

The logo for Water Wizards GIS Consulting features a stylized purple and blue wizard's hat with yellow stars on the left. To its right, the words "WATER WIZARDS" are written in a large, bold, sans-serif font with a blue-to-purple gradient and a subtle galaxy pattern. Below this, the words "GIS CONSULTING" are written in a smaller, bold, sans-serif font with a purple-to-blue gradient and a similar galaxy pattern.

# WATER WIZARDS

## GIS CONSULTING

Tay Floyd: Project Manager and GIS Analyst

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## TABLE OF CONTENTS

### 1. INTRODUCTION

1.1 Summary.....	3
1.2 Purpose.....	3
1.3 Scope.....	4

### 2. LITERATURE REVIEW.....5

### 3. PROPOSAL

3.1 Data.....	6
3.2 Methodology.....	8
3.3 Implications.....	10
3.4 Budget.....	11
3.5 Timetable.....	11
3.6 Final Deliverables.....	14

### 4. Conclusion.....14

### 5. References.....14

### 6. Participation.....15

# 1. Introduction

## 1.1 Summary

Central Texas is home to a large abundance of water bodies, several of which are noted as being among the purest in the nation. The San Marcos River, the Guadalupe River, and the Comal River are all listed within the top five purest rivers in America and are often cited as a focal point for many people on why they chose to relocate to our area. On top of being a great source of pride for many Texans, these tranquil waterways also contribute to the Edwards Aquifer recharge zone. Now, it's no secret that over the last few years Central Texas has experienced a monumental population boom. This has its pros and cons, but for environmentalists this influx of people has been accompanied by a growing concern of what effect it could have on our freshwater supply. The Greater Edwards Aquifer Alliance (GEAA) and The Water Wizards consulting group have come together as a unit, and we will identify and map Wastewater Treatment Plants (WWTPs) within the Aquifer's Recharge Zone to determine which parts are at risk of contamination from sewage leaks.

## 1.2 Purpose

The Edwards Aquifer is an underground body of rock and sediments that stores and transports freshwater to natural springs and wells. It is the main source of drinking water for the greater San Antonio-New Braunfels metropolitan area, and it contributes to the local economy and cultural identity of several different cities. It is a karst aquifer, which means it contains an array of tunnels, sinkholes, and other types of chambers that make up its unique structure. While the Aquifer's geologic structure enables it to quickly refill with freshwater, it also serves as its Achilles heel. Its dynamic series of caves, tunnels, and chambers make the aquifer especially susceptible to contamination.

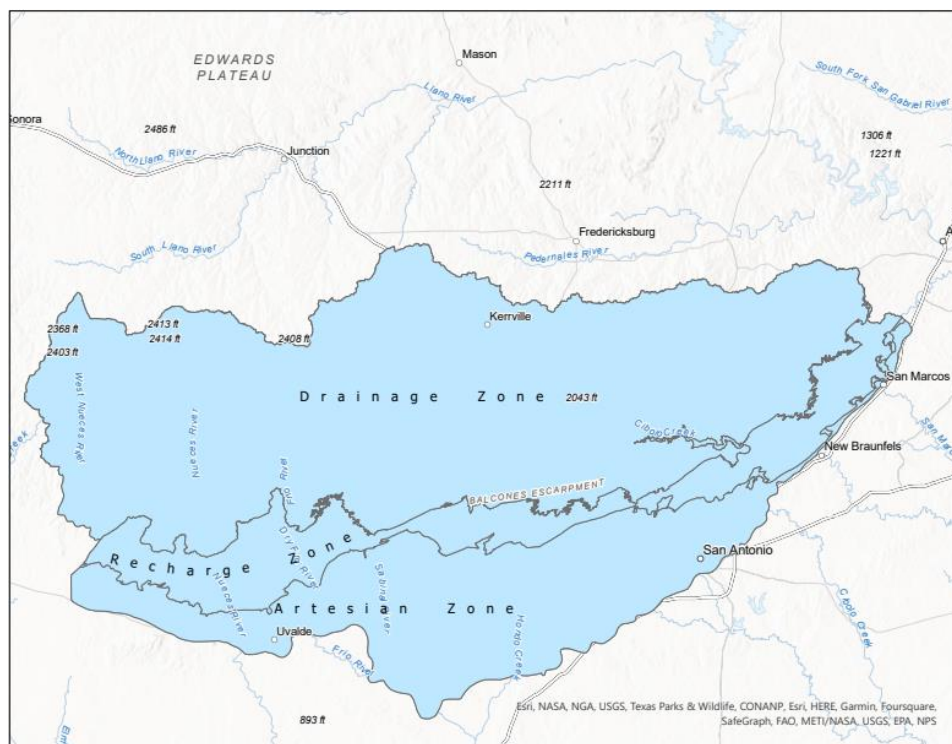
This is not an inherently unique problem though, as there are many karst aquifers spread throughout the world with several existing in other parts of the United States. The real issue lies with the population boom that Central Texas is currently experiencing. Between 2021 and 2022 nearly half a million people moved to Texas from another state,

with the vast majority having moved to Austin, New Braunfels, and San Antonio. The karst formations combined with the rapid increase in local human activity has potential to compound the risk of pollutants entering the aquifer and contaminating it beyond repair. For the Water Wizards consulting group, our main objective is to help the GEAA preserve the purity of the Edwards Aquifer. Ideally, we will achieve this goal by implementing geoprocessing tools and data analysis techniques found within ArcGIS Pro. This will lead to us creating a WebMap to visually display WWTPs and annotating which plants are under compliance and which plants are in violation.

### 1.3 Scope

As previously stated, the Edwards Aquifer recharge zone spans a vast area; 1,250 square miles to be exact. The counties of Travis, Hays, Comal, Bandera, Medina, Frio, Bexar, Kinney, and Uvalde are to be prioritized. Wastewater Treatments plants that exist in these counties will be investigated on their practices, with emphasis being placed on those found within the Barton Springs and San Antonio segments of the Edwards Aquifer recharge zone.

Figure 1. Edwards Aquifer recharge zone



## 2. Literature Review

The Edwards Aquifer is responsible for being one of the major reasons why cities such as San Antonio, Austin, and other Texas cities have been able to develop over the course of time since their establishment. The Edwards Aquifer has now become a necessity for the surrounding Texas areas as it stands as the main source of drinking water for well over 1.7 million people in central Texas. As city populations rise and more people become reliant on the aquifer, data and knowledge concerning the maintenance and restoration of the Edwards Aquifer has become crucial.

One of the most concerning aspects of the Edwards Aquifer water supply is the possible presence of pollutants making their way into the water of the Edwards Aquifer. Residential and commercial developments along the recharge zone of the aquifer are increasing due to the population increase which means a higher likelihood of pollutants within the aquifer. One way of reducing the pollutants making their way into the aquifer is making sure that all areas of public and government land being used are taken into account when designing the most productive outcome for sewage treatment. A study on

sanitary sewage systems and water supply from a city in Brazil in 2022 showed that areas situated peripherally from the most focused areas had the highest risk of leakage (Silva, 2022). Many areas located outside of a major city can be looked over when designing or redesigning sewage infrastructure which is why they may be at risk for contaminating the groundwater or recharge zone of the Edwards Aquifer. Management and maintenance to higher risk areas is essential since sewer mains could become sources of urban groundwater recharge and contamination posing health and environmental risks.

While it is nearly impossible to prevent pollutants from making their way into the Edwards Aquifer, there are things that can be done to locate where and when pollutants enter the aquifer. An experiment conducted in 2018 in east Ukraine aimed to locate the problem areas of the sewage infrastructure (Vystavna, 2018). The experiment conducted showed a strong link between the condition of the water infrastructure and the occurrence of disorderly artificial recharge in urban areas. The Edwards Aquifer recharge zone spans across seven counties making it difficult to determine where and when sewage infrastructure is failing and allowing pollutants into the aquifer. Although the area is large, there are things that can be done to mitigate the issue. Tests like the one performed in the Ukraine would be beneficial in locating where certain pollutants originate from and how they react with various other chemicals in the aquifer.

### **3. Proposal**

#### **3.1 Data**

- Start and permit renewal date of TPDES and TLAP permits
- Address / Description of location
- Volume of Treatment
- Method of Treatment
- Phosphorus and Nitrogen discharges permitted
- Past violations (if any)
- Beneficial Reuse (if any)
- Additional Conditions of Permit (if any)
- County maps, shapefiles, and quantitative data, which depict locations and vulnerability rankings for wastewater lines
- State Population Trends by Census Tract

- Edwards Aquifer Zones and Regulatory Boundary
- Surface water quality criteria, such as TCEQ/EPA stream impairment status
- Available wastewater spills data

The completion of the project relies on the data that we acquire to complete the vulnerability assessment and create a visualization of our findings. All necessary data has been provided to us that we just needed to clean before using. Most of the data we use comes from TCEQ, the state’s regulatory body for the safe management of waste. A public information request was submitted to TCEQ by a previous group working to complete this project and the data was not given to that group in time to complete the project fully. TCEQ has now provided the data in time for Water Wizards GIS Consulting to complete this project for GEAA. This data includes information about the wastewater treatment plans that will later inform our vulnerability analysis.

The remaining shapefiles needed to complete this project will be acquired through an open-source ArcGIS server through ArcGIS Pro. These files include county maps, Edwards Aquifer zones, and state populations by census tract. Further details about how we will use all of the data as stated within the methodology section of this proposal.

Table 1. Detailed Master Data List

<b>Entity</b>	<b>Attributes</b>	<b>Spatial Object</b>	<b>Status</b>	<b>Source</b>
Wastewater Treatment Plants	Name, Location	Point	Available	TECQ
Edwards Aquifer	Zones, Area: Acres, Sq. Feet, Sq. Miles, Boundary	Polygon	Available	TCEQ
TCEQ Regions	Zones	Polygon	Available	TECQ

WWTP details	Start and permit renewal date of TPDES and TLAP permits, Address / Description of location, Volume of Treatment, Method of Treatment, Phosphorus and Nitrogen discharges permitted, Past violations, Beneficial Reuse, Additional Conditions of Permit	N/A	Available	TCEQ
SSURGO	1:24,000	Polygon	Available	NRCS
Geology of Study Area	Type of Media, Extent, Depth, Location of Fault Lines	Polygon	Available	USGS
Digital Elevation Model	10m Grid	Raster	Available	USGS
LULC	30m	Grid	Available	TNRIS
Texas Base Map	Counties, Roads	Polygon	Available	TNRIS
Geologic Units	1:250,000	Polygon	Available	TNRIS

### 3.2 Methodology

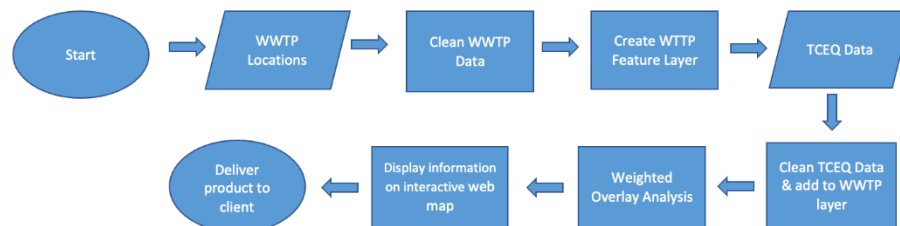
After having received all the necessary data to complete this project we were able to begin our work without being held back by waiting for various companies to respond to information requests. The first task was assessing the data provided and cleaning it. Since our project is focused on WWTP data from within the seven counties provided, we were able to remove data that lies outside of them which cleans the data a great deal. After the data has been cleaned, only information from the focused counties will remain for the next step in our process.



While cleaning the data will undoubtedly be the most tedious task on our list, there are multiple other steps that will go into creating a final product. Our group will also be providing a weighted vulnerability analysis that will identify the wastewater treatment plants with the potential to cause the most harm. This will be done with a weighted overlay that will take into account several factors of importance. The components of this weighted analysis will be the number of violations, volume of output, and proximity to waterways. Wastewater treatment plants with many violations and a high output pose the greatest risk to the Edwards Aquifer, particularly those in close proximity to waterways that feed into the aquifer. Another factor to consider during this process is the rising population. High population growth areas pose a strong risk for wastewater treatment plants having to increase output, so proximity to high population growth census tracts will be included as part of our weighted analysis. This should provide GEAA with an accurately ordered list of the plants they should be allocating resources towards monitoring and holding accountable moving forward.

Once the analysis has been completed, the data will be used to create an interactive web map that the GEAA will be able to use and share with the public. This map will display the locations of each WWTP in the Edwards Aquifer recharge zone along with relevant information pertaining to each location, as well as identify the facilities we deem most at risk of harming the aquifer. Users of the web map will be able to query specific locations by name, location, or attribute to learn more information about the wastewater treatment plants they are interested in. These tools will allow GEAA and citizens to have a clear understanding of the spread and impact of wastewater treatment plants in their communities.

Figure. 2 Project Flow Map



### 3.3 Implications

We aim to implement relevant GIS based data and shapefiles to create an interactive WebMap application. This application will live in Texas State University’s server and will display the Edwards Aquifer recharge zone and all the wastewater treatment plants that reside within. Upon selecting a specific WWTP point, the user will be presented with that plant’s compliance status based on the data acquired from the Texas Commission on Environmental Quality (TCEQ). Whether a WWTP is in or out of compliance will be determined by the number of violations or leaks that specific plant has experienced.

### 3.4 Budget

Table 2. Budget for project completion

<b>Data Collection/Pre-Processing</b>			
	Job Title	Hourly Wage	Hours Worked
	Project Manager	\$59.26	25
	GIS Analyst (2)	\$28.80	60
	Total Hours		85
	Total Pay	\$3,209.50	
<b>Data Interpretation &amp; Map Design</b>			
	Job Title	Hourly Wage	Hours Worked
	Project Manager	\$59.26	25
	GIS Analyst (2)	\$28.80	60
	Web Map Designer	\$33.26	10
	Total Hours		95
	Total Pay	\$3,542.10	
<b>Equipment/Software</b>			
	ArcGIS Pro	4,150	
	Workstations (3)	\$620.99	
	Adobe Illustrator	\$94.47	
<b>SUBTOTAL</b>		\$11,617.06	

### 3.5 Timetable

Table 3. Timetable highlighting important dates for project schedule.

## February

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
31	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18

<b>19</b>	<b>20</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>	<b>25</b>
<b>26</b>	<b>27</b>	<b>28</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>

## March

<b>SUNDAY</b>	<b>MONDAY</b>	<b>TUESDAY</b>	<b>WEDNESDAY</b>	<b>THURSDAY</b>	<b>FRIDAY</b>	<b>SATURDAY</b>
<b>26</b>	<b>27</b>	<b>28</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>
<b>19</b>	<b>20</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>	<b>25</b>
<b>26</b>	<b>27</b>	<b>28</b>	<b>29</b>	<b>30</b>	<b>31</b>	<b>1</b>

# April

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

Wed, February 22 - Proposal presentations to clients

Wed, March 29 - Progress report presentation

Wed, April 26 - All final deliverables are due by 4:00 pm

Mon, May 1 – Final Project Presentation

### 3.6 Final Deliverables

Upon completion of our project, we will have successfully developed an interactable WebMap application. This WebMap will aid the GEAA in their mission of providing the Edwards Aquifer with a greater form of protection from local sewage leakage. Our WebMap will allow for the ease of selecting specific WWTPs spread throughout the many counties that exist within the aquifer's recharge zone. Our WebMap will contain nothing but relevant information and will be fitted with a search bar, customized icons and symbols, and other animations that will enhance the user's overall experience.

## 4. Conclusion

Ultimately, our group's mission is to produce a viable interactive map of wastewater treatment plants found within the counties in our study area. By compiling spreadsheets, geographic data, and by implementing the use of ArcGIS Pro and Texas State's server we will accomplish our goal. With the Greater Edwards Aquifer Alliance (GEAA) and the Water Wizards consulting group working in unison, we can ensure that the Edwards Aquifer retains its purified waters and iconic status.

## 5. References

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## **6. Participation**

**Tay Floyd:** Project Manager, GIS and Data Analyst, Graphic Designer, Budget, Timetable, and Participation

**Haley Busse:** GIS and Data Analyst, Literature Review, Researcher, Data, Methodology, and References

**Tyler Heck:** GIS Analyst, Web Map Designer, PowerPoint Designer, Summary, Purpose, Scope, Implications, Final Deliverables, and Conclusion