



Aids to Understanding System Wide Eutrophication Model (SWEM) Results for NY/NJ Harbor Preliminary Sub-Regional Nutrient TMDL Plans

Presented below is clarifying information related to interpreting SWEM results for sub-regional Harbor nutrient TMDL planning. Specifically, “Volume Weighted Days of Non-Attainment” and “Planned Improvements” are further explained.

1.0 Definition of "Volume Weighted Days of Non-Attainment"

Days of non-attainment of various dissolved oxygen criteria and standards calculated by SWEM have been presented on spatial maps for each loading scenario evaluated. Each map displays the maximum days of non-attainment occurring at any depth for every grid cell location in the domain of SWEM. Although these outputs display a very detailed view of the status of standards attainment everywhere in the Harbor for a specific nitrogen and carbon loading condition, they do not summarize concisely how standards attainment compares for a number of different loading conditions. Further, the spatial resolution of individual grid cells presented on the maps is often too much information to view at once for making general comparisons between standards attainment under different loading conditions.

To address the need for making concise comparisons of the status of standards attainment across a number of nitrogen and carbon loading conditions, bar diagrams of days of non-attainment were constructed for each sub-region. Each bar on these diagrams represents days of non-attainment within a sub-region for a different nitrogen and carbon loading condition. The maximum days of standards non-attainment calculated by SWEM for each grid cell within a sub-region as displayed on the maps were averaged for a sub-region and presented as a bar. In calculating the average of the results across grid cells within a sub-region, volume-weighting was used so that a sub-regional average was influenced more by larger grid cells and less by smaller grid cells. This calculation of sub-regional averages with a weighting by volume is presented by each bar as “Volume Weighted Days of Non-Attainment”.

Calculation of a simple mathematical average involves adding up the numbers you wish to average and then dividing by how many numbers are being averaged. For example, the average of 10, 15, and 20 is 15 and is calculated as:

$$10 + 15 + 20 = 45 \text{ and } 45/3 = 15$$

When volume weighting is used, the numbers are multiplied by volume before they are added and instead of dividing by how many numbers are being averaged, dividing by total volume is used. For example, the volume weighted average of 10, 15, and 20 would be calculated as:

$$10 (V1) + 15 (V2) + 20 (V3)/(V1 + V2 + V3) = \text{volume weighted average}$$

where V1, V2, and V3 represent volumes.

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It is noted that each grid cell in SWEM includes ten depth layers. Each depth layer in SWEM is 10% of the depth at that grid cell location. Since depth layers are always 10% of the total depth, it is a mathematical fact that the exact same “Volume Weighted Days of Non-Attainment” would be calculated whether the volume of a grid cell in a single layer or the volume of the grid cell for all ten layers are used to do the weighting. The reason for this is inserting a 10% multiplier into both the numerator and denominator of the volume weighted average calculation cancels itself out.

1.1 Potential Variations on "Volume Weighted Days of Non-Attainment"

If EPA and the States had a specific need, different types of bar diagrams could be constructed; however, alternative bar diagrams would not be summarizing the information shown on the maps. Alternative bar diagrams could present somewhat different information. Two potential examples are offered based on informal conversations with EPA and the States. These include, “Total Volume Weighted Days Non-Attainment” and “DO Volume Days Non-Attainment”.

1.1.1 “Total Volume Weighted Days Non-Attainment”

“Total Volume Weighted Days Non-Attainment” would be very similar to the Volume Weighted Days Non-Attainment” already calculated. The only difference is that instead of using only the maximum days of non-attainment for each grid cell and one volume, the days of non-attainment in each of the ten layers in each grid cell and the volumes of each of these grid cells would be used in making the volume weighted calculations for a sub-region. These calculations might show somewhat lower volume weighted days of non-attainment for a sub-region because surface layers where days of non-attainment are likely to be lower are being averaged in. The degree to which “Total Volume Weighted Days Non-Attainment” could look different than “Volume Weighted Days Non-Attainment” will differ for stratified vs. non-stratified areas. Neither “Volume Weighted Days Non-Attainment” nor “Total Volume Weighted Days Non-Attainment” is more technically correct than the other. They are just different presentation styles. Technical correctness comes from using them consistently across the Harbor. Also, neither “Total Volume Weighted Days Non-Attainment” nor “Volume Weighted Days Non-Attainment” carries any real regulatory significance. Attainment of standards is specific to a location. Averaging attainment results across a sub-region is being suggested only for purposes of summarizing relative benefits of different loading options.

1.1.2 “DO Volume Days Non-Attainment”

“DO Volume Days Non-Attainment” is a metric that would be intended to capture both the magnitude of days of non-attainment and the total volume in non-attainment with a single number. This would be calculated by multiplying the days of non-attainment calculated by SWEM by the volume of water in non-attainment. This calculation could be done for the entire Harbor, for each sub-region, or for each grid cell. A “DO Volume Days Non-Attainment” calculation would have its greatest utility in attempting to evaluate difference between the water quality benefits of various loading reduction options and in attempting to select a “knee of the curve”. Another utility for “DO Volume Days Non-Attainment” would be for tracking progress as phased TMDL actions are implemented. The advantage is that one number captures both duration and spatial extent. A disadvantage of “DO Volume Days Non-Attainment” is that the units are volume-time and the magnitude of the numbers are very large and hard to relate to. For example, it is much easier to understand days of non-attainment because you know the total can't possibly exceed 365. The public, regulatory, and regulated communities don't have a priori understanding of what the maximum number of days-m³ for the Harbor should be, for example.

The “DO Volume Days Non-Attainment” calculation has a history based in living marine resources and the development of the federal marine dissolved oxygen criteria that is informative to consider. During the development of the Long Island Sound Nitrogen TMDL, EPA formed a Living Marine Resources Work Group (LMRWG). At that time, the LMRWG was working with data that had been collected in Long Island Sound to support the initial development work underlying the current federal marine dissolved oxygen criteria. The data collected in Long Island Sound illustrated relationships between duration of dissolved oxygen at certain levels and the impacts on individual organism survival and population biomass for a number of different organisms. Based on these data, percent mortality for a given dissolved oxygen range and percent biomass reduction for a given dissolved oxygen range were established by the LMRWG. This percentage information was passed to HydroQual and two indices were developed, “BAD” and “SAD”. “BAD” or Biomass Area Days was calculated by HydroQual by multiplying the number of days dissolved oxygen fell within a certain range by the area where the dissolved oxygen was occurring and by the percentage reduction in biomass associated with that dissolved oxygen range. Similarly, “SAD” or Survival Area Days was calculated by HydroQual by multiplying the number of days dissolved oxygen fell within a certain range by the area where the dissolved oxygen was occurring and by the percentage mortality associated with that dissolved oxygen range. “BAD” and “SAD” were calculated both Sound-wide and for various response regions within Long Island Sound.

Over the past 20 to 30 years, “BAD” and “SAD” have been upgraded. The final development and promulgation of the federal marine dissolved oxygen criteria led to the replacement of the approximating and site-specific percentages of biomass reduction and mortality calculated by the LMRWG for use in “BAD” and “SAD” with days of non-attainment of the federal marine dissolved oxygen criteria for any or all of three living marine resource based endpoints: juvenile and adult survival, larval survival, and growth. In addition, it was also realized that volume, rather than area, provided a better description of spatial extent.

2.0 Role of HEP Planned Improvements

The SWEM sub-regional TMDL planning simulations all include a number of agreed upon Planned Improvements for the Harbor. Specifically, the Planned Improvements include:

- loading reductions related to implementation of the Clean Air Interstate Rule (CAIR)
- Long Island Sound Nitrogen TMDL (including associated carbon loading reductions)
- Jamaica Bay Consent Order
- relocation of the North Bergen Central WWTP discharge
- Non-Tidal Passaic River Basin Phosphorus TMDL
- updated Owls Head WWTP loads

Specification of the Planned Improvements loadings and the expected receiving water results calculated by SWEM have been previously presented to EPA and the States in detail (see the HydroQual June 3, 2008 report, *Input Documentation and Summary Results for the “Planned Improvements” and “Limit of Technology” Regional SWEM Simulations* and the HydroQual August 2008 report, *System Wide Eutrophication Model (SWEM) Sensitivity Analysis to Dundee Dam Loading Assumptions for Planned Improvements*). While Planned Improvements were simulated with SWEM simultaneously, professional judgment can be used to offer an opinion as to which elements of Planned Improvements are benefitting specific Harbor sub-regions. This professional judgment is captured in the table presented below.

Inferred Contributions of Planned Improvements Loadings to Reducing SWEM Calculations of Dissolved Oxygen Standards Non-Attainment in NY/NJ Harbor Sub-Regions					
PLANNED IMPROVEMENT	INFERRED CONTRIBUTION TO DISSOLVED OXYGEN STANDARDS ATTAINMENT				
	<u>Hackensack River</u>	<u>Passaic River & Newark Bay</u>	<u>Raritan River & Bay</u>	<u>Kills</u>	<u>Hudson River & Upper NY Bay</u>
Clean Air Interstate Rule	no	no	no	no	no
LIS Nitrogen TMDL	no	yes	yes	yes	yes
Jamaica Bay Consent Order	no	no	no	no	no
North Bergen WWTP relocation	yes	yes	no	no	no
Non-Tidal Passaic River P TMDL	yes	yes	yes	yes	no
Updated Owls Head WWTP load	no	no	no	no	no
All of the above	~40 days	~ 16 days	~7 days	~ 4 days	~ 8 days

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