PHILADELPHIA WATER DEPARTMENT
Randy E. Hayman, Esq., Water Commissioner

April 5, 2024

Delaware River Basin Commission
P.O. Box 7360
West Trenton, NJ 08628

Subject: Comments on Draft Report: *The Impact of Sea Level Rise on Salinity Intrusion in the Delaware River Estuary (DRBC, March 2024)*

Dear Mr. Tambini, Ms. Kavanaugh and Ms. Shallcross,

The Delaware River Basin Commission (DRBC) submitted a March 2024 deliberative draft report, *The Impact of Sea Level Rise on Salinity Intrusion in the Delaware River Estuary* ('DRBC SLR and Salinity Report'), to the Advisory Committee on Climate Change (ACCC) for review and comment on March 8, 2024. Supplemental materials, comprised of the March 2024 draft *Three-Dimensional Hydrodynamic and Salinity Model for the Delaware River Estuary Calibration Report* ('SM3D Calibration Report') and the March 2024 draft DRBC SLR and Salinity Report Appendices ('Appendices'), were also provided to the DRBC ACCC upon request. The Philadelphia Water Department (PWD) Climate Change Adaptation Program (CCAP) compiled comments on the DRBC SLR and Salinity Report and SM3D Calibration Report in coordination with PWD staff involved in water supply planning, modeling and policy. This letter summarizes the comments and feedback collected from the PWD CCAP and the PWD Water Quality Compliance Modeling Program.

PWD commends the DRBC for assessing the impacts of sea level rise on salinity intrusion in the lower Delaware River Basin using their calibrated three-dimensional salinity model, SM3D. Salinity intrusion in the Delaware Estuary is a high priority risk that PWD is addressing through long-term water supply and infrastructure planning efforts. PWD is vigorously assessing the resiliency of watershed management and PWD infrastructure under various conditions and future sea level rise scenarios using our own calibrated 3D salinity model.

PWD thanks DRBC for the opportunity to review their SM3D Calibration Report and the DRBC SLR and Salinity Report. As DRBC prepares to apply the information contained in the SLR and Salinity Report to water supply planning and policy efforts, PWD has several recommendations for DRBC to consider.

Sea Level Rise

1. *The comments that PWD submitted to DRBC in September 2021 regarding DRBC's Draft Sea Level Rise Scenarios for Water Supply Planning and Modeling report should be considered in the context of the DRBC March 2024 SLR and Salinity Report. Comments that PWD submitted in September 2021 are still relevant in the context of the March 2024 DRBC SLR and Salinity Report, specifically:*

a. *Consider the trend of observed data when selecting a sea level rise projection to be applied for a water quality planning need less than ten years away.*
b. *Develop a flexible drinking water supply planning risk standard based on an appropriate risk tolerance level. It is important to align the assessment of the level of allowable risk with what is being protected, whether infrastructure or water quality.*
c. *Include the RFAC in discussions related to salinity modeling scenarios and DRBC sea level rise research and planning.*

Please refer to the September 2021 comments, included here as an attachment, for more details. Since PWD submitted comments in September 2021, NOAA released an Application Guide for the 2022 federal interagency report: *Global and Regional Sea Level Rise Scenarios for the United States*. The Application Guide supports comment 'a' above by recommending that observation-based extrapolations should be used to guide near-term planning and decision-making efforts. Specifically, the Guide states that 'The historic trends provide evidence of recent SLR – and of an acceleration in the rate of rise – to help ground discussions with stakeholders using tangible and observed measurements to which they can relate. … For near-term planning, the narrow range of SLR scenarios out to 2050 coupled with the regional observation-based extrapolations provide a valuable guide about likely SLR out to 2050.' For the Northeast region, the Intermediate-Low scenario from the 2022 federal interagency report tracks most near the current observation-based trajectory of water levels on the Delaware River. The Intermediate-Low scenario represents a 0.4 meter SLR projection out to 2050.

Beyond 2050, assessments using observation-based extrapolations of future sea level rise become less informative and should be used with caution, as it is assumed that processes (i.e. ice sheet melting) not fully represented in the observations could become more dominant.

2. *Provide more context and caveats regarding the use of very high SLR projections (especially 1.6 meters) in Delaware River Basin Commission water supply planning and policy applications. Such high sea level rise projections have an extremely low probability of occurring within this century according to the latest science and should not be considered for near-term water supply planning and policy decisions.*

In the DRBC Sea Level Rise and Salinity Report, it is acknowledged that 1.6 meters of SLR has a low probability of being realized or exceeded by 2100. The report should acknowledge upfront that any simulation results that are based on the 1.6 meters SLR projection represent an extreme upper bound and represent conditions which are not likely to occur within this century. Additionally, DRBC should explicitly state that extreme and highly unlikely SLR projections will not be used to inform near-term water supply planning and policy decisions. Other approaches, including sea level monitoring and identifying system thresholds or triggers for action, should be prioritized to deal with the large degree of uncertainty inherent in SLR projections for the second half of this century (2050 and beyond).

In addition, DRBC should consider the localized SLR projections released as part of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6). These projections indicate that under a high emissions scenario (SSP5-8.5), Philadelphia is anticipated to experience

3.36 ft. of sea level rise, significantly lower than 1.6 meters (5.25 ft.) by 2100[1]. The IPCC AR6 projections provide an additional frame of reference for the SLR scenarios selected for DRBC's salinity model simulations.

Model Setup

3. *Model setup appears to be contributing to SM3D underpredicting salinity from the Ben Franklin Bridge to the upstream intakes. Factors contributing to this underprediction include assigning point sources zero salinity, not including all tributaries, and underestimating the tributary loadings by 50-300% in some locations.*

It is PWD's observation, based on experience simulating the same river reaches with the same modeling software, that DRBC's SM3D model setup is leading to an underprediction of salinity in the most critical river reach for salinity intrusion, from the Ben Franklin Bridge to the PWD and American Water intakes. In a review of a preliminary SM3D calibration report shared with PWD on April 10, 2023, PWD noted this underprediction and indicated contributing factors in comments shared with DRBC on May 30, 2023. The most recently released updated calibration report contains the same model setup previously reviewed and therefore same under prediction of salinity in this critical river section. The entirety of PWD's previous calibration review is attached. To summarize, in SM3D loadings in the upper estuary are not fully characterized given that:

- Point sources that are known to discharge salinity are assigned zero salinity discharge concentration in SM3D.
- All major tributaries are not included in SM3D. SM3D includes 32 major tributaries in the model domain from Trenton to the end of the Delaware Bay, yet the PWD model of the upper estuary, with a domain less than a third the size of SM3D, includes 42 tributaries.
- Tributaries that are included in SM3D are assigned salinity concentrations far below observed data. SM3D is assigning salinity concentrations to tributaries between the Schuylkill and Trenton the same concentration as Trenton. However, USGS grab sampling data indicates that tributaries such as the Neshaminy and Assunpink have salinity concentrations 2-3 times higher than Trenton.

DRBC sensitivity runs indicate that increasing tributary loading contributes to an extra mile of salinity intrusion, which is a very large response. It is unclear how much DRBC raised the tributary loading to demonstrate this large response. Regardless, the results of this sensitivity test demonstrate that tributary loadings are a critical component to capture correctly in the model setup. For use in studying salinity intrusion under current and near term (10-20 years) the SM3D model setup should reflect observed data with regards to tributary and point source concentrations of salinity.

4. *The most helpful graphs demonstrating SM3D model performance during intrusion events are not possible to interpret because the observed data and model results are not converted from specific conductivity to chloride with the same equation.*

[1] IPCC AR6 projections for Philadelphia were obtained from the NASA IPCC AR6 Sea Level Projection Tool available at: https://sealevel.nasa.gov/data_tools/17.

It is known that SM3D is not capturing the full loading of local salt (non-ocean) in the upper estuary and this is likely contributing to an underprediction of the model in these reaches (see comment above). It is difficult to determine the extent to which this influences salinity intrusion predictions in the vicinity of the PWD intake due to the confounding way that specific conductivity to chloride conversions are used in some of the most informative graphs in the SM3D calibration report, graphs 9.1.2-11, 9.1.2-12 and 9.1.2-13.

These graphs present SM3D model results compared to USGS observed specific conductivity data, yet the model results and observed data are not converted to chloride using the same equation. The juxtaposition of observed and modeled chloride time series overlain on top of each other, yet derived from different conversion equations, raises the question of what the graph is depicting – differences due to conversion equations or differences due to model performance?

The primary issue is how the observed USGS data is converted to chloride using a USGS derived equation converting specific conductance to chloride. This could be remedied by using the widely accepted standard method for conversion of specific conductance to salinity, Standard Methods 2520 B and D, and then the DRBC equation for conversion of salinity to chloride (Equation 2.2-2). DRBC model results are already converted from salinity to chloride with the DRBC-derived Equation 2.2-2.

It is critical in reviewing model performance to look closely at how the model is performing during intrusion events, and graphs capture a different facet of model performance than statistics. Yet, when the graphs and statistics are not comparing 'apples to apples' the interpretation of model performance is unclear. PWD recommends DRBC make this simple fix to graphs 9.1.2(11-13) to aid in evaluation of model performance.

In conclusion, PWD would again like to thank DRBC for preparing a thorough report regarding the outcomes of SM3D simulations under different sea level rise scenarios in the Delaware Estuary. PWD has presented a few recommendations for your consideration, mostly specific to the interpretation and application of simulation results. PWD is available to discuss any points within this letter and looks forward to continuing to work with you on sea level rise and salinity planning.

Sincerely,

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Manager, Climate Adaptation and Watershed Protection
Philadelphia Water Department

CC
Marc Cammarata, Deputy Commissioner, Philadelphia Water Department
Kelly Anderson, Director, Office of Watersheds, Philadelphia Water Department
Sue Weaver, Pennsylvania Department of Environmental Protection
Hoss Liaghat, Pennsylvania Department of Environmental Protection

<u>**Attachments**</u>

1. *PWD Comments on Draft Sea Level Rise Scenarios for Water Supply Planning and Modeling (DRBC 2021)* - Submitted September 10, 2021

2. *PWD Comments on Three-Dimensional Hydrodynamic and Salinity Model for the Delaware Estuary* - Submitted May 30, 2023

PHILADELPHIA WATER DEPARTMENT
Randy E. Hayman, Water Commissioner

Delaware River Basin Commission
P.O. Box 7360
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September 10, 2021

Subject: Draft Sea Level Rise Scenarios for Water Supply Planning and Modeling (DRBC 2021)

Dear Ms. Shallcross and Ms. Kavanaugh,

The Delaware River Basin Commission (DRBC) submitted an updated draft technical report, *Sea Level Rise Scenarios for Water Supply Planning and Modeling* ('DRBC SLR Report'), to the Advisory Committee on Climate Change (ACCC) for review and comment on July 28, 2021, in advance of the August 3rd ACCC meeting. During the ACCC meeting, Committee members discussed the report's content and provided preliminary feedback on the SLR projections selected by DRBC for use in a range of water supply planning and modeling scenarios. The Philadelphia Water Department (PWD) Climate Change Adaptation Program worked to compile comments on the DRBC SLR Report and engage with PWD staff involved in water supply policy and planning. This letter summarizes the comments and feedback collected from the PWD Water Resources Management and Protection Programs.

PWD commends the DRBC for carrying out such a comprehensive review of the best available sea level rise science for our region and the Delaware River Basin. In providing a thorough review of the science and making recommendations for sea level rise planning and modeling scenarios, the DRBC SLR Report will be a valuable resource for water supply managers and other planning entities throughout the Basin. As DRBC prepares to apply the selected SLR projections to water supply and salinity modeling, PWD has several recommendations for DRBC to consider.

1. *Consider the trend of observed data when selecting a sea level rise projection to be applied for a water quality planning need less than ten years away.*

PWD would like to recommend for DRBC consideration an approach for near-term planning needs that are less than ten years away. The recommendation in this context is targeted to water quality applications, because any newly constructed PWD infrastructure typically has a useful life of more than ten years and new PWD infrastructure design procedures incorporate sea level rise projections that align with the end of useful life. PWD would like to recommend that sea level rise planning for applications within ten years be based on the observed data trend from a recent time period or a projection that closely aligns with the observed data trend.

This approach assumes that the more recent acceleration of sea level rise has been captured in the observed record and that sea level rise will not dramatically speed up in the next few years. PWD feels it is more appropriate for near-term water quality planning applications to use what is observed, and ultimately likely. While there is historic precedence for a dramatic increase in sea level rise in a short period of time, such meltwater pulse events have coincided with rapid melt or collapse of Earth's ice sheets. While there is uncertainty and a lack of understanding surrounding the stability of ice sheets, it is not anticipated that the Greenland or Antarctic Ice Sheet will collapse by 2030.

Planning beyond ten years absolutely needs to take into account global climate model projections because they include the dynamic relationship between collapsing and melting ice sheets, changing hydrothermal expansion and emissions scenarios. However, planning for water quality policy and operational decisions in the next ten years needs to be based on a likely minimum with a high probability of occurrence. A projection based on observed data for the next ten years can inform what that likely minimum expected sea level rise will be.

An example here is provided based on observed data at Reedy Point compared to NOAA projections for that same location. Similar to the NOAA projections included in the DRBC SLR Report for Lewes, DE, NOAA also has projections for Reedy Point further up in the estuary. Using linear regression, PWD has calculated an increasing trend of annual average water level from 1981 – 2020 to be 4.286 mm/yr (0.01406 ft/yr). Applying this rate of change from 2000 to 2030 would yield an increase of 0.42 ft by 2030 at Reedy Point. Following the conclusion of this letter is a table of supporting information comparing excerpted projections from the DRBC SLR Report with the observed data projection.

The observed data-based projection of 0.42 ft by 2030 closely tracks with the USACE Low and Intermediate projections, NOAA Low and Intermediate-Low projections, and the STAP 95% and 83% chance projections. PWD would like to recommend DRBC consider these sea level projections for their use in water quality planning within the next ten years.

2. *Clarification is needed on DRBC's method to select SLR projections and to assign associated probability ranges.*

The DRBC SLR Report proposes six sea level rise projections for evaluating salinity for drought and flow management planning, stating 'values were chosen to represent "likely" SLR in the year 2060 as well as possible values for year 2100' (pg. 19). The projections for 2030 found in Table 6, which are the most important for informing policy that will be adjusted and adopted in the coming decade, appear to be assigned the exceedence for the 2060s. For example, Table 6 states a 0.3m rise with a 95% exceedence by 2030. This may need additional DRBC review. According to the STAP report and the DNREC report, as well as the probabilities interpolated by DRBC on page 19, this probability appears to be too high for a 0.3m rise. According to the STAP report, 0.3m (~1 ft) has a less than 17% chance of being exceeded in the 2030s (Table 5, page 17). The DNREC report estimates 0.3 meter has a 12% chance of being exceeded in the 2030s (Table 4). DRBC could consider including a small write up within this section that details how DRBC derived the exceedences for the projections selected for 2030, 2060 and 2100.

3. *Develop a flexible drinking water supply planning risk standard based on an appropriate risk tolerance level. It is important to align the assessment of the level of allowable risk with what is being protected, whether infrastructure or water quality.*

The term "risk-averse infrastructure" is considered to be applicable to the protection of structural water and sewer elements. Drinking water treatment plants, intake structures, raw water basins, sewage treatment works, water/sewer/stormwater pumping stations, and electrical supplies are, to varying degrees of importance, risk-averse infrastructure components of the PWD water and sewer service system. It is important that this type of critical service infrastructure be protected against damage by increases in sea level, storm surge or riverine flooding. These kinds of infrastructure are protected to a fairly high degree (low-risk), typically to a one in one hundred year event level of service protection if they are located in the existing floodplain. PWD also assesses risk and protects its critical, risk-averse physical infrastructure against future conditions by using a low probability sea level rise scenario. A low risk tolerance and corresponding high level of protection reflect the fact that failure of these assets or systems is a high-consequence scenario that could result in loss of service, significant and costly disruption to operations and potential impacts to the customer base and employee and public health and safety.

In contrast to the level of protection typically afforded to "risk-averse infrastructure", consider typical risk-based approaches afforded to receiving water quality protection. For example, under Pennsylvania water quality regulations, the required level of protection for compliance with water quality criteria is "99% of the time". At that level of protection, the water quality criteria are not to be exceeded more than 1% of the time for compliance purposes, which in an average year means the water quality criteria cannot be violated for more than 3.65 days to assure compliance. 1% of the time is a very different standard of protection than once in a hundred years (an annual 1% chance of occurring) that is needed for "risk-averse infrastructure". Another example is the National CSO Control Policy that admits on a presumptive basis as many as 4 uncontrolled overflows in a typical year after the implementation of remedial controls. That essentially is a level of protection equivalent to a three-month storm return interval, which also stands in contrast to the much more protective once in one hundred years level of protection discussed above for "risk-averse infrastructure".

Clearly, drinking water supply protection needs are not necessarily the same needs as those for physical "risk-averse infrastructure", nor are they relatable to needs for receiving water quality protection. Drinking water supply protection needs also vary by parameter, given differences in public health impacts, regulatory structure, and treatment technology. PWD recommends conducting a dialogue among water supply planners to consider a reasonable risk-based level of protection for water quality issues such as salinity intrusion. It may be prudent to start off by considering a reasonable mid-term planning probability risk level of 50% exceedance to address source water quality protection for salinity for the next twenty to thirty-year horizon (2031-2050). A 50% exceedance probability represents a more reasonable level of protection corresponding to an estimate of likely sea level rise that water suppliers can expect and plan for, as opposed to much lower exceedance-levels corresponding to higher projections that are more appropriate to the risk tolerance levels associated with protecting constructed, critical infrastructure.

4. *Include the RFAC in discussions related to salinity modeling scenarios and DRBC sea level rise research and planning.*

As DRBC knows, the Regulated Flow Advisory Committee (RFAC) includes the Decree Parties, as well as the DRBC, PWD and Pennsylvania Fish and Boat Commission. As the Decree Parties work to understand the impact of sea level rise on salinity intrusion in support of the 2017 FFMP, it would be appropriate to present this information to them at a meeting of the RFAC.

In conclusion, PWD would again like to thank DRBC for preparing such a thorough summary of sea level rise projections targeted to the Delaware River Basin. PWD has presented a few recommendations for your consideration, mostly specific to near-term water quality planning and the need for water quality specific levels of protection different from infrastructure. As a member of the ACCC, PWD would like to offer to present to the ACCC the analyses and recommendations the PWD Climate Change Adaptation Program has completed for our water and sewer system infrastructure planning. We are also available to discuss any points within this letter and look forward to continuing to work with you on sea level rise and salinity planning.

Sincerely,

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SUPPORTING INFORMATION

Comparison of Sea Level Rise Projections for 2030

SLR Projection Source	Scenario	Projected 2030 Sea Level Rise from 2000	
		Feet	Meters
NOAA Observed Data, PWD Calculated Trend*	Observed Data Trend	0.42	0.128
USACE** Reedy Point	Low	0.34	0.104
	Intermediate	0.46	0.140
	High	0.85	0.259
NOAA Reedy Point	Low	0.52	0.158
	Intermediate-Low	0.62	0.189
	Intermediate	0.89	0.271
	Intermediate-High	1.18	0.360
	High	1.41	0.430
	Extreme	1.54	0.469
STAP (State of NJ)	>95% chance (Low, Mod, High)	0.3	0.091
	>83% chance (Low, Mod, High)	0.5	0.152
	~50% chance (Low, Mod, High)	0.8	0.244
	<17% chance (Low, Mod, High)	1.1	0.335
	<5% chance (Low, Mod, High)	1.3	0.396
DNREC	12% exceedance	0.984	0.3
DRBC	Near-Term Adaptation Planning	0.984	0.3
	Medium Range Planning	1.64	0.5

**Linear regression of annual average water level at Reedy Point 1981-2020, rate of change 0.01406 ft/yr applied from 2000 – 2030.*
*** USACE projections adjusted to a year 2000 baseline using the observed sea level rise trend*

PHILADELPHIA WATER DEPARTMENT

Randy E. Hayman, Water Commissioner

Delaware River Basin Commission
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May 30, 2023

Subject: PWD Comments on Three-Dimensional Hydrodynamic and Salinity model for the Delaware Estuary

Dear Ms. Shallcross,

Following a presentation of DRBC salinity modeling efforts to PWD on March 21, 2023 and sharing of the draft Three-Dimensional Hydrodynamic and Salinity Model for the Delaware Estuary Report (SM3D Report), PWD would like to commend DRBC for their efforts to build and calibrate a three dimensional salinity model of the Delaware Estuary. It is no small task to build a three-dimensional salinity model and the efforts of the DRBC staff are recognized. PWD is driven to build and maintain advanced models of the Delaware Estuary for regulatory and infrastructure planning purposes. The region can only benefit if both DRBC and PWD have produced well validated and documented salinity models to study the Delaware Estuary.

PWD thanks the DRBC for the opportunity to review their salinity model, SM3D, through the draft of the validation report that was shared on April 10, 2023. The following comments are intended to support DRBC in their modeling efforts by sharing the PWD modeling team's collective experience and expertise simulating the upper Delaware Estuary. Overall, it appears the model performs well, however, we are requesting clarity in graphics, metrics and chloride conversions so that we may better evaluate SM3D performance, specifically, during salinity intrusion events. Many of the graphs and metrics include time periods that are too long to identify performance during intrusion events. The PWD comments offer feedback on how the SM3D model setup may be contributing to underpredictions of salinity at Ben Franklin Bridge and potentially locations upstream. PWD would also like to keep an open, supportive dialogue as DRBC analyzes oversimulation of the 2017 event and undersimulation of the 2001-2002 intrusion events.

PWD would like to again commend the DRBC staff on their efforts to build a three-dimensional salinity model. PWD looks forward to continuing our dialogue with DRBC and with external parties interested in both our salinity modeling efforts.

Sincerely,

Kelly Anderson

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Validation period

1. *It is difficult to tell how the DRBC SM3D model performs during a salinity intrusion event based on the size of the datasets used to calculate statistics presented in the report.* The two-year 2017-2018 time period used to calculate validation statistics presented in the report is too long to understand model performance, specifically during a 2-3 month salinity intrusion event. While overall model performance looks good based on the two-year statistics, statistics calculated from such a large dataset could mask oversimulation or undersimulation of the model during salinity intrusion events. PWD commends DRBC for presenting comprehensive validation statistics but recommends calculating validation statistics on just the 2016 intrusion event. For example, PWD used 9/1-10/26 for both the 2014 and 2016 events.
2. *References in the text to model calibration, validation and the time periods involved are not clear*. Many years are mentioned across the report for both calibration and validation, including 2001-2003, 2011-2012, 2013, 2017-2018, 2019 and 2016-2020. It is unclear if the same set of years is used for calibration and validation (for example 2017-2018) or if other years were used only for calibration. The text mentions the model was calibrated for 2017-2018 and then recalibrated for 2016-2020. This makes it unclear *which version* of the model produced the 2017-2018 statistics presented in the report. If other years informed calibration, a demonstration of model performance in these years, why model changes may have been needed and what changes were made should be added to the text for clarity. Further clarification, or simplification, of the text as it relates to what role specific years played in calibration and/or validation would be informative.

Chloride Conversion

3. *The most helpful graphs demonstrating model performance during intrusion events are not possible to interpret because they include three different chloride conversions.* Most importantly, the observed data is converted differently than the modeled output in Figures B1.2-10, B1.2-11, B1.2-12, B1.2-13, B2.3-7. PWD recognizes the challenges in converting specific conductance and salinity to chloride at low concentrations. PWD uses an equation similar, yet slightly different, than the DRBC equation. PWD uses the same approach to develop the conversion equation but includes more paired data from PWD sampling efforts in the lower salinity area of the estuary. Given the large differences in conversion method, for this report PWD recommends that DRBC convert the USGS observed data from specific conductance to chloride using the DRBC equation to support interpreting model performance.
4. It may benefit both PWD and DRBC for our salinity analysis efforts to use the same conversion equation, because while similar, they are slightly different and therefore produce different chloride concentrations when converted from salinity.
   The PWD conversion for salinity (S) to chloride (Cl) is S = Cl*1.8e-03 + 0.046
   The DRBC conversion for salinity (S) to chloride (Cl)is S = Cl*1.7e-03 + 0.057

Tributaries, Intakes and Discharges

5. *Many tributaries appear to be excluded from the model.* The report states that SM3D includes 32 major tributaries in the SM3D model domain. The PWD salinity model, which has a model domain nearly one third the size of SM3D, includes 43 tributaries. Tributaries are

responsible for influencing local flow and salinity loading to the model domain, which is especially important during drought conditions and at locations upstream of Ben Franklin Bridge. These locations in the upper estuary are highly influenced by local sources of flow and salt which help establish ambient chloride concentrations before and after an intrusion event.

6. *It is unclear how ungauged areas are assigned flow and salinity values.* The SM3D report did not detail how ungauged areas are assigned flow and salinity values. When PWD was performing model calibration, ungauged tributary flow estimates and unmonitored water quality estimates were both known sources of potential error and utilized as calibration parameters. More information is needed to understand how flow and salinity is assigned to ungauged and direct runoff areas and if these sources of error were used as calibration parameters.
7. *Replacing missing data on the Schuylkill with 0.1 ppt salinity is below the long-term median*. The SM3D report states that missing Schuylkill River salinity values were set to 0.1 ppt. It is unclear how many values had to be replaced and if this is a large portion of the Schuylkill River salinity dataset. The long-term median salinity of the Schuylkill River is approximately 0.2 ppt. If a large number of gaps are filled with the lower number, Schuylkill salinity may be underestimated by approximately 50%. PWD found the Schuylkill River to be responsible for 21% of the chloride load to the PWD model domain, making the Schuylkill a critical source of salinity.
8. *Assigning tributaries between Trenton and the Schuylkill River salinity levels similar to Trenton may be under estimating salinity loading to the upper estuary*. Freshwater chloride concentrations are known to increase with development and population. The area between Trenton and the Schuylkill River is among the most developed in the Delaware River Basin. PWD would like to recommend reassigning tributary chloride in this area to be more representative of a developed tributary, such as the Schuylkill or Neshaminy.
9. *More intakes, discharges and combined facilities could be added to the upper estuary*. The SM3D report includes 71 point source discharges and 8 withdrawals from Trenton to the mouth of the Delaware Bay. The PWD salinity model includes over 80 discharges in just the upper estuary portion. The PWD salinity model includes 52 discharges, 30 withdrawals, 30 facilities that include a withdrawal and a discharge, and 11 return flow facilities. Each of these withdrawals and discharges are different in their flow and salinity contribution to the upper estuary, but categorically they are important to local salinity loading and flow which contribute to ambient water quality concentrations.
10. *SM3D does not assign salinity to point sources that are known to contain salinity.* The majority of the point sources included in SM3D are municipal treated wastewater discharges. The point sources are known to contain chloride in their discharge, even though concentrations are not required to be reported in DMRs. PWD recommends that DRBC consider assigning salinity to all point sources where data exists and estimating where data is not available. PWD found municipal and industrial discharges to be responsible for 21.5% of the chloride load to the PWD model domain, making these municipal and industrial discharges a critical source of salinity.
11. *A comparison to observed data from the USGS monitoring stations at Ben Franklin and Pennypack Woods would help to understand if the tributary and point source discharge and flow comments above contribute to underprediction in this portion of the upper estuary.* Ben Franklin is presented in many graphs, however the graphs are difficult to interpret due

to a large time scale being plotted and the use of three conversion methods in some of the graphs. While noting these challenges to interpreting the graphs provided in the SM3D report, the model appears to be undersimulating salinity at Ben Franklin Bridge. A similar comparison of model results to observations at USGS Pennypack Woods, in the vicinity of the Baxter intake, would help to identify if the estuary upstream of Ben Franklin Bridge is also undersimulated by the model.

Horizontal Diffusion Setting

12. *Please provide more explanation of why the horizontal diffusion setting was selected, it is PWD's understanding this setting would not influence SM3D*. In SM3D Report Section 4.2.3 Horizontal Eddy Diffusivity, it was described that the minimum and maximum values of AHD to ensure numerical stability are 0.005 to 0.02, and that a value 0.01 is ultimately used for all simulations. What were the symptoms of instability that this setting improved?

    A review of the EFDC documentation and source code by Sen Bai of Tetra Tech found that the use of AHD is appropriate only for *central* difference numerical scheme, which has been found to have oscillations in numerical solutions between neighboring model cells. This AHD setting should have no effect on results with the upwind *finite* difference numerical scheme that is used in SM3D as researched from Hamrick 1992.

    The EFDC theory and algorithm document (John Hamrick, 1992, A THREE-DIMENSIONAL ENVIRONMENTAL FLUID DYNAMICS COMPUTER CODE: THEORETICAL AND COMPUTATIONAL ASPECTS) mentions that "The horizontal diffusion coefficient, AH, is often specified as a minimum constant value necessary to smooth cell to cell spatial oscillations in the solution field when the central difference form of the advective acceleration, equation (49) is used. When the horizontal turbulent diffusion is used to represent subgrid scale mixing, AH may be determined as suggested by Smagorinsky (1963)".

Graphs from other DRBC model calibration report included in SM3D report

13. *Figures for Section 5.0 of the SM3D report include figures made with a different model*. For example, pdf pages 232 through 257 in SM3D report and pages 33 through 71 in HydroCalibration_2021-12_AppsL-N_Draft.pdf are identical. Since the grid, numerical scheme and turbulence closure settings were changed between these two models, the use of the earlier model version figures to demonstrate SM3D performance with different vertical layers is not appropriate. PWD recommends reproducing the figures using the final validated model described in the SM3D report. Specific figure and page number comparisons are included in the table below.

Hydrodynamic Model Report Fig. #, page (pdf) Appendices L-N	SM3D Report Fig. #, page (pdf)	Notes
3.4-2, p. 34	5.1-2, p. 232	Map is the same. If the model is different, performing sensitivity tests to speak to SM3D using the other hydrodynamic model presented in this map isn't valid. Especially because the models have different turbulent closure schemes and grids.
3.4-2(1) – 3.4-5(2), p. 35-41	5.1-3(1) - 5.1-5 (2), p. 233-236	The graphs are not made with SM3D, they are made with the other hydrodynamic model. They do not represent SM3D performance with different vertical layers. These results are not relevant to SM3D, recommend reproducing these figures with the final validated model.
3.4-6(1) – 3.4-11(2), p. 42-53	5.1-6(1) – 5.1-11(2), p. 237-248	These graphs are not made with SM3D, they are identical to the results from the other hydrodynamic model, recommend reproducing these figures with the final validated model and additional vertical layers.
3.4-12(1) – 3.4-20(2), p. 54-71	5.1-12 – 5.1-20, p. 249-257	These graphs are not made with SM3D, they are identical to the results from the WQ model, recommend reproducing these figures with the final validated model and additional vertical layers.