10 Appendix E – Linkages of the Dynamic Model to Estuarine Models

The Chesapeake Bay Program partnership uses a suite of models that include a land use change model and models of the airshed, watershed, and estuary. The output of the Phase 6 dynamic model is supplied to the estuarine model, known as the CBP's Water Quality and Sediment Transport Model (WQSTM) to estimate the effects of different loading scenarios on Chesapeake Bay water quality.

From time to time, the output of the dynamic model is also used as input to other estuarine models developed and operated by academic institutions, state governments, or contractors. The linkage between the dynamic model and an estuarine model can be achieved with the development of a geospatial linkage and a variable linkage.

Geospatial linkage

The geospatial linkage is a crosswalk of estuarine model segments and watershed model segments. Recall that most river segments have simulated rivers, but that some that drain directly to tidal water do not. The simulated rivers that are pour points for river networks must each be matched with an estuarine model cell. The areas downstream of river networks that do not have simulated rivers must also be matched with the collection of cells receiving output from them. Point source facilities in land-river segments without simulated rivers can be either added proportionally just as the linkage of non-point source loads or the outfalls can be individually mapped to estuarine model cells. The selected option is applied for linkage of all point source and therefore both options cannot be exercised simultaneously. For the second option, linkage of point source facilities and outfalls to estuarine model grid cells are incorporated in the point source data files and therefore a separate linkage file is not needed.

River Segments are watersheds. Land-river segments are the intersection of river segments and land segments, which are mostly consistent with county boundaries. Land-river segments can be aggregated up to river segments or land segments. More details on river segments and land-river segments are available in Section 11.

GIS coverages of the Phase 6 segmentation are available from the CAST GIS page:
http://cast.chesapeakebay.net/Documentation/BMPsModelsGeography
The files p600_[*EstuarineModel*]_rsegs.csv and p600_[*EstuarineModel*]_lrsegs.csv must be produced. p600_[*EstuarineModel*]_PS.csv is optional. Linkage files for the Phase 6 watershed and estuarine models are available at this FTP links below –

ftp://ftp.chesapeakebay.net/Modeling/Phase6/WSM_WQSTM_Linkage/p600_WQSTM_rsegs.csv
ftp://ftp.chesapeakebay.net/Modeling/Phase6/WSM_WQSTM_Linkage/p600_WQSTM_lrsegs.csv
ftp://ftp.chesapeakebay.net/Modeling/Phase6/WSM_WQSTM_Linkage/p600_WQSTM_lrsegs_PS.csv

p600_[*EstuarineModel*]_rsegs.csv

The phase 6 model has 64 river segments that are pour points for rivers entering the tidal water of the Chesapeake. A comma-delimited table must be produced with the following form:

cell,rseg,weight***
10850,SL2_2480_0001,0.333333333
10878,SL2_2480_0001,0.333333333
10907,SL2_2480_0001,0.333333333
11048,EU1_2650_0001,1
…

'cell' refers to an alphanumeric label for the receiving model's geography.
'rseg' is the phase 6 river segment
'weight' is the fraction of the river segment load that is to be loaded to the receiving model's cell. Weights must sum to 1 for each of the 64 river segments.

Using the headings of the attribute table, for each **RiverSeg** with the **DSID** = 1 and **Region** = "Chesapeake Bay Watershed", determine the estuarine cell or cells that it drains into. Populate the file with your estuarine cell ID, the **RiverSeg**, and the fraction of the **RiverSeg** that flows into the estuarine cell. This fraction will often be 1.0, but there may be places in large rivers where an estuarine model has more than one cell at the furthest upstream point. A DSID is an identifier for the downstream reach where '1' signifies tidal water.

p600_[*EstuarineModel*]_lrsegs.csv

The phase 6 model has 535 segments that are pour points for rivers entering the tidal water of the Chesapeake. A comma-delimited table must be produced with the following form:

cell,lseg,rseg,weight***
8934,N10001,EM3_4326_0000,0.1
8935,N10001,EM3_4326_0000,0.1
8936,N10001,EM3_4326_0000,0.1
8937,N10001,EM3_4326_0000,0.1
8938,N10001,EM3_4326_0000,0.6
11048,N10003,EU1_2981_0000,1
11043,N10003,EU1_2983_0000,0.8
11046,N10003,EU1_2983_0000,0.2
…

'cell' refers to an alphanumeric label for the receiving model's geography.
'lseg' is the phase 6 land segment
'rseg' is the phase 6 river segment
'weight' is the fraction of the land-river segment load that is to be loaded to the receiving model's cell. Weights must sum to 1 for each of the 535 land-river segments.

Using the headings of the attribute table, for each **LndRvrSeg** with the **DSID** = 0 and **Region** = "Chesapeake Bay Watershed", determine the estuarine cell or cells that it drains into. Populate the file with your estuarine cell ID, the **FIPS_NHL**, which is the land segment, the **RiverSeg,** and the fraction of the **LndRvrSeg** that flows into the estuarine cell. A DSID is an identifier for the downstream reach where '0' signifies tidal water, but with no simulated river.

Variable Linkage

The Phase 6 dynamic model has the outputs listed in Table 1. Conversion factors between watershed model and estuarine model variables must be specified. Variables may be divided by flow to yield concentration. For example, temperature can be found by dividing heat by flow. BOD is in units of oxygen, but can be converted to labile organic carbon, nitrogen, or phosphorus using the factors 0.2475, 0.00603, and 0.0436 respectively. Similarly, phytoplankton can be converted to carbon, nitrogen, or phosphorus using the factors 0.49, 0.0119, and 0.0863 respectively.

Table 1: Simulated constituents in the Phase 6 dynamic model

NAME	Description, Unit
WATR	water acft/hour
HEAT	heat BTU/hour
DOXY	dissolved oxygen lb/hour
SAND	sand ton/hour
SILT	silt ton/hour
CLAY	clay ton/hour
NO3D	nitrate lb/hour
NH3D	dissolved ammonia lb/hour
NH3A	ammonia on sand lb/hour
NH3I	ammonia on silt lb/hour
NH3C	ammonia on clay lb/hour
RORN	refractory org N lb/hour
LORN	labile org N lb/hour
PO4D	phosphate lb/hour
PO4A	phosphate on sand lb/hour
PO4I	phosphate on silt lb/hour
PO4C	phosphate on clay lb/hour
RORP	refractory org P lb/hour
LORP	labile org P lb/hour
BODA	BOD lb/hour
TORC	refractory organic carbon lb/hour
PHYT	phytoplankton lb/hour

SSCR sediment scour ton/hour

The linkage file used in the Phase 6 model is represented below:

```
WQM57K | WQunit | RVAR | WSunit | factor   | divide by | ***
doxx   | mg/l   | DOXY | lb/hr  | 0.00525  | flow |

temp   | c      | HEAT | BTU/hr | 2.917e-9 | flow |

chla   | ug/l   | PHYT | lb/hr  | 0.03672  | flow |

flow   | cms    | WATR | acft/hr| 0.01428  |      |

po4x   | kg/d   | PO4D | lb/hr  | 0.45359  |      |

nh4x   | kg/d   | NH3D | lb/hr  | 0.45359  |      |
nh4x   | kg/d   | NH3A | lb/hr  | 0.45359  |      |
nh4x   | kg/d   | NH3I | lb/hr  | 0.45359  |      |
nh4x   | kg/d   | NH3C | lb/hr  | 0.45359  |      |

no3x   | kg/d   | NO3D | lb/hr  | 0.45359  |      |

totn   | kg/d   | NO3D | lb/hr  | 0.45359  |      |
totn   | kg/d   | NH3D | lb/hr  | 0.45359  |      |
totn   | kg/d   | NH3A | lb/hr  | 0.45359  |      |
totn   | kg/d   | NH3I | lb/hr  | 0.45359  |      |
totn   | kg/d   | NH3C | lb/hr  | 0.45359  |      |
totn   | kg/d   | RORN | lb/hr  | 0.45359  |      |
totn   | kg/d   | BODA | lb/hr  | 0.01977  |      |
totn   | kg/d   | PHYT | lb/hr  | 0.03914  |      |

totp   | kg/d   | PO4D | lb/hr  | 0.45359  |      |
totp   | kg/d   | PO4A | lb/hr  | 0.45359  |      |
totp   | kg/d   | PO4I | lb/hr  | 0.45359  |      |
totp   | kg/d   | PO4C | lb/hr  | 0.45359  |      |
```

```
totp   | kg/d   | RORP | lb/hr  | 0.45359  |       |
totp   | kg/d   | BODA | lb/hr  | 0.002736 |       |
totp   | kg/d   | PHYT | lb/hr  | 0.005417 |       |

orgp   | kg/d   | RORP | lb/hr  | 0.45359  |       |
orgp   | kg/d   | BODA | lb/hr  | 0.002736 |       |
orgp   | kg/d   | PHYT | lb/hr  | 0.005417 |       |

orgn   | kg/d   | RORN | lb/hr  | 0.45359  |       |
orgn   | kg/d   | BODA | lb/hr  | 0.01977  |       |
orgn   | kg/d   | PHYT | lb/hr  | 0.03914  |       |

pipx   | kg/d   | PO4A | lb/hr  | 0.45359  |       |
pipx   | kg/d   | PO4I | lb/hr  | 0.45359  |       |
pipx   | kg/d   | PO4C | lb/hr  | 0.45359  |       |

tocx   | kg/d   | TORC | lb/hr  | 0.45359  |       |
tocx   | kg/d   | BODA | lb/hr  | 0.1123   |       |
tocx   | kg/d   | PHYT | lb/hr  | 0.2223   |       |

tssx   | kg/d   | SAND | ton/hr | 907.18   |       |
tssx   | kg/d   | SILT | ton/hr | 907.18   |       |
tssx   | kg/d   | CLAY | ton/hr | 907.18   |       |
tssx   | kg/d   | PHYT | lb/hr  | 0.45359  |       |

sand   | kg/d   | SAND | ton/hr | 907.18   |       |

silt   | kg/d   | SILT | ton/hr | 907.18   |       |

clay   | kg/d   | CLAY | ton/hr | 907.18   |       |

phyt   | kg/d   | PHYT | lb/hr  | 0.45359  |       |

end

COMMENTS:
```

```
**   1 lb/day = .45359 kg/day

**   1 ton/day = 907.18 kg/day

******* wdms have loads in lb/hour, but hours are added in the program so total loads are by day


**   1 acft/day = 0.01428 cms


**   BPCNTC = percentage of biomass which is carbon = 49

**   CVBPC  = factor to convert P to C             = 106 mols/mol

**   CVBPN  = factor to convert P to N             = 16  mols/mol

**   CVBO   = factor to convert biomass to oxygen   = 1.98

**   RATCLP = ratio of chla to P in phytoplankton   = 0.6


**   BOD to carbon          = BODA / CVBO * BPCNTC/100                                        = 0.2475   * .45359 = 0.1123

**   BOD to P               = BODA / CVBO * BPCNTC/100 * (31/12 gP/gC per mole) / CVBPC        = 0.00603  * .45359 = 0.002736

**   BOD to N               = BODA / CVBO * BPCNTC/100 * (14/12 gN/gC per mole) / CVBPC * CVBPN = 0.0436   * .45359 = 0.01977


**   phytoplankton to carbon = PHYT * BPCNTC/100                                              = 0.49     * .45359 = 0.2223

**   phytoplankton to P      = PHYT * BPCNTC/100 * (31/12 gP/gC per mole) / CVBPC              = 0.0119   * .45359 = 0.005417

**   phytoplankton to N      = PHYT * BPCNTC/100 * (14/12 gN/gC per mole) / CVBPC * CVBPN      = 0.0863   * .45359 = 0.03914


**   phytoplankton to chla   = PHYT * BPCNTC/100 * (31/12 gP/gC per mole) / CVBPC * RATCLP *1000 = 7.165



** DO, Temperature, and chlorophyll are given in concentration rather

**  than load through special treatment in the loading program

****** to calculate concentrations, divide load by flow

******* there must be a variable called 'flow' in this file

****** mass is lb per hour, but added to lb per day in the input file

**

**           M  ( lb/day  )  (  m^3   ) (453590 mg) (    day     )

**   [c] =  ---  ---------    --------   ---------   ------------   =  M/Q * 0.00525  ( mg/l )

**           Q  ( m^3/sec )  ( 1000 l ) (    lb   ) (3600*24 sec )

***

**

**      sand, silt, clay gets multiplied by 2000 for a factor of 735.4

**

****  to calculate temperature, get heat relative to freezing, divide by mass and specific heat

**            q

**  T (c) = -----

**           M C
```

```
**
*****                          q (btu/day )
**      T(c) = -------------------------------------------------------------------------
**              (Q m^3) (1000 l) (3600*24 sec) (1000 g) ( 1 cal ) (0.003968 btu)
**              (-----) (------) (-----------) (------) (-------) (------------)
**              ( sec ) ( m^3  ) (   day     ) (   l  ) ( g c   ) (   cal      )
**
**
**      T(c) = q/Q * 2.917e-9
```