Kentucky Interagency Groundwater Monitoring Network: Expanded Monitoring Programs

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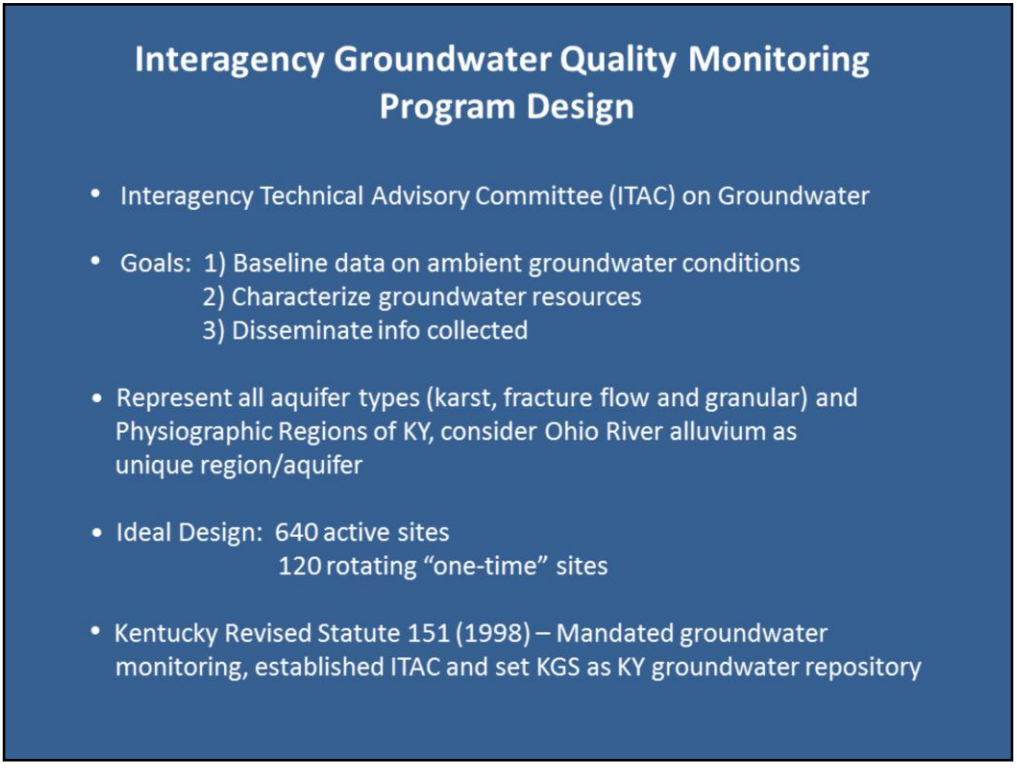


ITAC formed in early 1990s, large group of professionals representing various government agencies, universities and geological surveys. Ultimately put together framework document for groundwater monitoring in KY, with goals and design elements necessary to achieve them. KRS151 passed in 1998 formalized GW Network .

Actual Groundwater Quality Monitoring in Kentucky

Actual (Reasonable) Design:

- Ambient Groundwater Quality Monitoring Network:
  - 59 active sites (~10% of "Ideal")
    - 29 wells and 30 springs
  - Sampled 4 times per year (some less frequent)
  - Priority given to Public Water Suppliers using groundwater (18 wells, 5 springs)

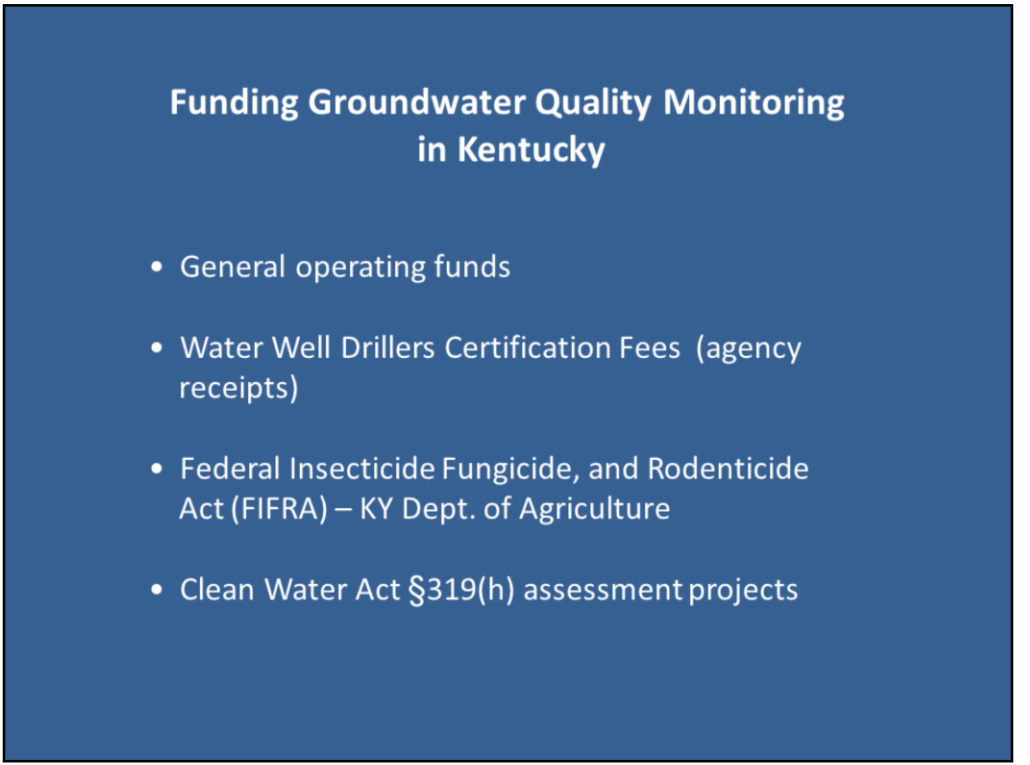
- Approximate total of 200 samples per year
  - Roughly 120 from GW Quality Network
  - Remainder from NPS studies, technical assistance, complaint investigations and one-time sites

Over the years, typically about 60 active sites. Current breakdown and stats in slide. Side note that about 1.8 million people in KY rely on GW PWSs for their drinking water.

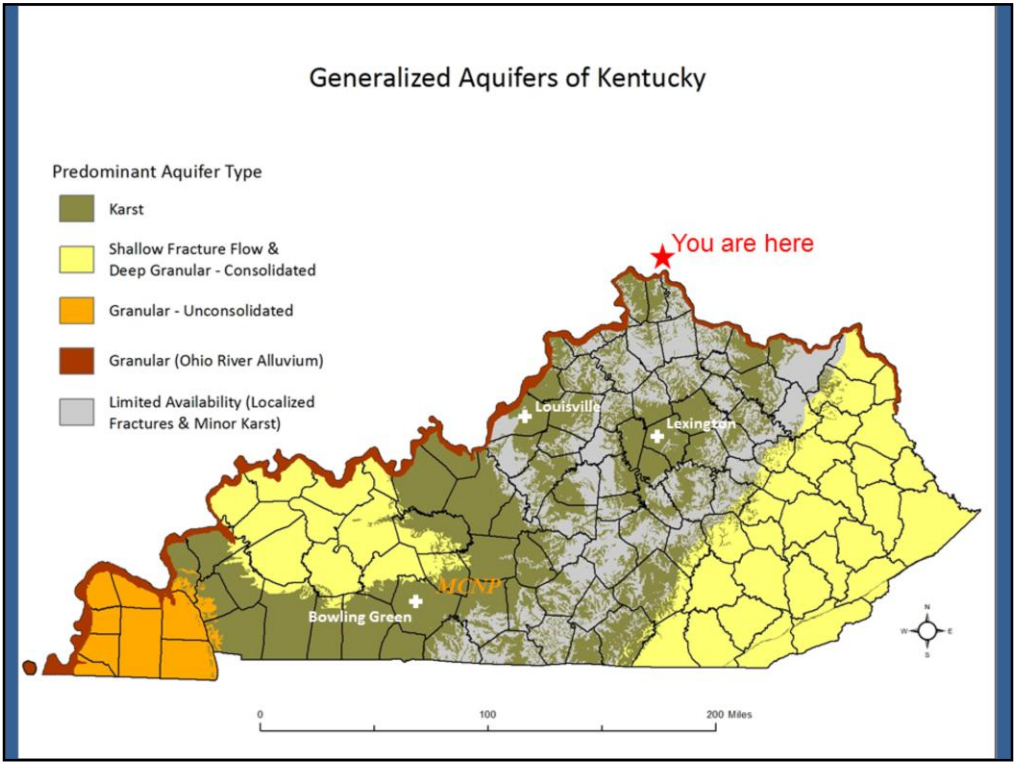
Parameters Summarized

- **Bulk Parameters** – pH, Temp, Specific Conductance, TSS & TDS
- **Nutrients** – NO_3-N, NO_2-N, NH_3-N, TKN, TOC, Total-P & Ortho-P
- **Major Inorganic Ions** – Cl^-, F^- & SO_4^-
- **Metals** (Dissolved and Total) – Ca, Fe, Mg, K, Na, Al, As, Ba, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag & Zn
- **Organics** – N/P and Chlorinated Pesticides, Herbicides & PCBs
- **Volatile Organics** – BTEX & MTBE (numerous others)
- **Caffeine** – recent addition, surrogate for potential anthropogenic impacts

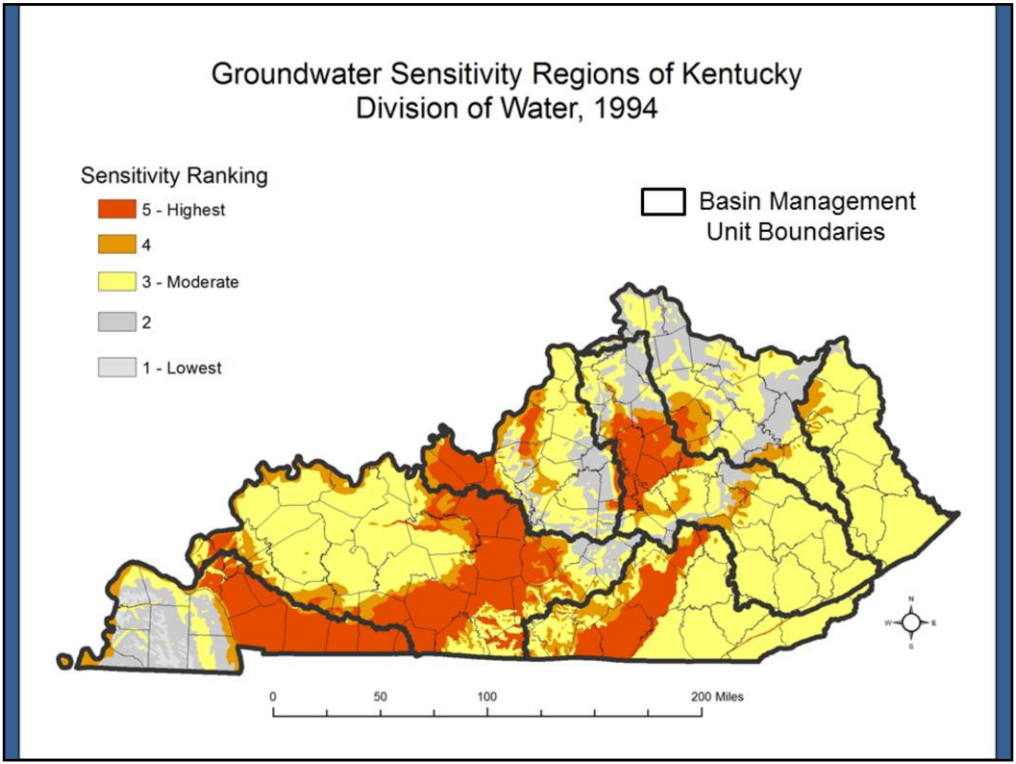
Collect a broad range of parameters, major parameter groups listed. Each lab report has about 325 analytes. We capture just about all of the Primary and Secondary Drinking Water Standards from US EPA for treated, public drinking water. Exceptions are bacteria (due to holding times) and radioactive isotopes (no major issues with these in KY).



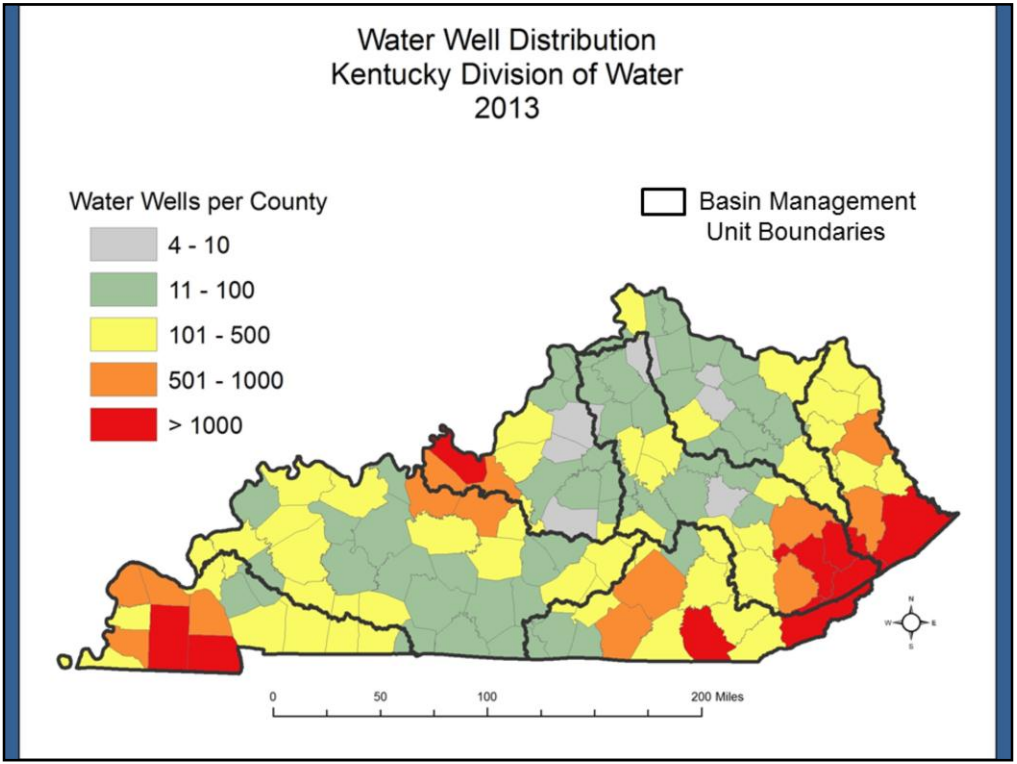
Various funding streams. Well drillers program money only used for equipment and supplies. CWA 319 grants for regional or watershed-based groundwater assessments.



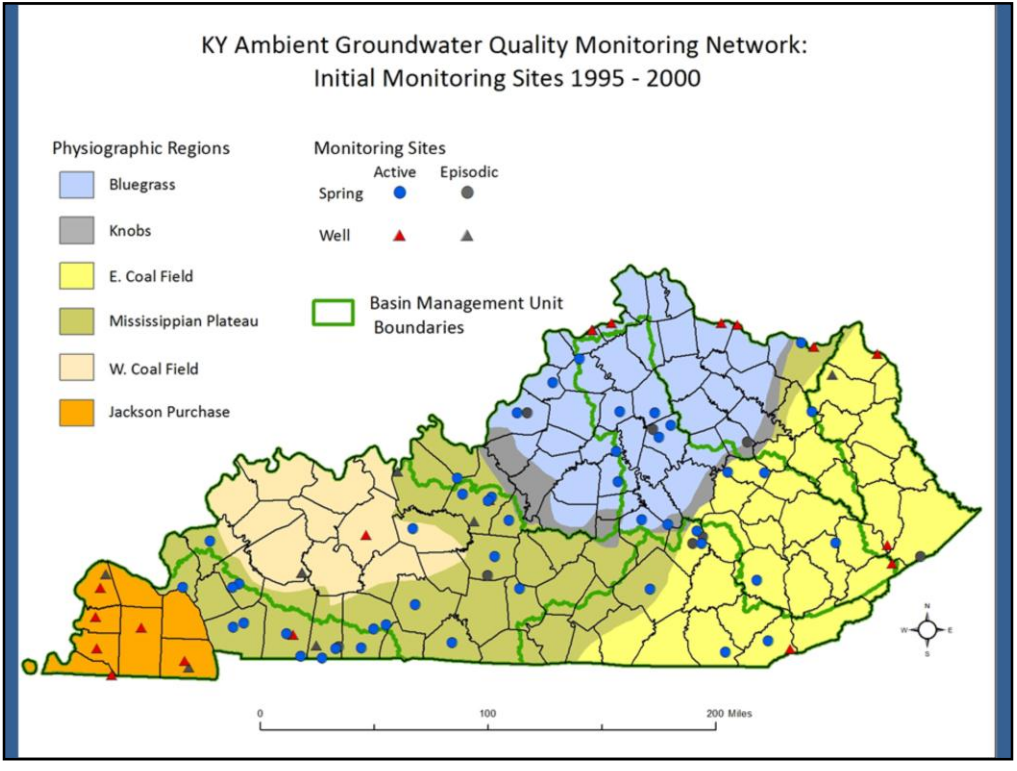
KY Aquifers in a nutshell. About 50% of KY underlain by karst aquifers, most notably Mammoth Cave (MCNP). Mainly fracture flow in Eastern and Western Coalfields (yellow regions), but deeper consolidated granular aquifers are present. Jackson Purchase (orange region) is mainly unconsolidated sediments. Ohio River alluvium (red area making northern border) is highly productive and widely used aquifer. Gray shaded area has different rock units from north to south, but all have generally limited groundwater availability.



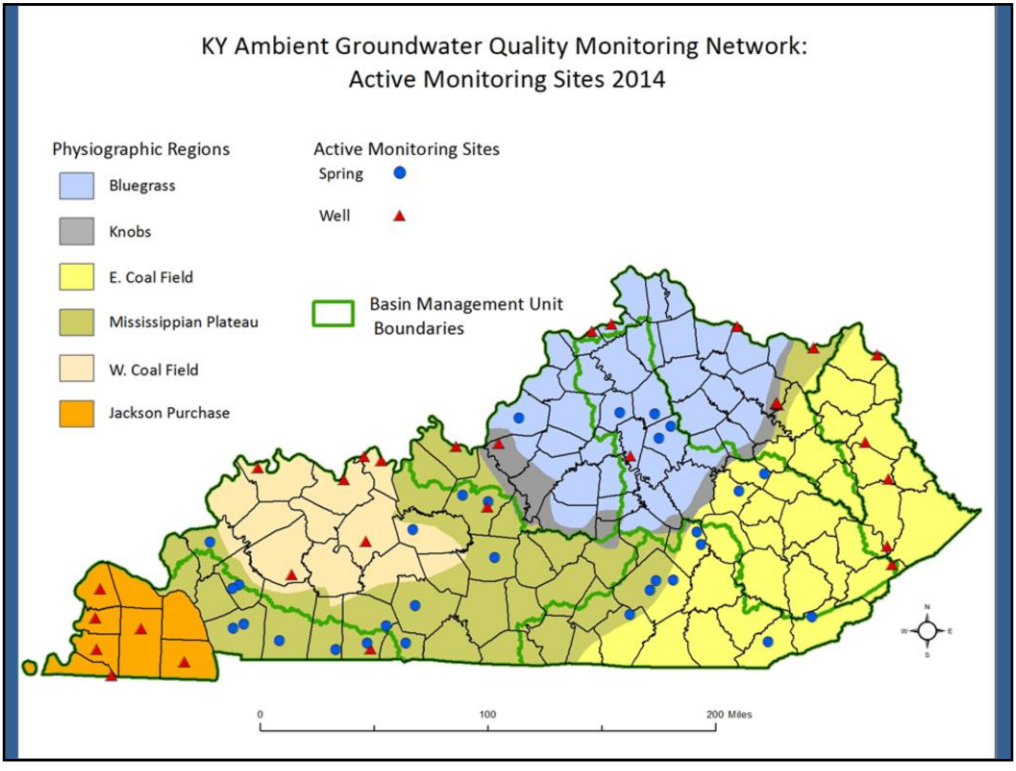
Groundwater Sensitivity to Pollution (intrinsic susceptibility) based on the velocity of water movement into, through and out of the aquifers. Highest ratings in red and orange generally coincide with karst aquifers, but some parts of Ohio River alluvium rank as fairly high sensitivity. Moderate ratings in yellow generally denote fracture flow. Lowest ratings in gray are granular aquifers and some areas of limited groundwater availability. More in-depth discussion on the actual published map from DOW, 1994.



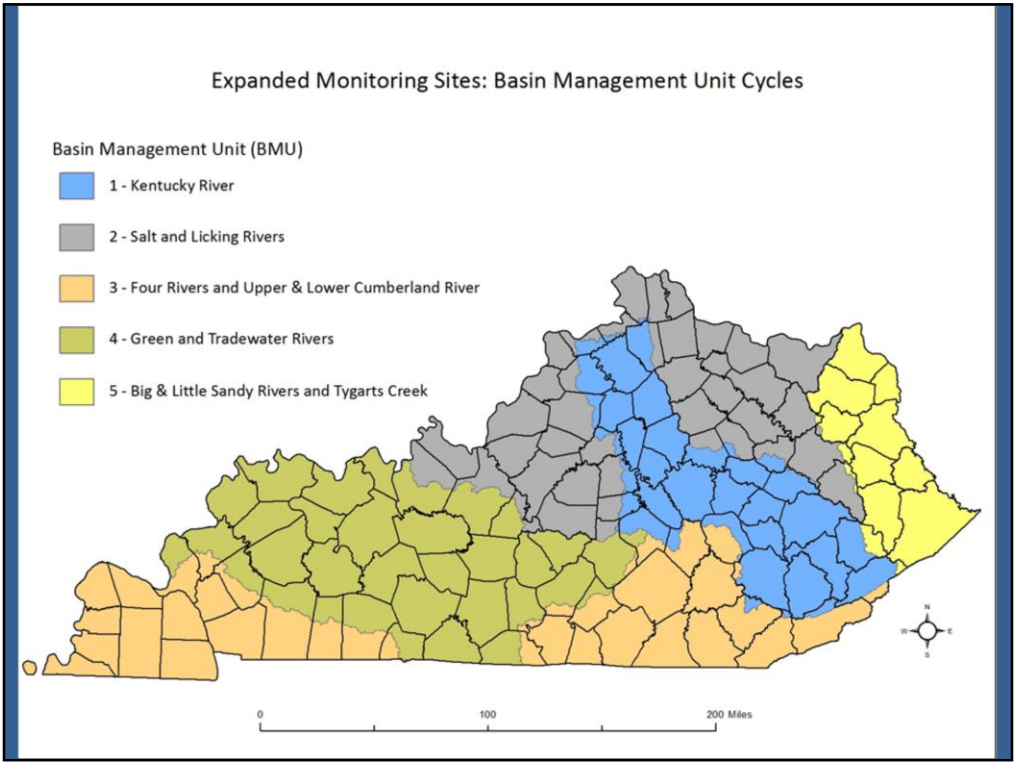
Concentrations of domestic water wells per county in KY. Red and orange shaded counties are where we have our greatest numbers of private water wells. Side note that we estimate 450,000 people in KY don't have a connection to public water supplies – we believe the majority of them utilize domestic water wells for their needs. Each of these maps (Aquifers, Sensitivity and Usage) were considered during the initial design of the GW Monitoring Network and are still used today for site selection and prioritization.



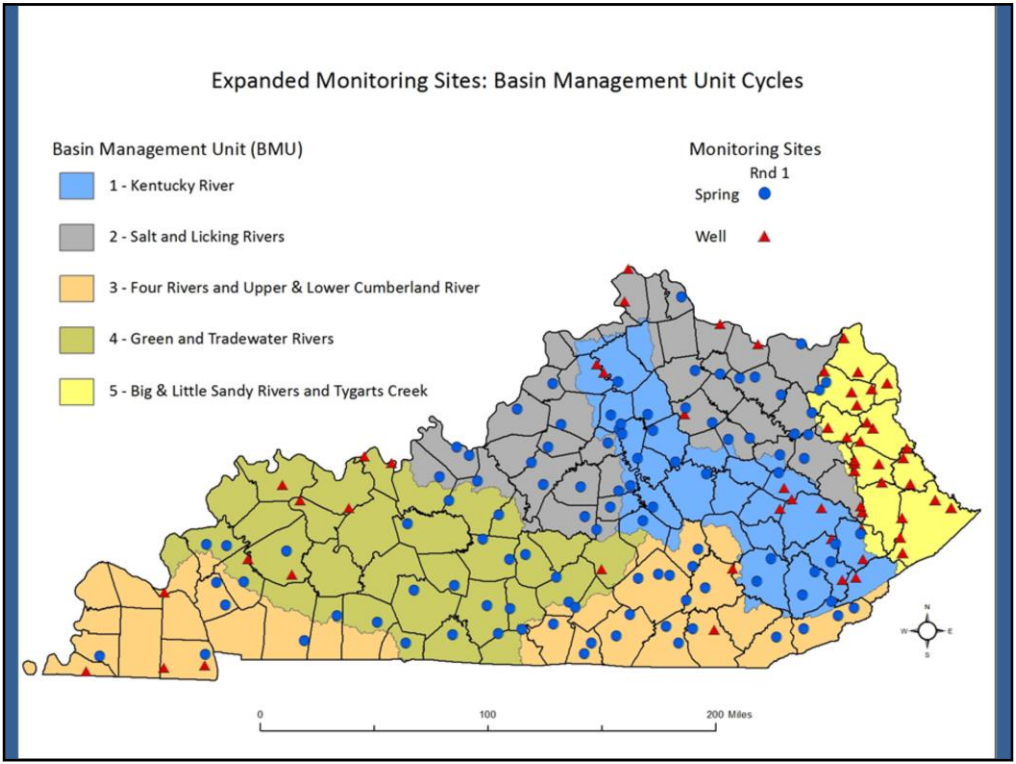
Early days of the GW Network. 60 Active sites, with about 12 episodic sites. Relied heavily on springs due to ease of access. Note large gaps between monitoring sites and significant areas being under-represented.



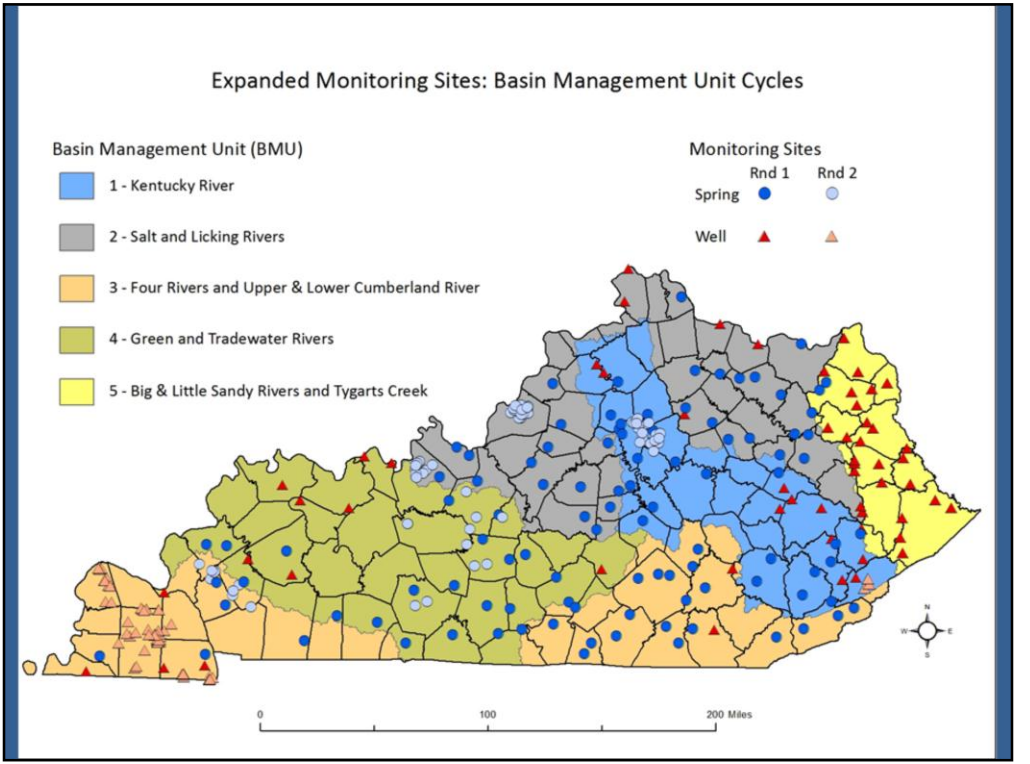
Map showing last few years of GW Network. Incremental changes to drop springs and replace with water wells – more even balance. In particular, better representation of Ohio River Alluvium and large capacity PWS wells. Also, a little bit better coverage in the coal fields. However, still large gaps between points and have worked to better represent these areas.



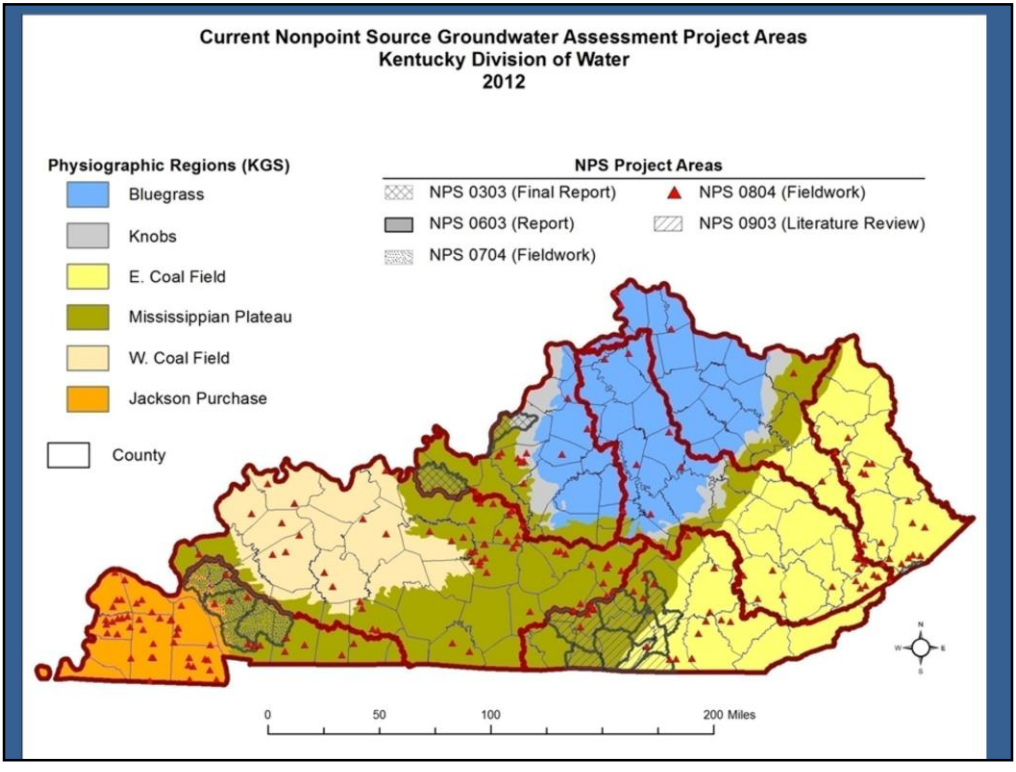
Most effective means to expand groundwater monitoring efforts has been through the 319 grant program under the Clean Water Act. Initial studies started in the late 1990s and used a rotating cycle through the Basin Management Units. First year was BMU 1, second year BMU 2, etc.



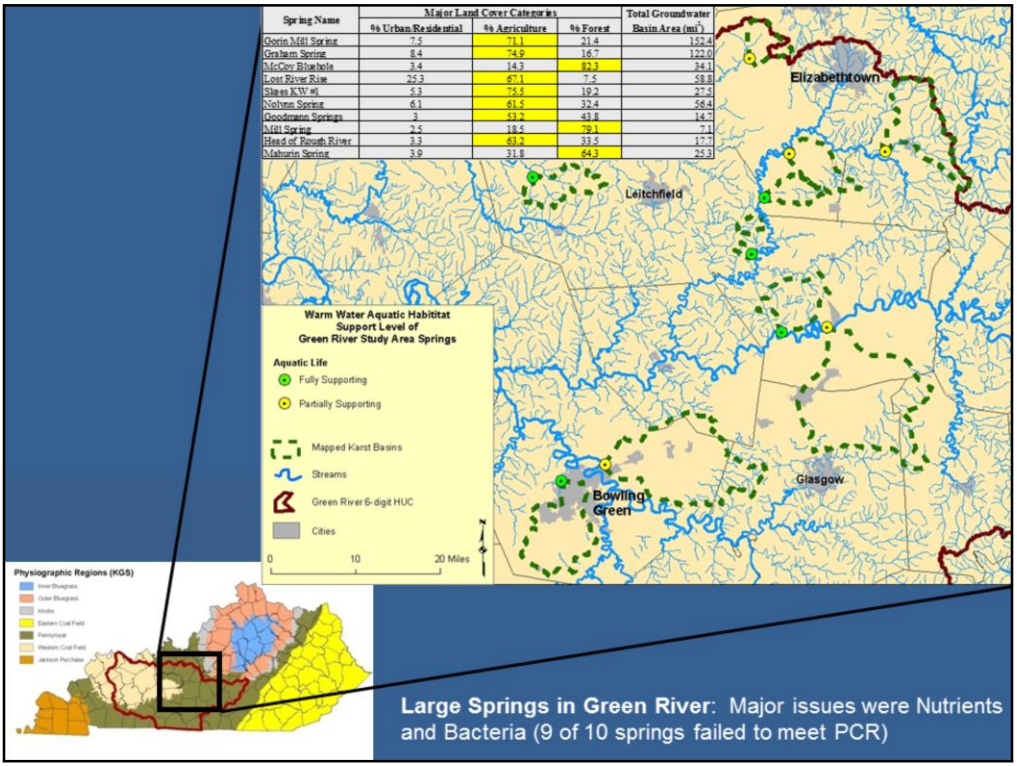
In each BMU, 30 sites were selected to represent the various aquifer types and physiographic regions present. Sites were sampled quarterly for one year. At the end of the monitoring period, those data along with data from any GW Network sites in the basin were analyzed. Data were used to report on the general groundwater geochemistry and any non-point source pollution issues. Map is filled in much better following the first round of projects, but we must remember that monitoring was limited to one year.



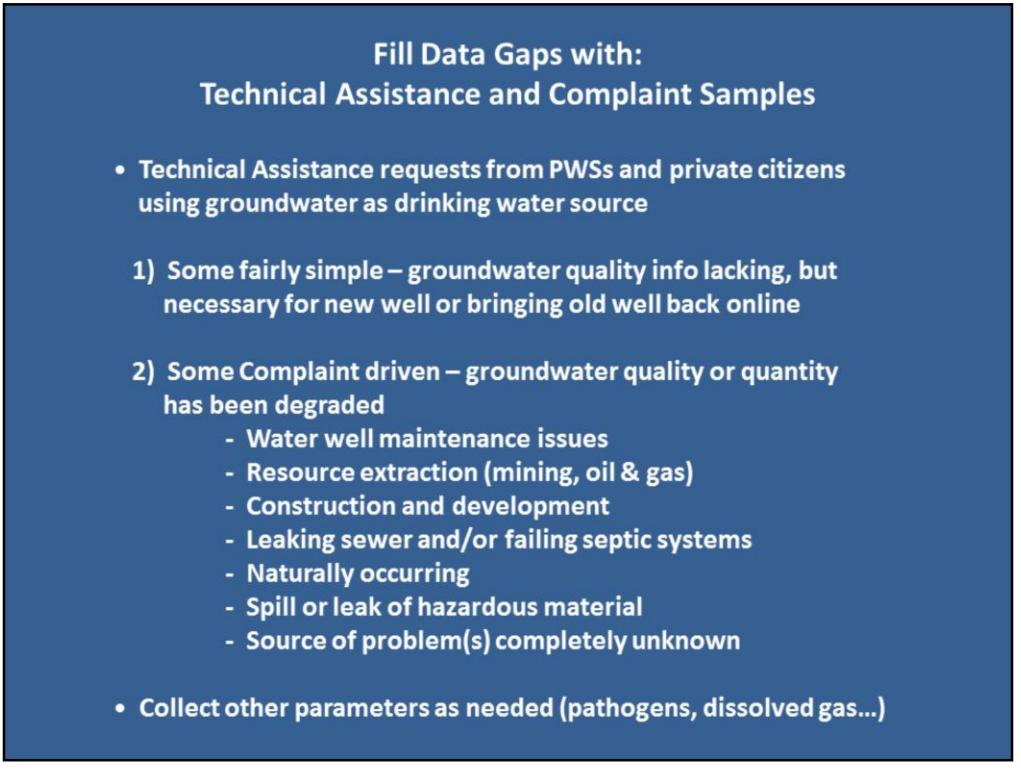
Follow-up studies conducted in each basin on the same cycle. Second Round studies focused on sub-regions and/or watersheds. Study areas chosen either because a water quality impairment had been noted that required further investigation, or it was an area totally lacking GW quality information. Smaller areas meant being able to sample fewer sites, focused on single aquifer type, and collect more frequent samples in the one-year monitoring period.



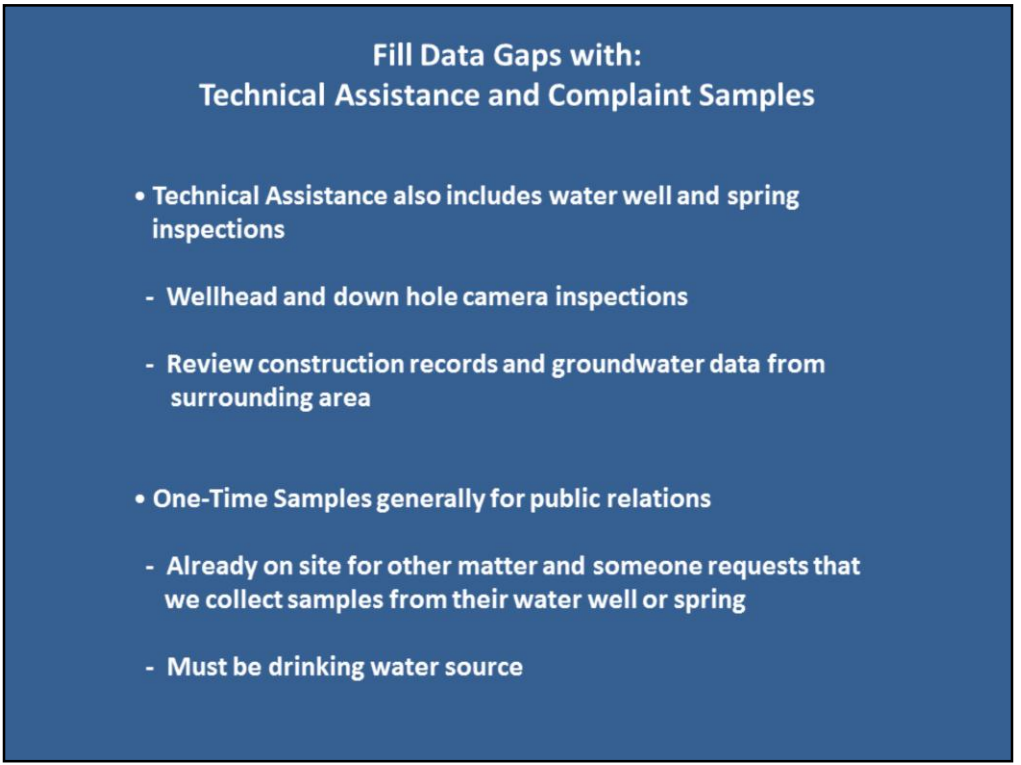
Map showing more recently active 319 grant GW studies. Red triangles represent 200 domestic water wells that were part of the statewide pathogens study – our first systematic statewide assessment of bacteria in domestic water wells. Gray shaded areas are sub-regions and watersheds with studies ranging from site reconnaissance and selection up through the report writing phase.



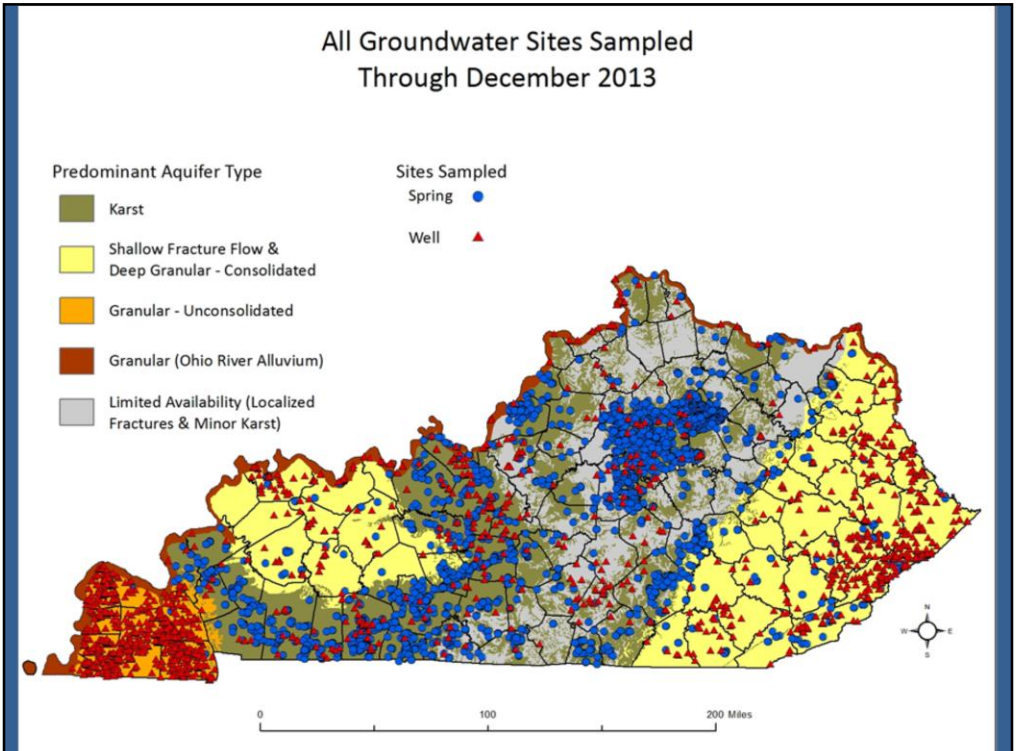
Recent 319 studies in karst areas have used new approach, with integrated Surface Water Monitoring Protocols. Chemical samples collected once per month for 12 consecutive months, bacteria samples during recreation season (May-Oct) and biologists evaluated macroinvertebrate population. Data compared to standards for Aquatic Habit and Primary Contact Recreation. In karst areas, groundwater-surface water interaction is very direct. Springs are headwaters of many streams and provide significant base flow where they discharge – therefore they have a strong influence on stream health. The area above shows a relative lack of surface drainage, this is due to extensive karst development and most drainage in the subsurface. Large areas could not be assessed by surface water sampling, more sensible to evaluate spring water quality by surface standards.



Tech Assistance and Complaint samples also used to fill data gaps. Some straightforward, people just need GW data on their source to make decisions about its use. If complaint driven then samples are just part of an investigation, may collect other parameters as needed. Must remember that samples might not represent ambient conditions.



We don't seek out one-time sample sites like we used to due to budget constraints, these are more for public relations. Groundwater source must be used for drinking water, and we'll do our best to include with other monitoring.



All groundwater sites sampled through December 2013. Total of about 6300 wells and springs for which we have groundwater quality data. However, must remember that the vast majority of sites have a single sampling event or limited data.

Success

- Collected considerable amount of groundwater quality data
  - Roughly 19,000 sample results from ~6300 groundwater sources
- Baseline geochemistry in all physiographic regions and aquifers
- Determined problematic issues: Nutrients, Pesticides, Pathogens and education/outreach about water well maintenance
- Provide groundwater data to support other agencies/programs
- KGS developed web-interfaces to Groundwater Repository

Self explanatory.

Challenges

- Data gaps spatially and temporally
  1) Need to expand geographically/number of sites
  2) Need increased frequency in karst areas
- Only minor changes in nearly 20 years
  1) Added, dropped and changed sampling frequency
  2) Time to review and evaluate goals and design
  3) Review, evaluate and report on all available data
- Personnel and resource constraints
  1) Sample smarter not harder?

Self explanatory.

Acknowledgements

- Interagency Technical Advisory Committee on Groundwater
  - Past and present representatives
- Commonwealth of Kentucky Legislature and Department of Agriculture
- US Environmental Protection Agency
- DOW and KGS field staff – field activities, data management & analysis and reporting

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Special thanks to those people who initially formed ITAC and started systematic groundwater monitoring efforts in KY