MODFLOW Simulation of Pumping Test Data in a Fractured Sedimentary Rock Aquifer

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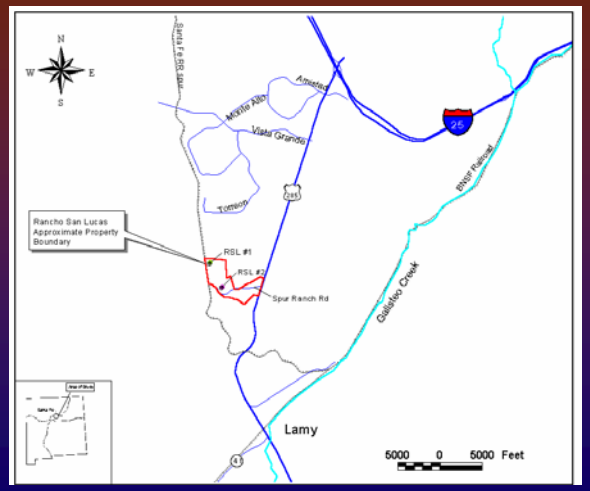
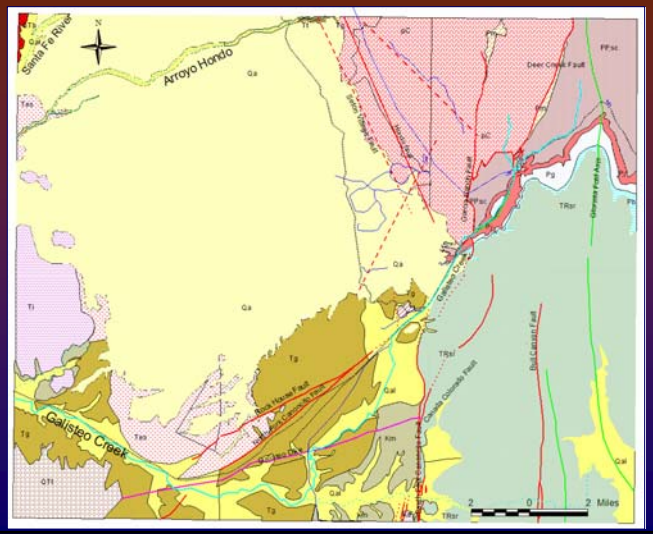
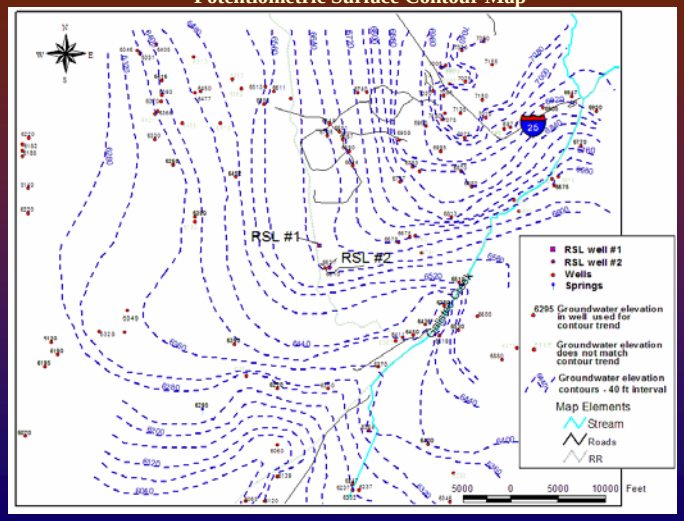
Site Location Map



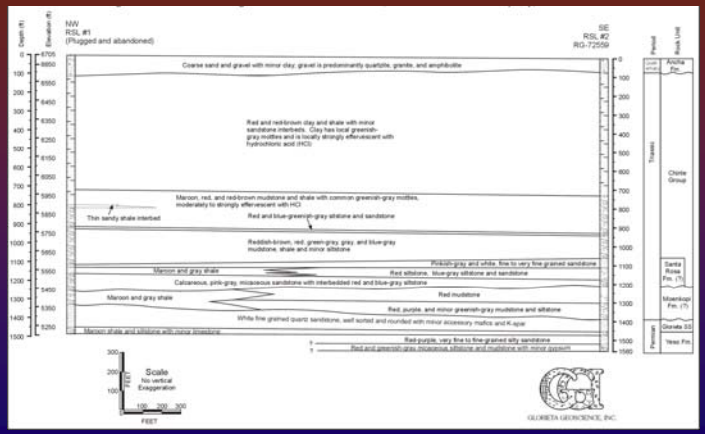
Generalized Geologic Map



Potentiometric Surface Contour Map

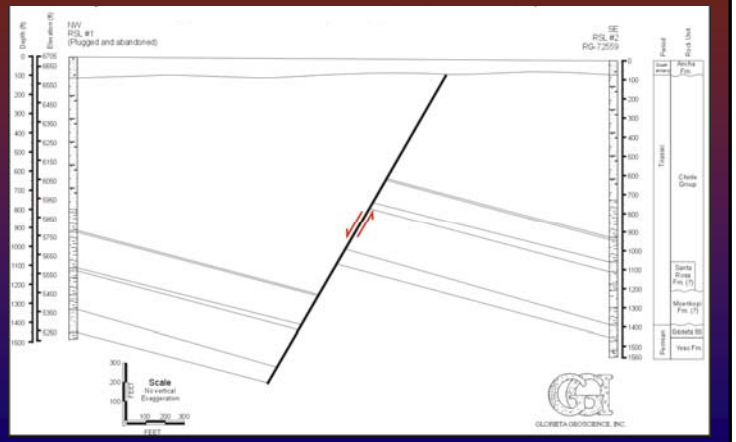


Correlation diagram from RSL#1 to RSL #2



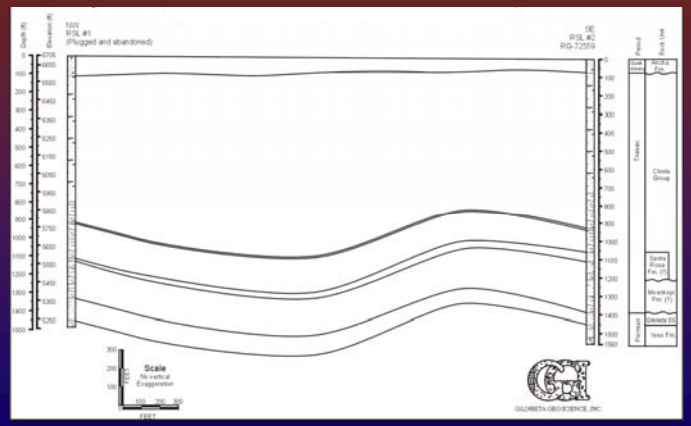
Schematic cross section from RSL#1 to RSL#2

Hypothesis 1: Buried fault reconciles dip of bedding with elevation of units in the wells

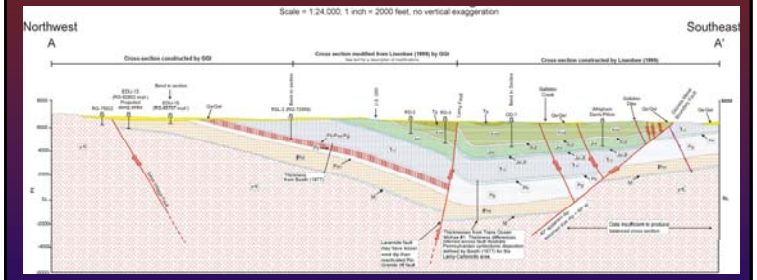


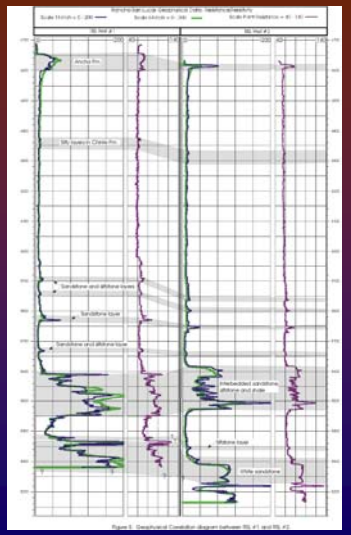
Schematic cross section from RSL#1 to RSL#2 (b)

Hypothesis 2: Buried folds reconcile dip of bedding with elevation of units in the wells

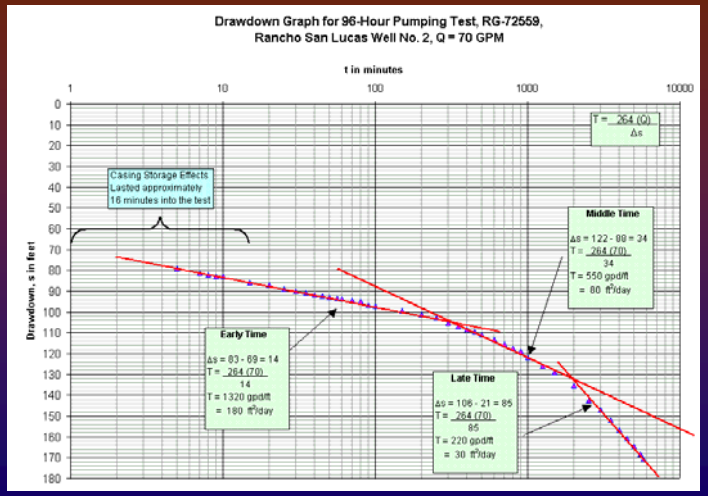


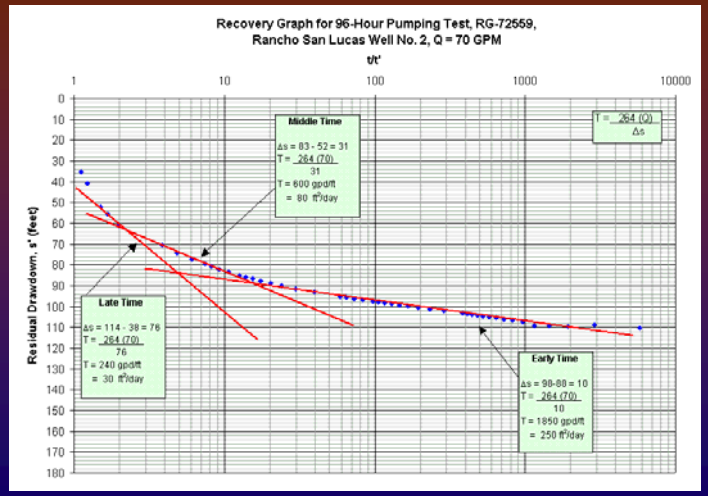
Generalized North-South Geologic Cross Section

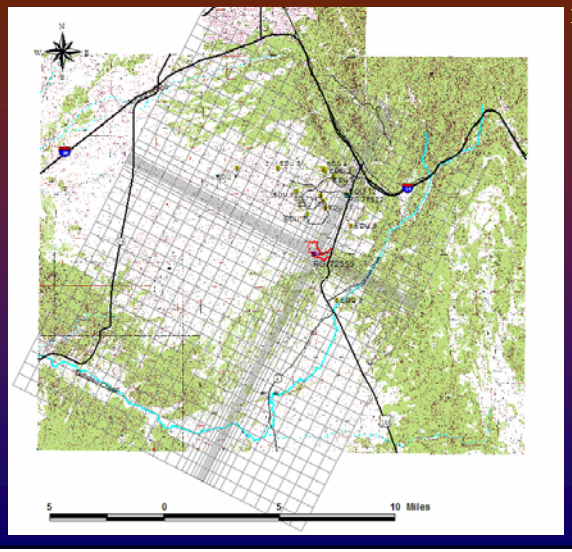




Rancho San Lucas Geophysical Data Correlation: RSL #1 and RSL #2





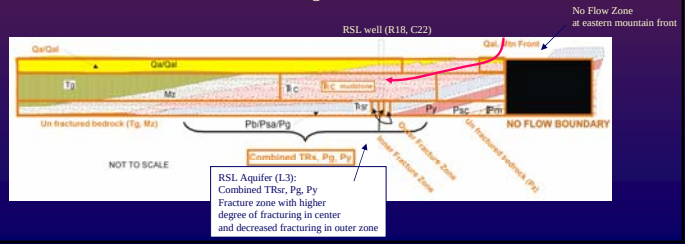


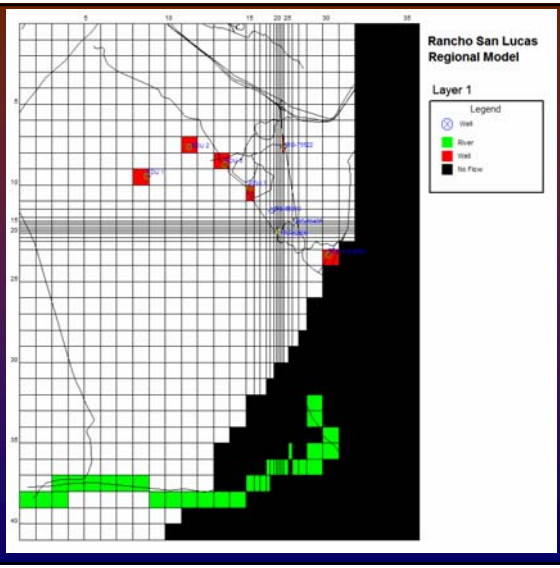
MODFLOW Model Grid

Schematic Cross sections of Model

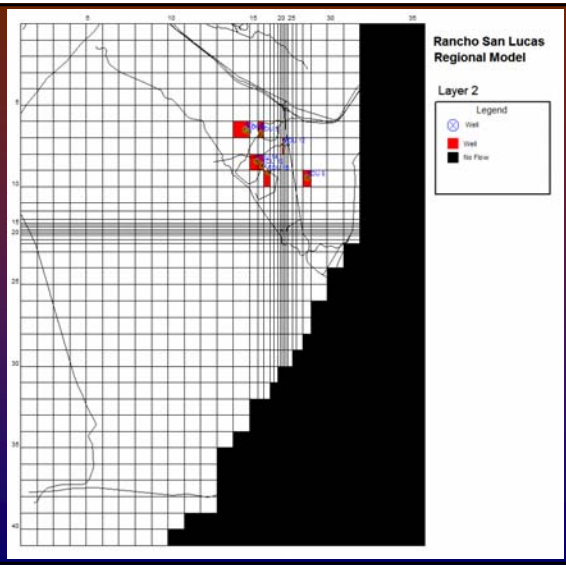
Northwest – south model schematic cross section through RSL well (based on Plate 1)

East-west model schematic cross section through Row 18 of the model at RSL well

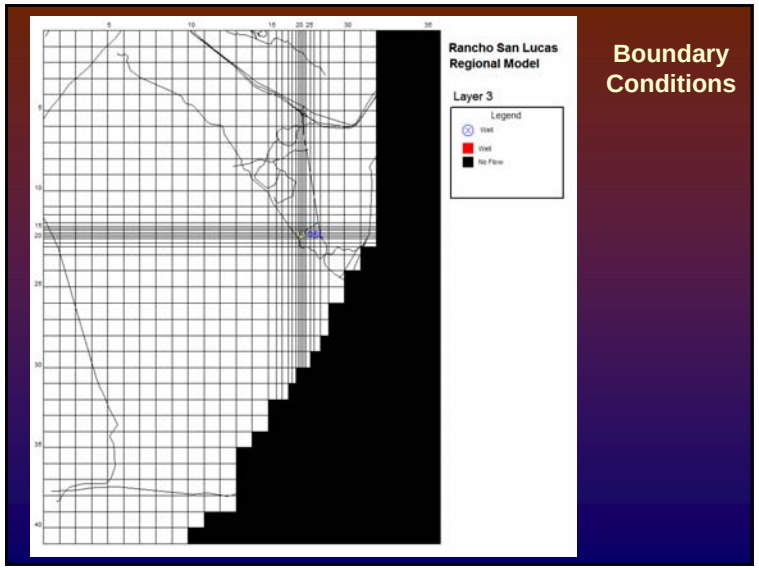


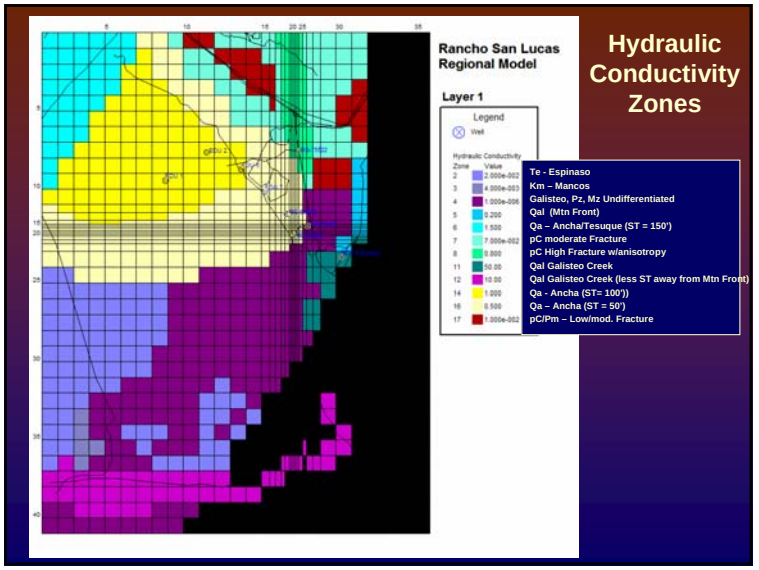


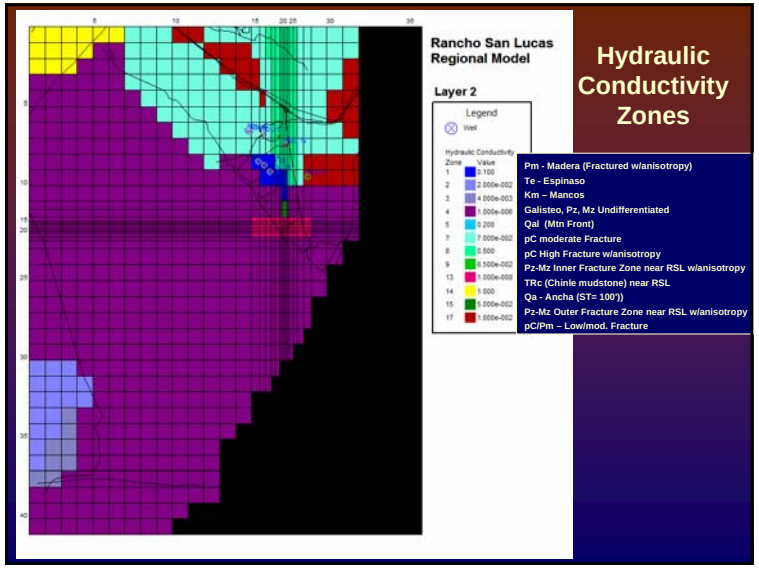
Boundary Conditions

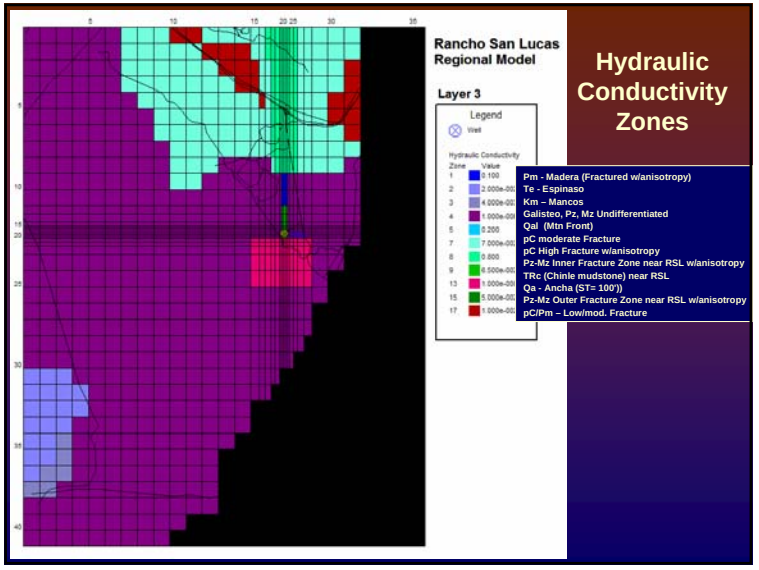


Boundary Conditions


Rancho San Lucas
Regional Model
Layer 3
Legend
Well
Well
No Flow
Boundary
Conditions


Rancho San Lucas
Regional Model
Layer 1
Legend
Well
Hydraulic Conductivity
Zone Value
Te - Espinaso
Km – Mancos
Galisteo, Pz, Mz Undifferentiated
Qal (Mtn Front)
Qa – Ancha/Tesuque (ST = 150')
pC moderate Fracture
pC High Fracture w/anisotropy
Qal Galisteo Creek
Qal Galisteo Creek (less ST away from Mtn Front)
Qa - Ancha (ST= 100'))
Qa – Ancha (ST = 50')
pC/Pm – Low/mod. Fracture
Hydraulic
Conductivity
Zones


Rancho San Lucas
Regional Model
Layer 2
Legend
Well
Hydraulic Conductivity
Zone Value
Pm - Madera (Fractured w/anisotropy)
Te - Espinaso
Km – Mancos
Galisteo, Pz, Mz Undifferentiated
Qal (Mtn Front)
pC moderate Fracture
pC High Fracture w/anisotropy
Pz-Mz Inner Fracture Zone near RSL w/anisotropy
TRc (Chinle mudstone) near RSL
Qa - Ancha (ST= 100'))
Pz-Mz Outer Fracture Zone near RSL w/anisotropy
pC/Pm – Low/mod. Fracture
Hydraulic
Conductivity
Zones


Rancho San Lucas
Regional Model
Layer 3
Legend
Well
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Zone Value
Pm - Madera (Fractured w/anisotropy)
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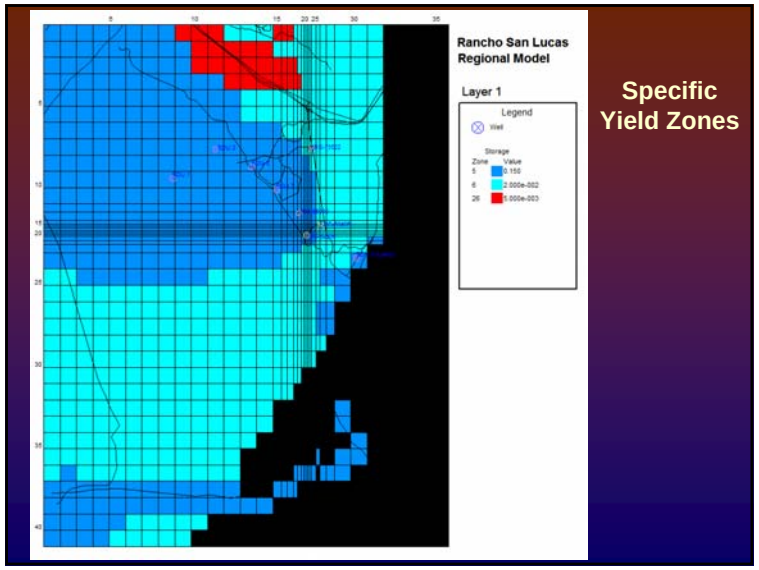
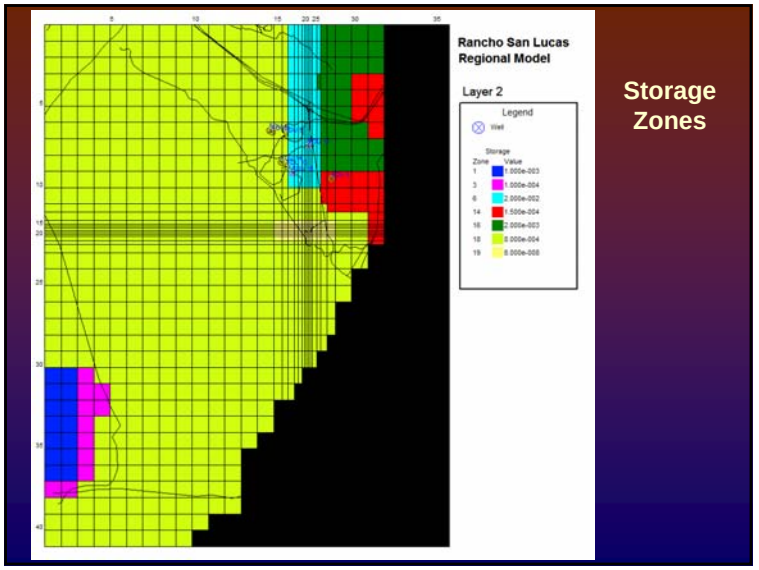
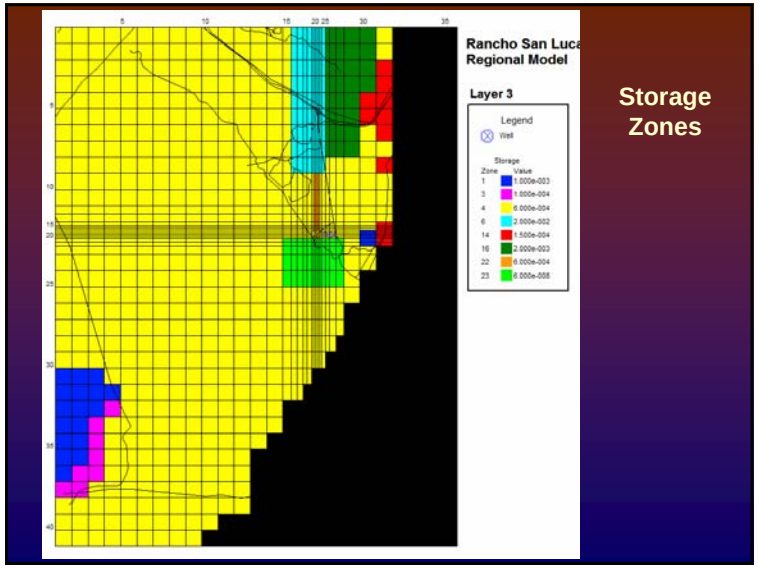
pC/Pm – Low/mod. Fracture
Hydraulic
Conductivity
Zones



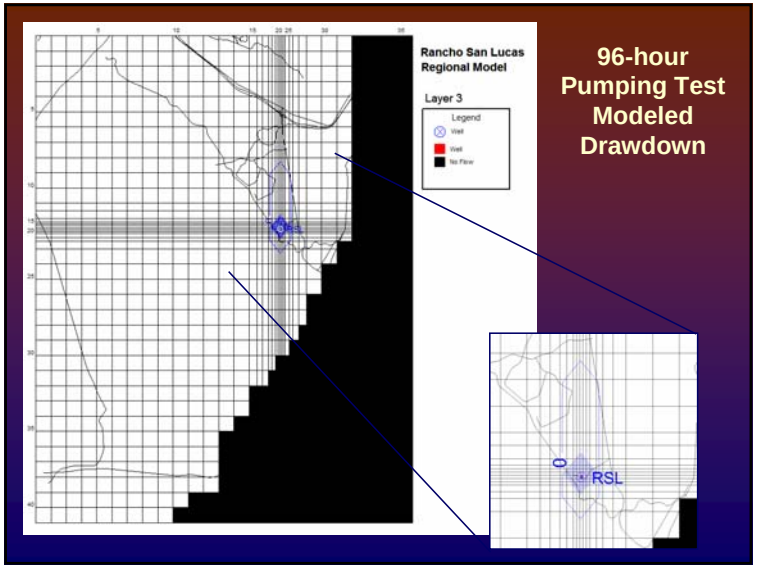
Specific Yield Zones



Storage Zones

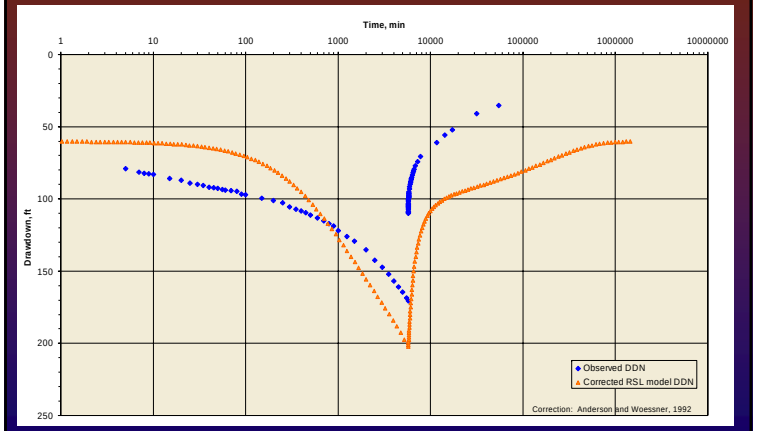


Storage Zones



96-hour Pumping Test Modeled Drawdown

Observed vs. Modeled Drawdown for 96-hour, 70-gpm Pumping Test at RSL #2



Well Drawdown Correction for Modeled Pumping Test

Anderson and Woessner, 1992
pg 146 - 151
Head (drawdown) correction for wells in Finite Difference Model

$$h_w = h_{i,j} - \frac{Q_{WT}}{2(pi)\,T} \ln\left[\frac{r_e}{r_w}\right]$$

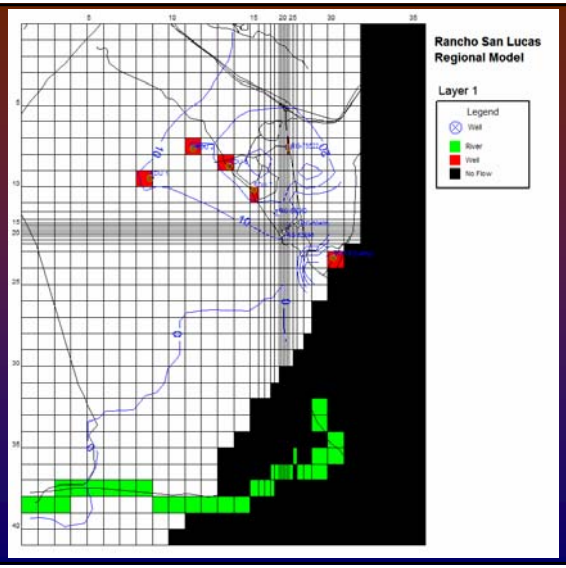
For a regular grid (x ® = y ©)

$r_e = 0.208\ a$
a = row or column width

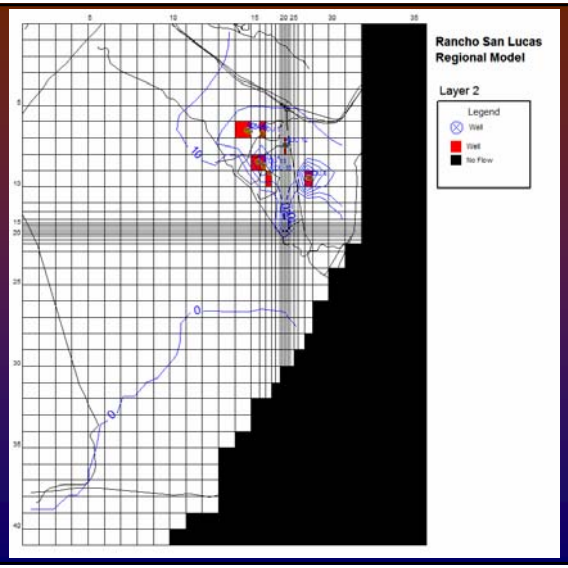
h_w = head in the well
$h_{i,j}$ = head computed by the finite diff model for the well node
r_e = radial distance, measured from the node at which head is equal to hi,j (effective block radius)
r_w = radius of the well
T = transmissivity
Q_{WT} = pumping rate of well

$h_{i,j}$ =	-141.91	ft	(negative #)
a =	375	ft	
r_e =	78	ft	$r_e = 0.208\ a$
r_w =	0.5	ft	
T =	180	ft^2/day	
Q_{WT} =	13475.7	ft^3/day	(positive #)

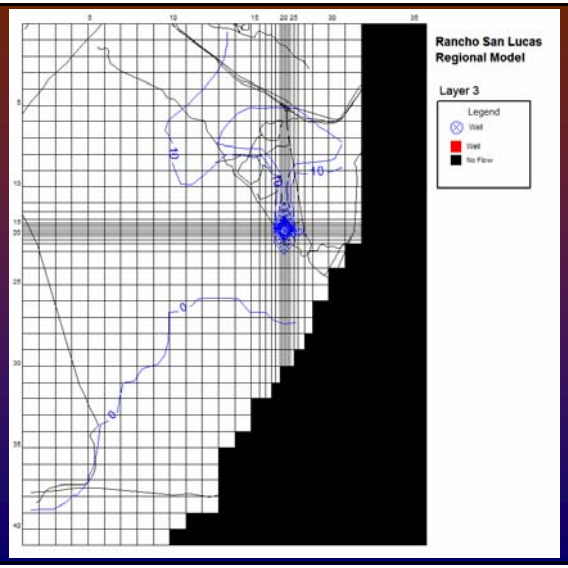
h_w =	-202.1	ft
Drawdown =	202.1	ft



100 Year Drawdown Contours



100 Year Drawdown Contours



100 Year Drawdown Contours

Off-site Effects After 100 Years of Pumping

	Eldorado Utilities (EDU) wells				
Well Name	EDU 1	EDU 2	EDU 3	EDU 4	EDU 5
W/RSL pumping	12.23	21.27	29.06	30.37	26.24
W/out RSL pumping	12.20	21.17	28.72	30.05	25.78
Effects from RSL pumping (subtract bottom from top row)	0.04	0.10	0.34	0.31	0.46

Well Name	EDU 6	EDU 7	EDU 8	EDU 9 (Lamy)	EDU 12
W/RSL pumping	23.16	25.92	104.47	46.25	25.00
W/out RSL pumping	22.84	24.86	103.58	46.25	24.36
Effects from RSL pumping (subtract bottom from top row)	0.32	1.06	0.89	0.00	0.64

Well Name	EDU 13	EDU 14	EDU 15
W/RSL pumping	42.20	51.20	31.43
W/out RSL pumping	41.42	50.56	30.46
Effects from RSL pumping (subtract bottom from top row)	0.78	0.64	0.96

	Off-site Commercial	nearby Off-site Domestic		
Well Name	RG-75522	RG-62896	RG-60406	RG-65040
W/RSL pumping	25.18	11.20	0.05	16.39
W/out RSL pumping	24.51	8.75	0.03	13.33
Effects from RSL pumping (subtract bottom from top row)	0.67	2.46	0.01	3.07

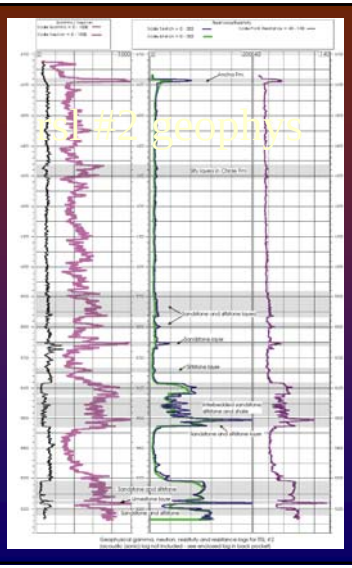
Drawdown Effects After 100 Years of Pumping
(in Feet of Drawdown in the Well)

On-site Effect After 100 years of Pumping

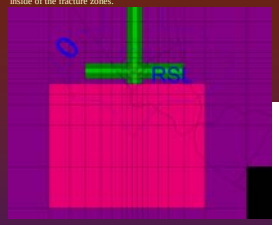
Well Name	RSL
W/RSL pumping	192.17
W/out RSL pumping	14.77
Effects from RSL pumping (subtract bottom from top row)	177.40

Conclusions

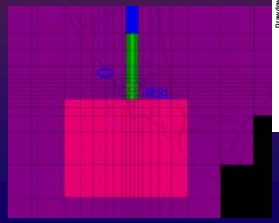
- The Rancho San Lucas Well is capable of providing a 100-year supply for the proposed subdivision
- The anisotropic groundwater model is a conservative estimate of on-site and off-site effects of pumping



Change model construction by adding ~EW higher T zone to represent bedding plane fracture orientation parallel to strike and ~EW arroyo (Old Ranch Road). This construction places all of the RSL property inside of the fracture zones.



Original Model configuration in Layer 3 with ~NE oriented Higher T zone



Pumping Test Curve showing observed data in blue diamonds, the original model pumping test reconstruction in orange triangles and the EW zone model version reconstruction in pink squares. Note that the newer model version fits the shape of the observed pumping test data better than the older model, but still overestimates the total drawdown and recovery time.