Little Calumet and Portage Burns Waterway TMDL for *E. coli* Bacteria

Final TMDL Report

Prepared for the

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

INTRODUCTION

Water quality data collected from the Little Calumet and Portage Burns Waterway has shown that that it does not meet the state's water quality standards for *Escherichia coli* (*E. coli*) bacteria. As a result, the Indiana Department of Environmental Management (IDEM) has placed six stream segments, comprising over 30 miles of the Little Calumet–Portage Burns Waterway, on Indiana's Section 303(d) list of impaired waters. Section 303(d) of the Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be established. A Total Maximum Daily Load (TMDL) is the total pollutant load from point and nonpoint sources that a water body can assimilate while maintaining its designated use (water quality standards). It also includes an appropriate margin of safety.

WATER QUALITY STANDARDS

Indiana's water quality standards for state waters within the Great Lakes System (327 IAC 2-1.5-8) limits *E. coli*, from April 1st through October 31st, to a geometric mean that does not exceed 125 colony forming units per 100 milliliters (cfu/100mL), based on not less than five samples equally spaced over a 30-day period. The standard also states that any one sample in a 30-day period cannot exceed 235 cfu/100mL.

PROCESS FOR DEVELPING TMDLs

IDEM follows six steps to develop TMDLs. Each step has been documented for the Little Calumet – Portage Burns Waterway.

Step 1: Data Report (Earth Tech, December 2002). Inventoried the data that is available for the development of the TMDL.

Step 2: Source Identification and Assessment Report (Earth Tech, August 2003). Evaluated the documented sources of *E. coli* within the watershed using the best available data/information such as monitoring data and literature values.

Step 3: Modeling Framework Report (Earth Tech, September 2003). Described the modeling objectives that will be required to develop the TMDLs and based on an evaluated alternative computer models selected the best tool (computer model) for analyzing the sources of pollutants and their in-stream water quality impacts.

Step 4: Watershed and Water Quality Modeling Report (Earth Tech, February 2004). Describe the setup/organization and calibration of the water quality model (WASP) that used to establish the TMDL.

Step 5: Allocation Report (Earth Tech, June 2004). Identified the magnitude of the contribution of point and nonpoint sources in the impairment of the receiving waterbodies.

Step 6: TMDL Report (Earth Tech, August 2004). It is this report that establishes the TMDL for the Little Calumet – Portage Burns Waterway.

SOURCES OF *E. COLI*

E. coli is found in the intestinal tract of warm-blooded animals, including humans, livestock, domestic pets, and wildlife. They are found in both point source and nonpoint source pollution and are present as free-floating bacterium as well as attached to solids. Nonpoint source pollution is separated into urban and rural components. In rural areas, sources of bacteria may include animal waste, runoff from concentrated areas of livestock, wildlife, and failing septic systems. In urban and residential areas, the nonpoint source pollution is associated with impervious areas, leakage of sanitary sewers, wildlife/domestic animals, and failing septic systems.

There were no apparent patterns to the water quality violations relating to *E. coli* that would suggest that violations were more common during a certain time of year or under some critical flow or weather conditions. From the available data, one could not identify the magnitude of any single source of *E. coli*. However, there are five general pollutant sources that need to be considered.

- NPDES Discharges (point sources) – assumed to be in steady-state condition based on known data.
- Combined Sewer Overflow (CSO) discharges – intermittent discharges based on estimates using known data about the discharge event.
- Urban Nonpoint Sources Stormwater – no known sampling data, however, could estimate loads knowing runoff volume and land use.
- Other Nonpoint Sources (such as livestock, wildlife, and failing septic systems) – there is no known data to quantify loads form these sources.
- Loads from Tributary Watersheds (Coffee Creek, Salt Creek, Deep River, and Hart Ditch).

ANALYSIS

The Water Quality Analysis Simulation Program, version 6 (WASP6) model was used for the simulation of six historical flows and water quality conditions (May 24, 2000, June 21, 2000, July 26, 2000, July 31, 2000, August 15, 2000, August 22, 2000). The WASP6 is a generalized framework for modeling contaminant fate and transport in surface waters developed by the U.S. EPA. The model broke the watercourse into 20 rectangular boxes (referred to as Junctions or Segments) that defines the physical hydrodynamic parameters of each segment of the river. DYNHYD5, a hydrodynamics model, was used to calibrate the hydraulic routing parameters used by WASP6.

ALLOCATIONS

The major source of the *E. coli* bacteria impairment in the Little Calumet – Portage Burns Waterway appears to be nonpoint sources. Nonpoint sources most likely to be contributing to the impairment of water quality include: failing septic systems, unknown illicit discharges of sewage, wildlife, small agriculture operations, bacteria laden sediments, and urban runoff.

Point sources are well below water quality standards. Therefore, point sources of *E. coli* make up such a small percent of the total load that further reductions would not significantly improve water quality.

CSOs are a known source of *E. coli* and play a major role in the water quality impairment when they occur. However, CSOs did not coincide with the dates of the simulated events, indicating that the waterbody was impaired by other sources in addition to CSOs.

TMDL

Based on the modeling and data analyzed, the allowable TMDLs for the Little Calumet – Portage Burns Waterway will require a reduction of over 90 percent in nonpoint source loads. However, there is still uncertainty as to the magnitude that various nonpoint sources of *E. coli* play in the impairment of the Little Calumet and Portage Burns Waterway. Therefore, an adaptive management approach is proposed to be taken in implementing the recommendations that are to address the water quality concerns for Little Calumet and Portage Burns Waterway. Key to this approach to watershed management is the feedback the managers will receive from continued water quality monitoring. Some improvements and modifications to the monitoring network should be considered to quantify the loads from specific nonpoint sources of *E. coli*.

Point sources are well below water quality standards. Therefore, no additional reduction will be required by point source discharges.

The TMDL has not been designed to address CSO contribution to the Little Calumet River-Burns Harbor waterway. The CSO Long Term Control Plan (LTCP) and NPDES permit are designed to address any contribution from these types of discharges that would cause or contribute to the *E. coli* impairment. Therefore, it is unnecessary for the TMDL to also address these types of discharges more specifically. The Gary Sanitary District and the Hammond Sanitary District are in the process of preparing their LTCPs and the implementation of the nine minimum controls. Recommendations for reducing the Waste Load Allocation (WLA) attributed from CSOs will come from the LTCP. If after the CSO LTCP is in place and they are still causing or contributing to the *E. coli* impairment, then the TMDL would more specifically address there contributions as a source of *E. coli*.

The Margin of Safety (MOS) will be an additional one percent reduction for the west branch of the Little Calumet River and Burns Ditch and an additional six percent reduction for the East Branch of the Little Calumet River and the outfall to Lake Michigan. This is the average reduction in pollutant loads necessary to move from a concentration of 125cfu/100mL to 107cfu/100mL. A concentration of 107cfu/100mL is the maximum allowable concentration assuming one measurement at the maximum concentration of 235 cfu/100mL, to achieve a geometric mean of 125 cfu/100mL.

1. INTRODUCTION

1.1 Study Area

Six stream segments (Figure 1-1), comprising over 30 miles of the Little Calumet – Portage Burns Waterway, are currently listed on Indiana's Section 303(d) list of impaired waters (Table 1-1). The parameters of concern for Little Calumet River and Portage Burns Waterway are *Escherichia coli* (*E. coli)* bacteria, based on the 2002 - 303(d) list. Segments 23 and 24 of the Little Calumet River were also listed as being impaired for cyanide. However, recent monitoring by IDEM contradicts previous monitoring resulting in IDEM to begin the delisting process for segments 23 and 24. Little Calumet River is located in the Little Calumet – Galien Watershed (USGS Cataloging Unit 04040001) and Chicago Watershed (USGS Cataloging Unit 07120003). Portage Burns Waterway is located entirely in the Little Calumet – Galien Watershed in Northwest Indiana. Appendix A shows the river miles referenced throughout this document.

TABLE 1-1

STUDY REACHES AND PARAMETERS
(2002 - 303(d) List)

Water Body	303(d) #	Segment ID Numbers	Location	Impairment
Little Calumet	22	INC0161_T1023 INC0162_T1060 INC0163_T1061 INC0162_T1082	Unnamed tributary east including headwaters of the stream in Porter and LaPorte Counties	*E. coli*
Little Calumet	21	INC0164_T1018 INC0164_T1086	Confluence of the West Branch of LCR and Burns Ditch east to an unnamed tributary, just west of Hwy 20 in Porter County	*E. coli*
Portage Burns Waterway	2	INC0164_T1108	Confluence of East Branch LCR and Burns Ditch North, in Porter County	*E. coli*
Portage Burns Waterway	24	INC0143_T1010 INC0143_T1090	Burns Ditch west to Deep River, just east of I-65 in Porter and Lake Counties	*E. coli*
Little Calumet	24	INC0142_T1009	Deep River west to Black Oak, between SR 912 and SR 53	*E. coli* Cyanide *****
Little Calumet	23	INK0335_T1004 INK0335_T1005 INK0336_T1002	Black Oak to Illinois, in Lake County	Cyanide *****

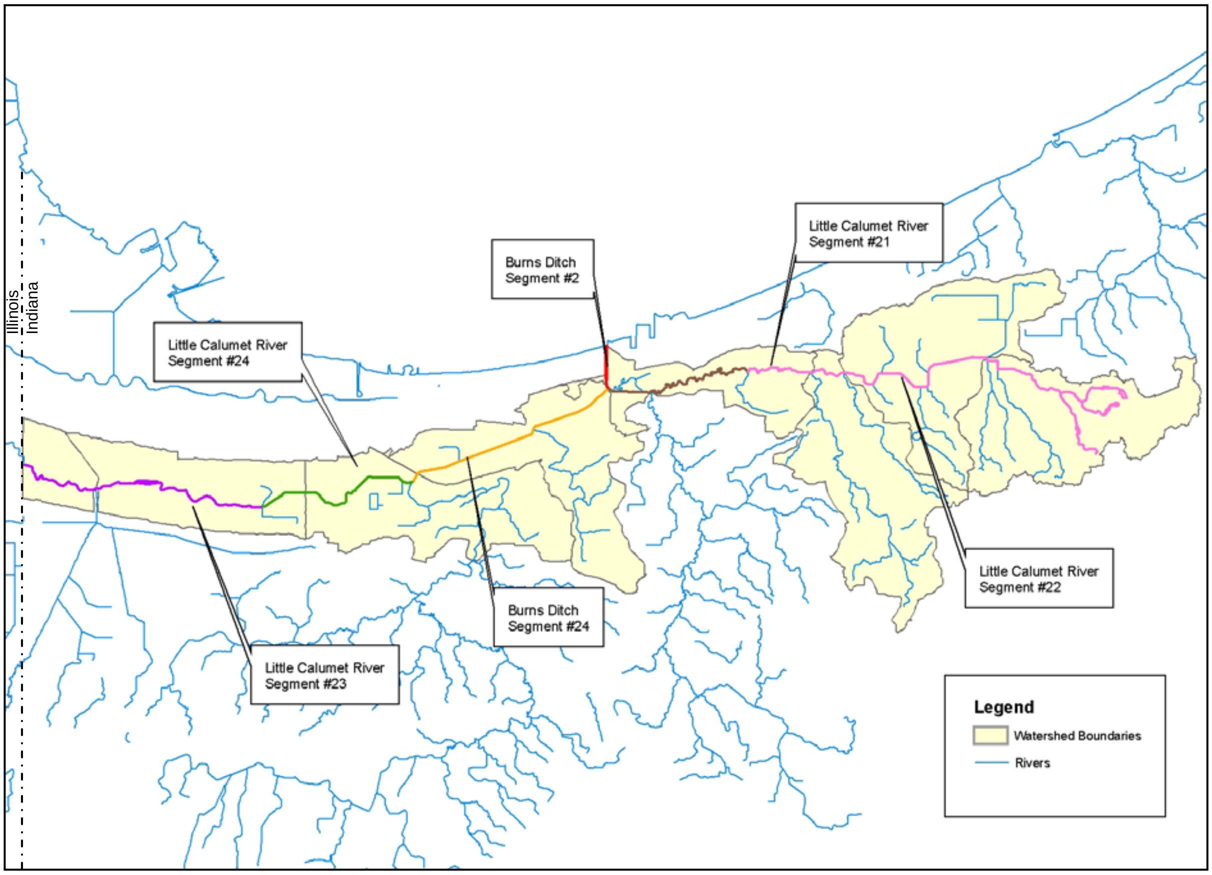
* Reach is in the 303(d) process of being delisted for cyanide

1.2 TMDL Program

Section 303(d) of the Clean Water Act requires states, territories, and authorized tribes to develop lists of impaired waters. These lists are submitted to the US EPA on April 1st of each even-numbered year. The waters on these lists are prioritized, with consideration given to the severity of the pollution and the intended uses of the water. The parameters of concern for Little Calumet River and Burns Ditch were *E. coli* bacteria, DO, cyanide, and pesticides based on the 1998 (303)d list. However, as of the latest 303(d) list (2002), pesticides and DO were removed. IDEM is taking Segments 23 and 24 through the delisting process for cyanide. It is anticipated that this process will be completed by the time the 2004 303(d) list is published.

FIGURE 1-1

STREAM SEGMENTS LITTLE CALUMET RIVER AND PORTAGE BURNS WATERWAY



As part of the priority ranking system, states are to establish Total Maximum Daily Loads (TMDLs) that will meet the water quality standard considering seasonal variations, a margin of safety, and future growth. A TMDL is based on the relationship between sources of pollution and in-stream water quality conditions. This establishes the allowable loadings to a waterbody that will still enable it to meet water quality standards. The following generic equation describes a TMDL:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where: LC = loading capacity;
WLA = wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;
LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources and natural background; and
MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be implicit or explicit.

1.3 Applicable Water Quality Standards

Indiana has set water quality standards to maintain the chemical, physical, and biological integrity of the waters in the state. Both Little Calumet River and Burns Ditch are designated for full-body contact recreation. The East Branch of Little Calumet River is designated as salmonid water that shall be capable of supporting salmonid fisheries. A portion of the study reach of Burns Ditch (from the confluence with the East Branch of Little Calumet River to the mouth) is also designated as a salmonid water. The West Branch of Little Calumet River, along with the rest of Burns Ditch, is designated for warm water communities.

Indiana's water quality standards for state waters within the Great Lakes System (327 IAC 2-1.5-8) limits *E. coli*, from April 1st through October 31st, to a geometric mean that does not exceed 125 colony forming units per 100 milliliters (cfu/100mL), based on not less than five samples equally spaced over a 30-day period. The standard also states that any one sample in a 30-day period cannot exceed 235 cfu/100mL.

1.4 TMDL Planning Process

IDEM follows six steps to develop TMDLs. Each step has been documented for the Little Calumet – Portage Burns Waterway.

Step 1: Data Report (Earth Tech, December 2002). Inventoried the data that is available for the development of the TMDL.

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Step 3: Modeling Framework Report (Earth Tech, September 2003). Described the modeling objectives that will be required to develop the TMDLs and based on an evaluated alternative computer models selected the best tool (computer model) for analyzing the sources of pollutants and their in-stream water quality impacts

Step 4: Watershed and Water Quality Modeling Report (Earth Tech, February 2004). Describe the setup/organization and calibration of the water quality model (WASP) that used to establish the TMDL.

Step 5: Allocation Report (Earth Tech, June 2004). Identified the magnitude of the contribution of point and nonpoint sources in the impairment of the receiving waterbodies.

Step 6: TMDL Report (Earth Tech, August 2004). This report establishes the TMDL for the Little Calumet – Portage Burns Waterway.

1.5 Availability of Data (Step 1)

Data was gathered from a number of federal, state and local sources including the USGS, NOAA, NRCS, IDEM, IDNR, Purdue University, Lake and Porter counties, Gary Sanitary District, and the City of Chesterton. The data assessment did not include extensive inventory or analysis of watersheds tributary to the Little Calumet River (Salt Creek, Coffee Creek, Deep River, and Hart Ditch).

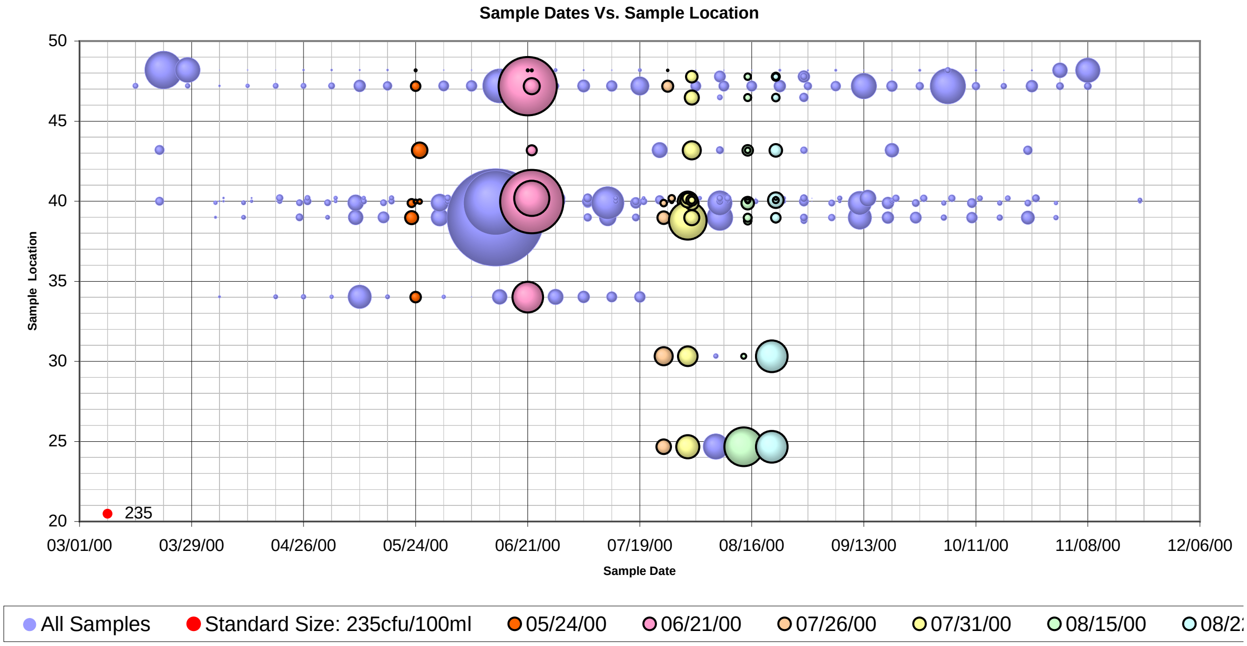
There are eight key stream gages in the watershed, with records ranging from 60-years (Hart Ditch at Munster - 05536190) to 10-years (Burns Ditch at Portage - 04095090). Five of the eight stream gages are currently active. The high correlation between some gages were used to create a synthetic streamflow records for gages and locations that were missing data.

There are over 80 sampling sites throughout the watershed operated by different agencies. The frequency and duration of the sampling is also highly variable. At best, samples were taken monthly from April though October, this left large gaps between samples. The calendar year 2000 had the most water quality data available. The bubble graph illustrates (Figure 1-2) sampling dates for the year 2000 along the horizontal axis and the river-mile where samples were taken along the vertical axis. River-mile 40 represents the confluence of the Portage-Burns Waterway with Lake Michigan. The size of the bubble represents the concentration of bacteria observed in that sample. Dates used in this analysis are colored and indicated in the legend. Dates that were chosen had to have at least three samples in the East Branch of the Little Calumet River (river-miles 40 – 50) and three samples in the west branch (river-miles 20 - 40).

The water quality of point source discharges was obtained from their discharge monitoring reports. The only data that quantifies CSOs was collected by the Gary Sanitary District as part of their 2002 Water Quality Assessment Report.

FIGURE 1-2

DISTRIBUTION OF WATER QUALITY SAMPLES



1.6 General *E. coli* Sources (Step 2)

E. coli is found in the intestinal tract of warm-blooded animals, including humans, livestock, domestic pets, and wildlife. They are found in both point source and nonpoint source pollution and are present as free-floating bacterium as well as attached to solids. Nonpoint source pollution is separated into urban and rural components. In rural areas, sources of bacteria may include, animal waste, runoff from concentrated areas of livestock, wildlife, and failing septic systems. In urban and residential areas, the nonpoint source pollution is associated with impervious areas, leakage of sanitary sewers, wildlife/domestic animals, and failing septic systems.

There were no apparent patterns to the water quality violations relating to *E. coli* that would suggest that violations were more common during a certain time of year or under some critical flow or weather conditions. From the available data, one could not identify the magnitude of any single source of *E. coli*. However, there are five general pollutant sources that need to be considered.

- NPDES Discharges (point sources) – assumed to be in steady-state condition based on known data.
- CSO discharges – intermittent discharges based on estimates using known data about the discharge event.
- Urban Nonpoint Sources Storm Water – no known sampling data, however could estimate loads knowing runoff volume and land use.
- Other Nonpoint Sources (such as livestock, wildlife and failing septic tanks) – there is no known data to quantify loads form these sources.

- Loads from Tributary Watersheds (Coffee Creek, Salt Creek, Deep River and Hart Ditch).

1.7 Modeling Approach (Steps 3 and 4)

The initial conclusion from the Source Identification and Assessment Report (Earth Tech, August 2003) suggested that nonpoint sources were likely more responsible for the violation of water quality standards than were point sources. However, there was very little information to quantify the contribution of the various nonpoint sources with any degree of certainty.

Therefore, an iterative approach was proposed to develop the TMDL for *E. coli*. The first iteration developed a model that will estimate the loads that result in the observed water quality conditions. Subtracting loads associated with point sources and CSO discharges from the modeled estimated loads provided an indication of the loads associated with nonpoint pollution sources. Given the magnitude from nonpoint source loads and the land use characteristics of the watershed, more reasonable conclusions were made as to the possible contribution from the various potential sources.

The Water Quality Analysis Simulation Program, version 6 (WASP6) model was used for the development of the TMDLs for *E. coli*. WASP6 simulated a series of six historical conditions that represented a range of flows and water quality conditions. The model assumed that bacteria followed a first-order decay that was first described by Chick in 1908 and is now known as Chick's Law. Chick's Law represented by the equation:

Where:

$$\frac{N_t}{N_O} = 10^{-kt}$$

N_t = number of bacteria at time t
N_O = number of bacteria at time 0
t = time in days
k = first order die-off rate constant (days^{-1})

The WASP6 is a generalized framework for modeling contaminant fate and transport in surface waters developed by the U.S. EPA. The model broke the watercourse into 15 rectangular boxes (referred to as Junctions or Segments) that defines the physical hydrodynamic parameters of each segment of the river. There are an additional four inflow Junction (Junctions 16, 17, 18, 19, and 20), representing tributaries to the Little Calumet and Portage Burns Waterway system, which establish boundary conditions for the WASP6. DYNHYD5, a hydrodynamics model, was used to calibrate the hydraulic routing parameters used by WASP6.

1.8 Allocations (Step 5)

The major source of the *E. coli* bacteria impairment in the Little Calumet – Portage Burns Waterway appears to be nonpoint sources. Nonpoint sources most likely to be contributing to the impairment of water quality include: failing septic systems, unknown illicit discharges of sewage, wildlife, small agriculture operations, bacteria laden sediments, and urban runoff.

Point sources are well below water quality standards. Therefore, point sources of *E. coli* make up such a small percent of the total load that further reductions would not significantly improve water quality.

CSOs are a known source of *E. coli* and play a major role in the water quality impairment when they occur. However, The TMDL has not been designed to address CSO contribution to the Little Calumet River-Burns Harbor waterway. The CSO Long Term Control Plan (LTCP) and NPDES permit are designed to address any contribution from these types of discharges that would cause or contribute to the *E. coli* impairment. Therefore, it is unnecessary for the TMDL to also address these types of discharges more specifically. The TMDL is allowing the CSO LTCP to be developed and address these so that they no longer contribute to the *E. coli* impairment. If after the CSO LTCP is in place and they are still causing or contributing to the *E. coli* impairment, then the TMDL would more specifically address there contributions as a source of *E. coli*.

1.9 Purpose

The Little Calumet and Portage Burns Waterway has been identified through the 303 (d) listing process as being impaired for *E. coli* by the Indiana Department of Environmental Management (IDEM). The purpose of this report is to establish the *E. coli* TMDL for point and nonpoint pollutant loads, with a margin of safety, that will allow the waterbody to meet water quality standards for *E. coli*.

2. TMDL ENDPOINT AND WATER QUALITY ASSISSMENT

2.1 Selection of Modeling Endpoints

Numeric endpoints represent the water quality goals that are to be achieved in order to meet the both part of the water quality standards (i.e. the geometric mean and the maximum daily concentration). For the Little Calumet River and Portage Burns Waterway TMDL, the applicable endpoint is Indiana's water quality standard for state waters within the Great Lakes System (327 IAC 2-1.5-8), which restricts the geometric mean for *E. coli* to 125 cfu/100mL. This endpoint was selected because it represents the long-term average that we hope to achieve by the implementation of this TMDL. However, it is recognized that extreme events will occur from time to time.

2.2 Selecting Endpoints for CSOs

Communities with CSOs are developing LTCP to minimize impacts to water quality. The CSO LTCP and NPDES permit are designed to address any contribution from these types of discharges that would cause or contribute to the *E. coli* impairment. Therefore, it is unnecessary for the TMDL to set endpoints. If, after the CSO LTCP is in place, it is determined that CSOs are still causing or contributing to the *E. coli* impairment, the TMDL will be modified to more specifically address there contributions as a source of *E. coli*.

2.3 Selection of Critical Condition

Many TMDLs are designed around the concept of a "critical condition", such as a low flow condition that would minimize dilution of a continuous pollutant source. This approach assumes that if controls can achieve the established water quality goals under the "critical condition" then water quality conditions will be achieved for all other conditions. However, *E. coli* sources in the Little Calumet River and Portage Burns Waterway watershed arise from a mixture of point and nonpoint sources under both wet- and dry-weather conditions. Therefore, there is no single "critical condition" that can be applied and the TMDLs developed here were developed to meet water quality standards under all conditions.

3. SOURCE ASSESSMENT

3.1 Modeling Approach

The Water Quality Analysis Simulation Program, version 6 (WASP6) was used to establish TMDLs for the Little Calumet River and Portage Burns Waterway. The WASP6 is a generalized framework for modeling contaminant fate and transport in surface waters developed by the U.S. EPA. WASP6 is based on the flexible compartment modeling approach. WASP6 includes DYNHYD, which is a hydrodynamic model. DYNHYD was calibrated to predict water velocities, flows, water heights (heads) and volumes required by WASP6 based on the channel characteristics. Figure 3-1 shows a schematic of junctions/segments of the Little Calumet River and Portage Burns Waterway used in the DYNHYD and WASP6 models.

The models break the watercourse into 15 rectangular boxes (referred to as Junctions) that defines the physical hydrodynamic parameters of each segment of the river. There are an additional four inflow Junction (Junctions 16, 17, 18, 19, and 20), representing tributaries to the Little Calumet and Portage Burns Waterway system, which establish boundary conditions for the WASP6 and DYNHYD5 models. Water elevation in Lake Michigan establishes the final boundary condition for the models. Calibration of the WASP6 and DYNHYD5 models is described in Appendix B and C.

The WASP6 model was used for the simulation of six historical flows and water quality conditions. Two dates reported no rainfall for the previous five days and were considered to represent “Dry” antecedent conditions (July 26, 2000 and August 22, 2000). Two days reported rainfall at least the day of sampling and were consider to represent “Wet” antecedent conditions (June 21, 2000 and July 31, 2000). The remaining two dates were considered average conditions, reporting no more than 0.2-inches of rainfall no sooner than two days prior to the sampling date and no rainfall no later than four days prior to sampling.

Pollutant loads were estimated for each segment. Starting from the most upstream segment and working successively downstream, loads are varied until the predicted concentrations matched the observed data. Known loads associated with point sources discharges were subtracted from the estimated watershed loads to estimate nonpoint pollution loads. Given the magnitude from nonpoint source loads and the land use characteristics of the watershed, more reasonable conclusions can then be made as to the possible allocations from the various potential sources.

Literature reports a wide range of values for the die-off of E. coli. McFeters and Stuart (1972) reported die-off rates for *E. coli* ranging from 0.20 to 0.99 day^{-1}. The simulations assumed an average die-off rate of 0.3 day^{-1} based on research conducted by McFeters and Stuart (1972), and Easton, John, et.al., (1999).

3.2 Summary of Predicted Loads

Table 3-1 summarizes the predicted point and nonpoint loads for each Junction. Because of the limited availability of data and the size of the system being modeled, some discretion was made in the interpretation of the simulated results. In other words, one should use a combination of the predicted results of the WASP6 model along with knowledge of what may be going on in the field to draw conclusions about the cause of the water quality observation.

3.3 Point Sources Contributing to the *E. coli* Impairment

Of the 10 NPDES facilities discharging into segments of the Little Calumet River and Portage Burns Waterway (Appendix D), only four have waste discharge that contains *E. coli.* Estimated bacteria loads from point sources, summarized in Table 3-2, are based on the monthly discharge monitoring reports from 2000 for each facility. Loads are reported as average daily loads for each month.

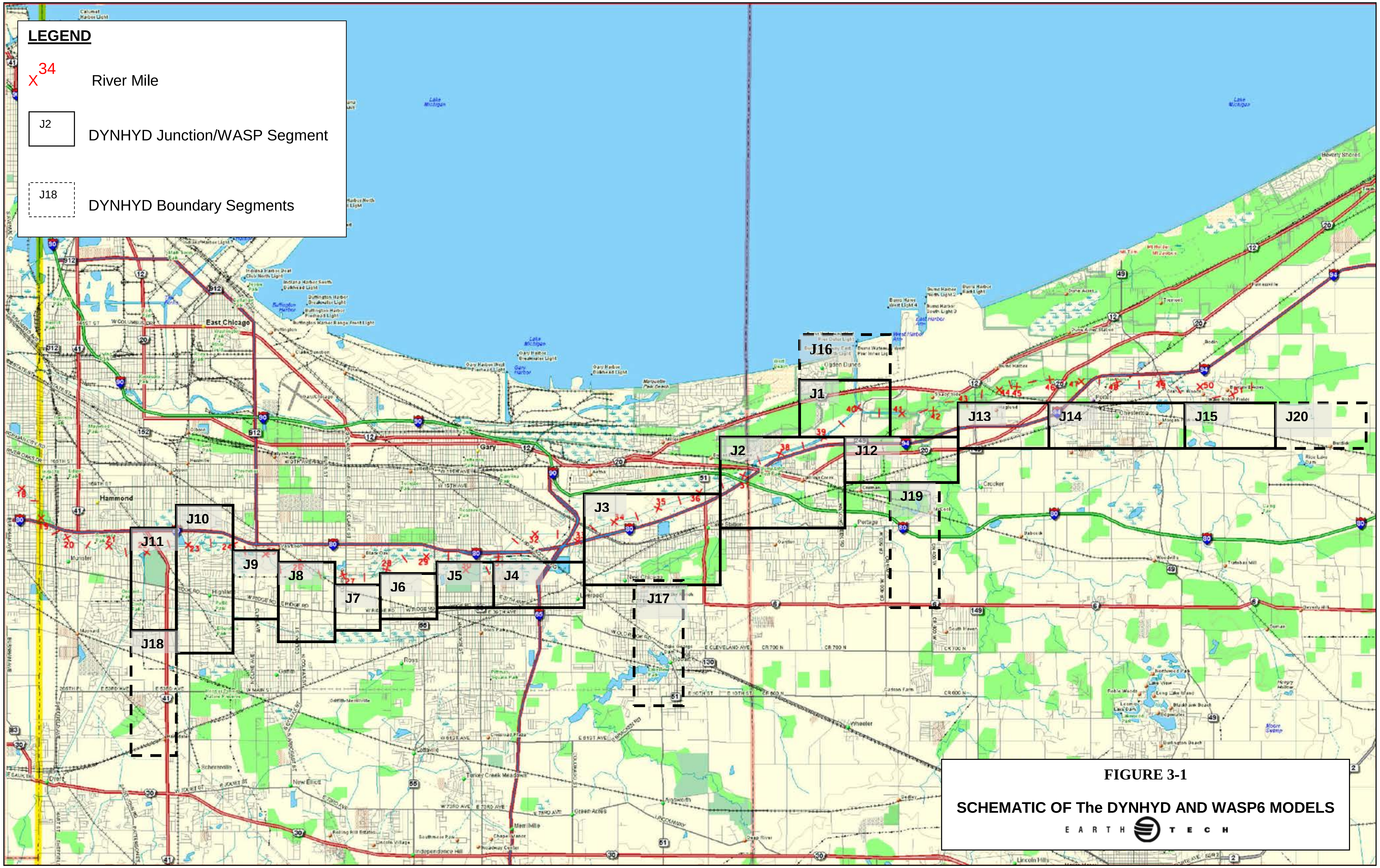


FIGURE 3-1

SCHEMATIC OF The DYNHYD AND WASP6 MODELS

3.3.1 Industrial Point Sources

Only three industrial facilities that discharge into the Little Calumet River and lower reaches of Burns Ditch have discharge limits for bacteria. None of the facilities are currently required to monitor their discharge for *E. coli;* instead, they monitor for fecal coliform. Burns Harbor permit number INU060801 is a municipal WWTP that does not currently contain *E. coli* limits in its permit. Burns Harbor effluent discharges to the Bethlehem Steel effluent pipe. This combined effluent discharges to the Little Calumet River from Outfall 031 of Bethlehem Steel permit number IN0000175. Due to the sanitary component of the Burns Harbor effluent, IDEM will require the addition of *E. coli* limits to permits INU060801 and IN0000175 during the next permit cycle.

The Bethlehem facility (IN0000175) is now owned and operated by ISG and is called ISG Burns Harbor. The ISG Burns Harbor site had an internal outfall for the sanitary treatment plant. This was sold to Burns Harbor, who now holds the operational permit. Any future limits on *E. coli* will apply to the facility now owned by Burns Harbor.

National Steel is now owned and operated by US Steel and is now called US Steel Midwest. The US Steel National Facility has recently applied for a pretreatment permit that would allow the facility to discharge the sanitary waste to the City of Portage. If the sanitary waste has been removed by the time the permit comes up for renewal, the current internal outfall and the corresponding requirements will be removed from the permit.

TABLE 3-1

SUMMARY OF PREDICTED LOADS

Junction	Estimated Loads (cfu/day)						
	5/24/00	6/21/00	7/26/00	7/31/00	8/15/00	8/22/00	Average Load
11	0	1.50×10^{12}	1.50×10^{11}	3.65×10^{11}	9.25×10^{11}	6.00×10^{11}	5.90×10^{11}
10	0	1.50×10^{12}	1.50×10^{11}	3.65×10^{11}	9.25×10^{11}	6.00×10^{11}	5.90×10^{11}
9	0	1.50×10^{12}	1.50×10^{11}	3.65×10^{10}	9.25×10^{11}	6.00×10^{11}	5.90×10^{11}
8	0	5.00×10^{12}	3.00×10^{10}	6.50×10^{10}	0	1.13×10^{11}	4.30×10^{10}
7	0	5.00×10^{10}	3.00×10^{10}	5.00×10^{10}	0	1.00×10^{11}	3.83×10^{10}
6	0	5.00×10^{10}	2.20×10^{10}	2.80×10^{10}	0	6.50×10^{10}	2.75×10^{10}
5	0	5.00×10^{10}	2.9×10^{10}	3.00×10^{10}	0	8.00×10^{10}	3.15×10^{10}
4	0	5.00×10^{10}	2.3×10^{10}	5.20×10^{10}	0	0	2.08×10^{10}
3	1.55×10^{11}	1.20×10^{13}	1.80×10^{11}	6.95×10^{11}	1.42×10^{11}	4.70×10^{10}	2.20×10^{12}
2	0	5.95×10^{13}	0	3.13×10^{11}	0	0	9.97×10^{12}
1	0	5.00×10^{10}	0	3.00×10^{11}	0	0	5.83×10^{10}
12	0	8.50×10^{12}	4.70×10^{10}	1.03×10^{11}	7.50×10^{9}	4.00×10^{10}	1.45×10^{12}
13	1.11×10^{11}	3.00×10^{11}	6.00×10^{9}	9.30×10^{10}	1.85×10^{10}	2.00×10^{10}	9.14×10^{10}
14	2.15×10^{10}	3.00×10^{11}	6.00×10^{9}	1.10×10^{10}	3.75×10^{9}	5.00×10^{9}	5.79×10^{10}
15	0	2.00×10^{10}	2.55×10^{10}	4.20×10^{10}	1.38×10^{10}	1.80×10^{10}	1.99×10^{10}

3.3.2 Municipal Point Sources

There are two permitted municipal wastewater treatment facilities (Chesterton Municipal STP IN0022578 and Portage Municipal STP IN0024368). A third municipal facility, the Town of Porter WWTP (INU046949), discharges to the Chesterton Sewage Treatment Plant (IN0022578).

3.4 Estimating Point Source Loads

Some NPDES permits require the permittee to sample for fecal coliform bacteria and not *E. coli*. This is a common dilemma for researchers. In order to make use of existing data a number of studies have correlated *E. coli* concentrations to fecal coliform concentrations (The Center for Environmental Research and Service, 2000, US EPA Region 10, 2000, LTI, 1999, ODEQ, 2000). Literature concludes that *E. coli* is generally around 80 percent of the fecal coliform concentration. Therefore, point source *E. coli* loads were estimated by multiplying the reported average daily fecal loads for the month by the conversion factor of 0.8.

3.5 Combined Sewer Overflows Contributing to the *E. coli* Impairment

The Town of Chesterton, the City of Hammond, and the City of Gary have CSOs that discharge into the Little Calumet River. The Town of Chesterton has a single CSO that combines with the effluent from their wastewater treatment plant through a single pipe that discharges into 303(d) Number 22 of the Little Calumet River. The City of Hammond has nine CSOs that discharge into 303(d) Number 23 of the Little Calumet River and an additional 11 that discharge to the Grand Calumet River and Schoon Ditch. The City of Gary has six CSOs that discharge to 303(d) Number 24 of the Little Calumet River and 303(d) Number 24 of the Portage Burns Waterway and an additional seven that discharge to the Grand Calumet River.

CSOs are a known source of *E. coli*. Since there are no reported overflows during the dates simulated the contributions from the CSO overflow shall be discussed within this document through literature values and limited observed data. Communities with CSOs, the Cities of Gary and Hammond and the Town of Chesterton, are required to implement nine minimum controls, submit a LTCP and characterize the impact of CSOs on the receiving water. It is through this program that the contributions to the impairment of water quality from CSOs will be addressed. If after the LTCP is in place and it is determined that CSOs are still causing or contributing to the *E. coli* impairment, the TMDL will be modified to more specifically address there contributions as a source of *E. coli*.

3.6 Linking Nonpoint Source Loads

3.6.1 Impervious Area

Changing the natural landscape with the addition of homes, buildings, factories and roadways, increases not only the volume and rate of storm water runoff but also increases the concentration of pollutants contained in the storm water runoff. There is a strong correlation between impervious area in a watershed and bacteria concentrations in the receiving stream (Tufford and Marchall, 2002). To better discuss the impact of land use in the Little Calumet watershed, the watershed was broken into six drainage basins: the Little Calumet River-East 1(LCR-East1), Little Calumet River-East 2 (LCR-East2), Little Calumet River West (LCR-West), Portage Burns Waterway-West (PBW-West), Salt Creek and Deep River (Figure 3-2).

TABLE 3-2

ESTIMATE AVERAGE MONTHLY DAILY POINT SOURCE LOADS (*E. coli*)

Facility Name and ID	5/2000			6/2000			7/2000			8/2000		
	Discharge (mgd)	Concentration (cfu/100 mL)	Load (cfu/day)	Discharge (mgd)	Concentration (cfu/100 mL)	Load (cfu/day)	Discharge (mgd)	Concentration (cu/100 mL)	Load (cfu/day)	Discharge (mgd)	Concentration (cfu/100 mL)	Load (cfu/day)
Bethlehem Steel Corporation IN0000175	0.285	1	8.56×10^6	0.296	1	8.96×10^6	0.298	1	9.04×10^6	0.335	2	2.03×10^7
National Steel, Midwest Division IN0000337	0.171	1	5.18×10^6	0.232	2	1.41×10^7	0.324	2	1.41×10^7	0.327	3	2.98×10^7
Chesterton Municipal STP IN0022578	1.76	1	6.66×10^7	2.18	4	3.30×10^8	1.95	23	1.70×10^9	1.86	36	2.53×10^9
Portage Municipal STP IN0024368	2.69	31	3.16×10^9	3.17	4	4.81×10^8	2.87	4	4.35×10^8	2.88	7	7.64×10^8

Estimates of the percent of impervious area for each of the major drainage basins were based on the existing land use for the watershed (described in Appendix E). The estimated percent cover in LCR-East2 (40%-66%), LCR-West (58%-82%), PBW-West (53%-77%), Salt Creek (46%-71%) and Deep River (63%-86%) range between 40 and 86 percent and between two to four percent for LCR-East. Applying the relationship developed by Tufford and Marchall (2002) for impervious area and fecal coliform bacteria for their South Carolina watersheds, an expected geometric mean for the LCR-East2, LCR-West, PBW-West, Salt Creek and Deep River drainage basin was predicted to be around 500 cfu/100mL and around 300 cfu/100mL for LCR-East 1. This is consistent with the numeric average for *E. coli* concentration calculated for the drainage basins in the Little Calumet watershed (Figure 3-3). The observed data indicates an average *E. coli* concentration exceeds the predicted 500 cfu/100mL for all but the LCR-East 1, which reports an average concentration of around 300 cfu/100mL. While this is by no means a scientific calculation, it does confirm that part of the explanation for observed bacteria concentration in the Little Calumet system can be linked to the amount of impervious area in the watershed.

FIGURE 3-2

DRAINAGE BASINS OF THE LITTLE CALUMET WATERSHED

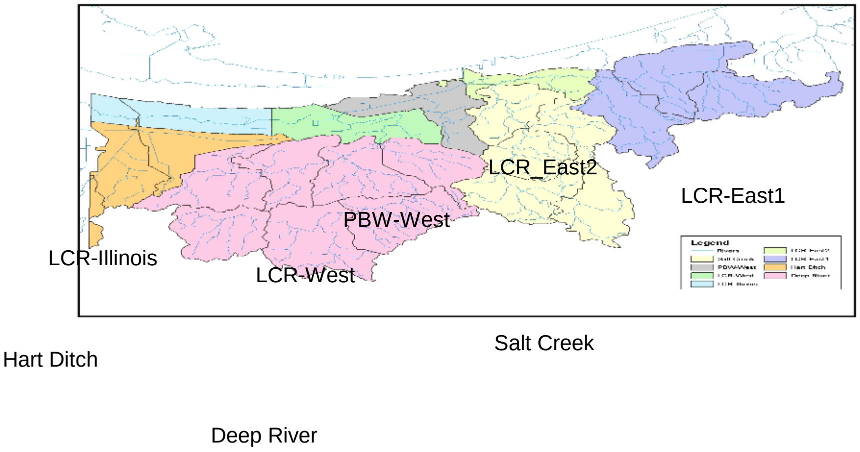
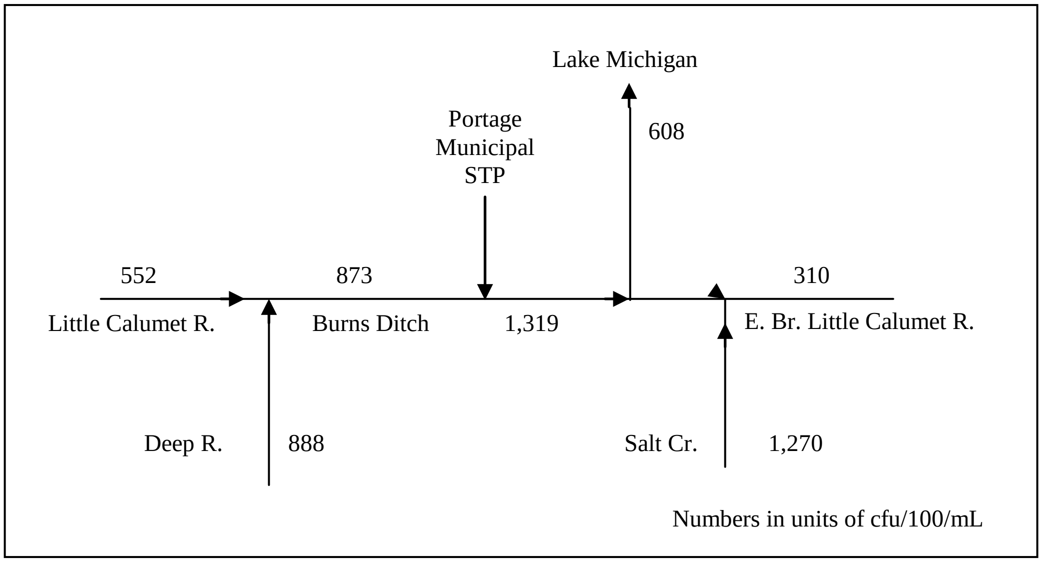


FIGURE 3-3

SCHEMATIC OF NUMERIC AVERAGE *E. COLI* CONCENTRATIONS LITTLE CALUMET – BURNS DITCH DRAINAGE BASINS



3.6.2 Failing Septic Systems

Septic system failure creates the potential of *E. coli* entering water bodies due to incomplete treatment of the waste. No county specific information was available for failure rates of septic system in the Little Calumet watershed. However, literature reports the failure rates to be between 2.5 percent and 18 percent (Johnson and Tuomari, 1998).

It is believed that failing septic tanks may be a major source of impairment in the East Branch of the Little Calumet River (Junction 15) and to some extent in the Black Oak subdivision in Gary (Junction 7). The average estimated nonpoint source load for Junctions 7 and 15 was estimated to be 3.83 x 10^{10} cfu/day and 1.99 x 10^{10} cfu/day, respectively. ODEQ (2001) estimated that failing septic systems could generate a daily load of around 1.516 x 10^{8} cfu/day.

$$1.516 \times 10^{8}\ \text{cfu/day} = (200\ \text{gallons/day})(20{,}000\ \text{cfu/100 mL})(0.00379\ \text{m}^{3}/\text{gallons})(1{,}000\ \text{L/m}^{3})(1{,}000\ \text{mL/L})/(100\text{mL})$$

If it was assumed that 100 percent of the nonpoint source load in Junctions 7 and 15 is effluent from failing septic systems discharging directly into the watercourse, the number of failing systems that it would take to generate that load would be around 200 to 300 systems for the Black Oak Subdivision (Junction 7), and approximately 100 to 150 systems upstream of Chesterton (Junction 15).

It is not likely that there are 200 to 300 failing systems in and around the Black Oak Subdivision. Therefore, there must be another significant source of *E. coli* in that part of the system. It is possible that there could be 150 failing systems in the 64 square mile watershed upstream of Chesterton. That translates to roughly one failing system for every 270 acres. Therefore, failing septic systems are likely not the only source of *E. coli* in the watershed.

3.6.3 Livestock

Discussions with Bill Moran in the Lake County NRCS office and Chuck Walker in the Porter County NRCS office indicated that there is very little livestock in the Little Calumet watershed. However, there are a number of small farming operations and “hobby farms” that graze a few cows and horses. These operations often do not follow Best Management Practice when it comes to manure and pasture management. Table 3-3 summarizes the bacteria production for various types of livestock and the equivalent number of animals that would be required to generate the bacteria loads estimated for Junction 15 (East Branch of the Little Calumet River upstream up Chesterton). Some operations allow cows and horses to graze in the stream. With this type of direct discharge to the system, these small agricultural operations are likely a significant source of impairment, in watersheds where they exist.

TABLE 3-3

BACTERIA LOADING RATES FROM VARIOUS LIVESTOCK (ASAE, 1998)

Animal	Assumed Daily Loading Rate for Fecal Coliform (cfu/animal/day)	Equivalent Animals to Equal Loads Estimated for Junction 15
Dairy Cow	1.01×10^{11}	1
Beef Cow	1.04×10^{11}	1
Hog/Swine	1.08×10^{10}	2
Sheep	1.2×10^{10}	2
Horse	4.2×10^{8}	47
Chicken	1.36×10^{8}	146
Turkey	9.3×10^{7}	213
Dogs	4.09×10^{9}	5

3.6.4 Wildlife

Table 3-4 summarizes the bacteria production for various types of wildlife and the equivalent number of animals that would be required to generate the bacteria loads estimated for Junction 7 (around Clark Avenue) and Junction 15 (East Branch of the Little Calumet River upstream up Chesterton). The estimates assume that a waste are deposited directly into the watercourse and also assumes no die-off. Estimating the actual annual loads to the Little Calumet River from wildlife will require wildlife managers to estimate of the number of animals in the watershed. However, even without an accurate population estimate it appears that wildlife could contribute to *E. coli* impairment.

3.6.5 Sediment

Sediments may become sources of bacteria when they come into contact with fecal material. Accumulated sediments in the channel and floodplain could become contaminated from years of CSOs and storm water discharges. Land application of manure is another way that soils can accumulate high concentrations of bacteria. When these sediments are eroded, the soil particles carry with it the bacteria that it had come into contact with. Bacteria, like *E. coli*, can survive for longer periods of time in sediments than the free-floating bacteria (Thomann, 1987). The fact that the bacteria may be surviving longer that expected by living off of sediment that is being carried by the stream, might explain how *E. coli* concentrations remain high long after it is predicted to have died off (following the first-order decay). Although there is some research that indicates that deposits of sediments with high concentrations of bacteria could potentially continue to be a source of bacteria for a much longer time after a CSO event or the deposition of manure in the stream, the mechanisms involved in the exchange of *E. coli* bacteria from the sediments into the water column are not completely understood. In addition, the data needed to quantify the specific sediment contribution does not currently exist, which should be addressed by future monitoring programs. Therefore, computer models simulating the die-off of *E. coli* bacteria loads, like the WASP6 model that has been developed for the Little Calumet and Portage Burns Waterway, accounts for the contribution of bacteria from sources like sediment in a general lumped category that includes all nonpoint sources of *E. coli*.

TABLE 3-4

BACTERIA LOADING RATES FROM VARIOUS WILDLIFE SPECIES

Source	Animal	Assumed Daily Loading Rate for Fecal Coliform (cfu/animal/day)	Equivalent Animals to Equal Loads Estimated for	
			Junction 7	Junction 15
ASAE (1998)	Goose	4.90×10^{10}	1	1
"	Duck	2.43×10^{9}	16	8
Arnold (2003)	Deer	5.0×10^{10}	1	1
"	Beaver	2.5×10^{8}	153	80
"	Raccoon	1.25×10^{8}	306	159

4. ALLOCATION

4.1 Summary of Predicted Loads

Table 4-1 summarizes the sources of the predicted loads in the watershed. The major source of the bacteria impairment in the Little Calumet – Portage Burns Waterway appears to be nonpoint sources.

TABLE 4-1

POLLUTANT LOAD ALLOCATION
LITTLE CALUMET – PORTAGE BURNS WATERWAY

Junction	TOTAL AVERAGE LOADs (cfu/day)	Estimated Loads from Tributaries (cfu/day)	Percent of Total Load	Estimated Loads from Point Sources (cfu/day)	Percent of Total Load	Estimated Loads from Nonpoint Sources (cfu/day)	Percent of Total Load
11	5.90×10^{11}	5.90×10^{11}	100%			--	--
10	5.90×10^{11}					5.90×10^{11}	100%
9	5.90×10^{11}					5.90×10^{11}	100%
8	4.30×10^{10}					4.30×10^{10}	100%
7	3.83×10^{10}					3.83×10^{10}	100%
6	2.75×10^{10}					2.75×10^{10}	100%
5	3.15×10^{10}					3.15×10^{10}	100%
4	2.08×10^{10}					2.08×10^{10}	100%
3	2.20×10^{12}	1.44×10^{12}	65%			7.60×10^{11}	35%
2	9.97×10^{12}			9.68×10^{8}	<0.01%	9.97×10^{12}	99.9%
1	5.83×10^{10}			1.26×10^{7}	<0.01%	5.83×10^{10}	99.9%
12	1.45×10^{12}	6.90×10^{11}	48%	9.38×10^{7}	<0.01%	7.60×10^{11}	52%
13	9.14×10^{10}					9.14×10^{10}	100%
14	5.79×10^{10}			2.53×10^{9}	4%	5.54×10^{10}	96%
15	1.99×10^{10}					1.99×10^{10}	100%

However, the discharge from the Chesterton facility meets and is well below, water quality standards. Therefore, point sources of *E. coli* make up such a small percent of the total load that further reductions would not significantly improve water quality. CSOs and sanitary sewer overflows (SSOs) are not factored into these calculations, because no discharge events coincided with the dates of the simulated events. Loads for CSOs and SSOs will come from observed values and literature values. In addition to the loads from CSOs and SSOs, nonpoint sources appear to play a major role in the water quality impairment. Nonpoint sources most likely to be contributing to the impairment of water quality include: failing septic systems, unknown illicit discharges of sewage, wildlife, small agriculture operations, bacteria laden sediments and urban runoff.

4.2 Observed CSO *E. coli* Loads

The Gary Sanitary District reported the volume and average concentration (reported as a geometric mean) of *E. coli* for two CSO discharge events (GSD, 2002). The first occurred on September 19, 2001 and the second on April 27, 2002, which carried over to April 28, 2002. Only two of the six CSO outfalls in the Little Calumet watershed reported discharges during these two events, Outfall 004 (at 15th Avenue & Elkhart Street) in Segment J3 and Outfall 005 (at 32nd Avenue & West Broadway Street) in Segment J5. Table 4-2 summaries the observed discharge volumes and concentrations for each event. A daily load was then estimated from these measurements. The volume discharged ranged from 0.12 million gallons to 0.77 million gallons. The estimated daily loads for these events ranged from 9.5×10^{10} to 4.2×10^{12} cfu/day.

TABLE 4-2

ESTIMATED LOADS OF OBSERVED CSO EVENTS

Outfall	Junction/ Segment	Date	Volume (million gallons)	Average *E. coli* Concentration as a geometric mean for the event (cfu/100mL)	Estimated Daily Load for Discharge Event (cfu/day)
4	J3	September 19, 2001	0.12	462,817	3.5×10^{11}
5	J5	September 19, 2001	0.18	622,571	4.2×10^{12}
5	J5	April 27, 2002	0.77	19,282	5.6×10^{11}
5	J5	April 28, 2002	0.13	19,282	9.5×10^{10}

4.3 WASP6 Sensitivity

A sensitivity analysis was performed on the WASP6 model to determine its responsiveness to variations in the pollutant loadings. The upstream limits of the west branch (WASP6 Junctions 9, 10, and 11) were specifically chosen as the focus of the sensitivity analysis because of the scarcity of observed sampling data in that reach. The July 31, 2000 calibrated model was selected as the baseline condition due to the existence of observed data points in Junctions 9 and 5. The pollutant loadings were independently varied in Junctions 9, 10, and 11, and then the model results in Junctions 9 and 5 were compared to the baseline condition.

From the analysis, it was possible to determine that the loads coming upstream of Indianapolis Boulevard in Junction 11 (representing the load coming from Hart Ditch) had little impact on the predicted values downstream of Cline Avenue (in Junction 9). In order to achieve a five percent change in the predicted value at Cline Avenue, it was necessary to increase the load entering from Hart Ditch by over 200 percent.

Varying the loads entering around Kennedy Avenue (in Junction 10) had slightly more impact on the predicted values at Cline Avenue (Junction 9), but had negligible effects on predicted values downstream of Broadway (Junction 5). To achieve a five percent increase in the predicted *E. coli* concentration at Broadway, the load in Junction 10 had to be increased by almost 400 percent.

Changing the load entering around Cline Avenue (in Junction 9) by as much as 300 percent resulted in a predicted increase in the *E. coli* concentration of only 1.4 percent at the confluence with Deep River (Junction 3).

These results suggest that *E. Coli* loads entering the system upstream of river mile-24.7 (Cline Avenue) have limited impact on the E. coli concentrations observed downstream of I-65 and downstream of the confluence with Deep River. The results of this analysis indicate that though there is uncertainty as to the loads entering the system upstream of I-65, that uncertainty has little effect on the predicted values in the reaches downstream of Deep River.

4.4 Travel Time and Pollutant Reduction Goals

Travel time through the Little Calumet – Portage Burns Waterway plays an important role in establishing pollutant reduction goals. It is generally assumed that bacteria (*E. coli*) follow a first-order decay. Therefore, after a travel time of one-day, the number of bacteria declines by as much as 30 to 70 percent (depending on the assumed decay rate) and after two days, the number of bacteria is reduced between 60 to 90 percent. Table 4-3 shows the general travel time from key locations in the watershed to the mouth of the Portage Burns Waterway at Lake Michigan. It suggests that observed water quality violations of *E. coli* bacteria at the confluence of the Portage Burns Waterway and Lake Michigan is not likely caused by pollutant sources upstream of Hart Ditch or the City of Chesterton, but rather more local sources. However, if the *E. coli* bacteria is attached to soil particles that are being transported by the river and not free-floating as is assumed by this analysis, the die-off rates would be less (as discussed in section 3.6.5) and the percent of die-off would be less than that reported in Table 4-3. Since observed *E. coli* concentrations are influenced more by local sources than sources further up in the watershed, the system can be compartmentalized (Table 4-4) within which TMDL pollution reduction goals will be established.

TABLE 4-3

APPROXIMATE TRAVEL TIMES THROUGH RIVER SYSTEM

Location	Travel Time to Lake Michigan (days)	% Die-Off Assuming Chicks Law of First Order of Decay
Hart Ditch	4	100
Deep River	0.5	44
Salt Creek	0.5	44
Chesterton	2	90

TABLE 4-4

TMDL RIVER REACHES

RiverReach Number	Description
1	Hart Ditch Watershed
2	Deep River Watershed
3	Salt Creek Watershed
4	Little Calumet River - Hart Ditch to Grant Street
5	Little Calumet River at Grant Street to Burns Ditch at Deep River
6	Burns Ditch at Deep River to Confluence with East Branch of Little Calumet River
7	Burns Ditch at the Confluence with East Branch to Lake Michigan
8	Confluence with East Branch of Little Calumet River to Salt Creek
9	Little Calumet River at Salt Creek through Chesterton
10	Little Calumet River at Chesterton to N450 E
11	Little Calumet River upstream of N450 E

4.5 Pollutant Reduction Goals

Pollutant loads for each Junction were reduced until the modeling endpoint was met (water quality concentration of 125/100mL). Table 4-5 summarizes the average targeted pollutant loads that would allow the Little Calumet – Portage Burns Waterway to achieve the water quality standard. Table 4-5 also shows the percent reduction in pollutant loads (*E. coli*) that is required to achieve the water quality standard (geometric mean) during runoff events (wet discharge) and during baseflow conditions (dry discharge).

TABLE 4-5

**TARGETED POLLUTANT LOADS
LITTLE CALUMET – PORTAGE BURNS WATERWAY**

Junction	TOTAL AVERAGE LOADs (cfu/day)	Target Load Reduction from Tributaries			Remaining Target Loads from System		
		Average Daily Load (cfu/day)	Percent Reduction from Average Loads		Average Daily Load (cfu/day)	Percent Reduction from Average Loads	
			Wet Discharge	Dry Discharge		Wet Discharge	Dry Discharge
11	5.90×10^{11}	5.79×10^{11}	97%	99%	1.89×10^{10}	96%	96%
10	5.90×10^{11}				3.70×10^{10}	93%	85%
9	5.90×10^{11}				2.11×10^{10}	96%	92%
8	4.30×10^{10}				4.71×10^{9}	89%	91%
7	3.83×10^{10}				3.94×10^{9}	91%	92%
6	2.75×10^{10}				2.66×10^{9}	91%	93%
5	3.15×10^{10}				3.50×10^{9}	88%	95%
4	2.08×10^{10}				5.03×10^{9}	83%	85%
3	2.20×10^{12}	1.39×10^{12}	50%	11%	9.52×10^{10}	95%	46%
2	9.97×10^{12}				2.44×10^{10}	97%	0%
1	5.83×10^{10}				2.27×10^{10}	71%	0%
12	1.45×10^{12}	4.41×10^{11}	27%	12%	6.23×10^{10}	79%	23%
13	9.14×10^{10}				5.24×10^{9}	97%	38%
14	5.79×10^{10}				5.28×10^{9}	82%	44%
15	1.99×10^{10}				2.02×10^{10}	0%	41%

4.6 Combined Sewer Overflows

E. coli impairs water quality in the Little Calumet and Portage Burns Waterway even without the impact of CSOs. To establish an allocation for CSOs the maximum daily concentration (235 cfu/100mL) was set as the water quality target (Table 4-6). The difference between the targeted pollutant loads in Table 4-5 and the targeted pollutant loads in Table 4-6 represents the allowable pollutant allocation for CSOs. However, it will be the LTCPs, which are currently under review by IDEM and the US EPA, that will establish the actual water quality target for CSOs.

TABLE 4-6

TARGETED SINGLE DAY POLLUTANT LOADS LITTLE CALUMET – PORTAGE BURNS WATERWAY

Junction/ Segment	Total Average Loads (cfu/day)	Estimated Average Day (125 cfu/100mL) Target Loads (cfu/day)	Estimated Maximum Day (235 cfu/100mL) Target Loads (cfu/day)	Maximum Allowable Loads per Event (cfu/day)
11	5.90 x 10^{11}	1.89 x 10^{10}	Not Applicable Same as Average Day Target Loads (NA)	
10	5.90 x 10^{11}	3.70 x 10^{10}	NA	
9	5.90 x 10^{11}	2.11 x 10^{10}	NA	
8	4.30 x 10^{10}	4.71 x 10^{9}	NA	
7	3.83 x 10^{10}	3.94 x 10^{9}	1.72 x 10^{10}	1.33 x 10^{10}
6	2.75 x 10^{10}	2.66 x 10^{9}	NA	
5	3.15 x 10^{10}	3.50 x 10^{9}	8.05 x 10^{9}	4.55 x 10^{9}
4	2.08 x 10^{10}	5.03 x 10^{9}	9.37 x 10^{9}	4.32 x 10^{9}
3	2.20 x 10^{12}	9.52 x 10^{10}	1.79 x 10^{11}	8.35 x 10^{10}
2	9.97 x 10^{12}	2.44 x 10^{10}	NA	
1	5.83 x 10^{10}	2.27 x 10^{10}	NA	
12	1.45 x 10^{12}	6.23 x 10^{10}	NA	
13	9.14 x 10^{10}	5.24 x 10^{9}	NA	
14	5.79 x 10^{10}	5.28 x 10^{9}	NA	
15	1.99 x 10^{10}	2.02 x 10^{10}	NA	

NA: higher loads computed for only Junctions/Segments with CSOs

The Gary Sanitary District's CSOs are located in Junction 7 (CSO – 003, at 27th Avenue & Old Chase Street), Junction 5 (CSOs – 005, at 32nd Avenue & West Broadway Street and 015, at 32nd Broadway and Alley 1 East), Junction 4 (CSOs 013, at 25th Avenue and Louisiana Street and 014, at 25th Avenue and Wisconsin Street) and Junction 3 (CSO 4, 15th Avenue & Elkhart Street). Table 4-6 shows the additional loads that could be added to Junctions 3, 4, 5, and 7 (under the same hydrologic conditions) to bring the *E. coli* concentration in those reaches to allowable maximum daily concentration of 235 cfu/100mL. Junction 7 shows the greatest ability for assimilation additional loads. The increase in the theoretical loading represents the potential allocation that could be assigned to the Gary Sanitary District's CSOs under these hydrologic conditions. The maximum allowable load for each discharge (CSO) event makes up about one half of the total loads that would meet the maximum daily water quality standard or 235 cfu/100mL.

Table 4-7 indicates that the additional allocation varies with stream flow. Higher flow rates have higher assimilative capacity. The model indicated that the impact of these additional loads would have minor impact on the water quality of downstream reaches, increasing the *E. coli* concentration by only a few percentages.

TABLE 4-7

MAXIMUM ALLOWABLE CSO POLLUTANT LOADS

	Stream Flow (cubic meters per second)	Junction (cfu/day)		
		4	5	7
May 24, 2000	0.28	3.10×10^9	3.90×10^9	6.00×10^9
June 21, 2000	4.67	1.08×10^{10}	8.50×10^9	5.00×10^{10}
July 26, 2000	0.20	3.15×10^9	3.47×10^9	5.03×10^9
July 31, 2000	0.54	3.55×10^9	4.55×10^9	8.73×10^9
August 15, 2000	0.23	2.85×10^9	3.65×10^9	5.40×10^9
August 22, 2000	0.14	2.59×10^9	3.24×10^9	4.37×10^9

5. TMDL DEVELOPMENT

Table 5-1 summarizes the pollutant reduction needed to achieve water quality standards for *E. coli*.

5.1 Waste Load Allocation (WLA)

A review of the monthly discharge reports between 1997 and 2002 indicated that point sources in the Little Calumet – Portage Burns Waterway are complying with their permit limits for *E. coli*. In addition, point sources in the study area make up such a small percent of the total load that it is assumed that point sources will not be required to make any further reductions.

CSOs in Gary and Chesterton are in compliance with the limits of their operating permits (Hammond's CSOs do not enter into the impaired segments of this investigation). Communities with CSOs are required under the National Combined Sewer Overflow (CSO) Control Policy to implement "nine minimum controls," submit a LTCP and characterize the impact of CSOs on the receiving water. The Gary Sanitary District and the Hammond Sanitary District are in the process of preparing their LTCPs and the implementation of the nine minimum controls. The TMDL has not been designed to address CSO contribution to the Little Calumet River-Burns Harbor waterway. The CSO Long Term Control Plan (LTCP) and NPDES permit are designed to address any contribution from these types of discharges that would cause or contribute to the *E. coli* impairment. Therefore, it is unnecessary for the TMDL to also address these types of discharges more specifically. Recommendations for reducing the WLA attributed from CSOs will come from the LTCP. If after the CSO LTCP is in place and it is determined that CSOs are still causing or contributing to the *E. coli* impairment, the TMDL will be modified to more specifically address there contributions as a source of *E. coli*.

5.2 Load Allocation (LA)

Analysis of pollutant loads indicates that nonpoint source pollution is the dominant cause of the water quality impairment. Therefore, the TMDL will be based on the LA. In the more developed western portion of the watershed (River Reaches 4–6 in Table 5-1) the estimated loads under wet conditions were not that much different from those estimated for dryer conditions. Therefore, the load reduction during wet and dry conditions appears to be similar. However, in the less developed eastern portion of the watershed (River Reaches 8-11 in Table 5-1) the pollutant loads estimated in Table 3-1 were greater during the simulated "wet" events (June 21 and July 31, 2000) than dry conditions (July 26 and August 22, 2000). The difference in water quality conditions between the two branches can be attributed to the difference in nonpoint pollution sources (Table 5-2) and will require different remediation strategies.

5.3 Combined Sewer Overflows Allocations

Water quality modeling suggests that a waste load allocation could be developed for the Gary Sanitary District's CSOs. Junction 7 shows a greater ability for assimilation than either Junctions 4 or 5. The allocation would be roughly double the LA for those river reaches with CSOs. At that level, the *E. coli* concentration would not exceed the maximum daily standard of 235 cfu/100mL. The analysis also indicated that the additional allocation could be varied with stream flow. For an example, the assimilative capacity of Junction 7 was ten times greater ($5.00 \text{ x } 10^{10}$ versus $4.37\text{x } 10^{9}$ cfu/day) at the higher simulated flow rate ($4.56 \text{ m}^3/\text{s}$ – 165 cfs) than that at the lower flow rate ($0.14 \text{ m}^3/\text{s}$ – 5 cfs).

TABLE 5-1

POLLUTANT LOAD REDUCTION
LITTLE CALUMET – PORTAGE BURNS WATERWAY

River Reach	Model Junction/Segment	Description	WLA	LA (wet)	LA (dry)	MOS
1	J18	Hart Ditch Watershed	0%	95%	80%	1%
2	J17	Deep River Watershed	0%	95%	80%	1%
3	J19	Salt Creek Watershed	0%	80%	30%	1%
4	J11 – J5	Little Calumet River - Hart Ditch to Grant Street	0%	92%	92%	1%
5	J4 – J3	Little Calumet River at Grant Street to Burns Ditch at Deep River	0%	84%	84%	1%
6	J2	Burns Ditch at Deep River to Confluence with East Branch of Little Calumet River	0%	70%	70%	1%
7	J1	Burns Ditch at the Confluence with East Branch to Lake Michigan	0%	70%	70%	6%
8	J12	Confluence with East Branch of Little Calumet River to Salt Creek	0%	46%	46%	6%
9	J13 – J14	Little Calumet River at Salt Creek through Chesterton	0%	97%	50%	6%
10	J15	Little Calumet River at Chesterton to N450 E	0%	81%	59%	6%
11	J20	Little Calumet River upstream of N450 E	0%	70%	34%	6%

TABLE 5-2

NONPOINT POLLUTANT SOURCES OF *E. COLI*

West Branch Little Calumet River/ Burns Portage Waterway	East Branch Little Calumet River
Urban Nonpoint	Urban Nonpoint
Illicit Discharges	Failing Septic Systems
Bacteria Laden Sediments	Agriculture Practices (hobby farms)
Wildlife	Wildlife

Impairment of water quality from CSOs will be addressed through the CSO LTCP program. The Wet Weather Group and the US EPA will set limits for CSO communities through the planning and implementation of the LTCP. Since the assimilative capacity of the river changes from reach to reach and increases as the flow in the river increases, limits could be developed based on flow conditions for each river reach at the time of the COS event.

5.4 Margin of Safety (MOS)

TMDLs must include a margin of safety (MOS). The MOS is the additional reduction in pollutant loads to account for the uncertainties in the calculation of the TMDL. The calibration and verification of the computer models minimized the uncertainties of the calculated loads and load reductions of the TMDL and to minimize the size of the estimated numeric value of the MOS. For this TMDL the numeric value of the MOS was estimated to be one percent for the west branch of the Little Calumet River and Burns Ditch and six percent for the East Branch of the Little Calumet River and the outfall to Lake Michigan.

The calibration and verification of the computer models (described in Appendix C and Appendix D) was conducted to reduce the uncertainties of the models. Accurately characterizing the rate that *E. coli* dies off was key in accurately estimating pollutant loads. This is a function of the assumed die-off rate used in the WASP6 model and the time that it takes bacteria to travel though the system, estimated by the DYNHYD model.

The predictive capability of the calibrated DYNHYD model to estimate the hydraulics of the system was verified with two flow conditions (April 9, 2000, 19.1 m^3/s and July 26, 2000, 6.7 m^3/s). Each run had a mean square error of less than one tenth of one percent. This shifts the uncertainty of the analysis to the selected die-off rate of *E. coli*. The reasonableness of the calibrated and verified die-off rate (0.3 day^{-1}) was further tested by the sensitivity analysis that varied the die-off rate.

The numeric MOS was established based on the water quality standard. The standard allows a maximum daily concentration of 235 cfu/100mL, but limits the geometric mean of five samples taken over a 30-day period to 125 cfu/100mL. Therefore, if one of the five samples is assumed to be 235 cfu/100mL, the remaining four samples would have to average 107 cfu/100mL.

Therefore, the MOS was defined by the additional reduction in pollutant loads that would be required to reduce the water quality target from 125 cfu/100mL to 107 cfu/100mL. In the west branch of the Little Calumet River and Burns Ditch, the additional reduction in pollutant load is estimated to be one percent. In the East Branch of the Little Calumet River and the outfall to Lake Michigan, the level of pollutant reduction is estimated to be six percent.

Greater urbanization in the west branch resulted in a smaller difference between the two water quality targets. It represents a greater certainty that the sources of *E. coli* are known and can be attributed to illicit discharges, stormwater runoff and CSOs/SSOs. Most of the sources are regulated and will be addressed through programs such as the NPDES stormwater permit or the wet weather program and LTCP for CSOs.

The sources of *E. coli* in the more rural east branch are less understood. Therefore, a greater MOS is required. Failing septic systems and inadequate agriculture practices are two of the most likely sources of the *E. coli* impairment. However, their relative contributions are unknown, as are the contributions of other sources such as wildlife. There are few programs to correct these deficiencies. Therefore, because of the uncertainty of the sources and the ability to control them a higher MOS was used.

6. REASONABLE ASSURANCE

Reasonable assurance that the goals of the TMDL will be achieved will be based on 1) the identification of a responsible party that will be held responsible to follow through on the recommendations and 2) adequate funding at the federal, state, and local levels to assure staff, programs, and grants are available to landowners. Programs such as the CSO LTCP and the NPDES storm water permitting programs will reduce the impact of CSOs and storm water in the watershed. Continuation of the existing water quality monitoring programs by IDEM and others will provide continuity and a baseline for which water quality trends may be documented to show whether programs and projects are effective. Should future monitoring fail to show improvement in water quality the implementation plan will be modified.

6.1 Ongoing Investigations

The Northwest Indiana Regional Planning Commission (NIRPC) is in the process of developing a watershed management plan (WMP) for the Little Cal-Galien watershed, HUC 04040001, and the portion of the Kankakee watershed 0712001 that lies within Lake, Porter and Laporte counties. This plan will be complete in September 2005. A WMP for Coffee Creek watershed was completed in April 2003. They are currently implementing the plan under Great Lakes Coastal Grant. Other watershed projects in the Little Calumet-Galien watershed (but in different sub-watersheds) include Dunes Creek, and Trail Creek.

6.2 Financial Assistance

The US EPA has compiled a useful website to help identify funding sources for watershed protection. It is:

http://www.epa.gov/efinpage or http://cfpub.epa.gov/fedfund/

An initial query of the website identified over 40 different grant programs to assist with watershed management, nonpoint source control, storm water management, and best management practices.

6.3 Technical Assistance

There are a number of agencies that can assist with the securing of financial assistance and the implementation of designs, management plans, and drafting of ordinances. IDEM's watershed program has a number of specialists and watershed managers who can advise local governments on the implementation of the TMDL. IDNR has resource specialists who can provide assistance through their lake and river enhancement program, erosion control program, forestry, and wildlife biologists. In addition, each county has a Soil and Water Conservation District that is supported by the USDA NRCS Distinct Conservationist, who may have technicians, conservation planners, and engineers who could provide technical assistance and educate elected officials, the general public, and private land owners on watershed and water quality management issues and programs.

7. FUTURE MONITORING

There is still uncertainty as to the magnitude that various nonpoint sources of *E. coli* play in the impairment of the Little Calumet and Portage Burns Waterway. Therefore, an adaptive management approach is proposed to be taken in implementing the recommendations that are to address the water quality concerns for Little Calumet and Portage Burns Waterway. Key to this approach to watershed management is the feedback the managers will receive from continued water quality monitoring. Some improvements and modifications to the monitoring network should be considered and are described in this section.

There are a number of monitoring networks currently in the Little Calumet and Portage Burns Watershed. There are inconsistencies with the frequency and the seasonal operation of these networks. This has resulted in an abundance of data in some places and very limited data in others. Some sampling sites are duplications. Therefore, a reprioritization of sites as well as a coordination of sampling (time and frequency), should be undertaken. It is recognized that some of this is currently reflected in the existing monitoring programs. However, with the need to gather additional and specific data as part of the implantation of the TMDL, a full review of the programs should be undertaken.

Areas that need further investigation:

- Septic System Inventory
- Bacteria Contribution from Sediments
- Regrowth of Bacteria
- Contribution from Wildlife
- Specific Site Investigation

In addition, there are portions of the watercourse that have very little if any information. This is specifically true of the Little Calumet River upstream of Chesterton and upstream of Deep River. The current body of data clearly indicates that the system is impaired *by E. coli*. The indication is that the source of this impairment is from nonpoint sources. CSOs do contribute to water quality violations. However, the water quality standards were often violated before the overflow events occurred. What is not as well documented is how the system responds to pollutant loads entering the system. Therefore, it is recommended that the monitoring network become more diagnostic and focus on identification of unaccounted pollutant sources and the die-off/regrowth of the bacteria once it enters the system.

IDEM should develop an integrate water quality monitoring program that coordinates the collection of water quality samples of other stakeholders, such as the Interagency Task Force. Sampling priorities should be established to achieve two general objectives. The first objective is to track water quality trends. It is assumed that the trend would indicate an improvement in water quality as BMPs and put into place in the watershed. The second objective is to conduct further investigations that will diagnose the source and magnitude *E. coli* from nonpoint sources (septic system inventory, bacteria contribution from sediments, regrowth of bacteria, contribution from wildlife, specific site investigation). The integrated program would adjust the frequency at which sampling would occur at key locations. The diagnostic monitoring might require adjusting both the location and frequency of the sampling.

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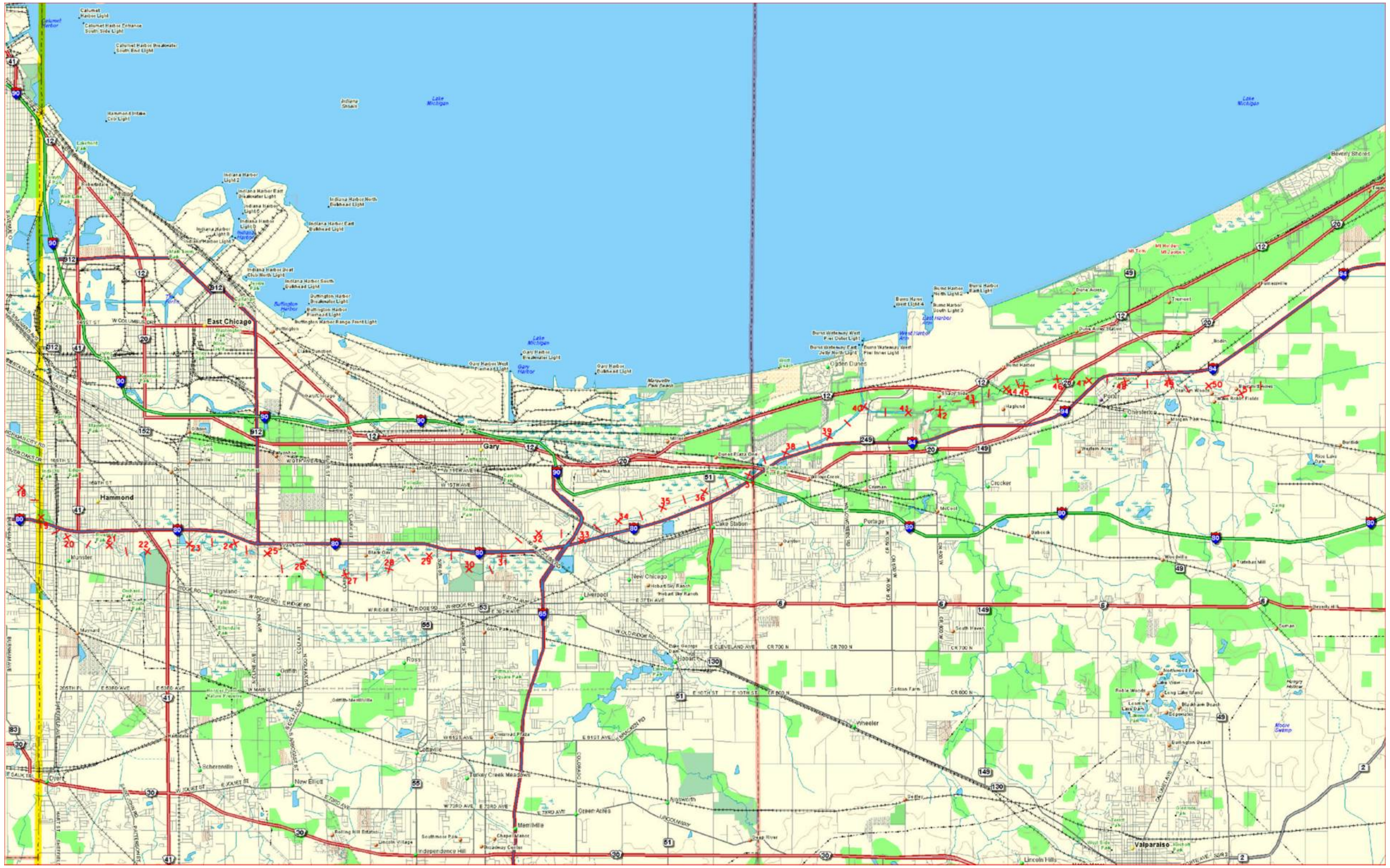
APPENDIX A

River Miles for the Little Calumet River and Portage Burns Waterway System

APPENDIX A
RIVER MILES FOR THE LITTLE CALUMET RIVER AND PORTAGE BURNS WATERWAY SYSTEM



APPENDIX B - DYNHYD CALIBRATION

B.1 DYNHYD Setup

The die-off of bacteria is primarily a function of travel time through the river system. However, WASP's simplistic approach to routing flows requires only the volume of water and a flow rate between each segment of the model. Therefore, it was important to accurately define these variables. DYNHYD solves one-dimensional equations describing the propagation of a long wave through a shallow water system while conserving both momentum (energy) and volume (mass). The conservation of momentum, predicts water velocities and flows and conservation of volume, predicts water heights (heads) and volumes. Data required of DYNHYD is organized into four data input groups: Junctions, Channels, Inflows and Boundary Conditions.

Junctions are storage nodes that track the mass balance of water within each river segment. Parameters include: initial water surface elevation, surface area, bottom elevation, and channels entering and leaving the junction.

Channels route water between segments. Parameters include: length, width, cross-sectional area, roughness coefficient, initial velocity, initial hydraulic radius (or depth), and Junctions connecting to the channel.

Inflows describe flow into or out of the system. Flow into the system is represented by negative values whereas positive values represent flow out of the system (Figure B-1). Input tables of time versus inflow were obtained from the USGS gaging stations for each tributary in the DYNHYD model.

The boundary conditions were based on the variable water surface elevations obtained from the USGS gaging stations. The variable inflows were added at five (5) boundary segments within the system: Segments 16, 17, 18, 19, and 20.

B.2 DYNHYD Inflow Estimation

Inflow tables were created from the USGS gauging stations for each boundary Segment (16, 17, 18, 19, and 20).

Segment 16 - Outflow to Lake Michigan: is based on the USGS gage on Burns Ditch at Portage (gage# 04095090).

Segment 17 – Deep River: is based on the USGS Burns Ditch gage at Gary (gage# 04093500) and predicted inflows from the Willow Creek watershed. Flows from the Willow Creek watershed were estimated using the ratio of the drainage areas from the Little Calumet River at Porter (gage# 04094000).

Burns Ditch at Gary = 1.25* [Deep River at Lake George outlet at Hobart] + 11.67

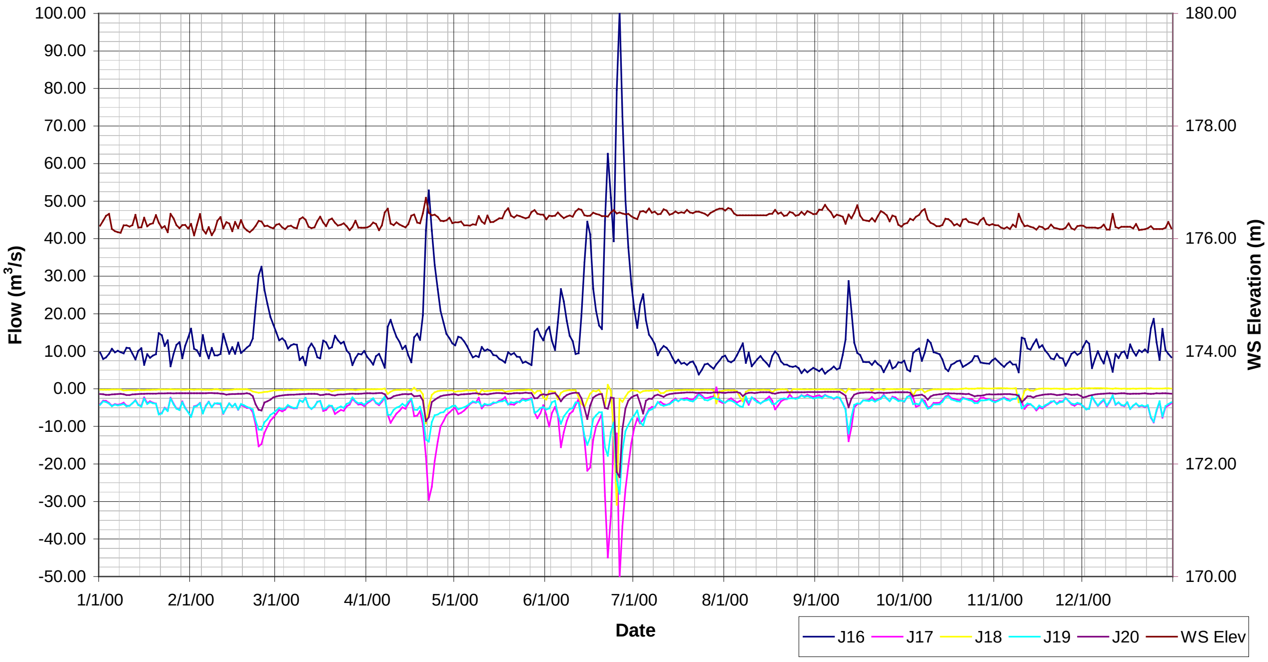
Segment 18 – Hart Ditch: is based on the USGS Hart Ditch gage at Munster (gage# 05536190) and the Little Calumet River gage at Munster (05536195). In the majority of days during 2000, flows from Hart Ditch exceeded the flows measured at the Little Calumet River gage (05536195). Therefore, flows from Hart Ditch were estimated from the difference between the Hart Ditch and the Little Calumet River gages.

Segment 19 – Salt Creek: 2000 flows were estimated from the correlation of flows (WHPA, 2003) between 1945 and 1991 from Little Calumet River at Porter (gage# 04094000) and the Salt Creek gage near McCool (gage# 04094500). The equation derived from the correlation of flows is:

Salt Creek Flows = 0.92* [LCR @ Porter] + 9.16

FIGURE B-1

DYNHYD FLOW AND BOUNDARY CONDITIONS
(For the year 2000)



Segment 20 – East Branch: was based on the USGS gage on the Little Calumet River at Porter (gage# 04094000).

The difference between flows from the outfall of Burns Ditch at Portage (gage# 04095090) and the sum of all other inflows were assumed to enter the system evenly between the computed inflows and the observed outflows as "lateral flow". Therefore, lateral flow was equally distributed among Segments J1, J2, J3, J12, and J13 based on the length of channel within each junction.

B.3 DYNHYD Calibration

DYNHYD was calibrated to match the hydraulic profile estimated by the HEC-2 and UNET models for the average daily flows for the calendar year 2000. Average daily flows were estimated for each of the four inflow points and the one outflow using the reported stream gage information (Table B-1). The boundary conditions were based on the average water surface elevations for the entire year of 2000 reported by the USGS gage station at the mouth of Burns Ditch.

TABLE B-1

FLOWS USED FOR CALIBRATION AND VERIFICATION

Description	Date	Flow Junction 16 Lake Michigan (m^3/s)	Flow Junction 17 Deep River (m^3/s)	Flow Junction 18 Hart Ditch (m^3/s)	Flow Junction 19 Salt Creek (m^3/s)	Flow Junction 20 E. Branch Little Calumet (m^3/s)	Downstream Water Surface Elevation (m)
Calibration	Average Annual Flows 2000	12.16	-5.37	-0.52	-4.59	-1.68	176.10
Verification Event 1	April 9, 2000	19.10	-9.02	-0.74	-6.88	-2.46	176.30
Verification Event 2	July 26, 2000	6.66	-2.40	-0.20	-3.04	-1.02	176.40

(negative values represent flows entering system and positive values represent flows leaving the system)

B.3.1 Calibration Parameters

Junctions (Table B-2) and Channel (Table B-3) parameters were calibrated to data from the FIS models (1981 and 1982) and the US Army Corps of Engineer's, West Reach Levee System UNET model (1995). Roughness coefficients were adjusted as needed for each channel until DYNHYD water surface elevation for each junction matched water surface profiles from HEC-RAS FIS models and UNET models. The DYNHYD User Manual recommends that the roughness coefficient be used a 'knob' for the calibration of the model, because all other input variables that would affect the water surface profile relate directly to the geometry of the stream and can therefore be measured directly.

TABLE B-2

DYNHYD CALIBRATED JUNCTION PARAMETERS

Junction	River Mile	Initial Water Surface Elevation (m)	Surface Area (m^2)	Bottom Elevation (m)	Channels Entering/ Leaving Junction		
11	22.54	180.0	74,392	178.8	10	17	
10	23.74	180.0	129,499	176.7	9	10	
9	24.92	179.9	86,942	177.2	8	9	
8	26.32	179.9	57,063	179.1	7	8	
7	27.68	179.9	40,823	178.9	6	7	
6	28.96	180.0	34,337	179.1	5	6	
5	30.73	179.6	46,912	179.0	4	5	
4	32.51	178.5	50,318	177.5	3	4	
3	35.25	177.4	116,460	175.8	2	3	16
2	38.64	176.1	143,312	175.1	1	2	
1	40.00	176.2	103,122	173.9	1	11	15
12	41.71	178.9	93,904	177.9	11	12	18
13	44.82	183.9	96,330	183.5	12	13	
14	47.71	186.9	76,328	185.8	13	14	
15	49.75	189.2	56,543	188.8	14	19	
16	L. Mich.	176.1	103,122	173.0	15		
17	Deep R.	178.5	50,318	177.5	16		
18	Hart D.	180.0	74,392	179.0	17		
19	Salt Cr.	183.9	84,191	183.5	18		
20	East Br.	192.0	56,543	191.5	19		

TABLE B-2

DYNHYD CALIBRATED CHANNEL PARAMETERS

Channel	Length (m)	Width (m)	Initial Hydraulic Radius (Depth) (m)	Roughness Coefficient (sec/m$^{1/3}$)	Initial Velocity (m/s)	Down-stream Junction	Up-stream Junction
10	2,038	64.6	1.37	0.050	0.006	10	11
9	2,141	56.1	2.83	0.050	0.003	9	10
8	2,144	25.3	0.52	0.050	0.043	8	9
7	2,131	27.7	0.58	0.060	0.034	7	8
6	2,335	11.0	0.40	0.055	0.110	6	7
5	2,883	15.8	0.30	0.100	0.122	5	6
4	3,222	13.4	0.43	0.200	0.098	4	5
3	4,200	10.0	0.43	0.200	0.213	3	4
2	5,194	27.4	0.88	0.130	0.232	2	3
1	3,740	27.4	0.88	0.150	0.232	1	2
11	3,653	16.5	0.37	0.200	0.305	11	12
12	5,095	14.0	0.82	0.200	0.107	12	13
13	5,151	16.8	0.11	0.150	0.101	13	14
14	5,055	12.8	0.11	0.100	0.049	14	15
15	3,740	27.4	1.00	0.040	0.232	1	16
16	4,200	17.7	1.43	0.040	0.213	3	17
17	2,038	64.6	1.37	0.040	0.006	11	18
18	5,095	14.0	0.82	0.040	0.107	12	19
19	5,055	12.8	0.11	0.040	0.049	15	20

B.3.2 DYNHYD Calibration Results

Figure B-2 shows the results calibration of the DYNHYD model. The green squares represent the invert of the channel (BELEV(J)). The blue triangles define the hydraulic profile from the HEC-RAS model and the red circles are the hydraulic profiles for the DYNHYD. The mean square error for the DYNHYD versus the HEC-RAS is less than one tenth of one percent indicating that the model is well calibrated.

B.4 DYNHYD Verification Results

The DYNHYD model was also run for two verification runs. The April 9, 2000 represented a higher flow (19.1 m^3/sec) condition and the other, July 26, 2000, represented a lower flow (6.7 m^3/sec) event. Boundary Conditions were again obtained from the USGS gage stations. Figure B-3 and Figure B-4 compare the water surface elevations estimated by DYNHYD to those estimated by HEC-RAS. Each run has a mean square error of less than one tenth of one percent. Channel geometry dictated that in the upper reaches of the east and west branches that the water surfaces between the two flow conditions differed by about 0.1 m. However, closer to the confluence of the east and west branch the difference was as much as 1.0 m. Profiles for both events were influenced by the surface water elevation of Lake Michigan, which did not vary more than 0.1 m between the two events.

FIGURE B-2

DYNHYD CALIBRATION WATER SURFACE PROFILES

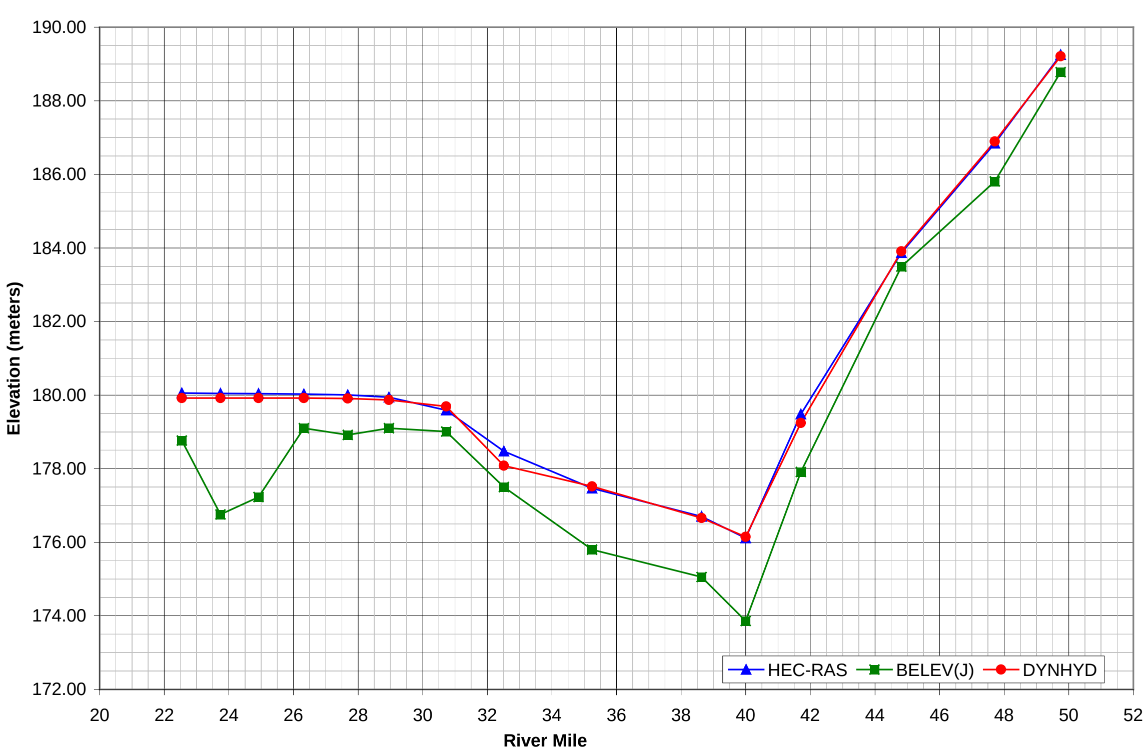


FIGURE B-3

DYNHYD VERIFICATION HYDRAULIC PROFILE
APRIL 9, 2000

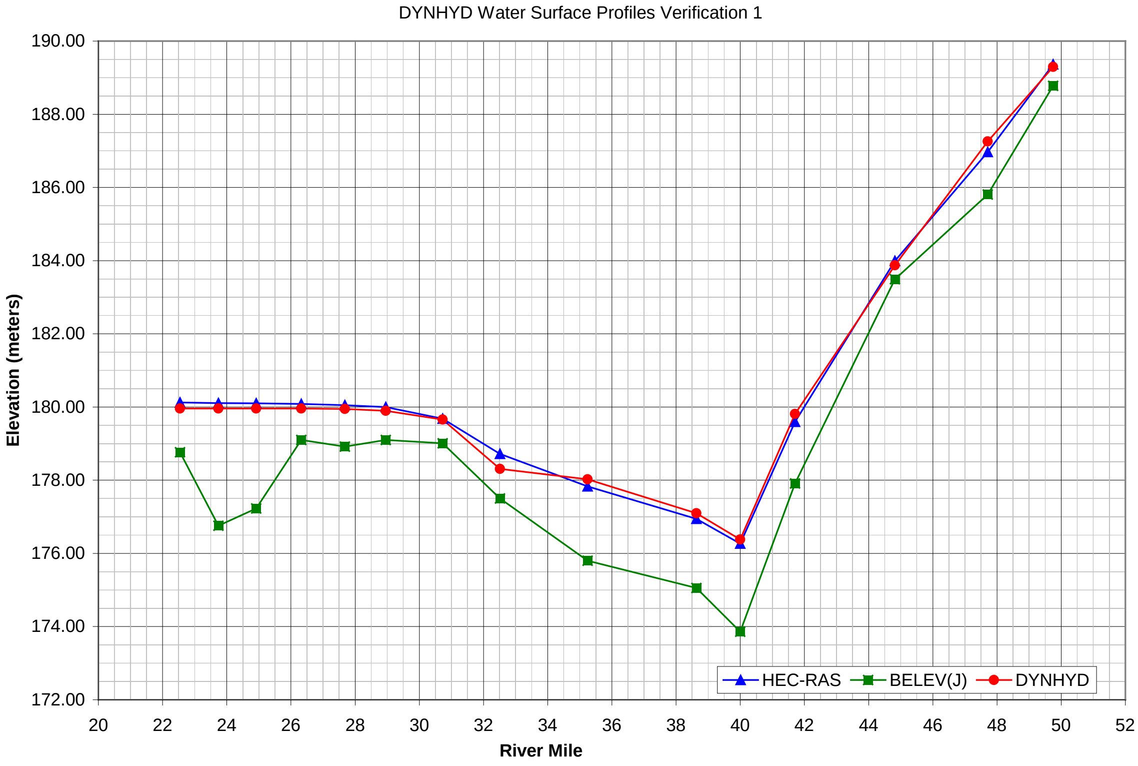
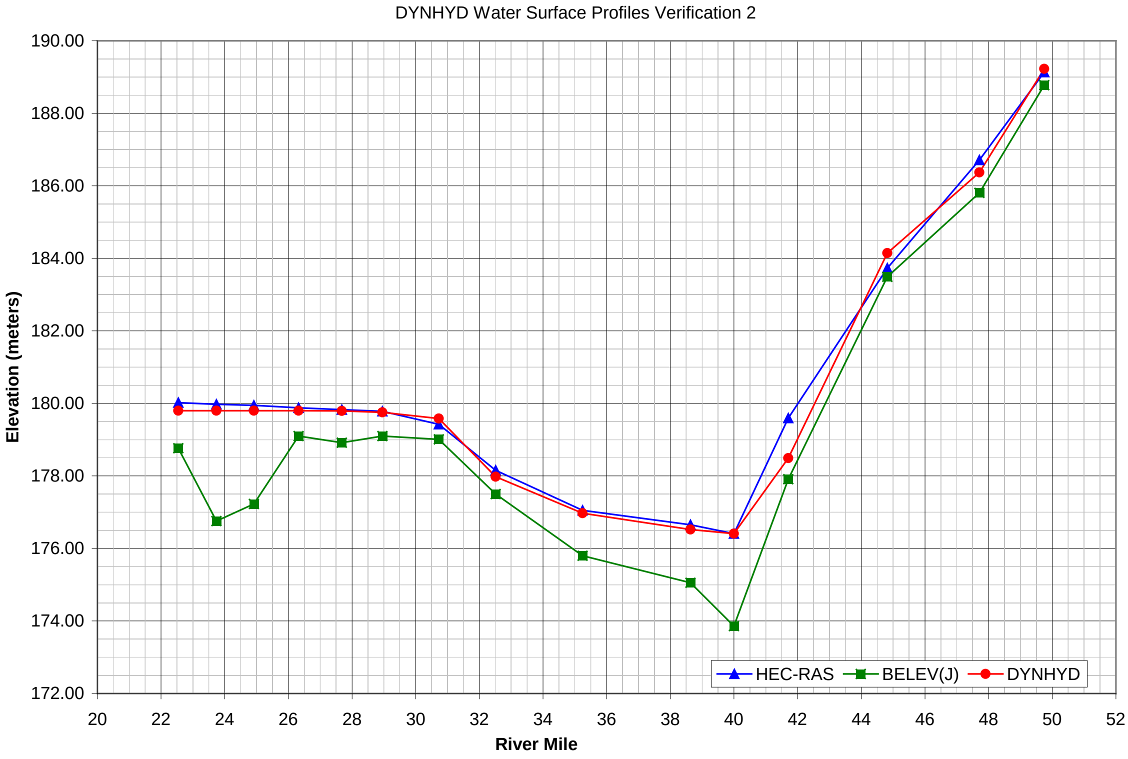


FIGURE B-4

DYNHYD VERIFICATION HYDRAULIC PROFILE
July 26, 2000



APPENDIX C - WASP CALIBRATION

C.1 WASP Setup

Junctions 1 through 15 in DYNHYD were mapped directly into WASP segments 1 through 15. The calibrated DYNHYD volumes for each simulated flow condition, estimated for each segment, were used in each of the WASP runs. DYNYHD junctions 16 through 20 are considered boundary segments in the WASP6 model and therefore were not assigned a WASP segment number.

The average flow and *E. coli* concentration from the week preceding the simulated event were used to set the initial model condition. The WASP6 model was allowed to equilibrate to these initial conditions prior to the simulation of the desired conditions.

Literature reports a wide range of values for the die-off of *E. coli*. McFeters and Stuart (1972) reported die-off rates for *E. coli* ranging from 0.20 to 0.99 day^{-1}. The simulations assumed an average die-off rate of 0.3 day^{-1} based on research conducted by McFeters and Stuart (1972), and Easton, John, et.al., (1999).

Pollutant loads were estimated for each segment. Starting from the most upstream segment and working successively downstream, loads are varied until the predicted concentrations matched the observed data.

C.2 WASP Calibration Results

WASP simulation of bacteria loadings and in-stream water quality was designed to take maximum advantage of the available data. The calendar year 2000 has the most data available to choose from. The bubble graph illustrates (Figure C-1) sampling dates along the horizontal axis and the river mile, where samples were taken, along the vertical axis. Size of the bubble represents the concentration of bacteria in that sample. Dates used in this analysis are colored and indicated in the legend.

Figures C-2 and C-3 show the results of the calibration and verification of the WASP model. The observed values represent the result of the sampling conducted for each of the associated dates (July 31, 2000 and July 26, 2000). The predicted values represent the water quality concentrations were estimated by the WASP model, in response to the modeled daily loads of *E. coli*.

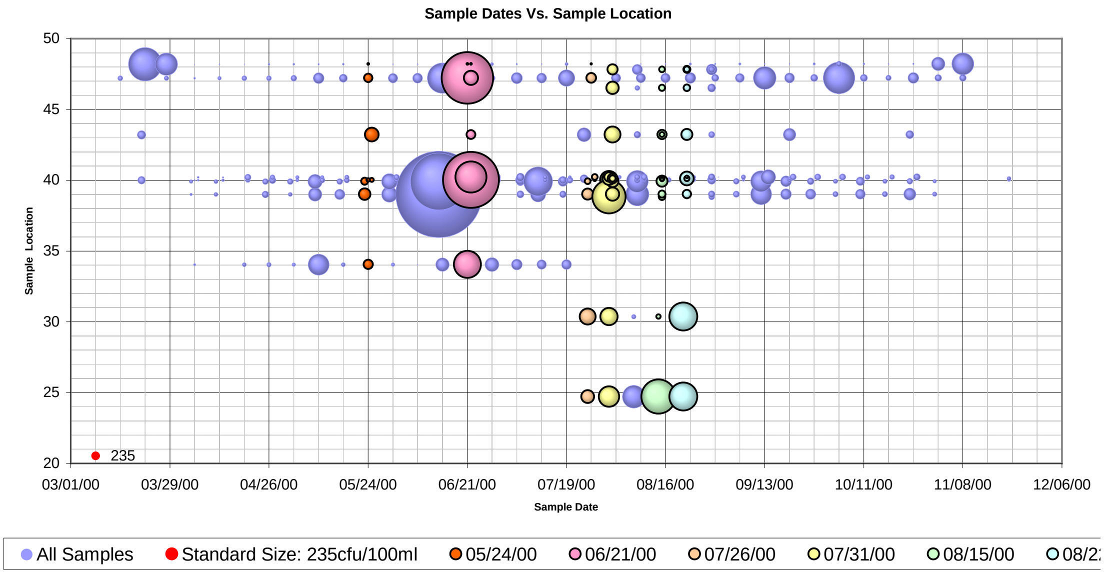
The confluence of Deep River with Burns Ditch is around river mile 33. This corresponds to Junction 03 in the computer models. Results for Junction 03 are identified by models by the centroid of the Junction, which in this case is around river mile 35.2. In each figure, the modeled load of *E. coli* around river mile 35 was significantly greater than the modeled loads elsewhere in the system. It appears that this “peak” load may be attributed to the pollutant loads from Deep River. Likewise, Salt Creek which joins the Little Calumet between river miles 41 and 42, is in Junction 12. Therefore, the influence of Salt Creek corresponds to the results at river mile 44.65. River mile 40 corresponds to the confluence of Portage Burns Waterway and Lake Michigan (Segment 01).

For calibration, the hydrologic and water quality conditions for July 31, 2000 were chosen (Figure C-2). The predicted loads simulated the observed concentration of *E. coli* fairly closely in the East Branch of the Little Calumet River and the Portage Burns Waterway (and west branch of the Little Calumet River). The variability in the observed water quality around river mile 40 represents all of the sampling conducted between the confluence of the east and west branches and the confluence with Lake Michigan. These observations are lumped together in the simulation in Segment 01. Therefore, the simulation targets an average of the observed values.

The modeling technique was verified using data from July 26, 2000 (Figure C-3). The predicted loads again simulated the observed concentration of *E. coli* fairly closely in the East Branch of the Little Calumet River and the Portage Burns Waterway and west branch of the Little Calumet River.

FIGURE C-1

DISTRIBUTION OF WATER QUALITY SAMPLES



C.3 WASP Sensitivity Analysis

A sensitivity analysis was conducted to assess the potential impact on the decisions that will result from use of these models. The die-off rate chosen in the simulation is one of the most sensitive variables. Figure C-4 shows the shift in the predicted bacteria concentration that would result in changing the die-off rate from 0.3 day^{-1} to 0.2 and 0.5 day^{-1}. The shift in the die-off rate results in about a 30 percent difference in the predicated bacteria concentrations (increase and decrease). The use of either die-off rate would require a corresponding increase or decrease in the predicted bacteria loads. However, the patterns of where the relative high or low loading rates will occur will not change. Therefore, the existing modeling technique appears to produce reasonable results upon which decisions regarding wasteload and load allocations can be made. Uncertainty of the actual value for parameters, such as the die-off rate, will factor into the estimation of the value of the Margin of Safety (MOS) for the Total Maximum Daily Load (TMDL).

FIGURE C-2

WASP CALIBRATION SIMULATION
(July 31, 2000)

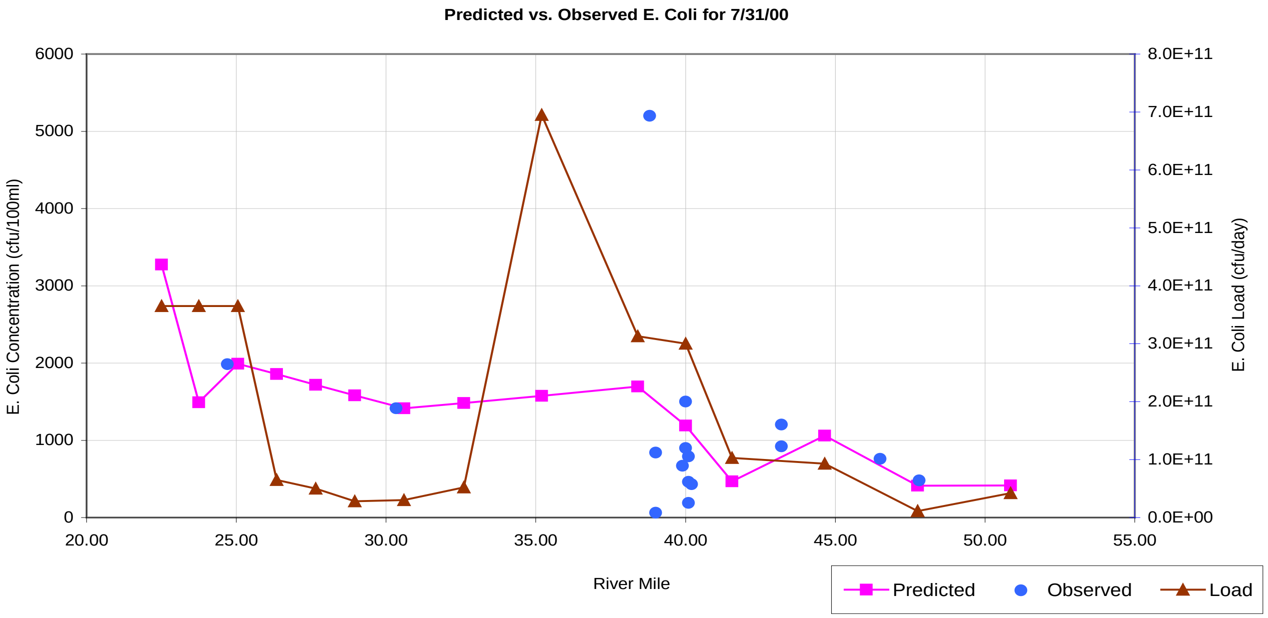


FIGURE C-3

WASP VERIFICATION SIMULATION
(July 26, 2000)

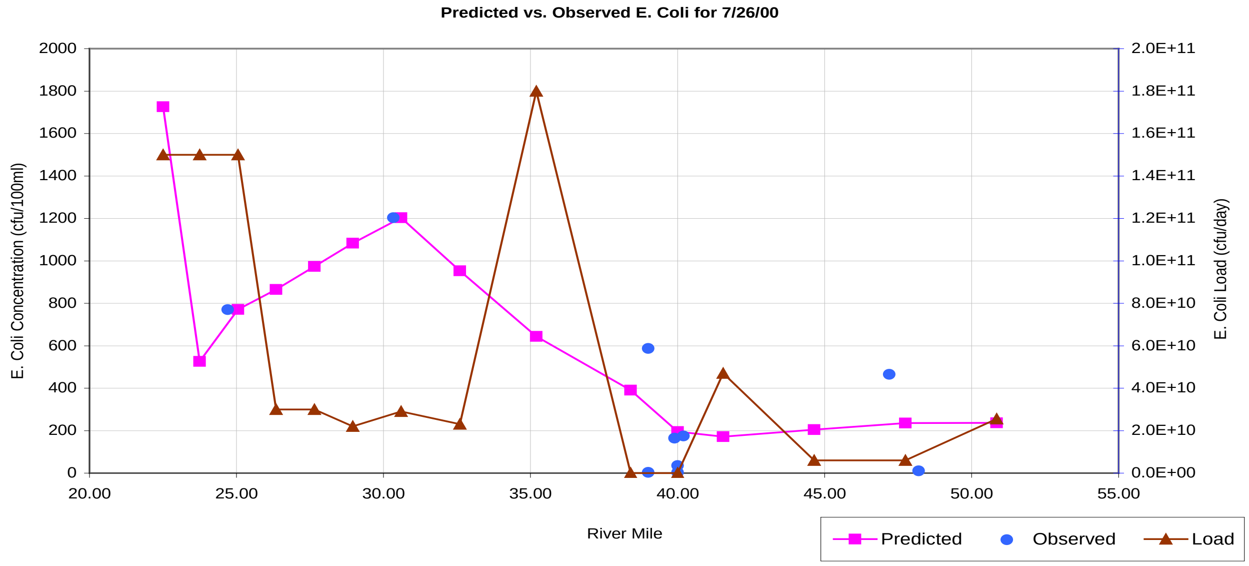
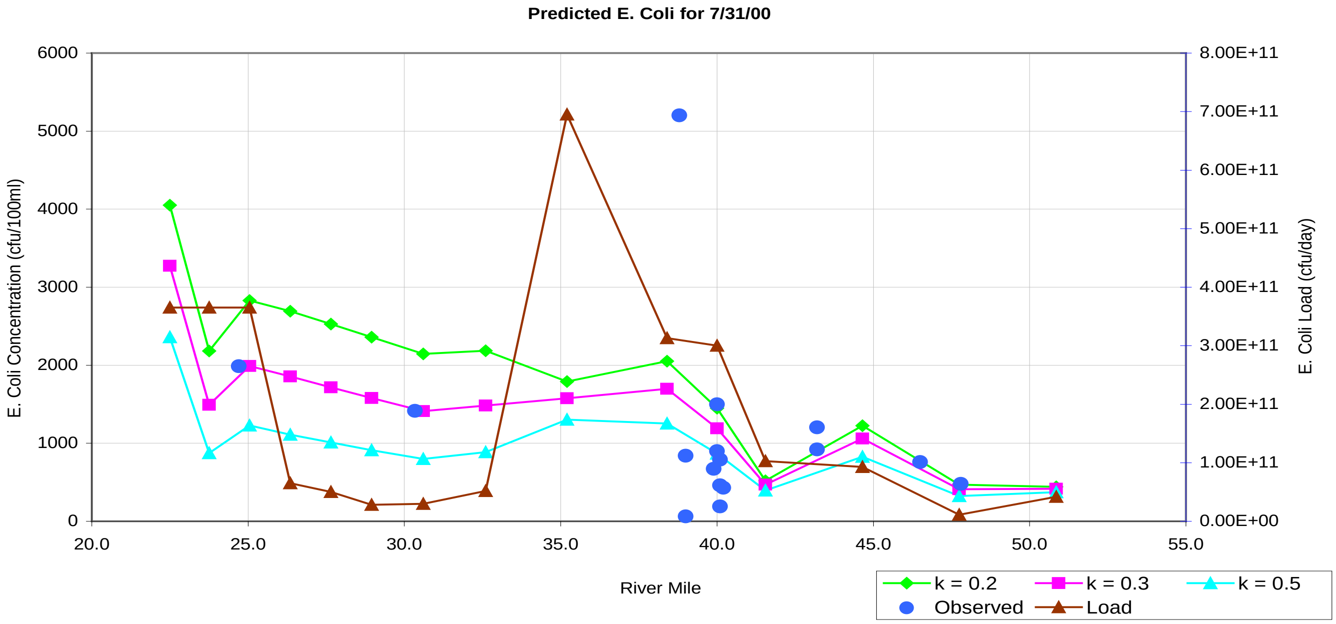


FIGURE C-4
SENSITIVITY ANALYSIS



APPENDIX D - PERMITTED NPDES FACILITIES

TABLE D-1

LITTLE CALUMET-BURNS DITCH POINT SOURCE (NPDES) FACILITIES

NPDES Facility ID	Facility Name	Major Minor	Municipal or Industrial	Bacteria in Discharge	Receiving Water
ING080159	Wolverine Pipeline Company	Inactive	Industrial	Yes	Little Calumet River via groundwater
IN0059714	Beta Steel Corporation	Minor	Industrial	No	Burns Harbor West Arm via storm sewer
IN0000175	Bethlehem Steel Corporation	**Major**	Industrial	Yes	Little Calumet River and Burns Harbor
INU060801	Burns Harbor and Bethlehem Steel	Minor	Industrial	Yes	Little Calumet River via Bethlehem Steel
IN0022578	Chesterton Municipal STP	**Major**	Municipal	Yes	Little Calumet River to Lake Michigan
INS200001	Indiana Pickling and Processing	Minor	Industrial	Yes	Burns Harbor West Arm
IN0000337	National Steel, Midwest Division	**Major**	Industrial	Yes	Burns Ditch to Lake Michigan
IN0024368	Portage Municipal STP	**Major**	Municipal	Yes	Burns Ditch to Lake Michigan
INU046949	Town of Porter WWTP	Minor	Municipal	Yes	Little Calumet River East Branch
IN0043435	Praxair, Burns Harbor Facility	Minor	Industrial	No	Little Calumet River to Lake Michigan

APPENDIX E - ASSESSMENT OF NONPOINT SOURCES

E.1 General Sources

Nonpoint source of pollution is separated into urban and rural components. In rural areas, sources of bacteria may include animal waste, runoff from concentrated areas of livestock, wildlife, and failing septic systems. In urban and residential areas, the nonpoint source pollution is associated with impervious areas, leakage of sanitary sewers, and failing septic systems.

E.2 Land Uses Contributing to *E. coli* Impairment

There is a strong correlation between impervious area in a watershed and bacteria concentrations in the receiving stream (Tufford and Marchall, 2002). Tufford and Marchall observed that geometic mean concentration of fecal coliform bacteria from a mixed land use watershed ranged between 400 and 600 cfu/100 mL. Bannerman, et. al. (1991) sampled bacteria concentrations from various source areas (residential rooftops, industrial rooftops, residential streets, commercial parking lots, etc.) Bannerman found that runoff from urban residential areas contained greater concentrations of fecal bacteria than commercial and industrial areas. Residential streets contributed most of the bacteria, while parking lots and arterial streets were significant sources of bacteria in commercial and industrial areas. Bannerman sampling of pet feces in the Monroe Street drainage area suggested that domestic pets (dogs and cats) represented less than 15 percent of the total fecal coliform bacteria measured from the study area. Therefore, it was concluded that the distribution of bacteria was attributed more to the distribution of urban wildlife (birds, squirrels, raccoons, etc.) than domestic pets.

To better discuss the impact of land use in the Little Calumet watershed, the watershed was broken into six drainage basins: the Little Calumet River-East 1(LCR-East1), Little Calumet River-East 2 (LCR-East2), Little Calumet River West (LCR-West), Portage Burns Waterway-West (PBW-West), Salt Creek and Deep River. The watershed delineations were based on 14-digit USGS hydrologic unit areas

Twenty land use classes were identified in the watershed. These were grouped into eight categories. Table E-1 below lists the various categories along with the percentage of imperviousness for each category.

TABLE E-1

LAND USE CATEGORIES

Land Use Categories	Pervious/Impervious (Percentage)	USGS Land Use Categories
AGRICULTURE	Pervious (100%)	Cropland and Pasture Confined Feeding Ops Other Agricultural Land Orchards, Groves, Vineyards, Nurseries, or Ornamentals
Residential	Impervious (20 – 40%)	Residential
Forest	Pervious (100%)	Deciduous Forest Land Evergreen Forest Land Forested Wetland
Water	Pervious (100%)	Reservoirs Nonforested Wetland Lakes
Industrial	Impervious (60 – 80 %)	Industrial
Commercial	Impervious (75 - 95%)	Commercial and Services
Urban	Impervious (30 - 60%)	Mixed Urban or Built-up Other Urban or Built-up Transportation, communication, utilities Transitional areas
Other	Pervious (100%)	Strip Mines Sandy Areas (non-Beach) Nonclassified land uses

Table E-2 shows the present land use distribution in each of the six drainage basins in the Little Calumet watershed.

TABLE E-2

LAND USE DISTRIBUTIONS BY DRAINAGE BASIN

Land Use	Drainage Basins Within the Little Calumet Watershed											
	LCR-East1		LCR-East2		Salt Creek		PBW-West		LCR-West		Deep River	
	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area
Agriculture	45.71	71.3%	3.12	29.2%	51.33	66.3%	8.43	43.1%	5.79	29.6%	93.36	66.7%
Residential	1.02	1.6%	1.91	17.9%	8.33	10.8%	4.33	22.1%	7.76	39.5%	17.15	12.3%
Forest	13.41	20.9%	2.49	23.3%	11.94	15.4%	2.38	12.2%	1.89	9.7%	14.52	10.3%
Water	1.06	1.7%	0.31	2.8%	0.72	0.9%	0.85	4.4%	0.26	1.4%	2.29	1.6%
Industrial	0.00	0.00%	0.77	7.2%	0.05	0.1%	0.00	0.00%	0.00	0.00%	0.36	0.3%
Commercial	0.67	1.0%	0.50	4.7%	2.62	3.4%	1.68	8.6%	1.95	9.9%	6.50	4.7%
Urban	2.21	3.5%	1.51	14.1%	1.92	2.5%	1.53	7.8%	1.93	9.9%	5.07	3.6%
Other	0.00	0.00%	0.09	0.8%	0.54	0.7%	0.36	1.8%	0.00	0.00%	0.64	0.5%
Total	64.08	100%	10.7	100%	77.45	100%	19.56	100%	19.58	100%	139.89	100%

E.3 Failing Septic Systems Contribution of *E. coli*

Septic system failure creates the potential of *E. coli* entering water bodies due to incomplete treatment of the waste. No county specific information was available for failure rates of septic system in the Little Calumet watershed. However, literature reports the failure rates to be between 2.5 percent and 18 percent (Johnson and Tuomari, 1998). Horsley and Whitten (1996) estimated an average daily effluent discharge of 70 gallons/capita/day and a concentration of fecal bacterial of 10^4 cfu/100 mL. Using the estimated loads reported by ODEQ (2001) for failing septic systems, each system could be responsible for generating a daily load of 1.516×10^8 cfu/day.

$$1.516 \times 10^8 \text{ cfu/day} = (200 \text{ gallons/day})(20{,}000 \text{ cfu/100 mL})(0.00379 \text{ m}^3\text{/gallons})(1{,}000 \text{ L/m}^3)(1{,}000 \text{ mL/L})/(100 \text{ mL})$$

E.4 Wildlife Sources of *E. coli*

Previous TMDLs estimated bacteria loadings attributed to wildlife by using a single wildlife species, such as the white tail deer, to represent the total load to the watershed (Table E-3).

TABLE E-3

BACTERIA LOADING RATES FROM WILDLIFE FROM PREVIOUS INVESTIGATIONS

Study and State	Animal	Assumed Animal Density	Assumed Daily Loading Rate for Fecal Coliform
Muddy Creek TMDL, VA 1999	Deer	35/mi^2	0.5×10^9 count/animal/day
Crooked Creek TMDL, AL 2001	Deer	45/mi^2	0.5×10^9 count/animal/day
Duck Creek TMDL, AK 2000	Ducks Dogs	50/WATERSHED 1,250/watershed	2.43×10^9 count/animal/day 5×10^9 count/animal/day
Norfolk Wildlife Center, Yarmouth, UK 2001	Rabbits	NA	NA

Estimates of the loading rates for other wildlife species are summarized in Table E-4. Estimating annual loads to the Little Calumet River from wildlife will require an estimate of animals in the watershed and in some cases an estimate of daily amount of waste each animal produces. All literature sources report fecal coliform counts and not *E. coli*. Therefore, an estimate of the *E. coli* produced will have to be based on a percentage of fecal coliforms. Several researchers have established correlations between fecal coliforms and *E. coli* bacteria (LTI, 1999 and Chapman, 2001).

TABLE E-4

BACTERIA LOADING RATES FROM VARIOUS WILDLIFE SPECIES

Source	Animal	Assumed Daily Loading Rate for Fecal Coliform	Units
Crane (1983)	Field Mouse	3.3×10^5	counts/g
"	Rabbit	20	counts/g
"	Chipmunk	1.48×10^5	counts/g
"	Rat	1.8×10^5	counts/g
"	Robin	0.25×10^5	counts/g
"	English Sparrow	0.25×10^5	counts/g
"	Starling	0.1×10^5	counts/g
"	Blackbird	0.09×10^5	counts/g
"	Pigeon	0.1×10^5	counts/g
ASAE (1998)	Goose	4.90×10^{10}	count/animal/day
"	Duck	2.43×10^9	count/animal/day
Arnold (2003)	Deer	5.0×10^{10}	count/animal/day
"	Beaver	2.5×10^8	count/animal/day
"	Raccoon	1.25×10^8	count/animal/day

E.5 Agricultural Sources of *E. coli*

Discussions with Bill Moran in the Lake County NRCS office and Chuck Walker in the Porter County NRCS office indicated that there is very little livestock in the Little Calumet watershed. Therefore, estimates of loads from this source will likely be lumped in with the estimate of loads from wildlife. Bacteria production for livestock that has been reported in the literature is summarized in Table E-5.

TABLE E-5

BACTERIA LOADING RATES FROM VARIOUS LIVESTOCK (ASAE, 1998)

Animal	Assumed Daily Loading Rate for Fecal Coliform	Units
Dairy Cow	1.01×10^{11}	count/animal/day
Beef Cow	1.04×10^{11}	count/animal/day
Hog/Swine	1.08×10^{10}	count/animal/day
Sheep	1.2×10^{10}	count/animal/day
Horse	4.2×10^8	count/animal/day
Chicken	1.36×10^8	count/animal/day
Turkey	9.3×10^7	count/animal/day
Dogs	4.09×10^9	count/animal/day

APPENDIX B

DYNHYD Calibration

APPENDIX C

WASP Calibration

APPENDIX D

Permitted NPDES Facilities

APPENDIX E

Assessment of Nonpoint Sources