

# Response to the Independent Science Advisory Panel Workshop No. 5 Report

## Questions Presented to the Panel

The Project Team presented the following questions for the Panel's consideration in Workshop 5. This letter report addresses each of the questions.

1. Is the information presented on the tertiary MBR testing results adequate to:
  - a. Support regulatory application for more than 2.5 log removal credit for MBR?
  - b. Demonstrate the product water will be suitable for groundwater recharge in the proposed groundwater basins?
  - c. Characterize the impact of the reverse osmosis (RO) concentrate stream for ocean discharge, and residual streams on Joint Water Pollution Control Plant (JWPCP) operations?
  - d. Adequately address source control for meeting project objectives?
2. Based on the tertiary MBR testing results and secondary NDN evaluation, or new information acquired since the last workshop, are there important additional factors that the Project Team should consider in evaluating secondary MBR for potable reuse applications?

## General Comments

The Panel commends the Metropolitan Water District Project Team on the level of research effort, the quality of the results, and the straightforward presentation of the materials for Workshop 5.

The Panel recognizes Metropolitan's substantial effort to move the Project forward since Workshop 4 on December 9, 2020. Following Workshop 4, the Panel was unable to give a consensus opinion on the desirability of secondary versus tertiary MBR alternatives. Workshop 5 represents the Project Team's updated work; the Panel is generally satisfied with the information provided.

## Panel Response to Questions

In this section, the Panel offers their opinions and recommendations in response to questions from the Project Team.

- 1a. **Is the information presented on the tertiary MBR testing results adequate to support regulatory application for more than 2.5 log removal credit for MBR?**

**Response.** The Panel is impressed with the microbial analytical results and level of effort undertaken to generate this information. It is a remarkable contribution to the advancement of using recycled water in the United States. The Panel believes the data support a minimum of 3.0 log removal credit for tertiary MBR for *Giardia* and *Cryptosporidium* based on the Demonstration Project operating conditions. The Panel will require additional analysis to support LRVs beyond 3.0 as described further below.

The Panel understands the binning approach used in the LRV analysis. There are alternative approaches that can be explored that make fuller use of the information in this very large dataset, which may have the potential for validating greater LRVs. The Panel requests a copy of the protozoan and turbidity data spreadsheet.

The Panel is interested in working with the Metropolitan Project Team to look at other analytical approaches contingent on authorization and funding by Metropolitan Water District.

The Panel recommends that Metropolitan:

- Keep the monitoring approach for compliance with LRV requirements as simple as possible. The Panel suggests further statistical analysis of the MBR data for the proposed LRV/turbidity binning approach. In addition, the Panel suggests that Metropolitan investigate a simpler compliance monitoring approach. The Panel believes that additional data analysis might lead to more monitoring approaches. At this time, the Panel does not have enough information to suggest appropriate modifications to the monitoring approach, such as changes in turbidity, pressure decay tests (PDTs), or pathogen monitoring.
- However, NWRI Panel members can work with the Metropolitan Project Team to analyze data and determine what, if any, modifications to the binning and monitoring approaches are appropriate. Please note that the NWRI DPR Criteria Panel advising the State Water Board Division of Drinking Water suggested a simpler compliance approach in its February 28, 2022, presentation; this information may be useful to consider for an MBR approach for the entire advanced water treatment (AWT) facility.

Response: Thank you for the feedback. The Metropolitan Project Team met with the ISAP subpanel on September 1, 2022 and received feedback on this topic (“Subpanel Review of Tertiary MBR Pathogen LRV Results” dated November 4, 2022). The subpanel supported the use of the 5<sup>th</sup> percentile LRV with Monte Carlo binned by Max Turbidity, and recommended that the Project Team to continue to remain flexible on alternate pathogen data analytical approaches as future MBR operational and performance data became available.

**1b. Is the information presented on the tertiary MBR testing results adequate to demonstrate the product water will be suitable for groundwater recharge in the proposed groundwater basins?**

**Response.** The treatment plant can produce water that is suitable for recharge.

The Panel recommends that Metropolitan:

- Verify that boron concentrations can be reduced at demonstration scale. It is likely that boron concentrations in the RO product water can be reduced sufficiently with pH adjustment to a portion of the first-pass product water followed by RO and blending with first-pass water to meet Main San Gabriel Basin objectives through the use of partial second-pass RO.
- Provide the pending report on basin assimilative capacity for boron to the Panel. The Panel supports the concept of basin assimilative capacity to address boron concentrations in the product water delivered and recharged in the Main San Gabriel Basin.

Response: Recent boron monitoring in a secondary MBR configuration and a higher rejection RO membrane has shown that boron concentrations in the purified product water continue to remain stable, and increased boron rejection has been observed through the new membranes. The current RO system is not configured to be able to pH adjust a portion of the RO feedwater, however, this feasibility will be considered for future testing. The requested boron report will be provided separately.

- Try to assess the useful life of the oilfields that contribute boron to the Joint Water Pollution Control Plant (JWPCP). The Panel supports continued efforts to manage sources of boron in the feed water to the treatment plant. Perhaps these fields will reduce production over time and will become less meaningful contributors to boron concentrations. The oil producers may be able to provide information on their projections for future production, which could help clarify concerns about meeting boron targets through removal or blending. Please note the link below to a recent Los Angeles Times article citing the phasing out of some regional oil field production in the near to mid-term: <https://www.cnbc.com/2022/01/26/los-angeles-bans-new-oil-and-gas-wells-will-phase-out-old-ones.html>

Response: We concur that assessing the useful life of the oilfields is important and will continue monitoring and evaluating the boron contributions to the collection system. The future outlook on boron sources indicates an overall decreasing trend. Based on the 2019 Annual Report of the State Oil and Gas Supervisor, oil production in southern California peaked in 1985 and has continued to decline at an average rate of 2.2% per year. The decrease has been due to, in large part, a natural decline in production and is anticipated to continue along this trend into the future. As older oil wells break down mechanically, depending on the market condition, oil producers are likely to abandon failed oil wells instead of rehabilitating them. In addition, Los Angeles County voted in 2021 to ban new oil and gas wells, and to phase out existing wells in unincorporated areas. Los Angeles City and Culver City passed similar bans in 2022 to phase out existing wells over a period of five years, as mentioned in the article cited above. The decline in production of oil and aging infrastructure and legislative efforts will result in a decrease of boron from oil wells over time.

- Assess potential interactions between basin water, aquifer media, and recharge water. This process can begin with a review of available literature on introducing recycled water into groundwater basins and managing any effects on basin geochemistry.

Response: (Input pending from MWD)

- Provide the Panel with any studies/analyses that are underway to support the upcoming environmental documentation.

Response: Metropolitan released the Notice of Preparation (NOP) on September 29, 2022, and comments were received during the review period from September 30, 2022 to November 14, 2022. The NOP can be found here: <https://www.mwdh2o.com/building-local-supplies/pure-water-southern-california/#erdocs>. The general list of the types of technical studies being prepared for the Environmental Impact Report (EIR) are below, and these reports will likely be referenced and included in the EIR as appendices. Due to the extensive list of studies, as there are potentially many more technical memorandums being prepared for the project to support the EIR, reports can be provided separately as specifically requested once the documents are finalized.

- Air Quality, Greenhouse Gas Emissions, and Energy Technical Report
- Biological Technical Report

- Cultural Resources Technical Report
  - Preliminary Geotechnical Evaluation
  - Geotechnical Assessment of Joint Site
  - Geotechnical Assessment for Conveyance
  - Hazards Materials Assessment
  - Hydrology and Water Quality Study
  - Brine Concentrate and Alternative Disposal Methods Memorandum
  - Hydrology/Groundwater Memorandum
  - Noise and Vibration Report
  - Transportation Impact Analysis
  - Paleontological Assessment Report
- The Panel noted that the proposed California Public Health Goals (PHGs) for PFOA and PFOS are 0.007 ppt and 1 ppt, respectively, effectively drive unnecessary and expensive treatment. By comparison, the EPA's Health Advisory for PFOA and PFOS is 70 ppt, although they are likely to lower it. Standards should reflect significant health-based target risks for important contaminants. Also, while future MCLs for these compounds will not likely be as low as the PHGs, analytical reporting limits may need to be adjusted to reflect new limits (Slide 149 PFOA/PFOS).

Response: The reporting levels from the commercial labs that provided analyses for PFAS compounds ranged from 2 to 5 ng/L, depending on the matrix and required dilutions. The Project Team will continue to consider data evaluation in the context of recent changes in notification limits, and potential future changes to PHGs.

- The Panel noted that the PFAS-TOPA (total oxidizable precursor assay) test is adequate, but adsorbable organic fluorine (AOF) is emerging as an important measurement ([https://www.epa.gov/system/files/documents/2021-09/cq1\\_br1\\_shoemaker.pdf](https://www.epa.gov/system/files/documents/2021-09/cq1_br1_shoemaker.pdf)).

Response: Thank you for the feedback. The project team will consider AOF for future monitoring.

**1c. Is the information presented on the tertiary MBR testing results adequate to characterize the impact of the reverse osmosis (RO) concentrate stream for ocean discharge, and residual streams on Joint Water Pollution Control Plant (JWPCP) operations?**

**Response.** RO concentrate toxicity levels appear low. The Panel noted that the proposed 1/166 dilution ratio is more conservative than necessary since 1 percent seems to be adequate from the tests.

The Panel recommends that Metropolitan:

- Explore the single kelp toxicity finding further. The Project Team should identify what actions would be taken to manage a potential full-scale toxicity finding. The Project Team should also consider permit discussions with regulators regarding allowing some level of retesting if an outlier finding occurs. The Panel would like to review any additional information on the kelp study.

Response: The current 2017 JWPCP surface water discharge permit (NPDES permit) specifies how LACSD is to conduct effluent toxicity testing and how to respond to observed toxicity at the instream waste

concentration (IWC). In short, the permit does not allow for “do-overs” in the event of a toxicity test outlier. However, the permit specifies that if one toxicity test fails the Test of Significant Toxicity (TST), an additional 4 tests must be performed. If all 4 tests pass the TST (no toxicity) there is an immediate return to routine monthly compliance testing, although this does not negate the initial toxicity finding. While LACSD is not specifically permitted to “retest if an outlier finding occurs,” the accelerated testing process provides greater insight into whether the initial TST failure was transient toxicity, persistent toxicity, an outlier, etc. Attached is the contract lab’s toxicity testing report. In addition, all the raw data will be provided in the tMBR final report appendices.

In summary, the following was conducted to evaluate the single kelp toxicity finding:

1. Chemical feed data was evaluated from the day on which the single kelp sample was collected, and compared to chemical feed data from the week leading up to sample collection and over a previous broader timeframe that encompassed portions of both baseline and challenge testing phases. No anomalies or major differences were identified as part of this evaluation (see Attachment 1).
2. A cursory review of average metals concentrations (i.e., copper, arsenic, nickel, lead, selenium, and zinc) in the JWPCP final effluent and RO concentrate during tMBR baseline testing was conducted. The evaluation suggests that metals would not have been present in the diluted RO concentrate at levels expected to produce toxicity to marine aquatic life (California Ocean Plan, 2019).
3. In addition to the Test of Significant Toxicity, a point estimation statistical analysis (i.e.,  $IC_{25}$ , or inhibitory concentration to 25% of the organisms) was also applied to the kelp test in question. This statistical approach, commonly used in toxicology, evaluates the entire dataset as opposed to the Test of Significant Toxicity which independently compares each test concentration with the control result. Evaluation of the  $IC_{25}$  data indicated that toxicity would not be present at the 1% RO concentrate tested for the kelp germ tube mean length endpoint, but at a dose nearly 80X greater.
  - o Consider how higher CEC concentrations in the discharge might be perceived and addressed in the environmental documentation. The Panel understands that the contaminants of emerging concern (CEC) loading in the outfall will remain unchanged, although there will be changes in CEC concentration.

Response: The ocean discharge of RO concentrate is a critical component of this project and we believe it can be done in an environmentally safe manner, not impacting the ocean environment and in compliance with all requirements. Although the loading of compounds may remain generally the same, we understand the concern of concentrating these compounds. We have focused on conducting testing to assess impacts, have included monitoring for a wide variety of CECs and plan to provide an overview in the environmental planning documents of the assessments conducted and findings for toxicity testing and other water quality testing. In regards to CECs, we are evaluating how high dilution and mixing of RO concentrate with secondary effluent and ocean water would affect CEC concentrations. LACSD implements a comprehensive coastal monitoring program to assess impacts from current effluent discharge (as measured by water and sediment quality, benthic and fish surveys, tissues analysis and microbiological assessments). Because the total mass of chemicals discharged to the ocean from the RO concentrate is anticipated to be the same as the current mass discharged from JWPCP effluent, it is expected that marine impacts will continue to be minimal and can continue to be assessed through monitoring.

Monitoring of a wide array of CECs during the baseline phase at the demonstration facility showed that 16 of 53 CEC compounds monitored were not detected in the RO concentrate. LACSD will continue to follow State Board efforts to address CECs, including conducting voluntary monitoring in response to recommendations from Science Advisory Panels charged with developing monitoring strategies for CECs in aquatic ecosystems and recycled water. LACSD has analyzed the tMBR RO concentrate CEC results in comparison to all available Monitoring Trigger Levels (MTLs) for aquatic life impacts or human health impacts contained in the published Science Advisory Panel reports and no concerns were identified when accounting for blending with JWPCP secondary effluent and dilution with ocean water at the outfall. The most recent Science Advisory Panel Report for CECs in aquatic ecosystems (published in 2012) did not identify any MTLs specifically pertaining to aqueous concentrations of CECs in ocean discharges. The State Board reconvened the Science Advisory Panel for CECs in aquatic ecosystems in 2022; LACSD is tracking the status of the Panel's findings and intends to implement any monitoring recommendations, if applicable and feasible, following publication of the final report.

- Review literature on scaling inhibitors and apply that knowledge to the outfall; it appears to be a manageable issue. Chemical equilibrium model calculations should show whether the secondary effluent-RO concentrate is supersaturated with minerals of concern after mixing, and the experience of other AWT systems should give information on the life of inhibitors in RO concentrate.

Response: Metropolitan and LACSD will review antiscalant literature and experience of other AWT systems as suggested. LACSD has completed preliminary equilibrium calculations of secondary effluent blended with RO concentrate. The preliminary calculations indicate that some minerals of concern may be supersaturated, including calcium carbonate, calcium phosphate, calcium fluoride, and barium sulfate. However, the degree of supersaturation for these minerals is well within the control limits of available antiscalant products. At project buildout, there would be two times more volume of secondary effluent compared to concentrate for dilution. In addition, the travel time in the outfall is expected to be less than the effective life of the antiscalants that will be in the concentrate.

- Review experience at other RO plants to determine if scaling is a problem in similar concentrates. The tests that showed no increase in turbidity or suspended solids in a sample that was allowed to stand for some time was not convincing because scaling can occur without either of these parameters increasing. Also, using a chemical equilibrium model to show the degree of supersaturation with solids that might scale after the RO concentrate is diluted with secondary effluent can provide useful information as to whether or not a problem might exist. If scaling is likely, it might be necessary to add more scale inhibitor.

Response: Metropolitan and LACSD will review the experience at other RO plants with similar concentrates as suggested. The bench test methodology used is a standardized protocol developed by the antiscalant supplier that is used to assess the efficacy of their products. The general testing approach of using turbidity measurements as well as filtration (on a membrane filter with a nominal pore size in the colloidal size range, for example 0.22-micron used in testing of RO concentrate) with subsequent elemental analysis of the material captured on the filter is not an uncommon approach used by antiscalant suppliers and researchers to assess the formation of colloidal precipitates. During the subject test, it was demonstrated that the antiscalant was able to prevent significant formation of colloidal precipitates in undiluted concentrate for 72 hours. These results, in combination with the preliminary equilibrium calculations, indicate that outfall scaling is a manageable issue. Additionally, as mentioned above, at project buildout there would be two

times more volume of secondary effluent compared to concentrate for dilution. In addition, the travel time in the outfall is expected to be less than the effective life of the antiscalants that will be in the concentrate.

- The Panel noted that, given the low concentration of pathogens in the RO concentrate, it does not appear that disinfection of the concentrate before discharge to the outfall is necessary.

Response: Thank you for the feedback.

- The Panel would like to understand and review the plan for continued toxicity testing over the next 6-18 months of AWT operations.

Response: Toxicity tests performed during sMBR Baseline Testing will generally follow the same plan used for tMBR testing and will consist of the following: shrimp acute test (n=8), topsmelt chronic test (n=10), inland silverside chronic test (n=8), red abalone (n=8), and giant kelp (n=10). In addition, acute toxicity information will be derived from the two chronic fish tests (i.e., from the 96-hour acute endpoints). Half of the aforementioned tests will be performed using 100% RO concentrate while the other half will use the four combinations of RO concentrate and JWPCP secondary effluent described in the sMBR Testing and Monitoring Plan.

- The Panel noted that the current draft of the final tertiary MBR testing report provides median, maximum, and diluted concentrations of many CECs in both the JWPCP secondary effluent and the RO concentrate. However, the Panel did not see interpretation of those results in the report. The Panel recommends interpreting these results in the final report to give readers some perspective on the environmental relevance of the CEC monitoring data.

Response: The tertiary MBR testing final report will be revised to include interpretation of the CEC results in the RO concentrate. As indicated in the response to bullet #2 under Question 1c, to assess the environmental relevance of the results, the data were compared to Monitoring Trigger Levels (MTLs) found in reports produced by the State Board Science Advisory Panels for CECs in aquatic ecosystems and recycled water. When considering blending with JWPCP secondary effluent at the outfall, no results exceeded any MTLs. It should be noted however that these MTLs are not regulatory limits, criteria, or objectives. Furthermore, the most recent Science Advisory Panel Report for CECs in aquatic ecosystems (published in 2012) did not identify any MTLs specifically pertaining to aqueous concentrations of CECs in ocean discharges. The available MTLs pertained to human health impacts from recycled water, freshwater or estuarine waters, and thus have limited applicability for assessing impacts to marine aquatic life. The State Board reconvened the Science Advisory Panel for CECs in aquatic ecosystems in 2022. LACSD is tracking the status of the Panel's findings and will re-assess RO concentrate CEC results, as applicable, following publication of the final report.

**1d. Is the information presented on the tertiary MBR testing results adequate to address source control for meeting project objectives?**

**Response.** Yes.

The Panel recommends that Metropolitan:

- Establish a standard operating procedure to guide the collaborative assessment and response to unanticipated discharges that impact plant operations.

- Continue outreach through the advisory board.

Response: Thank you for the feedback. Metropolitan and LACSD are keeping in mind the need to identify appropriate responses to unanticipated discharges that would impact plant operations (e.g. diversion of off-spec water or changes in concentrate quality). This will be further developed as a preferred treatment train is identified. We also agree that it is important to continue outreach with the Industry Advisory Council and will continue to engage and keep them informed of our efforts.

**2. Based on the tertiary MBR testing results and secondary NDN evaluation, or new information acquired since the last workshop, are there important additional factors that the project team should consider in evaluating secondary MBR for potable reuse applications?**

- The Panel is satisfied with the data and the proposed approach; the proposed approach is logical, and the model results match the data.
- Carefully consider the operational/coordination requirements of tertiary and secondary MBR and where an institutional “line” is drawn. Since MBR is a critical part of LRV compliance, the AWT operations team should have, at minimum, high visibility of MBR performance information. Notwithstanding physical site constraints, MBR should ideally be under the operational control of the entity that has permit responsibility for drinking water compliance.
- The Panel acknowledges the high level of collaboration between Metropolitan and the Los Angeles County Sanitation Districts. The Project Team should ultimately establish a standard operating procedure to guide the collaborative assessment and response to unanticipated discharges that impact plant operations to ensure timely resolution of issues.
- The Panel believes the use of chlorine in the AOP is appropriate, minimizes the use of other chemicals, and somewhat reduces costs and handling issues.

Response: Thank you for the feedback. The project team agrees that more discussions between Metropolitan and LACSD are needed to understand the boundaries of different treatment technologies and their implications for full-scale operation and coordination. Metropolitan and LACSD are in discussion regarding operational considerations from various perspectives. We appreciate the Panel’s input.

**Additional Panel Comments**

- The Panel is comfortable reducing pressure decay testing (PDT) frequency. The Project Team should propose an alternative frequency.

Response: Metropolitan is currently proposing an alternative PDT frequency of monthly.

- The Project Team should consider making a formal request to the State to update several key Public Health Goals (PHGs) that can affect reuse treatment process decisions. Several PHGs are far out of date and much lower than necessary to protect public health (examples are bulleted below). Mode of Action results conclude that these should be assessed using safety factors rather than the unvalidated hypothetical linear risk models.



This issue was raised in the last report, but the technologists responded it was outside of their scope. It is something that Metropolitan and water providers can/should initiate and could help avoid some unnecessary limitations and expenditures. Considering an initiative to the Office of Environmental Health Hazard Assessment (OEHHA) from a broader segment of conventional and recycled water producers would be desirable.

Examples of PHGs that could be updated are:

- 1,4-Dioxane has been reexamined in detail in the latest Canadian Drinking Water guideline. It is not a genotoxic carcinogen at drinking water levels, and the official Canada guideline is now 50 ppb.
- The human health-based value for boron (borate) should be updated from 0.5 ppm.
- Bromate is about to be reported to be non-genotoxic in drinking water for all of the animal tumors from the old National Toxicology Program (NTP) study. A Water Research Foundation (WRF) report has been released and a peer-reviewed publication is in the works.
- Chromium VI has been shown to be a non-genotoxic carcinogen in drinking water. Protective health-based value is at least 50 ppb. California has proposed an MCL of 10 ppb that was remanded due to inadequate consideration of small-system impacts.
- The Project Team should have a plan to address how changing regulations in California or by the EPA may influence key design and operating decisions. OEHHA is treating trihalomethanes (THMs) as genotoxic carcinogens with PHGs below 1 ppb, whereas the World Health Organization (WHO) and EPA do not treat them as such. These should be handled similarly.

[Response:](#) Thank you for the feedback. Metropolitan recognizes the constraints that existing PHGs will impose on the project and will take these into consideration as the program moves forward.

- The Panel would like to see an analysis of the advantages and disadvantages of the proposed MBR approach. It would be instructive to see the capital and operations and maintenance (O&M) cost projections for the proposed 45–50 MBRs compared to a tertiary treatment plant. The Panel would also like a comparison of water quality and maximum LRVs that could be obtained from a tertiary plant or an Orange County-type treatment train with secondary treatment followed by microfiltration.

[Response:](#) Full-scale analyses of alternative trains beyond MBR are being performed to understand different treatment train options against various criteria, including costs. Metropolitan will consider a comparison of water quality with another tertiary treatment plant followed by microfiltration (and RO and UV/AOP). Maximum LRVs for the overall trains would vary depending on the assumptions for the MBR or microfiltration, RO, and upstream processes. Metropolitan and LACSD are considering an evaluation of comparative performance of such processes (i.e. MBR versus MF) at the demonstration plant to build on work previously done at JWPCP using secondary effluent as feedwater during the 2010-2012 pilot study, and in more recent work completed in 2018.

- The Panel believes it is likely that secondary MBR performance results will be less satisfactory than the tertiary results since the input will be a much lower quality water. The decision logic for selection should be developed in advance, including an evaluation of the minimum performance requirements to make

secondary MBR a viable choice. Potential LRVs associated with the secondary treatment process should also be considered as part of the evaluation of secondary versus tertiary MBR approaches.

Response: Metropolitan and LACSD appreciate the considerations raised to make the appropriate decision. It is anticipated that with the regulatory support of the WRF 4997 Tier 1 MBR pathogen LRVs, secondary MBR is anticipated to be a viable choice and the data gathered at the demonstration plant is expected to continue to support these minimum LRVs (i.e. 2.5 LRV for protozoa, and 1.0 LRV for virus). The criteria for proceeding with secondary versus tertiary MBR is multi-pronged, with the regulatory pathway and technology acceptance being one among many others, including, for example: operational reliability, redundancy, and complexity; impacts to environment and JWPCP, and flexibility for the future.

- The Project Team should develop an understanding of likely DPR requirements that might provide some basis for current treatment and operating decisions if DPR becomes an option.

Response: Metropolitan has been engaged in the dialogue with the State Water Resources Control Board and WateReuse California's DPR subgroup, discussing the draft DPR criteria since the framework documents were initially released. Metropolitan staff and project team members have held several workshops to develop concepts for integration of DPR into the Pure Water Southern California program, through raw water augmentation. DPR is anticipated to be a key component of the future full-scale facility, initially below a ten percent blend, above which additional ozone/BAC treatment is expected to be required. Metropolitan looks forward to engaging the Panel in discussion on preliminary concepts for DPR at the next workshop.

## Attachment 1

### Expanded Response to Independent Science Advisory Panel Workshop No. 5 Report Comment on RO Concentrate Toxicity Test Results (Question 1c)

Based on the Panel’s request, operational data and RO feed water characteristics (**Table 1**) were compared between two test periods (1) a test of significant toxicity (TST) failure with a 1% RO sample concentration (9/9/2021 to 9/14/2021 during Challenge testing), and (2) a test without TST failure (7/2/2020 to 10/6/2020 during Baseline and 4/29/2021-8/17/2021 during Challenge testing), referred hereafter as high toxicity period (HTP) and low toxicity period (LTP), respectively.

No major discrepancies were identified between the HTP and LTP test conditions with respect to operational parameters and water quality. One notable operational change was a lower caustic dose fed into the secondary effluent, coupled with a lower acid feed rate at the RO feed location. Since the project team was transitioning MBR operations from nitrifying-denitrifying to nitrifying-only, a gradual reduction in caustic dose was planned to lower chemical consumption, while maintaining nitrifying conditions within the bioreactor (target pH > 6.5). While pH setpoint adjustments were being made, the RO feed pH was slightly higher during the HTP, when compared to the LTP (pH 6.8 and 6.5, respectively). However, the LTP test immediately prior to the HTP test, where the median RO feed pH value was also relatively high (pH 6.8) did not show TST failure. As such, when comparing the HTP and LTP, the project team does not believe that changes in the RO feed pH, and subsequent RO concentrate pH, had any negative impact on test results.

**Table 1. Median data for periods<sup>1</sup> of low toxicity and high toxicity**

Parameter	Data from 7/2/2020 to 5/10/2021 TST – Pass LTP	Data from 8/12/2021 to 8/17/2021 TST – Pass LTP	Data From 9/9/2021 to 9/14/2021 TST – Fail <sup>2</sup> HTP
<b>MBR</b>			
Filtrate Ammonia (mg-N/L) <sup>3</sup>	0.020	0.014	0.017
Filtrate TKN (mg/L) <sup>3</sup>	1.89	2.75	2.29
Filtrate Nitrite (mg-N/L) <sup>3</sup>	< 0.01	<0.01	< 0.01
<b>RO</b>			
Recovery (%)	83.2	81.6	81.3
Feed TOC (ppm)	10.6	8.21	8.44
Feed Conductivity (µS/cm)	2,458	2,579	2,647
Feed pH	6.5	6.8	6.8
Antiscalant flow (gph)	0.05	0.06	0.06
Total Chlorine (mg/L)	0.93	0.94	0.92
Permeate TOC (ppb)	30	37	42
Concentrate TOC (ppm) <sup>3</sup>	20	18	17
Concentrate Ammonia (mg-N/L) <sup>3</sup>	0.65	1.07	1.22

<sup>1</sup>Periods for SCADA data analysis includes data for 5-days prior to each toxicity sampling, which includes the following dates: 7/2/20-7/7/20; 7/30/20-8/4/20; 8/6/20-8/11/20; 8/13/20-8/18/20; 8/20/20-8/25/20; 8/26/20-8/31/20; 9/3/20-9/8/20; 9/25/20-9/30/20; 10/1/20-10/6/20; 4/29/21-5/3/21; 5/5/21-5/10/21; 8/12/21-8/17/21; and 9/9/21-9/14/21. Periods in between 7/2/20 and 10/6/20 were during Baseline Testing, while periods between 4/29/21 to 9/14/21 were during Challenge Testing.

<sup>2</sup>TST failure at 1% RO concentrate level for mean germ tube length in *M. pyrifer*.

<sup>3</sup>Biweekly grab water quality results were used for these parameters. All other data were analyzed using 24-hour data (5-min increments) from SCADA.