



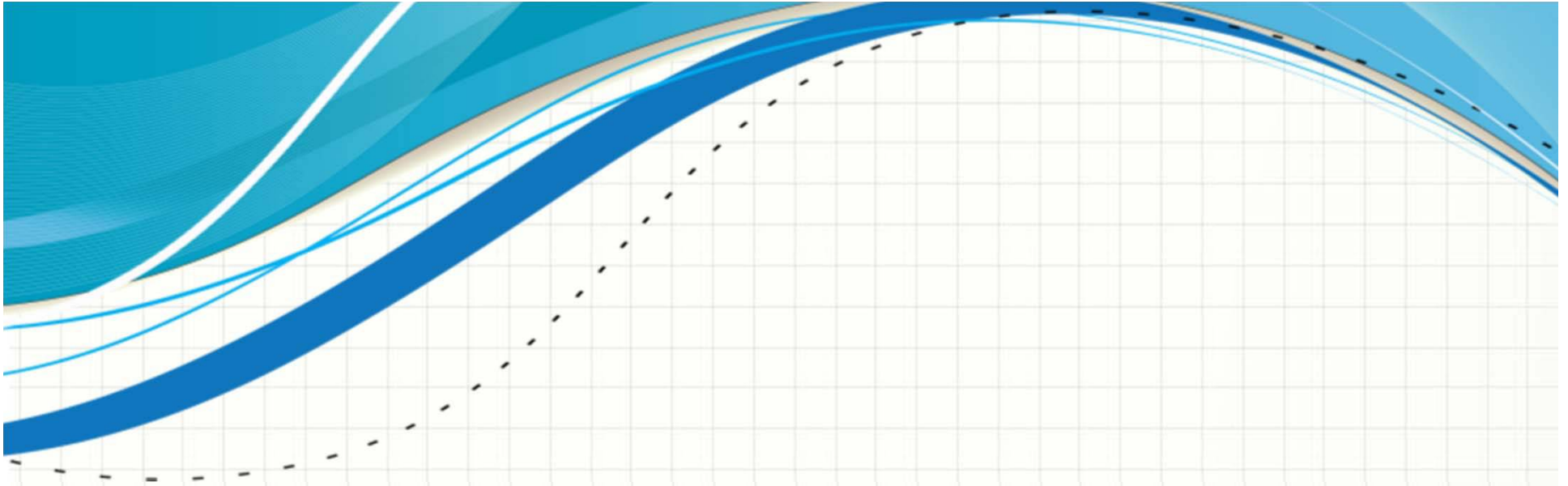
INTRODUCTION TO GROUNDWATER

Cindy Ridgeway, Manager
Texas Water Development Board
Groundwater Availability Modeling (GAM)
August 13, 2014



DISCLAIMER

The following presentation is based upon professional research and analysis within the scope of the Texas Water Development Board's statutory responsibilities and priorities but, unless specifically noted, does not necessarily reflect official Board positions or decisions.



**...THE EXISTENCE, ORIGIN, MOVEMENT, AND COURSE
OF [GROUNDWATER] ... ARE SO SECRET, OCCULT, AND
CONCEALED...**

Texas Supreme Court (Houston & Texas Central
Railroad Co. vs A. East, 1904) quoted from Ohio
Supreme Court (Frazier vs Brown, 1861)

Educational Groundwater Video Team



RPS

- RPS Espey



BIG LOOK PRODUCTIONS
creative production studio

- Big Look! Productions



Watearth[™]
Water Resources + Green Infrastructure

- Watearth



AQUAVEO[™]

- Aquaveo

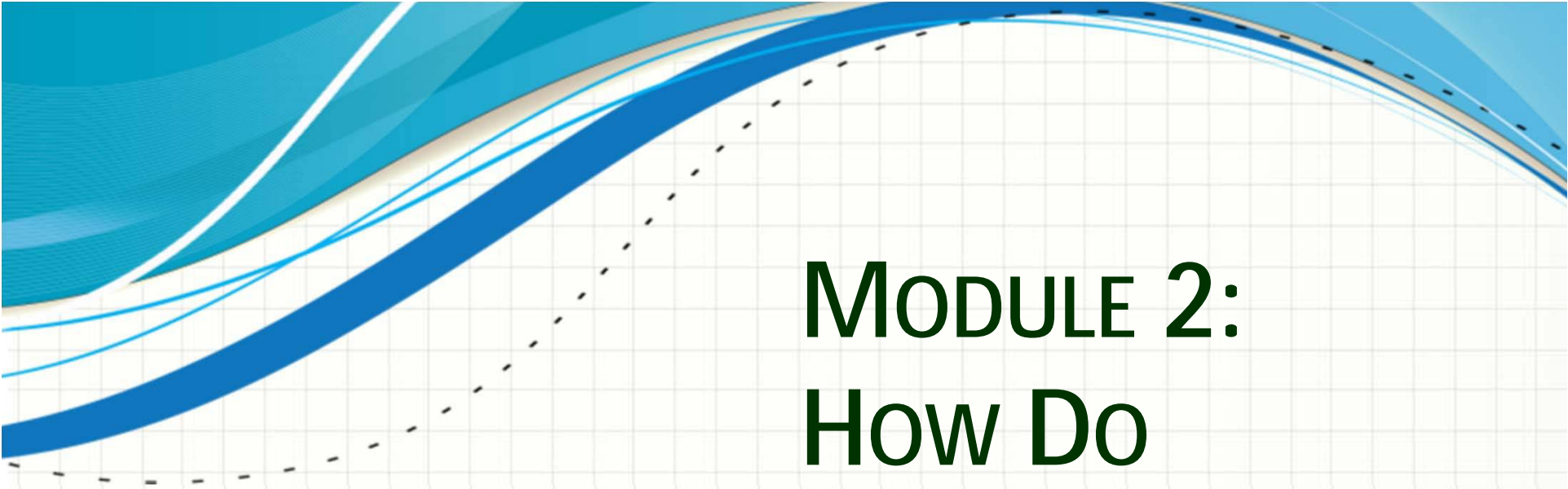


Texas Water
Development Board

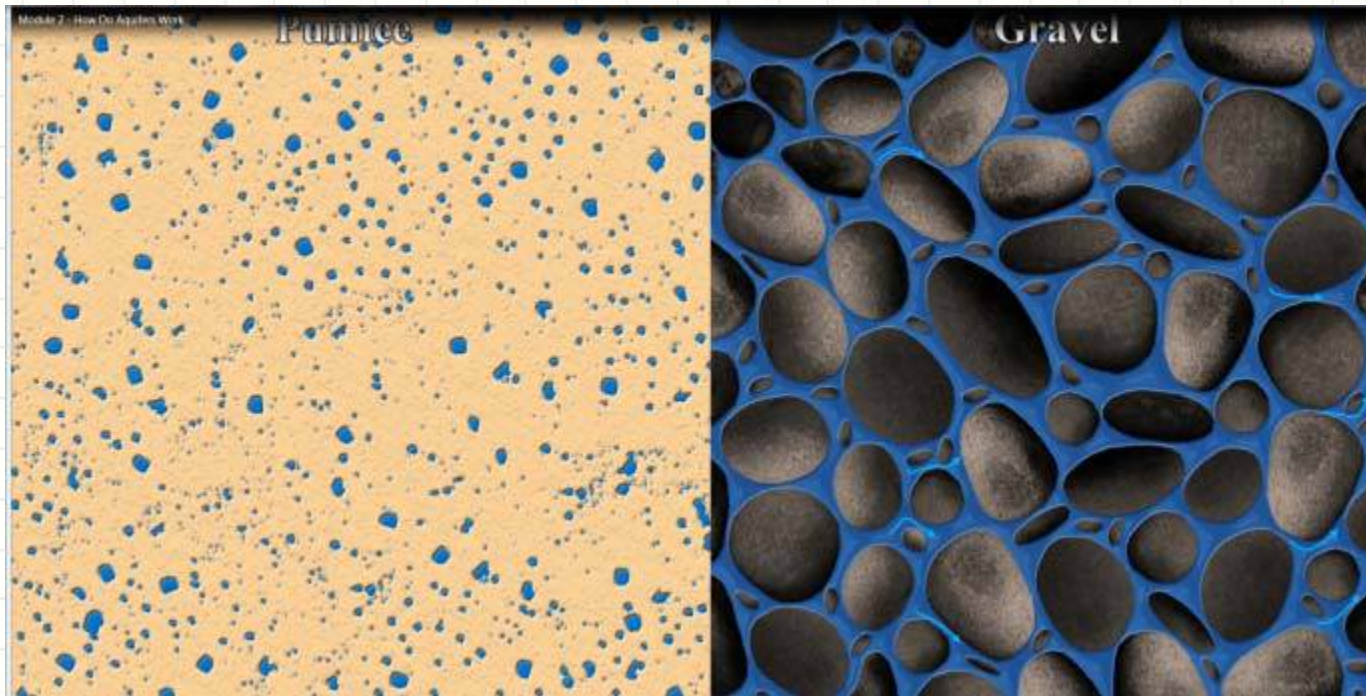


Video Modules

1. Aquifers in Texas
2. How do Aquifers Work
3. Groundwater Budget and Availability Models
4. Using Groundwater Availability Models in Water Planning



MODULE 2: How Do AQUIFERS WORK?

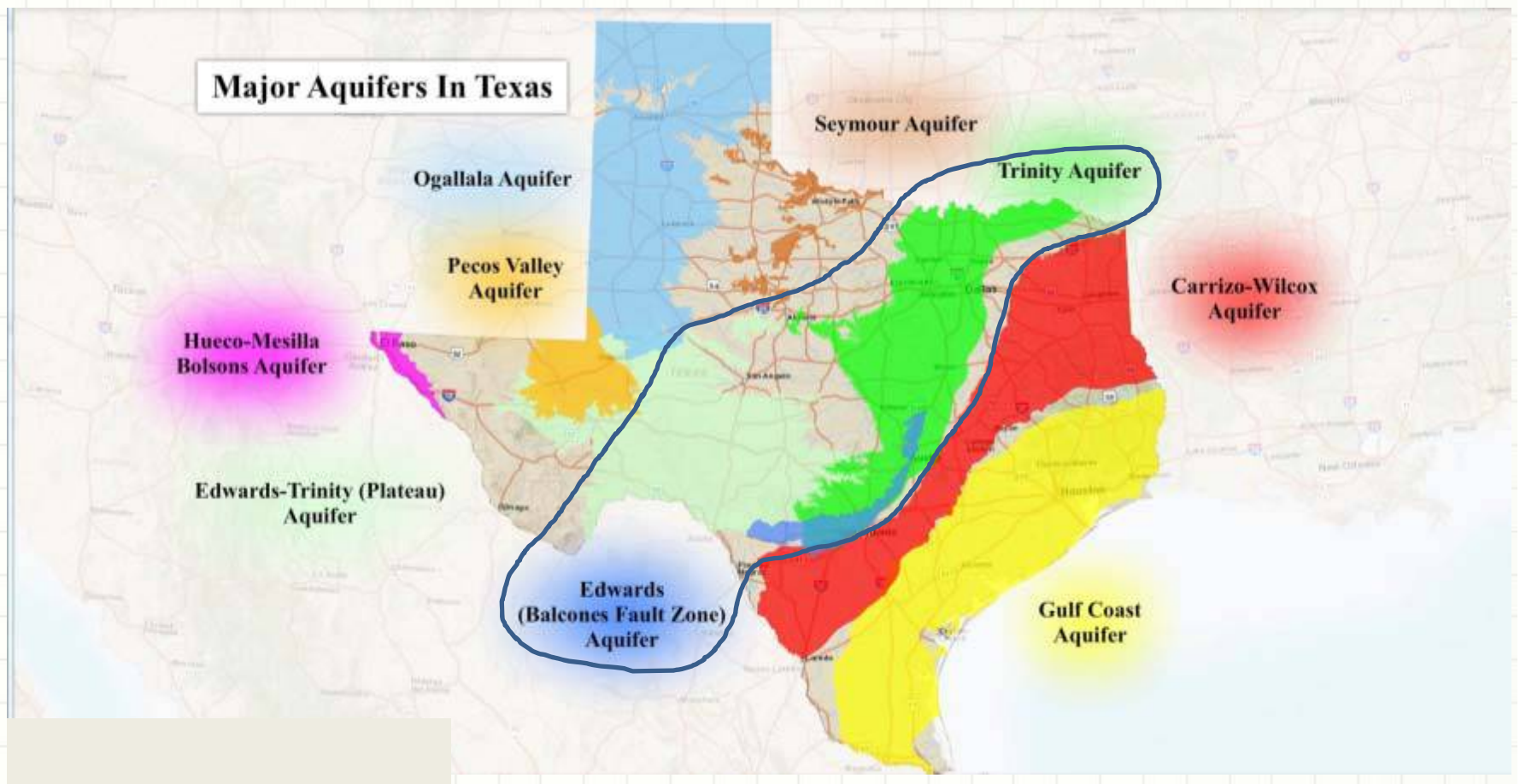


Porosity:

- Measure of the volume of empty space—or pore spaces—inside the rock.
- Represents the volume of water a rock formation can hold

Permeability

- Measure of how readily water can flow within the rock



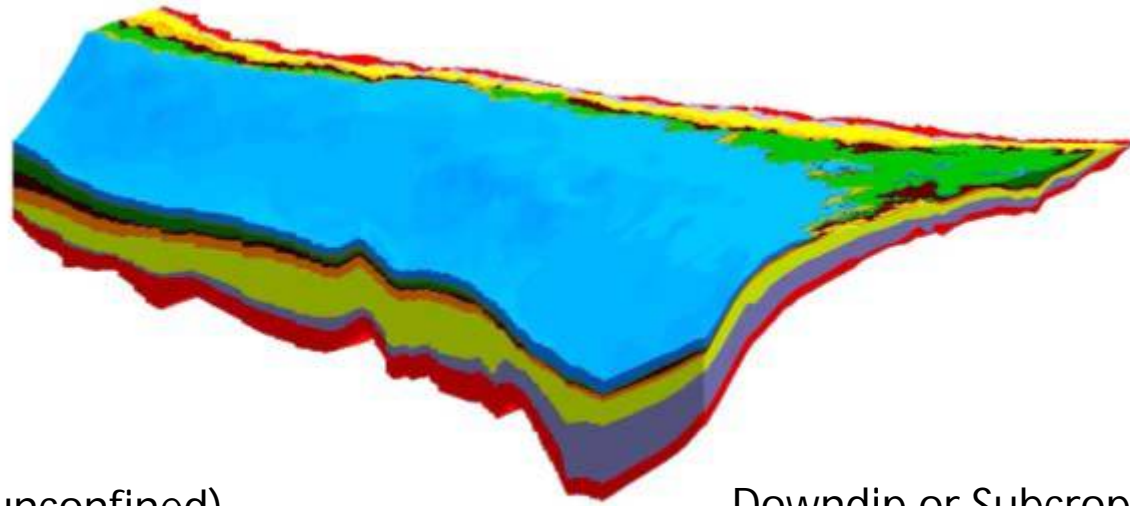
Aquifers from Sedimentary Rocks:

- Gulf Coast
- Carrizo-Wilcox
- Seymour
- Ogallala
- Pecos Valley
- Hueco-Mesilla Bolsons

Aquifers with Limestone (Karst)

- Edwards (Balcones Fault Zone)
- Trinity
- Edwards-Trinity (Plateau)

Parts of an Aquifer...

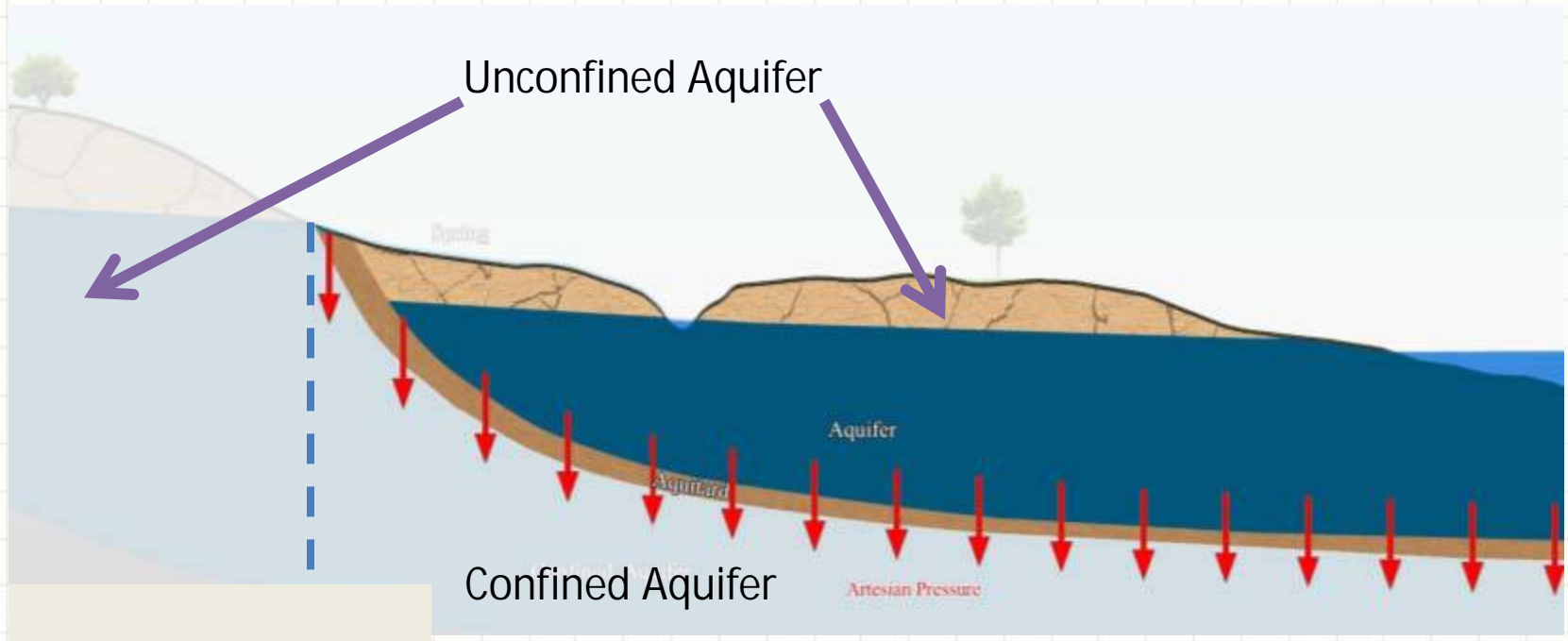


Outcrop (unconfined)

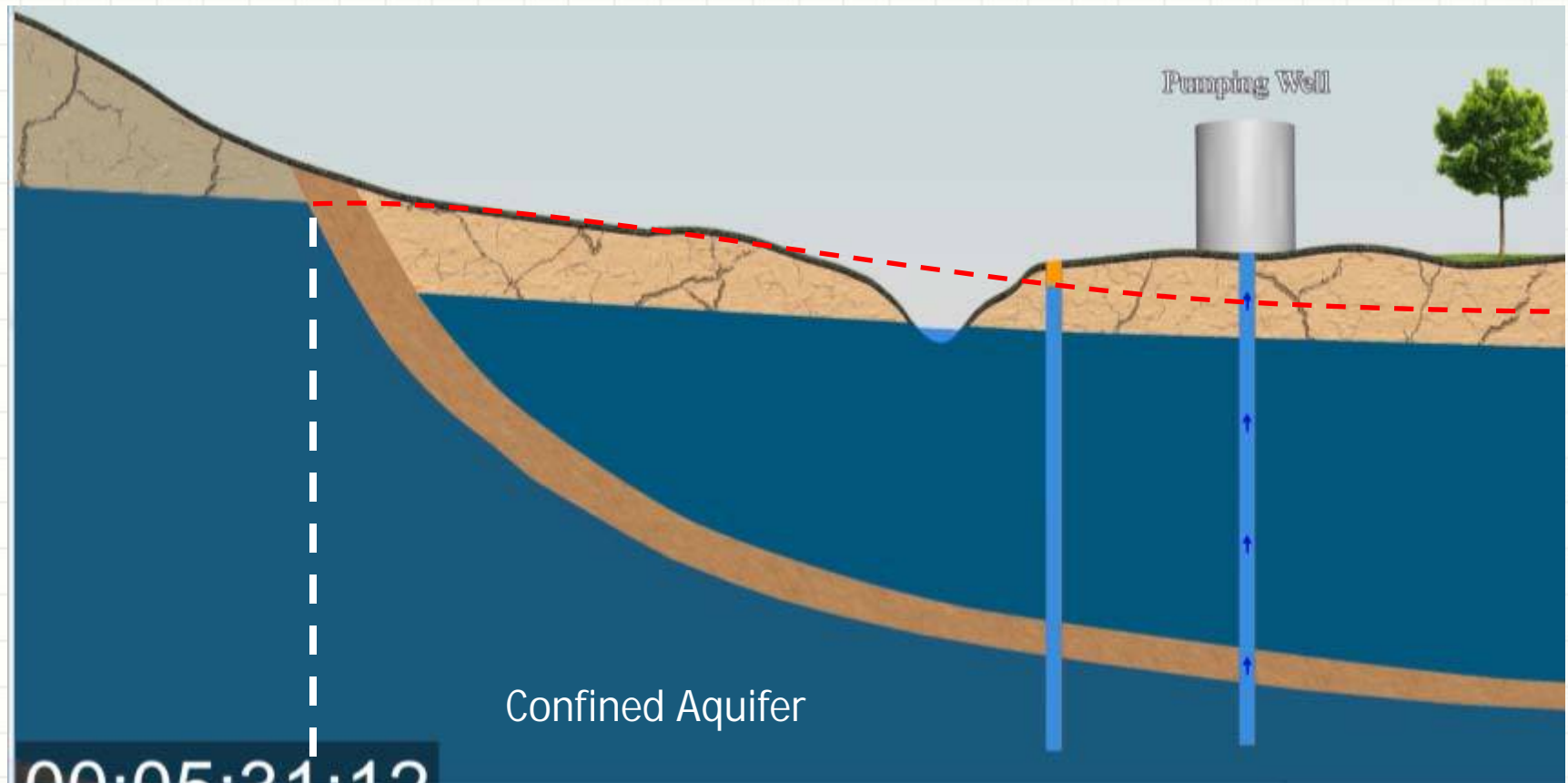
Downdip or Subcrop (confined)



Confined or Unconfined?

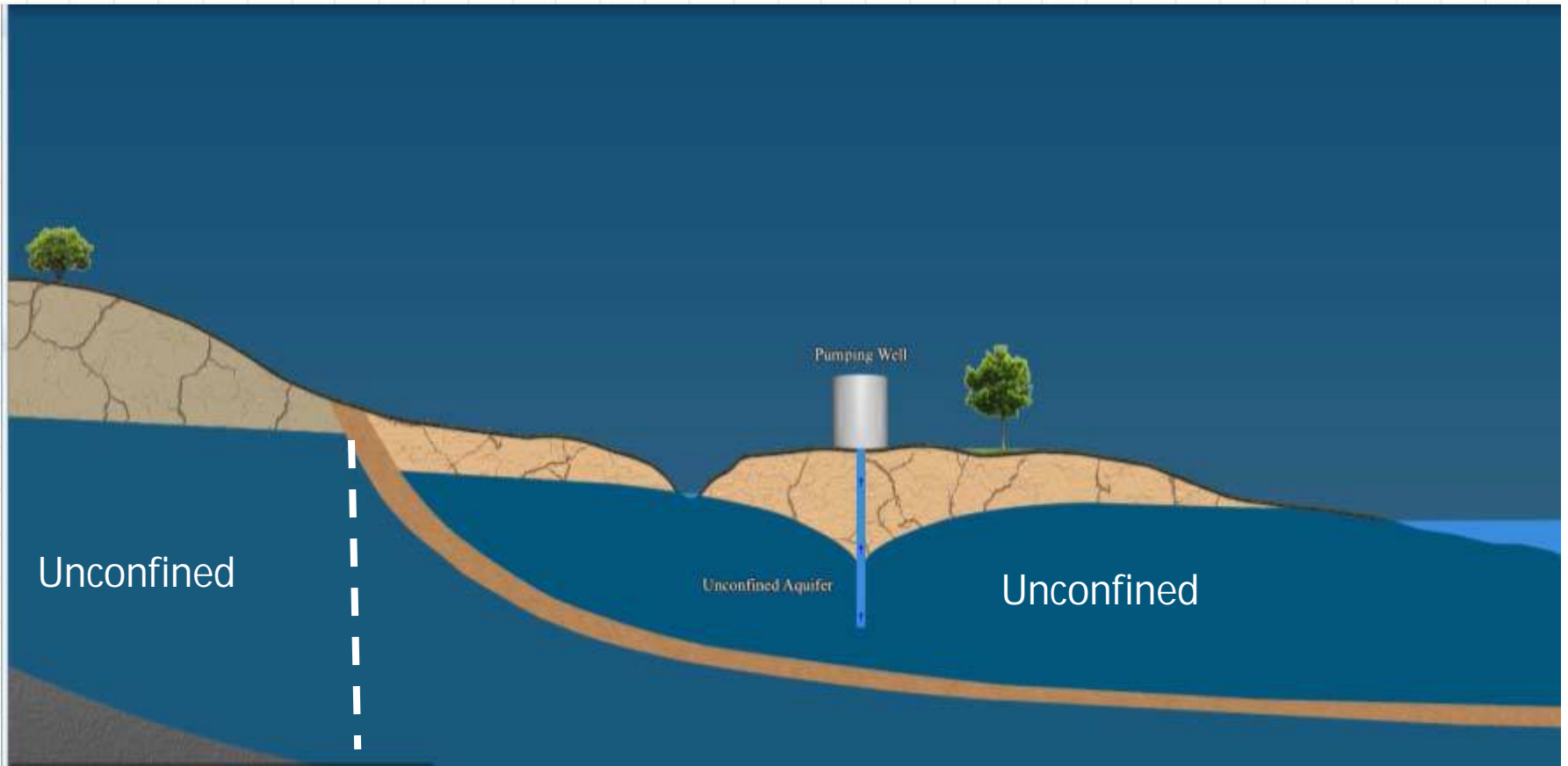


Confined Aquifer

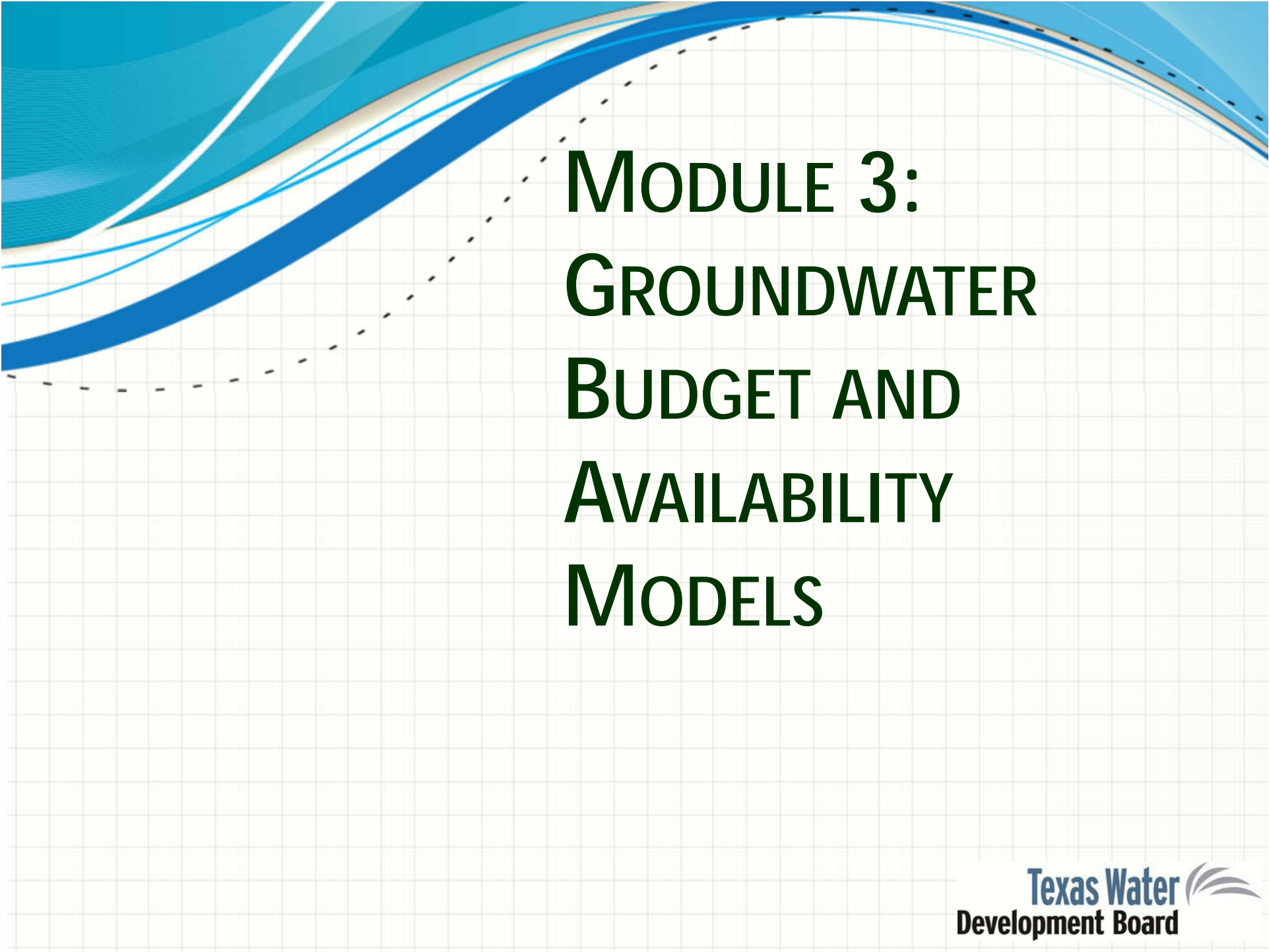


- Not exposed to atmosphere (surrounded by "aquitards" confining units)
- Water levels are above "aquifer unit"
- Water under pressure
- Usually less energy to pump
- Recharge only through "inflows" – no precipitation recharge or surface water interactions

Unconfined Aquifer

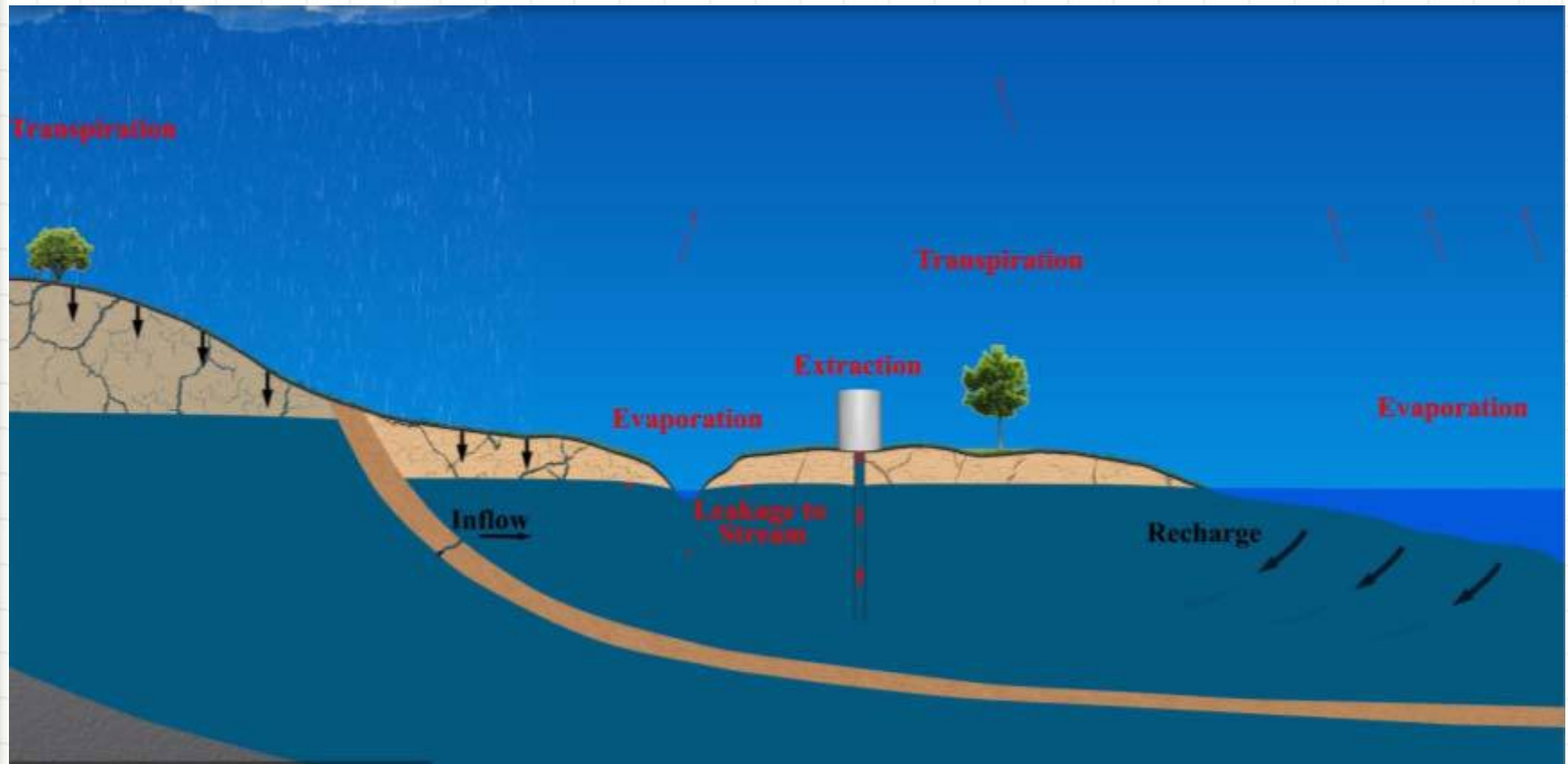


- Exposed to “atmosphere”
- Allows interaction with surface water, plants, evaporation, and recharge from precipitation
- Usually more energy to pump
- Pumping can lower water levels in aquifer itself



MODULE 3: GROUNDWATER BUDGET AND AVAILABILITY MODELS

Water Cycle:



Inflows (black)
Outflows (red)

Simple water budget

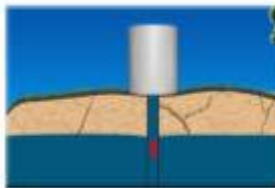


Credits



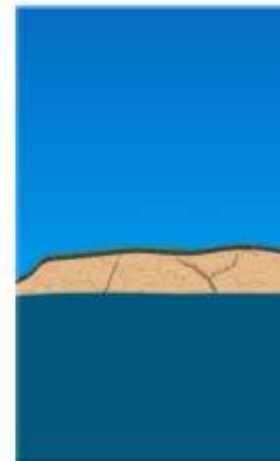
Inflow

Debits



Outflow

Balance



Storage

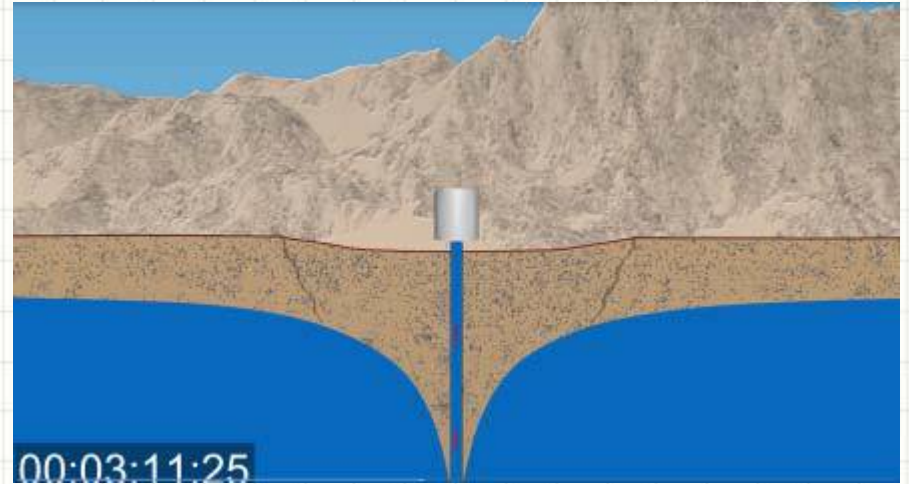
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Some concerns with pumping...

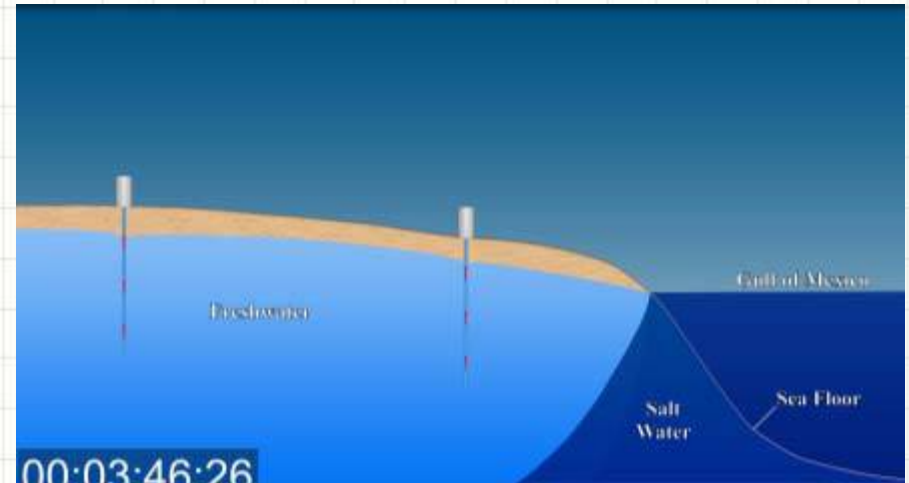
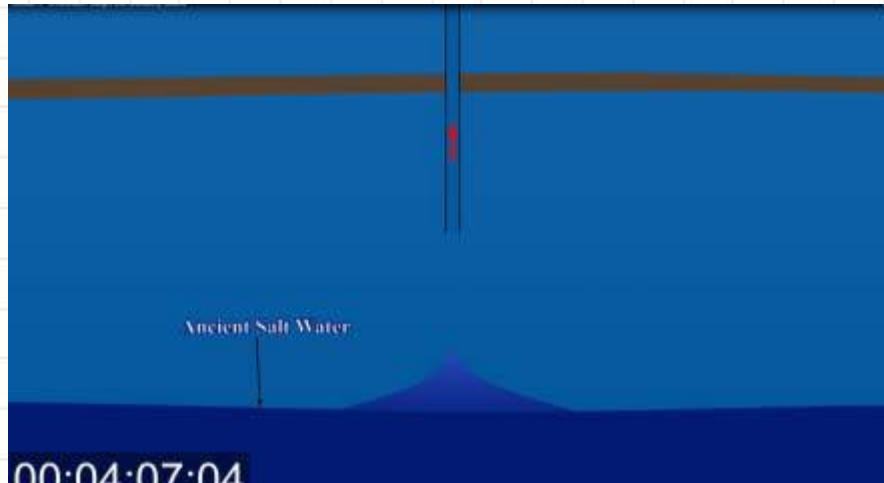
Surface water/groundwater interactions



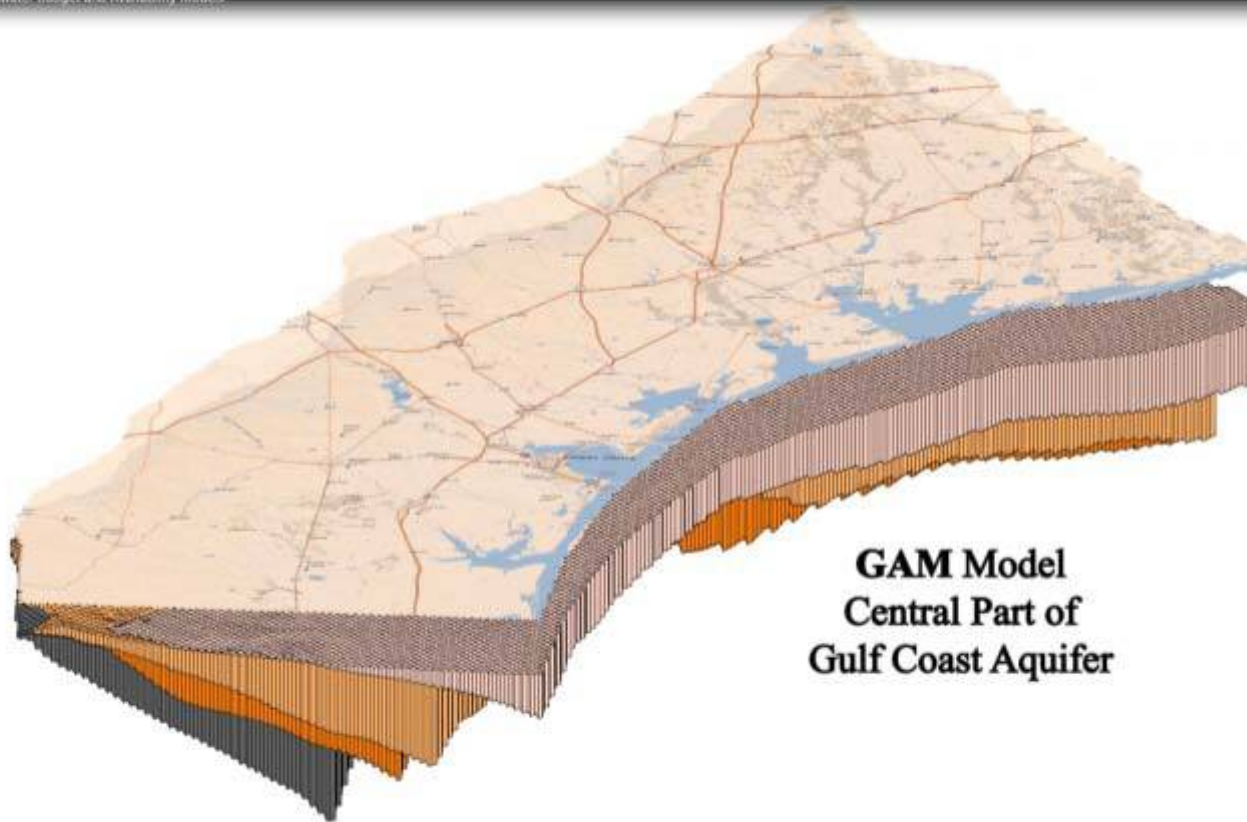
Subsidence



Water quality issues

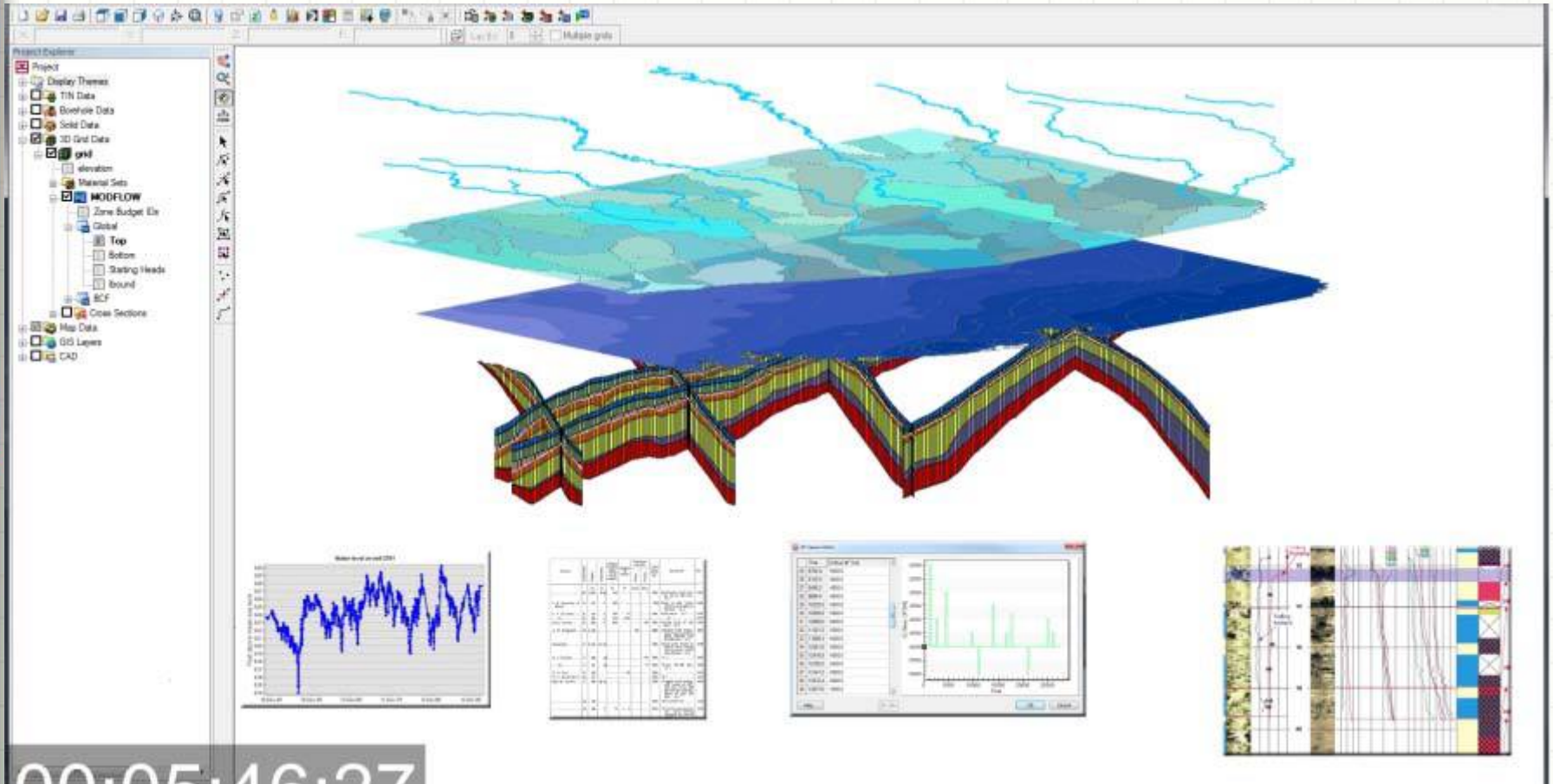


Groundwater Availability Models (GAM)

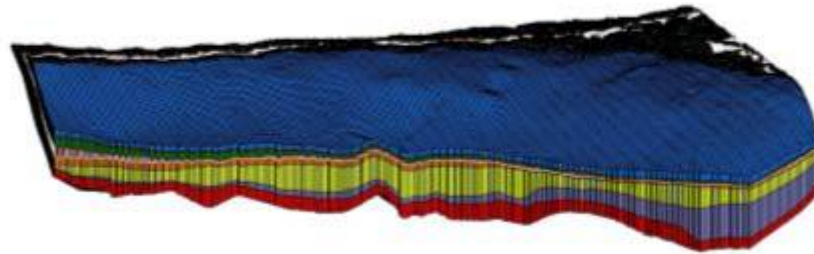
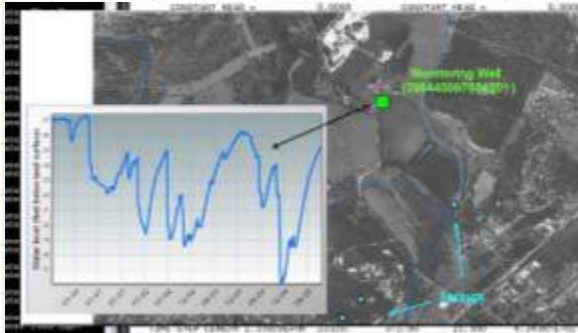


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Review data to develop conceptual model



Model calibrations and simulations...



Col:log: Stress period:	Time:	Time step:	Groundwater-Flow Exp.:
Col:log: Stress period:	81	Time step:	Groundwater-Flow Exp.
Col:log: Stress period:	81	0.0002 minutes	Groundwater-Flow Exp.
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Col:log: Stress period:	109	Time step:	Groundwater-Flow Exp.
Col:log: Stress period:	109	0.0002 minutes	Groundwater-Flow Exp.

File Edit Format View Help

UNDOV4 SAVING " STREAM LEAKAGE" ON UNIT 40 AT TIME STEP 2, STRESS PERIOD 29

UNDOV4 SAVING " P9W" ON UNIT 40 AT TIME STEP 2, STRESS PERIOD 29

UNDOV4 SAVING "ENGT, IN STORAGE" ON UNIT 40 AT TIME STEP 2, STRESS PERIOD 29

UNDOV4 SAVING "FARM WELLS" ON UNIT 40 AT TIME STEP 2, STRESS PERIOD 29

UNDOV4 SAVING "FARM NET RECH." ON UNIT 40 AT TIME STEP 2, STRESS PERIOD 29

HEAD WILL BE SAVED ON UNIT 40 AT END OF TIME STEP 2, STRESS PERIOD 29

SHUTDOWN WILL BE SAVED ON UNIT 47 AT END OF TIME STEP 2, STRESS PERIOD 29

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 2 IN STRESS PERIOD 29

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/Y
IN:		IN:	
STORAGE =	4490108150.8108	STORAGE =	4879481.8268
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
HEAD DEP BOUNDS =	82695007.1843	HEAD DEP BOUNDS =	71836.1363
STREAM LEAKAGE =	117942890.7743	STREAM LEAKAGE =	117380.8929
P9W =	109404295.0218	P9W =	145883.8266
ENGT, IN STORAGE =	4483158491.7608	ENGT, IN STORAGE =	7051700.5497
FARM WELLS =	0.0000	FARM WELLS =	0.0000
FARM NET RECH. =	1055008603.1501	FARM NET RECH. =	3244870.1524
TOTAL IN =	1240053836.7027	TOTAL IN =	1750012.0747
OUT:		OUT:	
STORAGE =	2870431262.8600	STORAGE =	1759186.1677
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
HEAD DEP BOUNDS =	636122705.1673	HEAD DEP BOUNDS =	1802869.2359
STREAM LEAKAGE =	40221.8601	STREAM LEAKAGE =	0.0000
P9W =	1248881207.9001	P9W =	2242986.5218
ENGT, IN STORAGE =	681803371.1980	ENGT, IN STORAGE =	19512.4478
FARM WELLS =	6599772127.1310	FARM WELLS =	12101875.9372
FARM NET RECH. =	55069325.4738	FARM NET RECH. =	132817.8206
TOTAL OUT =	12394341426.1255	TOTAL OUT =	17487308.1230
IN - OUT =	8232210.5772	IN - OUT =	3403.9517
PERCENT DISCREPANCY =	0.05	PERCENT DISCREPANCY =	0.02

TIME SUMMARY AT END OF TIME STEP 2 IN STRESS PERIOD 29

TIME STEP LENGTH	SECONDS	MINUTES	HOURS	DAYS	YEARS
TIME STEP LENGTH	1.31800E+06	22320.	372.00	15.500	4.24167E-02
STRESS PERIOD TDM	2.07840E+06	48840.	788.00	21.000	5.48734E-02
TOTAL TIME	7.62810E+07	1.27333E+08	21392.	483.00	2.4375

STRESS PERIOD NO. 30, LENGTH = 30.00000

NUMBER OF TIME STEPS = 2

MULTIPLIER FOR DELT = 1.000

INITIAL TIME STEP SIZE = 15.00000

BOUND. NO.	LAYER	ROW	COL	THICK	CONDUCTANCE
1	1	27	17	85.70	0.1000E+05
1	1	28	18	81.80	0.1000E+05
1	1	28	19	62.30	0.1000E+05

00:06:30:03

Tentative Schedule

- **January to March, 2014:** Review draft videos for pace, images, sound
- **March to August 2014:** Provide draft videos for review and screening
- **September to December 2014:** Finalize with closed captions
- **January 31, 2015:** Provide final draft deliverables to Texas Water Development for review and comment
- **June 30, 2015:** Review final deliverables and close contract

Summary

- Aquifers behave differently depending on the aquifer materials
- Aquifers behave differently depending if they are unconfined or confined
- Large pumping (outflows) usually affect the status quo or balance of the aquifer system
- ...the existence, origin, movement, and course of [groundwater] may be somewhat concealed but is not always so secret or occult. (groundwater models help!)

Contact Information

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QUESTIONS?