APPENDIX AC

Supplemental Report on the Effects of a Retrofitted Diffuser on the Discharge Outfall for the Ocean Desalination Project at Huntington Beach, CA

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The Ocean Desalination Project at Huntington Beach, CA utilizes existing infall and outfall infrastructures at the AES Huntington Beach Generating Station. As presently configured, the offshore intake tower at this facility is fitted with a velocity cap while the discharge tower is not. Consequently the discharge stream produces a single jet directed vertically upward, creating a boil on the sea surface that is visible from the shoreline. All hydrodynamic analysis is based on this existing infrastructure to determine the dilution and dispersion of the concentrated sea salts that would be added to the discharge stream by the proposed desalination plant (REIR, 2005; Jenkins and Wasyl, 2004, revised 2010). This supplement provides several hydrodynamic model results to examine how dilution and dispersion of these concentrated sea salts might be altered by the addition of a diffuser to the existing discharge tower.

There are perhaps hundreds of diffuser designs used in ocean outfalls, but only a handful would be practical for retrofitting to the existing outfall tower of the AES Huntington Beach Generating Station. These diffuser designs are constrained by the hydraulic design parameters of the existing sea water circulation system, in particular the design pressure and gradient along the discharge pipeline. The existing discharge pipeline was not designed for high levels of pressure, which immediately rules out conventional multi-ported diffusers that utilize many small diameter diffuser ports to create high velocity, super-critical discharge jets to induce initial dilution. If retrofitted to the discharge tower, such designs would result in too much back pressure for the existing pipeline to maintain structural integrity. The existing discharge tower produces a discharge point about mid-depth in the water column, making the retrofit of a conventional diffuser with lateral discharge arms infeasible from a structural strength and support perspective. Given these structural limitations of the existing infrastructure, it appears that the only viable diffuser concept is a velocity cap retrofitted to the discharge tower, identical to the one that already exists on the intake tower (see Figure 1.2, App-C, REIR, 2005). A velocity cap would provide 4 lateral diffuser ports with rectangular cross section, producing 4 horizontal discharge jets. We assume these jets are oriented in the cross-shore and along shore directions, parallel to the walls of the discharge tower. Even so, the gap between the velocity cap and the flat of the opening atop the discharge tower can not be made less than 3 ft, per original design specifications, (Drawing #545486, cf. Figure 1.2, App-C, REIR, 2005) due to the necessity of avoiding excessive back pressure in the discharge pipeline. With the velocity cap added, the discharge cross-sectional area is reduced from its present 346.5 ft^2 to 225 ft^2. Consequently, discharge velocities will increase from 0.34 ft/sec directed vertically upward for low-flow and stand-alone operations without a velocity cap, to 0.53 ft/sec directed horizontally with a velocity cap. For flow augmented stand-alone operations utilizing 152 mgd of source water intake flow rate, discharge velocities will increase from 0.46 ft/sec for low-flow without a velocity cap, to 0.70 ft/sec with a velocity cap.

Figure-1 illustrates the bottom salinity distribution if the velocity cap diffuser were retrofitted to the *low-flow* event scenario in Figure 4.3 of App-C, REIR, 2005. Figure-2 shows the corresponding results for the bottom dilution factors with the velocity cap diffuser, that compare with Figure 4.8 of App-C, REIR, 2005. Figure-3 compares the salinity with distance averaged over all directions away from the outfall. These comparisons indicate that the velocity cap diffuser would cause faster dilution of the sea salts beyond 600 ft from the outfall (far-field), but would result in higher salinities on the seafloor within 600 ft from the outfall (near-field). The velocity cap diffuser eliminates the hyper-saline surface boil and increases the dilution factor at the shoreline from 32 to 1 to 38 to 1. However, these favorable far-field and inshore effects produced by the diffuser are overshadowed by increased benthic impacts near the outfall. A comparison of Figure 3 shows that the diffuser would increase maximum seabed salinity at the base of the outfall from 48.3 ppt to 50.0 ppt for the *low-flow* event scenario, and a comparison of Figure 1 with Figure 4.3 of App-C, REIR, 2005 shows that the benthic area experiencing a 10% increase in salinity or more would increase from 15.6 acres to 20.5 acres. The short coming of the velocity-cap diffuser is that it limits the dilution volume to only the lower half of the water column near the outfall where salinity is highest. Without the velocity cap this hyper-saline discharge takes a vertical trajectory toward the sea surface, forming a surface boil, before subsiding back to the seafloor, passing through the full depth of the water column in the immediate neighborhood of the outfall, and thereby increasing the nearfield dilution.

In Figure 4, the bottom salinity profiles for flow-augmented stand alone operations at 152 mgd using the worst-case mixing conditions of the *low-flow* event scenario. These results also show higher salinity near the discharge tower with a velocity cap than without a velocity cap; although the salinity is lower due to the reduced end-of-pipe salinity (49.9 ppt) that is a result of higher intake flow. Figure 4 shows that maximum seabed salinity at the base of the outfall is 44.2 ppt without the velocity cap diffuser, and increases to 45.6 ppt with the addition of the velocity cap; while the benthic area experiencing a 10% increase in salinity or more would increase from 11.1 acres to 14.3 acres.

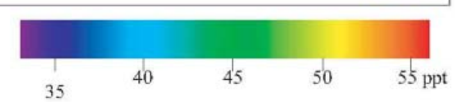
In conclusion, in all cases of co-located and stand-alone operation studied by hydrodynamic modeling, a velocity cap diffuser provides mixed benefits with an increased brine dilution at the shoreline and in the farfield (beyond 600 ft- 1000 ft distances from the outfall). However, these velocity cap benefits occur at relatively benign salinity and are overshadowed by increases in the seabed salinity near the outfall.

References:

Jenkins, S. A. and J. Wasyl, 2004, revised 2010 "Hydrodynamic modeling of source watermake-up and concentrated seawater dilution for the ocean desalination project at the AES Huntington Beach Generating Station," Appendix-C in REIR, 2005, 298 pp.

REIR, 2005, "Re-circulated Environmental Impact Report Sea Water Desalination Project at Huntington Beach," City of Huntington Beach, prepared by RBF Consulting, April 5, 2005, 10 sections + append.

Figure 1. Bottom Salinity for low-flow operations with velocity cap: R.O. = 50 mgd, intake flow rate = 126.7 mgd, worst-case mixing conditions (cf. App-C, REIR,2005).



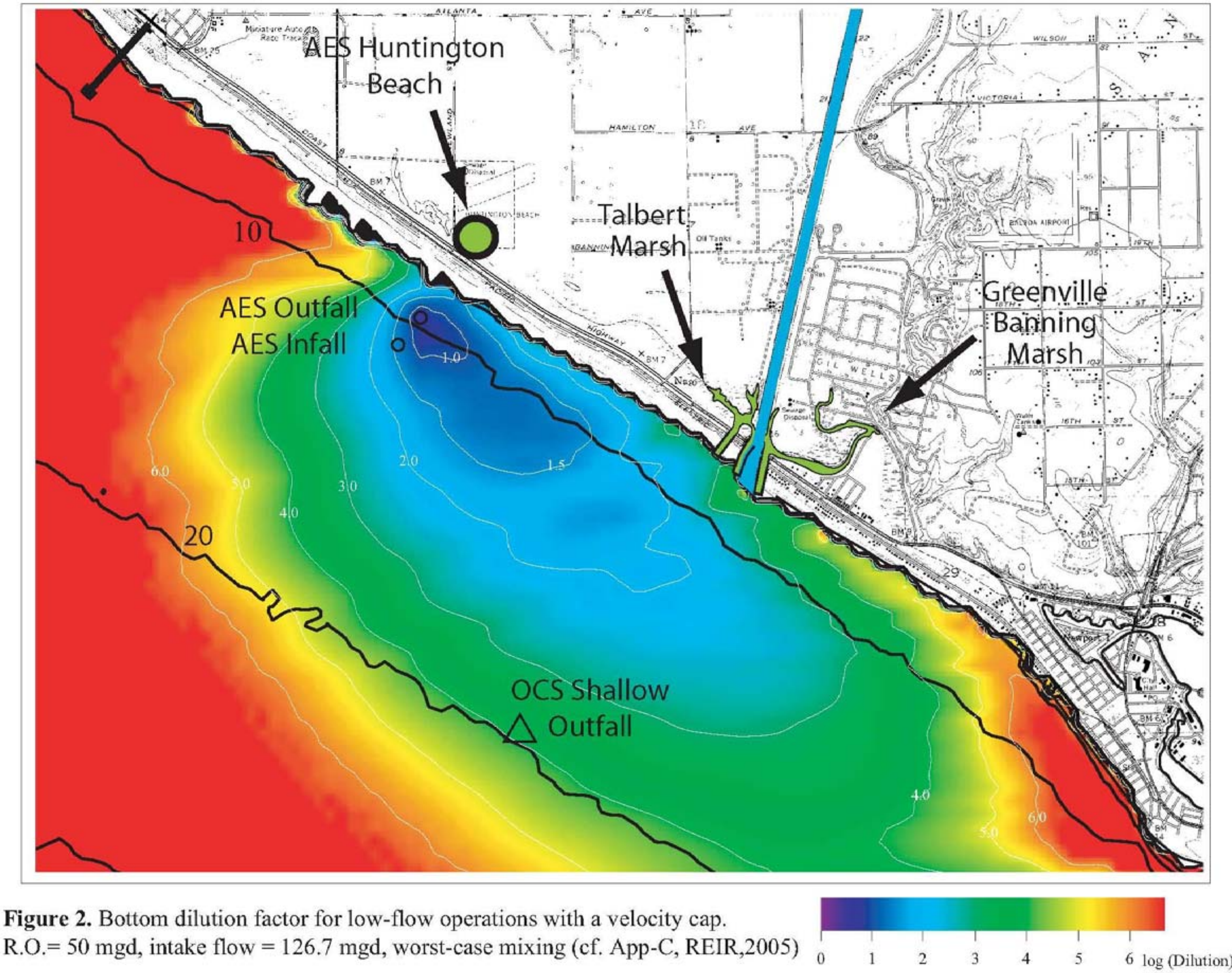


Figure 2. Bottom dilution factor for low-flow operations with a velocity cap.
R.O.= 50 mgd, intake flow = 126.7 mgd, worst-case mixing (cf. App-C, REIR,2005)

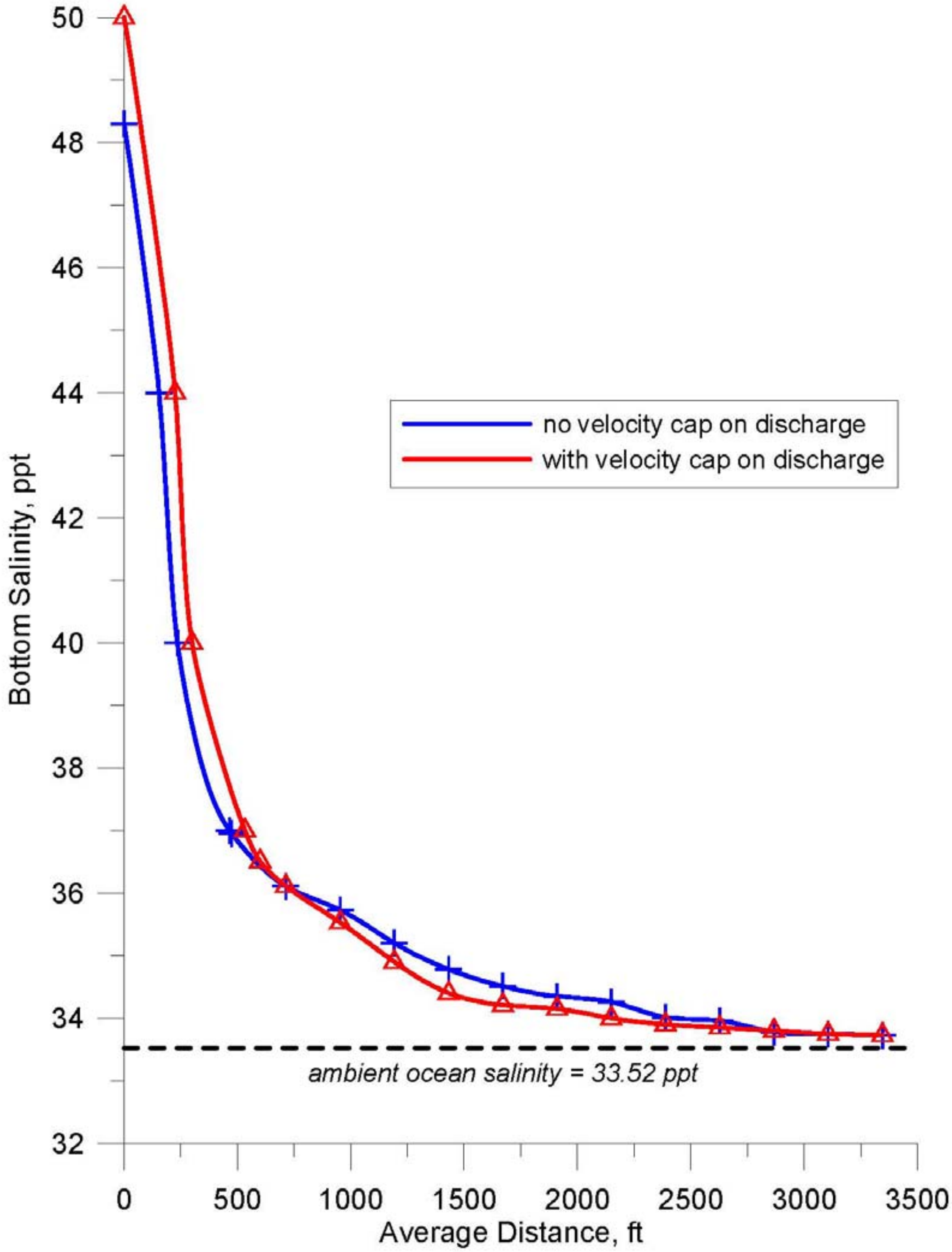


Figure 3. Bottom salinity vs. average distance from discharge for low flow operations without velocity cap (blue) and with velocity cap (red), based 126.7 mgd intake flow rate, 50 mgd R.O. production rate and worst case mixing conditions in receiving water (cf:App-C,REIR, 2005).

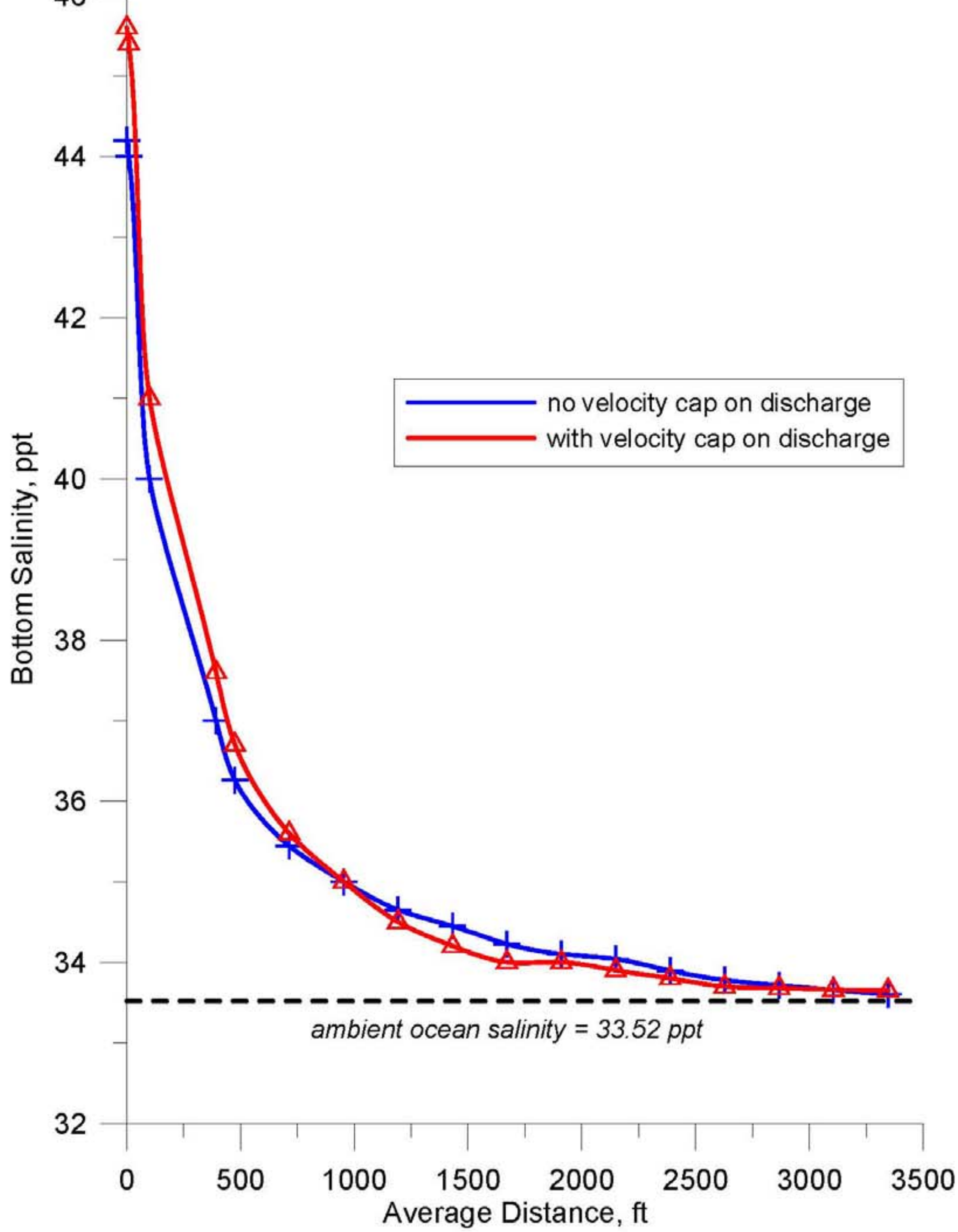


Figure 4. Bottom salinity vs. average distance from discharge for flow-augmented stand-alone operations without velocity cap (blue) and with velocity cap (red), based on 152 mgd intake flow rate, 50 mgd R.O. production rate and worst case mixing conditions (cf:App-C,REIR, 2005).

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