Memorandum

Review of "Dilution Analysis of the San Jose – Santa Clara Regional Wastewater Facility Discharge to South San Francisco Bay" Technical Memorandum

January 3, 2018

Project Name	Santa Clara Valley Water District RO Concentrate Management Plans	SCVWD Agreement No. SCVWD CAS File No. GHD Project No.	A4034G 4691 11110722
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1. Overview

A review has been conducted of the RMA Bay-Delta Model results, as described in "*Dilution Analysis of the San Jose – Santa Clara Regional Wastewater Facility Discharge to South Francisco Bay*" Technical Memorandum (March 2017).

The review provides an opinion as to the ability of the model, as described in the technical memorandum (TM), to capture impacts and dilution characteristics associated with wastewater discharges into South San Francisco Bay. In the absence of details of the scope provided to RMA, no comment is offered as to whether the model is likely to satisfy any other requirements.

Please refer to the attachment for a description of the regulatory framework for dilution requirements at the San Jose-Santa Clara Regional Wastewater Facility (SJ-SC RWF).

2. Background and Key Assumptions

The review was undertaken in keeping with the following context and understanding:

- The study was commissioned by the Santa Clara Valley Water District (SCVWD)
- The study builds on modeling work previously completed by RMA for a multitude of clients, as listed in Table 1 of the report. These reports date back to 1996.
- The stated objective of the modeling study was to investigate dilution of the discharge from the SJ-SC RWF to South San Francisco Bay.
- It is understood that the primary purpose behind commissioning the study was to gain an appreciation of whether the model is likely to be a suitable tool for assessing a potential combination of reverse osmosis (RO) discharge from the SCVWD with discharge from the RWF, leading to a determination of whether

more in-depth modeling could evaluate the ability of future discharge scenarios to meet designed regulatory requirements. The SCVWD noted that the primary purpose of this exercise was to evaluate the potential for dilution in the South Bay for the wastewater treatment plant effluent, and that the modeling exercise was regarded as preliminary.

- Dilution characteristics are more important in dry conditions, when fresh water inflows from rivers and creeks are lower.

3. Review Comments

Section 3 of this review lists key observations. Conclusions and recommendations follow in subsequent sections.

RMA Bay-Delta Model

[1] The RMA software has been in existence for several decades, and has enjoyed wide usage. It is well-suited to the assessment of complex shaped waterways, utilizing the flexibility of a finite element mesh with varying sized elements.

[2] It is noted in the executive summary of the memo that the Bay-Delta Model has been used extensively.

[3] The model comprises both 1D and 2D segments, while RMA11 has been utilized to simulate water quality (in the form of electrical conductivity).

[4] While the model appears to have been developed over a twenty year period, it is unclear whether the use of a 2D, depth-averaged approximation will accurately capture mixing effects associated with varying densities associated with both the discharge and receiving environment.

Bathymetry

[5] A number of ponds have been added into the model. It is understood that flow into and out of these ponds is regulated via control structures, which have been incorporated into the model.

[6] Bathymetric data have been provided from several sources, the most recent of which appears to be 2010. The area of interest (refer to Figures 3 through 5) appears to be quite complex in terms of the planform of the various waterways. The waterways are relatively shallow, and potentially would not be subject to strong flushing characteristics from tidal forces.

The definition/distinction between the various sloughs is not clearly represented in the memo.

Model Boundary Conditions

[7] Dilution characteristics have been assessed through the use of a tracer (typically neutrally buoyant). This is a reasonably common approach, noting the accuracy of results will depend on how well the relative density of the discharge and that of the receiving environment have been captured.

[8] The model boundaries comprise both inflows and outflows, reinforcing the impression of detailed hydrodynamics.

[9] A list of major control structures has been provided, without the provision of any details of dimensions or elevations. It is assumed for the purpose of this review that structures have been accurately entered into the model.

[10] Page 15 of the report indicates an EC boundary of 50,000 umhos cm^{-1} at the Golden Gate Bridge, and notes that EC boundaries have also been set at all inflow boundaries, without quoting what these boundary values are.

[11] For the consideration of dilution, the SJ-SC RWF discharge was assigned a value of 100, with all other inflows set to zero. This is a standard approach, with the value of 100 to be considered as representing 100% discharge (i.e., 100% of water is effluent).

[12] The source of boundary conditions is noted on page 18 of the memo. There is no indication that wind has been applied as a boundary condition (which can be important in shallow areas, and/or those not otherwise exposed to mixing forces).

2011 – Calibration and Tracer Analysis Period

[13] The model has been run for the period March to December 2011. This reportedly includes both wet and dry periods.

[14] A constant discharge of 38 MGD is quoted. It is noted that:

- The average daily effluent flow was calculated based on the likely reduction in effluent flow from the plant due to increased recycling and/or potable reuse. Hence the report is based on the use of a forecast effluent flow case. This is broadly consistent with 2 of the 4 cases evaluated in the Mass Balance memorandum[1], which looked at flows of 38.1 and 40.1 MGD. Flows of 30.1 and 22.1 MGD, also evaluated in the Mass Balance memorandum representing higher recycling approaches and reduction in flows during dry weather conditions, have not been considered in the RMA model. Current flows are 80 to 170 MGD.
- The model appears to assume an input of effluent flows from the Sunnyvale and Palo Alto plants. It is assumed the data set presented in Figure 13 has been used. The flows from these plants will also decrease with effluent recycling.
- The salinity of the effluent stream was not evident in the report.

[15] Values of EC have been applied to all model inflows, as is indicated on page 20. Where available, data sources have been quoted. Where data does not exist, the report indicates a value of 120 umhos cm^{-1} was adopted for all other freshwater inflows.

[16] The nine-month simulation period allows the representation of a range of tidal conditions.

[17] Figures 9 to 15 provide an indication of the magnitude of several of the inflows (and evidence of major wet weather flows around April)

[1] Technical Memorandum dated February 14, 2017 by EOA, Inc., titled *Impact of RO Concentrate from Expanded SVAWPC on SJ-SC RWF Combined Final Effluent NPDES Permit Compliance.*

[18] Figure 16 indicates measured EC values associated with inflows for three rivers. It can be seen that all have EC values of less than 900 umhos cm^{-1}

2011 Calibration Check

[19] The report indicates that the "RMA Bay-Delta model has been calibrated during numerous previous studies". While referenced in Table 1 of the report, none of these previous studies were made available for review. We therefore cannot confirm whether previous calibration efforts were focused solely on hydrodynamics / water levels, or whether any calibration to water quality has also been achieved. Comments on calibration have therefore been limited to the evidence presented in the RMA memo of March 2017.

[20] The text suggests that spot measurements of water levels have been used to confirm whether the gate structure configuration was reasonable. However, neither velocity nor flow data were available within the South Bay.

Obtaining velocity data would significantly strengthen the ability to calibrate (and prove calibration) of the model.

[21] The calibration plot (Figure 18) is too compressed to assess whether calibration to water levels is of a high standard. Reference should be made to subsequent figures.

Calibration to water levels is generally far easier to achieve than calibration to water quality or physio-chemical parameters. Matching water levels typically comprises only the first step in calibrating a water quality model.

[22] Figure 19 suggests that the calibration to water level at Dumbarton Bridge is good. This is to be expected, given the location of the bridge in deeper water. Figure 21 provides a plot demonstrating calibration at Coyote Creek, which is closer to the SJ-SC RWF discharge site, and hence of greater importance. The water level calibration remains good at Coyote Creek.

EC Calibration Check

The technical memo notes the following:

[23] While the model runs from 1st March (thereby capturing wet weather conditions, which are of importance), results pertaining to dilution during dry weather are of primary interest, and hence have been the focus of calibration.

[24] For EC values, "…the model has a slower and less dramatic response to the wet weather flows than observed…", and that

[25] "Observed data show significant stratification…".

Statements made in the memorandum ([23] to [25] above) have been considered in reviewing the EC calibration figures. The following comments [26] to [28] are offered in response.

[26] With reference to Figure 22 (EC at San Mateo Bridge), and to Statement [24] above, it can be seen that the discrepancy between observed and modelled EC is significant, extending over several weeks. While observed values fall from over 35,000 umhos cm-1 to around 22,000 umhos cm-1, the computed values initially rise to over 40,000 umhos cm-1 and do not fall below 34,000 umhos cm-1.

[27] EC calibration is improved at Dumbarton Bridge (Figure 23), though still much weaker during wet periods than dry periods.

[28] At the Alviso Slough (Figure 24), the match is again relatively poor.

Discussion of EC calibration

Items [26] to [28] indicate that the model is generally unable to replicate EC (salinity) changes during wet weather periods. The implication is that while hydrodynamics (in the form of water levels) are generally well matched, anything reliant on density is not. The greater the difference in salinity (density) between discharge and receiving environment, the more likely that impacts will not be well represented. This may be due to a number of factors, including depth averaging through application of a 2D model, and the possible absence of wind forcing (suspected but not confirmed), especially in shallow areas.

The Technical Memo specifically states that the primary interest (and purpose) of the model is its performance during dry periods. Accordingly, this review has placed greater emphasis on the standard of calibration during dry periods than that during wet periods.

However, should there be a future need to rely on the model's ability to accurately replicate salinity during wet periods, additional calibration work is likely to be needed at that time.

Results of Tracer Analysis

[29] Dilution analysis is based on a constant flow rate of 38 MGD. It is noted in the memo that the use of a constant value takes away one of the variables, such that the main driver should largely be tidal.

A relatively simple dilution calculation method (wastewater + receiving water)/(wastewater) has been adopted, with the note that this is consistent with the approach of the Regional Water Board.

[30] Model results have been presented in two ways: (i) tabulations of tracer concentrations (dilution) from the entire March to December simulation, and (ii) plots for the 24-hour period (single day) of 22 October.

[31] The former will capture both wet and dry periods, while the latter is specifically targeted to dry periods. Both should be representative of a state of quasi-equilibrium, whereby any long-term build-up of effluent associated with the wastewater plume (as represented by tracer concentration), has been captured.

[32] Figure 25 indicates tracer dilution for October 22 in the Artesian Slough. Dilutions of no better than 1 in 4 (i.e., 4:1) are indicated, noting the potential limitations of 2D depth averaging. Given the salinity of the discharge is not clearly indicated, the value of the results to assess potential impacts on any environmentally sensitive areas in this area cannot be confidently stated.

[33] Figure 26 indicates "% Tracer" (at the mouth of Artesian Slough) oscillating between 16% and 26% (approximately), where the percentage denotes that remaining from the original discharge (concentration of 100%). It is not clear from the presentation of results as to the timing and impact of adjacent ponds (in terms of flow exchange).

Conclusions of March 2017 Technical Memo

[34] The following conclusions are agreed with:

- The RMA2 model has been enhanced to include more detailed bathymetric representations in the vicinity of the outfall
- Hydrodynamics (in terms of water levels) are well represented by the model.

The comment in the Technical Memo that the calibration check using EC data, is computing reasonable transport of salinity from the Golden Gate boundary into the South Bay is only partially supported. It is clear that calibration is better in dry periods (which are stated as the more important). However, the calibration plots do show divergence between measurements and model predictions through August and September 2011.

The representation of EC during wet periods is clearly less accurate than that during dry periods at several locations. However, it is acknowledged that wet periods are not the primary period of interest.

Appendix – Baseline Dilution Results

[35] The appendix presents results for a dilution analysis for the baseline condition. This is based on the actual discharge (80 to 170 MGD), as presented in Figure 13 of the Technical Memorandum. Results are presented for October 23, 2011 (when the discharge sits between 90 and 100 MGD) and for March 31, 2011 (140 to 160 MGD).

[36] Results appear to only be presented for those areas where dilution is less than 5:1. A comparison of Figures 29 and 30 suggests that under the wet conditions modelled, (when the effluent discharge is also higher), greater dilution is indicated. This is evidenced through the smaller area (Figure 30) with less than 5:1 dilution, and the higher dilution range in similar locations.

[37] Figure 29 (dry period, existing conditions) was also compared to Figure 25 (dry period, constant reduced discharge of 38 MGD). This comparison indicates that the higher discharge results in less dilution (i.e., a larger area with dilution at less than 5:1). While this is an opposite trend to that indicated in [36] above, the latter was also associated with a wet period, when dilution tends to be higher.

[38] With reference to [36] and [37], it can be seen that the model is predicting improved dilution during wet periods (though not the focus of the Technical Memorandum), and reduced dilution for higher effluent discharges.

[39] Comments on dilution characteristics are qualified on the basis that while the effluent has been "tagged" with a tracer, it is unclear what the effluent properties (density, salinity) are.

4. Conclusions

1. The model has been developed over a 20-year period, and has been applied for the benefit of more than 10 clients within the modeled extent
2. However, while the model appears to accurately replicate tidal levels, there is no strong evidence of a good calibration to EC, especially during wet periods.
3. Regardless, the model appears to represent salinity (EC) reasonably well in dry periods across much of the model domain. The lack of data and 3D representation close to the outfall is likely to limit the accuracy of the model in assessing dilution close to the outfall, and through to Coyote Creek.
4. A 2D (depth averaged) model has been applied and, by definition, will not pick up variations in salinity/density with depth.
5. It is assumed that no wind boundary conditions have been applied.
6. The implications of the above limitations will be dependent on the location of environmentally sensitive areas.
7. Based on the information presented in the memo, there is some uncertainty as to the ability of the model to represent water quality variations in detail in the vicinity of the outfall. There were a number of factors raised in the review (e.g. data, 3D, performance across a range of conditions) that collectively indicate uncertainty. This level of uncertainty will decrease with improvements in any of the aforementioned factors.
8. On the basis of the content of the Technical Memorandum, it is not possible at this time to clearly state whether any uncertainty in the model would tend to over-estimate or under-estimate dilution characteristics.
9. Results in the vicinity of the outfall have been presented with dilution factors no greater than 5:1. This level of dilution will likely be sufficient for NPDES compliance, given recent conversations with the Regional Water Quality Control Board and the fact that other POTWs in the area have been granted exceptions to the dilution requirements in the San Francisco Bay Basin Plan for many years.

5. Recommendations

The model as presented can be regarded as preliminary, and, as with all models, would benefit from additional data and calibration over time. When considered in terms of likely scrutiny (public or regulator), and the assumed needs of San Jose to meet current NPDES permit requirements, the suitability of the RMA Bay-Delta Model to represent dilution characteristics in sufficient detail to inform future decisions around modifying the current discharge is limited. Should there be an opportunity to further develop the model, the following recommendations could be considered:

1. The memo was not clear as to what salinity was adopted in the effluent streams. Ideally, key properties of the discharge (density/salinity) adopted in the model would be clearly stated. The Technical Memorandum currently does not state the salinity of the discharge, indicating only that it has been

tagged with a tracer. This implies that the effluent discharge is considered by the model as fresh (zero salinity) water.

2. This approach to salinity is more valid in relation to existing conditions (EC < 1000-1500 umhos cm^{-1}), but will be less so for the proposed effluent stream. However, if EC remains relatively low, then the use of a tracer should remain reasonable.
3. Salinities will increase as the quantum of recycling increases, and more RO concentrate is added into the effluent. If EC values were to become significant (e.g., EC > 10,000 umhos cm^{-1}), then density effects may not be correctly represented in the model, and relevant properties will need to be assigned to the discharge.
4. The need for additional modelling will depend on several factors:
   - The size of area over which initial dilution is allowed
   - Whether populations of fish or other special-status species present in the vicinity of Artesian Slough would be affected by dilution of 5:1 or less.
   - Whether changes in the nature of pollutants contained in the proposed blended effluent will trigger a need for more stringent targets.
5. Where practical, additional modeling is likely to require:
   - Salinity data in the vicinity of the outfall
   - Potential refinement of the model grid (and consideration of the need/benefit of a 3D model) in the vicinity of the outfall (i.e., nearby shallow areas where measured salinity is not uniform).
6. In response to Comment [29], we would recommend that the model is rerun using the range of flow and concentration scenarios envisaged in the current study. There may be a need to re-model cases with further reduction in effluent from the SJ-SC RWF of 30.1 and 22.1 MGD, subject to pollutant concentrations contained in the effluent
7. It is recognized that there may be the opportunity to further develop the model in the future. Items that could be considered with such development could include one or more of the following:
   - Running of a dry year
   - Converting the model to 3D (noting that SFEI has a 3D model already under development)
   - Sensitivity testing. Coupled with calibration or verification to additional data, such testing would help to better quantify model uncertainty. Uncertainty is a feature of all hydrodynamic models.

Attachments:

1. Regulatory Framework Regarding Dilution Requirements at the SJ-SC RWF

References

1. “Dilution Analysis of the San Jose – Santa Clara Regional Wastewater Facility Discharge to South San Francisco Bay Technical Memorandum”, RMA, March 2017

2. “San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)”, California Regional Water Quality Control Board San Francisco Bay Region, January 2007

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Regulatory Framework regarding Dilution Requirements at the SJ-SC RWF

The San Francisco Bay Basin Plan (Basin Plan) requires a 10:1 dilution for discharges into shallow waters, as stated in Basin Plan Table 4-1:

> Table 4-1: Discharge Prohibitions
>
> It shall be prohibited to discharge:
>
> 1. Any wastewater which has particular characteristics of concern to beneficial uses at any point at which the wastewater does not receive a minimum initial dilution of at least 10:1, or into any nontidal water, dead-end slough, similar confined waters, or any immediate tributaries thereof. Waste discharges will contain some levels of pollutants regardless of treatment. This prohibition will require that these pollutants, when of concern to beneficial uses, be discharged away from areas such as nontidal waters and dead-end sloughs. This prohibition will (a) provide an added degree of protection from the continuous effects of waste discharge, (b) provide a buffer against the effects of abnormal discharges caused by temporary plant upsets or malfunctions, (c) minimize public contact with undiluted wastes, and (d) reduce the visual (aesthetic) impact of waste discharges.

The Basin Plan defines "initial dilution" as follows:

> 3.1 In general, the objectives are intended to govern the concentration of pollutant constituents in the main water mass. The same objectives cannot be applied at or immediately adjacent to submerged effluent discharge structures. Zones of initial dilution within which higher concentrations can be tolerated will be allowed for such discharges.
>
> For a submerged buoyant discharge, characteristic of most municipal and industrial wastes that are released from submerged outfalls, the momentum of the discharge and its initial buoyancy act together to produce turbulent mixing. Initial dilution in this case is completed when the diluting wastewater ceases to rise in the water column and first begins to spread horizontally.
>
> For shallow water submerged discharges, surface discharges, and nonbuoyant discharges, characteristic of cooling water wastes and some individual discharges, turbulent mixing results primarily from the momentum of discharge. Initial dilution, in these cases, is considered to be completed when the momentum-induced velocity of the discharge ceases to produce significant mixing of the waste, or the diluting plume reaches a fixed distance from the discharge to be specified by the Regional Board, whichever results in the lower estimate for initial dilution.

In addition, the Basin Plan allows for dilution credits for cyanide, and specifically lists the City of San Jose as being granted a 3:1 dilution credit.

> Table 4-6: Dilution Credits for Calculation of Cyanide - Water Quality-Based Effluent Limits for Shallow Water Dischargers
>
> City of San Jose Artesian Slough 3.0:1
>
> a. The dilution credit is expressed as the ratio of total parts mixed (effluent and receiving waters) to one part effluent.

Section 4.2 of the Basin Plan goes on to provide for exceptions to the 10:1 dilution requirements under certain circumstances, namely:

- An inordinate burden would be placed on the Discharger relative to the beneficial uses protected, and an equivalent level of environmental protection can be achieved by alternate means;
- A discharge is approved as part of a reclamation project;
- Net environmental benefits will be derived as a result of the discharge; or
- A discharge is approved as part of a groundwater cleanup project.

The 2014 NPDES Permit issued for the San Jose-Santa Clara RWF includes an exception to the 10:1 dilution requirements, as follows:

> Surrounded by an extensive network of mudflats, sloughs, marshes, and salt ponds, South San Francisco Bay is generally confined and shallow, except for a deep central channel, and does not receive a minimum initial dilution of 10:1. When the Regional Water Board reissued this permit in 1988, it granted an exception to the prohibition based on the discharge providing a net environmental benefit. In 1990, the State Water Board overruled the Regional Water Board by concluding that the Discharger had failed to demonstrate a net environmental benefit. Nonetheless, it acknowledged that relocating the discharge north of the Dumbarton Bridge was not economically or environmentally sound. It also concluded that an exception to the prohibition could be granted on the basis of "equivalent protection" provided that certain conditions were met. Attachment I provides more details regarding the past actions taken by the Discharger, Regional Water Board, and State Water Board. This Order continues to grant an exception based primarily on "undue burden" and "equivalent protection" as follows:
>
> a. Moving the Discharger's outfall to deep water (i.e., north of the Dumbarton Bridge) would be an inordinate burden because such relocation would require pipeline construction through protected wetlands, which would be costly and disturb wetland habitats.
>
> b. The requirements of this Order (i.e., its prohibitions, limitations, and provisions) implement applicable water quality objectives and protect all relevant beneficial uses.
>
> c. The Discharger continues to provide an equivalent level of environmental protection by providing advanced secondary treatment through a higher level of BOD5 and TSS removal and nitrification and maintaining its pretreatment and pollution prevention programs.
>
> To further justify an exception to Basin Plan Discharge Prohibition 1, the Discharger continues to pursue wastewater reclamation projects to reduce its discharge volumes. It provides about 14 MGD of recycled wastewater for non-potable purposes to customers throughout its service area. In collaboration with the Santa Clara Valley Water District, it also recently completed construction of the Silicon Valley Advanced Water Purification Center, which produces 8 MGD more recycled wastewater. Moreover, the discharge appears to enhance certain beneficial uses of the receiving water (San José-Santa Clara Regional Wastewater Facility 2013 Annual Self-Monitoring Report, Attachment B – Net Environmental Benefit Discussion). Both the momentum of the water flowing through Artesian Slough and Coyote Creek and the high level of dissolved oxygen in that water enhance the following beneficial uses: cold freshwater habitat, fish migration, fish spawning, warm freshwater habitat, wildlife habitat, contact recreation, and non-contact recreation. The freshwater outfall channel also provides habitat for migrating waterfowl.

From these excerpts, it is evident that it will be important for the SJ-SC WRF to maintain its existing exception to the Basin Plan's dilution requirement. The exception is currently based primarily on "undue burden" and "equivalent protection", but also is based on recycling efforts. Potable reuse will increase recycling; ROC management will not likely affect the "undue burden" finding; and ROC management should be evaluated carefully to determine if it would affect the "equivalent protection" finding.