APPENDIX G

SOUTH BAY OCEAN OUTFALL PLUME TRANSPORT MODELING

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TECHNICAL MEMORANDUM

TO: Patrick Goodwin, Eastern Research Group, Inc. (ERG)

FROM: Matthew Reusswig, PG Environmental

DATE: May 25, 2022

SUBJECT: South Bay Ocean Outfall Plume Transport Modeling

I. Introduction

PG Environmental (PG) was tasked by Eastern Research Group, Inc. (ERG) to analyze the potential for effluent plumes from the South Bay Ocean Outfall (SBOO) to travel to nearby sensitive sites. The SBOO, operated and maintained by the City of San Diego, discharges treated effluent from the South Bay International Wastewater Treatment Plant (ITP) and South Bay Water Reclamation Plant (SBWRP) to the Pacific Ocean at a distance of approximately 3.4 miles offshore at 32° 23.2591 N, 117° 10.9988 W.

II. Description of SBOO Diffuser

The outfall consists of a wye diffuser with a 1,981-foot-long northern leg and a 1,981-foot-long southern leg (see Figure 1). Each diffuser leg is composed of sets of 82 risers, which contain discharge ports, with one riser located on the mainstem of the wye where the two legs meet (165 risers in total). Each riser possesses four ports, which discharge in four directions—both directions along the line of the diffuser pipeline, and both directions perpendicular to the pipeline. There are 660 port holes in total. The diffuser ports are located at a depth of approximately 94 feet below the ocean surface.

According to a recent inspection report (City of San Diego, 2019), the outfall pipe running to the diffuser is approximately 210 degrees (°) to 215° (south south-west facing). The pipe begins at a depth of 71 feet below sea level and ends approximately 90 feet below sea level at the diffuser wye. The north diffuser leg is aligned at 340° (north facing) and the south leg is 185° (south facing).

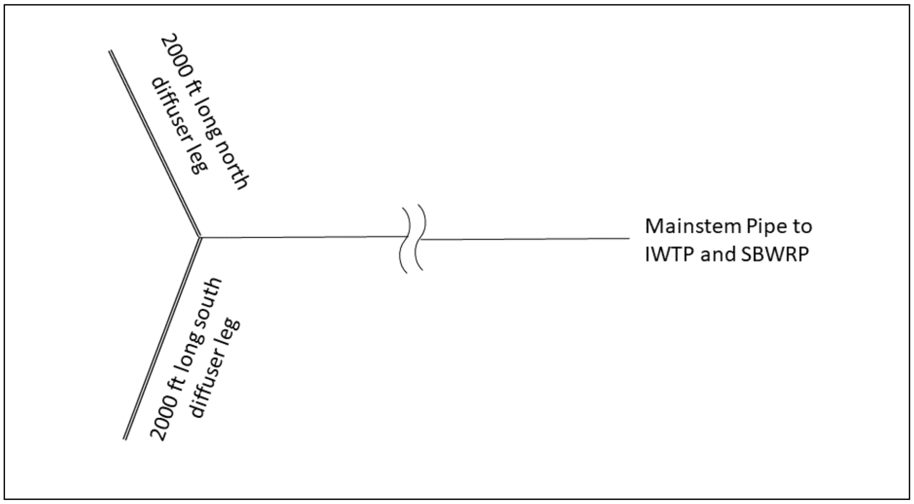

Figure 1. Diagram of SBOO diffuser.

Table 1. SBOO Diffuser Riser and Port Configuration

Diffuser Section	Port Diameter	Riser Count	Port Count [1]	Ports in Active Service
Wye [2]	2.357 inches	1	4	4
South Leg	2.375 inches	26	104	4
	2.500 inches	26	104	4
	2.625 inches	29	116	56
	2.625 inches	1	4	4
North Leg	2.375 inches	26	104	0
	2.500 inches	26	104	0
	2.625 inches	29	116	0
	2.625 inches	1	4	0
	Total	**165 risers**	**660 ports**	**72 ports**

1. Hypothetical port number if all risers were placed into service. At present, only the riser on the wye (four ports) and 17 risers (68 ports) on the south leg are open and operational (total of 72 ports), and all other risers are capped.
2. Point where the legs meet.

Not all port holes are currently in service according to Permit No. R9-2014-009. Of the 165 risers on the diffuser, only 18 risers (72 ports) on the southern leg and the wye are currently in service. The remainder are sealed (i.e., either capped or closed with a blind flange in place of the diffuser head) (City of San Diego, 2019) in order to maintain minimum necessary effluent discharge velocities.

The design hydraulic capacities of the SBOO with all ports open is 174 million gallons per day (MGD) (average) and 258 MGD (peak). According to Permit No. R9-2014-009, the maximum permitted effluent discharge rate through the SBOO is 40 MGD. The permit provides for a 94.6

dilution factor based on the 40 MGD flow rate, using ambient monitoring data dating from 2002 to 2004, and assuming 72 ports are open and functioning.

Upgrades to the facilities that contribute flow to the SBOO are being considered by the United States (U.S.) Environmental Protection Agency (EPA) and the U.S. Section of the International Boundary and Water Commission (USIBWC). This memorandum analyzes the differences in potential pollutant transport from SBOO discharges under the existing operational conditions of the SBOO (with an assumed average daily flow of 35 MGD), and an alternative scenario where the contributing facilities have been upgraded (with an assumed average daily flow of 110 MGD).

III. Methods

Model Structure and Scenarios

Modeling was performed with the UM3 model from the Visual Plumes software suite (Plumes18 edition[1]). The modeling effort was structured into two scenarios:

- Baseline Scenario: Based on current permitted wastewater sources (assumed average daily flow of 35 MGD) and discharge characteristics.
- Alternative Scenario: Addition of new permitted flows from new or existing plants (assumed average daily flow of 110 MGD, a net 75-MGD increase over Baseline[2]; EPA, 2021).

Under each model scenario, a series of nearfield dilution estimates were computed based on a series of ambient depth profiles for density, current speed, and current direction over the period of record. The ambient profile corresponding to May 2019 produced the median nearfield dilution estimate. The nearfield dilution estimates for the two scenarios using the May 2019 ambient profile were linked to results from the Brooks Far Field model in Visual Plumes to estimate pollutant transport phenomena within a 20-kilometer radius of the SBOO under the assumption of no shoreline interactions.

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[1] Visual Plumes is a free outfall modeling software suite developed by EPA and currently distributed in partnership between the State Water Resources Control Board and Walter Frick, the lead software developer/maintainer. Plumes18 edition retrieved on January 5, 2021, from: https://www.waterboards.ca.gov/water_issues/programs/ocean/

[2] The increased flow rates under the Alternative Scenario reflects an assumed future average daily flow that would occur once the full capacity of the expanded ITP comes into service in response to projected population growth in Tijuana, Mexico by 2050. This is intended to present a "worst-case" estimate of the differential impacts of the two scenarios.

Diffuser Input Values—Baseline Scenario

Under the Baseline Scenario, the discharge is modeled using an average daily discharge rate of 35 MGD. The SBOO is configured with 72 open ports—consistent with typical, current day operations at the SBOO.

The UM3 model is not able to replicate the port orientation used at the SBOO (i.e., four ports per riser all oriented 90° or orthogonally from one another). Instead, the diffuser is modeled as a linear diffuser with ports all oriented in the same direction and spaced at one-fourth the distance between risers (i.e., one-fourth of 24 feet is an equivalent distance of 6 feet). This modification is consistent with typical best practices when using UM3 to model diffusers with non-linear structures (EPA, 2003).

As discussed in Section II, the south leg of the diffuser is oriented along a bearing of 185° (south facing). In the UM3 model, all ports were set to discharge orthogonally from the orientation of the diffuser such that the direction of discharge is a bearing of 95° (flowing eastward from the discharge port). The ports on the risers discharge at a flat horizontal angle (i.e., an angle of 0° from the horizontal).

The equivalent average diameter of the ports was estimated by computing the average area of the ports in operations (see Table 1) and then computing the equivalent diameter of circle with this area (2.59 inches). The diffuser ports are located at a depth of approximately 94 feet below the ocean surface.

The total discharge flow rate through the SBOO under the Baseline Scenario is 35 MGD and reflects a long-term average flow condition. Long-term average effluent salinity and temperature for the ITP and SBWRP were modeled based on monitoring data collected between 2015 and 2020 (see Scenario 1B; PG Environmental, 2022). Total dissolved solids concentrations in milligrams per liter (mg/L) were converted to salinity in millimhos per centimeter (mmhos/cm) according to the following formula (University of California: Salinity Management, 2021):

Salinity (mmhos/cm) = Total Dissolved Solids (mg/L) / 640

Total dissolved solids concentrations were converted to equivalent salinity levels using the Visual Plumes unit conversion tool.

Under the Baseline Scenario, the SBOO discharge characteristics related to density were:

- Total dissolved solids = 1,285 mg/L
- Salinity = 2.01 mmhos/cm = 1.19 practical salinity units (PSU)
- Temperature = 23.6° Celsius (C)

Diffuser Input Values—Alternative Scenario

Under the Alternative Scenario, the discharge is modeled using an average daily discharge rate of 110 MGD. The configuration of the SBOO diffuser under this hypothetical situation is not known. Under this modeling exercise, it was assumed all ports on the south leg of the diffuser would be placed into service to accommodate the increased flow rate. Under this assumed configuration, there would be 332 ports in service on the south diffuser leg and on the wye location in total.

In the Alternative Scenario, the diffuser was modeled as a linear diffuser and utilized the same port-spacing and orientation inputs as the Baseline Scenario. The equivalent average diameter of the ports was estimated by computing the average area of the ports in operations (see Table 1) and then computing the equivalent diameter of circle with this area (2.51 inches). The diffuser ports are located at a depth of approximately 94 feet below the ocean surface.

The total discharge flow rate through the SBOO under the Alternative Scenario is assumed to be 110 MGD and reflects a long-term average flow condition. Long-term average effluent salinity and temperature were modeled based on data from the ITP, SBWRP, and new contributing sources like the Arturo Herrera Wastewater Treatment Plant, La Morita Wastewater Treatment Plant, Rio Alamar flows, and collected stormwater (see Scenario 5A; PG Environmental, 2022).

Total dissolved solids concentrations were converted to equivalent salinity levels using the Visual Plumes unit conversion module.

Under the Alternative Scenario, the SBOO discharge characteristics related to density were:

- Total dissolved solids = 1,320 mg/L
- Salinity = 2.06 mmhos/cm = 1.23 PSU
- Temperature = 23.2° C

Ambient Input Values—Baseline and Alternative Scenarios

The San Diego Regional Water Board provided PG with ambient monitoring data (salinity and temperature) on December 11, 2020, for Station I16 near the SBOO. Quarterly depth profiles for salinity and temperature (collected in February, May, August, and November) collected between August 2018 and November 2020 were used in the model to characterize ambient density stratification conditions in the nearfield. Monitoring Station I16 is located where the northern and southern legs of the wye diffuser meet. Refer to Figure 2 for a map of monitoring stations in the vicinity of the SBOO.

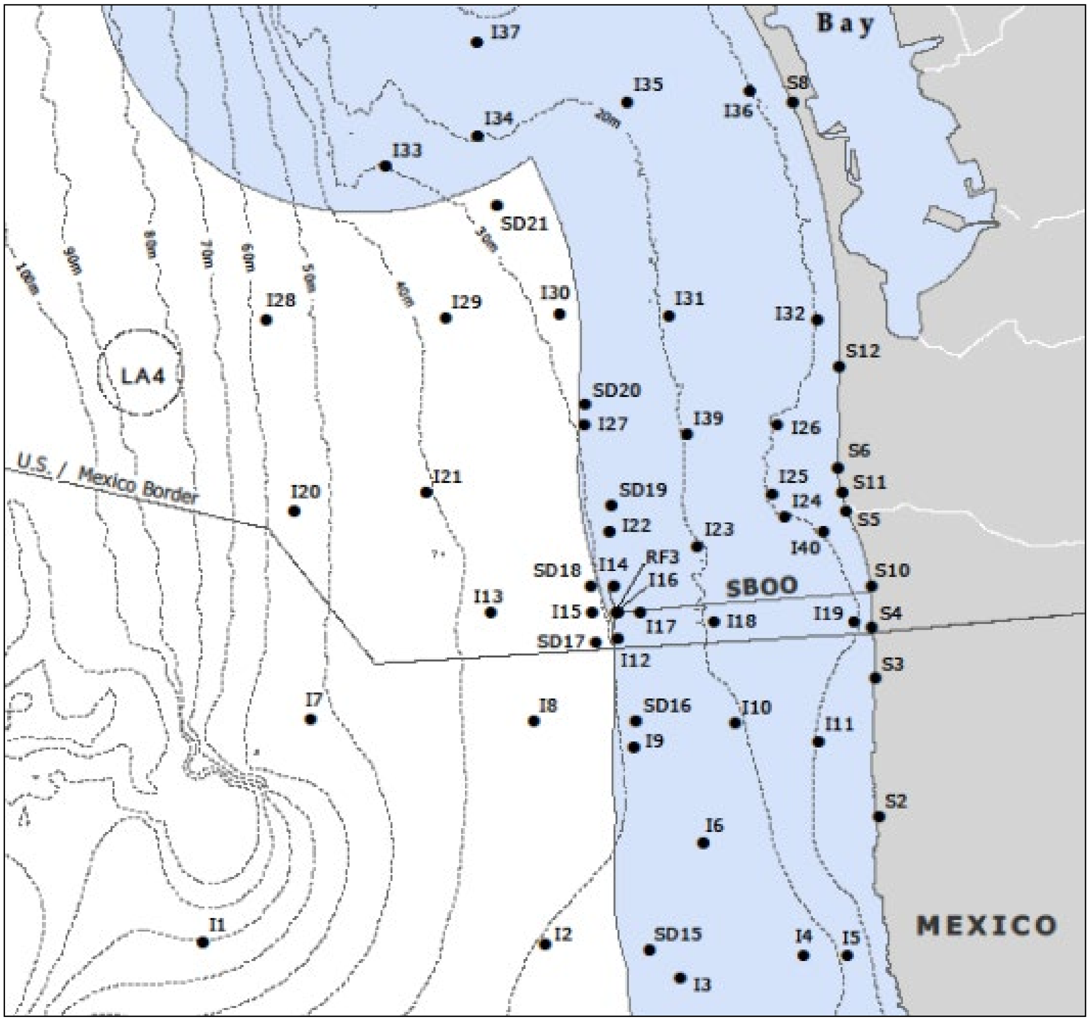

Figure 2. Receiving water monitoring stations in the vicinity of the SBOO. Source: Attachment B to Permit No. R9-2014-0009.

The quarterly ambient monitoring data had relevant data for depths ranging from 0 to 27 meters at 1-meter intervals.

Depth profiles for ambient current speed and direction were estimated for the period of records using data collected from two acoustic doppler current profilers (ADCP) deployed in the vicinity of the SBOO diffuser. The ADCP devices collected high frequency time series current speed and direction data which was aggregated by calendar monthly average for the period of record (August 2018 to November 2020). Current direction was adjusted by +12.8° to correct to true north. Nearfield current speed and direction depth-profiles were paired with density profiles by date.

To estimate potential far-field transport processes over a longer time-period, current speed and direction from the ADCP devices for the period of record were visualized (Figure 3) and the predominant direction of flow was identified. North-south currents predominate, with weaker east-west currents present. Monthly visualizations were also made, which demonstrate currents during the period of record would switch between northerly and southerly current patterns (Figure 4).

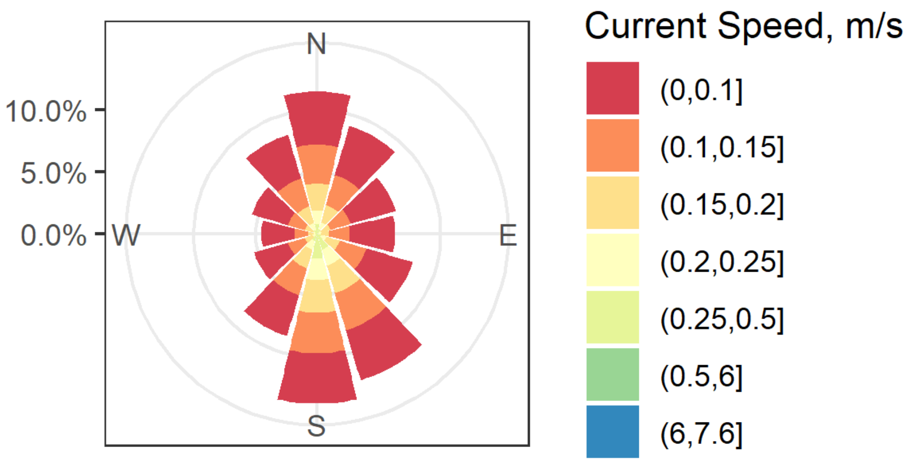

Figure 3. Current speed and direction measurements at the SBOO for total period of record (August 2018 to November 2020). Radius represents fraction of measurements within that speed and direction category.

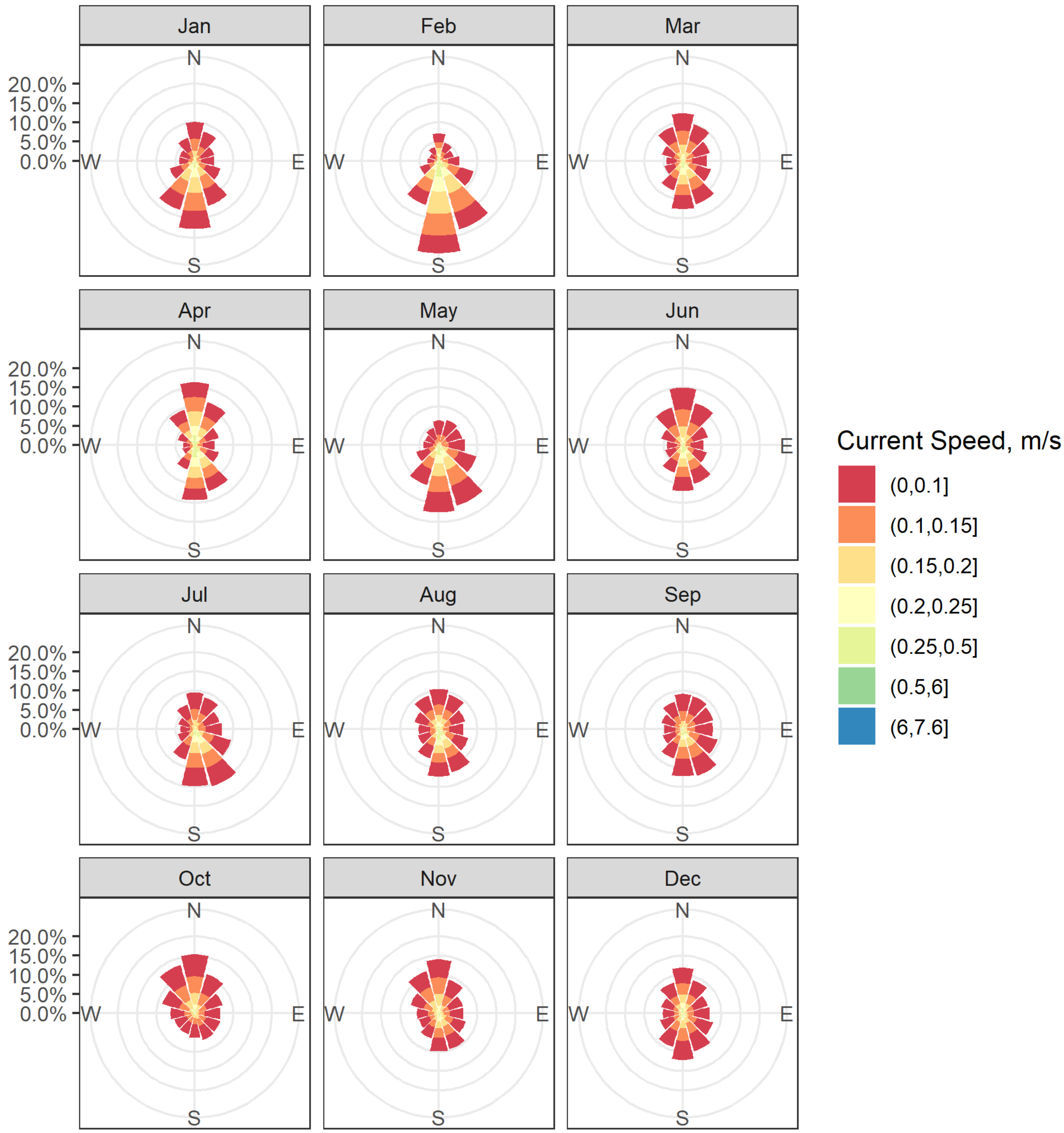

Figure 4. Monthly current speed and direction measurements at the SBOO. Radius represents fraction of measurements within that speed and direction category.

To account for the periodic shifts in current direction, an average current speed was estimated for flows traveling broadly north (bearings between 315° to 45°), east (45° to 135°), south (135° to 225°), and west (225° to 315°):

- North (0° or 360°): 0.124 meters per second (m/s)
- East (90°): 0.105 m/s
- South (180°): 0.146 m/s
- West (270°): 0.102 m/s

Pollutant Decay Rates

The Baseline and Alternative Scenarios were run in the UM3 model for two different pollutants:

- Aldrin—a pesticide with a decay half-life of 576 hours (EPA, 1998) in surface waters. This pesticide had the median decay half-life of all pesticides listed in the source reference document. Half-lives for other pesticides ranged from 57 hours to three years.
- Polychlorinated biphenyls (PCBs)—a group of persistent organic pollutants, which degrade in surface water at a slow rate of 1,450 to 240,000 hours (Sinkkonen et al., 2000) that is unlikely to be observable over the model domain.

When running the UM3 model, aldrin was assumed to decay according to first-order reaction kinetics using the decay half-life of 576 hours ($k = 3.34E\text{-}7\ s^{-1}$; EPA, 1998). PCBs were conservatively assumed not to decay over the model domain ($k = 0$).

IV. Results and Discussion

As discussed in Section III, the Baseline and Alternative Scenarios were modeled using the UM3 model linked with the Brook's far-field diffusion algorithm. Ambient current and density inputs were selected to reflect typical or average conditions. An initial pollutant discharge concentration from the SBOO was assumed to be 100 parts per million (ppm).

Results are graphically presented in Figures 5 through 8 for aldrin and PCBs. As discussed in Section III, boundary conditions—like shorelines—were not considered in the UM3 model. Reported results should only be considered valid for areas of open ocean and should not be considered valid at or near shearlines or areas of land.

Under the modeled scenarios, the results for both pollutants (aldrin and PCBs) were approximately equal since the total first-order decay rates for both pollutants were sufficiently low such that pollutant loss via transformation pathways (i.e., settling, volatilization, photodegradation, biochemical degradation) was negligible over the model domain. In addition to aldrin, PG reviewed decay rates for: chlordane, dieldrin, endrin, methoxychlor, heptachlor, dicofol, isodrin, trifluralin, and toxaphene (EPA, 1998). Reported composite surface water decay rates for all reviewed pesticides were sufficiently low such that pollutant losses are expected to be negligible over the model domain.

The model predicts that receiving water concentrations under the Alternative Scenario (i.e., higher loading scenario) will be lower (i.e., more diluted) than the Baseline Scenario in a radius of approximately 500-meters surrounding the outfall. This phenomenon could be due, in part, to the increase in effective length of the diffuser achieved by bringing more ports into service to accommodate additional flow. Another contributing factor is the differences in effluent density under the Baseline and Alternative Scenarios.

As the plume extends farther into the far-field, the slower rate of diffusion under the Alternative Scenario results in a reversal—i.e., concentrations under the Alternative Scenario are expected to be higher than under the Baseline Scenario at any given location. Since both scenarios utilize the same ocean current inputs, this differential in the dilution entrainment rate is likely to be driven by differences in the scale of the plume width at the point when the wastefield transitions from the nearfield mixing processes (i.e., mixing primarily due to discharge-induced momentum) to far-field mixing processes (i.e., ocean current driven diffusion). A larger initial plume width will result in lower rates of receiving water entrainment when ocean currents mixing processes dominate. As noted in the discussion of far-field ocean current mixing in Fischer et al. (1979, pg. 411), it is sometimes the case that "further dilution [in the far-field] by ocean turbulence is relatively minor for large diffusers while it can be effective for small diffusers" assuming all other significant factors are equal.

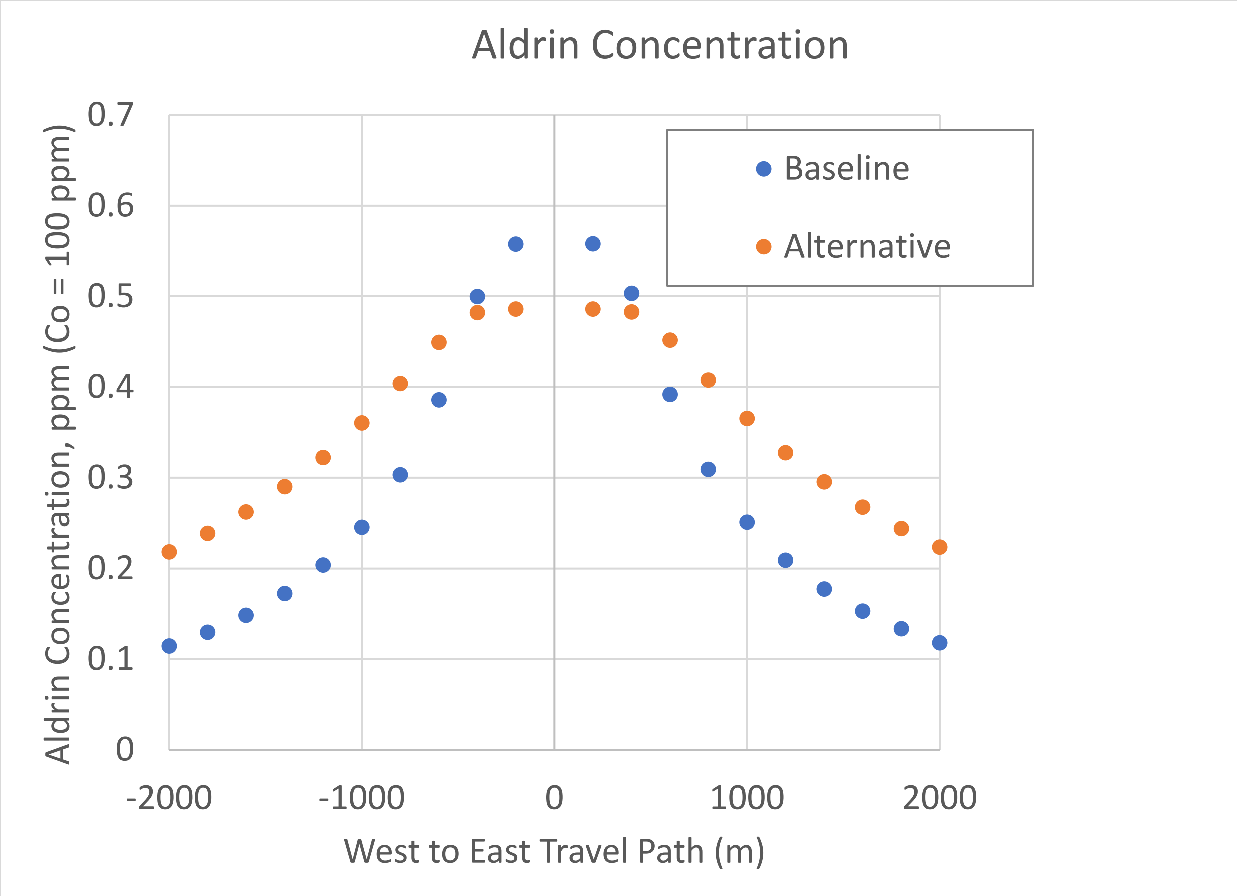

Figure 5. Estimated far-field aldrin concentrations along a west-east axis from the SBOO.

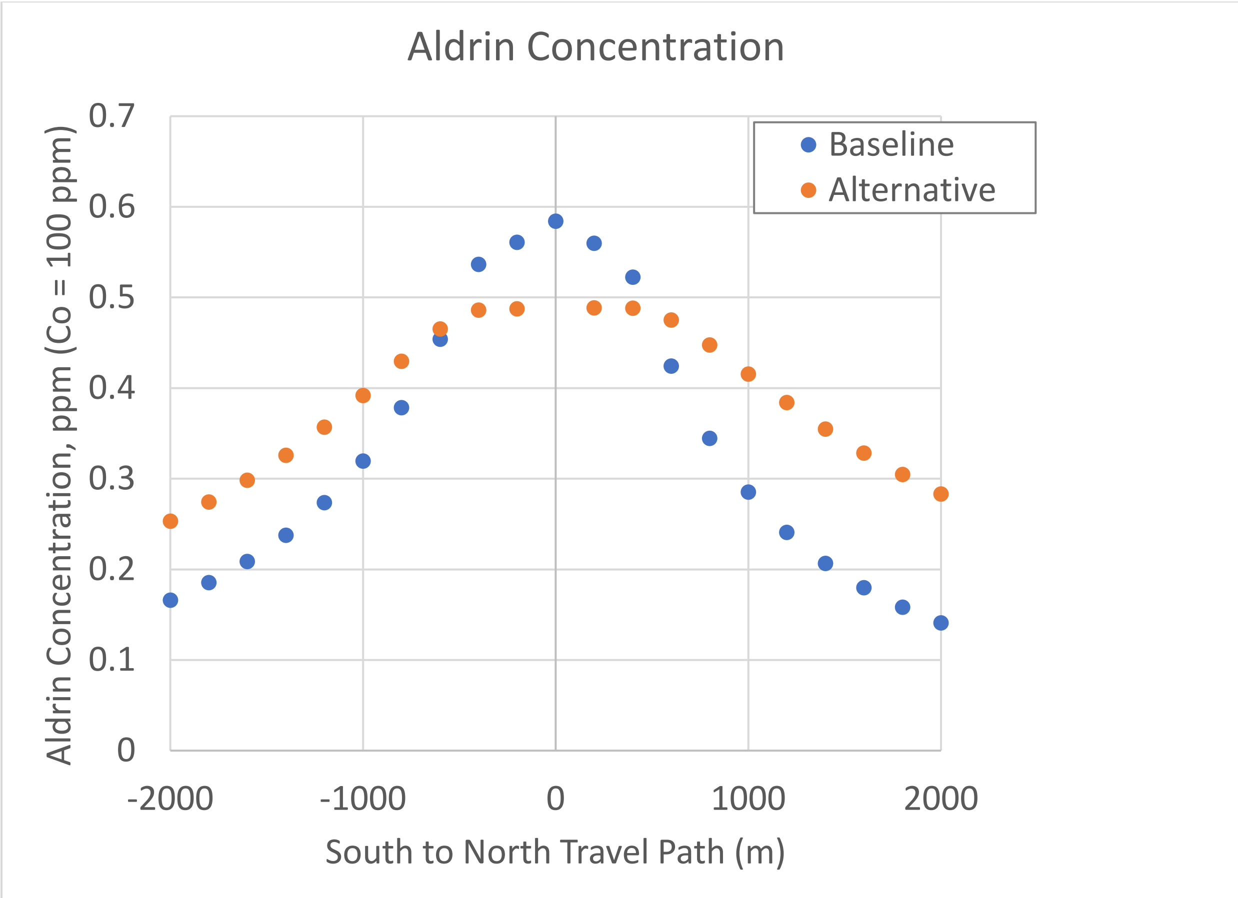

Figure 6. Estimated far-field aldrin concentrations along a south-north axis from the SBOO.

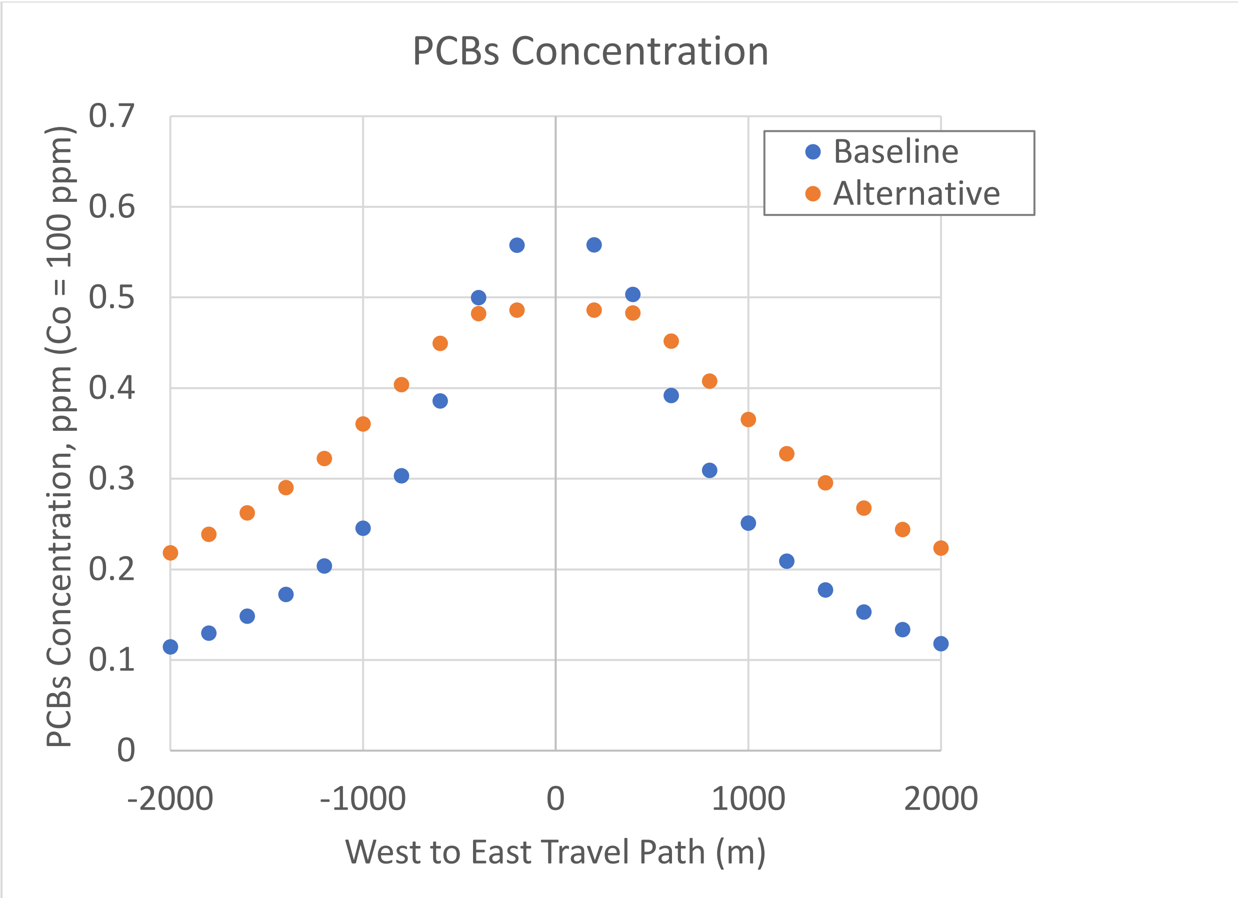

Figure 7. Estimated far-field PCB concentrations along a west-east axis from the SBOO.

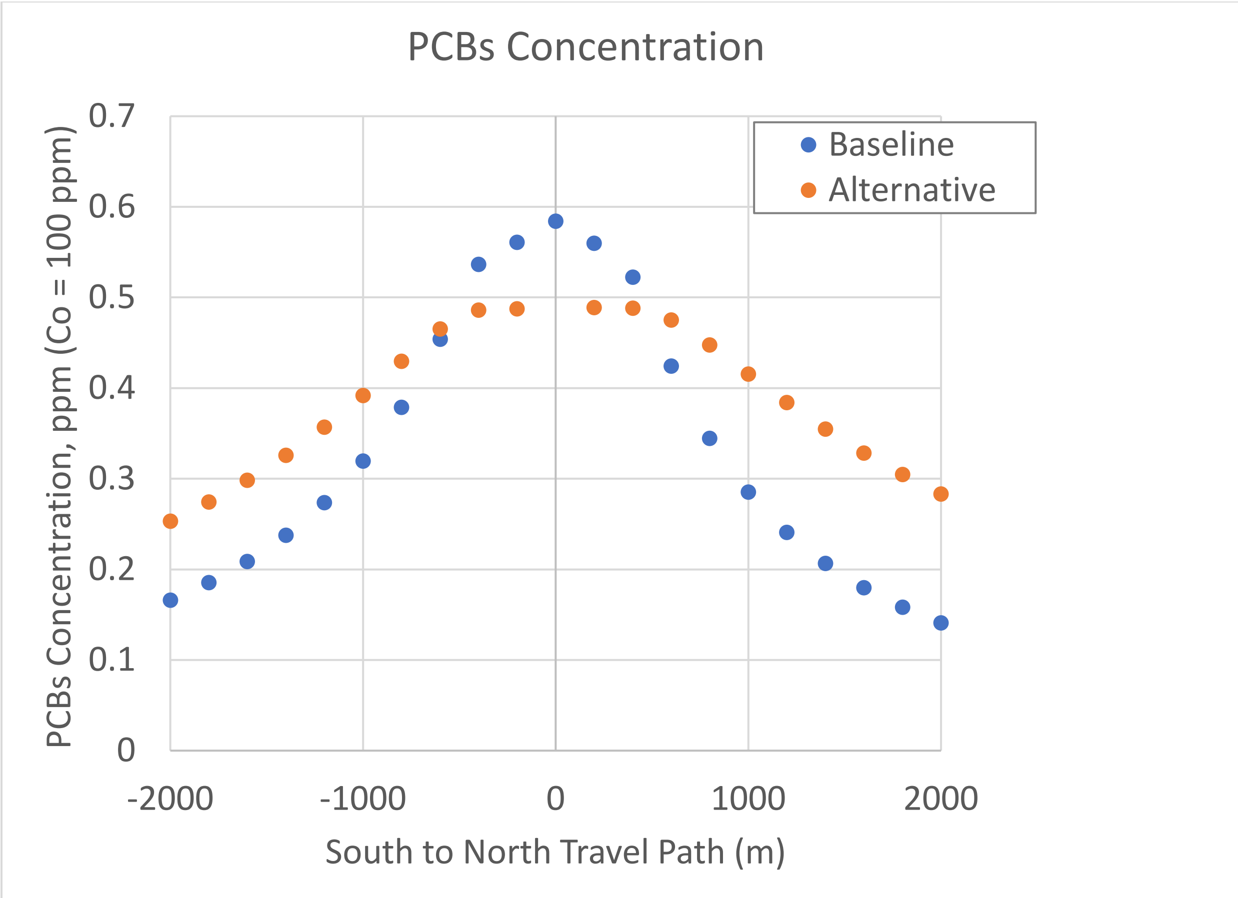

Figure 8. Estimated far-field PCB concentrations along a south-north axis from the SBOO.

References

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