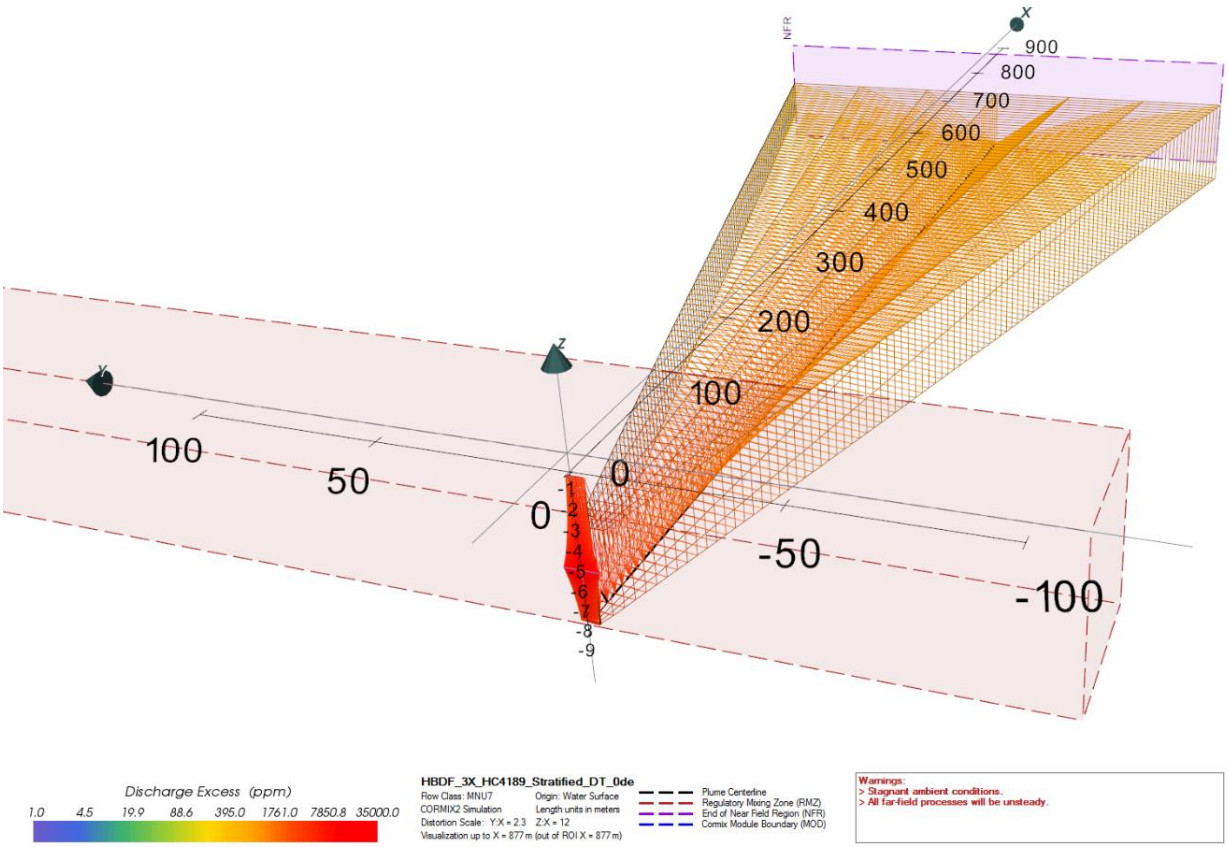
Alternative Hydrodynamic Model Analysis of the Alden Designed 3-Port Duckbill Diffuser Retrofit at Huntington Beach Desalination Facility (HBDF)-Version 2



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NOTICE TO THE READER:

This is an amendment of the HBDF dilution study by Jenkins, (2017-KKKK2). This amendment was prompted by the discovery of spurious output from the CORMIX v10.0 model while attempting to optimize the proposed HBDF diffuser for minimal turbulent shear impacts while still maintaining compliance with brine discharge limits set under the amended Ocean Plan. The problem was reported to Mixzon, Inc. (developer of the EPA certified CORMIX model) on 7 November 2017. Mixzon responded that there was a "bug" in Module 252 of CORMIX v 10.0, and provided a corrective executable file for the model on 16 November 2017 that fixed the problem, (see Appendix-G for more details). Mixzon has designated the amended CORMIX model as version 10.0.3.0, which now produces dilution values roughly comparable to those reported in the original 28 July 2017 submission of this report, but those dilution values are realized at increased distances from the point of discharge, resulting in increases in the effective size of the *brine mixing zone*, (BMZ). Consequently, we are resubmitting the report based on output from the corrected CORMIX v10.0.3.0 model. The new dilution curves prompted by the amended CORMIX v10.0.30 dilution model precipitated one additional change from the original 28 July 2017submission, namely: the TideFlex duckbill check valves fitted to the 36 in. diameter diffuser ports have been changed from a Series 35/TF-2 to a Series 35-D/HC4189 (or equivalent) in order to maintain compliance with the Ocean Plan brine discharge limits. All fundamental conclusions of the original submission remain unchanged with no significant changes to the diffuser design itself.

EXECUTIVE SUMMARY:

An EPA-certified mixing model (CORMIX v10.0.3.0) and a commercially available computational fluid dynamics (CFD) model (*COSMOS/ FLowWorks*) were applied to a proposed diffuser design for the Huntington Beach Desalination Facility (HBDF) in order to determine brine discharge compliance with new water quality objectives set forth under the recently amended California Ocean Plan. The models were initialized to resolve initial dilution and brine discharge plume trajectories under standard NPDES dilution modeling protocols (as defined in the California Ocean Plan); according to which "*Initial Dilution will be considered the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge".* As such the models did not consider any additional mixing due to the action of ocean currents, waves, tides or wind and treated the receiving water as a quiescent, stagnant ocean.

The modeled HBDF desalination operating conditions were based on two worst-case discharge scenarios involving ultimate maximum daily brine discharges from a 3-port duckbill diffuser design*: Daily Worst-Case #1* utilizes 62.5 mgd of concentrated seawater (brine) effluent at a salinity of 62.4 ppt; and *Daily Worst-Case #2* discharges 54 mgd of concentrated brine at a salinity of 67 ppt. Per initial dilution analysis requirements set forth under the Ocean Plan, both scenarios discharge into quiescent ocean receiving waters having a natural background salinity of 33.52 ppt and worst-case month temperature salinity profiles obtained from the extensive KOMEX (2003) monitoring of the AES Huntington Beach Generating Station (HBGS) intake and outfall, performed for the California Energy Commission. No heat generation is assumed to occur within the HBGS and the delta-T of the undiluted brine relative to ocean water temperature

is assumed to be between $\Delta T = 0\ ^0C$ and $\Delta T = +2\ ^0C$. The models were initialized for ocean water elevations at mean sea level bounded by the existing bathymetry surrounding the offshore discharge site for the HBDF.

Both worst-case scenarios were found to be insensitive to the small assumed range in delta-T. Due to relatively high port Froude numbers (F_r = 12.3 to 14 .1), the discharge plume becomes vertically fully mixed over the water column within a short distance (about 5 m or 16 ft.) from the point of discharge, a finding corroborated by both the CORMIX and CFD models. The proposed HBDF diffuser was found to dilute brine to within 2 ppt of natural background at distances of between 69.9 m (229 ft.) and 91.8 m (301 ft.) from the point of discharge. The region around the discharge where brine salinity is equal to or greater than 2 ppt of natural background is referred to as the *brine mixing zone* (BMZ), and the newly amended Ocean Plan requires that the BMZ can extend no further than 100 m horizontally from the point of discharge. Therefore, the two worst-case daily discharge scenarios satisfying the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. The dilution factor at 100 m (328 ft.) from the point of discharge ranges from Dm = 15.8 for Worst-Case #1 operating conditions to Dm = 16.5 for Worst-Case #2. The CORMIX v10.0.3.0 dilution model produced solutions out to 877 m (2877 ft.) from the discharge point where dilution factors ranged from Dm = 45.1 to Dm = 46.9 to 1. Here the CORMIX v10.0.3.0 solutions terminated due to stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requires initial dilution calculations are performed under conditions of no waves, currents or tides, which is the primary reason for stagnant ambient conditions at the point where CORMIX v10.0.3.0 terminated the simulation). Because of these stagnant ambient conditions, we assume dilution is complete at 877 m from the discharge point, marking the limit of the *zone of initial dilution* (ZID), where the minimum initial dilution reaches an ultimate limit of Dm = 45.1 to 46.9.

Under Ocean Plan implementation polices, mitigation scaling for brine impacts to marine organisms inside the limits of the BMZ are based on worst-case monthly discharge scenarios. The two worst-case monthly discharge scenarios studied are: *Monthly Worst-Case #1* which utilizes an average brine discharge of $\overline{Q}$ = 56.7 mgd that includes R.O. backwash, and has an end-of-pipe discharge salinity S_b = 63.1 ppt; and *Monthly Worst-Case #2* composed of brine discharge with *recycled backwash* that is discharged at a rate of $\overline{Q}$ = 50 mgd with an end-of-pipe discharge salinity S_b = 67 ppt. The monthly worst-case outcomes produced slightly higher dilution rates than the worst-case daily outcomes. Under worst-case monthly operating conditions, the proposed HBDF diffuser was found to dilute brine to within 2 ppt of natural background at distances of between 69.1 m (227 ft.) and 86.3 m (283 ft.) from the point of discharge. The dilution factor at 100 m (328 ft.) from the point of discharge ranges from Dm = 16.2 for monthly Worst-Case #1 operating conditions to Dm = 16.8 for monthly Worst-Case #2 operations. Dilution was completed at 877 m (2877 ft.) from the discharge point (the limit of the ZID) where the monthly worst-case dilution factors ultimately reached Dm = 46.3 to Dm = 47.9.

The Ocean Plan requires that brine diffusers minimize re-suspension of benthic sediments. The computational fluid dynamics (CFD) modeling of ultimate maximum brine discharge from the proposed HBDF diffuser (62.5 mgd) determined that diffuser induced velocities on the seafloor are everywhere less than the threshold of motion speed of the finest-grained, most mobile seabed sediments found at the HBDF discharge site. Consequently, it was concluded that re-suspension of benthic sediments by the HBDF diffuser will not occur.

1) Introduction:

The present study began as a follow-on to the Appendix KKKK technical note, "*Dilution Analysis Alden 3-Port Duckbill Diffuser Retrofit at Huntington Beach Desalination Facility (HBDF)"*, dated 11 June 2017, (see Jenkins, 2017-KKKK). The follow-on study (Jenkins, 2017-KKKK2) was prompted by review comments on the Appendix KKKK technical note received from the Santa Ana Regional Water Quality Control Board in an untitled memorandum < comments on 060917 brine dilution study_DPE_MR (003).docx>. Responses to those comments are found in Appendix-D, with directions to particular pages and sections for further details. This report is an amendment of the follow-on study Jenkins, (2017-KKK2) prompted by discovery of a bug in the CORMIX v10.0 dilution model code (see Appendix-G for details).

There are two new factors raised in recent Regional Board comments which this study addresses: 1) increased brine discharge rates in the characterization of daily worst-case scenarios, and 2) implementation of an alternative EPA-certified dilution model in evaluating initial dilution of the new worst-case scenarios. The two new worst-case operating scenarios represent the ultimate maximum daily brine discharge flows that the HBDF would be capable of producing, and are defined as follows.

> ***Daily Worst-Case #1***: Ultimate maximum volume discharge of brine from the HBDF will be $\overline{Q}$ = 62.5 mgd with an end-of-pipe discharge salinity S_b = 62.44 ppt. This is based on 54 mgd of R.O. effluent at 67 ppt blended with 8.5 mgd of backwash at 33.5 ppt. The combined effluent discharge temperature differential over ambient receiving water temperature is anticipated to be between $\Delta T = 0^0$ C and $\Delta T = +2^0$ C.
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> ***Daily Worst-case #2:*** Ultimate maximum volume discharge of brine from the HBDF will be $\overline{Q}$ = 54 mgd with an end-of-pipe discharge salinity S_b = 67 ppt. This is based on 54 mgd of R.O. effluent at 67 ppt with no backwash. The combined effluent discharge temperature differential over ambient receiving water temperature is anticipated to be between $\Delta T = 0^0$ C and $\Delta T = +2^0$ C.

In order to address initial dilution modeling protocols under the Ocean Plan, (cf. Section 2), we will assume these ultimate maximum brine discharge conditions persist for an entire month, in combination with worst-case ambient receiving water temperature/salinity profiles. However, worst-case discharge conditions which are more likely to persist for a month would involve monthly average discharges of $\overline{Q}$ = 56.7 mgd brine with an end-of-pipe discharge salinity S_b = 63.1 ppt for Worst-case #1, or monthly average discharges of $\overline{Q}$ = 50 mgd with an end-of-pipe discharge salinity S_b = 67 ppt for Worst-case #2. These worst-case monthly average operating conditions were evaluated in the previous Appendix KKKK technical note, (Jenkins, 2017).

The second new factor in the present study implementing a different model to perform the initial dilution analysis, switching over from the Visual Plumes (UM3) nearfield mixing model to the recently updated CORMIX version 10.0.3.0 model, (see Appendix-G for details of most recent CORMIX update). Both models are EPA certified. This change in implementation strategy began with a suggestion from the Regional Board to consider the CORMIX model because of its ability to deal with sloping sea beds, whereas the Visual Plumes model cannot. The bottom slope is an important factor in the dilution processes, because the brine is a dense

(heavier than ambient seawater) discharge that spreads out across the seafloor, as a gravity flow that follows the bottom gradients. But other factors were considered as well. CORMIX version 10.0 was released in April 2017, (subsequently revised as version 10.0.3.0 on 16 November 2017, see Appendix-G) and incorporates a number of new features that make it more capable than the Visual Plumes (UM3) that hasn't been updated since 2003 (cf. Frick et al., 2003). Among the new CORMIX capabilities is its ability to explicitly model *fanned* and multi-directional discharge ports, which adapts well to the arrangement of the discharge ports of the Alden-designed *3-Port Duckbill Diffuser Retrofit* (cf. Figures 1 & 2) that is being proposed for the HBDF. Visual plumes on the other hand can only admit to diffusers in which all of the discharge ports that point in the same direction.

2) Regulatory Requirements for Brine Discharges:

Regulatory requirements begin with Appendix-A of the amended California Ocean Plan, (SWRCB, 2015), which defines water quality objectives for salinity of brine discharges and establishes the following requirements:

> *a) Discharges shall not exceed a daily maximum of 2.0 ppt above natural background salinity measured no further than 100 meters (328 feet) horizontally from the discharge* (referred to as the *brine mixing zone* or *BMZ*). *There is no vertical limit to this zone, and this discharge limit must be satisfied regardless of whether salinity in the receiving water is at natural background or at the historical daily maximum.*
>
> *b) Natural background salinity shall be determined by averaging 20 years of historical salinity data at a location representative of the discharge site that is without human influences*
>
> *c) The owner or operator shall develop a dilution factor (Dm) based on the distance of 100 meters (328 feet) or initial dilution, whichever is smaller*.
>
> *d) Initial dilution is defined as the dilution factor, Dm, when dilution is complete and must be evaluated under the assumption that no currents, of sufficient strength to influence the initial dilution process, flow across the discharge structure.* The point in the receiving water where initial dilution is complete establishes the limit of the *zone of initial dilution*, or *ZID*.

The implementation section of the brine amendment to the California Ocean Plan, Section III.M.2 (b), requires that:

> *Multiport diffusers shall be engineered to maximize dilution, minimize the size of the brine mixing zone, minimize suspension of benthic sediments, and mortality of all forms of marine life*

These regulatory requirements establish two hydrodynamic analysis objectives for the present study: 1) perform an initial dilution analysis of the proposed HBDF discharge, and 2) determine if that discharge generates shear stresses on the seabed that are sufficient to mobilize and re-

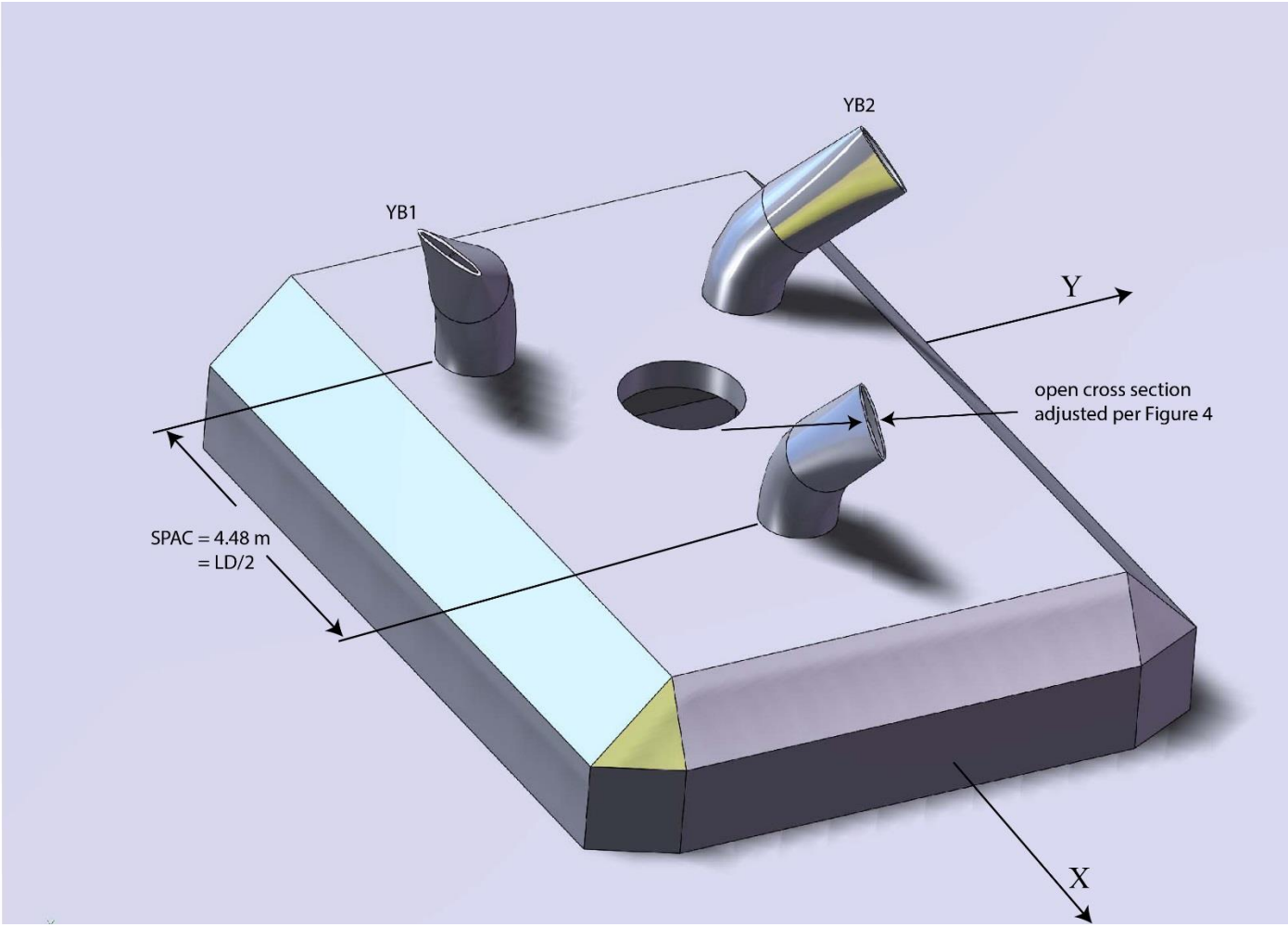


Figure 1: Three-dimensional CAD of the Alden-designed *3-Port Duckbill Diffuser Retrofit* at the discharge tower site of the HBGS, located at latitude 33º 38' 19" N, longitude 117º 58' 57" W, approximately 1,500 ft (457 m) offshore from the mean lower-low water tide line at a depth of 27.9 ft (8.5 m) below mean sea level. For the dilution analysis in this technical memorandum, the 4.5-ft. diameter man hole that appears in the center of the diffuser was capped with a circular cover plate as shown in Figures 10,13 & 15.

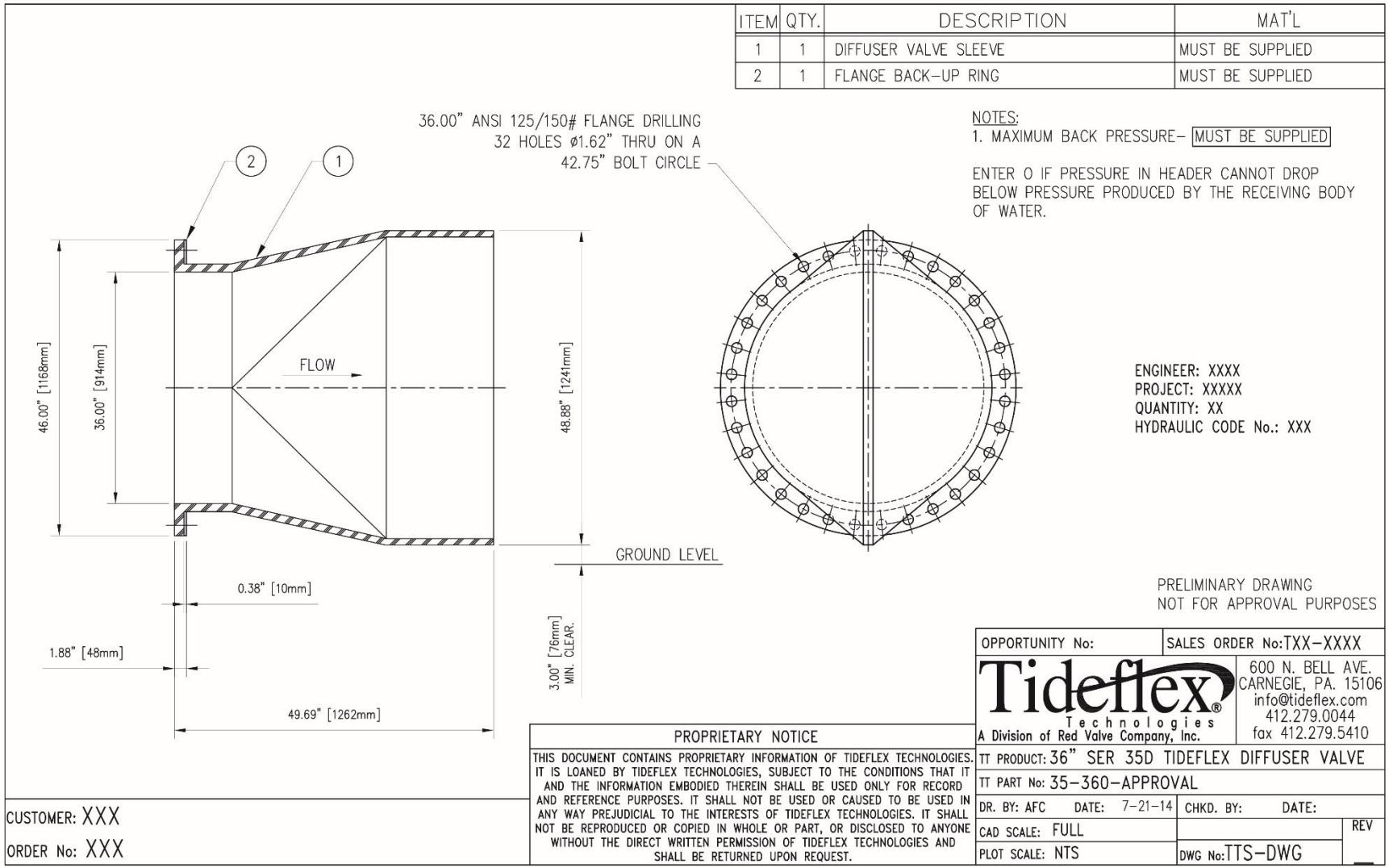


Figure 2: Series 35-D/HC4189 TideFlex duckbill check-valve specified by Red Valve Co. to be fitted to the 36 in. diameter ports of the HBDF *3-Port Duckbill Diffuser Retrofit*, (cf. Figure 4 for performance specifications and additional details).

suspend the native benthic sediments at the HBDF discharge site. The initial dilution analysis will be performed by an EPA-certified nearfield mixing model while the sediment resuspension analysis will be aided by computational fluid dynamics (CFD) modeling of the bottom shear stress field.

3) Details of the Proposed HBDF Discharge:

The proposed discharge structure for the Huntington Beach Desalination Facility (HBDF) consists of a multiport diffuser retrofitted to the top of the discharge tower of the Huntington Beach Generating Station (HBGS), after the upper section of the tower has been removed so that the diffuser does not extend above the elevation of the existing tower (Figure 1). The existing discharge tower is located at latitude 33° 38' 19" N, longitude 117° 58' 57" W, approximately 1,500 ft (457 m) offshore from the mean lower-low water tide line at a depth of 27.9 ft (8.5 m) below mean sea level (Figure 3).

The diffuser to be studied herein was designed by Alden Research Laboratory and is referred to as the *3-Port Duckbill Diffuser Retrofit* (Alden Diffuser). The Alden Diffuser has three 36-in. duckbill check valves and one 4.5-ft. diameter port. The port will be operated only for higher power plant flows if necessary and HBDF brine will not be discharged. As shown in Figure 1, the check valves are generally oriented to provide a net uni-directional flux of discharge momentum. The horizontal angles between the check valves is 45 degrees to provide fanned total discharge to enhance the entrainment of ambient ocean water to increase dilution rates using only three discharge ports. Flow to the check valves would come from a new common plenum under the tower cap, which would otherwise be sealed. The plenum with imbedded pipes would sit on top of the existing tower after the existing grating and two tower riser rings are removed; all other existing elements of the tower and the 14-ft. diameter supply pipe would be used.

Under the operating conditions for these two worst-case discharge scenarios, the single 4.5-ft. diameter man-hole in Figure 1 will be capped with a cover plate. Because the open cross sectional area of the duckbill check valves changes with discharge rate, it was necessary to adjust the nozzle geometry of the duckbills in the CAD model in Figure 1 according to an empirical relation between nozzle cross section and flow rate as shown in Figure 4. This relation was derived from manufacturer provided specifications for the 36 in. Tideflex Series 35-D/HC4189 duckbill check valve, (cf. Appendix-K) and quantifies how the rubberized duckbill flappers open up to increase the available cross sectional area of the check valve as the discharge flow rate increases. As these check valves progressively open up with increasing flow rate, the nozzle cross section of the check valve transitions from elliptic to circular. The cross-sectional area relation in Figure 4 is based on the equivalent circular cross section because there are no models to predict the dilution from elliptically-shaped check valves. However this provides a conservative estimate of dilution because experiments by Lee and Tang, (1999) show that the centerline dilutions from elliptical nozzles are greater than from equivalent round nozzles due to the larger surface area available for entrainment; and that the dilutions asymptotically approach those of equivalent round nozzles at about 12 equivalent jet diameters from the nozzle.

Under Daily Worst-Case-1 conditions, with total discharge $\overline{Q}$ = 62.5 mgd (2.738 m^3/s), each check valve provides A_i = 0.193 m^2 of equivalent circular cross sectional area

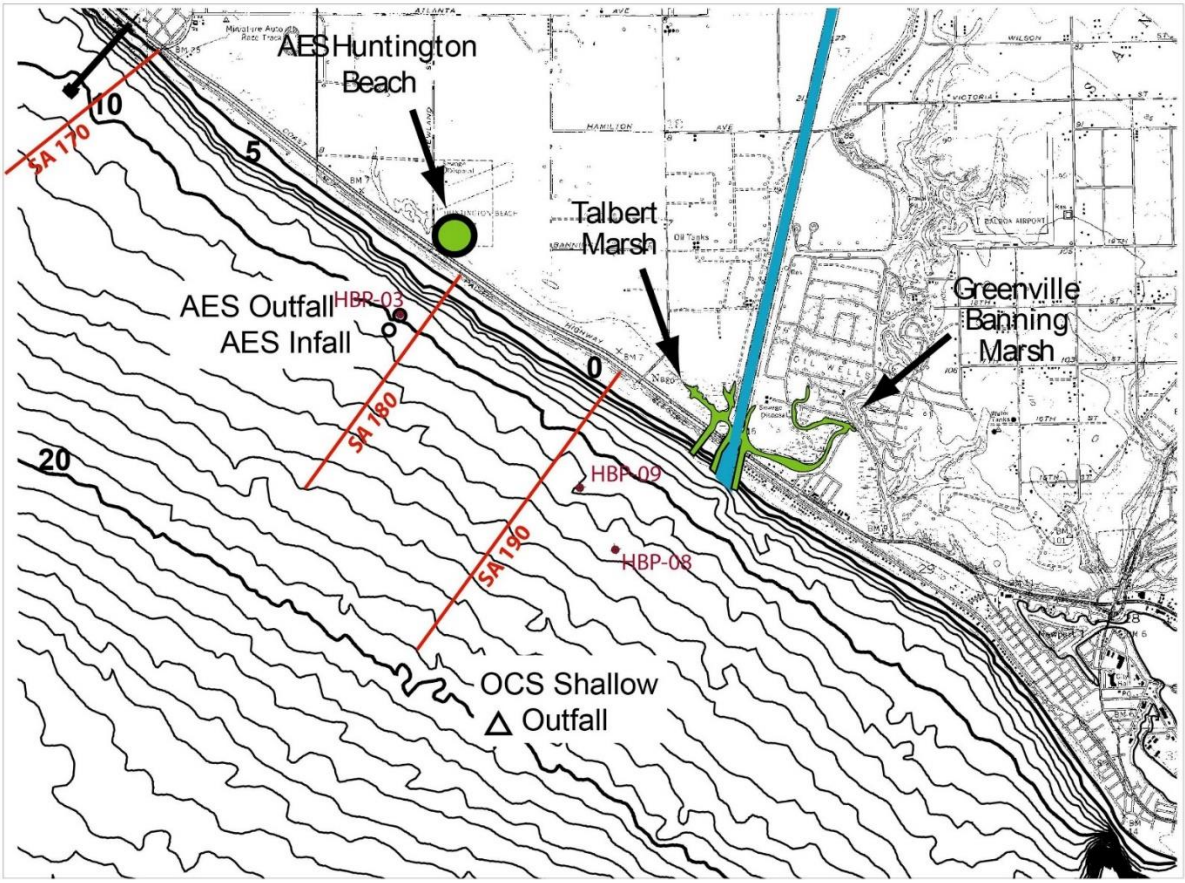


Figure 3: Coarse outer grid at 1 arc-second resolution extracted NOAA's National Geophysical Data Center using the Southern California Coastal Relief Model (1 arc-second)" layer. Red points sediment sampling locations. Red lines denote beach profile ranges.

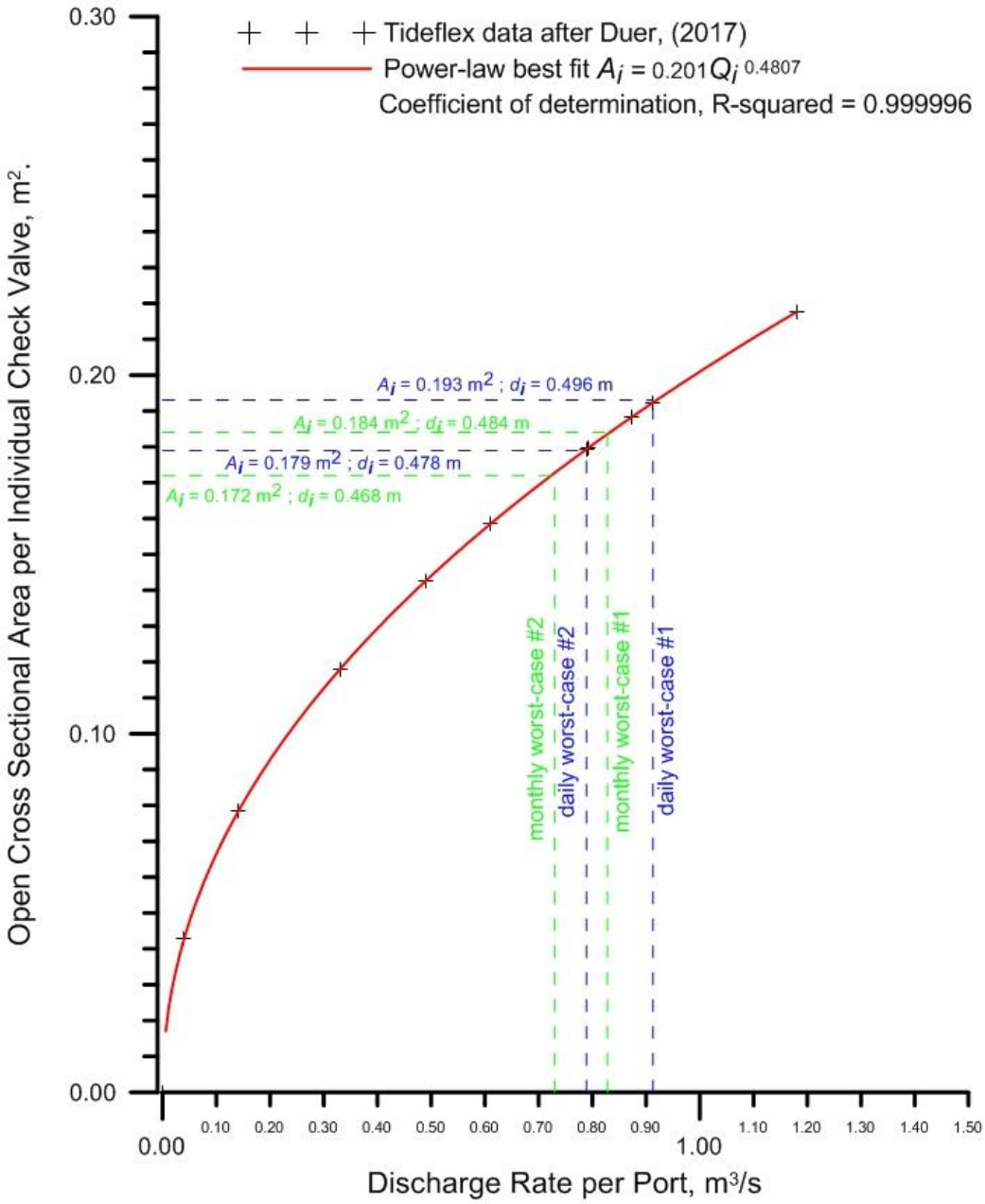


Figure 4: Sensitivity of open cross-sectional area of a single 36 in. Tideflex Series 35-D/HC4189 duckbill check valve as a function of discharge rate, cf. Duer, (2016, 2017) and Appendix-K.

with an effective diameter of d = 0.496 m in order to discharge $Q_i = \overline{Q}/3$ = 0.913 m^3/s from each check valve, (cf. Figure 4). This gives a maximum discharge velocity of u_0 = 4.72 m/s, (15.49 ft/s). For Daily Worst-Case-2 conditions, ($\overline{Q}$ = 54 mgd or 2.366 m^3/s),each check valve provides A_i = 0.179 m^2 of equivalent circular cross sectional area with an effective diameter of d = 0.478 m in order to discharge $Q_i = \overline{Q}/3$ = 0.789 m^3/s from each check valve, (cf. Figure 4), resulting in a maximum discharge velocity of u_0 = 4.39 m/s, (13.48 ft/s).

4) Technical Approach and Model Selection

There are presently only three mixing models certified by the U.S. Environmental Protection Agency and the California State Water Resources Control Board for use in ocean outfall design (Baumgartner, et al., 1994), namely: *PDSWIN*, *Visual Plumes (UM3)* or *CORMIX*. PDSWIN is an outdated 1990's vintage model, (Baumgartner, et al., 1994), primarily used to estimate dilution of tributary channels entering into larger water bodies. Also, it has never been validated in a marine environment. The Visual Plumes UM3 model is a *Lagrangian* initial dilution plume model based on the UM model described in Baumgartner, Frick, and Roberts (1994). The term "Lagrangian" means that the model follows the trajectory of plume elements after leaving a discharge port at a particular initial velocity. Visual Plumes UM has been modified for three dimensions using vectorized computations and by assuming the Projected Area Entrainment (PAE) hypothesis after Winiarski and Frick, 1976; Frick, 1984. The PAE hypothesis represents the entrainment entering the plume element from the side using a vector pointing at right angles to the plane formed by the instantaneous direction of motion of the plume element and the gravitational acceleration vector. The behavior of multi-port plumes is also assumed to be the same as single-port plumes up to the point of merging. After merging the sideways component of entrainment is distributed over all plumes. The latter assumption limits Visual Plumes (UM3) to discharge structures having regularly spaced discharge ports that all have the same orientation in the vertical and horizontal planes. Also, Visual Plumes (UM3) only admits to a flat, no-sloping seabed, which is a significant limitation at the HBDF discharge site because the heavy brine is capable of moving downslope as a gravity flow following the gradients in the bottom bathymetry which are about 2% (cf. Figure 3). Furthermore, the Visual Plumes (UM3) model is only available for outdated 32 bit computers running Windows 2000 operating systems, and has not been updated since 2003.

CORMIX is an empirically based *expert systems model*, (Frick, et al., 2003), and its rule-based predictions are founded on laboratory and field databases that have evolved through 10 generations of model development, culminating with version 10.0 released in April 2017. CORMIX Version 10.0.3.0 admits to both near and far-field bottom slopes, and complex diffuser geometries with multiple branches, variable port geometries, and variable or fanned port orientations. It is clearly the most highly refined and capable among the tree available EPA-certified mixing models and was therefore selected for the initial dilution analysis of this study.

The CORMIX 10.0.3.0 represents dilution in terms of a *mixing ratio*, which represents the ratio of the total parts of a water sample per parts effluent contained in that

sample. CORMIX 10.0.3.0 uses the symbol *"S"* for its mixing ratio definition of dilution. However the relevant dilution metric under the Ocean Plan is *dilution factor*, *Dm*, which is defined as parts seawater per parts effluent, (Appendix-I, SWRCB, 2015). Mixing ratio, *S*, and dilution factor *Dm* are related by the following:

$$D_m(x) = \frac{S_b(x=0) - S_b(x)}{S_b(x) - S_0} = S - 1 \qquad (1)$$

Here: $S_b(x)$ is the effluent salinity at distance, *x* from the point of discharge, where $S_b(x=0)$ represents the salinity at the point of discharge; and S_0 is the natural background salinity in the receiving water equal to 33.52 ppt. When this equation is evaluated at the 100 m regulatory brine mixing zone, the term $S_b(x=0)$ becomes equivalent to the effluent concentration limit, $S_b(x=0)=C_e$ as defined in Appendix-I of the Ocean Plan; S_0 is equivalent to background seawater concentration, $S_0 = C_s$; and $S_b(x = BMZ)$ is equivalent to the water quality objective to be met, $S_b(x = BMZ) = C_o$.

For the diffuser-induced bottom shear stress computations required for the sediment re-suspension analysis of we employ a class of models known as ***computational fluid dynamics*** (CFD). The commercially available *COSMOS/ FLowWorks* developed by the French aerospace company Dassault Systems was employed in this study to resolve the velocity and shear stress fields around the diffuser and corroborate the brine plume trajectories predicted by CORMIX 10.0.3.0. COSMOS/ FLowWorks calculates the regeneration of turbulent kinetic energy from downslope flow using *Star-CD* , Version 3.1, with *QUICK* space discretization for the mean flow and first order up-winding of the turbulence equations. It was validated for application in diffuser problems by Iaccarino, (2000). COSMOS/ FLowWorks is an especially powerful analytic tool for design and analysis of diffuser systems because it is a CAD embedded CFD model. This allows a 3-d CAD model of the diffuser and the surrounding boundaries to be directly imported into the CFD model for flow simulation and analysis. The 3-dCAD model of the discharge structure was built using the commercially available COSMOS SolidWorks software, which provides the computational mesh for the CFD model using COSMOS/FloWORKS.

All CFD models provide nearly exact solutions to the equations of fluid motion (Navier-Stokes equations) based on various turbulence closure schemes. Since the early 1980s, CFD codes have grown in complexity, particularly in physical modelling, but with less emphasis on dealing with geometric complexity. In 1999, *COSMOS/SOLIDWORKS* introduced the first version of COSMOS/FloWorks, providing for the first time a CFD simulation capability inside a 3-dimensional CAD system based on the C-D Star turbulence closure model, and directly using native CAD geometry without modification as the starting point for the CFD process. (Note, C-D Star is the best performing turbulence closure model for diffuser related problems, cf. Iaccarino, G, 2000). CAD describes the solid model, whereas CFD is primarily concerned with the flow space (the solution domain minus the solid model). Historically, for traditional CFD codes, the fluid space is created by Boolean subtraction of the solid model within the CAD system, and this inverse solid is passed to the CFD tool for meshing. (Mesh generators in traditional CFD are usually based on body-fitted algorithms). The COSMOS/FloWORKS

technology (now marketed in the United States as *SOLIDWORKS/ Flow Simulation*) is based upon the use of Cartesian-based meshes which is the key element of the CAD/CFD bridge for CAD-embedded CFD (Li Ding, et al. 2007).

As a result of using Cartesian-based meshes we have computational cells which are located fully in solid bodies (solid cells), in the fluid (fluid cells) and cells intersected by the immersed boundaries (which we term 'partial cells'). Mesh generation is started by dividing the rectangular computational domain into a set of rectangular cells (cuboids) formed by intersection of planes parallel to the axes of coordinate system. The mesh can be refined (by splitting each cuboid into 8 geometrically-similar cuboids) using various adaptation criteria that can be defined for each solid body (curvature, narrow channels, small features, etc.) and automatically according to gradients in the solution. These refinement procedures are essential to resolve features of the CAD geometry like surfaces with small curvature, small features, narrow discharge ports or the internal void spaces of the discharge structure; and it is this feature which makes COSMOS/FloWORKS and SOLIDWORKS Flow Simulation technology the best available technology for resolving the shear stress field around a complex multi-port discharge structure.

The CAD embedded CFD codes of COSMOS/FloWORKS and SOLIDWORKS Flow Simulation have been substantially validated in the peer reviewed literature (Balakin, et al., 2004; Oberkampf, W.L. and Trucano, 2002; Melnik, et al., 2015). As with all novel technologies, considerable attention is paid to Validation and Verification (V&V). A four-level classification of validation has been employed in current practice for the V&V procedures used with COSMOS/FloWORKS and SOLIDWORKS Flow Simulation. This can be portrayed by four levels of an inverted pyramid, with each level being based upon, and supported by the previous level. The experimental data and analytical solutions have been well reproduced numerically via flow simulation with acceptable degree of accuracy. In general, the predictive skill at each of the four V & V levels has ranged from 0.96 to 0.98 where 1.0 represents perfect prediction.

5) Model Initialization

The initialization of CORMIX 10.0.3.0 for the dilution simulations is fully disclosed in the session reports in Appendix-A for Worst-Case #1 and in Appendix-B for Worst-Case #2. Here we provide discussion on how the choice of input values in the session reports were chosen.

The models were initialized for quiescent, tide-less ocean receiving waters at mean sea level bounded by the existing beach and offshore bathymetry surrounding the discharge tower for the HBDF. The discharge tower was initialized in the model according to as-built drawings. The temperature and salinity profiles in the receiving water were initialized from NPDES permit monitoring for the AES HBGS outfall and the nearby Orange County Sanitation Department (OCSD) outfall supplemented by buoy and ship data collected under the CDIP (2012) and CalCOFI, (2014) programs as archived by SCCOOS, (2014).

5.1) Bathymetry: Because brine is negatively buoyant, it will continue to flow downslope following bottom gradients once it falls to the sea floor after being discharged. Therefore, bathymetry provides a controlling influence on the initial dilution process vis a vis, the trajectory of the brine plume after impact with the seafloor. Bathymetry is derived from NOAA's National Geophysical Data Center using the Southern California

Coastal Relief Model (1 arc-second)" layer http://maps.ngdc.noaa.gov/viewers/wcs-client/ . Gridding is by latitude and longitude beginning with an outer computational domain of 15.4 km x 18.5 km centered around the HBDF site (Figure 3). From this outer coarse-grid an area of receiving water measuring 6 km x 6 km around the HBGS discharge tower was input to ARCGIS kriging algorithms to create a high-resolution 3-dimensional CAD model of the seafloor at 0.1 arc-second horizontal. This 3-d CAD model of the seafloor was input to the COSMOS/FloWORKS model to perform the bottom shear stress and brine trajectory simulations as discussed in Section 6.

5.2) Salinity and Natural Background Definition: N*atural background salinity* according to the amended Ocean Plan is the mean of at least 20 years of ocean salinity measurements at a reference location that is representative of the discharge location. For the purposes of this evaluation, we have adopted reference locations in the coastal waters offshore of the HBDF derived from NPDES permit monitoring data at the co-located AES HBGS outfall from data reported in MBC, 1980-2004, and at the nearby the Orange County Sanitation Department (OCSD) outfall from OCSD 1993, 2000. This data is plotted in Figure 5a and includes the same period of record from the SEIR (2010). The expanded period of record in Figure 5a, spanning 25.6 years of continuous NPDES monitoring during the period from 1980 through July 2004, also includes the extensive KOMEX (2003) monitoring of the AES HBGS intake and outfall, performed for the California Energy Commission. Inspection of Figure 5a indicates that the ocean salinity varies naturally by 10% between summer maximums and winter minimums, with a long term (25-year) average value of 33.52 parts per thousand (ppt). Maximum salinity was 34.34 ppt during the 1998 summer El Nino when southerly winds transported high salinity water from southern Baja up into the Southern California Bight. Minimum salinity was about 31.02 ppt during the 1993 winter floods. The variation between maximum and minimum salinity is about 3.32 ppt, which is about 10 % of the average value of 33.5 ppt. The ocean salinity exceeded the 33.5 ppt average value during 2,488 days out of 7,523 days during the period of record, and was below average during 1,543 days. Therefore above average salinities are more common than below average salinities. Average salinities were observed a total of 3,492 days of the period of record, or about 46 % of the time. These data are also confirmed by Roemmich, (1989), and Bograd, et al, (2001), by long term salinity monitoring at Scripps Pier NOAA Station #941-0230, and by 55 CalCOFI cruises in the Southern California Bight between 1984 and 1997, see SIO, 2013; at https://scripps.ucsd.edu/programs/shorestations/shore-stations-data/. The aggregate conclusion drawn from these observations and the data in Figure 5 is that natural background salinity at Huntington Beach (and throughout the lower Southern California Bight) is S_0 = 33.52 ppt.

5.3) Ocean Temperature: The ocean temperature effects the buoyancy of the brine discharge through the absolute temperature of the discharge. This buoyancy effect is calculated by the specific volume change of the discharge relative to the ambient ocean water (see Appendix-1). The buoyancy of the brine plume exerts a strong effect on the mixing and rate of assimilation of the sea salts by the receiving waters. We use the average of temperature records from the Scripps Institution of Oceanography for shore stations in proximity to Huntington Beach availabl at:
https://scripps.ucsd.edu/programs/shorestations/shore-stations-data/.

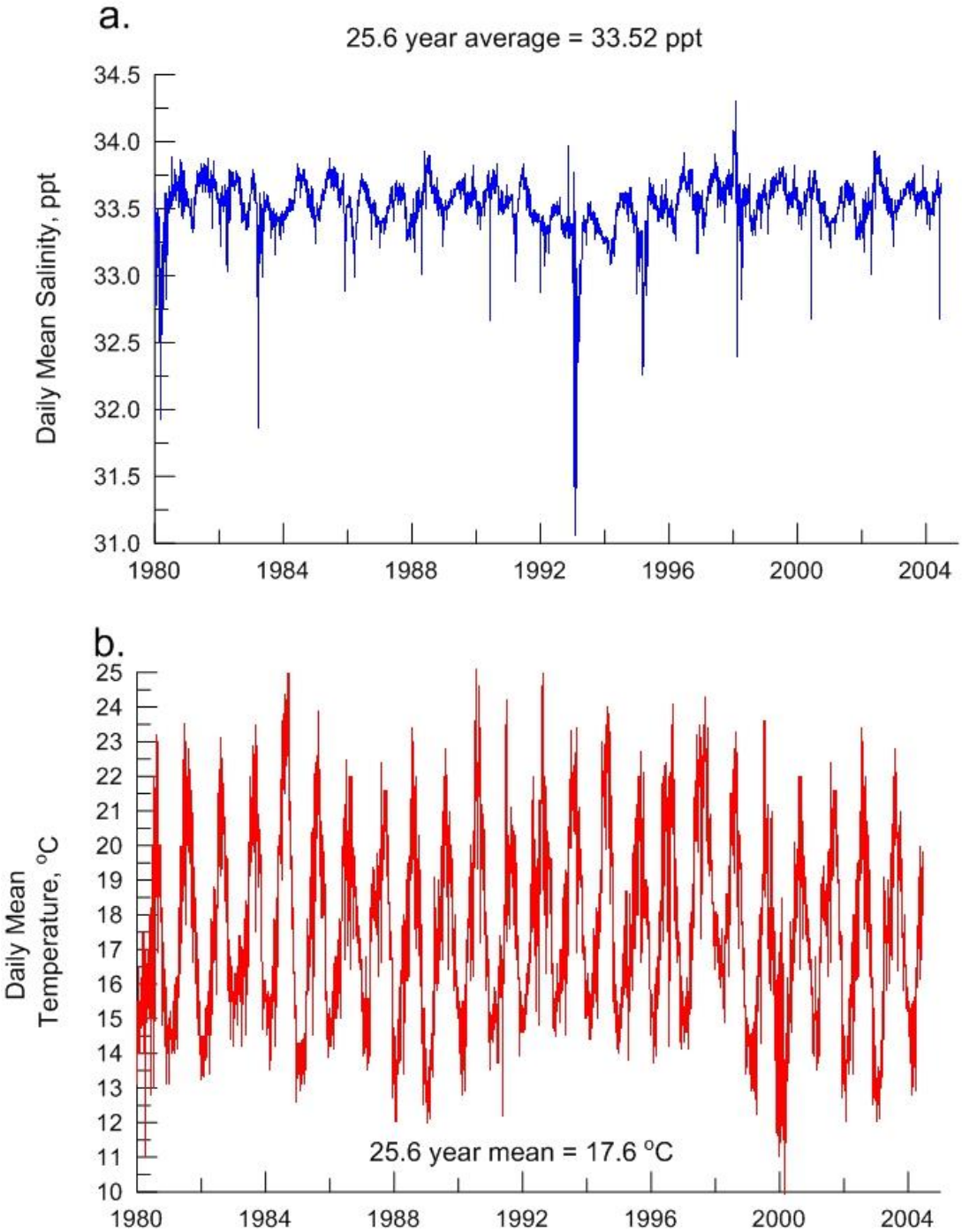


Figure 5: Controlling receiving water variables for brine dilution: a) daily mean salinity, and b) daily mean temperature. Data from shore station data base for California available at: https://scripps.ucsd.edu/programs/shorestations/shore-stations-data/

The 25.6 year record of daily mean ocean water temperatures extracted from these data bases is plotted in Panel-b of Figure 5. This includes the period of record for ocean temperature variation as that used in the SEIR, (2010) as well as that of the KOMEX (2003) water quality study. 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. On a percentage basis, the natural variability of the temperature of coastal waters in the vicinity of the HBDF is significantly greater than that of salinity (on the order of ΔT = 86% vs ΔS = 10%)

5.4) Temperature/Salinity Depth Profile. Under the terms within Appendix I of the *California Ocean Plan* the solution for the ZID boundary requires model input defined as, "*the trapping level when considering worst-case scenarios*". Trapping levels result from the vertical stratification of the receiving waters as a consequence of the temperature/salinity depth profile. A worst-case temperature salinity profile would be one that results in strong vertical stratification of the water column at the discharge site. These conditions would be most prevalent in summer months when a lens of warm low-salinity surface water overlies cooler, high salinity bottom water, causing the dense brine effluent to be trapped near the seabed; thereby limiting the volume of dilution available for entrainment by the brine plume, and inhibiting dilution rates. A computer search of the temperature and salinity records in Figures 5, finds the worst-case scenario occurs in the historic record during August 2002. The most detailed temperature and salinity profiles in the immediate neighborhood of the HBGS outfall during this period were due to KOMEX (2003), which measured temperature salinity profiles at 11 locations around the HBGS outfall, as shown in Figure 6. These profiles are plotted in Figures 7 and 8. Cast #1 on 22 August 2002 was used to represent worst-case because it was closest to the HBGS discharge tower. (Cast #1 on 20 August 2002 was incomplete and did not have a salinity profile). The 22 August 2002 Cast#1 ambient profile presents a well-defined vertically stratified water mass with warm, low salinity water at near the surface where temperatures are T =22.5 ^{0} C and salinity is S = 33.2 ppt. Approaching the seabed, the receiving water cools to T =20.75 ^{0} C while the salinity increases to S = 34.5 ppt, matching the long-term maximum observed salinity. This amount of vertical stratification in only 8.5 m of water depth, tends to suppress the brine from rising into the less dense water mass near the sea surface and confine it near the seabed where it remains more concentrated, thereby producing a worst-case dilution scenario.

CORMIX 10.0.3.0 accepts density inputs of the receiving water ρ at the sea surface and seafloor. These density inputs are calculated from the 22 August 2002 Cast#1 ambient profiles using the equation of state of seawater expressed in terms of the specific volume, $\alpha = 1/\rho$ or:

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

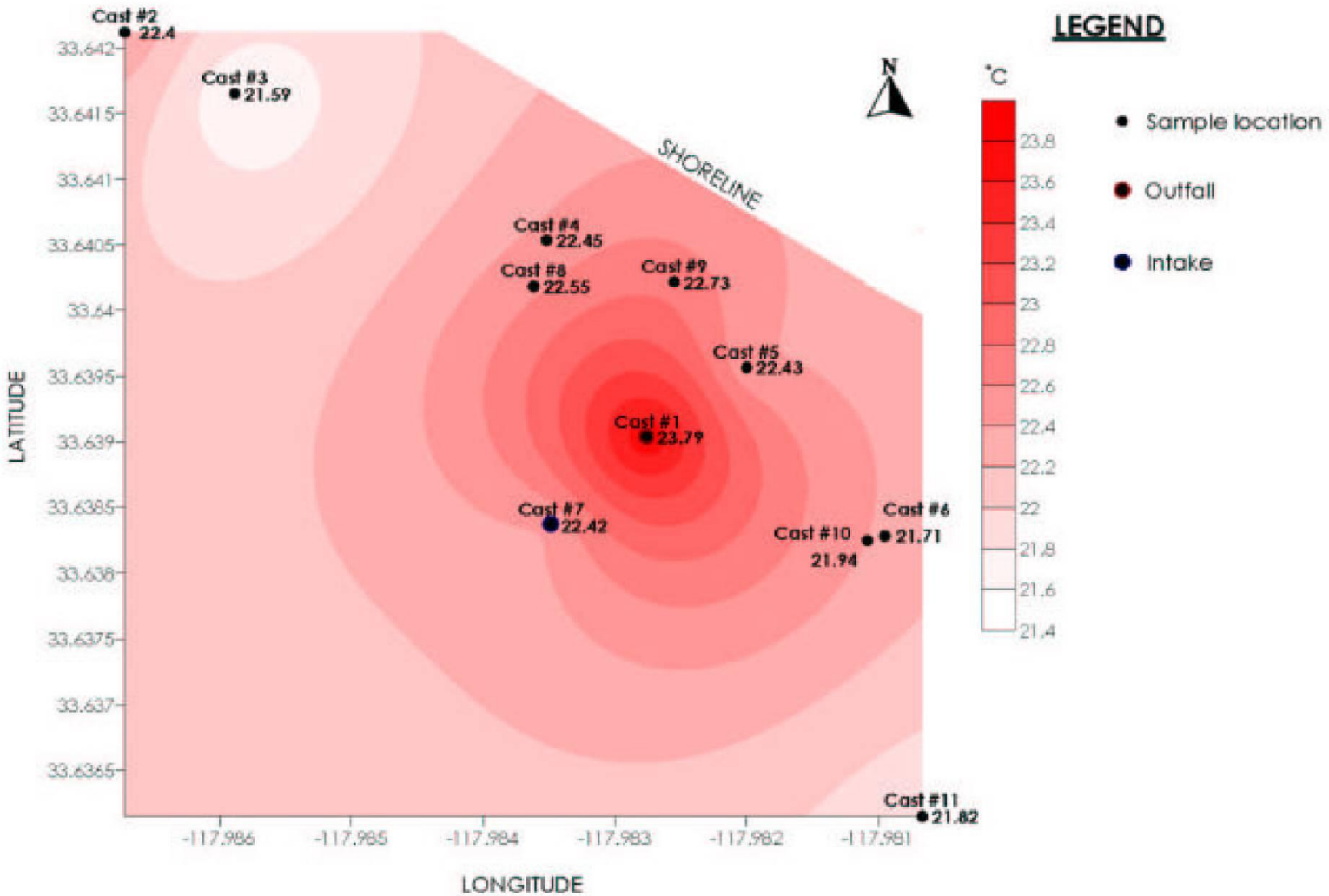
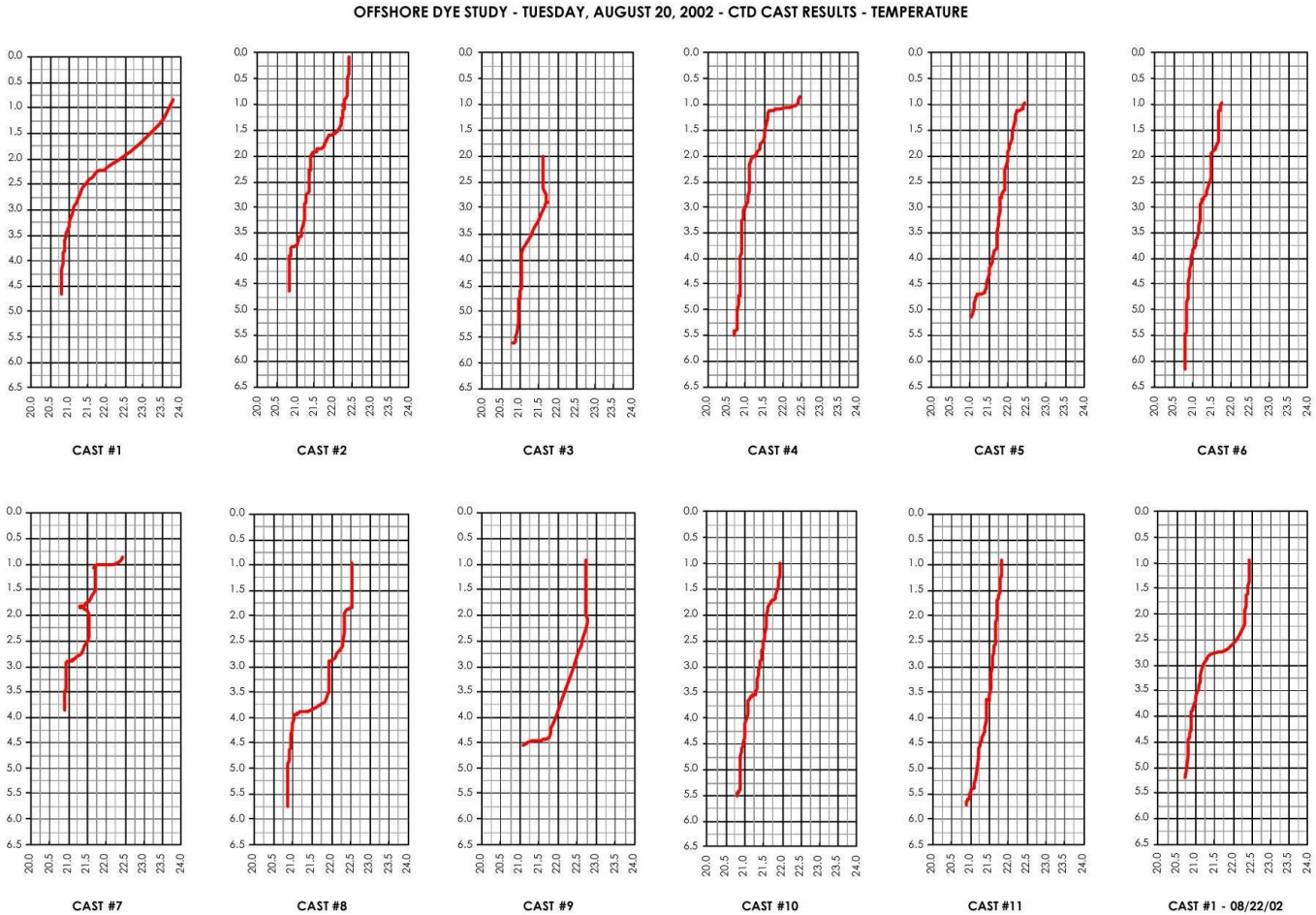


Figure 6: Cast locations for temperature and salinity profiles from the CEC Komex Study (2003) as shown in Figures 7 and 8. Color contours denote surface temperature distribution per the legend on the right hand side of the figure.



Depths (shown along the vertical axis in each graph) are in meters.
Temperatures (shown along the horizontal axis in each graph) are in degrees Centigrade

Figure 7: Temperature – depth profiles around the HBDF discharge tower during worst-case month, August 2002. Data from KOMEX (2003).

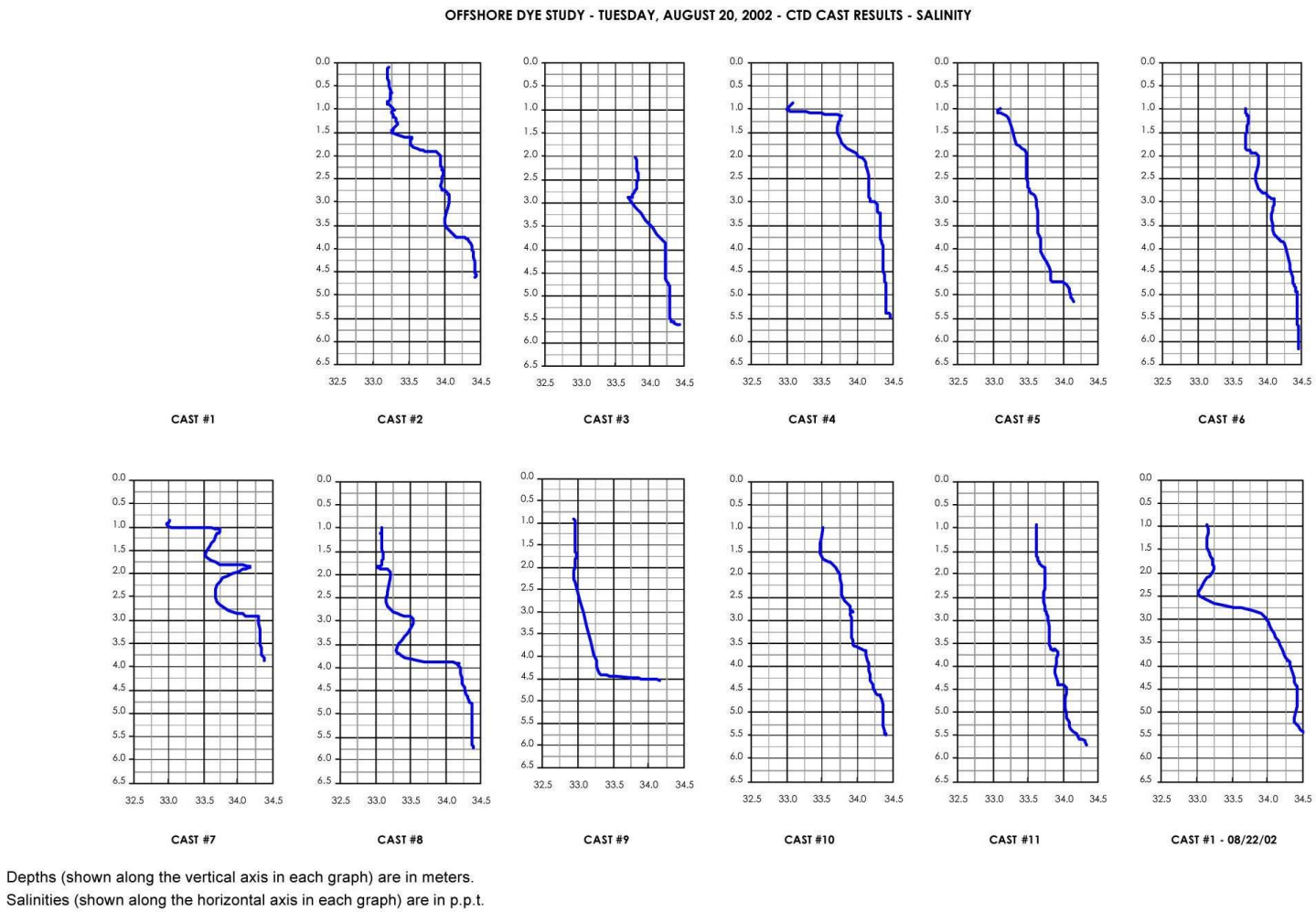


Figure 8. Salinity – depth profiles around the HBDF discharge tower during worst-case month, August 2002. Data from KOMEX (2003).

The factor $\partial\alpha / \alpha\partial T$, which multiplies the differential temperature changes, is known as the *coefficient of thermal expansion* and is 2 x 10^{-4} per ^{o}C for seawater; the factor $\partial\alpha / \alpha\partial S$ multiplying the differential salinity changes, is the *coefficient of saline contraction* and is -8 x 10^{-4} per part per thousand (ppt) where 1.0 ppt in psu units for standard seawater = 1.0 g/L of total dissolved solids (TDS). For standard seawater at a temperature of $\hat{T}$ = 0 ^{0}C, and a salinity of $\hat{S}$ = 35 ppt the specific volume has a value α = 0.97264 cm^3/g. Therefore, the 22 August 2002 Cast#1 ambient profiles give the following specific volumes and densities for worst-case summer stratified conditions at the HBGS discharge site:

Level 1: Surface Mixed Layer

$dT = T - \hat{T}$ = 22.5 ^{0}C - 0 ^{0}C = 22.5 ^{0}C;

$dS = S - \hat{S}$ = 33.13 ppt – 35 ppt = -1.87 ppt

α_1 = 0.978473 cm^3/g

$\rho_1 = 1/\alpha_1$ = 1,022.0 kg/m^3

Level 2: Bottom Layer

$dT = T - \hat{T}$ = 20.75 ^{0}C - 0 ^{0}C = 20.75 ^{0}C;

$dS = S - \hat{S}$ = 34.5 ppt – 35 ppt = -0.5 ppt

α_1 = 0.977066 cm^3/g

$\rho_1 = 1/\alpha_1$ = 1,023.473 kg/m^3

5.5) Brine Effluent Discharge Temperature: Because of similarities in design of pre-treatment and reverse osmosis facilities we shall use present discharge temperatures at the Carlsbad Desalination Project (CDP) as a proxy for the HBDF. The CDP began discharging brine effluent on 1 November 2015. Discharge monitoring results show an average temperature difference between intake and discharge temperatures during the first 3 operating months of ΔT = -0.7 ^{0}F = - 0.39 ^{0}C; increasing slightly to ΔT = + 2.74 ^{0}F = +1.96 ^{0}C during the following two operating months. Therefore, the CORMIX 10.0.3.0 and *COSMOS/ FLowWorks* models were initialized in two separate runs for effluent discharge streams having ΔT = 0 ^{0}C; and ΔT = + 2 ^{0}C.

5.5) Discharge Density: CORMIX 10.0.3.0 requires the user to input discharge density based on the ΔT and ΔS of the effluent relative to ambient receiving water. Because the CORMIX solutions were all found to be vertically fully mixed within a very short distance from the discharge point, the ΔT and ΔS of the effluent were calculated relative to the average temperature and salinity of the surface mixed layer and bottom layer. Based on this reasoning, the density of the brine effluent for Worst-Case #1 and #2 were calculated from equation (1) as follows:

Worst-Case # 1: $\Delta T = +2\ ^0C$; $\rho_b = 1/\alpha_b = 1{,}046.4\ kg/m^3$

Worst-Case # 1: $\Delta T = 0\ ^0C$; $\rho_b = 1/\alpha_b = 1{,}046.8\ kg/m^3$

Worst-Case # 2: $\Delta T = +2\ ^0C$; $\rho_b = 1/\alpha_b = 1{,}050.3\ kg/m^3$

Worst-Case # 2: $\Delta T = +2\ ^0C$; $\rho_b = 1/\alpha_b = 1{,}050.7\ kg/m^3$

5.6) Brine Effluent Discharge Temperature: CORMIX 10.0.3.0 takes inputs for effluent concentration in terms as *excess concentration* over ambient receiving water. The effluent excess concentration is measured in practical salinity units (psu) in parts per million (ppm). Brine excess concentrations for Worst-Case #1 and #2 were entered as follows:

Worst-Case # 1: $\Delta S = 28940$ ppm

Worst-Case # 2: $\Delta S = 33500$ ppm

5.7) Waves, Currents, Tides and Winds: Following Provision III.C.4.d of the Ocean Plan, initial dilution shall be modeled with no excitation of receiving water motion from waves, currents, tides or winds were input to either the CORMIX 10.0.3.0 and *COSMOS/ FLowWorks* models. Ocean water levels were set at a constant elevation of 0 m MSL. We refer to this set of boundary conditions as the Quiescent Ocean Dilution condition.

5.8) Water Quality Standard: CORMIX 10.0.3.0 takes inputs for the *water quality standard* in terms of *excess discharge concentration* over ambient receiving water at a specified distance from the point of discharge referred to as the *regulatory mixing zone value*. Based on Appendix-A of the amended California Ocean Plan, (that requires dilution of the brine discharge to within 2 ppt of natural background within 100 m from the point of discharge), the *water quality standard* was set an excess discharge concentration of 2000 ppm and the *regulatory mixing zone value* was set at 100 m.

6) BMZ Determination from Nearfield Dilution Analysis of Daily Worst-Case Discharges

The CORMIX 10.0.3.0 prediction files for daily worst-case are found in Appendix C for Worst-Case #1 outcomes and Appendix D for Worst-Case #2 outcomes. Worst Case #1 prediction files for $\Delta T = +2\ ^0C$ are found on Sheets C-1 through C-6, while Worst Case #1 prediction files for $\Delta T = 0\ ^0C$ are found on Sheets C-7 through C-12. Comparing these two sets of prediction sheets indicates that the brine dilution is essentially unaffected by a 2^0 C difference in the delta-T. The most striking feature of the CORMIX 10.0 predictions is that the Worst-Case #1 is that the discharge plume becomes vertically fully mixed the water column within 4.48 meters from the point of discharge, as illustrated in the CORMIX 3-d contour plot in Figure 9. Annotations in the prediction file also attribute additional rapid initial dilution to the fanned-out horizontal the three duckbill check valves of the Alden diffuser design. This is confirmed by the CFD simulation in Figure 10 of the discharge jets and entrainment streams from the Alden

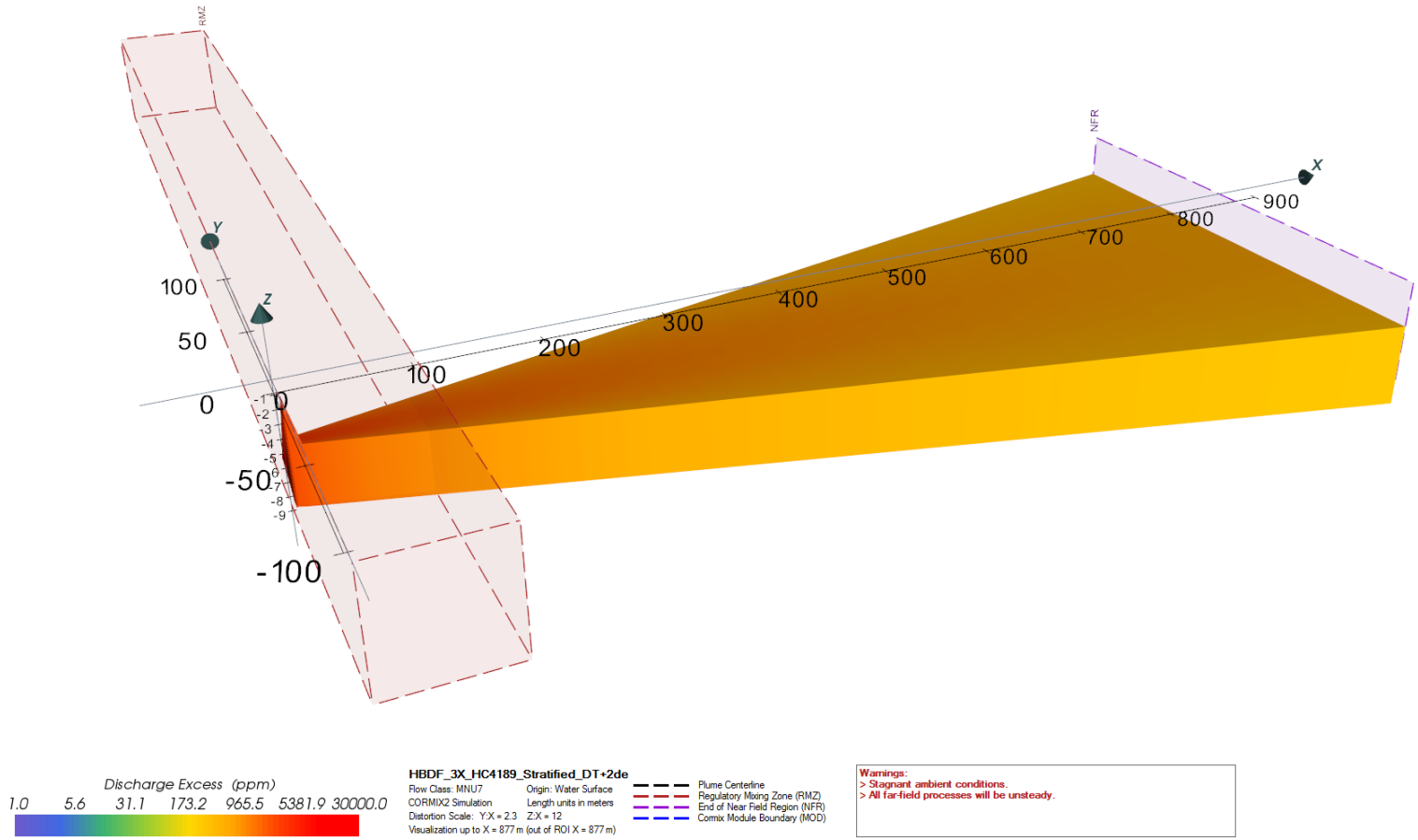


Figure 9: CORMIX v10.0.3.0 three-dimensional contour plot of the discharge plume for Worst-Case #1 operating conditions with brine discharge (including backwash) = 62.5 mgd at 62.44 ppt, with $\Delta T = +2\ ^0C$. Densimetric Froude number $F_r = u/\sqrt{\Delta\rho g d\ /\rho} = 14.08$. Contour plot represents excess salinity (salinity above natural background) in parts per million (ppm)

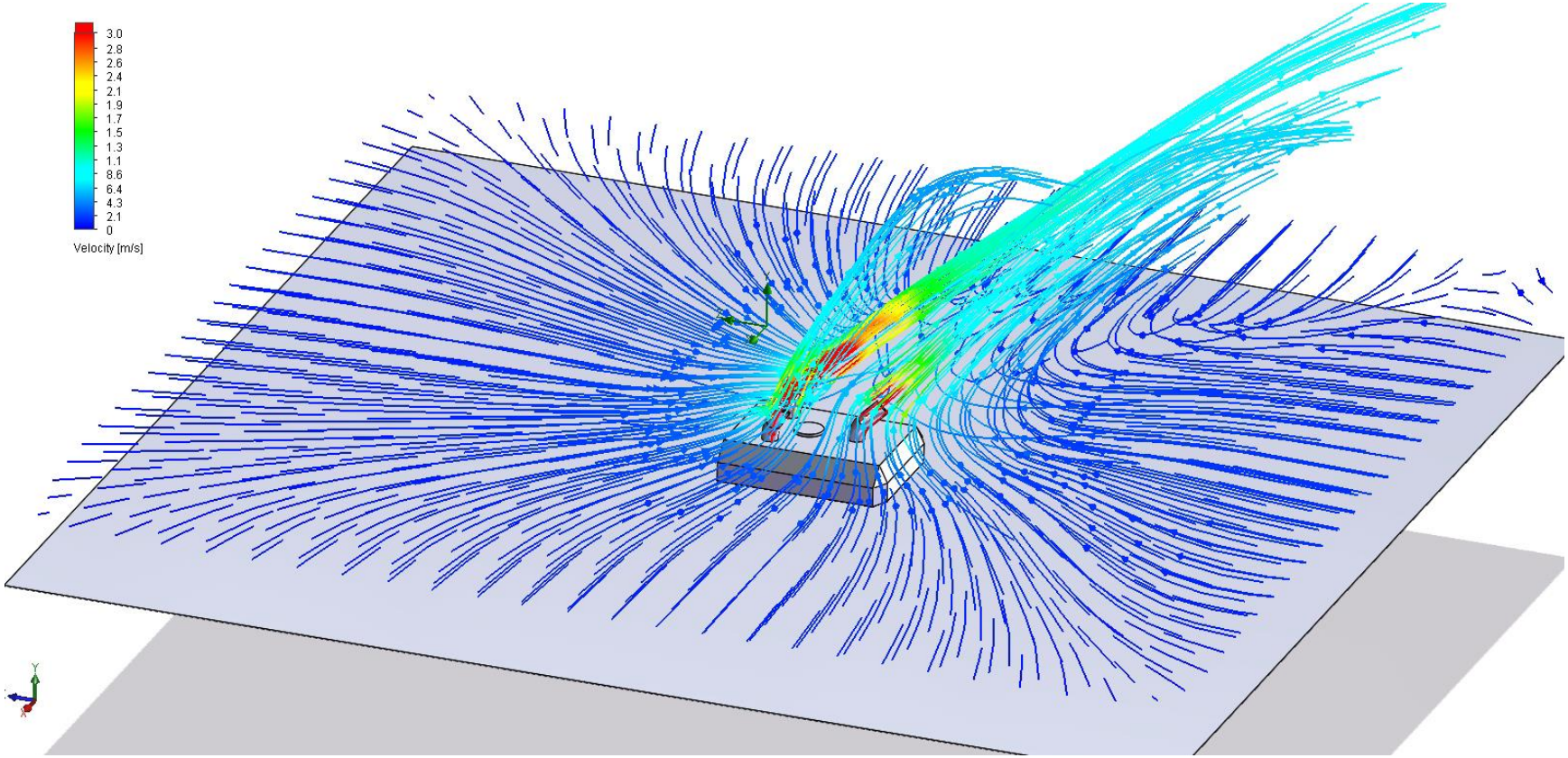


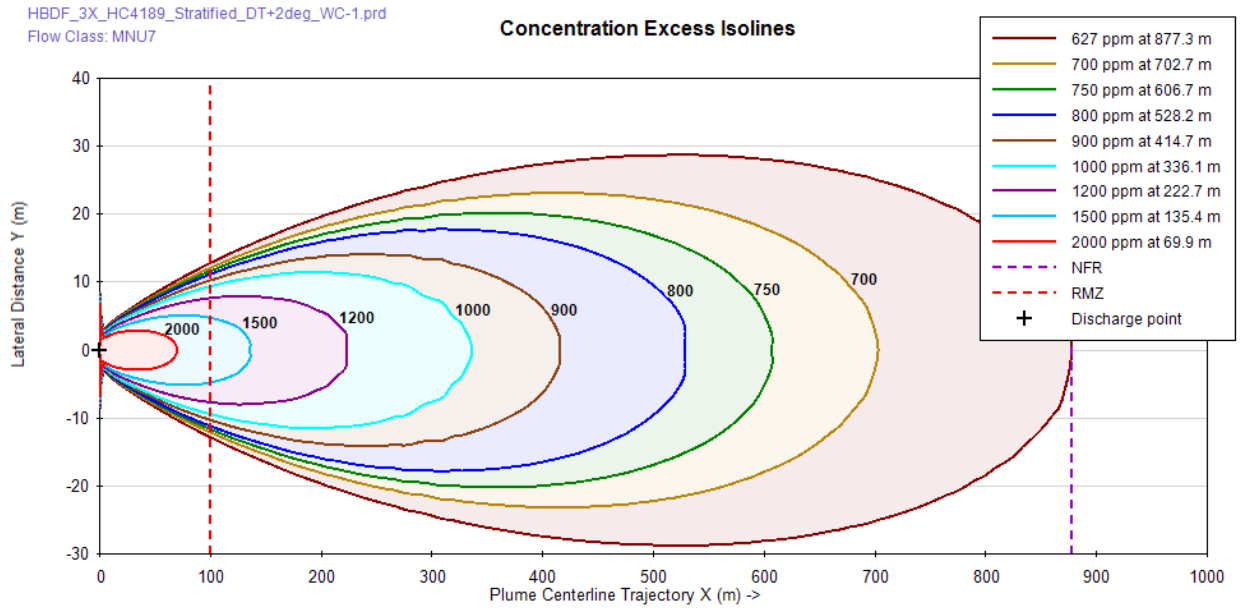
Figure 10: Worst-Case #1 *COSMOS/ FLowWorks* solutions of the discharge and entrainment streams from Alden Duckbill diffuser operating in the *stand-alone* regime using three 36 in. Series 35D/ Tideflex duckbill check valves with the 4.5-ft. diameter port capped. Simulation for Worst-Case #1 operating conditions with brine discharge (including backwash) = 62.5 mgd at 62.44 ppt, with $\Delta T = +2\ ^0C$. Densimetric Froude number $F_r = u/\sqrt{\Delta\rho g d/\rho} = 14.08$.

Diffuser operating under Worst-Case-#1discharge conditions. The discharge jets from the three duckbill check valves produce organized entrainment streams several meters above the bottom, (Figure 8) which draw receiving water inward toward the diffuser and then merge with the upward trajectories of the discharge streams to produce full vertical mixing over the entire water column within a few meters from the point of discharge.

The Module 252 CORMIX outputs for Worst-Case #1 are listed in Appendix-C and plotted in Figure 11. Excess discharge salinity (salinity above natural background) is represented in Panel-A of Figure 11 plotted as a footprint on the seabed. Dilution factor is based on $S_{\max}(x)$ = 62.44 ppt in equation (1). The CORMIX v10.0.3.0 model finds in Figure 11a that the Alden Diffuser dilutes 62.5 mgd of brine to within 2 ppt of natural background at 69.9 m from the point of discharge, and therefore satisfies the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. However, beyond this compliance point, the rate of increase in dilution declines, and at 100 m from the point of discharge (the regulatory mixing zone or RMZ) the mixing ratio reaches S = 16.8 and the dilution factor is Dm = 15.8. At 877 m from the point of discharge, the CORMIX 10.0.3.0 dilution simulation is terminated because of stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requirements for initial dilution calculations under conditions of no waves, currents or tides is the primary reason for stagnant ambient conditions at the point where CORMIX terminated the simulation). Because of these stagnant ambient conditions that prevail at 877 m from the point of discharge, we will assume dilution is complete at this point, marking the limit of the zone of initial dilution (ZID), where the mixing ratio reaches S = 46.1 and the dilution factor is Dm = 45.1.

CORMIX 10.0.3.0 predictions for Worst-Case #2 in Appendix D also show very rapid dilution within the first 4.5 meters from the discharge point. Inspection of the Module 272 output indicates that the discharge plume becomes vertically fully mixed over the water column within a few meters from the point of discharge as shown by the 3-d contour plot in Figure 12. The CFD simulations in Figure 13 show that the upward trajectories of the discharge streams produce the vertical spreading of the plume that promotes rapid vertical mixing over the entire water column near the point of discharge. The Module 252 CORMIX outputs for Worst-Case #2 are listed in Appendix-D and plotted in Figure 14. Excess discharge salinity (salinity above natural background) is represented in Panel-A of Figure 14 plotted as a footprint on the seabed. Dilution factor is based on $S_{\max}(x)$ = 67 ppt in equation (1). The CORMIX v10.0.3.0 model finds in Figure 11a that the Alden Diffuser dilutes 54 mgd of brine to within 2 ppt of natural background at 91.8 m from the point of discharge, and therefore satisfies the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. At 100 m from the point of discharge (the regulatory mixing zone or RMZ) the mixing ratio reaches S = 17.5 and the dilution factor is Dm = 16.5. At 877 m from the point of discharge, the CORMIX 10.0.3.0 dilution simulation is terminated because of stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requirements for initial dilution calculations under conditions of no waves, currents or tides is the primary reason for stagnant ambient conditions at the point where CORMIX terminated the simulation). Because of these stagnant ambient conditions that prevail at 877 m from the point of discharge, we will assume dilution is complete at this point, marking the limit of the zone of initial dilution (ZID), where the mixing ratio reaches S = 47.9 and the dilution factor is Dm = 46.9.

a)



b)

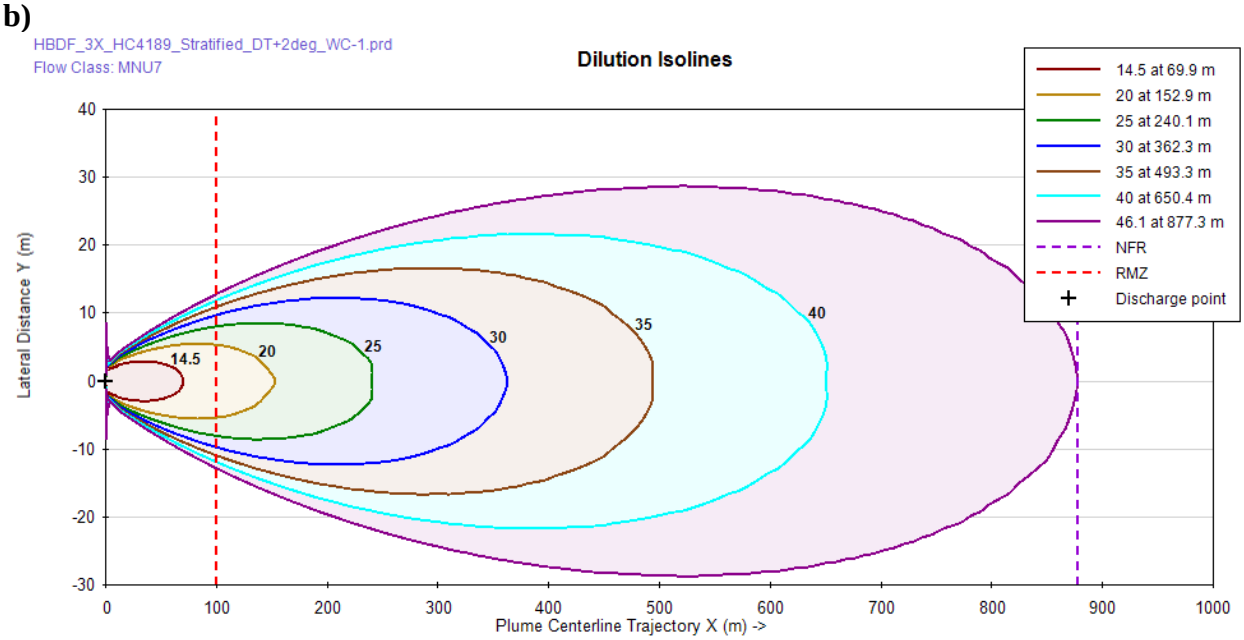


Figure 11: Isolines on the seabed for Daily Worst-Case #1 operating conditions: a) excess salinity (salinity above natural background) in parts per million (ppm); and, b) dilution expressed as mixing ratio, S, where S = Dm + 1. Note, dilution of the brine to within 2 ppt (2,000 ppm) of natural background is achieved at 69.9 m from the point of discharge where the mixing ratio is S = 14.5 and the dilution factor is Dm = 13.5. At the 100 m *regulatory mixing zone* (RMZ), the mixing ratio is S = 16.8 and the dilution factor becomes Dm = 15.8, ultimately reaching Dm = 45.1 at 877 m from the point of discharge which marks the limit of the *zone of initial dilution*, or ZID, (cf Appendix-C for detailed *Prediction File* and additional salinity & dilution figures)

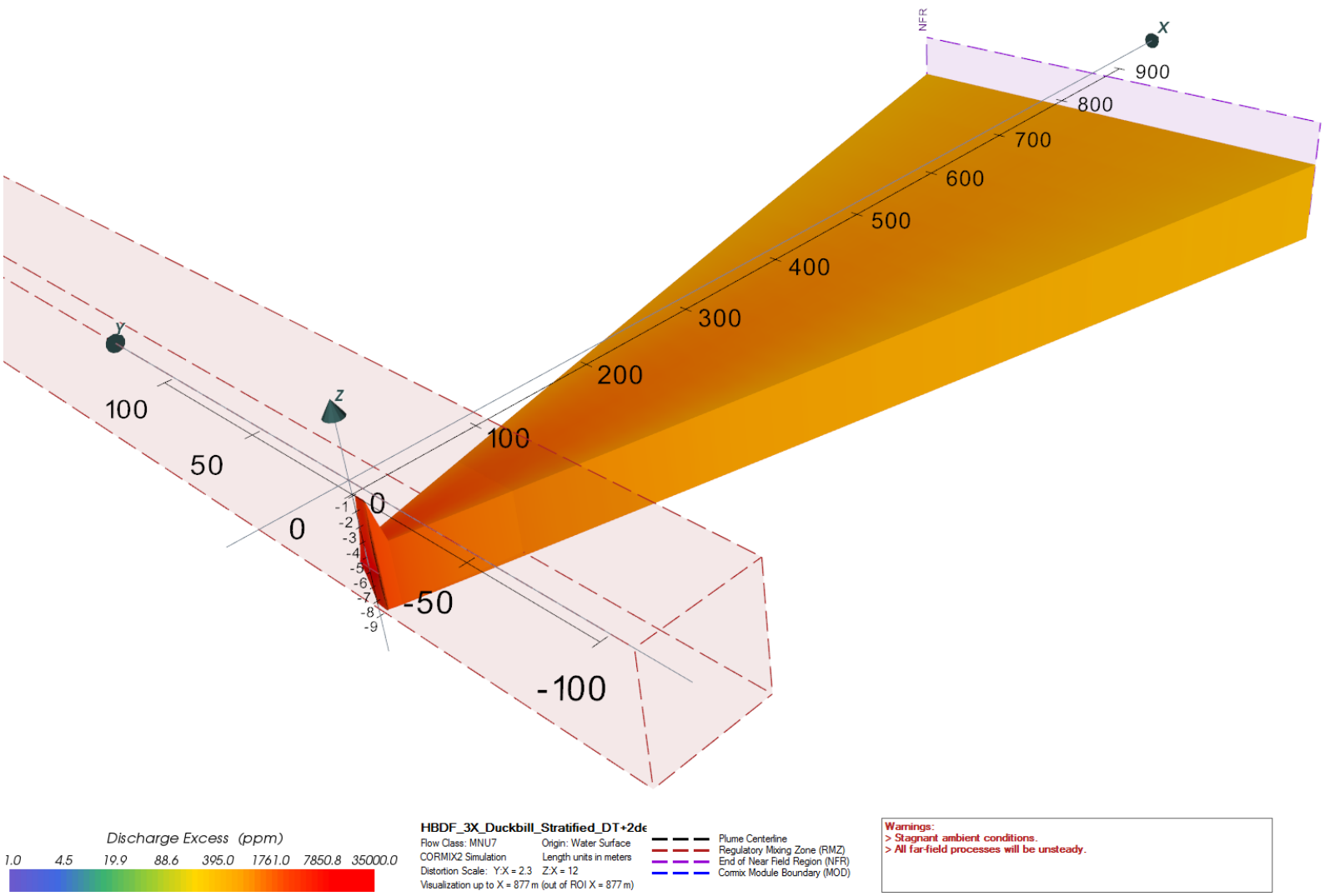


Figure 12: CORMIX v10.0.3.0 three-dimensional contour plot of the discharge plume for Worst-Case #2 operating conditions with brine discharge (including backwash) = 54 mgd at 67 ppt, with ΔT = +2 ^{0}C. Densimetric Froude number $F_r = u/\sqrt{\Delta\rho g d/\rho}$ = 12.36. Contour plot represents excess salinity (salinity above natural background) in parts per million (ppm)

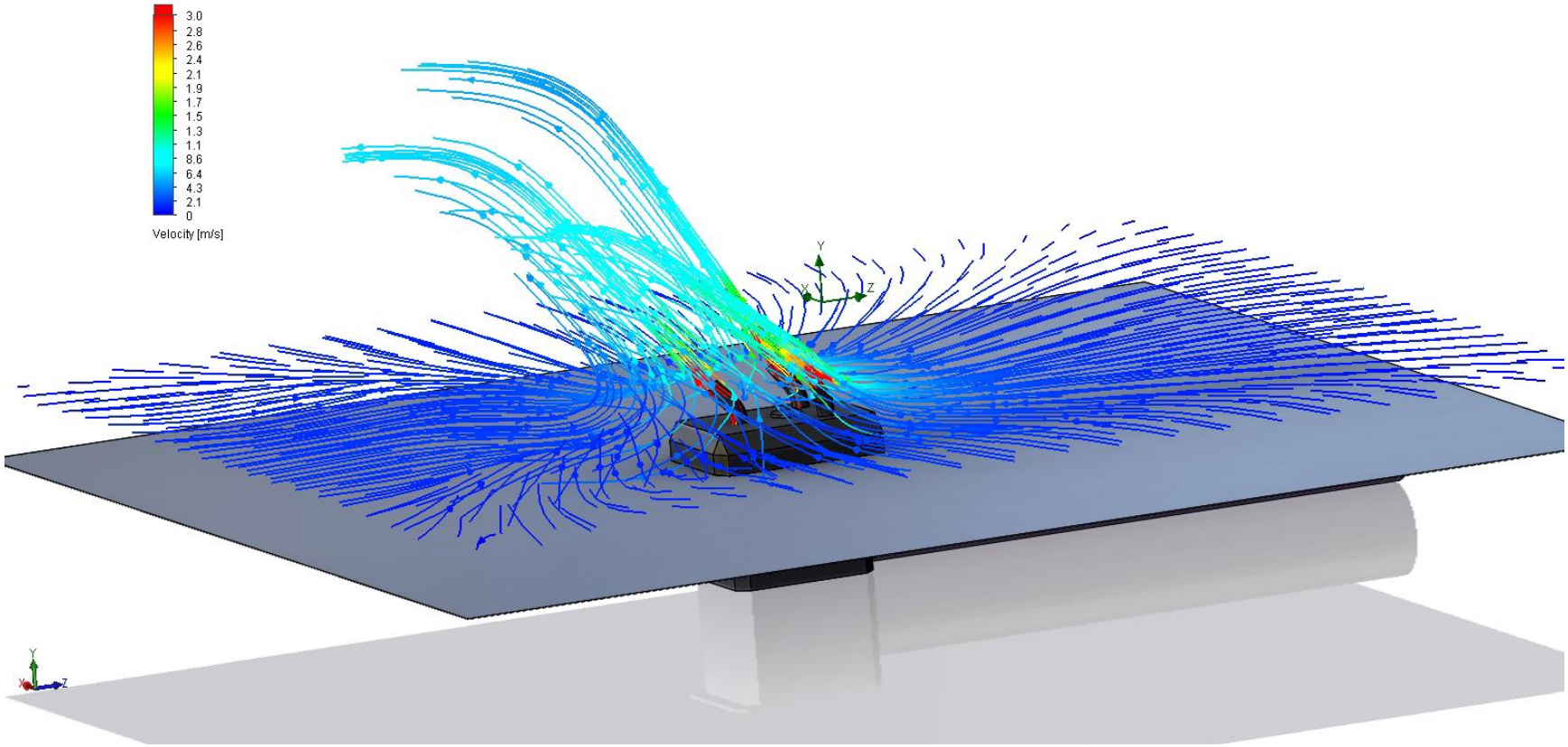
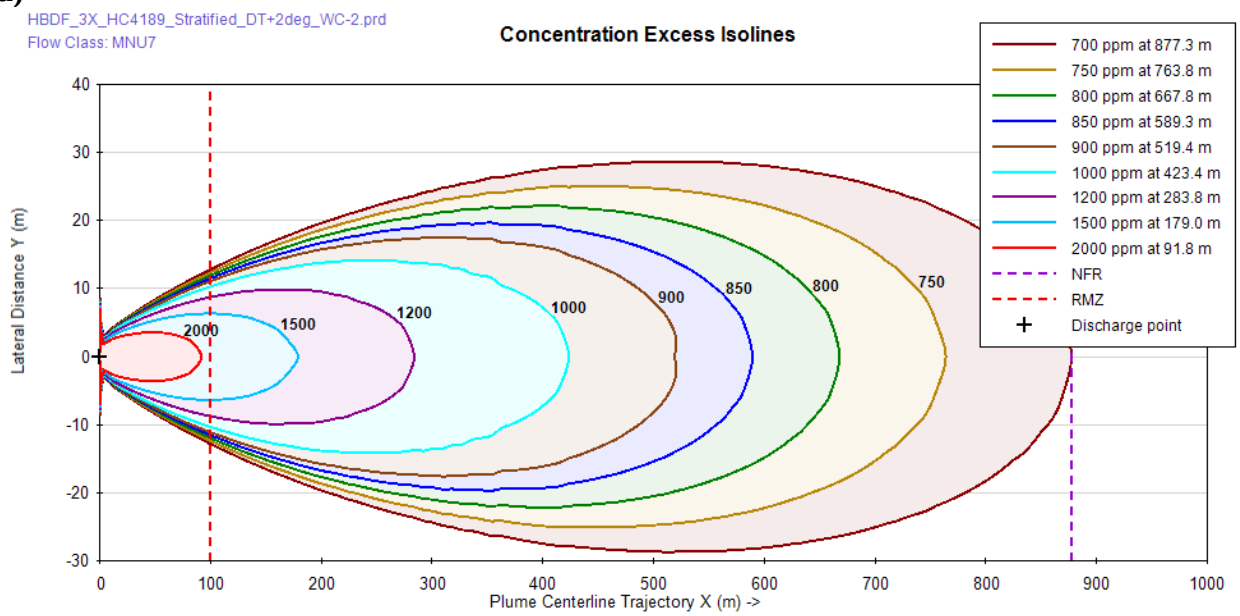


Figure 13: Worst-Case #2 *COSMOS/ FLowWorks* solutions of the discharge and entrainment streams from Alden Duckbill diffuser operating in the *stand-alone* regime using three 36 in. Tideflex Series 35-D/HC4189 duckbill check valves with the 4.5-ft. diameter port capped. Brine discharge (including recycled backwash) = 54.0 mgd at 67.0 ppt, with $\Delta T = +2\ ^0C$. Densimetric Froude number $F_r = u/\sqrt{\Delta\rho g d\ /\rho} = 12.36$.

a)



b)

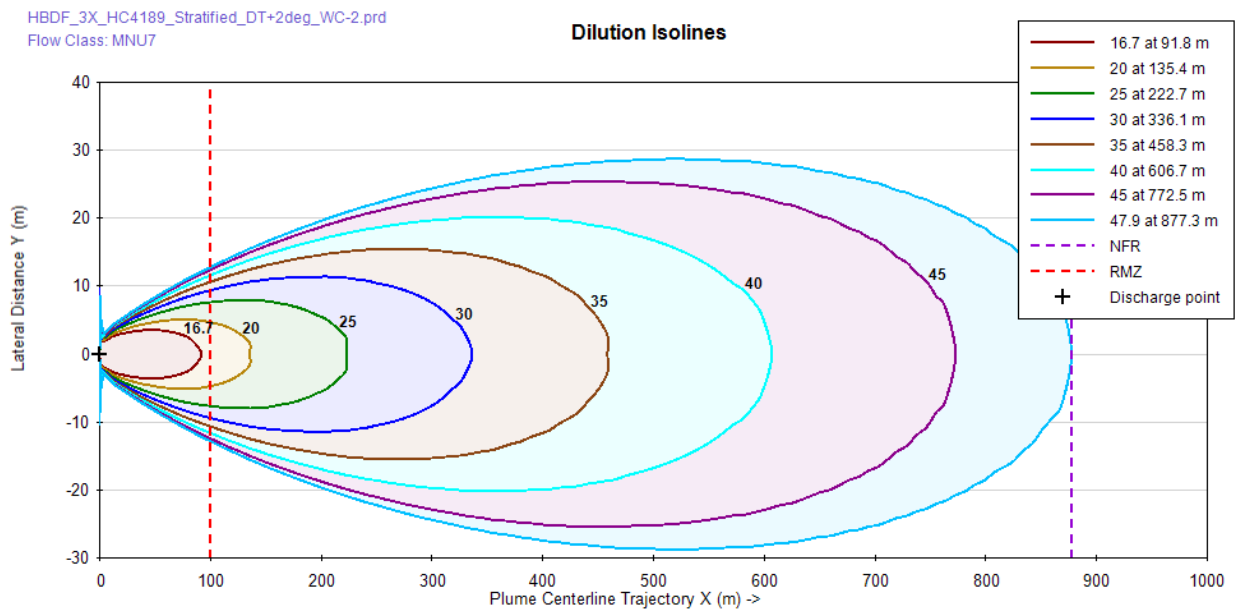


Figure 14: Isolines on the seabed for Daily Worst-Case #2 operating conditions: a) excess salinity (salinity above natural background) in parts per million (ppm); and, b) dilution expressed as mixing ratio, S, where S = Dm + 1. Note, dilution of the brine to within 2 ppt (2,000 ppm) of natural background is achieved at 61.8 m from the point of discharge where the mixing ratio is S = 16.75 and the dilution factor is Dm = 15.75. At the 100 m *regulatory mixing zone* (RMZ), the mixing ratio is S = 17.5 and the dilution factor becomes Dm = 16.5, ultimately reaching Dm = 46.9 at 877 m from the point of discharge which marks the limit of the *zone of initial dilution*, or ZID, (cf Appendix-D for detailed *Prediction File* and additional salinity & dilution figures)

7) BMZ Determination for Monthly Worst-Case Discharges

Under Ocean Plan implementation polices, mitigation scaling for brine impacts to marine organisms inside the limits of the BMZ are based on worst-case monthly discharge scenarios. The two worst-case monthly discharge scenarios studied are:

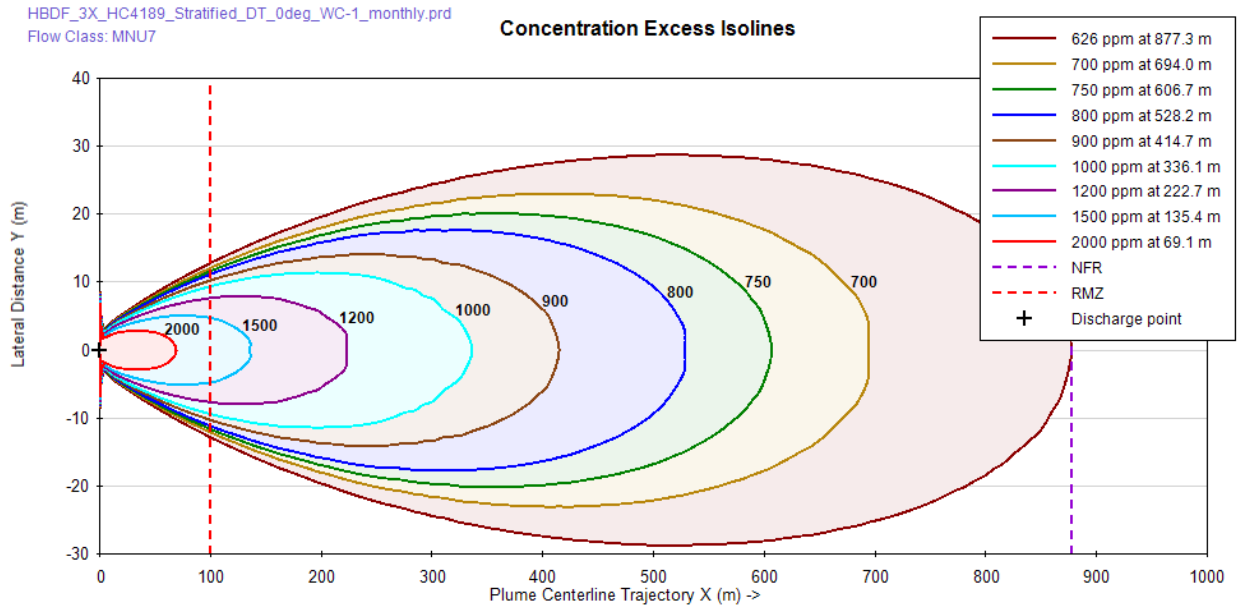
Monthly Worst-Case #1 which utilizes an average brine discharge of $\overline{Q}$ = 56.7 mgd that includes R.O. backwash, and has an end-of-pipe discharge salinity S_b = 63.1 ppt. Average monthly delta-T is $\Delta T \cong 0^0$ C, so that the density of the discharge is ρ_b =1,047.4 kg/m^3

Monthly Worst-Case #2 composed of brine discharge with *recycled backwash* that is discharged at a rate of $\overline{Q}$ = 50 mgd with an end-of-pipe discharge salinity S_b = 67 ppt. Average monthly delta-T is $\Delta T \cong 0^0$ C, so that the density of the discharge is ρ_b =1,050.7 kg/m^3

Under Monthly Worst-Case-1 conditions, with total discharge $\overline{Q}$ = 56.7 mgd (2.484 m^3/s), each Tideflex Series 35-D/HC4189 duckbill check valve check provides A_i = 0.184 m^2 of equivalent circular cross sectional area with an effective diameter of d = 0.484 m in order to discharge $Q_i = \overline{Q}/3$ = 0.828 m^3/s from each check valve, (cf. Figure 4). This gives a maximum discharge velocity of u_0 = 4.50 m/s, (14.77 ft/s) and the Densimetric Froude number is: $F_r = u/\sqrt{\Delta\rho g d/\rho}$ = 13.30. For Monthly Worst-Case-2 conditions, ($\overline{Q}$ = 50 mgd or 2.191 m^3/s), each check valve provides A_i = 0.172 m^2 of equivalent circular cross sectional area with an effective diameter of d = 0.468 m in order to discharge $Q_i = \overline{Q}/3$ = 0.730 m^3/s from each check valve, (cf. Figure 4), resulting in a maximum discharge velocity of u_0 = 4.245 m/s, (13.93 ft/s), and the Densimetric Froude number is: $F_r = u/\sqrt{\Delta\rho g d/\rho}$ = 11.98.

Session reports for CORMIX v 10.0.3.0 outputs for Monthly Worst-Case #1 are listed in Appendix-L and Prediction Files are listed in Appendix-M. Figure 15 plots isolines for excess discharge salinity (salinity above natural background) in Panel-A as a footprint on the seabed. Mixing ratios (dilution factor plus one) are plotted in Panel-B of Figure 15 for monthly Worst-Case #, based on in equation (1) for end-of-pipe discharge salinity $S_{\max}(x)$ = 63.1 ppt. The CORMIX v10.0.3.0 model finds in Figure 15 a that the Alden Diffuser dilutes 56.7 mgd of brine to within 2 ppt of natural background at 69.1 m from the point of discharge, (nearly the same as for the daily Worst-Case #1 in Figure 11), and therefore satisfies the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. At 100 m from the point of discharge (the regulatory mixing zone or RMZ) the mixing ratio reaches S = 16.8 and the dilution factor is Dm = 15.8. At 877 m from the point of discharge, the CORMIX 10.0.3.0 dilution simulation is terminated because of stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requirements for initial dilution calculations under conditions of no waves, currents or tides is the primary

a)



b)

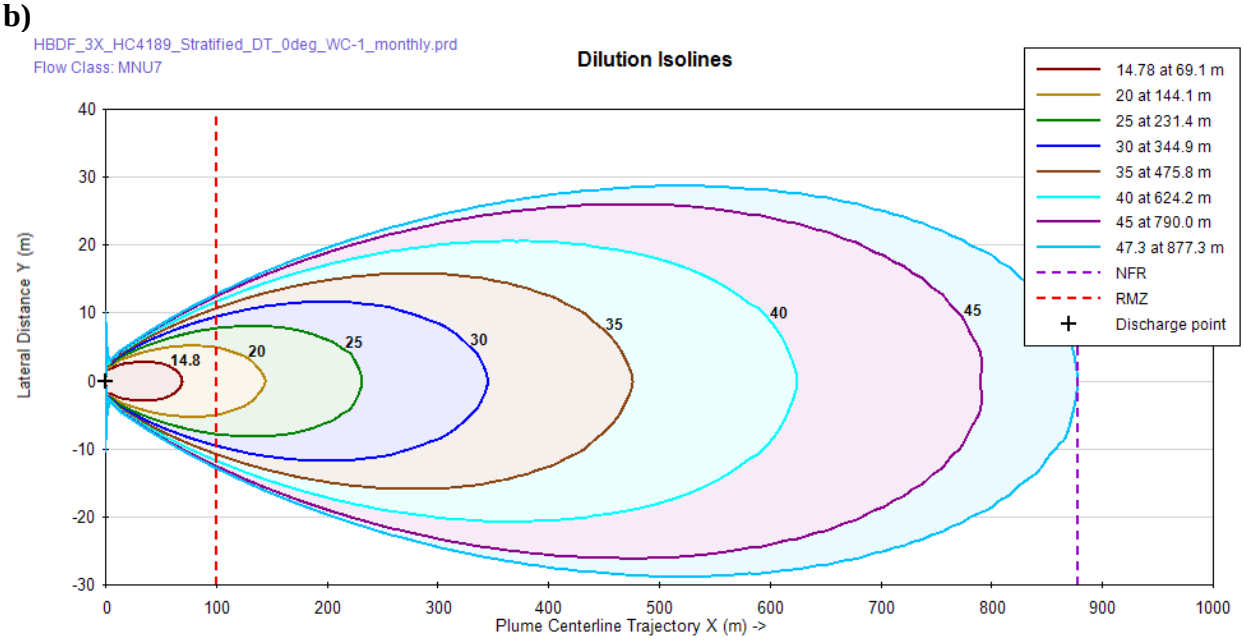


Figure 15: Isolines on the seabed for Monthly Worst-Case #1 operating conditions: a) excess salinity (salinity above natural background) in parts per million (ppm); and, b) dilution expressed as mixing ratio, S, where S = Dm + 1. Note, dilution of the brine to within 2 ppt (2,000 ppm) of natural background is achieved at 69.1 m from the point of discharge where the mixing ratio is S = 14.78 and the dilution factor is Dm = 13.78. At the 100 m *regulatory mixing zone* (RMZ), the mixing ratio is S = 17.2 and the dilution factor becomes Dm = 16.2, ultimately reaching Dm = 46.3 at 877 m from the point of discharge which marks the limit of the *zone of initial dilution*, or ZID, (cf Appendix-M for detailed *Prediction File*s)

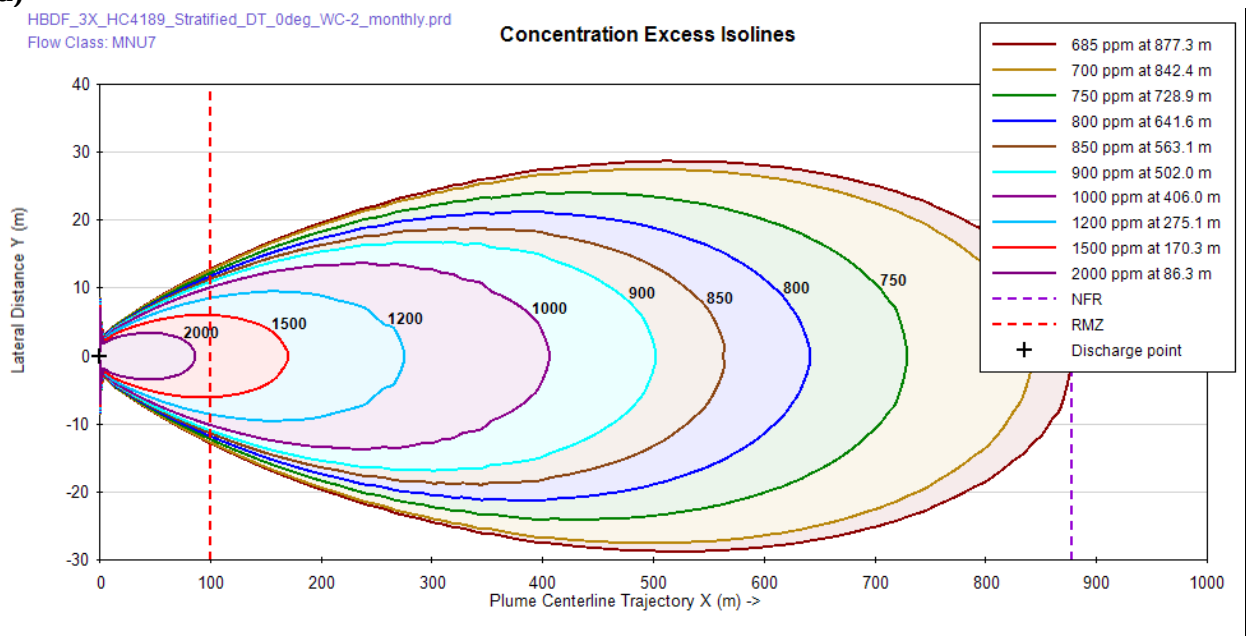
reason for stagnant ambient conditions at the point where CORMIX terminated the simulation). Because of these stagnant ambient conditions that prevail at 877 m from the point of discharge, we will assume dilution is complete at this point, marking the limit of the zone of initial dilution (ZID), where the mixing ratio reaches S = 47.3 and the dilution factor is Dm = 46.3, slightly better than what was found for daily Worst-Case #1 in Section 6.

Session reports for CORMIX v 10.0.3.0 outputs for Monthly Worst-Case #2 are listed in Appendix-N and Prediction Files are listed in Appendix-O. As was found with the daily worst cases in Section 6, CORMIX 10.0.3.0 predictions from Module 272 for Worst-Case #2 in Appendix O also show very rapid dilution within the first 4.5 meters from the discharge point. The Module 252 CORMIX outputs for Worst-Case #2 are plotted in Figure 16. Excess discharge salinity (salinity above natural background) is represented in Panel-A of Figure 16 and mixing ratios (dilution factor plus one) are plotted in Panel-B of Figure 16. The CORMIX v10.0.3.0 model finds in Figure 16a that the Alden Diffuser dilutes 50 mgd discharges of brine at 67 ppt to within 2 ppt of natural background at 86.3 m from the point of discharge, and therefore satisfies the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. At 100 m from the point of discharge (the regulatory mixing zone or RMZ) the mixing ratio reaches S = 17.75 and the dilution factor is Dm = 16.75. At 877 m from the point of discharge, the CORMIX 10.0.3.0 dilution simulation is terminated because of stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requirements for initial dilution calculations under conditions of no waves, currents or tides is the primary reason for stagnant ambient conditions at the point where CORMIX terminated the simulation). Because of these stagnant ambient conditions that prevail at 877 m from the point of discharge, we will assume dilution is complete at this point, marking the limit of the zone of initial dilution (ZID), where the mixing ratio reaches S = 48.9 and the dilution factor is Dm = 47.9, again, slightly better than what was found for daily Worst-Case #2 in Section 6.

8) Analysis of Potential Resuspension of Benthic Sediments

Here we examine the potential for the proposed HBDF/Alden 3-port duckbill diffuser to suspend benthic sediments. From the streamline patterns in Figures 10 &13, it is clear that the discharge jets from Alden diffuser do not directly impinge upon the seabed because the discharge ports are 2.8 m above the seabed and the duckbill check valves are angled upward toward the sea surface at a 47^0 angle (cf. Figure 1). Consequently, the initial trajectory of each discharge jet is upward away from the seabed and the brine plume becomes vertically well mixed within just a few meters from the point of discharge, thereby diluting the effluent momentum and greatly reducing the velocity of the plume at the seabed to about u_i = 0.14 m/s to 0.18 m/s, (0.46 ft/s to 0.60 ft/s), (cf. Figure 10). In fact, the flow trajectories in Figures 10 and 13 indicate that it is the entrainment streams (that are drawn into the jets) which produce most of the flow directly on the seabed in the immediate neighborhood of the HBDF discharge structure. A high-resolution velocity contour plot in Figure 17 maps the diffuser-induced velocities over the seabed plane around the base of the discharge structure using the COSMOS/FloWorks CFD model. Close inspection of Figure 17 reveals that the highest velocities on the seabed occur within 6 m, (20 ft.) of the base of the HBDF discharge structure where maximum velocities reach u_{max} = 0.60 ft/sec (0.18 m/sec).

a)



b)

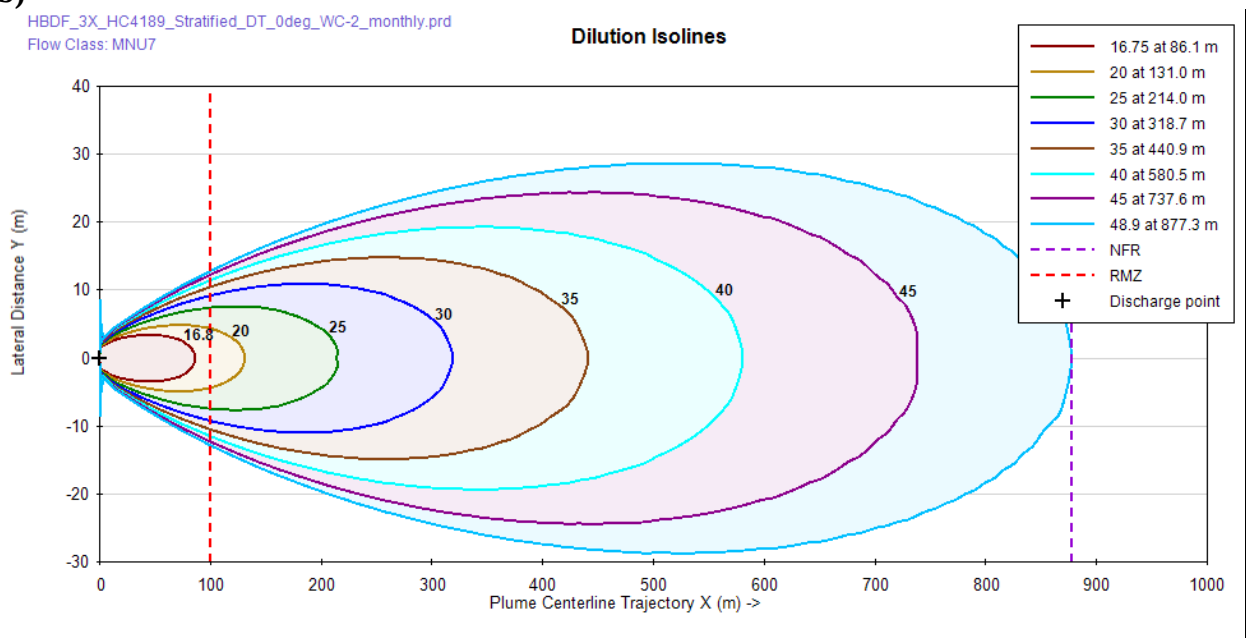


Figure 16: Isolines on the seabed for Monthly Worst-Case #2 operating conditions: a) excess salinity (salinity above natural background) in parts per million (ppm); and, b) dilution expressed as mixing ratio, S, where S = Dm + 1. Note, dilution of the brine to within 2 ppt (2,000 ppm) of natural background is achieved at 86.3 m from the point of discharge where the mixing ratio is S = 16.75 and the dilution factor is Dm = 15.75. At the 100 m *regulatory mixing zone* (RMZ), the mixing ratio is S = 17.8 and the dilution factor becomes Dm = 16.8, ultimately reaching Dm = 47.9 at 877 m from the point of discharge which marks the limit of the *zone of initial dilution*, or ZID, (cf Appendix-O for detailed *Prediction Files*)

The decisive question in this regard is whether a diffuser-induced flow across the seabed sediment/water interface is sufficient to erode and re-suspend the at-rest benthic sediments. This question revolves around the characteristic grain size of those sediments, (Jenkins, et al., 2007). Beach sediment grain sizes in the nearshore waters of Huntington Beach have been monitored by the US Army Corps of Engineers, Los Angeles District, and widely reported and summarized in Osborne (1983, and USACE 1994 & 2001). One of the sediment sampling stations used during these monitoring programs is Station HBP-03, located adjacent to the HBGS discharge tower, (cf. Figure 3). These data are plotted in Figure 18, which shows that there is considerable sediment stratigraphy with depth into the seabed, but surficial layers of seabed sediments are comprised primarily of very fine sand with grain sizes on the order of 0.1 mm; underlain by layers of very coarse sand on the order of 1 mm grain sizes. (Note: Appendix-E contains a Wentworth grain size chart for phi-unit conversions and grain size classifications). The surficial sediment data, characterized by the black line plot in Figure 18 indicates that the finest grained sediments, that are most susceptible to resuspension by the diffuser, have a grain size of $D_{\min}$ = 147 micron (0.147 mm). When this minimum grain size is plotted on the Hjulstrom Curve in Figure 19, (see black arrows), it is found that these offshore sediments have a threshold of motion (critical current speed) at u_{crit} = 0.65 ft/sec (0.2 m/sec). Because the maximum diffuser induced velocity on the seafloor (where $u_{\max}$ = 0.60 ft/sec) is less than the threshold of motion for the sediments found around the diffuser, $u_{\max} < u_{crit}$, we conclude the Alden 3-port duckbill diffuser will not cause suspension of benthic sediments, (cf. Dyer, 1985; Jenkins, et.al., 1994). This conclusion is conservative because it is based on the absolute finest grained sediments at the discharge site, under the influence of the absolute highest diffuser induced velocities on the seabed.

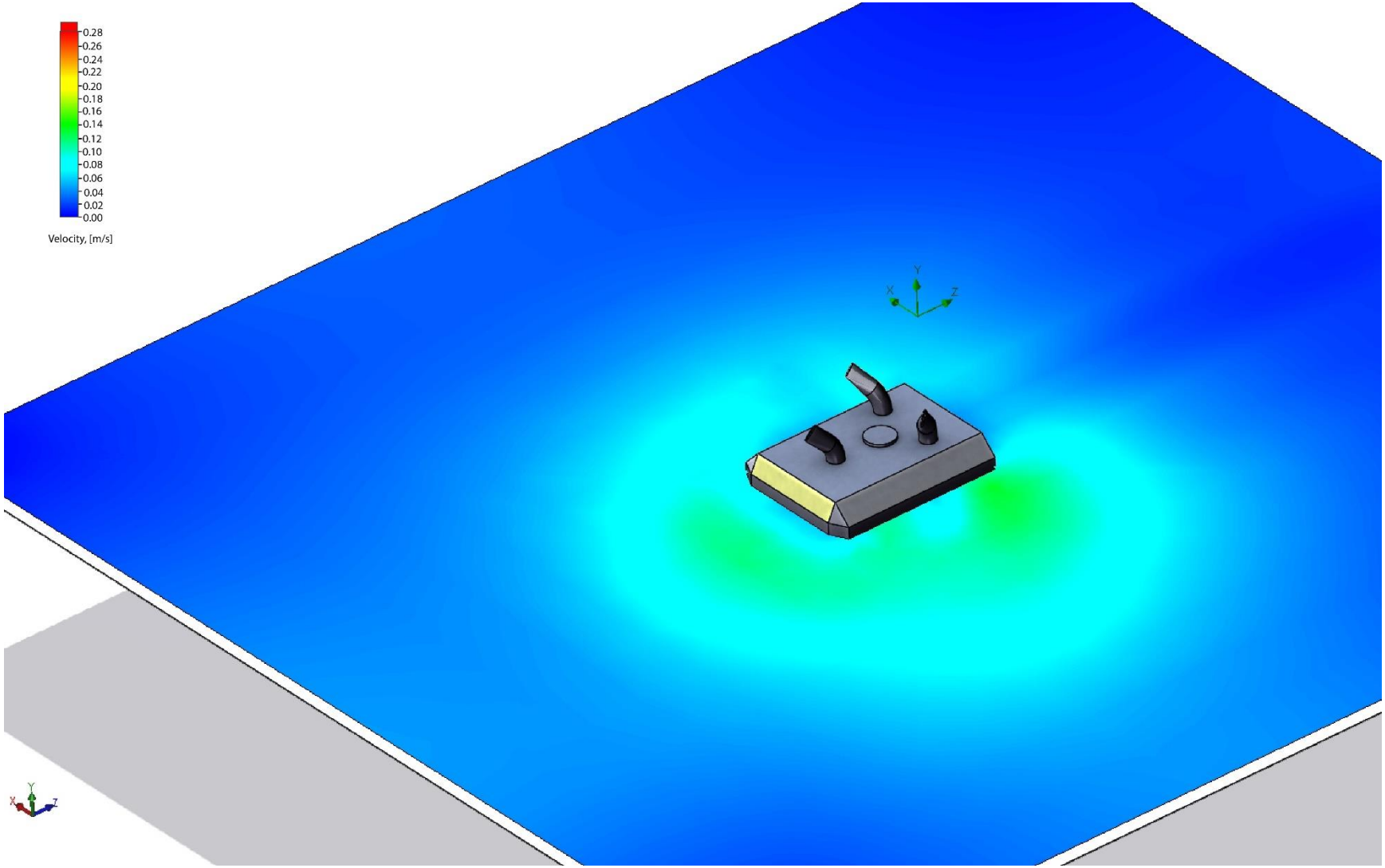


Figure 17: High resolution contour plot of velocities on the seabed induced by the HBDF 3-port duckbill diffuser discharging 62.5 mgd of brine at 62.4 ppt into a quiescent ocean with no ambient waves, currents or tides. Simulation due to COSMOS FloWorks CFD model.

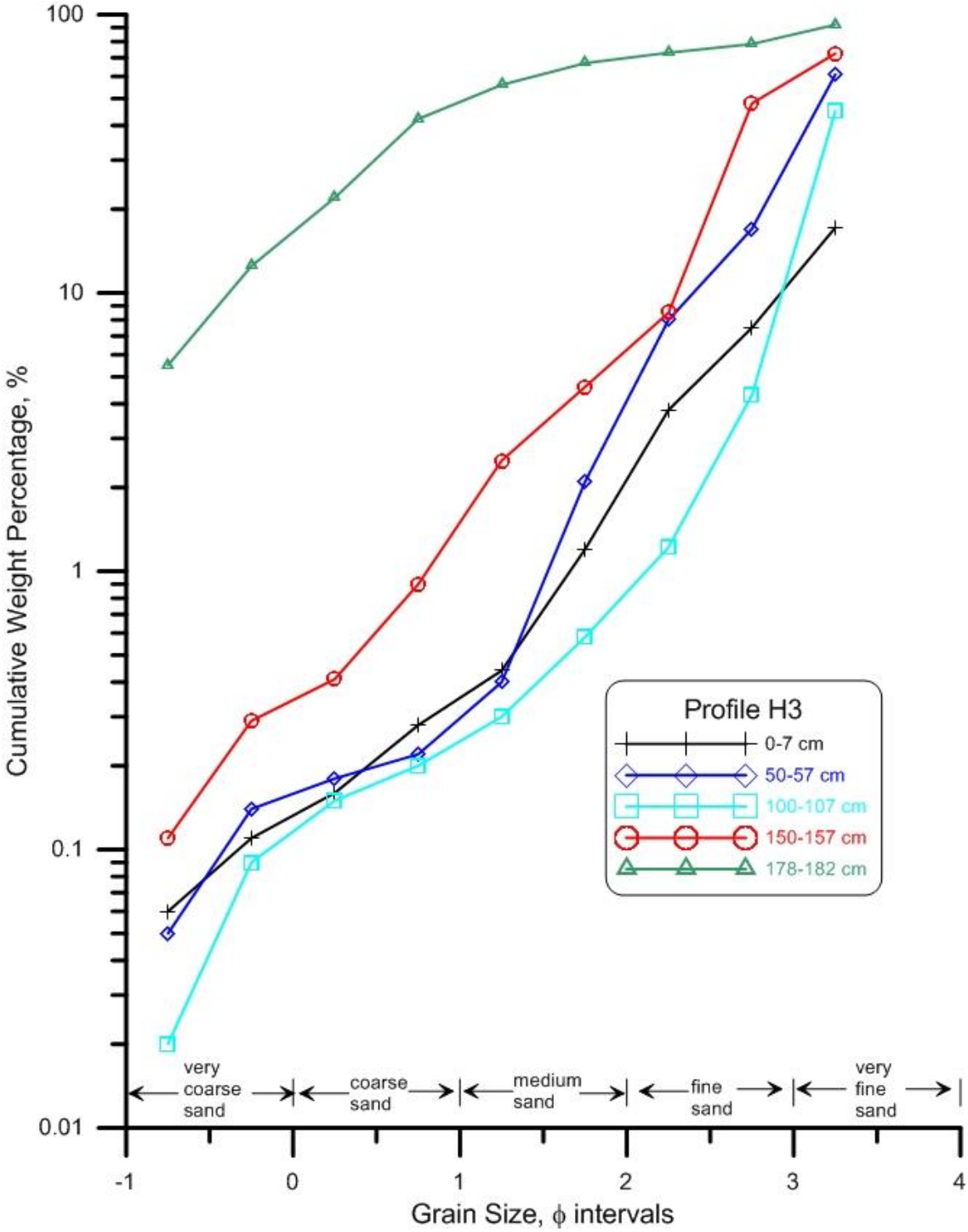


Figure 18: Vibracore measurements of grain size distribution and stratigraphy at historic sample station HBP-03 near the HBGS discharge tower, (cf. Figure 3). Data from Osborne,et al., (1983)

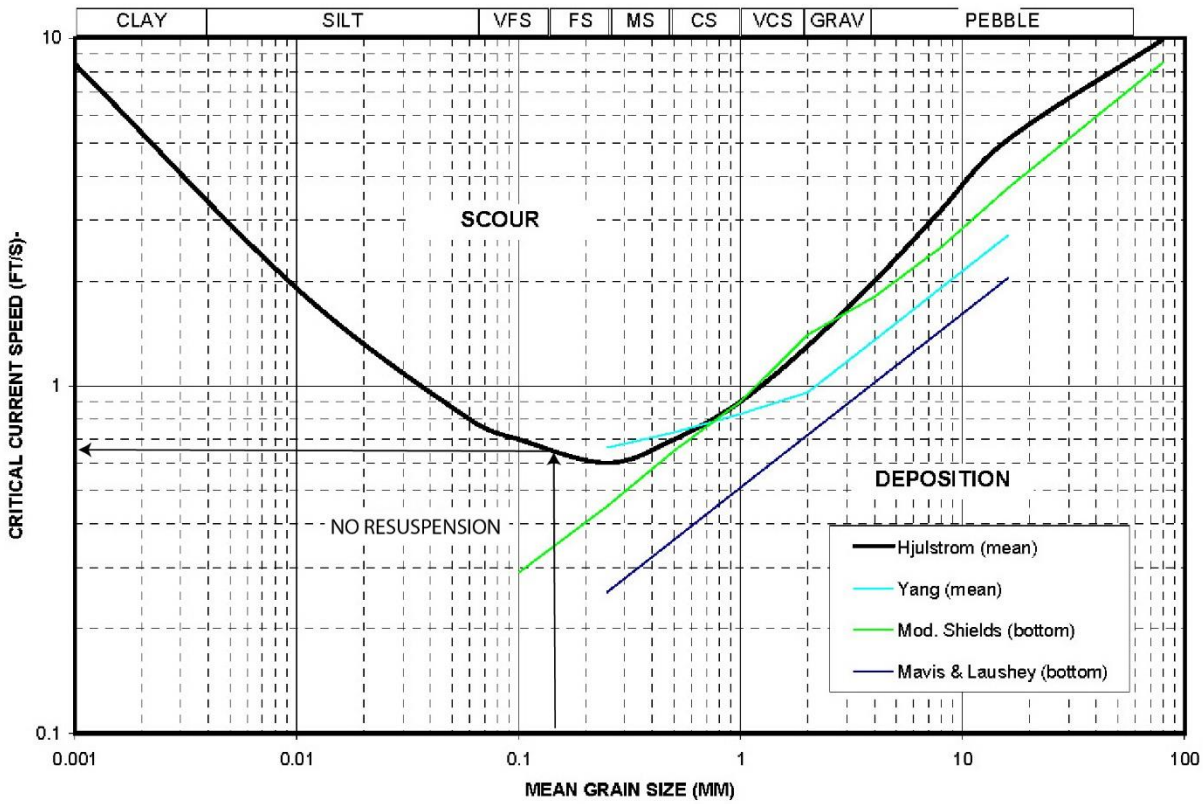


Figure 19: Hjulstrom curve after Bagnold, (1956, 1963) shown as black line for critical current speeds of quartz sediment as a function of mean grain size. Critical current speed for the finest grain size (very fine sand) at the HBGS discharge site is shown by the solid arrows. Area below the Hjulstrom curve corresponds to either no sediment motion or deposition; area above the curve corresponds to scour, erosion and resuspension of the sediments. The minimum sediment size at the HBGS discharge site is $D_{\min}$ = 0.147 mm which projects up to the Hjulstrom curve to a corresponding critical current speed of u_{crit} = 0.65 ft/sec, above which the very fine sand will scour and be suspended. The maximum diffuser induced velocity on the seafloor is $u_{\max}$ = 0.60 ft/sec. Hence the diffuser will not scour and re-suspend the seafloor sediments.

9) Conclusions:

An EPA-certified mixing model (CORMIX v10.0.3.0) and a commercially available computational fluid dynamics (CFD) model (*COSMOS/ FLowWorks*) were applied to a proposed diffuser design for the Huntington Beach Desalination Facility (HBDF) in order to determine brine discharge compliance with new water quality objectives set forth under the recently amended California Ocean Plan. The models were initialized to resolve initial dilution and brine discharge plume trajectories under standard NPDES dilution modeling protocols (as defined in the California Ocean Plan); according to which "*Initial Dilution will be considered the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge".* As such the models did not consider any additional mixing due to the action of ocean currents, waves, tides or wind and treated the receiving water as a quiescent, stagnant ocean.

The modeled HBDF desalination operating conditions were based on two worst-case discharge scenarios involving ultimate maximum daily brine discharges from a 3-port duckbill diffuser design*: Daily Worst-Case #1* utilizes 62.5 mgd of concentrated seawater (brine) effluent at a salinity of 62.4 ppt; and *Daily Worst-Case #2* discharges 54 mgd of concentrated brine at a salinity of 67 ppt. Per initial dilution analysis requirements set forth under the Ocean Plan, both scenarios discharge into quiescent ocean receiving waters having a natural background salinity of 33.52 ppt and worst-case month temperature salinity profiles obtained from the extensive KOMEX (2003) monitoring of the AES Huntington Beach Generating Station (HBGS) intake and outfall, performed for the California Energy Commission. No heat generation is assumed to occur within the HBGS and the delta-T of the undiluted brine relative to ocean water temperature is assumed to be between $\Delta T = 0\ ^0C$ and $\Delta T = +2\ ^0C$. The models were initialized for ocean water elevations at mean sea level bounded by the existing bathymetry surrounding the offshore discharge site for the HBDF.

Both worst-case scenarios were found to be insensitive to the small assumed range in delta-T. Due to relatively high port Froude numbers (F_r = 12.3 to 14 .1), the discharge plume becomes vertically fully mixed over the water column within a short distance (about 5 m or 16 ft.) from the point of discharge, a finding corroborated by both the CORMIX and CFD models. The proposed HBDF diffuser was found to dilute brine to within 2 ppt of natural background at distances of between 69.9 m (229 ft.) and 91.8 m (301 ft.) from the point of discharge. The region around the discharge where brine salinity is equal to or greater than 2 ppt of natural background is referred to as the brine mixing zone (BMZ), and the newly amended Ocean Plan requires that the BMZ can extend no further than 100 m horizontally from the point of discharge. Therefore, the two worst-case daily discharge scenarios satisfying the new Ocean Plan brine discharge limits in all quadrants around the HBDF discharge site. The dilution factor at 100 m (328 ft.) from the point of discharge ranges from Dm = 15.8 for Worst-Case #1 operating conditions to Dm = 16.5 for Worst-Case #2. The CORMIX v10.0.3.0 dilution model produced solutions out to 877 m (2877 ft.) from the discharge point where dilution factors ranged from Dm = 45.1 to Dm = 46.9 to 1. Here the CORMIX v10.0.3.0 solutions terminated due to stagnant ambient conditions that lead to unsteady flow behavior which the model cannot predict. (It should be noted that Ocean Plan requires initial dilution calculations are performed under conditions of no waves, currents or tides, which is the primary reason for stagnant ambient conditions at the point where CORMIX v10.0.3.0 terminated the simulation). Because of these stagnant ambient conditions, we assume dilution is complete at 877 m from the discharge point,

marking the limit of the *zone of initial dilution* (ZID), where the minimum initial dilution reaches an ultimate limit of Dm = 45.1 to 46.9.

Under Ocean Plan implementation polices, mitigation scaling for brine impacts to marine organisms inside the limits of the BMZ are based on worst-case monthly discharge scenarios. The two worst-case monthly discharge scenarios studied are: *Monthly Worst-Case #1* which utilizes an average brine discharge of $\overline{Q}$ = 56.7 mgd that includes R.O. backwash, and has an end-of-pipe discharge salinity S_b = 63.1 ppt; and *Monthly Worst-Case #2* composed of brine discharge with *recycled backwash* that is discharged at a rate of $\overline{Q}$ = 50 mgd with an end-of-pipe discharge salinity S_b = 67 ppt. The monthly worst-case outcomes produced slightly higher dilution rates than the worst-case daily outcomes. Under worst-case monthly operating conditions, the proposed HBDF diffuser was found to dilute brine to within 2 ppt of natural background at distances of between 69.1 m (227 ft.) and 86.3 m (283 ft.) from the point of discharge. The dilution factor at 100 m (328 ft.) from the point of discharge ranges from Dm = 16.2 for monthly Worst-Case #1 operating conditions to Dm = 16.8 for monthly Worst-Case #2 operations. Dilution was completed at 877 m (2877 ft.) from the discharge point (the limit of the ZID) where the monthly worst-case dilution factors ultimately reached Dm = 46.3 to Dm = 47.9.

The Ocean Plan requires that brine diffusers minimize re-suspension of benthic sediments. The computational fluid dynamics (CFD) modeling of ultimate maximum brine discharge from the proposed HBDF diffuser (62.5 mgd) determined that diffuser induced velocities on the seafloor are everywhere less than the threshold of motion speed of the finest-grained, most mobile seabed sediments found at the HBDF discharge site. Consequently, it was concluded that re-suspension of benthic sediments by the HBDF diffuser will not occur.

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Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +2^0 C; Sheet A-1

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\+2deg Delta-T\3-Port Duckbill Worst-Case #1\Worst-Case#1 28Nov2017 fix\HBDF 3X
HC4189 Stratified DT+2deg WC-1.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/28/2017--13:09:24
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                  HA      = 8.5 m
  Depth at discharge             HD      = 8.5m
  Bottom slope (single slope only)SLOPE  = 1.06 deg
  Ambient velocity               UA      = 0.0000 m/s
  Darcy-Weisbach friction factor  F      = 0.02
  Wind velocity                  UW      = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                RHOAS   = 1022 kg/m^3
  Level 1 Submergence            LEVEL1 = 8.5 m
  Density at Level 1             RHOA1   = 1023.473 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:            Submerged Multiport Diffuser Discharge
  Diffuser type                  DITYPE = unidirectional perpendicular
  Diffuser length                LD      = 8.96 m
  Nearest bank                           = left
  Diffuser endpoints             YB1     = 457 m;    YB2 = 465.96 m
  Number of openings             NOPEN   = 3
  Number of Risers               NRISER = 3
  Ports/Nozzles per Riser        NPPERR  = 1
  Spacing between risers/openings SPAC   = 4.48 m
  Port/Nozzle diameter           D0      = 0.496 m
    with contraction ratio               = 1
  Equivalent slot width          B0      = 0.0431 m
  Total area of openings         TA0     = 0.5797 m^2
  Discharge velocity             U0      = 4.72 m/s
  Total discharge flowrate       Q0      = 2.7383 m^3/s
  Discharge port height          H0      = 2.8 m
  Nozzle arrangement             BETYPE = unidirectional with fanning
  Diffuser alignment angle       GAMMA   = 90 deg
  Vertical discharge angle       THETA   = 47 deg
  Actual Vertical discharge angle THEAC  = 47 deg
  Horizontal discharge angle     SIGMA   = 0 deg
  Relative orientation angle     BETA    = 90 deg
  Discharge density              RHO0    = 1046.4000 kg/m^3
  Density difference             DRHO    = -23.6635 kg/m^3
  Buoyant acceleration           GP0     = -0.2269 m/s^2
  Discharge concentration        C0      = 28940 ppm
  Surface heat exchange coeff.   KS      = 0 m/s
  Coefficient of decay           KD      = 0 /s
------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)        q0      = 0.305614 m^2/s
  Momentum flux                  m0      = 1.443709 m^3/s^2
  Buoyancy flux                  j0      = -0.207107 m^3/s^3
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 4.13 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
------------------------------------------------------------------------------
```

Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +2^0 C; Sheet A-2

```
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 47.75
  Port/nozzle Froude number       FRD0   = 14.08
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 627.495800 ppm
  Dilution at edge of NFR              s = 46.1
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       25987.4629 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +2^0 C; Sheet A-3

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1724.062256  ppm
  Corresponding dilution               s = 16.8
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 25987.4629 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 14.5
  Plume location:                      x = 69.64 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 9.52 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +0^0 C; Sheet A-4

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\0deg Delta-T\3-Port Duckbill Worst-Case #1\Worst-Case#1 28Nov2017 fix\HBDF 3X HC4189
Stratified DT 0deg WC-1.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/28/2017--15:58:12
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                   HA     = 8.5 m
  Depth at discharge              HD     = 8.5m
  Bottom slope (single slope only)SLOPE  = 1.06 deg
  Ambient velocity                UA     = 0.0000 m/s
  Darcy-Weisbach friction factor  F      = 0.02
  Wind velocity                   UW     = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                 RHOAS  = 1022 kg/m^3
  Level 1 Submergence             LEVEL1 = 8.5 m
  Density at Level 1              RHOA1  = 1023.473 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD     = 8.96 m
  Nearest bank                           = left
  Diffuser endpoints              YB1    = 457 m;    YB2 = 465.96 m
  Number of openings              NOPEN  = 3
  Number of Risers                NRISER = 3
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC   = 4.48 m
  Port/Nozzle diameter            D0     = 0.496 m
    with contraction ratio               = 1
  Equivalent slot width           B0     = 0.0431 m
  Total area of openings          TA0    = 0.5797 m^2
  Discharge velocity              U0     = 4.72 m/s
  Total discharge flowrate        Q0     = 2.7383 m^3/s
  Discharge port height           H0     = 2.8 m
  Nozzle arrangement              BETYPE = unidirectional with fanning
  Diffuser alignment angle        GAMMA  = 90 deg
  Vertical discharge angle        THETA  = 47 deg
  Actual Vertical discharge angle THEAC  = 47 deg
  Horizontal discharge angle      SIGMA  = 0 deg
  Relative orientation angle      BETA   = 90 deg
  Discharge density               RHO0   = 1046.8 kg/m^3
  Density difference              DRHO   = -24.0635 kg/m^3
  Buoyant acceleration            GP0    = -0.2307 m/s^2
  Discharge concentration         C0     = 28940 ppm
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0     = 0.305614 m^2/s
  Momentum flux                   m0     = 1.443709 m^3/s^2
  Buoyancy flux                   j0     = -0.210608 m^3/s^3
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 4.08 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
------------------------------------------------------------------------------
```

Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +0^0 C; Sheet A-5

```
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 47.35
  Port/nozzle Froude number       FRD0   = 13.96
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 627.495800 ppm
  Dilution at edge of NFR              s = 46.1
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       25987.4629 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-A: CORMIX 10.0.3.0 Session Report for Worst-Case #1, ΔT = +0^0 C; Sheet A-6

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1724.062256  ppm
  Corresponding dilution               s = 16.8
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 25987.4629 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 14.5
  Plume location:                      x = 69.64 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 9.52 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +2^0 C; Sheet B-1

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\+2deg Delta-T\3-Port Duckbill Worst-Case #2\Worst-Case#2 28Nov2017 fix\HBDF 3X
HC4189 Stratified DT+2deg WC-2.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/28/2017--14:28:22
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                   HA     = 8.5 m
  Depth at discharge              HD     = 8.5m
  Bottom slope (single slope only)SLOPE  = 1.06 deg
  Ambient velocity                UA     = 0.0000 m/s
  Darcy-Weisbach friction factor  F      = 0.02
  Wind velocity                   UW     = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                 RHOAS  = 1022 kg/m^3
  Level 1 Submergence             LEVEL1 = 8.5 m
  Density at Level 1              RHOA1  = 1023.473 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD     = 8.96 m
  Nearest bank                           = left
  Diffuser endpoints              YB1    = 457 m;    YB2 = 465.96 m
  Number of openings              NOPEN  = 3
  Number of Risers                NRISER = 3
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC   = 4.48 m
  Port/Nozzle diameter            D0     = 0.478 m
    with contraction ratio               = 1
  Equivalent slot width           B0     = 0.0401 m
  Total area of openings          TA0    = 0.5384 m^2
  Discharge velocity              U0     = 4.39 m/s
  Total discharge flowrate        Q0     = 2.3659 m^3/s
  Discharge port height           H0     = 2.8 m
  Nozzle arrangement              BETYPE = unidirectional with fanning
  Diffuser alignment angle        GAMMA  = 90 deg
  Vertical discharge angle        THETA  = 47 deg
  Actual Vertical discharge angle THEAC  = 47 deg
  Horizontal discharge angle      SIGMA  = 0 deg
  Relative orientation angle      BETA   = 90 deg
  Discharge density               RHO0   = 1050.3 kg/m^3
  Density difference              DRHO   = -27.5635 kg/m^3
  Buoyant acceleration            GP0    = -0.2643 m/s^2
  Discharge concentration         C0     = 33500 ppm
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0     = 0.264051 m^2/s
  Momentum flux                   m0     = 1.160427 m^3/s^2
  Buoyancy flux                   j0     = -0.208433 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 3.30 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +2^0 C; Sheet B-2

```
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 42.71
  Port/nozzle Froude number       FRD0   = 12.36
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 700.009400 ppm
  Dilution at edge of NFR              s = 47.9
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       28986.4316 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +2^0 C; Sheet B-3

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1923.294922  ppm
  Corresponding dilution               s = 17.4
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 28986.4316 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 16.8
  Plume location:                      x = 91.08 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 11.81 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +0^0 C; Sheet B-4

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\0deg Delta-T\3-Port Duckbill Worst-Case#2\Worst-Case#2 28Nov2017 fix\HBDF 3X HC4189
Stratified DT 0deg WC-2.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/28/2017--16:29:00
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                   HA     = 8.5 m
  Depth at discharge              HD     = 8.5m
  Bottom slope (single slope only)SLOPE  = 1.06 deg
  Ambient velocity                UA     = 0.0000 m/s
  Darcy-Weisbach friction factor  F      = 0.02
  Wind velocity                   UW     = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                 RHOAS  = 1022 kg/m^3
  Level 1 Submergence             LEVEL1 = 8.5 m
  Density at Level 1              RHOA1  = 1023.473 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD     = 8.96 m
  Nearest bank                           = left
  Diffuser endpoints              YB1    = 457 m;    YB2 = 465.96 m
  Number of openings              NOPEN  = 3
  Number of Risers                NRISER = 3
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC   = 4.48 m
  Port/Nozzle diameter            D0     = 0.478 m
    with contraction ratio               = 1
  Equivalent slot width           B0     = 0.0401 m
  Total area of openings          TA0    = 0.5384 m^2
  Discharge velocity              U0     = 4.39 m/s
  Total discharge flowrate        Q0     = 2.3659 m^3/s
  Discharge port height           H0     = 2.8 m
  Nozzle arrangement              BETYPE = unidirectional with fanning
  Diffuser alignment angle        GAMMA  = 90 deg
  Vertical discharge angle        THETA  = 47 deg
  Actual Vertical discharge angle THEAC  = 47 deg
  Horizontal discharge angle      SIGMA  = 0 deg
  Relative orientation angle      BETA   = 90 deg
  Discharge density               RHO0   = 1050.7 kg/m^3
  Density difference              DRHO   = -27.9635 kg/m^3
  Buoyant acceleration            GP0    = -0.2681 m/s^2
  Discharge concentration         C0     = 33500 ppm
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0     = 0.264051 m^2/s
  Momentum flux                   m0     = 1.160427 m^3/s^2
  Buoyancy flux                   j0     = -0.211458 m^3/s^3
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 3.27 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
------------------------------------------------------------------------------
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +0^0 C; Sheet B-5

```
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 42.41
  Port/nozzle Froude number       FRD0   = 12.28
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 700.009400 ppm
  Dilution at edge of NFR              s = 47.9
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       28986.4316 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-B: CORMIX 10.0.3.0 Session Report for Worst-Case #2, ΔT = +0^0 C; Sheet B-6

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1923.294922  ppm
  Corresponding dilution               s = 17.4
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 28986.4316 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 16.8
  Plume location:                      x = 91.08 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 11.81 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-1

```
D-CORMIX PREDICTION FILE:
DDDD
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-2

```
MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.2894E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.289E+05   0.03     4.48     4.724   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.289E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.6 0.176E+05   0.08     4.41 .15573E-01
      0.09     0.00   -5.70     1.9 0.152E+05   0.17     4.35 .36191E-01
      0.13     0.00   -5.70     2.1 0.137E+05   0.25     4.29 .60093E-01
      0.18     0.00   -5.69     2.3 0.127E+05   0.34     4.23 .86651E-01
      0.22     0.00   -5.69     2.4 0.119E+05   0.42     4.17 .11550E+00
      0.27     0.00   -5.69     2.6 0.112E+05   0.51     4.11 .14640E+00
      0.31     0.00   -5.69     2.7 0.107E+05   0.60     4.06 .17917E+00
      0.36     0.00   -5.69     2.8 0.103E+05   0.68     4.00 .21366E+00
      0.40     0.00   -5.69     2.9 0.989E+04   0.76     3.95 .24977E+00
      0.45     0.00   -5.68     3.0 0.955E+04   0.85     3.90 .28740E+00
      0.49     0.00   -5.68     3.1 0.925E+04   0.93     3.85 .32648E+00
      0.54     0.00   -5.68     3.2 0.898E+04   1.02     3.80 .36694E+00
      0.58     0.00   -5.68     3.3 0.873E+04   1.10     3.76 .40872E+00
      0.63     0.00   -5.68     3.4 0.851E+04   1.19     3.71 .45176E+00
      0.67     0.00   -5.68     3.5 0.830E+04   1.27     3.67 .49603E+00
      0.72     0.00   -5.68     3.6 0.811E+04   1.36     3.62 .54147E+00
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-3

0.76	0.00	-5.67	3.6	0.793E+04	1.44	3.58	.58806E+00
0.81	0.00	-5.67	3.7	0.777E+04	1.53	3.54	.63575E+00
0.85	0.00	-5.67	3.8	0.762E+04	1.61	3.50	.68452E+00
0.90	0.00	-5.67	3.9	0.747E+04	1.70	3.46	.73434E+00
0.94	0.00	-5.67	3.9	0.734E+04	1.78	3.43	.78518E+00
0.99	0.00	-5.67	4.0	0.721E+04	1.87	3.39	.83702E+00
1.03	0.00	-5.66	4.1	0.709E+04	1.95	3.35	.88983E+00
1.08	0.00	-5.66	4.1	0.698E+04	2.04	3.32	.94359E+00
1.12	0.00	-5.66	4.2	0.687E+04	2.12	3.29	.99829E+00
1.16	0.00	-5.66	4.3	0.677E+04	2.21	3.25	.10539E+01
1.21	0.00	-5.66	4.3	0.667E+04	2.30	3.22	.11104E+01
1.25	0.00	-5.66	4.4	0.658E+04	2.38	3.19	.11678E+01
1.30	0.00	-5.66	4.5	0.649E+04	2.47	3.16	.12260E+01
1.34	0.00	-5.65	4.5	0.641E+04	2.55	3.13	.12851E+01
1.39	0.00	-5.65	4.6	0.633E+04	2.64	3.10	.13451E+01
1.43	0.00	-5.65	4.6	0.625E+04	2.72	3.07	.14058E+01
1.48	0.00	-5.65	4.7	0.617E+04	2.81	3.04	.14674E+01
1.52	0.00	-5.65	4.7	0.610E+04	2.89	3.02	.15297E+01
1.57	0.00	-5.65	4.8	0.603E+04	2.98	2.99	.15928E+01
1.61	0.00	-5.64	4.9	0.596E+04	3.06	2.96	.16568E+01
1.66	0.00	-5.64	4.9	0.590E+04	3.15	2.94	.17214E+01
1.70	0.00	-5.64	5.0	0.584E+04	3.23	2.91	.17868E+01
1.75	0.00	-5.64	5.0	0.578E+04	3.32	2.89	.18530E+01
1.79	0.00	-5.64	5.1	0.572E+04	3.40	2.86	.19199E+01
1.84	0.00	-5.64	5.1	0.566E+04	3.49	2.84	.19875E+01
1.88	0.00	-5.64	5.2	0.561E+04	3.57	2.82	.20558E+01
1.93	0.00	-5.63	5.2	0.555E+04	3.66	2.80	.21249E+01
1.97	0.00	-5.63	5.3	0.550E+04	3.74	2.77	.21946E+01
2.02	0.00	-5.63	5.3	0.545E+04	3.83	2.75	.22650E+01
2.06	0.00	-5.63	5.4	0.540E+04	3.91	2.73	.23361E+01
2.11	0.00	-5.63	5.4	0.536E+04	4.00	2.71	.24079E+01
2.15	0.00	-5.63	5.4	0.531E+04	4.08	2.69	.24803E+01
2.20	0.00	-5.63	5.5	0.527E+04	4.17	2.67	.25534E+01
2.24	0.00	-5.62	5.5	0.522E+04	4.25	2.65	.26272E+01
2.28	0.00	-5.62	5.6	0.518E+04	4.34	2.64	.27016E+01
2.33	0.00	-5.62	5.6	0.514E+04	4.42	2.62	.27766E+01
2.37	0.00	-5.62	5.7	0.510E+04	4.51	2.60	.28523E+01
2.42	0.00	-5.62	5.7	0.506E+04	4.59	2.58	.29286E+01
2.46	0.00	-5.62	5.8	0.502E+04	4.68	2.57	.30055E+01
2.51	0.00	-5.61	5.8	0.499E+04	4.76	2.55	.30830E+01
2.55	0.00	-5.61	5.8	0.495E+04	4.85	2.54	.31612E+01
2.60	0.00	-5.61	5.9	0.491E+04	4.93	2.52	.32399E+01
2.64	0.00	-5.61	5.9	0.488E+04	5.02	2.51	.33193E+01
2.69	0.00	-5.61	6.0	0.484E+04	5.10	2.49	.33992E+01
2.73	0.00	-5.61	6.0	0.481E+04	5.19	2.48	.34797E+01
2.78	0.00	-5.61	6.1	0.478E+04	5.27	2.46	.35608E+01
2.82	0.00	-5.60	6.1	0.475E+04	5.36	2.45	.36425E+01
2.87	0.00	-5.60	6.1	0.472E+04	5.44	2.44	.37248E+01
2.91	0.00	-5.60	6.2	0.469E+04	5.53	2.43	.38077E+01
2.96	0.00	-5.60	6.2	0.466E+04	5.61	2.42	.38911E+01
3.00	0.00	-5.60	6.3	0.463E+04	5.70	2.40	.39750E+01
3.05	0.00	-5.60	6.3	0.460E+04	5.78	2.39	.40596E+01
3.09	0.00	-5.59	6.3	0.457E+04	5.87	2.38	.41446E+01
3.14	0.00	-5.59	6.4	0.454E+04	5.95	2.37	.42303E+01
3.18	0.00	-5.59	6.4	0.451E+04	6.04	2.36	.43165E+01
3.23	0.00	-5.59	6.4	0.449E+04	6.12	2.36	.44032E+01
3.27	0.00	-5.59	6.5	0.446E+04	6.21	2.35	.44904E+01
3.32	0.00	-5.59	6.5	0.444E+04	6.29	2.34	.45782E+01
3.36	0.00	-5.59	6.6	0.441E+04	6.38	2.33	.46666E+01
3.40	0.00	-5.58	6.6	0.439E+04	6.46	2.32	.47554E+01
3.45	0.00	-5.58	6.6	0.436E+04	6.55	2.32	.48448E+01
3.49	0.00	-5.58	6.7	0.434E+04	6.63	2.31	.49347E+01
3.54	0.00	-5.58	6.7	0.431E+04	6.72	2.31	.50251E+01
3.58	0.00	-5.58	6.7	0.429E+04	6.80	2.30	.51160E+01
3.63	0.00	-5.58	6.8	0.427E+04	6.89	2.29	.52075E+01
3.67	0.00	-5.57	6.8	0.425E+04	6.97	2.29	.52994E+01
3.72	0.00	-5.57	6.8	0.422E+04	7.06	2.28	.53919E+01
3.76	0.00	-5.57	6.9	0.420E+04	7.14	2.28	.54848E+01
3.81	0.00	-5.57	6.9	0.418E+04	7.23	2.28	.55783E+01

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-4

```
      3.85     0.00   -5.57     7.0 0.416E+04   7.31     2.27 .56722E+01
      3.90     0.00   -5.57     7.0 0.414E+04   7.40     2.27 .57667E+01
      3.94     0.00   -5.57     7.0 0.412E+04   7.48     2.27 .58616E+01
      3.99     0.00   -5.56     7.1 0.410E+04   7.57     2.26 .59570E+01
      4.03     0.00   -5.56     7.1 0.408E+04   7.65     2.26 .60529E+01
      4.08     0.00   -5.56     7.1 0.406E+04   7.74     2.26 .61493E+01
      4.12     0.00   -5.56     7.2 0.404E+04   7.82     2.26 .62461E+01
      4.17     0.00   -5.56     7.2 0.402E+04   7.91     2.25 .63435E+01
      4.21     0.00   -5.56     7.2 0.401E+04   7.99     2.25 .64413E+01
      4.26     0.00   -5.55     7.3 0.399E+04   8.08     2.25 .65396E+01
      4.30     0.00   -5.55     7.3 0.397E+04   8.16     2.25 .66383E+01
      4.35     0.00   -5.55     7.3 0.395E+04   8.25     2.25 .67375E+01
      4.39     0.00   -5.55     7.4 0.393E+04   8.33     2.25 .68372E+01
      4.44     0.00   -5.55     7.4 0.392E+04   8.42     2.25 .69373E+01
      4.48     0.00   -5.55     7.4 0.390E+04   8.50     2.25 .70379E+01
 Cumulative travel time =           7.0379 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.4 0.390E+04   8.50     2.52 .70379E+01
     13.21     0.00   -8.50     8.7 0.332E+04   8.50     3.46 .73829E+02
     21.94     0.00   -8.50     9.8 0.295E+04   8.50     4.40 .15050E+03
     30.66     0.00   -8.50    10.8 0.267E+04   8.50     5.34 .23592E+03
     39.39     0.00   -8.50    11.7 0.246E+04   8.50     6.28 .32926E+03
     48.12     0.00   -8.50    12.6 0.230E+04   8.50     7.21 .42990E+03
     56.85     0.00   -8.50    13.4 0.216E+04   8.50     8.15 .53734E+03
     65.58     0.00   -8.50    14.1 0.205E+04   8.50     9.08 .65118E+03
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     74.30     0.00   -8.50    14.9 0.195E+04   8.50    10.02 .77109E+03
     83.03     0.00   -8.50    15.5 0.186E+04   8.50    10.95 .89675E+03
     91.76     0.00   -8.50    16.2 0.179E+04   8.50    11.88 .10279E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    16.8 0.172E+04   8.50    12.81 .11644E+04
    109.22     0.00   -8.50    17.4 0.166E+04   8.50    13.74 .13060E+04
    117.94     0.00   -8.50    18.0 0.161E+04   8.50    14.67 .14524E+04
    126.67     0.00   -8.50    18.6 0.156E+04   8.50    15.60 .16037E+04
    135.40     0.00   -8.50    19.1 0.151E+04   8.50    16.53 .17595E+04
    144.13     0.00   -8.50    19.7 0.147E+04   8.50    17.46 .19198E+04
    152.86     0.00   -8.50    20.2 0.143E+04   8.50    18.38 .20845E+04
    161.58     0.00   -8.50    20.7 0.140E+04   8.50    19.31 .22534E+04
    170.31     0.00   -8.50    21.2 0.137E+04   8.50    20.24 .24265E+04
    179.04     0.00   -8.50    21.7 0.134E+04   8.50    21.16 .26036E+04
    187.77     0.00   -8.50    22.1 0.131E+04   8.50    22.08 .27846E+04
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-5

196.50	0.00	-8.50	22.6	0.128E+04	8.50	23.01	.29695E+04
205.22	0.00	-8.50	23.1	0.126E+04	8.50	23.93	.31582E+04
213.95	0.00	-8.50	23.5	0.123E+04	8.50	24.85	.33507E+04
222.68	0.00	-8.50	23.9	0.121E+04	8.50	25.77	.35467E+04
231.41	0.00	-8.50	24.4	0.119E+04	8.50	26.70	.37464E+04
240.14	0.00	-8.50	24.8	0.117E+04	8.50	27.62	.39495E+04
248.86	0.00	-8.50	25.2	0.115E+04	8.50	28.54	.41562E+04
257.59	0.00	-8.50	25.6	0.113E+04	8.50	29.46	.43662E+04
266.32	0.00	-8.50	26.0	0.111E+04	8.50	30.37	.45795E+04
275.05	0.00	-8.50	26.4	0.110E+04	8.50	31.29	.47962E+04
283.78	0.00	-8.50	26.8	0.108E+04	8.50	32.21	.50160E+04
292.50	0.00	-8.50	27.2	0.106E+04	8.50	33.13	.52391E+04
301.23	0.00	-8.50	27.6	0.105E+04	8.50	34.04	.54654E+04
309.96	0.00	-8.50	27.9	0.104E+04	8.50	34.96	.56947E+04
318.69	0.00	-8.50	28.3	0.102E+04	8.50	35.88	.59271E+04
327.42	0.00	-8.50	28.7	0.101E+04	8.50	36.79	.61626E+04
336.14	0.00	-8.50	29.0	0.997E+03	8.50	37.71	.64010E+04
344.87	0.00	-8.50	29.4	0.985E+03	8.50	38.62	.66423E+04
353.60	0.00	-8.50	29.7	0.973E+03	8.50	39.54	.68866E+04
362.33	0.00	-8.50	30.1	0.962E+03	8.50	40.45	.71338E+04
371.06	0.00	-8.50	30.4	0.951E+03	8.50	41.36	.73838E+04
379.78	0.00	-8.50	30.8	0.941E+03	8.50	42.28	.76366E+04
388.51	0.00	-8.50	31.1	0.931E+03	8.50	43.19	.78922E+04
397.24	0.00	-8.50	31.4	0.921E+03	8.50	44.10	.81506E+04
405.97	0.00	-8.50	31.8	0.911E+03	8.50	45.01	.84117E+04
414.70	0.00	-8.50	32.1	0.902E+03	8.50	45.92	.86755E+04
423.42	0.00	-8.50	32.4	0.893E+03	8.50	46.83	.89420E+04
432.15	0.00	-8.50	32.7	0.885E+03	8.50	47.74	.92111E+04
440.88	0.00	-8.50	33.0	0.876E+03	8.50	48.65	.94828E+04
449.61	0.00	-8.50	33.3	0.868E+03	8.50	49.56	.97571E+04
458.34	0.00	-8.50	33.7	0.860E+03	8.50	50.47	.10034E+05
467.06	0.00	-8.50	34.0	0.852E+03	8.50	51.38	.10313E+05
475.79	0.00	-8.50	34.3	0.845E+03	8.50	52.29	.10595E+05
484.52	0.00	-8.50	34.6	0.837E+03	8.50	53.20	.10880E+05
493.25	0.00	-8.50	34.9	0.830E+03	8.50	54.11	.11167E+05
501.98	0.00	-8.50	35.2	0.823E+03	8.50	55.01	.11456E+05
510.70	0.00	-8.50	35.5	0.816E+03	8.50	55.92	.11748E+05
519.43	0.00	-8.50	35.7	0.810E+03	8.50	56.83	.12042E+05
528.16	0.00	-8.50	36.0	0.803E+03	8.50	57.73	.12339E+05
536.89	0.00	-8.50	36.3	0.797E+03	8.50	58.64	.12638E+05
545.62	0.00	-8.50	36.6	0.791E+03	8.50	59.54	.12939E+05
554.34	0.00	-8.50	36.9	0.785E+03	8.50	60.45	.13243E+05
563.07	0.00	-8.50	37.2	0.779E+03	8.50	61.35	.13549E+05
571.80	0.00	-8.50	37.4	0.773E+03	8.50	62.26	.13857E+05
580.53	0.00	-8.50	37.7	0.767E+03	8.50	63.16	.14168E+05
589.26	0.00	-8.50	38.0	0.762E+03	8.50	64.07	.14481E+05
597.98	0.00	-8.50	38.3	0.756E+03	8.50	64.97	.14796E+05
606.71	0.00	-8.50	38.5	0.751E+03	8.50	65.87	.15113E+05
615.44	0.00	-8.50	38.8	0.746E+03	8.50	66.78	.15433E+05
624.17	0.00	-8.50	39.1	0.741E+03	8.50	67.68	.15755E+05
632.90	0.00	-8.50	39.3	0.736E+03	8.50	68.58	.16079E+05
641.62	0.00	-8.50	39.6	0.731E+03	8.50	69.48	.16405E+05
650.35	0.00	-8.50	39.9	0.726E+03	8.50	70.38	.16733E+05
659.08	0.00	-8.50	40.1	0.721E+03	8.50	71.28	.17064E+05
667.81	0.00	-8.50	40.4	0.717E+03	8.50	72.18	.17396E+05
676.54	0.00	-8.50	40.6	0.712E+03	8.50	73.08	.17731E+05
685.26	0.00	-8.50	40.9	0.708E+03	8.50	73.98	.18068E+05
693.99	0.00	-8.50	41.1	0.704E+03	8.50	74.88	.18407E+05
702.72	0.00	-8.50	41.4	0.699E+03	8.50	75.78	.18748E+05
711.45	0.00	-8.50	41.6	0.695E+03	8.50	76.68	.19091E+05
720.18	0.00	-8.50	41.9	0.691E+03	8.50	77.58	.19436E+05
728.90	0.00	-8.50	42.1	0.687E+03	8.50	78.48	.19783E+05
737.63	0.00	-8.50	42.4	0.683E+03	8.50	79.38	.20132E+05
746.36	0.00	-8.50	42.6	0.679E+03	8.50	80.28	.20484E+05
755.09	0.00	-8.50	42.9	0.675E+03	8.50	81.17	.20837E+05
763.82	0.00	-8.50	43.1	0.671E+03	8.50	82.07	.21192E+05
772.54	0.00	-8.50	43.3	0.668E+03	8.50	82.97	.21549E+05
781.27	0.00	-8.50	43.6	0.664E+03	8.50	83.87	.21909E+05
790.00	0.00	-8.50	43.8	0.660E+03	8.50	84.76	.22270E+05

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-6

```
    798.73     0.00   -8.50    44.1 0.657E+03   8.50    85.66 .22633E+05
    807.46     0.00   -8.50    44.3 0.653E+03   8.50    86.55 .22998E+05
    816.18     0.00   -8.50    44.5 0.650E+03   8.50    87.45 .23365E+05
    824.91     0.00   -8.50    44.8 0.647E+03   8.50    88.34 .23734E+05
    833.64     0.00   -8.50    45.0 0.643E+03   8.50    89.24 .24105E+05
    842.37     0.00   -8.50    45.2 0.640E+03   8.50    90.13 .24478E+05
    851.10     0.00   -8.50    45.4 0.637E+03   8.50    91.03 .24852E+05
    859.83     0.00   -8.50    45.7 0.634E+03   8.50    91.92 .25229E+05
    868.55     0.00   -8.50    45.9 0.631E+03   8.50    92.82 .25607E+05
    877.28     0.00   -8.50    46.1 0.627E+03   8.50    93.71 .25987E+05
 Cumulative travel time =       25987.4316 sec  (    7.22 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
D-CORMIX      End of Prediction File
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-7

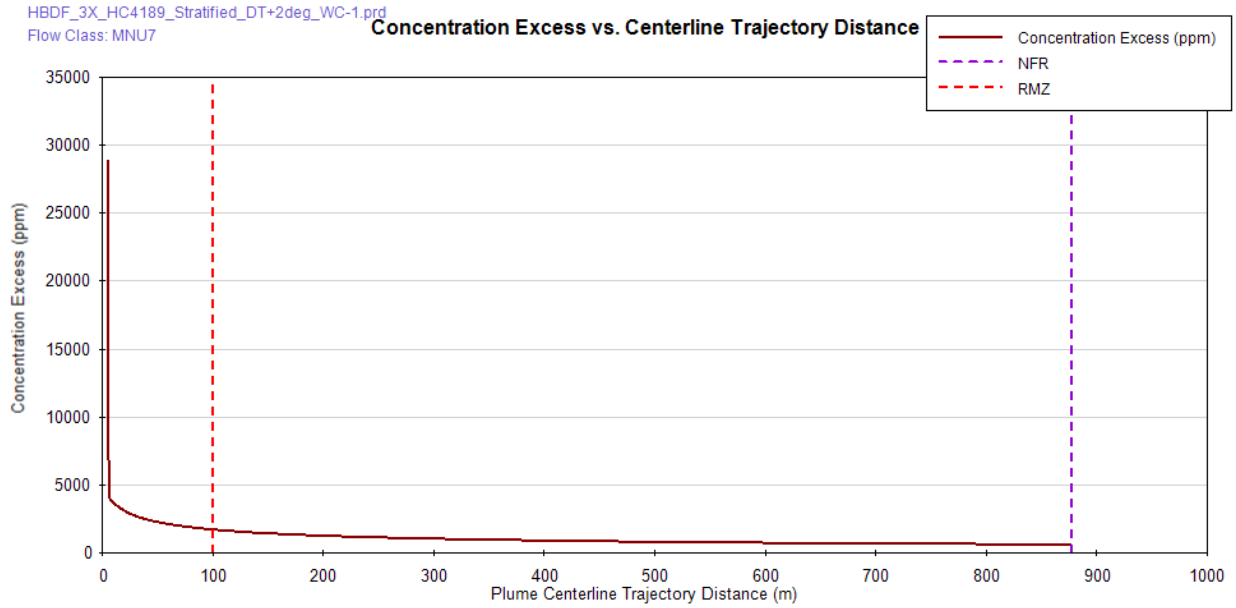

Figure C-1: Excess Salinity in ppm as a function of centerline trajectory distance for Worst-Case #1, ΔT = +2^0 C.

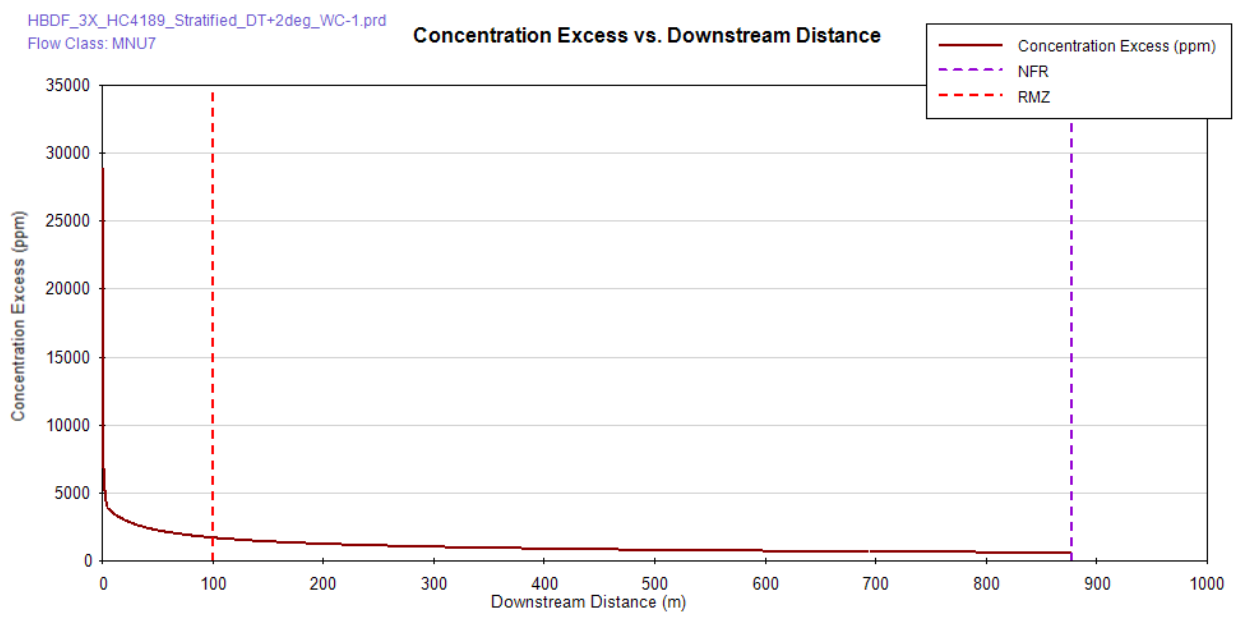

Figure C-2: Excess Salinity in ppm as a function of distance downstream for Worst-Case #1, ΔT = +2^0 C

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +2^0 C; Sheet C-8

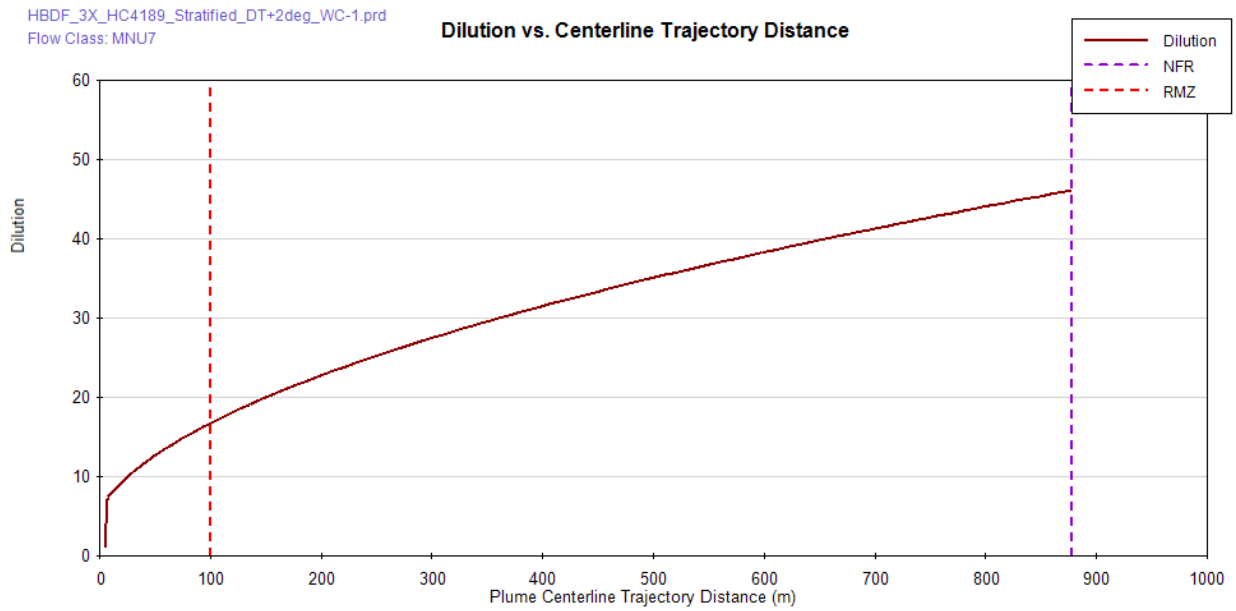

Figure C-3: Dilution expressed as mixing ratio, S**,** as a function of centerline trajectory distance for Worst-Case #1, ΔT = +2^0 C. Note S = 1 + Dm

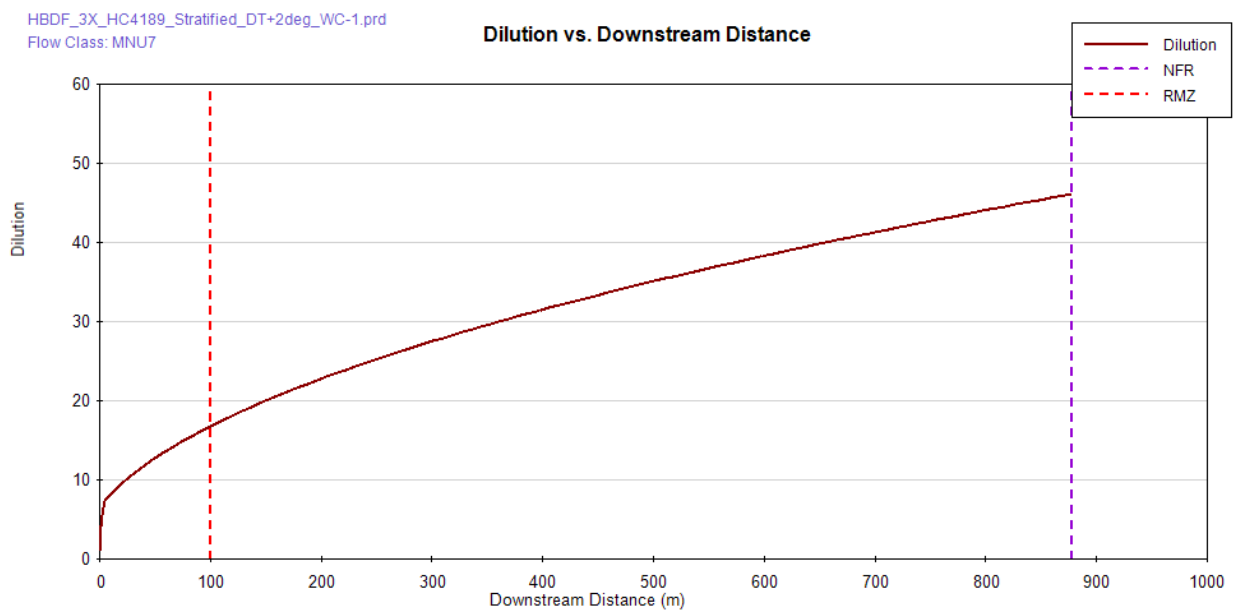

Figure C-4: Dilution expressed as mixing ratio, S**,** as a function of distance downstream for Worst-Case #1, ΔT = +2^0 C. Note S = 1 + Dm

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-9

```
D-CORMIX PREDICTION FILE:
DDDD
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-10

```
MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.2894E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.289E+05   0.03     4.48     4.724   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.289E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.6 0.176E+05   0.08     4.41 .15573E-01
      0.09     0.00   -5.70     1.9 0.152E+05   0.17     4.35 .36191E-01
      0.13     0.00   -5.70     2.1 0.137E+05   0.25     4.29 .60093E-01
      0.18     0.00   -5.69     2.3 0.127E+05   0.34     4.23 .86651E-01
      0.22     0.00   -5.69     2.4 0.119E+05   0.42     4.17 .11550E+00
      0.27     0.00   -5.69     2.6 0.112E+05   0.51     4.11 .14640E+00
      0.31     0.00   -5.69     2.7 0.107E+05   0.60     4.06 .17917E+00
      0.36     0.00   -5.69     2.8 0.103E+05   0.68     4.00 .21366E+00
      0.40     0.00   -5.69     2.9 0.989E+04   0.76     3.95 .24977E+00
      0.45     0.00   -5.68     3.0 0.955E+04   0.85     3.90 .28740E+00
      0.49     0.00   -5.68     3.1 0.925E+04   0.93     3.85 .32648E+00
      0.54     0.00   -5.68     3.2 0.898E+04   1.02     3.80 .36694E+00
      0.58     0.00   -5.68     3.3 0.873E+04   1.10     3.76 .40872E+00
      0.63     0.00   -5.68     3.4 0.851E+04   1.19     3.71 .45176E+00
      0.67     0.00   -5.68     3.5 0.830E+04   1.27     3.67 .49603E+00
      0.72     0.00   -5.68     3.6 0.811E+04   1.36     3.62 .54147E+00
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-11

0.76	0.00	-5.67	3.6	0.793E+04	1.44	3.58	.58806E+00
0.81	0.00	-5.67	3.7	0.777E+04	1.53	3.54	.63575E+00
0.85	0.00	-5.67	3.8	0.762E+04	1.61	3.50	.68452E+00
0.90	0.00	-5.67	3.9	0.747E+04	1.70	3.46	.73434E+00
0.94	0.00	-5.67	3.9	0.734E+04	1.78	3.43	.78518E+00
0.99	0.00	-5.67	4.0	0.721E+04	1.87	3.39	.83702E+00
1.03	0.00	-5.66	4.1	0.709E+04	1.95	3.35	.88983E+00
1.08	0.00	-5.66	4.1	0.698E+04	2.04	3.32	.94359E+00
1.12	0.00	-5.66	4.2	0.687E+04	2.12	3.29	.99829E+00
1.16	0.00	-5.66	4.3	0.677E+04	2.21	3.25	.10539E+01
1.21	0.00	-5.66	4.3	0.667E+04	2.30	3.22	.11104E+01
1.25	0.00	-5.66	4.4	0.658E+04	2.38	3.19	.11678E+01
1.30	0.00	-5.66	4.5	0.649E+04	2.47	3.16	.12260E+01
1.34	0.00	-5.65	4.5	0.641E+04	2.55	3.13	.12851E+01
1.39	0.00	-5.65	4.6	0.633E+04	2.64	3.10	.13451E+01
1.43	0.00	-5.65	4.6	0.625E+04	2.72	3.07	.14058E+01
1.48	0.00	-5.65	4.7	0.617E+04	2.81	3.04	.14674E+01
1.52	0.00	-5.65	4.7	0.610E+04	2.89	3.02	.15297E+01
1.57	0.00	-5.65	4.8	0.603E+04	2.98	2.99	.15928E+01
1.61	0.00	-5.64	4.9	0.596E+04	3.06	2.96	.16568E+01
1.66	0.00	-5.64	4.9	0.590E+04	3.15	2.94	.17214E+01
1.70	0.00	-5.64	5.0	0.584E+04	3.23	2.91	.17868E+01
1.75	0.00	-5.64	5.0	0.578E+04	3.32	2.89	.18530E+01
1.79	0.00	-5.64	5.1	0.572E+04	3.40	2.86	.19199E+01
1.84	0.00	-5.64	5.1	0.566E+04	3.49	2.84	.19875E+01
1.88	0.00	-5.64	5.2	0.561E+04	3.57	2.82	.20558E+01
1.93	0.00	-5.63	5.2	0.555E+04	3.66	2.80	.21249E+01
1.97	0.00	-5.63	5.3	0.550E+04	3.74	2.77	.21946E+01
2.02	0.00	-5.63	5.3	0.545E+04	3.83	2.75	.22650E+01
2.06	0.00	-5.63	5.4	0.540E+04	3.91	2.73	.23361E+01
2.11	0.00	-5.63	5.4	0.536E+04	4.00	2.71	.24079E+01
2.15	0.00	-5.63	5.4	0.531E+04	4.08	2.69	.24803E+01
2.20	0.00	-5.63	5.5	0.527E+04	4.17	2.67	.25534E+01
2.24	0.00	-5.62	5.5	0.522E+04	4.25	2.65	.26272E+01
2.28	0.00	-5.62	5.6	0.518E+04	4.34	2.64	.27016E+01
2.33	0.00	-5.62	5.6	0.514E+04	4.42	2.62	.27766E+01
2.37	0.00	-5.62	5.7	0.510E+04	4.51	2.60	.28523E+01
2.42	0.00	-5.62	5.7	0.506E+04	4.59	2.58	.29286E+01
2.46	0.00	-5.62	5.8	0.502E+04	4.68	2.57	.30055E+01
2.51	0.00	-5.61	5.8	0.499E+04	4.76	2.55	.30830E+01
2.55	0.00	-5.61	5.8	0.495E+04	4.85	2.54	.31612E+01
2.60	0.00	-5.61	5.9	0.491E+04	4.93	2.52	.32399E+01
2.64	0.00	-5.61	5.9	0.488E+04	5.02	2.51	.33193E+01
2.69	0.00	-5.61	6.0	0.484E+04	5.10	2.49	.33992E+01
2.73	0.00	-5.61	6.0	0.481E+04	5.19	2.48	.34797E+01
2.78	0.00	-5.61	6.1	0.478E+04	5.27	2.46	.35608E+01
2.82	0.00	-5.60	6.1	0.475E+04	5.36	2.45	.36425E+01
2.87	0.00	-5.60	6.1	0.472E+04	5.44	2.44	.37248E+01
2.91	0.00	-5.60	6.2	0.469E+04	5.53	2.43	.38077E+01
2.96	0.00	-5.60	6.2	0.466E+04	5.61	2.42	.38911E+01
3.00	0.00	-5.60	6.3	0.463E+04	5.70	2.40	.39750E+01
3.05	0.00	-5.60	6.3	0.460E+04	5.78	2.39	.40596E+01
3.09	0.00	-5.59	6.3	0.457E+04	5.87	2.38	.41446E+01
3.14	0.00	-5.59	6.4	0.454E+04	5.95	2.37	.42303E+01
3.18	0.00	-5.59	6.4	0.451E+04	6.04	2.36	.43165E+01
3.23	0.00	-5.59	6.4	0.449E+04	6.12	2.36	.44032E+01
3.27	0.00	-5.59	6.5	0.446E+04	6.21	2.35	.44904E+01
3.32	0.00	-5.59	6.5	0.444E+04	6.29	2.34	.45782E+01
3.36	0.00	-5.59	6.6	0.441E+04	6.38	2.33	.46666E+01
3.40	0.00	-5.58	6.6	0.439E+04	6.46	2.32	.47554E+01
3.45	0.00	-5.58	6.6	0.436E+04	6.55	2.32	.48448E+01
3.49	0.00	-5.58	6.7	0.434E+04	6.63	2.31	.49347E+01
3.54	0.00	-5.58	6.7	0.431E+04	6.72	2.31	.50251E+01
3.58	0.00	-5.58	6.7	0.429E+04	6.80	2.30	.51160E+01
3.63	0.00	-5.58	6.8	0.427E+04	6.89	2.29	.52075E+01
3.67	0.00	-5.57	6.8	0.425E+04	6.97	2.29	.52994E+01
3.72	0.00	-5.57	6.8	0.422E+04	7.06	2.28	.53919E+01
3.76	0.00	-5.57	6.9	0.420E+04	7.14	2.28	.54848E+01
3.81	0.00	-5.57	6.9	0.418E+04	7.23	2.28	.55783E+01

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-12

```
      3.85     0.00   -5.57     7.0 0.416E+04   7.31     2.27 .56722E+01
      3.90     0.00   -5.57     7.0 0.414E+04   7.40     2.27 .57667E+01
      3.94     0.00   -5.57     7.0 0.412E+04   7.48     2.27 .58616E+01
      3.99     0.00   -5.56     7.1 0.410E+04   7.57     2.26 .59570E+01
      4.03     0.00   -5.56     7.1 0.408E+04   7.65     2.26 .60529E+01
      4.08     0.00   -5.56     7.1 0.406E+04   7.74     2.26 .61493E+01
      4.12     0.00   -5.56     7.2 0.404E+04   7.82     2.26 .62461E+01
      4.17     0.00   -5.56     7.2 0.402E+04   7.91     2.25 .63435E+01
      4.21     0.00   -5.56     7.2 0.401E+04   7.99     2.25 .64413E+01
      4.26     0.00   -5.55     7.3 0.399E+04   8.08     2.25 .65396E+01
      4.30     0.00   -5.55     7.3 0.397E+04   8.16     2.25 .66383E+01
      4.35     0.00   -5.55     7.3 0.395E+04   8.25     2.25 .67375E+01
      4.39     0.00   -5.55     7.4 0.393E+04   8.33     2.25 .68372E+01
      4.44     0.00   -5.55     7.4 0.392E+04   8.42     2.25 .69373E+01
      4.48     0.00   -5.55     7.4 0.390E+04   8.50     2.25 .70379E+01
 Cumulative travel time =           7.0379 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
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BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.4 0.390E+04   8.50     2.52 .70379E+01
     13.21     0.00   -8.50     8.7 0.332E+04   8.50     3.46 .73829E+02
     21.94     0.00   -8.50     9.8 0.295E+04   8.50     4.40 .15050E+03
     30.66     0.00   -8.50    10.8 0.267E+04   8.50     5.34 .23592E+03
     39.39     0.00   -8.50    11.7 0.246E+04   8.50     6.28 .32926E+03
     48.12     0.00   -8.50    12.6 0.230E+04   8.50     7.21 .42990E+03
     56.85     0.00   -8.50    13.4 0.216E+04   8.50     8.15 .53734E+03
     65.58     0.00   -8.50    14.1 0.205E+04   8.50     9.08 .65118E+03
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     74.30     0.00   -8.50    14.9 0.195E+04   8.50    10.02 .77109E+03
     83.03     0.00   -8.50    15.5 0.186E+04   8.50    10.95 .89675E+03
     91.76     0.00   -8.50    16.2 0.179E+04   8.50    11.88 .10279E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    16.8 0.172E+04   8.50    12.81 .11644E+04
    109.22     0.00   -8.50    17.4 0.166E+04   8.50    13.74 .13060E+04
    117.94     0.00   -8.50    18.0 0.161E+04   8.50    14.67 .14524E+04
    126.67     0.00   -8.50    18.6 0.156E+04   8.50    15.60 .16037E+04
    135.40     0.00   -8.50    19.1 0.151E+04   8.50    16.53 .17595E+04
    144.13     0.00   -8.50    19.7 0.147E+04   8.50    17.46 .19198E+04
    152.86     0.00   -8.50    20.2 0.143E+04   8.50    18.38 .20845E+04
    161.58     0.00   -8.50    20.7 0.140E+04   8.50    19.31 .22534E+04
    170.31     0.00   -8.50    21.2 0.137E+04   8.50    20.24 .24265E+04
    179.04     0.00   -8.50    21.7 0.134E+04   8.50    21.16 .26036E+04
    187.77     0.00   -8.50    22.1 0.131E+04   8.50    22.08 .27846E+04
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-13

196.50	0.00	-8.50	22.6	0.128E+04	8.50	23.01	.29695E+04
205.22	0.00	-8.50	23.1	0.126E+04	8.50	23.93	.31582E+04
213.95	0.00	-8.50	23.5	0.123E+04	8.50	24.85	.33507E+04
222.68	0.00	-8.50	23.9	0.121E+04	8.50	25.77	.35467E+04
231.41	0.00	-8.50	24.4	0.119E+04	8.50	26.70	.37464E+04
240.14	0.00	-8.50	24.8	0.117E+04	8.50	27.62	.39495E+04
248.86	0.00	-8.50	25.2	0.115E+04	8.50	28.54	.41562E+04
257.59	0.00	-8.50	25.6	0.113E+04	8.50	29.46	.43662E+04
266.32	0.00	-8.50	26.0	0.111E+04	8.50	30.37	.45795E+04
275.05	0.00	-8.50	26.4	0.110E+04	8.50	31.29	.47962E+04
283.78	0.00	-8.50	26.8	0.108E+04	8.50	32.21	.50160E+04
292.50	0.00	-8.50	27.2	0.106E+04	8.50	33.13	.52391E+04
301.23	0.00	-8.50	27.6	0.105E+04	8.50	34.04	.54654E+04
309.96	0.00	-8.50	27.9	0.104E+04	8.50	34.96	.56947E+04
318.69	0.00	-8.50	28.3	0.102E+04	8.50	35.88	.59271E+04
327.42	0.00	-8.50	28.7	0.101E+04	8.50	36.79	.61626E+04
336.14	0.00	-8.50	29.0	0.997E+03	8.50	37.71	.64010E+04
344.87	0.00	-8.50	29.4	0.985E+03	8.50	38.62	.66423E+04
353.60	0.00	-8.50	29.7	0.973E+03	8.50	39.54	.68866E+04
362.33	0.00	-8.50	30.1	0.962E+03	8.50	40.45	.71338E+04
371.06	0.00	-8.50	30.4	0.951E+03	8.50	41.36	.73838E+04
379.78	0.00	-8.50	30.8	0.941E+03	8.50	42.28	.76366E+04
388.51	0.00	-8.50	31.1	0.931E+03	8.50	43.19	.78922E+04
397.24	0.00	-8.50	31.4	0.921E+03	8.50	44.10	.81506E+04
405.97	0.00	-8.50	31.8	0.911E+03	8.50	45.01	.84117E+04
414.70	0.00	-8.50	32.1	0.902E+03	8.50	45.92	.86755E+04
423.42	0.00	-8.50	32.4	0.893E+03	8.50	46.83	.89420E+04
432.15	0.00	-8.50	32.7	0.885E+03	8.50	47.74	.92111E+04
440.88	0.00	-8.50	33.0	0.876E+03	8.50	48.65	.94828E+04
449.61	0.00	-8.50	33.3	0.868E+03	8.50	49.56	.97571E+04
458.34	0.00	-8.50	33.7	0.860E+03	8.50	50.47	.10034E+05
467.06	0.00	-8.50	34.0	0.852E+03	8.50	51.38	.10313E+05
475.79	0.00	-8.50	34.3	0.845E+03	8.50	52.29	.10595E+05
484.52	0.00	-8.50	34.6	0.837E+03	8.50	53.20	.10880E+05
493.25	0.00	-8.50	34.9	0.830E+03	8.50	54.11	.11167E+05
501.98	0.00	-8.50	35.2	0.823E+03	8.50	55.01	.11456E+05
510.70	0.00	-8.50	35.5	0.816E+03	8.50	55.92	.11748E+05
519.43	0.00	-8.50	35.7	0.810E+03	8.50	56.83	.12042E+05
528.16	0.00	-8.50	36.0	0.803E+03	8.50	57.73	.12339E+05
536.89	0.00	-8.50	36.3	0.797E+03	8.50	58.64	.12638E+05
545.62	0.00	-8.50	36.6	0.791E+03	8.50	59.54	.12939E+05
554.34	0.00	-8.50	36.9	0.785E+03	8.50	60.45	.13243E+05
563.07	0.00	-8.50	37.2	0.779E+03	8.50	61.35	.13549E+05
571.80	0.00	-8.50	37.4	0.773E+03	8.50	62.26	.13857E+05
580.53	0.00	-8.50	37.7	0.767E+03	8.50	63.16	.14168E+05
589.26	0.00	-8.50	38.0	0.762E+03	8.50	64.07	.14481E+05
597.98	0.00	-8.50	38.3	0.756E+03	8.50	64.97	.14796E+05
606.71	0.00	-8.50	38.5	0.751E+03	8.50	65.87	.15113E+05
615.44	0.00	-8.50	38.8	0.746E+03	8.50	66.78	.15433E+05
624.17	0.00	-8.50	39.1	0.741E+03	8.50	67.68	.15755E+05
632.90	0.00	-8.50	39.3	0.736E+03	8.50	68.58	.16079E+05
641.62	0.00	-8.50	39.6	0.731E+03	8.50	69.48	.16405E+05
650.35	0.00	-8.50	39.9	0.726E+03	8.50	70.38	.16733E+05
659.08	0.00	-8.50	40.1	0.721E+03	8.50	71.28	.17064E+05
667.81	0.00	-8.50	40.4	0.717E+03	8.50	72.18	.17396E+05
676.54	0.00	-8.50	40.6	0.712E+03	8.50	73.08	.17731E+05
685.26	0.00	-8.50	40.9	0.708E+03	8.50	73.98	.18068E+05
693.99	0.00	-8.50	41.1	0.704E+03	8.50	74.88	.18407E+05
702.72	0.00	-8.50	41.4	0.699E+03	8.50	75.78	.18748E+05
711.45	0.00	-8.50	41.6	0.695E+03	8.50	76.68	.19091E+05
720.18	0.00	-8.50	41.9	0.691E+03	8.50	77.58	.19436E+05
728.90	0.00	-8.50	42.1	0.687E+03	8.50	78.48	.19783E+05
737.63	0.00	-8.50	42.4	0.683E+03	8.50	79.38	.20132E+05
746.36	0.00	-8.50	42.6	0.679E+03	8.50	80.28	.20484E+05
755.09	0.00	-8.50	42.9	0.675E+03	8.50	81.17	.20837E+05
763.82	0.00	-8.50	43.1	0.671E+03	8.50	82.07	.21192E+05
772.54	0.00	-8.50	43.3	0.668E+03	8.50	82.97	.21549E+05
781.27	0.00	-8.50	43.6	0.664E+03	8.50	83.87	.21909E+05
790.00	0.00	-8.50	43.8	0.660E+03	8.50	84.76	.22270E+05

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-14

```
    798.73     0.00   -8.50    44.1 0.657E+03   8.50    85.66 .22633E+05
    807.46     0.00   -8.50    44.3 0.653E+03   8.50    86.55 .22998E+05
    816.18     0.00   -8.50    44.5 0.650E+03   8.50    87.45 .23365E+05
    824.91     0.00   -8.50    44.8 0.647E+03   8.50    88.34 .23734E+05
    833.64     0.00   -8.50    45.0 0.643E+03   8.50    89.24 .24105E+05
    842.37     0.00   -8.50    45.2 0.640E+03   8.50    90.13 .24478E+05
    851.10     0.00   -8.50    45.4 0.637E+03   8.50    91.03 .24852E+05
    859.83     0.00   -8.50    45.7 0.634E+03   8.50    91.92 .25229E+05
    868.55     0.00   -8.50    45.9 0.631E+03   8.50    92.82 .25607E+05
    877.28     0.00   -8.50    46.1 0.627E+03   8.50    93.71 .25987E+05
 Cumulative travel time =       25987.4316 sec  (    7.22 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
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** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
D-CORMIX      End of Prediction File
DDDD
```

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-15

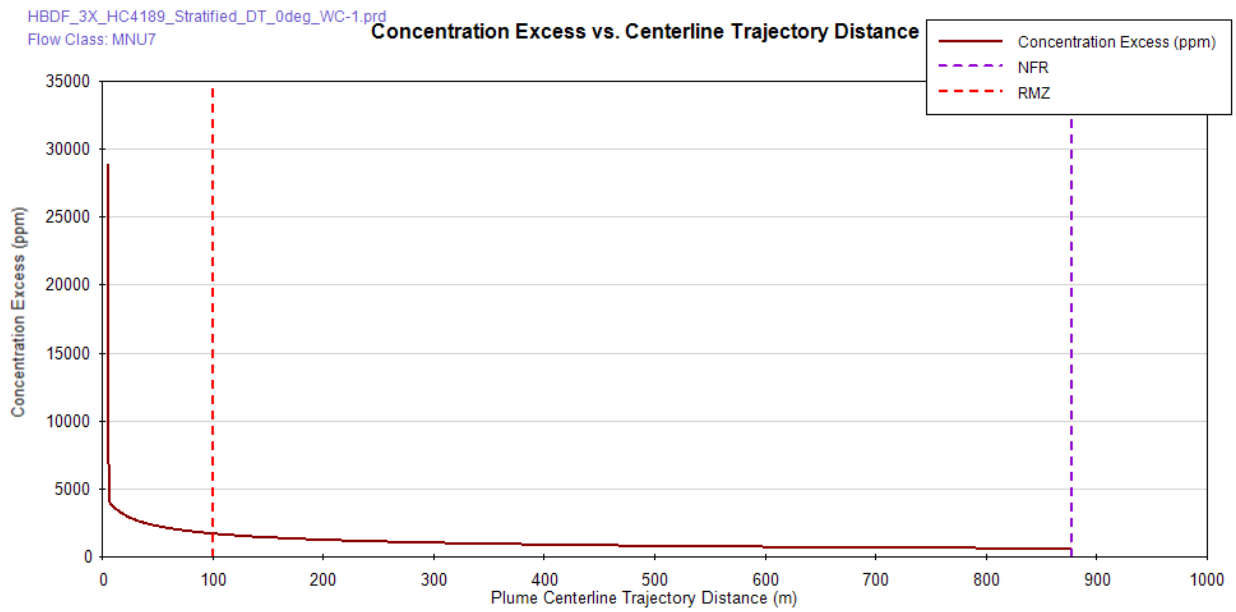

Figure C-5: Excess Salinity in ppm as a function of centerline trajectory distance for Worst-Case #1, ΔT = +0^0 C.

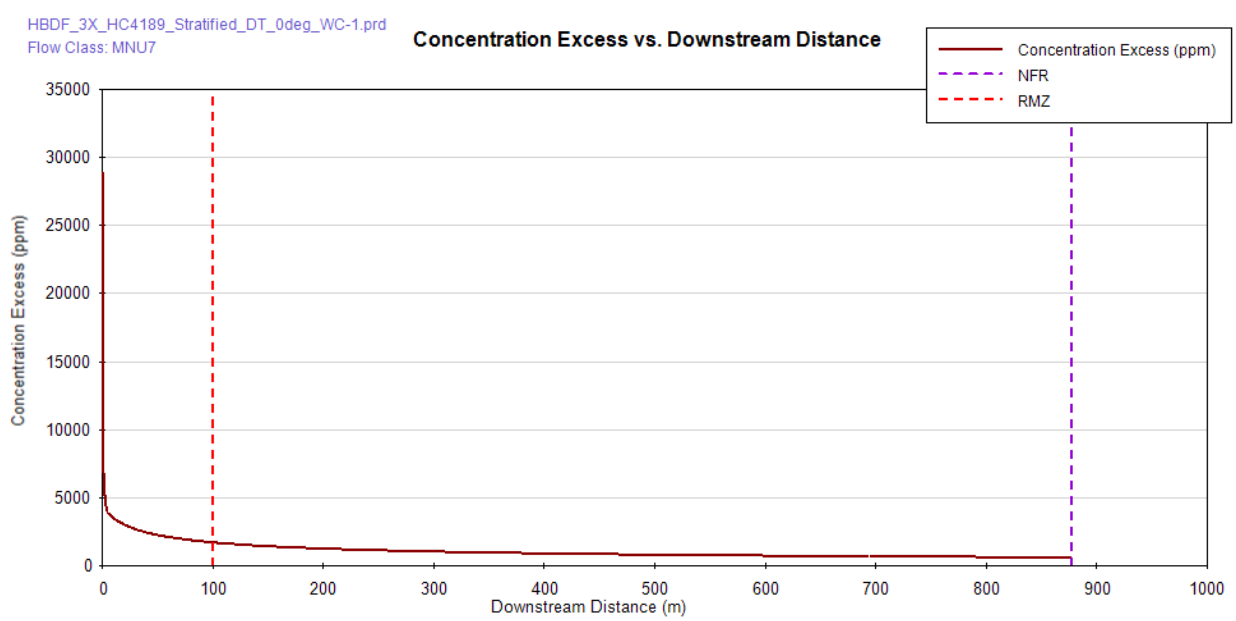

Figure C-6: Excess Salinity in ppm as a function of distance downstream for Worst-Case #1, ΔT = +0^0 C

Appendix-C: CORMIX 10.0.3.0 Prediction File for Worst-Case #1, ΔT = +0^0 C; Sheet C-16

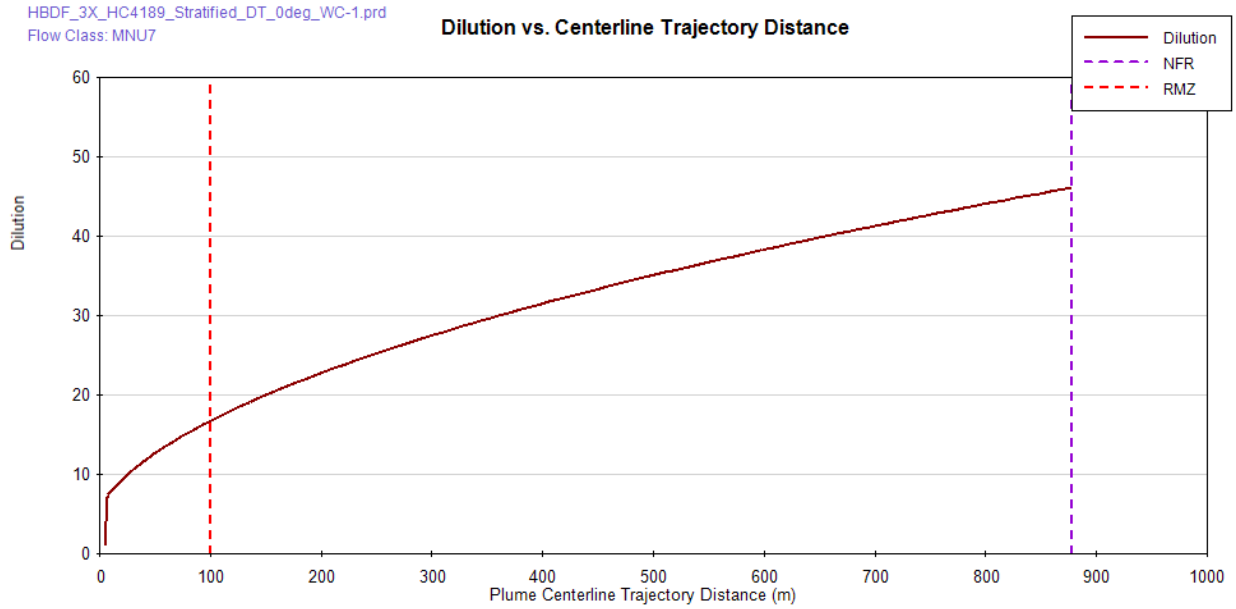

Figure C-7: Dilution expressed as mixing ratio, S**,** as a function of centerline trajectory distance for Worst-Case #1, ΔT = +0^0 C. Note S = 1 + Dm

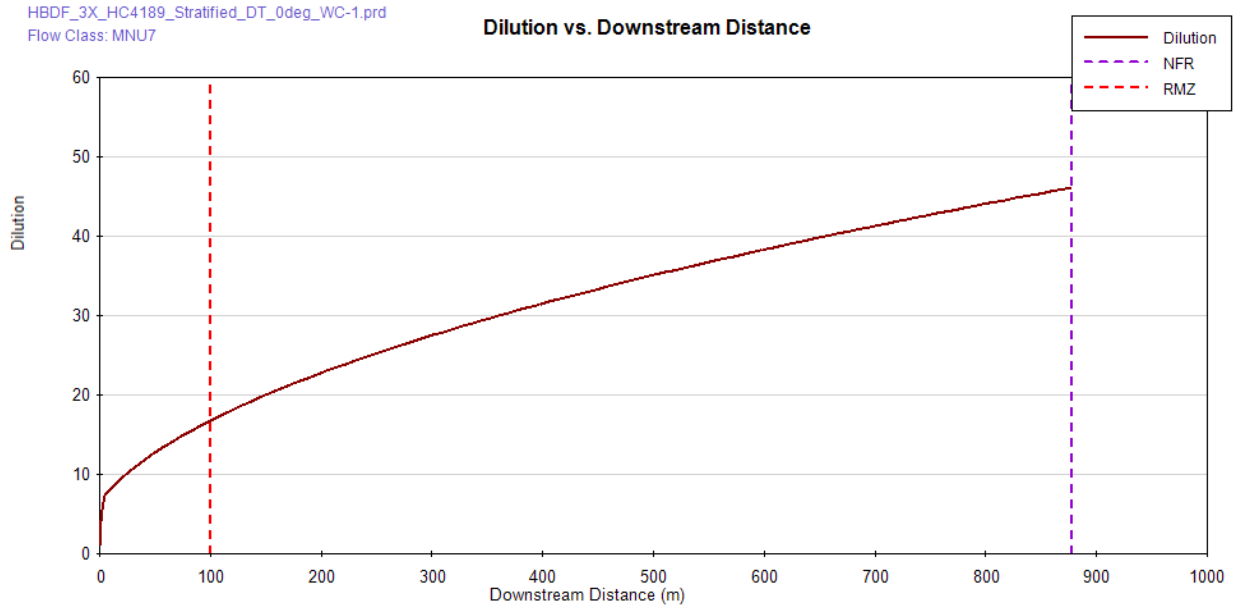

Figure C-8: Dilution expressed as mixing ratio, S**,** as a function of distance downstream for Worst-Case #1, ΔT = +0^0 C. Note S = 1 + Dm

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-1

```
D-CORMIX PREDICTION FILE:
DDDD
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-2

```
MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.3350E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48     4.395   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
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-----------------------------------------------------------------------------------------------
BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.7 0.201E+05   0.08     4.41 .17025E-01
      0.09     0.00   -5.70     1.9 0.172E+05   0.17     4.35 .39708E-01
      0.13     0.00   -5.70     2.2 0.155E+05   0.25     4.29 .66076E-01
      0.18     0.00   -5.69     2.3 0.143E+05   0.34     4.23 .95422E-01
      0.22     0.00   -5.69     2.5 0.134E+05   0.42     4.17 .12734E+00
      0.27     0.00   -5.69     2.6 0.127E+05   0.51     4.11 .16155E+00
      0.31     0.00   -5.69     2.8 0.121E+05   0.60     4.06 .19787E+00
      0.36     0.00   -5.69     2.9 0.116E+05   0.68     4.00 .23611E+00
      0.40     0.00   -5.69     3.0 0.111E+05   0.76     3.95 .27618E+00
      0.45     0.00   -5.68     3.1 0.107E+05   0.85     3.90 .31795E+00
      0.49     0.00   -5.68     3.2 0.104E+05   0.93     3.85 .36134E+00
      0.54     0.00   -5.68     3.3 0.101E+05   1.02     3.80 .40628E+00
      0.58     0.00   -5.68     3.4 0.981E+04   1.10     3.76 .45269E+00
      0.63     0.00   -5.68     3.5 0.955E+04   1.19     3.71 .50053E+00
      0.67     0.00   -5.68     3.6 0.932E+04   1.27     3.67 .54974E+00
      0.72     0.00   -5.68     3.7 0.910E+04   1.36     3.62 .60027E+00
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-3

0.76	0.00	-5.67	3.8	0.890E+04	1.44	3.58	.65208E+00
0.81	0.00	-5.67	3.8	0.872E+04	1.53	3.54	.70514E+00
0.85	0.00	-5.67	3.9	0.854E+04	1.61	3.50	.75940E+00
0.90	0.00	-5.67	4.0	0.838E+04	1.70	3.46	.81484E+00
0.94	0.00	-5.67	4.1	0.823E+04	1.78	3.43	.87142E+00
0.99	0.00	-5.67	4.1	0.809E+04	1.87	3.39	.92912E+00
1.03	0.00	-5.66	4.2	0.795E+04	1.95	3.35	.98792E+00
1.08	0.00	-5.66	4.3	0.782E+04	2.04	3.32	.10478E+01
1.12	0.00	-5.66	4.4	0.770E+04	2.12	3.29	.11087E+01
1.16	0.00	-5.66	4.4	0.758E+04	2.21	3.25	.11706E+01
1.21	0.00	-5.66	4.5	0.747E+04	2.30	3.22	.12336E+01
1.25	0.00	-5.66	4.5	0.737E+04	2.38	3.19	.12975E+01
1.30	0.00	-5.66	4.6	0.727E+04	2.47	3.16	.13624E+01
1.34	0.00	-5.65	4.7	0.717E+04	2.55	3.13	.14282E+01
1.39	0.00	-5.65	4.7	0.708E+04	2.64	3.10	.14950E+01
1.43	0.00	-5.65	4.8	0.699E+04	2.72	3.07	.15627E+01
1.48	0.00	-5.65	4.8	0.691E+04	2.81	3.04	.16313E+01
1.52	0.00	-5.65	4.9	0.683E+04	2.89	3.02	.17008E+01
1.57	0.00	-5.65	5.0	0.675E+04	2.98	2.99	.17712E+01
1.61	0.00	-5.64	5.0	0.667E+04	3.06	2.96	.18424E+01
1.66	0.00	-5.64	5.1	0.660E+04	3.15	2.94	.19145E+01
1.70	0.00	-5.64	5.1	0.653E+04	3.23	2.91	.19875E+01
1.75	0.00	-5.64	5.2	0.646E+04	3.32	2.89	.20612E+01
1.79	0.00	-5.64	5.2	0.640E+04	3.40	2.86	.21358E+01
1.84	0.00	-5.64	5.3	0.633E+04	3.49	2.84	.22112E+01
1.88	0.00	-5.64	5.3	0.627E+04	3.57	2.82	.22874E+01
1.93	0.00	-5.63	5.4	0.621E+04	3.66	2.80	.23644E+01
1.97	0.00	-5.63	5.4	0.615E+04	3.74	2.77	.24422E+01
2.02	0.00	-5.63	5.5	0.610E+04	3.83	2.75	.25207E+01
2.06	0.00	-5.63	5.5	0.604E+04	3.91	2.73	.26000E+01
2.11	0.00	-5.63	5.6	0.599E+04	4.00	2.71	.26801E+01
2.15	0.00	-5.63	5.6	0.594E+04	4.08	2.69	.27609E+01
2.20	0.00	-5.63	5.7	0.589E+04	4.17	2.67	.28424E+01
2.24	0.00	-5.62	5.7	0.584E+04	4.25	2.65	.29247E+01
2.28	0.00	-5.62	5.8	0.579E+04	4.34	2.64	.30077E+01
2.33	0.00	-5.62	5.8	0.574E+04	4.42	2.62	.30915E+01
2.37	0.00	-5.62	5.9	0.570E+04	4.51	2.60	.31759E+01
2.42	0.00	-5.62	5.9	0.566E+04	4.59	2.58	.32610E+01
2.46	0.00	-5.62	6.0	0.561E+04	4.68	2.57	.33469E+01
2.51	0.00	-5.61	6.0	0.557E+04	4.76	2.55	.34334E+01
2.55	0.00	-5.61	6.1	0.553E+04	4.85	2.54	.35206E+01
2.60	0.00	-5.61	6.1	0.549E+04	4.93	2.52	.36085E+01
2.64	0.00	-5.61	6.1	0.545E+04	5.02	2.51	.36970E+01
2.69	0.00	-5.61	6.2	0.541E+04	5.10	2.49	.37863E+01
2.73	0.00	-5.61	6.2	0.537E+04	5.19	2.48	.38762E+01
2.78	0.00	-5.61	6.3	0.534E+04	5.27	2.46	.39667E+01
2.82	0.00	-5.60	6.3	0.530E+04	5.36	2.45	.40579E+01
2.87	0.00	-5.60	6.4	0.527E+04	5.44	2.44	.41497E+01
2.91	0.00	-5.60	6.4	0.523E+04	5.53	2.43	.42422E+01
2.96	0.00	-5.60	6.4	0.520E+04	5.61	2.42	.43353E+01
3.00	0.00	-5.60	6.5	0.517E+04	5.70	2.40	.44291E+01
3.05	0.00	-5.60	6.5	0.513E+04	5.78	2.39	.45235E+01
3.09	0.00	-5.59	6.6	0.510E+04	5.87	2.38	.46185E+01
3.14	0.00	-5.59	6.6	0.507E+04	5.95	2.37	.47141E+01
3.18	0.00	-5.59	6.6	0.504E+04	6.04	2.36	.48103E+01
3.23	0.00	-5.59	6.7	0.501E+04	6.12	2.36	.49071E+01
3.27	0.00	-5.59	6.7	0.498E+04	6.21	2.35	.50046E+01
3.32	0.00	-5.59	6.8	0.495E+04	6.29	2.34	.51026E+01
3.36	0.00	-5.59	6.8	0.492E+04	6.38	2.33	.52012E+01
3.40	0.00	-5.58	6.8	0.490E+04	6.46	2.32	.53005E+01
3.45	0.00	-5.58	6.9	0.487E+04	6.55	2.32	.54003E+01
3.49	0.00	-5.58	6.9	0.484E+04	6.63	2.31	.55007E+01
3.54	0.00	-5.58	7.0	0.482E+04	6.72	2.31	.56016E+01
3.58	0.00	-5.58	7.0	0.479E+04	6.80	2.30	.57032E+01
3.63	0.00	-5.58	7.0	0.476E+04	6.89	2.29	.58053E+01
3.67	0.00	-5.57	7.1	0.474E+04	6.97	2.29	.59080E+01
3.72	0.00	-5.57	7.1	0.472E+04	7.06	2.28	.60113E+01
3.76	0.00	-5.57	7.1	0.469E+04	7.14	2.28	.61151E+01
3.81	0.00	-5.57	7.2	0.467E+04	7.23	2.28	.62195E+01

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-4

```
      3.85     0.00   -5.57     7.2 0.464E+04   7.31     2.27 .63244E+01
      3.90     0.00   -5.57     7.2 0.462E+04   7.40     2.27 .64299E+01
      3.94     0.00   -5.57     7.3 0.460E+04   7.48     2.27 .65359E+01
      3.99     0.00   -5.56     7.3 0.458E+04   7.57     2.26 .66425E+01
      4.03     0.00   -5.56     7.4 0.455E+04   7.65     2.26 .67496E+01
      4.08     0.00   -5.56     7.4 0.453E+04   7.74     2.26 .68573E+01
      4.12     0.00   -5.56     7.4 0.451E+04   7.82     2.26 .69655E+01
      4.17     0.00   -5.56     7.5 0.449E+04   7.91     2.25 .70742E+01
      4.21     0.00   -5.56     7.5 0.447E+04   7.99     2.25 .71835E+01
      4.26     0.00   -5.55     7.5 0.445E+04   8.08     2.25 .72933E+01
      4.30     0.00   -5.55     7.6 0.443E+04   8.16     2.25 .74036E+01
      4.35     0.00   -5.55     7.6 0.441E+04   8.25     2.25 .75145E+01
      4.39     0.00   -5.55     7.6 0.439E+04   8.33     2.25 .76258E+01
      4.44     0.00   -5.55     7.7 0.437E+04   8.42     2.25 .77377E+01
      4.48     0.00   -5.55     7.7 0.435E+04   8.50     2.25 .78501E+01
 Cumulative travel time =           7.8501 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
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-------------------------------------------------------------------------------------------
BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.7 0.435E+04   8.50     2.52 .78501E+01
     13.21     0.00   -8.50     9.0 0.371E+04   8.50     3.46 .82348E+02
     21.94     0.00   -8.50    10.2 0.329E+04   8.50     4.40 .16787E+03
     30.66     0.00   -8.50    11.2 0.298E+04   8.50     5.34 .26314E+03
     39.39     0.00   -8.50    12.2 0.275E+04   8.50     6.28 .36725E+03
     48.12     0.00   -8.50    13.1 0.256E+04   8.50     7.21 .47951E+03
     56.85     0.00   -8.50    13.9 0.241E+04   8.50     8.15 .59935E+03
     65.58     0.00   -8.50    14.7 0.228E+04   8.50     9.08 .72633E+03
     74.30     0.00   -8.50    15.4 0.217E+04   8.50    10.02 .86007E+03
     83.03     0.00   -8.50    16.1 0.208E+04   8.50    10.95 .10002E+04
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     91.76     0.00   -8.50    16.8 0.199E+04   8.50    11.88 .11466E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    17.5 0.192E+04   8.50    12.81 .12988E+04
    109.22     0.00   -8.50    18.1 0.185E+04   8.50    13.74 .14567E+04
    117.94     0.00   -8.50    18.7 0.179E+04   8.50    14.67 .16200E+04
    126.67     0.00   -8.50    19.3 0.174E+04   8.50    15.60 .17887E+04
    135.40     0.00   -8.50    19.8 0.169E+04   8.50    16.53 .19626E+04
    144.13     0.00   -8.50    20.4 0.164E+04   8.50    17.46 .21414E+04
    152.86     0.00   -8.50    20.9 0.160E+04   8.50    18.38 .23250E+04
    161.58     0.00   -8.50    21.5 0.156E+04   8.50    19.31 .25135E+04
    170.31     0.00   -8.50    22.0 0.152E+04   8.50    20.24 .27065E+04
    179.04     0.00   -8.50    22.5 0.149E+04   8.50    21.16 .29040E+04
    187.77     0.00   -8.50    23.0 0.146E+04   8.50    22.08 .31060E+04
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-5

196.50	0.00	-8.50	23.5	0.143E+04	8.50	23.01	.33122E+04
205.22	0.00	-8.50	23.9	0.140E+04	8.50	23.93	.35227E+04
213.95	0.00	-8.50	24.4	0.137E+04	8.50	24.85	.37373E+04
222.68	0.00	-8.50	24.8	0.135E+04	8.50	25.77	.39560E+04
231.41	0.00	-8.50	25.3	0.132E+04	8.50	26.70	.41787E+04
240.14	0.00	-8.50	25.7	0.130E+04	8.50	27.62	.44053E+04
248.86	0.00	-8.50	26.2	0.128E+04	8.50	28.54	.46358E+04
257.59	0.00	-8.50	26.6	0.126E+04	8.50	29.46	.48700E+04
266.32	0.00	-8.50	27.0	0.124E+04	8.50	30.37	.51080E+04
275.05	0.00	-8.50	27.4	0.122E+04	8.50	31.29	.53496E+04
283.78	0.00	-8.50	27.8	0.120E+04	8.50	32.21	.55949E+04
292.50	0.00	-8.50	28.2	0.119E+04	8.50	33.13	.58437E+04
301.23	0.00	-8.50	28.6	0.117E+04	8.50	34.04	.60961E+04
309.96	0.00	-8.50	29.0	0.116E+04	8.50	34.96	.63519E+04
318.69	0.00	-8.50	29.4	0.114E+04	8.50	35.88	.66111E+04
327.42	0.00	-8.50	29.7	0.113E+04	8.50	36.79	.68737E+04
336.14	0.00	-8.50	30.1	0.111E+04	8.50	37.71	.71396E+04
344.87	0.00	-8.50	30.5	0.110E+04	8.50	38.62	.74089E+04
353.60	0.00	-8.50	30.8	0.109E+04	8.50	39.54	.76814E+04
362.33	0.00	-8.50	31.2	0.107E+04	8.50	40.45	.79570E+04
371.06	0.00	-8.50	31.6	0.106E+04	8.50	41.36	.82359E+04
379.78	0.00	-8.50	31.9	0.105E+04	8.50	42.28	.85179E+04
388.51	0.00	-8.50	32.3	0.104E+04	8.50	43.19	.88030E+04
397.24	0.00	-8.50	32.6	0.103E+04	8.50	44.10	.90912E+04
405.97	0.00	-8.50	32.9	0.102E+04	8.50	45.01	.93824E+04
414.70	0.00	-8.50	33.3	0.101E+04	8.50	45.92	.96767E+04
423.42	0.00	-8.50	33.6	0.996E+03	8.50	46.83	.99739E+04
432.15	0.00	-8.50	33.9	0.987E+03	8.50	47.74	.10274E+05
440.88	0.00	-8.50	34.3	0.977E+03	8.50	48.65	.10577E+05
449.61	0.00	-8.50	34.6	0.968E+03	8.50	49.56	.10883E+05
458.34	0.00	-8.50	34.9	0.959E+03	8.50	50.47	.11192E+05
467.06	0.00	-8.50	35.2	0.951E+03	8.50	51.38	.11504E+05
475.79	0.00	-8.50	35.6	0.942E+03	8.50	52.29	.11818E+05
484.52	0.00	-8.50	35.9	0.934E+03	8.50	53.20	.12135E+05
493.25	0.00	-8.50	36.2	0.926E+03	8.50	54.11	.12455E+05
501.98	0.00	-8.50	36.5	0.918E+03	8.50	55.01	.12778E+05
510.70	0.00	-8.50	36.8	0.911E+03	8.50	55.92	.13104E+05
519.43	0.00	-8.50	37.1	0.903E+03	8.50	56.83	.13432E+05
528.16	0.00	-8.50	37.4	0.896E+03	8.50	57.73	.13763E+05
536.89	0.00	-8.50	37.7	0.889E+03	8.50	58.64	.14096E+05
545.62	0.00	-8.50	38.0	0.882E+03	8.50	59.54	.14432E+05
554.34	0.00	-8.50	38.3	0.875E+03	8.50	60.45	.14771E+05
563.07	0.00	-8.50	38.6	0.869E+03	8.50	61.35	.15112E+05
571.80	0.00	-8.50	38.9	0.862E+03	8.50	62.26	.15456E+05
580.53	0.00	-8.50	39.1	0.856E+03	8.50	63.16	.15803E+05
589.26	0.00	-8.50	39.4	0.850E+03	8.50	64.07	.16152E+05
597.98	0.00	-8.50	39.7	0.844E+03	8.50	64.97	.16503E+05
606.71	0.00	-8.50	40.0	0.838E+03	8.50	65.87	.16857E+05
615.44	0.00	-8.50	40.3	0.832E+03	8.50	66.78	.17214E+05
624.17	0.00	-8.50	40.5	0.826E+03	8.50	67.68	.17573E+05
632.90	0.00	-8.50	40.8	0.821E+03	8.50	68.58	.17934E+05
641.62	0.00	-8.50	41.1	0.815E+03	8.50	69.48	.18298E+05
650.35	0.00	-8.50	41.4	0.810E+03	8.50	70.38	.18664E+05
659.08	0.00	-8.50	41.6	0.805E+03	8.50	71.28	.19033E+05
667.81	0.00	-8.50	41.9	0.800E+03	8.50	72.18	.19404E+05
676.54	0.00	-8.50	42.2	0.795E+03	8.50	73.08	.19777E+05
685.26	0.00	-8.50	42.4	0.790E+03	8.50	73.98	.20153E+05
693.99	0.00	-8.50	42.7	0.785E+03	8.50	74.88	.20531E+05
702.72	0.00	-8.50	42.9	0.780E+03	8.50	75.78	.20911E+05
711.45	0.00	-8.50	43.2	0.775E+03	8.50	76.68	.21294E+05
720.18	0.00	-8.50	43.5	0.771E+03	8.50	77.58	.21679E+05
728.90	0.00	-8.50	43.7	0.766E+03	8.50	78.48	.22066E+05
737.63	0.00	-8.50	44.0	0.762E+03	8.50	79.38	.22456E+05
746.36	0.00	-8.50	44.2	0.758E+03	8.50	80.28	.22847E+05
755.09	0.00	-8.50	44.5	0.753E+03	8.50	81.17	.23242E+05
763.82	0.00	-8.50	44.7	0.749E+03	8.50	82.07	.23638E+05
772.54	0.00	-8.50	45.0	0.745E+03	8.50	82.97	.24036E+05
781.27	0.00	-8.50	45.2	0.741E+03	8.50	83.87	.24437E+05
790.00	0.00	-8.50	45.5	0.737E+03	8.50	84.76	.24840E+05

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-6

```
    798.73     0.00   -8.50    45.7 0.733E+03   8.50    85.66 .25245E+05
    807.46     0.00   -8.50    46.0 0.729E+03   8.50    86.55 .25652E+05
    816.18     0.00   -8.50    46.2 0.725E+03   8.50    87.45 .26061E+05
    824.91     0.00   -8.50    46.4 0.721E+03   8.50    88.34 .26473E+05
    833.64     0.00   -8.50    46.7 0.718E+03   8.50    89.24 .26887E+05
    842.37     0.00   -8.50    46.9 0.714E+03   8.50    90.13 .27302E+05
    851.10     0.00   -8.50    47.2 0.710E+03   8.50    91.03 .27720E+05
    859.83     0.00   -8.50    47.4 0.707E+03   8.50    91.92 .28140E+05
    868.55     0.00   -8.50    47.6 0.703E+03   8.50    92.82 .28562E+05
    877.28     0.00   -8.50    47.9 0.700E+03   8.50    93.71 .28986E+05
 Cumulative travel time =       28986.3965 sec  (    8.05 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
D-CORMIX      End of Prediction File
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-7

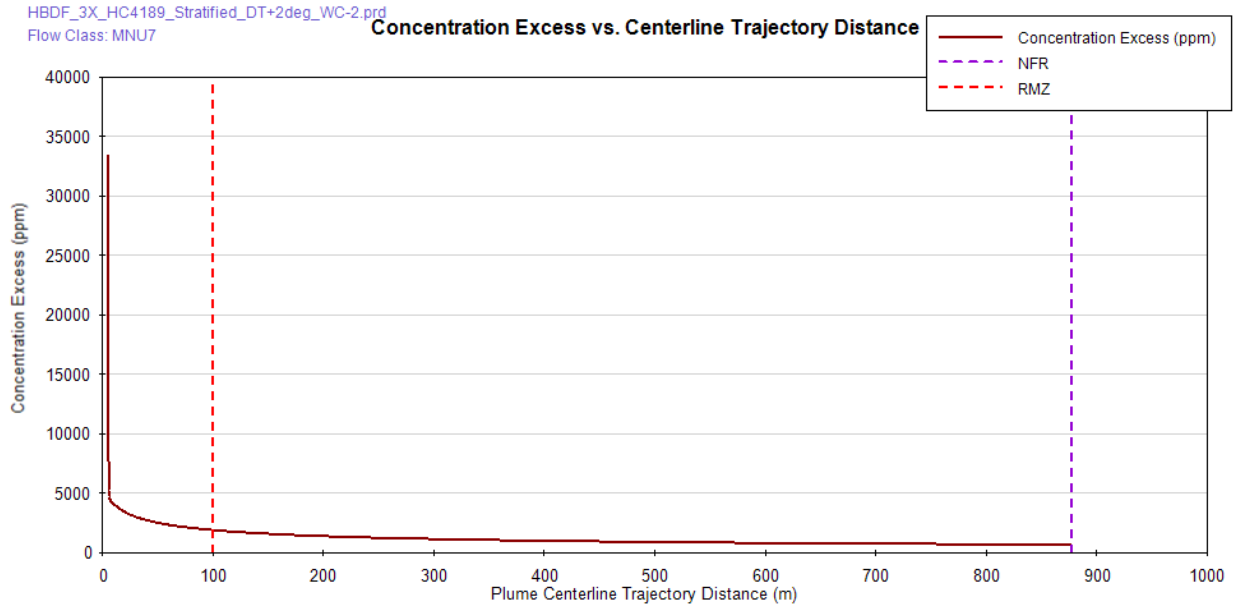

Figure D-1: Excess Salinity in ppm as a function of centerline trajectory distance for Worst-Case #2, ΔT = +2^0 C.

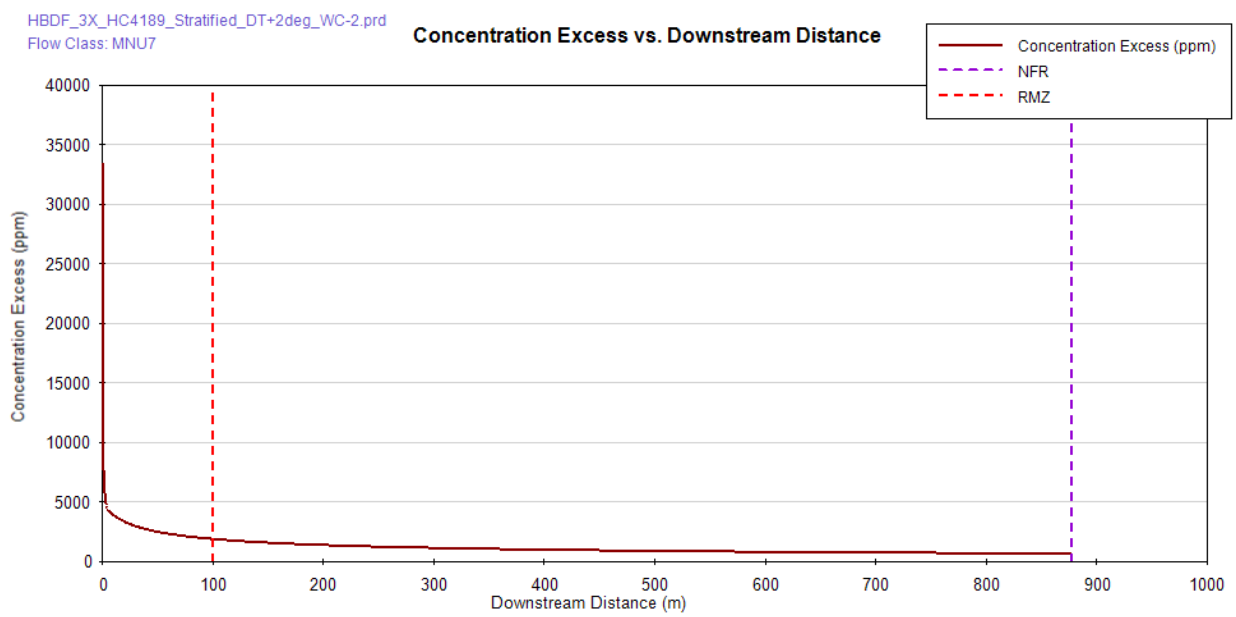

Figure D-2: Excess Salinity in ppm as a function of distance downstream for Worst-Case #2, ΔT = +2^0 C

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +2^0 C; Sheet D-8

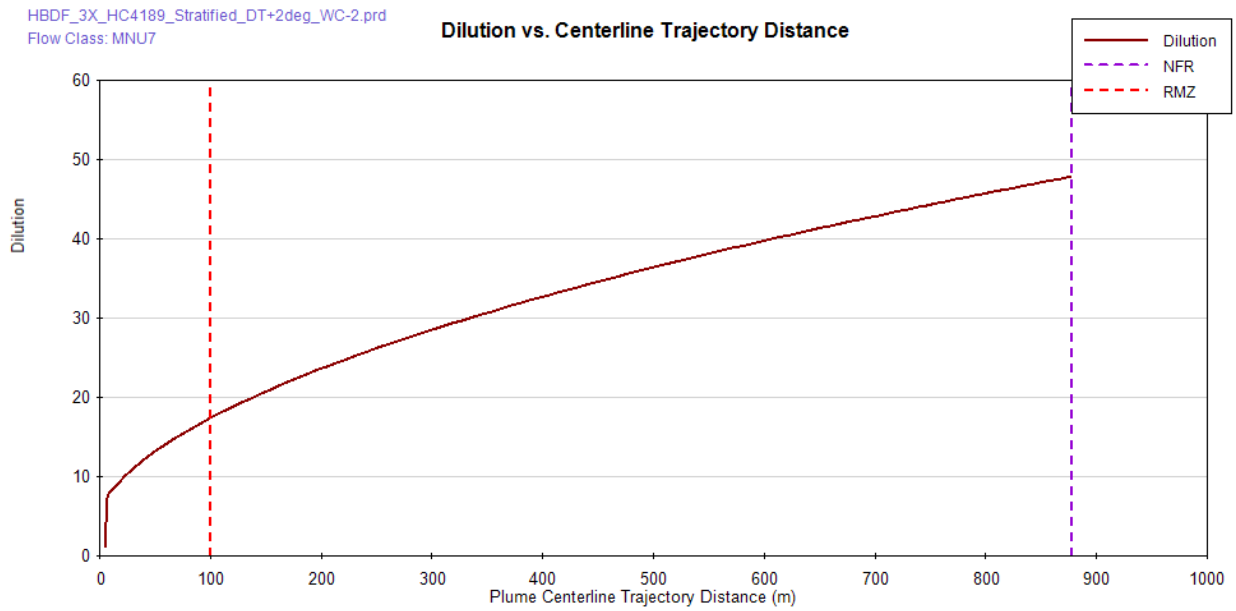

Figure D-3: Dilution expressed as mixing ratio, S**,** as a function of centerline trajectory distance for Worst-Case #2, ΔT = +2^0 C. Note S = 1 + Dm

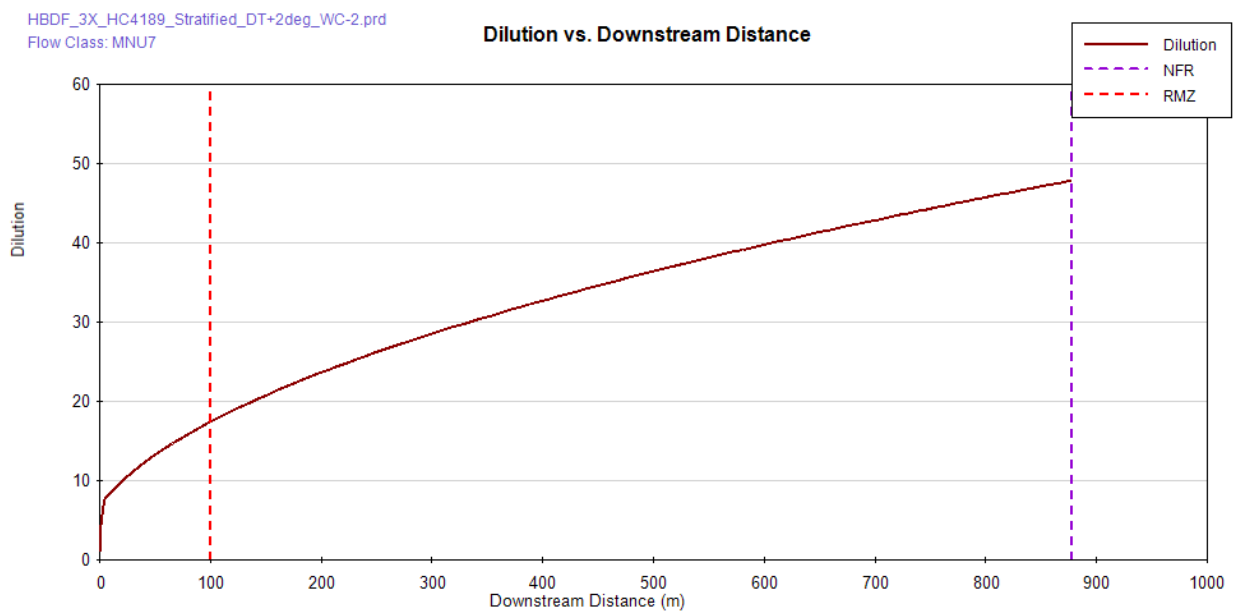

Figure D-4: Dilution expressed as mixing ratio, S**,** as a function of distance downstream for Worst-Case #2, ΔT = +2^0 C. Note S = 1 + Dm

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-9

```
D-CORMIX PREDICTION FILE:
DDDD
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-10

```
MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.3350E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48     4.395   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
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BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.7 0.201E+05   0.08     4.41 .17025E-01
      0.09     0.00   -5.70     1.9 0.172E+05   0.17     4.35 .39708E-01
      0.13     0.00   -5.70     2.2 0.155E+05   0.25     4.29 .66076E-01
      0.18     0.00   -5.69     2.3 0.143E+05   0.34     4.23 .95422E-01
      0.22     0.00   -5.69     2.5 0.134E+05   0.42     4.17 .12734E+00
      0.27     0.00   -5.69     2.6 0.127E+05   0.51     4.11 .16155E+00
      0.31     0.00   -5.69     2.8 0.121E+05   0.60     4.06 .19787E+00
      0.36     0.00   -5.69     2.9 0.116E+05   0.68     4.00 .23611E+00
      0.40     0.00   -5.69     3.0 0.111E+05   0.76     3.95 .27618E+00
      0.45     0.00   -5.68     3.1 0.107E+05   0.85     3.90 .31795E+00
      0.49     0.00   -5.68     3.2 0.104E+05   0.93     3.85 .36134E+00
      0.54     0.00   -5.68     3.3 0.101E+05   1.02     3.80 .40628E+00
      0.58     0.00   -5.68     3.4 0.981E+04   1.10     3.76 .45269E+00
      0.63     0.00   -5.68     3.5 0.955E+04   1.19     3.71 .50053E+00
      0.67     0.00   -5.68     3.6 0.932E+04   1.27     3.67 .54974E+00
      0.72     0.00   -5.68     3.7 0.910E+04   1.36     3.62 .60027E+00
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-11

0.76	0.00	-5.67	3.8	0.890E+04	1.44	3.58	.65208E+00
0.81	0.00	-5.67	3.8	0.872E+04	1.53	3.54	.70514E+00
0.85	0.00	-5.67	3.9	0.854E+04	1.61	3.50	.75940E+00
0.90	0.00	-5.67	4.0	0.838E+04	1.70	3.46	.81484E+00
0.94	0.00	-5.67	4.1	0.823E+04	1.78	3.43	.87142E+00
0.99	0.00	-5.67	4.1	0.809E+04	1.87	3.39	.92912E+00
1.03	0.00	-5.66	4.2	0.795E+04	1.95	3.35	.98792E+00
1.08	0.00	-5.66	4.3	0.782E+04	2.04	3.32	.10478E+01
1.12	0.00	-5.66	4.4	0.770E+04	2.12	3.29	.11087E+01
1.16	0.00	-5.66	4.4	0.758E+04	2.21	3.25	.11706E+01
1.21	0.00	-5.66	4.5	0.747E+04	2.30	3.22	.12336E+01
1.25	0.00	-5.66	4.5	0.737E+04	2.38	3.19	.12975E+01
1.30	0.00	-5.66	4.6	0.727E+04	2.47	3.16	.13624E+01
1.34	0.00	-5.65	4.7	0.717E+04	2.55	3.13	.14282E+01
1.39	0.00	-5.65	4.7	0.708E+04	2.64	3.10	.14950E+01
1.43	0.00	-5.65	4.8	0.699E+04	2.72	3.07	.15627E+01
1.48	0.00	-5.65	4.8	0.691E+04	2.81	3.04	.16313E+01
1.52	0.00	-5.65	4.9	0.683E+04	2.89	3.02	.17008E+01
1.57	0.00	-5.65	5.0	0.675E+04	2.98	2.99	.17712E+01
1.61	0.00	-5.64	5.0	0.667E+04	3.06	2.96	.18424E+01
1.66	0.00	-5.64	5.1	0.660E+04	3.15	2.94	.19145E+01
1.70	0.00	-5.64	5.1	0.653E+04	3.23	2.91	.19875E+01
1.75	0.00	-5.64	5.2	0.646E+04	3.32	2.89	.20612E+01
1.79	0.00	-5.64	5.2	0.640E+04	3.40	2.86	.21358E+01
1.84	0.00	-5.64	5.3	0.633E+04	3.49	2.84	.22112E+01
1.88	0.00	-5.64	5.3	0.627E+04	3.57	2.82	.22874E+01
1.93	0.00	-5.63	5.4	0.621E+04	3.66	2.80	.23644E+01
1.97	0.00	-5.63	5.4	0.615E+04	3.74	2.77	.24422E+01
2.02	0.00	-5.63	5.5	0.610E+04	3.83	2.75	.25207E+01
2.06	0.00	-5.63	5.5	0.604E+04	3.91	2.73	.26000E+01
2.11	0.00	-5.63	5.6	0.599E+04	4.00	2.71	.26801E+01
2.15	0.00	-5.63	5.6	0.594E+04	4.08	2.69	.27609E+01
2.20	0.00	-5.63	5.7	0.589E+04	4.17	2.67	.28424E+01
2.24	0.00	-5.62	5.7	0.584E+04	4.25	2.65	.29247E+01
2.28	0.00	-5.62	5.8	0.579E+04	4.34	2.64	.30077E+01
2.33	0.00	-5.62	5.8	0.574E+04	4.42	2.62	.30915E+01
2.37	0.00	-5.62	5.9	0.570E+04	4.51	2.60	.31759E+01
2.42	0.00	-5.62	5.9	0.566E+04	4.59	2.58	.32610E+01
2.46	0.00	-5.62	6.0	0.561E+04	4.68	2.57	.33469E+01
2.51	0.00	-5.61	6.0	0.557E+04	4.76	2.55	.34334E+01
2.55	0.00	-5.61	6.1	0.553E+04	4.85	2.54	.35206E+01
2.60	0.00	-5.61	6.1	0.549E+04	4.93	2.52	.36085E+01
2.64	0.00	-5.61	6.1	0.545E+04	5.02	2.51	.36970E+01
2.69	0.00	-5.61	6.2	0.541E+04	5.10	2.49	.37863E+01
2.73	0.00	-5.61	6.2	0.537E+04	5.19	2.48	.38762E+01
2.78	0.00	-5.61	6.3	0.534E+04	5.27	2.46	.39667E+01
2.82	0.00	-5.60	6.3	0.530E+04	5.36	2.45	.40579E+01
2.87	0.00	-5.60	6.4	0.527E+04	5.44	2.44	.41497E+01
2.91	0.00	-5.60	6.4	0.523E+04	5.53	2.43	.42422E+01
2.96	0.00	-5.60	6.4	0.520E+04	5.61	2.42	.43353E+01
3.00	0.00	-5.60	6.5	0.517E+04	5.70	2.40	.44291E+01
3.05	0.00	-5.60	6.5	0.513E+04	5.78	2.39	.45235E+01
3.09	0.00	-5.59	6.6	0.510E+04	5.87	2.38	.46185E+01
3.14	0.00	-5.59	6.6	0.507E+04	5.95	2.37	.47141E+01
3.18	0.00	-5.59	6.6	0.504E+04	6.04	2.36	.48103E+01
3.23	0.00	-5.59	6.7	0.501E+04	6.12	2.36	.49071E+01
3.27	0.00	-5.59	6.7	0.498E+04	6.21	2.35	.50046E+01
3.32	0.00	-5.59	6.8	0.495E+04	6.29	2.34	.51026E+01
3.36	0.00	-5.59	6.8	0.492E+04	6.38	2.33	.52012E+01
3.40	0.00	-5.58	6.8	0.490E+04	6.46	2.32	.53005E+01
3.45	0.00	-5.58	6.9	0.487E+04	6.55	2.32	.54003E+01
3.49	0.00	-5.58	6.9	0.484E+04	6.63	2.31	.55007E+01
3.54	0.00	-5.58	7.0	0.482E+04	6.72	2.31	.56016E+01
3.58	0.00	-5.58	7.0	0.479E+04	6.80	2.30	.57032E+01
3.63	0.00	-5.58	7.0	0.476E+04	6.89	2.29	.58053E+01
3.67	0.00	-5.57	7.1	0.474E+04	6.97	2.29	.59080E+01
3.72	0.00	-5.57	7.1	0.472E+04	7.06	2.28	.60113E+01
3.76	0.00	-5.57	7.1	0.469E+04	7.14	2.28	.61151E+01
3.81	0.00	-5.57	7.2	0.467E+04	7.23	2.28	.62195E+01

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-12

```
      3.85     0.00   -5.57     7.2 0.464E+04   7.31     2.27 .63244E+01
      3.90     0.00   -5.57     7.2 0.462E+04   7.40     2.27 .64299E+01
      3.94     0.00   -5.57     7.3 0.460E+04   7.48     2.27 .65359E+01
      3.99     0.00   -5.56     7.3 0.458E+04   7.57     2.26 .66425E+01
      4.03     0.00   -5.56     7.4 0.455E+04   7.65     2.26 .67496E+01
      4.08     0.00   -5.56     7.4 0.453E+04   7.74     2.26 .68573E+01
      4.12     0.00   -5.56     7.4 0.451E+04   7.82     2.26 .69655E+01
      4.17     0.00   -5.56     7.5 0.449E+04   7.91     2.25 .70742E+01
      4.21     0.00   -5.56     7.5 0.447E+04   7.99     2.25 .71835E+01
      4.26     0.00   -5.55     7.5 0.445E+04   8.08     2.25 .72933E+01
      4.30     0.00   -5.55     7.6 0.443E+04   8.16     2.25 .74036E+01
      4.35     0.00   -5.55     7.6 0.441E+04   8.25     2.25 .75145E+01
      4.39     0.00   -5.55     7.6 0.439E+04   8.33     2.25 .76258E+01
      4.44     0.00   -5.55     7.7 0.437E+04   8.42     2.25 .77377E+01
      4.48     0.00   -5.55     7.7 0.435E+04   8.50     2.25 .78501E+01
 Cumulative travel time =           7.8501 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
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BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.7 0.435E+04   8.50     2.52 .78501E+01
     13.21     0.00   -8.50     9.0 0.371E+04   8.50     3.46 .82348E+02
     21.94     0.00   -8.50    10.2 0.329E+04   8.50     4.40 .16787E+03
     30.66     0.00   -8.50    11.2 0.298E+04   8.50     5.34 .26314E+03
     39.39     0.00   -8.50    12.2 0.275E+04   8.50     6.28 .36725E+03
     48.12     0.00   -8.50    13.1 0.256E+04   8.50     7.21 .47951E+03
     56.85     0.00   -8.50    13.9 0.241E+04   8.50     8.15 .59935E+03
     65.58     0.00   -8.50    14.7 0.228E+04   8.50     9.08 .72633E+03
     74.30     0.00   -8.50    15.4 0.217E+04   8.50    10.02 .86007E+03
     83.03     0.00   -8.50    16.1 0.208E+04   8.50    10.95 .10002E+04
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     91.76     0.00   -8.50    16.8 0.199E+04   8.50    11.88 .11466E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    17.5 0.192E+04   8.50    12.81 .12988E+04
    109.22     0.00   -8.50    18.1 0.185E+04   8.50    13.74 .14567E+04
    117.94     0.00   -8.50    18.7 0.179E+04   8.50    14.67 .16200E+04
    126.67     0.00   -8.50    19.3 0.174E+04   8.50    15.60 .17887E+04
    135.40     0.00   -8.50    19.8 0.169E+04   8.50    16.53 .19626E+04
    144.13     0.00   -8.50    20.4 0.164E+04   8.50    17.46 .21414E+04
    152.86     0.00   -8.50    20.9 0.160E+04   8.50    18.38 .23250E+04
    161.58     0.00   -8.50    21.5 0.156E+04   8.50    19.31 .25135E+04
    170.31     0.00   -8.50    22.0 0.152E+04   8.50    20.24 .27065E+04
    179.04     0.00   -8.50    22.5 0.149E+04   8.50    21.16 .29040E+04
    187.77     0.00   -8.50    23.0 0.146E+04   8.50    22.08 .31060E+04
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-13

196.50	0.00	-8.50	23.5	0.143E+04	8.50	23.01	.33122E+04
205.22	0.00	-8.50	23.9	0.140E+04	8.50	23.93	.35227E+04
213.95	0.00	-8.50	24.4	0.137E+04	8.50	24.85	.37373E+04
222.68	0.00	-8.50	24.8	0.135E+04	8.50	25.77	.39560E+04
231.41	0.00	-8.50	25.3	0.132E+04	8.50	26.70	.41787E+04
240.14	0.00	-8.50	25.7	0.130E+04	8.50	27.62	.44053E+04
248.86	0.00	-8.50	26.2	0.128E+04	8.50	28.54	.46358E+04
257.59	0.00	-8.50	26.6	0.126E+04	8.50	29.46	.48700E+04
266.32	0.00	-8.50	27.0	0.124E+04	8.50	30.37	.51080E+04
275.05	0.00	-8.50	27.4	0.122E+04	8.50	31.29	.53496E+04
283.78	0.00	-8.50	27.8	0.120E+04	8.50	32.21	.55949E+04
292.50	0.00	-8.50	28.2	0.119E+04	8.50	33.13	.58437E+04
301.23	0.00	-8.50	28.6	0.117E+04	8.50	34.04	.60961E+04
309.96	0.00	-8.50	29.0	0.116E+04	8.50	34.96	.63519E+04
318.69	0.00	-8.50	29.4	0.114E+04	8.50	35.88	.66111E+04
327.42	0.00	-8.50	29.7	0.113E+04	8.50	36.79	.68737E+04
336.14	0.00	-8.50	30.1	0.111E+04	8.50	37.71	.71396E+04
344.87	0.00	-8.50	30.5	0.110E+04	8.50	38.62	.74089E+04
353.60	0.00	-8.50	30.8	0.109E+04	8.50	39.54	.76814E+04
362.33	0.00	-8.50	31.2	0.107E+04	8.50	40.45	.79570E+04
371.06	0.00	-8.50	31.6	0.106E+04	8.50	41.36	.82359E+04
379.78	0.00	-8.50	31.9	0.105E+04	8.50	42.28	.85179E+04
388.51	0.00	-8.50	32.3	0.104E+04	8.50	43.19	.88030E+04
397.24	0.00	-8.50	32.6	0.103E+04	8.50	44.10	.90912E+04
405.97	0.00	-8.50	32.9	0.102E+04	8.50	45.01	.93824E+04
414.70	0.00	-8.50	33.3	0.101E+04	8.50	45.92	.96767E+04
423.42	0.00	-8.50	33.6	0.996E+03	8.50	46.83	.99739E+04
432.15	0.00	-8.50	33.9	0.987E+03	8.50	47.74	.10274E+05
440.88	0.00	-8.50	34.3	0.977E+03	8.50	48.65	.10577E+05
449.61	0.00	-8.50	34.6	0.968E+03	8.50	49.56	.10883E+05
458.34	0.00	-8.50	34.9	0.959E+03	8.50	50.47	.11192E+05
467.06	0.00	-8.50	35.2	0.951E+03	8.50	51.38	.11504E+05
475.79	0.00	-8.50	35.6	0.942E+03	8.50	52.29	.11818E+05
484.52	0.00	-8.50	35.9	0.934E+03	8.50	53.20	.12135E+05
493.25	0.00	-8.50	36.2	0.926E+03	8.50	54.11	.12455E+05
501.98	0.00	-8.50	36.5	0.918E+03	8.50	55.01	.12778E+05
510.70	0.00	-8.50	36.8	0.911E+03	8.50	55.92	.13104E+05
519.43	0.00	-8.50	37.1	0.903E+03	8.50	56.83	.13432E+05
528.16	0.00	-8.50	37.4	0.896E+03	8.50	57.73	.13763E+05
536.89	0.00	-8.50	37.7	0.889E+03	8.50	58.64	.14096E+05
545.62	0.00	-8.50	38.0	0.882E+03	8.50	59.54	.14432E+05
554.34	0.00	-8.50	38.3	0.875E+03	8.50	60.45	.14771E+05
563.07	0.00	-8.50	38.6	0.869E+03	8.50	61.35	.15112E+05
571.80	0.00	-8.50	38.9	0.862E+03	8.50	62.26	.15456E+05
580.53	0.00	-8.50	39.1	0.856E+03	8.50	63.16	.15803E+05
589.26	0.00	-8.50	39.4	0.850E+03	8.50	64.07	.16152E+05
597.98	0.00	-8.50	39.7	0.844E+03	8.50	64.97	.16503E+05
606.71	0.00	-8.50	40.0	0.838E+03	8.50	65.87	.16857E+05
615.44	0.00	-8.50	40.3	0.832E+03	8.50	66.78	.17214E+05
624.17	0.00	-8.50	40.5	0.826E+03	8.50	67.68	.17573E+05
632.90	0.00	-8.50	40.8	0.821E+03	8.50	68.58	.17934E+05
641.62	0.00	-8.50	41.1	0.815E+03	8.50	69.48	.18298E+05
650.35	0.00	-8.50	41.4	0.810E+03	8.50	70.38	.18664E+05
659.08	0.00	-8.50	41.6	0.805E+03	8.50	71.28	.19033E+05
667.81	0.00	-8.50	41.9	0.800E+03	8.50	72.18	.19404E+05
676.54	0.00	-8.50	42.2	0.795E+03	8.50	73.08	.19777E+05
685.26	0.00	-8.50	42.4	0.790E+03	8.50	73.98	.20153E+05
693.99	0.00	-8.50	42.7	0.785E+03	8.50	74.88	.20531E+05
702.72	0.00	-8.50	42.9	0.780E+03	8.50	75.78	.20911E+05
711.45	0.00	-8.50	43.2	0.775E+03	8.50	76.68	.21294E+05
720.18	0.00	-8.50	43.5	0.771E+03	8.50	77.58	.21679E+05
728.90	0.00	-8.50	43.7	0.766E+03	8.50	78.48	.22066E+05
737.63	0.00	-8.50	44.0	0.762E+03	8.50	79.38	.22456E+05
746.36	0.00	-8.50	44.2	0.758E+03	8.50	80.28	.22847E+05
755.09	0.00	-8.50	44.5	0.753E+03	8.50	81.17	.23242E+05
763.82	0.00	-8.50	44.7	0.749E+03	8.50	82.07	.23638E+05
772.54	0.00	-8.50	45.0	0.745E+03	8.50	82.97	.24036E+05
781.27	0.00	-8.50	45.2	0.741E+03	8.50	83.87	.24437E+05
790.00	0.00	-8.50	45.5	0.737E+03	8.50	84.76	.24840E+05

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-14

```
    798.73     0.00   -8.50    45.7 0.733E+03   8.50    85.66 .25245E+05
    807.46     0.00   -8.50    46.0 0.729E+03   8.50    86.55 .25652E+05
    816.18     0.00   -8.50    46.2 0.725E+03   8.50    87.45 .26061E+05
    824.91     0.00   -8.50    46.4 0.721E+03   8.50    88.34 .26473E+05
    833.64     0.00   -8.50    46.7 0.718E+03   8.50    89.24 .26887E+05
    842.37     0.00   -8.50    46.9 0.714E+03   8.50    90.13 .27302E+05
    851.10     0.00   -8.50    47.2 0.710E+03   8.50    91.03 .27720E+05
    859.83     0.00   -8.50    47.4 0.707E+03   8.50    91.92 .28140E+05
    868.55     0.00   -8.50    47.6 0.703E+03   8.50    92.82 .28562E+05
    877.28     0.00   -8.50    47.9 0.700E+03   8.50    93.71 .28986E+05
 Cumulative travel time =       28986.3965 sec  (    8.05 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
D-CORMIX      End of Prediction File
DDDD
```

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = +0^0 C; Sheet D-15

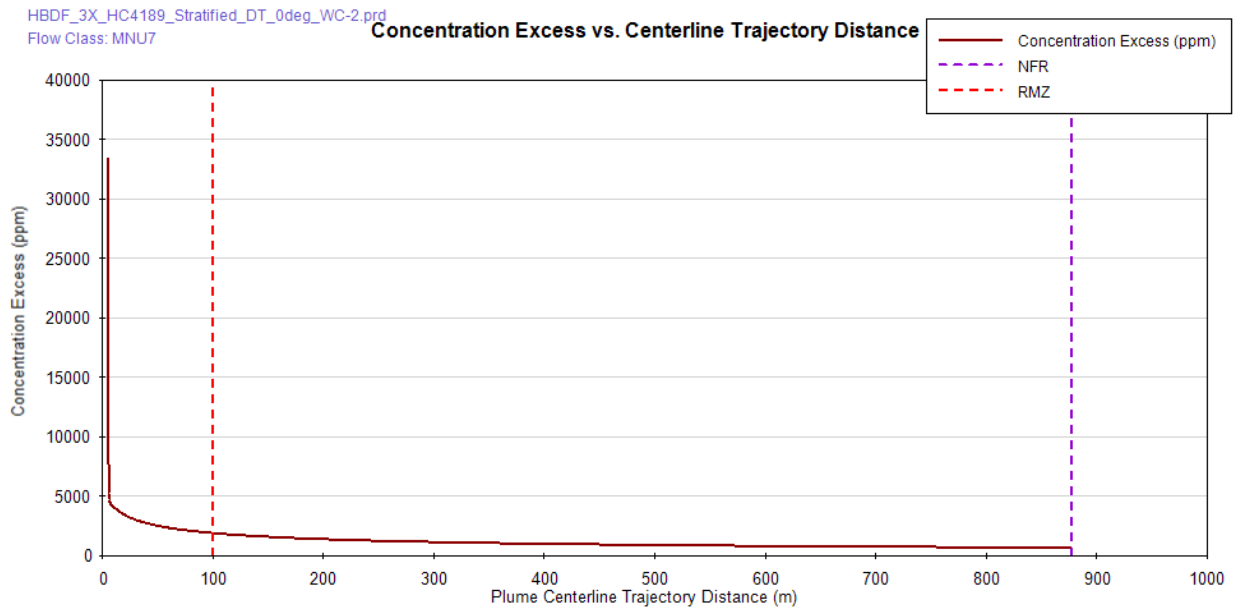


Figure D-5: Excess Salinity in ppm as a function of centerline trajectory distance for Worst-Case #2, ΔT = +0^0 C.

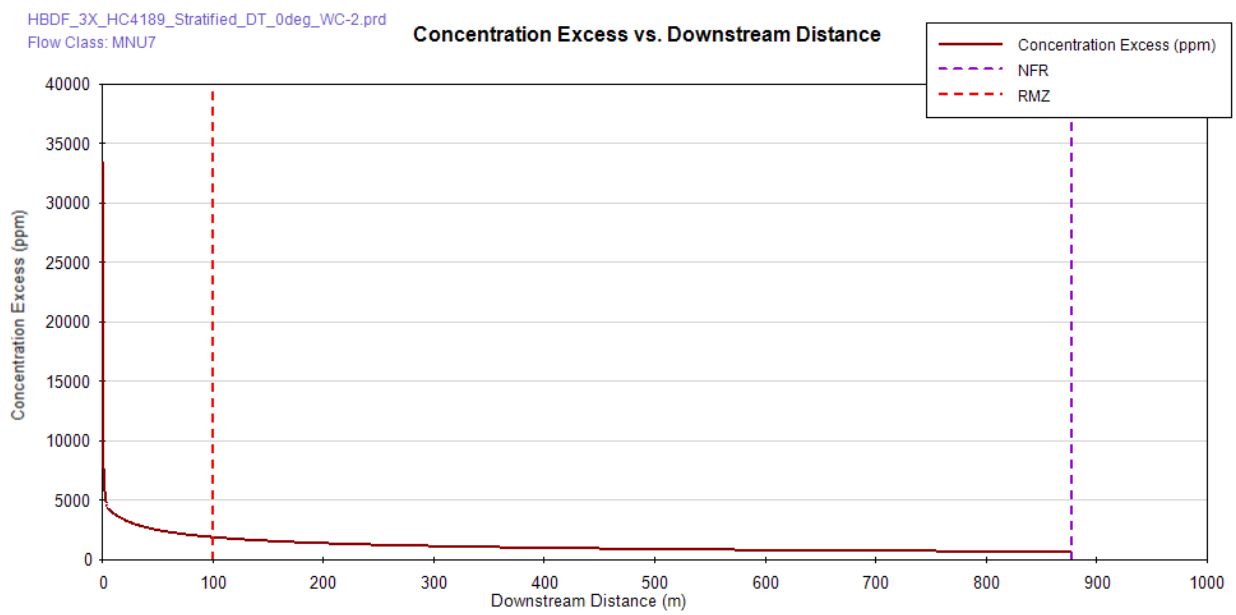


Figure D-6: Excess Salinity in ppm as a function of distance downstream for Worst-Case #2, ΔT = +0^0 C

Appendix-D: CORMIX 10.0.3.0 Prediction File for Worst-Case #2, ΔT = 0^0 C; Sheet D-8

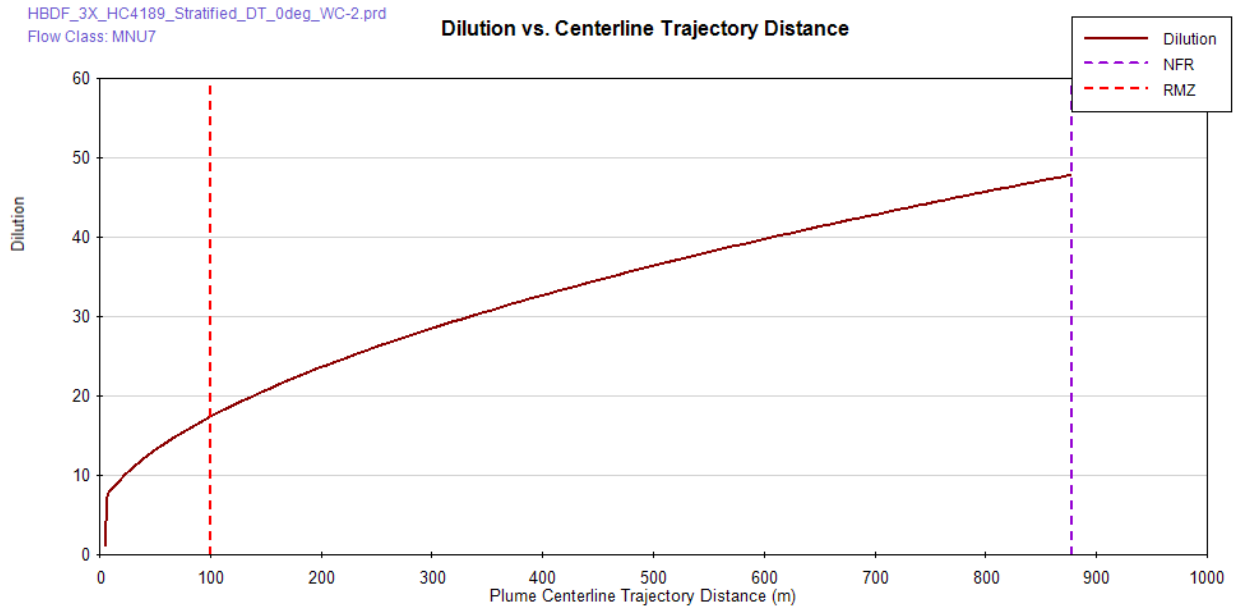


Figure D-7: Dilution expressed as mixing ratio, S**,** as a function of centerline trajectory distance for Worst-Case #2, ΔT = $+0^0$ C. Note S = 1 + Dm

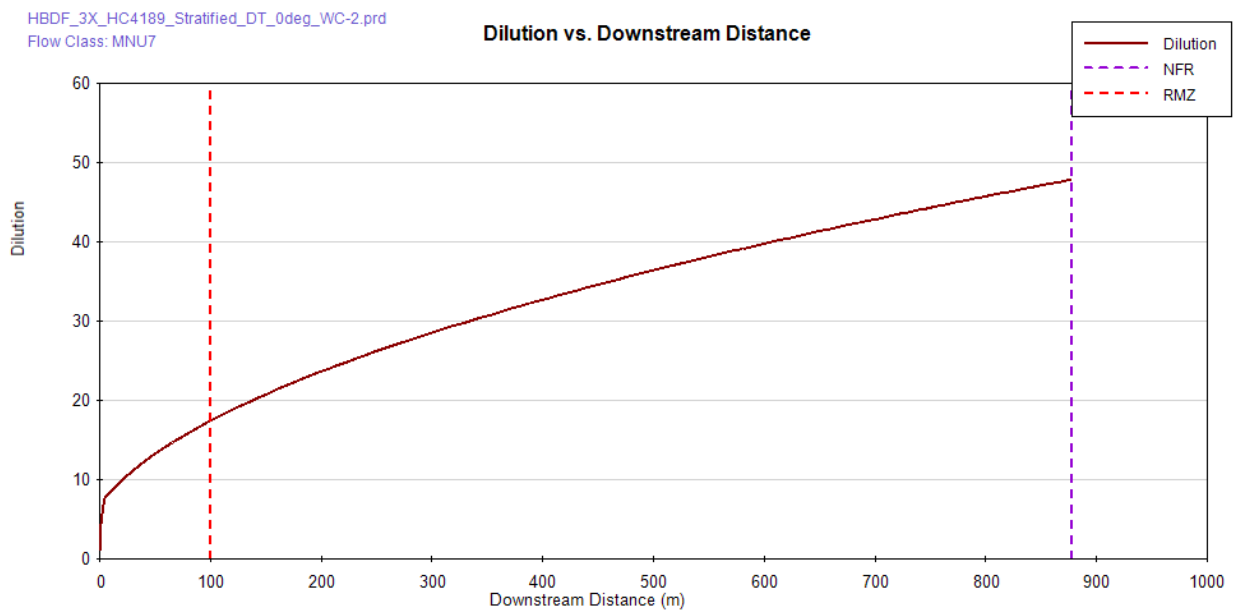
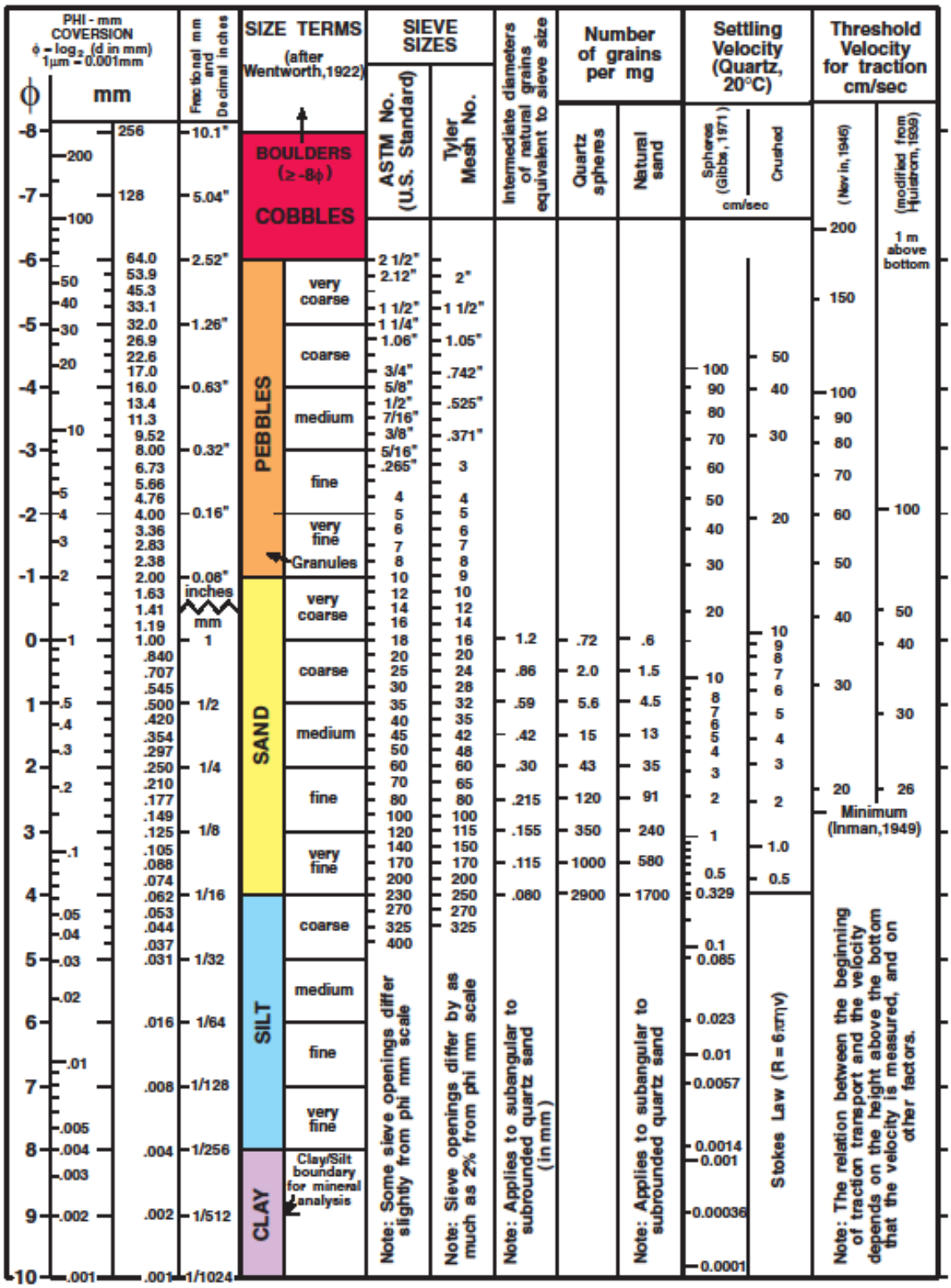


Figure D-8: Dilution expressed as mixing ratio, S**,** as a function of distance downstream for Worst-Case #2, ΔT = $+0^0$ C. Note S = 1 + Dm

APPENDIX- E: Wentworth grain size chart for converting grain size from phi units to mm.



Appendix-F: Response to Comments on Appendix KKKK from the Santa Ana Regional Water Quality Control Board, dated 9 June, 2017

Clarifications

Comment 1. The SLC's draft SEIR indicates that the depth of the diffuser is 33 ft at mean lower-low water level (section 4.0, 4.1.1.1, 8.1 and elsewhere). The dilution report states this depth is 27.9 ft. Please clarify the inconsistency between these two reports.

Response: p.42 of App C of the SEIR states that the discharge is 27.9 ft. below mean sea level…p 3 of the Appendix KKKK dilution report states the same.

Comment 2. Section 6 of the text states that the brine jet impacts the sea bed between 8.4 and 8.6 m from the discharge. However, the report also states that, for the scenario of 56.7 MGD at 63.1 ppt (likely operating scenario), the plume will impact the seafloor at 12 m from the point of discharge. Please clarify this inconsistency in estimates for the distance at which the brine jet impacts the sea bed.

Response: The Appendix KKKK report states in both Section 4 and in Section 6 that the horizontal distance from the point of discharge to the point where brine plume impacts the seabed is 8.4 to 8.6m The Appendix KKKK report states in Section 4 that the total length of the brine plume trajectory is 12m. The trajectory is a parabola that includes both the initial upward portion of the trajectory toward the sea surface plus the downward portion toward the seabed. Since the distance along the parabolic trajectory is greater than the straight line distance to the point of impact, there is no inconsistency.

Comment 3. The executive summary (and section 3.2) states that the background salinity is 33.52, while section 2.1 states the background salinity is 33.39. Staff believes this is a typographical error but request it be revised to be consistent throughout the report. Accordingly, the value of natural background salinity will determine the dilution factor Dm, so it is important the correct value be used.

Response: Staff is correct…33.39 ppt in the Appendix KKKK report was a typo, which has been corrected in the present report. We have verified that all the Dm curves in the Appendix KKKK report were based on natural background salinity in the receiving water equal to $S_0 = 33.52$ ppt

Comment 4. It is unclear which ambient profile was used in the model. It is unclear why the effluent temperature was set at delta 0 deg. C of ambient, when observed averages at the proxy facility ranged -0.7 to -0.4 deg. C. With specific knowledge of the input values, UM3 model sensitivity to this assumed value could be tested, relative to the observed temperatures (see comment 5).

Response: Cast #1 on 22 August 2002 was used because it was taken at the HBGS discharge tower. Cast #1 on 20 August 2002 was incomplete and did not have a salinity profile. Our understanding is that the delta-T at Poseidon's Carlsbad plant varies between +/- 1^0C

The *coefficient of thermal expansion* and is 2 x 10^{-4} per ^{o}C, so that a delta-T of -0.7 makes a change in density of only 0.014%. That is far beneath the ability of the UM3 model to resolve. Furthermore, the present study using CORMIX 10.0 finds no sensitivity to this range of delta-T.

Revisions

Comment 5. The model inputs/outputs were not provided (see section 3.7) and are required for the dilution study to be accepted.

Response: All model inputs and outputs for the present study are found in Appendices A-D.

Comment 6. The end of section 2.2 purports to address RCF 30, bullet 5, but does not clearly do so. It references four “peer-reviewed” papers, two of which are not included in the references. The other two papers cited deal with hypersonic cruise missiles and aerospace engineering. The information request in RCF 30 is specific to the FlowWorks model being applied to ocean discharges and any observational results that may be able to verify the use of this model. Please revise the report to explain how the references cited are relevant to RCF 30.

Response: the reference: Iaccarino, G, 2000, is very specific to diffusers. Its title is “Prediction of the turbulent flow in a diffuser with commercial CFD codes” *Center for Turbulence Research Annual Research Briefs 2000,* pp271-278*.* As far as the aerospace references, we point out that CFD was invented by the aerospace industry. We believe the next generation of mixing models will be CFD. In the present study, we are only using the CFD to predict bottom shear stresses for the sediment resuspension analysis. Both CORMIX 10.0 and Visual Plumes (UM3) do not predict bottom shear stresses. We also use CFD in the present report to corroborate the very near field predictions of CORMIX 10.0 that the plume is vertically well

Comment 7. Effluent Flow Rates: Both worst-case scenarios were based on anticipated annual average brine discharge rates. As defined in Section III.C.4.d of the Ocean Plan (2015), the minimum initial dilution is ”the lowest average initial dilution with any single month of the year”. This would suggest that a maximum average monthly effluent rate or higher would be more appropriate for estimating initial dilution. In addition, most toxic objectives in the Ocean Plan for protection of marine aquatic life have very short durations (i.e., instantaneous and daily maximums) more stringent than an annual average, suggesting use of an anticipated monthly average flow rate as a minimum and possible justification for use of anticipated maximum daily flows. In the existing 2012 permit, the plant’s maximum permitted discharge rate is 60.3 MGD.

Response: The present study evaluates absolute maximum discharge rates within the production capabilities of the proposed HBDF

Comment 8. A ZID of that size (~3300 meters) and associated toxics concentrations could present high risks of lethality to aquatic life, or risks of ecological distortions due to chronic effects, within the ZID. Figure 12 (pg 25) indicates that the ZID would dominate a large swath of coastal ocean waters and overlap with beaches all along the Huntington Beach shore. Section II.E.1 of the Ocean Plan prohibits the degradation of marine communities and may provide

justification for limiting the extent of the ZID. In addition, toxic plumes often have a repulsive effect on fish and other aquatic organisms. A ZID which causes mass migration of fish out of the area could potentially interfere commercial & sport fishing and other locally applicable beneficial uses.

Response: The ZID does not imply toxic levels…it is merely the zone where dilution induced by the momentum of the discharge is occurring, and in a quiescent ocean, brine dilution continues under the momentum flux of gravity. Regardless, the present study is based on the historic 1000 ft ZID applied to the HBGS in previous NPDES permit cycles.

Appendix-G: Communications with Mixzon, Inc., Resolution of Bug in CORMIX v10.0

-----Original Message-----
From: modeling@support.mixzon.com [mailto:modeling@support.mixzon.com]
Sent: Thursday, November 16, 2017 10:29 AM
To: Jenkins, Scott <Scott.Jenkins@mbakerintl.com>
Subject: [mixzon.com #15695] FW: support help ticket #15670: Revised clues on the MOD252 Bug

Dear Dr. Jenkins:

This is in response to your FIRST e-mail and case files that you sent to us yesterday, after our phone discussion.

1. We have fixed the Y-coordinate display bug in MOD252 in DHydro reported with your case files.

An updated DHydro executable can be downloaded from http://www.mixzon.com/public/rt-15695-ScottJenkins-DHydro-Bug-Fix/

Please download the file titled "DHydro.zip".

Navigate to the "System" sub-directory of your CORMIX v10.0 installation, usually at C:\Program Files (x86)\CORMIX 10.0\System\

Rename the existing "DHydro.exe" file to "DHydro.exe.old"

Extract the updated executable from the zip file you downloaded and copy it to the above System sub-directory.

You can now run CORMIX with the updated DHydro executable with the fix for Y-coordinate display bug in MOD252.

The prediction file will indicate the use of "DHYDRO Version 10.0.3.0 December 2017" at the beginning.

2. Please note on code review, in DHydro in MOD252: DIFFUSER INDUCED PLUME IN WEAK CROSS-FLOW, for your case - the final plume trajectory values are computed at module entry and then the output values are interpolated between the initial and final values.

The Y coordinate values at each step were being interpolated correctly, however only the final Y value was being output to the prediction file. This has now been corrected. Thank you for reporting this issue to us.

3. In the above URL, we also have a zip file called "rt-15695.zip".
These contain *.cmx, *.prd, *,ses and *.jrn files for both the case you sent to me - both before and after the bug fix.

Here are my notes regarding these cases:

A. File "HBDF_6X_0.2mDia_+2deg_No_Current_Normal_15Nov2017_v2" is specified with:

LD=26.88 NOPEN=6 SPAC=5.38 D0=0.200 and U0=14.527, UA=0

File does exhibit Y coordinate bug documented in RT #15670. This has now been fixed.

Values at RMZ=100 in MOD 252 in the fixed DHydro version are approximately as follows:
x=100.58 y=-1427.38 z=-8.75 Sc=103.2 BV=8.50 BH=156.83 TT=8.7 min

B. File "HBDF_20X_0.109mDia_+2deg_No_Current_Normal_15Nov2017" is specified with:
LD=89.60 NOPEN=20 SPAC=4.72 D0=0.110 and U0=14.528, UA=0

File does exhibit Y coordinate bug documented in RT #15670, This has now been fixed.

Values at RMZ=100 in MOD 252 the fixed DHydro version are approximately as follows:
x=99.78 y=-2052.25 z=-9.33 Sc=126.8 BV=8.50 BH=239.26 TT=15.8 min

C. Y coordinate display fix has been made.
S increase at 100m between two cases is likely due to increase in LD from 26.88 to 89.60m and NOT related to Y interpolation display bug in MOD 252.

D. For cases where you set UA=1 micron/s - CORMIX will automatically conclude this is a stagnant ambient and re-set UA = 0 m/s. This can be seen in the processing record where a message "AMBIENT IS STAGNANT" will be displayed based on the rule base conclusion, before hydro execution.

4. I have NOT yet had a look at your second e-mail and case files from yesterday. I will do this over the course of this week - if required.

5. I did talk to Dr. Doneker, this morning, briefly about your project. He said he had already contacted you with inputs and recommendations.

Hope this helps.

Regards,
-Adi
--
Adi S Ramachandran
Sr. Software/Systems & Modeling Engineer, MixZon Inc Suite 301, 1033 SW Yamhill St.
Portland, OR - 97205 USA
E-mail:adiram@mixzon.com
Ph: (503)-222-1022
Fx: (503)-296-2354

http://www.mixzon.com
http://www.cormix.info

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> On Wed Nov 15 14:12:09 2017, scott.jenkins@mbakerintl.com wrote:
> Hi Audi...attached is what I first sent to Robert this morning. It
> identifies the bug in MOD252 that causes a spurious Y-shift of the
> plume from a shore-parallel line source in zero ambient current.
> The Y-shift increases with increasing numbers of ports, and because
> dilution continues throughout the Y-shift, we get unrealistically
> rapid dilution with distance downstream along the x-axis. I hope these
> are helpful clues in debugging the problem.
> As I mentioned to Robert on Monday, I found a work around by giving
> the model a 1 micron/s ambient current to establish an x- axis
> reference frame, and I rotated the diffuser to a shore normal
> alignment to keep the RMZ downstream from the point of
> discharge...I'll send that result in the next e-mail much regards,
> scotty
>
> 9755 Clairmont Mesa Blvd. | San Diego, CA 92124 | [O] 858-614-5004
> scott.jenkins@mbakerintl.com<mailto:scott.jenkins@mbakerintl.com>
> www.mbakerintl.com<http://www.mbakerintl.com>
> [http://projects.mbakercorp.com/sigimg/MBI-email-sig-block-
72dpi.png]

Nature of the CORMIX v10.0 Bug

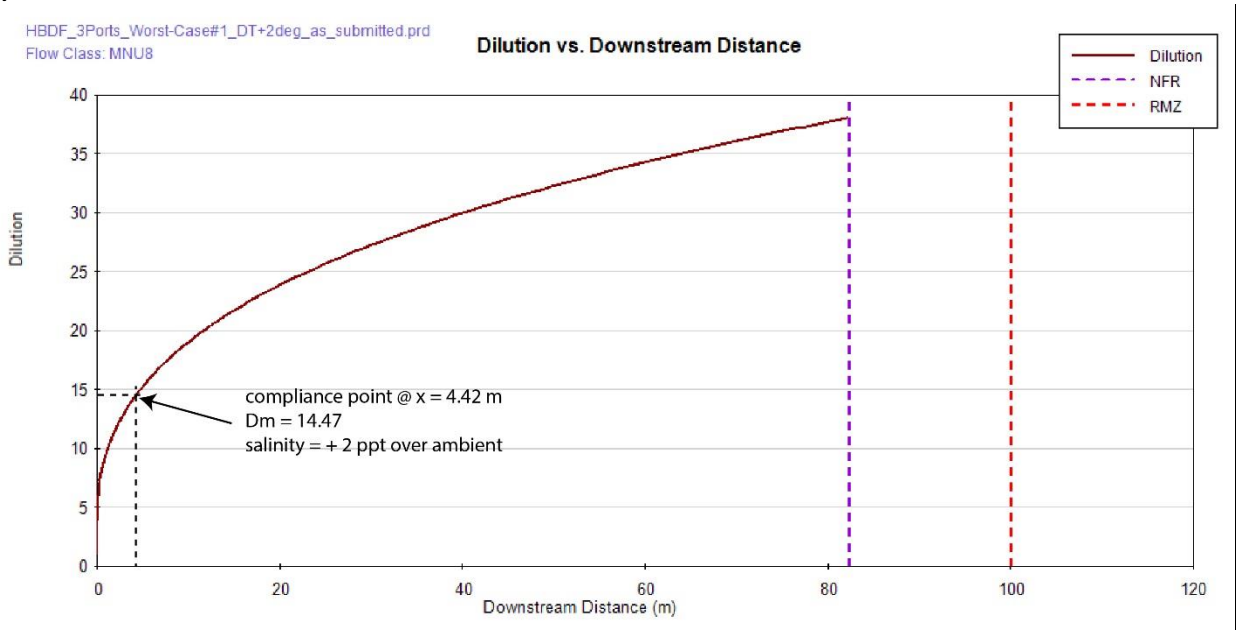
RE: Discussion Points for 20 November 2017Conference Call on CORMIX Bug

1) The California Ocean Plan requires that initial dilution analysis be performed with zero ambient currents in order to represent worst-case. Under these static receiving water conditions, spurious output from the latest CORMIX v10.0 model was recently discovered when the model was used to represent submerged diffuser discharges as line sources that are aligned parallel to the shoreline.
2) The symptoms of the spurious output include extremely rapid initial dilution across the first few meters from the point of discharge along the X-axis, (Figure 1a), concurrent with a large lateral shift in the discharge plume along the Y-axis (Figure 1b). In the case of the 3-port line source in Figure 1 (used to represent the brine diffuser for the Huntington Beach Desalination Project), dilution of 14.5 to 1 was achieved within only 4.4 m from the point of discharge (Figure 1a), while the plume shifted laterally 877 m along the Y-axis, (Figure 1b)
3) It was suggested the problem might be due to limitations in the CORMIX rule-based architecture to resolve line sources having only 3 discharge ports. However, the spurious model behavior persists for shore-parallel line sources with 6-ports (Figure 2a), and with 20 ports (Figure 2b), where the magnitude of the Y-shift increases with numbers of discharge ports, (Y-shift = 2624 m for 6 ports and 8,773 m for 20 ports). All three cases in Figures 1 & 2 involved the same total discharge (Q = 2.738 m^3/s) and shore parallel line sources with 4.48 m spacings between discharge ports.
4) Inspection of the prediction files for the examples in Figures 1 & 2 indicate that the Y-shift occurs during the transition from the Module 272 inner jet merging solutions to the Module 252 outer solutions after merging. During this transition, the model is calculating increasing dilution

with each meter of Y-shift. This gives rise to very steep initial dilution curves across the first few meters of distance downstream along from the discharges along the X-axis, (cf. Figure 1a).

5) This spurious behavior of CORMIX v10.0 was reported to Mixzon, Inc. on 7 November 2017. On 16 November 2017, Mixzon provided a new executable file for CORMIX v10.0 to correct the MOD252 bug and its associated Y-shift.

a)



b)

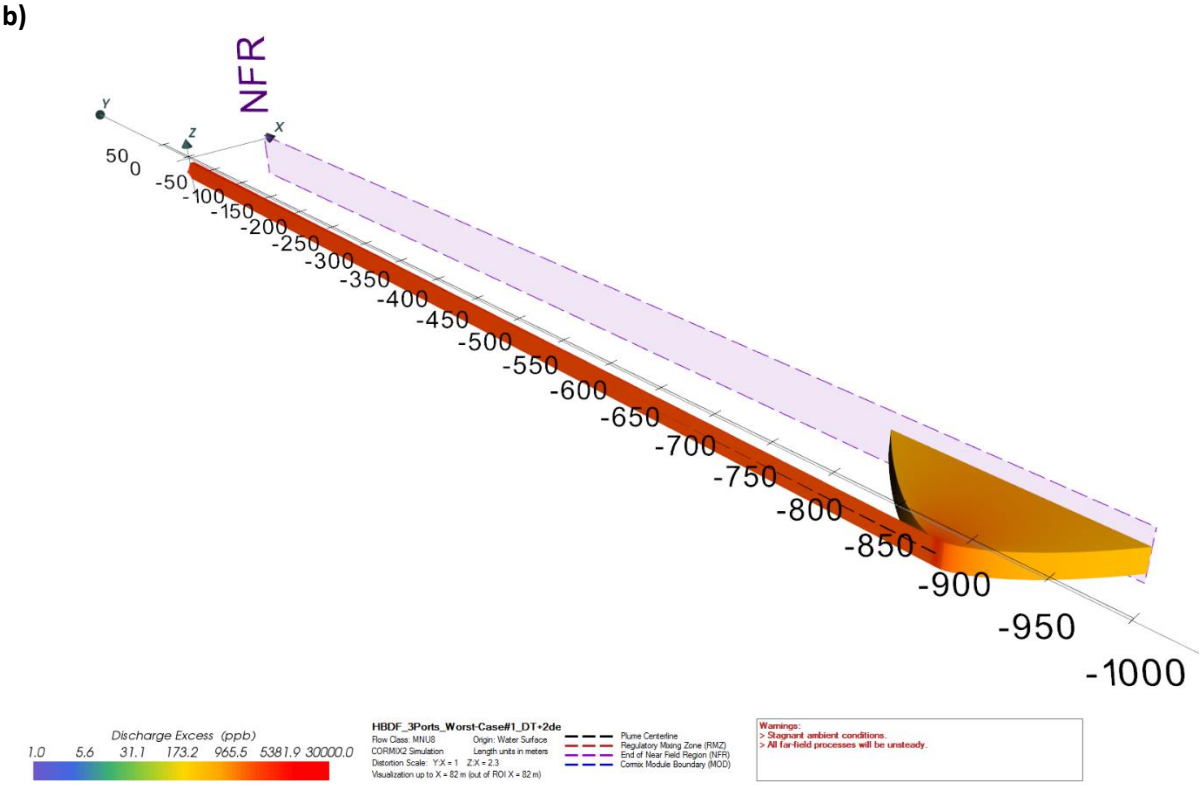
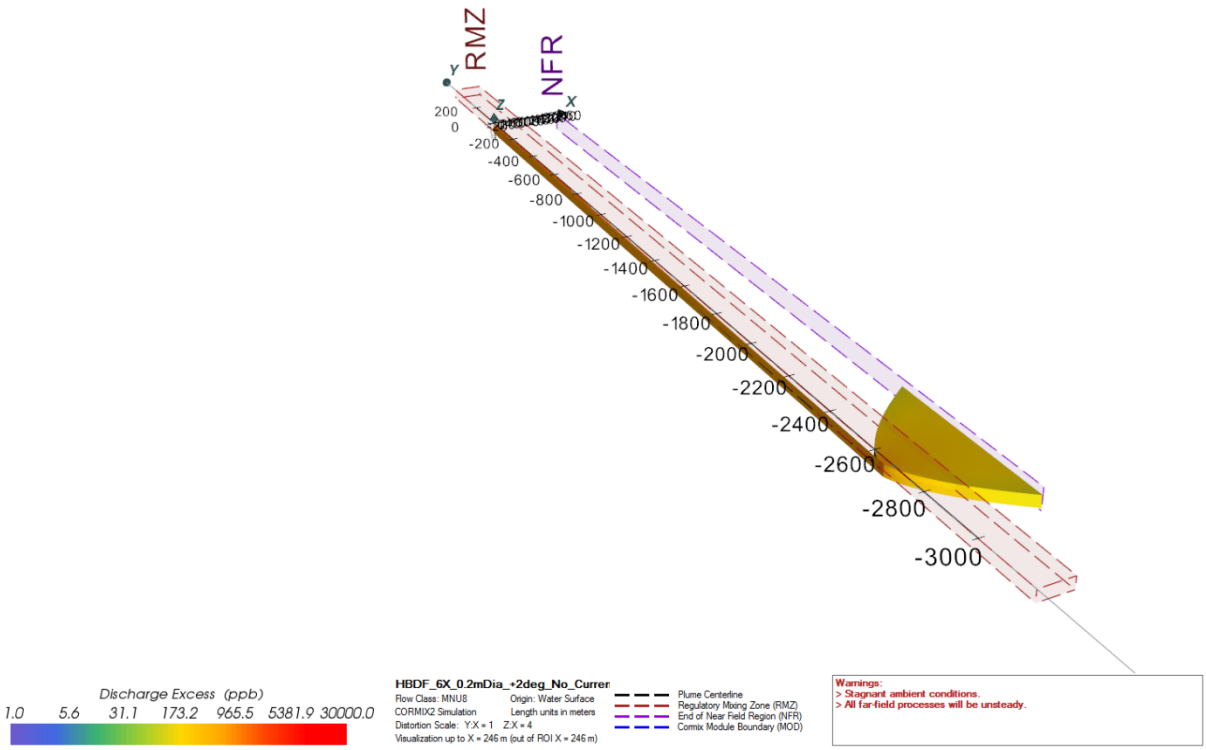


Figure G.1: a) Dilution results for the HBDF 3-port diffuser (modeled as a shore-parallel line source in zero ambient current), based on the CORMIX v10.0 bug. These results were contained in a report to the Santa Ana Regional Water Quality Control Board on 28 July 2017. **b)** Visualization of salinity over background for a the 3-port HBDF diffuser showing a Y-shift of 877 m in the plume due to the CORMIX v10.0 bug. Note the plume dilutes continuously throughout the Y-shift

a)



b)

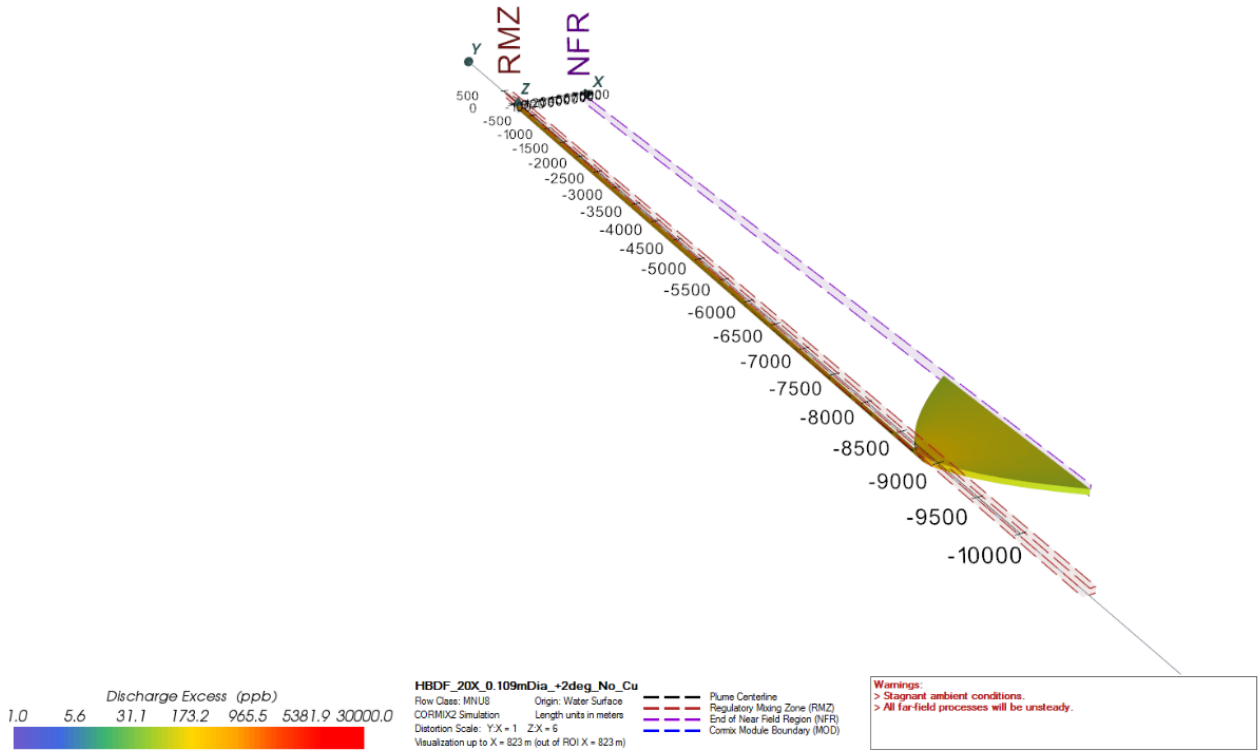


Figure G.2: Visualization of salinity over background based on the CORMIX v10.0 bug for: a) 6 port diffuser, and **b)** 20-port diffuser (both modeled as a shore-parallel line sources in zero ambient current).

Appendix-K: Technical Specifications of 36 in. TideFlex Duckbill Check Valve HC-4189

TIDEFLEX DIFFUSER (TFD) SYSTEM DATA ANALYSIS

MEDIA:		Effluent	
	Density or Spec. Gravity		lb/ft^3
		1	

FLOW RANGE:				
5	cfs	=	2244	gpm
28	cfs	=	12567	gpm
30.8	cfs	=	13824	gpm

AVAILABLE HEADLOSS@ DIFFUSER:	Minimum		feet
	Design		feet
	Maximum		feet

MAX. BACKPRESSURE:		feet

TFD SIZE (IN)	HYDRAULIC CODE
36	**4189**

DATE:	22-Nov-2017
CLIENT:	Poseidon Water
CONTACT:	
ENGINEER:	Michael Baker International
CONTACT:	Scott A. Jenkins, Ph.D.
PROJECT:	Huntingon Beach Desalination Outfall Diffuser
REP:	Crump & Co.
CONTACT:	Steve Crump

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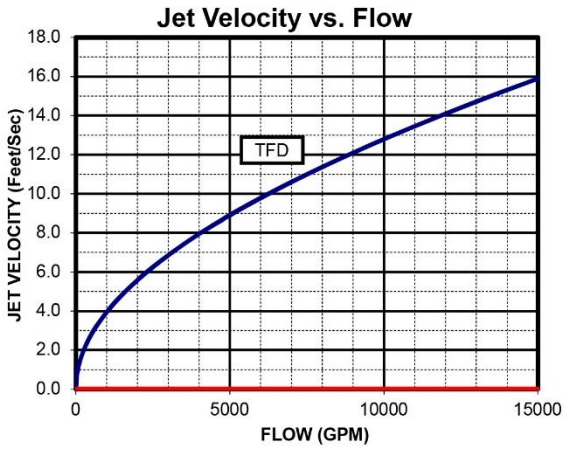
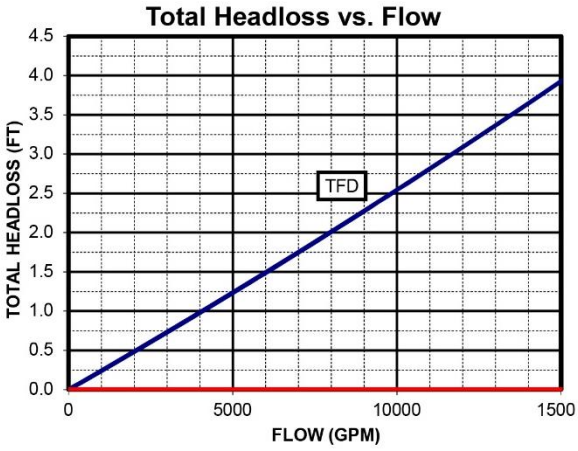
		PER TIDEFLEX DIFFUSER (TFD)			
*** TOTAL QUANTITY**	TOTAL FLOW (gpm)	FLOW (gpm)	**JET VELOCITY (fps)**	**HEADLOSS (feet)**	EFFECTIVE AREA (in^2)
1	2244.2	2244.2	5.9	0.5	121.7
	12567.3	12567.3	14.4	3.2	278.9
	13824.0	13824.0	15.2	3.6	291.4





TIDEFLEX TECHNOLOGIES, 600 NORTH BELL AVE., CARNEGIE, PA 15106, (412) 279-0044 phone (412) 279-5410 fax

From: Duer, Mike [mailto:MDUER@redvalve.com]
Sent: Wednesday, November 22, 2017 4:08 AM
To: Jenkins, Scott <Scott.Jenkins@mbakerintl.com>
Cc: Mitchell, Chris <cmitchell@redvalve.com>; Purvis, David <dpurvis@redvalve.com>; Stephen Crump <crumpco@pacbell.net>
Subject: RE: Huntington Beach Desalination Outfall Diffuser - Poseidon Water, CA

Scott,

Attached is a hydraulic analysis for (1) 36" Tideflex Diffuser Hydraulic Code (HC) 4189. If you are not familiar we can manufacture up to 50 different hydraulic variations of Tideflex Diffusers by changing geometry and relative stiffness. See attached paper presented at the 2016 IAHR-IWA conference entitled "Duckbill Nozzle Knowledge Base for Inland and Marine Outfall Diffuser Designers and Modelers". The geometry and stiffness of the 36" HC 4189 has a 279 in^2 (1.94 ft^2) effective open area at 28 cfs.

The flanged version is a Series 35D. I have attached a drawing (Autocad and pdf) and a specification.

You mentioned the 35D will be connecting to a riser pipe. If there is a concern with damage to the riser(s) from anchors, nets, etc., we can manufacture Tideflex Diffusers with integral wire-reinforced rubber risers and/or elbows. See page 6 of the attached paper. We can provide a drawing and spec upon request but would need to know more about the physical design.

Please review and let me know if you have questions or need anything else.

Thanks,

Mike Duer, P.E.
Red Valve Company, Inc.
Tideflex Technologies Division
600 North Bell Avenue
Carnegie, PA 15106
Tel: (412) 279-0044 x233
Fax: (412) 279-7878
mduer@tideflex.com
www.tideflex.com

Appendix-L: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet L-1

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\0deg Delta-T\3-Port Duckbill Worst-Case #1\Worst-case#1 Monthly 29Nov2017\HBDF 3X
HC4189 Stratified DT 0deg WC-1 monthly.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/29/2017--12:15:51
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                           = unbounded
  Average depth                   HA      = 8.5 m
  Depth at discharge              HD      = 8.5m
  Bottom slope (single slope only)SLOPE   = 1.06 deg
  Ambient velocity                UA      = 0.0000 m/s
  Darcy-Weisbach friction factor  F       = 0.02
  Wind velocity                   UW      = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                 RHOAS   = 1022 kg/m^3
  Level 1 Submergence             LEVEL1  = 8.5 m
  Density at Level 1              RHOA1   = 1023.47 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE  = unidirectional perpendicular
  Diffuser length                 LD      = 8.96 m
  Nearest bank                            = left
  Diffuser endpoints              YB1     = 457 m;    YB2 = 465.96 m
  Number of openings              NOPEN   = 3
  Number of Risers                NRISER  = 3
  Ports/Nozzles per Riser         NPPERR   = 1
  Spacing between risers/openings SPAC    = 4.48 m
  Port/Nozzle diameter            D0      = 0.484 m
    with contraction ratio                = 1
  Equivalent slot width           B0      = 0.0411 m
  Total area of openings          TA0     = 0.5520 m^2
  Discharge velocity              U0      = 4.50 m/s
  Total discharge flowrate        Q0      = 2.484176 m^3/s
  Discharge port height           H0      = 2.8 m
  Nozzle arrangement              BETYPE  = unidirectional with fanning
  Diffuser alignment angle        GAMMA   = 90 deg
  Vertical discharge angle        THETA   = 47 deg
  Actual Vertical discharge angle THEAC   = 47 deg
  Horizontal discharge angle      SIGMA   = 0 deg
  Relative orientation angle      BETA    = 90 deg
  Discharge density               RHO0    = 1047.4000 kg/m^3
  Density difference              DRHO    = -24.6650 kg/m^3
  Buoyant acceleration            GP0     = -0.2365 m/s^2
  Discharge concentration         C0      = 29600 ppm
  Surface heat exchange coeff.    KS      = 0 m/s
  Coefficient of decay            KD      = 0 /s
------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0      = 0.277252 m^2/s
  Momentum flux                   m0      = 1.247828 m^3/s^2
  Buoyancy flux                   j0      = -0.195839 m^3/s^3
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 3.70 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
```

Appendix-L: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet L-2

```
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 45.67
  Port/nozzle Froude number       FRD0   = 13.30
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 626.279300 ppm
  Dilution at edge of NFR              s = 47.3
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       27952.8633 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-L: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet L-3

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1720.719604  ppm
  Corresponding dilution               s = 17.2
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 27952.8633 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 14.8
  Plume location:                      x = 69.30 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 9.48 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************** FINAL DESIGN ADVICE AND COMMENTS *********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-1

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D-CORMIX PREDICTION FILE:
DDDD
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Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-2

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 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.2960E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.296E+05   0.03     4.48     4.501   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.296E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.7 0.178E+05   0.08     4.41 .16529E-01
      0.09     0.00   -5.70     1.9 0.153E+05   0.17     4.35 .38504E-01
      0.13     0.00   -5.70     2.1 0.138E+05   0.25     4.29 .64026E-01
      0.18     0.00   -5.69     2.3 0.128E+05   0.34     4.23 .92414E-01
      0.22     0.00   -5.69     2.5 0.120E+05   0.42     4.17 .12328E+00
      0.27     0.00   -5.69     2.6 0.113E+05   0.51     4.11 .15635E+00
      0.31     0.00   -5.69     2.7 0.108E+05   0.60     4.06 .19145E+00
      0.36     0.00   -5.69     2.9 0.103E+05   0.68     4.00 .22840E+00
      0.40     0.00   -5.69     3.0 0.993E+04   0.76     3.95 .26711E+00
      0.45     0.00   -5.68     3.1 0.958E+04   0.85     3.90 .30745E+00
      0.49     0.00   -5.68     3.2 0.928E+04   0.93     3.85 .34936E+00
      0.54     0.00   -5.68     3.3 0.900E+04   1.02     3.80 .39276E+00
```

Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-3

0.58	0.00	-5.68	3.4	0.875E+04	1.10	3.76	.43758E+00
0.63	0.00	-5.68	3.5	0.853E+04	1.19	3.71	.48376E+00
0.67	0.00	-5.68	3.6	0.832E+04	1.27	3.67	.53127E+00
0.72	0.00	-5.68	3.6	0.813E+04	1.36	3.62	.58005E+00
0.76	0.00	-5.67	3.7	0.795E+04	1.44	3.58	.63006E+00
0.81	0.00	-5.67	3.8	0.778E+04	1.53	3.54	.68127E+00
0.85	0.00	-5.67	3.9	0.763E+04	1.61	3.50	.73364E+00
0.90	0.00	-5.67	4.0	0.749E+04	1.70	3.46	.78715E+00
0.94	0.00	-5.67	4.0	0.735E+04	1.78	3.43	.84175E+00
0.99	0.00	-5.67	4.1	0.722E+04	1.87	3.39	.89744E+00
1.03	0.00	-5.66	4.2	0.710E+04	1.95	3.35	.95417E+00
1.08	0.00	-5.66	4.2	0.699E+04	2.04	3.32	.10119E+01
1.12	0.00	-5.66	4.3	0.688E+04	2.12	3.29	.10707E+01
1.16	0.00	-5.66	4.4	0.678E+04	2.21	3.25	.11305E+01
1.21	0.00	-5.66	4.4	0.668E+04	2.30	3.22	.11912E+01
1.25	0.00	-5.66	4.5	0.658E+04	2.38	3.19	.12528E+01
1.30	0.00	-5.66	4.6	0.650E+04	2.47	3.16	.13155E+01
1.34	0.00	-5.65	4.6	0.641E+04	2.55	3.13	.13790E+01
1.39	0.00	-5.65	4.7	0.633E+04	2.64	3.10	.14434E+01
1.43	0.00	-5.65	4.7	0.625E+04	2.72	3.07	.15087E+01
1.48	0.00	-5.65	4.8	0.617E+04	2.81	3.04	.15749E+01
1.52	0.00	-5.65	4.9	0.610E+04	2.89	3.02	.16419E+01
1.57	0.00	-5.65	4.9	0.603E+04	2.98	2.99	.17098E+01
1.61	0.00	-5.64	5.0	0.596E+04	3.06	2.96	.17785E+01
1.66	0.00	-5.64	5.0	0.590E+04	3.15	2.94	.18480E+01
1.70	0.00	-5.64	5.1	0.584E+04	3.23	2.91	.19184E+01
1.75	0.00	-5.64	5.1	0.578E+04	3.32	2.89	.19895E+01
1.79	0.00	-5.64	5.2	0.572E+04	3.40	2.86	.20615E+01
1.84	0.00	-5.64	5.2	0.566E+04	3.49	2.84	.21342E+01
1.88	0.00	-5.64	5.3	0.561E+04	3.57	2.82	.22077E+01
1.93	0.00	-5.63	5.3	0.555E+04	3.66	2.80	.22819E+01
1.97	0.00	-5.63	5.4	0.550E+04	3.74	2.77	.23569E+01
2.02	0.00	-5.63	5.4	0.545E+04	3.83	2.75	.24327E+01
2.06	0.00	-5.63	5.5	0.540E+04	3.91	2.73	.25091E+01
2.11	0.00	-5.63	5.5	0.535E+04	4.00	2.71	.25863E+01
2.15	0.00	-5.63	5.6	0.531E+04	4.08	2.69	.26643E+01
2.20	0.00	-5.63	5.6	0.526E+04	4.17	2.67	.27429E+01
2.24	0.00	-5.62	5.7	0.522E+04	4.25	2.65	.28222E+01
2.28	0.00	-5.62	5.7	0.518E+04	4.34	2.64	.29023E+01
2.33	0.00	-5.62	5.8	0.514E+04	4.42	2.62	.29830E+01
2.37	0.00	-5.62	5.8	0.510E+04	4.51	2.60	.30644E+01
2.42	0.00	-5.62	5.9	0.506E+04	4.59	2.58	.31465E+01
2.46	0.00	-5.62	5.9	0.502E+04	4.68	2.57	.32293E+01
2.51	0.00	-5.61	5.9	0.498E+04	4.76	2.55	.33127E+01
2.55	0.00	-5.61	6.0	0.494E+04	4.85	2.54	.33968E+01
2.60	0.00	-5.61	6.0	0.491E+04	4.93	2.52	.34815E+01
2.64	0.00	-5.61	6.1	0.487E+04	5.02	2.51	.35669E+01
2.69	0.00	-5.61	6.1	0.484E+04	5.10	2.49	.36529E+01
2.73	0.00	-5.61	6.2	0.481E+04	5.19	2.48	.37396E+01
2.78	0.00	-5.61	6.2	0.477E+04	5.27	2.46	.38269E+01
2.82	0.00	-5.60	6.2	0.474E+04	5.36	2.45	.39148E+01
2.87	0.00	-5.60	6.3	0.471E+04	5.44	2.44	.40034E+01
2.91	0.00	-5.60	6.3	0.468E+04	5.53	2.43	.40925E+01
2.96	0.00	-5.60	6.4	0.465E+04	5.61	2.42	.41823E+01
3.00	0.00	-5.60	6.4	0.462E+04	5.70	2.40	.42727E+01
3.05	0.00	-5.60	6.4	0.459E+04	5.78	2.39	.43636E+01
3.09	0.00	-5.59	6.5	0.456E+04	5.87	2.38	.44552E+01
3.14	0.00	-5.59	6.5	0.454E+04	5.95	2.37	.45474E+01
3.18	0.00	-5.59	6.6	0.451E+04	6.04	2.36	.46402E+01
3.23	0.00	-5.59	6.6	0.448E+04	6.12	2.36	.47335E+01
3.27	0.00	-5.59	6.6	0.446E+04	6.21	2.35	.48274E+01
3.32	0.00	-5.59	6.7	0.443E+04	6.29	2.34	.49219E+01
3.36	0.00	-5.59	6.7	0.440E+04	6.38	2.33	.50170E+01
3.40	0.00	-5.58	6.8	0.438E+04	6.46	2.32	.51127E+01
3.45	0.00	-5.58	6.8	0.436E+04	6.55	2.32	.52089E+01
3.49	0.00	-5.58	6.8	0.433E+04	6.63	2.31	.53056E+01
3.54	0.00	-5.58	6.9	0.431E+04	6.72	2.31	.54030E+01

Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-4

```
      3.58     0.00   -5.58     6.9 0.428E+04   6.80     2.30 .55009E+01
      3.63     0.00   -5.58     6.9 0.426E+04   6.89     2.29 .55993E+01
      3.67     0.00   -5.57     7.0 0.424E+04   6.97     2.29 .56983E+01
      3.72     0.00   -5.57     7.0 0.422E+04   7.06     2.28 .57978E+01
      3.76     0.00   -5.57     7.1 0.420E+04   7.14     2.28 .58979E+01
      3.81     0.00   -5.57     7.1 0.418E+04   7.23     2.28 .59985E+01
      3.85     0.00   -5.57     7.1 0.415E+04   7.31     2.27 .60997E+01
      3.90     0.00   -5.57     7.2 0.413E+04   7.40     2.27 .62013E+01
      3.94     0.00   -5.57     7.2 0.411E+04   7.48     2.27 .63035E+01
      3.99     0.00   -5.56     7.2 0.409E+04   7.57     2.26 .64063E+01
      4.03     0.00   -5.56     7.3 0.407E+04   7.65     2.26 .65095E+01
      4.08     0.00   -5.56     7.3 0.405E+04   7.74     2.26 .66133E+01
      4.12     0.00   -5.56     7.3 0.404E+04   7.82     2.26 .67176E+01
      4.17     0.00   -5.56     7.4 0.402E+04   7.91     2.25 .68224E+01
      4.21     0.00   -5.56     7.4 0.400E+04   7.99     2.25 .69277E+01
      4.26     0.00   -5.55     7.4 0.398E+04   8.08     2.25 .70335E+01
      4.30     0.00   -5.55     7.5 0.396E+04   8.16     2.25 .71399E+01
      4.35     0.00   -5.55     7.5 0.394E+04   8.25     2.25 .72467E+01
      4.39     0.00   -5.55     7.5 0.393E+04   8.33     2.25 .73540E+01
      4.44     0.00   -5.55     7.6 0.391E+04   8.42     2.25 .74619E+01
      4.48     0.00   -5.55     7.6 0.389E+04   8.50     2.25 .75702E+01
 Cumulative travel time =           7.5702 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.6 0.389E+04   8.50     2.52 .75702E+01
     13.21     0.00   -8.50     8.9 0.332E+04   8.50     3.46 .79412E+02
     21.94     0.00   -8.50    10.1 0.294E+04   8.50     4.40 .16188E+03
     30.66     0.00   -8.50    11.1 0.267E+04   8.50     5.34 .25376E+03
     39.39     0.00   -8.50    12.0 0.246E+04   8.50     6.28 .35416E+03
     48.12     0.00   -8.50    12.9 0.229E+04   8.50     7.21 .46241E+03
     56.85     0.00   -8.50    13.7 0.216E+04   8.50     8.15 .57798E+03
     65.58     0.00   -8.50    14.5 0.204E+04   8.50     9.08 .70043E+03
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     74.30     0.00   -8.50    15.2 0.194E+04   8.50    10.02 .82940E+03
     83.03     0.00   -8.50    15.9 0.186E+04   8.50    10.95 .96457E+03
     91.76     0.00   -8.50    16.6 0.178E+04   8.50    11.88 .11057E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    17.2 0.172E+04   8.50    12.81 .12525E+04
    109.22     0.00   -8.50    17.9 0.166E+04   8.50    13.74 .14047E+04
    117.94     0.00   -8.50    18.5 0.160E+04   8.50    14.67 .15623E+04
```

Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-5

126.67	0.00	-8.50	19.0	0.155E+04	8.50	15.60	.17249E+04
135.40	0.00	-8.50	19.6	0.151E+04	8.50	16.53	.18926E+04
144.13	0.00	-8.50	20.1	0.147E+04	8.50	17.46	.20650E+04
152.86	0.00	-8.50	20.7	0.143E+04	8.50	18.38	.22421E+04
161.58	0.00	-8.50	21.2	0.140E+04	8.50	19.31	.24238E+04
170.31	0.00	-8.50	21.7	0.136E+04	8.50	20.24	.26100E+04
179.04	0.00	-8.50	22.2	0.133E+04	8.50	21.16	.28005E+04
187.77	0.00	-8.50	22.7	0.130E+04	8.50	22.08	.29952E+04
196.50	0.00	-8.50	23.2	0.128E+04	8.50	23.01	.31941E+04
205.22	0.00	-8.50	23.6	0.125E+04	8.50	23.93	.33971E+04
213.95	0.00	-8.50	24.1	0.123E+04	8.50	24.85	.36041E+04
222.68	0.00	-8.50	24.5	0.121E+04	8.50	25.77	.38150E+04
231.41	0.00	-8.50	25.0	0.119E+04	8.50	26.70	.40297E+04
240.14	0.00	-8.50	25.4	0.117E+04	8.50	27.62	.42482E+04
248.86	0.00	-8.50	25.8	0.115E+04	8.50	28.54	.44705E+04
257.59	0.00	-8.50	26.2	0.113E+04	8.50	29.46	.46964E+04
266.32	0.00	-8.50	26.7	0.111E+04	8.50	30.37	.49259E+04
275.05	0.00	-8.50	27.1	0.109E+04	8.50	31.29	.51589E+04
283.78	0.00	-8.50	27.5	0.108E+04	8.50	32.21	.53954E+04
292.50	0.00	-8.50	27.9	0.106E+04	8.50	33.13	.56354E+04
301.23	0.00	-8.50	28.2	0.105E+04	8.50	34.04	.58787E+04
309.96	0.00	-8.50	28.6	0.103E+04	8.50	34.96	.61254E+04
318.69	0.00	-8.50	29.0	0.102E+04	8.50	35.88	.63754E+04
327.42	0.00	-8.50	29.4	0.101E+04	8.50	36.79	.66286E+04
336.14	0.00	-8.50	29.7	0.995E+03	8.50	37.71	.68851E+04
344.87	0.00	-8.50	30.1	0.983E+03	8.50	38.62	.71447E+04
353.60	0.00	-8.50	30.5	0.972E+03	8.50	39.54	.74075E+04
362.33	0.00	-8.50	30.8	0.960E+03	8.50	40.45	.76733E+04
371.06	0.00	-8.50	31.2	0.950E+03	8.50	41.36	.79422E+04
379.78	0.00	-8.50	31.5	0.939E+03	8.50	42.28	.82142E+04
388.51	0.00	-8.50	31.9	0.929E+03	8.50	43.19	.84891E+04
397.24	0.00	-8.50	32.2	0.919E+03	8.50	44.10	.87670E+04
405.97	0.00	-8.50	32.5	0.910E+03	8.50	45.01	.90479E+04
414.70	0.00	-8.50	32.9	0.900E+03	8.50	45.92	.93316E+04
423.42	0.00	-8.50	33.2	0.892E+03	8.50	46.83	.96182E+04
432.15	0.00	-8.50	33.5	0.883E+03	8.50	47.74	.99077E+04
440.88	0.00	-8.50	33.9	0.874E+03	8.50	48.65	.10200E+05
449.61	0.00	-8.50	34.2	0.866E+03	8.50	49.56	.10495E+05
458.34	0.00	-8.50	34.5	0.858E+03	8.50	50.47	.10793E+05
467.06	0.00	-8.50	34.8	0.851E+03	8.50	51.38	.11093E+05
475.79	0.00	-8.50	35.1	0.843E+03	8.50	52.29	.11397E+05
484.52	0.00	-8.50	35.4	0.836E+03	8.50	53.20	.11703E+05
493.25	0.00	-8.50	35.7	0.829E+03	8.50	54.11	.12011E+05
501.98	0.00	-8.50	36.0	0.822E+03	8.50	55.01	.12322E+05
510.70	0.00	-8.50	36.3	0.815E+03	8.50	55.92	.12636E+05
519.43	0.00	-8.50	36.6	0.808E+03	8.50	56.83	.12953E+05
528.16	0.00	-8.50	36.9	0.802E+03	8.50	57.73	.13272E+05
536.89	0.00	-8.50	37.2	0.795E+03	8.50	58.64	.13594E+05
545.62	0.00	-8.50	37.5	0.789E+03	8.50	59.54	.13918E+05
554.34	0.00	-8.50	37.8	0.783E+03	8.50	60.45	.14244E+05
563.07	0.00	-8.50	38.1	0.777E+03	8.50	61.35	.14574E+05
571.80	0.00	-8.50	38.4	0.771E+03	8.50	62.26	.14905E+05
580.53	0.00	-8.50	38.7	0.766E+03	8.50	63.16	.15239E+05
589.26	0.00	-8.50	38.9	0.760E+03	8.50	64.07	.15576E+05
597.98	0.00	-8.50	39.2	0.755E+03	8.50	64.97	.15915E+05
606.71	0.00	-8.50	39.5	0.750E+03	8.50	65.87	.16256E+05
615.44	0.00	-8.50	39.8	0.744E+03	8.50	66.78	.16600E+05
624.17	0.00	-8.50	40.0	0.739E+03	8.50	67.68	.16946E+05
632.90	0.00	-8.50	40.3	0.734E+03	8.50	68.58	.17295E+05
641.62	0.00	-8.50	40.6	0.730E+03	8.50	69.48	.17645E+05
650.35	0.00	-8.50	40.8	0.725E+03	8.50	70.38	.17999E+05
659.08	0.00	-8.50	41.1	0.720E+03	8.50	71.28	.18354E+05
667.81	0.00	-8.50	41.4	0.715E+03	8.50	72.18	.18712E+05
676.54	0.00	-8.50	41.6	0.711E+03	8.50	73.08	.19072E+05
685.26	0.00	-8.50	41.9	0.707E+03	8.50	73.98	.19434E+05
693.99	0.00	-8.50	42.2	0.702E+03	8.50	74.88	.19799E+05
702.72	0.00	-8.50	42.4	0.698E+03	8.50	75.78	.20166E+05

Appendix-M: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #1, ΔT = +0^0 C; Sheet M-6

```
    711.45     0.00   -8.50    42.7 0.694E+03   8.50    76.68 .20535E+05
    720.18     0.00   -8.50    42.9 0.690E+03   8.50    77.58 .20906E+05
    728.90     0.00   -8.50    43.2 0.686E+03   8.50    78.48 .21279E+05
    737.63     0.00   -8.50    43.4 0.682E+03   8.50    79.38 .21655E+05
    746.36     0.00   -8.50    43.7 0.678E+03   8.50    80.28 .22033E+05
    755.09     0.00   -8.50    43.9 0.674E+03   8.50    81.17 .22413E+05
    763.82     0.00   -8.50    44.2 0.670E+03   8.50    82.07 .22795E+05
    772.54     0.00   -8.50    44.4 0.666E+03   8.50    82.97 .23179E+05
    781.27     0.00   -8.50    44.7 0.663E+03   8.50    83.87 .23566E+05
    790.00     0.00   -8.50    44.9 0.659E+03   8.50    84.76 .23954E+05
    798.73     0.00   -8.50    45.1 0.656E+03   8.50    85.66 .24345E+05
    807.46     0.00   -8.50    45.4 0.652E+03   8.50    86.55 .24737E+05
    816.18     0.00   -8.50    45.6 0.649E+03   8.50    87.45 .25132E+05
    824.91     0.00   -8.50    45.9 0.645E+03   8.50    88.34 .25529E+05
    833.64     0.00   -8.50    46.1 0.642E+03   8.50    89.24 .25928E+05
    842.37     0.00   -8.50    46.3 0.639E+03   8.50    90.13 .26329E+05
    851.10     0.00   -8.50    46.6 0.636E+03   8.50    91.03 .26732E+05
    859.83     0.00   -8.50    46.8 0.632E+03   8.50    91.92 .27137E+05
    868.55     0.00   -8.50    47.0 0.629E+03   8.50    92.82 .27544E+05
    877.28     0.00   -8.50    47.3 0.626E+03   8.50    93.71 .27953E+05
 Cumulative travel time =       27952.8281 sec  (    7.76 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
D-CORMIX      End of Prediction File
DDDD
```

Appendix-N: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet N-1

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                       CORMIX MIXING ZONE EXPERT SYSTEM
                           CORMIX Version 10.0GTH
                        DHYDRO:Version-10.0.3.0  December,2017
SITE NAME/LABEL:                HBDF Huntington Beach
  DESIGN CASE:                  Alden 3- Port Duckbill
  FILE NAME:                    C:\projects\Poseidon HB MichalBaker\CORMIX\CORMIX v10.0GTH
Verification\0deg Delta-T\3-Port Duckbill Worst-Case#2\Worst-Case#2 Monthly 29Nov2017\HBDF 3X
HC4189 Stratified DT 0deg WC-2 monthly.prd
  Using subsystem BCORMIX2:     Multiport Diffuser Brine Discharges
  Start of session:             11/29/2017--13:04:46
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                           = unbounded
  Average depth                   HA      = 8.5 m
  Depth at discharge              HD      = 8.5m
  Bottom slope (single slope only)SLOPE   = 1.06 deg
  Ambient velocity                UA      = 0.0000 m/s
  Darcy-Weisbach friction factor  F       = 0.02
  Wind velocity                   UW      = 0 m/s
  Ambient Density Stratification with 1 subsurface level:
  Surface density                 RHOAS   = 1022 kg/m^3
  Level 1 Submergence             LEVEL1  = 8.5 m
  Density at Level 1              RHOA1   = 1023.47 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE  = unidirectional perpendicular
  Diffuser length                 LD      = 8.96 m
  Nearest bank                            = left
  Diffuser endpoints              YB1     = 457 m;    YB2 = 465.96 m
  Number of openings              NOPEN   = 3
  Number of Risers                NRISER  = 3
  Ports/Nozzles per Riser         NPPERR   = 1
  Spacing between risers/openings SPAC    = 4.48 m
  Port/Nozzle diameter            D0      = 0.468 m
    with contraction ratio                = 1
  Equivalent slot width           B0      = 0.0384 m
  Total area of openings          TA0     = 0.5161 m^2
  Discharge velocity              U0      = 4.24 m/s
  Total discharge flowrate        Q0      = 2.19063 m^3/s
  Discharge port height           H0      = 2.8 m
  Nozzle arrangement              BETYPE  = unidirectional with fanning
  Diffuser alignment angle        GAMMA   = 90 deg
  Vertical discharge angle        THETA   = 47 deg
  Actual Vertical discharge angle THEAC   = 47 deg
  Horizontal discharge angle      SIGMA   = 0 deg
  Relative orientation angle      BETA    = 90 deg
  Discharge density               RHO0    = 1050.7 kg/m^3
  Density difference              DRHO    = -27.9650 kg/m^3
  Buoyant acceleration            GP0     = -0.2681 m/s^2
  Discharge concentration         C0      = 33500 ppm
  Surface heat exchange coeff.    KS      = 0 m/s
  Coefficient of decay            KD      = 0 /s
------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0      = 0.244490 m^2/s
  Momentum flux                   m0      = 1.037832 m^3/s^2
  Buoyancy flux                   j0      = -0.195803 m^3/s^3
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.06 m         Lm  = 99999 m         LM  = 3.08 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
```

Appendix-N: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet N-2

```
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 41.83
  Port/nozzle Froude number       FRD0   = 11.98
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 2000 ppm
  Regulatory mixing zone                 = yes
  Regulatory mixing zone specification   = distance
  Regulatory mixing zone value           = 100 m (m^2 if area)
  Region of interest                     = 3500 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MNU7 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.  The ambient density stratification at the
  discharge site is relatively weak and unimportant so the discharge flow
  penetrates to the surface and/or breaks down the existing stratification
  through vigorous mixing.
  Applicable layer depth = water depth = 8.5 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the SURFACE:
 1) directly above the port/diffuser center for submerged discharges, OR:
 2) at the point of entry into the water for above surface discharges,
 461.48 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 685.3655 ppm
  Dilution at edge of NFR              s = 48.9
  NFR Location:                        x = 877.28 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  NFR plume dimensions:  half-width (bh) = 93.71 m
                          thickness (bv) = 8.5 m
Cumulative travel time:       30650.6855 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is greater than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is NEGATIVELY BUOYANT and will tend to sink towards
  the bottom.
-----------------------------------------------------------------------------
Stratification assessment:
  The specified ambient density stratification is weak relative to the
  discharge conditions and is dynamically unimportant. The discharge will
  behave as if the ambient were unstratified.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
```

Appendix-N: CORMIX 10.0.3.0 Session Report for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet N-3

```
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-------------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 1883.060181  ppm
  Corresponding dilution               s = 17.8
  Plume location:                      x = 100 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 12.76 m
                          thickness (bv) = 8.5 m
Cumulative travel time < 30650.6855 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction
file values - assuming linear interpolation between predicted points just
before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account
for this linear interpolation. Step size can be controlled by increasing
(reduces the prediction step size) or decreasing (increases the prediction
step size) the - Output Steps per Module - in CORMIX input.

At this position, the plume is NOT IN CONTACT with any bank.
Furthermore, the specified water quality standard has indeed been met
  within the RMZ. In particular:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 2000  ppm
  Corresponding dilution               s = 16.8
  Plume location:                      x = 86.63 m
    (centerline coordinates)           y = 0 m
                                       z = -8.5 m
  Plume dimensions:      half-width (bh) = 11.33 m
                          thickness (bv) = 8.5 m
-------------------------------------------------------------------------------
Regulatory Mixing Zone Analysis:
  The RMZ specification occurs before the near-field mixing regime (NFR) has
  been completed.  The specification of the RMZ is highly restrictive.
********************** FINAL DESIGN ADVICE AND COMMENTS *********************
CORMIX2 uses the TWO-DIMENSIONAL SLOT DIFFUSER CONCEPT to represent
  the actual three-dimensional diffuser geometry.  Thus, it approximates
  the details of the merging process of the individual jets from each
  port/nozzle.
In the present design, the spacing between adjacent ports/nozzles
  (or riser assemblies) is of the order of, or less than, the local
  water depth so that the slot diffuser approximation holds well.

Nevertheless, if this is a final design, the user is advised to use a
  final CORMIX1 (single port discharge) analysis, with discharge data
  for an individual diffuser jet/plume, in order to compare to
  the present near-field prediction.
-------------------------------------------------------------------------------
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-1

```
D-CORMIX PREDICTION FILE:
DDDD
```

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-2

```
MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.3350E+05  CUNITS=  ppm
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2000E+04
 REGMZ =  1
 REGSPC=  1         XREG  =    100.00  WREG  =      0.00  AREG  =      0.00
 XINT  =   3500.00  XMAX  =   3500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE an at the diffuser mid-point:
       461.48 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =100 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48     4.245   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

 Because of the FANNED-OUT HORIZONTAL ORIENTATION of the diffuser jets,
   the near-field dilution is slightly improved.

 In this laterally contracting zone the diffuser plume becomes VERTICALLY FULLY
  MIXED over the entire layer depth (HS =    8.50m).
   Full mixing is achieved after a plume distance of about five
   layer depths from the diffuser.

 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00   -5.70     1.0 0.335E+05   0.03     4.48 .00000E+00
      0.04     0.00   -5.70     1.7 0.199E+05   0.08     4.41 .17799E-01
      0.09     0.00   -5.70     2.0 0.170E+05   0.17     4.35 .41601E-01
      0.13     0.00   -5.70     2.2 0.153E+05   0.25     4.29 .69310E-01
      0.18     0.00   -5.69     2.4 0.141E+05   0.34     4.23 .10018E+00
      0.22     0.00   -5.69     2.5 0.132E+05   0.42     4.17 .13378E+00
      0.27     0.00   -5.69     2.7 0.125E+05   0.51     4.11 .16981E+00
      0.31     0.00   -5.69     2.8 0.119E+05   0.60     4.06 .20806E+00
      0.36     0.00   -5.69     2.9 0.114E+05   0.68     4.00 .24838E+00
      0.40     0.00   -5.69     3.1 0.109E+05   0.76     3.95 .29061E+00
      0.45     0.00   -5.68     3.2 0.106E+05   0.85     3.90 .33466E+00
      0.49     0.00   -5.68     3.3 0.102E+05   0.93     3.85 .38043E+00
      0.54     0.00   -5.68     3.4 0.992E+04   1.02     3.80 .42783E+00
      0.58     0.00   -5.68     3.5 0.964E+04   1.10     3.76 .47681E+00
      0.63     0.00   -5.68     3.6 0.939E+04   1.19     3.71 .52729E+00
      0.67     0.00   -5.68     3.7 0.916E+04   1.27     3.67 .57923E+00
```

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-3

0.72	0.00	-5.68	3.7	0.894E+04	1.36	3.62	.63257E+00
0.76	0.00	-5.67	3.8	0.875E+04	1.44	3.58	.68727E+00
0.81	0.00	-5.67	3.9	0.856E+04	1.53	3.54	.74329E+00
0.85	0.00	-5.67	4.0	0.839E+04	1.61	3.50	.80058E+00
0.90	0.00	-5.67	4.1	0.823E+04	1.70	3.46	.85913E+00
0.94	0.00	-5.67	4.1	0.808E+04	1.78	3.43	.91889E+00
0.99	0.00	-5.67	4.2	0.794E+04	1.87	3.39	.97983E+00
1.03	0.00	-5.66	4.3	0.780E+04	1.95	3.35	.10419E+01
1.08	0.00	-5.66	4.4	0.768E+04	2.04	3.32	.11052E+01
1.12	0.00	-5.66	4.4	0.756E+04	2.12	3.29	.11695E+01
1.16	0.00	-5.66	4.5	0.744E+04	2.21	3.25	.12350E+01
1.21	0.00	-5.66	4.6	0.733E+04	2.30	3.22	.13015E+01
1.25	0.00	-5.66	4.6	0.723E+04	2.38	3.19	.13690E+01
1.30	0.00	-5.66	4.7	0.713E+04	2.47	3.16	.14376E+01
1.34	0.00	-5.65	4.8	0.704E+04	2.55	3.13	.15072E+01
1.39	0.00	-5.65	4.8	0.695E+04	2.64	3.10	.15777E+01
1.43	0.00	-5.65	4.9	0.686E+04	2.72	3.07	.16493E+01
1.48	0.00	-5.65	4.9	0.678E+04	2.81	3.04	.17218E+01
1.52	0.00	-5.65	5.0	0.670E+04	2.89	3.02	.17953E+01
1.57	0.00	-5.65	5.1	0.662E+04	2.98	2.99	.18696E+01
1.61	0.00	-5.64	5.1	0.654E+04	3.06	2.96	.19450E+01
1.66	0.00	-5.64	5.2	0.647E+04	3.15	2.94	.20212E+01
1.70	0.00	-5.64	5.2	0.640E+04	3.23	2.91	.20983E+01
1.75	0.00	-5.64	5.3	0.634E+04	3.32	2.89	.21763E+01
1.79	0.00	-5.64	5.3	0.627E+04	3.40	2.86	.22551E+01
1.84	0.00	-5.64	5.4	0.621E+04	3.49	2.84	.23348E+01
1.88	0.00	-5.64	5.4	0.615E+04	3.57	2.82	.24154E+01
1.93	0.00	-5.63	5.5	0.609E+04	3.66	2.80	.24968E+01
1.97	0.00	-5.63	5.6	0.603E+04	3.74	2.77	.25790E+01
2.02	0.00	-5.63	5.6	0.598E+04	3.83	2.75	.26621E+01
2.06	0.00	-5.63	5.7	0.592E+04	3.91	2.73	.27460E+01
2.11	0.00	-5.63	5.7	0.587E+04	4.00	2.71	.28306E+01
2.15	0.00	-5.63	5.8	0.582E+04	4.08	2.69	.29161E+01
2.20	0.00	-5.63	5.8	0.577E+04	4.17	2.67	.30023E+01
2.24	0.00	-5.62	5.9	0.572E+04	4.25	2.65	.30893E+01
2.28	0.00	-5.62	5.9	0.568E+04	4.34	2.64	.31771E+01
2.33	0.00	-5.62	6.0	0.563E+04	4.42	2.62	.32657E+01
2.37	0.00	-5.62	6.0	0.559E+04	4.51	2.60	.33550E+01
2.42	0.00	-5.62	6.0	0.554E+04	4.59	2.58	.34450E+01
2.46	0.00	-5.62	6.1	0.550E+04	4.68	2.57	.35358E+01
2.51	0.00	-5.61	6.1	0.546E+04	4.76	2.55	.36273E+01
2.55	0.00	-5.61	6.2	0.542E+04	4.85	2.54	.37196E+01
2.60	0.00	-5.61	6.2	0.538E+04	4.93	2.52	.38125E+01
2.64	0.00	-5.61	6.3	0.534E+04	5.02	2.51	.39062E+01
2.69	0.00	-5.61	6.3	0.530E+04	5.10	2.49	.40006E+01
2.73	0.00	-5.61	6.4	0.527E+04	5.19	2.48	.40957E+01
2.78	0.00	-5.61	6.4	0.523E+04	5.27	2.46	.41915E+01
2.82	0.00	-5.60	6.4	0.519E+04	5.36	2.45	.42880E+01
2.87	0.00	-5.60	6.5	0.516E+04	5.44	2.44	.43851E+01
2.91	0.00	-5.60	6.5	0.513E+04	5.53	2.43	.44829E+01
2.96	0.00	-5.60	6.6	0.509E+04	5.61	2.42	.45815E+01
3.00	0.00	-5.60	6.6	0.506E+04	5.70	2.40	.46806E+01
3.05	0.00	-5.60	6.7	0.503E+04	5.78	2.39	.47805E+01
3.09	0.00	-5.59	6.7	0.500E+04	5.87	2.38	.48810E+01
3.14	0.00	-5.59	6.7	0.497E+04	5.95	2.37	.49821E+01
3.18	0.00	-5.59	6.8	0.494E+04	6.04	2.36	.50840E+01
3.23	0.00	-5.59	6.8	0.491E+04	6.12	2.36	.51864E+01
3.27	0.00	-5.59	6.9	0.488E+04	6.21	2.35	.52895E+01
3.32	0.00	-5.59	6.9	0.485E+04	6.29	2.34	.53932E+01
3.36	0.00	-5.59	6.9	0.482E+04	6.38	2.33	.54976E+01
3.40	0.00	-5.58	7.0	0.480E+04	6.46	2.32	.56026E+01
3.45	0.00	-5.58	7.0	0.477E+04	6.55	2.32	.57082E+01
3.49	0.00	-5.58	7.1	0.474E+04	6.63	2.31	.58144E+01
3.54	0.00	-5.58	7.1	0.472E+04	6.72	2.31	.59213E+01
3.58	0.00	-5.58	7.1	0.469E+04	6.80	2.30	.60287E+01
3.63	0.00	-5.58	7.2	0.467E+04	6.89	2.29	.61368E+01
3.67	0.00	-5.57	7.2	0.464E+04	6.97	2.29	.62455E+01

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-4

```
      3.72     0.00   -5.57     7.3 0.462E+04   7.06     2.28 .63547E+01
      3.76     0.00   -5.57     7.3 0.459E+04   7.14     2.28 .64646E+01
      3.81     0.00   -5.57     7.3 0.457E+04   7.23     2.28 .65750E+01
      3.85     0.00   -5.57     7.4 0.455E+04   7.31     2.27 .66861E+01
      3.90     0.00   -5.57     7.4 0.452E+04   7.40     2.27 .67977E+01
      3.94     0.00   -5.57     7.4 0.450E+04   7.48     2.27 .69099E+01
      3.99     0.00   -5.56     7.5 0.448E+04   7.57     2.26 .70227E+01
      4.03     0.00   -5.56     7.5 0.446E+04   7.65     2.26 .71361E+01
      4.08     0.00   -5.56     7.5 0.444E+04   7.74     2.26 .72501E+01
      4.12     0.00   -5.56     7.6 0.442E+04   7.82     2.26 .73646E+01
      4.17     0.00   -5.56     7.6 0.440E+04   7.91     2.25 .74796E+01
      4.21     0.00   -5.56     7.7 0.438E+04   7.99     2.25 .75953E+01
      4.26     0.00   -5.55     7.7 0.436E+04   8.08     2.25 .77115E+01
      4.30     0.00   -5.55     7.7 0.434E+04   8.16     2.25 .78283E+01
      4.35     0.00   -5.55     7.8 0.432E+04   8.25     2.25 .79456E+01
      4.39     0.00   -5.55     7.8 0.430E+04   8.33     2.25 .80634E+01
      4.44     0.00   -5.55     7.8 0.428E+04   8.42     2.25 .81819E+01
      4.48     0.00   -5.55     7.9 0.426E+04   8.50     2.25 .83008E+01
 Cumulative travel time =           8.3008 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

 Phase 1: Vertically mixed, Phase 2: Re-stratified

 Phase 1: The diffuser plume is VERTICALLY FULLY MIXED over the
          entire layer depth.
 Profile definitions:
   BV = layer depth (vertically mixed)
   BH = Gaussian 1/e (37%) half-width in horizontal plane normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH        TT
      4.48     0.00   -8.50     7.9 0.426E+04   8.50     2.52 .83008E+01
     13.21     0.00   -8.50     9.2 0.363E+04   8.50     3.46 .87077E+02
     21.94     0.00   -8.50    10.4 0.322E+04   8.50     4.40 .17751E+03
     30.66     0.00   -8.50    11.5 0.292E+04   8.50     5.34 .27825E+03
     39.39     0.00   -8.50    12.4 0.269E+04   8.50     6.28 .38834E+03
     48.12     0.00   -8.50    13.4 0.251E+04   8.50     7.21 .50704E+03
     56.85     0.00   -8.50    14.2 0.236E+04   8.50     8.15 .63376E+03
     65.58     0.00   -8.50    15.0 0.223E+04   8.50     9.08 .76803E+03
     74.30     0.00   -8.50    15.7 0.213E+04   8.50    10.02 .90945E+03
     83.03     0.00   -8.50    16.5 0.203E+04   8.50    10.95 .10577E+04
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.200E+04 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     91.76     0.00   -8.50    17.2 0.195E+04   8.50    11.88 .12124E+04
 ** REGULATORY MIXING ZONE BOUNDARY is within the Near-Field Region **
  In this prediction interval the plume DOWNSTREAM distance meets or exceeds
  the regulatory value =   100.00 m.
  This is the extent of the REGULATORY MIXING ZONE.
    100.49     0.00   -8.50    17.8 0.188E+04   8.50    12.81 .13733E+04
    109.22     0.00   -8.50    18.5 0.181E+04   8.50    13.74 .15403E+04
    117.94     0.00   -8.50    19.1 0.175E+04   8.50    14.67 .17131E+04
    126.67     0.00   -8.50    19.7 0.170E+04   8.50    15.60 .18914E+04
    135.40     0.00   -8.50    20.3 0.165E+04   8.50    16.53 .20752E+04
    144.13     0.00   -8.50    20.8 0.161E+04   8.50    17.46 .22643E+04
```

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-5

152.86	0.00	-8.50	21.4	0.157E+04	8.50	18.38	.24585E+04
161.58	0.00	-8.50	21.9	0.153E+04	8.50	19.31	.26578E+04
170.31	0.00	-8.50	22.5	0.149E+04	8.50	20.24	.28619E+04
179.04	0.00	-8.50	23.0	0.146E+04	8.50	21.16	.30708E+04
187.77	0.00	-8.50	23.5	0.143E+04	8.50	22.08	.32843E+04
196.50	0.00	-8.50	24.0	0.140E+04	8.50	23.01	.35024E+04
205.22	0.00	-8.50	24.4	0.137E+04	8.50	23.93	.37250E+04
213.95	0.00	-8.50	24.9	0.134E+04	8.50	24.85	.39519E+04
222.68	0.00	-8.50	25.4	0.132E+04	8.50	25.77	.41832E+04
231.41	0.00	-8.50	25.8	0.130E+04	8.50	26.70	.44186E+04
240.14	0.00	-8.50	26.3	0.128E+04	8.50	27.62	.46582E+04
248.86	0.00	-8.50	26.7	0.125E+04	8.50	28.54	.49019E+04
257.59	0.00	-8.50	27.1	0.123E+04	8.50	29.46	.51496E+04
266.32	0.00	-8.50	27.6	0.122E+04	8.50	30.37	.54013E+04
275.05	0.00	-8.50	28.0	0.120E+04	8.50	31.29	.56568E+04
283.78	0.00	-8.50	28.4	0.118E+04	8.50	32.21	.59161E+04
292.50	0.00	-8.50	28.8	0.116E+04	8.50	33.13	.61793E+04
301.23	0.00	-8.50	29.2	0.115E+04	8.50	34.04	.64461E+04
309.96	0.00	-8.50	29.6	0.113E+04	8.50	34.96	.67166E+04
318.69	0.00	-8.50	30.0	0.112E+04	8.50	35.88	.69907E+04
327.42	0.00	-8.50	30.4	0.110E+04	8.50	36.79	.72684E+04
336.14	0.00	-8.50	30.8	0.109E+04	8.50	37.71	.75496E+04
344.87	0.00	-8.50	31.1	0.108E+04	8.50	38.62	.78343E+04
353.60	0.00	-8.50	31.5	0.106E+04	8.50	39.54	.81224E+04
362.33	0.00	-8.50	31.9	0.105E+04	8.50	40.45	.84139E+04
371.06	0.00	-8.50	32.2	0.104E+04	8.50	41.36	.87088E+04
379.78	0.00	-8.50	32.6	0.103E+04	8.50	42.28	.90070E+04
388.51	0.00	-8.50	33.0	0.102E+04	8.50	43.19	.93084E+04
397.24	0.00	-8.50	33.3	0.101E+04	8.50	44.10	.96132E+04
405.97	0.00	-8.50	33.7	0.996E+03	8.50	45.01	.99211E+04
414.70	0.00	-8.50	34.0	0.985E+03	8.50	45.92	.10232E+05
423.42	0.00	-8.50	34.3	0.976E+03	8.50	46.83	.10547E+05
432.15	0.00	-8.50	34.7	0.966E+03	8.50	47.74	.10864E+05
440.88	0.00	-8.50	35.0	0.957E+03	8.50	48.65	.11184E+05
449.61	0.00	-8.50	35.3	0.948E+03	8.50	49.56	.11508E+05
458.34	0.00	-8.50	35.7	0.939E+03	8.50	50.47	.11834E+05
467.06	0.00	-8.50	36.0	0.931E+03	8.50	51.38	.12164E+05
475.79	0.00	-8.50	36.3	0.923E+03	8.50	52.29	.12497E+05
484.52	0.00	-8.50	36.6	0.915E+03	8.50	53.20	.12832E+05
493.25	0.00	-8.50	36.9	0.907E+03	8.50	54.11	.13170E+05
501.98	0.00	-8.50	37.3	0.899E+03	8.50	55.01	.13512E+05
510.70	0.00	-8.50	37.6	0.892E+03	8.50	55.92	.13856E+05
519.43	0.00	-8.50	37.9	0.884E+03	8.50	56.83	.14203E+05
528.16	0.00	-8.50	38.2	0.877E+03	8.50	57.73	.14553E+05
536.89	0.00	-8.50	38.5	0.870E+03	8.50	58.64	.14905E+05
545.62	0.00	-8.50	38.8	0.864E+03	8.50	59.54	.15261E+05
554.34	0.00	-8.50	39.1	0.857E+03	8.50	60.45	.15619E+05
563.07	0.00	-8.50	39.4	0.851E+03	8.50	61.35	.15980E+05
571.80	0.00	-8.50	39.7	0.844E+03	8.50	62.26	.16344E+05
580.53	0.00	-8.50	40.0	0.838E+03	8.50	63.16	.16710E+05
589.26	0.00	-8.50	40.3	0.832E+03	8.50	64.07	.17079E+05
597.98	0.00	-8.50	40.6	0.826E+03	8.50	64.97	.17451E+05
606.71	0.00	-8.50	40.8	0.820E+03	8.50	65.87	.17825E+05
615.44	0.00	-8.50	41.1	0.815E+03	8.50	66.78	.18202E+05
624.17	0.00	-8.50	41.4	0.809E+03	8.50	67.68	.18582E+05
632.90	0.00	-8.50	41.7	0.804E+03	8.50	68.58	.18964E+05
641.62	0.00	-8.50	42.0	0.798E+03	8.50	69.48	.19348E+05
650.35	0.00	-8.50	42.2	0.793E+03	8.50	70.38	.19736E+05
659.08	0.00	-8.50	42.5	0.788E+03	8.50	71.28	.20125E+05
667.81	0.00	-8.50	42.8	0.783E+03	8.50	72.18	.20518E+05
676.54	0.00	-8.50	43.1	0.778E+03	8.50	73.08	.20913E+05
685.26	0.00	-8.50	43.3	0.773E+03	8.50	73.98	.21310E+05
693.99	0.00	-8.50	43.6	0.768E+03	8.50	74.88	.21710E+05
702.72	0.00	-8.50	43.9	0.764E+03	8.50	75.78	.22112E+05
711.45	0.00	-8.50	44.1	0.759E+03	8.50	76.68	.22517E+05
720.18	0.00	-8.50	44.4	0.755E+03	8.50	77.58	.22924E+05
728.90	0.00	-8.50	44.6	0.750E+03	8.50	78.48	.23333E+05

Appendix-O: CORMIX 10.0.3.0 Prediction File for Monthly Worst-Case #2, ΔT = +0^0 C; Sheet O-6

```
    737.63     0.00   -8.50    44.9 0.746E+03   8.50    79.38 .23745E+05
    746.36     0.00   -8.50    45.2 0.742E+03   8.50    80.28 .24159E+05
    755.09     0.00   -8.50    45.4 0.737E+03   8.50    81.17 .24576E+05
    763.82     0.00   -8.50    45.7 0.733E+03   8.50    82.07 .24995E+05
    772.54     0.00   -8.50    45.9 0.729E+03   8.50    82.97 .25416E+05
    781.27     0.00   -8.50    46.2 0.725E+03   8.50    83.87 .25840E+05
    790.00     0.00   -8.50    46.4 0.721E+03   8.50    84.76 .26266E+05
    798.73     0.00   -8.50    46.7 0.718E+03   8.50    85.66 .26694E+05
    807.46     0.00   -8.50    46.9 0.714E+03   8.50    86.55 .27125E+05
    816.18     0.00   -8.50    47.2 0.710E+03   8.50    87.45 .27558E+05
    824.91     0.00   -8.50    47.4 0.706E+03   8.50    88.34 .27993E+05
    833.64     0.00   -8.50    47.7 0.703E+03   8.50    89.24 .28430E+05
    842.37     0.00   -8.50    47.9 0.699E+03   8.50    90.13 .28870E+05
    851.10     0.00   -8.50    48.2 0.696E+03   8.50    91.03 .29312E+05
    859.83     0.00   -8.50    48.4 0.692E+03   8.50    91.92 .29756E+05
    868.55     0.00   -8.50    48.6 0.689E+03   8.50    92.82 .30202E+05
    877.28     0.00   -8.50    48.9 0.685E+03   8.50    93.71 .30651E+05
 Cumulative travel time =       30650.6426 sec  (    8.51 hrs)

 Entire region is occupied by Phase 1.
   Plume does not re-stratify in this flow region.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW
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** End of NEAR-FIELD REGION (NFR) **

 SIMULATION STOPS because of STAGNANT AMBIENT conditions.
   All far-field processes will be UNSTEADY.
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D-CORMIX      End of Prediction File
DDDD
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