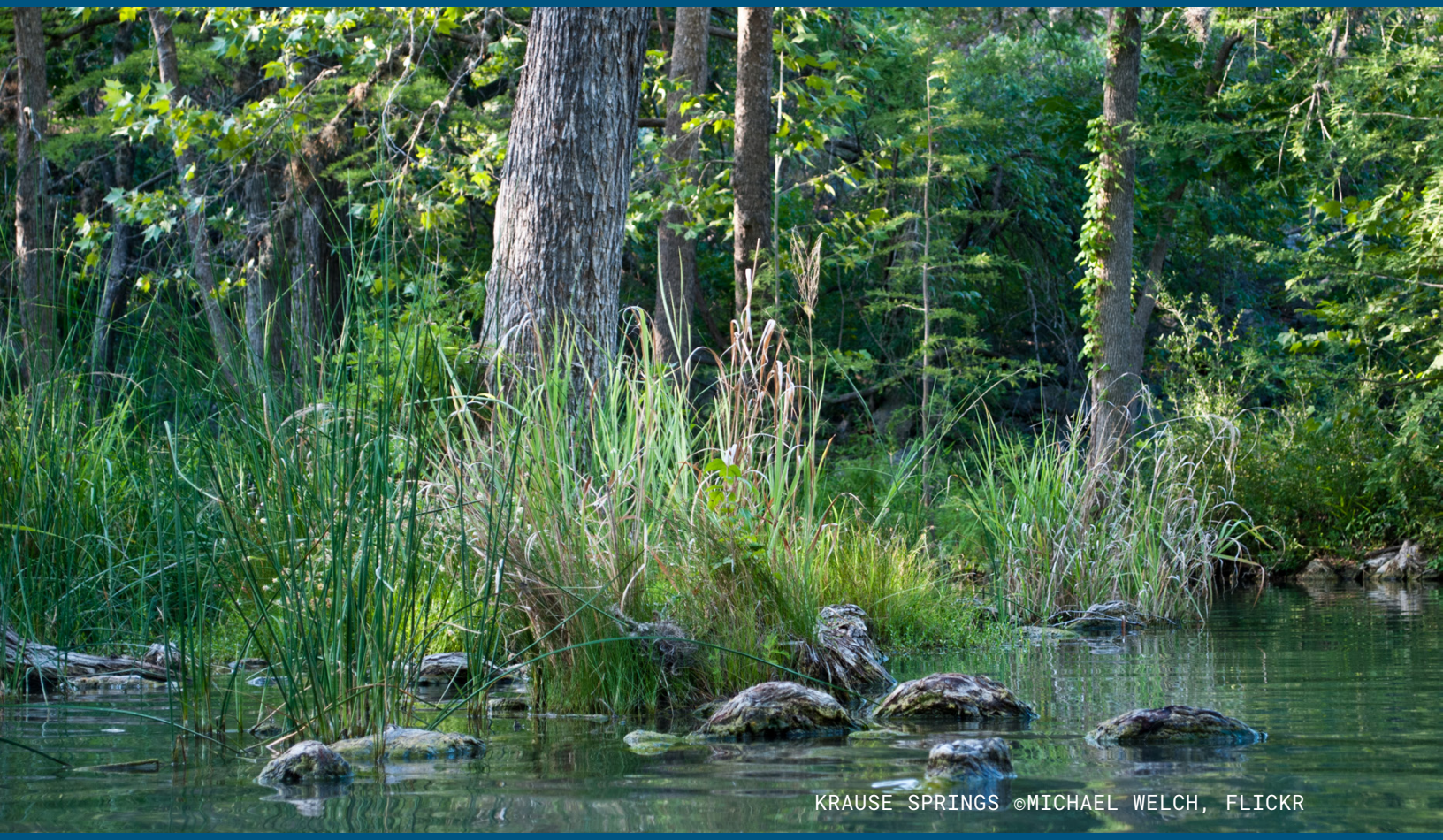
# Little Cypress Creek and Krause Springs Occurrence of Flowing Water, Burnet County, Texas: Phase 2

November 2022 | Report: 2022-06



KRAUSE SPRINGS ©MICHAEL WELCH, FLICKR


The Meadows Center for Water and the Environment
Texas State University

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MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

# Acknowledgements

The Meadows Center for Water and the Environment would like to thank the Central Texas Groundwater Conservation District for providing funding for the project.

We especially thank 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 joining aquifers would not be possible.


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Blue Creek Consulting LLC, Texas Geosciences Firm #50541

Mr. Wierman was the lead researcher for the project.

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KRAUSE SPRINGS WATERFALL ©CRAIG ALLEN PHOTOGRAPHY, FLICKR

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# ACRONYMS

| | |
|---|---|
| **CTGCD** | Central Texas Groundwater Conservation District |
| **DTW** | Depth to water (feet) |
| **GIS** | Geographic Information System |
| **LCC** | Little Cypress Creek |
| **LCRA** | Lower Colorado River Authority |
| **MP** | Measuring point (feet) |
| **MSL** | Mean sea level |
| **MW** | Monitoring well |
| **NM** | Not measured |
| **PVC** | Polyvinyl chloride |
| **RM** | River mile |
| **TD** | Total depth (feet) |
| **USGS** | United States Geological Survey |

ROPE SWING AT KRAUSE SPRINGS WATERHOLE ©CHUCK UNDERWOOD

# EXECUTIVE SUMMARY

Little Cypress Creek and Krause Springs are at a cross-roads as rapid growth in the Austin region intersects a fragile groundwater-fed ecosystem. The combined effects of increased groundwater pumping, extended droughts, and climate change influences recharge and spring flow from the aquifers and springs of the area. The Phase 1 study (Wierman, 2021) conducted in 2020-2021 concluded that the source of water to Little Cypress Creek and Krause Springs originated in the basal sands of the Cretaceous Age Sycamore Sand Formation. The Sycamore provides base flow to the creek and springs. The lateral and vertical extent of the basal springs was partially delineated through the interpretation of area well driller's logs.

During this Phase 2 study, additional monitoring wells were installed to complement an existing monitoring well that further confirmed the location of the basal sands and provided detailed groundwater level monitoring as part of a long-term monitoring program. Initial results indicate diurnal cycles in water levels occur due to evapotranspiration. Over the three-year period of record for the initial monitoring well, groundwater levels are declining in the vicinity of the springs.

The Central Texas Groundwater Conservation District installed two precipitation stations and soil moisture probes within the Cypress Creek watershed to aid in delineating potential groundwater recharge areas. Due to the current drought, little useful information has been collected to date.

Photographic reconnaissance was conducted via drone flight that confirmed the presence of a losing area of streamflow upstream of Krause Springs initially identified in Phase 1.

The Meadows Center assisted CTGCD with stakeholder engagement throughout Phase 2 with a series of stakeholder meetings to inform the community of the research goals, share preliminary results, and encourage public participation and guidance in future conservation efforts. Attendees expressed support for the research initiative and CTGCD's plans to move forward with proposed long-term groundwater protection efforts.

KRAUSE SPRINGS ©MICHAEL WELCH, FLICKR

# INTRODUCTION AND SCOPE OF STUDY

The report, "Krause Springs Occurrence of Flowing Water, Burnet County, Texas: Phase 2", summarizes the findings of activities performed as follow-up activities to the project "Krause Springs Occurrence of Flowing Water, Burnet County, Texas," hereafter referred to as Phase 1. Phase 1 was the initial study to perform an initial delineation of the spring shed of Krause Springs. Long term protection of spring flow at Krause Springs and Little Cypress Creek is a goal of the Central Texas Groundwater Conservation District (CTGCD) and local stakeholders.

It became apparent during Phase 1 that a long-term monitoring program needed to be established to further define the spring shed. Without adequate long-term monitoring and data collection, seasonal and long-term trends cannot be determined and effective spring protection measures cannot be developed. Phase 2 was designed to implement a long-term monitoring program. As such, this document should be considered a progress report on current activities. Where available, preliminary data is presented and discussed.

Based on the results of Phase 1, the following tasks were initiated:

- Two monitoring wells were installed by CTGCD. The wells provided information of subsurface stratigraphy and will allow for long term monitoring of groundwater elevations in the vicinity of the springs;
- Additional stream flow measurements in Little Cypress Creek were obtained to continue stream flow monitoring initiated in Phase 1;
- The CTGCD installed two precipitation measuring stations with accompanying soil moisture gauges to aid in delineating the source of recharge to groundwater and spring flow; and
- A community stakeholder process was initiated to present scientific data and receive community input on potential spring conservation and protection measures.

For most of the duration of Phase 2, the area was in severe drought conditions. This was a limitation on the study. With little or no rain fall, spring flows were down and Little Cypress Creek upstream of Krause Springs ceased to flow, though the springs themselves continued to flow. The purpose of Phase 2 was to put a long-term monitoring program in place to measure the hydrogeologic system's response to wet and dry periods. As described in this report, a few trends were evident and give some insight into how the system functions.

# STREAM DISCHARGE MONITORING

Additional synoptic discharge measurement (stream flow) events were performed in November 2021, April 2022, and July 2022. Based on available landowner access, measurements were made at semi-regular intervals along the length of the creek with "live" water. Like Phase 1, flow measurements were made using a FlowTracker (FT2) handheld Acoustic Doppler Velocimeter® generally following USGS protocols. River miles from the confluence of Little Cypress Creek and Lake Travis were determined using Geographic Information System (GIS) techniques.

Discharge measurements from select sites monitored during Phases 1 and 2 are shown in Table 1. These measurements include flow from upper Little Cypress Creek (LCC8 and LCC15) and downstream of Krause Springs (LCC5).

Measurements from LCC5 represent the total discharge from Little Cypress Creek upstream of the park and all the spring discharge originating at the park are shown in Figure 1. There is a decline in discharge over the study period. Given the relatively brief period of measurement, it is unclear if this is a long-term declining trend or a short-term response to the current drought.

**TABLE 1.** PHASE 1 AND 2 DISCHARGE MEASUREMENTS (CFS)

| DATE | LCC15 (RM 1.3) | LCC8 (RM 0.15) | LCC5 (RM 0) |
|---|---|---|---|
| 3/5/2020 | 0.42 | 0.56 | 1.12 |
| 3/26/2020 | 0.19 | 0.73 | 3.46 |
| 7/30/2020 | 0.15 | 0.07 | 0.45 |
| 12/3/2020 | 0.15 | 0.33 | 0.82 |
| 11/5/2021 | 0.092 | 0.485 | 0.134 |
| 4/12/2022 | 0.287 | 0.247 | 0.25 |
| 7/29/2022 | 0 | 0 | 0.166 |

*RM = river mile*

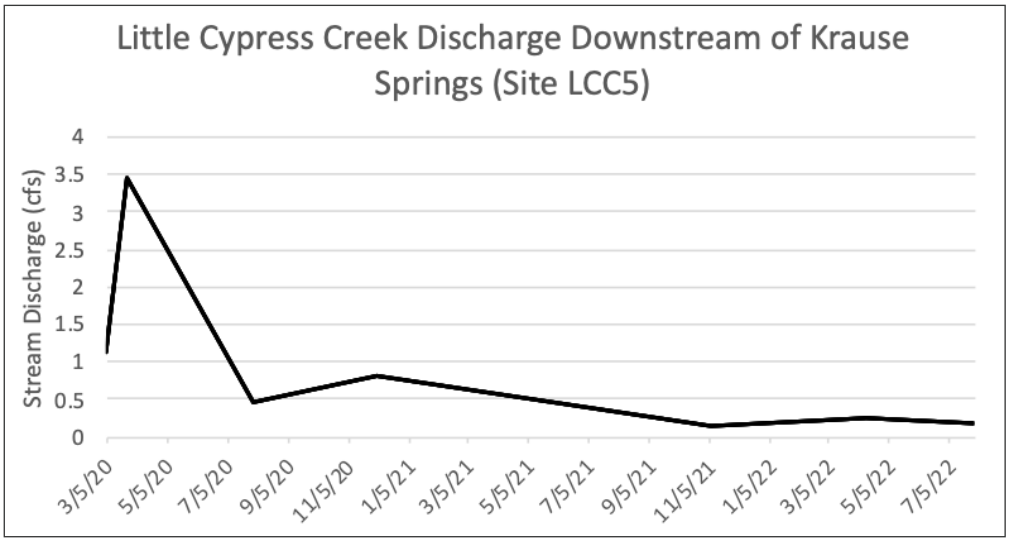


**FIGURE 1.** LITTLE CYPRESS CREEK DISCHARGE DOWNSTREAM OF KRAUSE SPRINGS (SITE LCC5)

# MONITORING WELL INSTALLATION

Two monitoring wells were drilled on December 21-23, 2021. They were drilled on Krause Property and the locations of the wells are shown on Table 2 and Figure 2 (595726-MW3 and 5957729-MW4). The purpose of the wells was to further delineate the extent of the previously identified sand and gravel unit that supports spring flow at Krause Springs. In addition, the wells will be used for long term monitoring of groundwater levels in the vicinity of the springs. The wells were drilled by Holt Engineering of Austin, TX under the supervision of the CTGCD and observed by the Meadows Center.

**TABLE 2.** WELL COORDINATES

| WELL | LATITUDE | LONGITUDE | ELEVATION (FT. MSL) |
|---|---|---|---|
| MW3 | 30.476197 | -98.150803 | 780 |
| MW4 | 30.480194 | -98.143388 | 747 |

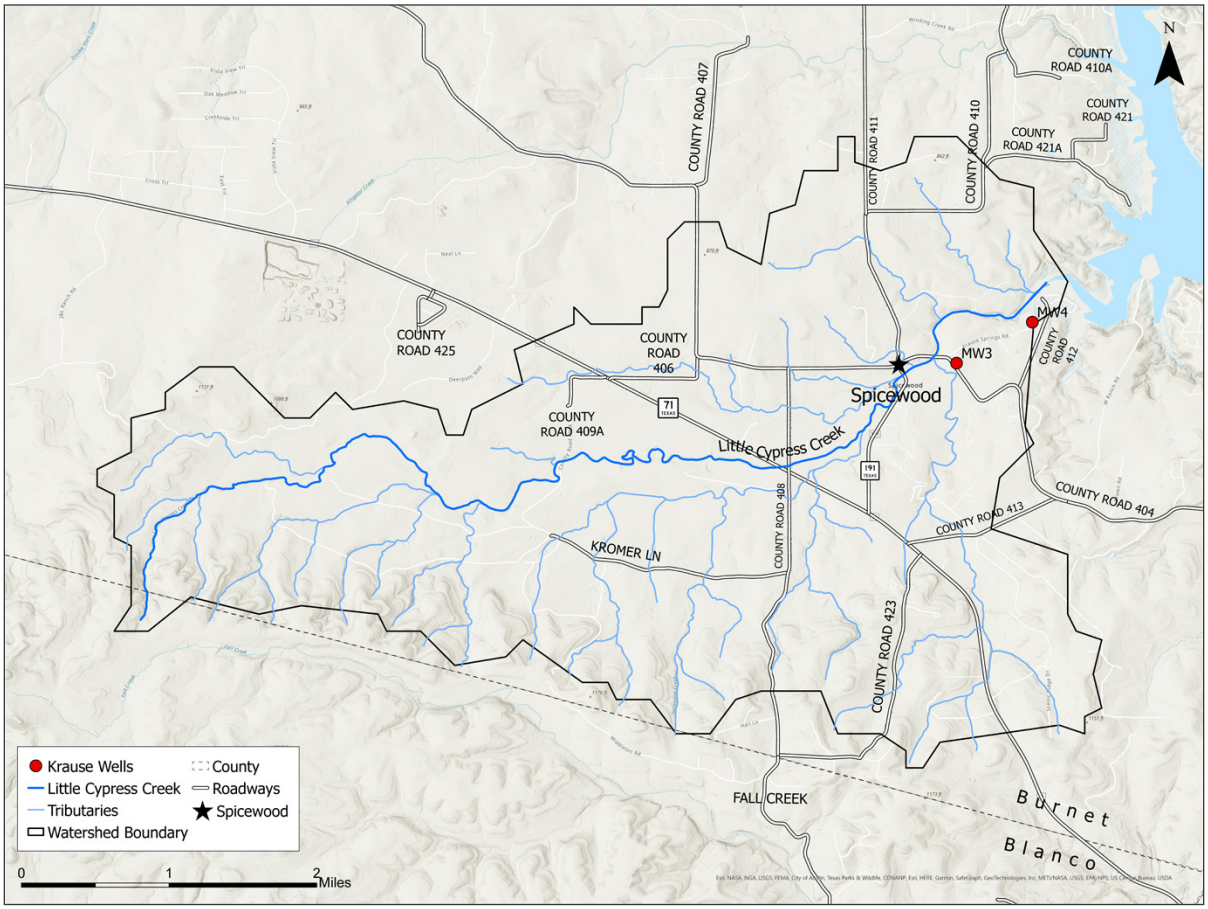


**FIGURE 2.** LOCATION MAP

During performance of the drilling, soil/rock samples were collected either with a split barrel corer (split spoon) or rock coring. Representative samples of subsurface materials were collected and are currently stored by the CTGCD. Upon completion of the borings, down hole geophysical logs were run, including gamma, SP and SPR. Geophysical logs are on file at the CTGCD. Two-inch ID polyvinyl chloride (PVC) monitoring wells with slotted screen bottom sections were installed in the bore holes. Flush mount concrete pads were installed at the surface. State well reports and soil boring logs are included in Appendix A and include the details of well installation and completion. After the installation of the wells, the CTGCD instrumented the wells with pressure transducers for continuous water level readings.

The sand and gravel unit delineated in Phase 1 was encountered at both locations. At MW3, approximately 30 feet of water bearing sand and gravel was encountered beneath 13 feet of surficial silt (Figure 4). The boring was terminated by auger refusal at 54 feet. The sand and gravel are interpreted to be part of the basal sandy facies of the Sycamore formation.

**FIGURE 3.** GEOPHYSICAL LOGGING AT MW4

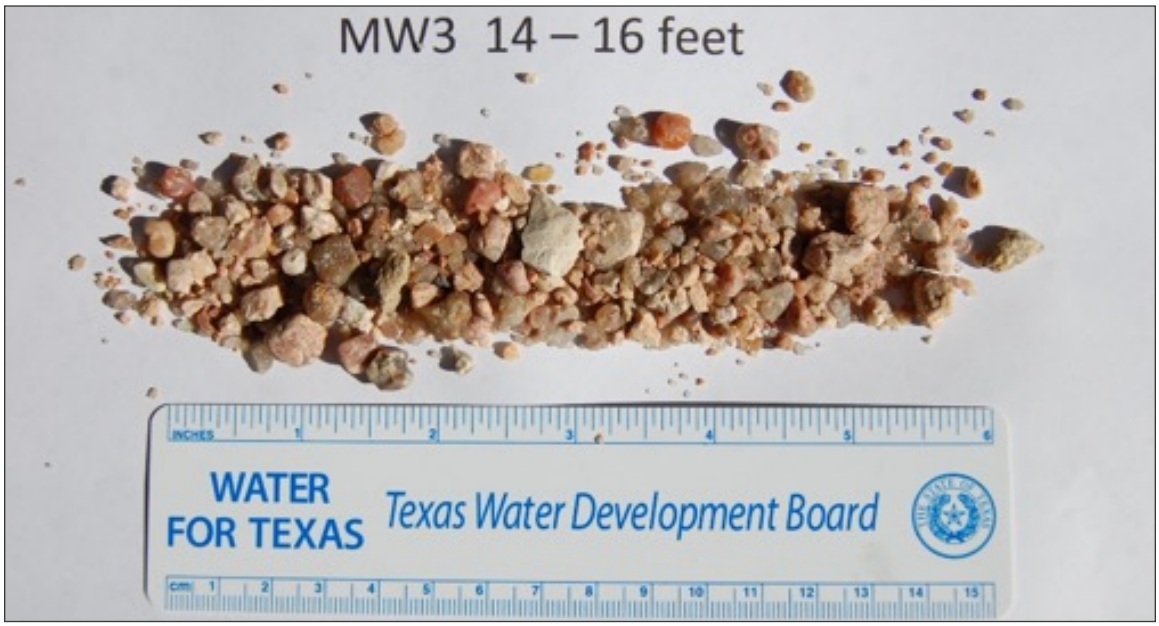


**FIGURE 4.** WASHED SAMPLE OF SAND AND GRAVEL AT MW3

At MW4, sand and gravel unit similar to MW3 was encountered from 0 to 19.5 feet. Auger refusal occurred at 19.5 feet. From 19.5 to 25 feet, a coarse conglomerate was cored (Figure 5). The upper sand and lower conglomerate are both part of the Sycamore Formation. The conglomerate was 4 feet thick and underlain by a light brown to bluish brown clay. The clay extended 10 feet to the terminus of the boring. The clay is the Smithwick Formation (Figure 7).

**FIGURE 5.** SYCAMORE CONGLOMERATE IN OUTCROP NEAR MW4

**FIGURE 6.** CORE SAMPLE OF THE SYCAMORE CONGLOMERATE AT MW4

**FIGURE 7.** ORE SAMPLE OF THE SMITHWICK CLAY AT MW4.

The occurrence of sand and gravel map and geologic cross section from the first report have been updated and are included as Figures 8 and 9. The results of the well installation program at consistent with the findings of the first report.

Continuous measuring pressure transducers were installed in the two new wells. Previously, a transducer was installed in MW2. The transducers measure the pressure of the water column which is converted to depth to water.

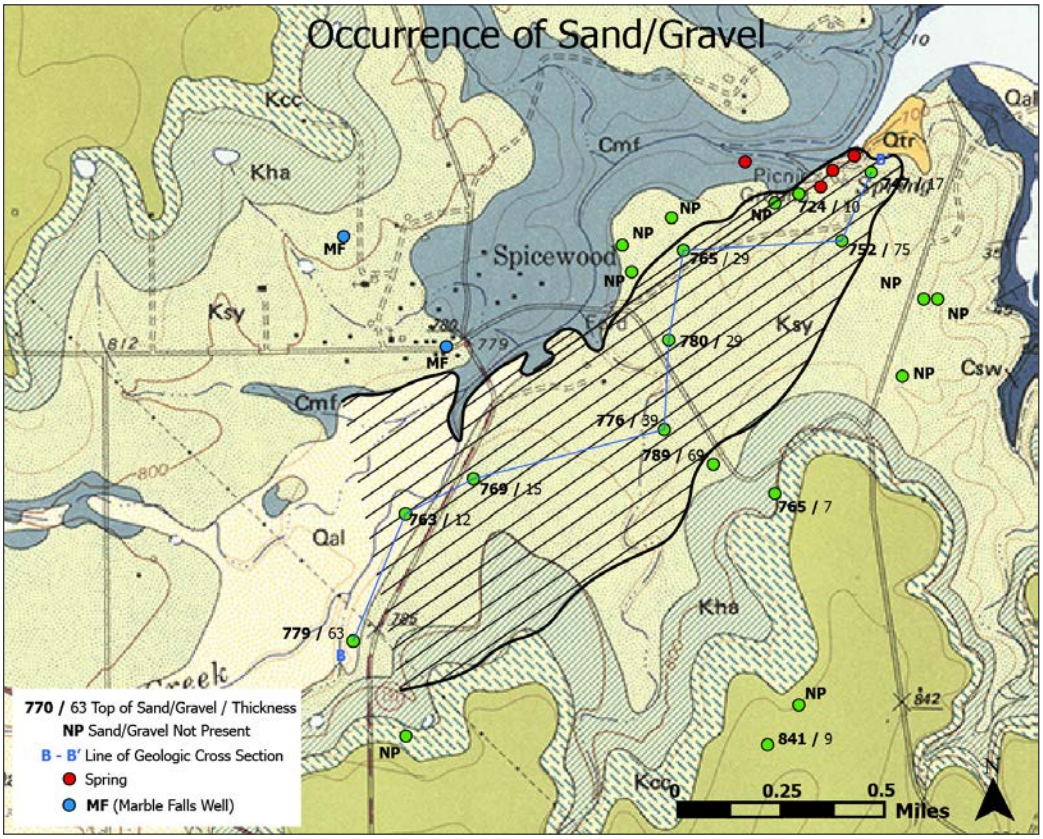


**FIGURE 8.** INFERRED OCCURRENCE OF SYCAMORE SAND. HATCHED AREA REPRESENTS THE INFERRED EXTEND OF SAND AND GRAVEL OF THE SYCAMORE SAND BASED UPON OUTCROPS AND SUBSURFACE WELL DATA. BASE MAP AFTER BARNES, 1982.

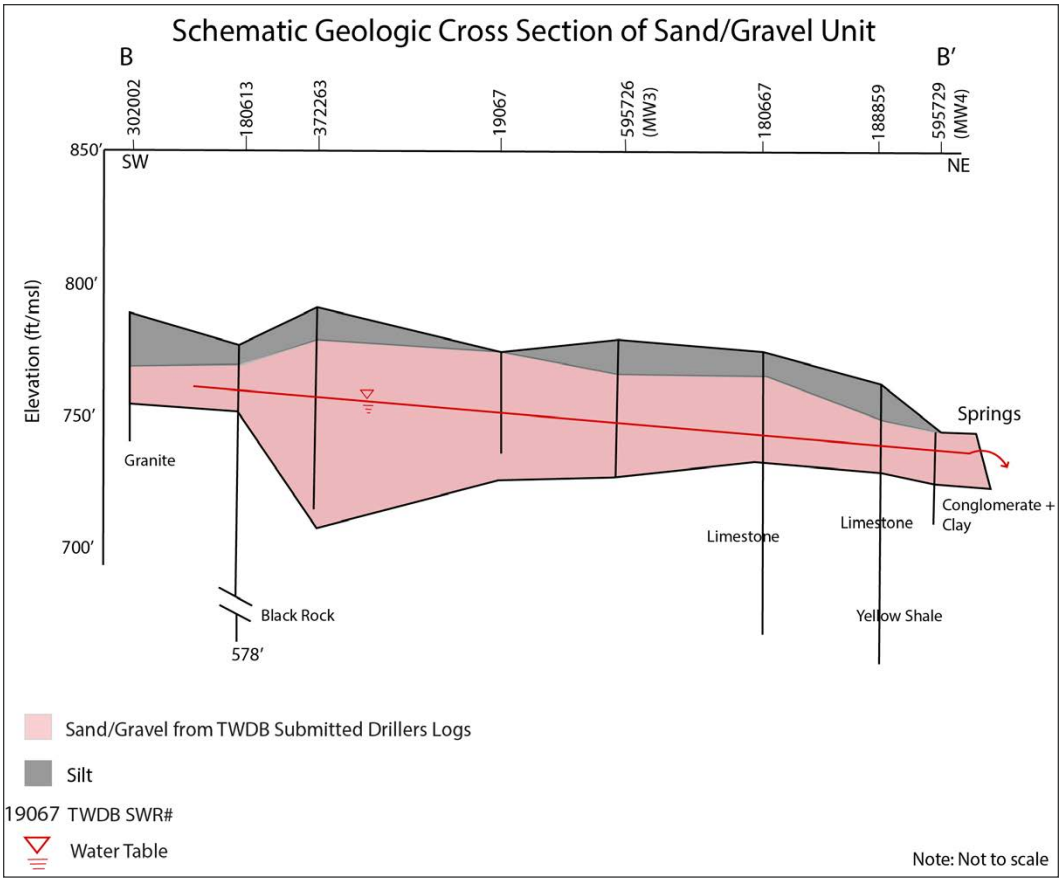


**FIGURE 9.** SCHEMATIC GEOLOGIC CROSS SECTION OF SAND AND GRAVEL UNIT

LITTLE CYPRESS CREEK ON JUNE 2022.©JENNA WALKER

# GROUNDWATER LEVEL MONITORING

On September 10, 2022, CTGCD staff measured water levels in area wells. A summary of water level data from Phase 1 (2020) and Phase 2 (2022) is shown on Table 3.

Groundwater elevations have slightly declined since 2020 but the data is sparse. Groundwater flow directions in 2022 are like 2020 with flow in the sand and gravel unit from south to north with discharge to Little Cypress creek via Krause Springs.

Pressure transducers were installed in the two new monitoring wells shortly after the wells were completed. A transducer was installed in MW2 in 2019. The transducers measure the pressure of the water column which is converted to depth to water.

**TABLE 3.** SUMMARY OF GROUNDWATER ELEVATIONS PHASE 1 AND PHASE 2

| CTGCD # | SWR # | OWNER | LATITUDE | LONGITUDE | GROUND SURFACE ELEVATION | TD | MP | DTW 7/30/2020 | GROUNDWATER ELEVATION 7/30/2020 | DTW 12/3/2020 | GROUNDWATER ELEVATION 12/3/2020 | DTW 8/10/2022 | GROUNDWATER ELEVATION 8/10/2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2113 | 180677 | Krause | 30.478055 | -98.150001 | 774 | 105 | 1.5 | 31.15 | 744.35 | 30.6 | 744.9 | NM | NM |
| 2201 | 188859 | Krause | 30.478338 | -98.145108 | 767 | 105 | 1.52 | 24.3 | 744.22 | 24.08 | 744.44 | 25.09 | 743.43 |
| NR | 5739312 | Krause | 30.478634 | -98.145278 | 764 | NM | 1.63 | 22.05 | 743.58 | 21.82 | 743.81 | 23.40 | 742.23 |
| 8532 | 5739320 | Krause (B-3) | 30.476011 | -98.150788 | 779 | 54 | Transducer | NM | NM | NM | NM | 26.32 | 752.68 |
| 8531 | 5739319 | Krause (B-4) | 30.480099 | -98.143519 | 748 | 25 | Transducer | NM | NM | NM | NM | 7.13 | 740.87 |
| 7177 | 5739318 | Krause (Park Land) | 30.479444 | -98.146389 | 744 | 65 | Transducer | NM | NM | NM | NM | 8.06 | 735.94 |
| NR | NR | Bible HD | 30.478001 | -98.153254 | 764 | NM | 2.15 | NM | NM | NM | NM | 10.24 | 755.91 |
| 212 | 19067 | Wall | 30.473411 | -98.15087 | 777 | 40 | 1.88 | NM | NM | NM | NM | 19.30 | 759.58 |
| NR | NR | Wall HD | 30.075106 | -98.152661 | 767 | NM | 2.6 | 13.2 | 756.4 | 13.25 | 756.35 | 14.49 | 755.11 |
| 6032 | 372263 | Miller | 30.472236 | -98.156111 | 791 | 75 | 0.94 | 34.5 | 757.44 | 34.78 | 757.16 | 36.54 | 755.40 |
| NR | NR | Yeager | 30.469497 | -98.159267 | 783 | 80 | 0.47 | 15.35 | 768.12 | 15.55 | 767.92 | 21.00 | 762.47 |
| 3569 | NR | Yeager/ Ashmore | 30.486477 | -98.159162 | 788 | 80 | 1.22 | 15.7 | 773.52 | 16.06 | 773.16 | 19.46 | 769.76 |
| 5555 | 283152 | Brown (Parish) | 30.471949 | -98146934 | 821 | 144 | 1.42 | 63.2 | 759.22 | 74.6 | 747.82 | 66.80 | 755.62 |
| 1993 | 168575 | LCRA | 30.476389 | -98.143056 | 777 | 140 | 1.21 | 39.6 | 738.61 | 39.72 | 738.49 | 41.62 | 736.80 |

*TD = total depth (feet)*
*MP = measuring point (feet)*
*DTW = depth to water (feet)*
*NM = Not Measured*

WATERFALL AT KRAUSE SPRINGS ©KIRK SCHEIDT

The short duration of deployment of the two new transducers precludes analysis of long-term trends. Water levels for the period of record for MW2 are shown in Figure 10.

Several trends are evident from the data. Water levels fluctuate seasonally with the lowest levels at the end of the summer months, with increasing water levels during fall and winter. These fluctuations reflect increased evapotranspiration during the sweltering summer months and less evapotranspiration in the winter months. The seasonality of water levels reflects when groundwater recharge is occurring (fall and winter). Groundwater recharge is typically higher in the fall and winter months due to lower evapotranspiration and higher precipitation.

From 2019 through 2022, there has been a steady decline in groundwater levels at MW2 (Figure 10). On a linear trend basis, there has been a 1 - 1.5-foot decline in water levels over the period of record at MW2. The decline is due to increased temperature causing increased evapotranspiration and less groundwater recharge. Changes in precipitation may be the cause, but site-specific data on precipitation is just now becoming available from the recently activated precipitation stations installed by the CTGCD. Continuation of the long-term monitoring program is necessary.

There is a daily water level fluctuation in groundwater. The fluctuation is identical at MW3 and MW4. Figure 11 is a graph of water levels from MW2 during the period 6/9 – 7/7/2022. The daily fluctuation is approximately 0.3 -0.4 feet. The peak water level consistently occurs around 9:00 AM. Water levels decline until approximately 6:30 - 7:00 PM, then begin to rise. The fluctuations are likely caused by increased water uptake by plants, or evapotranspiration during daylight hours. “One of the most important diurnal fluctuating-inducing factors is the water consumption of vegetation” (Gribovszki, 2010).

Diurnal fluctuations in shallow groundwater can cause similar fluctuations in spring flow. This is likely occurring at Krause Springs. Detailed instrumentation of spring discharge would be necessary to quantify the magnitude of the fluctuations.

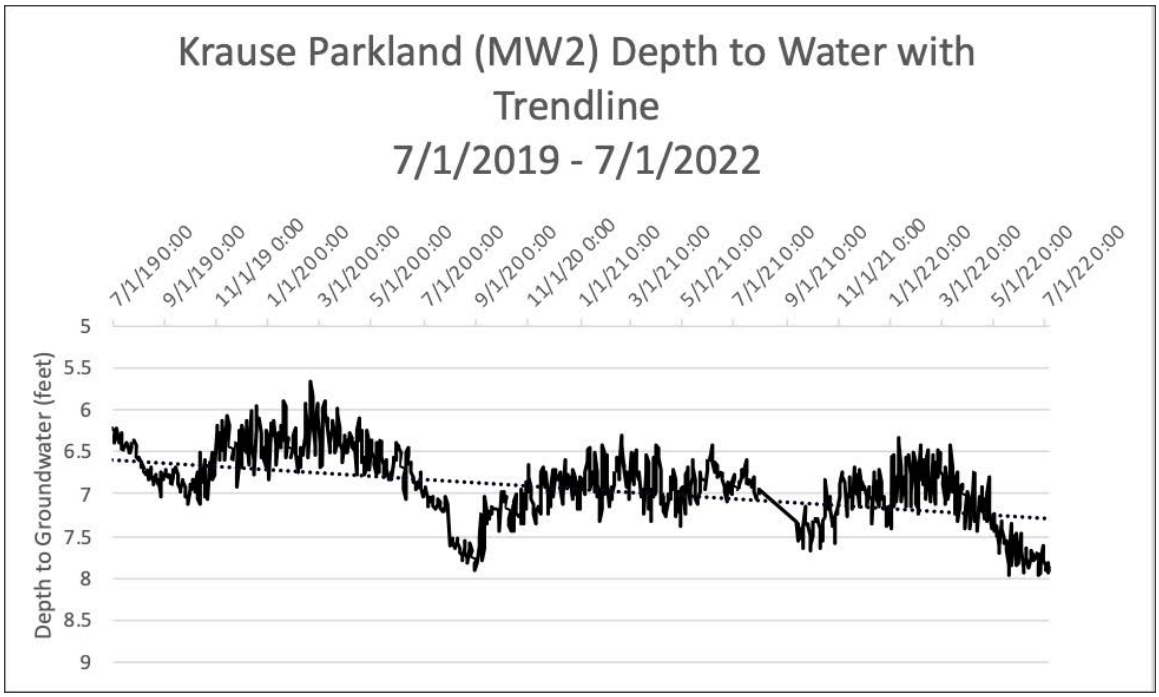


**FIGURE 10.** KRAUSE PARKLAND (MW2) DEPTH TO WATER 7/1/2019-7/1/2022

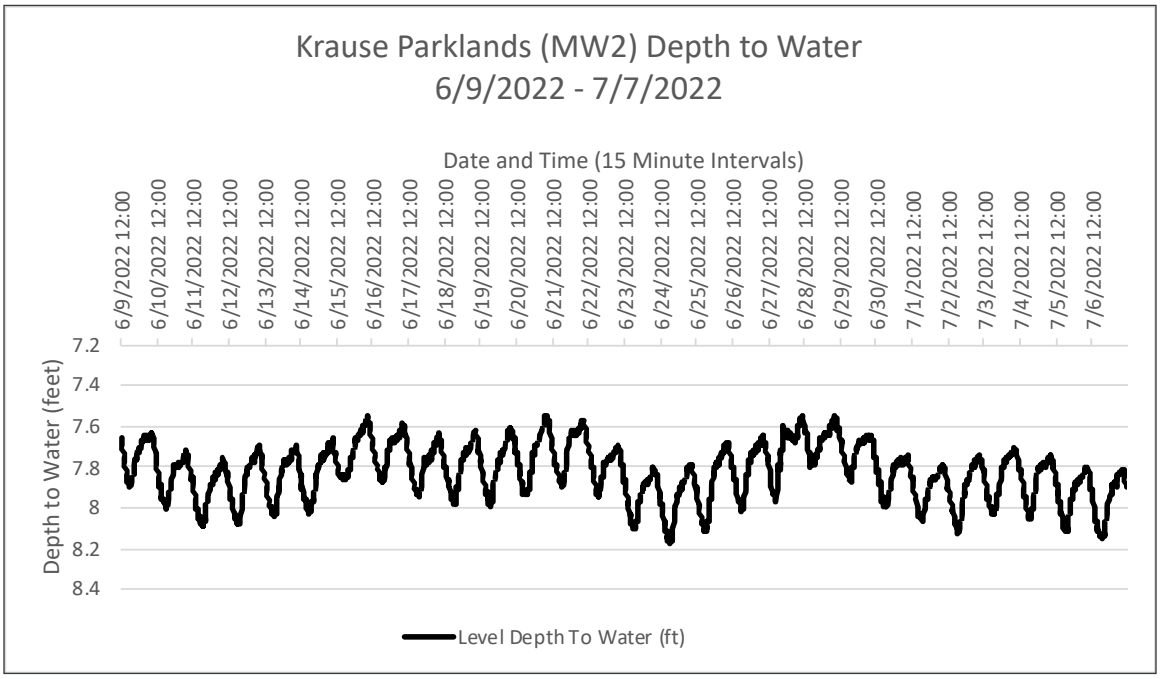


**FIGURE 11.** KRAUSE PARKLANDS (MW2) DEPTH TO WATER 6/9/2022 - 7/7/2022

# PRECIPITATION STATIONS

As part of the program, the CTGCD installed two precipitation gauges with accompanying soil moisture gauges to monitor soil moisture and potential groundwater recharge due to precipitation. The gauges are Onset HOBO USB Micro Station Data Loggers with HOBO Rain Gauge Data Loggers and EC5 Soil Moisture Smart Sensors installed at 4" and 10" below ground surface. The location coordinates of the stations are shown on Table 4.

Krause 1 is located within the park, near the springs and monitoring wells. Krause 2 was installed on the Manigold ranch, south of Hwy 71. The stations were placed at opposite ends of the watershed to be able measure differences in rainfall across the watershed and potentially determine differential groundwater recharge.

Data is collected on six-hour intervals but on Figure 12, the data has been converted to daily values. There was little or no precipitation from February to the beginning of June 2022. Soil moisture indicated dry soils at 4 and 10 inches. A value of 0 to 0.1 $m^3/m^3$ (soil moisture/soil volume) indicates oven-dry to dry soil, respectively. A value of 0.3 or higher normally indicates a wet to saturated soil (onsetcomp.com). Soil moisture increases in response to later precipitation events but is not sufficient to saturate soil down to the 10" depth. Monitoring over time, with the addition of data from the second station, will allow for the determination of rainfall/potential recharge trends.

**TABLE 4.** PRECIPITATION STATION COORDINATES

| STATION | LATITUDE | LONGITUDE | ELEVATION | INSTALLATION |
|---|---|---|---|---|
| Krause 1 | 30.47875 | -98.146298 | 753 ft. msl | February 2022 |
| Krause 2 (Manigold Ranch) | 30.463637 | 98.187553 | 878 ft. msl | July 2022 |

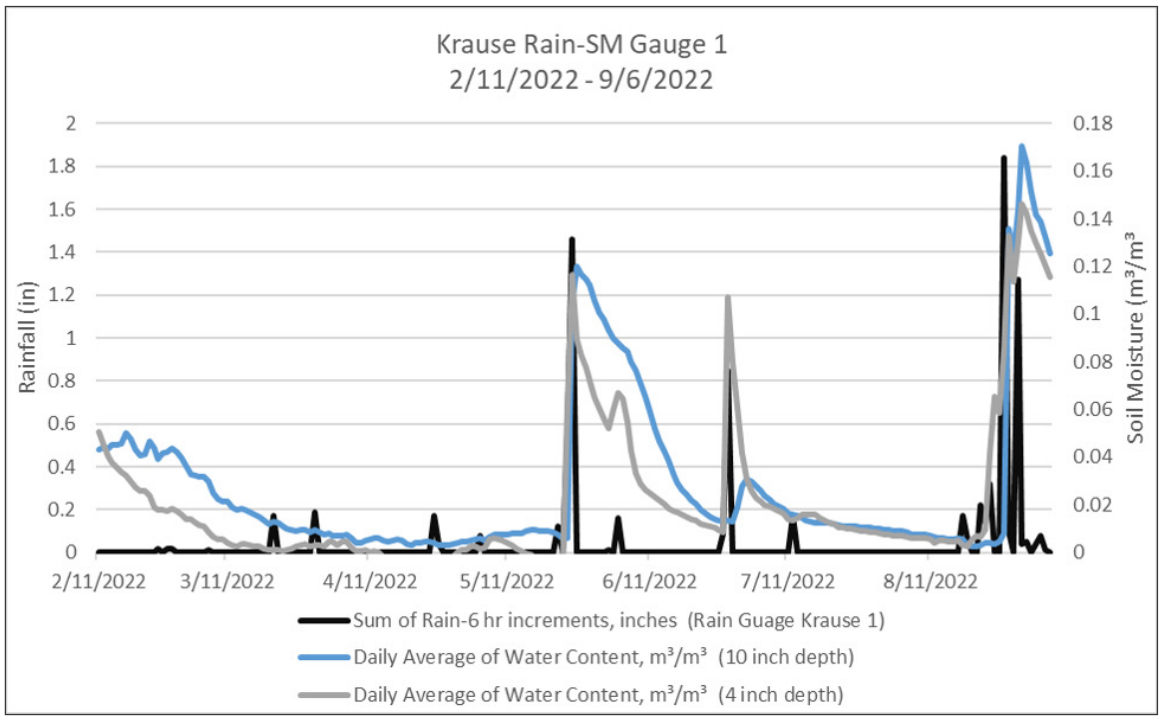


**FIGURE 12.** PRELIMINARY PRECIPITATION AND SOIL MOISTURE DATA

# AERIAL IMAGERY

Due to limited accessibility, aerial imagery was taken instead of the previously planned dye trace study. The platform used was a DJI Phantom 4 Pro drone. Eight hundred and sixteen images were collected from approximately 165 feet flight altitude. The orthomosaic was processed with Agisoft Metashape Pro with a TIF Resolution of 96dpi, pixel size = 2cm (about 0.79 in). The full image coverage area was 69.44 acres or 0.11 sq miles.

The lighter green vegetation represents cypress trees which are almost always an indication of perennial wet/ spring flow. Bare rock (most visible in the Central-West extent of the stream bed (Figure 17) indicates the losing section of the creek. A large spring sits southeast of where Little Cypress Creek often ceases to flow which then feeds into the Krause Springs swimming hole as a second contribution. Water chemistry analysis of both the creek and Krause Springs tell us, however, that the Little Cypress Creek water is discharged into the creek upstream of the springs.

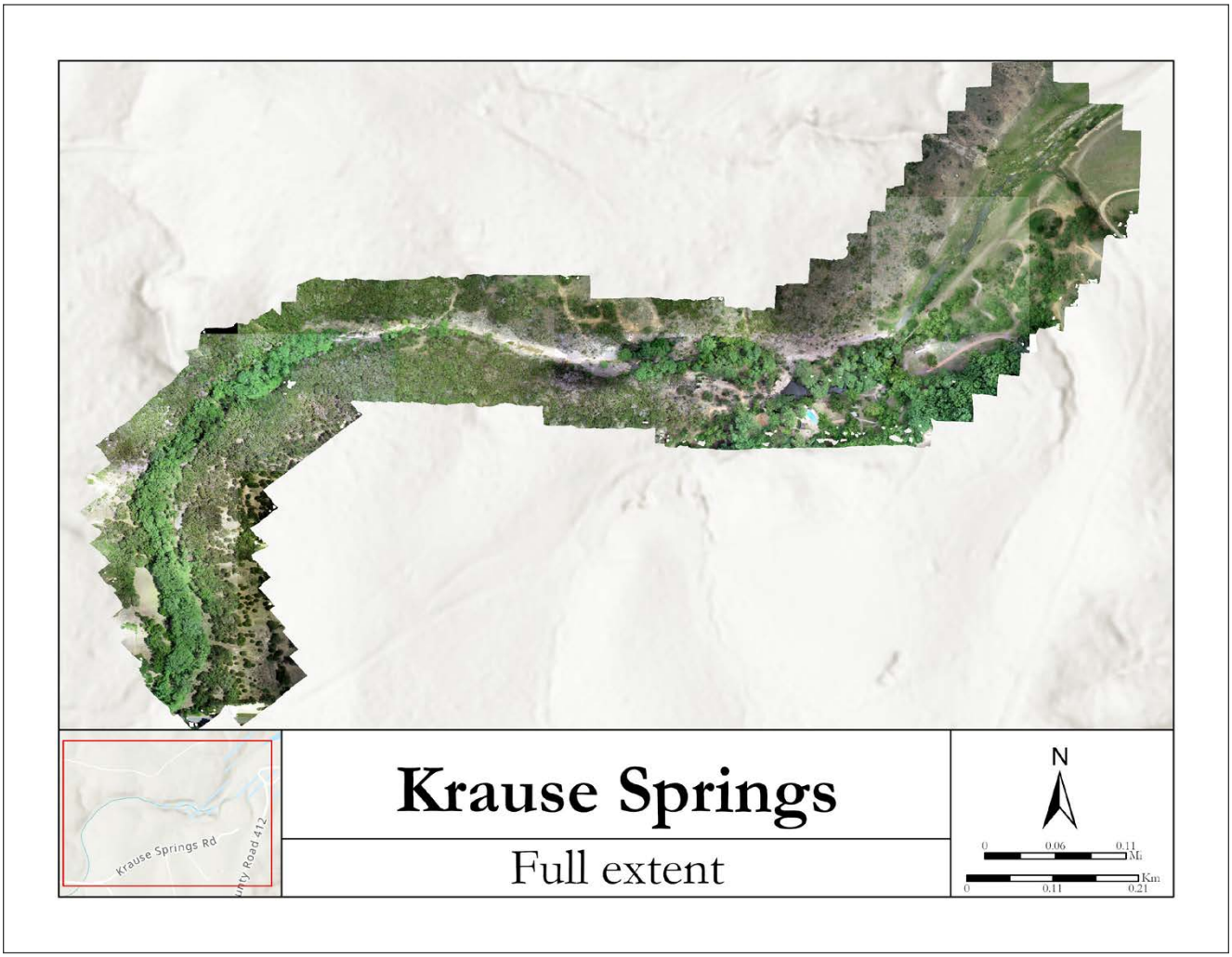


**FIGURE 13.** KRAUSE SPRINGS FULL EXTENT

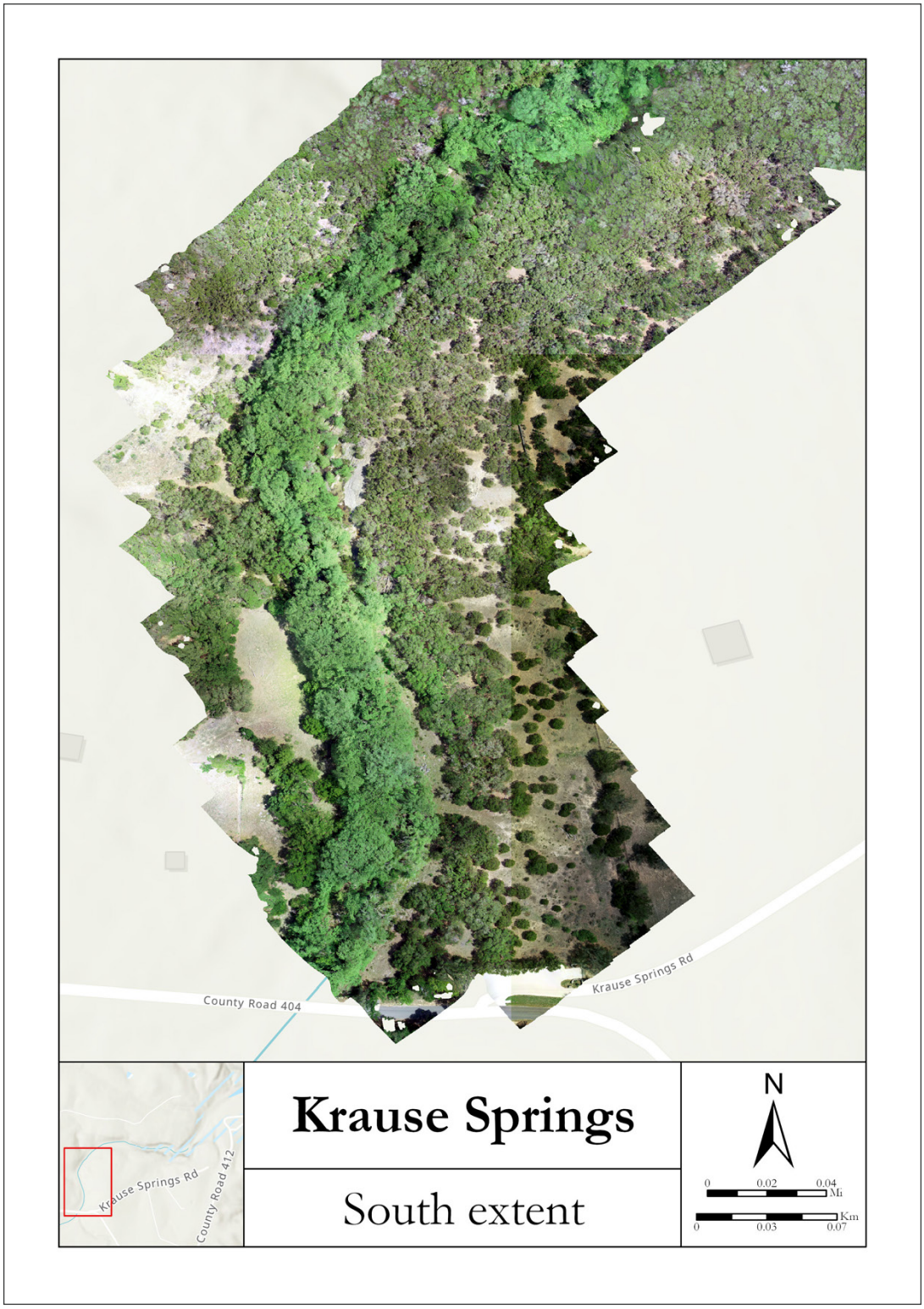


**FIGURE 14.** KRAUSE SPRINGS SOUTH EXTENT

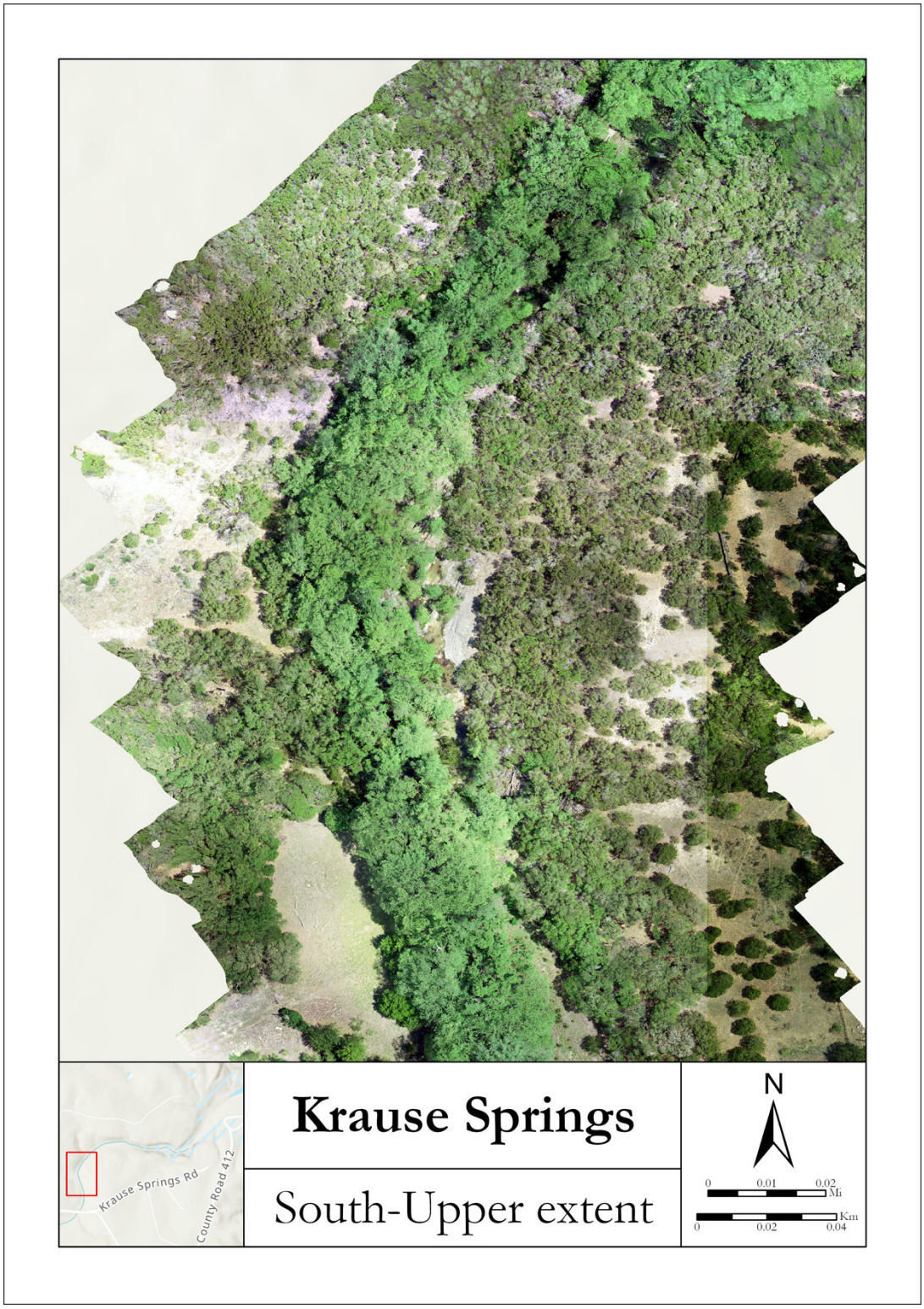


**FIGURE 15.** KRAUSE SPRINGS SOUTH-UPPER EXTENT

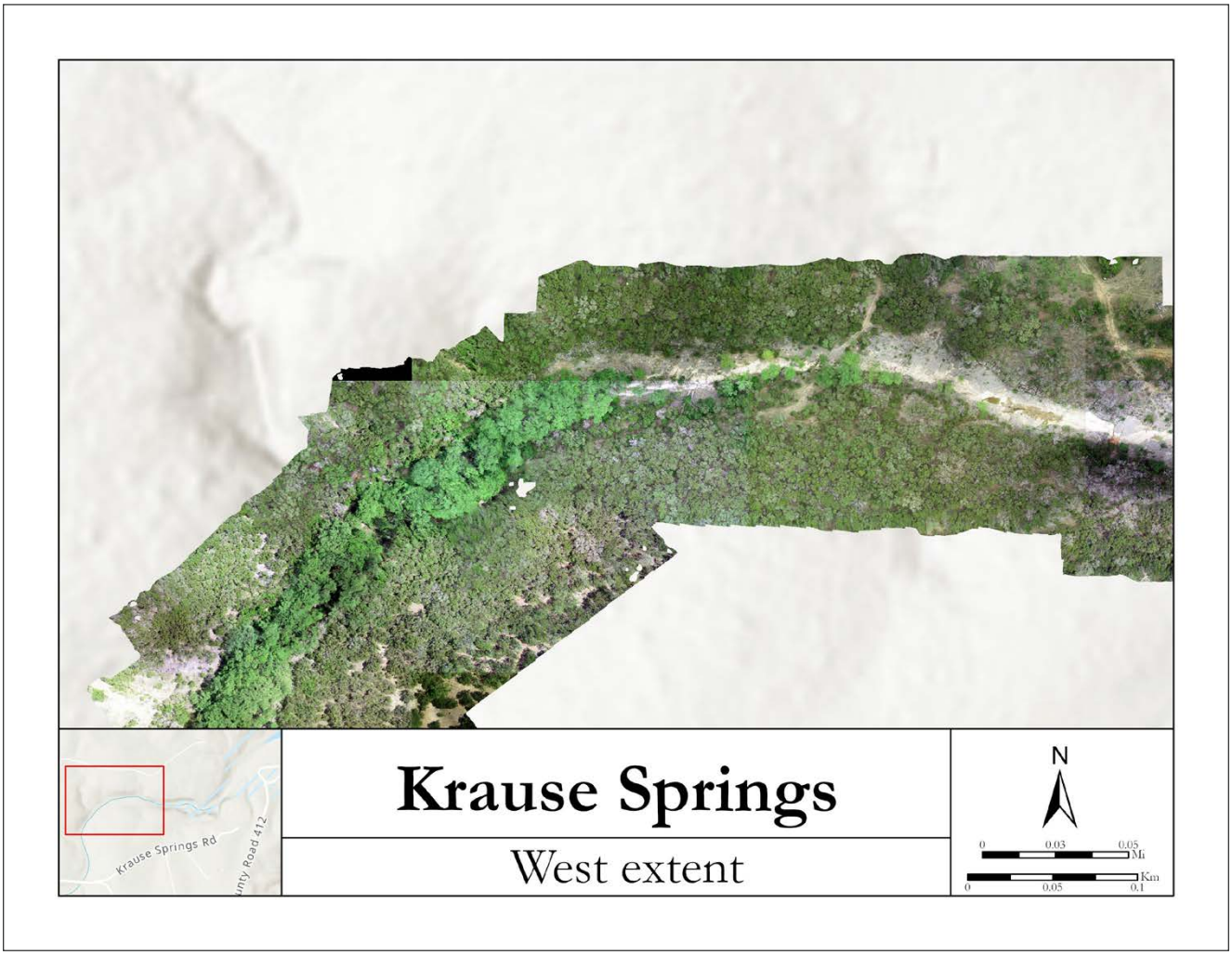


**FIGURE 16.** KRAUSE SPRINGS WEST EXTENT

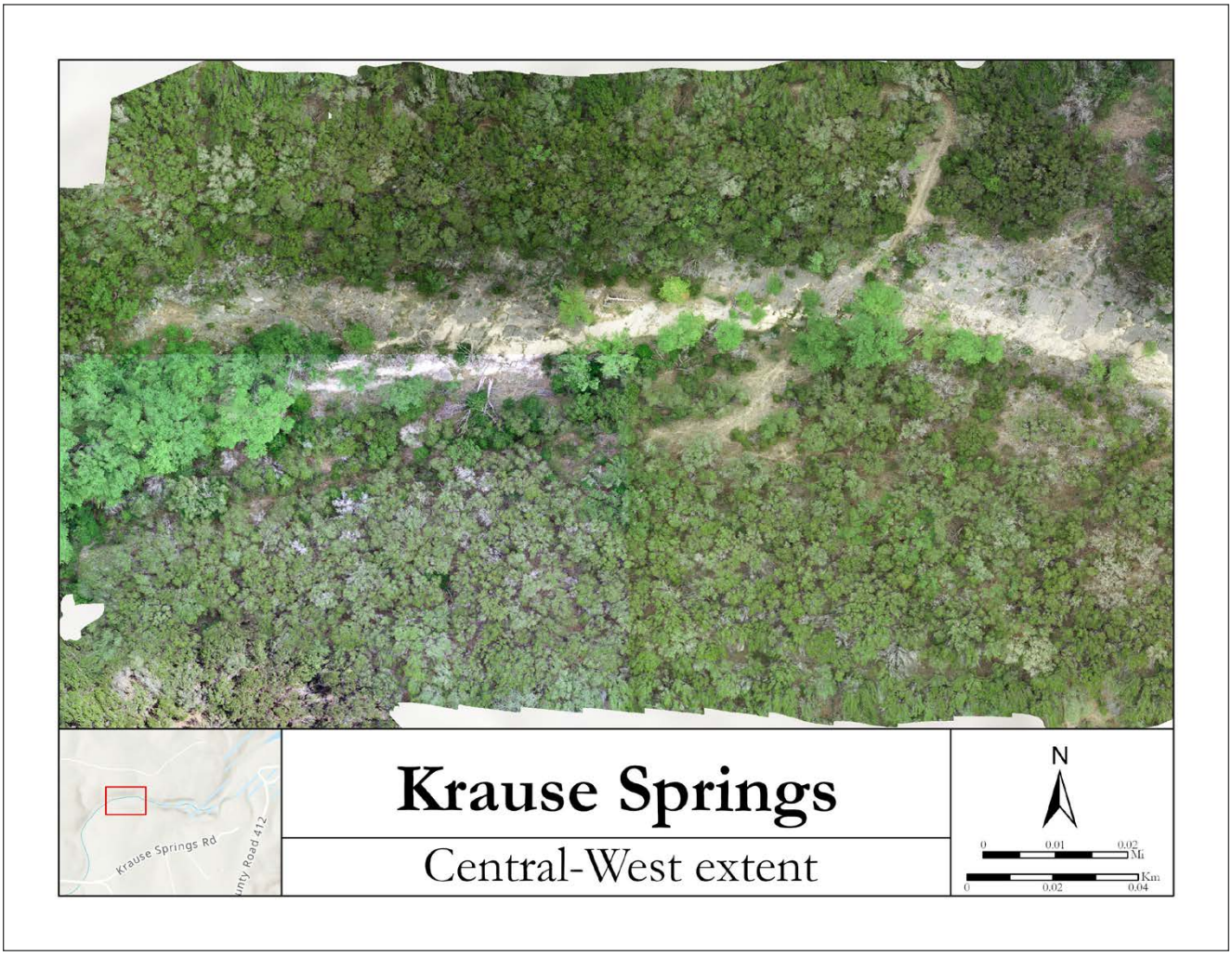


**FIGURE 17.** KRAUSE SPRINGS CENTRAL-WEST EXTENT

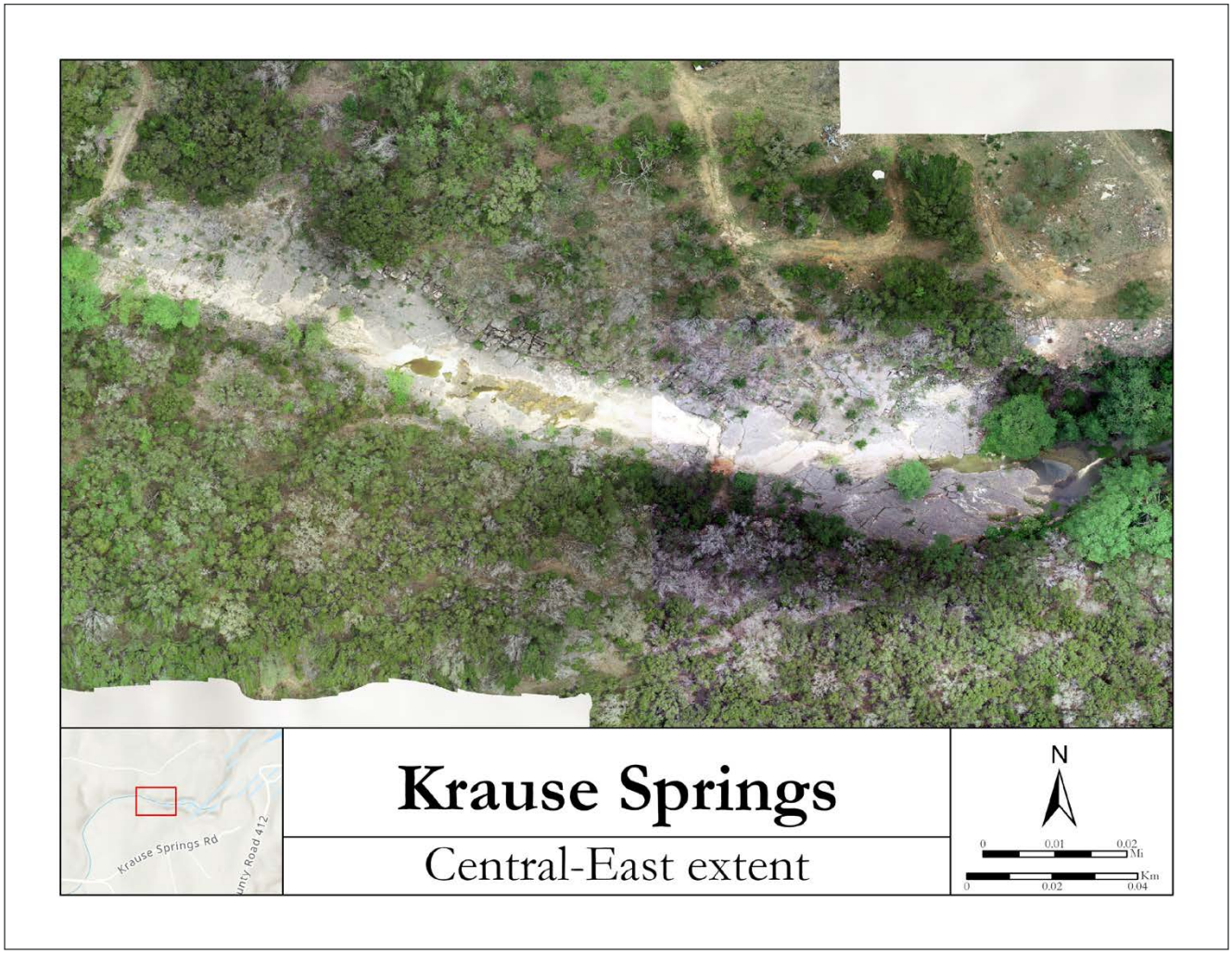


**FIGURE 18.** KRAUSE SPRINGS CENTRAL-EAST EXTENT

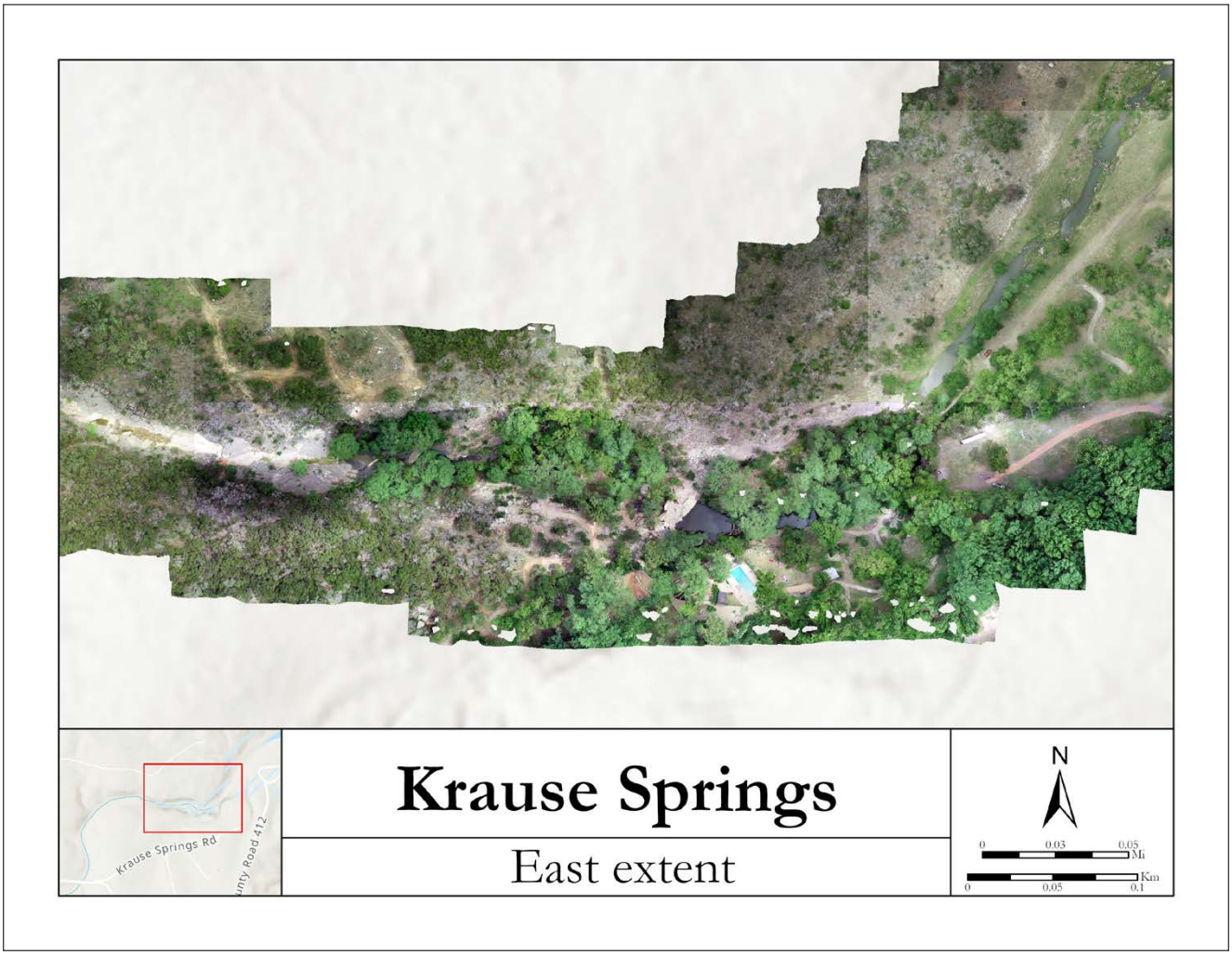


**FIGURE 19.** KRAUSE SPRINGS EAST EXTENT

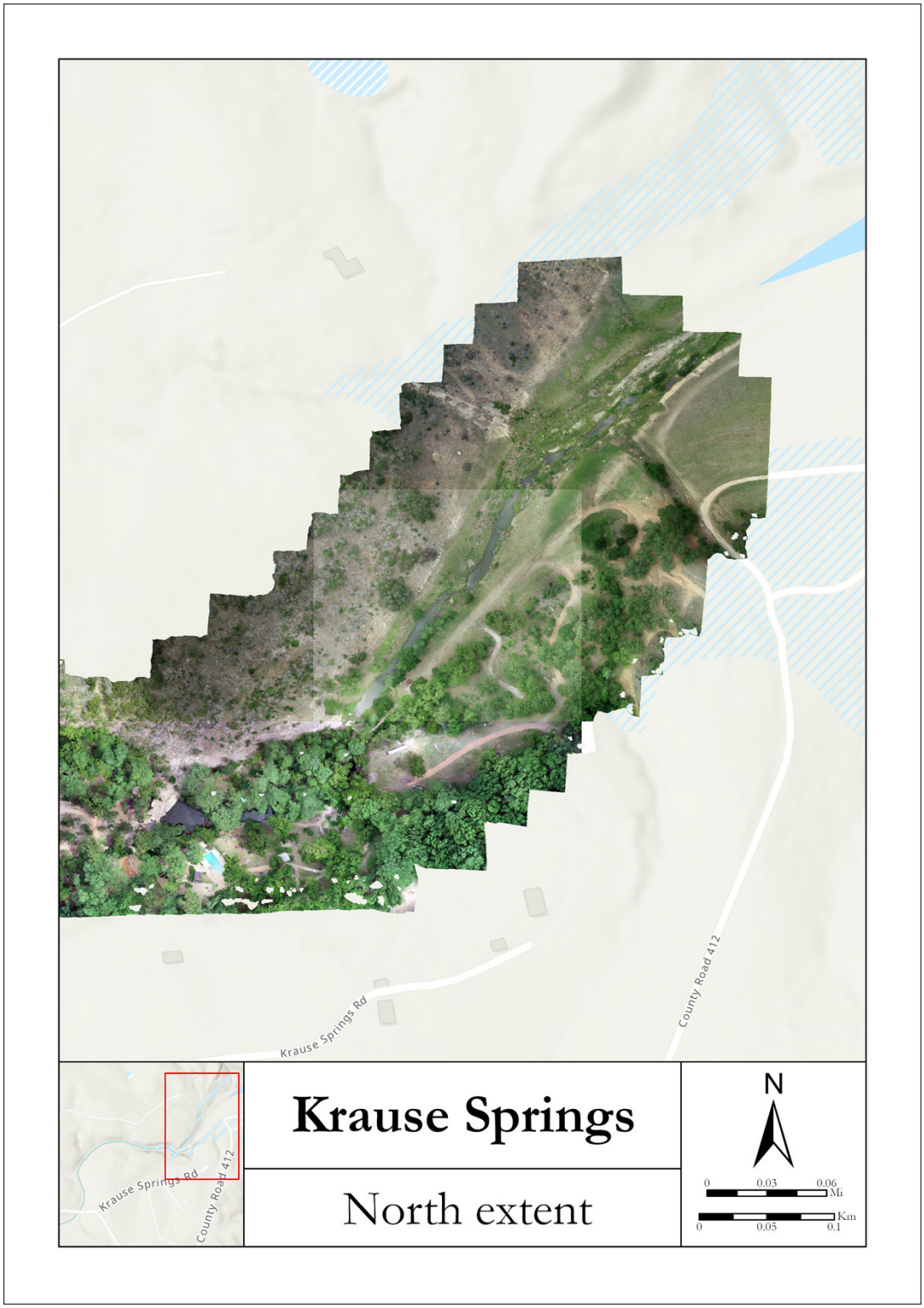


**FIGURE 20.** KRAUSE SPRINGS NORTH EXTENT

# STAKEHOLDER ENGAGEMENT

An initial stakeholder meeting was held at the Spicewood Community Center in November 2022 to introduce the Little Cypress Creek/Krause Springs Occurrence of Flow Study to a group of local stakeholders.

A second meeting was held at the Spicewood Community Center in July 2022. Following a project recap, Meadows Center Founder, Dr. Andrew Sansom, spoke to the group about the process and value of conservation easements. Meadows Center Director of Watershed Services, Nick Dornak, then spoke about the success of the first One Water school built in Texas (Blue Hole Primary School in Wimberley, TX) and co-presented with Doug Wierman on the Jacob's Well Groundwater Management Zone which was established based on the findings of the 2019 Science Advisory Group (Gary, et al, 2019).

A third stakeholder meeting was held on October 19, 2022, at Opie's Barbeque Restaurant in Spicewood, Texas. Following a project summary led by CTGCD and the Meadows Center, Spicewood landowner, Chris Harte, spoke about his experience establishing a conservation easement on his property with the Hill Country Conservancy. Representatives from Burnet County, Hill Country Conservancy, Colorado River Land Trust, Hill Country Alliance, and Texas Water Trade were also in attendance. National Wildlife Federation, The George and Cynthia Mitchell Foundation, neighboring groundwater conservation districts, and others expressed interest and support of the initiative to identify a plan to further protect the Little Cypress Creek and Krause Springs system.

A stakeholder survey was distributed at the final meeting that was initially completed by ten participants. Ninety percent rated maintaining spring flow long term as most important (10 on scale of 1 to 10 with 10 equaling the most important). One hundred percent answered, as a landowner/stakeholder, preservation of spring flow is a priority in the face of competing interests from development. Eighty five percent agreed that the district should manage to protect spring flow.

The following comments were offered regarding conservation easements:

- Love them
- Should always be the decision of the landowner
- Totally committed, as we have CE on our ranch (Cherry Spring Ranch, > 1000 acres)
- I believe we are stewards of the land and as such need to do our best to take care of it.
- We fully support conservation easements. We have a Hill Country Conservancy conservation easement on our own 1,000+ acres in Precinct 4 of Burnet County, extending into Blanco County.
- In the right situation, they can be a powerful tool for conservation.
- Great tool for land management especially for large tracts of land. Not for everyone due to the large expense to landowner in putting it in place.
- They are great, we need more!
- They are a good way to protect land, but out of reach to many landowners.

The following opinions were offered regarding the best solutions to ensuring spring flow:

- 1) Improved Tools for groundwater conservation districts, 2) Improve county development oversight, 3) Land stewardship education
- Limiting development within the watershed that utilizes groundwater.
- Stop granting water rights to developers--Is this a Lower Colorado River Authority (LCRA) board issue?

- Limit large development
- Pretty obvious and I have no new suggestions: 1. Less development 2. More responsible land use, etc.
- Consider establishing a special management zone for the GCD to expand its regulatory capabilities
- Education on the use of finite resources. Rainwater collection to ease stress on groundwater use. Vote for environmentally conscious candidates.
- Conservation easements, watershed protection, larger minimum lot sizes, water use easements
- Restrict development in critical groundwater areas. Set larger minimum lot sizes. Write codes for groundwater.

A key takeaway is that community members are supportive of the district's goals of maintaining springflow through increased regional management. However, the community at large is not being reached in these stakeholder events for one reason or another. Feedback included the need to focus more on the urgent issue of potential wells going dry, hosting another event in the evening after most people get off work, and lots of names of "fancy" organizations. A few local participants volunteered to help with local messaging, marketing, and coordination of a Little Cypress Creek stakeholder group in the future.

KRAUSE SPRINGS ©EARL NOTTINGHAM/TEXAS PARKS & WILDLIFE DEPARTMENT

# DISCUSSION AND NEXT STEPS

The elements of long-term monitoring program were put in place during this study. Initial data indicates declining shallow groundwater levels in the vicinity of the springs in the last several years. Surface water flow in Little Cypress Creek declined as well. Stream flows upstream of Krause Springs ceased in the last year. These declines are due to the current drought but may also be part of the longer-term trend of climate change. Given the short record of data, it is not possible at this time to predict long-term trends.

Next steps should include the following:

1. Continued monitoring of the in-place systems (groundwater, soil moisture and precipitation). Establish a routine frequency of data collection.
2. Expand monitoring upsteam and further throughout the spring shed.
3. Periodically, post interpretive data graphics on the CTGCD webpage for public consumption.
4. Develop an initial simple groundwater model to develop a surface water/groundwater water budget of the spring shed. A water budget will aid in confirming the present spring shed delineation.

# REFERENCES

Gary, M.O., Hunt, B.B., Smith, B.A., Watson, J.A., and Wierman, D.A., 2019, Evaluation for the Development of a Jacob's Well Groundwater Management Zone, Hays County, Texas. Meadows Center for Water and the Environment, Texas State University, July 2019.

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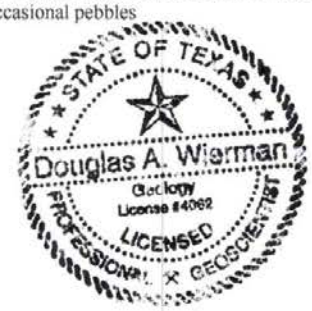
Wierman, D.A., Walker, J., Arismendez, S., Schlandt, A., Navaro, A., Vasquez, D. 2021. Krause Springs Occurrence of Flowing Water, Burnat County, Texas. Meadows Center for Water and the Environment. Texas State University at San Marcos, TX.

# APPENDIX A: SOIL BORINGS

Log of Soil Boring

| | | | |
|---|---|---|---|
| Boring/Well Number: MW3 | Project Name: CTGCD Krause Springs Hydrogeologic Characterization | Drilling Date(s): 12/21/21 | |
| State Well #: 595726 | | | |
| Driller: Holt Engineering, Austin, TX | Project Location: Krause Springs, Spicewood, TX | Latitude: 30.476197 | |
| Geologist: Doug Wierman | | Longitude: -98.150803 | |
| Company: Blue Creek Consulting LLC | | Elevation: 780 (GE) | |

| Sample Type | Depth (feet bgs) | Lithologic Description | USCS Symbol | Moisture Content | Well Construction |
|---|---|---|---|---|---|
| Hollow Stem Augers - Split Spoon Samples on 5 foot intervals (shaded depth intervals) | 1–2 | SILT - medium brown (topsoil) | ML | Moist | 3 Bags bentonite, 1 foot concrete cap, flush mount |
| | 3–13 | SILT - dense, light brown to tan | ML | Dry - Moist | 2 inch ID solid PVC pipe |
| | 14–23 | SAND with gravel - light brown, coarse to small pebbles, occasional clay, finer sand 17 - 18 ft. | SP | Moist | |
| | 24 | | | | |
| | 25 | CLAY - silty, light gray | CL - ML | M | |
| | 26–54 | SAND, fine to medium, increasing fine to medium gravel with depth, occasional pebbles | SP | Wet - Water @ 25.5 feet while drilling | 5 bags filter sand; 2 inch ID PVC slotted well screen |
| | 55 | Auger refusal at 54 feet | | | |



# Log of Soil Boring

| | | | | | |
|---|---|---|---|---|---|
| Boring/Well Number: MW4 | | Project Name: CTGCD Krause Springs Hydrogeologic Characterization | | Drilling Date(s): 12/22-23/21 | |
| State Well #: 595729 | | | | | |
| Driller: Holt Engineering, Austin, TX | | Project Location: Krause Springs, Spicewood, TX | | Latitude: 30.480194 | |
| Geologist: Doug Wierman | | | | Longitude: -98.143388 | |
| Company: Blue Creek Consulting LLC | | | | Elevation: 747 (GE) | |
| **Sample Type** | **Depth (feet bgs)** | **Lithologic Description** | **USCS Symbol** | **Moisture Content** | **Well Construction** |
| Solid and Hollow Stem Augers 0 -19.5 ft. Rock Coring 19.5 -35 ft. Split Spoon Samples shown as shaded intervals. | 1 | SILT and SAND/GRAVEL (road base) | ML, SP, GP | Dry | 1 bag bentonite; 5 ft. solid PVC |
| | 2 | | | | |
| | 3 | SAND with gravel, medium to coarse, few pebbles (drilled hard 4 - 9 ft.) 6 inch layer reddish CLAY at 19 - 19.5 ft. | SP, GP | Water at 6 feet during drilling | 4 bags of filter sand 5 - 25 ft. with 1 bag concrete cap. Flush mount completion; 2 inch ID PVC slotted well screen 5 - 25 ft |
| | 4 | | | | |
| | 5 | | | | |
| | 6 | | | | |
| | 7 | | | | |
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| | 15 | | | | |
| | 16 | | | | |
| | 17 | | | | |
| | 18 | | | | |
| | 19 | | | | |
| | 20 | Auger refusal at 19.5 ft. Switched to continuous 5 ft. coring runs. | | | 2 Bags of bentonite 25 - 35 ft. |
| | 21 | CONGLOMERATE, up to 2 inch rounded to subangular clasts, grey matrix, hard (consolidated Sycamore Formation) | | | |
| | 22 | | | | |
| | 23 | | | | |
| | 24 | | | | |
| | 25 | CLAY, light brown to bluish brown, medium plasticity, wet (Smithwick Formation) | | | |
| | 26 | | | | |
| | 27 | | | | |
| | 28 | | | | |
| | 29 | | | | |
| | 30 | | | | |
| | 31 | | | | |
| | 32 | | | | |
| | 33 | | | | |
| | 34 | | | | |
| | 35 | | | | |
| | 36 | End of boring at 35'. | | | |

# APPENDIX B: WELL REPORTS

## STATE OF TEXAS WELL REPORT for Tracking #595726

| | | | |
|---|---|---|---|
| Owner: | **Central Texas GCD** | Owner Well #: | **B-3-MW** |
| Address: | **225 S. Pierce Street<br>Burnet, TX 78611** | Grid #: | **57-39-3** |
| Well Location: | **424 CR 404<br>Spicewood, TX 78669** | Latitude: | **30° 28' 33.64" N** |
| | | Longitude: | **098° 09' 02.84" W** |
| Well County: | **Burnet** | Elevation: | **No Data** |
| Type of Work: | **New Well** | Proposed Use: | **Monitor** |

Drilling Start Date: **12/21/2021** Drilling End Date: **12/21/2021**

Borehole:

| *Diameter (in.)* | *Top Depth (ft.)* | *Bottom Depth (ft.)* |
|---|---|---|
| **4** | **0** | **54** |

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Perforated or Slotted**

Annular Seal Data:

| *Top Depth (ft.)* | *Bottom Depth (ft.)* | *Description (number of sacks & material)* |
|---|---|---|
| **0** | **1** | **Concrete 1 Bags/Sacks** |
| **1** | **18** | **Bentonite 3 Bags/Sacks** |
| **18** | **54** | **Sand 5 Bags/Sacks** |

Seal Method: **Hand Mixed**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Steel Cased** **Surface Completion by Driller**

Water Level: **25.6 ft.** below land surface on **2021-12-21** Measurement Method: **Electric Line**

Packers: **No Data**

Type of Pump: **No Data**

Well Tests: **No Test Data Specified**

Water Quality:

| Strata Depth (ft.) | Water Type |
|---|---|
| **No Data** | **No Data** |

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which contained injurious constituents?: **No**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Holt Engineering**

**2220 BARTON SKWY**
**Austin, TX 78704**

Driller Name: **Will McGee** License Number: **59972**

Comments: **No Data**

Lithology:
DESCRIPTION & COLOR OF FORMATION MATERIAL

| Top (ft.) | Bottom (ft.) | Description |
|---|---|---|
| **0** | **2** | **Brown Clay** |
| **2** | **13** | **Tan Silt** |
| **13** | **24** | **Tan Sand with Gravel** |
| **24** | **25.3** | **Brown Clay with Sand** |
| **25.3** | **26** | **Tan Silt** |
| **26** | **54** | **Brown Sand with Gravel** |

Casing:
BLANK PIPE & WELL SCREEN DATA

| Dia (in.) | Type | Material | Sch./Gage | Top (ft.) | Bottom (ft.) |
|---|---|---|---|---|---|
| **2** | **Blank** | **New Plastic (PVC)** | **40** | **0** | **18** |
| **2** | **Perforated or Slotted** | **New Plastic (PVC)** | **40 0.010** | **18** | **45** |

**IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

**Texas Department of Licensing and Regulation**
**P.O. Box 12157**
**Austin, TX 78711**
**(512) 334-5540**

# STATE OF TEXAS WELL REPORT for Tracking #595729

| | | | |
|---|---|---|---|
| Owner: | **Central Texas GCD** | Owner Well #: | **B-4-MW** |
| Address: | **225 S. Pierce Street<br>Burnet, TX 78611** | Grid #: | **57-39-3** |
| Well Location: | **424 CR 404<br>Spicewood, TX 78669** | Latitude: | **30° 28' 48.36" N** |
| | | Longitude: | **098° 08' 36.67" W** |
| Well County: | **Burnet** | Elevation: | **No Data** |
| Type of Work: | **New Well** | Proposed Use: | **Monitor** |

Drilling Start Date: **12/22/2021** Drilling End Date: **12/22/2021**

| | *Diameter (in.)* | *Top Depth (ft.)* | *Bottom Depth (ft.)* |
|---|---|---|---|
| Borehole: | **4** | **0** | **35** |

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Perforated or Slotted**

Annular Seal Data:

| *Top Depth (ft.)* | *Bottom Depth (ft.)* | *Description (number of sacks & material)* |
|---|---|---|
| **0** | **1** | **Concrete 1 Bags/Sacks** |
| **1** | **5** | **Bentonite 1 Bags/Sacks** |
| **5** | **25** | **Sand 4 Bags/Sacks** |
| **25** | **35** | **Bentonite 2 Bags/Sacks** |

Seal Method: **Hand Mixed**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Surface Slab Installed** **Surface Completion by Driller**

Water Level: **8 ft.** below land surface on **2021-12-22** Measurement Method: **Electric Line**

Packers: **No Data**

Type of Pump: **No Data**

Well Tests: **No Test Data Specified**

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Texas State University

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