CLEAN CHESAPEAKE COALITION

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EXECUTIVE COMMITTEE

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C. PAUL SMITH
COUNTY COMMISSIONER

April 4, 2013

John B. Smith, Chief
Mid-Atlantic Branch Division of Hydropower Licensing
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Project No.: 405-106 - Maryland Conowingo Hydroelectric Project
Exelon Generation Company

Dear Mr. Smith:

Thank you for your letter dated March 29, 2013.

In your letter, you suggest:

> As a rule, staff does not meet separately with interested entities during the licensing process. Although we do not meet separately with interested entities, the Commission's integrated licensing process provides numerous opportunities for stakeholder input.

Preliminarily, we are not an "interested entity." The coalition members are local governments that have been provided the authority to engage in land use planning, to engage in watershed implementation planning, to adopt and enforce laws and rules relative to environmental impacts to the Chesapeake Bay and Bay tributaries, and to tax our citizens in order to fund Bay restoration endeavors. We are and remain concerned that FERC cannot coordinate or cooperate with us in those hopefully mutual endeavors if it refuses to meet with us and to obtain our input.

Since September 2012, we have not had any opportunity to provide input into the relicensing process. We have communicated with Emily Carter on a number of occasions to inquire how we might have input in the relicensing process. Ms. Carter, who has been very polite and responsive, has told us that we should not intervene until after FERC issues the "ready for environmental analysis notice." She further advised that information submitted before the "ready for environmental analysis notice" would not be considered until after that notice is issued. Our concern, particularly in light of recent developments, is that at that late juncture, our input will be meaningless.

We remain very concerned with the *Final Study Report, Sediment Introduction and Transport Study RSP 3.15, Conowingo Hydroelectric Project, FERC Project 405* that was prepared for Exelon by URS Corporation and Gomez & Sullivan Engineers, P.C. in August 2012. At a meeting on or about September 22, 2011, Michael Langland of the United States Geologic Survey told Exelon and the authors of the report that the report and the conclusions reached in the report were flawed and invalid because of the misplaced reliance on the HEC-6 model that was misused by Exelon's "experts" to interpret data. Specifically, Mr. Langland advised Exelon and its "experts":

> USGS determined the HEC-6 to be insufficient for reservoir modeling. The HEC-6 model is preferably used for bed movement and not designed for cohesive sediment dynamics. The USGS went into great detail explaining the model, the deficiencies, results and limitations of the HEC-6.[1]

Again, the Exelon Sediment Introduction and Transport Study misused the USGS information underpinning the report thereby reaching invalid and unsupported conclusions.

We thought Executive Order 13508 and the National Environmental Policy Act require FERC to communicate and coordinate with USGS about such matters. Yet, Exelon has not requested that the flawed Exelon Sediment Introduction and Transport Study be reworked using proper analytical methods.

Questions:

1. How can Exelon be permitted to rely on a sediment report that is premised on the misuse of a USGS model and USGS data?

2. Has FERC approved the *Final Study Report, Sediment Introduction and Transport Study RSP 3.15, Conowingo Hydroelectric Project, FERC Project 405* that was prepared for Exelon by URS Corporation and Gomez & Sullivan Engineers, P.C. in August 2012 without any additional information requests?

Ms. Carter advised that FERC would be issuing the "ready for environmental analysis notice" after the period provided to Exelon to submit additional information (*i.e.*, through March 29, 2013). Such notice has not yet been posted on the electronic docket maintained by FERC. We understand Exelon has requested that the period be extended for one hundred and twenty (120) days.

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[1] Attached to this letter are the comments provided by Mr. Langland to Exelon and its "experts" in September 2011. The quoted language is found on Page 15 of the redline version of the May 2011 report.

Question:

3. When does FERC anticipate that it will issue the "ready for environmental analysis notice"?

We note with interest the letter from Jay Ryan, Exelon's attorney, to Secretary Bose. The letter intimates that FERC will give preference to a "settlement" being negotiated by twenty-three (23) resource agencies and other stakeholders. More specifically, Mr. Ryan states:

> Exelon filed final license applications with FERC for the Conowingo and Muddy Run Projects on August 31, 2012 and August 29, 2012 respectively. Immediately thereafter, Exelon began contacting resource agencies and other stakeholders to begin negotiations on settlement terms and conditions to address key resource issues at the Projects over the new license term. Exelon and stakeholders met almost bi-weekly since October 2012 in large group setting at the Projects, and there have been numerous small-group meetings and site visits, conferences calls, and exchanges of information during that period.
>
> ...
>
> [T]he parties need additional time to complete negotiations, develop comprehensive settlement documents, and prepare an Offer of Settlement.
>
> ...
>
> Delaying issuance of the REA Notice, as the Commission has in other proceedings, will give the parties additional time to reach a comprehensive settlement that will resolve most, if not all, of the issues in the relicensing process for both Projects. This, in turn, will ease the Commission's administrative burden by reducing or eliminating the number of contested issues, facilitating environmental review, and allowing for a more expeditious conclusion to these relicensing proceedings.

(Footnote omitted.)[2]

Questions:

4. Who are the 23 settlement parties that that are negotiating a settlement with Exelon?

5. Does FERC maintain an administrative record of those settlement negotiations so that interested parties, interveners, and the public have access to such settlement

[2] A copy of Mr. Ryan's letter dated March 29, 2013 is attached to this letter.

proceedings and the documents and information being generated during such settlement proceedings?

6. How can the local governments that are members of the Clean Chesapeake Coalition ("CCC") obtain access to the settlement proceedings and the information exchanged during the settlement proceedings?

7. Why have the local governments that are members of the CCC not been invited to participate in such settlement negotiations?

8. Will FERC give any deference to any Offer of Settlement or any of the comprehensive settlement documents developed by the clique of twenty-three (23) settlement parties?

9. What *quid pro quo* is being and has been exchanged by the settlement parties and/or any officials representing the settlement parties?

10. What consideration if any will be given by FERC to any comprehensive settlement documents and any Offer of Settlement submitted during the relicensing process?

Needless to say, the process to date raises questions of procedural due process, to say nothing of the lack of transparency.

Sincerely,

Ronald H. Fithian
Chairman, Clean Chesapeake Coalition
Commissioner, Kent County, Maryland

Enclosures
cc: Kimberly D. Bose, Secretary
Emily Carter, Project Coordinator

58599.001:154175v2

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Jay T. Ryan
(202) 298-1878
jtr@vnf.com

March 29, 2013

VIA ELECTRONIC FILING

Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: Conowingo Hydroelectric Project, FERC Project No. 405
Muddy Run Pumped Storage Project, FERC Project No. 2355

Filing of Response to Additional Information Request and Request for Delay of Issuance of "Ready for Environmental Analysis" Notice

Dear Secretary Bose:

On December 28, 2012, Exelon Corporation, on behalf of its wholly-owned subsidiary, Exelon Generation Company, LLC (Exelon), filed its responses to all but one of the Federal Energy Regulatory Commission's (FERC) additional information requests (AIRs) for the Conowingo Hydroelectric Project (Conowingo Project) and the Muddy Run Pumped Storage Project (Muddy Run Project). On December 21, 2012, FERC granted an extension of time until March 29, 2013 for Exelon to file its response to request number 2 in FERC's AIR for the Conowingo Project regarding a cost estimate for potential sediment removal activities at several recreational facilities. Accordingly, Exelon encloses for filing its response to request number 2 in FERC's AIR for the Conowingo Project.

Pursuant to 18 C.F.R. § 5.22(a), after the licensee addresses any deficiencies in the application and provides responses to all AIRs, FERC will issue a "Ready for Environmental Analysis" (REA) Notice. The REA Notice will set the deadline for resource agencies to submit recommendations, preliminary terms and conditions, and preliminary fishway prescriptions for the Projects.

Exelon filed final license applications with FERC for the Conowingo and Muddy Run Projects on August 31, 2012, and August 29, 2012, respectively. Immediately thereafter, Exelon began contacting resource agencies and other stakeholders to begin negotiations on settlement terms and conditions to address key resource issues at the Projects over the new license term. Exelon and stakeholders have met almost bi-weekly since October 2012 in a large-group setting at the Projects, and there have been numerous small-groups meetings, site visits, conference calls, and exchanges of information during that period.

As a consequence, the settlement parties have made significant progress developing a conceptual framework for settlement, particularly with regard to fish passage and flow measures. Despite this progress, the parties need additional time to complete negotiations, develop comprehensive settlement documents, and prepare an Offer of Settlement. Exelon believes that issuance of the REA Notice will divert resource agencies' resources away from settlement negotiations in progress, and could lead to a trial type hearing. Accordingly, Exelon respectfully requests a 120-day delay in the Commission's issuance of the REA Notice.[1]

Additional time to complete settlement negotiations is warranted in these proceedings because the parties are attempting to reach consensus on settlement terms and conditions for two major projects, rather than one. This undertaking is further complicated by the fact that Pennsylvania has section 401 Clean Water Act jurisdiction over Muddy Run while Maryland has section 401 Clean Water Act jurisdiction over Conowingo. Additionally, there are approximately 23 settlement parties participating in settlement negotiations, including a number of state and federal resource agencies, national and local non-governmental organizations, and upstream licensees.

Delaying issuance of the REA Notice, as the Commission has in other proceedings,[2] will give the parties additional time to reach a comprehensive settlement that will resolve most, if not all, of the issues in the relicensing process for both Projects. This, in turn, will ease the Commission's administrative burden by reducing or eliminating the number of contested issues, facilitating environmental review, and allowing for a more expeditious conclusion to these relicensing proceedings. Moreover, the proposed 120-day postponement will not delay the Commission's overall relicensing process for the Projects, as the licenses do not expire until August 31, 2014 and September 1, 2014, and the Commission has not yet issued a procedural schedule for the remaining steps in the relicensing progress. Exelon also commits to file its water quality

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1 The Commission has not yet issued a procedural schedule for processing Exelon's application under the Integrated licensing Process. See Notice of Application Tendered for Filing with the Commission and Establishing Deadline for Submission of Final Amendments, Project No. 405-106 (issued Sept. 13, 2012).

2 *See, e.g.*, Letter from Ann Miles, FERC, to Jorge Carrasco, Seattle City Light, Project No. 2144-038 (issued Jan. 26, 2010) (granting licensee's request for FERC to refrain from issuing the REA Notice until the settling parties have filed offers of settlement and additional information responses); Letter from Ann Miles, FERC, to James A. Besha, Albany Engineering Corporation, Project No. 13-023 (issued Sept. 2, 2009) (granting licensee's request for FERC to refrain from issuing the REA Notice for over four months to allow parties to complete settlement negotiations).

certification applications with the State of Maryland and the Commonwealth of Pennsylvania at least one year in advance of the expiration of the project licenses.

Exelon and the settlement parties share a mutual goal and commitment to achieve a comprehensive settlement to resolve all of the issues relating to the operation and maintenance of the Projects during the new license term. Accordingly, Exelon respectfully requests that the Commission delay issuance of its REA Notice by 120 days, or until July 29, 2013, to allow the parties time to complete settlement negotiations and prepare an Offer of Settlement.

Exelon appreciates the Commission's consideration of this request. If you have any questions or require any additional information regarding this matter, please do not hesitate to contact the undersigned.

Respectfully submitted,

/s/ Jay Ryan
Jay Ryan
Counsel to Exelon Corporation

Attachment
Official Service List

CERTIFICATE OF SERVICE

Pursuant to Rule 2010 of the Rules of Practice and Procedure of the Federal Energy Regulatory Commission, I hereby certify that I have this day caused the foregoing document to be served upon each person designated on the official service lists compiled by the Secretary in these proceedings.

Dated at Washington, DC, this 29th day of March, 2013.

/s/ Jay Ryan

Jay Ryan
Van Ness Feldman, LLP
1050 Thomas Jefferson St., NW
Washington, D.C. 20007
(202) 298-1878

CONOWINGO HYDROELECTRIC PROJECT NO. 405-106
SUPPLEMENTAL RESPONSE TO NOVEMBER 2, 2012 FERC ADDITIONAL INFORMATION REQUEST

In correspondence dated November 2, 2012, FERC requested that Exelon provide additional information so that FERC may complete its environmental review. Exelon compiled a response to the requests submitted by FERC, and submitted this response in correspondence dated December 27, 2012. This submittal did not include a response to FERC's request for additional cost information related to dredging costs necessary to maintain Project related recreation (marina) facilities, as FERC had granted Exelon's request for an extension to March 29, 2013 to address this request. The response to this request is provided below.

Exhibit D – Project Costs. *In a footnote for table 4.5-1 in Exhibit D, you note that the cost for sediment removal activities related to recreational facilities will need to be determined. So that we can complete our developmental analysis, please provide a cost estimate for potential sediment removal activities.*

In order to address this request, information necessary to provide accurate costs of dredging had to be collected and compiled. This included information related to the composition of the dredge material, and the cost of removal of the material.

A determination on whether the existing material to be dredged from the river contains contaminants is a significant factor related to subsequent disposal costs. The cost differential between material which has no contaminants and material which contains known contaminants above regulatory limits prescribed by the states can be significant.

Sampling recently performed at the three sites revealed the presence of the heavy metal Cobalt in concentrations which do not meet current Pennsylvania state standards for the disposal of non-contaminated material. The Maryland Voluntary Clean Up Program does not regulate standards for Cobalt. The additional cost of disposal of contaminated dredge material is included for the Peach Bottom site located in Pennsylvania.

There are a variety of dredge methods available with each having its own cost variables, limitations, and logistical considerations. The two methods considered for this response are hydraulic and mechanical. The hydraulic dredge method considers the use of a 10-inch portable hydraulic dredge that digs and then pumps the bottom material as slurry to a not yet developed confined disposal site located within a mile of the dredge area. The mechanical dredge method considers the use of a small barge or Flexifloat mounted excavator that places the bottom material on an adjacent small barge or Flexifloat. The material barge is then pushed to land and unloaded by an excavator and transported to the adjacent parking lot and placed in a de-watering area. After de-watering, the dredge material will be treated by blending it with Portland cement to solidify the sediments, and it will then be transported and disposed at an approved Brownfield facility

Based on the continued consideration of both dredging options, the initial rough order of magnitude range of costs for the three recreational facilities is provided below:

DREDGE COST SUMMARY TABLE			
DREDGE OPTION & DISPOSAL	SITE		
	Conowingo Creek	Peach Bottom Creek	Broad Creek
Mechanical Dredge	$1,050,000	$2,500,000	$800,000
Hydraulic Dredge	$900,000	$1,350,000	$700,000
Contaminated Sediment Disposal	N/A	$3,000,000	N/A
Total Cost Range	$0.9 – 1.0 Million	$4.3 – 5.5 Million	$0.7 – 0.8 Million
	$5.9 – 7.3 Million		

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
BOX 25046 MS 406
Denver Federal Center
Denver, Colorado 80225

March 25, 2013

Michael Forlini
Funk & Bolton, P.A.
Twelfth Floor
36 South Charles Street
Baltimore, Maryland 21201-3111

Transmitted via Electronic Mail
Re: U.S. Geological Survey FOIA #USGS-2013-00061

Dear Mr. Forlini:

This letter transmits responsive documents pursuant to the Freedom of Information Act Request (FOIA) dated February 14, 2013 and referred to my office on March 8, 2013. The request was submitted by Mr. Ronald H. Fithian on behalf of the Clean Chesapeake Coalition. On March 14, 2013 the U.S. Geological Survey (USGS) verbally communicated with you to identify specific information being requested. The initial request was for:

> ".....any and all documents pertaining to the Conowingo Dam Hydroelectric project (located on the Pennsylvania/Maryland border on the Susquehanna River) from the Department of Interior's United States Geological Survey (USGS). Such records include reports, studies, reviews, evaluations, comments, and any and all communications relative to the Conowingo Dam Hydroelectric Project. Requested communications should include and not be limited to communications from the USGS to: Pennsylvania Department of Environment, Pennsylvania Department of Conversation and Natural Resources, United States Fish and Wildlife, the United States Department of Interior; the Federal Energy Regulatory Commission ("FERC"), and Exelon on matters related to the Conowingo Hydroelectric Project."

Pursuant to our call on March 14, 2013, the scope of the request was revised to narrow the request to USGS review and comment on the consultant's sediment study/modeling done as part of the FERC license. Michael Langland was identified as having had a conversation at a technical meeting/presentation indicating that the USGS had commented on the sediment study to Maryland Department of Environment (MDE). The request is for any letter(s) and/or any other documents (emails, etc.) relating to the letter to MDE or others pertaining to review of the consultant's sediment study.

Response Summary

Responsive information to the modified request is being transmitted in the enclosed two (2) electronic files.

If you consider this response to be a denial of your request under 43 CFR 2.28 (a) (2), you may file an appeal by writing to:

Freedom of Information Act Appeals Officer
U.S. Department of the Interior
Office of the Solicitor, Division of General Law
1849 C Street, NW
MS-6556
Washington, D.C. 20240

Your appeal must be received no later than 30 workdays after the date of this letter. The appeal should be marked, both on the envelope and the face of the appeal letter, with the words "FREEDOM OF INFORMATION APPEAL." Your appeal should be accompanied by a copy of your original request and this letter, along with any information you have which leads you to believe that responsive records do in fact exist, including where they might be found, if the location is known to you.

Also, as part of the 2007 OPEN Government Act FOIA amendments, the Office of Government Information Services (OGIS) was created to offer mediation services to resolve disputes between FOIA requesters and Federal agencies as a nonexclusive alternative to litigation. Using OGIS services does not affect your right to pursue litigation.

You may contact OGIS in any of the following ways:

Office of Government Information Services (OGIS)
National Archives and Records Administration
Room 2510
8601 Adelphia Road
College Park, Maryland 20740-6001

Email: ogist@nara.gov
Phone: 301 837-1996
Fax: 301 837-0348
Toll-free: 1-877-684-6448

We have assigned an individualized tracking number USGS-2013-00061 to your request. All future correspondence to USGS for this request should include this tracking number.
If you have any questions concerning your request, please contact me either by electronic mail kskipper@usgs.gov or by phone (303) 236-1477.

Thank you for your interest in the U.S. Geological Survey.

Sincerely,

Kenneth J. Skipper
U.S. Geological Survey
Water Resources Mission Area, FOIA Liaison

Enclosure: Two (2) electronic files

langland@usgs.gov **9/9/11**

to lowsusriver

Mike,
As of now, I'm planning on attending.

	Michael Langland, Hydrologist
U | S	Pennsylvania Science Center
-- + --	215 Limekiln Road
G | S	New Cumberland, PA 17070
	717-730-6953 (-6997 FAX)
	langland@usgs.gov

From: Lower Susquehanna Riverkeeper <lowsusriver@hotmail.com>

To: Michael J Langland <langland@usgs.gov>

Date: 09/08/2011 06:43 PM

Subject: Sept 22nd ! FW: Conowingo and Muddy Run FERC Relicensing Project (Relicensing Meeting)

Hey, Mike. I'm sure your busy with the current events, but the date has been set for Sept 22nd for the FERC meeting on sediment. Agenda attached. Let me know if you can make this. If not, let's get together or have a call so that I understand anything you've found in the Exelon study.

From the Mighty Susquehanna, Michael R Helfrich
Lower Susquehanna RIVERKEEPER®

Stewards of the Lower Susquehanna, Inc.
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CC: Colleen.Hicks@exeloncorp.com; JTR@vnf.com; tsullivan@gomezandsullivan.com; halfred.ryan@exeloncorp.com; Kimberly.Long@exeloncorp.com; robert.matty@exeloncorp.com; JHC@vnf.com; rbleistine@normandeau.com; sleach@normandeau.com; Dmathur@normandeau.com; tbrush@normandeau.com; johnmrinehart@verizon.net; Marjorie_Zeff@URSCorp.com; Bryan_Strawn@URSCorp.com; thoffman@gomezandsullivan.com; kgorski@gomezandsullivan.com; lkhitrik@gomezandsullivan.com; shaney@normandeau.com; glemay@gomezandsullivan.com

Subject: Conowingo and Muddy Run FERC Relicensing Project (Relicensing Meeting)

Date: Thu, 8 Sep 2011 14:28:23 -0400

Based on overall resource agency availability, Thursday September 22nd has been selected for a Conowingo and Muddy Run FERC relicensing meeting to discuss the following:

- Sediment Introduction and Transport Initial Study Report (Conowingo RSP 3.15)
- Follow-up discussion on the American shad population model (Conowingo RSP 3.4)
- Follow-up discussion on statistical analysis methodology related to the 2010 American Shad Telemetry and Attraction Flow Studies (Conowingo RSPs 3.5 and 3.6).

An agenda is attached. The meetings will be held at the Conowingo Visitors Center.

For those participating by phone, the call-in number is the following:
1-866-763-1619; Passcode 4531781#

If you have any questions or concerns, please contact Colleen Hicks or myself. Thanks.

Kirk Smith
Gomez and Sullivan Engineers, P.C.
41 Liberty Hill Road - Building 1
P.O. Box 2179
Henniker, NH 03242
T - 603-428-4960
C - 603-608-2540
F - 603-428-3973
ksmith@gomezandsullivan.com[attachment "September Initial Study Report Agenda.pdf" deleted by Michael J Langland/WRD/USGS/DOI]

All,

Please either update your availability on the Doodle poll or fill it out ASAP. I have to get this meeting set up within the next few days. Thanks!

Shawn

-----Original Message-----
From: Seaman, Shawn
Sent: Tuesday, August 09, 2011 11:18 AM
To: 'Mike Helfich'; 'Don Pugh'; 'Mark Bryer'; Halka, Jeff; Michael J Langland; 'Jim Spontak'; 'Andy Shiels'; ' (mihendrick@pa.gov)'; wcope@srbc.net; 'Andrew DeHoff'; 'Larry Miller'
Cc: Sadzinski, Bob A.; 'Steve Schreiner'; 'Bill Rickkus'
Subject: FW: Conowingo and Muddy Run FERC Relicensing Project

All,

I requested that Exelon set up a separate meeting for the sediment study and they agreed (see emails below). Now we need to figure out some dates that work for us. Please complete the Doodle poll I set up (link below) ASAP. I realize some of these dates are not good, I just blocked out 3 weeks.

http://www.doodle.com/amkt9ieteftx4k7v

* Please forward this message to anyone within your organization that may want to attend.

Thanks
- Shawn

-----Original Message-----

From: Tom Sullivan [mailto:tsullivan@gomezandsullivan.com]
Sent: Friday, August 05, 2011 9:01 AM
To: Seaman, Shawn; 'Kirk Smith'
Subject: RE: Conowingo and Muddy Run FERC Relicensing Project

Hi Shawn:

Your point is well taken. We can do the sediment discussion in September (Marjie Zeff is on vacation from 8/25 – 9/5). Please let us know what dates work for your folks and we will circulate some potential dates to other stakeholders. If you could do that soon it would help the other stakeholders with their scheduling.

To help us plan – could you give us some insight as to who MD may have attending and any specific issues you want to discuss?

Thanks
Tom

From: Seaman, Shawn [mailto:SSeaman@dnr.state.md.us]
Sent: Thursday, August 04, 2011 12:00 PM
To: 'Kirk Smith'
Cc: 'tsullivan@gomezandsullivan.com'
Subject: RE: Conowingo and Muddy Run FERC Relicensing Project

Kirk,

I looked at the attached agenda and have a concern that I'd like to discuss. I'm worried that we'll run out of time to adequately cover the sediment study. I'm glad to see you put it last on the agenda, but unless we fly through the other studies, there's no way we'll cover sediment and 5 other studies in 3.5 hrs or less. My suggestion is that you find another date (later) to discuss just the sediment study. There are several people who plan to attend just for this study so I think we need to be fair to them. Please let me know what you think ASAP.

- Shawn

-----Original Message-----
From: Kirk Smith [mailto:ksmith@gomezandsullivan.com]
Sent: Monday, August 01, 2011 4:51 PM
To: 'Al Blott'; 'Alex Balboa'; 'Alex Hoar'; 'Andrew DeHoff'; 'Andy Shiels'; 'Bill Rickkus'; Sadzinski, Bob A.; 'David Poe'; 'Donna Costango'; 'Dukes Pepper'; 'Eric Sennstrom'; 'Jacqueline Ludwig'; 'Janet Norman'; 'Jim Richenderfer'; 'Jim Spontak'; 'John Seebach'; 'John Seitz'; 'John Whittaker'; 'Juan Kimble';

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Subject: Conowingo and Muddy Run FERC Relicensing Project

Based on overall resource agency availability, Tuesday August 23rd and Wednesday August 24th have been selected for Conowingo and Muddy Run FERC relicensing meetings to discuss the following:

- Background presentation of the American shad population model (Conowingo RSP 3.4).
- Workshop to discuss statistical analysis methodology related to the 2010 American Shad Telemetry and Attraction Flow Studies (Conowingo RSPs 3.5 and 3.6).
- Discussion of the 2010 Relicensing Study Reports Issued after the February 22, 2011 FERC Initial Study Report filing.

A detailed agenda is attached. The meetings will be held at the Conowingo Visitors Center.

For those participating by phone, the call-in number is the following: 1-866-763-1619; Passcode 4531781#

If you have any questions or concerns, please contact Colleen Hicks or myself. Thanks.

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Subject: Conowingo and Muddy Run FERC Relicensing Project

Following up on our conference call discussion from June 30, Exelon would like to convene a two-day meeting at the Conowingo Visitors Center in late August to discuss the following:

1. Day 1=>Background presentation of the American shad population model (Conowingo RSP 3.4).
2. Day 1=>Workshop to discuss methodology for the 2011 Statistical Analysis for the American Shad Telemetry Study (Conowingo RSP 3.5).
3. Day 2=>Discussion of the 2010 Relicensing Study Reports Issued after the February 22, 2011 FERC Initial Study Report filing.

A more detailed agenda will be forthcoming, once meeting dates are settled upon. Per a suggestion from last week's conference call, please indicate your availability using the following doodle link. Thanks.

You have initiated a poll "Conowingo and Muddy Run Relicensing Meeting" at Doodle. The link to your poll is:

https://gomezandsulllivan.doodle.com/i44xs5zn524atimx

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Via Electronic Filing

May 6, 2011

Kimberly D. Bose Secretary

- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a net scour of 4,700,000 tons of sediment
- x Total estimated mass of sediment deposited in the system between surveys is 6,900,000

Federal Energy Regulatory Commission 888 First Street, N.E. Washington, DC 20426

Re: Conowingo Hydroelectric Project, FERC Project No. 405; Initial Study Report-Sediment Introduction and Transport Study (RSP 3.15).

Dear Secretary Bose:

Pursuant to the regulations of the Federal Energy Regulatory Commission (Commission or FERC), Title 18 Code of Federal Regulations (18 C.F.R.) § 5.15 (c) (1), Exelon Corporation, on behalf of its wholly-owned subsidiary, Exelon Generation Company, LLC (Exelon), encloses for filing the Initial Study Report-*Sediment Introduction and Transport Study* for the relicensing of the Conowingo Hydroelectric Project (Conowingo Project), FERC Project No. 405.

The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. Exelon is applying for license renewal using the FERC's Integrated Licensing Process (ILP). As part of the ILP, Exelon has previously filed its Pre-Application Document (PAD) and Notice of Intent (NOI) (March 12, 2009), Proposed Study Plan (PSP) (August 24, 2009), Revised Study Plan (RSP) (December 22, 2009), and Study Progress Report (October 19, 2010).

Exelon is filing this report with the Commission electronically. Exelon is also making the document available for download at its corporate website. To access the report here, navigate to http://www.exeloncorp.com/powerplants/conowingo/relicensing/Pages/overview.aspx.

In addition to this electronic filing with the Commission, paper copies of the report are also available upon request to Colleen Hicks (610-765-6791). Finally, Exelon is making available to the public the report at the Visitor's Center at Muddy Run Recreation Park in Holtwood, Pennsylvania, and the Darlington Public Library in Darlington, Maryland, during regular business hours.

If you have any questions regarding the above, please contact Colleen Hicks. Thank you for your assistance in this matter.

Respectfully submitted, Colleen E Hicks

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SEDIMENT INTRODUCTION

RSP 3.15

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405

AND TRANSPORT STUDY

RSP 3.15 CONOWINGO

HYDROELECTRIC

PROJECT FERC

PROJECT

NUMBER 405

URS Corporation

Gomez and Sullivan Engineers, P.C.

May 2011

Prepared for:

Prepared by:

EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Conowingo Project on February 4, 2010, approving the revised study plan with certain modifications. The final study plan determination required Exelon to conduct a Sediment Introduction and Transport Study.

The Conowingo Dam currently traps sediment and associated nutrients generated by erosion and upstream land uses. Previous studies have therefore suggested that ongoing operations of the Conowingo Hydroelectric Project have the potential to adversely impact the water quality of Chesapeake Bay by the release of sediment behind the dam as a result of a scour event associated with a major storm, or from the loss of sediment trapping capability when Conowingo Pond reaches its sediment storage capacity. Because sediment deposition and transport is a basin-wide, multi-dimensional issue, the goal of this Sediment Introduction and Transport study was to provide data for the future development of an overall sediment management strategy for the lower Susquehanna River and Chesapeake Bay by others.

This study involved three tasks: a review and compilation of existing information (Task 1); a quantitative assessment of sediment-related impacts of the Project on downstream habitat (Task 2); and an evaluation of options to manage sediment at the Project (Task 3). In conducting the tasks associated with this study,

Exelon tested the following assumptions underlying previous studies relating to the Project's potential effects: 1) 400,000 cubic feet per second (cfs) is the trigger flood event for scour; 2) the two upstream reservoirs—Lake Clarke and Lake Aldred—are at steady-state equilibrium with respect to sediment trapping; and 3) Tropical Storm Agnes (1972) was associated with a major scour event in Conowingo Pond.

Existing literature and data examined in Task 1 involved both regional and local published scientific investigations and Project-specific field studies. Specifically, Exelon reviewed: the sedimentary context of the Project area; previous studies of the Project area; relicensing field studies, which included a characterization of bank stability, shoreline erosion, and nearshore sedimentation; and additional relevant information, such as local bed level control by bedrock and tributary input. A key finding of Task 1 was that prior to the construction of Conowingo Dam, the river in the Project area was likely very similar to the condition of the river today downstream of the dam. A natural barrier existed at the site of the dam, and flow was strong enough to inhibit sediment deposition until near the mouth of the river.

In Task 2, Exelon performed three quantitative assessments to examine localized sediment-related impacts of the Project on downstream habitat. The first analysis calculated sediment entrainment potential ratios for different Project release scenarios by comparing bottom shear stresses to the critical shear stresses required to initialize and sustain mobility of substrates supporting persistent habitats for immobile life stages of biota. The second analysis tested hypotheses of earlier studies of potential scour in Conowingo Pond during major storm events. This was accomplished by using the HEC-6 model previously developed by the U.S. Geological Survey (USGS) for the lower Susquehanna River reservoir system. The third analysis used a regression equation developed by the USGS relating discharges at Conowingo Dam to quantities of bottom sediment scour in Conowingo Pond to compare with the HEC-6 results.

The HEC-6 results:

1 Do not seem to support the conclusion that the catastrophic impact to the Chesapeake Bay from Tropical Storm Agnes was due to scour from Conowingo Pond;

2 Suggest Lake Clarke is not in equilibrium and is, in fact, trapping sediment; and

3 Contradict the scour regression model which is predicated on a 400,000 cfs scour threshold.

Building on the results of Tasks 1 and 2, for Task 3, Exelon evaluated watershed-based sediment and nutrient management practices currently in place, including the Environmental Protection Agency's Chesapeake Bay Total Maximum Daily Load (TMDL) Program, which indicate that Best Management Practices (BMPs) from all sediment/nutrient source sectors are effective in reducing sediment and nutrient loads to Conowingo Pond. Exelon also examined traditional methods of preserving reservoir storage capacity and developed potential components of a proposed Sediment Management Plan for the Project. BMPs on Project lands that may be incorporated into a proposed Sediment Management Plan are:

x Stream restoration and stabilization to reduce erosion and provide habitat x Stream bank/channel stability assessment x

Riparian buffers

x

Natural/constructed wetlands

Finally, as part of Task 3, Exelon conducted a cumulative impacts analysis of Project relicensing on the lower Susquehanna River Basin and Chesapeake Bay. With or without a Sediment Management Plan, the cumulative impact of the Project will be to continue to reduce sediment and nutrient loads to the Chesapeake Bay until sediment storage capacity in Conowingo Pond is reached.

In addition to challenging the hypotheses upon which assumptions regarding Project impacts are based, this report identifies and highlights discrepancies and limitations of existing data and reveals the need for a single comprehensive and integrated analysis of the lower Susquehanna River watershed. The U.S. Army Corps of Engineers is currently planning to conduct such a study, which would include all three reservoirs, riverine processes in the Susquehanna River, and the tidal river mouth and upper Chesapeake Bay. This analysis would be able to better isolate Conowingo Pond scour from other sources of sediment passing the dam. The data provided herein will assist the Corps' analysis, as well as contribute to both ongoing and future efforts to develop an overall sediment management strategy for the lower Susquehanna River and Chesapeake Bay.

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1.0 Introduction

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt (MW) Conowingo Hydroelectric Project (Project). Exelon is applying for a new license using the FERC's Integrated Licensing Process (ILP). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014.

Exelon filed its Pre-Application Document (PAD) and Notice of Intent (NOI) with FERC on March 12, 2009. On June 11 and 12, 2009, a site visit and two scoping meetings were held at the Project for resource agencies and interested members of the public. Following these meetings, formal study requests were filed with FERC by several resource agencies. Many of these study requests were included in
Exelon's Proposed Study Plan (PSP), which was filed on August 24, 2009. On September 22 and 23,
2009, Exelon held a meeting with resource agencies and interested members of the public to discuss the PSP.

Formal comments on the PSP were filed with FERC on November 22, 2009 by Commission staff and several resource agencies. Exelon filed a Revised Study Plan (RSP) for the Project on December 22, 2009. FERC issued the final study plan determination for the Project on February 4, 2010, approving the RSP with certain modifications.

The final study plan determination requires Exelon to conduct a Sediment Introduction and Transport Study which is the subject of this report. The objective of this study is to provide data that will be useful in the future development of an overall sediment management strategy for the river and Chesapeake Bay. This is achieved by: 1) reviewing the processes influencing sediment transport past the Conowingo Dam to the upper Chesapeake Bay and the impacts of these processes; 2) assessing localized sediment-related impacts of project operations on downstream habitat to the downstream end of Spencer Island; and 3) discussing regional Best Management Practices (BMPs) that encompass the lower Susquehanna River drainage and sediment management options for Project lands.

2.0 Background

The Susquehanna River contributes about 50 percent of the freshwater discharged to the Chesapeake Bay (Bay) and, in a normal-flow year, about 25 percent of the sediment load and the greatest quantity of nutrients from non-tidal areas (nearly 66 percent of the nitrogen and 40 percent of the phosphorus transported to the Bay from the major river basins which contribute almost 90 percent of the freshwater) (Langland et al 1995; Langland 2009). Since their construction, the lower Susquehanna River hydroelectric dams (Safe Harbor, Holtwood, and Conowingo) have been trapping sediment and sediment-associated nutrients in their respective reservoirs (Lake Clarke, Lake Aldred, and Conowingo Pond). The lowermost dam, Conowingo Dam, represents the last barrier to sediment transport to the Bay.

The inference drawn from previous studies conducted in the Project area is that a potential effect of the ongoing operation of the Project is the impact to the Bay of a scour event associated with a major storm. This is based on these hypotheses:

1) 400,000 cfs is the trigger flood event for scour;

2) Safe Harbor and Holtwood impoundments are in equilibrium, and

3) Tropical Storm Agnes was associated with a major reservoir scour event in Conowingo Pond

These hypotheses are addressed in this report.

An additional hypothesis addressed is that there may be an impact to substrate character below the dam and the delivery of sediment downstream of Spencer Island.

To examine these hypotheses, it is necessary to consider the numerous overlapping and multi-dimensional sediment issues relevant to this Project. The literature survey provided in this report is intended to provide this background. Figure 2.0-1 provides an overview of the interrelationships of sediment transport issues addressed in this report (Task 1). Second, a HEC-6 analysis was conducted to test the aforementioned hypotheses and a sediment mobility analysis was conducted to examine potential downstream substrate effects (Task 2). Lastly, existing regional sediment management programs and in-reservoir sediment management options are discussed, and a list of actions Exelon can take on Project lands that offer the most beneficial impact with respect to sediment is presented (Task 3).

3.0 Review and Compilation of Existing Information (Task 1)

Figure 3.0-1 depicts the Project area for this report. The sources of existing literature and data in support of this report can be categorized as published scientific investigations of relevant disciplines, with and without a regional (lower Susquehanna River and upper Chesapeake Bay) or local (Project area specific) context, and unpublished Project-specific field studies. With this in mind, the review of existing literature and data is broken out into the following sub-sections:

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A number of field studies have been conducted to gather baseline data in support of the relicensing process. These studies include a shoreline inventory and habitat/wetlands surveys in 2006 – 2008 that yielded information on sediment erosion and deposition in the Project area. Studies conducted in 2010, concurrent with this report, provide additional data used as input to Task 2 analyses. A summary of these studies are provided in Appendix A.

3.1 Sedimentary Context of Project Area

Any discussion of sediment transport through a riverine system must consider river type – bedrock versus alluvial. The constraints on sediment movement in each are different. Existing literature and relicensing field studies indicate that the Project area can be divided into three types along a bedrock-alluvial continuum.

1) Holtwood Dam to downstream end of Hennery Island: little to no alluvial cover

2) Hennery Island to Conowingo Dam: continuous downstream thickening wedge of alluvial cover

3) Below Conowingo Dam: discontinuous surface of exposed bedrock or bedrock with a much thinner alluvial cover than in Conowingo Pond

This segmentation is an effect of the presence of the Conowingo Dam. Historical information and geological data suggest that prior to construction of Conowingo Dam the river had great enough energy and stream power throughout the Project area to sustain a mobile bedload with little sediment deposition until the river mouth was reached. The modern sedimentary setting, however, is one of interrupted sediment transport with significant sediment deposition in the lower Susquehanna River reservoirs. The sedimentary context of the Project area is discussed below to understand the response of this riverine system to the presence and operation of the Project.

3.1.1 Sedimentary Geology of the Lower Susquehanna River

Throughout the lower Susquehanna River in the Conowingo Project area the presence of bedrock is a major determinant of channel adjustment and sediment transport. In the Project area, the river transitions through different positions along a bedrock-alluvial channel continuum. This must be considered as an overprint on the sedimentary processes observed in alluvial systems. Sediment transport through the system must be understood within this context.

Alluvial channel morphology results from the entrainment, transport, and deposition of the unconsolidated sediments of the valley fill and floodplain deposits they traverse (Richards 1985). Alluvial river form "self-adjusts" in accordance with force-resistance relationships of flowing water and unconsolidated boundary sediments. In contrast, bedrock channel form and process are primarily governed by the physical character of the bedrock (lithology and structure) rather than the hydraulic and sediment-transport characteristics of the river (Ashley et al 1988). Channels with both bedrock exposures and accumulations of alluvium are intermediate between the extremes of alluvial and bedrock channels.

A useful sediment descriptor of the continuum between bedrock and alluvial channels is that of a "threshold" channel (NRCS 2007). The bed and bank of threshold channels are not easily mobilized by stream flow while alluvial channels are continuously or frequently reshaped by stream flow through erosion and deposition. Threshold channels are found where there are bedrock outcrops or coarse boundary materials.

The mobility and transport of an alluvial cover in a bedrock channel is complex (Turowski et al 2008a). A bedrock channel classification relevant to the Conowingo Project uses cover properties as its basis. Therein, a bedrock channel cannot substantially widen, lower, or shift its bed without eroding bedrock. End member types in this classification are: 1) channels confined entirely in bedrock with steep bedrock walls and exposed bedrock within the channel; 2) channels with steep bedrock walls, but thick alluvial cover in the bed; and 3) channels with an exposed bedrock bed, but set in an alluviated plain. The Conowingo Project, upstream and downstream of the Conowingo Dam, contains distinct conditions of bedrock exposure and alluvial cover that encompasses gradations of these types. These distinct conditions influence and greatly complicate the movement of sediment through the system.

In the gorge between Holtwood Dam and the downstream end of Hennery Island (the gorge), the river has little to no alluvial cover and can be classified at the bedrock channel extreme. From the base of Hennery

Island to the Conowingo Dam, the river is a bedrock channel with a continuous downstream thickening wedge of alluvial cover with a discontinuous distribution of consolidated and unconsolidated shorelines (see Appendix A). Below Conowingo Dam, the bed is a discontinuous surface of exposed bedrock or bedrock with a much thinner alluvial cover than in Conowingo Pond. There is a discontinuous distribution of consolidated and unconsolidated shorelines. Much of the unconsolidated shorelines within the bedrock channel are the consequence of rail embankment fill and former canal towpath berms.

Historical documents illustrating channel plan and profile prior to construction of the Conowingo Dam and recent investigations of the "strath terrace" landform prominent in the Conowingo Project area provide insight to the sediment regime of the Conowingo Project area prior to dam construction historically and during the recent geologic past of the Quaternary period (2.5 million years ago to the present).

The 1900 United States Geological Survey topographic map of the Susquehanna River in the project reach identifies "Amos Falls" at the present location of Conowingo Dam (Figure 3.1.1-1). Longitudinal channel profiles in Pratt (1909) (Figure 3.1.1-2), Matthews (1917) (Figure 3.1.1-3), and Knopf and Jonas (1929) (Figure 3.1.1-4) indicate a 20-foot drop associated with Amos Falls. The 1799 Hauducoeur map of the area shows two sets of falls between Octoraro Creek and Conowingo Creek (Hector's Falls and Amos's Falls)[1] (Figure 3.1.1-5). Other rapids and falls are noticeable on early maps and mentioned in contemporary descriptions of navigation through the river. Most notable of these are Bald Friar Falls and Smiths Falls, above and below the Conowingo Dam, respectively. Brown (2010) offers this description of accounts of the river between Peach Bottom and Smith Falls:

> The nine mile stretch from Peach Bottom to below Smith Falls was another test of the pilot's skill. The gradient on this stretch of the river is 4.49 feet per mile (Shank 1986), 35 percent less than the upper gorge, but still much faster than on the upper river. Before entering Maryland the mile wide river narrowed to 32 navigable feet at Fanny's Gap (Magee 1920). Beyond Fanny's Gap was Bald Friar Falls in Maryland, in which lay the infamous Hollow Rock, which claimed many lives in later years. At Amos Falls was the notorious Job's Hole which, if a body were dropped into it, it was never seen again (Brubaker 2002). Smith's Falls

[1]The Amos Falls of the USGS map is the Hector's Falls of the Hauducoeur map.

was more a barrier against going up river than a riffle, for it consisted of numerous rocks protruding from the water.

The pre-construction Labelle survey (1920) extends about two miles upstream of Conowingo Creek to about a half-mile downstream of Octoraro Creek. This survey identifies the locations of Hector Falls just upstream of where the dam would be placed and the beginning of rapids near Glen Cove opposite Conowingo Creek[2] (Figure 3.1.1-6 and 3.1.1-7).

Prior to construction of Conowingo Dam, the river in the modern impoundment and below the dam was a difficult-to-navigate bedrock channel. This is further substantiated by the studies of strath terraces in the project area and exposed bedrock surfaces in the gorge reach summarized below (Pazzaglia and Gardner 1993; Pazzaglia et al 1998, 2006, 2010; Reusser et al 2004, 2006).

Straths are erosional surfaces formed on the channel floor by bedload abrasion. Lateral erosion cuts wide straths during periods of prolonged base level[3] stability. During episodic pulses of accelerated vertical incision the strath surfaces are elevated and abandoned above river margins to produce a terrace landform. Straths are mantled with coarse alluvium representing the bedload transported through the river when the surfaces were cut; their thicknesses represent scour and entrainment depths of the prevailing flow. Along the project reach of the Susquehanna River, Quaternary strath terraces have been identified and mapped in all three bedrock-type reaches distinguished.

At the confluences of Muddy Creek, Fishing Creek, Broad Creek, Octoraro Creek, Deer Creek strath terraces are preserved 30 to 50 meters above the present channel. The alluvium consists of clasts ranging 2 to 8 cm with an occasional 1-meter boulder. Other terraces, 6 and 12 meters above the present channel, occur along the Susquehanna and Tidewater Canal and Conrail tracks at Peach Bottom, Muddy Creek, Octoraro Creek, and downstream of the Conowingo Dam to the river mouth. In the gorge area, a gravel mantled terrace 20 meters above the modern channel is present along the west bank from Holtwood Dam to Muddy Creek. Other strath surfaces are exposed along the sides of the gorge and on island tops without an alluvial mantle other than some boulders.

The correlation of strath ages and riverine deposits at the mouth of the modern Susquehanna River suggest strath formation was coincident with river sedimentation at the mouth of the ancestral Susquehanna River. This suggests that the Quaternary history of the lower Susquehanna River was one

[2]The rapids at Glen Cove are the Amos Falls of the Hauducoeur map. [3]Base level is the lowest level towards which a stream can erode, e.g., sea level for coastal streams.

of a river with great enough energy and stream power to sustain a mobile bedload with little sediment deposition until the river mouth was reached. Though this characterization reflects processes over recent geologic time, and is not a snapshot in time that can be directly extrapolated to a historic time scale, the historic maps and contemporary communications noted above suggest this may also have been the condition of the river prior to dam construction.

3.1.2 Modern Sedimentary Setting

Fine-grained suspended sediment and particle-bound and dissolved nutrients (nitrogen and phosphorus) originate within the Chesapeake Bay watershed from upland erosion by different land uses (e.g., agriculture, mining, construction) and from stream corridor erosion (channel bed and banks) (Gellis et al. 2003, 2005). Sediment also originates from the ocean and from within the Bay itself (shoreline erosion, coastal marsh erosion, biogenic material) (Langland et al. 2003). Dissolved nitrogen and phosphorus are transported to surface waters by point source discharges, runoff and soil water, and groundwater (Phillips and Lindsey 2003).

In a year of normal or average stream flow, the Susquehanna River contributes nearly 50 percent of the freshwater discharge to Chesapeake Bay and about 25 percent of the sediment load from non-tidal areas (Langland et al 1995; Langland 2009). The Susquehanna River is the major source of sediment to the northern bay (Langland et al. 2003). Agriculture is the dominant source of nitrogen and phosphorus to the Susquehanna River Basin (Sprague et al. 2000).

Before reaching Chesapeake Bay, sediment originating from upland erosion is stored within the watershed on upland surfaces (e.g., bases of hillslopes, swales and depressions), in reservoirs and impoundments behind dams, and on floodplains (Herman et al. 2003). During storm events, sediments delivered to impoundments, and sediment already stored within impoundments, are made available for transport, deposition, resuspension (scour) and redeposition. Conowingo Pond is the largest of the three lower Susquehanna River reservoirs with a surface area of 9,000 acres. By comparison, the surface areas of Lake Clarke and Lake Aldred are 6,080 acres and 2,560 acres, respectively[4]. The design water-storage capacities of the three reservoirs are 150,000 acre-feet (Lake Clarke)[5], 60,000 acre-feet (Lake Aldred)[5], and 310,000 acre-feet (Conowingo Pond). After construction, the reservoirs began fill with sediment.

[4]Lake Clarke and Lake Aldred surface areas are converted from square miles provided in Hainly et al (1995). [5]From Hainly et al (1995)

Previous reports suggest the two upper reservoirs, Lake Clarke and Lake Aldred, have reached a state of equilibrium (steady-state) with respect to sediment deposition. That is, these reservoirs no longer store increasing volumes of sediment and have reached their sediment-storage capacity. While sediment continues to be deposited and eroded from those reservoirs and transported downstream to the next reservoir, there is a net throughput of sediment. In contrast, there is a net deposition of sediment in Conowingo Pond. That is, Conowingo continues to "trap" sediment. Updated storage-capacity curves indicate that water storage capacity of Conowingo Pond is currently 162,000 acre-feet (Langland 2009).

Lake Clarke, created in 1931, was surveyed in 1931, 1939, 1940 1950, 1951, 1959 and 1964 (Reed and Hoffman 1997; Langland and Hainly 1997). Based on these surveys, the water storage capacity of the reservoir decreased from about 145,000 acre-feet* in 1931 to about 81,000 acre-feet in 1950. Much of the deposition during this time was sand and coal which was dredged each year from 1954 to 1972 as part of a coal-recovery operation. A survey conducted in 1964 indicated that the dredged material was being replaced by the deposition of incoming sediment. Subsequent surveys have been conducted 1990, 1993, 1996, and 2008. Since 1950, only small changes in water capacity have been measured, suggesting the reservoir reached a state of equilibrium (steady-state) with respect to sediment deposition since 1950. However, Langland (2009) reports that a net deposition of 1,700,000 tons of sediment occurred in Lake Clarke between 1996 and 2008.

True. This survey was completed in the late summer of 1996. Capacity was added from the scour from the 1996 storm event and therefore some re-deposition was expected.

Lake Aldred, created in 1910, was surveyed in 1939, 1950, 1961, 1990, 1993, 1996, and 2008. Reed and Hoffman (1997) report that the decrease in quantity of sediment stored in the lake from 1939 to 1961, identified in the 1961 survey, is attributable to decreasing sediment loads reaching the lake after the construction of Safe Harbor Dam in 1931. Reed and Hoffman (1997) concluded that since Lake Aldred is about half the size of Lake Clarke, and Lake Clarke reached equilibrium with sediment transport in about 20 years, Lake Aldred probably reached a state of equilibrium in 10 years, (i.e., around 1920). However, Langland (2009) reports a net deposition of 1,000,000 tons of sediment occurred in Lake Aldred between 1996 and 2008.

See note in red above concerning the additional capacity from the 1996 flood event.

The Academy of Natural Sciences of Philadelphia (1994) more aptly describes the steady-state equilibrium condition of this reservoir system as a punctuated equilibrium. That is, periods of gradual accumulation are punctuated by episodic flood-driven scour events with stochastic timing and magnitudes unable to be predicted with certainty. What can be predicted with confidence, however, is that the long term average level of stored sediment in the reservoirs will be below their non-flood

Exactly what happened as discussed above.

*The value 145,000 acre-feet does not agree with the design capacity value of 150,000 acre-feet reported in Hainly et al (1995).

steady state levels because of sporadic scouring by major floods.

Agree, and I also mention that in the 2008 report. The concept is that the reservoirs will be in a state of quasi-equilibrium dependent on scour events and subsequent re-filling of the capacity.

The Academy report also points out that the actual quantity of sediments derived from the three reservoirs during major floods, rather than from other reaches of the lower Susquehanna River or from its floodplain, needs to be more accurately estimated than has previously been done so that the impact of the reservoirs can be isolated from the impacts of other sources of sediment during these events.

Agree, the USGS has and continues to improve a regression equation to predict scour form the reservoirs in high flow events.

3.2 Previous Studies of Project Area

Numerous empirical and simulation sediment studies have been conducted by USGS and others in the Project area. These include quantitative studies on sediment accumulation rates, storm event scour, reservoir storage volume, sediment-storage capacity, sediment chemistry, sediment and nutrient loads, and sediment transport modeling. These are summarized below. Key parameters are tabulated in Table 3.2-1.

3.2.1 Sediment Accumulation

USGS has compared historic bathymetric surveys (1929, 1959, 1990, 1993, and 1996) and its most recent 2008 survey to identify areas of net sediment accumulation, net sediment loss, and scour (Langland 2009; Langland and Hainly 1997; Reed and Hoffman 1997) in Conowingo Pond. Langland and Hainly (1997) depict discrete areas of scour and deposition (between 1993 and 1996) as a plan view map. In contrast, Reed and Hoffman (1997) illustrate cross-sectional vertical changes 1959-1993. Each study quantifies net sediment gains and losses overall in three sections of the reservoir – upper, middle, and lower reservoir sections.

Bathymetric data, in combination with sub-bottom profiling (for sediment thicknesses), bottom-sediment sampling (for grain-size distributions), and sediment transport modeling (see Section 3.2.6) have been integrated in these USGS studies to evaluate sedimentary processes active in the reservoir. The following is a summarization of these USGS investigations.

The 3.2-mile section of the reservoir immediately below Holtwood Dam downstream to Hennery Island experiences high water velocities due to releases from Holtwood Dam, discharges from the Muddy Run Pump Storage facility, and a naturally narrow channel. As a consequence, appreciable sediment deposition does not occur here. Similar to a wedge of sediment, thicknesses increase downstream ranging 0-10 feet in the upper section below Hennery Island, 10-20 feet in the middle section, and greater than 20 feet in the lower section below Broad Creek to the Conowingo Dam. Most of the sand in the bottom sediment of the reservoir is found in the upper section (45 percent sand and 7 percent clay) with only 5 percent sand (35 percent clay) in the sediment immediately above the dam. Coal content ranges 2-30 percent throughout the reservoir.

USGS has converted bottom elevation changes in bathymetry to masses of sediment, assuming an average density of dry sediment of 67.8 pounds per cubic foot. This has allowed areas of sediment accumulation (and scour) to be quantified and trends in sediment accumulation identified. The spatial distribution of accumulation has been related to hydraulic parameters such as flow velocity and discharge. Sediment deposition has also been compared with sediment load estimates entering and leaving the reservoir.

An updated 2009 report calculates: 1) approximately 12 million tons of sediment was deposited in Conowingo Reservoir between 1996 and 2008 with all of the deposition occurring in the lower reaches of the reservoir; 2) there was a net sediment loss of 1.8 million tons in the middle reservoir; and 3) a net deposition in the lower reservoir of 13.8 million tons. The reservoir above the Peach Bottom Power Plant displayed little volumetric change and several of the USGS studies suggest that this portion of the reservoir has reached equilibrium with sediment deposition and storage capacity.

3.2.2 Sediment Scour

As noted above, scouring during major flood events interrupts "steady-state" periods of reservoir filling (Academy of Natural Sciences of Philadelphia 1994). The dynamics of sediment and nutrient storage in the reservoir system can more accurately be described as periods of gradual accumulation (net deposition) punctuated by scour events (major storms) that remove stored sediment and increase storage capacity. A flood pulse of sediment and nutrient loading to the Bay is followed by a decrease in loading as deposition replaces scoured sediment. The impact of this process on sediment and nutrient loading to Chesapeake Bay is to alter the timing of sediment and nutrient delivery to the Bay (more during major floods and less during non-flood periods).

The most in-depth previous analysis of sedimentary processes in the lower Susquehanna River reservoir system during major storm events can be found in Langland and Hainly (1997). Analytical approaches to quantifications described in that report rely on the works of Gross et al (1978) and Lang (1982) which established 400,000 cfs as the stream flow above which sediment is scoured from the lower Susquehanna River reservoirs and carried downstream.

Gross et al (1978) originally suggested this value as the scour threshold in the reservoirs noting that the quantity of suspended sediment passing the USGS Harrisburg station is less than the suspended sediment load measured at the USGS station at Conowingo Dam at peak daily discharges exceeding 400,000 cfs.

Lang (1982) compared suspended sediment concentrations at the Harrisburg and Conowingo stations during three high flow events – March 1979, March 1980, and February 1981 (Figure 3.2.2-1). The author concluded that the source of sediment to account for the greater suspended sediment load at Conowingo Dam than at Harrisburg during the March 1979 storm (peak discharge >400,000 cfs) is the resuspension, or scour, of sediment behind the lower Susquehanna River dams. Neither of these reports, however, provides data on the river channel or the suspended sediment load between Harrisburg and Conowingo. This is a data gap that affects the logic of 400,000 cfs as a scour threshold for the reservoirs.

Visually, there is distinct color change generally from light to medium brown to darker brown and greys at and above 400,000 cfs. This is thought to be resuspension of anaerobic sediments.

Subsequent analysis of sediment loads coming in from the major tributaries within the reservoirs conclude there is a "net" increase of approximately 5-10 percent. This is mentioned in the next few paragraphs (footnote 7)

Langland and Hainly (1997) identified areas of sediment scour and sediment deposition in the lower Susquehanna River reservoirs by comparing bottom elevation contours of bathymetric surveys conducted in 1993 and 1996. Scour was assumed to be the consequence of resuspension by flows greater than 400,000 cfs. Deposition would occur when flows less than 400,000 cfs redeposited scoured sediment or newly introduced sediment. The change in sediment mass during the interval between the two surveys (at established reservoir cross sections) was estimated by applying a conversion factor representing average density of dry sediment to changes in water volume. The change in water volume was estimated between cross sections over an averaged depth.

The only storm event with a measured discharge greater than 400,000 cfs between the two surveys occurred in January 1996. Thus, Langland and Hainly (1997) attributed the computed mass of scoured sediment primarily to that particular storm. Although a storm with a peak instantaneous discharge of 365,000 cfs (March 26, 1994) was noted in the report, this storm is not considered by the authors to contribute to the observed changes in bottom elevation over the three-year period between surveys. This method calculated 4,700,000 tons of sediment were scoured from the reservoir system and transported downstream.

In their report, Langland and Hainly (1997) estimated the overall error of their methodology by comparing their results (based on bathymetry) with those of an input/output model. Assuming all scour is from one particular storm, mass balance requires that the total suspended sediment load moving through the system during that storm (i.e., river input entering the system plus contributions of reservoir sediment) approximate the suspended sediment load leaving the system (i.e., output). The contribution of reservoir sediment (referred to as the Reservoir Factor in the current literature review) can be viewed as positive (added to wash load in the water column by resuspension) or negative (removed from the wash load by settling and deposition). The Reservoir Factor equals the total mass of sediment deposited in the reservoirs between surveys plus the net mass of deposition plus the net mass of scour. This equation was solved by Langland and Hainly (1997) as follows:

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- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)

Based on this calculation, the authors estimated that a total of 14,800,000 tons of sediment moved through the system but only 7,000,000 tons exited it. This leaves 7,800,000 tons of sediment, more than 50 percent, unaccounted for in the first calculations. Langland and Hainly (1997) went on to identify possible sources of error for the discrepancies between the two approaches:

x Difficulty in obtaining samples at the dam during dangerous storm conditions; x Accuracy of depth sounding equipment utilized in the surveys; x Averaging depth to calculate cross-sectional areas; x Interpreting missing data from backup paper charts; and x Not including inputs from smaller tributaries.'

Another potential source of error may be the reliance on a 400,000 cfs scour threshold value used to explain changes in bathymetry. In fact, Schuleen and Higgins (1953) (cited in Reed and Hoffman 1997) report preferential scour in Lake Clarke with net scour of silt and clay when river flow exceeded 250,000 cfs and net scour of sand likely when river flow exceeded 840,000 cfs.

My have a point here. For each size particle the scout threshold value will be different. The 400,000 cfs is an average for the sediment column.

The bases of the hypothesis that 400,000 cfs is the scour threshold are the works of Gross et al (1978) and Lang (1982). Both those investigations viewed sediment transport through the reservoir system as a simple mass balance between suspended sediment loads at Harrisburg and Conowingo. Neither study considered other sediment load data between Harrisburg and Conowingo, including sources other than the reservoirs themselves. These are the limitations of their studies. As originally suggested by the Academy of Natural Sciences of Philadelphia (1994) (see Section3.1.2), there continues to be a need to clearly discriminate between scour in the reservoirs and other sediment sources during major floods.

The Conestoga River and Pequea Creek are included in the recent analysis

Conestoga River and Pequea Creek are included.

3.2.3 Rates of Sediment Accumulation'

USGS also analyzed its dataset to determine average annual sediment deposition rates in Conowingo Reservoir since construction of the dam (1928), including the time covered by the term of the existing license (1980 to 2014).

Climate (number, duration, timing and magnitude of storm events) and implementation of

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sediment-erosion and runoff-control BMPs in the watershed are important factors influencing rates of accumulation. Annual rates also depend on the length of time over which the data are extrapolated.

Decreases in sediment deposition rates in the reservoir from 1929 to 1993 have been attributed by USGS to watershed BMPs and may also reflect reduced reservoir trapping efficiencies. The period 1985-1989 experienced two years with well below normal rainfall and no scour events. Similarly, for the period 1996-2008, there were minimal scour events and well below normal rainfall for three of four consecutive years (1999-2002).

Using the average deposition rate for 1959 to 2008 of 2.0 million tons per year, a reservoir trapping efficiency of 55 percent, and no large scour events, USGS predicts that the 30 million tons of sediment needed to bring the reservoir to steady-state (sediment storage capacity) is 15 to 20 years (2023 to 2028), extending into the new license period. USGS computes that a reduction of sediment yield rates of 20 percent will extend this 5 to 10 years.

Radionuclides (cesium-124, cesium-127, and lead-210) adsorbed onto sediment particles have been used as tracers of sediment transport and deposition and as tools to compute sediment accretion rates and reservoir trapping efficiencies (Donoghue et al 1989; McLean et al 1991; McLean and Summers 1990). These studies have been conducted by the Maryland Department of Natural Resources, Oak Ridge National Laboratory, USGS, and others. During a time period without major storm scour events some of

'The USGS reports convert volume changes in water capacity (based on bathymetric changes) to mass of sediment. These numbers, therefore, represent an accumulation rate. The term deposition rate used in the source documents are retained here. 'From SRBC (1991) estimate based on input/output balance between Harrisburg and Conowingo.

the conclusions of these studies are that more than 60 percent of river sediment entering the reservoir system is trapped there, 3 percent is deposited on the Susquehanna Flats (the 10 kilometers of the upper Bay below the river mouth), and 37 percent is transported beyond Susquehanna Flats. Net accretion rates range from about 2 cm per year half a kilometer downstream of the Peach Bottom Atomic Power Station to about 7 cm per year at the mouth of Broad Creek.

Future weather patterns, particularly scour events and BMP impacts to sediment loads, make estimates of future sediment accumulation rates very difficult to predict with any certainty.

3.2.4 Reservoir Storage Volume and Sediment-Storage Capacity

Based on comparisons of bathymetric surveys, the USGS has calculated changes in water-storage capacity of Conowingo Pond and converted volume changes to sediment mass in order to assess sediment deposition. In 2008, USGS conducted a bathymetric survey of Conowingo Pond (Langland 2009) to update storage volume relationships based on a 1996 bathymetric survey (Reed and Hoffman 1997). Water volume changes and quantities of sediment deposition (or scour) at 21 cross-sections were computed. Quantification of the remaining sediment-storage capacity volume was also updated by comparing cross-sectional area changes along the length of the reservoir with conveyance-based equilibrium cross-sectional areas. Three-dimensional longitudinal profiles were also simulated. The total storage capacity of Conowingo Pond is 204 million tons; current storage is 174 million tons; thus there is about 30 million tons of sediment storage capacity remaining.

3.2.5 Sediment Quality

The Susquehanna River Basin Commission (SRBC) issued a report in 2006 characterizing the sediment behind the three lower Susquehanna River dams (Hill et al 2006). This was a cooperative effort of the Maryland Geological Survey, the University of Maryland, and the United States Geological Survey. An objective of this study was to provide information on sediment quality.

Coal is a major constituent of the sediment and correlates with sand and silt content. Within Conowingo Pond, the average coal content in cores increases upstream to Holtwood Dam. High coal content (high carbon content) promotes anoxic conditions which can affect the presence and movement of metals and nutrients. Metals were found to be within the range of the main stem of northern Chesapeake Bay. Elevated metal concentrations are correlated with fine grained sediment and localized sources, and are found in higher concentrations at greater depths within cores.

Relatively low sulfur concentrations were found. PAHs, PCBs, and pesticides are present behind all three dams, with higher concentrations found in the upper Conowingo Pond. Hot spots of radioactivity were not found.

3.2.6 Sediment Transport Modeling

The USGS has performed quantitative sediment transport modeling studies in the form of a HEC-6 sediment transport simulation (Hainly et al 1995) and a regression model of peak and daily mean stream flow data that predicts bottom scour (Langland and Hainly 1997). These USGS reports are summarized below.

3.2.6.1 HEC-6 Sediment Transport Simulation (Hainly et al 1995)

The Corps HEC-6 numerical model can simulate hydraulic characteristics of a stream and the deposition and scour of different sediment grain-sizes. USGS selected this particular model because of its ability to simulate long-term trends of deposition and scour; scour routines that handle the full range of grain sizes observed in reservoir inflows; and to compute sediment transport by grain-size fractions, handling both hydraulic sorting and bed armoring. Input inflow data included particle-size fractions (bedload and suspended sediment) of mean daily loads of up to nine discharge values selected to define the full range of the sediment-transport curve. Empirical input data included bottom grain-size distributions of cross-sections (sand, silt and clay) and sub-bottom seismic profiling data for sediment thickness. Simulation variables included fall-velocities; specific gravities; shear-stress thresholds for both deposition and erosion; compaction; and grain-shape. Hydrologic data included tributary inflow and outflows; discharge durations; and temperature.

USGS determined the HEC-6 to be insufficient for reservoir modeling. The HEC-6 model is preferably used for bed movement and not designed for cohesive sediment dynamics.

The model was hydraulically calibrated by the USGS for 1987 (calendar year) flows and closely replicated the high water profile of the 1972 Tropical Storm Agnes. Sediment transport was calibrated to estimates of monthly and annual inflows and outflows of sediment loads for calendar years 1987-89. Inflow and outflow loads and the reservoir trap efficiencies for the calibration period were computed. The model initially appeared to under-predict reservoir traps efficiencies for 1987 when compared to other models (Cohn et al 1989) and empirical concentration and flow data. The model was subsequently revised by having more coarse sediment enter the system. The output data of the revised model for the three reservoir system as a whole, for the calibration year of 1987 and verification years of 1988 and 1989, are provided in Table 3.3.2.6-1. The data show no sand passing the system, passage of clay and silt with some trapping, and a consistent overall trapping efficiency of 65 to 70 percent.

The USGS went into great detail explaining the model, the decencies, results, and limitations of the HEC-6. This entire section just repeats the results with no mention of the limitations and potential misuse of the model in a reservoir setting.

The sediment transport simulation of the model for May and June 1972 (which includes the Tropical Storm Agnes flood) indicated some scour of clay and silt during this two-month period with 86 percent of the sand being trapped (Table 3.3.2.6-2). Hainly et al (1995) believed the model did not simulate sediment transport during Agnes as well as the period 1987-1989 because it simulated about 2 million tons of sediment deposited in the system rather than the 23 million tons of scour estimated with a simple mass balance of suspended sediment loads between Harrisburg and Conowingo.

3.2.6.2 Regression Model of Bottom-sediment Scour (Langland and Hainly 1997)

A regression model was developed by Langland and Hainly (1997) relating discharges at Conowingo Dam to quantities of bottom sediment scour in Conowingo Pond. The regression curve was fit to scour loads based on differences between entire loads of suspended sediment entering the three reservoir system (input) and exiting the system at Conowingo Dam (output) for six storm events between 1972 and 1996 when peak flows at Conowingo Dam exceeded 400,000 cfs (Figure 3.2.6.2-1). These six storms are identified by Langland and Hainly (1997) as occurring in 1972 (Agnes), 1975 (Eloise), 1996 (January), and three unidentified storms between 1979 and 1996.

This model is based on the hypotheses that 400,000 cfs is the scour threshold and that the Safe Harbor and Holtwood impoundments are in steady-state equilibrium. This is why the difference in reservoir system input and output is attributed to scour in Conowingo Pond. This regression curve was used by Langland and Hainly (1997) to predict loads of total nitrogen and phosphorus from bottom scoured sediments from Conowingo Pond (not the system as a whole). Langland (2009), in contrast, used this curve to estimate the sediment load between 1996 and 2008 from the entire reservoir system from three flood events with daily mean flows greater than 390,000 cfs.

Recent improvements in load estimation techniques confirm what has always been suspected. That the Cohn estimation technique may not be representative of "actual" sediment loads due to limitations of model fit (multiple non-linear patterns in the highly variable data).

3.2.7 Flow and Sediment Regimes below Conowingo Dam

The effects of river regulation on downstream sediment dynamics is currently understood primarily in terms of calculated sediment-trapping efficiencies and suspended sediment loadings to Chesapeake Bay.

Reported sediment trapping efficiency computations vary widely. USGS estimated the sediment trapping efficiency of Conowingo Dam in 1997 to be 70 percent and uses a value of 55 percent in 2009 calculations of future conditions. Based on radionuclides, Olsen et al (1989) estimated 50 percent; Doneghue et al (1989) estimated 11 percent; and McLean et al (1991) estimated 8 to 23 percent during a 10-year period (1966 to 1976) that experienced two major storms. By removing the effect of scour by these storms, their estimate for sediment retention increases to 33 to 63 percent. Based on reservoir geometry and inflow rates, Williams and Reed (1972) estimated 17 percent.

Reservoir trapping efficiencies (TE) is highly variable and varies by length of time the approximation is for due the scour fill dynamics relating to flow. I did an extensive review of TE at other reservoirs in other countries and found a convergence at around 55%

Suspended sediment and nutrients are monitored at USGS Gage Station 01578310 immediately downstream of the Conowingo Dam as part of the River Input Monitoring (RIM) program. RIM includes sites at the downstream non-tidal reaches of nine major tributaries to Chesapeake Bay. Trends in flow-weighted concentrations, flow-adjusted concentrations, and annual loads have been evaluated by USGS and SRBC for the period 1985-2009 at Conowingo Dam. Flow-weighted concentrations are used to assess actual concentrations and their variability; flow-adjusted concentrations estimate trends independent of stream flow, and reflect changes in the processes that deliver the constituents to the stream such as nutrient and sediment reduction activities. SRBC (2010) showed statistically significant downward trends in flow-adjusted concentration of total nitrogen, total phosphorus, and suspended sediment during this period of time throughout the lower Susquehanna River watershed (Figure 3.2.7-1).

The river below the dam is a bedrock-floored channel with a patchy distribution of an alluvial substrate, largely lacking in sediment finer that medium sand. This diminished supply of sediment downstream is a consequence of many inter-related factors, not simply a matter of coarse sediment being trapped behind Conowingo Dam. These factors include flow strength and timing of regulated water releases and storm discharges; sediment load passing the dam from upstream; tributary sediment supply downstream of the dam; and sediment-transport capacities of water releases and storm flows. Existing scientific literature of sedimentary processes below large dams is included in the literature review in Appendix B.

3.3 Other Studies Relevant to Project Study

3.3.1 Substrate Mobility and Biota

Substrate mobility is an element of sediment transport that impacts stream ecology. Schwendel et al (2010) summarizes the published literature pertaining to the impacts of flowing water on benthic communities. Under conditions of low flow velocity and low shear stress sediment will not be entrained, thus, the impact on benthic organisms is limited to the shear force (drag and lift) exerted by flowing water which could lead to a patchy distribution of benthic organisms and the downstream displacement of macrophytes, periphyton, and invertebrates. Bedload transport will begin as flow velocities and shear stresses increase. With Phase-I bedload transport finer sediment is winnowed and rolled over a mostly stable coarser bed. This can impact biota by abrasion. With Phase-II bedload transport, a critical flow velocity is reached that initiates the movement of larger particles which may disrupt armored surfaces and resulting in the patchy distribution of scour and deposition. With more extreme flood events, the whole bed may be mobilized potentially affecting habitat structure by plant and invertebrate displacement and invertebrate mortality by rolling material. Thus, assessments of shear stress and entrainment are means to examine the relationship between benthic biota and bed stability.

Bovee et al (2004) describe how, with the varying discharges accompanying hydropeaking dams, habitat patches can move from one place to another. The instability of patch formation, deformation and migration affect organisms with limited mobility more than highly mobile organisms. Mobile organisms can move to a preferred habitat at another location. Shear stresses capable of moving substrate can also displace infauna. Persistence of habitat, defined as habitat that remains in the same location over variable discharges, is a measure of the spatial stability of a particular habitat patch.

The analysis of localized downstream response of sediment to Project operations in Section 4.1 looks at the effect of shear stress on the persistent habitats where granular substrates exist.

3.3.2 Tropical Storm Agnes: Sediment Delivery from Susquehanna River to Chesapeake Bay

The wealth of data that was collected during and immediately following Agnes provides our best insight to date of the effects of major storms on Chesapeake Bay and the role of sediment discharged to it by the Susquehanna River. A composite of the findings of these studies follows. These include Chesapeake Bay Research Council (1973); Zabawa and Schubel (1974); Gross et al (1978); Schubel and Zabawa (1977); Schubel (1974, 1977); Hirschberg and Schubel (1979); and Schubel and Pritchard (1986).

Suspended sediment concentrations at Conowingo Dam during May 1972 and the first 20 days of June 1972, 10-25 milligrams per liter (mg/l), were higher than normal for that time of year. During the passage of Agnes, concentrations over 10,000 mg/l were reached (June 23) (Figure 3.3.2-1). On June 25, one day after the river crested, concentrations fell to 1,456 mg/l. Surface and mid-depth concentrations of sediment along the axis of the upper Bay following Agnes on June 26 shows a sharp downstream decline from about 700 mg/l off Turkey Point to 400 mg/l at Tolchester to 175 mg/l at the Bay Bridge off Annapolis. While still anomalously high, suspended sediment concentrations in the upper Bay had been reduced considerably by June 29 due to sediment settling and deposition. By the end of July the suspended sediment concentration of the upper Bay was near "normal". While significant erosion occurred farther upstream in the drainage basin, the impact of Agnes on Chesapeake Bay was one of deposition, not erosion. There was little evidence of shoreline or bay bottom erosion.

To identify the sedimentary record left by Agnes and delineate depositional patterns, cores 2 to 4 meters in length were retrieved from upper Chesapeake Bay in August 1972. Cores identified an Agnes sediment layer consisting of laminated silts and clays with minor fine sand. There was a sharp contact with the underlying structureless and bioturbated layer. The sand was primarily quartz and detrital coal. Grain size and clay mineralogy analyses indicated no significant differences between the upper Agnes layer and the lower layer aside from the laminations. The sediment load discharged to the upper Bay was similar in texture as that normally discharged, consisting primarily of silt and clay with fine sand. This is supported by core data showing there is little difference in Agnes sediment and pre-Agnes deposits.

Repeat coring of sampling stations indicated that by June 1973 burrowing infauna had destroyed the laminations with the exception of the station with the thickest Agnes unit. At Susquehanna Flats, about 10 acres of new islands (mud and fine sand) and several hundred acres of new intertidal areas were formed. Being of low relief, they were rapidly eroded.

Examination of these cores indicated that most of the sediments discharged to the upper Bay were deposited in the upper 45 kilometers (above Tolchester) with an average thickness of about 20 cm. More specifically, the thickness of the Agnes layer was greatest between Howell Point and Elk River (20 to 30 cm), under 20 cm from Pooles Island to Howell Point, and 10 to 20 cm between Elk River and Turkey Point (Figure 3.3.2-2). A recognizable layer attributable to Agnes, only a few millimeters thick, was identified in grab samples collected just above the Bay Bridge at Annapolis.

As a point of comparison, Pb_{210} analysis indicated that the Great Flood of 1936 (March 1936) produced a deposit about 36 cm thick in the upper 45 kilometers of the Bay. Although the peak flow of the 1936 storm was less than the peak Agnes flow, the total volume of water discharged was greater and the sediment layer deposited in the Bay by the Great Flood was thicker (Hirschberg and Schubel 1979).

4.0 Downstream Impacts (Task 2)

4.1 Localized Downstream Response of Sediment to Project Operations

4.1.1 Study Objective

The substrate below Conowingo Dam is mainly bedrock with some areas of loose sediment size (Figure 4.1.1-1). While not devoid of finer grained sediment, the fact that the non-bedrock substrates are primarily coarse gravel suggests that the prevalent flow is too swift to allow for the deposition of fine material and/or there is a limited supply of fine-grained sediment. Project operations can influence both of these conditions by water releases and sediment impoundment. And, by affecting the distribution of substrate, can affect the distribution of habitats. Thus, the objective of this study, as stated in the RSP, is to identify Project-related impacts to downstream sediment that could affect habitat.

4.1.2 Methodology Rationale

Substrate mobility affects benthic habitat. The organisms most susceptible to being impacted by bed instability are those with limited mobility. As discussed in Section 3.3.1, analyses of bottom shear stress and particle motion are used to examine the relationship between benthos and bed stability.

The IFIM study for this project (RSP 3.16) identifies the location of persistent habitats for immobile life stages of target species. Persistent habitats remain at the same location over variable discharges; they are a measure of spatial stability (Bovee et al 2004). However, the IFIM model constraints include a static substrate. Thus, this analysis focuses on the potential for sediment to mobilize at the identified persistent habitats under varying flow conditions. A finding of extensive sediment mobility poses a potentially adverse impact to immobile life stages, if present.

Wilcock et al (2009) distinguishes between two classes of sediment transport principles, incipient motion and transport rate. Sediment transport rates are inappropriate for issues regarding frequency of bed disturbance. Rather, the incipient motion principle should be applied. Therefore, an incipient motion analysis is conducted for this study.

The presence of vegetation can interfere with sediment mobilization by changing ambient hydraulics and by trapping or binding sediment. Thus, the distribution of vegetation at persistent habitats was also evaluated.

4.1.3 Methods

The analytical methods used in this report have been adapted from other studies evaluating the movement of coarse grained alluvial cover of bedrock channels and/or river segments affected by flow regulation below dams (Elliot and Gyetvai 1999; Elliot and Hammack 2000; Elliot 2002; Haschenburger and Wilcock 2003; Pohl 2004; Barton et al 2005; Turowski et al 2008b).

A sediment grain resting on a stream bed during fluid flow is subjected to a number of opposing forces (Boggs 2001; Fischenich 2001). Gravity and frictional forces (and cohesion for fine, clay-sized particles) act to resist motion while drag and lift forces are exerted by the flowing water to promote movement. A threshold state occurs when forces acting to move the particle are balanced with forces resisting movement. The critical conditions of flow to initiate grain movement can be estimated by the average boundary shear stress (τ_0) (force per unit area in flow direction) exerted by the fluid on the stream bed. The critical shear stress (τ_c) is that needed to initiate sediment movement.

The Shields equation is commonly used to estimate the τ_c to entrain a median grain size of bottom sediment, or, the critical discharge associated with τ_c (i.e., the minimum stream flow to entrain d_{50}[*] sediment). Gessler (1971) (cited in USACE 1995) reviewed Shields' data and developed a probabilistic approach to incipient movement of sediment mixtures. When τ_c equals τ_0 there is a 50 percent chance for
a given particle to move. Thus, there can be entrainment of some grains even when τ_0 is less than τ_c. All grains of a given size class will not be entrained until τ_0 is greater than $2\tau_c$."

When τ_0 is compared to τ_c at various locations (such as along a stream cross-section) for different discharges, one can assess sediment-entrainment potential of each discharge with respect to a particular surface on the cross-section (Elliot and Hammack 1999; Elliot 2002). Entrainment potential (EP) can be expressed as the τ_0/τ_c ratio. A ratio of 1 represents incipient movement of a few particles or in a small area. A ratio of 2 represents widespread mobility.

In this study, boundary shear stresses associated with simulated Conowingo Dam releases are compared to critical shear stresses associated with substrates of persistent habitats. τ_0 was computed by River 2D

10 d_{50} is the median particle size "The "entrainment potential" calculations in this report are comparable to the "relative shear stress" calculations in RSP 3.16 (Instream Flow Habitat Assessment below Conowingo Dam) and differ in terminology in order to be consistent with each study's respective literature. The equations and methods used in both reports are identical, and the grain size classes are the only difference. The grain size classification in this study (Appendix C) is consistent with the sediment transport literature, while the mussel study utilizes HSI grain size classes to be consistent with other analyses conducted in that report.

modeling software (see RSP 3.16). Substrate and vegetation data were collected in RSP 3.17. τ_c values used for non-cohesive grain size classes are taken from Julien (2010) (Table 4.1.3-1). The d_{50} value of the streambed used to select an appropriate τ_c was assumed to be the predominant grain size of the substrate[12]. For grain sizes that have a range of τ_c values, the lowest value was chosen as this would represent the worst-case for sediment mobility by maximizing the τ_0/τ_c ratio. This analysis does not evaluate erosion or deposition, only whether an unconsolidated non-cohesive sediment grain of a particular size fraction will be mobilized.

Persistent habitats derived in RSP 3.16 for immobile life stages were used in this study. These are:

Persistent habitats were derived for four simulated release flow-pairs:

- x Minimum 3,500 cfs ; maximum 86,000 cfs
- x Minimum 5,000 cfs ; maximum 86,000 cfs
- x Minimum 7,500 cfs ; maximum 86,000 cfs
- x Minimum 10,000 cfs ; maximum 86,000 cfs

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Kimberly D. Bose Secretary

- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a net scour of 4,700,000 tons of sediment
- x Total estimated mass of sediment deposited in the system between surveys is 6,900,000 tons
- x Suspended sediment concentrations measured at the USGS Conowingo station during the January 1996 storm event estimates an output of 7,000,000 tons
- x 1929 to 1958 3.1 million tons per year

This represents the full range of Project flows from minimums to full generation. The minimum values are required minimum releases established by the settlement agreement of 1989. The maximum value of 86,000 cfs is the full generation flow.

[12] Sediment classified in accordance with the Udden-Wentworth scale (see Appendix C).

A finding of incipient particle movement or widespread mobility indicates that particle critical shear has been exceeded, but it does not imply erosion and removal of the habitat. This analysis assesses whether sediment be mobilized, not whether erosion or deposition occurs. These are theoretical calculations and repeated visits to habitat locations show that substrates remain. Clearly the critical shear stresses are not exceeded for long enough periods of time to remove the substrate or prevent sediment reaching these locations from being deposited.

Entrainment potential is being used in this study as a means to assess the likelihood that sediment mobility due to Project operations causes adverse disturbances to immobile biota potentially inhabiting suitable substrates. For this study, persistent habitats were chosen as the basis of the analyses because, by definition, these habitats exist over the full range of Project operations and are therefore appropriate for an analysis of bed disturbances by Project operations.

The following steps were completed for this study:

1 Identify non-bedrock (mobile) substrate areas
2 Overlay persistent habitat areas on non-bedrock substrates under varying Project release regimes
3 Assign τ_c values to each substrate grain size within habitat
4 Overlay shear stress layer on non-bedrock substrate substrates
5 Compute entrainment potential for each substrate under varying Project release flow regimes
6 Overlay vegetation layer on habitats

4.1.4 Results

Twelve non-bedrock substrate areas are identified (Figure 4.1.4-1; Table 4.1.4-1). Detailed views of each are provided in Appendix B with associated vegetation. All but two (Areas 3 and 11) had persistent habitats present. Table 4.1.4-2 identifies the acreage of substrate type in each area and Table 4.1.4-3 indicates which substrates in each area coincided with a persistent habitat under four release flow-pairs. The areas with the most permutations of persistent habitat, life stages, and flow scenarios are Areas 1, 9, 10, and 12. Area 1 is at the mouth of Octoraro Creek and Areas 9, 10, and 12 are below Deer Creek and Smith Falls. The analysis that follows focuses on these four areas.

Table 4.1.4-4 summarizes the results of computed entrainment potentials for each substrate area. For each substrate area under each of the evaluated release flows evaluated (3,500 cfs, 5,000 cfs, 7,500 cfs, 10,000 cfs, 86,000 cfs) the acreage of computed EP values (<1, 1-2, >2) is shown. This table is visually depicted in Figures 4.1.4.1-1 through 4.1.4.1-4.

4.1.4.1 Area 1

At Area 1, at the mouth of Octoraro Creek, the boulder and cobble substrates remain immobile (EP < 1) under each flow release condition (Figure 4.1.4.1-1). The area of maximum mobilization (EP > 2) occurs in a small patch of granule substrate in the shallow pool and remains the same for 3,500, 7,500 and 10,000 cfs releases. Partial mobilization in the shallow pool granule substrate (EP 1-2) increases from one patch at 3,500 cfs to two similar patches at 7,500 and 10,000 cfs. At 86,000 cfs the flow pattern changes such that the shallow pool granule EP is reduced to < 1 and with partial and widespread entrainment shifting to the shallow riffle with granule substrate.

The persistent habitats in the boulder and cobble substrates under all flow scenarios are unaffected by sediment mobility. Persistent habitats with granule substrates exhibit varying degrees of entrainment in different locations under each flow release scenario. Vegetation during the growing season would not affect sediment mobility in the sensitive granule substrate areas in Area 1.

The boulder and cobble substrates of Area 1 comprise persistent habitat for striped bass fry, striped bass spawning, shortnosed sturgeon fry, shortnosed sturgeon spawning, caddisfly, American shad spawning, and American shad fry (Table 4.1.4-3). These substrates are stable under all flow release scenarios. The granule substrate areas comprise persistent habitats for striped bass fry, striped bass spawning, shortnosed sturgeon fry, caddisfly, and American shad fry. While the granule substrate areas are mobile for all scenarios, at 86,000 cfs the acreage of widespread mobility is reduced by 93% with a shift in location of incipient motion. At most, the area of widespread mobility of the granule substrate (0.0286 acres) represents a very small portion (less than 1%) of the total acreage of mobile substrate (4.75 acres) and its modeled instability has little impact on the available habitat at this site.

4.1.4.2 Area 9

Area 9 surrounds Robert Island below Smith Falls. At Area 9, all substrates have EP < 1 at 3,500 cfs, but partial entrainment begins at the downstream tip of the medium sand substrate at 5,000 cfs (Figure 4.1.4.1-2). At 7,500 cfs this area progresses to widespread mobility with other patches of the sand becoming partially mobile. At 10,000 cfs a large swath of the medium sand had EP 1-2 or >2 while some of the pebble substrate has begun to move (EP 1-2). At 86,000 cfs there is mobility throughout most of the medium sand and pebble substrates, either 1-2 or >2, while the boulder and cobble remain immobile for each scenario. However, as an overprint, during the growing season SAV will have a strong influence on substrate mobility. The sand and pebble substrates have heavy and moderate water milfoil cover, respectively. The SAV will trap and bind sediment grains and act as a force in opposition to grain movement in accordance with the bottom shear stresses.

The boulder and cobble substrates of Area 9 comprise persistent habitat for striped bass fry, striped bass spawning, shortnose sturgeon fry, caddisfly, and American shad fry (Table 4.1.4-3). These substrates are stable under all flow release scenarios. Medium sand is persistent habitat for shortnose sturgeon fry, small mouth bass spawning, caddisfly, and American shad fry. The pebble substrate is persistent habitat for shortnose sturgeon fry, shortnose sturgeon spawning, American shad spawning, and American shad fry. The effect of habitat instability for immobile biota at these locations may be mitigated during the growing season due to the impact of the SAV.

The growing season for the SAV species is July through September (RSP 3.17: Downstream EAV/SAV Study). Periodicity tables produced in the IFIM study (RSP 3.16) indicate the seasonal occurrences of target species. The SAV growing season coincides with the occurrence of American shad fry and caddisfies. At other times during the year, if other conditions are suitable and target organisms are present, sand and pebble substrate mobility may adversely impact the target species when flows increase in strength from 7,500 to 86,000 cfs. During the growing season, American shad fry and caddisfly habitat would be more stable due to the flow dissipation by vegetation.

4.1.4.3 Area 10

At Area 10, along the river margin at Port Deposit, all three substrates (medium sand, granule, and boulder) remain immobile at 3,500 and 5,000 cfs (Figure 4.1.4.1-3). The areas of incipient sand mobility expand between 7,500 cfs and 10,000 cfs. At full generation (86,000 cfs) most of the sand and the riverward half of the granule substrate are in widespread motion. The boulders remain immobile throughout. The heavy water milfoil community in the granule substrate will not have a direct effect on grain motion in that it is located where the model shows EP < 1 for all flows. The moderate water milfoil on the sand substrate, however, may retard mobility during the growing season.

At this location, boulder substrate is a persistent habitat only for caddisfly (Table 4.1.4-3). This substrate is stable under all flow release scenarios. However, granule substrate is persistent habitat for smallmouth bass fry, smallmouth bass spawning, and American shad fry. Granule mobility begins at 10,000 cfs and the substrate is unstable at 86,000 cfs. Medium sand substrate is persistent habitat for shortnose sturgeon fry, smallmouth bass spawning, and American shad fry. The sand substrate gradually progresses from incipient motion at 7,500 cfs to widespread motion at 86,000 cfs. SAV may have a stabilizing effect on the sand during the growing season.

There is potential for adverse impacts of habitat instability for target species in sand and granule habitats at release flows above 7,500 cfs. Entraining flows will be dissipated by SAV during the growing season. This will benefit caddisflies and American shad fry.

4.1.4.4 Area 12

Area 12, near Spencer Island, all three substrates (pebble, cobble, and boulder) remain immobile at 3,500, 5,000, 7,500 and 10,000 cfs (Figure 4.1.4.1-4). At 86,000 cfs the entire extent of the pebble substrate mid-channel between Spencer Island and the west margin of the river is mobilized (EP >2). During the growing season the pebble substrate is minimally covered with water milfoil which is expected to have a minimal impact on the modeled entrainment potential. The boulders and cobbles remain stable throughout all flows.

The boulder substrate here is a persistent habitat for smallmouth bass and caddisfly, and cobbles are persistent habitat for mayfly, caddisfly, and American shad fry (Table 4.1.4-3). Both these substrates are stable under all flow release scenarios. The pebble substrate is persistent habitat for striped bass fry and striped bass spawning. The pebble substrate undergoes widespread mobility during flows greater than 10,000 cfs but less than 86,000 cfs. Substrate mobility may adversely impact target species between 10,000 and 86,000 cfs, if present.

4.1.5 Conclusions

Mobile substrates are limited downstream of the dam. Where present, boulder and cobble are most prevalent. Four areas provide the most persistent habitat for the most species. One area is at the mouth of Octoraro Creek and the other three are located below Deer Creek and Smith Falls. It is postulated that tributary sediment supply and change in river gradient are key reasons for these habitats to have developed at these locations.

Trapping of coarse sediment behind Conowingo Dam limits the supply downstream. Additionally, flow conditions in the river are naturally turbulent, inhibiting deposition until the change in gradient below Smith Falls. Between Rowland and Roberts Islands, the river bottom would be essentially bedrock without the Project, much as it is today, except where there is a discrete sediment supply.

The sediment from major tributaries, Octoraro Creek and Deer Creek, is the source for sediment deposited in areas of locally dissipated flow. This occurs at Areas 1, 9, 10, and 12. The paucity of non bedrock substrate downstream of the dam boosts the value of the few habitats that exist. The shear stress analysis indicates that there is potential for substrate instability impacts for target species, if present, in sand and gravel substrates below Smith Falls, for modeled Project operation releases ranging 7,500 to 86,000 cfs. These areas are the sand and pebble substrates at Area 9, the sand and granule substrates in Area 10, and the pebble substrate in Area 12.

4.2 Storm Events

4.2.1 Study Objectives and Rationale

A potential impact of the ongoing operation of the Project is the impact to the Bay from a scour event in Conowingo Pond associated with a major storm. Three hypotheses underlie previous analyses of examining this potential impact:

1 400,000 cfs is the trigger flood event for scour;

2 Safe Harbor and Holtwood are at equilibrium, and

3 A major scour event from Agnes was associated with Conowingo Pond.

The HEC-6 model previously developed for the lower Susquehanna River by USGS was selected as an existing analytical tool to test these hypotheses.

If scour of lower Susquehanna River reservoir sediments contributes large quantities of sediment to load already transported to the pond from the watershed, one would expect to see the distribution of the suspended sediment grain sizes to be skewed to coarser sizes compared to non-storm flows. The greater bottom shear stress of storms can resuspend larger grain size fractions and will keep a greater proportion of them in suspension. As a corollary, one would also expect catastrophic storm deposits to be recognized in the sediment record as a coarser grained deposit than non-storm deposits. Thus, another objective of this task is to test the hypothesis that the contribution of scoured bottom sediment from the reservoirs to the total suspended sediment load passing Conowingo Dam during catastrophic storms is reflected in grain size.

In summary, the methodology rationale described above leads to the following questions which are the specific objectives for this study.

1 Are HEC-6 simulations of scour and deposition during storms exceeding 400,000 cfs consistent with scour quantities predicted by the regression model based on a scour threshold of 400,000 cfs?

2 Are HEC-6 simulations of sediment movement between reservoirs in bulk and by grain size class consistent with storm scour quantities determined from mass balance input/output models comparing Harrisburg/Marietta suspended loads with Conowingo Dam suspended loads?

3 Are large quantities of reservoir bottom scour recognized as a source of suspended sediment at Conowingo Dam by its grain size distribution?

4.2.2 Methods

4.2.2.1 HEC-6 Model

HEC-6 is a 1-dimensional numerical model developed by the US Army Corps to simulate and predict changes in river profiles from scour (resuspension) and deposition. Using a series of stream geometry cross sections as input, HEC-6 applies the standard step backwater method to develop a water surface profile of a given river reach, where energy slope, velocity, depth are computed at each cross section. Using these computed hydraulic parameters, sediment transport rates are then calculated at each section for a series of grain size fractions. These sediment transport rates, along with the magnitude and duration of stream flow, allow for a volumetric accounting of sediment transport in one direction (upstream to downstream) and the deposition and scour of specific grain sizes. HEC-6 is typically used to model a series of steady-state flows over long periods; however it is capable of being applied to single flood events.[11]

The lack of appropriate input data for the current study precluded a revision of the 1990 USGS HEC-6 model for the lower Susquehanna River reservoir system in this study. Since sediment deposition has led to changes in water depth since the 1987-1989 calibration period of the model, a sensitivity analysis was conducted to see if changes in depth in this system affect simulated velocities and shear stresses produced by the model. Table 4.2.2.1-1 shows simulation values for velocity and shear stress at each of the HEC-6 transects between Holtwood Dam and Conowingo Dam for the 1972 Agnes event with the model bathymetry and with 5-foot raised bottom. Velocities and shear stresses virtually do not change. The water column depth is great enough over the bed such that changes in bed elevation do not alter velocity and shear stress. Therefore, the 1990 model is suitable for this analysis.

Original HEC-6 input decks were procured from the USGS (Michael Langland, pers. comm., USGS, September 16, 2010) and the HEC-6 model of the lower Susquehanna River was reconstituted in an

[11] HEC-6 User's Manual (Introduction)

electronic format. The model encompassed the river reach from the Marietta USGS gage downstream to Conowingo Dam, approximately 34 miles, and included stream flow and sediment inputs from Pequea Creek and Conestoga River, the largest tributaries and sediment sources to the Susquehanna River between Marietta and Conowingo Dam.

Key inputs to the USGS HEC-6 model included a series of 42 stream geometry cross sections, as well as the mobile and immobile stream bed sediment thickness at each cross section (Figure 4.2.2.1-1). The input for the main river reach and two tributaries to Lake Aldred (i.e., Pequea Creek and Conestoga River) included sediment load (tons/day), by grain size classification, and flow (cfs) relationships. In addition, particle size distributions for sand, silt, and clay are included for the in-channel sediment located at each model cross section. User specified inputs included stream flow and duration, inflow temperature, sediment properties and transport parameters (i.e., specific gravity and shear stress thresholds) and a rating curve at the downstream end of the river reach.

USGS hydraulically calibrated the model for 1987 (calendar year) flows and was able to closely replicate the high water profile of the 1972 Hurricane Agnes flood. The sediment transport simulation was calibrated by USGS to estimates of monthly and annual inflows and outflows of sediment loads for calendar years 1987-89. The estimated inflow and outflow loads, as well as the reservoir trap efficiencies for the calibration period were computed based on a methodology developed by Cohn et al (1989).

Initial HEC-6 simulations by USGS for the calibration year of 1987 indicated that no sand and only small amounts of coarse silt passed the three reservoirs (Clarke, Aldred, Holtwood, and Conowingo) in the river reach, which was deemed reasonable given that the peak flow for the period was 236,000 cfs. The simulations also indicated that the finer silt and nearly all clay material passed the three reservoirs. However, the model predicted low reservoir trap efficiencies compared to those predicted by the Cohn methodology and field measurements. To address this discrepancy, the USGS elected to shift the particle size distribution data described in the sediment load versus discharge relationships within the model, so that less clay and more silt and sand would enter the system. These adjustments were made until the computed trap efficiency for the reservoir system was within one standard error of those predicted by the Cohn methodology. After these adjustments were made the model predicted sediment transport reasonably well for low and intermediate flows. As noted earlier in Section 3.2.6.1 the simulations for Tropical Storm Agnes were considered to have underestimated scour from the reservoirs.

As I mentioned earlier in this review, the limitations of using HEC-6 in reservoirs were presented in the USGS report. Is it a real surprise if in this this study the consultant used the same data and model, the results would be nearly identical.

In the current study, the model is applied to previous storm events with discharges greater than 400,000 cfs - June 22-28, 1972, September 26-30, 1975, January 20-23, 1996 and September, 19-21, 2004. The simulated storm events span the period 1972 to 2004.

4.2.2.2 Scour Regression Model

The Langland and Hainly (1997) regression model (see Section 3.2.6.2) was ? used to estimate scour quantities to compare with the HEC-6 results. Peak stream flow has a narrower spread of the 95-percent confidence limit than daily mean stream flow (R^2 = 0.91) (Figure 3.2.6.2-1). Thus, peak stream flow is considered the better predictor of bottom scour in this report. The regression equation defining this relationship was used to estimate tons of bottom scour within Conowingo Pond as a consequence of the same four storm events in 1972, 1975, 1996 and 2004 that were analyzed with the HEC-6 model for comparison purposes.

4.2.2.3 Grain Size Distribution

The USGS suspended sediment database provides daily discharge and size distributions of suspended material at Conowingo Dam from 1979 to 1996. During this span, two storm events (February 1984 and April 1993) with discharges greater than 400,000 cfs occurred. Twenty-one data points were recorded during these events compared to 255 data points recorded when the daily mean flow at the station was less than 400,000 cfs. This set of data was analyzed to evaluate the impact of flow events greater than 400,000 cfs on sand transport in Conowingo Pond. Specifically, analysis attempted to determine whether sand content transported during storm events, as a percentage of total suspended sediment, was greater than the sand content transported during normal flow. In order to accomplish this, data were evaluated using the Mann-Whitney U Test.

4.2.3 Results

The output data of the HEC-6 simulations are summarized in Tables 4.2.3-1 and 4.2.3-2. The data include trapping efficiencies of each reservoir for sand, silt and clay; tons of sediment passing through each reservoir (total, sand, silt, and clay); and net deposition and scour in each reservoir (total, sand, silt, and clay). The scour quantities (total) derived from the regression equations are presented in Table 4.2.3-3. This table also includes peak flow and flow frequency. Table 4.2.3-4 provides the suspended sediment grain size distribution during the 1996 storm.

1) HEC-6 simulations indicate that each reservoir traps little to no silt or clay during each storm event, essentially passing it through the system (Table 4.2.3-1). Some silt/clay scour is suggested in Lake Clarke and Lake Aldred. While Lake Clarke and Conowingo Pond trap virtually all sand received from upstream during the simulated storm flows, Lake Aldred passes much of it through

to Conowingo Pond where it is deposited. Overall, Lake Aldred behaves differently than Lake Clarke and Conowingo Pond, acting more as a conduit of sediment transport that the other two reservoirs.

USGS studies already state this. No new finding.

2) The breakdown of quantities of sediment associated with the HEC-6 simulated trapping efficiencies shown in Table 4.2.3-1 is provided in Table 4.2.3-2. In Conowingo Pond, nearly all the sand entering the reservoir from Aldred during each storm is deposited; silt passes during the highest flows (Agnes) but up to 10 percent is trapped in the lesser storms; and all clay passes. Net scour does not occur in Conowingo Pond. Table 4.2.3-3 presents regression curve estimates of the quantity of sediment attributable to scour in Conowingo Pond during each storm evaluated. The absence of scour in Conowingo Pond in the HEC-6 model contradicts the regression model. And, although scour is computed by the HEC-6 simulation in Lake Clarke and Lake Aldred, it is far less than quantities indicated by the studies discussed earlier.

3) Both the HEC-6 model (see #1 above) and Langland and Hainly (1997) suggest Lake Aldred behaves more as a conduit of sediment transport than the other two reservoirs. (Already mentioned above in number 1). While scour and depositional areas are identified in Lake Aldred, minimal net changes in sediment mass and storage-capacity were identified (Langland and Hainly 1997). Rather than exporting more sediment than it imports (from sediment supplied by bottom scour), sediment entering and/or scoured from within Lake Aldred may just be redeposited elsewhere in the reservoir or passed through it.

Channel shape may be a contributing factor. Lake Clarke and Conowingo Pond are larger and wider than Lake Aldred (Table 4.2.3-5). The smaller and narrowing morphology of Lake Aldred may favor transport over deposition. Reed and Hoffman (1997) illustrate how conveyance, a measure of carrying capacity of a channel, is affected by shape. Theoretically, more water is conveyed through a deeper and narrower channel of the same cross-sectional area as a shallower and wider channel because less water is in frictional contact with the channel boundaries. Lake Aldred is not only narrower, overall, than the other two reservoirs but is characterized with steep
sided "deeps" in the narrowest reaches (Reed and Hoffman 1997; Langland 2009).

There are 16 tributaries entering Lake Aldred, including Pequea Creek, Conostoga River, and Otter Creek (PPL and Kleinschmidt 2007). Sediment influx from Otter Creek and 13 smaller tributaries are not included in the HEC-6 run or the Langland and Hainly (1997) analysis. The inclusion of these tributaries might have brought the apparent behavior of Lake Aldred in line with the other reservoirs.

Similarly, the exclusion of tributaries to Conowingo Pond (e.g., Muddy Creek, Fishing Creek, Peters Creek, Michaels Run, Broad Creek and Conowingo Creek) as additional sources to the suspended sediment load reaching the Pond from upstream produces a data gap in both the HEC6 and Langland and Hainly (1997) analyses produces an over estimation of the contribution of bottom scour to Conowingo Project sediment output during storms events. Other suspended sediment sources unaccounted for include overland sheet flow conveyed to channel margins.

Agree they were not included. There is no information on sediment concentrations. However, a gross estimate can be made of the combined input based on landuse, slope, and stream length and sinuosity. That estimate would be less than 1% of total sediment inflow from the Susquehanna River. The overestimation (as indicated above) is considered inconsequential.

4) Turbulence created by the operation of bottom-release turbine gates and flood release gates at Conowingo Dam inhibits deposition of sediment near the dam (Hainly et al 1995; Reed and Hoffman 1997; Langland 2009). Hainly et al (1995) estimates this effect extends upstream from the dam for about 1.25 miles (River Mile 11). This turbulence occurs during non-storm normal operations (turbines) and during storm events (flood gates) regardless of flow relative to 400,000 cfs.

Nearly 85 percent (2,010,000 tons) of the net scour in Conowingo Pond reported in Langland and Hainly (1997) occurred in the lower Pond. Of this, more than half (1,119,000 tons) occurred within the zone of influence of turbulence generated by the dam. Thus, a large percentage of scour estimated by Langland and Hainly (1997) in Conowingo Pond is not a consequence of the storm generated resuspension.

This is not true. No study has determined the net gain or loss in terms of sediment load from "turbulence". Recent data suggest this zone of influence (1.25 miles) is over estimated. There is both active sediment deposition and scour in this area, regardless of turbine influence.

5) HEC-6 depicts a system that, during major storm events, carries little sand in suspension and delivers little sand downstream. This is supported by the suspended sediment distribution at Conowingo Dam measured during the January 1996 storm, and by the sedimentary record of major storm events in upper Chesapeake Bay.

Agree with you, I have the complete historic particle size record for Conowingo. Sand transport over the dam is 10 percent or less.

Williams and Reed (1972) evaluated the grain size distribution of suspended sediment transported by streams in the Susquehanna River basin during times of peak discharges. Consistent particle size distributions are displayed across physiographic provinces, averaging 10 percent sand, 50 percent silt and 40 percent clay.

The daily mean flow hydrograph at Conowingo for the January 1996 storm event is provided in Figure 4.2.3-1. Table 4.2.3-4 shows the corresponding suspended sediment size distribution. Less than 10 percent of the suspended sediment load was sand. This is not unlike the non-storm size distribution. The statistical analysis conducted of size distributions of suspended material at Conowingo Dam indicates no significant difference ($a = 0.05$) in sand transport during flow events greater than 400,000 cfs and flow events less than 400,000 cfs ($p = 0.223$). Median sand transported during high flow events for this interval, as a percent of suspended sediment, was 2.9 percent. During periods of flow less than 400,000 cfs, mean percent sand transported was 5.7 percent.

This analysis is completely wrong. The numbers are biased low in storms due to large amount of silt and clay that is in transport, therefore on a percentage, sand would appear to be less. Need to report the actual mass of the sediment transported.

Sediment core data (see Section 3.3.2) show deposits in upper Chesapeake Bay from Agnes, a catastrophic storm, consist of laminated silts and clays with minor fine sand and little difference in grain size and clay mineralogy between Agnes and pre-Agnes sediment deposits. This would seem to support the HEC-6 analysis.

4.2.4 Conclusions

The storm event sediment transport analysis conducted for this study tested three hypotheses. The conclusions reached with respect to these hypotheses are:

1 The HEC-6 analysis does not seem to support the conclusion of the literature that the catastrophic impact to Chesapeake Bay from Agnes was due to scour from Conowingo Pond.

2 The model suggests Lake Clarke is not in equilibrium and is, in fact, trapping a lot of sediment. It does, however, support the hypothesis that Lake Aldred is in equilibrium.

A temporary condition caused by the 1996 flood event.

3 The HEC-6 analysis contradicts the scour regression model which is predicated on a 400,000 cfs scour threshold and computations equating sediment input to the three reservoir system at Safe Harbor and output at Conowingo to a simple comparison of suspended sediment loads at Harrisburg/Marietta and suspended sediment loads at Conowingo.

The literature review and HEC-6 analysis highlight the need for a single comprehensive and integrated analysis of the lower Susquehanna River watershed, including all three reservoirs, riverine processes in the Susquehanna River, and the tidal river mouth and upper Bay, in order to address the discrepancies and limitations of previous studies. Such an analysis will serve to better isolate reservoir scour from other sources of sediment passing Conowingo Dam.

The Army Corps is currently planning to conduct such a study. Their study should be able to fill data gaps and resolve questions surrounding the aforementioned hypotheses.

4.3 US Army Corps 'Sediment Behind the Dams Study'

On October 29, 2009 the Baltimore District of the Corps convened a Sediment Task Force to discuss sediment build-up behind the lower Susquehanna River dams. Funding has been authorized from Congress for the Corps to "restart" a study originally authorized in 2002 to "examine management measures that could be undertaken to address the sediment behind the dams on the lower Susquehanna River." The states of Maryland (MDE) and Pennsylvania (PADEP) are serving as non-federal sponsors for the current authorization to conduct this study (USACE 2011). Specifically, this federal/non-federal cost-sharing effort, referred to as the 'Sediment Behind the Dams Study' has established the following goals (USACE 2010):

1 Recommend and prioritize sediment management measures that will maintain and/or increase Conowingo Dam sediment and nutrient storage capacity to assist Maryland in meeting EPA mandated TMDL.

2 Recommend and prioritize sediment management measures that will reduce the volume of sediment and associated nutrients available for transport during high flow storm events from behind the Conowingo Dam.

3 Determine the adverse impacts of the loss of sediment and nutrient storage behind the Conowingo Dam to the Chesapeake Bay.

The two major components of the Army Corps 'Sediments Behind the Dams' effort are comprehensive: 1) sediment transport modeling and 2) development of a regional sediment management plan. These components are described below.

The consensus of the 2009 Sediment Task Force meeting was that elevating current understanding to the next level for the purposes of developing meaningful resource management approaches requires a monumental multi-model effort that integrates watershed, riverine, reservoir, and estuarine (lower river and Bay) processes. This 'Sediment Behind the Dams Study' will use a sediment transport analysis approach by integrating different analytical models to achieve these goals.

At the October 2009 Sediment Task Force meeting the capability of sediment transport modeling tools to advance our understanding of sediment yield to the lower Susquehanna River, sedimentation within Conowingo Pond, and Conowingo Dam's effect on Chesapeake Bay were discussed. Separate models would need to be applied in combination to assess sediment issues. These models will be integrated to support the development of a Lower Susquehanna River Sediment Management Plan (Figure 4.3-1)

(USACE 2010). The step-wise sediment transport approach and models currently proposed are described below (Figure 4.3-2) (USACE 2010).

4.3.1 EPA Watershed Model

The EPA Chesapeake Bay Program Watershed Model (WSM) uses a modified HSPF (Hydrological Simulation Program-FORTRAN) to simulate flow and sediment/nutrient load delivery to the Chesapeake Bay from the watershed (Martucci et al 2006; USEPA 2010a). Sediment transport is modeled as separate land and river processes. The latest refinement of the model, Phase 5.3, combines processes of land surface erosion, storage, and delivery to river segments based on land use and distance from a river reach to estimate an Edge-of-Stream Load. Riverine sediment deposition and scour processes are then modeled to compute a load delivered to a river segment outlet. Sand, silt, and clay are simulated separately. This model will be applied to the lower Susquehanna River watershed to provide loads to the reservoirs from key locations within the watershed.

4.3.2 HEC-RAS Model

HEC-RAS, developed by the Corps, consists of four 1D (one dimensional) components for the analysis of steady flow water surface profile computations; unsteady flow simulation; movable boundary sediment transport computations; and water quality analysis in rivers. It will be applied to route sediment loads (assessed by grain size fraction) through the upper two reservoirs (Lake Clarke and Lake Aldred).

4.3.3 ERCD-2D ADH Model

ADH (Adaptive Hydraulics) is a 2D (two dimensional) model developed by the Corps. The ADH model can simulate riverine transport for cohesionless sand and cohesive silt and clay, bed erosion and deposition, and morphologic change. It can interface with HEC-RAS hydraulic data and model tidal areas. In combination with HEC-RAS data, ADH can route the sediment load (assessed by grain size fraction) through the Conowingo Pond, Conowingo Dam, and Susquehanna Flats. It will apply to reservoir and riverine sediment transport and deposition to assess consequences of sediment load reductions to the river.

4.3.4 Chesapeake Bay Environmental Model Package

CBEMP (Chesapeake Bay Environmental Model Package) is a system of watershed, hydrodynamic and eutrophication models with dynamic sediment transport capabilities. The three models at the core of the package are the watershed HSPF model, CH3D-WES and CE-QUAL-ICM (Cerco et al 2004). HSPF computes the distribution of flows and loads from the watershed; these flows are input for the CH3D

WES hydrodynamic model which computes three-dimensional intratidal transport; and the computed loads and transport are the input to CE-QUAL-ICM, a eutrophication model. Refinements of the computational grid and model recalibrations have been ongoing since the initial coupling of these models, including those to provide assessment capabilities of living resources (i.e., benthos, zooplankton, and SAV) and to improve the accuracy of water clarity indicators, DO, and chlorophyll.

CBEMP is currently being used to support Bay TMDL development and it will be used in the 'Sediment Behind the Dams Study' to compute water quality and living resources impacts of sediment and associated nutrient loads to the Bay.

This integrated transport modeling approach will enable the evaluation of the effects of various scenarios. The following modeling scenarios are being considered (USACE 2010).

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- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a net scour of 4,700,000 tons of sediment
- x Total estimated mass of sediment deposited in the system between surveys is 6,900,000 tons
- x Suspended sediment concentrations measured at the USGS Conowingo station during

5.0 Sediment Management (Task 3)

5.1 EPA Chesapeake Bay TMDL Framework

The EPA Chesapeake Bay TMDL Program currently in place is a comprehensive regulatory framework that addresses sediment and nutrient loadings in the lower Susquehanna River basin (USEPA 2010b).

The EPA established a watershed Total Maximum Daily Load (TMDL) for Chesapeake Bay for sediment, nitrogen, and phosphorus on December 29, 2010. TMDLs for sediment and nutrients were developed so that the Bay and its tidal tributaries achieve water quality standards for dissolved oxygen, water clarity, and chlorophyll *a* by the year 2025. The Bay TMDL will be implemented in phases with an interim target allocation of 60 percent total load reductions by 2017 and 100 percent by 2025. A state's progress toward meeting TMDL goals will be assessed by EPA every two years.

The TMDL allocates loads by major river basin and state in the Chesapeake Bay watershed; included are the Susquehanna River Basin and its watershed states of Maryland, Pennsylvania, and New York. To meet TMDL goals, states must implement measures to reduce sediment and nutrient loads from major sources. To this end, states developed Final Phase I Watershed Implementation Plans (WIPs) describing
strategies, actions, and schedules to meet TMDL allocations. EPA's review of final WIPs resulted in
modifications that are reflected in the final TMDL and revised WIPs.

Future key milestones are:

x 2011

June 2011 Draft Phase II WIP

Nov 2011 Final Phase II WIP

Dec 2011 EPA refines TMDL, if necessary

x 2017

June 2017 Draft Phase III WIP

Nov 2017 Final Phase III WIP

Dec 2017 EPA refines TMDL, if necessary

x 2025

Final target loads achieved

5.2 Load Reductions

EPA findings that are used to support the TMDL allocations are provided in Section 4 of the TMDL document (Sources of Nitrogen, Phosphorus, and Sediment to the Chesapeake Bay). Existing load estimates are based on the 2009 scenario run through the Phase 5.3 Chesapeake Bay Watershed Model.

The 2009 scenario uses 2009 estimates for land uses, point and nonpoint source loads, numbers of animals, and atmospheric deposition, and tracked and reported BMPs in each Bay watershed. Table 5.2-1 provides the model estimates of sediment and nutrient loadings to Chesapeake Bay by major source sector and jurisdiction. The major sectors contributing sediment/nutrient loads from these states are shown as follows:

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x Sedimentary Context of Project Area (Section 3.1)

Regulated point sources included in the EPA simulation are: municipal wastewater discharges, industrial discharges, combined sewer and sanitary sewer overflows, NPDES permitted storm water discharges (MS4s, industrial, construction) and NPDES permitted CAFOs (concentrated animal feeding operations). Nonpoint sources included in the simulation are: agricultural applications (manure, biosolids, chemical fertilizers), atmospheric deposition, forest lands, septic systems, nonregulated storm water runoff, oceanic inputs, stream bank and tidal shoreline erosion, tidal resuspension and wildlife. The model accounts for natural background.

Reductions in sediment accumulation rates in Conowingo Pond have been attributed to the implementation of lower Susquehanna River basin-wide BMPs (Langland 2009). Simpson and Weammert (2009) of the Mid-Atlantic Water Program at the University of Maryland conducted a comprehensive analysis of the way BMPs are implemented in the Chesapeake Bay watershed. They assign effectiveness values to defined BMPs that have been utilized or are proposed to be utilized in state WIPs based on average operational conditions. This is a more realistic approach than previous studies that based BMP effectiveness on controlled research conditions. Their effectiveness values vary with level of management, design, hydrogeomorphic location, and land use (Table 5.2-2).

The US Department of Agriculture evaluated the usage of BMP implementation on farmlands throughout the Bay watershed (NRCS 2011). Their study uses models to quantify the reductions in sediment and nutrient loading to basin streams by the implementation of agricultural conservation practices such as cover crops, conservation tillage, and forest buffers in the 10 percent of watershed comprised of cultivated cropland in use 2003-2006. NRSC (2011) calculates reductions in sediment and nutrient loads to Chesapeake Bay from the Susquehanna River due to conservation practices used in 2003-2006, compared to loading without use of these practices (Tables 5.2-3). Loads delivered to edge of field are equivalent to farm field exports and loads delivered to watershed outlets are equivalent to loads delivered to streams. These tables indicate these BMPs have reduced sediment/nutrient loads to and from the Susquehanna River as follows:

In summary, implementation of watershed BMPs from all sediment/nutrient source sectors are effective in reducing sediment/nutrient loads to Conowingo Pond.

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- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)

5.3 Watershed Implementation Plan BMPs

The final WIPs prepared by Susquehanna River watershed states (Maryland, Pennsylvania, and New York) are the most up-to-date compilation of current and future watershed-based management practices and programs to reduce sediment and nutrient loading to the lower Susquehanna River, including Conowingo Pond. None of the WIPs include strategies to escalate sediment/nutrient reduction efforts if the sediment trapping efficiency of Conowingo Pond is found to decline.

Individual state efforts described in the WIPs (directly or by reference) are listed below by state.

Maryland

x Barnyard Runoff: Animal waste management systems, livestock and poultry; barnyard runoff controls including roof control, diversions, and heavy-use poultry area concrete pads; manure storage; and forested and grass buffers Livestock Waste: Precision feeding of livestock and poultry; Phytase feed additives for poultry; ammonia emission controls; comprehensive nutrient management plans; enhanced nutrient management; dairy and poultry manure incorporation technology; manure transport; alternative uses of manure; mortality composters; Maryland animal feeding operation permits; 100-foot contained animal feeding operations and Maryland animal feeding operation setbacks; and 35-foot contained animal feeding operations and Maryland animal feeding operation vegetative buffers

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New York

x Barnyard Runoff: Animal waste management systems, rotational loafing lots; barnyard runoff controls including roof control and diversions; manure storage; and forested and grass buffers

x Livestock Wastes: Precision feeding of livestock and poultry; comprehensive nutrient management plans; enhances nutrient management; mortality composters; and contained animal feeding operations permits for more than 200 animals

- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a net scour of 4,700,000 tons of sediment
- x Total estimated mass of sediment deposited in the system between surveys is 6,900,000 tons
- x Suspended sediment concentrations measured at the USGS Conowingo station during the January 1996 storm event estimates an output of 7,000,000 tons
- x 1929 to 1958 3.1 million tons per year
- x 1959 to 1993 2.5 million tons per year
- x 1985 to 1989 1.8 million tons per year (SRBC estimate) 9
- x 1996 to 2008 1.5 million tons per year
- x Striped bass fry
- x Striped bass spawning
- x Shortnosed sturgeon fry
- x Shortnosed sturgeon spawning
- x Smallmouth bass fry
- x Smallmouth bass spawning
- x American shad fry
- x American shad spawning
- x Stonefly
- x Mayfly
- x Caddisfly
- x Baseline existing conditions of water quality and sediment accumulation
- x Water quality and sediment loads after implementation of Bay TMDL
- x Impact of reaching steady-state behind Conowingo Dam on TMDL achievement and water quality
- x Effect of scour behind Conowingo Dam at steady-state during winter/spring runoff using January 1996 event
- x Effect of scour behind Conowingo Dam at steady-state during tropical storm in June/July
- x Effect sediment bypassing Conowingo Dam by varying intake and/or outfall locations:

- x Field Erosion and Excess Nutrients: Cereal and commodity cover crops; conservation plans including contour farming, strip cropping, conservation tillage, residue management, crop rotations, grassed waterways, sediment basins, and grad stabilization structures including terraces, diversions, and drop structures; conservation tillage including minimal disturbance, continuous and annual no-till, and advanced no-till; nutrient management agriculture; yield reserve; manage precision agriculture; and forested and grass buffers
- x Pasture Erosion: Rotational grazing; precision rotational grazing; forested and grass buffers; stream fencing; off-stream watering systems; and stream protection without fencing
- x Land Retirement and Restoration: Highly erodible land retirement; tree, shrub, and grass planting; wetland restoration; stream restoration; and road ditch stabilization
- x Forest Harvesting: New York State Department of Environmental Conservation BMP Field guide including guidelines and technical references for harvesting, skidding, landing, and constructing haul roads
- x Mining: Marcellus Shale mining and high volume hydraulic fracturing regulated by state multi-sector pollutant discharge elimination system; general permit for stormwater discharges; erosion and sediment control and post-construction stormwater management for well pads, access roads, pipelines, etc.; spill prevention and control countermeasures including secondary containment for process liquids; and wastewater disposal plans
- x Urban Runoff: Municipal separate storm sewer system pollutant discharge elimination system; municipal separate storm sewer system stormwater management plan; stormwater pollution prevention plan; residential phosphorous fertilizer prohibited without a soil test demonstrating a need for all lawn or non-agricultural turf growth (pending Legislative approval); and fertilizer on lawn or non-agricultural turf prohibited between December first and April first on impervious surfaces, and within twenty feet of surface water except where there is a continuous vegetative buffer of at least ten feet (pending Legislative approval)
- x Roadways: Hydro-seeding, grade breaks and check dams, underdrains, French mattresses, crown reshaping, profile and cross slope modification, high-water bypass, and different surface aggregates; in-stream design structures including cross vanes and culverts; and wetland and other buffers to restore and capture road ditch runoff, reduce energy and capture sediments, and denitrify atmospheric and automobile exhaust sources of nitrogen

x Supporting Agencies: New York State Department of

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- Sedimentary Context of Project Area (Section 3.1)
- Previous Studies of Project Area (Section 3.2)

Environmental Conservation, New York State Department of Environmental Conservation Division of Water; New York State Department of Health; New York Soil and Water Conservation Districts; USDA/NRCS; and Upper Susquehanna Coalition

Pennsylvania

- Barnyard Runoff: Animal waste management systems, barnyard runoff controls including roof control and diversions; manure storage; and forested and grass buffers
- Livestock Waste: Precision feeding of livestock and poultry; comprehensive nutrient management plans; enhanced nutrient management technology including solid separation and flocculation; manure treatment, methane digesters; manure-to-energy programs; Pennsylvania Nutrient Trading Program
- Field Erosion and Excess Nutrients: Cereal and commodity cover crops; conservation plans including contour farming, strip cropping, conservation tillage, residue management, crop rotations, grassed waterways, sediment basins, and grade stabilization structures including terraces, diversions, and drop structures; conservation tillage including minimal disturbance, continuous and annual no-till, and advance no-till; nutrient management agriculture; yield reserve; managed precision agriculture; and forested and grass buffers
- Pasture Erosion: Rotational grazing; precision rotational grazing; forested and grass buffers; stream fencing; off-stream watering systems; and stream protection without fencing
- Land Retirement and Restoration: Highly erodible land retirement; tree, shrub, and grass planting; wetland restoration; and stream restoration
- Mining: Coal mining permit requires national pollutant discharge elimination system permit; and erosion and sediment control general permit for oil and gas activities that disturb five acres or more at one time including exploration, production, processing, treatment operations, and transmission facilities
- Urban Runoff: Municipal Separate Storm Sewer System Pollutant Discharge elimination System; municipal separate storm sewer system stormwater management plan; and stormwater pollution prevention plan
- Sewage: Revoking and reissuing permits; plant retrofits for enhanced nutrient removal; and nutrient trading program

Specific sediment/nutrient BMPs identified by County Conservation Districts in the four counties surrounding the Conowingo Project include Agricultural BMPs and Erosion and Sediment Control BMPs. Agricultural BMPs include:

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The Erosion and Sediment Control BMPs include: x Check Dam x Erosion Matting x Earth Dike x Grass Buffer

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- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a

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5.4 Chesapeake Bay Program BMPs for Sediment and Nutrients (CBP 2006)

- x Sedimentary Context of Project Area (Section 3.1)
- x Previous Studies of Project Area (Section 3.2)
- x Relicensing Field Studies (Appendix A)
- x Other Studies Relevant to Project Study (Section 3.3 and Appendix B)
- x x Suspended sediment concentrations measured at the USGS Marietta station during the January 1996 storm event estimates a river input of 3,200,000 tons Reservoir Factor is a net scour of 4,700,000 tons of sediment
- x Total estimated mass of sediment deposited in the system between surveys is 6,900,000 tons
- x Suspended sediment concentrations measured at the USGS Conowingo station during the January 1996 storm event estimates an output of 7,000,000 tons
- x 1929 to 1958 3.1 million tons per year
- x 1959 to 1993 2.5 million tons per year
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- x 1996 to 2008 1.5 million tons per year
- x Striped bass fry
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- x Smallmouth bass fry
- x Smallmouth bass spawning
- x American shad fry
- x American shad spawning
- x Stonefly
- x Mayfly
- x Caddisfly
- x Baseline existing conditions of water quality and sediment accumulation

Chesapeake Bay Program (2006), in its report titled *Best Management Practices for Sediment Control and Water Clarity Enhancement*, specifically addresses sediment-related BMPs applicable to the Bay watershed. These include riparian buffers, stream restoration, urban stormwater management; structural shoreline erosion controls; and restoring SAV. A summary of these BMPs is provided in Table 5.4-1.

5.5 Preserving Reservoir Storage Capacity

Methods to curtail the accumulation of sediment in reservoirs are typically viewed from three perspectives: 1) control volume of sediment entering reservoir, 2) create flow conditions within reservoir to prevent accumulation, or 3) remove sediment that has already been deposited. (Annandale 1987; Sloff 1991; Palmieri et al 2003). Traditional methods are summarized in Table 5.5-1.

A particular method is not necessarily appropriate or feasible for individual dams and reservoirs. For example, flushing requires complete drawdown or partial drawdown of the reservoir to generate high flow velocities capable of remobilizing deposited sediment; is most effective during flood events; causes sediment to be released at much higher concentrations than typical for the system; and partial drawdown usually only relocates sediment upstream to downstream (Morris and Fan 1998; Palmieri et al 2003).

Mechanical removal of reservoir sediment also may not be appropriate in all instances. FERC, in its Environmental Assessment (EA) for the Morgan Falls Hydroelectric Project (Project No, 2237-017) issued November 9, 2007, reviewed sediment accumulation in Bull Sluice Lake, a 7-mile long 684-acre impoundment on the Chattahoochee River, Georgia.[ii] The EA found the reservoir to be at or approaching equilibrium with respect to sedimentation such that if dredging occurred, it would only increase

[ii]Environmental Assessment for Hydroelectric License. Morgan Falls Hydroelectric Project 2237-017. Georgia. Federal Energy Regulation Commission. Office of Energy Projects. Division of Hydropower Licensing. November 2007.

sedimentation until equilibrium was re-established. To prevent this from happening, dredging would have to be continuous rather than a one-time event. Requests by the Riverkeeper and American Rivers to dredge the reservoir to improve recreational boating and fishing and water resources were not found to be a reasonable alternative to current project operations because dredging would not provide any benefit to generation; would provide minimal benefits to boating recreationists; and costs far outweighed the benefits.[u]

5.6 In-Reservoir Options for Conowingo Pond

In-reservoir sediment management options at Conowingo Pond, including two not listed above, are assessed in two SRBC documents (SRBC 1995; SRBC 2002). Additionally, the Susquehanna Riverkeeper has actively engaged the USGS and Army Corps in discussions of potential in-reservoir management options. Table 5.6-1 summarizes these efforts and they are discussed further below.

The modification of dam operations to address sediment was dismissed outright by the Sediment Task Force Sediment Symposium convened in December 2000 because it conflicts with the Project's primary purpose of generating electricity (SRBC 2002).

5.6.1 Reservoir By-Passing

Sediment bypassing encourages the movement of sediments through dams during less critical flow periods (non-storm, or base load) so that there is storage capacity to receive sediment for deposition during higher flows. However, while this may reduce the loads passing the dam during these storm events, it does not effectively reduce the loads carried by larger storms that scour reservoir sediment. In addition, it would increase the base load of sediment reaching the Bay.

5.6.2 Flushing

Flushing high sediment flows through turbine units, acting as low-level outlets, was initially considered until it was recognized that large amounts of sediment are already passing over the spillway during high flow events. Flushing results in high flows transporting large amounts of sediment. Passing sediment over the spillway also does not gain lost capacity and does not reduce loads reaching the Bay.

[u] Order Issuing New License. Georgia Power Company. Project No. 2237-017. May 22, 2008.

5.6.3 *In situ* Sediment Capping, Fixing, and Hardening

Capping is a method of controlling contamination in sediments by covering the contaminated material with clean dredged material to isolate the contaminant from the benthic environment. Sediments may also be chemically treated to "fix" the contaminant, i.e., render it inert in the ambient environment.
Neither capping nor fixing is appropriate for preserving storage capacity since these techniques would not change the amount of sediment passing through the system to the Bay and does not add capacity. The idea of hardening the sediment to prevent scouring was considered. This would not, however, increase capacity. In addition, it was not clear how this could be done.

5.6.4 Siphoning

Siphoning (hydrosuction dredging) sediment from the reservoir side of the dam to the toe on the other side with a large flexible hose was reviewed as another possible option. This process can be accomplished during non-storm flows. However, downstream deposition will be higher than normal during times of average or lower flows and excessive oxygen demands may result.

5.6.5 Conventional Dredging

The effort and technical feasibility to dredge was quantified in the 1995 SRBC report. Depending on the length of discharge pipe used, a cutterhead dredge with an 8-inch pipe has a rated output range of 50 to 100 cubic yards per hour and a 20-inch pipe has an output of up to 300 to 1500 cubic yards per hour. Assuming the Conowingo Reservoir would require 8,000 feet of pipe to dredge at its widest reach, and 4,000 feet on average, a 20-inch diameter pipe would be able to dredge 350 to 500 cubic yards per hour. Assuming a yearly volume of sediment trapped of 2.3 million cubic yards, it would take 4,600 to 6,600 hours of dredging to keep up with average annual deposition; in other words, working 24-hours a day 190 to 275 days per year.

To dispose of this dredged material off-site, 80 100-ton railroad hopper cars would be filled each day at the 350 cubic yards per hour dredging rate, and 116 cars would be filled each day at the 500 cubic yards per hour rate.

SRBC also approximated the cost to dredge. Assuming an appropriately sized dredge and a disposal transport distance less than two miles, the unit cost to operate a 20-inch cutterhead is $12 (1995 dollars) per cubic yard. Assuming an annual average accumulation of 2.3 million cubic yards, it would cost $28 million (1995 dollars) per year just to keep pace with incoming sediment. Assuming a 71 percent cost escalation based on the Means Historical Cost Index, the 2010 costs are estimated to be $20.52 per cubic yard to dredge and $47.88 million per year to keep pace with sedimentation in the reservoir.

Options for the disposal of sediment removed from Conowingo Pond consist of placement at existing dredged material placement sites and beneficial use of the sediment. Complete sediment characterization is needed to identify the appropriate option. The discharge of dredged material to waters, including wetlands, require Federal and state permits. Non-toxic sediment may be permitted to be placed at open-water sites or upland contained sites. Toxic sediments would require a confined disposal facility. Other issues to be considered for the selection of a dredged material disposal site are volume of sediment and the distance between dredge site and disposal site. .

5.7 Coarse Sediment Replenishment

Replenishment of sediments below dams is a means to re-supply a river system with an interrupted sediment supply. This procedure is used, in particular, to increase and improve salmonid habitat downstream of dams (Kondolf and Matthews 1991; Bunte 2004). The method of sediment placement can be active or passive, dependent on objective. Active (direct) replenishment involves the direct placement of sediment where it is needed to meet the objective while passive (indirect) replenishment involves introducing a bedload supply upstream of the intended areas of improvement relying on natural river flow to transport, distribute, and deposit the sediment in the desired fashion. Success may be short-term with the active approach if the replenished sediment is washed away. In contrast, the passive approach creates an artificial localized pulse of sediment to the system that depends on flows with the entrainment potential to transport the material away for the site of placement. Artificial pulses may move by translation
downstream as a 'sediment wave' or be dispersed in place without moving downstream by translation
(Sklar et al 2009). The success of sediment replenishment requires the selection of a technique and location appropriate for clearly developed objectives and the ability to predict sediment movement after placement.

6.0 Sediment Management Plan

Based on information collected in other studies, the proposed Sediment Management Plan for the Conowingo Project may incorporate the following BMPs on Project lands as part of a Land Management Plan:

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The shoreline erosion study of the reservoir conducted for the relicensing found the erosion to be predominantly due to natural processes - wind generated waves, river flow, surface runoff, and mass wasting (Appendix A). Boat wakes are likely another contributing factor at the summer recreation level of the Pond, and ice effects may be important during colder winters. Shoreline erosion was found to be ubiquitous, yet did not pose a threat to existing infrastructure or safety. Erosion does, however, supply sediment to the reservoir. And, depositional areas of shoaling have been identified in the reservoir, some of which inhibit recreational use. Thus, in conjunction with development of the Project shoreline management and recreation plans, the following are proposed:

x Revisit sites of shoreline erosion to identify potential sites for bank stabilization to reduce sediment loads. x Identify areas where sedimentation has affected recreational use in Project lands and evaluate sites for targeted dredging.

These actions will be prioritized after the Shoreline Management process has been completed.

The Army Corps study may result in the need for benchmarks. Exelon will work with the Army Corps to establish benchmarks, if needed.

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