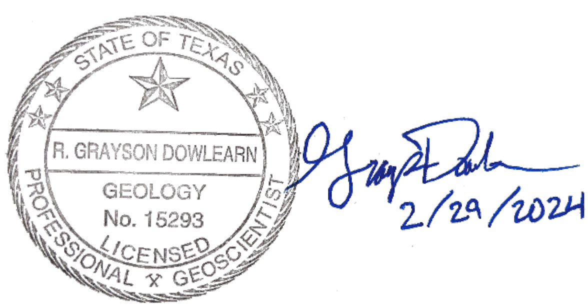
GAM Run 24-002: Neches & Trinity Valleys Groundwater Conservation District Management Plan

Grayson Dowlearn, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-475-1552
February 29, 2024



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EXECUTIVE SUMMARY:

Texas Water Code § 36.1071(h), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Neches & Trinity Valleys Groundwater Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information, which includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
2. the annual volume of water that discharges from the aquifer to springs and any surface-water bodies, including lakes, streams, and rivers, for each aquifer within the district; and
3. the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The groundwater management plan for the Neches & Trinity Valleys Groundwater Conservation District should be adopted by the district on or before June 14, 2024 and submitted to the executive administrator of the TWDB on or before July 14, 2024. The current management plan for the Neches & Trinity Valleys Groundwater Conservation District expires on September 12, 2024.

We used three groundwater availability models for the Neches & Trinity Valleys Groundwater Conservation District. Information for the Trinity Aquifer is from version 2.01 of the groundwater availability model for the Northern Trinity and Woodbine aquifers (Kelley and others, 2014). Information for the Nacatoch Aquifer is from the groundwater availability model for the Nacatoch Aquifer (Beach and others, 2009). Information for the Carrizo-Wilcox, Queen City, and Sparta aquifers is from version 3.01 of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers (Panday and others, 2020).

This report replaces the results of GAM Run 18-017 (Wade, 2019). This report includes values from the updated groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers. Additionally, values may differ from the previous report as a result of routine updates to the spatial grid file used to define county, groundwater conservation district, and aquifer boundaries, which can impact the calculated water budget values, and the approach used for analyzing model results is reviewed during each update and may have been refined to better delineate groundwater flows. Tables 1 through 5 summarize the groundwater availability model data required by statute. Figures 1, 3, 5, 7, and 9 show the area of the models from which the values in Tables 1 through 5 were extracted. Figures 2, 4, 6, 8, and 10 provide a generalized diagram of the groundwater flow components provided in Tables 1 through 5. If the Neches & Trinity Valleys Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions after reviewing the figures, please notify the TWDB Groundwater Modeling Department at your earliest convenience.

The flow components presented in this report do not represent the full groundwater budget. If additional inflow and outflow information would be helpful for planning purposes, the district may submit a request in writing to the TWDB Groundwater Modeling Department for the full groundwater budget.

METHODS:

In accordance with the provisions of the Texas Water Code § 36.1071(h), the groundwater availability models mentioned above were used to estimate information for the Neches & Trinity Valleys Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods in the respective groundwater availability models. For the Trinity Aquifer, water budgets were extracted over the historical calibration period (1980 through 2012) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). For the Nacatoch Aquifer, water budgets were extracted over the historical calibration period (1980 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). For the Carrizo-Wilcox, Queen City, and Sparta aquifers, water budgets were extracted over the historical calibration period (1981 through 2013) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021). The average annual water budget values for recharge, surface-water outflow, inflow to the district, outflow from the district, and the flow between aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Groundwater availability model for the Northern Trinity and Woodbine aquifers

- We used version 2.01 of the groundwater availability model for the Northern Trinity and Woodbine aquifers (Kelley and others, 2014) to analyze the Trinity Aquifer. See Kelley and others (2014) for assumptions and limitations of the model.

- This groundwater availability model contains eight layers:

    - Layer 1 represents the surficial outcrops of the modeled units in layers 2 through 8

    - Layer 2 represents the Woodbine Aquifer

    - Layer 3 represents the Washita and Fredericksburg groups, and the Edwards (Balcones Fault Zone) Aquifer

    - Layers 4 through 8 represent the Trinity Group

- Water budget values for the district were determined for the Trinity (Layers 4 through 8).

- Perennial rivers and reservoirs were simulated using the MODFLOW River package. Ephemeral streams, flowing wells, springs, and evapotranspiration in riparian zones were simulated using the MODFLOW Drain package.

- Water budget terms were averaged for the period 1980 through 2012 (stress periods 92 through 124).

- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

Groundwater availability model for the Nacatoch Aquifer

- We used version 1.01 of the groundwater availability model for the Nacatoch Aquifer (Beach and others, 2009) to analyze the Nacatoch Aquifer. See Beach and others (2009) for assumptions and limitations of the groundwater availability model.

- This model includes two layers:

    - Layer 1 represents overlying Midway and Upper Navarro Group, as well as major alluvium and terrace deposits.

    - Layer 2 represents the Nacatoch Aquifer with some minor alluvial and terrace deposits.

- Active model cells in Layer 2 up-dip from the Nacatoch Aquifer boundary within the district were considered to represent younger alluvium.

- Water budget terms were averaged for the period of 1980 through 1997 (stress periods 4 through 21).

- The model was run using MODFLOW-2000 (Harbaugh and others, 2000).

Groundwater availability model of the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers

- We used version 3.01 of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers (Panday and others, 2020) to analyze the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Panday and others (2020) for assumptions and limitations of the model.

- This model contains nine layers:

    - Layer 1 represents Quaternary Alluvium

    - Layer 2 represents the Sparta Aquifer and equivalent units

    - Layer 3 represents the Weches Formation (confining unit)

    - Layer 4 represents the Queen City Aquifer and equivalent units

    - Layer 5 represents the Reklaw Formation (confining unit)
    - Layers 6 through 9 represent the Carrizo-Wilcox Aquifer and equivalent units.

- Water budget values for the district were determined for the Carrizo-Wilcox (Layers 6 through 9), the Queen City (Layer 4) and the Sparta (Layer 2) aquifers.
- Water budget values from the Quaternary Alluvium (Layer 1) were combined with the Carrizo-Wilcox, Queen City, and Sparta aquifers where Quaternary Alluvium directly overlies the respective aquifers within the aquifer outcrop boundaries.
- Water budget terms were averaged for the period 1981 through 2013 (stress periods 2 through 34).
- The model was run with MODFLOW 6 (Langevin and others, 2017).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the aquifers located within the Neches & Trinity Valleys Groundwater Conservation District and averaged over the historical calibration period, as shown in Tables 1, 2, 3, 4, and 5.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 5. Figures 1, 3, 5, 7, and 9 show the area of the models from which the values in Tables 1 through 5 were extracted. Figures 2, 4, 6, 8, and 10 provide a generalized diagram of the groundwater flow components provided in Tables 1 through 5. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

Table 1: Summarized information for the Trinity Aquifer that is needed for the Neches & Trinity Valleys Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	98
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	167
Estimated net annual volume of flow between each aquifer in the district	To Trinity Aquifer from Trinity equivalent units	68

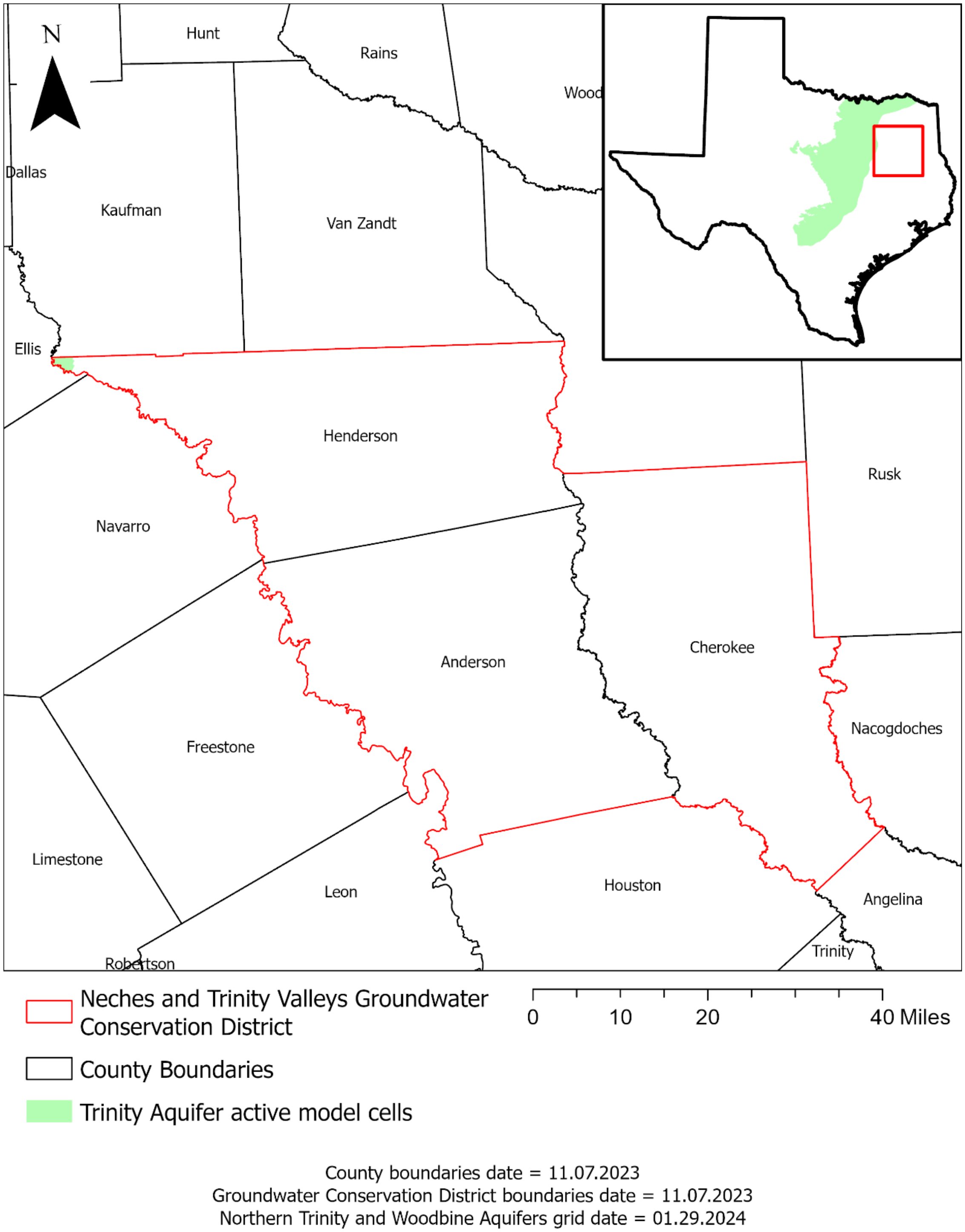
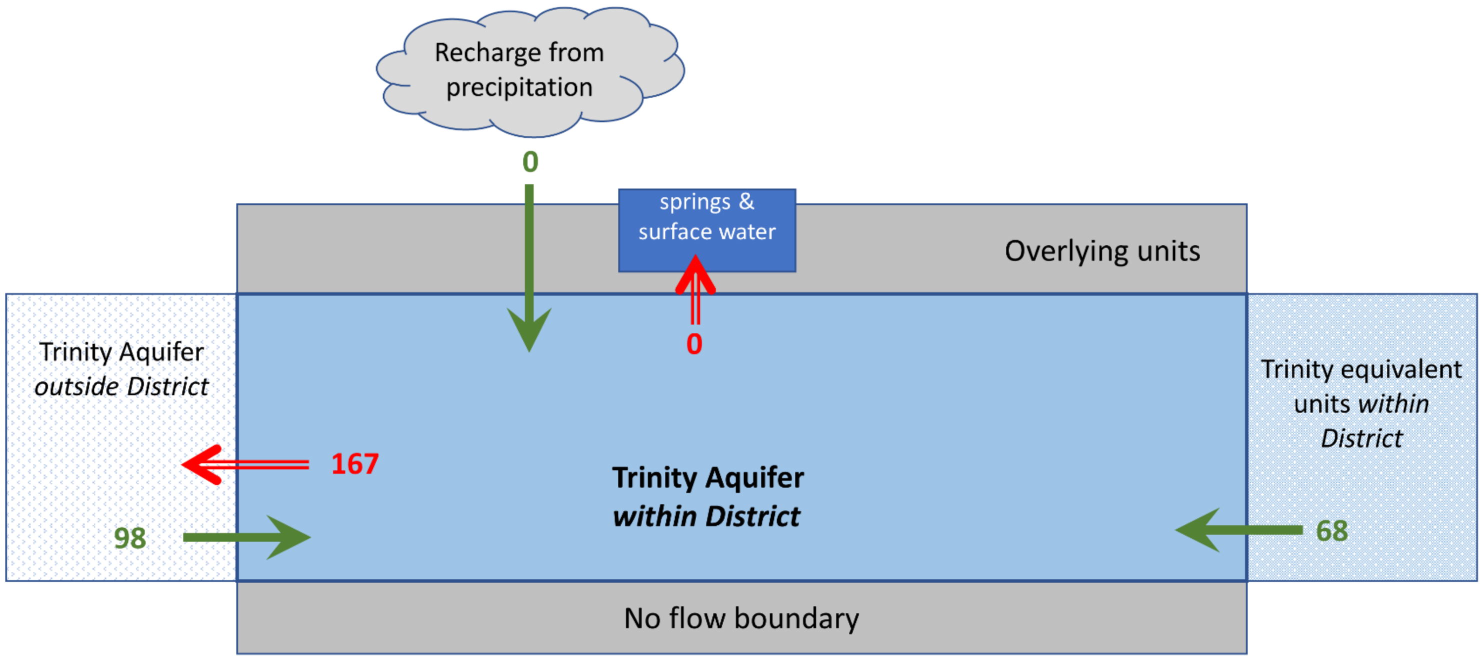


Figure 1: Area of the groundwater availability model for the Northern Trinity and Woodbine aquifers from which the information in Table 1 was extracted (the Trinity Aquifer extent within the district boundary).



Caveat: This diagram only includes the water budget items provided in Table 1. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 2: Generalized diagram of the summarized budget information from Table 1, representing directions of flow for the Trinity Aquifer within the Neches & Trinity Valleys Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 2: Summarized information for the Nacatoch Aquifer that is needed for the Neches & Trinity Valleys Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Nacatoch Aquifer	56
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Nacatoch Aquifer	357
Estimated annual volume of flow into the district within each aquifer in the district	Nacatoch Aquifer	428
Estimated annual volume of flow out of the district within each aquifer in the district	Nacatoch Aquifer	101
Estimated net annual volume of flow between each aquifer in the district	To Nacatoch Aquifer from Nacatoch equivalent units	518
	To Nacatoch Aquifer from overlying units	211

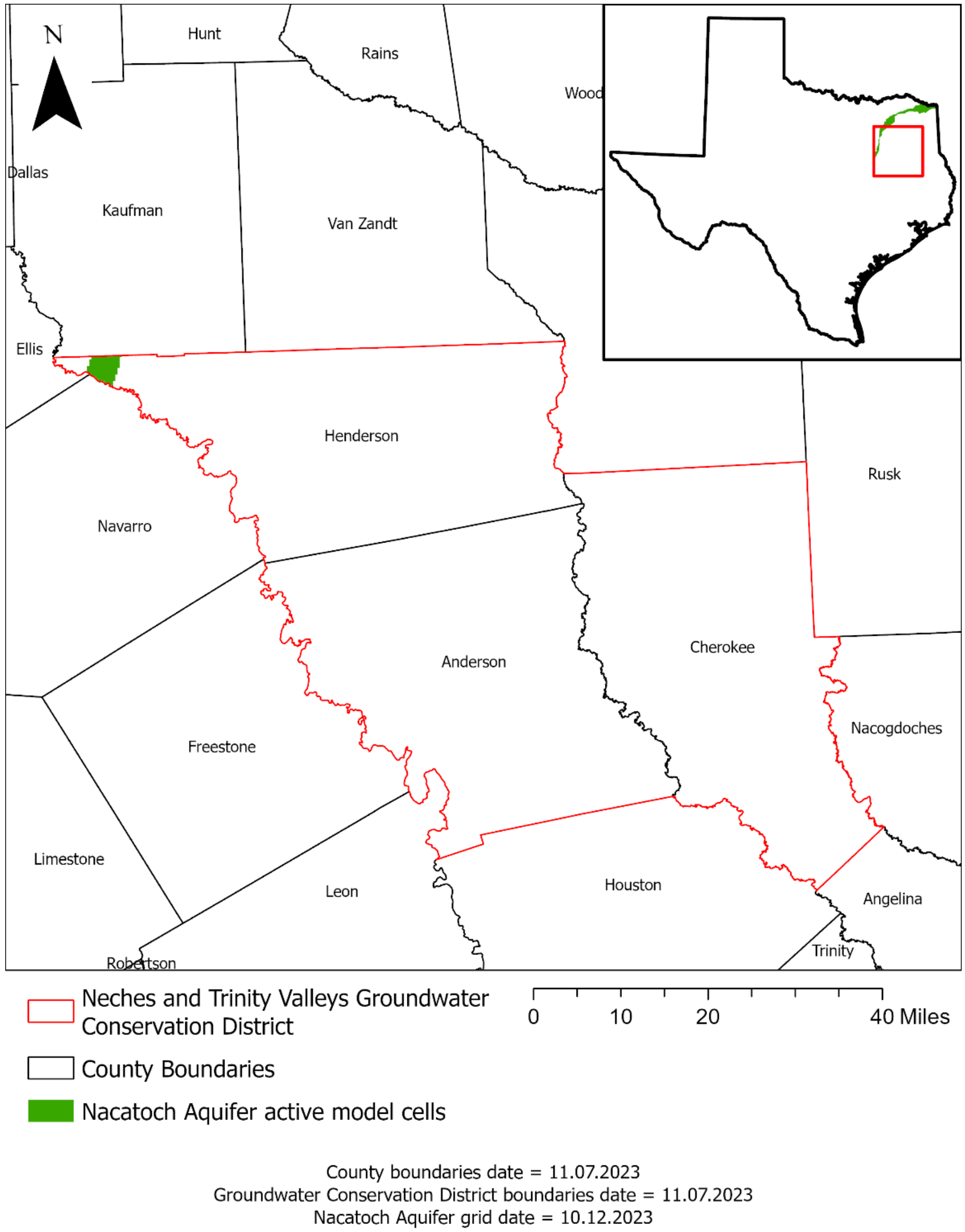
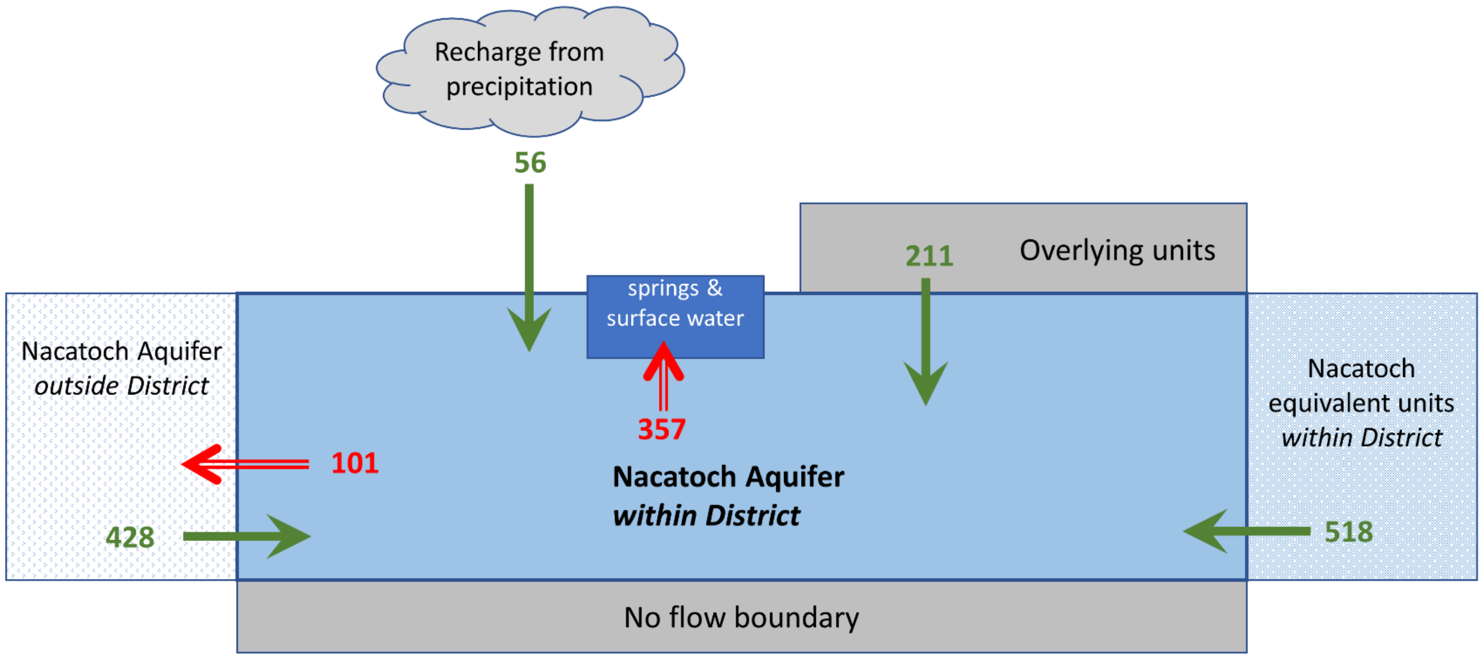


Figure 3: Area of the groundwater availability model for the Nacatoch Aquifer from which the information in Table 2 was extracted (the Nacatoch Aquifer extent within the district boundary).



Caveat: This diagram only includes the water budget items provided in Table 2. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 4: Generalized diagram of the summarized budget information from Table 2, representing directions of flow for the Nacatoch Aquifer within the Neches & Trinity Valleys Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 3: Summarized information for the Carrizo-Wilcox Aquifer that is needed for the Neches & Trinity Valleys Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	14,528
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Carrizo-Wilcox Aquifer	5,884
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	15,233
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	16,353
Estimated net annual volume of flow between each aquifer in the district	To Carrizo-Wilcox Aquifer from Carrizo-Wilcox equivalent units	30
	To Carrizo-Wilcox Aquifer from Alluvium	3,376
	To Carrizo-Wilcox Aquifer from Queen City Aquifer	4,506
	To Carrizo-Wilcox Aquifer from Reklaw Formation	7,174

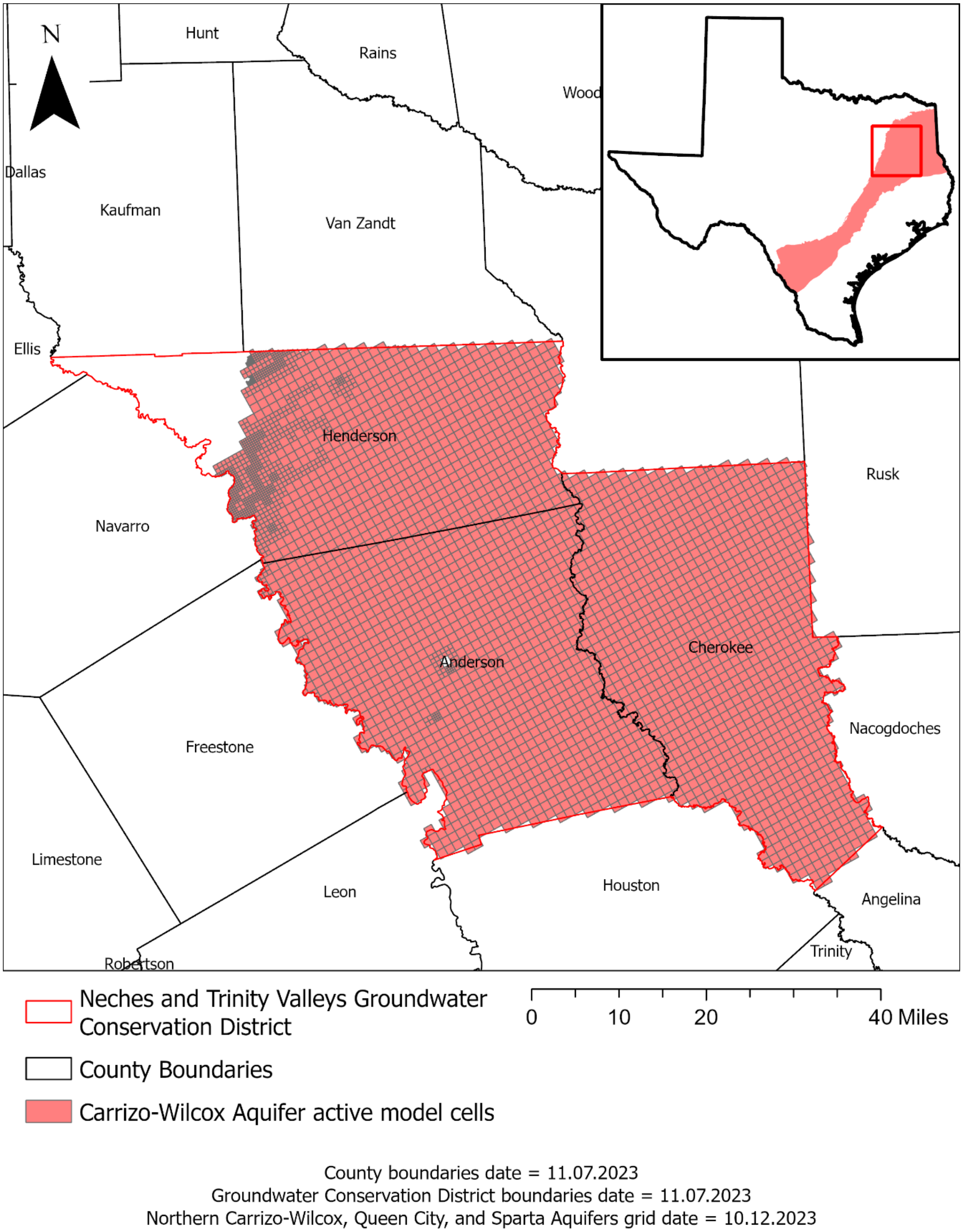
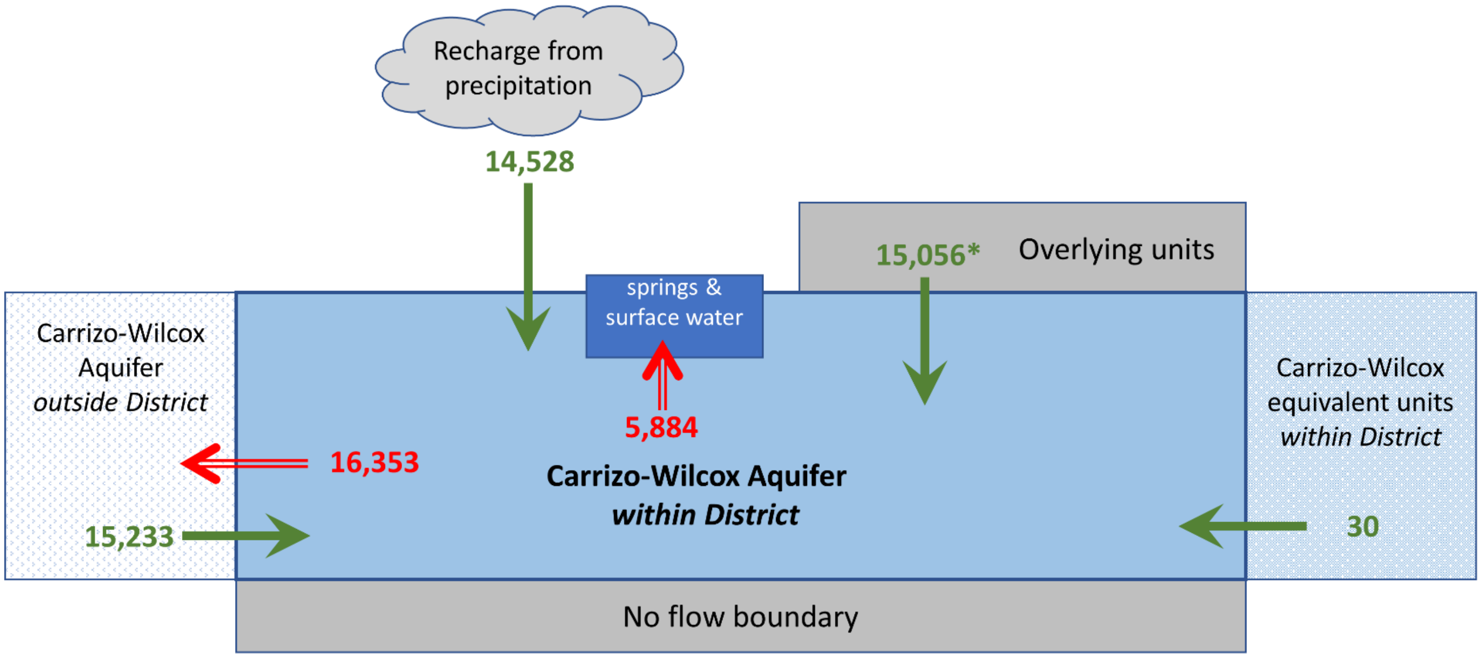


Figure 5: Area of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers from which the information in Table 3 was extracted (the Carrizo-Wilcox Aquifer extent within the district boundary).



* Flow from overlying units includes net inflow of 3,376 acre-feet per year from Alluvium, a net inflow of 4,506 acre-feet per year from the Queen City Aquifer, and 7,174 acre-feet per year from the Reklaw Formation.

Caveat: This diagram only includes the water budget items provided in Table 3. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 6: Generalized diagram of the summarized budget information from Table 3, representing directions of flow for the Carrizo-Wilcox Aquifer within the Neches & Trinity Valleys Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 4: Summarized information for the Queen City Aquifer that is needed for the Neches & Trinity Valleys Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Queen City Aquifer	51,142
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Queen City Aquifer	32,674
Estimated annual volume of flow into the district within each aquifer in the district	Queen City Aquifer	5,600
Estimated annual volume of flow out of the district within each aquifer in the district	Queen City Aquifer	3,407
Estimated net annual volume of flow between each aquifer in the district	To Queen City Aquifer from Queen City equivalent units	41
	From Queen City Aquifer to Alluvium	280
	To Queen City Aquifer from Sparta Aquifer	321
	To Queen City Aquifer from Weches Formation	5,266
	From Queen City Aquifer to Reklaw Formation	4,334
	From Queen City Aquifer to Carrizo-Wilcox Aquifer	4,506

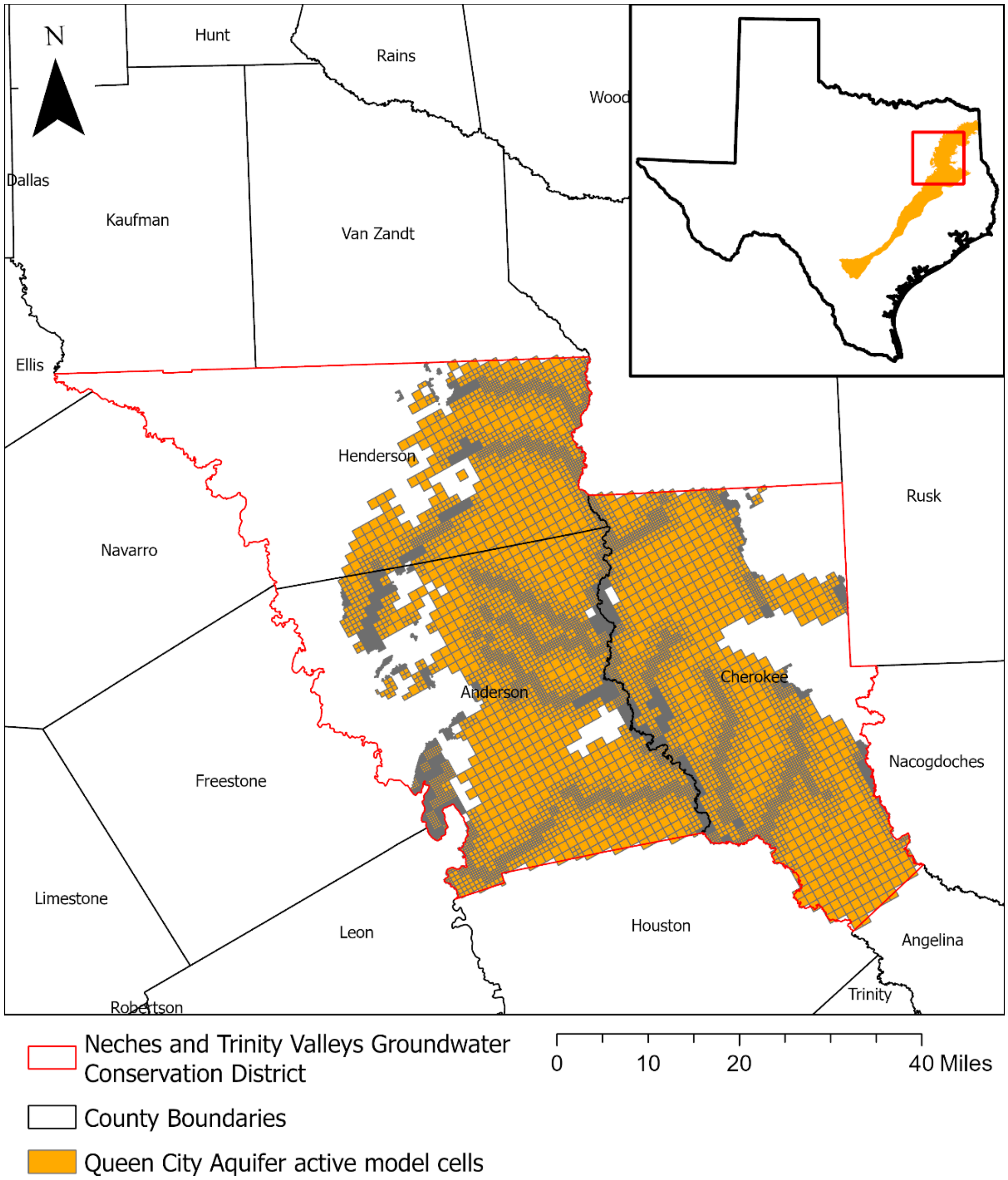
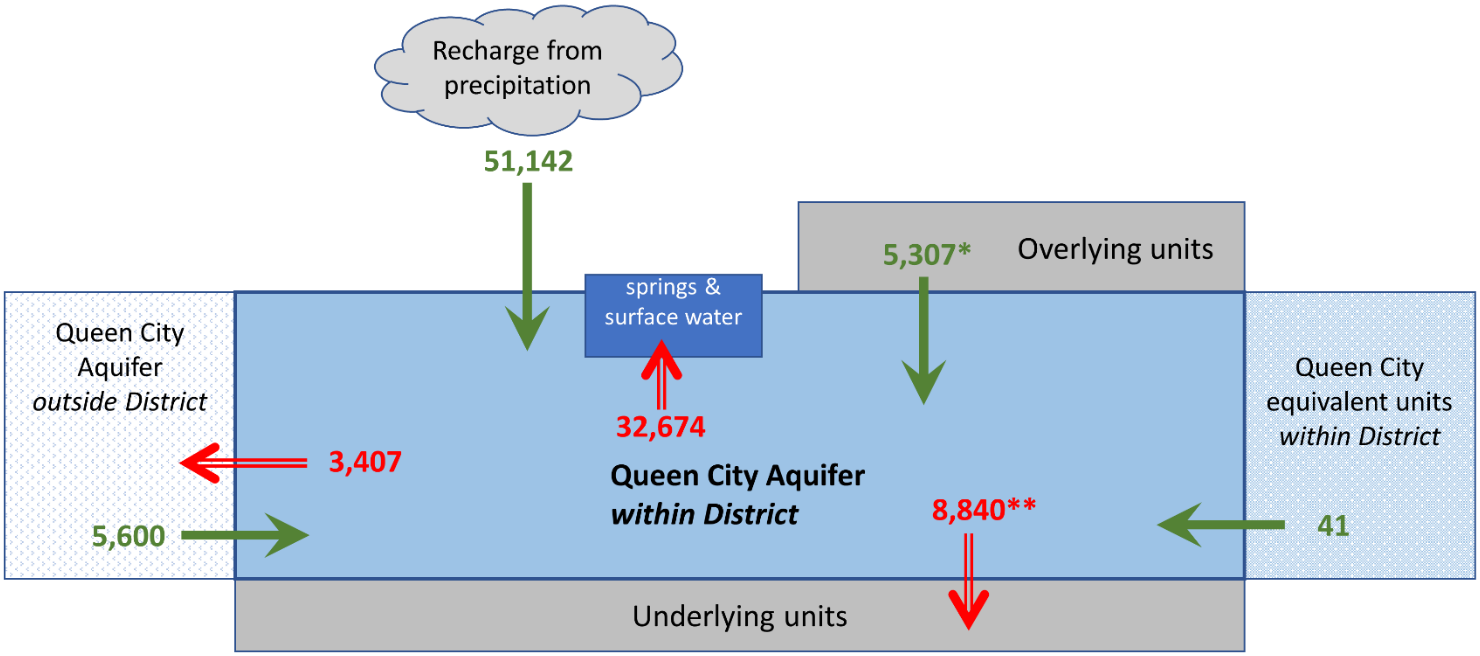


Figure 7: Area of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers from which the information in Table 4 was extracted (the Queen City Aquifer extent within the district boundary).



* Flow from overlying units includes net outflow of 280 acre-feet per year to Alluvium, a net inflow of 321 acre-feet per year from the Sparta Aquifer, and a net inflow of 5,266 acre-feet per year from the Weches Formation.

** Flow to underlying units includes net outflow of 4,334 acre-feet per year to the Reklaw Formation and a net outflow of 4,506 acre-feet per year to the Carrizo-Wilcox Aquifer.

Caveat: This diagram only includes the water budget items provided in Table 4. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 8: Generalized diagram of the summarized budget information from Table 4, representing directions of flow for the Queen City Aquifer within the Neches & Trinity Valleys Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 5: Summarized information for the Sparta Aquifer that is needed for the Neches & Trinity Valleys Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Sparta Aquifer	7,157
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Sparta Aquifer	1,310
Estimated annual volume of flow into the district within each aquifer in the district	Sparta Aquifer	580
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta Aquifer	1,329
Estimated net annual volume of flow between each aquifer in the district	From Sparta Aquifer to Sparta equivalent units	21
	From Sparta Aquifer to Alluvium	346
	From Sparta Aquifer to Weches Formation	1,320
	From Sparta Aquifer to Queen City Aquifer	321

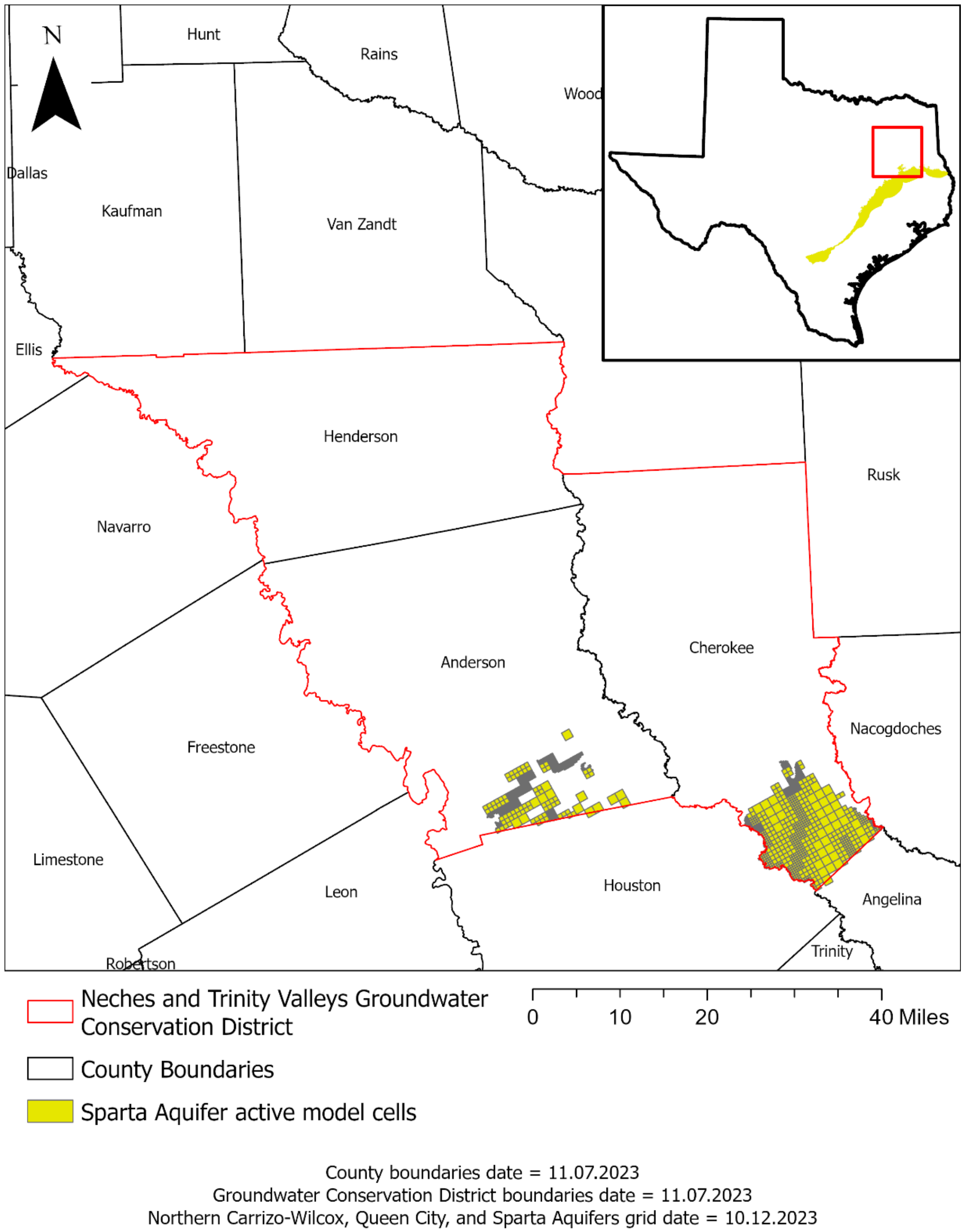
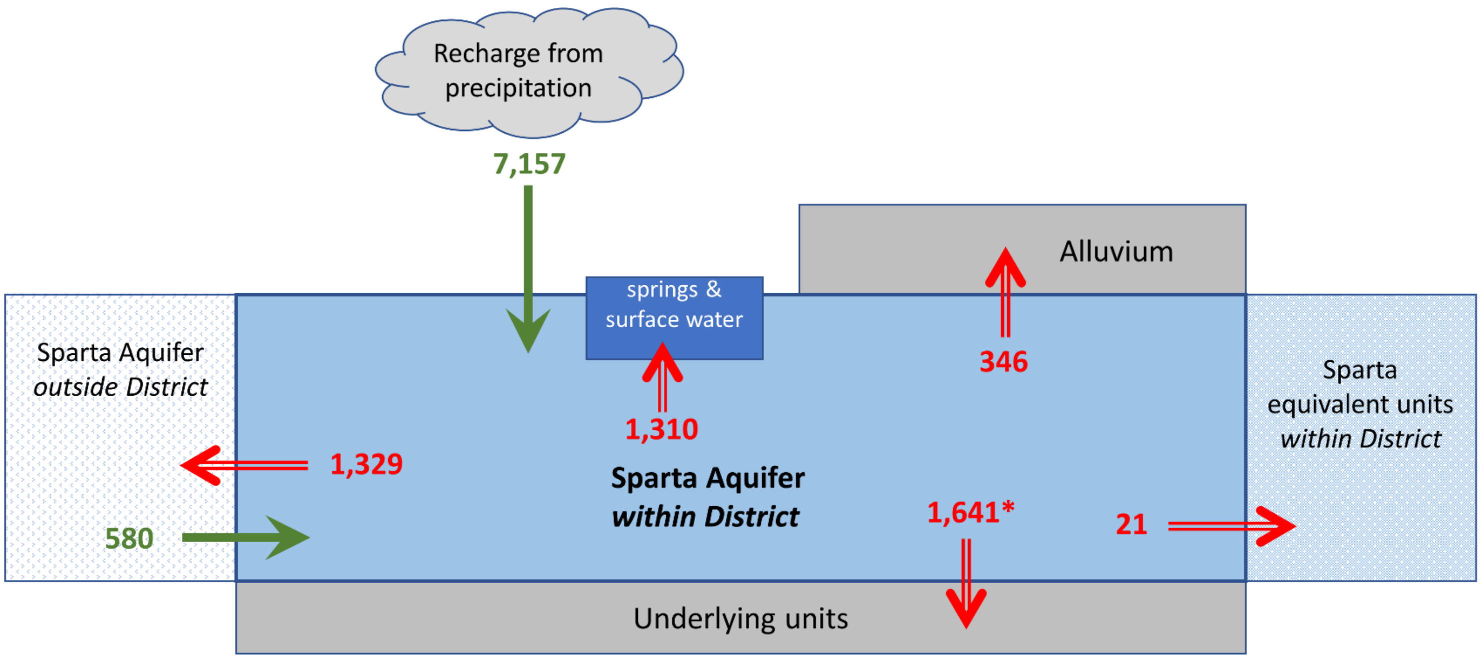


Figure 9: Area of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers from which the information in Table 5 was extracted (the Sparta Aquifer extent within the district boundary).



* Flow to underlying units includes net outflow of 1,320 acre-feet per year to the Weches Formation and a net outflow of 321 acre-feet per year to the Queen City Aquifer.

Caveat: This diagram only includes the water budget items provided in Table 5. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 10: Generalized diagram of the summarized budget information from Table 5, representing directions of flow for the Sparta Aquifer within the Neches & Trinity Valleys Groundwater Conservation District. Flow values are expressed in acre-feet per year.

LIMITATIONS:

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historical pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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