Hydrodynamic Analysis of Near-shore Dispersion and Dilution of Concentrated Sea Water from Closed-Cycle Cooling Systems at Encina Generating Station, Carlsbad, CA

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ABSTRACT:

This study invokes a well-tested and peer-reviewed hydrodynamic model (SEDXPORT) to assess dispersion and dilution of concentrated sea water (brine) arising from the production of make-up water for a closed-cycle cooling system at Encina Generating Station. The make-up water would be produced by a small reverse osmosis desalination system that would draw source water off the existing sea water circulation system at Encina. The source water intake flow will be 3,000 gpm. The make-up water desalination system will draw 848 gpm off this source water stream and will produce 505 gpm of brine by-product. The concentration factor of the 505 gpm of brine is only 1.679, as compared to a concentration factor of 2.0 for the Carlsbad Desalination Project that was issued a certified EIR, (referred to as EIR, 2005, herein). For an average ambient ocean salinity of 33.52 ppt, the salinity of the brine reject from the closed-cycle cooling system will average 56.29 ppt (as compared to 67.04 ppt for brine produced by the Carlsbad Desalination Project). The brine from closed-cycle cooling will be mixed with a residual source water throughput of 2,152 gpm, producing a combined discharge of 2,657 gpm through the jetty fortified discharge channel. The combined discharge in the discharge channel will have an average salinity of 37.84 ppt.

Even for the worst-case outcome (an event with a probability of 0.013% occurrence), the hydrodynamic model analysis finds that hyper-salinity impacts and suppressed dilution rates arising from brine discharge by the closed-cycle cooling system are benign. Nowhere in the nearshore environment do salinity values in the brine plume approach the threshold (38-40 ppt) for hyper-salinity tolerance of local marine organisms. Kelp beds and tide pools to the south of the Encina discharge will experience salinity elevations from brine plume

impingement that are no greater than what occurs inter-annually under natural seasonal fluctuations of ocean salinity. The strictest standards contemplated for discharges from ocean desalination plants under proposed amendments to the California Ocean Plan are generally satisfied, even in the worst-case assessment. Only the strictest proposed standard (a 36.5 ppt numeric limit) is slightly exceeded in a small localized area of surfzone seabed amounting to 1.44 acres. The less severe 10% over background standard being proposed for the California Ocean Plan is satisfied everywhere in worst-case. Existing NPDES discharge permit limits on minimum dilution presently applied to thermal effluent are also satisfied everywhere by the brine discharge along the perimeter of the "zone of initial dilution" (ZID) under worst-case conditions.

In addition to the worst-case scenario, as many as 7,523 modeled cases were evaluated using ocean water mass properties and mixing conditions from the same 20.5-year long period of record as used in the certified EIR (2005). From these large numbers of solutions, high resolution histograms (probability density functions) were constructed of salinity and dilution factor. On average, the long term simulations show that only 0.31 acres of the sub-tidal beach face and sandy bottom nearshore habitat immediately seaward of the discharge jetties would experience salinity that would exceed (slightly) the 36.5 ppt discharge limit proposed as an amendment to the California Ocean Plan. Further offshore, in the middle of the ZID, the long term median salinity was found to be 34.2 ppt, which is a value in the range of naturally occurring salinity in the coastal ocean off Carlsbad. The maximum salinity in the middle of the ZID was found to be 35.8 ppt, which is well within the salinity tolerance of the local keystone species. At the outer edge of the ZID, median salinity is within 0.14 ppt of average ocean salinity off Carlsbad, and the maximum salinity is only 34.5 ppt, roughly equivalent to the maximum naturally occurring value in these coastal waters. Over this representative 20.5 year long period of record, there is a 90% probability that maximum salinity on the edge of the ZID will not exceed 33.87 ppt. This is well within in the range of natural seasonal variability of ambient ocean salinity for this coastal region.

Dilution factors of the brine discharged from closed-cycle cooling operations are considerably better than what was found for the Carlsbad Desalination Project. In the middle of the ZID, minimum dilution was typically 33.5 to 1, and at the outer edge of the ZID minimum dilution climbs to a median value of 162 to 1, with worst-case here being no less than 23.2 to 1. In 90% of the model runs, minimum dilution of brine at the edge of the ZID exceeds 98 to 1.

We conclude that closed-cycle cooling operations at Encina will produce brine plume effects that are well below what could be tolerated by indigenous marine organisms, and are within the strictest standards being contemplated through amendments to the California Ocean Plan. In addition, minimum dilution levels of the brine discharge will also satisfy present NPDES discharge limits permitted for the Encina thermal effluent.

1) Introduction:

This study invokes a well-tested and peer-reviewed hydrodynamic model (SEDXPORT) to assess dispersion and dilution of concentrated sea water (brine) arising from the production of make-up water for a closed-cycle cooling system at Encina Generating Station. The make-up water would be produced by a small reverse osmosis desalination system that would draw source water off the existing sea water circulation system at Encina. The required flow to the desalination system will be 848 gpm and will produce 505 gpm of brine by-product having an initial salinity of 56.29 ppt before being recombined with the residual source water stream. The available source water intake flow will be 3,000 gpm. The 505 gpm of brine by-product would be blended with a residual 2,152 gpm of source water and subsequently discharged into the nearshore through the existing discharge channel at a combined rate of 2,657 gpm and salinity of 37.85 ppt.

The dilution and dispersion of this discharge in the nearshore environment was studied using the same models, ocean forcing functions and water mass properties applied in the certified EIR for the much larger Carlsbad Desalination Project, (referenced herein as EIR, 2005). However, the proposed study will evaluate the brine discharges from closed-cycle cooling operations at Encina as a stand alone process, independent of any hyper-saline discharges from the Carlsbad Desalination Project. We ultimately compare the model results against criteria for hyper-salinity tolerance of local marine species (as adopted in the certified EIR of the Carlsbad Desalination Project); as well as considering potential compliance with proposed amendments to the California Ocean Plan that would set salinity discharge limits on coastal desalination plants (see Appendix A, Issue 10).

2) Technical Approach

This study addresses the concerns of brine dilution by utilizing a coupled set of numerical tidal and wave transport models. The numerical model used to simulate tidal currents in the nearshore and shelf region of Encina Generating Station is the finite element model TIDE_FEM. Wave-driven currents are computed from the shoaling wave field by a separate model, OCEANRDS. The dispersion and transport of concentrated seawater and backwash discharge by the wave and tidal currents is calculated by the finite element model known as SEDXPORT.

A) Model Pedigree: Besides being validated in coastal waters of southern California, the SEDXPORT modeling system has been extensively peer reviewed. Although some of the early peer review was confidential and occurred inside the Office of Naval Research and the Naval Research Laboratory, the following is a listing of 5 independent peer review episodes of SEDXPORT that were conducted by 9 independent experts and can be found in the public records of the State Water Resources Control Board, the California Coastal Commission and the City of Huntington Beach.

1997- Reviewing Agency: State Water Resources Control Board

Project: NPDES 316 a/b Permit renewal, Encina Power Plant, Carlsbad, CA

Reviewer: Dr. Andrew Lissner, SAIC, La Jolla, CA

1998- Reviewing Agency: California Coastal Commission

Project: Coastal Development Permit, San Dieguito Lagoon Restoration

Reviewers: Prof. Ashish Mehta, University of Florida, Gainesville
Prof. Paul Komar, Oregon State University, Corvallis; Prof. Peter Goodwin, University of Idaho, Moscow

2000- Reviewing Agency: California Coastal Commission
Project: Coastal Development Permit, Crystal Cove Development
Reviewers: Prof. Robert Wiegel, University of California, Berkeley
Dr. Ron Noble, Noble Engineers, Irvine, CA

2002- Reviewing Agency: California Coastal Commission
Project: Coastal Development Permit, Dana Point Headland Reserve
Reviewers: Prof. Robert Wiegel, University of California, Berkeley ;
Dr. Richard Seymour, University of California, San Diego

2003- Reviewing Agency: City of Huntington Beach
Project: EIR Certification, Poseidon Desalination Project
Reviewer: Prof. Stanley Grant, University of California, Irvine

B) Model Architecture: The model has been built in a modular computational architecture (see Jenkins and Wasyl, 2005 a & b). The modules are divided into two major clusters: 1) those which prescribe hydrodynamic forcing functions; and, 2) those which prescribe the mass sources acted upon by the hydrodynamic forcing to produce dispersion and transport. The cluster of modules for hydrodynamic forcing ultimately prescribes the velocities and diffusivities induced by wind, waves, and tidal flow for each depth increment at each node in the grid network.

The finite element research model, TIDE_FEM, (Jenkins and Wasyl, 1990; Inman and Jenkins, 1996) was employed to evaluate the tidal currents within the Oceanside Littoral Cell. TIDE_FEM was built from some well-studied and proven computational methods and numerical architecture that have done well in predicting shallow water tidal propagation in Massachusetts Bay (Connor and Wang, 1974) and along the coast of Rhode Island, (Wang, 1975), and have been reviewed in basic text books (Weiyan, 1992) and symposia on the subject, e.g., Gallagher (1981). The governing equations and a copy of the core portion of the TIDE_FEM FORTRAN code are found in Jenkins and Wasyl, 2005 a & b. TIDE_FEM employs a variant of the vertically integrated equations for shallow water tidal propagation after Connor and Wang (1975). These are based upon the Boussinesq approximations with Chezy friction and Manning's roughness. The finite element discretization is based upon the commonly used Galerkin weighted residual method to specify integral functionals that are minimized in each finite element domain using a variational scheme, see Gallagher (1981). Time integration is based upon the simple trapezoidal rule (Gallagher, 1981).

The computational architecture of TIDE_FEM is adapted from Wang (1975), whereby a transformation from a global coordinate system to a natural coordinate system based on the unit triangle is used to reduce the weighted residuals to a set of order-one ordinary differential equations with constant coefficients. These coefficients (influence coefficients) are posed in terms of a shape function derived from the natural coordinates of each nodal point in the computational grid. The resulting systems of equations are assembled and coded as banded matrices and subsequently solved by Cholesky's method, see Oden and Oliveira (1973) and Boas (1966). The hydrodynamic forcing used by TIDE_FEM is based upon inputs of the tidal constituents derived from Fourier decomposition of tide gage records. Tidal constituents are input into the module TID_DAYS, which resides in the hydrodynamic forcing function cluster (see Jenkins and Wasyl, 2005 a & b for a listing of TID_DAYS code). TID_DAYS computes the distribution of sea surface elevation variations in Oceanside Littoral Cell based on the tidal constituents derived from the Scripps Pier tide gage station (NOAA #941-0230). Forcing for TIDE_FEM is applied by the distribution in sea surface elevation across the deep water boundary of the computational domain.

Wave driven currents were calculated from wave measurements by the Coastal Data Information Program (CDIP) arrays and/or buoys (CDIP, 2004). These measurements were back refracted out to deep water to correct for island sheltering effects between the monitoring sites and Carlsbad. The waves were then forward refracted onshore to give the variation in wave heights, wave lengths and directions throughout the nearshore around Carlsbad and the surrounding areas of Oceanside Littoral Cell. The numerical refraction-diffraction code used for both the back refraction from these wave monitoring sites out to deep water, and the forward refraction to the Carlsbad site is OCEANRDS and may be found in Jenkins and Wasyl, 2005 a & b. This code calculates the simultaneous refraction and diffraction patterns of the swell and wind wave components propagating over bathymetry replicated by the OCEANBAT code found in Jenkins and Wasyl, 2005 a & b. OCEANBAT generates the associated depth fields for the computational grid networks of both TID_FEM and OCEANRDS using packed bathymetry data files derived from the National Ocean Survey (NOS) depth soundings. The structured depth files written by OCEANBAT are then throughput to the module OCEANRDS, which performs a refraction-diffraction analysis from deep water wave statistics. OCEANRDS computes local wave heights, wave numbers, and directions for the swell component of a two-component, rectangular spectrum.

The wave data are throughput to a wave current algorithm in SEDXPORT (see Jenkins and Wasyl, 2005 b) which calculates the wave-driven longshore currents, v(*r*). These currents were linearly superimposed on the tidal current. The wave-driven longshore velocity, v(*r*), is determined from the longshore current theories of Longuet-Higgins (1970). Once the tidal and wave driven currents are resolved by TIDE_FEM and OCEANRDS, the dilution and dispersion of brine and backwash constituents is computed by the stratified transport algorithms in SEDXPORT . The SEDXPORT code is a time stepped finite element model which solves the advection-diffusion equations over a fully configurable 3-dimensional grid. The vertical dimension is treated as a two-layer ocean, with a surface mixed layer and a bottom layer separated by a pycnocline interface. The code accepts any arbitrary density and velocity contrast between the mixed layer and bottom layer that satisfies the Richardson number stability criteria and composite Froude number condition of hydraulic state.

The SEDXPORT codes do not time split advection and diffusion calculations, and will compute additional advective field effects arising from spatial gradients in eddy diffusivity, (the so-called "gradient eddy diffusivity velocities" after Armi, 1979). Eddy mass diffusivities are calculated from momentum diffusivities by means of a series of Peclet number corrections based upon TSS and TDS mass and upon the mixing source. Peclet number corrections for the surface and bottom boundary layers are derived from the work of Stommel (1949) with modifications after Nielsen (1979), Jensen and Carlson (1976), and Jenkins and Wasyl (1990). Peclet number correction for the wind-induced mixed layer diffusivities are calculated from algorithms developed by Martin and Meiburg (1994), while Peclet number corrections to the interfacial shear at the pycnocline are derived from Lazara and Lasheras (1992a;1992b). The momentum diffusivities to which these Peclet number corrections are applied are due to Thorade (1914), Schmidt (1917), Durst (1924), and Newman (1952) for the wind-induced mixed layer turbulence and to Stommel (1949) and List, et al. (1990) for the current-induced turbulence.

SEDXPORT solves the eddy gradient form of the advection diffusion equation for the water column density field:

$$\frac{\partial \rho}{\partial t} = (\vec{u} \bullet \nabla \varepsilon) \bullet \nabla \rho - \varepsilon \nabla^2 \rho + \rho_b Q_b / V_b \qquad (1)$$

where $\vec{u}$ is the vector velocity from a linear combination of the wave and tidal currents, γ is the mass diffusivity, Λ is the vector gradient operator and ρ is the water mass density in the nearshore dilution field; and ρ_b is the density of the combined discharge flowing at a rate Q_b through a discharge channel of volume V_b. In (1) the term $\nabla \varepsilon$ acts much like an additional advective field in the direction of high to low eddy diffusivity. This additional "gradient eddy diffusivity velocity" is the result of local variations in current shear and wave boundary layer thickness. Both are bathymetrically controlled and the latter is associated with the refraction/diffraction pattern and is strongest in the wave shoaling region nearshore.

Both the density of the receiving water ρ and the density of the discharge fluid ρ_b is a function of temperature, *T*, and salinity, *S*, according to the equation of state expressed in terms of the specific volume, $\alpha = 1/\rho$ and $\alpha_b = 1/\rho_b$ or:

$$\frac{d\alpha}{\alpha} = \frac{1}{\alpha}\frac{\partial \alpha}{\partial T} dT + \frac{1}{\alpha}\frac{\partial \alpha}{\partial S} dS \qquad (2)$$

$$\frac{d\alpha_b}{\alpha_b} = \frac{1}{\alpha_b}\frac{\partial \alpha}{\partial T} dT_b + \frac{1}{\alpha_b}\frac{\partial \alpha}{\partial S} dS_Q$$

where dS_Q is the salinity contrast between the combined discharge and the ambient ocean water. The factor M∀/MT, which multiplies the differential temperature changes, is known as the coefficient of thermal expansion and is typically 2 x 10^{-4} per ^{o}C for seawater; the factor M∀/MS multiplying the differential salinity changes, is the coefficient of saline contraction and is typically 8 x 10^{-4} per part per thousand (ppt) where 1.0 ppt = 1.0 g/L of total dissolved solids (TDS). For a standard seawater, the specific volume has a value ∀ = 0.97264 cm^3/g. If the percent change in specific volume by equation (3) is less than zero, then the water mass is heavier than standard seawater, and lighter if the percent change is greater than zero.

Solutions to the density field of the discharge plume from the outfall are calculated from equation (1) by SEDXPORT**,** from which computations of local discharge salinity, $S(x,y,z)$, can be made using equation (3). The salinity field of the discharge plume can be used to solve for the dilution factor $D_b(x,y,z)$ of the brine effluent according to:

$$D_b(x,y,z) = \frac{S_b - S_o}{S_o - S(x,y,z)} \qquad (3)$$

where S_o is the ambient seawater salinity in ppt, S_b is the salinity of the brine, and $S(x,y,z)$ is the local salinity in the discharge plume from the model solution in ppt. Model solutions will find a significant variation in the salinity with water depth, *z*. Therefore we introduced a depth-averaged dilution factor,

$$\overline{D}(x, y, H) = \frac{1}{H(x, y)} \int_{0}^{H} D(x, y, z)\, dz \qquad (4)$$

Where $H = (Hx, y) = h + \eta$ is the local water depth, h is the local water depth below mean sea level and η is the tidal amplitude.

Solutions for the density and concentration fields calculated by the SEDXPORT codes from equations (1)-(2), are throughput to the dilution codes of MULTINODE to resolve dilution factors according to (3)-(4). These codes solve for the dilution factor (mixing ratio) for each cell in the finite element mesh of the nearshore computational domain based on a mass balance between imported exported and resident mass of that cell (see Jenkins and Wasyl, 2005 a & b). The diffusivity, γ, in (1) controls the strength of mixing and dilution of the seawater and storm water constituents in each cell and varies with position in the water column relative to the pycnocline interface. Vertical mixing includes two mixing mechanisms at depths above and below the pycnocline: 1) fossil turbulence from the bottom boundary layer, and 2) wind mixing in the surface mixed layer. The pycnocline depth is treated as a zone of hindered mixing and varies in response to the wind speed and duration. Below the pycnocline, only turbulence from the bottom wave/current boundary layer contributes to the local diffusivity. In the nearshore, breaking wave activity also contributes to mixing. The surf zone (zone of initial dilution) is treated as a line source of turbulent kinetic energy by the subroutine SURXPORT (see Jenkins and Wasyl, 2005 a & b). This subroutine calculates seaward mixing from fossil surf zone turbulence, and seaward advection from rip currents embedded in the line source. Both the eddy diffusivity of the line source and the strength and position of the embedded rip currents are computed from the shoaling wave parameters evaluated at the breakpoint, as throughput of OCEANRDS.

3) Initial Conditions:

Uninterrupted, long-term monitoring of ocean properties has not been maintained at Encina, but are available from the nearby Scripps Pier. The Scripps Pier site has many physical features in common with the nearshore area around Encina. Both sites have a narrow shelf and a submarine canyon nearby. Consequently, internal waves are an active mechanism at both sites in causing daily (diurnal) variations in salinity, temperature, and other ocean properties. The longer period variations at seasonal and multiple year time scales are the same at both sites due to their proximity. The Scripps Pier Shore Station data (SIO, 2001) and the Coastal Data Information Program monitoring at Scripps Pier (CDIP, 2004) are used as surrogates for long term records of physical ocean properties at Encina. These properties exhibit considerable natural variability over the period of record from 1980 to mid 2000 due to daily and seasonal changes, as well as climate cycles.

A) Flow Rates and Discharge Salinity: The existing sea water circulation system of the power plant draws source water from the lagoon, which is subsequently discharged into the ocean through an independent discharge channel located between Middle Beach and South Beach. The existing cascade of circulation and service water pumps available at Encina Generating Station can provide a maximum once-through flow rate of 808 million gallons per day (mgd). The make-up water would be produced by a small reverse osmosis desalination system that would draw source water off this existing sea water circulation system. The source water intake flow will be 3,000 gallons per minute (gpm). The make-up water desalination system will draw 848 gpm off this source water stream and will produce 505 gpm of brine by-product. The concentration factor of the 505 gpm of brine is only 1.679 (40.45% recovery), as compared to a concentration factor of 2.0 (50.0% recovery) for the Carlsbad Desalination Project, (EIR, 2005). For an average ambient ocean salinity of $S_0 = 33.52$ ppt, the salinity of the brine reject from the closed-cycle cooling system will average $S_b = 56.29$ ppt (as compared to 67.04 ppt for brine produced by the Carlsbad Desalination Project). The brine from closed-cycle cooling will be mixed with a residual source water throughput of 2,152 gpm, producing a combined discharge of $Q_b = 2{,}657$ gpm through the jetty fortified discharge channel. The combined discharge in the discharge channel will have an average salinity of $S_Q = 37.84$ ppt.

B) Environmental Variables: Altogether there are six environmental variables that enter into the computer model for resolving the dispersion and dilution of the unheated concentrated seawater by-product discharged from the stand-alone desalination plant. These environmental variables may be organized into *boundary conditions* and *forcing functions*. The boundary conditions include: ocean salinity, ocean temperature and ocean water levels. The forcing function variables include waves, currents, and winds. For the present analysis, we use the same set of environmental variables applied to the dilution analysis in the certified EIR for the Carlsbad Desalination Project.

Overlapping 20.5 year long records of the boundary condition and forcing function variables are reconstructed in Sections 3.1 and 3.2 of Jenkins and Wasyl (2005) found in Appendix E of the certified EIR (2005). These records contain 7,523 consecutive daily observations of each variable between 1980 and the middle of 2000. For clarity, these long term records are plotted here in Figures 1 and 2. We search this 20.5 year long period of record for the historical combination of these variables that give a worst-case day, generally defined by benign ocean conditions that minimize mixing and dilution rates. We then overlay

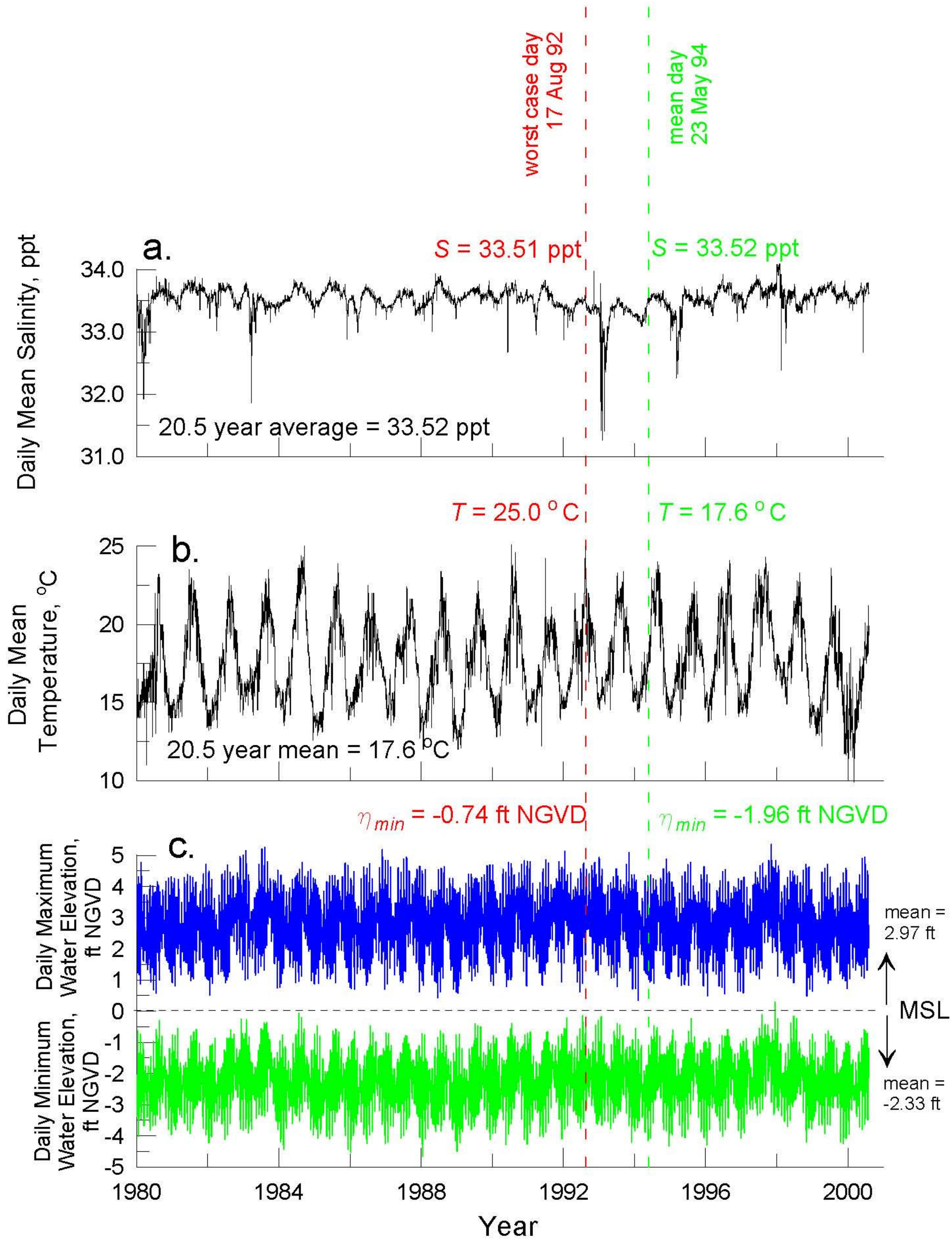

Figure 1. Period of record of boundary conditions, Encina Power Plant, 1980-2000.5: a) daily mean salinity, b) daily mean temperature, and c) daily high and low ocean water level elevations.

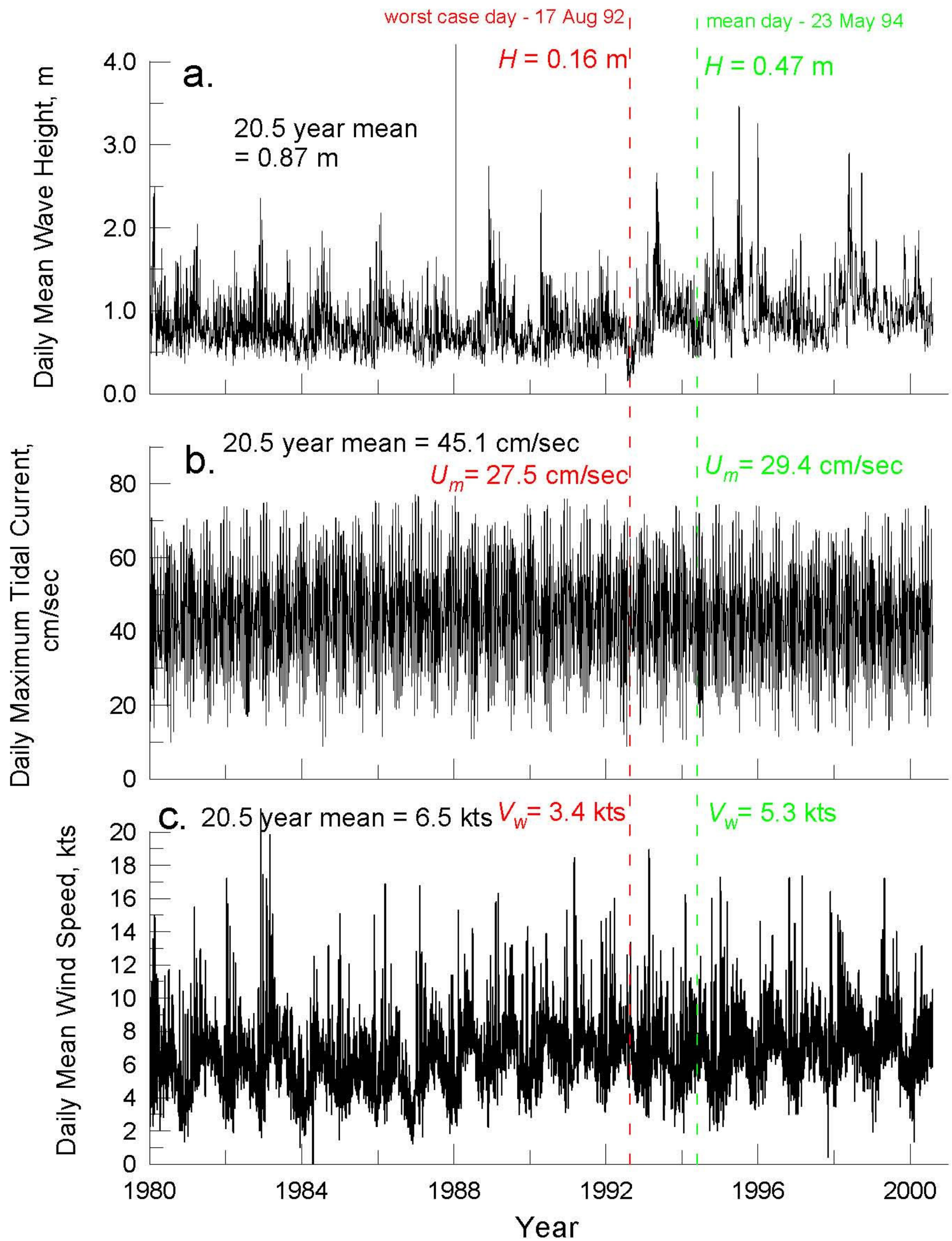

Figure 2. Period of record of forcing functions in the nearfield of Encina Power Plant, 1980-2000.5: a) daily mean wave height, b) daily maximum tidal current velocity, and c) daily mean wind.

the brine discharge scenario for the closed-cycle cooling system on those extremely benign ocean conditions. The criteria for the historical extreme day was based on the simultaneous occurrence of the environmental variables having the highest combination of absolute salinity and temperature during the periods of minimal wave, wind, currents, and ocean water levels (including both tidal oscillations and climatic sea level anomalies). We repeat the analysis using average ocean mixing conditions. The average day scenarios were based on the 20.5 yr mean of the 6 environmental variables.

C) Worst-Case Assignments: The 20.5 year long records of the boundary condition variables in Figure 1 and the forcing function variables in Figure 2 were subjected to a joint probability analysis for the simultaneous occurrence of the "*worst-case*" combination of these variables. The criteria used to define worst-case combinations of environmental variables for this analysis is outlined in Table 1. The joint probability analysis involved 7,523 historic combinations of ocean salinity, temperature, wave, current and wind variables, for which the maximization/minimization criteria in Table 1 were applied. The joint probability analysis produced a worst-case day solution for 17 August 1992. This day is represented by the vertical dashed red line in Figures 1 and 2. The monthly periods containing these extreme events are shown in Figures 3 and 4. The environmental factors of this day were associated with a building El Niño that subsequently climaxed in the winter of 1993. The ocean salinity was 33.51ppt, (about the same as the long term mean), but the ocean temperature was 25.0 ^{o}C, within 0.1 ^{o}C of the 20.5 year maximum. The waves were only 0.16 m, which was the 20.5 year minimum. Winds were 3.4 knots and the maximum tidal current in the offshore domain was only 27.5 cm/sec (0.53 knots). The sluggish tidal current was due to neap tides occurring on this day with a minimum water level of -0.74 ft NGVD.

Table 1: Search Criteria and Ecological Significance for Worst-Case Combinations of Environmental Variables.

Variable	Search Criteria	Ecological Significance
Ocean Salinity	Maximize	Higher salinity leads to higher concentrations of RO by-product causing greater stress on marine biology
Ocean Temperature	Maximize	Higher temperature leads to greater stress on marine biology
Ocean Water Levels	Minimize	Lower water levels result in less initial dilution in the discharge channel
Waves	Minimize	Smaller waves result in less mixing in surfzone and less inshore dilution
Currents	Minimize	Weaker currents result in less advection and less offshore dilution
Winds	Minimize	Weaker winds result in less surface mixing and less dilution in both the inshore and offshore

This combination of environmental variables represents a situation that would place maximum thermal stress on the marine biology; and one in which the dilution of the concentrated seawater by-product of the closed-cycle cooling system would occur very slowly due to minimal ocean mixing. The probability of occurrence of these worst-case mixing conditions is 1day in 7,523 days, or 0.013%.

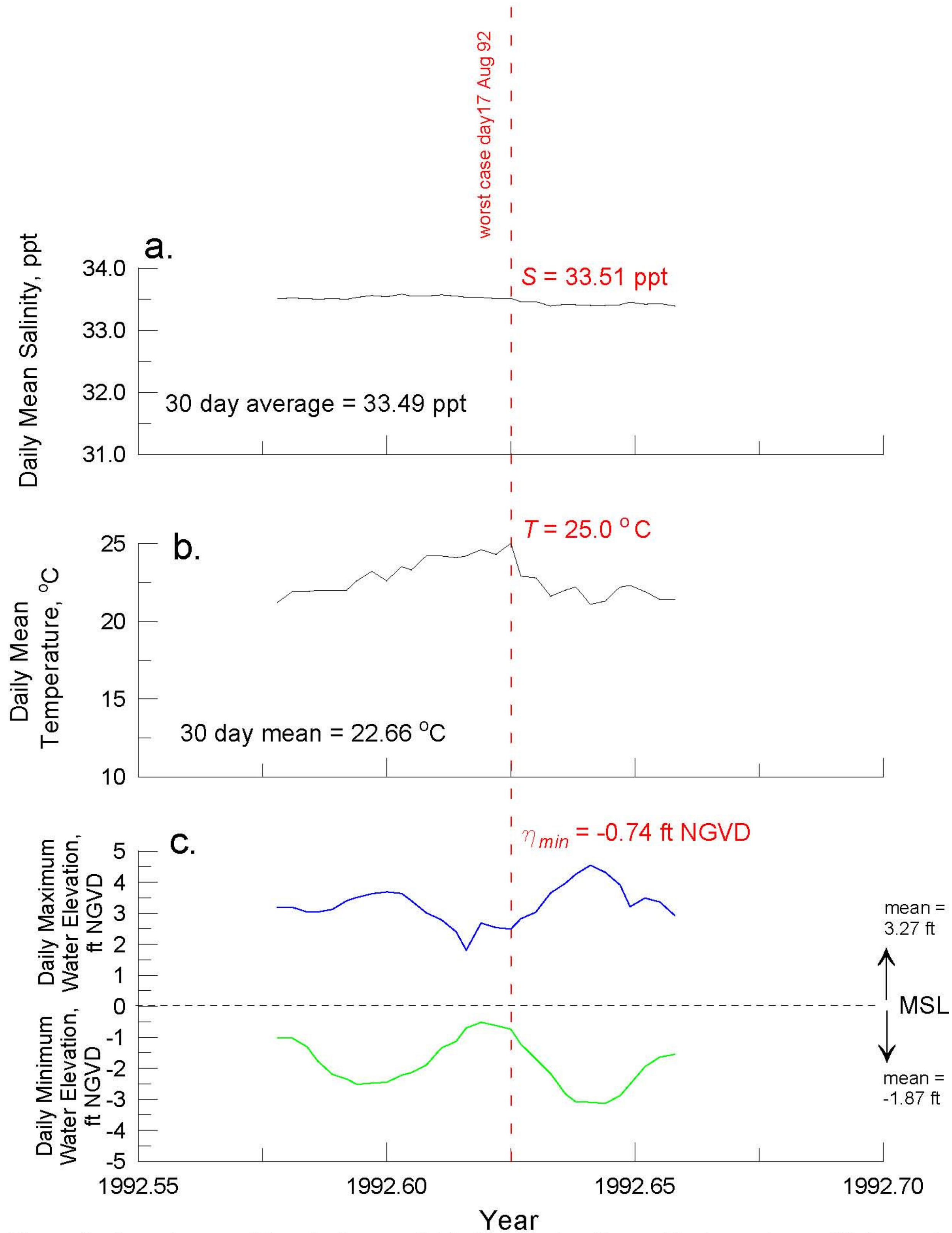

Figure 3. Boundary conditions in the nearfield of the Encina Power Plant: worst case 30 day period: a) daily mean salinity, b) mean temperature, and c) high and low ocean water elevations.

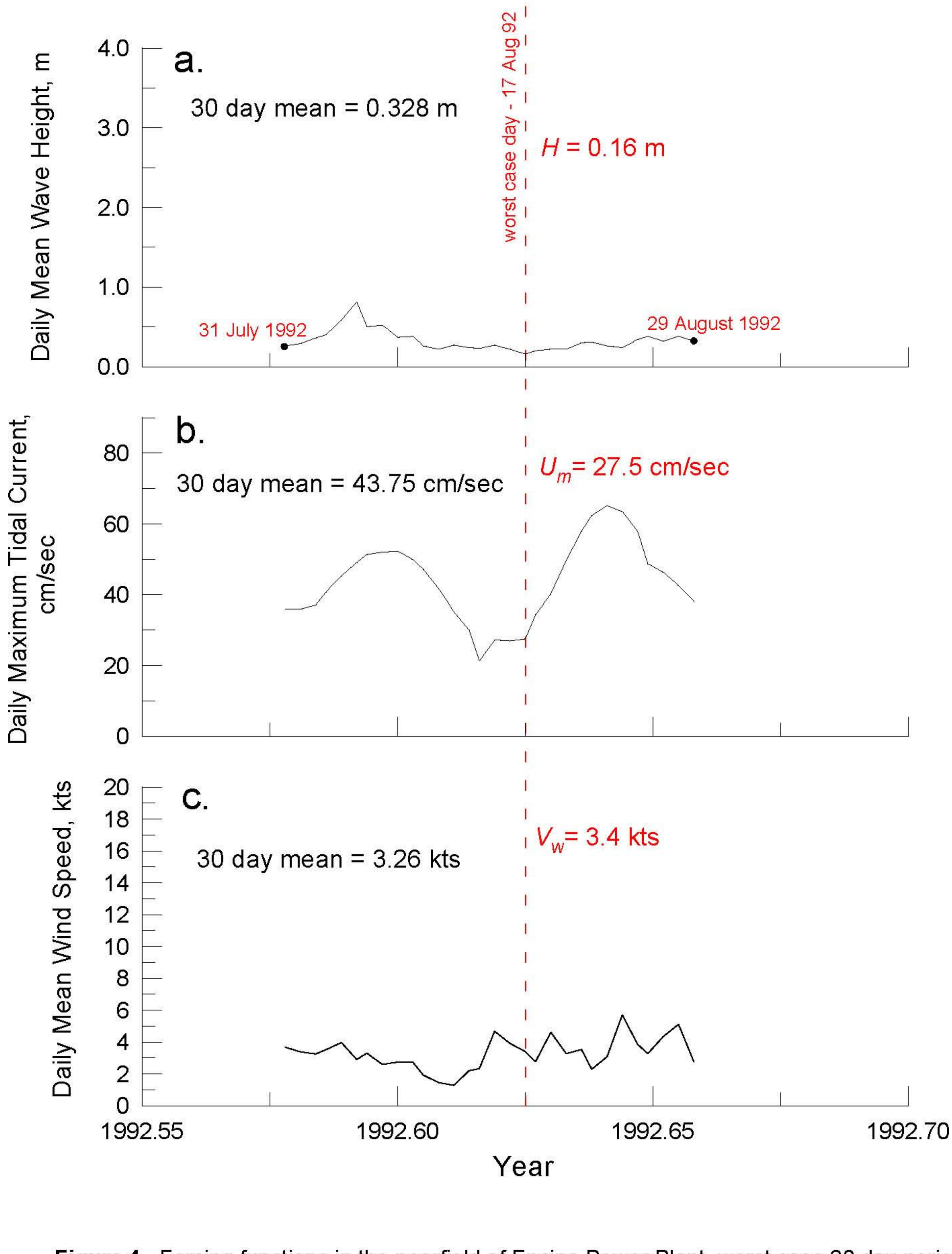

Figure 4. Forcing functions in the nearfield of Encina Power Plant, worst case 30 day period: a) daily mean wave height, b) daily maximum tidal current velocity, and c) daily mean wind.

D) Average Case Assignments: The average daily combination of the 7 controlling variables over the 20.5 year period of record was found to be represented by the conditions on 23 May 1994. This day is represented in Figures 1 and 2 by the vertical dashed green line. This was a spring day with moderate temperature, winds, waves, and currents. The Southern Oscillation Index (SOI) was zero indicating that the oceanic conditions relative to El Niño were in a neutral phase. Ocean salinity was 33.52 ppt and ocean temperature was 17.6 ^{o}C, both identically the 20.5 year mean. Wave heights were 0.65 m, slightly below the 20.5 year mean, and maximum tidal currents reached 29.4 cm/sec (0.57 knots), also less than the 20.5 year mean. The daily low water level at -1.96 ft NGVD was very close to the mean low tide (MLT). Winds were 5.3 knots, slightly above the 20.5 year mean.

3) Results:

Results are presented for worst-case and average conditions in terms of four principle model outputs: 1) salinity of the combined discharge on the sea floor, 2) dilution factors for the raw concentrate at the sea floor, 3) depth-averaged salinity of the combined discharge, and 4) depth-averaged dilution factors for the raw concentrate in the water column.

Salinity fields are contoured in parts per thousand (ppt) according to the color bar scale at the bottom of each plot. For purposes of comparing scenarios, the salinity scale range spans from 33.5 ppt to 38.0 ppt. Ambient ocean salinity is stated in the caption of each salinity field plot. Of particular concern in dilution analyses of preceding desalination projects has been areas in which the discharge plume elevates the local salinity above 38- 40 ppt. When salinities rise above 38 to

40 ppt, increases in mortality and reductions in reproductive rates have been found in some marine organisms (see Graham, EIR, 2005). However, in the present analysis this concern is not a factor because discharge salinities at end-of-pipe remain below 38 ppt (cf. Section 3a). However, there have been recent proposed amendments to the California Ocean Plan that would either set numeric limits on discharges from ocean desalination plants at 36.5 ppt (see Appendix A, Issue 10, Alternative 3); or set relative limits on discharges at 10% over natural background (see Appendix A, Issue 10, Alternative 2). The 10% over background standard would place discharge limits on a plant sited in Carlsbad at 37 ppt. Therefore we will pay particular attention to any portion of the discharge plume that exceeds 36.5 ppt - 37 ppt.

The dilution fields in the following sections are contoured in base-10 log according to the color bar scale at the bottom of each plot, with a scale range that spans from 10^0 to 10^7. We are particularly concerned about the dilution factor of the raw concentrate in the water column at the edge of the "zone of initial dilution" (ZID), 1000 ft in any direction from the mouth of the discharge channel. The present NPDES permit for the thermal effluent requires a dilution factor of 15 to 1 at the edge of the ZID, and this standard might possibly be applied to the brine by-product of a closed-cycle cooling system at Encina.

A) Worst-Case Hyper-Saline Effects and Dilution Rates: The combined brine discharge effluent flowing from the discharge channel at $Q_b = 2{,}657$ gpm and salinity of $S_Q = 37.84$ ppt is heavier than the ambient ocean water, which has a salinity of 33.51 ppt and a temperature of 25.0 ^{o}C on the worst-case day (represented by proxy, 17 August 1992). As a result, the brine plume concentrates on the seabed, flowing down-slope along the beach and subtidal bathymetry as a gravity flow. This action causes the highest salinity anywhere in the

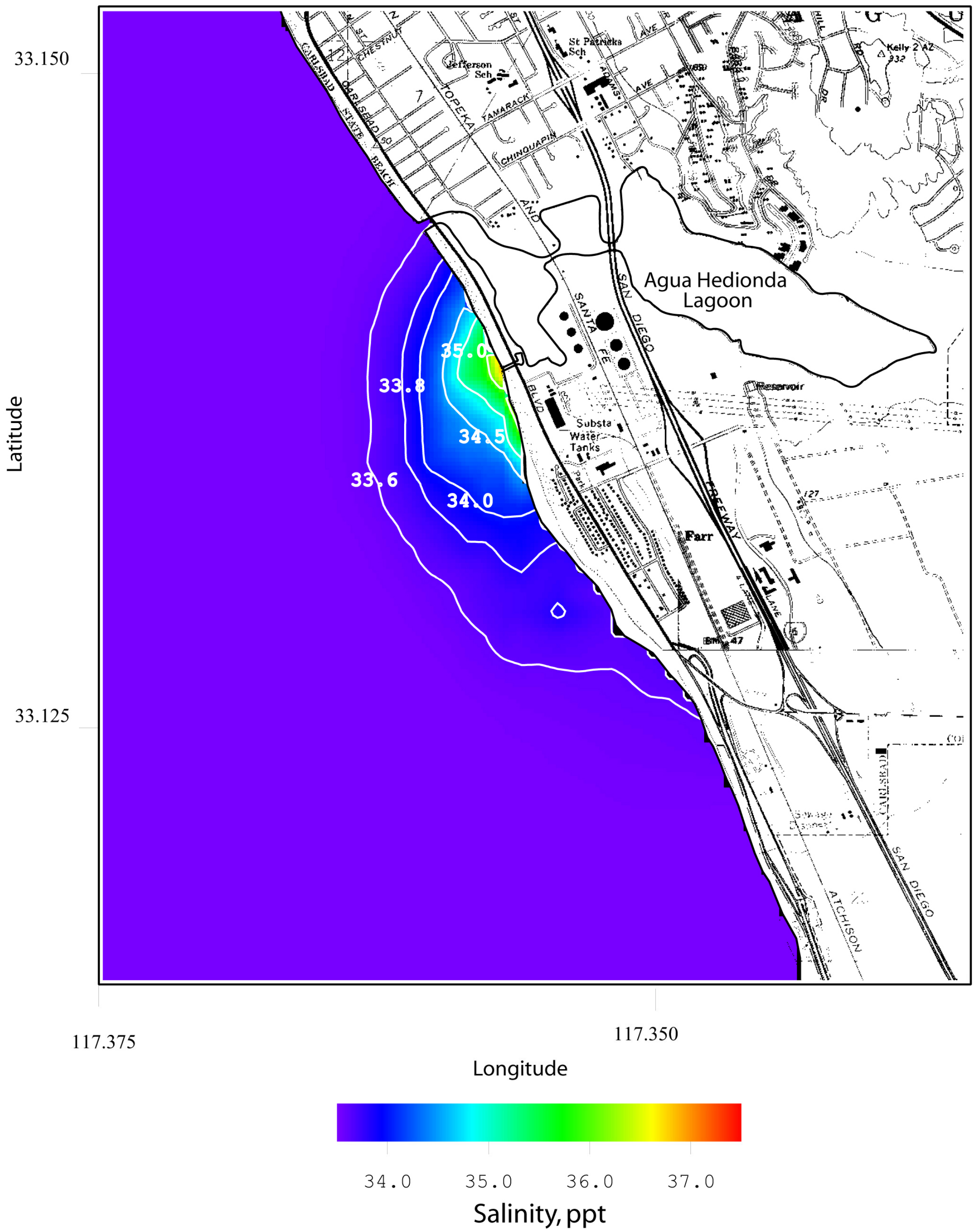

Figure 5. Daily average of bottom salinity due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.51 ppt, ocean conditions, 17 August 1992, representing worst case.

receiving water to be found in the brine footprint on the seafloor. Figure 5 gives the salinity field in the hyper-saline bottom boundary layer as it spreads down-slope (seaward) across on the sea floor under the worst-case mixing conditions. Out of 7,523, modeled outcomes, no other results are more extreme in terms of hyper-salinity impacts than what is shown in Figure 5. The salinity field is averaged over a 24 hour period. The inner core of the hyper-saline bottom boundary layer (contoured in yellow immediately seaward of the head of the discharge jetties) is at a maximum salinity of 36.61 ppt, and 1.44 acres in the inner core is at a salinity that exceeds the proposed numeric limit of 36.5 ppt. This 1.44 acres that exceeds the proposed numeric limits is well inside the ZID. Maximum bottom salinity found anywhere along the boundaries of the ZID is 34.5 ppt, occurring 1000 ft directly offshore of the discharge channel. This ZID boundary maximum is a value that is approached as a result of the natural variability of coastal ocean temperatures, (where the maximum value recorded in Figure 1a is 34.44 ppt). The brine plume in the bottom boundary layer follows a general southward trajectory, but only produces elevated salinity on the order of 0.1 ppt to 0.4 ppt above ambient in either the offshore kelp beds or the tide pools to the south near Terra Mar. This is well within the range of inter-annual variability. Bottom dilution factors for the raw concentrate are shown in Figure 6 for worst-case ambient mixing. Minimum dilution on the sea bed at the edge of the ZID is 23.2 to 1 for worst-case, providing a comfortable margin over the minimum 15 to 1 prescribed by the present NPDES discharge permit on the Encina thermal effluent. It should be noted that these ultimate worst-case outcomes for salinity maximums and dilution minimums on the seafloor are extremely rare and non-persistent, representing an event with a 0.013% chance of occurrence. The relatively higher salinity found in the brine plume on the seabed is confined to a thin bottom

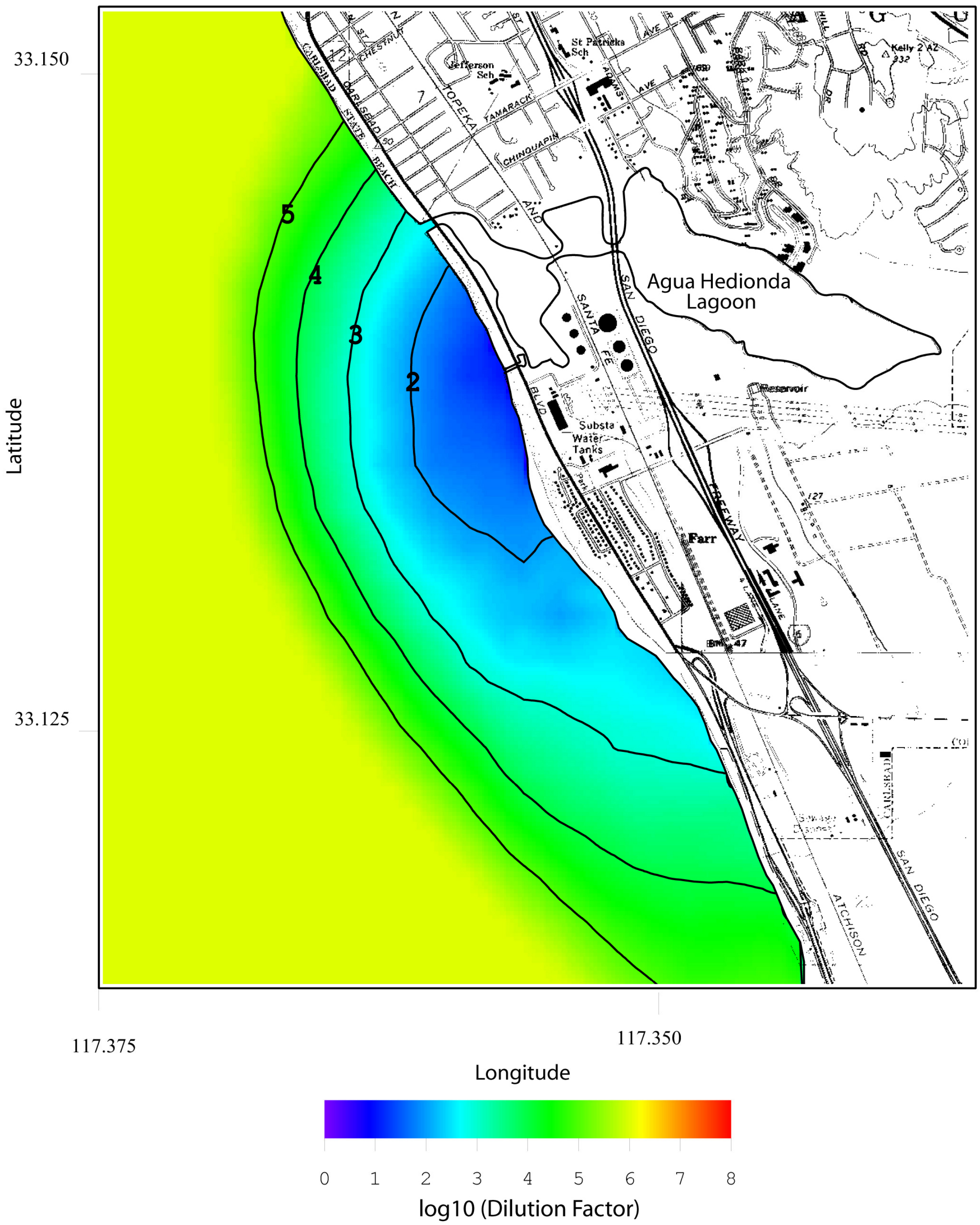

Figure 6. Daily average of bottom dilution due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.51 ppt, ocean conditions, 17 August 1992, representing worst case.

boundary layer that is constrained from mixing significantly upward into the water column. This is a consequence of the small bottom stresses and low eddy diffusivity that prevail during the worst-case mixing conditions. Above this bottom boundary layer the salinity drops rapidly. Maximum salinity in the water column for worst-case is found to be 34.0 ppt in the surfzone immediately seaward of the discharge jetty (Figure 7). The pelagic area subject to salinity in excess of 40 ppt is 3.3 acres. About 28 acres of pelagic habitat are subjected to salinity reaching 10% over ambient. Maximum water column salinity at the edge of the ZID is 33.9 ppt, found in the surf zone 1000 ft to the south of the discharge channel. These values are all within the range of typical inter-annual variability associated with higher evaporation rates during summer months. Figure 8 shows that in the water column, where 316(A) dilution standards apply, minimum dilutions improve to 59.9 to 1 at the edge of the ZID, significantly higher than the 15 to 1 prescribed by the present NPDES discharge permit on the Encina thermal effluent.

In summary, the worst-case outcome for hyper-salinity impacts and suppressed dilution rates arising from brine discharge by a closed-cycle cooling system are found to be benign. Nowhere in the nearshore environment do salinity values in the brine plume approach the threshold (38-40 ppt) for hyper-salinity tolerance of local marine organisms. Kelp beds and tide pools to the south of the Encina discharge will experience salinity elevations from brine plume impingement that are no greater than what occurs inter-annually under natural seasonal fluctuations of ocean salinity. Even the strictest standards contemplated for discharges from ocean desalination plants under proposed amendments to the California Ocean Plan are generally satisfied. Only the strictest proposed standard (a 36.5 ppt numeric limit) is slightly exceeded in a small localized area of surfzone seabed amounting to 1.44 acres. The less severe 10% over background standard

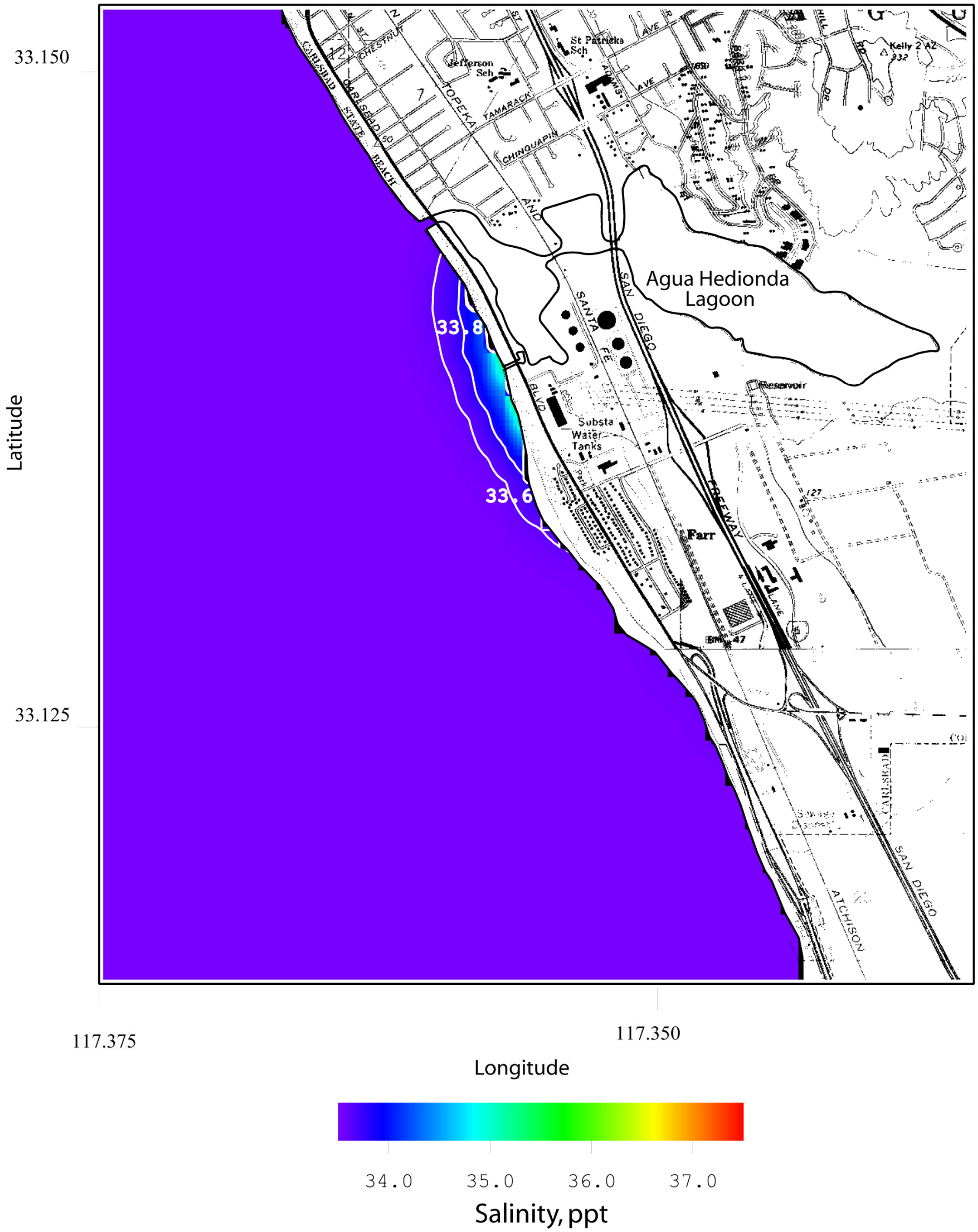

Figure 7. Daily average of depth-averaged salinity due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.51 ppt, ocean conditions, 17 August 1992, representing worst case.

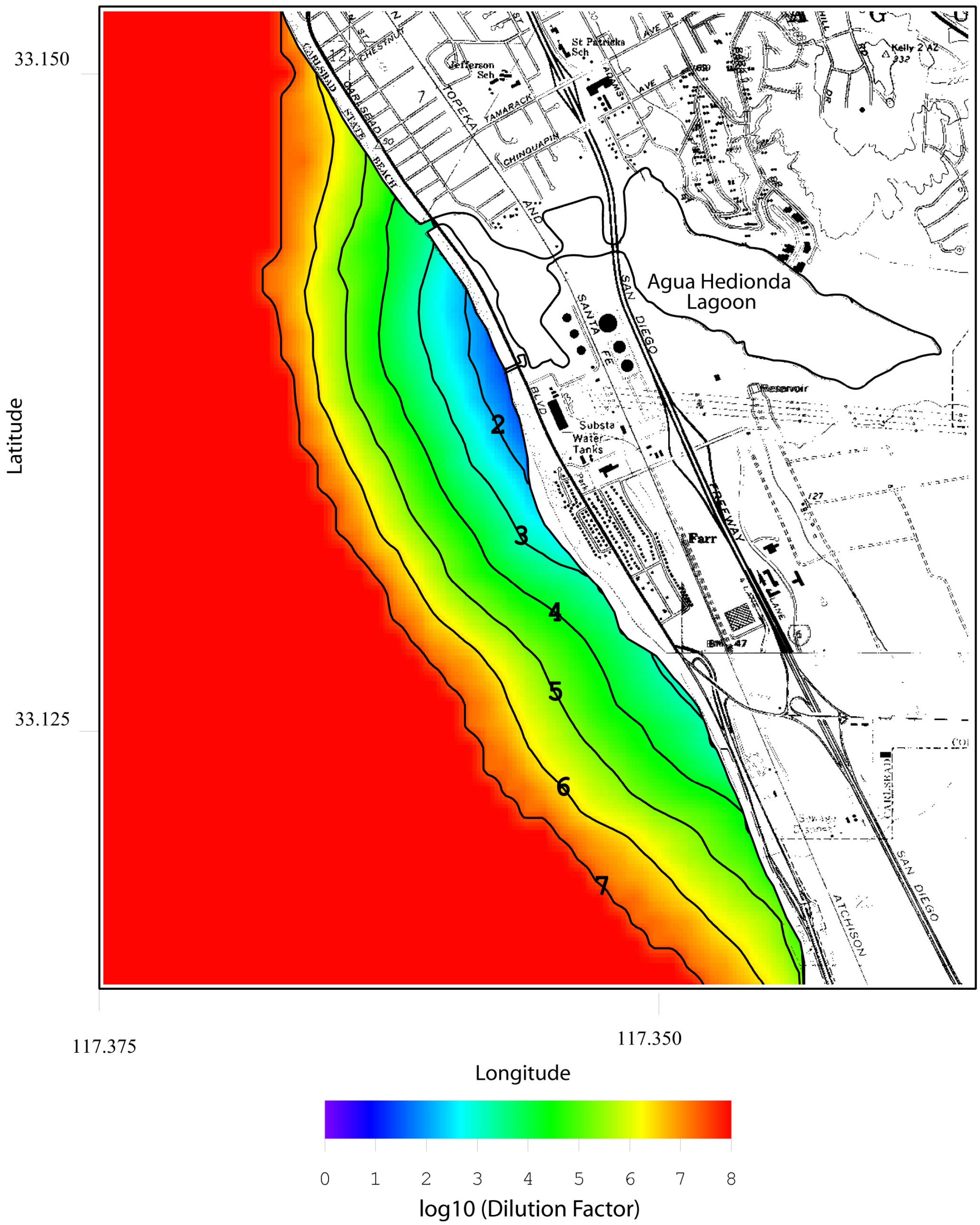

Figure 8. Daily average of depth-averaged dilution due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.51 ppt, ocean conditions, 17 August 1992, representing worst case.

being proposed for the California Ocean Plan is satisfied everywhere in worst-case outcomes. Existing NPDES discharge permit limits on minimum dilution presently applied to thermal effluent are satisfied everywhere by the brine discharge along the perimeter of the ZID under worst-case conditions.

B) Average Case Hyper-Saline Effects and Dilution Rates: Figure 9 shows the salinity field on the sea floor resulting from brine dispersion from the closed-cycle cooling system under average case mixing conditions (as represented by proxy records from 23 May 1994). The salinity field is averaged over a 24 hour period. Maximum bottom salinities reach 36.5 ppt over an area of 0.31 acres of the sub-tidal beach face and sandy bottom nearshore habitat immediately seaward of the discharge jetties. Nowhere is any benthic habitat subjected to salinity elevated 10 % above ambient ocean conditions. Only 7.3 acres in the inner portion of the ZID are subjected to bottom salinity that exceeds the upper limit of natural variability (34.44 ppt). Maximum bottom salinity found anywhere along the boundaries of the ZID is 33.66 ppt, occurring at the shoreline 1000 ft south of the discharge channel. Bottom dilution factors for the raw concentrate in Figure 10 indicate that minimum dilution on the sea bed at the south end of the ZID at the shoreline is 162 to 1 under average mixing conditions. Therefore in-place NPDES discharge permit limits on minimum dilution are satisfied for the brine effluent by a wide margin under average conditions.

Maximum salinity in the water column for average case conditions is found in Figure 11 to be 35.2 ppt in the surfzone immediately seaward of the discharge jetty. No pelagic area is subject to brine salinity in excess of any of discharge limits being proposed under amendments to the California Ocean Plan. Maximum water column salinity under average conditions at the edge of the ZID is 33.6 ppt,

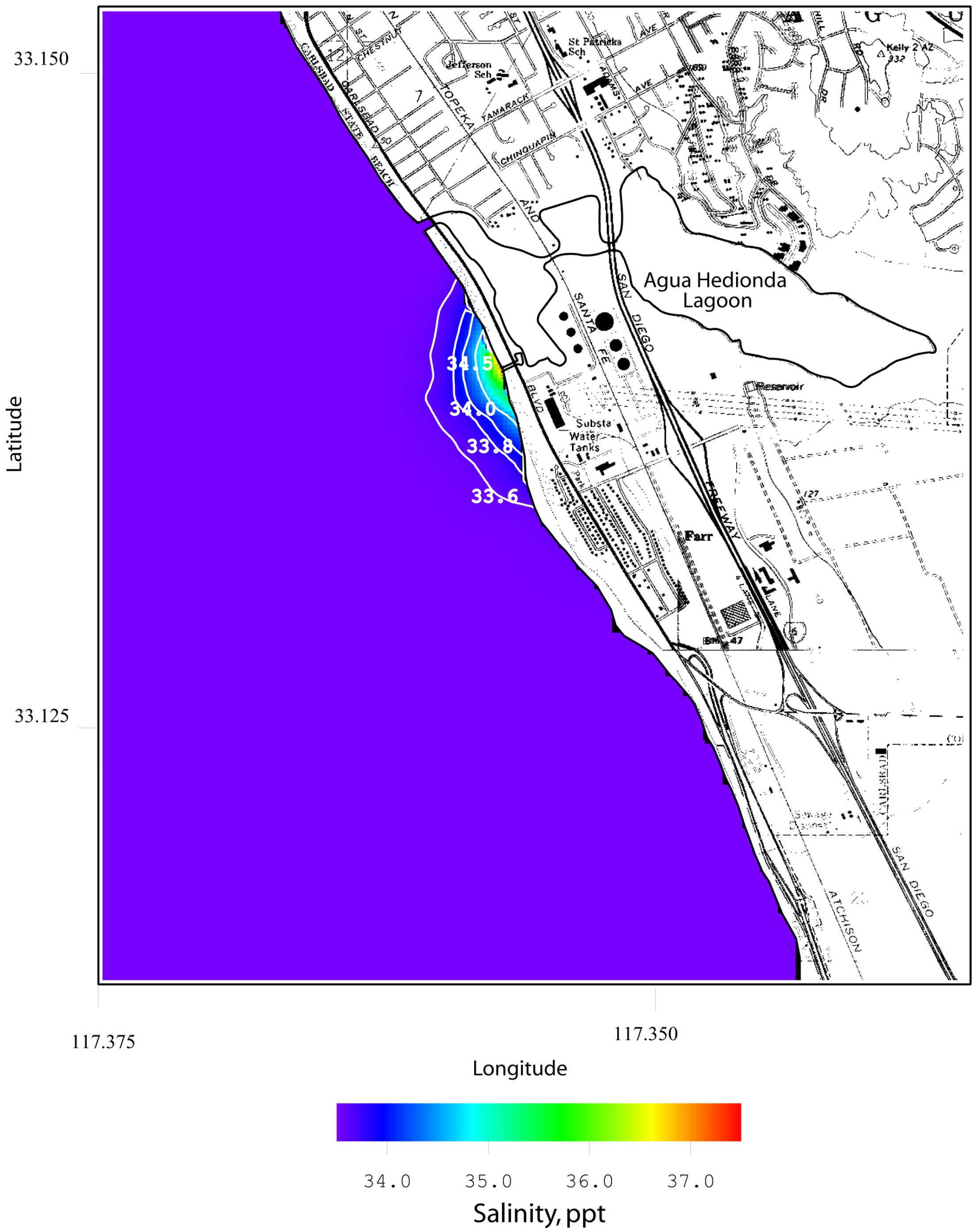

Figure 9. Daily average of bottom salinity due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.52 ppt, ocean conditions, 23 May 1994, representing average case.

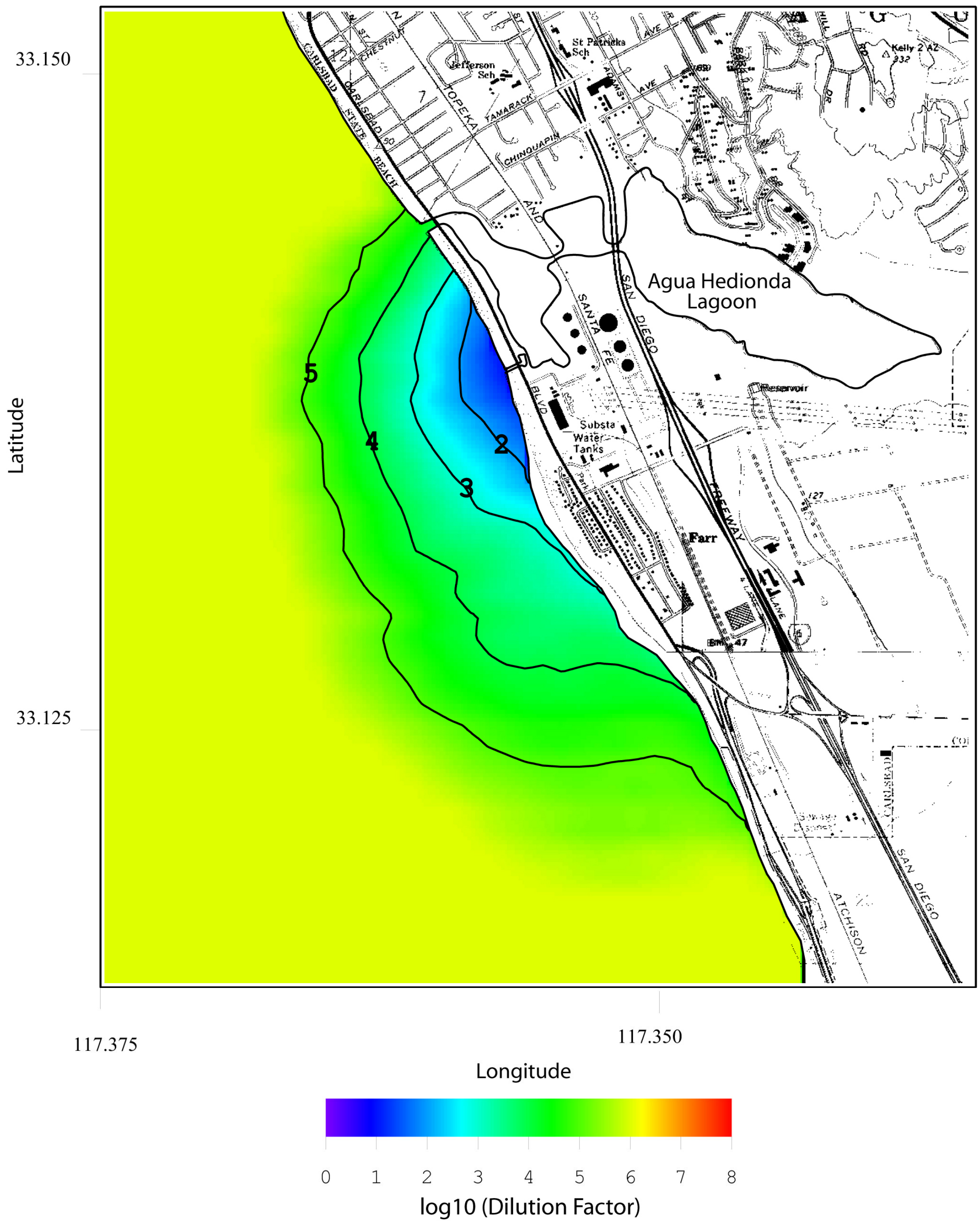

Figure 10. Daily average of bottom dilution due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.52 ppt, ocean conditions, 23 May 1994, representing average case.

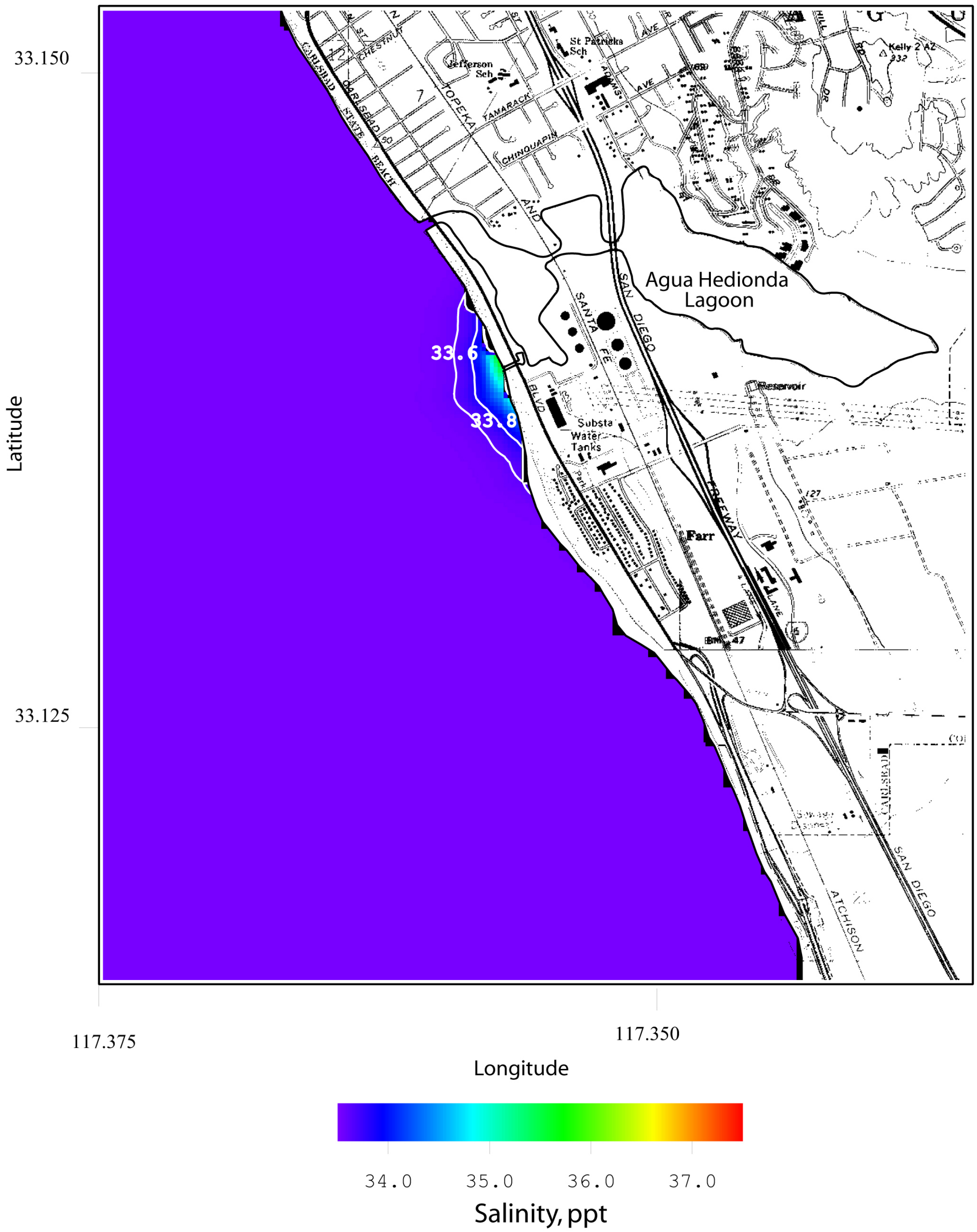

Figure 11. Daily average of depth-averaged salinity due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.52 ppt, ocean conditions, 23 May 1994, representing average case.

found in the surf zone at the shoreline 1000 ft south of the discharge channel. Figure 12 shows that in the water column, where 316(A) dilution standards apply, minimum dilutions are 285 to 1 at the south end of the ZID.

In summary, brine dispersion under average case conditions results in no instances of elevated salinity outside the ZID that exceed the range of natural seasonal variability. Inside the ZID only 7.3 acres are subjected to bottom salinity that exceeds the upper limit of natural variability, and only 0.31 acres of the sub-tidal beach face and sandy bottom nearshore habitat immediately seaward of the discharge jetties would experience salinity that would exceed (slightly) the strictest proposed discharge limit to the California Ocean Plan (36.5 ppt discharge limit). No pelagic area is subject to brine salinity in excess of any of discharge limits being proposed under amendments to the California Ocean Plan. Existing NPDES discharge permit limits on minimum dilution presently applied to thermal effluent are satisfied everywhere by a wide margin for brine discharges under average conditions.

C) Long-Term Salinity and Dilution Statistics: Here we solve the brine dilution problem utilizing all 7,523 possible combinations of fluid forcing and water mass properties from the 1980-2000 period of record (Figures 1& 2). Among these 7,523 dispersion and dilution solutions are the worst-case scenarios shown in Figures 5- 8, along with all the other more common outcomes. From this large ensemble of dilution calculations we are able to construct probability density functions that quantify both the extremes and the means of the envelope of possible outcomes. The purpose of this long-term continuous modeling exercise was to both establish the viability of the event analysis presented in the preceding sections, as well as to explore the persistence of all the intermediate outcomes occurring

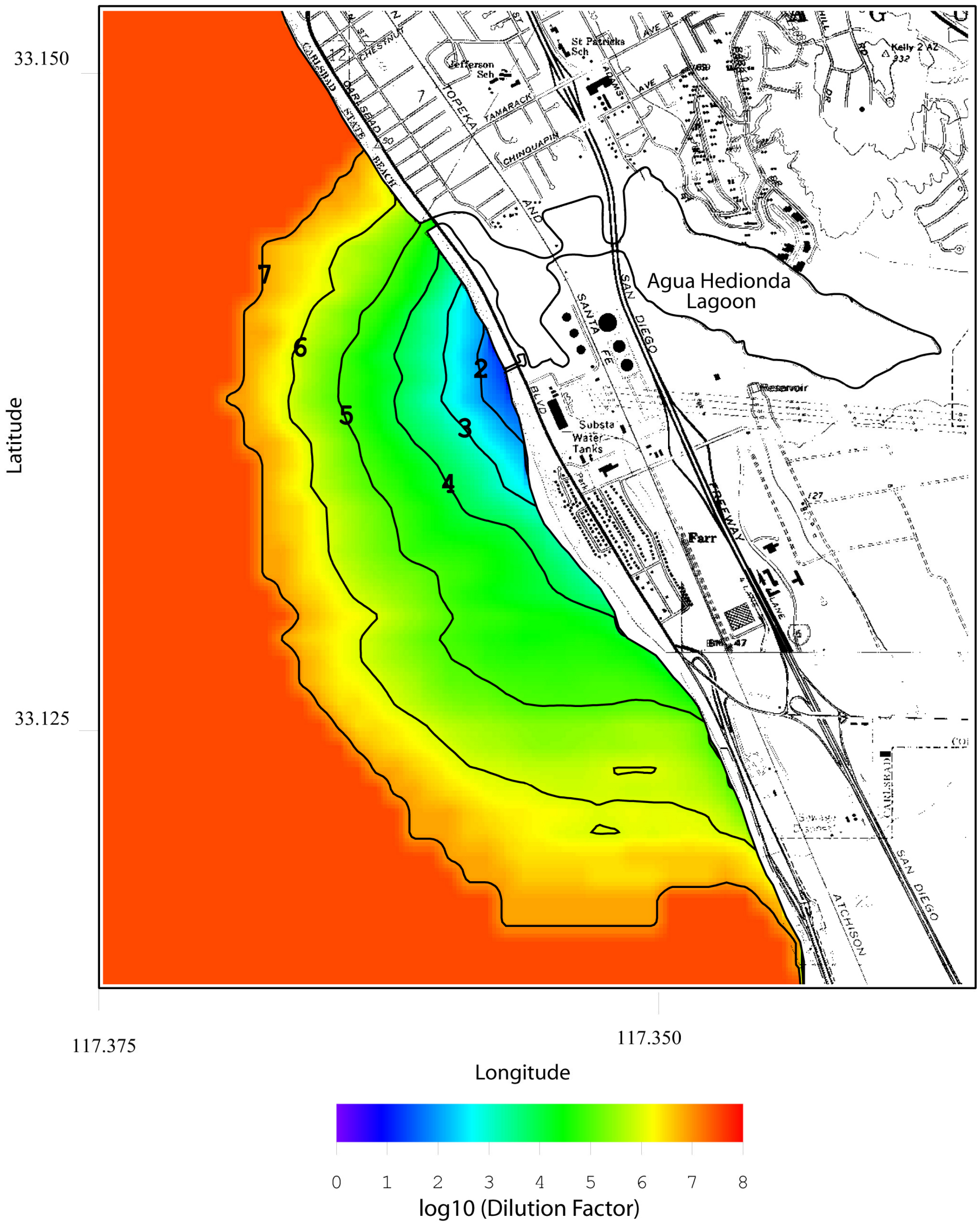

Figure 12. Daily average of depth-averaged dilution due to concentrated seawater discharge from closed-cycle cooling system at Encina Generating Station. Plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm. Combined discharge = 2,657 gpm @ 37.85 ppt end-of-pipe. Ambient ocean salinity = 33.52 ppt, ocean conditions, 23 May 1994, representing average case.

between worst and average cases. Our focus here is what goes on inside and along the perimeter of the ZID, as these are the areas of the solution space where the highest salinity and lowest dilution were found by the preceding event analyses.

The historic boundary conditions from Figure 1 and the forcing functions from Figure 2 were sequentially input to the model, producing daily solutions for the brine plume. This input stream of variables produced 7,523 daily solutions for the salinity and dilution fields. A numerical scan of each of these daily solutions searched for the maximum salinity and minimum dilution anywhere on the seabed or in the water column at distances of 500 and 1000 ft from the head of the discharge jetties. For each of these search radii, the largest salinity and smallest dilution found in any direction away from the discharge channel was entered into a histogram bin for ultimately assembling a probability density function and cumulative probability from the 7,523 outcomes. Histogram bins were constructed at salinity increments of 0.05 ppt and dilution factor increments of 5:1. The bins were summed to calculate the cumulative probability distribution.

Figure 13 shows that the median salinity in the middle of the ZID was 34.2 ppt, which is a value that occurs naturally (on occasions) in the coastal ocean off Carlsbad. The maximum salinity in the middle of the ZID was found to be 35.8 ppt, which is well within the salinity tolerance of the keystone species targeted by the certified EIR (2005) and less the 36.5 ppt numeric discharge limit being proposed as an amendment to the California Ocean Plan. The long term model simulations prove there is a 90% probability that maximum salinity levels in the middle of the ZID will not exceed 34.72 ppt. At the outer edge of the ZID in Figure 14, median salinity is 33.66 ppt, or within 0.14 ppt of average ocean salinity off Carlsbad; and the maximum salinity is only 34.5 ppt, roughly equivalent to the

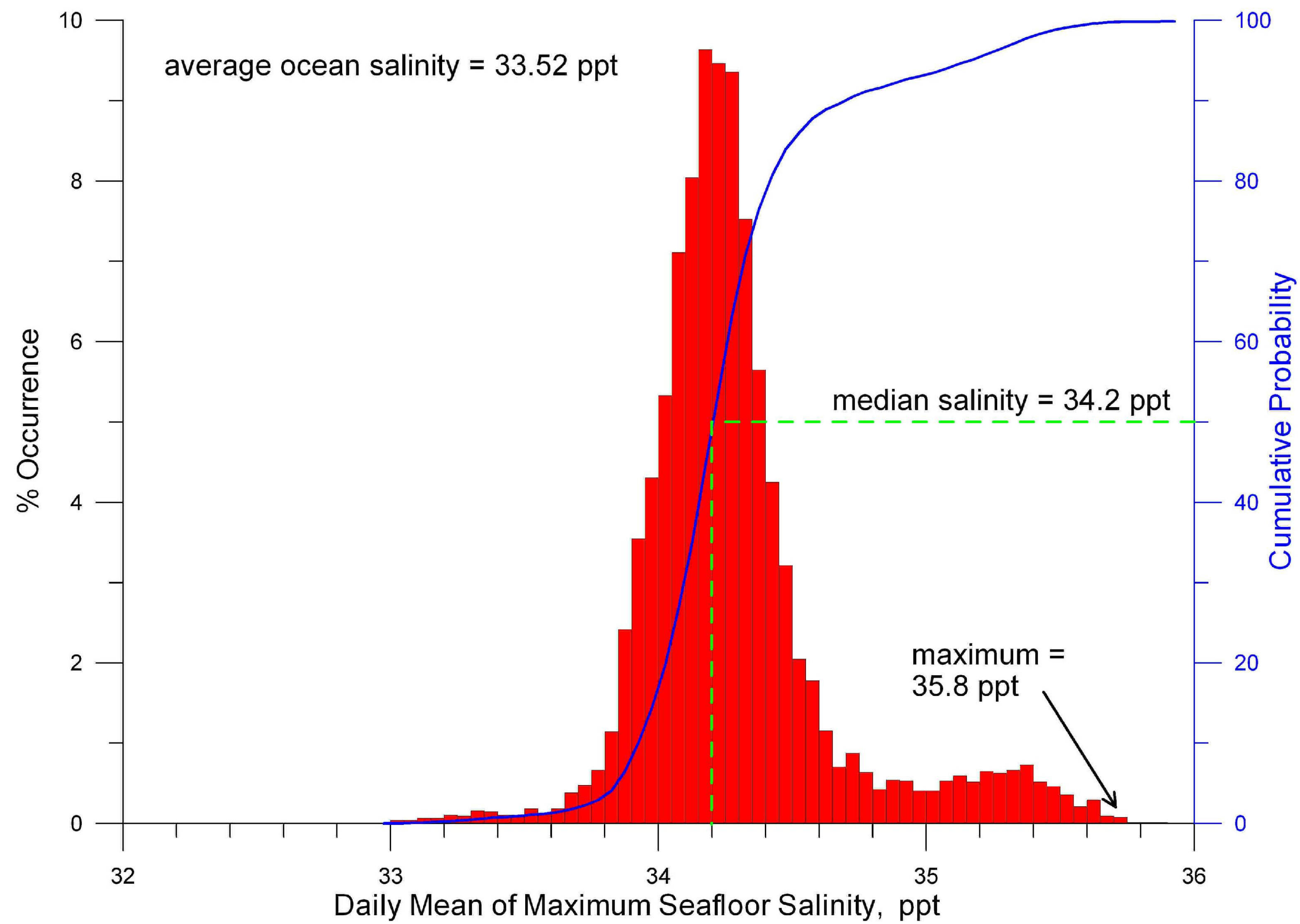

Figure 13. Histogram of maximum seafloor salinity at 500 ft from the discharge (middle of zone of initial dilution, ZID). Model results based on concentrated seawater discharge from closed-cycle cooling system, plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm, combined discharge = 2,657 gpm @ 37.85 ppt, end of pipe, applied to ocean mixing, and water mass properties, 1980-2000. Cumulative probability shown in blue.

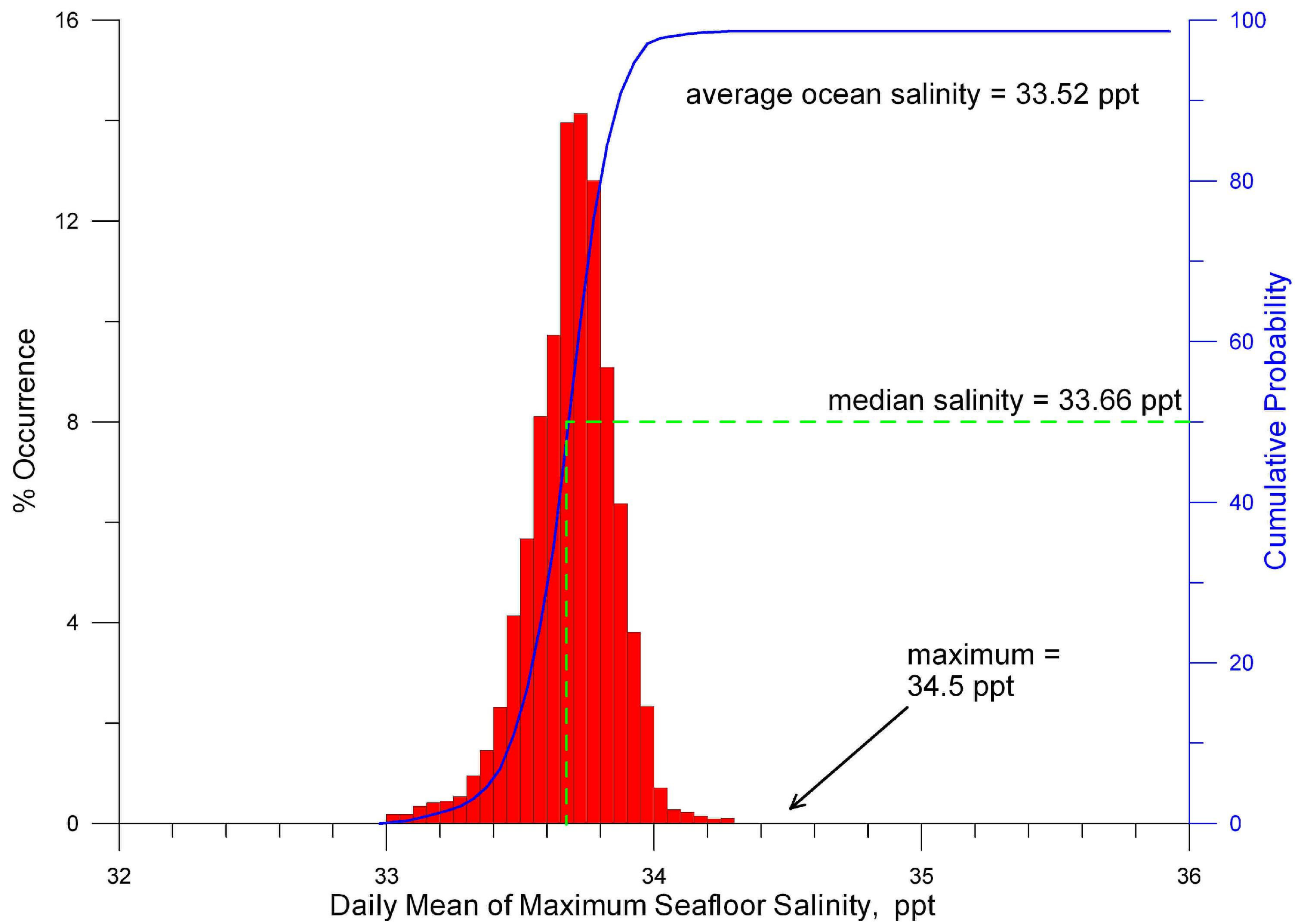

Figure 14. Histogram of maximum seafloor salinity at 1000 ft from the discharge (outer edge of zone of initial dilution, ZID). Model results based on concentrated seawater discharge from closed-cycle cooling system, plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm, combined discharge = 2,657 gpm @ 37.85 ppt, end of pipe, applied to ocean mixing, and water mass properties, 1980-2000. Cumulative probability shown in blue.

maximum naturally occurring value in these coastal waters. Over this representative 20.5 year long period of record, there is a 90% probability that maximum salinity on the edge of the ZID will not exceed 33.87 ppt.

Dilution factors of the brine discharged from the closed-cycle cooling operations are considerably better than what was found for the Carlsbad Desalination Project. In the middle of the ZID (Figure 15) minimum dilution was found to have a median value of 33.5 to 1. Ninety percent of the time, the minimum dilution would exceed 17.5 to 1, even greater than the 15 to 1 required by the NPDES permit at the edge of the ZID, another 500 ft further away from the discharge jetties. The smallest minimum dilution in the middle of the ZID was found to be 9.9 to 1 for the worst-case mixing event (with a 0.013% probability of occurrence). This does not represent a violation of the NPDES permit standard for the thermal effluent because it occurs inside the ZID. The point to be acknowledged here is that the brine dilution inside the ZID remains impressively large. At the outer edge of the ZID (Figure 16) minimum dilution climbs to a median value of 162 to 1, with the lowest dilution factor here being no less than 23.2 to 1 for the worst-case mixing scenario. This result does not stand out in Figure 16 because worst-case is so rare, but it is note worthy that the next most impaired dilution events still produce minimum dilutions on the order of 50 to 1, comfortably above the NPDES limit of 15 to 1 set on thermal effluent. Ninety percent of the time, minimum dilution of brine at the edge of the ZID exceeds 98 to 1.

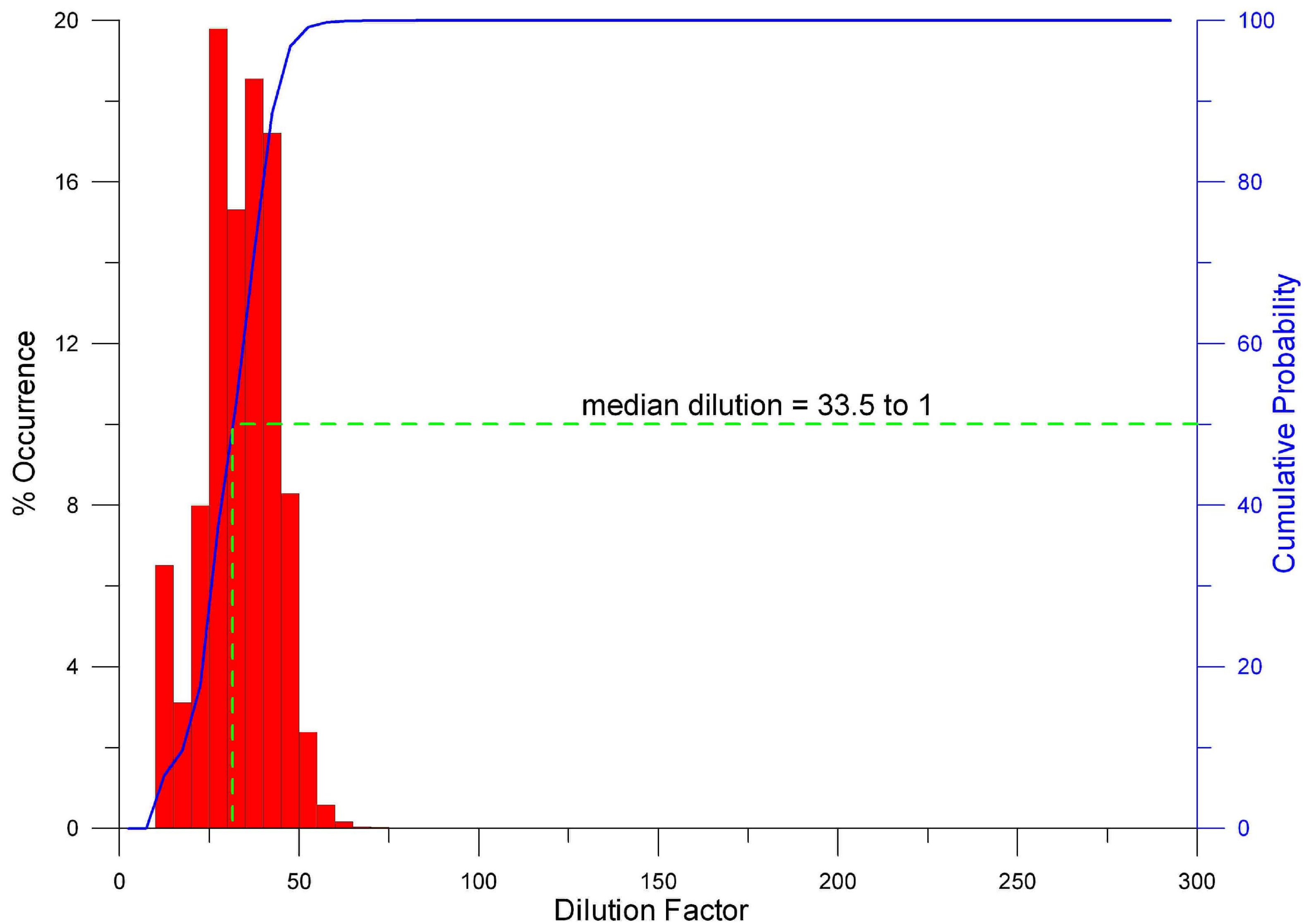

Figure 15. Histogram of minimum dilution of brine at 500 ft from the discharge (middle of zone of initial dilution, ZID). Model results based on concentrated seawater discharge from closed-cycle cooling system, plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm, combined discharge = 2,657 gpm @ 37.85 ppt, end of pipe, applied to ocean mixing, and water mass properties, 1980-2000. Cumulative probability shown in blue.

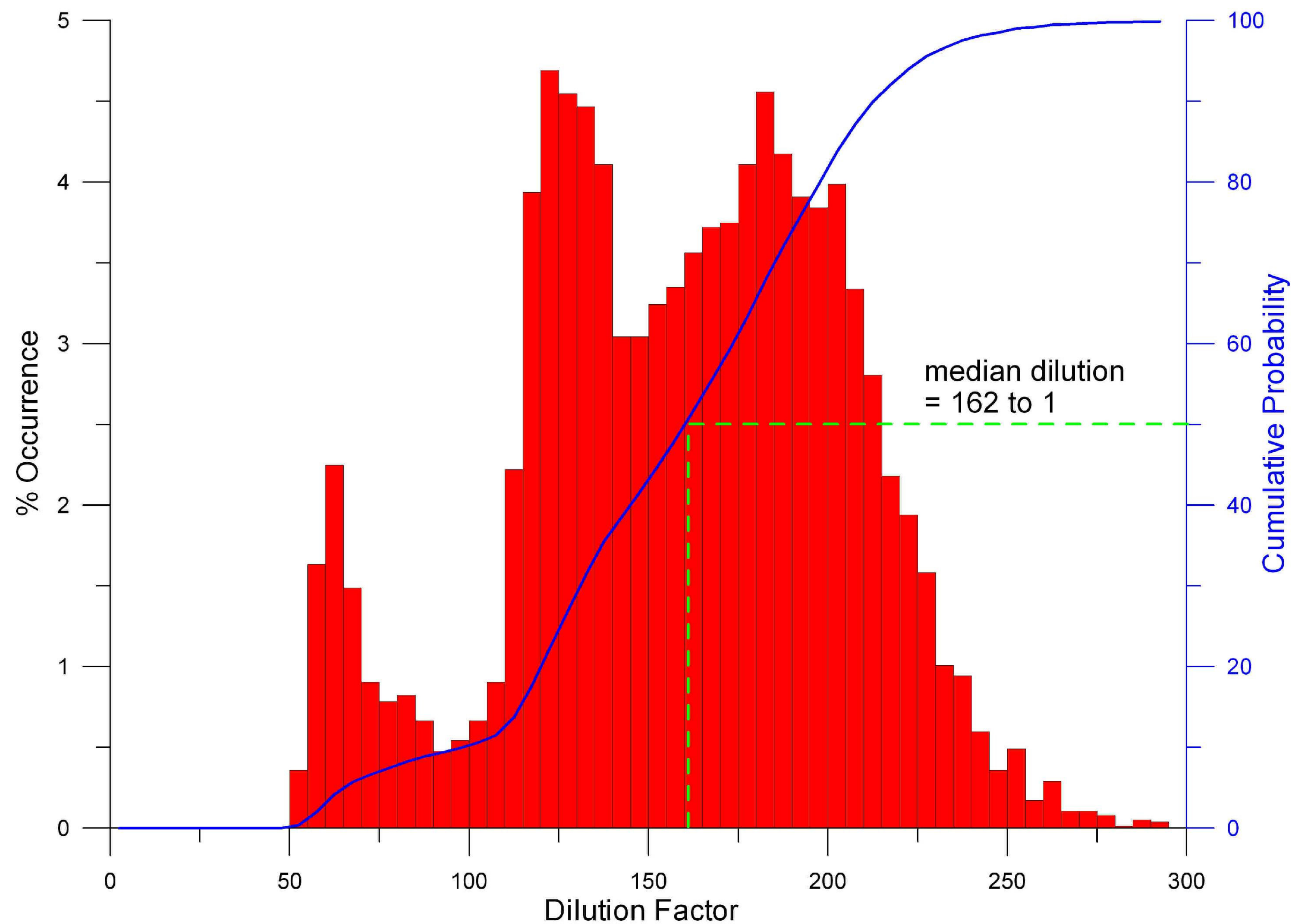

Figure 16. Histogram of minimum dilution of brine at 1000 ft from the discharge (outer edge of zone of initial dilution, ZID). Model results based on concentrated seawater discharge from closed-cycle cooling system, plant inflow rate = 3,000 gpm, R.O. production rate = 343 gpm, combined discharge = 2,657 gpm @ 37.85 ppt, end of pipe, applied to ocean mixing, and water mass properties, 1980-2000. Cumulative probability shown in blue.

4) Summary and Conclusions:

This study invokes a well-tested and peer-reviewed hydrodynamic model (SEDXPORT) to assess dispersion and dilution of concentrated sea water (brine) arising from the production of make-up water for a closed-cycle cooling system at Encina Generating Station. The make-up water would be produced by a small reverse osmosis desalination system that would draw source water off the existing sea water circulation system at Encina. The source water intake flow will be 3,000 gpm. The make-up water desalination system will draw 848 gpm off this source water stream and will produce 505 gpm of brine by-product. The concentration factor of the 505 gpm of brine is only 1.679, as compared to a concentration factor of 2.0 for the Carlsbad Desalination Project that was issued a certified EIR, (referred to as EIR, 2005, herein). For an average ambient ocean salinity of 33.52 ppt, the salinity of the brine reject from the closed-cycle cooling system will average 56.29 ppt (as compared to 67.04 ppt for brine produced by the Carlsbad Desalination Project). The brine from closed-cycle cooling will be mixed with a residual source water throughput of 2,152 gpm, producing a combined discharge of 2,657 gpm through the jetty fortified discharge channel. The combined discharge in the discharge channel will have an average salinity of 37.84 ppt.

Even for the worst-case outcome (an event with a probability of 0.013% occurrence), the hydrodynamic model analysis finds that hyper-salinity impacts and suppressed dilution rates arising from brine discharge by the closed-cycle cooling system are benign. Nowhere in the nearshore environment do salinity values in the brine plume approach the threshold (38-40 ppt) for hyper-salinity tolerance of local marine organisms. Kelp beds and tide pools to the south of the Encina discharge will experience salinity elevations from brine plume impingement that are no greater than what occurs inter-annually under natural seasonal fluctuations of ocean salinity. The strictest standards contemplated for discharges from ocean desalination plants under proposed amendments to the California Ocean Plan are generally satisfied even in the worst-case assessment. Only the strictest proposed standard (a 36.5 ppt numeric limit) is slightly exceeded in a small localized area of surfzone seabed amounting to 1.44 acres. The less severe 10% over background standard being proposed for the California Ocean Plan is satisfied everywhere in worst-case. Existing NPDES discharge permit limits on minimum dilution presently applied to thermal effluent are also satisfied everywhere by the brine discharge along the perimeter of the zone of initial dilution (ZID) under worst-case conditions.

Brine dispersion under average case conditions results in no instances of elevated salinity outside the ZID that exceed the range of natural seasonal variability. Inside the ZID only 7.3 acres are subjected to bottom salinity that exceeds the upper limit of natural variability, and only 0.31 acres of the sub-tidal beach face and sandy bottom nearshore habitat immediately seaward of the discharge jetties would experience salinity that would exceed (slightly) the strictest proposed discharge limit to the California Ocean Plan (36.5 ppt discharge limit). No pelagic area is subject to brine salinity in excess of any of the discharge limits being proposed under amendments to the California Ocean Plan. Existing NPDES discharge permit limits on minimum dilution presently applied to thermal effluent are satisfied everywhere by a wide margin for brine discharges under average conditions.

In addition to the worst-case and average case scenarios, as many as 7,523 modeled cases were evaluated using ocean water mass properties and mixing conditions from the same 20.5-year long period of record as used in the certified

EIR (2005). From these large numbers of solutions, high resolution histograms (probability density functions) were constructed of salinity and dilution factor. On average, the long term simulations show that only 0.31 acres of the sub-tidal beach face and sandy bottom nearshore habitat immediately seaward of the discharge jetties would experience salinity that would exceed (slightly) the 36.5 ppt discharge limit proposed as an amendment to the California Ocean Plan. Further offshore, in the middle of the ZID, the long term median salinity was found to be 34.2 ppt, which is a value in the range of naturally occurring salinity in the coastal ocean off Carlsbad. The maximum salinity in the middle of the ZID was found to be 35.8 ppt, which is well within the salinity tolerance of the local keystone species. At the outer edge of the ZID, median salinity is within 0.14 ppt of average ocean salinity off Carlsbad, and the maximum salinity is only 34.5 ppt, roughly equivalent to the maximum naturally occurring value in these coastal waters. Over this representative 20.5 year long period of record, there is a 90% probability that maximum salinity on the edge of the ZID will not exceed 33.87 ppt, well within in the range of natural seasonal variability of ambient ocean salinity for this coastal region.

Dilution factors of the brine discharged from closed-cycle cooling operations are considerably better than what was found for the Carlsbad Desalination Project. In the middle of the ZID, minimum dilution was typically 33.5 to 1, and at the outer edge of the ZID minimum dilution climbs to a median value of 162 to 1, with worst-case here being no less than 23.2 to 1. In 90% of the model runs, minimum dilution of brine at the edge of the ZID exceeds 98 to 1.

We conclude that closed-cycle cooling operations at Encina will produce brine plume effects that are well below what could be tolerated by indigenous marine organisms, and within the strictest standards being contemplated through amendments to the California Ocean Plan. In addition minimum dilution levels of the brine discharge will also satisfy present NPDES discharge limits permitted for the Encina thermal effluent.

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APPENDIX A: 2007 Proposed Desalination Amendments to the California Ocean Plan

Scoping Document

Amendment of

The Water Quality Control Plan

Ocean Waters of California

June 2007

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ANALYSIS

Alternative 1: No Action. Do not change the existing Ocean Plan: As noted above, the current Ocean Plan is outdated and is not protective of beneficial uses. If the Ocean Plan is not amended it will not be consistent with water quality laws governing vessel waste discharges. Inconsistency between the plan and state and federal laws will pose substantial difficulties for both dischargers and water quality regulators in interpretation, implementation, and compliance with these regulatory requirements.

Alternative 2: Amend the Ocean Plan to delete the exclusion for vessel wastes and to reflect current state and federal requirements governing vessel wastes. This option provides a much greater degree of protection for beneficial uses than is currently required in the Ocean Plan. This approach is consistent with the statutes and would ameliorate inconsistencies between the Ocean Plan and state and federal laws. This would aid both dischargers and water quality regulators in interpretation, implementation, and compliance, and thus ensure that the Ocean Plan's provisions facilitate discharger compliance. Furthermore, this option would not be disruptive to the State's marine economy.

Alternative 3: Prohibit all waste discharges from all vessels, regardless of size or type (e.g., commercial, private recreational, barges, military vessels, etc.), with the exception of passive discharges from hulls. This alternative would be difficult if not impossible for the regulated community to fully comply with due to excessive costs, absence of suitable replacement vessels, or technological retrofit solutions designed to prevent the discharge of the various waste streams described above.

For example, container vessels are generally designed to carefully manage ballast water loads to maintain stability while the vessel is being off-loaded, on-loaded, and while underway (e.g., due to swells and adverse weather conditions at sea). Commercial vessels generally have a useful life of 20-30 years, and each vessel costs millions of dollars to replace.

PRELIMINARY RECOMMENDATION

Alternative 2: Amend the Ocean Plan to delete the exclusion for vessel wastes and to reflect current state and federal requirements governing vessel wastes.

Issue 10. DESALINATION FACILITIES AND BRINE DISPOSAL

PROBLEM

Currently, there is no Ocean Plan objective that applies specifically to brine waste discharges from desalination plants or groundwater desalination facilities. Untreated brine waste discharges into the ocean have different physical and chemical properties than either wastewater treatment plant freshwater effluent or brine waste-freshwater mixtures. Brine wastes discharged into the ocean may form a dense plume that tends to settle to the ocean floor prior to eventual mixing with ocean water. The resulting effect of exposing benthic marine life to a dense, highly saline plume is not well understood, but staff is concerned about potential harmful effects.

Average ocean salinity worldwide is about 35 parts per thousand, or grams per kilogram (g/kg). The coastal marine waters of California generally have lower salinity than open ocean waters, due to runoff. 33.5 g/kg may be used as an approximate ocean salinity for California near coastal marine waters.

Preliminary studies on the effect of increased salinity to marine species were conducted by the Southern California Coastal Water Research Project (SCCWRP) in 1992. Percent normal development of purple sea urchin (*Strongylocentrotus purpuratus*) embryos were reduced 56 to 75 percent in salinities of 36.5 g/kg.

ALTERNATIVES

1. No Action. Do not change the existing Ocean Plan.
2. Establish a narrative water quality objective where salinity should not exceed a certain percentage of natural background.
3. Establish a numeric water quality objective.

ANALYSIS

<u>Alternative 1: No Action. Do not change the existing Ocean Plan</u>. This alternative would keep the Ocean Plan as it currently exists and it would not provide guidance for brine waste discharges necessary for protection of beneficial uses.

<u>Alternative 2: Establish a narrative water quality objective where salinity should not exceed a certain percentage of natural background.</u> Additional toxicological studies would need to be reviewed by staff from the scientific literature to firmly determine a percentage of natural background that is protective of beneficial uses. This option would provide protection for benthic marine organisms and other beneficial uses while also providing flexibility to Regional Water Boards for addressing the natural background, or where a site-specific desalination water quality objective is needed.

<u>Alternative 3: Establish a numeric water quality objective</u>. This alternative would set an absolute upper limit on saline discharges. A preliminary numeric water quality objective of 36.5 g/kg may be justified from the SCCWRP 1992 sea urchin embryo study. Additional toxicological studies would need to be reviewed by staff from the scientific literature. This option may be too prescriptive for Regional Water Boards in addressing the natural background (different in different portions of the State's ocean waters).

PRELIMINARY RECOMMENDATION

Alternative 2: Establish a narrative water quality objective where salinity should not exceed a certain percentage of natural background.

Issue 13. REVIEW TABLE B WATER QUALITY OBJECTIVES

PROBLEM

Staff considered the Table B objectives in order to identify any obvious deficiencies, and has determined that the radioactivity objective is not adequate. The Table B marine aquatic life objective for radioactivity in the 2005 Ocean Plan states: "Not to exceed limits specified in Title 17, Division 1, Chapter 5, Subchapter 4, Group 3, Article 3, Section 30253 of the California Code of Regulations. Reference to Section 30253 is prospective, including future changes to any incorporated provisions of federal law, as the changes take effect." However the citation in Title 17 refers to human exposure (through occupational exposure) and references federal regulations on the same subject. The referenced section may have originally contained the radioactivity criteria for drinking water, which has since been moved to Title 22.

The current objective therefore may not provide protection for aquatic life, is instead applicable to human health, and is difficult to follow. A new objective is needed.

ALTERNATIVES

1. No Action. Do not amend the numeric radioactivity objective.
2. Adopt human health based objectives.
3. Adopt water quality objectives for aquatic life based on the standards proposed by the U.S. Department of Energy in 10 CFR Part 834.
4. Review literature and independently develop standards.

ANALYSIS

Alternative 1: No Action. Do not amend the numeric radioactivity objective. This alternative would keep the Ocean Plan as it currently exists and it would perpetuate the inadequate and confusing nature of this objective.

Alternative 2: Adopt human health based objectives. These are readily available in both federal and state regulatory standards. State and federal drinking water regulations have both gross radiation and specific isotope standards. USEPA approved (40 CFR) test methods exist for these parameters and the standards are in units applicable to water analysis. However, these existing regulations do