COMSOL Modeling of Groundwater Flow and Contaminant Transport in Two-Dimensional Geometries with Heterogeneities

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Groundwater contributes an immense amount of water and subsequently nutrients to rivers in the Delmarva Peninsula. The region is large and complex geologically. The purpose of this project is to determine general rules about how clay heterogeneities affect both the movement of groundwater within the aquifer and the transport of nutrient concentration to rivers.

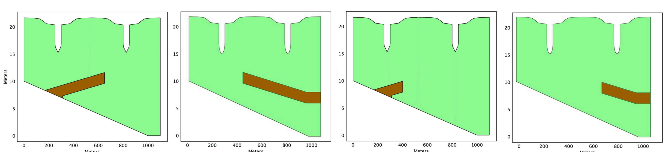

Figure 1. Underlying clay heterogeneities disrupt uniformity, creating dynamics which are very difficult to quantify in their entirety.

PDE (1) – Darcy velocity, gives rise to the direction which recharge takes, and which river this water flows to. PDE (2) – the Advection-Diffusion equation is used to quantify the time at which nutrients reach the river beds.

$$v = \frac{q}{n} = -\frac{\overline{K}}{n}\nabla\phi \qquad (1)$$

$$\frac{\partial C}{\partial t} = -\nabla\cdot\left(-D\nabla C + vC\right) \qquad (2)$$

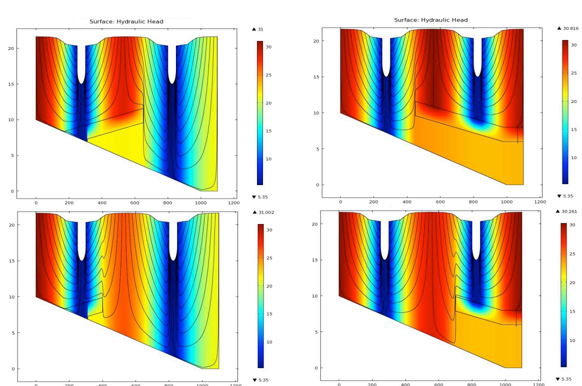

Figure 2. Changes in hydraulic pressure head occur, directing flow towards proximate streams.

Velocity is directly proportional to pressure head, changes in pressure effect nutrient transport. Nutrient movement between the two rivers is of greatest interest.

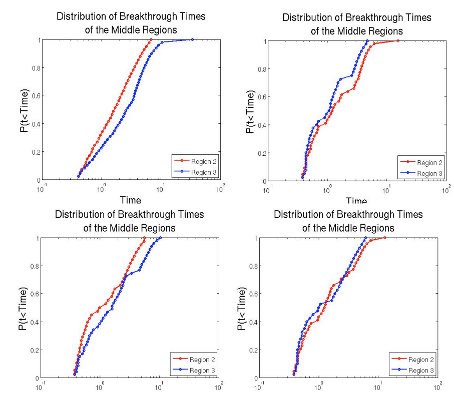

Figure 3. Nutrient breakthrough times - the first time which concentration levels along the river boundary reach above, $C_{threshold}$= 0.001.

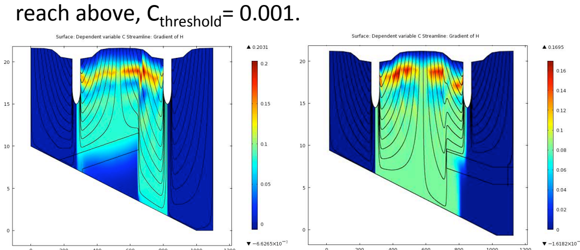

Figure 3. Concentration within the aquifer after 70 years of fertilization.

Conclusion: Heterogeneities change the dynamics within the aquifer, changing flow velocity and phreatic divides. These results can be used as a general framework for the large complicated landscape.

References:

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