Chapter 3

Pollutant Loading Analysis

3.1 Pollutants of Concern

As previously discussed in Chapter 2 Tyler Creek is identified as Full Support of its Aquatic Life Designated Use. The only impairment that the IEPA has identified is attributable to fecal coliform bacteria. Even though few impairments are listed in the watershed, the Fox River, which is the receiving waterbody, is listed for nutrients, siltation and a host of other pollutants. The key to addressing the impairments in the Fox River is reducing pollutant loads from the tributary watersheds. This is one of the important considerations for the Best Management Practices (BMPs) recommended in this watershed plan. Compared to other watersheds in Illinois, the Tyler Creek watershed is relatively pristine. The main pollutants of concern are generated from non-point sources and include fecal coliform, nutrients, and sediment The main sources of non-point pollutant loads in the watershed at present are agriculture and urban runoff from the isolated developed areas around Woodstock and Gilberts. Rapid development poses the main threat to future water quality in the watershed.

3.2 Pollutant Loading Analysis

A pollutant loading analysis was performed to identify the sources of pollutants and quantify their potential contributions to any identified impairments. The pollutant load analysis is a useful tool for identifying management strategies for addressing existing impairments and potential impairments that may occur as the result of increased human activities. The results of the analysis can help identify problem areas or ‘hot spots’ under existing and future conditions.

Because of the limited amount of water quality data available in the watershed and the purposes of the analysis, sophisticated modeling approaches were not used. A GIS-based Generalized Watershed Loading Function (GWLF) model was used to estimate the pollutant loads for the six subwatersheds. The GWLF is a mid-level model based on its ease of use and degree of complexity. The model uses readily available watershed specific characteristics such as land cover, topography, soil types and meteorology to estimate pollutant loads. GWLF output consists of monthly averaged quantities that can indicate seasonal trends.

The Illinois Department of Natural Resources (IDNR) 1999 land cover data was enhanced with 2005 aerial photograph of the Tyler Creek watershed and used for this analysis. The GWLF model uses nine categories of land cover. Since some of the land use data had more categories than those used in the GWLF model, some land use maps were aggregated to produce the required nine categories. Table 1 in the attached appendix presents the assignment of the available land uses into these nine land uses.

The following land use categories were used in the analysis.

- Wetlands
- Forest
- Hay/Pasture
- Row Crops
- Low Density Development (≤ 1unit per 1.2 acres)
- High Density Development (≥ 1unit per 1.2 acres)
- Transitional/Quarries
- Turfgrass/Golf Course
- Water

The USGS and Kane County Department of Environmental Management operate station 05550300 at Elgin, Illinois, with records of precipitation from October 1, 1998 to date. Daily precipitation records from this station were used in the Tyler Creek GWLF model. The records defined a 5-year period that was used to estimate the average monthly precipitation and pollutant loads for each subwatershed.

Maximum and minimum daily temperatures are required for GWLF model. Records from the meteorological site at the Argonne National Laboratory, Illinois (USGS Station 414204087594201) were used for the 5-year period modeled. Although this site is outside the Tyler Creek watershed; the records reflect the temperature pattern over the study area. The topography and soil types of Tyler Creek Watershed were defined by USGS Digital Elevation Model (DEM) and USDA-NRCS soil survey of Kane County respectively.

The model was used to generate two scenarios for each subwatershed; the existing land use conditions in the watershed and future year 2030 developed conditions. Projections of future land use were generated using various sources of maps including the Kane County Comprehensive Plan, municipal comprehensive plans and proposed development plan information.

The pollutants analyzed by the GWLF model are sediment and nutrients (nitrogen and phosphorus). These pollutants are considered surrogates for a variety of pollutants generated in typical rural and urban settings. Typically, urban runoff constituents of interest include oils and grease, bacterial, and heavy metals in addition to nutrients and TSS. Sediment particles are also vehicles for transporting other pollutants such as heavy metals, nutrients, oils and grease.

Fecal coliform bacteria are of concern in the watershed. However, the sources of the bacteria are not well known. The main source of the fecal coliforms is suspected to be urban runoff. Fecal coliform concentrations are very variable and unless the sources of these bacteria are isolated, it is difficult to implement an effective pollutant reduction strategy. Nevertheless, as a starting point to addressing the fecal coliform, a simple export-coefficient procedure was used to determine the relative contribution of the pathogen loadings from each subwatershed. The results enabled the most ‘critical’ subwatershed to be isolated so that appropriate BMPs could be prescribed. The simple procedure is justified by the lack of knowledge of the nature of the source and field data. The results of the fecal coliform bacteria load calculations are tabulated in the Sectopn

3.3. In addition to the BMPs, It is recommended that additional monitoring be conducted to further isolate the sources. Typically such monitoring should include low-flow and wet-season sampling. Once the source of the elevated concentrations is identified, then BMPs appropriate to the nature of the sources may be prescribed. More information on the recommended monitoring can be found in Chapter 13, Section 2.

In interpreting and comparing the model results, it is important to note several issues;

- A given amount of sediment from an urban development may contain a greater number of pollutants than the same amount from an agricultural area. In other words, urban sediment contains more pollutants (such as Oils & Grease, toxic metals) than sediment from agricultural areas.
- Seasonal patterns in pollutant movements are important because water quality violations generally occur seasonally. For this reason, the GWLF model can present a more realistic picture of pollutant movement in the watershed than simple event-based models which give annual loads.
- Although total pollutant loads are a good indicator of the overall cause of water quality impairments, water quality criteria/standards are based on concentrations. This is because the toxicity of a pollutant to the aquatic life is more dependent on concentrations than actual total loads.
- Although point sources can be included in the model, their small discharges appeared to be a small compared to non-point source loads.

In conclusion, annual pollutant loads are a good indicator of the potential for impairments but they should be interpreted with caution as they do not necessarily give a complete picture of the vulnerability of a watershed to impairments caused by a particular pollutant. Pollutant load results need to be supplemented with monitoring, especially biological monitoring to have a better assessment of the ecological health of a watershed.

3.3 Pollutant Loading Results and Pollutant Reduction Strategies

3.3.1 Runoff Volume

Runoff is the most critical component of any watershed process. Changes in a watershed physiographic conditions signal changes in runoff. Likewise, changes in runoff may cause profound changes in the dynamics of pollutant processes. As anticipated, the most noticeable change when a watershed urbanizes is an increased in the volume of runoff. The changes of runoff volumes in the Tyler Creek watershed from existing conditions to future conditions for each watershed are summarized in Table 3.1.

Table 3.1: Impact of Development in Runoff Volume

Subwatershed	Area (acres)	Runoff	Runoff	Percent Increase
		(ac-ft/yr)	(ac-ft/yr)	
Lower Tyler Cr.	5,008	1,469	1,531	4.2%
Central Tyler Cr.	5,194	1,617	1,875	16.0%
Upper Tyler Cr.	6,366	1,571	1,735	10.4%
Sandy Cr.	2,217	631	737	16.8%
Lower Pingree Cr.	1,825	491	587	19.6%
Upper Pingree Cr.	5,361	1,518	1,588	4.6%

The results demonstrate that projected future growth scenario in the watershed may result in runoff volume increases in the range 4% to 20%. If such volume increases are not mitigated, impacts from the increased runoff may include more frequent flooding, changes in stream morphology, higher sediment and pollutant loads, and changes in habitat. It may be noticed that the increase in the Lower Tyler Creek is modest because the watershed is already relatively more developed. However, the impact of the increases will be most severe in this subwatershed because it is the most downstream. As discussed in Section 4.2.2 the risk of increased flooding, especially in the of the lower reaches of Tyler Creek on the Judson University Campus as well as residential structures that are currently in proximity to the 100-year floodplain at Wing Street and North Lyle Avenue will need to be considered as part of the long term watershed management strategy.

Best Management Practices for Runoff Reduction

Because the impacts from increased runoff are caused primarily from runoff from upstream subwatersheds, the runoff reduction strategy must focus more on upstream subwatersheds. Mitigation for the effects of increases within the Lower Tyler Creek watershed can be achieved by preserving and restoring the floodplain, discouraging floodplain encroachment, and channel stabilization. It should be noted that such restoration measures manage the runoff rather than reducing it. Watershed-wide BMPs for reducing runoff volumes are recommended, and include:

- Rain garden / rain barrel programs to promote infiltration & runoff re-use
- Preserving open lands to promote infiltration
- Practicing Low Impact Development (Reduction of imperviousness)
- Wetland conversion/restoration to encourage retention and infiltration
- Removal/abandonment of agricultural tile systems.

More information on the above BMPs are provided in Chapter 4.

3.3.2 Tyler Creek pollutant loading results

The following tables summarize the results for pollutant loading analysis for the existing conditions scenario for the Tyler Creek subwatersheds. Estimates of fecal coliform loads from each of the subwatersheds re presented for rural and urban areas separately. The simple ‘export’ coefficient method was used in which urban and rural areas were assigned an average annual fecal coliform concentrations of 286 FCU/100mL and 250

FCU/100mL respectively. These values were judged to be representative of similar watersheds in Northern Illinois, such as the Poplar Creek or Sequiot Creek watersheds.. Detailed monthly loads for each subwatershed are included in the Appendix 3. The results show the seasonality of pollutant loads, an important factor in planning a monitoring program.

Table 3.2 Estimated Existing Annual Pollutant Load by Subwatershed

Subwatershed	Area (acres)	Sediment (ton/yr)	Total N (lbs/yr)	Total P (lbs/yr)
Lower Tyler Cr.	5008	782.5	20331.3	1300.5
Central Tyler Cr.	5194	979.3	22863.8	1660.8
Upper Tyler Cr.	6366	1755.5	33669.1	3161.2
Sandy Cr.	2217	515.2	9514.4	848.5
Lower Pingree Cr.	1825	460.0	8240.6	820.6
Upper Pingree Cr.	5361	1983.3	37756.7	3893.2
Total	25971	6475.8	132375.9	11684.8

Table 3.3 Estimated Annual Loads of Fecal Coliform Bacteria

Subwatershed	Area (acres)	Annual FC loads (10^9 FCU)	
		Existing	Future (2030)
Lower Tyler Creek Subwatershed			
Urban	2,642	23,348	25,683
Rural	2,366	12,792	11,363
Subtotal	5,008	36,140	37,046
Central Tyler Creek Subwatershed			
Urban	1,230	10,872	11,959
Rural	3,963	21,432	20,767
Subtotal	5,194	32,304	32,726
Upper Tyler Creek Subwatershed			
Urban	436	3,854	4,239
Rural	5,930	32,068	31,832
Subtotal	6,366	35,922	36,072
Sandy Creek Subwatershed			
Urban	931	8,229	9,052
Rural	1,286	6,955	6,451
Subtotal	2,217	15,184	15,503
Lower Pingree Creek Subwatershed			
Urban	315	2,779	3,057
Rural	1,511	8,170	8,000
Subtotal	1,825	10,949	11,057
Upper Pingree Creek Subwatershed			
Urban	196	1,729	1,902
Rural	5,165	27,932	27,826
Subtotal	5,361	29,661	29,729
Total Watershed	25,971	160,160	162,132

Table 3.4 Pollutant load Contribution Index

Subwatershed	Area (acres)	Sediment	Total N	Total P
Lower Tyler Cr.	5,008	63	80	58
Central Tyler Cr.	5,194	76	86	71
Upper Tyler Cr.	6,366	111	104	110
Sandy Cr.	2,217	93	84	85
Lower Pingree Cr.	1,825	101	89	100
Upper Pingree Cr.	5,361	148	138	161

Contribution index = (Percent of total watershed load coming from subwatershed ÷ Percent of watershed area that subwatershed comprises) × 100. Index above 100 indicates subwatershed produces disproportionately large pollutant load. (Adopted from Poplar creek watershed plan)

Table 3.5 Load Contribution Index for Sediment, Total N, and Total P

Subwatershed ID	Area (acres)	Contribution Index		
		Sediment	Total N	Total P
Lower Tyler Creek	5;008	63	80	58
Central Tyler Creek	5;194	76	86	71
Upper Tyler Creek	6;366	111	104	110
Sandy Creek	2;217	93	84	85
Lower Pingree Creek	1;825	101	89	100
Upper Pingree Creek	5;361	148	138	**161**

Contribution index = (Percent of total watershed load coming from subwatershed ÷ Percent of watershed area that subwatershed comprises) × 100. Index above 100 indicates subwatershed produces disproportionately large pollutant load. (Adopted from Poplar creek watershed plan)

Table 3.6 Load Contribution Index for Fecal Coliform

Subwatershed		Contribution as a proportion of watershed		Contribution Index*
ID	Name	Area	Load	
1	Upper Tyler Creek	25%	22%	91
2	Upper Pingree Creek	21%	19%	90
3	Lower Pingree Creek	7%	7%	97
4	Central Tyler Creek	20%	20%	101
5	Sandy Creek	9%	9%	111
6	Lower Tyler Creek	19%	23%	**117**
Total		100%	100%	

In the GWLF output, the annual pollutant loads are broken down by monthly and land cover contribution. The load calculations suggest that:

- The Lower Tyler Creek and Central Tyler Creek subwatersheds contribute more runoff per acre than the other subwatersheds and less sediment and nutrients. This is due to their predominantly urban land cover.
- The Lower Tyler Creek appears to be a ‘hot-spot’ for fecal coliform loads-as expected because of the higher degree of urbanization.
- The Upper Tyler Creek and Upper Pingree Creek subwatersheds contribute more sediment and nutrients per acre than the subwatersheds. This is due to their predominantly agricultural land cover.

A future conditions land cover scenario was analyzed using the GWLF model. This future land cover scenario combines the proposed comprehensive land use and development data from both Kane County and the municipalities within and adjacent to the watershed. The following assumptions were made to create this scenario:

- Assume that existing wetlands will be preserved.
- Areas defined as open area (forest preserves, etc.) in the Kane County data will retain their existing land cover,
- Area defined as resource management area in the Kane County 2030 Plan data will become low density development (< 1 unit/acre) in the future.

For the existing conditions land use scenario, the primary source of nutrients and sediments are from the agricultural area. As these areas become developed, the total annual nutrient loads decrease. The model predicts decreases in nutrient loads of about 30 percent for TSS, 22 percent for Nitrogen and 38 percent for phosphorus. The reduction in nutrient loads does not necessarily mean improved water quality because as previously discussed, urban runoff contains a greater the range of pollutants, and more toxic pollutants than agricultural runoff (heavy metals, hydrocarbons, etc.).

3.3.3 Pollutant Load Reduction BMP Summary

There is very little data available that would enable subwatershed specific estimates of the pollutant reductions. As was described in Section 2.2.3 Tyler Creek is listed for only fecal coliform impairments. The limited water quality data that has been collected (See Section 2.2.3) though elevated, does not indicate actual impairments according to the IEPA. The management objectives therefore of the watershed plan remain primarily to preserve existing natural resources and to mitigate for future impacts which may result in impairments. Pollutant load reduction targets are normally based on the water quality standards (WQS). For the case of Tyler Creek, there are apparently no violations of WQS. Furthermore, there are no Illinois standards for nutrients in streams. Since the management objectives for the watershed are to preserve the existing natural resources, and to address impairments in the Fox River, a practical, simple approach for assigning pollutant load reduction targets could be assigning average values typical of pristine or high quality streams. Based on the average values for the watershed presented in Section 2.2.3, the proposed target reductions by constituent are listed in Table 3.7 below.

Table 3.7 Pollutant Load Reduction Targets

Constituent	Target Value for Pristine Streams	Average Value adopted for Tyler Creek	Target Load Reduction
	mg/L	mg/L	
Phosphorus	0.08	0.31	74%
Nitrate	2.18	2.61	16.4%
Sediment (TSS)	<113	113	5 to 40%
Fecal Coliform (FC)	<200	200	20 to 30%

The fact that phosphorus loads would require much higher reductions than nitrates is consistent with the fact that phosphorus is usually the limiting nutrient for lakes and streams. The goal of achieving 74% nutrient reduction is therefore conservative, being based on the limiting constituent. Additionally, in the long-term the nutrient loads from the watershed will be reduced as the land use changes from agriculture to urban land use. Since the main source of nutrients in the watershed are fertilizer, the best strategies for reducing pollutant loads would be agricultural BMPs which focus on agricultural activities. In addition, the greatest opportunities for load reductions would be from the undeveloped predominantly agricultural subwatersheds such as Upper Pingree. Opportunities for reducing of pollutant load in urbanized areas of the watershed are limited by cost and land. Urban BMPs can reduce predominantly urban pollutants such as oils & grease, toxic metals, and temperature. They are therefore recommended to supplement the rural BMPs. The effectiveness of BMPs varies depending on the watershed characteristics. The GWLF model was also used to predict the effectiveness of several BMPs in agricultural subwatersheds such as the Upper Pingree Creek Subwatershed.

3.3.3.1 Agricultural Best Management Practices for Reducing Pollutant Loads

Agricultural BMPs are necessary because the watershed is still predominantly agricultural and may remain so for a long period. Typical agricultural BMPs include:

- **Preserving open lands to promote infiltration**
- **Wetland conversion/restoration to encourage retention and infiltration**
- **Removal/abandonment of agricultural tile systems**.
- **Nutrient Management**: Nutrient management is an effective measure for reducing nutrient loads from agriculture. Nutrient management involves managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendment. Nutrient management also applies to farm animal operations. The Kane County NRCS might already be conducting such a program in the watershed and its success might even be the reason why pollutant loads although elevated are not as high as in comparable watersheds in the country. It is recommended that the program be continued or expanded as necessary because of its effectiveness.
- **Riparian Buffers**: A riparian buffer is an area of vegetation (shrubs, grasss or trees) located adjacent to and up-gradient from water bodies and water courses. The location, layout, width, length and plant density are designed to accomplish a specific purpose and function. Riparian

buffers are used to: 1. Create shade to lower water temperatures to improve habitat for fish and other aquatic organisms. 2. Provide a source of detritus and large woody debris for fish and other aquatic organisms.3. Provide wildlife corridors, and 4. Reduce excess amounts of sediment, organic material, nutrients, and pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

3.3.3.1 Best Management Practices for Urban Areas to Reduce Pollutant Loads

Urban BMPs are prescribed for the urbanized sectors of the watershed, particularly the ‘hot-spots’. The BMPs are particularly intended to reduce fecal coliform loads because urban runoff has been suspected to be the main contributor. Typical urban BMPs considered include:

- **Regulatory BMP:** Regulatory BMPs include ordinances, regulations, and enforcement procedures that are applicable throughout the watershed and which have a cumulative effect of preventing water quality degradation. Examples include NPDES II pre- and post-construction pollution prevention regulations, zoning codes and regulations countywide stormwater regulations, soil-erosion and sediment control regulations and permitting, and disposal of hazardous wastes. Their effectiveness in reducing pollutant loads vary depending on the degree of enforcement. Regulation-driven pollution prevention controls can reduce pollution significantly (Lori S., Bear, 2007). For purposes of estimating pollutant reduction or removal efficiency of regulatory programs, conservative reduction rates of 2 to 5% have been assumed.

- **Street sweeping:** The effectiveness of street sweeping in removing pollutants varies greatly depending on frequency and the sophistication of the equipment. Modern vacuum dryer sweepers can reduce annual sediment loads by 55 to 88% and nutrients by 0 to 15% (Stormwater Managers Resource Center: http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/ParkingLotandStreetCleaning.htm)

- **Retrofitting existing ponds**

- **Retrofitting outfalls**

- **Practicing Low Impact Development (LID):** LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and managing / treating stormwater in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small, cost-effective landscape features located at the lot level. This includes not only open space, but also rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment / revitalization projects

- **Pet waste management:** According to the 'The Practice of Watershed Protection, Art 17', the presence of pet waste in stormwater runoff has a number of implications for urban stream water quality with perhaps the greatest impact from fecal bacteria (for more information see. According to recent research, non-human waste represents a significant source of bacterial contamination in urban watersheds. Genetic studies by Alderiso et al. (1996) and Trial et al. (1993) both concluded that 95 percent of the fecal coliform found in urban stormwater was of non-human origin. Bacterial source tracking studies in a watershed in the Seattle, Washington area also found that nearly 20% of the bacteria isolates that could be matched with host animals were matched with dogs. Pet waste Management is therefore a very important component of reducing fecal coliform bacterial loads in urban runoff.

- **Stormwater Management/Wetland Systems:** Stormwater Management Facilities that utilize a wet pond cell leading to a wetland cell have been reported to be very effective in removing pollutants from urban runoff. The wet pond cell is apparently very effective in pre-treating the incoming runoff; it also reduces its velocity and distributes it more evenly across the marsh.

- **Sand filters** are a relatively new technique for treating storm water, whereby the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel.

- **Filter Strips:** These are vegetated sections of land designed to accept runoff as overland sheet flow from upstream development. They may adopt any natural vegetated form, from grassy meadow to small forest. The dense vegetative cover facilitates pollutant removal. Filter strips cannot treat high velocity flows; therefore, they have generally been recommended for use in agriculture and low density development.

- **A Water Quality Inlet** is a three-stage underground retention system designed to remove heavy particulates and small amounts of petroleum products from storm water runoff. Also known as an Oil/grit Separator or an Oil-water Separator. As water flows through the three chambers, oils and grease separate either to the surface or to sediments and are skimmed off and held in the catch basin or storage tank. The storm water then passes on to the sanitary sewer, storm sewer**.**

- **Streambank Stabilization** controls erosion through management of water velocity and/or stream bank stability by natural and manmade controls to decrease bank erosion and sediment loading in waterways. Structural or vegetative means may be used separately or together**.**

Each of the BMPs listed above may be applied individually or in combination to meet desired pollutant load reduction targets as presented in the subsequent chapters for each subwatershed. Further descriptions of the recommended BMPs for Tyler Creek are presented in Chapter 4. Specific BMPs, their locations in the watershed and their expected pollutant load reduction are presented in Chapters 5,6,7,8,9, and 10 corresponding to the six subwatersheds that make up the Tyler Creek Watershed.