SECTION 9: Wastefield From OCSD Deep Outfall

9) Wastefield From OCSD Deep Outfall

A) Initialization

The outfalls for the Orange County Sanitation District Treatment Plant No. 2 are located offshore of the mouth of the Santa Ana River. The deep outfall is at 33°34'36"N, 118°00'36" W indicated by the inverted triangle in Figure 1.3 (OCSD, 1999). The shallow 78" emergency outfall is indicated by the regular triangle in Figure 1.3 located at 33°36'56"N, 117°58'13"W. The emergency outfall has never been operated since construction of the deep outfall, and will therefore be omitted from any analysis herein. The deep outfall of the OCSD Treatment Plant No. 2 is located on the broad shelf region of the Newport Coast at a depth of 195 ft (59 m). This discharge depth is well below the inter-annual maximum depth excursions of the surface mixed layer. The 120" diameter deep outfall has a certified maximum discharge rate of 480 MGD, and achieves an initial dilution at its diffusers of 148 to 1 (see OCSD, 1999).

For these initial dilutions, effluent from the deep outfall will rise vertically in the water column no higher than the pycnocline (thermocline), where the discharge plume will subsequently "pancake," spreading laterally but unable to rise into the warmer, more buoyant waters of the surface mixed layer (Figure 9.1). Ocean temperature monitoring of the nearshore waters around the outfall indicate that the typical inter-annual variation in the mean thermocline depth is between -15 m and -30 m MSL (OCSD, 1993, 2000). On the other hand the infall for the Huntington Beach Generating Station is located 5.6 m below the mean ocean surface and is therefore usually above the thermocline in the surface mixed layer. Under normal oceanographic conditions the generating station infall and OCSD deep outfall remain segregated in two different water masses by ocean

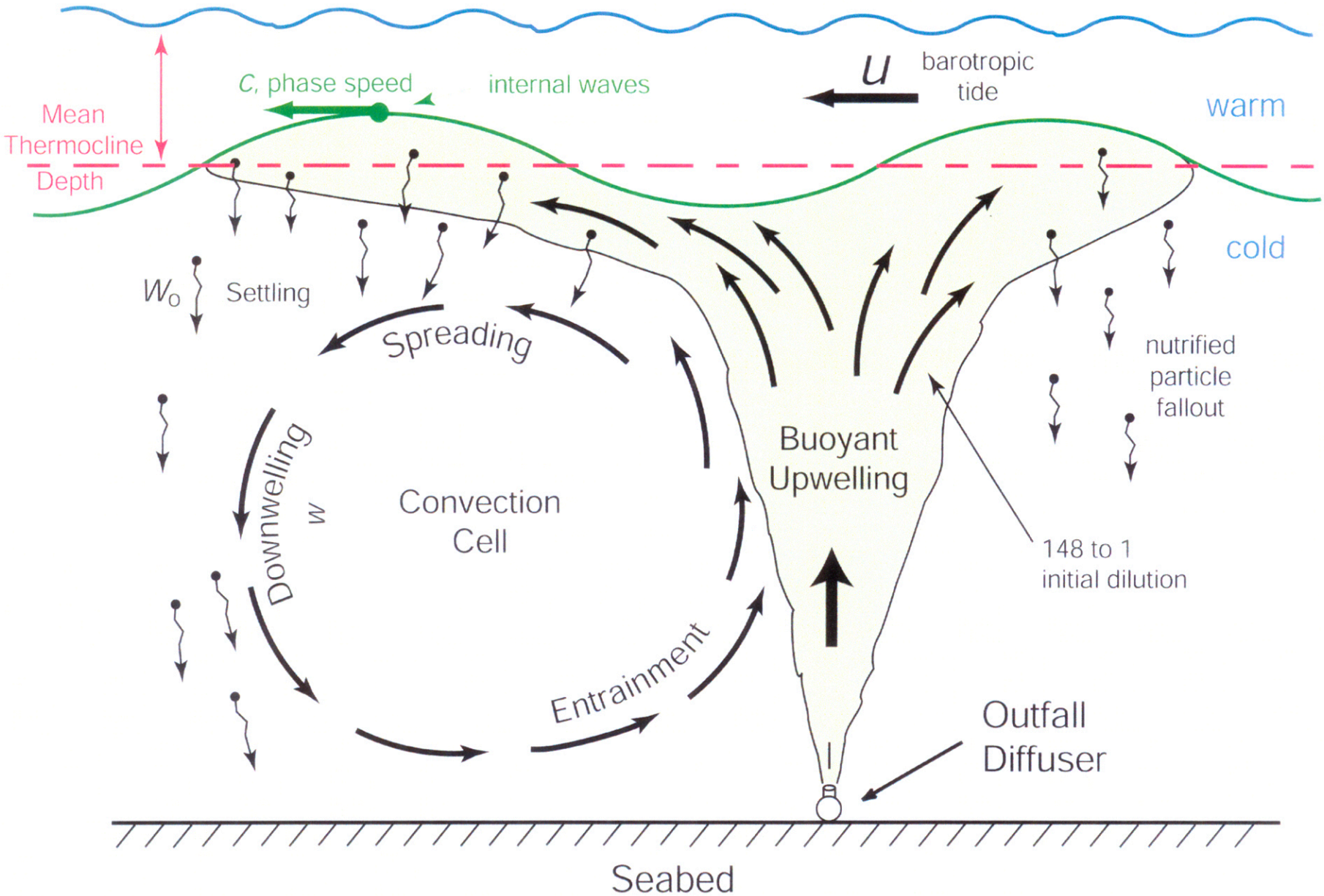


FIGURE 9.1. Schematic diagram of convection cell set up by the rising buoyant plume of treated sewage effluent from the OCS deep outfall diffuser.

stratification with no appreciable exchange between those water masses. Furthermore, currents over the middle shelf are typically ebb dominated with a net mass transport downcoast to the southeast (Figure 3.16 in Section 3). Therefore discharges from the outfalls of the OCSD Treatment Plant No. 2 are normally advected **away** from the infall of the Huntington Beach Generating Station by the predominant wave and tidal transport.

In this section we simulate a combination of atypical conditions that would provide the maximum likelihood scenario for the dispersion of the OCSD wastefield toward the AES infall. These conditions include:

1) Discharge from the OCSD deep outfall at maximum rate certified under NPDES permit restrictions (480 mgd);
2) A shallow thermocline depth such that the velocity cap of the AES infall is periodically below the thermocline in the presence of internal waves;
3) A current regime with net transport directed upcoast toward the northwest;
4) End of pipe total coliform counts at the mid to high end of operational ranges prior to OCSD disinfection resolution, (OCSD, 2002)

5) AES Infall operating at maximum flow rate (506.9 mgd), with maximum certified intake velocity of 2 ft/sec (NPDS Permit, CRWQCB, 1993). Conditions (1) and (4) maximize source loading and bacterial emissions from the OCSD outfall, (even though OCSD has been disinfecting it's discharge since 2002). Condition (2) allows the infall to draw from the same water mass as the wastefield by placing the infall under the density discontinuity that caps the rise of wastefield. Condition (3) provides for current advection from the OCSD outfall toward the AES infall. The

simultaneous occurrence of these atypical conditions is extremely rare because they tend to be mutually exclusive. For instance, the reversal of the net coastal transport (3) is more common during an El Niño, while the shallow thermocline depth is a summer La Niña condition (Section 3). The operation of the outfall at the maximum certified discharge rate of 480 mgd (1) is primarily a wet weather, winter time procedure resulting from the infiltration of surface runoff into the sewer conveyance system, (OCSD, 1999). On the other hand, coliform levels in the discharge typically reached maximum values (prior to adopting the disinfection resolution) in the summer when discharge rates and in-the-pipe dilution volumes are lowest. If we treat these factors as independent variables with the El Niño and La Niña return periods of 3 to 7 years and the remaining factors as annual, then the simultaneous occurrence of these atypical conditions is no less than a once in 9 year event, and perhaps as rare as a once in 49 year event. Because the probability for these conditions all happening together is low, the persistence of this combination is also probably quite low. In addition, the maximum flow rate condition for the AES infall (5) is a hot weather, high user demand condition and is specified concurrent with conditions (1-4) to examine if there is any likelihood of the suction flow of AES entraining or drawing the OCSD wastefield towards the shoreline. We stress that the intent here of evaluating these often mutually exclusive aggravating conditions is to determine if under any conceivable circumstance the wastefield from the OCSD might be ingested by the AES generating station infall and thereby impact the log-r requirements of the RO membranes to be used by the desalination plant.

To initialize the model for the simultaneous occurrence of these atypical conditions, we use wave and tidal currents from the El Niño summer events of

August 1997. The south swells of 7 August 1997 with 2.2 m deep water wave heights from 190° (Figure 3.12 in Section 3) are combined in the model problem with the Perigean Spring tides of 17 August 1997(Figure 3.20 in Section 3). Together this combination of events produces the strongest possible reversal of net transport toward the northwest in both the nearshore and middle shelf regions surrounding the OCSD outfall and the city of Huntington Beach. The mean thermocline depth was set at -10 m MSL. Temperature above the thermocline was set in the model at 20° C and at 15° C below the thermocline. This assignment posses a strongly stratified two-layer system in which mass transport by internal waves will be maximized (Figure 9.1). The OCSD outfall was set to discharge at 480 mgd with end-of-the-pipe total coliform counts varied between 10^7 to 10^8 mpn/100 ml. Ambient ocean background coliform levels were set at 0 mpn/100 ml.

B) Results:

Figure 9.2 shows the suction velocity at the depth of the infall velocity cap (-5.6 m MSL) induced by the AES infall while operating at maximum flow rate (506.9 mgd). Intake velocities are 61 cm/sec at the velocity cap of the infall. However, suction velocity decays rapidly with increasing distance away from the infall tower (where the decay rate is proportional to the inverse of the square of the distance from the infall). Consequently, suction velocity decays to O (0.1 cm/sec) beyond the 15 meter depth contour, and is only 0.0015 cm/sec at the OCSD outfall. On the other hand the onshore velocity component of induced by internal waves was found to range from 5 to 10 cm/sec while the longshore velocity component of the barotropic tides ranges from 10 cm/sec to 50 cm/sec depending on cross-shore position on the shelf (see Figure 3.20 in Section 3). Therefore, at

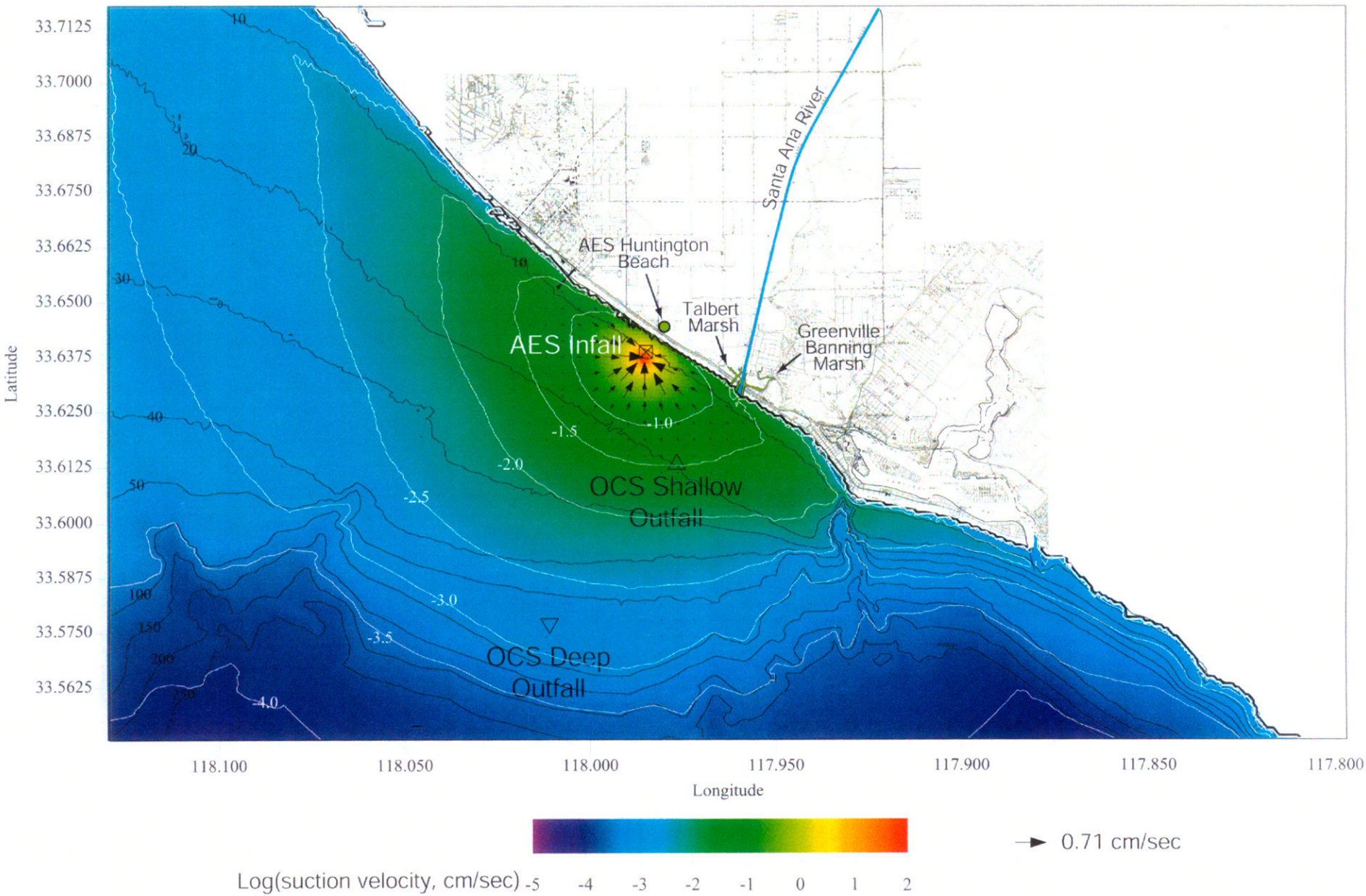
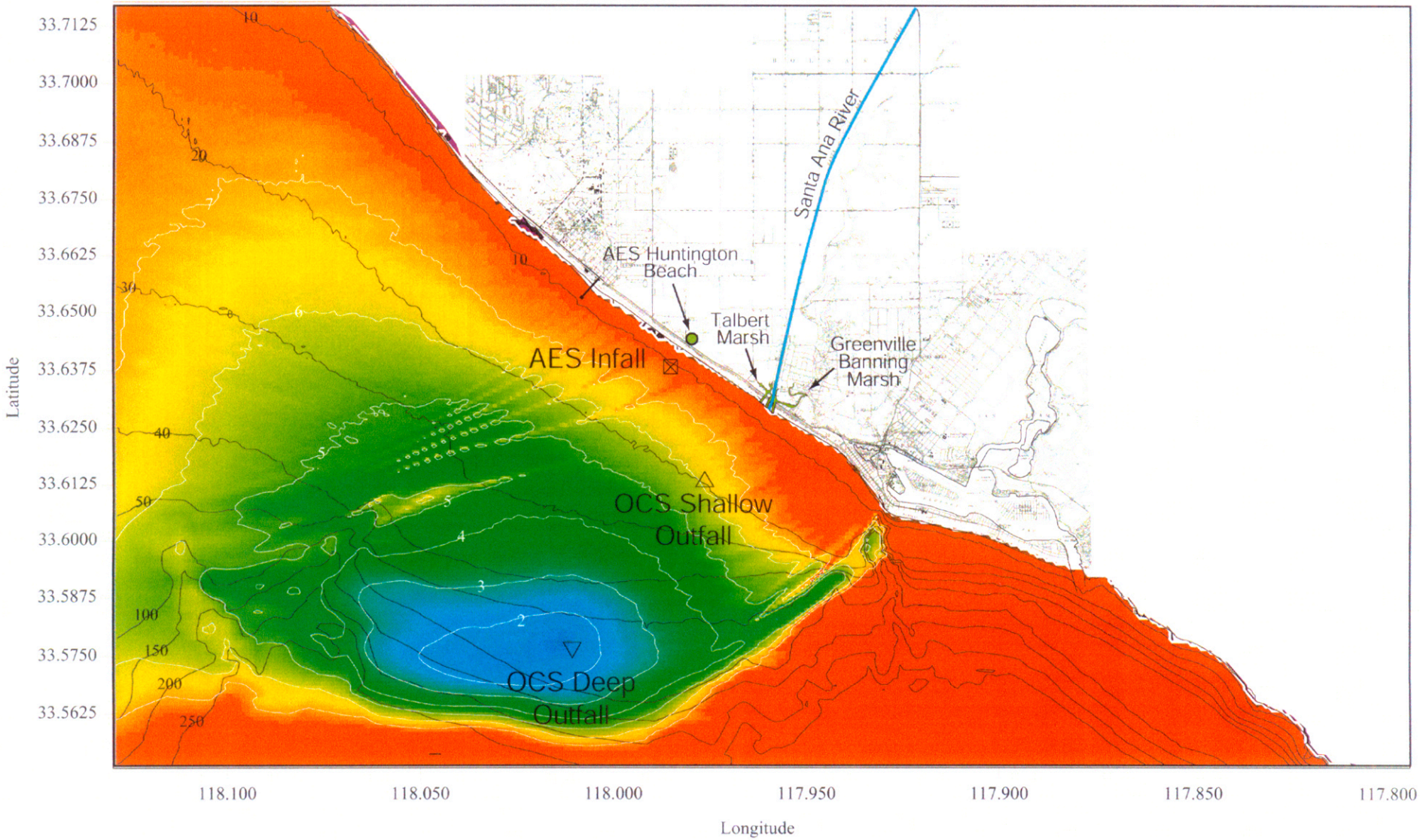


Figure 9.2. Suction velocity field due to AES Infall at maximum flow rate (506.9 mgd). Contours of Log (suction velocity) in cm/sec with progressive vectors relative to scale arrow (lower right corner).

any distance beyond 50 m from the infall, the AES suction velocity is insignificant in comparison to natural transport by the internal waves and barotropic tides.

Figure 9.3 gives a 6 hour average during flood (rising) tide of the dilution field of the OCSD wastefield for these worst case conditions derived from combining the south swells of 7 August 1997 with the spring flood tides of 17 August 1997. The dilution factors for the wastefield are plotted at the depth of the infall velocity cap (-5.6 m MSL). Dilution factors are contoured on a log10 scale. Inspection of Figure 9.3 indicates that the wastefield is diluted to about 30 million to 1 at the AES infall. In general, the shape of the dilution field in Figure 9.3 suggests that the wastefield predominantly moves parallel to the depth contours in the direction of transport of the barotropic tide during the flood tide phase (towards the northwest). This result is consistent with OCSD (1993). In the mid to inner shelf regions, the dilution field shows a rather complex structure associated with the refraction pattern of the shoaling internal waves computed by parabolic equation methods applied to the mild slope equations, (see discussion of the **OCEANRDS** model in Section 2). These waves produce shoreward directed transport during flooding tide with amplitudes that were found to vary typically from 3-5 m. In regions where refraction induced locally higher wave amplitudes, the wastefield is raised higher in the water column resulting in a zone of diminished dilution. Similarly in regions where internal wave refraction produces locally small wave amplitudes, the thermocline remains below the depth of the AES infall velocity cap and the dilution factor at infall depth is high. A particularly active area for shoaling of these internal waves is the Newport Canyon, where internal wave amplitudes were found to be as large as 8 m, raising the thermocline to within 2 m of the sea surface and forming a band of low



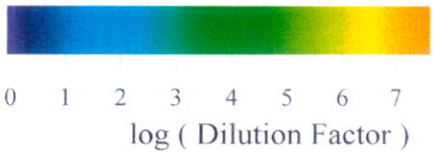


Figure 9.3. Dilution factor at depth of velocity cap due to OCS deep outfall operating at 480 mgd, El Niño conditions (August 1997).

dilution contours $0(10^4)$.

The dispersion of total coliform bacteria from the OCSD outfall (assuming no disinfection) is contoured in Figure 9.4 based on mid-range end-of-the-pipe concentrations of 10^7 mpn/100 ml. Because it is not sensible to count a fraction of an organism, the edge of the wastefield is found in Figure 9.4 to advance no closer to the shoreline than the 15 meter depth contour in front of the AES Huntington Beach generating station, consistent with OCSD (2000). Total coliform counts at the AES infall are found to be non-detectable. We note that the closest the wastefield gets to the shoreline is at the head of the Newport Canyon, about 500 m (1500 ft) from the shoreline.

When the OCSD outfall discharges at maximum flow rates without disinfection at the high-end total coliform levels (10^8 mpn/100 ml), see Figure 9.5, we find that the edge of the wastefield is just offshore of the AES infall. In this case, perhaps 1-3 mpn/100ml total coliforms from the OCSD outfall might be found at the AES infall. However, these counts would be indistinguishable from the ambient ocean background and are therefore neither significant nor detectable. Furthermore, this outcome is not persistent, having a duration of 1/2 of a semi-diurnal tidal cycle (6 hr 12.5 min). With the ensuing ebb tide, the longshore currents of the barotropic tides reverse from what is shown in Figure 3.20 in Section 3 and begin flowing downcoast to the southeast while the crosshore component of the internal waves flows offshore, thereby advecting the wastefield away from the AES infall.

Shoreward transport of micro-organisms by internal waves has been reported in the literature (Pineda, 1991 and 1999). However, these observations have not demonstrated transport reaching the shoreline from an offshore deep-water point

source as distant as 7 km, such as the OCSD outfall.

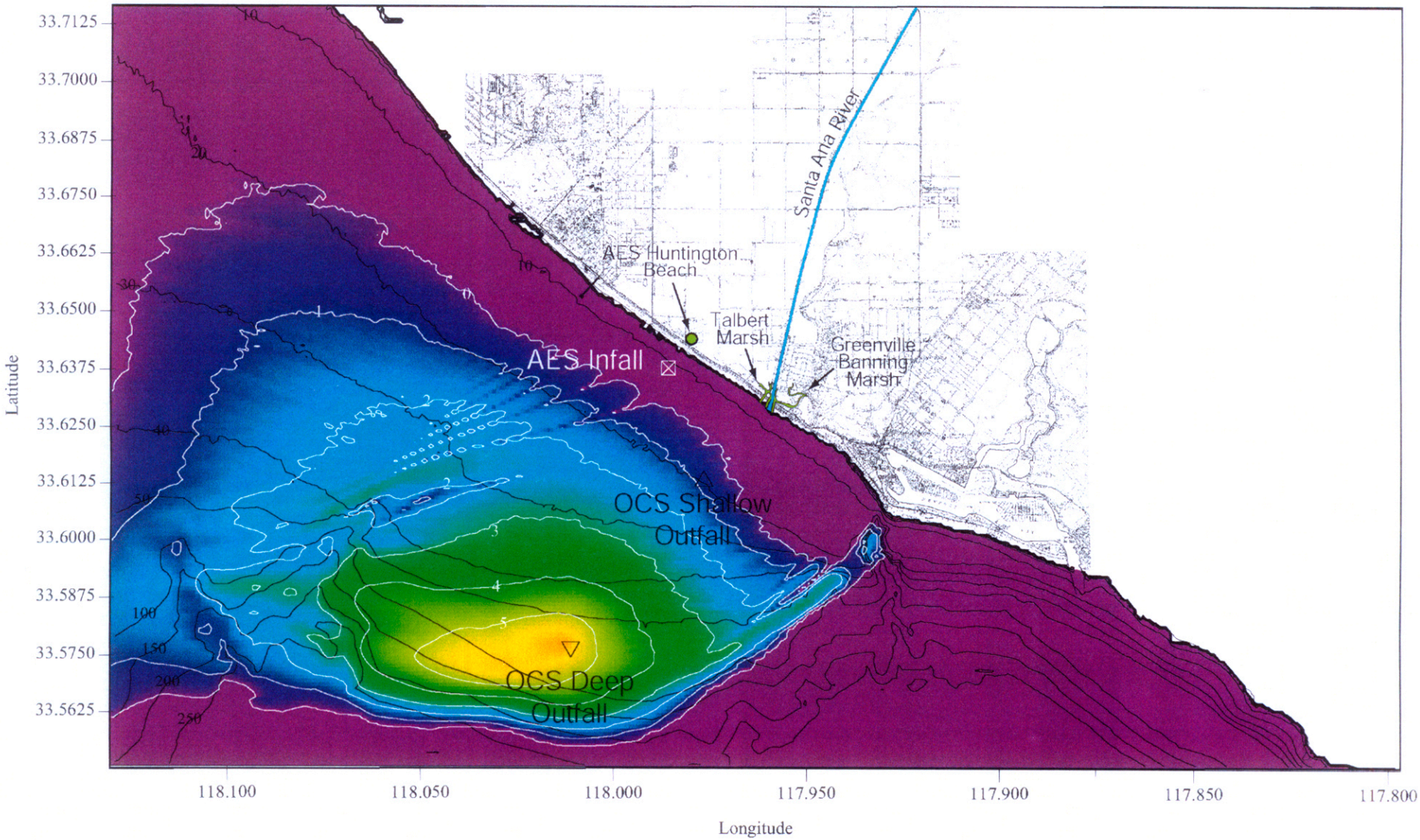
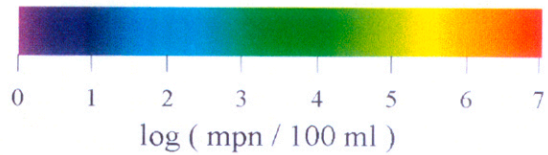
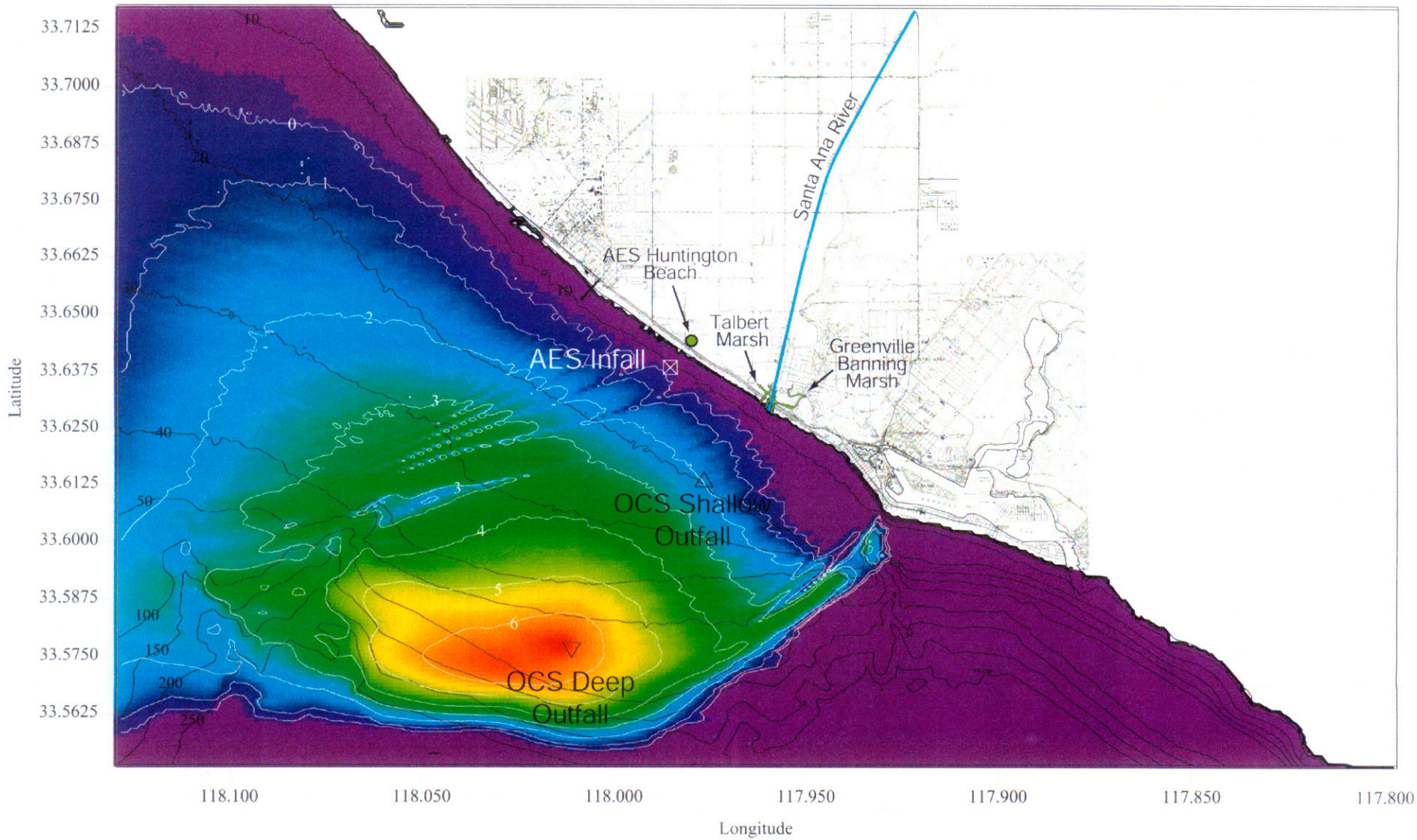


Figure 9.4. Dispersion of total coliform at depth of velocity cap due to OCS deep outfall operating at 480 mgd and 10^7 mpn/100 ml at end of pipe, El Niño conditions (August 1997).





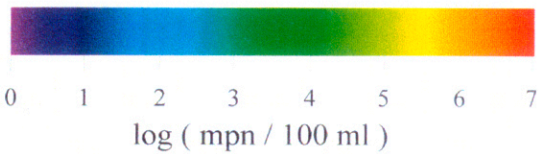


Figure 9.5. Dispersion of total coliform at depth of velocity cap due to OCS deep outfall operating at 480 mgd and 10^8 mpn/100 ml at end of pipe, El Niño conditions (August 1997).