ENIGMMA: The Evolving Network of Illinois Groundwater Monitoring and Modeling Analyses

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Daniel Hadley
George Roadcap
Shelby Ahrendt

ENIGMMA

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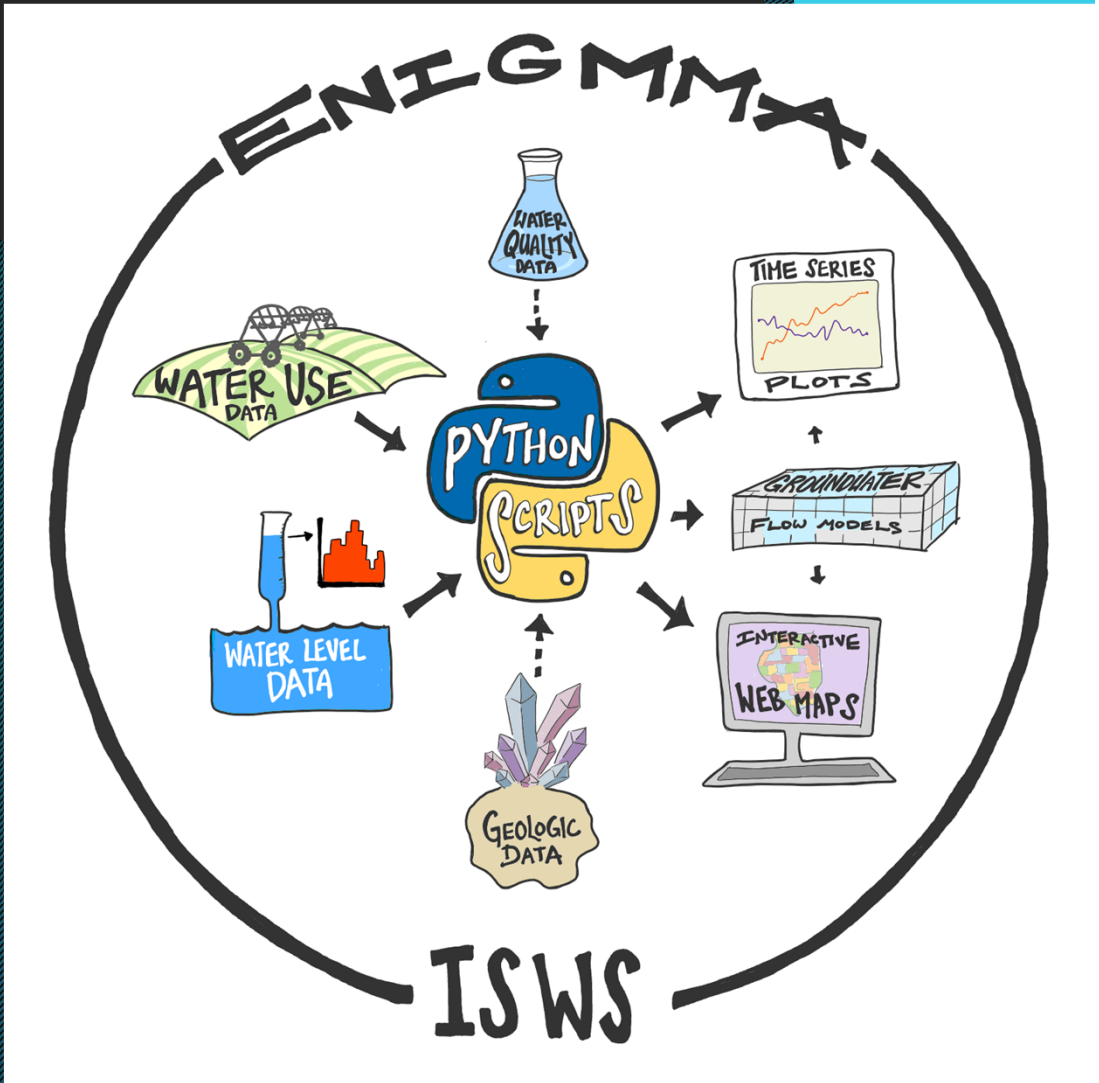
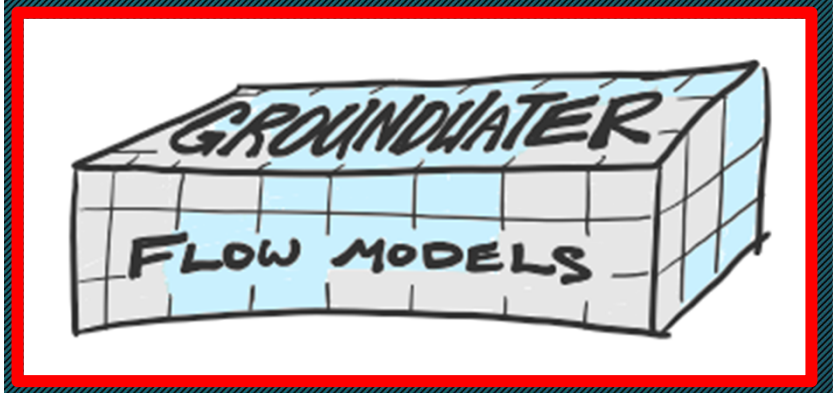
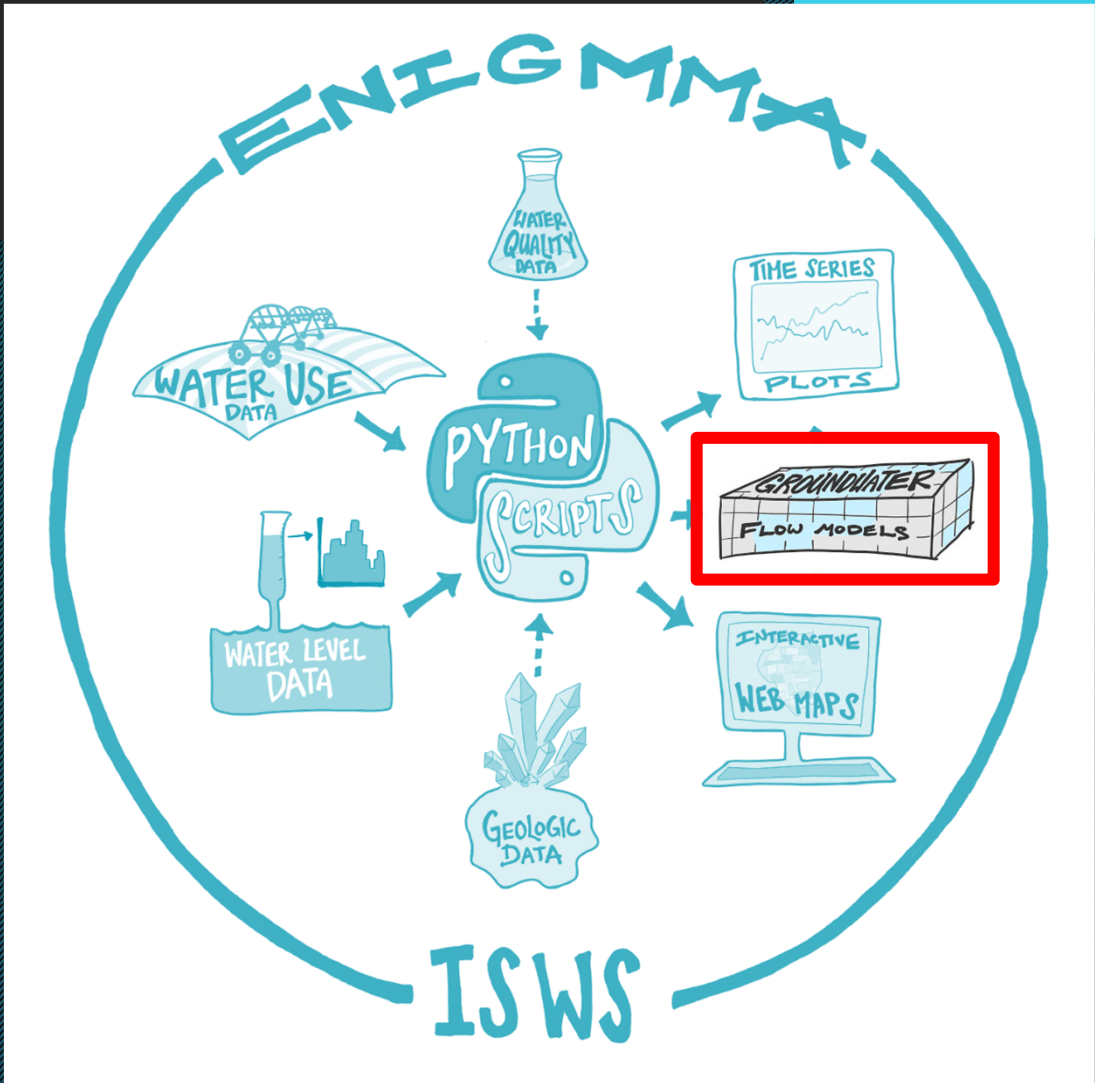


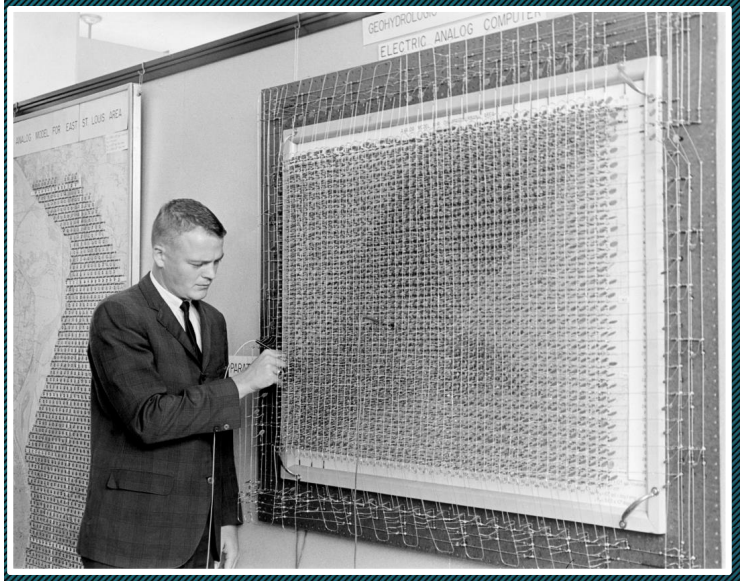
The ENIGMMA Team

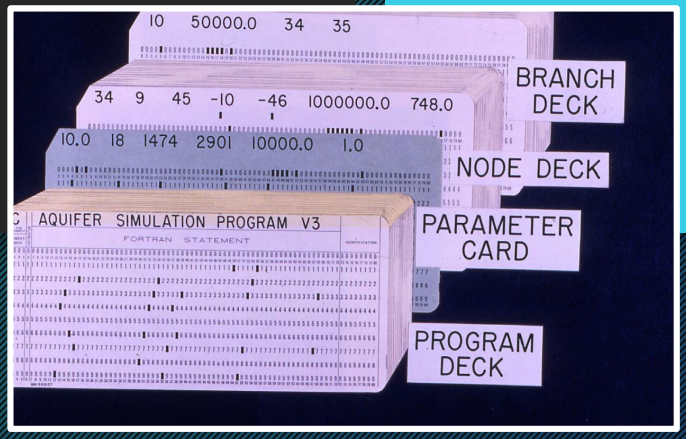
ENIGMMA

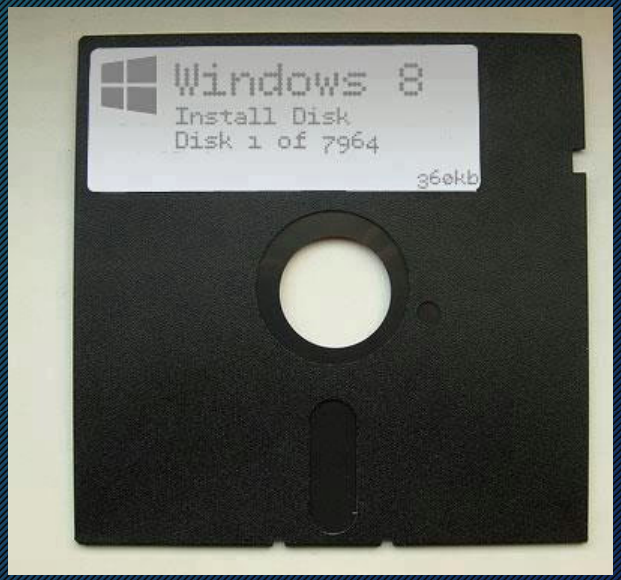

GROUNDWATER
FLOW MODELS


ENIGMMA
WATER QUALITY DATA
WATER USE DATA
PYTHON SCRIPTS
TIME SERIES PLOTS
GROUNDWATER FLOW MODELS
WATER LEVEL DATA
INTERACTIVE WEB MAPS
GEOLOGIC DATA
ISWS

The Problem: Technology leaps ahead of archived models

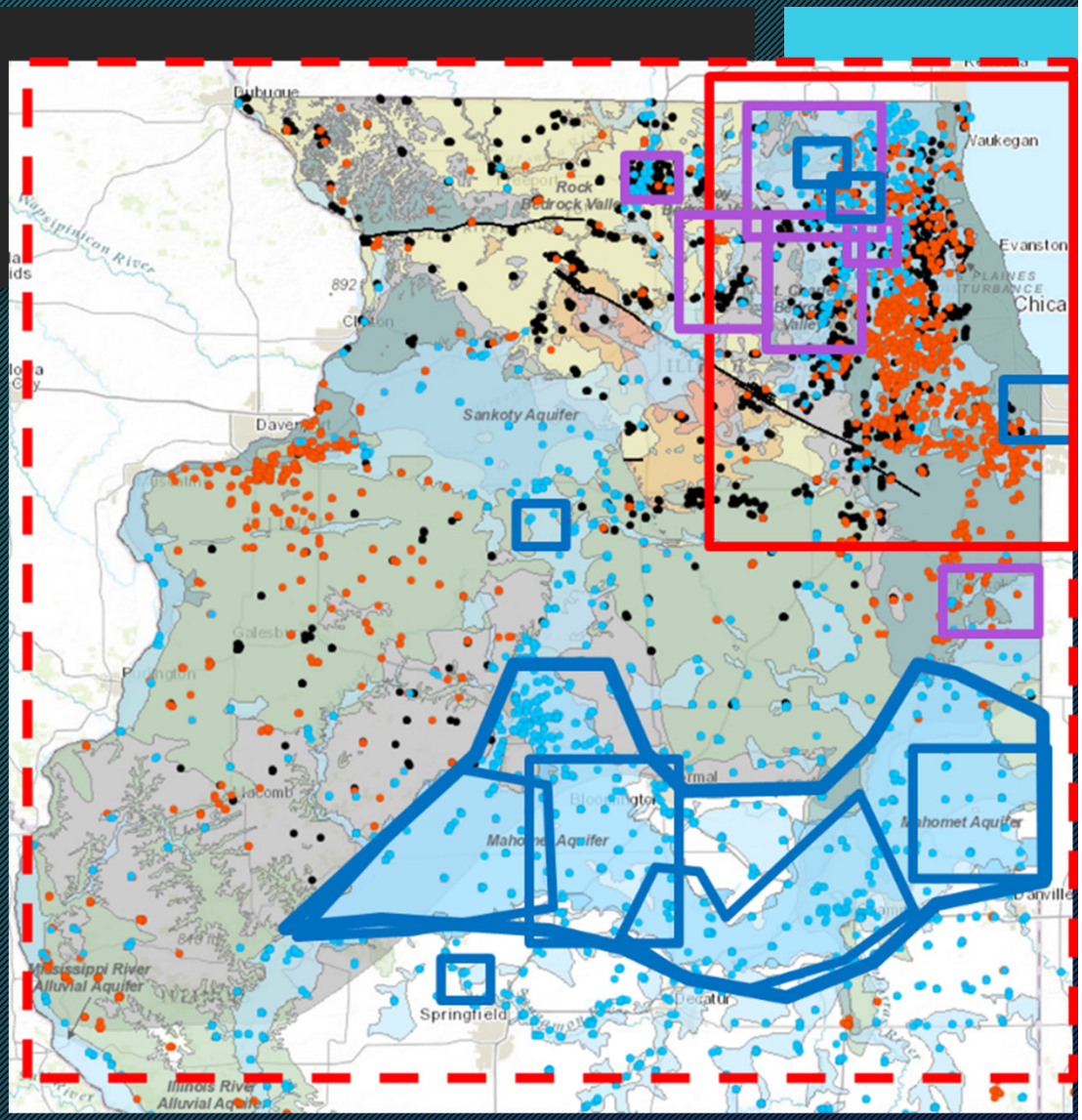






Vision:
Create One Model

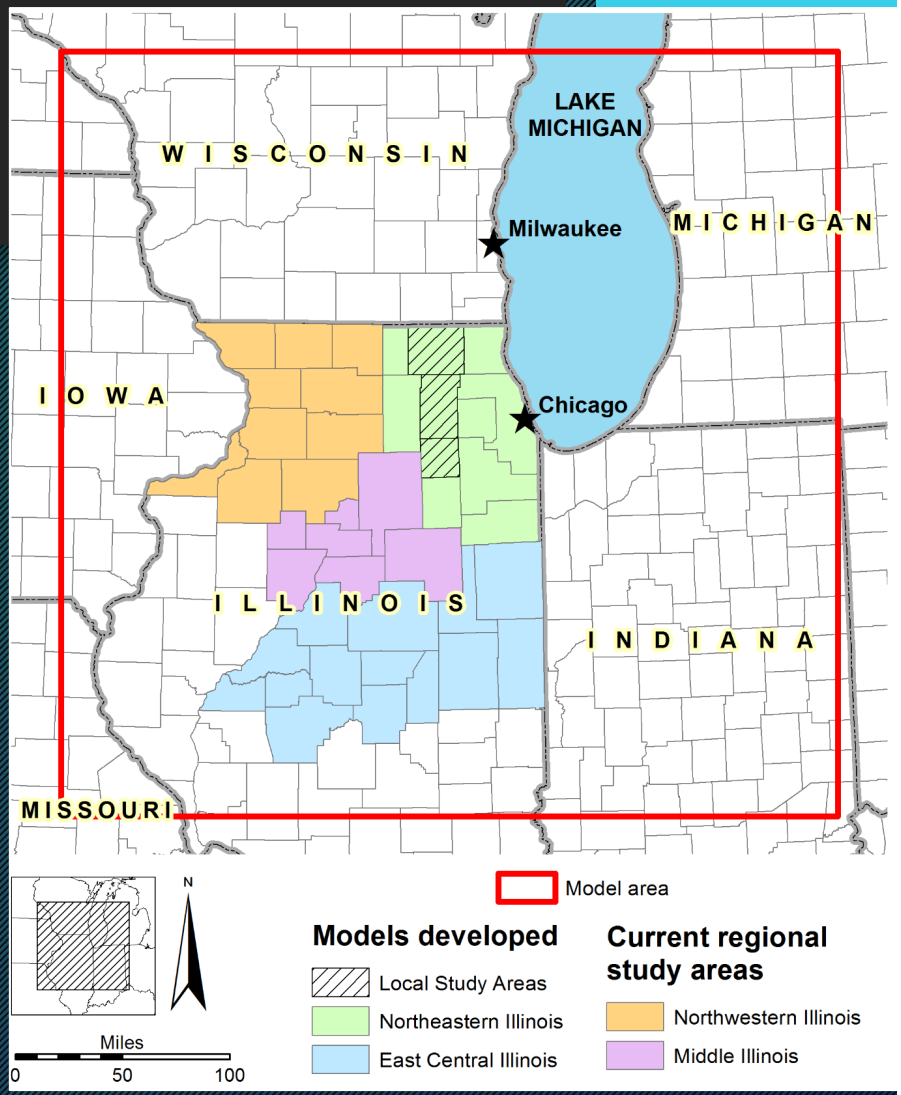
- Combine local and regional models into one model framework
- Common grid
- Common database and methodology
- Ability to zoom in on local problems
- ALWAYS UPDATED
- Serve as a starting point for new local models



ILLINOIS GROUNDWATER FLOW MODEL

PRIORITIES CHANGE DEPENDING ON THE PROJECT

- Water supply planning
- Capture zone analysis
- Impacts of irrigation
- River water infiltration
- Aquifer test analysis
- Quarry dewatering
- Contaminant transport



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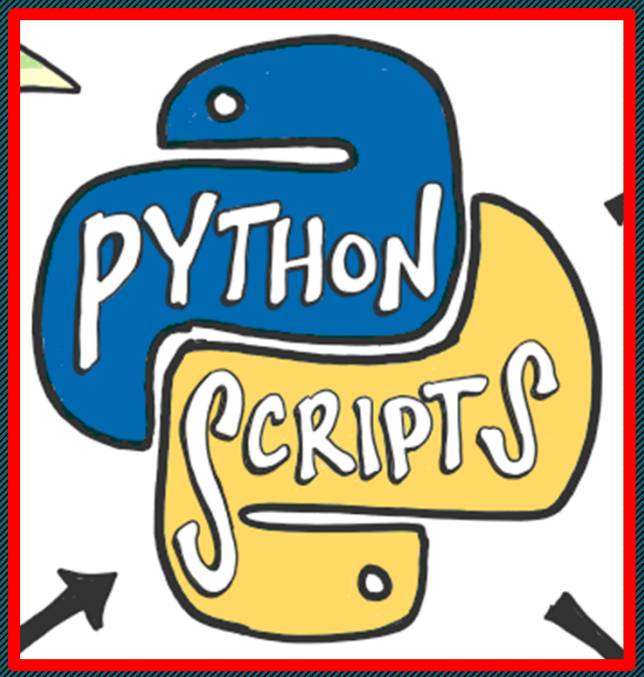
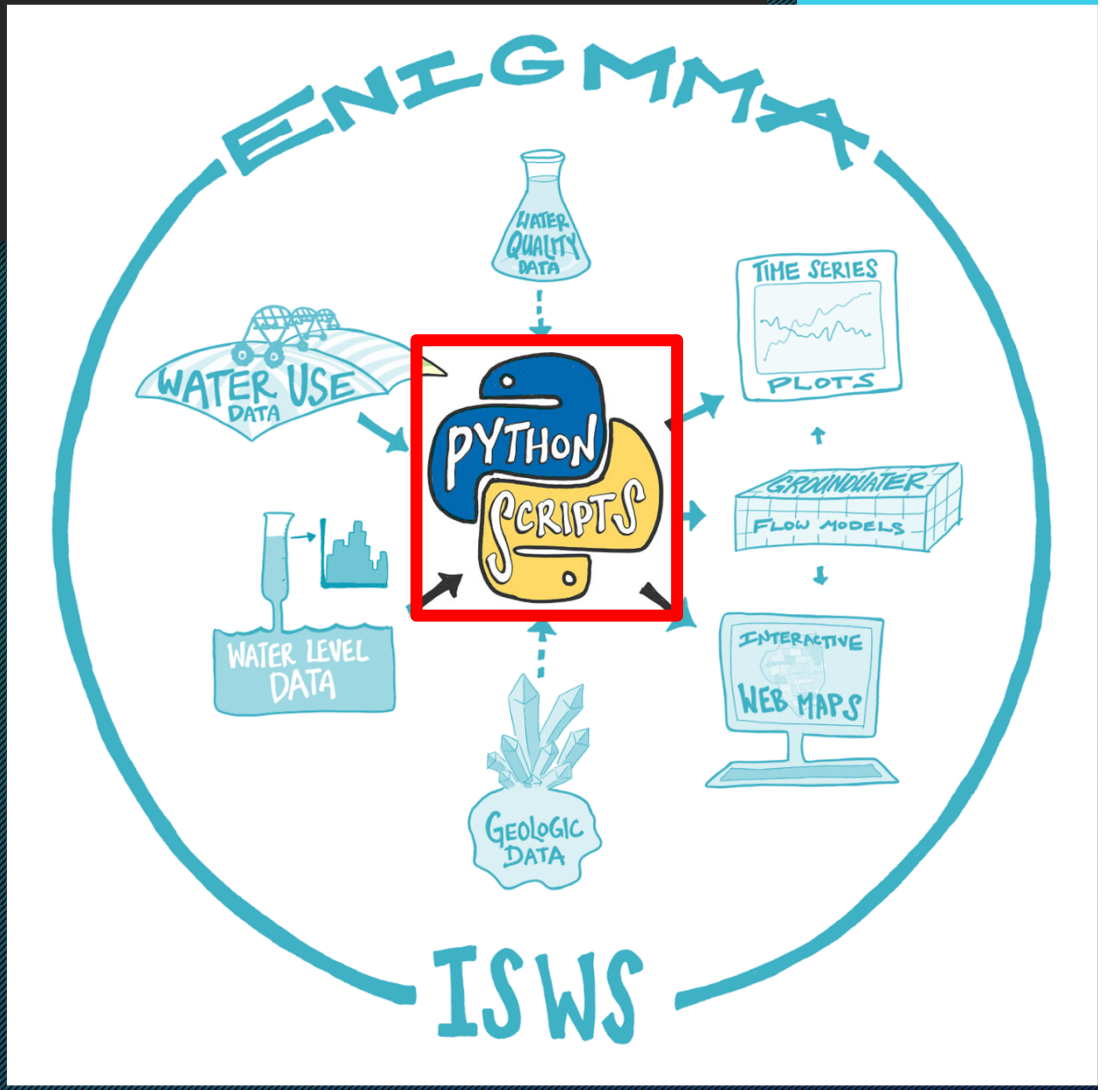

PYTHON
SCRIPTS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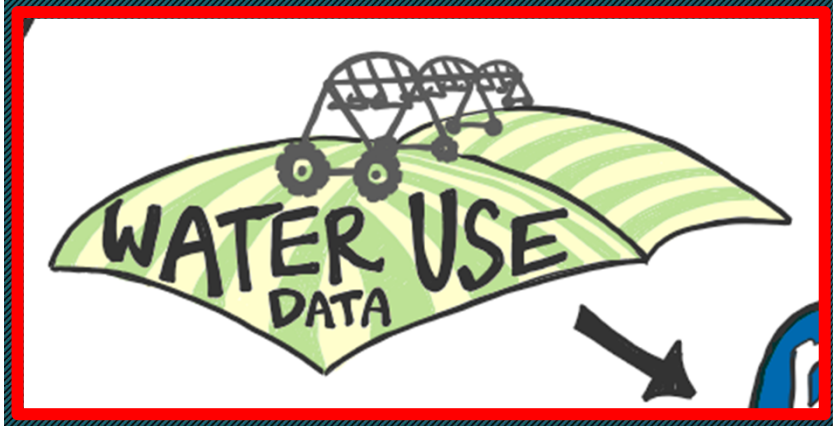
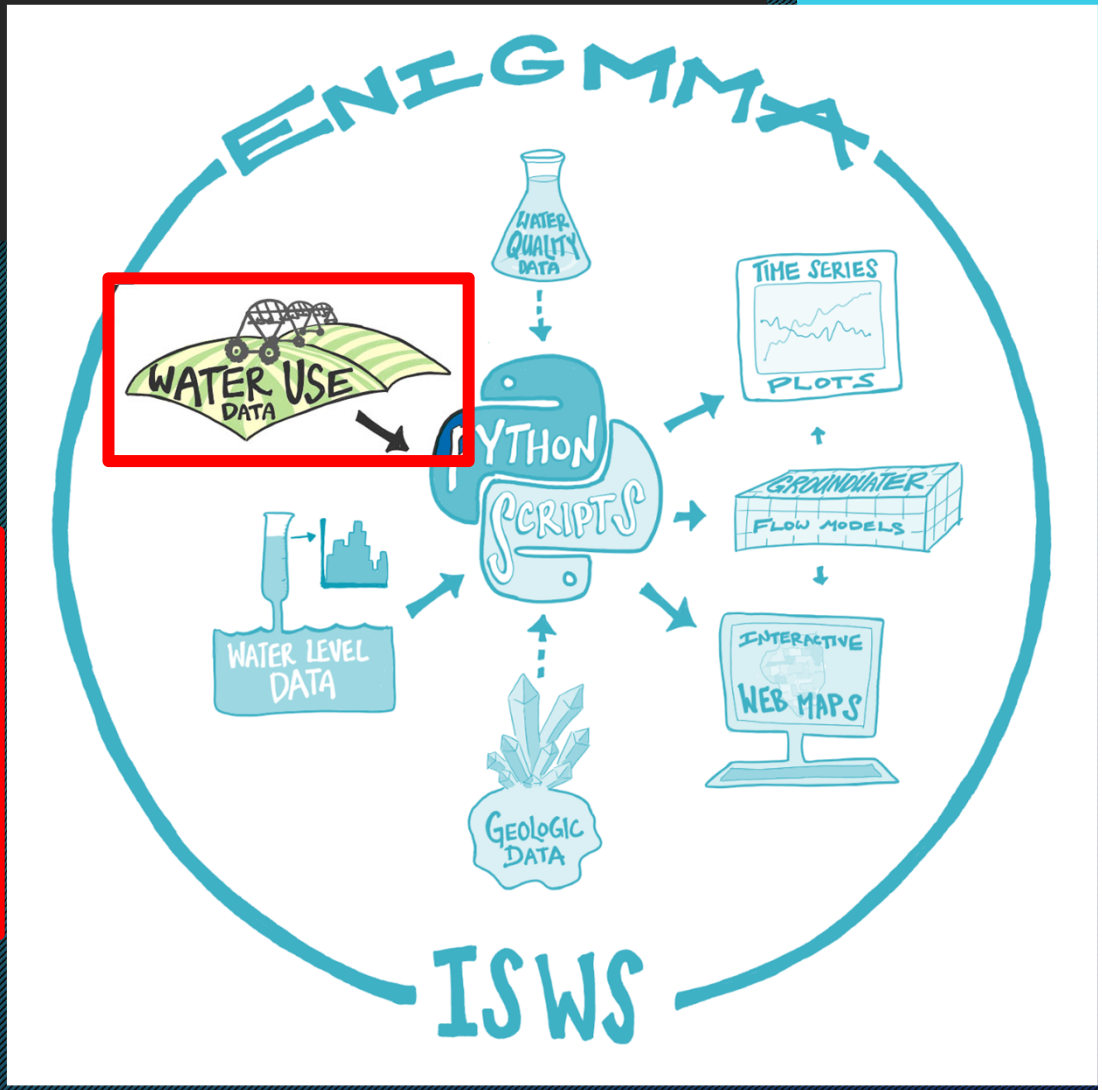

WATER USE
DATA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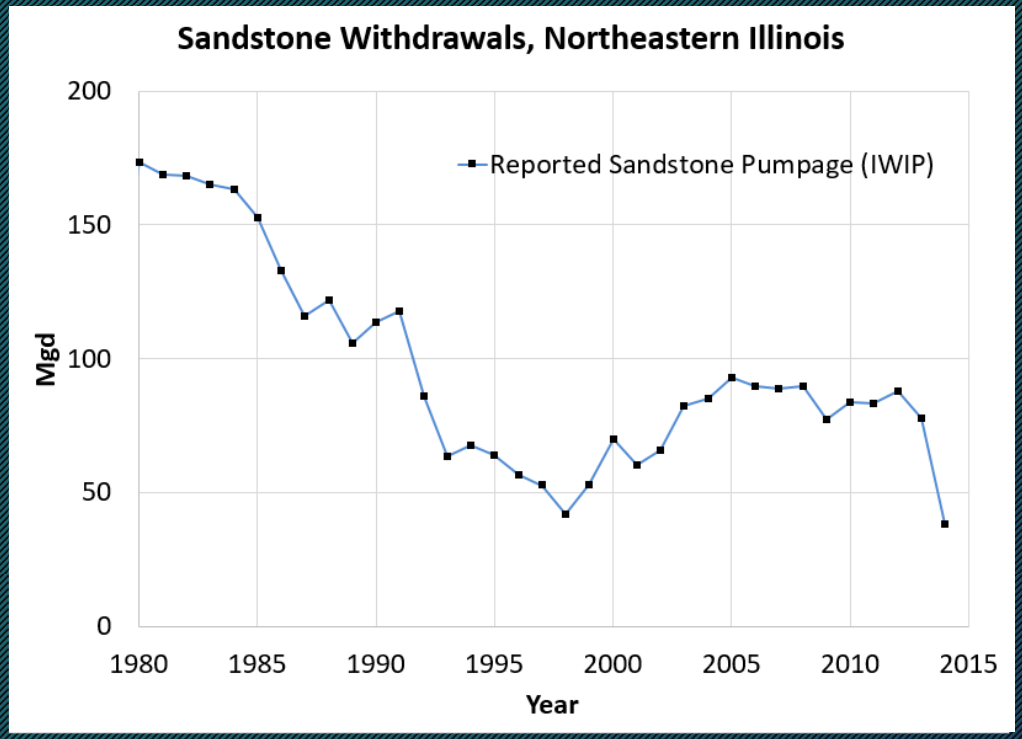
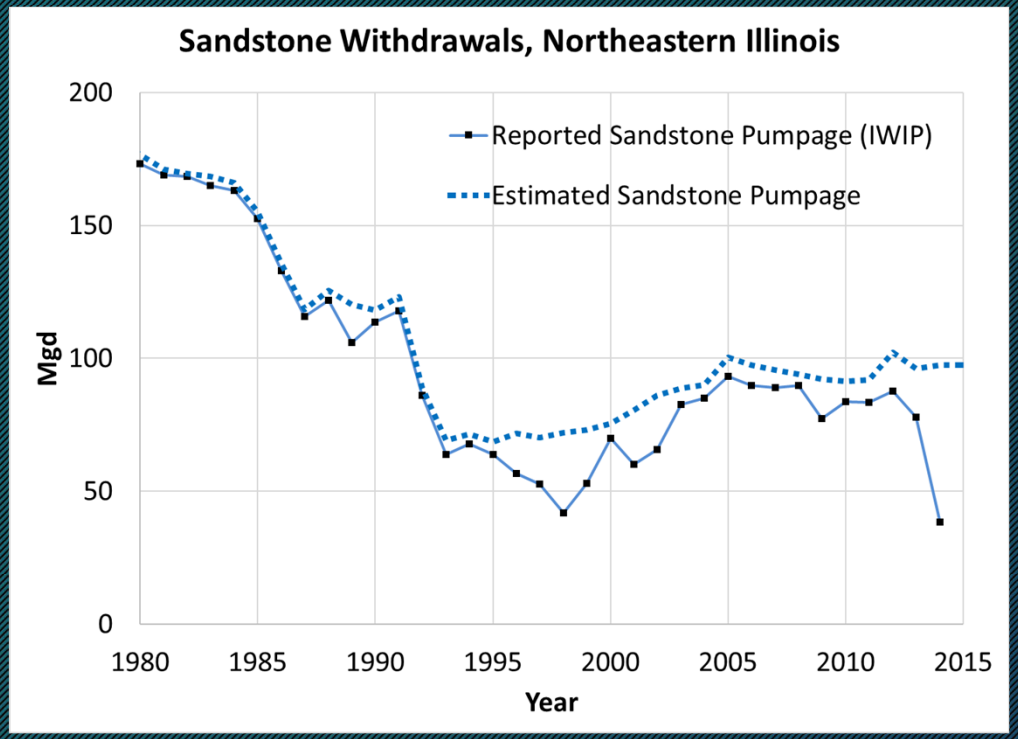
Example 1: Withdrawals



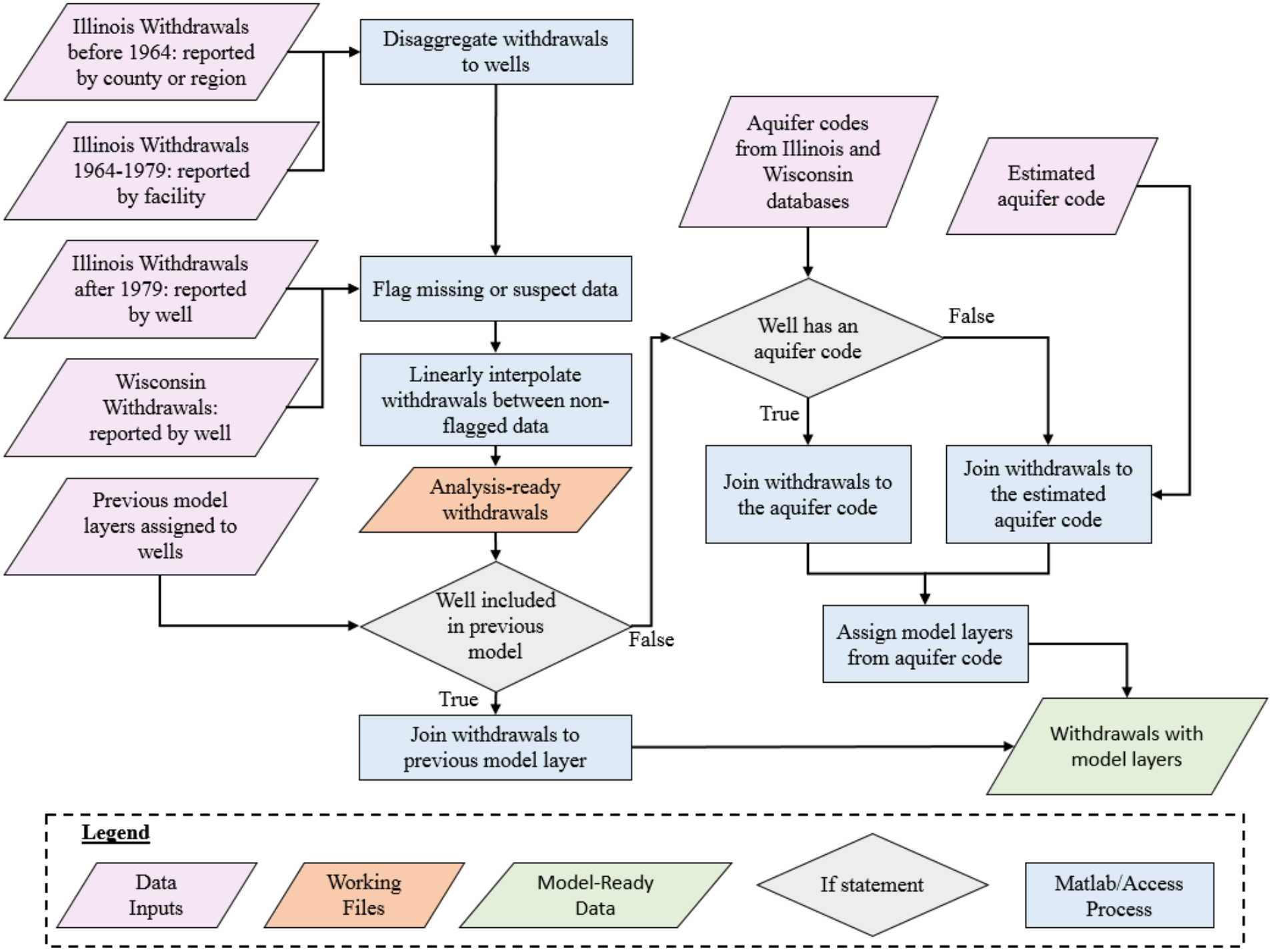
Raw reported water use data is preserved in a database by Illinois Water Inventory Program (IWIP) staff.

Reported withdrawals include data gaps and outliers that have traditionally been handled on a case-by-case basis and not reflected in a database.

Example 1: Withdrawals

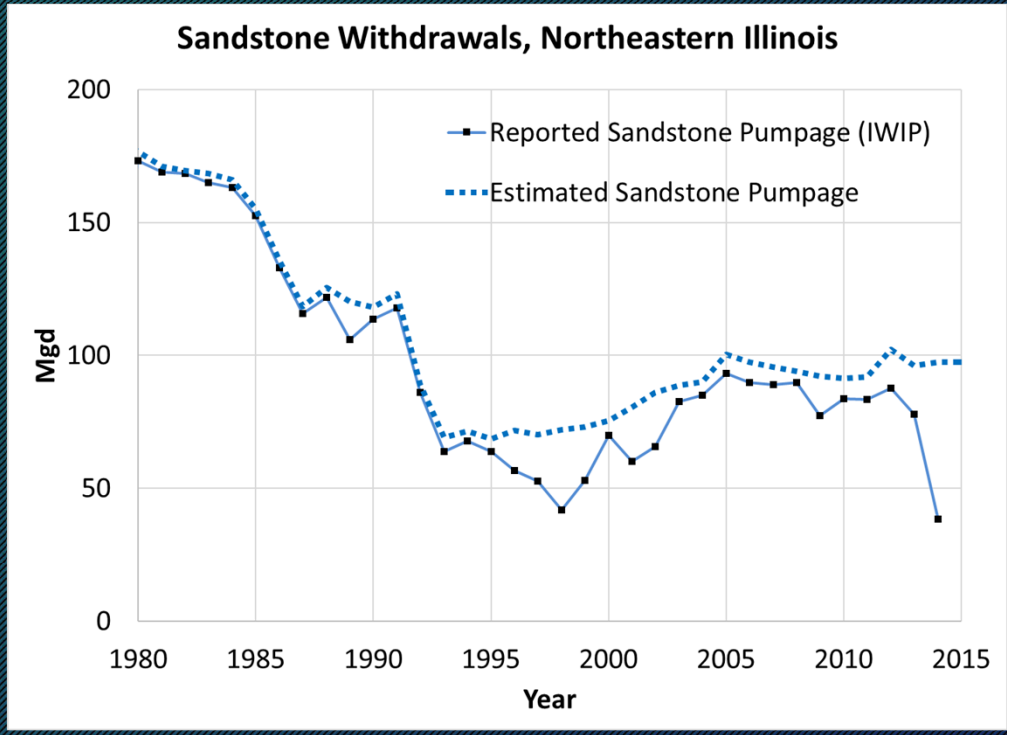


Estimated withdrawals are now scripted using MATLAB (transitioning to Python). Moving forward, the decision criteria will be consistent across all models, and will be allowed to evolve.

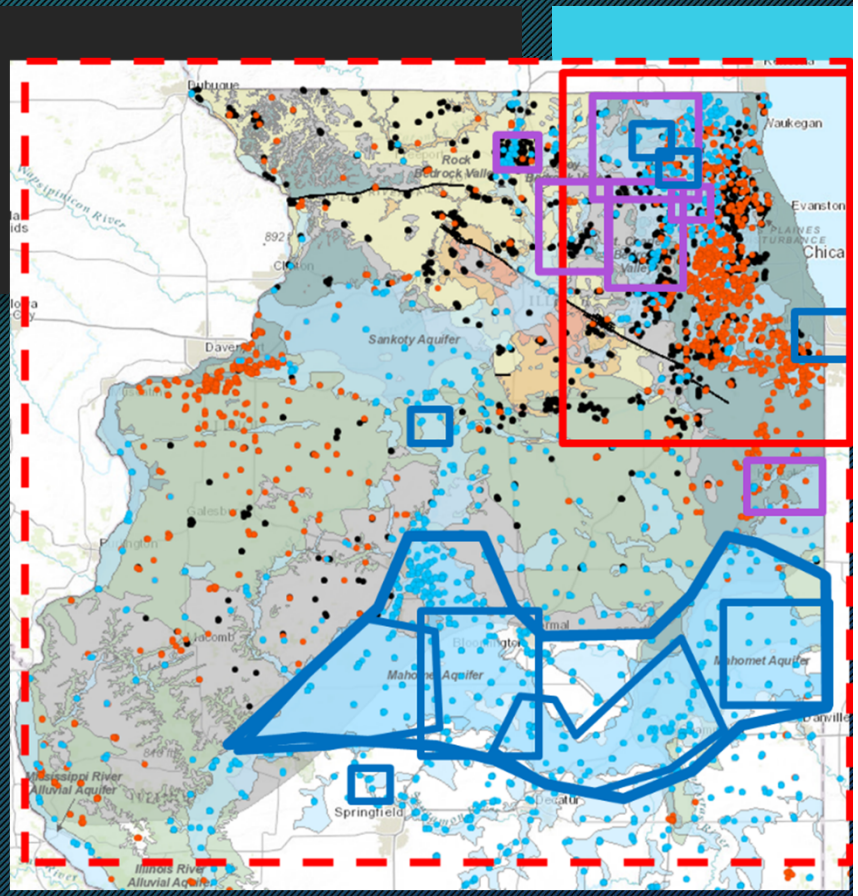

Illinois Withdrawals before 1964: reported by county or region
Illinois Withdrawals 1964-1979: reported by facility
Illinois Withdrawals after 1979: reported by well
Wisconsin Withdrawals: reported by well
Previous model layers assigned to wells
Disaggregate withdrawals to wells
Flag missing or suspect data
Linearly interpolate withdrawals between non-flagged data
Analysis-ready withdrawals
Well included in previous model
False
True
Join withdrawals to previous model layer
Aquifer codes from Illinois and Wisconsin databases
Estimated aquifer code
Well has an aquifer code
False
True
Join withdrawals to the aquifer code
Join withdrawals to the estimated aquifer code
Assign model layers from aquifer code
Withdrawals with model layers
Legend
Data Inputs
Working Files
Model-Ready Data
If statement
Matlab/Access Process

IMPORTANT PROCESSES

- Remove outliers
- Fill data gaps (particularly at the end of the record)
- Adjust future demands based on most recent year of reporting
- Assign points to the proper aquifer



Import withdrawals into the groundwater flow model via FloPy



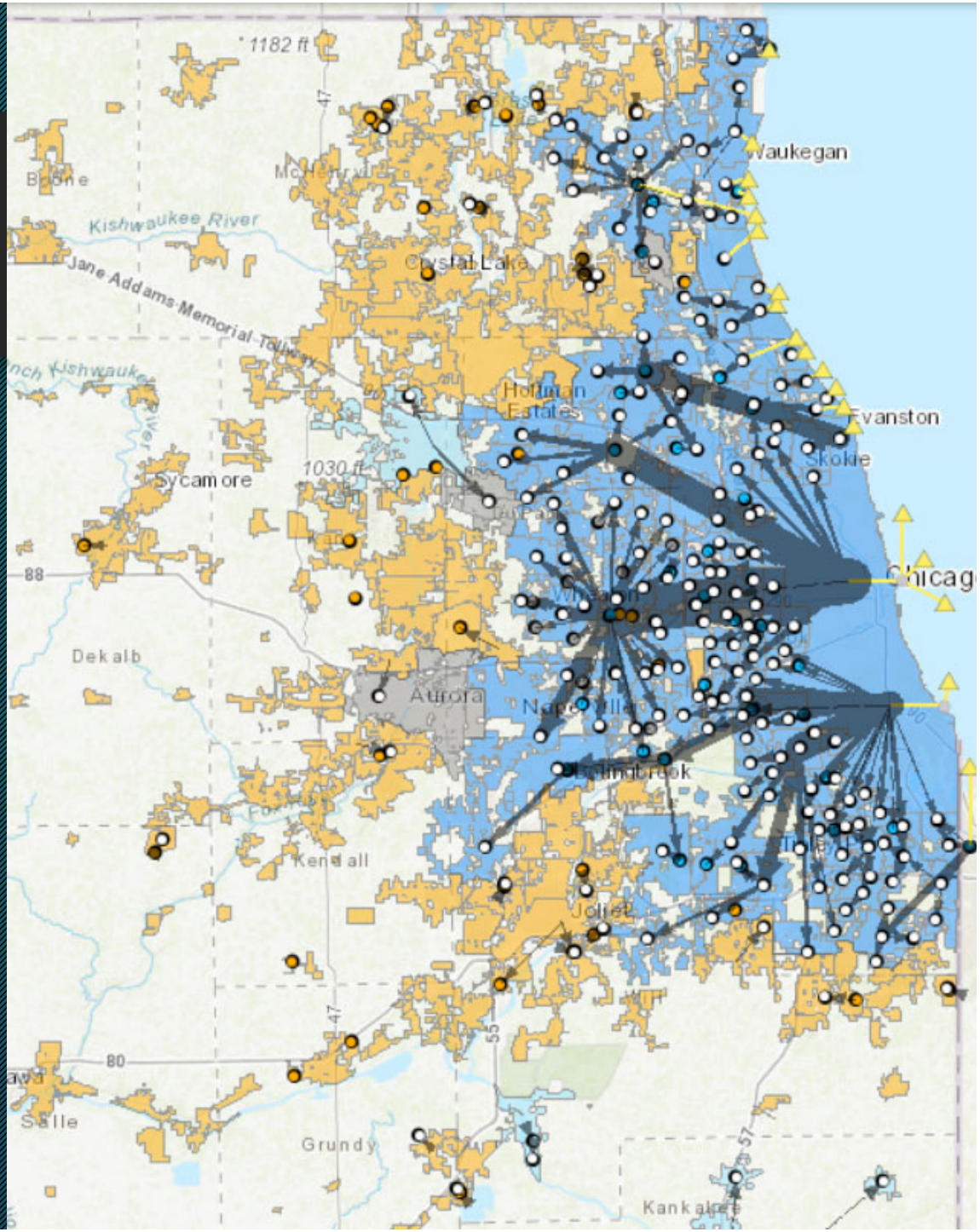
Bakker, M., Post, V., Langevin, C.D., Hughes, J.D., White, J.T., Starn, J.J., and Fienen, M.N., 2018, FloPy v3.2.9 – develop: U.S. Geological Survey Software Release, 05 June 2018, http://dx.doi.org/10.5066/F7BK19FH

FloPy

a Python package to create, run, and post-process MODFLOW-based models.

WATER USAGE

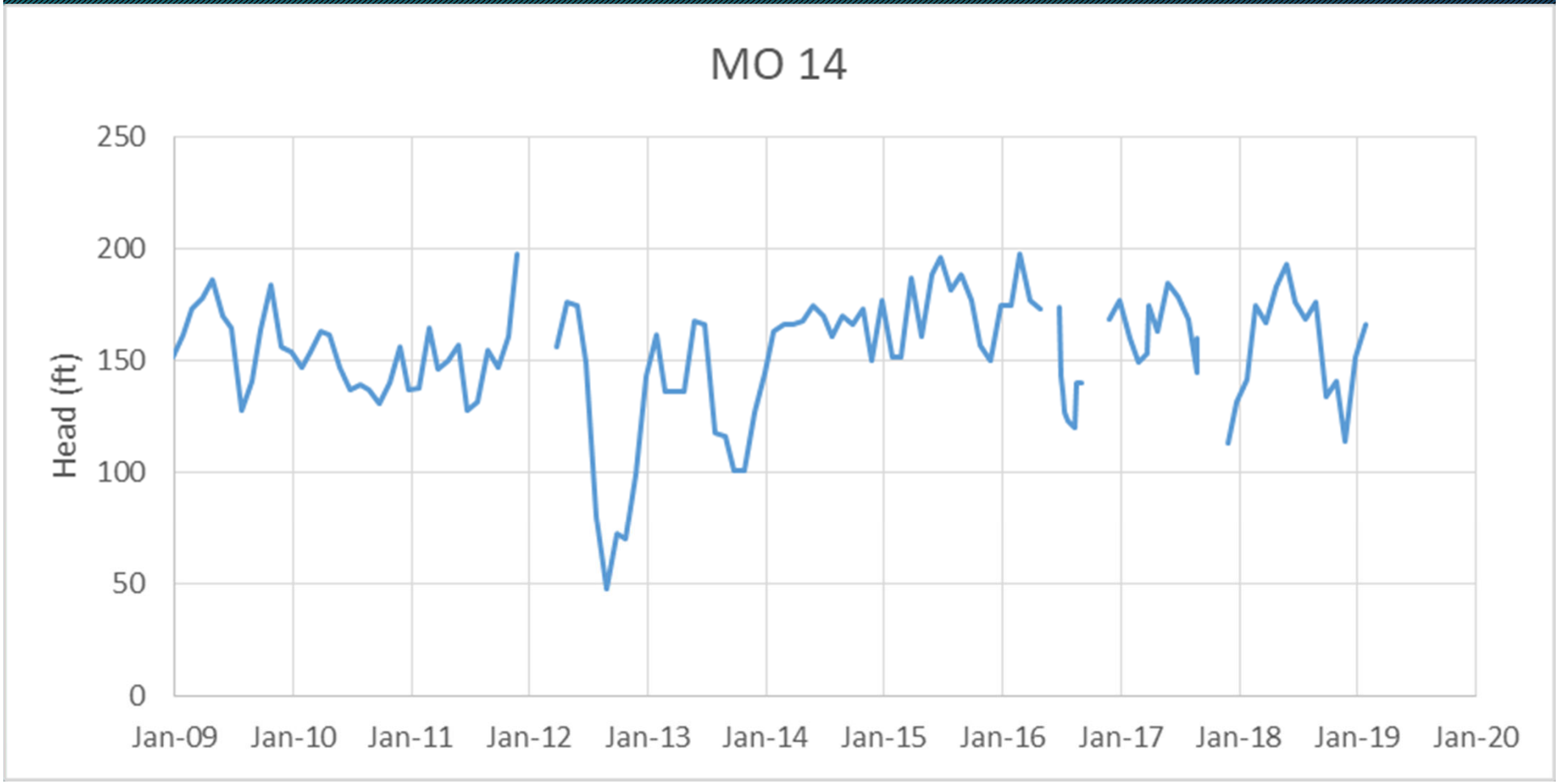
- Account for all purchases and sells of water to calculate water use
- Critical for water demand projections
- Let's take a quick look to see some of the complications with this



Monthly data

- Currently discussing in-house how to best handle monthly data (Montgomery, Shorewood, Joliet provide regularly)
- Need a sustainable method to continue this and allow for rapid analyses

Monthly data- Montgomery 14



Monthly data- Montgomery 4

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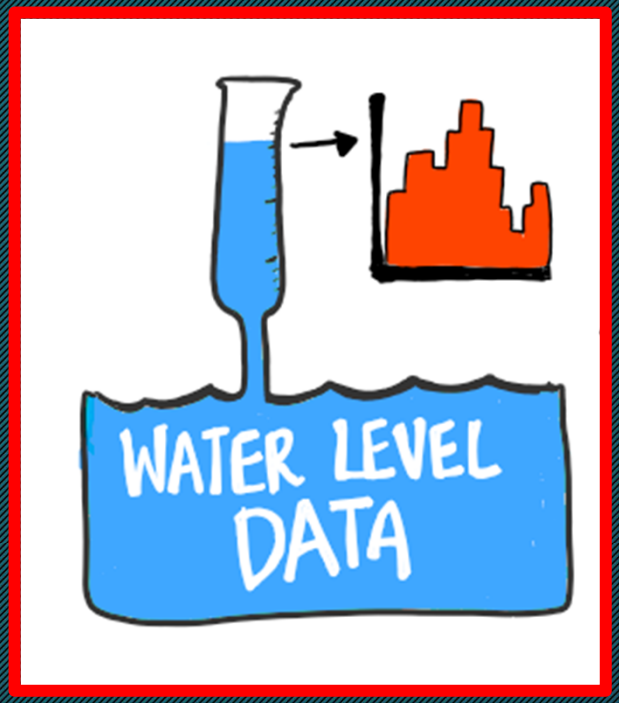
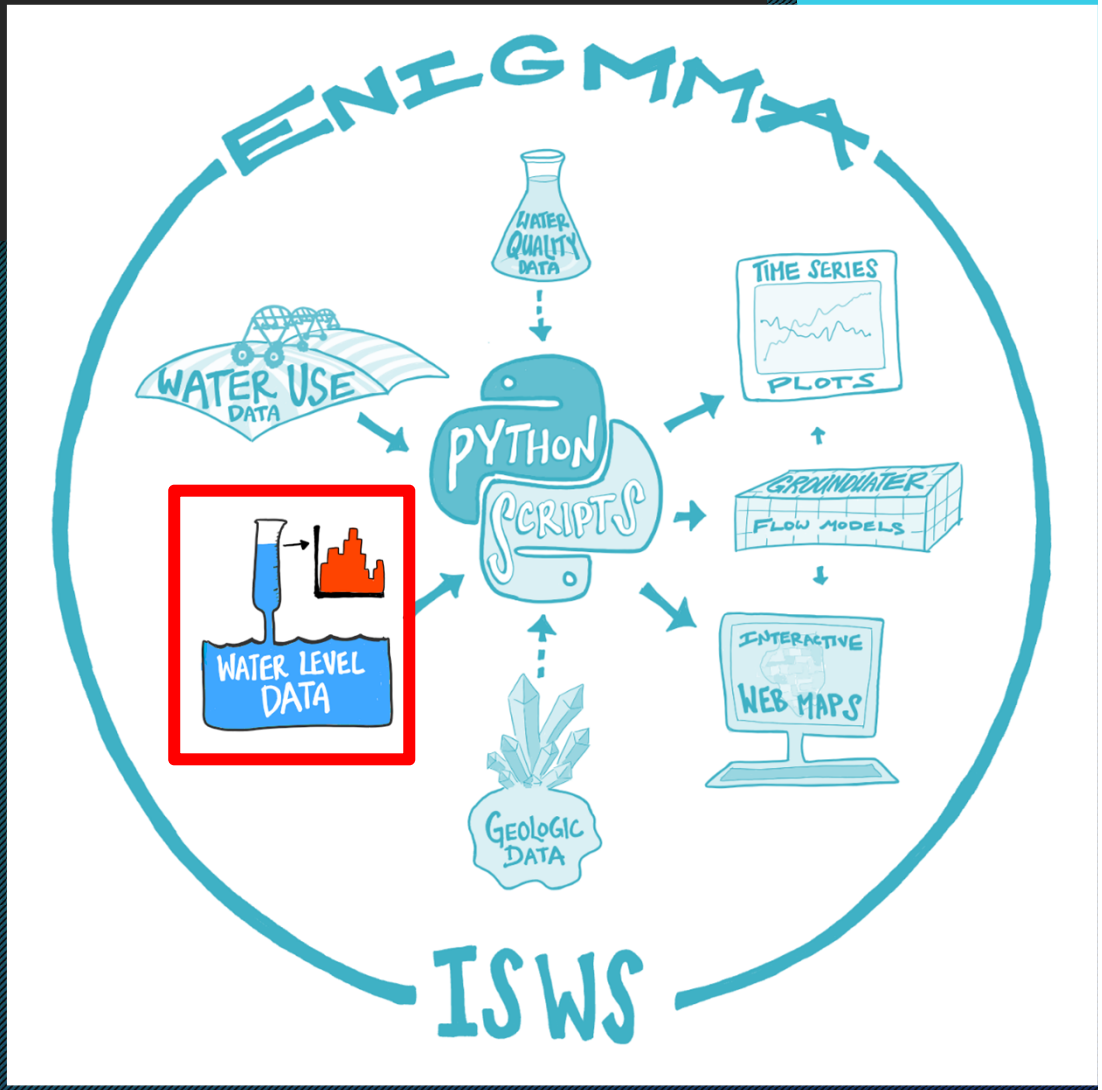

WATER LEVEL DATA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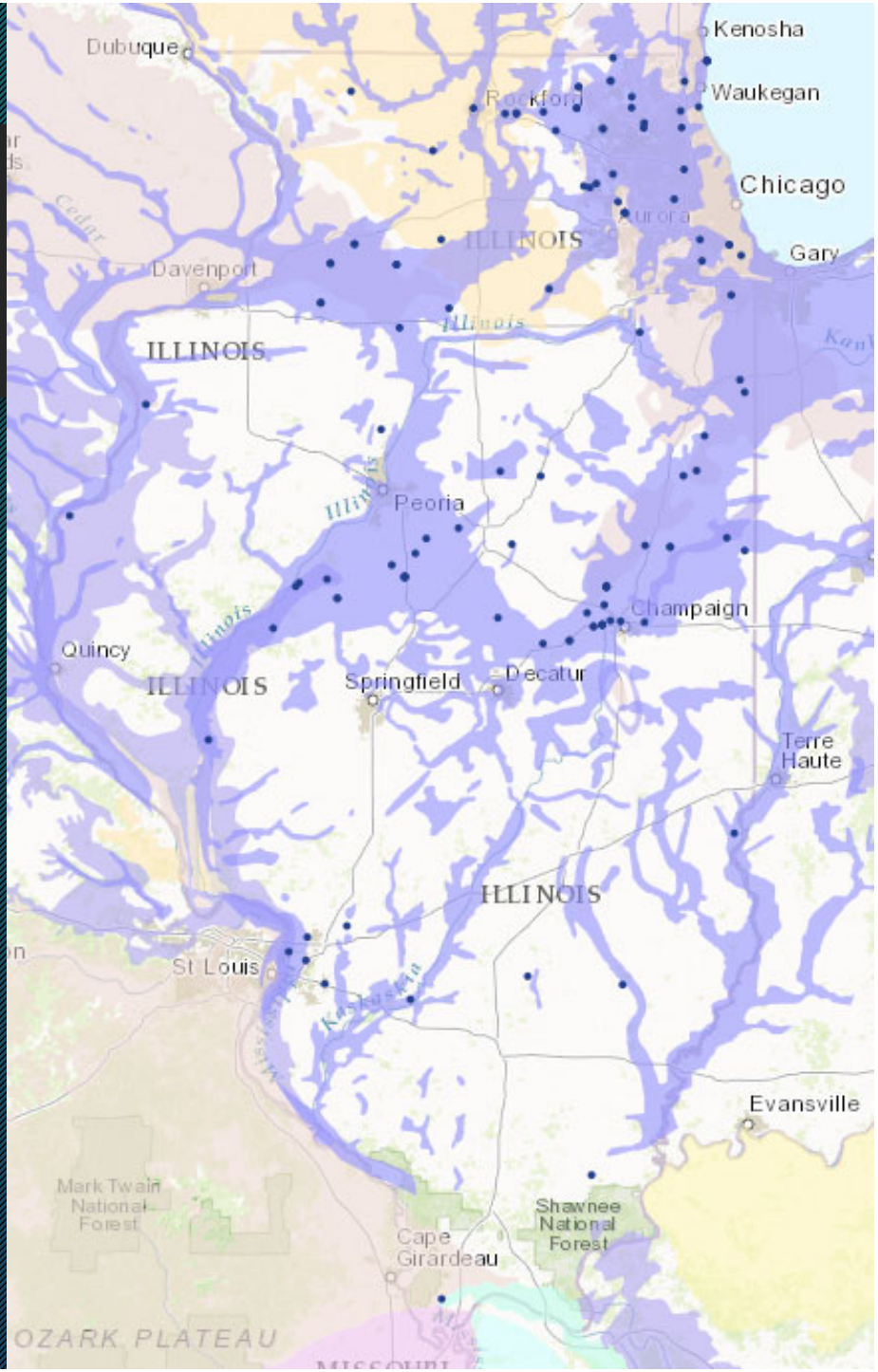
ISWS

Illinois Monitoring Networks

Currently 111 water level sites in the National Groundwater Monitoring Network

- 63 USGS sites
- 48 ISWS sites
  - Additional 6 sites pending, will be added as data goes live

Plus many many others, some with real-time data



Real-time monitoring wells

Data streamed in live to ISWS data servers and stored in a database

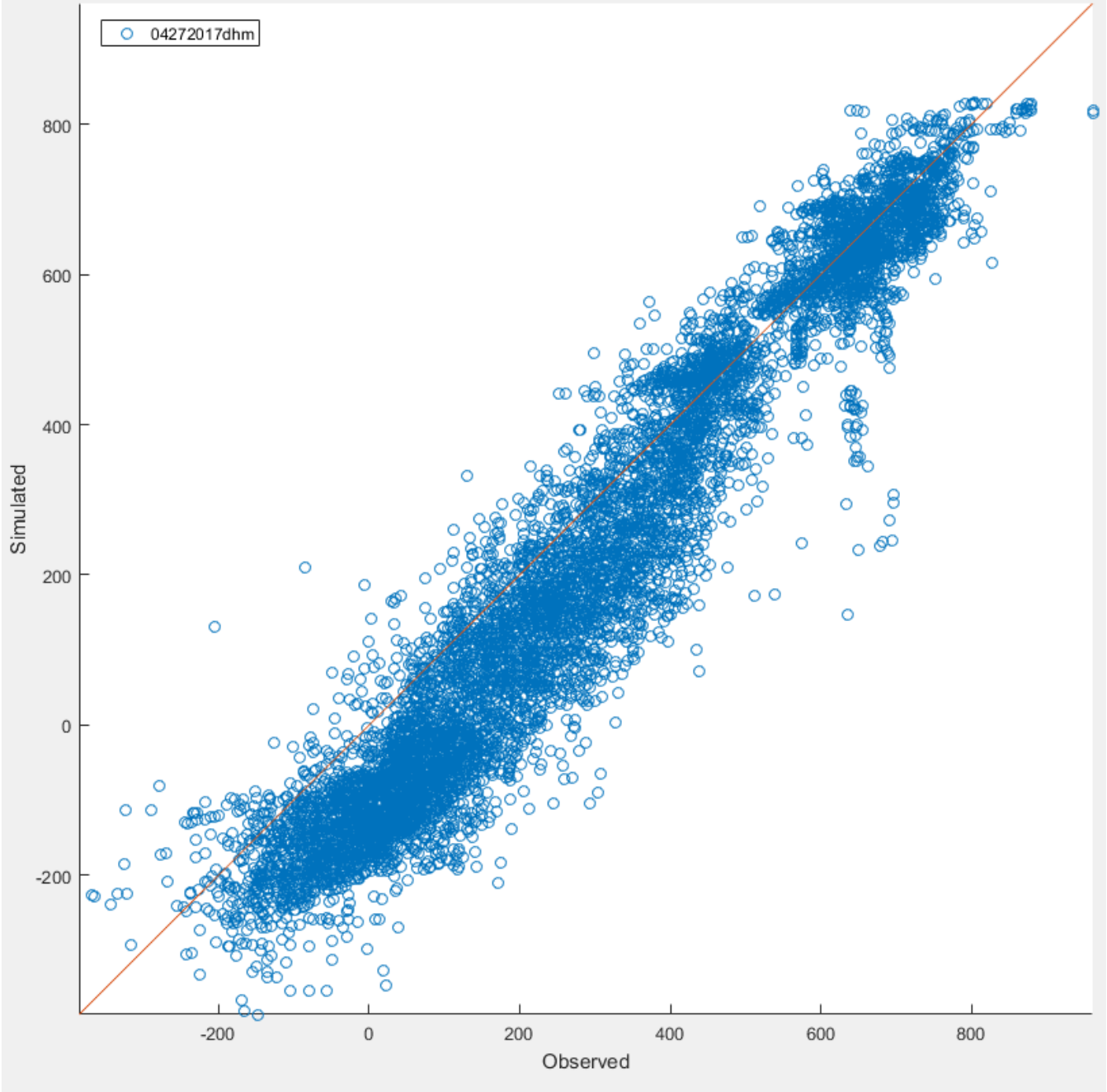
In the process of developing live updates of web services

Calibration Toolbox

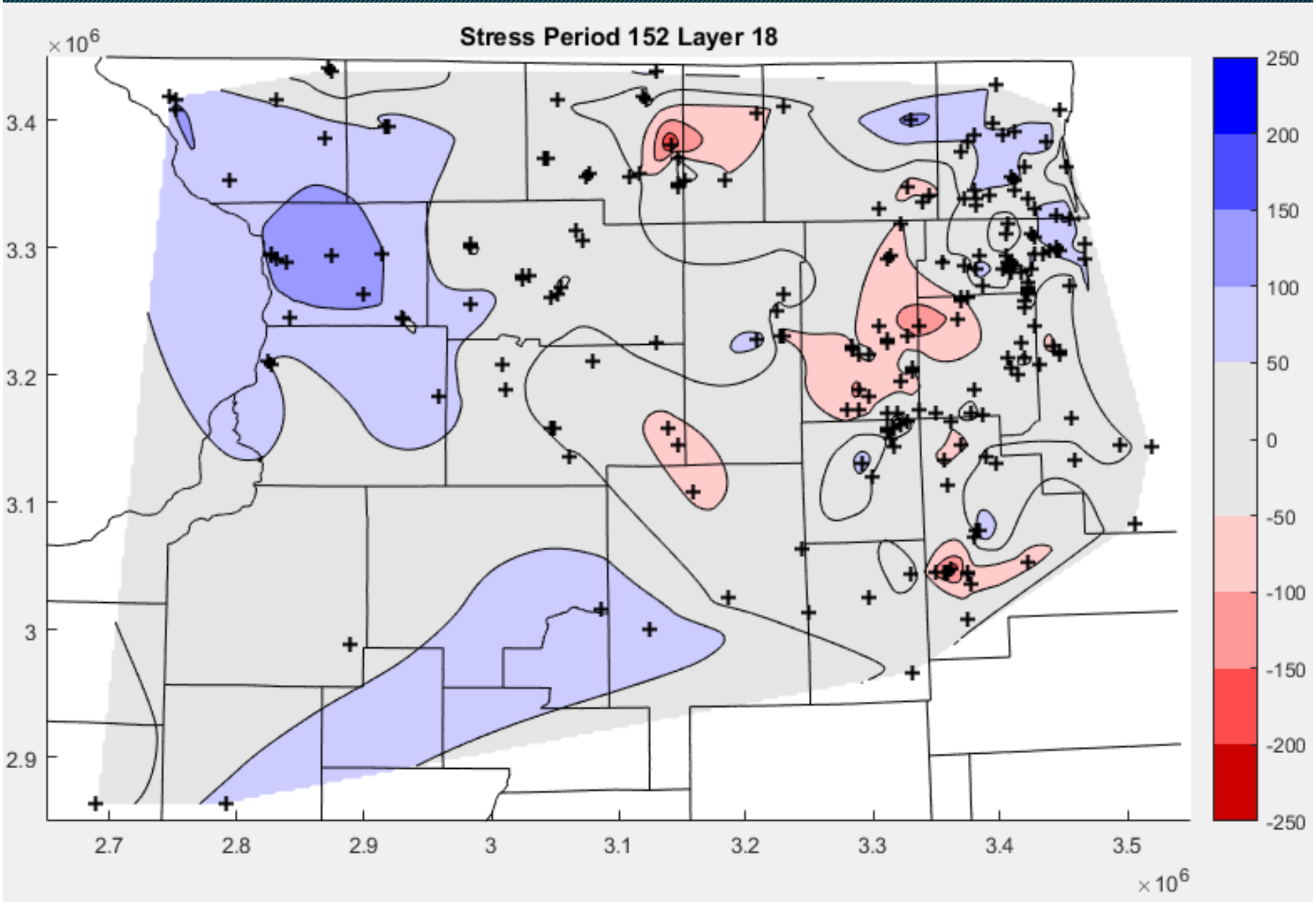
MATLAB based GUI

Allows the user to rapidly assess calibration.

Code is being modified to automate calibration statistics and plots when withdrawals and observation data are updated in a model.



Head error: 2014



Spatial change between two model simulations

Inputs
Log #:
IGWFM.Final
Rows 625
Layers 21
Columns 604
SPs 153
Load .hds and .shp files
Files loaded
Load .mat file

Filters
Layer
15
18
20
Stress Period
123
129
133
138
145
152
Parameter 1
7071
7095
7109
7131
7187
Parameter 2
1515
1518
1520
1818
1820
Parameter 3
23
24
25
26
36

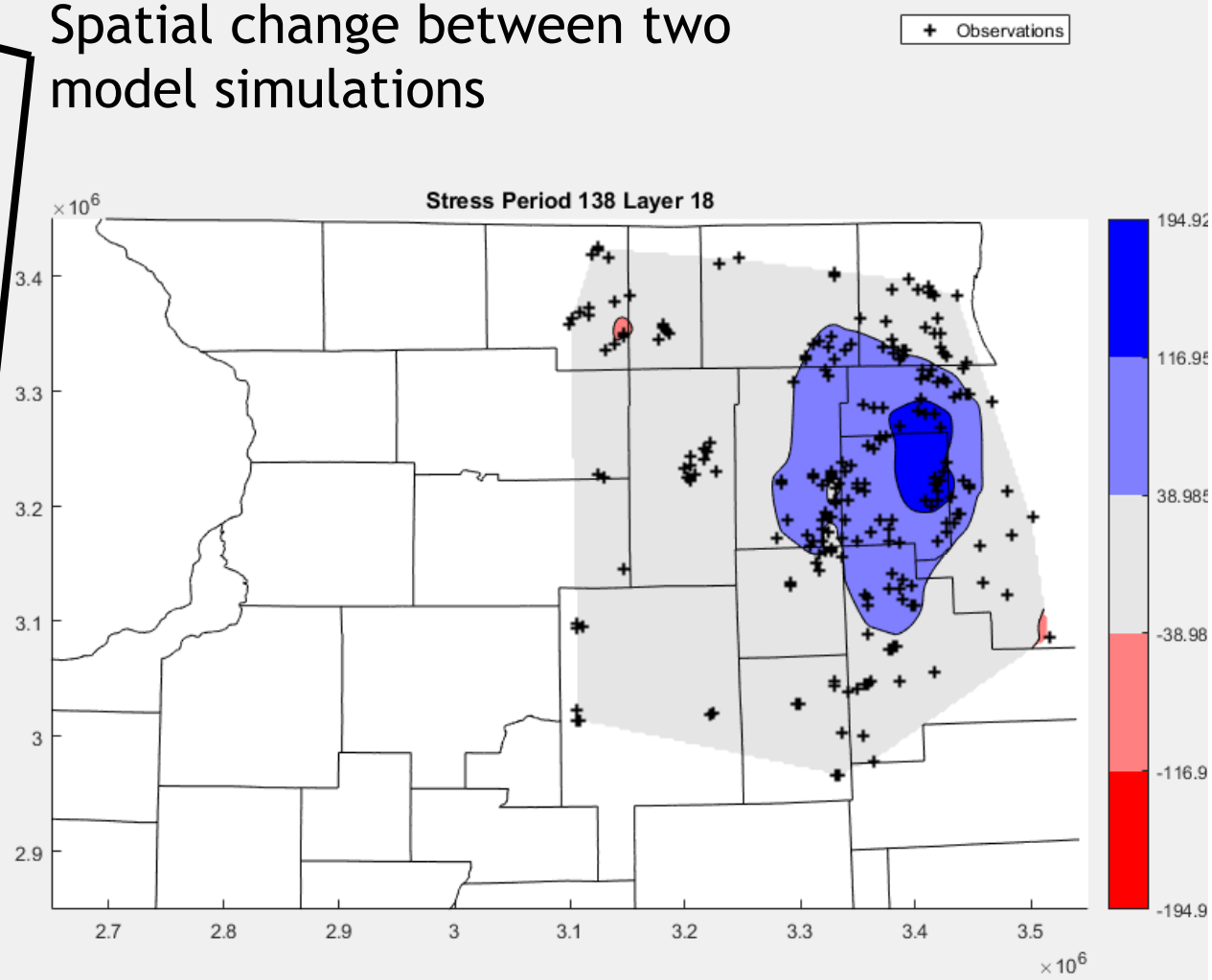
Calibration Plot
Group by:
Nothing
1:1
Stats

Calibration statistics
Type of plot
Mean Error Plot
X-axis
Stress Period
Stats

Spatial plot
Map

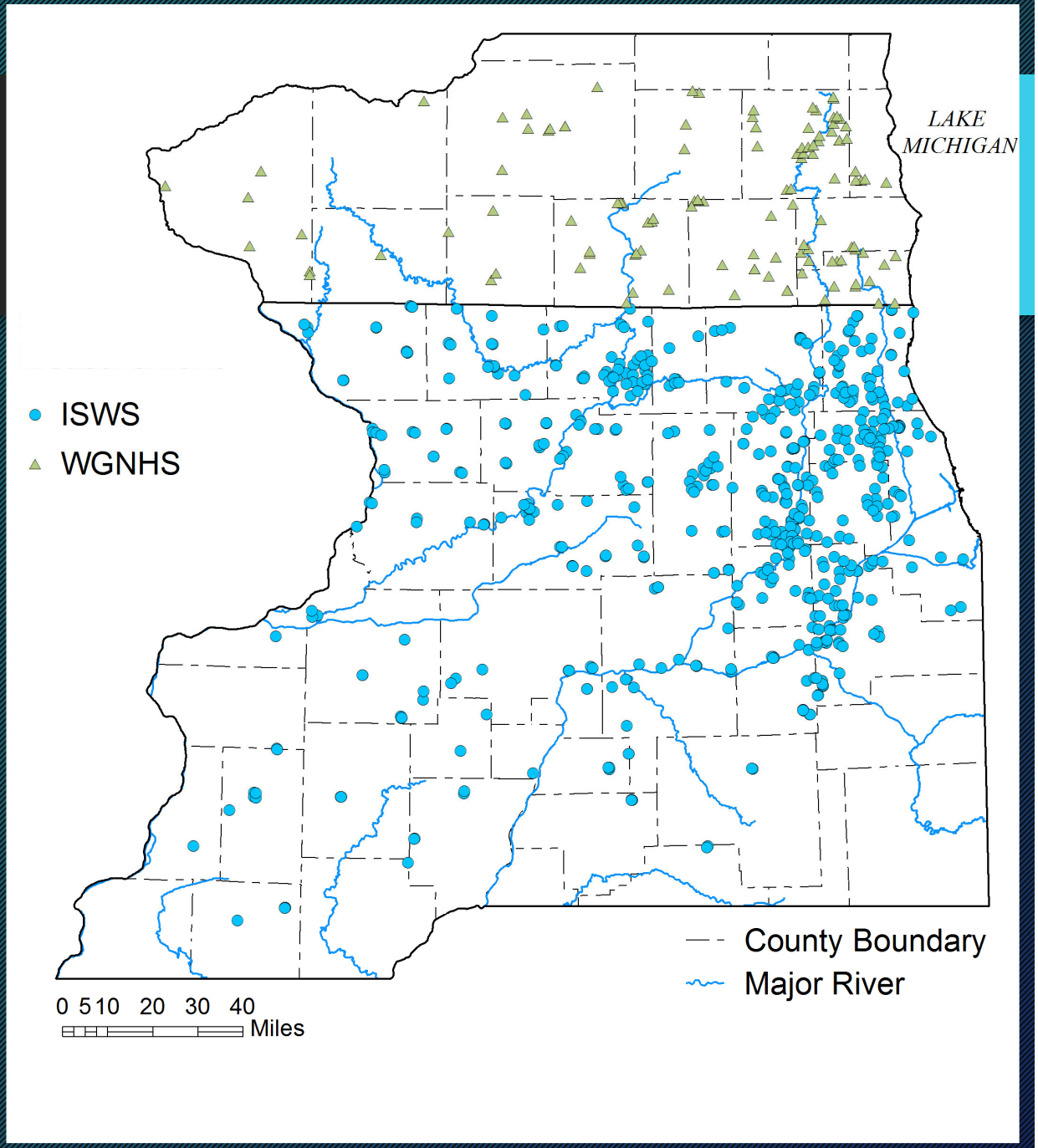
Comparison
Spatial change
03302017dhm_1
Compare

Save Figure

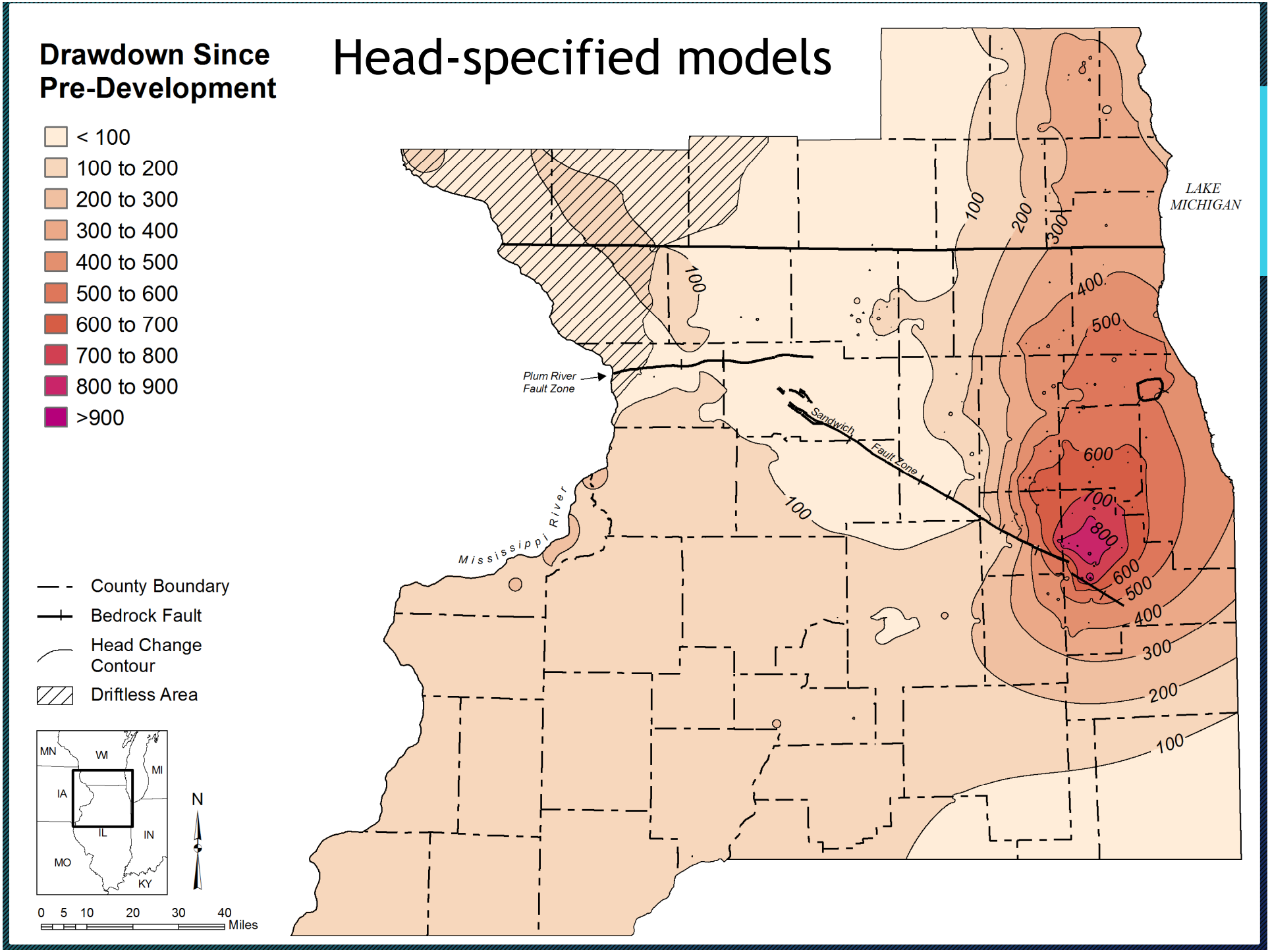


2014 Synoptic Measurement

- 675 wells
- Collaboration with Wisconsin Survey (WGNHS)
- Static water levels under non-pumping conditions

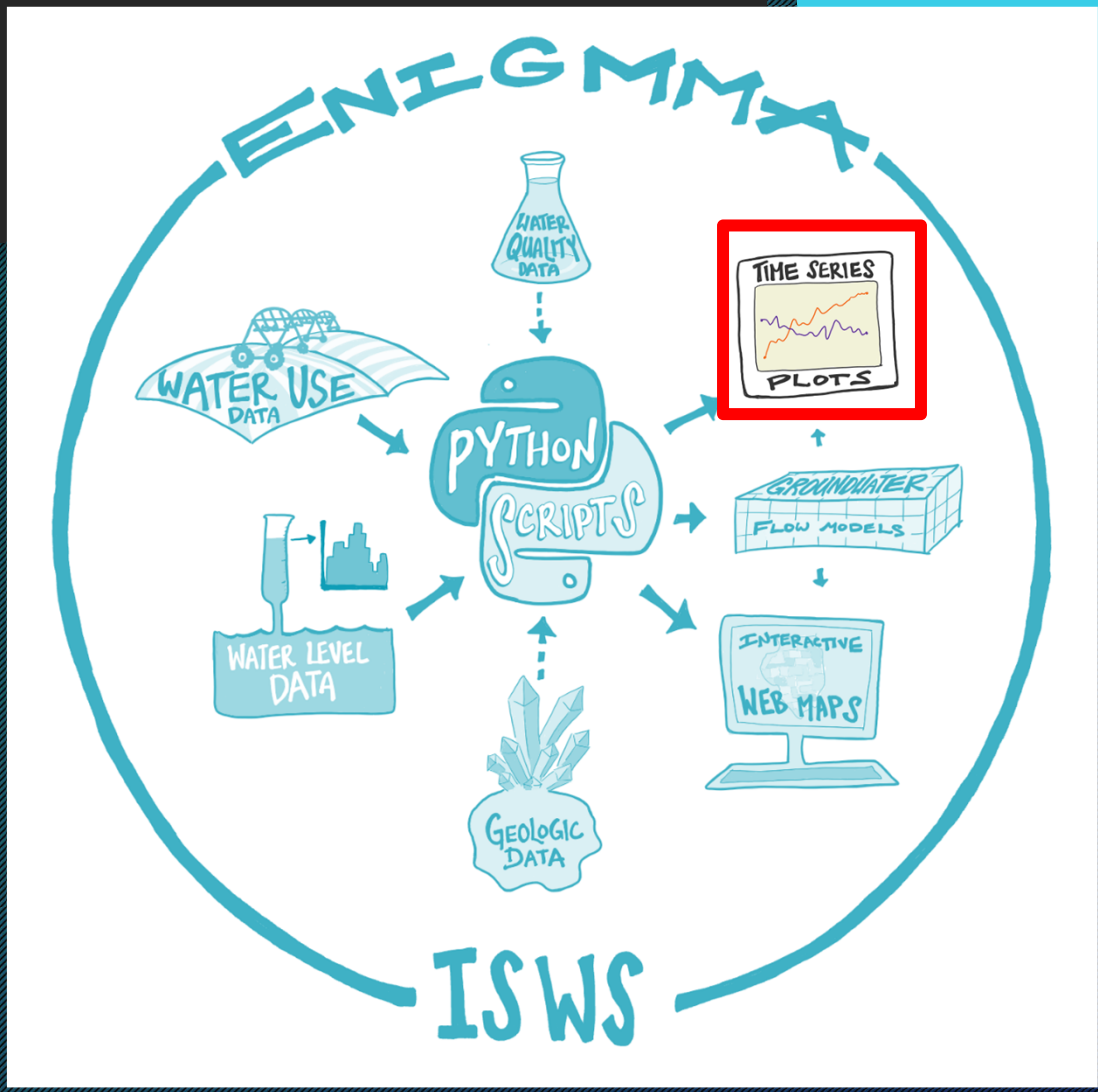


Head-specified models



ENIGMMA


TIME SERIES
PLOTS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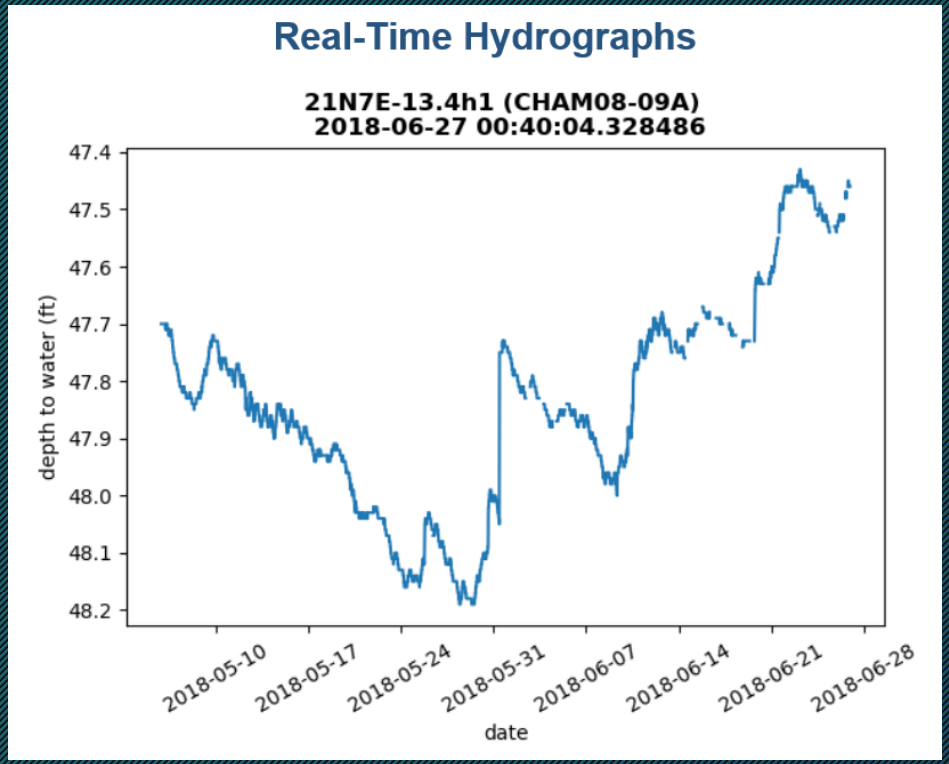
USGS web services

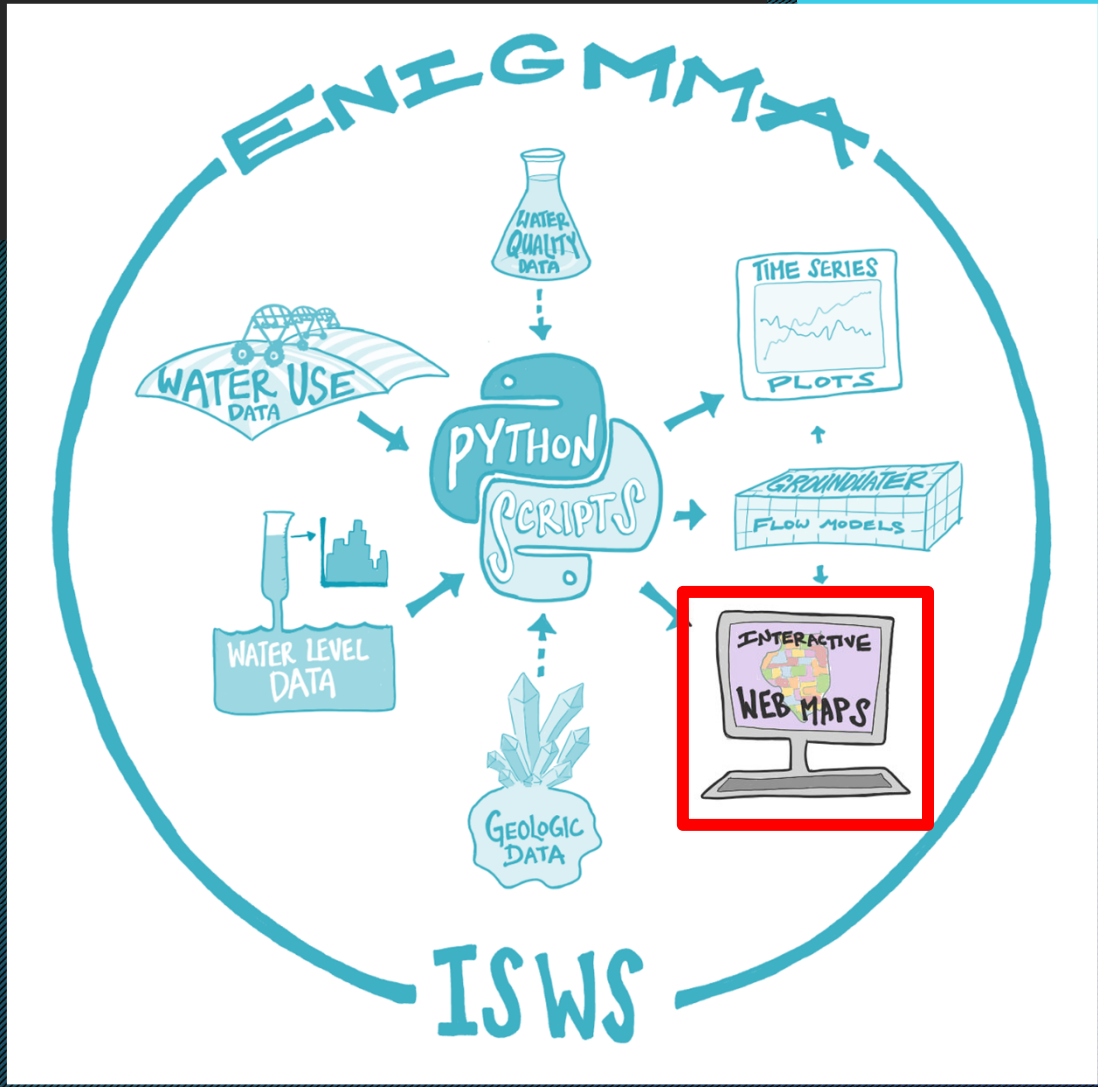


Python script developed to access web services from the USGS for surface water stage and groundwater head observations

In the process of scripting this data into a groundwater flow model as specified-head boundary or observation target.

ENIGMMA


INTERACTIVE
WEB MAPS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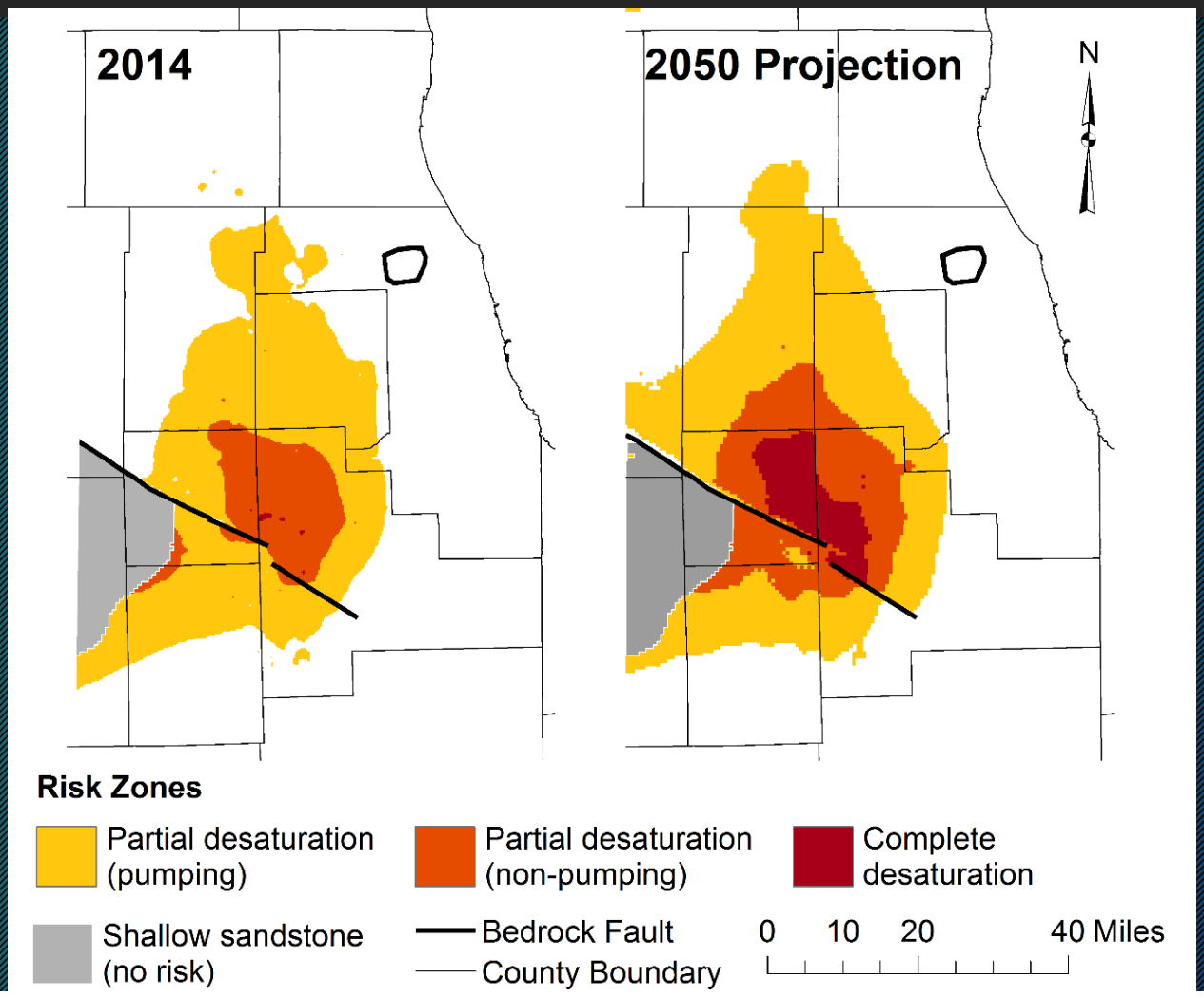
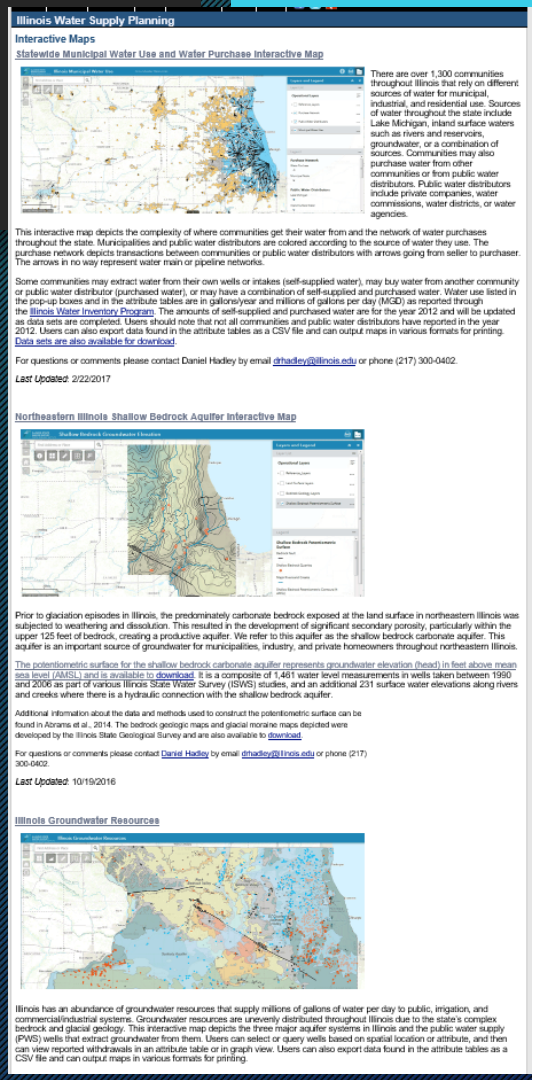
Example web maps





Illinois Water Supply Planning

Interactive Maps

Statewide Municipal Water Use and Water Purchase Interactive Map

There are over 1,300 communities throughout Illinois that rely on different sources of water for municipal, industrial, and residential use. Sources of water throughout the state include Lake Michigan, inland surface waters such as rivers and reservoirs, groundwater, or a combination of sources. Communities may also purchase water from other communities or from public water distributors. Public water distributors include private companies, water commissions, water districts, or water agencies.

This interactive map depicts the complexity of where communities get their water from and the network of water purchases throughout the state. Municipalities and public water distributors are colored according to the source of water they use. The purchase network depicts transactions between communities or public water distributors with arrows going from seller to purchaser. The arrows in no way represent water main or pipeline networks.

Some communities may extract water from their own wells or intakes (self-supplied water), may buy water from another community or public water distributor (purchased water), or may have a combination of self-supplied and purchased water. Water use listed in the pop-up boxes and in the attribute tables are in gallons/year and millions of gallons per day (MGD) as reported through the Illinois Water Inventory Program. The amounts of self-supplied and purchased water are for the year 2012 and will be updated as data sets are completed. Users should note that not all communities and public water distributors have reported in the year 2012. Users can also export data found in the attribute tables as a CSV file and can output maps in various formats for printing. Data sets are also available for download.

For questions or comments please contact Daniel Hadley by email dhadley@illinois.edu or phone (217) 300-0402.

Last Updated: 2/22/2017

Northeastern Illinois Shallow Bedrock Aquifer Interactive Map

Prior to glaciation episodes in Illinois, the predominately carbonate bedrock exposed at the land surface in northeastern Illinois was subjected to weathering and dissolution. This resulted in the development of significant secondary porosity, particularly within the upper 125 feet of bedrock, creating a productive aquifer. We refer to this aquifer as the shallow bedrock carbonate aquifer. This aquifer is an important source of groundwater for municipalities, industry, and private homeowners throughout northeastern Illinois.

The potentiometric surface for the shallow bedrock carbonate aquifer represents groundwater elevation (head) in feet above mean sea level (AMSL) and is available to download. It is a composite of 1,461 water level measurements in wells taken between 1990 and 2006 as part of various Illinois State Water Survey (ISWS) studies, and an additional 231 surface water elevations along rivers and creeks where there is a hydraulic connection with the shallow bedrock aquifer.

Additional information about the data and methods used to construct the potentiometric surface can be found in Abrams et al., 2014. The bedrock geologic maps and glacial moraine maps depicted were developed by the Illinois State Geological Survey and are also available to download.

For questions or comments please contact Daniel Hadley by email dhadley@illinois.edu or phone (217) 300-0402.

Last Updated: 10/19/2016

Illinois Groundwater Resources

Illinois has an abundance of groundwater resources that supply millions of gallons of water per day to public, irrigation, and commercial/industrial systems. Groundwater resources are unevenly distributed throughout Illinois due to the state's complex bedrock and glacial geology. This interactive map depicts the three major aquifer systems in Illinois and the public water supply (PWS) wells that extract groundwater from them. Users can select or query wells based on spatial location or attribute, and then can view reported withdrawals in an attribute table or in graph view. Users can also export data found in the attribute tables as a CSV file and can output maps in various formats for printing.

Status of ENIGMMA: Undergoing review

- Illinois Groundwater Flow Model 2018.0 report, introducing ENIGMMA
  - Process outlines and flow-charts
- A few scripts/functions are undergoing ENIGMMA team review and discussion
  - JSON web service extractor (Python function)
  - Water level alert generator (Python function)
  - Calibration toolbox (MATLAB GUI and source code)
  - Example scripts for scientists new to Python (Jupyter Notebooks)
- ENIGMMA GITHUB page will launch in 2019.
- E-mail dbabrams@Illinois.edu for provisional versions

Status of ENIGMMA: In development

- Model-ready pumpage generator (with GUI)
  - Flag and remove outliers
  - Fills in data gaps
- Water use generator (with GUI)
  - Account for purchases and sells
- Web map updater
  - Updates from a real-time database pull of water level and water use data

Will be added to the ENIGMMA GITHUB as they become available

Thanks

Funding from the Illinois Department of Natural Resources

Special thanks to Greg Rogers, the benevolent overlord of coding and web development at ISWS