Groundwater Hydrology Subgroup:

Conduit and Fracture Flow Modeling

Wendy Graham
Rob de Rooij
Wesley Henson

Water Institute
University of Florida

Interim results presented at UF/SJRWMD CRISPS Annual Meeting- Sept 1, 2015

General problem statement

Currently, groundwater flow in the Silver Springs Watershed is simulated using an equivalent porous medium model (i.e. Northern District Groundwater Flow Model based on MODFLOW-SURFACT)

There do exist modeling codes that could account for the presence of conduits in the subsurface. (i.e. MODFLOW-USG, MODFLOW-CFP, DisCo)

We thus may ask questions like:

Does including conduits lead to different modeling results?
Does this lead to a model that will improve management decisions?

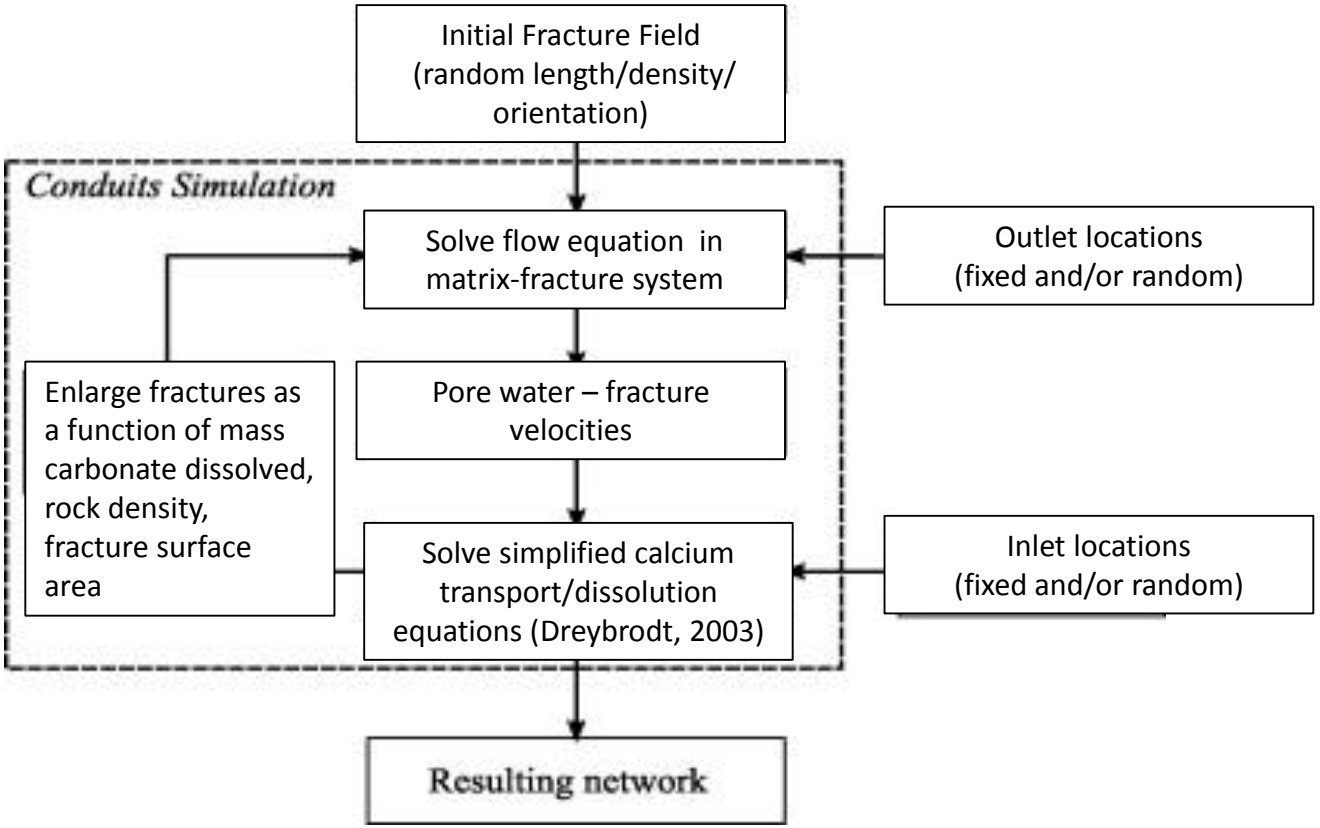
General objective & specific tasks

Develop a model for the Silver Springs watershed that includes the conduits using MODFLOW-USG

Tasks:

- **Develop a methodology to generate conduit networks.**
- Unconditional Monte Carlo flow and transport experiments.
- Evaluate parameters that contribute most to model uncertainty.

Conduit generation

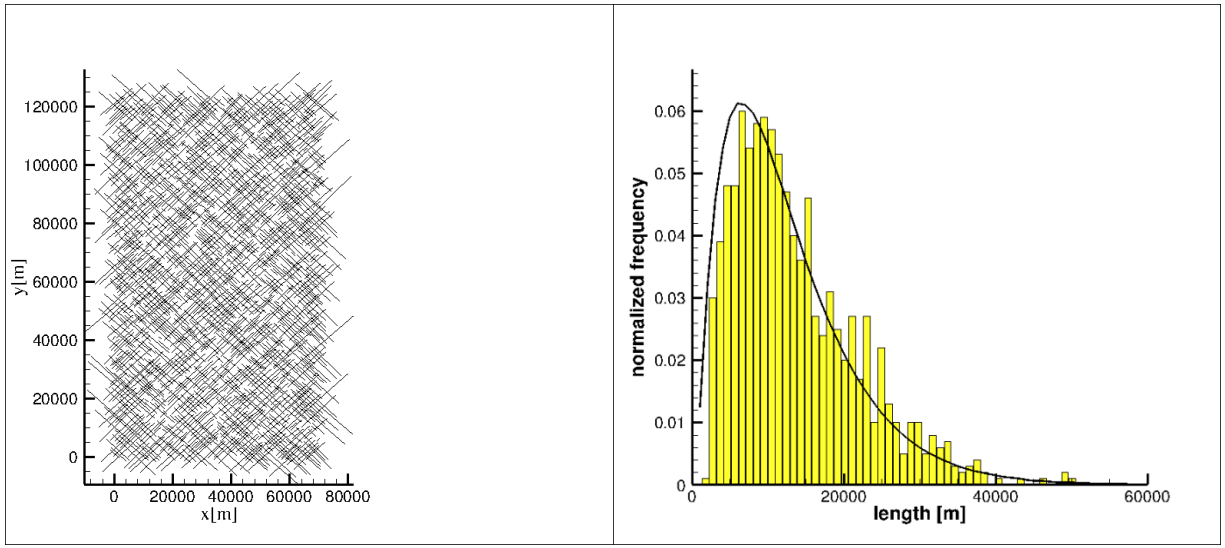


Conduit generation is simulated with DisCo
In essence, the conduits are generated with a reactive-solute transport model.

Required input for conduit generation

Initial conduit network

This network is generated stochastically
(very similar to stochastic fracture network generators)



Flow and transport parameters

Boundary and initial conditions for flow and transport

(For example the inlet and outlets)

Boundary conditions for flow

Note:

As the diameters of the conduits are progressively enlarged, the overall conductivity of the subsurface is increased and head gradients will decrease if the b.c.'s are held constant.

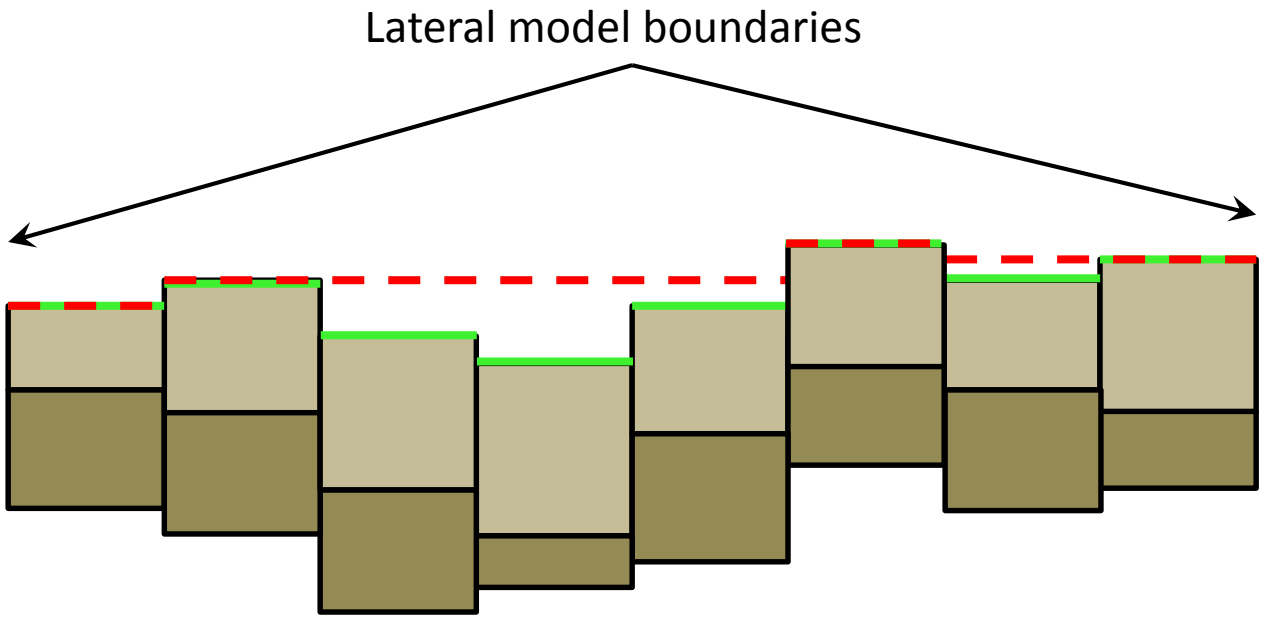
Problem:

During the early stages of the simulation, head gradients may be very steep and the groundwater levels may be unrealistic (i.e. above the surface)

Solution:

Implementation of a dynamic drain boundary condition on the topmost cells

Dynamic drain b.c. at the surface

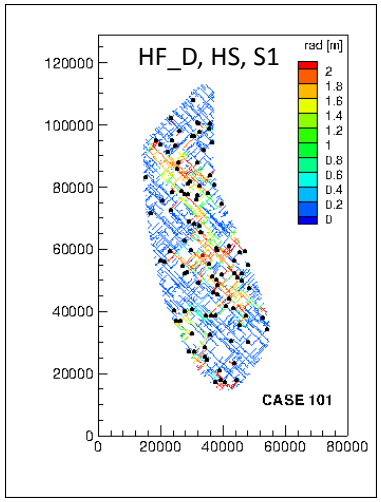


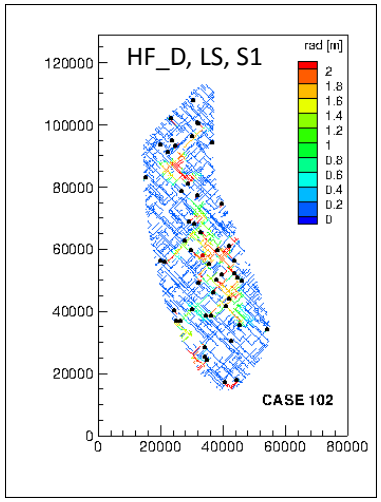
land surface

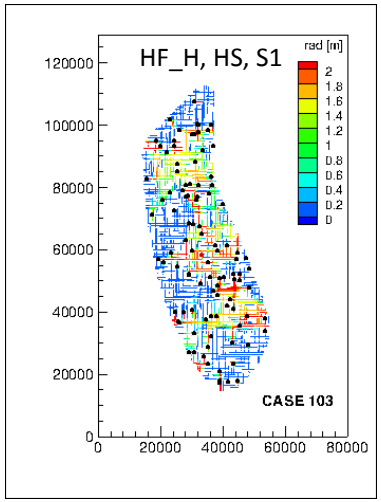
spill elevation: z_s

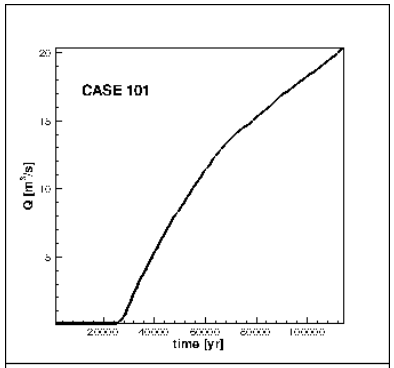
$$q_{\text{OUT}} = \begin{cases} \gamma\left(h_{\text{cell}} - z_s\right) & \text{if } h_{\text{topmost cell}} > z_s \\ 0 & \text{if } h_{\text{topmost cell}} \le z_s \end{cases}$$

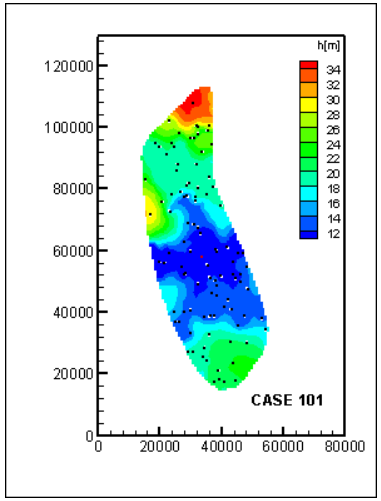
Examples of conduit realizations

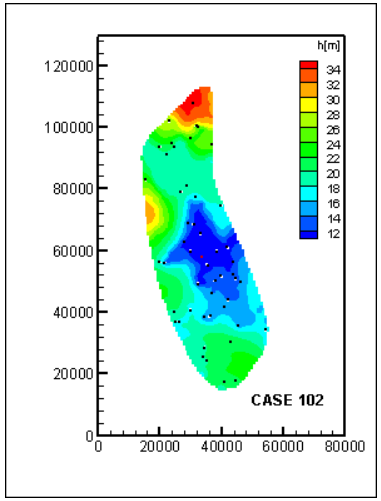


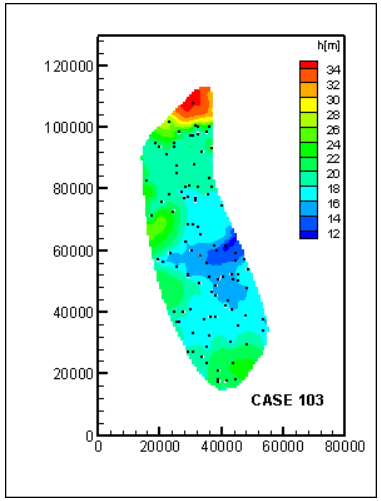


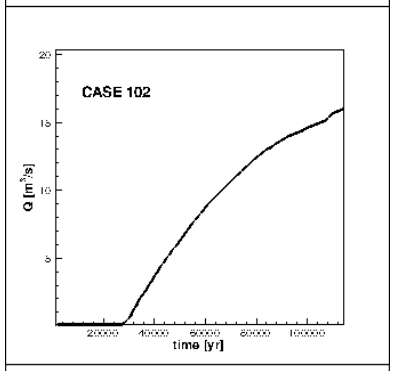


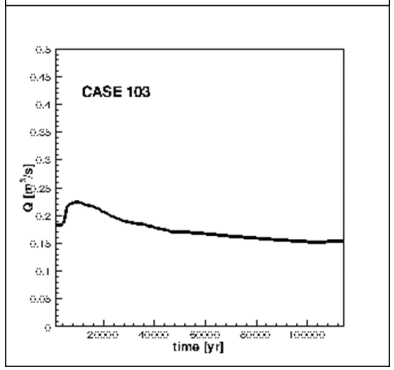






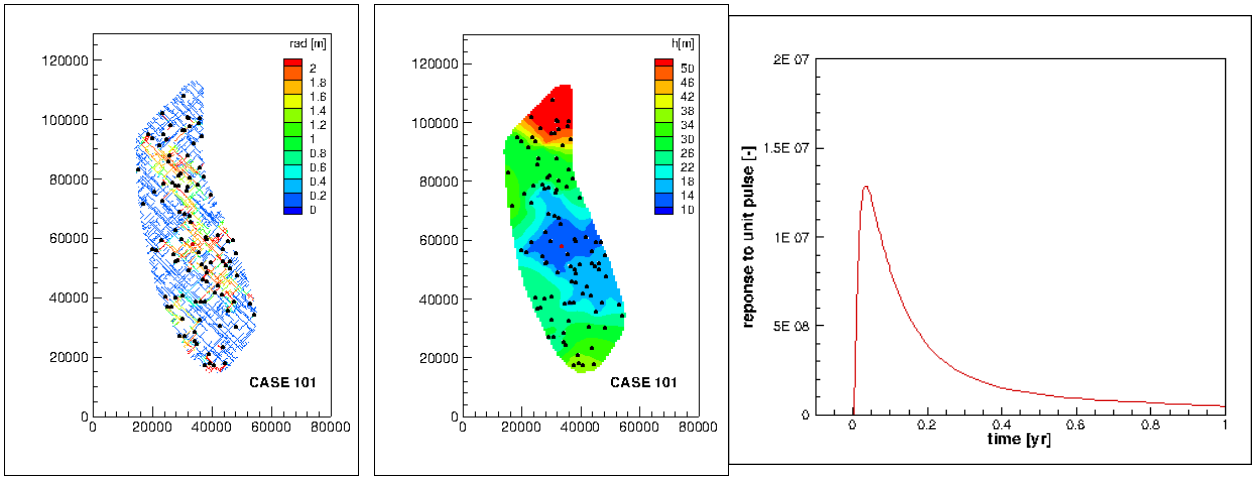




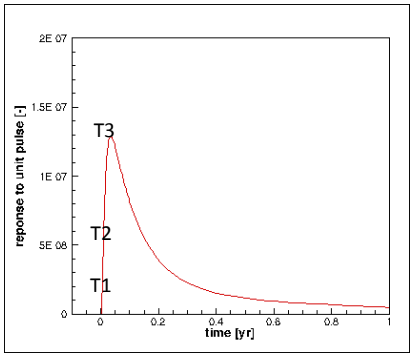


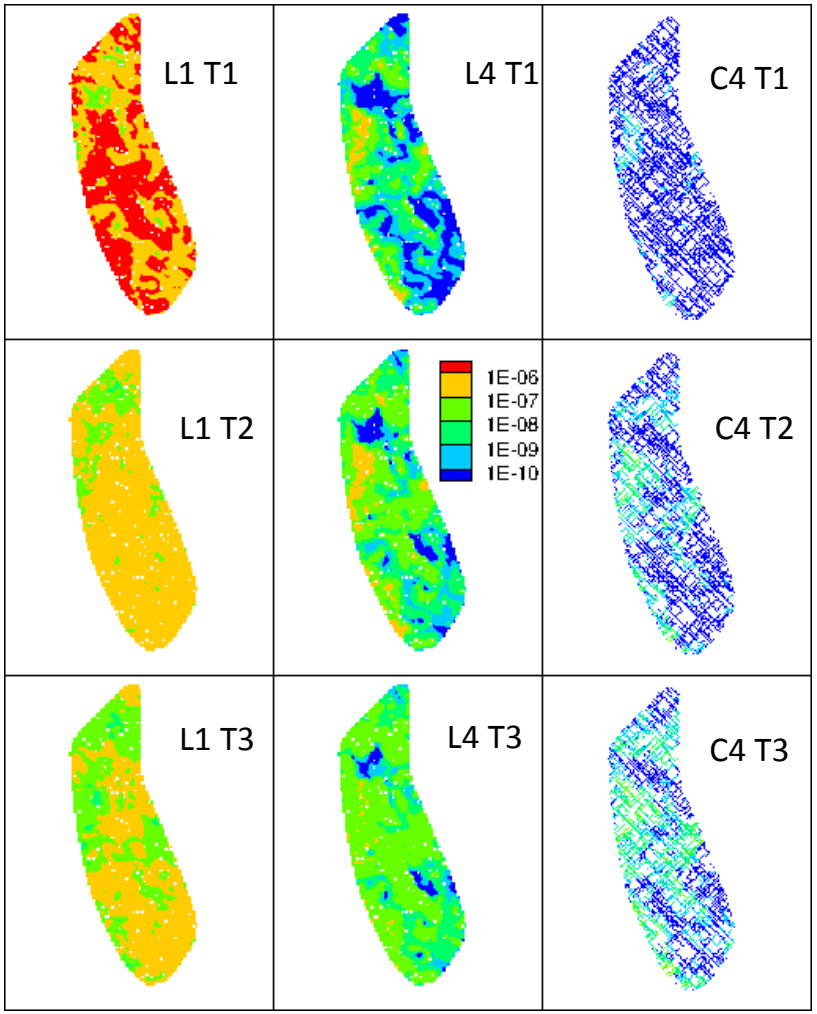
Interim results presented at UF/SJRWMD CRISPS Annual Meeting- Sept 1, 2015

BTC at Silver Springs resulting from unit pulse at surface (1)



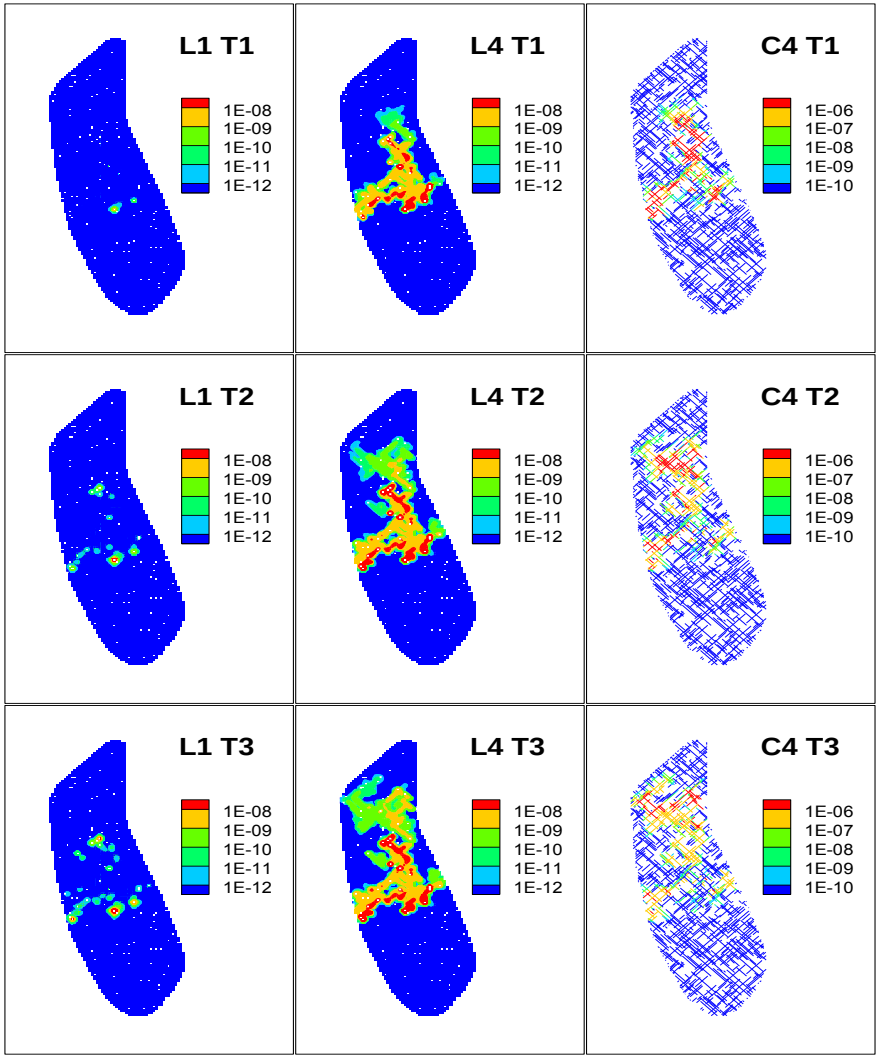
BTC at Silver Springs resulting from unit pulse at surface (2)





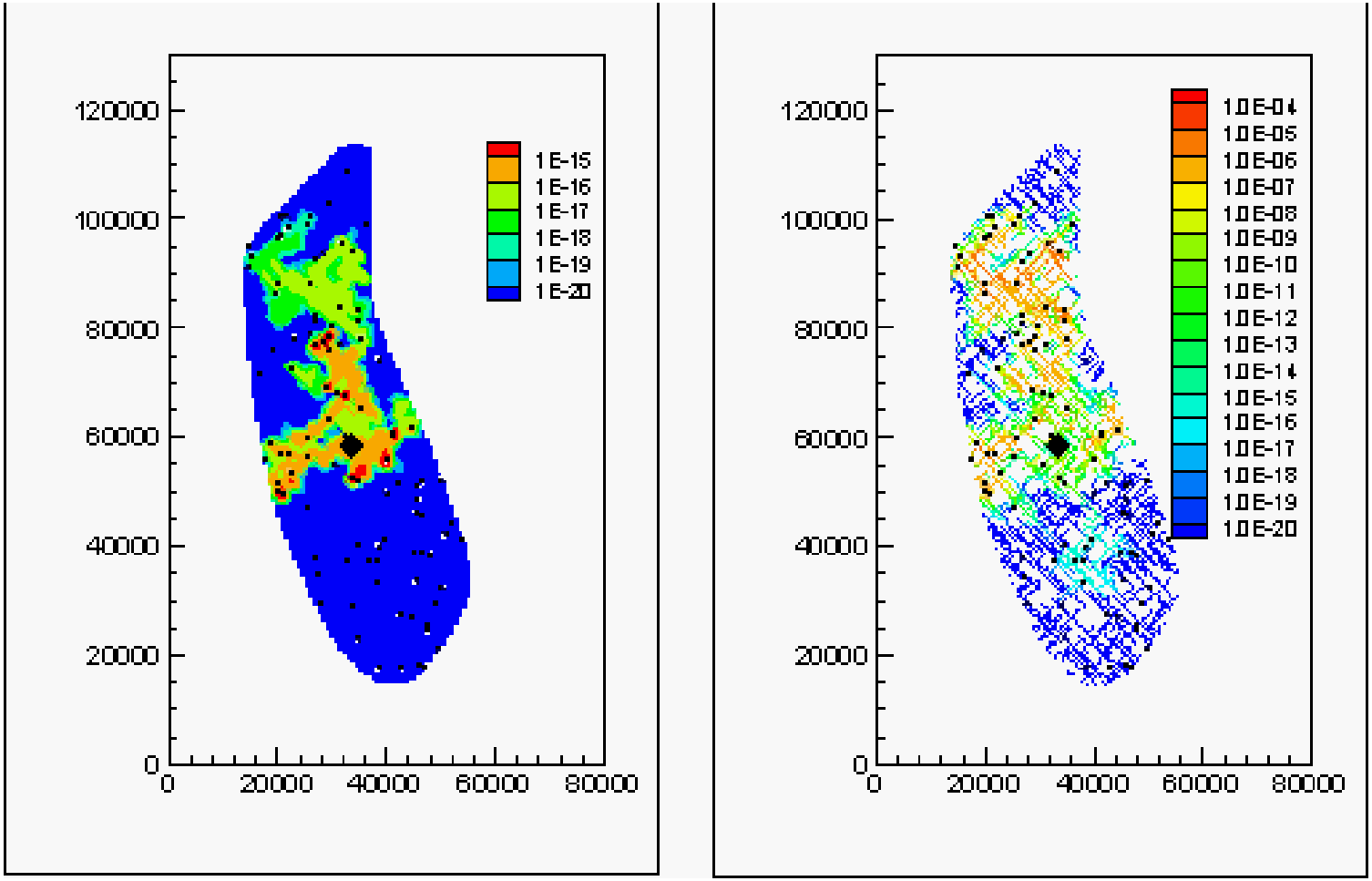
Interim results presented at UF/SJRWMD CRISPS Annual Meeting- Sept 1, 2015

Backward transport (in time) with unit pulse at Silver Springs (1)



Interim results presented at UF/SJRWMD CRISPS Annual Meeting- Sept 1, 2015

Backward transport (in time) with unit pulse at Silver Springs (2)



Conclusions and outlook

Conduit generation algorithm has been developed

Flow boundary conditions have a strong influence

Sink hole density and location also strongly influence the conduit network

Fracture density and orientation are also influential, but influence is minor above a certain fracture density

It was found that using the same b.c.'s as in the original equivalent porous medium model did not work well. Therefore we adopted a dynamic drain boundary condition for the topmost subsurface cells.