Attachment A

LSRWA Modeling Review Final Report

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Introduction and Purpose

FlowWest has reviewed the modeling analyses performed for the Lower Susquehanna River Watershed Assessment (LSRWA) to determine if the general conclusions presented in the LSRWA were supported by the underlying modeling analyses, to ensure that the appropriate input data and assumptions were used, and to offer professional opinions on additional or revised modeling analyses that should have been performed. We have reviewed the LSRWA Draft Report and its associated modeling appendices (MD and PA 2014, Scott and Sharp 2014, Langland and Koerkle 2014, Cerco and Noel 2014) and consulted with the Lower Susquehanna Riverkeeper regarding concerns about the inputs and assumptions for the various modeling analyses. This report documents our findings and conclusions.

LSRWA Overview

The modeling approach of the LSRWA can be summarized as follows: 1) a 1D HEC-RAS model was used to simulate hydraulic flow and sediment transport through LSR and its three reservoirs, 2) sediment loading predicted by the HEC-RAS model was used as input to a 2D AdH model that simulated hydraulic flow and sediment transport in and out of Conowingo Reservoir, and 3) sediment outflow from Conowingo Reservoir predicted by the AdH model and sediment and nutrient loads from the Chesapeake watershed were used to simulate water quality in Chesapeake Bay with the CBEMP suite of models. In some cases, with the AdH model, and with the CBMEP models, the modeling studies evaluated the relative differences in sediment loading and water quality amongst a range of current and future management scenarios.

During the course of our review we discovered several issues with the available models or omissions that led to important underestimations of potential impacts. We summarize these for each modeling effort below and then discuss the importance and treatment of sediment loads in the greater context of the LSRWA.

Peak Storm Flowrates

During our review of the LSRWA documents, we found that storms were characterized by peak flowrate, but in two different ways, leading to some confusion. Tropical Storm Lee, for example, was modeled by both the USGS with HEC-RAS and the USACE with AdH, based on ***daily average*** flow. For Tropical Storm

Lee, the highest daily average flow occurred between 12:00 am on September 8, 2011 and 12:00 am on September 9, 2011, and was 709,000 cubic feet per second (cfs).

While this daily average flow represents the 24-hour period that symmetrically spans the time 00:00 on any given day, a ***24-hour running average flow*** can be calculated at any other similarly arbitrary window, such as the window that produces the highest peak 24-hour averaged flow. For Tropical Storm Lee, this occurs by averaging instantaneous flows between 15:30 and 15:30 each day of the event, resulting in a peak 24-hour average flow of 746,000 cfs.

When the USACE AdH modelers compared their results against USGS measurements of sediment loads[1] (shown in Figure 2), Tropical Storm Lee is represented based on ***storm average flow***, or 632,000 cfs.

Based on ***instantaneous flow***, Tropical Storm Lee peaked at 778,000 cfs at 04:15 on September 9, 2011. All four methods of characterizing the flow during Tropical Storm Lee are illustrated in Figure 1. The method by which the "peak" flow is calculated has important implications for how corresponding sediment and nutrient loads to the Chesapeake Bay during storm events were modeled in the LSRWA. These implications are discussed in more detail in the sections that follow.

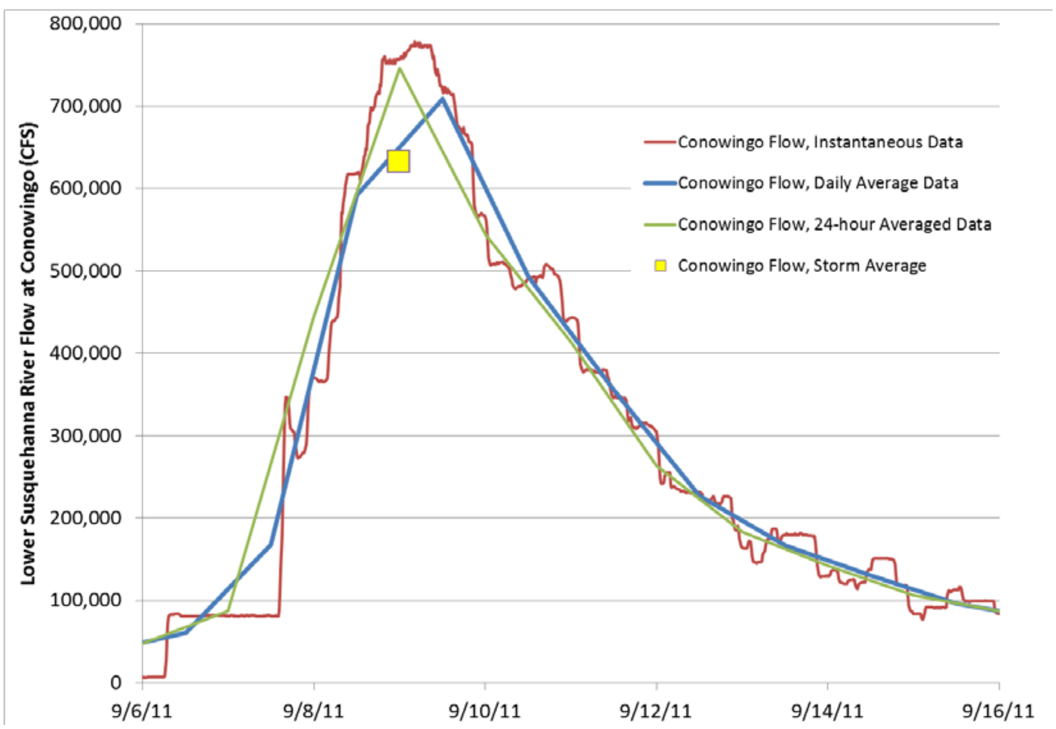

FIGURE 1: COMPARISON OF CONOWINGO FLOW BASED ON INSTANTANEOUS RECORD, DAILY AVERAGE FLOW RECORD, A 24-HOUR RUNNING AVERAGE, AND STORM AVERAGED FLOW

HEC-RAS MODEL REVIEW

The USGS used a 1D HEC-RAS model to determine hydraulics and sediment transport in the three Lower Susquehanna River reservoirs and to output estimated sediment loads to Conowingo Reservoir for use

[1] Scott and Sharp 2014, pg. 30, Figure 16.

as boundary conditions to a more sophisticated 2D AdH model built by the USACE. The reported outcome of HEC-RAS modeling was that the results were not generally reliable and it was only used to generate sediment loading inputs to the AdH model. This should have been expected given the limitations of the model software, the lack of input data, and the complexity of the system being modeled. We discovered the following specific issues or limitations:

- The modelers describe in section 4.1.1 Discharge[2], that they obtained "Continuous (recorded every 15 minutes) and daily-mean streamflow (discharge) data for the Susquehanna River at Marietta, Pennsylvania (USGS 01576000) and the Susquehanna River at Conowingo, Maryland (USGS 01578310) streamgages…from the USGS National Water Information System." However, in that same section, in Figure 5[3], they show the ***daily average*** streamflow record from the Conowingo gage, which was likely used as their input flow data – the same as used by the USACE in the AdH modeling (detailed later in this document). Use of daily average streamflow as input rather than instantaneous data under-predicts potential reservoir scour due to the lower discharges considered and the exponential relationship[4] between discharge and suspended sediment concentration.

- In some locations within the model domain, when the modelers increased the input parameter of the sediment's critical shear stress, which should have reduced predicted scour, the model predicted increased scour. Such a result[5] calls the analysis and/or model into question. The "critical shear stress" parameter in a sediment transport model is an input value related to the type of sediment that makes up the channel or reservoir bottom. These values typically come from literature, and are specific to a size and type of sediment (e.g., boulders would have a different critical shear stress value than gravels, and cohesive clays would have a different value than loose sands). For a given location, the sediment transport model compares predicted hydraulic forces on the bed of the channel (shear stresses) against the critical ("threshold of erosion") shear stress of sediment in that location and if the predicted hydraulic forces exceed the critical shear stress, the model would predict erosion. If predicted hydraulic forces are lower than the critical shear stress, no erosion would be predicted. Therefore, if the modelers *increased* the critical shear value, this should have had the effect of making the channel bed more difficult to erode; however, the opposite effect occurred in some cases. Such a result calls into question the reliability of the model, and the accuracy of its predictions of sediment loads entering Conowingo Reservoir which were in turn used as input to the AdH model.

- In the summary of the HEC-RAS report the authors state[6] that "the boundary-condition data from the 1-D model were helpful in the calibration of the USACE 2-D model" – however, the AdH USACE 2-D model was never calibrated[7] (only validated). Calibration of a model involves:

    1. Calibration data collection: measuring hydraulic (e.g. water surface elevations) and sediment transport (e.g. suspended / bedload transport rates and/or changes in bed elevations) parameters in the river system during (a) particular period(s)

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[2] Langland and Koerkle 2014, pg. 9.
[3] Langland and Koerkle 2014, pg. 10.
[4] Langland and Koerkle 2014, pg. 17.
[5] Langland and Koerkle 2014, pg. 23.
[6] Langland and Koerkle 2014, pg. 30.
[7] Scott and Sharp 2014, pg. 22.

2. Calibration runs: simulating that period or those periods with the model
3. Calibrating the model: tuning input parameters until the model predicts the same hydraulic and sediment transport parameters as were measured.

In general, this is very difficult and sometimes impossible for sediment transport models because of the financial and technical constraints involved in calibration data collection.

Given the uncertainties in the HEC-RAS modeling it is not clear how the boundary condition data from the 1-D model was "useful in calibrating the USACE 2-D model" (especially since the USACE 2-D model was not calibrated), or whether the boundary condition data are trustworthy given the limitations[8] of the modeling. The HEC-RAS modeling performed by the USGS resulted in predicted scour loads carried forward into the USACE AdH modeling of Conowingo Reservoir significantly lower than other estimates[9] for Tropical Storm Lee.

AdH Model Review

The 2d AdH model analysis performed detailed hydrodynamics and sediment transport within and out of Conowingo Reservoir. The analysis also evaluated response of Conowingo to various sediment management actions. A key driver of the AdH modeling was the input sediment loading condition taken from the HEC-RAS modeling by USGS. The AdH report states[10]:

"The HECRAS simulations produced two sediment inflow scenarios. The first scenario indicated no scour from the upper two reservoirs. The total inflow into Conowingo for this scenario was approximately 22.0 million tons [*note: the actual value reported by USGS*[9] *was 22.1 million tons*]. The second scenario was for approximately 1.8 million tons of scour from the upper two reservoirs [*note: this value appears to actually be 2.1 million tons as reported in the USGS report*[9]], for a total Conowingo inflow load of approximately 24 million tons [*note: the actual value reported by USGS*[9] *was 24.4 million tons*]. For the AdH model runs, the maximum scour load from the upper two reservoirs is needed because the maximum load may influence transport capacity in Conowingo, and thus impact bed scour potential. Therefore the 24 million ton HECRAS load was increased by 10 percent to reflect a potential maximum scour load from the upper reservoirs."

The inaccurate reporting of USGS HEC-RAS results by the USACE makes it somewhat difficult to trace the usage of HEC-RAS output in the AdH model. Nevertheless, the determination of the 10% factor for additional load to reflect maximum scour was not justified. Per the USGS HEC-RAS report[11], discharges in the four-year simulation period for HEC-RAS modeling (2008-2011) reflected "normal to less than normal flows for the first 3 years." In the fourth year (classified as "above normal[11]" in terms of discharge), there were only four days "exceeding 400,000 cfs, the estimated average bed scour threshold. The average return interval for flows of 400,000 cfs is every 5 years." Therefore, in the context of a 40 to 50-year FERC relicensing process, simply increasing scour loads by only 10% from a generally below-normal period with only four days out of four years of discharge exceeding the scour

[8] Langland and Koerkle 2014, pg. 22.
[9] Langland and Koerkle 2014, pg. 26, Table 6.
[10] Scott and Sharp 2014, pg. 16.
[11] Langland and Koerkle 2014, pg. 9.

threshold was not an appropriate method for estimating “maximum potential scour” from the two upstream reservoirs. Given that the HEC-RAS modeling was found to consistently under-predict reservoir scour, even a 10% increase in HEC-RAS model output does not effectively represent a “maximum” scour condition, especially considering that the four-year period modeled included three below-normal flow years and Tropical Storm Lee represented an approximately 20-year return interval event. For the 40-50-year planning horizon, the “maximum” scour condition feeding Conowingo Reservoir would undoubtedly be substantially higher, and the AdH modeling effort should have recognized this and performed additional simulations with substantially higher sediment loading conditions.

The USACE AdH modelers compared the output of their model for the Tropical Storm Lee event against a USGS curve relating magnitude of storm event (in terms of daily average flow) to total scour load, the results of which are shown below in Figure 2.

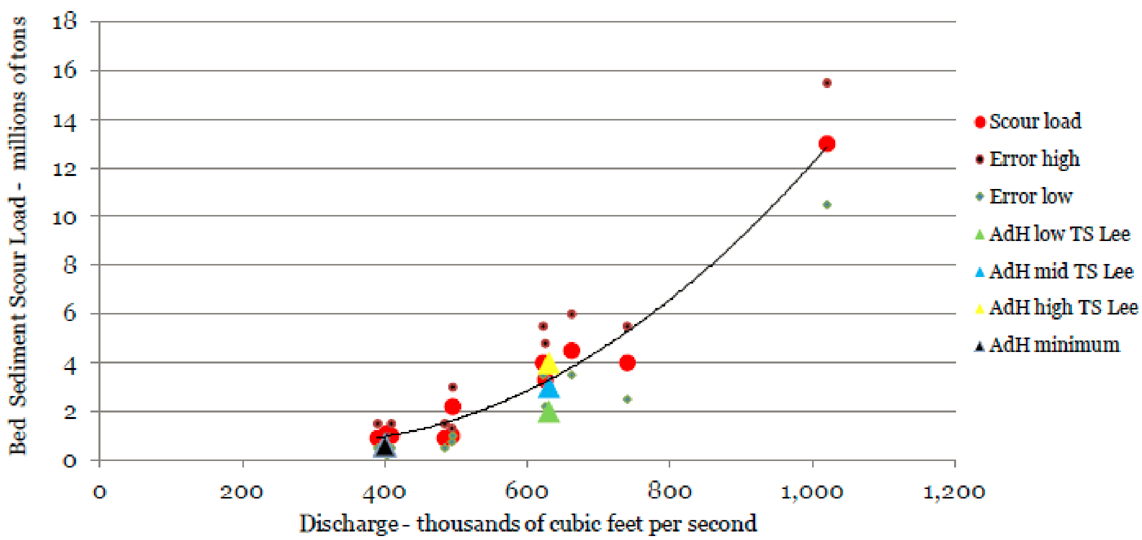

FIGURE 2: COMPARISON OF ADH RESULTS FOR TROPICAL STORM LEE AGAINST USGS SCOUR CURVE

The AdH modeling effort simulated Tropical Storm Lee under “low, mid, and high” model settings, which resulted in estimates of total scour of 2 million, 2.9 million, and 4 million tons, respectively (Figure 2). Yet as shown in Figure 2, when compared against the USGS scour estimates, which also are presented as range of values for each storm event, the AdH results are lower than the USGS estimates for Tropical Storm Lee and lower than the regression curve. While actual values were not reported by USACE for the USGS curve, from visual inspection it appears that for Tropical Storm Lee, the low, mid, and high USGS estimates are approximately 2.1 million, 3.5 million, and 5 million tons (Figure 2). These represent potential under-predictions of Tropical Storm Lee scour of 5%, 17%, and 20%, respectively by the AdH model.

One potential cause for the under-prediction of scour from Tropical Storm Lee was the decision of the AdH modelers to use daily average flow as their model input rather than the available instantaneous flow data from the USGS stream gage at Conowingo[12]. Figure 3 below shows a comparison of the four-year LSR streamflow record at Conowingo represented as a daily average flow (blue, as used by AdH modelers) and as instantaneous (i.e., on a 15-minute interval[13], shown as red).

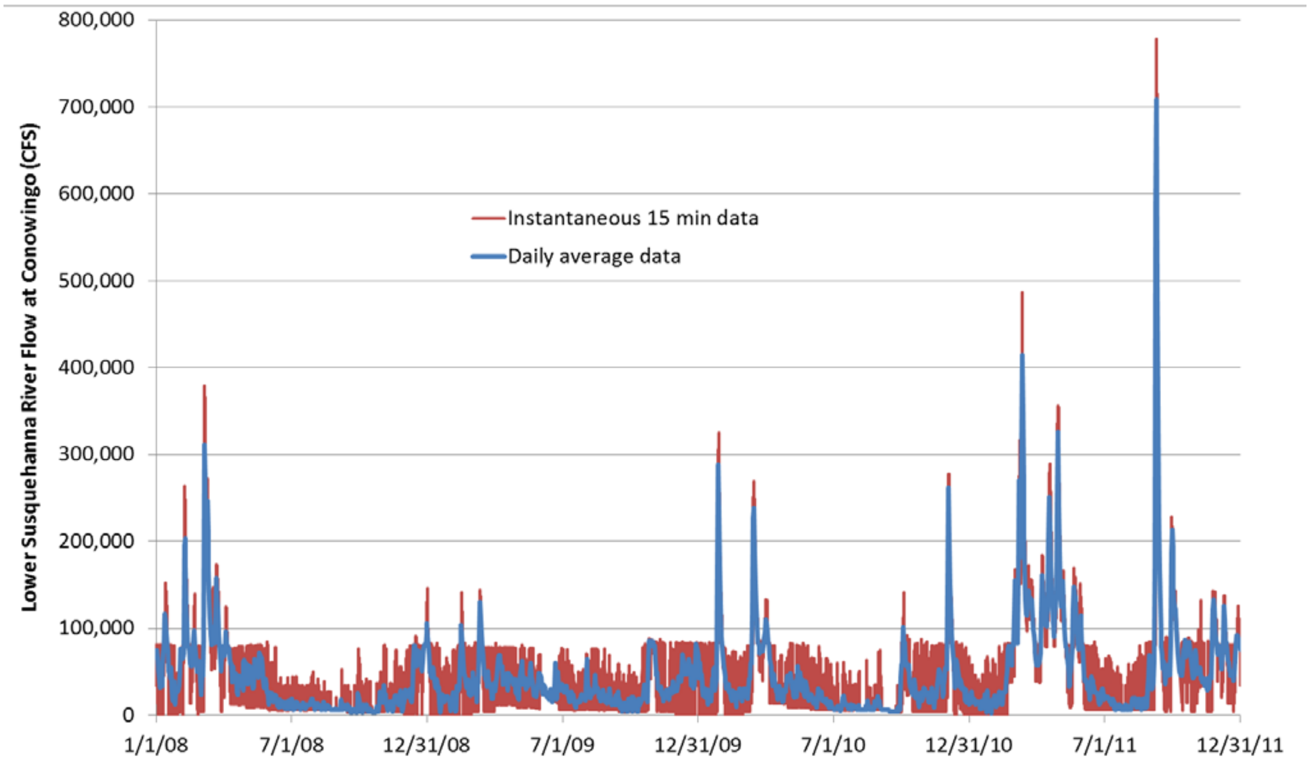

FIGURE 3: COMPARISON OF DAIL AVERAGE VS INSTANTANEOUS FLOW RECORDS FOR LSR AT CONOWINGO

It is clear from Figure 3 that USACE's use of the daily average flow record rather than the instantaneous record resulted in substantially lower peak flows during storm events in the 2008 to 2011 modeling time frame. During that four-year period, there were two events above the 400,000 cfs scour threshold and eight additional events between 200,000 and 400,000 cfs, where scour of finer sediments is known to begin[14]. Because the relationship between flow and transport of sediment is an exponential relationship, the AdH modeling would have predicted a higher four-year sediment load and a higher Tropical Storm Lee load to the Chesapeake Bay had the analysis used the instantaneous data as its input flow, potentially resulting in a better match against the USGS regression equation (Figure 2) for Tropical Storm Lee. The AdH model's estimate of sediment load out of Conowingo from Tropical Storm Lee was directly used in the CBEMP model to represent storm scour, and therefore this under-prediction represents a key factor in the degree to which representative conditions of scour were evaluated in the LSRWA.

[12] Scott and Sharp 2014, pg. 15.

[13] USGS Gage 01578310 SUSQUEHANNA RIVER AT CONOWINGO, MD; http://waterdata.usgs.gov/usa/nwis/uv?01578310.

[14] Scott and Sharp 2014, pg. 36.

CBEMP Models Review

The CBEMP included the WSM and the WQM models. The WSM simulated the whole Chesapeake Bay watershed to estimate loads of sediment and nutrients to the Bay. The WQM simulates water quality in the Chesapeake Bay itself. These two models were coupled in an analysis spanning 1991 to 2000 with adjustments made to apply scour results from the 2008-2011 AdH output for Tropical Storm Lee to the 1991-2000 period. We discovered the following issues during our review:

- The CBEMP modeling considered only daily average flows on the LSR, rather than instantaneous (i.e., 15-minute data) flows. This meant that the January 1996 storm, which peaked at 909,000 cfs, was considered to have been a 622,000 cfs event. A modeling approach considering the higher flows from instantaneous data would have produced greater sediment loads to the Chesapeake Bay, which would likely have resulted in greater nutrient-related impacts.

- WSM sediment results at Conowingo for the January 1996 event showed little to no scour which did not agree with observed data[15]; modelers performed an "erosion adjustment" to improve the results. It is not clear exactly what was done to make this adjustment, although we assume from the report that the CBEMP modelers added the predicted scour from the Tropical Storm Lee simulation from the AdH model on top of watershed sediment loads predicted by the WSM model. We further assume, although it is not documented, that the CBEMP modelers added the "mid TS Lee" predicted scour from AdH (Figure 2).

  Given 1) the inability of the USGS HEC-RAS model (which provided the sediment loading input to the AdH model) to accurately estimate reservoir scour, 2) the USACE AdH model's use of a low input sediment loading condition not representative of maximum probable sediment loads during the 40-50-year planning horizon, and 3) the low prediction of Tropical Storm Lee scour by the AdH model relative to USGS estimations (Figure 2), it is unlikely that the CBEMP model evaluated the effects of a representative storm scour condition on the Chesapeake Bay.

- The AdH modeling, which spanned the years 2008-2011, included Tropical Storm Lee, an approximately 20-year return interval flow event. The CBEMP modeling, which spanned the years 1991-2000, included the January 1996 storm event whose peak flow represented 25-50-year return interval flow event. However, since only daily average flows were considered, rather than peak flows (as described above this reduced the event from a 909,000 cfs event to a 622,000 cfs event), it represents an approximately 20-year return interval flow event similar to Tropical Storm Lee.

  It is notable that the WSM predicted little to no scour from Conowingo during the January 1996 event, requiring the modelers to add scour contributions from Conowingo from the AdH modeling of Tropical Storm Lee to the WSM to bring it into agreement with observations. Given that the FERC licensing process for Conowingo is likely to be more than 40 years, the effects of larger storm scouring events on the Chesapeake Bay should have been performed. In a given 40-year period, there is an approximately 33%

[15] Cerco and Noel 2014, pg. 24.

chance that a 100-year return interval flow event will occur, meaning that there is a reasonable chance in the next FERC license period for Conowingo that a bed scour event substantially larger than either the Tropical Storm Lee or January 1996 event will occur. Because the AdH modeling produced lower scour predictions from Conowingo than estimated by USGS (Figure 2), the CBEMP evaluations carried these low scour predictions forward to the impacts analysis which underestimated storm-based scour loads on the Chesapeake Bay.

- In Figure 4-2 of the CBEMP modeling report[16] (shown below as Figure 4), the authors present an illustration of how addition of predicted sediment scour from the AdH modeling was added to the CBEMP model to bring predictions of suspended sediment concentration in line with observations from the January 1996 storm event.

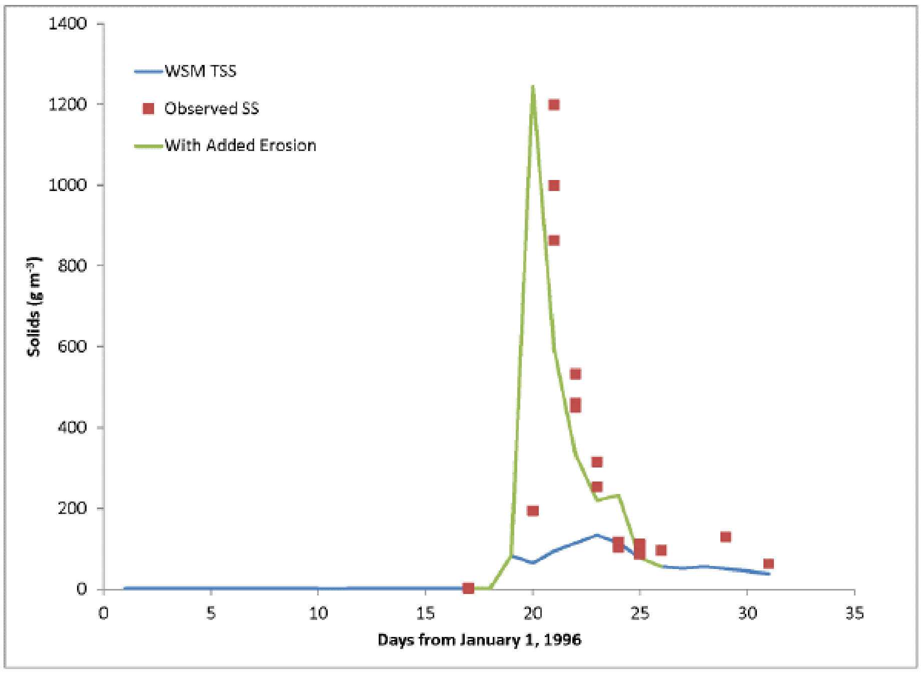

FIGURE 4: OBSERVED AND COMPUTED SUSPENDED SOLIDS AT THE CONOWINGO OUTFALL, JANUARY 1996. COMPUTATIONS ARE SHOWN FOR THE WSM AND FOR THE WSM WITH ADDITIONAL EROSION LOAD.

While the comparison seems to indicate a very close agreement between the shape of the sediment data for the January 1996 event and the "peak" sediment concentration of the event, this is not true. The highest observed value for sediment concentration was 1200 g/m^3, which was recorded on January 21, 1996 at 13:15. This sample was collected almost ***20 hours after the peak of the storm, which was on January 20, 1996 at 17:00***. The collected sample coincided with a flow of 623,000 cfs, approximately 31% lower than the peak of 909,000 cfs. Furthermore, this "peak" sample was collected on the receding limb of the event, further illustrated by the fact that the green model line is offset backwards in time from the red point of the sample in Figure 4. Because of the fact that 1) the relationship between suspended sediment concentration and flow is

[16] Cerco and Noel 2014, pg. 33.

exponential and 2) as reported by Scott and Sharp[17], "the highest suspended sediment concentrations are found on the ascending leg of the hydrograph, whereas the descending leg typically has lower values," then had the erosion-adjusted model been accurately predicting suspended sediment leaving Conowingo, the green line in Figure 4 would have peaked significantly (potentially several times) higher. This is because had a sediment sample been taken at or near the peak of the January 1996 storm of 909,000 cfs (sediment samples cannot generally be taken above 600,000 cfs due to safety concerns[18]), its concentrations would have been much greater than 1,200 g/m^3, because the relationship between sediment concentration and flow is exponential.

- The CBEMP modeling analysis of impacts of sediment on Chesapeake Bay should have included an analysis of a 100-year return interval event because it has at least a 33% likelihood of occurring in the next FERC license period (40-50 years) for Conowingo, and may occur during a time when Conowingo is full of sediment, maximizing the release of sediment and potential impacts to Chesapeake Bay. Due to the exponential relationship between sediment loads and flow, such analysis would have resulted in evaluation of sediment loads several times greater than those evaluated, potentially altering the LSRWA's conclusions.

- The CBEMP modeling considered the impacts on the Chesapeake Bay in the months of January, June, and October, in an attempt to evaluate likely timing of large storm events. The spring growing season for submerged aquatic vegetation (SAV) was excluded from this analysis. Yet as reported by Langland and Koerkle[19], over the period 1967 – 2013, more days with daily mean flow at or above the erosion threshold for LSR reservoirs happened in the March through May spring season than the entire rest of the seasons combined (33 in spring vs. 31 in winter, summer, and fall) as shown in Figure 5. The analysis should therefore have included a simulation with a spring storm to evaluate potential ecosystem impacts.

[17] Scott and Sharp, 2014, pg. 24.
[18] Scott and Sharp, 2014, pg. 17.
[19] Langland and Koerkle 2014, Figure A3, pg. 38.

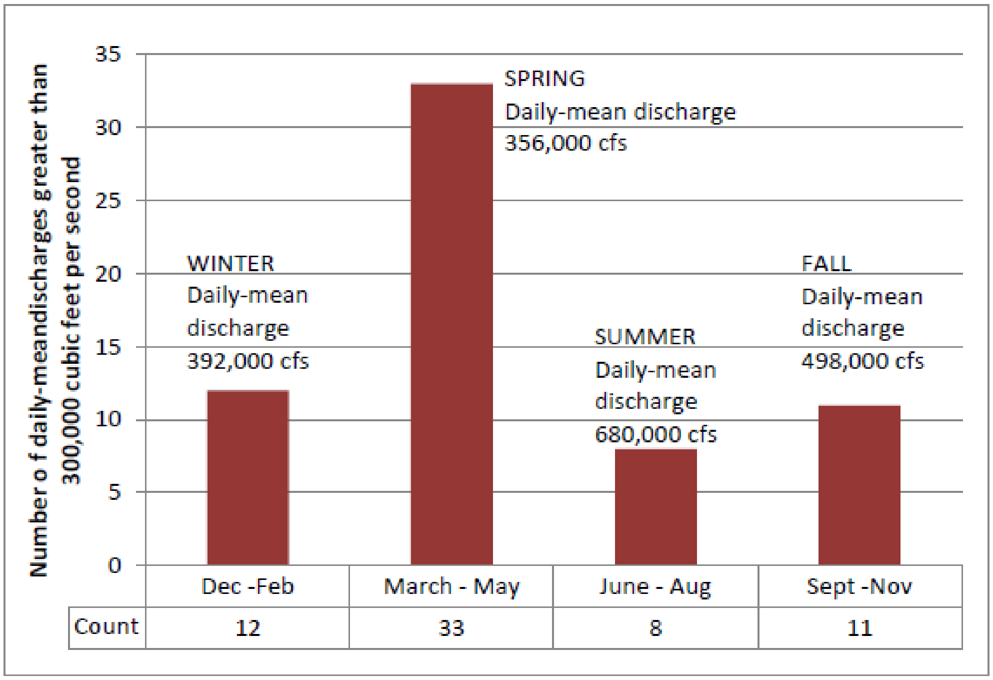

FIGURE 5: NUMBER OF DAILY-MEAN DISCHARGES GREATER THAN 300,000 CUBIC FEET PER SECOND (CFS) AND DAILY MEAN DISCHARGE BY SEASON AT SUSQUEHANNA RIVER AT CONOWINGO, MARYLAND (1967-2013).

ESTIMATES OF ANNUAL SEDIMENT LOAD TO CHESAPEAKE BAY FROM THE LOWER SUSQUEHANNA RIVER/ CONOWINGO RESERVOIR

Concerns have been raised by the LSR Riverkeeper about the estimates of annual sediment load to the Chesapeake Bay from the LSR, and whether the modeled predictions are representative of a wide enough range of conditions. We reviewed the assumptions and methods used by various entities involved in the LSRWA to develop these. During the course of the LSRWA study, several different estimates of sediment loads from the LSR to the Chesapeake Bay were developed through modeling or bathymetry/sediment data analysis. They can be summarized as follows:

- USACE AdH Modeling: The AdH modelers from USACE used a rating curve developed from the USGS HEC-RAS model as the input sediment load to Conowingo Reservoir for their simulations. For their four-year modeling window, which included the effects of Tropical Storm Lee in 2011, the AdH modelers used the maximum predicted sediment load from upstream of Conowingo, "approximately" 22 million tons, and increased this by 10% to either 26.2 or 26.3 million tons (this value is reported differently in different parts of the report). For Conowingo sediment output to Chesapeake Bay, their results indicated a range from 20.3 million tons (1996 bathymetry) to 22.3 million tons (2011 bathymetry). Their predicted Conowingo scour loads from the bed of the reservoir ranged from 1.8 million tons (1996 bathymetry) to 3.0 million tons (2011 bathymetry).

  Therefore, the AdH model assumed ~6.6 million tons per year (26.2 million tons / 4 years) inflow to Conowingo and predicted ~5 – 5.5 million tons per year (20.3 – 22.3

million tons / 4 years) outflow to Chesapeake Bay including 0.5 – 0.8 million tons of reservoir bed scour, and 1.0 to 1.5 million tons per year of sediment trapping[20].

- CBEMP Modeling: The CBEMP modeling used its WSM component to estimate sediment loads to and out of Conowingo Reservoir. The modeling window for this work was 1991-2000, which included the effects of a large storm in 1996. This model erroneously predicted no bed scour from Conowingo, and therefore added scour results from the AdH model (modified to reflect differences between Tropical Storm Lee and the 1996 storm). Sediment loading was reported as an average per day during the modeling window. They reported daily loads out of Conowingo Reservoir of 3,056,623 kg for the 2010 progress condition (baseline) and 4,113,762 kg for the No Conowingo scenario (assuming no trapping in Conowingo and full transport of sediment from upstream of Conowingo to the Chesapeake Bay). WSM-computed loads of sediment inflowing to Conowingo were not reported.

  Therefore, the CBEMP modeling predicted ~1.2 million tons per year (converted from ~3 million kg/day) outflow to Chesapeake Bay under the baseline scenario and ~1.7 million tons per year (converted from ~4.1 million kg/day) under the No Conowingo scenario, which equals ~0.5 million tons per year of sediment trapping[21].

- USGS estimations: The USGS estimated sediment loads based on surveys and sediment data coming into and leaving Conowingo Reservoir in five time periods between 1928 and 2012. During the 1993-2012 window, which generally spans the years of modeling with AdH and CBEMP, the USGS estimated the cumulative load to all three LSR reservoirs and from LSR ultimately to Chesapeake Bay.

  The USGS estimated 3.8 million tons per year inflow to the three reservoirs and 1.8 million tons per year outflow to Chesapeake Bay, and 2.0 million tons per year of sediment trapping[22].

A comparison of modeled sediment loading vs. that estimated by USGS is presented in Table 1.

	USACE AdH Model	CBEMP Model	USGS Estimates
Conowingo Sediment Inflow	6.6	NA	NA
Sediment Outflow to Chesapeake	5.5	1.2 - 1.7	1.8
Conowingo Sediment Trapping	1.0 - 1.5	0.5	2

Table 1: Summary of annual sediment quantities. All quantities are in millions of tons per year.

The CBEMP modeling estimated average annual export of sediment to Chesapeake Bay from the LSR at a lower level than either the AdH model or the USGS estimates (1.2 – 1.7 million tons/yr vs. 1.8 – 5.5 million tons/yr). The CBEMP modeling also estimated sediment trapping by Conowingo substantially lower than other efforts (0.5 million tons/yr vs. 1.0-2.0 million tons/yr). This means that the CBEMP

[20] Scott and Sharp, 2014, pgs. 29-31.
[21] Cerco and Noel, 2014, Table 4-1, pg. 27.
[22] Langland and Koerkle, 2014, Table 6, pg. 26.

water quality modeling and biological impacts analyses likely underestimated effects of sediment loading to the Chesapeake Bay on an annual average basis, and possibly underestimates the benefits that Conowingo can provide to the Chesapeake Bay through sediment trapping.

Review Summary

Based on our review of the available documents and modeling analyses, we have concluded the following:

- The LSRWA analysis of sediment and nutrient impacts on the Chesapeake Bay depended on a "daisy chain" of models that passed outputs successively from one model to another. At each stage, predicted sediment quantities were lower than the best available estimates or actual measured data suggested, in some cases by considerable amounts. This resulted in an underrepresentation of potential sediment impacts (and in turn likely nutrient impacts) on the Chesapeake Bay.

- In general, the AdH and CBEMP modelers did not appropriately reflect the exponential relationship between flow and sediment load, and selected input model flowrates that did not reflect the expected magnitude of events likely to occur during the 40-50 year FERC licensing window.

- The AdH and CBEMP models predicted and evaluated the impacts of annual sediment loading rates to the Chesapeake Bay that were lower than estimates made from actual observations of bathymetric change and measured sediment loads by the USGS, therefore underestimating the impacts of typical annual sediment loading on the Chesapeake Bay.

- The CBEMP modeling did not adequately consider the seasonal effects of storm scour loads in the spring growing season for SAV.

References

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