Irrigation modeling in Prairie Ronde Township, Kalamazoo County

SW Michigan Water Resources Council meeting May 15, 2012



Development of a Groundwater Flow Model



INFLOWS

• Areal recharge from precipitation that percolates through the unsaturated zone to the water table

• Recharge from losing streams, lakes, and wetlands

OUTFLOWS

• Discharge to streams, lakes, wetlands, and springs

- Evapotranspiration
- Ground-water pumpage



Develop Conceptual Model

A conceptual model is a representation of the system upon which the computer model is based

Consists of the definition of the aquifers and confining units, the directions of groundwater flow, and the boundaries of the system

Develop Numerical Model

- Model grid and boundaries
- Layer geometry
- Hydraulic conductivities/leakances
- Recharge
- Lake and stream locations and conductances
- Well locations and withdrawal rates
 Initial estimate of water levels

Development of Kalamazoo Model

Multiple competing uses (municipal, manufacturing, and private wells) Some reductions in lake and stream levels Natural and human-induced stresses on the groundwater system led to concerns about the long-term availability of groundwater for people to use and for replenishment of lakes and streams

Kalamazoo Model Scenarios

Evaluate changes in water levels with reductions in recharge

- Climate variation
- Urban areas
- Evaluate changes in water levels with changes in withdrawals
 - Irrigated areas
 - Projected 2010 pumping rates
- Evaluate transient changes in water levels under seasonal and monthly time scales

Possible Effects of Changes in Recharge

Simulated steady-state ground-water levels in the upper aquifer generally were higher in some areas during the average recharge conditions than during reduced recharge conditions.

Simulated steady-state streamflows generally are lower for the reduced recharge conditions than for average recharge conditions.



Selection of Prairie Ronde Township for additional investigation

 Area within Kalamazoo model area with measured streamflows and few lakes
 Area with groundwater withdrawals for irrigation

Kalamazoo Model Area Prairie Ronde Township



Location of irrigation withdrawals



Prairie Ronde Township



Approach

Regrid model in Prairie Ronde Township area (cell size in township reduced to 100 x 100 ft)

 Convert river cells within township representing Flowerfield Creek to stream cells

Develop transient model (initial steady-state stress period followed by monthly stress periods representing 5 years / 30 years)

Incorporate irrigation withdrawals

Groundwater Withdrawals



Variation in Recharge



Flow from Flowerfield Creek



Change in flow at end of August

Scenario		Flow, cfs	Percent reduction
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no irrigation	5 yrs average recharge	25.0	
Partial Irrigation	5 yrs average recharge	24.5	1.9
Partial Irrigation	2 yrs ave rch, 3 yrs low rch	22.3	10.7
Most Irrigation	5 yrs average recharge	22.5	9.8
Most Irrigation	2 yrs ave rch, 3 yrs low rch	20.3	18.6
All Irrigation wells pumping	5 yrs average recharge	21.5	14.1
All Irrigation wells pumping	2 yrs ave rch, 3 yrs low rch	19.3	22.8

Irrigation Pumping and Flow Reductions



Reduction in flow, cfs (all irrigation wells pumping, average recharge for 5 years)

Reduction in flow, cfs (all irrigation wells pumping, average recharge for 2 years, reduced recharge for 3 years)
 M onthly irrigation pumpage, cfs

30-year Model Scenarios

No irrigation wells pumping
Irrigation wells pumping at average rates
Irrigation pumping increased by 20 % for years 3-5

Average recharge rates for 30 years

Recharge rates representative of rates observed from 1942-1970

Flow in Flowerfield Creek with varying pumping and recharge rates



Change in flow during 30-year run

Scenario		Flow, cfs (end of August yr 5)	Flow, cfs (end of yr 30)
no irrigation	average recharge	25.0	24.2
All Irrigation, average rates	average recharge	20.6	21.8
All Irrigation, average rates	90% recharge, yrs 3-5	18.4	21.8
All Irrigation, average rates	75% recharge, yrs 3-5	15.2	21.8
All Irrigation, incr yrs 3-5	75% recharge, yrs 3-5	14.5	21.8

Comparison with Screening Tool

- Screening tool depletion (sum for 42 irrigation wells): ~6 cfs
- Groundwater model (reduction in flow at end of August with average recharge conditions): ~4 cfs

Variation in precipitation with overall, pre-1970 and post-1970 averages



Estimated recharge rates for 30 year scenario



Flow in Flowerfield Creek with varying pumping and recharge rates

