LEE ENGINEERING

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Pressure Front Calculation
Sinclair State B-3
Unit Letter O
Section 36
T-17-S, R-28-E

The Sinclair State B-3 was drilled to a depth of 2857' and abandoned by Donnelly Drilling in 1956. The well was plugged by pulling 319' of 8 5/8" casing, which was set at 560' with 25 sacks of cement and placing:

15 sacks of cement at 743'-783' (Base of salt)
10 sacks of cement at 580'-610' (Top of salt)
20 sacks of cement at 293'-349' (Across open 8 5/8 Csg.)
Cemented dry hole marker at surface

Melrose Operating desires to convert the Artesia Unit (AU) #18 to an injection well. The AU #18 lies within ½ mile of the Sinclair State B-3. There is question as to whether this well was adequately plugged to protect the fresh water zone, which is at 409'-420' according to the drillers report.

The following analysis has been performed using a Pressure Front Calculation presented in the Mathews & Russell Pressure Build Up Monograph #1. This equation calculates the pressure increase at a specific point in the reservoir, due to injection of incompressible fluid. The Texas Railroad Commission uses this calculation in similar situations. I have historically employed this calculation in formulating and presenting an analysis to the RRC, in situations where an operator requests injection into a formation but there is sketchy information available on offset plugged wells.

Melrose has one proposed injection well, the Artesia Unit #18, within ½ mile of the Sinclair State B-3. The input variables for the calculation are:

Permeability- No cores are available for wells in the Artesia Unit. A Roswell Geological Society Symposium report stated the average Artesia Field permeability is 90 md. For the purposes of this analysis, 45 md was used.

Injection Volume- The average injection rate of current wells is 300 BWPD. This would likely go down over time due to increased reservoir pressure.

Thickness- The reservoir thickness was determined by examining the log of the Artesia Unit #83, the closest well with modern logs. The reservoir thickness in this well is 36'.

Distance to Well- The distance between Artesia Unit #18 and the Sinclair State B-3 calculates to be 1875', based on footages of the well locations.

Porosity- The porosity was determined by examining the log of the Artesia Unit #83, the closest well with modern logs. The average porosity in this well is 11%.

Current Bottomhole Pressure- The bottomhole pressure was measured by shooting a fluid level in a nearby shut-in producer, the Artesia Unit #33.

Formation Volume Factor- This is estimated to be 1 for an incompressible fluid.

Viscosity- The viscosity of salt water is estimated to be .75. This is based on charts found in *Petroleum Reservoir Engineering* by Amyx, Bass and Whiting.

Compressibility- The estimated compressibility for salt water is .0000031. This is based on charts found in *Petroleum Reservoir Engineering* by Amyx, Bass and Whiting.

Time- Time is shown on the chart in years and in days. The pressures are shown at various time intervals, demonstrating how pressure increases as injection continues.

Formation PSI @ offset well- This is the calculated pressure at the Sinclair State B-3. After 20 years of injection the pressure would be 579 psi.

This analysis shows the pressure at the Sinclair State B-3 would be 579 psi after 20 years of injection into the reservoir interval requested. The shallowest injection interval will be the Loco Hills. This interval is at a depth of 2230' in the Sinclair State B-3. If the pressure after 20 years were 579 psi, it would be sufficient to raise a column of fluid 1232', assuming a .47 fluid gradient. The greatest height the fluid would reach is 998', which is the depth of the Loco Hills at 2230' minus the fluid column of 1232'. The fresh water is above 500', which the drillers report showed to be at 409'-420'. Based on this, the fresh water would not be affected by injection from the Artesia Unit #18.

This calculation results in a higher pressure than would be seen in reality because it assumes there is no production from the reservoir. The injected fluid will tend to move toward the areas of lower pressure. By producing the Artesia Unit #83, a pressure sink will be created in the reservoir causing the offsetting injected fluids to migrate in that direction. Also, it is assumed the injection rate of 300 BWPD would remain constant. The injection rate will probably decrease over time as reservoir pressure increases.

The results of this analysis are also presented graphically. The attached graph shows the reservoir pressure at the Sinclair B-3 increasing over time, the line marked with squares. The pressure needed to raise the fluid level to 500' is shown as a constant over time by the line marked by triangles. After 20 years of injection in the Artesia Unit #18, the reservoir pressure is only 579 psi, which is 234 psi less than what, is necessary to raise the fluid level to 500'.

Based on this analysis it is my conclusion and opinion the injection water from the Artesia Unit #18 will not adversely impact the freshwater in the Sinclair State B-3.

Sincerely,

Robert Lee

Robert Lee
TX PE #65821

PRESSURE FRONT CALCULATIONS -- FROM MATTHEWS & RUSSELL, 1967

Well:	Artesia Unit #18							
Offset Well:	Sinclair State B-3							
$P(R,T) = PI + ((162.6*Q*U*B)/(K*H)) * Log[(K*T)/(70.4*P*U*C*R*R)]$								
Where:				**Value Sets**				
Variable	**Symbol**	**Units**	**Source**	**1**	**2**	**3**	**4**	**5**
Permeability	K	md	Fld Data	45	45	45	45	
Volume	Q	Bbls/day	Given	300	300	300	300	
Thickness	H	ft	log	36	36	36	36	
Distance to Unplugged Well	R	ft	map	1875	1875	1875	1875	
Porosity	P	decimal	Log	0.11	0.11	0.11	0.11	
Current BHP	PI	psi	Meas	495	495	495	495	
Formation Volume Factor	B	decimal	Est	1	1	1	1	
Viscosity	U	cp	Calc	0.75	0.75	0.75	0.75	
Compressibility	C	psi^{-1}	Calc	0.0000031	0.0000031	0.0000031	0.0000031	
Time	T	years	Given	2	5	10	20	
Time	T	days		730	1825	3650	7300	0
Formation psi @ offset well =			**P(R,T) =**	**556**	**565**	**572**	**579**	**#DIV/0!**
Loco Hills Interval is about 2230' in Donnelly #3								
Max Pressure of 579# = 1232 feet of fluid								
Greatest Fluid Height reached = 2230-1232=998'								
Fresh Water is above 500' therefore the fresh water is not reached.								

Sinclair B-3 Pressure Front Calculation