

Table of Contents

CHAPTER 1. INTRODUCTION	1
1.1 Project Authorization.....	1
1.2 Project Sponsors and Partners.....	1
1.3 Study Area.....	2
1.4 Purpose and Need	5
1.5 Significance	6
1.6 Problem Background	8
1.7 Watershed Vision.....	10
1.8 Goals.....	11
1.9 Assessment Products.....	11
1.10 Assessment Approach.....	14
CHAPTER 2. MANAGEMENT ACTIVITIES IN THE WATERSHED	19
2.1 Chesapeake Bay Restoration	19
2.1.1 Chesapeake Bay Agreements.....	19
2.1.2 Total Maximum Daily Load (TMDL).....	21
2.2 Sediment Management Investigations	25
2.2.1 SRBC Sediment Task Force	26
2.2.2 Scientific and Technical Advisory Committee (STAC).....	26
2.3 Federal Energy Regulatory Commission Relicensing.....	27
2.3.1 Safe Harbor Hydroelectric Station	27
2.3.2 Holtwood Hydroelectric Station.....	27
2.3.3 Muddy Run Pumped Storage Facility.....	27
2.3.4 Conowingo Hydroelectric Station	28
2.4 Water Withdrawal and Consumptive Water Use Regulations	28
2.5 Conowingo Pond Management Plan.....	29
2.6 Ecological Flow Management Study.....	30
CHAPTER 3. MODELING TOOLS AND APPLICATIONS	31
3.1 HEC-RAS Model.....	31
3.2 AdH model.....	33
3.3 CBEMP Model.....	37
3.3.1 Chesapeake Bay Estuarine Models	38
3.3.2 Chesapeake Bay Watershed Model.....	40
3.3.3 WSM Scenarios.....	42
3.3.4 1996 January High-Flow Event Scenario	42
3.3.5 Simulation of Sediment and Nutrient Loads to Chesapeake Bay	43
3.3.6 Assessment of Chesapeake Bay Water and Habitat Quality Responses	44
3.3.7 Chesapeake Bay Water Quality Standards Attainment Assessments.....	49
3.3.8 Water Quality Standards Assessment Period.....	51
3.3.9 CBEMP Uncertainty.....	51
3.4 Modeling Scenarios.....	52

CHAPTER 4. PROBLEM IDENTIFICATION.....	55
4.1 Future Conditions of the Chesapeake Bay Watershed.....	55
4.1.1 Population and Land Use Changes	57
4.1.2 Consumptive Water Use in Susquehanna Basin.....	57
4.1.3 Public Water Supply – Withdrawals Downstream of Conowingo Dam	58
4.1.4 Global Climate Change	58
4.1.5 Sea-Level Change	59
4.1.6 Chesapeake Bay Ecosystem Improvements.....	60
4.2 River and Reservoir Conditions and Implications to the Bay.....	60
4.2.1 Sediment Transport and Scouring Dynamics	61
4.2.2 Storm Effects and Implications	72
4.2.3 Environmental Implications.....	81
CHAPTER 5. DEVELOPMENT OF SEDIMENT MANAGEMENT STRATEGIES	103
5.1 Sediment Strategy Development Process.....	104
5.2 Reducing Sediment Yield from the Watershed	106
5.2.1 Concept-Level Plan and Costs for Watershed Alternatives.....	108
5.3 Minimizing Sediment Deposition.....	110
5.3.1 Sluicing.....	111
5.3.2 Density Current Venting.....	111
5.3.3 Flushing	111
5.3.4 Agitation Dredging	112
5.3.5 Screening Conclusions for Minimizing Sediment Deposition Alternatives	113
5.4 Increasing or Recovering Storage Volume.....	114
5.4.1 Hydraulic Dredging.....	114
5.4.2 Mechanical Dredging.....	115
5.4.3 Beneficial Reuse.....	119
5.4.4 Sediment Bypassing	120
5.4.5 Biological Dredging (Floating Wetlands).....	121
5.4.6 Upland Placement	121
5.4.7 Evaluation of Increasing and Recovering Volume Strategies.....	122
5.5 Development of Concept-Level Plans and Costs.....	123
5.6 Effectiveness and Impacts of Management Strategies.....	132
5.6.1 Strategic Dredging.....	137
5.6.2 Extreme Dredging.....	138
5.6.3 Long-Term Strategic Dredging	140
5.6.4 Sediment Bypassing	141
5.7 Sediment Management Strategy Results.....	143
CHAPTER 6. STAKEHOLDER INVOLVEMENT.....	149
CHAPTER 7. RECOMMENDATIONS FOR MODELING TOOL ENHANCEMENTS ...	153
7.1 HEC-RAS Model.....	153
7.2 AdH Model.....	153
7.3 CBEMP Model.....	154

CHAPTER 8. ASSESSMENT FINDINGS.....	155
8.1 Future Needs and Opportunities in the Watershed	164
CHAPTER 9. REFERENCES.....	169
CHAPTER 10. LIST OF ACRONYMS AND ABBREVIATIONS.....	183
CHAPTER 11. GLOSSARY OF TERMS.....	185
CHAPTER 12. LIST OF PARTICIPANTS.....	191

List of Tables

Table 1-1. Information on the Lower Susquehanna Hydroelectric Dams.....	5
Table 1-2. LSRWA Major Products.....	12
Table 2-1. Chesapeake Bay TMDL Load Allocations by Jurisdiction.....	24
Table 3-1. LSRWA Major Baseline and Future Conditions Scenarios.....	53
Table 3-2. LSRWA Major Sediment Management Modeling Scenarios.....	54
Table 4-1. Potential Measures to be Undertaken to Meet TMDLs.....	57
Table 4-2. Projected Sea-Level Rise for Baltimore, MD.....	59
Table 4-3. Hydrologic Parameters for the Marietta and Conowingo Gages.....	65
Table 4-4. Calculated Sediment Transport under Various Bathymetries ¹	69
Table 4-5. Additional Calculated Sediment Load Due to Increased Transport Capacity, 2011 vs. 1996.....	70
Table 4-6. Trapping Efficiency and Load Transport for Multiple Time Periods, 1928-2012.....	72
Table 4-7. Scour and Load Predictions for Various Flows in Conowingo Reservoir.....	78
Table 4-8. Summary of Modeling Simulations of Various Conowingo Bathymetries ¹	79
Table 4-9. LSRWA Major Baseline and Future Conditions Scenarios and Result Summary.....	82
Table 4-10. Conditions Controlling Storm Effects on SAV Beds.....	87
Table 4-11. Estimated Deep-Channel Dissolved Oxygen Nonattainment for Key Scenarios.....	91
Table 4-12. Estimated Deep-Water Dissolved Oxygen Nonattainment for Key Scenarios.....	92
Table 5-1. 2012 Estimated State Sediment Loads and 2010 Chesapeake Bay TMDL State Allocations for the Susquehanna River Watershed.....	107
Table 5-2. Examples of Units Costs for Urban/Suburban BMPs.....	110
Table 5-3. Estimated Costs to Implement the E3 Scenario.....	110
Table 5-4. Increasing or Recovering Storage Volume: Strategies with Fatal Flaws.....	122
Table 5-5. Evaluation of Increasing and Recovering Storage Volume Strategies.....	124
Table 5-6. Summary of Representative Alternatives.....	131
Table 5-7. LSRWA Sediment Management Scenarios and Results.....	133
Table 5-8. Comparison of Sediment Transport in Conowingo Reservoir: 1996 to 2011 ¹	139
Table 5-9. Comparison of Sediment Transport in Conowingo Reservoir with Tropical Storm Lee Percentage: 1996 to 2011 ¹	139
Table 5-10. Sediment Management Strategy Summary Matrix.....	147

List of Figures

Figure 1-1. Lower Susquehanna River Watershed.....	3
Figure 1-2. LSRWA Detailed Study Area.....	4
Figure 1-3. Chesapeake Bay Significance and Integrated Water Resource Management.....	7
Figure 1-4. LSRWA Modeling Areas	16
Figure 1-5. Flow Chart of Modeling Components and Applications	17
Figure 2-1. Major Watershed Management Activities.....	20
Figure 3-1. Location Map of HEC-RAS Model Area	32
Figure 3-2. Location Map of AdH Model Area	33
Figure 3-3. Numerical Mesh of Conowingo Reservoir for AdH.....	35
Figure 3-4. Numerical Mesh of Lower Susquehanna River and Flats for AdH.....	35
Figure 3-5. Chesapeake Bay Water Quality and Sediment Transport Model	39
Figure 3-6. Segmentation and Reach Simulation of the Phase 5.3.2 Chesapeake Bay WSM.....	41
Figure 3-7. Chesapeake Bay Segments	46
Figure 3-8. Chesapeake Bay Tidal Water Designated Use Zones	47
Figure 3-9. Minimum Oxygen Survival Requirements (mg/L)	48
Figure 3-10. Attainment Assessment of the Chesapeake Bay Water Quality Standards.....	50
Figure 4-1. USGS Scour Load Predictions with AdH Model Results	64
Figure 4-2. Flow Hydrographs for 11 Recent High-flow Events at Conowingo, MD	65
Figure 4-3. LSRWA Dynamic Equilibrium Concept.....	67
Figure 4-4. Additional Calculated Sediment Load Due to Increased Transport Capacity, 2011 vs. 1996.....	71
Figure 4-5. Timing of Storm Events Affects Ecological Impacts.....	73
Figure 4-6. Tropical Storm Lee vs. Hurricane Sandy Plumes in Upper Bay	75
Figure 4-7. Comparison of Major Historical Flow Events.....	77
Figure 4-8. Estimated Nonattainment of the Deep-Channel DO under Current Conditions	94
Figure 4-9. Estimated Deep-Channel DO Nonattainment for Scenario 3.....	96
Figure 5-1. LSRWA Sediment Strategy Development Process	105
Figure 5-2. Sediment Management Strategies.....	106
Figure 5-3. Pipeline to Transport Dredged Material	114
Figure 5-4. Clamshell Dredging Operations.....	116
Figure 5-5. Potential Placement Sites, Susquehanna River Watershed.....	117
Figure 5-6. Potential Placement Sites, Upper Chesapeake Bay.....	118
Figure 5-7. Potential Placement Sites, Lower Chesapeake Bay	118

Figure 5-8. Innovative Reuse Process for LWA 119

Figure 5-9. Schemes of Two Different Sediment Bypass Tunnel Systems..... 121

Figure 5-10. Schematic of Sediment Management Strategies..... 128

Organization and Purpose of Report

This Lower Susquehanna River Watershed Assessment (LSRWA) report includes a main document that discusses the assessment activities and findings. Appended to this main report are 11 appendices with various attachments that discuss more detailed technical findings as well as provide extensive and detailed back-up documentation to information and findings laid out in the main document.

The purpose of this report organization is to provide an overview of LSRWA activities and findings in the main report document, and also to have detailed discussion of technical analyses findings available to the reader in the appendices.

List of Appendices

Appendix A: Calibration of a One-Dimensional Hydraulic Model (HEC-RAS) for Simulating Sediment Transport through Three Reservoirs, Lower Susquehanna River Basin, 2008-2011

Attachment A-1: Additional Information for Susquehanna River at Marietta, Pennsylvania (01576000), and Conowingo, Maryland (01578310) and Conowingo Reservoir

Attachment A-2: Additional Information for Sand Distribution in Conowingo Reservoir

Attachment A-3: Additional Information for Estimation of Full Sediment Storage Capacity in Conowingo Reservoir

Appendix B: Sediment Transport Characteristics of Conowingo Reservoir

Attachment B-1: Evaluation of AdH Model Simplifications in Conowingo Reservoir Sediment Transport Modeling

Attachment B-2: SEDflume Erosion Data and Analysis

Attachment B-3: Change in Deposition and Bed Scour between the 2008 and 2011, Conowingo Reservoir Bathymetry Surveys

Attachment B-4: Modeling Analysis to Support Agitation Dredging in Conowingo Reservoir

Appendix C: Application of the Chesapeake Bay Environmental Model Package to Examine the Impacts of Sediment Scour in Conowingo Reservoir on Water Quality in the Chesapeake Bay

Attachment C-1: Data Assembly for Application of the CBEMP in the Lower Susquehanna River Watershed Assessment

Attachment C-2: Individual Results for Each Chesapeake Bay Environmental Model Package in the LSRWA

Appendix D: Estimated Influence of Conowingo Infill on the Chesapeake Bay Water Quality

Appendix E: Coastal and Environmental Geosciences File Report No. 14-05: Susquehanna River Flat Surficial Sediment Survey, Harford and Cecil Counties, Maryland

Appendix F: U.S. Geological Survey Conowingo Outflow Suspended Sediment Data Report

Appendix G: 2011 Exelon Conowingo Pond Bathymetric Survey Analysis: URS Corporation and Gomez and Sullivan Engineers (GSE). 2012b. *Sediment Introduction and Transport Study (RSP 3.15)*. Kennett Square, PA: Exelon Generation, LLC.

Appendix H: Literature Search Findings Report

Attachment H-1: Evaluation of Reservoir Sediment Management Implementation.

Attachment H-2: Literature Search Overview Presentation.

Appendix I: Stakeholder Involvement

Attachment I-1: Stakeholder Outreach Plan

Attachment I-2: Stakeholder Coordination Tracking

Attachment I-3: Press Releases

Attachment I-4: Study Initiation Notice

Attachment I-5: Resource Agency Coordination

Attachment I-6: Quarterly Meeting Summaries (Meeting enclosures, such as handouts and presentations, can be found at <http://bit.ly/LowerSusquehannaRiver>)

Attachment I-7: Stakeholder Review Comments and Responses

Attachment I-8: Public Comments and Responses

Appendix J: Plan Formulation

Attachment J-1: Sediment Management Options for the Conowingo Dam Restricting Sediment in the Watershed by Implementing Best Management Practices

Attachment J-2: Cost Documentation “Factsheets” and Summary Table of Costs

Attachment J-3: Summary Table of Sediment Management Alternative Evaluation

Attachment J-4: Summary Table of Major Modeling Scenarios and Results

Attachment J-5: Summary of Model Inputs and Results for Each Significant LSRWA Model Run

Appendix K: Existing Conditions of the Watershed