Meadows Report 25-002

Cypress Creek Flow Study, Phase 2: Blanco and Travis Counties, Texas

Cypress Mill, Texas - Jenna Walker, 2025

Prepared by

Douglas A. Wierman, P.G., Jenna Walker, M.A.Geo., Nicky Vermeersch, M.S., Laura Parchman, Megan Flannery, Christina Lopez, Ph.D., and Noah Powell

The Meadows Center for Water and the Environment, Texas State University

April 2025

The Meadows Center for Water and the Environment

Texas State University

MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

Meadows Report 25-002

Cypress Creek Flow Study, Phase 2: Blanco and Travis Counties, Texas

Prepared by

Douglas A. Wierman, P.G., Lead Researcher

Jenna Walker, M.A.Geo., Researcher

Nicky Vermeersch, M.S., Researcher

Laura Parchman, Researcher

Megan Flannery, Student Researcher

Christina Lopez, Ph.D., Contributor

Noah Powell, Student Contributor

The Meadows Center for Water and the Environment, Texas State University

The Meadows Center for Water and the Environment

Texas State University

601 University Drive, San Marcos Texas 78666

512.245.9200 | MeadowsCenter@txstate.edu | meadowscenter.tx.edu

MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

Acknowledgements

This project was funded in part by grants from the Blanco Pedernales Groundwater Conservation District and the Hershey Foundation.

We especially thank all of the landowners that allowed us to enter their property. Without the cooperation of private landowners, opportunities for us to expand our knowledge of the river and local aquifers would not be possible.

Douglas A. Wierman, PG #4062

Blue Creek Consulting LLC

Texas Geosciences Firm #50541

Mr. Wierman was the lead researcher for the project.

Contents

Contents

List of Tables

Key Terms

Aquifer: A body of permeable rock which can contain or transmit groundwater

Base flow: Water that seeps into a stream from groundwater

Carbon-14: A long-lived naturally occurring radioactive carbon isotope of mass 14, used in carbon dating and as a tracer in biochemistry

Cretaceous: The last period of the Mesozoic era, between the Jurassic and Tertiary periods, or the system of rocks deposited during it

Discharge: The volume of water moving down a stream or river per unit of time, commonly expressed in cubic feet per second or gallons per day

Downgradient: An area that is at a lower level, water will flow in that direction

Eline: A wireline that provides real time measurements, such as depth to water

Ellenburger formation: A geologic group that is part of a Lower Ordovician carbonate platform sequence, covering a large area of the United States

Ellenburger San Saba Aquifer: A minor aquifer that is found in parts of 16 counties in the Llano Uplift area of Central Texas

Fault: A fracture or zone of fractures between two blocks of rock

Gain-loss study: A study to identify the segments of the rivers which gain water from the underlying aquifers (termed gaining) and which segments lose water to the underlying aquifers (losing)

Groundwater: Water held underground in the soil or in pores and crevices in rocks

Groundwater-surface water interaction: Groundwater and surface water physically overlap at the groundwater/surface water interface through the exchange of water and chemicals as a part of the hydrologic cycle

Hensel formation: A geologic group in Texas that formed in the Early Cretaceous period

Hammett Shale: A geologic group in Texas that forms a confining unit between the middle and lower zones of the Trinity aquifer

Hydro-blitz: A water quality monitoring event

Hydrogeology: The branch of geology concerned with water occurring underground or on the surface of the earth

Impervious cover: Any type of surface that does not absorb rainfall

Marble falls formation: A geologic formation consisting of a shelf of limestone running diagonally across the Colorado River from northeast to southwest

Paleozoic: The era between the Precambrian eon and the Mesozoic era, or the system of rocks deposited during it

Potentiometric surface: An imaginary surface representing the static head of ground water in tightly cased wells that tap a water-bearing rock unit (aquifer); or, in the case of unconfined aquifers, the water table.

Runoff: The draining away of water (or substances carried in it) from the surface of an area of land, a building or structure, etc.

Sonic meter: A meter that uses sound waves to measure well water level

SonTek FlowTracker: A handheld, portable, and precise wading discharge measurement instrument

Spring: A place where water moving underground finds an opening to the land surface and emerges

Stormwater: Surface water in abnormal quantity resulting from heavy falls of rain or snow

Surface water: Water that collects on the surface of the ground

Tributary: A river or stream flowing into a larger river or lake

Watershed: An area or ridge of land that separates waters flowing to different rivers, basins, or seas

YSI EXO1 Multiparameter Sonde: A device that uses multiple probes to collect real time, instantaneous water quality measurements

Acronyms

AMS: Accelerator Mass Spectrometry

BP: Before Present

BPGDC: Blanco Pedernales Groundwater Conservation District

EARDC: Edwards Aquifer Research and Data Center

GIS: Geographic Information Systems

GMZ: Groundwater Management Zone

LCRA: Lower Colorado River Authority

MCWE: The Meadows Center for Water and the Environment

MRLC: Multi-Resolution Land Characteristics

NLCD: National Land Cover Database

POR: Period of Record

pMC: Percent Modern Carbon

SWQMIS: Surface Water Quality Monitoring Information System

TCEQ: Texas Commission on Environmental Quality

TWDB: Texas Water Development Board

1 Executive Summary

This report presents the results of a Phase 2 study conducted in 2024 of surface water/groundwater interactions of Cypress Creek in Blanco and Travis counties, Texas. Phase 1, conducted in 2020, focused on surface water flow. Phase 2 focused on groundwater conditions in the vicinity of the creek and its connection to surface water.

The presence of two significant areas of springs has been known for a long time. The studies have shown there is a connection between shallow groundwater and the two spring systems. The origin of one of the springs appears to be related to faulting in the Ellenburger Formation where springs flow from both the north and south sides of the creek. Complex geologic structure/faulting involving the Ellenburger/Marble Falls and Trinity formations gives rise to the second area of springs. Water quality sampling indicates relatively young Carbon 14 dates at both sets of springs, indicating local recharge areas.

While the Phase 2 Study focused on groundwater and its relationship to spring and stream flow, the conclusions from the Phase 1 study are still relevant. The results of these studies indicate that Cypress Creek has not been significantly degraded and is in very good condition. Its current condition is the result of little development in the watershed and the good land stewardship of the landowners.

2 Introduction

Surface water and groundwater are managed separately in Texas, though they are physically connected. Research on groundwater-surface water interaction in the Texas Hill Country is currently limited. The complex groundwater-surface water interactions give the Texas Hill Country its signature features— distinctive spring-fed creeks, limestone bluffs, towering cypress trees, and endemic species. As Texas' population is projected to double by 2060, with particularly high growth in the Texas Hill Country region, the state's water resources must be carefully evaluated and effectively managed (Mace and Wade 2008; Texas Water Development Board [TWDB] 2022). Aquifers currently provide approximately 55% of Texas' water supply (TWDB 2022), yet they face growing vulnerabilities. Recharge rates, storage capacities, and flow regimes are increasingly variable due to climate change, over-pumping, and land cover changes (Banner et al. 2010; Yoon et al. 2018).

To better understand ground-surface water interactions in this critical region, The Meadows Center for Water and the Environment (MCWE or the Meadows Center) conducted the present study as a follow-up to an initial Phase 1 study within the Cypress Creek watershed (Figure 1), which was supported by numerous previous studies under the Meadows Center's research series "How Much Water is in the Pedernales?" (Wierman et al. 2021). This study builds on the results, conclusions, and recommendations of the Phase 1 Study to include additional sampling sites; sampling, land cover, and historical data; and analyses. This study has been funded by the Blanco Pedernales Groundwater Conservation District (BPGCD) and the Hersey Foundation.

Phase 1 study was limited to surface water sampling and flow measurements to determine gaining and losing reaches of the creek. Groundwater levels and water quality in wells were not part of the Phase 1 study. During Phase 2, groundwater levels and water quality samples were collected to better understand surface water/ groundwater interactions.

Figure 1. Cypress Creek watershed

3 Background and purpose

3.1 Key Findings from Previous Watershed Studies

Previous Pedernales River Watershed Studies

Several entities have studied various aspects of the Pedernales watershed since the 1950s. In 1962, a gain-loss study conducted by the United States Geological Survey (USGS) confirmed that the Pedernales River is a gaining stream — the flow rate generally increases as the stream moves downstream due to springs, seeps from the underlying aquifers, and inflows from the tributaries. Historic and more recent changes in land use activities can affect the flow in the Pedernales River and its tributaries, aquifer storage, as well as the groundwater-surface water interaction. These changes, in conjunction with groundwater extraction and population growth, underscore the importance of understanding the complex interactions between surface water and groundwater, which is essential for sustainable groundwater management that supports not only human populations but also wildlife and critical ecosystem services.

More recent studies include The Hill Country Alliance's "The State of the Pedernales: Threats, Opportunities and Research Needs" (Romans, 2015). Also in 2015, the Meadows Center began investigating the hydrogeology of the watershed by refining gain-loss studies with updated hydrological data to identify critical river segments for improved ground/surface water management. A two-day "Hydro-Blitz" event documented flow conditions at 931 sites across the watershed during a summer dry spell, laying the groundwork for a future gain-loss study. Building on this, a 2016 gain-loss base flow study of the Pedernales River identified the critical role of over 20 major tributaries, including Cypress Creek, in sustaining river flows. The study emphasized the need to extend future efforts into key tributaries to inform priority groundwater/surface water management strategies.

The cumulative findings prompted the "Cypress Creek Flow Study: Blanco and Travis Counties, Texas," a 2021 study by the Meadows Center referred to as hereafter as Phase 1. Phase 1 scope included several synoptic surface water flow measurement events, surface water sample collection and chemical analyses, and a review and summary of groundwater data, primarily obtained from the TWDB. No actual groundwater level measurements were collected. The study results indicate that, based on available data, Cypress Creek has not been significantly degraded. Conditions in 2021 were likely the result of little development in the watershed and the good land stewardship of the landowners, e.g., changes to land cover (large conversion of grassland and forest to shrub/scrub growth) do not appear to impact the volume of flow or water quality based on the data sets reviewed in this study.

3.2 Study Area

Cypress Creek, a major tributary of the Pedernales River, is situated in the northeast portion of the Pedernales Watershed in Blanco County and southwestern Travis County in the Texas Hill country (Figure 2). The watershed spans 81.60 square miles, or approximately 52,200 acres. US Highway 281 crosses the western portion of the Cypress Creek Watershed in a north/south orientation, and RM 962 roughly parallels the creek to the north in a northwest-southeast orientation. The town of Round Mountain is located at the intersection of US Highway 281 and RM 962. The upstream portion of the watershed consists of North and South Cypress Creeks, with their confluence creating the main stem of Cypress Creek near Round Mountain/US Highway 281.

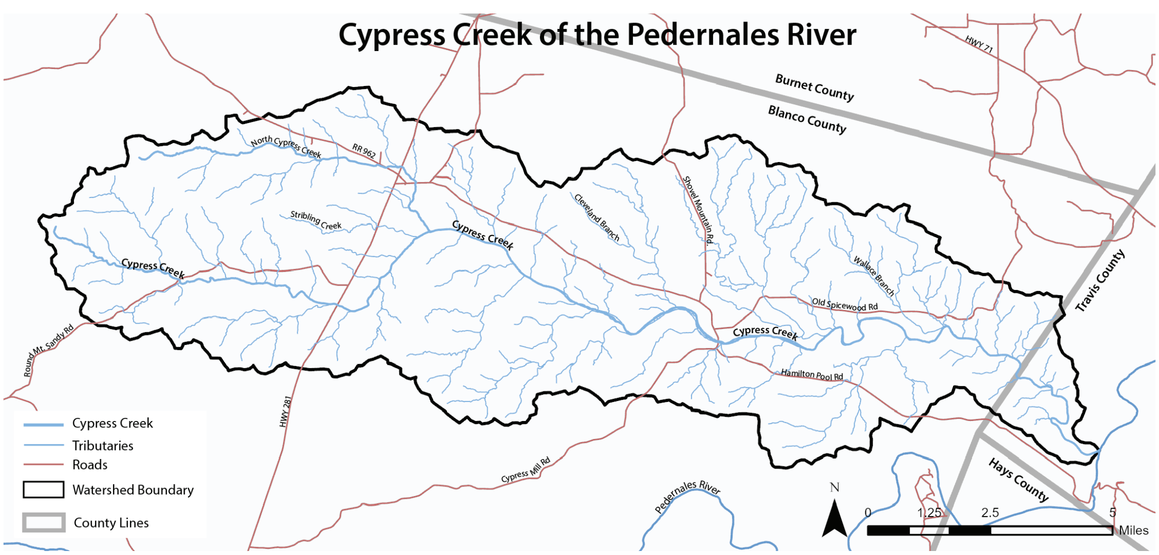

Figure 2. Hydrogeology of Cypress Creek Watershed

Cypress Creek flows eastward towards its confluence with the Pedernales River shortly before flowing into Lake Travis just west of Austin, Texas. In river miles, the creek is approximately 26 miles in length. The gradient is fairly uniform at approximately 31 ft per mile (Figures 3 and 4). Lake Travis is a reservoir on the Colorado River formed by Mansfield Dam. The Colorado River, managed by the Lower Colorado River Authority (LCRA), is the primary drinking water source for the City of Austin and surrounding communities, serving a population of 1.4 million. Despite their socio-ecological significance, headwater streams, such as Cypress Creek, are highly susceptible to alteration due to diverse land uses (Wohl, 2017). Cypress Creek's close coupling with groundwater interactions and adjacent riparian and terrestrial environments further underscores the importance of maintaining hydrological connectivity, water quality, and ecological integrity across the watershed. Currently, the Cypress Creek Watershed is sparsely developed and populated, making this a unique and timely study area.

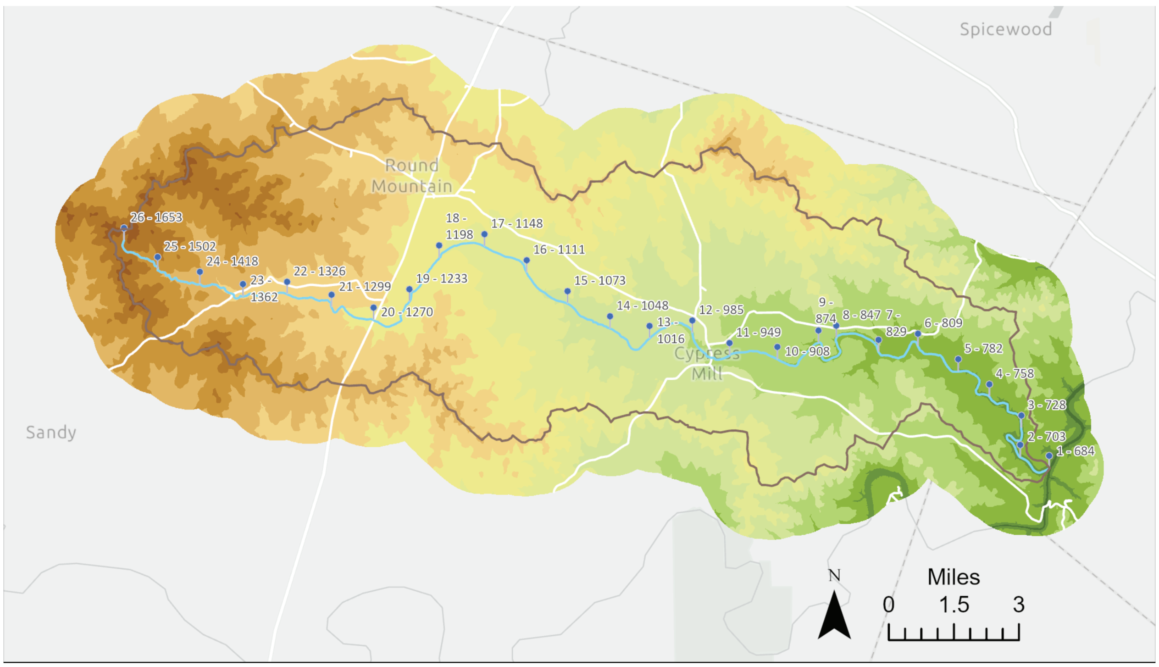

Figure 3. Elevation at river mile

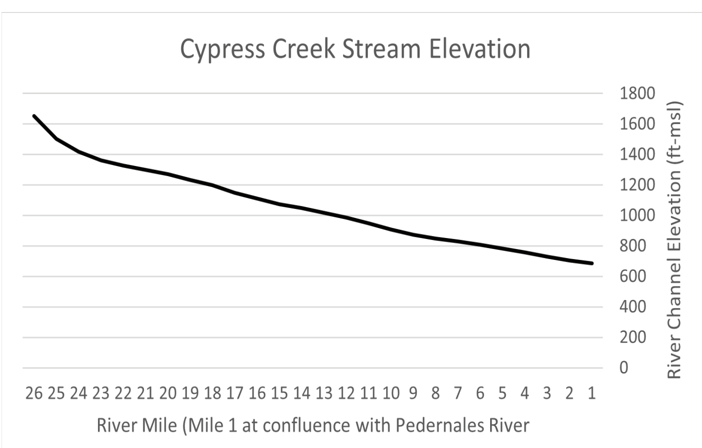

Figure 4. River gradient

The watershed has three distinct areas in terms of hydrogeologic character. The western area, west of Highway 281, is dominated by the Cretaceous Trinity Group strata. Both South Cypress and North Cypress Creeks originate in this area. Both creeks are ephemeral, or wet weather. The geology of the central watershed area consists of Paleozoic strata, primarily the Ellenburger/San Saba Group, in the center of the watershed and Cretaceous Trinity rocks on the upland flanks as show in Figures 5 and 6.

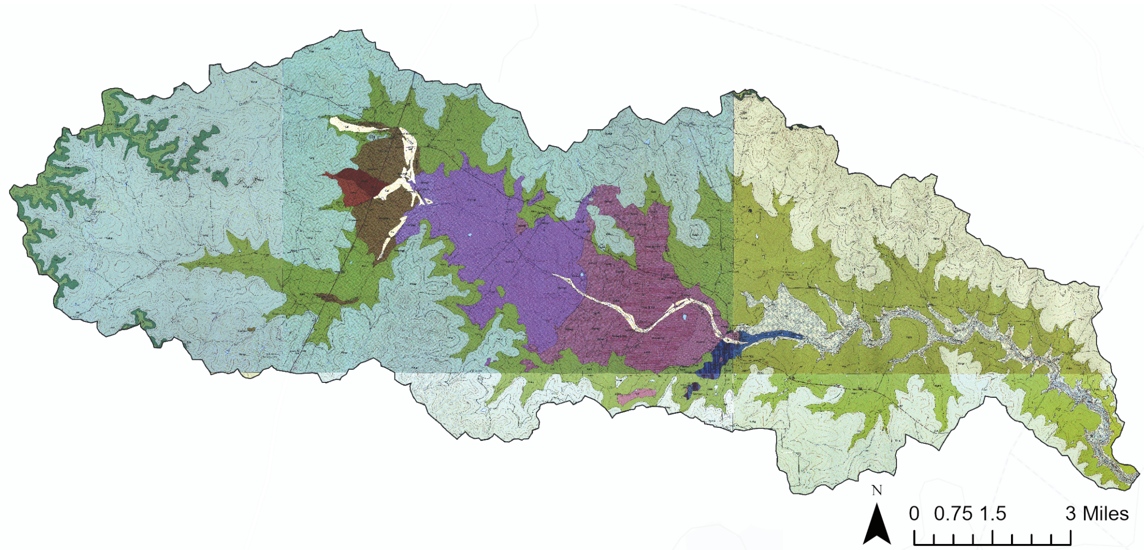

Figure 5. Geologic map of the Cypress Creek Watershed (source: GAT)

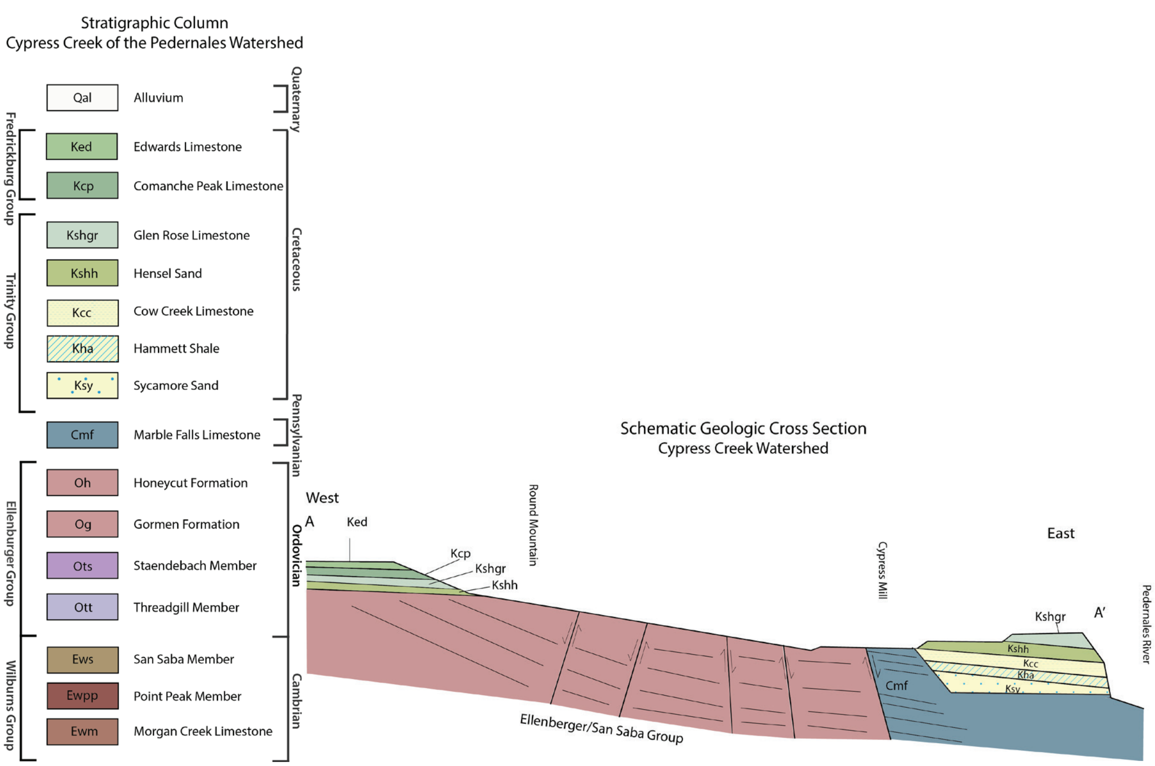

Figure 6. Stratigraphic column and cross section of the Cypress Creek Watershed (Wierman et al. 2021)

Major springs originate in Ellenburger and possibly the Marble Falls near Cypress Mill. There is a losing reach in the center of the central area with roughly half of the upstream flow lost during the two synoptic events as shown in Figure 7. Losses could be greater during drier times. Flow resumes downstream of the losing reach, including several permanent springs. It is not clear how the losing reach and downstream springs are related.

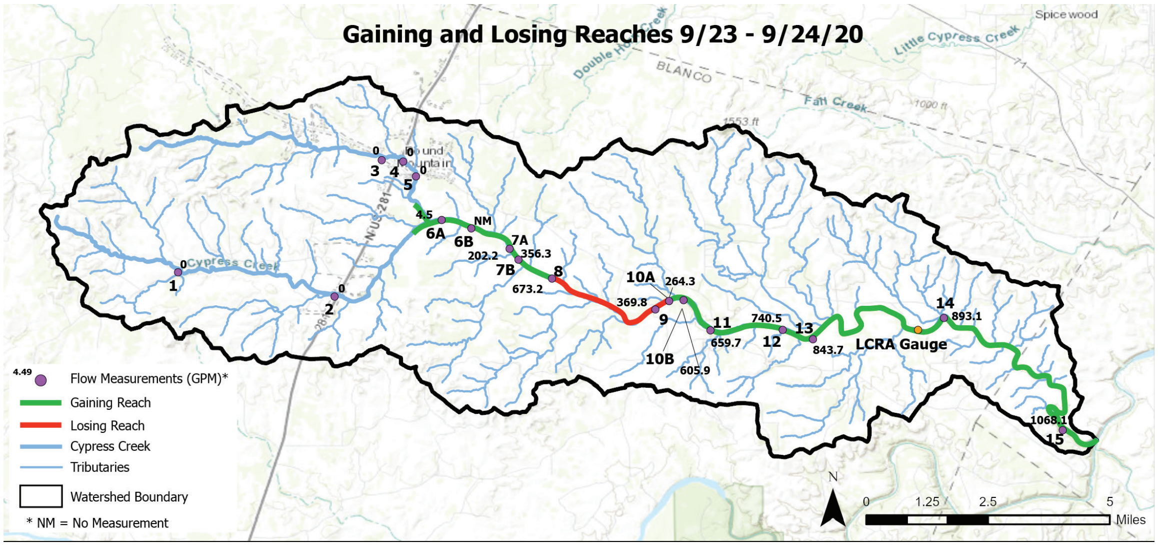

Figure 7. Surface water flow measurements (September 23, 2020)

The eastern area is characterized by the creek incised into the Trinity Group. Based on field measurements, flow roughly doubles across the eastern area. No major springs were observed or found in the literature over the eastern reach, though access was limited in this area. The flow increase is likely the result of local recharge discharging from the base of the more permeable strata, such as the Cow Creek, which is underlain by impermeable Hammett Shale. Groundwater flow directions determined from historic TWDB data are generally to the southeast. Southeasterly flow direction tends to follow the regional structure dip of the Paleozoic and Cretaceous aquifers.

Water quality results indicate good water quality, typical of carbonate aquifers. Little or no change was noted over the period of record (POR) of water quality sampling. The waters of the Paleozoic and Cretaceous aquifers and surface water are similar, and very young indicating a similar source. The aquifers and, therefore the creek, is supported by local recharge originating primarily in the watershed.

3.3 Phase 2 – Scope of Work

The study area for Phase 2 spanned from the headwaters of Cypress Creek west of Highway 281 to Hammett's crossing where Cypress Creek feeds into the Pedernales River. Phase 2 incorporated a preliminary analysis of historical data from the BPGDC and TWDB databases, composition of Geographic Information Systems (GIS) maps, stakeholder engagement, surface water and groundwater quality sampling, groundwater level measurements and laboratory analysis.

The scope of work performed during the Phase 2 study included the following:

1. Literature review of current research and gaps
2. Review, compilation and evaluation of data housed in the BPGCD Hydros Database and TWDB databases
3. Prepared/updated land use changes in the watershed based on the most current National Land Cover Database (NLCD)
4. Stakeholder outreach, including information distribution and engagement meeting, to identify groundwater wells available and suitable for monitoring
5. Synoptic groundwater level measurement event
6. Collection of groundwater samples for inorganic water quality parameters and age dating analyses
7. Surface water flow measurements and collection of surface water samples for inorganic water quality parameters
8. Preparation of this report incorporating newly collected data and incorporating data from Phase 1 where appropriate

Note: Historical aerial imagery analysis was explored but unsuccessful due to poor image quality prior to 2013.

4 Methods

4.1 Literature Review

A literature review was conducted to obtain background knowledge on Central Texas wells and groundwater as well as determine information gaps. Key search terms, including "groundwater-surface water interaction", "groundwater dating", "Central Texas aquifers", and "Texas groundwater law", were input into the Texas State University library database, the TWDB database, and Google Scholar to locate relevant and pertinent research. Additionally, the reference sections of past reports, including Phase 1 of this study, were utilized to extract additional articles relevant to this study. Overall, the literature review synthesized 26 research articles.

4.2 Land Cover Analysis

Due to the interconnection between land cover, base flow, and storm flow, a land cover analysis was conducted to assess changes in impervious cover and developed land over the past several years. GIS files of basin land cover data from 2001, 2016 and 2021 were obtained from the NLCD provided by the Multi-Resolution Land Characteristics (MRLC) Consortium (MRLC 2011). As stated in the Regional Water Quality Plan (2005), "In various published and unpublished reports and in unpublished data compilations, the City of Austin has indicated that physical and biological degradation of streams begins to occur at between five and eighteen percent (5-18 percent) impervious cover."

4.3 TWDB and BPGCD Database Evaluation

In addition to the wells monitored within the study, wells were identified through the BPGCD's Hydros database. All wells were exported from the database and ESRI ArcGIS software was used to reduce the sample size to wells within the Cypress Creek watershed only, resulting in 282 wells (Figure 8). For each of the extracted wells within the watershed, geolocation, address, land elevation, bottom of well elevation, well name, well ID, and State Well Number parameters were determined. The State Well Number was used to access any well reports within the TWDB database. However, when conducting the research, it was apparent not all wells within the watershed were present within the Hydros database or the TWDB database. In fact, out of the 47 wells selected for synoptic groundwater sampling based on the landowner responses from the outreach (discussed in more detail in section 4.4), only 27 were present on the Hydros Database.

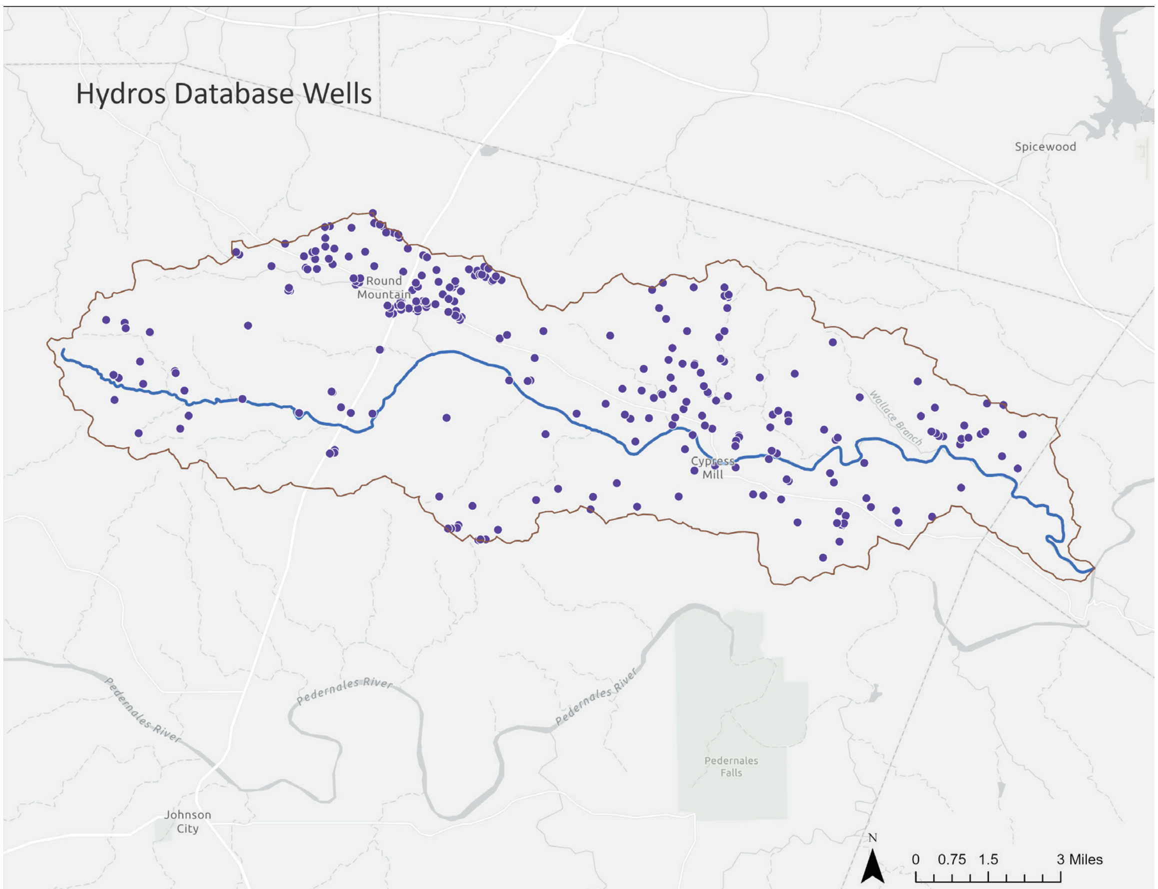

Figure 8. Wells from Hydros Database (n=282)

Figure 9 shows the wells monitored in the study. Unfortunately, not all of the identified wells could be measured due to inaccessible monitoring ports with only 30 being accessible. There are few wells on the south side of the creek with an increasing density of wells at Round Mountain and Cypress Mill. The majority of the wells monitored were in the Cypress Mill area.

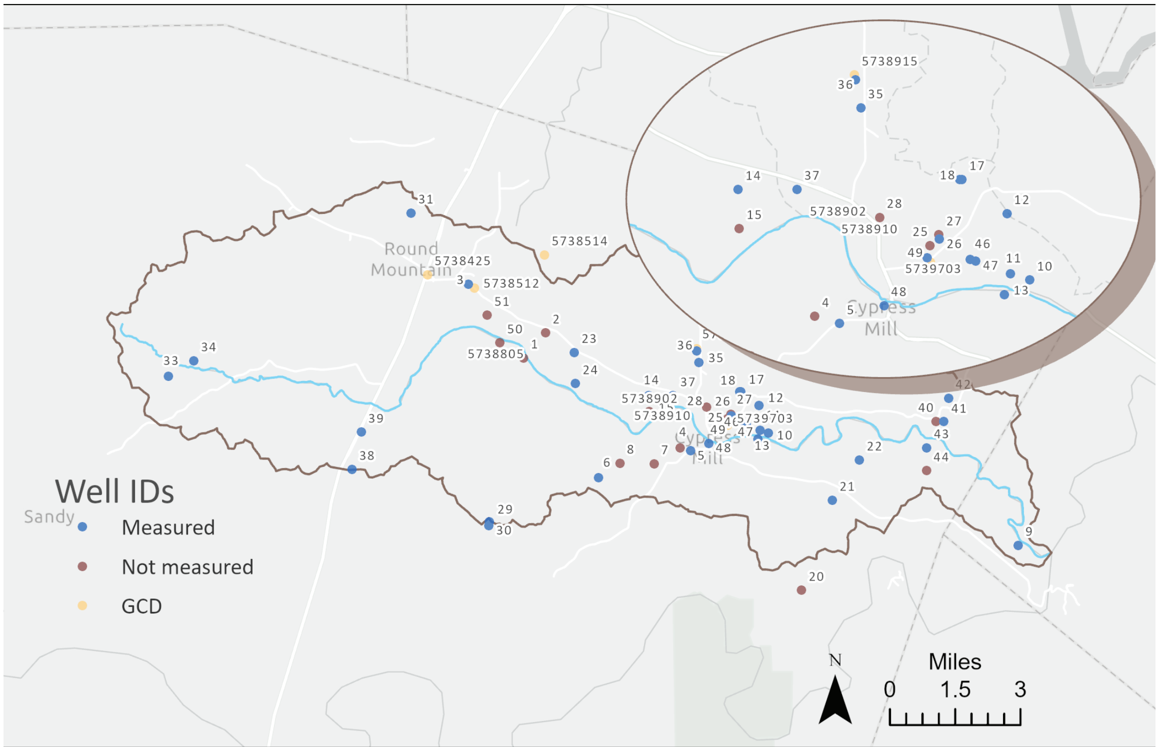

Figure 9. Study area wells (n=52 with 30 measured by MCWE, 17 not measured, and 5 measured by GCD)

4.4 Stakeholder Outreach and Engagement

Stakeholder engagement was utilized within this study to 1.) educate landowners on the project scope and goals and 2.) gain access to wells and surface water located on private property. To conduct this outreach, a list of names and addresses of residents within Blanco County was acquired from the county office. This list was used to send mailouts containing a press release and a flyer inviting landowners to an engagement

Figure 10. Douglas Wierman presenting at the stakeholder engagement meeting (photo credits: Nicky Vermeersch)

meeting about the study. A total of 456 were sent out to landowners with 49 returned to sender. The Landowner-Stakeholder Engagement meeting was hosted at St. Luke's Episcopal Church on June 1, 2024, where landowners were given the opportunity to learn about Phase 1 and 2 of the study and identify their private wells on a map (Figure 10). The engagement meeting had an attendance of 37 stakeholders and landowners with 13 landowners submitting information sheets to convey their interest in having their wells sampled. Landowners were subsequently contacted to schedule sampling and monitoring days. Information sheets were supplemented with landowners who participated in the Phase 1 study.

Figure 11. MCWE staff conducting a well level measurement using a sonic meter (photo credits: Nicky Vermeersch)

4.5 Synoptic Groundwater Level Measurements

Data on groundwater elevation is an essential component that can be used to guide water management strategies as well as monitor changes in water availability. MCWE conducted four separate groundwater monitoring events on July 24, 30, and 31, and August 7, 2024, to determine groundwater elevation at 47 wells across the Cypress

Creek Watershed (Appendix A-Field Work Datasheet). However, out of the 47 wells visited, only 30 wells were accessible to obtain a depth to water measurement. On each of the days, well 10 was measured to act as a control for external factors. At each well, the depth to water, stick-up height, and coordinates were determined. Respectively, the depth to water was measured using a WL650 Sonic Water Level Meter, as seen in Figure 11, and/or an Eline, stick up was measured using a measuring tape, and coordinates were gathered using Google Earth. In addition to the data gathered in the field, land elevation was determined at each well site by using Google Earth. To determine groundwater elevation, the stick-up height was added to the land elevation and subsequently, depth to water was subtracted. In addition to the groundwater elevation data collected directly by MCWE, historical well data was acquired from the BPGCD Hydros database as well as the TWDB well database, which was described in more detail in the previous section.

4.6 Groundwater Sampling

MCWE gathered groundwater samples from 13 out of 47 wells during three separate monitoring events on July 30 and 31, and August 7, 2024. Prior to collecting the sample, a hose was connected to the well faucet and allowed to dispense water continuously into a 5-gallon bucket in order to purge the piping and pressure tank. A YSI EXO1 multiparameter sonde was placed in the bucket and conductivity and temperature values were closely monitored. Once the values were stabilized and representative of the groundwater, conductivity (µS/cm), dissolved oxygen (mg/L), pH (s.u.), and water temperature (°C) measurements were acquired. To collect a sample, a sterile 125mL Nalgene HDPE bottle was rinsed twice with sample water before filling it with sample water for analysis. Samples were kept on ice for the duration of the day and delivered to the Newton/Schwartz lab at Texas State University to be analyzed for cations (lithium, sodium, ammonium, potassium, magnesium, manganese, calcium, strontium, and barium), anions (fluoride, chloride, nitrite, nitrate, bromide, phosphate, and sulfate), and alkalinity. The respective methods for these parameters were ATSM D6919 (cations), EPA 300.1 A (anions), and the preprogramed P_M Alkalinity (alkalinity). The samples were also analyzed for hardness by the Edwards Aquifer Research and Data Center (EARDC) lab using Standard Methods 2340C.

On December 10, 2024, five out of 47 wells were sampled for percent modern carbon (pMC) or fraction modern carbon. pMC was converted to apparent radiological age before present (BP). Prior to collecting the sample, a hose was connected to the well faucet and allowed to dispense water continuously into a 5-gallon bucket. As well water was dispensed into the bucket, water measurements of pH (s.u.), temperature (°C), and conductivity (µS/cm) were taken at five-to-ten-minute increments for a total of three to five sets of measurements to ensure the water being sampled was fresh as opposed to from the piping or pressure tank. To collect a sample, a sterile 1000mL Nalgene HDPE bottle was rinsed twice with sample water before filling it with sample water for analysis, ensuring no air bubbles were trapped in the bottle. The joint between the bottle and cap was then wrapped with electrical tape in a clockwise direction before placing the sample on ice. Samples were delivered to the LCRA laboratory to analyze modern carbon-14 using Standard Accelerator Mass Spectrometry (AMS).

4.7 Surface Water Sampling and Discharge

MCWE gathered surface water samples and measured stream flow at 6 locations along Cypress Creek on September 18, 2024. At each site, the YSI EXO1 multiparameter sonde was used to gather data on conductivity (µS/cm), dissolved oxygen (mg/L), pH (s.u.), and water temperature (°C) (Figure 12). A 125mL Nalgene HDPE samples bottle was then rinsed twice using sample water before collecting the official sample for lab analysis. Lastly, a SonTek FlowTracker2 was used to measure stream flow along the width of the creek. However, due to low flows at all 6 of the sites, 4 out of the 6 measured flow values were inaccurate. To address this deficiency, visual flow observations were made on September 18. The surface water quality samples were delivered to the Newton/Schwartz lab at Texas State University to be analyzed for cations (lithium, sodium, ammonium, potassium, magnesium, manganese, calcium, strontium, and barium), anions (fluoride, chloride, nitrite, nitrate, bromide, phosphate, and sulfate) and alkalinity. The respective methods for these parameters were ATSM D6919 (cations), EPA 300.1 A (anions), and the preprogramed P_M Alkalinity (alkalinity). The samples were also analyzed for hardness by the EARDC lab using Standard Methods 2340C.

Due to difficulties in measuring very low flows, supplemental flow data was acquired through LCRA. Raw flow data was acquired for flow gages 3558 (Cypress Creek near Cypress Mill) from 2006 to 2024.

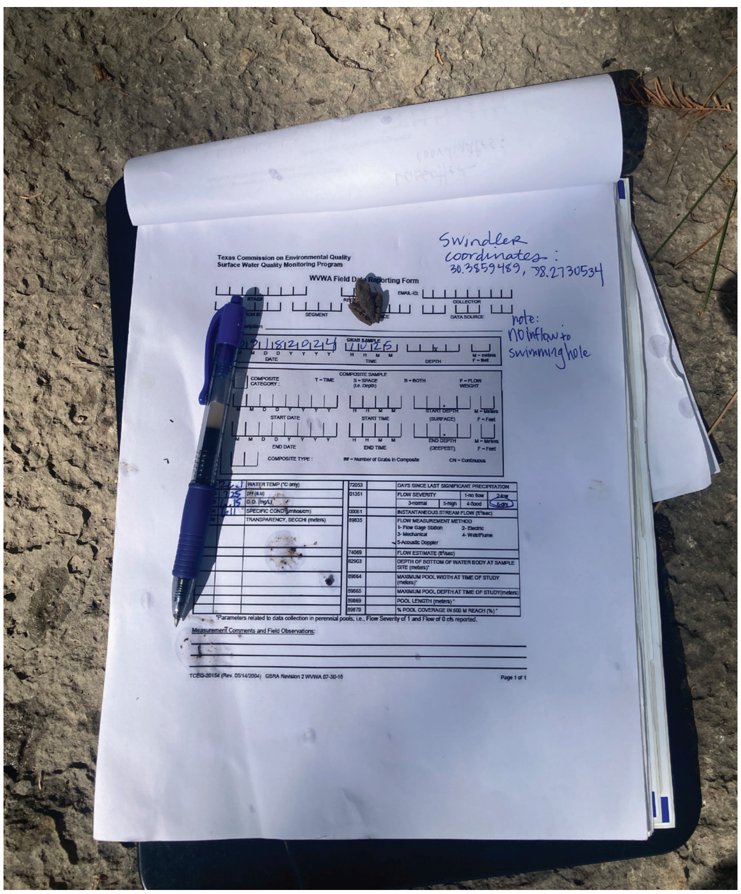

Figure 12. Frog resting on MCWE staff's clipboard while conducting surface water samples and measurements (photo credit: Jenna Walker)

4.8 Stormwater Sampling

Stormwater samples were gathered from a runoff producing rain event on January 30, 2025. Two samples were gathered at Cypress Creek at FM 962. The samples were delivered to the Newton/Schwartz lab at Texas State University to be analyzed for cations (lithium, sodium, ammonium, potassium, magnesium, manganese, calcium, strontium, and barium), anions (fluoride, chloride, nitrite, nitrate, bromide, phosphate, and sulfate), alkalinity, total phosphorus, total nitrogen, total dissolved solids/ conductivity, and alkalinity. The respective methods for these parameters were ATSM D6919 (cations), EPA 300.1 A (anions), preprogramed P_M Alkalinity (alkalinity), modified Standard Method 4500-P F (total phosphorus), modified Crumpton et al. (1992) (total nitrogen), and SM 2540 C (total dissolved solids). The samples were also analyzed for hardness by the EARDC lab using Standard Methods 2340C.

In addition to the samples acquired from the stormwater sampling event, water quality data for monitoring site 12258 on Cypress Creek at FM 962 was downloaded from the Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Web Reporting Tool. Historical data for chloride, fluoride, sulfate, total phosphorus, specific conductance, and total nitrogen were extracted for analysis.

4.9 Report Compilation

The final report for Phase 2 was put together using data from Phase 1 as well as newly acquired data from Phase 2. Particularly, GIS, water chemistry analysis, surface water discharge, hydrogeology, and land cover data (2001 and 2016) that was collected in Phase 1 was used to support the completion of Phase 2. New data from Phase 2 included water chemistry analysis for both wells and surface water, well elevation data (gathered in field and from Hydros and TWDB databases), surface water flow from LCRA gauges, and land cover data from 2021.

5 Results

The Phase 2 study field work occurred during 2024, which was a period of very low precipitation, and therefore greatly diminished stream flow as compared to the Phase 1 study (data collected Fall of 2020). Due to low flows, routine manual stream flow measurements are not conducted on Cypress Creek, though the LCRA maintains a gauging station on the creek (LCRA Gauge 35558) east of the RM 962/Cypress Creek intersection in Cypress Mill.

5.1 Land Use/ Land Cover Change

Land cover, particularly developed land use, can play a role in determining water quality, and both storm flow and base flow. Increased impervious cover, septic systems, organized sewage treatment, and non-point source pollution, such as agriculture, can impact water quality. GIS files of basin land cover data from 2001, 2016 and 2021 were obtained from the NLCD provided by the MRLC Consortium (MRLC 2016). NLCD is updated every five years. Figures 13-15 indicate between 2001 and 2021 land cover of the Cypress Creek watershed. An explanation of NLCD land cover types is included in Appendix B.

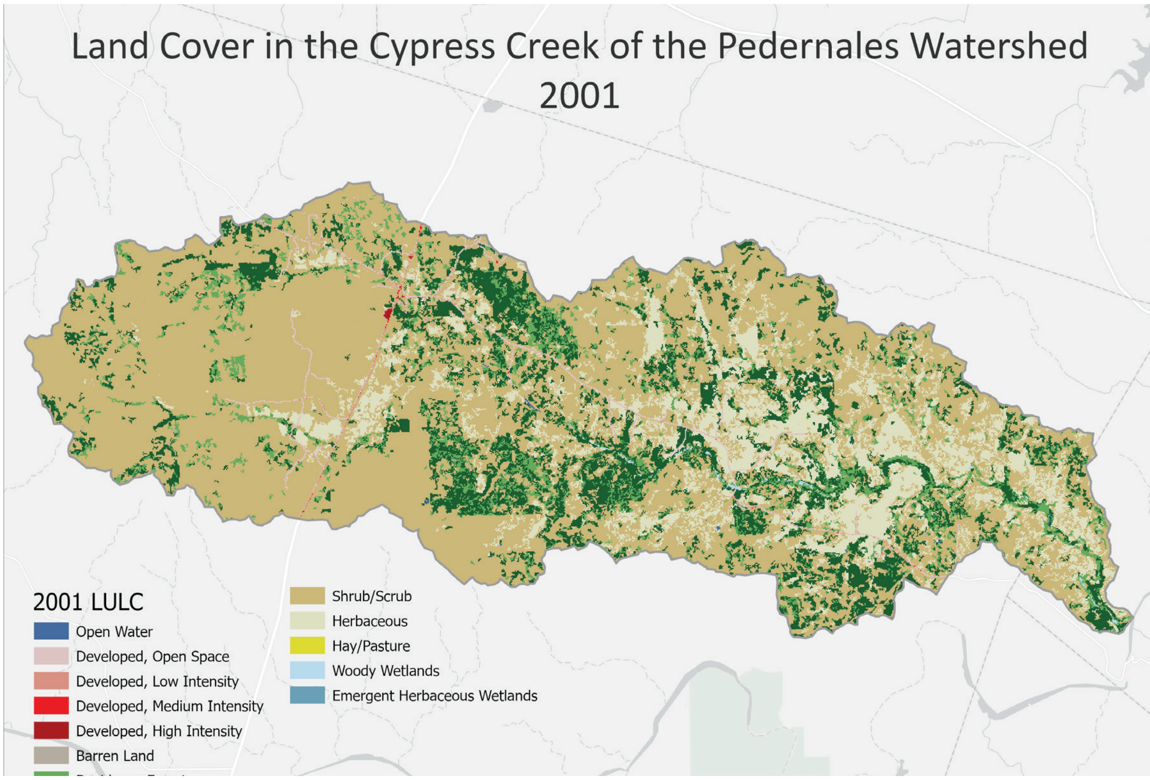

Figure 13. Land use land cover for 2001

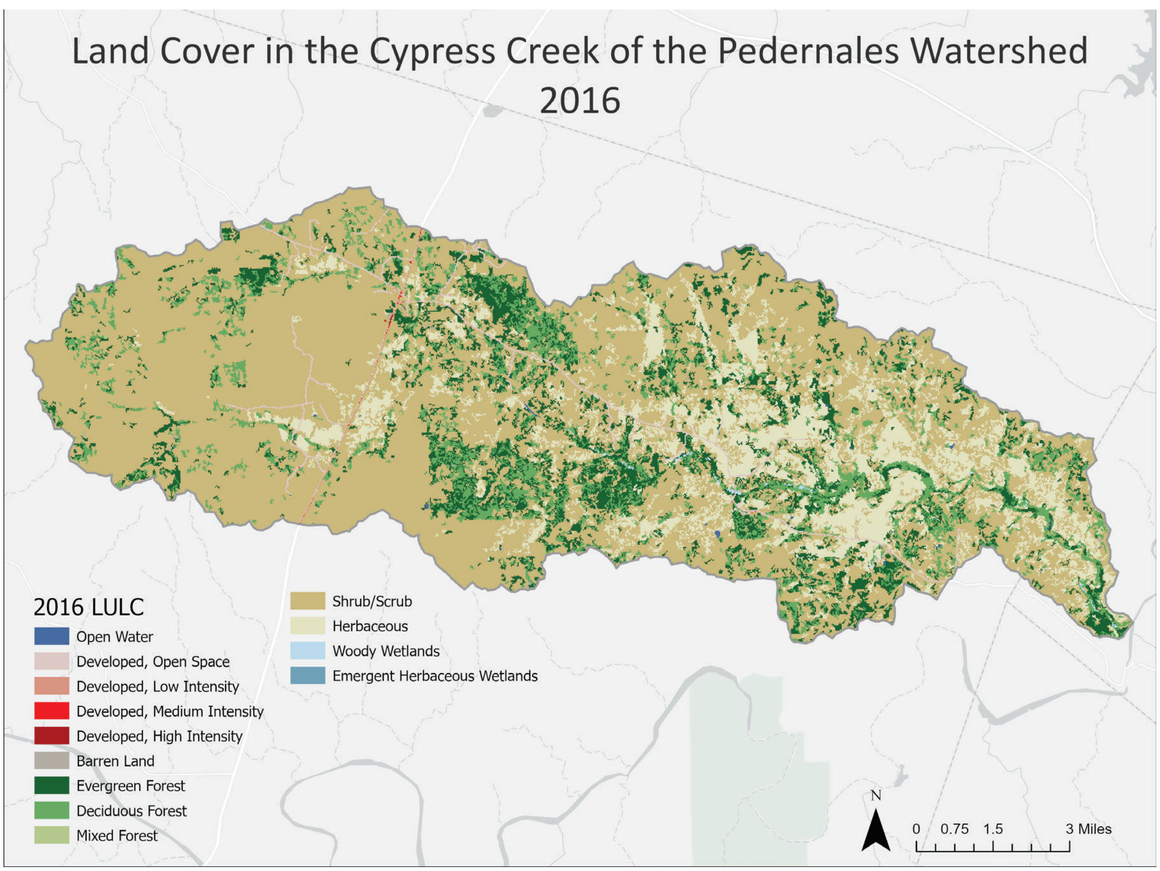

Figure 14. Land use land cover for 2016

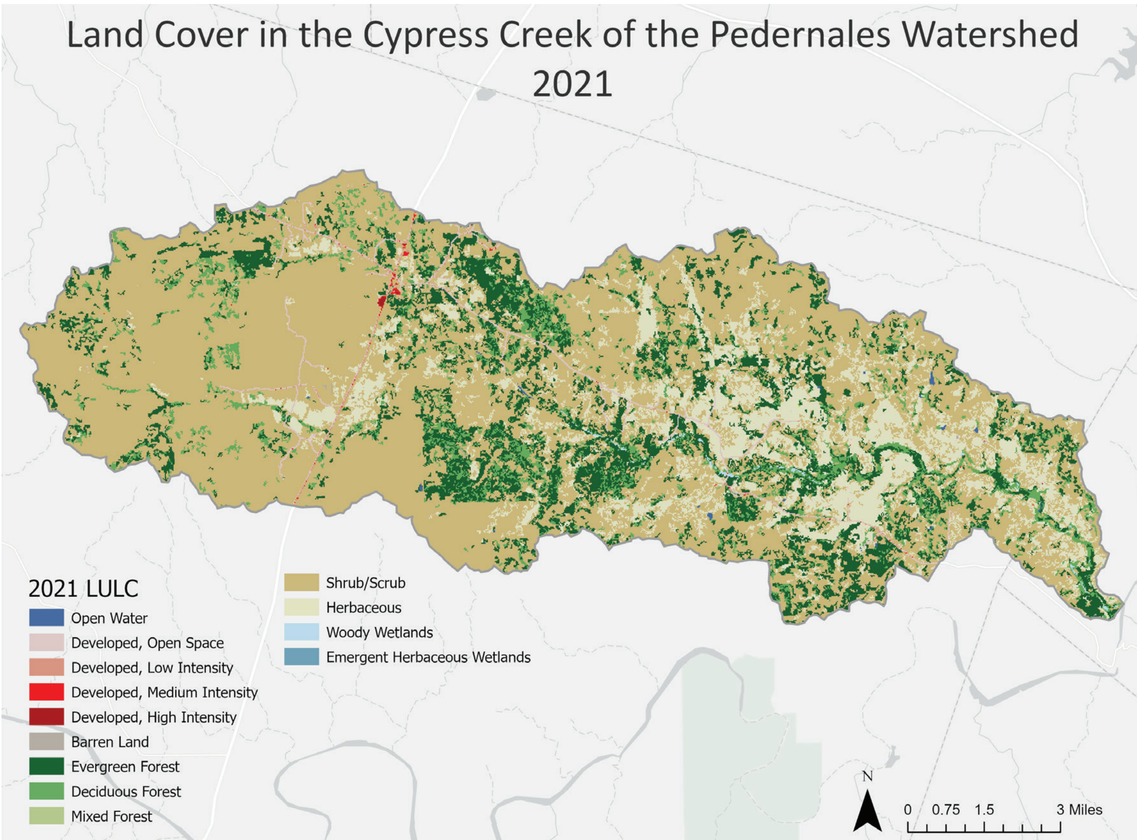

Figure 15. Land use land cover for 2021

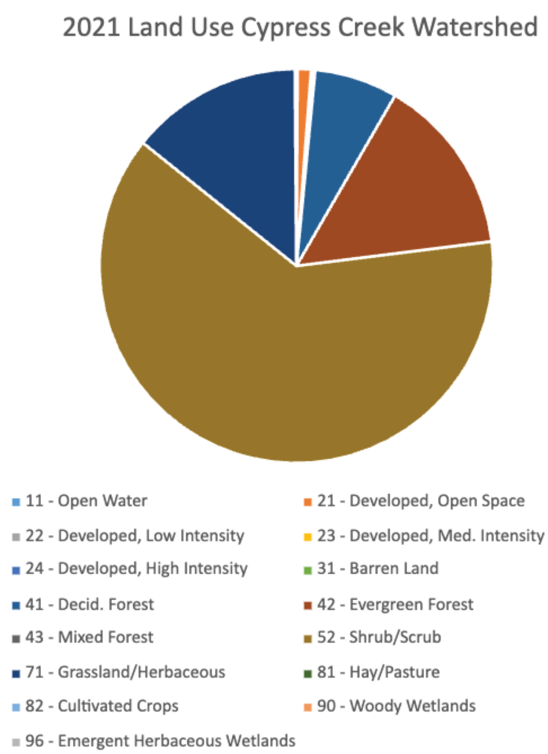

Figure 16. 2021 land use in the Cypress Creek Watershed

Table 1. Acreage and percentage of land classifications based on year.

CLASSI-FICATION VALUE	2001 ACREAGE	2016 ACREAGE	2021 ACREAGE	2001 PERCENT-AGE	2016 PERCENT-AGE	2021 PERECENT-AGE	DIFF ACREAGE 2021 - 2001
11 - Open Water	27.4	32.5	44.3	0%	0%	0%	16.9
21 - Developed, Open Space	399.0	543.3	582.9	1%	1%	1%	183.9
22 - Developed, Low Intensity	60.5	67.2	101.9	0%	0%	0%	41.4
23 - Developed, Med. Intensity	9.6	8.7	33.8	0%	0%	0%	24.2
24 - Developed, High Intensity	7.1	3.8	11.8	0%	0%	0%	4.7
31 - Barren Land	1.8	39.6	22.3	0%	0%	0%	20.5
41 - Decid. Forest	6918.0	5159.8	3568.6	13%	10%	7%	-3349.4
42 - Evergreen Forest	7382.7	6046.4	7651.5	14%	12%	15%	268.8
43 - Mixed	1.6	6.7	6.3	0%	0%	0%	4.7
52 - Shrub/ Scrub	26240.8	32690.5	32757.5	50%	63%	63%	6516.7
71 - Grassland/ Herbaceous	11004.3	7574.6	7380.0	21%	15%	14%	-3624.3
81 - Hay/ Pasture	0.0	0.0	0.3	0%	0%	0%	0.3
82 - Cultivated Crops	129.2	0.0	0.0	0%	0%	0%	-129.2
90 - Woody Wetlands	40.3	48.7	60.5	0%	0%	0%	20.2
96 - Emergent	0.0	0.4	0.6	0%	0%	0%	0.6
	52222	52222	52222	100%	100%	100%	

The majority of the watershed is deciduous forest, evergreen forest, shrub/scrub and grasslands, totaling 99 percent of the land area (Figure 16). Less than 1 percent (254 acres) of the watershed was developed. Table 1 includes a listing of land cover types with a detailed description of each type contained in Appendix B.

The land cover data sets from 2001 and 2021 were compared to determine land cover changes over the twenty-year period (Figure 17). The most striking change in land use was the conversion of deciduous forests and grassland to shrub/scrub lands. The increase in shrub/scrub land was over 6000 acres. Though a small percentage of the total acreage of the watershed, all classes of developed land increased to 1035 acres in 2021 from 477 acres in 2001. Most of the increase occurred along the HWY 281 corridor. Developed land use (low, medium and high density) totaled less than 150 acres (<1%) of the 52,222 acre watershed. The watershed remains rural, with little development.

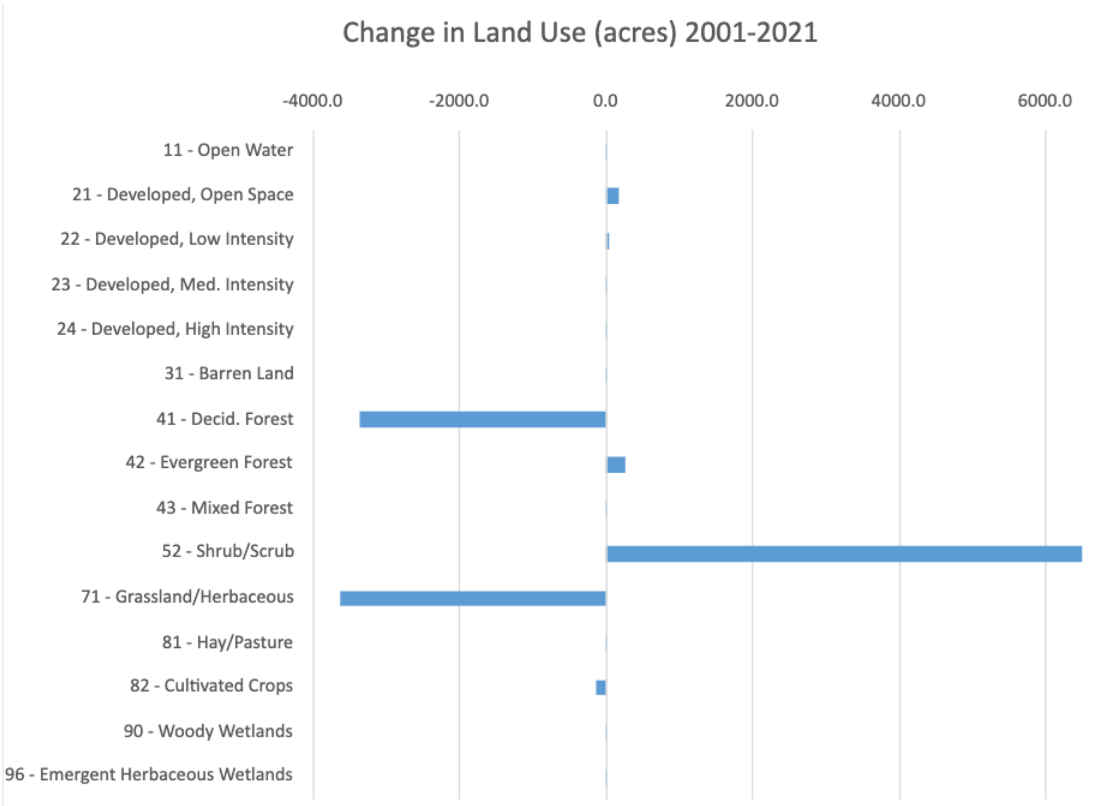

Figure 17. Changes in land use (acres) from 2001 - 2021.

5.2 Hydro Data Mining

Groundwater levels within the watershed have been monitored at several wells over the years by the BPGCD and TWDB. Historic trends in groundwater can be indicative of the health of the aquifer and provide data in determining surface water/groundwater interactions. The five wells with historical records are included in Table 2 and locations shown on Figure 9. Hydrographs for the period of record (POR) for the wells are included on Figures 18-22. Additionally, flow data was obtained from the LCRA Hydromet database for the flow gauge at Cypress Creek near Cypress Mill (3558). The POR for Gauge 3558 spanned from January 2006 to March 2024.

Table 2. Summary of data from historical measured water level

STATE WELL REPORT NUMBER	COMMON NAME	DATA COLLECTION AGENCY	COMPLETION FORMATION	WELL DEPTH (FT)	PERIOD OF RECORD	DEPTH TO WATER RANGE (FT BGS)
5738425	Version	BPGCD	Ellenburger	145	2010 - present	3 - 26
5738512	Jackson/Round Mt	TWDB	Ellenburger	110	1995 - 2011	50 - 60
5738514	Stoneridge/ Round Mt Ranch	BPGCD	Ellenburger	300	2017 - present	135 - 170
379833	Shovel Mt	BPGCD	Trinity/ Ellenburger	200	2022 - present	57 - 65
5739703	Old Windmill	TWDB	Trinity/ Marble Falls	180	1968 - 2011	40 - 63

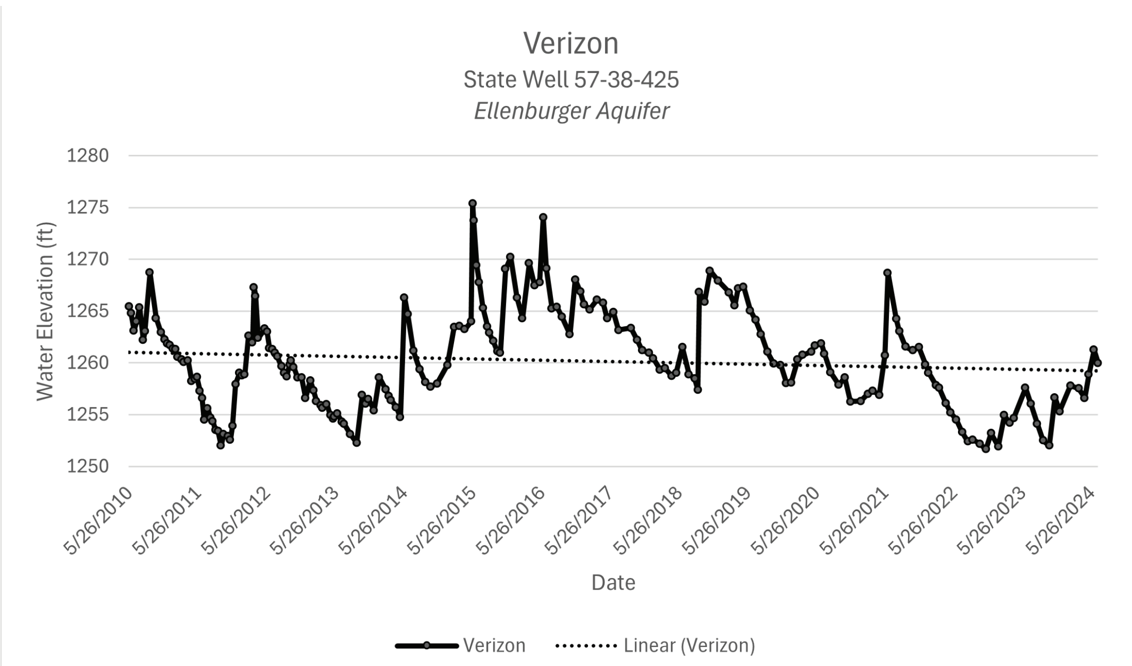

Figure 18. Verizon well water elevation results from 5/26/2012 to 7/2/2024 (source: TWDB, 2024)

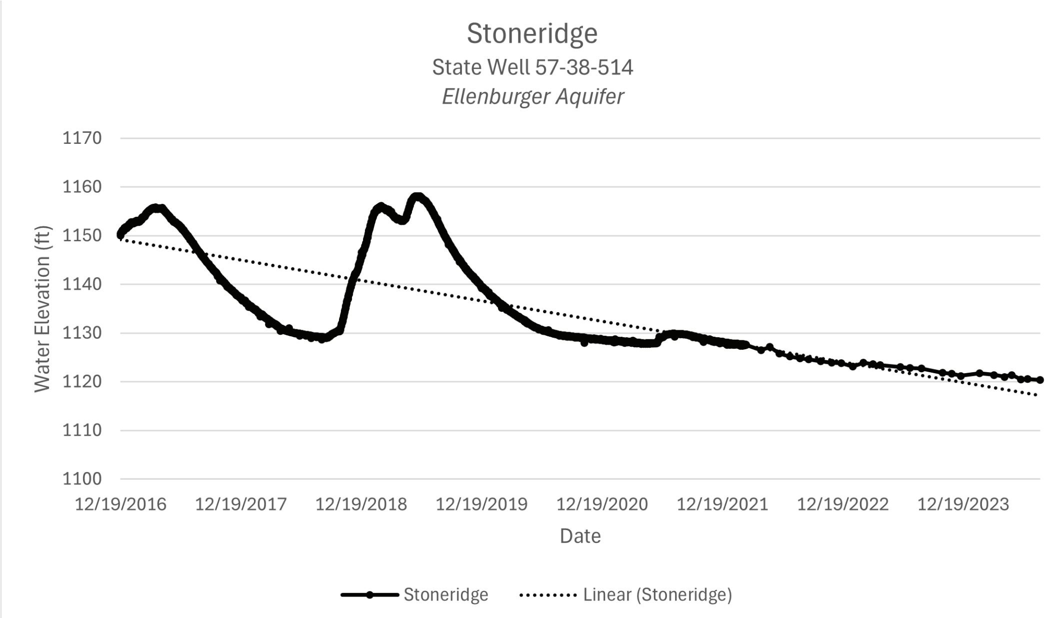

Figure 19. Stoneridge well water elevation results (source: TWDB, 2024)

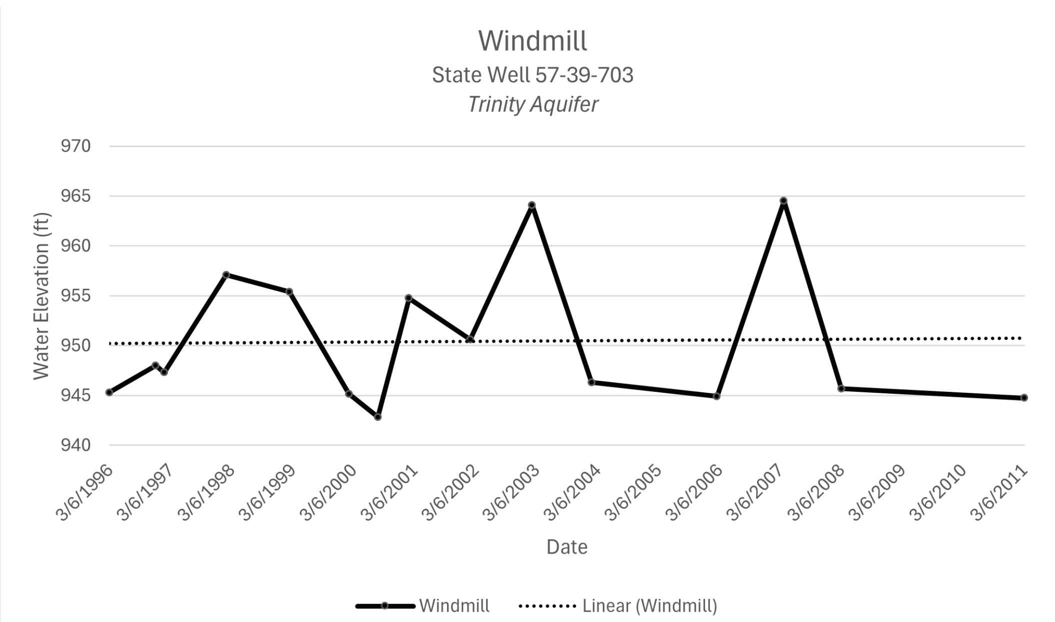

Figure 20. Windmill well water elevation results (source: TWDB, 2024)

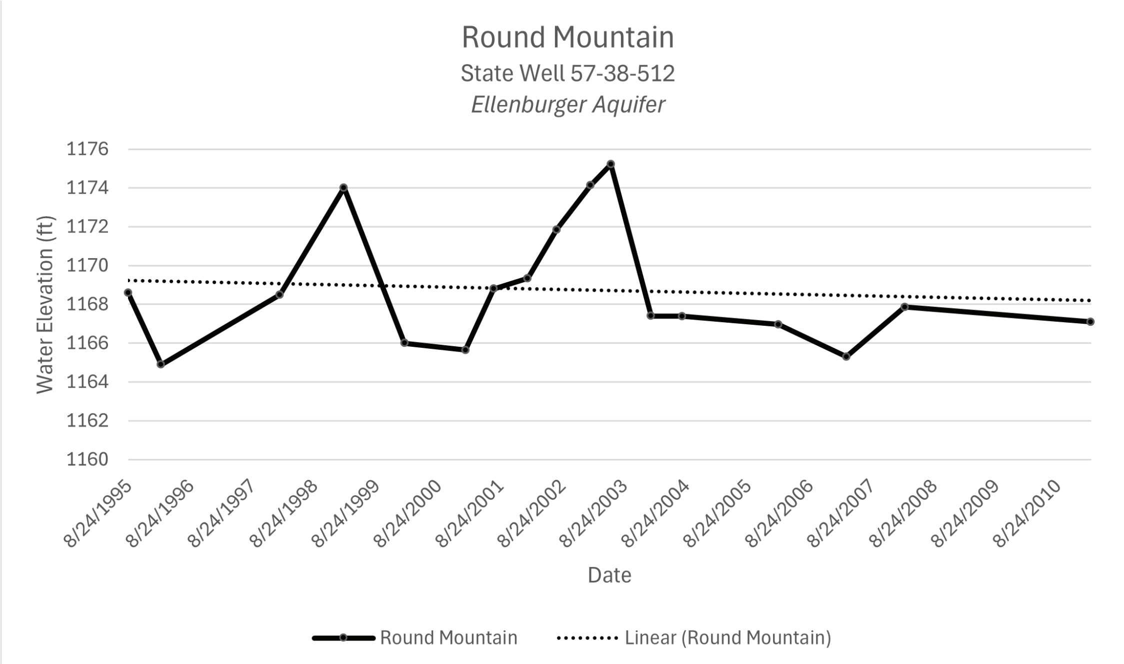

Figure 21. Round Mountain well water elevation results (source: TWDB, 2024)

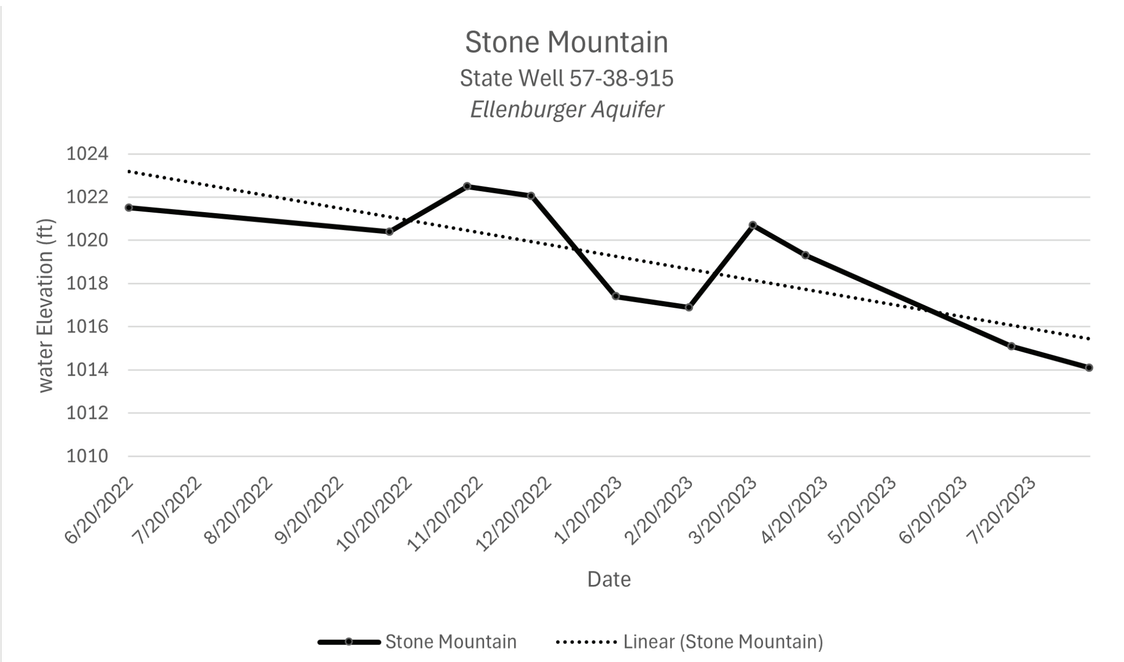

Figure 22. Stone Mountain well water elevation results (source: TWDB, 2024)

Figure 23 is an updated graph from Phase 1 of the flow in the creek as measured at LCRA Gauge 3558. The gauge indicates little or no flow since 2022. The mean daily discharge for the POR is 9.9 cfs with a median discharge of 1.9 cfs. The drought period since 2022 has resulted in the overall average mean daily flow and median flow decreasing to 0 cfs and 0 cfs, respectfully.

The oldest set of recorded water levels were obtained at the Windmill Well. There is no discernable upward or downward trend over the POR. A water level measurement

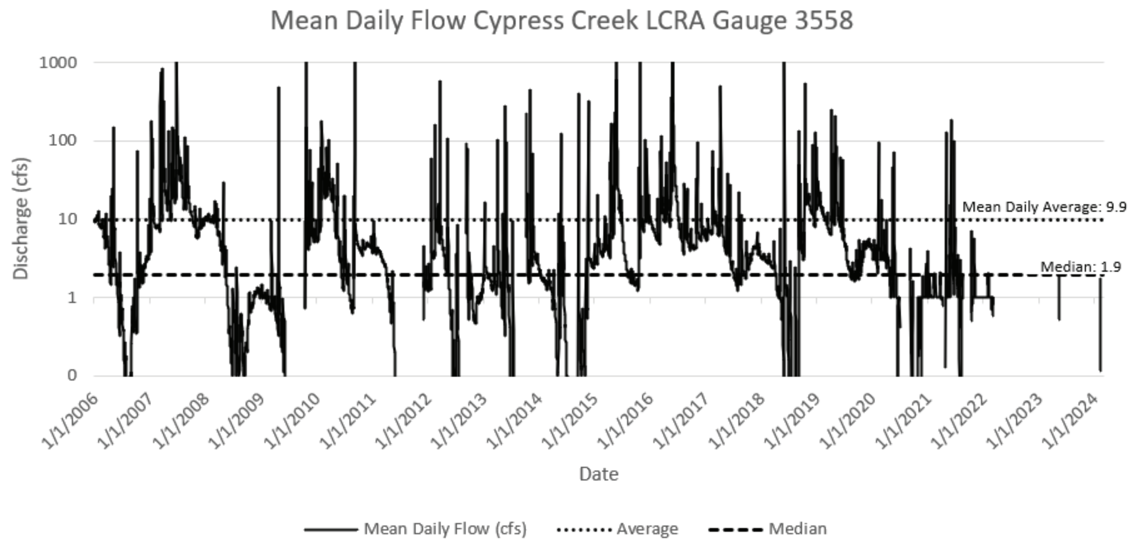

Figure 23. Stone Mountain well water elevation results (source: TWDB, 2024)

obtained during the current investigation was at the lower end of the range of historic levels.

The longest POR is at the Verizon Well. The water elevation data from the Verizon Well correlates strongly with the flow data of Gauge 3558, with strong depressions for both groundwater elevation and flow in 2011, 2013, and 2018. Furthermore, both groundwater elevation and flow dropped dramatically in 2022 and into 2023. Water levels have been trending downward since the wet period of 2015-2016.

Water levels in the Stoneridge Well peaked in 2017 and 2019 but have been in steady decline from 2020 to the present. Water levels have declined by ~40 ft. The wet period in 2021 was not reflected in groundwater levels at the Stoneridge Well. The Shovel Mt Well also indicates declining water levels since 2022, the POR for that well.

Though the historic water level record for both surface water and groundwater is limited, several observations can be made. Water levels tend to react to major wet and dry periods, with short rebound periods between dry and wet conditions. Two of the still actively monitored wells indicate declining water levels since the 2021-22 wet period.

5.3 Groundwater

5.3.1 Regional Groundwater Flow

To characterize regional groundwater flow, groundwater level data from the Hydros database were utilized. The database contains water level information, primarily from driller's well logs, measured when the well was drilled. 36 water level measurements were available. The wells were drilled over the period of many years therefore the levels reflect water levels conditions when the well was drilled. These data cannot be used to develop a synoptic potentiometric surface map, but general, regional flow directions can be determined. Figure 24 is a compilation of all of the historic water levels from the database. The Kriging method estimates values at unknown locations using the spatial correlation between the known values of nearby locations. It is assumed that closer points have more similar values than those farther away. Empirical Bayesian Kriging (EBK) estimates the spatial correlation between points using the data provided, rather than using a pre-defined model, while also accounting for uncertainty. EBK is a flexible method for sparse datasets.

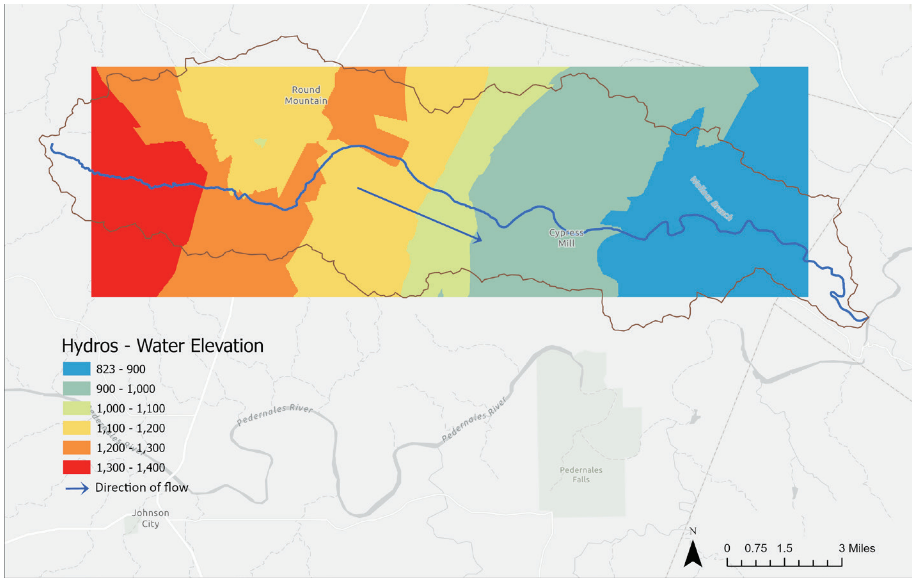

Figure 24. Hydros regional kriged water elevation map

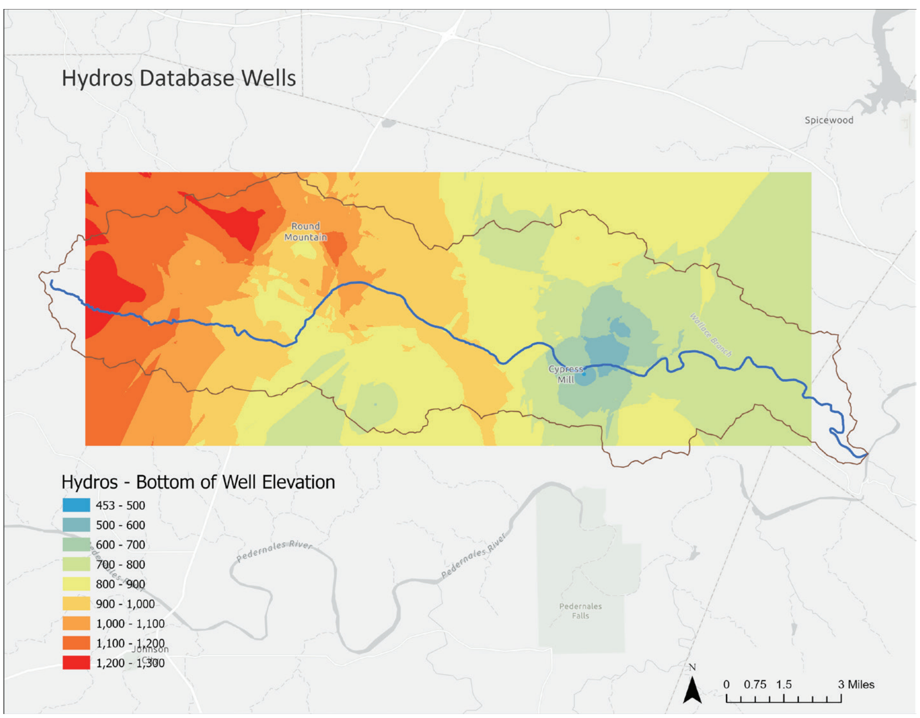

Figure 25. Bottom of well elevation from Hydros wells

Regional groundwater flow is from the west to east/southeast, similar to the regional dip of the underlying geologic strata. Elevations range from over 1400 ft msl to under 850 ft msl. Water levels obtained during this investigation are generally lower than the historic data ranges in the area immediately down gradient of Cypress Mill. Water levels in wells in the central area of the watershed are within the range of historic data.

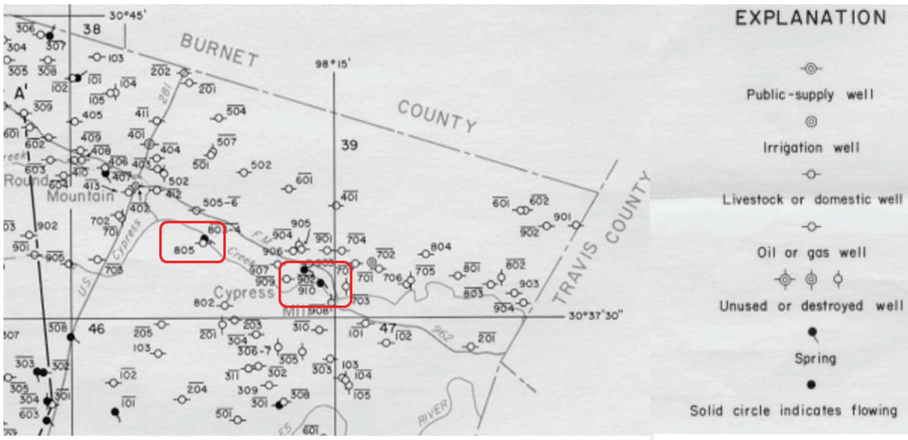

Figure 26. Well and spring locations (Follet 1973)

The Hydros data was also used to develop a map showing the bottom elevation of wells within the watershed. (Figure 25). The bottom of well elevations may relate to the elevation of water producing zones within the various aquifers. In general, shallower elevations may be related to shallower groundwater and hence possibly supporting spring flows (Figure 26). An area of relatively shallower groundwater is present in the vicinity of Cypress Mill. There is an area of very deep wells near Round Mountain.

Also shown are the synoptic water levels obtained during the current investigation (Figure 27). Results from the synoptic water level are reflected in the distribution of wells available for measurement and overall distribution of wells in the watershed. Many of the wells are in the vicinity of Cypress Mill. Measurements were made between July 24 and August 7, 2024. There was no significant precipitation during

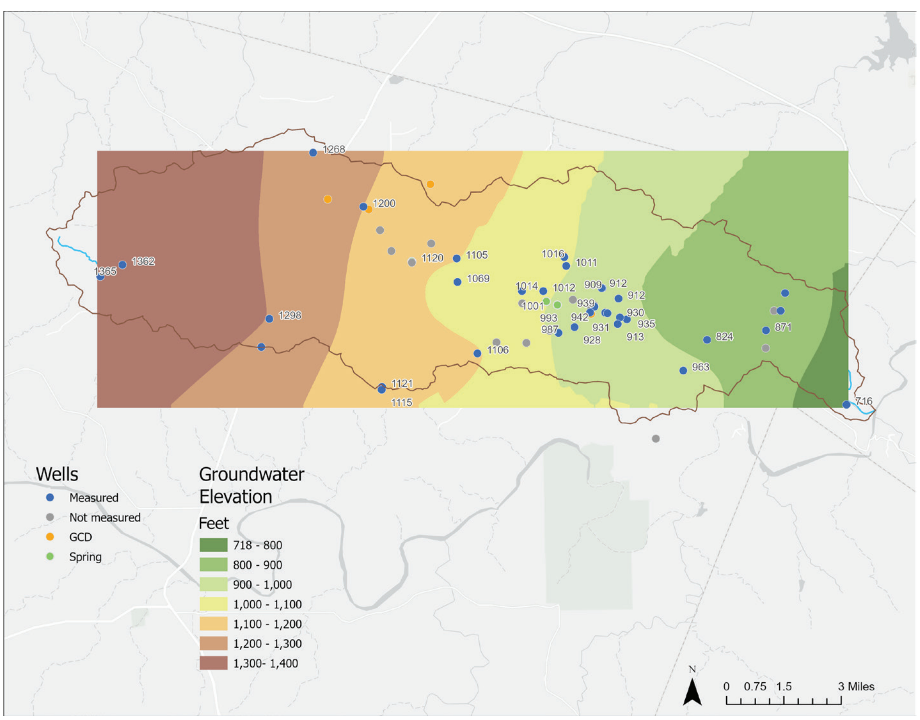

Figure 27. Synoptic groundwater elevations

the measurement period. Water levels at the control well (10) were steady. To aid in determining surface water/groundwater interactions and potential source areas for spring flow, creek elevations and location of documented springs were considered.

Groundwater measurements during the synoptic event are consistent with regional groundwater flow, namely west to east flow directions. Groundwater levels range from a high of ~1300 ft msl in the westernmost wells measured to 715 ft. msl near the confluence with the Pedernales River.

The origin of spring flow appears to be the result of several factors relating to geologic structure. At the western spring area, springs occur in an area of mapped southwest-northeast trending geologic faults in the Ellenburger formation (Barnes, V.E., 1978, Barnes, V.E., 1982a). The faults create a pathway for shallow groundwater, including the springs, to discharge into the creek. At this location, springs occur on both the north and south side of the creek. Groundwater levels at wells in the vicinity of the creek are above the base of the stream, setting up a gradient to the creek from the Ellenburger Formation.

Spring flow from the larger springs located just upstream of Cypress Mill occurs in the base of the creek. There are a series of mapped faults of the Ellenburger which provide a pathway for groundwater discharge via spring flow. There is a groundwater gradient in an area of mapped faults from north to south. There were an insufficient number of wells on the south side of the creek to measure flow directions. In general, water levels in wells near the springs were above the elevation of the spring, indicating a shallow groundwater source for spring flow.

The younger Marble Falls Formation has been down faulted along the Ellenburger Formation. The fault zone contact between the Ellenburger and Marble Falls Formations trends southwest to northeast. The Marble Falls is exposed along the creek in a narrow strip east of Cypress Mill. The Marble Falls is unconformably overlain by the Hensel Formation of the Trinity Aquifer System. The fault is not propagated up through the overlying Hensel. The fault may be acting as a restriction of horizontal flow, resulting in high water levels west of the fault and giving rise to the springs.

Several of the wells downgradient to the east of the Ellenburger/Marble Falls fault zone indicate somewhat lower water levels than wells west of the fault zone contact. These wells are likely drilled through the surficial Hensel and Cow Creek and completed in the Marble Falls. Water levels probably reflect heads in the lower Marble Falls.

5.3.2 Groundwater Sampling

The well samples were (Figures 28) analyzed by Newton Schwartz lab and EARDC and field parameters were collected by MCWE using a YSI EXO1 Multiparameter Sonde. Field parameters, lab results, data methods, and quality assurance can be found in Appendix C (well lab results). The wells sampled within Phase 2 for basic anions and cations are plotted on Figure 29 as a piper plot. The data is also presented in stiff plot format (Figure 30). The wells are relatively consistent and appear relatively high in calcium and carbonate, characteristic of Paleozoic and Cretaceous carbonate aquifers. This data is consistent with data presented in Phase 1 which summarized decades of sampling by TWDB (Figure 31).

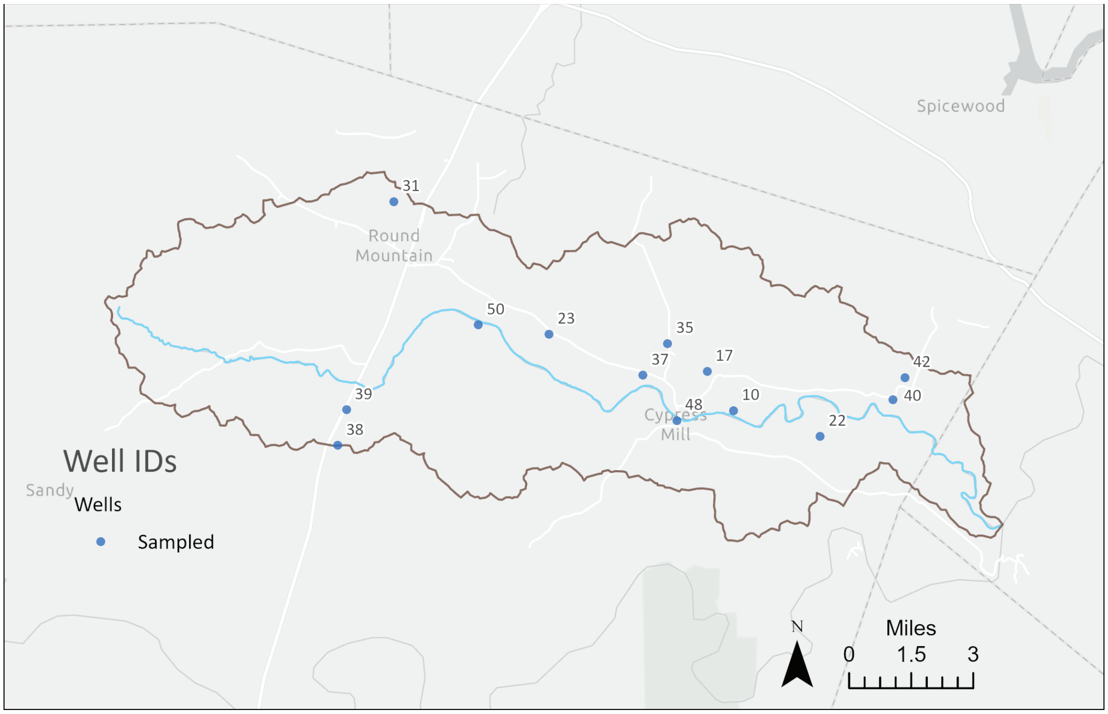

Figure 28. Sampled well locations

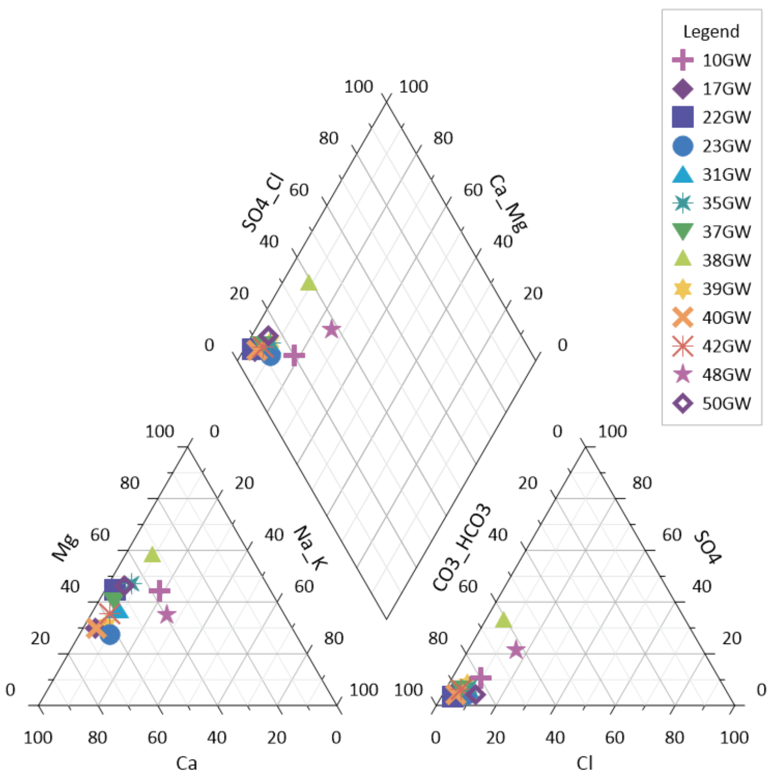

Figure 29. Piper plot of water quality data from sampled wells

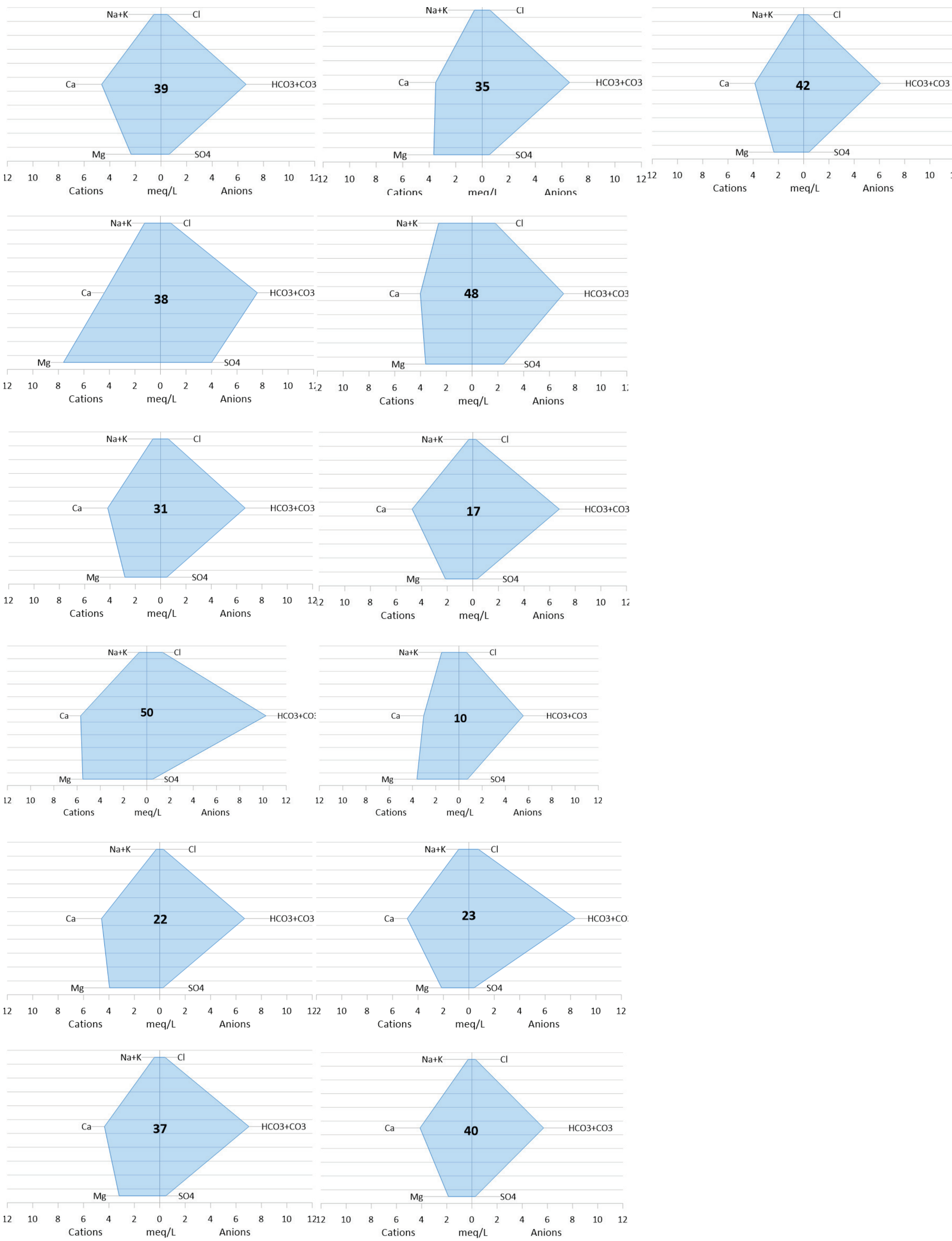

Figure 30. Stiff plot of water quality data for sampled wells

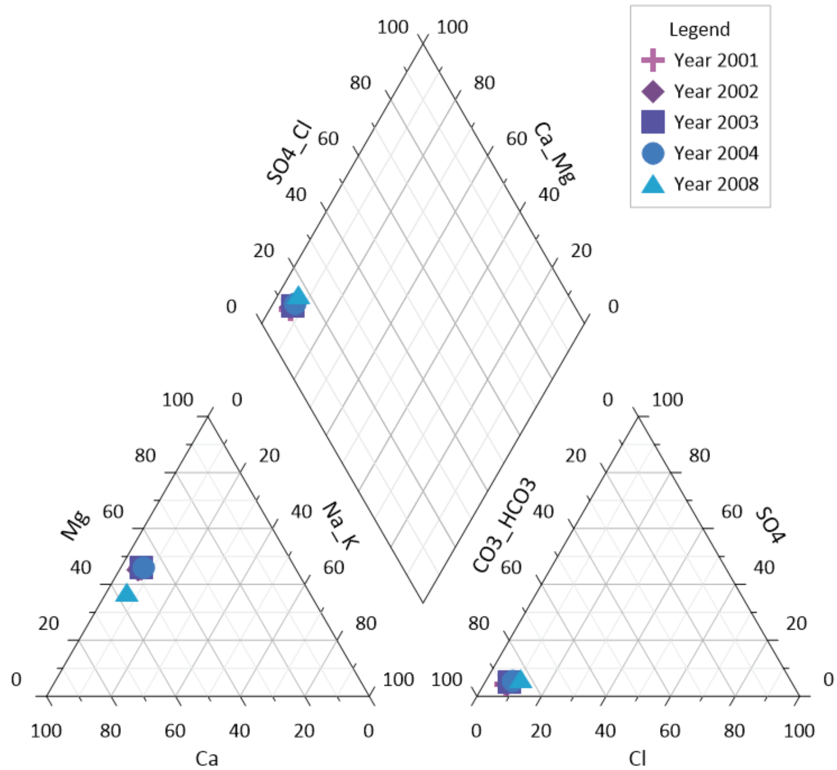

Figure 31. Water quality data from well 5738512 (TWDB, 2024)

One item worth noting is the outliers, wells 38 and 48. Both these wells tested lower in calcium and higher in sulfate when compared to the other 11 wells. Well 38 is located on the southern edge of the watershed where the Trinity strata are the thickest. Well 48 is located in the highly faulted interface between the Ellenburger and Marble Falls aquifers. No construction details are available for either wells to determine which aquifer the wells are completed.

During the research of TWDB data, it was noted that well 5738512 was sampled annually from 2001-2004 and 2008. According to the State Well Report, the well is a shallow Ellenburger well (110 feet deep). Water quality was consistent during the period of sampling. Groundwater levels for the same period obtained at the well (Figure 21 Round Mountain hydrograph) indicated minor fluctuations in water levels.

5.3.3 Age Dating of Water Samples

Groundwater samples were collected and analyzed for Carbon-14, (represented as percent modern carbon - pMC) at five locations. Lab results, data methods, and quality assurance can be found in Appendix D (carbon dating results). Age dating sampling locations for current and past sampling locations within the watershed are shown on Figure 32 and the data shown on Tables 3 and 4.

Carbon-14 dating, also called radiocarbon dating, is a method developed in the 1940s to determine the age of organic material. The half-life of Carbon-14 is 5,730 years. Any sample containing a pMC of 1 is very young water with Carbon-14 reflecting atmospheric level.

The results of the carbon dating indicate a wide range of pMC in groundwater in the watershed. pMC ranged from 0.349 (8450 years BP) and 1.028 (220 years BP). Spring samples (5738804 and 57388060) and well sample 24 show relatively young water, indicating a local source of recharge. Spring sample 5738902 and nearby well 37 also indicate relatively young water. Wells 35 and 48 show significantly older water: 3730-

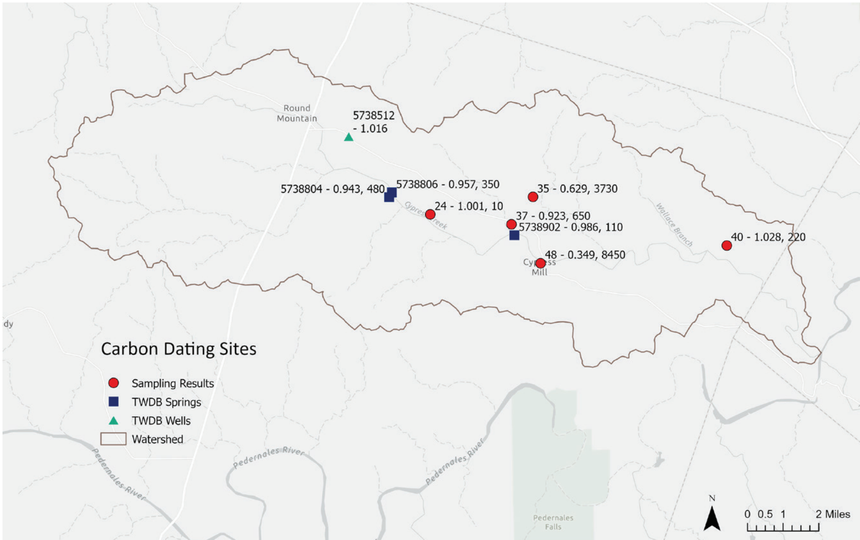

Figure 32. Locations of wells and springs analyzed for pMC and years BP by TWDB

Table 3. Carbon 14 dating results from sampled wells

CC ID	APPARENT AGE (YEARS BP)	PERCENT MODERN CARBON	
24	10	1.0008	
35	3730	0.6289	
37	650	0.9228	
40	220	1.0276	
48	8450	0.3494	

Table 4. Carbon 14 dating results from TWDB wells and springs

STATE WELL NUMBER	APPARENT AGE (YEARS BP)	PERCENT MODERN CARBON
5738512	not reported	1.016
5738804*	480	0.9426
5738806*	350	0.9569
5738902*	110	0.9864

*Note: *=Spring*

and 8450-years BP, respectfully. These wells are located in the faulted Ellenburger/Marble Falls area. These wells probably do not contribute significant source water to springs in the area. Well 5738512 indicates young groundwater. The well is a shallow Ellenburger with a very local recharge zone. Similarly, well 40, located in the Trinity Aquifer, is likely a shallow well as the Trinity is relatively thin in this area.

The results of the Phase 1 study indicated a losing reach in the creek between the two major gain/spring reaches. Easterly groundwater flow directions and similar pMC dating may indicate that the losing water is reappearing as spring flow downstream. A dye trace study could bring additional insights into this potential flow path.

5.4 Surface Water Sampling and Discharge

Surface water samples were collected at six different sites on Cypress Creek on 09/18/2024 and were submitted to the EARDC and the Newton/Schwartz labs for water quality analysis. Field parameters were also collected by MCWE staff using a YSI EXO1 Multipraramater Sonde. Field parameters, lab results, data methods, and quality assurance can be found in Appendix E (surface water lab results). Sampling locations are show on Figure 33 and the cations and anion concentrations for each site are depicted on a piper plot in Figure 34. Stiff plots of the data are included in Figure 35. Both upstream sites 1SW (near Springs 5738804 and 5738806) and 2SW appear to be outliers due to their concentrations in calcium and magnesium. Sites 1SW and 2SW are located in the upstream area of Cypress Creek within a gaining portion of the creek as seen in figure 7 from Phase 1. As the sites moved downstream towards Spring 5738902 and further downstream, the amount of calcium increased to a similar concentration as found within the well samples (Figure 35). The difference in water quality between the two may reflect the differing sources of water (Ellenburger vs Marble Falls/Trinity).

On September 18th, 2024, the Meadows Center visited 6 locations along Cypress Creek to attempt to collect flow measurements. However, due to low flows and lack of precipitation, the SonTek Flow Tracker 2, the flow measuring device, was not able to produce consistent and reliable measurements. Therefore, flow estimates were developed based on visual observations (Table 5).

Table 5. Flow estimates from sampled locations on Cypress Creek

CC ID	DATE	FLOW ESTIMATE (CFS)
1SW	9/18/2024	0.5
2SW	9/18/2024	0.1
3SW	9/18/2024	0.25
4SW	9/18/2024	0.3
5SW	9/18/2024	0.15

Note: *CFS = cubic feet per second (ft^3/sec)*

Note: *Historical aerial imagery analysis was explored but unsuccessful due to low resolution quality prior to 2013.*

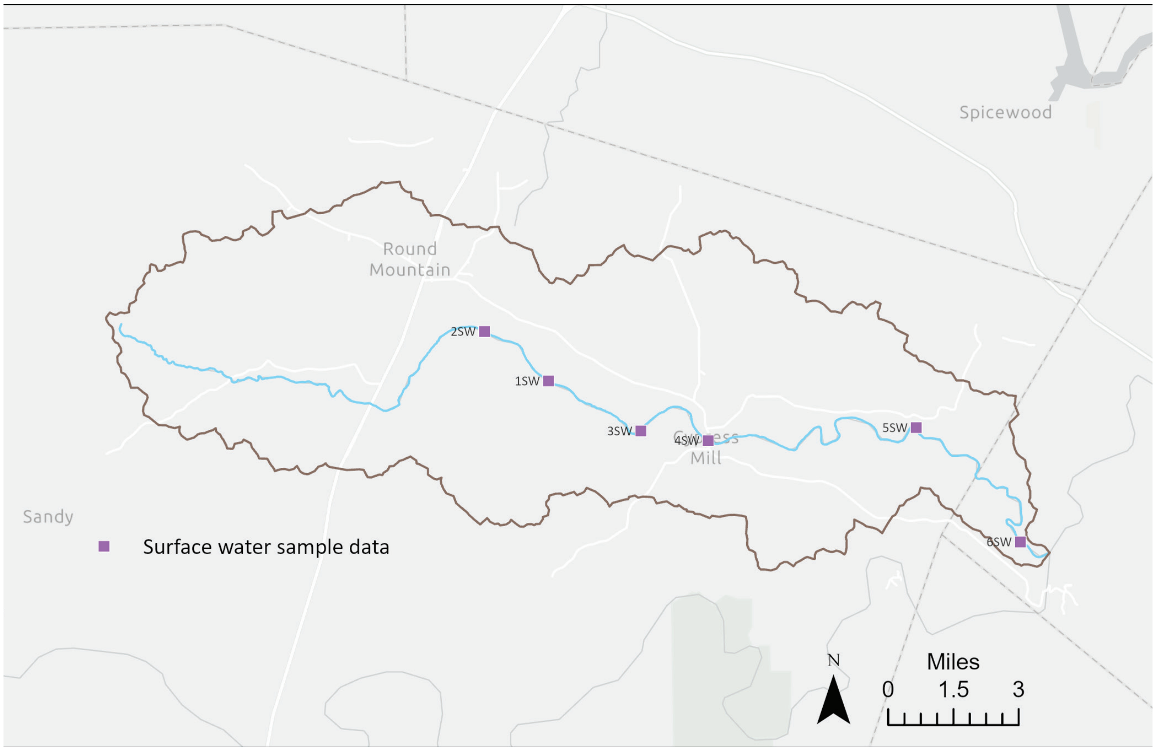

Figure 33. Surface water sampling locations.

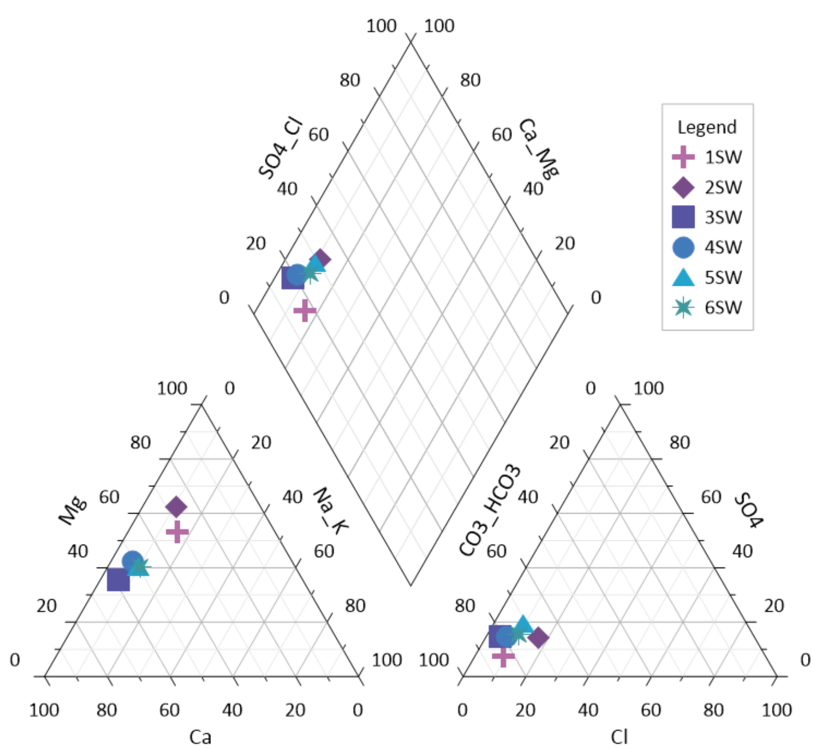

Figure 34. Piper Plot of water quality data for sampled surface water locations

Figure 35. Stiff plot of water quality data for sampled surface water

5.5 Stormwater Sampling

On January 30, 2024, stormwater samples were gathered from a runoff producing precipitation event. The rain event produced 1.15 inches of rain over a 7-hour period with peak precipitation occurring from 6:25am to 7:25am (figure 36). The samples were analyzed by Newton Schwartz lab and EARDC. Lab results, data methods, and quality assurance can be found in Appendix F (stormwater lab results).

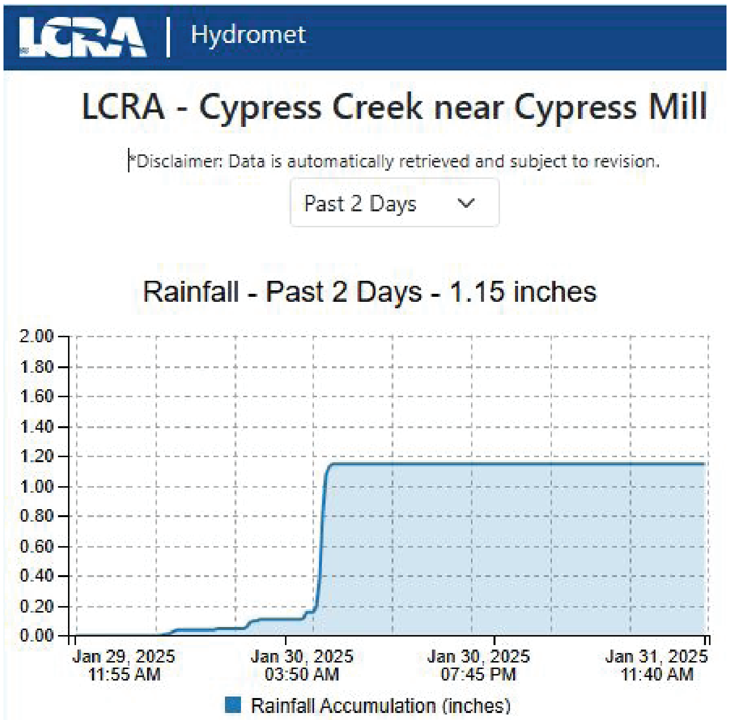

Figure 36. LCRA gauge Cypress Creek near Cypress Mill precipitation data

Total nitrogen and phosphorus values from the stormwater samples can be found in Table 6 and cation and anion concentrations on a piper plot in Figure 37. The parameters gathered from the stormwater samples were compared to historical water quality data gathered by TCEQ at site 12258 located at the RR 962 bridge that crosses Cypress Creek in Cypress Mill. Parameters including total nitrogen, specific conductance, total alkalinity, chloride, and sulfate have shown an increasing trend at site 12258 during the POR from August 1996 to August 2024 (Figures 38-44). The increasing trend of total nitrogen and specific conductance could reflect a potential degradation of water quality within the area. In terms of the stormwater runoff, all

Table 6. Carbon 14 dating results from TWDB wells and springs

CC ID	TOTAL PHOSPHORUS (MG/L)	TOTAL NITROGEN (MG/L)	SPECIFIC CONDUCTANCE (µS/CM)
1R	0.0121	0.5689	712
2R	0.007.9	0.595	725

sample data was found to be above average aside from the total phosphorus. For instance, the stormwater samples had total nitrogen readings of 0.568 and 0.595 mg/L. However, the average reading for the site is 0.37 mg/L. This is as expected considering runoff producing events allow stormwater runoff to gather pollutants on land and bring them directly into the water body. One item of interest is the large difference between average total alkalinity and fluoride at the monitoring site and the total alkalinity and fluoride measured in the stormwater samples.

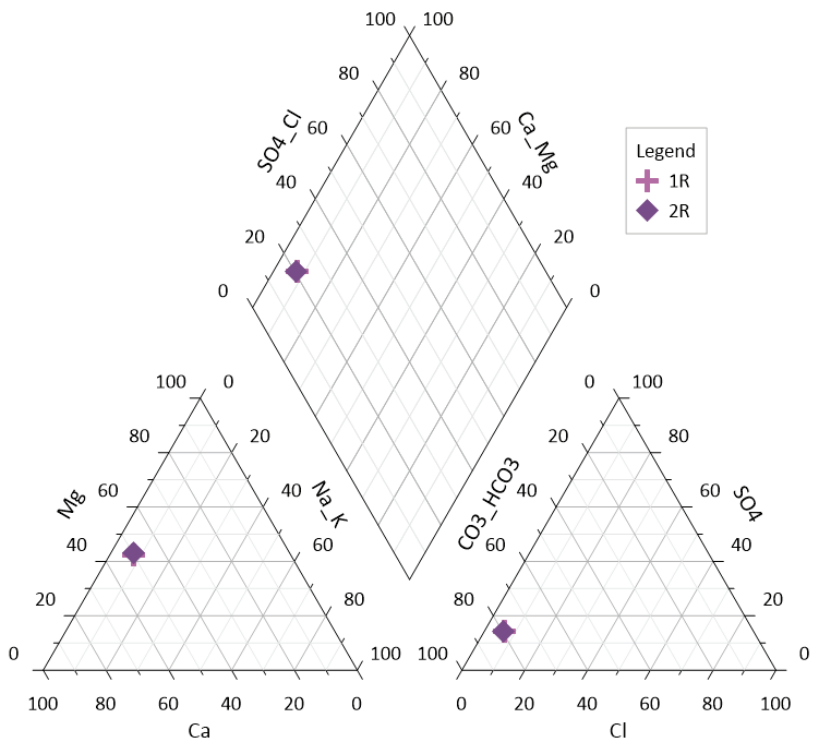

Figure 37. Water quality data for collected stormwater samples

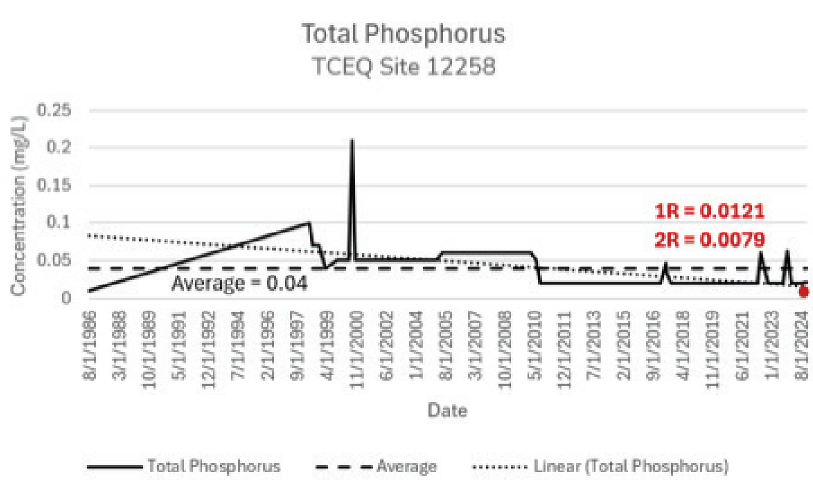

Figure 38. Total phosphorus values from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

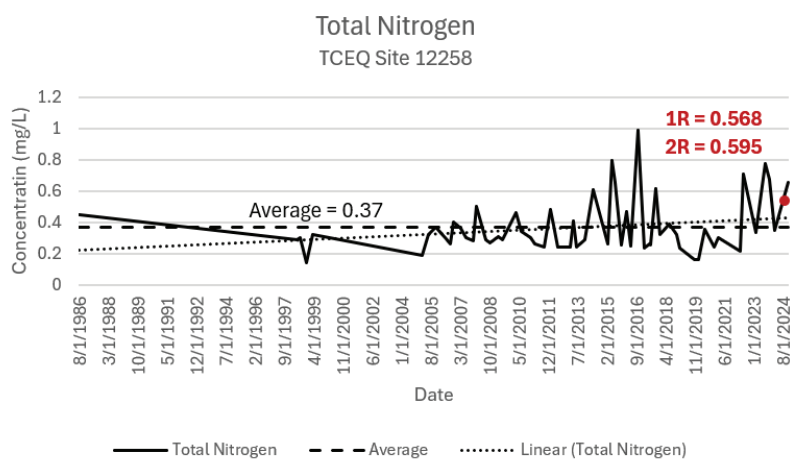

Figure 39. Total nitrogen values from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

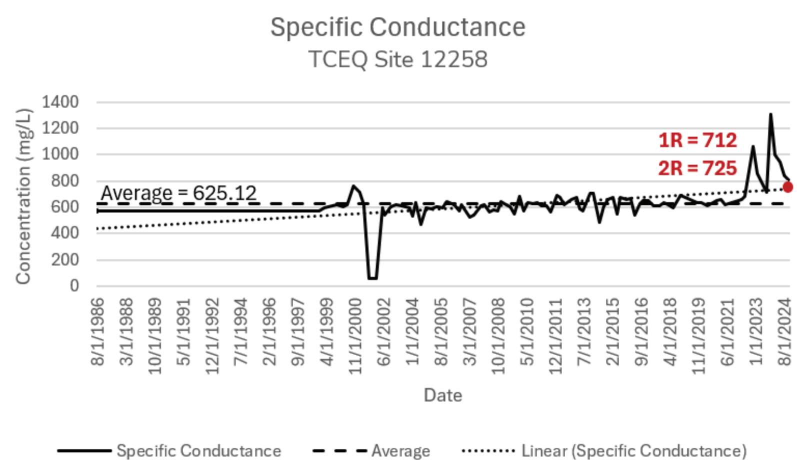

Figure 40. Specific conductance values from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

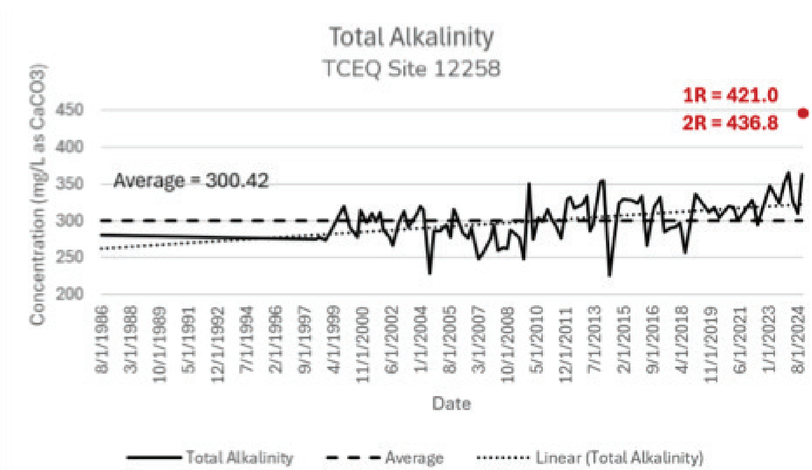

Figure 41. Total alkalinity values from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

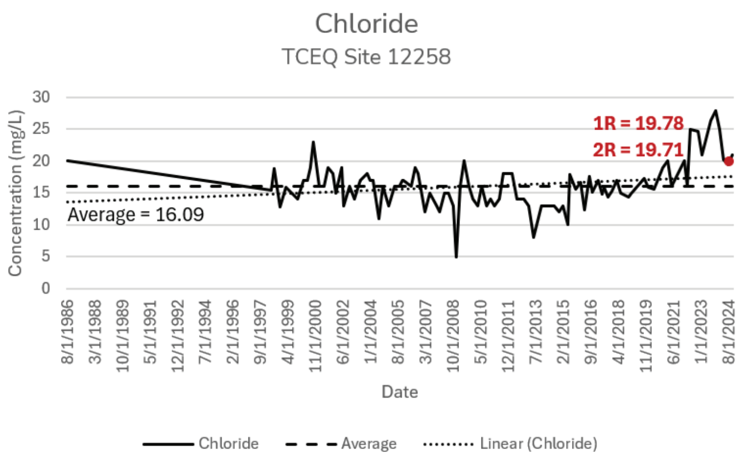

Figure 42. Chloride concentrations from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

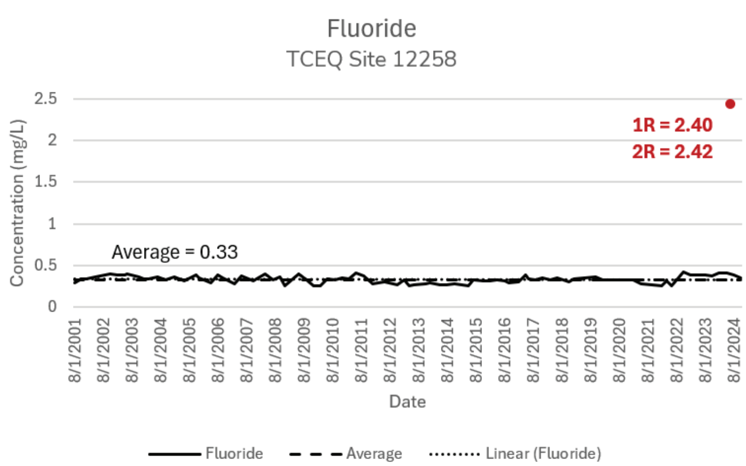

Figure 43. Fluoride concentrations from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

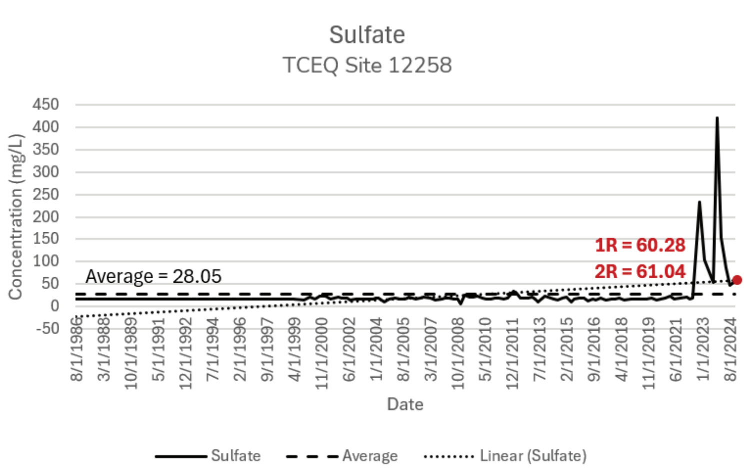

Figure 44. Sulfate concentrations from TCEQ site 12558 and collected stormwater samples (TCEQ, 2024)

6 Discussion

The Phase 2 study results, when combined with the Phase 1 results, show a picture of the surface water/groundwater interactions along Cypress Creek. Key points of the studies are discussed below.

Land use from 2001 through 2021 indicates the watershed is over 50% scrub and shrub. The percentage of scrub and shrub has increased significantly due to the loss of deciduous forest and grasslands. Developed land, with imperious cover, has only slightly increased. Imperious cover due to development can impact water quality and water quantity. The amount of developed land with imperious cover is quite small and should not have any measurable impacts to the watershed.

This study endeavored to locate any long-term groundwater level monitoring data for the watershed. Several wells were identified with records starting in the 1990's, but the records were discontinued. Several additional wells have been monitored for the last 15 or so years. Due to the lack of continuous historical water level monitoring, long term trends are difficult to ascertain. In the short term (i.e. last few years), water levels have been showing a downward trend. These declines are attributable to the current drought situation. A return to" normal" precipitation for a few years should reverse the downward trend. Continued drought will continue to depress groundwater levels.

Regional groundwater flow as determined from historic groundwater level measurements is generally from west to east. Groundwater measurements during the synoptic event during the Phase 2 study are consistent with regional groundwater flow, namely west to east flow directions. Groundwater levels range from a high of ~1300 ft msl in the western most well measured to 715 ft. msl near the confluence with the Pedernales River.

Groundwater levels near the major springs (5738804 and 5738806) indicate shallow groundwater in the major source of spring flow. The proximity of faulting in the Ellenburger appears to be a likely pathway for shallow groundwater to emerge as spring flow.

During the interval between the Phase 1 and Phase 2 studies, an off-channel impoundment and in-channel dam were constructed near springs 5738804 and 5738806. The off-channel pond was constructed over spring 5738804. The increased head of water over the springs may have negatively impacted spring flow ultimately entering Cypress Creek. Due to drought/low flow conditions and without detailed study, the extent of potential impacts is not clear.

There appears to be an increase in groundwater gradient across the Ellenburger/ Marble Falls structure near Cypress Mills. The fault zone between the Ellenburger and Marble Falls may be a conduit for spring flow in this area. Due to the complex geologic structure in this area (Marble Falls faulted downward against the Ellenburger and regional Trinity aquifer pinch out), it is difficult to determine which aquifers are tapped by which wells.

Carbon dating of spring flow and groundwater near spring indicate relatively young groundwater, indicating local recharge areas for local groundwater. Groundwater levels near major springs is shallow with gradient towards the springs. Older groundwater was measured north of the creek on Shovel Mountain Road and at Cypress Mill indicating this area is not significantly contributing to spring flow.

A preliminary stormwater sampling program indicated that stormwater runoff does create concern for issues with total nitrogen as well as total dissolved solids (as seen by the specific conductance values). Interestingly, the stormwater runoff did not show increased levels of total phosphorus, which is a common parameter found within runoff. Therefore, caution should be taken to protect the watershed from potential sources of nitrogen, such as septic tanks and fertilizer, as well as sediment, such as construction sites.

Figure 45. Hand dug well (Photo Credit: Nicky Vermeersh)

Next Steps

Although synoptic groundwater measurements were gathered throughout this study, there is a need to expand the ongoing well monitoring program within the watershed. To enhance the monitoring program, monitoring wells should be selected in a manner that represents the distribution of wells throughout the watershed.

To further enhance the monitoring program, the BPGCD could work with local landowners to convert out of service wells into district monitoring wells. This will allow the BPGCD to gain a more thorough and complete understanding of changing water levels and water quality throughout time. In conjunction with enhancing the well monitoring program, a watershed-wide inventory should be conducted to update the Hydros Database managed by the BPGCD. As mentioned in the methods section of the report, 20 out of the 47 wells selected were not included in the Hydros Database. By updating the database, the BPGCD can have a more complete dataset that provides an accurate reflection of the current state of the watershed, which would help with planning and monitoring. Furthermore, the combined effort of updating the database and establishing a robust monitoring program could assist with the development of a Groundwater Management Zone (GMZ). Considering water levels have shown a declining trend over recent years due to issues with drought, a GMZ could be implemented to protect groundwater quantity, especially with the uncertainty of future weather patterns and droughts.

Another item noted during the study was the functionality of the LCRA stream gauge 3558 located near the confluence of Cypress Creek and Wallace Branch over the last few years. Stream gages are essential in capturing data on precipitation and surface water flow. Considering the direct ties between water quality and flow as well as groundwater and surface water, we suggest BPGCD work with LCRA to address the functionality of the gage. Having accurate flow data available assists with the analysis of changes to water quality and water quantity, both issues that could develop within this watershed.

References

Banner, Jay L., Jackson Charles S., Yang, Zong-Liang., Hayhoe, Katharine., Woodhouse, Connie., Gulden, Lindsey., Jacobs, Kathy. 2010. “Climate Change Impacts on Texas Water: A White Paper Assessment of the Past, Present and Future and Recommendations for Action.” Texas Water Journal 1 (1). https://search.ebscohost.com/login.aspx?direct=true&db=edsdoj&AN=edsdoj.88c977eb80244c00959446d213a53b19&site=eds-live&scope=site.

Barnes, V.E., 1978, Geology of the Round Mountain Quadrangle, Blanco, Burnet, and Llano Counties, Texas Bureau of Economic Geology, University of Texas at Austin Geologic Quadrangle Map No. 47.

Barnes, V.E., 1982a, Geology of the Spicewood Quadrangle, Blanco, Burnet and Travis Counties. Bureau of Economic Geology, University of Texas at Austin Geologic Quadrangle Map No. 50.

Follett, C.R. 1973. Ground-Water Resources of Blanco County, Texas. Texas Water Development Board. Report 174. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R174/Report174.asp

Holland, P. H., and Hughes, L. S. 1962. BASE-FLOW STUDIES PEDERNALES RIVER, TEXAS: Quantity and Quality. Bulletin 6407. United States Geological Survey. https://www.twdb.texas.gov/publications/reports/bulletins/doc/B6407.pdf

Lower Colorado River Authority. 2025. LCRA Hydromet. Accessed January 8, 2025. https://hydromet.lcra.org/

Mace, R. E., and S. C. Wade, 2008, In hot water? How climate change may (or may not) affect the groundwater resources of Texas: Gulf Coast Association of Geological Societies Transactions, v. 58, p. 655-668.

National Land Cover Database 2011 (NLCD2011). (2011). Multi-Resolution Land Characteristics (MRLC) Consortium. Accessed December 4, 2024. https://www.mrlc.gov/

Multi-Resolution Land Characteristics Consortium (2011), National Land Cover Database.

Naismith Engineering, Inc. 2005. Regional Water Quality Protection Plan. Barton Springs-Edwards Aquifer Conservation District. https://bseacd.org/uploads/Final-RWQPP-VOL-I-2005-06-20.pdf

Romans, K. 2015. The State of the Pedernales: Threats, Opportunities, and Research Needs. The Hill Country Alliance. https://hillcountryalliance.org/wp-content/uploads/2015/01/Final_State-of-the-River_012015_PDF-reduced1.pdf

Texas Commission on Environmental Quality. 2024. Surface Water Quality Web Reporting Tool. TCEQ. Accessed December 13, 2024. https://www80.tceq.texas.

Texas Water Development Board. 2022. State Water Plan 2022: Future Population Projections for Texas. Texas Water Development Board. https://www.twdb.texas.gov/waterplanning/swp/2022/docs/04-SWP22_Future-Population.pdf.

Texas Water Development Board. 2024. Record of Wells Advanced Search. TWDB. Accessed December 19, 2024. https://www3.twdb.texas.gov/apps/reports/GWDB/RecordOfWellsAdvanced

Texas Water Development Board. 2024. Record of Wells by Well. TWDB. Accessed September 30, 2024. https://www3.twdb.texas.gov/apps/reports/GWDB/WellData

Wierman, D. A., Walker, J., Arismendez, S., Schlandt, A., Navarro, A., Vasquez, D. 2021. Cypress Creek Flow Study: Blanco and Travis counties, Texas. Report 2021-01, The Meadows Center for Water and the Environment - Texas State University. https://www.meadowscenter.txst.edu/research/water-conservation/how-much-water-is-in-the-hill-country/cypress-creek-flow.html

Wohl, Ellen. "The significance of small streams." Frontiers of Earth Science 11 (2017): 447-456.

Yoon, Jin-Ho, SY Simon Wang, Min-Hui Lo, and Wen-Ying Wu. 2018. "Concurrent increases in wet and dry extremes projected in Texas and combined effects on groundwater." Environmental Research Letters 13, no. 5: 054002.

Appendices

Appendix A

Table 7. Locations and elevations for wells monitored in Cypress Creek watershed

DATE	CC ID	ELEVATION (FT)	GROUND-WATER ELEVATION (FT)	LATITUDE OF WELL	LONGITUDE OF WELL	STICK UP (FT)	DATABASE MATCH
7/24/2024	1	1124	NM	30.406864	-98.312494	NM	State Well ID 5738805
7/24/2024	2	1158	NM	30.414047	-98.305244	NM	Well ID 20160077
7/24/2024	3	1250	1200	30.4279224	-98.3308681	0.8	Well ID 20140030
7/24/2024	4	1034	NM	30.3811367	-98.260491	NM	
7/24/2024	5	1043	987	30.3802861	-98.2571151	1	
7/24/2024	6	1140	1106	30.372559	-98.2877037	0	Well ID 20180017
7/24/2024	7	1101	NM	30.376523	-98.269212	NM	
7/24/2024	8	1107	NM	30.376686	-98.280567	NM	Well ID 20140002
7/24/2024	9	838	715.8	30.3531818	-98.1482566	1.8	
7/24/2024	10	954	934.25	30.3854	-98.23125	0.75	Well ID 20120320
7/24/2024	11	962	929.08	30.386117	-98.2339	14.5	Well ID 20120321
7/24/2024	12	960	911.47	30.3932027	-98.234363	4.17	Well ID 20150091
7/24/2024	13	957	912.53	30.3836545	-98.2347334	0.83	Well ID 20120323
7/24/2024	14	1060	1013.4	30.3960254	-98.270912	1.1	Well ID 20160106
7/24/2024	15	1051	NM	30.391438	-98.270762	NM	
7/24/2024	23	1148	1104.8	30.4084249	-98.2956474	1.8	
7/30/2024	17	999	911.1	30.3971909	-98.2404495	1.6	
7/30/2024	18	999	908.03	30.3971767	-98.2408126	0.83	
7/30/2024	10	954	931.45	30.3854	-98.23125	0.75	Well ID 20120320

DATE	CC ID	ELEVATION (FT)	GROUND-WATER ELEVATION (FT)	LATITUDE OF WELL	LONGITUDE OF WELL	STICK UP (FT)	DATABASE MATCH
7/30/2024	20	949	NM	30.3402704	-98.2202411	NM	State Well ID # 5747107
7/30/2024	21	966	962.4	30.366088	-98.2099783	1	
7/30/2024	22	930	823.08	30.3775955	-98.2009798	1.08	
7/30/2024	23	1149	1105.4	30.4084249	-98.2956474	1.8	
7/30/2024	24	1090	1068.1	30.3995125	-98.2952842	4.7	
7/30/2024	25	1001	NM	30.3894542	-98.2447984	NM	
7/30/2024	26	1000	938.6	30.3901888	-98.2435565	1	State Well ID 5739703
7/30/2024	27	998	NM	30.3907504	-98.2436179	NM	Well ID 20110091
7/30/2024	28	1022	NM	30.3927694	-98.2516769	NM	
7/31/2024	29	1395	1120.13	30.3598616	-98.3238162	0.83	Well ID 20120111 or 20120112
7/31/2024	30	1345	1114.18	30.3588398	-98.3239819	1.58	Well ID 20120111 or 20120112
7/31/2024	31	1356	1267.1	30.4483734	-98.3498602	1	
7/31/2024	10	954	930.05	30.3854	-98.23125	0.75	Well ID 20120320
7/31/2024	33	1559	1364.9	30.40155	-98.4303566	1.6	Well ID 20070014
7/31/2024	34	1466	1361.5	30.4060171	-98.4219821	1.6	Well iD 20070015
7/31/2024	35	1088	1010.73	30.4056097	-98.2542123	1.33	Well ID 20110068
7/31/2024	36	1077	1015.05	30.4088867	-98.2549559	1.3	Well ID 20100077
7/31/2024	37	1035	1011.7	30.3960445	-98.2628932	0	State Well ID 5738903
7/31/2024	38	1461	NM	30.3749081	-98.3694524	NM	
7/31/2024	39	1338	1297.9	30.3856313	-98.3664372	1.4	
8/7/2024	40	902	NM	30.3886733	-98.1755776	NM	

DATE	CC ID	ELEVATION (FT)	GROUND-WATER ELEVATION (FT)	LATITUDE OF WELL	LONGITUDE OF WELL	STICK UP (FT)	DATABASE MATCH
8/7/2024	41	890	NM	30.3886525	-98.1730587	NM	State Well ID 5739803
8/7/2024	42	1014	NM	30.3953317	-98.1714265	NM	Well Tracking Report 510142
8/7/2024	43	931	870.05	30.3811595	-98.1786853	1.85	
8/7/2024	44	998	NM	30.3745341	-98.1787557	NM	
8/7/2024	10	954	905.15	30.3854	-98.23125	0.75	
8/7/2024	46	986	927.1	30.3878499	-98.239388	0	
8/7/2024	47	983	930.4	30.3876533	-98.2386018	1.7	Well Tracking Report 191563
8/7/2024	48	993	927.7	30.3824105	-98.2510892	2.3	Well ID 20220127
8/7/2024	49	1003	941.3	30.3880041	-98.245197	0	State Well ID 5739703
8/7/2024	50	1171	NM	30.4112045	-98.3203207	NM	Well Tracking Report 472127
8/7/2024	51	1211	NM	30.4190985	-98.3246109	NM	Well Tracking Report 446272

Appendix B

National Land Cover Database Class Legend and Description

Class\ Value	Classification Description
Water	
11	**Open Water**- areas of open water, generally with less than 25% cover of vegetation or soil.
12	**Perennial Ice/Snow**- areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	
21	**Developed, Open Space**- areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity**- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	**Developed, Medium Intensity** -areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	**Developed High Intensity**-highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	
31	**Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	
41	**Deciduous Forest**- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	**Evergreen Forest**- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.

43	**Mixed Forest**- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrubland	
51	**Dwarf Scrub**- Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	**Shrub/Scrub**- areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	
71	**Grassland/Herbaceous**- areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72	**Sedge/Herbaceous**- Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73	**Lichens**- Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	**Moss**- Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	
81	**Pasture/Hay**-areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	**Cultivated Crops** -areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	
90	**Woody Wetlands**- areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	**Emergent Herbaceous Wetlands**- Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Appendix C

Table 8. Wells_Lab Results Client IDs

CC ID	SAMPLE DATE	SAMPLE TIME	MATRIX
38	7/31/2024	3:06pm	Groundwater
39	7/31/2024	3:25pm	Groundwater
31	7/31/2024	1:17pm	Groundwater
17	7/30/2024	1:34pm	Groundwater
10	7/30/2024	10:27am	Groundwater
22	7/30/2024	8:58am	Groundwater
23	7/30/2024	1:00pm	Groundwater
35	7/31/2024	10:36am	Groundwater
37	7/31/2024	12:32pm	Groundwater
10	8/7/2024	9:49am	Groundwater
40	8/7/2024	10:13am	Groundwater
22	8/7/2024	1:06pm	Groundwater
42	8/7/2024	2:53pm	Groundwater
48	8/7/2024	1:06pm	Groundwater
50	8/7/2024	2:53pm	Groundwater

Table 9. Wells_Lab Results Anions

	CCID												
	38	39	31	17	10	22	35	37	40	42	22	48	50
FLUORIDE MG/L	4.3	3.0	3.6	1.6	2.5	0.8	2.2	3.8	3.3	2.3	2.8	8.3	0.7
CHLORIDE MG/L	28.4	17.4	21.3	8.1	23.3	9.9	26.4	20.4	14.5	9.8	12.8	63.6	48.1
NITRITE (NO2-N) MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BROMIDE MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NITRATE (NO3-N) MG/L	1.5	3.1	9.1	65.3	1.6	4.2	11.0	3.1	2.9	3.1	2.7	1.4	7.4
PHOSPHATE (PO4-P) MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SULFATE MG/L	192.3	30.8	23.3	16.4	35.4	19.8	25.6	16.4	23.1	13	20	117.8	24.3

Table 10. Wells_Lab Results Alkalinity

CC ID	SAMPLE RUN DATE	ALKALINITY MG/L AS HCO3-
38	8/9/2024	463.1
39	8/9/2024	405.5
31	8/9/2024	407.1
17	8/9/2024	412.1
10	8/9/2024	337.9
22	8/9/2024	407
23	8/9/2024	510
35	8/9/2024	401.4
37	8/9/2024	337.9
10	8/9/2024	428.2
40	8/9/2024	407
22	8/9/2024	347.7
42	8/9/2024	370.9
48	8/9/2024	433.1
50	8/9/2024	625.9

Table 11. Wells Lab Resultes Cations

	CC ID												
	38	39	31	17	10	22	35	37	40	42	22	48	50
LITHIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SODIUM MG/L	22.5	11.5	13.2	6.5	31.5	5.7	17.1	12.0	8.8	6.3	8.8	51.8	14.6
AMMONIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
POTASSIUM MG/L	10.3	2.0	1.7	1.0	4.6	0.9	2.2	2.6	1.4	1.0	1.3	13.5	1.1
MAGNESIUM MG/L	92.4	28.4	34.3	26.0	44.0	48.1	26.1	44.5	38.8	22.7	28.7	43.8	67.0
MANGANESE MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CALCIUM MG/L	88.1	92.9	83.8	95.0	60.8	91.9	97.2	70.3	87.2	82.7	77.6	80.5	114.2
STRONTIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BARIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 12. Wells_Lab Results Total Hardness

CC ID	SAMPLE RUN DATE	TOTAL HARDNESS MG/L AS CACO3
38	8/8/2024	670
39	8/8/2024	380
31	8/8/2024	360
17	8/8/2024	370
10	8/8/2024	360
22	8/8/2024	330
23	8/8/2024	430
35	8/8/2024	360
37	8/8/2024	380
40	8/8/2024	350
42	8/8/2024	310
48	8/8/2024	430
50	8/8/2024	550

TEXAS STATE UNIVERSITY

The rising STAR of Texas

Water Analysis Report

Analyses performed on a Dionex ICS 1600

Parameter	Results	MDL	Coefficient of Determinatio n (r2)	Date Analyzed	Analyst	Method
Anions						
Fluoride	0.9901	1.0	99.9004	8/6/2024	AC	EPA 300.1 A
Chloride	0.9598	1.0	99.9496	8/6/2024	AC	
itrite (NO2-N)*	0.9556	1.0	99.9681	8/6/2024	AC	
Bromide	0.9828	1.0	99.9653	8/6/2024	AC	
trate (NO3-N)**	0.9774	1.0	99.9355	8/6/2024	AC	
sphate (PO4-P)***	0.9759	1.0	99.9698	8/6/2024	AC	
Sulfate	0.9553	1.0	99.9426	8/6/2024	AC	

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank	0	0		0	<20
LCS	5.0222	5		100.444	90-110%
Matrix Spike_1	1.0344	1		103.44	90-110%
Matrix Spike_2	51.7181	50		103.4362	90-110%
Sample Dup_1	14.5259		**Avg.**	14.59335	
Sample Dup_2	14.6608		**%RP**	0.9243936	0-20%

Parameter	Results	MDL	Coefficient of Determination (r2)	Date Analyzed	Analyst
Cations					
Lithium	0.0951	0.1	99.9178	8/6/2024	AC
Sodium	0.0965	0.1	99.981	8/6/2024	AC
Ammonium [ib]	0.0963	0.1	99.9361	8/6/2024	AC
Potassium	0.0985	0.1	99.9902	8/6/2024	AC
Magnesium	0.0974	0.1	99.9858	8/6/2024	AC
Manganese	0.0951	0.1	99.9753	8/6/2024	AC
Calcium	0.0974	0.1	99.9674	8/6/2024	AC
Strontium	0.0988	0.1	99.9144	8/6/2024	AC
Barium	0.0967	0.1	99.9851	8/6/2024	AC

Method

ATSM D6919

[b]Quadratic fit

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank	0	0		0	<20
LCS	10.0545	10		100.545	90-110%
Matrix Spike_1	1.1043	1		110.43	90-110%
Matrix Spike_2	49.9514	50		99.9028	90-110%
Sample Dup_1	38.8391		**Avg.**	38.82025	
Sample Dup_2	38.8014		**%RP**	0.0971143	0-20%

Parameter	Results	MDL	Determination (r2)	Date Analyzed	Analyst
Anions					
Fluoride	0.9962	1.0	99.9625	8/12/2024	AC
Chloride	0.9984	1.0	99.9847	8/12/2024	AC
Nitrite (NO2-N)*	0.9977	1.0	99.9954	8/12/2024	AC
Bromide	0.9981	1.0	99.9477	8/12/2024	AC
Nitrate (NO3-N)**	0.9995	1.0	99.9954	8/12/2024	AC
'hosphate (PO4-P)***	0.9982	1.0	99.9854	8/12/2024	AC
Sulfate	0.9996	1.0	99.9855	8/12/2024	AC

Method

EPA 300.1 A

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank	0	0		0	<20
LCS	4.9957	5		99.914	90-110%
Matrix Spike_1	1.0235	1		102.35	90-110%
Matrix Spike_2	49.9984	50		99.9968	90-110%
Sample Dup_1	17.7411		**Avg.**	17.76685	

Parameter	Results	MDL	Coefficient of Determination (r2)	Date Analyzed	Analyst	Method
Cations						
Lithium	0.0987	0.1	99.9841	8/12/2024	AC	ATSM D6919
Sodium	0.0993	0.1	99.7847	8/12/2024	AC	
Ammonium [ƚb]	0.1002	0.1	99.9571	8/12/2024	AC	
Potassium	0.0997	0.1	99.9877	8/12/2024	AC	
Magnesium	0.0990	0.1	99.9951	8/12/2024	AC	
Manganese	0.0989	0.1	99.9747	8/12/2024	AC	
Calcium	0.0995	0.1	99.9881	8/12/2024	AC	
Strontium	0.0947	0.1	99.9858	8/12/2024	AC	
Barium	0.0958	0.1	99.9781	8/12/2024	AC	

[b]Quadratic fit

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank	0	0		0	<20
LCS	10.0209	10		100.209	90-110%
Matrix Spike_1	0.9974	1		99.74	90-110%
Matrix Spike_2	49.6854	50		99.3708	90-110%
Sample Dup_1	14.5718		**Avg.**	14.55935	
Sample Dup_2	14.5469		**%RP**	0.1710241	0-20%

Appendix D

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

February 07, 2025

SANDRA ARISMENDEZ
The Meadows Center for Water and the Environment, TSU
601 University Dr.
San Marcos, TX 78666
sandra.arismendez@txstate.edu

RE: Final Analytical Report Q2453270

Attn: SANDRA ARISMENDEZ

Enclosed are the analytical results for sample(s) received by LCRA Environmental Laboratory Services. Results reported herein conform to the most current NELAP standards, where applicable, unless otherwise narrated in the body of the report. This final report provides results related only to the sample(s) as received for the above referenced work order.

Thank you for selecting ELS for your analytical needs. If you have any questions regarding this report, please contact us at (512) 730-6022 or environmental.lab@lcra.org. We look forward to assisting you again.

Authorized for release by:

Jason Woods
Account Manager
jason.woods@lcra.org

Enclosures:
CC:Jenna Walker

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Workorder: Q2453270
Workorder Description: MEADOWS_SUB_C14
Client: THE MEADOWS CENTER TSU
Profile: Paid by TWDB
Sampled By: JENNA WALKER

Report To: SANDRA ARISMENDEZ
The Meadows Center for Water and the Environment, TSU
601 University Dr.
San Marcos, TX 78666

Sample Summary

Lab ID	Sample ID	Matrix	Method	Date Collected	Date Received	Analytes Reported
Q2453270001	WELL 24	AQ	AMS, Carbon 14	12/10/2024 10:34	12/12/2024 16:00	1
Q2453270002	WELL 35	AQ	AMS, Carbon 14	12/10/2024 11:25	12/12/2024 16:00	1
Q2453270003	WELL 37	AQ	AMS, Carbon 14	12/10/2024 11:55	12/12/2024 16:00	1
Q2453270004	WELL 40	AQ	AMS, Carbon 14	12/10/2024 12:20	12/12/2024 16:00	1
Q2453270005	WELL 48	AQ	AMS, Carbon 14	12/10/2024 13:35	12/12/2024 16:00	1

Report Definitions

MRL - Minimum Reporting Limit
LOD - Limit of Detection
ML - Maximum Limit - Client Specified
MCL - Maximum Contaminant Level
LOQ - Limit of Quantitation - Client Specified
DF - Dilution Factor
(S) - Surrogate Spike
MDL - Method Detection Limit
RPD - Relative Percent Difference

Qualifier Definitions

J - Analyte detected below quantitation limit
R - RPD outside duplicate precision limit
S - Spike recovery outside limit
B- Analyte detected in method blank
N - Not Accredited
M - Analyte Detected Above Maximum Contaminant Level
SL - Spike Recovery Low
SH - Spike Recovery High
H - Analyzed Past Hold Time
CR - Confirmed Result
CH - Result confirmed by historical data

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Workorder Summary

Sample Comments

Q2453270001 (WELL 24) - Paying sample

ANALYTICAL COMMENTS: Q2453270001 (AMS, Carbon 14) subcontracted with customer's approval. Data provided in full with the ELS final report.

Q2453270002 (WELL 35) - Paying sample

ANALYTICAL COMMENTS: Q2453270002 (AMS, Carbon 14) subcontracted with customer's approval. Data provided in full with the ELS final report.

Q2453270003 (WELL 37) - Paying sample

ANALYTICAL COMMENTS: Q2453270003 (AMS, Carbon 14) subcontracted with customer's approval. Data provided in full with the ELS final report.

Q2453270004 (WELL 40) - Paying sample

ANALYTICAL COMMENTS: Q2453270004 (AMS, Carbon 14) subcontracted with customer's approval. Data provided in full with the ELS final report.

Q2453270005 (WELL 48) - Paying sample

ANALYTICAL COMMENTS: Q2453270005 (AMS, Carbon 14) subcontracted with customer's approval. Data provided in full with the ELS final report.

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Analytical Results

Client ID:	MEADOWS	**Date Collected:**	12/10/2024 10:34	**Matrix:**	Aqueous
Lab ID:	Q2453270001	**Date Received:**	12/12/2024 16:00	**Sample Type:**	SAMPLE
Sample ID:	WELL 24	**Location:**			
Project ID:	Paid by TWDB	**Facility:**			
		Sample Point:			

AMS, Carbon 14 has been subcontracted. See attached Subcontract Report.

Environmental Laboratory Services
The Solution Lab

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Analytical Results

Client ID:	MEADOWS	**Date Collected:**	12/10/2024 11:25	**Matrix:**	Aqueous
Lab ID:	Q2453270002	**Date Received:**	12/12/2024 16:00	**Sample Type:**	SAMPLE
Sample ID:	WELL 35	**Location:**			
Project ID:	Paid by TWDB	**Facility:**			
		Sample Point:			

AMS, Carbon 14 has been subcontracted. See attached Subcontract Report.

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Analytical Results

Client ID:	MEADOWS	**Date Collected:**	12/10/2024 11:55	**Matrix:**	Aqueous
Lab ID:	Q2453270003	**Date Received:**	12/12/2024 16:00	**Sample Type:**	SAMPLE
Sample ID:	WELL 37	**Location:**			
Project ID:	Paid by TWDB	**Facility:**			
		Sample Point:			

AMS, Carbon 14 has been subcontracted. See attached Subcontract Report.

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Analytical Results

Client ID:	MEADOWS	**Date Collected:**	12/10/2024 12:20	**Matrix:**	Aqueous
Lab ID:	Q2453270004	**Date Received:**	12/12/2024 16:00	**Sample Type:**	SAMPLE
Sample ID:	WELL 40	**Location:**			
Project ID:	Paid by TWDB	**Facility:**			
		Sample Point:			

AMS, Carbon 14 has been subcontracted. See attached Subcontract Report.

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Analytical Results

Client ID:	MEADOWS	**Date Collected:**	12/10/2024 13:35	**Matrix:**	Aqueous
Lab ID:	Q2453270005	**Date Received:**	12/12/2024 16:00	**Sample Type:**	SAMPLE
Sample ID:	WELL 48	**Location:**			
Project ID:	Paid by TWDB	**Facility:**			
		Sample Point:			

AMS, Carbon 14 has been subcontracted. See attached Subcontract Report.

Environmental Laboratory Services
The Solution Lab

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Beta Analytic
CARBON-14 TESTING

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: (305) 667-5167
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

January 23, 2025

Dale Jurecka
Lower Colorado River Authority
3505 Montopolis Drive
Austin, TX 78744
USA

Dear Dale Jurecka,

Enclosed are the radiocarbon dating results for the sample(s) recently sent to us. The samples provided plenty of carbon for accurate radiocarbon measurements. The results were obtained on the DIC and are reported both as percent modern carbon (pMC) and fraction of modern (F14C). The report sheet also includes the method used, material type, and applied pretreatments.

DIC extraction consisted of injecting sample water into an acid bath attached to an evacuated collection line. pH was reduced to < 1 and evolved CO2 was dried with methanol slush and collected in liquid nitrogen. CO2 was then graphitized over cobalt in a hydrogen atmosphere to produce the target for our AMS. Reported radiocarbon results are relative to NIST SRM-4990C.

Also mentioned on the report is an "Apparent Radiocarbon Age". This is for reference only. It would illustrate the residence time of the water in the absence of any hydro-geochemical effects. The best illustration of age would have to be derived by incorporating the radiocarbon pMC or fraction modern result into models which take the hydrologic conditions of the aquifer under study into account. The Apparent Radiocarbon Age is used as a relational tool, of understandable units to the layman, to interpret hydrologic differences between wells and to monitor temporal changes.

Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (e.g. < 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation. Please take this into consideration in your interpretation of results.

Reported carbon isotopes (13C) are relative to VPDB and deuterium and oxygen isotopes (2H and 18O) are reported relative to VSMOW. Measurement was performed using gas-bench Isotope Ratio Mass Spectrometer (IRMS) and Cavity Ring-Down Spectrometer (CRDS).

We analyzed the samples on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. The analysis was a combined effort of our entire professional staff. The results are ISO/IEC 17025:2017 accredited.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Digital signature on file

Mr. Ron Hatfield
Laboratory Management Group / President

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

BETA Beta Analytic
CARBON-14 TESTING

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: (305) 667-5167
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Dale Jurecka
Lower Colorado River Authority

Report Date: January 23, 2025
Received Date: December 30, 2024

Laboratory Number	pMC	$F^{14}C$	δ13C o/oo	δ18O o/oo	δ2H o/oo
Beta-727610	100.08 +/- 0.36 pMC	1.0008 +/- 0.0037	-12.39	-4.57	-25.43

Q2453270001
Standard AMS (14 business days)
ANALYZED MATERIAL/PRETREATMENT: (Water DIC):acidify-gas strip
COMMENT:The equivalent "Apparent" radiocarbon age to the reported pMC/fMDN values is ~ -10 BP (not adjusted for any hydro-geochemical effects on meteoric water 14CO2). Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (< 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation.

Laboratory Number	pMC	$F^{14}C$	δ13C o/oo	δ18O o/oo	δ2H o/oo
Beta-727611	62.89 +/- 0.23 pMC	0.6289 +/- 0.0023	-7.00	-4.44	-24.55

Q2453270002
Standard AMS (14 business days)
ANALYZED MATERIAL/PRETREATMENT: (Water DIC):acidify-gas strip
COMMENT:The equivalent "Apparent" radiocarbon age to the reported pMC/fMDN values is ~ 3730 BP (not adjusted for any hydro-geochemical effects on meteoric water 14CO2). Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (< 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation.

Laboratory Number	pMC	$F^{14}C$	δ13C o/oo	δ18O o/oo	δ2H o/oo
Beta-727612	92.28 +/- 0.33 pMC	0.9228 +/- 0.0034	-10.02	-4.57	-25.72

Q2453270003
Standard AMS (14 business days)
ANALYZED MATERIAL/PRETREATMENT: (Water DIC):acidify-gas strip
COMMENT:The equivalent "Apparent" radiocarbon age to the reported pMC/fMDN values is ~ 650 BP (not adjusted for any hydro-geochemical effects on meteoric water 14CO2). Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (< 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation.

Laboratory Number	pMC	$F^{14}C$	δ13C o/oo	δ18O o/oo	δ2H o/oo
Beta-727613	102.76 +/- 0.37 pMC	1.0276 +/- 0.0038	-10.39	-4.58	-25.25

Q2453270004
Standard AMS (14 business days)
ANALYZED MATERIAL/PRETREATMENT: (Water DIC):acidify-gas strip
COMMENT:The equivalent "Apparent" radiocarbon age to the reported pMC/fMDN values is ~ -220 BP (not adjusted for any hydro-geochemical effects on meteoric water 14CO2). Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (< 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation.

To validate report, scan this QR code on a mobile device or go to https://verify.betalabservices.com and enter the requested information.

Radiocarbon Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the 14C Modern Reference Standard used is from the National Institute of Standards and Technology (NIST) Oxalic Acid II (SRM 4990C). Conventional Radiocarbon Ages are reported using the Libby 14C half-life of 5568 years. Quoted errors represent 1-relative standard deviation statistics (68% probability). Counting errors are based on the combined error measurements of the sample, background, and modern reference standards. Reported isotopic ratios: d13C (1), d15N (2), d18O (3) and dH (4), were calculated relative to the VPDB (1), AIR N2 (2), VSMOW (3), VSMOW (4), respectively.

The Radiocarbon pMC and F14C values reported represent the Radiocarbon activity PRIOR to correction for fractionation. The Standard Deviation (+/- error) reported is at the One-Sigma confidence level.

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: (305) 667-5167
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Dale Jurecka
Lower Colorado River Authority

Report Date: January 23, 2025
Received Date: December 30, 2024

Laboratory Number	pMC	$F^{14}C$	δ13C o/oo	δ18O o/oo	δ2H o/oo
Beta-727614	34.94 +/- 0.13 pMC	0.3494 +/- 0.0013	-8.23	-4.37	-24.94

Q2453270005
Standard AMS (14 business days)
ANALYZED MATERIAL/PRETREATMENT: (Water DIC):acidify-gas strip
COMMENT:The equivalent "Apparent" radiocarbon age to the reported pMC/fMDN values is ~ 8450 BP (not adjusted for any hydro-geochemical effects on meteoric water 14CO2). Given the complex nature of groundwater DIC14 chemistry, duplicate measurements within 1-2 pMC are reasonable for a single water sample. For very low DIC concentration waters (< 20 mg/L HCO3) DIC14 and waters with complex organic chemistry, results can vary significantly outside of this expectation.

To validate report, scan this QR code on a mobile device or go to https://verify.betalabservices.com and enter the requested information.

Radiocarbon Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the 14C Modern Reference Standard used is from the National Institute of Standards and Technology (NIST) Oxalic Acid II (SRM 4990C). Conventional Radiocarbon Ages are reported using the Libby 14C half-life of 5568 years. Quoted errors represent 1-relative standard deviation statistics (68% probability). Counting errors are based on the combined error measurements of the sample, background, and modern reference standards. Reported isotopic ratios: d13C (1), d15N (2), d18O (3) and dH (4), were calculated relative to the VPDB (1), AIR N2 (2), VSMOW (3), VSMOW (4), respectively.

The Radiocarbon pMC and F14C values reported represent the Radiocarbon activity PRIOR to correction for fractionation. The Standard Deviation (+/- error) reported is at the One-Sigma confidence level.

Environmental Laboratory Services
The Solution Lab

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone (512)730-6022
Fax (512)730-6021

BETA Beta Analytic
CARBON-14 TESTING

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: (305) 667-5167
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990C and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date January 23, 2025
Submitter Dale Jurecka

QA MEASUREMENTS

Reference 1	
Expected Value	129.41 +/- 0.06 pMC
Measured Value	129.39 +/- 0.32 pMC
Agreement	Accepted
Reference 2	
Expected Value	0.44 +/- 0.04 pMC
Measured Value	0.44 +/- 0.04 pMC
Agreement	Accepted
Reference 3	
Expected Value	95.86 +/- 0.37 pMC
Measured Value	96.33 +/- 0.24 pMC
Agreement	Accepted

Comment All measurements passed acceptance tests.

Validation R.E. [signature] Date January 23, 2025

Digital signature on file

Page 4 of 4

End of Report

Appendix E

Table 13. Field parameters from surface water sites on Cypress Creek

CC ID	DATE	CONDUCTIVTY (µS/CM)	DISSOLVED OXYGEN (MG/L)	PH (STANDARD UNITS)	TEMPERATURE (°C)
2SW	9/18/2024	454	9.8	8.5	26.3
1SW	9/18/2024	314	5.7	5.5	25.7
3SW	9/18/2024	611	6.2	7.3	26.1
4SW	9/18/2024	782	3.9	7.2	25.3
5SW	9/18/2024	546	9.4	7.6	30.5
6SW	9/18/2024	468	7.6	7.8	28.1

Table 14. Surface water hardness

	SAMPLE ID					
	1SW	2SW	3SW	4SW	5SW	6SW
SAMPLE NAME	KRanch	Lasseter	Swingler	Casey	Scholar	Boyd
SAMPLE RUN DATE	9/25/2024	9/25/2024	9/25/2024	9/25/2024	9/25/2024	9/25/2024
TOTAL HARDNESS MG/L AS CACO3	130	200	310	400	330	210

Table 15. Surface water alkalinity

	SAMPLE ID					
	1SW	2SW	3SW	4SW	5SW	6SW
SAMPLE NAME	KRanch	Lasseter	Swingler	Casey	Scholar	Boyd
SAMPLE RUN DATE	9/20/2024	9/20/2024	9/20/2024	9/20/2024	9/20/2024	9/20/2024
ALKALINITY MG/L AS HCO3-	236.7	148.5	331.8	411.6	264.5	220.3

Table 16. Surface water sample IDs and associated tests

SAMPLE ID	SAMPLE DATE	SAMPLE TIME	MATRIX	TEST REQUESTED
1SW	9/18/2024	9:00	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity
2SW	9/18/2024	10:00	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity
3SW	9/18/2024	10:25	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity
4SW	9/18/2024	11:20	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity
5SW	9/18/2024	13:00	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity
6SW	9/18/2024	14:30	Surface Water	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
				Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
				Hardness
				Alkalinity

Table 17. Surface water anions

	SAMPLE ID					
	1SW	2SW	3SW	4SW	5SW	6SW
SAMPLE NAME	KRanch	Lasseter	Swingler	Casey	Scholar	Boyd
FLUORIDE MG/L	1.6	1.8	1.5	1.9	1.4	1.2
CHLORIDE MG/L	15.3	21.2	10.6	19.8	20.2	16.9
NITRITE (NO2-N) MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BROMIDE MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NITRATE (NO3-N) MG/L	<1.0	<1.0	1.1	1.4	0.8	<1.0
PHOSPHATE (PO4-P) MG/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SULFATE MG/L	16.8	24.4	47.1	60.3	57.3	36.2

Table 18. Surface water cations

	SAMPLE ID					
	1SW	2SW	3SW	4SW	5SW	6SW
SAMPLE NAME	KRanch	Lasseter	Swingler	Casey	Scholar	Boyd
LITHIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SODIUM MG/L	9.4	11.2	6.3	11.2	11.2	8.8
AMMONIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
POTASSIUM MG/L	3.8	2.6	3.6	2.8	3.6	4.4
MAGNESIUM MG/L	20.8	37.9	27.7	41.5	28.6	23.3
MANGANESE MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CALCIUM MG/L	20.0	26.9	75.4	82.6	58.7	47.4
STRONTIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BARIUM MG/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Water Analysis Report

Parameter	Results	MDL	Coefficient of Determination (r2)	Date Analyzed	Analyst	Method
Anions						
Fluoride	0.9979	1	99.9571	2/28/2022	AC	EPA 300.1 A
Chloride	0.9962	1	99.9877	2/28/2022	AC	
Nitrite (NO2-N)*	0.9922	1	99.9951	2/28/2022	AC	
Bromide	0.9902	1	99.9747	2/28/2022	AC	
Nitrate (NO3-N)**	0.9983	1	99.9881	2/28/2022	AC	
Phosphate (PO4-P)***	0.9984	1	99.9858	2/28/2022	AC	
Sulfate	0.9993	1	99.7847	2/28/2022	AC	

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank	0	0		0	<20
LCS	5.0107	5		100.214	90-110%
Matrix Spike_1	0.9984	1		99.84	90-110%
Matrix Spike_2	50.5809	50		101.1618	90-110%
Sample Dup_1	19.8		**Avg.**	19.8717	
Sample Dup_2	20.0		**%RI**	1.0839536	0-20%

Parameter	Results	MDL	Coefficient of Determination (r2)	Date Analyzed	Analyst	Method
Cations						
Lithium	0.1004	0.1	99.9004	2/28/2022	AC	ATSM D6919
Sodium	0.1012	0.1	99.9496	2/28/2022	AC	
Ammonium [b]	0.1037	0.1	99.9681	2/28/2022	AC	
Potassium	0.1091	0.1	99.9653	2/28/2022	AC	
Magnesium	0.1092	0.1	99.9355	2/28/2022	AC	
Manganese	0.1003	0.1	99.9698	2/28/2022	AC	
Calcium	0.1088	0.1	99.9426	2/28/2022	AC	
Strontium	0.1084	0.1	99.9477	2/28/2022	AC	
Barium	0.1092	0.1	99.9954	2/28/2022	AC	

[b]Quadratic fit

	Results (mg/L)	Expected (mg/L)		%Recovery	Acceptable Range
Lab Blank		0		0	<20
LCS	25.2609	25		101.0436	90-110%
Matrix Spike_1	0.9896	1		98.96	90-110%
Matrix Spike_2	99.7401	100		99.7401	90-110%
Sample Dup_1	11.2		**Avg.**	11.1789	
Sample Dup_2	11.2		**%RI**	0.1198687	0-20%

Appendix F

TN(µg-N/L):

Modified methods determined by Crumpton et al. (1992) Limnology and Oceanography 37(4): 907-913. Used Varian Cary 50 Scan Spectrophotometer. Water samples are quantified through second-derivative spectroscopy.

TP(µg-P/L):

Modified from Standard Methods 4500-P F. Used Varian Cary 50 Scan Spectrophotometer.

Ammonium molybdate and antimony potassium tartrate react with orthophosphate in an acid medium to form an antimony-phosphomolybdate complex, which, on reduction with ascorbic acid, yields an intense blue color suitable for photometric measurement.

Dissolved Ion Concentrations:

Instrument: Fisher Dionex ICS-1600

Anion Method: EPA 300.1 A

Cation Method: ATSM D6919

Alkalinity

Calculated by using the Thermo Scientific OrionStarT910 Automated Titrator. P and M alkalinity in a water sample are determined using the preprogrammed method P_M Alkalinity. Carbonate and bicarbonate concentrations may be calculated from the results of this titration based on some simplifying assumptions. P alkalinity is also known as phenolphthalein alkalinity and is determined by titrating to the phenolphthalein endpoint at pH 8.3. Total or M alkalinity is also known as methyl orange alkalinity and is determined by titrating to the methyl orange endpoint at pH 4.5. This application note describes the method using a direct titration to preset endpoints at pH 8.3 (P alkalinity) and pH 4.5 (M or total alkalinity) using sulfuric acid titrant. The calculations to determine carbonate and bicarbonate are also described.

Total Dissolved Solids (TDS)

Using method SM 2540 C

Table 19. Stormwater sample IDs and associated tests

SAMPLE ID	SAMPLE DATE	MATRIX	TEST REQUESTED
1R	1/30/2025	Stormwater	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
			Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
			Total Phophorus, Total Nitrogen, Total Dissovled Solids/ Conductivity
2R	1/30/2025	Stormwater	Anions: Fluoride, Chloride, Bromide, Nitrite, Nitrate, Phosphate, Sulfate
			Cations: Lithium, Sodium, Ammonium, Potassium, Magnesium, Manganese, Calcium, Strontium, Barium
			Total Phophorus, Total Nitrogen, Total Dissovled Solids/ Conductivity

Table 20. Lab results for stormwater samples

	SAMPLE ID	
	1R	2 R
ALKALINITY MG/L AS HCO3-	421.022	436.76
TOTAL HARDNESS (MG/L)	440	460
CONC. TP-(µG-P/L)	12.1	7.9
CONC. OF TN-(µ-N/L)	568.9	595.0
TDS (MG/L)	476	485
CONDUCTIVITY (µS/CM)	712	725
CONDUCTIVITY (µS/CM)	2.3963	2.4174
CHLORIDE MG/L	19.78	19.71
NITRITE (NO2-N) MG/L	0	0
BROMIDE MG/L	0	0
NITRATE (NO3-N) MG/L	1.41	0.00

	SAMPLE ID	
	1R	2 R
PHOSPHATE (PO4-P) MG/L	0	0
SULFATE MG/L	60.28	61.04
LITHIUM MG/L	0	0
SODIUM MG/L	13.77	13.79
AMMONIUM MG/L	0	0
POTASSIUM MG/L	1.66	1.31
MAGNESIUM MG/L	44.94	4689
MANGANESE MG/L	0	0
CALCIUM MG/L	87.38	89.01
STRONTIUM MG/L	0	0
BARIUM MG/L	1.51	1.47

The Meadows Center
for Water and the Environment
TEXAS STATE UNIVERSITY
601 University Drive, San Marcos Texas 78666
512.245.9200 | MeadowsCenter@txstate.edu | www.MeadowsWater.org
MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**