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# Integration of Geologic and Geophysical Data to Model Hydrologic Processes Beneath a Recharge Pond

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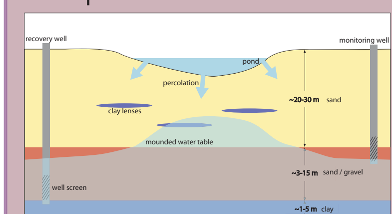
## Background and Motivation

The Harkins Slough Recharge Pond (HSRP) near Watsonville, CA, is part of a local artificial storage and recovery project. The HSRP was developed to mitigate saltwater intrusion resulting from excessive groundwater pumping by replenishing the unconfined aquifer over which it lies. Filtered storm-flow run-off is diverted to the pond during the winter, allowed to percolate into the underlying aquifer, and recovered in the summer when demand for agricultural water deliveries is highest. The pond faces two operational challenges. The first is a decrease in the infiltration throughout the winter, reducing the amount of water recharged to the aquifer. The second is a recovery rate of less than 25%. Operators require clearer understanding of the hydrologic processes governing movement and storage of water below the pond.

As part of that effort, we have developed a structural model of the HSRP using advanced visualization software. ( We have elected to use Schlumberger's PETREL software for this study.) Integrating geophysical and hydrologic data using the visualization software allows an understanding of the impacts subsurface structure on flow behavior above what could be achieved examin. Transferring this information into a multiphase flow simulator, we model the predicted flow below the pond over 12 months. Flow simulations for this research were run using Schlumberger's ECLIPSE software.

## Conceptual Model

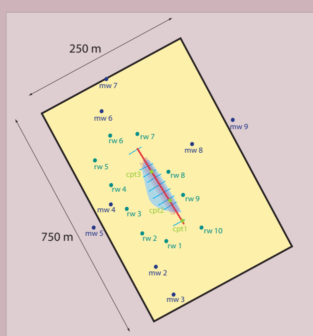


(after Haines et al., 2008)

Prior to data collection, the conceptual model of the HSRP was an unconfined aquifer of sands and gravels, possibly with small clay lenses, underlain at ~50 m by a thick clay layer. The water table was expected to mound during percolation, and the recovery wells to draw water from the high permeability gravel layer that overlies the clay aquitard.

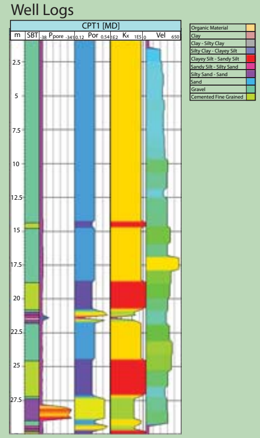
## Data Acquisition

- Model Boundary
- Recharge Pond
- Monitoring Well: water table elevations on 15 min intervals
- Recovery Well: lithology logs, production rate on hour intervals
- Cone Penetrometer Test (CPT) Log: soil behavior type, pore pressure, and shear wave velocity logs
- 2m Core Transect: 10 transects, lithology descriptions
- Ground Penetrating Radar: 11 lines, 225-300 m, 250 MHz PulseEkko survey
- 2D Shear Wave Seismic: 300 m line with 3-m geophone spacing, 100 m line with 1-m geophone spacing inset



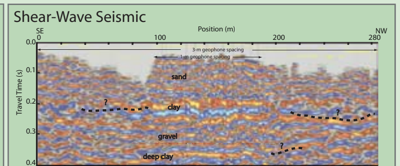

## Data Assimilation

### Well Logs



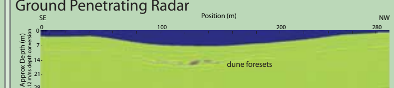
Original soil behavior type (SBT), pore pressure, and velocity data from CPT log 1. Porosity and permeability are derived from empirical relationships based on grain size estimates for each SBT.[1,2]

### Shear-Wave Seismic



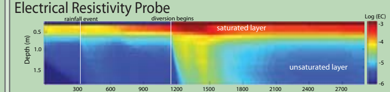
2D S-wave survey conducted summer 2007. S-wave velocity inversions using CPT log velocities as constraints were used to interpret the layers shown.[3]

### Ground Penetrating Radar



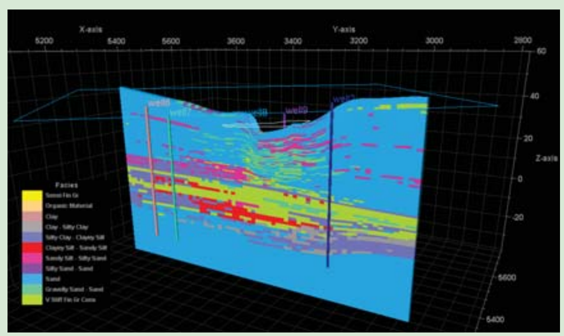
11 Lines of GPR data were collected parallel to the 2D seismic line with 2 m between each line. Magnetite rich sand from the surrounding hills create reflections along migrating dune foresets in the sandy packages.

### Electrical Resistivity Probe



A dipole-dipole survey using 25 electrodes along a 2-m probe was repeated every 0.5 hrs for 3 months. Conductivities show continuous saturation in a top layer with higher fines content while the lower coarser sands never fully saturate.

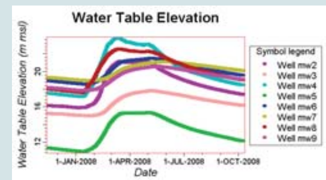
## Structural Model



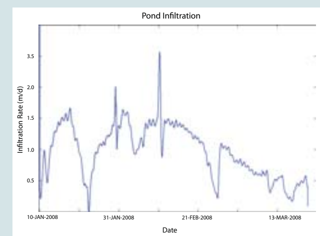
Population of model space with SBT (labeled Facies) using sequential indicator simulation. Porosity and permeability values associated with each SBT as shown in the logs above are assigned to each facies. A fines-rich layer and shallow clay seen in the electrical resistivity probe and CPT log were included in the facies and property simulations.

## Flow Simulations

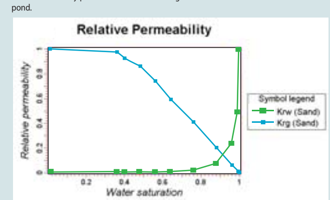
### Flow Conditions



Change in water table elevations as observed at 8 monitoring wells from Nov 2007- Oct 2008. Monitoring wells are screened from ~20-25 m msl.

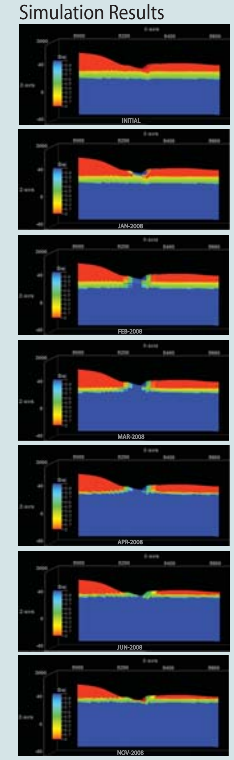


Infiltration rates observed at the pond from diurnal variations in electrical conductivity at the electrical resistivity probe. Values are verified against estimates of infiltration over the whole pond.



Relative permeability curves governing the movement of water through the unsaturated zone. Curves were derived using standard van Genuchten parameters.

### Simulation Results




## References

1 Beard, D.C., and P.K. Weyl, 1973, Influence of texture on porosity and permeability of unconsolidated sand, *AAPG Bulletin*, **57**(2), 349-369.
2 Chapuis, R.P., and M. Aubertin, 2003, On the use of the Kozeny-Carman equation to predict the hydraulic conductivity of soils, *Can. Geotech. J.*, **40**, 616-628.
3 Haines, S.S., A. Pidlisecky, and R. Knight, 2009, Hydrogeologic structure underlying a recharge pond delineated with shear wave seismic reflection and cone penetrometer data, *Near Surface Geophysics*, **7**(5-6), 329-339.

## Acknowledgments

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