

# The Science Desired Future Conditions and Managed Available Groundwater

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# Desired Future Conditions

The amount of water remaining in the aquifer at the end of the planning period (50 years)



# “Quantifiable” DFCs

## Examples:

- 50% of existing saturated thickness
- 50% of the spring flow

DFCs must be “physically possible”  
(i.e., work in the groundwater models)



# Managed Available Groundwater

The amount of water available for use for the next 50 years.

Determined by TWDB with numerical models.



# Why do we use models?

Aquifers are complex.

Each aquifer is different.

- Unconfined vs. confined
- Limestone vs. sand & gravel vs. volcanic, etc.
- Shallow vs. deep

Much variation within each aquifer.

*Models can tabulate all this complex data!*



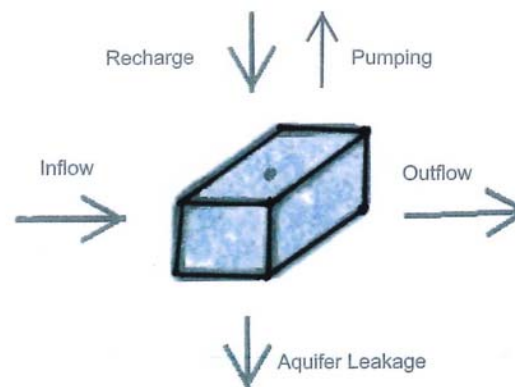
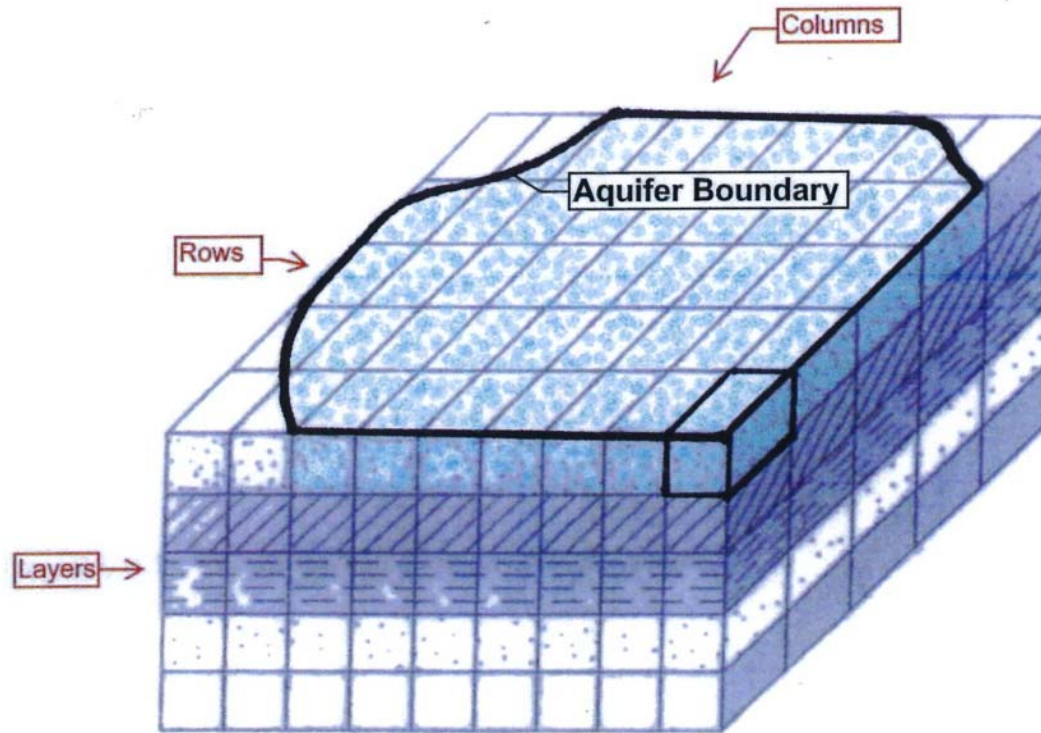
# Groundwater Availability Model (GAM)

Numerical models developed by TWDB and state contractors.

Tool used to determine Managed Available Groundwater.

*“These models are presumed to provide the best information on groundwater availability and must almost always be used in state and regional planning efforts.”*  
(Texas Water Law Glossary)





$$\frac{\partial}{\partial x} \left( K_{xx} \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_{yy} \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_{zz} \frac{\partial h}{\partial z} \right) - W = S_s \frac{\partial h}{\partial t}$$

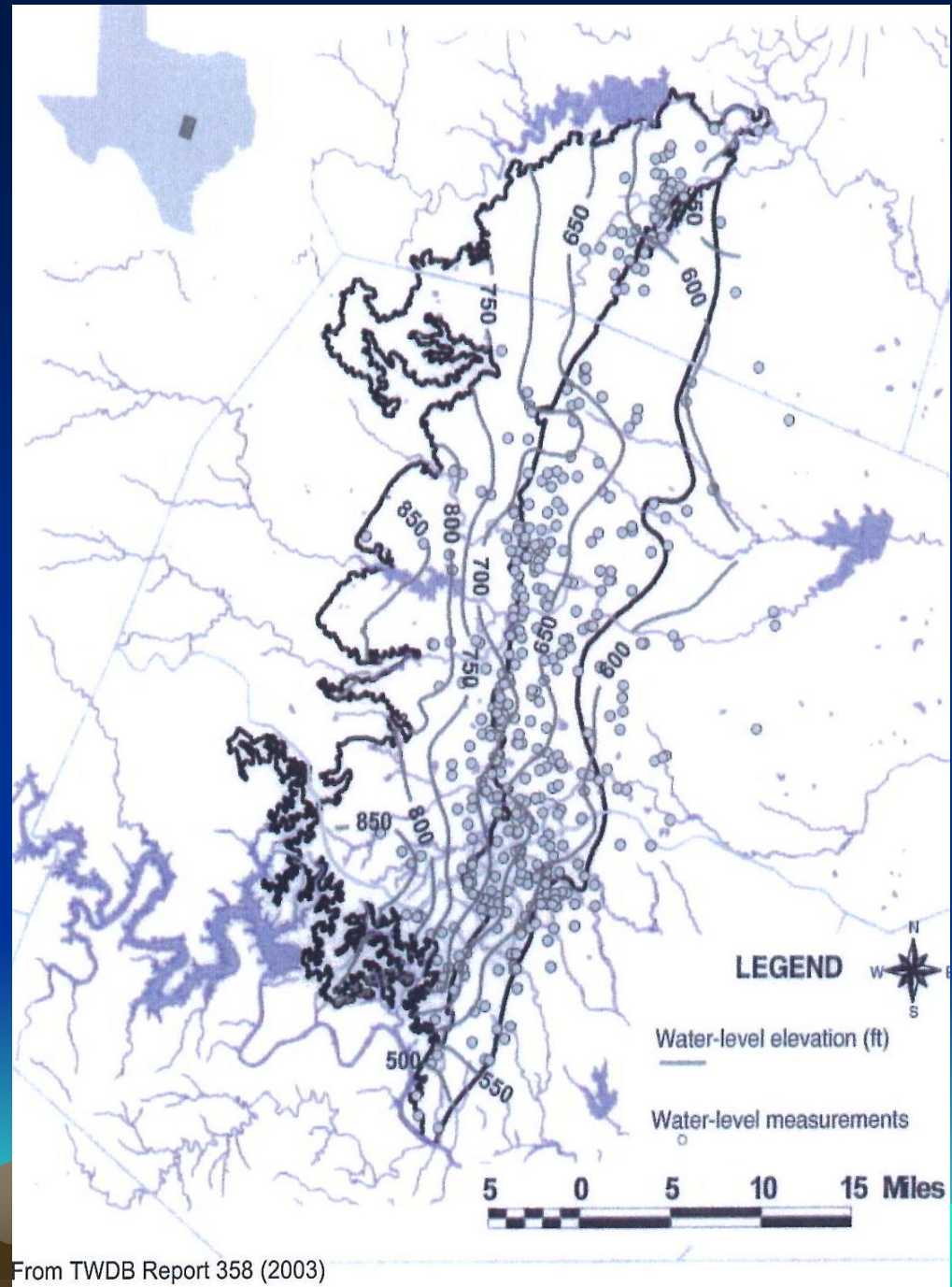


# Top of the Aquifer

Hydraulic head  
(top of the aquifer)

$$\frac{\partial}{\partial x} \left( K_{xx} \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_{yy} \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_{zz} \frac{\partial h}{\partial z} \right) - W = Ss \frac{\partial h}{\partial t}$$

# Top of Aquifer



From TWDB Report 358 (2003)

# Bottom of Aquifer



Please use black ink.  
Send original copy by certified mail to the Texas Department of Water Resources, P. O. Box 13087, Austin, Texas 78711

**State of Texas**  
**WATER WELL REPORT**

Texas Water Well Drillers Board  
P. O. Box 13087  
Austin, Texas 78711

ATTENTION OWNER: Confidentiality Privilege Notice on Reverse Side

1) OWNER Red River Boat Co. Address 3333 E. First Sherman, TX 75090  
(Name) (Street or RFD) (City) (State) (Zip)

2) LOCATION OF WELL: County DeWitt 3 1/2 miles in N.W. direction from Sherman  
(N.E., S.W., etc.) (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

Legal description: Section No. \_\_\_\_\_ Block No. \_\_\_\_\_ Township \_\_\_\_\_  
Abstract No. \_\_\_\_\_ Survey Name \_\_\_\_\_  
Distance and direction from two intersecting section or survey lines \_\_\_\_\_

See attached map.

3) TYPE OF WORK (Check):  
 New Well  Deepening  Reconditioning  Plugging

4) PROPOSED USE (Check):  
 Domestic  Industrial  Public Supply  Irrigation  Test Well  Other \_\_\_\_\_

5) DRILLING METHOD (Check):  
 Mud Rotary  Air Hammer  Driven  Bored  Air Rotary  Cable Tool  Jetted  Other \_\_\_\_\_

6) WELL LOG:  
Date drilled 8-21-84

DIAMETER OF HOLE		7) BOREHOLE COMPLETION:
Dia. (in.)	From (ft.) To (ft.)	
	Surface <u>427</u>	<input type="checkbox"/> Open Hole <input type="checkbox"/> Straight Wall <input type="checkbox"/> Unreamed <input checked="" type="checkbox"/> Gravel Packed <input type="checkbox"/> Other _____ If Gravel Packed give interval . . . from <u>427</u> ft. to <u>30</u> ft.

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

From (ft.)	To (ft.)	Description and color of formation material	Dia. (in.)	New or Used	Steel, Plastic, etc. Part, Slotting, etc. Screen Mfg., if commercial	Setting (ft.)	Gage Casing Screen
<u>0</u>	<u>20</u>	<u>surface</u>					
<u>20</u>	<u>275</u>	<u>black shale</u>					
<u>275</u>	<u>277</u>	<u>rock</u>	<u>4 1/2</u>	<u>N</u>	<u>Steel</u>	<u>0</u>	<u>427</u>
<u>277</u>	<u>345</u>	<u>gray shale</u>	<u>11</u>	<u>11</u>	<u>stotted</u>	<u>427</u>	<u>427</u>
<u>345</u>	<u>350</u>	<u>sand</u>					
<u>350</u>	<u>384</u>	<u>gray shale</u>					
<u>384</u>	<u>385</u>	<u>sand</u>					
<u>385</u>	<u>386</u>	<u>rock</u>					
<u>386</u>	<u>397</u>	<u>sand</u>					
<u>397</u>	<u>400</u>	<u>mixed shale</u>					
<u>400</u>	<u>427</u>	<u>stotted sand</u>					

9) CEMENTING DATA (Rule 319.44(b))  
Cemented from 0 ft. to 30 ft.  
Method used Faulkner & Son

10) SURFACE COMPLETION  
 Specified Surface Stab Installed [Rule 319.44(c)]  
 Pitses Adapter Used [Rule 319.44(d)]  
 Approved Alternative Procedure Used [Rule 319.71]

11) WATER LEVEL:  
Static level 250 ft. below land surface Date \_\_\_\_\_  
Artesian flow \_\_\_\_\_ gpm. Date \_\_\_\_\_

12) PACKERS: Type \_\_\_\_\_ Depth \_\_\_\_\_

13) TYPE PUMP:  
 Turbine  Jet  Submersible  Cylinder  
Depth to pump bowls, cylinder, jet, etc., 357 ft.

14) WELL TESTS:  
Type Test:  Pump  Barrier  Jetted  Estimated  
Yield: 15 gpm with 50 ft. drawdown after 8 hrs.

15) WATER QUALITY:  
Did you knowingly penetrate any strata which contained undesirable water?  Yes  No  
If yes, submit "REPORT OF UNDESIRABLE WATER"  
Type of water? \_\_\_\_\_ Depth of strata \_\_\_\_\_  
Was a chemical analysis made?  Yes  No

I here by certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 12 will result in the log(s) being returned for completion and recommitment.

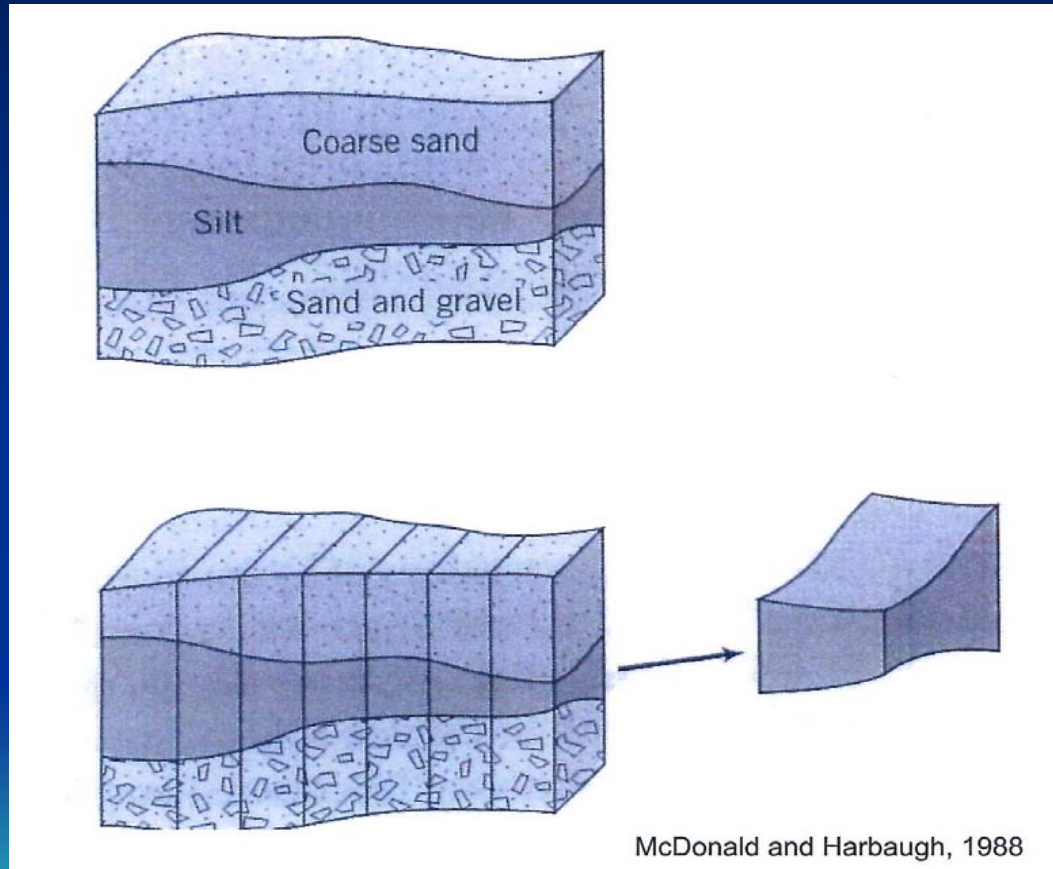
COMPANY NAME Faulkner & Son Water Well Driller's License No. 1584  
(Type or Print)  
ADDRESS RT. 1 Box 9591 Pattisboro TX 75076  
(Street or RFD) (City) (State) (Zip)  
(Signed) J. C. Faulkner (Signed) \_\_\_\_\_ (Registered Driller-Trainee)  
(Licensed Water Well Driller) (Well No. 15-19-45D Located on map Yes/No)

Please attach electric log, chemical analysis, and other pertinent information, if available.

DEPARTMENT OF WATER RESOURCES COPY

TOWR 0392 (12/29/83)

# “Deformed” model cell

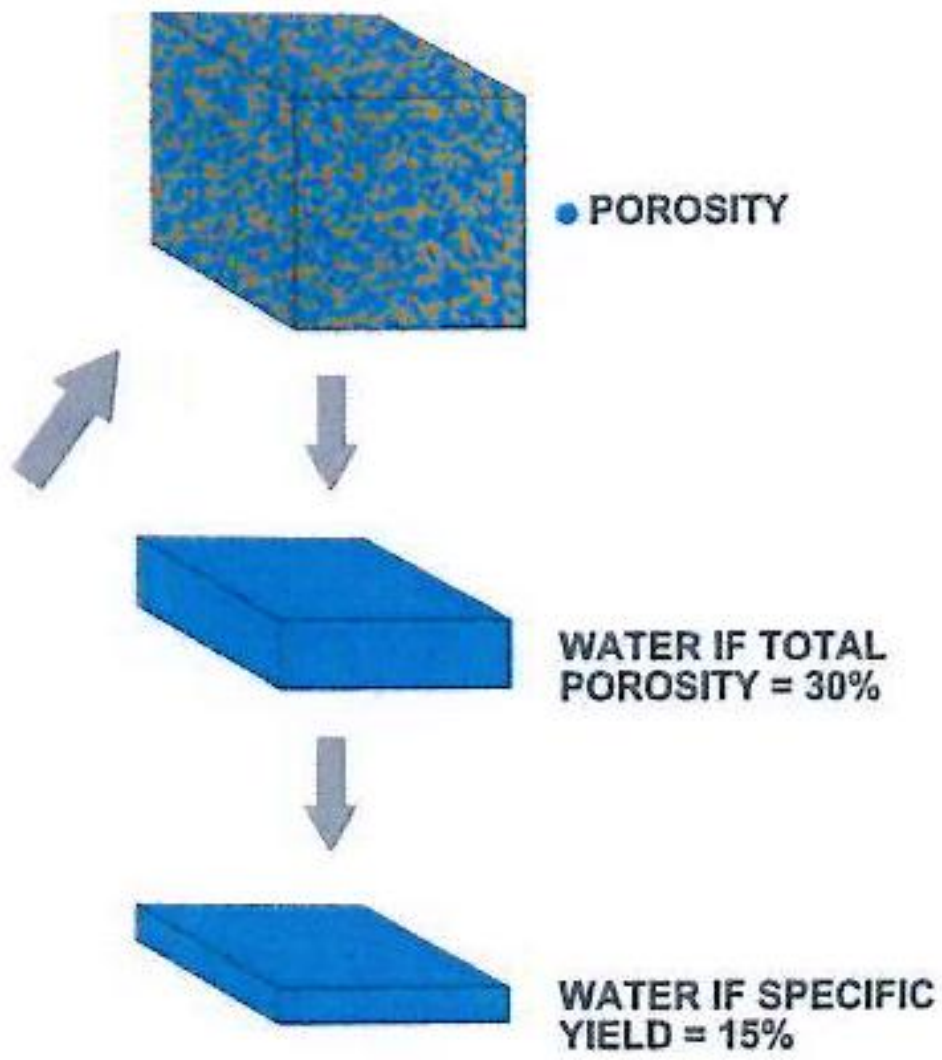
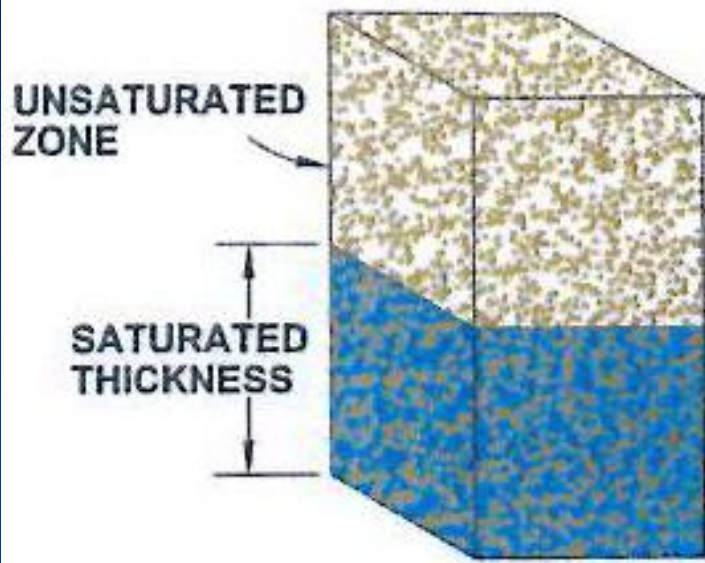


# Specific Storage

Specific Storage

$$\frac{\partial}{\partial x} \left( K_{xx} \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_{yy} \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_{zz} \frac{\partial h}{\partial z} \right) - W = Ss \frac{\partial h}{\partial t}$$

How much water can we extract from the aquifer?



# Hydraulic Conductivity

The diagram shows a box labeled "Hydraulic Conductivity" at the top. Three arrows point downwards from this box to the three terms in the following equation:  $\frac{\partial}{\partial x} (K_{xx} \frac{\partial h}{\partial x})$ ,  $\frac{\partial}{\partial y} (K_{yy} \frac{\partial h}{\partial y})$ , and  $\frac{\partial}{\partial z} (K_{zz} \frac{\partial h}{\partial z})$ . The terms  $K_{xx}$ ,  $K_{yy}$ , and  $K_{zz}$  are each enclosed in a red box.

$$\frac{\partial}{\partial x} (K_{xx} \frac{\partial h}{\partial x}) + \frac{\partial}{\partial y} (K_{yy} \frac{\partial h}{\partial y}) + \frac{\partial}{\partial z} (K_{zz} \frac{\partial h}{\partial z}) - W = Ss \frac{\partial h}{\partial t}$$

How the water moves through the aquifer.

# Flux

Flux Term  
Pumping, Recharge, etc.

$$\frac{\partial}{\partial x} \left( K_{xx} \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_{yy} \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_{zz} \frac{\partial h}{\partial z} \right) - W = Ss \frac{\partial h}{\partial t}$$

- Water being added or removed from the aquifer:
  - Pumping
  - Recharge
  - Spring Flow
  - Irrigation Return Flow

Time

$$\frac{\partial}{\partial x} \left( K_{xx} \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_{yy} \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_{zz} \frac{\partial h}{\partial z} \right) - W = \rho_s \frac{\partial h}{\partial t}$$

- Change through time
- For the GAMs ... 50 years.

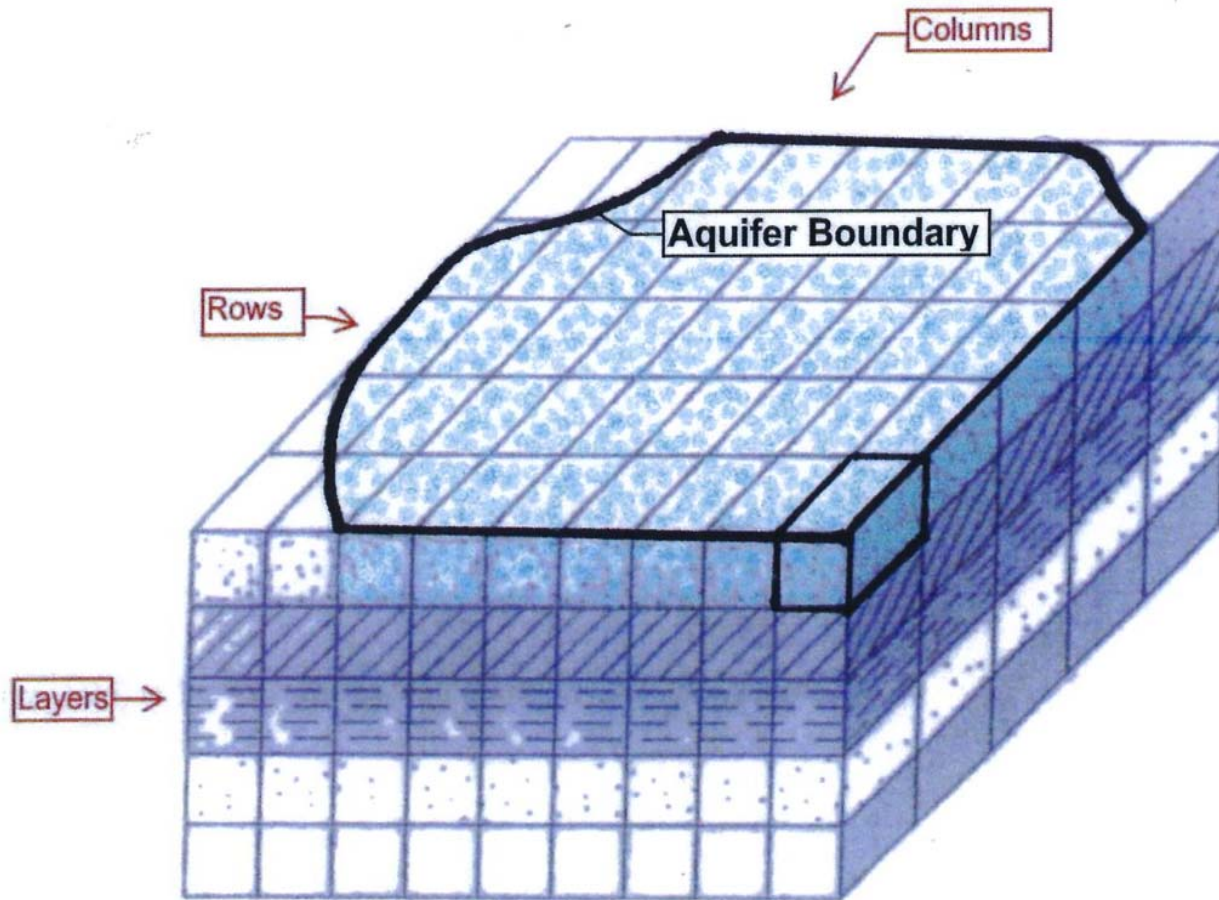
# Major Aquifer Parameters

*(Input values in models)*

- Top of aquifer
- Bottom of aquifer
- Hydraulic Conductivity
- Specific storage
- Flux - Recharge, pumping, spring flow
- Time



# Run the model



# Groundwater Availability Model (GAM)

Definition from Texas Water Law Glossary:

*“These models are presumed to provide the best information on groundwater availability and must almost always be used in state and regional planning efforts.”*



# What can science do for you and your client?

- Provide site specific aquifer evaluations
  - Evaluate the accuracy of the model
  - Compare actual data to modeled data
- *Proactive approach???*...  
*Before rules are established and models are run!*



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