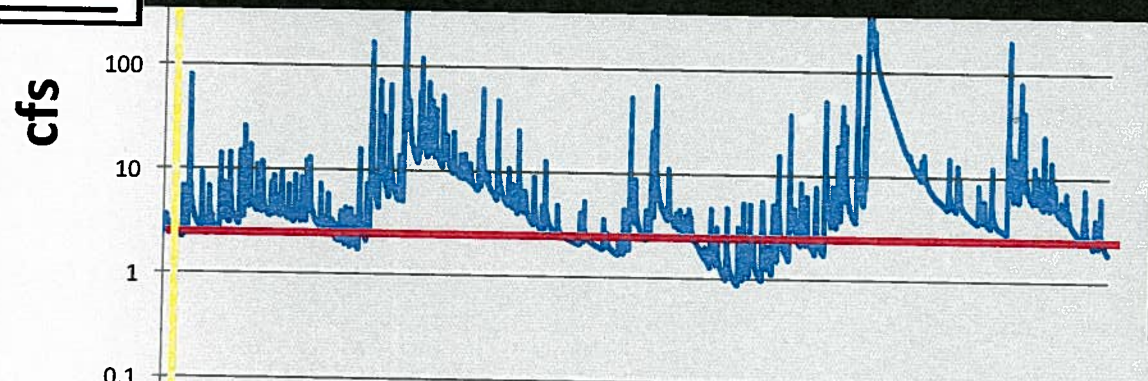
Prot Exh. 10

REVIEW OF THE MODEL RAISED A NUMBER OF CONCERNS I WILL SUMMARIZE AFTER EXPLAINING THE MOST IMPORTANT CONCERN

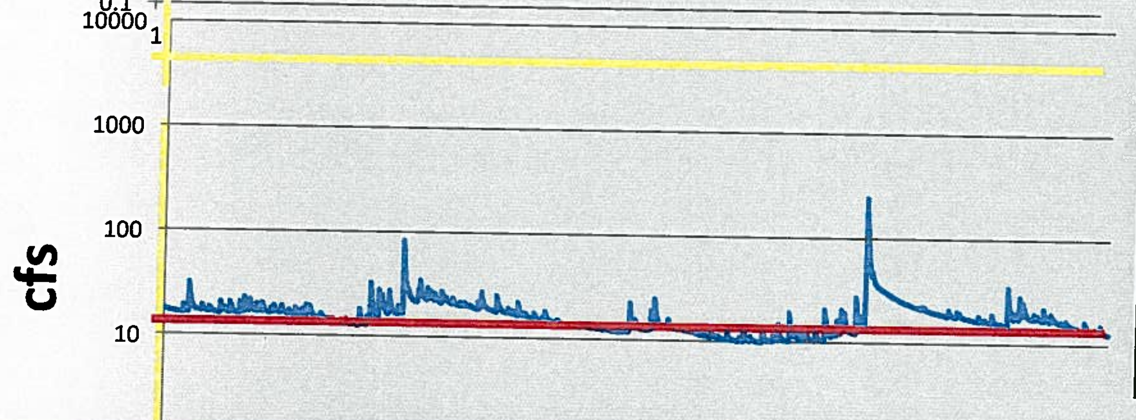
WHICH IS IMPORTANT BECAUSE LOW FLOW MATTERS TO FISH HABITAT

THE MODEL IGNORES THE UNCONFINED AQUIFER BEHAVIOR OF SHALLOW ZONE

SO FOR THE SAME CASE:



Without Unconfined Zone, BASEFLOW 75% exceedance 2.5 cfs



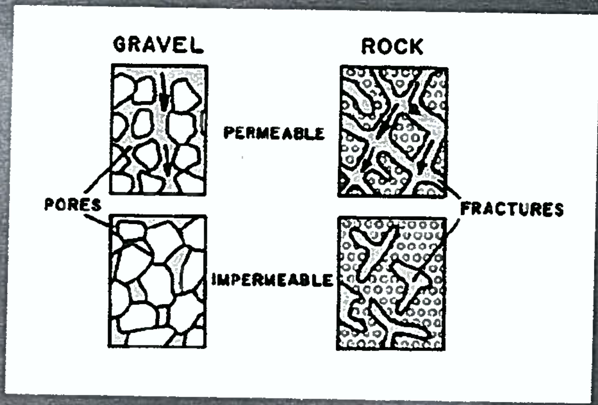
With Unconfined Zone, BASEFLOW 75% exceedance 13.2 cfs

AVERAGE ANNUAL BASEFLOW IS THE SAME FOR BOTH CASES

If average base flow is of interest THEN only recharge matters

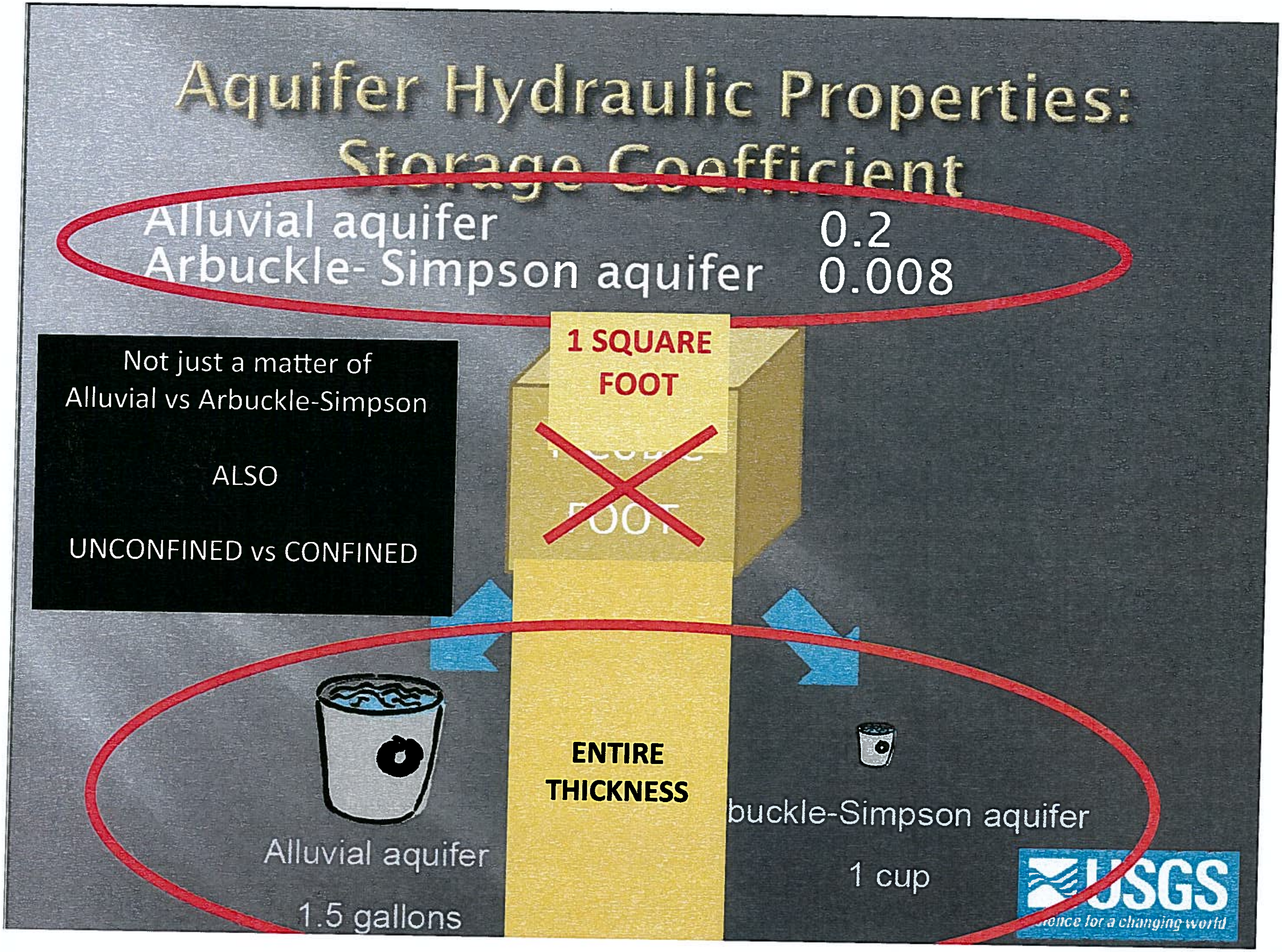
AND WE DO NOT NEED A NUMERICAL MODEL

Aquifer hydraulic properties: Storage coefficient

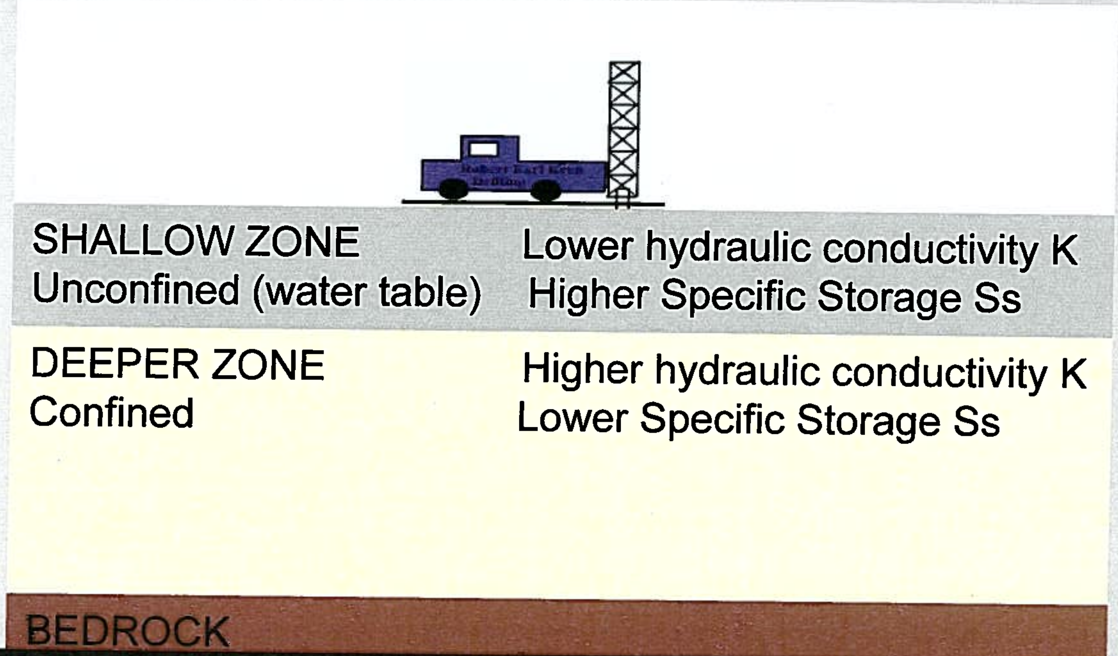


The volume of water given up per unit area of an aquifer per unit drop of the water-table or potentiometric surface.

USGS
science for a changing world


Aquifer Hydraulic Properties:
Storage Coefficient
Alluvial aquifer 0.2
Arbuckle- Simpson aquifer 0.008
Not just a matter of
Alluvial vs Arbuckle-Simpson
ALSO
UNCONFINED vs CONFINED
1 SQUARE
FOOT
ENTIRE
THICKNESS
Alluvial aquifer
1.5 gallons
buckle-Simpson aquifer
1 cup

ALL HYDROLOGISTS TESTIFYING YESTERDAY AGREED THE SHALLOW ZONE IS UNCONFINED



NOT TO SCALE

Fairchild and others (1990) reported that "information from drillers and land owners suggests that the upper few hundred feet of the Arbuckle Group has a much lower permeability than the lower part."

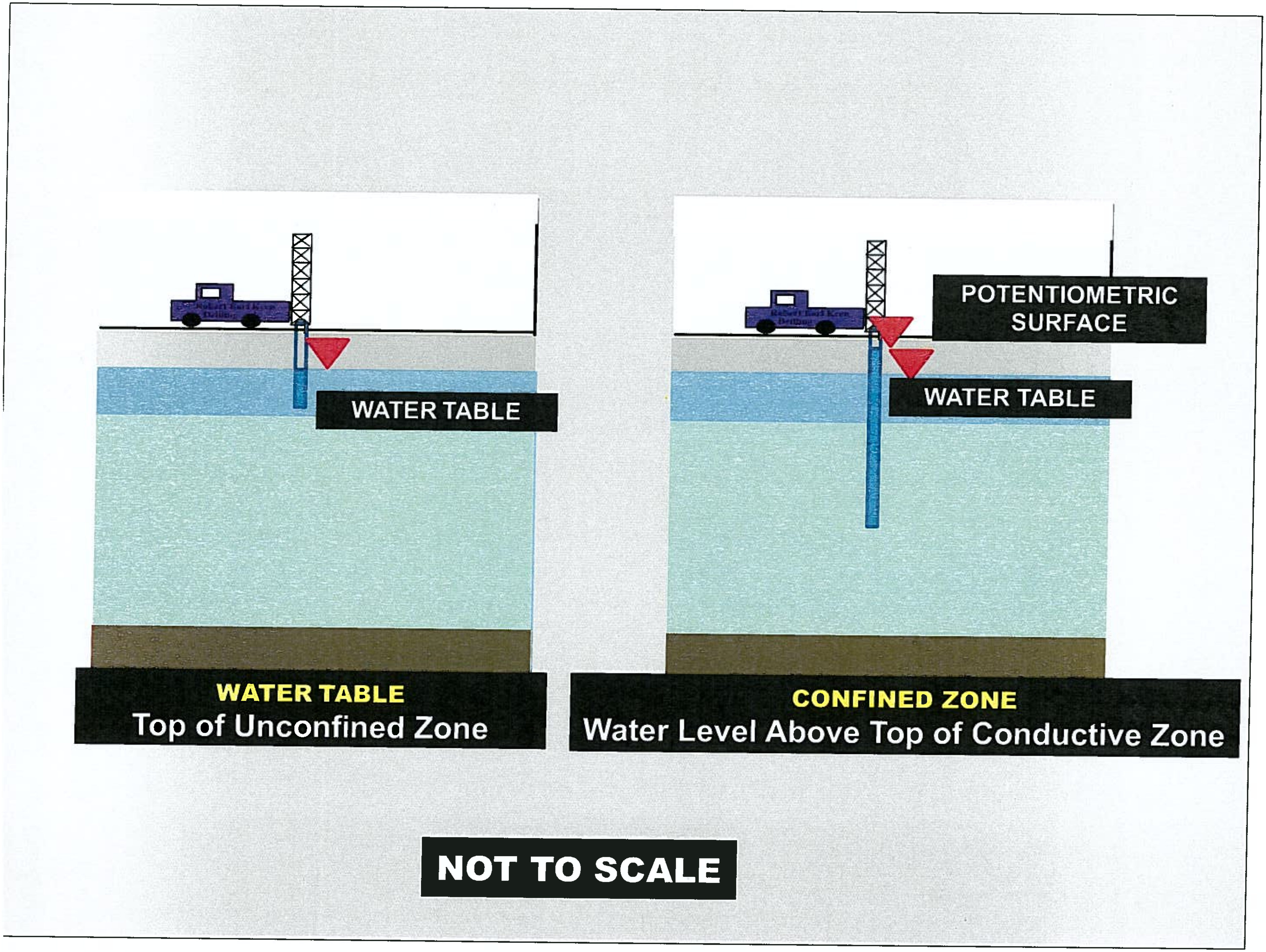
K is permeability, also called hydraulic conductivity

K is ability to push water through

Ss = Specific Storage is ability to store water per unit of thickness

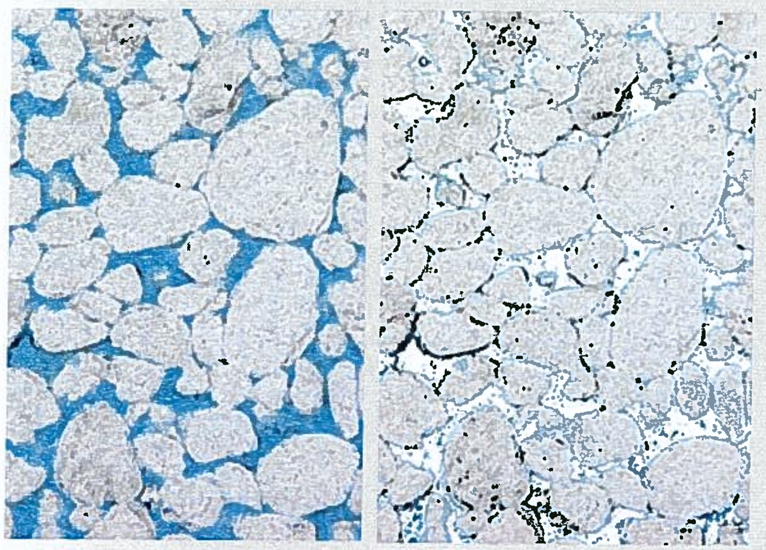
S = Storage Coefficient is ability to store water in entire thickness

S = Ss x Thickness

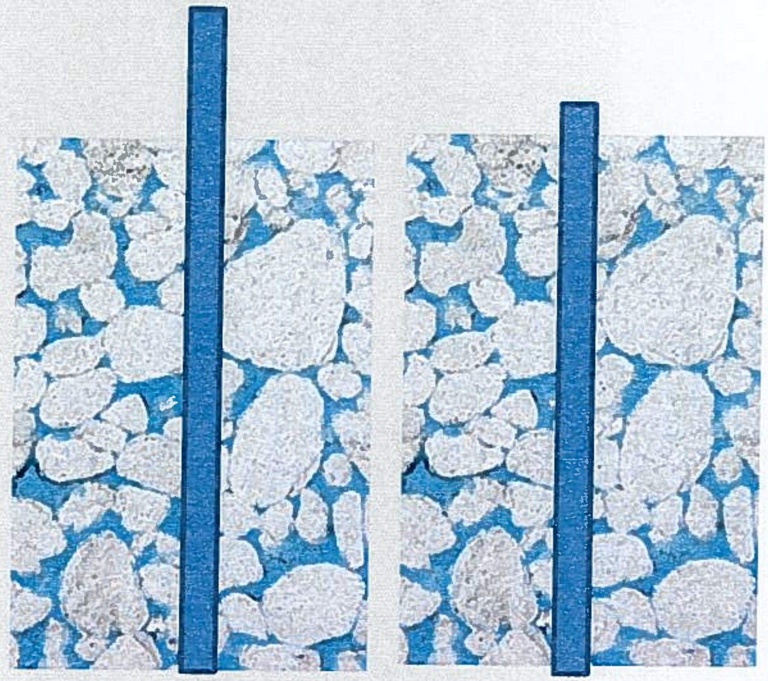

WATER TABLE
POTENTIOMETRIC SURFACE
WATER TABLE
WATER TABLE
Top of Unconfined Zone
CONFINED ZONE
Water Level Above Top of Conductive Zone
NOT TO SCALE

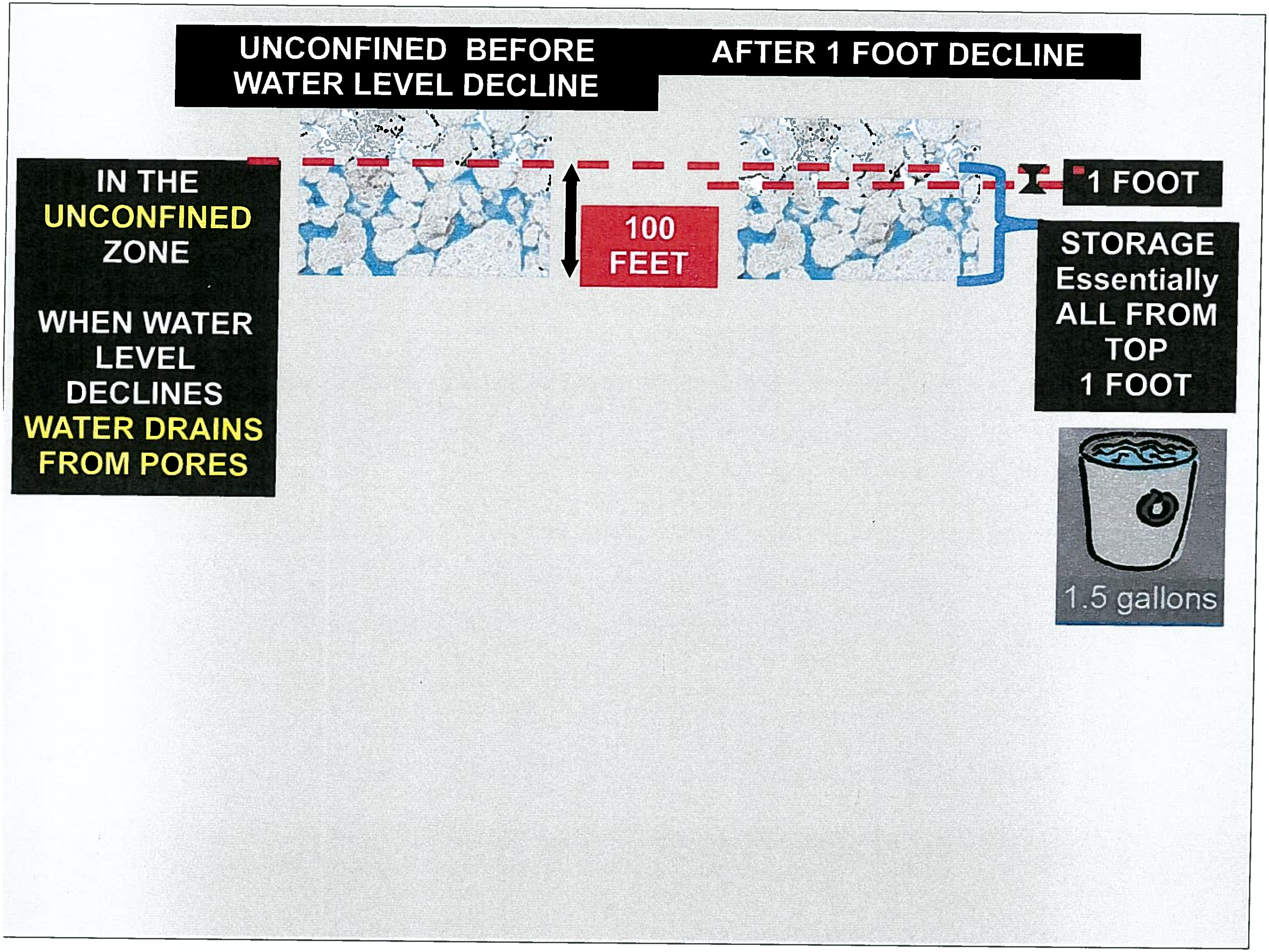
ALL HYDROLOGISTS TESTIFYING YESTERDAY AGREED PORES DRAIN WHEN WATER LEVEL DECLINES IN UNCONFINED ZONE

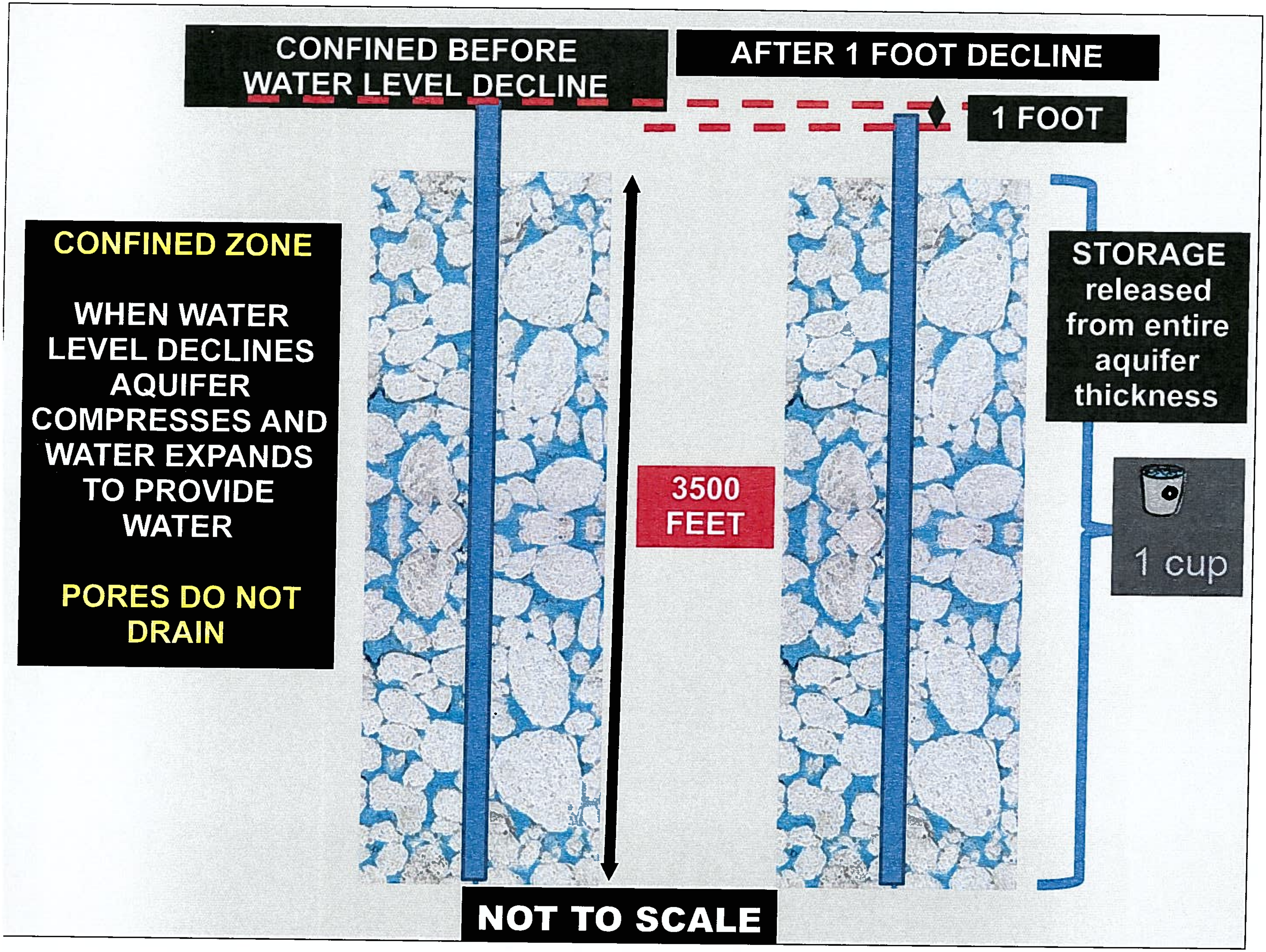
UNCONFINED AQUIFER
PORES DRAIN WHEN WATER LEVEL LOWERS

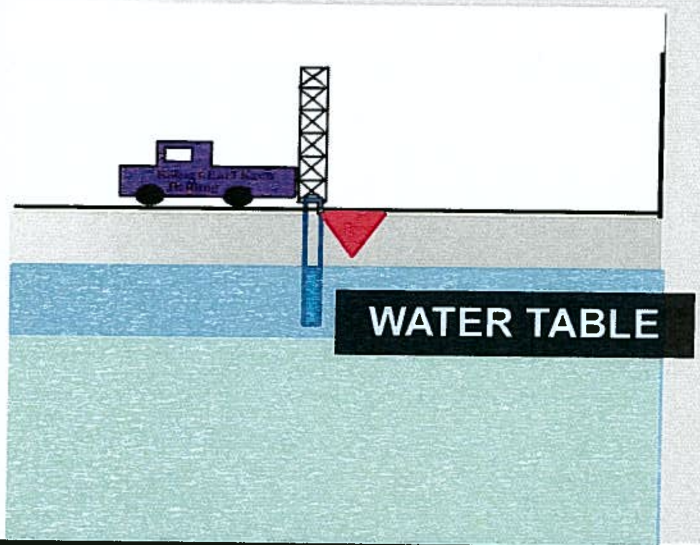


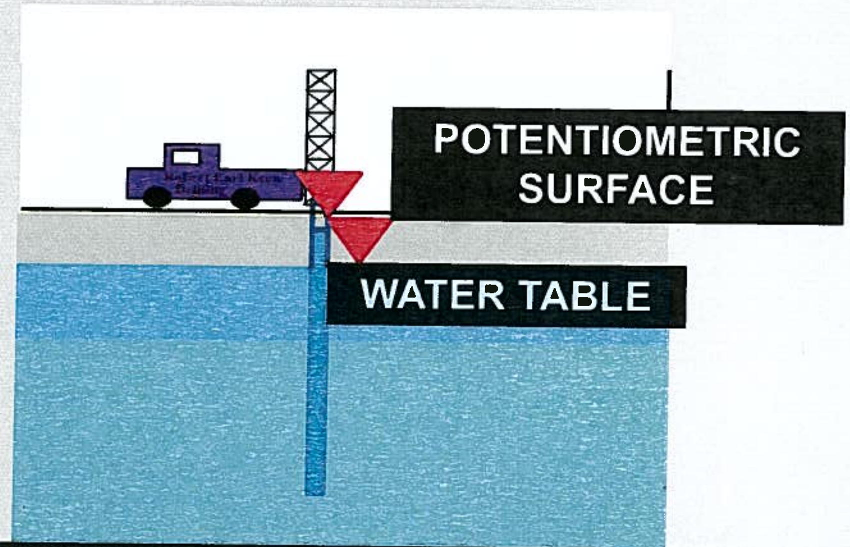
CONFINED AQUIFER
PORES DO NOT DRAIN WHEN WATER LEVEL LOWERS




UNCONFINED BEFORE
WATER LEVEL DECLINE
AFTER 1 FOOT DECLINE
IN THE
UNCONFINED
ZONE
WHEN WATER
LEVEL
DECLINES
WATER DRAINS
FROM PORES
100
FEET
1 FOOT
STORAGE
Essentially
ALL FROM
TOP
1 FOOT
1.5 gallons


CONFINED BEFORE WATER LEVEL DECLINE
AFTER 1 FOOT DECLINE
1 FOOT
CONFINED ZONE
WHEN WATER LEVEL DECLINES AQUIFER COMPRESSES AND WATER EXPANDS TO PROVIDE WATER
PORES DO NOT DRAIN
3500 FEET
STORAGE released from entire aquifer thickness
1 cup
NOT TO SCALE





FEW WELLS ARE COMPLETED IN THE UNCONFINED ZONE IN THE STUDY AREA BECAUSE LOW K MAKES THEM LESS DESIRABLE FOR WATER SUPPLY

ONE WELL IN THIS ZONE
OWRB 85182, 53 FT DEEP
STORAGE COEFFICIENT 0.075

NEARLY ALL WELLS OF STUDY AREA ARE IN THE CONFINED ZONE

MANY MEASUREMENTS OF THIS STORAGE COEFFICIENT RANGE FROM
0.002 to 0.02

0.075 is NOT a very small value as was stated yesterday
It does NOT indicate a confined condition as was stated yesterday
It is indicative of unconfined conditions

USGS used CONFINED MODFLOW layers to simulate the UNCONFINED portion of the Arbuckle-Simpson aquifer

STATED THIS WAS BECAUSE:
- Storage coefficients similar
- Drawdown would be small
- The model solution will be more stable

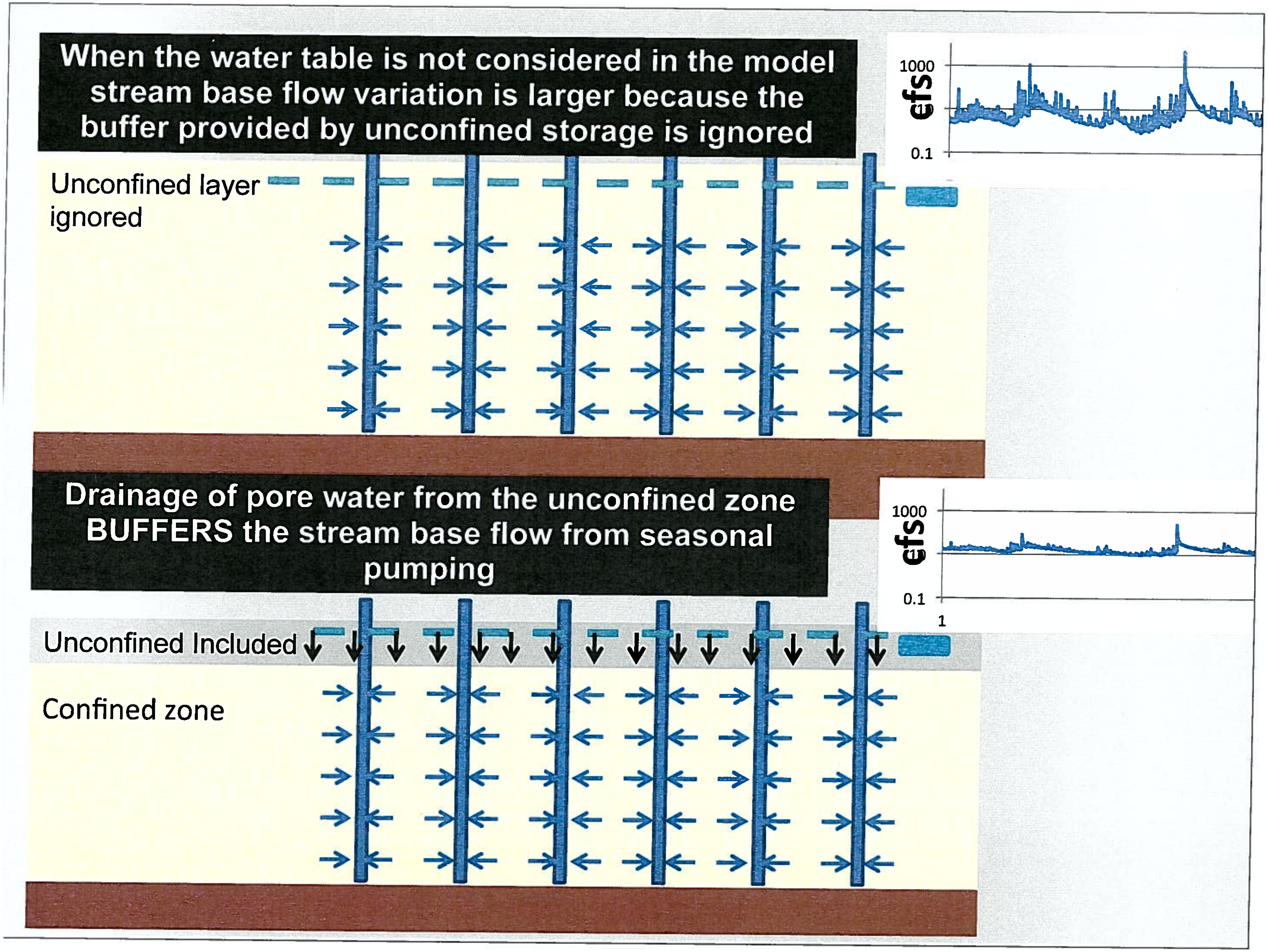
Using confined MODFLOW layers is acceptable as long as storage in the top layer represents drainage of water from the pores, but this was not done in the USGS model, so the streams were too sensitive to pumping.

As three hydrologists noted yesterday Storage Coefficient is typically much higher in unconfined zone.

Even if the S values are both 0.008, the Ss value was entered incorrectly in MODFLOW, making S of the top layer only 2% of what it should be.

If S of top layer is 0.008, Ss should be 0.008/20m = $0.0004 m^{-1}$, not $0.000008 m^{-1}$

This required procedure for input of S of the top layer is demonstrated by the SYTP parameter in the MODFLOW HUF2 package.

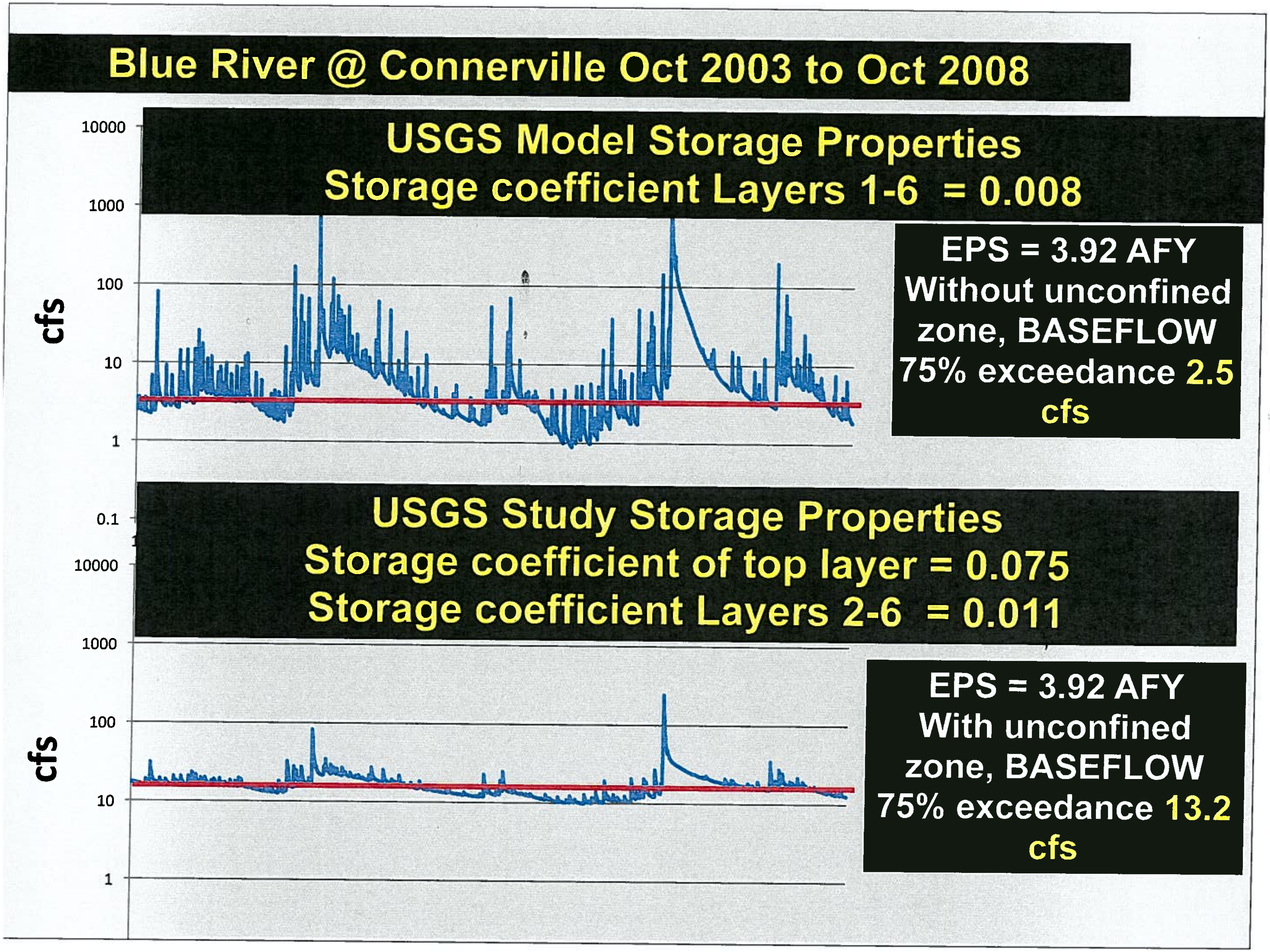

When the water table is not considered in the model stream base flow variation is larger because the buffer provided by unconfined storage is ignored
1000
cfs
0.1
Unconfined layer ignored
Drainage of pore water from the unconfined zone BUFFERS the stream base flow from seasonal pumping
1000
cfs
0.1
1
Unconfined Included
Confined zone

I ran simulations to determine the influence
of representing the top layer as unconfined

SIMULATION INVOLVED:
Running the transient calibration model with the 0.392 (A-F/A)/Yr, eps
Repeating until the cumulative budget did not change

RUN #1
USGS Model Storage Properties
Storage coefficient of 0.008 and a thickness of 1000m
ALL LAYERS Ss = S/thk = 0.000008

RUN #2
USGS Field Measured Storage Properties
Storage coefficient of 0.075 and a thickness of 20m
TOP LAYER Ss = S/thk = 0.00375
Storage coefficient of 0.011 and a thickness of 1040m
LAYERS BELOW TOP Ss = S/thk = 0.00001056


Blue River @ Connerville Oct 2003 to Oct 2008
USGS Model Storage Properties
Storage coefficient Layers 1-6 = 0.008
EPS = 3.92 AFY
Without unconfined zone, BASEFLOW
75% exceedance 2.5 cfs
10000
1000
100
10
1
0.1
cfs
USGS Study Storage Properties
Storage coefficient of top layer = 0.075
Storage coefficient Layers 2-6 = 0.011
EPS = 3.92 AFY
With unconfined zone, BASEFLOW
75% exceedance 13.2 cfs
10000
1000
100
10
1
cfs

RESULTS OF THE SIMULATION DO NOT PROVIDE INFORMATION ON THE EXPECTED BASE FLOW

The point is not that we have the right values, rather that including the unconfined zone while using reasonable S values, properly input, makes a substantial difference in low flow of streams

Storage coefficient of unconfined zone needs to be better measured in the field and properly input to MODFLOW

Storage Coefficients need to be included in the calibration process.

Stream conductance

- Units given in report were incorrect (m/d, should be m^2/d)
- A constant value of 1000 was used and not explained $C= KLW/b$

Steady State Calibration

- Steady State simulation used 4 time steps, only one is needed
- Unsubstantiated "steady-state" data for steady-state calibration
- Multi-level nature of observation data was not included in the model
- Parameter estimation process was not presented nor files provided
- Residuals exhibited spatial bias
- The guidance for effective model calibration of Hill and Tiedeman 2007 was not followed

Steady state and transient calibrations were not combined

Transient Calibration

- Initial conditions for transient simulation were not generated properly
- Only two transient calibration targets were used, transient head data were not used
- Transient calibration did not optimize the value of storage coefficient

Prediction sensitivities were not provided so we do not know which parameters influenced the predictions

Uncertainty in predictions was not presented

CONCLUSION

Given the importance of determining a safe and fair equal proportionate share, the model evaluation should be rigorous.

The model is not ready for use in making policy decisions until

storage coefficients have been properly measured and incorporated in the model

shortcomings outlined in previous slide are addressed