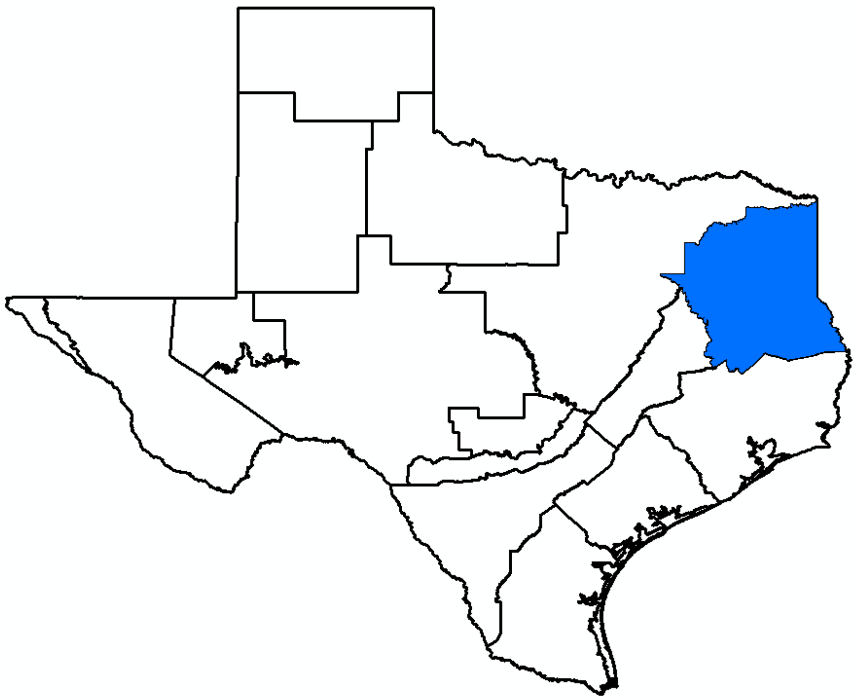
*GMA 11 Technical Memorandum 26-01*

# Documentation of Updated Specific Yield Values for the Groundwater Availability Model of the Northern Portion of the Carrizo-Wilcox, Queen City and Sparta Aquifers



***Prepared for:***
**Groundwater Management Area 11**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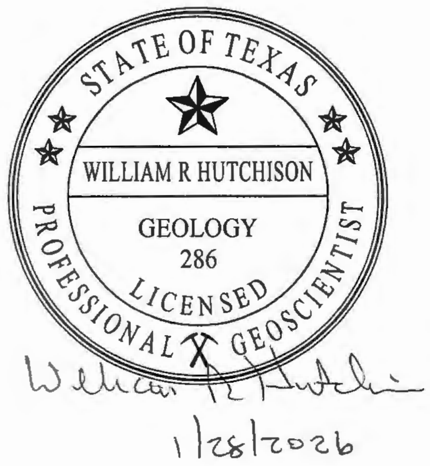

# 1.0 Introduction and Background

## 1.1 Updated Groundwater Availability Model and Joint Planning in GMA 11

Panday and others (2020) completed an update of the Groundwater Availability Model (GAM) for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers. This updated GAM was used as part of the development of desired future conditions adopted by the groundwater management districts in Groundwater Management Area 11 on August 11, 2021. One of the features of the updated GAM was significantly lower specific yield parameters as compared to the previous GAMs.

The development of desired future conditions is also known as the joint planning process. Among the documents used in the joint planning process was Hutchison (2021), which included a groundwater budget analysis that evaluated the impacts of increased pumping associated with the adopted desired future conditions. In summary, in all aquifers in Groundwater Management Area 11, average pumping from 1981 to 2013 was estimated to be about 130,000 AF/yr. Average pumping in Groundwater Management Area 11 from 2014 to 2080 in Scenario 33 (the basis for the desired future condition) was assumed to be about 385,000 AF/yr, a 255,000 AF/yr increase.

The analysis in Hutchison (2021) showed that 72 percent of the pumping increase would be sourced from the alluvium associated with the surface water system in the area, and, by extension, from surface water flow. In other words, most of the pumping increase would be sourced from surface water flow. Also, only about 3 percent of the pumping would be sourced from decreased storage.

## 1.2 Comments on Specific Yield Values in GAM

On September 1, 2021, I presented the groundwater budget impacts results at the 2021 Groundwater Summit hosted by the Texas Alliance of Groundwater Districts (TAGD). James Beach of Advanced Groundwater Solutions LLC raised questions regarding the conclusions given the low specific yield and specific storage parameters used in the updated GAM. The specific yield parameters in the updated GAM differed significantly from those used in the old GAM, and the influence of the lower specific yield parameters on the results of the analysis were questioned.

On December 15, 2025, I met with consultants for the Trinity River Authority and the Texas Water Development Board. Among the topics discussed, the issue of specific yield values were discussed. I described work that was completed in 2021 in response to Mr. Beach's comments in 2021 and how this information was used to inform the update of the GAM of the Southern Portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers.

The Texas Water Development Board stated that these changes could be made and documentation of the changes be provided. This Technical Memorandum is the documentation of the changes.

## 1.3 Specific Yield Parameters in Previous GAMs

Schorr and others (2020, pg. 118-119) noted that previous GAMs of the area (Fryar and others, 2003 and Kelley and others, 2004) used storage parameters that allowed the model to reproduce changes in groundwater levels throughout the study area. Schorr and others (2020) specifically noted that the specific yield values from the previous GAMs were 0.15 for the Sparta, Queen City, Carrizo, and Wilcox aquifers, and a value of 0.10 was specified for the Weches and Reklaw confining layers.

Schorr and others (2020) referenced the report by Lupton and others (2015) which included measured storativity parameters from aquifer tests in Panola County. Lupton and others (2015) reported the results of aquifer tests on public supply wells and aquifer tests performed for permitting in Panola County GCD. Five tests yielded unreasonable values for storativity, and 24 tests that yielded reasonable storativity values. The median storativity value for the 24 tests that yielded reasonable results was 4.67E-04. Lupton and others (2015) noted that these values indicated primarily confined conditions in the Wilcox Aquifer in Panola County despite the conventional and historical that the Wilcox Aquifer in Panola County is in the outcrop area. Lupton and others (2015) stated that the low storativity values were “not unexpected” given the interbedded sands and clays of the Wilcox combined with well depths of several hundred feet. Lupton and others (2015) concluded that except for very shallow wells or wells in river alluvium, groundwater in Panola County occurs under confined conditions.

As noted in Hutchison (2017 and 2021), the specification of relatively high specific yield values in the previous GAMs had an impact on the calculations of Total Estimated Recoverable Storage (Wade and others, 2014). Hutchison (2017 and 2021) specifically noted:

> *A key parameter in these calculations is the specific yield in the downdip portion of the aquifer. In most cases, the model’s estimate of specific yield in the downdip area is never “used” in model. 23,320 cells of the 58,269 cells in the downdip area have an artesian head of over 500 feet, which is about 40 percent of the cells in the model. Unless heads drop below the top of the aquifer, these parameters are simply place holders and were never calibrated.*
>
> *In general, a specific yield values of 0.1 to 0.15 is representative of a clean sand. As drilling and electric logs show, interlayered sands and clays are common in the Carrizo-Wilcox. The model has thick layers (about 24 percent of the cells are over 500 feet thick). Thick cells increase the chance of interbedded clay, and this would result in reduced specific yield estimates. Although the higher specific yield values may be appropriate for individual sand units, the thicker layers increase the chance that the overall specific yield value is lower than the place-holder value in the model input files.*

Based on the unreasonableness of the specific yield values in the previous GAM that was the basis for the total estimated recoverable storage estimates, Hutchison (2017 and 2021) suggested that the total estimated recoverable storage values of Wade and others (2014) may be overestimated by one or two orders of magnitude.

Hutchison (2017 and 2021) also noted the high specific yield parameters may have also contributed to issues with simulations with the previous GAMs related to rising groundwater levels in the outcrop areas. The rising water levels may have been the result of flat gradients that restrict flow from the outcrop area to the downdip areas.

Panday and others (2020) adjusted initial values of specific storage and specific yield during calibration of the updated GAM "to provide appropriate magnitude of fluctuations of water levels". Panday and others (2020) noted that the low specific yield value used in the calibrated model (7.14E-04) "indicates there may be partial confinement of the aquifer system even in the outcrop (unconfined) regions". Panday and others (2020) also reported that the simulated water levels were not overly sensitive to storage properties and that the storage terms effect on the nature and magnitude of fluctuations was small, and that higher values provided similar results.

# 2.0 Model Files

All model files are available on Google Drive:

*https://drive.google.com/drive/folders/1cXYhI3V-0845pJDJISGS5BobwhkbEgRZ?usp=sharing*

Specific yield values for the alluvium (layer 1) were set to 0.1 which is more consistent with thin and young deposits of sand, silt, and clay. Specific yield values for all other layer (layers 2 to 9) were unchanged at 7.14E-04, as described above.

MODFLOW 6 input files used to check the GAM calibration with the updated specific yield values are categorized in two groups below. The files in Table 1 are the files that remain unchanged from the Panday and others (2020) version, and Table 2 lists the files that were changed to implement the updated specific yield values.

**Table 1. GAM Input Files Unchanged from Panday and others (2020)**

**From nam file:**

| Type | File Name | Description |
|---|---|---|
| DISU6 | tr58_g_final_model_gwv_L2top_newK.dis | Spatial discretization |
| IC6 | tr58_g_final_model_gwv_L2top_newK.ic6 | Initial Conditions |
| NPF6 | tr58_g_final_model_gwv_L2top_newK.npf | Node property flow (aquifer parameters) |
| RIV6 | tr58_g_final_model_gwv_L2top_newK.riv | River |
| GHB6 | tr58_g_final_model_gwv_L2top_newK.ghb | General head boundary |
| WEL6 | tr58_g_final_model_gwv_L2top_newK.wel | Well |
| RCH6 | tr58_g_final_model_gwv_L2top_newK.rch | Recharge |
| EVT6 | tr58_g_final_model_gwv_L2top_newK.evt | Evapotranspiration |

**From npf file:**

| File Name | Description |
|---|---|
| tr58_g_final_model_gwv_L2top_newK._kx | Horizontal hydraulic conductivity |
| tr58_g_final_model_gwv_L2top_newK._kz | Vertical hydraulic conductivity |

**From sto file:**

| File Name | Description |
|---|---|
| tr58_g_final_model_gwv_L2top_newK._ss | Specific Storage |

**Table 2. Updated GAM Input Files for Specific Yield Values**

| Description | File Names |
|---|---|
| **From nam file:** | |
| Standard output | alt1.lst |
| Output control | alt1.oc6 |
| **From sto file:** | |
| Specific yield | alt1.sy |
| **From oc6 file:** | |
| Cell-by-cell flow | alt1.cbb |
| Heads file | alt1.hds |

## 3.0 Calibration Statistics

Simulated heads from the Panday and others (2020) version of the GAM were compared with actual groundwater elevation data downloaded from TWDB's groundwater database. This same comparison was also completed using the simulated heads from the updated version of the model. The post-processor that was written to complete this comparison is named *ActSim.exe*. All files associated with this comparison are available for download in the link provided above.

The post-processor reads a list of the 1,121 wells used in this analysis (*actwelllist.dat*). The post processor then reads attributes of each of these wells, including the cell number(s) associated with the cell in the file *GMA11CalPerspqccwNN.csv*). Please note that Carrizo-Wilcox wells are assigned to all active cells in layers 6 to 9.

The post-processor then assigns an "end-of-year" groundwater elevation for each year and writes an array of measured annual groundwater elevations from 1980 to 2013 (*GMA11ActGWE.dat*).

Simulation heads are read next, and three files are written (one for the Sparta, one for the Queen City, and one for the Carrizo-Wilcox) with a comparison of the actual groundwater elevations and the simulation groundwater elevations.

These results were imported into Excel spreadsheets:

- Panday and others (2020) version: *origActSimHed.xlsx*
- Updated version: *updatedActSimHed.xlsx*

Various calibration statistics are calculated in the spreadsheet and the results are summarized in Table 3.

**Table 3. Summary Comparison of Calibration Statistics**

| Statistic | Sparta Aquifer | | Queen City Aquifer | | Carrizo-Wilcox Aquifer | |
|---|---|---|---|---|---|---|
| | Panday and others (2020) | Proposed Updated | Panday and others (2020) | Proposed Updated | Panday and others (2020) | Proposed Updated |
| Residual Mean | 324.48 | 324.48 | 375.75 | 375.75 | 280.75 | 280.75 |
| Absolute Residual Mean | 31.10 | 31.05 | 46.04 | 45.98 | 72.47 | 72.29 |
| Residual Standard Deviation | 119.71 | 119.71 | 90.79 | 90.79 | 127.55 | 127.55 |
| Sum of Squared Residuals | 770,564 | 768,750 | 7,567,230 | 7,543,916 | 108,574,003 | 107,662,997 |
| Root Mean Square Error | 42.09 | 42.04 | 64.89 | 64.79 | 103.42 | 102.99 |
| Minimum Residual | 157.19 | 157.19 | 45.00 | 45.00 | -377.00 | -377.00 |
| Maximum Residual | 543.44 | 543.44 | 615.40 | 615.40 | 615.40 | 615.40 |
| Number of Observations | 435 | 435 | 1,797 | 1,797 | 10,151 | 10,151 |
| Range in Observations | 979.00 | 979.00 | 611.00 | 611.00 | 2,233.00 | 2,233.00 |
| Scaled Residual Standard Deviation | 0.1223 | 0.1223 | 0.1486 | 0.1486 | 0.0571 | 0.0571 |
| Scaled Absolute Residual Mean | 0.0318 | 0.0317 | 0.0754 | 0.0752 | 0.0325 | 0.0324 |
| Scaled Root Mean Square Error | 0.0430 | 0.0429 | 0.1062 | 0.1060 | 0.0463 | 0.0461 |
| Scaled Residual Mean | 0.3314 | 0.3314 | 0.6150 | 0.6150 | 0.1257 | 0.1257 |

Please note the similarity of all statistics between the Panday and others (2020) version and the updated version. Of note is that using a calibration dataset that is different from the one used in

Panday and others (2020), the TWDB standard of scaled absolute residual mean is always below 0.1 for all versions and all aquifers.

In summary, it is apparent that specific yield is not a sensitive parameter in the context of GAM calibration. However, it is conceptually more correct to specify a specific yield value of 0.1 for the alluvium, so the updated version is recommended to be used in future simulations in the joint planning process in GMA 11.

# 4.0 References

Fryar, D.G., Senger, R. Deeds, N.E., Pickens, J., and Jones, T., 2004. Groundwater Availability Model for the Northern Carrizo-Wilcox Aquifer. Prepared for the Texas Water Development Board, January 31, 2003, 529p.

Hutchison, W.R., 2017. Desired Future Conditions Explanatory Report (Final), Carrizo-Wilcox, Queen City, Sparta Aquifers for Groundwater Management Area 11. January 24, 2017, 445p.

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Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004. Groundwater Availability Models of the Queen City and Sparta Aquifers. Prepared for the Texas Water Development Board, October 2004, 867p.

Lupton, D.M., Dale, T.F., and Oliver, W.A., 2015. Characterization of Wilcox Aquifer Structure, Composition and Hydraulic Properties in Panola County, Texas. Report Prepared for Panola County Groundwater Conservation District by INTERA Incorporated, July 2015, 158p.

Panday, S., Rumbaugh, J., Hutchison, W.R., Schorr, S., 2020. Numerical Model Report: Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. Final Report prepared for Texas Water Development Board, Contact Number #1648302063. 198p.

Schorr, S., Zivic, M., Hutchison, W.R., Panday, S., and Rumbaugh, J., 2020. Conceptual Model Report: Groundwater Availability Model for Northern Portion of the Queen City, Sparta, and Carrizo Wilcox Aquifers. Prepared for Texas Water Development Board, Contract No. 1648302063. 240p.

Wade, S., Shi, J., and Seiter-Weatherford, C., 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 151p.