

Implementing the Pecos River WPP through a Heliborne Electromagnetic (EM) Survey Final Report

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Final Report

TSSWCB Project 12-11

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List of Acronyms

BRACS	Brackish Resources Aquifer Characterization System Database
EM	Electromagnetic
EPA	Environmental Protection Agency
GIS	Geographic Information System
HEM	Heliborne Electromagnetic
QAPP	Quality Assurance Project Plan
QPR	Quarterly Progress Report
SWCD	Soil and Water Conservation District
TDS	Total Dissolved Solids
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
WPP	Watershed Protection Plan

Introduction

The Pecos River is among the saltiest rivers in North America with salinity levels regularly exceeding 7,000 ppm at the Texas and New Mexico border and 12,000 ppm near Girvin, Texas. High salinity in the river has adversely affected the stability and biodiversity of the riparian ecosystems, as well as, the economic uses of the river and reservoirs. Irrigated agriculture has suffered and continually faces problems associated with highly saline irrigation water from the river, and has caused those still farming to increasingly use groundwater for irrigation. Human consumption has also been threatened by increasingly saline waters in the Pecos River. Amistad International Reservoir, located on the Rio Grande below its confluence with the Pecos, is a major source of potable water for numerous Texas and Mexico cities and communities. Miyamoto et al. (2005) found that on average, the flow of the Pecos River accounts for approximately 26 percent of the salts entering the reservoir, yet only 9.5 percent of annual inflow. At these levels, it can have a considerable impact on salinity levels in the reservoir. The *2012 Texas Integrated Report* documents a mean total dissolved solids (TDS) level from 85 samples collected over the previous seven years as 561.19 mg/L. While this is not problematic, it is nearing the state's drinking water standard for TDS of 800 mg/L. Salinity issues also extend to shallow groundwater along the Pecos that has deteriorated because of salty river water replenishing depleted water tables, through reversal of normal flow paths.

In general, natural sources of salt throughout the watershed cause the Pecos to be salty. Remnant salt deposits left by the ancient Permian Sea in both New Mexico and Texas are the culprit in this case, and over time, have been exposed by erosion. Nature is not the sole cause of these salts finding their way into the river. Human disturbances have undoubtedly had an impact on the pathways that salt uses to enter the river. Groundwater pumping and oil and gas exploration and production are the primary activities with the greatest chance to impact instream salinity.

Evaluations to identify specific sources of salt loading to the river have only occurred at gross scales in the past; however, the general consensus is that there are four primary reaches of the river that contribute the largest amounts of salt to the river. Three of these reaches lie within New Mexico: Santa Rosa to Puerto de Luna, Acme to Artesia, and Malaga to Pierce Canyon Crossing; the other reach lies in Texas between Coyanosa and Girvin. In all cases, groundwater intrusion to the river is seen as a primary delivery mechanism for these salts reaching the river.

Salinity issues and devising a strategy to address them was a driving factor in the development of *A Watershed Protection Plan for the Pecos River in Texas* (Gregory and Hatler 2008). This document was developed with watershed landowner input and described the current state of knowledge about the watershed, areas where additional

information is needed and also described recommended management measures to restore instream water quality. Salinity management was one area noted to need further investigation to determine specific salt sources before any remedial actions begin. The Coyanosa to Girvin reach of the river was identified in the watershed protection plan (WPP) as the most critical area of the river needing to be addressed. A better understanding of surface-ground water interactions, groundwater flow movement and specific source(s) and exact locations of salt contributions is needed. Evaluations that analyze and identify salinity source contributions are specifically called for in the WPP to provide guidance for future salinity management efforts.

Working together, Texas Water Resources Institute (TWRI), Texas A&M AgriLife Research (AgriLife Research) and Texas A&M AgriLife Extension Service (Extension) personnel developed a project proposal that was funded by the Texas State Soil and Water Conservation Board (TSSWCB) Project 12-11, titled “Implementing the Pecos River Watershed Protection Plan through a Heliborne Electromagnetic (EM) Survey” to address these needs. The project was originally scheduled to run from November 1, 2012 to October 31, 2014. The overall goals of the project are to: 1) identify salinity sources and understand mechanisms of solute transport in the Pecos River and 2) gain a better understanding of hydrological connections between surface water and groundwater as well as inter-aquifer (shallow-deep aquifers) exchange. Project tasks include: (1) project administration, public notification and public engagement; (2) quality assurance; (3) conduct a desktop hydrogeological assessment of surface water and groundwater interactions; and (4) conduct the heliborne EM survey for the selected reaches and EM data analysis.

The measures of success for this project included:

- Completed water resources database and GIS coverage of assessed areas of the watershed, including data, information, and analysis results from the desktop hydrogeological assessment and heliborne EM survey data.
- Completion of preliminary hydrogeological assessment of the study area.
- Completion of heliborne EM survey and its data analysis.
- Delineation and mapping of potential saline intrusion areas as illustrated in EM results.
- Identification of saline intrusion hotspots and areas where ground truthing is needed.

However, the project was terminated eight months early (February 28, 2014) due to reasons explained below. As a result, many of the original project goals, objectives and measures of success were not achieved.

Project Tasks

Task 1: Project Administration, Public Notification and Public Engagement

TWRI administered the project through the development of quarterly reports, hosting coordination meetings, completing financial status reports, hosting the program website, developing the project final report, facilitating the acceptance of bids from companies capable of collecting heliborne electromagnetic (HEM) data, awarding the HEM contract, and ultimately terminating the HEM contract.

Quarterly progress reports (QPRs) were developed in coordination with project collaborators and were submitted to TSSWCB on or before the 15th day following each federal fiscal quarter. These reports are housed on the Pecos River Watershed Protection Plan (WPP) Implementation Program website. Coordination meetings and conference calls were held frequently throughout the course of this project due to its complicated and changing nature. Between meetings, countless phone calls between the TWRI project manager/watershed coordinator and the TSSWCB project manager were held as well. Coordination meetings are documented in project QPRs.

Financially, only a portion of originally allocated project funding was expended due to the project's early termination. Expenditures were primarily related to personnel salaries and benefits, travel costs for project and landowner meetings, survey planning and mailings to landowners. Table 1 illustrates the original budget, project expenditures and the remaining balance.

Table 1: Budget summary for the Implementing the Pecos River WPP through a Heliborne Electromagnetic (EM) Survey project

	Federal Funds	Matching Non-Federal Funds	Total Funds
Original Budget	\$378,320	\$205,819	\$584,139
Project Expenditures	\$92,351	\$77,665	\$170,016
Remaining Balance	\$285,969	\$128,154	\$414,123

In January 2013, a request for bids from companies capable of collecting HEM data was released by TWRI. Bids were received through February 2013, and the contract was awarded in May 2013. SkyTEM was the company that provided the bid with the best value and met data collection requirements.

As a part of the Pecos River WPP Implementation Project (TSSWCB o8-o8), public meetings were held in the watershed June 4–5, 2013, in Pecos, Imperial, Iraan and Ozona. Throughout these public meetings, this project (TSSWCB 12-11) was discussed.

During the meeting in Imperial on June 4, landowners voiced concerns over the planned HEM survey methodology and private property rights. Additionally, the project was discussed with other groups including the three Soil and Water Conservation Districts (SWCDs) in the survey area (Upper Pecos, Sandhills and Trans Pecos) and irrigation districts in the survey area. Efforts continued in this arena in a focused meeting with landowners, SWCD directors, and irrigation district directors from the study area on July 27 in Imperial. During the July 27 meeting, landowners continued to voice concerns about the planned HEM data collection approach and private property rights. The project team discussed ways to move the project forward with the meeting attendees.

As a result of the aforementioned discussions and concerns regarding private property rights, the project team was directed by TSSWCB to ask landowners in the survey area to enroll their property in the planned survey. Upper Pecos SWCD obtained real estate tax rolls from Crane County Appraisal District, Ward County Appraisal District and Pecos County Appraisal District. From these tax rolls, TWRI developed a list of landowners in the area of interest based on their proximity to the river. In total, there were 1,816 individual landowners in the study area. In October 2013, TWRI mailed letters and post cards to each landowner seeking their permission to collect HEM data over their property. Upper Pecos SWCD processed 165 responses and mapped the properties where permission was granted. Permission was received to apply the HEM technology on 16 percent of the study area (Figure 1). This level of permission did not warrant HEM application; therefore, the contract with the selected contractor was terminated. Via a second mailing of postcards by TWRI, landowners were notified that the HEM would not be applied and they were thanked for their cooperation.

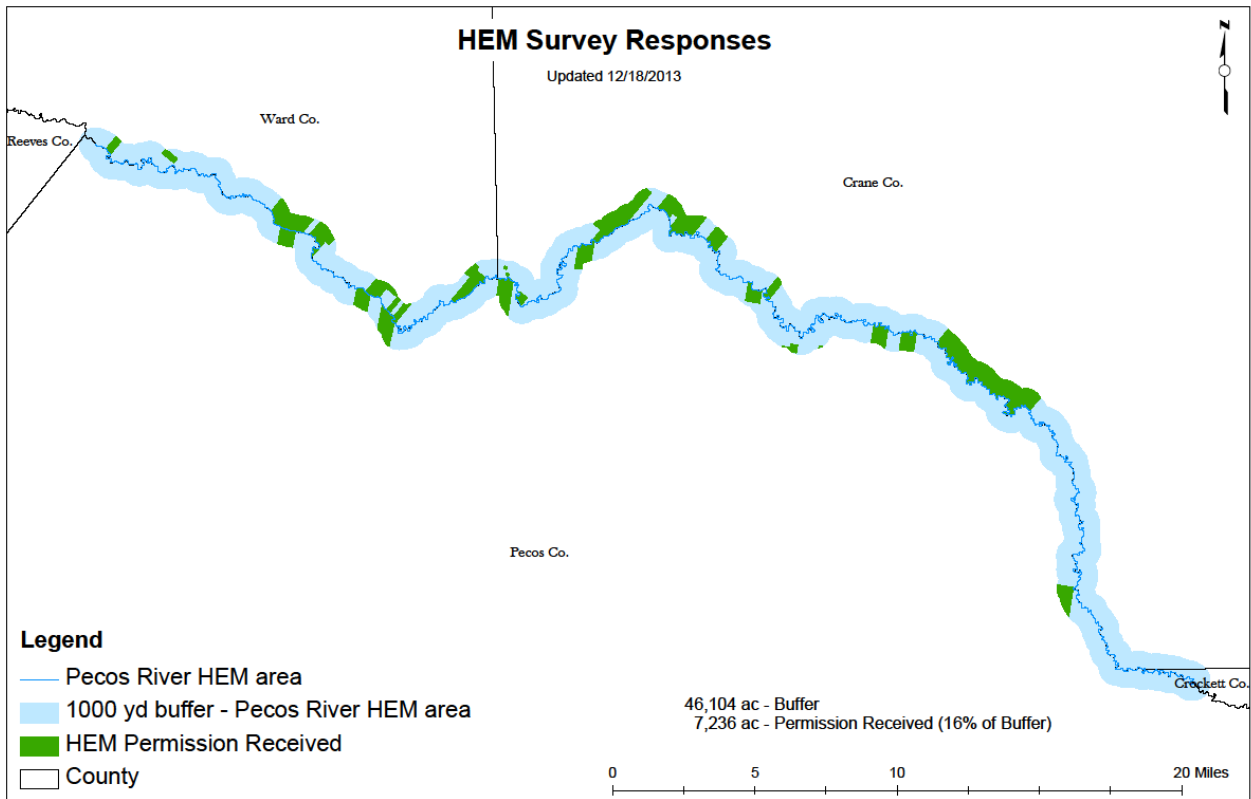


Figure 1: Distribution map showing general location of responses granting HEM survey permission.

Watershed landowners were briefed on the project in the December 2012, July 2013, and March 2014 newsletters distributed through the Pecos WPP Implementation Project. Approximately 1,050 newsletters were distributed with each issue.

With termination of the project prior to application of the HEM technology, the need for coordinating ground control efforts during the survey did not materialize. Thus, this task was never initiated nor completed. All other subtasks under Task 1 were completed.

Task 2: Quality Assurance

TWRI and AgriLife Research worked with SkyTEM to develop and complete a draft version of the Quality Assurance Project Plan (QAPP). This document described the planned approach to collect, analyze and report environmental and geospatial data utilized and created through the project. This draft document was sent to TSSWCB for review in May 2013; however, it was never sent on to EPA for review due to the cancellation of the HEM component of the project.

With termination of the project, Subtask 2.2 was never initiated nor completed. All other subtasks under Task 2 were completed.

Task 3: Conduct a Desktop Hydrogeological Assessment of Surface Water and Groundwater Interactions

In the process of developing the project QAPP, AgriLife Research began compiling existing groundwater monitoring data, which included water level, water quality, borehole lithological data, and borehole geophysical survey data, and relevant GIS layers when available. Upon approval of the project QAPP, these data would have been integrated into a water resources database and GIS coverage that would have ultimately enabled the establishment of a hydrogeological framework for the survey area. AgriLife Research conducted a preliminary review of the hydrogeological data gathered from existing sources to gain a better understanding of the known temporal and spatial variations of groundwater quality and to identify data gaps in existing data sets. This data review was also used to inform HEM data collection planning decisions and QAPP development.

Data Sources

Two extensive sources of data were obtained during this preliminary assessment:

- 1) Texas Water Development Board (TWDB, 2012) GIS Groundwater database (<https://www.twdb.state.tx.us/mapping/gisdata.asp>) for delineation of aquifer boundaries within the study area (Figure 1), and
- 2) TWDB Brackish Resources Aquifer Characterization System Database (BRACS) (Meyer et. al. 2011, Meyer 2012) for wells and water quality data (<https://www.twdb.state.tx.us/innovativewater/bracs/database.asp>).

A total of 507 wells in the Pecos Valley Aquifer within the study area (Figure 2) from the TWDB (BRACS) database were selected for inclusion in the initial data set based on availability and completeness of the observed water quality data within the Pecos Valley aquifer; however, after reviewing the data, it was discovered that available data were inconsistent across wells and over time. As a result, a subset of wells and data available were selected for use in the hydrogeological assessment. The years selected for the initial assessment were 2000, 2002, 2004 and 2007. The available water quality data at each of the selected years varies. For example, records were available for nine wells for the year 2000, 23 for 2002, four for 2004 and 19 for 2007, respectively (Figure 2).

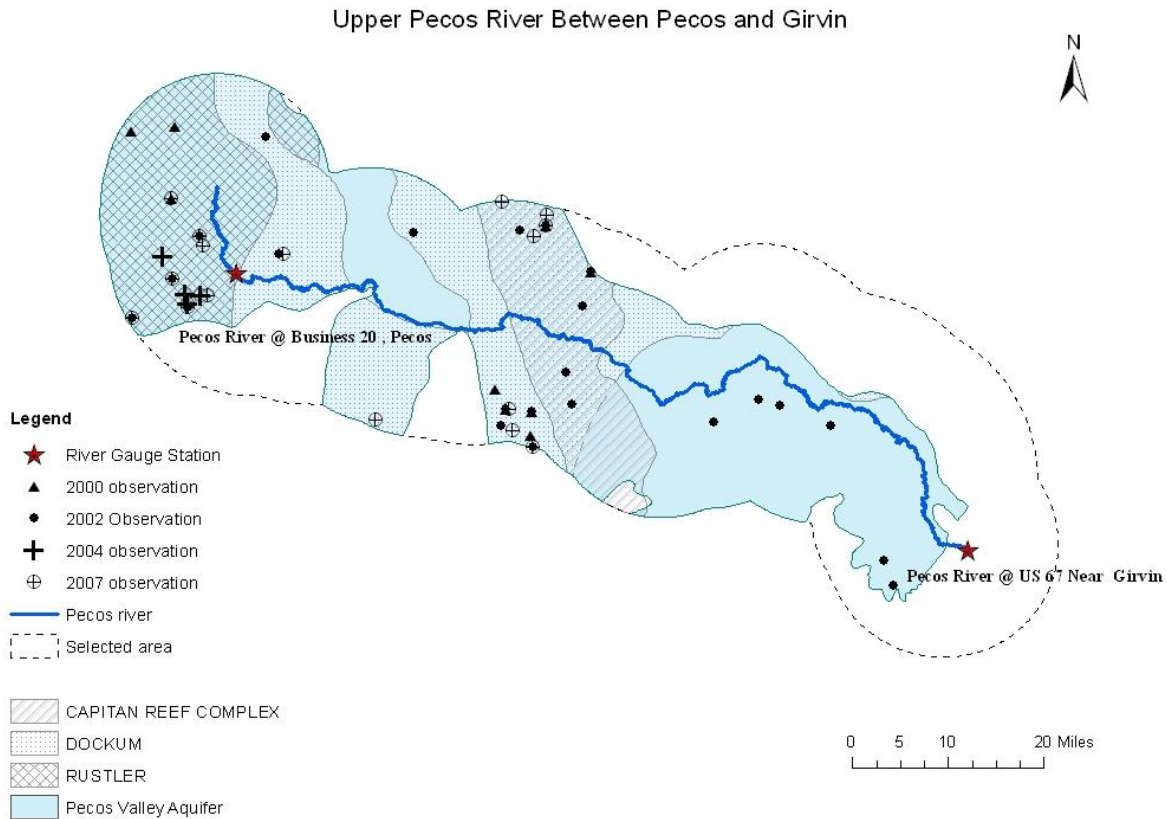


Figure 2: Study area and selected wells for the hydrological assessment.

Methodology and Review Criteria

A preliminary data review was conducted to develop a current knowledge baseline in the Pecos Valley aquifer and to further review the known temporal and spatial variations of salinity as well as the exchange of water between surface and groundwater and between aquifer layers. Water quality data gathered for the years 2000, 2002, 2004 and 2007 were plotted over time to illustrate obvious changes in water quality over time. The BRACS database was queried to extract water quality constituents and well locations from the selected years within the Pecos Valley aquifer. These data were linked to the TWDB GIS and BRACS GIS data, which generated a spatial distribution of water quality.

Only wells with observation data located in the Pecos valley aquifer and within ten miles of the river in the study area (Coyanosa to Girvin) were selected. Spatial and temporal distribution of water quality constituents such as total dissolved solids (TDS), specific conductance, sodium, chloride and sulfate were noted to gain a better understanding of the distribution of the fresh and saline waters within the study area. Data interpolations

illustrated approximated salinity levels between well locations within the study area. Comparing these maps over time enabled a better understanding of the spatial distribution of salinity for each selected year. Descriptive statistics such as minimum, maximum and mean values were computed for each year for the whole area to plot a time series of the existing data. The preliminary review showed high TDS in the northwest and southeast parts of the study area and lower TDS, or fresher water, in the middle portion of the area (Figure 3).

Limitations of Data and Recommendations

Numbers of the observation points for the selected years are different from each other, which creates a discrepancy in comparing the spatial distribution between different years. For example in the year 2002, there are two extra observation points in the southeast part that are not available for the remaining years selected. Most observed points are located in the northwest part of the study area, which could yield inaccuracies in the future interpolation of values for the entire study area. This data review confirmed the need for more observational data, especially in the middle and southeast parts of the study area. As planned, this data would have been combined with the HEM survey to the source of water salinity and interactions between waters with different qualities.

Additional analyses of water quality data are required to understand the patterns of salinity changes over time. Water chemistry data in the Captain Reef Complex, Rustler and Dockum aquifers will also be evaluated to understand exchange of water among aquifers.

With termination of the project, Subtasks 3.4 and 3.5 were never initiated nor completed. Subtask 3.1 was completed and subtasks 3.2 and 3.3 were initiated with a cursory review.

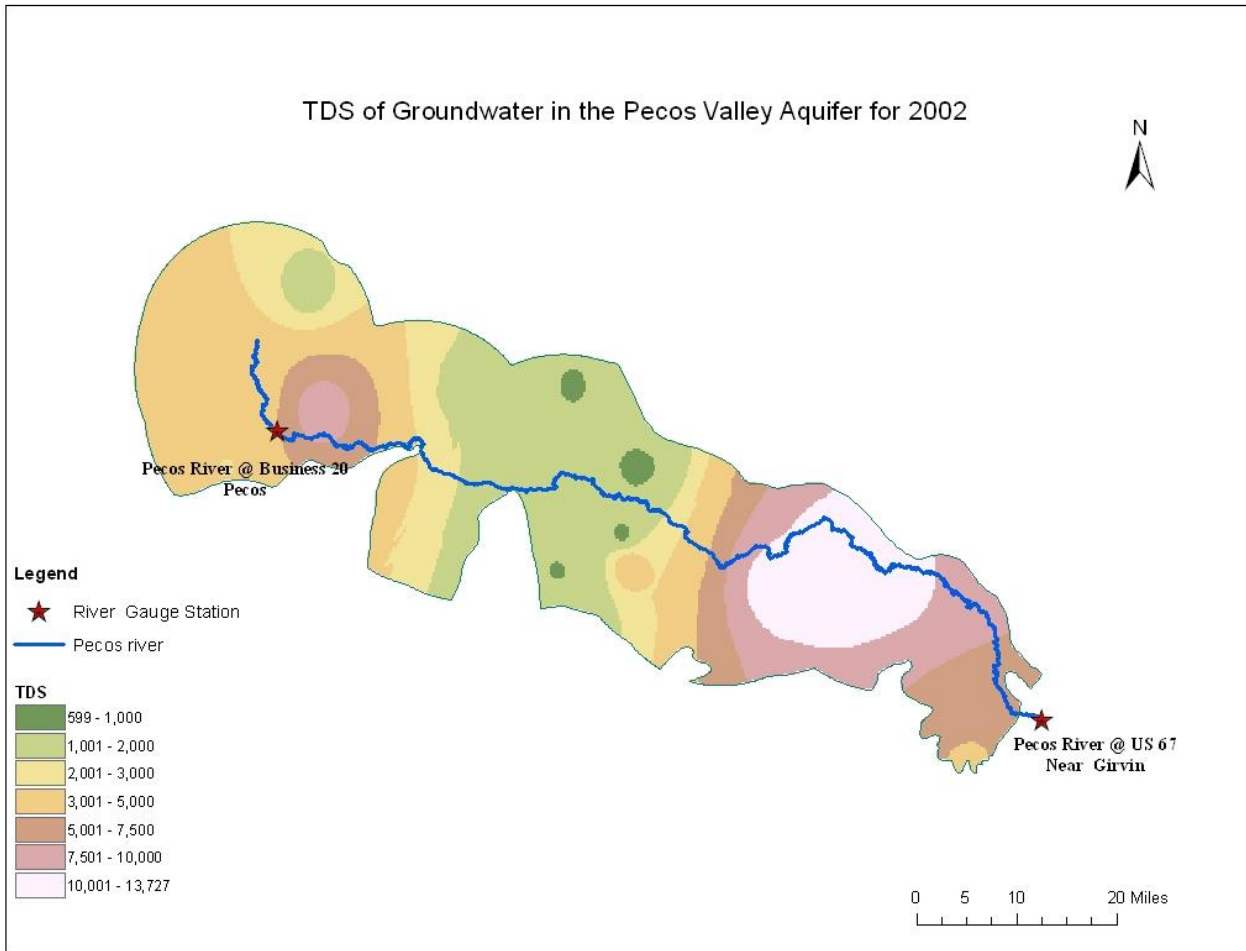


Figure 3: Distribution of TDS of the groundwater in the Pecos Valley Aquifer.

Task 4: Conduct the Heliborne EM Survey for the Selected Reaches and EM Data Analysis

Due to landowner concerns regarding private property rights, the project team was directed by TSSWCB to ask landowners in the survey area to enroll their property in the planned survey. Post cards were sent to landowners of record for properties in the study area seeking their permission to conduct the survey over their property. The response rate was very low and permission to conduct the study was only received for roughly 16 percent of the study area (Figure 1). As such, the application of the HEM technology in this project was not justified. Landowners were subsequently notified that the HEM technology would not be deployed in the study area. The contract for HEM work was terminated.

No work was completed for this task.

Conclusions

Identifying the source of salts in the Pecos River in Texas remains an important need in the long-term efforts to improve the river's health. This project was designed to address this need; however, the inability to maintain positive support for the project and to later gain express written permission from landowners to map the water resources that they owned prevented this project from being completed. Despite an extensive effort to contact property owners, permission was received to conduct the project on only 16 percent of the study area, thus leaving the project unfeasible.

The initial screening of available groundwater quality data illustrates the current state of knowledge regarding the area's aquifers, but are insufficient for planning effective salinity management. Further evaluations are needed to allow future planning and landowners in the watershed continue to support efforts to improve the river's quality. However, this approach was not palatable to some and received significant resistance during the public involvement process.

A preliminary assessment of previously existing data did illustrate the current state of knowledge regarding salinity sources and hydrological connections between those sources and the river. Without application of the HEM technology, no data were produced through this project, thus the understanding of salt sources and the river's hydrology were not improved.

Given the difficulties faced throughout this project, alternative strategies to identify salinity intrusion points should be considered. A potentially feasible alternative discussed is to tow a high-sensitivity, GPS linked, fiber-optic temperature sensor downstream to identify subtle changes in water temperature. Temperature changes instream are analogous to new sources of water entering the stream. Pairing this approach with in situ water quality monitoring can quickly identify problematic intrusion points along the river. Additionally, this approach avoids landowner permission issues as the State of Texas owns rivers, which are thus publicly accessible at road crossings. A deficiency of this approach is that it does not provide information regarding the flow paths of water moving to the river as the HEM survey would. However, it can identify salt intrusion points where further land-based investigations are needed. If those areas are near where permission to conduct the HEM study was granted, obtaining permission to conduct needed land-based investigations may be feasible.

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