ATTACHMENT 3

Revised Draft Engineering Report: Pure Water Monterey Groundwater Replenishment Project (July 1, 2016)

Excerpted Pages showing Revisions

REVISED DRAFT ENGINEERING REPORT

VOLUME I: ENGINEERING REPORT

MRWPCA PURE WATER MONTEREY GROUNDWATER REPLENISHMENT PROJECT

~~July~~ September 16, 2016

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6.1. PROPOSED RESPONSE RETENTION TIME COMPONENTS

6.1.1. Proposed RRT Concept

The proposed RRT aims to protect public health by allowing for an interim safe drinking water source to be secured in the unlikely event that “off-specification” recycled water is injected into the ground with an emphasis on constituents that pose acute (short-term) health risks. Most chemical contaminants monitored in drinking water pose chronic (long-term) health risks (i.e., short-term exceedances of a limit would not result in adverse health consequences). Thus, the proposed RRT is based on microbial pathogens (using total coliform organisms as the indicator organism), nitrogen compounds (nitrate and nitrite), and perchlorate, because they represent acute risks (i.e., short-term health risks to the water consumers) that require immediate attention. These contaminants posing acute risks are similar to RRTs derived for other groundwater replenishment projects. If any of these constituents are measured above acceptable levels in the product water (see Table 6-1), DDW will be informed and the response outlined within this section will be initiated.

Table 6-1: Acute Contaminants and Concentrations at which RRT Response is Initiated

Acute Parameters	Concentration	Units
Total coliform	2.2 (7-day median) 23 (in more than 1 sample in any 30-day period) 240 (any sample)	MPN/100mL
Nitrate (as N)	10.0	mg/L
Nitrite (as N)	1.0	mg/L
Perchlorate	0.006	mg/L

It is noteworthy that the exceedance of these acute parameters is highly unlikely as MRWPCA will incorporate the following safety features that are part of the Project: (1) continuous online monitoring of RO treatment with real-time results reviewed by the AWT Facility operators; (2) multiple levels of critical control points for AWT Facility operations, alarms, and unit process redundancy; and (3) the ability to shut down the AWT Facility at a moment’s notice. Additionally, piloting results for the proposed AWT Facility support the reliability of the AWT Facility product water (see Table 6-2).

Table 6-2: Summary of Results from AWT Piloting – RO Permeate

Acute Parameters[a]	Number of Detects/ Total Number of Samples	Median (Range)	Units
Coliform	0/26	<1 (all non-detects)	MPN/100mL
Nitrate (as N)	17/26	<0.2 (<0.2 – 0.7)	mg/L
Nitrite (as N)	20/26	<0.1 (<0.1 – 0.4)	mg/L
Perchlorate	0/1	<0.002 (only 1 sample taken)	mg/L

[a] All of these constituents would be further reduced through UV/AOP treatment (UV/AOP was not included in the pilot testing)

6.1.2. Time to Identify Water Quality Problem and Complete Confirmation Sampling

Real-time tracking of critical control points at the AWT Facility serves to identify early signs of any treatment performance issues. The RRT however is based on the worst-case hypothetical scenario –

As part of the confirmation sampling efforts, MRWPCA will launch weekly monitoring of acute contaminants at two locations: (1) the AWT Facility product water and (2) the nearest monitoring well to the injection well. Both sites will be sampled weekly ahead of and during the theoretical arrival of the "off-specification" water at the monitoring well, as well as four weeks after the theoretical arrival at the monitoring well. The monitoring well provides early warning for the down-gradient potable production wells. Based on modeling results, travel time to the monitoring well (this monitoring well also serves as the monitoring well for the tracer test) is between 2 weeks to 1 month. The duration used for the RRT calculation is twice that predicted by the model to account of uncertainties, as set forth in Title 22 Section 60320.224(d). Pursuant to Title 22 Section 60320.212(d)(1), product water and monitoring well samples will be collected until four consecutive weekly results are below the contaminant's MCL.

The total time to identify water quality problem and complete confirmation sampling is 19 weeks and is the sum of:

- Longest time elapsed between sample collection (1 month);
- Longest turnaround for routine results (12 days);
- Travel time to monitoring well, doubled to account for uncertainty in numerical model (4 weeks x 2 = 8 weeks);
- Four consecutive weekly samples after passage of "off-specification" water at monitoring well to demonstrate all four concentrations are below contaminant's MCL (4 weeks); and
- Longest turnaround for expedited results (4 days).

6.1.3. Time to Assess Water Quality Results with DDW and RWQCB

MRWPCA will inform DDW and RWQCB if RRT response is initiated and will keep the regulators abreast of the findings. After the last set of results are available, t~~T~~he time required for MRWPACA, DDW, and RWQCB to assess the sample results and make decisions regarding the appropriate response(s) is estimated to be 1 week.

6.1.4. Time to Procure Safe Interim Drinking Water Supply

As discussed in previous sections, MRWPCA has a response plan with remedial actions for plant operators if the product water cannot meet reuse or discharge standards, including immediate shutdown of recycled water deliveries. MRWPCA also has contingency plans for disposal of "off-specification" recycled water via the ocean outfall (this water will meet NPDES permit effluent limitations). In this section, MRWPCA presents an additional response plan for procuring a safe interim drinking water supply (plan) in the unlikely event that a water quality problem by-passes the multiple fail-safe measures associated with the AWT and injection facilities. The eight steps of the plan, discussed in this section, provide a systematic and comprehensive approach for addressing a water quality issue in the Seaside Basin on both a short-term and long-term basis.

The time required for MRWPCA to ~~collaborate~~ notify and coordinate with regulatory agencies and stakeholders ~~to suspend replenishment operations and, if necessary, to provide relief measures or an alternative water supply~~on a water quality problem and initiate steps of this plan is estimated to ~~be~~ take one week. ~~MRWPCA has a response plan with remedial actions for plant operators if the product water cannot meet reuse or discharge standards, including immediate shutdown of recycled water deliveries. MRWPCA also has contingency plans for disposal of "off-specification" recycled water via the ocean outfall (this water will meet NPDES permit effluent limitations).~~

In addition to actions at the AWT Facility, MRWPCA will immediately implement appropriate steps in the ~~proposed action plan (~~plan~~)~~ outlined below to mitigate any potential impacts to the drinking water supply. Explanation and assumptions for each step of the plan are also provided.

~~Examples given in t~~The plan focuses on potential impacts to the ~~closest~~ downgradient drinking water wells associated with the fastest subsurface arrival time of Project water; these two wells, ASR-1 and ASR-2[37], ~~both of which~~ are located about 1,000 feet from the injection wellfield. However, the plan also applies to other potentially impacted downgradient wells, including the City of Seaside Well No. 4, located southwest of the injection wellfield. Although this well is also located about 1,000 feet from the wellfield, it is not directly downgradient and is associated with much longer travel times from the injection wells. For all other downgradient wells, the actions associated with the plan remain the same, but ~~additional~~ even more time would be available to mitigate impacts (given the longer travel times to other wells). Although the plan provides protection for both aquifers receiving injectate, actions target the Santa Margarita Aquifer first due to faster travel times, closer drinking water wells, and higher reliance on the deeper aquifer for water supply. Injection can also be transferred from one aquifer to the other, if appropriate.

Because the AWT Facility will be shut down if the water quality problem cannot be immediately remedied, any potential impacts to the groundwater supply are anticipated to be of relatively short duration. However, the plan also covers the potential for long-term impacts through wellhead treatment and other actions (Steps 7 and 8).

1. Notify Well Owners and Key Stakeholders, and Coordinate Appropriate Actions

Once a water quality issue is identified, downgradient well owners will be notified immediately. The ~~closest~~ downgradient drinking water wells with the fastest travel times, ASR-1 and ASR-2, are operated by MPWMD for injection on behalf of CalAm. Both of these entitities are also involved in the Project as Project Participants (see Table 2-1). Because the most likely affected well owners and operators are Project partners, selection and implementation of effective actions will be more easily coordinated. In addition, the City of Seaside will be included in all notifications and planning steps; the City operates a downgradient drinking water supply well and has been cooperating with MRWPCA on Project development and implementation for several years. Finally, the Seaside Basin Watermaster will also be included in the notification process and subsequent response actions. Although the Watermaster is not a well owner, it has groundwater basin management responsibilities and the Watermaster Technical Advisory Committee has closely tracked and supported the Project.

It is noted that ASR-1 is operated by CalAm for production of drinking water into their distribution system. Well ASR-2 is not yet permitted for drinking water production, but when that occurs, it will also be operated by CalAm through their water system permit. In the event that a problem is identified that

[37] Although this well has not yet been permitted for use as a drinking water supply, it assumed that permitting will be completed prior to Project start up.

quality goals. ASR-2 well could be pumped for blending without significantly spreading the impacted groundwater. By capturing the impacted groundwater locally at the ASR-1/ASR-2 well site, problematic constituents could be contained in a manner that prevents additional downgradient wells from being impacted, while meeting drinking water standards in the CalAm distribution system.

6. Shift Production from Impacted Well to other Existing Wells

A review of existing well capacities in the vicinity of the Project indicates that some excess capacity is likely available at any given time to shift production to a non-impacted well. This was the result of an analysis conducted in support of the Project EIR. That analysis considered specific capacities of existing wells along with reasonable assumptions for CalAm demand requirements from the Seaside Basin. The analysis also considered times when existing ASR wells would be required for ASR injection or recovery. Results of the analysis indicated that existing wells provide excess capacity under almost all of the recharge and recovery scenarios over a 32-year simulation period.

Data provided by CalAm to support the EIR analysis indicated that a total minimum capacity of 3,653 gpm is available from the five existing CalAm wells in coastal subareas: Luzern #2, Ord Grove #2, Paralta, Playa #3, and Plumas #4 (not including capacities of two low-capacity wells planned for abandonment by CalAm). Additional capacity is available from four existing ASR wells drilled at two well sites: ASR-1 and ASR-2 at the Santa Margarita well site; and ASR-3 and ASR-4 at the Seaside Middle School well site. It is recognized that only one ASR well (ASR-1) is permitted currently for drinking water supply, but additional permitting is anticipated to occur prior to Project operation. ASR wells are capable of pumping up to about 3,000 gpm each for backflushing purposes. However, both wells at each well site would not be pumped simultaneously due to hydraulic interference associated with the relatively close well spacing. Further, well capacities decrease with ongoing injection. As a conservative assumption, an ASR capacity of 1,750 gpm is assumed for each ASR well site (total 3,500 gpm for the two sites). Even with these reduced rates, existing CalAm basin wells and ASR wells are capable of more than 7,153 gpm, a rate more than sufficient to meet anticipated future CalAm demand in the Seaside Basin of approximately 9,100 AFY (about 5,642 gpm).

Further, it is noted that ASR wells are not operated full time. For example, the ASR wells were not operated in 2014 for either injection or recovery. If the closest downgradient wells (ASR-1 and ASR-2) were impacted during these time periods, no additional capacity within the system would be required until ASR injection and recovery began again. This would provide additional time for planning and remediation if such an impact occurred in the future.

Potential use of an existing intertie between the CalAm system and the City of Seaside water system is also incorporated into this step. The intertie provides additional flexibility for the plan, allowing the ability to suspend production from an impacted City well and provide access to the CalAm system. This intertie, located near the intersection of LaSalle Avenue and Lincoln Street in Seaside, has been used recently while a City well was offline for maintenance. MRWPCA will coordinate plan implementation steps with the City, CalAm, and MPWMD so that all parties are informed of any water quality issue in advance of potential impacts to any drinking water well.

~~In addition~~Finally, several additional wells in the Seaside Basin are capable of providing potable water if permitted and re-commissioned to do so. These wells represent a potential emergency backup water supply to accommodate demand if a drinking water well is offline temporarily. Several of these wells include the Reservoir Well, the MMP well, and the PRTIW well (among others). Most of these wells are

7. AWT FACILITY RECYLED WATER QUALITY

A pilot-testing program was conducted between mid-October 2013 and mid-July 2014, with extensive sampling conducted between December 2013 and June 2014 (Trussell Technologies 2014a, attached as **Appendix C**). The pilot facility treated a flow of 30 gpm of undisinfected RTP secondary effluent with the goals of (1) evaluating the performance of the ozone-MF-RO portion of the proposed AWT Facility processes, and (2) developing design criteria for each unit process. Although AOP will be included in the AWT Facility, it was not included in the pilot testing and sampling program. Design of an AOP system typically does not typically require a pilot demonstration and sufficient information on treatment efficacy is available from existing groundwater replenishment projects. During the pilot testing and the source water sampling campaign, Salinas agricultural wash water (Salinas IWTF influent) was diverted to the RTP collection system where it mixed with untreated municipal wastewater from April 1, 2014 through the end of the sampling program. Data from this period are reflective of the blended water quality of these two sources. The results and details of the pilot testing are included in **Appendix C.**

The pilot facility treated the RTP secondary effluent with sodium hypochlorite (to form chloramines), ozone, MF, and RO. Water quality sampling during piloting included general water quality parameters, pathogens and pathogen indicators, disinfection byproducts, pesticides of local interest, priority pollutants, CECs, constituents with MCLs (inorganics, synthetic organic contaminants), NLs, AALs, and constituents on the UCMR lists (1 through 3) to determine the presence and removal of the constituents (also see **Subsection 4.2.4.2**).

Pilot water quality sampling results indicated that the AWT Facility product water is expected to meet all applicable regulations, including the Title 22 Criteria for groundwater replenishment, RWQCB Basin Plan objectives, MCLs, NLs, and AALs. The RO permeate met all requirements except NDMA, where concentrations were higher than the NL (e.g., 20-32 ng/L). However, the UV/AOP system will be designed to reduce NDMA by at least 1.5-log to achieve the target goal of 1 ng/L.

Two pesticides—dieldrin and DDE (a breakdown product of the legacy pesticide DDT)—were detected in low concentrations in the new source waters. Bench tests were conducted in February 2016 evaluating the removal of these two contaminants through the RTP, membrane filtration and ozonation in order to ensure compliance with the California Ocean Plan water quality objectives for these two contaminants when discharging the RO concentrate through the ocean outfall. Results of these bench tests are summarized in **Section 7.5.4** and the complete bench test report is provided in **Appendix K**.

7.1. TOTAL NITROGEN

The Title 22 Criteria include a total nitrogen limit of 10 mg/L in the recycled water or recharge water (before or after injection), where the limit applies to the average of the results of two consecutive samples collected at least three days apart for each week. During the pilot study, the final pilot effluent consistently met the total nitrogen limit, where the total nitrogen ranged from 1.5 mg/L to 2.9 mg/L, significantly lower than the 10 mg/L regulatory limit (Figure 7-1~~.~~). After the addition of the agricultural wash water to the RTP in April 2014, the average pilot influent (RTP secondary effluent) total nitrogen decreased from 43.7 mg N/L to 34.8 mg N/L. This was expected because the wash water has a lower total nitrogen concentration compared to the typical RTP effluent.

7.5.3. Remaining Priority Pollutants

The Title 22 Criteria require that recycled water and groundwater (from down gradient monitoring wells) be monitored for Priority Pollutants (chemicals listed in 40 CFR Part 131.38, "Establishment of numeric criteria for priority toxic pollutants for the State of California") specified by DDW, based on DDW's review of the project's engineering report. Sixty-four Priority Pollutants were sampled and analyzed during the pilot plant sampling program. Of these constituents, a total of 16 Priority Pollutants were found in the RO permeate after the pilot testing, all of which had MCLs or NLs that are addressed elsewhere in this section. It is noted that of the 16 Priority Pollutants detected, only NDMA was found above its NL. As previously noted, the UV/AOP process, which will follow the RO process in the full-scale AWT Facility, will be designed to reduce the NDMA concentration to below the NL of 10 ng/L.

7.5.4. Bench Tests for Pesticide Removal

Two persistent legacy pesticides that have been banned for decades but were detected in low concentrations in samples of Blanco Drain water are dieldrin and DDE (a breakdown product of DDT). The median detected concentration of dieldrin was 17 ng/L, with a range of less than 10 ng/L (below the method detection limit) to 31 ng/L; DDE was detected only once at a concentration of 21 ng/L. Bench tests were conducted in February 2016 evaluating the removal of these two contaminants through the RTP, membrane filtration and ozonation in order to ensure compliance with the California Ocean Plan water quality objectives when discharging the RO concentrate through the ocean outfall.

Bench test results showed significant dieldrin and DDx (congeners of DDT, DDE, DDD were all tested) removal through the RTP, ozonation and membrane filtration. For dieldrin, 84% removal was seen through the RTP, 44% - 63% removal (depending on ozone dose) was seen through ozonation, and 97% - 98% removal was seen through membrane filtration. For DDx, 93% removal was seen through the RTP, 36% - 48% removal was seen through ozonation, and 92% - 94% removal was seen through membrane filtration. Overall, 91% to 99.9% dieldrin removal and 96% to 99.8% DDx removal was observed through the RTP, ozonation and filtration. Additional removal of these contaminants through the RO and UV/AOP processes was not evaluated as part of this bench testing.

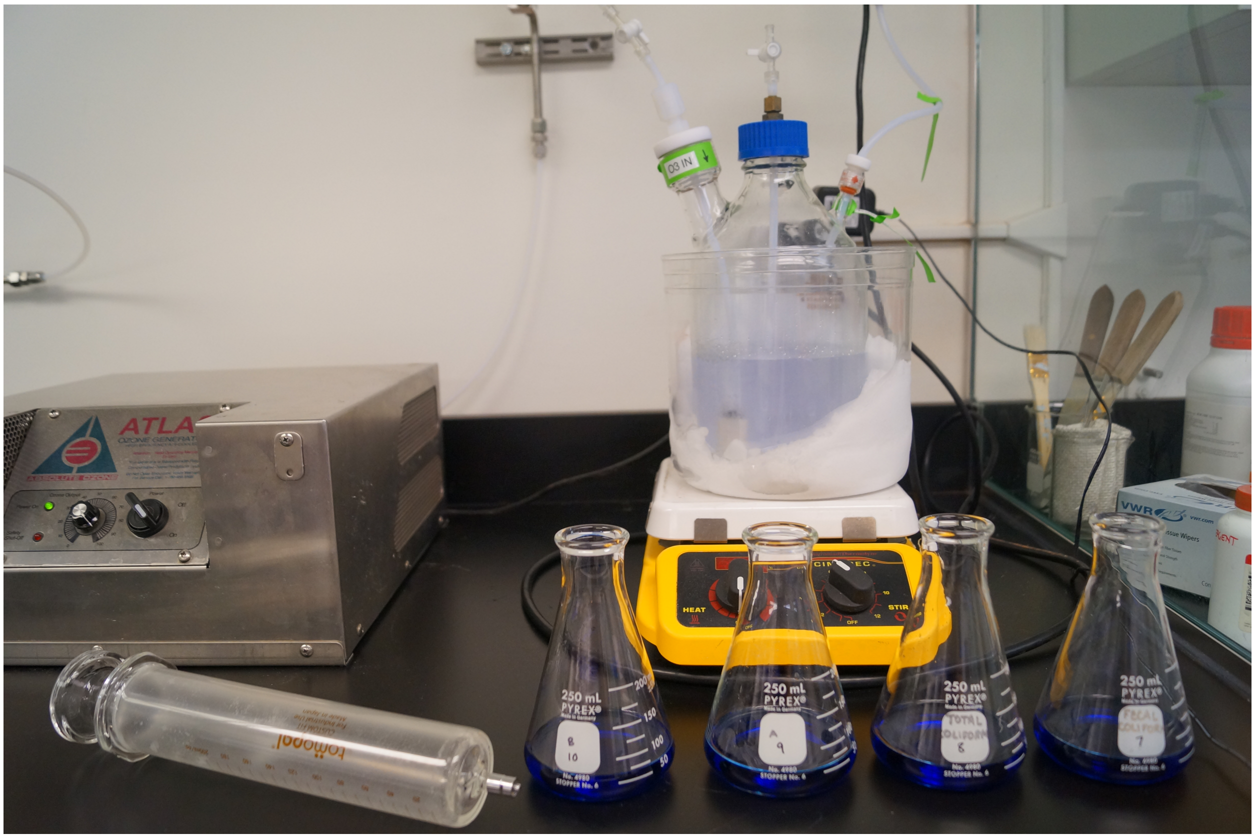
Conclusions of these tests were that removal of these contaminants through the RTP alone was sufficient to meet the California Ocean Plan water quality objectives. Removal through the advanced treatment processes in the AWT Facility offers additional layers or redundancy and robustness to treatment of these contaminants. The complete bench test report is provided in **Appendix K**.

APPENDIX K

Dieldrin and DDx Removal Testing for the Pure Water Monterey Groundwater Replenishment Project

Dieldrin and DDx Removal Testing for the Pure Water Monterey Groundwater Replenishment Project

DRAFT REPORT



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EXECUTIVE SUMMARY

The Monterey Regional Water Pollution Control Agency (MRWPCA) is in the process of developing the Pure Water Monterey (PWM) project to help address potable water needs on the Monterey Peninsula. As part of this project, MRWPCA is designing an Advanced Water Treatment Facility (AWTF), which will include ozonation, membrane filtration (MF), reverse osmosis (RO) and further treatment. The AWTF will receive secondary effluent from the Regional Treatment Plant (RTP), which will receive additional diversions of water sources for the PWM project. One additional water that will be diverted to the RTP is the Blanco Drain, which has elevated levels of dieldrin and DDx.

The California Ocean Plan (COP) has water quality objectives for dieldrin and DDx that are used to develop discharge limits. A by-product of RO treatment is a concentrate stream, which will be discharged through the RTP ocean outfall. The discharge of RO concentrate, along with secondary effluent, has been evaluated for compliance with COP objectives. This assessment concluded that removal of dieldrin and DDx through the RTP, ozone, and MF may be required to meet COP objectives. This report summarizes an effort to evaluate dieldrin and DDx removal through these processes.

Removal of dieldrin and DDx through the RTP, ozone, and MF were evaluated through sampling and bench-scale testing. Samples were collected from the RTP and analyzed with low-detection limit methods to assess removal of ambient dieldrin and DDx through the RTP. Bench-scale testing was conducted on blends of Blanco Drain water and samples from the RTP. Tests included ozonation, membrane filtration, and bench-scale approximations of RTP processes.

Significant dieldrin and DDx removal occurred through the RTP, ozonation, and filtration (see summary of results, with respect to COP compliance of the RTP and the AWTF processes, in Table E-1). Removal through the RTP alone was sufficient to meet COP objectives. Removal through ozonation and MF offer additional layers of redundancy and robustness.

Table E-1: Dieldrin and DDx removals through RTP and AWTF processes related to COP compliance

Constituent	Qualifier	Removal (%)			
		RTP	Ozone	MF	Total
Dieldrin	Required for COP	--	--	--	61% - 78%
	Observed or estimated	84%	44% - 63%	1% - 98%	91% - 99.9%
DDx	Required for COP	--	--	--	58% - 71%
	Observed or estimated	93%	36% - 48%	2% - 94%	96% - 99.8%

1 INTRODUCTION

1.1 Background

Pending reductions in Carmel River water diversions are spurring the development of additional potable water supplies on the Monterey peninsula. The Monterey Peninsula Water Management District (MPWMD) and the Monterey Regional Water Pollution Control Agency (MRWPCA) are developing the Pure Water Monterey (PWM) Groundwater Replenishment (GWR) project to help address the water shortage. The project includes diversion of additional waters to the Regional Treatment Plant (RTP), which produces both a secondary treated wastewater and tertiary treated wastewater. A portion of the secondary effluent will be diverted to an Advanced Water Treatment Facility (AWTF), while the remaining secondary effluent will be treated at the Salinas Valley Reclamation Plant (SVRP) for non-potable recycled water or discharged to the Monterey Bay through the ocean outfall. The AWTF will produce high quality recycled water suitable for groundwater replenishment. The main components of the RTP and AWTF treatment train are the following:

- **Regional Treatment Plant (RTP):** screening, primary clarification, optional Chemically Enhanced Primary Treatment (CEPT), non-nitrifying trickling filters, bio-flocculation (solids contact basins), and secondary clarification; and,
- **Advanced Water Treatment Facility (AWTF)**: chloramination, ozonation, membrane filtration (MF), reverse osmosis (RO), advanced oxidation (AOP) with hydrogen peroxide and ultraviolet (UV) light, and product water stabilization.

Additional raw water sources will be diverted to the RTP collection system including agricultural wash water and industrial wastewater from the Salinas Industrial Wastewater Treatment Facility (SIWTF), and agricultural tile drainage and runoff waters from the Blanco Drain, Reclamation Ditch, and stormwater from the City of Salinas. Source water monitoring was conducted from July 2013 to June 2014 to characterize the proposed new source waters for the GWR project (Trussell Technologies, 2014). Two legacy pesticides that have been banned for decades, dieldrin and 4,4’dichlorodiphenyldichloroethylene (4,4’DDE), were detected during the monitoring of the Blanco Drain. The median concentration of dieldrin detected in the Blanco Drain samples was 17 nanograms per liter (ng/L), with a range of less than 10 (below the method detection limit) to 31 ng/L; 4,4’DDE was detected once, at a concentration of 21 ng/L.

DDE is a breakdown degradate of dichlorodiphenyltrichloroethane (DDT), and exists as one of two congeners: 4,4’DDE or 2,4’DDE. Although only one of the congeners was detected in the source water monitoring, all six congeners of DDT (2,4’DDT, 4,4’DDT, 2,4’DDE, 4,4’DDE, 2,4’dichlorodiphenyldichloroethane (DDD), and 4,4’DDD) have been included in this investigation, and will be collectively referred to as DDx. The RTP effluent and the SIWTF were also sampled, in addition to the Blanco Drain, during the source water monitoring. Dieldrin and DDx were not detected in the RTP effluent and the SIWTF (utilizing methods with method reporting limits as low as 10 ng/L).

Both dieldrin and DDx have established water quality objectives in the 2012 California Ocean Plan (COP), as well as the draft 2015 version (State Water Resources Control Board, 2012 and 2015). Ocean discharges in California must meet the water quality objectives described in the

COP. The AWTF will produce an RO concentrate that will be discharged through an ocean outfall, along with varying quantities of secondary treated wastewater. The concentrations of dieldrin and DDx in this RO concentrate are of concern due to the potential to exceed COP water quality objectives.

Modeling of AWTF RO concentrate and secondary effluent discharge suggests that an overall removal of 61% to 78% and 58% to 71% would be required through the RTP and ozone for dieldrin and DDx, respectively, in order for future discharges to comply with the COP objectives. Compliance assessment efforts (Trussell Technologies, 2015b) have estimated concentrations of dieldrin and DDx in the RO concentrate for purpose of evaluating compliance with COP objectives. These efforts assumed that removal through ozone was 90% for dieldrin and 70% for DDx, based on scientific literature (Ormad, 2008). An additional 20% removal of dieldrin and DDx was assumed to occur through the RTP, based on limited sampling that identified the portions of dieldrin in the Blanco Drain that were dissolved or suspended (*i.e.*, filtered or retained on a 0.45-µm glass fiber filter). These assumptions for RTP and ozone removals equate to overall assumed removals of 92% for dieldrin and 76% for DDx.

The objective of this testing was to verify these previously used assumptions for dieldrin and DDx removal prior to RO by measuring dieldrin and DDx removal through the RTP, ozonation, and simulated membrane filtration.

1.2 Test Protocol

Testing was conducted following the bench test plan (attached as Appendix B). Major components of testing were the following:

- RTP sampling,
- RTP bench testing, and
- AWTF bench testing.

Bench testing was conducted on the following three blends of samples from the RTP and the Blanco Drain in order to simulate treatment with this new source water through the RTP:

- Primary influent mixture: primary influent sample and Blanco Drain sample,
- Solids contactor effluent mixture: solids contactor effluent sample and filtered Blanco Drain sample, and
- Secondary effluent or AWTF feed mixture: secondary effluent sample and filtered Blanco Drain sample.

The filtered Blanco Drain sample was produced by filtering the Blanco Drain sample first through the 100-µm filter, then the 45-µm, and lastly the 10-µm filter, to simulate RTP treatment. The mixtures contained 12% Blanco Drain water, which is the maximum contribution projected for the RTP source water blends. The mixtures were subjected to treatment processes that simulate treatment processes in the RTP and the AWTF (treatment processes shown Table 1-1).

Bench-scale filtration was used to mimic primary, secondary, and membrane filtration treatment. For primary and secondary treatment, a 100-µm hydrophilic nylon net filter (“100-µm filter”) was used as a pre-filter, followed by a 45-µm hydrophobic polypropylene filter (“45-µm filter”) as another pre-filter, and then by a 10-µm hydrophobic polypropylene filter ("10-µm filter"). To mimic membrane filtration, either a 0.7-µm glass fiber filter ("7-µm filter") or the 10-µm filter was used to pre-filter the samples, followed by a 0.45-µm hydrophilic nitrocellulose membrane ("0.45-µm") as another pre-filter, and then by a 0.1-µm hydrophilic polyethersulfone membrane filter ("0.1-µm filter").

Table 1-1: Bench-scale treatment processes used to simulate full-scale treatment processes

RTP or AWTF treatment process	Bench-scale treatment process
Primary clarification (RTP)	Filtration through 100-, 45- and 10-µm filters
Secondary clarification (RTP)	Filtration through 100-, 45- and 10-µm filters
Ozonation (AWTF)	Solution ozone test (SOT)
Membrane filtration (AWTF)	Filtration through 0.7-µm or 10-, 0.45- and 0.1-µm filter

The solution ozone test (SOT) is a bench-scale ozonation test conducted with a stable stock of ozone solution. Deionized water is ozonated to make a stock of ozone solution that is stable at low temperatures over short time scales. The stock solution concentration is measured using the indigo method[1] and the sample is dosed with the ozone stock solution. Indigo solution was prepared the day of testing and the ultraviolet absorbance (UVA) at 600 nanometers (nm) was checked for quality control (*i.e.*, UVA greater than or equal to 0.2 per centimeter). SOTs were conducted at three ozone-to-total-organic-carbon (O_3:TOC) ratios, after accounting for initial nitrite demand of the sample, where the middle ratio represented the AWTF design O_3:TOC ratio.

RTP sampling was conducted for two purposes: (1) to provide samples for the mixtures that were used in bench testing (blends of RTP samples and Blanco Drain sample), and (2) to measure ambient dieldrin and DDx removal across the RTP. The locations of the RTP sampling and the water qualities simulated during bench-scale testing are shown in Table 1-2.

Table 1-2: RTP and AWTF sample and bench-test water qualities

<table>
<tr><th>Facility</th><th colspan="4">RTP</th><th colspan="3">AWTF</th></tr>
<tr><th>Sample location</th><th>Primary influent</th><th>Primary effluent</th><th>Solids contact effluent</th><th colspan="2">Secondary clarifier effluent</th><th>Ozone effluent</th><th>Membrane filtration filtrate</th></tr>
<tr><td>RTP sampling</td><td>Sample</td><td>--</td><td>Sample</td><td colspan="2">Sample</td><td>--</td><td>--</td></tr>
<tr><td>Bench-scale testing</td><td>Blend</td><td>Filtered</td><td>Blend</td><td>Filtered</td><td>Blend</td><td>SOT</td><td>Filtered</td></tr>
</table>

Samples from the Blanco Drain and RTP were collected by Monterey Bay Analytical Services (MBAS) and MRWPCA on February 9, 2016, and shipped to Eurofins Eaton Analytical and Vista Analytical Laboratories for analysis and to the Trussell Technologies Pasadena Laboratory for bench-scale testing. The SOT bench-scale testing was conducted the following day (February

[1] Standard Methods 4500-O_3 B Indigo Colorimetric Method

10), and RTP bench-scale testing was completed February 11. Both laboratories received all samples within the method hold time based on the initial sample collection of February 9.

Dieldrin and DDx were analyzed by two laboratories: Vista Analytical Laboratories (VAL) and Eurofins Eaton Analytical (EEA). Low detection limit methods were used at VAL to ensure detection of dieldrin and DDx through treatment; EEA was used for continuity with previous source water sampling for dieldrin. Environmental Protection Agency (EPA) method 1699 was used at VAL, with dieldrin and DDx congener minimum quantification limits (also known as method reporting limits) of 30 picograms per liter (pg/L) when no interferences are present and method detection limits (MDLs) ranging from 1 to 5 pg/L. EPA method 505 was used at EEA with a dieldrin method reporting limit (MRL) of 10,000 pg/L and an MDL of 5,000 pg/L. Unless otherwise specified, sample results are total concentrations of dieldrin and DDx (suspended plus dissolved). VAL filtered one sample through a 0.7-µm filter to measure the fraction retained and filtered; EEA filtered one sample through a 0.45-µm filter to measure the suspended and dissolved fraction.

2 SAMPLING RESULTS

2.1 Comparison to Previous Measurements

Dieldrin and DDx concentrations measured in the Blanco Drain sample and the secondary effluent sample are compared to historical measurements below.

The comparison between the dieldrin and DDx concentrations in the Blanco Drain sample and previous Blanco Drain source water sampling is presented in Table 2-1, which shows that concentrations in the water used for bench testing were similar to previous levels.

Dieldrin concentrations were toward the high end of those observed during previous source water sampling (compared to nine low detection limit samples previously). 2,4-DDE and 2,4-DDD were at higher concentrations than previously observed (compared to one sample for each previously), resulting in a higher DDx concentration in this sample than seen previously. Results from 4,4-DDx and 2,4-DDT were consistent with previous sampling results. The somewhat elevated concentrations of dieldrin and DDx may have been due to rain in the preceding weeks, which may have washed dieldrin- and DDx-bound sediment into the Blanco Drain.

Table 2-1: Blanco drain sample results compared to historical source water sampling

Constituent	2/9/2016 sample (pg/L)[1]	7/14 to 6/15 source water sampling (pg/L)[2]
Dieldrin	28,800 & 27,000	< 10,000 – 31,000
4,4-DDD	20,900	< 10,000
4,4-DDE	87,600	21,000
4,4-DDT	9,700	< 10,000
2,4-DDD	5,260	< 5,000
2,4-DDE	1,130	< 5,000
2,4-DDT	3,320	< 10,000
DDx	127,910	< 61,000

[1] All results from EPA method 1699 except for dieldrin result of 27,000, which was from EPA method 505
[2] Lowest MRL of EPA methods 505, 8081, 608, and 525.2 reported from source water sampling; sampling events were typically twice quarterly for dieldrin and typically quarterly for 4,4-DDx; lowest detection limit methods, including 2,4-DDx, were conducted for one sampling event for DDx

A comparison between the concentration of dieldrin retained on a 0.45-µm glass fiber filter (suspended fraction) and the concentration that passed through the filter (dissolved fraction) in the Blanco Drain sample and an earlier source water sampling event is shown in Table 2-2. Dieldrin is highly hydrophobic; accordingly, it was suspected that a large fraction would be retained with the solids and organics on the filter. The relatively low suspended fraction in the 2014 sample compared with the higher suspended fraction in the 2016 sample suggests that dieldrin may absorb to relatively small organic molecules that pass through 0.45-µm filters with moderately high efficiency. The size of these molecules may vary in the Blanco Drain with time, which may partially explain the difference in split results (*i.e.*, dissolved and suspended fractions) between the two dates. Additionally, the concentration of suspended solids varies in the Blanco Drain, particularly due to rain events, which may affect the split between dissolved and suspended.

Table 2-2: Blanco Drain split sample of dieldrin compared to historical source water sampling

Date	February 9, 2016[1]	July 24, 2014[1]
Dissolved fraction (%)	44%	81%
Suspended fraction (%)	56%	19%

[1] EPA method 505

A comparison between dieldrin and DDx concentrations measured in the secondary effluent sample and historical levels is shown in Table 2-3. The dieldrin and DDx concentrations were within the range of previously observed levels.

Table 2-3: Dieldrin and DDx concentrations in the RTP secondary effluent compared to historical final effluent concentrations

Constituents	2/9/2016 sample[1] (pg/L)	2008 to 2015 CCLEAN[2] (pg/L)
Dieldrin	366	163 - 629
DDD (2,2 & 4,4)	202	109 - 951
DDE (2,2 & 4,4)	802	214 - 343
DDT (2,2 & 4,4)	240	Below detection - 120
DDx	1244	387 - 1362

[1] EPA method 1699
[2] Data collected by the Central Coast Long-Term Environmental Assessment Network (CCLEAN) on the final effluent, which may include hauled brine

Note that the World Health Organization (WHO) drinking water guidance level for DDT is 1,000,000 pg/L, several orders of magnitudes higher than the concentrations observed in the RTP secondary effluent and the Blanco Drain samples.

2.2 Regional Treatment Plant

2.2.1 Removal Through Regional Treatment Plant

Dieldrin and DDx were measured in all samples collected from the RTP, allowing for determination of ambient dieldrin and DDx removal through the RTP (results are shown in Figure 2-1). Removals of 84% and 93% were observed through the RTP for ambient dieldrin and DDx, respectively, which are greater than the required removals for COP compliance. The increase in dieldrin and DDx in the solids contactor effluent is discussed in the next section.

The RTP secondary effluent was filtered by Vista Analytical Laboratories to further investigate the amount of dieldrin and DDx found in the particulate and dissolved phases (0.7-µm filter). Removals of 29% and 80% were observed for dieldrin and DDx, respectively through the filtering process. Removal through the AWTF membrane filter (MF) is expected to be greater than through the 0.7-µm filter, as the design nominal MF pore size is smaller (0.1-µm to 0.01-µm).

The RTP was operating under typical conditions when samples were collected for dieldrin and DDx (see Table A.6-1 in Appendix A for RTP water quality data and operational setpoints from the date water samples were collected).

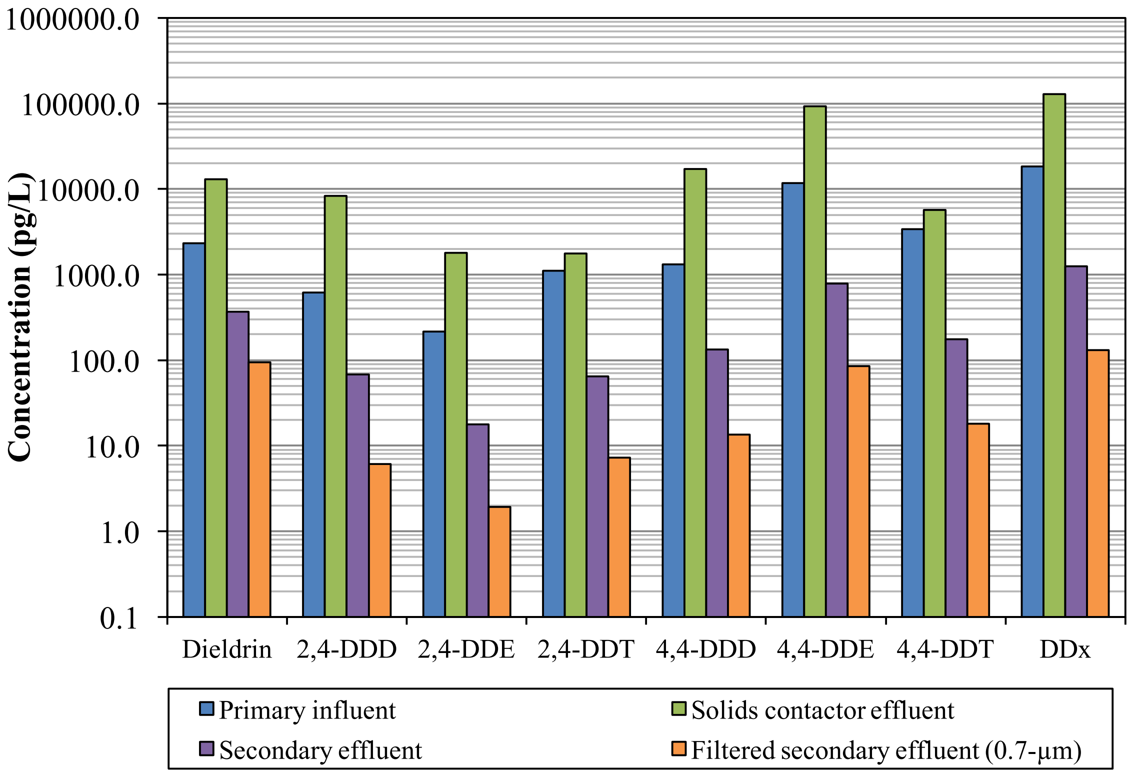

Figure 2-1: RTP dieldrin and DDx congener sampling results

2.2.2 Removal and Volatile Suspended Solids

Dieldrin and DDx concentrations were correlated with volatile suspended solids (VSS) concentration through the RTP (see Figure 2-2; relationship to DDx congeners is shown in Figure A-1 in Appendix A), which suggests that VSS may provide a surrogate for dieldrin and DDx removal through the RTP and operational changes that impact VSS removal may also impact dieldrin and DDx removal.

DDx and dieldrin have a strong affinity to absorb to organics due to their nonpolar structure, minimal hydrogen bonding, and relatively high molecular weight[2]. VSS is comprised of organic matter, such as biological matter in the trickling filter and solids contact process, and the correlation between VSS and dieldrin and DDx appears to be due to the strongly hydrophobic nature of dieldrin and DDx.

[2] Log octanol-water partition coefficients typically measured in the range of 5.9 to 6.9; *i.e.*, the concentration of dieldrin and DDx in an octanol phase of a two phase octanol-water system tends to be 790,000 to 7,900,000 times higher than in the water phase, where octanol is an organic solvent

Dieldrin and DDx concentrations are higher in the solids contact process (Figure 2-1) where a reserve of biological mass is grown and stored to meet carbon removal and solids retention time (SRT) targets. Subsequent clarification and wasting of waste activated sludge (WAS) removes biological mass, including any dieldrin and DDx that may be absorbed to the organic mass. Given this apparent relationship, dieldrin and DDx removal is dependent on secondary clarification removal efficiency.

The primary influent VSS has a similar affinity to dieldrin and DDx as the solids contactor effluent and secondary clarifier effluent VSS. The primary influent contains recycle streams, including the clarified backwash wastewater from SVRP. The solids in the secondary contactor effluent and the secondary clarifier effluent are similar in composition, as both are primarily bacteria from the solids contact and trickling filter processes. The clarified backwash wastewater from SVRP may also be similar in composition, as it contains bacteria removed from the secondary effluent. Presumably, organic runoff with absorbed dieldrin and DDx enter the collection system. These organics may then be oxidized or desorbed by bacteria in the trickling filter-solids contact process or become part of the mixed liquor volatile suspended solids (MLVSS). Influent dieldrin and DDx loading is greater than dieldrin and DDx associated removal through solids wasting (SRT of 33 hours and solid contactor average hydraulic residence time (HRT) of 3.8 hours), which allows for the elevated, equilibrium levels of dieldrin and DDx in the solids contactors.

Although the relationship between dieldrin and DDx may vary with the constitution of organic matter in the RTP influent, trickling filters, and solids contactors, it offers a potential predictive tool as a process surrogate for dieldrin and DDx removal, which suggest that required dieldrin and DDx removals can still be achieved even if VSS concentrations increase with the PWM project. The PWM project is expected to increase the RTP influent flow to a maximum monthly average of 27.8 million gallons per day (MGD). This flowrate is significantly higher than wastewater flows have been in recent years (*e.g.*, the flow as 17.7 MGD on the day of sampling). The increased flowrate may impact the ability of the RTP to remove VSS, dieldrin and DDx, as primary and secondary clarifier loading rates will be increased, among other operational impacts; however, the potential increase in dieldrin and DDx concentrations is expected to be within the range where removal through the RTP, ozone, and MF can maintain compliance with the COP water quality objectives.

The secondary effluent total suspended solids (TSS) concentration was one-third of the National Pollutant Discharge Elimination System (NPDES) permit monthly average limit during sampling (10 milligrams per liter during sampling compared to a limit of 30 milligrams per liter). Assuming a “worst-case” three-fold increase in TSS, and corresponding increase in VSS, dieldrin, and DDx, the observed DDx removal in the RTP would be sufficient to meet COP objectives, and dieldrin COP objectives would be met if ozone and MF achieved a removal of 23%, or greater (bench-scale ozone and MF removals exceeded 23% by approximately a factor of two; see Bench-scale testing results section).

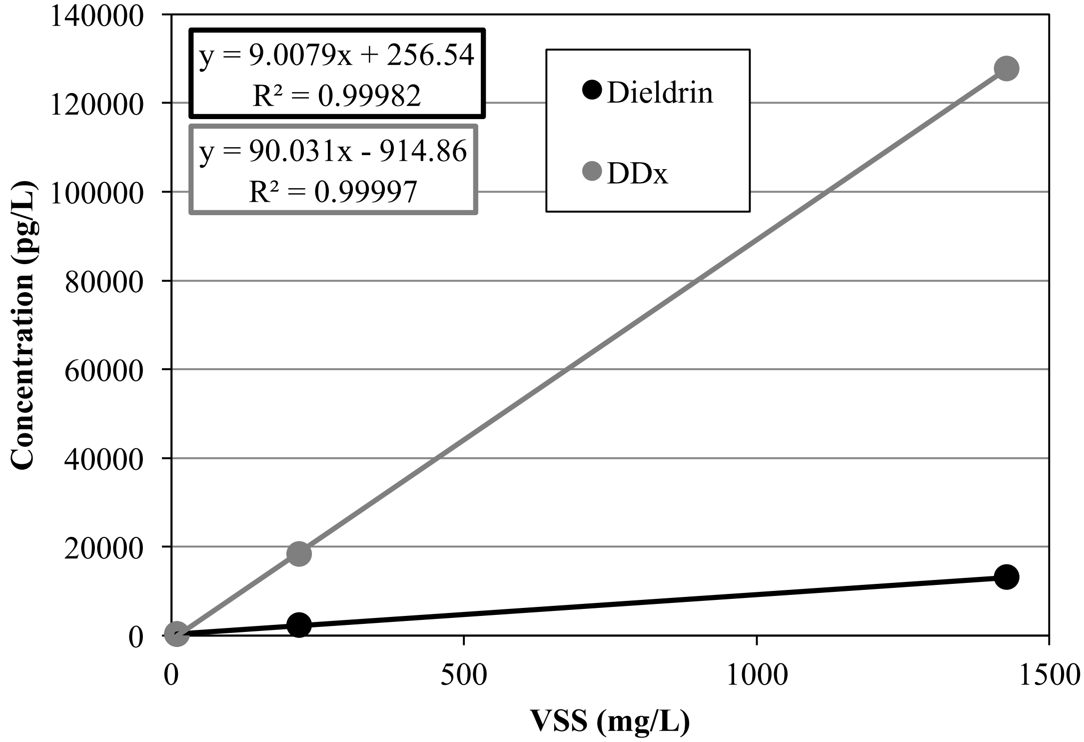

Figure 2-2: Relationship between VSS and total dieldrin and DDx in the RTP (samples points from left to right: secondary effluent, RTP influent, solids contactor effluent)

3 BENCH-SCALE TESTING RESULTS

3.1 Regional Treatment Plant

The removal of dieldrin and DDx through bench-scale testing of RTP processes is shown in Figure 3-1. The bench-scale removals (which included Blanco Drain water) match those observed through the RTP (which did not include Blanco Drain water), suggesting that dieldrin and DDx in the Blanco Drain may be removed similarly to ambient dieldrin and DDx in the RTP influent. The bench-scale removals were 84% and 93% for dieldrin and DDx, respectively, which is greater than the required removals for COP compliance.

The concentrations of the solids contactor effluent mixture Blanco Drain portion were numerically adjusted to account for the dieldrin and DDx accumulation that was observed during RTP sampling. Removals observed through filtration of the solids contactor effluent mixture were applied to the adjusted solids contactor effluent mixture to develop the estimate of the secondary effluent concentrations (unadjusted removals are shown in Appendix A).

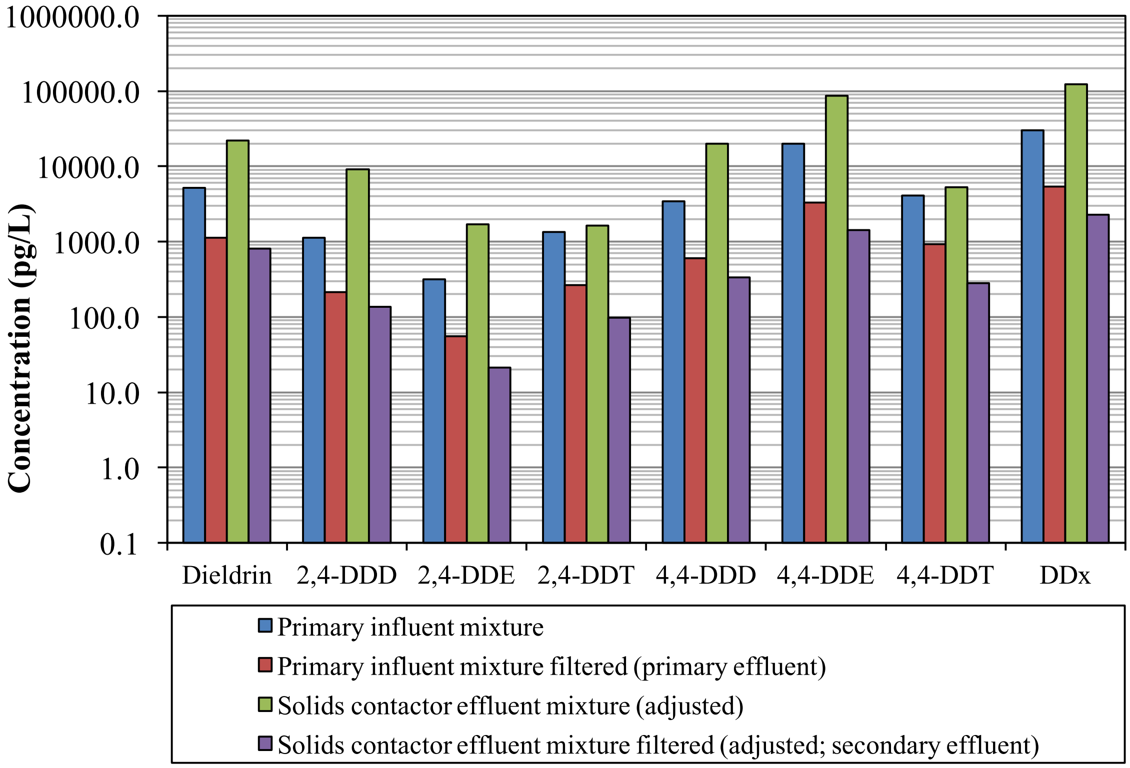

Figure 3-1: Removal of dieldrin and DDx congeners through RTP bench-scale testing (mixtures are blends of RTP and Blanco Drain samples; Blanco Drain contribution adjusted for accumulation of dieldrin and DDx observed at the RTP)

3.2 Solution Ozone Test

Removal of 44% to 63% and 36% to 48% were observed through bench-scale ozonation for dieldrin and DDx, respectively, with higher levels of removal observed with higher ozone doses (see Figure 3-2). While the ozonation removal alone was not sufficient to maintain COP compliance, it does add an additional layer of redundancy and robustness to dieldrin and DDx removal through the RTP and the AWTF. Removal of dieldrin and DDx through ozonation occurs via a chemical oxidation process, which does not occur in the RTP.

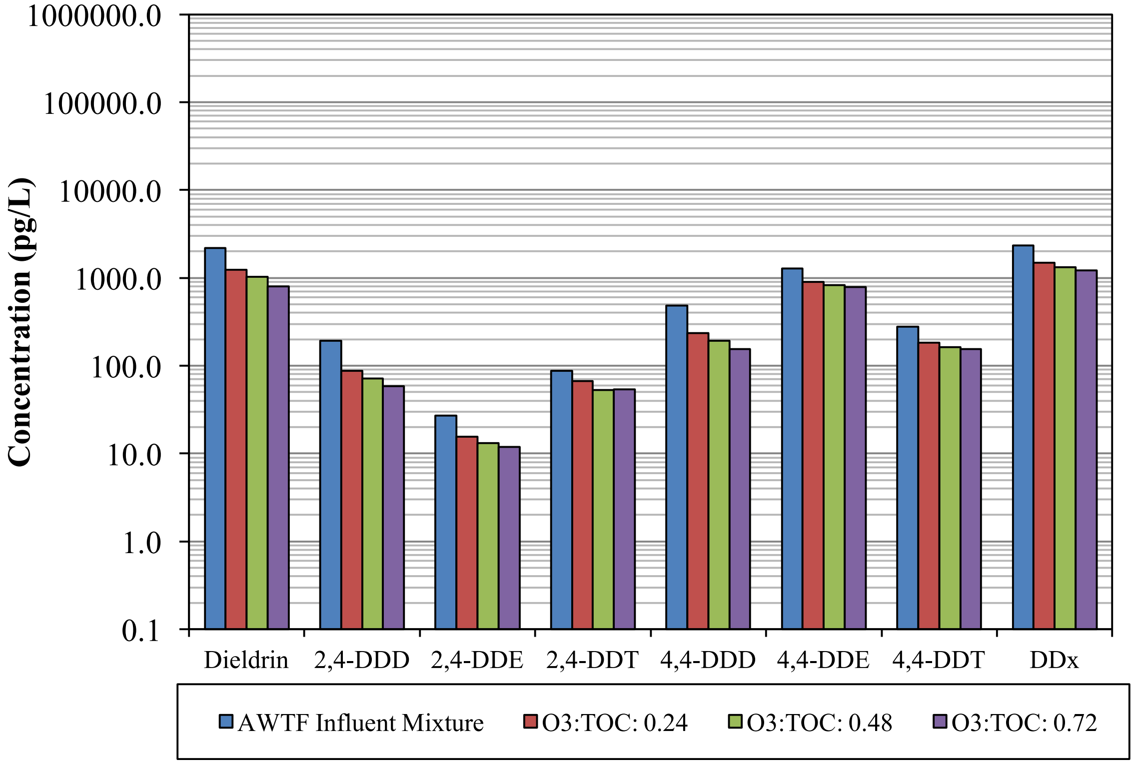

Figure 3-2: Dieldrin and DDx congener removal through ozonation of Blanco Drain-RTP effluent mixture

The water quality of the secondary effluent and Blanco Drain mixture prior to and after bench-scale ozonation are shown in Table 3-1. Three O_3:TOC ratios were tested, where the middle test condition (O_3:TOC wt./wt. ratio of 0.48) represents the AWTF design O_3:TOC ratio. The nitrite concentration was within the range typically observed in the secondary effluent, albeit on the low side. Nitrification may have occurred in the sample bottle prior to measurement (*e.g.*, 1.28 mg/L of DO could have facilitated the conversion of 1.12 mg/L as N of nitrite to nitrate, if the necessary bacterial population were present); however, the method utilized for comparing O_3:TOC ratios accounts for nitrite, likewise accounting for any changes in nitrite concentrations that may have occurred. Turbidity, TOC, and temperature were within typical ranges.

Table 3-1: General water quality of the solution ozone test samples

Parameter	Units	Values		
O_3 dose[1]	mg/L	4.2	7.9	11.6
O_3:TOC ratio[2]	gO_3/gC	0.24	0.48	0.72
Before ozonation				
Nitrite	mg/L as N	0.161		
TOC[4]	mg/L	15.4		
pH	--	8.06	8.06	8.06[2]
Temperature	°C	26.7	26.7	22.7
Turbidity	NTU	3.72		
After ozonation				
TOC[4, 1]	mg/L	14.6	15.2	15.4
pH	--	7.89	7.83	7.96
Temperature	ºC	25.0	25.0	21.4
UVT_{254nm}[1]	%	56%	61%	63%

[1] Accounts for dilution from O_3 stock (results were corrected for dilution to show value without effects of dilution)
[2] Accounts for immediate nitrite demand
[3] At 26.7°C
[4] General Electric (GE) Sievers 5310C

The apparent changes in TOC values due to ozonation are likely due to limited accuracy of the method, as the greatest degree of mineralization, if any, would be expected at the largest ozone dose, which did not exhibit a change in TOC. The decrease in pH is presumably due to both the dilution of the samples with the ozone stock solution and oxidation of organics. The ultraviolet light transmittance (UVT) increased with increasing ozone dose, a phenomenon that was observed at the pilot and elsewhere.

The impact of O_3:TOC ratios on dieldrin and DDx removal is shown in Figure **3-3** (removal for DDx congeners is shown in Figure A-3). The relationship between removal and O_3:TOC ratio was linear under the ranges tested; however, it appears that there may be an initial rapid removal of dieldrin and DDx at lower ozone doses, prior to the linear range, as lines fit to the data do not intersect the origin.

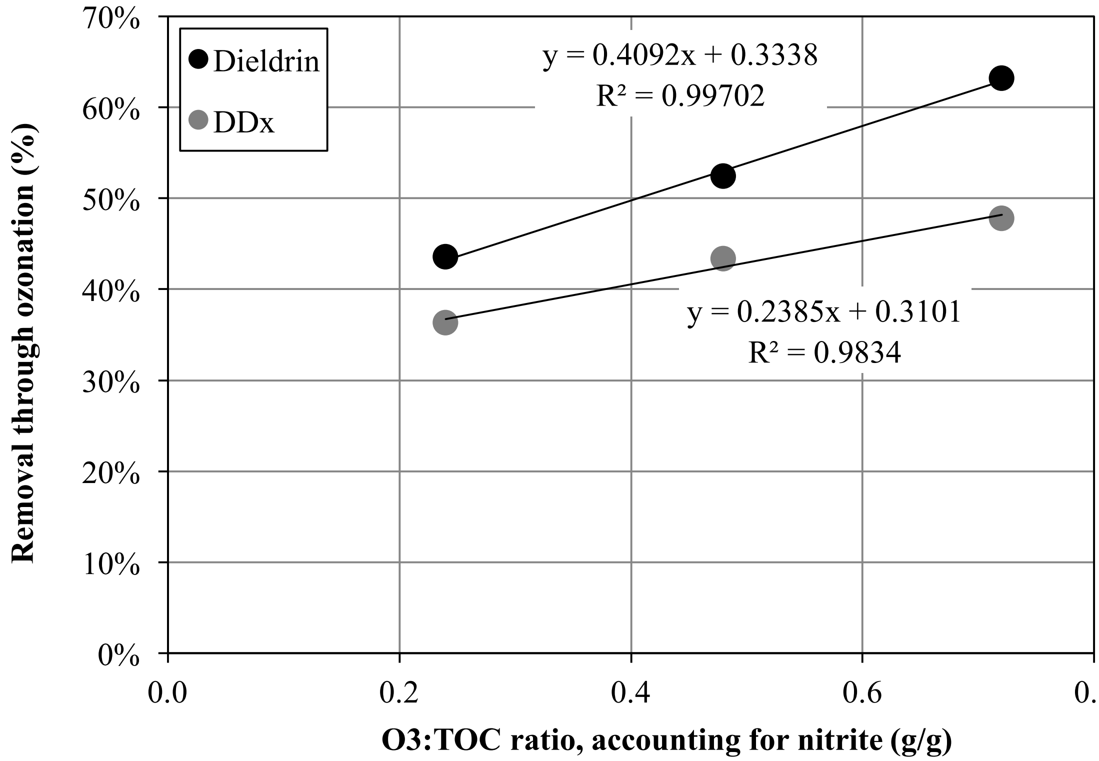

Figure 3-3: Impact of O_3:TOC ratio on dieldrin and DDx removal in Blanco Drain-RTP effluent mixture

3.3 Membrane Filtration

The results from membrane filtration of select ozonated mixtures are shown in Figure 3-4. Removals of 97% to 98% and 92% to 94% were observed for dieldrin and DDx, respectively. These removals may be more representative of full-scale MF removal than the removal observed through the 0.7-µm filter on the non-ozonated secondary effluent described earlier. When no secondary effluent is discharge to the ocean, the MF system, following ozonation, can significantly reduce discharges of dieldrin and DDx to the ocean by removing dieldrin and DDx in the AWTF feed water with high efficiencies.

Dieldrin and DDx adsorbed to organics and particulates that are captured on the MF membrane will be returned to the RTP headworks during regular backwashes and clean-in-places (CIP) events. This recycling of waste backwash water slightly increases the concentrations of dieldrin and DDx in the RTP influent and may marginally increase concentrations in RTP effluent; however, the overall removal of dieldrin and DDx is expected to increase, as recycling increases the amount of dieldrin and DDx removed through the RTP and the ozone system. The increase in dieldrin and DDx concentrations, and the increase in the amount of dieldrin and DDx removed through the RTP and ozone, is a function of flowrates through the RTP and the AWTF and removals through the RTP, ozone and MF. The average increase is expected to be approximately

4% and 2%, or less, for dieldrin and DDx, respectively, based on removals observed during this study and design conditions.[3]

When no secondary effluent is recycled through the SVRP (*i.e.*, when more secondary effluent is being discharged through the ocean outfall), removal through the MF system contributes to a reduction in dieldrin and DDx discharged to the ocean by the increase in dieldrin and DDx removed through the RTP and ozone. Assuming no increase in removal efficiency of the recycled dieldrin and DDx, the decrease in dieldrin and DDx discharged would range from approximately 1% and 2% to 28% and 31% for dieldrin and DDx, respectively, depending on the proportion of secondary effluent and AWTF RO concentrate in the discharge stream to the ocean outfall.[4]

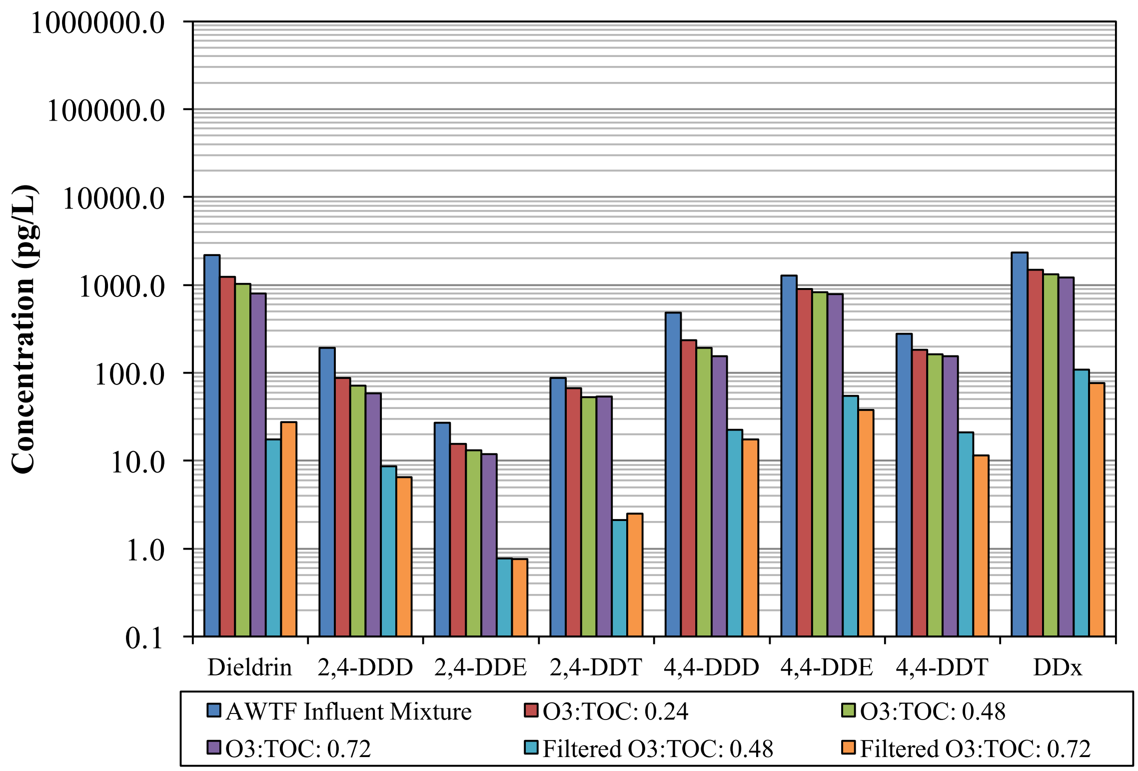

Figure 3-4: Dieldrin and DDx congener removal through membrane filtration of Blanco Drain-RTP effluent mixture

The removal of dieldrin through various size filters for different water qualities is shown in Figure 3-5. From these data, it appears that (1) there may have been negligible interference from dieldrin and DDx adsorption onto the filter material, (2) finer filters result in more dieldrin and DDx removal for low VSS concentrations, and (3) filters removal may be increased if VSS

[3] Low projected average monthly RTP flow of 15 MGD, high AWTF feed flows of 6.85 MGD, high observed removals through 0.1-µm filters, low ozone removal through 0.24 O_3:TOC ratio.

[4] Based on the observed removals through RTP and RTP bench-scale testing, the range of removals observed through bench-scale ozonation and membrane filtration (including through the 0.7-µm filter), and flowrates of 15 to 28 MGD through the RTP and 1.6 to 6.9 MGD through the AWTF.

concentrations were to increase during an upset. The data exhibit a log-linear relationship between filter size and removal for water relatively low in solids and/or for filter sizes of 0.7-µm or less (left size of graph). This relationship appears to be independent of filter material, suggesting negligible adsorption of dieldrin and DDx onto the filters (*i.e.*, that the hydrophobic polypropylene 0.1-µm filters behaved similarly to the hydrophilic glass fiber filters). The AWTF MF membranes will be thermally induced phase separation (TIPS) polyvinylidene fluoride (PVDF), which are moderately hydrophobic. These membranes are expected to behave similarly.

The data in Figure 3-5 also suggest that removal is dependent on another variable besides filter size for samples with relatively high concentrations of solids when filtering through the 10-µm filter (right size of graph). Figure 3-6 shows that better removal was observed for samples with more solids. The increased removal is presumably due to cake filtration, where large material is removed on the filter (e.g., VSS) which in turn can either effectively reduces the pore size, thereby increasing dieldrin and DDx removal, or increase adsorption sites for removal of dieldrin and DDx. Removal through cake filtration can evidently be significant and equivalent to removal through filters with nominal pore sizes 100 times smaller (e.g., compare "solids contactor effluent & 10-µm filtered Blanco Drain" mixture to the mixtures filtered through 0.1-µm filters).

In the event of a process upset at the RTP, where higher concentrations of VSS, and possibly associated higher levels of dieldrin and DDx, enter the AWTF, these data suggest that MF removal may be well fortified through cake filtration, thereby maintaining low dieldrin and DDx concentrations in the MF filtrate (*i.e.*, RO feed).

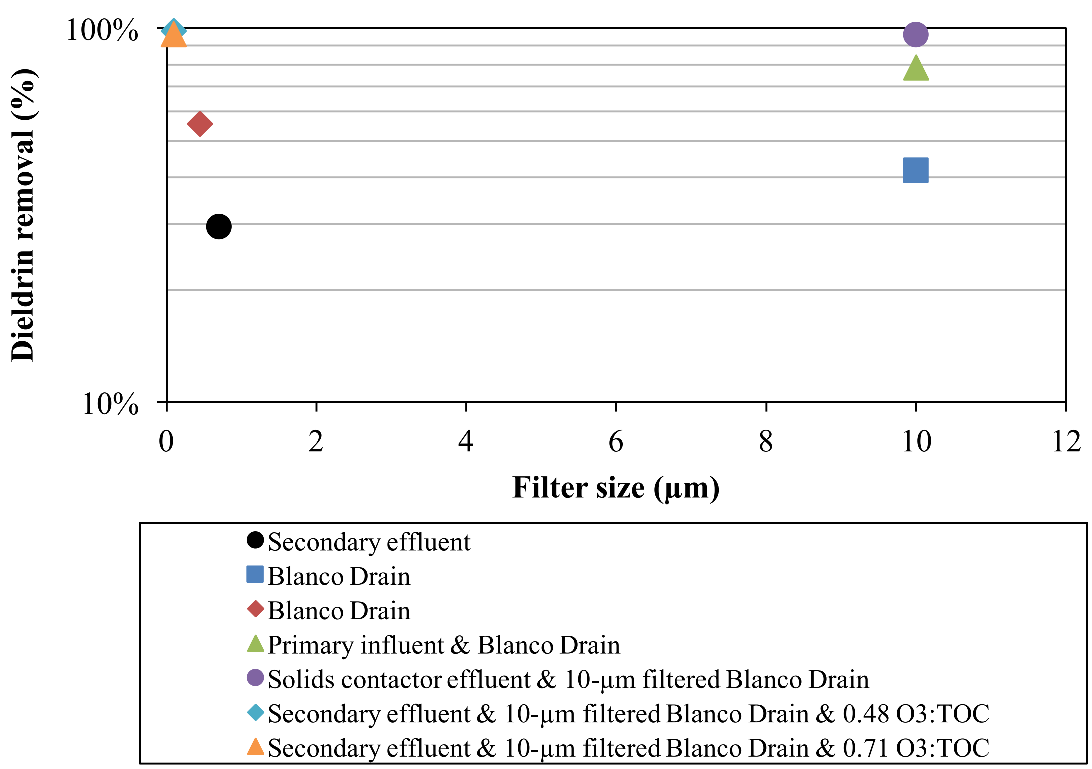

Figure 3-5: Dieldrin removal through filtration as function of filter size and water quality

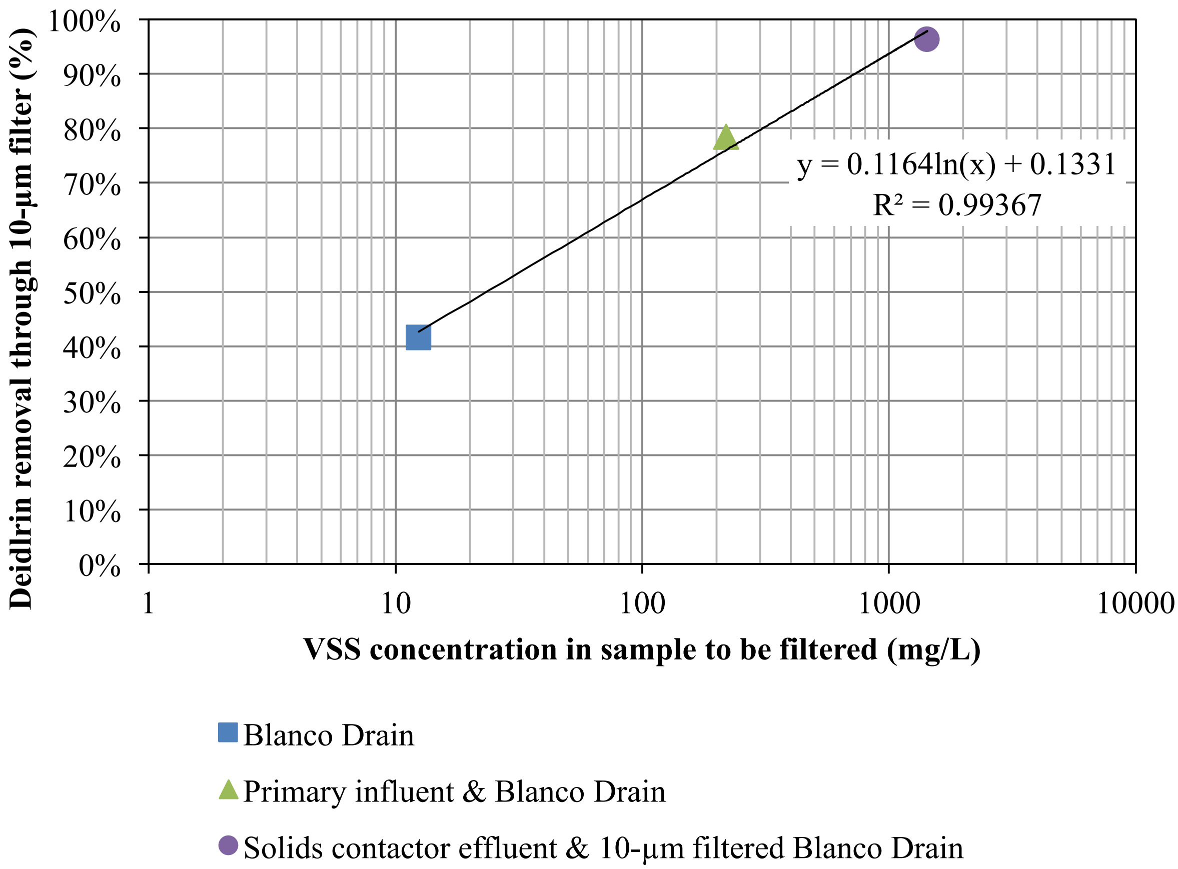

Figure 3-6: 10-µm filter removal of dieldrin and VSS concentration

4 SUMMARY AND CONCLUSIONS

A summary of removals observed through full-scale sampling of the RTP and bench-scale testing is shown in Table 4-1. A summary of removals previously assumed for COP compliance, required for COP compliance, and observed through the RTP sampling and bench-scale testing with respect to COP compliance and RTP and AWTF processes is shown in Table 4-2.

Table 4-1: Summary of dieldrin and DDx removals observed through full-scale sampling and bench-sale testing

Process	Test	Removal (%)	
		Dieldrin	DDx
RTP	Full-scale sampling	84%	93%
RTP[1]	Bench-scale (RTP-Blanco blend)	84%	93%
Ozone[2]	Bench-scale (RTP-Blanco blend)	44% - 63%	36% - 48%
Membrane filtration	Bench-scale (RTP-Blanco blend)	97% - 98%	92% - 94%

[1] Blanco Drain contribution adjusted for accumulation of dieldrin and DDx observed at the RTP
[2] O_3:TOC ratios of 0.24 to 0.71 gO_3:gC, accounting for nitrite demand

Table 4-2: Summary of dieldrin and DDx removals through RTP and AWTF processes related to COP compliance

Constituent	Qualifier[1]	Removal (%)			
		RTP[2]	Ozone[3]	MF[4]	Total
Dieldrin	DEIR assumption	20%	90%	--	92%
	Required for COP	--	--	--	61% RTP or 78% O_3
	Observed	84%	44% - 63%	1% - 98%	91% - 99.9%
DDx	DEIR assumption	20%	70%	--	76%
	Required for COP	--	--	--	58% RTP or 71% O_3
	Observed	93%	36% - 48%	2% - 94%	96% - 99.8%

[1] "Draft Environmental Impact Report (DIER) assumption" refers to previous COP analysis (Trussell Technologies, 2015b); "Required for COP" refers to the values needed to meet COP objectives, where the requirements depend on where the removal is achieved; and "Observed" refers to removals observed through RTP sampling and bench-scale testing for RTP and AWTF processes relating to COP compliance
[2] Ambient dieldrin and DDx removal observed through RTP and adjusted RTP bench-scale removals
[3] O_3:TOC ratios of 0.24 to 0.71 gO_3:gC, accounting for nitrite demand
[4] Considering the recycling of backwash solids to the head of the RTP: additional removal through RTP and ozone processes when 26.2 MGD of secondary effluent (max flow) is discharged through the ocean outfall with 1.6 MGD going to the AWTF, 0.7-µm glass fiber filtration of ambient dieldrin and DDx in secondary effluent assumed for MF removal and the high-end ozone removal assumed to 0.1-µm filtration of ozonated Blanco Drain-RTP secondary effluent mixture, accounting for potential increases in dieldrin and DDx concentrations, where the latter represents the case where no secondary effluent is discharged through the ocean outfall (see discussion in 3.3).

The following conclusions can be drawn from the sampling and bench-scale testing:

- Significant dieldrin and DDx removal occurred through the RTP, ozonation, and filtration;
- Removal through the RTP alone was sufficient to meet COP objectives (based on previous COP compliance analysis); and

- Removal through ozonation and MF offer additional layers of redundancy and robustness.

5 REFERENCES

Ormad et al. (2008). *Pesticides removal in the process of drinking water production*. Chemosphere, 71, 97-106.

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Trussell Technologies, 2015b. *Ocean Plan Compliance Assessment for the Pure Water Monterey Groundwater Replenishment Project*. Technical Memorandum. February 2015.

Trussell Technologies, 2016. *Bench-Top Dieldrin and DDT Removal Testing for the MRWPCA Groundwater Replenishment Project*. Technical Memorandum. January 2016.

APPENDIX A – ADDITIONAL FIGURES AND TABLES

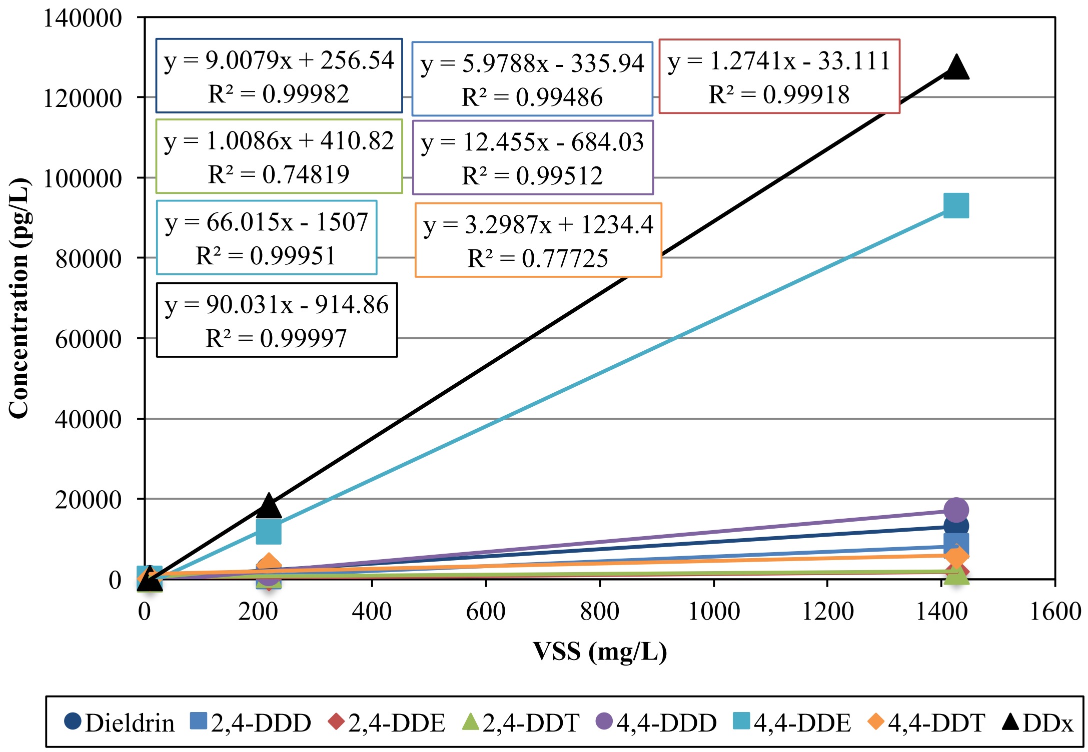


Figure A-1: Relationship between VSS and dieldrin and DDx congeners

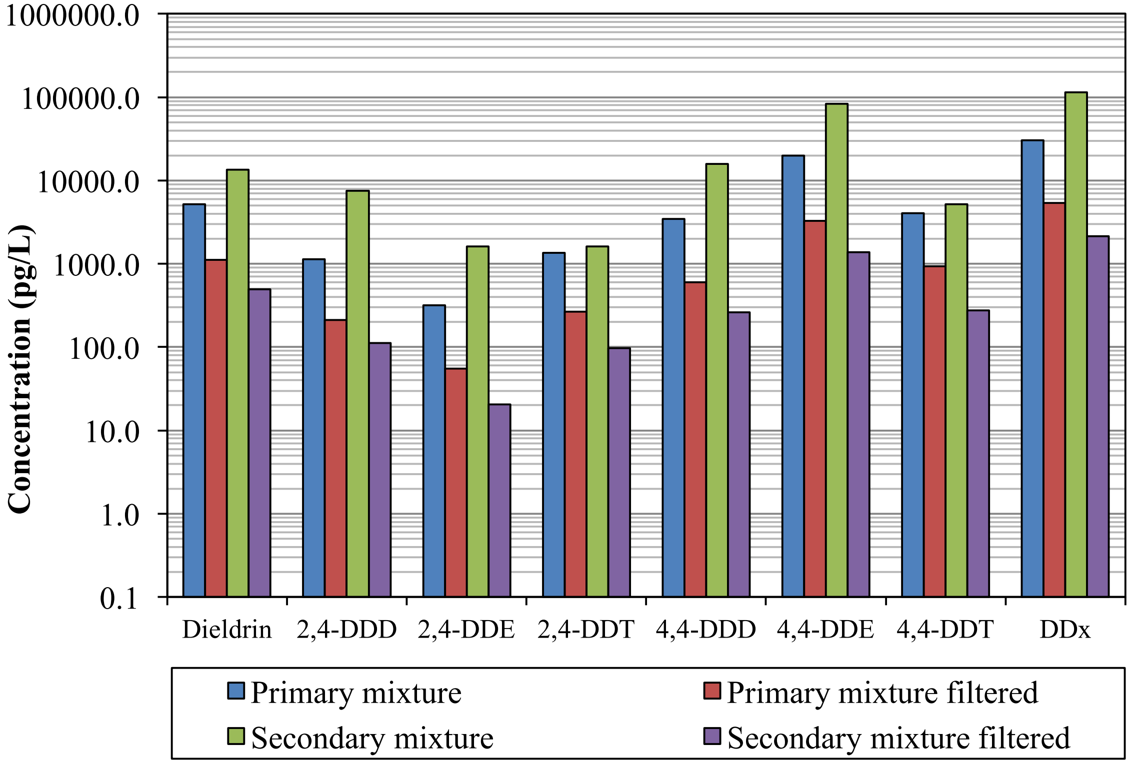


Figure A-2: RTP bench testing dieldrin and DDX congener removal without adjusting for accumulation of the Blanco Drain dieldrin and DDx in the secondary process (mixtures are blends of RTP and Blanco Drain samples**)**

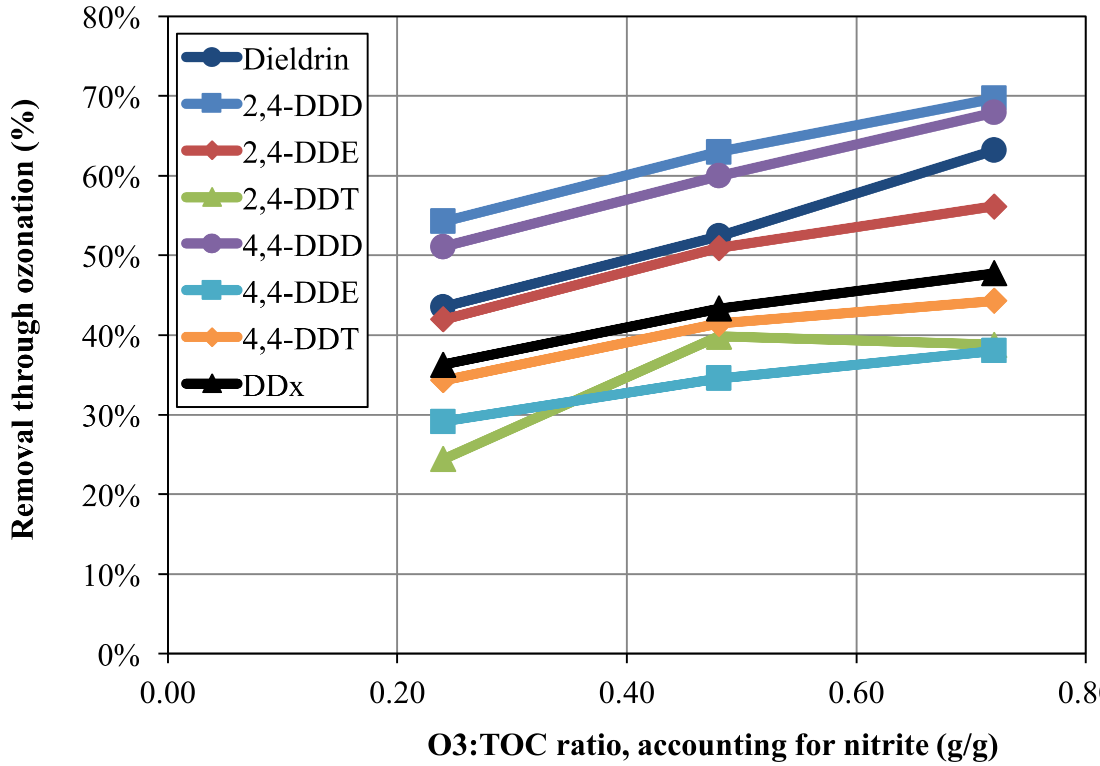


Figure A-3: Relationship between O_3:TOC ratio and dieldrin and DDx congener removal

Table A-1: General quality parameters and operational conditions at RTP during sampling

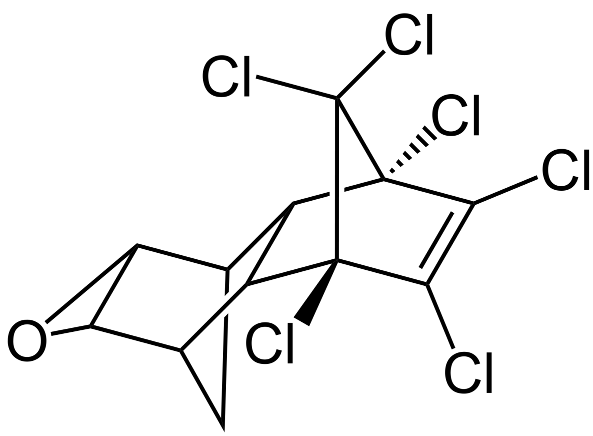
Collect Date	Parameter	Site							Units	Sample Type	Reporting Limit	Method
		Blanco Drain	Salinas Pump Station	Monterey Pump Station	RTP Headworks	Primary Influent	Solids Contact Eff (MLSS)	Sec Eff				
09-Feb-16	CBOD	4.5	--	--	--	310	810	9	mg/L	Grab	1	SM 5210 B
09-Feb-16	COD	38.6	--	--	--	740	2303	61.6	mg/L	Grab	--	Hach 8000
09-Feb-16	pH	7.7	--	--	--	6.99	7.26	7.44	--	Grab	--	SM 4500-H+ B
09-Feb-16	TBOD	1.2	--	--	--	314	1274	31.3	mg/L	Grab	--	SM 5210 B
09-Feb-16	TDS	2380	--	--	--	876	810	883	mg/L	Grab	20	SM 2540 C
09-Feb-16	Temperature	11.7	--	--	--	18.9	17.5	19.2	°C	Grab	--	SM 2550 B
09-Feb-16	TSS	89	--	--	--	248	1830	10	mg/L	Grab	1	SM 2540 D
09-Feb-16	Turbidity	52.9	--	--	--	200	869	5	NTU	Grab	0.4	SM 2130 B
09-Feb-16	VSS	14	--	--	--	88	78	94	%	Grab	--	SM 2540 E
09-Feb-16	Ferric Dose	--	21	235	0	--	--	--	mg/L	Composite	--	Meter Reading
09-Feb-16	Flow Rate	--	10.91	2.65	17.7	--	--	--	MGD	Composite	--	Meter Reading

Notes:
1. SIWTF shunted into the RTP collection system during sampling
2. Average primary clarifier surface loading rate of 623 gallons per day per square foot (gpd/sf), with maximum and minimum of 1001 and 247, respectively
3. Trickling filter recycle ratio of 5%
4. Solids contact SRT of 1.38 days
5. Solids contact dissolved oxygen (DO) of 1.28 mg/L
6. Average secondary clarifier overflow rate of 10225 gallons per day per foot (gpd/ft), with maximum and minimum of 16442 and 4053, respectively

APPENDIX B – EXPERIMENTAL PLAN

Bench-Top Dieldrin and DDT Removal Testing for the MRWPCA Groundwater Replenishment Project

TEST PROTOCOL



Prepared for:

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1 Introduction

1.1 Background

Pending reductions in Carmel River water diversions are spurring the development of additional potable water supplies on the Monterey peninsula. The Monterey Peninsula Water Management District (MPWMD) and the Monterey Regional Water Pollution Control Agency (MRWPCA) are developing the Pure Water Monterey Groundwater Replenishment (GWR) Project to help address the water shortage. The project includes diversion of additional waters to the Regional Treatment Plant (RTP), which produces a secondary treated wastewater that would be the influent to an Advanced Water Treatment Facility (AWTF). The AWTF will produce high quality recycled water suitable for groundwater replenishment. The main components of the RTP and AWTF treatment train are the following:

- **Headworks and primary treatment** (RTP): screening, primary clarification, and optional Chemically Enhanced Primary Treatment (CEPT);
- **Secondary treatment (RTP)**: non-nitrifying trickling filters, bio-flocculation (solids contact basins), and secondary clarification; and,
- **Advanced treatment (AWTF)**: ozonation, membrane filtration (MF), reverse osmosis (RO), advanced oxidation (AOP) with hydrogen peroxide and ultraviolet (UV) light, and product water stabilization.

Additional raw water sources would be diverted to the RTP collection system including agricultural wash water, agricultural tile drainage and runoff waters, which could include waters from the Blanco Drain, Reclamation Ditch, and/or Tembladero Slough. Source water monitoring was conducted from July 2013 to June 2014 to characterize the proposed new source waters for the GWR Project (Trussell Technologies, 2014). Two legacy pesticides that have been banned for decades, dieldrin and Dichlorodiphyenyldichloroethylene (DDE), were detected during the monitoring in the Blanco Drain water. The median concentration of dieldrin detected was 17 ng/L, with a range of <10 to 31 ng/L; 4,4'DDE was detected once in four samples at a concentration of 21 ng/L.

DDE is a breakdown degradate of dichlorodiphenyltrichloroethane (DDT), and exists as one of two congeners: 4,4'DDE or 2,4'DDE, where the 4,4'DDE isomer was the isomer detected in the Blanco Drain. Although only one of the congeners of DDT was detected in the source water monitoring, all six congeners of DDT (2,4'DDT, 2,4'DDE, 2,4'DDD, 4,4'DDT, 4,4'DDE, 4,4'DDD) will be included in this investigation, and will be referred to as DDx.

Both dieldrin and DDx have established water quality objectives in the 2012 California Ocean Plan ("Ocean Plan") (State Water Resources Control Board, 2012)[1]. Ocean discharges in California must meet the water quality objectives described in the Ocean Plan. The AWTF would produce an RO concentrate that would be discharged along with different quantities of secondary treated wastewater. Modeling efforts of the various discharge scenarios related to the GWR Project have indicated that the future discharges would comply with the COP objectives (Trussell Technologies, 2015); however, the estimated concentrations of dieldrin and DDx

[1] DDT in the Ocean Plan is the sum of the two DDT congeners and the congeners of the DDT byproducts, DDE and dichlorodiphenyldichloroethanet (DDD), 4,4'DDT, 2,4'DDT, 4,4'DDE,

congeners in the RO concentrate were estimated using assumed removals (90% reduction of dieldrin and 70% reduction of DDx) from scientific literature (Ormad 2008).

The overall objective of this test protocol is to verify these previous assumptions used for dieldrin and DDx removal from a blend of Blanco Drain water and wastewater through sedimentation, ozonation, and membrane filtration.

1.2 Literature Review

The existing literature on dieldrin and DDx removal through the relevant treatment processes (i.e., adsorption, sedimentation, filtration and ozone destruction) was reviewed; however, conflicting results were observed for ozone oxidation. Certain factors will likely influence the destruction of these pesticides via ozone, specifically the type of water (*i.e.* source water quality) and the applied ozone doses. Two studies conducted by Ormad et al. on pesticides removal through oxidation yielded different results. Using the same ozone to total organic carbon (TOC) ratio for both studies of 0.14, and the same initial dieldrin concentration of 500 ng/L, the first study cited a removal efficiency of 90% with ozonation (Ormad et al., 2008), whereas the second study reported only 20% removal (Ormad et al., 2010). The ozone to TOC ratio is typically used in ozonation studies to normalize the effects of ozonation across differing water qualities. An investigation by Westerhoff et al., using ozone to TOC ratios between 0.63 and 1, cited minimal oxidation in the presence of ozone (<20%) (Westerhoff et al., 2005).

Both dieldrin and DDx are very hydrophobic, with K_{OW} values of 5.40 for dieldrin and between 6.02 and 6.91 for the congeners of DDx (Westerhoff, 2005). Therefore, significant removal (55%) of dieldrin and DDx through adsorption and sedimentation with enhanced coagulation and then filtration has also been reported (Robeck et al., 1965). Due to the differences observed in the level of destruction, and the variability of removal rates based on influent water quality, treatment processes and ozone dose, it was decided that bench-scale testing specific to the GWR project would be conducted.

1.3 Protocol Objectives

The objectives of this protocol are the following:

1. Determine the removal of dieldrin and DDx through adsorption onto particulate material and then course filtration (10 μm), which will be used to estimate removal through primary and secondary treatment at the RTP;
2. Determine dieldrin and DDx degradation through bench-scale ozone testing, using the design ozone to TOC ratio[2] for the proposed AWTF, to estimate the removal through the future ozone system; and,
3. Determine the remaining dissolved component of dieldrin and DDx after ozonation by filtering the ozonated water through a membrane disk filter (0.1 μm), which will be used to estimate removal through an MF filter.

Testing will be conducted at the Trussell Tech Laboratory in Pasadena, CA, using a laboratory blend of filtered (10 μm filter to represent solids removal during RTP treatment) Blanco Drain water with RTP secondary effluent at a ratio that represents the highest expected future

[2] The design ozone to TOC ratio incorporates immediate nitrite demand based on the detected nitrite concentration prior to ozonation.

contribution of agricultural drainage water to the wastewater collection system. Additionally, testing will be conducted on a blend of Blanco Drain water and RTP primary influent at the same ratio to investigate the potential of dieldrin and DDx adsorption onto organic solids. Bench testing, including the membrane filtration and solution ozone test, will be conducted by Trussell Tech, and the dieldrin and DDx analyses will be performed by commercial laboratories (Eurofins and Vista Laboratories).

2 Experimental Design

Water samples from the RTP will be collected, put on ice and shipped overnight to the Trussell Tech laboratory in Pasadena, CA. Water samples from the Blanco Drain will be shipped overnight to three different locations to minimize handling times prior to analysis: Eurofins Eaton Analytical Laboratory ("Eurofins"), Vista Laboratory ("Vista") and the Trussell Tech laboratory. MRWPCA staff will collect samples from the RTP, and Monterey Bay Analytical Services (MBAS) will be contracted to collect the water sample from the Blanco Drain. Trussell Tech staff will conduct the filtration and ozonation tests described in detail below. Throughout the bench-scale test, untreated samples (*i.e.*, non-filtered and non-ozonated Blanco Drain samples) and treated samples (*i.e.*, filtered and ozonated) will be collected and shipped to a certified laboratory for dieldrin and DDx analysis.

2.1 Sample Collection and Preparation

Trussell Tech performed an assessment of the impact the brine discharge, including the additional source waters, could have on the Monterey Bay in relation to the California Ocean Plan Objective (Trussell Technologies, 2015). For this assessment, water quality data for several types of discharge waters were used to estimate the future combined water quality in the ocean outfall discharge, including consideration of (1) different flow scenarios that varied based on time of year and/or drought conditions, (2) variation in the volume of water from each new source water, and (3) an estimate of the highest concentrations of Ocean Plan constituents from all data received during the source water monitoring. From this analysis, a worst-case scenario concerning dieldrin and DDx was identified to occur during times of maximum contribution from the Blanco Drain, which was determined to be 12% of the total influent water volume based on 2019 projected RTP flows.

To estimate the removal of dieldrin and DDx through the RTP and proposed AWTF, water samples will be collected from the Blanco Drain, RTP primary influent, solids contactor effluent and RTP secondary effluent. The amount of water collected will be as follows:

- 12 L from Blanco Drain,
- 5 L from RTP primary influent autosampler,
- 4.5 L from RTP solids contactor effluent, and
- 14 L from RTP secondary effluent.

These water samples will then be shipped overnight to Vista Laboratories, Eurofins, Caltest and the Trussell Tech laboratory. The temperature of the water will be recorded on the Chain of Custody when the samples are received. The samples will be stored at 6 degrees Celsius for a maximum of 24 hours.

Prior to the start of testing, the water will be brought to room temperature (similar to expected temperature of the wastewater) so that results are not impacted by slower reaction kinetics associated with lower temperatures. Three test mixtures will then be created:

1. **Primary:** 0.26 L Blanco Drain water combined with 2.14 L RTP primary influent,
2. **Secondary:** 0.26 L filtered Blanco Drain water combined with 2.14 L RTP solids contactor effluent, and
3. **AWTF Influent:** 1.32 L filtered Blanco Drain water combined with 10.68 L RTP secondary effluent.

The Primary mixture will be used to focus on the removal of dieldrin and DDx through adsorption and subsequent sedimentation during primary treatment at the RTP. Therefore, this mixture will only be filtered (see Section 2.2) and not subjected to ozonation. The average residence time through the RTP's primary treatment process will be applied during the bench-scale testing to mimic the time available for adsorption to occur. Therefore, the Primary mixture will be filtered after the respective residence time for primary treatment has passed.

The Secondary mixture will be used to estimate the removal of dieldrin and DDx through adsorption and subsequent sedimentation during secondary treatment at the RTP.

The AWTF Influent mixture most accurately represents the proposed AWTF influent water quality, and so it will be used to study the impacts of ozonation and membrane filtration on dieldrin and DDx destruction and removal. Specifically, the amount of total organic carbon (TOC) present in the AWTF Influent mixture will be more similar to the actual RTP effluent water. This is important because the ozone to TOC ratio can significantly impact the ozone demand of the water, which could affect the observed dieldrin and DDx destruction.

2.2 Filtration

Filtration will be used to mimic primary, secondary, and membrane filtration treatment. Several filtration scenarios will be done to investigate the amount of dieldrin and DDx removal attributable to adsorption of the constituents onto suspended solids and subsequent removal through sedimentation and straining. A 10-micron filter will be used to simulate primary and secondary treatment, and a 0.1-micron filter will be used for membrane filtration.

The Primary mixture testing will involve first combing the Blanco Drain and RTP primary influent waters as specified in Section 2.1. The mixed water will then be filtered through a 10-micron filter. For the Secondary mixture, Blanco Drain water will first be filtered through a 10-micron filter, and then will be mixed with the RTP solids contactor effluent water. The Blanco Drain water is filtered separately in this scenario because in the full-scale plant, this water will first go through primary treatment prior to membrane filtration, and the RTP solids contactor effluent water collected will have already gone through this treatment. Similarly, the AWTF Influent mixture will be made with filtered Blanco Drain water (10-micron) mixed with RTP secondary effluent water.

The AWTF Influent mixture only will receive ozone treatment, to simulate the first process in the AWTF treatment train. Ozonation procedures are discussed in Section 2.3. Following ozonation, the AWTF Influent mixture will be filtered through a 0.1-micron filter to simulate membrane filtration. Depending on the final design of the full-scale AWTF, there will either be a microfiltration (0.1 – 10 micron pore size) or an ultrafiltration (0.01 – 0.1 micron pore size) treatment step. To be conservative, a pour size similar to a typical microfiltration membrane was chosen for this study.

2.3 Ozonation

The first step of the proposed AWTF will be ozonation to control the amount of fouling on the downstream membranes, and allow a higher operating flux. The degree of fouling is related to the amount of TOC in the membrane influent water, and so the ozone dose required to be effective at preventing fouling is based on the ozone to TOC ratio. The ozonation test in this study will be performed using the AWTF Influent mixture to most accurately mimic the AWTF influent water quality, specifically the amount of TOC and nitrite present. Once the AWTF Influent mixture has been made, approximately 200 mL will be sampled and used for TOC and nitrite analysis, which will be conducted in the Trussell Tech laboratory. Once the results have been obtained, a transferred ozone dose will be selected such that the ozone to TOC ratio (accounting for nitrite demand) matches the ratio that will be targeted at the AWTF, which is 0.48 (w./w.). Two additional ozone doses will also be tested, +/- 50% of the design ozone to TOC ratio, to determine degradation based on a range of ozone doses.

Trussell Tech staff will then perform the Solution Ozone Test (SOT) method to mimic full-scale ozonation. This method utilizes a stock ozone solution, which will be prepared by bubbling ozone through deionized water (apparatus shown in Figure 1). The ozone concentration will be quantified using the gravimetric indigo method, as described by Rakness (2005). The results from the TOC analysis will be used to calculate the ozone dose required to produce an ozone to TOC ratio of 0.48. A known volume of the stock ozone solution will then be added to the water sample of interest to deliver the dose associated with the target ozone to TOC ratio.

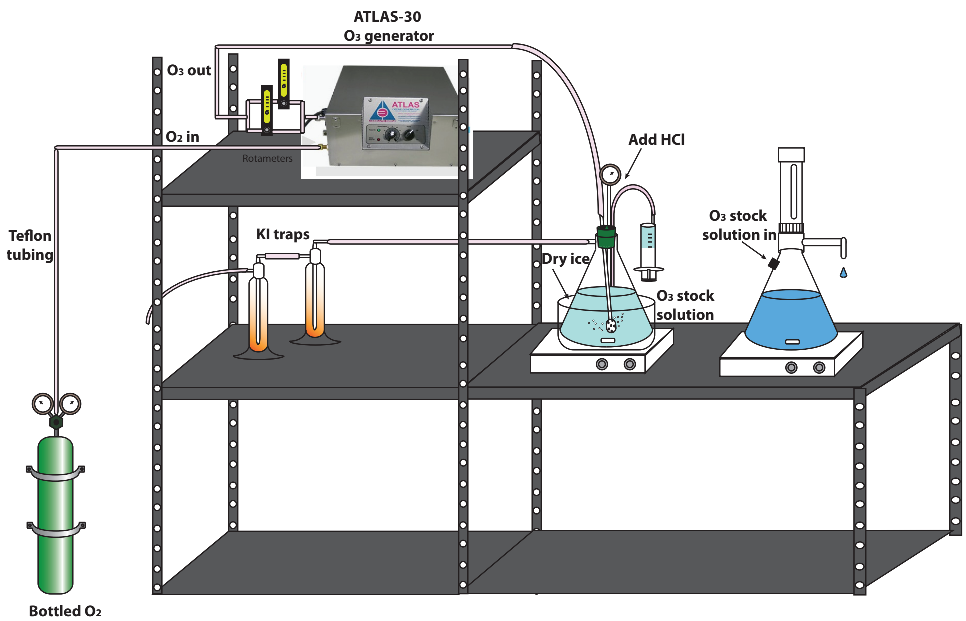

Figure 1 - Solution Ozone Test apparatus

2.4 Laboratory Analysis

Certified laboratories will be contracted for the analysis of dieldrin and DDx throughout the filtration and ozonation steps described above. Eurofins Eaton Analytical ("Eurofins") is a California certified laboratory that will be consulted for the analysis of dieldrin in the particulate and dissolved phases using EPA Method 505. This method has a method-reporting limit (MRL) of 0.012 ug/L, and requires six 40-mL vials, or a total of 240-mL per sample for analysis of both phases. Caltest Analytical Laboratory ("Caltest") will be consulted for the analysis of DDx using EPA Method 608, which will also be used to analyze the samples for particulate and dissolved phases separately. These methods have MRLs ranging from 0.005 – 0.01, depending on the congener, and require two 1-L bottles, or a total of 8-L per sample. DDE was found in one sample at a concentration of 21 ng/L and dieldrin was found in the Blanco drain at a median concentration of 17 ng/L; therefore, these laboratory methods will only be used on the initial raw water sample of Blanco Drain water, and will not be used to analyze the Primary, Secondary and AWTF Influent mixtures due to the MRL.

Vista Laboratories ("Vista") is another California certified laboratory that will be contracted for the low-detection limit analysis of dieldrin and DDx using EPA Method 1699. This method has an MRL of 40 pg/L and 80 pg/L for dieldrin and DDx respectively, and the sample volume required per analysis is 2 L. Method 1699 will be used to analyze all of the initial source waters, and all of the samples once the mixtures have been made, which will include the samples collected from the following:

1. Primary influent raw water;

2. Solids contactor effluent raw water;
3. Secondary effluent raw water;
4. Blanco Drain raw water;
5. Primary mixture after filtration through the 10-micron filter;
6. Blanco Drain raw water after filtration through the 10-micron filter;
7. Secondary mixture after filtration through the 10-micron filter;
8. The AWTF Influent mixture:
    a. After ozonation (3 samples), and
    b. After filtration through the 0.1-micron filter (2 samples).

2.5 Testing Supplies

The following supplies will be obtained and prepared in advance of testing:

- Sample bottles, cooler, gel-ice and Chain of Custody documentation (delivered to sampling location),
- Filtration equipment,
- 47-mm diameter filters with 10-micron and 0.1-micron pore sizes,
- TOC, turbidity and nitrite analysis equipment, and
- SOT apparatus.

2.6 Laboratory Procedure

The testing and sampling procedure is described in this section and graphically shown in Figure 2.

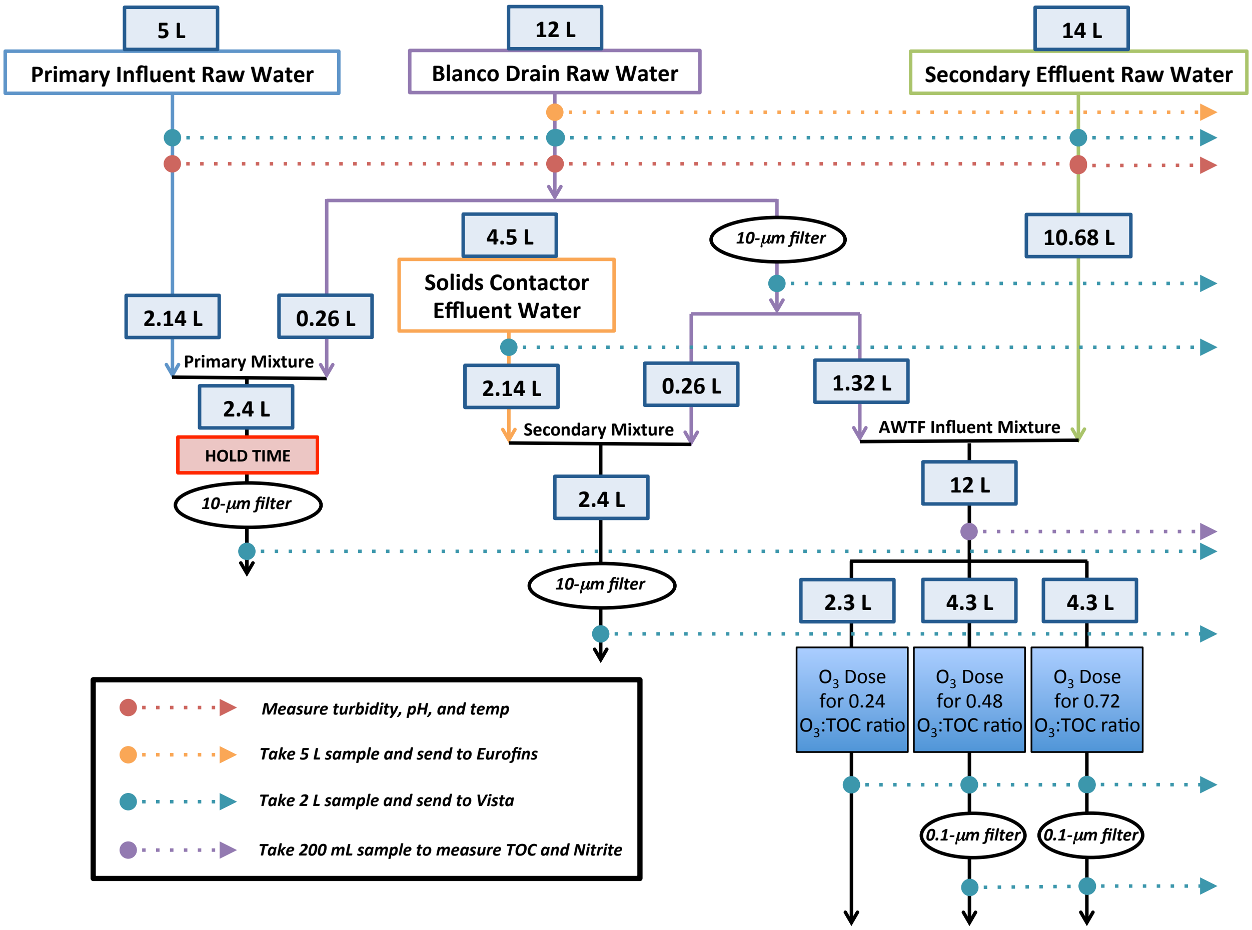

Figure 2 - Testing and sampling procedure. Note: the O_3:TOC ratio accounts for nitrite demand

Field:
Collect water samples as follows:

- **Blanco Drain:** fill six 40-mL amber glass vials for EPA Method 505, four 1-L amber glass bottles for EPA Method 608. Send these bottles directly to Eurofins. Fill two 1-L amber glass bottles for EPA Method 1699 and send directly to Vista. Fill four 1-L amber glass bottles and send to Trussell Tech laboratory in Pasadena, CA.
- **RTP Primary Influent:** Fill two 1-L amber glass bottles from the auto-sampler for the primary influent and send to Vista. Fill three 1-L amber glass bottles and send to Trussell Tech laboratory.
- **RTP Solids Contactor Effluent:** Fill two 1-L amber glass bottles from the solids contactor effluent water and send to Vista. Fill three 1-L amber glass bottles and send to Trussell Tech laboratory.
- **RTP Secondary Effluent:** Fill two 1-L amber glass bottles from the secondary effluent and send to Vista. Fill twelve 1-L amber glass bottles and send to Trussell Tech laboratory.

Lab:

1. Take a 10-mL water sample from each source and measure turbidity, pH and temperature.

2. Combine 2.14-L RTP primary influent water with 0.26-L Blanco Drain water to create the Primary mixture.
3. After the simulated primary treatment residence time (1.7 hours), filter the Primary mixture through a 10-micron pore size filter.
4. Fill two 1-L Vista laboratory analysis bottles with the Primary mixture filtered water, set aside.
5. Filter 3.7-L Blanco Drain water through a 10-micron filter.
6. Combine 0.26-L filtered Blanco Drain water with 2.14-L RTP solids contactor effluent water to create the Secondary mixture.
7. Filter the Secondary mixture through a 10-micron pore size filter.
8. Fill two 1-L Vista laboratory bottles with the Secondary mixture filtered water, set aside.
9. Combine 1.32-L of the remaining filtered Blanco Drain water with 10.68-L RTP secondary effluent water to create the AWTF Influent mixture.
10. Fill two 1-L Vista laboratory analysis bottles with the filtered Blanco Drain water, set aside.
11. Take a 40-mL sample of the AWTF Influent mixture and measure the total organic carbon and take a 20-mL sample and measure the total nitrite. Determine the ozone doses needed for ozone:TOC ratios of 0.24, 0.48 and 0.72 accounting for nitrite demand.
12. Divide the AWTF Influent mixture into three separate beakers labeled A, B and C containing 2.3 L, 4.3 L and 4.3 L respectively.
13. Once waters have reach room temperature, perform the SOT on the three filtered AWTF Influent mixtures:
    A. 2.3 L AWTF Influent mixture = ozone:TOC of 0.24
    B. 4.3 L AWTF Influent mixture = ozone:TOC of 0.48
    C. 4.3 L AWTF Influent mixture = ozone:TOC of 0.72
14. From tests A through C of the ozonated AWTF Influent mixtures, fill two 1-L Vista laboratory analysis bottles and set aside.
15. Filter the ozonated mixtures from tests B and C through a 0.1-micron filter.
16. Fill two 1-L Vista laboratory analysis bottles with the filtered AWTF Influent mixtures of tests B and C, set aside.
17. Send the 16 reserved Vista analysis bottles to Vista labs for analysis.

3 References

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