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Evaluation of Karst Spring Water Quality Using Water Quality Indices in Northeast Tennessee

Lukman Fashina

Ingrid E. Luffman
East Tennessee State University

EVALUATION OF KARST SPRING WATER QUALITY USING WATER QUALITY INDICES IN NORTHEAST TENNESSEE

LUKMAN FASHINA
&
Ingrid Luffman, Ph.D.

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DEPARTMENT *of* GEOSCIENCES
College of Arts & Sciences
EAST TENNESSEE STATE UNIVERSITY

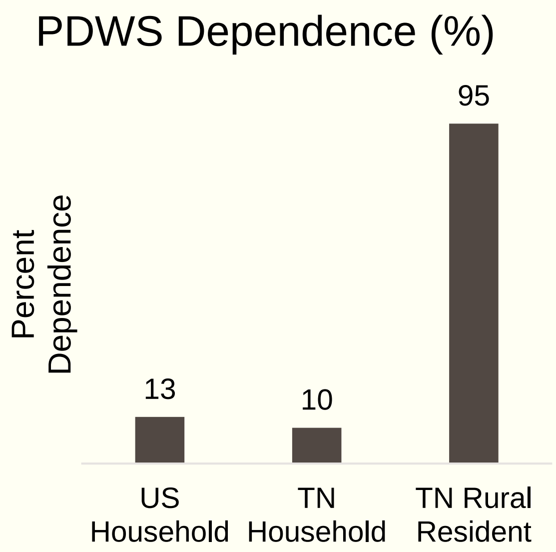
Presentation outline

- Background
- Research Objective
- Evaluation of karst spring water quality using water quality indices
- Conclusions
- Limitations of study and Recommendations

Background: Why spring water?

- Important Private Drinking Water System (PDWS) but **unregulated** and often **untreated**[1, 2]

✓ Households' dependence on PDWS[3,4,5]



- Spatial and temporal variability
- Vulnerability to contamination,
- Health-based SDWAct violations:

✓ **Microbes**: enteric viruses, fecal indicator bacteria, and cryptosporidiosis;

Tennessee[6,7,8], central Applachia[9,10], Arkansas[11], Missouri[12]

✓ **Nutrients**: Kentucky[13], Illinois[14]

✓ **Metals**: central Applachia[15,16]

✓ **Radionuclides** (Radon): Tennessee[17]

- Gap in previous spring/ groundwater research in the study area:

✓ spring water discharge[18,19,20]

✓ Limited water quality parameters and use of traditional method of reporting[21, 22, 23, 24, 25,26]

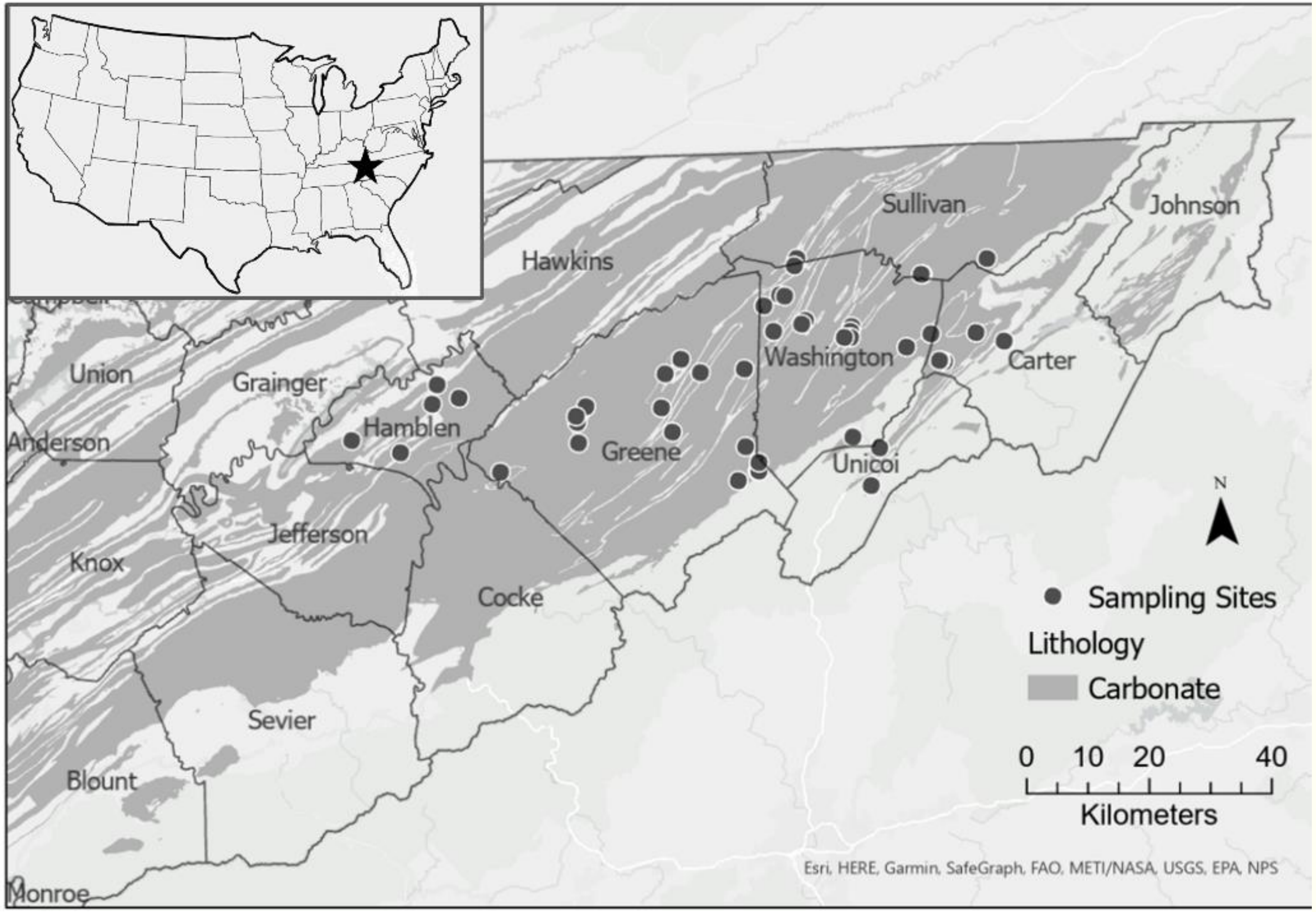
Paper Overview

- Objective:

To determine the overall drinking water quality of the sampled springs through water quality index calculation.

- To aid the public and policymakers better understand critical water quality information

Geologic Map of Study Area and Sampling Points



Data

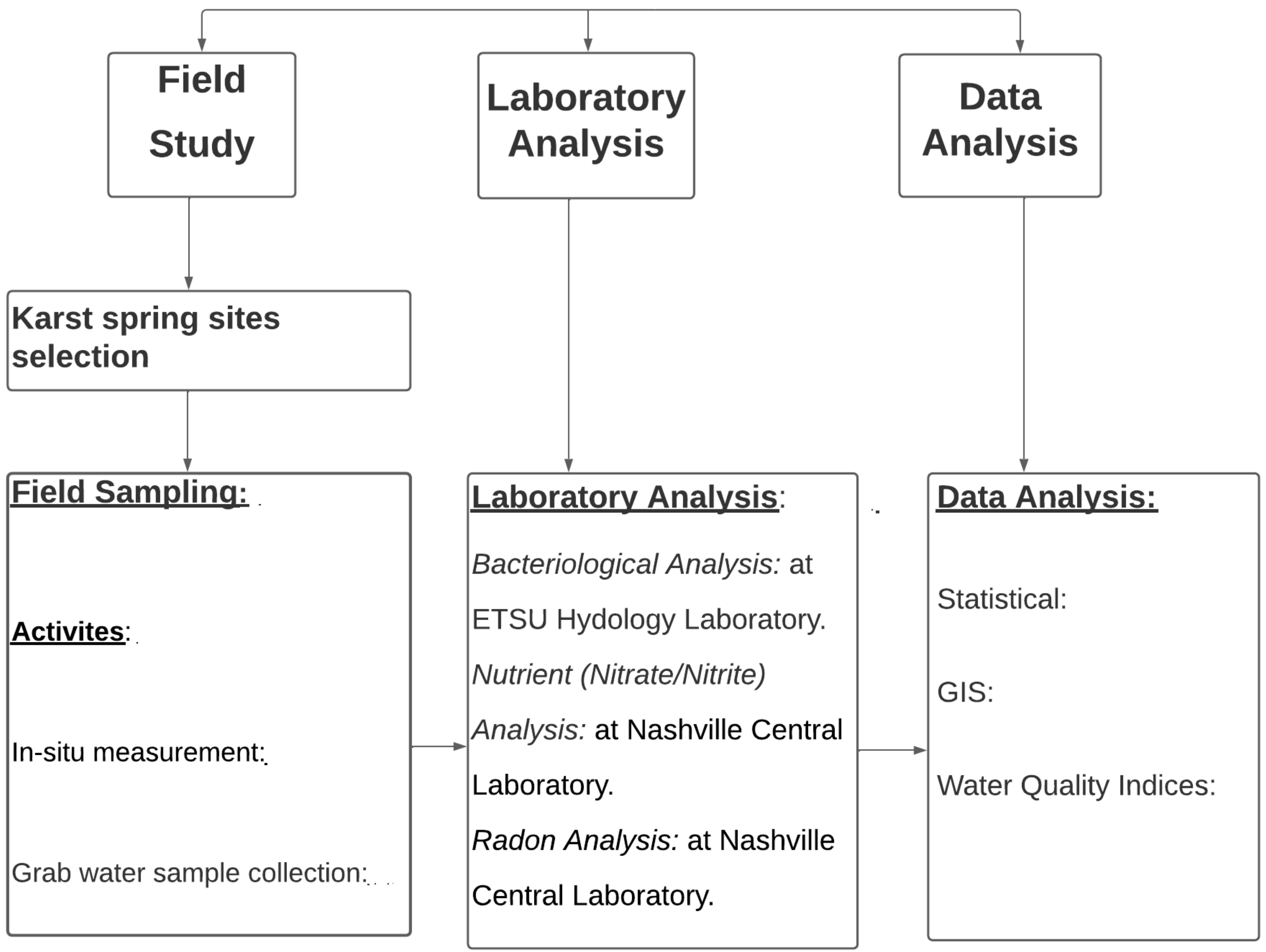
Primary Data

- ✓ **Physicochemical**: pH, dissolved oxygen, temperature, turbidity, conductivity, specific conductance, total dissolved solids, and oxidation reduction potential
- ✓ **Microbial**: fecal coliform and *Escherichia coli* (*E. coli*)
- ✓ **Nutrients**: Nitrate and Nitrite
- ✓ **Radionuclide**: Radon

Secondary Data

- ✓ Spring location/sites coordinate data[27]
- ✓ Shape files (US[28], TN County Boundaries[29])
- ✓ TN geologic map[30] and fault map[31] data
- ✓ Land Use Land Cover (2019) data[32]
- ✓ Climate (precipitation) data[33]

Methodology



Water Quality Index (WQI)

WQI: aggregates and summarizes water quality data into a single value or index that characterizes the general health status of water at a given location in an easy-to-understand way

Developed by Horton 1965, with several modifications ever since.

Utilization in karst spring water quality research:

Sïtambuk-Giljanovic 1999, Cristina et al. 2014; Ameen 2019; Hoaghia et al. 2021

Steps in WQI Computation

Step 1
Water quality parameter selection

Step 2
Parameter sub-indices generation

Step 3
Parameter weight values establishment

Step 4
Final WQI aggregation

BWQI & NSFWQI (Delphi-based methods)

Model Parameters	Selected Parameters	USEPA & TDEC standards (S_n)	Unit Weight (W_n)
Temperature (^{o}C)	Temperature (^{o}C)	30.5	0.106231
Dissolved oxygen (mg/L)	Dissolved oxygen (DO: mg/L)	5	0.648011
pH	pH	8.5	0.381183
Nitrate (mg/L)	Nitrate (mg/L)	10	0.324006
Total phosphate (TP) (mg/L)			
Turbidity (NTU)	Turbidity (NTU)	5	0.648011
Biochemical oxygen demand (BOD) (mg/L)			
Total solid content (mg/L)	Total Dissolved Solids (mg/L)	500	0.006480
Fecal coliform (FC) CFU/100mL			
	*Radon (pCi/L)	300	0.010800
	*Conductivity (µs/cm)	800	0.004050

Brown et al. WQI (9-Parameter Model)

BWQI & NSFWQI (Delphi-based methods)

Original Weight Score		Revised Weight Score	
Parameter	**Weight Score**	**Selected Parameter**	**Weight Score**
Dissolved oxygen saturation (%)	0.17	Dissolved oxygen saturation (%)	0.2057
Fecal coliform (CFU/100mL)	0.16	Fecal coliform (MPN/100mL)	0.1936
pH	0.11	pH	0.1331
Temperature change (ºC)	0.10	Temperature change (ºC)	0.1210
Nitrates (mg/L)	0.10	Nitrates (mg/L)	0.1210
Turbidity (NTU)	0.08	Turbidity (NTU)	0.0968
Total solids (mg/L)	0.07	Total Dissolved Solids (mg/L)	0.0847
Biochemical oxygen demand (mg/L)	0.11		
Total phosphate (mg/L)	0.10		
Total	1	Total	1

National Sanitation Foundation WQI (7-Parameter Model)

WQIs references for rating water quality

BWQI

WQI	Water Quality Status	Possible Use
0-25	Excellent	Drinking, irrigation, and industrial
26-50	Good	Drinking, irrigation, and industrial
51-75	Poor	Irrigation and industrial
76-100	Very poor	Irrigation
>100	Unfit for drinking	Proper treatment required before use

Source[36]

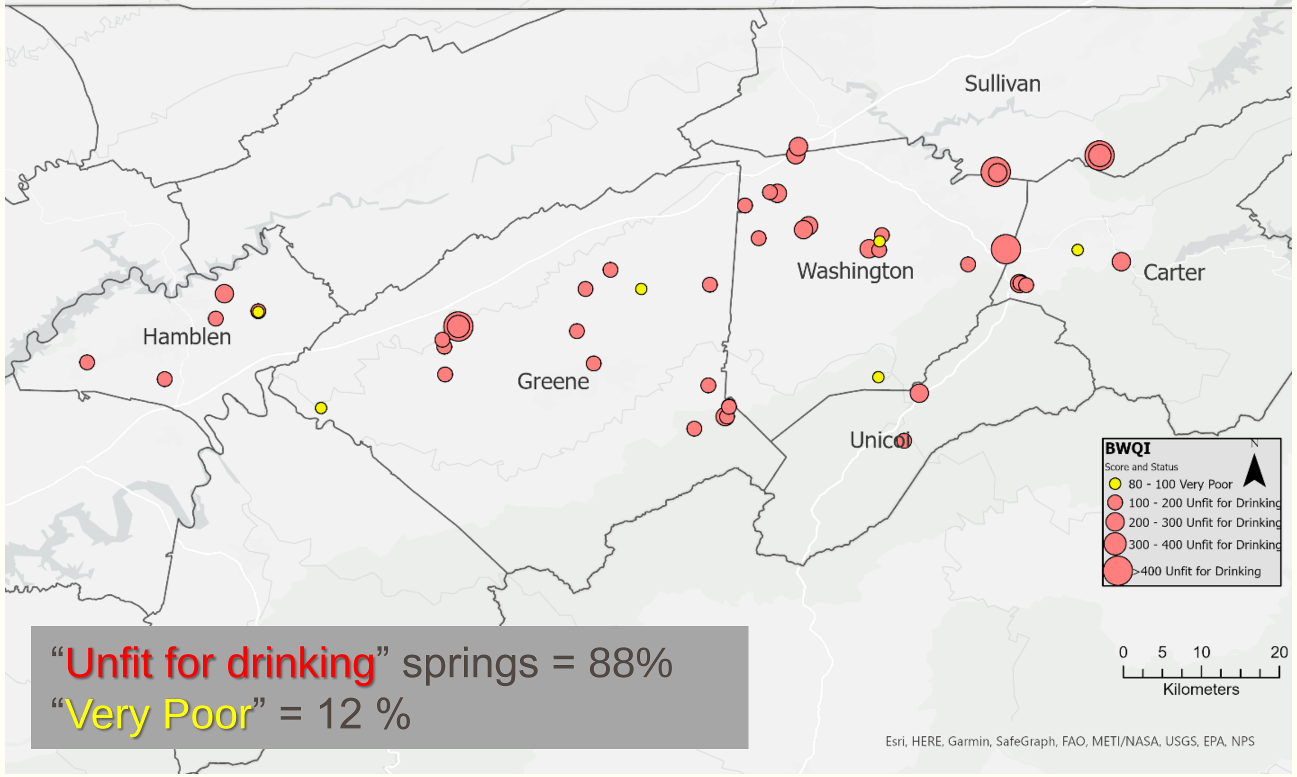
NSFWQI

NSFWQI Score	Criteria
0-25	Very Bad
26-50	Bad
51-70	Medium
71-90	Good
91-100	Excellent

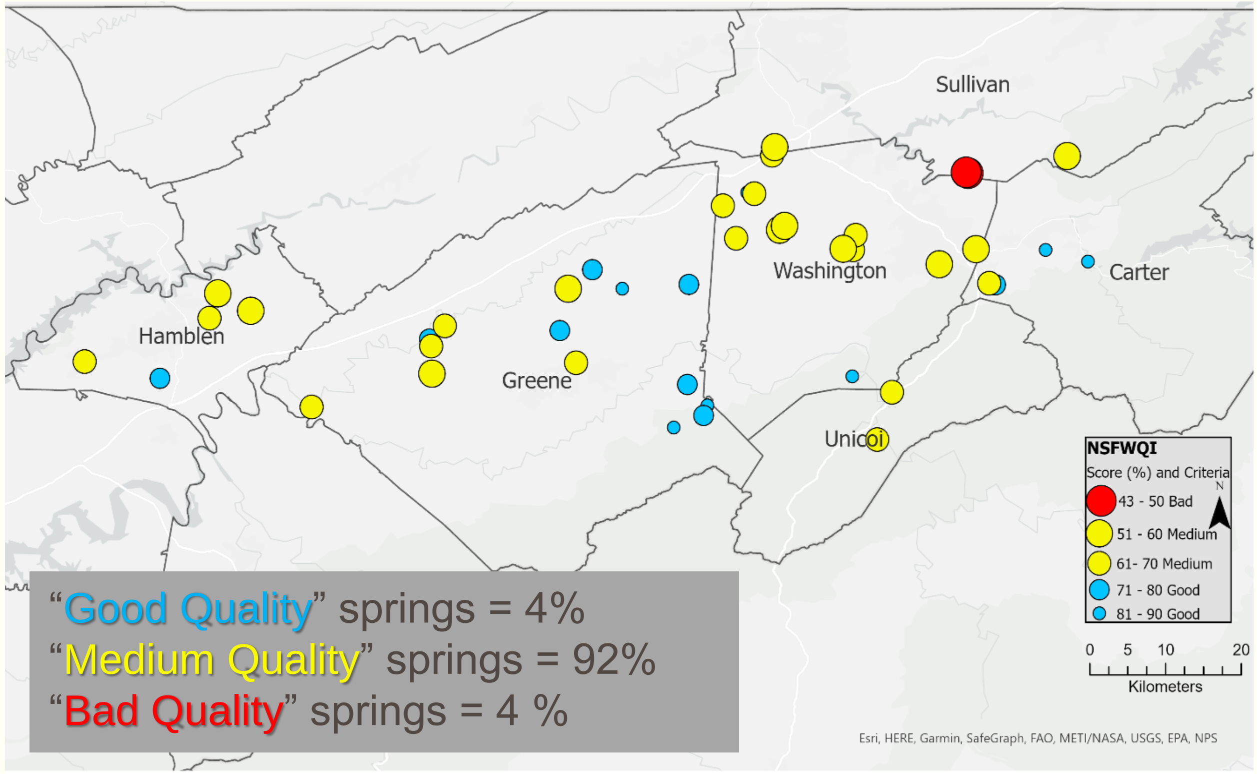
Source[37]

WQI-based spatial distribution maps of spring water quality

BWQI



NSFWQI



General conclusions

Research Goal	Main Findings
To determine the overall drinking water quality using WQI	✓Water quality ratings were “very poor” to “medium” or “unfit for drinking”, with 4% of springs ranked “good”. ✓Both BWQI & NSFWQI emphasis more on aesthetic WQ issues & less on health-based WQ issues. ✓NSFWQI produced more liberal WQ ranking than BWQI which is consistent with previous studies[34,35,36].

Contrary to many spring water users’ opinion; that it is clean water doesn’t always mean it is safe (drinking) water!

Significance

- ✓ Water treatment procedures for microbial pollution purification are advised before studied springs are used as a drinking water source.
- ✓ Water users in areas of high radon concentration (above MCL) should conduct regular monitoring of radon in their water to ensure that the concentration is below that which contributes to elevated indoor air radon. A reduction in indoor air radon will likely reduce lung cancer risk exposure.
- ✓ Research findings will enhance the work of SafeWatch Program of the Tennessee Department of Health(TDH) and CDC in better understanding the safety of private drinking water systems that include springs.
- ✓ The research data will serve as a historical record and vital information to keep the springs healthy into the future.

Limitations of study and recommendations

Limitations of study:

- ❖ Single sampling approach.
- ❖ Water quality data and the choice of WQI computation methods.

Therefore, for future research:

- ✓ Additional/repeated sampling (e.g., 5 in 30 sampling method) is recommended to develop a spatiotemporal database of water quality in the study area.
- ✓ When more water quality data (metals, organic compounds, etc.) are available, statistical or non-Delphi-based WQI models and specific water use indices should be considered.

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- ✓ ETSU Department of Geosciences Hydrology Laboratory

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Thank you for listening!
Questions?