memo

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Date |	April 3, 2012		
To |	Mike Vavricka	**Contact info |**	
cc |		**Contact info |**	
From |	Nancy-Jeanne LeFevre Cecilio Olivier	**Contact info |**	
Regarding |	Model Framework Memo: Final Task 2 deliverable of the Mustinka River (09020102) & Bois de Sioux River (09020101) HSPF Model Work Plan		

Since our last monthly memo (February 27, 2012), the HSPF model has been updated to incorporate initial parameterization for PWATER, IWATER and HYDR, specific cross-section geometry in all reach FTables, reservoir operation of Lakes Traverse and Mud, flow from minor point sources, and observed flow .wdm file. The model successfully executes and the WinHSPF interface is usable for model editing. This memo describes the model framework and is the final deliverable of Task 2. Much of the information contained in this model framework memo was presented in previous monthly updates; this memo and the associated files replace all the in-progress memos and files previously submitted.

Files associated with this monthly update have been uploaded to our ftp site. You can access them as follows: go to ftp://ftp.eorinc.com – username: MPCA, password: waterquality, folder: *Mustinka_BoisdeSioux_HSPF*.

Met Data and Met Segmentation

Data (Table 1) were available from 13 unique combinations of precipitation gages, meteorological gages (cloud cover, dewpoint temperature, solar radiation, and wind speed) and temperature gages. The majority of these data were available from the BASINS data inventory. Some daily precipitation data were obtained from the State of Minnesota Soil and Water Conservation District and were disaggregated to hourly timesteps using the nearest five hourly BASINS records. The hour of observation was assumed to be 8 am, and a disaggregation tolerance of 0.5 was used.

Met segments were identified by first assigning to each watershed the closest precipitation and meteorological gages. Then, each individual met segment was evaluated such that the 19 met segments were reduced to only 13 met segments (for HSPF modeling manageability). From there, the nearest temperature gage was assigned to each met segment. Penman Pan PEVT calculations were conducted using the WDM utility for each met segment. Temperature and meteorological gages corresponding to each met segment were used in the PEVT calculations. The final met segmentation scheme is summarized in Table 1.

Data set numbers in the .wdm were assigned according to the following numbering schemes:

- First two digits represent the met segment such that met segment A = 11, B = 12, …, M = 23
- Second two digits represent the parameters:
  - 01 PREC
  - 02 EVAP
  - 03 ATEM
  - 04 WIND
  - 05 SOLR
  - 06 PEVT
  - 07 DEWP
  - 08 CLOU
  - 09 TMAX
  - 10 TMIN
  - 11 DWND
  - 12 DCLO
  - 13 DPTP
  - 14 DSOL
  - 15 DEVT
  - 16 DEVP

Table 1. Meteorological segmentation scheme.

Met Segment Code	Precipitation Gage[1]	Meteorological Gage (cloud cover, dewpoint temperature, solar radiation, and wind speed)[1]	Temperature Gage[1]
A	MN211063	MN727533	MN211063
B	239606_5	MN727533	MN727533
C	239606_5	MN726565	MN726565
D	MN215638	MN726565	MN726565
E	MN218907	MN727533	MN218907
F	MN218947	MN727533	MN218947***
G	228730_5	MN727533	MN211245*
H	MN211245°	MN726560	MN211245**
I	229871_5	MN726560	MN211245**
J	MN216228	MN726560	MN726560
K	SD398652	MN727533	SD398652
L	ND325186	MN727533	SD398652
M	SD397742	MN727533	SD397742

[1] Gages beginning with a two-letter state abbreviation are from the BASINS inventory of meteorological records; gages beginning with numbers are from the State of Minnesota Soil and Water Conservation District records obtained from the State Climatologist Office (stations are identified by the utm x-value and the first number of the utm y-value).
* Supplemented with MN218947 for 2006/2/1 through 2006/12/31
** Supplemented with MN726560 for 2006/2/1 through 2006/12/31
*** Supplemented with MN218907 for 1995/1/1 through 2000/2/29
° Supplemented with 228730_5 for 2005/12/30 through 2006/12/31

Land Cover / Land Segmentation

Land segmentation (land cover) was completed based on the methodology presented in the Tetra Tech memo (dated December 15, 2008) and the conference call with MPCA on December 22nd, 2011. The watershed is 81% agricultural. Data sets used for land segmentation are:

- 2006 National Land Cover Dataset reclassified according to Section 3.1 of the Tetra Tech memo
- USGS STATSGO2 - The dominant HSG for each map symbol was determined based on the HSG having the highest total percent of the map unit.
- Bois de Sioux Watershed District 5-m DEM (agree_dem grid) – Slope was calculated for each DEM grid cell using Spatial Analyst in ArcMap.

The project-wide distribution of the land covers is presented in Table 2.

Table 2. Project-wide summary of land cover.

Land Cover* (Cover - Hydrologic Soil Group - Percent Slope)	Square Miles	% Area
Other-CD-0to2%	753	38%
Other-AB-2.1+%	366	19%
Other-AB-0to2%	351	18%
WETL	107	5.5%
DEV	98	5.0%
Water	77	3.9%
Other-CD-2.1+%	62	3.2%
Sugarbeets-CD-0to2%	49	2.5%
GRASS-AB-0to6%	30	1.5%
GRASS-AB-6.1+%	22	1.1%
GRASS-CD-0to6%	16	0.82%
FOREST	15	0.76%
Sugarbeets-AB-0to2%	8.3	0.42%
GRASS-CD-6.1+%	4.9	0.25%
Sugarbeets-AB-2.1+%	1.8	0.092%
BARREN	0.90	0.046%
Sugarbeets-CD-2.1+%	0.48	0.024%
Total	**1,962**	**100%**

* 'Other' stands for crops other than sugarbeets, mainly corn, soybeans, and spring wheat.

Deliverables: met.wdm, metsegments2012Feb21.jpg, landcover_segs.shp, landcover_segs.tif, landcover_segs.jpg

Subwatershed Delineation

The Bois de Sioux Watershed District consultant provided a detailed watershed delineation throughout the project area using a LiDAR-based 5m DEM and field reconnaissance (WSN 2011). These watersheds, which are relatively small, were aggregated to the HUC 12 scale for the purposes of HSPF modeling. The BASINS automatic delineation tool was used to refine delineation to lake areas, flow monitoring locations, and critical stream confluences, as applicable. In the future water quality phase of this project, additional delineation to water quality monitoring stations may be needed.

Deliverables: subbasins2012Feb17.shp

Lake Representation

Lake Selection

A lake analysis was conducted in order to determine which lakes to model explicitly in HSPF. The analysis was conducted according to the RESPEC memo provided by MPCA dated March 17, 2011. Ultimately, twelve lakes were selected to be included in the Mustinka-Bois de Sioux HPSF model: all lakes are in Minnesota. Table 3 shows each lake that is modeled in HSPF; lakes are categorized by the criteria (decision points) that were identified in the RESPEC memo. Shapefiles containing the National Hydrography Dataset and MNDNR layers of the modeled lakes are enclosed.

Lake FTable Development

The Bois de Sioux Watershed District HEC-HMS model included stage-area-discharge curves for the lakes (WSN 2011). These summaries included live *and* dead storage for only one of the lakes (Big Lake). HEC-HMS data for nine of the lakes includes live storage only. Dead storage (lake bathymetry/stage-area-discharge data at elevations below where discharge occurs) was estimated using best available data as described below and summarized in Table 4. Mud and Traverse Lakes were modeled based on USACE reservoir operations (refer to *Reservoir Operation* in the next section).

MNDNR bathymetry data was prioritized for use in estimating dead storage. MNDNR bathymetry data was available for three lakes. For the remaining lakes, the topography of the live storage was extrapolated below the water surface. Maximum depth was estimated based on MNDNR Lake Finder data, if available. Else, the depth of the lake was estimated at six feet; this value is roughly based on similar area lakes. In all cases, the surface of the lake was based on HEC-HMS stage-area-discharge data, where discharge equals zero.

Deliverables: lakes_HSPF_MNDNR.shp, lakes_HSPF_NHD.shp, Must_BDS.uci (FTables)

Table 3. Lakes explicitly modeled in HSPF according to the RESPEC memo methodology (dated March 17, 2011).

<table>
<tr><th>Decision Points and Corresponding HSPF Model Lakes</th><th>No. of HSPF Lakes</th></tr>
<tr><td>Impaired lakes on MPCA's draft 2010 list (excluding mercury impairments & N and S Dakota impairments): none</td><td>0</td></tr>
<tr><td>NHD lakes greater than 350 acres and intersect a primary reach:
<table>
<tr><th>NHD Name</th><th>NHD Reach Code, 902010…</th><th>NHD Acres</th><th>DNR ID</th></tr>
<tr><td>East Toqua Lake</td><td>2000817</td><td>430</td><td>6-138P</td></tr>
<tr><td>Lightning Lake</td><td>2000654</td><td>520</td><td>26-282P</td></tr>
<tr><td><s>Cottonwood Lake</s>[1]</td><td><s>1001129</s></td><td><s>600</s></td><td><s>N/A (SD)</s></td></tr>
<tr><td>[unnamed]</td><td>1002971</td><td>2,400</td><td>78-24P</td></tr>
<tr><td>Lake Traverse</td><td>1001245</td><td>11,000</td><td>78-25P</td></tr>
</table></td><td>4</td></tr>
<tr><td>NHD lakes that do not intersect a primary reach but are greater than 600 acres: none</td><td>0</td></tr>
<tr><td>Special Exceptions – Lakes that were identified in the BdSWD Management Plan (all are greater than 160 acres):
<table>
<tr><th>DNR Lake Name</th><th>DNR ID</th><th>NHD Reach Code, 902010…</th></tr>
<tr><td>Big</td><td>26-194P</td><td>2000724</td></tr>
<tr><td>Cottonwood Lake</td><td>26-185P</td><td>2000764</td></tr>
<tr><td>Elbow</td><td>26-140P</td><td>2000914</td></tr>
<tr><td>Fish</td><td>75-277P</td><td>2000794</td></tr>
<tr><td>East Niemacki Lake (NHD: Niemackl Lakes)</td><td>26-213P</td><td>2000747</td></tr>
<tr><td>Round</td><td>26-149P</td><td>2000915</td></tr>
<tr><td>Upper Lightning</td><td>56-957P</td><td>1000869</td></tr>
<tr><td>West Toqua</td><td>6-137P</td><td>2000826</td></tr>
</table></td><td>8</td></tr>
<tr><td>TOTAL</td><td>12</td></tr>
</table>

[1] Bathymetry data is not available for Cottonwood Lake in SD. In addition, it is surrounded by a wetland complex and appears to be a shallow lake (borderline wetland) system. Cottonwood Lake ultimately discharges to Traverse Lake. Cottonwood Lake in SD is not explicitly modeled in HSPF.

Table 4. Lake FTable data sources.

Lake Name	DNR Public Water Inventory Number	Data Source	
		Live Storage	Dead Storage
Big	26-194P	HEC-HMS	HEC-HMS
Cottonwood	26-185P	HEC-HMS	MNDNR
East Niemackl	26-213P	HEC-HMS	Bathymetry: adjacent topography Max Depth: 6 feet
East Toqua	6-138P	HEC-HMS	MNDNR
Elbow	26-140P	HEC-HMS	Bathymetry: adjacent topography Max Depth: 6 feet
Fish	75-277P	HEC-HMS	Bathymetry: adjacent topography Max Depth: 6 feet
Lightning	26-282P	HEC-HMS	MNDNR
Mud[1]	78-24P (Mud)	USACE 1994	USACE 1994
Traverse[1]	78-25P (Traverse)	USACE 1994	USACE 1994
Round	26-149P	HEC-HMS	Bathymetry: adjacent topography Max Depth: 6 feet
Upper Lightning	56-957P	HEC-HMS	Bathymetry: adjacent topography Max Depth: 6 feet
West Toqua	6-137P	HEC-HMS	Bathymetry: adjacent topography Max Depth: MNDNR

[1] Refer to *Reservoir Operation* (Page 7) for details.

Reservoir Operation

Lake Traverse discharges into Mud Lake, which discharges into the Bois de Sioux River. The U.S. Army Corps of Engineers, St. Paul District, Water Control Manual describes reservoir operation (USACE 1994). Lake Traverse is regulated at Reservation Dam, which is a rolled-earth fill dam with 17 stoplog bays (aerial photograph in Figure 1). There is no low flow outlet. Lake Traverse conservation pool elevation is 976 (Mean Sea Level 1912 vertical datum, used throughout this description), which is maintained at 976.8 throughout the recreational season to account for evaporation. Winter drawdown to 975.5 or 974.5 begins March 1 and is completed by March 31 to allow storage for spring floods. The specific drawdown elevation is determined based on snow-water content in the watershed (if greater than 3 inches by late February, drawdown is maximized). In the spring when the pool elevation rises to 976.8, all stoplogs are removed and Lake Traverse and Mud Lake operate as one reservoir until spring flooding concludes.

Mud Lake is regulated at White Rock Dam (sometimes referred to as Mud Lake Dam), which is a rolled-earth fill dam having three reversed Tainter gates (aerial photograph in Figure 2). White Rock Dam also has 2-foot diameter low-flow gate in the center bulkhead (low flow agreement with DNR in Table 5). Mud Lake conservation pool elevation is 972.0 during the recreation season. During periods of low flow and winter operation, the two outer Tainter gates are closed and a bulkhead is installed in the center stoplog slot. The middle Tainter gate is left open. During March drawdown of Lake Traverse, Mud Lake continues to be held to 972.0. There is no winter drawdown of Mud Lake[1]. During flood control, Mud Lake pool elevation is controlled to an elevation of 981.0. If Mud Lake exceeds 981.0 during flood control, the gates open wide until the pool falls below 981.0. The max design pool elevation is 982.0. During flood control, discharges are dependent upon the target stage at Wahpeton (just below the HSPF model project area), which is 10 feet or 12 feet depending on the late February snow-water content.

Lake Traverse is bounded to the south by Browns Valley Dike, which separates Lake Traverse (the Red River of the North watershed) from the Little Minnesota River (the Minnesota River basin). Breakout flows are assumed to occur at a Little Minnesota River discharge of approximately 3,000 cfs and have a 10 percent chance of being equaled or exceeded in any given year, based on open water conditions (USACE 2000). This frequency is assumed to increase when ice jams are taken into account. Within the period of record of the HSPF model (1995-2009), breakout flows are known to have occurred in 2001 and 2007 (USACE 2001).

[1] While Mud Lake has no explicit winter drawdown for anticipated spring flows, year 2000 management plan for habitat (emergent and submerged aquatic vegetation) included a two-year drawdown of the lake during which the water level would be held at least four feet lower than the normal level and, increased by two feet the first year, and returned to normal the second year after drawdown. The first of these drawdowns began in March of 2002 and continued into 2003. In March 2004 a second drawdown began and continued through September, but water levels were raised for fall hunting season. The same may have occurred in 2005. Source: *Mud Lake Water Management*, USACE, St. Paul District. http://www.mvp.usace.army.mil/pring/default.asp?pageid=144&subpageid=0

HSPF FTables for Mud and Traverse Lakes are shown in Figure 3. Each lake is represented as having three exits (outlets). The operational exit is controlled by a daily COLIND timeseries (one for each reservoir), which identifies the exit used for each timestep in the model. For both reservoirs, the first exit operates from June through February (conservation pool management), the second exit operates in March (drawdown conditions), and the third exit is operational in April and May (flood management). The Water Control Manual identified rating curves for the outlet control structures, and electronic stage-storage tables (one for each reservoir) were available online from the Army Corps. Low flow assumptions (refer to Table 5) are simplified and added to each FTable discharge record (based on the low flow operation scheme: a function of the pool elevation and the month of operation of the exit). Further description of the FTables in Figure 3 is presented below.

Lake Traverse (RCHRES 114)

- Exit 1 (June through February): Conservation pool elevation of 976.8
- Exit 2 (March): March drawdown to approximately 975
- Exit 3 (April, May): Flood control where storage occurs up to 976.8, above which stoplogs are removed and full flow capacity is allowed

Mud Lake (RCHRES 112)

- Exit 1 (June through February): Conservation pool elevation of 972.0 and discharge through one Tainter gate
- Exit 2 (March): Continued control pool elevation of 972.0 and discharge through one Tainter gate
- Exit 3 (April, May): Flood control where Tainter gates open fully between the elevation of 980.5 and 981.5
- Low flow: Added to each discharge record based on month of operation and pool elevation (refer also to Table 5).

Deliverables: Must_BDS.uci (FTables & reservoir operation), COLIND.wdm

Table 5. Lake Traverse project low flow agreement with the Minnesota DNR.

	Low Flow (cfs)		
Elevation	April 1 - June 15	June 15 - Sept 30	Oct 1 - March 31
above 976.8	50	50	40
976.8 - 976.0	25	15	10
976.0 - 975.5	15	10	5
below 975.5	10	5	5

Source: Table D-2 (USACE 1994)

Figure 1. Reservation Dam, which controls Lake Traverse looking northeast (downstream is to the north).

Figure 2. White Rock Dam, looking south (downstream).

```
  FTABLE     114
 rows cols                                                                   ***
   25    6
     depth       area     volume  outflow1 ***
       0.0        0.0        0.0        0.0        0.0        0.0
       0.2     4800.0    30500.0        0.0        0.0        0.0
       3.2     7500.0    48500.0        0.0        0.0        0.0
       5.2     9200.0    65550.0        0.0        0.0        0.0
       7.2    10150.0    84500.0        0.0        0.0        0.0
      7.85    10402.0    91260.0        0.0      170.0        0.0
       8.3    10576.0    96010.0        0.0      338.0        0.0
      8.65    10712.0    99895.0        0.0      508.0        0.0
      8.95    10828.0   103225.0        0.0      674.0        0.0
      9.25    10942.0   106555.0        0.0      842.0        0.0
       9.8    11131.0   112660.0        0.0     1182.0        0.0
     10.05    11215.0   115435.0      170.0     1350.0     1350.0
      10.5    11346.0   120520.0      338.0     1688.0     1688.0
     11.05    11506.0   126790.0      619.0     2026.0     2026.0
     11.55    11652.0   132525.0      927.0     2362.0     2362.0
     12.05    11798.0   138275.0     1216.0     2702.0     2702.0
     12.65    11973.0   145535.0     1646.0     3040.0     3040.0
      13.2    12133.0   152300.0     1984.0     3592.0     3592.0
      13.7    12279.0   158550.0     2320.0     4094.0     4094.0
      14.2    12425.0   164800.0     2668.0     4596.0     4596.0
      14.7    12563.0   171050.0     2939.0     5098.0     5098.0
      15.2    12700.0   177300.0     3335.0     5600.0     5600.0
      16.2    13050.0   190000.0     4309.0     5600.0     5600.0
      17.2    13275.0   202900.0     5341.0     5600.0     5600.0
      18.2    18375.0   215800.0     5600.0     5600.0     5600.0
  END FTABLE114

  FTABLE     112
 rows cols                                                                   ***
   25    6
     depth       area     volume  outflow1 ***
      0.00       0.00       0.00        5.0        5.0       10.0
       0.3       50.0       75.0        5.0        5.0       10.0
       1.0      400.0      250.0        5.0        5.0       10.0
       2.0      750.0      500.0        5.0        5.0       10.0
       3.0     1400.0     1500.0        5.0        5.0       10.0
       4.0     2100.0     3600.0        5.0        5.0       10.0
       5.0     3850.0     6400.0        5.0        5.0       10.0
       5.5     4222.0     8950.0       72.0       72.0       10.0
       6.0     4594.0    11500.0      138.0      138.0       10.0
       7.0     5339.0    18800.0      272.0      272.0       10.0
       8.0     6083.0    27200.0      405.0      405.0       10.0
       9.0     6828.0    36000.0      541.0      538.0       15.0
      10.0     7572.0    45200.0      712.0      707.0       50.0
      11.0     8317.0    54500.0      845.0      840.0       50.0
      11.5     8689.0    59500.0      912.0      907.0       50.0
      12.0     9061.0    64500.0      978.0      973.0       50.0
      12.5     9433.0    69600.0     1045.0     1040.0       50.0
      13.0     9806.0    74700.0     1112.0     1107.0       50.0
      13.5    10178.0    79850.0     1178.0     1173.0       50.0
      14.0    10550.0    85000.0     1245.0     1240.0     3650.0
      15.0    10725.0    95500.0     2546.0     2541.0     7552.0
      16.0    10900.0   106500.0     2725.0     2720.0     8089.0
      17.0    11075.0   117500.0     2894.0     2889.0     8597.0
      18.0    11250.0   128500.0     3056.0     3051.0     9082.0
      19.0    11250.0   128500.0     3210.0     3205.0     9546.0
  END FTABLE112
```

Figure 3. HSPF FTables for Lake Traverse (RCHRES 114) and Mud Lake (RCHRES 112).

River Channel Representation

River channel FTables in the model are based on stream cross-section data available from:

- Field surveys conducted for the Bois de Sioux Watershed District for the Mustinka TMDL by EOR (fall 2011)
- Field surveys conducted for the Bois de Sioux Watershed District by WSN as interpreted for the cross-sections in the calibrated BdSWD HEC-HMS model, which is part of the *Red River of the North Basin: Basin-Wide Watershed Management Planning* project, the federal project lead of which is the USACE (http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1237).

Data from these sources were processed for determination of representativeness for each HSPF watershed. Channel length and slope were calculated. Manning's n was based on HEC-HMS values and, as necessary, aerial photography. Ultimately, channel geometry, length, slope, and Manning's n were then used as input into EPA's *HSPF BMP Toolkit: Stage-Storage-Discharge, Storm Sewer, and Storage BMP Tool*. The *Natural Channel* function was used (http://www.epa.gov/athens/research/modeling/HSPFWebTools/storage/index.html).

Deliverables:

- HSPF model files ('Must_BDS') including reach FTables
- stream reaches (reach_prelim2012Mar9.shp) - the geometry data contained in the attributes of this shapefile are preliminary because this file was used to load HSPF from BASINS. More detailed channel geometry per actual stream cross-section data was ultimately used to populate FTables; data sources for stream cross-section data appear as attributes in the shapefile in the field 'XS_Source'.

Point Sources

A total of eight minor point sources (FLOW) are included in the model as daily timeseries (Table 6). Ultimately, water quality from these point sources will be added, but only flow is included in the model to date. All of these systems are pond systems that discharge discrete volumes a few times a year. 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 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.

Table 6. 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

Deliverables: HSPF model files ('Must_BDS'), PointSource.wdm, point_sources.shp

Observed Flow Calibration and Validation Data

The observed flow data to be used for calibration have been compiled into flow.wdm. HSPEXP (Expert System) will be used for hydrologic calibration and validation. Calibration flow data can be summarized as follows (in order of decreasing completeness):

- Two complete sets of daily data from 1995-2006 at USGS Gage Stations: 05051300 and 05050000. These are both on the Bois de Sioux River downstream of the Traverse and Mud Reservoirs.
- Partial daily dataset from DNR Site 54017001, which is on the Rabbit River also in the Bois de Sioux Watershed. The site contains primarily growing season data from 1998 through 2006.
- Daily flow data from USGS Gage Station 05049000 on the Mustinka River for only March through June 2007. Per your suggestion, these data have been supplemented based on USACE elevation data at this station:
  - Water surface elevation data were available for the USGS gage 05049000 (north of Wheaton, MN) between the years 2000 and 2009, which was collected by the U.S. Army Corps of Engineers. No rating curve was available for this site, neither by USGS or USACE. Therefore, original USGS field data (40 pairs of measurements of stage and discharge) were used to create a rating curve. The general broad-crested weir equation was used to model the relationship between elevation and flow, in the format $Q = C \cdot z^x$, where C is an unknown constant, x is an unknown exponent, and z is the water surface elevation. C and x were determined in Excel using Solver to minimize the sum of the errors between the known data points and the fitted curve. C was determined to be 3.857, and x was determined to be 2.444. Vertical datums were converted to NAVD88. Elevations in the USGS field data were converted from NGVD29, and USACE elevations were converted from MSL1912.
- Due to the paucity of data in the Mustinka Watershed, data from the Bois de Sioux WD were obtained. Data available included several sites with stage measurements (somewhat frequent, but never daily) and rating curves. Based on completeness of data and geographic location, data from three sites in the Mustinka Watershed (Gages 1, 22, & 34) and one site in the Bois de Sioux Watershed (Gage 49, on the Rabbit River for comparison to DNR Site 54017001) were selected for flow conversion. These flow data were converted to continuous daily flow using HEC-DSS[2] including the period from spring 1997 through 2006. These data have long periods (months at a time) of interpolation, which would be flagged or rejected during the calibration process.

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[2] HEC-DSS is a program that contains a utility designed for timeseries management. If data are sporadic (multiple measurements on a single day and then no measurements for a period of time), HEC-DSS creates a continuous daily timeseries during the timeframe of the original dataset by averaging the flow for days with multiple flow measurements and interpolates between known data to assign a flow rate to days lacking measurements.

Flow datasets from USGS Gage Stations 05051300 and 05050000 on the Bois de Sioux River will be used for calibration and validation of both the Bois de Sioux and Mustinka watersheds. Sparse flow data in the Mustinka Watershed (from USGS Gage Station 05049000 and the four BdSWD sites, which originate from sporadic data) will be used as checkpoints during calibration.

Deliverables: Flow.wdm

HSPF Model Files

The UCI file (Must_BDS) and all associated HSPF model files (including *.wdm files) are included with this submittal. In addition, monitored flow data to be used for calibration purposes is included (flow.wdm).

References

U.S. Army Corps of Engineers (USACE), St. Paul District. August 23, 2001. *CEMVP-ED-H Memorandum for Record. Subject: Interbasin Flow, Browns Valley Dike, Browns Valley, Minnesota, 2001 Flood and Historical Information*.

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Widseth Smith Nolting & Associates (WSN). April 29, 2011. *Final Submittal – Bois de Sioux Tributary HEC-HMS Model: Basin-Wide Modeling Approach, Hydrologic Modeling – HEC-HMS Model Development – Various Tributaries above the Red River of the North at Doran, MN*.