Irrigation in the Midwest
Trends and potential issues

AgriBusiness Association of Kentucky 2013 Annual Meeting
November 5-7, 2013
Louisville, Kentucky

Howard W. Reeves, USGS Michigan Water Science Center
Moisture Control to Improve Crop Yields

- Tile Drainage
- Irrigation
- Growth in both tile drainage and irrigation
CEDAR RAPIDS, Iowa (AP) — Counterintuitive as it may seem, farm fields with the best tile drainage systems generally produced the highest yields during last year's drought, Iowa farmers and other experts say.

“I saw that right away in the first field I harvested this fall,” said Marion-area farmer Curt Zingula.

Zingula said he became “100 percent convinced” of the benefits of tile drainage in a dry year when he observed a disappointing harvest of soybeans on his traditionally wettest field. “My conclusion is that you have a better soil structure yielding better root growth in well-drained fields,” he said.
Improving water management is an important way to increase crop yields. By minimizing crop-water stress, the producer obtains more benefits from improved cultural practices and realizes the full yield of the cultivars now available. Crops are particularly sensitive to water stress when they are undergoing reproductive growth.

Richard Cooke, Department of Agricultural and Biological Engineering, University of Illinois
Precipitation and potential moisture loss for 3 places in Illinois from the Illinois Agronomy Handbook

http://extension.cropsci.illinois.edu/handbook/pdfs/chapter11.pdf

Moisture deficit

Moisture surplus

Figure 11.5. Average monthly precipitation and potential moisture loss from a growing crop in three regions of Illinois.
Trends

- Trends for some SW Michigan Counties, irrigated acres by county from Census of Agriculture

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<th>Year</th>
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<th>Cass</th>
<th>Kalamazoo</th>
<th>St. Joseph</th>
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Total Irrigation Withdrawals in Million Gallons per Day for Indiana from USGS National Water Use Program
The Source of Water Derived from Wells

Essential Factors Controlling the Response of an Aquifer to Development

From a paper presented before the Arizona Section

By Charles V. Theis

Geologist in Charge of Ground-Water Investigations in New Mexico, U.S. Geological Survey, Department of the Interior, Albuquerque, N.Mex. (Published with the permission of the Director of the Geological Survey)

This paper discusses in a general way the essential factors that control the response of an aquifer to development by wells. A knowledge of these factors, including the role of time, is necessary for the interpretation of existing records of water levels, and can yield the only method of predicting the effect of ground-water development in an area where records of long duration are lacking. Some of these factors have been long recognized but others have come to light in the last few years, and the intensive work now being done in quantitative ground-water hydrology will doubtless still further refine our concepts.

Continued increase in the use of ground water for municipal and industrial purposes, and for irrigation, makes more pressing the question as to the extent of reserves of ground water and the advisability and methods of regulating its use. Proper regulation, of course, is conditioned upon the ability to forecast with some degree of accuracy the future history of water levels in wells in a given area. Mr. Theis here gives a clear picture of the factors that must be taken into account in such forecasts, and concludes with a brief summary of recommendations for “the ideal development of any aquifer from the standpoint of maximum utilization of the supply.”

Water, or by movement vertically or laterally from another ground-water body. The latter process is more or less an incident in the movement of water underground, and will not be discussed here. Two possible conditions in the recharge area must be considered. The potential recharge rate may be so large in wet seasons or cycles, or even uniformly, as to exceed the rate at which water can flow laterally through the aquifer. In this case the aquifer becomes over-full and available recharge is rejected. The water table stands at or near the surface in the recharge area. There may be permanent or seasonal springs in low places discharging the excess water, or there may be marshes or other areas of vegetation draw...
Source of water to wells

- Initially, water level near well decreases – water released from storage
- Cone of depression forms around well
- Cone expands until boundaries are encountered
- All water produced by a well is balanced by a loss of water somewhere
  - Loss of water from storage (water level declines)
  - Increase in recharge (decrease in runoff)
  - Decrease in discharge to surface water
Potential for well-to-well conflict

- High-capacity irrigation wells can cause large drawdowns that extend far enough to interfere with neighbors' wells.
- Drawdown amount, extent, and timing depends on the pumping rate, geometry, and geologic setting of the system.
- Be aware of areas where neighbors rely on shallow wells, especially jet wells, a couple feet of drawdown can make those wells ‘go dry’ by lowering the water level below the pump intake.
Example, Saginaw County, Michigan

~4.5 miles from Marion Springs to irrigation well

~0.5 miles from USGS MW to irrigation well

From USGS WRIR 01-4227
Jasper County, Indiana

- Installation of center pivot irrigation systems with 34 wells in a limestone aquifer
- 1981-84, nearly 130 household wells impacted
- 150-200 more wells impacted after this report, especially during 1988 drought
- Motivated water right and use legislation in Indiana to provide means for people with domestic wells to work through problems caused by high-capacity wells
Factors determining drawdown

- Local geology, aquifer type
  - Confined or unconfined
  - Fractured rock, unconsolidated material
- Geometry
  - Distance to boundaries
  - Configuration of aquifers
- Pumping rate and duration
- To minimize drawdowns (Theis):
  - Place wells near discharge areas
  - Spread demand over several wells
Groundwater/Surface-Water Interaction
Streamflow depletion by wells

- Methods to complement field data and analysis
- http://pubs.usgs.gov/circ/1376/
Common Misconception from Leake and Barlow

- Total development of groundwater resources from an aquifer system is ‘safe’ or ‘sustainable’ up to the average rate of recharge.
- If development = rate of recharge, rate of natural discharge will approach zero if recharge has not increased.
Approaches to Estimating Groundwater/Surface-Water Interaction

- Field methods: installation of shallow monitoring wells paired with streamgage with addition of temperature measurement
- Analytical modeling
- Numerical modeling
Provisional data subject to USGS revision
Temperatures for Gage 04097450 and Piezometer 415318085243401

Provisional data subject to USGS revision
Analytical models

- Mathematical expressions relating streamflow depletion to pumping rate and aquifer characteristics
- Simple geometry, homogeneous aquifer
- Simple input requirements
Numerical Modeling

- Irregular geometry of aquifer or boundaries
- Irregular geometry of streams, lakes
- Non-uniform aquifer properties
- Complex pumping schedules and multiple wells
- Nonlinear conditions- properties change with aquifer condition
- Numerical models or approaches such as analytic element modeling
From USGS
Circular 1376
Agriculture must increase production for a growing population while simultaneously reducing its environmental impacts. These goals need not be in tension with one another.
Resources

- **Illinois Agricultural Extension, Agronomy Handbook:**
  http://extension.cropsci.illinois.edu/handbook/

- **MSUE St. Joseph County Portal Irrigation Resources page (Lyndon Kelley, MSU-Purdue Cooperative Extension)**
  http://www.msue.msu.edu/portal/default.cfm?pageset_id=28706&page_id=361029

- **Mark Basch, Water Rights and Use Section, Indiana Department of Natural Resources, Division of Water**

- **USDA**  http://go.usa.gov/Kow

- **Kentucky Cooperative Extension Service**

- **Kentucky Geological Survey**
  - Water wells and springs
    http://kgs.uky.edu/kgsmap/KGSWater/viewer.asp

- **Kentucky Department of Agriculture**

- **USGS Kentucky Water Science Center**