted by available data. Parsons will perform a sensitivity analysis to identify key model parameters. The model will be designed to estimate pollutant sources and loads of bacteria by subwatershed which can be used in the future as a tracking system to provide feedback to the stakeholders that bacteria reductions by source category are being realized over time. Using the calibrated model, Parsons will estimate pollutant loading and evaluate allowable loads necessary to meet water quality targets. It is assumed that water quality targets will be provided to Parsons. The calibrated model will be reviewed and discussed with the City and TCEQ and model inputs and assumptions will be summarized (Technical Meeting). At this time the City will provide Parsons with a brief list of preferred management strategies, identified through City-led stakeholder meetings. The impacts of these management strategies on instream water quality will be simulated using the calibrated model, to the extent that the model is capable of simulating them and budget is available. Model output will be summarized to determine the utility of management strategies in achieving the water quality targets.

The results of this modeling analysis will be prepared for presentation to the City, TCEQ and stakeholders. Parsons will facilitate discussion of the modeling results and uncertainty analysis with stakeholders and identify any recommended modifications to incorporate into a final modeling run.

Task 4. Final Model Run and Preparation of Modeling Report: Upon completion of Tasks 1 through 3, Parsons shall conduct another meeting with the City and TCEQ to discuss how to proceed with finalizing the modeling analysis in response to the discussion and recommendations from the stakeholder meetings and the proposed outline for the draft modeling report (Technical Meeting). Parsons will discuss options of summarizing the model output statistically and graphically. Parsons will then commence making the final model run to incorporate the stakeholder recommendations and direction provided by the City and TCEQ. After the final modeling run is completed, Parsons will prepare a draft modeling report describing the results of model development, calibration, load estimation, allowable loading, and management scenario evaluation. Within 30 days of receipt of comments from the City, Parsons will revise the report to address the comments and provide a revised final modeling report.

Draft Modeling Report Review and Comment: Parsons shall prepare and submit a draft modeling report in an electronic format to the City and TCEQ. The City shall direct the review and comment process associated with the draft modeling report and provide written comments to Parsons summarizing the recommended revisions.

Final Modeling Report Preparation: Based on the comments received on the draft modeling report from the City, Parsons shall prepare a final modeling report for submittal to the City and the stakeholder committee. Parsons shall provide the City with electronic files of the final modeling report.

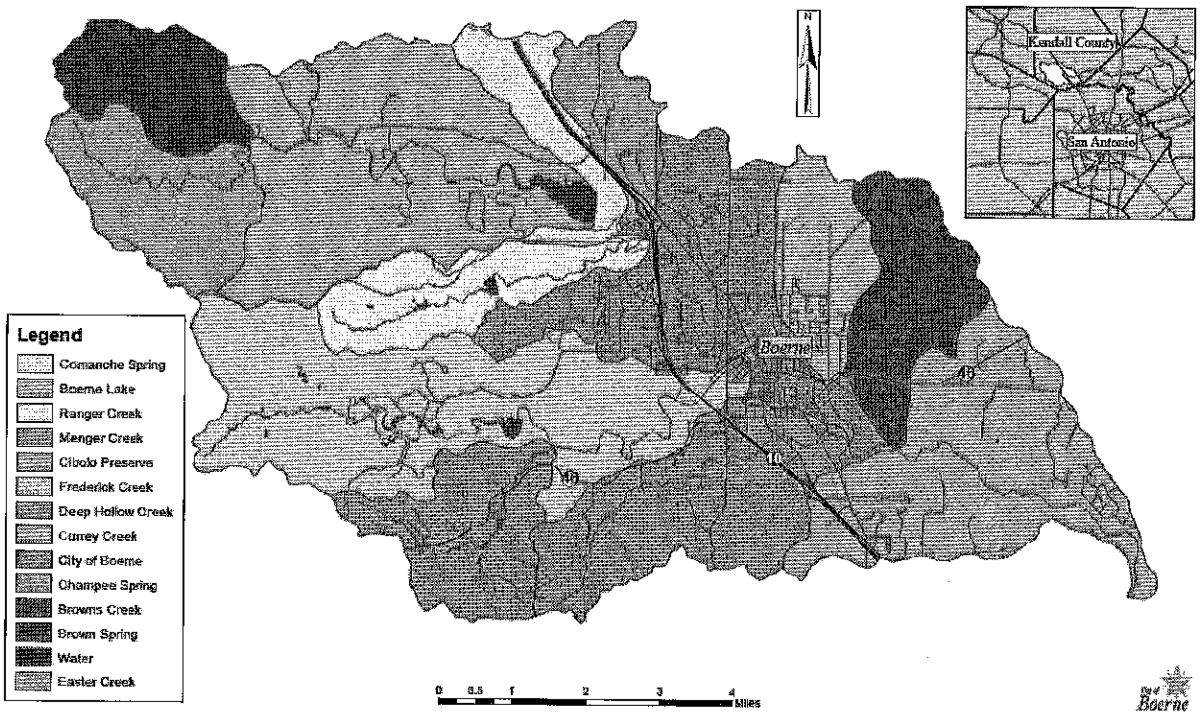
Project Deliverables and Schedule
A preliminary list of deliverables for each task is provided below in Table A6.1. All deliverable target dates are subject to revisions based on the official contract start date.

Table A6.1. List of Project Deliverables

Task	Deliverables	Target Date
Task 1: Project Management, Coordination, and Communication (WBS 01000)	• Monthly invoices	Monthly
	• Monthly progress reports	Monthly
	• Coordination	Monthly
	• Kick-off meeting	September 9, 2011
	• Technical Meeting	January 2012
	• Stakeholder Meetings	January, April, June 2012

Task	Deliverables	Target Date
Task 2: Data Compilation and Quality Assurance Project Plan (WBS 02000)	• List of data requirements	September 2011
	• TCEQ/EPA Approved QAPP	November 2011
Task 3: Watershed/Water Quality Modeling (03000)	• Calibrated Model	December 2011
	• Graphical and statistical summaries of model output	January 2012
Task 4: Modeling Report (WBS 04000)	• Draft Modeling Report (electronic copy)	April 2012
	• Final Modeling Report (electronic copy)	June 2012

Figure A6.1. Upper Cibolo Creek Sub-Watersheds



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 TCEQ 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.

QAPP Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the City of Boerne Project Manager to the TCEQ NPS Project Manager in writing using the QAPP amendment form *(Lead Organizations should request the amendment form from TCEQ Project Managers)*. The TCEQ project manager will consult with the TCEQ QAS to determine if the changes are substantive. The changes are effective immediately upon approval by the TCEQ NPS Project Manager and TCEQ QAS, or their designees, and the EPA Project Officer *(if applicable)*. Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved QAPP amendment form will be distributed to all individuals on the QAPP distribution list by the City of Boerne QAO.

Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS

In this project, no new data, geospatial or otherwise, will be generated. Data used for model development and calibration will be industry standard data and will undergo quality assurance checks and peer review. The best available (and most defensible) data will be used. Best available data will be determined based on the following criteria:

1. Data source: Datasets publicly distributed by the USGS or other federal agencies, or by State of Texas agencies, will be considered defensible for the purposes of this project. Other data extracted from private sources such as annual precipitation data will be considered defensible if it has been published and distributed in citable publicly available formats, such as books or journal publications, if no better sources for that data are available. Water quality data for calibration will include only historical data from the TCEQ SWQMIS database and recent data collected by the City of Boerne or TCEQ under an approved QAPP that has not yet been submitted to SWQMIS.

2. Currency: More recently produced datasets will be considered superior to older datasets; datasets derived from primary data collected recently will be considered better than datasets derived from older data.

3. Defensibility: Metadata, or other descriptions of data quality and how the data were collected or developed, will be compiled when available for data sources.

4. Accuracy: Given the wide range of data types to be used, it is difficult to specify uniform criteria for positional or attribute accuracy. However, when more than one source of a given type of data is available, the data source with higher accuracy (as stated in the metadata) will be used. When assessing ambient water quality data for pollutants from different agencies, different analytical methods may have been used. This data will be reviewed for consistency and data quality objectives prior to performing statistical analyses. Then the datasets will be tested using *t*-tests to confirm that they are not significantly different at a 95% confidence level (p=0.05). If they are not significantly different, the datasets will be combined.

5. Resolution: Data of high spatial resolution are preferred for this project. The key datasets are the digital elevation models (DEMs) and stream features used in identifying contributing watersheds, which form the basis of the pollutant source assessment. For this project, 10 meter (1/3 arc second) DEMs from the National Elevation Dataset are deemed acceptable.

6. Spatial and temporal coverage and representativeness: Data should be representative of the period from September 1991 through September 2011, the model calibration period. The model will also simulate an initial four-year "spin-up" period to minimize the impact of initial conditions, but this period (1987-1991) will not be used for calibration. For some data types that are unlikely to change on a large scale with time, such as elevation and soil type, older data may be considered representative of the more recent period. Where possible, only the most recent 10 years of data will be used to support findings and calculations.

7. Format: Data should be available in electronic format. Files should be either 1) in a grid or shape file type that can be read by ESRI ArcGIS; 2) in a text, database, or spreadsheet format with geographic coordinates, such as latitude and longitude or other defined coordinate system, that can be used in GIS; or 3) in a text, database, or spreadsheet format with spatial reference information, such as county name, that can be spatially joined to existing ESRI ArcGIS shapefiles.

Model calibration: SWAT model calibration, in this setting, is defined as how well the model is able to reproduce current observed flow rates and in-stream measurements of DO, nutrient, and fecal bacteria concentrations for the period of January 1991 through December 2006, and January 2008 to December 2010. This period was selected because:

- SWAT is considered a long-term model

- The period allows simulation of four and one-half wet years, each with more than 45 inches of rainfall, and four and one-half dry years, with less than 21 inches of rain.

- There has been little intensive water quality data collection in Upper Cibolo Creek. Thus, calibration must rely on a long period of routinely but sparse (quarterly or biannual) monitoring data.

- The location of the USGS flow gage in the watershed has moved from time to time. This period would permit calibration at three separate locations, with varying contributing watershed size, each for a period of three or more years.

It must be noted, however, that the population of Kendall County grew by 63% from 1990 to 2000 and by 41% from 2000 to 2010. It is desirable to simulate the most current conditions. Thus, after calibration the model output will be based on the most recent 10 year period.

More specific information about calibration of these models can be found in Section B7.

A8 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

All project staff using GIS must be trained and experienced in the use of any GIS software/equipment required to fulfill their functions. The staff involved in the compilation, processing, and assessment of data to support the project will have, at a minimum, a bachelor's degree in geography, engineering, or a natural science as well as a minimum of three years experience in GIS and data management. Persons with less than three years of experience, but otherwise meeting the educational and training requirements, may work under the direct supervision of a person with more than five years experience.

The staff responsible for model development and calibration will have, at a minimum, a bachelor's degree in engineering or a natural science and five years of experience in water quality modeling, including experience in the application of SWAT. There are no other special training or certification requirements for this modeling project.

A9 DOCUMENTATION AND RECORDS

Limited hard copy documentation is expected to be produced in this project. These documents will consist of the QAPP and amendments (if any) and QAPP distribution documentation, CARs (if necessary), progress reports, final modeling report, and the modeling log. The Parsons QAO is responsible for distributing hard copies of the approved QAPP to all Parsons staff listed on the distribution list (Section A3) as well as of any subsequent approved amendments.

Paper records are maintained in project files at Parsons Austin, Texas office (8000 Centre Park, Suite 200) throughout the project and for a period of one year thereafter. At that point, files are archived to a secure off-site location maintained by a contracted document management company, and available for retrieval within a few days of request. The files will then be maintained in the archive for a period of not less than four (4) years after project completion.

Datasets, metadata, and model output will be maintained and submitted in electronic format. All electronic data will be maintained on Parsons intranet server in Austin, Texas. Data management is addressed in Section B10.

Modeling Log
A modeling log will be used to document the key activities and decisions made in regard to model development and calibration. The log will describe the reasoning behind these key decisions in sufficient detail for future model testing and peer review. The log will also describe the steps taken in the iterative calibration process.

Table A9.1 Project Documents and Records

Document/Record	Location	Retention*a	Form*b
QAPPs, amendments, and appendices	Parsons	5 years	Paper/Electronic
QAPP distribution documentation	Parsons	5 years	Paper/Electronic
Model user's manual or guide (including application-specific versions)	Parsons	5 years	Electronic (PDF)
Assessment reports or metadata for acquired data	Parsons	5 years	Electronic
Raw data files	Parsons	5 years	Electronic
Model input files	Parsons	5 years	Electronic
Model output files	Parsons	5 years	Electronic
Model executable files	Parsons	5 years	Electronic (binary)
Model source code (if available)	Parsons	5 years	Electronic
Modeling log	Parsons	5 years	Paper
Code verification reports	Parsons	5 years	Electronic
Calibration documentation	Parsons	5 years	Electronic
Model assessment documentation	Parsons	5 years	Electronic
Progress reports	City of Boerne /TCEQ	4 years	Paper/Electronic
Corrective Action Reports	City of Boerne	4 years	Paper
Final Modeling Report	City of Boerne	4 years	Paper/Electronic

*a – After the close of the project
*b – Electronic files should be ASCII pipe-delimited text files or MS Word/Excel; model input and output files can be archived in the format used by the modeling software, provided the capability of conversion to ASCII pipe-delimited text files or MS Word/Excel (TCEQ compatible version) is maintained over the time of retention. Electronic versions of model User's Manual and/or User's Guide may be in portable document format (PDF). Model executable will be in binary format, although source code (if available) will be maintained in ASCII format.

The TCEQ may request records from the City of Boerne at any time and/or elect to take possession of records at the conclusion of the specified retention period.

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SECTION B: MEASUREMENT AND DATA ACQUISITION

This project does not involve the creation or collection of new data, but rather the acquisition of existing geospatial, flow, and water quality data originally created or collected by other organizations for other uses, and covered under other QAPPs. The flow and water quality data utilized in this project are addressed in Section B9.

B1 SAMPLING PROCESS DESIGN

Not Relevant – This QAPP does not cover any sample collection activities.

B2 SAMPLING METHODS

Not Relevant - No new sampling data will be collected under this QAPP during this project.

B3 SAMPLE HANDLING AND CUSTODY

Not Relevant - No new sampling data will be collected under this QAPP during this project.

B4 ANALYTICAL METHODS

Not Relevant - No new sampling data will be collected under this QAPP during this project.

B5 QUALITY CONTROL

Not Relevant - No new sampling data will be collected under this QAPP during this project.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Not Relevant - No new sampling data will be collected under this QAPP during this project.

B7 MODEL CALIBRATION

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 models are able to reproduce measured values.

The model calibration period will be from January 1, 1991 through December 31, 2006 and January 1, 2008 through December 31, 2010 for reasons described in Section A7.

In the SWAT calibration, model parameters related to watershed/landscape processes will be adjusted to match the measured and simulated flow, nutrients, fecal bacteria, and dissolved oxygen at key locations in the watersheds. During the calibration process, the model parameters to which the model is most sensitive (as indicated by the sensitivity analysis described below) will be adjusted within literature recommended ranges or as indicated from watershed specific data (i.e., grazing, fertilizer application rates, septic tank density, etc). The most sensitive parameter is adjusted first, followed by the next most sensitive, and so on, although there may be some iterations.

Calibration is done systematically, in the following order:

1. stream flow and water balance
2. suspended sediments (nonfilterable residue)
3. total Kjeldahl nitrogen (TKN) and total phosphorus (TP)
4. ammonia nitrogen (NH_3-N), nitrate + nitrite nitrogen (NOx-N), and orthophosphorus (PO_4-P)
5. dissolved oxygen (DO)
6. *Escherichia coli* (EC) bacteria.

There will likely be multiple iterations, as model parameter changes can affect more than one of the modeled water quality parameters. A list of key model calibration parameters is included below, with notations on the acceptable ranges based on model guidance. This list is based on the past experience of the lead modeler with SWAT as well as knowledge of the fundamental processes. It will not be necessary or beneficial to adjust all these parameters.

Table B7.1 Key Model Parameters and Calibration Ranges

Calibration Target	Parameter	Units	Description	Calibration Range (Default Value)
Channel flow	TRNSRCH	--	Fraction of transmission losses from the main channel to the deep aquifer	0 – 1 (0)
	CH_N1	--	Tributary channel Manning's N	0.01 – 0.15 (.02)
	CH_K1	mm/hour	Effective hydraulic conductivity of channel alluvium	0 – 500 (0)
Surface Runoff	CN2	--	SCS curve number	30 - 100 (varies with HRU)
	SURLAG	hour	Surface runoff lag coefficient	0.05 – 24 (4)
	OV_N	--	Manning's N for overland flow	0.015 – 0.6 (0.15)
Ground water	GW_DELAY	day	Amount of time groundwater spends in the vadose zone	0 – 500 (31)
Ground water	RCHRG_DP	--	Fraction of infiltrated water lost to a deep aquifer	0 – 1 (0.05)
Ground water	ALPHA_BF	day	Baseflow recession constant	0 – 1 (0.048)

Calibration Target	Parameter	Units	Description	Calibration Range (Default Value)
Ground water	GW_REVAP	--	Groundwater revap coefficient	0.02 – 0.2 (0.02)
Ground water	REVAP_MN	mm	Threshold depth of water in shallow aquifer for revap to occur	0 – 500 (1)
Soil Water	SOL_AWC	mm/ mm Soil	Soil available water content for plant uptake	0 – 1 (varies with HRU)
Soil Water	SOL_K	mm/hour	Saturated hydraulic conductivity of soil	0 – 2000 (varies with HRU)
Soil Water	GWQMN	mm	Threshold depth of water in shallow aquifer for percolation to occur	0 – 5000 (0)
Soil Water	ESCO	--	Soil evaporation compensation factor	0 – 1 (0.95)
Soil Water	EPCO	--	Plant uptake compensation factor	0 – 1 (1)
Sediment	SPCON	--	Linear parameter for calculating sediment re-entrainment in the channel	0.0001 - .01 (0.0001)
Sediment	SPEXP	--	Exponential parameter for calculating sediment re-entrainment in the channel	1 – 1.5 (1)
Soil nitrogen	CDN	--	Denitrification exponential rate coefficient	0 – 3 (1.4)
Soil nitrogen	SDNCO	--	Denitrification threshold water content	0 – 1 (0)
Soil nitrogen	NPERCO	--	Nitrogen percolation coefficient	0 – 1 (0.2)
Soil nitrogen	N_UPDIS	--	Nitrogen uptake distribution factor	0 – 100 (20)
Soil nitrogen/ phosphorus	CMN	--	Rate coefficient for mineralization of humus	0.001 – 0.003 (0.001)
Soil nitrogen/ phosphorus	RSDCO	--	Rate coefficient for decomposition of fresh organic matter	0.02 – 1 (0.5)
Soil phosphorus	PSP	--	Phosphorus availability index	0.01 – 0.7 (0.4)
Soil phosphorus	PHOSKD	m^3/mg	Phosphorus soil partitioning coefficient	100 – 200 (175)
Soil phosphorus	P_UPDIS	--	Phosphorus uptake distribution factor	0 – 100 (20)
Soil phosphorus	PPERCO	--	Phosphorus percolation coefficient	10 – 17.5 (10)
Channel nitrogen	BC1	day^{-1}	Rate constant for biological oxidation of ammonia	0.1 – 1 (0)
Channel nitrogen	BC2	day^{-1}	rate constant for oxidation of nitrite to nitrate	0.2 – 2 (0)

Calibration Target	Parameter	Units	Description	Calibration Range (Default Value)
Channel nitrogen	BC3	day^{-1}	rate constant for oxidation of organic nitrogen to ammonia	0.02 – 0.4 (0)
Channel nitrogen	RS3	mg/m^2-day	In-stream benthic ammonia nitrogen source rate at 20 deg C	0 – 1 (0.5)
Channel nitrogen	RS4	day^{-1}	In-stream organic nitrogen settling rate at 20 deg C	0.001 – 0.1 (0.05)
Channel nitrogen	SHALLST_N	mg/L	Nitrate nitrogen concentration in shallow aquifer	0 – 1000 (0)
Channel nitrogen	LAT_ORGN	mg/L	Organic nitrogen concentration in base flow	0 – 200 (0)
Channel phosphorus	BC4	day^{-1}	rate constant for decay of organic phosphorus to dissolved inorganic phosphorus	0.01 – 0.7 (0)
Channel phosphorus	RS5	day^{-1}	In-stream organic phosphorus settling rate at 20 deg C	0.001 – 0.1 (0.05)
Channel phosphorus	RS2	mg/m^2-day	In-stream benthic dissolved phosphorus source rate at 20 deg C	0.001 – 0.1 (0.05)
Nutrient	GWSOLP	mg/L	Soluble phosphorus concentration in shallow groundwater	0 – 1000 (0)
Nutrient	LAT_ORGP	mg/L	Organic phosphorus concentration in base flow	0 – 200 (0)
Reservoir Phosphorus	PSETLR		Phosphorus settling rate in reservoir	2 – 20 (10)
Reservoir Nitrogen	NSETLR		Nitrogen settling rate in reservoir	1 – 15 (5.5)
DO	RK1	day^{-1}	CBOD decay rate coefficient at 20 deg C	0.02 – 3.4 (1.71)
DO	RK2	day^{-1}	Oxygen reaeration rate at 20 deg C	0 – 100 (50)
DO	RK3	day^{-1}	CBOD settling rate at 20 deg C	-0.36 – 0.36 (0.36)
DO	RK4	mg/m^2-day	benthic oxygen demand at 20 deg C	0 – 100 (2)
Bacteria soil	WDPQ	--	Die-off factor for persistent bacteria in soil solution	0 – 1 (0)
Bacteria soil	WDLPQ	--	Die-off factor for less persistent bacteria in soil solution	0 – 1 (0)
Bacteria soil	WDPS	--	Die-off factor for persistent bacteria adsorbed to soil particles	0 – 1 (0)
Bacteria soil	WDLPS	--	Die-off factor for less persistent bacteria adsorbed to soil particles	0 – 1 (0)

Calibration Target	Parameter	Units	Description	Calibration Range (Default Value)
Bacteria soil	BACTKDQ	--	Bacteria soil partitioning coefficient	0 – 500 (175)
Bacteria soil	THBACT	--	Temperature adjustment factor for bacteria die-off/ growth	0 – 10 (1.07)
Bacteria runoff	WOF_P	--	Wash-off fraction for persistent bacteria	0 – 1 (0)
Bacteria runoff	WOF_LP	--	Wash-off fraction for less persistent bacteria	0 – 1 (0)
Bacteria stream	RK5	1/day	Coliform die-off rate in stream at 20 deg C	0.05 – 4 (2)

Time series and flow/load duration plots (between simulated and observed data) and observed and modeled averages will be used to evaluate the prediction (performance) of the model during calibration. Model calibration statistics, including coefficient of determination (r^2), mean error (ME), mean absolute error (MAE), root-mean-square error (RMSE), and Nash-Sutcliffe modeling efficiency (NSE) (Nash and Sutcliffe 1970), will be used as quantitative measures of model fit to supplement the visual evaluation of fit. The formulas for model fit statistics are provided below, where y_i is the measured value, $\hat{y}_i$ is the model predicted value, an overscore indicates a mean value, and n is the number of measurements.

Coefficient of Determination

$$r^2 = \left\{ \frac{\sum_{i=1}^{n} (y_i - \bar{y})(\hat{y}_i - \bar{\hat{y}})}{\left[\sum_{i=1}^{n} (y_i - \bar{y})^2\right]^{0.5} * \left[\sum_{i=1}^{n} (\hat{y}_i - \bar{\hat{y}})^2\right]^{0.5}} \right\}^2$$

Mean Error

$$ME = \left(\sum_{i=1}^{n} (y_i - \hat{y}_i) \right) / n$$

Mean Absolute Error

$$MAE = \left(\sum_{i=1}^{n} |y_i - \hat{y}_i| \right) / n$$

Root Mean Square Error

$$RMSE = \left\{ \left[\sum (y_i - \hat{y}_i)^2 \right] / n \right\}^{0.5}$$

Nash-Sutcliffe Efficiency

$$NSE = 1 - \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 / \sum_{i=1}^{n} (y_i - \bar{y})^2$$

Acceptance Criteria for Model Calibration
The following goodness-of-fit criteria have been established for this project as acceptable model calibration targets:

- Total annual averages of daily flows will be calibrated so that predicted values agree with measured values within 20%, the r^2 of daily flows is greater than 0.5, and the NSE for daily flows is greater than 0.4. These criteria are consistent with those for more than 100 SWAT calibration studies from the U.S. reported in the literature (Gassman et al., 2007).

- Concentrations of TKN, TP, NH_3-N, NO_x-N, dissolved PO4-P, fecal bacteria (as EC), and DO will be calibrated so that the mean of the predicted values falls within two standard deviations of the mean of observed concentrations within the calibration period.

These calibration fits will be judged at each monitoring station or flow gage with a sufficient monitoring dataset, as judged by at least three years of daily flow measurements and at least thirty routine ambient water quality measurements collected over a minimum five years.

The fecal bacteria are problematic calibration targets. EC are considered a major subset of fecal coliform (FC), a broader group of fecal bacteria which may contain other species of bacteria that are not EC. FC was measured before 2003, and EC was measured since 2001. There are approximately two years of data with co-located FC and EC measurements from the same samples. In these samples, the median ratio of EC to FC was 0.708, and the difference was not statistically significant because the ratio did vary widely. Given the uncertainty present in the model, it might be reasonable to pool the FC and EC data for the model period. However, we will instead focus the calibration only on the EC measurements, which cover a more recent period and are the basis for current water quality criteria.

In the instance that these calibration standards are not obtained, Parsons will:

- Check data for deficiencies and correct any that are found,
- Check model algorithms for deficiencies and correct any that are found, and
- Re-calibrate the model after corrections of deficiencies.

The results of these steps will be summarized and submitted to the City of Boerne and TCEQ in a CAR. If these steps do not bring predicted values within calibration standards, the Parsons QAO will work with the City of Boerne QAO and TCEQ NPS lead QAS to arrive at an agreeable compromise.

Model Sensitivity Analysis
Sensitivity analysis determines the effect of a change in a model input parameter or variable on the model outcome. Sensitivity analysis will be applied during calibration to identify those parameters whose adjustment will produce the largest effect on model outcome. Sensitivity analysis will also be performed after the model has been calibrated to identify those parameters whose uncertainty may be contributing most to model uncertainty. Sensitivity analysis will be

performed using integrated SWAT tool for sensitivity analysis that utilizes Latin hypercube sampling of one parameter at a time for calibration parameter values between an upper and lower bound.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Not Relevant - No new sampling data will be collected under this QAPP during this project

B9 NON-DIRECT MEASUREMENTS (DATA ACQUISITION REQUIREMENTS)

The available data sources that provide input parameters for model development include both inherently geospatial data sources, such as land use data or elevation grids, as well as other tabular data that will be converted to geospatial format for processing. The key data sources that will be investigated and compiled (if available) to support model and/or WPP development are listed below. These data sources are industry standard for identifying, characterizing, and displaying pollutant sources, conducting water quality assessments, and developing WPPs. If measured data are not available for a particular subwatershed, model inputs will be selected and adjusted based on recent research and calibration in similar watersheds. Additional information on data acceptance, use, and validity are provided in Section B10 (Data Management), Section C (Assessment and Oversight), and Section D (Data Validation and Usability) of this document. The following inherent limitations associated with available data sources do not preclude their use in WPP development:

- Data sets have variable periods of record.
- Each data set or source has different acceptance criteria and methods of QA/QC applied prior to its release for general use.
- Most data sets are not available on a watershed basis and need to be converted for spatial analysis.

Table B9.1 Data Sources for Model and WPP Development

Data Set	Description	Source & Transfer Method	Application
National Elevation Dataset	A 1/3 arc-second (~10-meter) resolution digital elevation model (DEM) will be used in determination of the contributing watersheds. Derivative data sets from the elevation grid include flow direction, flow accumulation, and slope grids, as well as watershed boundaries and outlets.	USGS Metadata link: http://seamless.usgs.gov/products/3arc.php Industry standard, public domain data source that can provide resolution necessary to conduct watershed modeling. Transfer by FTP as an ESRI grid from USGS server //seamless.usgs.gov/ to Parsons	Elevation used in subwatershed delineation in SWAT. Also used to extract basin topographic parameters in SWAT.

Data Set	Description	Source & Transfer Method	Application
Streams - National Hydrography Dataset (NHD)	The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system.	USGS Metadata link: http://nhd.usgs.gov/ Industry standard, public domain data source that can provide resolution necessary to conduct GIS mapping, modeling, data analysis. Transfer as an ESRI geodatabase by FTP from USGS server //nhd.usgs.gov/ to Parsons	Stream network for SWAT. Aids in subwatershed delineation, outlet placement, and extraction of SWAT stream parameters (length, gradient).
Soils - STATSGO soil map unit boundaries and soil properties	This data set is integrated into the SWAT model. It includes soil map unit boundaries, physical, hydrologic, and chemical properties, which directly impact watershed hydrology and constituent loads.	Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) database built in the ArcSWAT geodatabase NRCS metadata link: http://soildatamart.nrcs.usda.gov/ Integrated into SWAT model, downloaded as a ZIP-compressed file from http://swatmodel.tamu.edu/ software/arcswat/ by Parsons	Assignment of soil properties to SWAT HRUs.
Land use/ land cover - National Land Cover Dataset (NLCD)	This dataset, based on Landsat imagery from approximately 2006, converted to a 30-meter resolution grid, is currently the best available statewide land use coverage. The land use categories of the NLCD land use scheme will be re-classified in SWAT to provide simplified land use categories that are more meaningful in terms of estimating pollutant loading rates.	USGS National Land Cover Dataset 2006 Link: http://www.mrlc.gov/ Industry standard, public domain data source that can provide resolution necessary to conduct GIS mapping and modeling. Transfer as an ESRI GRID file by FTP from USGS server //seamless.usgs.gov/ to Parsons	Definition of SWAT HRUs. Assignment of land use characteristics to SWAT HRUs.
Meteorological data – National Climatic Data Center	Daily total precipitation, maximum and minimum daily temperature recorded at the National Weather Service (NWS) cooperative station at Boerne (in the watershed) for the period 1987 to 2011. The few small data gaps may be filled using data from nearby NWS stations in Comfort or Sisterdale.	National Climatic Data Center Link: http://www.ncdc.noaa.gov/ Public domain data source that provides more accurate local daily meteorological data than any other source available that is necessary for modeling. Transfer of comma-delimited text file by FTP from above link to Parsons	SWAT input.

Data Set	Description	Source & Transfer Method	Application
USGS stream gage data	Spatial data for USGS gage stations in the study area and historical flow records for each gage stations (daily stream flows).	USGS Link: http://waterdata.usgs.gov/nwis/dv/?referred_module=sw Best public domain data source available that can provide site specific data necessary to support modeling. USGS is only source of historical flow records in study area. Transfer of tab-delimited text file by http from above link to Parsons	SWAT hydrologic calibration.
Point source wastewater discharge (to Cibolo Creek)	Self-reported monthly data for the City of Boerne wastewater treatment plant discharge. Data to be obtained include flow rates, TSS, DO, NH3-N, CBOD, and FC concentrations.	City of Boerne. Transfer of Excel spreadsheet from City of Boerne to Parsons via email attachment	SWAT input.
Ambient surface water quality data	Quality-assured water quality measurements and analyses from stream monitoring locations within the study area collected by the TCEQ, San Antonio River Authority, City of Boerne, and other entities for the calibration period.	Transfer by hypertext transfer protocol (HTTP) from TCEQ SWQMIS http://www8.tceq.state.tx.us/SwqmisWeb/public/index.faces Recent (2010-2011) data collected by the City of Boerne under the QAPP "Water Quality Monitoring for the Upper Cibolo Creek (Segment 1908) Watershed Protection Plan" will be transferred from the City of Boerne to Parsons in an Excel spreadsheet as an email attachment.	SWAT calibration.

Data Set	Description	Source & Transfer Method	Application
Texas livestock census data	Total population estimates for various livestock species derived from 1997 to 2007 agricultural census for Kendall County. In addition to cattle, goats, swine, sheep, and poultry, population estimates for a number of other types of livestock are provided. This data was compiled by the Census of Agriculture every five years, providing the only source of consistent, comparable, and detailed agricultural data for every county in America (USDA 2007).	National Agricultural Statistics Service, USDA. Data link: http://quickstats.nass.usda.gov/ Only public domain data source available that provides data necessary for assessment. Transfer as comma-delimited text file by HTTP from above link to Parsons.	Estimation of average annual quantities of grazing and manure deposition to be input to SWAT.
Texas crop census data	Acreage estimates by crop type for various management practices (row crop, pasture/ forage crop, etc) at the county level, derived from 2007 census.	National Agricultural Statistics Service, USDA. Data link: http://quickstats.nass.usda.gov/ Transfer as comma-delimited text file by HTTP from above link to Parsons.	Estimation of parameters for SWAT management input files.
Nutrient atmospheric loads	Measured ammonia and nitrate nitrogen air deposition fluxes will be input as direct sources to the watershed.	National Atmospheric Deposition Program Data Link: http://nadp.sws.uiuc.edu/data/ Transfer as comma-delimited text file by HTTP from above link to Parsons.	SWAT input parameter
Septic System Density	Number and locations of septic systems within the Upper Cibolo Creek watershed	Ryan Bass, City of Boerne. GIS Shapefile developed from maps of county parcels with improved structures and from list of sewer customers from City of Boerne.	SWAT input parameter
Septic System failure rate	Septic System failure rate	Reed, Stowe, and Yanke. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility Systems in Texas, Prepared in Cooperation with the Texas On-Site Wastewater Treatment Council. Report obtained as PDF via email from Reed, Stowe, and Yanke.	SWAT input parameter

Data Set	Description	Source & Transfer Method	Application
Livestock Manure Production and Characteristics	Estimates of the amount of manure produced by livestock and the nutrient, oxygen demand, and EC loads associated with it.	1992. U.S. Department of Agriculture. 1992. Agricultural Waste Management Field Handbook. 210-AWMFH. American Society of Agricultural Engineers (ASAE). 1998. *ASAE Standards, 45th edition: Standards, Engineering Practices, Data.* St. Joseph, MI. Metcalf & Eddy. 1991. *Wastewater Engineering: Treatment, Disposal and Reuse.* Third edition. George Tchobanoglous and Franklin L. Burton, Eds.	SWAT input parameter
Water withdrawals	Monthly surface water use by the City of Boerne withdrawn from Boerne City Lake	City of Boerne records Transferred from the City of Boerne to Parsons in an Excel spreadsheet as an email attachment.	SWAT input parameter

The sources of secondary data will be identified in all deliverables and will be evaluated based on the criteria listed in Section A7 (Quality Objectives & Criteria).

Quality and Limitations of SWAT Model Data

It is not currently possible to comprehensively quantify the error in SWAT model predictions, thus there are no quantitative data quality requirements. It is possible, however, to list model limitations. Model limitations may be the result of data used in the model, inadequacies in the model, or using the model to simulate situations for which it was not designed. The following is a list of notable SWAT model limitations:

Meteorology: Meteorology is the driving force for any hydrologic model. Data collected at a single point (in Boerne) will be applied to the entire watershed (274 square miles). Rainfall can be quite variable, especially in the spring when convective ("pop-up") thunderstorms produce precipitation with a high degree of spatial variability. It may rain heavily at a weather station, but may be dry a short distance away. On an average annual or average monthly basis, these errors may cancel. Other meteorological parameters, such as solar radiation and relative humidity, will be based on SWAT-generated statistical monthly estimates. This limitation among others, cautions us against using daily model output.

Radical parameter changes: Scenarios involving radical changes to the basin result in greater uncertainty. The SWAT model is calibrated using estimates of what is presently occurring in the basin. Large departures from calibration conditions raise the level of uncertainty in model predictions.

Small area land covers: Land uses that cover very small areas are not represented in the SWAT model. Land uses that occupy limited areas such as unpaved roads, bare areas, construction sites, and some row crops may not be simulated. In addition, most of these features may not be depicted in the available land cover. Some of these small areas may contribute many times more sediment on a per unit area basis than rangeland. Although significant, they may not be able to be simulated with the currently available data.

HRU characteristics: Each HRU in a particular subbasin is assumed to have the same characteristics by the SWAT model. For instance, the same slope is used for all rangeland HRUs in a single subbasin.

Management uncertainty: There is a great deal of uncertainty associated with pasture and other agricultural land management practices. In reality, management varies significantly from field to field, and from day to day. It is not possible to easily determine what types of specific agricultural activities are happening at a given time or place, or to simulate all agricultural activities in the model. Therefore, categories are created to cover expected management choices only.

Default parameter values: It is not practical to measure or calibrate all of the parameters utilized in the SWAT model in this particular watershed. A large number of parameters will be maintained at the "default" values found to be appropriate in other SWAT models. A sensitivity analysis will be utilized to identify the most sensitive parameters, which will be adjusted during calibration if measured values are unavailable.

Calibration: Calibrated parameter values are not necessarily accurate. They may simply correct for inaccuracies in other parameters or data. This may limit the model's accuracy in predicting future conditions.

Temporal change: The model will be calibrated to a twenty year period, but many of the data sources, including land cover, are based on "snapshots" in time.

B10 DATA MANAGEMENT AND HARDWARE/SOFTWARE CONFIGURATION

B10 (A) Data Management

The available data sources that will be utilized to develop the WPP include both inherently geospatial data, such as land use data or elevation grids, as well as other tabular data, such as weather, flow, and water quality time-series, that will be compiled in a database and converted to the input formats required by SWAT. Data tasks will be performed by the Parsons Lead Modeler with review by the Parsons QAO.

Data Delivery
Upon completion of the models, output data (average loadings and load reductions) will be used to write a modeling report and, subsequently, by the City of Boerne to write a WPP. Copies of derived input and output datasets as well as the modeling report will be provided to TCEQ. All components will be burned to CD-ROM or DVD-ROM and provided by U.S. mail or express carrier.

Migration/Transfer/Conversion
Large geospatial datasets will be retrieved from the host servers to Parsons by file transfer protocol (FTP), while smaller datasets may be transferred by HTTP or as email attachments. The sources and modes of transfer for each dataset are provided in Section B9.

Zip-compressed files will be de-compressed using the Microsoft® Windows Extraction Wizard. When required, comma-, space- or tab-delimited text files will be loaded into Microsoft Excel spreadsheets or Microsoft Access database for conversion to the text-based format required by ArcSWAT.

When required, geospatial data files will be projected to the following Albers Equal Area Conic projection as needed:

Projection	Albers
Datum	NAD83
Spheroid	GRS80
Units	meters
Zunits	meters
Xshift	0.0
Yshift	0.0
Parameters	
29.5000	1st standard parallel
45.5000	2nd standard parallel
-96.0000	central meridian
23.0000	latitude of projection's origin
0.0000	false easting (meters)
0.0000	false northing (meters)

Information Dissemination
Copies of all derived input and output datasets as well as the modeling report will be provided to the City of Boerne and the TCEQ. All components will be burned to CD-ROM or DVD-ROM and provided by U.S. mail or express carrier.

Project updates will be provided to the TCEQ NPS Project Manager in progress reports and the information will be made available at stakeholder meetings. Input data and model outputs resulting from the project described in this QAPP will be accessible to the general public through the City of Boerne.

B10 (b) Hardware/Software Configuration

Parsons uses laptop personal computers and desktop personal computers that run the Microsoft® Windows XP operating system. Databases include Microsoft® Excel and Microsoft® Access. GIS processing will be completed using ArcGIS 9.3.1. The watershed model will be completed using the SWAT version 2009, revision 477 or later, (Neitsh et al., 2011) and ArcSWAT 2009.93.7b (Winchel et al., 2010), which is an ArcGIS extension and graphical user input interface for SWAT.

All electronic data will be maintained on Parsons' intranet server in Austin, Texas. The Parsons Local Area Network (LAN) consists of a Dell Poweredge server, running Microsoft® Windows Server software, providing storage, database access, as well as file and print services to a 100/1000 MBps switched Ethernet network. Storage devices include hard disk arrays (5 terabytes) with a Redundant Array of Inexpensive Devices (RAID) controller. Parsons uses Dell computers with the Microsoft® Windows XP Professional and Windows 7 operating systems. Parsons computers are equipped with the Microsoft® Office Professional Suite. Trend Micro's Office Scan is installed on all Parsons computers and on the Parsons server to prevent computer viruses. Full virus scans are automatically run each week.

The Parsons domain also includes a firewall to protect its networks from unauthorized access. Access to the Parsons network is username and password protected and allows only Internet access by default. Access to servers or routers is governed by internal LAN username and password. Parsons operates its own Microsoft Exchange email server, which prohibits messages containing file types commonly associated with computer viruses. All email accounts are password protected. Office Scan also checks email messages for viruses.

Archives/Data Retention

Electronic data files on the Parsons network are archived to a stand-alone "Archive" server after approximately one year. The Archive server has two redundant mirrors, one onsite and one stored offsite that are periodically swapped in a rotation schedule.

Backup/Disaster Recovery

The Parsons server is backed up to a local disk array and copied to remote servers in Richardson, Texas. Incremental backups are performed nightly. The entire server is backed up each week. Users are advised not to store critical data on a local hard drive.

References

Gassman, P.W., M.R. Reyes, C.H. Green, and J.G. Arnold. 2007. The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions. *Transactions of the ASABE*, 50(4): 1211-1250.

Nash, J.E., and J.V. Sutcliffe. 1970. River flow forecasting through conceptual models part I – A discussion of principles. *Journal of Hydrology*, 10 (3): 282-290.

Nietsch, S.L. J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2011. *Soil and Water Assessment Tool, Theoretical Documentation, Version 2009*. Texas Water Resources Institute Technical Report 406. Texas A&M University System. College Station, TX.

Winchell, M., R. Srinivasan, M. Di Luzio, and J. Arnold. 2010. *ArcSWAT Interface for SWAT2009. User's Guide*. Texas Agrilife Research. Temple, TX.

SECTION C: ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

Since most of the data used in this project have been produced under well-documented quality conditions, it will be subjected to only a consistency check and a determination, based on its existing metadata, that it meets the project requirements as described under Section A7. Geospatial data assessment will be performed by a Parsons GIS specialist. The Parsons lead modeler will evaluate data to be used in calibration and as model input according to criteria discussed in Section A7 and will follow-up with the various data sources on any concerns that may arise. Direction and routine supervision of data tasks will be provided in a team effort by the Parsons lead modeler, Parsons QAO, and Parsons project manager.

The consistency check for geospatial data will include verification that the datasets completely cover the project area, boundaries coincide with other data layers (*e.g.*, county boundaries), and that they are projected and contain units in agreement with their metadata. A consistency check will be performed as each spatial data layer is obtained from the various sources. If inconsistencies are not easily remedied, an alternate data source meeting the project requirements may be identified.

The consistency check for times series data (*e.g.*, flow rates, weather data, water quality concentrations) will include verification that the reported values are within reasonable ranges (*e.g.*, no negative flows or concentrations are included) as well as statistical analysis to determine if datasets collected by different organizations or using different methods can be combined, or to identify potential statistical outliers.

The model calibration procedure and targets for acceptable outcomes are provided in Section B7. Results will be reported to the Parsons QAO. If agreement is not achieved between the calibration targets and the observed values, the following corrective actions will be led by the Parsons lead modeler with the involvement of the Parsons QAO:

- Check data for deficiencies and correct any that are found,
- Check model algorithms for deficiencies and correct any that are found, and
- Re-calibrate the model after corrections of deficiencies.

The results of these steps will be summarized and submitted to the City of Boerne QAO and TCEQ lead NPS QAS in a CAR. If these steps do not bring predicted values within calibration standards, the Parsons QAO will work with the City of Boerne QAO and TCEQ lead NPS QAS to arrive at an agreeable compromise.

Software requirements, software design, and 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.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	City of Boerne project manager	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of Parsons' performance and data quality	Report to TCEQ in Quarterly/Monthly Report. Ensure project requirements are being fulfilled.
		Parsons project manager	Monitoring of the project status and records to ensure requirements are being fulfilled.	Monthly Progress Report to City of Boerne
Check geospatial data	Before model development	Parsons lead modeler	Consistency check	Changes in data sources documented by Parsons project manager in monthly report
Check times series datasets	Before model development	Parsons lead modeler & Parsons QAO	Consistency check, including statistical analysis of times series datasets	Changes in data sources or exclusion of data documented by Parsons project manager in monthly report
Model calibration	After calibration	Parsons lead modeler and Parsons QAO	Verify that model calibration meets acceptance criteria	If not met, a CAR will be developed.
Technical Systems Audit	Dates to be determined by TCEQ	TCEQ lead NPS QAS	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP	30 days to respond in writing to the TCEQ to address corrective actions

Internal Assessment
Since this project is primarily a modeling endeavor, traditional performance and system audits are not appropriate. Instead, the modeling results will be evaluated during the validation and model output interpretation processes. Modeling performance assessments will be made continually by the City of Boerne and the TCEQ NPS Program as described in the calibration and validation sections.

Modeling data and project deliverables will be internally quality-controlled by the TCEQ NPS project manager's in-house review. The TCEQ NPS project manager will maintain overall responsibility for examining the contracted work to ensure methodologies and processes are consistent with the procedures outlined in this QAPP.

Corrective Action
The Parsons project manager is responsible for implementing and tracking corrective action procedures as a result of audit findings. Records of audit findings and corrective actions are maintained by the TCEQ NPS project manager and City of Boerne QAO. Corrective action documentation will be submitted to the TCEQ NPS 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.

The City of Boerne QAO is responsible for documenting deficiencies and nonconformances and reporting these to their management. A CAR must be completed and submitted to the TCEQ with the next progress report due after the deficiency and/or nonconformance occurred.

C2 REPORTS TO MANAGEMENT

Reports to City of Boerne Project Management
Monthly Progress Report –Submittal of progress reports will be at a monthly interval. It summarizes the City of Boerne's activities for each task; reports monitoring status, problems, delays, status of non-conformances and corrective actions; and outlines the status of each task's deliverables. Format of the submitted progress report will be as specified in the contract or work orders. Reports should provide enough information so the City of Boerne project manager can evaluate the modeling effort.

Final Report – After the final modeling run is completed, Parsons will prepare a draft modeling report describing the results of model development, calibration, load estimation, allowable loading, and management scenario evaluation. Within 30 days of receipt of comments from the City, Parsons will revise the report to address the comments and provide a revised final modeling report.

Reports to TCEQ Project Management
Quarterly Progress Report –Submittal of progress reports by the City of Boerne will be at a quarterly frequency. It summarizes the City of Boerne's activities for each task; reports

monitoring status, problems, delays, status of non-conformances and corrective actions; and outlines the status of each task's deliverables. The format of the submitted progress report will be as specified in the contract or work orders. Reports should provide enough information so the TCEQ project manager can evaluate the modeling effort.

Final Report – The City of Boerne will provide the draft modeling report (prepared by Parsons) for TCEQ comment. After revisions by Parsons, the City of Boerne will provide the revised final modeling report to the TCEQ NPS Project Manager.

Corrective Action Report (CAR) – Identifies any deficiencies and nonconformances. The cause(s) and program impacts are discussed. The completed corrective actions are documented, and the report is submitted to the TCEQ NPS project manager with the first progress report occurring after the deficiencies and/or nonconformance was identified.

Audit Report and Response - Following any audit performed by the City of Boerne, a report of findings, recommendations and responses are sent to the TCEQ project manager in the quarterly/monthly progress report. Such reports will include model performance assessments, calibration, and validation performance determination.

Reports by TCEQ Project Management
City of Boerne Evaluation - The City of Boerne is evaluated in a City of Boerne evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurements and Contracts Section.

SECTION D: DATA VALIDATION AND USABILITY

Validation - Validation is an extension of the calibration process that reduces uncertainty. The rates and settings developed during calibration are checked for adequacy using data set(s) that represent the modeled waterbody under different conditions than were observed during the calibration data set. The rates then, if necessary, are adjusted further so that they work adequately well for all data sets. Validation is the comparison of the modeled results with independently derived numerical observations from the simulated environment. Model validation is, in reality, an extension of the calibration process. Its purpose is to assure that the calibrated model properly assesses the range of variables and conditions that are expected within the simulation.

D1 DEPARTURES FROM VALIDATION CRITERIA

The calibrated model will be validated versus data collected during the years 2007 and 2011. These are the most recent exceptionally wet and dry years. In 2007, more than 58 inches of rain fell in the watershed, while 2011 has thus far been one of the driest years on record. The model validation criteria will be identical to the data quality objectives outlined in Section B7. If the model meets the validation criteria for these two recent but extreme years, as well as the calibration criteria for the calibration period, the model will be considered usable for project purposes. Nonattainment of validation criteria will trigger additional rounds of calibration and validation to achieve the best model calibration possible.

It is possible that one or a very few "high-leverage" observed data points may be responsible for non-attainment of one or more validation criteria. In this case, several items will be performed:

- laboratory quality control data pertaining to those measurements will be reviewed,
- the data will be evaluated by statistical procedures to see if they should be considered outliers, and
- the degree to which these high-leverage measurements are representative of ambient conditions will be evaluated.

These steps will be performed by the Parsons QAO in concert with the City of Boerne QAO. The statistical outlier tests will include Rosner's test (for 25 or more samples) or Dixon's test (for less than 25 samples) at a 95% confidence level using EPA's ProUCL software (Singh et al. 2010).

If, in the opinion of the City of Boerne QAO, the high-leverage data are identified as statistical outliers, are deemed unrepresentative, or are analytically questionable, the validation statistics may be re-run without those data points.

The additional rounds of calibrations will be performed and documented as described under Section C1 for corrective action.

D2 VALIDATION METHODS

Model Validation

The SWAT watershed model 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, are adjusted to provide a better fit. Moreover, these model parameters will be adjusted within literature recommended values consistent with existing knowledge of watershed processes. This helps ensure that the results are scientifically valid and defensible. However, because there are more free parameters than sets of field data, it is unlikely that there is a unique optimal solution to the calibration process. Statistical measures used for evaluating the model's fit to observed data during calibration and validation help ensure that the model results are reliable.

In the validation process, the model is operated with input parameters set during the calibration process, as described in Section B7 (Calibration), without any change and the results are compared to a separate set of observed data for the years 2007 and 2011 to evaluate the accuracy of model prediction versus the validation criteria. The model validation criteria will be identical to the data quality objectives outlined in Section B7. In case the matching between simulated and observed data does not meet the validation targets, the calibration and validation processes will be revisited until a best fit between simulated and observed data is obtained. The validation process will be led by the Parsons lead modeler.

While statistical measures and criteria will guide the assessment of the SWAT model, the final determination of model validity will be based on a more qualitative visual assessment of the model's ability to predict observed variations. This determination will be made by the City of Boerne QAO based on input from Parsons' lead modeler and QAO.

D3 RECONCILIATION WITH USER REQUIREMENTS

The Parsons QAO and the City of Boerne QAO will review and evaluate the draft modeling report and calculations for technical consistency with the requirements of this QAPP. The TCEQ, City of Boerne, and Parsons project managers will evaluate the draft final report for quality and consistency with the scope of work described in Section A6. Necessary revisions and refinements will be made to the draft modeling report based on comments. Any significant limitations on data used shall be communicated between the project personnel listed in this subsection and documented in the modeling report.

The SWAT model developed for this project will be used to evaluate flow and pollutant loading to Upper Cibolo Creek. The model will be developed to provide the City of Boerne and local stakeholder groups with information pertaining to watershed characteristics and to the prediction of possible pollution problems.

Output data generated by the models will be presented in the project deliverables as graphical comparisons of observed and predicted water quality constituents and stream gage flow data. A comparison of predicted and measured averages will also be provided to show the models' prediction with respect to observed data at several locations in the watersheds.

Using the qualitative-quantitative approach discussed in A7 Quality Objectives and Criteria and Section C1 for model inputs and outputs, a determination will be made of the overall technical credibility of the methodology for addressing the pollutants of concern in Upper Cibolo Creek: dissolved oxygen, nutrients, and fecal bacteria. If model outputs show that they can meet the calibration and validation targets, then they will be considered to be technically defensible, and therefore useable, to provide water quality results for developing a WPP for Upper Cibolo Creek.

Model results may be subsequently analyzed and used by the City of Boerne and TCEQ for WPP development, stream standards modifications, permit decisions, and water quality assessments.

References

Singh, A., N. Armbya, and A.K. Singh. 2010. ProUCL Version 4.00.05 Technical Guide. EPA/600/R-7/041. U.S Environmental Protection Agency, Washington, DC.

APPENDIX A. ADHERENCE LETTER

Appendix A. Example Letter to Document Adherence to the QAPP

TO: Ryan Bass, Watershed Coordinator
City of Boerne

FROM: *(name)*
(organization)

RE: Watershed Protection Plan Development for Upper Cibolo Creek

Please sign and return this form by *(date)* to:

Ryan Bass
City of Boerne, Public Works Annex
402 E. Blanco
Boerne, Texas 78006

I acknowledge receipt of the "Watershed Protection Plan Development for Upper Cibolo Creek Quality Assurance Project Plan for Modeling, Revision *Date*". I understand the document describes quality assurance, quality control, data management and reporting, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria. My signature on this document signifies that I have read and approved the document contents pertaining to my program. Furthermore, I will ensure that all staff members participating in NPS modeling activities will be required to familiarize themselves with the document contents and adhere to them as well.

____

Signature Date

Note: Copies of the signed letter should be sent by the City of Boerne to the TCEQ NPS Project Manager within 30 days of the final TCEQ approval the QAPP. <u>This letter should be submitted for all subcontractors</u> that did not sign the QAPP (under section A1 of this QAPP).