GMA 12

Differences Between the Previous and Updated GAMs

by

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The Previous GAM

- MODFLOW
- Uniform one-mile grid spacing
- Eight Layers
- Very flow restrictive to sometimes sealing faults
- Calibration 1980-1999

The Updated GAM

- MODFLOW-USG (unstructured grid)
- Non-uniform grid
- Ten layers
- Updated faults so not sealing
- Calibration 1930-2010

Model Differences

- Addition of two new model layers:
  - River alluvium
  - Shallow groundwater flow system
- Updating of location and characteristics of faults
- Calibration time period 1930-2010
- Grid refinement around rivers and streams
- Improving surface water-groundwater interactions *(grid refinement, two new layers)*
- Some localized changes in aquifer properties and structure

Comparison to Updated GAM

- Task was to run the previous amount and distribution of pumpage in the updated GAM and compare the results
- Direct comparison of results not possible for numerous reasons:
  - Calibration time period through 2010
  - Refinement of the grid around rivers and streams
  - Additional of two new model layers
- Methods developed to convert and assess the well file from the previous GAM may be different than the methods that should be used moving forward

Approved DFCs

GCD or County	Average Aquifer Drawdown (ft) measured from January 2000 through December 2069					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
BVGCD	12	12	61	125	295	207
FCGCD	47	64	110	Declared as non-relevant		
LPGCD	5	15	62	100	240	165
METGCD	5	2	80	90	138	125
POSGCD	28	30	67	149	318	205
Falls	--	--	--	--	-2	27
Limestone	--	--	--	11	50	50
Navarro	--	--	--	-1	3	3
Williamson	--	--	--	-11	47	69
GMA-12	***16***	***16***	***75***	***114***	***228***	***168***

Calibration Time Period

- Previous GAM calibrated through 1999
- Predictive run was 2000 to 2070
- All DFC statements were therefore stated as "Drawdowns from January 2000 to [future date]"
- Updated GAM calibrated through 2010
- Predictive run is now 2011 to 2070
- 2000-2010 will not be included in DFCs for updated GAM

Drawdown from 2000-2010 using Updated GAM

GCD or County	Average Aquifer Drawdown (ft) modeled from January 2000 through December 2010					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
BVGCD	3	3	6	11	25	14
FCGCD	13	11	10	Declared as non-relevant		
LPGCD	4	4	6	7	9	9
METGCD	4	3	3	3	5	4
POSGCD	3	2	6	10	18	11
Falls	--	--	--	--	2	1
Limestone	--	--	--	0.2	-0.3	-0.2
Navarro	--	--	--	0	-0.1	-0.1
Williamson	--	--	--	9	5	4
GMA-12	***6***	***4***	***6***	***7***	***12***	***8***

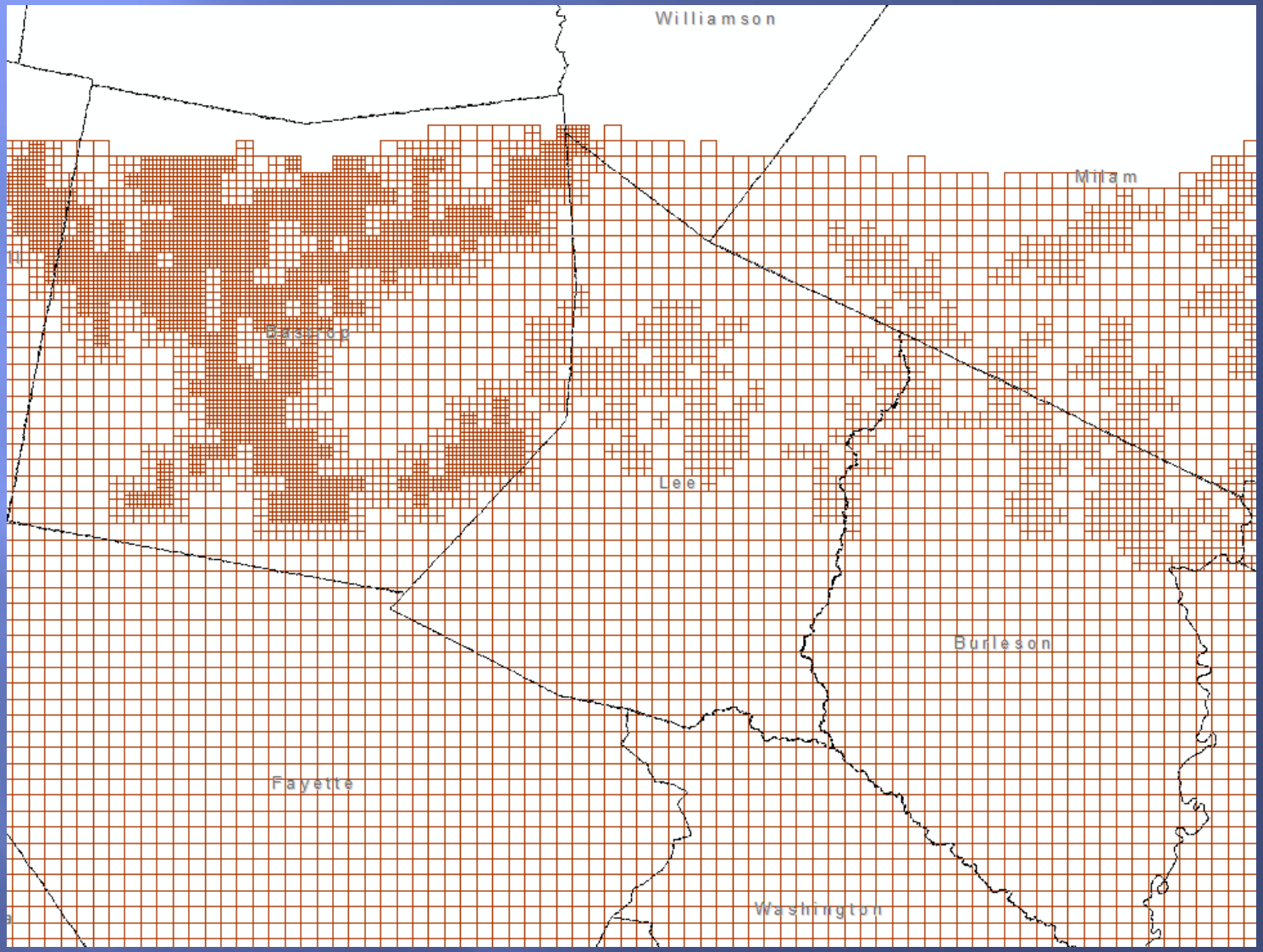
Drawdown from 2000-2010 using Previous GAM

GCD or County	Average Aquifer Drawdown (ft) modeled from January 2000 through December 2010					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
BVGCD	2	1	1	23	88	49
FCGCD	0	0	1	Declared as non-relevant		
LPGCD	-2	-1	0	9	31	21
METGCD	-1	-1	16	24	36	32
POSGCD	1	0	-2	22	66	45
Falls	--	--	--	--	-1	3
Limestone	--	--	--	1	16	10
Navarro	--	--	--	-1	2	1
Williamson	--	--	--	-3	15	7
GMA-12	***0***	***0***	***6***	***19***	***49***	***33***

Grid Refinement

- Grid in the updated GAM was refined around the rivers and streams
- Done to enhance the resolution on surface-water/groundwater interactions
- Selected model cells containing river or streams divided up into either four or sixteen cells
- Refinement was done by converting the previous MODFLOW model to MODFLOW-USG (unstructured grid)

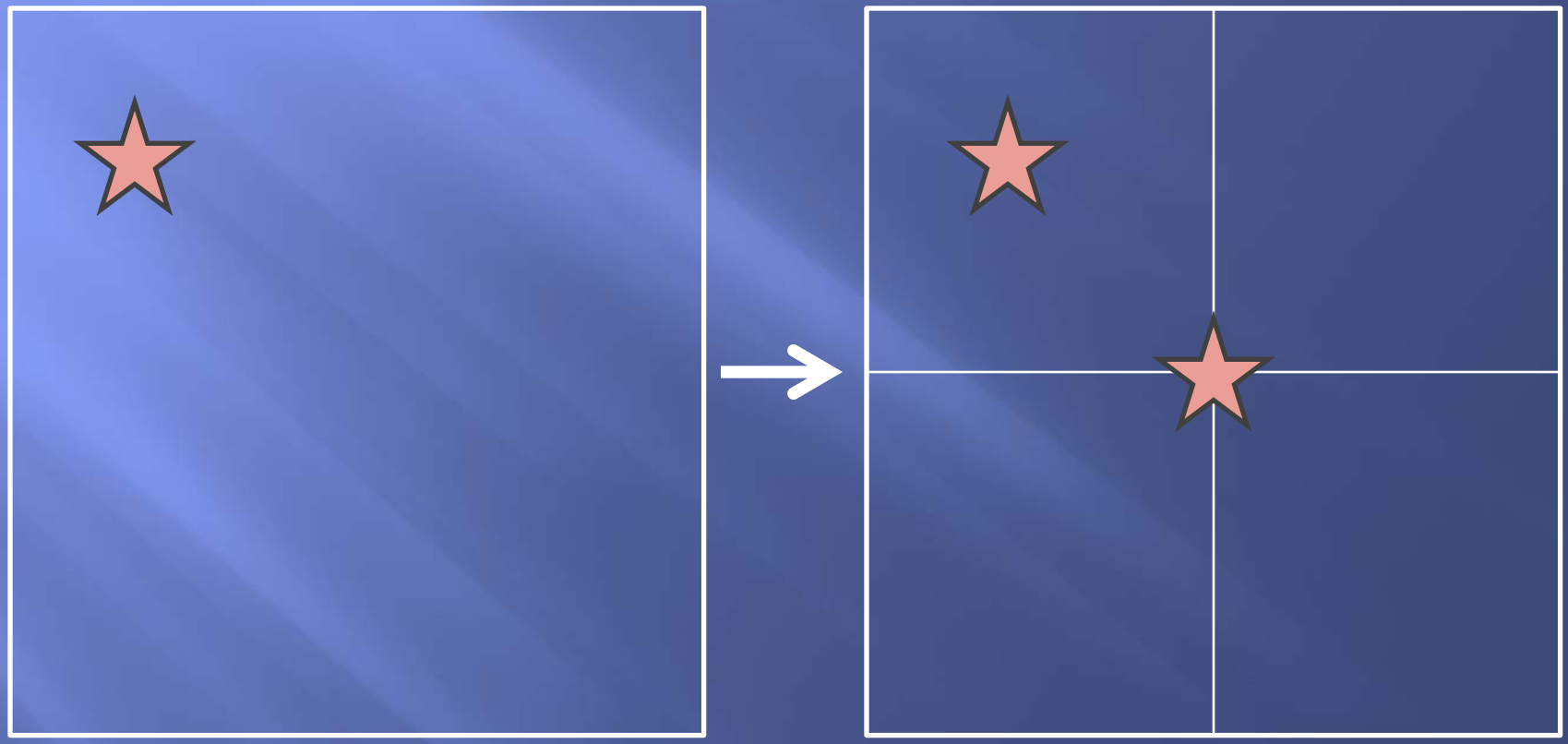
Grid Refinement



Grid Refinement

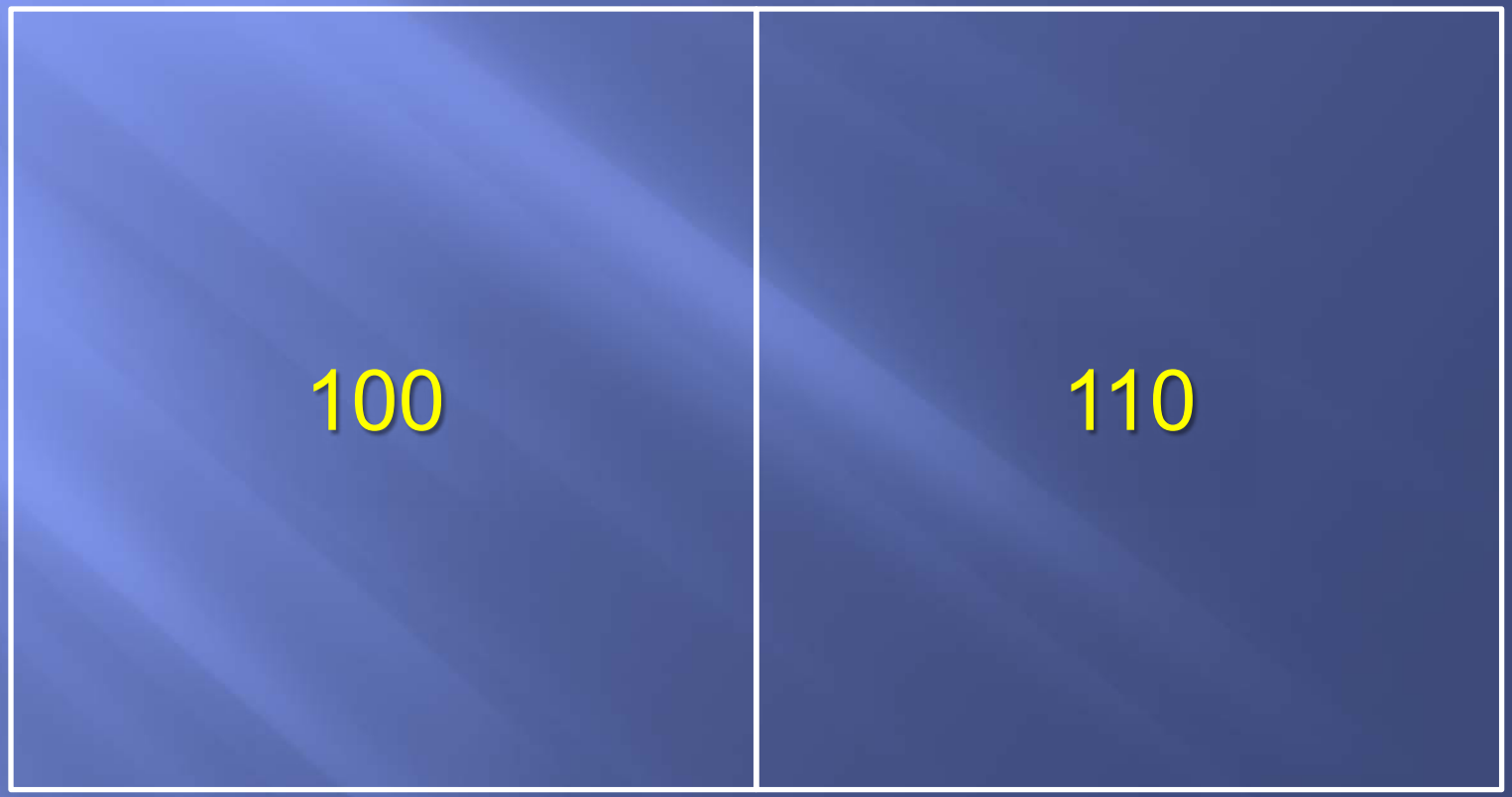
- Had to determine how to divide up the pumpage from the previous DFC run in cells that had been subdivided
  - Evenly divided the previous pumpage between all new cells in order to replicate previous distribution
- Had to revise analysis of average drawdowns calculations
  - Cell size had to be considered for calculations

Pumpage



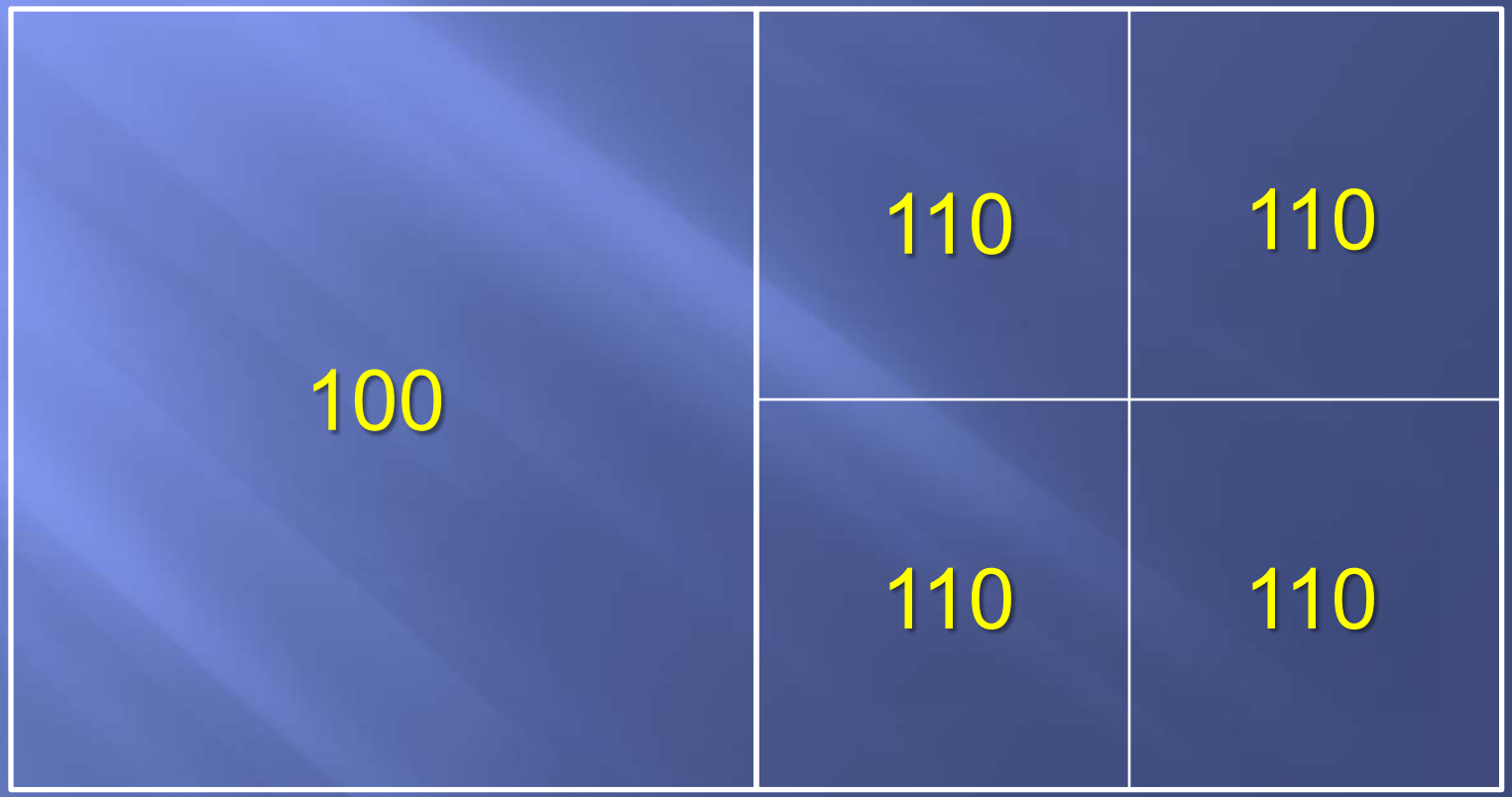
How is a well represented in the converted well file?

Average Drawdowns



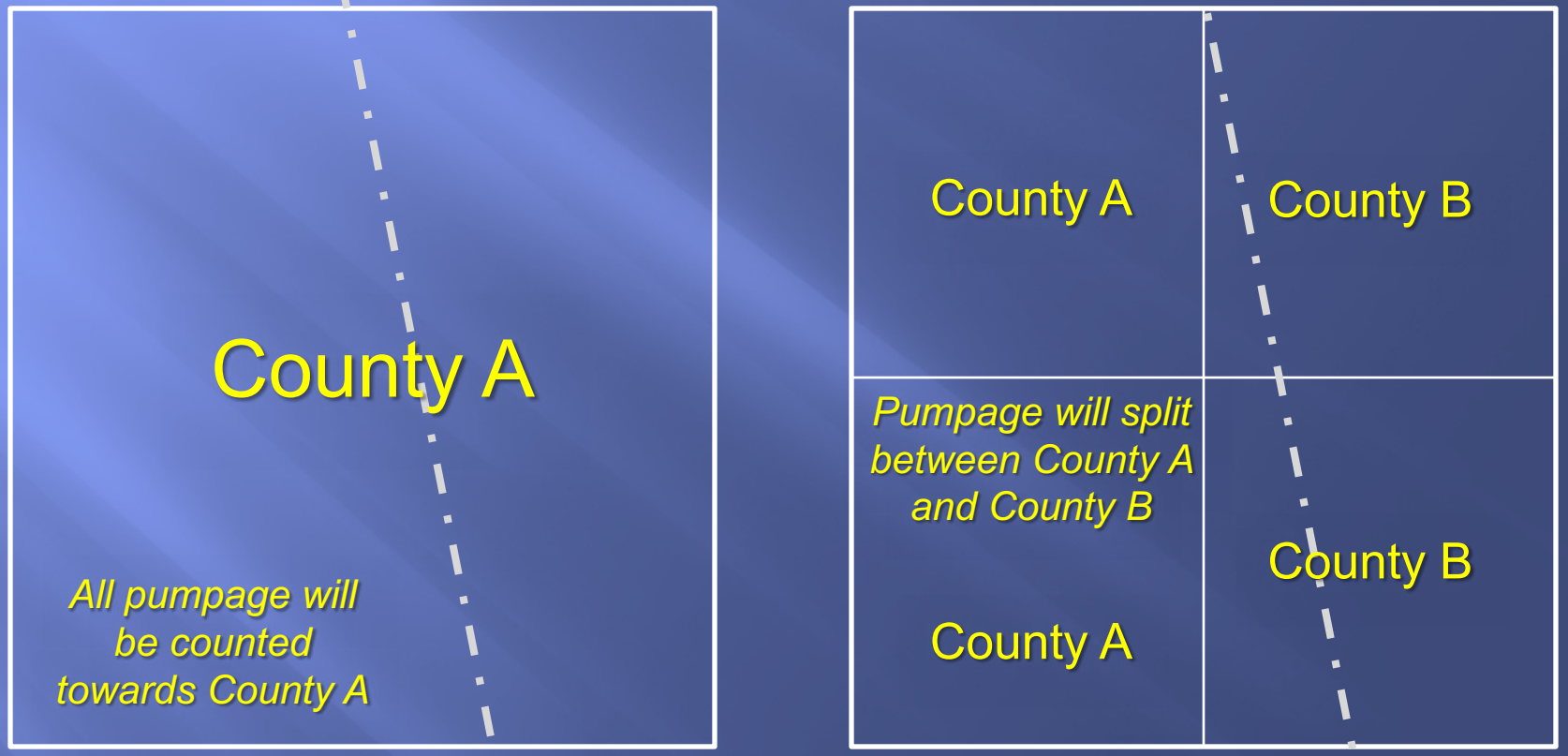
Average = 105 feet

Average Drawdowns



Average drawdown calculation methods must be updated

County Pumping Totals



Assignment of pumpage to counties will change

Additional Layers

- Updated GAM includes two new layers
  - Layer 1- River alluvium
  - Layer 2- Shallow groundwater flow systems

Addition of Layer 1

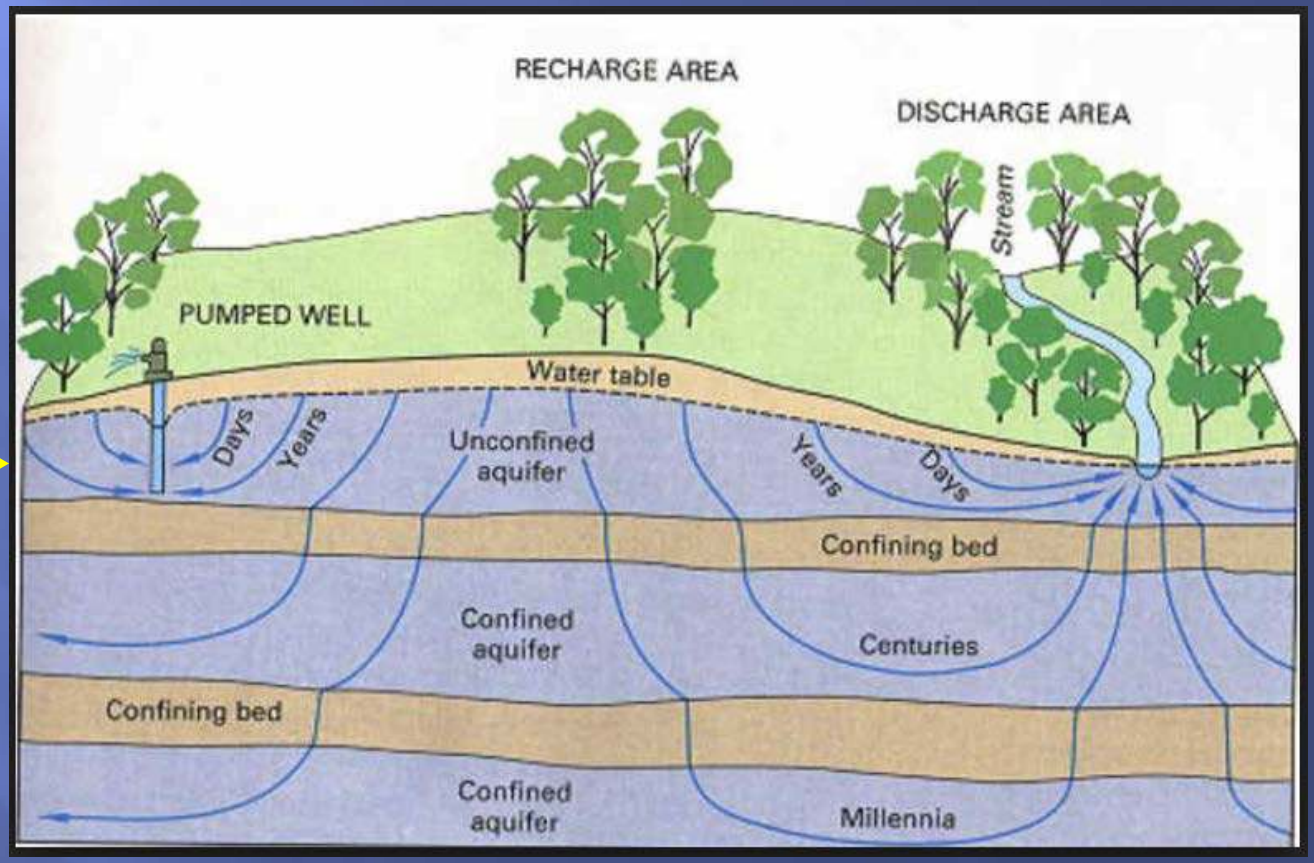
- Layer 1 is only present for the Brazos and Colorado Rivers
- Adds a significant amount of pumpage to the model which was not previously included because the alluvium was not present in the GAM
- What do we use for the predictive pumpage?
- Used 2010 pumpage for each year of the predictive time period.

Addition of Layer 2

- Layer 2 is the shallow flow systems associated with all of the deeper aquifers
- Layer 2 typically represents the land surface or bottom of the alluvium (top) to 25 to 75 feet below the predevelopment water level (bottom)

Addition of Layer 2

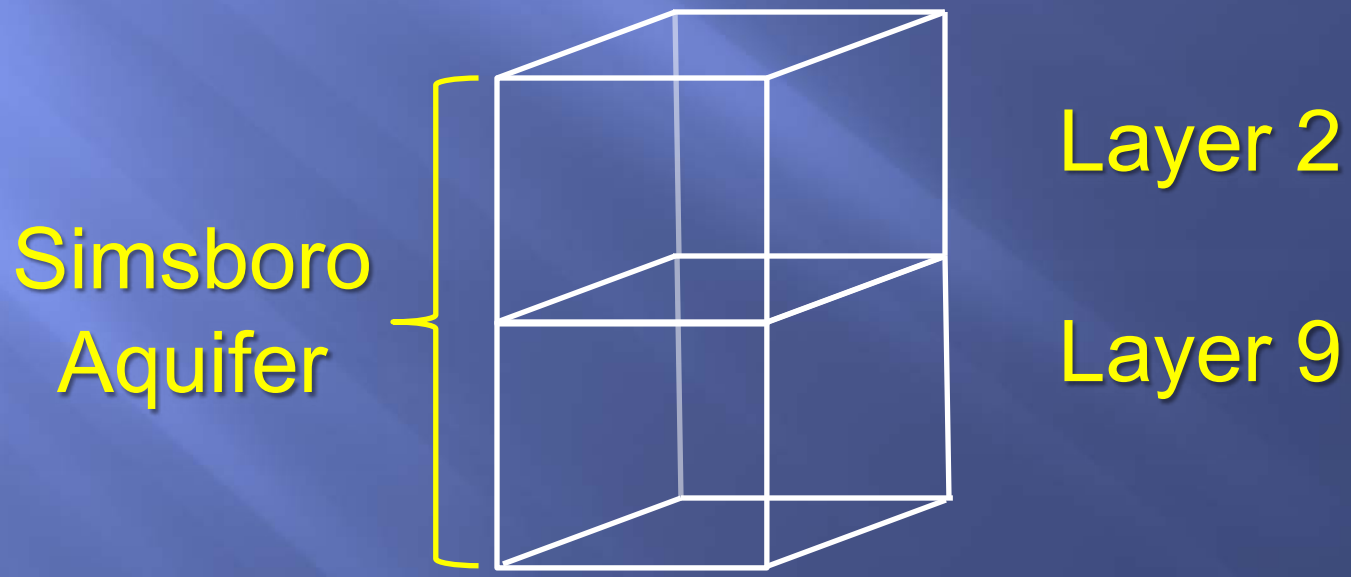
Layer 2 ⟶



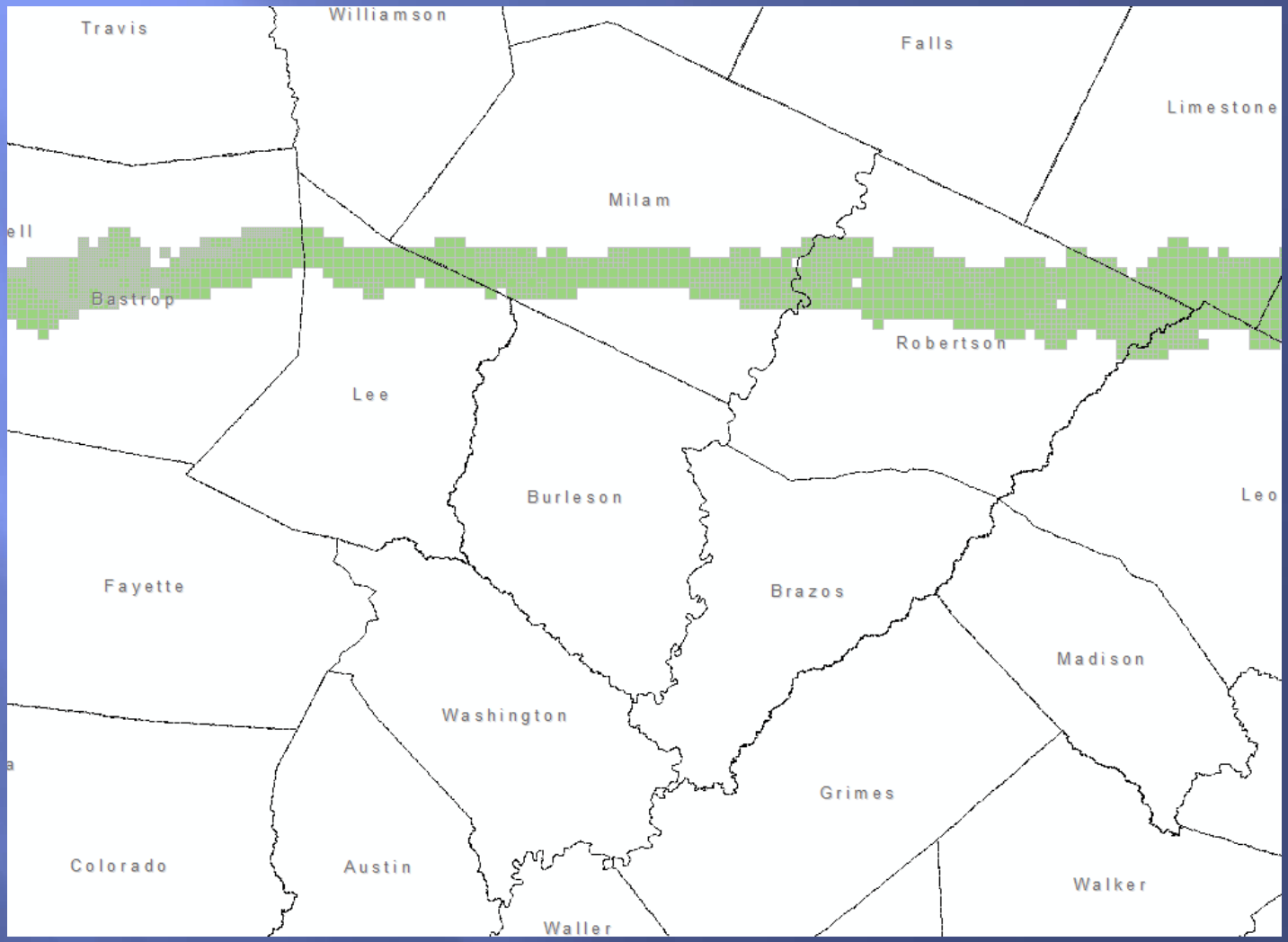
from Winter and others, 1999

Addition of Layer 2

- Results in vertically adjacent cells representing the same aquifer



Location of Vertically Adjacent Cells in Calvert Bluff Aquifer



Vertically Adjacent Cells

- How do we distribute the pumpage?
- How do we calculate drawdowns?

Pumpage Distribution

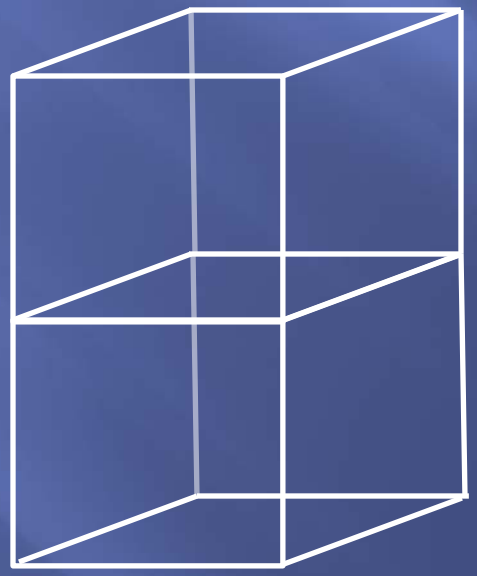
- Ran the GAM with and without pumpage in Layer 2
- Ultimately should include pumpage in the shallow flow system but where and when to include the pumpage is uncertain
- Used the trend of Layer 2 pumpage for each county in historic calibration well file to estimate future trend in predictive well file

Pumpage Distribution

- Pumpage distributed to Layer 2 was compared to the previous MAG for each county.
  - If the pumpage in Layer 2 > MAG, then the pumpage in Layer 2 was decreased to the MAG and no pumpage was distributed to the lower layer
  - If the pumpage in Layer 2 < MAG, then this pumpage was subtracted from the MAG and the remainder was distributed to the lower layer

Drawdown Calculations

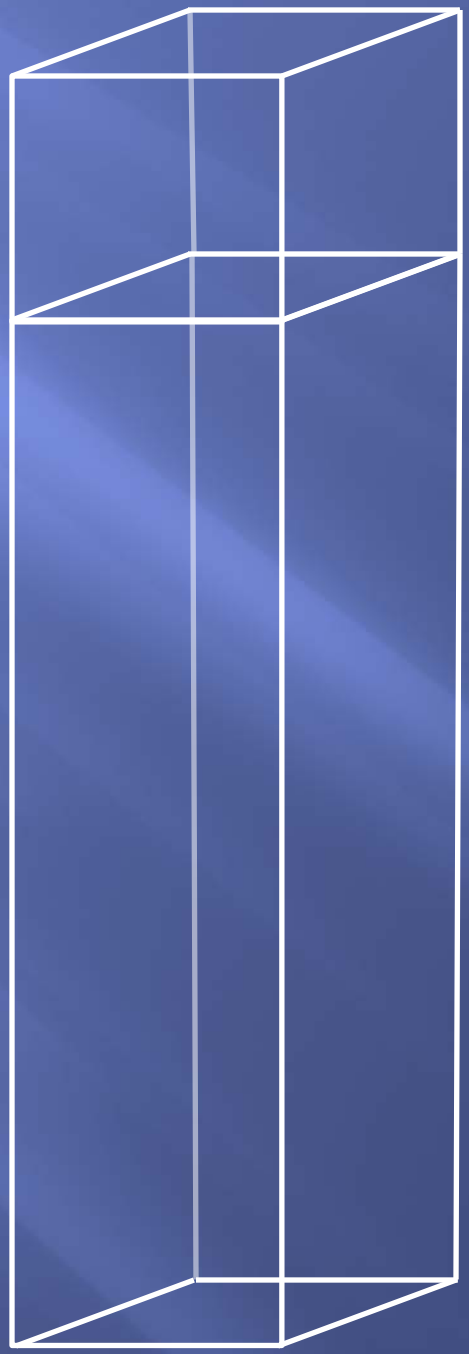
- The presence of two vertically adjacent cells representing the same aquifer presents the problem of what water level/drawdown to use for that particular geographic location



5 feet

50 feet

??



5 feet

50 feet

??

Drawdown Calculation Options

- Use only the water levels/drawdowns in the cell representing the deeper flow system
- Use an average of the water levels/ drawdowns in both the shallow and deep flow systems (straight or weighted average)
- Use the maximum of drawdowns in the shallow and deep flow systems

Runs Conducted

- Run 1- No pumpage in Layers 1 or 2
  - Resulted in slightly decreased drawdowns in all aquifers
- Run 2- No pumpage in Layer 2
  - Resulted in slightly increased drawdowns in Layers 3-10
- Run 3- Pumpage included in all layers
  - This should be the standard method moving forward

Preliminary Results- All Runs

GCD or County	Average Aquifer Drawdown (ft) modeled from January 2011 through December 2070					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
BVGCD	~40	~35-40	~65-75	~80-85	~145-150	~115-125
FCGCD	~35	~65	~135	Declared as non-relevant		
LPGCD	~25	~30	~100	~85-90	~140-145	~105
METGCD	~25	~20	~40	~40	~50	~50
POSGCD	~60-65	~30-35	~105-110	~110-115	~190-200	~150
Falls	--	--	--	--	~10-15	~5
Limestone	--	--	--	~10	~10	~5
Navarro	--	--	--	~0	~0	~0
Williamson	--	--	--	~30	~25-30	~15
GMA 12	***~35***	***~35***	***~80-85***	***~80-85***	***~125-130***	***~105***

Summary

- Several significant differences between the previous and updated GAMs- faults, calibration time period, grid, layering
- Updated GAM significantly impacts calculated drawdowns from previous GAM run
- It was not possible to do an exact comparison of the previous amount and distribution of pumpage (MAGs) in the updated GAM
  - Multiple ways that PS-12 can be converted for use in the updated GAM
  - Multiple ways to evaluate results and calculate drawdowns

Summary

- Exclusion of pumpage in Layer 1 (alluvium) decreases the drawdowns by 0 to 8 feet
- Exclusion of pumpage in Layer 2 (shallow flow systems) increases the drawdowns by 0 to 2 feet
- Drawdowns are similar between runs
- Drawdowns in Sparta and Queen City are higher than using previous GAM
- Drawdowns in Carrizo similar (GMA-wide) as the previous GAM *(but vary by GCD)*
- Drawdowns in all three Wilcox aquifers are lower than using the previous GAM

Summary

- It is apparent that all users *(GMA 12, GCDs, TWDB, etc.)* must come to a consensus as to how the model will be set up and used for joint groundwater planning
- It is less important as to which methods are used than it is that everyone uses the same methods to run and analyze the desired pumpage