Monthly Letter Progress Report # 4:
July 9, 2016-August 5, 2016
Study of Brackish Aquifers in Texas – Project No. 4 – Trinity Aquifer
TWDB Contract No. 1600011950

1.0 Budget and Expenses

This report summarizes the project costs for the billing period from Contract Approval Date (January 6, 2016) through the end of Period 11 of Fiscal Year 2016 (August 5, 2016). The total expenses through this period are $37,452.86. A breakdown of the budget by task is provided in Table 1. A copy of the progress report has been sent to Texas Water Development Board (TWDB) contracts department along with the monthly invoice.

2.0 Progress on Tasks

This report summarizes activities on project tasks during Fiscal Year 2016, Period 11 (encompassing July 9, 2016 - August 5, 2016) and represents the fourth progress report on this contract.

Task 1: Project Management

During the reporting period, progress was made on setting up the subcontracts with the two subcontractors, INTERA and the Bureau of Economic Geology (BEG), as well as on the agreements with the two in-kind teaming partners, Edwards Aquifer Authority (EAA) and Barton Springs Edwards Aquifer Conservation District (BSEACD). Based on discussions with our teaming partner INTERA, the Northern Trinity and the Hill Country Trinity Aquifer regions will be divided for the majority of this project (Figures 1 and 2). SwRI will be responsible for the Hill Country region and the area between the Hill Country and Northern Trinity Groundwater Availability Models (GAM)s. INTERA will be responsible for the Northern Trinity. At the end of the project both regions will be combined into one deliverable.

Task 2: Data Acquisition and Method Development

Task 2 has been subdivided into 4 subtasks. Progress on the subtasks is as follows:

Subtask 2.1 Acquisition and Initial Analysis of Groundwater Samples

Spatial queries on the Brackish Resources Aquifer Characterization System (BRACS)/TWDB databases continued during this period. The SwRI team has begun evaluating other sources of information, including groundwater conservation districts, oil and gas databases, and water supply wells. The team began work on the project database of water quality data within a data acquisition domain that we defined (Figure 1). The primary focus has been on collection and processing of the most recent TWDB data. The down-dip extent for the project domain is under

evaluation. Progress on this evaluation is detailed in the following sub-section (Subtask 2.2). This evaluation will be ongoing for most of the project.

Subtask 2.2 Acquisition and Initial Analysis of Geophysical Logs

Wells from the TWDB Brackish Resources Aquifers Characterization System (BRACS) database were evaluated against the data acquisition domain (Figure 1). Wells were selected using a structure contour surface of the (i) upper Glen Rose and (ii) lower Glen Rose. These surfaces were extracted from the Fratesi et al. (2015) geologic framework model. The elevations from this surface are consistent with the elevations of the Upper Trinity structure contour surface from the Hill Country GAM. Total well depth for each well was used to constrain logs that fell within the depths of these two surfaces. A well log matrix was created to categorize well logs based on digital quality and information useful for this analysis. The matrix will help to fully evaluate each well and any subsequent data that we acquire.

Geophysical logs acquired from TWDB were evaluated for quality and coverage. Wells that lie within our data acquisition domain in Figure 1 have been identified. Based on review of the well locations and geophysical log availability, there are 235 wells and 426 associated logs (148 gamma ray logs, 137 resistivity logs, and 141 spontaneous potential logs) available for digitization. All available gamma ray logs will be digitized immediately by Well Green Tech Inc. with the remaining logs processed after receipt of the gamma ray data. Digitization is expected to take approximately 7-10 days from submission date. Additional log digitization will be done on an as-needed basis to fill in gaps in data coverage.

The development of a database with spatial attributes of all available logs (e.g., BRACS, Information Handling Services Markit (IHS Markit) , BEG) continued during this period with care to adhere to BRACS format. Other sources of information including Groundwater Conservation Districts, Oil and Gas databases, water supply wells, Texas Commission on Environmental Quality (TCEQ) Public Supply, United States Geological Survey (USGS) Produced Water databases, and literature are being evaluated.

Subtask 2.3 Develop Technical Approach for Estimating Total Dissolved Solids from Geophysical Logs

Preliminary work on this task has been initiated. Given its technical complexity, work on this task will continue for most of the duration of the project.

Subtask 2.4 Use Geophysical Log Interpretation to Analyze Stratigraphy and Map Fresh, Brackish, and Saline Groundwater

Wells from the BRACS database with good quality logs (e.g., gamma ray, spontaneous potential, and/or resistivity) will be sent to be digitized in period 12. Gamma ray logs will be utilized for stratigraphic analysis, and resistivity and spontaneous potential (SP) logs will be utilized for salinity analysis.

Task 3: Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes

Task 3 is subdivided into two subtasks: (i) subtask 3.1 is to extend stratigraphy for the Hill Country Trinity Aquifer, and (ii) subtask 3.2 is to determine volumes of fresh, brackish, and saline groundwater. For this project, a firm understanding of the regional stratigraphy, coupled with a good sense of the characteristic signature of each stratigraphic unit in terms of subsurface wireline logging and formational water chemistry data, is required. This information will allow for a more robust interpretation of the well log information. To expedite this task, key wells throughout the study area will be identified. A key well is a well that is tightly constrained in terms of identification, position information, well geometry, pick information in measured depth, wireline log data tied to interval picks in measured depth, and formation water chemistry.

Ideally, a key well for each depositional domain and structural position within the study area would be available. This would allow calibration of each well log interpretation against a geologically reasonable data set including depositional environment and structural domain changes across the study area. Below is a list of desired information for each key well (if available).

Key Well requirements:

- Identification – To be able to consistently track key wells across multiple databases. The following fields for each key well are desirable; well name, well ID, UWI, API, and well type.
- Position – To properly place key wells in space and to confidently determine the datum from which all measurements were taken, reliable XY location and land surface datum for each well are needed.
- Well geometry – To construct the correct well trajectory in three dimensions, total vertical depth of each well and the deviation survey for each well are required.
- Pick information – To be able to utilize the key well for regional log interpretation, stratigraphic horizon tops, fault tops, and any layer dip information are required.
- Log data – To be able to interpret key data, existing log data (i.e., gamma ray, spontaneous potential, resistivity, sonic, and density logs) relative to formation boundaries are desirable.
- Water chemistry – A key well for water chemistry would have the following characteristics:
    - A record of the depth of the screened or open-hole interval so that the source of water in the well can be linked to a particular horizon.
    - Results of analyses of at least one water chemistry sample. The results must include measured specific conductivity, total dissolved solids (TDS), all major ions, pH, or all of these. The most useful data will be from analyses conducted after 1970.

Once we have sufficiently defined key well attributes, the project team and other contacts will be queried to ascertain whether and where key wells exist. We plan to send this list to a wide range of contacts with the hope that key wells can be identified and that we can use this information to assist with data evaluation and interpretation. Progress on the subtasks is as follows:

Subtask 3.1 Extend Stratigraphy for the Hill Country Trinity

The data acquisition domain for this project has been defined (Figure 1). Information on stratigraphy will be collected and evaluated based on the extent of this domain. The literature search and assessment of relevant literature continues. Literature is being assessed for useful stratigraphic and structural information (e.g., cross-sections, fence diagrams, structure contour maps, well header information, stratigraphic horizon picks from wells, and fault maps). In addition, a number of the well logs from the BRACS well database have stratigraphic information including stratigraphic horizon picks and lithologic information. This information is being evaluated to determine whether it is useful and credible. Log information from the IHS Markit database will be evaluated once we have access to the database.

Subtask 3.2 Determine Volumes of Fresh, Brackish, and Saline Groundwater

Progress on this subtask is contingent on completion of the previous subtasks.

Task 4: Delineate Potential Production Areas

Progress on this subtask is contingent on completion of the previous subtasks.

Task 5: Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water

Progress on this subtask is contingent on completion of the previous subtasks.

Task 6: Stakeholder Communication

Progress on this subtask is contingent on completion of the previous subtasks.

Task 7: Reporting

Task 7 has been subdivided into 2 subtasks. Progress on the subtasks is as follows:

Subtask 7.1 Project Monitoring Procedures

The project timeline has been reviewed periodically and frequently. The project budget has been monitored on a weekly basis using the SwRI Project Cost System. Project activity is summarized in status reports for review by TWDB.

Subtask 7.2 Project Deliverables

Progress on this task to during this reporting period has included preparing and delivering "Monthly Letter Progress Report #3: Period 10, Fiscal Year 2016."

3.0 Planned Activities for the Next Reporting Period (Fiscal Year 2016, Period 12)

Task 1: Project Management

Subcontracts with the two subcontractors, INTERA and BEG, as well as on the agreements with the two in-kind teaming partners, EAA and BSEACD, will be finalized in the next reporting period.

Anticipating the finalization of the subcontract with INTERA before the end of Period 12, projected progress by INTERA during the next subperiod is included below.

Task 2: Data Acquisition and Method Development

Task 2 has been subdivided into four subtasks. Planned activities for the subtasks are as follows:

Subtask 2.1 Acquisition and Initial Analysis of Groundwater Samples

Data on water quality from within the data acquisition domain will continue to be gathered during the next reporting period. The extent of the data acquisition domain is illustrated in Figure 1. This evaluation will be ongoing for most of the project.

Spatial queries will continue on BRACS/TWDB databases. Analysis and results of the groundwater data will continue. Collection of data on water quality will continue, as will evaluation of other sources of information, such as groundwater conservation districts, oil and gas databases, and water supply wells.

INTERA plans to initiate an inventory of water wells with water quality measurements in the Northern Trinity study area. INTERA will start assessing screen completions in terms of aquifer units.

Subtask 2.2 Acquisition and Initial Analysis of Geophysical Logs

Digitized logs provided by the vendor will be interpreted to support development of an interpretation approach. Development of a database with spatial attributes of all available logs (e.g., BRACS, IHS, BEG), with care to adhere to BRACS format, will continue. Other sources of relevant information including literature, Groundwater Conservation Districts, Oil and Gas databases, water supply wells TCEQ Public Supply, and USGS Produced Water databases will continue to be gathered and evaluated. A project database of water quality data relevant to project domain and preliminary hydrochemical facies analysis for project domain will continue to be developed using TWDB's groundwater database. A license for the Gulf Coast IHS database will be acquired. Key well information will be gathered as provided by our contacts.

INTERA plans to inventory existing geophysical logs in the Northern Trinity footprint from the Northern Trinity GAM development, determine which logs have sand/limestone/shale picks (from Scott Hamlin at the BEG), and determine which logs have been digitized to LAS files. INTERA will also inventory available geophysical logs (e.g., short/long resistivity, spontaneous

potential). Additionally, they will initiate determination of whether proximity of existing logs is sufficient for water well/geophysical log pairings.

Subtask 2.3 Develop Technical Approach for Estimating Total Dissolved Solids from Geophysical Logs

Efforts towards developing a method for correlating Total Dissolved Solids (TDS) data and geophysical log attributes will be initiated. Interpretation of logs for stratigraphy will begin as well as estimation of TDS/Salinity from logs.

Subtask 2.4 Use Geophysical Log Interpretation to Analyze Stratigraphy and Map Fresh, Brackish, and Saline Groundwater

Digitized well logs will be evaluated and the development of our interpretation approach will begin. Progress on this subtask is expected to continue during the next several reporting periods.

Task 3: Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes

Task 3 has been subdivided into two subtasks. Planned activities for the subtasks are as follows:

Subtask 3.1 Extend Stratigraphy for the Hill Country Trinity

Progress on this task will continue in the next reporting period with the assessment of relevant data.

Subtask 3.2 Determine Volumes of Fresh, Brackish, and Saline Groundwater

Evaluation of the relationship between electrical resistivity and fluid salinity will continue during the next period. It is recognized that articulating this relationship will be challenging due to the confounding influences of electrically conductive clay zones, but this work will be central to delineating the extent of brackish water in the Trinity Aquifer because geophysical logs will be the primary source of information used in this subtask.

Task 4: Delineate Potential Production Areas

No work is expected to occur in the next reporting period.

Task 5: Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water

No work is expected to occur in the next reporting period.

Task 6: Stakeholder Communication

No work is expected to occur in the next reporting period.

Task 7: Reporting

Task 7 has been subdivided into 2 subtasks. Planned activities for the subtasks are as follows:

Subtask 7.1 Project Monitoring Procedures

The project timeline will continue to be reviewed periodically and frequently. The project budget will continue to be monitored on a weekly basis using the SwRI Project Cost System. Project activity will continue to be summarized in status reports for review by TWDB.

Subtask 7.2 Project Deliverables

The fifth progress report will be submitted to TWDB during Fiscal Year 2016, Period 13.

Table 1. Project Budget Versus Expenses

Task	Description	Budget (from Project Cost System)	Invoices			Remaining Budget
			Current	Previous	Total	
1	Project Management	$22,640.00	-$1,617.36[1]	$10,411.59	$16,266.72	$6,373.28
2	Data Acquisition and Method Development	$134,555.00	$8,559.99	$7,688.33	$19,377.19	$115,177.81
3	Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes	$116,878.00	$0.00	$0.00	$0.00	$116,878.00
4	Delineate Potential Production Areas	$40,001.00	$0.00	$0.00	$0.00	$40,001.00
5	Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water	$56,740.00	$0.00	$0.00	$0.00	$56,740.00
6	Stakeholder Communication	$35,631.00	$0.00	$0.00	$0.00	$35,631.00
7	Reporting	$13,555.00	$1,808.95	$0.00	$1,808.95	$11,746.05
Total		$420,000.00	$8,751.58	$18,099.92	$37,452.86	$382,547.14

[1] During period 11, a new charge code was added to the project for Task 7 (Reporting). Work for this task had previously been charged to Task 1. Hours that should have been charged to the now-present Task 7 charge code were transferred from Task 1 to Task 7, resulting in a negative amount spent for Task 1 in this period.

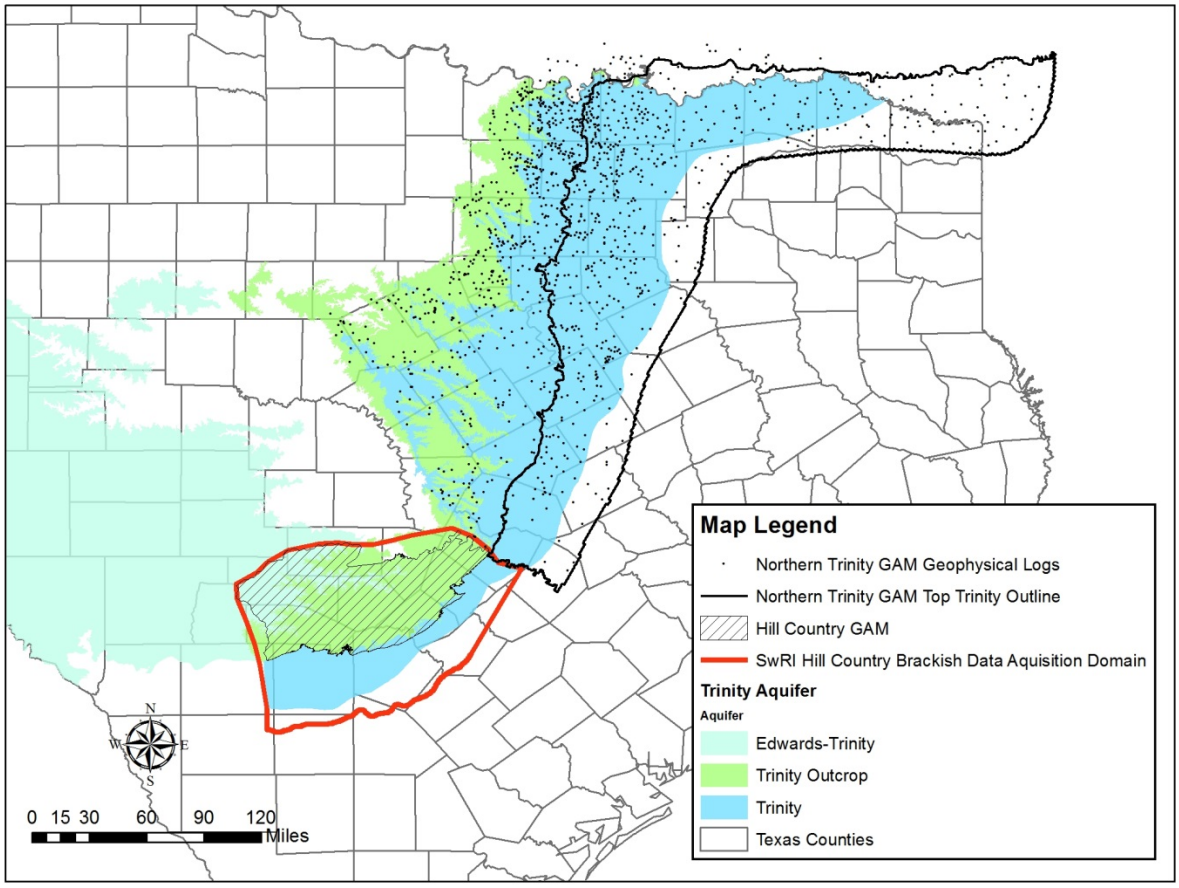

Figure 1. SwRI data acquisition domain for Hill Country GAM. This domain provides a consistent constraint for the selection and evaluation of available data within a domain that is comprehensive of the Hill Country GAM domain and coincident with the Northern Trinity GAM.