Appendix T

MRWPCA GWR Discharge Dilution Analysis

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TECHNICAL MEMORANDUM

DATE: November 10, 2014

TO: Robert Holden
Monterey Regional Water Pollution Control Agency (MRWPCA)

FROM: Gang Zhao, Ph.D., P.E., Aaron Mead, P.E., E. John List, Ph.D., P.E.

SUBJECT: **MRWPCA GWR Discharge Dilution Analysis**
FSI 144082

1. Introduction

As part of the preparation process for the Monterey Peninsula Groundwater Replenishment Project (GWR Project), Flow Science Incorporated (Flow Science) was retained by Monterey Regional Water Pollution Control Agency (MRWPCA) to analyze characteristics of the plume resulting from the discharge of effluent (comprised of secondary effluent from the Regional Treatment Plant (RTP), truck hauled brine, and brine concentrate produced by the Advanced Water Treatment Facility (AWTF) for the proposed Pure Water Monterey Groundwater Replenishment Project (GWR Project)) through the existing MRWPCA ocean outfall.

In October 2014, Flow Science performed a dilution analysis of the proposed GWR Project effluent for six (6) selected discharge scenarios, as summarized in **Table 1**. These scenarios were selected based on the results of a dilution analysis for fourteen (14) prescreening scenarios, as listed in **Appendix C**. Scenarios in **Appendix C** were selected to cover a wide range of discharge conditions, and to provide preliminary knowledge of the various factors affecting dilution of the effluent. For each scenario in **Table 1**, temperature of the combined flow was assumed to be 20 °C, and effluent dilution was analyzed for three seasonal conditions: Davidson (January), Upwelling (July) and Oceanic (September). Zero ocean current was used for all scenarios consistent with the California Ocean Plan (State Water Resources Control Board, SWRCB, 2012).

Table 1 – Diffuser scenarios modeled

Scenario	Flow Assumptions (mgd)				TDS Assumptions (mg/L)			
	Wastewater	Hauled Brine	GWR Brine	Total Flow	Wastewater	Hauled Brine	GWR brine	Combined
1	0.2	0.1	0.94	1.24	1100	40,000	5,800	7800
2	0.4	0.1	0.94	1.44	1100	40,000	5,800	6869
3	0.6	0.1	0.94	1.64	1100	40,000	5,800	6166
4	0.8	0.1	0.94	1.84	1100	40,000	5,800	5615
5	1.0	0.1	0.94	2.04	1100	40,000	5,800	5173
6	1.2	0.1	0.94	2.24	1100	40,000	5,800	4809

mgd = million gallons per day, mg/L = milligrams per liter, TDS = total dissolved solids.

This Technical Memorandum (TM) summarizes the analysis Flow Science completed for the scenarios presented in **Table 1** and describes the input data, methods and results of Flow Science's analysis.

2. Analysis Input Data

Diffuser Configuration

The existing MRWPCA diffuser has 172 ports. Half of the ports discharge horizontally from one side of the diffuser and half discharge horizontally from the other side of the diffuser in an alternating pattern. Since Visual Plumes, the model used to analyze effluent dilution in this analysis, does not have the capability to model ports on alternating sides of a diffuser, all ports were modeled to be on one side of the diffuser. This assumption leads to conservative model results because the plumes from individual ports overlap more quickly under modeled conditions than in reality, and so modeled effluent dilutions are somewhat lower than would be reflected in reality.

According to MRWPCA, the fifty-two (52) ports nearest to the shore (i.e., the shallowest ports) are currently closed. In this analysis, Flow Science calculated dilution of effluent discharged through the 120 open ports for Scenarios 1 through 6. A typical section of the current diffuser is shown in **Figure 1**, although the actual cross-sectional profile of the pipe ballast may have changed over time. The ports are approximately 6 inches above the rock bedding of the diffuser pipeline, and drawings[1] (see **Figure 1**) indicate that they are located approximately 3.9 feet above the seafloor[2]. The gravel bedding dimensions are nominal, as shown in **Figure 1**, and therefore, the port height above the seafloor is not known with high accuracy. Momentum and buoyancy of the effluent are the key factors in determining the dilution within the zone of initial dilution (ZID). Toward the end of the ZID, the plume slows down and mixing is not as strong as at the beginning of the ZID. Therefore, the dilution results are not likely to change by much if the port height is not precisely known and, considering the overall uncertainty in the analysis, it is not critical to determine the diffuser port height with high accuracy. In this analysis, it was assumed that effluent plumes do not interact with the ballast, which is supported by the plume dimensions computed. Details of the current diffuser configuration are summarized in **Table 2**.

Table 2 – Current diffuser configuration.

Parameter	Value
Diffuser length	1368 feet (417 m)
Depth of diffuser ports	95 to 109 feet below MSL
Number of open ports	120
Port spacing	8 feet (2.44 m)
Port diameter	2 inches (0.051 m)
Port exit condition	Tideflex Series 35 4-inch duckbill valves
Port vertical angle	0° (horizontal)
Port elevation above sea floor	3.9 feet (1.19 m)

m = meters, MSL = mean sea level

[1] Section F, Drawing P-0.03, Contract Documents Volume 1 of 1: Ocean Outfall Contract No. 2.1, January 1982 by Engineering Science for MRWPCA.
[2] The 3.9 feet (ft) above seafloor used in this analysis is slightly higher than the 3.5 ft used in previous analyses for the desalination brine because the thickness of the pipe wall (about 5 inches) is included. All effluent plumes in this analysis are positively buoyant, and therefore, this change has no impact on the results of this analysis.

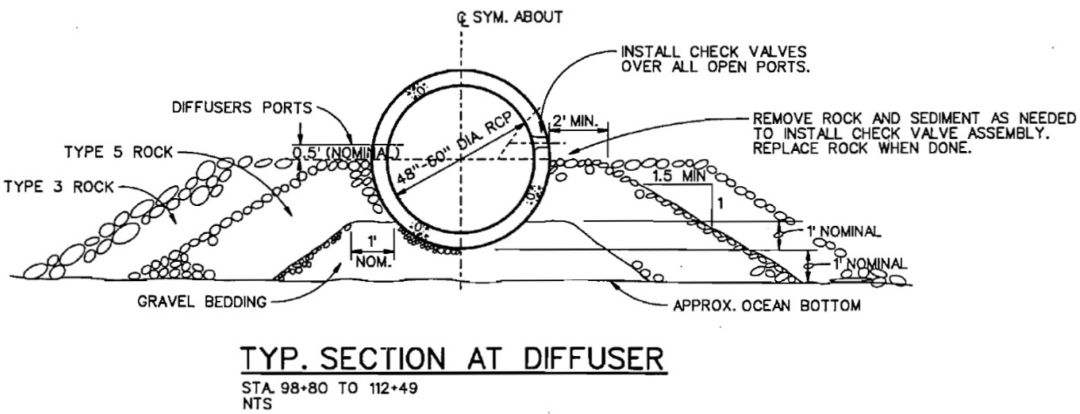

Figure 1. Typical diffuser section (currently in place).

The 120 ports that are currently open are fitted with Tideflex "duckbill" check valves, as shown in **Figure 2**. The shape of the duckbill valve opening is elliptic and the area of the opening depends on the discharge flow rate. The valve opening area in this analysis was determined from an effective open area curve provided by Tideflex Technologies (included as **Appendix A**). Although the ports were modeled as round openings with the same opening area as the "duckbill" valves, because of the oblateness of the actual port opening, the actual dilution will be slightly higher than the dilution computed assuming circular ports. This is because the perimeter of ellipse, which is where the entrainment of diluting water occurs, is larger than that of a circle having the same area.

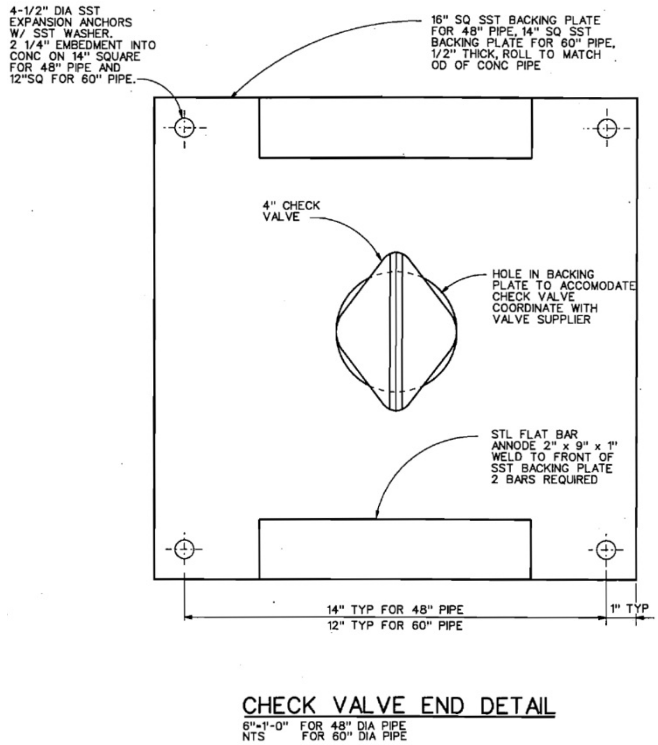

Figure 2. Typical "duckbill" valve detail (shown closed, i.e., with no flow).

Discharge Characteristics

Total Dissolved Solids (TDS) and temperature data for the proposed GWR Project brine concentrate, hauled brine and the MRWPCA wastewater have been compiled and provided by Trussell Technologies, Inc. (Trussell Tech). TDS is a measure of water salinity, and salinity and temperature are used to calculate the density of the effluent and ambient ocean water, which are important parameters in dilution analyses.

Discharge rate, temperature, and TDS data, provided by Trussell Tech and presented in **Table 3**, were used in the analysis for all three seasonal conditions. For the combined proposed GWR Project brine concentrate, trucked brine, and wastewater flow scenarios, the concentrate was assumed to be fully mixed with the wastewater. Thus, the temperature and TDS of the combined flow were calculated as the flow-weighted average temperature and salinity of the brine and wastewater.

All scenarios summarized in **Table 3** were analyzed for zero ocean current velocity conditions, which represent worst-case conditions since any ocean current only increases dilution. Ocean currents increase the amount of dilution that occurs because they increase the flow of ambient water past the diffuser (i.e., increase the amount of ambient water available for mixing with the discharge). Although ocean currents increase effluent dilution, the California Ocean Plan (State Water Resources Control Board, SWRCB, 2012) requires that the no-current condition should be used in initial dilution calculations.

Table 3 – Summary of input for analyzed scenarios.

Scenario	Combined Flow (mgd)	Combined TDS (mg/L)	Combined Temp. (^oC)	Number of Diffuser Ports	Effective Port Diameter (inches)
1	1.24	7800	20	120	0.93
2	1.44	6869	20	120	0.97
3	1.64	6166	20	120	1.01
4	1.84	5615	20	120	1.05
5	2.04	5173	20	120	1.09
6	2.24	4809	20	120	1.12

Receiving Water Profiles

Representative ocean receiving water profile data (temperature and salinity) for the three months corresponding to the selected seasonal conditions (July, January, and September) used in a previous dilution study (Flow Science, 2014) for the proposed Monterey Peninsula Water Supply Project Desalination Plant were also used in this analysis. Receiving water profile data were collected by the Monterey Bay Aquarium Research Institute (MBARI) at station C1 at the head of Monterey Canyon, approximately five miles northwest of the MRWPCA wastewater ocean outfall (see **Figure 3**). This location has been occupied since 1988 by MBARI. Monthly conductivity, temperature, and depth (CTD) profiles have been collected since 2002. The proximity of the location to the MRWPCA ocean outfall and the long data record make this the most appropriate and useful data set to characterize the ambient conditions for the brine discharge analysis. Vertical profiles of temperature and salinity were analyzed for the upper 50 meters of the water column for the years 2002-2012, and a single representative profile was selected for each of the three ocean seasons. The appropriate profiles were selected based on which were most complete, i.e., which profiles had data for the entire water column (in some cases profiles did not extend over the entire depth of the water column), and to ensure that the profiles represented typical conditions of the seasonal ocean profiles. For the July model run, temperature and salinity profiles from 2011 were selected. For the September model run, profiles from 2004 were selected. For the January model runs, a temperature profile from 2004 and a salinity profile from 2011 were selected. Profile data are shown in tabular form in **Appendix B**. Maximum and minimum values for each profile are shown in **Table 4**.

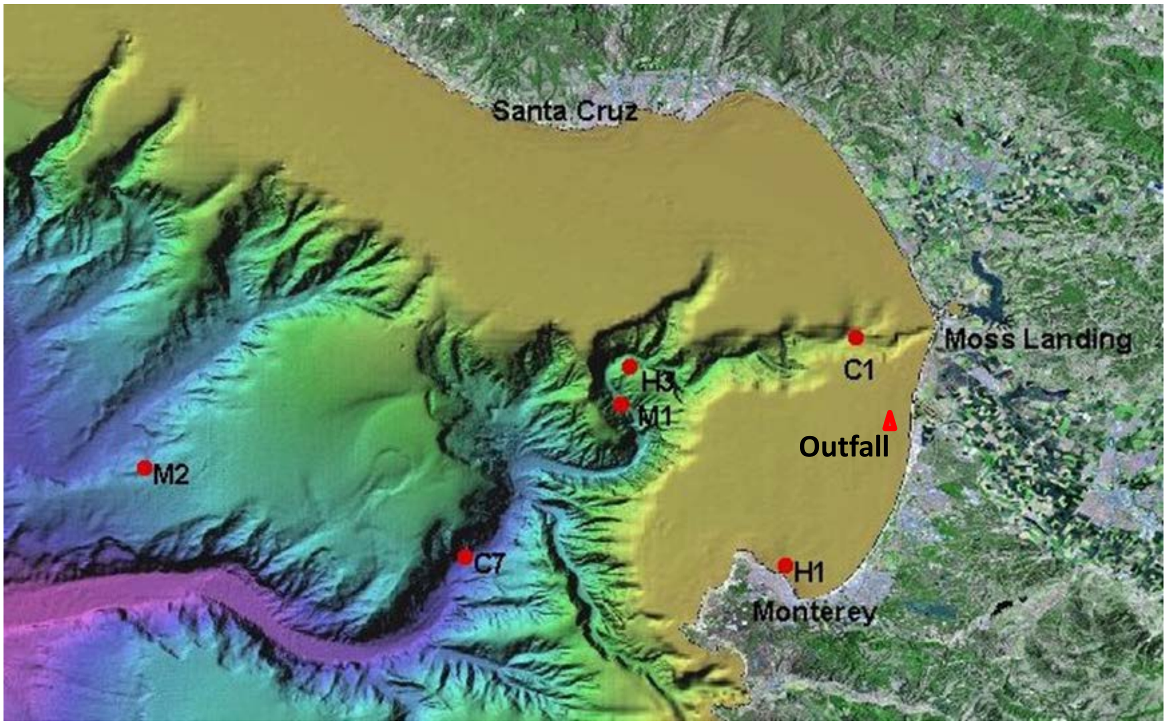

Figure 3. Location map, MBARI ocean monitoring stations and MRWPCA outfall.

Table 4 – Maximum and minimum ocean profile data.

Parameter	Season	Minimum	Maximum
Salinity (ppt)	Upwelling (July)	33.7	33.9
	Davidson (January)	33.2	33.5
	Oceanic (September)	33.5	33.6
Temperature (C^o)	Upwelling (July)	10.0	13.0
	Davidson (January)	10.7	12.7
	Oceanic (September)	10.6	15.8

Source: ESA (2013); Appendix B.

Receiving water flow conditions

As detailed in **Figure 1**, the existing diffuser ports are located just above the mid-point of the outfall pipe (i.e., below the crown of the outfall pipe), about 6 inches above the top of the ballast used to anchor the diffuser to the seafloor. Because the outfall rises above the seafloor, it will influence the patterns of currents (receiving water flow velocity) at the ports, and the current velocity at each individual port will be a complex function of the local geometry. Local field data collection would be required to characterize the actual current conditions at the diffuser ports, which was beyond the scope and budget of this analysis. To simplify the analysis, effluent dilution was analyzed for a uniform 0.0 foot per second (fps) current, which amounts to a "worst case," stagnant (no current) receiving water condition. Stagnant conditions are typically used as the basis for developing NPDES permits, and the California Ocean Plan (SWRCB, 2012) requires the no-current condition be used in initial dilution calculations.

3. Plume Analysis Method

The UM3 model—part of the U.S. Environmental Protection Agency (US EPA) Visual Plumes diffuser modeling package—was used to simulate the discharge of GWR Project effluent and wastewater from the existing MRWPCA ocean diffuser. Visual Plumes is a mixing zone computer model developed from a joint effort led by US EPA. Visual Plumes can simulate both single and merging submerged plumes, and stratified ambient flow can be specified by the user. Visual Plumes can be used to compute the plume dilution, trajectory, diameter, and other plume variables (US EPA, 2003).

The UM3 model is based on the projected area entrainment hypothesis, which assumes ambient fluid is entrained into the plume through areas projected in directions along the plume centerline and perpendicular to the centerline (US EPA, 1994). In addition, shear entrainment is included. The plume envelope is assumed to be in steady state, and as a plume element moves through the envelope, the element radius changes in response to velocity convergence or divergence, and entrainment of ambient fluid. Conservation equations of mass, momentum and energy are used to calculate plume mass and concentrations.

The actual depth of the diffuser ports varies between 95 and 109 feet below mean sea level (MSL) since the diffuser is quite long and is situated on a sloping portion of the ocean floor. However, since Visual Plumes cannot model a sloping diffuser, an average depth of 104 feet below MSL was used for the 120-port scenarios (the deepest 120 ports on the diffuser are assumed to discharge in this case, thereby increasing the average port depth). Modeled ocean conditions are summarized in **Table 5**.

Visual Plumes assumes circular discharge ports, so the actual elliptical discharge area was calculated for each port (**Appendix A**) and then converted to an effective circular discharge diameter for use in Visual Plumes.

Table 5 – Visual Plumes modeled seasonal ocean conditions.

Depth (m)	Upwelling (July)		Davidson (January)		Oceanic (September)	
	Temp. (°C)	Salinity (ppt)	Temp. (°C)	Salinity (ppt)	Temp. (°C)	Salinity (ppt)
0	12.98	33.78	12.65	33.20	15.75	33.46
2	12.87	33.77	12.65	33.22	15.75	33.46
4	12.64	33.74	12.65	33.22	15.75	33.46
6	11.97	33.71	12.65	33.23	15.53	33.46
8	11.61	33.70	12.74	33.24	14.46	33.46
10	11.34	33.70	12.57	33.26	13.81	33.46
12	11.10	33.73	12.50	33.28	13.17	33.46
14	10.84	33.75	12.42	33.30	12.27	33.46
16	10.51	33.78	12.33	33.30	11.83	33.46
18	10.38	33.79	12.24	33.30	11.52	33.46
20	10.38	33.80	12.22	33.28	11.19	33.46
22	10.38	33.80	12.07	33.30	11.06	33.46
24	10.38	33.82	12.05	33.30	11.22	33.49
26	10.38	33.82	11.90	33.30	11.39	33.50
28	10.38	33.84	11.81	33.32	11.39	33.50
30	10.38	33.84	11.71	33.34	11.31	33.50
32	10.37	33.84	11.71	33.37	11.23	33.50
34	10.31	33.84	11.63	33.39	11.22	33.50
36	10.30	33.84	11.63	33.42	11.05	33.50
38	10.30	33.84	11.54	33.43	10.97	33.50

Source: Interpolated from ESA | Water (2013) ocean profile data, Appendix B.

The UM3 model was used to calculate the size of the plume and dilution of the discharged effluent within the ZID. The ZID is defined as the zone immediately adjacent to a discharge where momentum and buoyancy-driven mixing produces rapid dilution of the discharge. For a positively buoyant (rising) effluent plume, the ZID ends at the point where the effluent plume reaches the water surface or attains a depth level where the density of the diluted effluent plume becomes the same as the density of ambient water (i.e., the "trap" level). Typically, within the ZID, which is limited in size, constituent concentrations are permitted to exceed water quality standards. A discharge is generally required to meet the relevant water quality standards at the edge of the ZID.

Analysis of the buoyant (rising) plume within and beyond the "trap" level would require additional analysis methods. In the analysis presented here the spreading of the effluent within and beyond the trap level and the subsequent additional dilution that would ensue, has not been analyzed. Flow Science recommends that the computed dilution at the trap level, (i.e., at the end of the ZID), be used as the basis for any NPDES permitting activities and to analyze impacts.

4. Dilution Results

Several key results for the effluent plumes are reported at the edge of the ZID. As noted above, the ZID is defined as the zone immediately adjacent to a discharge where momentum and buoyancy-driven mixing produces rapid dilution of the discharge. Results for positively buoyant plumes presented in this Technical Memorandum were taken at the point where the plumes just reached the trap level, which is the depth level where the density of the diluted plume becomes the same as ambient seawater. Horizontal spreading of plumes at their trap levels was not included in this analysis. Results from each scenario generally include the following quantities:

- the minimum dilution of the plume at the point at which the plume reaches the trap level or sea surface;
- an estimate of the size of the plume (diameter) at the trap level or sea surface (i.e., at the edge of the ZID);
- the horizontal distance from the diffuser port to the point at which the plume reaches the trap level or sea surface;
- the height of the trap level above diffuser ports.

Figure 4 shows a sample schematic graphic of the trajectory of a positively buoyant plume from a horizontal discharge drawn approximately to scale, and the analysis results described in the list above are illustrated. As the effluent travels away from the discharge port, it entrains ambient seawater, which increases the diameter of the plume and decreases the effluent concentration.

Table 6 presents analysis results for the six (6) modeled scenarios for the selected three seasonal conditions. Effluent plumes are positively buoyant for all analyzed scenarios, and all plumes reach trap levels below sea surface. The calculated minimum dilution value is 218 for all scenarios under all three seasonal conditions.

Figure 5 illustrates the trajectory and shape of the buoyant plumes just reaching the trap level, as computed from Visual Plumes for Scenario 4. Plumes computed for other scenarios have similar trajectories and shape as shown in the figure.

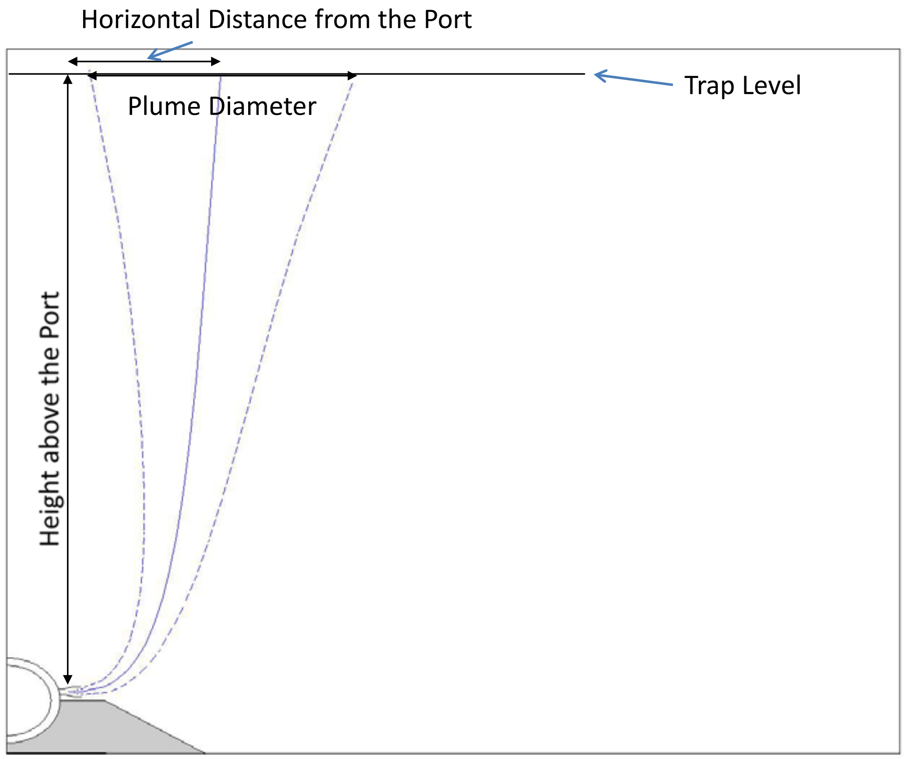

Figure 4. Sample graphic showing the trajectory of a rising plume.

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Table 6– Analysis results.

Scenario	Total Flow (MGD)	Combined TDS (mg/L)	Number of Open Ports	Davidson (Jan.)				Upwelling (July)				Oceanic (Sept.)			
				Plume Diam. (ft)	Minimum Dilution	Horiz. Distance from Port (ft)	Height above Port (ft)	Plume Diam. (ft)	Minimum Dilution	Horiz. Distance from Port (ft)	Height above Port (ft)	Plume Diam. (ft)	Minimum Dilution	Horiz. Distance from Port (ft)	Height above Port (ft)
1	1.24	7800	120	8	218	6	26	13	541	7	49	11	474	7	42
2	1.44	6869	120	11	285	7	34	13	512	7	50	11	439	7	43
3	1.64	6166	120	11	274	7	35	13	483	8	50	11	418	7	43
4	1.84	5615	120	11	263	8	35	13	453	8	50	11	396	8	44
5	2.04	5173	120	11	252	8	35	13	440	8	51	11	373	8	44
6	2.24	4809	120	11	242	8	36	14	426	9	52	11	362	8	45

Analysis results are at plume trap levels.

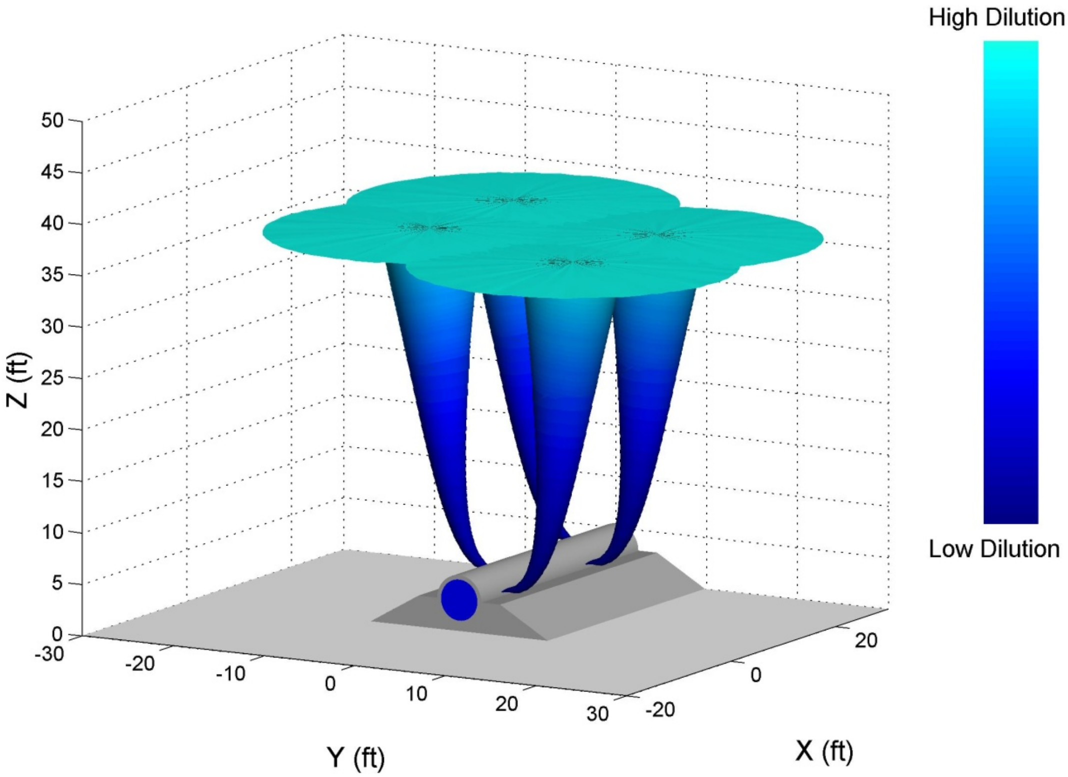

Figure 5. Plume computed from VP for Scenario 4.

5. References

Flow Science (2014). *Draft Technical Memorandum: MRWPCA Brine Discharge Diffuser Analysis*. Submitted to Environmental Science Associates (ESA), August 29, 2014.

State Water Resources Control Board (2012). *California Ocean Plan, Water Quality Control Plan for Ocean Waters of California*.

US EPA (1994). *Dilution Models for Effluent Discharges (3rd edition)*. EPA/600/R-94/086, June, 1994.

US EPA (2003). *Dilution Models for Effluent Discharges (4th edition)*. EPA/600/R-03/025, March, 2003.

APPENDIX A – DUCKBILL VALVE, EFFECTIVE OPEN AREA

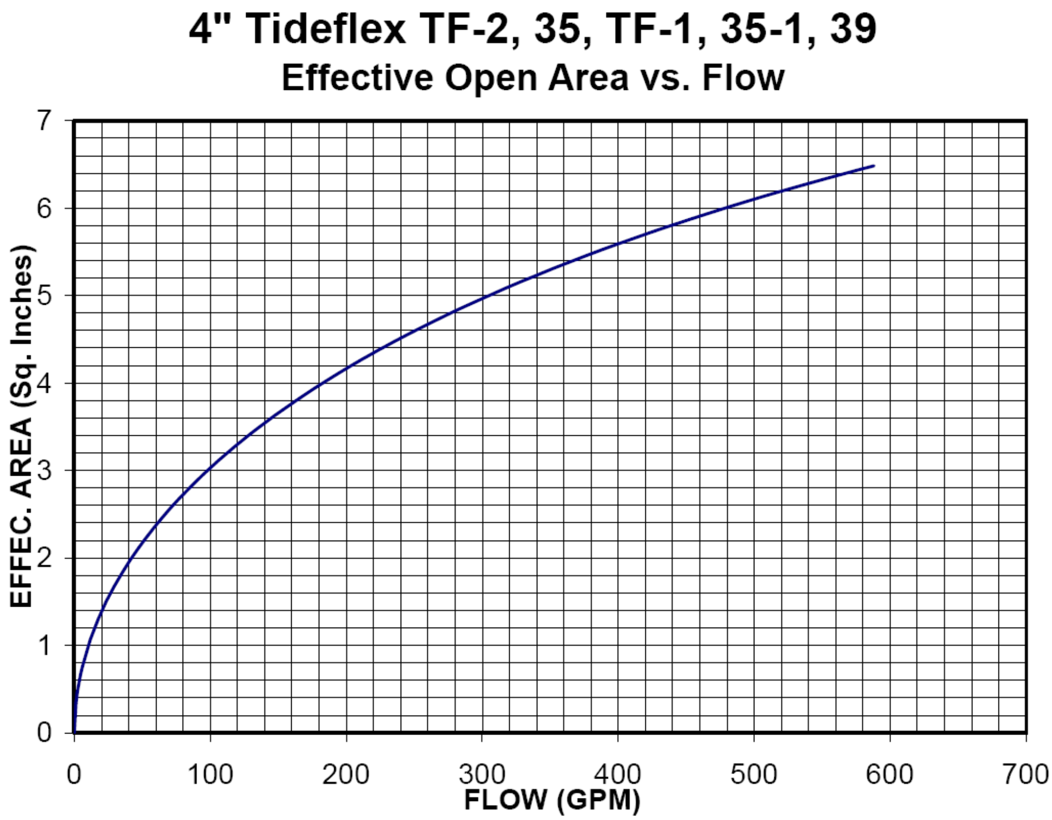

Chart provided by Tideflex Technologies.

APPENDIX B – AMBIENT OCEAN PROFILE DATA

Table B1- Ambient ocean profile data, MBARI station C1 (Source: ESA)

Upwelling (July)				Transition-Oceanic (Sept)				Davidson (Jan)			
2011 Profile		2011 Profile		2004.2 Profile		2004.1 Profile		2011 Profile		2004 Profile	
S (ppt)	Z (m)	T (°C)	Z (m)	S (ppt)	Z (m)	T (°C)	Z (m)	S (ppt)	Z (m)	T (°C)	Z (m)
33.78	-0.93	12.98	-0.59	33.46	-3.30	15.83	-4.22	33.20	-0.41	12.65	-2.35
33.76	-1.97	12.91	-1.63	33.46	-4.29	15.66	-4.22	33.22	-0.40	12.65	-2.35
33.78	-1.98	12.84	-2.68	33.46	-5.28	15.66	-5.22	33.22	-1.44	12.65	-3.34
33.78	-3.03	12.77	-2.68	33.46	-6.28	15.75	-6.21	33.22	-2.47	12.65	-4.33
33.76	-4.06	12.77	-3.73	33.46	-7.27	15.83	-6.21	33.22	-3.51	12.65	-5.32
33.74	-4.05	12.70	-3.73	33.46	-8.27	15.75	-6.21	33.22	-4.54	12.65	-6.31
33.72	-4.04	12.63	-4.78	33.46	-9.26	15.66	-6.21	33.22	-5.57	12.65	-7.30
33.74	-5.10	12.56	-4.78	33.46	-10.25	15.23	-6.21	33.22	-6.61	12.74	-7.30
33.72	-5.09	12.35	-4.80	33.46	-11.25	15.15	-6.21	33.24	-6.60	12.74	-8.29
33.70	-6.13	12.28	-4.80	33.46	-12.24	15.06	-6.21	33.24	-7.63	12.65	-8.29
33.70	-7.17	12.21	-4.80	33.46	-13.23	14.98	-7.21	33.26	-8.65	12.57	-9.29
33.70	-8.22	12.14	-4.81	33.46	-14.23	14.89	-7.21	33.26	-9.69	12.57	-10.28
33.70	-9.27	12.07	-5.85	33.46	-15.22	14.81	-7.21	33.28	-10.71	12.57	-11.27
33.70	-10.32	12.00	-5.86	33.46	-16.22	14.72	-7.21	33.28	-11.74	12.48	-12.27
33.72	-11.37	11.93	-5.86	33.46	-17.21	14.64	-7.21	33.30	-12.77	12.48	-13.26
33.74	-12.43	11.86	-6.91	33.46	-18.20	14.55	-7.21	33.30	-13.80	12.39	-14.26
33.74	-13.48	11.79	-6.91	33.46	-19.20	14.47	-8.20	33.30	-14.83	12.39	-15.25
33.74	-14.52	11.72	-6.92	33.46	-20.19	14.38	-8.20	33.30	-15.87	12.31	-16.24
33.76	-14.53	11.65	-7.97	33.46	-21.18	14.30	-8.20	33.30	-16.90	12.31	-17.23
33.78	-15.59	11.58	-7.97	33.46	-22.18	14.21	-9.19	33.30	-17.93	12.22	-18.23
33.78	-16.64	11.51	-9.02	33.46	-23.17	14.12	-9.19	33.30	-18.97	12.22	-19.22
33.78	-17.69	11.44	-9.02	33.50	-24.16	14.04	-9.19	33.28	-20.01	12.22	-20.21
33.80	-18.74	11.36	-10.07	33.50	-25.16	13.95	-9.19	33.28	-21.05	12.14	-21.21
33.80	-19.79	11.29	-10.07	33.50	-26.15	13.87	-10.19	33.30	-22.07	12.05	-22.20
33.80	-20.84	11.29	-11.11	33.50	-27.14	13.78	-10.19	33.30	-23.10	12.05	-23.19
33.80	-21.89	11.22	-11.12	33.50	-28.14	13.70	-10.19	33.30	-24.14	12.05	-24.19
33.80	-22.93	11.15	-11.12	33.50	-29.13	13.61	-10.19	33.30	-25.17	11.97	-25.18
33.82	-23.99	11.08	-11.13	33.50	-30.12	13.53	-11.18	33.30	-26.20	11.88	-26.18
33.82	-25.04	11.08	-12.17	33.50	-31.12	13.44	-11.18	33.32	-27.23	11.88	-27.17
33.82	-26.08	11.01	-13.22	33.50	-32.11	13.36	-12.17	33.32	-28.26	11.80	-28.16
33.82	-27.13	10.94	-13.22	33.50	-33.11	13.27	-12.17	33.34	-29.28	11.80	-29.16
33.84	-28.19	10.87	-13.22	33.50	-34.10	13.19	-12.17	33.34	-30.32	11.71	-29.16
33.84	-29.24	10.80	-14.27	33.50	-35.09	13.10	-12.17	33.36	-31.34	11.71	-30.15
33.84	-30.28	10.73	-15.32	33.50	-36.09	13.02	-12.17	33.38	-32.36	11.71	-31.14
33.84	-31.33	10.66	-15.32	33.50	-37.08	12.93	-12.17	33.38	-33.40	11.71	-32.13
33.84	-32.38	10.59	-15.33	33.50	-38.07	12.85	-12.17	33.40	-34.42	11.63	-33.13
33.84	-33.42	10.52	-15.33	33.50	-39.07	12.76	-13.17	33.42	-35.44	11.63	-34.12
33.84	-34.47	10.45	-16.38	33.50	-40.06	12.67	-13.17	33.42	-36.48	11.63	-35.11
33.84	-35.52	10.38	-17.42	33.50	-41.06	12.59	-13.17	33.42	-37.51	11.63	-36.10
33.84	-36.57	10.38	-18.46	33.50	-42.05	12.50	-13.17	33.44	-38.53	11.54	-37.10
33.84	-37.61	10.38	-19.51	33.50	-43.04	12.42	-13.17	33.44	-39.57	11.54	-38.09
33.84	-38.66	10.38	-20.55	33.54	-44.03	12.33	-14.16	33.44	-40.60	11.46	-39.09
33.84	-39.71	10.38	-21.59	33.54	-45.03	12.25	-14.16	33.44	-41.64	11.37	-40.08
33.84	-40.75	10.38	-22.63	33.54	-46.02	12.16	-14.16	33.46	-42.66	11.29	-41.08
33.84	-41.80	10.38	-23.67	33.54	-47.01	12.08	-14.16	33.46	-43.69	11.20	-42.07
33.84	-42.85	10.38	-24.71	33.54	-48.01	11.99	-15.16	33.46	-44.73	11.20	-43.06
33.84	-43.90	10.38	-25.76	33.57	-49.00	11.91	-15.16	33.46	-45.76	11.20	-44.05
33.84	-44.94	10.38	-26.80	33.57	-49.99	11.82	-15.16	33.46	-46.79	11.12	-45.05

Table B1 (continued)

Upwelling (July)				Transition-Oceanic (Sept)				Davidson (Jan)			
2011 Profile		2011 Profile		2004.2 Profile		2004.1 Profile		2011 Profile		2004 Profile	
S (ppt)	Z (m)	T (^oC)	Z (m)	S (ppt)	Z (m)	T (^oC)	Z (m)	S (ppt)	Z (m)	T (^oC)	Z (m)
33.84	-45.99	10.38	-27.84			11.82	-16.15	33.48	-47.82	11.03	-46.05
33.86	-47.05	10.38	-28.88			11.74	-17.14	33.50	-48.84	11.03	-47.04
33.86	-48.09	10.38	-29.92			11.65	-18.14	33.50	-49.87	10.95	-48.03
33.86	-49.14	10.38	-30.97			11.57	-18.14	33.51	-50.90	10.86	-49.03
33.86	-50.19	10.37	-32.01			11.48	-18.14	33.51	-51.93	10.86	-50.02
33.86	-51.23	10.37	-33.05			11.39	-18.14	33.53	-52.95	10.77	-51.01
33.86	-52.28	10.30	-34.09			11.31	-18.14	33.53	-53.99	10.77	-52.01
		10.30	-35.14			11.22	-19.13			10.77	-53.00
		10.30	-36.18			11.22	-20.12			10.69	-53.99
		10.30	-37.22			11.14	-20.12			10.69	-54.98
		10.30	-38.26			11.14	-21.12				
		10.30	-39.30			11.05	-21.12				
		10.30	-40.34			11.05	-22.11				
		10.30	-41.39			11.14	-23.11				
		10.30	-42.43			11.22	-24.10				
		10.23	-43.47			11.31	-25.09				
		10.23	-44.52			11.39	-26.09				
		10.16	-45.56			11.39	-27.08				
		10.16	-46.60			11.39	-28.07				
		10.16	-47.65			11.39	-29.07				
		10.09	-48.69			11.31	-30.06				
		10.09	-49.73			11.31	-31.06				
		10.09	-50.78			11.22	-32.05				
		10.02	-51.82			11.22	-33.04				
						11.22	-34.04				
						11.14	-35.03				
						11.05	-36.02				
						11.05	-37.02				
						10.97	-38.01				
						10.88	-39.01				
						10.88	-40.00				
						10.88	-40.99				
						10.88	-41.99				
						10.80	-42.98				
						10.79	-43.98				
						10.79	-44.97				
						10.71	-45.96				
						10.71	-46.96				
						10.62	-47.95				
						10.62	-48.94				
						10.62	-49.94				
						10.62	-50.93				
						10.62	-51.93				
						10.62	-52.92				
						10.62	-53.91				

APPENDIX C – ANALYSIS RESULTS FOR ADDITIONAL SCENARIOS

FLOW SCIENCE®

Table C1- Analysis results for additional scenarios

NO.	Flow Assumptions (mgd)				TDS Assumptions (mg/L)				Davidson (Jan.)				Upwelling (July)				Oceanic (Sept.)			
	WW	Hauled Brine	GWR Brine	Total Flow	WW	Hauled Brine	GWR brine	Total	Plume diam. (ft)	Min. Dilution	Horiz. Dist. from port (ft)	Height above port (ft)	Plume diam. (ft)	Min. Dilution	Horiz. Dist. from port (ft)	Height above port (ft)	Plume diam. (ft)	Min. Dilution	Horiz. Dist. from port (ft)	Height above port (ft)
Wastewater at design capacity																				
1a	29.6	0.1	0	29.7	800	40,000	4,000	932	23	143	34	75	19	136	31	64	17	126	30	58
1b	24.7	0.1	0.94	25.7	800	40,000	4,000	1069	22	152	31	73	18	144	28	63	17	134	28	57
Sensitivity Analysis: GWR Brine Flow																				
2a	0	0.1	0.41	0.51	800	40,000	4,000	11059	6	240	4	20	12	718	5	41	10	776	5	41
2b	0	0.1	0.82	0.92	800	40,000	4,000	7913	7	231	5	24	13	636	6	48	10	560	6	42
2c	0	0.1	0.3	0.4	800	40,000	4,000	13000	6	240	4	19	9	567	4	32	10	863	4	40
Sensitivity Analysis: Hauled Waste Flow																				
3a	0	0	0.94	0.94	800	40,000	4,000	4000	8	254	5	26	13	651	6	48	10	583	5	42
3b	0	1	0.94	1.94	800	40,000	4,000	22557	7	111	10	21	14	318	12	46	11	291	11	42
3c	3	0	0.94	3.94	800	40,000	4,000	1563	11	209	10	39	14	336	11	54	12	283	10	47
3d	3	0.1	0.94	4.04	800	40,000	4,000	2515	12	206	11	40	14	331	11	55	12	279	11	47
3e	3	1	0.94	4.94	800	40,000	4,000	9344	12	168	13	38	14	277	13	54	12	231	13	47
Sensitivity Analysis: GWR TDS																				
4a	0	0.1	0.94	1.04	800	40,000	4,000	7462	8	226	6	25	13	597	6	48	10	532	6	42
4b	0	0.1	0.94	1.04	1100	40,000	5,800	9088	8	218	6	25	13	592	6	49	10	523	6	42
4c	3	0.1	0.94	4.04	1100	40,000	5,800	3156	11	201	11	39	14	334	11	55	12	271	11	46
Sensitivity Analysis: Hauled Waste TDS																				
5a	0	0.1	0.94	1.04	800	63,000	4,000	9673	7	214	6	24	13	576	6	48	10	509	6	42

All scenarios were analyzed using a 20 °C temperature for the combined flow discharging from 120 open ports. Analysis results are at plume trap levels.