1 November 2012

**Lower Susquehanna River Watershed Assessment**

**Initial Modeling Runs to be Conducted**

**Discussions**:

* Carl Cerco with the assistance of Steve Scott and Mike Langland put together a white paper discussing the various modeling input options for his CBEMP/WQSTM model (enclosure 1).
* After reviewing the options, it was agreed that using the Chesapeake Bay Program’s watershed model (WSM) input would provide a big picture or macro view of the problem right now. This input can be done relatively simply and in a short timeframe. The primary focus of this work is to assess the sediment impacts on the upper Bay area.
* Carl has agreed to accomplish four scenario runs (schedule still to be determined):
	1. 2010 land uses with 1991-2000 flow values and 1991-2000 Conowingo capacity
	2. Watershed implementation plans (WIPs) in place with 1991-2000 flow values and 1991-2000 Conowingo capacity
	3. 2010 land uses with 1991-2000 flow values and Conowingo storage full
	4. WIPs in place with 1991-2000 flow values and Conowingo storage full
* For the purposes of evaluating the effectiveness of alternatives, the HEC-RAS/AdH input is required. The input is focused on 2008-11 flow values and current bathymetry so it is a more accurate representation of the existing conditions. Using this input will result in more detailed information about the geographic distribution of sediments as well as the impacts to the upper Bay area.
* These modeling runs have been coordinated with MDE (Sachs, Rowe), MDNR (Michael), ERDC (Scott, Cerco), and USACE-Baltimore (Compton, O’Neill)
* Table below summarizes the imminent (macro) runs and eventual (micro) runs:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **MACRO** | **MICRO** |  |
| **Question to be Answered** **by Modeling Run** | **WSM Input** | **HEC-RAS/****AdH Input** | **Notes** |
| 1. What is the system’s current condition? | √ | √ | Establish baseline for comparing alternatives |
| 2. What is the system’s condition if the WIPs are in full effect? | √ | ? | Watershed management alternative; TMDL focus |
| 3. What happens when the reservoir fills? | √ | √ | Establish future without condition |
| 4. What happens when the reservoir fills and WIPs are in full effect? | √ | ? |  |
| 5. What is impact of alternative TBD? |  | √ |  |
| 6. What is impact of alternative TBD? |  | √ |  |
| 7. What is impact of alternative TBD? |  | √ |  |
| 8. What is impact of alternative TBD? |  | √ |  |
| 9. What is impact of alternative TBD? |  | √ |  |
| 10. What is impact of alternative TBD? |  | √ |  |
| Hydrology / flow values | 1991-2000 | 2008-2011 |  |
| Reservoir condition | 1991-2000 | 2008-2011 |  |

**Questions and Answers about the Scenarios and the Attached Modeling White Paper:**

* **Have any runs already been made? See reference in Table 3 of the PMP for scenarios 1 and 2.** No. EPA has a ton of versions of the WSM running around. ERDC has not completed runs with the revised TMDL’s or the 2010 land use versions. They need to make the two base runs.
* **Is the WQSTM model the same as the CBEMP package?** Yes, it is somewhat. WQSTM is part of CBEMP. WQSTM includes water quality and sediment transport; CBEMP also includes an air quality segment, for example.
* **Is the CBP WSM team on board with recalibration for the Conowingo full run?** Carl Cerco and Lewis Linker have been in communication; EPA is 100 percent on board with doing this. But, Gary, Carl, and Lewis have not come to a full understanding of the approach. Simple approach could be that EPA gives him sediment loads incoming to Conowingo system as the representative of the full reservoir scenario. Carl was concerned about the preliminary nature of the results if presented at the November 19th meeting. We will need to make sure that ALL understand that it is not for publication (any presentation will be off the record).
* **How long will it take to get the CBP WSM recalibration completed?** 2 to 4 weeks (from 23 October) maybe. That is Carl’s guess. He hopes to get more feedback from Gary and Lewis.
* **How soon can he complete all four runs? Will this be done before November 19th?** At this time, Carl thinks they can only complete two preliminary runs – the 2010 progress run (current conditions) with and without the reservoir full.
* **The way we understand it, WSM uses different flow values and reservoir conditions from our HEC-RAS/AdH models. What does this impact? The validity of the results?** AdH simulation is based on short-term timeframes. The CBP models tend to be more long-term timeframe. Steve’s outgoing rating curve = sediment concentrations vs. flow is what Carl needs for the CBEMP. They will need to check that the values derived from WSM vs. HEC-RAS/AdH to see if the calibration gives good results. The hope is that the relationship of sediment concentration vs. flow is the same with the 1990’s flows as with the 2008-11 flows. The WSM model has come under a lot of scrutiny throughout the years so it has been fully vetted and is respected.
* **Will we need to re-run questions 3 and 4 with the HEC-RAS/AdH input? Note reference in Table 3 of the PMP for scenario 3.** Probably. We will need to look at results. Carl thinks it is possible that we might not need to do additional runs for scenarios #2 and #4 in table above (hence the question marks in the third column). Given that we didn’t do the phosphorus component, we have $30,000 of unspoken funds in his scope. We could use that to do more runs in the future.
* **Do we really need to have a separate model run for question 4? Can the answer be deduced from looking at 1 vs. 2 output and 1 vs. 3 output?** Not necessarily. Carl recommends doing all four runs.
* **As I remember, ERDC had enough funds to run six scenarios? Is this right? If so, should we run a winter scouring event with reservoirs no longer trapping and a summer scouring event with reservoirs no longer trapping to see any changes to the downstream impacts?** Yes, they have funds in hand to do six runs. Until we see the results, Carl recommends waiting to make any decisions on runs 5 and 6.
* **How does Bob Hirsch’s analyses enter into the picture? Does his conclusion of lower flows provoking scour influence the CBEMP analyses?** We can and should do a comparison between EPA WSM results and Bob Hirsch’s results.

**Options for Running Initial Chesapeake Bay Scenarios – October 5, 2012**

**Scenarios**

 Consensus exists on the first four scenarios to be run for Chesapeake Bay:

* Present land uses (2010) using 1991 – 2000 hydrology. Conowingo storage capacity consistent with 1991 – 2000 period.
* Watershed Implementation Plans (WIPs) in place, 1991 – 2000 hydrology. Conowingo storage capacity consistent with 1991 – 2000 period.
* Present land uses (2010) using 1991 – 2000 hydrology. Conowingo reservoir full.
* Watershed Implementation Plans (WIPs) in place, 1991 – 2000 hydrology. Conowingo reservoir full.

The Chesapeake Bay Water Quality and Sediment Transport Model (WQSTM) requires specification of flow, solids loads, and nutrient loads at the Conowingo outfall. Flows and nutrient loads come from the Chesapeake Bay Program Watershed Model (WSM). There are multiple options for the solids loads. Depending on the option selected, the portion of the nutrient loads attached to solids may be affected.

**ADH**

 The ADH model provides high spatial resolution of processes in Conowingo Reservoir and high levels of detail in the predicted loads flowing over the dam. The model also provides the opportunity to represent the bathymetry of the filled-in reservoir and the influence of the new bathymetry on sediment scour. There are numerous factors to consider in the use of ADH to provide loads:

**Application Period** – ADH is undergoing calibration for the 2008 – 2011 period. The WQSTM scenarios are planned for 1991 – 2000 hydrology. This hydrologic period is required to match previous TMDL scenarios. Consequently, new ADH input decks must be constructed to represent the 1991 – 2000 period.

**Upstream Boundary Conditions** – ADH requires flows and solids loads at the upper entrance to Conowingo Reservoir. For 2008 – 2011, these come from the HEC-RAS model. However, for the 1991 – 2000 period, flows and loads must come from the CBP WSM. The WSM is the only source of projected WIP flows and loads. For ultimate fidelity to the WSM, we should also include in ADH the estimated loads directly to the Conowingo reservoir. There is a risk if we calibrate ADH to loads from HEC-RAS and then switch to the WSM for scenarios. If HEC-RAS and the WSM diverge greatly in the boundary conditions provided to ADH, the loads routed by ADH through Conowingo reservoir may not be reliable.

**Particulate Nutrient Loads** – Portions of the nutrient loads flowing over Conowingo are in particulate form. These particulate nutrients are an element of the loads from the WSM but not of the loads from ADH. If we use ADH, we will have to find a way to adjust the WSM nutrient loads for the nutrients associated with solids deposition and scour computed by ADH.

**Computational Burden** – The ADH model code, associated with the highly-resolved computational mesh, requires execution on a high-performance computer. The ten-year scenario runs are projected to consume 60 hours of computer time. This resource demand leaves little margin for errors, repeated runs, power outages, etc.

**HEC-RAS**

 The primary intent for the HEC-RAS modeling is to provide boundary conditions to the ADH model at the upper end of Conowingo. HEC-RAS takes loads at Marietta and routes them through the upper two reservoirs. The HEC-RAS model also incorporates a one-dimensional representation of the Conowingo reservoir. Because HEC-RAS represents Conowingo, it provides an alternative to using ADH to provide flows and loads to the WQSTM. Factors to consider in the potential use of HEC-RAS include:

**Application Period** – HEC-RAS is undergoing calibration for the 2008 – 2011 period. The WQSTM scenarios are planned for 1991 – 2000 hydrology. This hydrologic period is required to match previous TMDL scenarios. Consequently, new HEC-RAS input decks must be constructed to represent the 1991 – 2000 period.

**Upstream Boundary Conditions** – HEC-RAS requires, as inputs, flows and solids loads at the entrance to the reservoir system. Several alternatives have been examined for the solids loads from 2008 - 2011. The latest approach is to use the USGS Estimator (a regression program) for the loads. Flows are based on observations. However, for the 1991 – 2000 period, flows and loads must come from the CBP WSM. The WSM is the only source of projected WIP flows and loads. HEC-RAS must also include the solids loads directly from the adjacent watershed to the reservoir system. There is a risk if we calibrate HEC-RAS to loads from the USGS Estimator and then switch to the WSM for scenarios. If the Estimator and the WSM diverge greatly in their results at the head of the reservoir system, the loads routed by HEC-RAS to the bay may not be reliable.

**Particulate Nutrient Loads** – Portions of the nutrient loads flowing over Conowingo are in particulate form. These particulate nutrients are an element of the loads from the WSM but not of the loads from HEC-RAS. If we use HEC-RAS, we will have to find a way to adjust the WSM nutrient loads for the nutrients associated with solids deposition and scour computed by HEC-RAS.

**Computational Burden** – The HEC-RAS model runs rapidly on desktop computers. The rapid execution provides advantages over ADH. There should be reasonable margin for errors and repeated runs, if necessary.

**CBP WSM**

 The WSM is immediately available to provide flows and loads to the WQSTM for scenarios with Conowingo at its 1991 – 2000 storage capacity. The WSM incorporates Conowingo reservoir so the model could be configured to represent a filled-in reservoir although the methodology to do this is undecided. Also, the representations of deposition and scour in the WSM are less sophisticated than in ADH or HEC-RAS so the predictions may be less reliable. One option to represent the filled-in reservoir is to change the bathymetry in the model input deck. A second option, currently favored by the CBP WSM team, is to re-calibrate the deposition and scour to reproduce the loads vs. flow relationship derived from recent data by Robert Hirsch of the USGS. These loads are purported to represent a nearly-full reservoir. The WSM offers the following advantages over ADH and HEC-RAS:

**Application Period** – The WSM is calibrated and validated for the 1991 – 2000 scenario period.

**Upstream Boundary Conditions** – The WSM is calibrated and validated using computed boundary conditions at the upper end of the reservoir system. There is no risk of calibrating to one set of conditions and running scenarios based on an alternate set.

**Particulate Nutrient Loads** – The partitioning of nutrient loads into dissolved and solid forms is retained from the original WSM values.

**Computational Burden** – The burden is moderate compared to ADH but requires much more time and a more sophisticated computer system than HEC-RAS. Considerable time and effort is required to set up and execute a WSM run. These resources will be provided by CBP.

**A Potential Resolution**

 There are multiple trade-offs to consider in selecting a model to provide boundary conditions for the WQSTM. The major advantage of the WSM is its availability right now. We can provide management insights within a few weeks of today. The advantages of ADH or HEC-RAS are high accuracy in solids transport although the time frame for results is longer than for the WSM. The PMP calls for up to ten WQSTM scenarios. One path forward is to proceed with four scenarios immediately using the WSM. Then re-run these scenarios based on ADH or HEC-RAS in the future to re-examine results using more accurate sediment transport modeling capacity.