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Technical Memorandum 1

Subject: Responses to Comments on the TM entitled: Evaluation of Ammonia Toxicity during Elk River Wastewater Effluent Mixing in Humboldt Bay

Date: July 2, 2020

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Introduction

This technical memorandum (TM) provides a response to the email dated May 20, 2020, from Cathleen Goodwin, on behalf of the City of Eureka (City). The GHD/Brown and Caldwell (BC) team has prepared this preliminary response to comments from the State of California Regional Water Quality Control Board, North Coast Region (Regional Water Board) staff concerning the City's Elk River Wastewater Treatment Plant (WWTP) discharge to Humboldt Bay (Bay). The TM first presents an overview of the approach taken by the team, followed by an item by item response to the Regional Water Board's email.

Overview

Regional Water Board staff raised a question about critical conditions for a Bay discharge. The GHD/BC Team focused on the space immediately around outfall and especially each diffuser port since the Water Board staff has said that the WWTP discharge would receive no dilution credit. Several key considerations informed the approach presented in BC's November 2019, technical memorandum:

1. Based on past consultation with Regional Water Board staff and knowledge of the State of California Enclosed Bays and Estuaries Plan and the California Toxics Rule, we understood that the potential ammonia toxicity was the primary concern.
2. The ammonia concentrations at which toxicity potentially can occur can be calculated direct from equations provided by the United State Environmental Protection Agency (USEPA). Ammonia toxicity is caused by unionized ammonia, a constituent strongly dependent upon instantaneous pH.
3. Information from the literature (e.g., *Mixing in Inland and Coastal Waters* by H. B. Fischer, et al. (1979) and *Marine Wastewater Outfalls and Treatment Systems* by PJ.W. Roberts, et al., (2010)) combined with experience from thousands of dilution modeling analyses shows that dilution occurs very rapidly as effluent releases with velocity from a diffuser port—on the order of 10:1 within 20 port diameters. Addition of Tideflex™ valves by Red Valve, as now contemplated by the City, would ensure very good jet mixing even at the lowest expected discharge rates. The Tideflex valves also would maximize jet velocity and hence, initial mixing at all effluent flow rates.
4. The literature listed above describe that lowest dilution would occur at slack water. The California Ocean Plan supports this premise because that plan does not allow consideration of any current across a diffuser when calculating initial dilution, i.e., that plan focuses on a worst-case condition/lowest possible initial dilution. Thus, the critical dilution condition would be a no-current condition. Previous BC work has indicated initial dilution during that condition of approximately 30:1. The referenced literature and the many initial dilution modeling runs by BC mentioned in Point 3 above have repeatedly validated this conclusion.
5. Our knowledge of water chemistry and characteristics of the City effluent and of Humboldt Bay waters suggested that even the smallest dilution resulting from physical mixing would ensure non-toxic conditions.
6. BC selected dry weather effluent samples and flow rates because these conditions would have the highest ammonia concentrations and warmest effluent temperature. Higher infiltration/inflow would dilute the ammonia in wastewater at other times of the year.
7. Regional Water Board staff raised the question about why BC chose to focus on the immediate initial dilution and the area where it occurs. BC focused on initial dilution in the immediate port vicinity because it is expected that the un-ionized ammonia concentration would be greatest immediately adjacent to the ports. For reference during Regional Water Board staff review about BC's choice of conditions for modeling, note that initial dilution is always lowest at slack water. If the modeler adds current across the diffuser, the dilution will improve dramatically. Our analyses confirmed that un-ionized ammonia was highest immediately adjacent to the ports, even though our calculations showed no

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toxicity owing to very rapid dilution. Regarding the discharge and potential impacts on Humboldt Bay, in our opinion, if the discharge is not toxic immediately upon discharge and the diluted effluent largely flushes rapidly from Entrance Bay through careful discharge timing and through the general flushing characteristics/low water age in Entrance Bay, then the discharge would have no adverse environmental impacts, i.e., no detrimental impacts on beneficial uses. When the City authorizes it, future analyses can examine other conditions and areas further afield from the discharge point.

8. The City understands the Regional Water Board's interest in exploring the potential for ammonia toxicity under a wider range of conditions than addressed by the modeling performed to date. To make any future modeling tasks manageable, we recommend the City and Regional Water Board define and agree upon a limited set of conditions and endpoints to be modeled. These conditions and endpoints should reflect the scientific understanding of the discharge, the Bay, and conditions likely to be critical. They should also reflect reasonably conservative endpoints that are consistent with how California and USEPA normally evaluate outfalls and ammonia toxicity. We recommend that modeling and associated conditions/assumptions should be a topic of follow-up communications.

Response to Regional Water Board Comments

Introductory Remarks from the Regional Water Board in the May 20, 2020 Email

Comment: Regional Water Board staff has reviewed the City's November 25, 2019 Technical Memorandum 1, *Evaluation of Ammonia Toxicity during Elk River Wastewater Effluent Mixing in Humboldt Bay* (Technical Memorandum). Regional Board staff appreciates the City's ongoing efforts to comply with the NPDES permit requirements and to protect Humboldt Bay. This email conveys Regional Board staff's initial comments on the Technical Memorandum.

The modeling assessment of the City's discharge must be robust and well-supported. It must include sufficient detail to demonstrate that the resulting findings are defensible and show that Eureka's discharge to Humboldt Bay will result in ammonia concentrations that are below the required ammonia criteria in all locations outside those set aside for mixing, at all times, thus posing no toxicity risk outside the zone of mixing.

The Regional Water Board has the following specific comments based on the City's modeling effort completed to date and presented in the Technical Memorandum.

Item-by-Item GHD/BC Response to Regional Water Board Email

1. **Comment:** The selection of a modeling platform should be carefully considered.

   The modeling platform must provide the capability to incorporate all factors necessary to fully evaluate ammonia toxicity in Humboldt Bay. The selected modelling software must be able to model all conditions and ensure conservative values and/or assumptions are used to mitigate the limitations of the model. The Technical Memorandum must clearly discuss how limitations of the model were mitigated.

   For example, Visual Plumes does not evaluate the potential effects of plume interaction with complex bottom shape, nearby shorelines, and tidal currents and how they change over time, all of which may

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reasonably be expected to affect the City's discharge into Humboldt Bay. These limitations must be addressed, all assumptions shown, and fully explained.

If these limitations cannot be fully addressed using Visual Plumes, a more sophisticated program capable of incorporating these factors, such as CORMIX, may need to be used.

Item 1 Response: Brown and Caldwell selected Visual Plumes because it allows for fine-spatial-scale calculation of physical dilution occurring at the discharge ports, including the simulation of dilution just as a port discharge enters Humboldt Bay (Bay). As the preliminary calculations show, the area immediately around the ports is the area of most interest with respect to potential ammonia toxicity. Visual Plumes has better capabilities than CORMIX for making predictions at this spatial scale. Further, BC concluded that without toxicity at the point and instant of discharge, the discharge would have no impacts further distant.

2. **Comment:** The intended conditions being modeled must be clearly stated.

   For example, clarify that the Visual Plumes model is intended for buoyant-plume mixing (initial dilution) only and would not be used to model any other mixing or dilution dynamic (e.g. far-field). Alternative Models such as CORMIX may need to be considered if there is a need to understand more complex mixing or dilution dynamics than what Visual Plumes can model.

   Item 2 Response: For Regional Water Board understanding, be advised that Visual Plumes does include far field consideration using the method of Brooks for spreading after initial dilution ends. Also recognize that CORMIX would not provide the complex circulation modeling that the Regional Water Board refers to elsewhere in the comments.

3. **Comment:** The current modelling effort does not define a spatial area of mixing. Defining a spatial area of mixing and the dilution within that area would provide additional clarity as we review the model and would be used for any future permitting.

   Item 3 Response: As noted above, our modeling showed a lack of ammonia toxicity immediately adjacent to diffuser ports, i.e., in the first centimeters or 10s of centimeters. Because ammonia concentrations would only decrease further from the ports, this result showed that ammonia toxicity was unlikely at any spatial scale. If additional modeling is performed, it could investigate/confirm this result under a wider array of conditions. If desired, a specific area of mixing could be defined for permitting purposes.

4. **Comment:** All assumptions need to be clearly stated and explained, adequate factors of safety applied, and all work and supporting calculations and documentation provided.

   a. **Comment:** The Technical Memorandum must explain all modeling challenges encountered and how they were addressed. It must also explain which assumptions where made and demonstrate that they are conservative in their impact on the resulting model output. This includes modeling coinciding worst case conditions, such as the effect of high background ammonia levels, high effluent ammonia concentration, and worst-case tidal mixing conditions should these all occur simultaneously, or clear evidence that specific sets of worst-case conditions cannot coincide. See also item (5) below requesting inclusion of a sensitivity analysis based on further model runs.

Item 4a Response: The Board's need for complete documentation is noted. Full documentation of additional modeling efforts will be provided with subsequent submittals.

b. **Comment**: The model assumed no ammonia was present in Humboldt Bay, a "zero background concentration". Given the enclosed nature of the Bay, the findings of the 2014 Study that not all effluent exits the Bay on the outgoing tide, and the possibility of other sources of ammonia to the Bay (including ammonia from the City's discharge), this assumption does not be appear to be correct or conservative.

   i. **Comment**: The City is encouraged to perform a literature search and utilize any ambient ammonia data that may exist and/or conduct additional sampling to support and verify this assumption before using it in the model. If no data are available, a conservative assumption should be used and fully explained and justified.

      Item 4b.i Response: Additional modeling can include and document data-based assumptions about background ammonia concentrations. GHD/BC will base the background value on a review of available monitoring data and available scientific reports, e.g., Annual and Seasonal Dissolved Inorganic Nutrient Budgets for Humboldt Bay with Implications for Wastewater Discharges by C.R. Swanson, HUS, December 2015.

   ii. **Comment:** The model should either assess the impacts of ammonia in the City's discharge on ambient ammonia concentrations within the area being modelled or provide clear demonstration and a defensible explanation to support any proposition that ammonia from the discharge does not remain in the vicinity of the discharge.

      Item 4b.ii Response: As noted in responses above, the preliminary modeling was focused on the location where ammonia concentrations would be the highest—adjacent to the diffuser ports. Transport to other areas would be accompanied by additional dilution and biochemical attenuation.

c. **Comment:** The model was run with an effluent ammonia concentration that is lower than values that have been recorded in the discharge. The model should be run with the a more conservative ammonia concentration based on a statistical analysis of the effluent ammonia data from the last five years. At a minimum, the model should use the maximum effluent concentration of ammonia detected during the last five years. The concentration selected should be fully explained.

   Item 4c Response: Additional modeling can address a range of effluent ammonia concentrations. BC believes that assumptions related to effluent ammonia concentrations should be consistent with how California and USEPA normally address effluent variability and derive permit limits. These methods do not utilize the maximum daily concentration observed, but an estimate of upper percentile ammonia concentration in conjunction with the appropriate averaging period (e.g., 4-day average with saltwater chronic ammonia criteria; 1-hour average with acute criteria). The definition of reasonably conservative critical conditions does not require every variable to be placed at a worst-case value, which would result in a combination of assumptions that are highly unlikely to ever co-occur. The team looks forward to additional communications on the appropriate combination of conditions for modeling.

d. **Comment:** The model was run for effluent flow rates of 6 mgd and 30 mgd but appears to assume a continuous discharge. The Technical Memorandum should explicitly describe how the actual pattern of discharge flows (two pulses per day) and their interaction with the tidal current cycle in the bay was considered.

Item 4d Response: BC showed dilution analyses for a flow rate close to the current average annual flow and one approaching the peak annual discharge. The analyses do not assume continuous discharge. The analyses show how, where and for how long initial dilution would occur for a couple representative discharge conditions. The analysis did not attempt to replicate an ever-changing initial dilution but rather show representative conditions.

e. **Comment:** Page 1 of the Technical Memorandum contains a statement regarding late summer/early fall conditions, implying that this represents the most sensitive conditions with regard to dilution and impacts on aquatic species. The Technical Memorandum should clearly document why this represents the most sensitive conditions.

Item 4e Response: The dry conditions of summer/early fall were considered the appropriate critical condition due to lack of wet-weather dilution of ammonia concentrations in the effluent.

f. **Comment**: The Technical Memorandum should discuss whether there are ammonia sensitive species present near the diffuser and within areas likely to be affected by the effluent plume and consider the potential impacts of the discharge on these species.

Item 4f Response: The analysis used USEPA's saltwater ammonia criteria, which were based on toxicity testing of a wide range of species and controlled by sensitive species. The California Ocean Plan uses USEPA's saltwater ammonia criteria. Compliance with the USEPA criteria thereby demonstrates protectiveness of sensitive species. It is recommended that the focus of any investigation remain on compliance with established water quality criteria.

g. **Comment:** The Technical Memorandum should include the entire data set from the Fall 2019 sampling event.

Item 4g Response: GHD/BC can provide additional data as part of a future submittal.

h. **Comment:** The analysis and discussion should demonstrate that the plume doesn't interact with any boundaries such as bottom or shoreline and does not affect designated uses at the water's surface despite being predicted by the existing model to rise to a depth of less than 3 feet.

Item 4h Response: As noted above, the team does not think that boundary interactions will affect the final outcome of the analysis given that the diluted effluent field is not toxic.

i. **Comment:** The analysis should address currents by performing model runs that include tidal effects or give a defensible explanation as to why it is reasonable not to consider the ambient flow reversals over the tidal cycle.

Item 4I Response: As described above, the worst-case condition occurs at or very near zero current conditions. Future analyses can document such results directly.

j. **Comment:** The Technical Memorandum should include the Excel spreadsheet for Table 3-2 in digital format, to allow Regional Water Board staff to review all calculations in the table, particularly the calculations for unionized and total ammonia criteria. The values in the un-ionized criterion columns appear less stringent than the values that result from using the formulas in the U.S. EPA 1989 *Ambient Aquatic Life Water Quality Criteria for Ammonia (Salt Water).*

Item 4j Response: According to the EPA's 1989 saltwater ammonia criteria document, the value of the un-ionized chronic criterion remains fixed at 0.035 mg/L. The formulas are used only to adjust total ammonia criteria values or to calculate un-ionized ammonia from total ammonia and other water quality parameters. Regardless, moving forward, BC can share the relevant calculations.

k. **Comment:** The model report should either demonstrate that chemical transformation modelling is not needed (i.e., demonstrate that model assumptions are conservative, dilution alone is not sufficient to demonstrate compliance with ammonia limits), otherwise chemical transformation of ammonia may be necessary.

Item 4k Response: The preliminary calculations focused on the area immediately around the discharge ports. At this location, the effluent field would have insufficient time for chemical transformation except for the very rapid conversion of un-ionized ammonia to NH4+.

5. **Comment:** A sensitivity analysis should be conducted in the model over a wide variety of conditions and with varied assumptions.

   Multiple model runs should be evaluated and discussed in the Technical Memorandum along with supporting details. This effort is necessary to demonstrate that the most appropriate and conservative conditions and factors were covered by the modeling effort.

   For example, the model should consider a wide range of discharge rates, temperatures, pH levels, ammonia concentrations in both the discharge and Humboldt Bay, and tidal conditions and how these factors may vary with depth.

   Item 5 Response: See previous responses that acknowledge the Board's interest in modeling a range of conditions and recommend *a priori* definition of a limited set of reasonable critical conditions, consistent with California and USEPA.

6. **Comment:** Sampling may be needed to validate the model results if adequate data do not already exist, or if the results do not closely correlate to measured values. This validation effort should be considered early in the process.

   Item 6 Response: Starting in July, the City will undertake some sampling to document total filterable ammonia, pH, alkalinity, and temperature, taking samples from the Chevron dock to illustrate real world conditions near the discharge. On the City's behalf, the GHD/BC team can forward the proposed sampling plan via a separate email.

Conclusion

The City of Eureka, GHD and Brown and Caldwell team appreciate the Regional Water Board's review of the effluent ammonia toxicity evaluation. The team thinks that with the addition of agreed upon evaluation conditions, additional data collection, and revision of the previous model runs, the Regional Water Board can support higher ammonia limits that are proven to be protective of the Humboldt Bay and aquatic life.

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