memo

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Date |	April 18, 2012		
To |	Mike Vavricka	**Contact info |**	
cc |		**Contact info |**	
From |	Nancy-Jeanne LeFevre Cecilio Olivier	**Contact info |**	
Regarding |	Point Sources and Atmospheric Deposition per Task 3 of the Mustinka River (09020102) & Bois de Sioux River (09020101) HSPF Model Work Plan		

This memo illustrates the methods used to formulate timeseries records for minor point sources and atmospheric deposition in the Mustinka and Bois de Sioux Watersheds. Files associated with this deliverable have been uploaded to our ftp site. You can access them as follows: ftp://ftp.eorinc.com – username: MPCA, password: waterquality, folder: *Mustinka_BoisdeSioux_HSPF*.

Minor Point Source Daily Timeseries Formulation

A total of eight minor point sources are included in the model as daily timeseries (Table 1). All of these systems are pond systems that discharge discrete volumes a few times a year. The Big Stone Co. Hutterite Colony facility appears to service feedlot wastewater. All of the other pond systems appear to service domestic municipal wastewater exclusively. Data from DMRs were converted to daily timeseries for the following constituents:

- Flow Volume (AF), last digit of the DSN = 0
- Heat (BTU), 3
- Dissolved oxygen (lb), 5
- Ultimate BOD (lb), 2
- Nitrate (lb), 7
- Nitrite (lb), 8
- Total ammonia nitrogen (TAM) (lb), 1
- Organic nitrogen (lb), 9
- Total inorganic phosphorus (lb), 6
- Organic phosphorus (lb), 0
- Organic carbon (lb), 2
- Silt (ton), 1
- Clay (ton), 4

In the list above, the last digit of the 4-digit DSN is indicated for each constituent. Since there are 13 constituents, the last digit is repeated in three cases (i.e. two 0s, two 1s, two 2s). The first three digits of the DSNs are the RCHRES to which the point source discharges. Therefore, for those duplicate last-digits, 300 was added to the 3-digit preceding RCHRES number so as to maintain unique DSNs. For instance, the BOD timeseries that discharges to RCHRES 343 has a DSN of 3432 and the organic carbon timeseries that discharges to the same reach has a DSN of 6432.

The following descriptions illustrate the approach and data sources used for converting minor point source (WWTF) monthly discharge monitoring reports (DMRs) to daily timeseries.

Flow Volume

Typically, the total number of days of flow and the total volume of flow was reported monthly in the discharge monitoring reports (DMR). Daily flow was then calculated by simple division. Flow was assumed to begin on the first of every month (of months having flow) at the daily average rate and continue the total number of days of discharge, as recorded on the DMR. In some cases, flow data was missing (e.g. the month did *not* have a label of 'no discharge' and water quality parameters were measured, but flow data was not reported). In these cases, missing flow values were replaced with values from the same season (e.g. adjacent month), or the same season in an adjacent (or nearest) year. This assumption was deemed reasonable given the cyclic nature of discharge exhibited in the DMRs. All unmeasured flow having the comment 'Lagoon Processing' and no water quality values reported were assumed to have zero flow.

Heat

No temperature data was available from any of the WWTF DMRs. However, Richard and Hutchins (1995) reported on municipal lagoon effluent temperatures in the small, cold-climate, Rocky Mountain community of Winter Park, CO. Average monthly effluent temperatures ranged from less than 34°F to 64°F, with average monthly temperatures in December through February of less than 34°F. This information was used to estimate the following average monthly temperatures for the WWTFs:

- January: 34°F
- February: 34°F
- March: 45°F
- April: 50°F
- May: 55°F
- June: 60°F
- July: 62°F
- August: 64°F
- September: 62°F
- October: 55°F
- November: 45°F
- December: 34°F

Discharge volume and the specific heat capacity of water were used to convert temperature to BTU.

Dissolved Oxygen

Typically, dissolved oxygen was reported in the DMRs as calculated monthly minimum. These reported monthly values were used as daily values for the timeseries of the respective months. In some discharge months, dissolved oxygen data was not reported. In these cases, missing values were replaced with values from the same season (e.g. adjacent month), or the same season in an adjacent (or nearest) year. This assumption was deemed reasonable given the cyclic nature of discharge exhibited in the DMRs.

Ultimate BOD

Typically, carbonaceous biochemical oxygen demand (CBOD) was reported in the DMRs as calculated monthly average. It is not uncommon for the CBOD of municipal lagoon systems to equal (or be within 10-20% of) ultimate BOD (Richard 2003). Reported monthly average CBOD values were used as daily values for the timeseries of the respective months. In some discharge months, CBOD data was not reported. In these cases, missing values were replaced with values from the same season (e.g. adjacent month), or the same season in an adjacent (or nearest) year. This assumption was deemed reasonable given the cyclic nature of discharge exhibited in the DMRs.

Nitrogen

No nitrogen data was available from any of the WWTF DMRs. Therefore, literature values and values for related constituents were used to make reasonable estimates. Nitrite and nitrate concentrations were estimated to be 2.5 mg/L and 15 mg/L, respectively, based on typical ranges in lagoon effluent concentrations reported by Ripple (2003). The estimated nitrate concentration was also based on the fact that dissolved oxygen concentrations at the lagoons tend to be high.

For the municipal lagoon systems, ammonia (NH_4^+) and organic nitrogen were estimated based on literature values for medium strength untreated wastewater (Ripple 2003), which were then diluted by the same ratio as the literature values for untreated wastewater BOD to the reported effluent BOD values from the WWTF DMRs. Ammonium (NH_3) was estimated based on ammonia using the dissociation constant $K_a = 10^{-9.25} = [NH_3][H^+]/[NH_4^+]$. This equation assumes an activity coefficient of 1.0 since data regarding the ionic strength of lagoons was not found. This assumption may result in an underestimate of ammonium. Total ammonia nitrogen (TAN, $NH_4^+ + NH_3$) was then calculated through simple addition.

For the Big Stone Co. Hutterite Colony facility, which treats feedlot runoff, ammonium and organic nitrogen were estimated based on literature values for swine manure lagoon sludge (Chastain et al. 2003). Values were then diluted by the same ratio as literature values for swine manure lagoon sludge phosphorus to the reported effluent phosphorus values from the facility DMR. Ammonia was then estimated based on ammonium using the same dissociation constant expressed in the preceding paragraph. Total ammonia nitrogen (TAM, $NH_4^+ + NH_3$) was then calculated through simple addition.

These methods resulted in estimated concentrations for organic nitrogen, ammonium, ammonia, and total ammonia nitrogen as illustrated in Table 2.

Phosphorus

Typically, monthly average total phosphorus was reported in the DMRs for each month exhibiting discharge. Any missing values during discharge periods were replaced with values from the same season (e.g. adjacent month), or the same season in an adjacent (or nearest) year. This assumption was deemed reasonable given the cyclic nature of discharge exhibited in the DMRs. Inorganic and organic phosphorus were determined based on total phosphorus using the following relationship: organic P = 0.17*inorganic P. This relationship was found to be consistent with ratios derived from data from the Water Environment Federation and American Society of Civil Engineers as cited in The EPA Municipal Nutrient Removal Technologies Reference Document (USEPA 2008).

Organic Carbon

Lagoon effluent data for organic carbon was not found. However, U.S. Fish and Wildlife Service data identified BOD/TOC ratios for the effluent of northern wastewater treatment wetlands (as cited in Kadlec and Wallace 2009). The low-end of these values was used (a ratio of 0.15), in order to estimate TOC from BOD values reported in the WWTF DMRs.

Silt and Clay

Silt and clay were assumed to exist at a ratio of 50/50 in reported TSS values. Typically, monthly average total suspended solids concentrations were reported in the DMRs for each month exhibiting discharge. Any discharge months missing TSS values were replaced with values from the same season (e.g. adjacent month), or the same season in an adjacent (or nearest) year. This assumption was deemed reasonable given the cyclic nature of discharge exhibited in the DMRs.

Deliverables: updated HSPF model files Must_BDS.uci (FLOW is incorporated in model runs, but HSPF water quality modules remain inactive), PointSource.wdm

Table 1. Minor point sources explicitly modeled in HSPF.

Name	Surface Discharge Station	Permit No.	RCHRES
Big Stone Co. Hutterite Colony	SD-1	MNG580168	343
Campbell WWTF	SD-1	MN0020915	205
Dumont WWTF	SD-2	MN0064831	338
Elbow Lake WWTF	SD-1	MNG580082	316
Graceville WWTF	SD-2	MNG580159	341
Herman WWTF	SD-3	MNG580177	325
Wendell WWTF	SD-1	MN0051501	318
Wheaton WWTF	SD-3	MN0047287	306

Table 2. Nitrogen concentration estimates - organic, ammonium, ammonia, TAM.

Name	Surface Discharge Station	Organic Nitrogen [mg/L]	Ammonium [mg/L]	Ammonia [mg/L]	Total Ammonia Nitrogen, (TAM, $NH_4^+ + NH_3$) [mg/L]
Big Stone Co. Hutterite Colony	SD-1	0.41	1.0	7.8E-6	1.0
Campbell WWTF	SD-1	2.5	5.3	1.5	6.8
Dumont WWTF	SD-2	2.8	19	1.7	21
Elbow Lake WWTF	SD-1	2.2	4.6	1.3	5.9
Graceville WWTF	SD-2	1.2	6.4	0.72	7.1
Herman WWTF	SD-3	1.4	72	0.81	73
Wendell WWTF	SD-1	1.2	10	0.74	11
Wheaton WWTF	SD-3	2.8	15	1.7	17

Atmospheric Deposition Timeseries Formulation

Dry and wet atmospheric deposition of nitrate (NO_3) and ammonium (NH_4) were obtained for the HSPF model. Dry deposition data were obtained from the USEPA Clean Air Status and Trends Network (CASTNET) at the site nearest the project watershed, which was Perkinstown, WI (Taylor County, Station ID PRK 134[1]). Data were converted from total weekly into a daily timeseries (mass per unit area). Wet deposition data were obtained from the National Atmospheric Deposition Program, National Trends Network (NTN) as an average monthly timeseries (concentration), which was converted into a daily timeseries. Data are from the site nearest the project watershed, which was

[1] http://www.epa.gov/castnet/javaweb/site_pages/PRK134.html

Camp Ripley, MN (Morrison County, Station ID MN23[2]). The dry and wet deposition data were entered into the EXTNL sources block as NIADFX and NIADCN (PERLND), NUADFX and NUADCN (IMPLND), and IQADFX and IQADCN (RCHRES), respectively. TSTYPES (and DSNs) were identified as DNO3 (3311), DNH4 (3210), WNO3 (4311), WNH4 (4210), which signifies dry deposition of nitrate (lb/ac), dry deposition of ammonium (lb/ac), wet deposition of nitrate (mg/L), and wet deposition of ammonium (mg/L), respectively. The DSN first digit indicates 3 for dry and 4 for wet, the second and fourth digits are odd for NO3 and even for NH4, the third digit is 1 indicating a daily timeseries.

Deliverables: updated HSPF model files Must_BDS.uci, updated met.wdm (including all atmospheric deposition)

References

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USEPA (United States Environmental Protection Agency). 2008. *The EPA Municipal Nutrient Removal Technologies Reference Document*. EPA-832-R-08-006.

[2] http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=MN23&net=NTN