Unmanaged Aquifer Recharge: Revisiting Sustainable Yield in Northeast Illinois

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Hydrostratigraphy of Northern Illinois

Source of Community Water Supplies

Recharge Areas to Sandstone Aquifers

Within northeast Illinois, very little natural recharge is present, limited to bedrock valleys and south of the Sandwich Fault Zone.
Previous Estimates of Aquifer Sustainability

- Estimates of sustainable yield of the sandstone aquifers range from 43 MGD (Suter et al., 1959) to 65 MGD (Walton, 1964)
- Both methods rely on using the regional gradient assuming similar head in all aquifers
  - Synoptic measurements biased toward high-capacity production wells, often open to multiple aquifers, masking local head separation
  - Neither estimate delineates the individual contributions from various units
  - Both approaches neglect changes in storage within confining units

Revisiting Sustainable Yield

- As the system is complicated by the presence of multi-aquifer wells (MAWs), with demands increasingly focused on a single aquifer, head differences in excess of 250 feet have developed near the center of the cone of depression
- Requires a data-driven approach honoring the actual lithology and observed heads in each aquifer

Head Specified Model

- Actual model lithology
- For sake of discussion

Application of head-specified model

Input - Water level measurements
Output - Flow rates
Calibrate to pumping rate over the entire history of withdrawals in northeast Illinois
If all sources of water are properly conceptualized, flow rate will match pumping rate
If there are additional sources of water not being modeled, flow rate will show a deficit compared to pumping
Excess flow compared to pumping indicates unallocated pumping or too much recharge over a time range

Estimated sources of water in NE Illinois

Vertical infiltration into sandstone (natural)
Vertical infiltration into sandstone (natural)

Provisional results

Flow from outside region

Provisional results

Flow from outside region (recharge)

Provisional results

Flow from outside region (basin)

Provisional results

Flow from outside region (basin)

Provisional results

Vertical leakage to sandstone (anthropogenic)
Vertical leakage to sandstone (anthropogenic)

Removal of water from storage

Removal of water from storage

What is sustainable?

Arguably, considering only induced leakage within Northeast Illinois provides the greatest water security for the region.

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- All other sources take water from elsewhere (putting NE Illinois at the mercy of outside development) or induce flow of poor quality water.
- Arguably, considering only induced leakage within Northeast Illinois provides the greatest water security for the region.
- However, traditional estimates of sustainable yield have included flow from recharge outside NE Illinois.

Provisional results

\[ 47 - 59 \text{ MGD} \]
or a \(-40-50\%\) reduction in withdrawals

Other considerations

- This approach does not consider reductions in natural groundwater discharge (yet), which would limit the amount of water available in recharge areas.
- Likely not a significant amount outside of northeast Illinois, but may be locally important in some streams and rivers.

The circuitous process of defining sustainability

- With increasing demands comes an increase in gradient, and thus increasing leakage... normally.
- Heads have fallen below confining units in most areas of northeast Illinois, meaning a maximum natural leakage rate has been achieved.

Artificial leakage

- However, a considerable portion of flow to sandstone aquifers within northeast Illinois is water draining from shallower units via wells with long open intervals.
- This is not expected to be a source of water long term, as much of this water is likely water draining from storage.

- Despite nearly 50% of modern demands coming from wells completed in only the Ironton-Galesville, model results suggest nearly 70% of sandstone flow comes from the St. Peter Sandstone.
- Ironton-Galesville increasingly dependent upon artificial leakage from wells.

Artificial leakage

- Red = Well completed in Cambrian-Ordovician (sandstone)
- Blue = Well completed in shallower units

1970

Aurora
Campton Township
Elgin
Marqueta Shale
St. Peter Sandstone

Provisional results
Conclusions

- Demands continue to exceed sustainable yield in northeast Illinois
  - Model simulations suggest as little as 6 MGD of additional demands in the center of the cone of depression could begin dewatering the Ironton-Galesville sandstone
- Sustainable yield estimate of 49–57 MGD assumes that both the St. Peter and Ironton-Galesville are being utilized
  - With the Ironton-Galesville receiving no direct recharge in Illinois, its sustainable yield is largely dependent upon artificial leakage

Northeast Illinois can be viewed as one long (unintentional) aquifer recharge project

- Model results suggest 16% of the total sandstone flow for the entire history of withdrawals may have been water draining from shallower units via wells with long open intervals
- Without the contribution of artificial leakage, the system would likely have been depleted several decades ago

Questions?

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I L L I N O I S

ILLINOIS STATE WATER SURVEY

Sandstone Aquifer Head (ft) Observations interpolated between non-measurement years

References