THE TEXAS WATER CRISIS: CONTRIBUTING FACTORS AND ALTERNATIVES TO RISING SURFACE AND GROUNDWATER

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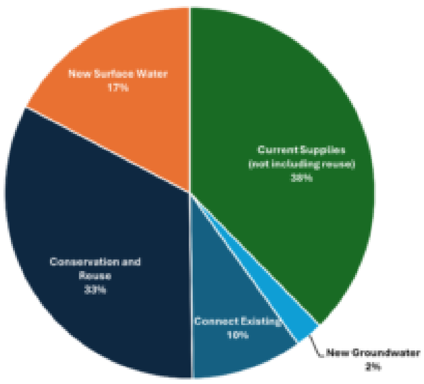
1. INTRODUCTION

Texas has faced a range of problems that could in the short term cause a water crisis in its different regions. According to data from the Texas Water Development Board, some regions of the State of Texas may face serious water shortages as early as 2030 if measures are not taken to increase water availability to meet the needs of all its users.

One of these regions facing this imminent crisis is Region C, made of 16 counties from the Dallas-Fort Worth Metroplex, representing 26% of the State's Population and 30% of the State's Economy.

According on a draft version of the 2026 Region C Water Plan, "Over the coming years, Region C's existing water supplies will not be able to meet the growing demands of the region. By 2080, dry-year water demands in Region C will reach 3 million acre-feet of water annually. With currently available regional water supplies at 1.7 million acre-feet of water annually, the region faces a potential annual shortfall of over 1.3 million acre-feet by 2080, absent development of new water supplies".

Under the plan, Region C's 2080 water demand would be met through the following water management strategy types:



- **38% – Current Supplies** (not including reuse)
- **33% – Water Conservation and Reuse**
- **17% – New Surface Water** (reservoirs and run-of-river projects)
- **10% – New Connections to Existing Supply Sources**
- **2% – New Groundwater**

Sources of Water Available to Region C as of 2080

At their meeting on February 24, 2025, the Region C Water Planning Group presented several data, such as Population and Water Demand Projections, Analysis of Water Supply, and Identification of Water Needed. Unmet needs data with current availability for Three Municipal WUGs (Celina, County-Other, Parker and Irving) were presented and Six Non-Municipal WUGs (Irrigation: Ellis, Fanning and Parker – Manufacturing: Ellis and Henderson – SEP: Freestone).

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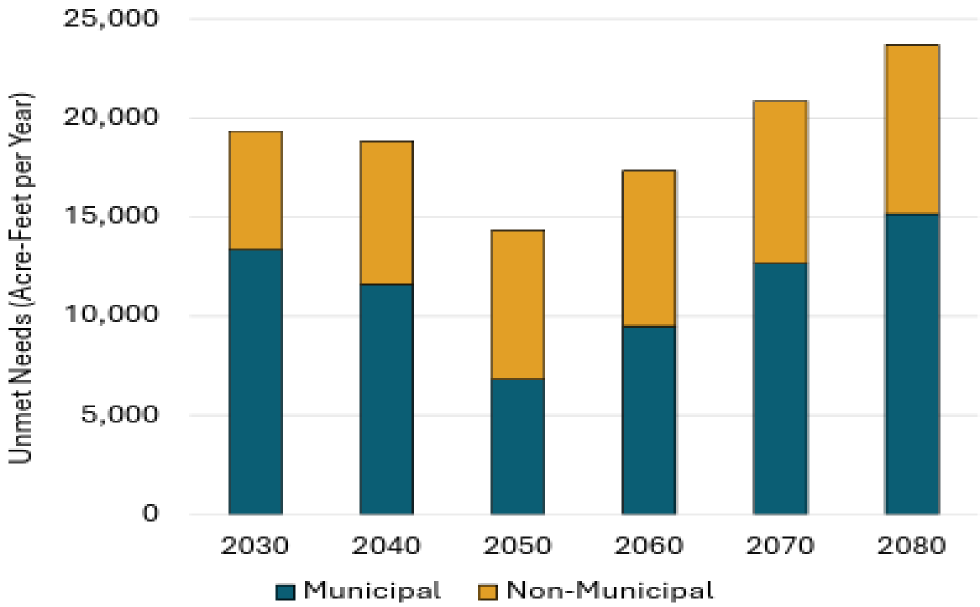


Source: Region C Water Planning Group

It can be seen from this graph that the current availability of water will not be able to meet the needs for various uses, ranging from the public supply of cities to the needs of industries and farms, as early as the year 2030.

Another example that proves the problem of water scarcity is the city of Georgetown, in Williamson County, which faces growth and increased demand for water, in addition to the scarcity of surface water. The city's demand for water is on track to outstrip supply by 2030 as well.

According to a publication by the Texas Standard Daily News Show, Georgetown’s water utilities director, Chelsea Solomon, said: *the city immediately began searching for additional water supply options — a challenging task.*

In September 2024, Senator Charles Perry (District 28), who chairs the Senate Committee on Water, Agriculture, and Rural Affairs, in an interview with KXAN News, said:

“We can’t grow, we can’t expand, we can’t have economic opportunity and jobs without water. We’ve reached our limit, there is no more. We’ve got to do some things different.”

Available data allow us to mention six factors that contribute to this situation:

1) State´s growth.

2) Weather conditions.

3) Degraded river springs.

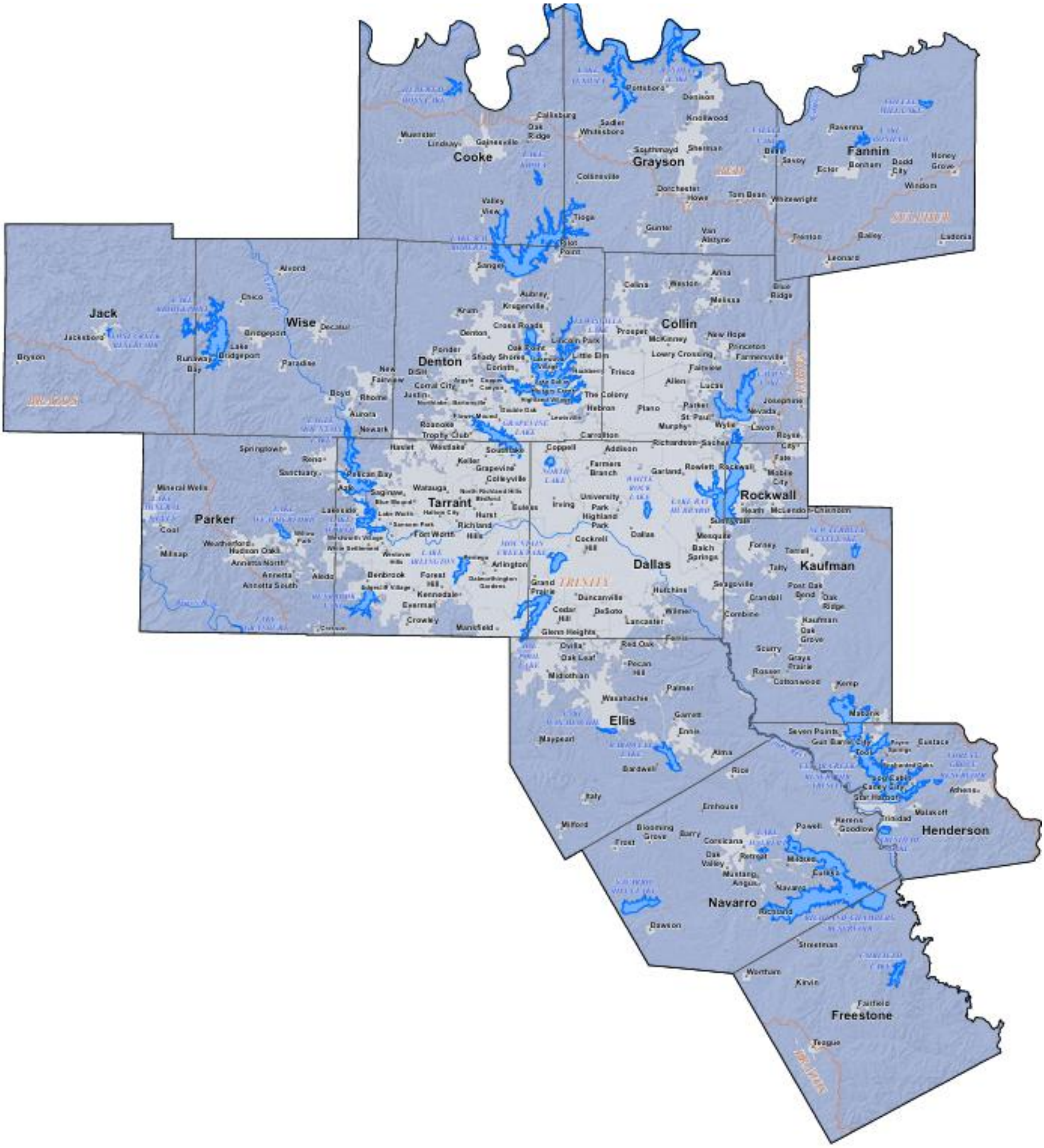
4) Soil types and little infiltration of rainwater.

5) Poor soil conservation.

6) Small number of riparian forests.

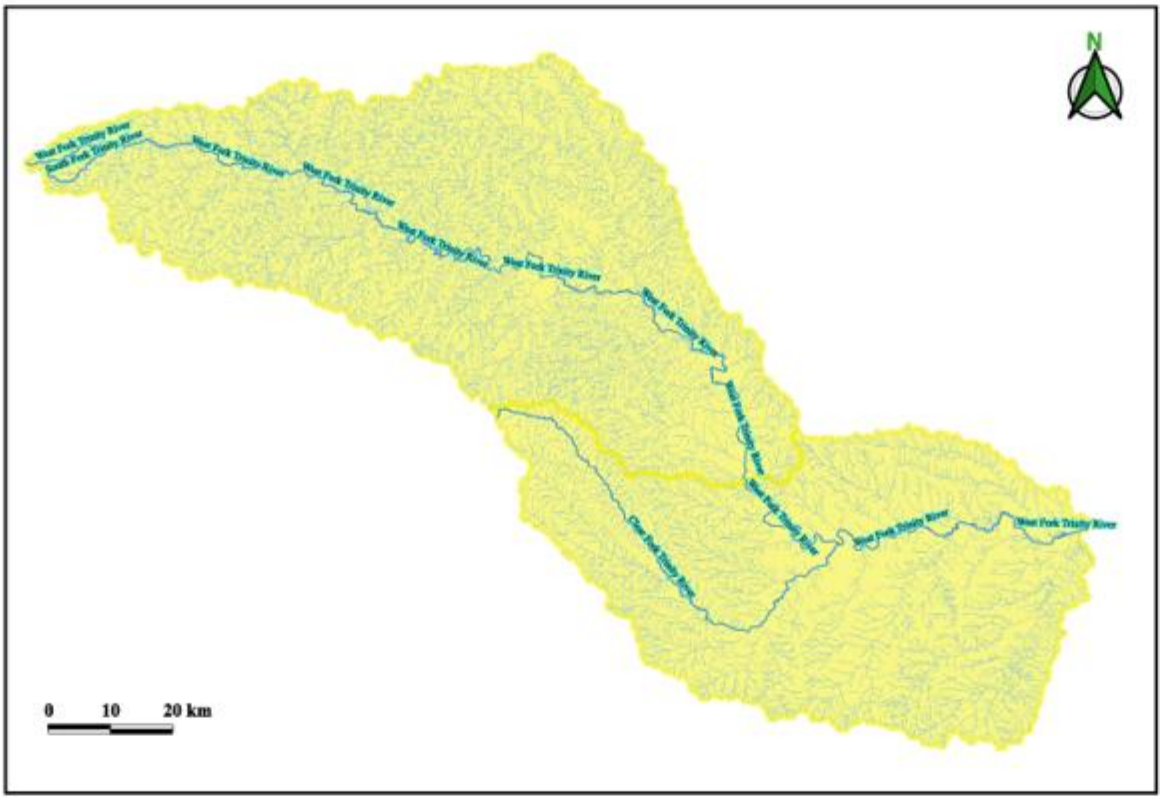
In turn, when we examine the Texas water grid, especially from Region C Watter Planning, we find that there is great potential for "surface freshwater production."

Region C, as can be seen on the map presented below, is bisected from north to south by the Trinity River and has several water reservoirs and lakes.



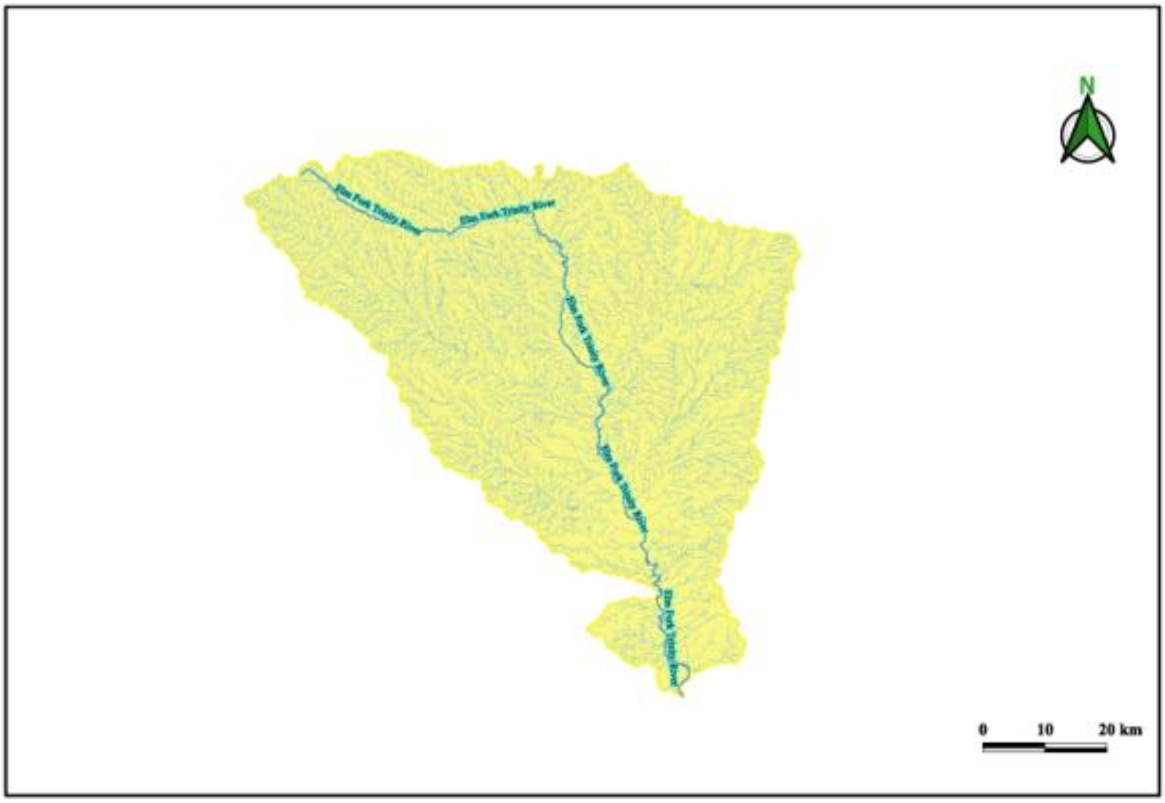
Source: TEXAS WATER DEVELOPMENT BOARD

When we proceed to a more specific evaluation of the micro basins of the West Fork Trinity River and the Elm Fork Trinity River, the great potential of surface fresh water that is contained in them is observed, due to the number of rivers and streams that constitute them, as can be seen in the maps shown below:



West Fork Trinity River Basin

Source: Hydrologic Unit Maps (USGS-United States Geological Survey)
Elaboration: Souza, Mateus and Siebert, Décio Eloi



Elm Fork Trinity River Basin

Source: Hydrologic Unit Maps (USGS-United States Geological Survey)
Elaboration: Souza, Mateus and Siebert, Décio Eloi

This article aims to present the main causes of water deficit in some regions of Texas and proposals for increasing surface and underground water availability.

2. MAIN CAUSES OF THE PREDICTED WATER DEFICIT FOR TEXAS REGIONS

2.1 State´s growth

Besides the highly variable climate, Texas's sustained population growth is a fundamental reason why the state has been at the forefront of long-range water supply planning since the 1960s.

Texas is the second most populous state in the U.S. and has attracted more new residents than any other state since 2000, mainly because of its thriving economy and expanding metropolitan areas. Texas has grown faster than the national average every decade since the 1850s.

The projections adopted by the Texas Water Development Board on November 9, 2023, reveal that Texas' population is projected to increase by more than 70 percent during the planning horizon, from 29.7 million in 2020 to more than 52.3 million in 2080.

At a county level, 29 Texas counties are projected to double or more in population between 2020 and 2070. Most of this population growth will occur in regions C, H, and L, which represent 63.86% of the total population.

According to the 2020 U.S. Census Data, Celina is a city in Collin and Denton counties, had a growth between 2020 and 2023 of more than 158%.

2020 US Census Data

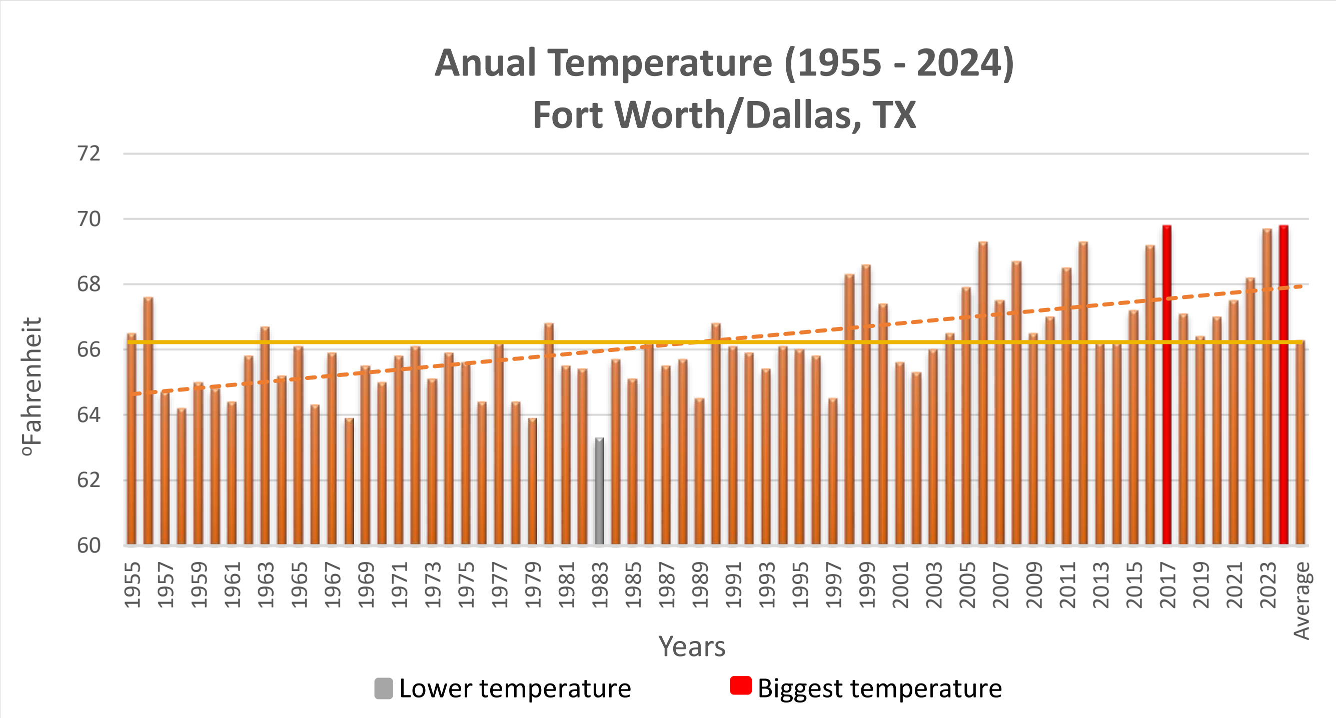
Population	Data
Population, Census, April, 1, 2020	16,739
Population estimates base, July 1, 2023 (V2023)	43,317

Statewide water demand is projected to increase by approximately 49 percent, from 5.9 million acre-feet per year in 2030 to 8.8 million acre-feet per year in 2080. Irrigation is the largest water demand category in each planning decade through 2050. However, municipal demand is expected to surpass irrigation demand by 2060. With the state's population booming, data indicates the state's water supply is falling behind. According to the state's 2022 water plan, water availability is expected to decline by 18%, with groundwater experiencing the steepest drop.

2.2 Weather conditions

According to data from the National Weather Service at Fort Worth/Dallas Station for the last 70 years, the average annual temperature in this period was 66.28 °F. The lowest average annual temperature was recorded in 1983 (63.3°F) and the minimum daily temperature was 5 °F, on December 24 and 25, 1983. The highest average annual temperatures in this period were recorded in 2017 and 2024 (69.8 °F), and the maximum daily temperatures recorded were 112 °F, on June 26 and 27, 1980 and on July 22, 2018.

In the graph presented below, the average annual temperatures from 1955 to 2024 can be observed:

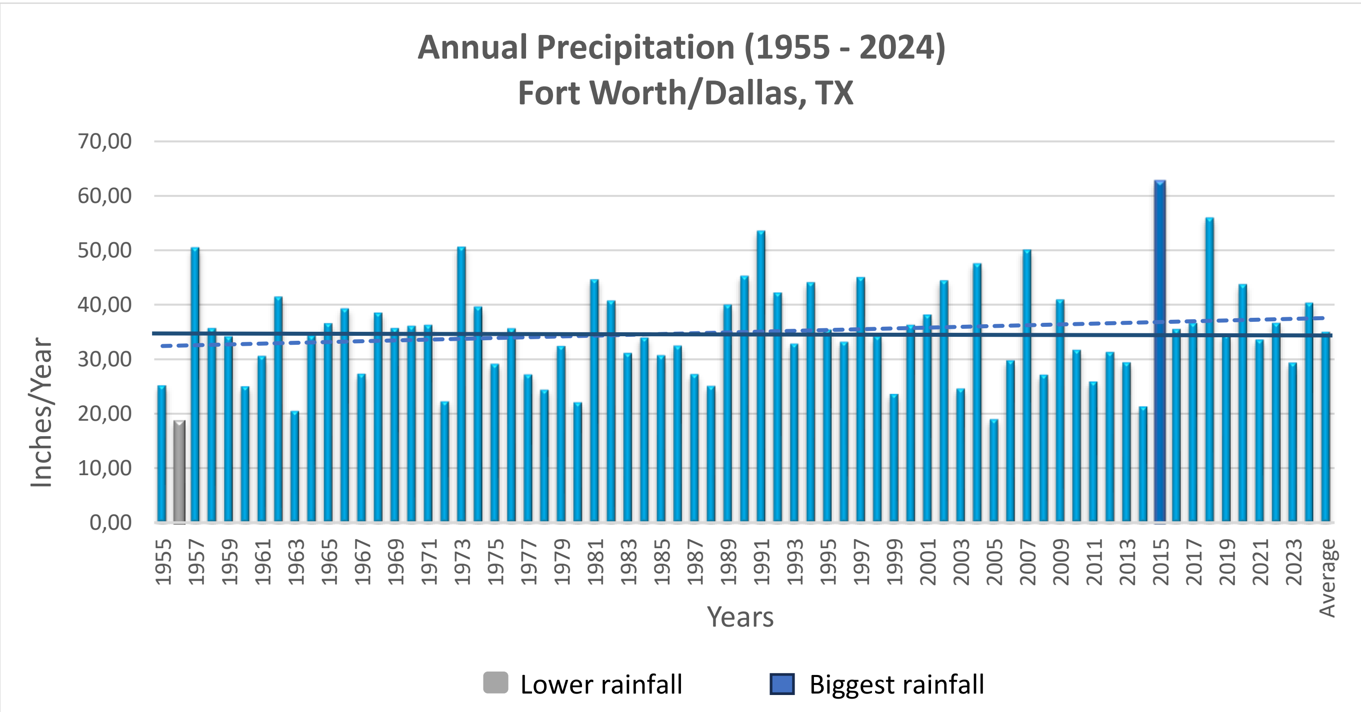


Source: https://www.weather.gov/fwd/dmotemp

Elaboration: Siebert, Décio Eloi

In this graph it is observed through the Trendline shown on the dotted line, that there was an increase in temperatures over the period. It is also observed that in the period from 1998 to 2024 (27 years), temperatures were recorded above the historical average in 22 years, which represents 81.48% of the period.

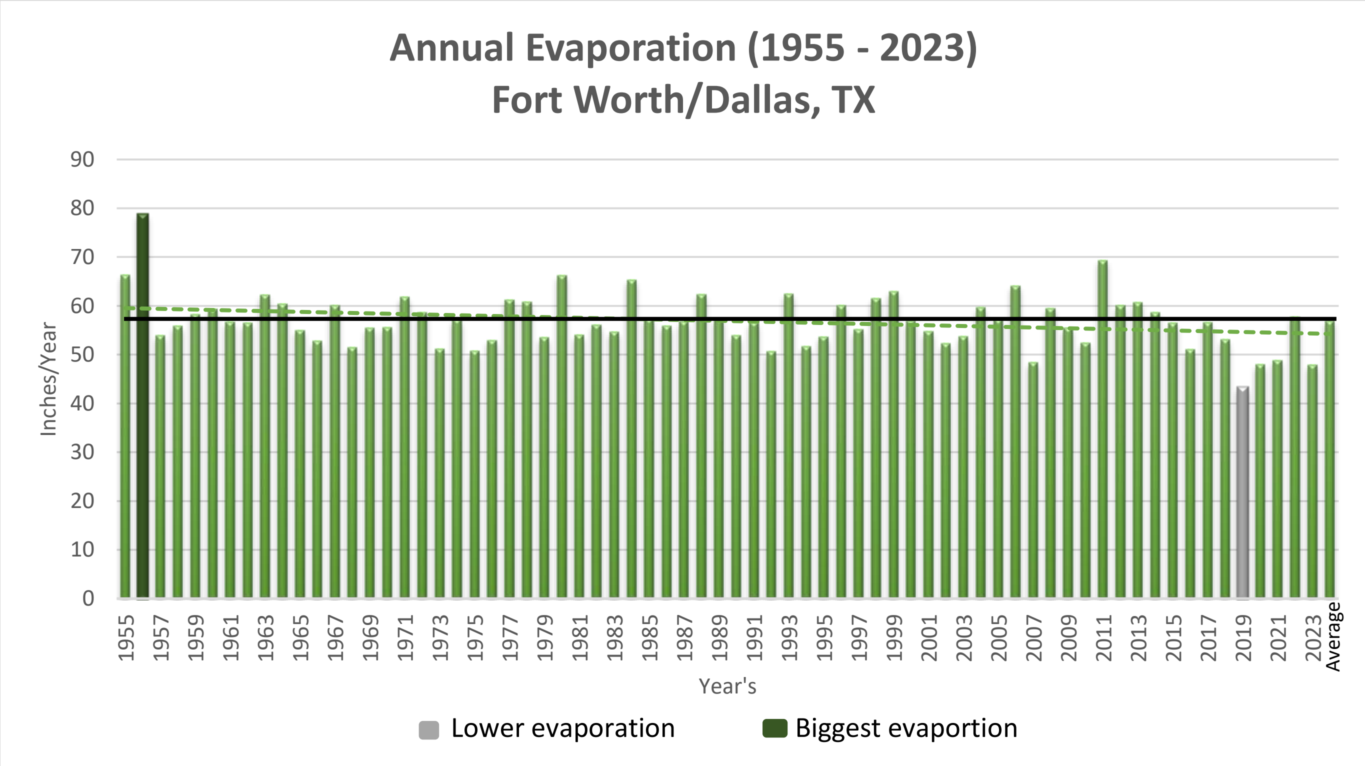
The average annual rainfall in the period from 1955 to 2024 was 35.00 inches per year. The highest average annual rainfall during this period was recorded in 2015, at 66.61 inches, and the lowest in 1956, at 18.55 inches. The data are presented in the following graph:



Source: https://www.weather.gov/fwd/dmoprecip
Elaboration: Siebert, Décio Eloi

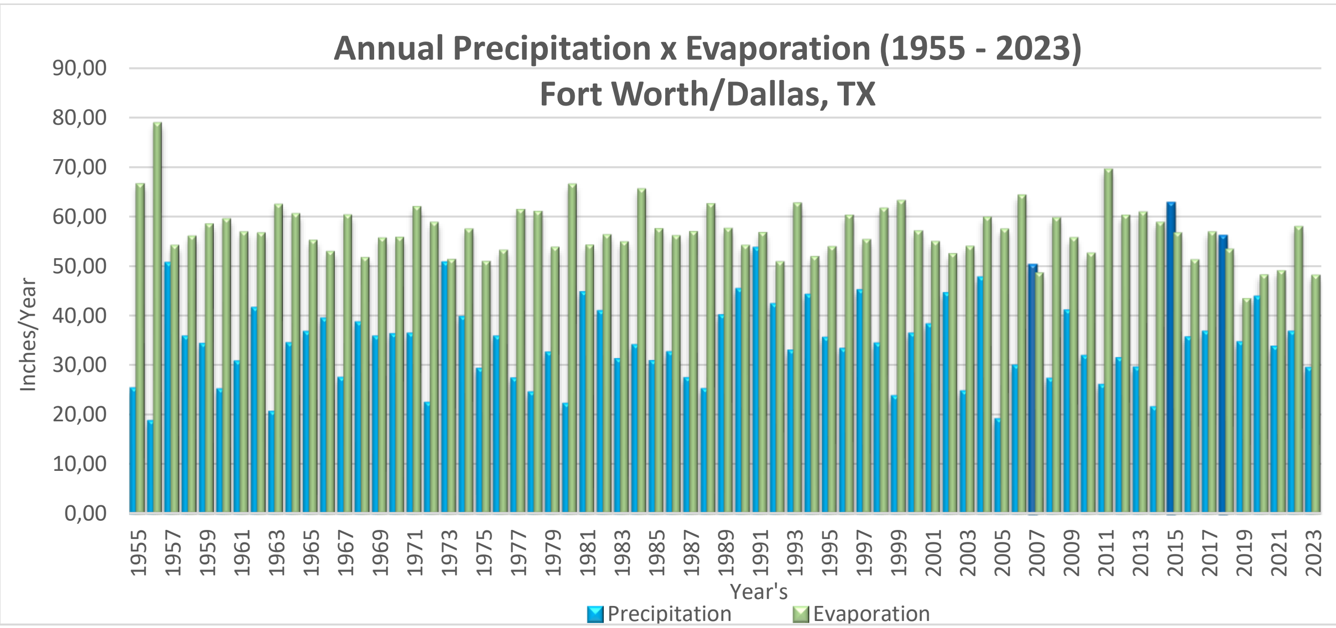
Through this graph it is possible to observe that the precipitation indices in the last 70 years did not have significant variations in relation to the annual average of the period. The Trendline shows a small upward trend.

The average annual gross evaporation from 1955 to 2023 was 56.90 inches per year. The highest average annual gross evaporation occurred in 1956 (78.64 inches), while the lowest was recorded in 2019 (43.18 inches).



Source: https://waterdatafortexas.org/lake-evaporation-rainfall
Elaboration: Siebert, Décio Eloi

The following graph shows a comparison of annual precipitation and gross evaporation:



Source: https://www.weather.gov/fwd/dmoprecip - https://waterdatafortexas.org/lake-evaporation-rainfall
Elaboration: Siebert, Décio Eloi

Information on precipitation and evaporation is an important reference for the knowledge of the climatological water balance extract.

Evaporation is more common over the ocean than precipitation, while over land precipitation typically exceeds evaporation.

However, in some regions, such as Texas, gross evaporation is greater than precipitation most of the time, as can be seen in the graph presented above.

This graph shows that in the period from 1955 to 2023, only in 3 years was precipitation greater than gross evaporation, more than 95% of years, precipitation was less than gross evaporation.

In view of this, it can be concluded that the storage of rainwater in underground reservoirs is more effective than storage in surface reservoirs, especially when it comes to large dams where the water depth is greater and therefore evaporation is more intense, especially in periods of high temperatures.

2.3 Degraded River Springs

Springs are an important source of freshwater and play a critical role in the hydrological cycle.

According to article KUMAR (2020) “The sustainable management of springs requires the protection of their recharge areas, regular monitoring of their health, and the implementation of restoration and water allocation strategies that prioritize the needs of different user groups”.

The formation and maintenance of springs is mainly due to the percolation of water through the soil and rocks with supply from underground aquifers. On the other hand, aquifers are made up of porous and permeable geological formations that can store and transmit groundwater. The formation of springs depends on specific conditions of the topography, geology and climatic conditions of the region.

The recharge area of a spring is the location where water infiltrates into the ground and percolates through the soil and rock formations before emerging as a spring. Determining the recharge area of a spring is important for identifying the sources of groundwater that feed the spring and for managing the land use practices that can impact water quality and quantity.

The recovery of a spring that has degraded or been damaged due to anthropogenic activities, involves restoring the flow and quality of its water.

There are some methods that can be used for spring recovery, such as the Caxambu Method, developed by the Agricultural Research and Rural Extension Company of Santa Catarina – Epagri (Brazil). This method basically consists of cleaning the spring and building a structure for channeling the water.

2.4 Soil types and rainwater infiltration capacity

The different types of soil are also important challenges for water filtration and retention, being originated under the influence of five factors: climate, topography, living organisms, time and source material (rocks and sediments), the soil can present different infiltration capacities that play an important role in maintaining the water table and recharging groundwater. If infiltration is considered slow, it becomes more difficult to recharge groundwater and aquifers.

The infiltration capacity of the soil depends in particular on its texture and porosity, and is greatly influenced by the local geology and the way in which weathering has altered the source material. Depending on the type of rock and sediment, water can percolate more easily: for example, sandbags allow faster infiltration than areas dominated by silty or clay materials.

Another factor that can increase infiltration is the presence of geological faults and fractures, which create additional paths for groundwater storage. Regarding the climate, the longer the soil is exposed to atmospheric agents, the greater its permeability and, therefore, the more effective the infiltration of rainwater will be. In regions with geological substrate and highly varied and complex pedological coverage, meeting water supply needs becomes correspondingly more challenging.

Texas has a rich variety of soil types, classified into 61 soil series, organized into 15 major land resource areas. Each area represents regions with soil characteristics, native vegetation, weather patterns and specific topographic characteristics and need to be known.

For Region C, counties have the following soil groups: Bluegrove-Bonti-Truce (number 17), Windthorst-Chaney-Duffau (number 35), Gasil-Crosstell-Callisburg (number 36), Aledo-Sanger-Bolar (number 38), Houston Black-Heiden-Wilson (number 39), Woodtell-Crockett (number 43) Edge-Tabor-Silstid (number 44), Wolfpen-Pickton-Cuthbert (number 49), and Tinn-Trinity-Kaufman (number 52) shown on the following map provided by the United States Department of Agriculture (USDA). Although varying in texture, depth, and drainage, these different soil groups have moderately leached profiles, climate-driven development, and importance to Texas's agricultural economy. They reflect the transitional nature of Texas's central and eastern landscapes—from prairie to forest, dryland to bottomland.

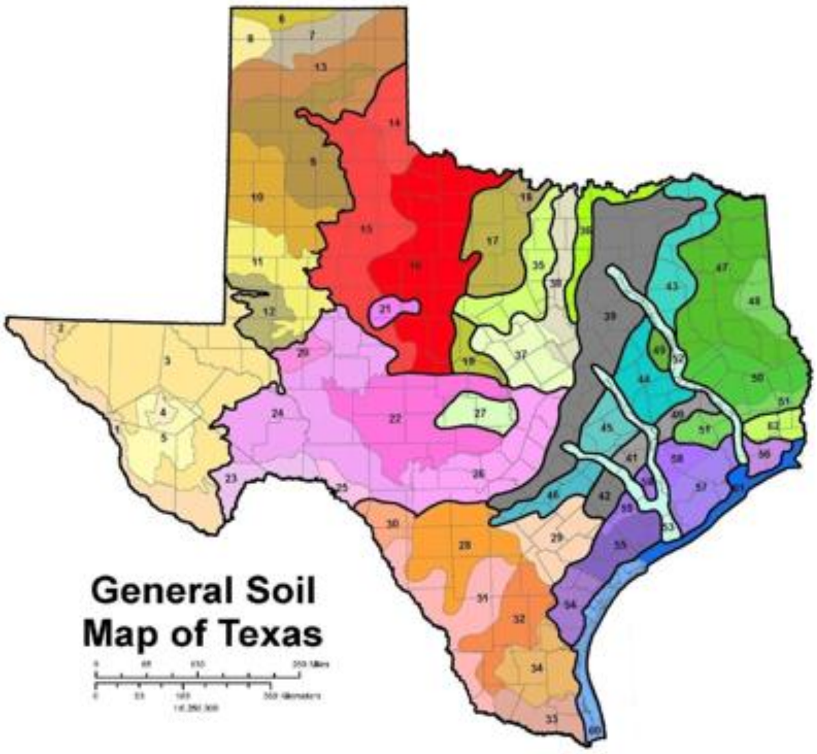


Fig. 1 – General Soil Map of Texas

Source: United States Department of Agriculture (USDA).

2.5 Soil Conservation Practices

Soil conservation encompasses all the strategies, techniques, and practices that are employed to prevent soil erosion, reduce the loss of soil fertility, and ensure sustainable land use. Soil erosion, caused by water, wind, and intensified and human activities, leads to the loss of topsoil, which is the most fertile layer of the soil. This not only reduces agricultural productivity but also contributes to the siltation of waterways, increased flooding, and the loss of valuable land.

There are numerous soil conservation practices that can be implemented to protect and enhance soil health. These practices vary depending on the specific needs of the area, the type of soil, and the prevailing climatic conditions.

According to USDA "Seventy percent of the nation's land is privately owned, and conservation of our nation's private lands not only results in healthy soil, water, air, plants, animals and ecosystems, it also provides productive and sustainable working lands".

Soil helps control where rain, snowmelt, and irrigation water go. Water flows over the land or into and through the soil.

Proper soil conservation practice increases the efficiency of water use and precipitation storage.

In 1939 was created The Texas State Soil and Water Conservation Board (TSSWCB), by the Texas Legislature to organize the state into soil conservation districts where there was a need expressed by local landowners.

Today, there are 216 Soil and Water Conservation Districts (SWCDs) organized across the state.

However, in many river basins there are problems of lack of soil conservation, which causes erosive processes and silting of rivers, which can cause a decrease in the volume of surface water.

2.6 Small number of Riparian Forests

According to Texas Parks and Wildlife Department (TPWP), "Riparian areas are the margins of streams, rivers and intermittent draws, where vegetation is strongly influenced by the presence of water. Riparian-dependent plant communities differ markedly from those of the immediately surrounding non-riparian habitats".

The Benefits of a Healthy Riparian Area

"Riparian areas perform key ecological functions that contribute to the health of the entire ecosystem. Nutrients, detritus, and water are transported into a riparian system from runoff. … Stems and roots of riparian vegetation stabilize the soil by reducing water velocity and minimizing erosion".

Three important aspects can be highlighted in relation to the benefits of the Riparian Forest: Water quality; Wildlife Habitat and Economics.

Riparian Forest enhance water storage and slowing the physical movement of water across the landscape increases the residence time of water, providing sources of water for plant transpiration, soil-water and plant-water storage, and seepage to groundwater.

Riparian forests act as regulators of surface and subsurface water flows, as well as maintaining their quality, by filtering water (MARTINS, 2005).

In Texas, riparian forest law is governed by various regulations and rights associated with riparian areas, which are the margins of streams and rivers.

However, the existing laws have not been sufficient to maintain minimum and desirable levels of riparian forests.

According TPWP, “Major factors that contribute to degradation of riparian zones in Texas include construction of roads, dams, reservoirs and impoundments, uncontrolled grazing, point and non-point pollution, urban development and timber cutting”.

3. PROPOSAL AIMED AT INCREASING SURFACE AND GROUNDWATER

3.1 Springs Rehabilitation

River rehabilitation has become a critical issue for water authorities and river managers around the world. Springs are places where groundwater emerges naturally to the earth's surface, giving rise to watercourses.

With the recovery of the springs, it is possible to immediately observe the increase in the flow of the rivers and recharge of the underground aquifers.

There are proven spring restoration techniques that can be implemented in Texas, leading to increased surface water quantity and quality.

3.2 Terrace Build

The construction of terraces is a soil conservation practice applied to prevent the runoff of rainwater, allowing erosion to be controlled**.**

Terraces provide many ecosystem services, including the reduction of runoff and sediment, and the improvement of grain yields and soil moisture.

Terracing allows enhanced water infiltration in the soil, which increases groundwater recharge.

3.3 Retention Basins

Retention basins are management practices designed to mitigate stormwater runoff.

The retention basin is important for the recharge of groundwater, especially the water table, as it favors the infiltration of water into the soil, as well as in the protection of terraces.

3.4 Erosion Control and Recovery of Degraded Areas

Containment of erosive processes and recovery of degraded areas, especially in the surroundings of water bodies to be recovered, are actions of fundamental importance to reduce the transport of sediments to riverbeds and water reservoirs.

To this end, it is necessary to identify the places affected by the erosive processes, and, in each place, to have knowledge of the causes and consequences of the erosive manifestation with a view to the implementation of known techniques appropriate to the discipline of the runoff waters.

3.5 Groundwater Recharge

Groundwater recharge is a hydrologic process, where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer.

According United States Geological Survey, groundwater can be recharged naturally and artificially.

Natural groundwater recharge occurs as precipitation falls on the land surface, infiltrates into soils, and moves through pore spaces down to the water table.

Artificial recharge can be done through the injection of water through wells. This method often is applied to recharge aquifers where application of water to the land surface is not effective at recharging these aquifers.

Technical team from the Institute for Environmental Protection and Conservation (IPAC) developed a mechanism to artificial water table recharge, denominate Groundwater Recharge Intensifier, that does not require pumping.

The Recharge Intensifiers must be installed on the terraces and in the rainwater containment basins located in the recharge areas of the water table.

In the following figure, it is possible to observe the drawing of an intensifier of groundwater recharge.

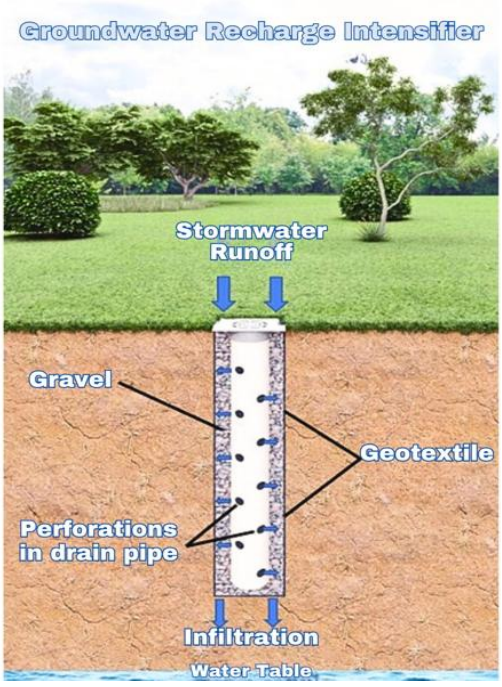


Fig. 2 – Design of the Groundwater Recharge Intensifier

3.6 Recovery of Riparian Forests

Planting of preferential native plant species to restore riparian forest areas, protect rivers and improve surface water quality.

4. CONCLUSION

Based on work carried out by the Institute for Environmental Protection and Conservation (IPAC), using appropriate methodology and the suggested measures implemented, it was possible to achieve an increase in Surface and Groundwater of at least 5% per year in the watershed worked.

If we use as an example the hydrographic basins of the Elm Fork Trinity River and the West Fork Trinity River, which together represent an area of 5,325.64 square miles, and the average annual rainfall records of the last 70 years, which is 35 inches/year, using the reference of the work carried out by IPAC, we will have an annual increase in water in these two hydrographic basins of 497,061,28 acre-feet per year.

In turn, if proposed work is implemented in the entire Trinity River Basin that falls on Region C, the volume of surface water generated could be more than 1,000,000 acre-feet per year, which will have a significant impact on the water supply of this region.

Water production can be further enhanced if rainwater drainage works are carried out in urban areas, through the installation of groundwater recharge intensifiers.

If the cost-benefit ratio is analyzed, it is concluded that it is a very cheap technology considering the results it provides.

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USDA – United States Department of Agriculture - **Land Conservation** - https://www.usda.gov/sustainability/conservation/land-conservation

TPWP - Texas Parks and Wildlife Department - **Managing Riparian Habitats for Wildlife -** https://tpwd.texas.gov/publications/pwdpubs/media/pwd_br_w7000_0306.pdf