

Water-Quality Time Series Modeling, Trend Analysis, and Sampling
Design for Indiana Fixed Station Monitoring Program Stream Sites
A USGS Analysis

The USGS provided analysis of trends in flow-adjusted concentrations of 12 nutrients, metals, ions, and solids in 7,345 stream-water samples from 57 Indiana Fixed Station Monitoring Program (FSMP) sites for 2000 to 2010. The results of this analysis were published in USGS Scientific Investigations Report 2014-5205. The Indiana FSMP included 163 sites in 2012. The 57 sites included in the concentrations trends analysis were located at or near USGS stream gages and had complete annual sample records for the 11 year study period.

For discussion purposes, a sampling schedule design to detect seasonal trends in these 12 constituents at the 57 sites was presented by USGS to IDEM in 2014. A *level of sensitivity* for detecting trends was proposed, based on the median for the 57 sites of the maximum of the median concentrations in 2010 for three defined seasons.

Seasonal trends rather than annual trends were proposed because some trends may only occur, or may only be high enough to detect during certain seasons and because the factors affecting trends can be seasonal. The three *seasons* used were: high flow (March – June), low flow (July – October), and variable flow (November – February).

The *concentration change* for a statistically significant seasonal trend was proposed as 0.5, 1, 2, 2.5, 3 or 4 times the level of sensitivity, subjectively considering the constituent and its water-quality criteria and reporting limit (table 1). Each season had a potentially different minimum number of samples needed to detect the specified magnitude of concentration change in trends for each constituent at each of the sites.

Annual sampling schedules were evaluated for each constituent for each site: monthly (12 samples), high-flow season weighted (8 samples total with 4 in high flow, 2 in low flow, and 2 in variable flow), bi-monthly (6 samples), and quarterly (4 samples).

For each site, a *sampling schedule design* was provided that optimized the number of annual samples required to detect a statistically significant seasonal trend in concentrations of the 12 constituents, based on a specified concentration change and level of sensitivity (table 2). The resulting designs were a mix of three sampling schedules (6, 8, or 12 samples per year) and applied to 57 of the 163 Indiana FSMP sites. Further analysis of sampling schedule designs by USGS was not requested by IDEM, after this initial discussion.

Table 1. Levels of sensitivity and concentration changes proposed for sampling schedule design evaluation

[mg/L, milligram per liter; µg/L, microgram per liter]

Constituent	Units	Level of sensitivity	Concentration change
Nitrate	mg/L	3.5	3.0
Organic nitrogen	mg/L	0.8	0.8
Phosphorus	mg/L	0.15	0.15
Suspended solids	mg/L	20	50
Copper	mg/L	3.0	3.0
Lead	mg/L	1.5	1.5
Iron	mg/L	800	1,600
Zinc	mg/L	15	60
Chloride	mg/L	40	40
Sulfate	mg/L	50	50
Hardness	mg/L	300	150
Dissolved solids	mg/L	400	200

Table 2. Sampling schedule design proposed for 57 Indiana Fixed Station Monitoring Program sites

Sampling schedule	Site identification numbers	No sample months	Number of sites
12 per year	UMC030-0004, UMC050-0002, WAW020-0004, WAW020-0039, WVE100-0001, WWL020-0003, WWL070-0003, WWL100-0001, WUW120-0002, WWL030-0003, WWL070-0003, WAW010-0063, WBU200-0003, WMI020-0002, WPA060-0002, WSA040-0005, WUW160-0006, WWL100-0005, WWU020-0005, WWU160-0001	none	20
8 per year	WAW005-0005, WDE050-0002, WED090-0004, WEU040-0001, WLV030-0003, WLV080-0003, WLV140-0001, WLV150-0001, WLV190-0012, WLV200-0001, WMI060-0004, WMI060-0005, WSU050-0002, WTI150-0011, WWE060-0002, WWE080-0001	August, October, December, February	16
6 per year	GMW040-0005, GMW070-0006, GMW080-0001, OBS140-0004, OBS150-0008, UMI050-0006, UMK060-0001, UMK080-0001, UMK110-0002, WAE050-0001, WAE070-0011, WEM070-0001, WTI010-0001, WWU010-0001, WWU090-0002, WWU100-0001, WWU110-0001, WWU110-0002, WWU120-0001, WWU120-0002, WWU140-0002	April, June, August, October, December, February	21