Appendix J

CK Associates CORMIX Evaluation

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MEMORANDUM

Date: **March 21, 2016**

To: **Delfin LNG**

From: **CK Associates**

Re: **CORMIX Evaluation in Response to Port Delfin Deepwater Port License Application USCG Follow-up Data Request No. 141 & 142**

CORMIX (Version 9.0 GTS) modeling results for discharge characteristics, including salinity and total suspended solids (TSS) concentrations from the reverse osmosis (RO) generator reject discharge and thermal plume from the FLNGV Essential Generator cooling water unit discharge, at the Port Delfin Deepwater Port (DWP) are presented below. Effluent characterizations, ambient and discharge geometry, and ambient waterbody data used in the simulations are largely representative of input parameters provided by the client in the Port Delfin LNG Deepwater Port License Application (DPLA). Additional model inputs were assigned based on information available in technical documents and are referenced accordingly. Model input data and results for CORMIX simulations are summarized Attachment 1. For each model run, CORMIX provided documentation of flow behavior, regulatory mixing zone (RMZ) data, boundary interaction behavior, and effluent current properties. CORMIX model session reports are provided in Attachment 2. A RMZ is defined at 40 CFR 125.121(c) as “the zone extending from the sea's surface to seabed and extending laterally to a distance of 100 meters in all directions from the discharge point(s) or to the boundary of the zone of initial dilution as calculated by a plume model approved by the director, whichever is greater, unless the director determines that the more restrictive mixing zone or another definition of the mixing zone is more appropriate for a specific discharge”.

RO Reject Discharge

RO Reject - Salinity

Model scenario 1 simulates a typical discharge of high salinity reject wastewater from the RO generator (desalinization unit) using a flow rate of 444 gallons per minute (gpm) and a salinity of 55 parts per thousand (ppt) or 55,000 mg.L. The effluent concentration was set to 21,075 mg/L (21.075 ppt) in excess over the ambient concentration.

Model Input Data

Effluent density[i]:	1039.0395 kg/m^3
Effluent salinity[ii]:	55,000 mg/L
Effluent temperature[iii]:	23.61 deg. C
Port diameter:	6 in
Port height above seabed:	11.36 m
Average ambient depth[iv]:	12.58m
Ambient seawater density[v]:	1023 kg/m^3
Ambient seawater salinity[vi]:	33,925 mg/L
Ambient average seawater temperature[vii]:	23.5 deg. C

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. Indicated by the results, modelled dilution of reject wastewater from the RO unit becomes significantly undifferentiated to the ambient conditions within minutes (cumulative travel time to RMZ: 468.7 sec). The resultant plume conditions at the RMZ are 48.75 mg/L in excess of ambient concentrations (i.e. ambient salinity concentrations at the point of discharge are equal to 33.925 ppt whereas predicted salinity concentrations at the 100 m RMZ are equal to 33.974 ppt).

RO Reject - TSS

Model scenario 2 reflects similar discharge characteristics as above, including excess TSS concentrations to simulate an intermittent seawater strainer/filter backwash cycle. This intermittent back wash cycle water would be comingled and discharged as part of the RO reject discharge. The effluent was assumed to function as a conservative brine discharge with pollutant (particulate) concentration set to 299 mg/L in excess over the ambient concentration. Referenced literature provides contours of suspended particulate matter in the northern Gulf of Mexico ranging from 16 mg/L closest to the shoreline to 0.125 mg/L in depths of 200 meters. A highly conservative value of 1 mg/L was chosen for modelling purposes to represent the point of discharge at Port Delfin DWP.

Model Input Data

Effluent TSS[viii]:	300 mg/L
Average ambient TSS[ix]:	1 mg/L

As seen in the CORMIX model session reports, hydrodynamics of the effluent are conceptualized as a mixing process occurring in two separate regions. In the “near field” region (NFR), the initial jet characteristics of momentum and port geometry influence the effluent trajectory and mixing. As the turbulent plume travels further away from the source into the “far-field” region, source characteristics give way to influential conditions existing in the ambient environment. Results of the simulation demonstrate NFR conditions, at 37.74 meters (128.8 feet) from the point of discharge, to be 0.694 mg/L above ambient concentrations (i.e. 1.694 mg/L). Cumulative travel time to the NFR edge is 157.57 seconds. Similar plume characteristics and corresponding dilution can be seen at the 100m RMZ boundary.

Essential Generator Cooling Water

Non-Contact Cooling Water - Thermal

Model scenario 3 simulates an intermediate discharge of non-contact cooling water associated with the Essential Generators on board each of the floating LNG vessels (FLNGVs) using a flow rate of 600 gpm. The effluent temperature was set to 1.465 deg. Celsius in excess of ambient conditions with a heat loss coefficient of 75 watts per square meter per degree Celsius ($W/m^2/°C$)[x] based on values for a lightly heated, natural water surface. The cooling water would be taken from the FLNGV’s sea chests, which pulls ambient seawater from the Gulf.

Model Input Data

Effluent density[xi]:	1019.8469 kg/m^3
Effluent salinity:	Ambient
Effluent temperature[xii]:	31.11 deg. C
Port diameter:	16 in
Port height above seabed:	11.96 m
Average ambient depth[xiii]:	17.68 m
Ambient summer seawater density[xiv]:	1020.4 kg/m^3
Ambient summer seawater salinity[xv]:	33,950 mg/L
Ambient summer seawater temperature[xvi]:	29.48 deg. C

Predicted dilution of the thermal discharge plume from the FLNGV Essential Generators becomes significantly undifferentiated of the ambient conditions within minutes. Results of the simulation demonstrate NFR conditions, at 40.40 meters (132.5 feet) from the point of discharge, to be 0.03 degrees Celsius above ambient concentrations (i.e. 29.51 degrees Celsius). Cumulative travel time to the NFR edge is 197.2 seconds. Similarly, the resultant plume conditions at the RMZ are 0.0296 degrees Celsius in excess of ambient concentrations (i.e. 29.51 deg. C). Cumulative travel time to the edge of the RMZ is 495.2 seconds.

Assumptions for All Model Runs

a. The CORMIX1 Single Port model was utilized.
b. The effluent was assumed to function as a conserved pollutant.
c. Average depth and depth at discharge are equal.

d. Wind velocity was set to 6.5 m/s based on estimated yearly average using data provided by client in DPLA Vol III, Attachment 37, Appendix C.
e. Ambient current speed (measured at the 10 m level) was set to 0.2 m/s based on estimated yearly average using data provided by client in DPLA Vol III, Attachment 37, Appendix A.
f. In the ambient density data field, a non-fresh water density was calculated using the non-uniform linear density profile.
g. The water body was considered to be unbounded and the bottom slope was set to 0.001 degrees using a single slope profile.
h. The nearest bank was set to 72,000 m to the left.
i. Bottom friction, represented by Darcy-Weisbach factor (f), was considered to be 0.20.
j. Vertical angle (θ) between the port centerline and the horizontal plane set to 0; horizontal angle (σ) between the projection of the port centerline onto the horizontal plane and the direction of ambient flow set to 270.
k. Port diameter and discharge depth were varied with the representative scenarios used in the modeling exercise.
l. Effluent were considered non-toxic, with no corresponding ambient water quality standard specified.
m. A downstream regulatory mixing zone (RMZ) distance was set to 100 m.

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[i] Calculated using UNESCO International Equation of State (IES 80) for seawater using average reported temperature of effluent 23.61 °C at discharge depth 8.1504 m and salinity 55 ppt.
[ii] Provided by client in DPLA no. 126 follow up response to data request 38.
[iii] Estimated average temperature using data supplied by client in DPLA Vol III, Attachment 20.
[iv] Ambient discharge depth (HD) altered (from 19.51 m) due to CORMIX model limitations. CORMIX1 is applicable to either a: deeply submerged discharge, where H0 <= 1/3 HD or a slightly submerged discharge where H0 >= 2/3 HD. In this case, the height of the discharge port above the bottom (H0) is 11.357 m and the local ambient water depth is HD = 19.507, which does not meet the CORMIX1 applicability criteria. A value of 12.58 m was used to re-schematize the model case based on the modeling advice available in Section 7.4 of the CORMIX1 technical report: Donaker and Jirka, *Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Submerged Single Port Discharges (CORMIX1) Technical Report*, 1990 [EPA/600/3-90/012].
[v] Seawater salinity statistics reported in DPLA Vol III, Attachment 37 (Appendix G). The specified ambient stratification using temperature and salinity data provided is weak relative to the discharge conditions and is dynamically unimportant for modelling. The discharge will behave as if the ambient were unstratified.
[vi] Estimated yearly average using data supplied by client in DPLA Vol III, Attachment 37 (Appendix G).
[vii] Estimated yearly average using data supplied by client in DPLA Vol III, Attachment 37 (Appendix G).
[viii] Provided by client in DPLA no. 126 follow up response to data request 38.
[ix] Guo, L., Santschi, P.H. and Baskaran, M. (1997); "Interactions of Thorium Isotopes with Colloidal Organic Matter in Oceanic Environments", Colloids and Surfaces A. Physicochemical and Engineering Aspects 120(1997) 255-271; and
Manheim, F.T., Hathaway, J.C., and Uchupi, E. (1972); "Suspended Matter in the Surface Waters of the Northern Gulf of Mexico" Limnology and Oceanography, January 1972 V17(1) , pp 17-27
[x] "Heat Disposal in the Water Environment", E.E. Adams, D.R.F. Harleman, G.H. Jirka, and K.D. Stolzenbach, Course Notes, R.M. Parsons Laboratory, Mass. Inst. of Techn., 1981.
[xi] Calculated using UNESCO International Equation of State (IES 80) for seawater using average reported temperature of effluent 31.11 °C at discharge depth 8.1504 m and ambient summer (Jun-Sept) salinity 32.95 ppt.
[xii] Estimated average summer (Jun-Sept) temperature using data supplied by client in DPLA Vol III, Attachment 20.
[xiii] Ambient discharge depth altered (from 19.51 m) due to CORMIX model limitations. A value of 17.68 m was used to re-schematize the model case based on the modeling advice available in Section 7.4 of the CORMIX1 technical report: Donaker and Jirka, *Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Submerged Single Port Discharges (CORMIX1) Technical Report*, 1990 [EPA/600/3-90/012].
[xiv] Calculated using UNESCO International Equation of State (IES 80) for seawater using average reported summer temperatures of 23.60 °C at surface with ambient summer (Jun-Sept) salinity 32.9025 ppt and average reported summer temperatures of 23.40 °C at 15 m with ambient summer (Jun-Sept) salinity 32.9975 ppt. However, the specified ambient stratification is weak

relative to the discharge conditions and is dynamically unimportant for modelling. The discharge will behave as if the ambient were unstratified. The estimated average density 1020.4 is given above.

[xv] Estimated summer (Jun-Sept) average using data supplied by client in DPLA Vol III, Attachment 37 (Appendix G).

[xvi] Estimated summer (Jun-Sept) average using data supplied by client in DPLA Vol III, Attachment 37 (Appendix G).

ATTACHMENT 1
CORMIX SIMULATIONS AND RESULTS

CORMIX Modeling - Delfin LNG Deepwater Port
USCG Response to Data Request No. 141 & 142

MODEL INPUT

	1	2	3
Ambient Geometry/Flow Field Data	**RO Reject Discharge - Salinity**	**RO Reject Discharge - TSS**	**FLNGV Essential Generator Cooling Water - Thermal**
Average Ambient Depth (m)*	12.58	12.58	17.68
Current Speed (m/s)	0.2	0.2	0.2
Ambient Surface Density (kg/m3)	1022.92	1022.92	1020.28 **
Ambient Near-Bed Density @ 15 m (kg/m3)	1023.03	1023.03	1020.46 **
Ambient TSS (mg/L)	NA	1.00	NA
Ambient Temperature (deg. C)	23.5	23.5	29.48
Effluent Data			
Effluent Flow Rate (gpm)	444	444	600
Effluent Density (kg/m3)	1039.0395	1039.0395	1019.8469
Effluent TSS (mg/L)	NA	300	NA
Effluent Temperature (deg. C)	23.61	23.61	31.11
Discharge Geometry			
Distance to Nearest Bank (m)	72,000	72,000	72,000
Single Port/Multiport/Channel	Single Port	Single Port	Single Port
Single Port			
Port Diameter (m)	0.018	0.018	0.406
Port Height above Seabed (m)	11.36	11.36	17.68
Vertical Orientation Angle	0	0	0
Horizontal Orientation Angle	270	270	270

RESULTS

	RO Reject Discharge - Salinity	**RO Reject Discharge - TSS**	**FLNGV Essential Generator Cooling Water - Thermal**
Effluent Concentration @ 100 m RMZ boundary	48.751102 mg/L	0.694 mg/L	0.029568 deg C
Dilution @ 100 m RMZ boundary	432.3	430.8	423.4

NOTES

* The actual ambient depth is 19.51 m (64 feet), but CORMIX depth input altered due to model limitations.

** Only summer months (Jun-Sept) considered for modelling purposes.

ATTACHMENT 2
CORMIX SESSION REPORTS

RO REJECT - SALINITY

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 9.0GTS
DYDRO:Version-9.0.0.0 September,2014
SITE NAME/LABEL: Port Delfin Deepwater Port
DESIGN CASE: RO Reject - Salinity
FILE NAME: P:\A-F\Fairwood Peninsula Energy Corporation - Houston, TX - FA0701\WATER QUALITY\ACTIVE PROJECTS\P13411 - Delfin LNG\REPORTS\TO 2 USCG 141-142\CORMIX files\RO Reject unit - Salinity (Brine - mgL).prd
Using subsystem BCORMIX1: Single Port Brine Discharges
Start of session: 03/17/2016--13:29:29
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 12.58 m
Depth at discharge HD = 12.58m
Bottom slope (single slope only)SLOPE = 0.00 deg
Ambient velocity UA = 0.2 m/s
Darcy-Weisbach friction factor F = 0.2
Wind velocity UW = 6.5 m/s
Ambient Density Stratification with 1 subsurface level:
Surface density RHOAS = 1022.92 kg/m^3
Level 1 Submergence LEVEL1 = 15 m
Density at Level 1 RHOA1 = 1023.03 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 720000 m
Port diameter D0 = 0.1524 m
Port cross-sectional area A0 = 0.0182 m^2
Discharge velocity U0 = 1.54 m/s
Discharge flowrate Q0 = 0.028012 m^3/s
Discharge port height H0 = 11.36 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge density RHO0 = 1039.0395 kg/m^3
Density difference DRHO = -16.0733 kg/m^3
Buoyant acceleration GP0 = -0.1541 m/s^2
Discharge concentration C0 = 21075 mg/l

Surface heat exchange coeff.   KS   = 0 m/s
Coefficient of decay   KD   = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.14 m   Lm = 1.04 m   Lb = 0.54 m
LM = 1.44 m   Lm' = 99999 m   Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0   = 10.02
Velocity ratio   R   = 7.68

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:

Toxic discharge   = no
Water quality standard specified   = no
Regulatory mixing zone   = yes
Regulatory mixing zone specification   = distance
Regulatory mixing zone value   = 100 m (m^2 if area)
Region of interest   = 100000 m

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HYDRODYNAMIC CLASSIFICATION:

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*------------------------*
| FLOW CLASS   = IH1 |
*------------------------*
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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 = 12.58 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,
720000 m from the left bank/shore.
Number of display steps NSTEP = 20 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 = 48.751100 mg/l
Dilution at edge of NFR s = 432.3
NFR Location: x = 39.79 m
(centerline coordinates) y = -3.37 m
z = -12.57 m
NFR plume dimensions: half-width (bh) = 5.52 m
thickness (bv) = 5.52 m
Cumulative travel time: 167.6499 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.

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 = 48.751102 mg/l
Corresponding dilution s = 432.3
Plume location: x = 100 m
(centerline coordinates) y = -3.58 m
z = -12.57 m
Plume dimensions: half-width (bh) = 5.56 m
thickness (bv) = 5.47 m
Cumulative travel time: 468.7068 sec.

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.

******************** FINAL DESIGN ADVICE AND COMMENTS *********************
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.

RO REJECT – TSS

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 9.0GTS
DYDRO:Version-9.0.0.0 September,2014
SITE NAME/LABEL: Port Delfin Deepwater Port
DESIGN CASE: RO Reject - TSS
FILE NAME: P:\A-F\Fairwood Peninsula Energy Corporation - Houston, TX - FA0701\WATER QUALITY\ACTIVE PROJECTS\P13411 - Delfin LNG\REPORTS\TO 2 USCG 141-142\CORMIX files\RO Reject unit - TSS (Brine).prd
Using subsystem BCORMIX1: Single Port Brine Discharges
Start of session: 03/18/2016--12:41:14
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 12.58 m
Depth at discharge HD = 12.58m
Bottom slope (single slope only)SLOPE = 0.00 deg
Ambient velocity UA = 0.2 m/s
Darcy-Weisbach friction factor F = 0.2
Wind velocity UW = 6.5 m/s
Stratification Type STRCND = U
Surface density RHOAS = 1023 kg/m^3
Bottom density RHOAB = 1023 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 720000 m
Port diameter D0 = 0.1524 m
Port cross-sectional area A0 = 0.0182 m^2
Discharge velocity U0 = 1.54 m/s
Discharge flowrate Q0 = 0.028012 m^3/s
Discharge port height H0 = 11.36 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge density RHO0 = 1038.9400 kg/m^3
Density difference DRHO = -15.9400 kg/m^3
Buoyant acceleration GP0 = -0.1528 m/s^2
Discharge concentration C0 = 299 mg/l
Surface heat exchange coeff. KS = 0 m/s

Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.14 m Lm = 1.04 m Lb = 0.54 m

LM = 1.44 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0 = 10.06

Velocity ratio R = 7.68

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:

Toxic discharge = no

Water quality standard specified = no

Regulatory mixing zone = yes

Regulatory mixing zone specification = distance

Regulatory mixing zone value = 100 m (m^2 if area)

Region of interest = 100000 m

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HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IH1 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.

Applicable layer depth = water depth = 12.58 m

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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,

720000 m from the left bank/shore.

Number of display steps NSTEP = 20 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 = 0.694 mg/l

Dilution at edge of NFR s = 430.8
NFR Location: x = 37.74 m
(centerline coordinates) y = -3.36 m
z = -12.57 m
NFR plume dimensions: half-width (bh) = 5.51 m
thickness (bv) = 5.51 m
Cumulative travel time: 157.5712 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.

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 = 0.694005 mg/l
Corresponding dilution s = 430.8
Plume location: x = 100 m
(centerline coordinates) y = -3.58 m
z = -12.57 m
Plume dimensions: half-width (bh) = 7.02 m
thickness (bv) = 3.04 m
Cumulative travel time: 468.8555 sec.

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.

******************** FINAL DESIGN ADVICE AND COMMENTS *********************

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.

ESSENTIAL GENERATOR COOLING
THERMAL

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 9.0GTS
HYDRO1:Version-9.0.0.0 September,2014
SITE NAME/LABEL: Port Delfin Deepwater Port
DESIGN CASE: Cooling Water Discharge
FILE NAME: P:\A-F\Fairwood Peninsula Energy Corporation - Houston, TX - FA0701\WATER QUALITY\ACTIVE PROJECTS\P13411 - Delfin LNG\REPORTS\TO 2 USCG 141-142\CORMIX files\Cooling Water unit (Thermal).prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 03/18/2016--14:53:34
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 17.68 m
Depth at discharge HD = 17.68 m
Ambient velocity UA = 0.2 m/s
Darcy-Weisbach friction factor F = 0.2
Wind velocity UW = 6.5 m/s
Stratification Type STRCND = A
Surface density RHOAS = 1020.28 kg/m^3
Bottom density RHOAB = 1020.46 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 720000 m
Port diameter D0 = 0.4064 m
Port cross-sectional area A0 = 0.1297 m^2
Discharge velocity U0 = 0.29 m/s
Discharge flowrate Q0 = 0.037854 m^3/s
Discharge port height H0 = 11.96 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge density RHO0 = 1019.8469 kg/m^3
Density difference DRHO = 0.5231 kg/m^3
Buoyant acceleration GP0 = 0.0047 m/s^2
Discharge concentration C0 = 1.465 deg.C
Surface heat exchange coeff. KS = 0.000018 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
 LQ = 0.36 m   Lm = 0.53 m   Lb = 0.02 m
 LM = 2.47 m   Lm' = 99999 m   Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
 Port densimetric Froude number FR0   = 6.46
 Velocity ratio   R   = 1.46

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
 Toxic discharge   = no
 Water quality standard specified   = no
 Regulatory mixing zone   = yes
 Regulatory mixing zone specification   = distance
 Regulatory mixing zone value   = 100 m (m^2 if area)
 Region of interest   = 100000 m
****
HYDRODYNAMIC CLASSIFICATION:

 | FLOW CLASS   = IPH1 |

 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 = 17.68 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
 Origin is located at the BOTTOM below the port/diffuser center:
   720000 m from the left bank/shore.
 Number of display steps NSTEP = 20 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 = 0.0299 deg.C

Dilution at edge of NFR s = 49.0
NFR Location: x = 40.40 m
(centerline coordinates) y = -1.67 m
z = 17.68 m
NFR plume dimensions: half-width (bh) = 2.15 m
thickness (bv) = 2.15 m
Cumulative travel time: 197.1868 sec.

Buoyancy assessment:
The effluent density is less than the surrounding ambient water density at the discharge level.
Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards the surface.

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.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 15034.34 m downstream.

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 = 0.029568 deg.C
Corresponding dilution s = 423.4
Plume location: x = 100 m
(centerline coordinates) y = -1.67 m
z = 17.68 m
Plume dimensions: half-width (bh) = 5.25 m
thickness (bv) = 2.26 m
Cumulative travel time: 495.1653 sec.

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.

******************** FINAL DESIGN ADVICE AND COMMENTS *********************
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.