Lower Susquehanna River Integrated Sediment & Nutrient Monitoring Program

Presented at the
Chesapeake Bay Program
Scientific and Technical Advisory Committee
(STAC) Workshop

January 13, 2016

Gomez and Sullivan Engineers AECOM Exelon Generation

Background

- Upon review of the LSRWA, STAC recommended more research be conducted regarding Conowingo Pond sediment and nutrient dynamics and their potential impact on Bay water quality.
  - ✓ Exelon agreed to fund this research in 2014
- Exelon, MDNR, MDE, USGS, and UMCES (the monitoring team) developed a Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program (Integrated Monitoring Program) with input from the CBP.
  - ✓ The monitoring program originally targeted 6 storm events with peak flows exceeding 100,000 cfs
- The monitoring team executed this program in 2014 and 2015.
- To date, the program has involved:
  - ✓ Construction of monitoring stations (Holtwood, Conowingo, and Darlington)
  - ✓ Conowingo Pond tributary data collection
  - ✓ Bathymetry surveys (Lake Clarke, Lake Aldred, and Conowingo Pond)
  - ✓ Collection and analysis of short and long cores. Analysis has included: geotechnical properties and sediment composition, biogeochemical analysis, bioreactivity experiments, and radionuclide analysis
  - ✓ Two official storm sampling events (2015) with peak flows in excess of 100,000 cfs
- A goal of the storm event sampling was to calculate a mass balance for sediment and nutrients around Conowingo Pond.
- Given the lack of storms which have occurred since 2011 and the looming TMDL Midpoint Assessment deadline, focus has shifted from data collection to modeling enhancements in support of the CBP modeling efforts.

Background (cont'd)

- This presentation will focus on an overview of, and observations from, the:
  - ✓ Two official sampling events which occurred in 2015;
  - ✓ Collection and analysis of the Conowingo Pond long cores (2015); and
  - ✓ Bathymetry surveys which have occurred at Lake Clarke, Lake Aldred, and Conowingo Pond since 2008.
- Subsequent presentations by UMCES will focus on the collection and analysis of the short cores as well as other biogeochemical and bioreactivity analysis and experiments.
- Following the afternoon break, WEST Consultants and HDR will be presenting proposed Lower Susquehanna River Reservoir System model enhancements in support of the ongoing TMDL Midpoint Assessment.

Integrated Sediment & Nutrient Monitoring Program – 2015 Major Activities

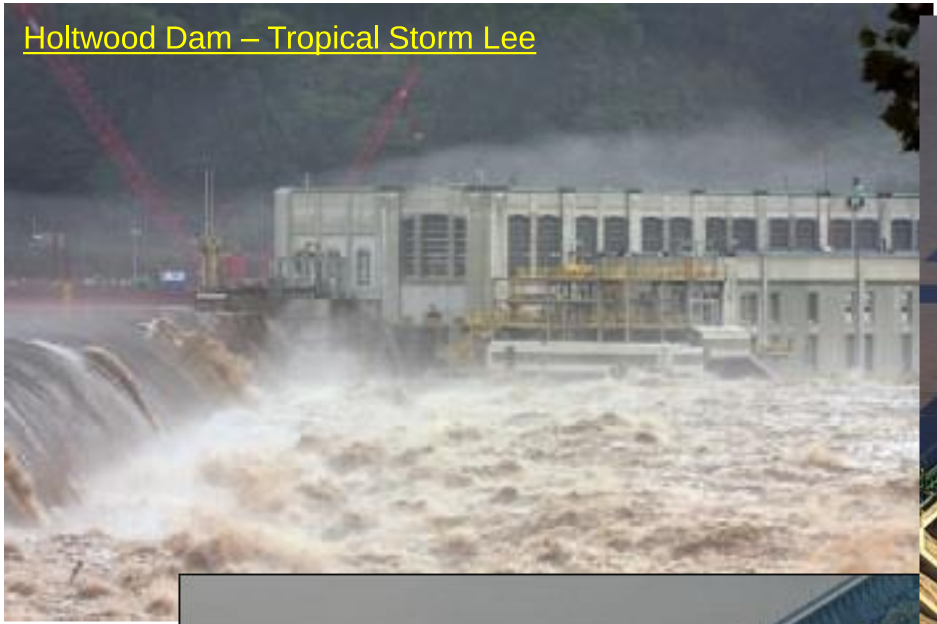
2015 Major Activities (Exelon)

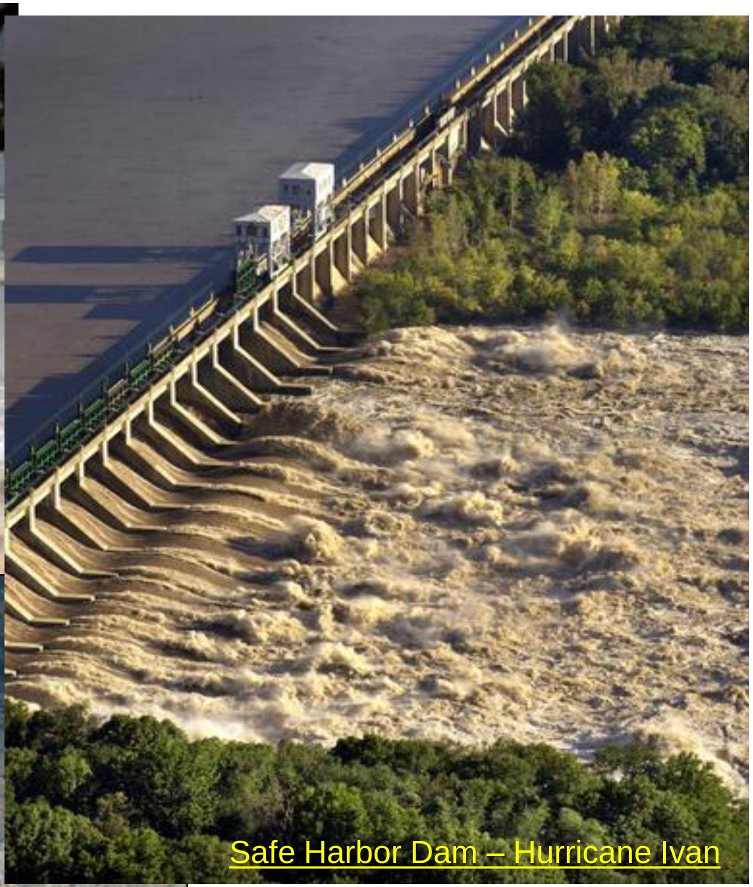
- **Official Sampling events:**
  - ✓ Sampling Event No. 1 – April 6-14, 2015
  - ✓ Sampling Event No. 2 – April 22-25, 2015
- **Conowingo Pond baseline bathymetry survey** – May 4-8, 2015
  - ✓ Previous surveys conducted by Exelon include: 2011, 2013, and 2014
- **Long Core collection** – August 2015
  - ✓ Piston cores collected at 10 locations throughout Conowingo Pond (plus 6 replicates)
- **Lake Clarke and Lake Aldred baseline bathymetry surveys** – October 2015
  - ✓ Previous surveys conducted by Exelon include: 2013
- **Lower Susquehanna River Reservoir System Modeling Enhancements**
  - ✓ Development of a HEC-RAS model(s) of Lake Clarke and Lake Aldred
  - ✓ Development of a coupled hydrodynamic sediment transport and nutrient flux model of Conowingo Pond
  - ✓ Ongoing, to be discussed in a later presentation

LOWER SUSQUEHANNA RIVER

SAMPLING EVENTS – *2015*

Lower Susquehanna River Reservoir System High Flow Events





Sources: Holtwood & Safe Harbor (www.lancasteronline.com), Conowingo (www.chesapeakequarterly.net)

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2015 Sampling Events - Overview

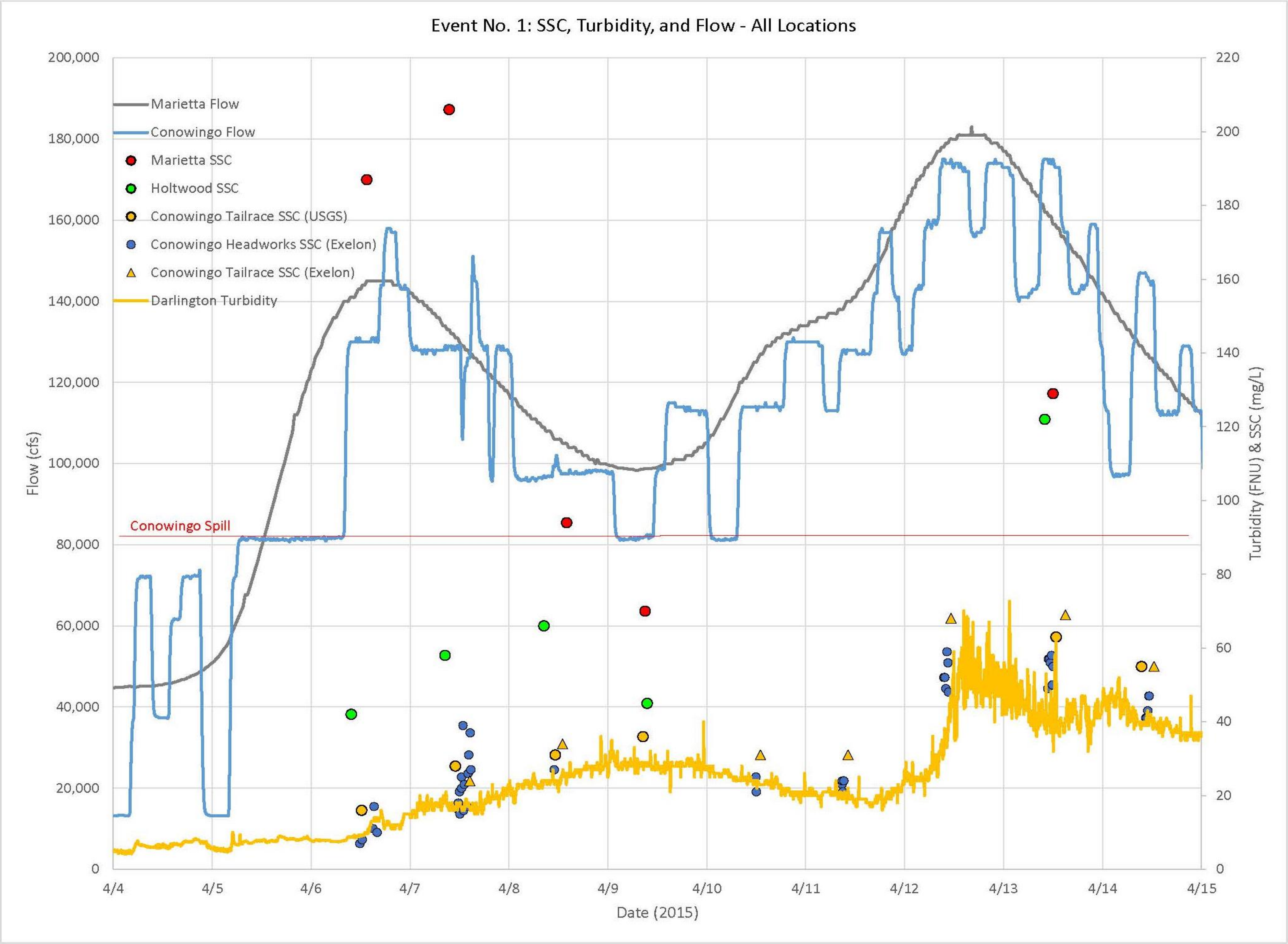
SAMPLING EVENT NO. 1 – *April 6-14, 2015*

- **Peak Flow(s):** 2 peaks – 1st peak 146,000 cfs, 2nd peak 182,000 cfs *(as recorded at Marietta)*
  - ✓ The first peak was driven by snow melt from across the watershed (particularly the upper basin). Minimal to no rainfall occurred leading up to the first peak.
  - ✓ The second peak was driven by a rain event in the upper portion of the basin, continued snow melt/thawing, and the already elevated flows from the first peak.
  - ✓ Due to the absence of a local or basin wide rain event a corresponding tributary event did not occur; this was an isolated mainstem event.
  - ✓ Conowingo Station opened 1-6 crest gates during the course of this event (a max of 3 gates during the first peak, 6 during the second).

SAMPLING EVENT NO. 2 – *April 22-25, 2015*

- **Peak Flow(s):** 125,000 cfs *(as recorded at Marietta)*
  - ✓ This event was driven by a moderate upper basin rain event, a low to moderate lower basin rain event, river ice melt, and some leftover snow melt.
  - ✓ A corresponding tributary event preceded the mainstem event from April 20-22.
  - ✓ The mainstem event lasted from April 21-26.
  - ✓ Conowingo Station opened 1-3 crest gates during the course of this event.

Sampling Event No. 1 - Results



Preliminary Data not for Distribution – Subject to revision

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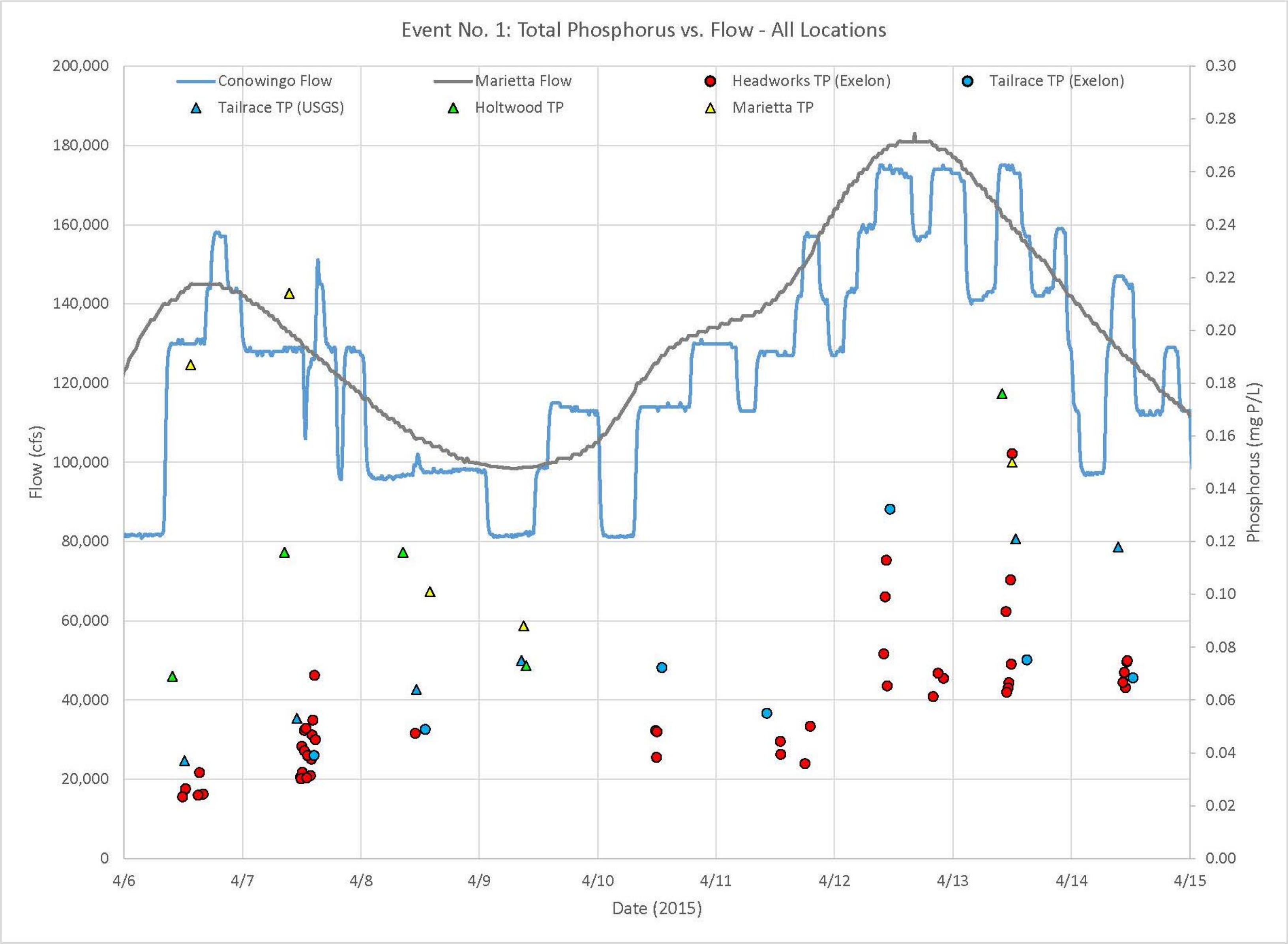
Sampling Event No. 1 - Results



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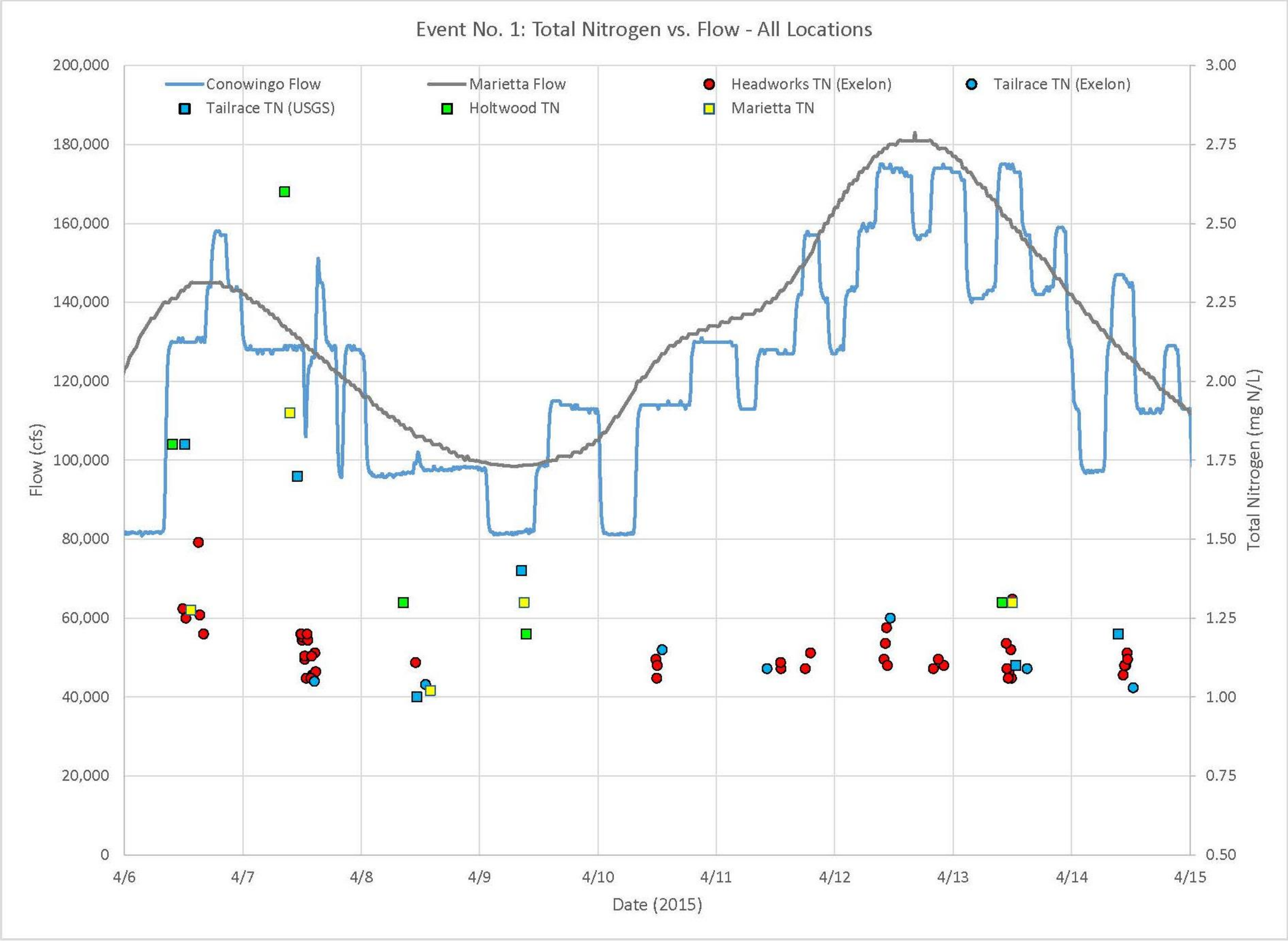

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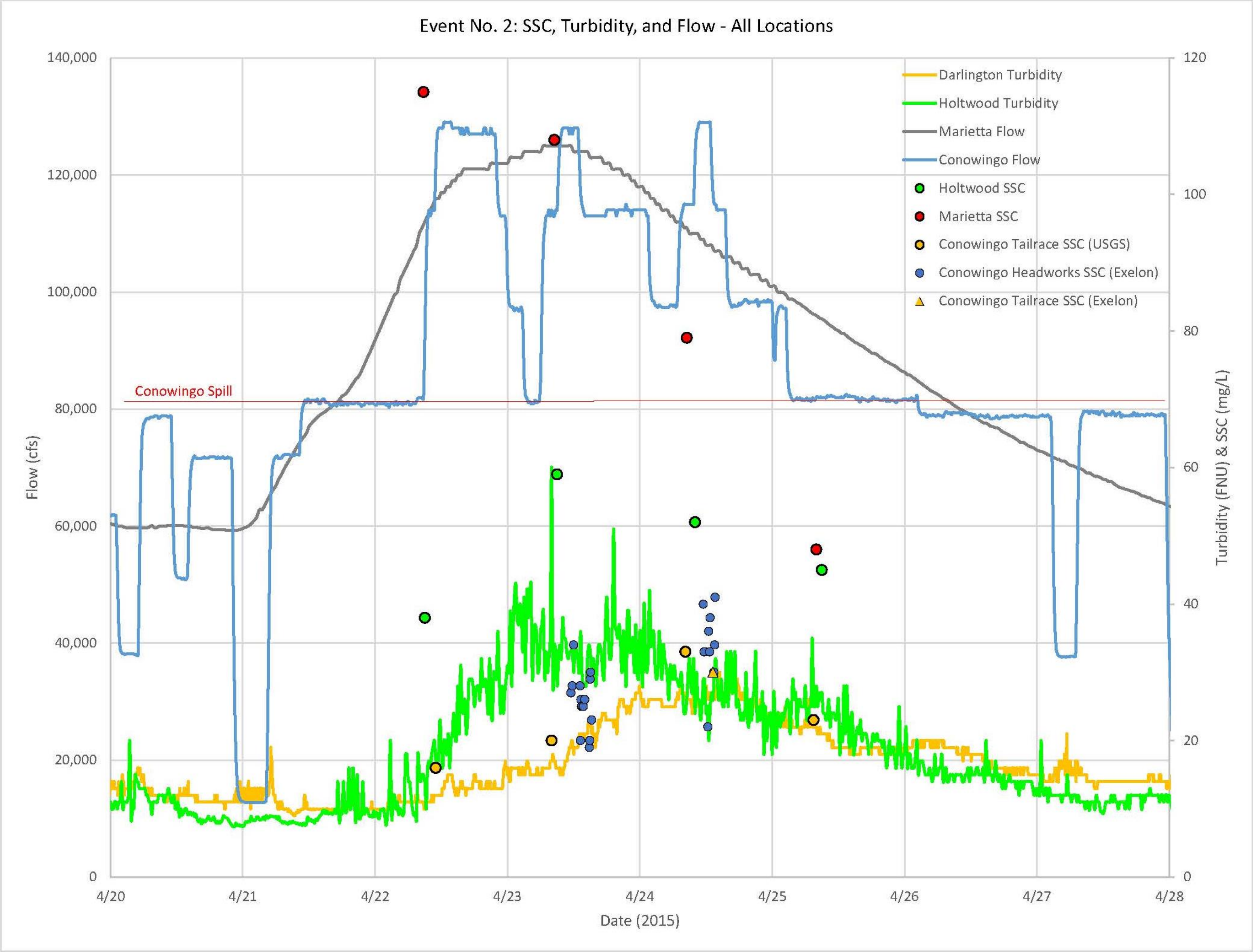

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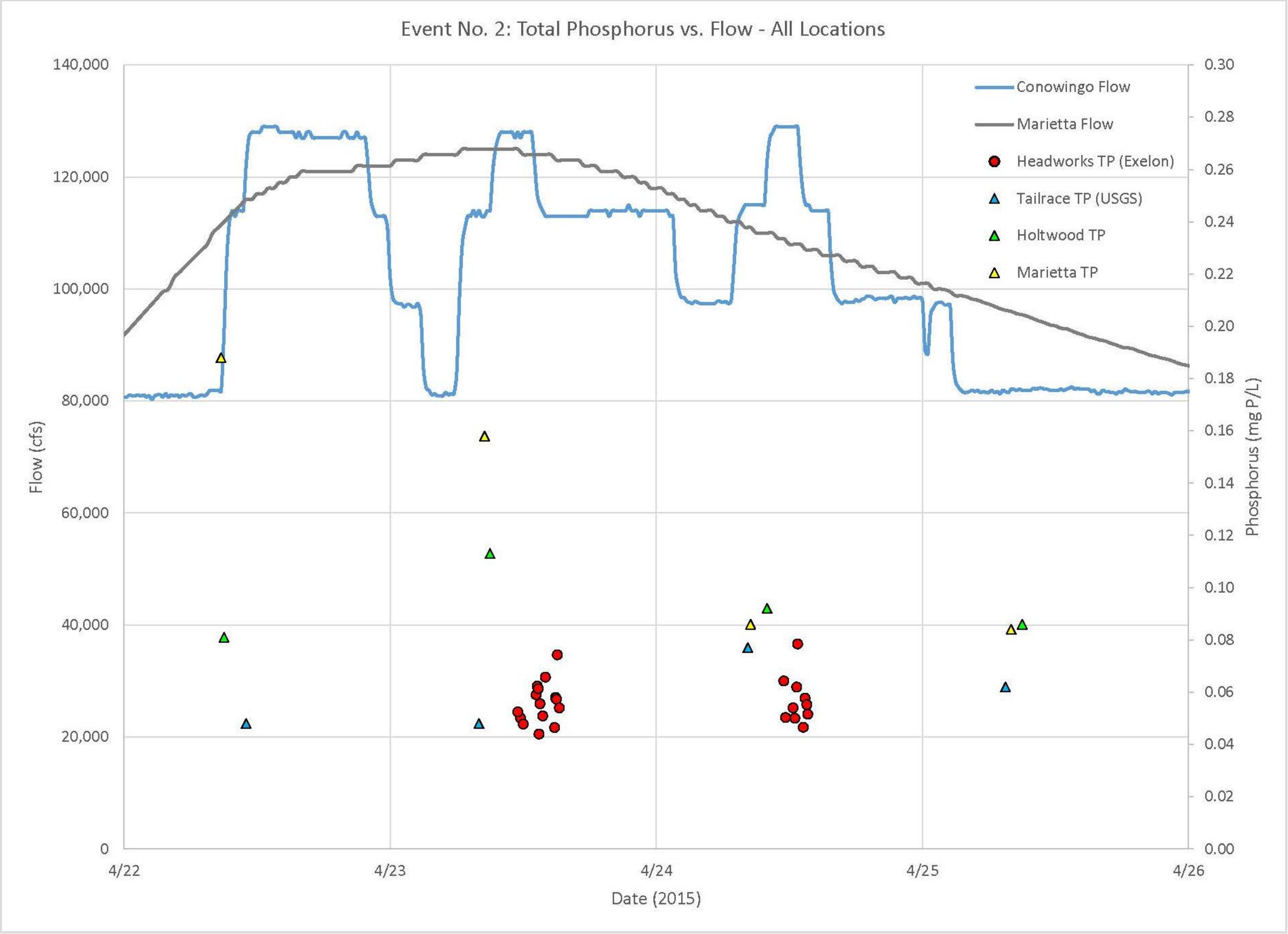

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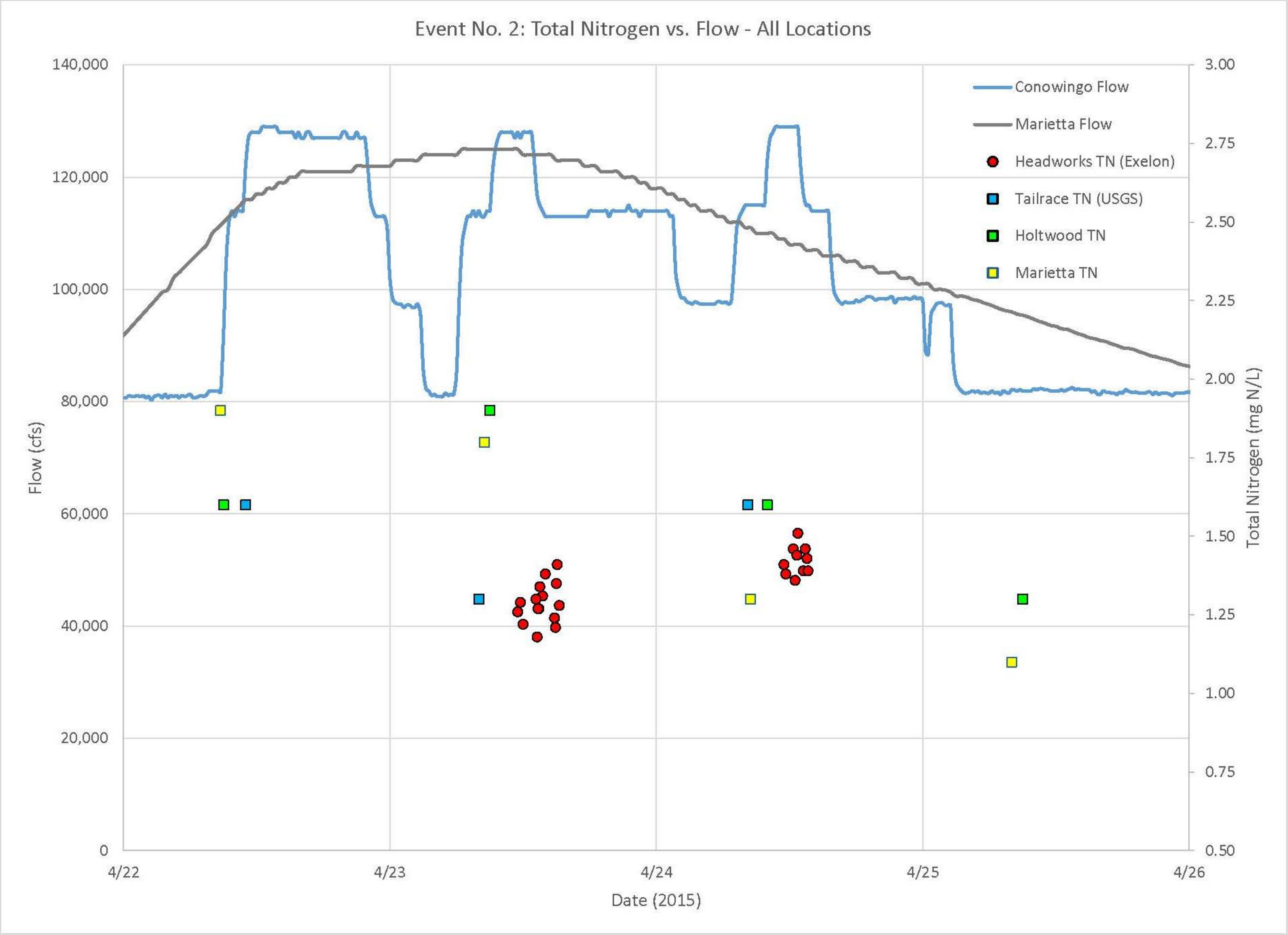

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2015 Sampling Events - Observations

SAMPLING EVENT OBSERVATIONS

- Peak flows for these events were: **146,000** and **182,000** cfs (Sampling Event No. 1) and **125,000** cfs (Sampling Event No. 2).
- Travel time of suspended sediment throughout the system for these events was on the order of ~1 day.
  - ✓ That is, the SSC peak at Marietta to the SSC peak at Holtwood was staggered by approximately 1 day. Likewise, the SSC peak from Holtwood Dam to Conowingo Dam was staggered by approximately 1 day as well.
- Data suggests that both events appeared to be **net depositional** and that trapping occurred in each reservoir. Evidence of scour was not observed in any reservoir.
  - ✓ Highest SSC values were observed at Marietta (Event No. 1, 1st peak: **206 mg/L,** Event No. 2: **115 mg/L**), then Holtwood Dam (**66** and **59 mg/L**), and finally Conowingo Dam (**36** and **33 mg/L**).
  - ✓ SSC peaks were not captured during the second peak of Sampling Event No. 1. Values recorded on 4/13 for Marietta, Holtwood Dam, and Conowingo Dam were: **129** (~2 days after the peak), **122** (~1 day after the peak), and **69** mg/L (at the peak), respectively.
- Not all storm events are created equal or have an equal significance.
  - ✓ Time of year and the cause of high flows (e.g., thaw event or regional soaking event) are important factors in determining the significance of a given flow event.
  - ✓ A seasonal thaw event which occurs in the spring may produce much lower SSC values than a regional soaking event that may occur later in the year.
- Representativeness of Conowingo tailrace measurements as compared to the entire cross-section are inconclusive and should be examined further.

CONOWINGO POND
LONG CORE COLLECTION – *2015*

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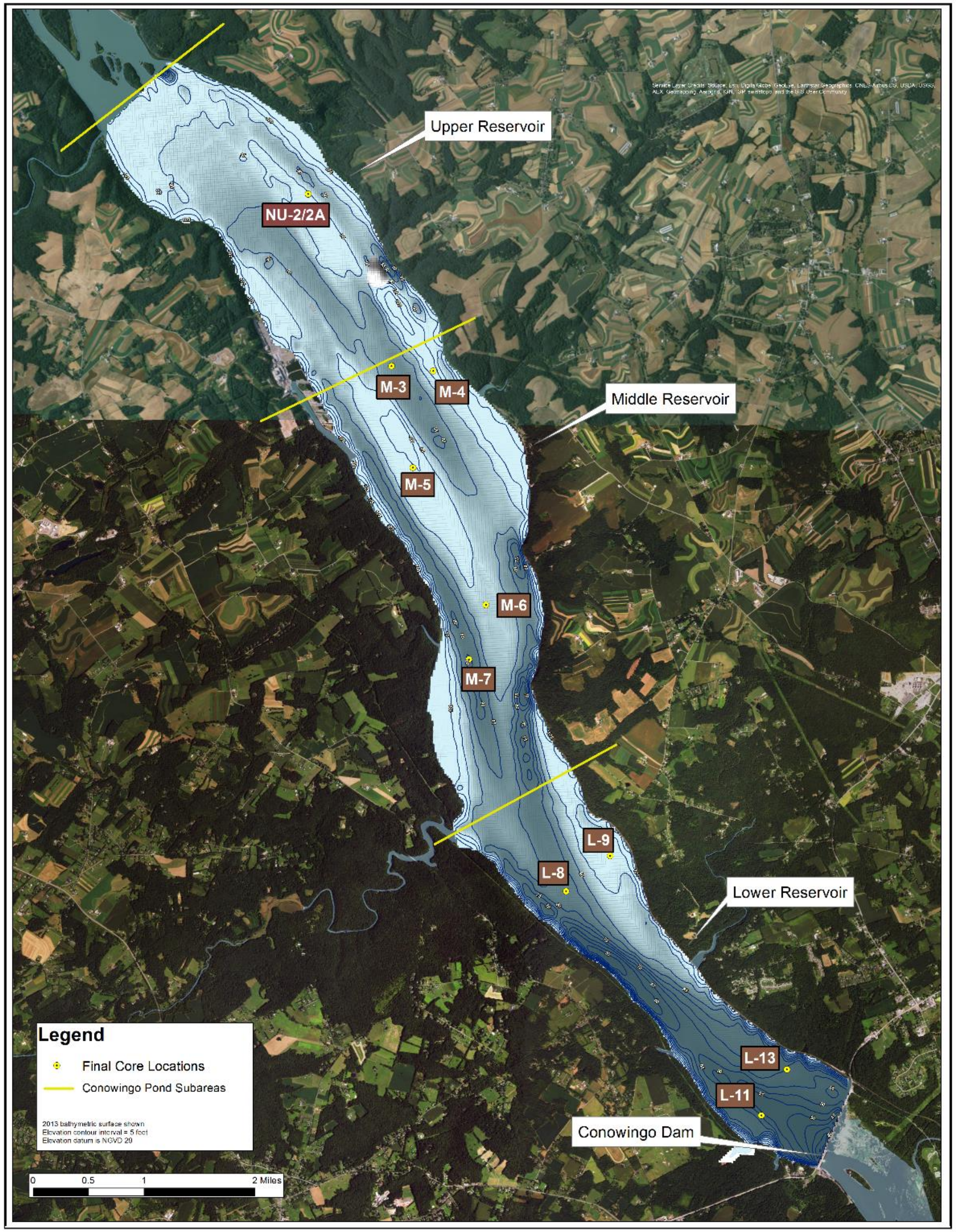
2015 Long Core Collection - Overview

- Thin-walled Shelby tube samples were collected at ten locations by barge using a piston tube sampler (ASTM D1587) in August 2015.
- Core locations were chosen in cooperation with UMCES, MDNR, and USGS to represent the range of geomorphic and geologic characteristics found throughout Conowingo Pond.
  - ✓ In-channel vs. out-of-channel, deep vs. shallow water
  - ✓ Erosional vs. depositional areas
  - ✓ Spanned the longitudinal extent of the reservoir
- Cores (10) were analyzed by Exelon/UMCES for:
  - ✓ Stratigraphy, standard index testing (water content, liquid and plastic limit, particle size, specific gravity, organic content), measured dry bulk density, grain size, and radionuclide dating
- Replicate cores (6) were analyzed by UMCES for:
  - ✓ Various biogeochemical analyses and bioreactivity experiments

2015 Core Locations

Water Depth (feet)	
NU-2/2A	9.5
M-3	21.1
M-4	4.7
M-5	7.4
M-6	13.6
M-7	27.1
L-8	26.4
L-9	11.5
L-11	50.4
L-13	37.1



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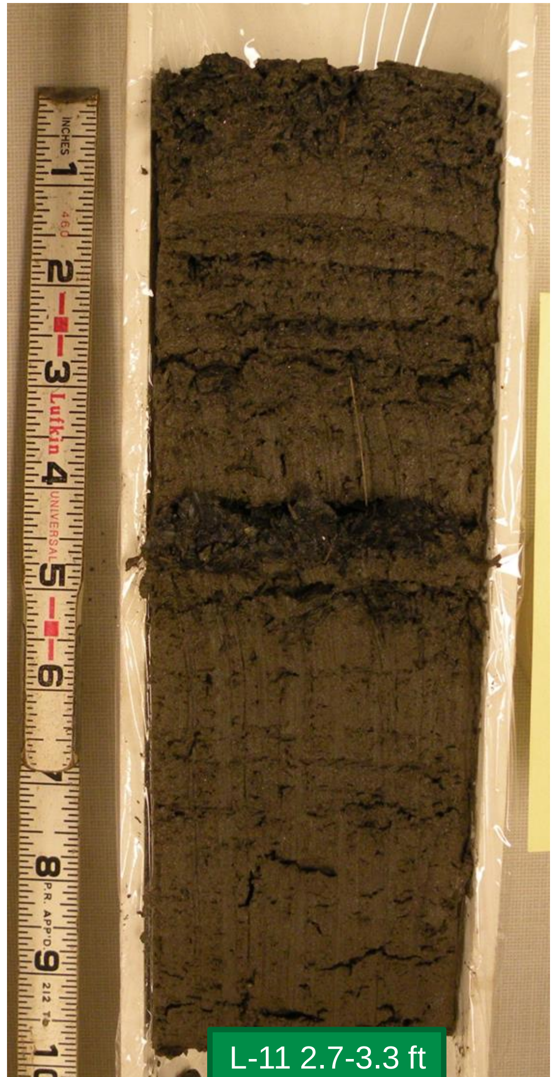
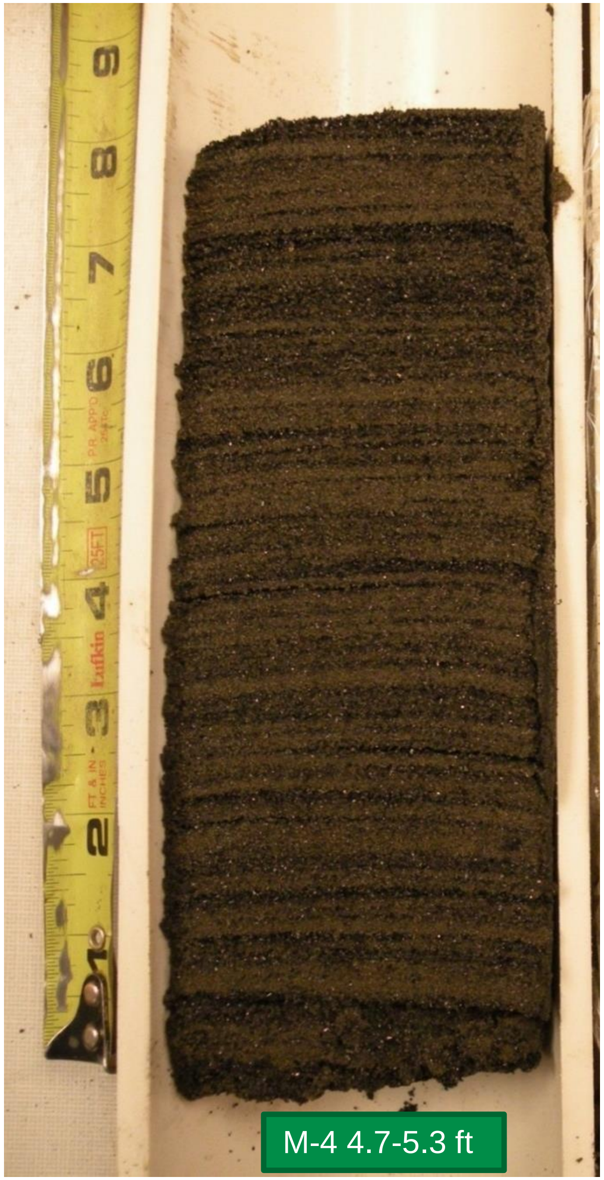
2015 Conowingo Pond Core - Examples

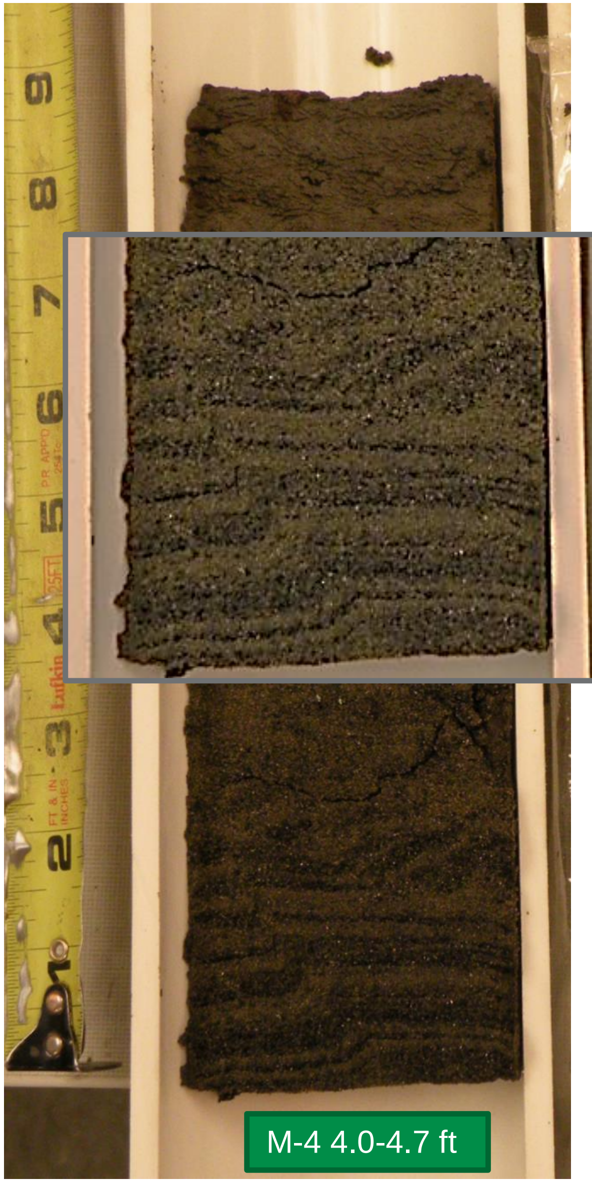


2015 Conowingo Pond Core – Examples (cont'd)

M-3 1.3-2.0 ft



M-4 4.7-5.3 ft



M-4 4.0-4.7 ft

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2015 Conowingo Pond Cores – Dry Bulk Density

Core	Modal Shepard Class	Range of Graphic Mean	Dry Unit Weight Ranges (All Samples) pcf
NU-2	sand	v. fine-coarse sand v. fine-med silt	sands: 57.2-74.6 silts: 47.4-51.2 **(60.6)**
M-3	sand	fine-med sand fine-med silt	sands: 77.8-78.4 silts: 45.8-57.3 **(68.7)**
M-4	sand	v. fine-fine sand fine-coarse silt	sands: 58.9-82.3 silts: 42.7-54.9 **(60.3)**
M-5	sand-silt-clay	fine-coarse silt v. fine-fine sand	sands: 58.3-71.6 silts: 49.6-55.7 **(55.3)**
M-6	clayey silt	fine-coarse silt v. fine-fine sand	sands: 53.8-79.5 silts: 48.3-56.4 **(58.7)**

Core	Modal Shepard Class	Range of Graphic Mean	Dry Unit Weight Ranges (All Samples) pcf
M-7	clayey silt	v. fine-fine silt v. fine sand	sands: 47.8-58.9 silts: 42.1-59.6 **(51.7)**
L-8	clayey silt	v. fine-coarse silt	sands: 45.8-53.3 silts: 35.3-43.8 **(39.7)**
L-9	clayey silt	v. fine-coarse silt v. fine sand	sands: 33.4-51.7 silts: 34.8-47.0 **(41.7)**
L-11	clayey silt	v. fine-coarse silt fine sand	sands: 38.4-49.3 silts: 38.7-52.1 **(42.7)**
L-13	clayey silt	v. fine-med silt	silts: 34.8-48.3 **(42.6)**

USGS: 67.8 pcf

2015 Conowingo Pond Core - Findings

- Geotechnical properties are variable within Conowingo Pond sediment
  - ✓ Upper and middle Pond cores consist of alternating layers of sands and silts of varying thickness, particle size, and coal content; lower Pond cores are more homogenous, consisting primarily of clayey silt
  - ✓ Modal grain-size of cores get progressively finer (sand to sand-silt-clay to clayey silt) in downstream direction
  - ✓ Visible organic debris (twigs, leaves, fibers) absent to present in trace amounts in upper and middle Pond; prevalent in lower Pond; laboratory organic matter of subsamples ranged 2.2 to 44.2 percent
  - ✓ Methane voids prominent in clayey silt beds of M-6 and M-7 and throughout the clayey-silt lower Pond cores; far less common in more upstream and coarser cores
  - ✓ Coal is an important component as distinct bed/lamina (primarily sand) or as faint laminations within silt units
  - ✓ Dry bulk density
    - Increases with increasing sand content and decreasing water content; lack of correlation with depth in core due to variability in grain-size and water content
    - Wide range in values within sand and silt classes (samples are poorly to very poorly sorted)
    - Silts consistently have lower values than sands (as per literature); downstream of M-6 sand values decrease approaching silt values
    - Weighted average of cores decreases downstream; highest values with modal class of sand; whole core average decreases as silt/clay content of core increases
  - ✓ USGS value (67.8 pcf) applied to all Pond locations is more consistent with values measured in the upper half of the Pond (average 60.7 pcf) rather than the lower half (average of 43.7 pcf). Current volume-to-mass conversions of scoured sediment may be over-estimated.

2015 Conowingo Core - Findings

- Preserved sediment record and potential processes
  - ✓ Thinly bedded and laminated sands (coal and non-coal grains) in upper and middle Pond: plane-bed phase of upper flow regime
  - ✓ Sand beds within homogenous silts near dam: storm deposit interrupting non-storm suspended load deposition
  - ✓ Bottom erosion occurs throughout Pond
  - ✓ Soft-sediment deformation suggests downslope slumping or sliding under influence of gravity or overloading by rapid sediment deposition: evidence of density currents?

LOWER SUSQUEHANNA RIVER BATHYMETRY SURVEYS – *2015*

LSR Reservoir Bathymetry Surveys - Overview

LOWER SUSQUEHANNA RIVER BATHYMETRY SURVEYS – 2000's

- **USGS**:
  - ✓ **Conowingo Pond:** 2008
  - ✓ **Lake Aldred** and **Lake Clarke**: 2008 (partial surveys)
- **Exelon**:
  - ✓ **Conowingo Pond**: 2011, 2013, 2014, and 2015
  - ✓ **Lake Aldred** and **Lake Clarke**: 2013 and 2015
  - ✓ As part of the Integrated Monitoring Program, future bathymetry surveys will be conducted annually and immediately following storm events exceeding 300,000 cfs (at least at Conowingo Pond)
- **MGS**:
  - ✓ **Conowingo Pond**: Side scan sonar, seismic profile, and bathymetry surveys were completed in 2014

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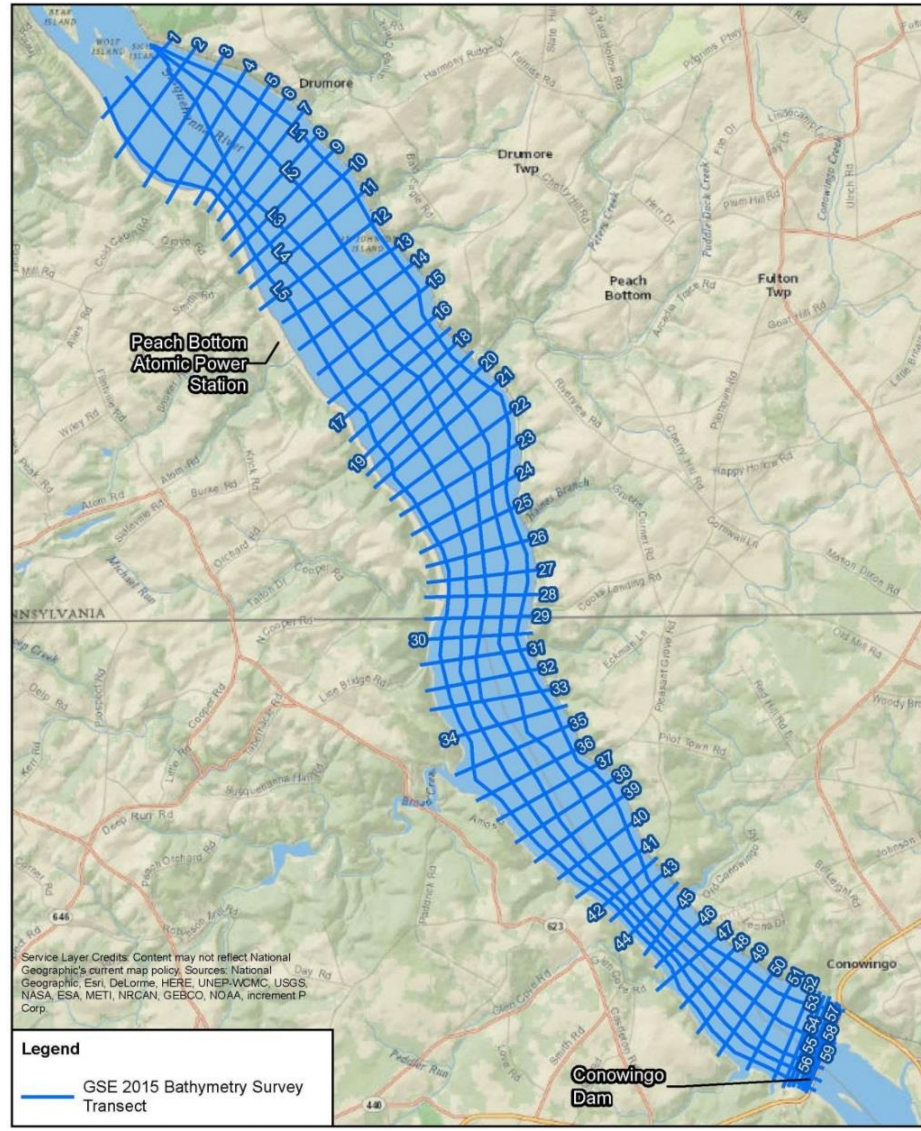
LSR Reservoir Bathymetry Surveys

- 2015 Surveys were conducted:
  - ✓ **Conowingo Pond**: May 2015
    - ✓ *59 transects and 5 longitudinals*
  - ✓ **Lake Clarke and Lake Aldred**: October 2015
    - ✓ *42 transects and 5 longitudinals (Lake Clarke)*
    - ✓ *38 transects and 5 longitudinals (Lake Aldred)*
- A SonTek RiverSurveyor M9 single beam ADCP and RTK GPS unit were used to collect the bathymetry data.
- All bathymetry surveys conducted by Exelon follow the same procedures and use the same equipment as the previous survey to allow for a direct comparison of the results.



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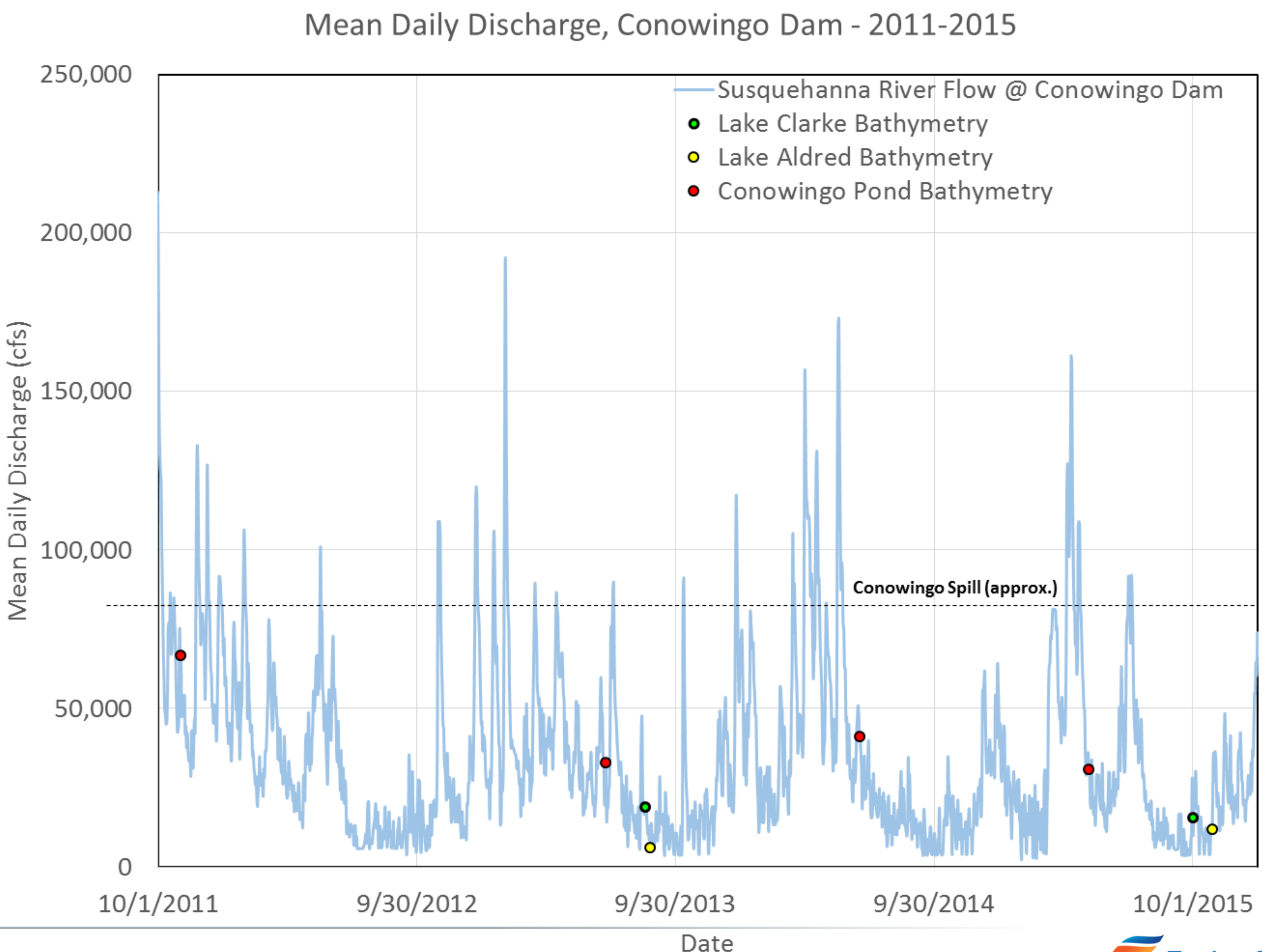
Mean Daily Discharge, Conowingo Dam – 2011-2015



Exelon Generation.

LSR Reservoir Bathymetry Observations – 2000's

LSR RESERVOIR BATHYMETRY OBSERVATIONS:

- During the survey period (Nov 2011 – today), storms greater than 190,000 cfs have not occurred. This has been a relatively low flow period.
- All three reservoirs have shown relatively little change during the survey period
- Observed changes are believed to be net depositional, however, changes may be within the accuracy of the survey equipment
- Analysis of the bathymetry datasets collected since 2011 is ongoing