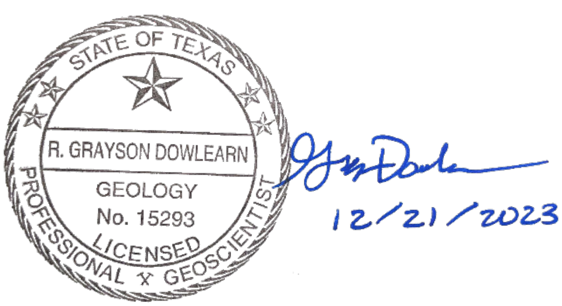
GAM RUN 23-025: PRAIRIELANDS GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Dwight Zedric Q. Capus, GIT and Grayson Dowlearn, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-936-2404
December 21, 2023



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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 Prairielands 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 Prairielands Groundwater Conservation District should be adopted by the district on or before March 2, 2024 and submitted to the TWDB Executive Administrator on or before April 1, 2024. The current management plan for the Prairielands Groundwater Conservation District expires on May 31, 2024.

This analysis used version 2.01 of the groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer (Kelley and others, 2014), version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer (Ewing and Jigmond, 2016), and version 1.01 of the groundwater availability model for the Nacatoch Aquifer (Beach and others, 2009), to estimate the management plan information for the aquifers within the Prairielands Groundwater Conservation District.

This report replaces the results of GAM Run 16-007 (Boghici, 2016) since it includes groundwater budgets for the Nacatoch and Brazos River Alluvium aquifers. Values may differ from the previous report as a result of routine updates to the spatial grid files used to define county, groundwater conservation district, and aquifer boundaries, which can impact the calculated water budget values. Additionally, 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 4 summarize the groundwater availability model data required by statute. Figures 1, 3, 5, and 7 show the areas of the respective models from which the values in Tables 1 through 4 were extracted. Figures 2, 4, 6, and 8 provide generalized diagrams of the groundwater flow components provided in Tables 1 through 4. If, after review of the figures, the Prairielands Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB 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 Texas Water Code § 36.1071(h), the groundwater availability models mentioned above were used to estimate information for the Prairielands Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Trinity and Woodbine aquifers (1980 through 2012) and Nacatoch Aquifer (1980 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Water budgets were extracted using ZONEBUDGET USG Version 1.00 (Panday and others, 2013) for the historical model period of the Brazos River Alluvium Aquifer (1980 through 2012). 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 portion of the Trinity Aquifer and Woodbine Aquifer

- We used version 2.01 of the groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer (Kelley and others, 2014). See Kelley and others (2014) for assumptions and limitations of the model.
- The groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer contains the following eight layers:
    - Layer 1 represents the surficial outcrop of the 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) and Woodbine aquifers (Layer 2).
- Perennial rivers and reservoirs were simulated using the MODFLOW River package. Ephemeral streams, flowing wells, springs, and evapotranspiration in riparian zones along perennial rivers were simulated using the MODFLOW Drain package.
- Water budget terms were averaged for the historical calibration 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 Brazos River Alluvium Aquifer

- We used version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer (Ewing and Jigmond, 2016). See Ewing and Jigmond (2016) for assumptions and limitations of the model.
- The groundwater availability model for the Brazos River Alluvium Aquifer contains the following three layers:
    - Layers 1 and 2 represent the Brazos River Alluvium Aquifer.
    - Layer 3 represents the surficial portions of the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers as well as various geologic units of the Cretaceous System.
- Perennial rivers and streams were simulated using the MODFLOW Streamflow-Routing package and ephemeral streams were simulated using the MODFLOW River package. Springs were simulated using the MODFLOW Drain package.
- Water budget terms were averaged for the period 1980 through 2012 (stress periods 32 through 427).
- The model was run with MODFLOW-USG (Panday and others, 2013)

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). See Beach and others (2009) for assumptions and limitations of the groundwater availability model.
- The groundwater availability model contains the following 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.
- Water budgets terms were averaged for the period of 1980 through 1997 (stress periods 4 through 21).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving an 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 Prairielands Groundwater Conservation District and averaged over the historical calibration period, as shown in Tables 1 through 4.

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 4. Figures 1, 3, 5, and 7 show the area of the model from which the values in Tables 1 through 4 were extracted. Figures 2, 4, 6, and 8 provide generalized diagrams of the groundwater flow components provided in Tables 1 through 4. 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 for the Prairielands 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	7,351
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	27,166
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	27,537
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	15,052
Estimated net annual volume of flow between each aquifer in the district	From Trinity Aquifer to Trinity equivalent units	64
	To Trinity Aquifer from overlying Washita and Fredericksburg groups	8,317

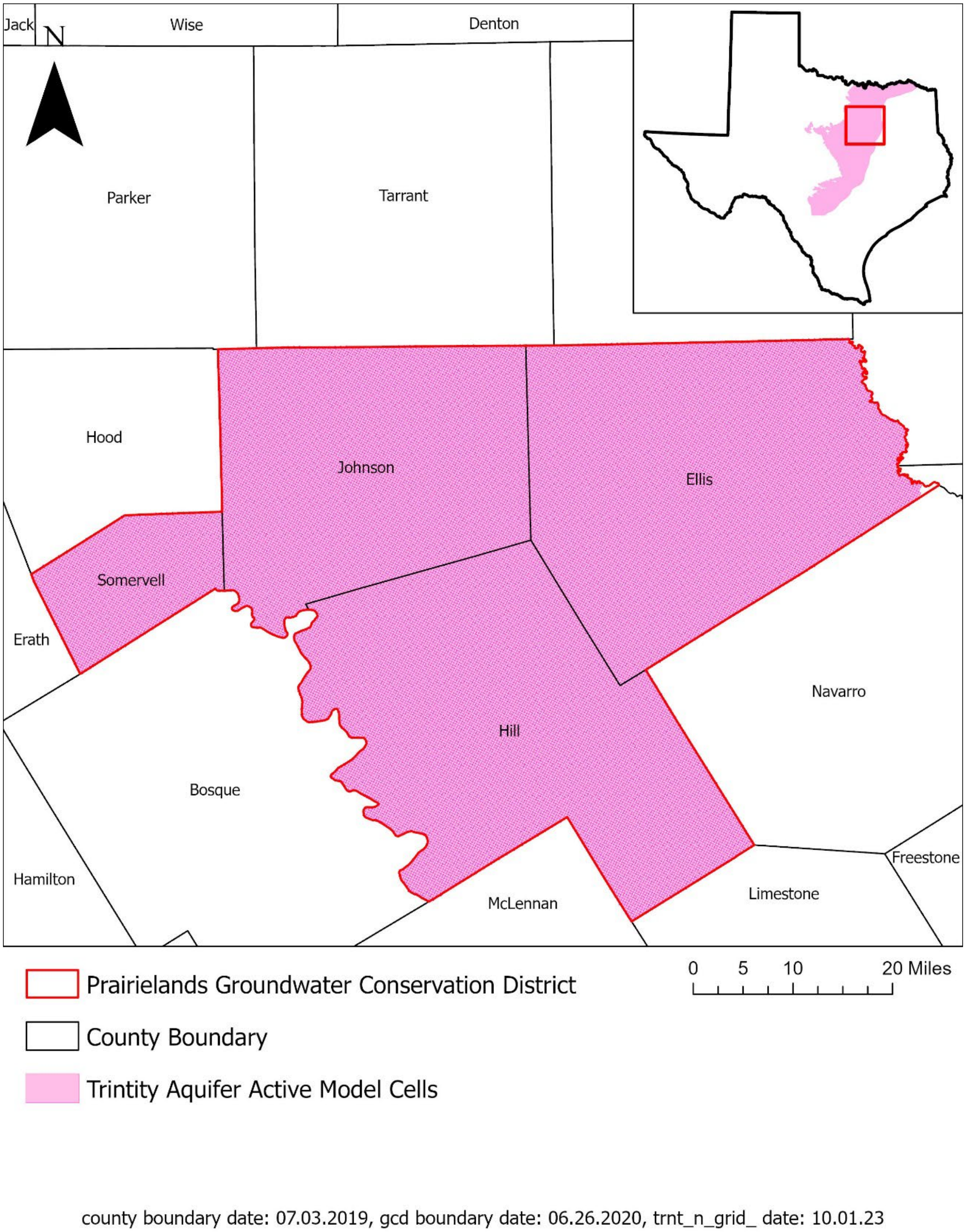
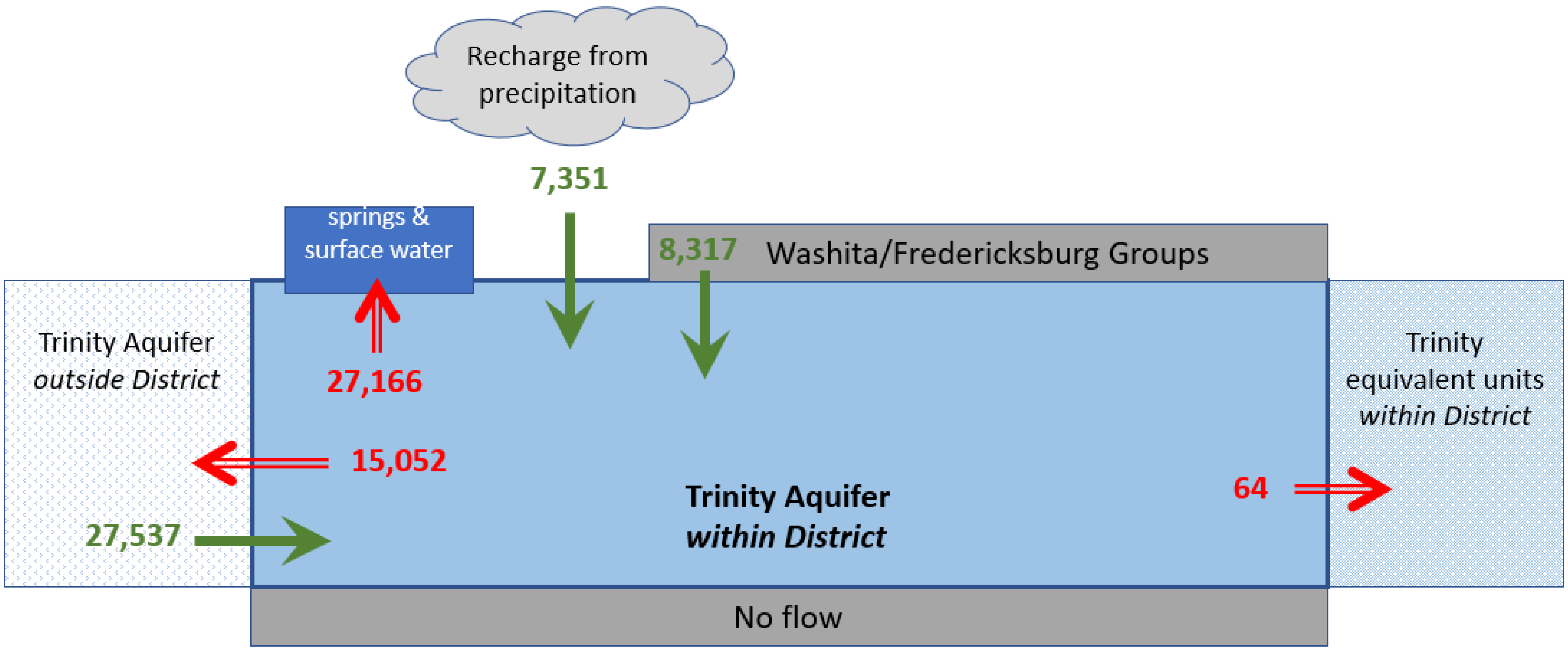


Figure 1: Area of the groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer from which the information in Table 1 was extracted (the Trinity Aquifer extent within the district boundary).



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 Prairielands Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 2: Summarized information for the Woodbine Aquifer for the Prairielands 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	Woodbine Aquifer	21,777
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Woodbine Aquifer	17,084
Estimated annual volume of flow into the district within each aquifer in the district	Woodbine Aquifer	720
Estimated annual volume of flow out of the district within each aquifer in the district	Woodbine Aquifer	754
Estimated net annual volume of flow between each aquifer in the district	To Woodbine Aquifer from Woodbine equivalent units	19
	To Woodbine Aquifer from younger sediments	3,686
	From Woodbine Aquifer to underlying Washita and Fredericksburg groups	8,299

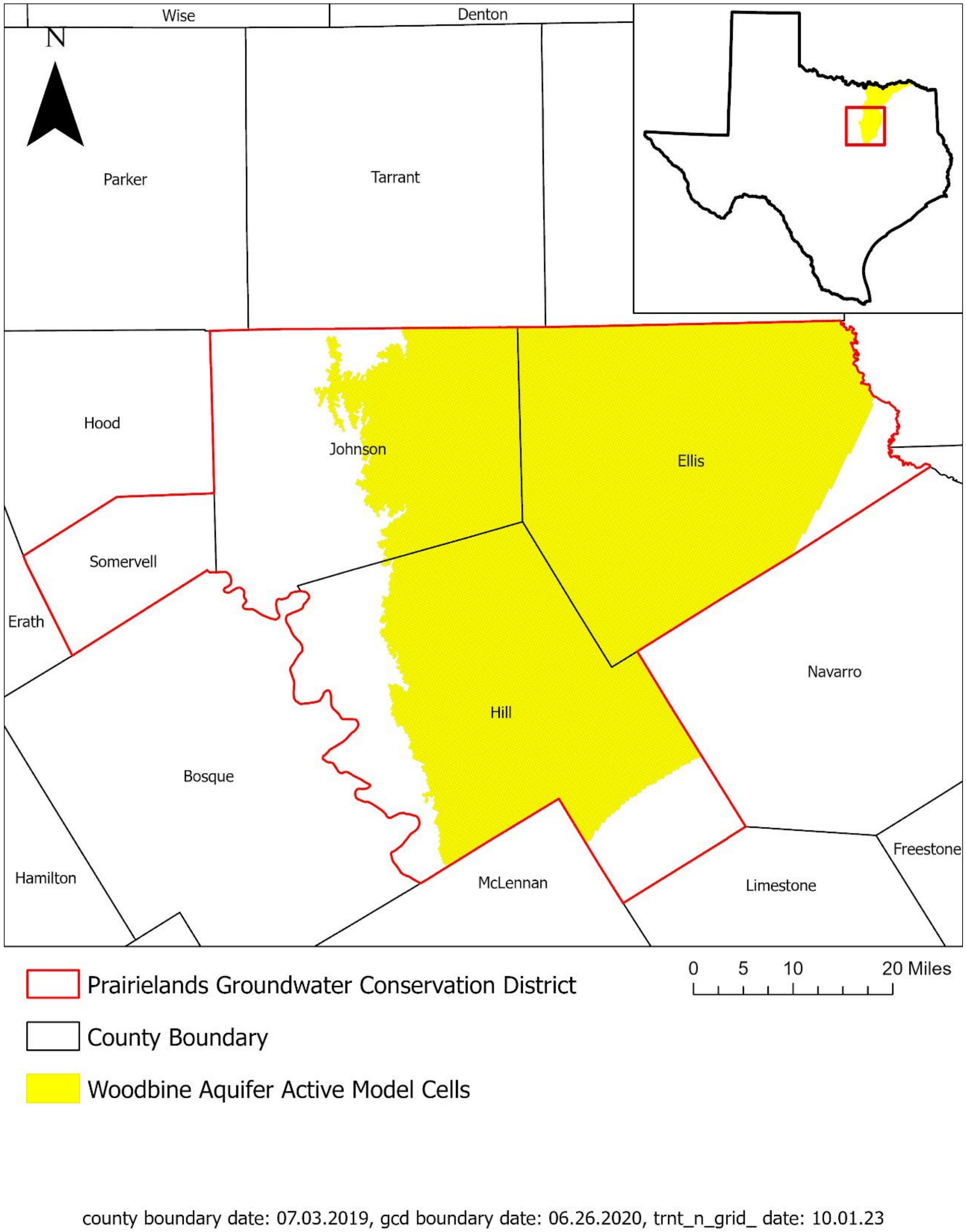
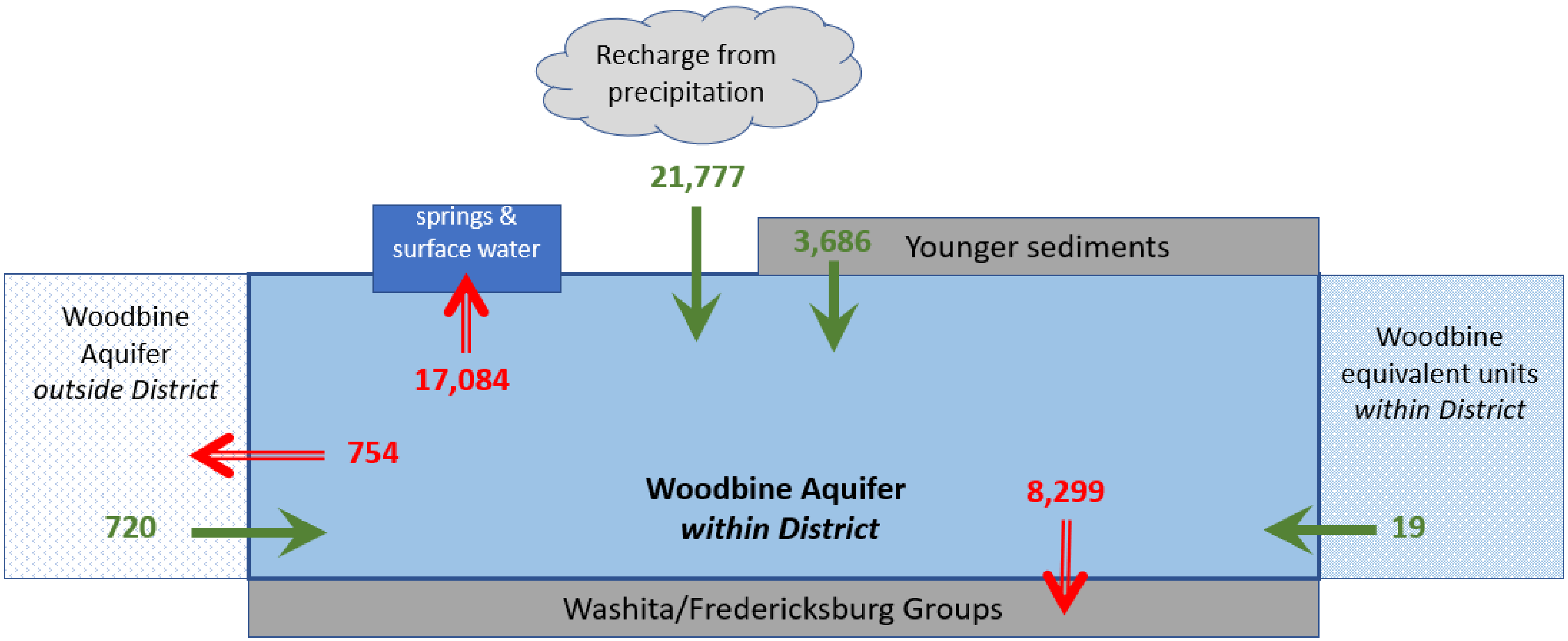


Figure 3: Area of the groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer from which the information in Table 2 was extracted (the Woodbine Aquifer extent within the district boundary).

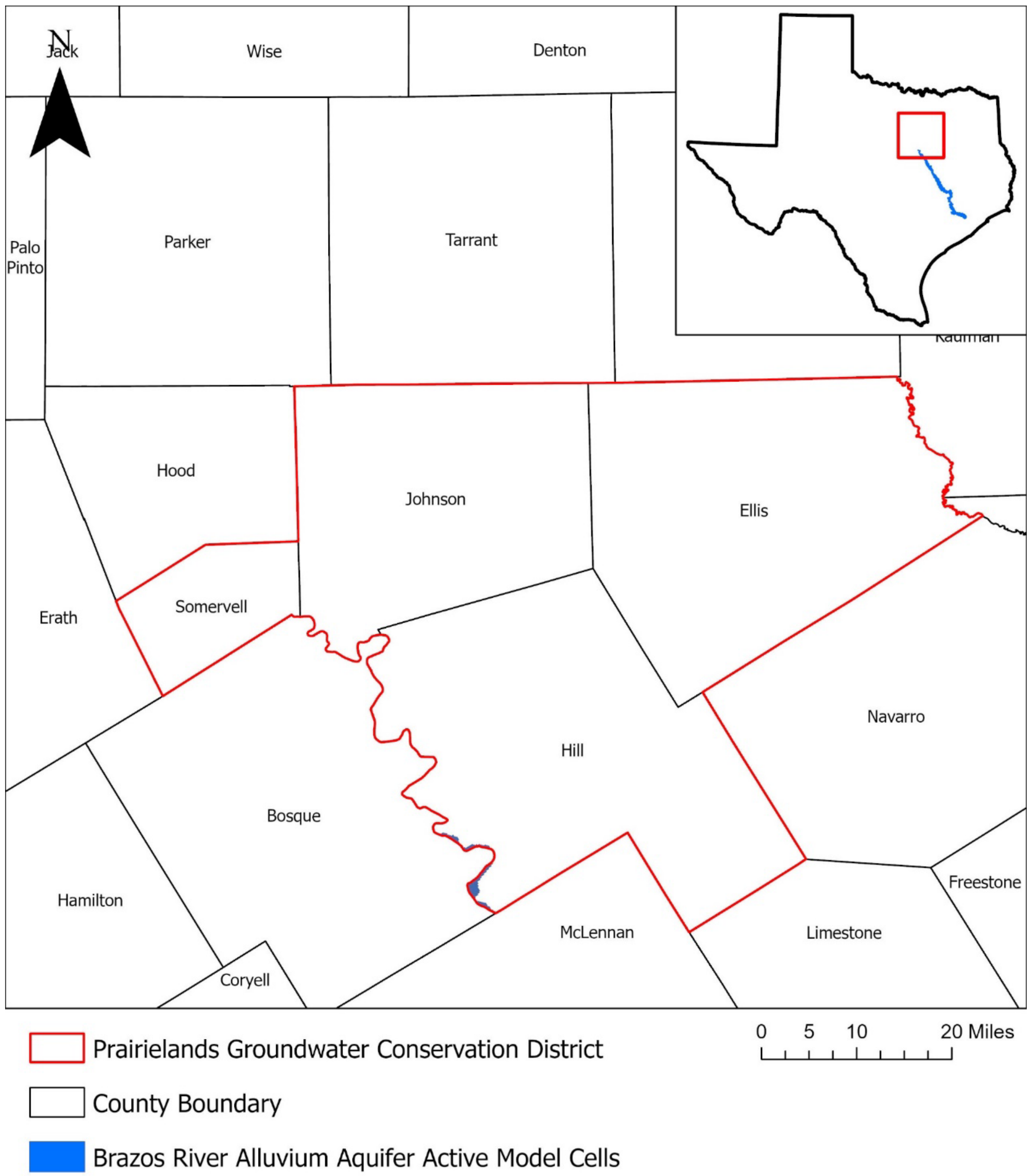


Caveat: This diagram only includes the water budget items provided in Table 2. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

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

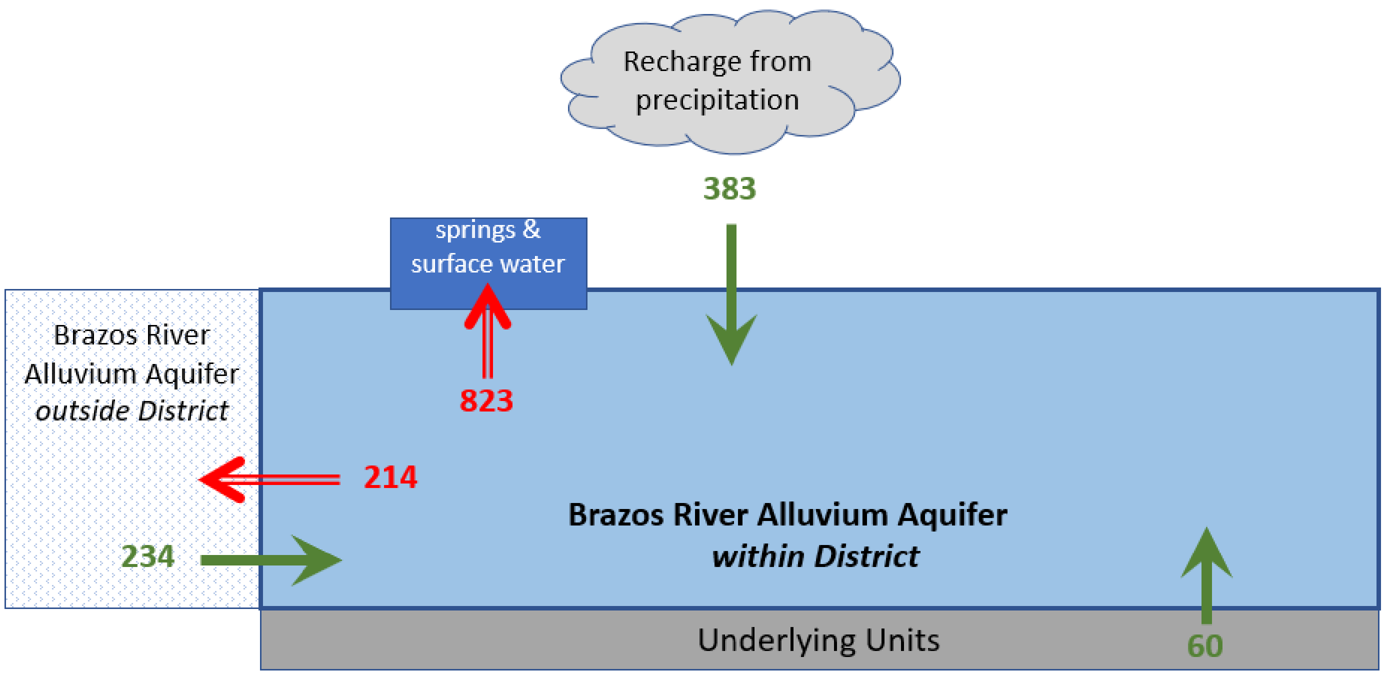
Table 3: Summarized information for the Brazos River Alluvium Aquifer for the Prairielands Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Brazos River Alluvium Aquifer	383
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Brazos River Alluvium Aquifer	823
Estimated annual volume of flow into the district within each aquifer in the district	Brazos River Alluvium Aquifer	234
Estimated annual volume of flow out of the district within each aquifer in the district	Brazos River Alluvium Aquifer	214
Estimated net annual volume of flow between each aquifer in the district	To the Brazos River Alluvium Aquifer from underlying units	60



county boundary date: 07.03.2019, gcd boundary date: 06.26.2020, bra_grid grid date: 10.01.2023

Figure 5: Area of the groundwater availability model for the Brazos River Alluvium Aquifer from which the information in Table 3 was extracted (the Brazos River Alluvium Aquifer extent within the district boundary).



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 Brazos River Alluvium Aquifer within the Prairielands Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 4: Summarized information for the Nacatoch Aquifer for the Prairielands 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	1
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Nacatoch Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Nacatoch Aquifer	19
Estimated annual volume of flow out of the district within each aquifer in the district	Nacatoch Aquifer	8
Estimated net annual volume of flow between each aquifer in the district	From Nacatoch Aquifer to Quaternary Alluvium	14

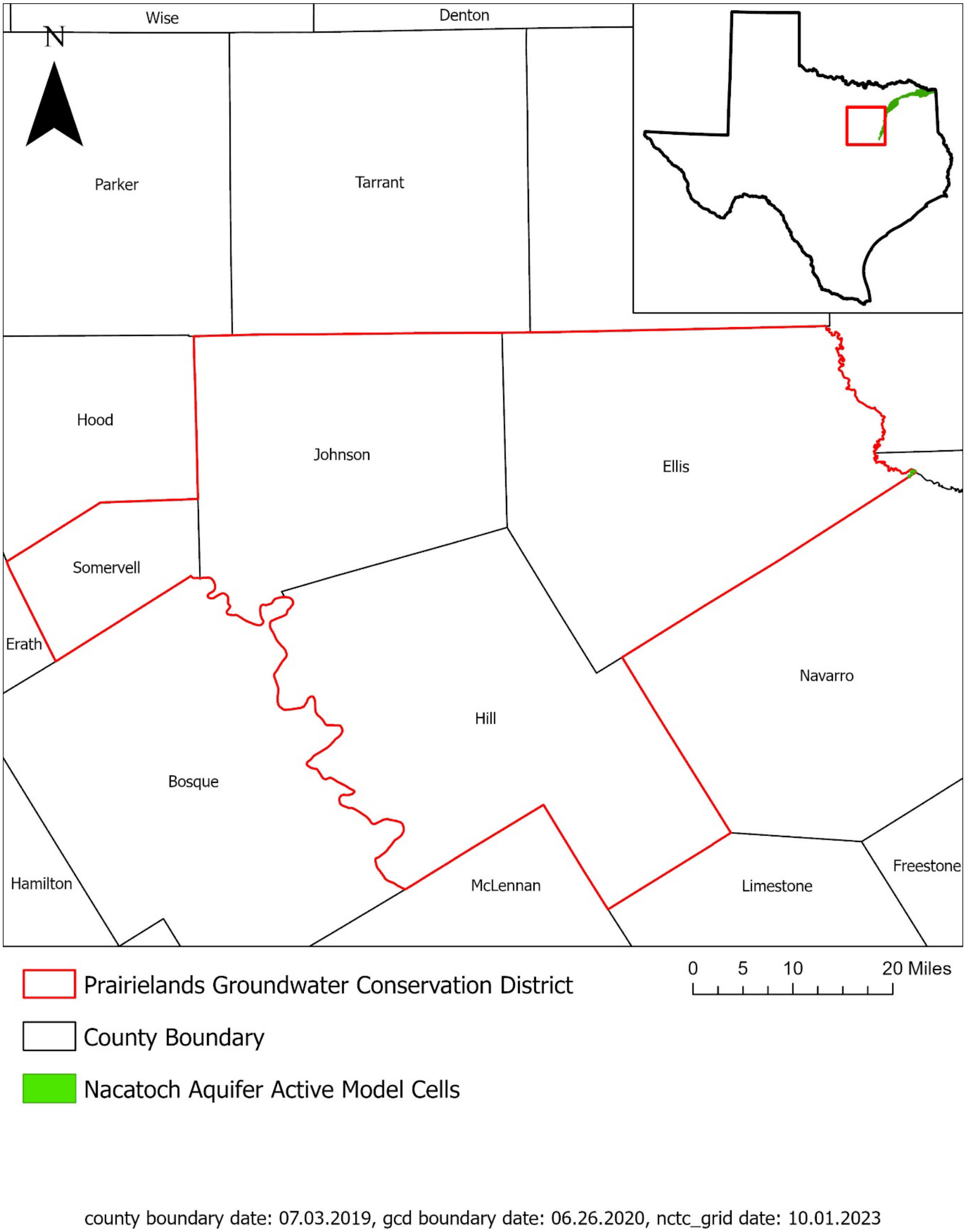
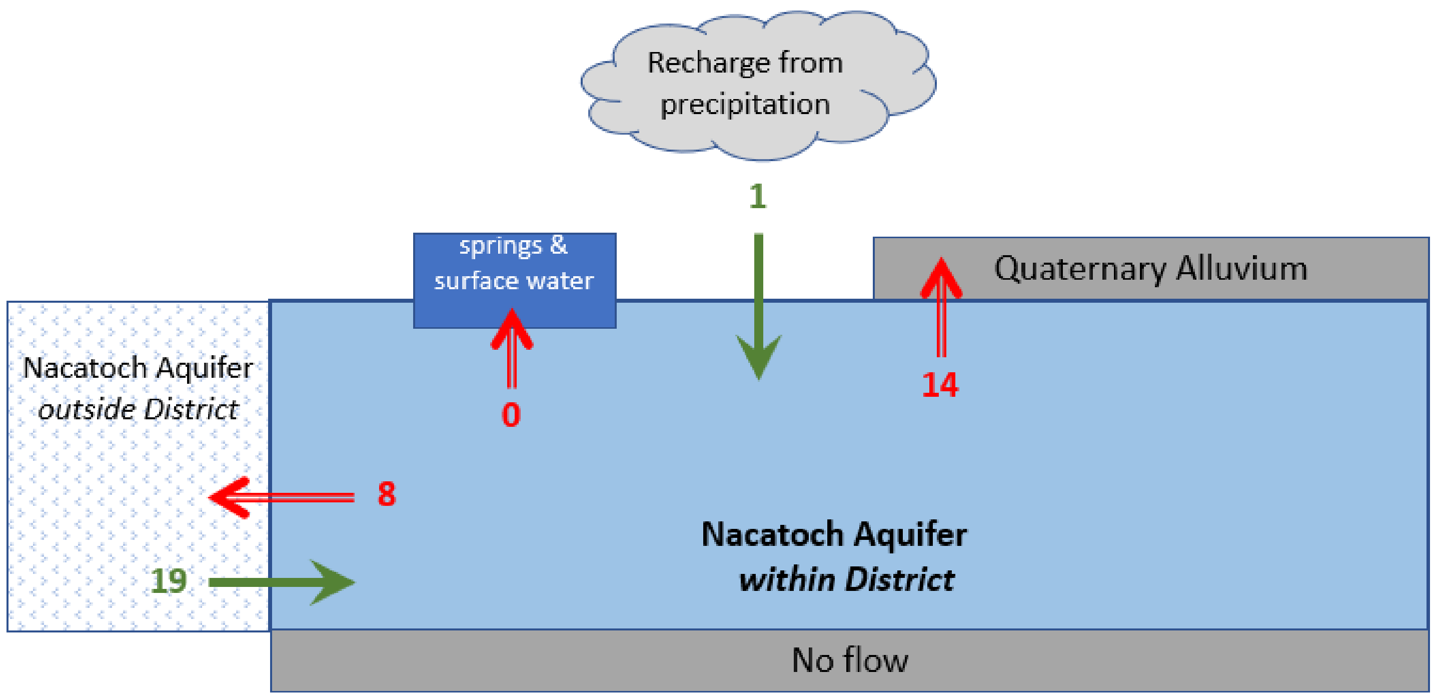


Figure 7: Area of the groundwater availability model for the Nacatoch Aquifer from which the information in Table 4 was extracted (the Nacatoch Aquifer extent within the district boundary).



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 Nacatoch Aquifer within the Prairielands 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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Texas Water Code § 36.1071