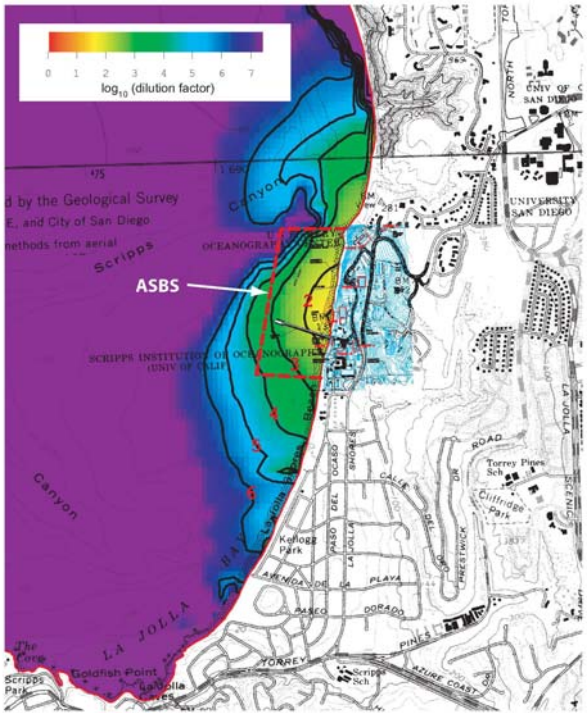
Hydrodynamic Simulations of Shoreline Discharges of Laboratory Seawater and Storm Water at Scripps Beach, CA

By

Scott A. Jenkins, Ph. D. and Joseph Wasyl



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Dr. Scott A. Jenkins Consulting
14765 Kalapana Street
Poway, CA 92064

Submitted to:
Facilities Design and Construction
University of California, San Diego
La Jolla, CA 92093-0916

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Executive Summary

As a condition of the Univeristy of California, San Diego/Scripps Institution of Oceanography (UCSD/SIO) Waste Discharge Permit, the Regional Water Quality Control Board, San Diego Region, requires UCSD/SIO to provide a quantitative dilution assessment of seawater and storm water discharged from the following five separate locations along the Scripps Beach seawall to determine the initital dilution and dispersion of the discharge during storm water discharges and during non-storm water discharges:

- Outfall 001 and Outfall 003: Discharge seawater effluent from aquarium and research facilities. During wet weather, storm water is also discharged from these outfalls.
- Outfall 004a and 004b: Discharge seawater holding tank overflow and sand filter backwash respectively (intermittent discharges). These outfalls do not discharge storm water during wet weather.
- Outfall 002: Discharges storm water during wet weather.

When overlaid on the multi-decadal dry/wet climate cycle of Southern California, this dichotomy in the composition of the UCSD/ SIO discharge led to

the formulation of dry and wet weather extreme casescenarios to study the maximum range of potential impact on the nearshore waters, particularly those waters within the Area of Special Biological Significance (ASBS # 31) located directly adjacent to SIO.

Dilution analysis of the five Scripps Beach discharges for dry and wet weather extreme case scenarios were studied in numerical simulation using the ***SEDXPORT*** hydrodynamic modeling system (Model) that was developed at SIO for the US Navy's *Coastal Water Clarity System* and *Littoral Remote Sensing Simulator*. This Model has been peer reviewed multiple times, calibrated, and validated in the Southern California Bight for 4 previous water quality and design projects. In addition, this model was approved by the EPA in December 2004 for use in this study.

Extreme case scenarios for dry and wet weather used the highest concentrations of total suspended solids (TSS) and copper detected from monitoring the five outfalls during the Winter of 2004-05 period for the 7,523 separate simulations of dilution fields.The following conclusions are reached:

1) Dry weather dilution rates range 100 : 1 to 1,000,000 : 1 in ASBS #31 everywhere seaward of the surf zone.
2) Wet weather dilution rates range 100 : 1 to10,000 : 1 in ASBS #31 everywhere seaward of the surf zone.
3) Minimum dilution inside the surf zone averages 31 : 1 (median value) when maximum seawater discharge rates are perpetuated over the long term with a minimum dilution range as high as 96:1 and as low as 7:1, (occurring only 0.13% of the time). Minimum dilutions greater than 20:1

occur 89% of the time.

Based on model results, a long-term dilution factor for the near shore surf zone should be greater than 20 to 1. Using the maximum copper concentration observed during dry weather monitoring and the proposed dilution factors, copper discharged from the beach outfalls would be found in the receiving water at concentrations no more than 0.04 μg/L in the portions of the ASBS immediately seaward of the surf zone and more typically 0.0001 μg/L to 0.000001 μg/L in the offshore portions of the ASBS. These concentrations are below quantifiable detection limits. For the wet weather extreme case, copper concentrations would be no more than 0.13 μg/L in the portions of the ASBS immediately seaward of the surf zone and 0.01 μg/L to 0.001 μg/L in the offshore portions of the ASBS.

1) Introduction

As a condition of the Scripps Institution of Oceanography (SIO)/University of California, San Diego (UCSD) National Pollutant Discharge Elimination System (NPDES) Permit, the Regional Water Quality Control Board, San Diego Region, requires UCSD/SIO to conduct a quantitative dilution assessment of the five seawater and storm water shoreline discharges to Scripps Beach to determine the initital dilution and dispersion of the discharge during storm water discharges and during non-storm water discharges. Water from these five discharge points flows into neighboring nearshore waters. The locations of these discharges are shown in Figure 1 and are characterized by the following outfall descriptions:

Outfall 001 consists of a concrete box dissipater on the North Seawall, north of Scripps Pier that discharges seawater from the Birch Aquarium at Scripps, SIO's Hubbs Hall Experimental Aquariums, the National Marine Fisheries aquaria, and from test tanks at the Hydraulics Laboratory, but also receives storm water runoff during wet weather. During the period of this study, maximum discharge rates were 486 gallons per minute (gpm) of seawater and 5,700 gpm of storm water.

Outfall 002 is an 8 inch storm water outlet on the north seawall directly under the Center for Coastal Studies. Maximum discharge rates during this study period were 200 gpm of storm water

Outfall 003 is a 10 inch pipe located on South Seawall adjacent to the SIO Administration Building. Maximum discharge rates during this study period

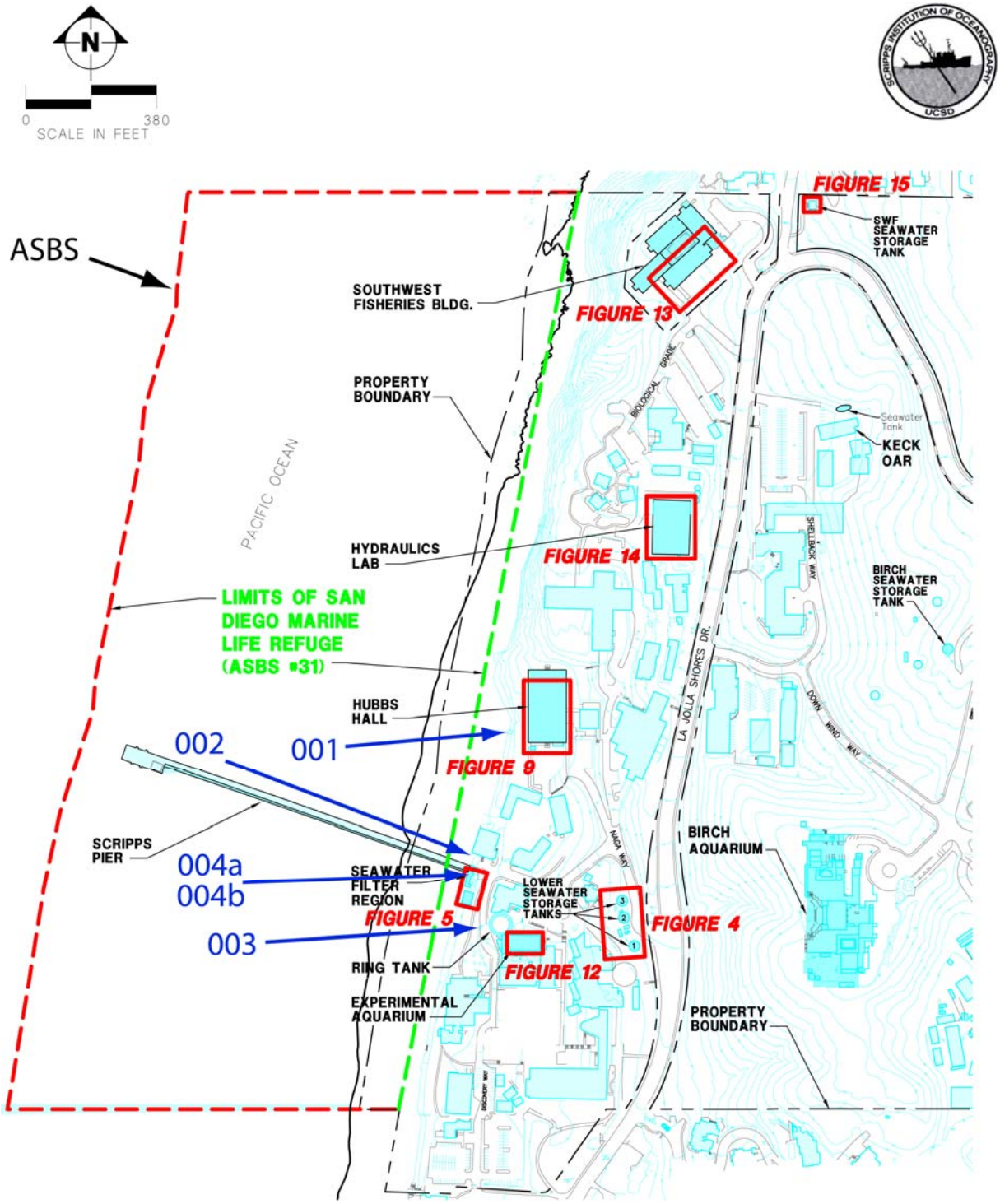

Figure 1: Scripps Institution of Oceanography campus with discharge outfalls shown in blue and boundary of the Area of Special Biological Signifcance (ASBS # 31) shown in red.

were 139 gpm of storm water augmented by seawater from the Experimental Aquarium.

Outfalls 004a & b consist of episodic overflow from the sea water settling tanks and episodic seawater backwash from the aquarium filters, located at the south bents of the land terminus of Scripps Pier. Maximum discharge rates are 97 gpm of seawater only.

The neighboring nearshore waters that receive theses discharges include an Area of Special Biological Significance referred to as ASBS #31. The boundaries of ASBS #31 are shown as a red dashed line in Figure 1 that encloses 88 acres of predominantly sandy bottom habitat with several rocky outcrops at the Dyke Rock formation withnumerous tide pools along the northern half of its shoreline. Of particular concern to this study are the dilution levels of the existing discharges within the boundaries of ASBS #31.

The quantification of dilution requires solving the hydrodynamic transport equations for a spatial and temporal variation of dilution factor throughout the effected receiving water. The dilution factor analysis will be evaluated at two distinct extreme case scenarios: 1) peak seawater flows during dry weather with low mixing rates in the receiving waters due to quiescent ocean/atmosphere conditions; and 2) storm water runoff co-mingled with peak seawater discharge during high energy conditions typical of a winter storm event.

It is sensible to bifurcate the model problem into these dry and wet weather extreme cases based on the multi-decadal dry/ wet cycles that the regional climate undergoes. The California coast is subject to climate cycles of about 20-30 years

duration known as the Pacific/ North American pattern (for atmospheric pressure) or the Pacific Decadal Oscillation (for sea surface temperature). These dry/ wet cycles are apparent in the historic rainfall record of San Diego shown in Figure 2a. A dry period extended from about 1945-1977, followed by an episodically wet period from 1978-1998 that included the occurrence of 6 strong El Niño events (Inman and Jenkins 1997; and Goddard and Graham 1997). Based on the historic duration of these cycles, 1998 was likely the end of the wet cycle of climate in California with a return to the dry climate that prevailed from 1945-1977 (White and Cayan 1998).

To illustrate the historical evidence for these dry and wet climate cycles, the rainfall record in Figure 2a was analyzed for climate trends using the Hurst (1951, 1957) procedure that was first used for determining decadal climate effects on the storage capacity of reservoirs (Inman and Jenkins, 1999). Climate trends become apparent when the data are expressed in terms of cumulative residuals of rainfall RF_n taken as the continued cumulative sum of departures of annual values of a time series RF_i from their long term mean value RF_a such that $RF_n = \sum_0^n (RF_i - RF_a)$ where *n* is the sequential value of the time series. When this procedure was applied to the rainfall record in Figure 2b, dry periods are revealed by segments of the cumulative residuals having negative (downward) slopes while the wet periods have positive (upward) slopes. A dry period is found from 1945-1977, (negative slopes) while a wet period (positive slope) is shown from 1978-1998. The wet period of the climate cycle is more irregular caused by 6 strong El Niño events (water years 1978, 80, 83, 93, 95, and 98) and one 4-year period (1987-1990) of low rainfall.

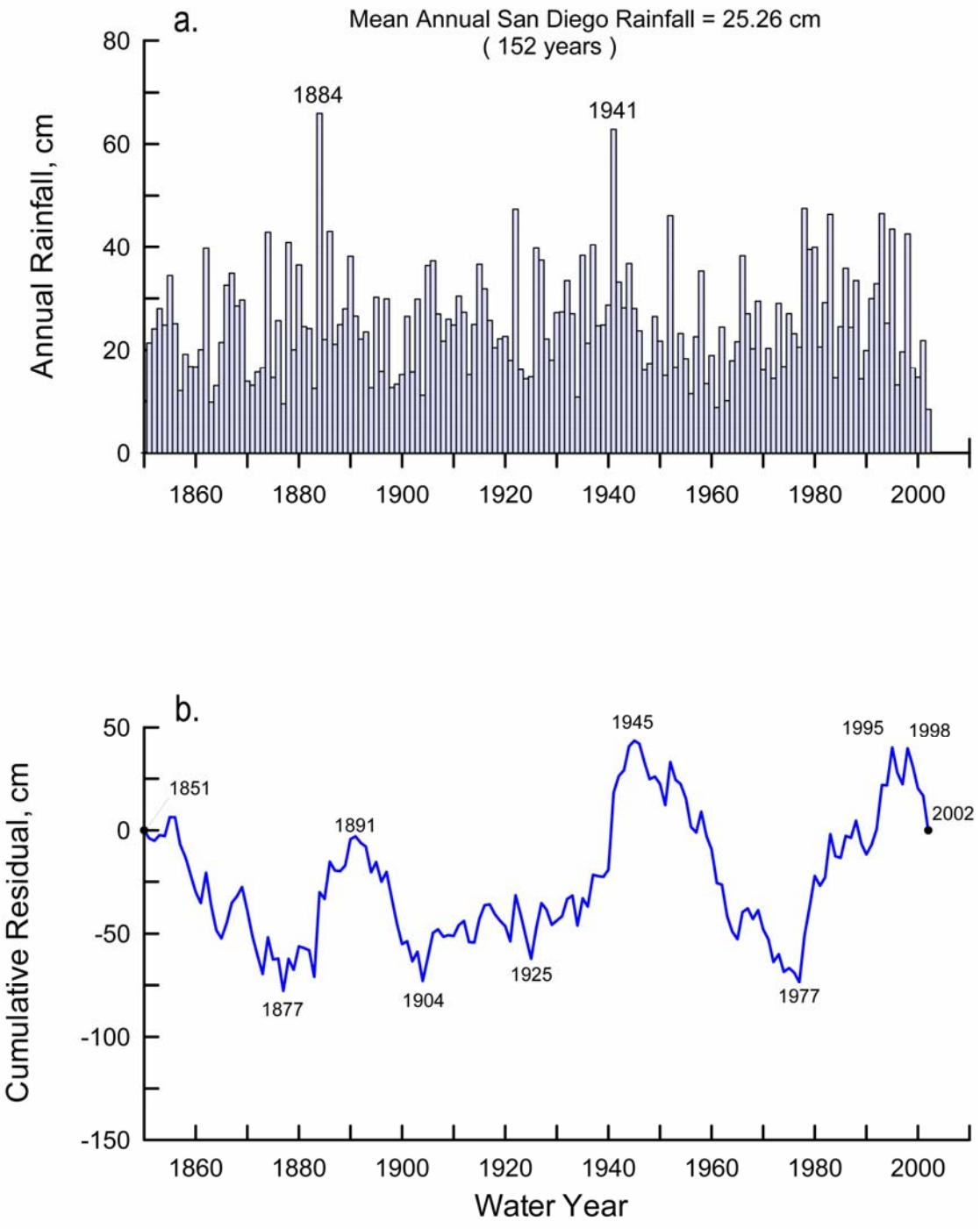

Figure 2. a) Period of record of San Diego rainfall and b) cumulative residual

The analysis shows that the average annual rainfall increased by about 38% from the dry to the wet portions of the cycle. Furthermore, both the minimum and maximum ranges in rainfall are higher in the wet period, while the averages of the 6 major rainfall events in 21 year periods before and after the climate change (1977/78) are about 8 to 9 inches greater during the wet period. These sharp distinctions in the statistics of dry vs wet climate periods lead to posing the model problem of discharge dilution in terms of dry and wet extreme case scenarios in order to bracket the envelope of potential variability.

Altogether there are seven primary variables that enter into a solution for resolving the dispersion and dilution of shoreline discharges such as those found along Scripps Beach.The statistics of these seven variables all change between dry and wet climate periods. These seven variables may be organized into ***boundary conditions*** and ***forcing functions***. The boundary conditions include: ocean salinity, ocean temperature, ocean water levels and discharge flow rates. There is an additional boundary condition associated with offshore bathymetry beyond closure depth (typically greater than 12-15 m) that we will treat as constant. These boundary condition variables are developed in Section 3.1. The forcing function variables include: waves, currents, and winds and are developed in Section 3.2.

Overlapping 20.5 year long records containing 7,523 consecutive days between 1980 and 2000 are reconstructed in Sections 3.1 and 3.2 for each of the seven controlling variables. We search this 20.5 year period for the historical combination of these variables that give an historic extreme day in the sense of benign ocean conditions that minimize mixing and dilution rates, and a high energy day giving mixing and dilution rates typical of winter storm conditions with rainfall. We then overlay the peak discharge rates of seawater and storm water on

those environmental conditions, respectively. The criteria for an extreme dry weather day was based on the simultaneous occurrence of the environmental variables having the highest combination of absolute salinity and temperature during the periods of lowest mixing and advection in the local ocean environment. These conditions coincide with the simultaneous occurrence of the lowest 5% wave, wind, currents, and ocean water levels averaged over a 24 hour period . The extreme wet weather scenarios were found by a statistical search of these records for the simultaneous occurrence of the highest 5% wave, wind, currents, and ocean water levels averaged over a 24 hour period. This procedure produced the model scenarios defined in Section 3.3. We also set up the model in Section 3.3 to solve for the minimum dilution in the surf zone for all 7523 combinations of the 7 controlling variables in order to establish the statistical properties the ***zone of initial dilution*** (***ZID***).

The technical approach used to evaluate these scenarios for historical extremes and average case conditions involved the use of the SEDXPORT hydrodynamic transport models. The pedigree and physics of this modeling system is described briefly in Section 2, with additional details provided in Appendices A-F. The dilution fields simulated by this model are presented in Section 4, giving results for the dry weather extreme in Section 4.1, the wet weather extreme in Section 4.2 and the long term minimum dilution in the ZID in Section 4.3. Dilution fields for an offshore outfall alternative are given in Section 4.4.

2) Model Description and Capabilities

This study utilizes a coupled set of numerical tidal and wave transport models to evaluate dilution and dispersion of the discharges from the five beach outfalls operated by UCSD/SIO at Scripps Beach (Figure 1). The numerical model used to simulate tidal currents in the nearshore and shelf region offshore of Scripps Beach 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 storm water discharge by the wave and tidal currents is calculated by the finite element model known as **SEDXPORT**.

The finite element research model, **TIDE_FEM**, (Jenkins and Wasyl, 1990; Inman and Jenkins, 1996) was employed to evaluate the tidal currents within La Jolla Bay and in particular, the ventilation of the ASBS #31. **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 Appendix A. **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 Appendix B for a listing of TID_DAYS code). **TID_DAYS** computes the distribution of sea surface elevation variations in La Jolla Bay 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 Scripps SAS station at Torrey Pines (Pawka, 1982) and by the CDIP arrays and/or buoys at Scripps Pier, La Jolla Bay, Huntington Beach, San Clemente, and Oceanside, CA, see CDIP (2005). These measurements were back refracted out to deep water to correct for island sheltering effects between the monitoring sites and Scripps

Beach. The waves were then forward refracted onshore to give the variation in wave heights, wave lengths and directions throughout the nearshore around Scripps Beach. 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 Scripps Beach site is **OCEANRDS** and may be found in Appendix C. 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 Appendix D. **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** (Appendix E) 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 storm water runoff and seawater discharge 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 discharge of seawater or the combined discharge of seawater and storm water from the 5 UCSD/SIO beach outfalls is represented as sources in the surface mixed layer. The source initializations for these beach discharges are handled by a companion code called **MULTINODE** (Appendix F) that couples the computational nodes of **TIDE_FEM** and **OCEANRDS** with **SEDXPORT**. The 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 Total Suspended Solids (TSS) and Total Dissolved Solids (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.

In its most recent version, **SEDXPORT** has been integrated into the Navy's Coastal Water Clarity Model and the Littoral Remote Sensing Simulator (LRSS) (see Hammond, et al., 1995). The **SEDXPORT** code has been validated in mid-to-inner shelf waters (see Hammond, et al., 1995; Schoonmaker, et al., 1994). Validation of the SEDXPORT code was shown by three independent methods: 1) direct measurement of suspended particle transport and particle size distributions by means of a laser particle sizer; 2) measurements of water column optical properties; and, 3) comparison of computed stratified plume dispersion patterns with LANDSAT imagery.

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 8 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, Scripps Beach, 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

SEDXPORT has been built in a modular computational architecture with a set of subroutines 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 subroutines **RIVXPORT** and **BOTXPORT** in **SEDXPORT** solve for the mixing and advection of the seawater and buoyant storm water discharge in response to the wave and tidal flow using an rms vorticity-based time splitting scheme. Both **BOTXPORT** and **RIVXPORT** solve the eddy gradient form of the advection diffusion equation for the water column density field:

$$\frac{\partial \rho}{\partial t} = (\vec{u} \bullet \nabla \varepsilon) \bullet \nabla \rho - \varepsilon \nabla^2 \rho + \rho_0 Q_0 \qquad (1)$$

where $\vec{u}$ is the vector velocity from a linear combination of the wave and tidal currents, ε is the mass diffusivity, ∇ is the vector gradient operator and ρ is the water mass density in the nearshore dilution field; and ρ_0 is the density of the water discharged by the outfall at a flow rate $\frac{dV_0}{dt}$. The density of the discharge is a function of the bulk density of the suspended solids ρ_s and the density of the discharge fluid ρ_f that transports those solids, or:

$$\rho_0 = \rho_s + (1-N)\,\rho_f = \rho_q N + (1-N)\,\rho_f \qquad (2)$$

where N is the volume concentration of suspended solids equal to the ratio of suspended solids to sample volume; and ρ_q = 2.65 g/cm^3 is the density of the suspended solid particles taken to be fine-grained quartz.

Both the density of the receiving water ρ and the density of the discharge fluid ρ_f 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 $\alpha_f = 1/\rho_f$ or:

$$\frac{d\alpha}{\alpha} = \frac{1}{\alpha}\frac{\partial \alpha}{\partial T}dT + \frac{1}{\alpha}\frac{\partial \alpha}{\partial S}dS \qquad (3)$$

$$\frac{d\alpha_f}{\alpha_f} = \frac{1}{\alpha_f}\frac{\partial \alpha_f}{\partial T}dT + \frac{1}{\alpha_f}\frac{\partial \alpha_f}{\partial S}dS$$

The factor $\partial\alpha/\partial T$, 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 $\partial\alpha/\partial S$ 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 TDS. For a standard seawater, the specific volume has a value α = 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.

The dilution ratio is given by the volume concentration of the discharged suspended solids in the receiving water and follows from the sediment continuity equation:

$$\frac{\partial N}{\partial t} = \left(\vec{u} \bullet \nabla \varepsilon\right) \bullet \nabla N - \varepsilon \nabla^2 N - W_0 \frac{dN}{dz} \qquad (4)$$

where W_0 is the settling velocity of suspended particles. It is necessary to correct dilution ratio calculations for the loss of suspended particles due to deposition, so that loss is not included as a pseudo-dilution. The deposition flux is the net between settling and re-suspension and is found from a sub-set of solutions to (4) at the seabed as originally posed for steady flow by Krone (1962) and expanded to oscillatory flow by Jenkins and Wasyl (1990):

$$\Lambda = \frac{-K_s g N_c \left[W_0 N_c - \varepsilon \left(\frac{\partial N}{\partial z} \right)_{z=0} \right]}{\left(1 - N_c / N_s\right)} \qquad (5)$$

where K_s = 4 x 10^{-14} sec is the sedimentation coefficient after Fujita (1962); g is the acceleration of gravity; N_c is the volume concentration at the top of the wave boundary layer; and N_s is the volume concentration of the seabed sediments. If N_0 is the volume concentration of suspended solids at the point of discharge (end-of-pipe); and $N(x, y, z)$ is the volume concentration at any location in the receiving waters, then the dilution factor at that location (corrected for deposition losses) is:

$$D(x, y, z) = \frac{N_0}{N(x, y, z)} - \frac{\Lambda}{W_0} \qquad (6)$$

Hence, net deposition ($\Lambda > 0$) in say the ASBS acts to increase the retention of discharged particulate there, and consequently reduces the apparent dilution factor.

In (1) and (4) 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.

The settling velocity W_0 in (4) and (5) is particle size dependent. The **SEDXPORT** code is configured to accept up to nine particle size bins which for fine-grained particulate are assigned according to the particle size distribution after Jerlov (1976):

$$N(d) = \hat{N}\left(\frac{d}{\hat{d}}\right)^{\gamma} \tag{7}$$

where

$$N_0 = \sum_d N(d) \tag{8}$$

Here $\hat{d}$ is the reference grain size, typically taken as 1.0 microns; and γ is the slope of the particle size distribution on log-log scale where $\gamma \cong 2.5$ for the global average, and $\hat{N}$ is the volume concentration of the reference grain size that is adjusted such that (8) satisfies the measure value N_0 at end-of-pipe.

Solutions for the density and concentration fields calculated by the **SEDXPORT** codes from equations (1)-(4), (7) & (8) are through put to the dilution codes of **MULTINODE** to resolve dilution factors according to (5)- (6). 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 Appendix F). The diffusivity, ε, 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. 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** (Appendix E). 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) Model Initialization

Uninterrupted, long-term monitoring of ocean properties has been conducted at the nearby Scripps Pier. The Scripps Pier has been the site of both a NOAA tide gage station (NOAA #941-0230) as well as a monitoring station of the Coastal Data Information Program. It has also been the site where many new monitoring

techniques have been developed and validated. We will take advantage of these long term observations to develop the data bases for initializing the boundary conditions and forcing functions used in the model. Statistical searches of these data bases will be performed to extract the dry and wet weather extreme case scenarios.

These dry and wet weather model scenarios are proxies for the extremes of the long term climate variability of the region, and serve to bracket the envelope of potential discharge effects on ASBS #31. Climate variability begins with seasonal variations in Earth's exposure to the sun, producing inter-annual variations in atmospheric pressure fields which in turn cause the Earth's inter-annual seasons. Upon occasion, the typical seasonal weather cycles are abruptly and severely modified on a global scale. These intense global modifications are signaled by anomalies in the pressure fields between the tropical eastern Pacific Ocean and Australia/Malaysia known as the ***El Niño Southern Oscillation***, commonly referred to as ***ENSO***. The intensity of the oscillation is often measured in terms of the ***Southern Oscillation Index (SOI)***, defined as the monthly mean sea level pressure anomaly in mb normalized by the standard deviation of the monthly means for the period 1951-1980 at Tahiti minus that at Darwin, Australia. The Southern Oscillation is in turn, modulated over multi-decadal periods by the ***Pacific Decadal Oscillation***, which results in alternating decades of strong and weak El Niño. The long-term variability of the Pacific Decadal Oscillation (PDO) is shown in Figure 3 and the cumulative residual of the Southern Oscillation Index, between 1882 and 1996, is plotted in Figure 4. Southern Oscillation effects give rise to enhancements and protractions of the inter-annual seasonal cycles, and their two extremes are referred to as El Niño (SOI negative) and La Niña (SOI positive).

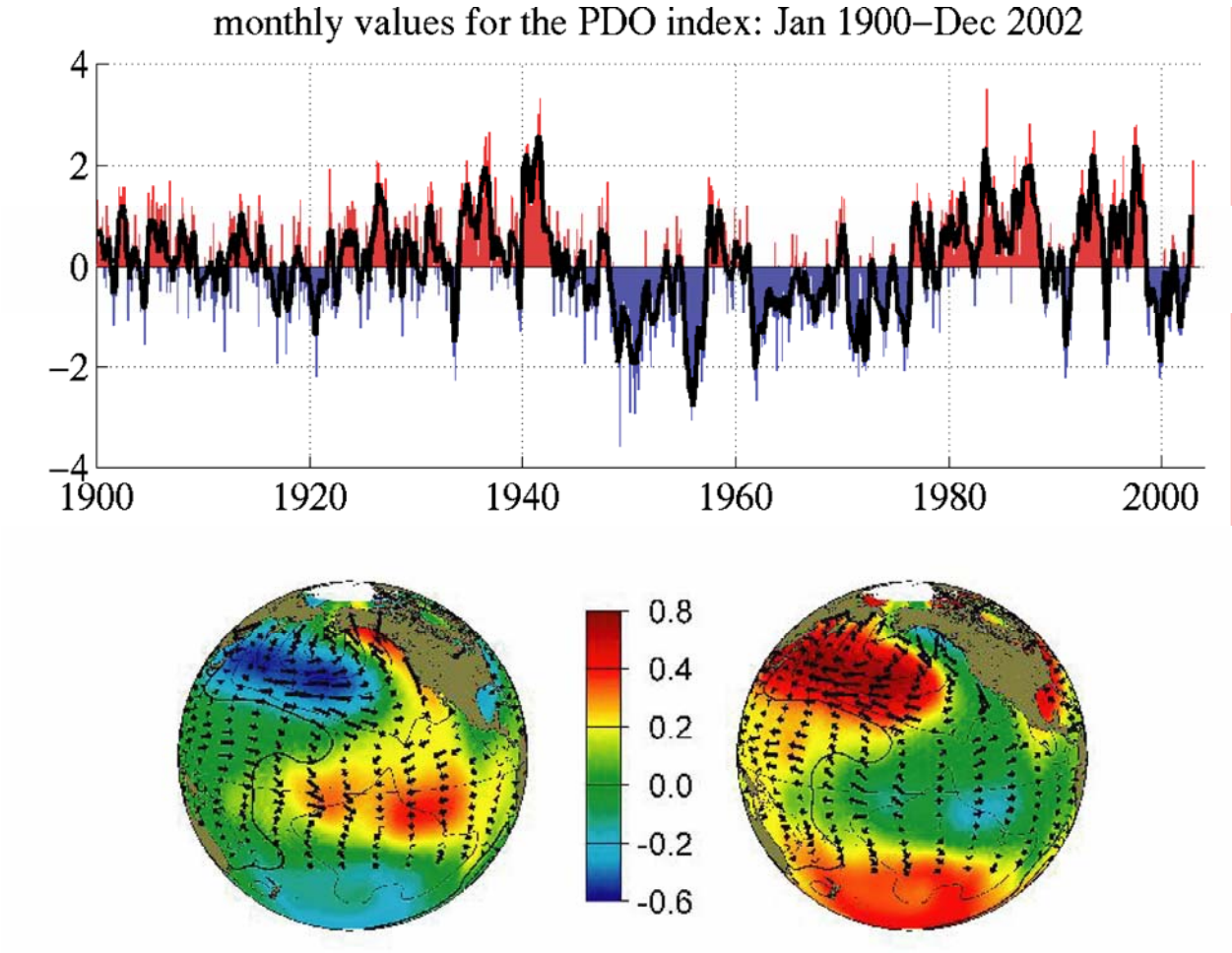

Figure 3. Typical wintertime Sea Surface Temperature (colors), Sea Level Pressure (contours) and surface wind stress (arrows) anomaly patterns during warm and cool phases of PDO. Red colors indicate warm, blue indicates cool.

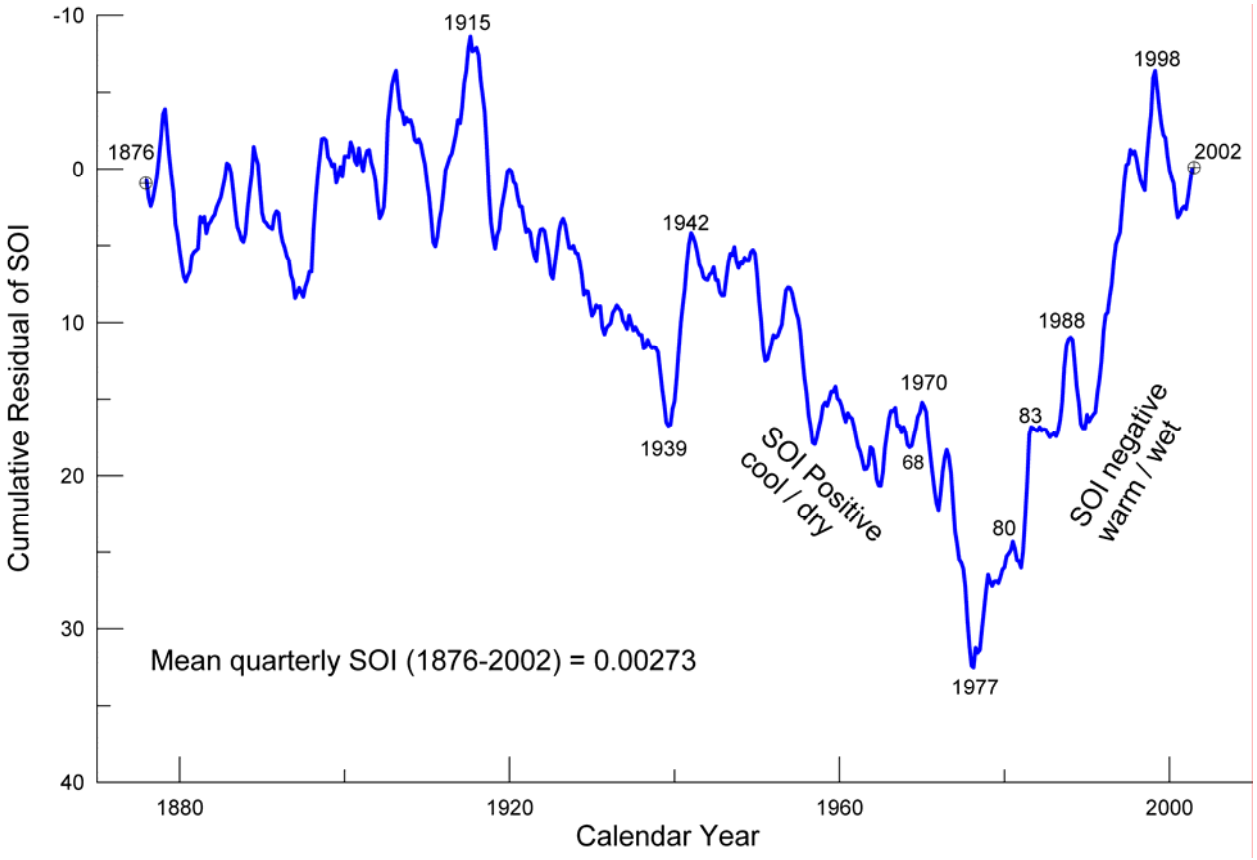

Figure 4. Cumulative residual of quarterly values of Southern Oscillation Index (SOI) [data from Australian Commonwealth Bureau of Meteorology].

Inspection of Figures 3 and 4 reveals a number of large positive oscillations in the SOI between 1944 and 1978 corresponding to La Niña dominated climate; and a series of very large negative oscillations occurring between 1978 and 1998 which correspond with El Niño dominated climate. Along the southern California coast, a period of mild-stable weather occurred during the 30 years between the mid-1940's and mid-1970's when La Niña dominated pressure systems prevailed. The average SOI for this period was +0.1, with strong La Niña events in 1950, (SOI = +1.4); 1955/56, (+1.2); 1970/71, (+1.0); 1973/74, (+1.0); and 1975/76 (+1.4). Winters

were moderate with low rainfall (see Figure 2), and winds were predominantly from the west-northwest. The principal wave energy was from Aleutian lows having storm tracks which usually did not reach southern California. Summers were mild and dry with the largest summer swells coming from very distant southern hemisphere storms.

Beginning in 1978, the southern California climate began transitioning into a warmer wetter period characterized by a succession of powerful El Niños, particularly those in, 1978, 1980, 1983, 1993, 1995 and 1998, [Inman & Jenkins, 1997]. The average SOI for this period was -0.5, with the 1978/79 El Niño averaging -1.2, the 1982/83 El Niño averaging a record -1.7 and the 1993/94 El Niño recording a mean of -1.0. Heavy rainfall accompanied each of these El Niño events (see Figure 2) causing flood run off to exceed many times the long term mean for all the major rivers and tributaries throughout Southern California (Inman and Jenkins, 1999). The wave climate in southern California also changed, beginning with the El Niño years of 1978/79 and extending until 1998. The prevailing northwesterly winter waves were replaced by high energy waves approaching from the west or southwest, and the previous southern hemisphere swell waves of summer have been replaced by shorter period tropical storm waves during late summer months from the more immediate waters off Central America. Other strong El Niño events of the past have also been accompanied by extreme wave events, although none of these have been as sustained as the succession of El Niños from 1978 to 1995. The 1939/42 El Niño had an average SOI of -1.3 and was associated with a series of destructive wave events in the Southern California Bight, the most intense being the 24/25 September 1939 storm which seriously damaged the breakwater system at Long Beach, CA. The El Niño of 1904/05 had

a mean SOI of -1.4 and was attended by a series of damaging west swells in March 1904 and again in March 1905 [Horrer, 1950; Marine Advisors, 1961]. A similar succession of El Niño floods also preceded the cool/dry period of 1944-77, causing major episodes of sediment yield in 1927, 1937, 1938, 1941 and 1943.

From Figures 2 - 4 it is apparent that an inter-decadal pattern of rainfall and SOI has persisted for at least the last century an a half, characterized by alternating cool/dry La Niña dominated periods with little or no sediment yield, followed by warm/wet El Niño dominated periods when heavy rainfall produces most of the total sediment runoff. This kind of inter-decadal climate variability is observed throughout the west coast of the Americas and is now known as the ***Pacific Interdecadal Oscillation (PDO)***, see Mantua et al (1997) and Zhang et al (1997). In this study we attempt to capture the potential range of PDO variability in the UCSD/SIO discharge areas by constructing the longest possible time series of the seven controlling model inputs from existing data bases, and then invoke statistical searches of those time series for the wet and dry extremes.

3.1) Boundary Conditions

A) Bathymetry: Bathymetry provides a controlling influence on all of the coastal processes at work in both the nearfield and farfield of Scripps Beach. The bathymetry consists of two parts: 1) a stationary component in the offshore where depths are roughly invariant over time, and 2) a non-stationary component in the nearshore where depth variations do occur over time. The stationary bathymetry generally prevails at depths that exceed ***closure depth*** which is the depth at which net on/offshore transport vanishes. Closure depth is typically -15 m mean sea level (MSL) in the Oceanside Littoral Cell, [Inman et al. 1993]. The stationary

bathymetry was derived from the National Ocean Survey (NOS) digital database as plotted in Figure 3 seaward of the 15m depth contour. Gridding is by latitude and longitude with a 3 x 3 arc second grid cell resolution yielding a computational domain of 15.4 km x 18.5 km. Grid cell dimensions along the x-axis (longitude) are 77.2 meters and 92.6 meters along the y-axis (latitude). This small amount of grid distortion is converted internally to Cartesian coordinates, using a Mercator projection of the latitude-longitude grid centered on Scripps Pier. The convention for Cartesian coordinates uses x-grid spacings for longitude and y-grid spacings for latitude.

For the non-stationary bathymetry data inshore of closure depth (less than -15 m MSL) we use the equilibrium beach algorithms from Jenkins and Inman (2006). Depth contours generated from these algorithms vary with wave height, period and grain size and are plotted in Figure 3 landward of the 15m depth contour for the wave parameters of the wet weather extreme scenario (see Section 3.3)

B) Ocean Salinity: Since the five UCSD/SIO outfalls discharge across Scripps Beach and into the surfzone, the surface salinity is used in (3) to initialize SEDXPORT. This input is obtained from monitoring data at Scripps Pier and permitted the reconstruction of a 20.5 year record of ocean salinity, as shown in Panel-a of Figure 6. In the period of record from 1980 through mid 2000, the maximum recorded salinity was 34.44 ppt (parts per thousand) and the minimum was 31.26 ppt. Smaller variations occurred over daily and seasonal time scales, while the maximum range of salinity variation (10%) was concurrent with the powerful 1993 (ENSO cycle). The 20.5 year average salinity was 33.52 ppt. Typically the salinity tends to increase during dry summer months due to increased

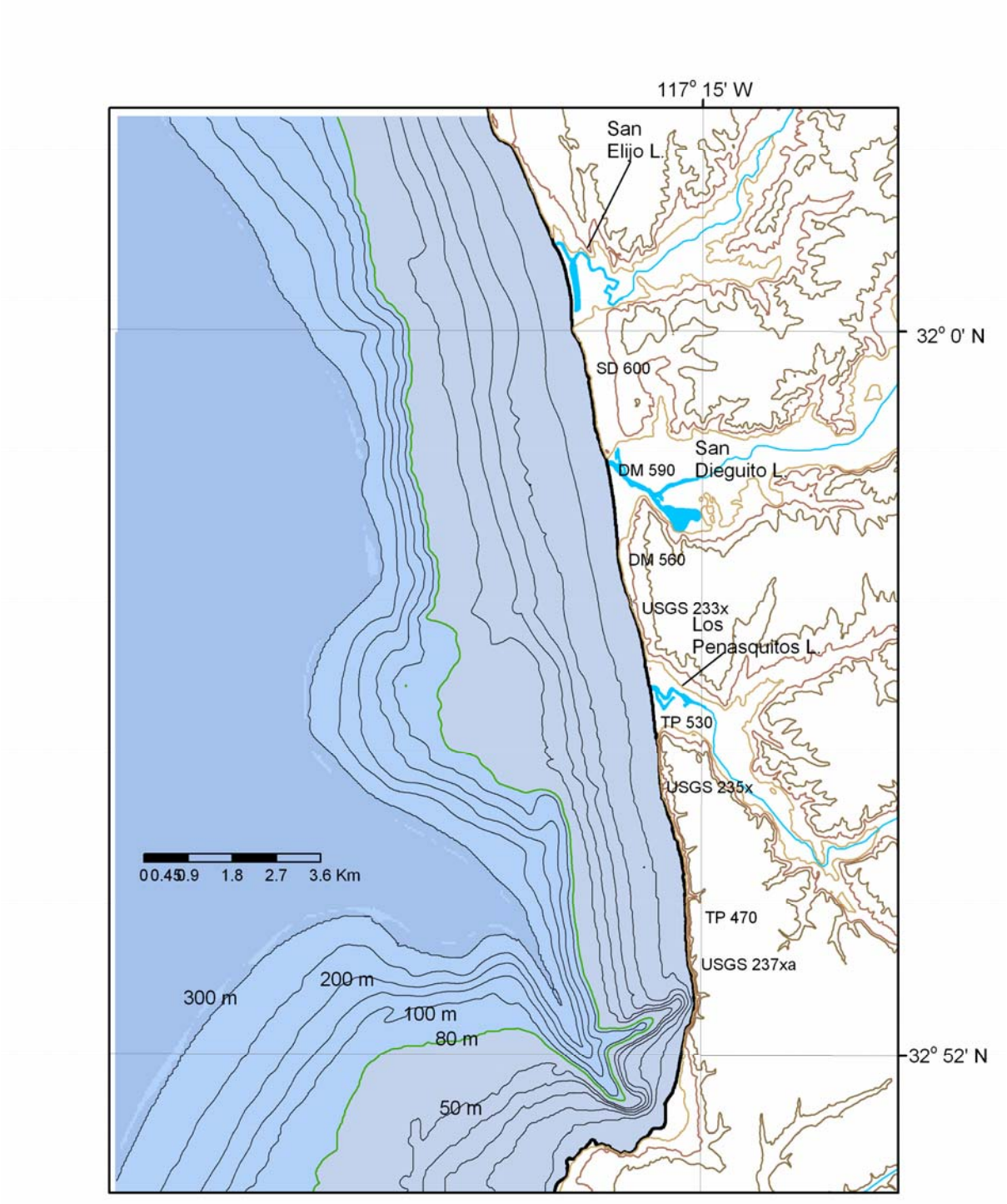

Figure 5: Composite bathymetry from NOS data base and equilibrium profiles after Jenkins and Inman (2006) for wave conditions of wet weather scenario. Depth contours shown in meters mean sea level.

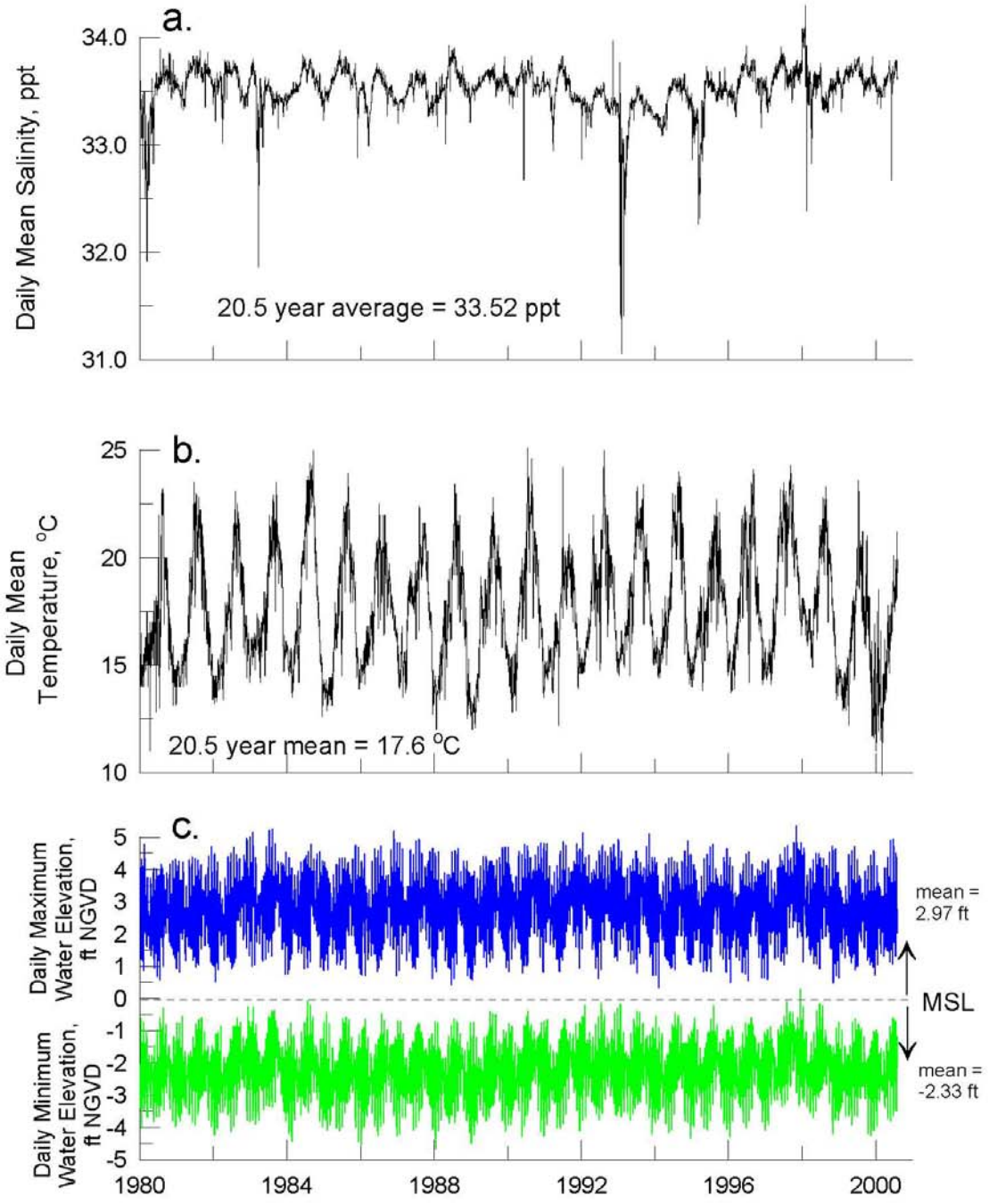

Figure 6. Controlling ocean boundary conditions for SIO beach discharge dilution: a) daily mean salinity, b) daily mean temperature, and c) daily high & low water elevations.

evaporation and diminished fresh water runoff. This inter annual variation is enhanced during El Niño periods when high salinity water off Southern Baja intrudes into the Southern California Bight during summers, and above average winter rainfall and runoff depresses salinity during winter.

C) Ocean Temperature: Following the same rationale as used with salinity, ocean surface temperature measurements from Scripps Pier characterize the long term temperature environment off Scripps Beach. The 20.5 year long reconstruction of surface temperatures from the Scripps Pier Shore Station monitoring is given in Panel-b of Figure 6. A pronounced seasonal variation in these temperatures is quite evident with the maximum recorded daily mean temperature reaching 25.1 ^{o}C during the summer of the 1993 El Niño and the minimum falling to 9.9 ^{o}C during the winter of the 1999-2000 La Niña. The 20.5 year mean temperature was found to be 17.6 ^{o}C. Consequently natural temperature variability of the coastal waters in the vicinity of the Scripps Pier and Scripps Beach is on the order of 86%.

D) Ocean Water Levels: In the shallow nearshore environment off Scripps Beach, the dilution volume is limited by the time variation in ocean water level. Ocean water level varies in response to both tidal and climate oscillations such as ENSO. The ocean water level is monitored by the tide gage station located on Scripps Pier, La Jolla, CA. This tide gage (National Oceanic Atmospheric Administration (NOAA) #941-0230) was last leveled using the 1960-78 tidal epoch, which resulted in the following tidal datum measured in National Geodetic Vertical Datum (NGVD):

MEAN HIGHER HIGH WATER (MHHW) = +2.81 FT. NGVD

MEAN HIGH TIDE (MHT) = +2.06 FT. NGVD

MEAN SEA LEVEL (MSL) = +0.19 FT. NGVD

MEAN LOWER LOW WATER (MLLW) = -2.56 FT. NGVD

Water levels measured by the Scripps Pier Tide Gage (#941-0230) have been archived by NOAA (2005) for the period of record, 1980 through mid 2000. Reconstruction of a water level time series was performed on the entire set of 1980-2000 NOAA measurements. The resulting time series of daily maximum and minimum ocean water levels is plotted in Panel-c of Figure 6. The positive sea level anomalies are a persistent and sustained occurrence in the observations of ocean water levels during this period of record and are another signature of El Niño. The warming of the coastal ocean during El Niño events causes thermal expansion of seawater by the second term in the equation of state, (3). A very significant number of diurnal tide cycles during the 20.5 period of record (466) have produced water level elevations well in excess of the extreme higher-high water levels (EHHW) of the astronomic tides, (where EHHW = +4.28 ft. NGVD for a perigean spring tide occurring once every 4.5 years). In the period of record shown by the blue trace in Figure 6d, the maximum ocean water level was +5.35 ft. NGVD occurring during the 1997 El Niño, 1.31 ft. higher than the astronomic tides of the tide tables. These high water levels promote initial dilution of any beach discharge because they provide additional water depth and dilution volume where these discharges enter the sea. On the other hand, the minimum ocean water level was -4.66 ft. NGVD, occurring during the 1988 winter. These low water levels shown in the green trace of Figure 6d reduce initial dilution of beach discharge.

E) Discharge Flow Rates: Section 316(a) of the Clean Water Act requires compliance with the State water quality standards for ocean discharges. The

California State Water Resources Control Board is the regulatory agency responsible for administering the National Pollutant Elimination System (NPDES) permit program required by the U.S. Environmental Protection Agency. As a requirement of the 2004 UCSD/SIO NPDES permit (R9-2005-0008, NPDES Permit No. CA0107239, cited as UCSD (2005 a-e) in the bibliography), the five beach discharges are monitored for flow and constituent levels and reported in the Quarterly Monitoring Reports. These data are used to define the variation in constituent concentrations observed during dry and wet discharge conditions at UCSD/SIO. This monitoring period captured the heavy rainfall events of the winter of 2005 whose cumulative rainfall totals were comparable to the El Niño winters of 1978, 83, 95 and 98 during the preceding multi decadal wet period of the PDO, but followed consecutive drought years from 2000-04 behaving as a signature “first flush” event.

Figure 7 gives the measured daily flow rates of the two major UCSD/SIO outfalls during the monitoring conducted between 21 September 2004 and 30 June 2005. Units of flow are in gallons per day. The largest volume outfall, #001 (Figure 7a) produced a combined peak discharge (storm water + seawater) of 1,553,400 gallons per day which averages out to 1,079 gallons per minute (gpm), or about 1/5 of the maximum storm water capacity of the outfall design. This peak flow event occurred 27 October 2004 and was the first major storm of the winter (first flush event). The average combined discharge rate of Outfall #001 over the entire monitoring period was 420,877 gallons per day (292 gpm) or about half the seawater capacity of the outfall design. Therefore, the outfall was observed to operate at only a fraction of its maximum capacity during the monitoring period despite the occurrence of above average rainfall. The second largest volume

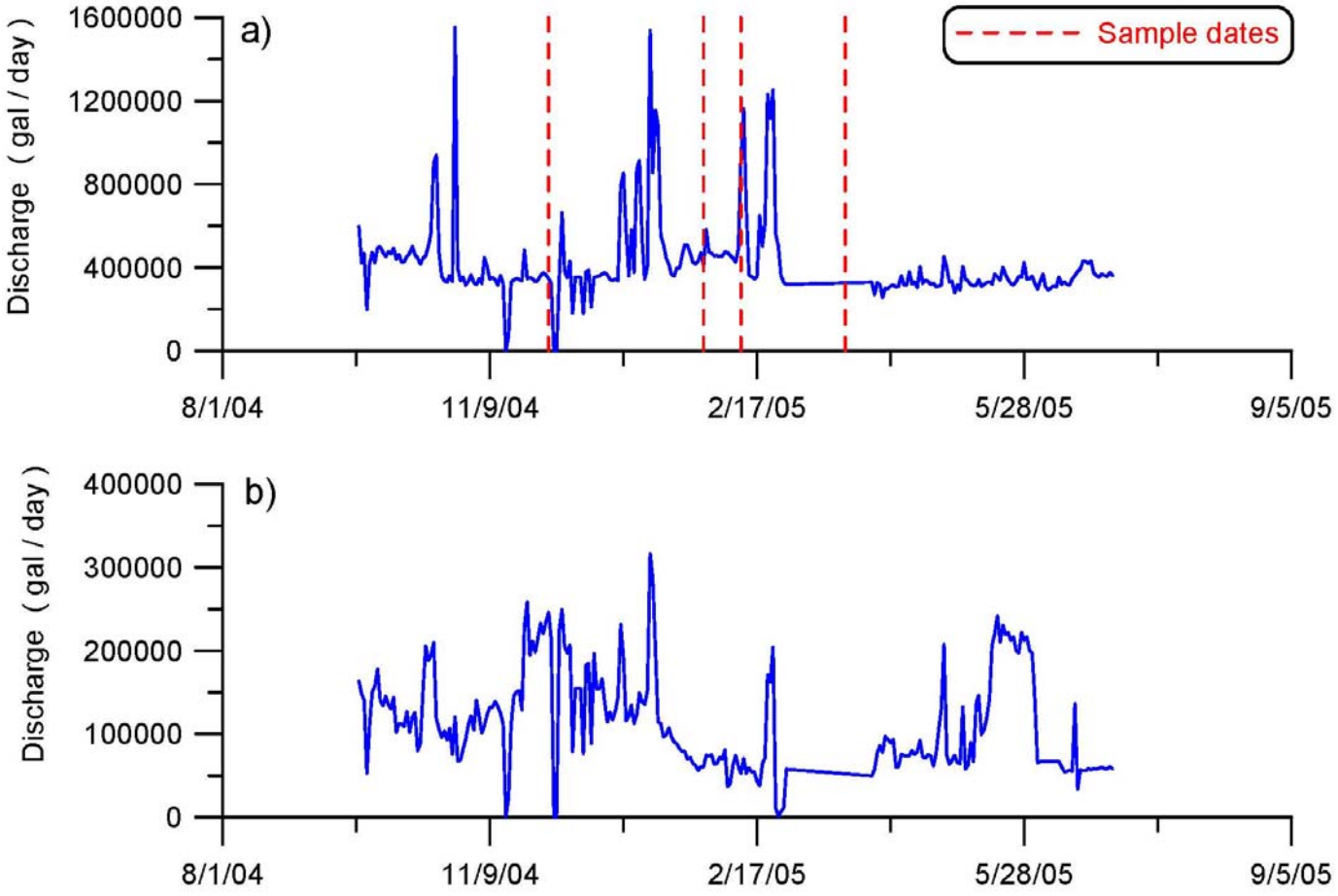

Figure 7 . UCSD/SIO Monitoring data of discharge flow rates for period of record 21 September 04 -30 June 05: a) Outfall-001; b) Outfall-003

outfall, #003 (Figure 7b), was found to yield a combined peak discharge of 316,340 gallons per day (220 gpm) and averaged 114,310 gallons per day (79.4 gpm) throughout the monitoring period (roughly half its design seawater capacity).

3.2) Forcing Functions

A) Waves: Because the combined discharges of storm water and seawater from the UCSD/SIO Outfalls are discharged into the surfzone, the wave climate

exerts leading order control on the initial dilution and dispersion of TSS as well as the copper or TCDD constituents adsorbed on the surfaces of the fine grained sediments that make up the suspended solids. The wave forcing records are derived from measurements during the Coastal Data Information Program, (CDIP). This program routinely monitored waves at several locations in the lower Southern California Bight since 1980. The nearest CDIP ***directional*** wave monitoring sites for the Oceanside Littoral Cell and Torrey Pines Sub-Cell (Figure 8) are:

a) Oceanside Array

- Station ID: 00401
- Location:
  - 33 11.4^0 North, 117 23.4^0 West
  - 500 feet SW of pier
- Water Depth (m): 10
- Instrument Description:
  - Underwater Directional Array
- Measured Parameters:
  - Wave Energy
  - Wave Direction

b) San Clemente

- Station ID: 05201
- Location:
  - 33 25.2^0 North, 117 37.8^0 West
  - 1000 ft NW of San Clemente Pier
- Water Depth (m): 10
- Instrument Description:
  - Underwater Directional Array

  Measured Parameters:
  - Wave Energy
  - Wave Direction

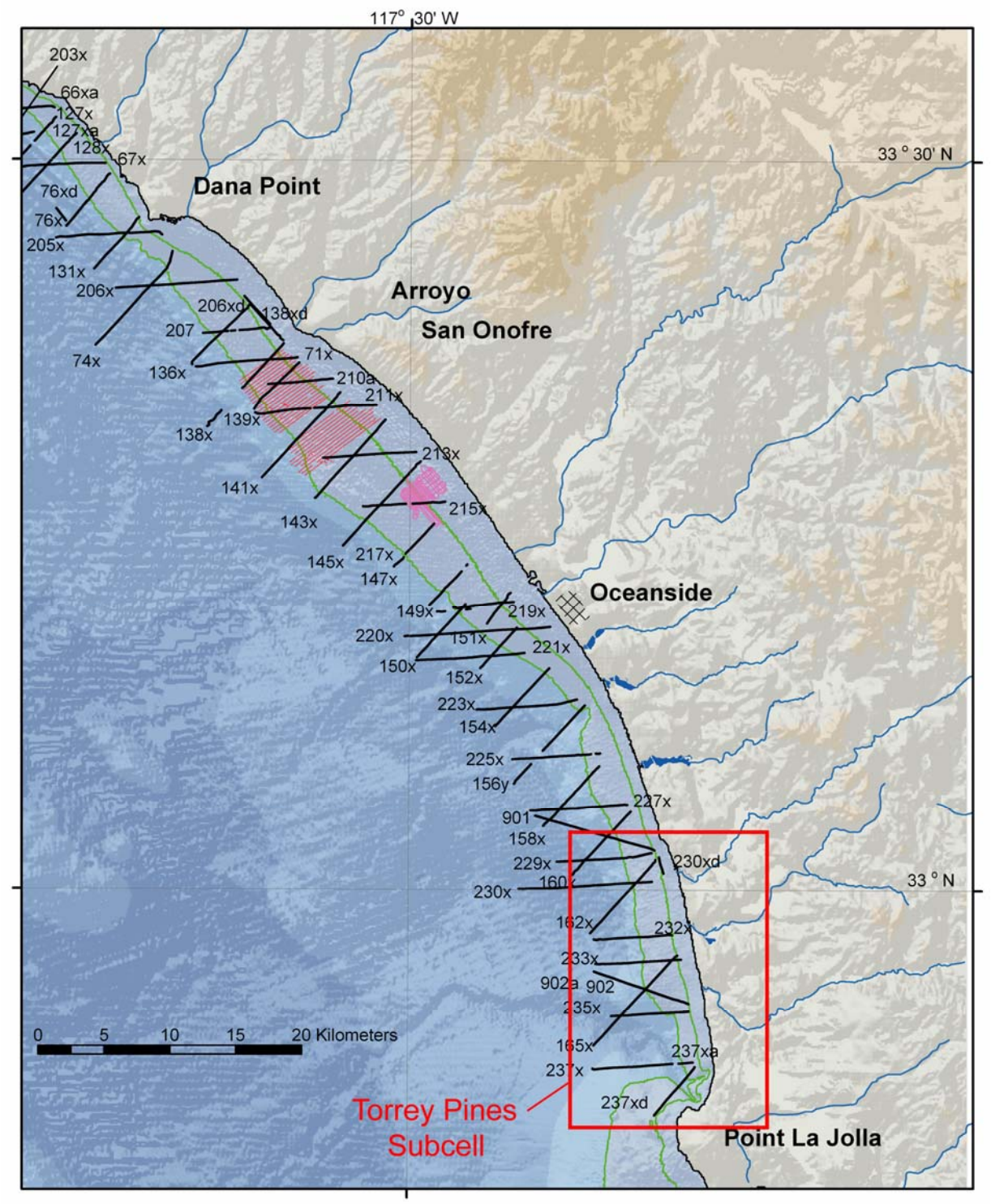

Figure 8: Oceanside Littoral Cell and Torrey Pines Sub-Cell.

c) Huntington Beach Array

- Station ID: 07201
- Location:
  - 33 37.9^0 North, 117 58.7^0 West
  - Approximately 1 mile west of lifeguard headquarters at Huntington Beach, CA
- Water Depth (m): 10
- Instrument Description:
  - Underwater Directional Array
- Measured Parameters:
  - Wave Energy
  - Wave Direction

Data for these CDIP wave monitoring sites is available beginning January 1980 through March 2002 [CDIP, 2004]. In addition to the CDIP sites, waves have been monitored at Torrey Pines Beach from 1972 until 1984 by the SAS Stations deployed by SIO, Pawka (1982). The ensemble of data from the CDIP and SAS monitoring stations were pieced together into a continuous record from 1980-2000 and entered into a structured preliminary data file.

The data in the preliminary file represent partially shoaled wave data specific to the local bathymetry around Oceanside, San Clemente or Huntington Beach. To correct these data to the Torrey Pine Sub-Cell in which the dilution modeling is performed, the data are entered into a refraction/diffraction numerical code, back-refracted out into deep water, and subsequently brought onshore into the immediate neighborhood of the Torrey Pines Sub Cell (as delineated in Figure 5 and 8). CDIP wave data are shoaled into Scripps Beach and the neighboring

beaches of the Torrey Pines Sub-Cell using the **OCEANRDS** refraction-diffraction computer codes. The primitive equation for this code are lengthy, so a listing of the FORTRAN codes of **OCEANRDS** appear in Appendix C. These codes calculate the simultaneous refraction and diffraction patterns propagating over a Cartesian depth grid. "OCEANRDS" uses the parabolic equation method (PEM), Radder (1979), applied to the mild-slope equation, Berkhoff (1972). To account for very wide-angle refraction and diffraction relative to the principle wave direction, "OCEANRDS" also incorporates the high order PEM Pade approximate corrections modified from those developed by Kirby (1986a-c). Unlike the recently developed REF/DIF model due to Dalrymple et al (1984), the Pade approximates in "OCEANRDS" are written in tesseral harmonics, per Jenkins and Inman (1985); in some instances improving resolution of diffraction patterns associated with steep, highly variable bathymetry along the shelf break. These refinements allow calculation of the evolution and propagation of directional modes from a single incident wave direction; which is a distinct advantage over the more conventional directionally integrated ray methods that are prone to caustics (crossing rays) and other singularities in the solution domain where bathymetry varies rapidly over several wavelengths.

An example of a reconstruction of the back-refracted wave field throughout the Bight is shown in Figure 9 using the CDIP data from the San Clemente array. Wave heights are contoured in meters according to the color bar scale and represent 6 hour averages, not an instantaneous snapshot of the sea surface elevation. Note how the sheltering effects of Catalina and San Clemente Islands have induced longshore variations in wave height throughout the Southern California Bight. These variations (referred to as shadows and bright spots) induce

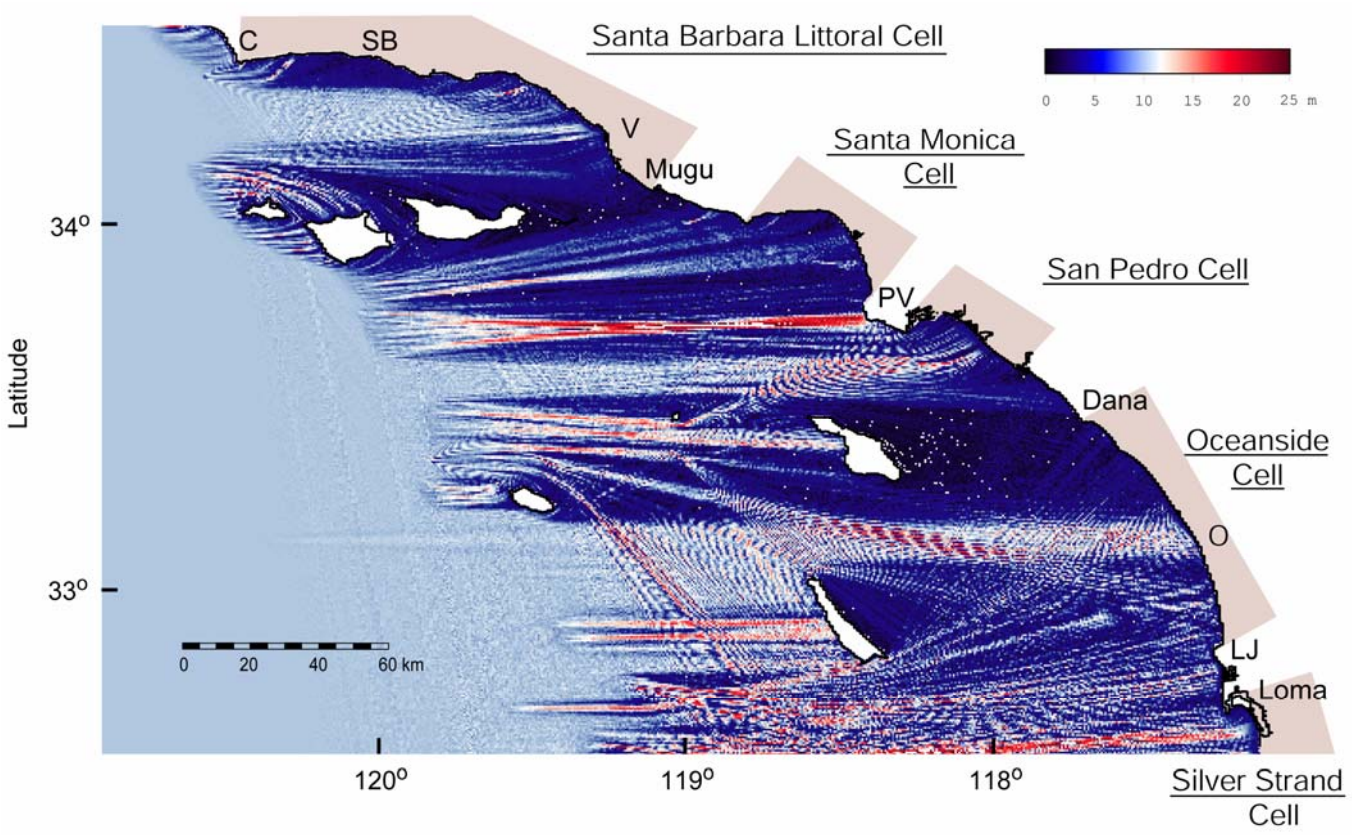

Figure 9: Back-refraction using *oceanrds.for* with waves measured by San Clemente CDIP station during the storm of 17 January 1988 with 10m high waves at 17 second period approaching the Southern California Bight from 270^0

longshore transport away from areas of high waves (bright spots, red) and towardareas of low waves (shadows, dark blue). Figure 10 shows the deep water significant wave heights, periods and directions resulting from the series of back-refraction calculations for the complete CDIP and SIO data set at Δt = 6 hour intervals over the 1980-2000 period of record. The data in Figure 10 are the values used as the deep water boundary conditions of the forward refraction computations

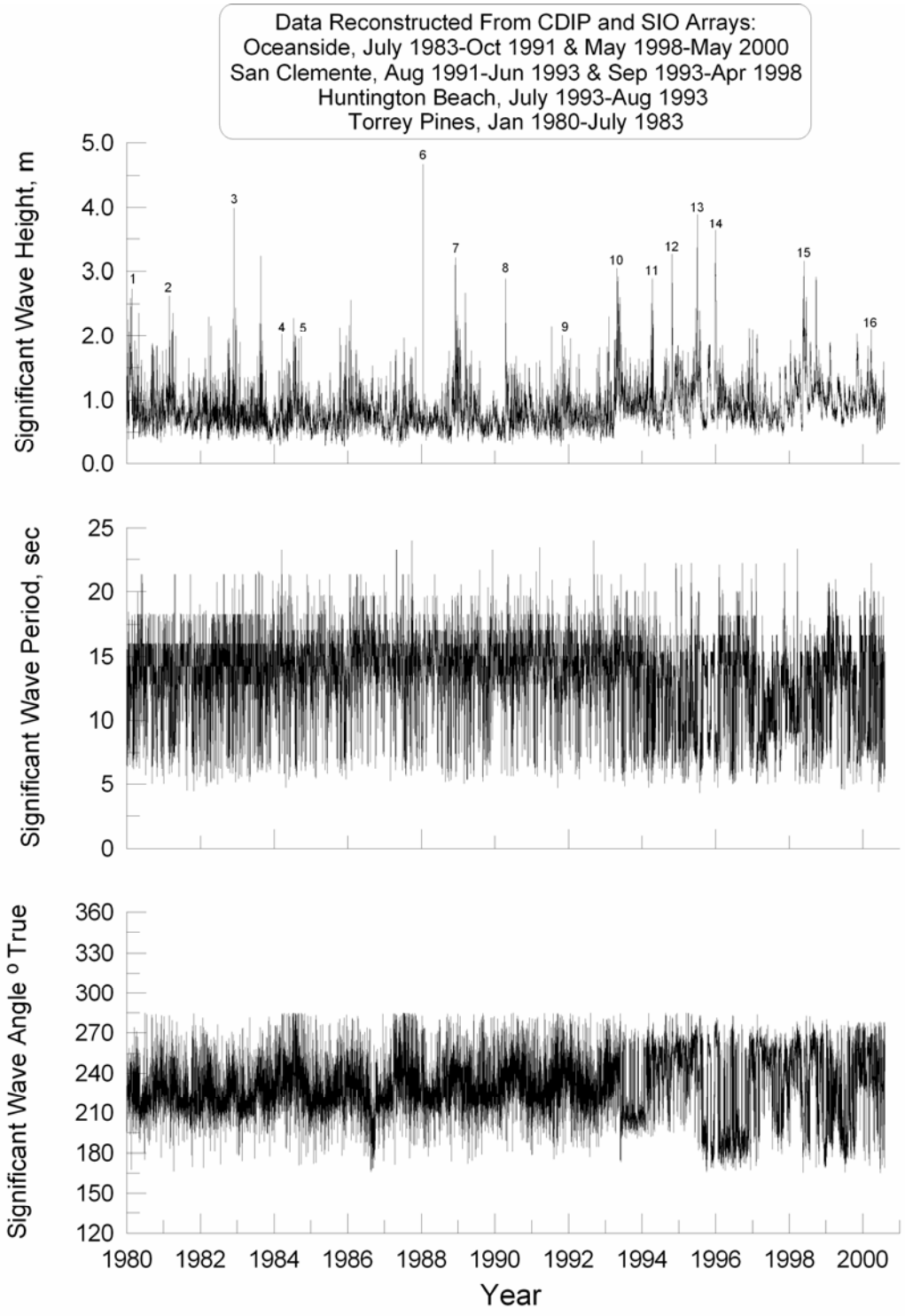

Figure 10: Deep water wave data for wave forcing in Torrey Pines Sub-Cell derived from back refraction of CDIP monitoring data

into the Torrey Pines Sub Cell (Figure 8). The deep water wave angles are plotted with respect to the direction (relative to true north) from which the waves are propagating at the deep water boundary of Figure 8. Inspection of Figure 10 reveals that a number of large swells lined up with the wave windows open to the Torrey Pine Sub-Cell during the El Niño's of 1980-83, 1986-88, 1992-95, and 1997-98. The largest of these swell events was the 18 January 1988 storm, producing 4.5 m deep water swells off Scripps Beach (see event #6 in Figure 10).

Figure 11 gives an example of the forward refraction calculation over the Torrey Pines Sub-Cell and La Jolla Bay region for the low energy waves used to characterize the low mixing conditions of the dry weather modeling scenario. These particular waves were observed on 17 August 1992, and had a daily mean wave height of only 0.2 m, approaching Scripps Beach from 210^0 with 10 sec period. In contrast, the refraction/diffraction pattern for the wet weather scenario is shown in Figure 12 for 2m high storm swells shoaling onto Scripps Beach from 285^0 with 15 sec period. The longer period northwest swells of the stormy wet weather scenario produce a pronounced pattern of shadows (regions of locally smaller waves) and bright spots (regions of locally higher waves). Wave driven nearshore currents flow away from bright spots and converge on shadows. Inspection of Figure 12 reveals that the Scripps campus (shown as the light blue patch) is in a shadow zone flanked by bright spots to the north and to the south. Consequently the zone of initial dilution of the UCSD/SIO beach Outfalls is located in a region of converging longshore currents during the wet weather scenario. Such a convergence of drift results in rip currents and offshore flow, acting to disperse the beach discharges into deep water.

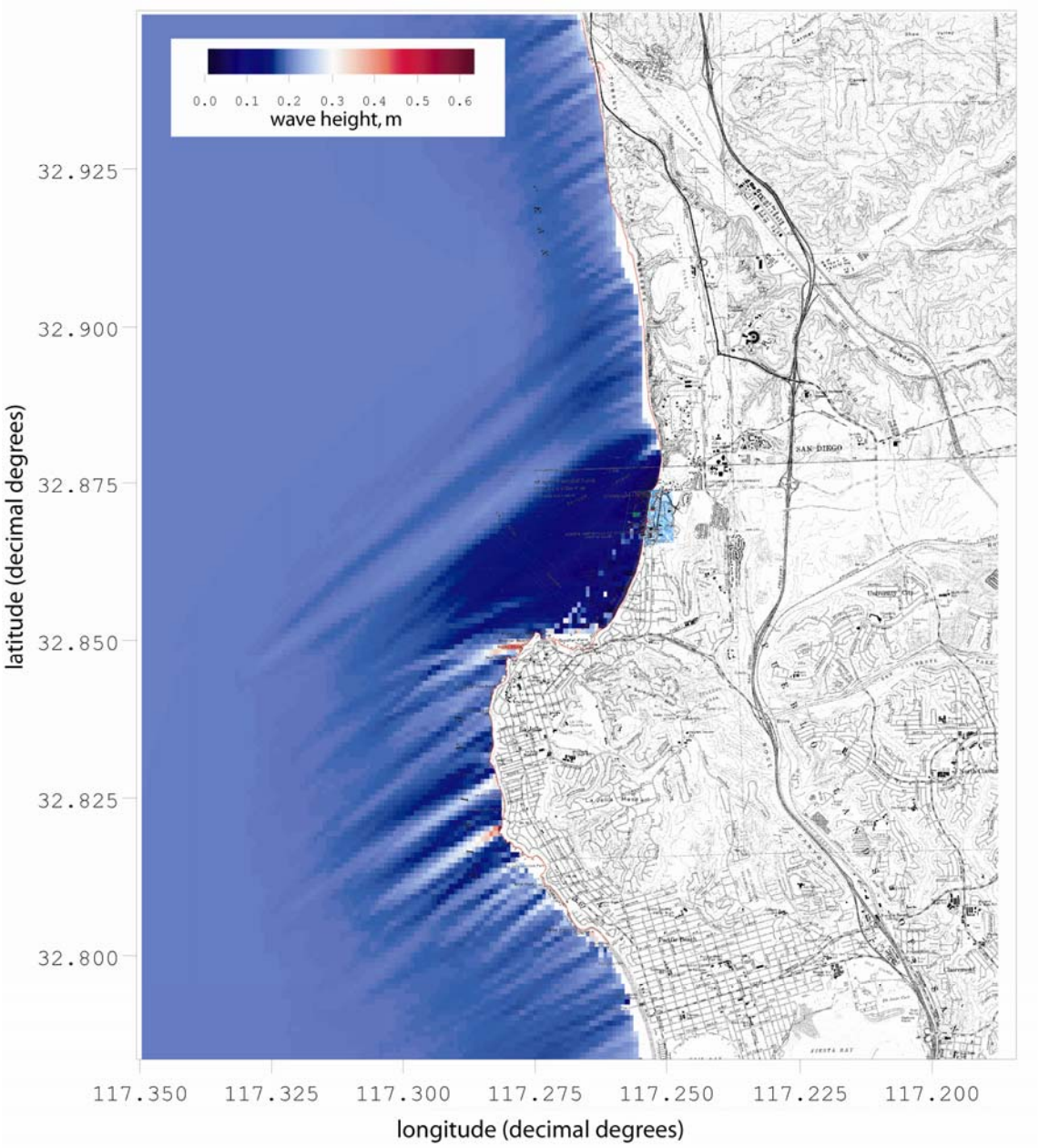

Figure 11: High resolution refraction/diffraction computation for extreme dry weather model scenario based on 0.2m deep water wave height from 210^0 with 10 sec period.

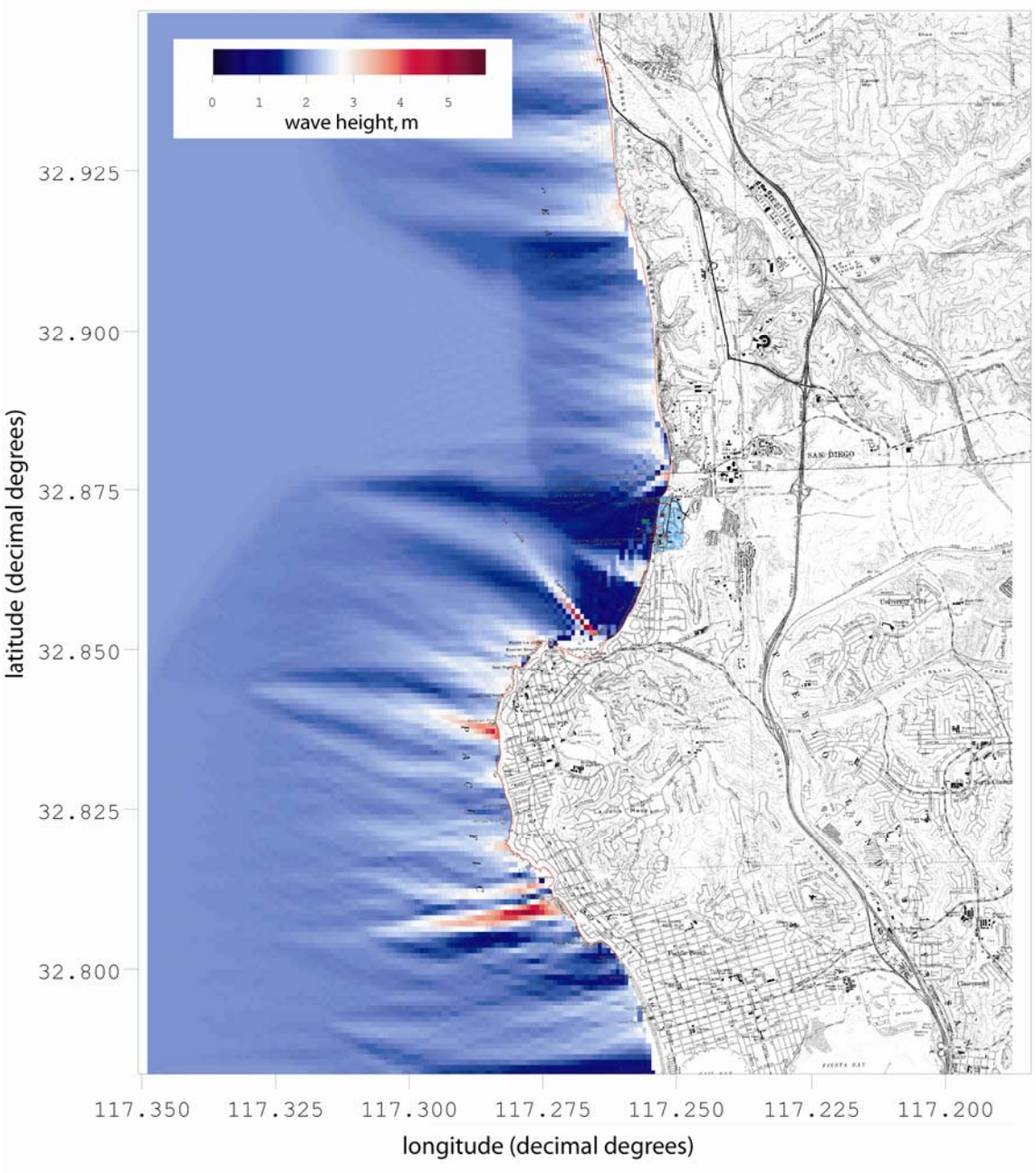

Figure 12: High resolution refraction/diffraction computation for typical wet weather model scenario based on 2m deep water wave height from 285^0 with 15 sec period.

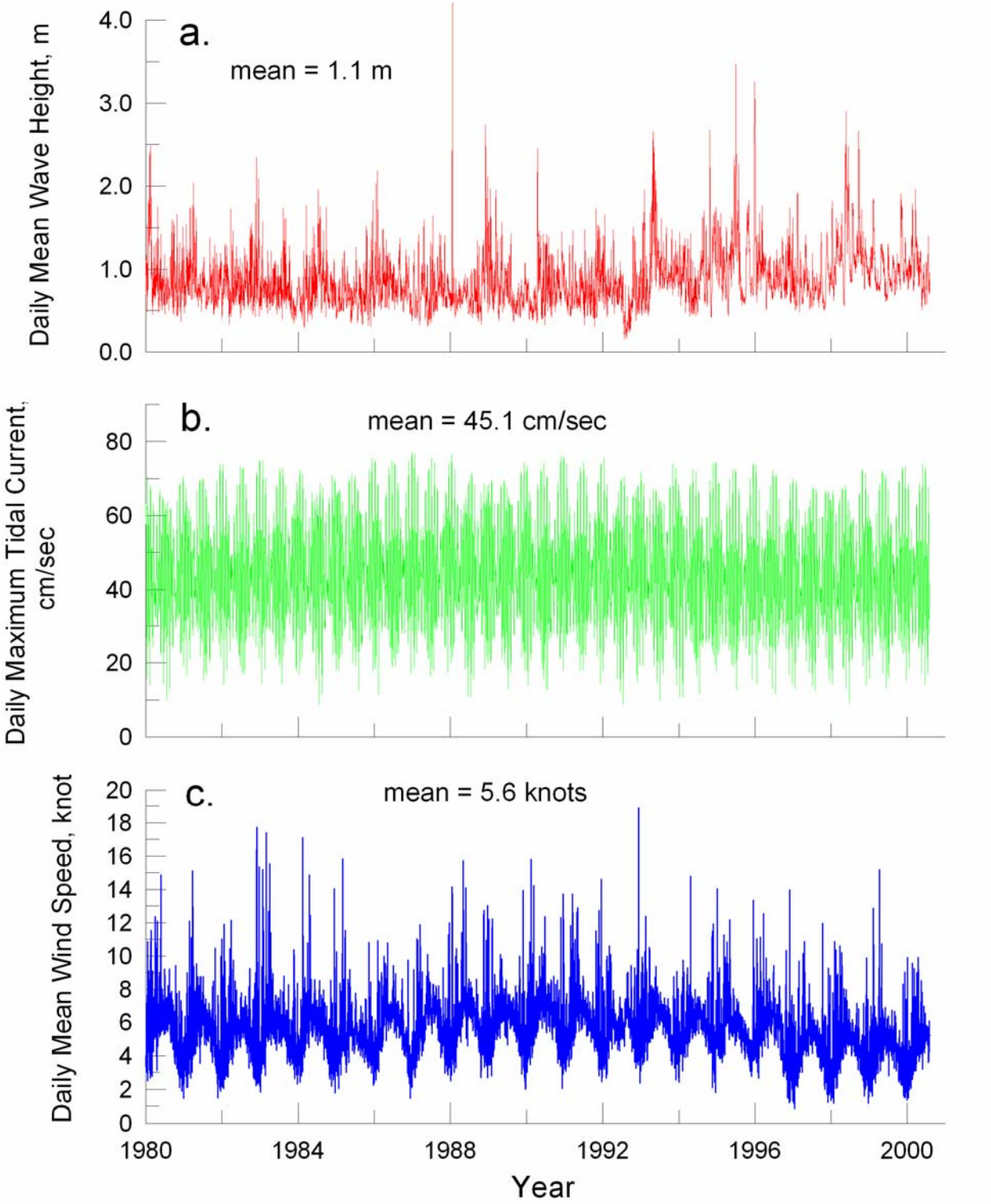

Figure 13: 20.5 year record of forcing for La Jolla Bay. a) daily mean wave height, b)daily maximum tidal current amplitude, and c) daily mean wind speed

The wave height record derived from refraction analysis of the type shown in Figures 11 and 12 has been overlaid on the ensemble records of forcing function in Figure 13a for subsequent probability analysis. The average wave height at Scripps Beach over this 20.5 year period is 0.87 m while the maximum is 4.51 m occurring during the January 1988 storm, and the minimum is 0.16 m occurring on 17 August 1992 during the building phase of the 1993 El Niño.

B) Currents: While waves dominate the initial dilution and dispersion of storm water and seawater discharges in the inshore domain, the tidal currents control dilution and dispersion in the offshore domain, particularly over most of the ASBS #31footprint. A general southward net tidal drift is produced by the daily average of all the potential combinations of standing and progressive mixed tides. This net southward drift is an indication that the tidal transport in this region is ***ebb dominated***. The strength of the net drift varies with the spring-neap cycle, with the strongest southward drift produced on the spring tides. In the La Jolla Bay portion of the Torrey Pines Sub-Cell, the southward drift is deflected by Pt La Jolla, producing a complex eddy structure in La Jolla Bay with a jet of converging flow immediately to the South of Pt La Jolla. The La Jolla Bay eddy is of particular interest because it often exerts sufficient entrainment near shore to cause ventilation of the ASBS by currents.

Figure 14 shows a progressive vector plot of the net tidal drift in La Jolla Bay during a neap tidal day, 17 August 1992. This current field is used to represent the minimal offshore mixing and advection conditions of the dry weather modeling scenario. It can be seen from the vector field in Figure 14 that the La Jolla Bay eddy entrainment during neap tide does not extend close enough to shore to cause any appreciable ventilation of Scripps Beach (denoted by the blue patch of SIO

campus) or the adjoining ASBS. The tidal drift ranges from nothing to at most 5 cm/sec along the offshore boundary of the ASBS. The core of the La Jolla Bay eddy remains several kilometers offshore and its convergence with the broad field drift produces a 25 cm/sec jet flowing to the south near Marine Street in La Jolla. Given these features, the neap tidal drift used in the dry weather modeling scenario would appear to provide minimal dispersion of the beach discharges at Scripps Beach.

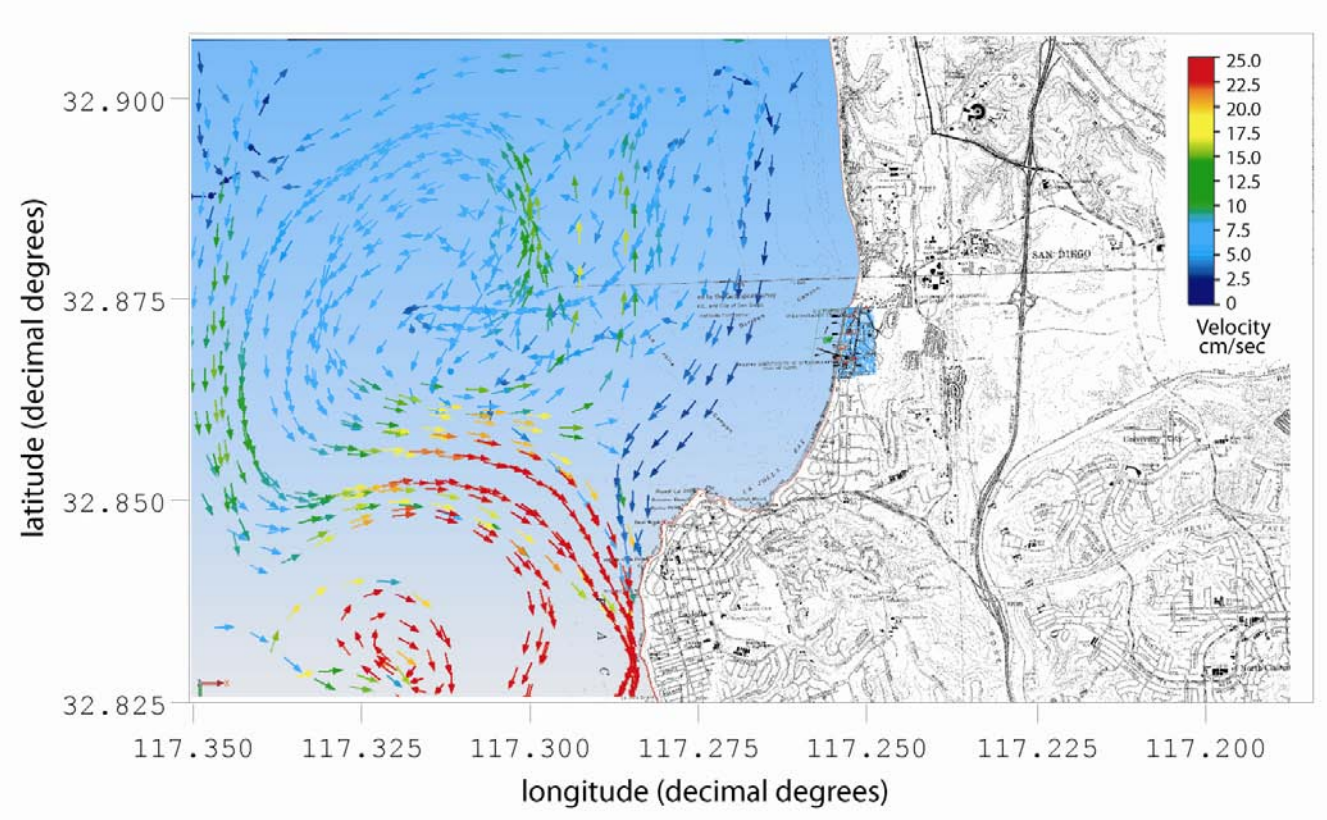

Figure 14: Progressive vector plot of current field in La Jolla Bay during a neap tidal day used in the dry weather modeling scenario. Vector magnitude scaled by the color bar in the upper right corner.

By contrast, Figure 15 gives a progressive vector plot of the net tidal drift in La Jolla Bay during the spring tidal day concurrent with the wave conditions in Figure 12. This current field is used to represent the offshore mixing and advection conditions of the wet weather modeling scenario. In this case the La Jolla Bay eddy has moved closer to shore and becomes paired with a system of counter rotating

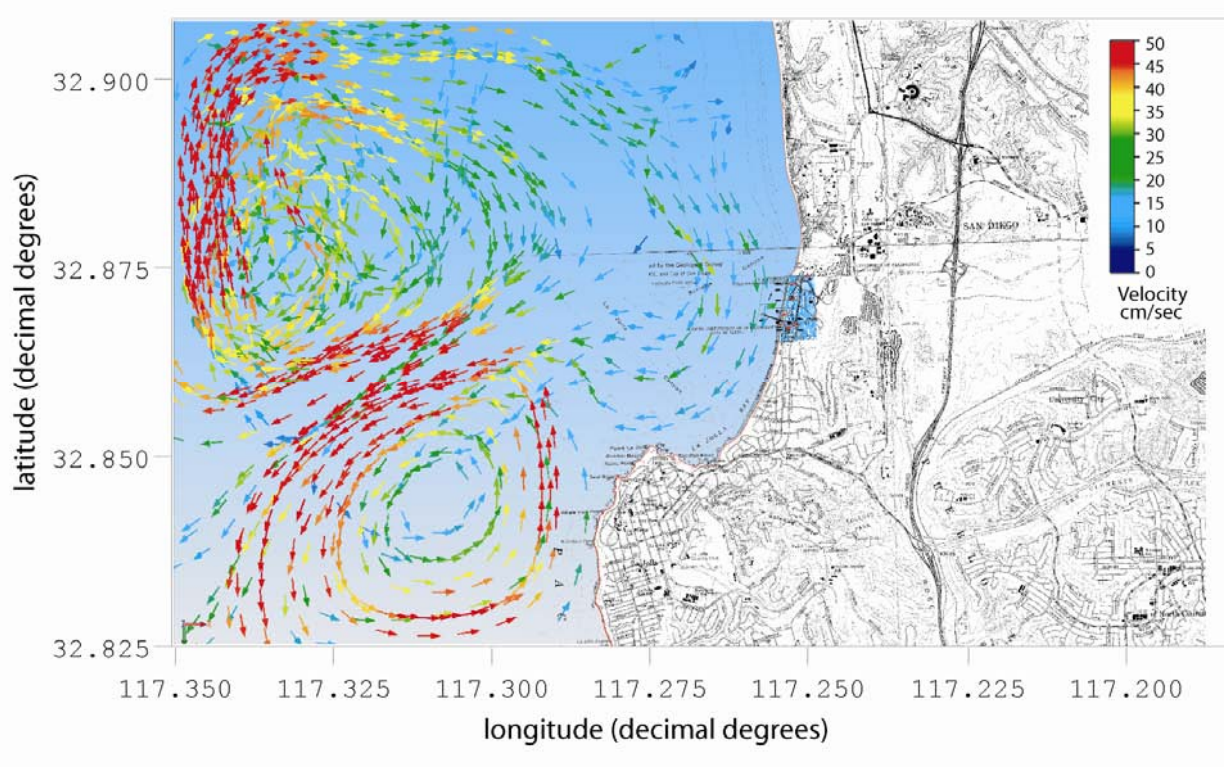

Figure 15: Progressive vector plot of current field in La Jolla Bay during a spring tidal day used in the wet weather modeling scenario. Vector magnitude scaled by the color bar in the upper right corner.

eddies off Pt La Jolla. The eddy entrainment currents off Scripps Beach and through ASBS#31 are 10-15 cm/sec flowing toward the south, following the shoreline contours along La Jolla Shores and subsequently feeding an eddy pair off Pt La Jolla. This eddy pair in turn discharges a jet flowing 45 cm/sec into deeper waters several kilometers west of Pt La Jolla. In total, the eddy system in the La Jolla Bay region during spring tides forms a very efficient conveyor for transporting near shore discharges at Scripps Beach into deep water off shore with significant intervening vorticity and eddy mixing to promote dilution.

C) Wind: Daily mean winds from the Scripps Pier Shore Station (SIO, 2001) and the Scripps Pier CDIP station (CDIP, 2002) were compiled over the 20.5 year period from January 1980 thru July 2000. This wind record is plotted in Panel-c of Figure 13. Because the lower Southern California Bight is a "wind drought" region due to orographic blocking by the Peninsular Range, the 20.5 year mean wind speed is only 4.9 knots. However, El Niño storms and North Pacific cold fronts episodically increase daily wind speeds with the maximum sustained 24 hour mean wind speed reaching 19.6 knots during the 1997 El Niño storms. The minimum daily mean wind speed is 0 knots. In general the coastal winds off Scripps Pier and Scripps Beach are benign, thereby limiting the degree of wind mixing of the surface water mass.

3.3) Model Scenarios

Based on discussions held in November 2004 between UCSD/SIO and the San Diego Regional Water Quality Control Board, it was decided that the numerical modeling study of the beach discharges from Outfalls 001-004 should be

based on a dry weather and wet weather worst-case scenario to bracket the envelope of the possible outcomes. The analysis of the multi-decadal rainfall variability of the San Diego found at the start of Section 3 provides justification for this approach.

A) Search Criteria for Dry/Wet Proxies: The 20.5 year long records of the boundary condition variables in Figure 6 and the forcing function variables in Figure 13 were subjected to a joint probability analysis for the simultaneous recurrence of the ***dry weather worst case*** combination of these variables and for the ***wet weather worst case*** combination. The environmental factors for the ***dry weather worst case*** scenarios were prescribed by the search criteria in Table 1 below. The dry weather worst case involves no storm water in the beach discharge concurrent with ocean conditions that promote minimal mixing and advection in the receiving water. Therefore, the search criteria in Table 1 overlays the maximum rated seawater discharges on simultaneous minimums in waves, winds and currents that minimize the stirring and ventilation of the water mass in the nearshore regions around the ASBS. The offshore currents are minimized by a small tidal range which also minimizes volume exchange between the nearshore and offshore water masses. Since the dry weather discharge is almost entirely from indoor aquariums, the search criteria seeks elevated salinity and temperatures in the receiving water that would maximize the density contrast with the indoor conditioned discharge. The higher the density contrast between discharge and receiving water, the slower the discharge is assimilated by the receiving water.

Table 1: Search Criteria for Dry Weather Worst-Case Combinations of Controlling Variables.

Variable	Search Criteria	Physical Significance
Discharge Rate	Maximize	Higher seawater discharge flow rates increase constituent fluxes
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
Tidal Range	Minimize	Smaller tidal range results in less volume exchange in nearshore waters with smaller tidal currents
Ocean Salinity	Maximize	Higher salinity leads to greater density contrast between discharge and receiving water
Ocean Temperature	Maximize	Higher temperature leads to density contrast between discharge and receiving water

Table 2 provides the search criteria that was applied to the 20.5 year records in Figures 6 and 13 to establish the wet weather worst case combination of model inputs. The principle requirement of the wet weather worst-case is to maximize the combined discharge of seawater and storm water. Because wet weather conditions occur during the passage of Pacific storms over the Southern California Bight, the worst case criteria of minimal ocean mixing tends to be mutually exclusive with

Table 2: Search Criteria for Dry Weather Worst -Case Combinations of Controlling Variables.

Variable	Search Criteria	Physical Significance
Discharge Rate	Maximize	Higher storm water and seawater discharge flow rates increase constituent fluxes
Waves	Minimize Highest 10%	Smaller waves result in less mixing in surfzone and less inshore dilution
Currents	Minimize Highest 10%	Weaker currents result in less advection and less offshore dilution
Winds	Minimize Highest 10%	Weaker winds result in less surface mixing and less dilution in both the inshore and offshore
Ocean Water Level	Minimize	Lower water level results in less dilution volume in receiving water
Ocean Salinity	Maximize	Higher salinity leads to greater density contrast between discharge and receiving water
Ocean Temperature	Minimize	Higher temperature leads to density contrast between discharge and receiving water

the occurrence of storm water runoff. Wet weather worst case conditions for the receiving water involve storm minimums with respect to winds, waves and currents. To find such conditional minimums from among the 7,523 combinations found in Figures 6 & 13, the computer search criteria solved for the minimum of

the largest 10% of the wind, waves and current combinations. Because the storm water discharge is predominately fresh water that is warmer than ocean water, the search criteria seeks salinity maximums and temperature minimums in the receiving water concurrent with the storm minimums of waves, winds and currents. In this way the maximum possible density contrast is achieved between the discharge and receiving water to retard the dilution rates of the discharge as much as possible under wet weather conditions.

B) Dry Weather Worst-Case Assignments: The joint probability analysis of the 20.5 year period of record in Figures 6 and 13 produced a set of dry weather extremes for the receiving water based on 17 August 1992. The maximum rated seawater discharge capacity for Outfalls #001 and #003 was superimposed on the receiving water conditions of this day. These dry weather conditions were antecedent to a building El Niño that subsequently climaxed during the winter of 1993. The ocean temperature was 25.0 ^{o}C, (within 0.1 ^{o}C of the 20.5 year maximum) while the ocean salinity was 33.51ppt. The waves were only 0.2 m, (the 20.5 year minimum) approaching La Jolla Bay from the southwest at 210^{0} with a 10 sec period. The refraction/diffraction pattern of these waves over La Jolla Bay and the lower end of the Torrey Pines Sub-Cell are shown in Figure 11. Winds were 0.0 knots and the maximum tidal current in ASBS#31 was only 5 cm/sec flowing toward the southwest along La Jolla Shores (Figures 13 & 14). The sluggish tidal current was due to neap tides occurring on this day with a minimum water level of -0.74 ft NGVD. On this combination of receiving water variables the model superimposed 486 gpm of seawater discharge from Outfall #001, 139 gpm of seawater discharge from Outfall #003, and 97 gpm of seawater discharge from

Outfall #00 4 a/b. The measured dry weather TSS concentration of ρ_0 = 0.71 mg/L was applied to these flow rates.

C) Wet Weather Worst-Case Assignments: The daily combination of receiving water variables that were recovered from the search criteria in Table 2 was represented by the conditions on 1 February 2000. This day was post frontal in a series of weak El Nino storms with moderate, winds, waves, and currents. Ocean salinity was 33.12 ppt, depressed about 0.4 ppt by the run off from storms in the previous days while the ocean temperature was 14.6^{o} C, about 3^{o} C below the annual mean. Wave heights were 2.0 m, approaching La Jolla Bay from the northwest at 285^{0} with a 15 sec period. The refraction/diffraction pattern of these storm swells are shown in Figure 12. Winds were post-frontal northwest winds at 11 knots from at 290^{0}. The maximum tidal currents in ASBS#31 were 10-15 cm/sec flowing toward the south, following the shoreline contours along La Jolla Shores (Figure 15). The tidal current was due to a moderate spring tide with a minimum water level of -3.89 ft NGVD. With this combination of receiving water variables the model overlaid the maximum rated discharges for all Outfalls, including: 486 gpm of seawater and 5,700 gpm of storm water discharged from Outfall #001, 200 gpm of storm water discharged from Outfall #002, 139 gpm of seawater and storm water discharged from Outfall#003, and 97 gpm of seawater discharge from Outfall #004 a/b. The maximum TSS concentration observed in the monitoring program, ρ_0 = 31.0 mg/L, was applied to all Outfalls.

D) Long-Term Simulations of Zone of Initial Dilution: The historic boundary conditions from Figure 6 and the forcing functions from Figure 13 were sequentially input into the model, producing daily solutions for the dilution field due to maximum rated seawater discharge from the Scripps Beach Outfalls. The input stream of seven controlling variables from Figures 6 & 13 produced 7,523 daily solutions for the dilution field in the ZID taken as the surfzone. A numerical scan of each of these daily solutions searched for the minimum dilution averaged between the wave break point and the shoreline. Based on the ZID definition contained in the NPDES permit for beach discharges at the nearby Encina Generating Station, the search for the minimum dilution was taken out to a distance of 1000 ft (305 meters) away from the discharge points in all directions, (although the minimum dilution was found without exception to be within 150m of the discharge points). The solution scans searched for minimum dilution in both the water column and along the sea floor. For each search, the minimum dilution found in any direction away from the Outfall was entered into a histogram bin for ultimately assembling a probability density function and cumulative probability from the 7,523 outcomes . These results provided a statistical basis for assessing long term variability of dilution in the ZID.

3.4 Calibration

The coupled sets of wave, current and dilution/dispersion models were calibrated for end-to-end simulations of known dye dispersion events measured off Scripps Beach by Inman et al. (1971). Initializations for the model were derived from the measured forcing functions reported in that publication. Free parameters in the subroutines of the **SEDXPORT** dilution/dispersion model were adjusted

iteratively until a best fit was achieved between the measured and simulated dye concentrations and dilution factors.

The subroutines of **SEDXPORT.for** contain seven free parameters which are selected by a calibration data set specific to the coastal type for which the hindcast calibration simulation is run. These parameters are as follows according to subroutine:

BOTXPORT·f

*ak2 - stretching factor for vertical eddy diffusivity, ϵ

*ak - adjusts mixing lengths for outfalls

NULLPOINT·f

*ak7 - adjusts the asymmetry of the bedform distribution curve, μ

SURXPORT·f

*aks - adjusts the surf zone suspended load efficiency, K_s

ak4 - stretching factor for the horizontal eddy diffusivity, ϵ_x

RIVXPORT·f

*ak3_1 - adjusts the jetty mixing length and outfall mixing lengths

*ak3 - stretching factor for the horizontal eddy diffusivity of the river plume, ϵ_H

The set of calibration values for these parameters was used without variation or modification for all model scenarios.

4) Results

The model scenarios defined in Section 3.3 are run in simulations of one tidal day using the numerical codes described in Section 2 and listed in Appendices A-F. The dilution fields are then depth averaged and averaged over the simulation period. In the sections that follow, dilution fields are contoured in base-10 log according to the color bar scale in the upper or lower corner of each plot, with a scale range that covers dilution factors between 10^0 and 10^7. For each scenario, two perspectives of the results are given: 1) a broad-scale view showing the footprint of the dilution field in relation to the Torrey Pines Sub-Cell and Pt La Jolla formation; and, 2) a nearfield view showing the dilution field in relation to the boundaries of ASBS #31, the SIO campus and La Jolla Shores.

4.1) Extreme Dry Weather Case for Existing Conditions

Figure 16 shows the footprint of the dilution field in the broad-scale view for the extreme dry weather case scenario involving maximum rated seawater discharge from Outfalls #001, #003 and #004 a/b with a TSS concentrationof ρ_0 = 0.71mg/L for all Outfalls. In the broad-scale perspective, the dilution field remains close to shore and generally spreads along shore between the Scripps and La Jolla Submarine Canyons with a slight bias towards the south. These features reflect low cross shore mixing due to the small waves of the dry weather scenario and the weak southward directed tidal drift (Figure 14). Zooming in for a nearfield view in Figure 17 the dilution field is shown in relation to the boundaries of ASBS #31(delineated by dashed red line). Figure 17 indicates that the dilution factors in the ASBS range form a minimum of 10^2 near shore to 10^4 – 10^6 along the seaward

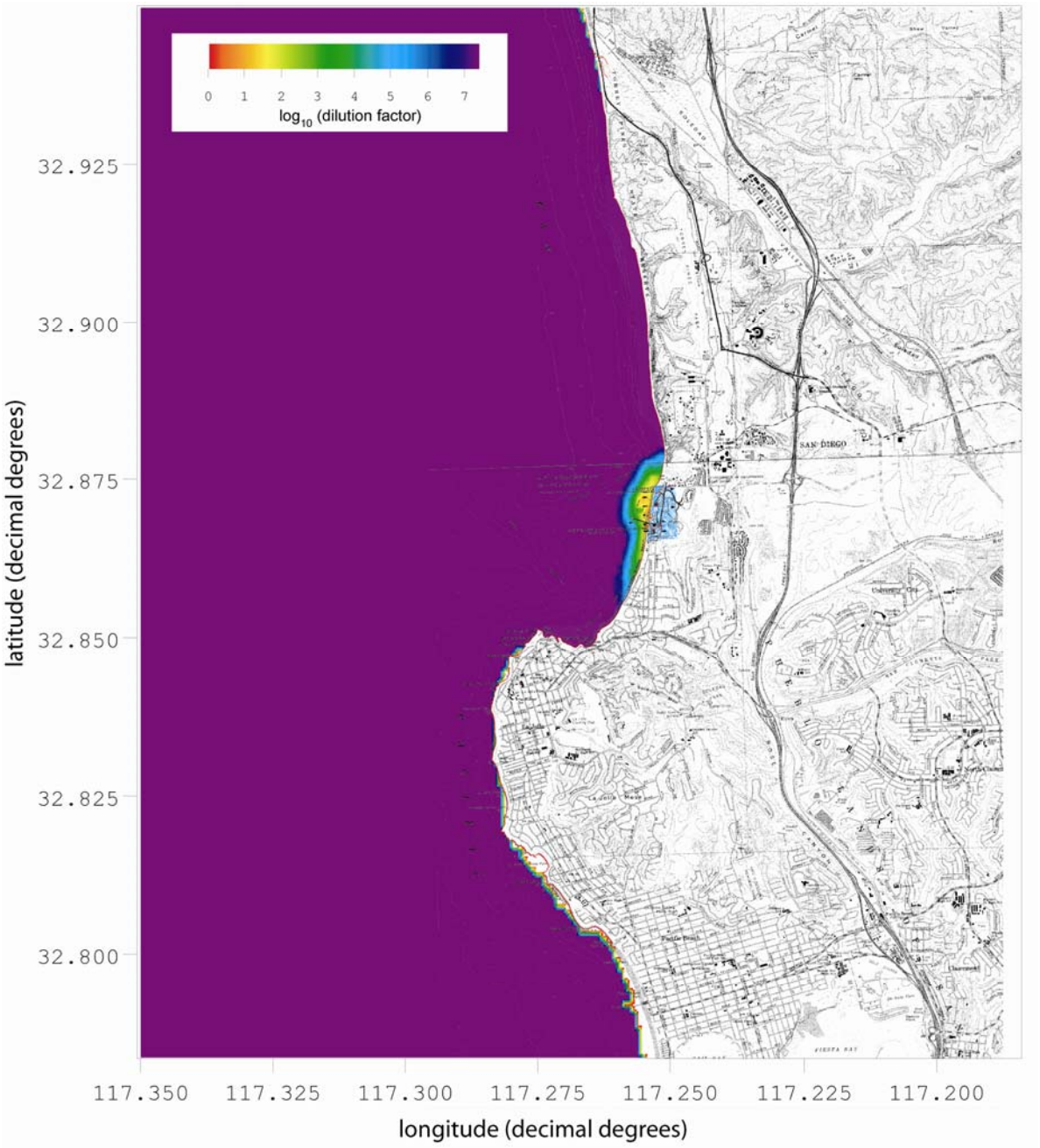

Figure 16. Dry weather worst case: Outfall-001 = 0 gpm storm water, 486 gpm seawater, Outfall-002 = 0 gpm storm water, Outfall-003 = 139 gpm seawater, Outfall-004a/b = 97 gpm seawater; waves: H = 0.2 m, T = 10 s, $\alpha = 210^{o}$; wind = 0 kts.

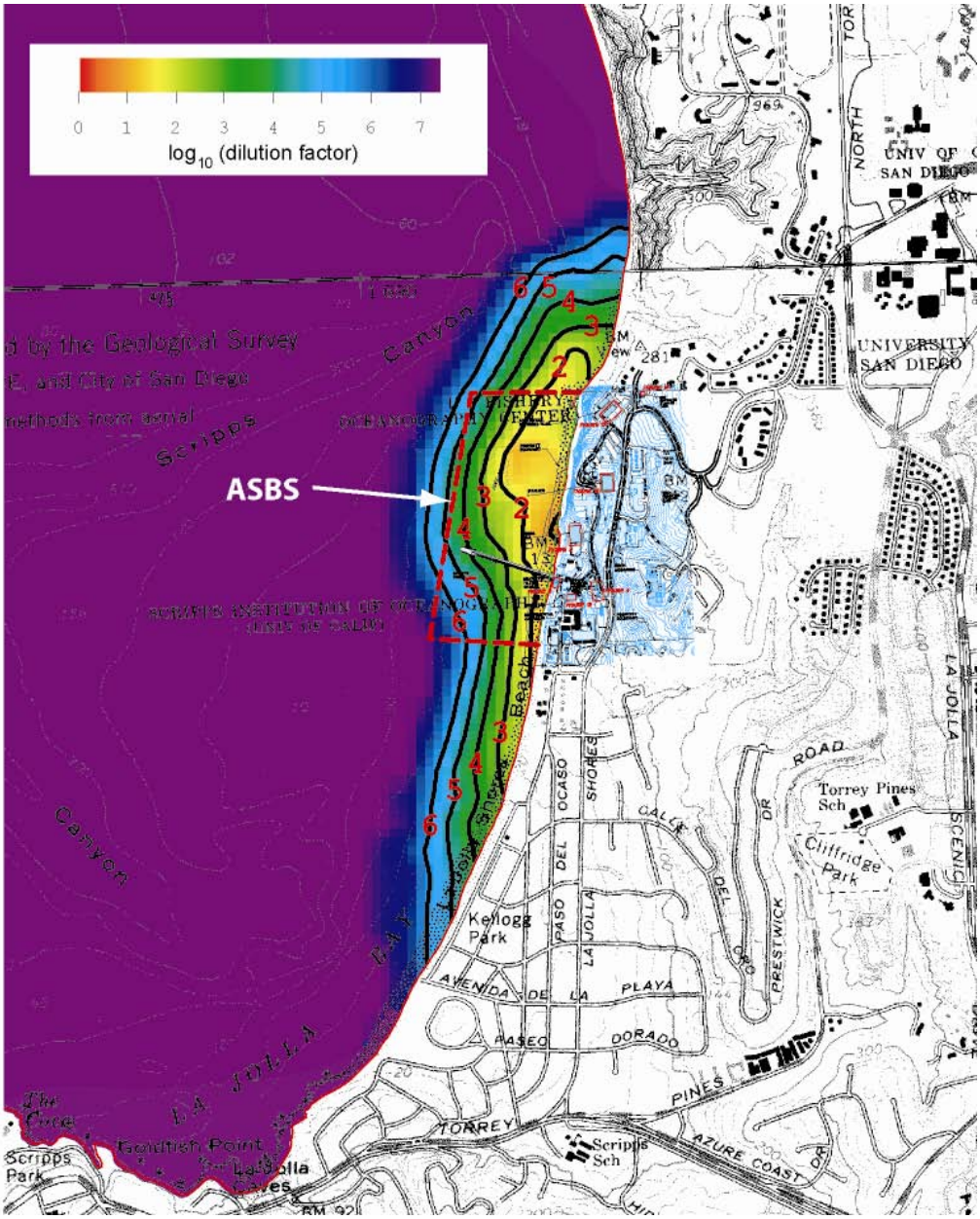

Figure 17. Dry weather worst case (enlarged): Outfall-001 = 0 gpm storm water, 486 gpm seawater, Outfall-002 = 0 gpm storm water, Outfall-003 = 139 gpm seawater, Outfall-004a/b = 97 gpm seawater; waves: H = 0.2 m, T = 10 s, α = 210^{o}; wind = 0 kts.

boundary. The surf zone is not resolved on the scale of Figure 17, but dilution factors in the surfzone are treated separately in Section 4.3. Using the maximum copper concentration observed during dry weather monitoring, copper discharged from the beach Outfalls would be found in the receiving water at concentrations no more than 0.04 µg/L in the portions of the ASBS immediately seaward of the surf zone and more typically at non-quantifiable levels ranging from 0.0001 µg/L to 0.000001 µg/L in the offshore portions of the ASBS.

4.2) Extreme Wet Weather Case for Existing Conditions

Figure 18 shows the broad-scale view of the footprint of the dilution field for the extreme wet weather case scenario involving maximum rated seawater discharges from all Outfalls #001, #003 and #004 a/b and maximum rated storm water discharges from Outfalls #001, #002 and #003. To these discharges, the maximum TSS concentration observed in the monitoring program, ρ_0 = 31.0 mg/L, was applied for all Outfalls. In the broad-scale view, the dilution field spreads nearly a kilometer seaward of the shoreline due to vigorous cross shore mixing and advection from the storm winds and shoaling swells of the wet weather receiving water scenario. The wind set up and divergence of from the shoaling waves cause a down-welling over the Scripps Submarine Canyon, producing a hole in the dilution field near its northern flank. The dilution field also spreads down-coast to La Jolla Shores under the advective influence of the southward directed tidal drift (Figure 21).

The nearfield view in Figure 19 indicates that the dilution factors in the ASBS during the extreme wet weather case range form a minimum of 10^2 near shore to 10^4 along the ASBS boundary adjacent to Scripps Submarine Canyon. The

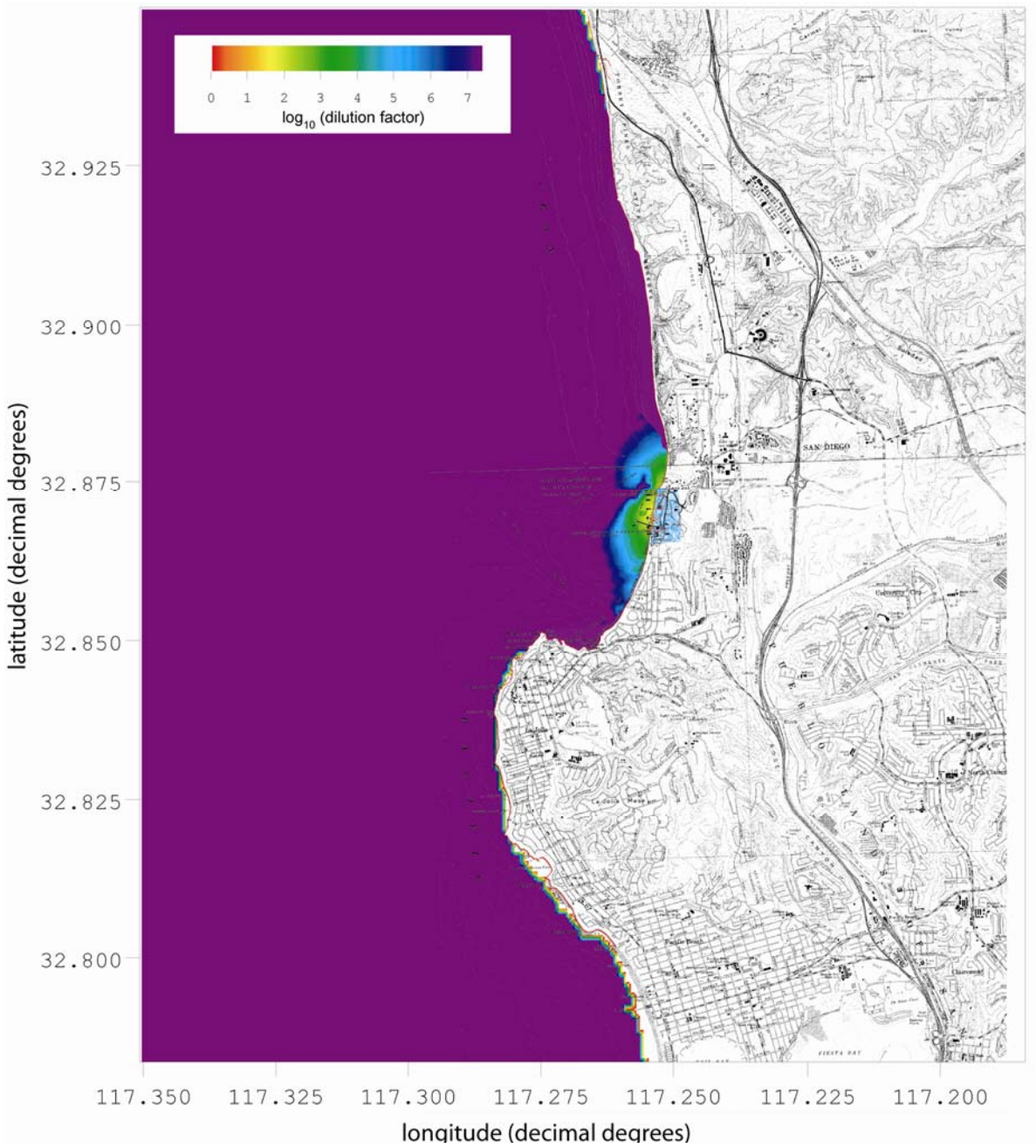

Figure 18. Wet weather worst case: Outfall-001 = 5700 gpm storm water, 486 gpm seawater, Outfall-002 = 200 gpm storm water, Outfall-003 = 139 gpm seawater, Outfall-004a/b = 97 gpm seawater; waves: H = 2.0 m, T = 15 s, α = 285^{o}; wind = 18 kts.

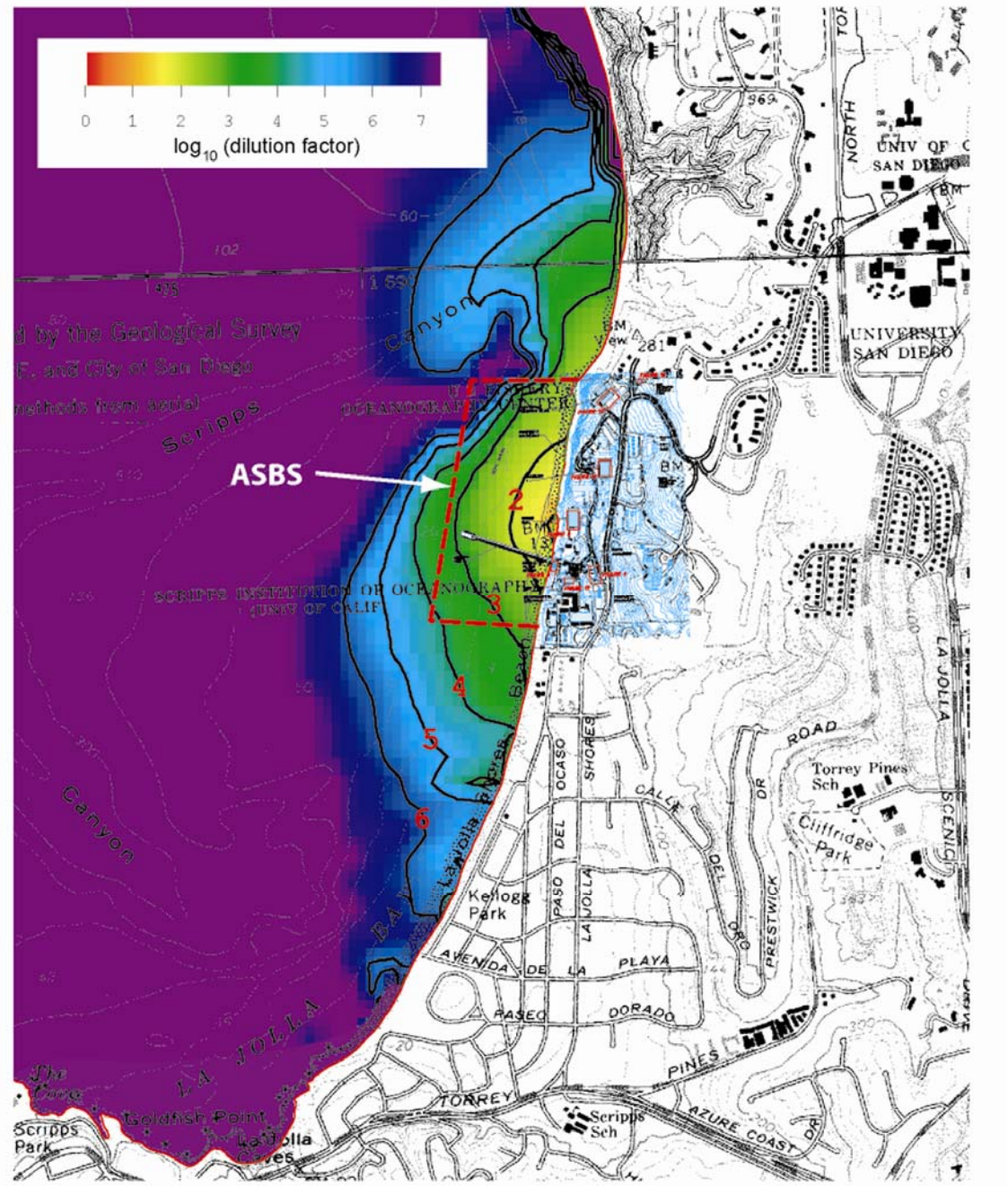

Figure 19. Wet weather worst case (enlarged): Outfall-001 = 5700 gpm storm water, 486 gpm seawater, Outfall-002 = 200 gpm storm water, Outfall-003 = 139 gpm seawater, Outfall-004a/b = 97 gpm seawater; waves: H = 2.0 m, T = 15 s, α = 285^{o}; wind = 18 kts.

10^4 dilution factors near Scripps Submarine Canyon are a consequence of down-welling into deep water, but in general the dilution factors in the preponderance of the ASBS are in the 10^2 to 10^3 range. These values are less than the dilution found for the dry weather scenario for two reasons: 1) the wet weather discharge rates are more than an order of magnitude greater than during dry weather, so there is more discharge volume to dilute in essentially the same nearshore dilution volume; and 2) the wet weather discharge is brackish due to the high content of fresh water from the storm water constituent, resulting in greater density contrast between the effluent and the receiving water with diminished rate of assimilation. The inhibition of dilution due to density contrast is evident in the turbidity front shown in the photo in Figure 20. Even so, with these dilution factors, the maximum possible concentration of copper (adsorbed on the surfaces of suspended particles) would generally be no more than 0.13 µg/L in the portions of the ASBS immediately seaward of the surf zone and vary between 0.01 µg/L to 0.001 µg/L in the offshore portions of the ASBS. These estimates are based on the maximum copper concentration observed during the monitoring program and still result in concentrations below quantifiable detection limits in the ASBS for this extreme case scenario.

Figure 20: Discharge plume from Outfall #001 during storm water runoff event 22 March 2005. Note front line of turbidity associated the discharge effluent.

4.3) Long-Term Minimum Dilution in the Surf Zone

Because of the disparity in length scales between dilution in the offshore region (Figures 16-19) versus the surfzone, a separate analysis was performed on a nested fine scale grid covering the surf zone for a long shore reach that extended 1000 ft (305 meters) either side of the beach outfalls. The size of this grid was based on precedent already set for the definition of a ZID by the Regional Water Quality Control Board, San Diego. All 7,523 combinations of receiving water variables from Figures 6 and 19 were input for daily simulations of dilution using the numerical codes described in Section 2 and listed in Appendices A-F. The ZID was searched for the minimum dilution after averaging across the width of the surf zone. A TSS particle concentration of 0.71mg/L was used for all outfalls in the extreme dry weather case scenario.

Figure 21 presents a probability density function (red histogram) with corresponding cumulative probability (blue line) of the minimum surfzone dilution within the ZID for an ensemble of 7,523 daily outcomes (20.5 years). The median outcome is a minimum dilution factor of 31 to 1 based on the historical sequence of receiving water variables found in Figures 6 and 13. However the potential range of minimum dilution within the ZID goes as high as 96 to 1, and as low as 7 to 1. The extreme dry weather case scenario produced the 7 to 1 minimum dilution outcome that had a probability of occurrence of 0.13%. Only 3.2 % of the potential outcomes produce dilutions of less than 15 to 1 in the ZID. Altogether, 89% of the potential outcomes produce minimum dilutions in the ZID greater than 20 to 1.

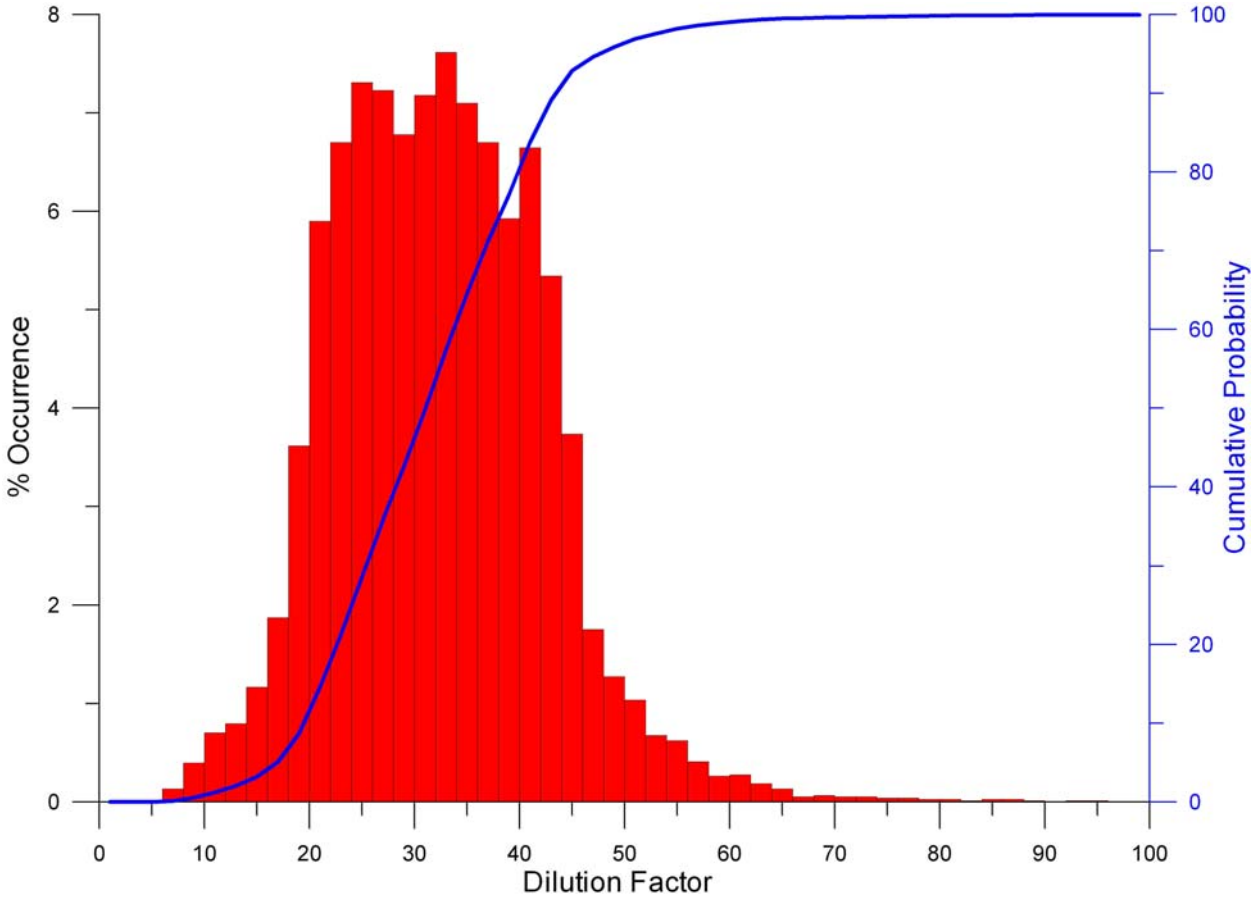

Figure 21. Histogram of minimum dilution of SIO discharges in the surfzone for historic observations of daily ocean mixing and water mass properties, 1980-2001. Outfall-001 = 0 gpm stormwater, 486 gpm seawater. Outfall-002 = 0 gpm stormwater. Outfall-003 = 139 gpm seawater, Outfall-004a/b = 97 gpm seawater.

5) Summary and Conclusions:

The dilution and dispersion of effluent from the five Scripps Beach outfalls was studied by numerical simulation of dry and wet weather extreme case scenarios using the ***SEDXPORT*** hydrodynamic modeling system. This process-based model was developed at Scripps Institution of Oceanography for the US Navy's *Coastal Water Clarity System* and *Littoral Remote Sensing Simulator* and has a proven ability to predict dispersion patterns and dilution ratios.

Based on an analysis of monitoring data from the five outfalls for Ocean Plan constituents during the heavy rainfall period of winter 2004-05, detected concentrations of TSS and copper were used in the dispersion modeling.

From 7,523 separate simulations of dilution fields, including both the dry and wet historical extreme case scenarios, the following conclusions are reached:

1) Dry weather dilution rates range 100 : 1 to 1,000,000 : 1 in ASBS #31 everywhere seaward of the surf zone.
2) Wet weather dilution rates range 100 : 1 to 10,000 : 1 in ASBS #31 everywhere seaward of the surf zone.
3) Minimum dilutions inside the surf zone ranged from 7:1 to 96:1 with a median dilution of 31 : 1 when maximum seawater discharge rates are perpetuated over the long term. The 7:1 dilution had the probability of occurring only 0.13% of the time while minimum dilutions greater than 20:1 had the probability of occuring 89% of the time.

Using the maximum copper concentration observed during dry weather monitoring, it was concluded that the copper discharged from the beach outfalls

would be found in the receiving water at concentrations no more than 0.04 μg/L in the portions of the ASBS immediately seaward of the surf zone and more typically 0.0001 μg/L to 0.000001 μg/L in the offshore portions of the ASBS. These concentrations are below quantifiable detection limits. For the wet weather worst case, copper concentrations would be no more than 0.13 μg/L in the portions of the ASBS immediately seaward of the surf zone and 0.01 μg/L to 0.001 μg/L in the offshore portions of the ASBS.

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APPENDIX A: Governing Equations and Code for the TIDE_FEM Current Model

A finite element approach was adapted in preference to more common finite difference shallow water tidal models, e.g., Leendertse (1970), Abbott et al (1973), etc. Finite difference models employ rectangular grids which would be difficult to adapt to the complex geometry of the La Jolla Bay. It is believed that large errors would accumulate from attempting to approximate the irregular boundaries of the La Jolla Bay system with orthogonal segments. On the other hand, finite element methods allow the computational problem to be contained within a domain bounded by a continuous contour surface, such as the S_f contours stored within the ***bathy*** bathymetry file.

A finite element tidal hydraulics model, **TIDE_FEM**, [Inman and Jenkins, 1996] was employed to evaluate the tidal hydraulics of the La Jolla Bay (containing ASBS #31). **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 estuaries in Rhode Island, [Wang, 1975], and have been reviewed in basic text books [Weiyan, 1992] and symposia on the subject, e.g., Gallagher (1981).

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 (see Figure A-1) is used to reduce the weighted residuals to a set of order-one ordinary differential equations with

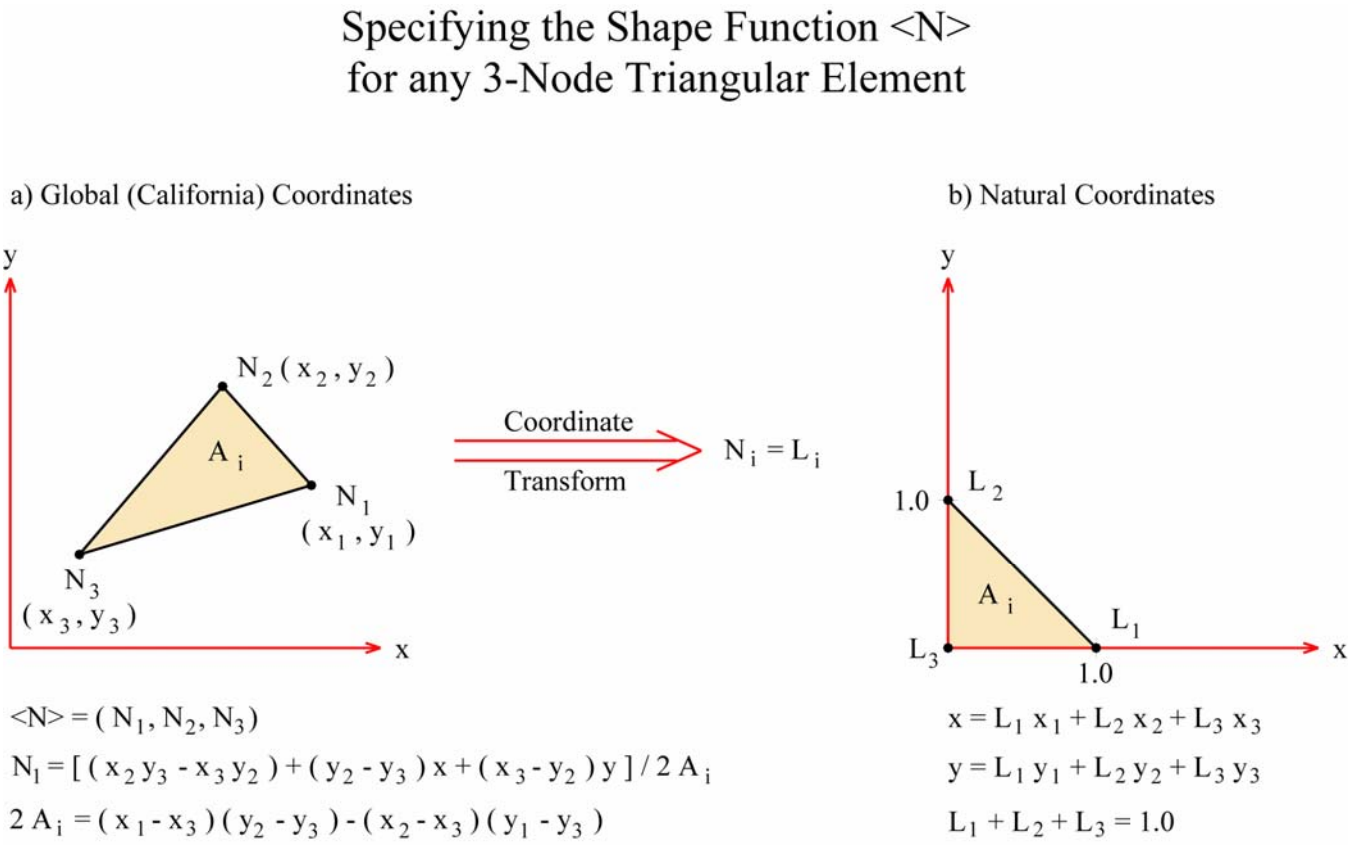

Figure A-1: Shape function polynomial and transform to natural coordinates for a generalized 3-node triangular element in the cross-shore plane .

constant coefficients. These coefficients (***influence coefficients***) are posed in terms of a ***shape function*** derived from the natural coordinates of each nodal point. 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).

We adapt the California coordinates as our **global** coordinate system (x, y) to which the nodes in the computational mesh are referenced, with **x** (easting) and **y** (northing). The vertical coordinate **z** is fixed at 0.0 ft NGVD and is positive upward. The local depth relative to 0.0 ft NGVD is **h** and the mean surface elevation about 0.0 ft NGVD is **η**. The total depth of water at any node is **H = h + η**. The vertically averaged xy-components of velocity are $(\bar{u}, \bar{v})$. The continuity and momentum equations may be written from Connor and Wang, (1974), as:

$$\begin{aligned}
&\frac{\partial}{\partial t}\rho H + \frac{\partial}{\partial x}q_x + \frac{\partial}{\partial y}q_y = 0 \\
&\frac{\partial}{\partial t}q_x + \frac{\partial}{\partial x}\bar{u}q_x + \frac{\partial}{\partial y}\bar{u}q_y = B_x + \frac{\partial}{\partial x}\left(F_{xx} - F_p\right) + \frac{\partial}{\partial x}F_{yx} \\
&\frac{\partial}{\partial t}q_y + \frac{\partial}{\partial x}\bar{v}q_x + \frac{\partial}{\partial y}\bar{v}q_y = B_y + \frac{\partial}{\partial y}\left(F_{yy} - F_p\right) + \frac{\partial}{\partial x}F_{xy}
\end{aligned} \qquad \text{(A2)}$$

Here $\mathbf{q_x}$, $\mathbf{q_y}$ are mass flux components

$$q_x = \rho\int_{-h}^{\eta}\bar{u}\,dz \qquad \text{(A3)}$$

$$q_y = \rho\int_{-h}^{\eta}\bar{v}\,dz \qquad \text{(A4)}$$

and $\mathbf{q_I}$ is the mass flux through the ocean inlet due to water surface elevation changes in the estuary:

$$q_I = \rho \frac{\partial}{\partial t}\left(\frac{\partial s}{\partial \eta}\right) \qquad \textbf{(A5)}$$

$\mathbf{F_p}$ is the pressure force resultant and $\mathbf{F_{xx}}$, $\mathbf{F_{xy}}$, $\mathbf{F_{yy}}$ are "equivalent" internal stress resultants due to turbulent and dispersive momentum fluxes

$$\begin{aligned} F_p &= \int_{-h}^{\eta} p\,dz = \frac{\rho g H^2}{2} \\ F_{xx} &= 2\varepsilon \frac{\partial}{\partial x} q_x \\ F_{yy} &= 2\varepsilon \frac{\partial}{\partial y} q_y \\ F_{yx} &= F_{xy} = \varepsilon\left(\frac{\partial}{\partial y} q_y + \frac{\partial}{\partial x} q_x\right) \end{aligned} \qquad \text{(A6)}$$

and ε is the eddy viscosity. $\mathbf{B_x}$ and $\mathbf{B_y}$ are the bottom stress components

$$\begin{aligned} B_x &= \tau_x + \rho g H \frac{\partial h}{\partial x} \\ B_y &= \tau_y + \rho g H \frac{\partial h}{\partial y} \end{aligned} \qquad \text{(A7)}$$

In Equation (A7), $\boldsymbol{\tau_x}$ and $\boldsymbol{\tau_y}$ are the bottom shear stress components that are quasi-linearized by Chezy-based friction using Manning's roughness factor, $\mathbf{n_o}$:

$$\tau_x = -\frac{g}{\rho H^2 C_z^{\,2}} q_x \left(q_x^{\,2} + q_y^{\,2}\right)^{1/2}$$
$$\tau_y = -\frac{g}{\rho H^2 C_z^{\,2}} q_y \left(q_x^{\,2} + q_y^{\,2}\right)^{1/2} \qquad \text{(A8)}$$

where $\mathbf{C_z}$ is the Chezy coefficient calculated as:

$$C_z = \frac{1.49}{n_0} H^{1/6} \qquad \text{(A9)}$$

Boundary conditions are imposed at the locus of possible land/water boundaries, $\mathbf{S_f}$ in the ***bathym*** file and at the shoreline, $\mathbf{S_o}$. Flux quantities normal to these contours are denoted with "n" subscripts and tangential fluxes are given "s" subscripts. At any point along a boundary contour, the normal and tangential mass fluxes are:

$$q_n = \int_{-h}^{\eta} \rho u_n dz = \alpha_{nx} q_x + \alpha_{ny} q_y$$
$$q_s = \int_{-h}^{\eta} \rho u_s dz = -\alpha_{nx} q_x + \alpha_{ny} q_y \qquad \text{(A10)}$$
$$\alpha_{nx} = \cos(n, x)$$
$$\alpha_{ny} = \cos(n, y)$$

Components of momentum fluxes across a boundary are equivalent to internal force resultants according to:

$$F_{nx} = \alpha_{nx}(F_{xx} - F_p) + \alpha_{ny} F_{yx}$$
$$F_{ny} = \alpha_{ny}(F_{yy} - F_p) + \alpha_{nx} F_{xy} \qquad \text{(A11)}$$

On land boundary contours, the flux components are prescribed

$$q_n = q_s = 0 \qquad \text{on land} \qquad \text{(A12)}$$

On the deep water ocean boundary, the normal boundary forces (due to sea surface elevation) are continuous with ocean values, and the mass exchange is limited by the storage capacity of the estuary. Hence

$$F_{nm} = \overline{F}_{nm} \quad \text{and} \quad q_{nm} = q_I \qquad \text{ocean boundary} \qquad \text{(A13)}$$

In the problem at hand $\overline{F}_{nn}$ is prescribed on the shoreline by the ocean tidal elevation, η_0 , and the local depth, $\mathbf{h_o}$ according to

$$\overline{F}_{nm} = \frac{\rho g}{2}(\eta_0 + h_0)^2 \qquad \text{on } S_0 \qquad \text{(A14)}$$

Ocean ***tidal forcing functions*** η_0 were developed in Section 3.1. The ocean boundary condition as specified by Equation (A13) places a dynamic boundary condition on the momentum equations and a kinematic boundary condition on the continuity equation that is constrained by the storage rating curve. Solutions are possible by specifying only the dynamic boundary condition, but then mass exchanges are controlled by the wetting and drying of individual grid cells with associated discretization and interpolation errors which threaten mass conservation. The technique of over specifying the ocean boundary condition with both a dynamic and kinematic condition is discussed in the book by Weiyan (1992).

The governing equations (A2-A9) and the boundary conditions (A10-A13) are cast as a set of integral functionals in a variational scheme, [Boas, 1966].

Within the domain of each element of the mesh, $\mathbf{A_i}$ the unknown solution to the governing equations is simulated by a set of ***trial functions*** $(\hat{H}, \hat{q})$ having adjustable coefficients. The trial functions are substituted into the governing equations to form ***residuals,*** $\mathbf{(R_H, R_q)}$. The residuals are modified by ***weighting functions,*** $\mathbf{(\Delta H, \Delta q)}$. The coefficients of the trial functions are adjusted until the weighted residuals vanish. The solution condition on the weighted residuals then becomes:

$$\iint_{A_i} R_H \Delta H dA = 0$$
$$\iint_{A_i} R_q \Delta q dA = 0$$

By the Galerkin method of weighted residuals, [Finlaysen, 1972], the weighting functions are set equal to nodal ***shape functions***, **<N>**, or:

$$\Delta H \sim N_i$$
$$\Delta q \sim N_j$$

The shape function, <N>, is a polynomial of degree which must be at least equivalent to the order of the highest derivative in the governing equations. The shape function also provides the mechanism to discretized the governing equations. Figure A-1 gives the shape function polynomial in terms of ***global (California)*** coordinates for the first nodal point, $\mathbf{N_1}$ of a generalized 3-node triangular element of area $\mathbf{A_i}$. Wang (1975) obtained significant numerical efficiency in computing the weighted residuals when the shape functions of each nodal point, $\mathbf{N_i}$, are transformed to a system of ***natural*** coordinates based upon the unit triangle, giving

$\mathbf{N_i} \rightarrow \mathbf{L_i}$ as detailed in Figure A-1. The shape functions also permit semi-discretization of the governing equations when the trial functions are posed in the form:

$$\hat{H}(x,y,t) = \sum_i H_i(t) N_i(x,y)$$
$$\hat{q}(x,y,t) = \sum_j q_j(t) N_j(x,y) \qquad \text{(A15)}$$

Discretization using the weighting and trial functions expressed in terms of the nodal shape functions allows the ***distribution*** of dependent variables over each element to be obtained from the values of the independent variables at discrete nodal points. However, the shape function at any given nodal point, say $\mathbf{N_1}$, is a function of the independent variables of the two other nodal points which make up that particular 3-node triangular element, see Figure A-1. Consequently, the computations of the weighted residuals leads to a series of influence coefficient matrices defined by

$$a_{ij} = \frac{1}{A_i}\iint N_i N_j dA$$
$$s_{ij} = \frac{1}{A_i}\iint N_i \frac{\partial N_j}{\partial x} dA$$
$$t_{ij} = \frac{1}{A_i}\iint N_i \frac{\partial N_j}{\partial y} dA \qquad \text{(A16)}$$
$$g_{ijk} = \frac{1}{A_i}\iint N_i N_j \frac{\partial N_k}{\partial x} dA$$
$$h_{ijk} = \frac{1}{A_i}\iint N_i N_j \frac{\partial N_k}{\partial y} dA$$

The influence coefficient matrices given by equation (A16) are evaluated in both global and natural coordinates. Once the influence coefficients have been calculated for each 3-node element, the weighted residuals reduce to a set of order-one ordinary differential with constant coefficients. The continuity equation becomes:

$$\sum\left(a_{ij}\frac{dH_i}{dt}\right) = -\sum_i\sum_k\left[g_{ijk}\left(H_i q_{xk} + H_k q_{xi}\right) + h_{ijk}\left(H_i q_{yk} + H_k q_{yi}\right)\right]$$
$$\sum\left(a_{ij}\frac{dq_{xj}}{dt}\right) = -\sum_j\sum_k\left[g_{ijk}\left(q_{xk} q_{xj}\right) + h_{ijk}\left(q_{yj} q_{xk}\right)\right] + N_i\sum_j N_j S_{fj} + g\sum_i s_{ij} H_i \qquad \text{(A17)}$$
$$\sum\left(a_{ij}\frac{dq_{yj}}{dt}\right) = -\sum_j\sum_k\left[g_{ijk}\left(q_{xj} q_{yk}\right) + h_{ijk}\left(q_{yj} q_{xk}\right)\right] + N_i\sum_j N_j S_{fj} + g\sum_i t_{ij} H_i$$

Equations (A17) are essentially simple oscillator equations forced by the collection of algebraic terms appearing on the right hand side; and are therefore easily integrated over time. The time integration scheme used over each time step of the tidal forcing function is based upon the ***trapezoidal rule***, see Gallagher 1981) or Conte and deBoor (1972). This scheme was chosen because it is known to be unconditionally stable, and in tidal propagation problems has not been known to introduce spurious phase differences or damping. It replaces time derivatives between two successive times, $\Delta t = t_{n+1} - t_n$, with a truncated Taylor series. For the water depth it would take on the form:

$$\frac{dH}{dt} = \eta(t)$$

$$H_{n+1} - H_n = \frac{\Delta t}{2}\left(\eta_{n+1} + \eta_n\right) + E\Delta t \qquad \text{(A18)}$$

$$E = \frac{1}{12}\left(\Delta t\right)^2 \left|\frac{d^2\eta}{dt^2}\right|$$

To solve equation (A18), iteration is required involving successive forward and backward substitutions.

Of particular interest are the ***hydraulic friction slope coefficients, S_{fj},*** appearing as damping terms on the right hand side of equation (A17). Two separate formulations are used. One is given for the 3-node triangular elements situated in the interior of La Jolla Bay which do not experience successive wetting and drying during each tide cycle. The other formulation is used for the hydraulic friction slope coefficients for the elements situated along the wet and dry boundaries of the shoreline. These have been formulated as 3-node triangular elements with one curved side based upon the cubic-spline matrices developed by Weiyan (1992). The wet-dry boundary coordinates of the curved side, (x', y'), are linearly interpolated for any given water elevation from the contours stored in the ***bathym*** file.

The influence and friction slope coefficient matrices together with the trapezoidal rule reduce equations (A16) and (A17) to a system of algebraic equations [Grotkop, 1973] which are solved by Cholesky's method per a numerical coding scheme by Wang (1975). For more details, refer to the TIDE_FEM code below, and Gallagher (1981) or Oden and Oliveira (1973).

Bathymetry errors are the most common cause of modeling errors. Other sources of errors include:

ELEMENT INTERPOLATION ERROR: Due to the degree of the polynomial used to specify shape function, N_i.

DISCRETIZATION ERRORS: Due to mesh coarseness and approximating the curved wet/dry boundary side of an element with a quadratic spline.

QUADRATURE ERRORS: Due to reducing the weighted residual integral with the influence coefficient matrices.

ITERATION ERRORS: Due to solving the system of algebraic equations reduced from the Galerkin Equations.

ROUNDOFF ERRORS: Due to time integration by the trapezoidal rule.

SEA LEVEL ANOMALIES: Due to discrepancies between the astronomic tides and the actual observed water levels in the ocean.

INSUFFICIENT CALIBRATION DATA: Due to limitations in the period of record

The following is a listing of the TIDE_FEM code:

```
C..tide_fem.f

c..Finite element tidal hydraulics model using the Galerkin weighted
c..residual process to implement the finite element scheme
c..with Chezy based friction terms.
c..Adapted from Wang (1975) by Scott Jenkins and Joseph Wasyl.
c..7/16/04
c
        dimension X(500), Y(500), H(500),B1(1000,100),B2(500,50),
     & U(500), V(500), ETA(500), UVP(500), EP(500),MEXT(500),
     & MINT(500), R1(1000),R2(500),A(20,1000),Q(1000),MB(500),
     & CMAN(1000),CHEZ(1000),AREA(1000),N1(1000),N2(1000),N3(1000),
     & MH(10),MLE(200),ANG(200),tide(500),time(500)
      character*12 tidein, bathym, nodes, datout, temp
c
      open(20,file='tide_fem.inp',status='old')
      read(20,'(a12)')tidein
      read(20,'(a12)')bathym
      read(20,'(a12)')nodes
      read(20,'(a12)')temp
      read(20,'(a12)')datout
c
C..READ COMPUTATIONAL PARAMETERS
      READ(20,280) NN,NM,NW
280   FORMAT(3I10)
      READ(20,281) T,TLIM,DT,WW
281   FORMAT(4F10.0)
      READ(20,282) ATTD,HA,WX,WY
282   FORMAT(4F10.1)
      READ(20,283) STEP0,PUNCH
283   FORMAT(2F10.0)
      READ(20,284) UNIT,UNAR
284   FORMAT(2F10.0)
      READ(20,285) SILL
285   FORMAT(F10.3)
C
      open(21,file=bathym,status='old')
      open(22,file=nodes,status='old')
      open(23,file=tidein,status='old')
      open(24,file=datout,status='unknown')
      open(16,file=temp,status='unknown')
```

```
c
C..READ GLOBAL COORDINATE OF EACH NODE
     WRITE(16,298)
298   FORMAT(IH,' NODE NUMBER',5X,'X',9X,'Y',9X,'DEPTH',/)
     DO 205 I=1,NN
     READ(21,300)MEXT(I),MB(I),X(I),Y(I),H(I)
300   FORMAT(I4,I1,2F10.5,F3.1)
205   MINT(MEXT(I)=I
     WRITE(16,301)MEXT(I),I,MB(I),X(I),Y(I),H(I),I=1,NN
301   FORMAT(2(3I5,3F10.3))
C
C..READ ELEMENT DATA
C
     READ(22,302)N1(I),N2(I),N3(I),I=1,NM)
302   FORMAT(3I3)
     WRITE(16,303)
303   FORMAT(1H ,'THE ELEMENT CONNECTIONS ',/)
     WRITE(16,304) (I,N1(I),N2(I),N3(I),I=1,NM)
304   FORMAT(5(I7,2X,3I4)
C
C..READ OPEN AND LAND BOUNDARY
C
     READ(22,306)MHNO,(MH(I),I=1,MHNO)
     READ(22,306)MLNO,(MLE(I),I=1,MLNO)
306   FORMAT(16I5)
     WRITE(16,307)MHNO
307   FORMAT(1H,'THERE ARE',I5,'NODES ON THE OPEN BOUNDARY')
     WRITE(16,309) (MH(I),I=1,MHNO)
     WRITE(16,308)MLNO
308   FORMAT(1H,'THERE ARE',I5,'NODES ON THE OPEN BOUNDARY')
     WRITE(16,309) (MLE(I),I=1,MLNO)
309   FORMAT(3X,15I5)
     READ(22,310)(ANG(I),I=1,MLNO)
310   FORMAT(8F10.4)
     WRITE(16,311)
311   FORMAT(1H ,' THE OUTWARD DIRECTIONS ',/)
     WRITE(16,312)(MLE(I),ANG(I),I=1,MLNO)
312   FORMAT(5(I8,F10.4))
     STEBC=1.e10
     NBAND=0
     CRHO=0.00114
     G=32.174
     CDRAG=0.0025
     F=3.141592/21600.0*SIN(ATTD/180.0*3.141592)
```

```
      NWN=2*NW-1
      NN1=NN*2
      NW1=NW*2+1
      CCX=CDRAG*CRHO*ABS(WX)*WX
      CCY=CDRAG*CRHO*ABS(WY)*WY
      C1=1.0/3.0
      C2=1.0/3.0
      C3=1.0/3.0
      C4=1.0/12.0
      C5=1.0/12.0
      C6=1.0/12.0
      C7=1.0/6.0
      C8=1.0/6.0
      C9=1.0/6.0
      DO 201 I=1,NN
      X(I)=X(I)*UNIT
201   Y(I)=Y(I)*UNIT
      DO 202 I=1,MLNO
202   ANG(I)=ANG(I)*DATAN(6.1001)/45.0
      DO 204 I=1,NN1
      DO 204 J=1,NWN1
204   B1(I,J)=0.0
      DO 203 I=1,NN
      DO 203 J=1,NWN
203   B2(I,J)=0.0
C
C
      DO 10 I=1,NM
      N1(I)=MINT(N1(I))
      N2(I)=MINT(N2(I))
      N3(I)=MINT(N3(I))
      L1=IABS(N1(I)-N2(I))+1
      L2=IABS(N2(I)-N3(I))+1
      L3=IABS(N3(I)-N1(I))+1
      IF(NBAND.LT.L1) NBAND=L1
      IF(NBAND.LT.L2) NBAND=L2
      IF(NBAND.LT.L3) NBAND=L3
C
C..TRANSFER TO LOCAL COORDINATE
C
      XP1=(2.0*X(N1(I))-X(N2(I))-X(N3(I)))/3.0
      XP2=(2.0*X(N2(I))-X(N1(I))-X(N3(I)))/3.0
      XP3=(2.0*X(N3(I))-X(N1(I))-X(N2(I)))/3.0
      YP1=(2.0*Y(N1(I))-Y(N2(I))-Y(N3(I)))/3.0
```

```
      YP2=(2.0*Y(N2(I))-Y(N1(I))-Y(N3(I)))/3.0
      YP3=(2.0*Y(N3(I))-Y(N1(I))-Y(N2(I)))/3.0
C
C..CALCULATE ELEMENT AREA
C
      AREA=0.5*(XP2*YP3+XP1*YP2+XP3*YP1-XP2*YP1-XP3*YP2-XP1*YP3)
C
C..CALCULATE MANNING FACTOR
C
      CMAN(I)=0.03
C
C..CALCULATE COEFFIECIENTS OF SHAPE FUNCTION
C
      A(1,I)=(XP2*YP3-XP3*YP2)/2.0*AREA(I))
      A(2,I)=(YP2-YP3)/2.0*AREA(I))
      A(3,I)=(XP3-XP2)/2.0*AREA(I))
      A(4,I)=(XP3*YP1-XP1*YP3)/2.0*AREA(I))
      A(5,I)=(YP3-YP1)/2.0*AREA(I))
      A(6,I)=(XP1-XP3)/2.0*AREA(I))
      A(7,I)=(XP1*YP2-XP2*YP1)/2.0*AREA(I))
      A(8,I)=(YP1-YP2)/2.0*AREA(I))
      A(9,I)=(XP2-XP1)/2.0*AREA(I))
C
C
      AREA(I)=AREA(I)*UNAR
      DIS1=SQRT((X(N1(I))-X(N2(I)))**2+(Y(N1(I))-Y(N2(I)))**2)
      DIS2=SQRT((X(N2(I))-X(N3(I)))**2+(Y(N2(I))-Y(N3(I)))**2)
      DIS3=SQRT((X(N3(I))-X(N1(I)))**2+(Y(N3(I))-Y(N1(I)))**2)
      DH1A=DIS1/SQRT(G*H(N1(I)))
      DH1B=DIS1/SQRT(G*H(N2(I)))
      DH2A=DIS2/SQRT(G*H(N2(I)))
      DH2B=DIS2/SQRT(G*H(N3(I)))
      DH3A=DIS3/SQRT(G*H(N3(I)))
      DH3B=DIS3/SQRT(G*H(N1(I)))
      IF(STEBC.GT.DH1A)  STEBC=DH1A
      IF(STEBC.GT.DH1B)  STEBC=DH1B
      IF(STEBC.GT.DH2A)  STEBC=DH2A
      IF(STEBC.GT.DH2B)  STEBC=DH2B
      IF(STEBC.GT.DH3A)  STEBC=DH3A
      IF(STEBC.GT.DH3B)  STEBC=DH3B
C
C..FORM THE GLOBAL MATRIX
C
      II=N1(I)
```

```
      JJ=N2(I)
      KK=N3(I)
      II1=NW
      JJ1=JJ-(II-NW)
      KK1=KK-(II-NW)
      B2(II,II1)=B2(II,II1)+C7*AREA(I)
      B2(II,JJ1)=B2(II,JJ1)+C4*AREA(I)
      B2(II,KK1)=B2(II,KK1)+C6*AREA(I)
      II1=II-(JJ-NW)
      JJ1=NW
      KK1=KK-(JJ-NW)
      B2(JJ,II1)=B2(JJ,II1)+C4*AREA(I)
      B2(JJ,JJ1)=B2(JJ,JJ1)+C8*AREA(I)
      B2(JJ,KK1)=B2(JJ,KK1)+C5*AREA(I)
      II1=II-(KK-NW)
      JJ1=JJ-(KK-NW
      KK1=KK-NW
      B2(KK,II1)=B2(KK,II1)+C6*AREA(I)
      B2(KK,JJ1)=B2(KK,JJ1)+C5*AREA(I)
      B2(KK,KK1)=B2(KK,KK1)+C9*AREA(I)
10    CONTINUE
      WRITE(16,320) NBAND,STEBC,UNAR
320   FORMAT(1H0,' THE BANDWIDTH =  ',I5,'THE SMALLEST L/SQRT(GH) ='
     &   ,F10.,//,1H,' ELEMENT AREA (UNIT',F10.2,' SQRT FEET)')
      WRITE(16,321)(I,AREA(I),I=1,MN)
321   FORMAT(5(I6,F12.4))
      DO 12 I=1,NN
      DO 12 J=1,NWN
      B1(2*I-1,2*J)=B2(I,J)
12    B1(2*I,2*J)=B1(2*I-1,2*J)
C
C..ROTATE COORDINATE ON THE BOUNDARY
      LB1=NWN-1
      LB2=(NN1-NW1+2)/2
      DO 13 NI=1,MLNO
      I=MINT(MLE(NI))
      NMB=MB(I)
      GO TO (14,13,14,13),NMB
14    CALL ROTB1(B1,ANG(NI),NN1,NW1,NWN1,NW,I,LB1,LB2)
13    CONTINUE
      DO 23 NI=1,MLNO
      I=MINT(MLE(NI))
      NMB=MB(I)
      GO TO (15,23,15,21),NMB
```

```
15    DO 16 J=1,NWN1
16    B1(2*I-1,J)=0.0
      B1(2*I-1,NW1)=1.0
      GO TO 23
21    DO 22 J=1,NWN1
      B1(2*I-1,J)=0.0
22    B1(2*I,J)=0.0
      B1(2*I,NW1)=1.0
      B1(2*I-1,NW1)=1.0
23    CONTINUE
C
C..L U DECOMPOSE MATRIX
C
      CALL MATRIX(B1,NN1,NW1,NWN1)
      DO 17 NI=1,MHNO
      I=MINT(MH(NI))
      DO 18 J=1,NWN
18    B2(I,J)=0.0
      B2(I,NW)=1.0
17    CONTINUE
      CALL MATRIX(B2,NN,NW,NWN)
C
C
C..SET INITIAL VALUES
C
      READ(23,318)(I,TIDE(I),U(I),V(I),I=1,NN)
      DO 9 I=1,NN
      if(TIDE(I).GT.sill)THEN
      ETA(I)=TIDE(I)
      ELSE
      ETA(I)=SILL+0.00001
      ENDIF
      Q(2*I-1)=U(I)*(ETA(I)+H(I))
9     Q(2*I)=V(I)*ETA(I)+H(I))
C
      KL=0
      ML=0
      MLL=1
C
C..START SEMI-IMPLICIT METHOD
C
      IF(KL.EQ.ML*STEP0) GO TO 27
      GO TO 28
27    ML=ML+1
```

```
      TIM=T/60.0
      WRITE(16,315)TIM
315   FORMAT(/,' TIME='F10.2)
      WRITE(16,316)
316   FORMAT(2X,'ELEMENT  TIDE    U VELOCITY  V  VELOCITY')
      WRITE(16,317)(I,MEXT(I),ETA(I),U(I),V(I),I=1,NN)
317   FORMAT(3(2I4,3F10.3))
28    IF(KL.EQ.MLL*PUNCH) GO TO 34
      GO TO 36
34    MLL=MLL+1
      WRITE(24,318)(I,ETA(I),U(I),V(I),I=1,NN)
318   FORMAT(I5,3F1.4,I5,3F11.4)
36    CALL WH(T,HH,WW,HA)
      DO 38 NI=1,MHNO
      I=MINT(MH(NI))
      ETA(I)=HH
38    CONTINUE
39    DO 40 I=1,NN
      R1(2*I-1)=0.0
40    R1(2*i)=0.0
      DO 42 I=1,NM
      UU=Q(2*N1(I)-1)**2+Q(N*N2(I)-1)**2+Q(2*N3(I)-1)**2
      VV=Q(2*N1(I))**2+Q(N*N2(I))**2+Q(2*N3(I))**2
      AVEG=((UU+VV)/3.0)**0.5
      HE1=H(N1(I))+ETA(N1(I))
      HE2=H(N2(I))+ETA(N2(I))
      HE3=H(N3(I))+ETA(N3(I))
      AVEG=((HE1+HE2+HE3)/3.0)**2
      CHEZ(I)=1.49/CMAN(I)*((HE1+HE2+HE3)/3.0)**(1.0/6.0)
      C746E=C7*ETA(N1(I))+C4*H(N2(I))+C6*ETA(N3(I))
      C485E=C4*ETA(N1(I))+C8*H(N2(I))+C5*ETA(N3(I))
      C659E=C6*ETA(N1(I))+C5*H(N2(I))+C9*ETA(N3(I))
      C746H=C7*H(N1(I))+C4*H(N2(I))+C6*H(N3(I))
      C485H=C4*H(N1(I))+C8*H(N2(I))+C5*H(N3(I))
      C659H=C6*H(N1(I))+C5*H(N2(I))+C9*H(N3(I))
      A258E=A(2,I)*ETA(N1(I))+A(5,1)*ETA(N2(I))+A(8,1)*ETA(N3(I))
      A369E=A(3,I)*ETA(N1(I))+A(6,1)*ETA(N2(I))+A(9,1)*ETA(N3(I))
      PREX1=G*(C746H+C746E)*A258E
      PREX2=G*(C485H+C485E)*A258E
      PREX3=G*(C659H+C659E)*A258E
      PREY1=G*(C746H+C746E)*A369E
      PREY2=G*(C485H+C485E)*A369E
      PREY3=G*(C659H+C659E)*A369E
      C746U=C7*Q(2*N1(I)-1)+C4*Q(2*N2(I)-1)+C6*Q(2*N3(I)-1)
```

```
      C485U=C4*Q(2*N1(I)-1)+C8*Q(2*N2(I)-1)+C5*Q(2*N3(I)-1)
      C659U=C6*Q(2*N1(I)-1)+C5*Q(2*N2(I)-1)+C9*Q(2*N3(I)-1)
      C746V=C7*Q(2*N1(I))+C4*Q(2*N2(I))+C6*Q(2*N3(I))
      C485V=C4*Q(2*N1(I))+C8*Q(2*N2(I))+C5*Q(2*N3(I))
      C659V=C6*Q(2*N1(I))+C5*Q(2*N2(I))+C9*Q(2*N3(I))
      QXX1=Q(2*N1(I)-1)**2/HE1
      QXX2=Q(2*N2(I)-1)**2/HE2
      QXX3=Q(2*N3(I)-1)**2/HE3
      QYY1=Q(2*N1(I))**2/HE1
      QYY2=Q(2*N2(I))**2/HE2
      QYY3=Q(2*N3(I))**2/HE3
      QXY1=Q(2*N1(I)-1)*Q(2*N1(I))/HE1
      QXY2=Q(2*N2(I)-1)*Q(2*N2(I))/HE2
      QXY3=Q(2*N3(I)-1)*Q(2*N3(I))/HE3
      CONU=(A(2,I)*QXX1+A(5,I)*QXX2+A(8,1)*QXX3+
     &A(3,I)*QXY1+A(6,I)*QXY2+A(9,I)*QXY3)/3.0
      CONV=(A(2,I)*QXY1+A(5,I)*QXY2+A(8,1)*QXY3+
     &A(3,I)*QYY1+A(6,I)*QYY2+A(9,I)*QYY3)/3.0
      GACA=G*AVEG/(CHEZ(I)**2)/AVEGH
      FRU1=GACA*C746U
      FRV1=GACA*C746V
      FRU2=GACA*C485U
      FRV2=GACA*C485V
      FRU3=GACA*C659U
      FRV3=GACA*C659V
      UK1= (CONU+PREX1-F*C746V-CCX+FRU1)*AREA(I)
      UK2= (CONU+PREX2-F*C485V-CCX+FRU2)*AREA(I)
      UK3= (CONU+PREX3-F*C659V-CCX+FRU3)*AREA(I)
      VK1= (CONV+PREY1-F*C746V-CCX+FRU1)*AREA(I)
      VK2= (CONV+PREY2-F*C485V-CCX+FRU2)*AREA(I)
      VK3= (CONV+PREY3-F*C659V-CCX+FRU3)*AREA(I)
      II=N1(I)
      JJ=N2(I)
      KK=N3(I)
      R1(II*2-1)=R1(II*2-1)-UK1
      R1(JJ*2-1)=R1(JJ*2-1)-UK2
      R1(KK*2-1)=R1(KK*2-1)-UK3
      R1(II*2)=R1(II*2)-VK1
      R1(JJ*2)=R1(JJ*2)-VK2
42    R1(KK*2)=R1(KK*2)-VK3
C
      T=T+DT/2.0
      DO 50 NI=1,MLNO
      I=MINT(MLE(NI))
```

```
      NMB=MB(I)
      GO TO (49,50,49,52),NMB
52    R1(2*I-1)=0.0
      R1(2*I)=0.0
      GO TO 50
49    CALL ROTUV(R1(2*I-1),R1(2*I),ANG(NI))
      R1(2*I-1)=0.0
50    CONTINUE
      CALL SOLVE(B1,R1,UVP,NN1,NW1,NWN1)
      DO 53 NI=1,MLNO
      I=MINT(MLE(NI))
      NMB=MB(I)
      GO TO (54,53,54,53),NMB
54    CALL ROTUV(UVP(2*I-1)+DT*UVP(2*I),-ANG(NI))
53    CONTINUE
      DO 56 I=1,NN
      Q(2*I-1)=Q(2*I-1)+DT*UVP(2*I-1)
56    Q(2*I)=Q(2*I)+DT*UVP(2*I)
      DO 62 I=1,NN
      HE=H(I)+ETA(I)
      U(I)=Q(2*I-1)/HE
      V(I)=Q(2*I)/HE
62    R2(I)=0.0
      DO 64 I=1,NM
      EK=(A(2,1)*Q(2*(N1(I))-1)+A(5,1)*Q(2*(N2(I))-1)+
     &    A(8,1)*Q(2*(N3(I))-1)+A(3,1)*Q(2*(N1(I))-1)
     &    A(6,1)*Q(2*(N2(I)))+A(9,1)*Q(2*(N3(I))))/3.0*AREA(I)
      II=N1(I)
      JJ=N2(I)
      KK=N3(I)
      R2(II)=R2(II)-EK
      R2(JJ)=R2(JJ)-EK
64    R2(KK)=R2(KK)-EK
      T=T+DT/2.0
      CALL WHP(T,HP,WW,HA)
      DO 66 NI=1,NHNO
      I=MINT(MH(NI))
      EP(I)=HP
      R2(I)=EP(I)
66    CONTINUE
      CALL SOLVE(B2,R2,EP,NN,NW,NWN)
      DO 68 I=1,NN
68    ETA(I)=ETA(I)+DT*EP(I)
      KL=KL+1
```

```
      IF(T-TLIM) 25,25,70
70    STOP
      END
C
      SUBROUTINE WH(T,HH,WW,HA)
      HH=COS(2.0*3.141592*T/WW)*HA
      RETURN
      END
C
      SUBROUTINE WHP(T,HP,WW,HA)
      HP=-2.0*3.141592/WW*SIN(2.0*3.141592*(T/WW))*HA
      RETURN
      END
C
C..LU DECOMPOSITION
C
      SUBROUTINE MATRIX(A,N,NW,NWN)
      DIMENSION A(N,NWN)
      M=N-1
      DO 30 K=1,M
      I1=K+1
      NW1=NW+K-1
      IF(NW1.le.N) GO TO 20
      NW1=N
20    DO 30 I=I1,NW1
      NI=NW-1+I1
      Y=A(I,NI-1)/A(K,NW)
      A(I,NI-1)=Y
      NW11=NI+NW-2
45    DO 30 J=NI,NW11
      A(I,J)=A(I,J)-Y*A(K,J+I-K)
30    CONTINUE
      RETURN
      END
C
      SUBROUTINE SOLVE(A,B,X,N,NW,NWN)
      DIMENSION A(N,NWN),B(N),X(N)
      X(1)=B(1)
      K1=NW-1
      DO 60 K=2,N
      SUM=0.0
      NW2=NW-K+1
      IF(K.le.NW) GO TO 54
      NW2=1
```

```
54    DO 55 J=NW2,K1
55    SUM=SUM+A(K,J)*X(J-NW+K)
60    X(K)=B(K)-SUM
      X(N)=X(N)/A(N,NW)
      K=N
      NW4=NW+1
62    SUM=0.0
      K=K-1
      NW3=NW+N-K
      IF(NW3.LT.NWN) GO TO 64
      NW3=NWN
64    DO 65 J=NW4,NW3
65    SUM=SUM+A(K,J)*X(J-NW+K)
      X(K)=(X(K)-SUM)/A(K,NW)
      IF(K.EQ.1) GO TO 80
      GO TO 62
80    RETURN
      END
C
C..COORDINATE POSITION
C
      SUBROUTINE ROTB1(B1,ANGLE,NN1,NWN1,NWNI,LB1,LB2)
      DIMENSION B1(NN1,NWN1)
      NWM=NW-1
      IF(I.LE.NW) GO TO 20
      LB=LB1
9     DO 10 J=NW,LB
      II=I-J+NW-1
      CALL ROTSM(B1(2*II-1,2*J+2),B1(2*II-1,2*J+3),B1(2*II,2*J+1),
     &B1(2*II,2*J+2),ANGLE)
      NWJ=4*NW-2*J
      B1(2*I,NWJ-2)=B1(2*II-1,2*J+2)
      B1(2*I,NWJ-3)=B1(2*II-1,2*J+3)
      B1(2*I-1,NWJ-1)=B1(2*II,2*J+1)
      B1(2*I-1,NWJ-2)=B1(2*II,2*J+2)
10    CONTINUE
      GO TO 30
20    IF(I.EQ.1)GO TO 30
      LB=I+NW-2
      GO TO 9
30    IF(I.GT.LB2 GO TO 60
      LB=1
50    DO 70 J=LB,NWM
      II=I-J+NW
```

```
      CALL ROTSM(B1(2*II-1,2*J),B1(2*II-1,2*J+1),B1(2*II,2*J-1),
     &B1(2*II,2*J),ANGLE)
      NWJ=4*NW-2*J
      B1(2*I,NWJ)=B1(2*II-1,2*J)
      B1(2*I,NWJ-1)=B1(2*II-1,2*J)
      B1(2*I-1,NWJ+1)=B1(2*II-1,2*J-1)
      B1(2*I-1,NWJ)=B1(2*II,2*J)
70    CONTINUE
      GO TO 90
60    IF(I.EQ.NN1/2)GO TO 90
      LB=1+(I-LB2)
90    RETURN
      END
C
      SUBROUTINE ROTSM(SM1,SM2,SM3,SM4,ANGLE)
      SM1P=SM1*COS(ANGLE)+SM2*SIN(ANGLE)
      SM2=SM1*SIN(ANGLE)+SM2*COS(ANGLE)
      SM3P=SM3*COS(ANGLE)+SM4*SIN(ANGLE)
      SM4=SM3*SIN(ANGLE)+SM4*COS(ANGLE)
      SM1=SM1P
      SM3=SM3P
      RETURN
      END
C
      SUBROUTINE ROTUV(A,B,ANGLE)
      AP=A*COS(ANGLE)+B*SIN(ANGLE)
      B=A*SIN(ANGLE)+B*COS(ANGLE)
      A=AP
      RETURN
      END
C
```

APPENDIX B: Code for the TID_DAYS Tidal Forcing Model

```
c: Tidal Forcing Model TID_DAYS.FOR
c           Sep 23, 2004
c..only does 1 month at user selected interval TIMER
c..modified STORX and u2 arrays to 50000
c..outputs in feet NGVD
c.....6 minute
C  This program outputs the predicted tidal amplitudes at 1 hr
C  intervals for a 24 hr period beginning at local time 00:00 of
C  January of the year selected in the input file.  The input file
C  must contain the amplitude and phase of the local tidal constituents
C  (up to 37 constituents).
C  Uses Long's code for the prediction of tides using harmonic
C  equations from U.S. Dept of Commerse SP #98 1988
C  by Scott A. Jenkins & Joseph Wasyl
c
C*************************************************************
      character nameref*60,ifile*60
     LOGICAL          MKTABLE
     INTEGER      STARTDATE(3),  BEGIN_DAY(12),  END_DAY(12)
     INTEGER          MO(12)
     DIMENSION          A(37),       AMP(37),    PHASE(37)
     DIMENSION        SPD(37),       AMPA(37),    EPOCH(37)
     DIMENSION     STORX(50000)
     DIMENSION       YODE(37),       YVPU(37)
     DIMENSION       JDAYF(12),     JDAYL(12),    JWKDA(12)
C
C  Tidal constituant speeds in degrees per hour
C
c  Tidal constituents speed, amplitude, phase angle read from data
c  file tideconsts.dat (degrees/hr, feet, degrees)
c
c
     DATA       MO/  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12 /
C
     DATA BEGIN_DAY/  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1 /
C
     DATA   END_DAY/ 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 /
```

```
C
      COMMON /AC1/    SPD,     EPOCH,       AMPA
      COMMON /AC2/  STORX,       MO,   BEGIN_DAY,   END_DAY,
     &            NUMCON,   MKTABLE,        JP,      LPYR,
     &             TIMER,     NOHRS
C
C  PRELIMINARY CONSTANTS
C
      MKTABLE=.TRUE.                !MAKE A TABLE
      CON=2048./90.                 !UNITS/DEG, DISCRETE COS LOOP
      NUMCON=37                      !# OF TIDAL CONSTITUANTS
c* read from input file      TIMER=1.  !# OF PREDICTIONS/HOUR
      NUM_MONTHS=12                  !# OF MONTHS TO RUN
c
c
      open(25,file='tides1mo.inp',status='old')
c
      read(25,*)IYR
      read(25,*)IMO
      read(25,*)TIMER
      read(25,'(a)')nameref
      close(25)
c
       JP=IMO
c
        write(ifile,1000)nameref(1:LSTGDCHR(nameref))
c
1000    format(a)
c
c.....tidal constituents from file name in input file 'tide_1yr.inp'
c
      open(26,file=ifile,status='old')
c
      do 49 ic=1,numcon
      read(26,*)A(ic),AMP(ic),PHASE(ic)
49     continue
c
      read(26,*)c1
      close(26)
c
       M2=AMP(1)
c
C
C  COMPUTE INDEX OF THE WEEKDAY OF 1 JAN OF COMPUTATION YEAR
```

```
C  (1=SUNDAY, 2=MONDAY, ... , 7=SATURDAY)
C
     IDAY11=1+MOD((IYR-1+INT(FLOAT(IYR-1)/4.)),7)
C
C  CHECK FOR AND DEAL WITH LEAP YEAR
C
     LPYR=0
     NDAYS=365
     IF(MOD(IYR,4).EQ.0) THEN
       LPYR=1
       END_DAY(2)=29
       NDAYS=366
     END IF
C
C  SET STARTING DATE
C
     STARTDATE(1)=IYR              !YEAR
     STARTDATE(2)=1               !MONTH
     STARTDATE(3)=1               !DAY
C
C  SET EQUILIBRIUM ARGUMENTS (?)
C
     CALL EQU(NUMCON,STARTDATE,NDAYS,YODE,YVPU)
C
C  OUTPUT CONTENTS OF YODE AND YVPU (COMMENT OUT IF NOT NEEDED)
C
C    OPEN(11,FILE='EQUOUT.DAT',STATUS='UNKNOWN',FORM='FORMATTED')
C    WRITE(11,'(1X," YODE(J)",7X," YVPU(J)",/)')
C    DO 10 J=1,NUMCON
C      WRITE(11,'(1X,F8.3," ----- ",F8.3)') YODE(J),YVPU(J)
C  10 CONTINUE
C    CLOSE(11)
C
     WRITE(*,'(1X,/,1X,"Calculating tide predictions.",1X,/)')
C
C  CREATE OPERATING ARRAYS:  AMPA, EPOCH, SPD
C
     DO 20 J=1,NUMCON
       AMPA(J)=AMP(J)*YODE(J)
       TEMX=YVPU(J)-PHASE(J)
       IF(TEMX .LT. 0.) TEMX=TEMX+360.
       EPOCH(J)=TEMX*CON
       SPD(J)=A(J)*CON/TIMER
   20 CONTINUE
```

```
C
C  COMPUTE JULIAN START AND END DAYS AND WEEK DAY OF 1ST OF
C  EACH MONTH BASED ON END_DAY ARRAY AND IDAY11
C
     JDAYF(1)=1
     JDAYL(1)=END_DAY(1)
     JWKDA(1)=IDAY11
     DO 25 N=2,12
       JDAYF(N)=JDAYL(N-1)+1
       JDAYL(N)=JDAYL(N-1)+END_DAY(N)
       JWKDA(N)=1+MOD( (JDAYF(N)+IDAY11-2) ,7)
   25 CONTINUE
C
C  CALL ROUTINES TO DO TIDAL PREDICTION CALCULATIONS
C
C**********Only calculate month from input file**********
c.....      DO 30 JP=1,NUM_MONTHS
        CALL CTIDE
        CALL TIDEOUT(M2,c1,IYR,IMO,IDAY,JDAYF(JP),JDAYL(JP),JWKDA(JP))
c.....   30 CONTINUE
C
     WRITE(*,'(1X,/,1X,"Tide calculations complete.")')
C
     END
C
C
C
C
     SUBROUTINE CTIDE
C
C  COMPUTES  TIMER  PREDICTIONS PER HOUR OF THE TIDES AND
C  STORES THE RESULT IN ARRAY STORX.
C  NUMCON =  MAX NUMBER OF TIDAL CONSTITUENTS
C  MKTABLE = LOGICAL FLAG;  WHEN .TRUE. IT MAKES A TABLE
C          OF 8193 COSINES (SAVED IN ARRAY XCOS) THAT
C          REPRESENT 360 DEGREES FOR A TABLE LOOK-UP OF
C          THE TIDAL COSINE FUNCTION
C  TABHR =   HOURS TO THE BEGINNING OF EACH MONTH, OFFSET
C          BY 24.  FIRST 12 ELEMENTS FOR A NORMAL YEAR;
C          SECOND 12 FOR LEAP YEAR.
C
     LOGICAL          MKTABLE
     INTEGER     BEGIN_DAY(12),  END_DAY(12),     MO(12)
     DIMENSION       XCOS(8193),     ARG(37)
```

```
      DIMENSION         SPD(37),    EPOCH(37),    AMPA(37)
      DIMENSION       TABHR(24),  STORX(50000)
      DOUBLE PRECISION        H
C
      COMMON /AC1/          SPD,       EPOCH,       AMPA
      COMMON /AC2/        STORX,          MO,   BEGIN_DAY,
     &               END_DAY,      NUMCON,     MKTABLE,
     &                  JP,        LPYR,       TIMER,
     &                NOHRS
C
      DATA TABHR/  -24.,  720., 1392., 2136., 2856., 3600.,
     &          4320., 5064., 5808., 6528., 7272., 7992.,
     &           -24.,  720., 1416., 2160., 2880., 3624.,
     &          4344., 5088., 5832., 6552., 7296., 8016./
C
      IF(MKTABLE) THEN
        H=8.D0*DATAN(1.D0)/8192.D0
        DO 10 I=1,8193
          XCOS(I)=SNGL(DCOS(DFLOAT(I-1)*H))
10      CONTINUE
        MKTABLE=.FALSE.
      END IF
C
C  SET DATES AND TIMES
C
      NOD=END_DAY(JP)-BEGIN_DAY(JP)+1       !# OF DAYS
      NOHRS=(NOD*24)*NINT(TIMER)+1          !# OF SAMPLES
      NOHRS=NOHRS+24*NINT(TIMER)            !ADD 12 HRS AT ENDS
c.......NOHRS is the total number of tidal realizations
C
C  FIRST = # OF ESTIMATION POINTS (HOURS*TIMER), COUNTING
C  FROM 0000 1 JAN OF PREDICTION YEAR, OF FIRST PREDICTION
C
      FIRST=(TABHR(MO(JP)+12*LPYR)+24.*BEGIN_DAY(JP))*TIMER
      FIRST=FIRST-12.*TIMER                 !START @ 1200, DAY 0
C
C*************************************************************
C  START MAIN COMPUTATION LOOP                              *
C*************************************************************
C
      DO 30 K=1,NOHRS
C
C  SET NUMCON VALUES OF ARG(J)
C
```

```
      IF(K.EQ.1) THEN
        DO 40 J=1,NUMCON
          ARGU=SPD(J)*FIRST+EPOCH(J)
          ARG(J)=AMOD(ARGU,8192.)
          IF(ARG(J).LT.0.) ARG(J)=ARG(J)+8192.
 40       CONTINUE
      ELSE
        DO 50 J=1,NUMCON
          ARG(J)=ARG(J)+SPD(J)
          IF(ARG(J).GE.8192.) ARG(J)=ARG(J)-8192.
 50       CONTINUE
      END IF
C
C  SUM NUMCON CONSTITUENT CONTRIBUTIONS FOR ONE TIDAL ELEVATION
C
      TIDE=0.
      DO 60 J=1,NUMCON
        NP=INT(ARG(J)+1.5)
        TIDE=TIDE+AMPA(J)*XCOS(NP)
 60    CONTINUE
C
C  SET FINAL OUTPUT
C
      STORX(K)=(TIDE+0.26)c..convert from feet MSL to feet NGVD C
 30 CONTINUE
C
C*************************************************************
C  END OF MAIN COMPUTATION LOOP                    *
C*************************************************************
C
    RETURN
    END
C
C
C
C
    SUBROUTINE TIDEOUT(M2,c1,IYR,IMO,IDAY,JDAYB,JDAYE,JDAYW)
C
C  WRITES TIDAL PREDICTION ARRAY AND COMPUTED TIME TO AN
C  OUTPUT FILE.  JDAYB AND JDAYE ARE BEGINNING AND ENDING
C  JULIAN DAYS OF THE JP'TH MONTH.  JDAYW IS THE WEEKDAY OF
C  THE 1ST OF THE MONTH (1 = SUNDAY, 2 = MONDAY, ... ,
C  7 = SATURDAY)
C
```

```
      LOGICAL           MKTABLE
      CHARACTER*2           CYR
      CHARACTER*3     MONAME(12)
      CHARACTER*10         FNAME
      INTEGER      BEGIN_DAY(12),   END_DAY(12),     MO(12)
      DIMENSION       STORX(50000),  u0(50000)
C
      COMMON /AC2/         STORX,          MO,  BEGIN_DAY,
     &                 END_DAY,       NUMCON,    MKTABLE,
     &                    JP,         LPYR,      TIMER,
     &                  NOHRS
C
      DATA MONAME/ 'Jan','Feb','Mar','Apr','May','Jun',
     &           'Jul','Aug','Sep','Oct','Nov','Dec'/
C
C  CORRECTION MINUTES, HOURS AND DAYS FOR OFFSET START TIME
C
      IMNOFF=0
      IHROFF=0
      IDAOFF=0
C
C  NAME OUTPUT FILE
C
      WRITE(CYR,'(I2)') MOD(IYR,100)
      FNAME=MONAME(JP)//CYR//'.DAT'
      WRITE(*,*) ' Writing to ', FNAME
C
      OPEN(10,FILE=FNAME,STATUS='UNKNOWN',FORM='FORMATTED')
C
c********comment out the bullshit headers*******
c      WRITE(10,'(2X,"Tides for ",A3,", ",I4)') MONAME(JP), IYR
c      WRITE(10,'(2X,"Julian days ",I3," to ",I3)') JDAYB, JDAYE
c      WRITE(10,'(2X,I1," = weekday of ",A3," 1st",/)') JDAYW,
c     &   MONAME(JP)
c      WRITE(10,'(2X," date/time",3X,"m (NGVD)",/)')
C
      PLUSTIME=60./TIMER
      IMN=-PLUSTIME + IMNOFF             !START @ 0 MIN + FIX
      IHR=12 + IHROFF                  !START @ NOON + FIX
      IDA=BEGIN_DAY(JP) - 1 + IDAOFF      !START @ DAY 0 + FIX
C
c**********only write out 00:00 day1 - 23:00 day 30,31,28,29)*******
      TIMER12=TIMER*12
      NOHRS12T=NOHRS-12*NINT(TIMER)-1
```

```
c
      DO 10 I=1,NOHRS
        IMN=IMN+PLUSTIME
        IF(IMN.GE.60) THEN
          IHR=IHR+1
          IMN=IMN-60
        END IF
        IF(IHR.GE.24) THEN
          IDA=IDA+1
          IHR=IHR-24
        END IF
        ITIME=100*IHR+IMN
        if(I.LE.TIMER12)go to 1111
        if(I.GT.NOHRS12T)go to 1111
c
        Im1=I-1
c*****************************tide current module*****************************
       eldif=(STORX(I)-STORX(Im1))
       u0(I)=(2.04*9.8*ABS(eldif)*M2/c1)**0.5
       if(eldif.LT.0)dir=0
       if(eldif.GE.0)dir=180
c*************************************************************************
c
        chrs=1.0*(I-TIMER12-1)/TIMER        WRITE(10,'(F10.2,F10.4)')
     &      chrs,STORX(I)
1111     continue
   10 CONTINUE
C
      CLOSE(10)
C
      RETURN
      END
C
C
C
C
      SUBROUTINE EQU(NSPED,IDT,LENGTH,FFF,VAU)
C
C  CALCULATE TIDAL EQUILIBRIUM ARGUMENTS (VAU) AND NODE
C  FACTORS (FFF).  DEVELOPERS:  E.E. LONG, B.B. PARKER,
C  L. HICKMAN AND G. FRENCH.  NOTES:  VAU IS CALCULATED
C  FOR THE BEGINNING OF THE SERIES;  FFF IS ADJUSTED TO
C  THE MIDPOINT OF THE YEAR BEING CALCULATED
C
```

```
      CHARACTER*10       LNAME,  LABEL(37)
      DIMENSION     NODAYS(12),    FFF(37), VAU(37),  IDT(3)
      DIMENSION        CXX(30),     OEX(5)
      DOUBLE PRECISION    SPEED,    SPD(37)
C
      COMMON /LOCAT/    TM,  GONL
      COMMON /COSTX/   CXX,   OEX
      COMMON   /FAD/ IPICK
      COMMON   /VEE/   TML,   CON,    U,    Q,   UI
      COMMON  /BOXA/    S,    XL,   PM,   PL,   SL,   PS,
     &              PLM,  SKYN,   VI,    V,   XI,  VPP
      COMMON  /BOXB/    VP,     P,  AUL,  AUM,  CRA,  CQA
      COMMON  /BOXS/    AW,    AI,   AE,  AE1,  ASP
C
      DATA NODAYS/ 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 /
C
      DATA  LABEL/
     &   'M(2)      ' , 'S(2)      ' , 'N(2)      ' , 'K(1)      ' ,
     &   'M(4)      ' , 'O(1)      ' , 'M(6)      ' , 'MK(3)     ' ,
     &   'S(4)      ' , 'MN(4)     ' , 'Nu(2)     ' , 'S(6)      ' ,
     &   'Mu(2)     ' , '2N(2)     ' , 'OO(1)     ' , 'Lambda(2) ' ,
     &   'S(1)      ' , 'M(1)      ' , 'J(1)      ' , 'Mm        ' ,
     &   'Ssa       ' , 'Sa        ' , 'Msf       ' , 'Mf        ' ,
     &   'Rho(1)    ' , 'Q(1)      ' , 'T(2)      ' , 'R(2)      ' ,
     &   '2Q(1)     ' , 'P(1)      ' , '2SM(2)    ' , 'M(3)      ' ,
     &   'L(2)      ' , '2MK(3)    ' , 'K(2)      ' , 'M(8)      ' ,
     &   'MS(4)     ' /
C
C  SET SOME VARIABLES:
C    NSPED = NUMBER OF CONSTITUENTS TO BE CALCULATED
C    MONTH = MONTH OF FIRST DATA POINT
C     IDAY = DAY OF FIRST DATA POINT
C     IYER = YEAR OF FIRST DATA POINT
C   LENGTH = LENGTH (IN DAYS) OF SERIES TO BE GENERATED
C
      IYER=IDT(1)
      DAYB=0.0
      GRBS=0.0
C
C  DEAL WITH LEAP YEAR FEBRUARY, DAYS/YEAR AND MIDDLE DAY/TIME
C
      IF(MOD(IYER,4) .EQ. 0) THEN
        NODAYS(2)=29
        NDAY=366
```

```
      DAYM=184.0
      GRMS=0.0
    ELSE
      NODAYS(2)=28
      NDAY=365
      DAYM=183.0
      GRMS=12.0
    END IF
C
    XYER=FLOAT(IYER)
C
C  CALL ROUTINE TO COMPUTE BASIC ASTRONOMICAL CONSTANTS
C
    CALL ASTRO(XYER,DAYB,DAYM,GRBS,GRMS)
C
C  MORE CONSTANTS FOR COMMON BLOCKS
C
    TM=0.0
    GONL=0.0
    TML=0.0
    JUDAY=IDT(3)
C
C  LOOK UP CONSTITUENT PARAMETERS BY NAME MATCHING
C
    DO 10 J=1,NSPED
      LNAME=LABEL(J)
      SPEED=0.D0
      CALL NAME(SPEED,LNAME,ISUB,INUM,2)
      SPD(J)=SPEED
      CALL VANDUF(SPEED,E,F,1)
      FFF(J)=F
      VAU(J)=E
  10 CONTINUE
C
C  ROUND NODE TO 3 DECIMAL PLACES, VO+U TO 1 DECIMAL PLACE
C
    DO 30 J=1,NSPED
      FFF(J)=ANINT(FFF(J)*1000.)*0.001
      VAU(J)=ANINT(VAU(J)*10.)*0.1
  30 CONTINUE
C
    RETURN
    END
C
```

```
C
C
C
      SUBROUTINE ASTRO(XYER,DAYB,DAYM,GRBS,GRMS)
C
C  COMPUTES ASTRONOMICAL CONSTANTS FOR THE YEAR BEGINNING
C  DAY (DAYB) AND HOUR (GRBS) AND FOR THE YEAR MIDDLE DAY
C  (DAYM) AND HOUR (GRMS)
C
      DIMENSION  CXX(30), OEX(5)
C
      COMMON /LOCAT/   TM,  GONL
      COMMON /COSTX/  CXX,   OEX
      COMMON   /VEE/ TML,   CON,    U,    Q,    UI
      COMMON  /BOXA/   S,    XL,   PM,   PL,    SL,    PS,   PLM,
     &             SKYN,    VI,    V,   XI,   VPP
      COMMON  /BOXB/   VP,     P,  AUL,  AUM,   CRA,   CQA
      COMMON  /BOXS/   AW,    AI,   AE,  AE1,   ASP
      COMMON /BOXXS/  VIB,    VB,  XIB,  VPB,  VPPB,  CXSB,  CXPB,
     &             CXHB, CXP1B
C
      PINV  = 57.29578               !degrees/radian
C
C  ORBIT SETS LUNAR AND SOLAR MEAN LATITUDES FOR THE BEGINNING OF
C  THE CENTURY CONTAINING THE TIDE YEAR XYER (FROM TABLE 1 IN
C  S.P. 98)
C
      CALL ORBIT(XCEN,XSX,XPX,XHX,XP1X,XNX,OEX,T,XYER,5)
C
C  FROM TABLE 1 IN S.P. 98:
C
C   XW = OBLIQUITY OF THE ECLIPTIC = MAX DECLINATION OF THE SUN
C        (w) (DEGREES)
C   XI = INCLINATION OF THE MOON'S ORBIT TO PLANE OF THE ECLIPTIC
C        (i) (DEGREES)
C   AW = XW IN RADIANS
C   AI = XI IN RADIANS
C   AE = ECCENTRICITY OF MOON'S ORBIT (e)
C  AE1 = ECCENTRICITY OF EARTH'S ORBIT (e1)
C  ASP = SOLAR FACTOR (S')
C
      XW=23.4522944+T*(-0.0130125+T*(-0.00000164+T*(0.000000503)))
      XI  =  5.14537628
      AW  =  0.0174533*XW                        !w
```

```
      AI  =  0.0174533*XI                        !I
      AE  =  0.0548997                          !e
      AE1 =  0.01675104+T*(-0.0000418+T*(-0.000000126))  !e1
      ASP =  0.46022931                         !S'
C
      DO 30 NOE=1,30
        CXX(NOE) = 0.0
   30 CONTINUE
C
C  This next section must have something to do with the 1/4 day per
C  year difference between the Common Year and the Julian Year
C
      IF(DAYB.GT.0.0) DAYB = DAYB-1.       !reduce beginning day by 1
      IF(DAYM.GT.0.0) DAYM = DAYM-1.       !reduce middle day by 1
      AMIT  = 0.0                    !initialize correction
      AMI   = XYER-XCEN                 !years into current century
      CPLEX = XCEN/400.+0.0001           !century/400 + epsilon
      DICF  = CPLEX-AINT(CPLEX)          !remainder after century/400
      IF(AMI .EQ. 0.) GO TO 40           !skip if exact century year
      XCET  = XCEN+1.                  !century year + 1
      CDIF  = XYER-XCET                 !years into century - 1
      DOBY  = CDIF/4.+0.0001             !(yrs in cent - 1)/4 + eps
      AMIT  = AINT(DOBY)                 !truncate (yrs in cent -1)/4
      IF(DICF .LT. 0.001) AMIT = AMIT+1.0  !add 1 if 1600's or 2000's
   40 CONTINUE
C
      DBMT  = DAYB+AMIT                 !fix for 1/4 day/(year in cent)
      DMMT  = DAYM+AMIT                  !         ditto
C
C  FROM TABLE 1, S.P. 98, BOX 4, CXX(1-8) ARE RATES OF CHANGE OF
C  MEAN LATITUDE OF:
C
C    CXX(1) = MOON TO BEGINNING DAY AND BEGINNING HOUR
C    CXX(2) = LUNAR PERIGEE TO BEGINNING DAY AND HOUR
C    CXX(3) = SUN TO BEGINNING DAY AND HOUR
C    CXX(4) = SOLAR PERIGEE TO BEGINNING DAY AND HOUR
C    CXX(5) = LUNAR PERIGEE TO MIDDLE DAY AND HOUR
C    CXX(6) = MOON'S NODE TO MIDDLE DAY AND HOUR
C    CXX(7) = LUNAR PERIGEE TO MIDDLE DAY AND BEGINNING HOUR
C    CXX(8) = MOON'S NODE TO BEGINNING DAY AND HOUR
C
      CXX(1)=XSX+  129.384820*AMI+  13.1763968*DBMT+0.549016532*GRBS
      CXX(2)=XPX+  40.6624658*AMI+ 0.111404016*DBMT+0.004641834*GRBS
      CXX(3)=XHX- 0.238724988*AMI+ 0.985647329*DBMT+0.041068639*GRBS
```

```
      CXX(4)=XP1X+ 0.01717836*AMI+ 0.000047064*DBMT+0.000001961*GRBS
      CXX(5)=XPX+  40.6624658*AMI+ 0.111404016*DMMT+0.004641834*GRMS
      CXX(6)=XNX-  19.3281858*AMI- 0.052953934*DMMT-0.002206414*GRMS
      CXX(7)=XPX+  40.6624658*AMI+ 0.111404016*DMMT+0.004641834*GRBS
      CXX(8)=XNX-19.328185764*AMI-0.0529539336*DBMT-0.002206414*GRBS
C
C  Round CXX(1-8) to nearest 0.01 deg and, if negative, increment
C  by 360 deg (essentially modulo 360 arithmetic)
C
      DO 50 J=1,8
        ZAT = CXX(J)/360.                    !# of loops + fraction
        IF(ZAT .LT. 0.) THEN                  !if negative angle
          CXX(J) = ((ZAT-AINT(ZAT))+1.)*360.      !360 + fraction*360
        ELSE                                 !if positive angle
          CXX(J) = (ZAT-AINT(ZAT))*360.          !fraction*360
        END IF
        CXX(J) = FLOAT(IFIX(CXX(J)*100.+0.5))*0.01  !nearest 0.01 deg
   50 CONTINUE
C
C  Use latitude of moon's node (N) at beginning day and hour
C
      ANG = CXX(8)
C
C  Set astronomical constants at beginning day and hour
C
      CALL TABLE6(VIB,VB,XIB,VPB,VPPB,XX,XX,XX,XX,XX,ANG,ANB,ATB)
C
      CXX(26) = VIB       !I at beginning day and hour
      CXX(27) = VB        !nu at          "
      CXX(28) = XIB       !zi at          "
      CXX(29) = VPB       !nu' at         "
      CXX(30) = VPPB      !2*nu" at       "
C
      CXSB  = CXX(1)      !s at beginning day and hour
      CXPB  = CXX(2)      !p            "
      CXHB  = CXX(3)      !h            "
      CXP1B = CXX(4)      !p1           "
C
C  Use latitude of moon's node (N) at middle day and hour
C
      ANG   = CXX(6)
C
C  Set astronomical constants at middle day and hour
C
```

```
      CALL TABLE6(VI,V,XI,VP,VPP,CIG,CVX,CEX,PVC,PVCP,ANG,AN,AT)
C
      CXX(9)  = VI        !I at middle day and hour
      CXX(10) = V         !nu at        "
      CXX(11) = XI        !zi at        "
      CXX(12) = VP        !nu' at       "
      CXX(13) = VPP       !2*nu" at     "
C
C  Round CXX(9-13) to nearest 0.01 deg
C
      DO 60 J=9,13
        CXX(J) = FLOAT(IFIX(CXX(J)*100.+0.5))*0.01
   60 CONTINUE
C
C  Define P = p - zi following Eq. 191, para. 122.
C
      PGX = FLOAT(IFIX((CXX(5)-CXX(11))*100.+0.5))*0.01  !define P to 0.01 deg
      ZAT = PGX/360.                          !modulo 360 math
      IF(ZAT .LT. 0.) THEN
        PGX = ((ZAT-AINT(ZAT))+1.)*360.             !360+fraction*360
      ELSE
        PGX = (ZAT-AINT(ZAT))*360.                  !fraction*360
      END IF
      XPG = PGX*0.0174533                         !P in radians
      CXX(14) = PGX
C
C  For argument of constituent L2, compute R of Eq. 214, para. 129 (which
C  info. is also tabulated in Table 8 of S.P. 98):
C
C               RAXE = sin(2P)
C               RAXN = -cos(2P) + 1/6 [cot(I/2)]**2
C                 R = arctan(RAXE/RAXN)
C
      RAXE    = SIN(2.*XPG)
      RAXN    = -COS(2.*XPG)+1./(6.*(TAN(0.5*AT)**2))
      RXX     = 0.
      IF(RAXE .EQ. 0. .OR. RAXN .EQ. 0.) GO TO 70
      RAX     = RAXE/RAXN                         !tan(R)
      IF(RAX .GT. 3450.) GO TO 70
      RXX     = ATAN(RAX)*PINV                    !R in degrees
      CXX(22) = RXX
   70 CONTINUE
C
C  For amplitude of constituent L2, compute 1/Ra with Eq. 213 of
```

```
C  para. 129 [for which Table 7 lists log(Ra) ]:
C
C   1/Ra = Sqrt[ 1 - 12 tan^2(I/2) cos(2P) + 36 tan^4(I/2) ]
C
     CRA = SQRT(    1.
    &           -12. * (  TAN(0.5*AT)**2  ) * COS(2.*XPG)
    &           +36. * (  TAN(0.5*AT)**4  )    )
C
C  Find constant terms in cosine argument of Eq. 212, para. 129.
C
     UM2     = 2.*(CXX(11)-CXX(10))         !2(zi-nu)
     CXX(21) = UM2                          !2(zi-nu)
     CXX(24) = CRA                          !1/Ra
     U12     = UM2-RXX                      !2(zi-nu)-R
     U12     = U12+180.                     !2(zi-nu)-R+180
     CXX(15) = U12
C
C  Compute Q of Eq. 202, para. 123:
C
C              Q = arctan[(5 cos I - 1)*tan P / (7 cos I + 1)]
C
     ZES     = (5.*COS(AW)-1.) * SIN(XPG)
     ZEC     = (7.*COS(AW)+1.) * COS(XPG)
     CALL FITAN(ZES,ZEC,QXX,SPXX,2)
     CXX(23) = QXX                          !Q in proper quadrant
C
C  For constant terms in cosine argument of Eq. 201, para. 123.
C  Note:  sign on 90 is opposite to that given in S.P. 98
C
     CRAV    = 0.5*UM2+QXX+90.              !zi-nu+Q+90
     CXX(16) = CRAV
C
C  For 1/Qa of Eq. 195, para. 122 for M1 tide:
C  Note:  changed AW to AT to be consistent with S.P. 98!!!
C
C  -> OLD TERM:    CQA = SQRT(   0.25
C    &           +1.50 * COS(2.*XPG) * COS(AW) / (COS(0.5*AW)**2)
C    &           +2.25 * (COS(AW)**2) / (COS(0.5*AW)**4)    )
C
     CQA = SQRT(   0.25
    &           +1.50 * COS(2.*XPG) * COS(AT) / (COS(0.5*AT)**2)
    &           +2.25 * (COS(AT)**2) / (COS(0.5*AT)**4)    )
C
     CXX(25) = CQA
```

```
C
C  Round CXX(14-23) to nearest 0.01 deg
C
      DO 80 J=14,23
        CXX(J) = FLOAT(  IFIX( CXX(J)*100.+0.5 )  )*0.01
   80 CONTINUE
C
C  Give names to some of the array elements
C
      PM   = CXX(1)         !s (beginning day)
      PL   = CXX(2)         !p       "
      SL   = CXX(3)         !h       "
      PS   = CXX(4)         !p1      "
      PLM  = CXX(5)          !p (middle day)
      SKYN = CXX(6)          !N       "
      VI   = CXX(9)         !I       "
      V    = CXX(10)        !nu      "
      XI   = CXX(11)        !zi      "
      VP   = CXX(12)        !nu'     "
      VPP  = CXX(13)         !2*nu"  "
      P    = CXX(14)        !P       "
      AUL  = CXX(15)         !2zi-2nu-R+180  (middle)
      AUM  = CXX(16)         !zi-nu+Q+90        "
      CRA  = CXX(24)        !1/Ra
      CQA  = CXX(25)        !1/Qa
C
      U    =  V*0.0174533    !nu in radians
      Q    =  P*0.0174533    !P  in radians
      UI   = VI*0.0174533    !I  in radians
C
      RETURN
      END
C
C
C
C
      SUBROUTINE FITAN(AUS,AUC,RTA,SPDX,JMAP)
C*********************************************************
C  THIS APPEARS TO BE A FORM OF THE FUNCTION ATAN2, BUT   *
C  WITH SOME ADDITIONAL STUFF.                            *
C*********************************************************
      IF(AUC .EQ. 0.) THEN
        IF(AUS .LT. 0.) THEN
          RTA = 270.
```

```
      ELSE IF(AUS .EQ. 0.) THEN
        RTA = 0.
      ELSE
        RTA = 90.
      END IF
    ELSE
      RTA = 57.2957795*ATAN(AUS/AUC)
      IF(JMAP .EQ. 2) THEN
        IF(AUS .LE. 0.) THEN
          IF(AUC .LT. 0.) THEN
            RTA = RTA+180.
          ELSE IF(AUC .EQ. 0.) THEN
            RTA = 0.
          ELSE
            RTA = RTA+360.
          END IF
        ELSE
          IF(AUC .LT. 0.) THEN
            RTA = RTA+180.
          ELSE IF(AUC .EQ. 0.) THEN
            RTA = 90.
          END IF
        END IF
      END IF
    END IF
C
    SPDX = 0.
C
    RETURN
    END
C
C
C
C
    SUBROUTINE ORBIT(XCEN,XSX,XPX,XHX,XP1X,XNX,OEX,T,
   &   XYER,NNN)
C
C  Computes fundamental astronomical variables from Table 1 in
C  S.P. 98 (1988 ed.)
C
C    S = rate of change of mean longitude of the moon per solar day
C    P = rate of change of mean longitude of lunar perigee/solar day
C   XH = rate of change of mean longitude of the sun per solar day
C   P1 = rate of change of mean longitude of solar perigee/solar day
```

```
C   XN = rate of change of mean longitude of moon's node/solar day
C    T = number of Julian centuries (36525 days) reckoned from
C        Greenwich mean noon, 31 December 1899
C   YR = number of days and half days to correct astronomical
C        constants to 0000 hrs, 1 January of proper century, starting
C        with the year 1600 (correction is 0.5 days for 20th century,
C        i.e., noon on 31 December 1899 to 0000 hrs, 1 January 1900)
C  GAT = the century (XCEN) in which the year XYER resides
C  OEX = array of (NNN =) 5 elements, redundantly returned with the
C        mean latitudes listed below as of 0000 hrs, 1 January of
C        the proper century:
C
C         XSX = OEX(1) = mean longitude of moon (s)
C         XPX = OEX(2) = mean longitude of lunar perigee (p)
C         XHX = OEX(3) = mean longitude of sun (h)
C        XP1X = OEX(4) = mean longitude of solar perigee (p1)
C         XNX = OEX(5) = mean longitude of moon's node (N)
C
      DIMENSION OEX(NNN)
C
      S    = 13.1763968
      P    = 0.1114040
      XH   = 0.9856473
      P1   = 0.0000471
      XN   = -0.0529539
      XCAN = XYER*0.01+0.001
      XCEN = AINT(XCAN)*100.
      T    = -3.0
      YR   = 2.5
      GAT  = 1600.
C
      DO 10 JK=1,30
        GP  = GAT/400.+0.00001
        COL = GP-AINT(GP)
        IF(COL .LT. 0.01) THEN
          IF(GAT .EQ. XCEN) GO TO 12
        ELSE
          IF(GAT .EQ. XCEN) GO TO 12
          YR = YR-1.
        END IF
        GAT = GAT+100.
   10 CONTINUE
   12 CONTINUE
C
```

```
      T     = (GAT-1900.)*0.01
C
      OEX(1) = 270.437422 + T*( 307.892    + T*( 0.002525
     &                       + T*( 0.00000189))) + YR*S
      OEX(2) = 334.328019 + T*( 109.032206 + T*(-0.01034444
     &                       + T*(-0.0000125)))  + YR*P
      OEX(3) = 279.696678 + T*(   0.768925 + T*( 0.0003205))
     &                                  + YR*XH
      OEX(4) = 281.220833 + T*(   1.719175 + T*( 0.0004528
     &                       + T*( 0.00000333))) + YR*P1
      OEX(5) = 259.182533 + T*(-134.142397 + T*( 0.00210556
     &                       + T*( 0.00000222))) + YR*XN
C
      DO 100 I=1,5
      ZAT = OEX(I)/360.
      IF(ZAT .LT. 0.) THEN
        OEX(I) = ((ZAT-AINT(ZAT))+1.)*360.
      ELSE
        OEX(I) = (ZAT-AINT(ZAT))*360.
      END IF
      OEX(I) = FLOAT(IFIX(OEX(I)*100.+0.5))*0.01
  100 CONTINUE
C
      XSX  = OEX(1)
      XPX  = OEX(2)
      XHX  = OEX(3)
      XP1X = OEX(4)
      XNX  = OEX(5)
C
      RETURN
      END
C
C
C
C
      SUBROUTINE VANDUF(SPEED,E,F,ITYPE)
C
C  Computes phases and node factors for tidal constituents.
C
C  References:
C
C  S.P. 98 = US Dept of Commerce, Coast and Geodetic Survey,
C            "Manual of Harmonic Analysis and Prediction
C            of Tides," 1988 Ed.
```

```
C  A.M.    = British Admiralty, "Admiralty Manual of Tides,"
C           1941 Ed.
C
C  Common block variables have the following meanings (as
C  best I can tell):
C
C  /LOCAT/ TM and GONL are 0.0 in main program, not defined,
C         but may be related to meridian differences of
C         local time and Greenwich time per Eq. 318, para.
C         223 in S.P. 98
C
C  /FAD/   IPICK is defined in this routine as constituent
C         index based on matching SPEED with array of SPD
C         in NAMES common block
C
C  /VEE/   TML = not defined (may relate to TM in /LOCAT/)
C          CON = defined in this routine
C            U = nu for middle day in radians
C            Q = P          "
C           UI = I          "
C
C  /BOXA/    S = not defined
C           XL = not defined
C           PM = s for beginning day in degrees
C           PL = p           "
C           SL = h           "
C           PS = p1          "
C          PLM = p for middle day in degrees
C         SKYN = N           "
C           VI = I           "
C            V = nu          "
C           XI = zi          "
C          VPP = nu"         "
C
C  /BOXB/   VP = nu' for middle day in degrees
C            P = P          "
C          AUL = 2*zi - 2*nu - R + 180 , middle day, deg
C          AUM = zi - nu + Q + 90 , middle day, deg
C          CRA = 1/Ra  for L(2) constituent
C          CQA = 1/Qa  for M(1) constituent
C
C  /BOXS/   AW = w   obliquity of ecliptic (max. declination of Sun)
C           AI = i   inclination of Moon's orbit to ecliptic plane
C           AE = e   eccentricity of Moon's orbit
```

```
C         AE1 = e1  eccentricity of Earth's orbit
C         ASP = S'  Solar factor
C
C  Order of constituents is same as in  NAMES  common.
C
C  NOTE:  Constituents marked with * have phases shifted
C  by 180 deg from what is given in S.P. 98.  These are coded
C  with the option of adding 180 deg by setting ISHIFT = 1.
C  Original code is retained by setting ISHIFT = 0.
C
      DOUBLE PRECISION     SPEED,  SPD(37)
      DIMENSION           MS(37)
C
      COMMON  /LOCAT/    TM, GONL
      COMMON    /FAD/ IPICK
      COMMON    /VEE/   TML, CON,   U,   Q,  UI
      COMMON   /BOXA/     S,  XL,  PM,  PL,  SL,  PS,  PLM,
     &               SKYN,  VI,   V,  XI, VPP
      COMMON   /BOXB/    VP,   P, AUL, AUM, CRA, CQA
      COMMON   /BOXS/    AW,  AI,  AE, AE1, ASP
      COMMON /SPEEDS/   SPD
      COMMON   /MMSS/    MS
C
      ISHIFT=0             ! if 1, flips *'d constituents by 180 deg
C
      CON  = SL+TML         ! h, beginning day + TML
      C5AW = COS(0.5*AW)    ! cos(w/2)
      C5AI = COS(0.5*AI)    ! cos(i/2)
      C5UI = COS(0.5*UI)    ! cos(I/2)
      SAW  = SIN(    AW)    ! sin w
      SAI  = SIN(    AI)    ! sin i
      SUI  = SIN(    UI)    ! sin I
C
      DO 600 J=1,37
        IPICK = J
        IF(SPEED .EQ. SPD(J)) GO TO 610
  600 CONTINUE
      WRITE(*,'(2X,"SPEED MATCH NOT FOUND IN VANDUF -> QUIT")')
      WRITE(*,'(2X,"SPEED = ",F12.7)') SPEED
      STOP
  610 CONTINUE
C
      GO TO (  1,  2,  3,  4,  5,  6,  7,  8,  9, 10,
     &        11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
```

```
     &       21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
     &       31, 32, 33, 34, 35, 36, 37), IPICK
C*****************************************************************
C  CONSTITUENT CALCULATION CODES
C*****************************************************************
C
C  M(2): term A39, p. 22 and Eq. 70, 78, S.P. 98
C
    1 E = 2.*(CON-PM+XI-V)
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  N(2): term A40, p. 22 and Eq. 70, 78, S.P. 98
C
    2 E = 2.*(CON+XI-V)-3.*PM+PL
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  S(2): p. 39, S.P. 98
C
    3 E = 2.*TML
      F = 1.
      GO TO 800
C
C  *O(1): term A14, p. 21 and Eq. 67, 75, S.P. 98
C
    4 E = CON-V-2.*(PM-XI)-90.+ISHIFT*180.
      F = SAW*(C5AW**2)*(C5AI**4)/(SUI*(C5UI**2))
      GO TO 800
C
C  *K(1): Eq. 222 and 227, p. 45, S.P. 98
C
    5 E = CON-VP+90.+ISHIFT*180.
      F = SQRT(0.8965*(SIN(2.*UI)**2)+0.6001*SIN(2.*UI)*COS(U)
     &                               +0.1006)
      F = 1./F
      GO TO 800
C
C  K(2): Eq. 230 and 235, p. 46, S.P. 98
C
    6 E = 2.*CON-VPP
      F = SQRT(19.0444*(SUI**4)+2.7702*(SUI**2)*COS(2.*U)+0.0981)
      F = 1./F
      GO TO 800
```

```
C
C  L(2): Term A41, p. 22, Eq. 212, p. 44, and Eq. 70, 78, and 215,
C        S.P. 98
C
    7 E = 2.*CON-PM-PL+AUL
      F = (C5AW**4)*(C5AI**4)/(CRA*(C5UI**4))
      GO TO 800
C
C  2N(2): Term A42, p. 22, and Eq. 70, 78, S.P. 98
C
    8 E = 2.*(CON+XI-V+PL)-4.*PM
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  R(2): Term B47, p. 39, and para. 118, p. 40, S.P. 98
C
    9 E = SL-PS+180.+2.*TML
      F = 1.
      GO TO 800
C
C  T(2): Term B40, p. 39, and para. 118, p. 40, S.P. 98
C
   10 E = 2.*TML-(SL-PS)
      F = 1.
      GO TO 800
C
C  Lambda(2): Term A44, p. 22, and Eq. 70, 78, S.P. 98
C
   11 E = 2.*(CON+XI-V-SL)-PM+PL+180.
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  Mu(2): Term A45, p. 22, and Eq. 70, 78, S.P. 98
C
   12 E = 2.*(CON+XI-V+SL)-4.*PM
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  Nu(2): Term A43, p. 22, and Eq. 70, 78, S.P. 98
C
   13 E = 2.*(CON+XI-V+SL)-3.*PM-PL
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
```

```
C  *J(1): Term A24, p. 22, and Eq. 68, 76, S.P. 98
C
   14 E = CON+PM-PL-V+90.+ISHIFT*180.
      F = SIN(2.*AW)*(1.-1.5*(SAI**2))/SIN(2.*UI)
      GO TO 800
C
C  *M(1): Eq. 201, p. 42, and Eq. 206, p. 43, S.P. 98
C
   15 E = CON-PM+AUM+ISHIFT*180.
      F = SAW*(C5AW**2)*(C5AI**4)/(CQA*SUI*(C5UI**2))
      GO TO 800
C
C  *OO(1): Term A31, p. 22, and Eq. 69, 77, S.P. 98
C
   16 E = CON-V+2.*(PM-XI)+90.+ISHIFT*180.
      F = SAW*(SIN(0.5*AW)**2)*(C5AI**4)/(SUI*(SIN(0.5*UI)**2))
      GO TO 800
C
C  P(1): Term B14, p. 39, and para. 118, p. 40, S.P. 98
C
   17 E = TML+270.-SL
      F = 1.
      GO TO 800
C
C  *Q(1): Term A15, p. 21, and Eq. 67, 75, S.P. 98
C
   18 E = CON-V-3.*PM+2.*XI+PL-90.+ISHIFT*180.
      F = SAW*(C5AW**2)*(C5AI**4)/(SUI*(C5UI**2))
      GO TO 800
C
C  *2Q(1): Term A17, p. 21, and Eq. 67, 75, S.P. 98
C
   19 E = CON-V-4.*PM+2.*XI+2.*PL-90.+ISHIFT*180.
      F = SAW*(C5AW**2)*(C5AI**4)/(SUI*(C5UI**2))
      GO TO 800
C
C  *Rho(1): Term A18, p. 21, and Eq. 67, 75, S.P. 98
C
   20 E = CON-V-3.*PM+2.*XI-PL+2.*SL-90.+ISHIFT*180.
      F = SAW*(C5AW**2)*(C5AI**4)/(SUI*(C5UI**2))
      GO TO 800
C
C  M(4): para. 139, p. 47, S.P. 98
C
```

```
   21 E = 4.*(CON-PM+XI-V)
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))**2
      GO TO 800
C
C  M(6): para. 139, p. 47, S.P. 98
C
   22 E = 6.*(CON-PM+XI-V)
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))**3
      GO TO 800
C
C  M(8): para. 139, p. 47, S.P. 98
C

   23 E = 8.*(CON-PM+XI-V)
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))**4
      GO TO 800
C
C  S(4): para. 139, p. 47, S.P. 98
C
   24 E = 4.*TML
      F = 1.
      GO TO 800
C
C  S(6): para. 139, p. 47, S.P. 98
C
   25 E = 6.*TML
      F = 1.
      GO TO 800
C
C  *M(3): Term A82, p. 35, and para. 106, p. 35, S.P. 98
C
   26 E = 3.*(CON-PM+XI-V)+180.+ISHIFT*180.
      F = (C5AW**6)*(C5AI**6)/(C5UI**6)
      GO TO 800
C
C  *S(1): para. 119, p. 40, S.P. 98
C
   27 E = TML+180.+ISHIFT*180.
      F = 1.
      GO TO 800
C
C  *MK(3): p. 68, A.M., M(2)+K(1) interaction
C
   28 E = 2.*(CON-PM+XI-V)+(CON-VP+90.)+ISHIFT*180.
```

```
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))
      F = F/SQRT(0.8965*(SIN(2.*UI)**2)+0.6001*SIN(2.*UI)*COS(U)
     &                                  +0.1006)
      GO TO 800
C
C  *2MK(3): p. 68, A.M., assume M(4)-K(1) interaction, sign is unsure
C
   29 E = 4.*(CON-PM+XI-V)-(CON-VP+90.)+ISHIFT*180.
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))**2
      F = F/SQRT(0.8965*(SIN(2.*UI)**2)+0.6001*SIN(2.*UI)*COS(U)
     &                                  +0.1006)
      GO TO 800
C
C  MN(4): p. 68, A.M., M(2)+N(2) interaction
C
   30 E = 4.*(CON+XI-V)+PL-5.*PM
      F = ((C5AW**4)*(C5AI**4)/(C5UI**4))**2
      GO TO 800
C
C  MS(4): p. 67, A.M., M(2)+S(2) interaction
C
   31 E = 2.*(CON-PM+XI-V)+2.*TML
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  2SM(2): p. 68, A.M., 2M(2)-S(2) interaction
C
   32 E = 4.*TML-2.*(CON-PM+XI-V)
      F = (C5AW**4)*(C5AI**4)/(C5UI**4)
      GO TO 800
C
C  Mf: Term A6, p. 21, and Eq. 66, 74, S.P. 98
C
   33 E = 2.*(PM-XI)
      F = (SAW**2)*(C5AI**4)/(SUI**2)
      GO TO 800
C
C  MSf: Term A5, p. 21, and Eq. 65, 73, S.P. 98; p. 67, A.M.,
C       S(2)-M(2) interaction
C       Note:  F was redefined to be consistent with S.P. 98,
C              old F is commented out...
C
   34 E = 2.*TML-2.*(CON-PM+XI-V)
C     F = (C5AW**4)*(C5AI**4)/(C5UI**4)
```

```
      F = ((2./3.-(SAW**2))*(1.-1.5*(SAI**2)))/(2./3.-(SUI**2))
      GO TO 800
C
C  Mm: Term A2, p. 21, and Eq. 65, 73, S.P. 98
C
   35 E = PM-PL
      F = ((2./3.-(SAW**2))*(1.-1.5*(SAI**2)))/(2./3.-(SUI**2))
      GO TO 800
C
C  Sa: para. 119, p. 40, S.P. 98
C
   36 E = SL
      F = 1.
      GO TO 800
C
C  Ssa: Term B6, p. 39, S.P. 98
C
   37 E = 2.*SL
      F = 1.
      GO TO 800
C*********************************************************************
C  END OF CONSTITUENT CALCULATION CODES
C*********************************************************************
C
  800 CONTINUE
C
      IF(ITYPE .EQ. 2) THEN
        E = E + FLOAT(MS(IPICK))*GONL-SPD(IPICK)*TM/15.
      ELSE IF(ITYPE .EQ. 1) THEN
        ZAT = E/360.                    !# OF CIRCLES
        IF(ZAT.LT.0.) THEN
          E = (ZAT-AINT(ZAT)+1.)*360.      !360 + MOD(E,360)
        ELSE
          E = (ZAT-AINT(ZAT))*360.         !MOD(E,360)
        END IF
      END IF
C
      F = 1./F
C
      RETURN
      END
C
C
C
```

```
C
      SUBROUTINE TABLE6(VI,V,XI,VP,VPP,CIG,CVX,CEX,PVC,
     &                  PVCP,ANG,AN,AT)
C
C  Using as input the longitude of the moon's node N (here
C  called ANG) and the astronomical constants w, i, e, e1
C  and S' (here called AW, AI, AE, AE1 and ASP, respectively,
C  and input through the common block BOXS) from the beginning
C  of subroutine ASTRO, computes the 5 astronomical entities
C  listed in Table 6 of S.P. 98 and used for tidal computations,
C  specifically:
C
C    VI = inclination of moon's orbit to celestial equator (I)
C         in degrees to nearest 0.01 deg
C     V = right ascension or longitude in celestial equator of
C         moon's orbit (nu) in degrees to nearest 0.01 deg
C    XI = longitude in moon's orbit of the lunar intersection
C         (zi) to nearest 0.01 deg
C    VP = nu' of Eq. 224 in S.P. 98 in degrees
C   VPP = 2*nu" of Eq. 232 in S.P. 98 in degrees
C
C  Also returned are:
C
C   CIG = VI (I) in radians
C   CVX = V (nu) in radians
C   CEX = XI (zi) in radians
C   PVC = VP (nu') in radians
C  PVCP = VPP (2*nu") in radians
C    AN = ANG (N) in radians
C    AT = CIG identically, i.e., redundancy
C
      COMMON /BOXS/ AW, AI, AE, AE1, ASP
C
      PI   = 4.*ATAN(1.)            !YOU KNOW, PI
      DTR  = 180./PI                !DEG./RAD., 57.295780
      RTD  = PI/180.                !RAD./DEG., 0.0174533
C
C  Initialize returned values
C
      V    = 0.0       !nu, right ascension
      XI   = 0.0       !zi, long. in moon's orbit of intersection
      VP   = 0.0       !nu' of Eq. 224
      VPP  = 0.0       !2*nu" of Eq. 232
      AN   = ANG*RTD   !N in radians
```

```
C
      AX   = ANG                              !redundant replacement
      EYE  = COS(AI)*COS(AW)-SIN(AI)*SIN(AW)*COS(AN)  !cos(I)
      C9   = DTR*ACOS(EYE)                    !I in deg
      VI   = FLOAT(IFIX(C9*100.+0.5))*0.01    !I to nearest 0.01 deg
      CIG  = RTD*VI                           !VI in radians
      AT   = CIG                              !redundant CIG
C
C  Special condition checks
C
      IF( CIG .EQ.   0. ) GO TO 230
      IF(  AX .EQ.   0. ) GO TO 230
      IF(  AX .EQ. 180. ) GO TO 230
C
C  Spherical trigonometry to get nu (Fig. 1, Pg. 6, S.P. 98)
C
      VXXE = SIN(AI)*SIN(AN)
      VXXN = COS(AI)*SIN(AW)+SIN(AI)*COS(AW)*COS(AN)
      IF( VXXE .EQ. 0. ) GO TO 201
      IF( VXXN .EQ. 0. ) GO TO 201
      VXX  = VXXE/VXXN                        !tan(nu)
      C10  = DTR*ATAN(VXX)                    !nu in deg.
      V    = FLOAT(IFIX(C10*100.+0.5))*0.01   !nu to 0.01 deg
      IF( V .GT. 0. .AND. AX .GT. 180. ) V = -V     !- for 180 < N < 360
C
  201 CONTINUE
C
      CVX  = RTD*V                            !nu in radians
C
C  Spherical trigonometry to get zi (Fig. 1, Pg. 6, S.P. 98)
C
      TERM = SIN(AI)*COS(AW)/SIN(AW)
      EXX  = TERM*SIN(AN)/COS(AN) + (COS(AI)-1.)*SIN(AN)
      EZZ  = TERM+COS(AI)*COS(AN) + (SIN(AN)**2)/COS(AN)
      IF( EXX .EQ. 0. )     GO TO 202
      IF( EZZ .EQ. 0. )     GO TO 202
      EXEZ = EXX/EZZ                          !tan(zi)
      IF( EXEZ .GT. 3450. ) GO TO 202
      C11  = DTR*ATAN(EXEZ)                   !zi in deg.
      XI   = FLOAT(IFIX(C11*100.+0.5))*0.01   !zi to 0.01 deg
      IF( XI .GT. 0. .AND. AX .GT. 180.) XI = -XI   !- if 180 < N < 360
C
  202 CONTINUE
C
```

```
      CEX  = RTD*XI                          !zi in radians
C
C  From paragraph 133 of S.P. 98 to find nu':
C
      A22  = (0.5+0.75*(AE**2))*SIN(2.*CIG)        !lunar coeff. A of Eq. 216
      B22  = (0.5+0.75*(AE1**2))*ASP*SIN(2.*AW)    !solar coeff. B of Eq. 217
      VPXE = A22*SIN(CVX)                    !numerator in Eq. 224
      VPXN = A22*COS(CVX)+B22                !denominator in Eq. 224
      IF( VPXE .EQ. 0. )   GO TO 203
      IF( VPXN .EQ. 0. )   GO TO 203
      VPX  = VPXE/VPXN                       !tan(nu')
      IF( VPX .GT. 3450. ) GO TO 203
      VP   = DTR*ATAN(VPX)                   !nu' in degrees
      IF( VP .GT. 0. .AND. AX .GT. 180.) VP = -VP   !- if 180 < N < 360
C
  203 CONTINUE
C
      PVC  = RTD*VP                          !nu' in radians
C
C  From paragraph 135 in S.P. 98 for 2*nu":
C
      A47  = (0.5+0.75*(AE**2))*(SIN(CIG)**2)      !lunar coeff. A of Eq. 218
      B47  = (0.5+0.75*(AE1**2))*ASP*(SIN(AW)**2)  !solar coeff. B of Eq. 219
      VPYE = A47*SIN(2.*CVX)                 !numerator in Eq. 232
      VPYN = A47*COS(2.*CVX)+B47             !denominator in Eq. 232
      IF( VPYE .EQ. 0. )   GO TO 204
      IF( VPYN .EQ. 0. )   GO TO 204
      VPY  = VPYE/VPYN                       !tan(2*nu")
      IF( VPY .GT. 3450. ) GO TO 204
      VPP  = DTR*ATAN(VPY)                   !2*nu" in degrees
      IF( VPP .GT. 0. .AND. AX .GT. 180.) VPP=-VPP  !- if 180 < N < 360
C
  204 CONTINUE
C
      PVCP = RTD*VPP                         !2*nu" in radians
C
C  Special condition jump address
C
  230 CONTINUE
C
      RETURN
      END
C
C
```

```
C
C
      SUBROUTINE NAME(SPDD,ITAG,ISUB,INUM,ICODE)
C*********************************************************
C  ROUTINE IDENTIFIES A CONSTITUENT BY ITS SPEED         *
C  (ICODE=1), ITS NAME LABEL (ICODE=2), OR ITS CONSTITU-  *
C  ENT NUMBER (ICODE=3), AND MAKES IT AVAILABLE FOR      *
C  LABELING.  IT ALSO DETERMINES THE SUBSCRIPT OF THE    *
C  CONSTITUENT.  THE ORDER OF THE CONSTITUENT SPEEDS IS:  *
C                                        *
C    M(2)    N(2)    S(2)    O(1)      K(1)     K(2)     *
C    L(2)   2N(2)    R(2)    T(2)  LAMBDA(2)    MU(2)     *
C   NU(2)    J(1)    M(1)   OO(1)      P(1)     Q(1)     *
C   2Q(1)  RHO(1)    M(4)    M(6)      M(8)     S(4)     *
C    S(6)    M(3)    S(1)   MK(3)     2MK(3)    MN(4)     *
C   MS(4)  2SM(2)   MF     MSF        MM       SA       *
C  SSA                                    *
C*********************************************************
      CHARACTER*10     LABLE(37), ITAG
      DIMENSION          IP(37)
      DOUBLE PRECISION   SPD(37), SPDD
C
      COMMON   /MMSS/    IP
      COMMON /SPEEDS/   SPD
      COMMON  /NAMES/ LABLE
C
    1 FORMAT(10X,'Speed constituent ',F12.7,' not in list')
    2 FORMAT(10X,'Constituent named ',A10,' not in list')
    3 FORMAT(10X,'Constituent number ',I4,' not in list')
C
      IF(ICODE.EQ.1) THEN             !SEARCH BY SPEED
        DO 100 J=1,37
          IF(SPDD.NE.SPD(J)) THEN
            GO TO 100
          ELSE
            ITAG=LABLE(J)
            ISUB=IP(J)
            INUM=J
            GO TO 400
          END IF
  100     CONTINUE
        WRITE(*,1) SPDD
C
      ELSE IF(ICODE.EQ.2) THEN        !SEARCH BY NAME
```

```
      DO 200 I=1,37
        IF(ITAG.NE.LABLE(I)) THEN
          GO TO 200
        ELSE
          SPDD=SPD(I)
          ISUB=IP(I)
          INUM=I
          GO TO 400
        END IF
 200    CONTINUE
      WRITE(*,2) ITAG
C
    ELSE IF(ICODE.EQ.3) THEN        !SEARCH BY NUMBER
      K=INUM
      IF(K.GT.0 .AND. K.LE.37) THEN
        ITAG=LABLE(K)
        SPDD=SPD(K)
        ISUB=IP(K)
        GO TO 400
      END IF
      WRITE(*,3) INUM
    END IF
C
    WRITE(*,'("****EXECUTION STOPPED IN SUBROUTINE NAME****")')
    STOP
C
 400 CONTINUE
C
    RETURN
    END
C
C
C
C
    BLOCK DATA CONSTS
C*********************************************************
C  37 CONSTITUENT ELEMENTS IS NOAA STANDARD AS OF PEARL   *
C  HARBOR DAY 1987                                        *
C*********************************************************
    CHARACTER*10    LABLE(37)
    INTEGER          MS(37)
    DOUBLE PRECISION  SPD(37)
C
    COMMON /SPEEDS/   SPD
```

```
      COMMON  /NAMES/ LABLE
      COMMON   /MMSS/    MS
C
C  Tidal constituent speeds in degrees per hour
C
      DATA        SPD/
     &    28.9841042D0,  28.4397295D0,  30.0000000D0,  13.9430356D0,
     &    15.0410686D0,  30.0821373D0,  29.5284789D0,  27.8953548D0,
     &    30.0410667D0,  29.9589333D0,  29.4556253D0,  27.9682084D0,
     &    28.5125831D0,  15.5854433D0,  14.4966939D0,  16.1391017D0,
     &    14.9589314D0,  13.3986609D0,  12.8542862D0,  13.4715145D0,
     &    57.9682084D0,  86.9523127D0, 115.9364169D0,  60.0000000D0,
     &    90.0000000D0,  43.4761563D0,  15.0000000D0,  44.0251729D0,
     &    42.9271398D0,  57.4238337D0,  58.9841042D0,  31.0158958D0,
     &     1.0980331D0,   1.0158958D0,   0.5443747D0,   0.0410686D0,
     &     0.0821373D0/
C
C  Constituent subscripts
C
      DATA         MS/
     &            2,          2,          2,          1,
     &            1,          2,          2,          2,
     &            2,          2,          2,          2,
     &            2,          1,          1,          1,
     &            1,          1,          1,          1,
     &            4,          6,          8,          4,
     &            6,          3,          1,          3,
     &            3,          4,          4,          2,
     &            0,          0,          0,          0,
     &            0/
C
C  Constituent names
C
      DATA       LABLE/
     &   'M(2)      ' , 'N(2)      ' , 'S(2)      ' , 'O(1)      ' ,
     &   'K(1)      ' , 'K(2)      ' , 'L(2)      ' , '2N(2)     ' ,
     &   'R(2)      ' , 'T(2)      ' , 'Lambda(2) ' , 'Mu(2)     ' ,
     &   'Nu(2)     ' , 'J(1)      ' , 'M(1)      ' , 'OO(1)     ' ,
     &   'P(1)      ' , 'Q(1)      ' , '2Q(1)     ' , 'Rho(1)    ' ,
     &   'M(4)      ' , 'M(6)      ' , 'M(8)      ' , 'S(4)      ' ,
     &   'S(6)      ' , 'M(3)      ' , 'S(1)      ' , 'MK(3)     ' ,
     &   '2MK(3)    ' , 'MN(4)     ' , 'MS(4)     ' , '2SM(2)    ' ,
     &   'Mf        ' , 'Msf       ' , 'Mm        ' , 'Sa        ' ,
     &   'Ssa       ' /
```

```
C
      END
c**********************************************************************
      INTEGER FUNCTION LSTGDCHR(NAMESUB)
c
      CHARACTER*(*)     NAMESUB
      INTEGER     II,CLEN,INDEX
c
      CLEN = LEN(NAMESUB)
      DO 100 II = CLEN,1,-1
100   IF( ICHAR(NAMESUB(II:II)) .GT. 60 .AND.
     1     ICHAR(NAMESUB(II:II)) .LT. 127 )GOTO 101
101   INDEX=II
c
      LSTGDCHR = INDEX
      RETURN
c
      END
```

APPENDIX C: Codes for the OCEANRDS Refraction/Diffraction Model

There is a family of OCEANRDS codes, with each specific to particular grid domains. For the back refraction problems and other far field applications the **oceanrds_socal.for** version is used on a 2,405 x 4,644 raster formatted grid that encompasses the entire Southern California Bight. The input parameters output files which are required by **oceanrds_socal.for** are

graham_m.grd *……...* (name.grd) bathymetry input file
-1.0…….*(gis) if data is parsed GIS data gis= -1.0, if NOS data gis=1.0
1……..* wave exposure 1=west, 2=north, 3=east, 4=south (icoast)
0.0 …….* sea level adjustment MSL meters (sealev) (+ = deeper water)
77.5 ……..* outer grid dimensions in meters perpendicular to coast (sx)
92.6……...* outer grid dimensions in meters parallel to coast (sy)
4644 .....* number of grid cells in from deep water perpendicular to coast raster (nx)
2405…….* number of grid cells along coast from top edge (ny)
17.0…….* wave period in seconds (persw)
270.0……...* wave direction degress clockwise from true north (asw)
10.0……* wave height meters (hsw)

```
c**********************************************************************
c
c       Ocean refraction - diffraction module oceanrds_socal.for
c
c    programmed to run on full socal elevation data (graham_m.grd)
c    extracted from GIS grid  by read_graham_bathy_full.for
c                        10 oct, 2002
c
c**********************************************************************
c   This program is the first program in a 2 program series to treat
c   the distribution of wave heights, angles, wave numbers from the
c   combined effect of a wave field containing two distinct periods
c   and/or directions. The second program (windwave.f) must also be run
c   in order for the ultimate output file to be properly name for use
c   by the other modules even if there is 0 energy in the second band.
c   It solves a parabolic approximation to the mild slope equation
c   for the transmitted field of a linear wave.  Outputs wave height,
c   wave number, and wave angle for each grid point in a 2405 x 4644
c   grid array with 3 second x 3 second spacing.  Bathymetry is read from
c   a formatted 2405 x 4644 real number array called 'ifile'.grd,
c   created by the oceanbat.f module, where'ifile' corresponds to
c   the inputted site name.  Program uses "oceanrd.inp" input file.
c   All output files are named 'ifile' with different extensions,
c   ie. 'ifile'.wh1.
c**********************************************************************
c**********************************************************************
c
          parameter (max=10000000)
       character  name*8,ifile*12
       character ofile1*12,ofile2*12,ofile3*12,ofile4*12
       character ofile5*12,ofile6*12,ofile7*12
      dimension  ccg(max),di(max),hab(max),rlb(max),dib(max),ih(max)
      dimension depth(4644,4644),wht(4644,4644)
      dimension ang(4644,4644)
       dimension depthold(4644,4644)
       real kbar(2,max),kave
c
       complex aa(max),bb(max),cc(max),dd(max),uu(max),aprev(max)
       complex c3,t1,t2,t3,f,alast(max),aphys(max),mim,mip
c
       common /grid/ ny,sy,sx,dely,delx,ndely,freq,dcon,ify,ifx,tide
            common /cut/ dc
c
       pi=acos(-1.)
```

```
c
c    open parameter input file, return error message if missing
c
c
c
      open(2,file='oceanrds_socal.inp',status='old',err=900)
      read(2,'(a)') name
         read(2,*) gis
      read(2,*) icoast
         read(2,*) tide_elev
         read(2,*) sx
      read(2,*) sy
         read(2,*) nx
      read(2,*) ny
         read(2,*) persw
         read(2,*) asw
         read(2,*) hsw
c
      tide=tide_elev
      amp=hsw
      dir=asw
      per=persw
c
         freq=1/per
c
c... change to proper rotation frame, flag if theta not between +/- 45
c
      IF (icoast .EQ. 1) coast=270.0
      IF (icoast .EQ. 2) coast=90.0
      IF (icoast .EQ. 3) coast=0.0
      IF (icoast .EQ. 4) coast=180.0
c
         theta=coast-dir
c
c... set some variables to constant values
c
c       dcon = 1. for nuwave version
        dcon=1.
c
c       cutoff depth (dc) -5.0 meters
        dc=-5.0
c
c       breaking wave switch (ibreak) (1=on, 0=off)
        ibreak=1
```

```
c
c       breaking criteria (bc) 0.5  for wave height = (bc)*depth
        bc=0.5
c
c       lateral b.c.: ibc=(0) transmitting, ibc=(1) reflective
        ibc=0
c       if trans: (isn=0) straight snell, isn=(1) kirby's improved
        isn=1
c       idf=(0) small angle diff, idf=(1) large angle dif
        idf=1
c
c
          write(*,'(5(/),10x,a)')
     &'  KIRBY HIGHER ORDER REFRACTION-DIFFRACTION PROGRAM '
          write(*,'(/,10x,a)')
     &'- based on the parabolic equation method (PEM) of solving'
          write(*,'(10x,a,5(/))')
     &'  the mild-slope equation. '
c
          nn=8
          do 3 m=8,1,-1
3         if(name(m:m).eq.' ') nn=m-1
c
c
c... open grid file
c
          write(ifile,'(a,a)') name(:nn),'.grd'
        open(20,file=ifile,status='old',err=900)
c
c
c... open breaker ix,iy,wave height, wave angle, depth file
        write(ofile7,'(a,a)') name(:nn),'.bra'
         open(39,file=ofile7)
c
c
c... open sea level corrected ascii bathymetry file
        write(ofile1,'(a,a)') name(:nn),'.dep'
        open(31,file=ofile1)
c
c
c... open ascii wave number file
        write(ofile2,'(a,a)') name(:nn),'.wvn'
        open(32,file=ofile2)
c
```

```
c
c
c... open ascii wave height file
      write(ofile3,'(a,a)') name(:nn),'.wh1'
      open(33,file=ofile3)
c
c
c
c... open ascii wave angle file
       write(ofile4,'(a,a)') name(:nn),'.an1'
       open(34,file=ofile4)
c
c
c
c....  create depth array
c
       do 111 j=ny,1,-1
       read(20,*) (depthold(j,i),i=1,nx)
111     continue
       rewind(20)
c
c 10oct02 *******correct for sea level and change sign if GIS data
       do 711 i=1,nx
       do 811 j=1,ny
       depthold(j,i)=(gis*depthold(j,i))+sealev
811     continue
711     continue
c
c......write rotated ascii depth file for internal use in ref/dif
165     format(2405f12.2)
       DO 101 i=1,nx
       WRITE(31,165)(depthold(j,i),j=1,ny)
101     CONTINUE
       rewind(31)
c
c
       do 119 i=1,nx
       read(31,*) (depth(i,j),j=1,ny)
119     continue
       rewind(31)
c
c
c... read first depth to initialize offshore boundary
c
```

```
          read(31,*) (di(m),m=1,ny)
          ridep=di(ny/2)
          rewind(31)

c.... would like a grid step size on the order of 1/5 wavelength

          call getkcg(10.,wk,cg0)
          wl=2*pi/wk
          ifx=1+sx/(.2*wl)
          ify=1+sy/(.2*wl)
c
          nmx=ifx
          nmy=ify
c
       amp=amp/2.
c
c... calculate dimensions of interpolated grid
c
          dely=sy/ify
          delx=sx/ifx
       ndely=(ny-1)*ify
       ndelx=(nx-1)*ifx
c
c
       call getkcg(ridep,wk0,cg0)
c  wave length (m)
       wl=2*pi/wk0
c  wave frequency (rad/sec)
       sig=2*pi/per
c  radder's correction factor
       do 33 j=1,ndely+1
 33     ccg(j)=sqrt(sig*cg0/wk0)
c
c
           ltype=2
c... open binary wave height file
       write(ofile5,'(a,a)') name(:nn),'.bw1'
        open(9,file=ofile5,form='unformatted')
c
c... open binary wave angle file
       write(ofile6,'(a,a)') name(:nn),'.ba1'
        open(11,file=ofile6,form='unformatted')
c
c.. initialize depth array
```

```
          do 555 nn=1,ndely+1
          hab(nn)=0.
          ih(nn)=0
555       continue
c
c   enter initial condition at x=0
c
       call inbc(amp,wk0,theta,ndely,dely,alast)
c
       do 202 j=1,ndely+1
       kbar(1,j)=wk
202      kbar(2,j)=wk
c
c scale alast as in radder(1978)
       do 32 j=1,ndely+1
       alast(j)=alast(j)*ccg(j)
32       continue
c
c       call wwave(alast,ndely,nmy,dely,kbar)
c
c    solution of the parabolic eqn. by the crank-nicholson formulation
c
c    start x increments
c
       c2=1./2./dely**2
       c3=2.*(0,1)/delx
c
c---------------------------------------------------------------------
c increments in x-direction
c
       ikount=0
       do 100 l=1,ndelx
c
c... write every 10th step to the screen
c
          if(10*((l+1)/10).eq.l+1) then
       print *,' column ',l+1,' of ',ndelx+1
          endif
c
       lm=l
c
       call intkcg(lm,kbar,ccg,di,ikount)
c
c correction factor
```

```
      do 34 j=1,ndely+1
      ccg(j)=sqrt(sig*ccg(j)/kbar(2,j))
34     continue
c--------------------------------------------------------------------
c increments in y-direction - 1st. round
      do 200 j=2,ndely
c
      kave=(kbar(2,j)+kbar(1,j))/2.
c      kave=kbar(2,j)
c
      if(idf.eq.0) then
c small angle diffraction approximation
c
      t1=c2
      t3=c3*kave
      f=2*kave*(kave-wk)+c3/2*(kbar(2,j)-kbar(1,j))
c
      aa(j-1)=t1
      bb(j-1)=t3-2.*t1+f/2.
      cc(j-1)=t1
      dd(j-1)=-t1*alast(j+1)+(t3+2*t1-f/2)*alast(j)-t1*alast(j-1)
c
      endif
c
      if(idf.eq.1) then
c large angle diffraction approximation
c
      t1=c2/2.*(3.-wk/kave)
      t2=c2*c3/4./kave
      t3=c3*kave
      f=2*kave*(kave-wk)+c3/2*(kbar(2,j)-kbar(1,j))
c
      aa(j-1)=t1+t2
      bb(j-1)=t3-2.*(t1+t2)+f/2.
      cc(j-1)=t1+t2
      dd(j-1)=(t2-t1)*(alast(j+1)+alast(j-1))+(t3-2*(t2-t1)-f/2)
     &    *alast(j)
      endif
c
      if(j.eq.2) then
c      if(ibc.eq.1) cc(1)=aa(1)+cc(1)
c reflective b.c. : a1=a3
      if(ibc.eq.1) bb(1)=aa(1)+bb(1)
c reflective b.c. : a1=a2
```

```
      if(ibc.eq.0) then
c transmitting b.c.
c
      if(isn.eq.0) then
c straight snell
      mip= (0.,1.)*wk*sin(theta)/2.
      mip=(1./dely-mip)/(1./dely+mip)
      else
c  kirby's improved
      mip=(alast(2)-alast(1))/(alast(2)+alast(1))
      mip=(1.-mip)/(1.+mip)
      endif
c
      bb(1)=bb(1)+mip*aa(1)
      endif
      aa(j-1)=(0.,0.)
c
      endif
c
      if(j.eq.ndely) then
c      if(ibc.eq.1) aa(j-1)=aa(j-1)+cc(j-1)
c reflective b.c. : an=an-2
      if(ibc.eq.1) bb(j-1)=bb(j-1)+cc(j-1)
c reflective b.c. : an=an-1
      if(ibc.eq.0) then
c transmitting b.c.
c
      if(isn.eq.0) then
c   straight snell
      mim= (0.,1.)*wk*sin(theta)/2.
      mim=(1./dely+mim)/(1./dely-mim)
      else
c   kirby's improved
      mim=(alast(j+1)-alast(j))/(alast(j+1)+alast(j))
      mim=(1.+mim)/(1.-mim)
      endif
c
      bb(j-1)=bb(j-1)+mim*cc(j-1)
      endif
      cc(j-1)=(0.,0.)
      endif
c
200    continue
c--------------------------------------------------------------------
```

```
c
c              *****   compute the solution  *****
c
      neqs=ndely-1
c
      call tridag(aa,bb,cc,dd,uu,neqs)
c
      do 143 j=2,ndely
143     alast(j)=uu(j-1)
c load alast(j)
c
      if(ibc.eq.1) then
c      alast(1)=alast(3)
c reflective b.c.: a1=a3
c       alast(ndely+1)=alast(ndely-1)
c              : an=an-2
      alast(1)=alast(2)
c reflective b.c.: a1=a2
      alast(ndely+1)=alast(ndely)
c              : an=an-1
      endif
c
      if(ibc.eq.0) then
c transmitting b.c.
c
      alast(1)= mip*alast(2)
      alast(ndely+1)= mim*alast(ndely)
c
      endif
c
c transform back into phys. height
      do 37 j=1,ndely+1
37      aphys(j)=2.*alast(j)/ccg(j)
c
c           *********    check for breaking    *********
c
          if(ibreak.eq.1) then
      do 54 j=1,ndely+1
      hb=bc*di(j)
      rat=hb/cabs(aphys(j))
           if(di(j).lt.0) rat=0.
      if(rat.lt.1) then
c  save point just before wave first breaks
            if(ih(j).eq.0) then
```

```
                hab(j)=cabs(aprev(j))
                rlb(j)=(lm-1)/real(ifx)
c  calculate direction before breaking
                  if(j.eq.ndely+1.or.ih(j+1).eq.1) then
        xx=aimag((aprev(j)-aprev(j-1))/(dely*kbar(1,j)*aprev(j)))
                   if(xx.gt.1) xx=1.
                if(xx.lt.-1.) xx=-1.
                   dib(j)=asin(xx)
                  else
        xx=aimag((aprev(j+1)-aprev(j))/(dely*kbar(1,j)*aprev(j)))
                   if(xx.gt.1) xx=1.
                   if(xx.lt.-1.) xx=-1.
                dib(j)=asin(xx)
               endif
            dib(j)=270.-dib(j)*57.296-rot
                  if(dib(j).lt.0) dib(j)=360+dib(j)
          ih(j)=1
          endif
      aphys(j)=rat*aphys(j)
      alast(j)=rat*alast(j)
         endif
54       continue
      endif
c
c  *********************************************************************
c
c... writing wave field
         if(nmx*(lm/nmx).eq.lm.or.lm.eq.1) then
        call wwave(aphys,ndely,nmy,dely,kbar)
         endif
c
         do 55 nn=1,ndely+1
         aprev(nn)=aphys(nn)
55       continue
c
100    continue
c
c... output prebreak heights and directions
         open(24,file='break.dat')
         write(24,'(/,18x,a)') '        REFRACTION - DIFFRACTION        '
         write(24,'(/,18x,a)') ' WAVE HEIGHT AND DIRECTION BEFORE BREAKING'
         write(24,'(/,15x,a,a,a,f5.1,a,f4.1)')
    &  ' site: ',name,'   direction: ',dir,'  period: ',per
         write(24,'(/,20x,a,6x,a,6x,a,9x,a,//)')
```

```
     &'row',' H (m) ','col','dir'
           m=1
           write(24,'(18x,i4,f12.2,f12.1,f12.1)') m,hab(m),rlb(m),dib(m)
        alphab=dib(m)-shor
        irlb=NINT(rlb(m))+1
        breakd=(5.0/4.0)*hab(m)
***rasterisze break point file m.....ixbra
        ixbra=2405-m
        write(39,'(18x,i4,i4,f12.3,f12.1,f12.3)') ixbra,irlb,hab(m),
     &alphab,breakd
           if(nmy.eq.1) then
           is=2
           else
           is=nmy
           endif
           mm=1
           do 888 m=is,ndely,nmy
           mm=mm+1
           write(24,'(18x,i4,f12.2,f12.1,f12.1)') mm,hab(m),rlb(m),dib(m)
        alphab=dib(m)-shor
        irlb=NINT(rlb(m))+1
        breakd=(5.0/4.0)*hab(m)
        ixbra=2405-mm
        write(39,'(18x,i4,i4,f12.3,f12.1,f12.3)')ixbra,irlb,hab(m),
     &alphab,breakd
888      continue
c
c
        rewind (9)
        rewind (11)
c
c......create wave height and wave angle arrays
        do 114 i=1,nx
              read(9) (wht(i,j),j=1,ny)
              read(11) (ang(i,j),j=1,ny)
114      continue
c
c.... write array values to:
c.... ascii depth, wave number, wave angle, wave height grid files
c
c
c2002     format(4644f12.2)
c
cccc Comment out old way of writing arrays
```

```
ccccccccccc        do 134 i=1,nx
ccccccccccc        write(33,2002) (wht(i,j),j=1,ny)
ccccccccccc        write(34,2002) (ang(i,j),j=1,ny)
ccccccccccc134      continue
c
CCCCCC Raster way of writing arrays!!!!!!!!!!!!!
      DO 176 j=ny,1,-1
        write(33,6666) (wht(i,j),i=1,nx)
        write(34,6666) (ang(i,j),i=1,nx)
  176  CONTINUE
6666     format(4644f12.2)
6667     format(4644f12.6)
c
c
          go to 901
900       write(*,'(20x,a,a,a)') '**** error **** ',ifile,' missing'
          write(*,'(20x,a)') '    press any key to continue '
          read(*,'(a)') idum
901     continue
       stop
       end
c
c---------------------------------------------------------------------
c
       subroutine tridag(a,b,c,r,u,n)
c
       parameter (nmax=250002)
       complex gam(nmax),a(n),b(n),c(n),r(n),u(n),bet
c
       bet=b(1)
       u(1)=r(1)/bet
       do 11 j=2,n
       gam(j)=c(j-1)/bet
       bet=b(j)-a(j)*gam(j)
       if(bet.eq.0)pause
       u(j)=(r(j)-a(j)*u(j-1))/bet
11       continue
       do 12 j=n-1,1,-1
       u(j)=u(j)-gam(j+1)*u(j+1)
12       continue
       return
       end
c
c---------------------------------------------------------------------
```

```
c
      subroutine wwave(aphys,ndely,nmy,dely,kbar)
c
c  compute & write wave height and direction, initial breaking point
c     imax= max grid size nmax=max no. of steps
c
      parameter (nmax=45000000,imax=4500000)
         dimension amod(nmax),alfa(nmax)
         real kbar(2,nmax)
         complex aphys(nmax)
c
         nky=0
      do 350 j=1,ndely+1
         if(nmy*(j/nmy).eq.j.or.j.eq.1) then
         nky=nky+1
c
          amod(nky)=cabs(aphys(j))
          if(amod(nky).gt..05) then
          if(j.eq.ndely+1) then
          xx=aimag((aphys(j)-aphys(j-1))/(dely*kbar(2,j)*aphys(j)))
          if(xx.gt.1) xx=1.
          if(xx.lt.-1.) xx=-1.
          alfa(nky)=asin(xx)
          else
          xx=aimag((aphys(j+1)-aphys(j))/(dely*kbar(2,j)*aphys(j)))
          if(xx.gt.1) xx=1.
          if(xx.lt.-1.) xx=-1.
          alfa(nky)=asin(xx)
          endif
          else
          alfa(nky)=0
          endif
          alfa(nky)=alfa(nky)*57.296
         endif
350     continue
c
       write(9) (amod(jj),jj=1,nky)
       write(11) (alfa(jj),jj=1,nky)
c
      return
      end
c
c---------------------------------------------------------------------
c
```

```
      subroutine inbc(amp,wk,theta,ndely,dely,aa)
c
      complex aa(*)
c
      real ky
      pi=acos(-1.)
      theta=theta*pi/180.
      ky=wk*sin(theta)
c
      do 3 j=1,ndely+1
      ar=amp*cos(ky*(j-1)*dely)
      ai=amp*sin(ky*(j-1)*dely)
c      ar=(cos(ky*(j-1)*dely)+cos(-ky*(j-1)*dely))/2.
c 2 identical
c      ai=(sin(ky*(j-1)*dely)+sin(-ky*(j-1)*dely))/2.
c waves summed
      aa(j)=cmplx(ar,ai)
3      continue
c
      return
      end
c
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c
      subroutine getkcg(d,k,cg)
c
c....  depth (meters) and frequency are input
c....  returns wave number (2pi/l) and group velocity
c
      real k
      common /grid/ ny,sy,sx,dely,delx,ndely,f,dcon,ify,ifx,tide
      data tpi/6.2831853/
c
      sig=tpi*f
      a=d*sig*sig/9.81
      if(a.ge.1) then
            yhat=a*(1+1.26*exp((-1.84)*a))
            t=exp((-2)*yhat)
            aka=a*(1+2*t*(1+t))
      else
            aka=sqrt(a)*(1+a/6.*(1+a/5.))
      endif
      k=aka/d
      x=2*k*d
```

```
      cg=tpi*(f/k)*.5*(1+x/sinh(x))
      return
      end
c
c*********************************************************************
c
      subroutine intkcg(lm,kbar,ccg,di,ikount)
c
         parameter(max=45000002)
      real kbar(2,max)
      dimension ccg(max),d(2,max),di(max)
c
      save d
           common /cut/ dc
      common /grid/ ny,sy,sx,dely,delx,ndely,f,dcon,ify,ifx,tide
      data istart,ncol,eps/1,0,.0000001/
c
c... if this is the first call, load first two columns
c
      go to (1,3) istart
1       istart=2
c... read in first 2  columns
           do 777 i=1,2
777          read(31,*) (d(i,j),j=1,ny)
        ncol=1
c... interpolate grid points for first row
      do 2 i=1,ndely
      y=1+real(i-1)/real(ify)+eps
      ym=amod(y,1.)
      iy=int(y)
      di(i)=d(1,iy)+ym*(d(1,iy+1)-d(1,iy))+tide
      call getkcg(di(i)*dcon,rk,cg)
      ccg(i)=cg
2      kbar(2,i)=rk
c
c... figure out which bathymetry grid columns should be used
c
3      icol=1+real(lm)/real(ifx)+eps
      if(icol.ne.ncol) then
        do 5 i=1,ny
5        d(1,i)=d(2,i)
        read(31,*,end=999) (d(2,j),j=1,ny)
999          ncol=icol
      endif
```

```
      dd1=d(1,100)
c
c... bilinear interpolate depths for new column of k and cg
c
15     x=1+real(lm)/real(ifx)+eps
      xm=amod(x,1.)
      do 20 i=1,ndely
      y=1+real(i-1)/real(ify)+eps
      ym=amod(y,1.)
      iy=int(y)
      di(i)=d(1,iy)+xm*(d(2,iy)-d(1,iy))+ym*(d(1,iy+1)-d(1,iy))+
     &   xm*ym*(d(2,iy+1)-d(1,iy+1)-d(2,iy)+d(1,iy))+tide
      if(di(i).le.01) then
      di(i)=.01
      endif
c
c... shift k and ccg col 2 to 1 and calculate new 2's
c
           if(di(i).lt.dc) di(i)=dc
      kbar(1,i)=kbar(2,i)
      call getkcg(di(i)*dcon,rk,cg)
      kbar(2,i)=rk
20     ccg(i)=cg
      kbar(1,ndely+1)=kbar(1,ndely)
      kbar(2,ndely+1)=kbar(2,ndely)
      ccg(ndely+1)=ccg(ndely)
      di(ndely+1)=di(ndely)
c
      return
      end
```

For high resolution local refraction/diffraction calculations within the Torrey Pines Sub-Cell, we use the **oceanrds_tp.for** codes on a 441 x 236 raster formatted grid found in Appendix D. The input parameters output files which are required by **oceanrds_tp.for** are:

subbot50.grd…….*bathymetry input file
1.0……*(gis) if water values are negative gis= -1.0, if positive gis=1.0
1…… * wave exposure 1=west, 2=north, 3=east, 4=south (icoast)
0.0……* sea level adjustment MSL meters (sealev) (+ = deeper water)
50.0……..* inner grid dimensions in meters perpendicular to coast (sx)
50.0……..* inner grid dimensions in meters parallel to coast (sy)
236……* number of grid cells in from deep water perpendicular to coast raster (nx)
441……* number of grid cells along coast from top edge (ny)
15.0……...* wave period in seconds (persw)
285.0……* wave direction degress clockwise from true north (asw)
2.0…….* wave height meters (hsw)

```
c**************************************************************************
c
c       Ocean refraction - diffraction module oceanrds_tp.for
c
c    programmed to run on gis elevation data (tp_subbot50_grd.txt subbot50.grd)
c    extracted from GIS grid  by gis_ascii_utm-xyz.for
c                        14 sep, 2004
c
c**************************************************************************
c  Bathymetry is read from
c   a formatted 441 (row) x 236 (col) real number array called 'ifile'.grd,
c   created by gis_ascii_utm-xyz.for, where'ifile' corresponds to
c   the inputted site name.  Program uses "oceanrd_tp.inp" input file.
c   All output files are named 'ifile' with different extensions,
c   ie. 'ifile'.wh1.
c**************************************************************************
c**************************************************************************
c
          parameter (max=10000000)
       character  name*8,ifile*12
       character ofile1*12,ofile2*12,ofile3*12,ofile4*12
       character ofile5*12,ofile6*12,ofile7*12
      dimension  ccg(max),di(max),hab(max),rlb(max),dib(max),ih(max)
      dimension depth(4644,4644),wht(4644,4644)
      dimension ang(4644,4644)
       dimension depthold(4644,4644)
       real kbar(2,max),kave
c
       complex aa(max),bb(max),cc(max),dd(max),uu(max),aprev(max)
       complex c3,t1,t2,t3,f,alast(max),aphys(max),mim,mip
c
       common /grid/ ny,sy,sx,dely,delx,ndely,freq,dcon,ify,ifx,tide
            common /cut/ dc
c
       pi=acos(-1.)
c
c    open parameter input file, return error message if missing
c
c
c
       open(2,file='oceanrds_tp.inp',status='old',err=900)
       read(2,'(a)') name
          read(2,*) gis
       read(2,*) icoast
```

```
         read(2,*) tide_elev
         read(2,*) sx
      read(2,*) sy
         read(2,*) nx
      read(2,*) ny
         read(2,*) persw
         read(2,*) asw
         read(2,*) hsw
c
      tide=tide_elev
      amp=hsw
      dir=asw
      per=persw
c
         freq=1/per
c
c... change to proper rotation frame, flag if theta not between +/- 45
c
      IF (icoast .EQ. 1) coast=270.0
      IF (icoast .EQ. 2) coast=90.0
      IF (icoast .EQ. 3) coast=0.0
      IF (icoast .EQ. 4) coast=180.0
c
         theta=coast-dir
c
c... set some variables to constant values
c
c       dcon = 1. for nuwave version
       dcon=1.
c
c       cutoff depth (dc) -5.0 meters
       dc=-5.0
c
c       breaking wave switch (ibreak) (1=on, 0=off)
       ibreak=1
c
c       breaking criteria (bc) 0.5  for wave height = (bc)*depth
       bc=0.5
c
c       lateral b.c.: ibc=(0) transmitting, ibc=(1) reflective
       ibc=0
c       if trans: (isn=0) straight snell, isn=(1) kirby's improved
       isn=1
c       idf=(0) small angle diff, idf=(1) large angle dif
```

```
      idf=1
c
c
         write(*,'(5(/),10x,a)')
     &'  KIRBY HIGHER ORDER REFRACTION-DIFFRACTION PROGRAM '
         write(*,'(/,10x,a)')
     &'- based on the parabolic equation method (PEM) of solving'
         write(*,'(10x,a,5(/))')
     &'  the mild-slope equation. '
c
         nn=8
         do 3 m=8,1,-1
3        if(name(m:m).eq.' ') nn=m-1
c
c
c... open grid file
c
         write(ifile,'(a,a)') name(:nn),'.grd'
      open(20,file=ifile,status='old',err=900)
c
c
c... open breaker ix,iy,wave height, wave angle, depth file
       write(ofile7,'(a,a)') name(:nn),'.bra'
        open(39,file=ofile7)
c
c
c... open sea level corrected ascii bathymetry file
       write(ofile1,'(a,a)') name(:nn),'.dep'
       open(31,file=ofile1)
c
c
c... open ascii wave number file
       write(ofile2,'(a,a)') name(:nn),'.wvn'
       open(32,file=ofile2)
c
c
c
c... open ascii wave height file
      write(ofile3,'(a,a)') name(:nn),'.wh1'
      open(33,file=ofile3)
c
c
c
c... open ascii wave angle file
```

```
      write(ofile4,'(a,a)') name(:nn),'.an1'
      open(34,file=ofile4)
c
c
c
c....  create depth array
c
      do 111 j=ny,1,-1
      read(20,*) (depthold(j,i),i=1,nx)
111     continue
      rewind(20)
c
c 10oct02 *******correct for sea level and change sign if GIS data
      do 711 i=1,nx
      do 811 j=1,ny
      depthold(j,i)=(gis*depthold(j,i))+sealev
811     continue
711     continue
c
c......write rotated ascii depth file for internal use in ref/dif
165     format(2405f12.2)
      DO 101 i=1,nx
      WRITE(31,165)(depthold(j,i),j=1,ny)
101     CONTINUE
      rewind(31)
c
c
      do 119 i=1,nx
      read(31,*) (depth(i,j),j=1,ny)
119     continue
      rewind(31)
c
c
c... read first depth to initialize offshore boundary
c
          read(31,*) (di(m),m=1,ny)
          ridep=di(ny/2)
          rewind(31)

c.... would like a grid step size on the order of 1/5 wavelength

          call getkcg(10.,wk,cg0)
          wl=2*pi/wk
          ifx=1+sx/(.2*wl)
```

```
          ify=1+sy/(.2*wl)
c
          nmx=ifx
          nmy=ify
c
       amp=amp/2.
c
c... calculate dimensions of interpolated grid
c
          dely=sy/ify
          delx=sx/ifx
       ndely=(ny-1)*ify
       ndelx=(nx-1)*ifx
c
c
       call getkcg(ridep,wk0,cg0)
c  wave length (m)
       wl=2*pi/wk0
c  wave frequency (rad/sec)
       sig=2*pi/per
c  radder's correction factor
       do 33 j=1,ndely+1
 33     ccg(j)=sqrt(sig*cg0/wk0)
c
c
           ltype=2
c... open binary wave height file
       write(ofile5,'(a,a)') name(:nn),'.bw1'
        open(9,file=ofile5,form='unformatted')
c
c... open binary wave angle file
       write(ofile6,'(a,a)') name(:nn),'.ba1'
        open(11,file=ofile6,form='unformatted')
c
c.. initialize depth array
          do 555 nn=1,ndely+1
          hab(nn)=0.
          ih(nn)=0
555       continue
c
c   enter initial condition at x=0
c
       call inbc(amp,wk0,theta,ndely,dely,alast)
c
```

```
      do 202 j=1,ndely+1
      kbar(1,j)=wk
202     kbar(2,j)=wk
c
c scale alast as in radder(1978)
      do 32 j=1,ndely+1
      alast(j)=alast(j)*ccg(j)
32      continue
c
c      call wwave(alast,ndely,nmy,dely,kbar)
c
c    solution of the parabolic eqn. by the crank-nicholson formulation
c
c    start x increments
c
      c2=1./2./dely**2
      c3=2.*(0,1)/delx
c
c---------------------------------------------------------------------
c increments in x-direction
c
      ikount=0
      do 100 l=1,ndelx
c
c... write every 10th step to the screen
c
         if(10*((l+1)/10).eq.l+1) then
      print *,' column ',l+1,' of ',ndelx+1
         endif
c
      lm=l
c
      call intkcg(lm,kbar,ccg,di,ikount)
c
c correction factor
      do 34 j=1,ndely+1
      ccg(j)=sqrt(sig*ccg(j)/kbar(2,j))
34      continue
c---------------------------------------------------------------------
c increments in y-direction - 1st. round
      do 200 j=2,ndely
c
      kave=(kbar(2,j)+kbar(1,j))/2.
c      kave=kbar(2,j)
```

```
c
      if(idf.eq.0) then
c small angle diffraction approximation
c
      t1=c2
      t3=c3*kave
      f=2*kave*(kave-wk)+c3/2*(kbar(2,j)-kbar(1,j))
c
      aa(j-1)=t1
      bb(j-1)=t3-2.*t1+f/2.
      cc(j-1)=t1
      dd(j-1)=-t1*alast(j+1)+(t3+2*t1-f/2)*alast(j)-t1*alast(j-1)
c
      endif
c
      if(idf.eq.1) then
c large angle diffraction approximation
c
      t1=c2/2.*(3.-wk/kave)
      t2=c2*c3/4./kave
      t3=c3*kave
      f=2*kave*(kave-wk)+c3/2*(kbar(2,j)-kbar(1,j))
c
      aa(j-1)=t1+t2
      bb(j-1)=t3-2.*(t1+t2)+f/2.
      cc(j-1)=t1+t2
      dd(j-1)=(t2-t1)*(alast(j+1)+alast(j-1))+(t3-2*(t2-t1)-f/2)
     &    *alast(j)
      endif
c
      if(j.eq.2) then
c      if(ibc.eq.1) cc(1)=aa(1)+cc(1)
c reflective b.c. : a1=a3
      if(ibc.eq.1) bb(1)=aa(1)+bb(1)
c reflective b.c. : a1=a2
      if(ibc.eq.0) then
c transmitting b.c.
c
      if(isn.eq.0) then
c straight snell
      mip= (0.,1.)*wk*sin(theta)/2.
      mip=(1./dely-mip)/(1./dely+mip)
      else
c  kirby's improved
```

```
      mip=(alast(2)-alast(1))/(alast(2)+alast(1))
      mip=(1.-mip)/(1.+mip)
      endif
c
      bb(1)=bb(1)+mip*aa(1)
      endif
      aa(j-1)=(0.,0.)
c
      endif
c
      if(j.eq.ndely) then
c      if(ibc.eq.1) aa(j-1)=aa(j-1)+cc(j-1)
c reflective b.c. : an=an-2
      if(ibc.eq.1) bb(j-1)=bb(j-1)+cc(j-1)
c reflective b.c. : an=an-1
      if(ibc.eq.0) then
c transmitting b.c.
c
      if(isn.eq.0) then
c   straight snell
      mim= (0.,1.)*wk*sin(theta)/2.
      mim=(1./dely+mim)/(1./dely-mim)
      else
c   kirby's improved
      mim=(alast(j+1)-alast(j))/(alast(j+1)+alast(j))
      mim=(1.+mim)/(1.-mim)
      endif
c
      bb(j-1)=bb(j-1)+mim*cc(j-1)
      endif
      cc(j-1)=(0.,0.)
      endif
c
200    continue
c---------------------------------------------------------------------
c
c              *****   compute the solution  *****
c
      neqs=ndely-1
c
      call tridag(aa,bb,cc,dd,uu,neqs)
c
      do 143 j=2,ndely
143    alast(j)=uu(j-1)
```

```
c load alast(j)
c
      if(ibc.eq.1) then
c      alast(1)=alast(3)
c reflective b.c.: a1=a3
c      alast(ndely+1)=alast(ndely-1)
c             : an=an-2
      alast(1)=alast(2)
c reflective b.c.: a1=a2
      alast(ndely+1)=alast(ndely)
c             : an=an-1
      endif
c
      if(ibc.eq.0) then
c transmitting b.c.
c
      alast(1)= mip*alast(2)
      alast(ndely+1)= mim*alast(ndely)
c
      endif
c
c transform back into phys. height
      do 37 j=1,ndely+1
37     aphys(j)=2.*alast(j)/ccg(j)
c
c          *********    check for breaking    *********
c
         if(ibreak.eq.1) then
      do 54 j=1,ndely+1
      hb=bc*di(j)
      rat=hb/cabs(aphys(j))
           if(di(j).lt.0) rat=0.
      if(rat.lt.1) then
c  save point just before wave first breaks
            if(ih(j).eq.0) then
                  hab(j)=cabs(aprev(j))
                  rlb(j)=(lm-1)/real(ifx)
c  calculate direction before breaking
                    if(j.eq.ndely+1.or.ih(j+1).eq.1) then
          xx=aimag((aprev(j)-aprev(j-1))/(dely*kbar(1,j)*aprev(j)))
                     if(xx.gt.1) xx=1.
                  if(xx.lt.-1.) xx=-1.
                     dib(j)=asin(xx)
                   else
```

```
          xx=aimag((aprev(j+1)-aprev(j))/(dely*kbar(1,j)*aprev(j)))
                        if(xx.gt.1) xx=1.
                        if(xx.lt.-1.) xx=-1.
                     dib(j)=asin(xx)
                    endif
                dib(j)=270.-dib(j)*57.296-rot
                        if(dib(j).lt.0) dib(j)=360+dib(j)
              ih(j)=1
              endif
        aphys(j)=rat*aphys(j)
        alast(j)=rat*alast(j)
           endif
54         continue
        endif
c
c  ********************************************************************
c
c... writing wave field
           if(nmx*(lm/nmx).eq.lm.or.lm.eq.1) then
          call wwave(aphys,ndely,nmy,dely,kbar)
           endif
c
           do 55 nn=1,ndely+1
           aprev(nn)=aphys(nn)
55         continue
c
100     continue
c
c... output prebreak heights and directions
           open(24,file='break.dat')
           write(24,'(/,18x,a)') '         REFRACTION - DIFFRACTION         '
           write(24,'(/,18x,a)') ' WAVE HEIGHT AND DIRECTION BEFORE BREAKING'
           write(24,'(/,15x,a,a,a,f5.1,a,f4.1)')
     &  ' site: ',name,'   direction: ',dir,'  period: ',per
           write(24,'(/,20x,a,6x,a,6x,a,9x,a,//)')
     &'row',' H (m) ','col','dir'
           m=1
           write(24,'(18x,i4,f12.2,f12.1,f12.1)') m,hab(m),rlb(m),dib(m)
        alphab=dib(m)-shor
        irlb=NINT(rlb(m))+1
        breakd=(5.0/4.0)*hab(m)
***rasterisze break point file m.....ixbra
        ixbra=2405-m
        write(39,'(18x,i4,i4,f12.3,f12.1,f12.3)') ixbra,irlb,hab(m),
```

```
    &alphab,breakd
          if(nmy.eq.1) then
          is=2
          else
          is=nmy
          endif
          mm=1
          do 888 m=is,ndely,nmy
          mm=mm+1
          write(24,'(18x,i4,f12.2,f12.1,f12.1)') mm,hab(m),rlb(m),dib(m)
        alphab=dib(m)-shor
        irlb=NINT(rlb(m))+1
        breakd=(5.0/4.0)*hab(m)
        ixbra=2405-mm
        write(39,'(18x,i4,i4,f12.3,f12.1,f12.3)')ixbra,irlb,hab(m),
    &alphab,breakd
888     continue
c
c
      rewind (9)
      rewind (11)
c
c......create wave height and wave angle arrays
      do 114 i=1,nx
            read(9) (wht(i,j),j=1,ny)
            read(11) (ang(i,j),j=1,ny)
114     continue
c
c.... write array values to:
c.... ascii depth, wave number, wave angle, wave height grid files
c
c
c2002    format(4644f12.2)
c
cccc Comment out old way of writing arrays
ccccccccccc       do 134 i=1,nx
ccccccccccc       write(33,2002) (wht(i,j),j=1,ny)
ccccccccccc       write(34,2002) (ang(i,j),j=1,ny)
ccccccccccc134    continue
c
CCCCCC Raster way of writing arrays!!!!!!!!!!!!!
      DO 176 j=ny,1,-1
        write(33,6666) (wht(i,j),i=1,nx)
        write(34,6666) (ang(i,j),i=1,nx)
```

```
  176  CONTINUE
6666     format(236f12.2)
6667     format(236f12.6)
c
c
          go to 901
900       write(*,'(20x,a,a,a)') '**** error **** ',ifile,' missing'
          write(*,'(20x,a)') '    press any key to continue '
          read(*,'(a)') idum
901     continue
        stop
        end
c
c---------------------------------------------------------------------
c
        subroutine tridag(a,b,c,r,u,n)
c
        parameter (nmax=250002)
        complex gam(nmax),a(n),b(n),c(n),r(n),u(n),bet
c
        bet=b(1)
        u(1)=r(1)/bet
        do 11 j=2,n
        gam(j)=c(j-1)/bet
        bet=b(j)-a(j)*gam(j)
        if(bet.eq.0)pause
        u(j)=(r(j)-a(j)*u(j-1))/bet
11      continue
        do 12 j=n-1,1,-1
        u(j)=u(j)-gam(j+1)*u(j+1)
12      continue
        return
        end
c
c---------------------------------------------------------------------
c
        subroutine wwave(aphys,ndely,nmy,dely,kbar)
c
c  compute & write wave height and direction, initial breaking point
c     imax= max grid size nmax=max no. of steps
c
        parameter (nmax=45000000,imax=4500000)
           dimension amod(nmax),alfa(nmax)
           real kbar(2,nmax)
```

```
      complex aphys(nmax)
c
      nky=0
      do 350 j=1,ndely+1
      if(nmy*(j/nmy).eq.j.or.j.eq.1) then
      nky=nky+1
c
       amod(nky)=cabs(aphys(j))
       if(amod(nky).gt..05) then
       if(j.eq.ndely+1) then
       xx=aimag((aphys(j)-aphys(j-1))/(dely*kbar(2,j)*aphys(j)))
       if(xx.gt.1) xx=1.
       if(xx.lt.-1.) xx=-1.
       alfa(nky)=asin(xx)
       else
       xx=aimag((aphys(j+1)-aphys(j))/(dely*kbar(2,j)*aphys(j)))
       if(xx.gt.1) xx=1.
       if(xx.lt.-1.) xx=-1.
       alfa(nky)=asin(xx)
       endif
       else
       alfa(nky)=0
       endif
       alfa(nky)=alfa(nky)*57.296
      endif
350   continue
c
      write(9) (amod(jj),jj=1,nky)
      write(11) (alfa(jj),jj=1,nky)
c
      return
      end
c
c---------------------------------------------------------------------
c
      subroutine inbc(amp,wk,theta,ndely,dely,aa)
c
      complex aa(*)
c
      real ky
      pi=acos(-1.)
      theta=theta*pi/180.
      ky=wk*sin(theta)
c
```

```
      do 3 j=1,ndely+1
      ar=amp*cos(ky*(j-1)*dely)
      ai=amp*sin(ky*(j-1)*dely)
c      ar=(cos(ky*(j-1)*dely)+cos(-ky*(j-1)*dely))/2.
c 2 identical
c      ai=(sin(ky*(j-1)*dely)+sin(-ky*(j-1)*dely))/2.
c waves summed
      aa(j)=cmplx(ar,ai)
3      continue
c
      return
      end
c
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c
      subroutine getkcg(d,k,cg)
c
c....  depth (meters) and frequency are input
c....  returns wave number (2pi/l) and group velocity
c
      real k
      common /grid/ ny,sy,sx,dely,delx,ndely,f,dcon,ify,ifx,tide
      data tpi/6.2831853/
c
      sig=tpi*f
      a=d*sig*sig/9.81
      if(a.ge.1) then
            yhat=a*(1+1.26*exp((-1.84)*a))
            t=exp((-2)*yhat)
            aka=a*(1+2*t*(1+t))
      else
            aka=sqrt(a)*(1+a/6.*(1+a/5.))
      endif
      k=aka/d
      x=2*k*d
      cg=tpi*(f/k)*.5*(1+x/sinh(x))
      return
      end
c
c**********************************************************************
c
      subroutine intkcg(lm,kbar,ccg,di,ikount)
c
         parameter(max=45000002)
```

```
      real kbar(2,max)
      dimension ccg(max),d(2,max),di(max)
c
      save d
           common /cut/ dc
      common /grid/ ny,sy,sx,dely,delx,ndely,f,dcon,ify,ifx,tide
      data istart,ncol,eps/1,0,.0000001/
c
c... if this is the first call, load first two columns
c
      go to (1,3) istart
1       istart=2
c... read in first 2  columns
           do 777 i=1,2
777          read(31,*) (d(i,j),j=1,ny)
        ncol=1
c... interpolate grid points for first row
      do 2 i=1,ndely
      y=1+real(i-1)/real(ify)+eps
      ym=amod(y,1.)
      iy=int(y)
      di(i)=d(1,iy)+ym*(d(1,iy+1)-d(1,iy))+tide
      call getkcg(di(i)*dcon,rk,cg)
      ccg(i)=cg
2      kbar(2,i)=rk
c
c... figure out which bathymetry grid columns should be used
c
3      icol=1+real(lm)/real(ifx)+eps
      if(icol.ne.ncol) then
        do 5 i=1,ny
5        d(1,i)=d(2,i)
        read(31,*,end=999) (d(2,j),j=1,ny)
999          ncol=icol
      endif
      dd1=d(1,100)
c
c... bilinear interpolate depths for new column of k and cg
c
15     x=1+real(lm)/real(ifx)+eps
      xm=amod(x,1.)
      do 20 i=1,ndely
      y=1+real(i-1)/real(ify)+eps
      ym=amod(y,1.)
```

```
      iy=int(y)
      di(i)=d(1,iy)+xm*(d(2,iy)-d(1,iy))+ym*(d(1,iy+1)-d(1,iy))+
     &   xm*ym*(d(2,iy+1)-d(1,iy+1)-d(2,iy)+d(1,iy))+tide
      if(di(i).le.01) then
      di(i)=.01
      endif
c
c... shift k and ccg col 2 to 1 and calculate new 2's
c
           if(di(i).lt.dc) di(i)=dc
      kbar(1,i)=kbar(2,i)
      call getkcg(di(i)*dcon,rk,cg)
      kbar(2,i)=rk
20     ccg(i)=cg
      kbar(1,ndely+1)=kbar(1,ndely)
      kbar(2,ndely+1)=kbar(2,ndely)
      ccg(ndely+1)=ccg(ndely)
      di(ndely+1)=di(ndely)
c
      return
      end
```

APPENDIX D: Code for the OCEANBAT Bathymetry Retrieval Module

```
c**********************************************************************
c
c            Bathymetry data base retrieval module oceanbat.f
c                 Scott A. Jenkins & Joseph Wasyl Jan 10, 2001
c
c**********************************************************************
c
c    THE LATTITUDE AND LONGITUDE OF THE UPPER LEFT CORNER OF A
c    BATHYMETRY GRID REQUIRED.
c    (The dimensions are specified in number of 3 second lat/lon points)
c     (we have been using a default value of 200 x 200)
c
c   reads packed grid files for the Southern California Bight
c   and writes the data to an 200x200 formatted data file, 'site'.grd.
c
c**********************************************************************
      integer*2 gdata(1201,801),dlist(12,10)
      character name*8,ofile*20,ifile*60,lfile*13,cfile*13
      character name2*60
      dimension ilat(3),ilon(3)
           real*4 latmin,latmax,lonmin,lonmax
      common /param/ ixo,iyo,ix,iy,ixmin
      common /int/ dx,dy,dgx,dgy,ang,ngx,ngy
c
c... initialize the disk list
c
      call list(dlist)
c
c... get name of the active study area
     open(11,file='oceanbat.inp',status='old')
c
      read(11,'(a)') name
c
c
      read(11,'(a)') name2
```

```
      write(namesub,'(a)') name2
c
      nn=8
      do 2 m=8,1,-1
      if(name(m:m).eq.' ') nn=m-1
2      continue
c
      write(lfile,'(a,a)') name(:nn),'.log'
c
      open(8,file=lfile)
4      continue
c
      write(*,'(//,a)')
    &' OCEAN BATHYMETRY MODULE FOR THE CALIFORNIA COASTLINE
DATABASE'
c
c
c
     read(11,*) ilat(1)
     read(11,*) z
     ilat(2)=int(z)
     ilat(3)=nint(60.*(z-int(z)))
     read(11,*) ilon(1)
     read(11,*) z2
     ilon(2)=int(z2)
     ilon(3)=nint(60.*(z2-int(z2)))
c
      read(11,*) nx
      ngx=nx
c
      read(11,*) ny
       ngy=ny
c
c.....read in upper left corner as origin lat lon
c......write files across from left to right starting at origin
      nrot=3
c
c... figure out dimension of 3 sec by 3 sec grid
c
      dy=92.6
      rlat=real(ilat(1))+real(ilat(2))/60+real(ilat(3))/3600
      dx=dy*cos(rlat*.017453)
c
      if(nrot.eq.1.or.nrot.eq.3) then
```

```
          dsave=dx
          dx=dy
          dy=dsave
        endif
c
c
        imx=0
        imy=0
c
c...output information to log file
c
        write(8,'(6i4,a)') ilat,ilon
        write(8,'(2f5.1,a)') dx,dy
        write(8,'(2i5,a)') ngx,ngy
        write(8,'(a)') ' 0 0 0 0'
c
        ang=0
        ang=pi*ang/180
        if(ang.lt.0) ang=2*pi+ang
c
c... truncate origin to a grid point
c
        ilat(3)=3*(nint(real(ilat(3))/3.))
        ilon(3)=3*(nint(real(ilon(3))/3.))
c
        iyo=ilat(1)*1200+ilat(2)*20+ilat(3)/3-imy
        ixo=150000-(ilon(1)*1200+ilon(2)*20+ilon(3)/3)-imx
c
c... adjust origin based on rotation
c
        if(nrot.eq.1) then
              ixo=ixo-ngy+1
              nsave=ngy
              ngy=ngx
              ngx=nsave
         elseif(nrot.eq.2) then
              ixo=ixo-ngx+1
              iyo=iyo-ngy+1
         elseif(nrot.eq.3) then
              iyo=iyo-ngx+1
              nsave=ngx
              ngx=ngy
              ngy=nsave
         endif
```

```
c
c... find range of necesssary input data in both lat/lon and
c     database units.
c
c
      ixmin=ixo
      ixmax=ixo+ngx-1
      iymin=iyo
      iymax=iyo+ngy-1
c
c
c... convert back to lat/lon coordinates
c
      latmin=real(iymin-1)/1200.
      latmax=real(iymax)/1200.
      lonmax=(150000.-(ixmin+1))/1200.
      lonmin=(150000.-ixmax)/1200.
c
      print *,' lat/lon range ',latmin,latmax,lonmin,lonmax
c
      do 60 i=latmin,latmax
      nggx=1
      nggy=1
            iy=i*1200
            nys=iymin-iy
            nye=iymax-iy
            if(nys.lt.1) then
             nggy=abs(nys)+2
             nys=1
            endif
            if(nye.gt.1200) then
            if(nye.gt.2400) then
             nye=1200
             else
             nye=1200
             nggy=1
             endif
            endif
      do 60 j=lonmax,lonmin,-1
            ix=150000-(j+1)*1200-1
            nxs=ixmin-ix
            nxe=ixmax-ix
            if(nxs.lt.1) then
             nggx=abs(nxs)+2
```

```
                nxs=1
               endif
               if(nxe.gt.1200) then
c               if(nxe.gt.2400) then
c                    nxe=1200
c                    nggx=1201
c                    else
c                nggx=1
               nxe=1200
               endif
c              endif
c
c... figure out which bathymetry file to read
c
      il=i-31
      jl=j-116
      ndisk=dlist(il,jl)
c
 45    continue
c
c
      write(ifile,1000)name2(1:LSTGDCHR(name2)), i,j
c
1000    format(a,'/',i2,i3,'pg.dta')
c
      close(20)
      print *,' searching: ',ifile
      open(20,file=ifile,status='old',form='unformatted',err=50)
      go to 51
50     write(*,'(a,a,a)')
     +  ' ????? unable to find    ',ifile,'  on the disk ????? '
      write(*,'(a,\)') ' abort loading ? (y/n) : '
      read(*,*) ans
      if(ans.eq.'y'.or.ans.eq.'Y') then
      stop
      else
      go to 45
      endif
c
51     continue
c
      call unpack(gdata,nxs,nxe,nys,nye,nggx,nggy)
c
60     continue
```

```
c
c... output the grid array, one s to n column at a time from w to e
c
      write(ofile,2000) name(:nn)
2000    format(a,'.grd')
c
      open(12,file=ofile)
c
c... output depends on rotation
c
2009    format(200f8.3)
      if(nrot.eq.1) then
      do 70 j=1,ngy
      write(12,2009) (real(gdata(i,j))*.1+.853,i=ngx,1,-1)
70      continue
      elseif(nrot.eq.2) then
      do 71 i=ngx,1,-1
      write(12,2009) (real(gdata(i,j))*.1+.853,j=ngy,1,-1)
71      continue
      elseif(nrot.eq.3) then
      do 72 j=ngy,1,-1
      write(12,2009) (real(gdata(i,j))*.1+.853,i=1,ngx)
72      continue
      else
      do 73 i=1,ngx
      write(12,2009) (real(gdata(i,j))*.1+.853,j=1,ngy)
73      continue
      endif
c
c... make the default contour commmand file for the base map
c
c... maximum length is 5.5 inches
c
      rlmax=max(real(ngx)*dx,real(ngy)*dy)
      h=6.5*real(ngy)*dy/rlmax
      w=6.5*real(ngx)*dx/rlmax
      write(cfile,'(a,a)') name(:nn),'.cnt'
      open(7,file=cfile)
      write(7,'(a,a)') 'file     ',ofile
      write(7,'(a,a)') 'format   binary'
      write(7,*) 'axes ',lonmax,lonmin,latmin,latmax
      write(7,'(a)') 'xlabel Latitude'
      write(7,'(a)') 'ylabel Longitude'
      write(7,'(a)') 'caption'
```

```
      write(7,'(a)') 'title  Depth Contours (meters from MSL)'
      write(7,'(a)') 'letter   .1 .1 .1 .1 .1'
      write(7,'(a,f5.2)') 'width    ',w
      write(7,'(a,f5.2)') 'height   ',h
      write(7,'(a,i4,i4)') 'read     ',ngx,ngy
      write(7,*) 'plot ',.5*(8.5-w),.5*(11.-h)
      write(7,'(a)') 'stop'
c
c.....................................................................
c.........write ascii bathymetry
c        rewind(12)
c
c
c... open ascii bathymetry file
c       write(ofile1,'(a,a)') name(:nn),'.dep'
c       open(17,file=ofile1)
c
c
      end
c
c
c**********************************************************************
c
      subroutine unpack(gdata,nxs,nxe,ns,ne,ngx,ngy)
c
c... longitudes are reversed as read in to array since opposite of xy coor.
c
      integer*2 gdata(1201,801),dum
      integer*2 rec(1200),pdata(1200),idata(1200),dmin,dmax
      common /param/ ixo,iyo,ix,iy,ixmin
      data dmin,dmax/5001,-999/
c
c
c... loop through the files with desired data
c
      read(20) rec
c
c...  read records
c
      ny=ngy
      do 100 i=1,ne
c      print *, ' reading rec ',i
c...  unpacking data
c
```

```
c... check if record only contains deep water or land
c
      if(rec(i).lt.0) then
      if(i.lt.ns) go to 100
      if(rec(i).eq.-1) then
            depth=3050
      else
            depth=-20
      endif
            do 33 m=1,1200
33            idata(m)=depth
            go to 91
      endif
c
c... unpack the row
c
      icnt=1201
c
      if(i.lt.ns) then
      read(20) dum
      go to 100
      endif
c
      read(20) (pdata(m),m=1,rec(i))
c

      do 90 j=1,rec(i)
c
      if(pdata(j).lt.-10000) then
            if(pdata(j).lt.-20000) then
                  ncnt=abs(pdata(j)+20000)
                  depth=-20
            else
                  ncnt=abs(pdata(j)+10000)
                  depth=3050
            endif
            do 85 m=1,ncnt
            icnt=icnt-1
85            idata(icnt)=depth
            go to 90
      endif
c
      icnt=icnt-1
      idata(icnt)=pdata(j)
```

```
c
90      continue
c
c... place desired data from record into grid array
c
91      continue
        nx=ngx
c
        do 92 jj=nxs,nxe
c
        gdata(nx,ny)=idata(jj)
c       dmax=max0(gdata(kx,ky),dmax)
c       dmin=min0(gdata(kx,ky),dmin)
 92     nx=nx+1
c
 98     ny=ny+1
c
c.... save rec
c
100     continue
c       print *,dmin,dmax
c
c       ngx=nx
c       ngy=ny
        return
        end
c
c
c*******************************************************************************
c
        subroutine list(dlist)
c
c... contains the floppy disk no. for grid files i=lat-31; j=lon-116
        integer*2 dlist(12,10)
c
        do 10 i=1,12
        do 10 j=1,10
        dlist(i,j)=-1
10      continue
c
        dlist(1,1)=1
        dlist(1,2)=1
        dlist(1,3)=1
        dlist(2,2)=1
```

```
      dlist(2,1)=2
      dlist(2,3)=2
      dlist(3,2)=2
      dlist(4,4)=2
      dlist(2,4)=3
      dlist(5,5)=3
      dlist(3,3)=3
      dlist(3,4)=4
      dlist(4,5)=4
      dlist(5,6)=5
c
      return
      end
c*******************************************************************************
    INTEGER FUNCTION LSTGDCHR(NAMESUB)

    CHARACTER*(*)    NAMESUB
    INTEGER    II,CLEN,INDEX

    CLEN = LEN(NAMESUB)
    DO 100 II = CLEN,1,-1
100   IF( ICHAR(NAMESUB(II:II)) .GT. 60 .AND.
   1     ICHAR(NAMESUB(II:II)) .LT. 127 )GOTO 101
101   INDEX=II

    LSTGDCHR = INDEX
    RETURN

    END
```

APPENDIX E: Code for the SEDXPORT Transport Model

```
c**********************************************************************
c
c  sedxport3.for Transport Model - (bottom, surfzone, outfall sources)
c        with NULL POINT January. 24, 2005 & selected grid point - 10:00
c          TIME STEP MODE beach outfall source and canyon sink modules
c            Littoral Advection/Diffusion
c             Fine  Sediment  Dispersion MODEL
c             written by Scott A.Jenkins & Joseph Wasyl
c
c
c**********************************************************************
c
c**********************************************************************
c
      parameter (ni=200, nj=200)
c
       real*4 n0,n0_l
c
      character name*8,infil1*12,infil2*12
      character infile3*12,ifile2*12
      Dimension wnum(ni,nj),wht(ni,nj),depth(ni,nj)
      dimension iyb(nj),ixb(nj),bh(nj),ba(nj),bd(nj)
       dimension ubr(nj),dxbr(nj),dxbave(nj),ubave(nj)
      dimension zw(5)
       dimension r7(10,5),revr7(10,5)
       dimension d(10),rcp(10),rc(10),rcsp(10),rszcp(10)
       dimension rrs(10),rrsp(10)
c
c**********************null point arrays**********************
       dimension type(ni,nj)
c*********************************************************
c ... second outfall arrays
       dimension rrs2(10),rrsp2(10)
      dimension rrivr2(10,5),pnrr2(10,5)
c*********************************************************
c
c
       dimension rsurf(10,5),rriv(10,5),rbot(10,5)
       dimension pns(10,5),pnr(10,5),pnb(10,5),pnt(10,5)
```

```
      dimension sp(10),sp2(10),spp(10)
c
      dimension suml1(ni,nj),suml2(ni,nj)
      dimension suml3(ni,nj),suml4(ni,nj),b(ni,nj),b2(ni,nj)
      dimension ux(ni,nj),uy(ni,nj)
c
c_____________________________________________________________________
c.......arrays unique to selected grid point loop
      dimension sum2(101),zw3(101),dep2(101),slope(101),a4402(101)
      dimension r72(10,101),revr72(10,101),dep(100)
      dimension rsurf2(10,101),rriv2(10,101),rbot2(10,101)
      dimension pns2(10,101),pnr2(10,101),pnb2(10,101),pnt2(10,101)
c
c*******************************************************
c ... second outfall arrays unique to selected grid point
      dimension rriv2r2(10,101),pnr2r2(10,101)
c*******************************************************
c*******************************************************
c..Salinity module arrays
      dimension salmean(5),sal2mean(101)
      dimension sriv1(5),sriv2(5),salr7(5)
     dimension s2riv1(101),s2riv2(101),sal2r7(101)
     dimension sall1(ni,nj),sall2(ni,nj),sall3(ni,nj)
     dimension sall4(ni,nj)
     dimension acdom1(ni,nj),acdom2(ni,nj),acdom3(ni,nj)
     dimension acdom4(ni,nj),a440(101)
c**********************************************************************
c
C
c
c
c
      open(18,file='CEM_sedxport3.inp',status='old')
c
      read(18,'(a)') name
         read(18,*) nx
      read(18,*) ny
      read(18,*) igrdx
         read(18,*) igrdy
         read(18,*) sx
      read(18,*) sy
      read(18,*) persw
      read(18,*) perwin
      read(18,*) hsw
```

```
read(18,*) hwin
read(18,*) tanbeta
read(18,*) aks
read(18,*) akb
read(18,*) ak2
   read(18,*) rci
   read(18,*) rszi
read(18,*) ak
read(18,*) q
read(18,*) irx
read(18,*) iry
read(18,*) dr
read(18,*) rwidth
read(18,*) rrsi
read(18,*) q2
read(18,*) irx2
read(18,*) iry2
read(18,*) dr2
read(18,*) rwidth2
read(18,*) rrsi2
read(18,*) ak3
read(18,*) ak4
read(18,*) ak5
read(18,*) ibins
read(18,*) verdat
read(18,*) numlay
read(18,*) alay1
read(18,*) alay2
read(18,*) alay3
read(18,*) alay4
read(18,*) surf
read(18,*) river
read(18,*) river2
read(18,*) bottom
read(18,*) rhos
read(18,*) rhosr
read(18,*) rhosr2
read(18,*) tcon
read(18,*) tconriv
read(18,*) deltat
read(18,*) timestep
read(18,*) n0
read(18,*) gamma
read(18,*) salo
```

```
      read(18,*) w0sal
      read(18,*) ak3s
      read(18,*) ak5s
      read(18,*) aksal
      read(18,*) domslope
      read(18,*) dominter
      read(18,*) domback
      read(18,*) tconsal
      read(18,*) ak7
      read(18,*) ilat1
      read(18,*) z
      read(18,*) two_layer
      read(18,*) v
      read(18,*) ak8
      read(18,*) p_mbar
      read(18,*) dmix_for
      read(18,*) dmix
      read(18,*) ak2_l
      read(18,*) ak_l
      read(18,*) ak3_l
      read(18,*) ak5_l
      read(18,*) tcon_l
      read(18,*) tconriv_l
      read(18,*) n0_l
      read(18,*) gamma_l
      read(18,*) delsal_l
      read(18,*) w0sal_l
      read(18,*) ak3s_l
      read(18,*) ak5s_l
      read(18,*) aksal_l
      read(18,*) tconsal_l
c
c...convert time to seconds
      time=deltat*60*60
c.......convert tcon by multiplying by 10 E-6
      tcon=tcon*0.001
c
      if(timestep.NE.0.0)then
      open(27,file='dmix_wind.dat',status='old')
      read(27,*) dmix_old
      read(27,*) epsilonw_old
      dmix_old=dmix_old
      close(27)
      else
```

```
c.......when no forecast available dmix_old is set to nowcast n0_l at t=0
      dmix_old=n0_l
      endif
c
c.......convert background in mg/l to number of grains
      n0=n0*100
c
c
      ilat2=int(z)
      ilat3=nint(60.*(z-int(z)))
      theta=real(ilat1)+real(ilat2)/60+real(ilat3)/3600
      v=v*0.5148*100.0
      ak8=0.00009/((v**0.5)+1.1103)
      ustar=(ak8*(v**2))**0.5
      rot_e=0.000072685
      rho_a=0.001293*(p_mbar/760)**0.714285714
      f=2.0*rot_e*SIND(theta)
c
c
c......calculate for residual from previous time step
c.......epsilonw is in cgs units
      epsilonw=0.0000043*(v**2)
      if(v.LE.600)epsilonw=0.0000000102*(v**3)
      if(timestep.EQ.0.0)epsilonw_old=epsilonw
c
c..calculate sediment layer depth in meters when dmix_for=0 (no forecast)
      if(dmix_for.EQ.0.0)then
      dmix=0.4*ustar/(f*100)
      endif
c
c...if a forecast dmix is used do not modify from previous timestep
      if(dmix_for.NE.0)go to 1867
      dmix=dmix+((dmix_old-dmix)*
     &EXP(-1.0*epsilonw_old*time/(dmix_old*100.0)**2))
1867   continue
c
c............in a single layer system dmix is set to 500 meters!!
      if(two_layer.EQ.0.0)dmix=500.0
c
c
c........dmix still in meters prior to writing
       open(27,file='dmix_wind.dat',status='unknown')
       write(27,8030)dmix
       write(27,8030)epsilonw
```

```
8030     format(f20.10)
c
c.....convert dmix back to centimeters for subsequent calculations
       dmix=dmix*100.0
c
      alay3=(dmix-100)
      alay4=(dmix+100)
c
c
      open(19,file='bulk_density.dat',status='old')
      read(19,*) rci1
      read(19,*) rci2
      read(19,*) rci3
      read(19,*) rci4
      read(19,*) rci5
      read(19,*) rci6
      read(19,*) rci7
      read(19,*) rci8
      read(19,*) rci9
      read(19,*) rci10
      read(19,*) rci11
      read(19,*) rci12
      read(19,*) rci13
      read(19,*) rci14
c
      ires=101
      riv2=river2
      riv=river
      bot=bottom
c
c
      salmax=(domback-dominter)/domslope*(-1.0)
c
c....divide n0 grains among the first 5 grain size bins
      an0b1=n0*.767
      an0b2=n0*.179
      an0b3=n0*.0376
      an0b4=n0*.00886
      an0b5=n0*.00609
      an0b6=n0*.00142
      an0b7=n0*.000248
      an0b8=n0*.000121
      an0b9=n0*.0000484
      if(an0b1.LE.2.0)an0b1=2.0
```

```
      if(an0b2.LE.2.0)an0b2=2.0
      if(an0b3.LE.2.0)an0b3=2.0
      if(an0b4.LE.2.0)an0b4=2.0
      if(an0b5.LE.2.0)an0b5=2.0
      if(an0b6.LE.2.0)an0b6=2.0
      if(an0b7.LE.2.0)an0b7=2.0
      if(an0b8.LE.2.0)an0b8=2.0
      if(an0b9.LE.2.0)an0b9=2.0
c
c
       per=persw
c
      numlay=4
      if(numlay.GE.4)numlay=4
c

c.....open array of bulk density values from previous time step
c
c
      OPEN(2, FILE='timestep.sed', ACCESS='DIRECT', RECL=24,
     &  FORM='UNFORMATTED')
c
c.......open planview of grain number output files
c
c
c... open ascii file layer 1 grain number / cc
      open(41,file='layer1.sed')
      open(81,file='layer1.sal')
      open(85,file='layer1.dom')
      open(91,file='layer1.slp')
c
c
c... open ascii file layer 1 grain number / cc
      open(42,file='layer2.sed')
      open(82,file='layer2.sal')
      open(86,file='layer2.dom')
      open(92,file='layer2.slp')
c
      if(two_layer.NE.0)then
c... open ascii file layer 1 grain number / cc
      open(43,file='layer3.sed')
      open(83,file='layer3.sal')
      open(87,file='layer3.dom')
c
```

```
c... open ascii file layer 1 grain number / cc
      open(44,file='layer4.sed')
      open(84,file='layer4.sal')
      open(88,file='layer4.dom')
c
      endif
c
c
c
         freq=1/per
      pi=acos(-1.)
      g=980.0
      ro=1.03
     omega=2*pi/per
c
c
         nn=8
         do 3 m=8,1,-1
3        if(name(m:m).eq.' ') nn=m-1
c
c
c... open grain size and mass percent file 'masstotal.dat'
c
      open(26,file='masstotal.dat',status='old')
c
c... read data from file
c
      nfact=1
      do 44 i=1,ibins
      read(26,*)d(i),rcp(i),rcsp(i),rrsp(i),rrsp2(i)
c ..... convert microns to centimeters
      d(i)=d(i)*.0001
      rc(i)=rcp(i)*rci
      rszcp(i)=rcsp(i)*rszi
      rrs(i)=rrsp(i)*rrsi
      rrs2(i)=rrsp2(i)*rrsi2
      nfact=nfact*i
44    continue
c
c...open selected point file at selected grid point(igrdx,igrdy)
      open(99,file='profile.sed',status='unknown')
c
c
c*********************NULL POINT****************************
```

```
c... open bottom type classification file (from grass)
      open(29,file='bottom_type.dat',status='old')
c
c
c
c...open bottom distribution file at selected crossection(igrdy)
c.........this part of program commented out for integrated cwc model
c....     open(50,file='nullpt.dat',status='unknown')
c

c.....open bottom distribution file at selected point(igrdx,igrdy)
c.......this part commented out for integrated model
c.        open(88,file='nullpt.igrdx')
c
c*************************************************************
c
c... open ascii wave number file from swell component
      write(ifile2,'(a,a)') name(:nn),'.wvn'
      open(32,file=ifile2,status='old')
c
c... open ascii depth file corrected to tide
         write(infil1,'(a,a)') name(:nn),'.dep'
      open(20,file=infil1,status='old')
c
c.......open total wave height file
         write(infil2,'(a,a)') name(:nn),'.wht'
      open(9,file=infil2,status='old')
c
c... open ascii file x-component of current
      open(45,file='xcur.xpt')
c
c... open ascii file y-component of current
      open(46,file='ycur.xpt')
c
c
c... read bathymetry, wave height, swell wave number x1, y=1,200
c....read x-component of current, y-component of current
c.....x1, y1 is bottom left corner looking at page by convention
c
c.......read into arrays depth, wave height, wave number
      do 111 i=1,nx
      read(20,*) (depth(i,j),j=1,ny)
      read(9,*)(wht(i,j),j=1,ny)
      read(32,*)(wnum(i,j),j=1,ny)
```

```
111     continue
c
c.......read in xcur, ycur, bot type verticle system reversed (raster)
        do 168 j=ny,1,-1
        read(45,*)(ux(i,j),i=1,nx)
        read(46,*)(uy(i,j),i=1,nx)
        read(29,*) (type(i,j),i=1,nx)
c
168     continue
c
c
c..... open breaker input file
            write(infile3,'(a,a)') name(:nn),'.bra'
        open(38,file=infile3)
c
c.... read x,y, breaker height, breaker angle, breaker depth
        do 150 n=1,ny
        read(38,*) iyb(n),ixb(n),bh(n),ba(n),bd(n)
c
c..........determine wave height, wnum at the break point
         ibpx=ixb(n)-1
        whtbc=wht(ibpx,n)*100
       wnumbc=wnum(ibpx,n)/100
       depthbc=depth(ibpx,n)*100
        wndepb=wnumbc*depthbc
c
c...create ix by 200 arrays of dxbr's and ubr's at the break point
        dxbr(n)=whtbc/SINH(wndepb)
        ubr(n)=dxbr(n)*omega
c
150     continue
c
c...........calculate average values dxbave and ubave
         do 151 i=1,200
c
        im1=i-1
        im2=i-2
        ip1=i+1
        ip2=i+2
        if(im1.LT.1)im1=1
        if(im2.LT.1)im2=1
        if(ip1.GT.200)ip1=200
        if(ip2.GT.200)ip2=200
        dxbave(i)=(dxbr(i)+dxbr(im1)+dxbr(im2)+dxbr(ip1)+dxbr(ip2))/5
```

```
      ubave(i)=(ubr(i)+ubr(im1)+ubr(im2)+ubr(ip1)+ubr(ip2))/5
c
151     continue
c
c.............initilize icount to 0 outside of iy,ix, and ipart loops
c..........and rtold,rsold,qsold,qs2old,salold,salold2 for timestep=0
       icount=0
       rtold=0.0
       rsold=0.0
       qsold=0.0
       qs2old=0.0
       salold=0.0
       salold2=0.0
c
c..........determine wave height, wnum at the outfall
c       whtrm=wht(irx,iry)*100
c      wnumrm=wnum(irx,iry)/100
c      depthrm=depth(irx,iry)*100
c       wndeprm=wnumrm*depthrm
c
c
c........ at the outfall
c       drm=whtrm/SINH(wndeprm)
c       urm=drm*omega
c
      do 1800 iy=1,ny
      allxbrk=0
c
      bd1=bd(iy)*100
      if(bd1.LT.10.0)bd1=10.0
      ba1=ba(iy)
      bh1=bh(iy)*100
c
c..........determine wave height, wnum at the break point
       ibpx=ixb(iy)-1
      whtbc=wht(ibpx,iy)*100
     wnumbc=wnum(ibpx,iy)/100
     depthbc=depth(ibpx,iy)*100
      wndepb=wnumbc*depthbc
c
c........ at the break point
      dxb=whtbc/SINH(wndepb)
      ub=dxb*omega
c
```

```
c
c
      stopdep=bd(iy)
c
      do 1801 ix=1,nx
c
c***************null point - bottom type*******************************
      if(type(ix,iy).LE.100)go to 7006
c
      if(type(ix,iy).LE.200)then
      rci=(rci2-rci1)*(type(ix,iy)-100)/100+rci1
      go to 7007
      endif
c
      if(type(ix,iy).LE.300)then
      rci=(rci3-rci2)*(type(ix,iy)-200)/100+rci2
      go to 7007
      endif
c
      if(type(ix,iy).LE.400)then
      rci=(rci4-rci3)*(type(ix,iy)-300)/100+rci3
      go to 7007
      endif
c
      if(type(ix,iy).LE.500)then
      rci=(rci5-rci4)*(type(ix,iy)-400)/100+rci4
      go to 7007
      endif
c
      if(type(ix,iy).LE.200)then
      rci=(rci2-rci1)*(type(ix,iy)-100)/100+rci1
      go to 7007
      endif
c
      if(type(ix,iy).LE.300)then
      rci=(rci3-rci2)*(type(ix,iy)-200)/100+rci2
      go to 7007
      endif
c
      if(type(ix,iy).LE.400)then
      rci=(rci4-rci3)*(type(ix,iy)-300)/100+rci3
      go to 7007
      endif
c
```

```
      if(type(ix,iy).LE.500)then
      rci=(rci5-rci4)*(type(ix,iy)-400)/100+rci4
      go to 7007
      endif
c
      if(type(ix,iy).LE.600)then
      rci=(rci6-rci5)*(type(ix,iy)-500)/100+rci5
      go to 7007
      endif
c
      if(type(ix,iy).LE.700)then
      rci=(rci7-rci6)*(type(ix,iy)-600)/100+rci6
      go to 7007
      endif
c
      if(type(ix,iy).LE.800)then
      rci=(rci8-rci7)*(type(ix,iy)-700)/100+rci7
      go to 7007
      endif
c
      if(type(ix,iy).LE.900)then
      rci=(rci9-rci8)*(type(ix,iy)-800)/100+rci8
      go to 7007
      endif
c
      if(type(ix,iy).LE.1000)then
      rci=(rci10-rci9)*(type(ix,iy)-900)/100+rci9
      go to 7007
      endif
c
      if(type(ix,iy).LE.1100)then
      rci=(rci11-rci10)*(type(ix,iy)-1000)/100+rci10
      go to 7007
      endif
c
      if(type(ix,iy).LE.1200)then
      rci=(rci12-rci11)*(type(ix,iy)-1100)/100+rci11
      go to 7007
      endif
c
      if(type(ix,iy).LE.1300)then
      rci=(rci13-rci12)*(type(ix,iy)-1200)/100+rci12
      go to 7007
      endif
```

```
c
      if(type(ix,iy).LE.1400)then
      rci=(rci14-rci13)*(type(ix,iy)-1300)/100+rci13
      go to 7007
      endif
c
      if(type(ix,iy).GT.1400)then
      rci=rci14
      go to 7007
      endif
c
7006    rci=rci1
7007    continue
c
       distbp=((201-ix)-ixb(iy))*sx*100
c*****************************************************************
c
      uy1=uy(ix,iy)+0.000001
      ux1=ux(ix,iy)+0.000001
c
c
c
c.....ADD resident sediment volume
c..... initialize total grain variable at each x,y location
      suml1(ix,iy)=n0
      suml2(ix,iy)=n0
      suml3(ix,iy)=n0
      suml4(ix,iy)=n0
c
      sall1(ix,iy)=salo
      sall2(ix,iy)=salo
      sall3(ix,iy)=salo
      sall4(ix,iy)=salo
c
      b(ix,iy)=gamma
      b2(ix,iy)=gamma
c
c
     if(depth(ix,iy).LE.stopdep)then
     allxbrk=1.0
      do 478 irt=ix,nx
      suml1(irt,iy)=-1.0
      suml2(irt,iy)=-1.0
      suml3(irt,iy)=-1.0
```

```
      suml4(irt,iy)=-1.0
c
      sall1(irt,iy)=-1.0
      sall2(irt,iy)=-1.0
      sall3(irt,iy)=-1.0
      sall4(irt,iy)=-1.0
c
      acdom1(irt,iy)=-1.0
      acdom2(irt,iy)=-1.0
      acdom3(irt,iy)=-1.0
      acdom4(irt,iy)=-1.0
c
c
      b(irt,iy)=-1.0
      b2(irt,iy)=-1.0

478    continue
      go to 479
      endif
c
c
c
c ..... convert wave hieght, water depth, and wave number into cgs
      whtc=wht(ix,iy)*100
      wnumc=wnum(ix,iy)/100
      depthc=depth(ix,iy)*100
     wndep=wnumc*depthc
c
      d0=whtc/SINH(wndep)
      u=omega*d0
c
c
c
c
      do 1776 ipart=1,ibins
c
      dip=d(ipart)
      rrsfix2=rrs2(ipart)
      rrsfix=rrs(ipart)
      rcspfix=rszcp(ipart)
c
c************************null point begin*****************************
c
      d0np=d0
```

```
      dm=ak7*d0np
      unp=rszi/(rhos*pi*dm)
      unpd1=unp*d(1)
      if(unpd1.GT.ibins)unp=ibins/d(1)
      if(unp.LT.ibins/(100*d(1)))unp=ibins/(100*d(1))
      unpdip=unp*dip
      rc(ipart)=rci*6.092*(((unp*dip)**ibins)/nfact)*EXP(-1*unp*dip)
      if(rc(ipart).LT.0.0000000000000001)rc(ipart)=0.0000000000000001
c
c.....nullpt selected grid write commented out
c       if(iy.NE.igrdy)go to 8001
c       if(ix.NE.igrdx)go to 8002
c       write(88,8003)dip,rc(ipart),depth(ix,iy),unpdip
c8003   format(4e10.3)
c8002   continue
c8001   continue
c**********************null point end*********************************
      rcfix=rc(ipart)
c
c
       icount=icount+1
c
      if(timestep.EQ.0.0)go to 81
      read(2, REC=icount)rtold,rsold,qsold,qs2old,salold,salold2
81      continue
c
      if(ipart.EQ.1)w0=.00011
      if(ipart.EQ.2)w0=.00043
      if(ipart.EQ.3)w0=.0017
      if(ipart.EQ.4)w0=.0050
      if(ipart.EQ.5)w0=.0108
      if(ipart.EQ.6)w0=.044
      if(ipart.EQ.7)w0=.17
      if(ipart.EQ.8)w0=.38
      if(ipart.EQ.9)w0=.98
c
c*****************************************************************
      if(iy.NE.igrdy)go to 4000
      if(ix.NE.igrdx)go to 4001
c
      ipart2=ipart
c
c
      fw=EXP(5.2*((2.5*dip/d0)**0.2)-6.0)
```

```
c
      delta=0.72*d0*(2.5*dip/d0)**0.25
      deltab=0.72*dxb*(2.5*dip/dxb)**0.25
      deltar=0.72*dxbave(iy)*(2.5*dip/dxbave(iy))**0.25
      deltas=0.72*dxbave(iy)*(0.000006625/dxbave(iy))**0.25
c
c
c.....for the outfall sediment flux use running mean values of ub *dxb
     shieldr=ubave(iy)**2/((rhos/ro-1.0)*g*dip)
     epsilonr_l=0.00035*ak3_l*((ubave(iy)/w0)**0.68)*
    &(shieldr**0.4)*deltar*g*per
     if(epsilonr_l.LT.0.0000000001)epsilonr_l = 0.0000000001
     epsilonr=epsilonr_l+epsilonw
c**
c.....for the outfall plume salinity use running mean values of ub *dxb
     shieldrs=ubave(iy)**2/(.03*g*dr)
     epsilonrs_l=0.00035*ak3s*((ubave(iy)/w0sal)**0.68)*
    &(shieldrs**0.4)*deltas*g*per
     if(epsilonrs_l.LT.0.0000000001)epsilonrs_l = 0.0000000001
     epsilonrs=epsilonrs_l+epsilonw
c
c.....at the local break point
      shieldb=ub**2/((rhos/ro-1.0)*g*dip)
      epsilonb_l=0.00035*ak3*((ub/w0)**0.68)*(shieldb**0.4)
    &*deltab*g*per
      if(epsilonb_l.EQ.0)epsilonb_l=0.0000000001
      epsilonb=epsilonb_l+epsilonw
c
c.....at the local break point for disequilibrium profile
      epsilonbs_l=0.00035*ak3s*((ub/w0sal)**0.68)*(shieldrs**0.4)
    &*deltas*g*per
      if(epsilonbs_l.EQ.0.0000000001)epsilonbs_l = 0.0000000001
      epsilonbs=epsilonbs_l+epsilonw
c
c.......offshore
      shield=u**2/((rhos/ro-1.0)*g*dip)
      epsilon_l=0.00035*ak2*((u/w0)**0.68)*(shield**0.4)*delta*g*per
      if(epsilon_l.EQ.0.0000000001)epsilon_l = 0.0000000001
      epsilon=epsilon_l+epsilonw
c
c......outfall shields and epsilon calculated in RIVERM subroutine
c**
c**
      rrsfix2=rrs2(ipart2)
```

```
      rrsfix=rrs(ipart2)
      rcspfix=rszcp(ipart2)
      rcfix=rc(ipart2)
c
      if(riv.EQ.1)then
      CALL RIVERM(epsilonr,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
     &sy,rrsfix,ak5,w0,deltab,rhosr,ro,dip,g,per,ak3,time,qsold,
     &depthc,tconriv,qs)
      CALL SALM1(epsilonrs,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
     &sy,salo,ak5s,w0sal,deltas,rhosr,ro,dip,g,per,ak3,time,salold,
     &depthc,tconsal,sal)
c
      else
      continue
      endif
c
      if(riv2.EQ.1)then
      CALL RIVER2M(epsilonr,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2,sx,
     &sy,rrsfix2,ak5,w0,deltab,rhosr2,ro,dip,g,per,ak3,time,qs2old,
     &depthc,tconriv,qs2)
c**
c**
      CALL SALM2(epsilonrs,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2,sx,
     &sy,salo,ak5s,w0sal,deltas,rhosr2,ro,dip,g,per,ak3,time,salold2,
     &depthc,tconsal,sal2)
c
      else
      continue
      endif
c
      if(surf.EQ.1)then
      CALL SURFLM(epsilonb,bd1,ba1,bh1,ibpx,ix,iy,
     &ak4,aks,akb,dip,w0,pi,g,rhos,ro,tanbeta,rcspfix,time,rsold,
     &depthc,tcon,rs)
      else
      continue
      endif
c
c
      if(bot.EQ.1)then
c**
c**
      CALL BOTTOMM(ix,iy,u,shield,fw,ak,pi,wndep,rcfix,time,rtold,
     &depthc,tcon,rt,w0,epsilon)
```

```
      else
      continue
      endif
c
      do 2002 k2=1,ires
      zw3(k2)=depthc/100*(k2-1)
      dep2(k2)=depthc/100*(ires-k2)
      if(k2.EQ.1)zw3(k2)=delta
      if(k2.EQ.1)dep2(k2)=depthc-delta
c
c ....sediment transport calculations
c.....initialize sal2mean(k2)
     sal2mean(k2)=salo
      a4402(k2)=dominter-domslope*sal2mean(k2)
      if(sal2mean(k2).GE.salmax)a4402(k2)=domback
       if(dmix.GE.dep2(k2))then
      sal2r7(k2)=(-1.0)*dep2(k2)*aksal*w0sal/epsilonbs
      else
      sal2r7(k2)=(-1.0)*dep2(k2)*aksal*((dimx/4.21)**2.4)
    &*w0sal/epsilonbs_l
      endif
c
       if((depthc-dmix).GE.zw3(k2))then
      r72(ipart2,k2)=(-1.0)*zw3(k2)*w0/epsilon_l
      else
      r72(ipart2,k2)=(-1.0)*zw3(k2)*w0*(dmix/dip)**2.4/epsilon
      endif
       if((depthc-dmix).LT.0.0)r72(ipart2,k2)=(-1.0)
    &*zw3(k2)*w0/epsilon
c
       if(dmix.GE.dep2(k2))then
      revr72(ipart2,k2)=(-1.0)*dep2(k2)*w0/epsilonb
      else
      revr72(ipart2,k2)=(-1.0)*dep2(k2)*w0*
    &(dmix/dip)**2.4/epsilonb_l
     endif
c**
c**
      if(surf.EQ.1)then
      rsurf2(ipart2,k2)=rs*EXP(r72(ipart2,k2))
      pns2(ipart2,k2)=(6.0/(pi*dip**3))*rsurf2(ipart2,k2)/rhos
      else
      pns2(ipart2,k2)=0
      endif
```

```
C
      if(riv.EQ.1)then
      s2riv1(k2)=sal*EXP(sal2r7(k2))
      rivsum=s2riv1(k2)
      sal2mean(k2)=salo-s2riv1(k2)
      a4402(k2)=dominter-domslope*sal2mean(k2)
      if(sal2mean(k2).GE.salmax)a4402(k2)=domback
      rriv2(ipart2,k2)=qs*EXP(revr72(ipart2,k2))
      pnr2(ipart2,k2)=(6.0/(pi*dip**3))*rriv2(ipart2,k2)/rhosr
      else
      pnr2(ipart2,k2)=0
      endif
C**
C**
      if(riv2.EQ.1)then
      s2riv2(k2)=sal2*EXP(sal2r7(k2))
      rivsum=s2riv1(k2)+s2riv2(k2)
      if(rivsum.GT.salo)then
      rivsum=salo
      endif
      sal2mean(k2)=salo-rivsum
      a4402(k2)=dominter-domslope*sal2mean(k2)
      if(sal2mean(k2).GE.salmax)a4402(k2)=domback
      rriv2r2(ipart2,k2)=qs2*EXP(revr72(ipart2,k2))
      pnr2r2(ipart2,k2)=(6.0/(pi*dip**3))*rriv2r2(ipart2,k2)/rhosr2
      else
      pnr2r2(ipart2,k2)=0
      endif
c
      if(bot.EQ.1)then
      rbot2(ipart2,k2)=rt*EXP(r72(ipart2,k2))
      pnb2(ipart2,k2)=(6.0/(pi*dip**3))*rbot2(ipart2,k2)/rhos
      else
      pnb2(ipart2,k2)=0
      endif
C**
C**
      pnt2(ipart2,k2)=pns2(ipart2,k2)+pnr2(ipart2,k2)+pnb2(ipart2,k2)
     &+pnr2r2(ipart2,k2)
      if(pnt2(ipart2,k2).GT.9999999)pnt2(ipart2,k2)=9999999
      if(pnt2(ipart2,k2).LT.-1000)pnt2(ipart2,k2)=-55555
c
2002    continue
c
```

```
2005    continue
c
c
4001    continue
4000    continue
c
c
c*********************************************************************
c
       fw=EXP(5.2*((2.5*dip/d0)**0.2)-6.0)
c
       delta=0.72*d0*(2.5*dip/d0)**0.25
       deltab=0.72*dxb*(2.5*dip/dxb)**0.25
       deltar=0.72*dxbave(iy)*(2.5*dip/dxbave(iy))**0.25
       deltas=0.72*dxbave(iy)*(0.000006625/dxbave(iy))**0.25
c
c
c......for the outfall sediment flux use running mean values of ub *dxb
      shieldr=ubave(iy)**2/((rhos/ro-1.0)*g*dip)
      epsilonr_l=0.00035*ak3_l*((ubave(iy)/w0)**0.68)*
     &(shieldr**0.4)*deltar*g*per
      if(epsilonr_l.LT.0.0000000001)epsilonr_l = 0.0000000001
      epsilonr=epsilonr_l+epsilonw
c
c......for the accretion wave use running mean values of ub *dxb
      shieldrs=ubave(iy)**2/(.03*g*dr)
      epsilonrs_l=0.00035*ak3s*((ubave(iy)/w0sal)**0.68)*
     &(shieldrs**0.4)*deltas*g*per
      if(epsilonrs_l.LT.0.0000000001)epsilonrs_l = 0.0000000001
      epsilonrs=epsilonrs_l+epsilonw
c
c
       shieldb=ub**2/((rhos/ro-1.0)*g*dip)
       epsilonb_l=0.00035*ak3*((ub/w0)**0.68)*
     &(shieldb**0.4)*deltab*g*per
       if(epsilonb_l.EQ.0)epsilonb_l=0.0000000001
      epsilonb=epsilonb_l+epsilonw
c
c.......offshore
       shield=u**2/((rhos/ro-1.0)*g*dip)
       epsilon_l=0.00035*ak2*((u/w0)**0.68)*
     &(shield**0.4)*delta*g*per
       if(epsilon_l.LT.0.0000000001)epsilon_l = 0.0000000001
      epsilon=epsilon_l+epsilonw
```

```
c
c
c.....at the local break point for salinity
      epsilonbs_l=0.00035*ak3s*((ub/w0sal)**0.68)
     &*(shieldrs**0.4)*deltas*g*per
      if(epsilonbs_l.LT.0000000001)epsilonbs_l = 0.0000000001
     epsilonbs=epsilonbs_l+epsilonw
c
c......outfall shields and epsilon calculated in RIVERM subroutine
c
c
c
c
      if(riv.EQ.1)then
      CALL RIVERM(epsilonr,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
     &sy,rrsfix,ak5,w0,delta,rhosr,ro,dip,g,per,ak3,time,qsold,
     &depthc,tconriv,qs)
c
      CALL SALM1(epsilonrs,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
     &sy,salo,ak5s,w0sal,deltas,rhosr,ro,dip,g,per,ak3,time,salold,
     &depthc,tconsal,sal)
c
      else
      continue
      endif
c
C
      if(riv2.EQ.1)then
      CALL RIVER2M(epsilonr,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2,sx,
     &sy,rrsfix2,ak5,w0,deltab,rhosr2,ro,dip,g,per,ak3,time,qs2old,
     &depthc,tconriv,qs2)
c
      CALL SALM2(epsilonrs,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2,sx,
     &sy,salo,ak5s,w0sal,deltas,rhosr2,ro,dip,g,per,ak3,time,salold2,
     &depthc,tconsal,sal2)
c
      else
      continue
      endif
c
c
      if(surf.EQ.1)then
      CALL SURFLM(epsilonb,bd1,ba1,bh1,ibpx,ix,iy,
     &ak4,aks,akb,dip,w0,pi,g,rhos,ro,tanbeta,rcspfix,time,rsold,
```

```
     &depthc,tcon,rs)
       else
       continue
       endif
c
c
       if(bot.EQ.1)then
       CALL BOTTOMM(ix,iy,u,shield,fw,ak,pi,wndep,rcfix,time,rtold,
     &depthc,tcon,rt,w0,epsilon)
       else
       continue
       endif
c
c
c
      if(verdat.EQ.1)datum=depthc
      if(verdat.NE.1)datum=delta
c
      if(verdat.EQ.1)datmod=-1.0
      if(verdat.NE.1)datmod=1.0
c
       do 200 k=1,4
       if(k.EQ.1)zw(k)=depthc-100.0
       if(k.EQ.2)zw(k)=delta+100.0
       if(k.EQ.3)zw(k)=depthc-alay3
       if(k.EQ.4)zw(k)=depthc-alay4
c
      if(zw(k).GT.depthc)zw(k)=depthc
      if(zw(k).LT.delta)zw(k)=delta
       dep(k)=depthc-zw(k)
c
c ....erosion calculations
       salmean(k)=salo
       a440(k)=dominter-domslope*salmean(k)
       if(salmean(k).GE.salmax)a440(k)=domback
        if(dmix.GE.dep(k))then
       salr7(k)=(-1.0)*dep(k)*aksal*w0sal/epsilonbs
       else
       salr7(k)=(-1.0)*dep(k)*aksal*((dimx/4.21)**2.4)
     &*w0sal/epsilonbs_l
       endif
c
        if((depthc-dmix).GE.zw(k))then
       r7(ipart,k)=(-1.0)*zw(k)*w0/epsilon_l
```

```
      else
      r7(ipart,k)=(-1.0)*zw(k)*w0*(dmix/dip)**2.4/epsilon
c**************my fix 10-21-94**************
      if(k.EQ.2)r7(ipart,k)=(-1.0)*zw(k)*w0/epsilon_l
c**********************
      endif
       if((depthc-dmix).LT.0.0)r7(ipart,k)=(-1.0)
     &*zw(k)*w0/epsilon
c
       if(dmix.GE.dep(k))then
      revr7(ipart,k)=(-1.0)*dep(k)*w0/epsilonb
      else
      revr7(ipart,k)=(-1.0)*dep(k)*w0*
     &(dmix/dip)**2.4/epsilonb_l
     endif
c**
c
      if(surf.EQ.1)then
      rsurf(ipart,k)=rs*EXP(r7(ipart,k))
      pns(ipart,k)=(6.0/(pi*dip**3))*rsurf(ipart,k)/rhos
      else
      pns(ipart,k)=0
      endif
C
      if(riv.EQ.1)then
      sriv1(k)=sal*EXP(salr7(k))
      rivsum=sriv1(k)
      salmean(k)=salo-sriv1(k)
      a440(k)=dominter-domslope*salmean(k)
      if(salmean(k).GE.salmax)a440(k)=domback
      rriv(ipart,k)=qs*EXP(revr7(ipart,k))
      pnr(ipart,k)=(6.0/(pi*dip**3))*rriv(ipart,k)/rhosr
      else
      pnr(ipart,k)=0
      endif
C
C
      if(riv2.EQ.1)then
      sriv2(k)=sal2*EXP(salr7(k))
      rivsum=sriv1(k)+sriv2(k)
      if(rivsum.GT.salo)then
      rivsum=salo
      endif
      salmean(k)=salo-rivsum
```

```
      a440(k)=dominter-domslope*salmean(k)
      if(salmean(k).GE.salmax)a440(k)=domback
      rrivr2(ipart,k)=qs2*EXP(revr7(ipart,k))
      pnrr2(ipart,k)=(6.0/(pi*dip**3))*rrivr2(ipart,k)/rhosr2
      else
      pnrr2(ipart,k)=0
      endif
c
C
      if(bot.EQ.1)then
      rbot(ipart,k)=rt*EXP(r7(ipart,k))
      pnb(ipart,k)=(6.0/(pi*dip**3))*rbot(ipart,k)/rhos
      else
      pnb(ipart,k)=0
      endif
C
      pnt(ipart,k)=pns(ipart,k)+pnr(ipart,k)+pnb(ipart,k)
     &+pnrr2(ipart,k)
c
200     CONTINUE
c
1095     FORMAT(F8.5,3x,F8.3,3x,F17.4,3x,F12.8,f12.8)
c
499      continue
c
c.........sum numbers from each size bin together
      suml1(ix,iy)=pnt(ipart,1)+suml1(ix,iy)
      suml2(ix,iy)=pnt(ipart,2)+suml2(ix,iy)
      suml3(ix,iy)=pnt(ipart,3)+suml3(ix,iy)
      suml4(ix,iy)=pnt(ipart,4)+suml4(ix,iy)
c
c
      write(2, REC=icount)rt,rs,qs,qs2,sal,sal2
1776    continue
c
c
c*********************null point write*********************************
c.........null point write commented out
c.....         if(iy.NE.igrdy)go to 6005
c..        write(50,3000)rc(1),rc(2),rc(3),rc(4),rc(5),rc(6),rc(7),
c..     &rc(8),rc(9),unp
c..3000    format(10e10.3)
c..6005    continue
c************************************************************************
```

```
c
c
c.....put salinity values int x-y array
      sall1(ix,iy)=salmean(1)
      sall2(ix,iy)=salmean(2)
      sall3(ix,iy)=salmean(3)
      sall4(ix,iy)=salmean(4)
      acdom1(ix,iy)=a440(1)
      acdom2(ix,iy)=a440(2)
      acdom3(ix,iy)=a440(3)
      acdom4(ix,iy)=a440(4)
c
c
      if(suml1(ix,iy).GT.9999999)suml1(ix,iy)=9999999
      if(suml2(ix,iy).GT.9999999)suml2(ix,iy)=9999999
      if(suml3(ix,iy).GT.9999999)suml3(ix,iy)=9999999
      if(suml4(ix,iy).GT.9999999)suml4(ix,iy)=9999999
c
c
      if(suml1(ix,iy).LT.-1000)suml1(ix,iy)=-1000
      if(suml2(ix,iy).LT.-1000)suml2(ix,iy)=-1000
      if(suml3(ix,iy).LT.-1000)suml3(ix,iy)=-1000
      if(suml4(ix,iy).LT.-1000)suml4(ix,iy)=-1000
c
c
c...add fractional grains to the first 5 bins at surface & bottom
      pnt(1,1)=pnt(1,1)+an0b1
      pnt(2,1)=pnt(2,1)+an0b2
      pnt(3,1)=pnt(3,1)+an0b3
      pnt(4,1)=pnt(4,1)+an0b4
      pnt(5,1)=pnt(5,1)+an0b5
      pnt(6,1)=pnt(6,1)+an0b6
      pnt(7,1)=pnt(7,1)+an0b7
      pnt(8,1)=pnt(8,1)+an0b8
      pnt(9,1)=pnt(9,1)+an0b9
c
c
      pnt(1,2)=pnt(1,2)+an0b1
      pnt(2,2)=pnt(2,2)+an0b2
      pnt(3,2)=pnt(3,2)+an0b3
      pnt(4,2)=pnt(4,2)+an0b4
      pnt(5,2)=pnt(5,2)+an0b5
      pnt(6,2)=pnt(6,2)+an0b6
      pnt(7,2)=pnt(7,2)+an0b7
```

```
      pnt(8,2)=pnt(8,2)+an0b8
      pnt(9,2)=pnt(9,2)+an0b9
c
c
c
      kounts=0
      sumsp=0
      do 1790 is=1,3
      isp1=is+1
      sp(is)=ABS((LOG(pnt(isp1,1)/pnt(is,1)))/(LOG(d(isp1)/d(is))))
      sumsp=sumsp+sp(is)
      if(sp(is).LT.0.1)go to 1789
      kounts=kounts+1
1789  continue
1790  continue
c
      kountb=0
      sumsp2=0
      do 1788 is=1,3
      isp1=is+1
      sp2(is)=ABS((LOG(pnt(isp1,2)/pnt(is,2)))/(LOG(d(isp1)/d(is))))
      sumsp2=sumsp2+sp2(is)
      if(sp2(is).LT.0.1)go to 1787
      kountb=kountb+1
1787  continue
1788  continue
c
      b(ix,iy)=sumsp/(kounts+1)
      b2(ix,iy)=sumsp2/(kountb+1)
      if(b(ix,iy).GT.gamma)b(ix,iy)=gamma
      if(b(ix,iy).LT.1.0)b(ix,iy)=1.0
      if(b2(ix,iy).GT.gamma)b2(ix,iy)=gamma
      if(b2(ix,iy).LT.1.0)b2(ix,iy)=1.0
c
1791   continue
c
c
c****************selected grid loop start with ix,iy EQ igrdx igrdy***
      if(iy.NE.igrdy)go to 4002
      if(ix.NE.igrdx)go to 4003
        do 2006 k3=1,ires

c.....initialize sum2(k3) to background level n0
       sum2(k3)=n0
```

```
       do 2007 ipart3=1,ibins
c
c-----------------Slope Calculation for selected grid point------------
c...add fractional grains to the first 5 bins at each point in water
       pnt2(1,k3)=pnt2(1,k3)+an0b1
       pnt2(2,k3)=pnt2(2,k3)+an0b2
       pnt2(3,k3)=pnt2(3,k3)+an0b3
       pnt2(4,k3)=pnt2(4,k3)+an0b4
       pnt2(5,k3)=pnt2(5,k3)+an0b5
       pnt2(6,k3)=pnt2(6,k3)+an0b6
       pnt2(7,k3)=pnt2(7,k3)+an0b7
       pnt2(8,k3)=pnt2(8,k3)+an0b8
       pnt2(9,k3)=pnt2(9,k3)+an0b9
c
c
c.........sum numbers from each size bin together for selected location
       sum2(k3)=pnt2(ipart3,k3)+sum2(k3)
       if(sum2(k3).GT.9999999)sum2(k3)=9999999
2007     continue
c
c
2006    continue
c
c
      do 1462 k4=ires,1,-1
c.............calculate slope of profile.............
      sumspp=0
      kountp=0
c
      do 1795 is=1,3
      isp1=is+1
      spp(is)=ABS((LOG(pnt2(isp1,k4)/
     &pnt2(is,k4)))/(LOG(d(isp1)/d(is))))
      sumspp=sumspp+spp(is)
      if(spp(is).LT.0.1)go to 1794
      kountp=kountp+1
1794   continue
1795   continue
c
      slope(k4)=sumspp/(kountp+1)
      if(slope(k4).GT.gamma)slope(k4)=gamma
      if(slope(k4).LT.1.0)slope(k4)=1.0
      write(99,3001)dep2(k4),char(9),sum2(k4),char(9),
     &slope(k4),char(9),sal2mean(k4),char(9),a4402(k4)
```

```
1462    continue
4003     continue
4002     continue
c*********************end write selected grid pt file******************
c
1801    continue
479     continue
c
      ixdum=100
      write(*,*)ixdum,iy,suml1(100,iy)
      write(*,*)epsilonb
c
1800    continue
c
1096    format(200f8.4)
1097    format(200f10.0)
1098    format(200f8.3)
3001    format(f9.3,1a,f10.0,1a,f8.3,1a,f8.3,1a,f8.4)
c
      do 1935 iy=ny,1,-1
      write(81,1098) (sall1(ix,iy),ix=1,nx)
      write(85,1096) (acdom1(ix,iy),ix=1,nx)
      write(82,1098) (sall2(ix,iy),ix=1,nx)
      write(86,1096) (acdom2(ix,iy),ix=1,nx)

      if(two_layer.NE.0)then
      write(83,1098) (sall3(ix,iy),ix=1,nx)
      write(87,1096) (acdom3(ix,iy),ix=1,nx)
      write(84,1098) (sall4(ix,iy),ix=1,nx)
      write(88,1096) (acdom4(ix,iy),ix=1,nx)
      endif
1935     continue
c
      do 1802 ix=1,nx
      write(41,1097) (suml1(ix,iy),iy=1,ny)
      write(91,1098) (b(ix,iy),iy=1,ny)
      write(42,1097) (suml2(ix,iy),iy=1,ny)
      write(92,1098) (b2(ix,iy),iy=1,ny)
c
      if(two_layer.NE.0)then
      write(43,1097) (suml3(ix,iy),iy=1,ny)
      write(44,1097) (suml4(ix,iy),iy=1,ny)
      endif
c
```

```
1802    continue
c
c
       stop
       END
c
c**********************Outfall Subroutine*********************************
      SUBROUTINE RIVERM(epsilonr,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
     &sy,rrsfix,ak5,w0,deltab,rhosr,ro,dip,g,per,ak3,time,qsold,
     &depthc,tconriv,qs)
c
c
       drc=dr*100.0
       rwidthc=rwidth*100.0
       qc=q*1000000.0
c
c...modification to produce sediment plots using variable current
c..... (RADIANS).....
c
       uvdir=ATAN2(uy1,ux1)
       rxyr=((iry-iy+.000001)*sy)/(ABS(irx-ix+.000001)*sx)
      thta=uvdir+ATAN(rxyr)
      ut=qc/(rwidthc*drc)
     ur=ut*COS(thta)-((ux1**2+uy1**2)**0.5)*SIN(thta)
c.....
c
c
      e2r=ak5*(ur-(ur**2+4*w0*epsilonr)**0.5)/(2*epsilonr)
c
      rsr1=(ABS(ut*rrsfix))/(ut**2+4*w0*epsilonr)**0.5
      rsr3=e2r*((((irx-ix)*sx)**2)+(((iry-iy)*sy)**2))**0.5
      rsr2=EXP(rsr3)
      timedec=(time*tconriv*w0/depthc)
      if(timedec.GT.1.0)timedec=1.0
      timedec2=0.03116*(ux1**2+uy1**2)**0.5
      qsnew=rsr1*rsr2
      qfosl=qsold*(1-timedec)
      if(qsnew.GT.qfosl)then
      qs=qsnew+qfosl
      else
      qs=qsnew+qfosl*EXP(-1.0*timedec2)
      endif
      return
      end
```

```
c
c
c************************End Outfall Subroutine*********************
c
c
      SUBROUTINE SURFLM(epsilonb,bd1,ba1,bh1,ibpx,ix,iy,
     &ak4,aks,akb,dip,w0,pi,g,rhos,ro,tanbeta,rcspfix,time,
     &rsold,depthc,tcon,rs)
c
c************************Begin Surfl Subroutine*******************
c
      us=ABS((g*bd1)**0.5*COS(ba1)**2)
      e2=(us-(us**2+4*ak4*w0*epsilonb)**0.5)/(2*epsilonb)
      denom=pi*dip**3*(rhos-ro)*akb*bd1**2*9240.0/tanbeta
      rn=(24*aks*ro*bh1**2*(g*bd1)**0.5)/denom
      rr=pi*dip**3*rn*rhos/6
      rs1=(rr/(us**2+4*w0*epsilonb)**0.5)
      rs3=(e2*ABS(ibpx-ix)*77.5)
      rs2=EXP(rs3)
      rs=rs1*rs2*rcspfix+rsold*(1-(EXP(-1.0*depthc*tcon/(2*time*w0))))
c
      return
      end
c
c****************End Surfl Subroutine*****************************
c
c
     SUBROUTINE BOTTOMM(ix,iy,u,shield,fw,ak,pi,wndep,rcfix,time,
     &rtold,depthc,tcon,rt,w0,epsilon)
c
***************************** Begin Bottom Subroutine***************
c
       if (u.LT..000001) then
       nomo=1
       rt1=0.0
       go to 399
       endif
c
      rt5=shield*fw
      if(rt5.le..05)then
      nomo=1
      rt1=0.0
      go to 399
      endif
```

```
c
c
      rt2=(0.05/(rt5))**.5
      rt4=ACOS(rt2)
      rt1=ak*(fw*shield-0.05)*(2/pi)*rt4
399    continue
      rt=rt1+(rtold*(1-(EXP(-1.0*depthc*tcon/(2*time*w0)))))
c
c***************rcfix section was commented out Sept 12, 1994 10:00
      if(rt.GT.rcfix)then
      rt1=rcfix
      rt=rt1+(rtold*(1-(EXP(-1.0*depthc*tcon/(2*time*w0)))))
      endif
c
c
      return
      end
c
c*********************End Bottom Subroutine************************
c
c************************Outfall2 Subroutine*********************************
     SUBROUTINE RIVER2M(epsilonr,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2
    &,sx,sy,rrsfix2,ak5,w0,deltab,rhosr2,ro,dip,g,per,ak3,time,
    &qs2old,depthc,tconriv,qs2)
c
c
       drc=dr2*100.0
       rwidthc=rwidth2*100.0
       qc=q2*1000000.0
c
c...modification to produce sediment plots using variable current
c..................... (RADIANS).............................
c
       uvdir=ATAN2(uy1,ux1)
       rxyr=((iry2-iy+.000001)*sy)/(ABS(irx2-ix+.000001)*sx)
      thta=uvdir+ATAN(rxyr)
      ut=qc/(rwidthc*drc)
     ur=ut*COS(thta)-((ux1**2+uy1**2)**0.5)*SIN(thta)
c.....................................................................
c
      e2r=ak5*(ur-(ur**2+4*w0*epsilonr)**0.5)/(2*epsilonr)
c
      rsr1=(ABS(ut*rrsfix2))/(ut**2+4*w0*epsilonr)**0.5
      rsr3=e2r*((((irx2-ix)*sx)**2)+(((iry2-iy)*sy)**2))**0.5
```

```
      rsr2=EXP(rsr3)
      timedec=(time*tconriv*w0/depthc)
      if(timedec.GT.1.0)timedec=1.0
      timedec2=0.03116*(ux1**2+uy1**2)**0.5
      qsnew=rsr1*rsr2
      qfosl=qs2old*(1-timedec)
      if(qsnew.GT.qfosl)then
      qs2=qsnew+qfosl
      else
      qs2=qsnew+qfosl*EXP(-1.0*timedec2)
      endif
c
      return
      end
c
c
c************************End Outfall2 Subroutine*********************
c
c******************Accretion Outfall 1 Subroutine**************************
     SUBROUTINE SALM1(epsilonrs,dr,rwidth,q,ux1,uy1,ix,iy,irx,iry,sx,
    &sy,salo,ak5s,w0sal,deltas,rhosr,ro,dip,g,per,ak3,time,salold,
    &depthc,tconsal,sal)
c
c
       drc=dr*100.0
       rwidthc=rwidth*100.0
       qc=q*1000000.0
c
c...modification to produce sediment plots using variable current
c..... (RADIANS).....
c
       uvdir=ATAN2(uy1,ux1)
       rxyr=((iry-iy+.000001)*sy)/(ABS(irx-ix+.000001)*sx)
      thta=uvdir+ATAN(rxyr)
      ut=qc/(rwidthc*drc)
     ur=ut*COS(thta)-((ux1**2+uy1**2)**0.5)*SIN(thta)
c.....
c
c
      e2r=ak5s*(ur-(ur**2+4*w0sal*epsilonrs)**0.5)/(2*epsilonrs)
c
      rsr1=(ABS(ut*salo))/(ut**2+4*w0sal*epsilonrs)**0.5
      rsr3=e2r*((((irx-ix)*sx)**2)+(((iry-iy)*sy)**2))**0.5
      rsr2=EXP(rsr3)
```

```
      timedec=(time*tconsal*w0sal/depthc)
      if(timedec.GT.1.0)timedec=1.0
      timedec2=0.03116*(ux1**2+uy1**2)**0.5
      snew=rsr1*rsr2
      sfosl=salold*(1-timedec)
      if(snew.GT.sfosl)then
      sal=snew+sfosl
      else
      sal=snew+sfosl*EXP(-1.0*timedec2)
      endif
      return
      end
c
c
c**************End Accretion Outfall 1 Subroutine********************
c
c
c*****************Salinity Outfall2 Subroutine*************************
     SUBROUTINE SALM2(epsilonrs,dr2,rwidth2,q2,ux1,uy1,ix,iy,irx2,iry2
    &,sx,sy,salo,ak5s,w0sal,deltas,rhosr2,ro,dip,g,per,ak3,time,
    &salold2,depthc,tconsal,sal2)
c
c
       drc=dr2*100.0
       rwidthc=rwidth2*100.0
       qc=q2*1000000.0
c
c...modification to produce sediment plots using variable current
c..... (RADIANS).....
c
       uvdir=ATAN2(uy1,ux1)
       rxyr=((iry2-iy+.000001)*sy)/(ABS(irx2-ix+.000001)*sx)
      thta=uvdir+ATAN(rxyr)
      ut=qc/(rwidthc*drc)
     ur=ut*COS(thta)-((ux1**2+uy1**2)**0.5)*SIN(thta)
c.....
c
c
      e2r=ak5s*(ur-(ur**2+4*w0sal*epsilonrs)**0.5)/(2*epsilonrs)
c
      rsr1=(ABS(ut*salo))/(ut**2+4*w0sal*epsilonrs)**0.5
      rsr3=e2r*((((irx2-ix)*sx)**2)+(((iry2-iy)*sy)**2))**0.5
      rsr2=EXP(rsr3)
      timedec=(time*tconsal*w0sal/depthc)
```

```
      if(timedec.GT.1.0)timedec=1.0
      timedec2=0.03116*(ux1**2+uy1**2)**0.5
      snew=rsr1*rsr2
      sfosl=salold2*(1-timedec)
      if(snew.GT.sfosl)then
      sal2=snew+sfosl
      else
      sal2=snew+sfosl*EXP(-1.0*timedec2)
      endif
c
      return
      end
c
c
c************************End Accretion Outfall2 Subroutine*************
```

APPENDIX F: Code for the Multinode Dilution Model

```
c**********************************************************************
c
c      multinode.for - 18 June 2004
c**with verticle loop
c reads in raster 200 row 200 column arrays of:
c depths, wave heights, wave numbers, x- and y-directed current components
c Surface and Bottom Salinity & caluculates Dilution from these
c               written by Scott A. Jenkins & Joseph Wasyl
c
      character*26 infile1,infile2,infile4,infile5
c
      DIMENSION depth(200,200),wht(200,200),wvn(200,200)
      DIMENSION xcur(200,200),ycur(200,200),col(200,200)
c
     dimension z(5),s(5),ps1(5),ps1b(5),ps1bav(5)
     integer ipt(5),ix(5),iy(5)
     dimension pnx(200,200),pny(200,200),pn(200,200),pn_l(200,200)
     dimension brx(200,200),bry(200,200),brn(200,200),dmix(200,200)
     dimension salsur(200,200),salbrn(200,200),saldep(200,200)
     dimension dilriv(200,200),dildep(200,200),colriv(200,200)
     dimension dilbrn(200,200),dbrnav(200,200),sbrnav(200,200)
     dimension brxav(200,200),bryav(200,200),brnav(200,200)
     character*12 ifile,ofile1,ofile2,ofile3,ofile4,ofile5,ofile6
     character*12 ofile7,ofile8,ofile9,ofil10,ofil11,ofil12,ofil13
c
c
    open(42,file='multinode_agua_3.inp',status='old')
      read(42,3000)ifile
      read(42,3000)infile1
      read(42,3111)infile2
      read(42,3200)infile4
      read(42,3200)infile5
      read(42,3000)ofile1
      read(42,3000)ofile2
      read(42,3000)ofile3
      read(42,3000)ofile4
      read(42,3000)ofile5
```

```
read(42,3000)ofile6
read(42,3000)ofile7
read(42,3000)ofile8
read(42,3000)ofile9
read(42,3000)ofil10
read(42,3000)ofil11
read(42,3000)ofil12
read(42,3000)ofil13
read(42,*)num
read(42,*)imax
read(42,*)jmax
read(42,*)srivx1
read(42,*)srivx2
read(42,*)srivx3
read(42,*)srivx4
read(42,*)srivx5
read(42,*)srivy1
read(42,*)srivy2
read(42,*)srivy3
read(42,*)srivy4
read(42,*)srivy5
read(42,*)ub
read(42,*)vb
read(42,*)u2
read(42,*)v2
read(42,*)sx
read(42,*)sy
read(42,*)akx1_1
read(42,*)aky1_1
read(42,*)akx1_2
read(42,*)aky1_2
read(42,*)akx1_3
read(42,*)aky1_3
read(42,*)akx1_4
read(42,*)aky1_4
read(42,*)akx1_5
read(42,*)aky1_5
read(42,*)ak2_1
read(42,*)ak2_2
read(42,*)ak2_3
read(42,*)ak2_4
read(42,*)ak2_5
read(42,*)akz_1
read(42,*)akz_2
```

```
read(42,*)akz_3
read(42,*)akz_4
read(42,*)akz_5
read(42,*)thresh
read(42,*)back
read(42,*)salo
read(42,*)cline
read(42,*)isal
read(42,*)pnman
read(42,*)upper
read(42,*)brine
read(42,*)upperb
read(42,*)ibrn
read(42,*)brnman
read(42,*)per
read(42,*)ruf
read(42,*)rhos
read(42,*)wind
read(42,*)deglat
read(42,*)ibadx
read(42,*)ibady
read(42,*)qsa
read(42,*)qtc
read(42,*)widsa
read(42,*)widtc
read(42,*)akr_3
read(42,*)akr_4
read(42,*)u_blend
read(42,*)aksal
read(42,*)surdz
read(42,*)botdz
read(42,*)shrdec
read(42,*)swrdec
read(42,*)surmix
read(42,*)aksur
read(42,*)surhb
read(42,*)thermo
read(42,*)xmag
read(42,*)ymag
read(42,*)akocs
read(42,*)depo
read(42,*)thrmdz
read(42,*)coli
read(42,*)deep
```

```
      read(42,*)akzav
c
      rawbrn=2.0*salo
C**read in oceanbat .grd, oceanrds_200x200_raster and tidecur_agua arrays
c
      OPEN(UNIT=51,FILE=infile1,STATUS='OLD')
      OPEN(UNIT=52,FILE=infile2,STATUS='OLD')
      OPEN(UNIT=54,FILE=infile4,STATUS='OLD')
      OPEN(UNIT=55,FILE=infile5,STATUS='OLD')
C
      DO 8001 J=1,200
      READ(51,*)(depth(I,J),I=1,200)
      READ(52,*)(wht(I,J),I=1,200)
      READ(54,*)(xcur(I,J),I=1,200)
      READ(55,*)(ycur(I,J),I=1,200)
8001  CONTINUE
c
3000    format(a12)
3111    format(a26)
3200    format(a22)
c
      surhb=surhb*100.0
      surdz=surdz*100.0
      botdz=botdz*100.0
      cline=cline*100.0
      depo=depo*100.0
      thrmdz=thrmdz*100.0
      freq=1.0/per
      pi=ACOS(-1.0)
      g=980.0
      rho=1.03
      sigma=2.0*pi*freq
      deepl=2.0*pi*g/(sigma**2.0)
      wind=wind*0.5148*100.0
      ak8=0.00009/((wind**0.5)+1.1103)
      ustar=(ak8*(wind**2))**0.5
      rot_e=0.000072685
      f=2.0*rot_e*SIND(deglat)
      dmix_test=4.0*ustar/(f*100.0)
c.....epsilonw is in cgs units
      epsilonw=0.0000043*(wind**2.0)
      if(wind.LE.600)epsilonw=0.0000000102*(wind**3.0)
c
c
```

```
      open(20,file=ifile,status='old')
      open(21,file=ofile1,status='unknown')
      open(22,file=ofile2,status='unknown')
      open(23,file=ofile3,status='unknown')
      open(24,file=ofile4,status='unknown')
      open(25,file=ofile5,status='unknown')
      open(26,file=ofile6,status='unknown')
      open(27,file=ofile7,status='unknown')
      open(28,file=ofile8,status='unknown')
      open(29,file=ofile9,status='unknown')
      open(30,file=ofil10,status='unknown')
      open(31,file=ofil11,status='unknown')
      open(32,file=ofil12,status='unknown')
      open(33,file=ofil13,status='unknown')
c
c
c... open node file
        do 100 i=1,num
        read(20,1000) ipt(i),ix(i),iy(i),z(i)
100     continue
1000    format(i2,2i4,f7.2)
c
c..covert x and y coordinates to nearest integer
c..calculate or assign strength to each source
c
c**initialize particle output array
        do 870 iay=1,jmax
        do 860 iax=1,imax
        pn(iax,iay)=0.0
        pnx(iax,iay)=0.0
        pny(iax,iay)=0.0
        brn(iax,iay)=0.0
        brx(iax,iay)=0.0
        bry(iax,iay)=0.0
        brnav(iax,iay)=0.0
        brxav(iax,iay)=0.0
        bryav(iax,iay)=0.0
        xcur(iax,iay)=xmag*xcur(iax,iay)
        ycur(iax,iay)=ymag*ycur(iax,iay)
c
        depth(iax,iay)=depth(iax,iay)*100.0
c**make land in bays negative in increasing iax direction
        if(iland.EQ.1)depth(iax,iay)=-200.0
        if(depth(iax,iay).LE.0.0)then
```

```
      iland=1
      depth(iax,iay)=-200.0
      endif
c
c**dispersion routine for wave number
c.....initialize wave number array
       wvn(iax,iay)=-1.0
       amp2=0.05*deepl
       if(depth(iax,iay).LE.0)go to 1090
       b=(sigma**2*depth(iax,iay))/g
       if(depth(iax,iay).LT.amp2)then
        wvn(iax,iay)=sigma/(g*depth(iax,iay))**0.5
        go to 1090
        else
        endif
        a=b
       do 1030 k5=1,100
        h=tanh(a)
       fjw=b-a*h
       if (abs(fjw) .lt. 0.000001) go to 1040
       fd=-1.0*h-(a/cosh(a)**2)
       a=a-(fjw/fd)
1030    continue
       write(*,1050)
1050    format(' subroutine disp does not converge!!! ')
1040     wvn(iax,iay)=a/depth(iax,iay)
1090    continue
cEND DISPERSION SUBROUTINE
      wht(iax,iay)=wht(iax,iay)*100.0
c
860    continue
      iland=0
870    continue
c
c&&&&&&&&&&
      do 200 i=1,num
      ps1b(i)=0.0
      ps1bav(i)=0.0
200    continue
c
cPick each Source, use x and y location arrays ix(i), iy(i) of source
      do 799 i=1,num
cPick each x location of grid(iax) solve dx relative to x location of source ix(i)
      do 800 iax=1,imax
```

```
      dx=(iax-ix(i))*sx
      do 850 iay=1,jmax
      dmix(iax,iay)=4.0*ustar/(f*100.0)
      if(dmix(iax,iay).LE.cline)dmix(iax,iay)=cline
      if(depth(iax,iay).GT.0.0.AND.xcur(iax,iay).EQ.0.0)
     &xcur(iax,iay)=0.00001
      if(depth(iax,iay).GT.0.0.AND.ycur(iax,iay).EQ.0.0)
     &ycur(iax,iay)=0.00001
      dy=(iay-iy(i))*sy
      dr=((dx**2.0)+(dy**2.0))**0.5
      drxy=((sx**2.0)+(sy**2.0))**0.5
      if(dr.LT.drxy)dr=drxy
      theta=ABS(dx/dr)
      d0=wht(iax,iay)/SINH(wvn(iax,iay)*depth(iax,iay))+0.001
      uwav=sigma*d0
      ucur=(xcur(iax,iay)**2.0+ycur(iax,iay)**2.0)**0.5
      u=ucur+uwav
C------
      fw=EXP(5.2*((2.5*ruf/d0)**0.2)-6.0)
      delta=0.72*d0*(2.5*ruf/d0)**0.25
      shield=(u**2/((rhos/rho-1.0)*g*ruf))*fw
C-----
C************SIO_1 OUTFALL X-LOOP (ipt=1) lat=33 39' 19"N, lon=117 58' 57"W*****
      if(ipt(i).EQ.1)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      ps1bav(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4521
      endif
      s(i)=srivx1
      ak1=akx1_1
      ak2=ak2_1
      surdec=-1.0*((depth(iax,iay)/surhb)**aksur)
      epsur=surmix*(EXP(surdec))
c
c*U_BLEND logic
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
```

```
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(xcur(iax,iay).LT.0.0)then
      uwav=-1.0*uave
      else
      uwav=uave
      endif
      u0=xcur(iax,iay)+uwav+ub
      u0abs=ABS(u0)
c
      if(epsilon_l.EQ.0.0)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      depmdz=depth(iax,iay)-botdz
      botx=-1.0*akz_1*(botdz**1.0)/eps
      botav=-1.0*akzav*(depth(iax,iay)**1.0)/eps
      decbot=EXP(botx)
      decav=EXP(botav)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).GT.depmdz)decbot=decbot**shrdec
      ps1b(i)=s(i)*decbot/((uave**2+4.0*ruf*(eps+epsur))**0.5)
      ps1bav(i)=ps1b(i)*decav/decbot
c SIO_1 Inshore
      if(iax.EQ.237.AND.iay.EQ.133)write(*,*)iax,iay,epsilon_l,epsur,
     &ps1b(i),etrb
c SIO_1 Inshore
      if(iax.EQ.173.AND.iay.EQ.96)write(*,*)iax,iay,epsilon_l,epsur,
     &ps1b(i),etrb
c SIO_1 Inshore
      if(iax.EQ.179.AND.iay.EQ.94)write(*,*)iax,iay,epsilon_l,epsur,
     &ps1b(i),etrb
c SIO_1 Inshore
      if(iax.EQ.163.AND.iay.EQ.97)write(*,*)iax,iay,epsilon_l,epsur,
     &ps1b(i),etrb
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
```

```
      etr=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etr=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
c
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etrb=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etrb=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etrb=-1.0*ak1*(-1.0*(u0-theta*u0)+(4.0*ruf*eps)**0.5)/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
      etrb=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etrb=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4521  continue
c**********************END SIO_1 OUTFALL X-
LOOP*********************************
c
C*********SIO_3 OUTFALL X-LOOP (ipt=2) ***************************
      if(ipt(i).EQ.2)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4522
      endif
```

```
      if(xcur(iax,iay).LT.0.0)uwav=-1.0*uwav
      u0=xcur(iax,iay)+uwav+u2
      s(i)=srivx2
      ak1=akx1_2
      ak2=ak2_2
      epsilon_l=0.00035*ak2*(u**0.68)*(shield**0.4)*delta*g*per
      if(epsilon_l.EQ.0.0)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      dmxmdz=dmix(iax,iay)-thrmdz
      if(thrmdz.NE.0)then
      if(dmxmdz.GT.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &thrmdz=dmxmdz-depth(iax,iay)+thrmdz
      endif
      thrmx=-1.0*akz_2*(thrmdz**1.0)
      dcthrm=EXP(thrmx)
      if(depth(iax,iay).LE.depo)then
      ps1(i)=(s(i)*dcthrm/((u**2+4.0*ruf*eps)**0.5))*
     &((depth(iax,iay)/depo)**akocs)
      else
      ps1(i)=(s(i)*dcthrm/((u**2+4.0*ruf*eps)**0.5))*
     &((depth(iax,iay)/depo)**(akocs/deep))
      endif
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etr=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4522  continue
```

```
c**********************END SIO_3 OUTFALL X-
LOOP*********************************
c
C*********SIO_2 Outfall X-LOOP (ipt=3) ****************************
      if(ipt(i).EQ.3)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4523
      endif
      drc=z(i)*100.0
      wid=widsa*100.0
      qc=qsa*92903.0
      uvdir=ATAN2(ycur(iax,iay),xcur(iax,iay))
      ut0=qc/(drc*wid)
      ut=ut0/((((dx+0.00001)**2+(dy+0.00001)**2)**0.5)**akr_3)
      u0=xcur(iax,iay)-ut*COS(uvdir)
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
      s(i)=srivx3
      ak1=akx1_3
      ak2=ak2_3
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(epsilon_l.EQ.0.0)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
c***diagnostic
CCCCCCC       if(iay.EQ.118)write(*,*)iax,iay,ur,shield,deltar,eps
c***diagnostic
      surx=-1.0*akz_3*(surdz**1.0)
      decsur=EXP(surx)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).LT.surdz)decsur=decsur**thermo
      ps1(i)=s(i)*decsur/((u0**2+4.0*ruf*eps)**0.5)
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
```

```
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etr=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4523  continue
c**********************END  SIO_2 Outfall X-LOOP*******************************
c
C*********SIO_4  OUTFALL X-LOOP (ipt=4) ***************************
      if(ipt(i).EQ.4)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4524
      endif
      drc=z(i)*100.0
      wid=widtc*100.0
      qc=qtc*92903.0
      uvdir=ATAN2(ycur(iax,iay),xcur(iax,iay))
      ut0=qc/(drc*wid)
      ut=ut0/((((dx+0.00001)**2+(dy+0.00001)**2)**0.5)**akr_4)
      u0=xcur(iax,iay)-ut*COS(uvdir)
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
      s(i)=srivx4
      ak1=akx1_4
      ak2=ak2_4
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(epsilon_l.EQ.0.0000000001)epsilon_l=0.0000000001
```

```
      eps=epsilon_l+epsilonw
c***diagnostic
CCCCCCC       if(iay.EQ.118)write(*,*)iax,iay,ur,shield,deltar,eps
c***diagnostic
      surx=-1.0*akz_4*(surdz**2.0)/eps
      decsur=EXP(surx)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).LT.surdz)decsur=decsur**thermo
      ps1(i)=s(i)*decsur/((u0**2+4.0*ruf*eps)**0.5)
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etr=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4524  continue
c**********************END SIO_4 X-LOOP*******************************
c
C**********SIO_ Offshore OUTFALL X-LOOP (ipt=5) ***************************
      if(ipt(i).EQ.5)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4525
      endif
      if(xcur(iax,iay).LT.0.0)uwav=-1.0*uwav
      u0=xcur(iax,iay)+uwav
```

```
      s(i)=srivx5
      ak1=akx1_5
      ak2=ak2_5
      epsilon_l=0.00035*ak2*(u**0.68)*(shield**0.4)*delta*g*per
      if(epsilon_l.EQ.0.0000000001)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      ps1(i)=s(i)/((u**2+4.0*ruf*eps)**0.5)
      if(u0.GE.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*((u0-theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.GE.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*((u0+theta*u0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0-theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(u0.LT.0.0.AND.dx.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(u0+theta*u0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      au0=ABS(u0)
      if(dx.EQ.0.0)then
      etr=-1.0*ak1*(au0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4525  continue
c**********************END SIO Offshore OUTFALL X-
LOOP*********************************
c
      ps3=etr*((dx**2)+(dy**2))**0.5
      ps3b=etrb*((dx**2)+(dy**2))**0.5
c***
      ps2=EXP(ps3)
      ps2b=EXP(ps3b)
      pnx(iax,iay)=pnx(iax,iay)+(ps1(i)*ps2)
      brx(iax,iay)=brx(iax,iay)+(ps1b(i)*ps2b)
      brxav(iax,iay)=brxav(iax,iay)+(ps1bav(i)*ps2b)
c
c
850   continue
800   continue
799   continue
```

```
c
C**********V LOOPS **********
c
cPick each Source, use x and y location arrays ix(i), iy(i) of source
      do 1799 i=1,num
cPick each x location of grid(iax) solve dx relative to x location of source ix(i)
      do 1800 iay=1,jmax
      dy=(iay-iy(i))*sy
c
      do 1850 iax=1,imax
      dmix(iax,iay)=4.0*ustar/(f*100.0)
      if(dmix(iax,iay).LE.cline)dmix(iax,iay)=cline
      if(iax.EQ.ibadx.AND.iay.EQ.ibady)then
      ps1(i)=0.0
      ps1b(i)=0.0
      ps1bav(i)=0.0
      etr=0.0
      etrb=0.0
      go to 1777
      endif
      if(depth(iax,iay).GT.0.0.AND.xcur(iax,iay).EQ.0.0)
     &xcur(iax,iay)=0.00001
      if(depth(iax,iay).GT.0.0.AND.ycur(iax,iay).EQ.0.0)
     &ycur(iax,iay)=0.00001
      dx=(iax-ix(i))*sx
      dr=((dx**2.0)+(dy**2.0))**0.5
      drxy=((sx**2.0)+(sy**2.0))**0.5
      if(dr.LT.drxy)dr=drxy
      beta=ABS(dy/dr)
c
      d0=wht(iax,iay)/SINH(wvn(iax,iay)*depth(iax,iay))+0.001
      uwav=sigma*d0
      ucur=(xcur(iax,iay)**2.0+ycur(iax,iay)**2.0)**0.5
      u=ucur+uwav
C------
      fw=EXP(5.2*((2.5*ruf/d0)**0.2)-6.0)
      delta=0.72*d0*(2.5*ruf/d0)**0.25
      shield=(u**2/((rhos/rho-1.0)*g*ruf))*fw
C-----
c**************SIO_1 OUTFALL Y-LOOP***********************************
      if(ipt(i).EQ.1)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
```

```
      ps1bav(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4530
      endif
      s(i)=srivy1
      ak1=aky1_1
      ak2=ak2_1
      surdec=-1.0*((depth(iax,iay)/surhb)**aksur)
      epsur=surmix*(EXP(surdec))
c
c* U_BLEND logic
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(ycur(iax,iay).LT.0.0)then
      uwav=-1.0*uave
      else
      uwav=uave
      endif
      v0=ycur(iax,iay)+uwav+vb
      v0abs=ABS(v0)
c
      if(epsilon_l.EQ.0.0)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      depmdz=depth(iax,iay)-botdz
      botx=-1.0*akz_1*(botdz**1.0)/eps
      botav=-1.0*akzav*(depth(iax,iay)**1.0)/eps
      decbot=EXP(botx)
      decav=EXP(botav)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).GT.depmdz)decbot=decbot**shrdec
      ps1b(i)=s(i)*decbot/((uave**2+4.0*ruf*(eps+epsur))**0.5)
      ps1bav(i)=ps1b(i)*decav/decbot
      if(v0.GE.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.GE.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
```

```
      if(v0.LT.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0+beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      av0=ABS(v0)
      if(dy.EQ.0.0)then
      etr=-1.0*ak1*(av0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
c
      if(v0.GE.0.0.AND.dy.GT.0.0)then
      etrb=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.GE.0.0.AND.dy.LT.0.0)then
      etrb=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.LT.0.0)then
      etrb=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.GT.0.0)then
      etrb=-1.0*ak1*(-1.0*(v0+beta*v0)+(4.0*ruf*eps)**0.5)/
     &(2.0*eps)
      endif
      av0=ABS(v0)
      if(dy.EQ.0.0)then
      etrb=-1.0*ak1*(av0+(4.0*ruf*eps)**0.5)/
     &(2.0*eps)
      endif
      endif
4530  continue
C*************************END SIO_1 Y-LOOP*********************************
c
c*************SIO_3 OUTFALL Y-LOOP*************************************
      if(ipt(i).EQ.2)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
```

```
  go to 4531
  endif
  if(ycur(iax,iay).LT.0.0)uwav=-1.0*uwav
  v0=ycur(iax,iay)+uwav+v2
  s(i)=srivy2
  ak1=aky1_2
  ak2=ak2_2
  epsilon_l=0.00035*ak2*(u**0.68)*(shield**0.4)*delta*g*per
  if(epsilon_l.EQ.0.0000000001)epsilon_l=0.0000000001
  eps=epsilon_l+epsilonw
  dmxmdz=dmix(iax,iay)-thrmdz
  if(thrmdz.NE.0)then
  if(dmxmdz.GT.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
&thrmdz=dmxmdz-depth(iax,iay)+thrmdz
  endif
  thrmx=-1.0*akz_2*(thrmdz**1.0)
  dcthrm=EXP(thrmx)
  if(depth(iax,iay).LE.depo)then
  ps1(i)=(s(i)/((u**2+4.0*ruf*eps)**0.5))*
&((depth(iax,iay)/depo)**akocs)
  else
  ps1(i)=(s(i)/((u**2+4.0*ruf*eps)**0.5))*
&((depth(iax,iay)/depo)**(akocs/deep))
  endif
  if(v0.GE.0.0.AND.dy.GT.0.0)then
  etr=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
  endif
  if(v0.GE.0.0.AND.dy.LT.0.0)then
  etr=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
  endif
  if(v0.LT.0.0.AND.dy.LT.0.0)then
  etr=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
&(2.0*eps)
  endif
  if(v0.LT.0.0.AND.dy.GT.0.0)then
  etr=-1.0*ak1*(-1.0*(v0+beta*v0)+((4.0*ruf*eps)**0.5))/
&(2.0*eps)
  endif
  av0=ABS(v0)
  if(dy.EQ.0.0)then
  etr=-1.0*ak1*(av0+((4.0*ruf*eps)**0.5))/
&(2.0*eps)
  endif
  endif
```

```
4531    continue
c
C**********************END SIO_3  OUTFALL Y-LOOP*************************
c
c**************SIO_2 Outfall Y-LOOP************************************
      if(ipt(i).EQ.3)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4532
      endif
      drc=z(i)*100.0
      wid=widsa*100.0
      qc=qsa*92903.0
      uvdir=ATAN2(ycur(iax,iay),xcur(iax,iay))
      ut0=qc/(drc*wid)
      ut=ut0/((((dx+0.00001)**2+(dy+0.00001)**2)**0.5)**akr_3)
      v0=ycur(iax,iay)+ut*SIN(uvdir)
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
      s(i)=srivy3
      ak1=aky1_3
      ak2=ak2_3
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(epsilon_l.EQ.0.0)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      surx=-1.0*akz_3*(surdz**1.0)
      decsur=EXP(surx)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).LT.surdz)decsur=decsur**thermo
      ps1(i)=s(i)*decsur/((v0**2+4.0*ruf*eps)**0.5)
      if(v0.GE.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.GE.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.LT.0.0)then
```

```
      etr=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0+beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      av0=ABS(v0)
      if(dy.EQ.0.0)then
      etr=-1.0*ak1*(av0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4532  continue
c
C**********************END SIO_2 Y-LOOP*********************************
c
c*************SIO_4 Y-LOOP************************************
      if(ipt(i).EQ.4)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4533
      endif
      drc=z(i)*100.0
      wid=widtc*100.0
      qc=qtc*92903.0
      uvdir=ATAN2(ycur(iax,iay),xcur(iax,iay))
      ut0=qc/(drc*wid)
      ut=ut0/((((dx+0.00001)**2+(dy+0.00001)**2)**0.5)**akr_4)
      v0=ycur(iax,iay)+ut*SIN(uvdir)
      uave=(u_blend*ucur+u)/(u_blend+1)
      dxb=uave*per
      deltar=0.72*dxb*(2.5*ruf/dxb)**0.25
      fw=EXP(5.2*((2.5*ruf/dxb)**0.2)-6.0)
      shield=(uave**2/((rhos/rho-1.0)*g*ruf))*fw
      s(i)=srivy4
      ak1=aky1_4
      ak2=ak2_4
      epsilon_l=0.00035*ak2*(uave**0.68)*(shield**0.4)*deltar*g*per
      if(epsilon_l.EQ.0.0000000001)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
```

```
      surx=-1.0*akz_4*(surdz**2.0)/eps
      decsur=EXP(surx)
      if(dmix(iax,iay).GE.depth(iax,iay).AND.depth(iax,iay).GT.0.0)
     &dmix(iax,iay)=depth(iax,iay)
      if(dmix(iax,iay).LT.surdz)decsur=decsur**thermo
      ps1(i)=s(i)*decsur/((v0**2+4.0*ruf*eps)**0.5)
      if(v0.GE.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.GE.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0+beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      av0=ABS(v0)
      if(dy.EQ.0.0)then
      etr=-1.0*ak1*(av0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4533  continue
c
C************************END SIO_4 Y-LOOP*********************************
c
c*************SIO Offshore  OUTFALL Y-LOOP*********************************
      if(ipt(i).EQ.5)then
      if(depth(iax,iay).LT.10.0)then
      ps1(i)=0.0
      ps1b(i)=0.0
      etr=0.0
      etrb=0.0
      go to 4534
      endif
      if(ycur(iax,iay).LT.0.0)uwav=-1.0*uwav
      v0=ycur(iax,iay)+uwav
      s(i)=srivy5
      ak1=aky1_5
      ak2=ak2_5
```

```
      epsilon_l=0.00035*ak2*(u**0.68)*(shield**0.4)*delta*g*per
      if(epsilon_l.EQ.0.0000000001)epsilon_l=0.0000000001
      eps=epsilon_l+epsilonw
      ps1(i)=s(i)/((u**2+4.0*dl*eps)**0.5)
      if(v0.GE.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*((v0-beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.GE.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*((v0+beta*v0)+((4.0*ruf*eps)**0.5))/(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.LT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0-beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      if(v0.LT.0.0.AND.dy.GT.0.0)then
      etr=-1.0*ak1*(-1.0*(v0+beta*v0)+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      av0=ABS(v0)
      if(dy.EQ.0.0)then
      etr=-1.0*ak1*(av0+((4.0*ruf*eps)**0.5))/
     &(2.0*eps)
      endif
      endif
4534  continue
c
C**********************END SIO Offshore OUTFALL Y-LOOP*********************
c
1777   continue
      ps3=etr*((dx**2)+(dy**2))**0.5
      ps3b=etrb*((dx**2)+(dy**2))**0.5
c***
      ps2=EXP(ps3)
      ps2b=EXP(ps3b)
      pny(iax,iay)=pny(iax,iay)+(ps1(i)*ps2)
      bry(iax,iay)=bry(iax,iay)+(ps1b(i)*ps2b)
      bryav(iax,iay)=bryav(iax,iay)+(ps1bav(i)*ps2b)
c
1850   continue
1800   continue
1799   continue
c***********END V LOOPS************************************************
c
c sum pnx and pny together
```

```
      do 2800 iax=1,imax
      do 2850 iay=1,jmax
c       if(pnx(iax,iay).LE.0.00000001)pnx(iax,iay)=0.00000001
c       if(pny(iax,iay).LE.0.00000001)pny(iax,iay)=0.00000001
c       if(pnx(iax,iay).GE.1000000000.0)pnx(iax,iay)=1000000000.0
c       if(pny(iax,iay).GE.1000000000.0)pny(iax,iay)=1000000000.0
      pn(iax,iay)=(pnx(iax,iay)+pny(iax,iay))/2.0
c       pn_l(iax,iay)=LOG(pn(iax,iay))
      brn(iax,iay)=(brx(iax,iay)+bry(iax,iay))/2.0
      brnav(iax,iay)=(brxav(iax,iay)+bryav(iax,iay))/2.0
c
c
2850    continue
2800    continue
c
      if(isal.EQ.1)then
c find maximum pnmax
      pnmax=0.0
      brnmax=0.0
      do 2900 iax=1,imax
      do 2950 iay=1,jmax
      if(pn(iax,iay).GT.pnmax)pnmax=pn(iax,iay)
      if(brn(iax,iay).GT.brnmax)brnmax=brn(iax,iay)
2950    continue
2900    continue
      else
      brnmax=0.0
      do 2902 iax=1,imax
      do 2953 iay=1,jmax
      if(brn(iax,iay).GT.brnmax)brnmax=brn(iax,iay)
2953    continue
2902    continue
      pnmax=pnman
      endif
c
      if(ibrn.EQ.0)brnmax=brnman
      pnmx_l=LOG(pnmax)
      write(*,*)pnmax,brnmax
c
c*****SALINITY LOOP
      do 3100 iax=1,imax
      do 3150 iay=1,jmax
c*salinity at depth increment surdz below surface
      salsur(iax,iay)=salo*(1.0-((pn(iax,iay)/pnmax)**aksal))
```

```
      if(salsur(iax,iay).LT.0.0)salsur(iax,iay)=0.0
      if(depth(iax,iay).LE.0.0)salsur(iax,iay)=0.0
c**salinity at elevation botdz above the bottom
      salbrn(iax,iay)=salo*(1-(brn(iax,iay)/brnmax))+brine*
     &(brn(iax,iay)/brnmax)
c**depth averaged brine salinity
      sbrnav(iax,iay)=salo*(1-(brnav(iax,iay)/brnmax))+brine*
     &(brnav(iax,iay)/brnmax)
      if(iax.EQ.150.AND.iay.EQ.92)write(*,*)salbrn(iax,iay)
      if(iax.EQ.150.AND.iay.EQ.92)write(*,*)sbrnav(iax,iay)
c*salinity of sewage at depth increment thrmdz above thermocline
      saldep(iax,iay)=salo*(1.0-((pn(iax,iay)/pnmax)**aksal))
      if(saldep(iax,iay).LT.0.0)saldep(iax,iay)=0.0
      if(depth(iax,iay).LE.0.0)saldep(iax,iay)=0.0
c
c SIO_1 Inshore
      if(iax.EQ.174.AND.iay.EQ.94)write(*,*)iax,iay,pn(iax,iay),
     &salsur(iax,iay),salbrn(iax,iay),dmix(iax,iay)
c upper left (NW) corner of grid
      if(iax.EQ.1.AND.iay.EQ.1)write(*,*)iax,iay,pn(iax,iay),
     &salsur(iax,iay),salbrn(iax,iay),dmix(iax,iay)
c SIO_3 Inshore
      if(iax.EQ.173.AND.iay.EQ.96)write(*,*)iax,iay,pn(iax,iay),
     &salsur(iax,iay),salbrn(iax,iay),dmix(iax,iay)
c SIO_2
      if(iax.EQ.193.AND.iay.EQ.100)write(*,*)iax,iay,pn(iax,iay),
     &salsur(iax,iay),salbrn(iax,iay),dmix(iax,iay)
c SIO_4 Outfall
      if(iax.EQ.204.AND.iay.EQ.109)write(*,*)iax,iay,pn(iax,iay),
     &salsur(iax,iay),salbrn(iax,iay),dmix(iax,iay)
3150  continue
3100  continue
c
C****SALINITY MAXIMUM AND MINIMUM LOOP
      salsmx=0.0
      saldmx=0.0
      salbmn=33.52
      do 3160 iax=1,imax
      do 3170 iay=1,jmax
      if(salsur(iax,iay).GT.salsmx)salsmx=salsur(iax,iay)
      if(saldep(iax,iay).GT.saldmx)saldmx=saldep(iax,iay)
      if(salbrn(iax,iay).LT.salbmn)salbmn=salbrn(iax,iay)
3170  continue
3160  continue
```

```
      write(*,*)salsmx,saldmx,salbmn
c
c****DILUTION LOOP
      do 3180 iax=1,imax
      do 3190 iay=1,jmax
c dilution of storm water sources at depth increment surdz below surface
      dilriv(iax,iay)=LOG10(salsmx/(salsmx-salsur(iax,iay)+back))
c**storm waterdilution at elevation botdz above the bottom
     dilbrn(iax,iay)=LOG10((rawbrn-salbmn)/
    &(salbrn(iax,iay)-salbmn+back))
c**depth averaged brine dilution
     dbrnav(iax,iay)=LOG10((rawbrn-salbmn)/
    &(sbrnav(iax,iay)-salbmn+back))
      if(iax.EQ.150.AND.iay.EQ.92)write(*,*)dilbrn(iax,iay)
      if(iax.EQ.150.AND.iay.EQ.92)write(*,*)dbrnav(iax,iay)
c dilution of storm water at depth increment thrmdz above thermocline
      dildep(iax,iay)=LOG10(saldmx/(saldmx-saldep(iax,iay)+back))
c TSS counts of storm water at depth thrmdz above thermocline
      col(iax,iay)=LOG10(coli)-dildep(iax,iay)
      if(col(iax,iay).LT.0.0)col(iax,iay)=0.0
c
c TSS counts of outfall source at depth surdz below surface
      colriv(iax,iay)=LOG10(coli)-dilriv(iax,iay)
      if(colriv(iax,iay).LT.0.0)colriv(iax,iay)=0.0
c
3190   continue
3180   continue
c
c
      do 901 iay=1,jmax
      write(21,999)(pn(iax,iay),iax=1,imax)
901    continue
c
      close(21)
c
      do 902 iay=1,jmax
      write(22,999)(pn_l(iax,iay),iax=1,imax)
902    continue
c
      close(22)
c
c
      do 888 iax=1,imax
      do 887 iay=1,jmax
```

```
      if(depth(iax,iay).LT.surdz)salsur(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)salsur(iax,iay)=-2.0
      if(depth(iax,iay).LT.botdz)salbrn(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)salbrn(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)dilbrn(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)dildep(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)saldep(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)col(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)colriv(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)sbrnav(iax,iay)=-2.0
      if(depth(iax,iay).LE.0.0)dbrnav(iax,iay)=-2.0
887     continue
888     continue
c
      do 903 iay=1,jmax
      write(23,995)(salsur(iax,iay),iax=1,imax)
903     continue
c
      close(23)
c
c
      do 905 iay=1,jmax
      write(25,995)(salbrn(iax,iay),iax=1,imax)
905     continue
c
      close(25)
c
c
      do 906 iay=1,jmax
      write(26,995)(dilbrn(iax,iay),iax=1,imax)
906     continue
c
      close(26)
c
      do 904 iay=1,jmax
      write(24,999)(dilriv(iax,iay),iax=1,imax)
904     continue
c
      close(24)
cc
      do 907 iay=1,jmax
      write(27,995)(saldep(iax,iay),iax=1,imax)
907     continue
c
```

```
      close(27)
c
c
      do 908 iay=1,jmax
      write(28,995)(dildep(iax,iay),iax=1,imax)
908     continue
c
      close(28)
c
c
      do 909 iay=1,jmax
      write(29,995)(col(iax,iay),iax=1,imax)
909     continue
c
      close(29)
c
      do 910 iay=1,jmax
      write(30,995)(dmix(iax,iay),iax=1,imax)
910     continue
c
      close(30)
c
      do 911 iay=1,jmax
      write(31,995)(colriv(iax,iay),iax=1,imax)
911     continue
c
      close(31)
c
c
      do 912 iay=1,jmax
      write(32,995)(sbrnav(iax,iay),iax=1,imax)
912     continue
c
      close(32)
c
c
      do 913 iay=1,jmax
      write(33,995)(dbrnav(iax,iay),iax=1,imax)
913     continue
c
      close(33)
c
999     format(200e12.3)
995     format(200e15.6)
```

```
c
      stop
      end
```

APPENDIX G: Constituent Analysis of Water Samples from Outfall 001

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 001

Analyte	Sample Location	Date	Time 1	Time 2	Time 3	Time 4	Time 6	Time 7	Time 8	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
Oil and Grease	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	mg/L	ND		Wet Weather	1	EPA 1664A	1	5			75	25	40		NO
Total Suspended Solids	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	31	mg/L	31.00		Wet Weather	1	SM 2540 D	0.5	0.5			120	60	n/a		NO
Total Settleable Solids	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	mL/L	ND		Wet Weather	1	SM 2540 F	0.1	0.1			3.0	1.0	1.5		NO
Turbidity	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	5.21	NTU	5.21		Wet Weather	1	EPA 180.1	1	2			225	75	100		NO
pH (0-14)	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	8	pH units			Wet Weather	1	EPA 150.1	0.1	0.2			9.0			6.0	NO
Arsenic	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.33	ug/L		NA	Wet Weather	2	EPA 1640	0.01	0.015	18	90	234				NO
Cadmium	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.04	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	3	12	30				NO
Chromium VI (substitute total chromium value)	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.57	ug/l		NA	Wet Weather	2	EPA 1640	0.005	0.01	6	24	60				NO
Copper	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	8.49	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	5	32	86				NO
Lead	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	5.14	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	6	24	60				NO
Mercury	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	0.239	0.959	2.399				NO
Nickel	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.88	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	15	60	150				NO
Selenium	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 1640	0.01	0.015	45	180	450				NO
Silver	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	1.78	8.08	20.68				NO
Zinc	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	17	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	44	224	584				NO
Cyanide	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	SM 4500-CN	1	5	3	12	30				NO
Total Residual Chlorine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	80	ug/L		NA	Wet Weather	2	SM 4500-Cl	10	50	6	24	180				YES
Ammonia as Nitrogen	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	SM 4500-NH	10	50	1,800	7,200	18,000				NO
Acute Toxicity (TUa)/*Atherinops affinis*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.23	TUa			Wet Weather	2	EPA-821-R-02-012	N/A	N/A	n/a	0.3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Survival*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Biomass*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Germination*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Growth*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity /*Strongiyocentrotus purpuratus*	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Non-Chlorinated Phenolic Compounds	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	0.2	90	360	900				NO
Chlorinated Phenolic Compounds	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	0.2	3	12	30				NO
Endosulfan	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.027	0.054	0.081				NO
Endrin	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.006	0.012	0.018				NO
HCH	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.012	0.024	0.036				NO
Radioactivity Gross Alpha (pCi/L) Result ± Error	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	3.74 ± 2.72	pCi/L			Wet Weather	2	7110C		0.31							N/A
Radioactivity Gross Beta (pCi/L) Result ± Error	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	146 ± 63.0	pCi/L			Wet Weather	2	900.0		5.4							N/A
acrolein	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	4.3	20				660			NO
antimony	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.24	ug/L	0.24		Wet Weather	3	EPA 1640	0.01	0.015				3,600			NO
bis(2-chloroethoxy)methane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				13.2			NO
bis(2-chloroisopropyl)ether	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				3,600			NO
chlorobenzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.36	1.00				1,710			NO
Chromium III (substitute total chromium value)(total)	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	1.57	ug/L	1.57		Wet Weather	3	EPA 1640	0.005	0.01				570,000			NO
di-n-butyl phthalate	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.005	0.01				10,500			NO
dichlorobenzenes	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.38	1.00				15,300			NO
diethyl phalthalate	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.132	ug/L	0.132		Wet Weather	3	EPA 625	0.005	0.01				99,000			NO
dimethyl phalthalate	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.005	0.01				2,460,000			NO
4,6-dinitro-2-methylphenol	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1	0.2				660			NO
2,4-dinitrophenol	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1	0.2				12			NO
ethylbenzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.17	1.00				12,300			NO
fluoranthene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.001	0.005				45			NO
hexachlorocyclopentadiene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				174			NO
nitrobenzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				14.7			NO

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 001

Analyte	Sample Location	Date	Time 1	Time 2	Time 3	Time 4	Time 6	Time 7	Time 8	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
thallium	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 1640	0.005	0.01				6			NO
toluene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.35	1.00				255,000			NO
tributyltin	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	Krone et al 1989	0.001	0.003				0.0042			NO
1,1,1-trichloroethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.32	1.00				1,620,000			NO
acrylonitrile	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	3.6	20				0.3			NO(1)
aldrin	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000066			NO(1)
benzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.26	0.50				17.7			NO
benzidine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.000207			NO(1)
beryllium	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.005 E (DNQ)	ug/L	0.005 E (DNQ)		Wet Weather	4	EPA 1640	0.005	0.01				0.099			NO
bis(2-chloroethyl)ether	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.135			NO
bis(2-ethylhexyl)phthalate	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	7.2	ug/L	7.20		Wet Weather	4	EPA 625	0.005	0.01				10.5			NO
carbon tetrachloride	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.42	0.50				2.7			NO
chlordane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000069			NO(1)
chlorodibromomethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.45	1.00				25.8			NO
chloroform	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22	1.00				390			NO
DDT	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00051			NO(1)
1,4-dichlorobenzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01	0.05				54			NO
3-3'-dichlorobenzidine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.0243			NO(1)
1,2-dichloroethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22	0.50				84			NO
1,1-dichloroethylene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.31	1.00				2.7			NO
dichlorobromomethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.27	1.00				18.6			NO
dichloromethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	2.6	10				1,350			NO
1,3-dichloropropane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3	1.00				26.700			NO
dieldrin	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00012			NO(1)
2,4-dinitrotoluene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.8			NO
1,2-diphenylhydrazine (presence measured by atrazine)	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.005	0.01				0.48			NO
halomethanes	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	1.8	10				390			NO
heptachlor	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00015			NO(1)
heptachlor epoxide	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00006			NO(1)
hexachlorobenzene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00063			NO
hexachlorobutadiene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				42			NO
hexachloroethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.5			NO
isophorone	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	0.316	ug/L	0.32		Wet Weather	4	EPA 625	0.05	0.1				2,190			NO
N-nitrosodimethylamine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				21.9			NO
N-nitrosodi-N-propylamine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				1.14			NO
N-nitrosodiphenylamine	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.5			NO
PAH's	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.0264			NO
PCB's	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000057			NO(1)
TCDD equivalents	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	5.62E-07	ug/L	5.62E-07		Wet Weather	4	EPA 1613	A	A				1.17E-08			YES
1,1,2,2-tetrachloroethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.37	1.00				6.9			NO
tetrachloroethylene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.29	1.00				6			NO
toxaphene	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01	0.05				0.00063			NO(1)
trichloroethylene (aka trichloroethene)	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3	1.00				81			NO
1,1,2-trichloroethane	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.54	1.00				28.2			NO
2,4,6-trichlorophenol	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.87			NO
vinyl chloride	Outfall001	3/22/05	20:32	0:55	2:50	5:35	11:28	14:40	17:30	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.33	0.50				108			NO
Total coliform	Outfall001	3/22/05	20:32	N/A	N/A	N/A	N/A	N/A	N/A	11000	MPN/100mL			Wet Weather		SM 9221B	2	20				1000			YES
Fecal coliform	Outfall001	3/22/05	20:32	N/A	N/A	N/A	N/A	N/A	N/A	800	MPN/100mL			Wet Weather		SM 9222E	2	20				200			YES
Enterococcus	Outfall001	3/22/05	20:32	N/A	N/A	N/A	N/A	N/A	N/A	2187	MPN/100mL			Wet Weather		SM 9223	1	10				24			YES

A = See Appendix A for Detection Limit
ND = Not Detected at or Above Laboratory Method Detection Limits
E = Estimated Value below the reporting limit and above the method detection limit. DNQ= Detected, Not Quantified
(1) Method Dectection Limit is greater than Permit Exceedance Limit
(2) = Result based on estimated values

APPENDIX H: Constituent Analysis of Water Samples from Outfall 002

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 002

Analyte	Sample Location	Date	Time 1	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
Oil and Grease	Outfall002	3/22/05	20:45	ND	mg/L	ND		Wet Weather	1	EPA 1664A	1			75	25	40		NO
Total Suspended Solids	Outfall002	3/22/05	20:45	19	mg/L	19.0		Wet Weather	1	SM 2540 D	0.5			120	60	n/a		NO
Total Settleable Solids	Outfall002	3/22/05	20:45	0.2	mL/L	0.2		Wet Weather	1	SM 2540 F	0.1			3.0	1.0	1.5		NO
Turbidity	Outfall002	3/22/05	20:45	27.9	NTU	27.9		Wet Weather	1	EPA 180.1	1			225	75	100		NO
pH (0-14)	Outfall002	3/22/05	20:45	6.3	pH units			Wet Weather	1	EPA 150.1	0.1			9.0			6.0	NO
Arsenic	Outfall002	3/22/05	20:45	1.12	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	18	90	234				NO
Cadmium	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	3	12	30				NO
Chromium VI (substitute total chromium value)	Outfall002	3/22/05	20:45	1.04	ug/l		NA	Wet Weather	2	EPA 200.9	0.1	6	24	60				NO
Copper	Outfall002	3/22/05	20:45	50.1	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	5	32	86				YES
Lead	Outfall002	3/22/05	20:45	6.32	ug/L		NA	Wet Weather	2	EPA 200.8	0.05	6	24	60				NO
Mercury	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 200.8	0.05	0.239	0.959	2.399				NO
Nickel	Outfall002	3/22/05	20:45	1.75	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	15	60	150				NO
Selenium	Outfall002	3/22/05	20:45	0.42 E (DNQ)	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	45	180	450				NO
Silver	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	1.78	8.08	20.68				NO
Zinc	Outfall002	3/22/05	20:45	53.5	ug/L		NA	Wet Weather	2	EPA 200.8	0.1	44	224	584				NO
Cyanide	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	SM 4500-CN	1	3	12	30				NO
Total Residual Chlorine	Outfall002	3/22/05	20:45	360	ug/L		NA	Wet Weather	2	SM 4500-Cl	10	6	24	180				YES
Ammonia as Nitrogen	Outfall002	3/22/05	20:45	210	ug/L		NA	Wet Weather	2	SM 4500-NH	10	1,800	7,200	18,000				NO
Acute Toxicity (TUa)/*Atherinops affinis*	Outfall002	3/22/05	20:45	Not rested	TUa			Wet Weather	2	EPA-821-R-02-012	N/A	n/a	0.3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Survival*	Outfall002	3/22/05	20:45	Not rested	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Bioamass*	Outfall002	3/22/05	20:45	Not rested	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Germination*	Outfall002	3/22/05	20:45	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Growth*	Outfall002	3/22/05	20:45	>16	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	n/a	3	n/a				YES
Chronic Toxicity /*Stronglyocentrotus purpuratus*	Outfall002	3/22/05	20:45	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	n/a	3	n/a				NO
Non-Chlorinated Phenolic Compounds	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	90	360	900				NO
Chlorinated Phenolic Compounds	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	3	12	30				NO
Endosulfan	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.027	0.054	0.081				NO
Endrin	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.006	0.012	0.018				NO
HCH	Outfall002	3/22/05	20:45	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.012	0.024	0.036				NO
Radioactivity Gross Alpha (pCi/L) Result + Error	Outfall002	3/22/05	20:45	0.123 + 0.484	pCi/L			Wet Weather	2	900	.							NA
Radioactivity Gross Beta (pCi/L) Result + Error	Outfall002	3/22/05	20:45	2.46 + 0.887	pCi/L			Wet Weather	2	900.0	.							NA
acrolein	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	4.3				660			NO
antimony	Outfall002	3/22/05	20:45	0.48 E (DNQ)	ug/L	0.48 E (DNQ)		Wet Weather	3	EPA 200.8	0.1				3,600			NO(2)
bis(2-chloroethoxy)methane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05				13.2			NO
bis(2-chloroisopropyl)ether	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05				3,600			NO
chlorobenzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.36				1,710			NO
Chromium III (substitute total chromium value)(total)	Outfall002	3/22/05	20:45	1.04	ug/L	1.040		Wet Weather	3	EPA 200.8	0.1				570,000			NO
di-n-butyl phthalate	Outfall002	3/22/05	20:45	0.0733	ug/L	0.073		Wet Weather	3	EPA 625	0.005				10,500			NO
dichlorobenzenes	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.38				15,300			NO
diethyl phalthalate	Outfall002	3/22/05	20:45	0.187	ug/L	0.187		Wet Weather	3	EPA 625	0.005				99,000			NO
dimethyl phalthalate	Outfall002	3/22/05	20:45	0.0431	ug/L	0.043		Wet Weather	3	EPA 625	0.005				2,460,000			NO
4,6-dinitro-2-methylphenol	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1				660			NO
2,4-dinitrophenol	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1				12			NO
ethylbenzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.17				12,300			NO
fluoranthene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.001				45			NO
hexachlorocyclopentadiene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05				174			NO
nitrobenzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05				14.7			NO

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 002

Analyte	Sample Location	Date	Time 1	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
thallium	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 200.8	0.1				6			NO
toluene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.35				255,000			NO
tributyltin	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	Krone et al 198	0.001				0.0042			NO
1,1,1-trichloroethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.32				1,620,000			NO
acrylonitrile	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	3.6				0.3			NO(1)
aldrin	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.000066			NO(1)
benzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.26				17.7			NO
benzidine	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				0.000207			NO(1)
beryllium	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 200.8	0.1				0.099			NO
bis(2-chloroethyl)ether	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				0.135			NO
bis(2-ethylhexyl)phthalate	Outfall002	3/22/05	20:45	4.88	ug/L	4.88		Wet Weather	4	EPA 625	0.005				10.5			NO
carbon tetrachloride	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.42				2.7			NO
chlordane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.000069			NO(1)
chlorodibromomethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.45				25.8			NO
chloroform	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22				390			NO
DDT	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.00051			NO(1)
1,4-dichlorobenzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01				54			NO
3-3'-dichlorobenzidine	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				0.0243			NO(1)
1,2-dichloroethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22				84			NO
1,1-dichloroethylene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.31				2.7			NO
dichlorobromomethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.27				18.6			NO
dichloromethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	2.6				1,350			NO
1,3-dichloropropane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3				26,700			NO
dieldrin	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.00012			NO(1)
2,4-dinitrotoluene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				7.8			NO
1,2-diphenylhydrazine (presence measured by atrazine)	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.005				0.48			NO
halomethanes	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	1.8				390			NO
heptachlor	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.00015			NO(1)
heptachlor epoxide	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.00006			NO(1)
hexachlorobenzene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.00063			NO
hexachlorobutadiene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				42			NO
hexachloroethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				7.5			NO
isophorone	Outfall002	3/22/05	20:45	0.0886 E (DNQ)	ug/L	0.0886 E (DNQ)		Wet Weather	4	EPA 625	0.05				2,190			NO
N-nitrosodimethylamine	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				21.9			NO
N-nitrosodi-N-propylamine	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				1.14			NO
N-nitrosodiphenylamine	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				7.5			NO
PAH's	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.0264			NO
PCB's	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001				0.000057			NO(1)
TCDD equivalents	Outfall002	3/22/05	20:45	1.89E-07	ug/L	1.89E-07		Wet Weather	4	EPA 1613	A				1.17E-08			YES
1,1,2,2-tetrachloroethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.37				6.9			NO
tetrachloroethylene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.29				6			NO
toxaphene	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01				0.00063			NO(1)
trichloroethylene (aka trichloroethene)	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3				81			NO
1,1,2-trichloroethane	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.54				28.2			NO
2,4,6-trichlorophenol	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05				0.87			NO
vinyl chloride	Outfall002	3/22/05	20:45	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.33				108			NO
Total coliform	Outfall002	3/22/05	20:45	30000	MPN/100mL			Wet Weather		SM 9221B	2				1000			YES
Fecal coliform	Outfall002	3/22/05	20:45	700	MPN/100mL			Wet Weather		SM 9222E	2				200			YES
Enterococcus	Outfall002	3/22/05	20:45	1246	MPN/100mL			Wet Weather		SM 9223	1				24			YES

A = See Appendix A for Detection Limit
ND = Not Detected at or Above Laboratory Method Detection Limits
E = Estimated Value below the reporting limit and above the method detection limit
(1) Method Dectection Limit is greater than Permit Exceedance Limit
(2) = Result based on estimated values

APPENDIX I: Constituent Analysis of Water Samples from Outfall 003

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 003

Analyte	Sample Location	Date	Time 1	Time 2	Time 3	Time 4	Time 6	Time 7	Time 8	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
Oil and Grease	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	mg/L	ND		Wet Weather	1	EPA 1664A	1	5			75	25	40		NO
Total Suspended Solids	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.8	mg/L	0.80		Wet Weather	1	SM 2540 D	0.5	0.5			120	60	n/a		NO
Total Settleable Solids	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	mL/L	ND		Wet Weather	1	SM 2540 F	0.1	0.1			3.0	1.0	1.5		NO
Turbidity	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	NTU	ND		Wet Weather	1	EPA 180.1	1	2			225	75	100		NO
pH (0-14)	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	8.1	pH units			Wet Weather	1	EPA 150.1	0.1	0.2			9.0			6.0	NO
Arsenic	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	1.3	ug/L		NA	Wet Weather	2	EPA 1640	0.01	0.015	18	90	234				NO
Cadmium	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.02	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	3	12	30				NO
Chromium VI (substitute total chromium value)	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.8	ug/l		NA	Wet Weather	2	EPA 1640	0.005	0.01	6	24	60				NO
Copper	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	3.7	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	5	32	86				NO
Lead	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.71	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	6	24	60				NO
Mercury	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	0.239	0.959	2.399				NO
Nickel	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.47	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	15	60	150				NO
Selenium	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.01 E	ug/L		NA	Wet Weather	2	EPA 1640	0.01	0.015	45	180	450				NO
Silver	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	1.78	8.08	20.68				NO
Zinc	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	3.94	ug/L		NA	Wet Weather	2	EPA 1640	0.005	0.01	44	224	584				NO
Cyanide	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	SM 4500-CN	1	5	3	12	30				NO
Total Residual Chlorine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	SM 4500-Cl	10	50	6	24	180				NO
Ammonia as Nitrogen	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	SM 4500-NH	10	50	1,800	7,200	18,000				NO
Acute Toxicity (TUa)*Atherinops affinis*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.00	TUa			Wet Weather	2	EPA-821-R-02-012	N/A	N/A	n/a	0.3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Survival*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Biomass*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	4.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				YES
Chronic Toxicity / *Macrocystis pyrifera Germination*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Growth*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	8.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				YES
Chronic Toxicity /*Strongylocentrotus purpuratus*	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	1.00	TUc			Wet Weather	2	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Non-Chlorinated Phenolic Compounds	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	0.2	90	360	900				NO
Chlorinated Phenolic Compounds	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 625	0.1	0.2	3	12	30				NO
Endosulfan	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.027	0.054	0.081				NO
Endrin	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.006	0.012	0.018				NO
HCH	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L		NA	Wet Weather	2	EPA 625	0.001	0.005	0.012	0.024	0.036				NO
Radioactivity Gross Alpha (pCi/L) Result + Error	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	4.93 + 2.17	pCi/L			Wet Weather	2	7110C	.	0.35							N/A
Radioactivity Gross Beta (pCi/L) Result + Error	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	161 + 62.9	pCi/L			Wet Weather	2	900.0	.	4.1							N/A
acrolein	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	4.3	20.00				660			NO
antimony	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.57	ug/L	0.57		Wet Weather	3	EPA 1640	0.01	0.015				3,600			NO
bis(2-chloroethoxy)methane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				13.2			NO
bis(2-chloroisopropyl)ether	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				3,600			NO
chlorobenzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.36	1.00				1,710			NO
Chromium III (substitute total chromium value)(total)	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.8	ug/L	0.80		Wet Weather	3	EPA 1640	0.005	0.01				570,000			NO
di-n-butyl phthalate	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.005	0.01				10,500			NO
dichlorobenzenes	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.38	1.00				15,300			NO
diethyl phalthalate	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.085	ug/L	0.085		Wet Weather	3	EPA 625	0.005	0.01				99,000			NO
dimethyl phalthalate	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.005	0.01				2,460,000			NO
4,6-dinitro-2-methylphenol	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1	0.2				660			NO
2,4-dinitrophenol	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.1	0.2				12			NO
ethylbenzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.17	1.00				12,300			NO
fluoranthene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.001	0.005				45			NO
hexachlorocyclopentadiene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				174			NO
nitrobenzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 625	0.05	0.1				14.7			NO

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 003

Analyte	Sample Location	Date	Time 1	Time 2	Time 3	Time 4	Time 6	Time 7	Time 8	Result	Units	Calc. 30-Day Average	Calc. 6-Month Median	Wet or Dry Weather?	Permit Table	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
thallium	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 1640	0.005	0.01				6			NO
toluene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.35	1.00				255.000			NO
tributyltin	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	Krone et al 1989	0.001	0.003				0.0042			NO
1,1,1-trichloroethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	3	EPA 8260B	0.32	1.00				1,620.000			NO
acrylonitrile	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	3.6	20.00				0.3			NO(1)
aldrin	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000066			NO(1)
benzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.26	0.50				17.7			NO
benzidine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.000207			NO(1)
beryllium	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 1640	0.005	0.01				0.099			NO
bis(2-chloroethyl)ether	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.135			NO
bis(2-ethylhexyl)phthalate	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	4.74	ug/L	4.74		Wet Weather	4	EPA 625	0.005	0.01				10.5			NO
carbon tetrachloride	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.42	0.50				2.7			NO
chlordane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000069			NO(1)
chlorodibromomethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.45	1.00				25.8			NO
chloroform	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22	1.00				390			NO
DDT	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00051			NO(1)
1,4-dichlorobenzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01	0.05				54			NO
3-3'-dichlorobenzidine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.0243			NO(1)
1,2-dichloroethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.22	0.50				84			NO
1,1-dichloroethylene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.31	1.00				2.7			NO
dichlorobromomethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.27	1.00				18.6			NO
dichloromethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	2.6	10.00				1,350			NO
1,3-dichloropropane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3	1.00				26.700			NO
dieldrin	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00012			NO(1)
2,4-dinitrotoluene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.8			NO
1,2-diphenylhydrazine (presence measured by atrazine)	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.005	0.01				0.48			NO
halomethanes	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	1.8	10.00				390			NO
heptachlor	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00015			NO(1)
heptachlor epoxide	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00006			NO(1)
hexachlorobenzene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.00063			NO
hexachlorobutadiene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				42			NO
hexachloroethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.5			NO
isophorone	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	0.259	ug/L	0.259		Wet Weather	4	EPA 625	0.05	0.1				2.190			NO
N-nitrosodimethylamine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				21.9			NO
N-nitrosodi-N-propylamine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				1.14			NO
N-nitrosodiphenylamine	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				7.5			NO
PAH's	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.0264			NO
PCB's	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.001	0.005				0.000057			NO(1)
TCDD equivalents	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	2.22E-07	ug/L	2.22E-07		Wet Weather	4	EPA 1613	A	A				1.17E-08			YES
1,1,2,2-tetrachloroethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.37	1.00				6.9			NO
tetrachloroethylene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.29	1.00				6			NO
toxaphene	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.01	0.05				0.00063			NO(1)
trichloroethylene (aka trichloroethene)	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.3	1.00				81			NO
1,1,2-trichloroethane	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.54	1.00				28.2			NO
2,4,6-trichlorophenol	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 625	0.05	0.1				0.87			NO
vinyl chloride	Outfall003	3/22/05	21:23	1:10	3:15	6:00	12:00	14:50	17:40	ND	ug/L	ND		Wet Weather	4	EPA 8260B	0.33	0.50				108			NO
Total coliform	Outfall003	3/22/05	21:23	N/A	N/A	N/A	N/A	N/A	N/A	800	MPN/100mL			Wet Weather		SM 9221B	2	20				1000			NO
Fecal coliform	Outfall003	3/22/05	21:23	N/A	N/A	N/A	N/A	N/A	N/A	220	MPN/100mL			Wet Weather		SM 9222E	2	20				200			YES
Enterococcus	Outfall003	3/22/05	21:23	N/A	N/A	N/A	N/A	N/A	N/A	404	MPN/100mL			Wet Weather		SM 9223	1	10				24			YES

A = See Appendix A for Detection Limit
ND = Not Detected at or Above Laboratory Method Detection Limits
E = Estimated Value below the reporting limit and above the method detection limit
(1) Method Dectection Limit is greater than Permit Exceedance Limit
(2) = Result based on estimated values

APPENDIX J: Constituent Analysis of Water Samples from Outfall 004b

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 004b

Analyte	Sample Location	Date	Time 1	Tme 2	Time 3	Time 4	Time 6	Result	Units	Calc. 30-day average	Calc. 6-month median	Wet or Dry Weather?	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
Oil and Grease	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	mg/L	ND		Wet Weather	EPA 1664A	1	5			75	25	40		NO
Total Suspended Solids	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	23.4	mg/L	23.40		Wet Weather	SM 2540 D	0.5	0.5			120	60	n/a		NO
Total Settleable Solids	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	mL/L	ND		Wet Weather	SM 2540 F	0.1	0.1			3.0	1.0	1.5		NO
Turbidity	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	3.11	NTU	3.11		Wet Weather	EPA 180.1	1	2			225	75	100		NO
pH (0-14)	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	8	pH units			Wet Weather	EPA 150.1	0.1	0.2			9.0			6.0	NO
Arsenic	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.74	ug/L		NA	Wet Weather	EPA 1640	0.01	0.015	18	90	234				NO
Cadmium	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.02	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	3	12	30				NO
Chromium VI (substitute total chromium value)	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	3.58	ug/l		NA	Wet Weather	EPA 1640	0.005	0.01	6	24	60				NO
Copper	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.25	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	5	32	86				NO
Lead	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.9	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	6	24	60				NO
Mercury	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	0.239	0.959	2.399				NO
Nickel	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.37	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	15	60	150				NO
Selenium	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.05	ug/L		NA	Wet Weather	EPA 1640	0.01	0.015	45	180	450				NO
Silver	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.02	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	1.78	8.08	20.68				NO
Zinc	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	3.93	ug/L		NA	Wet Weather	EPA 1640	0.005	0.01	44	224	584				NO
Cyanide	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	SM 4500-CN	1	5	3	12	30				NO
Total Residual Chlorine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	40 E (DNQ)	ug/L		NA	Wet Weather	SM 4500-Cl	10	50	6	24	180				YES (DNQ)
Ammonia as Nitrogen	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	SM 4500-NH	10	50	1,800	7,200	18,000				NO
Acute Toxicity (TUa) *Atherinops affinis*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.00	TUa			Wet Weather	EPA-821-R-02-012	N/A	N/A	n/a	0.3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7-Day Survival*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.00	TUc			Wet Weather	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Atherinops affinis 7Day Biomass*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.00	TUc			Wet Weather	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Germination*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.00	TUc			Wet Weather	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Chronic Toxicity / *Macrocystis pyrifera Growth*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	4.00	TUc			Wet Weather	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				YES
Chronic Toxicity */Stronglyocentrotus purpuratus*	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.00	TUc			Wet Weather	EPA/600/R-95/136	N/A	N/A	n/a	3	n/a				NO
Non-Chlorinated Phenolic Compounds	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 625	0.1	0.2	90	360	900				NO
Chlorinated Phenolic Compounds	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 625	0.1	0.2	3	12	30				NO
Endosulfan	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 625	0.001	0.005	0.027	0.054	0.081				NO
Endrin	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 625	0.001	0.005	0.006	0.012	0.018				NO
HCH	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L		NA	Wet Weather	EPA 625	0.001	0.005	0.012	0.024	0.036				NO
Radioactivity Gross Alpha (pCi/L) Result + Error	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.62 + 3.00	pCi/L			Wet Weather	7110C	.	0.41							N/A
Radioactivity Gross Beta (pCi/L) Result + Error	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	208 + 66.9	pCi/L			Wet Weather	900.0	.	4							N/A
acrolein	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	4.3	20				660			NO
antimony	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.07	ug/L	0.07		Wet Weather	EPA 1640	0.01	0.015				3,600			NO
bis(2-chloroethoxy)methane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				13.2			NO
bis(2-chloroisopropyl)ether	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				3,600			NO
chlorobenzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.36	1.00				1,710			NO
Chromium III (substitute total chromium value)(total)	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	3.58	ug/L	3.58		Wet Weather	EPA 1640	0.005	0.01				570,000			NO
di-n-butyl phthalate	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.005	0.01				10,500			NO
dichlorobenzenes	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.38	1.00				15,300			NO
diethyl phalthalate	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.0293	ug/L	0.0293		Wet Weather	EPA 625	0.005	0.01				99,000			NO
dimethyl phalthalate	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.005	0.01				2,460,000			NO
4,6-dinitro-2-methylphenol	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.1	0.2				660			NO
2,4-dinitrophenol	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.1	0.2				12			NO
ethylbenzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.17	1.00				12,300			NO
fluoranthene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				45			NO
hexachlorocyclopentadiene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				174			NO
nitrobenzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				14.7			NO

ATTACHMENT F
MARCH 22, 2005, UCSD / SCRIPPS MONITORING SUMMARY
Outfall 004b

Analyte	Sample Location	Date	Time 1	Time 2	Time 3	Time 4	Time 5	Result	Units	Calc. 30-day average	Calc. 6-month median	Wet or Dry Weather?	Method	Method Detection Limit	Reporting Limit	6-Mo. Median	Daily Maximum	Instant. Maximum	30-Day Average	7-Day Average	Instant Minimum	Results > Permit Limits
thallium	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.01 E (DNQ)	ug/L	0.01 E (DNQ)		Wet Weather	EPA 1640	0.005	0.01				6			NO(2)
toluene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.35	1.00				255,000			NO
tributyltin	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	Krone et al 1989	0.001	0.003				0.0042			NO
1,1,1-trichloroethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.32	1.00				1,620,000			NO
acrylonitrile	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	3.6	20				0.3			NO(1)
aldrin	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.000066			NO(1)
benzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.26	0.50				17.7			NO
benzidine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				0.000207			NO(1)
beryllium	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.02	ug/L	0.02		Wet Weather	EPA 1640	0.005	0.01				0.099			NO
bis(2-chloroethyl)ether	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				0.135			NO
bis(2-ethylhexyl)phthalate	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.72	ug/L	1.72		Wet Weather	EPA 625	0.005	0.01				10.5			NO
carbon tetrachloride	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.42	0.50				2.7			NO
chlordane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.000069			NO(1)
chlorodibromomethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.45	1.00				25.8			NO
chloroform	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.22	1.00				390			NO
DDT	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.00051			NO(1)
1,4-dichlorobenzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.01	0.05				54			NO
3-3'-dichlorobenzidine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				0.0243			NO(1)
1,2-dichloroethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.22	0.50				84			NO
1,1-dichloroethylene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.31	1.00				2.7			NO
dichlorobromomethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.27	1.00				18.6			NO
dichloromethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	2.6	10				1,350			NO
1,3-dichloropropane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.3	1.00				26.700			NO
dieldrin	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.00012			NO(1)
2,4-dinitrotoluene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				7.8			NO
1,2-diphenylhydrazine (presence measured by atrazine)	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.005	0.01				0.48			NO
halomethanes	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	1.8	10				390			NO
heptachlor	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.00015			NO(1)
heptachlor epoxide	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.00006			NO(1)
hexachlorobenzene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.00063			NO
hexachlorobutadiene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				42			NO
hexachloroethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				7.5			NO
isophorone	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	0.0695 E (DNQ)	ug/L	0.0695 E (DNQ)		Wet Weather	EPA 625	0.05	0.1				2,190			NO(2)
N-nitrosodimethylamine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				21.9			NO
N-nitrosodi-N-propylamine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				1.14			NO
N-nitrosodiphenylamine	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				7.5			NO
PAH's	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.0264			NO
PCB's	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.001	0.005				0.000057			NO(1)
TCDD equivalents	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	1.53E-07	ug/L	1.53E-07		Wet Weather	EPA 1613	A	A				1.17E-08			YES
1,1,2,2-tetrachloroethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.37	1.00				6.9			NO
tetrachloroethylene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.29	1.00				6			NO
toxaphene	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.01	0.05				0.00063			NO(1)
trichloroethylene (aka trichloroethene)	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.3	1.00				81			NO
1,1,2-trichloroethane	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.54	1.00				28.2			NO
2,4,6-trichlorophenol	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 625	0.05	0.1				0.87			NO
vinyl chloride	Outfall004b	3/22/05	21:01	3:05	10:57	12:45	18:15	ND	ug/L	ND		Wet Weather	EPA 8260B	0.33	0.50				108			NO
Total coliform	Outfall004b	3/22/05	21:01	N/A	N/A	N/A	N/A	<20	MPN/100mL			Wet Weather	SM 9221B	2	20				1000			NO
Fecal coliform	Outfall004b	3/22/05	21:01	N/A	N/A	N/A	N/A	<20	MPN/100mL			Wet Weather	SM 9222E	2	20				200			NO
Enterococcus	Outfall004b	3/22/05	21:01	N/A	N/A	N/A	N/A	<10	MPN/100mL			Wet Weather	SM 9223	1	10				24			NO

(1) Method Dectection Limit is greater than Permit Exceedance Limit
(2) = Result based on estimated values
A = See Appendix A for Detection Limit
E = Estimated Value below the reporting limit and above the method detection limit
ND = Not Detected at or Above Laboratory Method Detection Limits