Appendices

A. Aquifer Assignment

A.1 Assigning Wells to Model Layers

Well data is contained in the "MasterWells" feature class in the project geodatabase. Well location, well depth and depth to screen(s) data were mostly sourced from the TWDB groundwater geodatabase and the TWDB Submitted Drillers Report geodatabase unless otherwise indicated in that dataset. Most well information is a duplicate of the information collected in the conceptual model report (Toll and others, 2018). However, since that project only included information up to 2015, the current dataset has been updated to include wells drilled from 2015 to 2020. Since well information came from several different sources, all wells were assigned a project-specific ID number in the format "HCa_#" to provide a unique well identifier for all project-related datasets. If a specific well was included in multiple source datasets, the well information was consolidated into one well entry with a single project-specific ID number. Thus, a single well entry in the "MasterWells" dataset may include multiple alternate ID numbers – for example, a TWDB state well number, a TCEQ public water supply well number, and a USGS site number.

Many of the source datasets used to compile the "MasterWells" dataset do include "source aquifer" information. However, these data are considered uncertain (sometimes unreliable) and even if not unreliable, may not include the subunits used in the current model. For instance, a source may list the aquifer as "Trinity" but not specify whether it is the upper, middle, or lower subunits of the Trinity Aquifer. To provide consistently defined "aquifer assignments" in this project, all wells were assigned to model layers (representing hydrostratigraphic units) based on the new geologic surface rasters that were created for this project, using the following assumptions:

Land surface elevation

While depth information from well drilling reports is considered fairly reliable, land surface elevation data is considered less reliable since it can come from a variety of sources, including GPS units or estimated from topographic maps. To ensure consistency, all wells were assigned a land surface elevation based on the NED 10-meter resolution digital elevation model. This is a known source of uncertainty but using a consistent source hopefully reduces the uncertainty that might otherwise be caused by using unknown sources of land surface elevation.

Wells with screen information

If at least 90% of the well screen length fell within a particular hydrostratigraphic unit, it was considered to be completely within that unit. If less than 90% of the well screen fell within a particular hydrostratigraphic unit, the well was assigned to the different component hydrostratigraphic units as a "mixed" type. To be included in the "mixed" type assignment, a hydrostratigraphic unit needed to contain at least 10% of the total well screen length.

Wells without screen information

Many wells do not have well screen information available, so "dummy" screen depths were assigned based on the following assumptions. In wells where the total well depth was less than 250 feet, the screen top depth was set equal to 80% of total well depth and screen bottom depth was equal to total well depth. For wells deeper than 250 feet, the screen top depth was set equal to 50 feet above total well depth and screen bottom depth was equal to total well depth.

Wells with no screen or depth information

If no depth information was available, wells were assigned to the hydrostratigraphic layer provided by the source if the source dataset was considered reliable (assigned state well numbers in the TWDB groundwater geodatabase, USGS NWIS monitoring sites, or TCEQ Public Water Supply wells). Aquifer assignments provided in the Submitted Drillers Report were not used since they were inconsistent and not considered reliable.

Exceptions

If a well fell within the Edwards Aquifer Authority extent, was drilled after its formation in 1993, and the original source dataset listed that well's aquifer as "Edwards", the well was assigned to the Edwards hydrostratigraphic unit. The reasoning is that the regulations related to Edwards Aquifer pumping within the Edwards Aquifer Authority are very strict and so there would have been a strong disincentive to label a well as "Edwards" in the source datasets if it was not in fact completed in the Edwards Aquifer.

A.2 How Layer assignments were used

A.2.1 Water level targets

For calibration, wells were only included as water level targets if the well was completely within a specific hydrostratigraphic unit, as defined above. Wells with "mixed" type assignments were not used as water level targets. All water level measurements that were compiled as potential water level calibration targets are included in the supplemental file "AllWaterLevelData_v1.xlsx".

A.2.2 Pumping

For pumping assignments in the WEL package, the pumping value assigned to a well location was weighted by the percentage of the screen falling within a particular aquifer. Every county was assigned a per-well pumping value for each hydrostratigraphic unit/water -use-type/year combination. If a well was completed 100% within that hydrostratigraphic unit, the entire per-well pumping value was assigned to that well location. If only 25% of the well falls within a hydrostratigraphic unit, only 25% of the per-well pumping value was assigned to that well location. The next section provides more detail on how the county per-well pumping value was calculated.

B. Pumping Distribution

B.1 Annual County-wide Pumping Values

The supplemental data files referenced in this section can be found in the supplemental data directory “Pumping”. The groundwater pumpage estimates for the years 1981 through 2020 for the southern portion of the Trinity Aquifer were developed by combining the results of a TWDB research contract that estimated pumping in the current study area (Furnans and others, 2022) and TWDB historical groundwater pumpage estimates (TWDB, 2025). The supplemental table “selectedData_1980_2020_WtCorr_v3.csv” provides the county-wide pumping data used in this project by year, aquifer and use type. The supplemental file “Original_Pumping_stackedCharts.pdf” provides graphs of this information by county and water use type. In general, the source used for the county-wide pumping value was chosen using the methodology provided in Table B.1. However, there are exceptions based on known county-specific issues, so please refer to the supplemental csv file (field “Source”) for the actual data source used.

There were some other assumptions made to cover gaps in the available annual data. The Furnans and others (2022) dataset does not begin until 1984 and the TWDB historical groundwater pumpage dataset (TWDB, 2025) has values for 1980 and 1984 but not 1981, 1982 or 1983. For the years 1981 through 1984 then, the source is listed as “Interp from 1980 pumpage” which indicates that it was calculated using a straight-line interpolation between the TWDB 1980 and 1984 estimates. The Furnans and others (2022) dataset ends in 2018 so water use in 2019 and 2020 is derived from TWDB historical groundwater pumpage estimates (TWDB, 2025) regardless of which source was used prior to that. The one exception is for county/use type combinations where the chosen 2018 pumpage value was derived from Furnans and others (2022) and equaled zero. These pumpage values were kept at zero to avoid a small jump in pumpage (assumed unlikely to be real) due to the change in source.

Since values were only available on a county basis, some county-wide pumping values also had to be adjusted if the entire county did not fall within the model area. The county-wide pumping values were multiplied by a weighting factor (Table B.2), that is the median value of three different calculations:

- Percentage of TWDB major aquifer area falling within the active model area versus within the entire county
- Percentage of TWDB state well numbers within TWDB major aquifer extent that fall within the active model area versus within the entire county
- Percentage of TWDB Submitted Driller Report wells within TWDB major aquifer extent that fall within the active model area versus within the entire county.

Note that the last two calculations do not incorporate the “aquifer assignments” discussed in the previous appendix. Since the geologic surfaces do not extend far beyond the model area, there was not a reliable way to assess wells that did not fall within the model boundary. Since the major aquifers in question are the main source of groundwater in these areas, the total number of wells within the aquifer extent was instead considered a reasonable proxy.

Table B.1 Data source for county-wide pumping values by water use type.

Water Use Type (Acronym)	Data source
Municipal (MUN)	Whichever source had greatest sum over total period
Manufacturing (MFG)	Whichever source had greatest sum over total period
Mining (MIN)	Furnans and others (2022)
Livestock (STK)	Furnans and others (2022)
Irrigation (IRR)	TWDB historical groundwater pumpage estimates (TWDB, 2025)
Rural Domestic (RD)	Furnans and others (2022)

Table B.2 Area weighting applied to county-wide pumping values in partial counties based on fraction within the active model area.

County	TWDB Major Aquifer	Aquifer Area Method	TWDB Groundwater Database Method	TWDB Submitted Drillers Database Method	Median
Burnet	Trinity	0.19	0.42	0.23	**0.23**
Edwards	Edwards-Trinity (Plateau)	0.79	0.83	0.84	**0.82**
Kimble	Edwards-Trinity (Plateau)	0.44	0.33	0.44	**0.40**
Mason	Edwards-Trinity (Plateau)	0.43	0.19	0.27	**0.29**
Sutton	Edwards-Trinity (Plateau)	0.01	0.00	0.02	**0.01**
Val Verde	Edwards-Trinity (Plateau)	0.05	0.04	0.04	**0.04**

B.2 Distributing County-wide Pumping Values by Hydrostratigraphic Subunit

The two pumping data sources described in the previous section do not provide values for the individual hydrostratigraphic units used in this model. Instead, they provide county-wide pumping values for each official major TWDB aquifer: Edwards (Balcones Fault Zone) Aquifer, Trinity Aquifer, or Edwards-Trinity (Plateau) Aquifer. Pumping attributed to the Edwards (Balcones Fault Zone) Aquifer was distributed to wells completed in Layer 1 (Edwards hydrostratigraphic unit). Pumping attributed to the Trinity Aquifer was distributed to wells completed in Layers 2 through 5 (upper Trinity, middle Trinity, Hammet, and lower Trinity hydrostratigraphic units) based on the number of wells completed in each Trinity subunit by county. Pumping attributed to the Edwards-Trinity (Plateau) Aquifer pumping was distributed to wells completed in Layers 1 through 5 based on the number of wells completed in each Edwards or Trinity subunit by county. The number of wells completed in each subunit was determined based on the percent of screen falling within each hydrostratigraphic unit. Thus, the number of wells may not be an integer. Table B.3 provides a simplified example for how a county-wide Trinity Aquifer pumping value would be split between the Trinity subunits used in the model. The supplemental file “WEL_Package_stackedCharts.pdf” provides graphs of this information by county and water use type.

Note that these county splits by water use type and year are calculated based on the wells assigned to each water use type that are “active” that year. A well was considered “active” if it was drilled that year or if it was drilled prior to that year and did not have a plugging report in the Submitted Drillers Report database as of that year. For this reason, it is possible to have a non-zero annual county-wide pumping value in the original dataset, but zero pumping applied in the model. This is because if there were no “active” well locations assigned to that particular water use type, there were no locations to distribute that pumping and apply it in the model. Please refer to the following section for more information regarding water use type assignments.

One known limitation of the current project’s methodology is that pumping is distributed evenly between all wells within the county. That is, there is no weighting by well size, pump size, or company/owner name. However, in reality, there are undoubtedly pumping variations (sometimes very large) between wells within the same county even if they are the same water use type. Currently, the size of the model area and project scope prevented the development of detailed county-specific investigations that would have been necessary to update these distributions in a meaningful way. The current methodology was chosen instead to provide the most consistent, reproducible pumping distributions over a large model area known to have inconsistent data availability. For stakeholders who are concerned about specific large-volume pumping locations, TWDB recommends careful review of the pumping distributions used in their area of interest, as it is likely that the current model may not be the appropriate tool for evaluating effects at specific high-production sites.

Table B.3 **Simplified example of distributing total county-wide pumping from the major Trinity Aquifer to the component hydrostratigraphic subunits.**

Well	Screen Fraction in upper Trinity	Screen Fraction in middle Trinity
A	1	0
B	0.5	0.5
C	0	1
D	0.25	0.75
Total "Wells"	1.75	2.25
Percentage of Trinity Pumping	44%	56%

B.3 Assigning Water Use Type

The "Type2Use" category in the "MasterWells" feature class provides which category the well was assigned to for pumping distribution purposes. Table B.4 shows how water use types from source datasets were initially sorted into the simplified TWDB water use types. If wells were assigned using these assumptions, the "TypeReason" field says, "*Based on Water Use from Source*". There are some exceptions where assigned water use types may have been updated based on additional data (ex. scanned well forms or TCEQ public water supply information) that may not have been available in the original datasets. These reasons are explained in the "TypeReason" field.

Assigning water use type to wells could be highly uncertain due to the assumptions required. As shown in Table B.4, some source datasets only included vague or no water use descriptions. Sometimes, sources provided conflicting information regarding the water use type. The size of the model area and the project scope did not allow for detailed well analysis by county, so the chosen methodology was instead intended to provide consistent assignments for a very large dataset with inconsistent data availability. TWDB recommends that stakeholders carefully review the pumping values and well assignments used in their area of interest to better evaluate the limitations of this model at a local scale.

Table B.4 **Water use types from source datasets categorized into simplified TWDB water use types.**

Use Type in Source Dataset	Simplified Use Description	TWDB Water Use Type (used to assign WEL pumping)
Industrial	Manufacturing	IND
Commercial	Manufacturing	IND
Industrial (cooling)	Manufacturing	IND
Medicinal	Manufacturing	IND
Irrigation	Irrigation	IRR
Rig Supply	Mining	MIN
De-watering	Mining	MIN
Public Supply	Municipal	MUN
Institution	Municipal	MUN
Recreation	Municipal	MUN
Public supply	Municipal	MUN
Recreation_Irrig.	Municipal	MUN
Fire	Municipal	MUN
Air Conditioning	Municipal	MUN
Domestic	Rural Domestic	RD
Stock	Livestock	STK
Livestock	Livestock	STK
Aquaculture	Livestock	STK
Unused	Unknown	UNK
Plugged or Destroyed	Unknown	UNK
Other	Unknown	UNK
Withdrawal of Water	Unknown	UNK
No	Unknown	UNK
Test Well	Unknown	UNK
Unknown	Unknown	UNK
Observation	Unknown	UNK
Outcrop	Unknown	UNK
Not Available	Unknown	UNK
Extraction	Unknown	UNK
Monitor	Remediation	No
USGS	Piezometer	No
Injection	Unknown	No
Environmental Soil Boring	Non-Groundwater	No
Closed-Loop Geothermal	Non-Groundwater	No

C. Calibration Parameters

The current project used an ensemble-type calibration which created thousands of potential model realizations. However, for the purposes of this project, a “final” model was chosen using the methodology described in Section 3.1.1. This “final” model refers to realization 525 from the final optimization iteration of the ensemble calibration process. The supplemental file “Calibration_parameters_real525.xlsx” contains the final parameter data related to realization 525. This file includes information usually contained in the pyemu output file “*.par_data” with the addition of potentially helpful fields (marked with * in Table C.1) to improve readability and usefulness. For instance, the default pyemu parameter names can be difficult to interpret, so the additional fields include zone numbers, zone names, and plain-language parameter descriptions. For parameters that are “multiplier” type, rather than “direct” type, the final calibrated parameter value “parval_Calib” does not correspond to the actual value used in the model, which is instead included in the added field “ModelVal”.

Table C.1 Description of fields provided in calibration parameter table.

Field	Description
parnme	Parameter name
partrans	Parameter transformation type
parchglim	Parameter change limit type
parval_Init*	Initial parameter value
parval_Calib	Final calibrated parameter value
parlbnd	Parameter lower bound
parubnd	Parameter upper bound
pargp	Parameter group
idx0	Node number
pname	Parameter group name
pstyle	Parameter style (d=direct; m= multiplier; a=additive)
ptype	Parameter type (zn = zone; gr=grid)
usecol	Relevant column in MODFLOW input file
partied	Tied parameter
ParGpName*	Plain-language parameter group description
Zone*	Zone number
ZoneName*	Zone name
Bname*	boundname (MODFLOW parameter)
ModelVal*	Value used in Model
Other*	Other notes
ParUnits*	Units of parameter value
ModUnits*	Units of model value

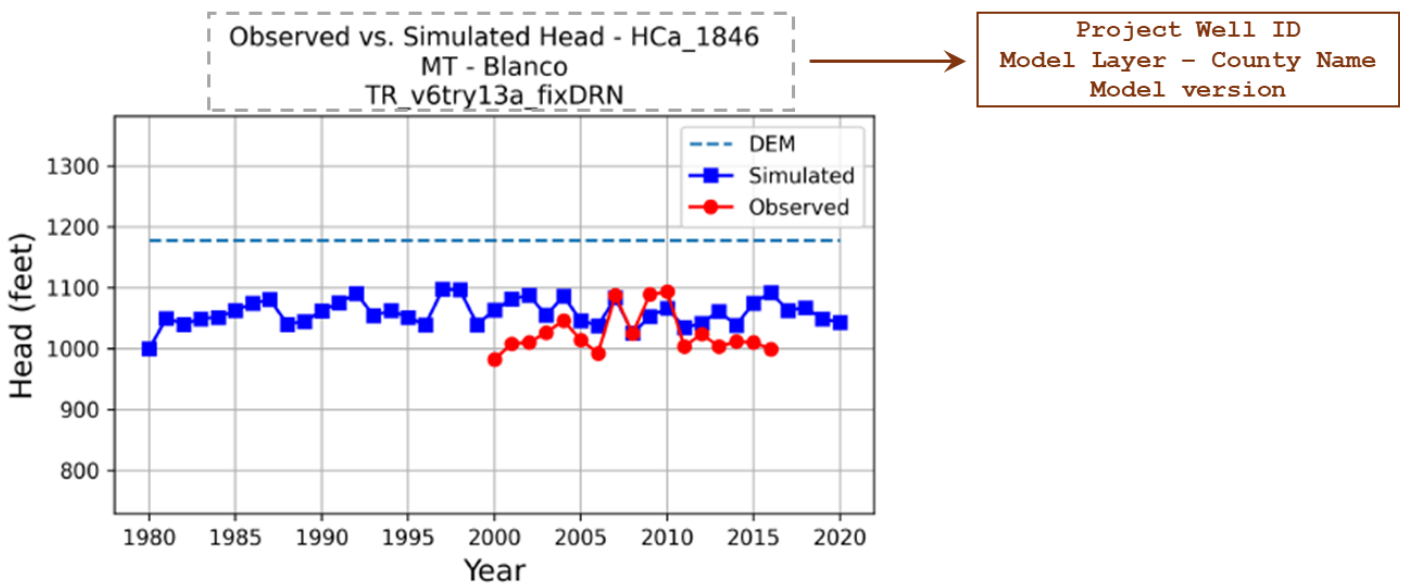
D. Comparison of Simulated and Observed Water Levels

The supplemental data directory “Hydrographs” provides well hydrographs that compare simulated and observed water levels organized by county (“By_County”) and by model layer (“By_HydroUnit”). Each hydrograph is labeled following the format shown in Figure D.1 where:

- Project Well ID = the project-specific ID
- Model layer = the 2-letter model layer acronym
- County Name = county name
- Model version = TWDB internal model version name

The “Project Well ID” is a number with an “HCa_” prefix and is provided in the “MasterWells” feature class in the project geodatabase. It is completely unrelated to other well ID numbers, like the state well number. The two-letter model layer acronyms are as follows: ED = Edwards, UT = upper Trinity, MT=middle Trinity, HM = Hammet, LT = lower Trinity.

Figure D.1 Example hydrograph to demonstrate label format.



E. Water Budgets

The supplemental data directory “Water_Budgets” provides water budget data by county and groundwater conservation district. The subdirectory “Budget_by_County_Name” provides individual Excel files of water budget data for each county. The subdirectory “Budget_by_CleanGCD” provides individual Excel files of water budget data for each groundwater conservation district and the Edwards Aquifer Authority. Please refer to “0_ReadMe.xlsx” file for more detailed explanations of the tables and data fields. For convenience, graphs of the net water budget components are also provided as PDF files by county and groundwater conservation district in the respective folders. However, the Excel files are more appropriate for detailed analysis.

For county water budgets, budget terms that are labeled “within” or “outside” the county refer strictly to the geographic extent of the county. However, the district water budgets account for both geographic extent AND for jurisdiction by aquifer. For instance, the Edwards Aquifer Authority has jurisdiction over the Edwards Aquifer within its extent, meaning districts only have jurisdiction over portions of the Edwards Aquifer that fall outside that extent. In that case, for the Edwards Aquifer Authority water budget, only the Edwards hydrostratigraphic unit (Layer 1) is considered to be “within” the authority’s boundary. For portions of districts that overlap the Edwards Aquifer Authority, the overlapping area of the Edwards hydrostratigraphic unit (Layer 1) is considered to be “outside” the district boundary. Only the non-overlapping section is considered “within” the district boundary.

Outside of the Edwards Aquifer Authority, the Barton Springs/Edwards Aquifer Conservation District has jurisdiction over the Edwards Aquifer within its extent. Thus, for the Plum Creek Conservation District water budget, the portion of the Edwards hydrostratigraphic unit (Layer 1) that overlaps with the Barton Springs/Edwards Aquifer Conservation District is considered “outside” the district boundary. Only the non-overlapping parts are considered “within” the district boundary, as long as they also do not fall within the Edwards Aquifer Authority extent.

Similarly, the Plum Creek Conservation District has jurisdiction over the Trinity Aquifer within its extent. Thus, for the Barton Springs/Edwards Aquifer Conservation District, the portions of Trinity Aquifer subunits (Layers 2 through 5) that overlap with the Plum Creek Conservation District are considered “outside” the district boundary and only the non-overlapping parts are considered “within” the district boundary.