Prospectus For Hydrologic Observatory: Ozark Plateaus Province – Upper White River/Illinois River Basins

Hydrologic Observatory Development Team

This is the initial team involved with concept development for this proposed Hydrologic Observatory (HO). We anticipate attracting additional partners in support of this proposed HO. The initial team includes: R.K. Davis, J.V. Brahana, M. Matlock, and I. Chaubey all at the University of Arkansas, Fayetteville, and R. Pavlowsky, South West Missouri State University.

Spatial Extent of Hydrologic Observatory

Site Characteristics

The proposed Hydrologic Observatory is centered in the Ozark Plateaus Province with special emphasis on the Upper White River Basin (Figure 1 and Figure 2). The proposed HO encompasses twelve 8-digit hydrologic units in the Upper White Drainage System (James River Basin, Beaver Lake Basin, Bull Shoals Lake Basin, Buffalo River Basin, Middle White Basin, North Fork Basin, Spring River Basin, Eleven Point Basin, Strawberry River Basin, Village Basin, Little Red River Basin, Upper Black River Basin, Lower Black River Basin, and the Current River), and two 8-digit hydrologic units in the Illinois River Drainage System (Illinois River Basin, and Elk River Basin). The HO covers 67,017 km^2, and includes five major reservoirs on the Upper White Drainage System: Beaver Lake, Table Rock Lake, Lake Taneycomo, Bull Shoals Lake, and Norfolk Lake, and one major Reservoir on the Illinois River, Lake Tenkiller.

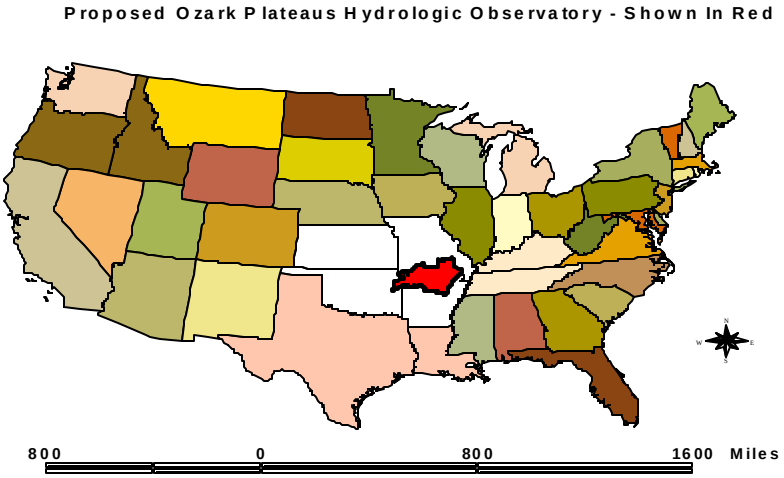
Karst features are prominent in the Salem, Ozark, and Springfield Plateaus of the HO, and include numerous solutionally enlarged fractures, caves, sinkholes, and sinking streams. The fractured limestone and dolomite of the watershed allows a direct linkage making aquifers underlying the watershed extremely susceptible to contamination (USGS 1996).

Both river basins head in northwestern Arkansas and transect the Ozark Plateaus. The Upper White River flows north from Arkansas into Missouri before turning to the south to exit the Ozarks near the northern end of the Mississippi Embayment. The Illinois River flows to the northwest entering Oklahoma before turning south before becoming tributary to the Arkansas River just west of Ft. Smith Arkansas. While the White River has been impacted by animal production, the Illinois River basin represents a system that has been highly impacted by animal agriculture. Both systems exhibit characteristic mantled karst topography and provide excellent natural laboratories for investigation of impacts resulting from natural and anthropogenic forces.

Biological Characteristics

The Upper White River drains approximately 40 percent of the Ozarks ecoregion. Within the basin are numerous and diverse biological communities, representing influences from 1) eastern deciduous forest, 2) Great Plains prairies, 3) arid southwest, and 4) relicts of northern species from the Pleistocene Ice Age. The White River and the Illinois River along, with associated

tributaries, contain a very diverse assemblage of fish species, with 163 native species identified.



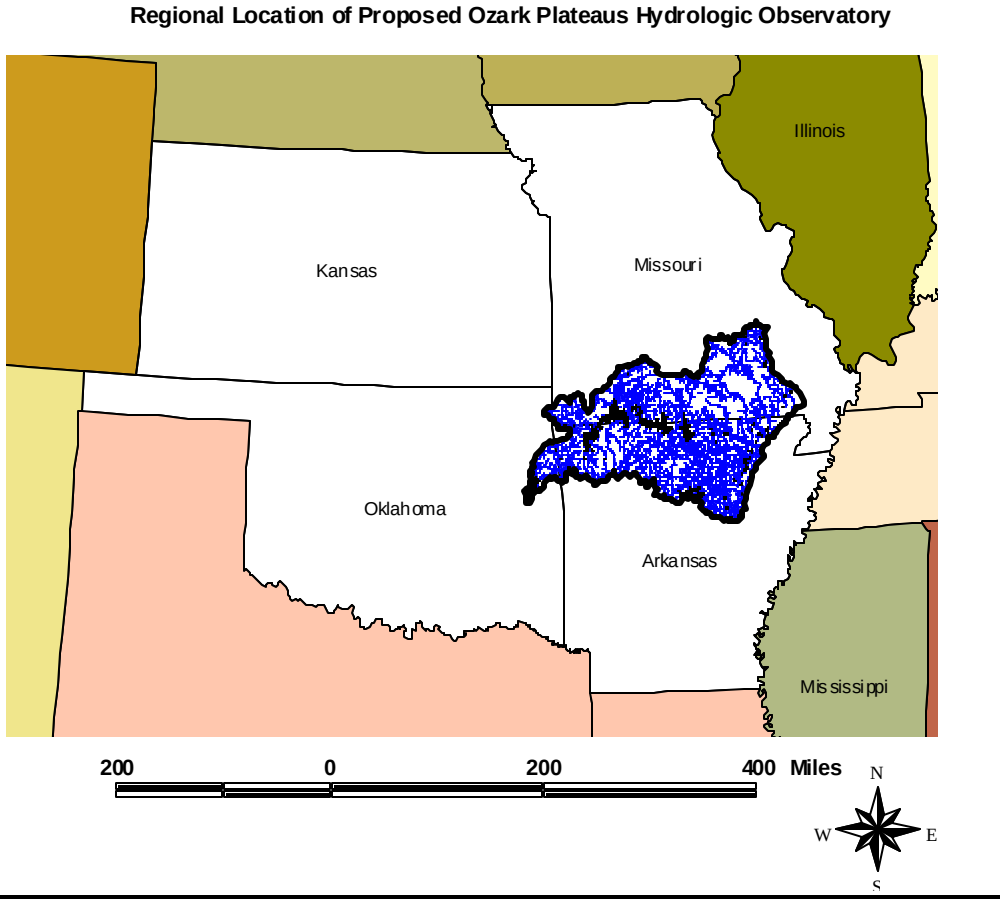


Figure 1 – Location of Proposed Ozarks Plateaus Hydrologic Observatory

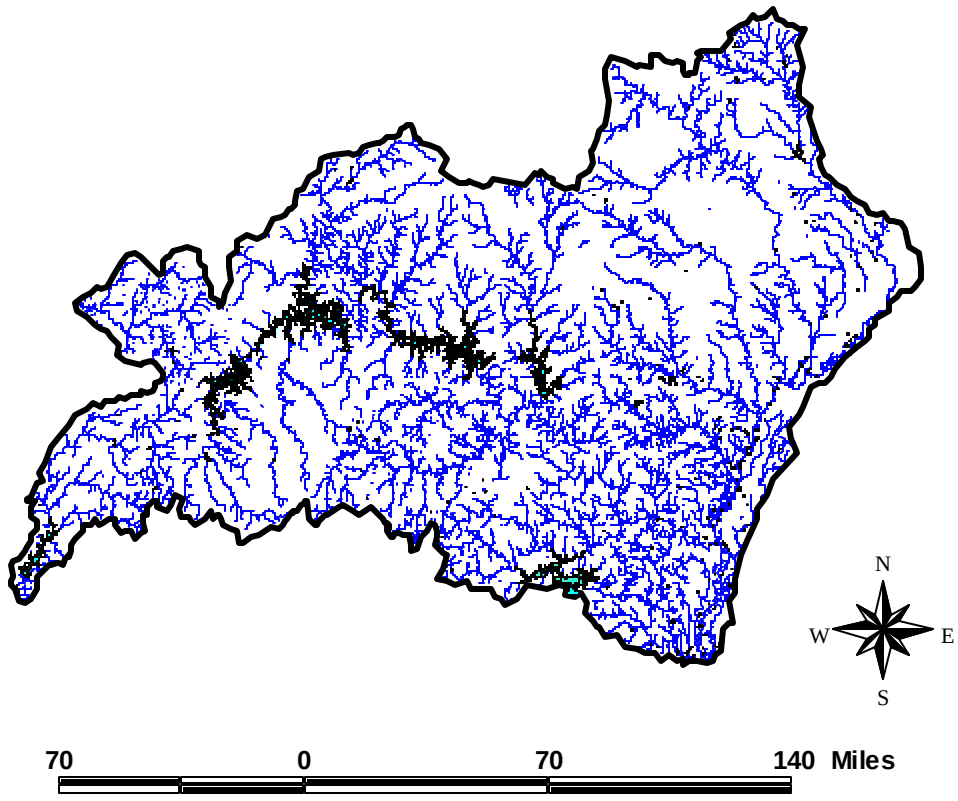


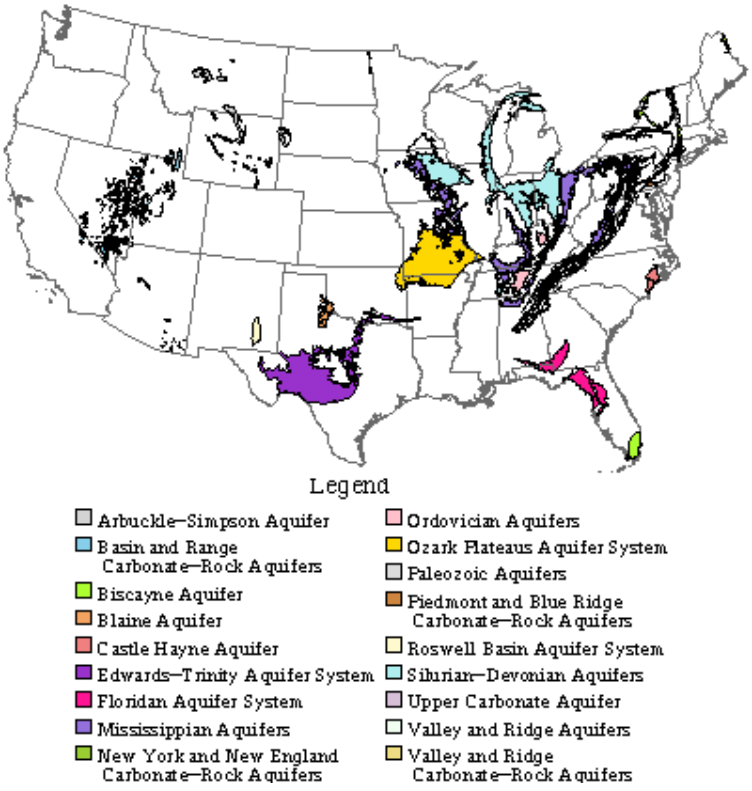
Figure 2 – Ozark Plateaus Hydrologic Observatory

These watersheds also contain a diverse and unique array of mussels, an imperiled river organism (38 species), and crayfish. In the watershed's extensive karst regions are found largely endemic subterranean organisms also dependent on good water quality—for example, the Ozark Cavefish, Bristly Cave Crayfish and the recently federally-listed Tumbling Creek Cave Snail. There are also diverse and unique upland communities associated with xeric dolomite forests, limestone savannas and dolomite glades. The HO represents a rich tapestry of biological elements in a unique and interesting mix from all the adjacent biomes.

Scientific rationale for design

Hypotheses:

1. The Upper White River is the main drain for the Ozarks Plateau Region and is characteristic of rivers draining other karst areas within the United States and the world (Figure 3)



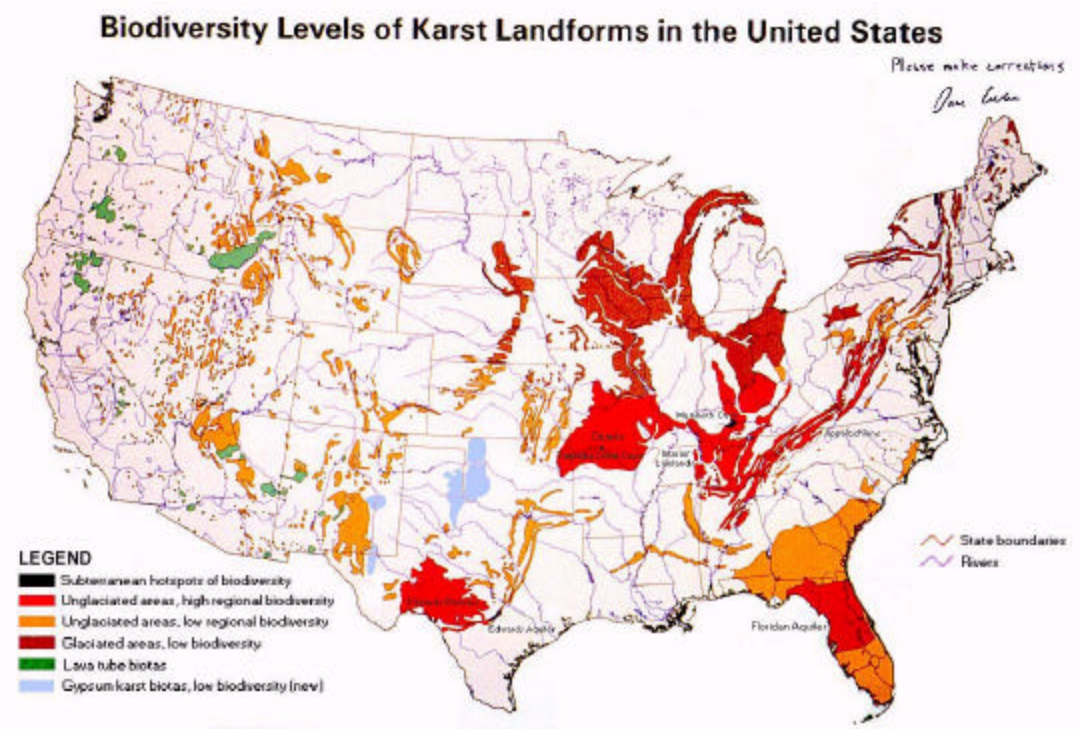


Figure 3a and 3b – Karst Landforms of the United States and Biodiversity Level of Karst Landforms in the United States (Culver, 1997)

2. Mantled karst aquifers characteristic of the Ozark Plateaus Region represent a coupled atmospheric/surface water/groundwater system that is highly susceptible to external forcing.

    a. Thriving karst cave communities, including threatened and endangered species, are dependent on steady fluxes of nutrients from surface sources.

    b. There is a very high degree of surface water – groundwater interaction in this mantled karst environment.

    c. Little attenuation of contaminants occurs as water moves from surface sources into and through the mantled karst aquifer to discharge naturally at springs and streams throughout the Ozark Plateau Region, and to wells.

    d. Because of the very open character of the aquifer, extremely dynamic biogeochemical cycling of nutrients occurs.

    e. The Ozark Plateaus Region is representative of other karst regions throughout the United States. The subbasins selected can be used to investigate processes of flow and contaminant fate and transport in these types of hydrogeologic environments with a high degree of applicability and transferability to other karst regions.

3. Upper White River Reservoir development, filling and operation historically have altered and continue to alter the hydrologic and ecosystems within the Ozarks Plateau Region.

    a. U.S. Army Corps of Engineers Reservoirs were established on the main stem of the Upper White River in early- to mid-1960's.

    b. The entire ecosystem on the White River was altered as a consequence of establishment of the reservoirs. What once was a classic free-flowing Ozark stream with prolific warm water (small mouth bass) fishery has changed to a cold water fishery that produces world record trout (not natural to the system). The full extent of ecosystem modification has not been adequately characterized. Establishment of a new hydrologic and ecosystem dynamic equilibrium is uncertain, but it is likely the system is still undergoing significant adjustment toward some new equilibrium state resulting from the impoundment and filling of the reservoirs 30 to 40 years ago.

    c. The Buffalo River was designated as the first scenic river in the United States, and has therefore been maintained in relatively unspoiled pristine condition. Whereas some external forcing has occurred, primarily related to animal agriculture in the watershed, forestry and recreational use of the river, the overall extent of external forcing on this system has been minimized. The Buffalo River is hydrologeologically and ecologically similar to the pre-impoundment Upper White River. Therefore, the opportunity exists to conduct comparative investigations of a system that has undergone extensive modification via control structures (White River) and one that is relatively pristine (Buffalo River).

4. Large scale animal production (poultry, swine, and cattle) results in forcing that causes negative surface water and groundwater quality impacts within the Ozarks Plateau Region.

    a. The region is the number two poultry producer in the United States with the majority of these birds produced in northwest Arkansas and southwest Missouri.

    b. Arkansas is the number eight Beef producer in the United States with a significant percentage of these cattle produced in Ozark Plateau Region (Arkansas Agricultural Statistics (2003).

    c. Animal manures associated with this large-scale animal production are applied as fertilizer to pasture, resulting in a significant non-point source of nutrients (phosphorus and nitrogen), and bacteria loading for surface water and groundwater throughout the region.

    d. A large portion of this animal production occurs in the Illinois River Basin which drains the western portion of the Ozarks Plateau region into the Arkansas River near Ft. Smith, Arkansas.

    e. Extensive research related to nonpoint source loading associated with large-scale animal production has occurred in the Illinois River Basin. The Savoy Experimental Watershed, a University of Arkansas field site, is dedicated to understanding the fate and transport of contaminants in the rivers and the mantled karst aquifer within the Ozarks Plateau Region.

5. A rapidly expanding urban/suburban population is creating a new set of forces with feedbacks that impact the quantity and quality of surface water and groundwater in the Ozarks Plateau Region which are only now beginning to show, and may not be fully realized for decades. The basin is largely rural, but is rapidly changing to an urban/suburban population. The Fayetteville, Arkansas area, has the 6th fastest growing population growth in the U.S., and recreational/tourism expansion in the Branson, Missouri (Country Music and Vacation paradise) area is rapidly changing that part of the basin from forest and pasture to a suburban environment. Springfield Missouri is a major urban area built on karst that routinely experiences problems associated with occupying these mantled karst environments. This rapid but relatively recent urban/suburban expansion provides a unique opportunity to investigate alteration of the hydrologic cycle and associated ecological impacts in a relatively pristine forested area for later comparison following conversion to urban/suburban environment. This topic area considers sustainability of water resources with special attention to sustaining quality surface water resources to meet municipal/domestic needs.

    a. Rural domestic, municipal, livestock and industrial water supplies are provided throughout the region largely from surface reservoirs (primarily those established on the main stem of the Upper White River), and from wells in the shallow mantled karst aquifer, as well as wells in deeper regional aquifers such as the Roubidoux Formation.

b. Development pressure is impacting both the quantity and quality of these supplies. The degradation of quality and quantity causes as yet undetermined ecological consequences. This is a prime research area that must be undertaken before development of the area is complete.

Existing Data Infrastructure

Measurement Technology

U.S. Geological Survey (USGS) NAQWA – Ozarks

The USGS recently completed a National Assessment of Water Quality within the Ozarks Plateau Region. These data provide a national level data set against which to compare future studies. Much of the data were collected within the area proposed for the HO.

Savoy Experimental Watershed

The University of Arkansas Savoy Experimental Watershed (SEW) is characteristic of the mantled karst hydrogeology in this area. The aquifer is covered by a thin, rocky soil, and a variable thickness of regolith. The karst ground-water system is underdrained by carbonate-rock aquifers that have been dissolved to form an open network of caves, enlarged fractures, bedding planes, conduits, sinkholes, swallets, sinking streams, and springs. Flow in these aquifers is typically rapid, flow directions are difficult to predict, interaction between surface water and ground water is extensive, and processes of contaminant attenuation are often absent (White, 1988; Ford and Williams, 1989; Winter *et al.*, 1998).

The SEW is a University of Arkansas (UA) property of approximately 1250 hectares (ha) that lies 24 kilometers (km) west of the UA campus in Fayetteville, Arkansas. It is located in the Springfield Plateau just north of the Boston Mountains Escarpment. An integrated research effort between the UA, Arkansas Department of Pollution Control and Ecology, Agricultural Research Service, Natural Resources Conservation Service and the U.S. Geological Survey has been established and is functioning as the Savoy Watershed Advisory Group. As part of this effort, studies have been ongoing to provide a detailed hydrologic budget, define basin boundaries, and assess basic inorganic chemistry and background nutrient and bacterial loading at the site. Site characterization of SEW was initiated in the spring of 1997 to define baseline water quality for discrete hydrologic-budget components, to describe controlling influences affecting nutrient and pathogen transport at the site, and to develop a preliminary conceptual model of hydrologic flow and transport at a site-specific scale of the watershed. For more information on SEW see http://www.uark.edu/depts/savoyres/index.html

Bull Shoals Field Station

Southwest Missouri State University maintains a research facility at Bull Shoals Reservoir called the Bull Shoals Field Station (http://www.bullshoals.smsu.edu). This facility is designed to provide faculty a chance for research on Ozarks ecology with a primary emphasis on large reservoir ecosystems.

U.S. Army Corps of Engineers Resevoirs

The U.S. Army Corps of Engineers maintains four major dams and reservoirs on the upper portion of the White River. Significant data are collected on a routine basis in relation to the operation of the reservoirs.

U.S. Forest Service

The U.S. Forest Service and the U.S. Geological Survey, in conjunction with numerous state agencies and universities have joined in research efforts within the Buffalo River Watershed, which was the first scenic river designated in the United States. The existing extensive data sets for this relatively pristine watershed provide the basis for comparative studies with the other more highly developed watersheds throughout the proposed HO. Focusing additional resources through partnerships developed as a result of the HO will greatly enhance and extend the data infrastructure in the Buffalo National River, creating a system for comparison with impacted streams throughout the United States and the world.

Upper White River Basin Foundation

Recently the U.S. Environmental Protection Agency awarded the Upper White River Basin Foundation one of 21 Watershed Initiative Grants to begin development of a comprehensive watershed plan and establishment of basic watershed data. The Upper White River Basin Foundation (UWRBF) is a nonprofit group with a primary emphasis of protecting and enhancing the quality of water resources in the Upper White River. This group will be an active partner in the HO. They will provide input on research needs as well as take an active role in grants solicitation. For additional information on the UWRBF see http://www.whiteriverbasin.org.

Surface Water Quality Data

There are extensive stream and reservoir water quality data sets that have been collected through U.S. Geological Survey, the University of Arkansas, Southwest Missouri State University, and the University of Missouri. These include low flow and storm induced events with sufficient data detail to allow calculation of nutrient loads.

Biological Assessment

Biological assessments of selected surface water and groundwater sites have been completed within the basin in the past few years. While some historic data are available much of the area still needs extensive assessment work. This provides significant opportunities to investigate ecosystem impacts related to hydrologic alteration in the proposed HO.

Cave and Karst Inventories

Detailed karst/cave inventories have been completed for selected portions of the proposed HO but much work remains to be completed. Many, but not all of the caves have been mapped, probably fewer than 50%. Research is ongoing to understand the relationship between karst features and the structural history of the region. This is critical to fully understanding fate and transport of contaminants in this highly coupled surface water – groundwater system.

Hydrologic Informatics

USGS Stream Monitoring Network

USGS maintains an extensive stream gage network throughout the Ozarks Plateau Region including the area of the proposed HO. As part of development of the HO, additional critical locations for stream data, both flow and water quality, will be identified. Cooperative relationships will be developed with USGS and other project partners to establish and maintain these additional critical sites.

Decision Support System Development

Ongoing research is using the extensive geographic information system and remotely sensed data available for the region in support of Decision Support Systems (DSS) for non-point source contaminant management within selected watersheds. The most extensive is being developed for the Beaver Watershed with others in progress for the James River watershed and the Kings River watershed. The goal is to provide a DSS in high priority watersheds in Arkansas and Missouri over the next several years and will be an invaluable tool for researchers involved with the HO.

GIS/Remotely Sensed Data

Additional GIS/Remote sensing data are being compiled into usable formats for the basin as part of U.S. EPA Watershed Initiative. Much of these data are gathered from University and State agency data warehouses including data sets available at the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas (http://www.cast.uark.edu) and data sets available through the Missouri Department of Naturual Resources.

Weather Stations/Rain Gages

Weather stations that report to the National Weather Service provide basic data on precipitation and evapotranspiration for the region. Precipitation data are supplemented with NEXRAD derived precipitation estimates. The spatial distribution of weather stations will be assessed as part of the HO development to determine the optimum density needed to provide estimates with a reasonable error when used in conjunction with NEXRAD.

Proposed Core Data

Network of weather stations sufficient to supplement precipitation data estimated from NexRad. A subset of these will need to be instrumented to estimate evapotranspiration. This component of the core data addresses fluxes between the atmosphere and the surface, and flowpaths both surface and subsurface.

Establish and maintain a real-time stream gage network on major streams and tributaries. The spatial distribution of the gages will be assessed as part of the HO development. Alternate methods of flow estimation will be assessed and employed where feasible. This component addresses flux, flowpath, residence time, and mass input and output.

Collect of critical core water quality data for base flow and storm events with sufficient resolution to calculate nutrient/contaminant loads. This should include major field parameters in real-time, and major water chemistry plus selected trace elements at targeted sites. This component addresses flux, residence time, flowpath, and mass input and output.

Develop and maintain a full set of GIS data including 1:24,000 soils, 1:24,000 geology, 30 m DEM, 10 m DEM, DOQQ's, multiple years of landuse/landcover data, and distributed network of monitoring wells/springs for water level and water quality analysis. This component is related to fluxes and flowpaths.

Expand data set related to karst/cave inventories, and make these data available to the user community via the GIS data warehouse.