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

Watershed Protection Plan Development for the Pecos River Basin

TSSWCB Project 04-11

Quality Assurance Project Plan
Revision # 1
Texas State Soil and Water Conservation Board

prepared by

Texas Water Resources Institute
Texas Cooperative Extension
And
Texas Agricultural Experiment Station

Effective Period: December 2005 to October 2007

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Section A1 Approval Sheet

Watershed Protection Plan Development for the Pecos River Basin

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Signature:______________________________________ Date:_________________________

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Title: Associate Professor, Extension Range Specialist; Project Director

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Name: Will Hatler
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Signature:______________________________________ Date:_________________________

Name: Alyson McDonald
Title: Extension Assistant, Hydrology

Signature:______________________________________ Date:_________________________

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Name: J. Bruce Moring, Ph.D.
Title: Senior Biologist, Investigator

Signature:______________________________________ Date:_________________________

Section A2: Table of Contents

Section: Title

Appendices

List of Tables

List of Figures

List of Acronyms

ACE	Ace Technologies, Inc.
AWRL	Ambient Water Reporting Limit
BMP	Best Management Practices
CAR	Corrective Action Report
COC	Chain-of Custody
CRP	Clean Rivers Program
DOC	Demonstration of Capability
DQO	Data Quality Objective
EPIC	Erosion Productivity-Impact Calculator, Environmental Policy Integrated Climate
FY	Fiscal Year
IBWC	International Boundary and Water Commission
MDMA	Monitoring Data Management & Analysis
QA	Quality Assurance
QAM	Quality Assurance Manual
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QC	Quality Control
QMP	Quality Management Plan
RBP	Rapid Bioassessment Protocol
RGBI	Rio Grande Basin Initiative
RL	Reporting Limit
ROTO	Routing Outputs to Outlets
RWA	Receiving Water Assessment
SOP	Standard Operating Procedure
SWQM	Surface Water Quality Monitoring
TMDL	Total Maximum Daily Load
TCEQ	Texas Commission on Environmental Quality
TCE	Texas Cooperative Extension
TRACS	Texas Regulatory Activities and Compliance System
TSSWCB	Texas State Soil and Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
TWRI	Texas Water Resources Institute
USDA-ARS	U.S. Department of Agriculture, Agricultural Research Service
USIBWC	U.S. International Boundary and Water Commission
VOA	Volatile Organic Analytes
WMT	Watershed Management Team

Section A3: Distribution List

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

United States Environmental Protection Agency, Region VI
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Section A4: Project/Task Organization

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

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

Randall Rush, USEPA Texas Nonpoint Source Project Manager

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

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

Aaron Wendt, TSSWCB Project Manager

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

Donna Long, TSSWCB Project Quality Assurance Officer

Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB and USEPA participants. Responsible for verifying that the QAPP is followed by project participants. Determines that the project meets the requirements for planning, quality assessment (QA), quality control (QC), and reporting under the CWA Section 319 program. Monitors implementation of corrective actions. Coordinates or conducts audits of field and modeling systems and procedures.

TWRI – Texas Water Resources Institute (TWRI), College Station, Texas. Project Facilitator. Provides the primary point of contact between the Texas State Soil and Water Conservation Board (TSSWCB) and the project contractors. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified. Responsible for coordination, review, and delivery of quarterly reports and the final project report.

Dr. C. Allan Jones, TWRI Director; Project Director

Responsible for ensuring the submittal of accurate and timely deliverables and costs to the TSSWCB Project Lead. Responsible for ensuring that tasks and other requirements in the contract are executed on time and in accordance with the QA/QC requirements in the system as defined by the contract work plan and in the QAPP. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data for this project. Responsible for the facilitation of audits and the implementation, documentation, verification, and reporting of corrective actions.

<u>Clint Wolfe, TWRI Quality Assurance (QA) Officer</u>

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

TCE – Texas Cooperative Extension, Fort Stockton, Texas. Project Director. Responsible for developing the watershed protection plan and educational training. TCE – Fort Stockton will contribute to the development of quarterly reports and the final project report.

<u>Dr. Charles Hart, Associate Professor, Extension Range Specialist, Project Director</u>

Responsible for ensuring that tasks and other requirements in the contract are executed on time and as defined by the grant work plan; assessing the quality of work by participants and developing a baseline assessment of the Pecos River basin. Responsible for coordinating and supervising field sampling activities. Responsible for ensuring that field personnel have adequate training and a thorough knowledge of standard operating procedures (SOPs) specific to the analysis or task performed and/or supervised. Responsible for developing educational components of the project. Responsible for identifying and characterizing saline water sources entering the Pecos River basin. Responsible for developing watershed protection plan.

<u>Will Hatler, Extension Assistant, Project Coordinator</u>

Responsible for coordinating attendance at conference calls, meetings, and related project activities and developing educational components of the project. Responsible for developing a website to disseminate information about the project. Responsible for developing watershed protection plan. Responsible for coordination of project activities with contracted parties. Responsible for verifying that the data produced are of known and acceptable quality.

<u>Alyson McDonald, Extension Assistant, Hydrologist</u>

Responsible for quantifying volume and fate of water salvage as a result of saltcedar control along the Upper Pecos River. Will characterize the relationship between surface water and ground water along a portion of the Upper Pecos River

TAES – Texas Agricultural Experiment Station, El Paso, Texas. Project Investigators. Responsible for identifying and characterizing saline water sources entering the Pecos River basin. Responsible for quantifying volume and fate of water salvage as a result of saltcedar control along the Upper Pecos River.

<u>Dr. Seiichi Miyamoto, Professor of Salinity Management, Investigator</u>

Responsible for identifying and characterizing saline water sources entering the Pecos River basin. Will simulate the flow and salinity of the Pecos River basin to provide a framework to evaluate river management options.

Dr. Zhuping Sheng, Assistant Professor of Hydrogeology, Investigator

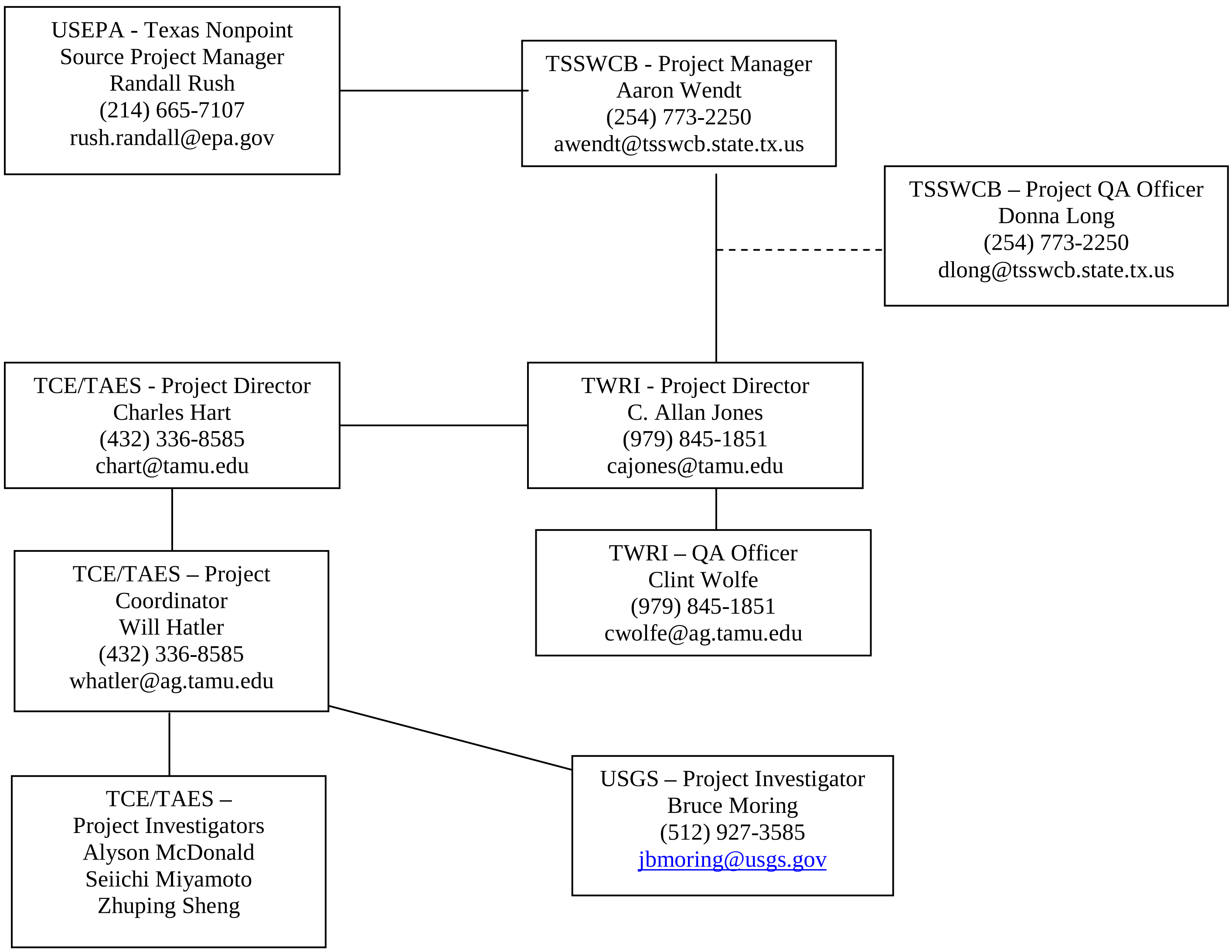
Responsible for quantifying volume and fate of water salvage as a result of saltcedar control along the Upper Pecos River. Will characterize the relationship between surface water and ground water along a portion of the Upper Pecos River.

USGS – U.S. Geological Survey. Responsible for completing aquatic life and stream habitat inventories and assessments.

Dr. Bruce Mooring, Senior Biologist, Investigator

Responsible for completing aquatic life and stream habitat inventories and assessments along the Pecos River.

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



Section A5: Problem Definition/Background

The Pecos River is a greatly depleted western river flowing 418 winding miles through hot, dry, semi-arid landscapes in Texas. It is the largest river sub-basin flowing into the Rio Grande River in Texas. As such, its importance historically, biologically and hydrologically to the future of the Rio Grande Basin is huge. The flows of the once great Pecos River have dwindled to a mere trickle due to many causes – some natural and some man-induced. Its upper reaches in Texas now resemble a very poor quality creek rather than a river. If the integrity of the entire Rio Grande basin below the Pecos is to be improved and maintained, then it is crucial that both the water quality and quantity of Pecos flows be drastically upgraded and stabilized within a natural flow regime to a viable level of in-stream flows.

Due to the lowered water quality and stream flows, the aquatic community of the Pecos River has been drastically altered according to fishery biologists and to local users of the river. No longer does it have a healthy diverse community of aquatic plants, invertebrates, microorganisms, fish and amphibians. The greatly reduced aquatic diversity has been negatively affected by changes in river hydrology, riparian community destruction, oil and gas activities, irrigation demands, long and short-term droughts, damming of the river and the desertification of the upland watershed due to grazing mismanagement. These factors, both natural and man-made, have allowed introduced plant species, such as saltcedar, to dominate the riparian systems within the watershed.

According to the data of USIBWC, the Pecos River contributes to the flow of the Rio Grande at an average rate of 274 million m^3, which accounts for 11% of the stream inflow into Amistad. However, it also contributes to salt loading into Amistad at an annual rate of 0.54 million tons or 29.5% of the total salt loading. Salinity of the Amistad exceeded 1000 ppm for a month in 1988, and has fluctuated since. It is important to control salt loading from the Pecos to Rio Grande if we are to be successful in keeping salinity of the reservoir below in compliance with the Texas Water Quality Standards (Table A5.1).

The decreasing water quality in the Pecos River has negatively affected the Rio Grande River. Being an international river, the Rio Grande is relied upon by both Mexico and the United States for drinking water, irrigation and industry and as such, it depends heavily upon its major Texas tributary – the Pecos River. The Pecos River itself is also the lifeblood of many communities within its reaches, mainly as an irrigation source, recreational uses, and as recharge for underlying aquifers. The environmental condition of both the Pecos and the lower Rio Grande River is extremely crucial to hundreds of thousands of residents of both Mexico and the U.S.

This project will assess the physical features of the Pecos River basin, facilitate communications with stakeholder groups and landowners in eight neighboring counties, and monitor the water quality of the Pecos River. Through this project a Watershed Protection Plan will be developed to assess current management measures as well as determine what future management measures need to be implemented in the river basin to protect the water quality of the Pecos River.

Table A5.1. Designated Uses and Criteria for Segments in and Adjacent to Study Area

Rio Grande Basin			Uses			Criteria						
Segment No.	SEGMENT NAME	BASIN	Recreation	Aquatic Life	Domestic Water Supply	Cl^{-1} (mg/L)	SO_4^{-2} (mg/L)	TDS (mg/l)	Dissolved Oxygen (mg/l)	pH Range (SU)	**Indicator Bacteria #/100ml	Temperature (°F)
2305	International Amistad Reservoir	Upper	CR	H	PS	150	270	800	5.0	6.5-9.0	126/200	88
2306	Rio Grande Above Amistad Reservoir	Upper	CR	H	PS	300	570	1,550	5.0	6.5-9.0	126/200	93
2309	Devils River	Upper	CR	E	PS	50	50	300	6.0	6.5-9.0	126/200	90
2310	Lower Pecos River	Upper	CR	H	PS	1,700	1,000	4,000	5.0	6.5-9.0	126/200	92
2311	Upper Pecos River	Upper	CR	H		7,000	3,500	15,000	5.0	6.5-9.0	126/200	92
2312	Red Bluff Reservoir	Upper	CR	H		3,200	2,200	9,400	5.0	6.5-9.0	126/200	90

**The indicator bacteria for freshwater is E. coli. Fecal coliform is an alternative indicator.

Section A6: Project/Task Description

The study area will be the Pecos River basin as shown in Figure A6.1. The Pecos River begins in the Sangre de Cristo Mountains of North-Central New Mexico, travels through Eastern New Mexico, crosses into Texas at the Red Bluff Reservoir, winds through west Texas, and then empties into the Rio Grande in Val Verde County above the International Amistad Dam. This study will conduct its monitoring and assessment of the Pecos sub-basin from the Red Bluff Reservoir to the confluence with the Rio Grande. Segment 2312- Red Bluff Reservoir, is designated for contact recreation and high aquatic use. Segment 2311- Upper Pecos River, and Segment 2310- Lower Pecos River are designated for contact recreation and high aquatic use with segment 2310 also being designated as a public water supply.

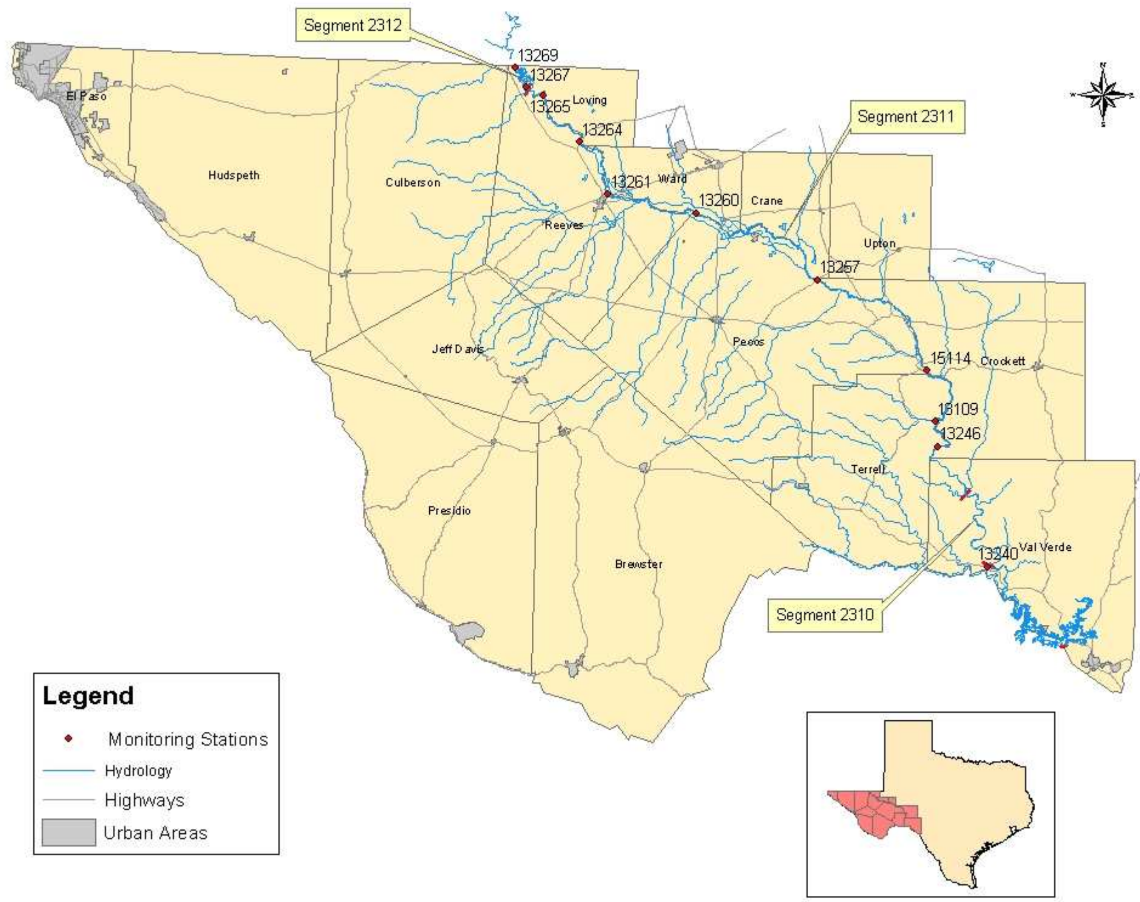


Figure A6.1. Map of Pecos River Basin including monitoring station locations.

As discussed in the workplan (Appendix A), this project will rely heavily on quality assured data collected through the IBWC Clean Rivers Program, USGS, TWDB, and the Rio Grande Basin Initiative. Specifically, data collection for subtask 3.2 and portions of subtask 1.4 are carried out by IBWC through the Clean Rivers Program (CRP). Data collection for subtask 1.5 and portions of subtask 3.3 are carried out by TAES through the Rio Grande Basin Initiative (RGBI).

Subtasks along with a listing of the responsible agency or agencies and an activity schedule are outlined in Table A6.1. The schedule listed below should provide adequate time for completion of the project in a timely manner.

Table A6.1. Project Plan Milestones

TASK	PROJECT MILESTONES	AGENCY	START	END
1.1	Aerial Photography, Delineation, and Characterization	TCE	Sep04	Aug05
1.2	Historical Water Quality, Irrigation Delivery, Rainfall, Red Bluff Lake Levels, and Groundwater Monitoring	TCE, TWRI	Sep04	Aug07
1.3	Aquatic Life and Habitat Inventory	USIBWC, USGS	Jun06	Jun06
1.4	Identify and Characterize the Volume and Quality of Tributaries and Springs	USIBWC, TCE, TAES	Jan06	Jan07
1.5	Identify and Characterize Saline Water Sources Entering the Pecos River	TAES	Sep04	Aug05
1.6	Simulate Flow and Salinity of the Pecos River for Evaluating River Management Options	TAES	Jan06	Jan07
1.7	Economic Modeling of the Pecos River Basin and Assessment of Saltcedar Control Activities	TCE	Mar06	Aug07
2.1	Publish Written Informational Materials to Educate Private Landowners, Stakeholders, and Policy Makers about the Pecos River basin and the Effects of Saltcedar	TCE, TWRI	Mar05	Aug07
2.2	Educational Meetings of Interested Parties for Input and Organizational Support	TCE, TWRI	Mar05	Aug07
2.3	Develop a Website for Dissemination of Information	TCE, TWRI	Sep04	Aug07
3.1	Develop a QAPP for Sampling Protocol	USIBWC, TCE, TWRI	Jan05	Dec05
3.1	QAPP Approval	TSSWCB, EPA	Dec05	Jan06
3.2	Water Quality Monitoring, including TDS, TSS, pH, DO, and EC	USIBWC, TCE, TWRI	Jan05	Jul07
3.3	Quantity and Fate of Water Salvage as a Result of Saltcedar Control	TCE, TAES	Jan06	Jan07
4.1	Submit year 1 Annual Report	TCE, TWRI		Dec05
4.1	Submit year 2 Annual Report	TCE, TWRI		Aug06
4.1	Submit final report	TCE, TWRI		Aug07
4.2	Submit draft watershed protection plan to TSSWCB	TCE, TWRI		Dec06
4.2	Submit final watershed protection plan to TSSWCB	TCE, TWRI		Aug07

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 verify and validate the water quality data collected under subtasks 1.3, 1.4, 1.6, and 3.3 (as discussed below).

Subtask 1.3 Aquatic life and habitat inventory
Biological monitoring will be utilized to assess the overall ecological integrity and the effects of nonpoint sources of pollution on the Pecos. Biological monitoring data collected during this project will provide baseline data that will allow comparisons to be made between sites on the Pecos River as well as comparisons to similar rivers in the state. Monitoring efforts will also provide a baseline for sites along the Pecos River. This data can be used to assess trends and future changes that may occur as conditions in the river change.

The U.S. Section International Boundary and Water Commission (USIBWC) Clean Rivers Program (CRP) will coordinate the biological assessment with assistance from USGS and other entities participating in the study. At three sites along the Pecos River between Pandale and Sheffield, Texas, data on benthic organisms, fish, and physical habitat characteristics of the river will be collected and catalogued in accordance with *TCEQ Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). These sites will be located upstream, downstream, and at the confluence of Independence Creek and the Pecos River to address the influence of increased contributing flows on aquatic biota and physical habitat conditions.

The addition of these three sites will fill a major data gap between two ongoing inventories. The USGS will be conducting one inventory upstream of this reach. In addition, the USGS is doing similar biological and stream habitat assessments for the U.S. National Park Service on the Pecos River at sites beginning downstream of Pandale extending to the confluence of the Pecos River and the Rio Grande. Additionally, riparian vegetation and habitat will be described.

Subtask 1.4: **Identify and characterize volume and quality of tributaries and springs**
In order to identify potential salinity sources, it will be necessary to locate and characterize selected tributaries of the Pecos River, whether perennial or intermittent, to determine water quantity, quality, and point of impacts from sources outside of the main stem. The first phase involves the review of information available such as U.S. Geological Survey (USGS) hypsography and hydrography maps to determine potential tributary locations. This data will then be compared to satellite imagery to locate active water runoff into the Pecos River. The second phase would include fieldwork and groundtruthing which will be necessary to locate each tributary and assess salinity levels. Flow volume will be estimated using published values. In the case of dry streambeds that could potentially carry water during storm events, sediment samples will be collected through the IBWC Clean Rivers Program for laboratory analysis.

Subtask 1.6 Simulate Flow and Salinity of the Pecos for Evaluating River Management Options
This subtask is to simulate flow and salinity of the Pecos River below Red Bluff for evaluating river management options and will be approached in three phases. The first phase is to develop and validate a simple mass balance model useful for assessing the effect of inflow from the Pecos River on salinity of Amistad Reservoir. Salinity of the reservoir has been increasing since construction in 1968. Salinity levels reached the drinking water limit of 1000 ppm during February 1988 and have continued to fluctuate. A simple model, which is largely based on salt balance analysis, is currently being developed under a separate program funded by the Texas Higher Education Coordinating Board. Existing complex models demand input data which are not readily available and do not

consider site-specific salt problems. Our simple model will be used to analyze the impact of the Pecos River on reservoir salinity on both short and long time scales, using the historical flow and salinity data available at Foster Ranch, Langtry and Amistad. These analyses include the development of a program useful for estimating salinity of the lake outflow from inflow data. We will also examine probable scenarios for reservoir salinity to exceed 1000 ppm, and how the inflow from the Pecos may affect the scenario.

The second phase is to collect or generate the data needed to develop and verify a water and salt transport model (which is described later). The data needed are two-types. The first type is the current river dimensions such as river cross-sections at various reaches, slope, the extent and the types of riparian zones, floodway dimensions, salinity and depth of water tables, permeability and soil type distribution, weather data and physical data of the catchment areas which yields surface or subsurface inflow into the Pecos. These data will be collected in conjunction with other tasks, especially Tasks 1.4 and 1.5. The second type of data is the historical records of flow and salinity at various reaches of the Pecos. These data are scattered among different agencies and unfortunately rather limited, except at Langtry. If the historical data are sufficient to analyze, we will examine the impact of irrigation on river salinity in a historical context. If not, we will use the historical records solely for calibrating our model.

The third phase is to develop a water and salt transport model for the main flow of the Pecos River below Red Bluff. The model is to be used for assessing river management options on flow and salinity of the Pecos at various segments, as well as for assessing salt loading into the Rio Grande, then to Amistad. Such a model is currently being developed for the Middle Rio Grande, and includes submodels needed to evaluate the impact of riparian zones on flow, salt storage, and release into the stream during bank overflow.

The model also accounts for two-dimensional seepage losses from the steam beds as well as seepage into the river, which is undoubtedly an important process in the case of the Pecos River. The model will be calibrated using the historical records and will be validated against the monitoring data from the Clean Rivers Program collected under subtask 3.2.

The overall objective of this modeling program is to develop a water and salt transport model useful for evaluating the impact of streamflow and riparian vegetation on salinity of streams and reservoirs, bank salt storage, and salt flushing and to calibrate and apply the model (tentatively referred to as “extended ROTO”) to the Pecos River below Red Bluff for evaluating river management options to maintain salinity of the river bank and streamflow to sustain biodiversity, and ongoing limited irrigation activities.

Models to be Used or Developed

The Soil and Water Assessment Tool (SWAT) developed at USDA-ARS Temple is a physically based watershed and landscape simulation model, and has been used successfully for addressing water quality issues (e.g., Arnold et al., 1998). We used the routing portion of the model (ROTO) to simulate salinity of Amistad Reservoir using the historical records of tributary inflow and diversion (Muttiah, Miyamoto, Borah and Walker, 2004). The model was also applied to the Wichita River located northeast of the Pecos Basin. In both cases, simulation of flow and salinity was less than desired for several reasons, including the lack of process routine related to salinity buffering in the reservoir, bank salt storage and release, and two- dimensional percolation along the stream. Many of these shortcomings are now corrected, but some aspects need additional work. The following outlines the components which will enter into the extended ROTO. (It is our intent to maintain the current form of ROTO as much as possible so as to facilitate a link with EPIC when need arises).

1. Flow and Salinity Relationships

This analysis is needed for estimating salinity of stream flow from inflow records or hypothesized inflow from tributaries, and has largely been completed for eleven USGS gauging stations along the Pecos River. The flow and salinity relationship will also be used to adjust measured streamflow salinity to salinity at different flow rates. (Frequency of water quality analyses is usually low at this river). Solubility of gypsum will be incorporated so as to set the maximum concentration of Ca and SO4 species. Gypsum is one of the prevailing evaporites in the Pecos River Basin, and it affects a type of equation we use to describe flow and salinity relationships.

2. Two-dimensional Seepage

The routing portion of the SWAT model did not have a routine which is capable of describing two-dimensional seepage from streamflow. This becomes a constraint when one attempts to use it in a river system where the interaction between streamflow and riparian bank has to be clarified. We found an analytical solution of the two-dimensional seepage flow under fluctuating streamflow conditions (Lockington, 1997). The analytical solution is now coded in FORTRAN. We believe that the addition of this routine to the ROTO will enhance its utility, for example, for estimating water table depths as a function of time and the distance from streamflow, besides estimating percolation losses from the stream.

3. Upward Water and Salt Flux in Riparian Zones

This is a process usually considered to be minor or negligible, because water losses associated with evapotranspiration are a slow process as compared to the fast moving streamflow. When dealing with the ecosystem stability of riparian zones sustained by saline water, the process of bank salt accumulation becomes a critical issue. Salinity of the Pecos between Red Bluff and Girvin is around 10,000 mg L^{-1}, instead of 1,000 mg L^{-1} which applies to most "saline" river systems. The quantity of salts which can potentially accumulate is going to be 10 times larger, or the time duration needed to build up certain levels of salts will be shortened by a factor of 10; 1 year instead of 10 years, or 4 years instead of 40 years. This means that functional riparian zones can be maintained only under "frequent" bank overflow, although the frequency is yet to be determined.

We reviewed pertinent literature related to evapotranspiration from salt cedars and other riparian vegetation. When the water table drops rather rapidly with the distance from streamflow, availability of soil moisture, and soil salinity affect transpiration. Unfortunately this system is not easy to model, unless water tables are considered stationally. The reach below Red Bluff usually has the perennial flow, and the first option would be to use the analytical solution applicable to the steady state. We already have a FORTRAN coding on upward water and salt flux under steady state conditions. Meantime, a cooperative project with Los Alamos National Laboratory produced an analytical solution of the Richards equation for the transient state. If the first option does not yield satisfactory results, we can explore the use of this transient model for estimating the upward flow of water and salts. Unfortunately, such a task will be time-consuming, as the analytical solution is fairly complex.

4. Estimate of Bank Overflow
The ROTO currently uses Manning equation to compute the travel time. Given the data on the river cross-sections, we can use it to compute the bank overflow. Other existing models will be tested if this existing method does not perform.

5. Salt Flushing and Leaching Estimates
Several empirical equations, mostly developed in Australia, are available for estimating the concentration of dissolved salts in storm runoff. One of these empirical models will be used to compute salt flushing. The first phase of Subtask 1.6 has shown that salt flushing can impact reservoir salinity. The first surge of reservoir salinity is associated with salt flushing from the middle Rio Grande, and to a lesser extent from the Pecos. Salt leaching from river banks and bench will be made by applying a mixing cell model to the infiltration equations as used in SWAT.

6. Reservoir Processes
We used a two-layer reservoir model (Killworth and Carmack, 1979) for simulating reservoir outflow salinity from inflow data with a satisfactory result. This method was applied to simulation of annual outflow salinity from Amistad Reservoir, and provided improved simulation of reservoir salinity. The existing ROTO yields reservoir salinity estimates similar to the salinity of the inflow, because of the lack of the reservoir processes. We also developed a method to estimate monthly outflow salinity from inflow salinity data. This method was tested satisfactorily using the data sets available at Elephant Butte, Amistad and Falcon (Inosako, Yuan and Miyamoto, 2005).

Subtask 3.3 Quantity and fate of water salvage as a result of saltcedar control
A study was initiated in 1999 using shallow groundwater monitoring wells and water level loggers to estimate net drawdown or recharge along the Pecos River under saltcedar infestations. Wells were installed at two sites within a study area and monitored for one growing season, and then saltcedar was killed on one site. Water salvage from saltcedar control is estimated by comparing pre treatment water level data to post treatment water level data for both sites using the EPA Paired Watershed Study Design protocol. Preliminary analysis indicates saltcedar control may yield a 60-70% reduction in water loss at the study site.

This task will further explore the effects of saltcedar control on the fate of salvaged water and determine amount of water released to downstream flow and groundwater recharge. Through the RGBI, TCE and TAES will characterize the aquifer beneath treated and untreated sites with borehole exploration; and install additional monitoring wells to configure subsurface flow patterns. Through this CWA Section 319 project, TCE will conduct flow measurements with designated releases from Red Bluff Reservoir.

First, a map of alluvial sediments will be developed to diagram subsurface flow patterns. Previous borehole exploration revealed a clay layer, which may limit vertical water flow within the shallow aquifer. This task is to delineate the extent of the shallow aquifer by drilling additional boreholes at untreated and treated plots along the Pecos River. Soil and water samples will be collected and analyzed, as needed through the RGBI, to determine spatial variation in hydrological properties. Second, additional monitoring wells will be installed through the RGBI. There are 5 existing monitoring wells at each site on one side of the river. In order to better understand flow regimes, additional wells will be drilled on the other side of the river from the existing well network. Data loggers will be used to record hourly changes in the water level in each of the new wells. Collected water level information will be processed to construct a flow net within the shallow aquifer. The flow net will be used to define the interaction between surface water and ground water, which will be used to assess volume and direction of flow.

Finally, to establish the relationship between surface water and ground water, designated releases from Red Bluff Reservoir will be scheduled. Multiple releases will be monitored for a period of several days during the project period to detect any seasonal changes in the shallow aquifer response to saltcedar control. Seepage losses, or gains, by the river will be calculated and the factors that influence seepage losses and gains will be assessed. During the releases, surface water flow will be measured at the upstream boundary of the untreated site, at the divide between untreated and treated sites and at the downstream boundary of the treated site. Concurrently, hourly water level in each of the wells will be recorded to determine impacts of increased river flow on the shallow aquifer flow.

In general, river inflows are precipitation, runoff, groundwater discharge and release from Red Bluff Reservoir. River outflows include seepage into aquifers, evaporation, transpiration, and irrigation diversion. These tasks will allow us to evaluate flows between the river and the aquifer. Other inflows and outflows will be addressed using funds form other sources. Ultimately, this data will be used with water quality/quantity data collected to predict the effect of saltcedar control on river water quality and quantity in the Pecos River Basin. Data will be used in the model presented in task 1.6 to predict changes in salinity of the river.

Section A7: Quality Objectives and Criteria

Field Parameters

The purpose of the field monitoring is to:

- complete aquatic life and stream habitat inventories and assessments at three sites on the Pecos River between Sheffield and Pandale,
- identify potential salinity sources to the Pecos River by measuring conductivity in the Pecos River and its tributaries, and
- explore the effects of saltcedar control on the fate of salvaged water and determine amount of water released to downstream flow and groundwater recharge by measuring flow.

Field monitoring conducted by Texas Cooperative Extension will be in accordance with *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003). These aquatic life, stream habitat, and water quality data, along with data collected by other organizations (e.g., USGS, TCEQ, etc.), will be subsequently reconciled for use and assessment. The measurement performance specifications to support the project objectives for a minimum data set are specified in Table A7.1.

Table A7.1. Data Quality Objectives for Field Measurements

Parameter	Units	Method Type	Method	MDL	Precision of Field Duplicates	Accuracy/Bias	Percent Complete
Specific Conductance	µS/cm	Meter	EPA 120.1 and TCEQ-SWQM SOP	20	10	±2% of range	90
Flow	cfs	Meter	TCEQ-SWQM SOP	NA	NA	NA	90
Fish	NA	TCEQ	TCEQ-SWQM SOP	NA	NA	NA	90
Benthics	NA	TCEQ	TCEQ-SWQM SOP	NA	NA	NA	90

Manufacturer specifications are presented for accuracy limits and method detection limits for field parameters.

Precision

Precision is a statistical measure of the variability of a measurement when a collection or an analysis is repeated and includes components of random error. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions.

Duplicate field measurements are used to assess the variability of the analytical process. Control limits for duplicate field measurements are defined in Section B5. Program-defined measurement performance specifications are defined in Table A7.1.

Accuracy/Bias

Accuracy/Bias is a statistical measurement of correctness and includes multiple components of systematic error. A measurement is considered unbiased when the value reported does not differ from the true value. Bias is verified through the analysis of control standards prepared with certified reference materials and by calculating percent recovery. Program-defined measurement performance specifications for control standards are specified in Table A7.1.

Representativeness

The data collected will be considered representative of the target population or phenomenon to be studied. The representativeness of the data is dependent on 1) the sampling locations, 2) the flow regime during sample collection 3) the number of years sampling is performed, and 4) the sampling procedures. Site selection, sampling of pertinent media and use of only approved analytical methods will assure that the measurement data represents the population being studied at the site.

Comparability

Confidence in the comparability of fixed data sets for this project and for water quality assessments is based on the commitment of project staff to use only approved sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP and in *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003). Comparability is also guaranteed by reporting data in standard units, by using accepted rules for rounding figures, and by reporting data in a standard format as specified in Section B10.

Completeness

The completeness of the data is basically a relationship of how much of the data is available for use compared to the total potential data. Ideally, 100% of the data should be available. However, the possibility of unavailable data due to accidents, lost data, and etcetera is to be expected. Therefore, it will be a general goal of the project that 90% data completion is achieved.

Criteria for Model Inputs / Outputs

The overall objective of this modeling program is to develop a water and salt transport model useful for evaluating the impact of streamflow and riparian vegetation on salinity of streams and reservoirs, bank salt storage, and salt flushing and to calibrate and apply the model (tentatively referred to as "extended ROTO") to the Pecos River below Red Bluff for evaluating river management options to maintain salinity of the river bank and streamflow to sustain biodiversity, and ongoing limited irrigation activities.

The Soil and Water Assessment Tool (SWAT) developed at USDA-ARS Temple is a physically based watershed and landscape simulation model, and has been used successfully for addressing water quality issues (e.g., Arnold et al., 1998). The routing portion of the model (ROTO) has been used to simulate salinity of Amistad Reservoir using the historical records of tributary inflow and diversion (Muttiah, Miyamoto, Borah and Walker, 2004). The model was also applied to the Wichita River located northeast of the Pecos Basin.

Model calibration and validation will be carried out first for each model component, then for the entire model. This two-phase approach is needed to assure the reliability of each model component and of the entire model, and in some cases, validate some of the existing data. Model component calibration and validation will be performed using the following datasets or database.

The relationship between flow and salinity (including ionic concentrations) had been calibrated at eleven gauging stations maintained by USGS for the Pecos River, and one station at Langtry maintained by IBWC. These data sets consist of daily flow, momentary flow rates at the time of water sampling or onsite salinity measurements, and the results of water quality analyses for salinity, including major cations and anions in most cases. The calibrated relationships will be used first to adjust salinity readings or ion concentrations to the monthly flow rates computed from daily flow data. For salt balance analysis, all salinity measures will be flow-weighted.

The flow and salinity relationship should ideally be established for each major tributaries and creeks. Because of intermittent nature of tributaries or creeks in dry portions of this basin, it is possible that inflow from small creeks and arroyo will be treated as a group assigned to each river reach.

The above method of salinity vs. flow calibration was found to be satisfactory at most of the gauging stations, with some scattered data at two stations; one at Pierce Canyon Crossing and another at the inlet to Red Bluff. In these cases, in-stream salinity fluctuates from 3,000 to 30,000 mg L^{-1}, because of the presence of saline springs in the middle of river bed, and dilution by reservoir release and storm runoff.

Two-dimensional seepage estimates will be first validated against published data (but not from the Pecos) on seepage rates and the depth to the water table as a function of the distance from the stream. Additional calibration will be made against the measured percolation losses in a short reach of the Pecos which are being carried out under Subtask 3.3. There are also records of additional percolation measurements (e.g., Clayton, 2002). The relationship between percolation losses and soil type will be examined, and percolation losses from other reaches will be estimated based on the state soil resources map. In the river reach close to Red Bluff, some difficulties are expected due to unstable nature of salt basin, including possible leakage due to salt dissolution. In these cases, streamflow data will be used to estimate “percolation” losses.

Calibration of the upward water and salt flux model will be made first against the soil moisture and soil salinity data we have collected along the middle Rio Grande. Two sites out of thirteen sites studied are located outside the levee, and have a shallow water table. These sites do not receive bank overflow and are ideally suited for testing upward movement of salts. The calculation of upward water and salt flux from the riparian areas of the Pecos River will be made and be compared against streamflow and soil salinity data collected at CRP stations.

Salt flushing will be calibrated against the continuous salinity and flow measurement being performed by TCE at Girvin. This station also has daily flow measurement by USGS. A station at Monahans (Coyanosa) also began to provide the continuous measurement of flow and salinity which can be used for calibrating salt flushing. Salt leaching will be calibrated using the same data set. The salt accumulation estimated by step 3 minus the salt load of the bank overflow will be considered salts which were leached.

Reservoir processes have already been calibrated and validated at Elephant Butte, Amistad and Falcon. If outflow data (quantity and salinity) kept by the Red Bluff District are determined to be usable, the model can also be validated on site.

Overall model validation will be conducted in the river reach between Red Bluff and Girvin, provided that necessary hydrologic data become available. The model will operate similarly to the ROTO, requiring the data on reservoir release, tributary and creek inflow, diversion and river cross section and the slope. These data are currently not available and are programmed to be obtained mostly under Subtask 1.4. Streamflow data are available at Orla and Girvin (USGS station) and Mentone, and Coyanosa (TCRP). It is also necessary to estimate the salinity of reservoir release. We will compute flow and salinity at Girvin, and compare against the measured. The projection will be made daily as the existing ROTO, although the output can be weekly or monthly depending on model use objectives.

The reach below Girvin receives fresh water inflow, and in-stream salinity decreases down to less than 2,000 mg L^{-1} at Langtry. Salinity at Langtry where the Pecos River enters the Rio Grande is controlled by salt load at Girvin, and is predictable without any complicated models. Also, there is no indication that riparian zones below Sheffield are subject to degradation with salts because of overland fresh water runoff into the River, besides having frequent bank overflow.

Model calibration is referred to as how well the model is able to simulate the observed flow rates and salinity. The following criteria have been established for this project as acceptable model calibration inputs and outputs, respectively.

1. Annual flow will be calibrated so that predicted values agree to measured values within 15%.
2. Flow water balance involving inflow losses and outflow from a hydrologic unit will be calibrated so that predicted values also agree to measured values within 15%.
3. In-stream salinity will be calibrated so that the mean of the predicted values falls within two standard deviations of the mean of the measured values.

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

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

If the standards are not obtained, a corrective action report will be submitted to TSSWCB with the following quarterly report. If these steps do not bring predicted values within calibration standards, TAES will work with the TWRI QAO and TSSWCB to arrive at an agreeable compromise.

Section A8: Special Training/Certification

No special certifications are required.

Section A9: Documents and Records

All records, including modeler's notebooks and electronic files, field notebooks, corrective action reports (CARs), quarterly reports, final reports, annual reports, watershed plans, and all data will be archived by TCE for at least five years. In addition, hard and electronic copies of the biological and habitat data will be archived at the USGS Texas Water Science Center for a period of at least five years.

Modeling records will document model testing, calibration, and evaluation and will include documentation of written rationale for selection of models, record of code verification (hand-calc 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.

Quarterly, annual, and final reports will note activities conducted in connection with the water quality monitoring program, items or areas identified as potential problems, and any variations or supplements to the QAPP. All reports will be formatted according to TSSWCB requirements. CARs will be utilized when necessary (Appendix B). CARs will be maintained in an accessible location for reference at TCE. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP. All reports, including but not limited to quarterly reports, annual reports, final reports, watershed plans, QAPPs, and QAPP revisions, will be distributed to personnel listed in Section A3 by the TWRI Project Director.

Project computers run Windows operating system and are backed up as needed to CD's and stored off site. In the event of a catastrophic systems failure, the CDs can be used to quickly restore the data.

The TSSWCB may elect to take possession of records pertaining to this study at the conclusion of the specified retention period.

Amendments to the QAPP

Revisions to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives, and methods; to improve operational efficiency; and to accommodate unique or unanticipated circumstances. Requests for amendments are directed from the TWRI QA Officer to the TSSWCB Project Manager in writing. They are effective immediately upon approval by the TWRI Project Director and QA Officer, the TSSWCB Project Manager and QA Officer, and the EPA Project Manager. They will be distributed by the TWRI Project Manager and incorporated into the QAPP by way of attachment and distributed to personnel on the distribution list.

Section B1: Sampling Process Design

This project is primarily designed to assess salinity and water quantity in the Pecos River basin. Through this project assessment, a Watershed Protection Plan will be developed to assess current management measures as well as determine what future management measures need to be implemented in the river basin to protect the water quality of the Pecos River.

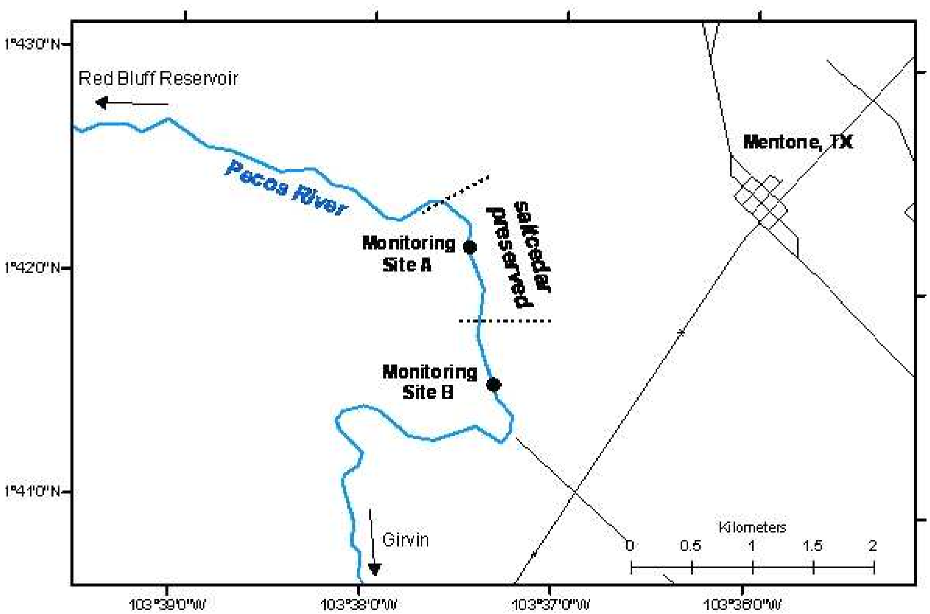
The field monitoring is designed to:

- explore the effects of saltcedar control on the fate of salvaged water and determine amount of water released to downstream flow and groundwater recharge by measuring flow,
- identify potential salinity sources to the Pecos River by measuring conductivity in the Pecos River and its tributaries, and
- complete aquatic life and stream habitat inventories and assessments at three sites on the Pecos River between Sheffield and Pandale.

<u>Assessing Effects of Saltcedar Removal</u>

A SonTek Doppler flow meter will be used to calculate discharge at three cross-sections located between Pecos River crossings at Texas F.M. 652 and State Hwy 302 (Figure B1.1). Sites are located above Monitoring Site A, between Monitoring Site A and B, and below Monitoring Site B. Flow measurements will be recorded at least semi-annually (once during growing season and once during non-growing season).

Figure B1.1 Flow monitoring sites



Identifying Potential Salinity Sources

The Pecos River and Red Bluff Reservoir sites will be monitored at least quarterly through the CRP Program. When flow is present at the tributary sites, conductivity will be measured on a biweekly basis. All conductivity monitoring sites are listed in Table B1.1 and shown in Figure B1.2. Field monitoring conducted by Texas Cooperative Extension will be in accordance with *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003). All sites are located at major road crossings and accessible in all weather conditions. These water quality data and data collected by other organizations (e.g., USGS, TCEQ, etc.) will be subsequently reconciled for use and assessment.

Table B1.1. Conductivity Monitoring Sites.

Site Number	Station Description	Lat	Long
1	Red Bluff Reservoir 1/2 Mile S of TX - NM Border (CRP)	31.994	-103.983
2	Red Bluff Reservoir Above Dam, North of Orla (CRP)	31.908	-103.917
3	Salt Creek @ US 285	31.878	-103.95
4	Salt Creek @ Red Bluff Lake Rd.	31.844	-103.919
5	Pecos River @ Fm 652 Bridge NE of Orla (CRP)	31.872	-103.831
6	Four Mile Draw @ US 285	31.693	-103.796
7	Horsehead Draw @ US 285	31.667	-103.738
8	Pecos River Near Mentone, TX (CRP)	31.67	-103.63
9	Pecos River Near Pecos, TX (CRP)	31.44	-103.47
10	Toyah Creek @ Ranch Road 1450	31.363	-103.386
11	Toyah Creek @ US 285	31.317	-103.424
12	Barilla Draw @ US 285	31.282	-103.385
13	Salt Draw @ SR 17	31.296	-103.551
14	Hackberry Draw @ Ranch Road 1450	31.307	-103.128
15	Pecos River @ Fm 1776 SW Of Monahans (CRP)	31.366	-103.004
16	Hackberry Draw @ US 285	31.1	-103.229
17	Coyanosa Draw @ US 285	31.039	-103.137
18	Imperial Reservoir	31.271	-102.844
19	Leaking water well @ Ranch Road 1053	31.241	-102.723
20	Comanche Creek @ Ranch Road 11	31.138	-102.457
21	Pecos River @ Us 67 NE Of Girvin (CRP)	31.079	-102.359
22	Tunas Creek @ Ranch Road 11	30.942	-102.309
23	Pecos River 1.6 Mi above US 290 Bridge, SE of Sheffield (CRP)	30.681	-101.776

Figure B1.2 Conductivity Monitoring Sites

Aquatic Life And Stream Habitat Inventories And Assessments

Aquatic life and stream habitat inventories and assessments will be conducted in June 2006 by USGS, in coordination with IBWC, at three sites on the Pecos River between Sheffield and Pandale, Texas.

These sites bracket the confluence of Independence Creek and the Pecos River. The volume and quality of contributing flows to the Pecos from the Independence Creek drainage could affect the composition of fish and benthic macroinvertebrate assemblages, and affect stream habitat features. Therefore, one site (Table B1.2 and Figure B1.3) was selected approximately 10 miles upstream (USGS Pecos 003) of the confluence of Independence Creek. The second site (USGS Pecos 002) is about 0.5 miles downstream of the confluence of Independence Creek and the Pecos River. A third site (USGS Pecos 001) was selected about 25 miles downstream of the confluence of Independence Creek and the Pecos River near Pandale, Texas.

Table B1.2. Sites for aquatic life and habitat assessments.

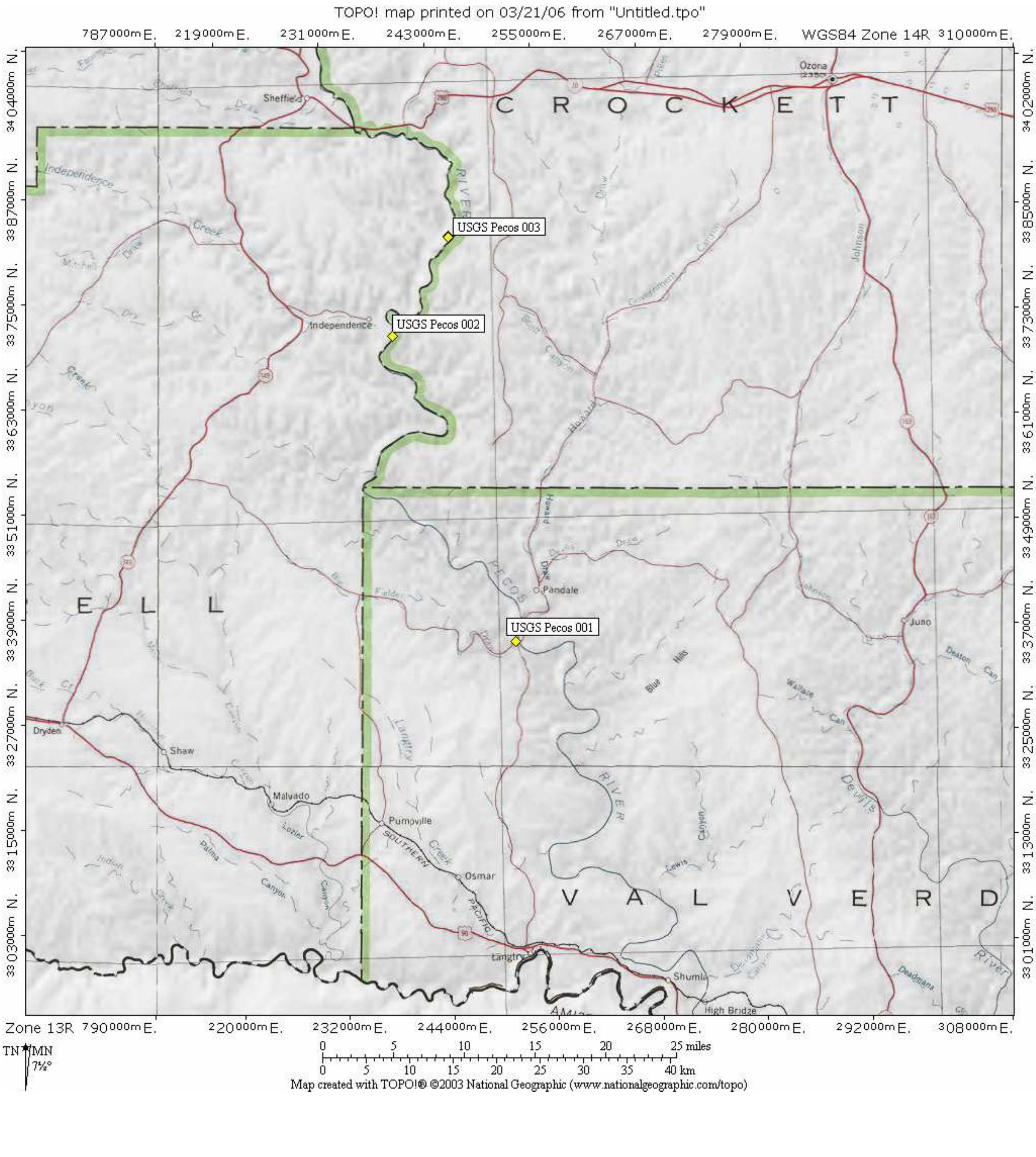
Site Name	Site ID	LAT	LONG
Pecos River at ford near Reagan Canyon	USGS Pecos 003	30.54596 N	101.65416 W
Pecos River near confluence of Independence Creek	USGS Pecos 002	30.44269 N	101.72027 W
Pecos River near Pandale, Tx at County Rd 1024 Bridge	USGS Pecos 001	30.12930 N	101.57331 W

Aquatic life inventories and physical habitat assessments will be completed at these sites in late June 2006 (Table B1.3). Field monitoring conducted by USGS will be in accordance with *TCEQ Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). These data and data collected by other organizations (e.g., IBWC, TCEQ, etc.) will be subsequently reconciled for use and assessment.

Table B1.3. Schedule for aquatic life and habitat assessments.

Site	June 22nd	June 23rd	June 24th
Pecos River at ford near Reagan Canyon			
Pecos River near confluence of Independence Creek			
Pecos River near Pandale, Tx at County Rd 1024 Bridge			

Figure B1.3. Sites for aquatic life and habitat inventories on the Pecos River.



Section B2: Sampling Methods

Field sampling will be conducted according to procedures documented in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003). Flow is measured using a SonTek Flow Tracker Hand Held APV doppler flow meter. Conductivity is measured using a Hydrolab Quanta Conductivity Meter.

Field measurements of conductivity are documented in field notebooks. Flow worksheets are also used when flow is measured. The following will be recorded for all visits:

1. Station Location
2. Sampling time
3. Sampling date
4. Sample collector's name/signature
5. Values for all measured field parameters (conductivity and flow)
6. Other observational data (*as applicable*), including:
   - water appearance
   - weather
   - days since last significant rainfall
   - flow severity
   - biological activity
   - pertinent observations related to water quality or stream uses (e.g., exceptionally poor water quality conditions/standards not met; stream uses such as swimming, boating, fishing, irrigation pumps, etc.)
   - watershed or instream activities (events impacting water quality, e.g., bridge construction, livestock watering upstream, etc.)
   - unusual odors

<u>Fish Assemblage Surveys</u>

Fish assemblages will be assessed in accordance with TCEQ's *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). At each site, a sampling reach will be selected based on a multiple of the wetted channel width (e.g., 40 times width for wadeable sites or minimum of 150 m). Each reach will include suitable habitat for the collection of benthic macroinvertebrates, and the reach should be wadeable for its entire length. A barge or backpack electrofishing unit will be used as the primary type of collection equipment. A complete pass of the reach will be made with the electrofishing unit with a minimum of 900 seconds that electrical current is in the water. In addition to electrofishing, a minimum of six seine hauls will be made in each reach. The number of seine hauls will be consistent from reach to reach and distributed equally across the geomorphic channel units (e.g., riffle, run or pool) present. All collected fish will be held on shore in an aerated holding tank pending processing of the fish.

Each fish will be identified or preserved on site, and retained for identification in the USGS laboratory. A minimum of two individuals of each species will be vouchered. Fish less than 0.3 meters in total length will be vouchered and preserved on site with 10% buffered formalin. Fish greater than 0.3 meter in total length will be photo-vouchered as per TCEQ protocols. Verification of problematic fish identifications and all preserved vouchered material will be processed by the curator of fishes at the Texas Natural History Collections of the University of Texas in Austin.

A Chain of Custody form will accompany each sample batch and will be signed each time the batch changes hands between USGS personnel, from USGS to the lab, throughout the lab procedures, and from the lab back to USGS. If samples are mailed to the lab, a copy of the signed COC form will be faxed to USGS once received. Care will be taken to assure that all tests have been performed, all data recorded, and all samples are labeled correctly. In labeling fish samples, care will be taken to accurately place the proper date, stream name and sample location on the containers, since this is critical to the proper analysis comparisons. Labeling will coincide with the data sheets and habitat assessment forms to ensure accuracy. Upon collection, all samples will be labeled appropriately (see Section B3) and transported in an iced container to the laboratory for analysis.

Benthic Macroinvertebrates

Benthic macroinvertebrates will be assessed in accordance with TCEQ's *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). Three replicate Surber samples will be collected in each reach to provide quantitative results for between site comparisons. Each Surber sample will be collected in a riffle habitat with a coarse substrate such as large gravel or small cobble. The three samples will be distributed in the riffles resulting in a sample that represents the heterogeneity of the coarse bed material present. A 0.25 m^2 area square frame will be place on the stream bottom in the coarse substrate, and the bed material disturbed at least 60 seconds to dislodge the organisms. Contents of the sampler will be rinsed into a 1 L sample jar, and preserved with 95% ethanol. The collection jar will be labeled appropriately (see Section B3). Specimens will be transported in a light restrictive container.

In labeling the benthic samples, care will be taken to accurately place the proper date, stream name and sample location on the containers, since this is critical to the proper analysis comparisons. Labeling will coincide with the data sheets and habitat assessment forms to ensure accuracy. Care will be taken to assure that all data is recorded, and all samples are labeled correctly.

All of the benthic macroinvertebrate samples will be submitted to a contract laboratory, and all organisms will be identified to the lowest possible taxon.

A Chain of Custody form will accompany each sample batch and will be signed each time the batch changes hands between USGS personnel, from USGS to the lab, throughout the lab procedures, and from the lab back to USGS. If samples are mailed to the lab, a copy of the signed COC form will be faxed to USGS once received.

To obtain calculations of bioassessment metrics, bioassessment scores, and functional feeding group compositions, the numbers of benthics collected will be entered in their proper taxonomic groups into a database created for EPA (EDAS). This database uses taxonomic classification, feeding groups, and tolerance levels to assess the biological condition of an aquatic community.

Physical Habitat Assessment

Physical habitat assessments will be conducted according to TCEQ's *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). The length of each sampling reach will be divided by 10 to determine the length of the transect interval. Eleven transects will be distributed through the reach. All habitat assessment measures are based on reach-based observations or transect-based measurements.

Each habitat parameter (habitat type, # of riffles, dominant substrate, in-stream cover, stream morphology and riparian environment) within a transect is assigned a numerical value by the observer based on the appearance of the stream. The individual values are summed to obtain a total score for the site. The same person(s) will do the evaluation at each site using the habitat assessment forms from TCEQ's *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological and Habitat Data* (August 2005). In completing the habitat assessment form the same area covered in the benthic and fish sampling protocol will be evaluated. Data sheets and habitat assessment forms will be completed accurately with the proper information. Care will be taken to assure that all tests have been performed, all data recorded, and all samples are labeled correctly.

Recording Data

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

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

Deficiencies, Nonconformances and Corrective Action Related to Sampling Requirements

Deficiencies are defined as unauthorized deviations from procedures documented in the QAPP or other applicable documents. Nonconformances are deficiencies, which affect quality and render the data unacceptable or indeterminate. Deficiencies related to sampling methods requirements include, but are not limited to, such things as sample site adjustments.

Deficiencies are documented in field notebooks by field staff and reported to the cognizant field supervisor who will notify the TWRI QAO. The TWRI QAO will notify the TSSWCB QAO of the potential nonconformance within 24 hours. The TWRI QAO will initiate a Nonconformance Report (NCR) to document the deficiency.

The TWRI QAO, in consultation with TSSWCB QAO (and other affected individuals / organizations), will determine if the deficiency constitutes a nonconformance. If it is determined the activity or item in question does not affect data quality and therefore, is not a valid nonconformance, the NCR will be completed accordingly and the NCR closed. If it is determined a nonconformance does exist, the TWRI QAO, in consultation with the TSSWCB QAO, will determine the disposition of the nonconforming activity or item and necessary corrective action(s); results will be documented by the TWRI QAO by completion of a Corrective Action Report.

Corrective Action Reports (CARs) document: root cause(s); impact(s); specific corrective action(s) to address the deficiency; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and the means by which completion of each corrective action will be documented. CARs will be included with quarterly progress reports. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TSSWCB immediately both verbally and in writing.

Section B3: Sample Handling and Custody

Each fish and benthic macroinvertebrate container will be marked with an identification number. The field biologist will document in a field notebook and chain-of-custody (COC) form the sample number, site, date, time, location, and sample type. A sample number will be assigned to the sample and data for each sample container will then be entered on a COC. The COC form will accompany all sets of sample containers. The sample number, location, date, changes in possession and other pertinent data will be recorded in indelible ink on the COC. The sample collector will sign the COC and transport it with the sample to the laboratory, where the laboratory staff member who receives the sample will sign it. A copy of a blank COC form used on this project is included as Appendix D.

Table B3.1 delineates sample container, preservation and holding time information for parameters of interest in this project.

Table B3.1. Sample Procedures and Handling Methods

Parameter	Method	Container	Preservation	Temperature	Holding Time
Laboratory Parameters					
Fish	TCEQ	HDPE	NA	4°C	24 hrs
Benthics	TCEQ	HDPE	95% Ethanol^{-}	Ambient	5 yrs
Field Parameters					
Specific Conductance	TCEQ	NA	NA	NA	NA
Velocity	Flow Probe	NA	NA	NA	NA

TCEQ = TCEQ's *Surface Water Quality Monitoring Procedures*
HDPE = High Density Polyethylene bottles
°C = degrees centigrade
SM = Standard Methods for Examination of Water and Wastewater, 18th and 20th editions
NA = not applicable; measured *in situ*
Flow Probe = SonTek Flow Tracker Hand Held APV doppler flow meter

After samples are received at the laboratory, they will be inventoried against the accompanying COC. Any discrepancies will be noted at that time and the COC will be signed for acceptance of custody. Sample numbers will then be recorded into a laboratory sample log, and samples will be checked for preservation (as allowed by the specific analytical procedure), pretreated as necessary, and placed in a refrigerated cooler dedicated to sample storage, where required.

The Laboratory Manager has the responsibility to ensure that all holding times are met. This is documented on COC for sample dates and times and on analytical run logs for analysis dates and times. Any problems will be documented with a corrective action report (CAR). CARs will be utilized when necessary (Appendix B). CARs will be maintained in an accessible location for reference at TCE. 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. Any items or areas identified as potential problems and any variations or supplements to QAPP procedures noted in the laboratory quality assurance/quality control report will be made known to pertinent project personnel and included in an update or amendment to the QAPP.

Hard copies of all data sheets, maintenance records, chain of custody forms (COCs), calibration logs, corrective action reports (CARs), GPS and GIS data, digital photographs, and laboratory analysis reports will be archived by TCE at the Fort Stockton Center in Fort Stockton, Texas for at least five years. In addition, TCE will archive electronic forms of all project data for at least five years. In addition, hard and electronic copies of the biological and habitat data will be archived at the USGS Texas Water Science Center for a period of at least five years. A CAR form is presented in Appendix B and a copy of a COC is presented in Appendix D.

Section B4: Analytical Methods

Conductivity and flow at sampling sites for this project will be measured *in-situ*. A listing of analytical methods and equipment is provided in Table B4.1. All assessments will be conducted according to TCEQ's *Surface Water Quality Monitoring Procedures* (TCEQ 2005).

In the event of a failure in the analytical system, the Project Manager will be notified. The Laboratory Manager, Quality Assurance Officer, and Project Manager will then determine if the existing sample integrity is intact, if re-sampling can and should be done, or if the data should be omitted.

Table B4.1. Laboratory Analytical Methods

Parameter	Method	Equipment Used
Laboratory Parameters		
Fish	TCEQ	Species ID/Count
Benthics	TCEQ	Speices ID/Count
Field Parameters		
Specific Conductance	TCEQ	Hydrolab Quanta Conductivity Meter
Flow	TCEQ	SonTek Flow Tracker Hand Held APV doppler flow meter

TCEQ = TCEQ *Surface Water Quality Monitoring Procedures Manual* (2005).

Section B5: Quality Control

Field Sampling Quality Control Requirements and Acceptability Criteria

Field QC requirements for aquatic life inventories, habitat assessments, flow measurements and conductivity are outlined in the *TCEQ Surface Water Quality Monitoring Procedures Manual*. Additional QC requirements for conductivity are outlined below. Field QC sample results are submitted with the data (see Section A9).

Field Duplicate - A field duplicate is defined as a second sample, from the same location, collected in immediate succession, using identical techniques specified in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003). This applies to all cases of routine surface water collection procedures. Field duplicates are collected on a 10% basis or one per trip, whichever is greater. The precision of field duplicate results is calculated by relative percent difference (RPD) using the following equation:

$$RPD = (X1-X2)/((X1+X2)/2)) * 100$$

RPD criteria listed in Table A7.1 will be used to screen field duplicate results as a possible indicator of excessive variability in the collection and analytical system. If it is determined that meaningful quantities of constituent (i.e., >AWRL) were measured and analytical variability can be eliminated as a factor, then variability in field duplicate results will primarily be used as a trigger for discussion with field staff to ensure samples are being handled in the field correctly. Some sample results or batches of samples may be invalidated based on the examination of all extenuating information. Professional judgment during data validation will be relied upon to interpret the results and take appropriate action. The qualification (i.e., invalidation) of data will be documented on the Data Summary. Deficiencies will be addressed as specified in this section under Deficiencies, Nonconformances, and Correction Action related to Quality Control.

Control Standard - A Control Standard consists of analyte-free water spiked with the analyte of interest prepared from standardized reference material. The Control Standard is spiked into laboratory-pure water at a level less than or equal to the mid-point of the calibration curve for each analyte. The Control Standard is carried through the complete preparation and analytical process. The Control Standard is used to document the bias of the analytical process. Control Standards are run prior to each day of sampling. Results of Control Standard are calculated by percent recovery (%R), which is defined as 100 times the measured concentration, divided by the true concentration of the spiked sample.

The following formula is used to calculate percent recovery, where %R is percent recovery; SR is the measured result; SA is the true result

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

Performance limits and control charts are used to determine the acceptability of LCS analyses. Project control limits are specified in Table A7.1.

Equipment blank - Equipment blanks are prepared at the laboratory. The QC check is performed before the sampling equipment is sent to the field. The analysis of equipment blanks should yield values less than the reporting limit. Otherwise, the equipment should not be used.

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

Procedures as outlined in Section B2 will be followed to address deficiencies, nonconformances and corrective action related to quality control.

Section B6: Equipment Testing, Inspection and Maintenance Requirements

Sampling equipment to be used include a SonTek Flow Tracker Hand Held APV doppler flow meter and a Hydrolab Quanta conductivity meter. All sampling equipment testing and maintenance requirements are detailed in the TCEQ Surface Water Quality Monitoring Procedures Manual (2003) and the manufacturer's specifications. Sampling equipment is inspected and tested upon receipt and is assured appropriate for use. Equipment records are kept on all field equipment and a supply of critical spare parts is maintained. The TCE Project Coordinator will be responsible for making sure that equipment is operating correctly and is tested in accordance to this QAPP. Procedures as outlined in Section B2 will be followed to address deficiencies, nonconformances and corrective action related to quality control.

Section B7: Instrument Calibration and Frequency

Sampling equipment to be used include a SonTek Flow Tracker Hand Held APV doppler flow meter and a Hydrolab Quanta conductivity meter. Calibration requirements, including methods, test criteria, standards, and frequency, are contained in the TCEQ Surface Water Quality Monitoring Procedures Manual (2003) and the manufacturer's specifications. These will be followed to ensure the highest quality of data. Post-calibration error limits and the disposition resulting from error are adhered to. Data not meeting post-error limit requirements invalidate associated data collected subsequent to the pre-calibration. Procedures as outlined in Section B2 will be followed to address deficiencies, nonconformances and corrective action related to quality control.

Section B8: Inspection/Acceptance Requirements of Supplies and Consumables

No special requirements for acceptance are specified for field sampling supplies and consumables.

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

Water quality determinations at sampling sites will be based upon data collected during the time frame of this project. However, aerial photos, flow and salinity data of known quality and collected by reputable organizations within the Pecos River or Rio Grande River Basins will be used as supplemental information to meet project objectives. Data collected at sites along the Pecos River will be used to assess the impact of water quality and salinity issues of the Pecos River Basin, develop a watershed protection plan and conduct educational programs. Key resources to be used include but are not limited to data from IBWC CRP, the Rio Grande Basin Initiative, USGS, TPWD, TWDB, and TCEQ. These data will be referred to as historical data.

All data used in the modeling procedures for this project are published values or collected in accordance with an approved QAPP under the state's Clean Rivers Program overseen by the TCEQ, or quality assurance procedures under the Texas Water Development Board or USGS. Measured stream flow will be collected at USGS stream gage stations. Published evaporation and seepage rates will also be utilized.

Section B10: Data Management

Biological and Physical Habitat Data Management and Analysis

All biological and physical habitat data will be reviewed and corrected before entry into a USGS project database. Original hard copies of all field generated data will be provided to the Pecos Project manager, and electronic copies of the data provided in a format at the discretion of the project manager. These data will be incorporated into the Pecos River Basin Water Quality Assessment Database. Hard and electronic copies of the data will be archived at the USGS Texas Water Science Center for a period of at least five years.

Biological and stream habitat data for the three sites will compliment aquatic life and stream habitat assessments that will be done by the USGS at 5-7 Pecos River sites extending downstream of Pandale to near the confluence of the Pecos River and Rio Grande. The USGS will collect data at the downstream sites in a manner that will facilitate data analysis and interpretation. A report will be produced in the summer of 2007 discussing all the biological assessment conducted by USGS in the Pecos watershed.

<u>Chain of Custody Forms</u>

A chain of custody (COC) form is used to record sample identification parameters and to document the submission of samples from USGS field staff to the analytical laboratory staff. Each COC has space to record data for at least 15 separate samples. A copy of the COC is found in Appendix D. All entries onto the COC forms will be completed in ink, with any changes made by crossing out the original entry, which should still be legible, and initialing and dating the new entry. COCs are kept in three-ring binders in the TCE office for at least five years.

Water Quality Data Management Process

Quantitative water quality measurements are taken in the field by personnel using a SonTek Flow Tracker Hand Held APV doppler flow meter and a Hydrolab Quanta conductivity meter. Qualitative measurements, which include observational data (i.e. weather conditions), are also taken in the field. The field investigator has prime responsibility to assure that all pertinent information is recorded, is recorded correctly, and is recorded in the proper units. All hand-entered data must be recorded legibly and with special care to maintain the decimal in its proper location.

Field measurements are performed according to procedures recorded in Section B2. Field data will be recorded in field notebooks. The data from the field notebooks will be reviewed and checked for outliers. The data will then be entered into a spreadsheet by the TCE Project Coordinator using Excel software. The Excel software is then used to evaluate the data for outliers and incorrect data format. The spreadsheet will contain only data collected by partners participating under this QAPP.

Water quality data that have been added to the spreadsheet undergo the following quality control checks:

1. Each set of data received by TCE will be reviewed for the following:
    a. valid and complete station location, date, and time and

   b. comparison of station location to station description to ensure they both represent the same sampling point.

2. The Data Review Checklist (Appendix C) will be utilized to insure that potential areas for error are addressed and reviewed prior to submission of data.

Even when accepted protocols are followed in collecting and analyzing environmental samples, a potential for loss of data quality arises in the manipulation and reporting of the data. All procedures that may lower the chance for number handling errors will be followed.

Field Data Errors and Loss

Upon receipt of field data, the TCE Project Coordinator insures that no outliers or errors in the data are present. If any are observed, the TCE Project Coordinator either corrects the error if possible or verifies the error with the source. The data is then entered into Excel and evaluated for any errors. Any errors discovered are corrected or removed from the spreadsheet.

Field Record Keeping and Data Storage

All field data received by the TCE Project Coordinator are archived in hard copy form and retained on-site by TCE for a minimum of five years. TCE and TAES personnel back up all electronic files on rewritable CD's.

Modeling Data Management Systems Design

Systems Design

TAES uses laptop personal computers and desktop personal computers. The computers run Windows operating system. Databases include Microsoft® Excel database. Both published (historical) and collected data are processed, compiled, analyzed, and transmitted utilizing the Windows operating system and Microsoft databases.

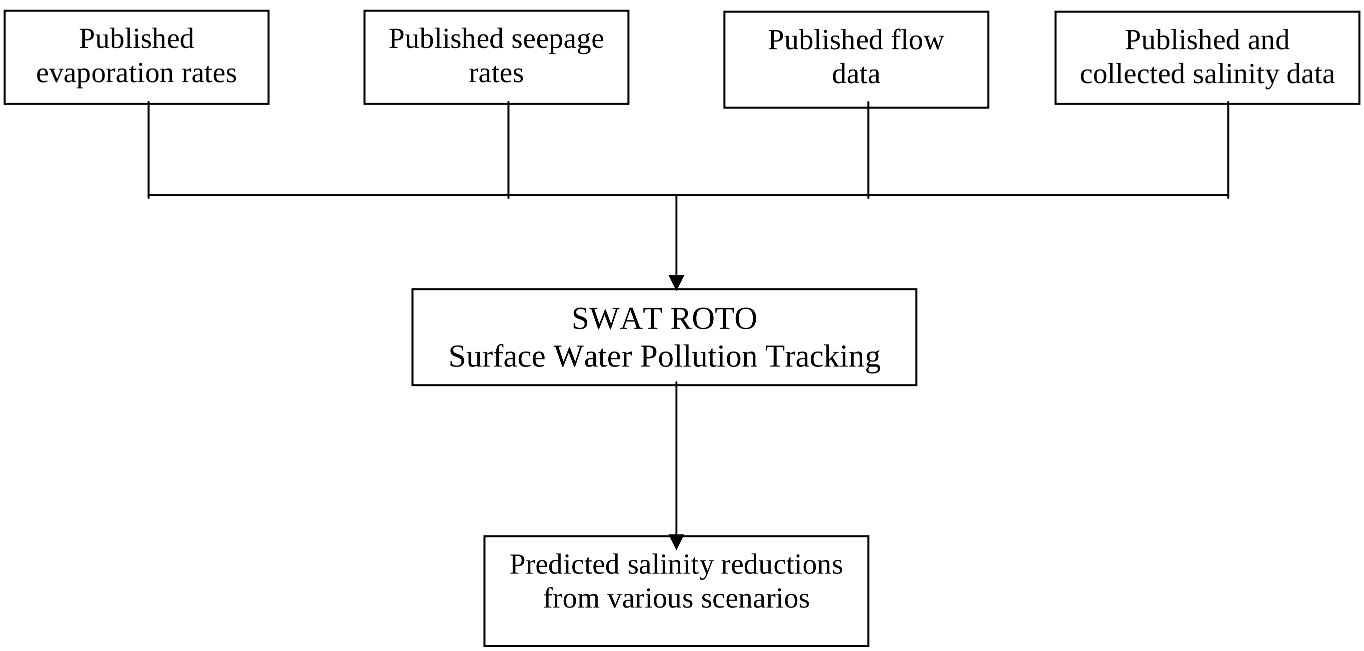
Backup and Disaster Recovery

The computers are backed up as needed to CD's and stored off site. In the event of a catastrophic systems failure, the CDs can be used to quickly restore the data. 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 CDs off-site.

Figure B10.1. Information Dissemination Diagram



Section C1: Assessments and Response Actions

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

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party(ies)	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TCE, TWRI	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
Monitoring Systems Audit	Minimum of one during the course of this project.	TSSWCB QAO	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Field sampling, handling and measurement; facility review; and data management as they relate to the project	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 B7 (Calibration), 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 QA officer 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. If the predicted value cannot be brought within calibration standards, the TSSWCB and TWRI Quality Assurance Officers will work together 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 specified 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.

Corrective Action

The TWRI QA Officer is responsible for implementing and tracking corrective action procedures as a result of audit findings. Corrective action documentation will be submitted to the project lead with the Progress Report.

Corrective action is taken anytime errors, deficiencies, or out-of-control circumstances occur. Corrective action can be an immediate response to remedy a spontaneous or non-recurring problem such as equipment malfunction. Long-term corrective action is necessary to correct recurring problems.

The TWRI QA Officer is notified immediately of all test results beyond control limits. The TWRI QA Officer will then determine the proper course of action. The TSSWCB QAO and TWRI QAO will address recurring QA/QC problems. Any recurring or unresolved QA/QC problems will be brought to the immediate attention of the QA Officer. A Corrective Action Report will be prepared and a copy will be forwarded to the TSSWCB QAO. The TWRI QAO and TSSWCB QAO will develop an appropriate corrective action plan. The TWRI QAO will review the results of the corrective action and determine if further action is required.

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

Section C2: Reports to Management

Sample collectors submit field data to TAES as it is collected. The TCE Project Coordinator transfers results from field notebooks that have been reviewed and approved into a spreadsheet. The data is reviewed utilizing the data review checklist prior to submittal. TAES and TCE subsequently report findings to TWRI Project Manager on a quarterly basis.

Quarterly progress reports will note activities conducted in connection with this water quality project, items or areas identified as potential problems, and any variations or supplements to the QAPP. Corrective action report forms will be utilized when necessary (Appendix B). If the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. Corrective Action Reports will be filled out to document the problems and the remedial action taken. CARs will be maintained in an accessible location for reference at TWRI. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP.

Section D1: Data Review, Verification, and Validation

For the purposes of this document, the term verification refers to the processes taken to determine compliance of data with project requirements, including documentation and technical criteria. The term validation refers to those processes taken independently of the data-generation processes to determine the quality of a data set specific to its intended use.

All field data will be reviewed and verified for integrity and continuity, reasonableness, and conformance to project requirements, and then validated against the data quality objectives, which are listed in Section A7. Only those data, which are supported by appropriate quality control data and meet the data quality objectives defined for this project, will be considered acceptable.

The procedures for verification and validation of data are described in Section D2 below and Appendix C. The TCE Project Coordinator is responsible for ensuring that field data are properly reviewed, verified, and submitted in the required format to the project database. Finally, the TWRI QAO is responsible for validating that all data collected meet the data quality objectives of the project and are suitable for reporting.

Section D2: Verification and Validation Methods

General Provisions

Data review, verification, and validation will be performed using self-assessments and peer and management review as appropriate to the project task. The information to be reviewed, verified, and validated (Table D1.1) is evaluated against technical and project specifications and checked for errors, especially errors in calculations, data reduction, and transcription. Potential errors are identified by examination of documentation and by manual *(or computer-assisted)* examination of corollary or unreasonable data. If a question arises or an error is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues, which can be corrected are corrected and documented. If an issue cannot be corrected, the task manager consults with higher-level project management to establish the appropriate course of action, or the data associated with the issue are rejected. Data reviews, verifications, and validations will be documented.

Table D2.1 Data Review, Verification, and Validation Tasks

Task	Verification	Validation	Responsibility
Field data reviewed for conformance with data collection, sample handling and chain of custody, analytical and QC requirements	Y		TWRI QAO
Post-calibrations checked to ensure compliance with error limits	Y		Field Personnel
Field data calculated, reduced, and transcribed correctly	Y		Field Personnel
Model data reviewed for conformance with QC requirements	Y		TWRI QAO
Analytical data documentation evaluated for consistency and/or improper practices	Y	Y	TWRI QAO
Analytical QC information evaluated to determine impact on individual analyses	Y	Y	TWRI QAO
Data set (to include field and model data) evaluated for reasonableness and if corollary data agree	Y	Y	TWRI QAO
Data review, verification, and validation performed and deviations documented		Y	TWRI QAO
Outliers confirmed and documented		Y	TWRI QAO
Field QC acceptable (e.g., field splits and trip, field and equipment blanks)		Y	TWRI QAO
Sampling and analytical data gaps checked and documented		Y	TWRI QAO
Verification and validation confirmed. Data meets conditions of end use and are reportable		Y	TWRI QAO

Data validation tasks to be addressed by TWRI include, but are not limited to, the confirmation of field data review, evaluation of field QC results, additional evaluation of anomalies and outliers, analysis of sampling and analytical gaps, and confirmation that all parameters and sampling sites are included in the QAPP. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data before data validation can be completed. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the TWRI QAO validates that the data meet the data quality objectives of the project and are suitable for reporting. Pertinent information having to do with inconsistencies with reporting limit specifications; failures in sampling methods and procedures resulting in unavailable data; etc. will be provided on the Data Summary when the data are submitted to the TCE Project Director.

The TCE Project Coordinator and TWRI QAO, as appropriate, are responsible for validating that the verified data are scientifically valid, defensible, of known precision, accuracy, integrity, meet the data quality objectives of the project, and are reportable to the TSSWCB. Additional considerations for field and modeling data validation are discussed below.

Model Calibration and Validation

In the validation process, the model is operated with input parameters set during the calibration process without any change and the results are compared to the remaining observed data to evaluate the model prediction. Same evaluation measures will be used for assessing the performance of the model during validation. Model calibration and validation will be carried out first for each model component, then for the entire model. This two-phase approach will assure the reliability of each model component and the entire model, and in some cases, validate some of the existing data. Model component calibration and validation will be performed using the following datasets or database.

The relationship between flow and salinity (including ionic concentrations) had been calibrated at eleven gauging stations maintained by USGS for the Pecos River, and one station at Langtry maintained by IBWC. These data sets consist of daily flow, momentary flow rates at the time of water sampling or onsite salinity measurements, and the results of water quality analyses for salinity, including major cations and anions in most cases. The calibrated relationships will be used first to adjust salinity readings or ion concentrations to the monthly flow rates computed from daily flow data. For salt balance analysis, all salinity measures will be flow-weighted.

The flow and salinity relationship should ideally be established for each major tributaries and creeks. Because of intermittent nature of tributaries or creeks in dry portions of this basin, it is possible that inflow from small creeks and arroyo will be treated as a group assigned to each river reach.

The above method of salinity vs. flow calibration was found to be satisfactory at most of the gauging stations, with some scattered data at two stations; one at Pierce Canyon Crossing and another at the inlet to Red Bluff. In these cases, in-stream salinity fluctuates from 3,000 to 30,000 mg L^{-1}, because of the presence of saline springs in the middle of river bed, and dilution by reservoir release and storm runoff.

Two-dimensional seepage estimates will be first validated against published data (but not from the Pecos) on seepage rates and the depth to the water table as a function of the distance from the stream. Additional calibration will be made against the measured percolation losses in a short reach of the Pecos which are being carried out under Subtask 3.3. There are also records of additional percolation measurements (e.g., Clayton, 2002). The relationship between percolation losses and soil type will be examined, and percolation losses from other reaches will be estimated based on the state soil resources map. In the river reach close to Red Bluff, we expect some difficulties due to unstable nature of salt basin, including possible leakage due to salt dissolution. In these cases, streamflow data will be used to estimate “percolation” losses.

Calibration of the upward water and salt flux model will be made first against the soil moisture and soil salinity data we have collected along the middle Rio Grande. Two sites out of thirteen sites studied are located outside the levee, and have a shallow water table. These sites do not receive bank overflow and are ideally suited for testing upward movement of salts. The calculation of upward water and salt flux from the riparian areas of the Pecos River will be made and be compared against streamflow and soil salinity data collected at CRP stations.

Salt flushing will be calibrated against the continuous salinity and flow measurement being performed by TCE at Girvin. This station also has daily flow measurement by USGS. A station at Monahans (Coyanosa) also began to provide the continuous measurement of flow and salinity which can be used for calibrating salt flushing. Salt leaching will be calibrated using the same data set. The salt accumulation estimated by step 3 minus the salt load of the bank overflow will be considered salts which were leached.

Reservoir processes have already been calibrated and validated at Elephant Butte, Amistad and Falcon. If outflow data (quantity and salinity) kept by the Red Bluff District are determined to be usable, the model can also be validated on site.

Overall model validation will be conducted in the river reach between Red Bluff and Girvin, provided that necessary hydrologic data become available. The model will operate similarly to the ROTO, requiring the data on reservoir release, tributary and creek inflow, diversion and river cross section and the slope. These data are currently not available and are programmed to be obtained mostly under Subtask 1.4. Streamflow data are available at Orla and Girvin (USGS station) and Mentone and Coyanosa (CRP). It is also necessary to estimate the salinity of reservoir release. We will compute flow and salinity at Girvin, and compare against the measured. The projection will be made daily as the existing ROTO, although the output can be weekly or monthly depending on model use objectives.

The reach below Girvin receives fresh water inflow, and in-stream salinity decreases down to less than 2,000 mg L^{-1} at Langtry. Salinity at Langtry where the Pecos River enters the Rio Grande is controlled by salt load at Girvin, and is predictable without any complicated models. Also, there is no indication that riparian zones below Sheffield are subject to degradation with salts because of overland fresh water runoff into the River, besides having frequent bank overflow.

Model calibration is referred to as how well the model is able to simulate the observed flow rates and salinity. The following criteria have been established as acceptable model calibration inputs and outputs, respectively.

1. Annual flow will be calibrated so that predicted values agree to measured values within 15%.
2. Flow water balance involving inflow losses and outflow from a hydrologic unit will be calibrated so that predicted values also agree to measured values within 15%.
3. In-stream salinity will be calibrated so that the mean of the predicted values falls within two standard deviations of the mean of the measured values.

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

1. Check data for deficiencies and correct any that are found.
2. Check model algorithms for deficiencies and correct any that are found.
3. Re-calibrate the model until a best fit between simulated and observed data is obtained.

Field Data Verification and Validation

All field data will be reviewed, verified and validated to ensure they conform to project specifications as described in Section A7. A *Data Review Checklist* is included in Appendix C. The staff and management of the respective field and data management tasks, as listed in this project, are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process. The field tasks ensure the verification of raw data, electronically generated data, and data on hard copy output from instruments.

Section D3: Reconciliation with User Requirements

Data generated by this project will be used for planning and education only. Representativeness and comparability of data, while unique to each individual collection site, is the responsibility of the TCE Project Director. By following the guidelines described in this QAPP, and through careful sampling design, the data collected in this project will be representative of the actual field conditions and comparable to similar applications.

The TCE Project Director will review the final data to ensure that it meets the requirements as described in this QAPP. Corrective Action Reports will be initiated in cases where invalid or incorrect data have been detected. Data that have been reviewed, verified, and validated will be summarized for each site individually, as well as all sites collectively, for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. These summaries, along with a description of any limitations on data use, will be included in the final report.

The modeling framework developed for this project will be used to evaluate water quality issues, as they pertain to salinity, in the Pecos River watersheds. It will be incorporated to provide the TSSWCB, NRCS, SWCDs and local stakeholder groups with optimum information pertaining to watershed characteristics and to the prediction of possible problems. This, in turn, will enhance their decision-making efforts as part of a comprehensive Watershed Plan management strategy.

Appendix A

Watershed Protection Plan Development for the Pecos River

Project Workplan

Watershed Protection Plan Development for the Pecos River
Texas State Soil and Water Conservation Board
Project #04-11

Nonpoint Source Summary Page

1. Title of Project: Watershed Protection Plan Development for the Pecos River

2. Project Goals/Objectives: (1) To assess the Pecos River Basin; (2) Increased landowner and stakeholder involvement through educational efforts; (3) A Watershed Protection Plan based on the river basin assessment.

3. Project Tasks: (1) Assess the current conditions of the Pecos River Basin; (2) Facilitate educational programs and stakeholder involvement; (3) Create and maintain a project website; (4) Establish a monitoring program; (5) Conduct a fate analysis for water salvaged by the saltcedar control; (6) Develop a Watershed Protection Plan

4. Measures of Success: (1) Coordination of a watershed stakeholder committee; (2) Dissemination of educational material developed through the project; (3) The development of a Watershed Protection Plan for the Pecos River Basin

5. Project Type: Statewide ( ); Watershed (X); Demonstration ( )

6. Waterbody Type: River (X); Groundwater ( ); Other ( )

7. Project Location: Pecos River Basin in Texas

8. NPS Management Program Reference: State of Texas Agricultural/Silvicultural Nonpoint Source Management Program approved November 1994; to be updated FY98-99

9. NPS Assessment Report Status: Impaired ( ); Impacted (X); Threatened ( ); Other ( )

10. Key Project Activities: Hire Staff ( ); Monitoring (X); Regulatory Assistance ( ); Technical Assistance ( ); Education (X); Implementation ( ); Demonstration ( ); Other ( )

11. NPS Management Program Elements: Milestones from the “1999 Texas Nonpoint Source Pollution Assessment Report and Management Program”, which will be implemented include: (1) Coordinating with Federal, State, and Local Programs (2) Committing to technology transfer, technical support, administrative support and cooperation between agencies and programs for the prevention of NPS pollution.

12. Project Costs: Federal ($709,380); Non-Federal Match ($626,103); Total ($1,335,483)

13. Project Management: Texas State Soil and Water Conservation Board

Project Period: 3 years from start date

Watershed Protection Plan for the Pecos River

Texas State Soil and Water Conservation Board

Project #04-11

WORKPLAN

Problem/Need Statement: The Pecos River is a greatly depleted western river flowing 418 winding miles through hot, dry, semi-arid landscapes in Texas. It is the largest river sub-basin flowing into the Rio Grande River in Texas. As such, its importance historically, biologically and hydrologically to the future of the Rio Grande Basin is huge. The flows of the once great Pecos River have dwindled to a mere trickle due to many causes – some natural and some man-induced. Its upper reaches in Texas now resemble a very poor quality creek rather than a river. If the integrity of the entire Rio Grande basin below the Pecos is to be improved and maintained, then it is crucial that both the water quality and quantity of Pecos flows be drastically upgraded and stabilized within a natural flow regime to a viable level of in-stream flows.

Due to the lowered water quality and stream flows, the aquatic community of the Pecos River has been drastically altered according to fishery biologists and to local users of the river. No longer does it have a healthy diverse community of aquatic plants, invertebrates, microorganisms, fish and amphibians. The greatly reduced aquatic diversity has been negatively affected by changes in river hydrology, riparian community destruction, oil and gas activities, irrigation demands, long and short-term droughts, damming of the river and the desertification of the upland watershed due to grazing mismanagement. These factors, both natural and man-made, have allowed introduced plant species, such as saltcedar, to dominate the riparian systems within the watershed.

According to the data of IBWC, the Pecos River contributes to the flow of the Rio Grande at an average rate of 274 million m^3, which accounts for 11% of the stream inflow into Amistad. However, it also contributes to salt loading into Amistad at an annual rate of 0.54 million tons or 29.5% of the total salt loading. Salinity of the Amistad exceeded 1000 ppm for a month in 1988, and has fluctuated since. It is important to control salt loading from the Pecos to Rio Grande if we are to be successful in keeping salinity of the reservoir below 1000 ppm.

The decreasing water quality in the Pecos River has negatively affected the Rio Grande River. Being an international river, the Rio Grande is relied upon by both Mexico and the United States for drinking water, irrigation and industry and as such, it depends heavily upon its major Texas tributary – the Pecos River. The Pecos River itself is also the lifeblood of many communities within its reaches, mainly as an irrigation source, recreational uses, and as recharge for underlying aquifers. The environmental condition of both the Pecos and the lower Rio Grande River is extremely crucial to hundreds of thousands of residents of both Mexico and the U.S.

General Project Description: This project will assess the physical features of the Pecos River basin, facilitate communications with stakeholder groups and landowners in eight neighboring counties, and monitor the water quality of the Pecos River. Through this project a Watershed Protection Plan will be developed to assess current management measures as well as determine what future management measures need to be implemented in the river basin to protect the water quality of the Pecos River.

Tasks, Objectives, Subtasks, Schedules, Deliverables and Estimated Costs:

TASK 1: Basin Assessment

Objectives: The purpose of this task is to set a baseline assessment on the Pecos River basin with regards to stream channel morphology, riparian vegetation, land use, salinity mapping, water inflows and outflows, aquatic habitats, historical perspectives, and economic modeling. This phase of the project is absolutely critical to identifying and evaluating potential problems and solutions. Aspects will be viewed from a historical perspective as well as current conditions. Six subtasks are identified and described.

Subtask 1.1 Aerial photography, delineation, and characterization.
High resolution, geo-processed, ortho-rectified aerial photography will be utilized along the main channel of the Pecos River. Remote sensing techniques will be used to identify and characterize stream channel locations, vegetation dynamics including a detailed analysis of saltcedar infestations, current land use, and potential gaining and losing segments of the river. The area will be flown during the fall of the year just prior to saltcedar leaf senescence to assist in determining saltcedar from mesquite and other trees and shrubs. This cannot be accomplished with current DOQQ photography, as they were flow during dormant season "leaf off" or winter months. An evaluation of past saltcedar control efforts will also be conducted to help in future planning efforts. Information from this subtask will also be used in subtasks 1.4, 1.5, and 1.7. (Months 1-24)

Additional data processing and mapping will be conducted by Zhuping Sheng and Joshua Villalobos of Agricultural Research and Extension Center at El Paso as follows:

1. Collect images (satellite and aerial photos) and shape files available for the Pecos River project area;
2. Process images and overlay different layers;
3. Develop maps over the base map (DEM, political boundary, aerial photos or transportation) in tiff or jpeg format to be shared by the project team through the project website:
    a. Watershed boundary;
    b. River channel, gage stations, flood plain, and riparian zone;
    c. Locations of test sites and boreholes;
    d. Saltcedar distribution (treated and untreated); and
    e. Groundwater well locations from TWDB/USGS.

Deliverables:
Aerial photography of the Pecos River for remote sensing
Document current stream channel location
Determination of saltcedar and other important riparian vegetation
Land use classification along the river
Shape files available via download from the website, and/or provided to the project team upon request.

Budget narrative: Dr. Charles Hart, Assoc. Professor and Extension Range Specialist will provide 15% of his time during year one toward this task. Dr. Zhuping Sheng, Assistant Professor will provide one half month of his time toward this task. Funding will be provided for low-level, high-resolution aerial digital photography and delineation of variables. This task will be contracted with a commercial entity. Funding is provided for Joshua Villalobos.

Subtask 1.2 Historical water quality, irrigation delivery, rainfall, Red Bluff Lake levels, and groundwater monitoring

Water data from state and federal agencies as well as the irrigation districts will be compiled and routinely updated so that water quality and quantity in the Texas segment of the Pecos River may be characterized. Groundwater well data will be collected from Texas Water Development Board. (Months 1-36)

Deliverable
Current database of water quality and quantity data

Budget narrative: Mr. Mike Mecke, Extension Program Specialist – Water Conservation, with assistance from a technician and student worker from the project will be working on this task. It is anticipated Mr. Mecke will spend 9.2% of his time collecting and analyzing data for this task. Time will be utilized gathering data from many sources in the Pecos River, Texas region. Travel will be to Red Bluff Water and Power Control District office, Irrigation District offices, NRCS offices, and other area agencies as needed. Considerable time will also be spent on Internet, publications, and phone research collecting data and summarizing.

Subtask 1.3 Aquatic life and habitat inventory
Traditionally, water quality monitoring has been focused on chemical attributes such as mineral content, metals, and other contaminants. Biological monitoring is becoming more frequently utilized to assess overall ecological integrity of the water body. Biological monitoring is particularly useful in assessing the effects of nonpoint sources of pollution such as nutrient enrichment and sedimentation. Biological monitoring data collected during this project will provide baseline data that will allow comparisons to be made between sites on the Pecos River as well as comparisons to similar rivers in the state. Monitoring efforts will also provide a baseline for sites along the Pecos River. This data can be used to assess trends and future changes that may occur as conditions in the river change.

The development of a sustainable Pecos River Basin water management plan would be a giant first step forward and a great aid to maintaining or increasing populations of Endangered Species found in the Basin. A healthy, natural watershed and riparian zone is critical to life, especially in semi-arid and desert regions. A listing of those Endangered Species is attached as Appendix B.

The U.S. Section International Boundary and Water Commission (USIBWC) Clean Rivers Program (CRP) will coordinate the biological assessment with assistance from other entities participating in the study. Ten sites will be selected along the Pecos River in Texas. At those sites, data on benthic organisms, fish, and physical habitat characteristics of the river will be collected and catalogued according to protocols previously published by the Texas Commission on Environmental Quality (TCEQ). Additionally, riparian vegetation and habitat will be described. (Months 1-24) Results will be reported within 12 months of the completion of data collection. (Months 24-36)

Deliverable
Biological data will be incorporated into a Pecos River Basin water quality assessment database along with other data collected during the study.

Budget narrative: Mr. Wayne Belzer with the Texas Clean Rivers Program through International Boundary and Water Commission will be providing the guidance to this task. Funding is requested for travel to sampling sites and misc. sampling supplies. Contracts will be made for data processing.

Subtask 1.4: **Identify and characterize volume and quality of tributaries and springs**
In order to identify potential salinity sources, it will be necessary to locate and characterize selected tributaries into the Pecos River, whether perennial or intermittent, to determine water quantity, quality, and point of impacts from sources outside of the main stem. The first phase involves the review of information available such as U.S. Geological Survey (USGS) hypsography and hydrography maps to determine potential tributary

locations. This data will then be compared to satellite imagery to locate active water runoff into the Pecos River. The second phase would include fieldwork and ground truthing, which will be necessary to locate each tributary and to acquire water and sediment samples, determine flow volume, and submit samples for laboratory analysis. In the case of dry streambeds that could potentially carry water during storm events, sediment samples will be collected for laboratory analysis and passive samplers will be installed to collect water from the tributaries during rain events. The USIBWC Clean Rivers Program personnel will oversee this effort and support additional Task 1 objectives by coordinating with the Texas Cooperative Extension (TCE) and Texas Agricultural Experiment Station (TAES). (Months 1-27)

Deliverables

- Hydrography and hypsography maps of the Pecos River Basin
- Satellite images of the Pecos River Basin
- Assessment and summary of laboratory data

Budget narrative: Mr. Wayne Belzer with the Texas Clean Rivers Program through International Boundary and Water Commission will be providing the guidance for this task. Funding for equipment will include dataloggers, sensors, and monitors for evaluating stream flows and quality. Funding will also include satellite imagery for documenting location of tributaries and sub-basins. This photography will be on a much larger scale than in task 1.1.

Subtask 1.5 Identify and Characterize Saline Water Sources Entering the Pecos River

The goal of the proposed work is to identify the location(s) and the magnitude of saline water sources entering the Pecos river below Red Bluff. Detailed investigation of individual sources entering the River is beyond the scope of the current study. Although the Pecos is known to be highly saline, little information is available as to the saline water sources entering the river. The suspected sources include saline creek, saline seeps, some of which may be aggravated by irrigation activities, and river seepage upstream which may produce saline seepage downstream, as the percolated water moves through salted sediments and halite beneath the river channel. The first phase of this subtask will be a review of existing reports on geology, hydrology, soils, surface and subsurface saline water sources, and ground water quality in coordination with subtasks 1.2 and 1.4. The purpose of this review is to develop a broad understanding of the basin and saline water sources. (Months 1 – 18)

The second phase is to identify saline water sources entering the river below Red Bluff, but above Girvin, which is a distance of about 150 river miles where saline inflow is believed to occur. Sources of saline water inflow will be identified by surveying streamflow salinity, pH and temperatures. Any substantial spatial changes in salinity, pH and/or temperature of the streamflow will be considered a potential site for inflow. The water sources to be examined include surface water from Red Bluff, saline seep, ground water, and selected creeks and tributaries. Chemical markers and isotopes will be used to trace sources to their origin.

Volume and salinity of inflow sources will be determined by the mass-balance calculation based on flow and salinity measurements above and below the entry points or segments. A potable acoustic velocimeter will be used for flow measurements. Water sampling and analyses will be performed in March, prior to the release of water from Red Bluff and again in August when agricultural drainage water usually peaks. This source tracking activity will be conducted in cooperation with Tasks 1.4 and 3.2 headed by Texas Clean Rivers Program/IBWC. The water samples collected are planned to be analyzed by the established IBWC contract lab in order to maintain continuity and analytical quality control (6 – 18 months). Surface water inflow into the Pecos is covered under Task 1.4.

Salts stored in the river bank and floodways can result in increased salinity downstream due to flushing during bank overflow. This scenario occurs in the Middle Rio Grande below Ft. Quitman, and there is an indication that this may also apply to the lower Pecos. If resources permit, we will collect exploratory bank soil samples and will analyze for salinity in the reach between Girvin and Langtry.

Once the major sources of saline water entering the Pecos are identified, we will be in a position to develop a detailed plan to investigate the individual sources. An additional proposal will be submitted at that point.

Deliverable

- A reconnaissance survey of saline water sources entering the Pecos below Red Bluff (In coordination with subtasks 1.4 and 3.2)

Budget narrative: Dr. Seiichi Miyamoto, Texas Agricultural Experiment Station in Elpaso, will be providing direction for this subtask. He has allocated 5.4% of his time in years 1 and 2 to this subtask. Funding is also requested for partial funding of a technician and a student worker for collecting and analyzing data. Travel is requested for project meetings and data collection and field work trips to the Pecos River. Funding for supplies are requested for sampling tools, measuring devices, flow meters and other general field supplies. Miscellaneous funding is also requested for isotope analysis, EM 34 sensor rental, and data analysis.

Subtask 1.6 Simulate Flow and Salinity of the Pecos for Evaluating River Management Options

This subtask is to simulate flow and salinity of the Pecos River below Red Bluff for evaluating river management options and will be approached in three phases. The first phase is to develop and validate a simple mass balance model useful for assessing the effect of inflow from the Pecos River on salinity of Amistad Reservoir. Salinity of the reservoir has been increasing since construction in 1968. Salinity levels reached the drinking water limit of 1000 ppm during February 1988 and have continued to fluctuate. A simple model, which is largely based on salt balance analysis, is currently being developed under a separate program funded by the Texas Higher Education Coordinating Board. Existing complex models demand input data which are not readily available and do not consider site-specific salt problems. Our simple model will be used to analyze the impact of the Pecos River on reservoir salinity on both short and long time scales, using the historical flow and salinity data available at Foster Ranch, Langtry and Amistad. These analyses include the development of a program useful for estimating salinity of the lake outflow from inflow data. We will also examine probable scenarios for reservoir salinity to exceed 1000 ppm, and how the inflow from the Pecos may affect the scenario. (Months 1-18)

The second phase is to collect or generate the data needed to develop and verify a water and salt transport model (which is described later). The data needed are two-types. The first type is the current river dimensions such as river cross-sections at various reaches, slope, the extent and the types of riparian zones, floodway dimensions, salinity and depth of water tables, permeability and soil type distribution, weather data and physical data of the catchment areas which yields surface or subsurface inflow into the Pecos. These data will be collected in conjunction with other tasks, especially Tasks 1.4 and 1.5. The second type of data is the historical records of flow and salinity at various reaches of the Pecos. These data are scattered among different agencies and unfortunately rather limited, except at Langtry. If the historical data are sufficient to analyze, we will examine the impact of irrigation on river salinity in a historical context. If not, we will use the historical records solely for calibrating our model. (Month 12-24)

The third phase is to develop a water and salt transport model for the main flow of the Pecos River below Red Bluff. The model is to be used for assessing river management options on flow and salinity of the Pecos at various segments, as well as for assessing salt loading into the Rio Grande, then to Amistad. Such a model is currently being developed for the Middle Rio Grande, and includes submodels needed to evaluate the impact of riparian zones on flow, salt storage, and release into the stream during bank overflow. The model also accounts for two-dimensional seepage losses from the steam beds as well as seepage into the river, which is undoubtedly an important process in the case of the Pecos River. The model will be calibrated using the historical records and will be validated against the monitoring data from Task 3.2. The projected time requirement would be approximately 12 to 24 months.

Deliverables

- Impact of saline water flow from the Pecos River on salinity of the Amistad International Reservoir
- A model for simulating flow and salinity of the Pecos River below Red Bluff

Budget narrative: Dr. Seiichi Miyamoto, Texas Agricultural Experiment Station Elpaso, will be providing direction for this subtask. He has allocated 13.3% of his time in years 1 and 2 and 6.6% in year three to this subtask. Funding is also requested for a research associate and student worker for collecting and analyzing data. Travel is requested for project meetings and data collection and field work trips to the Pecos River. Funding for supplies and miscellaneous expenses are requested for computer hardware, software, and general computer supplies.

Subtask 1.7 Economic modeling of Pecos river basin and assessment of saltcedar control activities
Objectives of this subtask are to (1) Create a crop acreage optimization model for surface water irrigation district producers using localized production budgets and salinity tolerance coefficients, (2) measure economic effects of saltcedar control on associated rangelands and riparian areas, and (3) use IMPLAN input/output model to measure indirect changes on the basin wide economy caused by saltcedar control.

The effects of saltcedar invasion are known. Costs of control can be easily measured. These cost are borne by landowners/operators and the taxpaying public. Both federal and state funds have been used for saltcedar control. Benefits from a technical standpoint may consist of additional streamflow, recharge into shallow aquifers, increased bank storage and improved water quality (decrease in salinity). The economic benefits of all these anticipated results are difficult to entirely quantify.

A linear programming model will be developed to estimate irrigated crop producer responses to changes in the availability and quality of irrigation water within surface water irrigation districts in the Pecos river basin. Historical acreage allocations by crop, localized production budgets developed by Texas Cooperative Extension and water use efficiencies for the identified crops will be used to identify possible scenarios. Crop yields will adhere to historical averages in conjunction with crop salinity tolerance coefficients. It is assumed that individual producers will seek to maximize their net income. Thus, the objective function of the model will be to maximize net returns for the basin within the constraints of available irrigated land, irrigation water with varying levels of quality and the availability of packing sheds and cotton gins. (Months 24-36)

The impact to associated rangelands will be assessed separately. Recovery of the riparian area will be monitored for increases in managed, sustainable grazing capacity. Surveys of appropriate stakeholders will be used to quantify increased usage as well as perceived impacts to wildlife. (Months 29-30)

Basin wide impacts of saltcedar control or other BMPs will be analyzed using the input-output model IMPLAN. This type of input-output model can be used to analyze the interrelationships between the agricultural sector and other sectors of the regional economy. Results from the separate LP models for surface and groundwater irrigators will be input into the IMPLAN model. In this case, increased availability or quality of irrigation water can be expected to increase demand for products in other sectors of the economy than just the agricultural sector. It is this ancillary increase in economic activity across all sectors of the Pecos River basin that will be measured and compared to the relative cost of BMPs. (Months 28-36)

Deliverables

- Development and publication of localized production budgets for irrigated crops in the Pecos river basin
- Development and documentation of irrigated acreage optimization models Reports summarizing results of modeling work will also be delivered

- Survey instruments for rangeland and/or riparian area owners/operators on perceived impacts of saltcedar control on wildlife or livestock
- Documentation and analysis of returned rangeland/riparian surveys from owner/operators
- Report on IMPLAN analysis of impact to Pecos river basin economy

Budget narrative: This subtask leader will be William J. Thompson, Assistant Professor and Extension Economist, Fort Stockton, TX. Mr. Thompson will spend approximately 10 percent of his time in year one collecting data and developing production budgets and historical crop acreage allocations. Mr. Thompson will then spend 15% of his time in year two through the conclusion of the project in year three. Year two activities will include the development and documentation of an irrigated acreage optimization model. Travel to farm sites across the Pecos river basin in years one and two is expected to require 7,500 miles at a cost of $1,050 per year. Miscellaneous office supplies of $750 per year will also be purchased. A graduate student will be hired in year 3 to assist with processing of LP model results through the input/output model. Dr. Lonnie Jones, Professor and Resource Economist, Texas Agricultural Experiment Station, will also contribute one month of his time in fitting the IMPLAN model to the Pecos river basin of west Texas. County level economic data will need to be acquired and verified. Site licenses and economic data are expected to cost $1,500. A total of 16,250 miles of travel at a cost of $2,275 is anticipated for Dr. Jones, a graduate student and Mr. Thompson in year 3. Per Diem costs of $700 are anticipated for the graduate student when working in the Pecos river basin from College Station, TX.

Task 2. Educational Programming

Objectives: TCE will work with various state and local agencies to assemble a series of three written publications targeted at landowners, stakeholders and policymakers. These publications will consist of (1) A description of the historical progression of the Pecos river basin to its current condition, (2) A summary of the multi-disciplinary approach which will be employed to monitor the river and the basin, (3) A detailed summary of the watershed plan developed though the course of this project. Additionally, TCE will work with various state and local agencies to organize, promote and conduct a series of educational meetings in each county within the Pecos river basin. The particular content of individual meetings will vary depending on the relationship between local landowners, operators and other interested parties and the Pecos river basin. An interactive internet website will also be created and maintained to provide the most current progress.

Subtask 2.1 Publish written informational materials to educate private landowners, stakeholders and policy makers about the Pecos River and effects of saltcedar

A series of three written publications will be developed, published and distributed to landowners, stakeholders, policymakers and other interested parties. The first publication in this series will present the historical progression of the Pecos river basin to its current condition and will be used to inform landowners, stakeholders and policymakers of the threats facing the basin. This historical view will put into perspective the size of the Pecos river basin and the size and type of issues being addressed. A description of the specific effects of saltcedar and a thorough summary of past saltcedar management efforts along the Pecos river will be presented in this educational publication. (Months 11-13)

The second publication will review the multi-disciplined, multi-agency efforts to monitor and assess the Pecos river basin. This will include:

- The Quality Assurance Project Plan (QAPP) sampling protocol developed by IBWC
- Water quality sites being monitored by the IBWC- CRP
- Saltcedar water use studies and monitoring being performed by TCE and TAES
- The study of the fate and influence of salvaged water being performed by TCE and TAES

- An aquatic life and habitat inventory performed by the IBWC and TCEQ.

The purpose of this publication is to illustrate the extensive study of the Pecos river basin and the need for the development of a watershed plan for the entire basin. This publication will also be available to interested parties when public comment on the proposed watershed plan is solicited. (Months 20-24)

The final publication will address the watershed plan for the Pecos river basin. This publication will include a detailed summary of the watershed plan, some likely consequences of not adopting a basin wide management plan and the anticipated changes to current management practices. The manner in which producer and landowner issues were addressed and possible conflicts resolved as well as how the watershed plan will be implemented and the time line for implementation will be summarized. An update on continuing monitoring activities and recourse for necessary adjustments to the watershed plan will also be included. This publication will incorporate inputs and comments received from stakeholders at public meetings as described in Task 2.2. (Months 30-34)

Deliverables

- A description of the historical progression of Pecos River basin to its current condition
- A review of the multi-disciplinary approach which will be employed to monitor the River
- A detailed summary of the watershed plan developed though the course of this project
- Develop and maintain an interactive website

Subtask 2.2 Educational meetings of interested parties for input and organizational support

Texas Cooperative Extension, with input from various state and local agencies, will organize, promote and conduct meetings in each of the eight counties encompassed in the Pecos river basin. County level Extension personnel have the ability, contacts, facilities and equipment to effectively facilitate meetings. Four categories of meetings will be hosted; (1) informational, (2) skill developing, (3) discovery meetings, and (4) public comment meetings.

<u>Informational Meetings</u> – This type of meeting is intended to inform landowners, operators and other interested parties about conditions within the basin and proactive efforts to monitor, correct or improve conditions. These types of meetings can be held before and after adoption of a basin wide watershed plan. An estimated measure of the impact of these educational programs with respect to Pecos river basin issues may be attained by comparing responses to similar questionnaires delivered before adoption of a watershed plan, and after a watershed plan has been developed and implemented. (Months 8-14)

<u>Skill Level Meetings</u> – Skill level programs will be intended to provide landowners/managers with new skills or to acquaint them with new technology. (Months 12-36)

Possible meeting topics include:

- Chemical, mechanical, and biological control of saltcedar and saltcedar regeneration issues.
- Salinity management of soil and irrigation water and crop salinity tolerances.
- Riparian management issues; recovery, diversity (replacement of saltcedar monoculture).
- Livestock and wildlife management techniques under high salinity conditions.

<u>Discovery Meetings</u> – A series of meetings in each of the counties within the Pecos river basin will be held to solicit input from landowners, operators, local policymakers and other interested parties on the development of a basin wide watershed plan. The status of monitoring and assessment efforts will be presented in the context of how a watershed plan will promote recovery or proper functions of the Pecos river basin watershed. (Months 24-30)

Public Comment Meetings – After development of the plan, but before implementation, a series of meetings will be hosted to present the proposed watershed plan and to allow interested or affected parties to comment on the proposed watershed plan. Much like the earlier meetings soliciting input from interested parties, the status of monitoring and assessment efforts will be presented in the context of how components of the watershed plan address specific issues or problems within Pecos river basin. Comments will be considered before the final watershed plan is released. (Months 30-36)

Deliverables

- TCE with input from various state and local agencies will conduct meetings in each of the counties encompassing the Pecos river basin. Four categories of meetings will be hosted; (1) informational, (2) skill developing, (3) discovery meetings, and (4) public comment meetings
- Meeting attendance and contact data will be reported
- A measure of the effectiveness of the programs in educating the public on environmental issues within the Pecos river basin will also be reported

Subtask 2.3 Develop a web site for dissemination of information

TCE will develop (Months 1-3), host and maintain (Months 3-36) an internet website for the dissemination of information on educational, monitoring and research activities taking place across the Pecos river basin. Website delivery of information will be the most time and cost effective way to disseminate information to any interested people or groups.

Information presented through the website will include:

- Review of individual research projects on Pecos river basin.
- Review of individual monitoring projects on Pecos river basin.
- PDF version of all reports, journal articles, faculty papers and presentations generated from this project.
- Links to all cooperating and/or participating agencies.
- Links to all project primary investigators.
- Links to University academic departments that are involved in the project.
- Links to other related websites
    - Texas State Soil and Water Conservation Board
    - Texas Water Resource Institute.
    - Rio Grande Basin Initiative.
    - Environmental Protection Agency-Office of Water, CWA Section 319
    - Etc.
    - Schedule of upcoming meetings/programs dealing with this project.

Deliverables

- Web site to publish results, bulletins, and reports.

Budget narrative: Co-leaders for this Task are Dr. Charles Hart, Michael Mecke and William J. Thompson. In year one, Dr. Hart will contribute 1.2 months and Mr. Mecke will contribute .6 of a month to this task. In year two, Dr. Hart, Mr. Mecke and Mr. Thompson will contribute 1.2 months, .95 month, and .6 month respectively. In year three, Dr. Hart, Mr. Mecke and Mr. Thompson will contribute .6 month, .95 month, and 1.2 months respectively.

Development of extension publications will cost $1,500 in each of the three years of the project ($4,500 total). A series of educational and public comment meetings will be held in each of the seven counties comprising the Pecos river basin. County level Cooperative Extension Agents in each of these counties will be contributing time and effort to this task. A total of 4.2 months per year will be contributed by these County

Agents. A total of 20,000 miles of travel at a cost of $2,800 for each year will be used by the task co-leaders, county agents and required presenters to commute to each of these meetings. $500 per year ($1,500 total) for miscellaneous office and meeting supplies are also expected.

A website will be developed in year one at a cost of $3,000. An existing web domain will be utilized to reduce overall costs. Costs for maintaining the structure and content of this website are expected to be $1,000 per year for a total of $3,000.

Task 3: Establish Monitoring Program

Objectives: To develop Data Quality Objectives (DQOs) and QAPP, estimate the effect of salt concentration(s) in the Pecos River watershed through data collection and analysis and water use studies, and study fate of and influence of salvaged water. The TCE will work with various state and local agencies to implement a monitoring program to determine the extent of high salt levels in the Pecos River due to NPS. The TCE will collaborate with the USIBWC –CRP as well as other local and state agencies to utilize and expand the current monitoring program in place. Findings from the data collection efforts in Task 3 will provide information necessary to develop best management practices (BMPs) and will form the basis of a watershed management plan for the Pecos River watershed in Texas. TCE will produce a report describing the results of the monitoring effort and the locations of sources that are impacted by high salt in the Pecos River.

Subtask 3.1 Develop QAPP for sampling protocol
CRP will oversee the development of DQOs and a QAPP as specified under EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans. (Months 1-3)

The surface water quality monitoring program conducted through the CRP will serve as a baseline to identify areas considered to be impacted by NPS for salinity. Portable sampling and flow measuring equipment, data sonde(s), and passive samplers will be utilized to monitor specific reaches to collect additional data. Aside from routine monitoring, intensive reconnaissance efforts will be utilized to identify and target specific areas of concern within the basin. All of the analyses in the monitoring program will be detailed in an EPA/TCEQ approved Quality Assurance Project Plan (QAPP).

Deliverable

- Approved QAPP

Budget narrative: Texas Water Resources Institute will provide guidance on this task. Funding for one month of salary will be provided to TWRI for development of the protocol. A small amount of funding is requested for printing costs. All funding for this task will be provided in year 1.

Subtask 3.2 Water quality monitoring, including Total Dissolved Solids (TDS), Total Suspended Solids (TSS), parts Hydrogen (pH), Dissolved Oxygen (DO) and electrical conductivity (EC)
CRP will oversee the collection of data at established sites along the Pecos River to establish baseline information. Parameters required to assess the effects of high salt conditions will be added to the monitoring schedule. Routine and intensive monitoring will be conducted as needed in determining areas impacted by high salt conditions and will be coordinated with the TCE and TAES to support other project tasks. (Months 4-27)

Deliverable

- Quarterly Data Reports

Budget narrative:
Mr. Wayne Belzer will provide direction for this task. Funding is requested for sampling equipment to compliment existing equipment provided by the CRP through IBWC. Water quality sampling equipment and supplies will be purchased and sampling sites established during the first two years of the project.

Subtask 3.3 Quantity and fate of water salvage as a result of saltcedar control
A study was initiated in 1999 using shallow groundwater monitoring wells and water level loggers to estimate net drawdown or recharge along the Pecos River under saltcedar infestations. Wells were installed at two sites within a study area and monitored for one growing season, then saltcedar was killed on one site. Water salvage from saltcedar control is estimated by comparing pre treatment water level data to post treatment water level data for both sites using the EPA Paired Watershed Study Design protocol. Preliminary analysis indicates saltcedar control may yield a 60-70% reduction in water loss at the study site.

This task will further explore the effects of saltcedar control on the fate of salvaged water and determine amount of water released to downstream flow and groundwater recharge. TCE and TAES will: (1) characterize the aquifer beneath treated and untreated sites with borehole exploration; (2) install additional monitoring wells to configure subsurface flow patterns, and (3) conduct flow measurements with designated releases from Red Bluff Reservoir. (Months 1-27)

First, a map of alluvial sediments will be developed to diagram subsurface flow patterns. Previous borehole exploration revealed a clay layer, which may limit vertical water flow within the shallow aquifer. This task is to delineate the extent of the shallow aquifer by drilling additional boreholes at untreated and treated plots along the Pecos River. Soil and water samples will be collected and analyzed, as needed, to determine spatial variation in hydrological properties. Second, additional monitoring wells will be installed. There are 5 existing monitoring wells at each site on one side of the river. In order to better understand flow regimes, additional wells will be drilled on the other side of the river from the existing well network. Dataloggers will be used to record hourly changes in the water level in each of the new wells. Collected water level information will be processed to construct a flow net within the shallow aquifer. The flow net will be used to define the interaction between surface water and ground water, which will be used to assess volume and direction of flow.

Finally, to establish the relationship between surface water and ground water, designated releases from Red Bluff Reservoir will be scheduled. Multiple releases will be monitored for a period of several days during the project period to detect any seasonal changes in the shallow aquifer response to saltcedar control. Seepage losses, or gains, by the river will be calculated and the factors that influence seepage losses and gains will be assessed.

During the releases, surface water flow will be measured at the upstream boundary of the untreated site, at the divide between untreated and treated sites and at the downstream boundary of the treated site. At the same time, hourly water level in each of the wells will be recorded to determine impacts of increased river flow on the shallow aquifer flow.

In general, river inflows are precipitation, runoff, groundwater discharge and release from Red Bluff Reservoir. River outflows include seepage into aquifers, evaporation, transpiration, and irrigation diversion. The proposed tasks will allow us to evaluate flows between the river and the aquifer. Other inflows and outflows will be addressed using funds form other sources. Ultimately, this data will be used with water quality/quantity data collected to predict the effect of saltcedar control on river water quality and quantity in the Pecos River Basin. Data will be used in the model presented in task 1.6 to predict changes in salinity of the river.

Deliverables

- Well monitoring schedule
- Map of soil physical properties within the study area
- Flow net, illustrating velocity and direction of subsurface flow
- Water balance analyses for seasonal seepage runs
- Prediction of impacts of the saltcedar control on the interaction of stream flows and groundwater.

Budget narrative: Drs. Charles Hart and Zhuping Sheng will act as co-principle investigators on this task. An Extension Assistant, will conduct water well monitoring, borehole exploration, and soil analyses. Funds are requested for travel from Ft. Stockton District Center to the study area in Reeves County. Funding for equipment will be used to purchase water level sensors and loggers, a portable flow meter and a portable HydroLab water quality instrument. Funds are also requested for supplies to purchase laboratory supplies such as glassware and reagents.

Task 4: Watershed Protection Plan

Subtask 4.1 Final Report of Basin Assessment, Educational Programming and Monitoring. In addition, Annual reports will be submitted to the TSSWCB by project PIs at the end of years on and two, with the final report submitted at year 3 end.

Subtask 4.2. The subtask will produce the final Watershed Protection Plan for Pecos River Segments 2312, 2311, and 2310 based on criteria set forth in the FY 04 guidelines. A draft plan will be completed within year 2 of the project and available for public comment at stakeholder meetings.

Budget narrative: A technical writer will be provided through the Texas Water Resources Institute to summarize all quarterly reports and write the proposed plan in year three. Funding is requested for investigators travels to developmental meetings and meetings with TSSWCB. Dr. Charles Hart will provide overall guidance to this phase and will be providing 1.2 months FTE to the task.

Coordination, Roles and Responsibilities

Texas State Soil and Water Conservation Board: The TSSWCB will provide supervisory oversight to the project.

Texas Cooperative Extension: responsible for estimating saltcedar acreage, historical water quality and quantity (Subtasks 1.1 and 1.2); educational programming (Task 2), saltcedar water use estimates and fate of salvaged water (Subtasks 3.3 and 3.4)

U.S. Section, IBWC Clean Rivers Program: will identify and characterize inflows (Subtasks 1.4 and aquatic life and habitat Subtask 1.3) Development of QAPP (Subtask 3.1) and oversee water quality monitoring Subtask 3.2

Texas Agricultural Experiment Station: will be responsible for collecting, analyzing and modeling salt flow (Subtasks 1.5, 1.6) saltcedar water use, surface-ground water interactions and responses to saltcedar management (Subtasks 3.3 and 3.4)

Texas Water Resources Institute: Will assist in composing the QAPP (Subtask 3.1) and educational efforts (Task 2). TWRI will also be responsible for compiling/writing quarterly reports and final watershed management plan.

Measures of Success and Performance:
Coordination of a watershed stakeholder committee
Dissemination of educational material developed through the project
Develop a Watershed Protection Plan for the Pecos River Basin

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Appendix A
Matrix of subtasks and respective watershed plan elements.

	a	b	C	d	e	f	g	h	i
1.1	x		x			x	x		
1.2	x	x	x			x	x	x	x
1.3	x					x	x	x	
1.4	x					x	x	x	
1.5	x					x	x	x	
1.6	x	x	x			x	x	x	
1.7				x					
2.1					x				
2.2					x	x	x		
2.3					x				
3.1								x	x
3.2								x	x
3.3		x	x					x	x
4.1	x	x	x	x	x	x	x	x	x
4.2	x	x	x	x	x	x	x	x	x

Appendix B

Federally Listed Endangered (E) and Threatened (T) Species for the Pecos River and Pecos Basin

Bald Eagle (Haliaeetus leucocephalus)– T – occasional migrant and wintering bird along the river and at reservoirs in the basin.

Southwestern Willow Flycatcher (Empidonax traillii extimus) – E – rare to uncommon migrant along the river corridor, few confirmed records.

Pecos Gambusia (Gambusia nobilis, a mosquitofish) – E – occurs in springs and cienegas in the basin (Diamond Y and Balmorhea area).

Comanche Springs pupfish (Cyprinodon elegans) – E – extirpated at Comanche Springs, remnant populations persist in Balmorhea spring complex.

Leon Springs pupfish (Cyprinodon bovinus)– E – only natural population occurs in Diamond Y Draw on TNC preserve.

Rio Grande silvery minnow (Hybognathus amarus) – E – historic occurrence in Pecos in Carlsbad to Toyah reach, extirpated in Texas.

Interior Least Tern (Sterna antillarum)– E – known to nest on islands in Lake Amistad, recorded at Sand Lake in Reeves County, some may use Red Bluff Reservoir.

Black-capped Vireo (Vireo atricapilla) – E- nesting populations known along riparian corridors and arroyo shrublands from Iraan south.

Pecos Sunflower (Helianthus paradoxus) – T – scattered and isolated small populations at Diamond Y Draw and Sandia Spring, other historical sites not recently confirmed.

Little Aguja Pondweed (Potamogeton clystocarpus) – E – known only from Little Aguja Canyon (Davis Mountains) which is a Pecos tributary via Balmorhea drainages.

Compiled by:
John Karges
Conservation Biologist
TNC
1 June 2004

Appendix B
Corrective Action Report

CAR #: ______________________________

Report Initiation Date: ____________________ **Area/Site:** ______________________

Reported by: ___________________________ **Analyte/Activity:** ________________

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

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

Project(s): ____________________ Attached documentation: NA COC FDS SampLink Flow8

Possible Causes and Corrective Actions Taken / Recommended:
____
____
____

CAR routed to: ____ Date: ___________

Supervisor: ____

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

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

For specific incident: Taken To be taken ____
____
____

To prevent recurrences: Taken To be taken ______________________________________
____
____

Effect on data quality: ____

Responsible Supervisor: ___________________________________ Date: ___________

Concurrence: ____

Program/Project Leader: ___________________________________ Date: ___________

TWRI Quality Assurance Officer: ____________________________ Date: ___________

TSSWCB Quality Assurance Officer: __________________________ Date: ___________

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

Appendix C
Data Review Checklist

Field Data Review	**Y**=yes; **N**=no; **N/A**=not applicable
A. QC samples (field splits) collected for all analytes as prescribed in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (2003)?	
B. Field documentation includes the following:	
(1) Identification of individual collecting samples(s)?	
(2) Sample site location?	
(3) Sample collection date and time?	
(4) Site observations (i.e. weather, etc.)?	
(5) Unusual occurrences that may affect sample?	
(6) Sample collection problems?	
Data Format and Structure	
A. Are there any duplicate sample sites?	
B. Are station locations assigned?	
C. Are sampling dates in the correct format, DD/MM/YYYY?	
D. Are samples listed in the correct units?	
E. Is the sampling time entered?	
Data Quality Review	
A. MDLs consistent with those in the QAPP?	
B. Outliers confirmed and documented?	
C. Documentation (verified error log) provided to TSSWCB?	
D. Checks on correctness of analysis or data reasonableness performed?	
E. Have at least 10% of the data in the database been reviewed against the data sheets?	

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

Data Range: ________________________________

Data Source: ________________________________

Project Director Signature:

____________________________________Date:_______________

Appendix D

Chain of Custody Form

CHAIN OF CUSTODY RECORD

Project:	Remarks:
Name and signature of collector:	Air bill #

Station ID	Sample ID	Media Code	Sample Type	Preserv-ation	Collection Date:	Time:	Num containers	Analyses	Remarks	Tag ID:

Relinquished by: (Signature):	Date:	Time:	Received by (Signature):	Date:	Time:	Laboratory Notes:
Relinquished by: (Signature):	Date:	Time:	Received by (Signature):	Date:	Time:	
Relinquished by: (Signature):	Date:	Time:	Received by (Signature):	Date:	Time:	
Relinquished by: (Signature):	Date:	Time:	Received by (Signature):	Date:	Time:	

Project Manager (Signature):