mmsd

2020 Facility Planning Project

TECHNICAL MEMORANDUM

POINT SOURCE LOADING CALCULATIONS FOR PURPOSES OF WATERCOURSE MODELING

January 29, 2007

Memorandum

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Subject: Point Source Loadings Calculations for Purposes of Watercourse Modeling; MMSD Planning Area

1. EXECUTIVE SUMMARY

The 2020 Team is performing watercourse modeling to evaluate the instream water quality conditions within the entirety of the Kinnickinnic River, Menomonee River, Milwaukee River, Root River, and Oak Creek watersheds. The watercourse computer modeling is intended to serve as a planning tool as part of the Milwaukee Metropolitan Sewerage District (MMSD) 2020 facilities planning effort and the Regional Water Quality Management Plan Update work by the Southeastern Wisconsin Regional Planning Commission (SEWRPC).

This modeling effort will consist of several phases. One of the initial phases involves modeling of the water quality in the watercourses (rivers, creeks and tributaries) that are located within the MMSD Planning Area. Point source pollutant loads are one of the input components to the computer model. The purpose of this memo is to compile historic data for model calibration and validation inputs for the point sources to the watercourses within the MMSD Planning Area. This memo summarizes the sources of data, assumptions, protocols and methodologies used to develop the pollutant loadings contributed by point sources including sanitary sewer overflows (SSOs), combined sewer overflows (CSOs), and other inputs. Other phases include modeling of the estuary and Lake Michigan within the MMSD Planning Area and modeling of the upper portions of the Milwaukee River watershed and lower portions of the Root Rivers. Separate technical memos prepared to address the point source loadings for the other phases are included as Appendices to this memo.

Point sources contribute pollutant loadings to the local area waterways through discernible, confined and discrete conveyances such as pipes, ditches, channels or conduits. Point source discharges in Wisconsin are generally permitted through the Wisconsin Pollutant Discharge Elimination System (WPDES) program and are subject to monitoring requirements and discharge limits. Point source discharges regulated by the WPDES program include municipal and private sewage treatment plants, municipal CSOs, municipal SSOs, and industrial process wastewaters. The WPDES program also permits storm water runoff for a large number of properties in Wisconsin. While storm water runoff often discharges through a single pipe or conduit, the discharges are generally more diffuse and are generally treated as non-point sources for the purposes of modeling.

2. INTRODUCTION

2.1. Purpose

The purpose of this memo is to summarize the types of pollutant point sources that discharge to the local waterways within the MMSD Planning Area (excluding direct discharges to Lake Michigan, which will be addressed separately). This memo identifies the sources of data, assumptions, protocols and methodologies used to calculate the point source loadings. These point source loadings are an input component in the watercourse modeling efforts.

2.2. Point Source Description and Identification

Point sources contribute pollutant loadings to the local area waterways through discernable, confined and discrete conveyances such as pipes, ditches, channels or conduits. Point source discharges in Wisconsin are generally permitted through the WPDES program and are subject to monitoring requirements and discharge limits. The pollutant loadings from the following point sources of pollutants are being quantified for the purposes of input to the watercourse modeling:

- MMSD Separate Sewer Overflows (SSO),
- MMSD Combined Sewer Overflows (CSO),
- Local Community Sanitary Sewer Bypasses,
- Private and Municipal Sewage Treatment Plants (see note below)
- Industrial Discharges, and
- Other Point Sources (as identified).

Pollutant loadings for sewage treatment plants are not presented in this memo because no sewage treatment plants discharge to the rivers within the MMSD Planning Area. Point sources that discharge directly to Lake Michigan and to the portions of the Milwaukee and Root Rivers outside the MMSD Planning Area are being handled under separate analyses.

The following pollutants require loading calculations to be performed for model input:

- Total Suspended Solids (TSS)
- Fecal coliform bacteria
- *E. coli* bacteria
- Biochemical Oxygen Demand (BOD)
- Dissolved oxygen (D.O.)
- Temperature
- Total Nitrogen (total of ammonia-nitrogen, organic-nitrogen[1], nitrate, and nitrite)[2]
- Total Phosphorus [3]
- Copper (Cu)

- Zinc (Zn), and
- Chlorophyll "a" [4]

[1]Total Kjeldahl Nitrogen (TKN) and ammonia are used to calculate organic nitrogen
[2] Each nitrogen species will be modeled
[3] Total phosphorus will be modeled instead of soluble phosphorus because it is a more conservative method of tracking phosphorus loadings than soluble phosphorus. Phosphorus data for the point source loads consists only of total phosphorus.
[4] Chlorophyll "a" is being modeled but none of the point sources presented in this memo are a source of chlorophyll "a"

2.3. Point Source Data Use In Modeling- Loadings Calculations

For each source of pollutant loads, it was necessary to develop an estimate of both flow and pollutant concentration so that a pollutant mass loading could be estimated for each source. Once volume and pollutant concentrations for a source were determined, these two factors were extended (flow volume x concentration) to calculate the 15-minute (or other appropriate time frame) pollutant mass contribution as follows:

Pollutant Loading (mass/time) = Pollutant Concentration (mass/volume) x Flow (Volume/Time)

These pollutant loadings were then converted to a time series in a format that would be appropriate for input into the Hydrologic Simulation Program-Fortran (HSPF) model.

3. MMSD SANITARY SEWER OVERFLOWS (SSOs)

3.1. Chemistry – Statistical Summary

The 2020 Team obtained SSO sampling data from MMSD for the period 1994 to 1999. There are 32 SSO locations within the MMSD system. An inventory of MMSD SSO locations is shown in Table 1-C (located in Appendix C). Automatic samplers took samples of the overflows at 10 of these outfalls as required in MMSD's permit. There is no sampling data available after 1999 because after that year, the MMSD was no longer required by the permit issued by the Wisconsin Department of Natural Resources (WDNR) to sample SSOs.

During 1994 to 1999, MMSD took 33 samples of SSOs to the Milwaukee River (representing 14 separate sampling dates) but only one each of the Menomonee and Kinnickinnic Rivers (note: one overflow event may be represented by several sampling dates.) The 2020 Team recommends using one set of concentrations to represent SSOs for all watersheds in the modeling because there is insufficient data to develop separate representative concentrations for SSOs that discharge to the Menomonee and Kinnickinnic Rivers.

The 2020 Team desired to use one set of pollutant concentrations to represent SSOs from MMSD and other municipal discharges within Wisconsin. The 2020 Team obtained SSO sampling data from WDNR that represented recent sampling from eleven Wisconsin communities. This community data was obtained to ensure that the SSO pollutant concentrations being used were representative of both the MMSD and local communities.

Following a quality assurance review of the sampling methods and data and in concert with the recommendations by the Technical Advisory Team (TAT) and SEWRPC, the 2020 Team added the BOD,TSS and total phosphorus data from six of the communities to the MMSD data prior to performing the statistical analysis.

MMSD analyzed the SSO samples for biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform and total phosphorus. SSO concentration data is also needed for the other parameters being modeled including *E. coli*, ammonia, Total Kjeldahl Nitrogen (TKN), nitrate, nitrite, dissolved oxygen, chlorophyll "a", copper, zinc and temperature. MMSD did not analyze the SSOs for these parameters. Municipalities typically do not sample and analyze SSOs and no data from other municipalities could be found regarding nitrogen species in SSOs.

The 2020 Team obtained CSO sampling data from the Ohio River Valley Water Sanitation Commission (ORVWSC, also known as ORSANCO in Ohio). The ORVWSC sampled CSOs for a variety of pollutants including ammonia nitrogen and TKN. The MMSD analyzes the influent to their wastewater treatment plants for a variety of pollutants including ammonia-nitrogen. Therefore, the 2020 Team performed regression analyses to determine if a relationship exists between BOD and ammonia nitrogen concentrations (and organic nitrogen) for both the Jones Island influent during wet weather and CSO sampling performed by the Ohio River Valley Water Sanitation Commission (ORVWSC). The regression analyses showed that a statistically significant linear relationship exists between BOD and ammonia nitrogen (and organic nitrogen). The MMSD SSO BOD concentrations were applied to the regression analyses to develop recommended concentrations for ammonia nitrogen and organic nitrogen. (See Appendices A and D of this memo for graphs of the regressions and associated R^2 values).

MMSD's CSO sample data was used to develop representative copper and zinc concentrations for SSOs. The regression analyses of the TSS, zinc, and copper CSO data showed that a statistically significant linear relationship exists between total suspended solids (TSS) and copper (and zinc). The MMSD SSO TSS concentrations were applied to the regression analyses to develop recommended SSO concentrations for copper and zinc. (See Appendices A and E of this memo for graphs of the regressions and the associated R^2 values).

The concentration of *E. coli* in SSOs is expected to be within a similar range of that in sewage influent. *E. coli* bacteria are subset of the fecal coliform bacteria. Dr. Sandra L. McLellan of the Great Lakes Water Institute (GLWI) provided a general relationship of *E. coli* to fecal coliform based on 102 influent samples (to Jones Island and South Shore wastewater treatment plants). Each of the fecal sample concentrations (in the MMSD's SSO data) was multiplied by this ratio (0.61) to obtain estimated *E. coli* values. The geometric and arithmetic mean of the estimated *E. coli* values were then calculated to represent *E. coli* concentrations in SSOs.

A detailed discussion of SSO chemistry analysis and the derivation of the recommended pollutant concentrations are presented in Appendix A. The 2020 Team recommends that the following values be used to represent the mean concentration data for calculating the loadings from the SSOs for modeling purposes:

TABLE 1
RECOMMENDED SSO MEAN CONCENTRATIONS FOR MODELING
(Directly From MMSD and Wisconsin Community Sampling Data)[4]

Parameter	BOD_5 (mg/L)	Total Suspended Solids (mg/L)	Fecal Coliform (#/100 mL) [1]	Total Phosphorus (mg/L)
Source of Data	MMSD sampling	MMSD sampling	MMSD sampling	MMSD sampling
All Watersheds (Arithmetic Means)	51	193	1,540,000	3.7
All Watersheds (Geometric Means)	26	95	450,000	2.5
Number of Values Analyzed[2]	35	35	25	28
Range (Min-Max)	0.1-250	11-1,264	15,000-21,000,000	0.43-15.7
Error of Mean [3]	9	47	820,000	0.74

Notes: 1) The fecal coliform concentrations were rounded to two significant figures. 2) The number of values analyzed is the number of sample results evaluated for that parameter. Details of this analysis are presented in Appendix A. 3) Standard error of the arithmetic mean. 4) Includes MMSD (source MMSD) and Wisconsin Community data (source: WDNR)

TABLE 2
RECOMMENDED SSO MEAN CONCENTRATIONS FOR MODELING
(Derived Values)

Parameter	Copper (mg/L)	Zinc (mg/L)	*E. coli* (#/100 mL)	Organic Nitrogen as N (mg/L)	Ammonia as N (mg/L)
Source of Data	MMSD Regression [1]	MMSD Regression [1]	*E. coli*/ Fecal Relationship-GLWI[2]	ORVWSC Sampling Regression [3]	ORVWSC Sampling Regression [3]
All Watersheds (Arithmetic Means)	0.03	0.17	940,000	5.1	1.8
All Watersheds (Geometric Means)	0.02	0.13	280,000	3.3	1.4
Number of Values Analyzed [4]	35	35	25	35	35
Range (Min-Max) [5]	0.01-0.14	0.06-0.81	9,150-12,800,000	0.44-23.5	0.48-7.1

Notes: 1). The copper and zinc concentrations were estimated based on a regression analysis with TSS performed on CSO data from the MMSD 2) The e-coil concentrations were estimated based on a relationship between *E. coli* and fecal coliform in sewage influent (presented to two significant figures). 3) The nitrogen species concentrations were estimated based on a regression analysis with BOD performed on CSO data from the ORVWSC. Details of these analyses are presented in Appendix A. 4) Number of values is the number of TSS SSO sample results applied to the regression analyses. Details of this analysis are presented in Appendix A. 5) The range is the min/max of calculated values from regression analysis and relationships.

The 2020 Team assumes that the concentrations of dissolved oxygen, nitrate, nitrite, and chlorophyll "a" in the SSOs are negligible. The 2020 Team does not expect SSOs to present a significant heat load to the watercourses and the temperature of SSOs should be relatively constant (within a range of 10 degrees F) because SSOs occur primarily in the spring and autumn. Therefore, the 2020 Team recommends the use of a default of 60 degrees F to represent temperature. (See Appendix A for the basis of this recommendation).

One can use arithmetic or geometric means depending upon the purpose of the analysis and how the data is distributed. The arithmetic mean is the average of a set of values. The geometric mean is the average of the log of the set of values (converted back to a non-log number). A geometric mean is normally used to represent a data set when the data is log-normally distributed. The arithmetic mean is used when the data is normally distributed. The probability plots of the data show that the data is closer to a log-normal distribution rather than a normal distribution, and therefore the geometric mean may better represent the mean for the way the data is distributed. In addition, a geometric mean is almost always used to represent fecal coliform since the data spans several orders of magnitude. Therefore, the modeling team will use the geometric means to calculate the pollutant loadings.

3.2. Volumes – Hydrographs

The 2020 Team obtained SSO recorded flow volumes and durations from MMSD for the period 1994 to 2002 (note: there were no SSOs in 1994). During this period, overflows were recorded on 66 days at 31 outfall locations. (Note: not all SSO locations overflowed during every event and one or more dates may represent one overflow storm event). At least 11 of the 66 days involved dry weather overflows. MMSD calculates the SSO flow volumes based on the water level in the junction chamber upstream of each diversion weir for each outfall. A modeled rating curve based on the weir equation (or another suitable equation) uses the water level in the junction chamber to calculate the volumes of the overflows. Note: The overflow volumes obtained for the 1994-2002 period will be used for calculating point sources for the model calibration. Overflow volumes for the model production runs will come from the conveyance model.

MMSD SSO reports identify only the total overflow volume and duration of the overflow. The HSPF model, however, requires the input of 15-minute time series data. A 15-minute simulated SSO time series was created in order to establish compatibility with the HSPF times series required for model input. The total overflow volume and duration of flow were distributed across an isosceles triangle shape to create each 15-minute time series. Because a peak flow was not known, an isosceles triangle shape distribution was assumed to simulate the SSO time series flow. A discussion of how the time series were created is presented in more detail in Appendix B. A 15-minute time series was created for each of the recorded overflows.

An example of a 15-minute time series (representing an isosceles triangle shape) produced from the data is presented below:

TABLE 3
EXAMPLE 15-MINUTE TIME SERIES-ISOSCELES TRIANGLE
Outfall #207 -August 6, 1998 storm event:
Duration: 2.0 hours
Volume: 0.8 million gallons (MG)
Calculated Peak Flow: 19.20 million gallons per day (MGD)

Time (min)	Calculated Flow Rate (MGD)	Volume (MG for 15-minute period)
0	0.00	0
15	4.80	0.05
30	9.60	0.10
45	14.40	0.15
60	19.20	0.20*
75	14.40	0.15
90	9.60	0.10
105	4.80	0.05
120	0.00	0
TOTAL VOLUME (MG)		**0.8**

* Peak of isosceles triangle shape distribution

Where:

Flow (MG) for each 15-minute period= Flow Rate (MGD) * 15 min * day/24 hr * hr/60 min

In some cases, the duration of an overflow was not provided for a particular SSO location, although a total overflow volume was provided. In these cases, the 2020 Team assumed that the duration of the overflow was equal to the average duration of the other SSOs for the same date, or to the total duration for the corresponding CSO event (whichever seemed more reasonable).

3.3. Pollutant Loadings

Once the 15-minute time series was produced for each outfall, the outfall volumes were consolidated by each river reach. The river reaches are segments of river as defined in the water quality calibration memos listed at the end of this memo.

In order to consolidate outfalls by river reach, the SSO locations were plotted on a map using designated GIS locations. GIS reference files have been created as noted at the end of this memo. All SSOs were characterized according to the reach in which they are located. A final flow at each 15-minute time step was calculated for each overflow event by summing all the outfall volumes within the specified reach.

A pollutant load was developed for each final flow time series using the recommended pollutant concentrations and each 15-minute flow. An example of a pollutant load calculation for a designated reach in the Menomonee River is presented below:

TABLE 4
EXAMPLE 15-MINUTE TIME SERIES POLLUTANT LOAD CALCULATION- SSO
Reach # 919 for Storm Event June 13, 1999:
Assume BOD concentration: 26 mg/L (geometric mean of all watersheds)

Time (min)	Calculated Flow Rate (MGD)	Volume (MG) for 15-minute time period	BOD (lbs for 15-minute time period)
0	0.00	0.00	0.0
15	0.20	0.002	0.5
30	0.39	0.004	0.9
45	0.59	0.006	1.4
60	0.79	0.008	1.8
75	0.99	0.010	2.3
90	1.18	0.013	2.9
105	1.38	0.014	3.2
120	1.58	0.016	3.6
135	1.78	0.019	4.3
150	1.97	0.021	4.7
165	2.17	0.023	5.2
180	2.37	0.025	5.6
195	2.17	0.023	5.2
210	1.97	0.021	4.7
225	1.78	0.019	4.3
240	1.58	0.016	3.6
255	1.38	0.014	3.2
270	1.18	0.013	2.9
285	0.99	0.010	2.3
300	0.79	0.008	1.8
315	0.59	0.006	1.4
330	0.39	0.004	0.9
345	0.20	0.002	0.5
360	0.0	0.000	0.00

Numbers presented to two significant figures for presentation purposes.

Where:

- BOD (lbs/15-minute period)= BOD (mg/L) * 10^6*(Volume, MG) * 3.785 L/gal* lb/453,592 mg

4. MMSD COMBINED SEWER OVERFLOWS (CSOs)

4.1. Chemistry – Statistical Summary

The 2020 Team obtained CSO sampling data from MMSD for the period 1994 to 2002. The sample data for BOD, TSS, fecal coliform, and total phosphorus cover the period from 1994-2002, while the sample data for zinc, copper, and *E. coli* cover the period from 2000-2002. The CSOs were not analyzed routinely for zinc, copper, and *E. coli* prior to 2000.

There are currently 117 permitted CSO locations listed on MMSD's permit. A system of 20 near-surface collectors serves to divert the flow into the Inline Storage System (ISS or Deep Tunnel). One or more CSO locations are connected to each collector. A list of the CSO locations and their associated near surface collectors is presented in Table 2-C (located in Appendix C). The MMSD samples the CSOs at each system of near-surface collectors using an automatic sampler that turns on once two set points are reached. The first set point is when the gates to the tunnel close. The second set point is when the elevation of water in the junction chamber reaches the elevation of the lowest CSO in that collector. The sampler is then activated and fills a 2.5-gallon glass bottle before turning off. This sampling method ensures that a sample is collected from the initial overflow in each system of near surface collectors.

During 1994 to 2002, MMSD took 332 samples of CSOs at the near-surface collectors (representing 33 separate sampling dates). Not all outfalls overflowed during every sampling date, several sampling dates may represent one storm event, and not all parameters were analyzed during every sampling date. The following samples were taken during the time period studied:

- Milwaukee River outfalls: 147 samples
- Menomonee River outfalls: 83 samples
- Kinnickinnic River outfalls: 64 samples
- Lake Michigan outfalls: 38 samples

The 2020 Team performed a series of spatial and event-based statistical analyses on the raw CSO pollutant concentration data to determine if the data could be combined for all watersheds and all events or if there are spatial or event-based data that should be considered outliers and either removed from the data set or treated separately. The statistical tests indicated that the BOD and TSS concentrations in the near-surface collector CT 5/6 (which contains combined sewer outfalls that discharge to the Menomonee River (located near 25th Street and the Menomonee River) were significantly different from the others. If the concentrations for these pollutants were removed from the data set (and treated separately), one set of mean concentrations could be used to represent all three watersheds. The statistical tests also indicated that the total phosphorus concentrations for each watershed were statistically different.

A detailed discussion of CSO chemistry analysis and the derivation of the recommended concentrations are presented in the memo located in Appendix A. The 2020 Team recommends that the following values be used to represent the mean concentration data for calculating the loadings from the CSOs:

TABLE 5
RECOMMENDED CSO GEOMETRIC MEAN CONCENTRATIONS FOR MODELING[3] – (Directly From MMSD Sampling Data)-

Parameter	BOD_5 (mg/L)	Total Suspended Solids (mg/L)	Fecal Coliform (#/100 mL)[1]	*E. coli* Coliform (#/100 mL)[1,2]	Total Phosphorus (mg/L)	Copper (mg/L)	Zinc (mg/L)
Source	MMSD sampling	MMSD sampling	MMSD sampling	MMSD Sampling	MMSD sampling	MMSD sampling	MMSD sampling
Menomonee River (all but CT 5/6)	9 (14)	56(88)	160,000 (650,000)	96,000 (130,000)	0.64(0.83)	0.02 (0.02)	0.09 (0.10)
Menomonee River (only CT 5/6)	54(134)	116(172)	160,000 (650,000)	96,000 (130,000)	1.07(1.46)	0.02 (0.02)	0.12 (0.17)
Kinnickinnic River	9(14)	56(88)	160,000 (650,000)	96,000 (130,000)	0.64(0.80)	0.02 (0.02)	0.09 (0.10)
Milwaukee River	9(14)	56(88)	160,000 (650,000)	96,000 (130,000)	0.48(0.58)	0.02 (0.02)	0.09 (0.10)
Number of Values Analyzed [4]	332	331	78	28	304	136	136
Range (Min-Max) [5]	0.1-1,200	4-680	400-24,000,000	18,000- 370,000	0.02-8.4	0.0059- 0.17	0.029-0.7
Error of Mean [6]	0.8 (59)	5 (36)	340,000	17,800	0.04-0.09 (0.4)	0.0012	0.005 (0.068)

1 Bacteria concentrations were rounded to two significant figures. 2) There were an insufficient number of samples to create an *E. coli* mean for each watershed. 3) Arithmetic means are presented in parentheses 4) Number of values analyzed is the number of CSO sample results from all watersheds (including CSOs to Lake Michigan). 5) Range is the min-max of all CSO sample results. 6) Standard error of arithmetic mean. Error of mean of BOD, TSS and zinc for CT 5/6 in parentheses. Error of mean for phosphorus varies by watershed (because mean varies by watershed) but it ranges from 0.04 (Milwaukee River) to 0.4 (Menomonee @ CT 5/6).

The probability plots of the data show that the data is closer to a log-normal distribution rather than a normal distribution, and therefore the geometric mean may better represent the mean for developing model inputs. In addition, a geometric mean is almost always used to represent fecal coliform since the data spans several orders of magnitude. Therefore, the modeling team will calibrate the model using the geometric means.

While the MMSD analyzes the CSO samples for BOD_5, total suspended solids (TSS), fecal coliform, *E. coli*, copper, zinc and total phosphorus, it does not analyze CSOs for the other parameters being modeled including ammonia, TKN, nitrate, nitrite, dissolved oxygen, chlorophyll "a", and temperature. These parameters are not analyzed by MMSD because its permit does not require them to analyze the parameters. Few municipalities have sampled their CSOs for nitrogen species. Therefore, the 2020 Team used the BOD/ammonia and BOD/organic nitrogen relationships identified by the regression analyses previously mentioned to develop estimates for nitrogen species concentrations in the CSOs. The BOD concentrations in MMSD's CSOs were applied to the regression analyses to develop recommended concentrations for ammonia nitrogen and organic nitrogen. A complete discussion on the judgments and development of derived values is presented in Appendix A. The 2020 Team recommends that the following values be used to represent nitrogen species concentrations in the CSOs.

TABLE 6
RECOMMENDED CSO GEOMETRIC MEAN CONCENTRATIONS FOR MODELING-NITROGEN SPECIES4
(Derived Values) -

Parameter	Organic Nitrogen-as N (mg/L)	Ammonia (mg/L)-as N	Nitrate/ Nitrite (mg/L) as N
Source	ORVWSC Sampling 1	ORVWSC Sampling 1	ORVWSC Sampling 2
Menomonee River (all but CT 5/6)	1.3 (1.7)	0.7 (0.8)	1
Menomonee River (only CT 5/6)	5.4 (12.8)	1.9 (4.0)	1
Kinnickinnic River	1.3 (1.7)	0.7 (0.8)	1
Milwaukee River	1.3 (1.7)	0.7 (0.8)	1
Number of Values Analyzed 3	332	332	162
Range (Min-Max) 5	0.44-111	0.48-32	0-7
Error of Mean 6	NA	NA	0.09

1) These values were calculated based on a BOD/Organic Nitrogen regression analysis performed on CSO data from the Ohio River Valley Water Sanitation Commission (ORVWSC). 2) There is no statistically significant linear relationship between BOD and nitrate/nitrite, therefore we recommend using the means directly from the ORVWSC study {0.9 rounded to 1}. Details of this analysis are presented in Appendix A. 3) Number of values for organic nitrogen and ammonia are the number of MMSD sample results (BOD concentrations) applied to the regression analysis. The number of nitrate/nitrate values is the number of nitrate/nitrate sample results provided by the ORVWSC. 4) Arithmetic means in parentheses. 5) Range is the min/max of calculated values from regression analysis. 6) Standard error of the arithmetic mean for nitrate/nitrite calculated directly from ORVWSC data. It is inappropriate to calculate arithmetic standard error of mean on the regressed data. The r squared values of 0.61 and 0.64, which estimates the amount of variance accounted for by the regression of BOD versus organic nitrogen and BOD versus ammonia, respectively are based upon the ORVWSC data set.

The 2020 Team assumes that the concentrations of chlorophyll "a" in the CSOs are negligible. The 2020 Team recommends using a value of 3.4 mg/L to represent D.O. in the CSOs based on data from the City of Chicago (see Appendix H to this memo).

The 2020 Team expects the temperature of the CSOs to be similar to the temperature of the storm water runoff and therefore we recommend that we treat the temperature of CSOs in a similar manner as how it will be treated for the storm water runoff in modeling.

4.2. Volumes – Hydrographs

The 2020 Team obtained MMSD CSO flow volume data from 1994 to 2002. During this period, overflows were recorded on 51 days at the permitted outfall locations. Not all outfalls overflowed during every recorded date and several dates may represent one storm overflow event. The overflow volumes obtained for the 1994-2002 period will be used for calculating point sources for the model calibration and verification. Overflow volumes for the production runs will come from the conveyance model.

The MMSD estimates the CSO flow volume at each outfall by utilizing both the level in the junction chamber upstream of the overflow weir and the level in the river at the end of the outfall pipe. Rating curves have been developed for each outfall using the geometry of the outfall and a computer model (United States Army Corp of Engineers' Hydrologic Engineering Center River Analysis System, HEC-RAS). A CSOLOG database program uses the two measured levels and the rating curve to estimate a peak flow rate and overflow volume. Rating curves are used in a similar method to calculate the flow rates for the several outfalls that are currently not incorporated in the CSOLOG database. In these cases, the overflow rates are calculated by MMSD personnel in a spreadsheet outside of the CSOLOG program.

MMSD overflow reports from 1998 to 2002 identified the peak flow, overflow volume, and duration of the overflow for each outfall location. A 15-minute simulated CSO time series was created in order to establish compatibility with the HSPF times series required for model input. The total overflow volume, peak flow, and duration of flow at each outfall were used to distribute the flow into a trapezoidal-shape distribution to create the 15-minute time series. A generalized equation was developed to simulate the trapezoidal shape. The 15-minute time interval flow volumes for each overflow at each outfall were calculated using the generalized equation and the three independent variables (peak flow, total volume and duration of flow).

MMSD overflow reports from 1994 to 1997 identified only the total overflow volume at each CSO location. Separate reports from MMSD provided the start and stop times for each overflow event (total event start and stop times; not for each CSO location). In order to calculate a 15-minute time series for CSOs from 1994 to 1997, we assumed that the duration of each CSO at each outfall was equal to the duration of the total event duration. Because a peak flow was not known, the total overflow volume at each CSO and the assumed duration were distributed across an isosceles triangle shape to create a 15-minute time series similar to the method for calculating the SSO time series.

A discussion of how the 15-minute time series were created is presented in more detail in Appendix B. A 15-minute time series was created for each of the recorded overflows. An example of a calculated 15-minute time series (representing a trapezoidal-shape distribution) for a CSO is presented below:

TABLE 7

EXAMPLE 15-MINUTE TIME SERIES- TRAPEZOIDAL SHAPE

Outfall #90 -August 12-13, 2002 storm event:
Duration: 5.75 hours (0.24 Days)
Volume: 17.6 million gallons (MG)
Peak Flow: 107 million gallons per day (MGD)

Time (min)	Calculated Flow Rate (MGD)	Volume (MG) for each 15-minute period
0	0.00	0
15	14.84	0.15
30	29.68	0.31
45	44.53	0.46
60	59.37	0.62
75	74.21	0.77
90	89.05	0.93
105	103.89	1.08
120	107.00	1.11*
135	107.00	1.11*
150	107.00	1.11*
165	107.00	1.11*
180	107.00	1.11*
195	107.00	1.11*
210	107.00	1.11*
225	107.00	1.11*
240	103.89	1.08
255	89.05	0.93
270	74.21	0.77
285	59.37	0.62
300	44.53	0.46
315	29.68	0.31
330	14.84	0.15
345	0.00	0
TOTAL VOLUME (MG)		**17.6**

*Top of trapezoidal-shape distribution

4.3. Pollutant Loadings

Once the time series was produced for each outfall, the CSO volumes were consolidated by river reach. In order to do this, all CSOs were plotted on a map using designated GIS locations. The outfalls were plotted on a map to determine which outfalls should be consolidated together by reach. A final flow at each 15-minute time step was calculated for each overflow event by summing all the outfall volumes within the specified reach.

A pollutant load was then developed for each final flow time series using the recommended pollutant concentrations and each 15-minute flow. An example of a pollutant load calculation for a designated reach in the Menomonee River is presented below:

TABLE 8
EXAMPLE 15-MINUTE TIME SERIES POLLUTANT LOAD- CSO
Example Time Series- Reach # 908 for Storm Event August 5, 2000:
Assume BOD concentration: 9 mg/L (geometric mean of all watersheds)

Time (min)	Calculated Flow Rate (MGD)	Volume (MG) for 15-minute time period	BOD (lbs for 15-minute time period)
0	0.0	0.00	0
15	160	1.7	130
30	260	2.7	210
45	300	3.1	230
60	320	3.3	250
75	300	3.1	230
90	200	2.1	160
105	100	1.0	75
120	0.0	0	0

Numbers presented to two significant figures for presentation purposes. Reach could change.

Where:

- BOD (lbs/15-minute period)= BOD (mg/L) * 10^-6*(Volume, MG) * 3.785 L/gal* lb/453,592 mg

5. LOCAL COMMUNITY SANITARY SEWER OVERFLOWS (SSOs)

5.1. Chemistry – Statistical Summary

The 2020 Team contacted the WDNR for available SSO chemistry data from the twenty-eight local communities that are in MMSD's Planning Area. Local communities are not required by the Wisconsin Department of Natural Resources (WDNR) to sample SSOs. The 2020 Team obtained SSO sampling data from eleven Wisconsin communities (two within the MMSD Planning Area; the remainder outside the Planning Area). A discussion of the development of the concentrations to be used to represent local SSOs is presented in Section 3.1 of this memo.

5.2. Volumes – Hydrographs

Overflow reports were obtained from each municipality and also from the WDNR for 1994 to 2002. During this period, overflows were reported on 95 days at approximately 170 locations (Note: The communities often reported one overflow volume for a particular date at "various locations" rather than at a specific location. Therefore, the actual number of overflow locations is likely much larger). The information from the WDNR and the local communities was consolidated into a single data set. The SSOs volumes from each municipality were either based on estimates or pump records. Table 3-C (located in Appendix C) summarizes the reported local municipality sanitary sewer overflow locations. On occasions where the local communities reported "overflows at various locations" and the community could not provide more specific information on overflow location, the 2020 team assumed the total overflow volume for those days to be equally distributed among the previously reported overflow locations.

The local communities reported only total flow volumes and duration of overflows for each overflow event. The 15-minute time series for the local community overflows were calculated in a method identical to that performed for the MMSD SSOs. The total volumes and duration of flow were distributed across an isosceles triangle shape. A 15-minute time series was created for each of the recorded overflows.

5.3. Pollutant Loadings

The historic pollutant loadings for the local community SSOs were calculated in the same manner as the pollutant loadings for the MMSD SSOs. Once a 15-minute time series was produced for each overflow location, the locations (based on reported street intersection) were plotted on a map using designated GIS locations and then aggregated according to river reaches. A final pollutant load was developed for each flow time series using the recommended MMSD SSO pollutant concentrations and each 15-minute flow. These pollutant loads will be used as model input for model calibration and verification.

The methodology for estimating local community SSO inputs for model production runs (as opposed to calibration/verification) is documented in a series of memos referenced at the end of this memo.

6. INDUSTRIAL POINT SOURCES

6.1. Types of Permitted Sources

Through its Wisconsin Pollutant Discharge Elimination System (WPDES) program the WDNR currently permits almost 1,000 discharges to surface waters in the portions of the watersheds located within the MMSD Planning Area. Of these almost 1,000 permits issued in the MMSD Planning Area, the percentage of the three major types of permits is broken down as follows:

TABLE 9
PERMITTED WPDES DISCHARGERS-MMSD PLANNING AREA [1]

Permit Type	Percent of Permits
Industrial Type [2]	31%
Storm water Runoff	66%
Sanitary Bypasses (overflows)	3%

1) Source: WDNR; received via e-mail February 2003, with additional information provided April 12, 2004 and October 11, 2004. Note: The list of permitted facilities changes with time and can only be valid as of a particular date because facilities continually eliminate discharges and add new discharges. 2) Some of these permitted facilities may actually be municipalities, but the types of permitted discharges indicated in the table are of operations that are considered "industrial" in nature (i.e. are not from municipal sanitary overflows and bypasses, which are permitted separately).

Industrial type permits include discharges that are not from storm water runoff or from municipal sanitary bypasses. A summary of the types of industrial discharge permits is presented below:

TABLE 10
PERMITTED WPDES "INDUSTRIAL" DISCHARGERS-MMSD PLANNING AREA [1,2]

Permit Type	Number of Currently Permitted Facilities in Each Category	Percent of Permits (out of 306)
Carriage/Interstitial Water From Dredging	1	0.3%
Concrete Products Operations	10	3.3%
Contaminated Groundwater Remedial Actions	37	12.1%
Hydrostatic Test Water & Supply Systems	24	7.8%
Land Applying Liquid Industrial Wastes	2	0.6%
Non-contact Cooling Water	129	42.2%
Nonmetallic Mining Operations	7	2.3%
Petroleum Contaminated Water	17	5.6%
Pit/Trench Dewatering	1	0.3%
Potable Water Treatment & Conditioning	16	5.2%
Swimming Pool Facilities	30	9.8%
Individual Permits	32	10.5%

1) Source: WDNR; received via e-mail February 2003, with additional information provided April 12, 2004 and October 11, 2004. Note: The list of permitted facilities changes with time and can only be valid as of a particular date because facilities continually eliminate discharges and add new discharges. 2) Some of these permitted facilities may actually be municipalities, but the types of permitted discharges indicated in the table are of operations that are considered "industrial" in nature (i.e. are not from municipal sanitary overflows and bypasses, which are permitted separately).

Table 4-C (located in Appendix C) provides a summary listing of these permitted facilities. With the exception of the Individual Permits, all the permits listed in the above table are General Permits. General Permits are designed to cover discharges from a class of facilities or industries that are similar in nature. The sampling and discharge limits of the General Permits within each type are similar because the WDNR has determined that the discharges to surface and/or groundwater within a General Permit type are relatively similar. An Individual Permit is issued by WDNR when the facility's discharges are considered unique and do not fit into one of the general permit categories.

Many of these permits require the permitted facility to sample their discharges on a monthly, quarterly, or annual basis and submit the data to the WDNR in a report called a Discharge Monitoring Report (DMR). The parameters required for sampling depend on the type of permit. In order to streamline efforts, the 2020 Team elected to focus on obtaining data from the sources that we anticipate may create the largest impact on the surface water pollutants that are being modeled. These sources were identified as:

- Non-contact Cooling Water, and
- Individual Permits.

Non-contact cooling water discharges represent the largest percentage of the group of industrial type permits. The General Permit for non-contact cooling water covers discharges of non-contact cooling water, air conditioning condensate, and boiler blowdown (with no additives or with nontoxic additives). These sources generally discharge large amounts of water that might have an elevated temperature (create a heat load) and/or contain nutrients such as phosphorus and ammonia. All three of these pollutants are being modeled.

Individual Permits and Contaminated Groundwater Remedial Action Permits both represent the next largest number of permits (32 and 37, respectively). While sources permitted by Individual Permits may or may not discharge a large pollutant load, they were considered worthy of review because of their unique character. Individual Permits often cover facilities that have non-contact cooling water discharges along with additional sources such as contact cooling water.

Contaminated Groundwater Remedial Action Permits cover sources that discharge from remedial action operations where the extracted contaminated groundwater is treated for pollutant removal and where the covered discharges will not have significant impacts on receiving surface or groundwaters. These sources are required to monitor flow, TSS, lead and a variety of organic compounds that are not being modeled. Of these parameters, the 2020 Team is modeling only TSS. Because these sources are not expected to have significant impacts on surface water and TSS is the only monitored parameter being modeled, the 2020 Team elected not to obtain monitoring data for the Contaminated Groundwater Remedial Action permitted sources.

The sampling and monitoring parameters required by each of the other General Permits depend upon the type of discharges permitted. Most of the monitoring requirements and constituent limits required by the permits are not being modeled by the 2020 Team. While almost all of the General Permits require an estimate of flow and a measurement of TSS, the permits, however, typically limit the TSS discharge to 40mg/L. The permit for Petroleum Contaminated Water requires one annual grab for BOD. The Hydrostatic Test Water permit requires a monthly measurement of dissolved oxygen (DO) only if oxygen scavengers have been used, and the Swimming Pool Facilities permit required a monthly measurement of DO only if using chemical addition for chlorine removal. Both of these permits limit the DO to a minimum of 5-6 mg/l depending upon the location of the discharge. The 2020 Team elected not to obtain additional monitoring data at this time from these remaining industrial point sources because their pollutant loads are not expected to significantly impact the modeled surface water quality.

In addition to point source discharge permits, the WDNR also currently permits various types of storm water runoff discharges (non-point) to portions of the watersheds located within the MMSD Planning Area through its WPDES program as follows:

TABLE 11
PERMITTED STORM WATER DISCHARGERS- MMSD PLANNING AREA

Permit Type	Number of Currently Permitted Facilities in Each Category[1]
Municipal or Group Storm Water Permits	6 [2]
Storm Water Auto Parts Recycling	26
Storm Water Construction Site Permits	107
Storm Water Industrial Tier 1 Permits	37
Storm Water Industrial Tier 2 Permits	348
Storm Water Industrial Tier 3 Permits[3]	111
Storm Water Scrap Recycling	16

1 Source: WDNR; received via e-mail February 2003, with additional information provided April 12, 2004 and October 11, 2004. Note: The list of permitted facilities changes with time and can only be valid as of a particular date because facilities continually eliminate discharges and add new discharges. 2 There are six (6) permits is this category covering 13 communities/entities (some have individual permits and some are included in group permits-per WDNR 10/11/04 e-mail). 3 As of August 1, 2004 WDNR terminated Tier 3 permits. Facilities now submit a certificate of no exposure to storm water in lieu of a Tier 3 permit.

Table 5-C (located in Appendix C) provides a summary listing of these facilities permitted to discharge storm water. While some storm water runoff may be discharged through a pipe, conduit or outfall, storm water runoff is generally considered a non-point pollutant source for purposes of modeling. Tier 3 facilities are those that have certified that they do not have storm water exposed to industrial operations. With the exception of the Tier 3 permits, each permit type requires the facilities to prepare Storm Water Pollution Prevention Plans (SWPPPs) and implement Best Management Practices (BMPs) to reduce the potential contamination of storm water runoff from industrial (or construction) activities.

Most of these permits, such as the Construction Sites, Tier 2 and Tier 3 permits do not require routine sampling and analysis of storm water runoff and therefore no sampling data is available for these permitted facilities. While construction sites may possibly be a source of elevated TSS (if BMPs are not implemented correctly), there is no monitoring data for these sources and they are temporary, thus making it difficult to incorporate any associated loads into a model. The Tier 1 permitted facilities are only required to sample twice during the life of the permit. The Auto Parts Recycling and Scrap Recycling facilities are only required to sample storm water runoff if they do not elect a cooperative compliance arrangement with the WDNR.

There is little to no sampling data on the runoff characteristics of the permitted storm water discharges. The pollutant loads from the storm water runoff will be accounted for in the non-point source runoff incorporated in the HSPF model that calculates pollutant loads from storm water runoff based on land use categories. For these reasons, obtaining further pollutant discharge information regarding these permitted storm water sources was not pursued.

6.2. Non-Contact Cooling Water – General Permits

6.2.1. Description – Number, Location, Monitoring, Data Sources-

The 2020 team obtained 2002 DMR data compiled in an Microsoft Excel ™ spreadsheet from WDNR {Ted Bosch prepared for internal WDNR analysis} with chemistry and annual flow volumes for a large number of the non-contact cooling water discharges in the MMSD Planning Area. The original spreadsheet prepared by the WDNR did not contain all the permitted non-contact cooling water sources or in some cases only three of the four quarters of 2002. The 2020 team visited WDNR on several occasions to obtain chemistry and volume data from the WDNR paper files to complete the gaps in spreadsheet data. In order to streamline efforts, 2003 data was used when it was more readily available than 2002 data.

Most of the facilities discharge into a storm sewer that eventually leads to a river or tributary. The 2020 Team located the permitted sources by plotting the facility location on a topographic map, and assigning the river reach by locating the closest downstream tributary, and then the closest river reach.

The river reach designations of the non-contact cooling water discharges were based on the discharge location provided by the WDNR. Reach designations are discussed in the water quality calibration memos referenced at the end of this memo.

6.2.2. Chemistry

The General Permit for non-contact cooling water requires dischargers who discharge to surface waters to report the following to the WDNR:

Parameter	**Sample Frequency**
Flow (gallons per day)	Quarterly- Estimate
Temperature[1]	Quarterly-Grab
Total Suspended Solids [1,2]	Quarterly-Grab
PH [2]	Annually- Grab
Oil & Grease [3]	Annually- Grab
BOD_5 [1,3]	Annually- Grab
Total Phosphorus[1]	Annually- Grab
Ammonia Nitrogen [1,3]	Annually- Grab
Water Treatment Additives	Monthly- Record Usage

1: Indicates parameters being modeled
2: Applies only to discharges with boiler blow down or boiler bleed off
3: Permitted source may receive monitoring waiver from WDNR after 2 years of reporting

These are the parameters that the WDNR considers to be of concern for these types of discharges. Therefore, we assume that the concentrations for other pollutants being modeled are insignificant. The 2002 (or 2003) annual (or quarterly) average concentration for each discharger was used to calculate the point source loads for each discharger. On occasion, a discharger did not report all the pollutant parameters for a variety of legitimate reasons. In those instances, we used the flow-weighted average concentration of all the other permitted sources to represent the concentrations for the parameters not reported.

Nitrate, nitrite and organic nitrogen data is normally not available from these industrial point sources. Most of the non-contact cooling water comes from municipal water systems who obtain the water from Lake Michigan. Since there are no known cooling water additives that would alter the nitrate and nitrite concentrations in the municipal water, it is reasonable to use the nitrate and nitrite concentrations in the water supply to represent the concentrations in the non-contact cooling water. Based on data from the Milwaukee Water Works it was decided that the following concentrations were to be used to represent the non-contact cooling water (see Appendix H for more details):

- Nitrate: 0.3 mg/L
- Nitrite: 0 mg/L
- Organic Nitrogen: 0 mg/L

Based on the experience of the modelers, the 2020 Team also elected to use the following concentrations to represent industrial point sources other than non-contact cooling water.

- Nitrate: 3.0 mg/L
- Nitrite: 0 mg/L
- Organic Nitrogen: 1.0 mg/L

6.2.3. Volumes

Each of the permitted dischargers reported an average daily flow on a quarterly basis. From this data we calculated an overall daily average (average of the four quarterly reported values) for each discharger. For the purposes of modeling, the 2020 Team used the overall daily average and assumed that this daily flow was distributed evenly over every 15-minute period of each day, in order to create a 15-minute time series suitable for modeling (i.e. assumed that the flow discharged 24 hours per day, 7 days per week, 365 days per year at the constant daily rate).

6.2.4. Pollutant Loadings

For each discharger, a daily pollutant loading was calculated by multiplying the reported concentration by the average daily flow to obtain a daily load in pounds. This daily load was then distributed across a 15- minute increment as in the following example:

- BOD (lbs/day)= BOD (mg/L) * 10^6*(Flow MGD) * 3.785 L/gal* lb/453,592 mg, and

- BOD (lbs/15-minute period)= BOD (lbs/day)* day/24 hrs* hr/60 min * 15 mins

Once a 15-minute time series pollutant load was produced for each overflow location, the locations were plotted on a map using designated GIS locations and aggregated according to river reach.

For typical point sources, the modeling team assumed an average heat content of the industrial discharges since only grab samples for some of the dischargers exist from the DMR data. The temperature for each point sources was made a constant value based on the average temperature from DMR reports and calculated as above for the chemical constituents. Major thermal discharges (i.e. power plant cooling water) discharge directly to the estuary (or Lake Michigan) and were evaluated in the estuary model, as appropriate.

A few of the industrial dischargers take in river water for cooling instead of using City water. Based on a review of these industries, their discharges, the monitored parameters, and the methodology of using average DMR data it was assumed that this situation is of limited importance for the vast majority of discharges and resultant impact to the water quality model.

6.3. Specific/Individual Permits

6.3.1. Description – Number, Location, Monitoring, Data Sources

The 2020 team obtained DMR data for the Individual Permits who are required to monitor pollutant parameters that are being modeled. In order to streamline efforts, 2003 data was used when it was more readily available than 2002 data.

6.3.2. Chemistry

The monitoring parameters required by the Individual Permits vary depending on the source, although they are often similar to the Non-contact Cooling Water Permit requirements. The 2020 Team obtained flow and chemistry data of the parameters being modeled, where available.

6.3.3. Volumes

The volumes for the Individual Permits were treated in the same manner as the Non-contact Cooling Water Permits.

6.3.4. Pollutant Loadings

The pollutant loadings for the Individual Permits were developed in the same manner as the Non-contact Cooling Water Permits.

7. OTHER DISCRETE SOURCES

7.1. Purpose and Identification

The pollutant loads from storm water runoff (non-point) will be developed, for the most part, by the HSPF model and land use categories. The 2020 Team, however, determined that the runoff from some properties might not be completely characterized by the computer model due to their unique character. Several sites identified for further review and analysis were as follows:

- General Mitchell International Airport
- Milwaukee County Zoo
- Wisconsin State Fairgrounds
- Timmerman Airport
- Miller Park

The storm water discharges from the Wisconsin State Fairgrounds, Timmerman Airport and the Milwaukee County Zoo are currently in the process of being permitted by the WDNR through a permit for Milwaukee County. There is no current storm water runoff sampling data available from the WDNR for these sources. The WDNR anticipates issuing a permit to Milwaukee County in the next year.

General Mitchell International Airport

The northern portion of General Mitchell International Airport (GMIA) drains to Wilson Park Creek (which flows into the Kinnickinnic River) and the southern portion of GMIA drains to Oak Creek. Storm water leaves GMIA property and drains into Wilson Park Creek near the intersection of Howell and Layton Avenues (designated as outfall #07) and into the Holmes Avenue Tributary (to Wilson Park Creek, designated as outfall #01)-. Storm water leaves GMIA and drains into Oak Creek near Rawson Avenue (designated as outfall #03c).

The storm water runoff from the GMIA has been studied extensively for approximately the past ten years. A study performed in 1995 (Technical Memorandum from CDM to Milwaukee County Department of Public Works entitled "General Mitchell International Airport Pollutant Load Calculations", dated May 1, 1995) showed that the quality of the storm water runoff during non-deicing conditions is comparable to typical urban runoff.

The concerns from the GMIA storm water discharges, however, stem from the runoff (rain and snowmelt) during cold weather (primarily November to April) when the airport uses deicing chemicals that contain ethylene and propylene glycol. These chemicals (particularly propylene glycol) can create an oxygen demand in the receiving water and can be toxic to aquatic life in high concentrations. Samples collected from runoff at GMIA have exhibited BOD concentrations in excess of 1,000 mg/L BOD, which are two to three orders of magnitude higher than typical urban runoff (Corsi, Steve et al. "Aircraft and Runway Deicers at General Mitchell International Airport, Milwaukee, Wisconsin, USA, 1. Biochemical Oxygen Demand and Dissolved Oxygen in Receiving Streams". Environmental Toxicology and Chemistry, Vol. 20, No.7, pp 1474-1482, 2001.)

The GMIA has instituted extensive efforts since 2000 to manage and reduce the deicing runoff that enters Wilson Park Creek. The GMIA provided the 2020 Team with instream water quality data for two locations in Wilson Park Creek near GMAI (outfalls #01 and #07) and for one location in Wilson Park Creek just before it joins the Kinnickinnic River main stem (at St. Luke's Medical Center). The data was from February 1997- April 2003. While instream data has been collected, no water quality data of the actual runoff from GMIA has been taken in recent years.

While the instream data still exhibits elevated BOD levels at all three locations (up to 39,000 mg/l at #01), the DO levels at the St. Luke's location were generally above 5 mg/L. The DO values, however, ranged from 1.1 to 23 mg/L (note: DO is not continuously recorded and only recorded at the St. Luke's location, not at #01 or #07). This wide fluctuation is indicative of a surface water that has high nutrient content and resulting algae blooms. The instream DO levels just after the Wilson Park Creek joins the Kinnickinnic River (MMSD sampling location RI-12) range between 6 to 20 mg/l (1994-2001 data) and the BOD levels range between 0 to 9.6 mg/L. The Kinnickinnic River has a long history of dissolved oxygen problems, especially in the lower reaches closer to Lake Michigan. These problems, however, are likely due to numerous factors including the extensive urbanization of the watershed and channelization of the watercourses.

The 2020 Team created special point source loads to ensure that the model captures the additional BOD load coming from Wilson Park Creek (See Appendix G for SEWRPC memo dated January 14, 2005 for the impetus to develop this loading). Using in stream concentration and flow data from GMIA, daily BOD and COD loads during de-icing events were estimated as follows:

TABLE 12
RECOMMENDED BOD AND COD LOADINGS FOR WILSON PARK CREEK DURING DE-ICING EVENTS[1]

Outfall Location	BOD (lb/day)	COD (lb/day)
Outfall 001	426	210
Outfall 007	2598	1450

[1]Calculated from daily geomean in stream loading values based on 1997-2003 data for both BOD and COD from GMIA. A more complete summary of data is shown in Appendix I to this memo.

Research to find out what criteria are used to decide to de-ice a plane was performed to determine when to apply these loads. The following information was collected from numerous internet sources regarding when a plane is de-iced:

1) According to 14 CFR Parts 121, 125 and 135 pilots are prohibited from takeoff when frost, ice or snow is adhering to wings, control surfaces, or propellers. The decision to deice and to takeoff is ultimately made by the Pilot in Command (PIC).

2) The determination to deice is primarily based on a visual and/or physical inspection of the aircraft surfaces by pilot and/or ground crew. Other information such as current and predicted weather, visibility and icing conditions are used by the pilot.

3) More than 30 factors have been identified that can influence whether ice, snow, or frost can accumulate and cause problems on the aircraft surfaces. They include ambient temperature, aircraft surface temperature, deicing fluid type, solar radiation, deicing fluid temperature and concentration, relative humidity, wind velocity, wind direction, precipitation intensity, and amount of water in the snow (melted liquid-equivalent snowfall rate).

4) Deicing/anti-icing is used in greatest quantities when the ambient temperature is near or below freezing and there is heavy (or wet) accumulating snow or ice falling or forming on surfaces. Relatively small volumes are required for dry, powdery snow conditions. Rain at or near freezing temperatures may also require significant deicing/anti-icing as a precaution. Freezing rain is said to require the highest volume of deicer.

4) The decision to deice and how long they can hold plane after deicing before taking off is so critical and complex that the FAA has developed a computerized Weather Support to Deicing Decision Making (WSDDM) software program that has been used in pilot programs at various airports.

Because of the complexity of the decision making to de-ice, it is not possible to accurately mimic when de-icing chemicals are applied. Since ice cannot form much above 32F, and we would not expect it to form too often when there is no precipitation, we felt that a simple rule of applying the BOD/COD load on entire days where the average temperature is 32F or below and when there is precipitation recorded for that day would capture the bulk of the days and times where deicing will occur. This rule may underestimate on some days and overestimate on others, but should balance out over a winter season. Therefore for purposes of modeling, the following rule was created to when to apply the daily load to the model:

- Apply the BOD/COD loading for the entire day when the daily average temperature is 32F or below and when there is measured precipitation for the day.
- Apply the loading values as presented in the above table for the entire day that meets the above criteria at Outfall 001 and Outfall 007 (not at St. Luke's location).

Milwaukee County Zoo

Due to daily cleaning of the animal enclosures, it was suspected that the Milwaukee County Zoo may present a larger load of bacteria, nutrients, and TSS than would be calculated by the model (based on its land use category of a park). A storm water management plan that estimated nonpoint source pollutant loadings was created for the zoo in 1998. (*Milwaukee County Zoological Gardens- Stormwater Management Plan*, Woodward-Clyde, July 1998)The zoo, however, has recently made significant changes to storm water management practices that may have improved the quality of the storm water runoff in the past several years including:

- Adding covers to trash dumpsters,
- Directing the wash down of vehicles to the sanitary sewer,
- Directing the runoff from Monkey Island to the sanitary sewer,
- Directing the "1st flush" of Dahl Sheep exhibit to the sanitary sewer, and
- Directing Elk yard & Pony yards to sanitary sewer (Planned for 2004)

There is no current storm water runoff data available from the WDNR for the zoo. During 2002 and 2003, the MMSD sampled Underwood Creek (which flows into the Menomonee River). Underwood Creek receives storm water runoff and animal enclosure wash-off from the zoo. In addition, the MMSD has taken samples of storm water runoff in the vicinity of the zoo during 2000-2003 as part of a comprehensive storm water sampling program in the MMSD Planning Area. The MMSD storm water data (2000-2003) taken from the runoff from the zoo indicates that the pollutant concentrations in the zoo runoff are similar to those in typical urban runoff analyzed in other parts of the Planning Area. In addition, the instream MMSD water quality data for Underwood Creek (DO, total N, total P, and fecal coliform), does not show an increase in the pollutant levels at the sampling point just downstream of the zoo runoff discharge location.

For these reasons, no separate loading factors will be developed for the zoo. The 2020 team may, however, elect to revise the land use category designated in the model to reflect urban runoff from impervious areas rather than a type of parkland (currently assigned to the zoo).

Wisconsin State Fairgrounds and Timmerman Airport

According to the "Storm Water Pollution Prevention Plan prepared for Lawrence J. Timmerman Airport" [Mead & Hunt, November 1998], the Timmerman Airport uses a minimal amount of glycol (one 55-gallon drum per year) for deicing and therefore the runoff from Timmerman is not expected to be significantly different from urban runoff.

The Wisconsin State Fairgrounds may present increased bacterial and nutrient pollutant loadings during times of the year when animals are housed at the grounds. Currently, there is no information regarding storm water runoff from the State Fairgrounds and therefore appropriate adjustments to the model cannot be made to reflect the runoff from the State Fairgrounds.

Miller Park

Questions were raised by some members of the 2020 Team regarding the pollutant loads to the Menomonee River from storm water discharges at Miller Park (due to the tailgating activities that occur before and during a game). Miller Park (Southeastern Wisconsin Professional Baseball Park District) has applied to WDNR for a NR 216 storm water permit. SLAMM Modeling was performed as a part of the permit application. A summary of the SLAMM modeling (page 10 of 15 of permit application) shows that the pollutant concentrations and annual loadings (with street sweeping and controls in place) are expected to be similar to typical urban runoff.

Appendices

A- CSO & SSO Pollutant Concentrations for Purposes of Watercourse Modeling, Technical Memorandum, December 13, 2004

B- Point Source Times Series Production, Technical Memorandum, April 9, 2004.

C- Inventory Information
- Table 1-C MMSD SSO Locations
- Table 2-C MMSD CSO Locations
- Table 3-C Local Community SSO Locations
- Table 4-C Industrial WPDES Permitted Facilities
- Table 5-C Permitted Storm Water Dischargers

D- SEWRPC Memorandum – February 5, 2004 – Draft memo of CSO & SSO Pollutant Concentrations for Purposes of Water Quality Modeling – Dated October 29, 2003 [Addresses nitrogen species concentration development in MMSD's CSOs and SSOs]
E- SEWRPC Memorandum –February 23, 2004– Draft memo of CSO & SSO Pollutant Concentrations for Purposes of Water Quality Modeling – Dated October 29, 2003 [Addresses zinc and copper concentration development in MMSD's SSOs]
F- SEWRPC Letter–May 12, 2004– Completed Review of April 9, 2004 "Point Source Loading Calculations for Purposes of Watercourse Modeling".
G- SEWRPC Letter January 14, 2005- SEWRPC Staff Comments "Draft MMSD 2020 FP/RWQMP Technical Memorandum: Point Source Loadings Calculations for Purposes of Watercourse Modeling Dated December 13, 2004.
H-SEWRPC Technical Memorandum –December 7, 2005- Point Source Loadings Calculations for Purposes of Watercourse Modeling-Addendum No. 3: Consideration of Chicago, Illinois CSO Concentration Data, Nitrogen Concentrations to be Used for Point Sources, and LeSaffre Yeast Corporation Loads.
I- Summary of GMIA BOD COD Loading Data 1997-2003.
J-SEWRPC Technical Memorandum- March 28, 2005- Point Source Calculations for Purposes of Watercourse Modeling-Addendum: Point Sources Located Outside of the MMSD Planning Area.
K-SEWRPC Technical Memorandum- June 28, 2005- Point Source Calculations for Purposes of Watercourse Modeling-Addendum No 2: Point Sources Located Outside of the MMSD Planning Area Under Planned 2020 Conditions.

Other References/Support Documentation

United States Environmental Protection Agency, Preliminary Data Summary Airport Deicing Operations (Revised), EPA-821-R-00-016, August 2000.

Tetra Tech Water Quality Calibration Memos and GIS reference files:

- Revised Water Quality Calibration Results for the Menomonee River (Task 4) (May 10, 2005)
- Draft Water Quality Calibration Results for the Kinnickinnic River (Task 4) (June 1, 2005)
- Revised Water Quality Calibration Results for the Oak Creek (Task 4) (July 5, 2005)