Introducing the Texas Water Network Explorer Tool

TWNET TOOL

WRITTEN BY

Dr. Nathan Jones

Christopher Callaghan

Reyna Loosmore

2026

INSTITUTE FOR HOMELAND SECURITY
SAM HOUSTON STATE UNIVERSITY

Abstract

This paper introduces the Texas Water Network Explorer (TWNet), a visualization and analytical tool developed by the Institute for Homeland Security at Sam Houston State University. TWNet is a freely accessible online tool that visualizes connections between water sources and systems as simple networks, enabling engagement with water data to support policymakers and Texas citizens as they try to understand the complexity of water interactions among different entities across Texas.

Contents

Introduction

This technical report serves as an introduction and primer to the Texas Water Network Explorer (TWNet) an online visualization tool. It also provides background information about the underlying data used in the visualizations. The TWNet tool is a powerful resource for both policymakers and Texas citizens trying to understand where their water comes from and where it flows, as they make important policy decisions at the local, state, and federal level. Water has long been recognized by the US government as a critical infrastructure sector and understanding the flows of this complex system are critical to Texas state level security planning.[1]

This tool can also inform decision making vis-à-vis Texas's long standing water sharing relationship with Mexico making it a foreign policy issue. The key value add of the TWNet tool is that it allows Texans and policymakers to rapidly visualize their own local water network. From there, they can explore the state more broadly. Due to human visual recognition, computing, and web display constraints, the TWNet visualization tool allows people to view one node at a time and all its connections. In short, it allows people to visualize the "ego network," as we say in social network analysis (SNA) parlance.[2] An ego network is a network in which there is a focus on a single node (entity) and its connections to other nodes which are “alters.”[3]

Using a static data set from the Water Use Survey (WUS) administered by the Texas Water Development Board (TWDB), the Institute for Homeland Security (IHS) at SHSU, with support from the Texas Water Foundation (TWF), has developed the Texas Water Network Explorer (TWNet), an online tool designed to help policymakers, and the public better understand and visualize the structural and functional characteristics of the state's water network.

This tool distills thousands of data points into intuitive visual analytics, simplifying how policymakers conceptualize water usage across Texas. Rather than simply asking, "How much water is used?" the tool broadens the scope to: "Who uses it, and who do they rely on? What kinds of uses interlink water users? And how much water is exchanged?" By applying a network-based approach, users can visualize and interpret the intricate relationships between water entities-such as water intake from sources, sales to industries and municipalities, and retail distribution to other systems. This framing enables policymakers to quickly identify strengths, dependencies, and weaknesses within the network and better understand how water moves through the system. In turn, this expanded insight supports more data-driven decision-making in key areas, including developing system resilience strategies, risk management, infrastructure planning, and the development of policies and regulations governing water use.

This technical report introduces the TWNet tool and discusses its data sources and its limitations. As such, it contains a set of intuitive visualizations of the network, to walk readers through the use of the tool and its capabilities. Because this tool may be used in important policy discussions, it is important for readers to know what assertions may be beyond the scope of the underlying dataset.

A separate companion technical report will provide a broader network analysis of the entire Texas water network through an exploratory social network analysis (SNA) on the overall network structure. That companion publication provides the reader with a deeper analytical context to supplement the simplified graphical representations available through the online application.

Roadmap

This paper will proceed in the following sections: (1) it will briefly describe the Texas Water Network Explorer tool (TWNet) and will illustrate the tool and its visualizations, (2) it will discuss the underlying data used to derive the network and its limitations, and (3) provide conclusions.

The Texas Water Network Explorer

The Texas Water Network Explorer (TWNet) allows users to visualize the interactions and water flow between water actors (suppliers, water sources, buyers) in the state of Texas. TWNet allows users to visualize and interpret complex relationships within the water distribution system and illustrate how water flows, is acquired, sold, and redistributed. This provides enhanced insights to inform decisionmakers about system resilience, risk management, and infrastructure planning.

The TWNet was built for ease of access and intuitiveness. Upon entering the landing page of the tool, users will be able to easily locate exploratory icons that will provide access to water sources and water systems in the tool. Additionally, the landing page contains a direct link to the top critical water sources and systems in Texas. As mentioned in the introduction, this tool uses a static data set from TWDB WUS. The WUS program conducts an annual survey of about 4,500 public water systems and 2,500 industrial facilities.[4] According to TWDB WUS website, “The Water Use Survey is intended to collect a comprehensive view of groundwater, surface water, and reuse use across the state for water supply planning.”[5]

Given the large size of the overall data set, the TWNet displays the Texas water network in manageable ego networks. An ego network is a network that includes only the node of interest, such as the Gulf Coast Aquifer, and the immediate ties to it which are known as alters. Ego networks also display the ties amongst alters, these are connections that represent the flow of water from one water entity to another. Those relationships connect a source-to-system (referring to intake) or system-to-system (referring to sales). This is an intuitive way to look at a network with more than 6,675 nodes without visualizations becoming too cumbersome and the human mind becoming overwhelmed by too many data points being presented. Arrows on the lines representing ties indicate the direction of water flow. TWNet is, however, only a snapshot of the overall network and thus an analysis of the overall network's topography will be provided in a subsequent report.

An example of the intuitive nature of the TWNet tool and the utility of an ego network visualization is provided in a screenshot below.

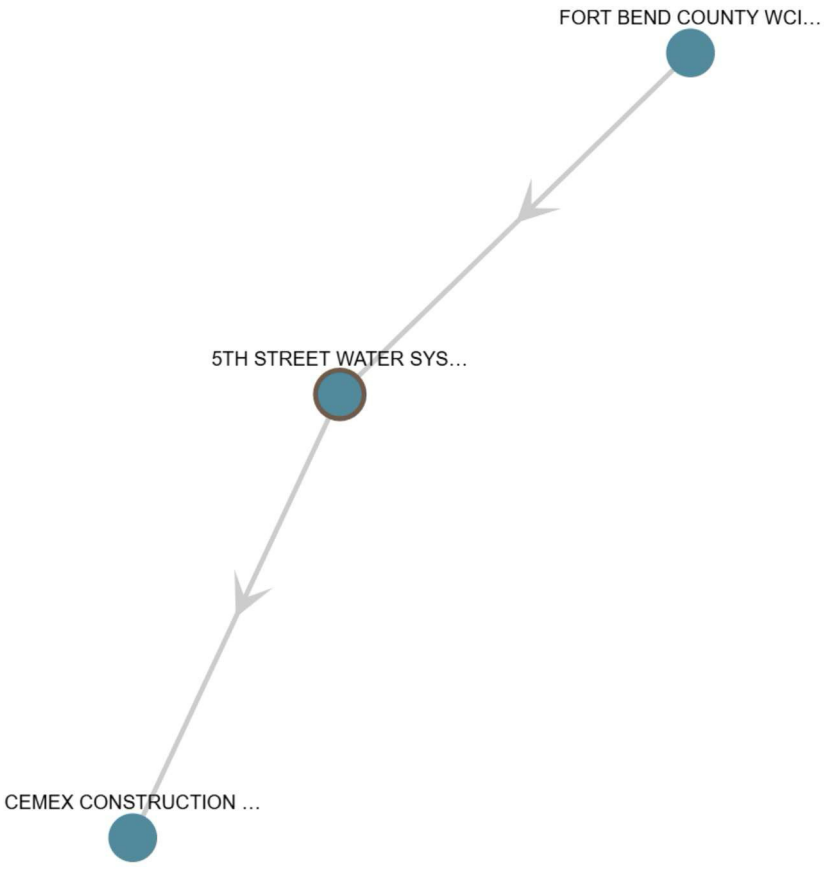

Figure 1. 5th Street Water System Ego Network Generated by the Texas Water Network Explorer (TWNet)

In Figure 1, we can see the 5th Street Water system in Stafford Texas in Fort Bend County, Southwest of Houston. We also see which major customers are supplied by the 5th Street Water System, such as CEMEX, a construction cement producer. We also see that the Fort Bend Water Control and Improvement District no. 2 supplies the 5th Street Water System. Directional arrows built into the TWNet tool demonstrate the direction of water flow. While the complete names for the water systems and buyers are not shown due to space constraints, hovering the cursor over the node in TWNet brings up the full names, TWDB Survey Number, type of water system or source, and the incoming and outgoing overall waterflow of that utility district. This is a rapid way to visualize specific local water distribution data and understand the overall flow of water through this network.

It is important to remember that 5th Street Water System, which provides water for CEMEX Construction, is only 1 of 6,675 nodes and 7,858 edges (relationships) depicted in the TWNet tool.[6]

Displaying all of the data in a single website visualization would be computationally impractical and would not yield useful information for people interested in local water flows. Thus, we chose to display ego networks and allow people to select their water sources or suppliers by name. Within TWNet users may find water systems with self-loops such as in the case of the City of Houston (Figure 2). These are cases in which water systems reuse their own water after treatment. It should be noted that basins may be a catch-all term, as sometimes systems may not know the original water source. It may be common for survey respondents to simply reference a large basin when they are unsure of the specific surface water sources. Thus, these data limitations should be kept in mind when using this tool.

It must be noted that for every water system, the tool will provide a statement indicating that the visualization will show water flowing into and out of the selected system. The visualization will omit any inputs and outputs that are not directly connected to the selected water system.

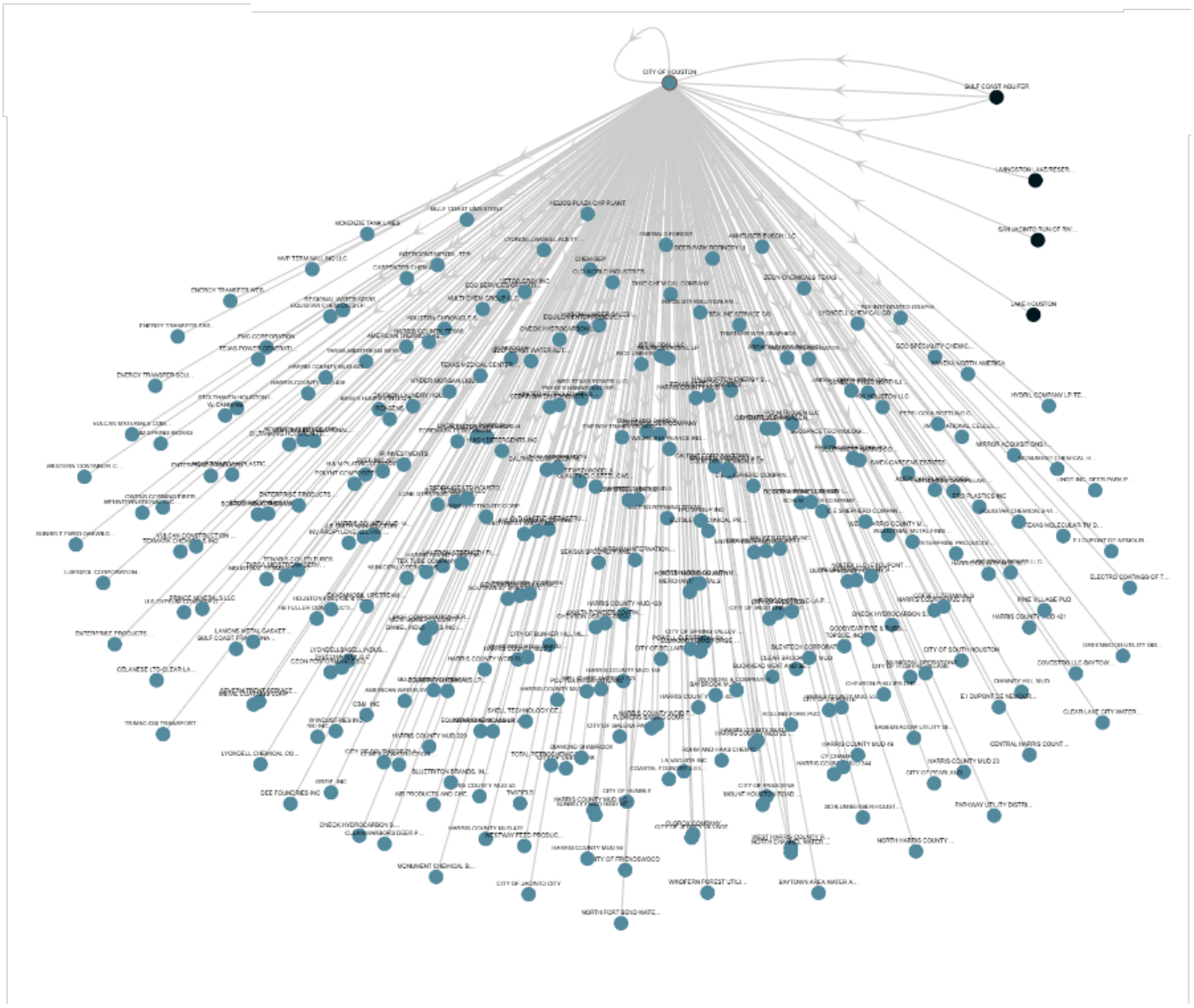

Figure 2. City of Houston Ego Network Generated by the Texas Water Network Explorer

The tool also provides an insights tab for every source and system. The insights tab provides information regarding that specific water system, in this case City of Houston (Figure 3) with outgoing flow, incoming flow, and number of outgoing connections (referring to the number of transactions (intake (incoming) and sales (outgoing)).

The insights tab also provides a summary of annual water transactions for a specific system.

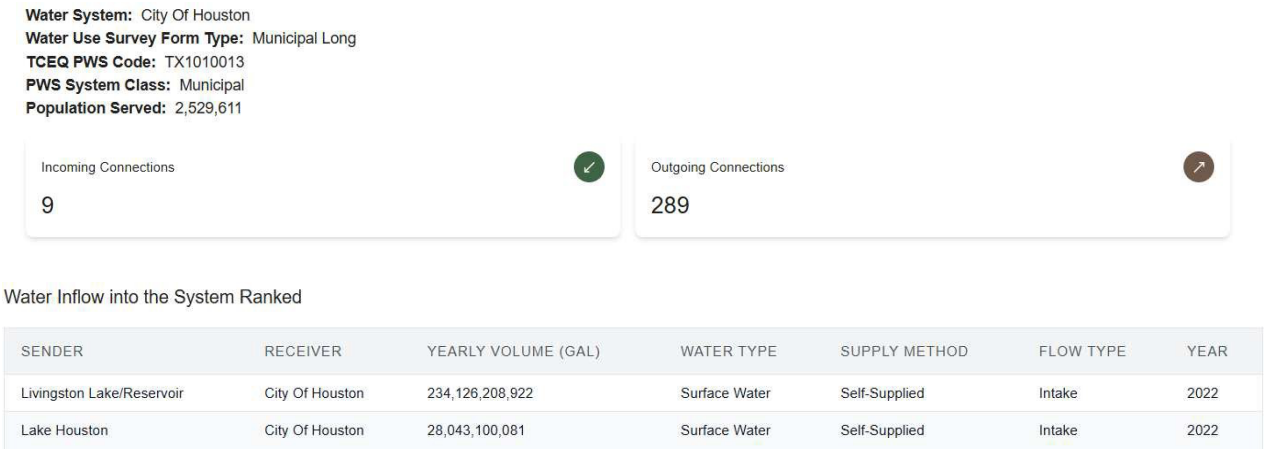

Figure 3. City of Houston Ego Network Insights Generated by the Texas Water Network Explorer

In network terms, the data above is considered to be node attribute data or individualized characteristics of the nodes. Though in some cases overall water flows through the nodes may blur the distinction between relational data and individual node attribute observations.

Data Overview

Data Source

TWNet was developed using 2022 data from the Texas WUS, administered by the TWDB. The Texas WUS data includes self-reported data collected from approximately 4,500 public water systems (PWSs) as well as approximately 2,500 industrial facilities.[7] Clarifications on survey structure, data, and data quality were obtained through consultation with TWDB.

The Texas WUS is required by law. The survey includes two types of surveys, municipal water use and industrial water use surveys.[8]

According to a TWDB response to our data inquiry, the response rate for the 2022 Municipal and Industrial surveys combined is 77%, with an additional 23.31% based on estimated data (non-responsive surveys estimated by TWDB). Estimates are based on the survey's previous year's submission or other relevant data.[9] In 2025, TWDB released a summary of the 2023 WUS, which has a 77% response rate to the survey.[10] For other data points, TWDB bases estimates on the most recent year available and revises as additional data becomes available. The TWDB estimates that approximately 4.6% of the total Texas population relies on private wells not connected to any PWS. This is largely rural. While not included in the survey data, water use estimates for rural domestic producers exist at the county level. Further, the TWDB estimates that less than 5% of water use is not captured due to survey nonresponse. This gives us a sense of a dataset which is fairly comprehensive and representative of the overall Texas water network with these caveats in mind.

From this survey, two key relational tables – PWS Intake (self-supplied and purchased) and PWS Sales (water sales wholesale to other PWS or industrial systems) were used to construct network data. In our data model, nodes represent either water sources (e.g., aquifers) or systems, and edges represent the reported transactions moving water between nodes for a given year.

Data Limitations

While the TWDB conducts data cleaning and validation to enhance accuracy, these processes cannot eliminate potential inaccuracies. It is therefore recommended that all users interpret the data with caution and consider supplementing it with additional sources or validation methods where precision is critical.

From review of the data, limitations can include but are not limited to the following:

1. The survey does not include all water providers in Texas.
2. Many water systems are reporting their water source as unknown.
3. Not all buyers are reported, especially industrial buyers.
4. Reporting methods and definitions of water intake vary across systems.
5. Data is estimated for surveys that are not returned using the previous year's data.
6. Entities may not submit a survey every year.
7. Volumes are self-reported and revised as additional or more accurate data becomes available.
8. Volumes might not be consistent due to meter accuracy, water loss, or data errors.
9. Only data collected from community public water systems are included in the map along with selected industrial facilities as their buyer.
10. The tool is based on static data for the year 2022 and does not reflect the most updated changes.

One limitation not listed above includes the concern for the representation of water flow in

this system. In this network, edge weights represent the volume of water purchased or extracted, but this closed system does not account for the recharge process for natural sources such as aquifers.

Consequently, the analysis of the flow of water may overstate the depletion of finite resources, since source replenishment is not accounted for and occurs at an unknown rate. The TWNet tool thus does not account for water recharge and could leave viewers with the mistaken impression that water levels may deplete. Thus, we discourage users of TWNet from using the tool to make assessments about water depletion. Those assessments are beyond the scope of this tool.

Conclusions

The Texas Water Network Explorer tool (TWNet) provides Texas policymakers, citizenry, and stakeholders with valuable insights into their own local water networks. It allows them to visualize from a single node such as their own aquifer or utility district, where their water comes from and where it flows. This allows them to see their own vulnerabilities and dependencies, such as having only one water source, and think about the consequences of being cut off from that source.

Given data computational limitations, TWNet cannot provide complex and rapid visualization down to the residential consumer level. Nonetheless, understanding where a local utility district gets its water, how that water flows and may be sold to other entities such as large corporate buyers or other cities/utility districts, provides important information for policymakers and citizens as they debate how to use this important Texas resource.

Water is widely recognized as a critical infrastructure sector,[11] and is critical to economic development.[12] Humans process information visually, and ego networks are a way for humans to see and rapidly understand the water networks in which we are embedded. The TWNet tool allows people to better understand their own water flow network and where they fit within it. This empowers not just better decision making at the policy level, but also empowers Texans, which enables participation in the democratic process and accountability.

Acknowledgements

The authors would like to thank the Texas Water Development Board and the Texas Water Foundation for their discussions and clarifications on the data used in this project and its context and limitations.

Disclaimer

Any analysis contained within this report does not necessarily reflect the views of the Texas Water Development Board, the Texas Water Foundation or the official policy of the Institute for Homeland Security.

Additionally, these entities may host the TWNet tool on their websites, though that does not imply their endorsement of the underlying data or visualizations generated by the TWNet tool.

Endnotes

[1] For a discussion on the security importance of water see Jeremiah O. Asaka et al., "Climate Change Risks to Water Security: Exploring the Interplay between Climate Change, Water Theft, and Water (in)Security," *Water Policy,* March 13, 2024, https://doi.org/10.2166/wp.2024.213.
[2] For more on Ego Network analysis see: Nick Crossley et al., *Social Network Analysis for Ego-Nets: Social Network Analysis for Actor-Centred Networks* (Sage, 2015).
[3] For useful definitions of egos and alters see Sean F Everton, *Disrupting Dark Networks*, (Cambridge University Press, 2012). For an example of the application of Ego Network analysis to drug cartel alliances see: Nathan P. Jones et al., "A Social Network Analysis of Mexico's Dark Network Alliance Structure," *Journal of Strategic Security* 15, no. 4 (2022): 76–105, https://doi.org/10.5038/1944-0472.15.4.2046.
[4] "Water Use Survey and Water Service Boundary Viewer." Texas Water Development Board. https://www.twdb.texas.gov/waterplanning/waterusesurvey/faq.asp; *2023 Texas Water Use Estimates Summary* (Texas Water Development Board, 2025), https://www.twdb.texas.gov/waterplanning/waterusesurvey/dashboard/2023%20Texas%20Water%20Use%20Estimates%20Summary.pdf.
[5] "Water Use Survey and Water Service Boundary Viewer." Texas Water Development Board. https://www.twdb.texas.gov/waterplanning/waterusesurvey/faq.asp.
[6] All statistics produced in this report were generated in UCINET social network analysis software. Stephen P Borgatti et al., *Ucinet for Windows: Software for Social Network Analysis,* 2002.
[7] Response to email inquiry from TWDB representative Summer 2025.
[8] "Water Use Survey and Water Service Boundary Viewer." Texas Water Development Board. https://www.twdb.texas.gov/waterplanning/waterusesurvey/faq.asp.
[9] *2023 Texas Water Use Estimates Summary* (Texas Water Development Board, 2025), https://www.twdb.texas.gov/waterplanning/waterusesurvey/dashboard/2023%20Texas%20Water%20Use%20Estimates%20Summary.pdf.
[10] *2023 Texas Water Use Estimates Summary* (Texas Water Development Board, 2025), https://www.twdb.texas.gov/waterplanning/waterusesurvey/dashboard/2023%20Texas%20Water%20Use%20Estimates%20Summary.pdf.
[11] Jeremiah O. Asaka et al., "Climate Change Risks to Water Security: Exploring the Interplay between Climate Change, Water Theft, and Water (in)Security," *Water Policy,* March 13, 2024, https://doi.org/10.2166/wp.2024.213.
[12] On the importance of water to economic development and potential conflict see: Tim Marshall's chapters on the Middle East, Australia and especially North Africa. Tim Marshall, *Prisoners of Geography: Ten Maps That Explain Everything about the World*, (Simon and Schuster, 2015); Tim Marshall, *The Power of Geography: Ten Maps That Reveal the Future of Our World*, (Simon and Schuster, 2021).

The Institute for Homeland Security at Sam Houston State University is focused on building strategic partnerships between public and private organizations through education and applied research ventures in the critical infrastructure sectors of Transportation, Energy, Chemical, Water/Wastewater, Healthcare, and Public Health.

The Institute is a center for strategic thought with the goal of contributing to the security, resilience, and business continuity of these sectors from a Texas Homeland Security perspective. This is accomplished by facilitating collaboration activities, offering education programs, and conducting research to enhance the skills of practitioners specific to natural and human caused Homeland Security events.

Institute for Homeland Security

Sam Houston State University

Jones, N. Callaghan, C. Loosmore, R. (2026). Introducing the Texas Water Network Explorer (TWNet) Tool. (Report No. 2026 -1044). The Sam Houston State University Institute for Homeland Security.
https://doi.org/10.17605/OSF.IO/UXNZT

INSTITUTE FOR HOMELAND SECURITY
SAM HOUSTON STATE UNIVERSITY