Final Report

Manville WSC Permit Applications Review: Pumping Simulations

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October 5, 2023

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10/5/2023

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1.0 Introduction

1.1 Background

On October 26, 2022, Manville Water Supply Corporation (Manville WSC) submitted two operating permit applications as follows:

- Blue Well #8
- Blue Well #9

On March 7, 2023, Manville WSC submitted supplemental information as a Response to Request for Additional Information from LPGCD.

This report documents the results of groundwater model simulations that were completed as part of the LPGCD review of the permit application. Both wells are in the same GAM cell. Therefore, two simulations were completed: one with a single well pumping, and one with both wells pumping.

All files associated with this report have been uploaded to a Google Drive folder that can be accessed with this link:

https://drive.google.com/drive/folders/1Uk16pIueBaKxJLbGUxXZt7iDJ-ETUlwi?usp=sharing

1.2 Summary of Proposed Wells

Well data from the applications are summarized in Table 1. The permit applications included latitude and longitude coordinates. These were converted to GAM coordinates using Surfer, a commercial gridding program.

Table 1. Summary of Manville WSC Well Information

Well ID	Blue Well 8	Blue Well 9
Latitude	30.40389	30.40468
Longitude	-97.14933	-97.15447
X-Coordinate (GAM - ft)	5818067.62	5816445.61
Y-Coordinate (GAM - ft)	19388147.30	19388394.17
Depth (ft)	700	700
Screen Interval (ft)	600-700	600-700
Well Capacity (gpm)	950	950
Volume (AF/yr)	1532	1532

The applications listed the Simsboro Aquifer as the production formation.

1.3 Summary of Results and Conclusions

Key findings and conclusions of this analysis are:

One Manville Well Pumping

- Proposed pumping volume = 1,532 AF/yr
- Drawdown from 2011 to 2070 at well site = 27 ft
- Significant sources of the proposed pumping (> 10% of production):
    - Induced inflow from Milam County
    - Vertical inflow from the overlying Calvert Bluff formation
    - Storage reduction in the Simsboro Aquifer

Both Manville Wells Pumping

- Proposed pumping volume = 3,064 AF/yr
- Drawdown from 2011 to 2070 at well site = 55 ft
- Significant sources of the proposed pumping (> 10% of production):
    - Induced inflow from Milam County
    - Vertical inflow from the overlying Calvert Bluff formation
    - Storage reduction in the Simsboro Aquifer

2.0 Summary of Well Completions and GAM Data

2.1 Well Completions

The Fortran program *getcellnum.exe* was written to locate the proposed production wells and the monitoring wells in the GAM grid. Monitoring wells for the simulations were provided by James Totten, General Manager of the Lost Pines Groundwater Conservation District in an email dated August 14, 2023. The reported depths were used to assign the aquifer completion. Table 2 summarizes the well completion data, and Figure 1 presents a map with well locations (red circles represent the proposed Manville WSC wells and blue circles represent other registered wells used as monitoring points for the simulations).

Table 2. Summary of Aquifer Completion Results for All Wells

Well ID	Manville WSC Blue Well 8 and Blue Well 9	LP-000125 (58-39-6-0049)	LP-000124 (58-39-6-0048)	LP-002410 (58-39-9-0055)	LP-001338 (58-62-6-0005)	LP-000111 (58-39-9-0030)	LP-002871 (58-39-6-0022) (HoT Simsboro well)	LP-002782 (58-39-5-0014)	LP-000096 (58-39-8-0009)
Node	157588	156884	191007	127287	157589	127855	157591	156208	190240
Aquifer	9	9	10	8	9	8	9	9	10
Official Aquifer	1	1	1	1	1	1	1	1	1
Layer	9	9	10	8	9	8	9	9	10
Outcrop	0	0	0	0	0	0	0	0	0
Area (ac)	640	640	640	640	640	160	640	640	640
Top (ft)	139	283	-132	340	163	316	207	366	-81
Bottom (ft)	-375	-132	-656	-11	-308	-94	-333	-28	-394
Thickness (ft)	514	415	524	351	471	410	540	394	313

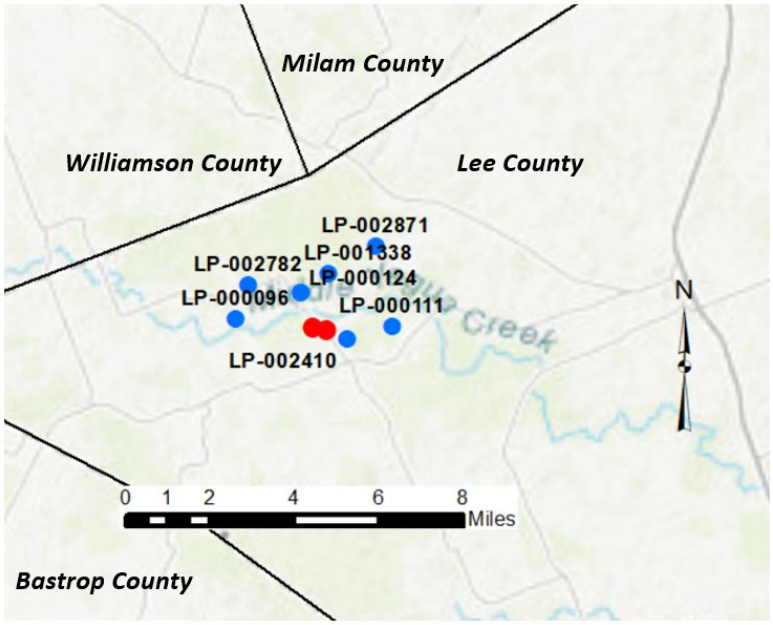

Figure 1. Location Map of Proposed Production Wells
Red Circles = Proposed Manville WSC Wells
Blue Circles = Other Wells Used as Monitoring Points for Simulations

2.2 GAM Parameters Manville WSC Well Locations

Data from the GAM at the locations of the two Manville WSC wells and the eight monitoring wells are presented in Table 3.

Table 3. GAM Parameters at Manville WSC Well Locations

Well ID		Manville WSC Blue Well 8 and Blue Well 9	LP-000125 (58-39-6-0049)	LP-000124 (58-39-6-0048)	LP-002410 (58-39-9-0055)	LP-001338 (58-62-6-0005)	LP-000111 (58-39-9-0030)	LP-002871 (58-39-6-0022) (HoT Simsboro well)	LP-002782 (58-39-5-0014)	LP-000096 (58-39-8-0009)
Node		157588	156884	191007	127287	157589	127855	157591	156208	190240
Layer		9	9	10	8	9	8	9	9	10
K (ft/day)		14.53	14.71	1.67	1.85	14.52	1.84	14.62	15.04	1.94
T (gpd/ft)		55,864	45,663	6,546	4,857	51,155	5,643	59,053	44,325	4,542
Storativity		2.79E-04	3.13E-04	3.68E-04	6.39E-04	2.74E-04	6.61E-04	3.49E-04	3.88E-04	2.79E-04
Specific Storage		1.50E-01	1.50E-01	1.00E-01	1.00E-01	1.50E-01	1.00E-01	1.50E-01	1.50E-01	1.00E-01
GWE 2010 (ft)		352.32	362.31	397.50	406.12	356.14	394.81	355.68	370.45	398.44
GWE 2070 (ft)		207.87	123.51	261.94	354.50	75.12	361.50	88.21	177.41	277.63
DFC Drawdown (ft)		144.45	238.80	135.56	51.62	281.02	33.31	267.47	193.04	120.81
Artesian Head 2010 (ft)		213.32	79.31	529.50	66.12	193.14	78.81	148.68	4.45	479.44
Pumping Test (36 hours) Drawdown (ft)	Q=100 gpm	4.04	4.87	30.26	38.77	4.40	33.61	3.79	4.95	43.39
	Q=300 gpm	12.13	14.60	90.77	116.31	13.20	100.82	11.37	14.85	130.16
	Q=500gpm	20.21	24.33	151.29	193.85	21.99	168.04	18.96	24.75	216.93
	Q=700gpm	28.29	34.06	211.80	271.39	30.79	235.26	26.54	34.64	303.70
	Q=900gpm	36.38	43.79	272.32	348.93	39.59	302.47	34.12	44.54	390.47

Comparing the parameters at the proposed wells sites to averages across the Lost Pines Groundwater Conservation District yields the following:

- Simsboro Aquifer thickness = 514 ft (LPGCD average = 269 ft)
- Aquifer transmissivity = 56,000 gpd/ft (LPGCD average = 26,770 gpd/ft)
- Artesian head = 210 ft (LPGCD average = 969 ft)

Based on these comparison, the proposed well sites are in a favorable portion of the Simsboro Aquifer as compared with the overall area of the Lost Pines Groundwater Conservation District.

3.0 GAM Simulations

The GAM simulation used by GMA 12 as the basis for the DFC (Run S-19) is documented in the 2022 GMA 12 Explanatory Report (Daniel B. Stephens & Associated Inc. and others, 2022). The most recent version of the GAM is documented in Young and Kushnereit (2020). Complete documentation of the GAM is available in Young and others (2018). The model files from Run S-19 were used and modified as described below.

3.1 Pumping Scenarios

The Fortran program *makepump.exe* was written to develop the WEL files for each of the pumping simulations. The main input to the program is the cell-by-cell flow file from the calibrated model (*RunS-19.cbb*) for the DFC GAM run (i.e. Run S-19). Because both proposed wells are in the same GAM cell, two WEL files were written:

- *ManvilleOneWell.wel* (one well pumping)
- *ManvilleTwoWells.wel* (two wells pumping)

3.2 GAM Files for Simulations

The pumping file used in each of the scenarios is documented above. The other input files used to run the simulations are summarized in Table 4. Please note that four of the files were modified from Run S-19 to eliminate echoing of input data to the standard output file (DRN, GNC, HFB, and RIV packages).

The executable for MODFLOW-USG is *mfusg-1.4.exe*, with a file date of 1/27/2021.

Output file names follow the convention of the pumping files by including the name of the scenario (Manville1 or Manville2). Output files include:

- Standard output (.lst)
- WEL package flow reduction (.afr)
- Cell by cell flow (.cbb)
- Groundwater elevations or heads (.hds)
- Drawdown (.ddn)

Table 4. Pumping Simulations Input Files (Excluding Pumping)

MODFLOW Package	File Name	File Date	Notes
BAS6	gma12.bas	1/27/2021	
DISU	gma12.dis	1/27/2021	
DRN	gma12.drn	2/24/2023	Added NOPRINT Specfication
EVT (5 files)	gma12.evt	1/27/2023	
	evt.depth.ref	1/27/2023	
	evt.nodes.ref	1/27/2023	
	evt.rate.ref	1/27/2023	
	evt.top.ref	1/27/2023	
GHB	gma12.ghb	1/27/2023	
GNC	gma12.gnc	2/24/2023	Added NOPRINT Specfication
HFB6	gma12.hfb	2/24/2023	Added NOPRINT Specfication
Initial Heads	inititial_2010_heads.hds	1/27/2021	
LPF	gma12.lpf	1/27/2023	
OC	gma12.oc	1/27/2023	
RCH	gma12.rch	1/27/2023	
RIV	gma12.riv	2/24/2023	Added NOPRINT Specfication
SMS	gma12.sms	1/27/2023	

3.3 Groundwater Elevation and Attributable Drawdown

The Fortran program *gethed.exe* was written to extract groundwater elevation and calculate attributable drawdown data from each model simulation (including Run S-19). The output from *gethed.exe* includes one file for each scenario (Run S-19, Manville1, and Manville2), and includes results from each well site. These files were imported into an Excel file and named *Manville Scenarios GWE ADD.xlsx*.

Please note that each tab of the spreadsheet file represents a single pumping scenario (Run S-19, Manville 1, and Manville 2). In each tab, columns C to K are the annual groundwater elevation estimates for each well location. In each tab, columns L to T are the drawdown attributable to the pumping of the proposed Manville WSC wells for the identified scenario (i.e., groundwater elevation from the DFC scenario minus the pumping scenario groundwater elevation). These results, therefore, represent the simulations results at the pumping well location and eight "monitoring" locations.

3.4 Groundwater Budgets

Cell by cell output from the simulations were used to develop groundwater budgets using Zone Budget (a post processor developed by the USGS):

- Because the proposed Manville WSC wells are to be completed in the Simsboro Aquifer, one set of groundwater budgets for these wells are based on defining zones based on model layer. Each model layer in LPGCD was assigned a unique zone number. Outside of LPGCD, each county was assigned a unique zone number. For the purposes of this

analysis, the Simsboro Aquifer is the unit of interest.

- An alternative means of evaluating groundwater budgets is to combine the individual formations in the Wilcox Aquifer (Calvert Bluff, Simsboro, and Hooper) for purposes of analysis. The groundwater budgets for these wells are based on lumping model layers 8, 9, and 10 together in Bastrop and Lee counties. All other layers retained their unique zone number. Outside LPGCD, each county was assigned a unique zone number. For the purposes of this analysis, the undifferentiated Wilcox Aquifer is the unit of interest (Calvert Bluff, Simsboro, and Hooper in GAM layer nomenclature).

Table 5 summarizes the file names associated with the groundwater budget analysis.

Table 5. Summary of Filenames - Groundwater Budget Analysis

Simulation Scenario	File Type	Water Budget Layering	
		Model Layers	Alternate Layering
Run S-19	DIS file	gma12.dis	gma12.dis
	Zone file	zbzones.dat	zbzonesAlt.dat
	cbb file	RunS-19.cbb	RunS-19.cbb
	Raw Budget file	RunS-19.2.csv	RunS-19Alt.2.csv
	Processed Budget file	wbRunS-19.xlsx	wbRunS-19alt.xlsx
Manville 1	DIS file	gma12.dis	gma12.dis
	Zone file	zbzones.dat	zbzonesAlt.dat
	cbb file	Manville1.cbb	Manville1.cbb
	Raw Budget file	Manville1.2.csv	Manville1Wilcox.2.csv
	Processed Budget file	wbManville1.xlsx	wb Manville1 Wilcox.xlsx
Manville 2	DIS file	gma12.dis	gma12.dis
	Zone file	zbzones.dat	zbzonesAlt.dat
	cbb file	Manville2.cbb	Manville2.cbb
	Raw Budget file	Manville2.2.csv	Manville2Wilcox.2.csv
	Processed Budget file	wbManville2.xlsx	wb Manville2 Wilcox.xlsx

4.0 Simulation Results

4.1 Groundwater Elevation and Drawdown Results

Groundwater elevation and attributable drawdown results are summarized in the following:

- Figure 2 presents the comparison of groundwater elevation in the proposed Manville WSC well sites for the DFC run (Run S-19) and the two pumping simulations.
- Figure 3 presents the attributable drawdown of the proposed Manville WSC pumping (one well and two wells) at the proposed Manville WSC wells sites.
- Appendix A presents the groundwater elevations and attributable drawdown hydrographs for the eight monitoring wells sites.
- Table 6 summarizes the attributable drawdown at all well sites due to the proposed pumping of the Manville WSC wells.

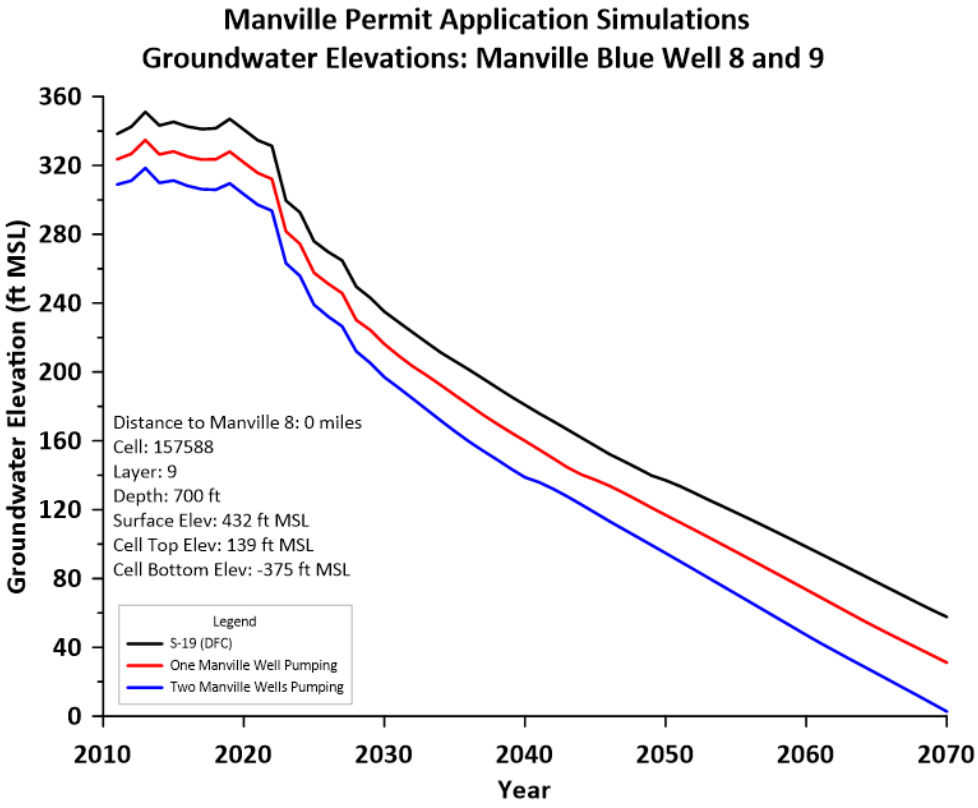

Figure 2. Groundwater Elevation Hydrograph (Manville WSC Well Sites)

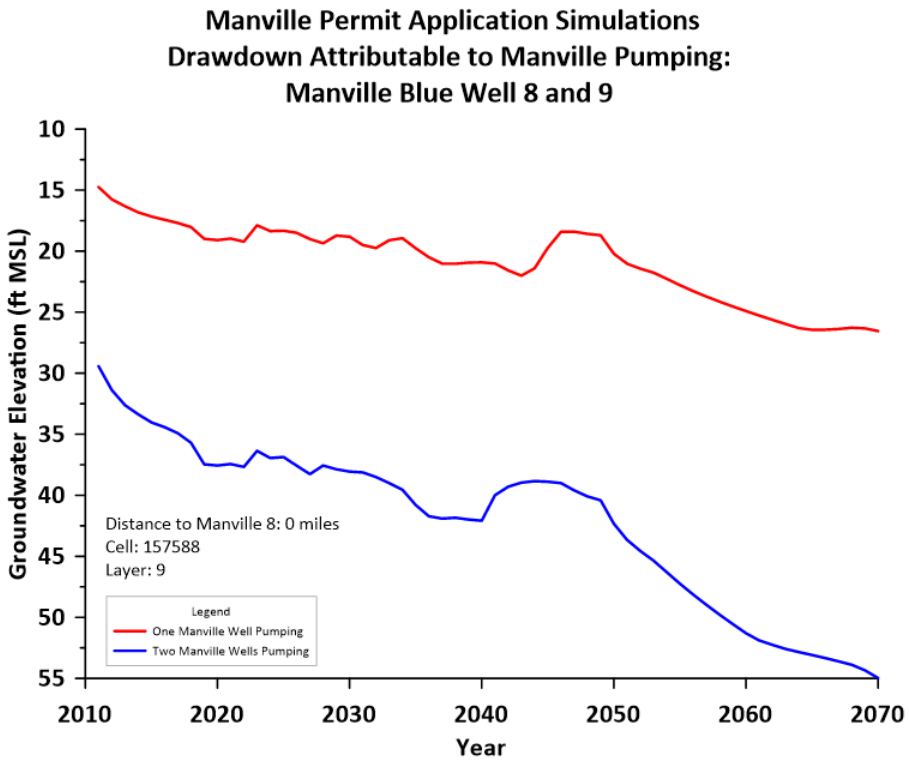

Figure 3. Attributable Drawdown Hydrograph (Manville WSC Well Sites)

Table 6. Summary of Attributable Drawdown at All Sites

Well Site	Model Layer (8=Calvert Bluff, 9=Simsboro, 10=Hooper)	Distance to Manville Blue 8 (miles)	Attributable Drawdown Due to Proposed Manville WSC Pumping (2011 to 2070, ft)	
			One Well Pumping	Two Wells Pumping
Manville Blue Well 8 and 9	9	0.00	27	55
LP-000125 (58-39-6-0049)	9	1.07	15	30
LP-000124 (58-39-6-0048)	10	1.07	5	9
LP-002410 (58-39-9-0055)	8	0.56	3	5
LP-001338 (58-62-6-0005)	9	1.35	17	35
LP-000111 (58-39-9-0030)	8	1.58	1	3
LP-002871 (58-39-6-0022) (HoT Simsboro well)	9	2.33	10	21
LP-002782 (58-39-5-0014)	9	2.12	12	24
LP-000096 (58-39-8-0009)	10	2.15	5	10

4.2 Groundwater Budget Results

4.2.1 LPGCD Portion of the Simsboro Aquifer

Table 7 presents the groundwater budget of the LPGCD portion of the Simsboro Aquifer for the DFC simulation and the simulation with one proposed Manville WSC well pumping. The difference between each water budget component is presented in AF/yr and as a percentage of the pumping increase associated with adding Manville WSC well pumping to the DFC simulation.

Table 7. Simsboro Aquifer Groundwater Budget Comparison – DFC Simulation and One Proposed Manville WSC Well Pumping Simulation

LPGCD Groundwater Budget Layered, Simsboro Aquifer	Run S-19 (DFC Run) 2011 to 2070 AF/yr	Manville 1 Well (2011 to 2070) AF/yr	Difference (AF/yr)	Difference (% of Pumping Increase)
Inflows				
From Alluvium (Layer 1)	126	127	1	0.06
From Shallow Flow System (Layer 2)	16,955	17,078	123	8.11
From Calvert Bluff (Layer 8)	35,351	35,744	392	25.87
From Hooper (Layer 10)	7,032	7,152	121	7.96
From Caldwell County	224	224	0	0.03
From Milam County	7,454	7,690	236	15.57
From Washington County	1,699	1,709	10	0.64
From Williamson County	924	928	3	0.20
Total Inflow	69,765	70,651		
Outflows				
Pumping	59,366	60,883	1,517	100.00
To Burleson County	18,177	18,053	125	8.21
To Fayette County	242	233	9	0.58
Total Outflow	77,785	79,168		
Storage				
Inflow minus Outflow	-8,020	-8,517	497	32.76
Model Storage Change	-8,020	-8,517		
Water Balance Error	0	0		

Please note that most of the pumping is sourced from induced inflow from Milam County, induced vertical flow from the overlying the Calvert Bluff formation, and storage decline.

Table 8 presents the groundwater budget of the LPGCD portion of the Simsboro Aquifer for the DFC simulation and the simulation with both proposed Manville WSC wells pumping. The difference between each water budget component is presented in AF/yr and as a percentage of the pumping increase associated with adding Manville WSC well pumping to the DFC simulation.

Table 8. Simsboro Aquifer Groundwater Budget Comparison – DFC Simulation and Two Proposed Manville WSC Wells Pumping Simulation

LPGCD Groundwater Budget Layered, Simsboro Aquifer	Run S-19 (DFC Run) 2011 to 2070 AF/yr	Manville 2 Wells (2011 to 2070) AF/yr	Difference (AF/yr)	Difference (% of Pumping Increase)
Inflows				
From Alluvium (Layer 1)	126	128	2	0.06
From Shallow Flow System (Layer 2)	16,955	17,193	239	7.86
From Calvert Bluff (Layer 8)	35,351	36,135	784	25.80
From Hooper (Layer 10)	7,032	7,272	240	7.91
From Caldwell County	224	225	1	0.03
From Milam County	7,454	7,919	465	15.31
From Washington County	1,699	1,719	19	0.64
From Williamson County	924	929	5	0.16
Total Inflow	69,765	71,519		
Outflows				
Pumping	59,366	62,403	3,038	100.00
To Burleson County	18,177	17,929	248	8.17
To Fayette County	242	224	18	0.58
Total Outflow	77,785	80,556		
Storage				
Inflow minus Outflow	-8,020	-9,037	1,017	33.49
Model Storage Change	-8,020	-9,037		
Water Balance Error	0	0		

The results of the two well scenario show that the sources of pumping are roughly the same as the one well scenario: most of the pumping is sourced from induced inflow from Milam County, induced vertical flow from the overlying the Calvert Bluff formation, and storage decline.

4.2.2 LPGCD Portion of the Wilcox Aquifer

Table 9 presents the groundwater budget of the LPGCD portion of the Wilcox Aquifer (Calvert Bluff, Simsboro, and Hooper) for the DFC simulation and the simulation with one proposed Manville WSC well pumping. The difference between each water budget component is presented in AF/yr and as a percentage of the pumping increase associated with adding Manville WSC well pumping to the DFC simulation.

Table 9. Wilcox Aquifer Groundwater Budget Comparison – DFC Simulation and One Proposed Manville WSC Well Pumping Simulation

LPGCD Groundwater Budget Layered, Wilcox Aquifer	Run S-19 (DFC Run) 2011 to 2070 AF/yr	Manville 1 Well Scenario 2011 to 2070 AF/yr	Difference (AF/yr)	Difference (% of Pumping Increase)
Inflows				
From Alluvium (Layer 1)	126	127	1	0.06
From Shallow Flow System (Layer 2)	45,998	46,348	349	23.02
From Carrizo (Layer 7)	5,545	5,623	78	5.12
From Caldwell County	1,493	1,495	2	0.12
From Milam County	9,226	9,483	257	16.97
From Washington County	1,939	1,950	12	0.77
From Williamson County	2,447	2,487	40	2.65
Total Inflow	66,774	67,513		
Outflows				
Pumping	63,367	64,884	1,517	100.00
To Burleson County	19,581	19,448	133	8.78
To Fayette County	537	526	12	0.76
Total Outflow	83,485	84,858		
Storage				
Inflow minus Outflow	-16,711	-17,345	633	41.75
Model Storage Change	-16,711	-17,345		
Water Balance Error	0	0		

Please note that most of the pumping is sourced from induced inflow from Milam County, induced vertical flow from the shallow flow system (Layer 2 of the GAM), and storage decline.

Table 10 presents the groundwater budget of the LPGCD portion of the Wilcox Aquifer (Calvert Bluff, Simsboro, and Hooper) for the DFC simulation and the simulation with both proposed Manville WSC wells pumping. The difference between each water budget component is presented in AF/yr and as a percentage of the pumping increase associated with adding Manville WSC well pumping to the DFC simulation.

Table 10. Wilcox Aquifer Groundwater Budget Comparison – DFC Simulation and Two Proposed Manville WSC Wells Pumping Simulation

LPGCD Groundwater Budget Layered, Wilcox Aquifer	Run S-19 (DFC Run) 2011 to 2070 AF/yr	Manville 2 Wells Scenario 2011 to 2070 AF/yr	Difference (AF/yr)	Difference (% of Pumping Increase)
Inflows				
From Alluvium (Layer 1)	126	128	2	0.06
From Shallow Flow System (Layer 2)	45,998	46,685	686	22.60
From Carrizo (Layer 7)	5,545	5,700	155	5.10
From Caldwell County	1,493	1,497	4	0.12
From Milam County	9,226	9,733	507	16.71
From Washington County	1,939	1,962	23	0.77
From Williamson County	2,447	2,525	78	2.58
Total Inflow	66,774	68,230		
Outflows				
Pumping	63,367	66,404	3,038	100.00
To Burleson County	19,581	19,316	265	8.73
To Fayette County	537	514	23	0.76
Total Outflow	83,485	86,234		
Storage				
Inflow minus Outflow	-16,711	-18,005	1,293	42.58
Model Storage Change	-16,711	-18,005		
Water Balance Error	0	0		

The results of the two well scenario show that the sources of pumping are roughly the same as the one well scenario: most of the pumping is sourced from induced inflow from Milam County, induced vertical flow from the shallow flow system (Layer 2 of the GAM), and storage decline.

5.0 References

Daniel B. Stephens & Associates Inc., INTERA Incorporated, and Groundwater Consultants LLC, 2022. Desired Future Condition Explanatory Report for Groundwater Management Area 12. Considered and approved by the member districts of Groundwater Management Area 12 on January 28, 2022, 859p.

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