

**COVER PAGE**

**AWARD NUMBER:** G18AC00088

**AGENCY NAME:** Texas Water Development Board

**TITLE:** Texas Water Development Board Support of Persistent Data Services for Wells and Springs in the National Ground-Water Monitoring Network

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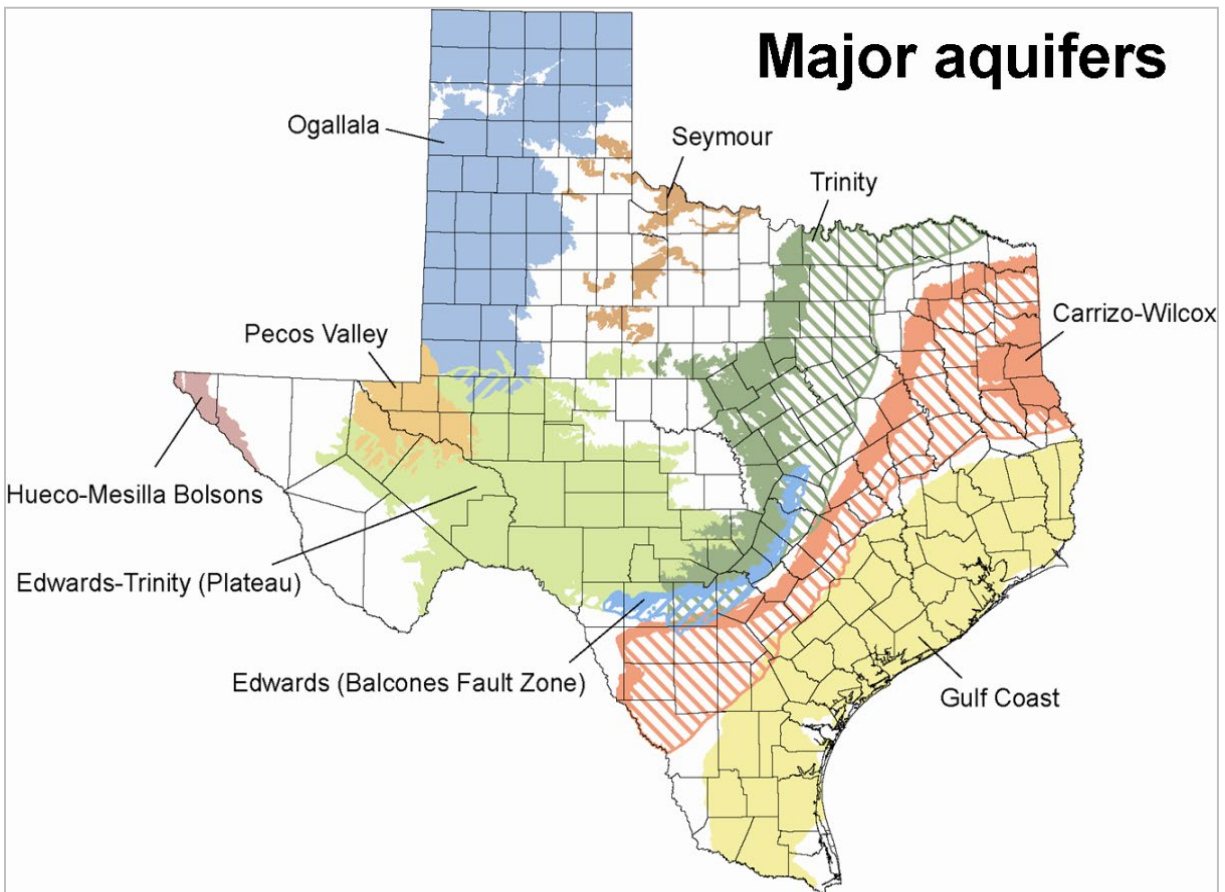
**TERM COVERED:** September 1, 2018 through August 31, 2021

**FINAL REPORT DATE:** November 18, 2021

# Summary of Texas Water Development Board participation in the National Ground-Water Monitoring Network

The Texas Water Development Board (TWDB) has participated in the U.S. Geological Survey (USGS) National Ground-Water Monitoring Network (NGWMN, or Network) since its acceptance as a pilot project in 2009. The TWDB, directed and allowed by the Texas Water Code (Chapter 16) to collect groundwater data, is the only agency in Texas that maintains statewide water-level and water-quality monitoring programs that include suitable sites available for inclusion in the NGWMN. Between 2009 and 2021, the TWDB selected over 1,350 representative wells and springs for the NGWMN with water-level and water-quality data in the state's nine major aquifers (Figure 1) and has provided web services for data retrieval in the NGWMN portal. Seven of eight USGS principal aquifers underlying Texas (Table 1) generally correspond to the nine major Texas aquifers, although configurations of the aquifers differ slightly (Figure 2). The eighth USGS principal aquifer, the Blaine Aquifer, is classified by the TWDB as a minor aquifer.

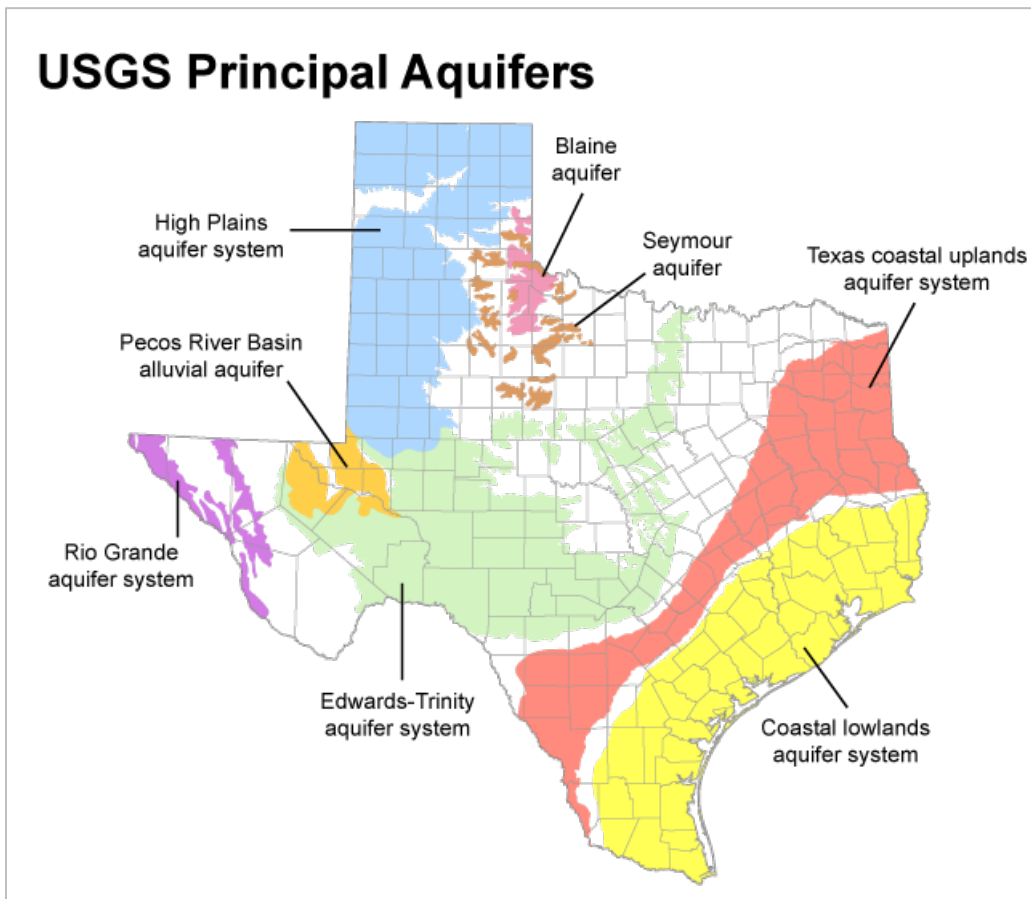
**Figure 1.** TWDB major aquifers in Texas



**Table 1.** Principal aquifers and corresponding major Texas aquifers

USGS principal aquifer	TWDB major aquifer
Coastal lowlands aquifer system	Gulf Coast Aquifer
Texas coastal uplands aquifer system	Carrizo-Wilcox Aquifer
Edwards-Trinity aquifer system	Trinity Aquifer
Edwards-Trinity aquifer system	Edwards (Balcones Fault Zone [BFZ]) Aquifer
Edwards-Trinity aquifer system	Edwards-Trinity (Plateau) Aquifer
Seymour aquifer	Seymour Aquifer
Pecos River Basin alluvial aquifer	Pecos Valley Aquifer
Rio Grande aquifer system	Hueco-Mesilla Bolsons Aquifer
High Plains aquifer system	Ogallala Aquifer

**Figure 2.** USGS principal aquifers in Texas (data from USGS, 2000)



## 2018 to 2020 TWDB National Ground-Water Monitoring Network activities

The TWDB, as an existing provider, received an award from September 2018 through August 2020 under Cooperative Agreement Number G18AC00088 to update water-quality web services to meet requirements as described in the Water-Quality Web Services Tip Sheet. While the work plan for this grant did not include maintaining and updating the current list of sites in the Network, the TWDB continued to maintain Network wells and fill metadata gaps. The USGS granted the TWDB a one-year extension on this grant due to staff turnover in our Information Technology department that delayed the updates to our water-quality web services. This extended the project and budget period to August 31, 2021. A new grant, Cooperative Agreement Number G20AC00176, was awarded to the TWDB for persistent data services covering the period from September 1, 2020 through August 31, 2022. This report describes work completed under G18AC00088 between September 1, 2018 and August 31, 2020 (the grant period before the time extension). This document reports the results of completed work, including updates to water-quality web services, description of Network well maintenance where data were available, and filling in metadata gaps. Maintenance and metadata gap filling performed between September 1, 2020 and August 31, 2021 will be included in the final report for Cooperative Agreement Number G20AC00176.

### Updates to Water-Quality Web Services

The work plan for Cooperative Agreement Number G18AC00088 contained four main tasks:

- 1) Update water-quality fields (Method Name and Analytical Method System) that were blank in the TWDB portal to capture the metadata correctly or to be populated with "unknown".
- 2) Modify water-quality web services to capture *Detection Limit* and *Detection Limit Value* for all wells in the water-quality subnetwork.
- 3) Modify characteristic names and parameter units to match the lists provided in the new Water-Quality Web Services Tip Sheet and resolve how non-detects are reported as a measure value.
- 4) Determine which analyses contain significant figure values in the *Measurement Value* field that do not align with the precision of the data and resolve such issues.

All four tasks identified in the work plan were completed (Table 2). The first task specifically mentioned two fields, *Method Name* and *Analytical Method System*, which have both been updated with the correct metadata or populated with "unknown" when data is not available; there are several other fields that remain blank. The USGS and the TWDB agreed that Task 1 was considered complete with the updates to *Method Name* and *Analytical Method System*; however, the TWDB will continue to work to fill in the blanks on the other fields.

Task 2 was completed with an update to the TWDB Groundwater Database stored procedure that formats the water-quality data provided to the NGWMN portal. *Detection Limit* was added as a field and an update was made to the *Detection Limit Value* field. Additional updates to the stored procedure resolved the significant digit issue described in task 4. To complete task 3, the *Constituent Name* and *Storet Unit of Measure* fields in the TWDB Groundwater Database were updated to match the characteristic names and parameter units found in the USGS Water Quality Data Elements tables.

**Table 2.** TWDB water-quality web services data updates

<b>NGWMN data field</b>	<b>TWDB data field</b>	<b>Update made</b>
<i>CharacteristicName</i>	<i>ConstituentName</i>	Updated to match USGS characteristic names
<i>ResultMeasureValue</i>	<i>StoretValue</i>	<i>StoretValue</i> was rounded to multiple significant digits based on <i>WaterQualityStoretCode</i>
<i>ResultMeasureUnitCode</i>	<i>StoretUnitOfMeasure</i>	Updated to match USGS parameter units
<i>Detection Limit</i>	<i>Detection Limit</i>	Detection Limit field was created and set to maximum detection limit (MDL) – determined by a <i>StoretValueFlagCode</i> = "<"
<i>ResultSampleFractionText</i>	<i>StoretLongDescription</i>	"Unfiltered" if <i>StoretLongDescription</i> contains the word 'total' and it does not contain the word 'dissolved' or if the analyte is a radioisotope. Otherwise, set to "Filtered"
<i>ResultDetectionConditionText</i>	<i>StoretValueFlagCode</i>	Set to "Not Detected" when <i>StoretValueFlagCode</i> is not null
<i>ResultAnalyticalMethodIdentifier</i>		Set to "Unknown" when <i>WaterQualityStoretCode</i> not known
<i>ResultAnalyticalMethodName</i>		Set to "EPA" for all except Temperature, which is set to null

## **Maintenance of existing Network wells**

### ***NGWM Water-Level Subnetwork***

The TWDB reviewed the status of data collection at approximately 1,350 existing sites in the Network after completion of the 2019 and 2020 water-level and water-quality seasons. The USGS NGWMN Monitoring Location Registry (registry) was edited to remove dropped wells and add replacement sites where feasible. An additional 1,721 sites in the High Plains, Rio Grande,

and Blaine aquifers were added to the registry at the end of the 2021 water-level season as part of a concurrent grant from the USGS (Cooperative Agreement Number G19AC00189). Data from these sites are not included in this report but will be described in the G19AC00189 final report and incorporated as part of the Network persistent data services maintenance performed by the TWDB going forward.

Between 2018 and 2020, the TWDB and cooperators collected tape-down or electric line measurements at 4,983 surveillance and trend wells, of which 719 are Network wells (Table 3 and Figures 3 thru 8). Of the total designated 796 Network wells, 75 surveillance wells were not able to be measured. Travel restrictions from the COVID-19 pandemic affected part of the 2020 and all of the 2021 water-level seasons. Attempts to measure most of the remaining sites (47 of the 75) will be made in late 2021 and early 2022, subject to any applicable COVID-19 pandemic restrictions. Twenty-seven of the 75 wells were no longer viable for producing publishable water-level measurements and were removed from the Network, and 9 wells were added as replacements (Table 4). Eleven sites are measured by cooperators who have not submitted water-level data in the last 2 years. Those cooperators will be contacted and if they are no longer able to obtain measurements, the TWDB will resume measuring those sites. Replacement sites are being evaluated as part of the current persistent data services grant, Cooperative Agreement Number G20AC00176.

**Table 3.** Number of water-level measurements by aquifer from September 1, 2018 to August 31, 2020

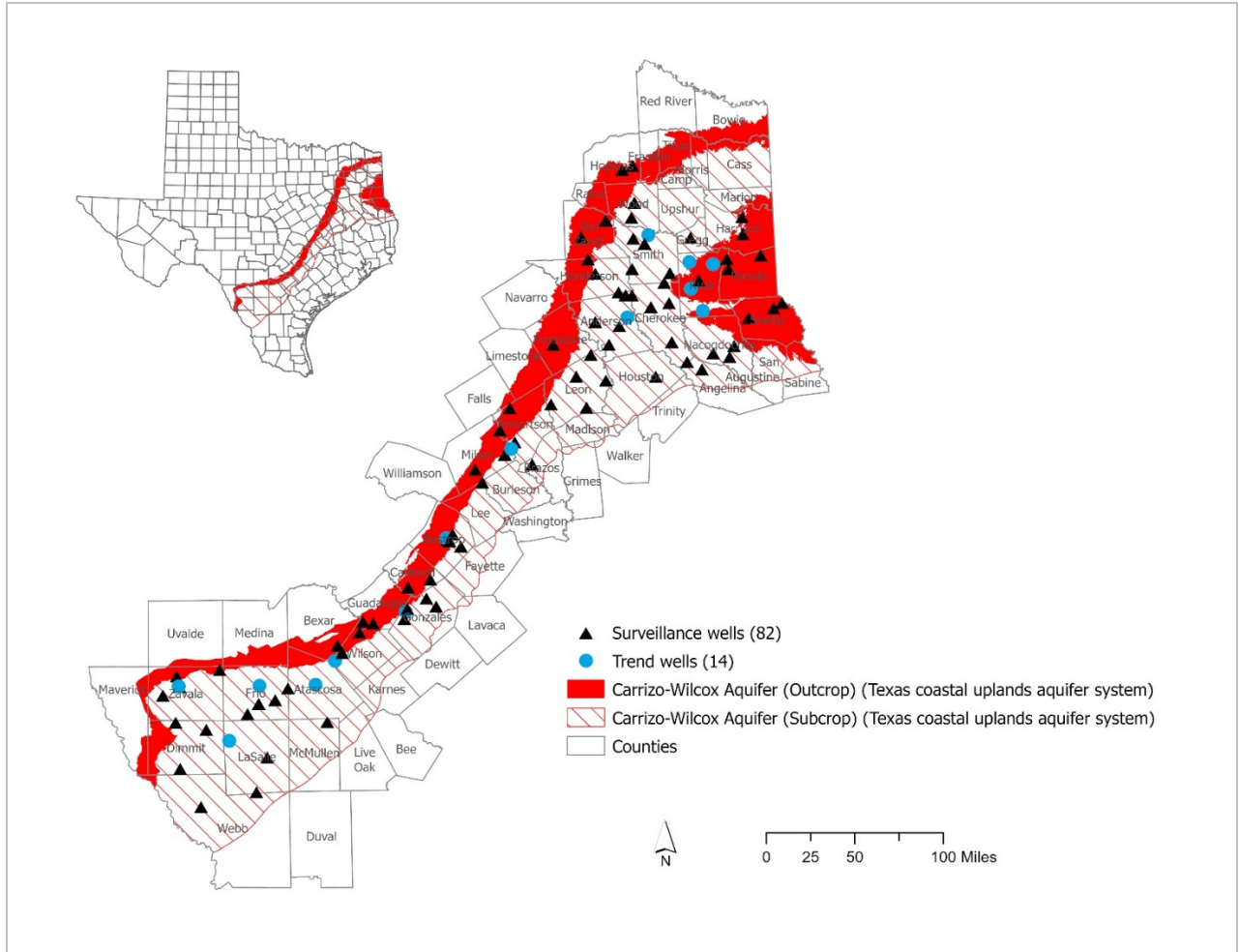
<b>Principal aquifer</b>	<b>NGWMN sites measured</b>	<b>Total NGWMN sites</b>
Edwards-Trinity aquifer system	159	185
Texas coastal uplands aquifer system	73	96
Coastal lowlands aquifer system	77	86
High Plains aquifer system	330	344
Pecos River Basin alluvial aquifer	29	31
Seymour aquifer	38	38
Rio Grande aquifer system	13	16
<b>Total</b>	<b>719</b>	<b>796</b>

**Table 4.** TWDB water-level subnetwork replacement wells added between September 1, 2018 and August 31, 2020

<b>TWDB Water-level Subnetwork Replacement Wells</b>			
<b>NGWMN site # removed</b>	<b>Replacement NGWMN site #</b>	<b>Principal aquifer</b>	<b>Well depth (ft)</b>
0557502	0557515	High Plains aquifer system	138
0640765	0640710	High Plains aquifer system	447
0707101	0709902	High Plains aquifer system	380
1449806	1449823	Seymour aquifer	37
4603401	4612402	Pecos River Basin alluvial aquifer	173
4904416	4904468	Rio Grande aquifer system	299
6951602	6944301	Edwards-Trinity aquifer system	1317
6961525	6958701	Texas coastal uplands aquifer system	182
7828501	7821804	Texas coastal uplands aquifer system	4300

All 124 trend wells remain in operation, remain in the Network, and continue to post near real-time, provisional hourly water-level measurements on the TWDB [Water Data for Texas webpage](#). The hyperlink provided for these wells via the NGWMN portal, however, provides connection to the TWDB Groundwater Database that includes six measurements per month from the trend wells rather than the provisional hourly measurements available on the Water Data for Texas webpage.

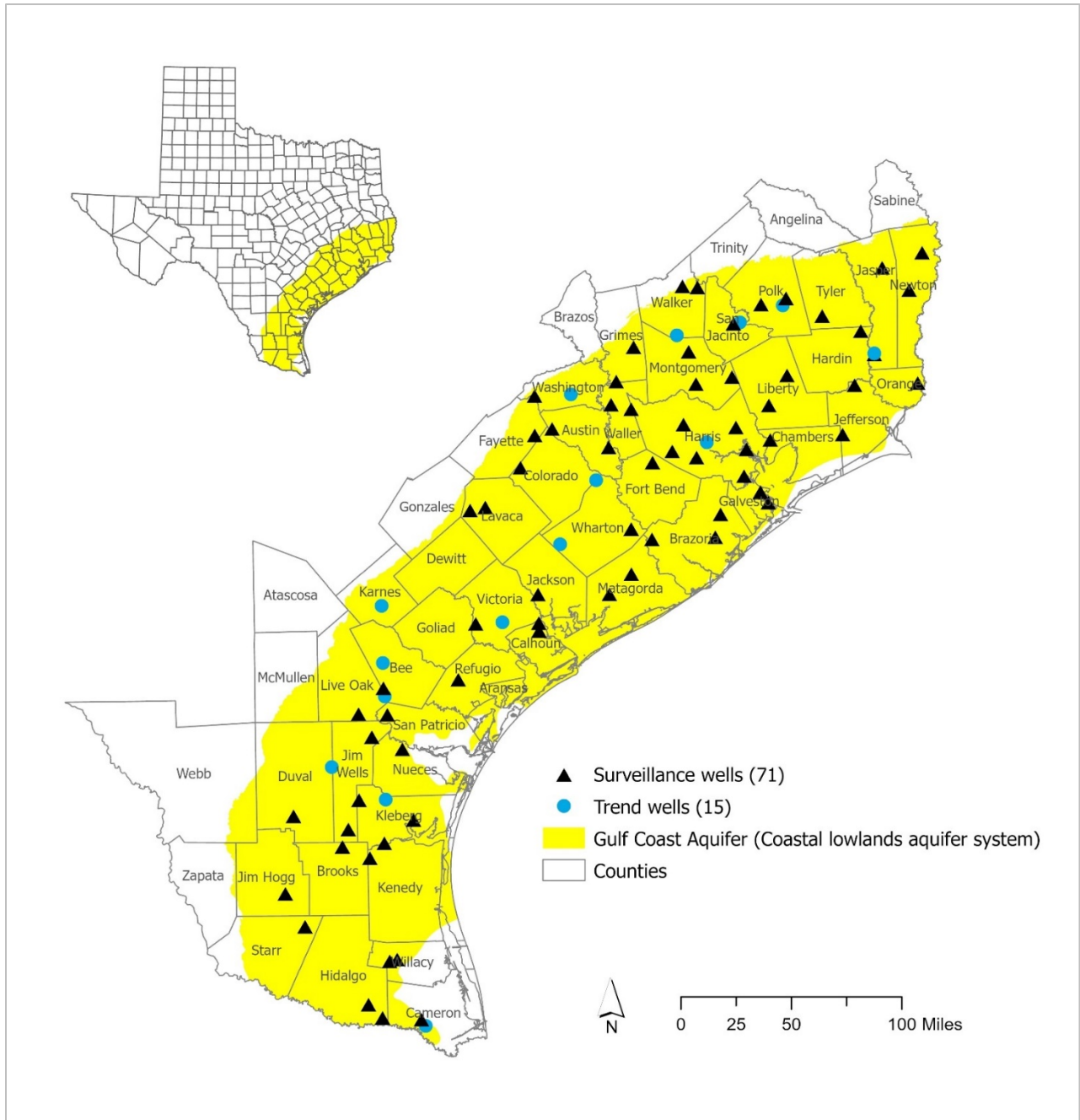
**Figure 3.** Trend and surveillance water-level subnetwork wells in the Texas coastal uplands aquifer system (Carrizo-Wilcox Aquifer)



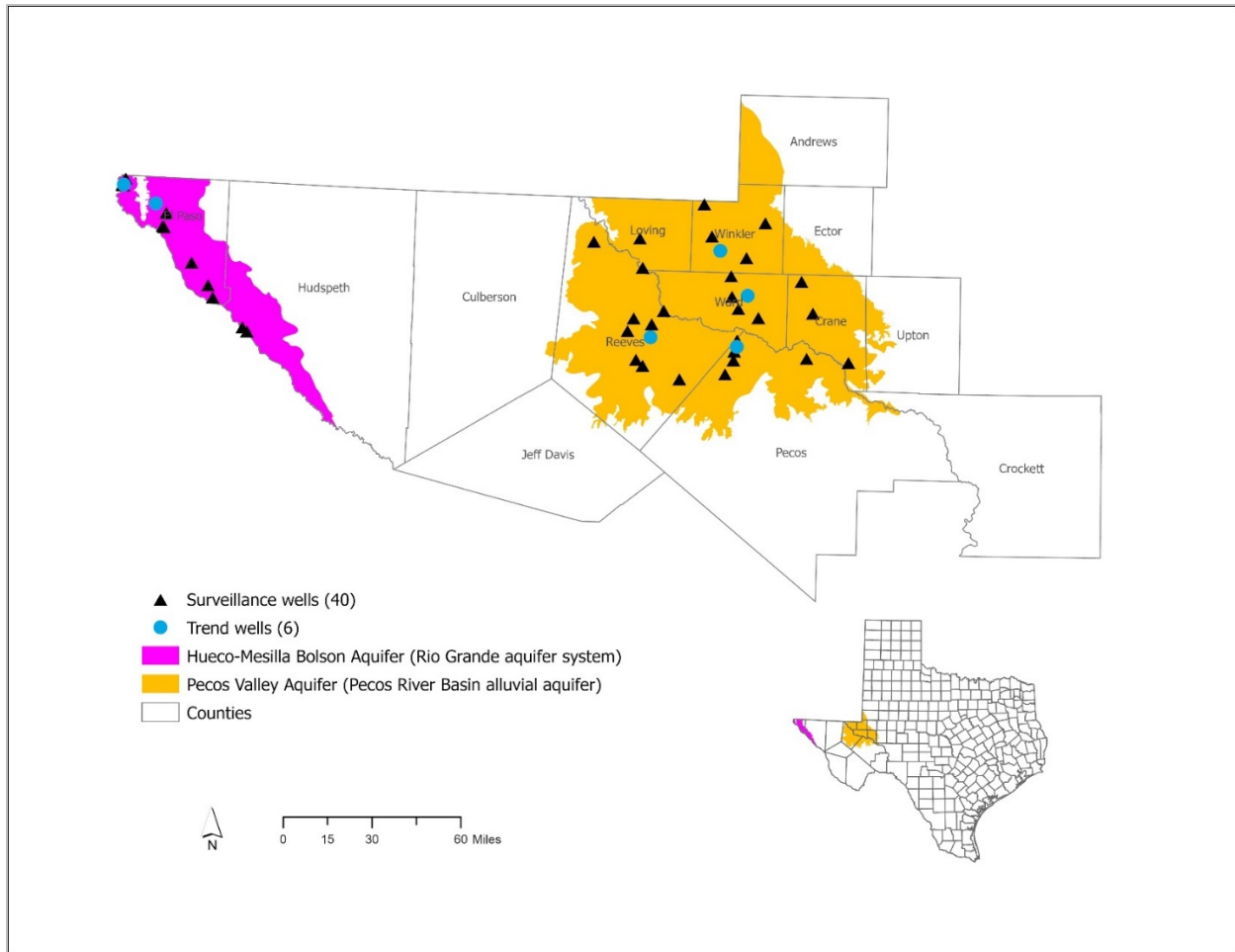




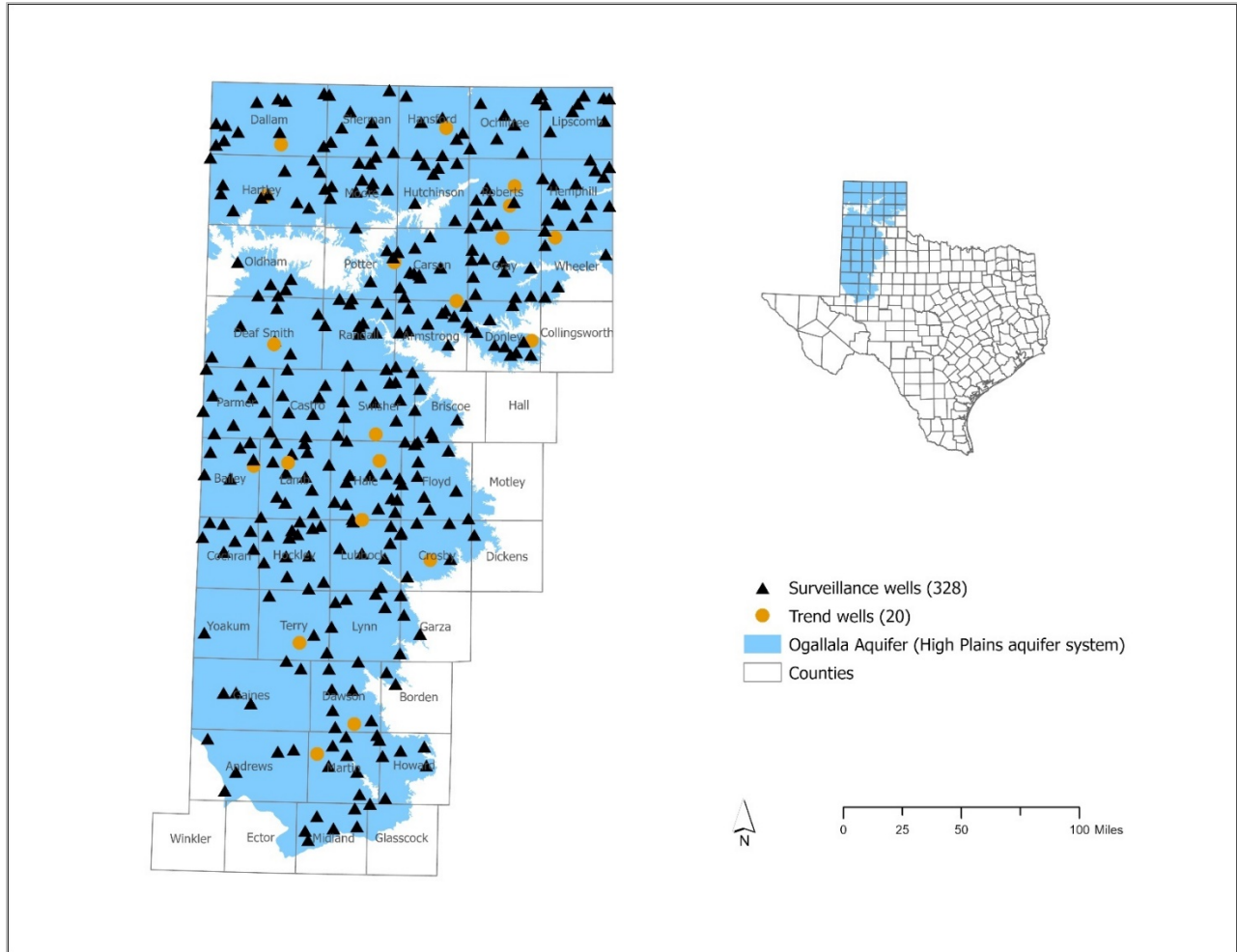
**Figure 5.** Trend and surveillance water-level subnetwork wells in the Coastal lowlands aquifer system (Gulf Coast Aquifer)



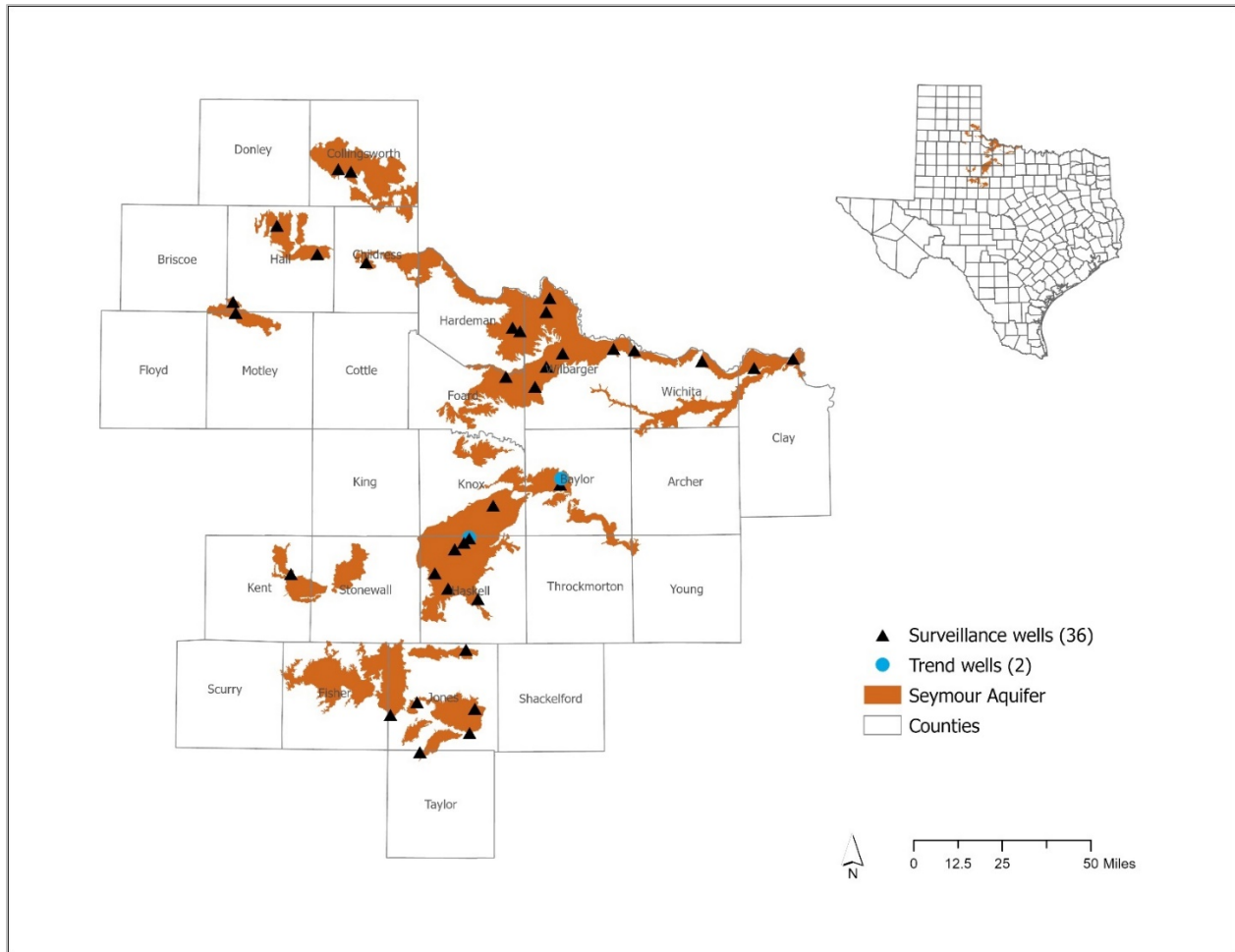
**Figure 6.** Trend and surveillance water-level subnetwork wells in the Pecos Valley Basin alluvial aquifer and the Rio Grande aquifer systems (Pecos Valley and Hueco-Mesilla Bolsons aquifers)



**Figure 7.** Trend and surveillance water-level subnetwork wells in the High Plains aquifer system (Ogallala Aquifer)



**Figure 8.** Trend and surveillance water-level subnetwork wells in the Seymour aquifer system (Seymour Aquifer)



### **NGWM Water-Quality Subnetwork**

In 2019, the TWDB sampled 220 wells in the Edwards-Trinity aquifer system. Of the total wells in the NGWM water-quality subnetwork, 197 sites are in the Edwards-Trinity aquifer system and 149 of these wells were re-sampled between September 1, 2018 and August 31, 2020 (Table 5 and Figures 9 and 10).

In 2020, the TWDB was scheduled to sample 166 wells in the High Plains aquifer system and the Seymour aquifer, but overnight travel was restricted due to the COVID-19 pandemic and sampling efforts were re-focused on sites within a day trip of the TWDB office in Austin. Consequently, monitoring efforts were shifted from the High Plains aquifer system to the Texas coastal uplands and Coastal lowlands aquifer systems. There are 104 wells in each of these aquifers designated as Network wells. Of the 45 sites sampled by the TWDB, 22 of these sites (7 in the coastal uplands and 15 in the coastal lowlands) were sampled between 2019 and 2020 (Table 5). The High Plains sites not sampled in 2020 are scheduled to be sampled in 2021.

Following the 2021 sampling season, the TWDB will review the four-year sampling schedule and work to include the Texas coastal aquifers, and the High Plains and Seymour aquifers in future sampling seasons.

**Table 5.** Water-quality samples by aquifer from September 1, 2018 to August 31, 2020

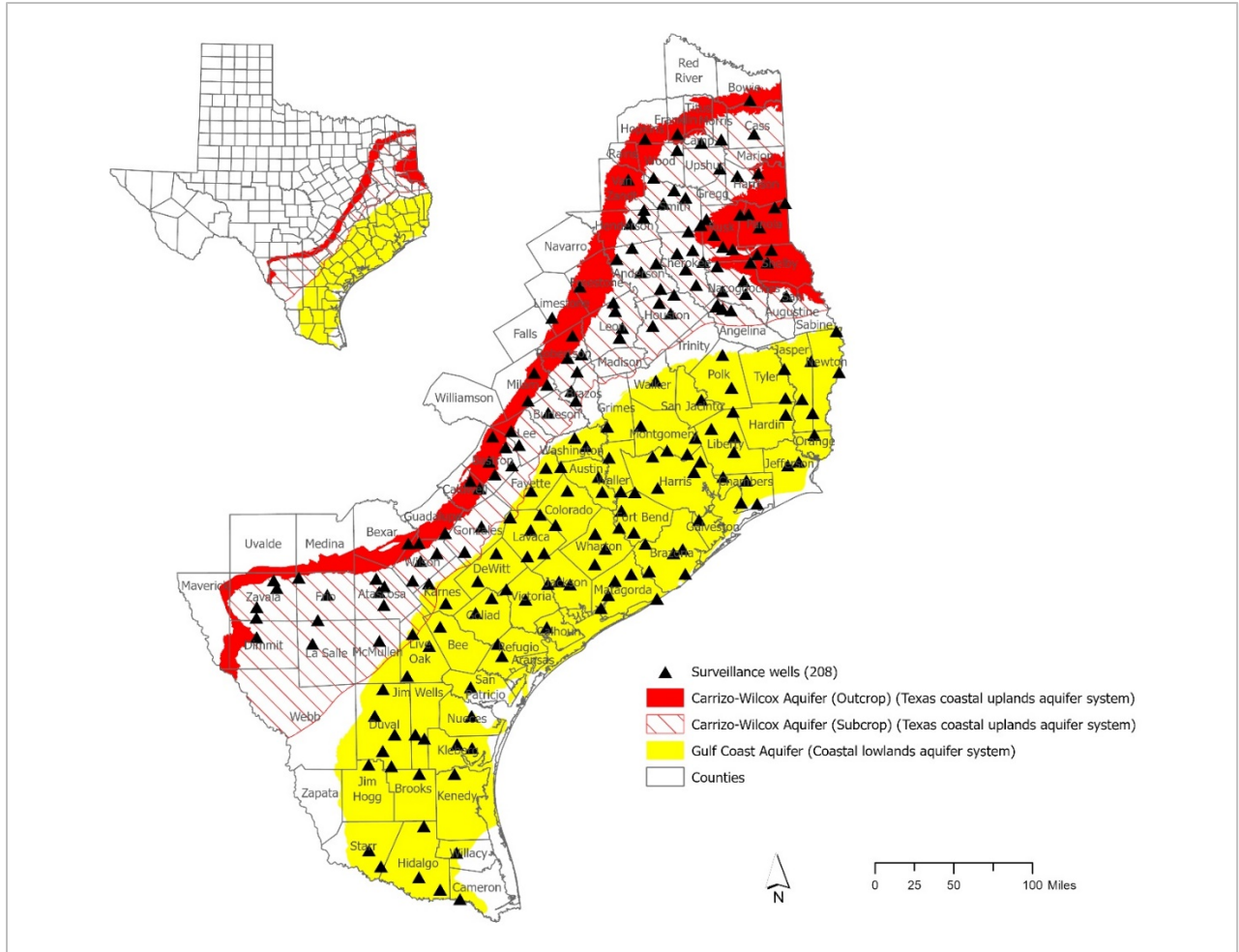
<b>Principal aquifer</b>	<b>Sampled sites *</b>	<b>NGWMN sites sampled</b>	<b>Total NGWMN sites</b>
Edwards-Trinity aquifer system	411	149	197
Texas coastal uplands aquifer system	16	7	104
Coastal lowlands aquifer system	29	15	104
High Plains aquifer	69**	1**	111
<b>Total</b>	<b>525</b>	<b>172</b>	<b>516</b>

*\*Includes sites sampled by cooperators; \*\*Sampled by the City of Amarillo*

Of the 516 designated water-quality Network wells in the four aquifer systems sampled between 2018 and 2020, only 33 percent (172 sites) were sampled primarily due to COVID-19 pandemic restrictions on travel. Additionally, a review of NGWMN sites at the end of the 2021 sampling season revealed that at least nine counties have more NGWMN sites than the number of sites currently being assigned by TWDB staff for sampling. The 2022 State Water Plan will be reviewed to determine the adequate number of sites needed in 2023 to monitor the state’s water supplies. As part of these calculations, the deficit between the number of Network wells and number of samples assigned will be addressed.

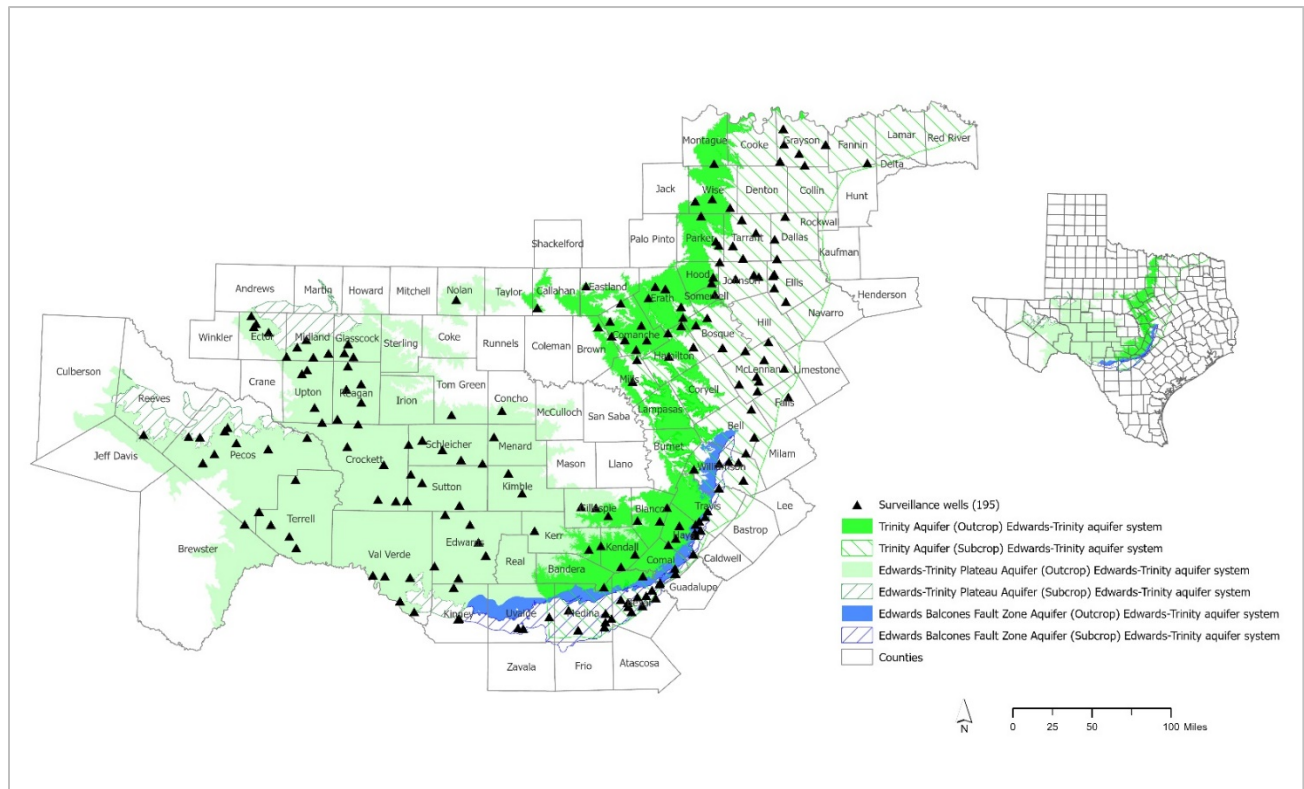
In general, the TWDB sampling schedule, which includes return visits to NGWMN and TWDB network wells once every four years, appropriately ensures that minimum frequency requirements are met, though challenges periodically arise. Challenges experienced during 2018 and 2020 included training new staff on sampling procedures and implementing a new program (Springs Monitoring Program). Specific NGWMN training is now provided prior to each sampling season, and spreadsheets have been developed to help staff better track the status of Network wells.

**Figure 9.** Water-quality samples collected in subnetwork wells between September 1, 2018 and August 31, 2020 in the Coastal Uplands and Coastal Lowlands Aquifer systems





**Figure 10.** Water-quality samples collected in subnetwork wells between September 1, 2018 and August 31, 2020 in the Edwards-Trinity Aquifer system



***Delinquencies***

Forty-six NGWMN water-level subnetwork sites were flagged delinquent with no publishable measurements for the past two years. Publishable measurements were obtained from nine of those sites this past water-level season, while 27 were deemed no longer viable for producing publishable measurements and were removed from the Network. Measurements were obtained from two of the remaining ten sites, but oil was detected at the water’s surface and current TWDB process documents require that these measurements be entered as questionable. The TWDB is currently evaluating the issue of presence of oil in monitoring wells. The fate of these wells will be determined by the outcome of those evaluations. The remaining eight sites are measured by cooperators who have not submitted water-level data for the past two years. Those cooperators will be contacted to determine if water-level data can be obtained.

**TWDB metadata gap filling and maintenance 2018 to 2020**

***Lithology***

During TWDB Groundwater Database restructuring in 2014, a lithology table was added to allow manual addition of data from scanned images of driller’s logs, if available. Wells drilled prior to the early 2000s have scanned images of driller’s logs. In the early 2000s, online submission of driller reports became an option for drillers, and lithology data is part of these reports. However,



the majority of the current NGWMN sites were drilled prior to the creation of the online drillers report application and lithology data must be manually entered from the scanned images. A previous NGWMN award allowed TWDB staff to populate the lithology tables for the Network wells first before continuing with gap filling for the remaining non-Network wells. This work is now incorporated as part of our persistent data services tasks, and TWDB staff continue to populate lithology for non-Networks wells as time allows.

Two-thirds of the Network wells have lithology data that will be accessible through web services (Tables 6 and 7). In general, more wells in the western part of the state lack lithology descriptions, possibly due to the relatively shallower depth (for example, in Seymour wells) and/or the more homogenous, predominantly sand- and gravel-rich alluvial formations.

**Table 6.** Metadata gap filling in TWDB water-level NGWM subnetwork wells

Principal aquifer	NGWMN sites	Sites with lithology data	Percent of total
Coastal lowlands aquifer system	86	66	77%
Texas coastal uplands aquifer system	96	66	69%
Edwards-Trinity aquifer system	185	114	62%
Seymour aquifer	38	14	37%
High Plains aquifer	344	258	75%
Pecos River Basin alluvial aquifer	31	9	29%
Rio Grande aquifer system	16	4	25%
<b>Total</b>	<b>796</b>	<b>531</b>	<b>67%</b>

**Table 7.** Metadata gap filling in TWDB water-quality NGWM subnetwork wells

Principal aquifer	NGWMN sites	Sites with lithology data	Percent of total
Coastal lowlands aquifer system	105	76	72%
Texas coastal uplands aquifer system	107	100	93%
Edwards-Trinity aquifer system	201	116	58%
Seymour aquifer	26	10	38%
High Plains aquifer	125	58	46%
Pecos River Basin alluvial aquifer	17	10	59%
Rio Grande aquifer system	8	6	75%
<b>Total</b>	<b>589</b>	<b>376</b>	<b>64%</b>

### **Local Aquifer Code and Site Name**

Periodic checks are performed on all data elements in the Network. Two fields known for having issues are *Local Aquifer Code* and *Site Name*. The TWDB reviews existing sites to replace local

aquifer codes with complete local aquifer names, and updates *Site Name* to ensure no personally identifiable information is present.

### **TWDB data collection methods**

TWDB data collection methods are in accordance with standardized field procedures consistent with the standards outlined in Appendix 5 of the groundwater monitoring framework document (SOGW, 2013). Water-level monitoring field procedures ([www.twdb.texas.gov/groundwater/docs/UMs/UM-52.pdf](http://www.twdb.texas.gov/groundwater/docs/UMs/UM-52.pdf)) were revised in 2016 to adhere more closely to standards in the framework document, and sampling protocols are included in a separate manual ([www.twdb.texas.gov/groundwater/docs/UMs/UM-51.pdf](http://www.twdb.texas.gov/groundwater/docs/UMs/UM-51.pdf)). The TWDB followed site selection criteria and the classification process when adding new sites as described in the final report for work performed under previous Cooperative Agreement Number G15AC00465.

### **TWDB quality assurance procedures**

As noted, TWDB staff adhere to procedures in the field and throughout the data collection process as described in the two user manuals (linked above) that address water-level measuring and water-quality sampling. These practices are further reiterated and specified in several Standard Operating Procedures, or Work Process Documents, that the Groundwater Division updates every two years. TWDB field personnel are also now entering data using ESRI's Collector App, intended to reduce the number of errors that could occur when transcribing information from field books into the TWDB Groundwater Database.

Although the TWDB Groundwater Division receives no funds from the US Environmental Protection Agency (USEPA), it prepares (or updates) the TWDB Quality Management Plan (QMP) yearly as other parts of the agency rely on the Groundwater Division's data in support of water-management strategies that may be partly funded by the USEPA. The QMP describes the quality system implemented by the agency for data-collection activities and is documentation required by the USEPA.

The TWDB collects water-quality data in 97 percent of the Network wells, with cooperators collecting water-quality data in the remaining 3 percent. However, cooperators measure water levels in more than 50 percent of Network wells and provide the TWDB with this information annually for uploading in the TWDB Groundwater Database. Additional quality assurance checks include automated flagging of anion-cation balance exceeding five percent when reviewing water-quality data and automated comparison/verification of outlier water-level measurements against previous values for TWDB and cooperator measurement data.

### **Serving data to the NGWMN data portal**

Lithology elements are listed in the USGS National Groundwater Monitoring Network Tip Sheet on Minimum Data Requirements for Candidate Sites, and the TWDB had web services

configured to provide these elements. However, the TWDB did not have a *lithology ID* field in addition to its site identification number. Additionally, the *Observation Method*, while currently only determined through driller's logs, must include possible other methods that may eventually be used.

## References

Subcommittee on Ground Water (SOGW), 2013, A National Framework for Ground-Water Monitoring in the United States, 182 p,  
[acwi.gov/sogw/ngwmn\\_framework\\_report\\_july2013.pdf](http://acwi.gov/sogw/ngwmn_framework_report_july2013.pdf).

Texas Water Development Board *Quality Management Plan*, 2017, prepared for the U.S. Environmental Protection Agency, Region VI.

U.S. Geological Survey (USGS), 2000, Groundwater Atlas of the United States: Online,  
[water.usgs.gov/GIS/metadata/usgswrd/XML/aquifers\\_us.xml](http://water.usgs.gov/GIS/metadata/usgswrd/XML/aquifers_us.xml), accessed November 2021.