Analytic Element Modeling of Transient Saltwater Interface Response in A Layered Freshwater Lens Aquifer

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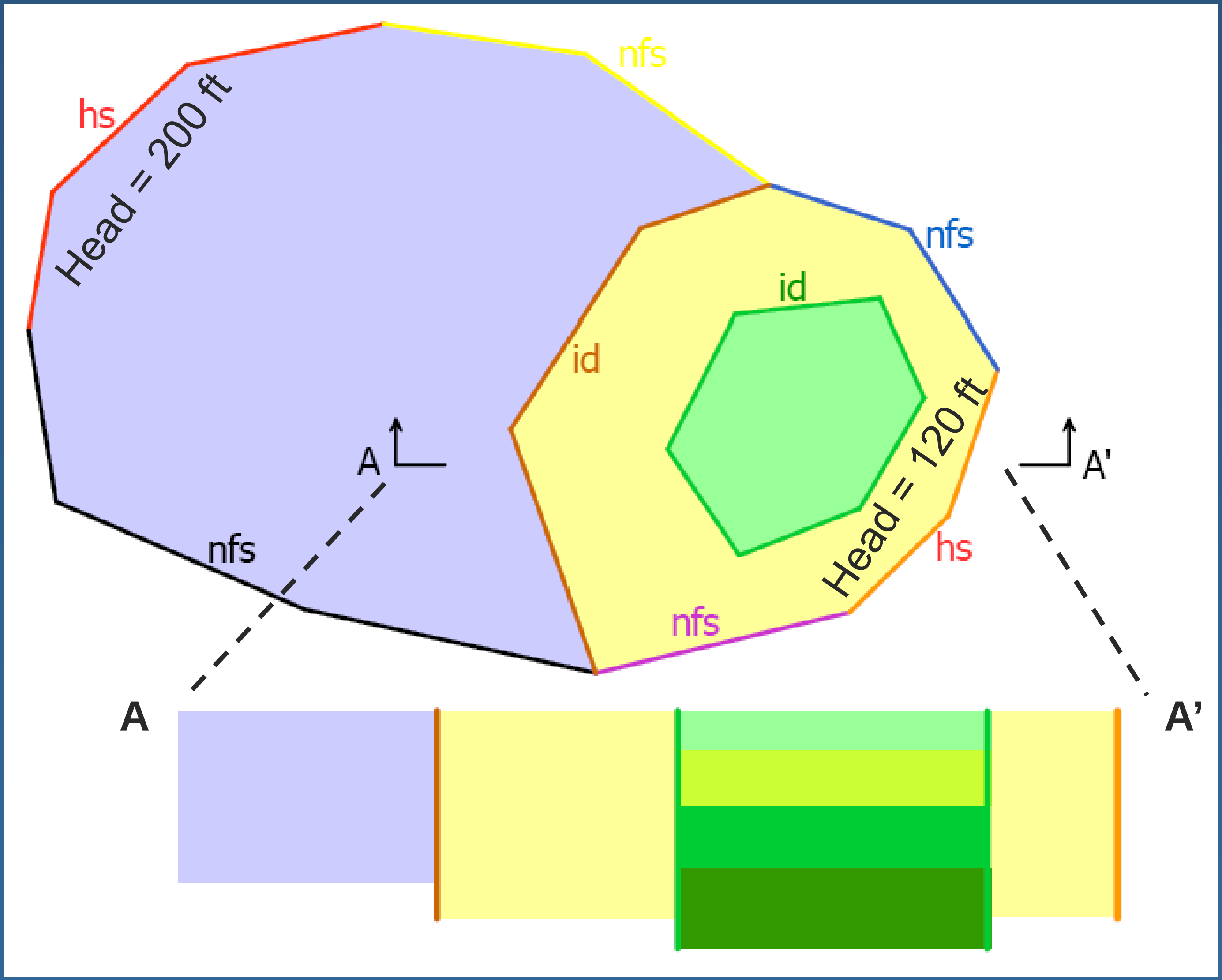
AnAqSim

- Subdomain method – Fitts 2010
- Incorporates certain methods of Strack, Haitjema, Jankovic, Barnes and others
- Isotropic or anisotropic flow
- Multiple layers (can abut single layer areas)
- Fully transient flow (FD solution for storage)
- Saltwater interface solution

Subdomains

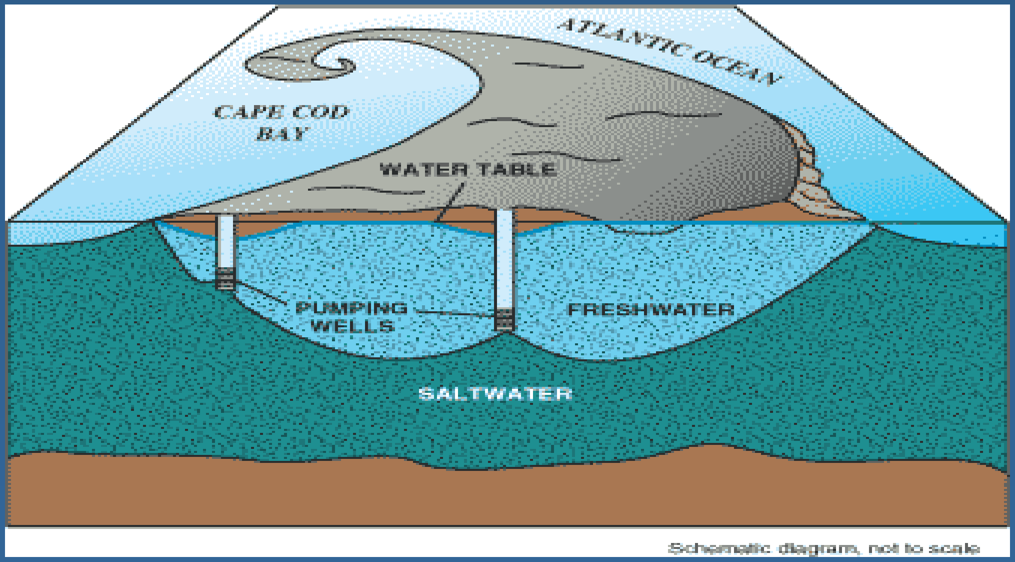


AnAqSim Elements

- Constant head & specified flux linesinks
- No-flow line boundaries & barriers
- River linesinks (with “dry up” capability)
- Areas with differing K, base elev, and recharge
- Wells:
    - single layer or multiple layer
    - discharge or head specified
    - steady or transient pumping

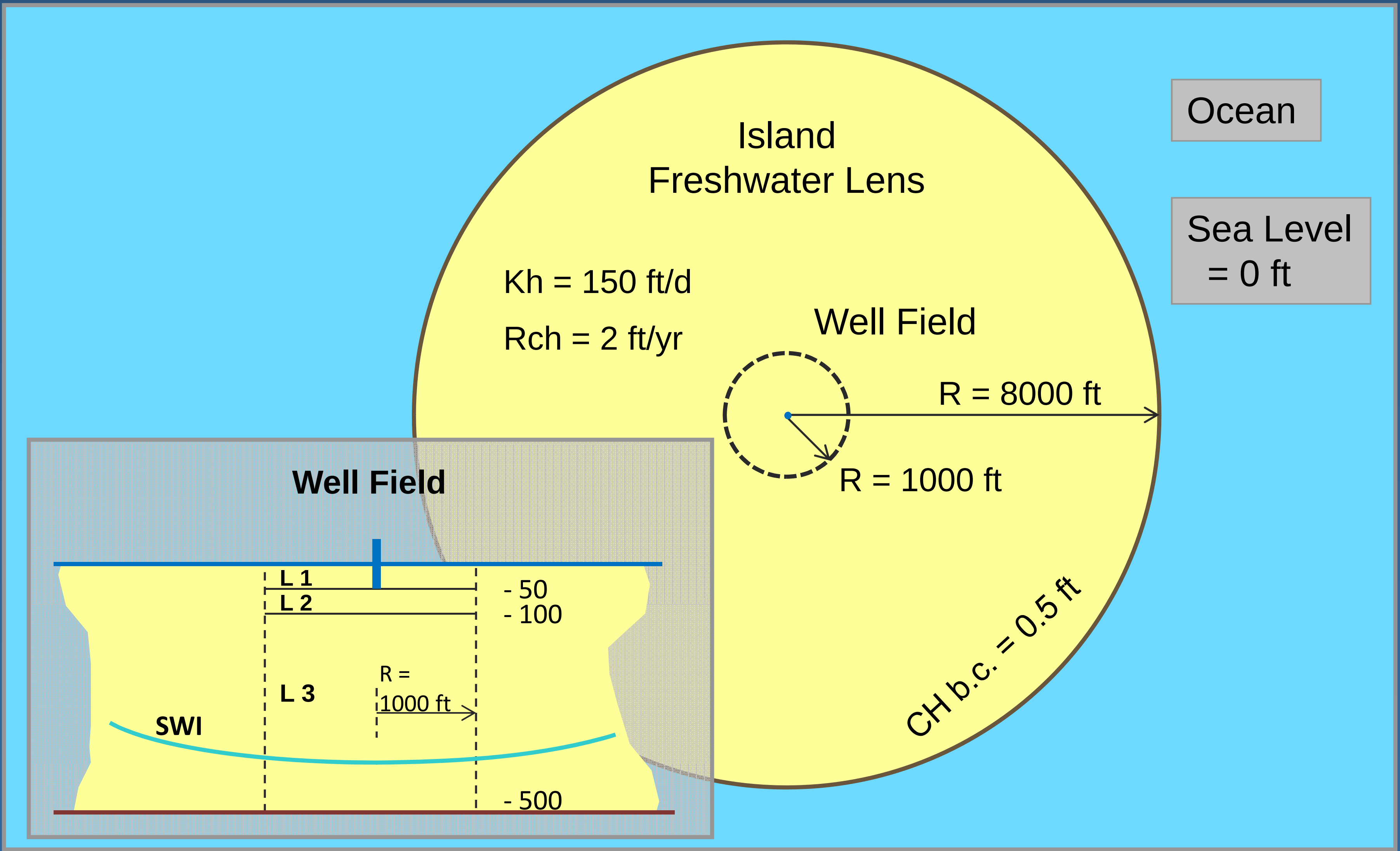
Saltwater Upconing

- Upconing beneath a shallow partially-penetrating pumping well



Source: USGS http://pubs.usgs.gov/gip/2005/13/index4.htm

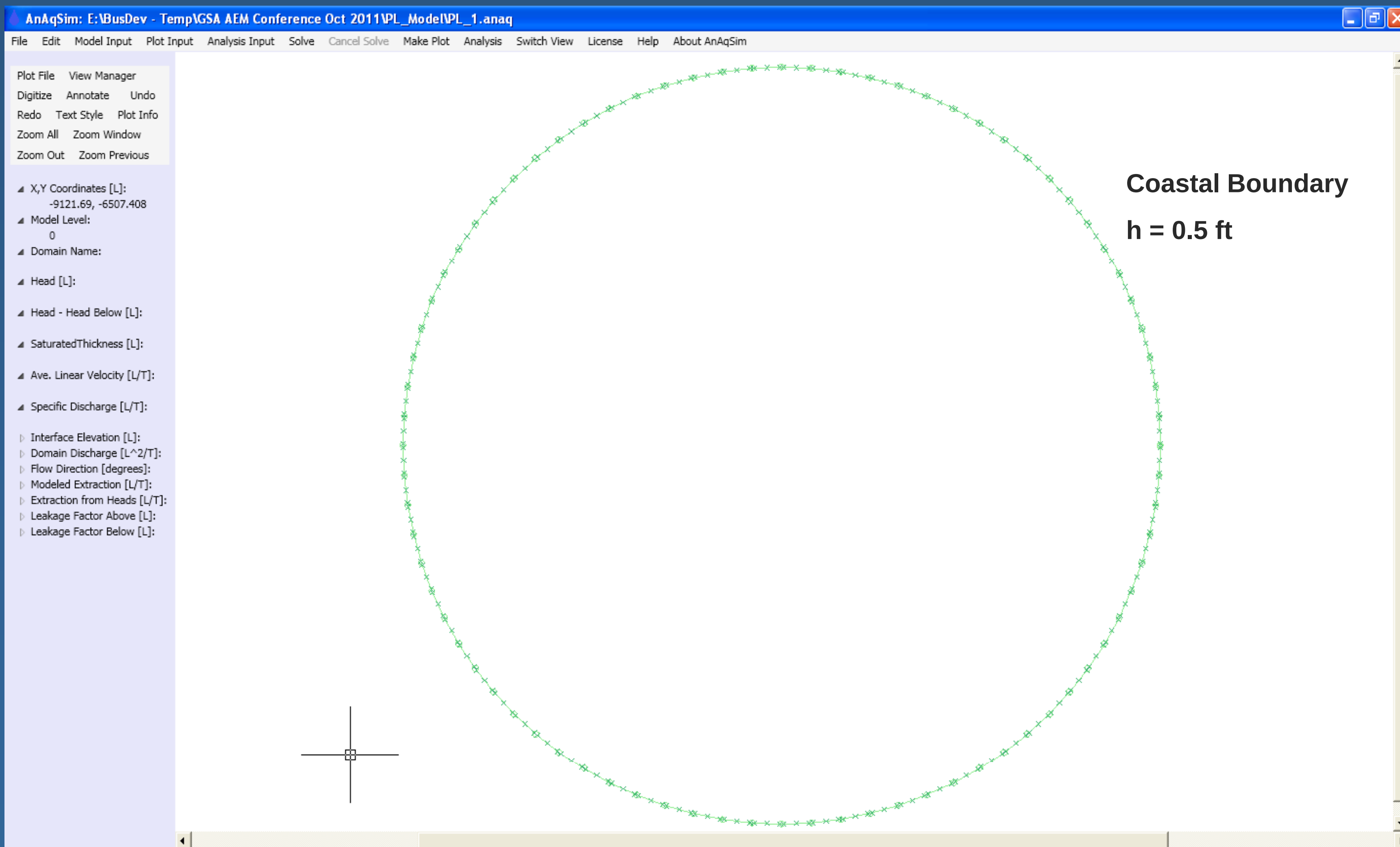
Upconing Example Model



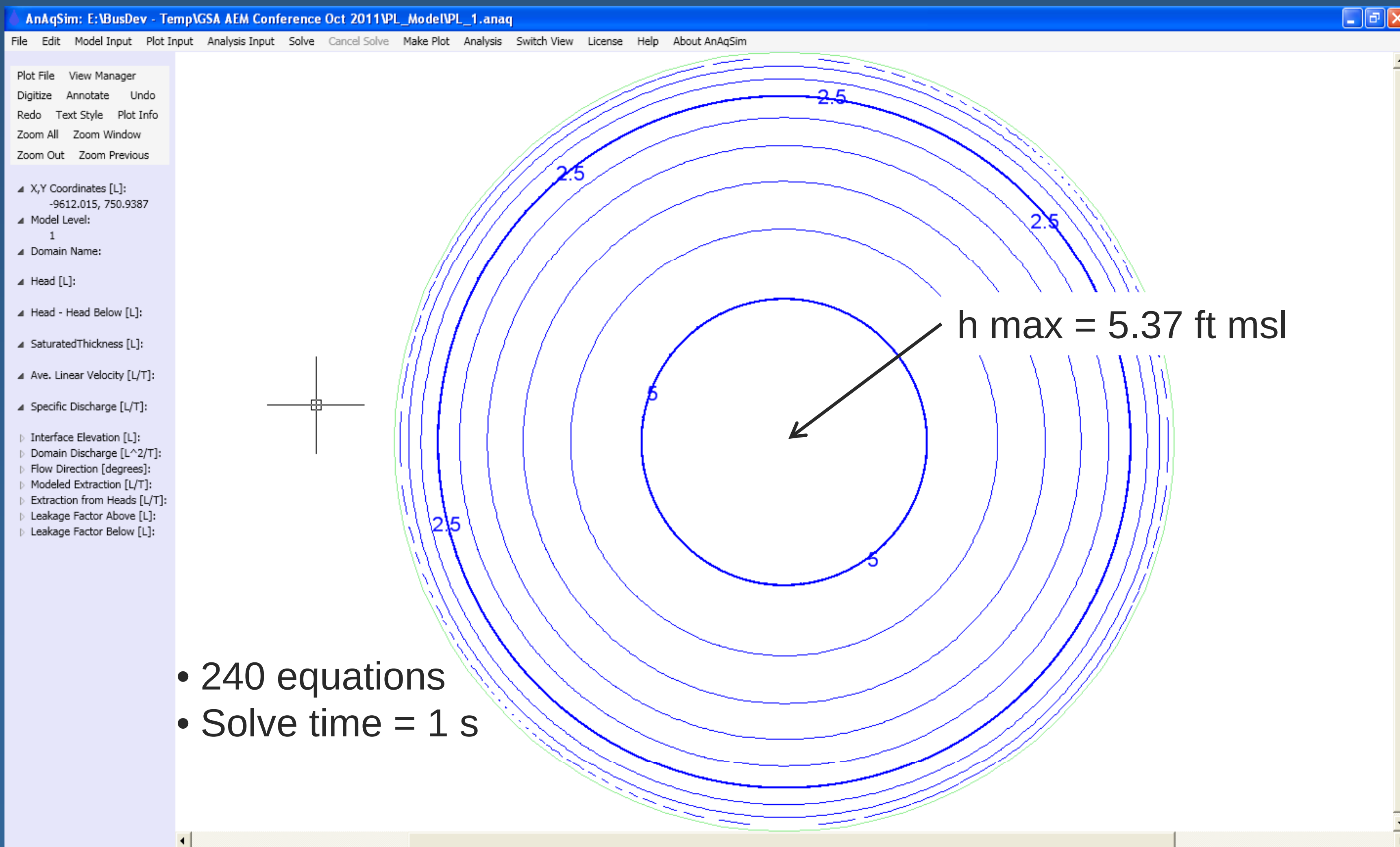
Base Case – Single Layer Lens

- Base Case 1: No pumping
- Base Case 2: Pumping from a fully penetrating well
  - o Q = -40,100 ft^3/d (300,000 gpd)

AnAqSim FW Lens Boundary

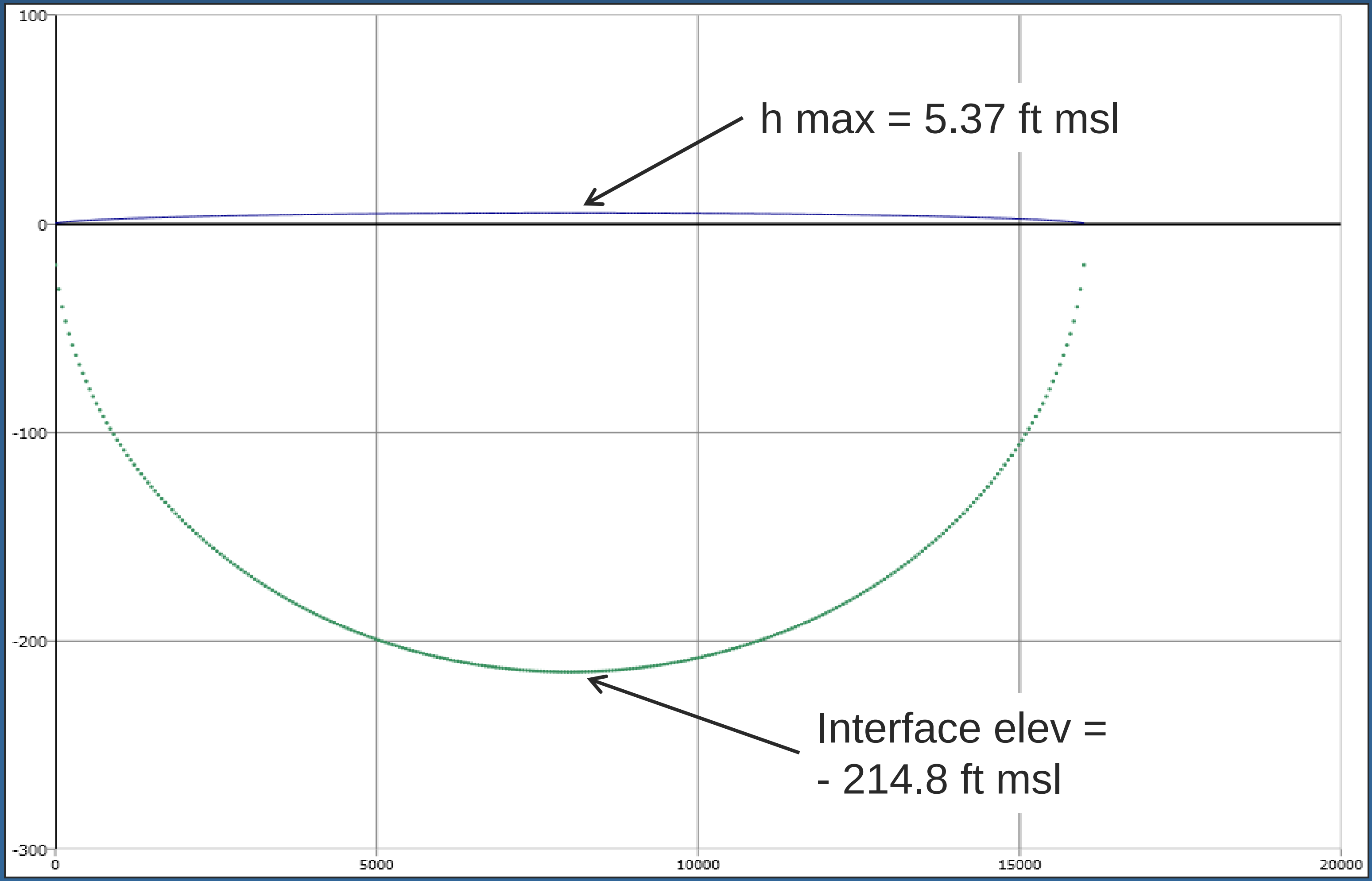


FW Lens Solution - Plan View

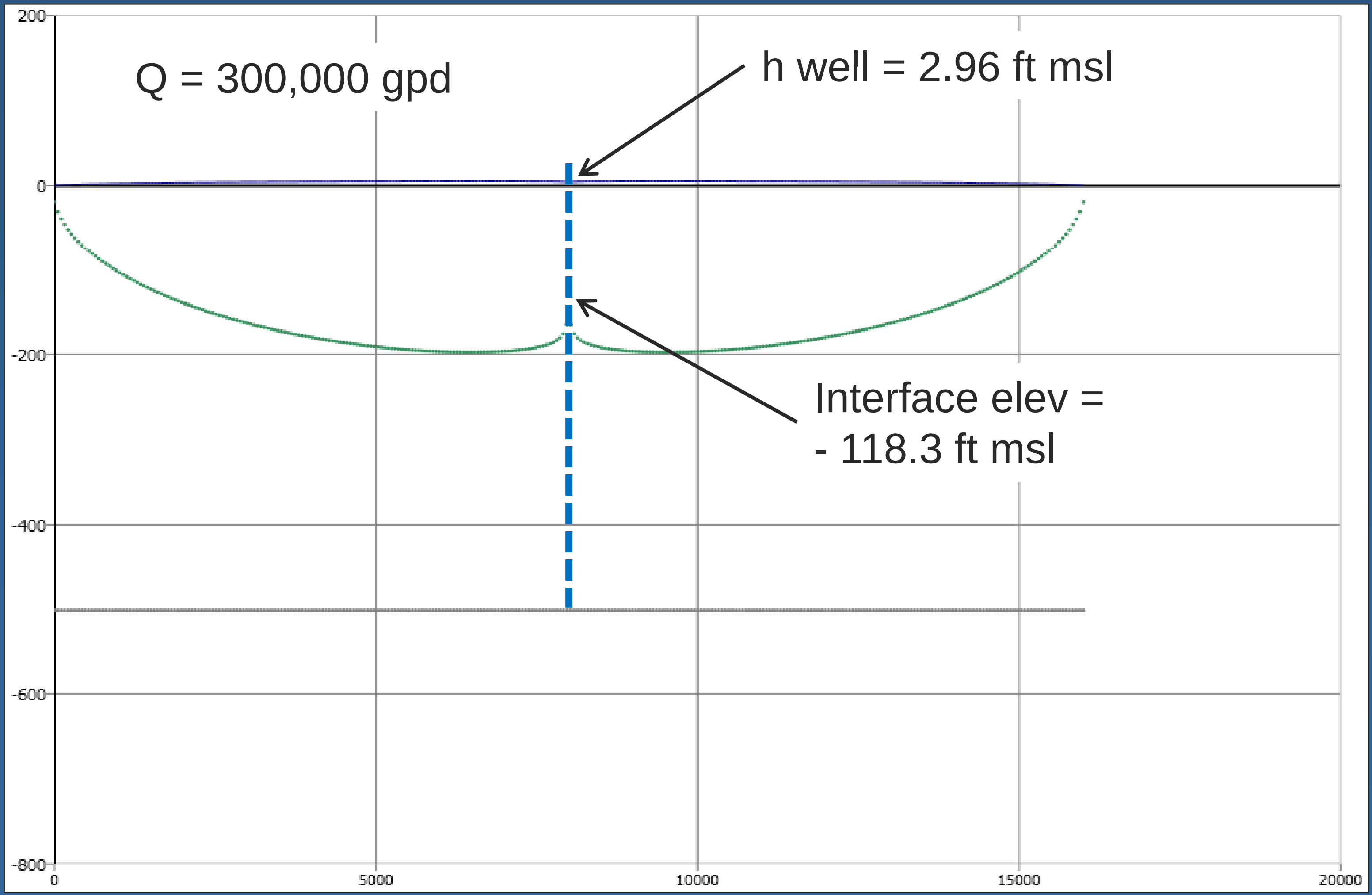


- 240 equations
- Solve time = 1 s

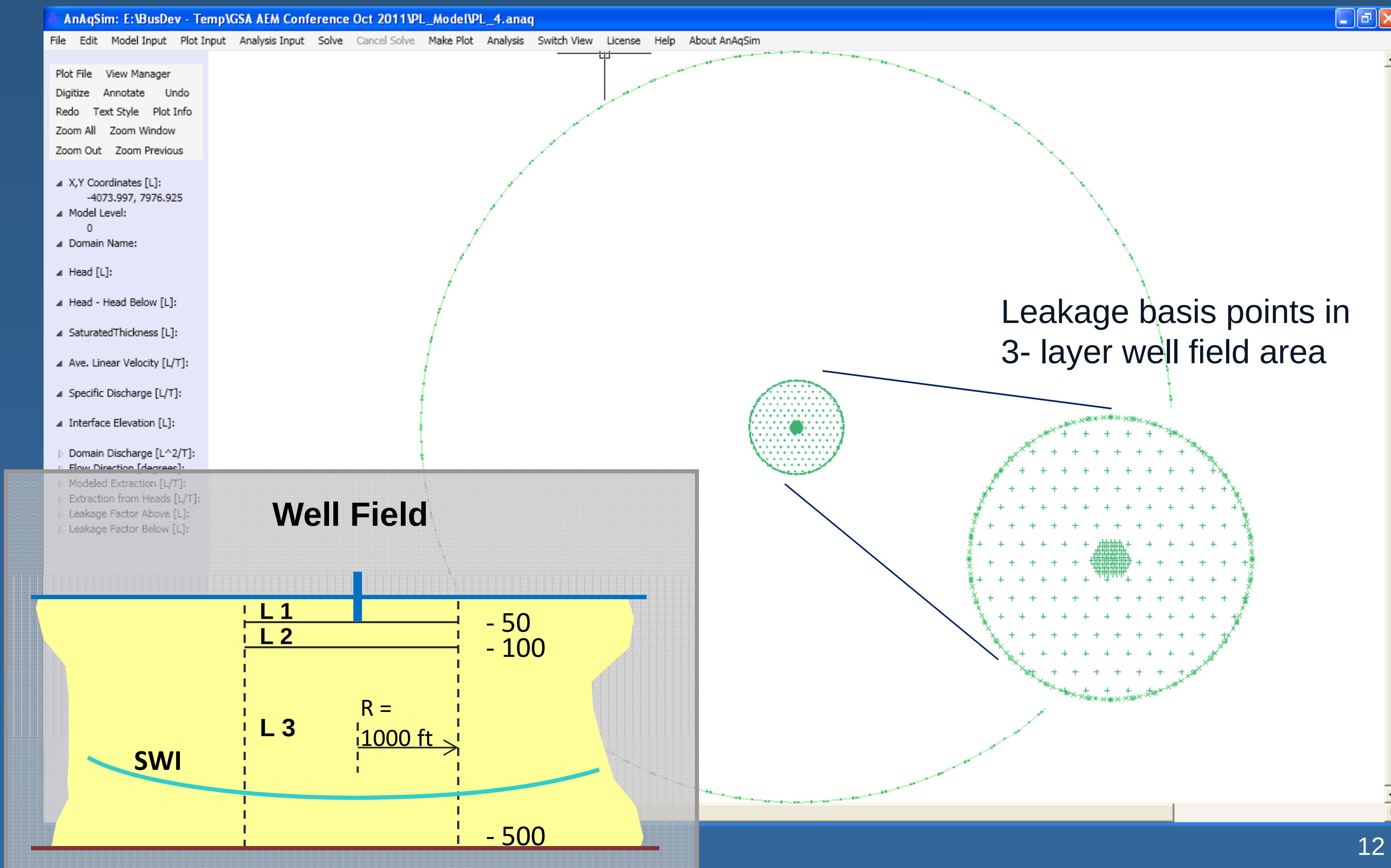
Base Case 1:
FW Lens Solution - Cross Section



Base Case 2:
Fully Penetrating Well Single Layer



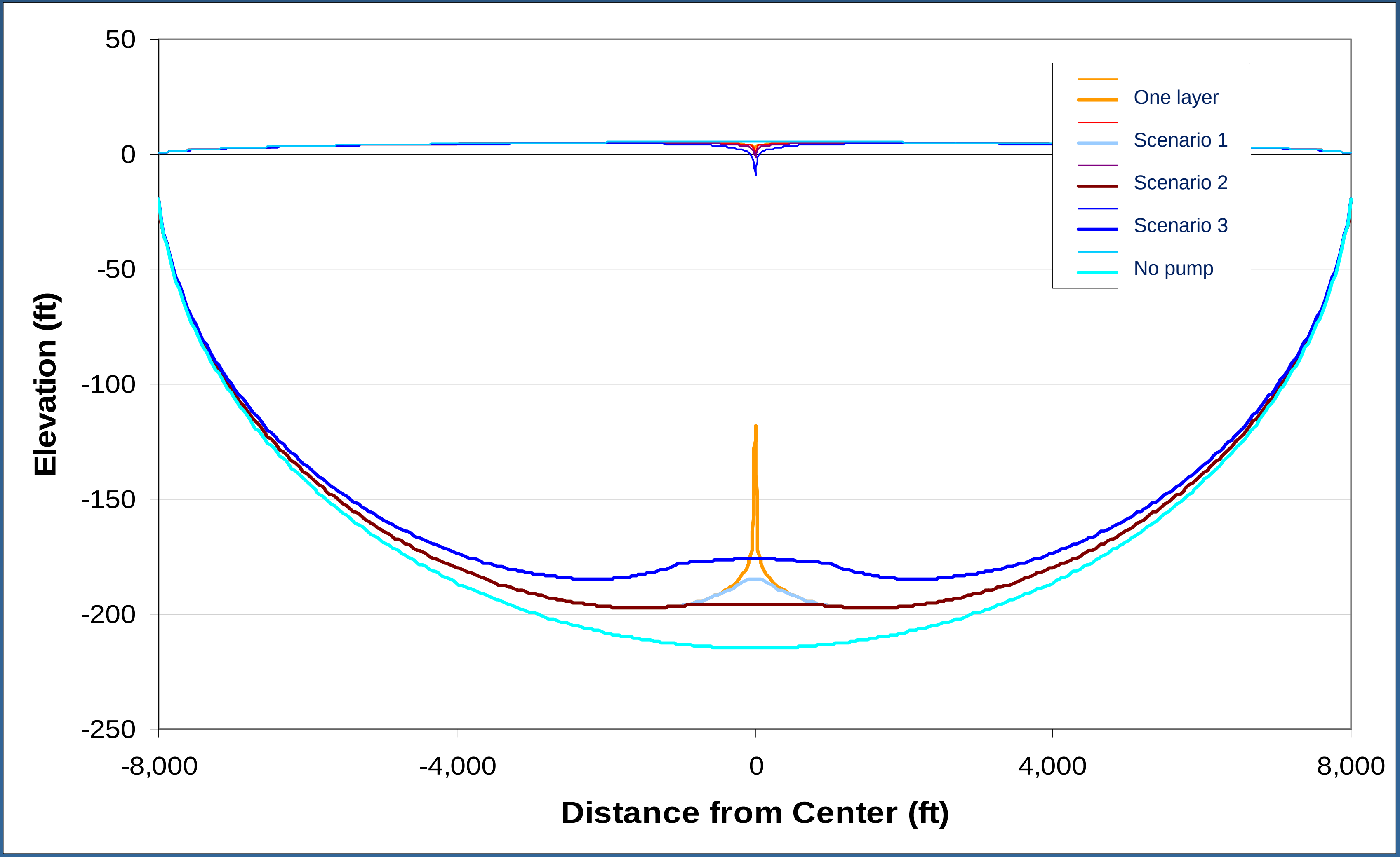
3-Layer Well Field Area with Partially Penetrating Well



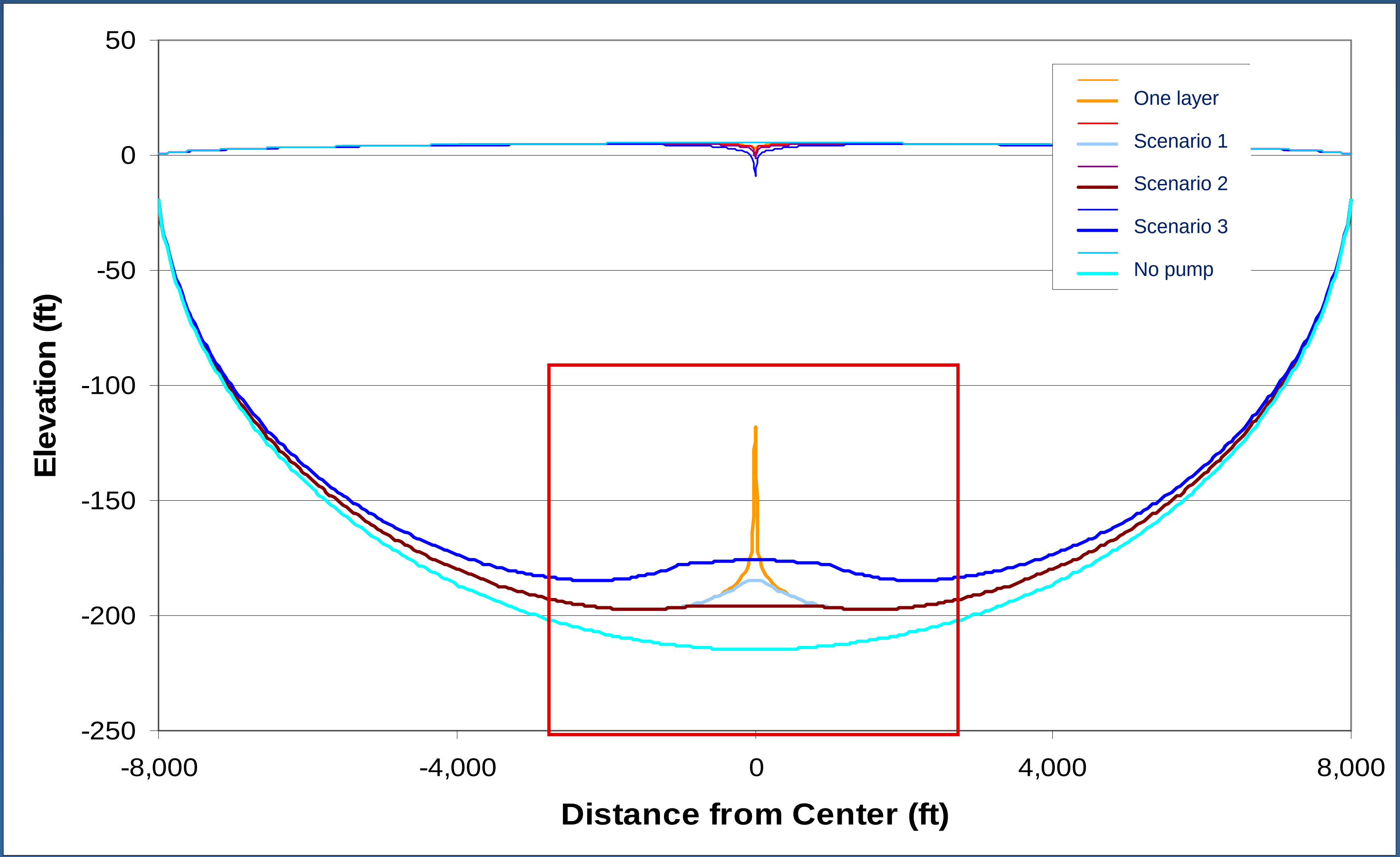
3 SWI Analyses

Scenario	Geology	Pumping (Layer 1 only)
1	Homogeneous geology – Layers 1, 2 & 3 – Kh = 150 ft/d; Kv = 30 ft/d	300,000 gpd
2	Layer 2 Low K – Kh = 3 ft/d; Kv = 0.1 ft/d	300,000 gpd
3	Layer 2 Low K – Kh = 3 ft/d; Kv = 0.1 ft/d	600,000 gpd

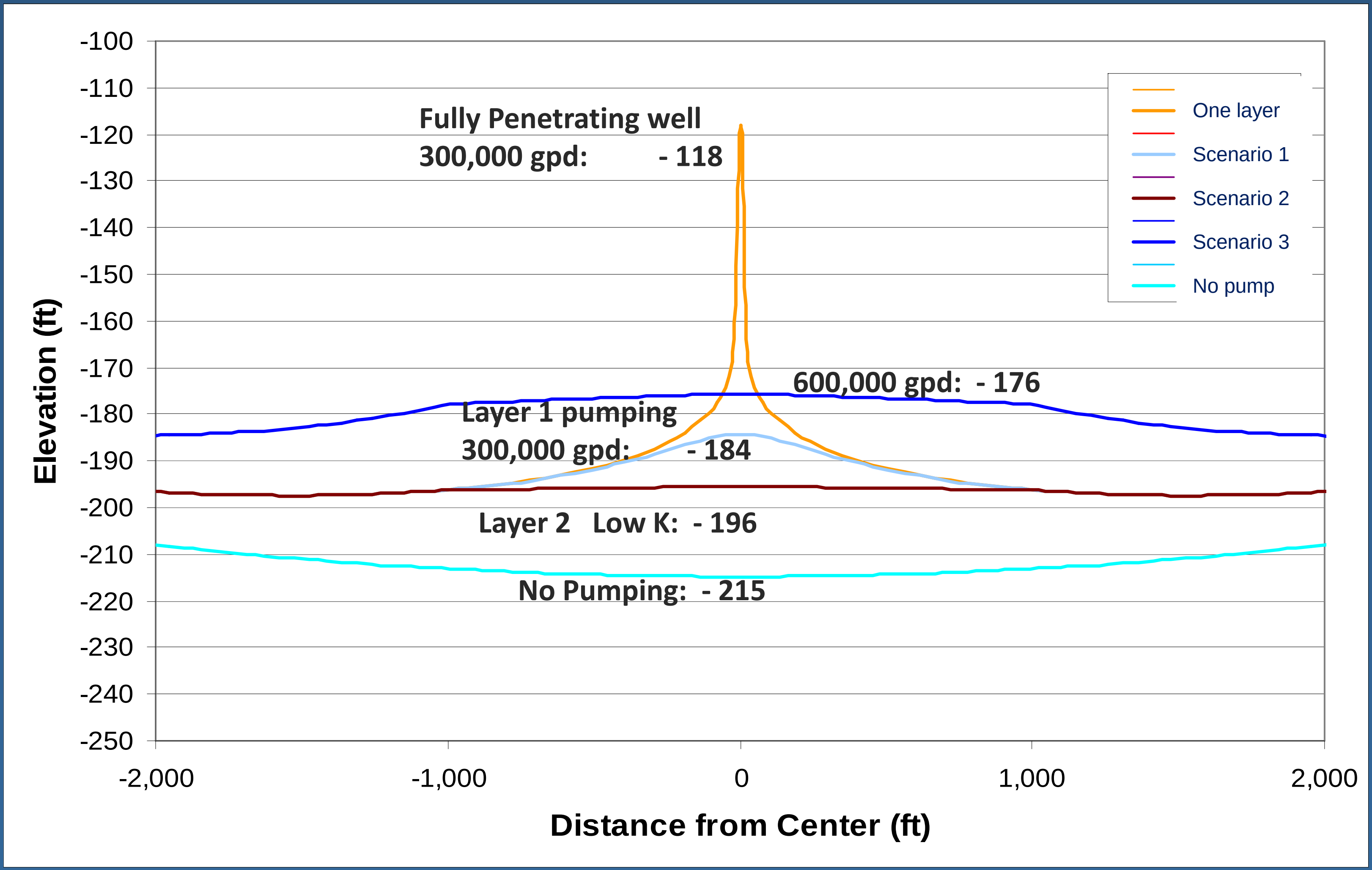
Upconing Analysis Summary



Upconing Analysis Summary



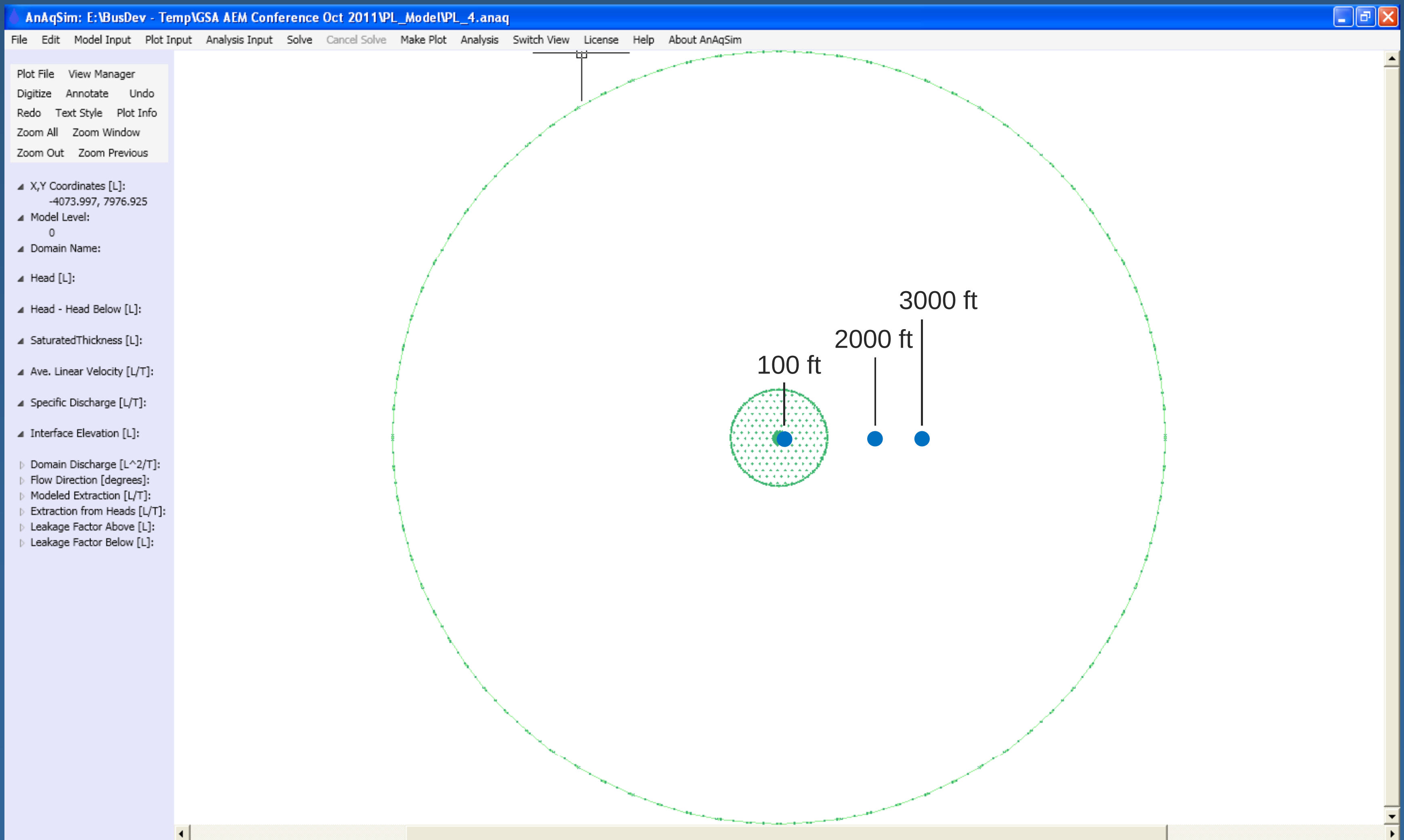
Upconing Analysis Summary



Transient Upconing Model

- Pumping from Layer 1;   Q = 600,000 gpd
- Aquifer storage sensitivity analysis
  - 3 scenarios: Low, med, and high storage
- 20-year transient simulation; 20 time steps (time step multiplier 1.2)
- Solve time = 3 min

Transient Observation Well Locations

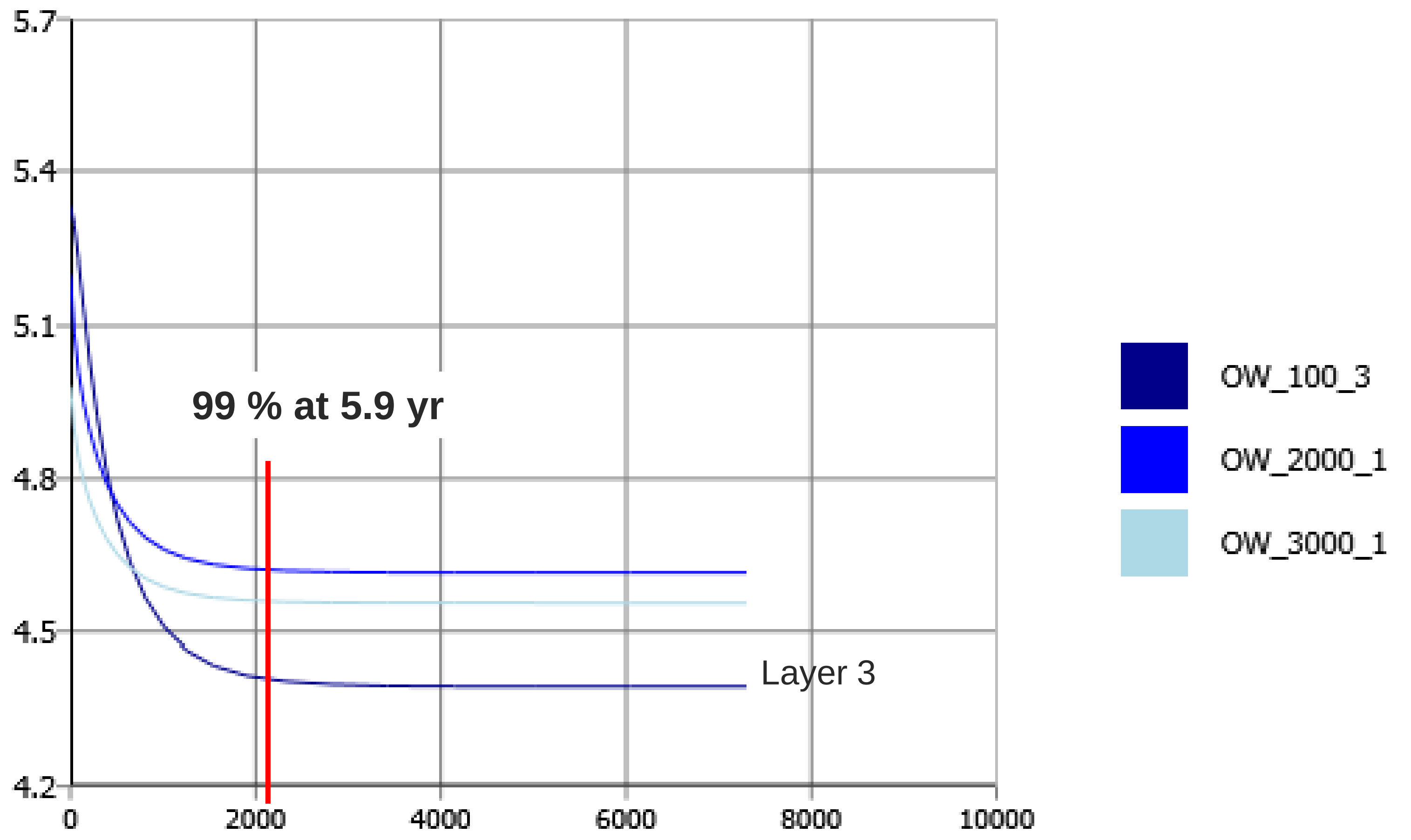


Storage Scenarios

		Storage Coefficient			
Scenario	Porosity	FW Lens	WF L1	WF L2	WF L3
Low	0.20	0.15	0.15	0.0001	0.00001
Med	0.35	0.25	0.25	0.001	0.0001
High	0.50	0.35	0.35	0.01	0.001

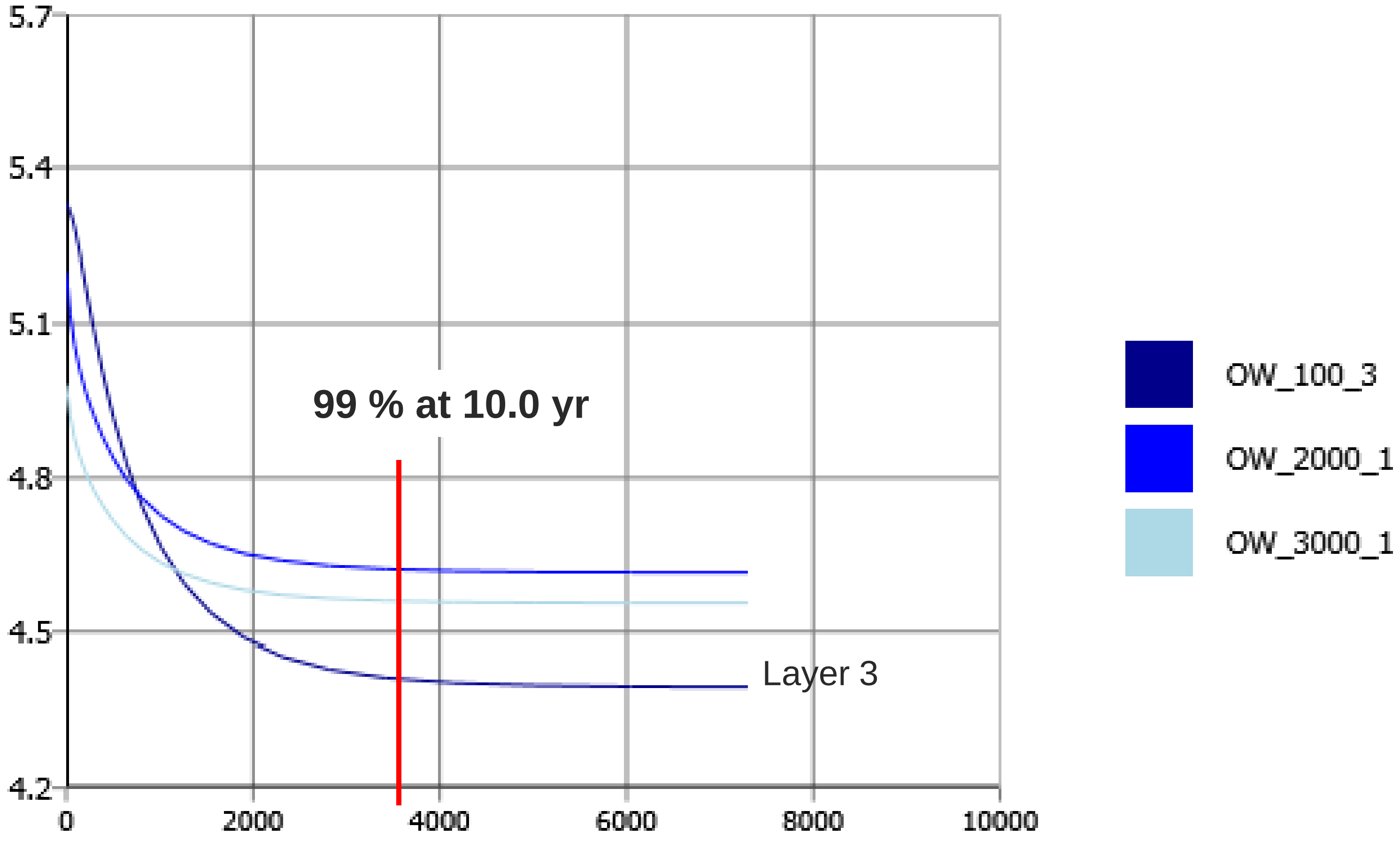
Transient Model Results

Low Aquifer Storage



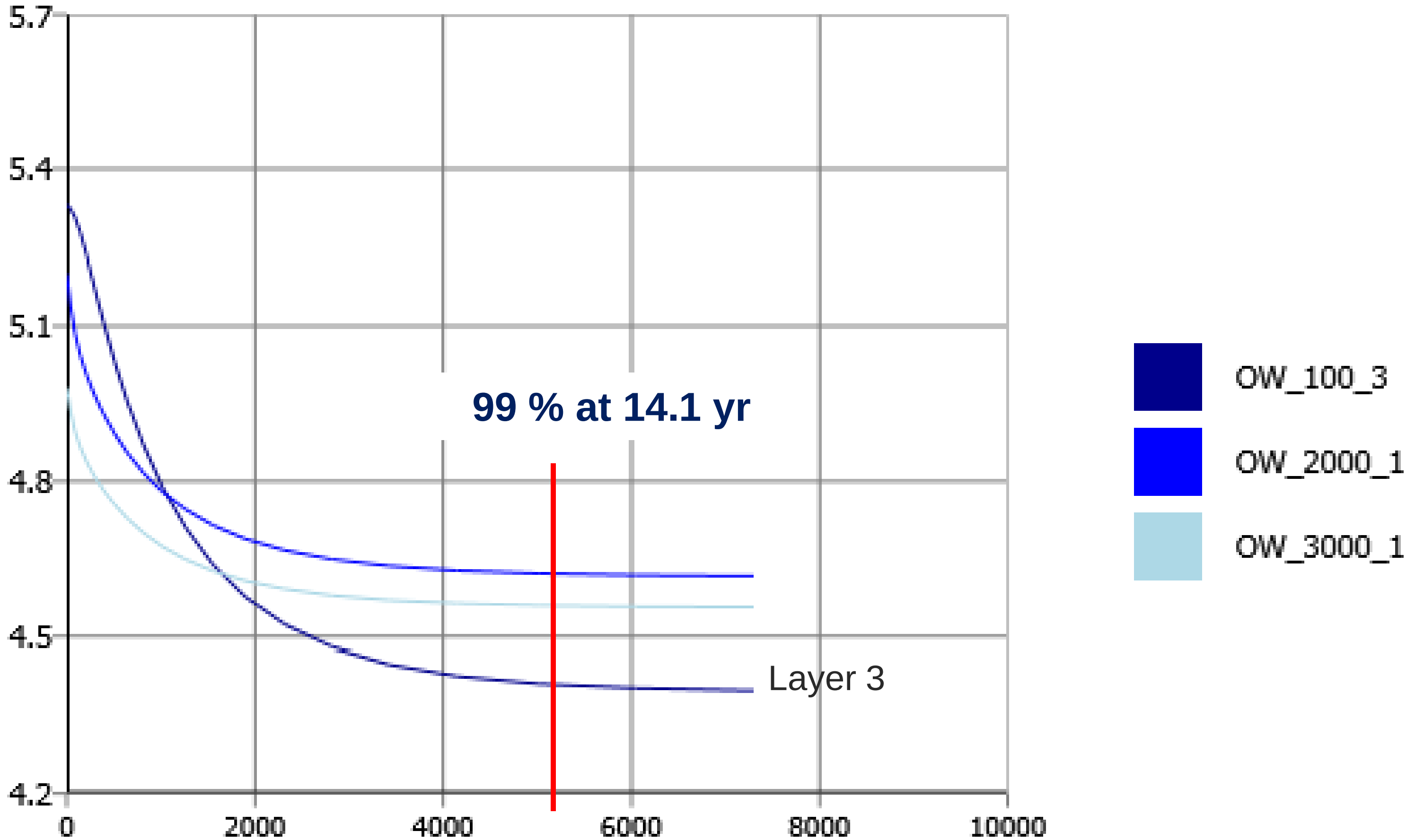
Transient Model Results

Medium Aquifer Storage

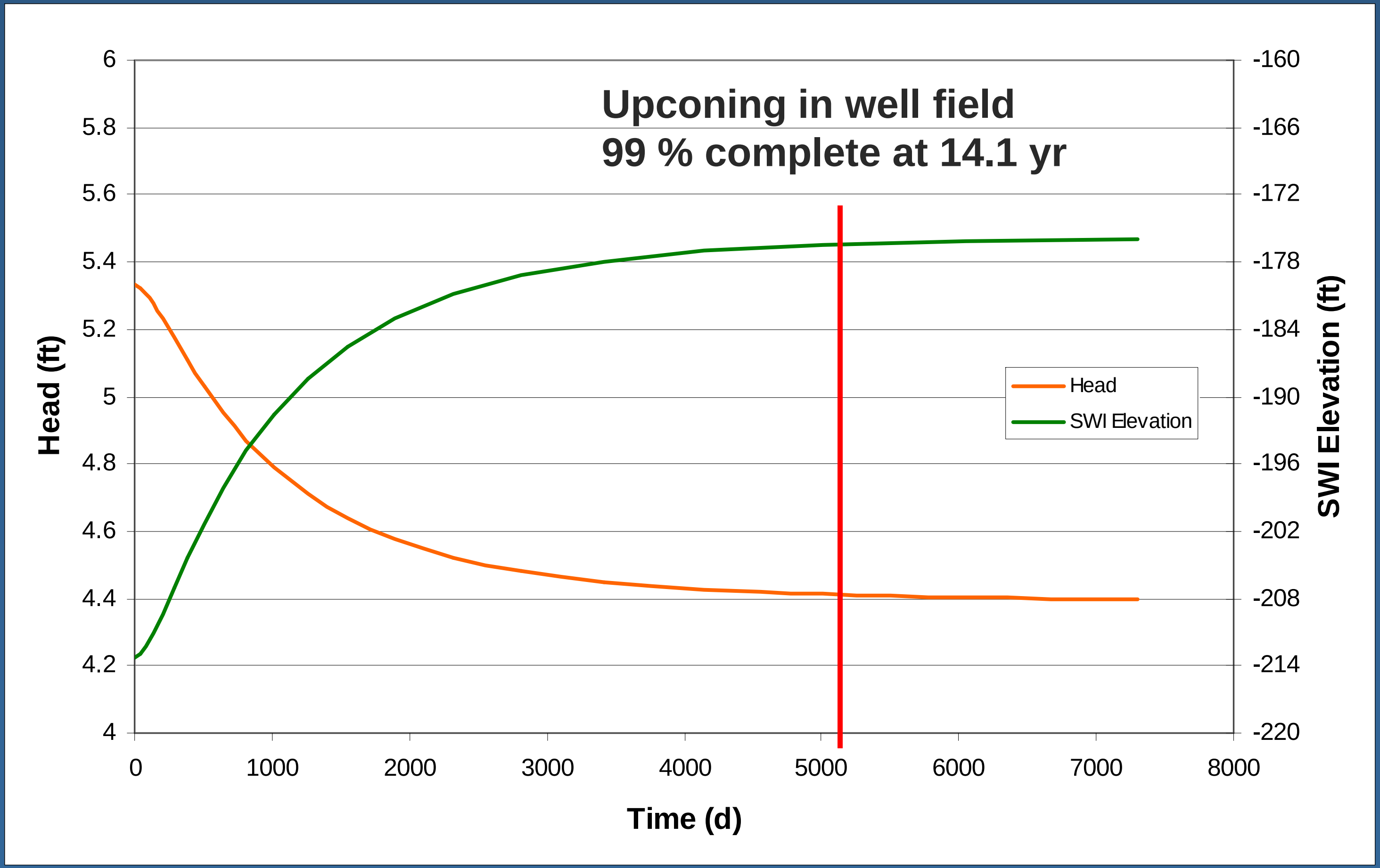


Transient Model Results

High Aquifer Storage



Transient Upconing
High Aquifer Storage



Conclusions

- AnAqSim provides ease and accuracy of AEM plus anisotropy, layers, transient, etc.
- Limited to small to moderate size problems
- Saltwater interface solution is a valuable tool for exploring potential well field sites and examining aquifer parameter effects
- AnAqSim SWI solve times are much quicker than density-dependent model solutions

END