Attachment I-7:
Stakeholder Review Comments and Responses

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Review of the Lower Susquehanna Watershed Assessment

STAC Review Report

August 2014

Annapolis, Maryland

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About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program (CBP) on measures to restore and protect the Chesapeake Bay. Since its creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical workshops, and (5) interaction between STAC members and the CBP. Through professional and academic contacts and organizational networks of its members, STAC ensures close cooperation among and between the various research institutions and management agencies represented in the Watershed. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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REVIEW OF THE LOWER SUSQUEHANNA RIVER WATERSHED ASSESSMENT

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INTRODUCTION AND EXECUTIVE SUMMARY

Background

The Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) assembled a team of 11 professionals with backgrounds in resource economics, and watershed, riverine, and estuarine processes to review the Lower Susquehanna River Watershed Assessment report. As stated in the first five sentences of the LSRWA report's Executive Summary (p. ES-1), "The U.S. Army Corps of Engineers, Baltimore District (USACE), and the Maryland Department of the Environment (MDE) partnered to conduct the Lower Susquehanna River Watershed Assessment (LSRWA). This assessment concludes with this watershed assessment report to better inform all stakeholders undertaking efforts to restore the Chesapeake Bay. The purpose of this assessment was to analyze the movement of sediment and associated nutrient loads within the lower Susquehanna watershed through the series of hydroelectric dams (Safe Harbor, Holtwood, and Conowingo) located on the lower Susquehanna River to the upper Chesapeake Bay. This included analyzing hydrodynamic and sedimentation processes and interactions within the lower Susquehanna River watershed, considering strategies for sediment management, and assessing cumulative impacts of future conditions and sediment management strategies on the upper Chesapeake Bay. The need for this assessment is to understand how to better protect water quality, habitat and aquatic life in the lower Susquehanna River and Chesapeake Bay."

As summarized in the letter to the review team from the STAC Executive Secretary, "The [LSRWA] report includes a main text (>200 p.) summarizing all of the analyses conducted and conclusions from those analyses. Thereafter are four technical sections (Appendices A-D) and input data and literature for each of these technical sections (Appendices E-H). The report also contains miscellaneous information in Appendices I (Stakeholder Involvement) and J (Overview of LSRWA Plan Formulation, including Descriptions of sediment management strategies evaluation and costs and a Summary Table of Major (14) Modeling Scenarios and Results). The technical sections are: Appendix A: Sediment Reservoir Transport Simulation of Three

Reservoirs in the Lower Susquehanna River Basin, Pennsylvania using HEC-RAS - Langland/USGS report (31 pp., plus sub-appendices); Appendix B: Sediment Transport Characteristics of Conowingo Reservoir - Scott/ERDC report (57 pp., plus sub-appendices); Appendix C: Application of the CBEM Package to Examine the Impacts of Sediment Scour in Conowingo Reservoir on Water Quality in the Chesapeake Bay - Cerco/ERDC report (124 pp.), with individual results for all CBEM scenarios available on request; and Appendix D: Estimated Influence of Conowingo Infill on the Chesapeake Total Maximum Daily Load - Linker/EPA report (28 pp.).

The charge from STAC to the review team was: "You should focus your comments on the following [questions], but you are encouraged to provide additional comment that would improve the analyses, report, or its recommendations." The body of review is thus organized into sections in response to that series of questions. Below is a general reaction of the review team to the LSRWA report followed by an Executive Summary of the review team's responses to the series of questions. Following the Executive Summary, the expanded responses to the series of questions is provided.

General reaction of the review team to the LSRWA report

The majority of the reviewers of the LSRWA report agree that its authors have done a commendable job in trying to address an extremely challenging set of issues. The authors have assembled a considerable body of useful observational data, applied sophisticated models, and "chained" the results together to assess the impacts of recent hydrologic and water quality processes on the Lower Susquehanna River and the Chesapeake Bay. Overall, the results of the study are reasonable, the major conclusions are important, and the report's recommendations are by-and-large appropriate and productive. It is obvious that considerable and thoughtful effort has gone into accrual and presentation of the widely disparate types of information used in this report. The project was an enormous effort with multiple participants, and the authors did an impressive job bringing together a wide range of information to support their report.

The science associated with assessing the evolving condition of the Lower Susquehanna River and its effects on the Chesapeake Bay is exceptionally challenging. As far as the reviewers are aware, the Conowingo situation is truly unique. A major reservoir that had been an effective trap for fine sediment and associated nutrients has largely transitioned to one that no longer has an ability to perform this long-term function. It is likely that this kind of transition has never been well documented before, and there are not analogous systems for which modeling efforts have previously attempted to predict how a system will behave as it moves through this transition. The science that needs to be done here is at the cutting edge of what sediment transport and water quality science has ever accomplished in the past. Thus, there are no standard models and protocols for such a study, and the existing capabilities are understandably limited. Hence, it is not surprising that the review team identified many sections of the report that would benefit from revisions, corrections and/or additional analysis.

Although the constructive criticisms provided by the reviewers are significant, they do not fundamentally undermine the importance of key conclusions and recommendations that follow logically from the findings of the LSRWA study. As interpreted and modified by the review team, these (A) conclusions and (B) recommendations include: (A1) The Conowingo Reservoir is essentially at full capacity and is no longer a long-term sink helping to prevent sediment-associated nutrients (primarily particulate phosphorus) from entering the Chesapeake Bay. (A2) Increases in particulate phosphorus loads entering the Bay as a result of the full reservoir are likely causing significant impacts to the health of the Chesapeake Bay ecosystem. (A3) Sources of nutrients upstream of the Conowingo reservoir have far more impact on the Chesapeake Bay ecosystem than do the increases in nutrients caused by scour plus reduced deposition in the reservoir. (A4) Managing sediment via large-scale dredging, bypassing and/or operational changes are clearly not cost-effective ways to offset Chesapeake Bay water quality impacts from the loss of long-term trapping of sediment-associated nutrients. (B1) As soon as possible, follow-up studies should more fully quantify the impact on Chesapeake Bay water quality from increases in sediment-associated nutrients brought about by reservoir infilling. (B2) There is no compelling reason to reduce sediment loads *per se* from the Susquehanna watershed to compensate for increased sediment passing out of the Conowingo reservoir. Nutrients are the main problem, not sediments. (B3) Additional particulate phosphorus load reductions from the Susquehanna watershed (beyond present WIPs) should be considered to compensate for changes to the Conowingo.

Executive Summary

Question 1: Does the main report clearly define the goals, strategies, and the results/conclusions of the study, and also present adequate background material at a level suitable for understanding by non-technical audiences?

The goals stated in the main report (which stress both sediment and nutrient management) are inconsistent with the methodological approach taken by LSRWA (which mainly emphasized sediment) and appear not to be the study's original goals. This review recommends that the original goals of the study (i.e., sediment management to extend the life of Conowingo Dam more than nutrient management to protect Chesapeake Bay water quality) be presented in the introduction followed by a fuller explanation of how and why the focus of the study evolved in time. Both the Executive Summary and Chapter 9 of the main report (entitled "Assessment Findings") present four categories of conclusions that generally correspond to each other. Within the individual context of the Executive Summary or Chapter 9, each set of conclusions is well written and easy to follow and understand. Their general content also includes the most important results and conclusions of the study. However, the phrasing, main emphasis, and ordering of these four categories is different in the Executive Summary versus Chapter 9, which is unnecessarily distracting. This review recommends that the four categories of main results/conclusions be presented in the same order in both the Executive Summary and in Chapter 9 and the headers be made more consistent and compelling. (Note that the answers to this question did not address the scientific validity of the study's results/conclusions in detail; that is the focus of Questions 3 and 4.) Although the background material within the main report is indeed presented at a level suitable for non-technical audiences, this review recommends that large portions of the background material (specifically all of Chapter 2, 50+ pages in length) be moved to an Appendix. The remainder of the main report never refers to Chapter 2. A non-technical end-user of the present report who attempted to read it in sequential order would likely be side-tracked by Chapter 2, and find it harder to locate the key material and findings of the LSRWA.

Question 2: Are the alternative sediment management approaches clearly described and documented? Does this background material provide supporting evidence for the finding and conclusions of the study with regard to alternative sediment management approaches?

Where clearly defined as methods for reducing the cubic yards of total sediment present in the reservoir, the alternative sediment management approaches were found by the large majority of the reviewers to be well-documented, well-described, and comprehensive. It should be emphasized that the positive comments regarding the analysis and comparison of alternative sediment management approaches depend on the fact that the main conclusions regarding the alternative sediment management approaches did not critically depend on the fidelity of the HEC-RAS and AdH models. As a result, the uncertainties in the reservoir modeling process should not have much influence on the overall findings. It must also be stressed early and repeatedly that the dollar costs associated with alternative sediment management approaches specifically focus on the cost of reducing the amount of total sediment behind the dam, not on the cost of managing the impact of associated nutrients on the Chesapeake Bay. Further analysis would be required to appropriately rank the alternative strategies based on a more environmentally relevant total cost in terms of dollars per pound of nitrogen and/or phosphorus reduction.

Questions 3 & 4: Does the main report provide clear, supporting evidence for the results, findings, and conclusions of the study? Does the report adequately identify key uncertainties in the model applications which, with better information, could change the predicted outcomes of the alternative management scenarios evaluated in this study?

The most important conclusions which follow logically from the findings of the LSRWA study are generally well-supported by the overall content of the study. Nonetheless, there are many areas that can be improved. The comments in this section focus on specific aspects of the study that are key sources of uncertainty but have not been fully explained as such in the main report. This section of the review also highlights some sections of the report that are most likely erroneous and/or are most in need of improvement or additional explanation. Although the report lists and discusses sources of uncertainty, it expresses the expected confidence intervals on its model predictions less often. Although there is no single accepted procedure for reporting uncertainty in the context of scenario modeling, a part of the report should more explicitly explain why confidence intervals on predictions are generally not provided.

Key areas of concern which are expanded upon in response to Questions 3 and 4 include: (1) Stated sediment discharges from the Conowingo Dam are inconsistent with the literature. The report authors should either correct their numbers or present a clear explanation that reconciles why their estimates are significantly different from other estimates that are based on analysis of observed data. (2) Reduced deposition associated with reservoir infilling has been neglected. The fundamental issue motivating the LSRWA study is that the net trapping efficiency of Conowingo Reservoir has decreased dramatically over the past 15 to 20 years. Net trapping efficiency is the sum of increases in average annual scour and decreases in average annual deposition. However, the simulations and calculations in the study only considered the increase in scour. (3) Grain size effects within and exiting the reservoir were not sufficiently considered. The combination of two grain size effects – (i) changing grain size in time in the reservoir and (ii) the greater effects of fine sediment in transporting nutrients - mean that the effects of the reservoir on water quality have not reached a full dynamic equilibrium. However, the report did not address whether reservoirs were in dynamic equilibrium with respect to nutrients other than by assuming that if sediment was at equilibrium, then nutrients were also. (4) Limitations of the HEC-RAS and AdH models were not made sufficiently clear in the main report. The HEC-RAS modeling effort was largely unsuccessful, and the HEC-RAS simulation was largely abandoned as an integral part of the main report. Although consistent with four observed, integrated sediment-related properties of the system, the AdH model was not fully validated, and the AdH model was forced by boundary conditions outside the range of observed values. This means that the AdH model alone was not reliably predictive, and until the AdH model has been improved, observations should instead be emphasized to support the most important conclusions of the LSRWA study.

Question 5: Are the recommended follow-up evaluations and analyses (Section 9.1) complete and comprehensive as well as clearly stated to enable the next phase of work to continue under the Partnership's Midpoint Assessment?

Many of recommendations for future work and modeling tool enhancement are very good and are consistent with the views of this review. However, the recommendations as presently written over emphasize the significance of sediment (relative to nutrients) and do not include some important additional possibilities. One of the outcomes of this study should be to identify areas where our scientific understanding may be insufficient to achieve management goals, and to suggest future scientific studies to provide this knowledge. Follow-up studies need to consider the full range of hydrologic conditions, from moderate to high flows, which generally do not result in scour (but still reduce the deposition of sediment-associated nutrients in the reservoir), all the way up to the very high but very rare events that do result in scour. The emphasis in the future should shift from the relative vague impact of additional "sediments and associated nutrients" to the differential impact of specific particulate and dissolved nutrients.

A key question is how to proceed to do the "adjusting" of the TMDL milestones to account for increased sediment-associated nutrients passing out of the reservoir. Key recommendations of this review in this regard include: (i) that the effect of the change in overall "trapping capacity" must be accounted for (the LSRWA analysis done so far relates only to increased scour and not to total trapping capacity), (ii) priority should be given to accounting for the added particulate phosphorus, and (iii) the additional sediment load (other than associated nutrients) should NOT be an additional burden on TMDLs. Calculations by Hirsch suggest that the net loss of trapping efficiency by Conowingo may be in the range of 2300 tons of phosphorus per year. The basic question facing the midpoint assessment then is: what would it take in terms of upstream phosphorus management in order to overcome the impact of ~2300 tons of phosphorus? This estimate is not highly accurate. The team that did the LSRWA report has the simulation expertise and capacity to test these estimates, but they have not yet performed this specific simulation. The follow up to this LSRWA effort really needs to address these estimates and replace them with better ones if they can (including uncertainty bounds).

This review supports enhanced long-term monitoring of the flux of sediment and associated nutrient flux in the lower Susquehanna River system. This LSRWA report certainly makes the case that it is needed, as there was inadequate observed data to sufficiently understand nutrient transport dynamics or for model calibration and validation. Updated technology should play a key role in enhanced long-term monitoring of the Lower Susquehanna/upper Chesapeake Bay (and other river/estuarine transitions in the Chesapeake Bay system). There are a variety of technologies that can be applied using *in situ* sensors to collect an essentially continuous record of sediment concentrations and flux for use in inferring sediment-associated nutrient transport, including inference of grain size distribution.

Question 6: Do the technical appendices provide the necessary documentation for the models and their applications in support of the study's results, findings, and conclusions?

As described above in response to Questions 3 and 4: (i) the HEC-RAS modeling effort was ultimately unsuccessful, and results of the HEC-RAS simulation did not form an integral part of the main report, and (ii) the existing application of the AdH model, although generally consistent with the validation data used, was not reliably predictive beyond constraints provided by a few integrated observations of sediment-related properties of the system. Additional comments from individual reviewers directed toward the HEC-RAS and AdH modeling efforts beyond the items discussed in response to Questions 3 and 4 are included in this section as responses to Appendix A and B. Appendix C and Appendix D of the LSRWA Draft Report describes applications of the Chesapeake Bay Environmental Modeling Package (CBEMP) to estimate changes arising from additional scour from behind Conowingo Dam during large events. Unlike the AdH and HEC-RAS models, which are relative new model systems that had not been applied before to the Lower Susquehanna environment, the CBEMP model has a decades-long history of applications and evolutionary improvements within the Chesapeake Bay system, including numerous peer-reviewed publications assessing its performance in this specific environment. The application of the CBEMP model to the LSRWA effort is generally well done, and the conclusions are reasonably supported, especially given that the LSRWA was intended as an exploratory analysis.

Additional comments on the appendices and main report

The last section of the review contains additional comments from individual reviewers referring (i) to the remaining appendices and (ii) to more isolated issues within the main report, with the latter specified by page number. Although these are individual issues that were not necessarily identified by multiple reviewers, these remaining comments are nonetheless important and should also be considered by the LSRWA authors in any revisions and/or follow up analyses.

SYNTHESIS OF INDIVIDUAL REVIEWERS' COMMENTS

Question 1: Does the main report clearly define the goals, strategies, and the results/conclusions of the study, and also present adequate background material at a level suitable for understanding by non-technical audiences?

<u>Goals and Strategies</u>

Although clearly stated on p.10, the goals declared in the main report (which stress both sediment and nutrient management) are inconsistent with the methodological approach taken by LSRWA (which mainly emphasized sediment). The main report's Introduction (p.10) states that: "…the specific goals and objectives for the LSRWA effort were: 1. Generate and evaluate strategies to manage sediment and associated nutrient loads delivered to Chesapeake Bay… 2. Generate and evaluate strategies to manage sediment and associated nutrients available for transport during high-flow storm events to reduce impacts on Chesapeake Bay. 3. Determine the effects to Chesapeake Bay due to the loss of sediment and associated nutrient storage within the reservoirs on the lower Susquehanna River." Note that the above goals statement repeatedly weights "sediment and associated nutrient(s)" equally. Yet the study put much more of its effort into addressing issues of sediment management to extend the life of Conowingo Dam as opposed to nutrient management to protect Chesapeake Bay water quality. In fact, there is very little content in the overall LSRWA effort which focuses on managing nutrients. The inconsistency between the stated goals and the general strategies followed is an issue that propagates throughout the analysis for the entire assessment.

Although the word "goal" does not appear in the Executive Summary, the Executive Summary does state (on p.ES-1), "The purpose of this assessment was to analyze the movement of sediment and associated nutrient loads within the lower Susquehanna watershed through the series of hydroelectric dams (Safe Harbor, Holtwood, and Conowingo) located on the lower Susquehanna River to the upper Chesapeake Bay. This included analyzing hydrodynamic and sedimentation processes and interactions within the lower Susquehanna River watershed, considering strategies for sediment management, and assessing cumulative impacts of future conditions and sediment management strategies on the upper Chesapeake Bay." A similar "purpose" statement appears in the Introduction on pp.5-6. Note that the word "nutrient" appears only once in the above statement, and the purpose of the study was mainly to address "sediment management". The above quote seems to be a more realistic statement of the actual goals of the study.

It appears that the goals as presently listed in the Introduction to the main report were not the original goals of the study. Page ES-4 states, "The conclusion that the primary impact to living resources in Chesapeake Bay was from nutrients and not sediments, was not determined until late in the assessment process… Management opportunities in the Chesapeake Bay watershed to reduce nutrient delivery are likely to be more effective than sediment reduction opportunities at reducing impacts to the Chesapeake Bay water quality and aquatic life from scour events, but these management opportunities were not investigated in detail during this assessment." By crafting a goals statement that reflects findings from late in the study, the report's authors may have unintentionally undermined the connection between the study's goals and approach. The assessment actually focuses much more on the movement of sediment and options for sediment removal from the Conowingo reservoir rather than managing the associated nutrients to improve water quality.

This review recommends that the "original goals" of the study (i.e., sediment management to extend the life of Conowingo Dam more than nutrient management to protect Chesapeake Bay water quality) be presented in the introduction followed by a fuller explanation of how and why the focus of the study evolved in time. Presently, the report only briefly states that during the course of the study it became clear that nutrients were more important than sediment. More background is needed in the introduction regarding how and why this judgment was made and how the course of the study then evolved.

Results and Conclusions

Both the Executive Summary and Chapter 9 of the main report (entitled "Assessment Findings") present four categories of conclusions that generally correspond to each other. Within the individual context of the Executive Summary or Chapter 9, each set of conclusions is well written and easy to follow and understand. Their general content also includes the most important results and conclusions of the study. However, the phrasing, main emphasis, and ordering of these four categories is different in the Executive Summary versus Chapter 9, which is unnecessarily distracting. Also, the most meaningful aspect of each category of findings is not necessarily used as the header for its respective category. Note that in this section of the review, the scientific validity of the study's results/conclusions is not addressed in detail; that is the focus of Questions 3 and 4.

This review recommends that the four categories of main results/conclusions be presented in the same order in both the Executive Summary and in Chapter 9 and the headers be made more consistent and compelling. Working from the ordering of the main findings as presented in Chapter 9, the following changes are recommended. The title "Finding #1: Conditions in the Lower Susquehanna reservoir system are different than previously understood" (p. 189) is simultaneously vague and obvious. The subheading that immediately follows: "Conowingo Reservoir is essentially at full capacity; a state of dynamic equilibrium now exists" is much more meaningful and to the point. A choice similar to the first bold heading in the Executive Summary (p. ES-1) – i.e., "Loss of Long-Term Trapping Capacity for Sediment-Associated Nutrients" could also be a good choice. One of these two (or another similarly meaningful header) should be used in both sections.

"Finding #2: The loss of long-term sediment trapping capacity is causing impacts to the health of the Chesapeake Bay ecosystem" (p. 192) aligns with the third heading in the Executive Summary ("Nutrients, Not Sediment, Have the Greatest Impact on Bay Aquatic Life", p. ES-3). Again, the Executive Summary header is more meaningful. They should be made consistent and both be listed second (or both third) among the main findings. Finding #3 – which might be slightly rephrased to "Sources upstream of Conowingo Dam deliver more nutrients and therefore have more impact on the upper Chesapeake Bay ecosystem than do the sediment-associated nutrients associated with the Conowingo Dam" (p. 193) – corresponds mainly to the second heading in the Executive Summary ("Watershed is the Principal Source of Sediment", p. ES-2). In this case, the spirit of the finding in Chapter 9 is more appropriate because it emphasizes nutrients. Again, they should be made consistent and both be listed third (or both second).

"Finding #4: Managing sediment via large-scale dredging, bypassing, and dam operational changes, by itself does not provide sufficient benefits to offset the upper Chesapeake Bay water quality impacts from the loss of long-term sediment trapping capacity" (p. 195) corresponds to the fourth heading in the Executive Summary ("Sediment Management Strategies", p. ES-3). These are problematic in that the phrase "Sediment Management Strategies" is not a conclusion, while Finding #4 as phrased in Chapter 9 is not strictly true. Repeated large-scale dredging and removal of accumulated sediment and isolated placement elsewhere would indeed restore sediment trapping ability of the reservoirs and associated water quality benefits to the upper Chesapeake Bay. The (valid) compromising issue is cost effectiveness. Thus, the fourth header/finding needs to be rewritten, perhaps to something with a meaning along the lines of "Managing sediment via large-scale dredging, bypassing, and dam operational changes is not a cost-effective approach to offsetting the upper Chesapeake Bay water quality impacts from the loss of long-term capacity for trapping sediment-associated nutrients".

Background Material

Although the background material is indeed presented at a level suitable for non-technical audiences, this review recommends that large portions of the background material contained in the main report (specifically all of Chapter 2) be moved to an appendix. The level of sophistication of Chapter 2 is suitable for scientifically literate audiences who are not necessarily well-versed in the environmental issues and technical approaches specific to Chesapeake Bay restoration. One reviewer noted approvingly that the level is well suited to an introductory course on Chesapeake Bay taught at their university. However, multiple reviewers also noted that the placing of so much background material (52 pages) in Chapter 2, immediately following the report's Introduction, is actually counterproductive.

The remainder of the main report never refers to Chapter 2. In contrast, the other Chapters refer to each other, and the sub-sections of the report's Introduction (Chapter 1) explicitly mirror the next several report chapters. Sections 1.1-1.3 and 1.5 "Project Authorization/Project Sponsors and Partners/Study Area/Significance" are analogous to Chapter 3 "Management Activities in the Watershed", Section 1.10 "Assessment Approach" (p. 13) is analogous to Chapter 4 "Modeling Tools and Applications", Section 1.6 "Problem Background" (p. 8) is analogous to Chapter 5 "Problem Identification"), and Section 1.9 "Assessment Products" (p. 10) is analogous to Chapter 6 "Development of Sediment Management Strategies"). Thus Chapter 2 notably interrupts the flow of the report and seems to be an awkward add-on.

A non-technical end-user of the present report who attempted to read it in sequential order would likely be side-tracked by Chapter 2, and find it harder to locate the key material and findings of the LSRWA. They might logically assume that Chapter 2 was part of the information that was input to the models used to complete the Assessment, when it actually contains free-standing information compiled separately from the rest of the project. Removing Chapter 2 from the main body of the report will make the main report much more manageable for end-users, reducing its length of the text by 25%, from over 200 pages to less than 150 pages. The average length of the remaining eight chapters of text would then be 19 pages each, compared with the unwieldy 50+ pages of Chapter 2. Nonetheless, it is not recommended that the background information in Chapter 2 be deleted from the Assessment as a whole. The material contained in Chapter 2 is generally well-written, useful information that, within the context of the Appendices, could be helpful to some readers to better understand this complex subject. It would be most logical to change Chapter 2 into Appendix A, but its precise location may be left to the authors.

Question 2: Are the alternative sediment management approaches clearly described and documented? Does this background material provide supporting evidence for the finding and conclusions of the study with regard to alternative sediment management approaches?

Where clearly defined as methods for reducing the cubic yards of total sediment present in the reservoir, the alternative sediment management approaches were found by the large majority of the reviewers to be well-documented, well-described, and comprehensive. However, the distinction between strategies, sediment management alternatives, representative alternatives, and scenarios should be made clearer at an earlier stage of the report. Multiple reviewers found these concepts difficult to separate as they initially read through the report. It should be emphasized that the positive comments regarding the analysis and comparison of alternative sediment management approaches depend on the fact that the main conclusions regarding the alternative sediment management approaches did not critically depend on the fidelity of the HEC-RAS and AdH models. The alternative management scenarios are actually only weakly coupled to the reservoir transport models; they are clear consequences instead of the long-term sediment budget as constrained by observations. As a result, the uncertainties in the reservoir modeling process should not have much influence on the overall findings.

It must also be stressed early and repeatedly that the monetary costs associated with alternative sediment management approaches specifically focus on the cost of reducing the amount of total sediment behind the dam, not on the cost of managing the impact of associated nutrients on the Chesapeake Bay. Consider, for example, scenarios 2C (open water placement, bypassing) and 3A (upland placement, Stancill Quarry) in Table 6-6 (p. 168). The estimated unit costs are only $6-12 per cubic yard for scenario 2C with bypass dredging, whereas the costs are $23-35 per cubic yard for scenario 3A with upland placement. This makes it seem that upland placement is about 3x more expensive than bypassing. However, it relies on the implicit assumption that a ton of sediment that is bypassed has the same environmental impact as a ton of sediment that is dredged and placed upland in a landfill. Even a ton of sediment that is removed is not uniformly equal given that nutrient (primarily P) loads are tied most closely to clay-sized sediment.

Although it is not specifically described as such in the draft report, the overall economic analysis in the LSRWA is in essence a cost-effectiveness analysis (CEA). In contrast to cost-benefit analysis in which the positive and negative impacts of alternatives are expressed and directly compared in monetary terms, CEA expresses some key impacts in non-monetary but still quantitative terms. One of the common challenges faced when conducting a CEA is that key impacts are often multi-dimensional and therefore difficult to fully capture and summarize in a single indicator. In specific parts of the main report and appendices (e.g., Table 6-10 in the main report entitled "Sediment Management Strategy Summary Matrix" and appendix attachment J-3 "Summary Table of Sediment Management Alternatives' Evaluation"), environmental impacts are presented side-by-side with the dollar costs of reducing cubic yards of sediment in the reservoir. In such a context, it is sufficiently clear that the "cheaper" alternatives are not the "better" alternatives.

This review recommends that further caveats be included throughout the report to clarify that the dollar-based cost estimates regarding alternative sediment management approaches are specifically for reducing cubic yards of total sediment in the reservoir, not for achieving broader goals regarding nutrient reductions. The dollar-based cost estimates in Table 6-6 are reported in the Executive Summary (p. ES-4) and elsewhere in the assessment report. Wherever the dollar-based cost estimates are stated, their meaning with regard to increasing reservoir capacity rather than improving water quality should be more clearly indicated. The report should also emphasize that further analysis would be required to appropriately rank the alternative strategies based on a more environmentally relevant total cost in terms of dollars per pound of nitrogen and/or phosphorus reduction.

There are an enormous number of potential management alternatives, far too many to consider in depth for a program of this size and scope. Narrowing them down to a reasonable number of representative examples, then further limiting those examples by a scoping analysis to a set that might be worth further study, was an appropriate approach to handle this complexity. Unfortunately, an artifact of the categorization techniques used to make sense of the multiple potential scenarios is an artificial limitation of cross-category considerations and benefits. Combinations of different scenarios and management approaches might actually be the best possible approach, either in parallel or sequentially. For example, a one-time major dredging in the region just upstream of the dam, followed by bypassing from further upstream to slow subsequent infill, might have longer lasting effects. These more complex scenarios are clearly beyond the scope of this report, but they should be mentioned and acknowledged as worthy of exploration.

The economic analysis and comparison of the alternatives could be further enhanced by considering, and at least discussing in qualitative terms, other possible co-benefits (and possibly co-costs) of the alternatives. For example, in addition to reducing loads to the Bay, many of the BMPs provide other ecosystem service benefits such as improved water quality upstream from the Bay, carbon sequestration, water storage/flood control, recreation benefits, etc. (see USEPA report EPA/600/R-11/001 for an analysis that includes some of these co-benefits). These co-benefits could meaningfully offset some the costs associated with the BMP alternatives; therefore, they should be acknowledged in the report. Similarly, dredging activities may entail aesthetic disamenities (i.e., external costs), which would have the opposite effect by increasing the total costs of this set of alternatives.

Question 3 & 4: Does the main report provide clear, supporting evidence for the results, findings, and conclusions of the study? Does the report adequately identify key uncertainties in the model applications which, with better information, could change the predicted outcomes of the alternative management scenarios evaluated in this study?

As discussed in the introduction to this review, the most important conclusions which follow logically from the findings of the LSRWA study are generally well-supported by the overall content of the study. Nonetheless, there are many areas that can be improved. The comments in this section focus on specific aspects of the study that are key sources of uncertainty but have not been fully explained as such in the main report. This section of the review also highlights some sections of the report that are most likely erroneous and/or are most in need of improvement or additional explanation.

General uncertainty

Although the report lists and discusses sources of uncertainty, it expresses the expected confidence intervals on its model predictions less often. For example, if storm sediment transport can hardly be measured to within +/- 50%, model predictions can hardly be expected to be better (for example, in Appendix A, an error of about this range is indicated for predicting reservoir scour). Ideally, ranges should be provided for all model predictions (rather than a specific number). Although there is no single accepted procedure for reporting uncertainty in the context of scenario modeling, a part of the report should more explicitly explain why confidence intervals on predictions are generally not provided.

Statistics inferring a 10% change in transport might be (well) within the uncertainty of the total-transport values. References to differentials as small as 0.1% (for example, see table 6.7) imply accuracies in characterizing the sedimentary system that could not be confirmed by any type of measurement known by the reviewers. However, if qualified as model results and indications are in relative terms, there may be value in such numbers as long as all such values are qualified as "well within measurement error." Hence, "we cannot infer any significant change" should be stated up-front based on results of such analyses. In many of the modeled scenarios, the changes in attainment of water quality criteria with fairly large management actions would appear to a non-technical reader to be very small. For instance, p. 135 states: "…estimated…non-attainment…of 1 percent, 4 percent, 8, percent, 3 percent…" One should ask if such estimates are statistically significant. Similarly, in appendix A, p. 25, the net deposition model indicated that ~2.1 million tons net deposition in the reservoirs occurred in 2008-11. This is the difference of two order-of-magnitude larger numbers (22.3M tons entered the reservoir, 20.2M tons entered the Bay). There is a rule-of-thumb in sedimentology: ±10% in concentration or transport is 'within error'. Does the precision of the computed difference fall within the margin of error in these metrics?

Propagation of uncertainty in model predictions from the reservoir sediment transport prediction to those of the Bay Ecological Model may be significant. If optimally constrained by observations, reservoir calculations may have reasonable accuracy and precision when averaged over longer timescales, but less accuracy over shorter timescales. However, the key timescales for many biological processes are much shorter than those of an annual sediment budget, and this could be a major source of uncertainty in the predictions of the efficacy of the sediment management scenarios. This disparity in process timescales is important to address in the text and in the conclusions of the study.

Anoxic volume days appears to be a variable that is relatively more sensitive to the model scenarios presented in the report (e.g., Table 6-8). This suggests something alluded to in the report on several occasions, that a large fraction of the deep water in Chesapeake Bay is sitting on the threshold of being anoxic, and seemingly small changes in concentration (0.2 mg/l) lead to substantial relative changes in anoxic volume. It is worth clearly stating that the high sensitivity of this one criteria to small changes in load stands out among the other variables (e.g., chlorophyll-a, chl-a). It strikes the reviewers that changes in chlorophyll and dissolved oxygen associated with "normal" inter-annual variability in climate and nutrient loading are much higher than those associated with additional Conowingo Dam-derived nutrients as simulated here. One might conclude that given this fact, that the potential effects of dam-derived particulates are trivial. Given the quantifiable effects on chl-a and DO derived from these model simulations, however, it may be worth emphasizing that it would be difficult to tease out the Dam effects from observations given natural variations in load, flow, chl-a, and DO, and that the models are therefore necessary for assessment and prediction.

Stated sediment discharges from the Conowingo Dam are inconsistent with the literature

On p. 113 the report states, "A close inspection of the model simulation results indicate that trace erosion does occur at lower flows (150,000 to 300,000 cfs), which is a 1- to 2-year flow event. This finding is consistent with prior findings reported by Hirsch (2012)." The Hirsch (2012) findings are different from what is expressed here. The relevant statement from Hirsch (2012) is: "The discharge at which the increase [i.e., the increase in suspended sediment concentrations at the dam] occurs is impossible to identify with precision, though it lies in the range of about 175,000 to 300,000 cfs. Furthermore, the relative roles of the two processes that likely are occurring – decreased deposition and increased scour – cannot be determined from this analysis."

In the second paragraph of p. 190, the report states that "…a major scour event will occur once every 4 to 5 years, and minor scour events with trace amounts of erosion will occur every 2-3 years (150,000 to 300,000 cfs)…" The statement that minor scour events will occur every 2-3 years is incorrect on two counts. First, the events in excess of 150,000 cfs happen on average about 3 times per year (not once every two to three years). The number of such days (with daily mean discharge between 150,000 and 300,000) is about 11 days per year. In contrast, days with daily mean discharge greater than 400,000 cfs happen about 0.45 days per year. Second, it is not clear that the increase in sediment loads in the 150,000 to 300,000 cfs range is really a result of scour. It may be that it is mostly a result of a decrease in the amount of deposition that occurs at these flows. The statement overall seems intended to downplay the importance of these moderately high flow days, but they do make a substantial difference in the trend in net outflows of sediment and phosphorus to the Bay. The impacts of changes must be viewed as a product of magnitude and frequency. The magnitude of the change at the 400,000+ cfs range is large, but the frequency is small. The magnitude of changes in the 150,000 to 400,000 cfs range is smaller, but the frequency is much higher.

Also on p. 190, the report indicates that, "The total sediment outflow load through the dam… increased by about 10 percent from 1996 to 2011…" These results are so strongly at odds with other published numbers on this subject that some explanation and discussion is certainly required. Hirsch (2012) reports an increase in flow-normalized flux over the period 1996-2011 of 97 percent (see Table 3 of Hirsch). Also, Langland and Hainly (1997) published an estimate of change in average flux from about 1997 to the time the reservoir is full of 250%. Reporting a 10% increase in light of these two other findings appears erroneous.

At bottom of p. 190 the text reports on reductions in TN, TP, and TSS as 19, 55, and 37%, respectively, for the past 30 years for loads "to the lower Susquehanna River", referenced to http://cbrim.er.usgs.gov. This could mean loads delivered to the upstream end of the reservoir system or loads delivered at the downstream end where the river enters the Chesapeake Bay. At the Marietta site (above the reservoirs), the actual results were downward trends of 29.9, 40.1, and 44.8%, respectively, while at Conowingo the USGS reports 22.3, 0.8, and 10%. In either case, these numbers are different from those mentioned in this report. An additional issue here is that the USGS values are trends in flow-adjusted concentration, expressed in percentage terms. The text is referring to trends in nutrient and sediment loads and not trends in concentrations.

For each of the above cases, the report authors should either correct their numbers or present a clear explanation that reconciles why their estimates are significantly different from other estimates that are based on analysis of observed data.

Reduced deposition associated with reservoir infilling has been neglected

The fundamental issue motivating the LSRWA study is that the net trapping efficiency of Conowingo Reservoir has decreased dramatically over the past 15 to 20 years. Net trapping efficiency is the sum of increases in average annual scour and decreases in average annual deposition. However, the simulations and calculations in the study only considered the increase in scour.

Based on the use of WRTDS (a published statistical method for evaluating fluxes and trends in fluxes, a method that is central to two of the publications cited by the LSRWA, i.e., Hirsch, 2012 and Zhang et al., 2013), the estimated flow-normalized flux of TP out of Conowingo Dam between the 1996 condition and the 2011 condition has increased by 3.65 tons/day (going from 6.64 to 10.29 tons/day). This increase equates to a 5329 ton increase over the four year simulation period. In the LSRWA report, the simulation of scour is captured as a single event with a total magnitude of 2600 tons (see Table 5-9 scenario 3). Based on these two numbers, it would be logical to conclude that the remainder of the increase over the 1996 to 2011 period would be the difference between 5329 and 2600 tons, which is 2729 tons. This suggests that about half of the increase in loading of TP to the Bay comes in days with discharges below 400,000 cfs. Without having the model simulate the full range of changes due to the loss of trapping efficiency, the report's authors have introduced a large uncertainty into the results, and it is one that surely leads to an underestimate of the impact of the filling of Conowingo.

This issue underlies a significant weakness in the report, which is that it focuses its inquiry on the impact of large, but infrequent, scour events rather on the total impact of the change in trapping efficiency of the reservoir system. The flaw in the logic of the report is expressed, for example, on p. 137: "Generally speaking, when flow is below the scour threshold, sediment is estimated to settle out when in dynamic equilibrium. Consequently, water quality in the Bay is the same as it would be if the reservoirs were still filling as long as there is no scour event." This same logical flaw appears again on p. 142: "...without storms, the reservoirs will continue to trap sediments in the short term at rates consistent with today", and on p. 190: "…major scour events will occur once every 4 to 5 years, and minor scour events with trace amounts of erosion will occur every 2-3 years (150,000 to 300,000 cfs) and at all other times, the reservoir will continue to trap sediment and associated nutrients."

The review recommends that all statements that indicate that reservoir trapping of sediment and associated nutrients is unchanged in the absence of scour be removed. In addition, a discussion should be added to the report that clearly states that decreases in the average annual deposition in the reservoir in the absence of scour have not been considered and that the added transport of sediment-associated nutrients past Conowingo Dam due to decreased deposition may be as large as that added due to increased scour.

Grain size effects within and exiting the reservoir were not sufficiently considered

It is reasonable to expect that the texture of the sediment behind the dam will continue to coarsen through successive scour events and deposition interludes. The report states in several places that less sand exits the dam at the downstream end than enters the reservoir at the upstream end (e.g., p. 191), both because it deposits first at the upstream end and because it is much more prone to settle out of suspension or transport as bedload after it is remobilized. The reservoirs are not in a final state of dynamic equilibrium if the sediment entering the reservoirs is coarser than the sediment leaving. The reservoirs appear to be preferentially storing sand and, with scour, exchanging that sand for silts and clays. Over time, this implies even a "full" reservoir will gradually fill with sand at the expense of fines. This progressive change in grain size will gradually change the threshold conditions for sediment entrainment and change the grain size of sediments that are typically mobilized by scour. But how long with this transition take? Thus, the dynamic equilibrium that is described in the report is changing over time, and it would be worthwhile to try to predict how many cycles of deposition and scour might be required before the dynamic equilibrium becomes less dynamic.

Nutrients associated with fine sediments, not with the total load of sediments, are the main water quality concerns. The report acknowledges that sand-sorbed P is more or less inconsequential in P transport. However, all sediment-discharge values are expressed as "total loads." Since P transport is closely tied to fines, and presumably very closely tied to clay-size particles, transport metrics computed for fines, and particularly for clay-size particles, might yield different conclusions than those derived from "total" load comparisons. It is also important to clearly define what is meant by total load. Sedimentological nomenclature denotes "total load" as all material in transport, be it defined as bedload plus suspended load (with caveats), or bed-material load plus washload (no caveats) (ASTM International, 1997, Terminology for Fluvial Sediment; Diplas et al., 2008, p. 306 at: http://water.usgs.gov/osw/techniques/Diplas_Kuhnle_others.pdf). It is not clear that "total load" refers to either of these metrics in the LSRWA report.

The combination of these two above grain size effects, (i) changing grain size in time and (ii) the greater effects of fine sediment in transporting nutrients, mean that the effects of the reservoir on water quality have not reached a full dynamic equilibrium. However, the report did not address whether reservoirs were in dynamic equilibrium with respect to nutrients other than by assuming that if sediment was at equilibrium, then nutrients were also. Although information was provided in the report on particle-size distributions in reservoir bed sediments and sampled streamflow, and on the relevance of particle size to P concentrations, there was no tie-together and possible revision of load values to indicate how the interplay of these metrics might result in changes to a fundamentally important metric, fine-sediment (particularly clay-size material) transport to the Bay. In reality, as the reservoir evolves in time toward containing a larger and larger fraction of sand, the sediment scoured during large events should progressively contain fewer fines and fewer associated nutrients.

The review recommends that the concept of dynamic equilibrium be clearly qualified in the report to indicate it does not yet apply to sediment grain size, and thus it does not yet fully apply to the flux of fine sediment or associated nutrients.

Limitations of HEC-RAS model were not made sufficiently clear in the main report

The HEC-RAS modeling effort was largely unsuccessful, and the HEC-RAS simulation was largely abandoned as an integral part of the main report. Reasons for this are listed on pp. 22-24 of Appendix A (Section 6.0 Model Uncertainty and Limitations). Apparently the primary reason why the HEC-RAS modeling failed had to do with sediment calculations: fall velocity estimates appeared to be off and could not be corrected and, for the cohesive model, only a single critical shear stress could be defined for the cohesive sediment bed. Critical shear stress simulations produced contradictory results, which remained unresolved. A member of the review panel familiar with the RAS model has also found that RAS, in the beta version used in the LSRWA study, simply makes incorrect calculations. Although HEC-RAS results were used to supply sediment to the upstream end of the 2d AdH model, this use of RAS output was fortunately of minor significance to the overall LSRWA effort. Upstream inputs to the Conowingo Reservoir could also be estimated from empirical analysis using USGS transport data.

Another source of inconsistencies between the HEC-RAS application and USGS transport estimates may be associated with the different definitions of bed-material load, washload, suspended load, bedload, and total load. The transport equations available in HEC-RAS produce bed-material load data. Bed-material load is that material in transport – suspended or as bedload – that is characteristic of the material composing the bed. The remainder, which is not characteristic of the bed, is washload, and washload is substantial in this system. Estimates from equations/models based on bed-material size data and hydraulic information do not include the washload component. Empirically derived "total load" estimates, on the other hand, are actually suspended-sediment loads, as is the output from the Estimator model. Suspended load is operationally defined as being computed from material captured by a suspended-sediment sampler. It includes the washload component. This is a distinction that seems to be fundamentally important to the LSRWA with respect to the interpretation of modeled and empirical suspended-sediment transport data. Conversely, most if not all output from the equations and models other than the empirically-based Estimator model and transport curves is expressed as bed-material load. Using different output metrics from various models amounts to computing "apples and oranges" in sediment and nutrient transport.

Presently, the description of the conclusions associated with HEC-RAS in Chapter 4 of the main text seems to underplay its poor performance. For example, p. 81 of the main report states, "For the LSRWA effort, the HEC-RAS model outputs were deemed acceptable because they provided relative understanding of the physical process of the upper two reservoirs…" This positive statement appears inconsistent with the analysis of HEC-RAS performance as assessed by this review. This review recommends that the failure of the HEC-RAS model be reported more clearly and fully in the Chapter 4 of the main report.

Although consistent with four observed, integrated sediment-related properties of the system, the AdH model was not fully validated

The AdH model was not calibrated, but instead the authors use what they refer to as a validation approach. Their use of the term validation differs from what is considered to be the norm in which a model is calibrated using part of a data set (typically part of a period for which data are available) and then evaluated, or validated, by applying the calibrated model to the balance of the data set. In their approach, four different parameter choices (defined primarily by the critical shear stress of the bed sediment) were used in four simulations and the model calculations were compared to simple, integrated properties of the system (net erosion and deposition cumulated over four years, average annual sediment retention during non-storm years, estimated reservoir scour for different events, and percent sand in sediment discharge). One of the four simulations was then selected for further work based on (i) net erosion and deposition for the entire reservoir, cumulated over four years (targeted to a net deposition of 3.0 to 4.0 million tons), (ii) estimated reservoir scour for different events (targeted to the USGS scour curve), (iii) sediment retention of about 1.0 to 1.5 million tons per year during the non-storm period, and (iv) percent sand in sediment discharge over Conowingo Dam less than 10%. That is, only four scalar quantities were used to validate the model. This is slim verification for such a large and detailed model. What one can conclude is that a suite of parameters and boundary conditions for a large, detailed, and complicated model with many possible interactions was found to come roughly close to mimicking the gross behavior of the system based on matching four simple, integral measurements.

Although many other aspects of the model can be evaluated, no further information is given in that regard. No information is provided regarding whether more detailed internal results of the model (e.g., patterns of local scour and deposition) were evaluated for plausibility and consistency. The major reason for using a 2d model is to capture both lateral and along-stream changes. Reservoir bed elevations are available from 2008 and 2011, which provides an opportunity to evaluate model performance. But it is not clear that these elevations were used in this way. No information is given regarding whether other combinations of parameters might have produced similarly good integral results. It remains unresolved whether the match between model and measurement was a case of getting the right answer for the wrong reasons.

Another aspect of this AdH discussion that could be improved is the effect of the uncertainties in AdH predictions near the Dam face. These uncertainties take two forms – the overly simple approximation of the boundary condition at the dam that is acknowledged in the text, and related problems associated with 3D flow effects very near the dam. How far away from the Dam are the predictions of flow and sediment transport likely to be affected? Will these uncertainties affect predictions of scour significantly, or are the primary scour zones outside the region of influence?

This review recommends that the limitations of the AdH application as described above be made much clearer in both Appendix A and the main report.

AdH was forced by boundary conditions outside the range of observed values

The tenuous nature of the model validation is made more uncertain by the fact that the values for the key boundary condition (critical bed shear stress for sediment entrainment) in the final selected model fell largely outside the range of values measured by the SEDFLUME or were unmeasured and taken from the literature. The critical stress reported from SEDFLUME had a median value of 0.083 lbf/ft^2, while the critical stress used for the top foot of the reservoir sediment in the selected AdH model was reported as 0.03 – 0.06 lbf/ft^2, largely outside the range of the measured SEDFLUME values. The critical stresses used in the model for sediment one-to-two feet and two-to-three feet below the surface were 0.1 lbf/ft^2 and 0.14 lbf/ft^2, respectively. These depths were unsampled in the field, and the critical stress values were taken from the literature.

Because sediment transport has a threshold and is a nonlinear function of flow, errors in the bottom boundary condition will, in general, produce large errors in calculated transport rate and morphodynamic change. Even though a set of parameters was selected that provided rough similarity to the observed net scour and deposition over the four year run time, this provides no assurance that the predicted patterns and timing of transport, scour, and deposition match reality. Thus the application of the AdH model does not extend the empirical understanding provided by existing reservoir bathymetry and stream gaging.

Rather than attempt to further refine the sediment bottom boundary conditions with direct measurements, a more promising approach would be to collect suspended sediment measurements in the reservoir and evaluate the choice of model boundary conditions by comparing a time series of transport calculations against observations. This could provide direct calibration, *in situ*, of model performance. The extensive and spatially explicit output from a model such as AdH provides many varied opportunities for evaluating model performance. Does the model aggrade where we see aggradation and degrade where we see degradation?

The AdH model alone was not reliably predictive; observations should be emphasized

The AdH application in this study has been developed to the point that scour and deposition is consistent with what is already known from survey and sampling observations. However, the AdH model application does not refine that empirical understanding. The uncalibrated and weakly constrained model application provides an essentially heuristic basis for scenario evaluation, and the AdH model has not, as yet, added substantial new understanding of the sediment dynamics of the reservoir. The modeling does not strongly reinforce the existence of a scour threshold at 300,000 and 400,000 cfs. At best, it can be said that an uncalibrated model was found that produces results that are consistent with that particular threshold. Other choices of model input (including bed sediment parameters more in the range observed by SEDFLUME) would likely produce a different scour threshold.

The report would be more convincing if some of the observational data in the Appendices were incorporated into the main report, particularly those that bear on the time-varying sediment budget. This is really the heart of the matter, and highly sophisticated (but weakly constrained) models are not essential to illustrate what is happening. Many of the important conclusions of the report regarding sediment and nutrient delivery from the reservoirs are direct consequences of the sediment budget of the system and its evolution through time (i.e., the amount of sediment delivered by the watershed and trapped by the reservoirs and how these amounts have varied over the last several decades). Even if the fidelity of the models can be questioned, the observational data are compelling.

At present, the conceptual weaknesses of the models and the inherent uncertainty in model results are not well-described or acknowledged in the main report. Many of the basic conclusions of the study are direct consequences of the long-term sediment budget of the watershed and reservoir system, and while supported by the model results, are independent of the weaknesses of the modeling, and therefore citing them would strengthen the conclusions. These can be easily added. The uncertainties are discussed more openly in Appendix A, and it is recommended to expand that discussion and move some to the main report.

Question 5: Are the recommended follow-up evaluations and analyses (Section 9.1) complete and comprehensive as well as clearly stated to enable the next phase of work to continue under the Partnership's Midpoint Assessment?

Many of recommendations for future work and modeling tool enhancement are very good and are consistent with the views of this review. Alternate and/or improved models should continue to be pursued in future work in combination with additional data collection. Predictions from multiple models should be compared, including relatively simple models (e.g., the analytical model presented at the beginning of Appendix C). However, the recommendations as presently written over emphasize the significance of sediment (relative to nutrients) and do not include some important additional possibilities. Recommendations #1 and #4 (reproduced below as 5.1 and 5.4), should be expanded to acknowledge the need to develop improved scientific understanding of several key issues, rather than simply collecting more data and developing better models. One of the outcomes of this study should be to identify areas where our scientific understanding may be insufficient to achieve management goals, and to suggest future scientific studies to provide this knowledge. The goal of these studies is not simply to provide monitoring data for analysis or model calibration, but to provide the conceptual understanding of the system that will lead to the improvement of models.

<u>5.1. Before 2017, quantify the full impact on Chesapeake Bay aquatic resources and water quality from the changed conditions in the lower Susquehanna River and reservoirs</u>:

Throughout the text following Recommendation 1, "sediment and associated nutrients" should be changed to "sediment-associated nutrients". A key finding of the LSRWA study that has large ramifications for management activities is that sediment-associated nutrients have a much larger impact on Bay water quality than the sediments themselves (see additional discussion of this issue within Section 5.2 below). In addition, Recommendation 1.2 would be better written as something like: "Determine the quantity and nature of the sediment-associated nutrients transported downstream under current conditions (dynamic equilibrium) versus conditions that prevailed in previous times when the reservoirs had substantial trapping ability." Follow-up studies need to consider the full range of hydrologic conditions, from moderate to high flows, which generally do not result in scour (but still reduce the deposition of sediment-associated nutrients in the reservoir), all the way up to the very high but very rare events that do result in scour (see additional discussion above under the header "Reduced deposition associated with reservoir infilling has been neglected").

The filling of Conowingo has relatively less impact on nitrogen inputs to the Bay (because so much of the total nitrogen load to the Bay is in the dissolved form) but it does cause a substantial increase in the particulate phosphorus inputs. Ecosystem studies of the Chesapeake Bay based on present-day algal communities indicate that Bay hypoxia is more sensitive to dissolved nitrogen input than particulate phosphorus input, so perhaps the hypoxia is presently relatively insensitive to particulate phosphorus from Conowingo. Alternatively, a resulting shift toward higher P:N ratio in the nutrients input to the Bay could result possibly in a shift in the types of phytoplankton. This is speculation - but could a higher P:N ratio cause a shift towards more blue-green algae that have an ability to fix N from the atmosphere, so that even with decreasing N loads from the watershed, the N available in the Bay might not decline due to this ecological shift? In any case, the emphasis in the future should shift from the relatively vague impact of additional "sediments and associated nutrients" to the differential impact of specific particulate and dissolved nutrients.

Future studies should also test the sensitivity of the biogeochemical model simulations to the reactivity of the scoured material for both nutrient release and water column and sediment respiration, which are linked. The latter influences DO directly. This could potentially require additional state variables to represent different pools of particulate matter in the sediments and water-column. Surely, scoured materials and other solids are deposited in sediments, where diagenesis releases nutrients back to the water column to fuel algal growth. But before these materials are deposited in sediments, they could fuel respiration directly in the water-column. They should also contribute to sediment oxygen demand, or in the case that sulfides are released to the water column from sediments, to lagged water column oxygen demand.

Also, where do the nutrient-containing particles flowing past the dam in large flow events go? Are they trapped in the turbidity maximum? Do they escape to the mid-Bay, and if so, under what flow conditions? Are the present parameterizations of transport behavior adequate to address these questions?

5.2. U.S. EPA and Bay watershed jurisdictional partners should integrate findings from the LSRWA into their ongoing analyses and development of the seven watershed jurisdictions' Phase III WIPs as part of Chesapeake Bay TMDL 2017 mid-point assessment:

One of the most important statements in the LSRWA report is found on p. 75. It says: "EPA stated within Appendix T of the 2010 Chesapeake Bay TMDL that 'if future monitoring shows the trapping capacity of the dam is reduced, then EPA would consider adjusting Pennsylvania, Maryland, and New York 2-year milestones loads based on the new delivered loads' (USEPA, 2012). In practical terms, this means that nutrient and sediment loads from the Pennsylvania, Maryland, and New York portions of the Susquehanna River basin would have to be further reduced to offset the increase in sediment and associated nutrient loads in order to achieve the established TMDL allocations and achieve the states' Chesapeake Bay." It seems clear that analyses of the monitoring data have indeed shown that the trapping capacity of the dam has significantly reduced. Now the question is how to proceed to do the "adjusting" of the TMDL milestones. That issue is thus the following: how much of a decrease in loads delivered to the reservoirs and/or increase in reservoir trapping efficiency would be required? Key recommendations of this review in this regard include: (i) that the effect of the change in overall "trapping capacity" must be accounted for (the LSRWA analysis done so far relates only to increased scour and not to total trapping capacity), (ii) priority should be given to accounting for the added particulate phosphorus, and (iii) the additional sediment load (other than associated nutrients) should NOT be an additional burden on TMDLs. The logic behind this resistance to including treating the sediment load as a penalty is expanded upon in the following two subsections:

The negative impacts of sediment input to the Chesapeake Bay (relative to nutrients) are overstated by present TMDLs and are overemphasized in management priorities

TMDL requirements for sediment loads are most likely overly restrictive. The water quality simulations conducted as part of the LSRWA study further support the conclusion that sediment alone does not have as great an impact on Bay aquatic life and attainment of water quality standards as previously thought. More generally, the common wisdom that sediment input in itself is a problem with respect to water quality is perplexing given that sediment loads in the late 1800's and early 1900's were much higher than they are now, yet Chesapeake Bay water clarity and overall quality were much better then than now.

An underlying assumption at the start of the LSRWA study, and indeed of the CBP in general, is that all sediment is bad. However, it is stated in several places in this report and in the broader literature that some sediments are actually good, important components of the estuarine ecosystem. Certain fishes and most healthy SAV beds need sand as a substrate for reproduction and growth. Even estuarine fine sediments are essential to certain habitats, such as tidal wetlands, and a further reduction in supply of fines to tidal wetlands threatens their sustainability in the face of coastal erosion and/or sea level rise. It is true that turbidity due to fine sediment input can locally limit SAV, but this report clearly points out that turbidity insults associated with scour from the Conowingo reservoir are temporary. Perhaps it is time to revisit the TMDL for sediment, especially sand, and especially in the context of the sediment behind the dam and in the lower Susquehanna and upper Bay.

Given the relatively minor impact of sediments in general (separate from their associated nutrients) to Bay water quality, it is especially clear that the additional sediments (separate from nutrients) associated with the filling of the Conowingo reservoir are particularly insignificant to overall Bay health. The reasonable (albeit approximate) estimate that ~90% of sediments originate from sources other than scour from the Conowingo reservoir suggests that completely mitigating the loss of sediment (but not nutrient) trapping in the Conowingo would solve only around 10% of what is already a minor problem. It is important to further note that minimum water clarity required by TMDLs for SAV habit is obtained in every scenario in Table 5-9, regardless of whether or not the Conowingo reservoir is full or whether or not WIPs are fully in place. Requiring further reductions in sediment input (separate from nutrients) elsewhere to compensate for loss of Conowingo storage, given the expense involved, is not cost-effective.

The overall negative impact of sediment scoured or otherwise moved or bypassed out of the Conowingo reservoir and into the Bay may be further reduced by the fact that it is sandier than sediment otherwise introduced to the Bay. As the "full" Conowingo reservoir evolves, it will continue to get sandier with time. Parts of the lower Susquehanna and upper Bay are sand-starved at present. Sand is a limiting resource for several types of important habitat in the upper Bay and lower Susquehanna, and it is far less likely to harbor high N or P loads. If sand could be bypassed around the dam without entraining significant fines its impacts might be more positive than negative.

The effectiveness of BMPs in reducing sediment loads to the Bay may be overstated by present TMDLs:

The description in Table 5-6 of almost constant flux to the Bay despite major reductions in upstream sources over time is a major point to be considered in thinking about future impacts of BMPs. What is true here might also be true at the watershed scale. Similar results have been seen in historical reconstructions of sediment yields from other watersheds. Reductions have been made in sources, but about the same amount of sediment continues to flow out, which is a small percentage of the amount mobilized upstream, and which appears insensitive to changes in that source amount. This is ultimately a result of massive watershed storage of sediment. Thus, the possibility that sediment BMPs may not lead to a major reduction in sediment coming from the upstream watershed needs to be considered as a real possibility in considering management actions. Models alone cannot answer this question, only more direct measurement in places downstream of BMPs can fully demonstrate whether they are effective.

This issue is again important in the context of statements made on p. 141 indicating that anticipated future changes include increased frequency of scour events associated with climate change but continued decline in watershed loads due to BMP implementation. Given the enormous volume of sediment in various storage compartments in the watershed, greater frequency of scour events may well lead to greater amounts of remobilized sediment, especially as the vast majority of sediment that moves is carried in big storms. Even if WIPs are fully implemented, they may not counter the influence of greater storm frequency, nor is it clear that they would be as effective as assumed even in the absence of greater storm frequency. The amount of sediment in storage with potential for remobilization is orders of magnitude higher than the typical annual load, and even if one believes that stream restoration can be effective in mitigating in-stream sources, there is no way that stream restoration projects will ever be built over enough of the cumulative length of the upstream drainage network to really mitigate this potential source.

The broader question of whether WIPs will actually be effective for sediment on the time scale important to managers is one that is a subject of debate among geomorphologists, and cannot be assumed to be true simply because existing TMDLs are predicated on that assumption. The significant uncertainties in predicting the effects of BMPs on watershed sediment yield must be acknowledged. The Chesapeake Bay Watershed Model, though highly sophisticated, does not account for long-term storage of either water or sediment, and these processes have an important influence on the lag time before improvements can be expected from the WIP process.

5.3. Develop and implement management options that offset impacts to the upper Chesapeake Bay ecosystem from increased nutrient and sediment loads:

It is suggested here that, once more, the phrase "nutrient and sediment loads" in the above recommendation be changed to "sediment-associated nutrients". This suggestion is consistent with the statement found in the main report two paragraphs below this recommendation (p. 200), but with an added insertion in square brackets: "Nutrient load reduction management and mitigation options are likely to be more effective and provide more management flexibility when compared to relying solely on sediment management options. As such, it is likely more appropriate and cost-effective to increase management actions targeted toward nutrients above and beyond WIP implementation in the Susquehanna River watershed [rather than expand sediment control BMPs in general]. It is therefore recommended to conduct further analysis and modeling to understand costs and water quality influence of controllable nutrient mitigation measures beyond the jurisdictions' WIPs." This paragraph goes on to list a number of nutrient reduction strategies. These are fine, but the list is somewhat limited. In terms of overall implications for managing Bay eutrophication there needs to be particular attention to non-point source nutrient management, especially to limiting application of phosphorus to soils where the P levels are already above their agronomic optimum, changing the manner in which chemical fertilizers and manure are applied to the landscape, and also the use of cover crops.

In his work, Hirsch has found that total phosphorus flux to the upper Chesapeake Bay is up by about 51% between 1996 and 2012, representing an increase of about 1300 tons/year. This increase is happening while upstream management actions are taking place to reduce TP flux. During this same period the flux from upstream (measured at Marietta) has been decreasing (in the neighborhood of 1000 tons/year) and most of that since about 2004. This suggests that the net loss of trapping efficiency by Conowingo may be in the range of 2300 tons of phosphorus per year. The basic question is then, what would it take in terms of upstream phosphorus management in order to overcome the impact of ~2300 tons of phosphorus? This estimate is not highly accurate. The team that did the LSRWA report has the simulation expertise and capacity to test these estimates, but they have not yet performed this specific simulation. The follow up to this LSRWA effort really needs to address these estimates and replace them with better ones if they can (including uncertainty bounds).

A statement made in the center of p. 133 is revealing in this context. This is the statement that, though the January 1996 storm simulations do indicate adverse impacts of scour from behind the dam on the Bay TMDL, these impacts are far less than the impacts of not implementing the WIPs already agreed to by the States. Furthermore, the following paragraph on p. 133 provides a first order estimate of the additional watershed nutrient load reductions (using a combination of N and P) that would be needed to offset the DO non-attainment caused by the scour loads. This is one of the most important pieces of information in the report.

5.4. Commit to enhanced long-term monitoring and analysis of sediment and nutrient processes in the lower Susquehanna River system and upper Chesapeake Bay to promote adaptive management:

This review supports enhanced long-term monitoring of the flux of sediment and associated nutrient flux in the lower Susquehanna River system. This LSRWA report certainly makes the case that it is needed, as there was inadequate observed data to sufficiently understand nutrient transport dynamics or for model calibration and validation. Nonetheless, Recommendation #4 should be rephrased to explicitly include studies designed to develop the conceptual scientific understanding needed to manage the lower Susquehanna River system and upper Chesapeake Bay. Gathering data and analyzing it is not enough.

Regardless, updated technology should play a key role in enhanced long-term monitoring of the Lower Susquehanna/upper Chesapeake Bay (and other river/estuarine transitions in the Chesapeake Bay system). There are a variety of technologies that can be applied using *in situ* sensors to collect an essentially continuous record of sediment concentrations and flux for use in inferring sediment-associated nutrient transport, including inference of grain size distribution. Turbidity, laser, densimetric, and hydroacoustic technologies have been/are being evaluated, and some are being integrated into operational monitoring programs (see for example Gray and Gartner, 2009 at: http://water.usgs.gov/osw/techniques/2008WR007063.pdf). Sediment hydroacoustics arguably is the most robust of the technologies for rivers that convey low-to-moderate sediment concentrations, such as the Susquehanna River and presumably most Bay tributaries. Finally, an *in situ* hydroacoustic monitoring system also can provide index-velocity information for computing and/or improving water-discharge computations.

Continued monthly sampling throughout the basin is important, but it is also crucial that sample collection includes a substantial effort to collect data from moderate to high discharge events (including likely scour events but also events that are well below the scour threshold). It is also important to sample within the reservoirs and not just above and below. In particular, suspended sediment and particulate nutrient samples from within the reservoir should help in identifying the discharge at which reservoir scour begins. Further, with new technologies it should be possible to collect water samples in the reservoir during floods. These measurements need not be collected in a complete transect for the purpose of providing the entire sediment flux. Rather, they would provide an indication of the flow, in a time series, at which reservoir scour becomes significant. This, more than the mass balance between inflow and outflow sediment, could be more useful in determining the appropriate bottom boundary condition for models. That is, the bottom boundary condition for substantial bed entrainment would be calibrated to the flows at which this actually happens.

Question 6: Do the technical appendices provide the necessary documentation for the models and their applications in support of the study's results, findings, and conclusions?

APPENDICIES

Below is a summary of review comments specifically directed at the Appendices, beyond those insights provided in earlier sections that indirectly addressed the Appendix contents.

Appendix A

As described above in the section of this review entitled “Limitations of HEC-RAS model…”, the HEC-RAS modeling effort was ultimately unsuccessful, and results of the HEC-RAS simulation did not form an integral part of the main report. Additional comments from individual reviewers directed at Appendix A beyond the items discussed in the earlier review section are included here.

The Estimator model was used in Appendix A in spite of the fact that its originator, Dr. Tim Cohn, has indicated his doubt as to whether it is adequate for use with “hysteretic” suspended sediment. Although it well may “work” in this relatively large river – larger rivers with smaller peak-to-base-flow discharge ratios and more languid precipitation-runoff responses tend to exhibit less hysteresis in suspended-sediment concentrations than smaller rivers – additional analysis might be required to confirm or refute that assumption.

Concern was expressed regarding the exclusion from the sediment transport curve of the high suspended-sediment concentration value (2,890 mg/L, at USGS gage 01578310 [Conowingo] on 9/8/2011) in Appendix A, p. 12, Figure 7. There is rumor of a similar ‘high outlier’ in 2004. The transport curve in Figure 7 may well effectively be discontinuous with a major break around 400,000 ft^3/s. The two transport-curve sections might be nearly parallel. It is possible that the present curve is valid for flows ~≤ 400,000 ft^3/s, and the new curve that would reflect natural increasingly sediment-laden flows plus scoured material is valid for flows ~> 400,000 ft^3/s. A promising approach would be to develop a particle size-to-flow relation and apply it to the transport curve resulting in two (or three) curves, including a fines-transport curve (the principal metric of interest). The concept is graphically similar if mechanistically dissimilar from a discontinuous suspended sediment transport curve that has been shown to occur when flows transition between subcritical and supercritical regimes.

Should the p. 13 Reference to Table 2 be to Table 3?

The p. 36 Summary of USGS sediment concentration and load estimates: there is no period of continuous data collection at Marietta and only a few years between 1979 and 1992 at Conowingo, so how are they estimating comparative sediment loads? The text says USGS has been estimating sediment loads at Marietta and Conowingo since 1987 but does not say how.

The ESTIMATOR was used to project changing sediment load over time. However, in looking at the USGS NWIS site there is only very limited information about actual sediment concentration and load data collected – a number of years during the period between 1979 and 1992 at Marietta, and presumably grab samples, but apparently no continuous record at Conowingo. Given all of this there is some skepticism about how well we really know the comparison between sediment loads at the two stations, especially going back to the early 20th century.

Appendix B

As described above in the three earlier sections focusing on limitations in the AdH model, this review concludes that the existing application of the AdH model was not reliably predictive beyond constraints provided by a few integrated observations of sediment-related properties of the system. The AdH model is only loosely validated and insufficient data are available to confidently evaluate model performance. In its current state, based on the information presented, the AdH model is not capable of extending the information on reservoir performance previously available from bathymetric surveys and stream gaging. Additional comments from individual reviewers directed at Appendix B beyond the items discussed in response to Questions 3 and 4 are included here.

The SEDFLUME results from a small number of cores account for a large fraction of Appendix B. But there is insufficient explanation as to how these results were translated into the parameter set utilized in the six material zones in the model. Given the variability within each core from one shallow layer to the next, and given the variation in particle sizes longitudinally as well as variation laterally across the reservoir in depth and modeled velocity, perhaps there is no way at this point to account for spatial patterns beyond the simple selection of six longitudinal zones; and perhaps it ultimately does not make much difference what choices one makes. But it is odd that so much space was devoted to the empirical results without explanation as to how they were actually applied or what difference the spatial pattern of parameter values within different zones might make, particularly given that a 2d model is being used. In calibrating the model, the authors varied critical shear stress parameters at shallow depths and maximum scour depth to keep the model from scouring too much sediment, but the discussion of how this was done did not make much reference to differences among zones or within zones. The way this issue was handled is not explicitly addressed in the text even though the small number of cores is identified as a source of uncertainty.

p. 4 Figure 1 shows in graphical form the same information that is provided in Table 5-6 of the main report but in each case the citation simply says "provided by USGS". How do we know that by 1959 (first paragraph, p. 5) there was a relatively constant inflow of 3.2 million tons/yr of sediment flowing into Conowingo?

pp.5-6 The Exelon revised HEC-6 study concluded that scouring flows above 400,000 cfs were net depositional in Conowingo? Not net erosional? Given conclusions provided elsewhere in both the main report and appendices, this is confusing.

p. 22 Under model validation the statement is made that "The maximum sample depth was only about 12 inches due to highly consolidated sediments in deeper layers preventing penetration of the sampling tube." If this is the case what does it say about the actual potential for scour in a large flood event?

p. 23 Here it says that although samples represented only the top foot of sediment, the model sediment bed was about three feet. It appears from later discussion of choices made for calibration purposes that the three-foot depth had to be modified in order to match better with other information. The choices made here are not always clear.

p. 25 This shows the flow-concentration curve for Conowingo and highlights both the variability at high flow and the existence of only a single point at the upper end of the curve. It would seem appropriate to try to quantify the uncertainty associated with use of this curve and develop a range of values in order to see how this uncertainty might affect conclusions and comparisons.

The USGS curve for prediction of scour as a function of Q has upper and lower bounds; so should the sediment concentration rating curve.

p. 27 The major trend was that most of the scour occurred in the upper 1/3 of the reservoir where there is more sand which constitutes 50% or more of total bed sediment. A significant amount of deposition occurred just upstream of the eastern end of the dam. Was this mostly fines or more sand? What is the effect of the changes here on the particle-size distribution of the deposit as a whole?

p. 28 Model validation involved a parametric model study where bed-property values were manipulated and results compared with USGS scour load prediction. Was any consideration given to whether properties might vary with depth or distance from the shoreline?

p. 29 The choice of limiting depth available for scour to one foot seems like a reasonable one for a lower bound, given what was learned from coring and laboratory tests.

p. 31 When fitting parameters to compute erosion rate – is it not possible to develop some scheme for projecting variation in relevant material properties either longitudinally or laterally? Given that a 2d model is being used and given the spatial patterns of texture and cohesion, this seems like an element that ought to be considered – or else reasons why it cannot be done should be articulated.

p. 33 The authors argue that the uncertainty associated with applications of AdH is made manageable by basing conclusions largely on simulations of management scenarios in which only one variable is changed. This amounts to saying, in effect, 'the model worked OK for a hindcast, even though we had to use boundary conditions that were outside of the measured range or unknown, and we have not documented that the internal workings of the model are making reasonable predictions. So, if we only change one part of the model we can hope that it will reliably calculate the change in system performance.' However, one application of the AdH model was to evaluate scour and deposition relative to different reservoir bathymetry. These applications are not of the change-one-thing-only management scenario type and instead directly depend on the fidelity of the selected model.

p. 33 In discussing role of alternative bathymetry – do these alternatives assume spatially invariant bed material properties?

p. 37 Do these flow fields try to account for the change in flow distribution at the outlet when the gates are opened during high flows? It is pointed out elsewhere that dam operations should be incorporated in the model for future studies – this would seem to imply that this is not the case here.

p. 44 The 2008 to 2011 period was somewhat atypical in terms of the frequency of days above the 400,000 cfs scour threshold. If we look at the frequency of days over 400,000 cfs during the 4-year simulation period it comes out to an average of 1 day per year above the threshold. If we look at the entire period from 1977 through 2012 the frequency of days above the threshold is about 0.5 days per year. Thus, the choice of 2008-2011 as the simulation period will overstate the importance of scour increases as compared to a simulation period that was more typical.

p. 60 In discussion of limitations posed owing to need for a more sophisticated approach to simulating flocculation – is there any way to estimate how much difference this might make to overall conclusions?

In the same paragraph it is suggested that field methods are needed for sampling storm concentrations or turbidity over the entire storm hydrograph. Presumably standard methods can be used for the samples for either concentration or turbidity without having a human operator have to stick a bottle in the flow (as apparently was the case for the single sample taken near the peak during Agnes). Is the issue one of how to deploy sensors or automated samplers in the vicinity of the various gates built to accommodate high flow?

Appendix B-1, Figure 3: One must be careful of drawing straight lines in log-log space that depict a transport curve. At some point, the relation must tail to the right, given that sediment concentrations have absolute limits.

Appendix B-1, Section 5-1: The total annual estimated sediment yield delivered to downstream reservoirs is cited here as 4.2 million tons; but there are multiple other estimates in these documents, mostly less than this value – there needs to be more consistency among these cited values, or else an explanation as to why they are different.

Attachment B-1: "Evaluation of Uncertainties in Conowingo Reservoir Sediment Transport Modeling" -- This section is misnamed. The section provides a useful discussion of different elements of flow and transport through reservoirs. Its basic purpose is to justify the use of a depth-averaged 2d model (AdH) rather than a fully 3d model for the simulation. Their conclusion that a 2d model is sufficient is reasonable (assuming proper calibration/validation). Alas, although uncertainties play a small role in the discussion (basically relating to uncertainties that might arise from reducing 3d flow field to 2d), the section provides no discussion of overall "Uncertainties in Conowingo Reservoir Sediment Transport Modeling." This is unfortunate, because those uncertainties are large and largely unexplored in the study.

Appendix B-1, Section 9: This section presents an AdH model of flow and transport on Susquehanna Flats. No discussion is given of any calibration or testing of the model in this environment, and one must presume that it is uncalibrated and untested. The roughness assigned to the flats with SAV and without SAV (winter) is sufficiently large that the majority of the flow and sediment transport occurs through the dredged channel. This is a reasonable result. The authors then reach a conclusion that is unsupported by the model and quite possibly incorrect: "the relatively higher bed roughness of the shallow flats will tend to continue to route the majority of the flow through the dredged navigation channel below Havre de Grace. Thus, discharge of sediment from Conowingo Dam due to bypassing or flushing operations will have minimal impact on the flats area, with sedimentation occurring in the dredged navigation channel or below the flats area." Just because most of the water and sediment go through the channel does not mean there will be no impact to the flats. If flow extends on to the flats, the authors have not demonstrated in any way that sediment carried in that flow will not deposit on the flats.

In fact, this is how floodplains are formed. If turbid water is being discharged from the dam, one can deposit sediment wherever the water goes. Estimates can be made from the sediment concentration and residence time of water over the flats.
Appendix B-2, Summary and Conclusions. This section is misnamed and should be changed to only "Summary". There are no conclusions stated here.

Appendix B-4 includes the following on its first page: "…sediment in transport in suspension is directly related to sediment particle size and the degree of turbulence." Density could also be a factor, particularly if it is true that some 10% of reservoir sediments are coal particles.

Appendices C & D

Appendices C and D of the LSRWA Draft Report describe application of the Chesapeake Bay Environmental Modeling Package (CBEMP) to estimate changes arising from additional scour from behind Conowingo Dam during large events. Unlike the AdH and HEC-RAS models, which are relatively new model systems that had not been applied before to the Lower Susquehanna environment, the CBEMP model has a decades-long history of applications and evolutionary improvements to the Chesapeake Bay system, including numerous peer-reviewed publications assessing its performance in this specific environment. The application of the CBEMP model to the LSRWA effort is generally well done; the writing is clear, the organization is logical, and the text is supported with extensive figures and tables. The conclusions are reasonably supported, especially given that the LSRWA was intended as an exploratory analysis. The data attachments to Appendix C are particularly useful, although they are not specifically reviewed here.

One significant area could use a bit more attention. The period of the CBEMP model simulations is different from the period of the HEC-RAS/ADH scour simulations. The watershed loading scenarios are not the actual scenarios observed during the CBEMP simulation period, but rather projections based on expectations for watershed management practices under two different conditions (2010 implementation and TMDL achieved). The major storm simulation presented uses sediment-associated nutrient concentrations from a different storm entirely, not the simulated storm. As a result of all of these juxtapositions and substitutions, it is unclear exactly what is being simulated and why – the runs do not ever appear to be representative of actual conditions. While the final scenarios make sense and are very revealing, the reasoning behind their construction is hard to follow. A summary of the PHILOSOPHY of scenario construction, not just its mechanics, would help. This description should occur right after the introduction of the modeling tools used, and it should be addressed to an audience that is not familiar with standard practice in the CBP.

As an example of the confusion that can result, it is stated on p. 3 that "the 1991-2000 hydrologic record is retained for this study". But in the next paragraph, it is stated that the 2010 progress run and the TMDL run of the watershed model are used to specify daily nutrient and solids loads for different scenarios. How can nutrient and solids loads from 2010 and a hypothetical TMDL condition be applied to a 1991-2000 hydrology – doesn't the hydrology largely drive the loads? Or do the 2010 and TMDL runs specify instead relationships between hydrology and loading that are transportable to different time periods? CBP modeling insiders probably understand this approach, but it will be hard for outsiders to grasp.

Table 3.1 details how the June storm scenario included a "transfer of the load record, hydrodynamic record, and the hydrodynamics". Does this mean that the simulation started on June 1st (with June sunlight and temperature), but included the hydrologic and hydrodynamic forcing as if it were January 1st? Or is it something else? Clearer language should be provided to describe how these runs were actually done. These details are important, because in Appendix C, p. 86, Figure 6-27, it is shown that the impact of the simulated 1996 storm on light attenuation was different in the tidal Bay for the 3 seasons tested, and one may wonder if this is only a biological effect of load.

Interestingly, the long-term impacts of the October Storm on DO seem less than the January storm (-0.25 in Jan from 1997-1999, -0.1 in October from 1997-1999, Figure 6-31). Why would this be? Is more of the January load processed that summer and cycled through the system, while much of the October load is buried over winter? This seems like a point worth investigating.

In Appendix C, there is no mention about how the diagensis (decay) rates for the scoured materials differ from the diagenesis rates of the algal-derived organic material, or how decay rates of the scoured material are treated in general. This is a central aspect of this study, as it controls the nutrient release rates that drive the responses seen for chlorophyll and DO in the numerous simulations reported here. Please include these values.

In Appendix C, p. 25, last sentence: the reviewer could not seem to find the results of these scenarios. They are important, given the fact that 2011 sediment nutrient content is probably more representative of future scour loads than 1996. If these results were missed, please reference the table that describes these different scenarios, or specifically identify the scenarios if they are few enough.

On a positive note, the Analytic Model presented in section 2 of Appendix C is quite well done and is a very useful tool for describing overall expectations and for informing the conceptual model. It would be straightforward (in the future, not for this effort) to expand this model to multiple spatial segments and sediment types in the reservoir, to aid in more realistic screening analyses. This expanded analytical approach would also provide a valuable grounding for more complex numerical analyses in the future.

ADDITIONAL COMMENTS ON THE APPENDICES AND MAIN REPORT

Appendix E

Table 1.2 and the introduction to Appendix E indicate that bathymetric data were acquired in Susquehanna Flats. They were not; only sediment grain size data were acquired.

Appendix H

A question that was not addressed in the report is related to the various techniques for sediment management explored in the literature review of Appendix H. While different kinds of power dredging are mentioned in the Appendix and in the body of the report, a technique known as hydro-suction dredging is mentioned several times in the Appendix but not mentioned explicitly in the report. This technique would be especially useful for sediment bypassing, because it makes use of the huge natural head difference between the reservoir and the river below the dam to maintain flow through a dredging pipe or bypass tunnel. Was this technique considered in figuring the relatively low cost of bypassing, or not? Would it make a difference?

The literature review in Appendix H ignored nutrients.

Appendix J

Are all the costs adjusted for inflation and expressed in constant dollars? The discussion of the BMP costs in J-1 indicates that all these costs are converted and expressed in 2010 dollars using the CPI. Was the same process used for the reported cost values in J-2 for the other alternatives? The main body of the report should clearly state the dollar years and inflation adjustment method.

The economic analysis uses a different interest rate (or discount rate) for the watershed BMP versus dredging scenarios. Specifically, p. 14 in Appendix J says "estimates of annualized costs reflect a 5% discount rate" for the watershed BMP scenario. However, p. 167 in Section 6 says that "annualized one-time investment costs are based on a 50-year project life and the fiscal year 2014 federal interest rate of 3.5 percent" for the dredging scenarios. Appendix J-2 shows the detailed calculations for dredging scenarios based on the 3.5% interest rate. Proper economic analysis should use the same interest rate to compare across the scenarios. The current analysis makes the watershed BMP approach seems more expensive based on using the higher 5% interest rate.

The 50-year project life for the dredging and bypassing alternatives is considerable longer than the range of project lives used for most BMPs. That may well be correct and appropriate, but it deserves some justification and explanation, since it could be an influential assumption.

The current analysis provides a breakdown of the total estimated costs by the three states in Table 3 on page 6 in Appendix J (also used as Table 6-3). But this summary by state/jurisdiction in not highly informative because it just reflects that Pennsylvania is the largest state.

Attachments 2 and 3 on pp. 12-13 in Appendix J show the costs by practice across the three states. However, the current information does not make it possible to assess the variation in cost-effectiveness of the various urban and agricultural BMPs in meaningful terms, such as the dollars per cubic yard of sediment removal. Importantly, the cost-effectiveness between practice types typically varies by one or two orders of magnitude. Hence, the current analysis aggregates all practices types and reports an overall cost estimate at $3.5 billion in Table 3 (or Table 6-3). Then the report provides an overall average cost effectiveness of $256-$597 per cubic yard in Table 6-6, and seems to imply that this watershed BMP approach is supposedly the most expensive. But this assessment that aggregates all practice types may overlook the high degree of heterogeneity in costs between practice types.

At a minimum, the watershed BMP scenario should provide separate scenarios for the agricultural versus urban BMPs. Compare, for example, the costs for agricultural BMPs in Attachment 2 versus urban BMPs in Attachment 3. This shows that urban represents about 90% of the total costs compared to about 10% for agricultural BMPs. But it is unlikely that urban represents 90% of the sediment load. In fact, there are two urban BMPs (urban infiltration BMPs and filtering BMPs) that represent over $2.5 billion, which is two-thirds of the total costs. The unit costs on these two urban BMPs are much higher than other BMPs, but the analysis is aggregated into a single number for cost-effectiveness of this alternative scenario.

Attachments 2 and 3 would be more informative if it included additional columns that provided both the cost-effectiveness in $/cubic yard (or $/ton of sediment) and the total amount of cubic yards (or tons of sediment) for each practice type. The former would provide the ranking in cost-effectiveness by practice type, and the latter would reveal how important this practice is for the overall load reduction. This would allow for a better assessment of the most effective suite of practice types, while not including those practices that are most inefficient. Alternative watershed scenarios could then be designed that look at the option of 100% of the E3 scenario (current analysis) versus another scenario that only adopts 50% of the sediment reduction for the E3 scenario using the most efficient suite of practices. The most effective 50% will be competitive with the dredging scenarios given the extreme heterogeneity in unit costs for ag BMPs in Exhibit 1 on p. 15 and urban BMPs in Exhibit 6 on p. 35 (varies from $0 per acre for conservation tillage to $2,351 per acre for the urban filtering BMP). There is even extreme variation in unit costs within agriculture BMPs that ranges over several orders of magnitude. This further confirms the need to provide disaggregated analysis on the cost effectiveness in $/cubic year by practice type.

There are numerous citations provided in Attachment 4 of the Appendix J on pp. 14-44. But there is no corresponding "References" section to provide the detailed info on these citations.

Attachment 4 of Appendix J on pp. 29-33 includes detailed information on "Septic Systems". However, septic systems are not discussed at all in the corresponding tables for the cost analysis in Attachments 2 and 3. This needs to be clarified. Future analysis should include septic systems particularly if the analysis is expanded to nutrient management options (not solely sediment strategies) because septic systems are an important nutrient load in rural Pennsylvania.

Other recommended edits/specific concerns for main report, by page number:

ES-2 In multiple places in the main report (ES-2, p. 10, p. 110, p. 141), there is a statement regarding dynamic equilibrium that says, "This state is a periodic cycle." This statement is very misleading, there is nothing periodic or cyclic about it. The driving event (high flow events of about an annual exceedance probability of 0.2 – a "5-year flood") is a random event and is not periodic. They may happen in rapid succession or there may be many years between them. All mentions of the equilibrium state being "periodic" should be removed.

ES-3 2nd paragraph: the text beginning with "Modeling done for this…." is confusing. It states that under current conditions, half of the deep-channel habitat is unsuitable. This is then compared to the 2025 conditions with full WIP implementation and increased scour that suggests that attainment in 3 of the 92 segments will not be achieved due to extra loads of nutrients. It is implied that full WIP implementation should lead to completely healthy deep-water habitat, but a new reader would not necessarily catch this. Perhaps a more straightforward way to write this is to state something like "currently half of the deep-channel habitat is unsuitable for life (non-attainment), and given full WIP implementation in 2025 (which should yield 100% attainment), deep-channel habitat in 3 of the 92 Bay segments (X % of deep channel habitat) will remain as unsuitable habitat due to elevated nutrient loads from dam scour".

ES-3 4th paragraph: The last sentence (starting "Given…") is a run-on sentence.

p. 6 "The Susquehanna River is the nation's 16th largest river, and the source of the freshest water …" What is meant by freshest water? Typo?

p. 8 "All reservoirs act as a sink….." A sink of what? Sediment? Perhaps it is obvious, but it is helpful to state clearly.

p. 8 "Due to flow deceleration as the water enters the reservoir, sediment transport capacity decreases, and the coarser fractions of the incoming sediment deposited in the reservoir form a delta near the entrance to the reservoir." Awkward sentence – tenses.

p. 8 Last sentence of 5th paragraph: It is worth adding to the last sentence that nutrient-laden sediments are more harmful because they can be utilized to fuel additional algal growth in the tidal waters of the Bay.

p. 9 Last complete paragraph: if the Susquehanna load is 3.1 million tons and 1.2 million tons is released then 59.4% is trapped, not 55%.

pp. 15-16 The flow charts in Figures 1.5 and 1.6 are repetitive but slightly inconsistent. Figure 1.6 makes more sense and may be sufficient.

p. 16 In notes under Figure 1-6, should "partners of this LSRWA effort" be changed to "partners outside of this LSRWA effort"?

p. 24 3rd paragraph: Would be clearer or more mechanistic to say "…than about 0.3 knots because water movement tends to be slowed by frictional forces in shallow water…"

p. 26 "Snow events" do not cause floods. SnowMELT may.

p. 28 Define saprolite or show in Figure 2-5.

p. 32 "Phosphorus binds to ~~river~~ fine sediments and is delivered to the Bay with sediment."

p. 32 (1) 2nd sentence: "Ammonia" should be "Ammonium". (2) 2nd sentence: It is worth noting that although ammonium tends to be less abundant than nitrate in surface waters, it is by far the dominant dissolved N form in deeper waters during warm months. (3) True, nitrite generally contributes little to TN, but nitrite can accumulate to significant concentrations during some times and places, including the region of the pycnocline during mid-summer and after hypoxia/anoxia breakdown in fall. Perhaps adding a line to the sentence to say "….and contributes little to TN for most times and places". (4) It is worth adding that organic nitrogen comes in both particulate and dissolved forms.

p. 34 A factual problem is the statement that indicates that TN, TP, and SS loads from Conowingo have been increasing since the mid-1990's. This is certainly true for TP and SS but for TN the trends have continued to be downward (Hirsch, 2012 reports a decrease of about 3 percent).

p. 36 Should define hypoxia in Figure 2-10 (<2.0 mg/L).

p. 37 Section 2.5.2, 2nd sentence – statement is misleading and should be deleted unless qualified by explaining that because of different designated uses and water quality criteria it is not surprising there is a difference in violations. As is, statement is comparing apples and oranges.

p. 45 Figure 2-14 is not clear as to whether or not the metrics are total over a decade or per year.

p. 46 Many species of plankton are capable of motility. Change "and are passively carried" to "and are, by in large, passively carried".

p. 69 Chapter 3 mentions 3 Chesapeake Bay agreements, which may have been true when this section was written. However, doesn't the Watershed Agreement signed in June 2014 count as the 4th Chesapeake Bay agreement?

p. 72 2nd to last paragraph: The word "special" should be "spatial".

p. 81 "The HEC-RAS model may not be suitable for ….. , active scour and deposition, and particle size." What does this mean with respect to "particle size"? That the model cannot represent particle size well? Explain so meaning is clear.

p. 81 3rd paragraph: Were the boundary conditions generated for the HEC-RAS simulation also used to drive the AdH model? Or was model output from HEC-RAS simulation for the upper two reservoirs used to create the boundary conditions for AdH? Please clarify.

pp. 81-83 The models are stated to be "well developed, widely accepted, and peer reviewed. Yet there are virtually no references in Sections 4.1 or 4.2. References are needed here to demonstrate that HEC-RAS and AdH are indeed peer-reviewed models.

pp. 84-85 Figure 4-3 and 4-4: The mesh in all or part of these figures is almost impossible to see – provide insets at larger scale. Insets in the appendix show this more effectively.

pp. 87-89 In Chapter 4, the description of the method for using the 2008-2011 HEC-RAS and ADH predicted scour in the CBEMP 1991-2000 model runs is confusing. It is simply stated that the reader should see Appendix C for the details. More description should be provided in the text of Chapter 4, at least a better overview of the approach and justification for this somewhat tricky (but justifiable) maneuver.

p. 89 “Since the ADH application period was 2008 to 2011 while the CBEMP application period was 1991 to 2000, an algorithm was applied to adjust estimated loads from the ADH for use in the CBEMP (see Appendix C for details on this algorithm).” This algorithm is not obvious in Appendix C. Should briefly explain here and then explain better in Appendix C.

p. 92 “documented in Chapter 3”(?) Is this a typo?

pp. 97-100 Table 4.2 seems a bit out of context in Chapter 4, referring as it does almost entirely to material in Chapter 6. Although not a requirement, this table would make more sense in Chapter 6 where it is directly discussed.

p. 112 Are the values in Table 5-4 adjusted for variations in flow?

p. 113 In Table 5-5 change “Additional” to “Additional Calculated” and change “Transport” to “Scour-Induced Transport”.

p. 114 Figure 5-4 presents exact same data as Table 5-5. Eliminate.

p. 114 Bottom: annual influx of sediment to Conowingo is here described as 3.8 million tons/yr over the last 20 years with 2 million being trapped. Elsewhere in the document we see different numbers ranging between 3 million and 4.2 million tons. If there are different estimates arrived at in different ways this needs to be made clear.

p. 115 Table 5-6 does not explain how the historical loads or more recent loads were calculated – it simply says that the results were calculated by USGS. More explanation is needed. Also indicate that Hurricane Agnes flows were excluded if they were indeed omitted.

p. 131 The reasoning for using the particular combinations of predicted scour, nutrient loading, and water quality modeling to test for the effects of scour is unclear. The procedure was likely valid, but better explanation is needed.

p. 135 paragraph 4: It would help if there was some discussion of why two upper Eastern Shore segments (CHSMH and EASMH) had non-attainment in Scenario 3. Does low-DO water advect into them from the mainstem or is nutrient availability enhanced by the breakdown of scoured solids that end up in these tributaries?

p. 138 Paragraph 2: Oysters are discussed here within a section that otherwise discussed the modeling and simulation activities. Is there a description of how model analysis was used in this report to determine flow and management effects on oysters? Whatever the case, it should be clearly stated where the oyster effects fit into this report and whether or not model simulations were used to understand effects on oysters.

p. 138 “Nitrogen loads…exceed phosphorus loads…” Given that P concentrations tend to be an order of magnitude lower than those for N, the statement does not tell the reader much, and might unduly impress those lacking an understanding of nutrient concentrations and dynamics.
p. 146 Sources of information here are based on “personal communication” with Kevin DeBell, Greg Busch, John Rhoderick, and Jeff Sweeney. It would be better to document and provide references for the original reports used for the BMP unit costs rather than only personal communication. Page 4 in Appendix J-1 similarly only provides personal communications.

p. 167 “This methodology was not applicable for the watershed management representative alternative since management strategies (e.g., BMPs) once implemented, continue to remove/reduce sediment.” This statement is not true for many BMPs. For example, vegetative buffers self-destruct if they receive excessive sediment – same with most BMPs that trap sediment rather than reducing its generation. As a result of this incorrect assumption, one might question whether costs are one time.

p. 175 3rd paragraph: The word “waters” on line 4 of this paragraph should be “water”.

p. 180 “costs of bypassing (diminished DO, increased chlorophyll) are roughly 10 times greater than the benefits gained from reducing scour.” Indicate exactly where these data are contained in the report. A similar statement also appears in the Executive Summary and on p. 181 and p. 197.

p. 192 In the first summary statement below finding #2, the “upper Chesapeake Bay” ecosystem is highlighted to be the area impacted by the dam. “upper” is an ambiguous word in this case, as the simulations suggest that effects can be seen south of the Bay Bridge (e.g., Appendix C).

p. 193 Second paragraph, line 5: should “frequently not unsuitable” be “frequently unsuitable”?

p. 200 Reference to additional management activities that can provide long-term storage includes mention of floodplain restoration. If this refers to floodplain excavation, there is some concern about this appearing as a recommendation without much more study than has been conducted to date. If it refers to some other form of floodplain restoration some explanatory language would be helpful.

p. 201 The report does not make the case for use in adaptive management, as adaptive management is mentioned for the first time in this recommendation. Adaptive management is not mentioned anywhere but in this recommendation. Thus, the phrase should be deleted here.

Literature Cited

Available at the CRC/STAC offices

Lower Susquehanna River Watershed Assessment Team Responses to the "Review of the LSRWA: Scientific and Technical Advisory Committee Review Report"
August 2014
Annapolis, Maryland
STAC Publication 14-006

Background
As requested by the Lower Susquehanna River Watershed Assessment (LSRWA) Team in the fall of 2013, the Chesapeake Bay Program partnership's Scientific and Technical Advisory Committee's (STAC) sponsored an independent scientific peer review of the June 2014 draft LSRWA report and its supporting technical appendices. STAC responded to a series of charge questions posed by the LSRWA team during their review in a report entitled "*Review of the Lower Susquehanna Watershed Assessment: STAC Review Report.*[1]" A complete copy of the STAC Review Report is provided in Attachment I-7 of Appendix I of the LSRWA report.

Overall Comments and Responses

-The LSRWA Team's responses below are framed around the charge questions (**in bold)** posed to STAC**.** Specific excerpts from the STAC review report are included in text denoted by From STAC. The response is included in text denoted by *LSRWA response;* response is in *italics.* If language in the main LSRWA report or any of the appendices was altered due to a STAC comment, this is indicated in the respective LSRWA response as well.

Question 1: Does the main report clearly define the goals, strategies, and the results/conclusions of the study, and also present adequate background material at a level suitable for understanding by non-technical audiences?

A. From STAC "The goals stated in the main report (which stress both sediment and nutrient management) are inconsistent with the methodological approach taken by LSRWA (which mainly emphasized sediment) and appear not to be the study's original goals."
…"The inconsistency between the stated goals and the general strategies followed is an issue that propagates throughout the analysis for the entire assessment."
…"It appears that the goals as presently listed in the Introduction to the main report were not the original goals of the study.

LSRWA response: The LSRWA goals were deliberated and established by the LSRWA team back in 2011. The study goals have never changed. The study was always focused on sediments and associated nutrients. The strong nutrient emphasis/importance became apparent near the end of study once the full suite of model scenarios were run and evaluated. The study did evaluate nutrient loads and transport processes via the Chesapeake Bay Environmental Modeling Package (CBEMP).

[1] Chesapeake Bay Program Scientific and Technical Advisory Committee. 2014. *Review of the Lower Susquehanna Watershed Assessment: STAC Review Report. August 2014. STAC Publication 14-006. Annapolis, Maryland.*

B. From STAC: "Both the Executive Summary and Chapter 9 of the main report (entitled "Assessment Findings") present four categories of conclusions that generally correspond to each other. Within the individual context of the Executive Summary or Chapter 9, each set of conclusions is well written and easy to follow and understand. Their general content also includes the most important results and conclusions of the study. However, the phrasing, main emphasis, and ordering of these four categories is different in the Executive Summary versus Chapter 9, which is unnecessarily distracting. This review recommends that the four categories of main results/conclusions be presented in the same order in both the Executive Summary and in Chapter 9 and the headers be made more consistent and compelling."
…."However, the phrasing, main emphasis, and ordering of these four categories is different in the Executive Summary versus Chapter 9, which is unnecessarily distracting."

LSRWA response: The Executive Summary and Chapter 9 headings have now been made consistent as much as possible. The executive summary and Chapter 9 (findings) have different purposes. The executive summary's purpose is to be a standalone document that summarizes the study background, process, findings and recommendations, while Chapter 9 focuses on findings.

C. From STAC "Although the background material within the main report is indeed presented at a level suitable for non-technical audiences, this review recommends that large portions of the background material (specifically all of Chapter 2, 50+ pages in length) be moved to an Appendix. The remainder of the main report never refers to Chapter 2."

LSRWA response: Section 2 has been removed from the main report and made into a supporting technical Appendix as recommended.

Question 2: Are the alternative sediment management approaches clearly described and documented? Does this background material provide supporting evidence for the finding and conclusions of the study with regard to alternative sediment management approaches?

A. From STAC "Further analysis would be required to appropriately rank the alternative strategies based on a more environmentally relevant total cost in terms of dollars per pound of nitrogen and/or phosphorus reduction."

LSRWA response: The LSRWA team agrees that costs in the report focus on sediment management removal/reduction. Nutrient reduction specific strategies and associated costs warrant further analysis. The premise for sediment management strategy development was: "The focus was on managing and evaluating sediment loads with the understanding that there are nutrients associated with those sediment loads; thus, in managing sediments, one is also managing nutrients. However, it must be noted that the relatively low importance of sediment from the dam as a stressor to Chesapeake Bay water quality and aquatic life versus nutrients was not known until late in the study process. For that reason, management measures focused primarily or solely on nutrients were not considered in this assessment."

B. From STAC: "This review recommends that further caveats be included throughout the report to clarify that the dollar-based cost estimates regarding alternative sediment management approaches are specifically for reducing cubic yards of total sediment in the reservoir, not for achieving broader goals regarding nutrient reductions. The dollar-based cost estimates in Table 6-6 are reported in the Executive Summary (p. ES-4) and elsewhere in the assessment report. Wherever the dollar-based cost estimates are stated, their meaning with regard to increasing reservoir capacity rather than improving water quality should be more clearly indicated. The report should also emphasize that further analysis would be required to appropriately rank the alternative strategies based on a more environmentally relevant total cost in terms of dollars per pound of nitrogen and/or phosphorus reduction."

LSRWA response: The premise for sediment management development is stated in report:

> *"This assessment included a survey-level screening of management strategies to address the additional loads to Chesapeake Bay from the reservoirs' bed sediment scour. The focus was on managing and evaluating sediment loads with the understanding that there are nutrients associated with those sediment loads. The reason for this is that nutrients are contained within the dam sediments..."*

The evaluation included upland and in-reservoir strategies along with impacts to water quality and costs associated with those improvements. The LSRWA team agrees that the costs presented do not correspond with and were not calculated for strategies focused on nutrient removal/reduction only, and that more analysis is warranted on nutrient specific reductions and costs. This is included as a recommendation in the report.

C. <u>From STAC</u>: "For example, a one-time major dredging in the region just upstream of the dam, followed by bypassing from further upstream to slow subsequent infill, might have longer lasting effects. These more complex scenarios are clearly beyond the scope of this report, but they should be mentioned and acknowledged as worthy of exploration."

LSRWA response: The LSRWA Team agrees with STAC comment/recommendation. The following language was added to the Chapter on Developing Sediment Management strategies:

> *"The alternatives were selected to offer a realistic range of costs for potential solutions. Whereas the representative alternatives were chosen due to their apparent viability relative to other similar strategies, no rigorous comparisons were conducted nor were the alternatives optimized (e.g. to more effective) through a detailed design process. Furthermore more complex alternatives were not developed (e.g. combining additional BMP's in conjunction with dredging)."*

D. <u>From STAC</u> "The economic analysis and comparison of the alternatives could be further enhanced by considering, and at least discussing in qualitative terms, other possible co-benefits (and possibly co-costs) of the alternatives. For example, in addition to reducing loads to the Bay, many of the BMPs provide other ecosystem service benefits such as improved water quality upstream from the Bay, carbon sequestration; water storage/flood control, recreation benefits, etc. (see USEPA report EPA/600/R-11/001 for an analysis that includes some of these co-benefits)."

LSRWA response: The LSRWA Team agrees this would be a valuable exercise, however, conducting such an evaluation was but not within the scope of this current effort. More site-

specific analyses would be required to back-up statements about ecosystem service benefits that are mentioned above. The evaluation of sediment management strategies in the assessment focused on water quality impacts, with some consideration of impacts to SAV. Other environmental and social impacts were only minimally evaluated or not evaluated at all. A full investigation of environmental impacts (possibly co-costs) along with co-benefits could be performed in any future, project-specific NEPA effort.

E. From STAC: "Similarly, dredging activities may entail aesthetic disamenities (i.e., external costs), which would have the opposite effect by increasing the total costs of this set of alternatives."
LSRWA response: The LSRWA Team agrees but more site-specific analyses would be required to back-up these statements and were outside of the scope of this effort. The following language added to the Chapter on Developing Sediment Management strategies:

> *"It should be noted that the LSRWA effort was a watershed assessment and not a detailed investigation of a specific project alternative(s) proposed for implementation. That latter would likely require preparation of a NEPA document. The evaluation of sediment management strategies in the assessment focused on water quality impacts, with some consideration of impacts to SAV. Other environmental and social impacts were only minimally evaluated or not evaluated at all. A full investigation of environmental impacts would be performed in any future, project-specific NEPA effort."*

Questions 3 & 4: Does the main report provide clear, supporting evidence for the results, findings, and conclusions of the study? Does the report adequately identify key uncertainties in the model applications which, with better information, could change the predicted outcomes of the alternative management scenarios evaluated in this study?

A. From STAC: **"**Although there is no single accepted procedure for reporting uncertainty in the context of scenario modeling, a part of the report should more explicitly explain why confidence intervals on predictions are generally not provided."
…"Although the report lists and discusses sources of uncertainty, it expresses the expected confidence intervals on its model predictions less often. For example, if storm sediment transport can hardly be measured to within +/- 50%, model predictions can hardly be expected to be better (for example, in Appendix A, an error of about this range is indicated for predicting reservoir scour)."

LSRWA response: Sources of uncertainty were identified for each of the model analyses and ranges for some of the modeling estimates in the main report were provided where they were available. Unfortunately, as noted in the STAC review comment above, methods of uncertainty estimates for an integrated model system, as was used in the LSRWA which combines four large and complex models of the watershed, airshed, reservoir, and estuary, have yet to be developed. In any case, the level of uncertainty analysis in the LSRWA was consistent with what was applied in the model scenario analyses supporting development of the 2010 Chesapeake Bay TMDL. Quantifying uncertainty in application of linked complex mechanistic models of this type is extremely difficult to impossible. The standard technique involves making a large number of simulations with varying inputs and examining the resulting change in outputs. The resources to *do this were unavailable to this study. In fact, we do not know of any comparable study where uncertainty was rigorously examined in this fashion. The authors put a lot of effort into describing sources of uncertainty and potential impacts. The readers will have to consider these and create value judgments regarding model uncertainty. For the specific HEC-RAS example, the highest predicted error for scour in table A3 is about 50%. However scour is only about 30% of total sediment transport, so the scour error is actually about 15% of total sediment transport. The following language was added in the introduction to the Modeling Tools and Application Chapter of the main report:*

> *"In regards to uncertainty model results can be reported with extensive precision, consistent with the precision of the computers on which the models are executed. Despite the precision, model results are inherently uncertain for a host of reasons including uncertain inputs, variance in model parameters, and approximations in model representations of prototype processes. The uncertainty in model results can be described in quantitative and qualitative fashions. Quantitative measures are usually generated through multiple model runs with alternate sets of inputs and/or parameters. The number of model runs quickly multiplies so that this type of quantitative uncertainty analysis is impractical for complex models with numerous parameters and extensive computational demands. A qualitative, descriptive uncertainty analysis is the practical alternative in these instances which is what was done for this LSRWA effort."*

B. From STAC: **"**1) Stated sediment discharges from the Conowingo Dam are inconsistent with the literature. The report authors should either correct their numbers or present a clear explanation that reconciles why their estimates are significantly different from other estimates that are based on analysis of observed data." "… Also on p. 190, the report indicates that,' The total sediment outflow load through the dam… increased by about 10 percent from 1996 to 2011…' These results are so strongly at odds with other published numbers on this subject that some explanation and discussion is certainly required.

LSRWA response: We are not sure exactly what is meant by literature values. There are not sufficient measurements of the inflowing sediment to the Conowingo reservoir to develop either an observed time history or a reliable rating curve. There are some observations of sediment load into the entire 3 reservoir system, but the mitigation of these loads by the presence of the upper 2 reservoirs must be modeled. Given these uncertainties, the modelers elected to allow a relatively high inflowing sediment load into the Conowingo reservoir; so that the scour potential was maximized (a low load could reduce scour potential by making sediment supply limiting). Regarding comment on the 10% increase from 1996-2011, hydrology is key. Language is already included that this 10% is specific to a 4 year AdH simulation period (2008-2011) of hydrology comparing 1996 bathymetry to 2011 bathymetry. This statement in the report means that, for the same 4 year water and sediment inflow hydrograph, model runs using the 2011 starting bathymetry yielded 10% more sediment exiting the Conowingo reservoir than did model runs using the 1996 starting bathymetry. This is somewhat different than conditions forming the bases of various analyses of Hainly, Hirsh, and Langland investigative studies.

C. From STAC: "Reduced deposition associated with reservoir infilling has been neglected. The fundamental issue motivating the LSRWA study is that the net trapping efficiency of Conowingo

Reservoir has decreased dramatically over the past 15 to 20 years. Net trapping efficiency is the sum of increases in average annual scour and decreases in average annual deposition. However, the simulations and calculations in the study only considered the increase in scour….”…….“This issue underlies a significant weakness in the report, which is that it focuses its inquiry on the impact of large, but infrequent, scour events rather on the total impact of the change in trapping efficiency of the reservoir system. The review recommends that all statements that indicate that reservoir trapping of sediment and associated nutrients is unchanged in the absence of scour be removed”

LSRWA Response: Both increases in scour and decreases in deposition were modeled by AdH. There are no artificial constraints on the model to retain a constant rate of deposition. The LSRWA Team agrees that the Chesapeake Bay impacts were primarily evaluated in the context of NET scour events or additional scour over varying bathymetries. However 1996, 2008, 2011 and full reservoir deposition were simulated, compared and presented in report. Perhaps the concept of dynamic equilibrium needs to be emphasized more in these statements, the time scale that we are referring to here is important.

"Dynamic equilibrium does not imply equality of sediment inflow and outflow on a daily, monthly, or even annual basis, or similar time scale. It implies a balance between sediment inflow and outflow over a long time period (years to decades) defined by the frequency and timing of scouring events. Sediments (and associated nutrients) that accumulate between high flow events are scoured away during storm events, whereby accumulation begins again. Over time, there is no net storage or filling occurring in the reservoirs."
The LSRWA team agrees with the STAC comment that lower flows will cause scour as the reservoir fills. The report language has been edited to state that:

> *"The study did not differentiate between increased scour and less deposition as a reason for an increase in solids at lesser flows but most likely is a combination of both."*

D. <u>From STAC</u>: “Grain size effects within and exiting the reservoir were not sufficiently considered. The combination of two grain size effects – (i) changing grain size in time in the reservoir and (ii) the greater effects of fine sediment in transporting nutrients - mean that the effects of the reservoir on water quality have not reached a full dynamic equilibrium. However, the report did not address whether reservoirs were in dynamic equilibrium with respect to nutrients other than by assuming that if sediment was at equilibrium, then nutrients were also. “…Grain size effects within and exiting the reservoir were not sufficiently considered….” “ The review recommends that the concept of dynamic equilibrium be clearly qualified in the report to indicate it does not yet apply to sediment grain size, and thus it does not yet fully apply to the flux of fine sediment or associated nutrients.” “…Thus, the dynamic equilibrium that is described in the report is changing over time, and it would be worthwhile to try to predict how many cycles of deposition and scour might be required before the dynamic equilibrium becomes less dynamic.”

*LSRWA Response**:** The LSRWA Team deliberated much on concept of dynamic equilibrium, which the report defines in simplest terms as no more long-term net trapping. Dynamic* *equilibrium also means, even at this end state, things in the reservoir will still change, for example grain size. In general we can agree that grain size and nutrient composition/flux will continue to change over time. But the overall definition of dynamic equilibrium as utilized in the report is adequate for the purposes of presenting the finding that long-term net trapping has ceased.*

Grain size implications are an interesting consideration. USGS indicates that a study done by Bricker (USGS) indicated that it would take 5,000 years for grain size to shift fully to sand and larger grain sizes. The grain size of the reservoir bed may change over time as the reservoir fills. Grain size was not considered explicitly (although grain size sorting was implicitly modeled). However, these effects, although important, are likely impossible to meaningfully quantify without significantly more and better field and laboratory observational data. These grain size effects fall well within the uncertainties of what is known. A qualitative discussion of grain size effects could be helpful, but attempts to quantify this are limited. This limitation is not due so much to the fidelity of the model as it is due to the uncertainty of the data. Grain size shifts and effects can be simulated with the AdH model, but the model cannot be validated to observed data, because there are not sufficient observed data to validate to (to within a reasonable range of uncertainty). So this must be considered qualitatively, as a discussion. How might this trend alter the load of fines downstream and hence the water quality? Although it might allow less storage of fines over time, it might also prevent the mass erosion of older stored fines, if they are buried under sands. A conceptual analytic model might be of some use here, or even some parametric numerical model runs, as long as it was made clear that these are unvalidated runs.

Regarding nutrient composition, the data to develop a nutrient budget based on possible alteration in grain size does not exist. We were fortunate to find data on particle nutrient content without regard to grain size. Determination whether the reservoir is in equilibrium or not with regard to nutrients is an impossible task. We would need a historical record of particle nutrient composition and content, a comprehensive accounting of nutrient storage and loss in the bottom sediments, and projections of future trends in nutrient load and particle composition. Any statement as to whether the reservoir is in equilibrium with regard to nutrients is speculative. The report does not state "assumed that if sediment was at equilibrium, then nutrients were also." The report is rightfully silent on this topic.

E. From STAC: "The HEC-RAS modeling effort was largely unsuccessful, and the HEC-RAS simulation was largely abandoned as an integral part of the main report." "Limitations of HEC-RAS model were not made sufficiently clear in the main report".

LSRWA response: The LSRWA team disagrees that HEC-RAS was largely unsuccessful. The team knew it had its flaws for this system, which is why the team used a 2D AdH model for Conowingo. However, application of this model helped the team understand conceptually that there is still scouring and deposition in the upper two reservoirs. Also, HEC-RAS was successful in calibrating the hydraulic (flow) for the simulation period and size distribution. It provided AdH a valid starting point for inflow into Conowingo Reservoir. These inflow numbers were increased due to the problems with mathematical computations in HEC-RAS related to sediment *transport. The issue was the magnitude of the sediment transported at Conowingo. Language has been revised in HEC-RAS discussion of the main report to read:*

> *"For the LSRWA effort, the HEC-RAS model outputs provided a relative understanding of the reservoir sediment dynamics, indicating all three reservoirs are active with respect to scour and deposition even in a dynamic equilibrium state (the upper two which have been considered to be in dynamic equilibrium for decades). Additionally the boundary-condition data from the HEC-RAS model were helpful in the calibration of the AdH model, especially by improving information on the inputs into Conowingo Reservoir."*

HEC-RAS is designed primarily for non-cohesive sediment transport (sands and coarse silts) with additional, but limited, capability to simulate processes of cohesive sediment transport (generally medium silts to fine clays). Thus the model may not be suitable for all reservoir simulations, especially in areas of highly variable bed shear stress (the force of water required to move bed sediments) and active scour and deposition. Limitations of the model most likely resulted in 1) less than expected deposition for the 2008-2011 simulation and 2) less than expected erosion (scour) for the Tropical Storm Lee seven day event simulation, when compared to other approaches and estimates. If a more detailed evaluation of the upper two reservoirs is required in the future, application of the AdH would be more appropriate.

F. From STAC: "The AdH model was not fully validated, and the AdH model was forced by boundary conditions outside the range of observed values. This means that the AdH model alone was not reliably predictive, and until the AdH model has been improved, observations should instead be emphasized to support the most important conclusions of the LSRWA study…." "Although consistent with four observed, integrated sediment-related properties of the system, the AdH model was not fully validated…" "The AdH model was not calibrated, but instead the authors use what they refer to as a validation approach…" "The tenuous nature of the model validation is made more uncertain by the fact that the values for the key boundary condition (critical bed shear stress for sediment entrainment) in the final selected model fell largely outside the range of values measured by the SEDFLUME or were unmeasured and taken from the literature."

LSRWA response: Not sure what is meant here by "fully" validated. Estimated data from AdH was compared to the actual measured data at Conowingo for total load transport and particle size. The validation of the AdH model was limited, primarily because the quantity and quality of the available field data are limited. Further validation against this limited data would create a misleading impression of confidence, since the uncertainties associated with the observations do not allow for "full" calibration and validation. The model was shown to match several integrated quantities well, which demonstrates that the general sediment scour and deposition behavior of the reservoir is well represented in the model Then, the model was subjected to gross sensitivity experiments, to determine the expected trends and behavoir of the reservoir and expected future behavior. These trends are consistent with what is known about the historic behavior of the reservoir.

The validation to integrated properties is undertaken partly because there are not sufficient data to validate the mode better. To do this, one would require a much more comprehensive history of sediment loading, a wider selection of SEDLUME cores, more information on settling velocities, consolidation rates, bioturbation, etc. That is, both the stratigraphic history and the processes that govern stratigraphic development must be observed. Since these data don't exist, the model is validated to the degree that the data allow, and the model is relied upon only inasmuch as it predicts "integrated" results (i.e. fraction of total load being eroded, sediment equilibrium arguments).

The critical shear stress was utilized essentially as a calibration parameter. The erosion rate constants and exponents were indeed taken from the SEDFLUME results, but the critical shear was increased beyond what was observed in the surficial SEDFLUME layers. There may be some allowance for this inasmuch as the SEDFLUME data may have been collected when the reservoir was in a less consolidated state than when the tropical storm event took place. But, in reality, these values were adjusted because these adjustments resulted in the best qualitative and quantitative fit against the observations.

It is true that the model could be improved, but it is not true that the model is of little use. It provides valuable insight into the sediment dynamics of the reservoir that is consistent with what is known. It also provides supporting evidence for the general conclusion that the reservoir is in dynamic equilibrium with respect to sediment storage and release over long term (multi-year) time scales. The AdH modeling effort is not designed to be reliably predictive in all aspects of sediment behavior, since the paucity of available field data make this effort beyond the skill of any model. Rather, the AdH effort is designed such that the main thing it seeks to evaluate is the general character of the sediment storage and release trend of the reservoir (i.e. whether the reservoir is approaching dynamic equilibrium) and approximately what percentage of the outflow from large storm events is associated with scour. With respect to these questions, the AdH model demonstrates the ability to predict what is known, and the future predictions are consistent with the observed trends. So the question is, are these general conclusions likely to change significantly, even if more data were available and better model validation were achieved? Although we disagree that the model is of little value, we agree that it is worth thinking through the possibilities associated with this question.

G. From STAC: "References to differentials as small as 0.1% (for example, see table 6.7) imply accuracies in characterizing the sedimentary system that could not be confirmed by any type of measurement known by the reviewers. However, if qualified as model results and indications are in relative terms, there may be value in such numbers as long as all such values are qualified as "well within measurement error." Hence, "we cannot infer any significant change" should be stated up-front based on results of such analyses. In many of the modeled scenarios, the changes in attainment of water quality criteria with fairly large management actions would appear to a non-technical reader to be very small. For instance, p. 135 states: "…estimated…non-attainment…of 1 percent, 4 percent, 8, percent, 3 percent…" One should ask if such estimates are statistically significant."

LSRWA response: The LSRWA Team agrees with the main point that since all of the water quality assessment results estimated in the LSRWA Report with estimated relative differences *ranging from 0.1 percent to 8 percent are from relative differences with a base scenario, the scenario estimates, though seemingly small, have merit. In most cases the base scenario was the Chesapeake Bay TMDL Watershed Implementation Plan (WIP) Scenario, which is estimated to fully attain the state's Chesapeake water quality standards. The base scenario was compared to key scenarios of Conowingo infill generating the percent differences described in the LSRWA Report. Existing language in main report states:*

> *"EPA provided a first order estimate of the degree of Susquehanna River watershed nutrient pollutant load reduction needed to avoid estimated increases in DO nonattainment of 1 percent in the deep-water and deep-channel areas; this analysis is described further in Appendix D. A rough estimate of the load reduction needed Bay-wide is about 2,200 tons of TN (4.4 million pounds) and 205 tons of TP (0.41 million pounds) to offset the DO nonattainment in the deep channel and deep water areas. Estimates of the nitrogen and phosphorus pollutant load reductions from the Susquehanna River watershed needed to offset the 1-percent increase in DO nonattainment are about 1,200 tons of nitrogen (2.4 million pounds) and 135 tons of phosphorus (0.27 million pounds)."*

H. <u>From STAC</u>: "Similarly, in appendix A, p. 25, the net deposition model indicated that ~2.1 million tons net deposition in the reservoirs occurred in 2008-11. This is the difference of two order-of-magnitude larger numbers (22.3M tons entered the reservoir, 20.2M tons entered the Bay). There is a rule-of-thumb in sedimentology: ±10% in concentration or transport is 'within error'. Does the precision of the computed difference fall within the margin of error in these metrics?"

LSRWA response: The HEC-RAS model did not perform well when compared to actual data. However the LSRWA team was testing for "significant change." Error bounds are presented in Appendix A (Attachment 1) for estimate of equation based regression scour and sediment loads transported into and out of the reservoir. This is just a simple subtraction of the in's and out's of Conowingo reservoir. The team already surmised that the estimate was under predicting the amount of deposition. It does fall within 10% of the metrics as presented, but that does not mean it's correct. It is also important to note that much of this load is "wash load" in that it passes through the reservoir without significant interaction with the bed. Therefore, with respect to erosion and deposition dynamics, the "within error" calculation should not include the wash load. .

I. <u>From STAC:</u> "If optimally constrained by observations, reservoir calculations may have reasonable accuracy and precision when averaged over longer timescales, but less accuracy over shorter timescales. However, the key timescales for many biological processes are much shorter than those of an annual sediment budget, and this could be a major source of uncertainty in the predictions of the efficacy of the sediment management scenarios. This disparity in process timescales is important to address in the text and in the conclusions of the study."

LSRWA response: This is a good point. Regarding the AdH model, utilizing erosion rates characterized by the SEDFLUME observations, erosion tends to occur rapidly in response to a rapid rise in the hydrograph. Hence, the eroded sediment from a rapid rise is pulsed rapidly *into the Bay. So, although the results are presented as integrated quantities, the model output to the ecological model does include this rapid pulse. The CBEMP model results ultimately hang on the assessment of attainment of water quality standards. Since the DO water quality standards have a space and time assessment that's considered to be relevant to living resources in the designated uses of Chesapeake Deep Water, Deep Channel, and other regions of the Chesapeake, the issue was largely addressed in the development adoption of the states' Chesapeake Bay water quality standards.*

J. From STAC "Anoxic volume days appears to be a variable that is relatively more sensitive to the model scenarios presented in the report (e.g., Table 6-8). This suggests something alluded to in the report on several occasions that a large fraction of the deep water in Chesapeake Bay is sitting on the threshold of being anoxic, and seemingly small changes in concentration (0.2 mg/l) lead to substantial relative changes in anoxic volume. It is worth clearly stating that the high sensitivity of this one criteria to small changes in load stands out among the other variables (e.g., chlorophyll-a, chl-a). It strikes the reviewers that changes in chlorophyll and dissolved oxygen associated with "normal" inter-annual variability in climate and nutrient loading are much higher than those associated with additional Conowingo Dam-derived nutrients as simulated here. One might conclude that given this fact, that the potential effects of dam-derived particulates are trivial."

LSRWA response: At places and times, the predicted response of Chesapeake Bay water quality conditions to scoured Conowingo nutrients is indeed small compared to inter-annual variability. Relatively small changes in dissolved oxygen can trigger a failure to meet rigorous state adopted Chesapeake Bay water quality standards. So even apparently small changes can be consequential. As suggested by the reviewers, it is the summer hypoxic period that is of concern and small difference in DO during this period make big differences to living resources as reflected in the development of the DO water quality standards.

The following language has been added to Appendix D:

> *"The Deep-Water and Deep-Channel DO water quality standards are on a knife-edge of attainment with the State Watershed Implementation Plans (WIPs). Achieving the Deep-Water and Deep-Channel DO standards in the 2010 TMDL was difficult and required management actions that went far beyond what was needed for sediment and chlorophyll (except in the case of James chlorophyll). The annual difference in DO generally ranges from about 12 mg/l in the winter to near hypoxia/anoxia conditions in the summer in the Deep-Water and Deep-Channel regions of the Chesapeake largely due to DO solubility differences with temperature and also due to the summertime presence of the pycnocline. But it is the summer hypoxic period that is of concern and a small difference in DO during this period makes big differences to living resources as reflected in the development of the DO water quality standards."*

K. From STAC: "The relevant statement from Hirsch (2012) is:' The discharge at which the increase [i.e., the increase in suspended sediment concentrations at the dam] occurs is impossible to identify with precision, though it lies in the range of about 175,000 to 300,000 cfs.

Furthermore, the relative roles of the two processes that likely are occurring – decreased deposition and increased scour – cannot be determined from this analysis.' "

LSRWA response: The reference to Hirsch has been removed from the text.

L. From STAC: "First, the events in excess of 150,000 cfs happen on average about 3 times per year (not once every two to three years). The number of such days (with daily mean discharge between 150,000 and 300,000) is about 11 days per year. Second, it is not clear that the increase in sediment loads in the 150,000 to 300,000 cfs range is really a result of scour."
LSRWA response: The LSRWA team disagrees with this comment regarding flow frequency. USGS calculations of the hydrologic record (Appendix A, Attachment 1) show that exceedance numbers for a 150,000 cfs is about once every year, 300,000 cfs is about every 2.1 years. The LSRWA Team agrees that we do not fully understand what is going on at the lower and more moderate flows which is why the report contains a recommendation to evaluate this more closely.
The report language revised to state:

> *"On average, in this dynamic equilibrium state, a major scour event will occur once every 4 to 5 years. Minor scour events with trace amounts of erosion will occur every 1-2 years (150,000-300,000 cfs); while at lower flows sediment (and associated nutrients) will accumulate until an erosion event occurs again. In the flow range of 150,000-300,000 cfs it is not fully understood if this increase in sediment load to the Bay is due to an increase in scour or due to a decrease in deposition in the reservoir itself; it very likely could be a combination of both and warrants further study."*

M. From STAC: "At bottom of p. 190 the text reports on reductions in TN, TP, and TSS as 19, 55, and 37%, respectively, for the past 30 years for loads "to the lower Susquehanna River", referenced to http://cbrim.er.usgs.gov. This could mean loads delivered to the upstream end of the reservoir system or loads delivered at the downstream end where the river enters the Chesapeake Bay."
LSRWA response: The STAC comment is correct about trends in flow-adjusted concentration. WRTDS can estimate trends in loads, but it currently cannot estimate error ranges around the estimates. Until that is resolved USGS will not publish trend in loads.
The report language has been revised to read:

> *"Over the past 30 years, due to widespread implementation of regulatory and voluntary nutrient and sediment reduction strategies, nutrient and sediment loads to the lower Susquehanna River are significantly lower than what was delivered in the mid 1980s. Flow adjusted concentrations of total nitrogen (TN), total phosphorus (TP), and suspended sediment concentration declined by 30, 40, and 45 percent, respectively between 1985 and 2012 at Marietta, PA (see http://cbrim.er.usgs.gov/)."*

N. From STAC: "Nutrients associated with fine sediments, not with the total load of sediments, are the main water quality concerns. The report acknowledges that sand-sorbed P is more or less inconsequential in P transport. However, all sediment-discharge values are expressed as "total loads." Since P transport is closely tied to fines, and presumably very closely tied to clay-size particles, transport metrics computed for fines, and particularly for clay-size particles, might yield different conclusions than those derived from "total" load comparisons. It is also important to clearly define what is meant by total load. Sedimentological nomenclature denotes "total load" as all material in transport, be it defined as bed load plus suspended load (with caveats), or bed-material load plus washload"

LSRWA Response: the report is referring to bed load plus washload, all sediment available. This is further refined in outputs as bed load and loads out of the reservoir, or total delivered load. For HEC-RAS specifically, transport equations in HEC-RAS are designed to move bed load. However, a transport curve with properties of the cohesive sediments is also included in the estimation of total transport from one cross-section to another in each time step. In addition, bed load transport is not a substantial part of the total load (<10%).

Language has been added to the main report's glossary clarifying that total load includes all material in transport (includes bed load plus washload (sediment) load).

Question 5: Are the recommended follow-up evaluations and analyses (Section 9.1) complete and comprehensive as well as clearly stated to enable the next phase of work to continue under the Partnership's Midpoint Assessment?

A. From STAC: "One of the outcomes of this study should be to identify areas where our scientific understanding may be insufficient to achieve management goals, and to suggest future scientific studies to provide this knowledge. Follow-up studies need to consider the full range of hydrologic conditions, from moderate to high flows, which generally do not result in scour (but still reduce the deposition of sediment-associated nutrients in the reservoir), all the way up to the very high but very rare events that do result in scour. The emphasis in the future should shift from the relative vague impact of additional "sediments and associated nutrients" to the differential impact of specific particulate and dissolved nutrients."

LSRWA Response: The LSRWA team fully agrees. Studies are now underway by USGS, MDE, and Exelon entitled "Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program focused on the Conowingo and the other two Lower Susquehanna reservoirs that are examining the fate and effects of nutrients mobilized from the Conowingo Reservoir from very high (>400,000 cfs) and moderately high flows (>100,000<400,00 cfs). The studies will be used to support Chesapeake Bay Program (CBP) partnership decisions on Conowingo infill offsets as part of the Partnership's Chesapeake Bay TMDL 2017 Midpoint Assessment. The ongoing research and field work on the mobilization and fate of nutrient from the Conowingo Pool will be applied to an integrated analysis using the CBP's partnership's suite of Chesapeake Bay watershed and estuarine water quality/sediment transport management models. Recommendations 1 and 4 already include language on evaluating moderate and lower flows and understanding bioavailability of different forms of nutrients.

The following language has been added to Recommendation #1, bullet #1:

> *"Determine the detailed characteristics and bioavailability of sediments and associated nutrients likely to be scoured within Conowingo Reservoir. The*

emphasis in the future should shift from the relative vague impact of additional "sediments and associated nutrients" to the differential impact of specific particulate and dissolved nutrients."

B. From STAC: "A key question is how to proceed to do the "adjusting" of the TMDL milestones to account for increased sediment-associated nutrients passing out of the reservoir. "…That issue is thus the following: how much of a decrease in loads delivered to the reservoirs and/or increase in reservoir trapping efficiency would be required? The logic behind this resistance to including treating the sediment load as a penalty is expanded upon in the following two subsections: The negative impacts of sediment input to the Chesapeake Bay (relative to nutrients) are overstated by present TMDLs and are overemphasized in management priorities…"
"…Key recommendations of this review in this regard include: (i) that the effect of the change in overall "trapping capacity" must be accounted for (the LSRWA analysis done so far relates only to increased scour and not to total trapping capacity), (ii) priority should be given to accounting for the added particulate phosphorus, and (iii) the additional sediment load (other than associated nutrients) should NOT be an additional burden on TMDLs. Calculations by Hirsch suggest that the net loss of trapping efficiency by Conowingo may be in the range of 2300 tons of phosphorus per year. The basic question facing the midpoint assessment then is: what would it take in terms of upstream phosphorus management in order to overcome the impact of ~2300 tons of phosphorus? This estimate is not highly accurate. The team that did the LSRWA report has the simulation expertise and capacity to test these estimates, but they have not yet performed this specific simulation. The follow up to this LSRWA effort really needs to address these estimates and replace them with better ones if they can (including uncertainty bounds)..."
"…The effectiveness of BMPs in reducing sediment loads to the Bay may be overstated by present TMDLs." "…The possibility that sediment BMPs may not lead to a major reduction in sediment coming from the upstream watershed needs to be considered as a real possibility in considering management actions. Models alone cannot answer this question; only more direct measurement in places downstream of BMPs can fully demonstrate whether they are effective..."

LSRWA response: Once the "Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program" studies examining the fate and transport of nutrients, including both phosphorus and nitrogen forms from Conowingo infill are complete in 2016, the Chesapeake Bay Program partnership will work with the LSRWA modelers to incorporate the new salient information into the full suite of the CBP partnership's Chesapeake Bay watershed and estuarine water quality/sediment transport models. Analysis and review of the synthesis of research, field work, and modeling will enable a complex and comprehensive quantification and programmatic evaluation of the options for Conowingo infill offsets by the CBP partners as part of the Partnership's Chesapeake Bay TMDL 2017 Midpoint Assessment. Ultimately a decision of how to achieve the states' Chesapeake Bay water quality standards in the presence of the current dynamic equilibrium in the Conowingo Reservoir will be made by the Partnership in 2017.

The LSRWA team notes that sediment management is important throughout Chesapeake Bay watershed to improve freshwater river habitat impaired by excess sediment, maintain floodwater conveyance, improve water supply quality, reduce reservoir infill and in the case reducing silts and clays, improve water clarity and support survival and growth of SAV resources in tidal *headwaters. It's important to note that the 2010 Chesapeake Bay TMDL does not manage for sand erosion input loads, only the fines, and recognizes that the sand erosion can be beneficial to habitat and SAV resources.*

The LSRWA team agrees with the STAC comment regarding the effectiveness of BMPs in reducing sediment loads to the Bay and that it may be overstated by present Chesapeake Bay TMDL. As previously described, sediment management is important throughout the watershed. Nevertheless, because of sediment storage throughout the watershed the lag time for sediment (and associated nutrients) delivered to the Chesapeake tidal waters could be on the order of decades to centuries. Decision rules in the Partnership development Chesapeake Bay TMDL and the jurisdictions developed WIPs account for sediment load reductions at the tidal Bay as soon as the sediment management BMP is established. While there are obvious disconnects between science and the practice, the Chesapeake Bay TMDL and the jurisdictions WIPs encourage implementation of management practices that reduce sediment and nutrient loads in the tidal Chesapeake Bay. Both share the core goal of the implementation of all required practices, treatments, and technologies by 2025 needed to achieve all the states' Chesapeake water quality standards. The establishment of the practices is what's required by 2025, not water quality standard attainment. There is an explicit understanding in the Chesapeake Bay TMDL that because of sediment and nutrient lag times, water quality standards attainment will lag management implementation. Regarding how to determine the effectiveness of BMP's; monitoring alone might not answer that question. The question of scale and the fact that the vast majority of streams have huge sediments supplies from disruptive historical land use practices, make this extremely difficult to detect change.

C. From STAC: "There are a variety of technologies that can be applied using *in situ* sensors to collect an essentially continuous record of sediment concentrations and flux for use in inferring sediment-associated nutrient transport, including inference of grain size distribution."

LSRWA Response: USGS is trying to secure long-term funding to get an instrument deployed (a partner is required to match 50/50). In the short-term Exelon will be funding the placement of in situ monitors at Marietta, Holtwood, and Conowingo locations.

D. From STAC: In addition, Recommendation 1.2 would be better written as something like: "Determine the quantity and nature of the sediment-associated nutrients transported downstream under current conditions (dynamic equilibrium) versus conditions that prevailed in previous times when the reservoirs had substantial trapping ability.

LSRWA response: The report text language revised as recommended in the above STAC comment.

E. From STAC: "Could a higher P:N ratio cause a shift towards more blue-green algae that have an ability to fix N from the atmosphere, so that even with decreasing N loads from the watershed, the N available in the Bay might not decline due to this ecological shift? In any case, the emphasis in the future should shift from the relatively vague impact of additional "sediments and associated nutrients" to the differential impact of specific particulate and dissolved nutrients. Future studies should also test the sensitivity of the biogeochemical model simulations to the reactivity of the scoured material for both nutrient release and water column and sediment respiration, which are linked. The latter influences DO directly. This could potentially require additional state variables to represent different pools of particulate matter in the sediments and water-column. Surely, scoured materials and other solids are deposited in sediments, where diagenesis releases nutrients back to the water column to fuel algal growth. But before these materials are deposited in sediments, they could fuel respiration directly in the water-column. They should also contribute to sediment oxygen demand, or in the case that sulfides are released to the water column from sediments, to lagged water column oxygen demand."

LSRWA response: The nutrient limiting to phytoplankton production varies with time and location throughout the Chesapeake Bay. In the future, the CBP partners could look at modeled response of nutrient limitation to alterations in the Conowingo Reservoir nutrient budget. The composition and reactivity of the particulate materials carried out of Conowingo Reservoir are large sources of uncertainty, as acknowledged in the report and in subsequent presentations and meetings. A study is planned to specifically address these issues. A study is also planned to examine the fate of and transport of particles swept over the Conowingo outfall into the Bay. Additional efforts with the model are not warranted until the results of these studies are available.

F. <u>From STAC</u>: "Develop and implement management options that offset impacts to the upper Chesapeake Bay ecosystem from increased nutrient and sediment loads. "It is suggested here that, once more, the phrase "nutrient and sediment loads" in the above recommendation be changed to "sediment-associated nutrients".

LSRWA response: The report text language revised as recommended above in STAC comment.

Question 6: Do the technical appendices provide the necessary documentation for the models and their applications in support of the study's results, findings, and conclusions?

<u>Appendix A</u>

A. <u>From STAC:</u> "The Estimator model was used in Appendix A in spite of the fact that its originator, Dr. Tim Cohn, has indicated his doubt as to whether it is adequate for use with "hysteretic" suspended sediment. Although it well may "work" in this relatively large river – larger rivers with smaller peak-to-base-flow discharge ratios and more languid precipitation-runoff responses tend to exhibit less hysteresis in suspended-sediment concentrations than smaller rivers – additional analysis might be required to confirm or refute that assumption."

LSRWA response: The USGS recently conducted a comparison of load estimations using both ESTIMATOR and WRTDS for the 9 major streams in the Chesapeake Bay watershed. Results indicted very good load and trend estimates with both models although WRTDS had a lower error and variance. The problem with ESTIMATOR is with "runaway quadratic estimations" where due the use of squared terms, if a high value is associated with a high flow value then a non-linear fit is needed for the relation. This can sometimes lead a bias and overestimation of load.

B. From STAC: "Concern was expressed regarding the exclusion from the sediment transport curve of the high suspended-sediment concentration value (2,890 mg/L, at USGS gage 01578310 [Conowingo] on 9/8/2011) in Appendix A, p. 12, Figure 7. There is rumor of a similar 'high outlier' in 2004. The transport curve in Figure 7 may well effectively be discontinuous with a major break around 400,000 ft3/s. The two transport-curve sections might be nearly parallel. It is possible that the present curve is valid for flows ~≤ 400,000 ft3/s, and the new curve that would reflect natural increasingly sediment-laden flows plus scoured material is valid for flows ~> 400,000 ft3/s."

LSRWA response: The graph has been updated to include this point.

C. From STAC: "A promising approach would be to develop a particle size-to-flow relation and apply it to the transport curve resulting in two (or three) curves, including a fines-transport curve (the principal metric of interest). The concept is graphically similar if mechanistically dissimilar from a discontinuous suspended sediment transport curve that has been shown to occur when flows transition between subcritical and supercritical regimes."

LSRWA response: This was attempted to help build a transport curve for the HES-RAS model, but the lack of and the variability of the particle size data did not produce a discernible relationship.

D. From STAC: "The ESTIMATOR was used to project changing sediment load over time. However, in looking at the USGS NWIS site there is only very limited information about actual sediment concentration and load data collected – a number of years during the period between 1979 and 1992 at Marietta, and presumably grab samples, but apparently no continuous record at Conowingo. Given all of this there is some skepticism about how well we really know the comparison between sediment loads at the two stations, especially going back to the early 20th century. "

LSRWA response: The comparison going back to the 20th century was based on various studies, including data from other agencies, compiled yields, and extrapolation from long-term flow record at Harrisburg, PA to Marietta, PA then mass balance to upper Chesapeake Bay. The estimated loads definitely have large errors, but does provide an indication of past to current historical trends.

Appendix B

A. From STAC: "The SEDFLUME results from a small number of cores account for a large fraction of Appendix B. But there is insufficient explanation as to how these results were translated into the parameter set utilized in the six material zones in the model. Given the variability within each core from one shallow layer to the next, and given the variation in particle sizes longitudinally as well as variation laterally across the reservoir in depth and modeled velocity, perhaps there is no way at this point to account for spatial patterns beyond the simple selection of six longitudinal zones; and perhaps it ultimately does not make much difference what choices one makes. But it is odd that so much space was devoted to the empirical results without explanation as to how they were actually applied or what difference the spatial pattern of parameter values within different zones might make, particularly given that a 2d model is being used. In calibrating the model, the authors varied critical shear stress parameters at shallow depths and maximum scour depth to keep the model from scouring too much sediment, but the discussion of how this was done did not make much reference to differences among zones or within zones. The way this issue was handled is not explicitly addressed in the text even though the small number of cores is identified as a source of uncertainty."

LSRWA Response: The critical shear stress was utilized essentially as a calibration parameter. The erosion rate constants and exponents were indeed taken from the SEDFLUME results, but the critical shear was increased beyond what was observed in the surficial SEDFLUME layers. There may be some allowance for this inasmuch as the SEDFLUME data may have been collected when the reservoir was in a less consolidated state than when the tropical storm event took place. But, in reality, these values were adjusted because these adjustments resulted in the best qualitative and quantitative fit against the observations.

B. <u>From STAC</u>: "p. 4 Figure 1 shows in graphical form the same information that is provided in Table 5-6 of the main report but in each case the citation simply says "provided by USGS". How do we know that by 1959 (first paragraph, p. 5) there was a relatively constant inflow of 3.2 million tons/yr of sediment flowing into Conowingo?"

LSRWA Response: This information is gleaned from the 2009 USGS report referenced in the document. The report can be found here: http://pubs.usgs.gov/sir/2009/5110/pdf/sir2009-5110.pdf.

C. <u>From STAC</u>: "pp.5-6 The Exelon revised HEC-6 study concluded that scouring flows above 400,000 cfs were net depositional in Conowingo? Not net erosional? Given conclusions provided elsewhere in both the main report and appendices, this is confusing."

LSRWA Response: Page 27 of the report discusses some of the reasons for this. The basic idea is that scour does not necessarily equate to net scour. For example, the upper section of the reservoir appears to scour, but a significant part of this material is sand, which appears to redeposit within the reservoir in the lower reach.

D. <u>From STAC</u>: "p. 22 Under model validation the statement is made that "The maximum sample depth was only about 12 inches due to highly consolidated sediments in deeper layers preventing penetration of the sampling tube." If this is the case what does it say about the actual potential for scour in a large flood event?"

LSRWA Response: It implies that there may be a practical limit for the total volume of scour. However, for his study, this practical limit was not systematically investigated further, as the large historical event studied here (in 2011) did not achieve this level of scour in the reservoir.

E. <u>From STAC</u>: "p. 23 Here it says that although samples represented only the top foot of sediment, the model sediment bed was about three feet. It appears from later discussion of choices made for calibration purposes that the three-foot depth had to be modified in order to match better with other information. The choices made here are not always clear."

LSRWA Response: The erosion properties at depth were unobtainable due to the inability to achieve core penetration. This implies that these sediments are stiffer than the surficial sediment, but not necessarily unerodable. Therefore, the model was supplied with layers at depth that were, in general, less erodible than the surficial layers. The properties of the deeper layer had to be approximated.

F. From STAC: "p. 25 This shows the flow-concentration curve for Conowingo and highlights both the variability at high flow and the existence of only a single point at the upper end of the curve. It would seem appropriate to try to quantify the uncertainty associated with use of this curve and develop a range of values in order to see how this uncertainty might affect conclusions and comparisons. The USGS curve for prediction of scour as a function of Q has upper and lower bounds; so should the sediment concentration rating curve."

LSRWA Response: This curve is for sediment outflow from the reservoir. Although significant uncertainty is indeed present in the data, a formal uncertainly analysis was not undertaken, because the data were not utilized significantly in the validation of the model. The primary use of the rating curve data was to extract grain size trends (that were qualitatively compared to model data) and to estimate integrated quantities, such as net sediment load. Although there was no formal uncertainty analysis, a general discussion of uncertainties in the data, including the hysteresis effect, is included.

G. From STAC: "p. 27 The major trend was that most of the scour occurred in the upper 1/3 of the reservoir where there is more sand which constitutes 50% or more of total bed sediment. A significant amount of deposition occurred just upstream of the eastern end of the dam. Was this mostly fines or more sand? What is the effect of the changes here on the particle-size distribution of the deposit as a whole?"

LSRWA Response: It is not known for certain, but some indirect evidence, as well as general sediment principles, implies that this deposited material is mostly sand. This indicates a redistributional effect within the reservoir with respect to sand, at least for this particular flow event. This implies a preferential trend toward the storage of coarser sediments over time. However, the increased availability of these sandy sediments in the lower reaches of the reservoir may also make them more likely to be available for transport out of the reservoir for large flow events in the future, so the trend could be more complex than it seems.

H. From STAC: "p. 28 Model validation involved a parametric model study where bed-property values were manipulated and results compared with USGS scour load prediction. Was any consideration given to whether properties might vary with depth or distance from the shoreline?"

LSRWA Response: Consideration was given for the variation of properties both spatially (based on the spatial distribution of the SEDFLUME samples) and at depth into the bed (based on variation of the SEDFLUME properties with depth into the cores, and also based on the observed trends toward a stiffer bed at depth into the bed).

I. From STAC: "p. 29 The choice of limiting depth available for scour to one foot seems like a reasonable one for a lower bound, given what was learned from coring and laboratory tests."

LSRWA Response: Only if it can be assumed that the limit of penetration implies the presence of a very stiff substrate. However, it is possible to have a layer that is difficult to penetrate with a push or gravity core, while still potentially erodible with higher shear stress (for example, sand rich substrate can exhibit this property).

J. From STAC: "p. 31 When fitting parameters to compute erosion rate – is it not possible to develop some scheme for projecting variation in relevant material properties either longitudinally or laterally? Given that a 2d model is being used and given the spatial patterns of texture and cohesion, this seems like an element that ought to be considered – or else reasons why it cannot be done should be articulated."

LSRWA Response: See response to I. There is variability in the applied properties, based on the SEDLFUME core distribution. The critical shear was indeed adjusted (essentially calibrated) in a more general sense, but the other erosion properties were assigned the distribution of values dictated by the SEDFLUME cores. Figure 10 on page 20 shows how the distribution of cores was applied at Zones in the model.

K. From STAC: "p. 33 The authors argue that the uncertainty associated with applications of AdH is made manageable by basing conclusions largely on simulations of management scenarios in which only one variable is changed. This amounts to saying, in effect, 'the model worked OK for a hind cast, even though we had to use boundary conditions that were outside of the measured range or unknown, and we have not documented that the internal workings of the model are making reasonable predictions. So, if we only change one part of the model we can hope that it will reliably calculate the change in system performance.' However, one application of the AdH model was to evaluate scour and deposition relative to different reservoir bathymetry. These applications are not of the change-one-thing-only management scenario type and instead directly depend on the fidelity of the selected model."

LSRWA Response: Although the model is only validated to integral quantities, they are 3 separate integral quantities. The models general agreement with all of these quantities demonstrates that, at least in a bulk sense, the model is behaving as the real reservoir does, and for similar reasons. So the model results can be relied upon to make these same types of integral predictions as long as the forcing conditions that the model is subjected to are not extended far outside of the existing conditions (and they are not in this exercise).

L. From STAC: "p. 33 In discussing role of alternative bathymetry – do these alternatives assume spatially invariant bed material properties?"

LSRWA Response: No. They assume the same property distribution that was used in the model validation, which in turn is based on the SEDFLUME core data (see response to J).

M. From STAC: "p. 37 Do these flow fields try to account for the change in flow distribution at the outlet when the gates are opened during high flows? It is pointed out elsewhere that dam operations should be incorporated in the model for future studies – this would seem to imply that this is not the case here."

LSRWA Response: No. the dam operations are not included. Hence, the influence of dam operations on the distribution and storage conditions of sediments in the lowermost reaches of the reservoir (especially sandy sediments) must be considered an additional source of uncertainty in the results.

N. From STAC: "p. 44 The 2008 to 2011 period was somewhat atypical in terms of the frequency of days above the 400,000 cfs scour threshold. If we look at the frequency of days over 400,000 cfs during the 4-year simulation period it comes out to an average of 1 day per year above the threshold. If we look at the entire period from 1977 through 2012 the frequency of days above the threshold is about 0.5 days per year. Thus, the choice of 2008-2011 as the simulation period will overstate the importance of scour increases as compared to a simulation period that was more typical."

LSRWA Response: Possibly. However, a more conclusive way to estimate this might be to integrate the inflow hydrograph against the net scour curve for the entire period of record, annualize the result, and compare this to same annualized quantity for the 2008-2011 hydrograph. This was not done for this study, however, as the focus of the study was just to establish the sensitivity of a given inflowing hydrograph and sediment load to changes in reservoir bathymetry.

O. From STAC: "p. 60 In discussion of limitations posed owing to need for a more sophisticated approach to simulating flocculation – is there any way to estimate how much difference this might make to overall conclusions?" "In the same paragraph it is suggested that field methods are needed for sampling storm concentrations or turbidity over the entire storm hydrograph. Presumably standard methods can be used for the samples for either concentration or turbidity without having a human operator have to stick a bottle in the flow (as apparently was the case for the single sample taken near the peak during Agnes). Is the issue one of how to deploy sensors or automated samplers in the vicinity of the various gates built to accommodate high flow?"

LSRWA Response: Some investigation of the influence of flocculation was made by simply investigating different settling velocity values. However, the implementation of a robust flocculation model would allow for less parameterization of the model, which improves its predictive reliability. There are methods available for collecting data during high discharge conditions, so this could be done if the investment were made.

P. From STAC: "Appendix B-1, Figure 3: One must be careful of drawing straight lines in log-log space that depict a transport curve. At some point, the relation must tail to the right, given that sediment concentrations have absolute limits."

LSRWA Response: This is true, although these limits are above the well above the concentrations given here.

Q. From STAC: “Appendix B-1, Section 5-1: The total annual estimated sediment yield delivered to downstream reservoirs is cited here as 4.2 million tons; but there are multiple other estimates in these documents, mostly less than this value – there needs to be more consistency among these cited values, or else an explanation as to why they are different.”

LSRWA Response: I think the confusion might lie in the fact that this section is discussing an estimate of the sediment load into the uppermost of the 3 reservoirs (i.e. the discharge from the river into the reservoir system) whereas in other places in the report the sediment load being discussed is either sediment load from the upper two reservoirs into Conowingo, or the sediment load from the Conowingo into the Bay.

R. From STAC: “Attachment B-1: “Evaluation of Uncertainties in Conowingo Reservoir Sediment Transport Modeling” -- This section is misnamed. The section provides a useful discussion of different elements of flow and transport through reservoirs. Its basic purpose is to justify the use of a depth-averaged 2d model (AdH) rather than a fully 3d model for the simulation. Their conclusion that a 2d model is sufficient is reasonable (assuming proper calibration/validation). Alas, although uncertainties play a small role in the discussion (basically relating to uncertainties that might arise from reducing 3d flow field to 2d), the section provides no discussion of overall “Uncertainties in Conowingo Reservoir Sediment Transport Modeling.” This is unfortunate, because those uncertainties are large and largely unexplored in the study.”

LSRWA Response: General uncertainty is discussed throughout the report. Uncertainty is not formally quantified in the report, partly because the paucity of available data might render any such formal quantification deceptively meaningful. That is, without sufficient data, even the attempt to quantify uncertainty is, well, uncertain. This section discusses, among other things, the limitations of using a Quasi 3d model (where sediment stratification effects are represented in a semi-analytic sense) rather than a fully 3D model. Hence, it is a useful supplementary document that goes into some detail about the general processes that govern reservoir sedimentation, and how the modeling framework selected influences the results of the modeling.

S. <u>From STAC</u>: “Appendix B-1, Section 9: This section presents an AdH model of flow and transport on Susquehanna Flats. No discussion is given of any calibration or testing of the model in this environment, and one must presume that it is uncalibrated and untested. The roughness assigned to the flats with SAV and without SAV (winter) is sufficiently large that the majority of the flow and sediment transport occurs through the dredged channel. This is a reasonable result. The authors then reach a conclusion that is unsupported by the model and quite possibly incorrect: “the relatively higher bed roughness of the shallow flats will tend to continue to route the majority of the flow through the dredged navigation channel below Havre de Grace. Thus, discharge of sediment from Conowingo Dam due to bypassing or flushing operations will have minimal impact on the flats area, with sedimentation occurring in the dredged navigation channel or below the flats area.” Just because most of the water and sediment go through the channel does not mean there will be no impact to the flats. If flow extends on to the flats, the authors have not demonstrated in any way that sediment carried in that flow will not deposit on the flats. In fact, this is how floodplains are formed. If turbid water is being discharged from the dam, one can deposit sediment wherever the water goes. Estimates can be made from the sediment concentration and residence time of water over the flats."

LSRWA Response: We agree in principle. The fact that flow is diverted to the main channel does not mean that deposition of fines will not take place in the SAV areas. The model does not show much deposition there, and deposition is being modeled there, but, as the reviewer points out, the model was not validated, So this effort may require some more work and further consideration, or at least further examination of the existing model results.

T. <u>From STAC</u>: "Appendix B-2, Summary and Conclusions. This section is misnamed and should be changed to only "Summary". There are no conclusions stated here."

LSRWA Response: Concur.

U. From STAC: "Appendix B-4 includes the following on its first page: "…sediment in transport in suspension is directly related to sediment particle size and the degree of turbulence." Density could also be a factor, particularly if it is true that some 10% of reservoir sediments are coal particles."

LSRWA Response: Concur.

<u>Appendix C and D</u>

A. <u>From STAC</u>: "One significant area could use a bit more attention. The period of the CBEMP model simulations is different from the period of the HEC-RAS/ADH scour simulations. The watershed loading scenarios are not the actual scenarios observed during the CBEMP simulation period, but rather projections based on expectations for watershed management practices under two different conditions (2010 implementation and TMDL achieved). The major storm simulation presented uses sediment-associated nutrient concentrations from a different storm entirely, not the simulated storm. As a result of all of these juxtapositions and substitutions, it is unclear exactly what is being simulated and why – the runs do not ever appear to be representative of actual conditions. While the final scenarios make sense and are very revealing, the reasoning behind their construction is hard to follow. A summary of the PHILOSOPHY of scenario construction, not just its mechanics, would help. This description should occur right after the introduction of the modeling tools used, and it should be addressed to an audience that is not familiar with standard practice in the CBP."

LSRWA response: The following language was inserted in Appendix C at the head of Chapter 3 Scenario Procedure and Listing Overview.

> *"The LSRWA makes use of existing tools and methodologies as well as new tools and applications developed specifically for this study. The use of existing models and practices is advantageous to the study since these tools could not be developed within the time and budget limitations of the LSRWA. The individual models within Chesapeake Bay Environmental Model Package (Watershed*

Model, Hydrodynamic Model, and Water Quality Model) are documented, have been extensively reviewed, and have lengthy application histories. The use of these existing tools provides some disadvantages and constraints, however, notably in the period emphasized in their application.

The AdH model, which computed sediment fate and transport in the Conowingo Reservoir, was a new application created especially for this study. AdH was applied over the period 2008 – 2011, in order to take advantage of recent data collected in the reservoir. The application included the Tropical Storm Lee event, which resulted in notable scour and provided an excellent opportunity for model calibration and validation. This period was not represented in the CBEMP, however, for which the primary application period was 1991 – 2000. The resources necessary to acquire raw observations, create model input decks, execute and validate the individual models within the CBEMP for the years 2008 – 2011 was beyond the scope of the LSRWA. Consequently, means were required to transfer information from the 2008 – 2011 AdH application to the 1991 – 2000 CBEMP. The crucial transfer involved combining scour computed by AdH for TS Lee with watershed loads computed by the WSM model for a January 1996 flood and scour event represented by the CBEMP.

The WSM provides computations of volumetric flow and associated sediment and nutrient loads throughout the watershed and at the entry points to Chesapeake Bay. Flow computations are based on precipitation, evapotranspiration, snow melt, and other processes. Loads are the result of land use, management practices, point-source waste loads and additional factors. The loads computed for 1991 – 2000 are no longer current and are not the loads utilized in the TMDL computation. To emphasize current conditions, a synthetic set of loads was created from the WSM based on 1991 – 2000 flows but 2010 land use and management practices. The set of loads is designated the "2010 Progress Run." The TMDL loads are a second set of synthetic loads created with the WSM. In this case, the 1991 – 2000 flows are paired with land uses and management practices sufficient to meet the TMDL limitations.

The AdH model provides computations of sediment load due to bottom scour, but not the load of associated nutrients. Limited observations of sediment-associated nutrients are available at the Conowingo outfall during the 1996 flood event. The composition of solids eroded from the bottom are difficult to glean from these observations, however, since samples at the outfall represent the mixture of solids washed down from the watershed and eroded from the bottom and as with the watershed loads, these observations may no longer represent current conditions. Consequently, the nutrients associated with scoured solids for use in scenarios was derived from observations of nutrients in the bottom sediments of Conowingo Reservoir.

Major storm events occur at different times of the year. In order to examine the effect of seasonality of storm loads on Chesapeake Bay, the January 1996 storm *was moved, within the model framework, to June and to October. The loads were moved directly from January to the other months. No adjustment was made for the potential effects of seasonal alterations in land uses. New Chesapeake Bay hydrodynamic model runs were completed based on the revised flows, to account for alterations in flow regime and stratification within the Bay.*"

B. From STAC: "Interestingly, the long-term impacts of the October Storm on DO seem less than the January storm (-0.25 in Jan from 1997-1999, -0.1 in October from 1997-1999, Figure 6-31). Why would this be? Is more of the January load processed that summer and cycled through the system, while much of the October load is buried over winter? This seems like a point worth investigating."

LSRWA Response: Good points for additional clarification. The text of Appendix D will be expanded to clarify these points as suggested: "The water quality effects in the October and January periods are diminished because of colder temperatures and decreased primary productivity, resulting in less interception of nutrient loads by algae. In the fall and winter a greater portion of the storm- pulsed nutrient load is transported down the Bay to be discharged at the ocean boundary or is lost though denitrification or deep burial in sediments. The long-term impacts of the October Storm on DO were estimated to be less than the January storm (see Figure 6-31 of Appendix C). This is because the simulated January storm load of particulate nutrients scoured from the Conowingo Reservoir was processed during that summer and cycled through the system, while much of the simulated October 1996 storm load was buried or discharged out of the Chesapeake Bay over the simulated 1996-97 winter before the particulate nutrient load was ultimately expressed as a depression of DO in the simulated 1997 summer."

Appendix E

A. From STAC: "…indicates that bathymetric data were acquired in Susquehanna Flats. They were not…"

LSRWA Response: The Appendix language has been revised to state that only sediment grain size data were acquired (vs. bathymetry).

Appendix H

A. From STAC: "A technique known as hydro-suction dredging is mentioned several times in the Appendix but not mentioned explicitly in the report. This technique would be especially useful for sediment bypassing, because it makes use of the huge natural head difference between the reservoir and the river below the dam to maintain flow through a dredging pipe or bypass tunnel. Was this technique considered in figuring the relatively low cost of bypassing, or not? Would it make a difference?"

LSRWA Response: By-passing could be done by various dredging techniques. The LSRWA team used past costs from actual projects of more traditional hydraulic dredging which were presented in the report. Costs for the specific Hydrosuction dredging technique could be investigated in the future but were not in the scope of this effort.

Appendix J

A. <u>From STAC:</u> "The economic analysis uses a different interest rate (or discount rate) for the watershed BMP versus dredging scenarios. Specifically, p. 14 in Appendix J says "estimates of annualized costs reflect a 5% discount rate" for the watershed BMP scenario. However, p. 167 in Section 6 says that "annualized one-time investment costs are based on a 50-year project life and the fiscal year 2014 federal interest rate of 3.5 percent" for the dredging scenarios. Appendix J-2 shows the detailed calculations for dredging scenarios based on the 3.5% interest rate. Proper economic analysis should use the same interest rate to compare across the scenarios."

LSRWA response: This is an artifact of cost development. The LSRWA team depended heavily on the Chesapeake Bay TMDL work done by the jurisdiction watershed partners in development of their Watershed Implementation Plans (WIP) to develop these watershed management strategies. LSRWA effort utilized costs developed (and processes used to develop these) through Chesapeake Bay TMDL and WIP development processes that were already available for BMP costs. As described in Section 5.2, "the LSRWA team relied heavily on the Bay TMDL work done by CBP and state partners to develop the watershed management strategies. As such, the LSRWA team adopted the CBP methodology and unit costs as the representative alternative for a watershed management strategy; additional cost and design analyses were not undertaken." Dredging/by-passing alternatives (i.e. increasing or recovering storage volume) were developed by LSRWA team using the 3.5% rate, which was the federal interest rate when costs were developed in the Federal Fiscal Year 2014. Language has been added to the main report to clarify this difference. The costs and the BMPs for the E3 scenario were developed years before the Lower Susquehanna River Assessment Project was initiated. At this point in time it would not be feasible for the Bay Program to re-calculate the costs of the E3 BMPs for a project other than the one for which they were originally intended.

B. <u>From STAC:</u> "Attachments 2 and 3 on pp. 12-13 in Appendix J show the costs by practice across the three states. However, the current information does not make it possible to assess the variation in cost-effectiveness of the various urban and agricultural BMPs in meaningful terms, such as the dollars per cubic yard of sediment removal. Importantly, the cost-effectiveness between practice types typically varies by one or two orders of magnitude. Hence, the current analysis aggregates all practices types and reports an overall cost estimate at $3.5 billion in Table 3 (or Table 6-3). Then the report provides an overall average cost effectiveness of $256-$597 per cubic yard in Table 6-6, and seems to imply that this watershed BMP approach is supposedly the most expensive. But this assessment that aggregates all practice types may overlook the high degree of heterogeneity in costs between practice types." "…At a minimum, the watershed BMP scenario should provide separate scenarios for the agricultural versus urban BMPs. Compare, for example, the costs for agricultural BMPs in Attachment 2 versus urban BMPs in Attachment 3. This shows that urban represents about 90% of the total costs compared to about 10% for agricultural BMPs. But it is unlikely that urban represents 90% of the sediment load. In fact, there are two urban BMPs (urban infiltration BMPs and filtering BMPs) that represent over $2.5 billion, which is two-thirds of the total costs. The unit costs on these two urban BMPs are much higher than other BMPs, but the analysis is aggregated into a single number for cost-effectiveness of this alternative scenario.

LSRWA response: Unfortunately, the per-unit reductions in delivered sediment for the E3 scenario were not available for the E3 scenario. It should be noted that the per-unit reductions *of each BMP are a function of the number of units implemented, the location of implementation, the programmed efficiencies or land use changes associated with each BMP and the interactions of all the BMPs in a given scenario. If it is important to have the per-unit reductions for the E3 scenario, funding should be provided to the Bay Program for staff time and model runs to develop them. Although this would provide useful information, it is a very complicated request that would be time consuming and costly to address. In order to address this properly the Chesapeake Bay Program partners would need to perform a series of model runs to implement each BMP separately and to the extent outlined in the E3 scenario then assess the sediment reduction and the available BMP units remaining following that model run. This process would have to be repeated again for each BMP until all the BMPs are implemented on all available land, because once a BMP is implemented on a given land use it is no longer available for another BMP. Therefore, the LSRWA team cannot accommodate this request due to the time and resources necessary to run the Chesapeake Bay watershed model for all potential BMP scenarios.*

C. <u>From STAC:</u> Attachments 2 and 3 would be more informative if it included additional columns that provided both the cost-effectiveness in $/cubic yard (or $/ton of sediment) and the total amount of cubic yards (or tons of sediment) for each practice type. The former would provide the ranking in cost-effectiveness by practice type, and the latter would reveal how important this practice is for the overall load reduction. This would allow for a better assessment of the most effective suite of practice types, while not including those practices that are most inefficient. Alternative watershed scenarios could then be designed that look at the option of 100% of the E3 scenario (current analysis) versus another scenario that only adopts 50% of the sediment reduction for the E3 scenario using the most efficient suite of practices. The most effective 50% will be competitive with the dredging scenarios given the extreme heterogeneity in unit costs for ag BMPs in Exhibit 1 on p. 15 and urban BMPs in Exhibit 6 on p. 35 (varies from $0 per acre for conservation tillage to $2,351 per acre for the urban filtering BMP). There is even extreme variation in unit costs within agriculture BMPs that ranges over several orders of magnitude. This further confirms the need to provide disaggregated analysis on the cost effectiveness in $/cubic yard by practice type.

LSRWA response: As stated above, the information needed to address this comment is not currently available. If a "disaggregated analysis on the cost effectiveness" by practice type is needed, funding would have to be provided to the Bay Program for staff time and model runs.

D. <u>From STAC:</u> "There are numerous citations provided in Attachment 4 of the Appendix J on pp. 14-44. But there is no corresponding "References" section to provide the detailed info on these citations."

LSRWA response: References provided.

E. <u>From STAC</u>: "Attachment 4 of Appendix J on pp. 29-33 includes detailed information on "Septic Systems." However, septic systems are not discussed at all in the corresponding tables for the cost analysis in Attachments 2 and 3. This needs to be clarified. Future analysis should include septic systems particularly if the analysis is expanded to nutrient management options (not solely sediment strategies) because septic systems are an important nutrient load in rural Pennsylvania. "

LSRWA response: Concur that septic systems should be included in future analyses if nutrient management options are expanded. Appendix 4 is simply providing background information on U.S. Environmental Protection Agency Approved Best Management Practices which includes septic systems though they were not analyzed under this assessment other than documenting that these are approved and a possible BMP to be investigated in the future.

Other recommended edits/specific concerns for main report, by page number:

1. From STAC: "ES-2 In multiple places in the main report (ES-2, p. 10, p. 110, p. 141), there is a statement regarding dynamic equilibrium that says, "This state is a periodic cycle." This statement is very misleading, there is nothing periodic or cyclic about it. The driving event (high flow events of about an annual exceedance probability of 0.2 – a "5-year flood") is a random event and is not periodic. They may happen in rapid succession or there may be many years between them. All mentions of the equilibrium state being "periodic" should be removed."

LSRWA Response: No report language altered: The LSRWA Team deliberated for quite some time on how to depict/describe this important concept of dynamic equilibrium to a non-technical audience. Though the storm event may happen in rapid succession or over many years (the average is every 4-5 years which is reported), the process when a storm does occur, still stands, during a storm of this magnitude there is scouring causing mass erosion. Post storm and during lower flows there is trapping and filling, i.e. a cycle that occurs on a periodic basis (on average every 4-5 years).

2. From STAC: "ES-3 2nd paragraph: the text beginning with "Modeling done for this…." is confusing. It states that under current conditions, half of the deep-channel habitat is unsuitable. This is then compared to the 2025 conditions with full WIP implementation and increased scour that suggests that attainment in 3 of the 92 segments will not be achieved due to extra loads of nutrients. It is implied that full WIP implementation should lead to completely healthy deep-water habitat, but a new reader would not necessarily catch this. Perhaps a more straightforward way to write this is to state something like "currently half of the deep-channel habitat is unsuitable for life (non-attainment), and given full WIP implementation in 2025 (which should yield 100% attainment), deep-channel habitat in 3 of the 92 Bay segments (X % of deep channel habitat) will remain as unsuitable habitat due to elevated nutrient loads from dam scour".

LSRWA Response: Language altered to be clearer: "Modeling done for this assessment estimated that currently more than half of the deep-channel habitat in the Bay is frequently not suitable for healthy aquatic life. However, it was estimated that with full implementation of the WIPs by 2025 (which should yield 100% suitable habitat for aquatic life), DO levels required to protect aquatic life in the Bay's deeper northern waters will not be achieved (in 3 of the 92 Bay segments) due to loads of extra nutrients associated with increased frequency and the amount of scoured sediments."

3. From STAC: "ES-3 4th paragraph: The last sentence (starting "Given…") is a run-on sentence."

LSRWA Response: Sentence fixed: "The primary impact to the Bay from the Susquehanna River watershed and the high river flows moving through the series of reservoirs is dissolved oxygen and impaired water clarity from algal growth. It is the nutrients associated with the sediments that are the most detrimental factor from scoured loads to healthy Bay habitats versus sediment alone."

4. From STAC: "p. 6 "The Susquehanna River is the nation's 16th largest river, and the source of the freshest water …" What is meant by freshest water? Typo?"

LSRWA Response: Sentence fixed:"and the largest source of fresh water."

5. From STAC: p. 8 "All reservoirs act as a sink….." A sink of what? Sediment? Perhaps it is obvious, but it is helpful to state clearly."

LSRWA Response: "sediment" added in front of "sink.'

6. From STAC: "p. 8 "Due to flow deceleration as the water enters the reservoir, sediment transport capacity decreases, and the coarser fractions of the incoming sediment deposited in the reservoir form a delta near the entrance to the reservoir." Awkward sentence – tenses."

LSRWA Response: Sentence fixed: "Due to flow deceleration as water enters the reservoir, sediment transport capacity decreases, and coarser fractions of the incoming sediment deposits in the reservoir forming a delta near the entrance to the reservoir."

7. From STAC: "p. 8 Last sentence of 5th paragraph: It is worth adding to the last sentence that nutrient-laden sediments are more harmful because they can be utilized to fuel additional algal growth in the tidal waters of the Bay."

LSRWA Response: Suggested language added.

8. From STAC: "p. 9 Last complete paragraph: if the Susquehanna load is 3.1 million tons and 1.2 million tons is released then 59.4% is trapped, not 55%."

LSRWA Response: Percentage fixed. On average the rate is 55-60% if the hydrologic record is evaluated over the last 30 years.

9. From STAC: "pp. 15-16 The flow charts in Figures 1.5 and 1.6 are repetitive but slightly inconsistent. Figure 1.6 makes more sense and may be sufficient."

LSRWA Response: No change. 1-5 and 1-6 are similar but have slightly different purposes. Both are conceptual graphics summarizing the overall (1) modeling components (2) analytical approach of the study for a non-technical audience.

10. From STAC: "p. 16 In notes under Figure 1-6, should "partners of this LSRWA effort" be changed to "partners outside of this LSRWA effort"?

LSRWA Response: Language changed as suggested above.

11. From STAC: "p. 24 3rd paragraph: Would be clearer or more mechanistic to say "…than about 0.3 knots because water movement tends to be slowed by frictional forces in shallow water…"

LSRWA Response: Language changed as suggested above.

12. From STAC: "p. 26 "Snow events" do not cause floods. SnowMELT may."

LSRWA Response: Language changed to snow melt as suggested above.

13. From STAC: "p. 28 Define saprolite or show in Figure 2-5."

LSRWA Response: Definition added. "The rock in much of the Piedmont is deeply buried below the surface by crumbling rock that has weathered in place known of as saprolite. Saprolite in the Piedmont can be tens of feet thick. Hard rock in the Piedmont is naturally exposed in landscape settings where the saprolite weathers away, such as along stream valleys and on steep hilltops. Human activities have greatly increased exposures of Piedmont rocks at locations such as roadcuts and quarries.

14. From STAC: "p. 32 "Phosphorus binds to ~~river~~ fine sediments and is delivered to the Bay with sediment."

LSRWA Response: Language changed as suggested above.

15. From STAC: "p. 32 (1) 2nd sentence: "Ammonia" should be "Ammonium". (2) 2nd sentence: It is worth noting that although ammonium tends to be less abundant than nitrate in surface waters, it is by far the dominant dissolved N form in deeper waters during warm months. (3) True, nitrite generally contributes little to TN, but nitrite can accumulate to significant concentrations during some times and places, including the region of the pycnocline during mid-summer and after hypoxia/anoxia breakdown in fall. Perhaps adding a line to the sentence to say "….and contributes little to TN for most times and places". (4) It is worth adding that organic nitrogen comes in both particulate and dissolved forms."

LSRWA Response: Language revised: "*Total nitrogen (TN) includes nitrate, nitrite, ammonia, and organic nitrogen. As typically measured in labs and for the purposes of this section, ammonia also includes ammonium. Nitrate is the primary form of nitrogen in dissolved form in surface waters. Ammonia is a dissolved form of nitrogen that occurs in surface waters less commonly than nitrate. However, ammonia is the dominant dissolved nitrogen form in deeper waters during warm months. Nitrite is generally unstable in surface water and contributes little to TN for most times and places. Organic nitrogen (mostly from plant material, but also including organic contaminants) occurs in both particulate and dissolved forms, and can constitute a substantial portion of the TN in surface waters. However, it is typically of limited bioavailability, and often of minimal importance with regard to water quality. Conversely, nitrate and ammonia are biologically available and their concentration is very important for water quality (USGS, 1999; Friedrichs et al, 2014).*"

16. From STAC: "p. 34 A factual problem is the statement that indicates that TN, TP, and SS loads from Conowingo have been increasing since the mid-1990's. This is certainly true for TP and SS but for TN the trends have continued to be downward (Hirsch, 2012 reports a decrease of about 3 percent)."

LSRWA Response: Language revised to more accurately summarize what cited references state: "Monitoring of nutrients in the Susquehanna River has shown that the flow-adjusted annual concentrations of TN, TP, and suspended sediment delivered to the dams have been generally decreasing since the mid-1980s. With corrections to account for year-to-year variation in river flows, over the 20-year period from 1990 to 2010, TN and sediment loads delivered to the Bay from the Susquehanna River showed statistically significant declines of 26 percent and 17 percent, respectively. TP loads declined by 7% over this time period, but the trend was not statistically significant (Langland et al., 2012). Environmental management measures in the watershed contributed to this decrease. However, one study has indicated that loads of particulate nitrogen, particulate phosphorus, and suspended sediment from the reservoir system to the Chesapeake Bay are increasing, and attributes this to decreasing trapping capacity of Conowingo Reservoir (Zhang et al., 2013)."

17. From STAC: "p. 36 Should define hypoxia in Figure 2-10 (<2.0 mg/L)."

LSRWA Response: Footnote added to figure.

18. From STAC: "p. 37 Section 2.5.2, 2nd sentence – statement is misleading and should be deleted unless qualified by explaining that because of different designated uses and water quality criteria it is not surprising there is a difference in violations. As is, statement is comparing apples and oranges."

LSRWA Response: Statement deleted.

19. From STAC: "p. 45 Figure 2-14 is not clear as to whether or not the metrics are total over a decade or per year."

LSRWA Response: A footnote was added: These amounts are representing annual averages during a particular decade.

20. From STAC: "p. 46 Many species of plankton are capable of motility. Change "and are passively carried" to "and are, by in large, passively carried".

LSRWA Response: Language changed as suggested above.

21. From STAC: "p. 69 Chapter 3 mentions 3 Chesapeake Bay agreements, which may have been true when this section was written. However, doesn't the Watershed Agreement sign in June 2014 count as the 4th Chesapeake Bay agreement?"

LSRWA Response: Correct. Language revised "…. three additional agreements have been adopted since that time."

22. From STAC: "p. 72 2nd to last paragraph: The word "special" should be "spatial".

LSRWA Response: Language changed as suggested above.

23. From STAC: "p. 81 "The HEC-RAS model may not be suitable for ….. , active scour and deposition, and particle size." What does this mean with respect to "particle size"? That the model cannot represent particle size well? Explain so meaning is clear."

LSRWA Response: First sentence of this paragraph discusses this: HEC-RAS is designed primarily for non-cohesive sediment transport (sands and coarse silts) with additional, but limited, capability to simulate processes of cohesive sediment transport (generally medium silts to fine clays). The model actually did well predicting major particle size. This sentence revised to say: "The HEC-RAS model may not be suitable for all reservoir simulations, especially in areas of highly variable bed shear stress (the force of water required to move bed sediments) and active scour and deposition."

24. From STAC: "p. 81 3rd paragraph: Were the boundary conditions generated for the HEC-RAS simulation also used to drive the AdH model? Or was model output from HEC-RAS simulation for the upper two reservoirs used to create the boundary conditions for AdH? Please clarify."

LSRWA Response: All simulations were conducted with the same Susquehanna River flow and inflowing sediment boundary conditions. The 4-year flow period from 2008 to 2011 was simulated in the AdH model. The flow and sediment entering the upstream model boundary (channel below the dam on Lake Aldred) were provided by the USGS from HEC-RAS model simulations of the 4-year flow record. These simulations included all three reservoirs, thus the sediment output from HEC-RAS included bed sediment scour from the upper two reservoirs. The sediment rating curve in the HEC-RAS simulations was developed by the USGS from suspended sediment measurements in the Susquehanna River above the reservoir system. The HEC-RAS outputs (boundary) conditions for flow, sediment load and particle sizes were given to AdH for ERDC use. Ultimately for AdH, ERDC created their own boundary conditions for Conowingo; however HEC-RAS input was a good starting point. The HEC RAS simulations for the upper two reservoirs were used to drive AdH, although the sediment discharge was increased over what HEC-RAS reported, in order to err on the side of higher sediment discharge.

25. From STAC: "pp. 81-83 The models are stated to be "well developed, widely accepted, and peer reviewed. Yet there are virtually no references in Sections 4.1 or 4.2. References are needed here to demonstrate that HEC-RAS and AdH are indeed peer-reviewed models."

LSRWA Response: Language revised to state: "The models were selected because they were well developed, widely accepted, and have had wide use and application." Do not agree that the main report is the place to discuss these models's use in other applications. The models (AdH and HEC-RAS) are built from theory based on scientific and research. They have had millions of dollars invested in them and have been applied by many studies around the country and world. The use of the latter two models has resulted in the successful construction and operation of hundreds of water resource management structures and systems.

A few examples for HEC-RAS use-
The HEC-RAS model data has been used for the Sacramento River Flood Project (CA); Comprehensive Study of Sacramento and San Joaquin River Basin (CA); White Oak Bayou Federal Flood Damage Reduction Project(TX); Mobile Bed Modeling of the Cowlitz River (WA); Flood Plain Modeling in the Kansas River Basin (KS); Flood Cyclone JFY 2010 Mini-Project Indonesia; and Flood Hazard Mapping in the Nan River Basin, Nan Province, Thailand.

HEC-RAS model data use outside of the U.S. Army Corps Engineers (USACE) includes the following:
Endensco, Inc. used HEC-2/HEC-RAS for hydraulic and hydrologic analysis of Route 1 Neabsco Creek in Prince William County, Virginia. The data was peer reviewed by the Virginia Department of Transportation.

NMP Engineering Incorporated performed a hydraulic study of Terrapin Branch. HEC-RAS was used for three design alternatives for the proposed bridge. The data was peer reviewed by the Maryland State Highway Administration.

WBCM was the lead design consultant for Corman Construction who designed and constructed the Hampstead Bypass Project using HEC-RAS to size bridge openings. The data was peer reviewed by the Maryland State Highway Administration.

For AdH:
The AdH model data has been used to construct the Moose Creek Floodway on the Chena River, a joint effort by the Coastal and Hydraulics Lab at the Engineering and Research Development Center and Alaska District Corps of Engineers; and the Jacksonville Harbor (FL) Navigation Project.

Regarding peer review for any USACE study involving construction of large water resource projects (such as those listed above), the models undergo review by the (1) USACE District conducting the study/modeling, (2) another USACE District (3) an independent (non-USACE) panel of reviewers that are designated experts from private companies and academia (4) any local, state, federal, or non-governmental organization requesting to be a cooperating agency on a study (5) general public and (6) USACE headquarters and division offices.

26. From STAC: "pp. 84-85 Figure 4-3 and 4-4: The mesh in all or part of these figures is almost impossible to see – provide insets at larger scale. Insets in the appendix show this more effectively."

LSRWA Response: Figures 4-3 and 4-4 are copied exactly from Appendix B.

27. From STAC: "pp. 87-89 In Chapter 4, the description of the method for using the 2008-2011 HEC-RAS and ADH predicted scour in the CBEMP 1991-2000 model runs is confusing. It is simply stated that the reader should see Appendix C for the details. More description should be provided in the text of Chapter 4, at least a better overview of the approach and justification for this somewhat tricky (but justifiable) maneuver."

LSRWA Response: Chapter 4 of Appendix C, Load Computation and Summary is largely devoted to explaining the derivation of scour loads. A paragraph was added at the end of Section 4.3.4 of main report: "Since the AdH application period was 2008 to 2011 while the CBEMP application period was 1991 to 2000, a procedure was employed to adjust estimated loads of scour from AdH for use in the CBEMP. A procedure to apply ADH calculations to the 1996 storm was developed based on the volumetric flow in excess of the threshold for mass erosion (400,000 cfs). The year 2011 contained two erosion events, an un-named event in March and Tropical Storm Lee, in September. The excess volume for each event was computed by integrating flow over time for the period during which flow exceeded 400,000 cfs. The amount of sediment eroded during each event was taken as the difference between computed loads entering and leaving Conowingo Reservoir. Sediment loads leaving the reservoir in excess of loads entering were taken as evidence of net erosion from the Conowingo reservoir bottom. Net erosion for January 1996 was calculated by linear interpolation of the two 2011 events, using excess volume as the basis for the interpolation (See Appendix C for more detail)."

28. From STAC: "p. 89 "Since the ADH application period was 2008 to 2011 while the CBEMP application period was 1991 to 2000, an algorithm was applied to adjust estimated loads from the ADH for use in the CBEMP (see Appendix C for details on this algorithm)." This algorithm is not obvious in Appendix C. Should briefly explain here and then explain better in Appendix C."

LSRWA Response: See Response above (#27).

29. From STAC: "p. 92 "documented in Chapter 3"(?) Is this a typo?"

LSRWA Response: Language changed to "discussed in Chapter 3"

30. From STAC: "pp. 97-100 Table 4.2 seems a bit out of context in Chapter 4, referring as it does almost entirely to material in Chapter 6. Although not a requirement, this table would make more sense in Chapter 6 where it is directly discussed."

LSRWA Response: Will leave as is. The idea was to introduce scenarios to reader here and provide results in Chapter 6.

31. From STAC: "p. 112 Are the values in Table 5-4 adjusted for variations in flow?"

LSRWA Response: These values are the total values associated with the 2008-2011 hydrograph: hence variations in flow are implicitly integrated into the analysis.

32. p. 113 In Table 5-5 change "Additional" to "Additional Calculated" and change "Transport" to "Scour-Induced Transport".

LSRWA Response: Will change to "Additional Calculated" but NOT change the Transport to "Scour Induced Transport". The increase could be due to a reduction in deposition.

33. From STAC: "p. 114 Figure 5-4 presents exact same data as Table 5-5. Eliminate."

LSRWA Response: Will leave. Figure provides a visual of curve.

34. <u>From STAC:</u> "p. 114 Bottom: annual influx of sediment to Conowingo is here described as 3.8 million tons/yr over the last 20 years with 2 million being trapped. Elsewhere in the document we see different numbers ranging between 3 million and 4.2 million tons. If there are different estimates arrived at in different ways this needs to be made clear."

LSRWA Response: Estimates always vary depending on total hydrologic years being evaluated. Will ensure that years of evaluation are included in each instance to make this clear. If averages were cited from a reference (for example Langland, 2009) in the LSRWA report those averages with appropriate hydrologic years evaluated are noted.

35. <u>From STAC:</u> "p. 115 Table 5-6 does not explain how the historical loads or more recent loads were calculated – it simply says that the results were calculated by USGS. More explanation is needed. Also indicate that Hurricane Agnes flows were excluded if they were indeed omitted."

LSRWA Response: This table is directly from Appendix A where further explanation is provided. Footnote revised to state that 1972 (year of Hurricane Agnes, not included) and (see Appendix A).

36. <u>From STAC:</u> "p. 131 The reasoning for using the particular combinations of predicted scour, nutrient loading, and water quality modeling to test for the effects of scour is unclear. The procedure was likely valid, but better explanation is needed."

LSRWA Response: The first paragraph under "Scour impacts" lays out the procedure in summary terms. Appendix C provides more detail on each scenario, what went into each scenario and why.

37. <u>From STAC:</u> "p. 135 paragraph 4: It would help if there was some discussion of why two upper Eastern Shore segments (CHSMH and EASMH) had non-attainment in Scenario 3. Does low-DO water advect into them from the mainstem or is nutrient availability enhanced by the breakdown of scoured solids that end up in these tributaries?"

LSRWA Response: Good point and discussion will be expanded to describe the region of contiguous Deep Water and Deep Channel waters in the segments of CH3MH, CB4MH, EASMH, and CHSMH. Language added to Appendix D: "The segments of CH3MH, CB4MH, EASMH, and CHSMH are in a region of contiguous Deep-Water and Deep- Channel waters. These CB segments have similar depths so that advection from gravitational circulation as well as tidal dispersion plays a role in the continuous area of hypoxia among these CB segments."

38. <u>From STAC:</u> "p. 138 Paragraph 2: Oysters are discussed here within a section that otherwise discussed the modeling and simulation activities. Is there a description of how model analysis was used in this report to determine flow and management effects on oysters? Whatever the case, it should be clearly stated where the oyster effects fit into this report and whether or not model simulations were used to understand effects on oysters."

LSRWA Response: No specific modeling simulations were run to quantify oyster impacts. However this resource is of high interest so this qualitative language was added. This paragraph was deleted from this section since the context here is specific LSRWA simulation results (i.e. quantified results). Section 2.7.4 discusses oysters and impacts from storm events summarizing a DNR report on effects from Tropical Storm Lee.

39. From STAC: "p. 138 "Nitrogen loads…exceed phosphorus loads…" Given that P concentrations tend to be an order of magnitude lower than those for N, the statement does not tell the reader much, and might unduly impress those lacking an understanding of nutrient concentrations and dynamics. "

LSRWA Response: A large body of work links Chesapeake Bay hypoxia to nitrogen loading (e.g. Hagy, J., W. Boynton, C. Keefe, and K. Wood. 2004. Hypoxia in Chesapeake Bay, 1950 – 2001: Long-term changes in relation to nutrient loading and river flow. Estuaries 27(4):634-658.; Murphy, R., W. Kemp, and W. Ball. 2011. Long-term trends in Chesapeake Bay seasonal hypoxia, stratification, and nutrient loading. Estuaries and Coasts 34:1293-1309.) Consequently, the notion that scoured nitrogen loads exceed scoured phosphorus loads is exceedingly important. This is not misleading at all. What is misleading is the continued emphasis on phosphorus loading, often to the exclusion of any consideration of nitrogen. However, as discussed in the LSRWA recommendations, an understanding of the relative bioavailability of this Nitrogen (versus total loads) warrants scrutiny to inform management decisions of the Bay.

40. From STAC: "p. 146 Sources of information here are based on "personal communication" with Kevin DeBell, Greg Busch, John Rhoderick, and Jeff Sweeney. It would be better to document and provide references for the original reports used for the BMP unit costs rather than only personal communication. Page 4 in Appendix J-1 similarly only provides personal communications."

LSRWA Response: As described in Section 5.2, "the LSRWA team relied heavily on the Bay TMDL work done by CBP and state partners to develop the watershed management strategies. As such, the LSRWA team adopted the CBP methodology and unit costs as the representative alternative for a watershed management strategy; additional cost and design analyses were not undertaken." Citations are included where appropriate (e.g. U.S. Environmental Protection Agency (U.S. EPA). 2010) however personal communication by LSRWA team was required to ensure that LSRWA interpretations of Chesapeake Bay Program work on watershed BMP's/strategies were accurate.

41. From STAC: "p. 167 "This methodology was not applicable for the watershed management representative alternative since management strategies (e.g., BMPs) once implemented, continue to remove/reduce sediment." This statement is not true for many BMPs. For example, vegetative buffers self-destruct if they receive excessive sediment – same with most BMPs that trap sediment rather than reducing its generation. As a result of this incorrect assumption, one might question whether costs are one time."

LSRWA Response: This statement is generalizing here. Nuance added. Language revised to state: "This methodology was not applicable for the watershed management representative alternative since management strategies (e.g., BMPs) once implemented, continue to remove or *reduce sediment (although many BMPs will need to be cleaned out and maintained to continue to be effective)." The point here is order of magnitude. Cleaning out multiple BMPs after a storm is nowhere near what it would cost to annually dredge at the scale discussed.*

42. From STAC: "p. 175 3rd paragraph: The word "waters" on line 4 of this paragraph should be "water"."

LSRWA Response: Language changed as suggested above.

43. From STAC: "p. 180 "costs of bypassing (diminished DO, increased chlorophyll) are roughly 10 times greater than the benefits gained from reducing scour." Indicate exactly where these data are contained in the report. A similar statement also appears in the Executive Summary and on p. 181 and p. 197."

LSRWA response: This comes from Bay model simulations, Appendix C. Language added to main report.

44. From STAC: "p. 192 In the first summary statement below finding #2, the "upper Chesapeake Bay" ecosystem is highlighted to be the area impacted by the dam. "upper" is an ambiguous word in this case, as the simulations suggest that effects can be seen south of the Bay Bridge (e.g., Appendix C)."

LSRWA response: Report is generalizing here, which is appropriate for this Chapter since it is providing "big picture" findings. Actual attainment issues were seen in 3 of the upper Bay segments which is discussed in detail and depicted via figures in the main report and Appendix C and D. Report attempts to provide geographic coverage of Bay consistent with how Bay Program defines areas of Chesapeake Bay.

45. From STAC: "p. 193 Second paragraph, line 5: should "frequently not unsuitable" be "frequently unsuitable"?"

LSRWA Response: Language changed as suggested above.

46. From STAC: "p. 200 Reference to additional management activities that can provide long-term storage includes mention of floodplain restoration. If this refers to floodplain excavation, there is some concern about this appearing as a recommendation without much more study than has been conducted to date. If it refers to some other form of floodplain restoration some explanatory language would be helpful."

LSRWA Response: Will delete specific mention since floodplain restoration is just one example thus is not necessary in context here.

47. From STAC: "p. 201 The report does not make the case for use in adaptive management, as adaptive management is mentioned for the first time in this recommendation. Adaptive management is not mentioned anywhere but in this recommendation. Thus, the phrase should be deleted here."

LSRWA Response: Will leave as is. The section below makes a case for adaptive management in that long-term monitoring will confirm if management practices are actually effective (or not) thus allowing management to be altered in the future.

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July 18, 2014

Anna Compton
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10 South Howard Street
Baltimore, MD 21201

Re: Lower Susquehanna River Watershed Assessment DRAFT Report
Comments of Exelon Generation Company, LLC

Dear Anna:

Exelon Generation Company, LLC (Exelon) appreciates the opportunity to provide feedback and comments to the U.S. Army Corps of Engineers (Corps) Lower Susquehanna River Watershed Assessment (LSRWA) Draft Report distributed for review on June 23, 2014. The LSRWA Draft Report represents a tremendous amount of work by the project partners and represents an important step in understanding the Susquehanna River/Chesapeake Bay (the Bay) water quality interactions.

After extensive review of the main report and appendices, Exelon has developed detailed comments, which are contained in the accompanying table. Additionally, during our review a number of significant concerns were identified; these concerns are discussed in detail below. Exelon hopes that these comments will assist the Corps in developing the most technically sound and understandable document possible.

Study Findings

Exelon believes that the LSRWA Draft Report represents a significant contribution to the understanding of the overall positive benefit Conowingo Dam (Conowingo) provides for the health of the Bay. Specifically, the LSRWA Draft Report makes several well-supported conclusions, including the following: (1) the majority of the sediment that enters the Bay during storm events originates from the watershed rather than from scour from Conowingo Pond; (2) given the small contribution of sediment from Conowingo Pond, the primary impact to the Bay is from sediment and nutrients from the Susquehanna River and Chesapeake Bay watershed; and (3) implementation of Watershed Implementation Plans has the largest influence on the health of Chesapeake Bay.

In particular, Exelon notes that the LSRWA Draft Report concludes that, while Conowingo Pond is in dynamic equilibrium, the Pond will continue to trap sediments and associated nutrients into the future during depositional periods. The report states that from 1993-2012 the annual trapping efficiency of Conowingo Pond was 55-60%. This finding, which is consistent with the assumptions of the Chesapeake

Bay TMDL, highlights the day-to-day benefits that Conowingo provides to the Bay. Exelon believes that, to further strengthen these findings, it would be helpful for the next draft of the LSRWA to explicitly state the assumed trapping efficiencies for each modeling scenario.

The LSRWA Draft Report also includes discussion of nutrient loading and other contaminants in the sediment emanating from the river and in the Bay. The LSRWA Draft Report's finding that "nutrients, not sediment, have the greatest impact on Bay aquatic life" represents a valuable step forward in understanding how best to improve water quality in the Bay. As the LSRWA Draft Report acknowledges in several locations, however, nutrients came up late in the study process. Nonetheless, the report makes definitive statements regarding the effects of nutrients from scour on Bay water quality. As currently written, the LSRWA Draft Report gives the impression that sediment-bound nutrients scoured from Conowingo Pond are the main threat to Bay water quality. In contrast, the appendices (in particular Appendix C) indicate that all nutrients entering Chesapeake Bay threaten water quality, whether they are watershed-derived or bound to scoured sediments. The impact of sediment-bound nutrients on Bay water quality is not fully understood at this time. Indeed, a discussion of supporting nutrient data and quantitative nutrient model assumptions is conspicuous by its absence in the report. The next draft of the report should either provide the field and model data supporting these conclusions, with any appropriate qualifiers, or simply list nutrient interactions in the Susquehanna River and Chesapeake Bay as areas requiring additional study.

As currently drafted, the LSRWA Draft Report understates the significance of sediment and nutrient loading from sources upstream of Conowingo Pond. The main report specifically states that 70-80% of sediment that flows to the Bay during a major storm originates from the watershed upstream of Conowingo Pond. Yet rather than focus on those sources, the main report instead focuses primarily on Conowingo Pond scour. The fact that the terms "scour event" and "scour" are used interchangeably throughout the main report and appendices (especially Appendix D) only further confuses the impact of the runoff event with the impact of the scour itself.

Moreover, while the study goals state that the LSRWA was intended to examine the "loss of sediment and associated nutrient storage within the reservoirs of the lower Susquehanna River," the discussion and findings of the report (including sediment management strategies) focus almost exclusively on Conowingo Pond. This problem is further exacerbated by the fact that, in various places, the LSRWA Draft Report uses the terms "Conowingo Reservoir" and "the reservoirs of the Lower Susquehanna" almost interchangeably. As such, the report gives the impression that only Conowingo Pond scour has a potential impact on Bay health, when in fact all three reservoirs are in dynamic equilibrium and susceptible to episodic scour. In order for this study to be a true Lower Susquehanna River assessment, all three reservoirs (Lake Clarke, Lake Aldred, and Conowingo Pond) should be discussed proportionately.

Modeling

The findings of the LSRWA are based in part on a complex suite of mathematical models that were developed by the U.S. Environmental Protection Agency (USEPA), Corps, and U.S. Geological Survey (USGS). The output from various sub-models (HEC-RAS, AdH, etc.) were used as input parameters for the Chesapeake Bay Environmental Model Package (CBEMP). While the individual modeling efforts' methods, assumptions, inputs and outputs are well explained in their respective appendices (Appendix A, B and C), we believe it would be helpful for the reader to have a single point of reference within the main report to explain all of the interactions between the various LSRWA models (HEC-RAS, AdH, WSM, WQSTM, etc.). This will allow the reader to better understand how each of the models are "connected" in spite of the varying model timesteps (e.g., daily vs. hourly vs. 15-min), and output parameters (e.g., sediment loads, nutrient loads, nutrient components). While Figure 1-5 in the main report (identical to Figure 1-2 of Appendix C) explains the model interaction in a general sense, we envision an accompanying figure and narrative within the main report to more specifically define the interactions. We have included an example of what we believe an accompanying figure describing the model interactions could look like in Attachment 1.

It is also difficult to track the input conditions/assumptions (e.g., 1996 vs. 2011 sediment nutrient content, and trapping efficiency), water quality attainment analysis periods (e.g., 1993-1995 vs. 1996-1998) and attainment results (e.g., 2% nonattainment in CB4MH deep channel DO) for each of the LSRWA modeling scenarios. While page one in Appendix J-4 describes many of the model input datasets and assumptions, as well as the water quality attainment analysis period, this table only describes six out of the seventeen runs mentioned in Table 3-1 of Appendix C. To understand input conditions for the other eleven model scenarios not described in page one of Appendix J-4, one has to piece together information from the main report, Appendix C, D and J. Additionally, Appendix D only included "stoplight plot" analysis results for a handful of the scenarios described in Table 3-1 of Appendix C. In particular, there was some confusion regarding what each scenario assumed for trapping efficiencies. We suggest the Corps consider adopting a table similar in format to Attachment 2 to explain all of the LSRWA runs described in Appendix C, plus add a brief summary of any water quality nonattainment for each scenario (if possible). Even if the nonattainment assessment is limited to certain 'critical' model segments (e.g., deep channel DO in CB4MH, EASMH and CHSMH), this would provide the reader with an easy way to compare all of the runs in a single table. We have attempted to fill in the table with our understanding of the model runs so the table's intent is well understood. We also recommend including the "stoplight plot" analysis results into Appendix D for all of the scenarios described in Table 3-1 of Appendix C.

Finally, the limits of the individual models and the uncertainties associated with the model outputs are stated in the appendices and provided, in part, within the main report. However, the main report does not evaluate how the uncertainties inherent to each model constrain the conclusions ultimately reached by the LSWRA study. Thus, the reader is left with the impression that the quantitative outputs of these complex mathematical models are definitive and absolute which is not the case. For example, Appendix B on the AdH model states: "Because of these uncertainties the AdH model may potentially over-predict to some degree transport of scoured bed sediment through the dam." This is not reported in Chapter 4 of the main report when discussing AdH model uncertainties. While uncertainties of the CBEMP model are also discussed in Chapter 4, the quantitative consequences of over-prediction by the AdH model to the output of the CBEMP model are not. The ultimate effect of AdH over-prediction on LSRWA conclusions is not examined.

Sediment Management Options

Exelon believes that having a full understanding of the potential environmental impacts of each of the various sediment management strategies will help facilitate a balanced, well-rounded examination of the alternatives. The LSRWA Draft Report includes a conceptual-level screening of various sediment management strategies. This screening includes a brief description of each alternative including pros and cons and approximate cost. Although this screening includes some preliminary discussion of potential environmental impacts, in general these were not discussed in sufficient detail. While Exelon understands that a full environmental assessment was not within the scope of this report, the discussion of each alternative should acknowledge the environmental resources that would need to be investigated and to provide a qualitative description of the expected relative impact. Depending on the alternative, environmental resources that could be impacted include: aesthetics, air quality, soils, water quality, wetlands, groundwater, surface water, floodplains, biological resources, cultural resources, land use, recreation and tourism, utility and transportation infrastructure, and public health and safety. In many cases the environmental impact to these resources could be far greater than the benefit the sediment management alternative would provide.

In addition, it should be reiterated here that, although the introduction to Chapter 6 discusses examining sediment management alternatives for the lower Susquehanna River reservoirs, the alternatives discussed throughout the rest of the chapter alternatively mention “the reservoirs” or “Conowingo Reservoir.” By interchanging these terms, it becomes unclear whether the sediment management alternatives are being proposed at all three lower Susquehanna River reservoirs or just Conowingo Pond. In many instances it appears the management alternative is targeting only Conowingo Pond, in which case sediment loads from Lake Clarke and Lake Aldred bed scour are implicitly not taken into consideration.

Detailed comments elaborating on the points discussed in this letter can be found in the accompanying table. Due to the short time frame provided for review, Exelon reserves the right to make additional comments in the future. We appreciate the opportunity to provide feedback and comments on the draft LSRWA and look forward to continuing to work with project partners in the future. Upon review of our comments if you have any questions please feel free to contact me at (610) 765-6791 or colleen.hicks@exeloncorp.com or Tom Sullivan at (603) 428-4960 or tsullivan@gomezandsullivan.com.

Respectfully submitted,

Colleen E. Hicks

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Manager Regulatory and Licensing, Hydro
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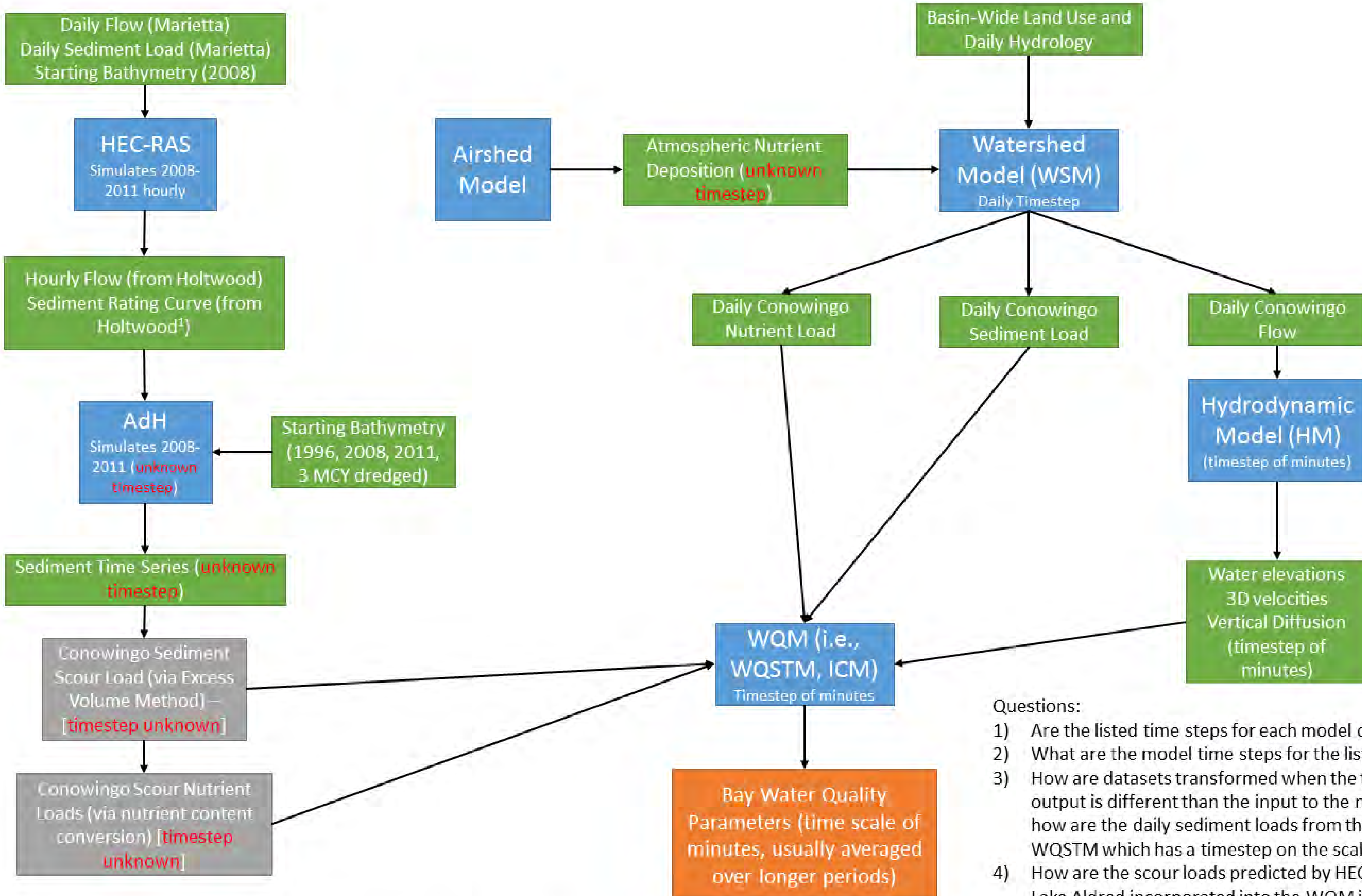
Attachment 1: Description of WQSTM model interactions.



Questions:

1) Are the listed time steps for each model correct?
2) What are the model time steps for the listed unknowns (e.g., AdH)?
3) How are datasets transformed when the timestep of a model output is different than the input to the next model? For example, how are the daily sediment loads from the WSM translated into the WQSTM which has a timestep on the scale of minutes?
4) How are the scour loads predicted by HEC-RAS for Lake Clarke and Lake Aldred incorporated into the WQM inputs?

[1]The Holtwood sediment outflows were calculated from the HEC-RAS "scour" model, plus an additional 10% beyond the HEC-RAS predicted sediment load.

Attachment 2: Potential format for describing model inputs for each LSRWA scenario.
Footnotes are included to describe conditions common for all scenarios. Black text describes information taken from Appendix J-4. Blue text describes information taken from Appendix C.

Model Code	Description or Study Question	Models Used	Land Use (i.e., watershed sediment/nutrient loads)	HEC-RAS Model Run (scour or depositional)	Reservoir trapping efficiency	Reservoir Scour Load Method	Reservoir Sediment Nutrient Content	Time period analyzed for WQ Nonattainment	Deep Channel DO Nonattainment in CB4MH	Deep Channel DO Nonattainment in EASMH	Deep Channel DO Nonattainment in CHSMH
LSRWA-3	What is the system's condition when WIPS are in full effect and reservoirs have not all reached dynamic equilibrium?	CBEMP[1,2]	TMDL – WIPS in place	N/A	1991-2000 levels[3]	None	N/A	1993-1995	0%	0%	0%
LSRWA-4	What is the system's current (existing) condition?	CBEMP	2010 Land Use	N/A	1991-2000 levels	None	N/A	1993-1995	?	?	?
LSRWA-5	2010 land use with Conowingo reservoir removed from WSM. All sediments and nutrients pass through – no deposition or scour.	CBEMP	2010 Land Use	N/A	0%	N/A	N/A	Not analyzed?	?	?	?
LSRWA-6	TMDL land use with Conowingo reservoir removed from WSM. All sediments and nutrients pass through – no deposition or scour.	CBEMP	TMDL – WIPS in place	N/A	0%	N/A	N/A	Not analyzed?	?	?	?
LSRWA-20	2010 land use with sediment/nutrient from Conowingo scour added in.	HEC-RAS AdH CBEMP	2010 Land Use	?	Existing[4]	Excess volume method from AdH results (from 2011 bathymetry)	2011 Tropical Storm Lee	Not analyzed?	?	?	?
LSRWA-21	What is the system's condition when WIPS are in full effect, reservoirs have not all reached dynamic equilibrium and there is a winter scour event?	HEC-RAS[5] AdH[5] CBEMP	TMDL – WIPS in place	?	2011 levels	Excess volume method from AdH results (from 2011 bathymetry)	2011 Tropical Storm Lee	1996-1998	1%[6]	1%	1%
LSRWA-31	TMDL land use, sediment/nutrients from Conowingo scour added in.	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	1996 levels?	Excess volume method from AdH results (from 2011 bathymetry)	2011 Tropical Storm Lee	Not analyzed?	?	?	?
LSRWA-18	What is the system's condition when WIPS are not in effect, reservoirs have all reached dynamic equilibrium and there is a winter scour event?	HEC-RAS AdH CBEMP	2010 Land Use	?	"Conowingo Full" condition	Excess volume method from AdH results (from 2008 bathymetry)	2011 Tropical Storm Lee	1996-1998	?	?	?
LSRWA-30	What is the system's condition when WIPS are in full effect, the reservoirs have all reached dynamic equilibrium and there is a winter scour event?	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	"Conowingo Full" condition	Excess volume method from AdH results (from 2011 bathymetry)	2011 Tropical Storm Lee	1996-1998	?	?	?
LSRWA-22	TMDL land use, sediment/nutrients from Conowingo scour added in.	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	Existing	Excess volume method from AdH results (from 2008 bathymetry)	Jan 1996 flood event	Not analyzed?	?	?	?
LSRWA-23	TMDL land use, 1996 storm removed from hydrologic record and load record	? CBEMP	TMDL – WIPS in place	?	Existing	N/A?	N/A	Not analyzed?	?	?	?
LSRWA-24	What is the system's condition when WIPS are in full effect, reservoirs have not all reached dynamic equilibrium and there is a summer scour event?	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	2011 levels	Excess volume method from AdH results (from 2008 bathymetry)	2011 Tropical Storm Lee	1996-1998	?	?	?
LSRWA-25	What is the system's condition when WIPS are in full effect, reservoirs have not all reached dynamic equilibrium and there is a fall scour event?	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	2011 levels	Excess volume method from AdH results (from 2008 bathymetry)	2011 Tropical Storm Lee	1996-1998	?	?	?
LSRWA-26	TMDL land use, January 1996 storm moved to June 1996	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	Existing	Excess volume method from AdH results (from 2008 bathymetry)	Jan 1996 flood event	Not analyzed?	?	?	?

Model Code	Description or Study Question	Models Used	Land Use (i.e., watershed sediment/nutrient loads)	HEC-RAS Model Run (scour or depositional)	Reservoir trapping efficiency	Reservoir Scour Load Method	Reservoir Sediment Nutrient Content	Time period analyzed for WQ Nonattainment	Deep Channel DO Nonattainment in CB4MH	Deep Channel DO Nonattainment in EASMH	Deep Channel DO Nonattainment in CHSMH
LSRWA-27	TMDL land use, January 1996 storm moved to October 1996	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	Existing	Excess volume method from AdH results (from 2008 bathymetry)	Jan 1996 flood event	Not analyzed?	?	?	?
LSRWA-28	TMDL land use, sediment/nutrients from Conowingo scour added, 3 MCY dredged from Conowingo Pond.	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	Post dredging (3 MCY removed)	Excess volume method from AdH results (from 2008 bathymetry, dredged 3 MCY)	2011 Tropical Storm Lee	Not analyzed?	?	?	?
LSRWA-29	TMDL land use, sediment/nutrients from Conowingo scour added, 3 MCY removed from Conowingo Pond to represent bypassing, sediments/nutrients bypassed downstream from December-February every year.	HEC-RAS AdH CBEMP	TMDL – WIPS in place	?	Post dredging (3 MCY removed), bypassing during some months	Excess volume method from AdH results (from 2008 bathymetry, dredged 3 MCY)	2011 Tropical Storm Lee	Not analyzed?	?	?	?

[1]CBEMP is a suite of models used to assess Chesapeake Bay water quality conditions. Sub-models within CBEMP include the watershed model (WSM), a hydrodynamic model (HM) and a water quality/eutrophication model (WQM).

[2]CBEMP is always run for a hydrology period from 1991-2000.

[3]The specific trapping efficiency (e.g., 55%) used for the run should be listed in addition to the year range the trapping efficiency is associated with (e.g., 1991-2000).

[4]Appendix C lists "Existing" bathymetry for several runs, including LSRWA-3, LSRWA-4, LSRWA-20 and LSRWA-21). It is not clear if this is referring to trapping efficiencies or something else. Appendix J-4, pg. 1 lists LSRWA-4 and LSRWA-21 as having different trapping efficiencies, where LSRWA-4 has "1991-2000 levels", and LSRWA-21 has "2011 levels." It is not clear what 2011 levels means.

[5]AdH and HEC-RAS were always run using the four year 2008-2011 hydrology period (Jan 1, 2008 – Dec 31, 2011). The HEC-RAS outputs that were input into AdH were always the "scour" model results.

[6]We recommend that nonattainment calculations include one additional significant figure beyond the decimal point (e.g., 1.4% nonattainment instead of 1% nonattainment)

Questions/Comments:

1) Please verify that the data we have entered into this table are correct.
2) Please list specific trapping efficiencies (e.g., 55%) in addition to qualitative descriptors (e.g., 1991-2000 trapping levels).
3) What do "2011 levels" refer to as far as trapping efficiencies?
4) Please include an additional significant figure beyond the decimal point for nonattainment calculations (e.g., 1.4% nonattainment instead of 1% nonattainment).

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
1	Exelon	Main Report	General	To be consistent with reference citations contained in the Conowingo Final License Application please see the correct citations below for Exelon RSP 3.11, 3.12, and 3.15: • URS Corporation and Gomez and Sullivan Engineers (GSE). 2012a. Water level management study (RSP 3.12). Kennett Square, PA: Exelon Generation, LLC. • URS Corporation and Gomez and Sullivan Engineers (GSE). 2012b. Sediment introduction and transport study (RSP 3.15). Kennett Square, PA: Exelon Generation, LLC. • Gomez and Sullivan Engineers. 2012. Hydrologic Study of the Lower Susquehanna River (RSP 3.11). Kennett Square, PA: Exelon Generation, LLC. Additionally, references to 2011 bathymetric surveys as Gomez and Sullivan (2012) should be referenced as: • URS Corporation and Gomez and Sullivan Engineers. 2012. Sediment introduction and transport study (RSP 3.15) (Appendix F). Kennett Square, PA: Exelon Generation, LLC.	Compton	Changes made to reference list and citations in main report.	Yes.
2	Exelon	Main Report	General	Importance of nutrients over sediment recognized "late in the game" so report focus is still on sediment. Seems like a better understanding of nutrient/sediment interaction is needed.	Compton	Other comments will address this.	Yes.
3	Exelon	Main Report	General	Instead of presenting an equal focus on all three reservoirs, there are still points within the report that focus primarily on Conowingo. General sections of the report that present ideas or concepts not specific to Conowingo Pond by itself should reference the three reservoirs or reservoir complex.	Compton	Discussion in multiple sections about why Conowingo is emphasized. Also AdH modeling results are specific to Conowingo so data must be presented this way for accuracy. Mention of all three reservoirs and universal concepts are noted where appropriate.	No.
4	Exelon	Main Report	General	Many of the figures are 'fuzzy' and it is difficult to read the legend text (e.g., the cover page, figure 2-6, figure 2-8, figure 4-7).	Compton	All figures mentioned have been updated.	Yes.
5	Exelon	Main Report	General	The "full" condition estimation should be more clearly explained. Pieces of the explanation are given throughout the report (Page 112, Appendix A-3), but there is not enough detail given in any one location (or even collectively throughout the report and appendices) to understand or follow how the estimation was derived.	Langland	The full condition is a term used to describe the storage capacity of a given reservoir. A reservoirs is full when it can no longer effectively trap sediments and associated nutrients in the long term (decades). This language added to page 112. "Full" is better described as dynamic equilibrium which is described in detail on pages 109-110.) More detailed language has been added to Appendix A, Attachment A-3.	No.
6	Exelon	Main Report	General	The terminology "major scour event" is used throughout the report. Instead of referring to these events as major flood events, they are named major scour events. This predisposes the reader to assume major scouring is occurring when flows exceed 400,000 cfs, and while there is mass wasting occurring, that still doesn't mean the loads entering the bay are a higher percentage of scour than watershed-based sediments. For example, see page 81, paragraph 3.	Compton	Specific reference here was changed to "major flood event". In general throughout report, if discussion is on a storm event in the watershed "flood event" is stated if discussing impacts from the scour of reservoirs, then scour even, mass scour event is discussed, especially when differentiating impacts between watershed loads and scour loads.	Yes.
7	Exelon	Main Report	General	There are numerous instances throughout the main report where statements are not cited or where statements are cited but they do not reflect what was actually stated in the citation. This is misleading to the reader and should be reviewed.	Compton	Agree. However, need specific instances in order to address.	No.
8	Exelon	Main Report	ES-1/paragraph 6	I believe the word "is" in the 5th line of this paragraph should be "are".	Compton	Change made.	Yes.
9	Exelon	Main Report	ES-2/paragraph 2	Paragraph focuses on sediments (no net trapping) with the potentially misleading implication that the same is necessarily true for nutrients. Nutrients, organic carbon, and other water quality aspects of sediments are reactive. If the residence times of nutrient-associated sediments are sufficient, labile materials may become refractory and non-reactive. Sediment transport is not necessarily equal to nutrient transport.	Cerco	We believe this paragraph is accurate and sufficient as written.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
10	Exelon	Main Report	ES-2/paragraph 3	"These additional loads due to the loss of sediment trapping capacity in the Conowingo Reservoir are causing adverse impacts to the Bay. These increased loads need to be managed or offset to restore the health of the Bay." This sentence contradicts the next section which states that the watershed is the principal source of sediment and leads the reader to believe that nutrients associated with sediment scoured from Conowingo Pond are the main problem in regard to Bay WQ.	Compton	No contradiction here. Both statements are presenting separate conclusions from modeling that (1) additional scour is causing impacts to Bay that are currently not being addressed and (2) in context, loads from watershed during these storms are more than loads from scour.	No.
11	Exelon	Main Report	ES-2/paragraph 3	Examples given are for sediment only. No information is given to determine if differences in flows are the cause of differences in sediment loads (W = Q C so if Q ↑, W ↑). No information is given to support the statement that reservoirs are trapping a smaller amount of nutrient loads from the upstream watersheds. No quantification of incoming or outgoing nutrient load.	Compton	Text altered to indicate that this conclusion is from a comparison of 1996 to 2011 bathymetry. Nutrients are discussed on ES-3. Also better quantification and reactivity of nutrients is identified as a recommendation of the study.	No.
12	Exelon	Main Report	ES-2/paragraph 3	"...upon analyzing the hydrology of the lower Susquehanna River from 2008-2011, this study estimated that the decrease in reservoir sediment trapping capacity from 1996-2011 (from Conowingo) resulted in a 10-percent increase in total sediment load to the Bay..., a 67-percent increase in bed scour..., and a 33-percent decrease in reservoir sedimentation..." Using a four year hydrology period is too short and contains an inordinate frequency of storms.	Scott	These data were the result of a comparison of the bathymetries, not a comparison of the 15 years between 1996 and 2011. Language updated to clarify this point.	Yes.
13	Exelon	Main Report	ES-2/paragraph 5(last)	Use of phrase "Conowingo Reservoir material" implies that the reservoir is the source of material rather than the reservoirs being a site where transient storage appears.	Compton	Text altered to indicate bed sediment stored behind Conowingo.	Yes.
14	Exelon	Main Report	ES-2/last paragraph	When stating that 20-30% of sediment entering the bay is from Conowingo Pond and the rest from the upper watershed it should be noted that all material in Conowingo Pond originated from the upper watershed.	Compton	Where sediment originally came from is mentioned several paragraphs before "Sediments and associated nutrients from the land, floodplain, and streams in the lower Susquehanna River have been transported and stored in the areas (reservoirs) behind the dams over the past century."	No.
15	Exelon	Main Report	ES-3/first paragraph	Under current (non-WIP) scenario, noncompliance in 3 of 92 segments. So material from Conowingo Pond changes from 20-30% to what?	Linker	Added "and achieves all dissolved oxygen levels required for healthy aquatic life." to improve clarity.	Yes.
16	Exelon	Main Report	ES-3/paragraph 3 (2nd full paragraph)	The sentence that states, "As a consequence, DO in the Bay's deep-water habitat is diminished by reservoir scour events" implies that there are no other influences in the Bay watershed that contribute to the health of deep-water habitat.	Linker	Disagree. The sentence, within the context of the paragraph, in no way implies that reservoir scour events are the only nutrient loads impacting Chesapeake hypoxia.	No.
17	Exelon	Main Report	ES-3/paragraph 3	Is this paragraph theoretical or based on actual data? If based on actual data a citation should be included. If theoretical, that should be stated.	Compton	This information is data from study, appendix C. Changed "This assessment " to "Modeling work for this assessment" at beginning of paragraph. Exec summary does not provide any citations.	Yes.
18	Exelon	Main Report	ES-3/paragraph 2-3	Paragraph 2 specifically discusses "...the sediment loads comprised of sand, silt, and clay particles from scouring of Conowingo Reservoir during storm events..." and concludes that these loads "are not the major threat to Chesapeake Bay water quality and aquatic life." Nonetheless, Paragraph 3 begins by stating that "...the nutrients associated with the sediments [from Conowingo Pond scour] were determined to be more harmful to Bay aquatic life than the sediment." Given the structure of these two paragraphs, it appears that the LSRWA Draft Report differentiates between nutrients associated with Conowingo scoured sediment and nutrients associated with sediment from upstream watershed sources (including the other two reservoirs). This differentiation is made throughout the entire report and leads the reader to believe that only those nutrients associated with sediment scoured from Conowingo Pond are harmful to Bay health.	Compton	Context of these two paragraphs is discussion of scour from Conowingo and they are conclusions of the study from modeling. ES-4, last paragraph discusses nutrients throughout the watershed and impacts, as well as more study is warranted on this issue.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
19	Exelon	Main Report	ES-3/paragraph 3	This paragraph regarding nutrients is repeated throughout the report in various forms. This paragraph cites "reservoir scour events," however, the remainder of the report focuses almost exclusively on Conowingo scour events. This language leads the reader to believe that only nutrients associated with sediment scoured from the reservoirs (and in later portions of the report exclusively from Conowingo Pond) have the most impact to Bay health. While nutrients associated with scoured sediment may be important it is not isolated to only those nutrients from Conowingo Pond scour.	Compton	Text changed to Conowingo scour events. Context here is discussing specific loads from scour of Conowingo. Many places in report discuss loads from Conowingo vs. watershed (including upper 2 reservoirs) or Conowingo and upper two dams and watershed. In discussion of these loads, nutrients and sediment are indicated to come from all of these sources.	Yes.
20	Exelon	Main Report	ES-4/paragraph 6	"The conclusion that the primary impact to living resources in the Bay was from nutrients and not sediment, was not determined until late in the assessment process. Further study on this is warranted." The impacts of nutrients on Bay water quality need to be examined in greater detail (as stated in the report). Adequate scientific understanding of nutrient dynamics from Conowingo Pond, the other reservoirs, and upstream watershed sources does not currently exist. The report, however, speaks in absolute, definitive terms that lead the reader to believe the various nutrient findings have been thoroughly examined and understood.	Compton	Report lays out uncertainty and notes where further study is warranted in various places. Conclusions are laid out in context of what we are certain of now based on work done and what needs further understanding.	No.
21	Exelon	Main Report	ES-4/paragraph 6(last)	Important context is missing: what is the fraction of nutrients delivered to the Bay that originate from the watershed ("washload") versus the fraction that is in transient storage within Susquehanna River bed sediments ("bed material load")? This process needs to be clarified in the report.	Cerco	The fraction of the nutrient load delivered from the watershed vs. the fraction from bed scour varies depending on the scour event and on the duration of the averaging period. The fraction from scour will be relatively high during the event but much less when a period of years is considered. There is no single number which is applicable. Some insight into this effect is provided in Table 6-1 of Appendix C. In any event, the subject paragraph does not need revision based upon this comment.	No.
22	Exelon	Main Report	CH. 2/Paragraph 4	The Exelon study cited (RSP 3.12) does not state these locations. Peach Bottom Atomic Power station is not located along Muddy Creek. Peach Bottom Atomic Power station is located approximately 7 miles upstream of the Conowingo Dam. Muddy Creek does not flow into Conowingo Pond 7 miles upstream of Conowingo Dam.	Compton	Assume reference is to Section 1.3 paragraph 2. Text altered per correction here.	Yes.
23	Exelon	Main Report	CH. 1/P.6/Paragraph Arrow 3	CBPO is not on the list of acronyms.	Compton	Acronym added.	Yes.
24	Exelon	Main Report	CH. 1/P.8/Paragraph 1	First sentence needs to recognize that sediment delivery of sediment and nutrients was occurring prior to construction of any dams.	Compton	Sentence added at end of paragraph, summarized from Section 2. "Prior to construction of the dams on the lower Susquehanna River, sediment and associated nutrient transport occurred, however minimal sediment storage took place.	Yes.
25	Exelon	Main Report	CH. 1/P.8/Paragraph 2	SRBC 2001 is not listed in the References.	Compton	SRBC 2001 citation deleted from this text.	Yes.
26	Exelon	Main Report	CH. 1/P.8/Paragraph 3	Statement that "Generally, low flow increases deposition, while during higher flows, deposition is reduced and some of the sediment is resuspended, transported downstream, or conveyed out of the reservoir" is somewhat of an over-simplification. It would be more neutral to state that "some sediment may be resuspended…"	Compton	Changed "is resuspended" to "may be resuspended"	Yes.
27	Exelon	Main Report	CH. 1/P.8/Paragraph 4	Large events not only scour additional sediment from behind the dams but also bring high sediment inflows from the upper watershed.	Compton	Added "which increase inflow loads from the watershed"	Yes.
28	Exelon	Main Report	CH. 1/P.8/Paragraph 5	Statement that "there would be a 100- to 250-percent increase in sediment load; a 20- to 70-percent increase in phosphorus load and a 2- to 3-percent increase in nitrogen load (CBP STAC, 2000)" is not meaningful without stating the basis for what represents the "normal" load. Increase relative to what? [Page 9. implies that basis is mid-1990s…]	Compton	STAC report compares this increase to what was observed most recently (data through 1990's). Text added "had been observed in the 1990's" ".	Yes.

Comment #	Agency	Main Report/ Appendix/A ttachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
29	Exelon	Main Report	CH. 1/P.10/Paragraph last (Sec 1.9) and Table 1-2	Assessment products include many overlapping, and not necessarily parsimonious, study elements. For example, the table states that HEC-RAS was used to compute sediment loads into Conowingo Pond. The Chesapeake Bay Watershed Model (CBWSM) also computes sediment loads to/though Conowingo Pond. How do they compare? SEDFLUME data were collected to determine erosion rates and erosion thresholds for sediment in Conowingo Pond. HEC-RAS, which was also used to calculate sediment transport, uses transport capacity relationships. How do the rates determined by the SEDFLUME work (and used in AdH) compared to calculations using HEC-RAS? Do they agree? The CBWSM also computes transport (because the reservoir is a node in the stream network) and uses an entirely different approach. How were differences handled? Which sediment load estimates were used to feed the CB water quality model (CE-QUAL-ICM) (Carl Cerco model)?	Langland/ Scott/ Cerco	HEC -RAS inputs of watershed loads compare well to CBWSM. USGS (HEC-RAS) annual average load for 1993 – 2012 is 1.5 million English tons/annum. This converts to 3.74 million kg/d. The WSM daily average load for 1991 – 2000 under 2010 Progress Run conditions is 3.06 million kg/d. The differences between the two estimates can be attributed to numerous factors including different summary intervals – 1993 – 2012 for USGS/HECRAS vs. 1991 – 2000 for the WSM. HECRAS also used some of the SEDflume data for estimation of several sediment model parameters.	No.
30	Exelon	Main Report	CH. 1/P.13/Section 1.10 and Table 1-5	Same issues as in Section 1.9. It is not clear how all tools/models were used. It is unclear how AdH was used to inform CE-QUAL-ICM. It looks like the CE-QUAL-ICM was fed estimates from the CBWSM.	Cerco	CE-QUAL-ICM is fed loads from the CBWSM. The CBWSM loads are augmented with Conowingo scour loads since the CBWSM does not compute scour. The scour loads are calculated based on ADH results. The text here will be revised to clarify this point: Under 3. CBPs Watershed Model ….. Add a sentence at the end of this paragraph "Watershed loads at the Conowingo outfall computed by the WSM were supplemented by bottom scour loads estimated through ADH and through data analysis."	Yes.
31	Exelon	Main Report	CH. 1/P.14/Figure 1-4	The orange area is supposed to indicate the CBP watershed model (WSM) extent. As indicated in the locus map, this means the 'watershed model' is really only the lower Susquehanna River watershed. Is this correct?	Cerco	This figure is simplified, highlighting the study area of the assessment. The watershed model covers the entire Chesapeake Bay watershed which lower Susquehanna is a part of. The WSM covers the entire Chesapeake Bay watershed including NY, PA, MD, WV, VA, and DC. The extent of the watershed and of the WSM is shown in gray in the inset. The orange highlights the lower Susquehanna River watershed. Footnote revised to clarify this.	Yes.
32	Exelon	Main Report	CH. 1/P.15/Figure 1-5	Why is a sediment rating curve used as input to Conowingo reservoir instead of a time series output? HEC-RAS is capable of providing a time series, and appendix A says providing a sediment load time series was the modeling objective.	Langland	We tried both the rating curve and HEC-RAS model output. There were problems with the HEC-RAS model as you point out later in comment #75.	No.
33	Exelon	Main Report	CH. 1/P.16/Figure 1-6	Figure does not clarify which model feeds sediment estimates to CE-QUAL-ICM and how differences between estimates from models in the suite (CBWSM, HEC-RAS, and AdH) are handled.	Cerco/ Compton	The information on CE-QUAL-ICM loading is provided in Figure 1-5. The differences in the model suite are not the subject of these flow charts. This flow chart is meant to provide a simplified, broad picture of the analytical approach of the study tailored for a wide-audience.	No.
34	Exelon	Main Report	CH. 1/P.16/Figure 1-6	Lake "Clarke" is misspelled in step 3 of the flow chart.	Compton	Change made.	Yes.
35	Exelon	Main Report	CH. 2/P.17/Paragraph 1	While the last portion of this paragraph describes why the discussion is focused on Conowingo it does not explain why there is no focus on the two upstream reservoirs. Why are these reservoirs not discussed at the same level of detail as Conowingo?	Spaur	Modify sentence "As such, it has potentially a large influence on the Chesapeake Bay during storm events due to scouring of nutrients and sediments stored behind this dam." to "Holtwood and Safe Harbor Dams were known to be at equilibrium at the start of this assessment. Because Conowingo was not believed to be in dynamic equilibrium and it reaching that condition could have a potentially large effect on the Bay, more attention is focused on Conowingo Dam than Holtwood or Safe Harbor Dams in this section."	Yes.
36	Exelon	Main Report	CH. 2/P. 17/Paragraph 1	This paragraph, and the third paragraph in particular, attempt to explain why Conowingo Pond is of particular importance; however, they do not quantify or adequately describe how much more important it is to Susquehanna River sediment loads versus Lake Clarke and Lake Aldred.	Spaur	Dealt with by response to #35.	Yes.
37	Exelon	Main Report	CH. 2/P. 18	It is difficult to differentiate between the "Major Basins" and "Main Segments" polygons in this figure.	Spaur	Concur, but figure originated from USEPA. Figure caption changed from Major Regions of the Chesapeake Bay" to "Figure 2-1. Major Regions of the Chesapeake Bay Mainstem" Also, removed "Chesapeake Main Segments"	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
38	Exelon	Main Report	CH. 2/P. 19/Paragraph 2	Last sentence says that the Flats are due to human influence, however, the delta area existed pre-European settlement and deltas are usually flat.	Spaur	Change sentence "The shallow character of the flats today is largely a result of anthropogenic sedimentation (Gottschalk, 1945)." to "Shallow waters of the Susquehanna River delta in the upper Bay expanded substantially in area following European settlement, and the expansive shallow flats that exist today largely derive from anthropogenic sedimentation (Gottschalk, 1945) (see Section 2.6.3)."	Yes.
39	Exelon	Main Report	CH. 2/P. 19/Paragraph 2	There are several references to various islands or other points of importance in this section – a location map of these landmarks would be useful.	Spaur	Figure 2-2 covers geographic names: Spesutie Island, Battery Island, Elk Neck, Havre de Grace, Susquehanna Flats. No figure revision needed.	No.
40	Exelon	Main Report	CH. 2/P. 21/Paragraph 4 (last part of Section 2.2)	The report identifies that climate change has resulted in recent years being wetter. In general, wetter years would mean increased watershed sediment delivery and transport through the reservoirs. This potentially conflicts with the conclusion that loads are increasing as a consequence of reduced trapping/dynamic equilibrium. It is unclear how earlier statements regarding decreases in trapping can be evaluated without first establishing how hydrologic (and land use) changes impact the watershed the river system.	Spaur	Added sentence to paragraph 2 on page 97, before "All of the Table 4-1 scenarios..." "However, there were no modeling runs formulated for forecasted climate change conditions; a general discussion of global climate change impacts can be found in Section 5.1.4. "	Yes.
41	Exelon	Main Report	CH. 2/P. 25/Paragraph 4	The watershed size is cited as 27,500 mi^2, but earlier it was noted as 27,510 mi^2. A consistent number should be used for significant figures.	Spaur	Change clause in 2nd sentence from "The basin drains more than 27,500 square miles, ..." to "The drainage basin covers 27,510 square miles,..."	Yes.
42	Exelon	Main Report	CH. 2/P. 27/Paragraph 3	The Exelon study cited (RSP 3.12) does not mention contributions to vertical circulation in the reservoir.	Spaur	Citation corrected to "(Normandeau Associates and GSE, 2011)" -- see comment response #48 for citation details.	Yes.
43	Exelon	Main Report	CH. 2/P. 29/Paragraph 1	Sentence two could be read that the maximum salinity anywhere in the Bay is 18 ppt, but we believe this is trying to say that within Maryland waters the maximum salinity is approximately 18 ppt. Please clarify.	Spaur	Change "Bay surface waters range from fresh in headwaters of large tidal tributaries to a maximum of about 18 ppt in Maryland in the middle Bay along the Virginia border, as illustrated in Figure 2-6. " to "In Maryland, Bay surface waters range from fresh in headwaters of large tidal tributaries to a maximum of about 18 ppt in the middle Bay along the Virginia border, as illustrated in Figure 2-6. "	Yes.
44	Exelon	Main Report	CH. 2/P. 29/Paragraph 4	Second sentence states that each of the Bay's major tidal tributaries has an ETM. Susquehanna River does not have an ETM.	Spaur	After "Each of the Bay's major tidal tributary systems has an ETM zone near the upstream limit of saltwater intrusion, as shown in Figure 2-7. " add new sentence "The Susquehanna River ETM zone occurs in the upper Bay mainstem."	Yes.
45	Exelon	Main Report	CH. 2/P. 32/Paragraph 4	Statement that nutrients released from bottom sediments provide a substantial portion of the nutrients required by phytoplankton is perhaps a little simplified. First, as noted, vertical stratification limits the vertical exchange of dissolved oxygen between the surface and bottom waters (as pointed out on page 34 paragraph 4) and, therefore, the vertical exchange of bottom water nutrients to surface waters is also limited. In addition, as pointed out in paragraph 3 of page 33, nutrients are recycled and reused many times over as they move downstream in rivers towards the Bay. They are also recycled and re-used in the Bay as well. Bottom nutrients are likely to contribute to the production of surface phytoplankton, but it is not clear what the balance between surface recycling of nutrients and bottom release of nutrients is in determining algal productivity.	Spaur	Concur that complicated topic, so will further simplify/generalize. Change "Nutrients contained in Bay bottom sediments are re-released into the water column seasonally, and these regenerated nutrients provide a substantial portion of the nutrients required by phytoplankton in summer, particularly in the middle Bay. " to "Nutrients contained in Bay bottom sediments are re-released into the water column seasonally, and these regenerated nutrients provide a substantial portion of the nutrients required by phytoplankton, particularly in the middle Bay. "	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
46	Exelon	Main Report	CH. 2/P. 34/Paragraph 1 (at top)	"Monitoring of nutrients in the Susquehanna River has shown that the flow-adjusted annual concentrations of total nitrogen, total phosphorus, and suspended sediment delivered to the dams have been generally decreasing since the mid-1980s." It is unclear how much of any trends are due to increasing data density over time and reduced uncertainty. There may be some apples and oranges comparisons beneath everything. As stated in the Zhang et al. (2013) paper, there is interpolation and extrapolation in load estimates. The next statements that "This decrease is attributed to the success of environmental management measures. However, total nitrogen, total phosphorus, and suspended sediment loads from Conowingo Reservoir itself to the Chesapeake Bay have shown an increasing trend since the mid-1990s, indicating decreasing reservoir trapping capacity (Zhang et al., 2013)" need further evaluation. Changes in sediment export from the River could also include changing sediment delivery from the watershed. It is unclear how the data analysis on which these statements rely was performed	Spaur	Change middle sentence from "This decrease is attributed to the success of environmental management measures." to "Environmental management measures in the watershed contributed to this decrease." to be less precise over relative importance of management measures versus other causes.	Yes.
47	Exelon	Main Report	CH. 2/P. 34/Paragraph 1	Zhang et al (2013) refers specifically to the reservoir system (reservoirs plural) and loads from the Conowingo Dam outlet. To quote from their conclusions: "Flow-normalized loads of SS, PP, and PN at the outlet of the Conowingo Reservoir have been generally rising since the mid-1990s. The reservoirs' capacity to trap these materials has been diminishing, and the Conowingo Reservoir has neared its sediment storage capacity."	Spaur	Change last sentence in paragraph (already recently revised as per above) from "One study has indicated that loads of total nitrogen, total phosphorus, and suspended sediment from Conowingo Reservoir to the Chesapeake Bay are increasing and attributes this to decreasing reservoir trapping capacity (Zhang et al., 2013)." to "One study has indicated that loads of total nitrogen, total phosphorus, and suspended sediment from the reservoir system of the lower dams to the Chesapeake Bay are increasing and attributes this to decreasing trapping capacity of Conowingo Reservoir (Zhang et al., 2013)."	Yes.
48	Exelon	Main Report	CH. 2/P. 37/Paragraph 4	The citation to Exelon (2011) regarding DO in the reservoir is not the 2011 report in the References section. The 2011 Exelon study RSP 3.1 should be cited for this statement.	Spaur	Changed citation to (Normandeau Associates and GSE, 2011). Added reference but used the format that Exelon requested in comment #1. New reference = Normandeau Associates, Inc., and Gomez and Sullivan Engineers. 2011. *Seasonal and Diurnal Water Quality in Conowingo Pond and below Conowingo Dam* (RSP 3.1). Kennett Square, PA: Exelon Generation, LLC.	Yes.
49	Exelon	Main Report	CH. 2/P. 40/Figure 2-12	Over what timeframe does this assessment of erosion vs. deposition occur? How can an area be forever erosional?	Spaur	Change sentence "The Bay's erosional and depositional patterns are portrayed in Figure 2-12. " to "Figure 2-12 portrays regions of Bay bottom and whether erosional or depositional processes dominate. Processes producing these patterns occurred naturally over geologic time as the Bay evolved driven by rising sea level. Conversely, human activity has induced substantial deposition in headwater tributaries and in the Susquehanna Flats over the last few centuries (see Section 2.6.3)."	Yes.
50	Exelon	Main Report	CH. 2/P. 41/Paragraph 1	The report cites Hartwell and Hameedi (2007) for the proposition that "[t]idal portions of the Anacostia River, Baltimore Harbor, and the Elizabeth River are hotspot areas of contaminants." However, Hartwell and Hameedi (2007) does not mention the Anacostia River, and the figure with the sites of greatest contamination does not include the Anacostia.	Spaur	Change reference to instead be "CBP, 2013" (That these are the three "hottest" contaminated regions of Bay is widely reported and not dependent upon an individual report.)	Yes.
51	Exelon	Main Report	CH. 2/P. 44/Paragraph 2	"TP probably does not show a pattern of decrease with depth into the sediment." Personal communication with Langland is cited here but what is Langland's basis for this comment?	Spaur	Add clause "Because the phosphorus adsorbed to bottom sediments is minimally bioavailable and not being utilized by organisms nor reacting chemically," prior to beginning of sentence "TP probably does not show a pattern of decrease with depth into the sediment (Michael Langland, Hydrologist, U.S. Geological Survey, personal communication, 2014). Comment based on years of collected data observations.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
52	Exelon	Main Report	CH. 2/P.44/Paragraph 2	Based on the estimates of bioavailable nitrogen and phosphorus quoted here, which could potentially be resuspended and transported into Chesapeake Bay, there is a serious mismatch between the bioavailable fractions of TN (96% typically of limited bioavailability) and TP (0.6-3.5% plant available) contained in the Conowingo Pond sediments and how they are incorporated in the CBEMP model, wherein they are assumed to be approximately 85% bioavailable, once they enter into the bay and are deposited back to the sediment bed in the Bay. Therefore, it is likely that the CBEMP is over-estimating the release of Conowingo nutrients from the sediment bed once they are deposited into the Bay sediments, and therefore the model is over-estimating the change in non-attainment of the DO water quality standard.	Spaur	The context here is IMMEDIATE bioavailability. Immediate added before bioavailability in this paragraph and this statement added: "The nutrients stored behind the dam that are not in immediately bioavailable forms might, however upon burial in the Bay bottom might be expected to gradually become bioavailable from microbial processes in the sediment (Michael Langland, Hydrologist, U.S. Geological Survey, personal communication, 2014). "	Yes.
53	Exelon	Main Report	CH. 2/P.44/Paragraph 3 (counting the partial at the top as 1)	The paragraph starting with "the sediment retained behind Conowingo Dam…" seems odd in that the focus is exclusively on Conowingo. Even if the measurements are from Conowingo Pond, it seems like the description would be applicable to all three reservoirs given that the sediments (and nutrients) are derived from the watershed. How do these measurements compare to the assumptions for labile and refractory carbon and nutrient distributions used to drive the Bay WQ model? Is/was this information used to update the bay WQ model?	Spaur	Statement at beginning of Section 2 informs reader why we focus on Conowingo. However, concur with need to provide additional information on sediments and nutrients of upper two dams. Please insert the following new paragraph covering this topic after paragraph 2 (p. 44, June 23 version): "TN and TP in bottom sediment samples collected in Lake Clarke considered vulnerable to scour ranged from 3.3 to 5.3 g/kg and 0.8 to 1.2 g/kg, respectively. TN and TP in bottom sediment samples collected in Lake Aldred considered vulnerable to scour ranged from 1.2 to 5.7 g/kg and 0.3 to 0.5 g/kg, respectively. Lake Clarke had higher clay content than Lake Aldred at these locations, likely accounting for greater TP content. Clay content of bottom sediments in downstream Lake Clarke remained consistent in comparison of findings of studies conducted in 1990 versus 1996. Conversely, clay content in bottom sediments in downstream portions of Lake Aldred decreased from 1990 to 1996 (Langland and Hainly, 1997)."	Yes.
54	Exelon	Main Report	CH. 2/P.44/Paragraph 5	The report does not appear to discuss the potential impacts that the particulate coal may have on collected data or model predictions, nor whether it is uncommon to have an 11-percent coal content.	Spaur	Unlikely that additional future coal to be transported into Bay from sediment behind the dams would have much effect on the Bay. The upper Bay already contains substantial coal as was stated in Section 2.6, and has for probably more than a century. Evaluating effects of additional coal input is one of many specific topics that were not evaluated in this assessment. An environmental impact statement covering any proposed project would be the appropriate place to specifically address this. However, we should change existing sentence on p. 38, 2nd paragraph in "Bay Bottom Materials and Processes" subsection from "Abundant coal occurs in Susquehanna Flats sediments (Robertson, 1998)." To "Abundant coal occurs in Susquehanna Flats sediments transported into the Bay from coal mining in the Susquehanna Basin (Robertson, 1998)." This would better clarify source and timing of coal deliveries to the Bay (coal mining having begun in earnest in Basin by early 1800s). (On side note, I skimmed MGS [1988] and Robertson [1998], but neither of these provides specific information on how much coal occurs in Bay's flats sediments, other than to state that it's abundant in certain strata near the surface.)	Yes.
55	Exelon	Main Report	CH. 2/P.44/Paragraph 5 & 6	Focus is only on Conowingo: what about the other reservoirs?	Spaur	See Comment #35.	No.
56	Exelon	Main Report	CH. 2/P.49/Paragraph 3	There appear to be many other substantial declines in total SAV acres that are not explained by storm events (figure 2-16 and figure 2-17). There is no narrative around this, leaving the reader with the impression that storm events are the primary reason for SAV abundance declining even though a close inspection of the graph doesn't necessarily prove this connection. In fact, Kemp et al (1983) examined potential reasons for the decline bay-wide and at the Flats from the mid-60s to 1983 and concluded that storms played a secondary role.	Spaur	Topic of SAV trends related to storms, eutrophication, and other stressors is covered adequately in last paragraph on bottom of p. 48. No change needed.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
57	Exelon	Main Report	CH. 2/P.51/Figure 2-18	Difficult to read the legend and text on this figure and determine what point the author is trying to make by referring to this figure.	Spaur	Figure has been revised.	Yes.
58	Exelon	Main Report	CH. 2/P.52/Paragraph 1	The first sentence states that "no SAV beds were mapped immediately below Conowingo Dam in the non-tidal and tidal Susquehanna River over the period 1997-2012." Exelon RSP 3.17 mapped SAV at the mouth of Octoraro Creek and at the island complex at near the mouth of Deer Creek (Robert, Wood, and Spencer Islands) and at Steel Island along the opposite bank in 2010 surveys.	Spaur	Change paragraph "No SAV beds were mapped immediately below the Conowingo Dam in the non-tidal and tidal Susquehanna River over the period 1997-2012. However, SAV was frequently mapped in the non-tidal and tidal river downstream to the river mouth from the 1990s through 2010 (VIMS, 2013)." to "VIMS mapped no SAV beds immediately below the Conowingo Dam in the non-tidal and tidal Susquehanna River over the period 1997-2012. However, VIMS frequently mapped SAV in the non-tidal and tidal river downstream to the river mouth from the 1990s through 2010 (VIMS, 2013). SAV was found to occur in 2010 downstream of Conowingo Dam at creek mouths and islands between the dam and Port Deposit in shallow areas with fine-grained sediment and low water velocities (URS and GSE , 2011).	Yes.
59	Exelon	Main Report	CH. 2/P.52/Paragraph 4 First sentence	The statement that well-established SAV communities appear to be absent in bedrock dominate portions of the Susquehanna River above Conowingo Reservoir was not stated in the cited Exelon report. This statement should be changed to: "Well-established SAV communities were not observed in the bedrock-dominated reach of the reservoir above Hennery Island during 2006/2007 surveys."	Spaur	No change. Report makes general point that SAV is absent from bedrock (except in cracks with sediment), so I think statements are fair as written.	No.
60	Exelon	Main Report	CH. 2/P.54/Paragraph 3	Last sentence of this paragraph does not reflect what the cited Exelon report (RSP 3.12) concluded. Exelon RSP 3.12 concludes that vegetated habitat would be affected most by a reduction of water levels below 106 feet NGVD, and, given that pond levels are rarely below this elevation "impacts to vegetated littoral habitat from water level fluctuations are unlikely."	Spaur	Change sentence "Changes in water levels have the potential to decrease the extent of or dewater SAV beds" to "Changes in reservoir water level fluctuations in Conowingo Reservoir over the range at which they are typically managed have negligible effects on SAV there"	Yes.
61	Exelon	Main Report	CH. 2/P.59/Figure 2-20	What do the red areas represent in this figure? The legend does not define it.	Spaur	Add sentence at bottom of figure "Red area is Aberdeen Proving Ground, U.S Army materials testing site."	Yes.
62	Exelon	Main Report	CH. 2/P.65/Table 2-9	While the usable storage in the FERC allowable pool (101.2-109.2) may be closer to 75,000 acre feet, the storage from 104.7 feet to 109.2 feet is closer to 40,000 acre feet.	Spaur	Add additional footnote "3" after number "75,400" and then insert new footnote text: "3 Usable storage in FERC allowable pool (101.2-109.2). Storage from 104.7 feet to 109.2 feet is approximately 40,000 acre feet."	Yes.
63	Exelon	Main Report	CH. 2/P.66/Paragraph 3	Second sentence cites RSP 3.12 as saying Conowingo water levels are "primarily confined to elevations between 104 and 109 feet NGVD29." This is incorrect. Page 31 of RSP 3.12 states: "Analyses conducted over varying temporal scales of historic water level elevation data collected for Conowingo Pond indicate that water level fluctuations are primarily confined to water elevations between 107 feet and 109 feet, and rarely fall below 106 feet."	Spaur	Change sentence "However, water levels are primarily confined to elevations between 104 and 109 feet NGVD29, and periods at which elevations are lower than 106 feet NGVD29 are infrequent and brief (Exelon, 2011)." to "However, water levels are primarily confined to elevations between 107 and 109 feet NGVD29, and rarely fall below 106 feet NGVD29 (Exelon 2012a)	Yes.
64	Exelon	Main Report	CH. 2/P.66/Paragraph 4	The report correctly cites Conowingo Dam has having 50 stony-type crest gates and two (available) regulating gates (the third is currently used by the fish ladder). This contradicts Appendix A which incorrectly describes the dam as having 54 gates.	Spaur	Appendix A updated.	Yes.
65	Exelon	Main Report	CH.3/P.75/Paragraph 1 & 2	The report clearly states in Paragraph 2 (based on TMDL Appendix T) the actions that will need to be taken if the trapping capacity of Conowingo Pond is found to be reduced. This language is not consistently applied throughout the report and appendices (particularly Appendix D) when discussing the reduced trapping capacity of Conowingo Pond as related to the TMDL. In all cases the actual language from the TMDL Appendix T should be used.	Linker	The TMDL Appendix T has been correctly cited, referenced, and characterized throughout the main report and Appendix D. Charges are unwarranted.	No.
66	Exelon	Main Report	CH.3/P.75/Paragraph 1 & 2	Table 5-6 of the main report is consistent with TMDL Appendix T in stating that the reservoir trapping capacity of Conowingo has been 55-60% from 1993-2012. Please elaborate on what trapping capacities were used in the various WSM model runs.	Linker/ Cerco	The LSRWA scenarios are fully described and characterized in Appendix D along with the estimated Conowingo bathymetries used in each scenario. That is the correct place for the scenario information and not page 75. Changes are unwarranted.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
67	Exelon	Main Report	CH.3/P.75/Paragraph 1 and 2	Appendix T of the 2010 Chesapeake Bay TMDL addresses the trapping capacity of all three dams of the Susquehanna River, including Safe Harbor (Lake Clarke) and Holtwood (Lake Aldred), but concludes that "Lake Clarke and Lake Aldred have no remaining sediment trapping capacity [and]…have been in long-term equilibrium for 50 years or more." Nonetheless, the LSRWA Draft Report shifts focus here from the three reservoirs/dams to only Conowingo Reservoir/Dam. We suggest adding language to clarify that, in addition to the assumptions regarding Conowingo Reservoir's trapping capacity, the TMDL assumes that Lake Aldred and Lake Clarke have no remaining sediment trapping capacity. The sediment and nutrient loads from Lake Clarke and Lake Aldred should be accounted for in the WQM input data.	Linker	Text revised too: The Chesapeake Bay TMDL assumed that the reservoirs above Conowingo, Lake Clarke (Safe Harbor Dam) and Lake Aldred (Holtwood Dam), have no remaining sediment trapping capacity and have been in long-term equilibrium for 50 years or more (USEPA, 2010b)."	Yes.
68	Exelon	Main Report	CH.3/P.77/Paragraph 4	PA DEP issues a 401 water quality certification for Muddy Run, not MDE.	Compton	Concur. MDE changed to PADEP.	Yes.
69	Exelon	Main Report	CH.3/P.77/Paragraph 4	The last two sentences of this paragraph need to be updated to reflect the current status of the relicensing process.	Balay	On June 3, 2014, PADEP issued a Section 401 Water Quality Certification (WQC) for the Muddy Run project. On July 30, 2014, FERC issued a draft Environmental Impact Statement (EIS) for the relicensing of the York Haven, Muddy Run, and Conowingo projects. At the writing of this report, a new FERC license for the Muddy Run project is pending.	Yes.
70	Exelon	Main Report	CH.3/P.78/Paragraph 2	The last two sentences of this paragraph need to be updated to reflect the current status of the relicensing process.	Balay	On July 30, 2014, FERC issued a draft EIS for the relicensing of the York Haven, Muddy Run, and Conowingo projects. At the writing of this report, Exelon still needs to acquire a 401 WQC from MDE, and a new FERC license for the Conowingo project is pending.	Yes.
71	Exelon	Main Report	CH. 4/P.81/Paragraph 2	Is Langland's 2009 report the correct citation for the previous 1D HEC model (i.e., HEC-6) used to study sediment transport in the lower Susquehanna River reservoir system? I believe this citation should be Hainley et al. (1995) titled "Deposition and Simulation of Sediment Transport in the Lower Susquehanna River Reservoir System".	Langland	Correct, please change this to Hainly and others, 1995.	Yes.
72	Exelon	Main Report	CH. 4/P.81/Paragraph 3, see Footnote #3	Footnote #3 indicates that HEC-RAS was used to simulate conditions in Conowingo Pond. HEC-RAS and AdH results for Conowingo Pond should be compared and contrasted. The simulated mass over Conowingo Dam in both models should be tabulated and compared. Any differences in outcomes reflect uncertainties in the assessment process that need to be identified and quantified. Also, given that HEC-RAS is used to drive the upstream boundary for the AdH model domain, it is reasonable to assume that similar sorts of differences would occur through each reservoir if AdH were used to simulate the upstream part of the system too. The upstream watershed (over Holtwood Dam) is the main source of sediment (and nutrients) entering Conowingo Pond. Uncertainties there propagate downstream.	Langland	It would be useful to show this comparison if the data existed. We gave Steve Scott (AdH modeler) the daily sediment load files which he used to help develop his sediment rating curve. I believe he found as we did that the HEC-RAS was not generating enough sediment to match measurements at Conowingo. It is unknown how HEC-RAS performed in the upper two reservoirs due to lack of calibration data, but chances are it also under predicted the load coming in to Conowingo. That is the reason Steve increased the sediment load for the 2008-2011 simulation period from 22 to 24 million tons. It also provided a range of conditions for Steve to make predictions.	No.
73	Exelon	Main Report	CH. 4/P.81/Paragraph 3	The statement "two major scour events (above 400,000 cfs)" is biased. This should be more factually stated as "two major <u>flood</u> events (above 400,000 cfs)."	Compton	Concur change made to two major flood events that included mass scour.	Yes.
74	Exelon	Main Report	CH. 4/P.81/Paragraph 3	The use of the term "major scour event" implies to the reader that scour is the major sediment transport process occurring in the lower Susquehanna River for these flow events, which contradicts what the study later concludes (only 20%-30% of the load is from scour). The wording on page 84, in the second paragraph, more accurately describes the events as "major high-flow events (above 400,000 cfs)".	Compton	Concur see change from comment #73.	

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
75	Exelon	Main Report	CH. 4/P.81/Paragraph 4	Use of HEC-RAS to simulate sediments with cohesive characteristics is problematic. The SEDFLUME results for Conowingo Pond provide a means to check on just how cohesive bedded sediments in the Lower Susquehanna are. SEDFLUME tests give information regarding the critical shear stress for erosion and erosion rate. If the critical erosion thresholds experimentally determined using the SEDFLUME differs substantially from the constraints that drive transport equations used in HEC-RAS, then HEC-RAS cannot be reasonably applied and cannot provide appropriate boundary conditions to drive AdH. The presumed occurrence of “dynamic equilibrium” in upstream reservoirs does not justify the use of HEC-RAS. As noted by the LSRWA, dynamic equilibrium does not imply that the sediment mass entering or leaving a reach of the stream will be equal on a day-to-day or month-to-month timeframe. It is not clear how the authors concluded that HEC-RAS provided understanding of physical processes in upstream reservoir if it does not represent the underlying physics of sediment transport.	Langland	Tying into comment number 32, that is why a rating curve was developed for AdH in Conowingo and the inflowing sediment from HEC-RAS was used as a backup.	No.
76	Exelon	Main Report	CH. 4/P.82/Figure 4-1	It appears the streams that were superimposed on this figure may be located slightly northwest of where they were intended to be.	Langland	Concur. Figure updated.	Yes.
77	Exelon	Main Report	CH. 4/P.83/Figure 4-2	The elevation datum used to construct this figure is not stated. The deepest elevations are +98 ft to -61 ft relative to what datum? The data used to represent sediment bed elevations should be verified to ensure it is consistent with the data used to determine water surface elevation boundary conditions in the model. Any differences could impact the inferred “scour threshold.”	Scott	Added text box "(NGVD 88)" after "feet" in legend of Figure 4-2.	Yes.
78	Exelon	Main Report	CH. 4/P.84/Paragraph 3	The ‘calculated “full” bathymetry’ was not calculated, it was empirically estimated from bathymetric observations. The report should describe more thoroughly how the ‘full’ bathymetry was determined.	Langland	see number 116 below.	Yes.
79	Exelon	Main Report	Ch. 4/P. 85-86	The discussion of uncertainties in AdH results does not discuss the uncertainties pertaining to the upstream load. If there are 3 million tons/yr. entering Conowingo Pond and only 1 million tons/yr. leaving it, then transport processes must be dominated by upstream inputs. Errors in erosion estimates within the Pond can be compensated by corresponding errors in deposition estimates. Coupled with the LSRWA opinion that AdH results are uncertain because of the inability to represent flocculation (and therefore deposition fluxes) [flocculation in AdH only considered concentration but does not consider water column shear forces], the uncertainty of AdH results may be very high.	Scott	Uncertainties in total load entering Conowingo will indeed affect scour and deposition, and thus affect total load output to the bay. On page 86 (para 3) added "Uncertainties in the total sediment load entering Conowingo Reservoir will affect scour and deposition, and thus affect the total load output to the Bay. Consequently, " before "To provide more information..."	Yes.
80	Exelon	Main Report	CH. 4	The runs with the 1996 nutrients should be reported, not just the runs using the 2011 nutrient data.	Cerco	The runs with 1996 nutrient composition are presented in an appendix to the CBEMP (Appendix C) report. We can't present every scenario in the main report due to length considerations. Only the scenarios judged most important and most relevant are presented.	No.
81	Exelon	Main Report	CH. 4/P.86/Paragraph 2	Salinity will also impact fine sediment flocculation – probably only an issue in the Bay.	Scott	Agree, but not in Conowingo Reservoir	No.
82	Exelon	Main Report	CH. 4/P.86/Paragraph 3	The report needs to more clearly state the uncertainties surrounding AdH, and for that matter HEC-RAS, and how greatly those uncertainties could affect the models for which the results are used as input parameters. Given that the AdH model is based on the output from the HEC-RAS model, could not account for the dam, used water samples that were not representative of the entire river cross-section and were not collected over the entire hydrograph AdH result uncertainty may be very high.	Scott	Agree, but this is clearly stated in the report	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
83	Exelon	Main Report	CH. 4/P.86/Paragraph 3	"One source of uncertainty is the exact composition and bioavailability of nutrients associated with sediments scoured from the reservoir [Conowingo] bottom." Yet throughout the document nutrients are discussed in absolute terms using definitive statements.	Cerco	This paragraph acknowledges clearly and upfront the uncertainties in composition and bioavailability. There is no need to repeat this statement throughout the report.	No.
84	Exelon	Main Report	CH. 4/P.86/Last Paragraph	References for regular updates and calibration? Which constituents calibrated? What parameters adjusted?	Linker	The cited reference (Linker et al., 2013) has a complete description of the different phases and versions of the CBP models. Added "; Linker et al. (2013) provides a complete description of the different phases and versions of the Chesapeake Bay models. " to 3rd sentence in noted paragraph.	Yes.
85	Exelon	Main Report	CH. 4/P.87/Paragraph 2	The CBEMP has been calibrated multiple times; however, it was unclear how the model was calibrated once the scour load from the AdH model was added as an input parameter.	Linker/ Cerco	That's not the correct way to think about model calibration. The CBP models used in the LSRWA study are calibrated to observed data from 1985 to 2005. The model runs with the ADH model are "what if" scenarios. Models aren't calibrated to scenarios	No.
86	Exelon	Main Report	CH. 4/P.87/Paragraph 3 & 4	Why was the AdH model (unknown time step) output at 2 hours to then be computed in the WQSTM model at 15 min?	Scott/ Cerco	The ADH time step is short, on the order of seconds to minutes, compared to the daily loadings. ADH computations from each time step were summed into daily loads for use in the WQ model.	No.
87	Exelon	Main Report	CH. 4/P.89/Paragraph 1	How are the scoured sediment and nutrient loads from Lake Clarke and Lake Aldred accounted for? Is it similar to the process for which Conowingo-scoured sediments (and thus nutrients) are superimposed on the WSM nutrient loads input to the WQM?	Cerco	Sediment loads from Lake Clarke and Aldred are not specifically identified in the Chesapeake Bay loads. The Chesapeake Bay model only "sees" loads at the Conowingo outfall. Loads from Clarke and Aldred are combined with other loading sources at this outfall. The only material superimposed on the WSM loads is scour calculated in Conowingo Reservoir.	No.
88	Exelon	Main Report	CH. 4/P.89/Paragraph 1	The discord in the timeframes simulated by the model is noteworthy in that it likely affects model outcomes. The Bay WQ model period is 1991-2000. The HEC-RAS and AdH simulations were 2008-2010. Given the non-linearity of sediment transport and associated nutrient transport, it is unclear how results for one timeframe were "adjusted" to a different timeframe that may have different conditions (e.g., precipitation, different winds, different land uses, etc.).	Cerco	The only adjustment that was necessary was to adjust the amount of scour calculated for TS Lee downwards to a value appropriate for the January 1996 storm. This procedure is detailed in Appendix C and comparisons are provided of computed and observed solids concentration at the Conowingo outfall for January 1996.	No.
89	Exelon	Main Report	CH. 4/P.89/Paragraph 2	"Phase 5.3.2 of the CB WSM provided daily sediment and nutrient loads from the watershed for application in the LSRWA effort." How does this compare to the AdH time step for scour loads? From Cerco The ADH time step is short, on the order of seconds to minutes, compared to the daily loadings. ADH computations from each time step were summed into daily loads for use in the WQ model.	Cerco/ Scott	The AdH time step ranged from 1000 seconds for low flow conditions to 100 seconds for storms.	No.
90	Exelon	Main Report	CH. 4/P.89/Paragraph 3	Are sediment loads from un-simulated reaches somehow accounted for? It appears they may, in aggregate, make up a substantial drainage area.	Cerco	The loads from these small watersheds are accounted for. They go directly into the water quality model at the shoreline of the sub-watershed. The absence of a "reach" means they do not have a modeled river segment flowing through them.	No.
91	Exelon	Main Report	CH. 4/P. 89-95/Sections 4.3.2 to 4.3.8	A comparison between CB WSM, HEC-RAS, and AdH results at Conowingo Dam should be made. The WQSTM model (using the WSM as its input) has been calibrated numerous times, however, once the AdH results were used as an input the WQSTM model should have been re-calibrated. Did this occur? If not, how did the results of the CB WSM, HEC-RAS, and AdH outputs compare?	Cerco/ Scott	The CB WSM model used AdH scour loads for TS LEE as input. There is no need to re-calibrate because these are additional loads not accounted for by the CB WSM model. At the time of this study, the WSM was operable only through 2002 while the ADH model covered the period 2008 - 2011. Consequently, no direct comparison is possible. No results from HEC-RAS at Conowingo were utilized so comparisons between ADH and HEC-RAS are not necessary. The sole connection between ADH and the WQ model is that ADH was used to guide quantification of scour loads. The WQ model does not require recalibration when scour loads are implemented.	No.
92	Exelon	Main Report	CH. 4/P.91/Paragraph 3, 5	If the three reservoirs are a single node in the current version of the watershed model, as we have come to understand, then this should be explicitly mentioned. The current wording is unclear. Paragraph 5 makes it sound like Conowingo Pond is broken out explicitly in the watershed model.	Cerco	The three reservoirs are not a single node in the watershed model. Each, including Conowingo, is modeled individually.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
93	Exelon	Main Report	CH. 4/P.91/Paragraph 5	What were the nutrients used for the AdH scour calculations? This appears to be explained on Page 92, Paragraph 1 but is still unclear. What about scour from upper two reservoirs?	Scott	No, nutrients were not in the AdH model	No.
94	Exelon	Main Report	CH. 4/P.91/Sections 4.3.3 & 4.3.4	If the WSM model does use only one node for all three reservoirs how can scour from just Conowingo Pond (AdH) then be added to determine the total outflow from the Pond that is used in the other models? What about scour from the upper two reservoirs?	Cerco	The three reservoirs are not a single node in the watershed model. Each, including Conowingo, is modeled individually. Scour from the upper two lakes is incorporated into the inputs to Conowingo. Only the scour from Conowingo is necessary to be added to the watershed model loads at Conowingo.	No.
95	Exelon	Main Report	CH. 4/P.92/Paragraph 2	Why are the nutrient loads from Conowingo Pond singled out in this paragraph when the larger watershed loads are not mentioned? No details are given on the nutrient content of watershed-derived sediment or Clarke/Aldred-derived sediment.	Cerco	This paragraph describes the process in which the nutrient fraction of sediment scoured from the bottom of Conowingo Reservoir was calculated. Nutrient composition of sediment entering Conowingo reservoir is considered by the WSM and was not altered or utilized directly in this study.	No.
96	Exelon	Main Report	CH. 4/P.92/Paragraph 3	Were these nutrient contents compared to Marietta samples to get an idea of what the 'watershed' makeup may have looked like?	Cerco	We did not find Marietta samples that provided relevant information for comparison with observations at Conowingo.	No.
97	Exelon	Main Report	CH. 4/P.92/Paragraph 2	The report should make explicit that the decision to use the 2011 data, in fact, results in a "worst case" scenario.	Cerco	The text revised to state this: After the sentence "For these reasons …. For LSWRA scenarios." Inserted a sentence "Use of the 2011 nutrient composition provides a worst-case analysis." In the next sentence, strike "Even so" and change to "Consequently".	Yes.
98	Exelon	Main Report	CH. 4/P. 95/Figure 4-9	What is the red CFD curve? This does not appear to be defined anywhere.	Linker	Language added to paragraph below figure to explain: for any modeled result where the exceedance in space and time (shown in Figure 4-9 as the area below the cumulative function distribution (CFD) reference curve, red line) exceeds the allowable exceedance (the area below the blue line that is shaded yellow), that segment is considered in nonattainment (U.S. EPA 2003a).	Yes.
99	Exelon	Main Report	CH. 4/P. 96	Based on the estimates of bioavailable nitrogen and phosphorus quoted here, which could potentially be resuspended and transported into Chesapeake Bay, there is a serious mismatch between the bioavailable fractions of TN and TP contained in the Conowingo Pond sediments and how they are incorporated in the CBEMP model wherein they are assumed to be approximately 85% bioavailable. Given this, it is likely that the CBEMP is over-estimating the release of Conowingo Pond nutrients from the sediment bed once they are deposited into the Bay sediments and therefore the model is over-estimating the change in non-attainment of the DO water quality standard	Cerco	The fractions assigned to G2 (slowly reactive) and G3 (inert) are based on long experience with the Bay model, as applied over the period 1985 – 2005. This interval includes multiple scour events so the assigned fractions are considered representative. Nevertheless, we acknowledge the reactivity of organic matter scoured from the reservoir bottom is an area of uncertainty. There are efforts underway to address this issue and this is a recommendation of the study.	No.
100	Exelon	Main Report	CH. 4/P.97/Paragraph 1	It is unclear how models were linked. It is also unclear what "desktop analyses" were used as model inputs (if any).	Compton	This section is an introduction and is to provide an overview. Details are provided later on in the section. Desktop analyses simply means that an actual model simulation was not run, instead calculations were made by one or more of the modelers. Text added ".... desktop analyses (calculations performed outside of the modeling tools)"	Yes.
101	Exelon	Main Report	CH. 5/P.105/Paragraph 2nd under 5.2.1	One could argue that, with a shallower depth, settling would be more rapid, since particles don't need to travel as far to reach the bottom. However, If you increase bottom shear stress because of increased velocities the likelihood of a particle settling to the bottom decreases.	Scott	Higher velocities in shallower depths will transport more sediment, these higher velocities also increase bed shear and erosion potential. The bulk of sediment passes to the bay during storms, thus scour potential is highest, along with transport of inflowing sediment through the dam. Subsections below indicate when desktop analyses were done, vs. a full model simulation.	No.
102	Exelon	Main Report	CH. 5/P.105/Paragraph 3rd under 5.2.1	The first sentence is not technically correct.	Scott	Transport of sediment size classes all depends on the flow regime, time consolidating, etc.; hence, exactly when scour occurs is unknown. First part of sentence "since the reservoir system is dynamic" was deleted.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
103	Exelon	Main Report	CH. 5/P.105/Paragraph 3rd under 5.2.1	The first sentence oversimplifies the system processes. Additionally, it is not clear what the difference between being "transported" as silts are, and "suspended" as clays are.	Scott	Clays are generally considered washload, with silts interacting with the bed depending on the flow. Revised text for paragraph 3 in Section 5.2.1 (to replace first sentence). New sentences are: "Generally in a reservoir, sediment transport dynamics are dependent on flow. For lower to moderate flows, sand-sized sediments will tend to deposit, along with the larger, silt-sized fine sediments. Clays are generally considered wash load in that they have the potential to transport through the reservoir as suspended load without interacting with the bed. All sediment sizes have the potential to transport through the dam, provided flow, and resulting turbulence, is high enough to maintain the sediments in suspension."	Yes.
104	Exelon	Main Report	CH. 5/P.105/Paragraph Last	This sentence implies that coarser-grained material (i.e., sand) is not scoured during storms. Suspended sand is part of the storm load measured at Conowingo Dam and deposited in the upper Bay. From Appendix. B, page 26: "Generally, at low flows, clay is the dominant sediment that is scoured. However, the silt fraction increases with increasing flow, along with the sand fraction."	Scott	the thin mixing layer consists of fines that transport at lower flows. Sands do scour at higher flows. The samples collected below the dam reflect this. Low flows are almost all clay, as flow increases, silt and sand increases in the outflow. Added "while frequently" before "leaving behind the coarser, sand-size sediments."	Yes.
105	Exelon	Main Report	CH. 5/P.105/Paragraph 3-4 (Sec. 5.2.1)	There is a shift in focus from transport in general for all three reservoirs (paragraph 3) to just transport within Conowingo Reservoir (paragraph 4). The same condition would be expected in all three reservoirs, not just Conowingo Pond.	Scott	There most certainly is scour in the upper two reservoirs that supply Conowingo. However, without field data to quantify it, it is very uncertain how much of the scour enters Conowingo. More field data measurements are needed below the dams.	No.
106	Exelon	Main Report	CH. 5/P.106/Paragraph 4	Last sentence of paragraph starting with "A close inspection of the LSRWA…" should have the appropriate citation listed.	Scott	This evaluation was done by Steve Scott. Added "performed for this assessment" after "simulation results" --	Yes.
107	Exelon	Main Report	CH. 5/P.106/Paragraph 4	What does "trace" erosion mean? Is it resuspended sediment that is moved within the pond and does not pass the dam? Is it erosion of the thin unconsolidated layer?	Scott	erosion of the mixing layer in the reservoir. Very unconsolidated that mobilizes at low shear rates (.004 psf)	No.
108	Exelon	Main Report	CH. 5/P.106/Paragraph 4 & 5	It is not clear why the report is citing Hirsch, as the study was already assessing the hypotheses Hirsch presented (reservoir settling rates, higher flow velocities, change in scour potential). This section should be clearer about the differences in "scour" as a process and "net scour" throughout the reservoir, as there can be local scour within a reservoir without net scour occurring. Net scour is defined well in page 24 of Appendix C.	Scott	The reservoir can scour with deposition of the scour material occurring in the reservoir. Comparison of the 2008 and 2011 surveys indicate 5 million tons of bed scour, but a portion of that most likely re-deposited in the reservoir and did not transport through the dam. Added sentence to end of paragraph 5 -- "While a reservoir can scour with deposition of material occurring in the reservoir, for this assessment, the main concern was the net scour – that is, the material scoured from the bottom of Conowingo Reservoir and carried over the Conowingo outfall."	Yes.
109	Exelon	Main Report	CH. 5/P.106-107/Paragraph USGS Scour Eqn	The basis for this is unclear. Its reliability is even more unclear particularly because the USGS equation is an empirical representation and simplification of an outcome that is itself uncertain because of uncertainties in upstream loads and processes. However you look at it, another problem is one of potential spurious self-correlation. Bed scour computed in AdH is related to discharge; so discharge occurs as a factor in both "independent" variables in the relationship.	Langland	Agree somewhat with your assessment. This is just a simple relation between MEASURED sediment loads from 2 sites, upstream and downstream of the reservoirs. The difference is most likely due to scour. You did note the error bars around each prediction to account for some of the uncertainty.	No.
110	Exelon	Main Report	CH. 5/P. 106-107	"Calibration" is presented in Figure 5-1. Since the sediment scour load is a also a function of flow as well as solids, an interesting calibration skill comparison would be to compare the solids concentrations computed by AdH to the observed solids data – see figure 12 in Appendix B	Scott	Agree. The information tin Appendix B; that should suffice. Additional information would not add to the LSRWA analyses and conclusions.	No.
111	Exelon	Main Report	CH. 5/P.106&112&121/Last Paragraph & Table 5-4 & Table 5-8	The bathymetric study cited as Gomez and Sullivan (2012) is Appendix F of the Exelon (2012) study in the reference section.	Compton	Yes. Per comment #1 references updated where applicable. References updated as noted to URS and GSE, 2012b.	Yes.

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112	Exelon	Main Report	CH. 5/P.111/Paragraph 2	This paragraph cites an 'active layer' depth of 2-3 feet. Specific study results that prove this statement should be provided or referenced. Appendix A of the LSRWA does not mention any 'thin unconsolidated mixing layer' as cited, and there is only a single reference to this in Appendix B which states that "[t]he top layer of Conowingo Reservoir sediments consists of a low density unconsolidated layer that may mobilize at lower flows."	Scott	The depth of sediments available for scour was assumed to be 2 - 3 feet in the model. Bed properties were measured in the SEDflume up to one foot of depth. The remaining 2 feet were estimated. Appendix B is the source of this info. Sentence in main report was changed from "The active layer has a depth …" to "For modeling purposes, the active layer is estimated to have a depth…"	Yes.
113	Exelon	Main Report	CH. 5/P.111/Paragraph 4	The USGS website cites the peak flow at Conowingo Dam during T.S. Lee as 778,000 cfs.	Scott	The mean daily flow was about 630,000 cfs. 778,000 is the peak instantaneous discharge. Text added to clarify this.	Yes.
114	Exelon	Main Report	CH. 5/P.111/Paragraph 5	How was the bed scour validation parameter derived? This should be described in the text or the appropriate section of Appendix B should be referenced.	Scott	The methodology for estimating the bed scour transport range for TS lee is well documented in the report (2 to 4 million tons). The change in survey calculations in the appendix indicates 5 million tons of bed scour, of which a percentage stays in the reservoir. For the 2 million-ton AdH estimate (the lower range), approximately 40 percent of the bed scour was estimated to leave the reservoir and 60 percent redepositing when referenced back to the change in survey calculations. For the upper range of AdH bed scour (4 million tons), approximately 80 percent of the bed scour was estimated to leave the reservoir, with 20 percent redepositing. On the average (3 million tons AdH transport), 60 percent of the bed scour leaves the reservoir, with 40 percent redepositing.	No.
115	Exelon	Main Report	CH. 5/P.112/Paragraph 2	It seems strange to jump immediately to describing the increase in scour (67%) between the 1996 and 2011 bathymetries rather than total pass-through increase (10%) that is described later. The 67% increase in scour load comes off as rather alarming until you realize that the 'scour load' is only 9-13% of the total sediment load entering the Bay. This point is not brought up until much later in the report (page 176).	Scott	Added sentence: "Although the scour load change is 67 percent, this scour load is a relatively small percentage (9 to 13 percent) of the total load delivered to the Bay. " as a second sentence to this paragraph; similar change as noted in comment #153.	Yes.
116	Exelon	Main Report	CH. 5/P.112/Table 5-4	The "full" condition bathymetry calculation is not well explained in the main report text. Upon investigation of Appendix A, it appears that the "full" estimation is based on assumption on how many acre-feet of sediment Conowingo Pond can store (146,000 acre-feet). The report does not provide any details regarding how this estimate of 146,000 acre-feet of sediment capacity was derived beyond general statements that recent bathymetry data were considered. Considering how frequently this "full" condition is cited throughout the report and Appendix A/B, more attention should be paid to how this value was arrived at, what assumptions were made and what methods were used to estimate this value.	Langland	The capacity of Conowingo is based upon original surveys from Conowingo Hydroelectric Company. The first estimation of the "full" capacity was made in Reed and Hoffman, 1996, USGS Report 96-4048. Some modifications have been made since that initial estimate based on more recent bathymetry. Additional details added to Appendix A. belong there. In response to comment #5, language was already added to para #1 on page 112.	Yes.
117	Exelon	Main Report	CH. 5/P.116/Paragraph 5	The statement that SAV species in the upper Bay were strongly affected by Hurricane Irene and Tropical Storm Lee is not cited. In addition, the graphs presented on pages 49 and 50 (figure 2-16 and figure 2-17) do not appear to support this statement.	Spaur	Add reference (Gurbisz and Kemp, 2013) to sentence on p. 116 covering this. Change sentence in Section 2.7.2 "Extent of the beds on the flats have varied notably in response to large storm events, with substantial declines occurring following Hurricane Ivan and Tropical Storm Lee (Gurbisz and Kemp, 2013)." to "Extent of the beds on the flats have varied in response to large storm events, with a minor decline occurring following Hurricane Ivan in 2004 but with substantial decline following Tropical Storm Lee in 2011 (Gurbisz and Kemp, 2013)."	Yes.

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118	Exelon	Main Report	CH.5/P.117/Figure 5-5	The second panel in this figure indicates that silt deposition buried oyster beds. It's not clear if this is a proven impact, as earlier in the report (page 57), evidence was cited that disproved the 'sediment burial theory' following Tropical Storm Lee and indicated that oyster mortality was likely due to excessive fresh water and low salinities for an extended duration. This is reiterated again on page 138.	Spaur	Second figure shows extent of sediment plume, not extent of substantial sediment deposition. Change sentence "As a result, sediment runoff from Tropical Storm Lee was quite extensive compared to that of Hurricane Sandy, as depicted in Figure 5-6. " to "As a result, sediment runoff from Tropical Storm Lee was quite extensive compared to that of Hurricane Sandy and produced a large sediment plume in Bay waters, as depicted in Figure 5-6. Where sediment transported into the Bay would be deposited is controlled by waves and currents, thus mainstem Bay deep waters and protected headwater tributary settings would likely retain sediment from this storm, whereas higher energy shallow waters of the mainstem Bay would be expected to show negligible deposition (see Section 2.6.1)."	Yes.
119	Exelon	Main Report	CH.5/P.118/Paragraph 1	It's not clear what "Average peak flow" means – is that the peak daily average flow (and if so at what location), or the average of the peak flows measured along the river? Also, the event says there was an ice dam breached "within the reservoir itself" but the specific reservoir (Clarke, Aldred, or Conowingo) was not described. It is our understanding that the ice jam breached in the Safe Harbor impoundment.	Langland	Correct, there is no average peak flow. Replaced "Average" with "The"; peak flow value changed to 908,000 cfs.	Yes.
120	Exelon	Main Report	CH.5/P.118/Paragraph 2	The 1996 event had a larger peak flow at the Conowingo USGS gage than Tropical Storm Lee did, as a result of the ice jam breach.	Langland	Correct, but for daily mean flow it was Lee. Inserted "(for daily mean flow)" after "the second largest recorded flood event"	Yes.
121	Exelon	Main Report	CH.5/P.119/Paragraph 2	Again Conowingo is specifically called out separately, while loads from Safe Harbor and Holtwood are just considered part of the "watershed" loads.	Langland	The design of the study was to model Conowingo since it was believed it had remaining capacity, was largest reservoir, and may have the greatest impact on the upper Bay	No.
122	Exelon	Main Report	CH.5/P.120/Table 5-7	Unclear language: what are scour load predictions are measured? How are these simulated values "measured"? Does this mean simulated values determined at the specified location?	Langland	Values are given flows, the specific location would be over Conowingo Dam. Modify title. Table 5-7 title to be "Scour and Load Predictions for Various Flows in Conowingo Reservoir	No.
123	Exelon	Main Report	CH.5/P.120/Table 5-7	Is there a reason that the AdH results were not used here instead?	Langland	The AdH model could not generate all the data included in Table 5-7.	No.
124	Exelon	Main Report	CH.5/P.122/Paragraph 5	What is the difference between trapping rates under the 2010 TMDL scenario and dynamic equilibrium conditions?	Cerco	We did not find in the text the topic addressed in this comment. There seems to be some confusion here. The 2010 TMDL scenario is a Watershed Model loading scenario. Trapping rates under dynamic equilibrium are computed by ADH. There is no comparison between these two different quantities.	No.
125	Exelon	Main Report	CH.5/P.125/Table 5-9	It would be more useful to the reader to list the absolute amount of nonattainment for each scenario, rather than a differential from other scenarios. It is difficult to 'back-calculate' the absolute nonattainment numbers from the differentials presented because of a lack of significant figures and because the 'baseline' scenario is different for several of the scenarios.	Linker	The critical period of the Chesapeake TMDL is 1993-95, but the year of the Big Melt high flow event on the Susquehanna was 1996, so a 1996-98 3-year period was used to capture the main scour event simulated in the LSRWA report. With the new 1996-98 period, the high flow event is simulated, but the scenario findings of the 1993-95 period are now lost. It is not a worthwhile exercise to compare the TMDL WIP or the 2010 scenarios on the 1996-98 period that is now disconnected to the 1993-95 hydrology and loads that the Chesapeake TMDL was based on. For this reason differential results are used.	No.
126	Exelon	Main Report	CH.5/P.131/Paragraph 3 and after	Further clarification should be provided in regard to how the Bay WQ model was calibrated once various input parameters were changed (i.e. AdH, sediment to nutrient analysis, etc.). In addition, assumptions about refractory vs. labile carbon forms and the reactivity of nutrient inputs should be clearly stated and discussed.	Cerco	The Bay model was not recalibrated for this study. The model framework and model parameters were not changed in any regard from the calibration conducted for the 2010 TMDL study. The model does not require recalibration to address changes in loads which were the only changes implemented for this study. The details on the partitioning of labile and refractory organic material are provided in the WQ model report.	No.
127	Exelon	Main Report	CH.5/P.133/Paragraph 4	Is this 'updated nutrient composition' from Tropical Storm Lee applied to all sediments (i.e., watershed sediments and bed scour sediments) or just bed sediments? If it is applied to just bed sediments, this same nutrient composition should be applied to the scour from Lake Clarke and Lake Aldred as well as Conowingo Pond.	Cerco	The TS Lee composition is applied only to scoured bed sediments. There is no need to apply any adjustment to lake Clarke and Aldred sediments. These loads are incorporated into the loading to Conowingo Reservoir.	No.

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128	Exelon	Main Report	CH.5	It should be noted (relative to the above comments) that the process parameters were also calibrated based on biochemical data as well (i.e., rates of primary production, community respiration, sediment oxygen demand, nutrient fluxes, etc.), so one would be a little concerned about the model being tuned to watershed loads “only” and how different the process parameterization would be given different loadings.	Cerco	The intent of this comment is not clear. As noted above, the Bay model was not recalibrated for this study. The model framework and model parameters were not changed in any regard from the calibration conducted for the 2010 TMDL study. The model does not require recalibration to address changes in loads which were the only changes implemented for this study.	No.
129	Exelon	Main Report	CH.5/P.137-138/Paragraph 4 (p. 137) and the next page	It is unclear how the LSRWA report reaches apparent conclusions about dynamic equilibrium in this paragraph (on 137).	Cerco	"Dynamic equilibrium" may be a poor choice of words here. Text revised: Change “caused by the dynamic equilibrium state” to “caused by the gradual filling”	Yes.
130	Exelon	Main Report	CH.5/P.139/Paragraph 4	Paragraph focuses on AdH results for Conowingo Pond and purported loss of storage despite prior (and subsequent) text suggesting that changes in sediment transport are not expected to have a big impact on Bay water quality.	Scott	The reservoir is currently in a dynamic equilibrium for which deposition and scour continually occurs without a net change in storage. Sediments will deposit during low flows and scour during periodic storms. The loads from TS Lee did not demonstrate a long-term adverse impact to water quality. There was a short-term impact as would be expected.	No.
131	Exelon	Main Report	CH. 6/P.142/Paragraph 1	Sediment being used as a surrogate for nutrients/water quality: Seems like a better understanding of interaction is needed	Compton/ Spaur	The concerns that served as impetus for study were the release into Bay of sediment and nutrients contained in the dam sediment. Study scope was developed accordingly. P is adsorbed to sediments, and management of P via managing sediments is one of the alternative P management measures that has been looked at for years by Bay Program and others. (This is less the case for N). Concur with the need for better consideration of bioavailability; this is discussed in Section 2.5.1 and is contained in Recommendation #1. Added sentences to first paragraph in Section 6.1: "The reason for this is that nutrients are contained within the dam sediments. A substantial portion of phosphorus delivered to the Bay is adsorbed to sediment. Some nitrogen is also delivered to the Bay with sediments. By virtue of their great volume, the dam sediments contain a great quantity of nutrients. Thus, by managing the dam sediments, one would also be managing the nutrients they contain." and deleted "; thus, in managing sediments, one is also managing nutrients"	Yes.
132	Exelon	Main Report	CH. 6/P.142/Paragraph 2	Goal of management not clearly stated. Stopping all sediment entering Bay is not possible or desirable.	Compton	Comment is vague. The referenced paragraph doesn't mention the word management or goal. There is no place the report that suggests stopping all sediment from entering the Bay. Goal/focus of the management strategies are adequately discussed in paragraphs 1 and 2.	No.
133	Exelon	Main Report	CH. 6/P.142/Paragraph 2	Equating reducing sediment with reducing nutrients. See prior comment.	Compton/ Spaur	See comment response to 131	Yes.
134	Exelon	Main Report	CH. 6/P.148/Paragraph 1	Isn’t minimizing deposition (and increasing delivery to Bay) counter to goals?	Compton	Added "during non-storm periods, so as to reduce large influxes of sediment to the Bay" to the end of the first sentence in Section 6.3.	Yes.
135	Exelon	Main Report	CH. 6/P.149/Paragraph all	Post-construction addition of low level outlets is extremely expensive and not feasible.	Balay	Revised text "Furthermore, post-construction addition of low-level outlets would be extremely expensive, and thus, not cost-effective."	Yes.
136	Exelon	Main Report	CH. 6/P.149	Density currents often do not make it all the way to the face of the dam depending on reservoir geometry and distance.	Balay	Add sentence to end of Current Density Venting paragraph on page 149: "However, density currents may not make it all the way downstream to the face of the dam, depending on specific reservoir geometry and distance to the dam structure."	Yes.
137	Exelon	Main Report	CH. 6/P.150/Paragraph 5 (Sec 6.3.4)	Particle size for transport by agitation dredging is unclear. A particle diameter of 0.1 mm (100 um) would be a very fine sand, not fine silt or clay. However, the focus on sediment alone seems misplaced. Need to consider that the grain sizes most likely to be transported are those that are most likely to be enriched in nutrients.	Scott	the analysis used a fine sand size because sediment agitated from the bottom will not re-suspend as individual particles, but aggregates that can easily be larger than sand sized. It was a conservative calculation.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
138	Exelon	Main Report	CH. 6/P.167-178	None of the evaluated dredging alternatives seem to consider sediment and nutrient (as well as other contaminant) releases during dredging. Such losses generally amount to several percent of all material handled	Compton/ Blama	Loss of sediment during mechanical dredging where material may fall from the bucket; regulations call this de minimis. When dredging is performed by hydraulic cutter head any contaminant attached to the sediment could be released due to the agitation of sediment. This can be calculated by running an elutriate test, however this test was not performed for the level analysis needed at the conceptual/watershed level. When dredging fines versus sand we lose more fines, so if we dredge more fines, we'd lose more material. Conversely, if we dredge more sand, we'd lose less. Language added to the report: When dredging is performed (hydraulically or mechanically) any contaminant attached to the sediment could be released during placement. To predict the release of contaminants elutriate tests can be performed. The standard elutriate test is used to predict the release of contaminants to the water column resulting from open water placement. The modified elutriate test is used to evaluate the release from a confined disposal facility. The results will vary depending on the grain size of the material being dredged. Since the LSRWA was a broad assessment of alternatives, elutriate tests were not performed on the potential dredged material. If specific dredging and placement sites are investigated in the future than it is recommended that	Yes.
139	Exelon	Main Report	CH. 6/P.177/Paragraph 2	Please check the units in this paragraph – it appears g/m^3 and mg/m^3 may be mixed up. Also, the 15% anoxia reduction is a little confusing – is this a reduction in time, space or in time/space as the % nonattainment is calculated?	Cerco	Chlorophyll is often reported as µg/L. This is equivalent to mg/m3. DO is often reported as mg/L. This is equivalent to g/m3. The reduction in anoxia is in a time-space integrated quantity reported as "volume-days." It is the time-space summary of water with DO concentration less than xx. See Appendix C for details.	No.
140	Exelon	Main Report	CH. 6/P.178/Paragraph 2	This paragraph cites reductions in sediment, bed scour, etc. after a 10-year period. What 10-year period is this referring to? Is this the estimate of how long it would take to dredge 31 MCY?	Scott	Yes, that assumes that 3 million tons per year are dredged (30 million tons total). However, you have to consider that 1.5 million tons are estimated to deposit annually, thus the net removal is less. Text revised at end of para 2, page 178 to: "...end of a 10-year period of long-term strategic dredging."	Yes.
141	Exelon	Main Report	CH. 6/P.178/Paragraph 4	The removal efficiency is described here, but this term is not defined.	Scott	Changed "efficiency" to "rate"	Yes.
142	Exelon	Main Report	CH. 6/P.178/Paragraph 7	The goals of the scenarios shouldn't be offhandedly mentioned in the middle of a section like this – they need to be clearly defined in the beginning of a chapter or section.	Compton	No report changes recommended. The text flows smoothly and is logical.	No.
143	Exelon	Main Report	CH. 6/P.182/Paragraph 1	How can one make the statement that nutrient-based mitigation options are more cost-effective when these are not presented or discussed in this report?	Linker	The main report text was modified to make the point more clear "could be more ….:"	Yes.
144	Exelon	Main Report	General Comment	Pertaining to all alternatives – not addressed are the potential environmental impacts as related to: aesthetics, air quality and greenhouse gases, soils, water quality, wetlands, groundwater, surface water, wetlands, floodplains, biological resources, cultural resources, land use, socioeconomic resources, recreation and tourism, utility and transportation infrastructure, public health and safety, and noise. In many cases the environmental impacts associated with a specific alternative may cause more harm than good.	Spaur/ Compton	This paragraph was inserted after last paragraph on page E-4 (before section titled "Future Needs of the Watershed") and after first paragraph on page 182 (before paragraph starting "Table 6-10 is a matrix….). "It should be noted that the LSRWA effort was a watershed assessment and not a detailed investigation of a specific project alternative(s) proposed for implementation. That latter would likely require preparation of a NEPA document. The evaluation of sediment management strategies in the assessment focused on water quality impacts, with some consideration of impacts to SAV. Other environmental and social impacts were only minimally evaluated or not evaluated at all. A full investigation of environmental impacts would be performed in any future, project-specific NEPA effort."	Yes.
145	Exelon	Main Report	CH. 7/P.186/Paragraph 6	The report states "a description of the meeting(s) will be placed here." Does that mean the final report will include a description of the public meeting?	Compton	Yes, it does mean that.	No.
146	Exelon	Main Report	CH. 8/P.187/Paragraph 2	"If a more detailed evaluation of the upper two reservoirs is required in the future, AdH would be the more appropriate model to apply." Given that this is used as the input to AdH to determine Conowingo Pond scour it would seem imperative to do this.	Scott	Detailed analysis of reservoir sediment transport is best performed with a 2D model. Although there was significant uncertainty in this application, improvements in the model through further research at ERDC will provide more capability with less uncertainty.	No.

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147	Exelon	Main Report	CH. 8/P.187/Paragraph 1-5 (all)	Recommendations for future use of HEC-RAS and AdH are unclear. A new 2-D version of HEC-RAS is now available. However, it is unclear if new sediment transport functionality (if any) would address the most basic limitations of the framework for using HEC-RAS. AdH also has limitations, some of which are beyond the limitation of the present flocculation approach.	Langland/ Scott	More capability is needed in AdH. The ability to simulate dam operations, particle flocculation dynamics and transport, and better sediment bed definition. Chapter 8 is not about future use of the model; it's about ideas for enhancements to those models. The new 2D HEC-RAS model does not have any specific additional sediment transport capability.	No
148	Exelon	Main Report	CH. 8/P.187/Paragraph 1	Agree that AdH may be better model to apply; however, using newer features in HEC-RAS (non-equilibrium transport, multiple channels) and better modeling techniques (using floc sizes instead of grain sizes) would make it more attractive.	Langland/ Scott	HECRAS is a very capable 1D model that is routinely used to determine sediment budgets in reservoirs. However, scour and deposition in reservoirs is a 2D process and should be evaluated in that context.	
149	Exelon	Main Report	CH. 8/P.188/Paragraph 4	Models are run for incongruent periods and hydrologic/sediment transport conditions. The appropriateness of substituting loads from models other than the Bay watershed model (e.g., HEC-RAS and AdH) as inputs to the Bay WQ model needs to be established.	Cerco	The only substitution of loads is to augment the watershed model results with estimated scour during the January 1996 storm. The estimate employs scour calculations from ADH during 2011. Appendix C clearly establishes that the calculated sediment concentration during January 1996 is vastly improved by addition of the scour loads. The Appendix also discusses and describes the result of various estimates of sediment composition on watershed model computed nutrient loads.	No.
150	Exelon	Main Report	CH. 8/P. 188	The CBEMP needs to take into account the reduced bioavailability of scoured Conowingo Pond sediments; present assumption used in CBEMP is that approximately 85% of the PON coming into the Bay over the Conowingo Dam go to G2 and the remaining fraction goes to G3. However, it is likely that the G2 in the Conowingo bed is the reverse approximately 85% G3 and 15% G2. This may have a significant impact on the scenario results and the non-attainment that results – particularly the portion that is ascribed to the Conowingo Pond scour.	Cerco	The fractions assigned to G2 (slowly reactive) and G3 (inert) are based on long experience with the Bay model, as applied over the period 1985 – 2005. This interval includes multiple scour events so the assigned fractions are considered representative. Nevertheless, we acknowledge the reactivity of organic matter scoured from the reservoir bottom is an area of uncertainty. This is a recommendation of the study that is currently being scoped by various agencies.	No.
151	Exelon	Main Report	CH. 9/P.189-190/Finding #1	The important point is to know if the trapping capacity assumed in the TMDL is the same as considered now. Based on reading Langland trapping efficiency data in Appendix T and this LSRWA report they are the same.	Langland	Good news. Thanks	No.
152	Exelon	Main Report	CH. 9/P.190/entire page	This test simply restates assertions made earlier in the report --> consequently, prior comments regarding the appropriateness of model use in the evaluation as well as underlying uncertainties need to be investigated and further considered before such definitive findings can be stated.	Compton	The team/has disclosed all sources of known uncertainties and recommendations to address these which are discussed in various places throughout report package. Findings/conclusions are made in this context and are valid.	No.
153	Exelon	Main Report	CH. 9/P.190/Paragraph 4	The point made on page 176 (that the scour load is only a small fraction of the total load entering the Bay) is not mentioned at all in this findings section – this should be made clear in this summary section.	Compton	Page 190, para 4, revised text: "It should be noted that although the scour load change is 67 percent, this scour load is a relatively small percentage (9 to 13 percent) of the total load delivered to the Bay." after calculation of 67 percent. Similar sentence was added in Chapter 5.	Yes.
154	Exelon	Main Report	CH. 9/P.191/Paragraph 2	Couldn't the amount of time for sediments to settle out increase if there is an increase in velocity due to decrease in depth? The statement may be too strong a statement since the time to settle is a unique combination of gravitational and fluid forces."	Langland/ Scott	No, because water is traveling faster, therefore, potentially, less time spent in reservoir.	No.
155	Exelon	Main Report	CH. 9/P.191/Paragraph 3	Re comparing with Hirsch findings: This is not consistent with the Hirsch report. Appendix B discusses scour that moves sediment around the reservoir and scour that passes the dam. P. 34 of Appendix. B states: "At 150,000 cfs, the maximum velocity in the reservoir is about 1.0 foot per second, with a bed shear less than the critical bed shear stress for erosion from the SEDflume studies (0.004 psf) over much of the reservoir." Also, on p. 34: "The 400,000 cfs event is considered the threshold for mass erosion of the reservoir bed."	Scott	Discharges in Conowingo Reservoir below 400,000 cfs can certainly scour and transport sediment from the surface unconsolidated layer (top centimeter of bed). Flows as low are 200,000 cfs can scour the bed and transport sediment. Mass erosion refers to scour in that penetrates the deeper layers, which occurs at higher flows with higher bed shear stresses (greater than 0.02 psu).	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/Section	Comment	LSRWA Lead	Response	Report Change?
156	Exelon	Main Report	CH. 9/P.191/Paragraph 4	More detail on this trace erosion should be presented in the report, and this statement should cite relevant sections or appendices. As stated in a previous comment, Appendix A did not mention any 'thin unconsolidated mixing layer', and there was only a single reference to this in Appendix B which stated "The top layer of Conowingo Reservoir sediments consists of a low density unconsolidated layer that may mobilize at lower flows."	Scott/ Langland	It occurs, but is not significant as compared to storm flows above 400,000 cfs and was not a focus of this assessment. Recommendations section outlines focus on understanding deposition and scour and flows below 400,000 cfs.	No.
157	Exelon	Main Report	CH. 9/P.191/Last Paragraph	Long term the sediment gradation will coarsen (more and more sand) and compact as less and less volume is scoured, and reservoir should reach more of a quasi-equilibrium	Scott/ Langland	Coarse sediments (sand) are deposited in the upper reaches of the reservoir. Storms move this sand load as either bed load or suspended load to lower reaches. Some of the finer sands pass through the dam, but coarse sands may deposit. As the reservoir fills, and becomes more shallow, fines will tend to transport due to higher velocities, with sands tending to stay within the reservoir.	No.
158	Exelon	Main Report	CH. 9/P.192/Finding #2	It seems strange that this finding is listed second, when finding #3 basically says that watershed sources are much more important than finding #2.	Compton	Findings are not presented in a particular order of importance.	No.
159	Exelon	Main Report	CH. 9/P.192/Finding #2	This finding seems to be misstated. Much of the LSRWA report documents that sediment transported from the river has relatively little impact on Bay water quality. Thus, this finding should be restated to focus on nutrients rather than sediment trapping. With respect to nutrients, most nitrogen is transported in a dissolved form so that trapping of particulates has no impact on nitrogen transport. With respect to phosphorus transport, there is a link between sediment transport, hydraulic conditions (particularly flow rate), and particle retention in the reservoirs. Increasing flow in recent years means that a greater load would be transported (and a smaller percentage trapped) regardless of conditions within the reservoirs. Given that the ultimate source of excess phosphorus is driven by fertilizer application on the land surface and the failure to control it before it enters the river, any finding that purports that infilling within the reservoir surface is the cause of impacts to the Bay appears to misstate the overall assessment. (i.e., the way Finding #2 is stated conflicts with Finding #3)	Compton	Disagree. It is clear from the text underneath the finding that nutrients are the issue see first "checkmark" note.	No.
160	Exelon	Main Report	CH. 9/P.195/Top of page	Key statement - Sediment will continue to the Bay with or without the dams, and contribution from pool scour should be less over time as beds coarsen and compact.	Compton	OK.	No.

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APPENDIX A – SEDIMENT RESERVOIR TRANSPORT SIMULATION OF THREE RESERVOIRS IN THE LOWER SUSQUEHANNA RIVER BASIN, PENNSYLVANIA USING HEC-RAS, 2008-2011

	Comment	Langland Response
GENERAL APPENDIX COMMENTS	To be consistent with the references in the Conowingo Final License Application, the reference to 2011 bathymetric surveys as Gomez and Sullivan (2012) should be referenced as: URS Corporation and Gomez and Sullivan Engineers. 2012. Sediment introduction and transport study (RSP 3.15) (Appendix F). Kennett Square, PA: Exelon Generation, LLC.	Reference updated.
	“Falling Velocity” is used throughout the report when the common scientific and industry term is “fall velocity”.	Changed all occurrences of falling to fall
	The model depends on how upstream boundary conditions (BCs), sediment bed properties, and transport processes are represented in order to “calibrate” the model to reproduce measured downstream BCs. With respect to the sediment BC, USGS used a function where upstream $TSS = 0.007\ Q^{0.9996}$. For all practical purposes, this is a linear relationship between TSS and Q. Although there is a lot of spread in the data, the maximum concentration reported at any Q is 700 mg/L (with a more general trend around 300 mg/L). Extrapolating the upstream BC function to the high flow of interest leads to TSS = 835 mg/L when Q = 1.2e6 cfs. This extrapolated TSS concentration is just ~15% more than the maximum reported value (and less than 3x more than the general trend value of ~300 mg/L). [If the upstream reservoirs are believed to in dynamic equilibrium (and Holtwood reservoir is very shallow), the increase in TSS concentration is modest given the factor of 2 extrapolation of flow beyond the limit of measurements.] In contrast, the downstream BC was represented using a parabolic function where downstream $TSS = 4e\text{-}09\ Q^2 – 0.0007\ Q + 34.313$. As before, there is a lot of scatter in the data but it is harder to see on the graph because the y-axis goes to such a high limit that typical values appear compressed. Nevertheless, typical values are on the order of 300 mg/L to ~1000 mg/L (at 600,000 cfs) with a maximum value of 3,000 mg/L (at 600,000 cfs). This may not be a reasonable representation of the downstream BC. Further, the form of this	Suspended-sediment concentration (SSC) was used not TSS, there is a bias difference in lab methods that generate an error when sand is present. The TSS method by using an aliquot taken at the middle of the sample potentially does not capture the heavier sands that have already settled. There are a lot of great discussion points here, linear vs quadratic relations, BC in and out of the reservoirs, maximum “measured” sediment concentrations, sediment recession, etc. It is important to note that the sediment concentrations shown in the sediment rating curves may NOT be the maximum concentrations. This is most likely the case at Marietta when the first (and highest at ~700 mg/L) measurement for the T.S.Lee event was 3 days after the peak. Most likely

	relationship presents a curious situation for several reasons: • the linear term, TSS = -0.0007 Q, is nearly identical in magnitude but opposite in direction to the upstream BC function • the quadratic term, TSS = 4e-09 Q^2, implies that concentration increase geometrically for a linear increase in flow • because the linear term is essentially equal to the upstream load (and opposite in sign), the mass represented quadratic term must be transported off the bed in the model in order for simulated TSS concentrations at the downstream boundary to equal measured values. When extrapolated, the relationship implies that TSS = ~5,000 mg/L when Q = 1.2e6 cfs. Not only is this concentration very high, it is 40% more than the maximum reported concentration of 3,000 mg/L (assuming that this 3,000 mg/L value is representative and not impacted by a sampling or measurement error), ~5x greater than other values measured at 600,000 cfs and ~10x higher than more typical values. There is no basis to determine if this downstream BC TSS relationship is reasonable or appropriate, particularly when extrapolated to 1.2e6 cfs. This situation is further exaggerated because the exponents in the sediment transport capacity/erosion relationships selected for HEC-RAS (1 for Parthenadies, 6/7 for Laursen) are much less than the value of 2 in the downstream BC relationship. This means that the model is forced to scour tremendous amounts of sediment from the reservoir bed to match downstream TSS levels. In short, with this downstream boundary, the model can only compute massive bed erosion and must be set-up so that erodible limits are sufficient to allow massive bed erosion.	this was well after the sediment peak and on the recession side of the sediment hydrograph. This monitoring location is just upstream of the reservoirs. The downstream site reflects the cumulative effect of the Susquehanna River and 3 reservoirs and therefore the sediment rating curve might be expected to be different than a rating curve outside of a reservoir system. The quadratic form of the equation suggests a different source of sediment than the linear upstream. as you mention, scoured bed sediments. This is reflected in the" measured" data at the Conowingo site. I'm not sure how you define "massive bed erosion". The conclusion of the model simulation was the model "UNDER ESTIMATED" the amount of sediment when compared to "measured data" at Conowingo.
	At a minimum, confidence intervals should be established for the upstream and downstream boundary conditions and alternative formulations should be explored for the functional relationships used for both BCs.	Selecting 2 different sediment transport functions for the model was the attempt to place some confidence interval in overall sediment transport from Conowingo.
	There is a link with the SEDFLUME data too (and the AdH report) for cohesive transport. As noted in the AdH report (Section 6.1 of Appendix B), the sampling tube could not penetrate the substrate indicating highly consolidated sediments. The AdH report notes that most of the cores were less than 1 foot in length. However, erodible depths in the HEC-RAS model	I did not collect the SEDFLUME data, but I am aware of some of the difficulties in the collection. Previous cores collected by USGS in 2000 and analyzed by University of

	ranged from 0 feet just downstream of each dam where the bed is composed of gravels, boulders, and bed rock to 20 feet in the deepest sediment accumulation areas. This seems a bit inconsistent.	Maryland, go down much deeper (average of 5 feet, deepest one 11.5 feet) and contain particle size information at incremental levels. In general, particle size becomes courser with depth, but there are many areas with erodible fines at depths greater than 5 feet. Just because the erodible depth is set to 20 feet, that does not mean the model is going to erode down that deep.

Chapter / Section	Page	Paragraph	Comment	Langland Response
Glossary	vi		"Shear" is misspelled as "Sheer" multiple times.	corrected
Glossary	vi		The two-dimensional modeling definition may be applicable to AdH but is not applicable to 2-D models in general.	
1.0 / Introduction	2	last	No references given as to Safe Harbor and Holtwood reaching their capacity to store sediment. Dynamic equilibrium term not used.	corrected
1.0 / Introduction	2	Last sentence	Conowingo should be described as in dynamic equilibrium not equilibrium.	OK
2.0 / Background	4	Bottom of middle one	Fall velocities do not change with water velocity, transport capacities and shear. Statement is incorrect.	Agree removed "due to"
3.0 / Purpose and Scope	5	First	HEC-RAS does not predict daily streamflow as stated. Streamflow is an input parameter to the model.	reworded
4.0 / Model	7	Second	The statement that all 20 particle size classes are required in the model is incorrect.	OK
4.0 / Model	8	First	First sentence states that transport can be computed using the selected sediment transport equation or Krone/Parthenaides. If the selected equation is used, it will extrapolate down to the smaller particle sizes which usually results in too much transport.	Maybe. We never had the problem of too much transport.
4.0 / Model	8	Table	The transport equation should read "Wilcock" not "Wilcox."	OK

4.1.2 / Sediment	11	Figure 6	Here and elsewhere (USGS regression equation) sediment transport curves are developed based on suspended sediment samples. Suspended samples do not capture bed load which is not estimated in the report. In addition there is always part of the water column on the bottom (usually with the highest concentrations) where the sampling device cannot collect data. I did not see any explanation of how the bed load or unmeasured loads were considered, if at all, in the analyses.	On page 24, under model limitations and uncertainty, this issue is addressed.
4.1.2 / Sediment	14	Table 3	The particle size classes <4 mm and <8 mm are not sand. 2 mm is the maximum size for sand.	Good catch
4.2 / Geometry &Hydraulic	17	Last	Gate ratings were developed and used to estimate gate openings. Were daily pool elevations not available so guessing at gage openings would not be necessary? Also, there are no HEC-RAS default values for Manning's n as stated.	The time step was run at less than daily intervals, the daily pool elevations would not provide the data needed for the simulation.
4.2 / Geometry &Hydraulic	17	1	Conowingo only has 53 gates.	OK, changed text.
5.0 / Calibration	18	Top of page	Only flows from two tributaries were included – any estimate of flow percentage missing from ungaged tributaries? Should be able to estimate by comparing outflow from Conowingo with sum of inflows from Marietta and gaged tributaries.	This was an additional exercise completed and included in attachment 1
5.0 / Calibration	18	2nd	N values of 0.3 are not within the range of normally accepted values.	I believe I mentioned the average is 0.034 and the range was to 0.3 for very rough bedrock and boulder. I did not mention anything about normal.
5.0 / Calibration	19	1st	USGS ESTIMATOR model is not described anywhere. It would be useful to include a description of the USGS ESTIMATOR model to eliminate the need to return to the reference.	Added a more descriptive sentence about the model.
5.0 / Calibration	20	1	Is the statement "Interaction, evaluation, and feedback of boundary-condition data provided by the USACE for the 2-D model also aided in model calibration" circular? Should they have been kept separate during calibrations?	They were independently developed then compared as to the magnitudes of results.

5.0 / Calibration	22	1st	The Appendix should recognize the significance of the fact that the model can only accept one non-varying series of cohesive sediment parameters even though the SEDflume data indicated a wide variability in these parameters.	I think all 8 limitations are all significant, not just 1 or 2.
6.0 / Model Uncertainty	23	2	The Appendix should recognize as significant that "project staff were not able to resolve these issues" (with critical shear for mass wasting).	I think all 8 limitations are all significant, not just 1 or 2.
6.0 / Model Uncertainty	24	4	Lots of problems were encountered with appropriate fall velocities for cohesive sediment. As recommended by HEC, the grain size distribution should reflect the flocs rather than discrete grains.	We did not have information about the floc size.
6.0 / Model Uncertainty	24	7	Statement is not exactly true. HEC-RAS solves sediment transport by size class.	With limited capacity
6.0 / Model Uncertainty	24		Missing a paragraph #9 which would point out that the hydrograph is being simulated by a series of steady flow pulses, and sediment transport is assumed at equilibrium for each flow pulse. This is different from true unsteady flow (non-equilibrium transport) models.	May be a little too technical to explain without adding more information on the difference (advantage, disadvantage) between steady and unsteady models
7.0 / Results	25	1	Why is there poor agreement with bathymetry?	Model performance and added "the estimated change"
7.0 / Results	25	Last	Model results are being compared to ESTIMATOR and scour equation results rather than directly to measured data. The model parameters were adjusted and a separate scour model with different parameters was created for the single Tropical Storm Lee event. This does not lend a lot of confidence to model results.	Agree, and one the important findings' of the study, that the HEC-RAS might not be the best choice of a model in this reservoir system
Appendix A-1	35	Table A1	It appears that the results were computed with Log-Pearson Type III distribution. The Appendix should note that this distribution is not always applicable for controlled systems.	I noted the difference might be due to flow regulation.

Attachment A-1	38	2	It is not clear how the Gomez and Sullivan (2012) bathymetry data were used in computing estimated scour loads from the lower Susquehanna River reservoirs for three reasons: 1) the 2011 survey described in Gomez and Sullivan (2012) was limited to Conowingo Reservoir (no bathymetry was collected in Lake Clarke or Lake Aldred); 2) the Gomez and Sullivan (2012) study compared bathymetry data from three years apart (2008-2011) and did not make an assessment of the 2011 flood event's specific contribution; and 3) the Gomez and Sullivan (2012) study calculated that there was net deposition from over the three year period from 2008-2011, not net scour.	Good points. 1 and 2. The GSE bathymetry was not the only data used to develop the equation. As the discussion indicates, the prediction equation is a tool, that allows a "quick" estimate of scour from the reservoir system, not just Conowingo. Based on the regression diagnostics, error bounds are plotted on figure A4. 3. Correct the study did indicate net deposition during the 2008-2011 interval, however that does not imply no scour during the short term T.S. Lee event.
Appendix A-1	38-39	Figure A4	Not clear how scour loads were computed and curve developed, important as used for model calibration. Also based on suspended load measurements only (no bedload).	Scour loads are defined as sediment capable of being lifted from the bed become "SUSPENDED" and transported through the dam. The bed is always moving to some degree, however, this study (and most of Chesapeake Bay Program is concerned with what exits the dam, not necessary how movable is the bed.

Attachment A-1	40	Table A2	Table A2 predicts the amount of scour exiting the Lower Susquehanna River reservoir system by using an equation fit to data from 1993-2011. Yet, 'scour' predictions are made for events as far back as 1936, when the reservoir system likely experienced much different sediment dynamics than it does in modern times. Additionally, it is not clear what criteria were used to estimate the scour load for these events, as the relationship between the two columns does not appear to fit a monotonic relationship.	Good point, I used the estimated trapping efficiency (table later in section) to estimate the scour load for storms previous to 1972.
Attachment A-1	41	Table A3	Do these numbers refer to just Conowingo Reservoir or all three reservoirs? If all three, caption to table should be modified accordingly.	Yes.
Attachment A-1	42	1	As velocity increases and bed shear increase, wouldn't the time for sediments to settle out also increase, not decrease?	NO, velocity increases, lessening the amount of time for sediment to settle out.
Attachment A-1	42	Table A4	There is no explanation given for how the estimated 146,000 acre-feet of sediment storage was calculated. Given that this number was then used to estimate the "full" bathymetry that was then carried throughout the assessment and ties into one of the study's major findings, this value needs to be more thoroughly explained.	Agree, and added some clarifying text.
Attachment A-1	43	Figure A-5	It should be clear that the Tropical Storm Agnes point (red dot) is an estimated point, and was not measured using bathymetric survey data. Also, there needs to be a more thorough explanation on how the other "estimated" points were derived.	Agree and added some clarifying text.

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APPENDIX B – SEDIMENT TRANSPORT CHARACTERISTICS OF CONOWINGO RESERVOIR

	Comment	Scott Response
GENERAL APPENDIX COMMENTS	This Appendix does a much better job of describing the uncertainties associated with the AdH results than the main report does. Specifically page 14, paragraph 2 which states that "Because of these uncertainties the AdH model may potentially over-predict to some degree transport of bed sediment through the dam." These points, for all models, need to be more clearly made and emphasized in the main report.	Main report will add this language.
	Caveat appears in several places that the results only describe sediment transport and do not imply a relationship exists between this and nutrient loads. This caveat should be included in the main report.	Main report will add this language.
	Lots of discussion about erosion threshold and SEDflume data but not much about deposition shear stress threshold. Are these set equal in the model?	Because of uncertainty in flocculation dynamics, there was no minimum depositional shear stress (based on particle fall velocity of individual particles
	The AdH model TSS upstream boundary condition is directly from the USGS HEC-RAS application. As noted in comments on Appendix A, USGS used a function where upstream TSS = 0.007 $Q^{0.9996}$. For all practical purposes, this is a linear relationship between TSS and Q. Although there is a lot of spread in the data, the maximum concentration reported at any Q is 700 mg/L (with a more general trend around 300 mg/L). It would be worth reviewing the basis and functional form for this upstream TSS BC. Uncertainty bounds and confidence limits for this relationship should also be established.	Agree. Perhaps the field data collection effort by Exelon and USGS can provide more data for such as effort.
	The AdH model TSS downstream boundary condition differs from the USGS HEC-RAS application. Whereas the USGS TSS downstream BC fit a parabolic function to the data and did not force the relationship to pass through the maximum point (TSS = 3,000 mg/L at Q = 600,000 cfs), the relationship used for AdH is forced through this maximum value. Consequently, at a flow of 600,000 cfs, AdH is calibrated to yield even more erosion than the USGS model. It would be worth reviewing the basis and functional form for this upstream TSS BC. Uncertainty bounds and confidence limits for this relationship should also be established.	The USGS did not use this linear function. They used actual data. The maximum value of their actual data set was more like 2700 mg/l. The AdH downstream output of TSS was based on both pass through sediment and bed scour contribution. The output of AdH was not forced through any curvefit. The actual measured values of concentration discharged through Conowingo were plotted as an exponential

		function that did pass through the maximum value.
	Boundary conditions should be reviewed to establish defensible ranges/relationships and quantify uncertainties.	Agree.
	SEDFLUME cores only penetrated to ~1 ft or less. In some cases the depth of scour identified in Figure 5 often exceeds 1 ft and can exceed 5-8 ft in several locations. Such model results are extrapolations beyond the range of measurements. Cores for the SEDFLUME could not penetrate sediment so it is likely that the erosion resistance of sediment at depth could be much more than at 1 ft below grade.	I agree. I increased the erosion threshold considerably for these deeper depths (greater than 1 ft) up to 5 – 6 pascals

Chapter / Section	Page	Paragraph	Comment	Scott Response
2 / Background	5	Bottom	"HEC-6 model did better when included coarser sediments." By using only suspended samples you are missing out on coarser particles that might transport as bedload	Agree.
3 / Approach and Goals	8-9		Goals stated more clearly here than in main report. This description should be incorporated into the main report.	Main report will be updated.
4 / Description of Modeling Uncertainties	All		This section does a much better job of describing the uncertainties associated with the AdH results than the main report does. Specifically page 14, paragraph 2 which states that "Because of these uncertainties the AdH model may potentially over-predict to some degree transport of bed sediment through the dam." These points, for all models, need to be more clearly made and emphasized in the main report.	Main report will be updated.
5.1 / Susquehanna River Flows	15	2	While 2008-2011 did have a range of flows, the frequency of the flows is not comparable to the long-term record.	Agree. TS Lee was 13 year return event.
5.2 / HEC-RAS output rating	16	1	USGS model input taken from inflowing suspended load not considering bedload – missing coarser materials?	Agree. Bedload not sampled
5.2 / HEC-RAS Output Rating Curve	16	2	It is not clear what exactly was input into AdH from HEC-RAS – was it an hourly time series of suspended sediment load, or was the flow time series simply correlated to a sediment rating curve that was constructed from data output by HEC-RAS?	HECRAS produced sediment loads for mean daily flows for different size classes. AdH used this for the inflowing sediment rating curve into Conowingo

5.2 / HEC-RAS output rating	17	1	Conservatively high inflowing sediment load assumed and used for all other simulations. This does not appear to have been stressed or explained well in the main report.	The USGS used measured suspended sediment concentration data to create a sediment rating curve into the uppermost reservoir. The output to the AdH model was based on HECRAS output to Conowingo.
5.2 / HEC-RAS output rating	17	1	What is the basis for increasing the HEC-RAS load 10%?	I believe HECRAS underestimated scour load from the upper two reservoirs
6 / Model Validation	22 & 23	2 & 2	One of the data sources used to validate the AdH model was the USGS data collected from the catwalks of Conowingo Dam. This data is not representative of the entire river cross-section. Moreover, if any of this data was collected during Tropical Storm Lee, the data may have been collected when the Station was shut down.	Agree
6 / Model Validation	23	3	What is the output time step of the AdH model?	Varied from 100 to 1000 seconds depending on the flow
6 / Model Validation	23	3	"The properties of the lower two feet were either approximated from the SEDflume results or determined from literature values." It would be useful to have a table of these properties.	I estimated increases in shear stress from literature.
7.1 / General flow and bed shear distribution in Conowingo Reservoir	34	1	Middle of paragraph, sentence starting with "This channel was not included…" and next sentence should include a citation.	Agree.
7.5 / Simulation full bathymetry	42	1	"The USGS provided the remaining storage volume…" Was this from Langland (2009) Figure 12?	No, the USGS estimated the remaining storage volume
7.6 / Discussion	44	1	Based on previous communication with Steve Scott it was indicated that the "consolidated" bulk density was wet bulk density. This is not clearly stated in the Appendix, please confirm.	Yes, it is the bulk (wet) density

7.6 / Discussion	46	2	What inflow load scenario was used where the relative load from Conowingo (versus the overall watershed) was up to 30% of the incoming load?	Inflow scenario was 24 million tons over the four years, 10 million tons from TS Lee
7.6 / Discussion	46	2	Last sentence of paragraph is speculative and goes to the uncertainty of using the HEC-RAS model as the input to the AdH model	Agree
9 / Impact of releases on flats	52	1	What is the age of the NOAA depth charts referenced?	35 edition 12/07 Number 12274
9 / Impact of releases on flats	52+	General	The description of this downstream model has much less detail and is shorter than the sections dealing with the upstream model.	Agree
9 / Impact of releases on flats	53-54	1, Fig. 34	What is the reference for the ratio of roughness with SAV?	The AdH users manual
9.2 / Sediment results	55	1	No description is given of the upstream or downstream boundary conditions. Assuming that the U/S BC is the outflow from the U/S AdH model, but which run? Or were measured SSCs used?	The upstream boundary was an arbitrary flow, not Specific conowingo outflow.
10.1 / Conclusions	57	1 & 3	Reinforces the importance of large less frequent events to sediment movement.	Agree
10.4 / Bypassing	59	1	Any guidance as to how these concentrations would impact wildlife?	Most the sediment released from Conowingo is fine sediments which passes below the flats. Not sure of the wildlife implications

11 / Recommendations to Improve Future Modeling Efforts	60	1	"…the model was not capable of passing sediment through the gates...this limitation impacted how sediment was spatially distributed in the lower reach of Conowingo Reservoir near the dam." How did it impact sediment? Further understanding on the exact impacts and uncertainty associated with this needs to be included in the Appendix and the main report.	Initially, we tried to input dam operations into the model (sequential opening and closing of gates as flood flows passed), however, the sediment transport component of the gate operation did not become operational during the conduct of the study. Opening the gates will affect the distribution of sediment from the powerhouse to the center of the channel, thus impacting sedimentation on the Eastern side of the dam (just upstream).
B-1, 6.0 Discussion & Conclusions	B-1		Using the provided graphs, the 86,000 cfs limit where all flows pass through the powerhouse accounts for about 30% of the annual sediment load. This should be mentioned.	Doesn't that depend on storm frequency? Not sure about that. Maybe "average" annual sediment load.

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APPENDIX C – APPLICATION OF THE CBEMP TO EXAMINE THE IMPACTS OF SEDIMENT SCOUR IN CONOWINGO RESERVOIR ON WATER QUALITY IN THE CHESAPEAKE BAY

GENERAL APPENDIX COMMENTS	Comment	Cerco Response
	The use of metric units when everything else is in English unnecessarily confuses the issue.	

Chapter / Section	Page	Paragraph	Comment	Cerco Response
Chapter 2	13	Table 2-1	How were the values of B and W determined for the analytical model?	The references cited indicate B varies from 500 to 10,000 g m^{-2} d^{-1} (0.006 to 0.12 g m^{-2} s^{-1}). The value employed, 0.019 g m^{-2} s^{-1}, was selected within the reported range so that C exceeds Cin when flow is 11,000 m^{3} s^{-2}, the threshold flow for erosion. Reported values of W range from 10^{0} to 10^{2} m d^{-1}. The value 10^{1} (geometric mean of reported range) was selected. This converts to 1.14 x 10-^{4} m s^{-1}.
Chapter 3	17	1	Although period examined has a range of flows, how representative is the flood frequency during this period with the long-term flood frequency?	The report indicates two erosion events (flow > 11,000 m^{3} s^{-1}) occurred during the ten-year simulation period. These events were in April 1993 and January 1996. Langland's report indicates flows in excess of 400,000 ft^{3} s^{-1} (11,000 m^{3} s^{-1}) have a recurrence interval of five years. Two events in ten years correspond well with the expected recurrence.

Chapter 3	18	2	How was the Conowingo Pond equilibrium condition determined?	The equilibrium bathymetry was determined by the team that modeled Conowingo Reservoir (Mike Langland, Steve Scott, and associates). This question must be answered by that team.
Chapter 3	18	2	The Main Report concludes Conowingo Pond is, at present, in a state of dynamic equilibrium. For example: • Page 10: "This assessment concludes that Conowingo Dam and Reservoir (along with upper two reservoirs) is currently in a dynamic equilibrium state." • Table 1-1: "Dynamic equilibrium reached in the mid-2000's, very limited capacity remaining." Appendix C (page 18) distinguishes between an "existing" bathymetry (2008) and an "equilibrium" bathymetry which "is the bathymetry projected to result when sediment loads in and out of the reservoir are in dynamic equilibrium and no net deposition occurs." However, Appendix D (page 21) says "the 2011 bathymetry is essentially the equilibrium bathymetry." The use of the term "dynamic equilibrium" and dynamic equilibrium conditions do not appear to be used in a consistent manner throughout the Main Report and the appendices.	We have endeavored to be consistent between reports as to the definition of "dynamic equilibrium." We believe the concept is clear despite the potential for differences in wording. Multiple bathymetry sets were employed in this report. The 2011 bathymetry was measured and provided to this study by Exelon. The "equilibrium" bathymetry was estimated by the sediment transport team. Application of the ADH model employing the 2011 and equilibrium bathymetry sets indicate little difference in calculated bottom erosion. Hence the statement "the 2011 bathymetry is essentially the equilibrium bathymetry." They are not literally the same but the calculated erosion from both sets is so close that they are the same for practical purposes.

Chapter 4	23	Entire Chapter	How are the scoured sediment and nutrient loads from Lake Clarke and Lake Aldred accounted for? Is it similar to the process for which Conowingo-scoured sediments (and thus nutrients) are superimposed on the WSM nutrient loads input to the WQM as described in Chapter 4 of Appendix C?	Sediment loads from Lake Clarke and Aldred are not specifically identified in the Chesapeake Bay loads. The Chesapeake Bay model only "sees" loads at the Conowingo outfall. Loads from Clarke and Aldred are combined with other loading sources at this outfall. The only material superimposed on the WSM loads is scour calculated in Conowingo Reservoir.
Chapter 4	23	1	"The loads at the head of the reservoir system are supplemented by inputs from the local watersheds immediately adjacent to the reservoirs." It would be useful if there were a figure depicting this either in the main report of this Appendix (or both).	A figure such as this one might be included in the main report. This doesn't appear to be a critical deficiency.
Chapter 4	26	3	Bullet 5 – "For key scenarios, an alternate set of nutrient loads was constructed based on 1996 observed nutrient fraction." These should be included and discussed in the main report.	The results from these scenarios are reported in the appendix to this report.
Chapter 4	32	Figure 4-1	Assuming that the Calculated eroded particulate nitrogen and phosphorus referenced are from AdH? Please confirm.	No, ADH does not calculate nutrients. The calculated eroded nutrients are based on ADH calculations of eroded sediment and on observed fractions of nutrients associated with sediments.

Chapter 6	48	last	How does this statement impact the LSRWA conclusions? Does it result in a greater modeled impact to the Bay from scour when applying the CBEMP? "The predominant role of net scour loads, reported here, is in contrast to the companion reports to this one (Scott and Sharp, 2013; Langland, 2013) in which scour is assigned a lesser fraction of the total storm loads."	This report emphasizes the marginal impact of a scour event on Bay water quality. The marginal impact of a scour event depends on the magnitude of the scour event. The magnitudes of the scour events in 1996 and in TS Lee were similar. The ADH computation of scour during TS Lee is 2.64 million metric tons. The scour calculated for 1996 is 2.37 million metric tons. The marginal impact of the scour load is not affected by the watershed load.
Chapter 6	48	last	Why is there such a big difference between this study and the Scott and Sharp estimate of the % scoured sediment load?	The report is explicit on this point. The 1996 and 2011 storm events were fundamentally different. Tropical Storm Lee was a tropical storm event which passed over the lower portion of the Susquehanna Watershed. This portion of the entire watershed contains several sub-watersheds which produce notably high sediment loads. The 1996 flood was generated, in part, by snowmelt which is relatively "clean" with regard to sediment content. Therefore, we expect the ratio of watershed load to scour load to differ for these two events. Please see the report for additional information.

Chapter 6	52	Equilibrium Bathymetry Section	See comment for page 18, paragraph 2.	We believe this section provides an accurate description of model application and conclusions to be drawn from the application. In our response to the earlier comment, we indicated there was little practical difference in scour calculated with the 2011 bathymetry and with the "equilibrium" bathymetry. Here we are indicating there is little detectable difference in Bay response to erosion calculated for 2008 bathymetry and to erosion calculated for equilibrium bathymetry. The implication is that the reservoir was approaching equilibrium as early as 2008.
Chapter 6	53	1	The last sentence may also be interpreted as a quantification of the benefit of Conowingo Dam to the Bay when depositional.	During depositional periods, the retention of nutrients in Conowingo Reservoir is apparently of benefit to the Bay.
Chapter 6	81-82	Figs 6-21/6-22	Can additional figures be generated that show the percentage of additional flux represented by Figs 6-21 and 6-22?	During the first summer (June – August) after the scour event, NH4 release increases by 16.2%, PO4 release increases by 7.8%. At this time, no major addition and re-numbering of figures is possible. We will revise the figure captions to report these statistics.

Chapter7	119	1	"Model results can be reported with extensive precision, consistent with the precision of the computers on which the models are executed. Despite the precision, model results are inherently uncertain for a host of reasons including uncertain inputs, variance in model parameters, and approximations in model representations of prototype processes." This statement and the rest of this section do a much better job of clearly stating the uncertainties associated with models and model results than the main report does. While the main report does generally acknowledge some model limitations/uncertainties it does not do as good of a job as the Appendices in stating how uncertain some of these results may be.	The potential to alter the main report to reflect this section of Appendix C is left to the authors of the main report.
Chapter 7	120	2	While uncertainty due to bioavailability of the nutrients is acknowledged and while the "scoured" refractory nutrients are handled in the same fashion as the other boundary nutrients could an estimate be made of how the scoured nutrients might be different than the current assumption of 86% of refractory PON going to G2 and 14% of refractory PON going to G3 (based on Cerco and Noel, 2004)? We believe that SFM computed G2 and G3 is likely to be the other way around with G3 > G2 for organic matter that has been in the sediment bed for several years, as would be the case between scour events in Conowingo Pond.	The material on the bottom of Conowingo Reservoir has not all been there for several years. Material is deposited continuously, including fresh organic matter from phytoplankton in the reservoir. The fractions assigned to G2 and G3 are based on long experience with the Bay model, as applied over the period 1985 – 2005. This interval includes multiple scour events so the assigned fractions are considered representative. Nevertheless, we acknowledge the reactivity of organic matter scoured from the reservoir bottom is an area of uncertainty. Our understanding is that experiments are planned to address this issue.

Chapter 7	120	3	It is stated that the SEDflume studies reported in Appendix B "indicate erosion does not occur below 9,300 m^3s^{-1} (330,000 cfs)." Please clarify if the author is referring to the beginning of "mass bed erosion" as defined in Appendix B. If so, shouldn't the value be 400,000 cfs?	The commonly accepted threshold for mass erosion is 400,000 cfs. The text will be revised.

LSRWA APPENDIX COMMENTS – JULY 2014

APPENDIX D – ESTIMATED INFLUENCE OF CONOWINGO INFILL ON THE CHESAPEAKE BAY TMDL

Chapter / Section	Page	Paragraph	Comment	Linker Response
Introduction	3	3	The last portion of this paragraph starting with "During the 2017 Midpoint Assessment…" discusses decisions being made regarding any necessary adjustments to the CB TMDL. It should be clearly noted here that Appendix T of the TMDL discusses actions that will be taken in the event that the status of Conowingo Pond changes from previously understood conditions. The language used should be that contained in TMDL Appendix T.	Appendix T is correctly cited, referenced, and characterized in Appendix D. It's clear from the text what's directly quoted and what's paraphrased. The citation and attribution is entirely correct and changes are unwarranted.
Results	11	LSRWA-3	It's not clear to what magnitude the WSM-calculated Conowingo scour and the LSRWA/AdH-calculated Conowingo scour are "double-counting" the same effect (if at all), since the AdH-calculated scour is superimposed on the WSM sediment/nutrient outputs before being input into the WSM.	Added Text: "See Figure 4-2 of Cerco and Cole, Appendix D (this report) to see the observed and computed suspended solids at the Conowingo outfall during January 1996 for the WSM alone and for the WSM with additional erosion load."
Results / DO Water Quality Standard Results	13	4	Last sentence of the paragraph starting with "The WIP Scenario…" lists LSRWA-4, we believe this should be LSRWA-3	Good catch. Corrected as suggested.
Results	20	Figure 5	While the differential values are useful, it is helpful for the reader to also list absolute nonattainment values rather than just relative values.	Listing the absolute values for Scenario LSRWA-21 and LSRWA-3 (and explaining why the 1996-1998 period is different from the 1993-1995 period and the reason they're different , etc., etc. would add confusion, not clarity. Adding absolute nonattainment values is unwarranted.
Results / LSRWA Results: Non-Management Scenarios	21	3 & 4	Why were the points of comparison changed for the June and October events from the comparisons made earlier in the section?	In the seasonal scenarios the comparison is being made among the January, June, and October seasons (or months) and the No Storm Scenario of LSRWA-23 allowed the comparison of the three seasons to be made. In this case we're looking at the relative difference among the different seasons and the use of LSRWA-23 is appropriate.
Results / LSRWA Results: Non-Management Scenarios	21	1	See comments on Appendix C (page 18) regarding existing bathymetry and equilibrium bathymetry. The use of the term "dynamic equilibrium" and dynamic equilibrium conditions do not appear to be used in a consistent manner throughout the Main Report and the appendices. The Main Report concludes Conowingo Pond is, at present, in a state of dynamic equilibrium. For example: • Page 10: "This assessment concludes that Conowingo Dam and Reservoir (along with upper two reservoirs) is currently in a dynamic equilibrium state." • Table 1-1: "Dynamic equilibrium reached in the mid-2000s, very limited capacity remaining" Appendix C (page 18) distinguishes between an "existing" bathymetry (2008) and an "equilibrium" bathymetry which "is the bathymetry projected to result when sediment loads in and out of the reservoir are in dynamic equilibrium and no net deposition occurs." However,	The exact date of the onset of dynamic equilibrium in the Conowingo Reservoir is unknown. But a definitive statement from the LSRWA report is that the Conowingo Reservoir is <u>now</u> in dynamic equilibrium. At some time prior to 2000 it was not. There is no contradiction.

Chapter / Section	Page	Paragraph	Comment	Linker Response
			Appendix D (page 21) says "the 2011 bathymetry is essentially the equilibrium bathymetry."	
Results / LSRWA Results: Non-Management Scenarios	21-22	June/Oct	It would be helpful if the stop-light tables 2a and 2b could be expanded to include the results from the various LSRWA scenarios. It is not clear at all as to whether the scenarios that are run with the nutrients collected with the 1996 scour event are significantly different that those using the 2011 water quality data. For example, for the June event, it is surprising that the non-attainment was reduced from 4% to 2% (a 50% reduction) for the Deep-Channel Attainment for Bay segment CB4MH comparing LSRWA26 vs. LSRWA-24, while no other changes in attainment were found.	Different simulation years (93-95) in table 2a and 2b from 1996-1998 period which contains the January 1996 Big Melt event.
Results / LSRWA Results: Non-Management Scenarios	23	Table 3	1) It would be useful to add a row for each of these columns specifically indicating which years are being analyzed for WQ attainment. 2) The nonattainment's should be listed with more significant figures (e.g., 1.4% nonattainment instead of 1% nonattainment) 3) The absolute nonattainment values (e.g., LSRWA-21 had 19% deep channel DO nonattainment in segment CBMH4) should be listed in addition to the relative nonattainment numbers (e.g., an increase of 1% nonattainment over the Base TMDL Scenario (LSRWA-3))	1) The text on (example page 18 paragraphs 2 and 3) provides sufficient information on when the 1996-1998 simulation period is used in order to simulate the January 1996 storm. 2) A single significant figure is sufficient and is consistent with the level of significance typically reported in the Chesapeake TMDL. 3) Listing both the absolute value and the base value along with the difference between the base scenario is from the base as suggested would be redundant, confusing, and unwieldy.
Results / LSRWA Results: Non-Management Scenarios	23-24	Tables 3-5	Why aren't LSRWA-22, 26, 27 discussed in these tables?	LSRWA-22, 26, and 27 are discussed in the text.
Conclusions	27	1	It is stated that the TMDL simulation period of 1991-2000 "was a condition prior to the current dynamic equilibrium state of sediment infill of the Conowingo Reservoir." However, an agreed timing of the onset of dynamic equilibrium is not clear in this report; nor is the relationship with changes in trapping efficiency. For example, Table 5-6 has the trapping efficiency of Conowingo Reservoir remaining at 55-60% for the time period 1993-2012. But Table 1-1 says dynamic equilibrium was first reached in the mid-2000s. Is this a contradiction?	The exact date of the onset of dynamic equilibrium in the Conowingo Reservoir is unknown. But a definitive statement from the LSRWA report is that the Conowingo Reservoir is now in dynamic equilibrium. At some time prior to 2000 it was not. There is no contradiction.
Conclusions	28	3	Second to last sentence of this paragraph references LSRWA-13. This scenario is not defined earlier in the Appendix.	Thank you for this correction. The text has been corrected to change LSRWA-13 to LSRWA-31.
Conclusions	29	1	"During episodic high flow scour events, large nutrient loads are delivered to Chesapeake Bay." The term "scour events" lead the reader to believe that the scour is responsible for all nutrient loads going to the Bay when in fact the vast majority of the loads originate from watershed sources upstream of Conowingo Pond and the Lower Susquehanna Reservoirs. This comment is true of any reference to "scour events" throughout the main report and appendices.	The scenarios referred to in the conclusion section separated the loads from the watershed and the scoured loads from the Conowingo by the difference between scenarios as described in the results section. The increase in nonattainment in Deep Water and Deep Channel DO (described in the results and discussed in the conclusions) were specifically because of the scoured nutrients from the Conowingo Reservoir.

Chapter / Section	Page	Paragraph	Comment	Linker Response
Conclusions	29	3	The last sentence of this paragraph discusses how the TMDL will account for changes in the trapping capacity of Conowingo Pond as per TMDL Appendix T. When discussing the TMDL and changes in Conowingo Pond trapping capacity throughout this Appendix, and the main report, it is important to always use consistent language from Appendix T in regard to how this will be handled.	Appendix T is correctly cited, referenced, and characterized in Appendix D. It's clear from the text what's directly quoted and what's paraphrased. The citation and attribution is entirely correct and changes are unwarranted.
LSRWA uncertainty			The CBEMP assumes that refractory organic nitrogen coming into the system and depositing to the sediment is 84% G2 and 16% G3 (Cerco and Noel, 2004). However, it is likely that scoured sediments from Conowingo Pond would have the reverse distribution G2 > G3. A model scenario should be constructed to evaluate this condition.	Agreed that the research now underway into the proportions of refectory and labile organics in Conowingo Reservoir sediments is needed in order to be definitive regarding the G2 and G3 fractions in the Conowingo bed.

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APPENDIX E – MGS SUSQUEHANNA FLATS SAMPLING RESULTS

	Comment	Ortt Response
GENERAL APPENDIX COMMENTS	The bathymetric map does not indicate the elevation datum for the contours.	Contour info added.
	The Introduction to the Appendix does not discuss Susquehanna Flats sediment sampling (it only discusses the need for bathymetry of the area) yet the first table in the Appendix is what appears to be a sediment core summary table. There is no information in the Appendix as to the scope of field efforts conducted in the Susquehanna Flats.	Text revised. MGS DID NOT perform any bathymetry for this project. USACE used NOAA for elevations.
	Nowhere in the Appendix is there a report summarizing field efforts (e.g., methodology, discussion, results, etc.) for either the sediment sampling or the bathymetry survey. Based on what is included in the Appendix, a reader would not know anything about how the data was collected, field conditions, etc.	Summary of field efforts (e.g., methodology, discussion, results, etc.) added.

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APPENDIX F – U.S. GEOLOGICAL SURVEY CONOWINGO OUTFLOW SUSPENDED SEDIMENT DATA REPORT

	Comment	Bloomquist Response
GENERAL APPENDIX COMMENTS	Cover letter states “samples were collected along a representative cross-section from the catwalk on Conowingo Dam…” Conowingo Dam catwalk sampling is not representative of the channel cross-section at the dam.	The data transmittal letter dated February 10, 2012, represents an accurate assessment of the relation between catwalk and cross-sectional variability, given the analysis of available historical USGS quality control data.
	A brief report to accompany the data would be useful (in addition to the cover letter provided). The report could highlight the sampling methods used, field conditions, hydrograph, sampling comments/notes, etc. In its current form, the Appendix does not provide the reader with very many details about the sampling event(s).	The data were collected using standard methods for the site as outlined in the QAPP on file with EPA CBPO. Streamflow records for the periods represented by these samples as well as the analytical results themselves are publically available at http://waterdata.usgs.gov. Limited time and funds availability precluded the preparation of a separate report detailing these data.

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APPENDIX G – 2011 EXELON CONOWINGO BATHYMETRY SURVEYS

	Comment
GENERAL APPENDIX COMMENTS	**No Comments**

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APPENDIX H – LITERATURE SEARCH FINDINGS REPORT

	Comment
GENERAL APPENDIX COMMENTS	No comments other than newspaper articles are not good references.

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APPENDIX I – STAKEHOLDER INVOLVEMENT

GENERAL APPENDIX COMMENTS	Comment
	No Comments

LSRWA APPENDIX COMMENTS – JULY 2014

APPENDIX J – PLAN FORMULATION

Chapter / Section	Page	Paragraph	Comment	Lead	Response
Introduction	N/A	1	The introduction does not clearly explain what the reader is viewing in any of the attachments. The introduction should explain how each attachment is used in the LSWRA and the main report.	Compton	Intro's expanded for each attachment.
Attachment J-1	2	2	The implication that sediment plumes as represented by TS Lee in Figure 3 are due to scour from Conowingo Reservoir is incorrect. As noted in the main report, these plumes are predominantly comprised of sediment from the watershed upstream of Conowingo Reservoir.	Michael	Page 2, paragraph 2 – change the last sentence to "The massive plume of sediment that occurred following Tropical Storm Lee extended from the Conowingo Dam past the mouth of the Patuxent River (Figure 3) and originated both from the watershed and from scour behind the dam.", with the majority of the sediment coming from the watershed.
Attachment J-1	4	3	In the text and references (p. 8-9) the affiliations of the personal communications are not clear.	Michael	Page 4, paragraph 3 – change "(Kevin DeBell, Ph.D., personal communication)" to "(Kevin DeBell, Ph.D., U.S. Environmental Protection Agency, Chesapeake Bay Program, personal communication)".
Attachment J-1	4	4	What model run is being referred to in the second sentence?	Michael	Page 4, paragraph 4 – change "The model run" to "Output from the Phase 5.3.2 Watershed Model".
Attachment J-1	5	2	In the text and references (p. 8-9) the affiliations of the personal communications	Michael	Page 5, paragraph 2 – change "(Greg Busch, personal communication)" to

			are not clear.		"(Greg Busch, Maryland Department of the Environment, personal communication)". Change "(John Rhoderick, personal communication)" to (John Rhoderick, Maryland Department of Agriculture, personal communication)". Page 8 – change "Blomquist, J. D. (24 October 2013)" to "Blomquist, J. D., United States Geological Survey (24 October 2013)". Change "Busch, G. C. (26 August 2013)" to "Busch, G. C., Maryland Department of the Environment (24 October 2013)". Change "DeBell, K. M. (9 September 2013) to "DeBell, K. M., United States Environmental Protection Agency, Chesapeake Bay Program (9 September 2013)". Change "Rhoderick, J. (13 September 2013)" to "Rhoderick, J., Maryland Department of Agriculture (13 September 2013)". Page 9 – change "Sweeney, J. D. (31 October 2013)" to "Sweeney, J. D., United States Environmental Protection Agency, Chesapeake Bay Program (31 October 2013)".
Attachment J-2	3 tables		Pertaining to all alternatives – not addressed are the potential environmental impacts associated with each alternative.	Compton	LSRWA effort was a watershed assessment and not a detailed investigation of a specific project

			Environmental resources that could be impacted could include: aesthetics, air quality and greenhouse gases, soils, water quality, wetlands, groundwater, surface water, wetlands, floodplains, biological resources, cultural resources, land use, socioeconomic resources, recreation and tourism, utility and transportation infrastructure, public health and safety, and noise.		alternative(s) proposed for implementation. That latter would require preparation of a NEPA document. The evaluation of sediment management strategies in the assessment focused on water quality impacts, with some consideration of impacts to SAV. Other environmental and social impacts were only minimally evaluated or not evaluated at all. A full investigation of environmental impacts would be performed in any future, project-specific NEPA effort.
Attachment J-4	1	Table	It is not clear what reservoir bathymetry/trapping efficiency means. If it is simply referring to trapping efficiency, then it should be stated as such. The actual trapping efficiencies should be listed as well (e.g., 55%) rather than just a level associated with a time period.	Compton	For scenarios 2-6 the input parameter is actual reservoir bathymetry per AdH. The exception is Scenario 1, which did not use AdH but was the TMDL/WSM only run which considered trapping rates/efficiency of the 1990s (which was around 55%). What is most important is what era is represented in the simulation which is depicted.
Attachment J-4	1,7	Table	It's not clear how nonattainment differentials are be compared between LSRWA-30 and LSRWA-3 (on page 7), since page 1 of this report says that the nonattainment's were calculated for different time periods for the two runs (1993-1995 for LSRWA-3, 1996-1998 for LSRWA-30). Similar comment for LSRWA-4 and LSRWA-18.	Compton	The CBEMP utilizes the 1991-2000 hydrologic period. For the criteria assessment procedure, a 3-year critical period (1993-95) was used as the period for assessing attainment of the water quality standards for several LSRWA model scenarios. The 1993–1995 critical period was chosen based on key environmental factors, principally rainfall and streamflow,

					which influenced attainment of the DO water quality standards for the deep-water and deep-channel habitats (USEPA, 2010a). Since the January 1996 high flow event was outside the 1993-95 critical period, the 1996-98 hydrologic period was used as the assessment period for LSRWA modeling scenarios that included an evaluation of a storm event.
Attachment J-4	1,7,8	Table	The DO nonattainment's should be listed by segment (similar to pieces from the stoplight plots), and must be listed as absolute numbers as opposed to differentials from other runs, as it becomes confusing for the reader to follow which runs are being compared to other runs. Also, the nonattainment's should carry an additional significant figure (e.g., 1.4% instead of 1%).	Compton/Linker	Organizing nonattainment by segment does not work in the format of the table. As comment states Appendix D stoplight plots organizes by segment if reader wants to view it this way. Listing the absolute nonattainment values is unwarranted. Significant figures will remain as we received comments earlier on that that amount of precision was not conducive.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
1	MES	Main Report	ES-2	last sentence of first paragraph. ".....to the Chesapeake Bay due to reservoir deposition within that increased capacity."	Original wording is ok, but I think that with the addition it makes clearer where the deposition is occurring. My addition in red	Compton	Concur. Change made.	Yes.
2	MES	Main Report	ES-2	Third Paragraph, second sentence: Change "from Conowingo" to "within Conowingo"		Compton	Concur. Change made.	Yes.
3	MES	Main Report	ES-2	4th paragraph, (first in Section "Watershed is the principal source of Sediment"); Last sentence, change "Consequently, this percentage of" to "Consequently, the relative proportion of"	A percentage number has not actually been calculated or identified.	Compton	Concur. Change made.	Yes.
4	MES	Main Report	ES-3	3rd complete paragraph; second one in the Section "Nutrients, not Sediment.....: In the sentence "As a consequence, DO in the Bay's deep-water habitat is diminished by reservoir scour events." change "by reservoir scour" to "following reservoir scour."	There is a time lag associated with nutrient delivery, utilization and regeneration, not immediately caused by simple delivery.	Compton	Concur. Change made.	Yes.
5	MES	Main Report	ES-5	Consider putting numbers 1 through 3 on the first three paragraphs.	Clearer relationship to the 3 strategies identified in the last paragraph of the previous page.	Compton	Instead of numbering paragraphs, descriptors from sediment management strategies 1-3 were added in parenthesis to each paragraph to make this clearer.	Yes.
6	MES	Main Report	ES-5	5th paragraph. I'll admit that I didn't check through the main report section for this, but it is not clear to me if the cost range in the first sentence ($5 to $90) is entirely related to physical removal of sediments, or if it also includes cost estimates for reduction of sediment delivery from the watershed. If the latter, the end of the first sentence can simply be changed from ".....yard of sediment removed." to "....yard of sediment reduced or removed."		Compton	Added a new sentence at the end of this paragraph. "Costs for reductions in sediment yield from the watershed were on the order of a one time cost of $1.5-$3.5 billion dollars which is estimated to manage approximately 117,000 cubic yards of sediment annually. "	Yes.
7	MES	Main Report, Chapter 1	8	last sentence 5th paragraph. Change "..chemical contaminants attached to them." to "associated with them."	contaminants may be attached or sorbed to the surface, or chemically attached, or simply present in the pore waters of fine grained sediments. Attached implies that they physically move with the sediments under changing geochemical states.	Compton	Concur. Change made.	Yes.
8	MES	Main Report, Chapter 1	10	last sentence of first paragraph. Change from "This assessment...." to "That assessment..."	This assessment would refer to this ACOE report, while I think you are still referring to the Hirsch effort.	Compton	Referring here to LSRWA effort. "LSRWA" added.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
9	MES	Main Report, Chapter 2	41	3rd paragraph which begins "However, erosional areas do occur…" should be changed to "However, historic data indicates that long-term erosional areas can occur…."	The MDNR report identified used historic data and there is no actual indication that the erosion or non deposition is occurring in the same areas at the present time. You might also consider adding the sentence "Erosion may or may not be dominant in these areas at the present time."	Compton	Concur. Change made.	Yes.
10	MES	Main Report, Chapter 2	49	Figure 2-16: Title should be …..1984-2013.	data extends beyond 2010	Compton	Concur. Change made.	Yes.
11	MES	Main Report, Chapter 4	95	Figure 4-9. Somewhere in the text there should be an explanation of "CFD", for the curve shown		Compton	Concur language revised in paragraph below figure 4-9. CFD is cumulative distribution function. For any modeled result where the exceedance in space and time (shown in Figure 4-9 as the area below the CFD reference curve, red line) exceeds the allowable exceedance (the area below the blue line that is shaded yellow), that segment is considered in nonattainment (U.S. EPA 2003a). The amount of nonattainment is shown in the figure as the area in white between the red line and the blue line and is displayed in model results as percent of nonattainment for that segment. The amount of nonattainment is reported as a whole number percentage. The CFD reference curve is based on observations of healthy ecosystem habitats for the assessed criterion where those observations exist with a default reference curve used in other areas (See Appendix D for more detail).	Yes.
12	MES	Main Report, Chapter 9	196	4th paragraph, first sentence: "Dredging limited quantities….Conowingo Reservoir cause a…" should be changed to "Dredging limited quantities….reservoir result in…"		Compton	Concur. Change made.	Yes.
13	MES	Main Report, Chapter 9	196	Second to last paragraph which begins "Strategic dredging had…" change the end of the last sentence from "….resulting from Tropical Storm Lee." to "….resulting from a storm with the same flow magnitude of a Tropical Storm Lee."		Compton	Concur. Change made.	Yes.
14	USACE-EN	Executive Summary	ES-1	Last paragraph, 2nd to last sentence, "The evaluations carried out through this assessment demonstrate that Conowingo Dam and Reservoir, as well as upstream Safe Harbor and Holtwood dams and their reservoirs, is no longer trapping sediment and the associated nutrients over the long term." should have the word 'is' changed to the word 'are'!	Grammar	Compton	Concur. Change made.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
15	USACE-EN	Executive Summary	ES-3	Last sentence has the first mention of dissolved oxygen, suggested adding the abbreviation (DO) after this first mention in the document.	Ease of reading	Compton	Concur. Change made.	Yes.
16	USACE-EN	Executive Summary	ES-5	Bullet 1. what are the Changed conditions we speak of here? Either briefly summarize here the changed conditions or have a callout to a specific section in the documentation.	Reader comprehension	Compton	No change to report made. Exec summary is a brief level. The changed conditions are discussed under the sub heading "Loss of Long-Term Sediment and Associated Nutrient Trapping Capacity" in the exec summary.	No.
17	USACE-EN	Main Report	Page 147	In the last paragraph on this page before table 6-2 why are we only looking at 192 acres in Maryland and over +100,000 acres in other states?		Compton	only a small portion of the Lower Susquehanna river watershed is in Maryland.	No.
18	USACE-EN	Main Report	Page 150	In section 6.3.4… Would agitation dredging negatively affect impellors on the turbines? Should we mention this?		Compton/ Balay	Possibly. But this method has been implemented elsewhere with success. Added following sentence to end of first paragraph on page 151: "Release of sediment through the turbines, in excess of what is transported normally during generation operations at higher streamflows, could cause significant damage."	Yes.
19	USACE-EN	Main Report	Page 151	Is Three Mile Island considered lower or middle?		Compton	Three-Mile Island is in the lower Susquehanna River watershed. It is located about 10 miles south of Harrisburg, PA. This site is in the LSRWA study area and the lower Susquehanna River sub-basin, as defined by USGS, NOAA, and others.	No.
20	USACE-EN	Main Report	Page 167	2nd paragraph, last sentence. The smaller BMPs will also need to be cleaned out and will not continue to reduce/remove sediment indefinitely.		Compton/ Michael	Language added at the end in "(although smaller BMPs will need to be cleaned out and maintained to continue to be effective).	Yes.
21	USACE-EN	Main Report	Page 181	3rd paragraph, talking about smaller BMP's. While it is a slow process in adding BMP's it could be done at a relatively cost effective rate and maintenance cost for the smaller facilities could be borne by local HOA's and not Federal/State interests.		Compton	OK. No language changed in report.	No.
22	USACE-EN			General thought. Right now we are going through the WV project and one of the things we state is that 4 of the top 10 events since 1865 have occurred in the last 20 years. May want to discuss climate change and the potential increase of the frequency of larger storms?	General Comment	Compton	Concur. This concept is discussed. Climate change is discussed in Section 2.2, 5.4, and Chapter 6.	No.
23	LS Riverkeeper	Main	ES-2	10% increase in load? Is this normalized to account for TS Lee, or does it include this?	Saying that there is a loss of trapping capacity because of the anomaly of two scouring events occurring in 2011 seems presumptuous.	Compton/ Scott	This range includes all flows during 2008-2011, which includes extreme events like Tropical Storm Lee as well as lower and moderate flows.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
24	LS Riverkeeper	Main	ES-3	Sediment settles out before the growth period for SAV?	Wouldn't this depend on the timing of the scour event?	Compton/ Cerco	Seasonality does play a role, which is why text indicates for most conditions examined. The report states accurately the results of the work conducted. We could perform more investigations, including moving the storm around to additional periods of the year. The additional investigations are not feasible at this time. Consequently, the report is limited to accurately stating the results of the investigations performed. Revised language indicates that if a storm events occurs during the SAV growing season some burial and light attenuation impacts could occur causing damage to SAV.	Yes.
25	LS Riverkeeper	Main	ES-5	As most decision-makers will not read this report, do we want to include a list of requested studies for information not obtained from LSRWA in the Executive Summary?	Including additional studies of physical effects of deposition on crabs, spawning areas, and SAV; nutrient cycling;4 effects of larger scouring events at 800,000, 900,000, and 1,000,000 cfs.	Compton	Recommended studies/information needs are laid out in section 9.1 and are not so easy to list out in a simple bulleted form, at least comprehensively. To keep the Exec summary concise we will keep the (4) overall summary statements of recommendations included currently.	No.
26	LS Riverkeeper	Main	P-19	The Susquehanna Flats are a natural feature, similar to any river delta, and that delta has existed for millions of years. Does everyone agree with the sentence- "The shallow character of the flats today is largely a result of anthropogenic sedimentation (Gottschalk, 1945). " ? Wouldn't it be better to be a little more precise by saying "The addition of 5-7 feet of sediment (or whatever number is accurate), giving the flats their shallow character today, is largely a result of anthropogenic sedimentation."?	It would seem that at best it would be a combination of natural and more recent (past 300 years) of anthropogenic impacts.	Spaur	Text changed too "Shallow waters of the Susquehanna River delta in the upper Bay expanded substantially in area following European settlement, and the expansive shallow flats that exist today largely derive from anthropogenic sedimentation (Gottschalk, 1945) (see Section 2.6.3)." Text in report does not get into total thickness or total age of delta - both more complicated topics dealing with Bay evolution and multiple bays over geologic time as sea-level has risen/fallen hundreds of feet).	Yes.
27	LS Riverkeeper	Main	P-34	1st Paragraph- Add the quantities of reductions in N, P, and sediment for context. How much has been reduced. This would also be good to emphasize total reductions from NY and PA's efforts.		Spaur	Add new sentence "With corrections to account for year to year variation in river flows, over the 20 year period from 1990 to 2010 TN loads delivered to the Bay from the Susquehanna River declined by 26%, while TP loads declined by 7%, and sediment loads declined by 17% (Langland et al., 2012)." Also add new reference: "Langland, M., J. Blomquist, D. Moyer, and K. Hyer. 2012. Nutrient and Suspended-Sediment Trends, Loads, and Yields and Development of an Indicator of Streamwater Quality at Nontidal Sites in the Chesapeake Bay Watershed, 1985–2010. U.S. Geological Survey. Scientific Investigations Report 2012–5093. 26 pages."	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
28	LS Riverkeeper	Main	P-55	Is Smith, et al., 2003 referring to the upper bay oyster habitat or is this a generalization? Is the Susquehanna currently experiencing "pre-European settlement conditions"? If so, is that on average? Does that take into account scouring events? During what period were the measurements done to quantify current "pre-European settlement conditions"? Was this a period that included a major scouring event?		Spaur	Smith and others (2003) sentence is a general statement on oysters' capability to survive sedimentation anywhere, it doesn't imply that it's specific to upper Bay. Sentence in earlier paragraph on page notes that oysters are most abundant elsewhere in Bay and nearest bed is ~20 miles from river mouth. In Bay where oysters occur, sedimentation today is occurring at about rate it did prior to pre-European settlement, as was covered in Section 2.6.3. Prior to European settlement, there was no major accumulation of sediment behind dams so nothing comparable to a scouring event of a major storm of today would likely have been produced. However, the nutrient and sediment loads from the watershed delivered during a major storm prior to European settlement would also likely have been vastly less than today. (Interestingly, nutrient loads from storms may have had positive impacts to SAV as indicated by Brush and others studies). So, I don't know that there's any value in attempting to speculate about this. Note that impacts of scouring from storms today is covered later in Section 2.7.4 on pages 56 and 57.	No.
29	LS Riverkeeper	Main	P-58	Improving passage of migratory fish through the dams is a topic of ongoing concern in reservoir relicensing." Should this be hydro-power project relicensing. I have never heard anyone refer to the reservoirs being relicensed.	End of 3rd paragraph	Spaur	Revise last sentence in paragraph 3 as suggested to "Improving passage of migratory fish through the dams is a topic of ongoing concern in relicensing of the Conowingo Dam hydropower project (CBP, 2013)."	Yes.
30	LS Riverkeeper	Main	P-63	Connectiv/ York Energy Center is a natural gas power plant at Peach Bottom, York County utilizing Conowingo Pool as their water source	http://www.keystoneedge.com/innovationnews/yorkenergycenter0616.aspx	Spaur	Add new row entry in last two columns of Conowingo Reservoir in Table 2-8 covering this. Entity: "York Energy Center." Usage: "water source."	Yes.
31	LS Riverkeeper	Main	P-70	Why does the chart say that Conowingo's license in 1980 was an "initial license"?		Compton	Instead of "Initial" chart should say "existing". On August 30, 2012, Exelon filed with FERC an application for a new license for its 573-MW Conowingo Hydroelectric Project, FERC Project No. 405 (Exelon, 2012). The existing license for the project was issued by FERC to Susquehanna Power Company and Philadelphia Electric Power Company on August 14, 1980, for a term ending August 31, 2014.	Yes.
32	LS Riverkeeper	Main	P-70	At, 2025, stating that the TMDL is met seems optimistic for a scientific document. Wouldn't "deadline for meeting TMDL requirements" be more appropriate?		Compton/ Linker	See your point, but will leave as is. Per EPA, the TMDL is mandatory, and is designed to ensure that pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025. EPA report is cited.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
33	LS Riverkeeper	Main	P-75	EPA has specifically refused to state that these changes would apply only to the Susquehanna. They have instead maintained a broad view that it would apply to NY, PA, and MD. If they have changed their position, I would like to see this in writing. Otherwise, this should not be stated this way in the document.	" In practical terms, this means that nutrient and sediment loads from the Pennsylvania, Maryland, and New York portions of the Susquehanna River basin would have to be further reduced to offset the increase in sediment and associated nutrient loads in order to achieve the established TMDL allocations and achieve the states' Chesapeake Bay water quality standards."	Linker/ Batiuk	The discussion of Appendix T (2010) on page 75 is entirely correct and changes are unwarranted.	No.
34	LS Riverkeeper	Main	P-77	I believe Muddy Run is in PA and requires a 401 certification from PADEP, which I believe they already received.		Balay	Last two sentences of final paragraph revised to: On June 3, 2014, PADEP issued a Section 401 Water Quality Certificate (WQC) for the Muddy Run project. On July 30, 2014, FERC issued a draft Environmental Impact Statement (EIS) for the relicensing of the York Haven, Muddy Run, and Conowingo projects. At the writing of this report, a new FERC license for the Muddy Run project is pending."	Yes.
35	LS Riverkeeper	Main	P-91	What is the explanation for why the WSM showed no scouring during the Jan 1996 storm?	"During the course of this LSRWA effort, it was determined that little or no scouring of reservoir bed material was calculated during the January 1996 flood event by the Chesapeake Bay WSM. As a consequence, computed solids concentrations, and potentially particulate nutrient concentrations, were less than observed. "	Cerco	Response added as a footnote: The WSM calculates deposition and scour. These processes are parameterized to improve agreement between computed and observed concentrations at the Conowingo outfall. However, there are no independent observations of deposition and scour. All that can really be calculated is the net difference between the two. The problem of correctly evaluating deposition and scour is acute during the rare erosion events that take place during the WSM application period (through 2002 at initiation of this study). The WSM can perform well for the majority of events but still miss rare and unusual events like the January 1996 storm. Apparently, the calculated scour during this event simply was not adequate.	Yes.
36	LS Riverkeeper	Main	P-96	Further explanation of this would be helpful. How does shifting the date reduce the uncertainty? This is not obvious to the reader and a sentence of explanation would be helpful.	"An additional source of uncertainty was that the January 1996 flow event was a very atypical storm event caused by a unique combination of snow melt and ice jams. This uncertainty was reduced by moving the storm's flows and sediment and associated nutrient loads to different seasons (June, October) to compare the storm's effects on Chesapeake Bay water and habitat quality."	Cerco	Some uncertainty in computed storm effects on Chesapeake Bay would result from considering solely a January storm. Bay response to storms in other seasons might vary. To reduce this uncertainty, the January storm was moved to June and to October. The June storm coincides with the occurrence of the notorious Tropical Storm Agnes, which resulted in the worst recorded incidence of storm damage to the Bay. The October storm corresponds to the occurrence of Tropical Storm Lee and is in the typical period of tropical storm events. This paragraph was added to report.	Yes.

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37	LS Riverkeeper	Main	P-105	At what depth of the core sample, and average of over what length of the core sample? For example, 20% in the first 3 feet of the core sample, representing the last 10 years.	"For example, in the lower portion of Conowingo Reservoir in 1990, particle size analysis from sediment cores indicated the area had about 5 percent sand; in 2012, it had 20 percent sand."	Langland	The percentage of sand in the cores is based on the top 2 feet of sediment. The results for 2012 are PROJECTED based on all previous cores. Changed sentence to: "For example, in the lower portion of Conowingo Reservoir in 1990, particle size analysis from 2-foot-deep sediment cores indicated the area had about 5 percent sand; in 2012, it was projected to have 20 percent sand based on all previous cores."	Yes.
38	LS Riverkeeper	Main	P-112	Eventual actual Dynamic Equilibrium must be met at some point, a point where the net deposition is zero, or at least approaches much closer to zero. It is illogical to say that the reservoir will always be at a state of 1 million ton per year deposition rate.	The net deposition for 2011 remains at 1 million tons per year. It is the same for "Full" condition.	Compton/ Scott	Net deposition is what sediment remained in Conowingo Reservoir during the 4-year simulation period as indicated in this chart. With a "full" bathymetry this 4-year simulation showed that on average 1 million tons deposited on average, a year. In dynamic equilibrium, long-term net deposition will be zero however deposition will still occur, until a scour event occurs.	No.
39	LS Riverkeeper	Main	P-113	Why were the increased sediment loads for 500,000 and 600,000 not included? These are important benchmarks.	Table 5-5	Scott	The purpose of this modeling simulation was - 1) there was a need to define the potential increase in scour after equilibrium, 2) 400,000 is the flow at which mass reservoir bed erosion occurs , and 700,000 was the highest flow in the 2008-2011 simulation, and 3) there was also a need to examine impact of scour at "full" condition for flows under 400,000 to see if the model could detect increased loads at flows lower than 400,000 cfs.	No.
40	LS Riverkeeper	Main	P-115	It would be good to include the date of the storm for comparison- October 2012	Hurricane Sandy	Compton	Added months to Sandy, Lee, and Agnes: "They are Hurricane Sandy (October 2012), Tropical Storm Lee (September 2011), the January 1996 "Big Melt," and Tropical Storm Agnes (June 1972). "	Yes.
41	LS Riverkeeper	Main	P-115-118	It would be helpful to include peak average flows in the text for all 4 storms for comparison, as was done for the 1996 storm. Figure 5-7 is helpful, but doesn't come in until after reading the narratives of each storm.		Langland	Peak instantaneous flows added for each event: Page 116, para 1, last sentence: "In addition, its peak discharge over Conowingo Dam in late October 2012 was only 155,000 cfs." Page 116, para 3, after 2nd sentence: "The peak Conowingo discharge during Lee was measured at 778,000 cfs. " Page 118, para 1, 2nd sentence, changed "Average peak flow for this event was 630,000 cfs." to "The instantaneous peak flow for this event was 908,000 cfs." Page 118, para 2, after 4th sentence added: "During the Agnes event, the flow over Conowingo Dam peaked at 1,098,000 cfs. "	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
42	LS Riverkeeper	Main	p-120	What is more important, peak flow or daily mean average, or some combination of the two? An explanation at this point could be helpful to readers.	"This methodology allowed the team to have a more detailed look at one scour event that was recent (Tropical Storm Lee) under various bathymetries (1996, 2008, 2011, and "full"). The AdH model estimated the impact of Tropical Storm Lee (approximately a 700,000-cfs event at peak discharge, with a 630,000-cfs mean daily flow) on the total load passing through the Conowingo Dam."	Scott/ Langland	See Comment 41.	No.
43	LS Riverkeeper	Main	P-121	So what were the scour loads from the upper two dams? When discussing the impacts of scour, are we only talking about Conowingo? It is addressed in the next paragraph, but without giving a total of scour impact. Adding the 4 million tons from the upper 2 reservoirs to the 3 million from Conowingo gives us just under 50% load caused by scouring.	"Regarding the contribution of Conowingo Reservoir bed scour to the total load to the Chesapeake Bay during a storm event, under 2011 bathymetry conditions, the sediment scour load (from the reservoir behind Conowingo Dam) during Tropical Storm Lee comprises about 20 percent of the Tropical Storm Lee total sediment load (about 3.0 million tons of the 14.5 million tons). This includes scour from the upper two reservoirs and loads from the rest of the Susquehanna River watershed."	Langland/ Scott	The first paragraph discuses just Tropical Storm Lee scour and total load, while the second paragraph disuses the entire 2008-2011 modeling scenario time period. The 3 million was increased during the Lee storm period (7 days) to 4 million. They are not additive. So in reality, instead of 3+4 it was 3+1. Last sentence in 2nd paragraph revised to say "....inflowing sediment rating curve for the AdH simulations was increased to ~~assumed~~ a maximum scour potential for the upper two reservoirs during Tropical Storm Lee of approximately 4 million tons.	Yes.
44	LS Riverkeeper	Main	P-121	Does this mean that as we improve watershed sediment control through BMPs and WIP implementation that the water (now carrying less sediment) will have a greater ability to scour reservoir sediment?	"The transport capacity of Conowingo Reservoir during a large flow event is strongly influenced by the sediment load entering into the system. Generally, the higher the inflowing sediment load, the lower the transport capacity and subsequent bed erosion in the reservoir."	Langland	While this statement follows logical concepts, I'm not sure it holds true in the 3 reservoir system. The transport capacity could be maximized in the upper reservoir, drop in the 2nd and regained in Conowingo. Text revised to say "The transport capacity of Conowingo Reservoir during a large flow event is strongly influenced by the sediment load entering into the system which could impact the transport capacity and bed scour and subsequent sediment transport through the reservoirs to the upper Chesapeake Bay.	Yes.
45	LS Riverkeeper	Main	P-122	This sentence makes no sense to me. Long-term storage has maximized. The ability to store more material has been minimized. Does this sentence mean, or should it be replaced with: "The ability to trap additional sediment in the reservoir system is much reduced compared to historical trapping."?	Sediment Transport, Storm Effects, and Scour Summary "Long-term sediment storage in the reservoir system is much reduced compared to historical trapping."	Compton	Yes change made. The dams are not trapping (and storing) as much as they were historically. "Sediment storage" has been replaced with "sediment trapping". This is discussed in numerous places in report but is not discussed explicitly in this summary section.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
46	LS Riverkeeper	Main	P-133	Could this be explained better? How do the numbers given here as a "first order estimate" compare with the numbers that we are using in state WIP's. For instance, PA needs to reduce TN by over 30 million pounds from the Susquehanna. Where does 4.4 million come from?	"EPA provided a first order estimate of the degree of Susquehanna River watershed nutrient pollutant load reduction needed to avoid estimated increases in DO nonattainment of 1 percent in the deep-water and deep-channel areas; this analysis is described further in Appendix D. A rough estimate of the load reduction needed Bay-wide is about 2,200 tons of TN (4.4 million pounds) and 205 tons of TP (0.41 million pounds) to offset the DO nonattainment in the deep channel and deep water areas. Estimates of the nitrogen and phosphorus pollutant load reductions from the Susquehanna River watershed needed to offset the 1-percent increase in DO nonattainment are about 1,200 tons of nitrogen (2.4 million pounds) and 135 tons of phosphorus (0.27 million pounds)."	Linker	As pointed out in the text, Appendix D provides details on the how the estimates were developed.	No.
47	LS Riverkeeper	Main	P-137	*"For most conditions examined"- I am concerned about this statement, and how it can be used to diminish the actual potential impacts. This research has only addressed January, June, and October. What are the effects of a March, April, May, July, and August storm? According to page 134, light attenuation can last for 90 days. Apply this to the eco-calendar on p. 117, Figure 5-5. What effects can we expect for each of the above monthly scenarios?	CBEMP modeling estimates showed that the sediment load (not including the nutrients that they contain) from Conowingo Reservoir scour events are not the major threat to Bay water quality. For most conditions examined,* sediments from bottom scour settle out of the Bay water column before the period of the year during which light attenuation is critical.	Cerco	The January storm is based on an actual occurrence. The October storm characterizes a storm during the usual tropical storm period. The June event characterizes the highly unusual tropical storm event Agnes. These runs establish principles. Winter storms pass without much effect. Late summer storms are not damaging because most of the SAV growing season is past. Late spring/early summer storms are potentially the worst. We could run an infinite number of occurrences. Each month. Early and late in each month. Each week in each month. The detailed results will change. The general principles won't change.	No.
48	LS Riverkeeper	Main	P-138	Is this a good place to emphasize the actual quantity or load of nitrogen added by scour, instead of using a percent comparison?	"The magnitude of nitrogen scour load has not been emphasized in preceding studies."	Cerco	The exact amount of scoured nitrogen load for numerous conditions is reported in Appendix C. Repeating those numbers is not necessary in a chapter entitled "problem Identification."	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
49	LS Riverkeeper	Main	P-151	While a statement regarding the cost of losing power production with little benefit to the environment is appropriate, the statement of purpose of the dams is irrelevant and improper. The operations of the dam are contingent on making every reasonable effort to reduce environmental impacts. This is equivalent to saying that there is no need to alter operations for fish passage because that is not the primary purpose of the dams. The first two sentences of this paragraph can be removed without impacting the meaning.	"Ultimately, the primary purpose for each of the lower Susquehanna River dams is to provide hydropower."	Compton/ Balay	Concur. Sentences removed.	Yes.
50	LS Riverkeeper	Main	P-161	HarborRock- "Material must be dried" listed twice?		Compton	Concur. Change made. Second mention, deleted.	Yes.
51	LS Riverkeeper	Main	P-171-174	Are the effects related in the table associated with the January 1996 storm occurring in January (Scenario's 8, 12,and 13 specifically)? What are the effects if this storm occurs in June?		Cerco	The scenarios were run for the January storm only. The order of magnitude for the response of DO and chlorophyll to dredging will likely not change for storms in other seasons.	No.
52	LS Riverkeeper	Main	P-180	This is a dangerous argument. The load per acre ratio is high. We have 3 dam reservoirs, an area of approximately 30 square miles delivering/ If you look at Table 6-9 on page 177, TS Lee was 65% of a 4-year load, and scouring was 21% of that. So for the 4 year period 3 facilities, with a 30 square mile footprint, contributed 13.65% of the total 4-year load of a 27,000 square mile watershed. This is a relatively LARGE load, and I believe that is the highest total load and percentage contribution of any facility/facilities in the Bay Watershed. Why is this a dangerous argument? Any BMP that requires annual implementation, taken individually, has little impact on the total load to the Bay. Why plant cover crops on a farm? One season's crop on one farm has little impact. Why spend money annually to manage manure? An argument or comparison of cost effectiveness per ton of sediment or pound of nutrient is valid, just like with all other BMP's. A blanket statement about the percent contribution toward reducing the total load is of definite concern and could be used against WIP implementation.	"Strategic dredging reduces bed sediment scour load. However, it is a relatively small contribution to the overall total sediment load dominated by watershed and upstream dam sources. Dredging limited quantities from depositional areas in the reservoir has a minimal impact on total sediment load transported to the Bay. Large periodic flood flows dominate sediment transport dynamics in Conowingo Reservoir. The amount of sediment passed through the dam during high flows, is significantly higher than the estimated bed scour load; thus, small reductions in bed sediment scour due to dredging operations provide minimal benefits in terms of sediment load reduction to the Bay over time. Strategic dredging had little effect on estimated water quality conditions in the Chesapeake Bay."	Scott/ Langland	The conclusions as stated are valid. Strategic dredging did not show a significant improvement to water quality. Removal of 1MCY while a large amount of material to remove, which is also high expense, is not a large amount in comparison to the total load entering the Bay during storms. Text here is not stating that the scour load is insignificant. It is stating that the amount dredged ends up being insignificant when it comes to improving water quality to the Bay. Carrying this argument further even when dredging/removing a more significant amount (back to 1996 bathymetry) at an even higher expense water quality conditions were still not improved significantly. This feeds into conclusions that the nutrients are the major water quality contributor, while removing, even large volumes of sediment, does not impact or meet water quality goals. What we really need is a comparison of the cost-effectiveness per ton of nutrient removal (phosphorus or nitrogen or both). Which is a recommendation, to develop nutrient focused measures. If we had that, we could assess the value of the BMPs versus direct sediment removal (dredging).	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
53	LS Riverkeeper	Main	P-190	Where did these numbers come from? I can find no significant reductions in phosphorus, let alone 55%. And dissolved inorganic phosphate has increased. See Marietta gauge at http://cbrim.er.usgs.gov/cgi-bin/loads12.p?STAID=1576000+--+SUSQUEHANNA+RIVER+AT+MARIETTA%2C+PA&PCODE=ALL&YEAR=ALL	"Over the past 30 years, due to widespread implementation of regulatory and voluntary nutrient and sediment reduction strategies, nutrient and sediment loads to the lower Susquehanna River are significantly lower than what was delivered in the mid 1980s. Total nitrogen (TN), total phosphorus (TP), and sediment have been reduced by 19, 55, and 37 percent, respectively (http://cbrim.er.usgs.gov/)."	Bryer/Langland	Text revised based on website review. "Flow adjusted contentraions of total nitrogen, total phosphorus, and suspended sediment concentration declined by 30, 40, and 45 percent, respectively, between 1985 and 2012 at Marietta, PA (see (http://cbrim.er.usgs.gov/).	Yes.
54	LS Riverkeeper	Main	P-192	I continue to be concerned about the fact that only June was analyzed for SAV effects, but then broad statements are made as if extensive evaluation was done. Specifically, only one month of the SAV growing season was analyzed, when the season can run from April to September, already in major decline by October. To analyze January, June and October, and then say, "For most conditions examined, sediments from bottom scour settle out of the Bay water column before the period of the year during which light attenuation is critical." is improper. Most conditions examined are 1 during the growing season and two not in the growing season. Of course "most conditions examined", being 2 out of 3 NOT during the growing season, will show little effect. I don't feel this is enough information to completely discount the effect of sediment in Finding #2. I would continue to include sediment in this finding. "Sediment and 'Nutrients associated with sediment scoured from the Conowingo Reservoir cause impacts to the upper Chesapeake Bay ecosystem'." It's OK to continue on that the nutrients are currently of bigger concern.	Finding #2- "Nutrients associated with sediment scoured from the Conowingo Reservoir cause impacts to the upper Chesapeake Bay ecosystem.	Cerco	The report accurately states the results of the investigations conducted. Additional model runs are not feasible at this time, nor are they necessary. The work conducted establishes principles. Winter storms pass without much effect. Late summer storms are not damaging because most of the SAV growing season is past. Late spring/early summer storms are potentially the most damaging. Detailed results from additional runs may differ from those conducted but the established principles will not..	No.
55	LS Riverkeeper	Main	P-193	Should this say "not suitable"?	"Modeling done for this assessment estimated that under current conditions (no WIP implementation), more than half of the deep channel habitat in the Chesapeake Bay is frequently not unsuitable for healthy aquatic life."	Compton	Concur. Yes change made.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
56	LS Riverkeeper	Main	P-194	This may be what the model says, but continuous scour and deposition, occurring at more frequent intervals and at lower flows, make this unlikely, if not impossible. If this were the case then there would be no scouring of the upper two dam reservoirs.	"So at some point, the bed will either not erode"	Compton/ Scott	This text is specifically talking about scouring at higher flows. There will come a point a high flow event where scouring will no longer occur due: "transport capacity and the ability of the reservoir bed to erode."	No.
57	LS Riverkeeper	Main	P-194	Again, are we only studying Conowingo? When you add the other two dams, scour is nearly 50% of the total load.	"These results imply that the Susquehanna River watershed located above the Conowingo Dam (including the two upstream reservoirs) provided 80 percent of the load during Tropical Storm Lee, with the remaining 20 percent from scoured bed sediment trapped in Conowingo Reservoir behind the dam."	Scott/ Langland	See Response to #43.	No.
58	LS Riverkeeper	Main	P-196	Again, this is a judgment for policy makers. A better approach would be to place the costs on a continuum of costs for BMPs. If it is too expensive, this will show it without making a judgment call. Urban reductions are also expensive. If we go too far with this argument it may be quoted against us in future efforts to gain urban WIP implementation.	"Increasing reservoir sediment storage volume yields minimal, short-lived benefits at high costs. Evaluation of a range of dredging alternatives did not yield any management strategies that could approach fully offsetting sediment and associated nutrient loads from the Conowingo reservoir due to scour events and provide meaningful, long-term Chesapeake Bay water quality benefits. Increasing or recovering sediment storage volume of the reservoirs via dredging or other methods is possible, and in some cases can effectively reduce sediment and associated nutrient scour. But analyses in the study indicate Upper Chesapeake Bay water quality benefits are minimal and short-lived, and the costs are high (Appendices C and J)."	Compton	We do lay out results of costs and impacts/effectiveness in report. However it is beneficial (and expected) for the team to draw conclusions based on the numbers that we see. Conclusions as stated here are supported by numbers presented. This is professional judgment of the team however implementation and meeting goals is ultimately an EPA/State matter.	No.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
59	LS Riverkeeper	Main	P-198	Add-a fourth area to build upon existing knowledge-Run models for storm flows of 800,000, 900,000, and 1,000,000 cfs.	Recommendation #1	Compton/ all modelers	Team has given this quite a bit of thought. We developed a brief paper on running an Agnes sized event. At this time we won't be recommending this. The simple answer is the LSRWA team would have made this run (along with other runs mentioned here) if data was available and existing modeling tools covered this period. However it is believed the reoccurrence of an event like Agnes (size and time of year) would cause severe impacts to the Bay from which it would take decades to recover. Accordingly, it was not believed that modeling to further clarify catastrophic effects would aid in decision-making, and thus it was determined that it was unnecessary to make the additional effort for synthesizing data and/or modifying modeling tools. Based on LSRWA results there is no amount of dredging/in-reservoir management that would reduce the impacts of an Agnes event in any meaningful way. For example during TS Lee modeling showed that the watershed load overwhelms the scour load so that mitigating the lesser scour load does not improve water quality. The case is the same for Agnes as well. Both the watershed and the scour are so immense that removal of sediment in reservoir is high cost and would not improve water quality conditions. In summary, though it would be an interesting exercise the expense needed to construct a model or simulation of Agnes is not	No.
60	LS Riverkeeper	Main	P-198	Add a fifth area to build upon existing knowledge-Determine effects on SAV during flow events applied to all growing season months - March through September.	Recommendation #1	Cerco	There's a large body of literature on this subject. For example Moore et al (1997) "Seasonal pulses of turbidity and their relations to eelgrass survival…" and Gurbisz and Kemp (2014) "Unexpected resurgence of a large submersed plant bed in Chesapeake Bay …" It's not a priority to add to this body of knowledge. Also, the ability to address effects of flow events with a model are limited. For example, burial and destruction from flood flows are not subject to mass-balance model approaches. It's not worth adding a fifth area to the recommended future investigations. One of the sub-recommendations already mentioned will cover this at least in general terms: "Determine impacts on shallow water habitats from reduced light availability and physical burial in the upper Chesapeake Bay due to delivery of scoured sediment from flood events. "	No.
61	LS Riverkeeper	Main	P-201	First paragraph should say "managers", not mangers.	"The importance of this long term monitoring is that it allows mangers to track and ensure effectiveness of implemented management strategies;"	Compton	Concur. Change made.	Yes.

Comment #	Agency	Main Report/ Appendix/Attachment	Page Number/ Section	Comment	Basis for Comment (if applicable)	Lead	Response	Report Change?
62	LS Riverkeeper	Main	P-201	Recommendation 4-1. A monitoring point at the state border would be advantageous, and may be necessary, to determine load allocations at the 2017 TMDL Mid-Point Assessment.		Langland	The state border is the middle of Conowingo Pond, not very conducive for flow and water-quality sampling. USGS has agreed to a short-term project where water-quality sampling and flow is being measures at Marietta, and Holtwood and Conowingo Dams.	No.

LSRWA-An Agnes sized event modeling scenario.
August 2014

This paper was developed with input from Carl Cerco (ERDC), Steve Scott (ERDC), Mike Langland (USGS), and Lewis Linker (EPA-CBP).

A. Background

For the LSRWA effort the team did not conduct a modeling scenario evaluating a Tropical Storm Agnes sized event. It was briefly discussed during scoping of the LSRWA effort but dismissed due to high cost, study time frame and lack of available data for a run like this.

Agnes occurred in June 1972 and has the highest recorded flows, highest scouring loads and is considered to have had the worst observed environmental impacts of all storms in Chesapeake Bay.

The LSRWA has received the comment that we should have conducted a modeling run of an Agnes sized event and impacts. The underlying concern is that this is really the worst case scenario and that we should know what this means to the Bay/reservoir system in its current state.

The simple answer is the LSRWA team would have made this run if data was available and existing modeling tools covered this period. However it is believed the reoccurrence of an event like Agnes (size and time of year) would cause severe impacts to the Bay from which it would take decades to recover. Accordingly, it was not believed that modeling to further clarify catastrophic effects would aid in decision-making, and thus it was determined that it was unnecessary to make the additional effort for synthesizing data and/or modifying modeling tools.

Based on LSRWA results there is no amount of dredging/in-reservoir management that would reduce the impacts of an Agnes event in any meaningful way. For example during TS Lee modeling showed that the watershed load overwhelms the scour load so that mitigating the lesser scour load does not improve water quality. The case is the same for Agnes as well. Both the watershed and the scour are so immense that removal of sediment in reservoir is high cost and would not improve water quality conditions.

In summary, though it would be an interesting exercise the expense needed to construct a model or simulation of Agnes is not conducive, since the simulations would still have high uncertainty and it would not provide additional management insight.

Below is a discussion on additional effort and various options to conduct an Agnes sized modeling scenario.

B. Agnes- sized event critical data gaps.

1. Reservoir bathymetry data is critical as data input for the 2D AdH model.

Reservoir bathymetry data for all three reservoirs both before and after Agnes does not exist in digital form to be readily used by existing computer models. Hand drawn maps may exist but this would require further investigation to confirm. USGS started collecting bathymetry data in 1990 in a digitized form (since 1990 there were four bathymetries conducted by USGS in all three reservoirs). Exelon would need to be contacted (Philadelphia Electric Company was the owner back in the1970's) and see if they have any records. Best case is that they would have hand drawn maps.

2. Data on flow and sediment entering and exiting the Reservoir system during a storm is critical as data input into HEC-RAS and 2D AdH models.

During Agnes there was no sampling at Conowingo Dam or Marietta (coordinated network water-quality monitoring really did not begin until the late 1970’s). Only Harrisburg has some record. Estimates of total load (30 M tons) and scour (20 M tons) were made by estimates of sediment thickness in the Upper Bay by Johns Hopkins University. There were supposed to be follow up studies, but these have not been located. The estimates were vague at best and based upon a previous study that reported yields based on land use types in the Susquehanna basin. The John’s Hopkins University estimate took sediment yields and multiplied by drainage area which was then compared to loads from the Susquehanna River Basin.

Also there was a conflict between the sediment load estimates based on yields and those based on limited cores in the Bay. The 20 M tons scour estimate is likely not reasonable for two reasons. First, at some point the river will reach sediment transport capacity and lose the ability to scour and second, bed and critical shear thresholds would limit the depth (and therefore the amount that can be scoured).

3. They hydrology of the time period that Agnes occurred in would need to be constructed for modeling.

The Chesapeake Bay Environmental Modeling Package (CBEMP) is based on a 1991-2000 hydrologic period which is not the time period that Agnes occurred. CBEMP was utilized to evaluate impacts to Chesapeake Bay from loads from the watershed and scour. This data would need to be built into the model and as discussed in #2 watershed loads and scour loads from this time period is lacking.

To make an appropriate simulation the CBEMP model require hourly rainfall though-out the Chesapeake Watershed in June 1972 to get the precipitation amount, intensity, and timing as well as land use. In reality we will never simulate anything close to Agnes, as this data is not available. All that can be done is to scale the Big Melt (1996 event) in the CH3D & Bay Model to Agnes like flows and estimate Agnes like loads. This alternate approach is discussed in Section D.

C. Agnes sized event scope (similar to LSRWA modeling scenarios).

1. A 2D AdH modeling grid for this simulation would need to be developed. As discussed earlier we don't know what the bathymetry was for this storm, so an estimate would need to be generated, and then mapped to the current modeling mesh.

2. All available sediment samples (concentrations and particle size) would need to be collected from this period.

3. Estimates could be made of the river transport (rating curves, land use yields, etc). It would be difficult to provide the data in a way that could be utilized by CBEMP.

4. Erosion characteristics with depth would be required which would require 6 ft vibracores in numerous locations. The SedFlume work alone for this is estimated to be 200k.

5. The total incoming load into Conowingo would need to be estimated.

6. Dam operations would need to be included in the model also, along with better methods for estimating particle flocculation.

The current AdH model does lack full dam operations capability and needs a more sophisticated method of accounting for particle flocculation. We would expect a more significant scour depth with the higher flows associated with an Agnes sized event, thus the 6 ft vibracores depths. Twice the amount of sediment could be potentially entering Conowingo, thus understanding the flocculation and fate of sediment would be a higher priority than for lower flow events like TS Lee. Although the current modeling has limitations, these limitations would be even more magnified for an Agnes event.

The field work, model development, boundary condition development, and model improvement, testing, and validation would probably have a cost of perhaps $400k. This would be for AdH/HEC-RAS component and does not include CBEMP component.

If this could be done, it would represent the most severe environmental effects (based on time and year and magnitude of flow, sediments, and associated nutrients). It has the potential for providing a range of conditions, but would be highly subjective based on the uncertainty of the input data.

D. Alternate-Agnes sized event scope

An alternate estimate approach would be to scale an existing storm to the Agnes level of flow and loads. For example in the LSRWA effort we moved the January 1996 event to June and October. There is potential to scale a recent event to an Agnes level storm. It would be a very first cut estimate. But as discussed previously the amount of data we have does not really support a very specific representation of Agnes.

For this alternate approach new field work and additional AdH simulations would not be required. A good rough estimate for an Agnes simulation would be our best estimate of total load leaving Conowingo which would be a combination of scour from the reservoir plus pass through load from upstream.

Below is one example of a calculation for estimating total loads and scour load for an Agnes event.

Estimate of Total load to the Bay from Conowingo Reservoir over a four year period that includes an Agnes Event.

1. The difference in recent Conowingo bathymetry surveys (2008 – 2011) indicated after the four years (and the Lee event) 8.8 million tons were deposited and 5.6 million tons were scoured (The TS Lee event data were taken from the comparison of surveys which is Appendix B of LSRWA report).

2. Assume 30 percent of bed scour stays in the reservoir, so scour load that leaves is 5.6 - (.3 * 5.6) = 3.9 million tons.

3. For the TS Lee event, assume 14 million tons (upper range) enter Conowingo. Load out = 14 + 3.9 - 8.8 = 9.1 million tons. 65% of total load passes to Bay.

4. For the TS Lee event, assume 10 million tons (lower range) enters Conowingo. Load out = 10 + 3.9 - 8.8 = 5.1 million tons. 51% of total load passes to Bay.

Estimate of Scour load to the Bay from Conowingo Reservoir during the Hurricane Agnes Event

1. Agnes has an estimated bed scour of 13.5 million tons (this estimate is based on USGS scour estimates and literature estimates which implies that this is the bed scour load that passes to the bay). Assume the total inflowing load during event is 20 million tons (lower range). Now the estimated total deposition is scaled by a factor of 2 (20 / 10), and is now 8.8 *2 or 17.6 million tons. Total Load out to Bay= 20+13.5-17.6 = 15.9 or 80 percent of total the load entering Conowingo during Agnes.

2. Now assume a total inflow load of 25 million tons (upper range), with total deposition scaled by 25/14 which is a scaling factor of 1.78. The mass balance is now 25 + 13.5 – 15.6 = 22.9 or 91 percent of the load inflowing load.

In summary, if you know the sediment load coming into Conowingo for the Agnes event, approximately 85 percent of it can be considered to be the total load passes to the bay. This would include both watershed load and bed scour. For example, if someone were to estimate the total load coming into Conowingo during Agnes to be 22 million tons, the load expected to pass through Conowingo would be 0.85 *22 million or 18.7 million tons. This is approximately twice the load that TS Lee passed considering the upper range of inflowing load (14 million tons).

Based on this total amount, a sediment rating curve can be developed using the hydrograph for Agnes, and the USGS data on sediment concentration measurements up to 700,000 cfs (TS Lee). This hydrograph can then be passed to CBEMP.

This method is a very rough approximating based on assumptions that the deposition will linearly increase from the Tropical Storm Lee event to the Agnes Event, and the estimation of scour for the Agnes event. The higher velocities and associated bed shear from Agnes may decrease sedimentation, thus increasing the load passed to the bay (greater than 85%). Additionally, a more accurate estimation of total load entering Conowingo for the Agnes event will potentially change the percentage of load discharged to the bay.

A CBEMP (CH3D) run and a couple of water quality runs with various hypothetical sediment management activities could be conducted. A rough estimate for this run would be $100K.