Appendix 5. Fox River Study Group Interim Monitoring Evaluation

Submitted to Fox River Study Group
26 March 2003

Introduction

The purpose of this report is to review data collected by the Fox River Study Group (FRSG) from April to December 2002 and evaluate the monitoring design. Statistic analyses were carried out with selected results presented in this report (details available upon request). While a complete review and recommendations will be provided in final report, analyses related directly to the FRSG data are summarized and presented to the FRSG to facilitate their decision on continuation or changes to data collection.

Existing Design

Study Design

The FRSG monitoring is designed as systematic sampling. Sites are sampled bi-weekly, every other Tuesday at 10 am. Systematic sampling gives excellent results when evaluating long-term trends. It is less suitable for evaluating runoff related problems than event related sampling. Current sampling design does not address problems related to CSOs, urban, or agricultural runoff. For example, evaluating compliance with IEPA standards for pathogens requires "a minimum of five samples taken over not more than a 30 day period."

Figure 1 shows average daily flow at the Algonquin gaging station (USGS 0555000) over the period sampled by the FRSG with the FRSG sampling dates marked (flow is on logarithmic scale). Many sampling dates and all those before September 12, 2002, are associated with runoff events of various magnitudes. Flow measured at Algonquin, South Elgin, and Dayton USGS gaging sites show flow conditions were above average from April to June 2002 and below average from July to December 2002. Water quality can change rapidly during runoff events with receding and raising portions of hydrograph yielding different concentrations for the same flow. Thus, a single sample is not representative of the mean concentration during the event. Flow proportional sampling is recommended to evaluate average event concentration or load associated with the event.

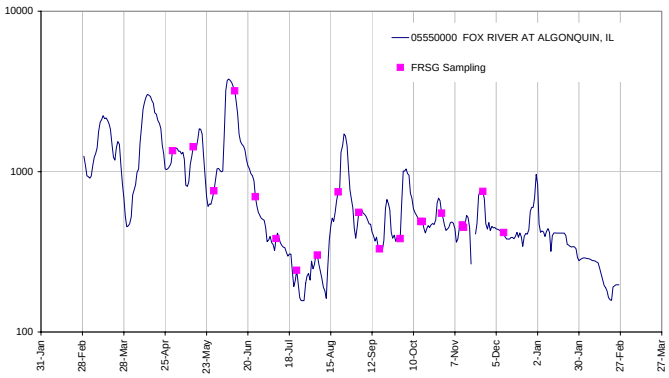


Figure 1. Flow at Algonquin site and the FRSG sampling dates. Flow in cfs on logarithmic scale.

Station Locations

The sites monitored by the FRSG correspond to IEPA ambient water quality sites. Figure 2 shows location of the FRSG sites as well as stream network and facilities with NPDES permits (1998 - present). NPDES facilities are classified by average design flow (mgd). Only stations with average design flow greater than 0.3 mgd and geographical information available are displayed. Information on NPDES facilities was downloaded from the USEPA EnviroFacts Data Warehouse.

The FRSG sites capture individual effects of most point sources displayed. However, there are several major NPDES facilities as well as tributaries on a reach between the Algonquin and Elgin monitoring sites. Their effect cannot be separated within the present monitoring locations.

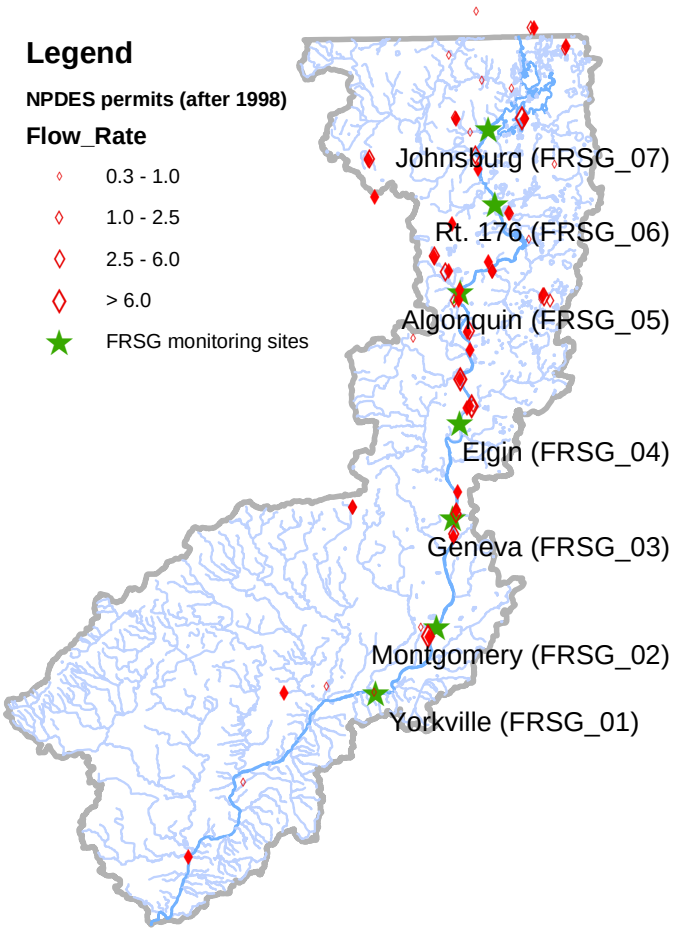


Figure 2. Location of FRSG monitoring sites with respect to point sources and the Fox River tributaries. Flow rate in mgd.

Parameters Analyzed

The FRSG monitoring focuses on nutrient and related issues. Samples are analyzed for organic matter (BOD_5), dissolved oxygen (DO), nitrogen, phosphorus, chlorophyll *a*, and other basic indicators. There are other parameters related to urbanization of watersheds not monitored by the FRSG, such as toxic metals (e.g., copper, lead, zinc, and cadmium), organic pollutants (e.g., pesticides, and PAHs). Other water quality issues related to urbanization are temperature increase, washoff of road deicing chemicals, and construction runoff. As these issues are related to runoff, event driven sampling would be required to properly evaluate their effect on water quality.

Water Quality

Spatial Comparison

Multiple sample comparison tests enable us to compare distributions (means) of measured parameters among the monitored sites. The test results carried out for measured parameters are summarized in the following table:

Parameter	**Mean different?**	**Groups**
Temperature	No	
Conductivity	Yes	(Yorkville, Montg., Elgin)> (Geneva, Algon., Rt. 176, Johnsburg)
Dissolved oxygen	Yes	(Yorkville, Montg., Geneva, Elgin, Johnsburg)> (Algon., Rt. 176)
BOD_5	No	
pH	No	
Suspended solids	No	
Organic nitrogen	No	
Ammonia nitrogen	No	
Nitrate nitrogen	Yes	(Yorkville)≥(Montg., Geneva, Elgin) ≥ (Algon., Johnsburg) ≥ (Rt. 176)
Kjeldahl nitrogen	No	
Total phosphorus	Yes	(Yorkville)>(Montg., Geneva, Elgin) > (Algon.) ≥ (Rt. 176) ≥ (Johnsburg)
Dissolved phosphorus	Yes	(Yorkville)>(Montg., Geneva, Elgin) > (Algon., Rt. 176, Johnsburg)
Chlorides	Yes	(Yorkville, Montg., Geneva, Elgin, Algon.) > (Rt. 176, Johnsburg)
Fecal coliform	Yes	(Yorkville, Montg., Geneva, Elgin) > (Algon.) ≥ (Rt. 176, Johnsburg)
Chlorophyll *a*	No	
Turbidity	No	
Biomass	No	

Differences in conductivity and total phosphorus among sites are illustrated in Figure 3 and Figure 4. Box-and-Whisker[1] plots in Figure 3 enable visual comparison of main statistical characteristics such as mean, standard deviation, median, and range. The plot in Figure 4 compares means of measured values estimated with 95 percent confidence.

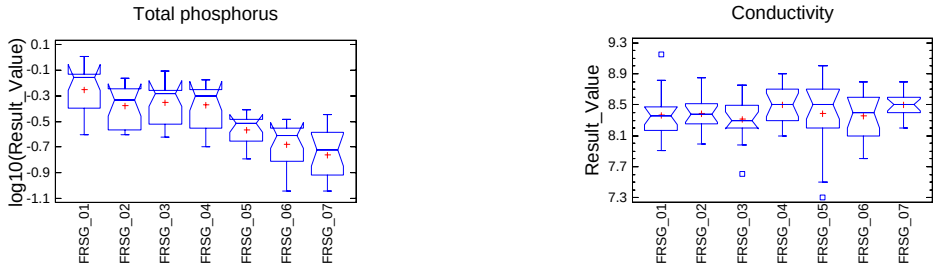


Figure 3. Box-and-Whisker plots – comparison among FRSG sites for total phosphorus and conductivity

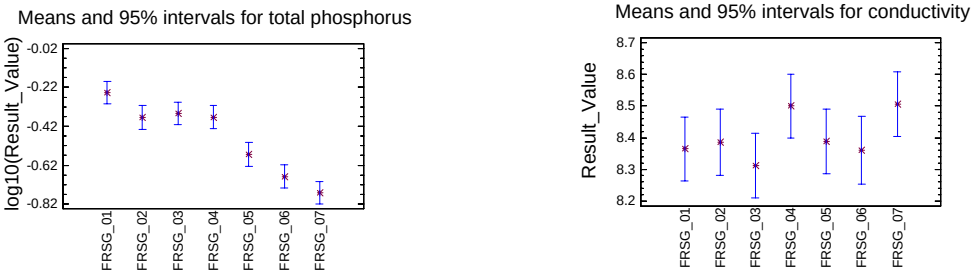


Figure 4. Means and 95% confidence intervals – comparison among FRSG sites for total phosphorus and conductivity

Longitudinal profiles of sampled days were plotted for selected parameters (DO, TP, N-Kjeldahl, chlorophyll *a*). Dissolved oxygen shows a significant drop in values at the Rt. 176 site (FRSG_06) compared to the upstream site at Johnsburg (see Figure 5, week 6). Total phosphorus concentration steadily increases from upstream to downstream sites (Figure 6). There is no general trend for nitrogen and chlorophyll concentration; it varies from week to week.

September 3, 2002 data show extremely low oxygen values for Johnsburg (FRSG_07) and Rt. 176 (FRSG_06) sites (3.6 and 3.8 mg/L, respectively). There are other instances where reported DO was below standard (6 mg/L).

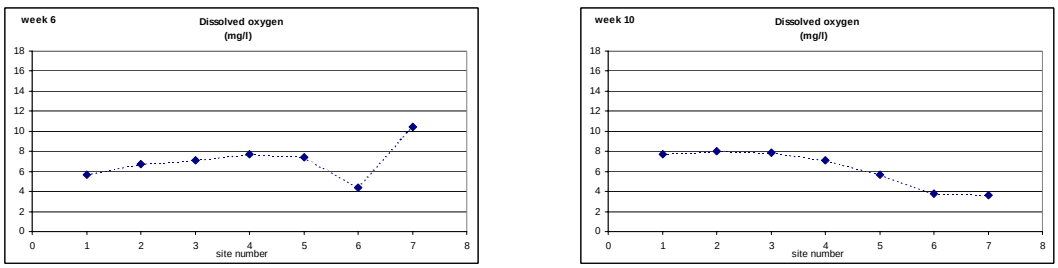


Figure 5. Dissolved oxygen – longitudinal profile for sampling events on July 9, 2002 (week 6) and September 3, 2002 (week 10)

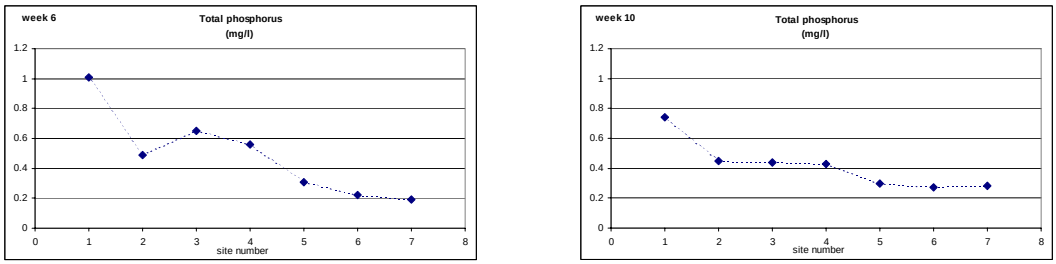
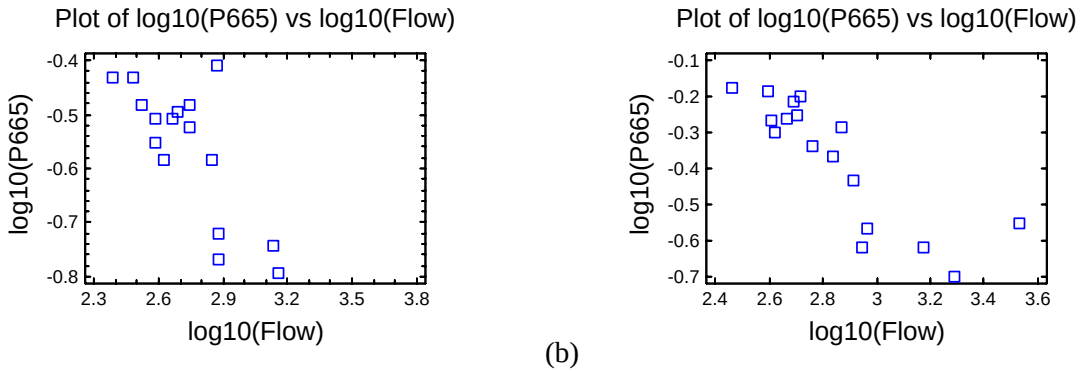


Figure 6. Total phosphorus – longitudinal profile for sampling events on July 9, 2002 (week 6) and September 3, 2002 (week 10)

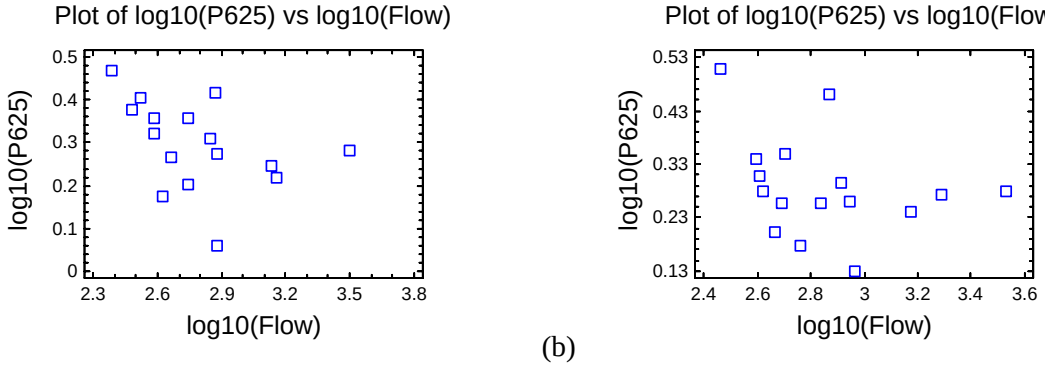
Relation with Flow

Parameters were plotted against the flow. Figure 7 shows a decrease in total phosphorus concentration with increasing flow. This indicates prevalence of point source contributions of phosphorus in the watershed. Higher nitrogen (Kjeldahl) concentrations are also associated with lower flows, although the relationship is not as obvious as for phosphorus (Figure 8). Conductivity, chlorides, and fecal coliform follow the same general trend of increasing concentrations with decreasing flows.



(a) (b)

Figure 7. Changes in total phosphorus with flow for Algonquin (a) and Elgin (b) sites. Log-log scale.



(a) (b)

Figure 8. Changes in Kjeldahl nitrogen with flow for Algonquin (a) and Elgin (b) sites. Log-log scale.

Comparison with IEPA

Two-sample comparison tests were carried out for stations and parameters sampled by both FRSG and IEPA (data from January 1998 to January 2002). Generally, the FRSG data indicate poorer water quality conditions than the IEPA data. The FRSG reports higher nutrient concentrations and lower dissolved oxygen values. However, the complete IEPA data from 2002 are not yet available for comprehensive analysis. Low flow conditions during the FRSG sampling period probably contributed to apparent lower water quality conditions. The true difference can be assessed when the full dataset for 2002 becomes available. Distributions have been compared for the following sites and parameters (α=0.05):

Parameter	**Montgomery**	**Elgin**	**Algonquin**	**Rt 176**
Dissolved oxygen	=	=	FRSG < IEPA	FRSG < IEPA
Nitrogen (Kjeldahl)	FRSG > IEPA	FRSG > IEPA	FRSG > IEPA	FRSG > IEPA
Total phosphorus	FRSG > IEPA	FRSG > IEPA	FRSG > IEPA	FRSG > IEPA
Fecal coliform	=	=	=	=
pH	=	>	FRSG > IEPA	=

= … no statistically significant difference
> … difference at α=0.1

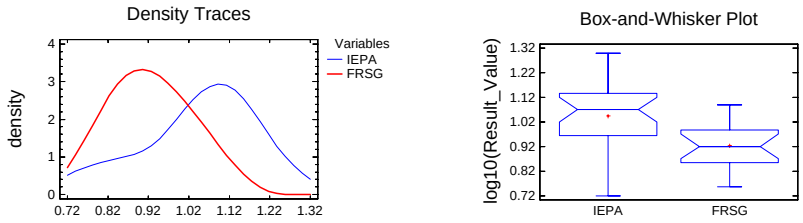


Figure 9. Dissolved oxygen – comparison of FRSG and IEPA measurements for Algonquin

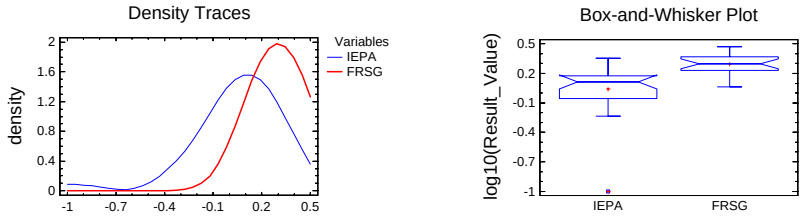


Figure 10. Kjeldahl nitrogen – comparison of FRSG and IEPA measurements for Algonquin

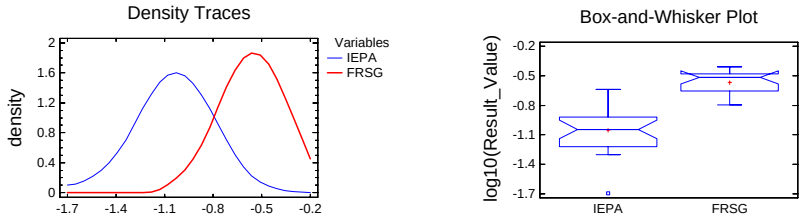


Figure 11. Total phosphorus – comparison of FRSG and IEPA measurements for Algonquin

Summary

- Wide range of flows sampled
- Water quality in the sampled year below 5-year average
- Design excellent for long term evaluation, less suitable to describe event driven changes
- Focus on nutrient related problems
- Contribution of point sources and tributaries cannot always be separated
- Between sites, difference identified in conductivity, DO, nitrate nitrogen, Kjeldahl nitrogen, total and dissolved phosphorus, chlorides, and fecal coliform
- Water quality deteriorates from upstream to downstream
- Point sources prevalent for phosphorus and Kjeldahl nitrogen; other parameters (conductivity, chlorides, fecal coliform) also show higher values for low flow conditions

[1]Box-and-Whisker plot: A graphical summary of the presence of outliers in data for one or two variables. This plot, which is particularly useful for comparing parallel batches of data, divides the data into four equal areas of frequency. A box encloses the middle 50 percent, where the median is represented as a vertical line inside the box. The mean may be plotted as a point.

Horizontal lines, called whiskers, extend from each end of the box. The lower (left) whisker is drawn from the lower quartile to the smallest point within 1.5 interquartile ranges from the lower quartile. The other whisker is drawn from the upper quartile to the largest point within 1.5 interquartile ranges from the upper quartile.

Values that fall beyond the whiskers, but within 3 interquartile ranges (suspect outliers), are plotted as individual points. Far outside points (outliers) are distinguished by a special character (a point with a + through it). Outliers are points more than 3 interquartile ranges below the lower quartile or above the upper quartile.