Re: Contribution of point and non-point sources to total phosphorus loads in the Fox River watershed downstream of Stratton Dam

Introduction

This Memorandum was prepared to aid the Fox River Study Group’s (FRSG) discussions in developing the Fox River Implementation Plan (FRIP). The Illinois State Survey (ISWS) has developed and calibrated a suite of HSPF models that simulate various water quality constituents including Total Phosphorus (TP). Details of the model development, calibration, and analyses of the results including future scenarios that were simulated with the model can be found in Bartosova (2013), Bartosova et al (2011), Bartosova et al (2007a and b), and Singh et al (2007).

The Fox River watershed study area as simulated by the HSPF models starts at Stratton Dam, includes the Fox River mainstem and its tributaries watersheds all the way to the Fox River’s confluence with Illinois River. The TP load simulated by the HSPF models to enter the stream from point and non-point sources in the Fox River watershed study area were summarized for this document. The impacts of the in-stream transport and transformation processes were not considered. This is important because the proportion of the load entering a stream and the in-stream load at a specified location, for example the Fox River reach that empties to Illinois River, varies significantly depending on where in the watershed the source is located. Individual tributary streams as well as mainstem reaches vary in their characteristics (e.g., channel slope, stream velocity, and water depth) that help determine these processes such as settling, algae growth, or release of P from sediments. Totaling all loads generated in the watershed could result in a load that is larger than loads determined by Bartosova (2013).

The TP loads presented in this Memorandum are loads generated within the watershed. All point sources (NPDES facilities but not MS4s or CSOs) are combined. Non-point sources as used in this Memorandum refer to all sources associated with surface and subsurface runoff including urban storm water. The TP loads generated from urban land uses were combined together, regardless of whether the discharge to stream occurs through MS4, CSO, or urban areas not covered by a permit. The TP loads generated on agriculture land were also combined (specified as corn and soy land use in the HSPF models). The remaining land uses were grouped together and are shown as “other” sources. The impact of the upstream boundary is also evaluated. For this discussion, the TP load carried by the Fox River at Stratton Dam can be considered an external load that enters the stream at that location.
Point and non-point sources of total phosphorus in Fox River

Long-term average annual load simulated for 1991-2011

The HSPF model input and output time series were processed to determine long-term average annual TP load generated in the watershed during the model simulation period. The full simulation period, January 1, 1990 to September 30, 2011, was adjusted to remove the impact of initial conditions and also the impact of the extreme flood event in 1996 by removing any data generated during 1990 and 1996. All remaining data were processed to determine average annual TP load.

Figure 1 shows percentage of TP loads that enters the streams in the study area. The first chart here and in the other figures as well represents the overall percentage including the contribution from the upstream boundary (Stratton Dam). The second chart then represents the loads generated within the watershed itself. Point sources represent the single largest source of TP load (53% when upstream boundary is included and 58% when only sources internal to the study area are considered). Agriculture represents the second largest source of TP load (26% when inputs at the upstream boundary are included). About 9% of the total TP load entering the Fox River study area comes from the upstream boundary, Fox River at Stratton Dam. Urban land cover contributes only 6% of the total TP load generated within the study area. The relative contribution from individual sources are not significantly impacted by the TP load present at the upstream boundary since the contribution of TP from the study area is much larger than the TP load entering Fox River at Stratton Dam.

Figure 2 shows the percentage of the TP load that entering the stream in the upper portion of the study area. The watershed between Stratton Dam and a confluence of Fox River and Ferson Creek is referred to as the Upper Fox. The Upper Fox has the same upstream boundary as the overall study area, i.e. Stratton Dam. Point sources represent the single largest source of TP load (61% when the upstream boundary is included and 79% when only sources internal to the study area are considered). The load present at the upstream boundary now represents the second largest source of TP load (23% when upstream boundary is included). About 8% of the total TP load that enters the streams in the Upper Fox comes from urban land cover. Agriculture contributes only 4% of the total TP load generated within the Upper Fox.

Figure 1. Long-term average annual TP load generated in the Fox River watershed downstream of Stratton Dam: a) with and b) without the upstream boundary contribution
Figure 3 shows the percentage of TP loads entering the lower portion of the study area. The watershed between the confluence of Fox River and Ferson Creek and the confluence of the Fox River and the Illinois River is referred to as the Lower Fox. The upstream boundary for the Lower Fox is the TP load leaving Upper Fox. Point sources still represent the single largest source of TP load but their contribution declines to 35% when the upstream boundary is included and 47% when only sources internal to Lower Fox are considered. Agriculture again represents the second largest source of TP load (31% when upstream boundary is included and 42% when only sources internal to Lower Fox are considered). About 26% of the total TP load entering the streams in the Lower Fox comes from the Fox River upstream of its confluence with Ferson Creek. Urban land over contributes 4% of the total TP load generated within the Lower Fox.

**Figure 2. Long-term average annual TP load generated in the Upper Fox River watershed: a) with and b) without the contribution from Stratton Dam**

**Figure 3. Long-term average annual TP load generated in the Lower Fox River watershed: a) with and b) without the contribution from Fox River upstream its confluence with Ferson Creek**

**Estimate of current annual load**

Long term average values evaluated in the previous section do not necessarily reflect changes that may have occurred in the NPDES facilities discharging in the watershed. The changes may include termination of a facility, increases in the treated flows, or changes in treatment processes. To account for these changes, the long-term average annual load generated by non-point sources was compared to the average annual load discharged from NPDES facilities during 2000-2011. While it is recognized that changes occurred during the selected time period also, it was important that the time frame be sufficiently long to ensure the inclusion both wet and dry years in the evaluated time period.
Figure 4, Figure 5, and Figure 6 show estimates of current TP load generated in the Fox River watershed study area, Upper Fox, and Lower Fox, respectively. The results are very similar to the results for long-term annual average loads. The largest difference was found for TP contribution from the upstream boundary for the Lower Fox watershed (3% of the total load).

**Figure 4.** Estimate of the current annual TP load generated in the Fox River watershed downstream of Stratton Dam: a) with and b) without the upstream boundary contribution

**Figure 5.** Estimate of the current annual TP load generated in the Upper Fox River watershed: a) with and b) without the contribution from Stratton Dam

**Figure 6.** Estimate of the current annual TP load generated in the Lower Fox River watershed: a) with and b) without the contribution from Fox River upstream its confluence with Ferson Creek
Assessing the change with time

In addition to the long-term average and the attempt to estimate current average annual TP loads, TP loads were totaled for two time periods: 2000-2011 and 2007-2011. TP loads from both point and non-point source were limited to the selected time periods.

Figure 7, Figure 8, and Figure 9 show a change in the proportion of TP load generated by the source categories during the selected time periods. The proportions are very similar among the different time periods with the exception of the 2007-2011 period. Flows during 2007-2011 were relatively high although not as extreme as during 1996. This is illustrated in Figure 10; note that average annual TP loads generated by non-point sources are much higher during this time period than during any other period evaluated.

Figure 7. Annual TP loads generated in the Fox River watershed downstream of Stratton Dam for 5 different time periods: a) with and b) without the upstream boundary contribution

Figure 8. Annual TP loads generated in the Upper Fox River watershed for 5 different time periods: a) with and b) without the contribution from Stratton Dam
Figure 9. Annual TP loads generated in the Lower Fox River watershed for 5 different time periods: a) with and b) without the contribution from Fox River upstream its confluence with Ferson Creek

Figure 10. Total annual TP loads generated in the Fox River watershed study area during 5 different time periods, lbs/year
References


Appendix: Point and non-point sources of total phosphorus loads in tributary watersheds

Charts presented in this section show relative contributions to the long-term average annual TP load and estimates of the current annual TP load for individual tributary watersheds and the areas directly contributing to the Fox River mainstem. The contribution varies significantly between watersheds depending on the land cover, presence of NPDES facilities, and other watershed characteristics.

For each watershed, the long-term average annual TP load simulated for 1991-2011 is shown on the left side and the estimate of current annual TP load (long-term average for non-point sources excluding initial period and 1996 and point sources during 2000-2011) is shown on the right. For most watersheds there is no noticeable difference between the two evaluations.