Proposal Application Form
2022–2023 TWRI Graduate Student Research Programs

Basic Information

1. **Title of proposal:** Groundwater salinity forecast of the Simsboro Aquifer in Brazos County, Texas, U.S. using a numerical model for groundwater flow and transport.

2. **Student name, contact information (email and phone number), university, department, degree being pursued as well as degree starting year and expected year of graduation:**

   Laura Rodriguez Lozada (Doctoral student)

   Email: lmrodriguezlo@tamu.edu Phone: (832) 208-6844

   Starting year/ Expected year of graduation: (Spring 2019 / Summer 2023)

   Department: Water Management and Hydrological Science, Texas A&M University, College Station, TX 77843

3. **Faculty advisor or committee chair name, title, contact information (email and phone number), university and department:**

   Dr. Hongbin Zhan, professor of Geology & Geophysics, Water Management & Hydrological Science, and Energy Institute.

   Email: zham@geos.tamu.edu Phone: (979) 862-7961

   Texas A&M University, College of Geosciences, Department of Geology and Geophysics.

4. **Which program(s) are you applying for (only select one option)? In addition, please also indicate, if applicable, if you are not eligible for Mills due to eligibility restrictions.**

   __ Mills Scholarship Program (Texas A&M, Galveston or Qatar only; tuition only)

   _**X**_ USGS Research Program (any Texas university; categorical funds and/or tuition)

   ___ Either program will fit my needs and eligibility

5. **Have you received either the Mills Scholarship or USGS Research Program funds before?**

   No.

6. **Would these funds be initiating new research or supporting ongoing research? If ongoing, please briefly explain where you are at in the research and project timeline, funding source, funding amount (please differentiate between federal and nonfederal), and project start and end dates.**

   These funds will be used to supplement my current research on forecasting salinity increase rates at the Simsboro aquifer using numerical models to simulate groundwater flow and contaminant transport. I am currently working on setting the boundary conditions for the numerical model and collecting well information from public websites to include them in the numerical model. Scholarship through this proposal would allow me to continue my research as described in this proposal. This project has not been funded. This project started on 5/1/2021 and it is scheduled to end on 5/1/2023.

7. **Focus Categories**. **Choose a maximum of three focus categories from the list provided (Attachment A) with the most preferred focus category first.**

   GROUNDWATER, WATER QUALITY, MODELS. (GW, WQL, MOD)

8. **Research Category**.

   Water Quality

9. **Keywords. Enter keywords of your choice that are descriptive of the proposed work.**

   Groundwater, salinity, water quality, management.

10. **Congressional District of the university where the work is to be conducted.**

    Texas's 17th congressional district.

11. **Abstract**. Please provide 200 words or less about your proposed research problem, methods, and objectives, and describe how your research will address the research priorities.

The cities of College Station and Bryan (Texas) rely on the Simsboro aquifer for their water needs. The Simsboro aquifer is believed to be a long-term source of sustainable potable water, but the water levels in the aquifer are decreasing while the salinity increases due to overpumping, which drives salinity plumes from the Millican salt dome towards the pumping wells. The purpose of this project is to develop a two-dimensional (2D) numerical model of groundwater flow and transport to forecast the rate of increase in salinity (TDS) in the Simsboro aquifer, with incremental changes in pumping rates (projected steady demand, moderate water demand, and extreme water demand) over the next 50 years. Additionally, cross-formational flows from aquifer units overlying and underlying the Simsboro aquifer with contrasting salinity levels will be included in the model to assess their relative contribution of these to the changes in TDS in the Simsboro aquifer.

12. **Description of your research proposed research**, emphasizing how it will address water resources-related concerns (particularly how, if possible, it will benefit Texas), including:

    a. ***Statement of critical regional or state water problem.***

Bryan and College Station acquire most of their groundwater from the Simsboro Aquifer, which is usually described as part of the Carrizo-Wilcox aquifer in Central Texas (Thorkildsen and Price 1991, Dutton, Harden et al. 2003). The Carrizo-Wilcox aquifer wells usually yield 2725 m^3/d. The largest yields can be obtained from the Simsboro and Carrizo aquifers in central Texas (Thorkildsen and Price 1991, Ashworth and Hopkins 1995). The Simsboro aquifer is believed to have high future potential. The strategic supply volume of the Simsboro aquifer will double from 2020 to 2050, according to the 2017 recommended water management strategies of the State Water Plan (Bruun, Jackson et al. 2016).

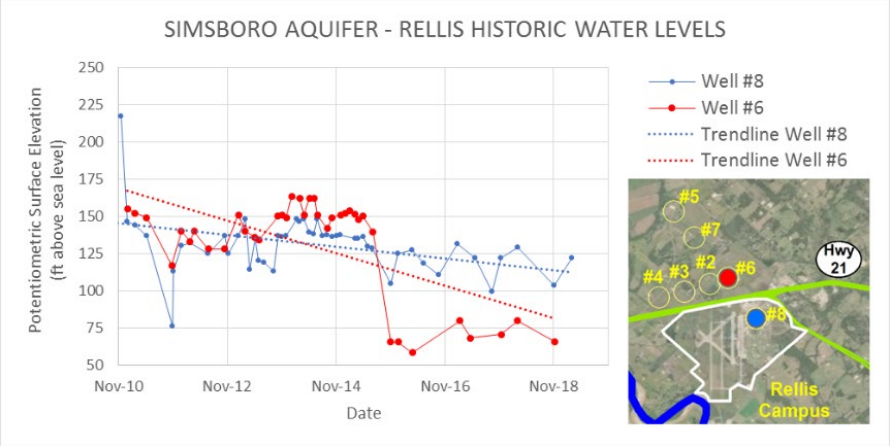

Figure 1. Potentiometric surface evolution for the Simsboro Aquifer. Wells #6 and #8 are pumping from the Simsboro Aquifer, while the remaining wells are pumping from overlying aquifers.

According to linear regressions the potentiometric surface evolution between 2000 and 2019 on the west College Station-Bryan area, the aquifer has suffered a local drawdown of almost 30 m in the last 18 years (Figure 1). This aquifer depletion is the consequence of the increase in the pumping rates over time, due to the substitution of old wells pumping groundwater from the Sparta aquifer to deeper wells pumping from the Simsboro aquifer at greater yields.

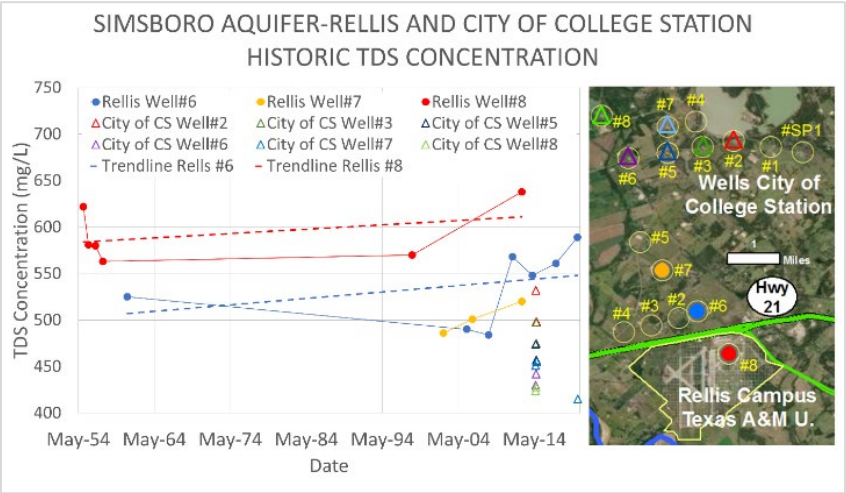

Figure 2. TDS evolution for the Simsboro Aquifer. The wells with circle marks are property of TAMU, and the triangles are property of the City of College Station. Long water quality time series data are available only for wells #6 and #8 property of TAMU.

The water quality time series analysis shows the Simsboro aquifer water TDS change in the College Station-Bryan area, including information for three wells of the TAMU property and seven wells from the City of College Station, north of RELLIS Campus (Figure 2). From the observation data, water quality in the Simsboro aquifer can be described as fresh and ideal for public use. There are not enough data points to predict the water quality of the City of College Station wells. However, the linear regression (Figure 2) indicates that the TDS values of RELLIS wells slightly increased from 1954 to 2020. This TDS forecast study will assist the institutions in developing management plans on groundwater quality and water supply in the area for the next 50 years.

The time series presented on figures 1 and 2 are a straightforward way to examine the past and actual status of the potentiometric surface and the TDS values. However, the time series analysis approach is very local, and does not represent the status of the aquifer at a regional level. Therefore, it is necessary to use a spatiotemporal approach combined with a numerical model for groundwater flow and contaminant transport.

b. ***Statement of expected results or benefits.***

According to our observations, we expect that the salinity will not increase if the pumping is the same, however, this result is based on a simple linear projection from sampled water quality sites (Figure 2). We expect to see either a slight increase or a steady TDS concentration in the College Station-Bryan area under a scenario where we set a 2D numerical model simulating the same pumping rates for the next 50 years. If we assume the increase on pumping rates over the Brazos County for the two-dimensional numerical model, the TDS concentrations will likely increase in the next 50 years, but the rate at which the TDS increase in the aquifer will occur is still uncertain.

Since the College Station - Bryan area is in the confined zone of the Simsboro aquifer, the recharge from precipitation would not impact the salinity content. However, the salinity reduction may be significant in the recharge areas where the aquifer is unconfined, and it is in contact with recharge from precipitation. This area will be located north of Hearne.

Additionally, the numerical model will allow us to determine if the cross formational flow plays a relevant role in the TDS increases, or if it entirely depends on salt domes dissolution occurring in south College Station. Recharge from cross-formational flow might impact the water quality in the College Station-Bryan area, however, it would be necessary to evaluate the volumetric exchange fluxes and TDS values from under and overlying aquifers to determine if the impact is significant. This numerical model, as well as the TDS forecast will assist public and private institutions in the Brazos County area to develop sustainable management plans for groundwater availability and groundwater quality security for the next 50 years.

c. ***Nature, scope, and objectives of the research, including a timeline of activities.***

The communities in Brazos County have experienced significant population growth over the last 25 years that also impact neighboring communities and counties. Over the next 20 years, the twin cities of Bryan and College Station will be the growth centers of Brazos County, with a population increase from an estimated 227,000 today to over 340,000 by 2040. Providing water to an extra 100,000 residents will be a challenging task.

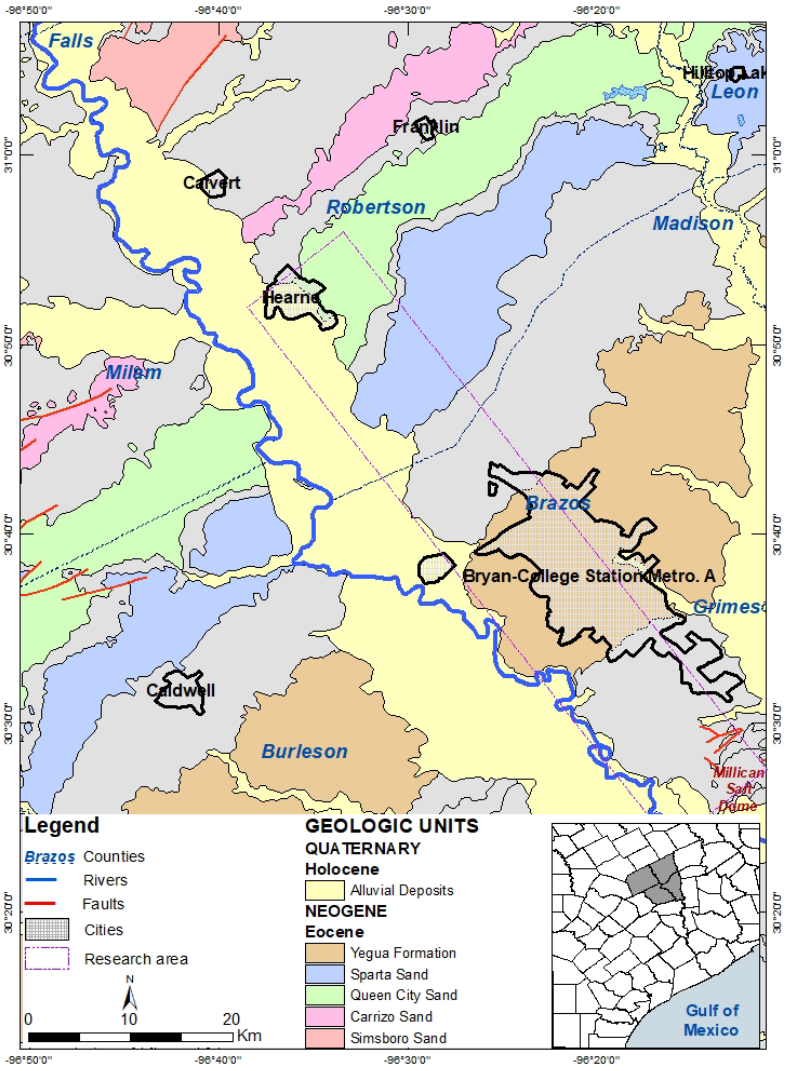

Figure 3. Geologic Map of Brazos, Burleson, Milam, and Robertson Counties, Central Texas.

Groundwater is the major water source supply for the Texas A&M University (TAMU), cities, farmers, ranchers, and residents of the Brazos, Burleson, and Robertson tri-county region. They rely on the Carrizo-Wilcox Aquifer and other minor aquifers to provide water for their domestic, municipal, commercial, industrial, agricultural, and livestock needs. There are four significant aquifers in the Brazos Valley region that produce water: Sparta Sands, Yegua-Jackson Aquifer, Carrizo Sands, and the Simsboro Sands from the Carrizo-Wilcox Aquifer, while the Simsboro is the most productive aquifer in the region. In addition to these four aquifers, the Brazos River Alluvium (BRA) Aquifer is a separate formation that provides irrigation water for farms near the river. Geologically, these aquifers consist of sandy fluvial and deltaic sediments, while marine silts and clays act as aquitards separating the water-yielding zones (Figure 3).

Groundwater in the Simsboro aquifer is naturally fresh, but its TDS content increases with depth. The Sparta and Carrizo aquifers provide smaller amounts of water to the twin cities. TAMU uses the Yegua-Jackson Aquifer to provide irrigation water for the golf course and assist fire suppression at the Brayton Fire Training Field in west College Station. It also produces some freshwater for the Wellborn District, south of College Station.

The objective of this research is to develop a two-dimensional (2D) numerical model of groundwater flow and transport across the Brazos County (Figure 3) and simulate over the next 50 years three different pumping scenarios (projected steady demand, moderate water demand, and extreme water demand) to forecast the TDS values under different stress conditions. Additionally, we will include in the model the cross-formational flows from aquifer units overlying and

underlying the Simsboro aquifer with different salinity levels to assess their relative contribution of these to the changes in TDS in the Simsboro aquifer.

Tasks	Summer 2022	Fall 2022	Spring 2023
Develop GMS model for the Simsboro Aquifer	X		
Calibrate and validate the GMS model		X	
Develop forecasting scenarios with BVGCD estimates		X	
Analyze forecasting scenarios.			X
Preparation of manuscript for publication			X

d. **Methods, procedures, and facilities.**

To develop a groundwater flow and transport model, useful to forecast conditions until 2050, it is necessary to collect information from observation wells, pumping rates, historical water quality tests, and information of water development plans for the College Station-Bryan and Brazos County areas. We will simulate the interval ranging from 2002 to 2020 since it is the range for which the official institutions have dense TDS time series data. Then, we will include information on recharge and cross-formational flow to build the numerical model. Finally, we will create different pumping scenarios to simulate future development using the projections from well permitting by the Brazos Valley Groundwater District (BVGWD), as well as the regulations that the groundwater district has in place to avoid well interference with neighboring pumping wells (BVGCD, 2020).

At last, we will use the GMS interface to build a two-dimensional model of the area, creating a cross-section between the towns of Hearne and Millican ranging from 2002 to 2020, and we will perform a TDS forecasting for the following 50 years on three main scenarios: (1) maintaining the actual pumping rates, and (2) two increasing water extraction scenarios (moderate and extreme) according to the projected water demands from the (BVGCD, 2020).

13. **Related research**.

The need to forecast groundwater TDS changes has promoted the use of numerical modeling approaches in previous studies. Evans (1989) developed numerical models that coupled dissolved salt transport to groundwater flow in salt diapiric environments, and Allagmand et al. (2013) acknowledged that groundwater numerical models were widely used to forecast groundwater paths accurately and saturated solute transport in one, two, and three-dimensional studies on wetlands to provide temporal predictions of wetland salinity, which can be used to assess ecosystem outcomes and preservation. Salt domes in east Texas were deeply studied by Fogg (1983), and he recommended the development of numerical models to approach the vertical movement of saltwater plumes due to pressure, temperature, and density differentials. All the above cited studies have reported important advantages of developing numerical models and strongly suggest pairing the simulations with field tests to produce fairly reliable maps of the salinity plumes distribution, and potential pathways depending on groundwater extraction trends.

14. **Training potential**.

This project will allow the training of one graduate student (doctoral).

15. **Intended career path** you anticipate pursuing:

I intend to pursue a career in academia as a teaching and research faculty member. I am passionate about contributing to the existing pool of knowledge and at the same time educate people about the advancements of science.

References

Allaghmand, S., et al. (2013). "A review of the numerical modeling of salt mobilization from groundwater-surface water interactions." Water Resources **40**(3): 325-341.

Ashworth, J. and J. Hopkins (1995). "Aquifers of Texas: Texas Water Development Board Report 345." Austin, TX: Texas Water Development Board. p **69**.

Bruun, B., et al. (2016). Texas Aquifers Study: Groundwater Quantity, Quality, Flow, and Contributions to Surface Water. Texas Water Development Board, Austin, Texas, USA.

BVGCD. (2020). Brazos Valley Groundwater Conservation District Management Plan Adopted on 2019.

Dutton, A. R., et al. (2003). "Groundwater availability model for the central part of the Carrizo-Wilcox aquifer in Texas." The University of Texas at Austin, Bureau of Economic Geology. Prepared for the Texas Water Development Board.

Evans, D. G. (1989). Theoretical and numerical models for heat and mass transport and groundwater flow near salt domes, Louisiana State University and Agricultural & Mechanical College.

Fogg, G. E., et al. (1983). Three-dimensional ground-water modeling in depositional systems, Wilcox Group, Oakwood salt dome area, East Texas, Texas Univ., Austin (USA). Bureau of Economic Geology.

Thorkildsen, D. and R. D. Price (1991). "Ground-water resources of the Carrizo-Wilcox aquifer in the Central Texas Region." Report/Texas Water Development Board (USA).