SLIDES: Groundwater-Surface Water Interactions

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Groundwater - Surface Water Interactions

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WHAT IS CAPTURE
CONCEPT OF CAPTURE

"Under natural conditions... previous to the development of wells, aquifers are in a state of approximate dynamic equilibrium."

PRE-DEVELOPMENT

Average recharge $R = $ Average discharge $D$
CONCEPT OF CAPTURE

Pre-development Recharge and Discharge

Recharge:
Losing stream
Underflow in
Mountain front recharge

Discharge:
Gaining stream
Underflow out
Evapotranspiration
CONCEPT OF CAPTURE

“Discharge by wells is thus a new discharge superimposed upon a previously stable system, and it must be balanced by an increase in recharge of the aquifer, or a decrease in the old natural discharge, or by a loss of storage in the aquifer, or by a combination of these.”

DEVELOPMENT

The system may respond in three different ways:
- increase in recharge: $R \rightarrow R + \Delta R$
- decrease in discharge: $D \rightarrow D - \Delta D$
- change in aquifer storage: $\Delta S$

Capture
CONCEPT OF CAPTURE

There is a new equilibrium:

\[(R + \Delta R) - (D - \Delta D) - Q = \frac{\Delta S}{\Delta t}\]

remembering

\[R = D\]

gives

\[\Delta R + \Delta D - Q = \frac{\Delta S}{\Delta t}\]

the term \(\Delta R + \Delta D\) is called capture.
CONCEPT OF CAPTURE

Stream

Original water table

Ground surface

Well

DIRECT WITHDRAWAL

Losing Stream

INTERCEPTION

Gaining Stream

Evapotranspiration

Original water table

Evapotranspiration

Capture

Reduced water table
HOW DO YOU CALCULATE CAPTURE
Capture Is Calculated with Models

- There will be a surface water model and a groundwater model.
- There will be a historical model and a base case model.
- The models will consist of control variables, state variables and parameters.
- There is no capture data values to compare or calibrate with calculated values.
MODEL CHARACTERISTICS

- Surface water model is one-dimensional
- Groundwater model is distributed parameter (Two or Three Dimensional)
- Interaction between surface and groundwater waters if governed by Darcy’s law

\[ Q = KWL \frac{H_S - H_A}{M} \]
HISTORICAL MODEL

- Attempts to match historical processes
- Can be calibrated with temporal and spatial data
- Used to demonstrate the viability, accuracy and robustness of the model
- Does not calculate capture.
BASE MODEL

• Based on little or no data
• May be fictional or artificial in nature
• May be the result of a negotiation process
• Should be composed of the same physical based parameters as the historical model

Examples: Steady State, Steady Oscillatory, Constrained Process
Subtracting the historical streamflows from the base streamflows provides an estimate of surface water capture by groundwater pumping.
PARAMETERS

• Physically or scientifically based parameters – Actual measurements

• Calibration or Ad Hoc parameters – No measurements (or bounds)

• Calibration of the models’ physically based parameters provides a measure of the natural error of the model.

• Calibration or Ad Hoc parameters mask the natural error of the model and may improperly influence the Base Model.
CONCEPT OF CAPTURE

Global Capture-Pumping-Storage Relations for San Pedro
Goode and Maddock (2001)

Capture
CONCEPT OF CAPTURE

Flow between stream and aquifer at selected locations

Years

Capture