D H E C
PROMOTE PROTECT PROSPER
C. Earl Hunter, Commissioner
Promoting and protecting the health of the public and the environment

MEMORANDUM

To: NPDES Permittee

From: Water Facilities Permitting Division

Date: May 21, 2009

RE: NPDES Application Supplement
Mixing Zone Request Form

The Department has determined that your facility may be subject to whole effluent toxicity (WET) monitoring and/or limitations based on the nature of your discharge(s). In order to get the appropriate information needed to determine permit requirements, the attached documents have been developed to assist you in submitting this information.

As explained on the attached Mixing Zone Request and Mixing Zone Analysis and Boundary Conditions documents, there are different permitting scenarios. For situations in which the receiving stream is effluent-dominated (the IWC is at least 80%), no mixing zone demonstration is needed. However, in order for us to determine mixing zone size and WET requirements for all other discharge(s), **please complete the attached Mixing Zone Request, supplemental CORMIX Checklist for Data Preparation (only if CORMIX modeling is used – the form is on page 39 of the attached documents from the CORMIX 5.0 Users Manual), and provide a diagram of the discharge showing the input values used. Please submit these forms with an attached cover letter and a report, if necessary, describing the work performed and any other pertinent information relative to the discharge(s) that might influence WET requirements.** Instream assessments that have already been performed may be valuable additional information.

If you choose to perform a mixing zone demonstration, the Department recommends a proposed demonstration plan be submitted for review and approval prior to any work being performed. The proposal must address the factors outlined in the Mixing Zone Request Form. Depending on the time needed to complete a demonstration, a schedule of compliance with a final chronic WET limit at 100% may be placed in the permit to allow time for the demonstration to be performed and the results submitted. Upon approval of the demonstration, a permit modification will be necessary to place different WET requirements in the permit based on the results of the demonstration.

In addition to the above, please indicate whether a pass/fail (single dilution) or multi-concentration test is preferred. The pass/fail, or single dilution, test provides for a confidence level of 99% on a chronic test for determining whether a test statistically passes or fails. The data from a pass/fail test may not, in some situations, be useful in determining whether reasonable potential for WET exists. The multi-concentration test, however, provides more information on toxicity over a range of concentrations and may give enough information to show that reasonable potential does not exist. The limitations for a multi-concentration test are expressed as a percent effect and allow for averaging of test results. A pass/fail test has a maximum pass or fail limit and does not allow for averaging of results to demonstrate compliance.

Should you have any questions or comments, please contact your permit writer or this office at 803-898-4300.

DHEC

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South Carolina Department of Health and Environmental Control

NPDES APPLICATION SUPPLEMENT

Mixing Zone Request for Surface Water Discharges

NPDES #: ____________________

Facility Name: ____________________

County: ____________________

Are you requesting a mixing zone for whole effluent toxicity (WET) in accordance with the back of this form?

☐ **No**. No further information is needed. Submit this form. If WET testing is required, a chronic test at 100% will be required, unless the IWC is at least 80%. Proposed IWC __________%

☐ **Yes**. Check one of the boxes below and submit this form with the appropriate information.

☐ Check this block if you are proposing to perform or have performed a mixing zone demonstration to determine the appropriate zone of initial dilution (ZID) and/or mixing zone size. Complete the remainder of this form and submit a mixing zone demonstration plan as described on the back of this form. The Department recommends the demonstration plan be approved prior to implementation of any demonstration work.

☐ Check this block if you are requesting a mixing zone by providing limited information such as a mixing model like CORMIX to determine mixing in accordance with suggested zone of initial dilution (ZID) and/or mixing zone sizes. Complete the remainder of this form, as applicable, and submit the CORMIX Supplement and modeling results (or other model assumptions, inputs and results).

What is the proposed ZID size (in meters)? Length: _______m Width:________m

What is the proposed acute WET test concentration? ____________%

What is the proposed mixing zone size (in meters)? Length: ______m Width:______m

What is the proposed chronic WET test concentration? ____________%

Printed Name: ____________________ **Firm:** ____________________

Signature: ____________________ **Date:** ____________________

Mixing Zone Analysis and Boundary Conditions

Mixing zones must have the qualities of no acutely toxic impact, must allow for safe passage of aquatic organisms, must provide for protection of existing and designated uses of the waterbody, and must not endanger public health and welfare. The Department recognizes different methods for establishing a mixing zone and its boundary conditions and suggests using the following protocol.

The Department has approved the establishment of mixing zones using the following methods of analysis.

- CORMIX modeling or other modeling tools (use the attached information from Chapter 4 of the CORMIX 5.0GT Manual)
- Instream assessments using dyes or conductivity measurements.
- Other appropriate methods.

Boundary conditions of mixing zones may be established as follows.

- *Effluent dominated discharges.* For situations where the instream waste concentration (IWC) using design flow conditions for domestic facilities or long term average flow for industrial facilities and where critical flow conditions (e.g., 7Q10) represent at least 80%, the Department considers that the discharge will be completely mixed within a reasonably minimized area and therefore, test concentrations may utilize 100% of the critical flow condition (e.g., 7Q10). Therefore, use of the complete dilution of the receiving body is appropriate.

- *Other discharges*. For other situations, a demonstration is required to minimize the mixing zone by using the above-mentioned methods to determine chronic mixing permit conditions based on a boundary of one-half the width of the stream (width) and a length downstream of twice the width of the river. Acute mixing conditions are based on a boundary of one-tenth the width of the stream (width) and a length downstream of one-third the width of the river. At the discretion of the permittee (or applicant), an alternative analysis may be prepared for possibly larger mixing zone boundaries, but methods should be used that address a mixing zone analysis consistent with the EPA Technical Support Document for Water Quality-based Toxics Control (TSD) and the water quality standards regulatory mixing zone requirements (e.g., biological, chemical, engineering, hydrological and physical factors).

- *Discharges with Diffusers.* Where a properly installed diffuser provides for a mixing zone that meets the criteria above and addresses biological, chemical, engineering, hydrological and physical factors, a test concentration can be set in a permit at the justified percentage of the critical flow condition (e.g., 7Q10) up to 100% of that critical flow condition. For boundary conditions, please see above.

Mixing Zone Request
for
Surface Water Discharges

1. Purpose:

This supplement will be completed as part of the NPDES permitting application. It will be provided to the Department for any new or reissuance NPDES permit application. This supplement is to provide a written statement on NPDES permit applicants request for a mixing zone as may be allowed.

2. General:

Mixing zone demonstration information will be submitted along with this form.

3. Item by Item Instructions:

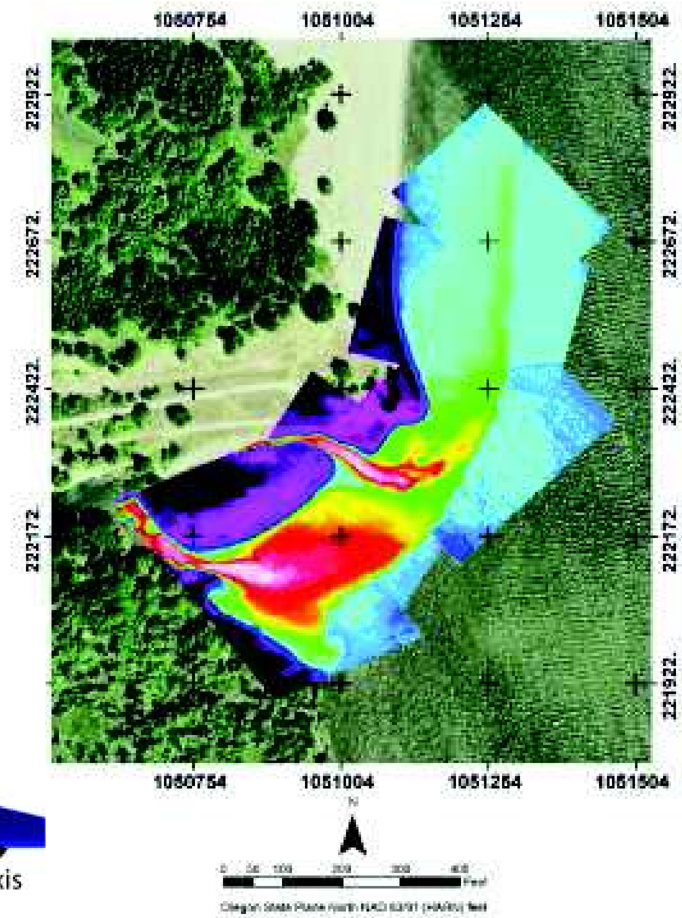
NPDES # :	Enter the NPDES permit of the facility. If this is a new discharge, enter Anew discharge.@
Facility Name:	Enter the name of the facility.
County:	Enter the county of the facility.
Questions:	Answer the questions and provide the appropriate information for a mixing zone demonstration, if applicable.
Printed Name:	Print name of individual signing the form.
Firm:	Enter the name of the company or engineering firm that the individual signing this form is employed by.
Signature:	Signature of responsible official.
Date:	Enter date form was signed.

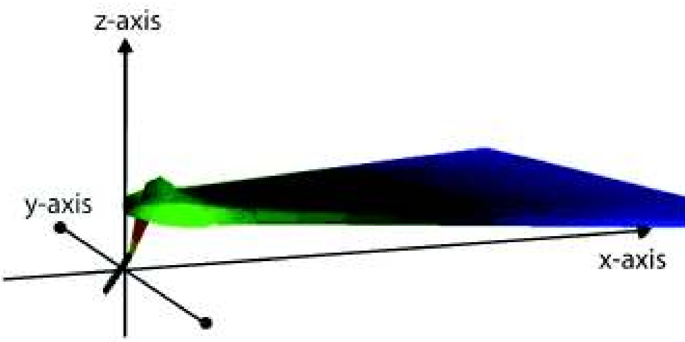
4. Office Mechanics:

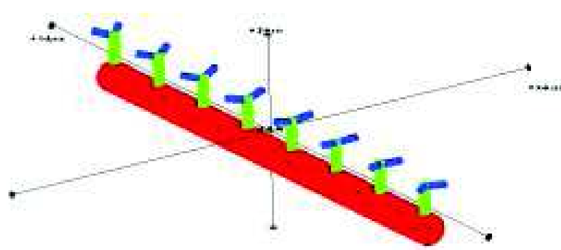
Copies of this supplement along with the required information on a mixing zone demonstration are provided to the Department with an NPDES permit application. This supplement is filed in the NPDES permit file.

CORMIX USER MANUAL

A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters







Chapter 4

CORMIX Data Input

4.1 General Aspects of Interactive Data Input

All CORMIX data input occurs interactively in a forms-based Windows graphical user interface (GUI). The user is automatically and sequentially prompted by a highlighted yellow data input box to complete specification of input data through mouse and keyboard inputs. Figure 4.1 shows the main CORMIX GUI with an active "Project" data tab.

Input data groups are arranged in six topical "tabs" which are: **Project** descriptions, **Effluent** properties, **Ambient** conditions, **Discharge** conditions, **Mixing Zone** definitions, and **Output** control as shown in Figure 4.1. The **Processing** tab controls program execution only; it has no required input data. Each of these six topical areas form input data sequences and are called "tabs" herein.

Several methods of user help are available internally through system prompts and externally via a web browser. Multiple layers of advice are available to provide help on how to prepare and enter data values when clarification is needed.

The "Online Help" command loads the program **User Guide** into a web browser. The User Guide contains a complete description of GUI menus, functions, and icons as well as hints for use. A technical description of program assumptions and data requirements is also available in the documentation reports (1,11,36).

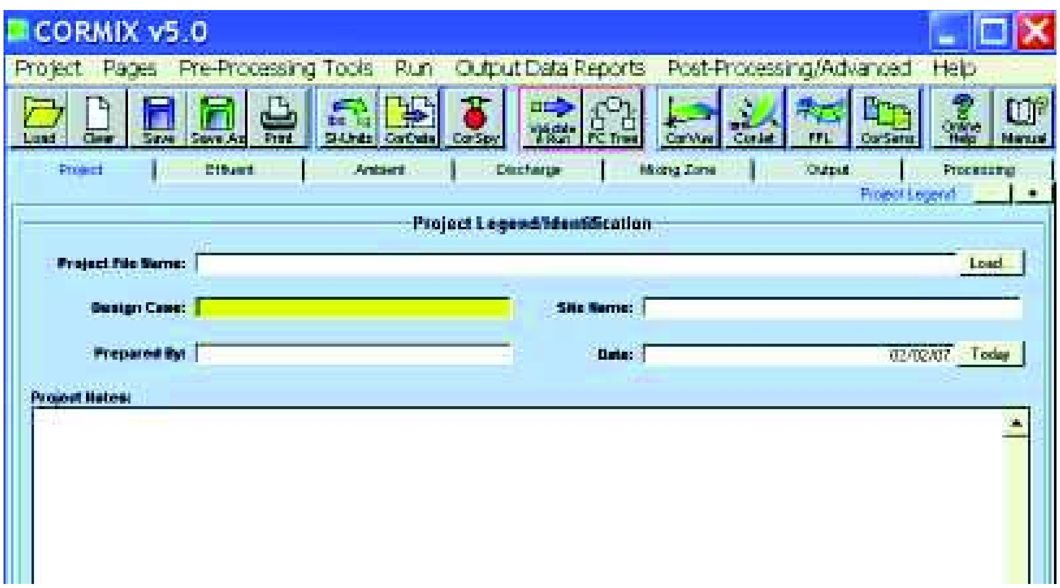


Figure 4.1 *CORMIX Graphical User Interface (GUI) with active Project Tab (top half of window shown only).*

Data can be entered in an open format without concern for decimal placement. The system checks data entries for consistency with question type (e.g. an alphabetic character for water depth), obvious physical errors (e.g. a negative length), possible inconsistencies with previous entries (e.g. an angular value implying that a port points directly back to the shoreline) and situations outside the normal range of model applicability. Inconsistency in data input values entered and obvious physical errors require immediate re-entry while possible inconsistencies with previous entries lead to warning messages issued in the Processing Record. Entries specifying situations outside the ranges of model applicability usually require data re-entry. The prompt is then set within the data entry tab and box needing correction.

> ***Warning:*** No attempt should be made to alter input data by manipulating any of the internal system data files that are used by the hydrodynamic programs and execute these programs separately without using the GUI and logic segments contained within CORMIX. Because of the inherent error and compatibility checking of input data within these program elements, unreliable prediction may result if they are bypassed! In addition, running CORMIX in a network environment within a "remote desktop" may cause unreliable results.

As discussed in Chapter 3, data input occurs by completing the input data tabs. Data input tabs and values may be completed in any order. It is recommended however that the tabs be completed in order from left to right in sequence. If a data value entered is not accepted (i.e. an error has been made) the user has another opportunity for entering corrected values.

It should be noted that only data entered will be used in a simulation. The program defaults to automatically erase data entered within a tab if the user changes how data values are specified. For example, if within the ambient data tab the user selects "bounded section" and enters a width value, then later changes the tab selection to "unbounded section" the previously entered width data will be erased. This behavior reflects the "positive data entry" convention used in CORMIX and is intended to prevent running a simulation with data entered by mistake or error in GUI interaction.

Due to the similarity of data entry, a common description is given for all input data sequences except discharge data to which a separate subsection for each CORMIX discharge configuration. Further guidance on data specification can be obtained from examining the case studies in the Appendices and the documentation manuals (1,11,36). Following the discussion of input data sequences, units of measure conversion factors and checklists for input preparation are presented.

The "Advanced User Mode" available within the Pre-processing drop down menu is intended to streamline data input and program control for experienced users. This mode will limit warning messages issued to the user and make Tool Bar icon buttons default to function on the data contained in the current GUI state.

All the data input requirements of CORMIX are included in the **Checklist for Data Preparation** (see following page) that can be photocopied by the reader for future multiple use. The checklist aids in the assembly and preparation of this data prior to beginning an analysis to verify that all necessary data are available.

4.2 Project Data Tab

The first data tab "Project" determines basic information needed for the program to operate, store files, and label simulations for later use. The first step in a new simulation is to use the "Save" command to create a new project input data file name. An active Project tab appears in Figure 4.1. In the evaluation (E) version, the "Save" command is not operable, thus loading a case from the sample file directory is suggested.

The user then supplies a Project File Name (fn), up to 256 characters long, and without extension (e.g.

CORMIX Checklist for Data Preparation – Version v5.0

PROJECT LEGEND

Project File Name: ____________________ **Design Case**: ____________________
Site Name: **Prepared By**: **Date**:

EFFLUENT DATA

☐ **Non-Fresh Water Effluent Density**

Density ρ_0: ....kg/m³

Discharge Excess Concentration:.................

☐ **Fresh Water Effluent Density**

☐ Temperature T_0: .... °C ☐ Density ρ_0: .... kg/m³

☐ Effluent Flowrate Q_0: ....m³/s ☐ Effluent Velocity U_0: ....m/s

Pollutant Types

☐ Conservative ☐ Non Conservative: ..../day ☐ Heated – Heat Loss Coefficient: ....W/m²/°C

☐ **Brine** ☐ **Sediment:** Chunks: .... % Sand: .... % Coarse Silt: .... % Fine Silt: ....% Clay: .... %
Total Sediment Concentration:........... kg/m³

AMBIENT GEOMETRY / FLOW FIELD DATA

Average Depth H_a: .... m
Depth at Discharge H_d: .... m

☐ **Unbounded**

☐ **Bounded**: Width BS: .... m
Appearance: ☐ Uniform ☐ Slight Meander ☐ Highly Irregular

☐ **Steady**

☐ Ambient Flowrate Q_a .... m³/s
☐ Ambient Velocity U_a .... m/s

☐ **Unsteady**

Period ....hr Max Velocity U_m .... m/s Tidal Velocity at this Time U_a: .... m/s
☐ At Time: ....hr Before Slack ☐ At Slack – Δ Time: .....hr ☐ At Time: ....hr After Slack

☐ **Single Slope**

Slope S: .... %
Near Shore Velocity:................................ m/s
Near Shore Darcy-Weisbach f: ....

☐ **Near & Far Slope**

☐ Near Shore Slope S_1 ....% ☐ Far Slope S_2: .... %
☐ Near Shore Velocity U_{a1}.......................m/s ☐ Far Shore Velocity U_{a2}: .... m/s
☐ Near Shore Darcy-Weisbach f_1: .... ☐ Far Shore Darcy-Weisbach f_2: ....
☐ Breakpoint: .... m

☐ Manning's n: .... Wind Speed: ....m/s

AMBIENT DENSITY DATA

Water Body: ☐ **Fresh Water** ☐ **Non-Fresh Water**

☐ **Uniform** — **Fresh**: ☐ Temperature: .... °C ☐ Density ρ_a: .... kg/ m³ — **Non-Fresh**: Density ρ_a: .... kg/ m³

☐ **Stratified** — ☐ **Type A** ☐ **Type B**: Pycnocline Height: ....m ☐ **Type C**: Pycnocline Height: ....m Jump: ....kg/ m³ / °C
Density ρ: At Surface ρ_{as} .... kg/m³/ °C At Bottom ρ_{ab}:................................ kg/ m³ / °C

☐ **Brine & Sediment Only** Level 1 Density ρ_1: .. kg/ m³ Sub 1:...........m; Level 2 Density ρ_2:.......kg/ m³ Sub 2:........... m

DISCHARGE GEOMETRY DATA

CORMIX 1 – Single Port

Nearest Bank: ☐ Left ☐ Right
Dist. to Nearest Bank: .... m
Vert. Angle θ_0:...... °; Horiz. Angle σ_0:..... °
☐ Port Diameter D_0: ....m
☐ Port Area A_0: ....m²

Submerged

Port Height above Bottom h_0: .... m

Above Surface

Port Height above Surface..................... m
☐ Jet-like ☐ Spray ☐ Area
Deflector Plate: . ☐ With or ☐ Without

CORMIX 2 – Multiport

Nearest Bank: ☐ Left ☐ Right
☐ Unidirectional ☐ Staged ☐ Altern./ Vert.
Nº of openings:........; Diffuser Length:.......... m
Dist. to 1nd end-point YB_1: ....m
Dist. to 2st far end-point YB_2: ....m
Port Height h_0: ....m; Port Diameter D_0: .... m
Contraction Ratio:...........

Angles (degrees)

Vert. Angle θ:........°; Horiz. Angle σ: .... °
Align. Angle γ: ......°; Relat.Orient. Angle β:...... °
Nozzle Direction: ☐ Same or ☐ Fanned Out

CORMIX 3 – Surface Discharge

Discharge Located: ☐ Left ☐ Right
Horiz. Angle σ: ....°
Local Depth at Discharge Outlet: .... m
☐ **Flush** ☐ **Co-flowing**
☐ **Protruding:** Distance from Bank: .... m

Discharge Outlet

☐ **Channel:** Width: ....m; Depth b_0: ..... m
☐ **Pipe:** Diameter D_0: .... m
Bottom Invert Depth:.................................... m
Local Bottom Slope at Chanel Entry:............ °

MIXING ZONE DATA

☐ **Non-Toxic Effluent** ☐ **Toxic Effluent**

☐ WQ Standard: .... ☐ No WQ Standard CMC : .... CCC : ....

☐ **Mixing Zone Specified** ☐ **No Mixing Zone Specified**

☐ Trajectory: ....m ☐ Downstream Distance: ....m ☐ Width: ....% / m ☐ Area: .... %
Region of Interest: ....m Grid Intervals for Display: ....

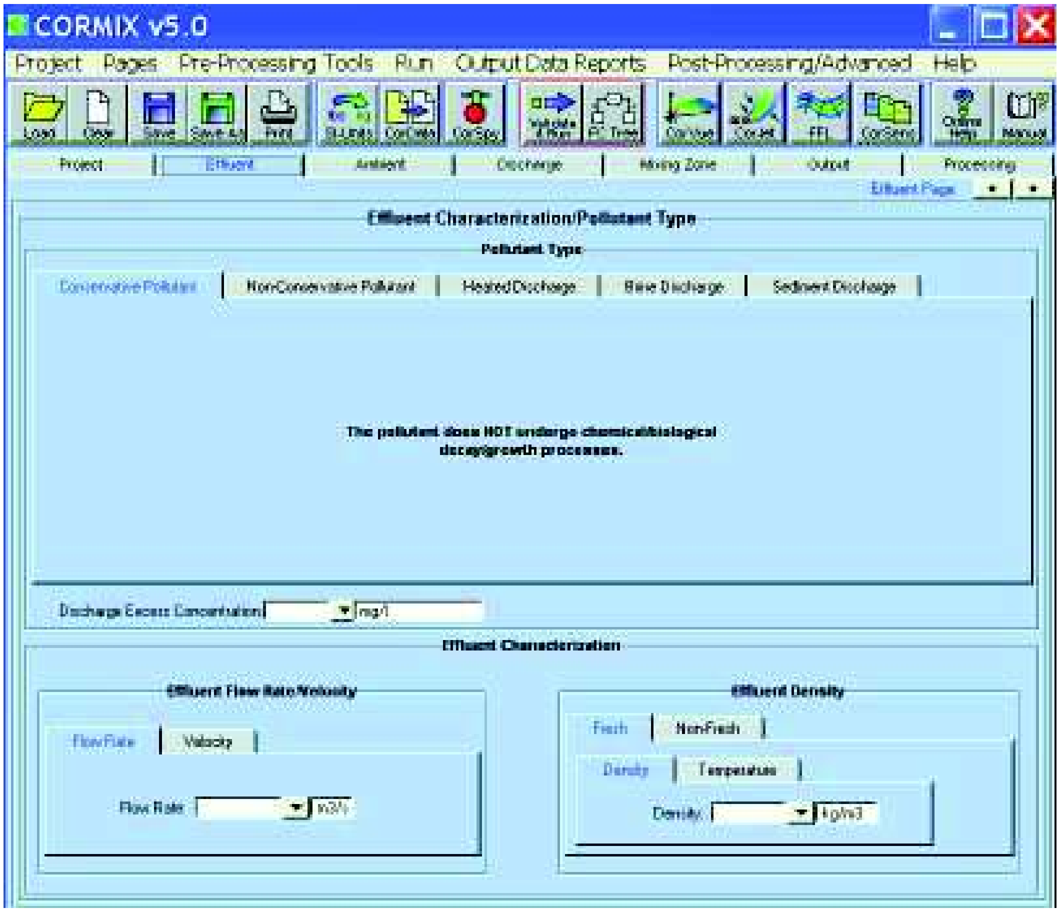


Figure 4.2 ***Effluent data tab**. Effluents may be specified as conservative, non-conservative (1st order growth/decay), heated, brine, or sediment. Specification of brine or sediment effluents will restrict ambient data to unbounded coastal environments.*

Multiport Low Flow Q0= 2.4 cms). CORMIX will use that user-specified file name to create, transfer, or store intermediate or final data files with that same file name, but with different extensions. The most important of these are the *input data file* (fn.cmx) and the *prediction output* and *session report* files, fn.prd and fn.ses, respectively. These are discussed further in Chapter 5.

For the Project tab it is also recommended to specify design case and site name labels that facilitate the rapid identification of printed output and aid in good record-keeping. The system provides for one label called "Site Name" (e.g. "Blue River"), another called "Design Case "(e.g. "7Q10-low-flow" or "high-velocity-port"). The user may also enter name or initials in the "Prepared by" data entry box. The "Project Notes" box accepts multiple lines of character input to further assist in record keeping.

4.3 Effluent Data Tab

The "Effluent" tab is used to specify effluent properties in CORMIX. An active Effluent tab appears in Figure 4.2. The type of effluent entered in this tab is used in subsequent input tabs to modify the data value sought by the system to complete a simulation. For example, if a brine effluent type is specified, the ambient data tab will allow only specification of unbounded sections because of hydrodynamic modeling assumptions.

4.3.1 Pollutant Type Data

The “Pollutant” type data in CORMIX allows five types of pollutant discharges. The pollutant types are:

1. **Conservative Pollutant —** The pollutant does not undergo any decay/growth processes. Typically, most discharges will be specified as conservative.
2. **Non-conservative Pollutant —** The pollutant undergoes a first order decay or growth process. One needs to specify the **coefficient of decay** (positive number) or **growth** (negative number) in units of day^{-1} (per day).
3. **Heated Discharge —** The discharge will experience heat loss to the atmosphere in cases where the plume contacts the water surface. This is important primarily for thermal discharge sources in predicting far-field plume behavior. It is necessary to specify the discharge condition in terms of excess temperature (ΔT or “delta T”) above ambient in units ^oC (degC), and the **surface heat exchange coefficient** in units $W/m^2, ^oC$. Values of the heat exchange coefficient depend on ambient water temperature and wind speed. Table 4.1 provides a guideline for the selection of heat loss coefficients (23).
4. **Brine Discharge —** This type of discharge typically results from desalination concentrate disposal or other industrial discharge sources. Within CORMIX, brine discharges are always assumed to have discharge densities greater than the ambient environments into which they discharge (i.e. brine discharges are strongly negatively buoyant (dense)).

For most dense single port and multiport diffuser discharges, it is recommended that mixing behavior be first assessed as a conservative effluent type by specified by a discharge density greater than ambient density. In subsequent analysis, the Brine effluent type may be specified for additional details of mixing behavior after boundary interaction in the far-field. Furthermore, in brine cases additional information about ambient conditions will be needed and certain restrictions will be imposed as discussed below. However, dense (negatively buoyant) surface (shoreline) discharges sources must always be specified as a brine or sediment effluent type.

If the brine tab is selected, the user can also enter a brine tracer concentration (C0) which can be conservative, non-conservative, or heated, similar to that described above.

Table 4.1 *Heat Loss Coefficients ($W/m^2, ^oC$). Ref: “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 Tech., 1981.*

Ambient Water	Wind Speed (m/s)					
Temp (°C)	0	1	2	3	4	5
5	5	10	14	24	33	42
10	5	11	16	27	38	49
15	5	12	18	31	44	59
20	5	14	21	38	52	68
25	6	16	25	45	63	82
30	6	19	30	54	76	100

5. **Sediment Discharge —** Discharges with suspended sediment are typically the result of dredging operations. Within CORMIX, all Sediment discharge effluents are assumed to have densities greater than ambient.

   Five sediment class sizes are supported (large chunky solids, sand, coarse silt, fine silt, and clay), and sedimentation is modeled using Stokes settling. Table 4.2 shows sediment size classes.

   In addition, a conservative or non-conservative tracer pollutant may be issued in the discharge, similar to that described above.

Table 4.2 *CORMIX Sediment Size Classes*

Sediment Size Class	Particle Size
Chunks/Solids	Large non-suspended solids and stones
Sand	62 mm
Coarse Silt	16-62 mm
Fine Silt	3.3-16 mm
Clay	< 3 mm

For all effluents, the source mass and buoyancy flux of the pollutant is needed. Therefore, the following input data is required:

1. **Effluent discharge flow rate (Q0)** or **discharge velocity (U0)**,
2. **Discharge density** or **discharge temperature** for essentially freshwater discharges, and
3. **Discharge concentration** of the material of interest.

The Q0 and U0 variables are related through the port cross sectional area and the program computes and displays the alternate value allowing for user inspection and verification. For freshwater effluents, discharge density can be directly related to temperature via an equation of state since the addition of any pollutant or tracer has negligible effect on density.

In all cases, the **discharge tracer concentration (C0)** of the material of interest (pollutant, tracer, or temperature) is defined as the ***excess*** concentration above any ambient background concentration of that same material. The user can specify this quantity in any **units of concentration** (e.g. mg/l, ppm, %, ^{o}C). CORMIX predictions should be interpreted as computed excess concentrations in these same units.

If no pollutant data is available, it is convenient to specify C0 = 100%.

4.4 Ambient Data Tab

An active "Ambient" data tab is shown in Figure 4.3. Ambient conditions are defined by geometric and hydrographic conditions in the discharge vicinity. Due to the significant effect of boundary interactions on mixing processes, the ambient data requirements for the **laterally bounded** and **unbounded** analysis situations are presented separately below.

CORMIX analyses, as all mixing zone evaluations, are usually carried out under the assumption of steady-state ambient conditions. Even though the actual water environment is never in a true **steady-state**, this assumption is usually adequate since mixing processes are quite rapid relative to the time scale of hydrographic variations. In highly **unsteady tidal reversing** flows, the assumption is no longer valid and significant concentration buildup can occur. CORMIX assesses this situation and computes some re-entrainment effects on plume behavior. The data requirements for that purpose are discussed in Section 4.4.3. Following are discussions on ambient density specification and on wind effects.

CORMIX requires that the actual cross-section of the ambient water body be described by a rectangular channel that may be laterally bounded or unbounded (15). Furthermore, that channel is assumed to be uniform in the downstream direction, following the

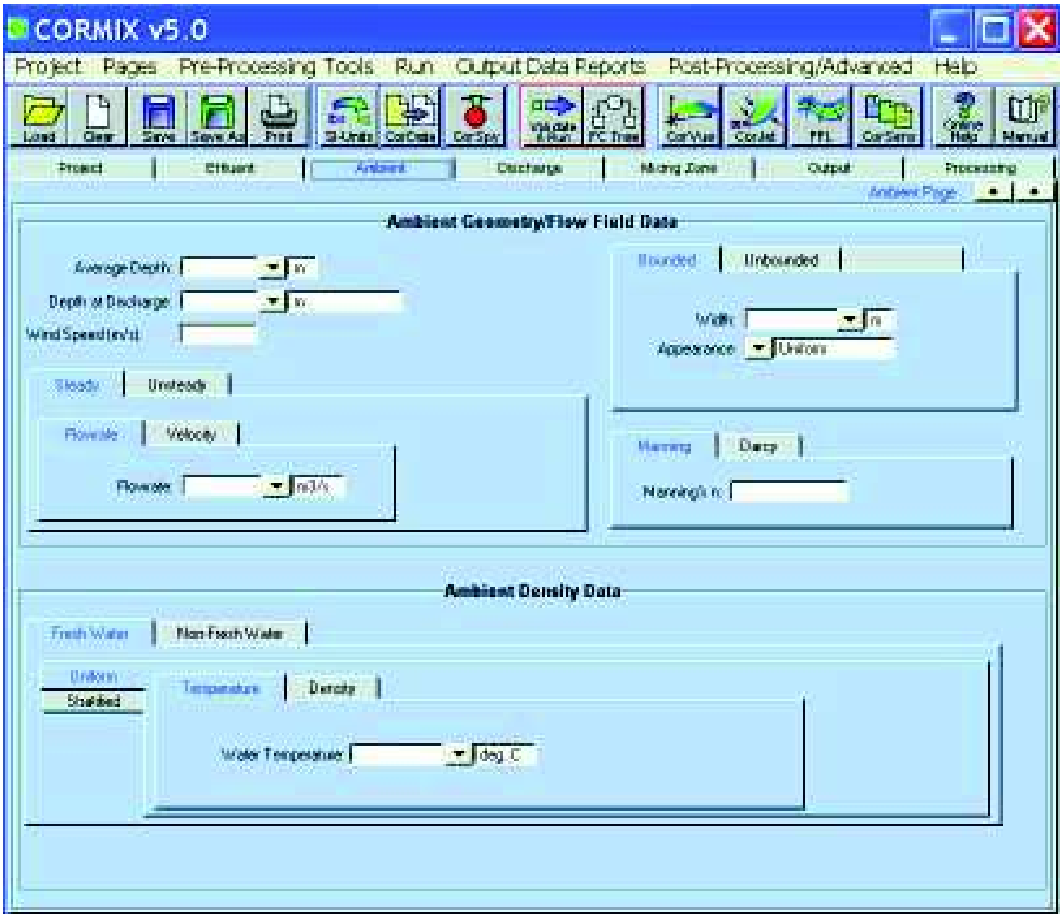


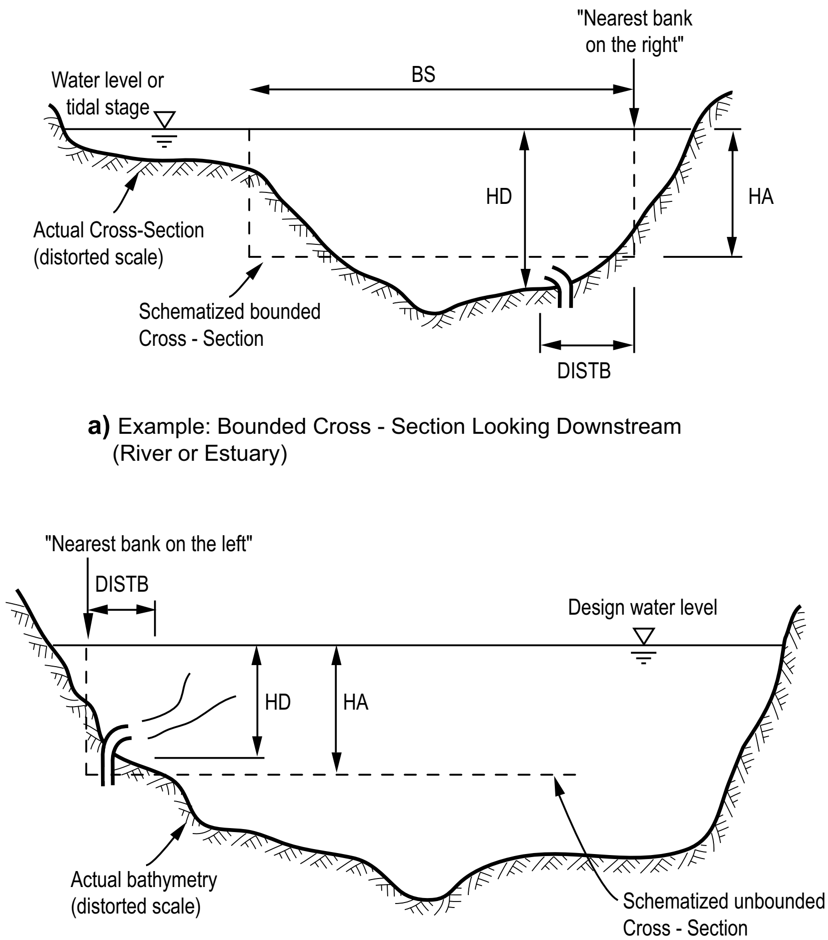
Figure 4.3 ***Ambient data tab.*** *Options are available to specify bounded/unbounded sections, ambient density profile, and discharge velocity field.*

mean flow of the actual water body that may be non-uniform or meandering. The process of describing a receiving water body's geometry with a rectangular cross-section is herein called **schematization**. Examples of schematization are shown in Figure 4.4.

Additional aids exist for the CORMIX user to interpret plume behavior in the far-field of actual non-uniform (winding or meandering) flows in rivers or estuaries (see Section 6.2 for the post-processor option FFL).

The first step towards specifying ambient conditions is to determine whether a receiving water body should be considered "bounded" or "unbounded." To do this, as well as answer other questions on the ambient geometry, it is usually necessary to have access to cross-sectional diagrams of the water body. These diagrams should show the area normal to the ambient flow direction at the discharge site and at locations further downstream. If the water body is constrained on both sides by banks such as in rivers, streams, narrow estuaries, and other narrow watercourses, then it should be considered "bounded." However, in some cases the discharge is located close to one bank or shore while the other bank for practical purposes very far away. When interaction of the effluent plume with the far bank or shore is impossible or unlikely, then the situation should be considered "unbounded." This includes discharges into wide lakes, wide estuaries, and coastal areas.

If the effluent type is brine or sediment, then an unbounded cross-section is assumed in all simulations.



a) Example: Bounded Cross - Section Looking Downstream (River or Estuary)

b) Example: Unbounded Cross - Section Looking Downstream (Small Buoyant Jet Discharge Into Large Lake or Reservoir)

Figure 4.4 *Examples of the schematization process for preparing CORMIX input data on ambient cross-sectional conditions*

4.4.1 Bounded Cross-Section

Both geometric (bathymetric) and hydrographic (ambient discharge) data should be used for defining the appropriate rectangular cross-section. This schematization may be quite evident for well channeled and regular rivers or artificial channels. For highly irregular cross-sections, it may require more judgment and perhaps several iterations of the analysis to get a better grasp on the sensitivity of the results to the assumed cross-sectional shape.

In any case, the user is advised to consider the following:

1. Be aware that a particular flow condition such as a river discharge is usually associated with a certain water surface elevation or "stage." Data for a stage discharge relationship is normally available from a **USGS** office; otherwise it can be obtained from a separate hydraulic analysis or from field measurements.

   In the simplest case of a river flow, if river depth is known for a certain flow condition (subscript 1 in the following) corresponding perhaps to the situation at the time of a field study, then the depth for a given design (e.g. low) flow (subscript 2) can be predicted from Manning's equation which is:

$$HA_2 = HA_1 \left[\frac{QA_2}{QA_1} \right]^{\frac{3}{5}}$$

in which QA is the ambient river flow and HA the mean ambient depth. This approach assumes that ambient width and frictional characteristics of the channel (i.e. *Manning's n*) remain approximately the same during such a stage change.

2. For the given stage/river discharge combination to be analyzed, assemble plots showing the cross-sections at the discharge and several downstream locations. Examine these to determine an "equivalent rectangular cross sectional area." Very shallow bank areas or shallow floodways may be neglected as unimportant for effluent transport. Also, more weight should be given to the cross-sections at and close to the discharge location since these will likely have the greatest effect on near-field processes. Figure 4.4a provides an example of the schematization process for a river or estuary cross-section.

3. The input data values for surface width (BS) and average depth (HA) should be determined from the equivalent rectangular cross-sectional area. When ambient discharge and velocity data are available, the reasonableness of the schematization should be checked with the continuity relation. Continuity specifies that ambient discharge equals velocity times cross-sectional area, where the area is given by the product of average width and depth.

   The discussion of the cumulative discharge method and FFL in Section 6.5 will provide additional perspective on the choice of these variables.

4. CORMIX also requires specification of the actual water depth (HD) in the general discharge location to describe local bathymetric features. A check is built in to ensure the local depth HD does not to differ from the schematized average depth HA by more than +/- 30%. This restriction is included to prevent CORMIX misuse in discharge/ambient combinations involving strongly non-uniform channels. Alternative schematizations can be explored by the user to work around the restriction. The choice for these alternatives may be influenced somewhat by the expected plume pattern. As an example, Figure 4.4b illustrates a small buoyant discharge that is located on the side slope of a deep reservoir and is rising upward. In this situation, the correct representation of the deeper mean reservoir depth is irrelevant for plume predictions. Although the illustration is for an unbounded example, the comments on choice of HA apply here too.

   When schematizing HA and HD in highly non-uniform conditions, HD is the variable that usually influences near-field mixing, while HA is important for far-field transport and never influences the near-field.

5. The ambient discharge (QA) or mean ambient velocity (UA) may be used to specify the ambient flow condition. Depending on which is specified, the program will calculate one and display the other. The displayed value should be checked to see whether it is consistent with schematizations and continuity principles discussed above.

   The simulation of stagnant conditions should usually be avoided. If zero or a very small value for ambient velocity or discharge is entered, CORMIX will label the ambient environment as stagnant. In this case, CORMIX will predict only the near-field of the discharge, since steady-state far-field processes require a mean transport velocity. Although stagnant conditions often, but not necessarily always, represent the extreme limiting case for a dilution prediction, a real water body never is truly stagnant. Therefore, a more realistic assumption for natural water bodies would be to consider a small, but finite ambient crossflow.

6. As a measure of the roughness characteristics in the channel, the value of Manning's *n*, or alternatively the Darcy-Weisbach friction factor *f*, must be specified. Friction values are useful for applications in laboratory studies. If Manning's *n* is given, as is preferable for field cases, CORMIX internally converts it to an *f* friction value using the following equation in which $g = 9.81\ m/s^2$.

$$f = 8g \frac{n^2}{HA^{1/3}}$$

The friction parameters influence the mixing process only in the final far-field diffusion stage and do not have a large impact on the predictions. Generally, if these values can be estimated within +/- 30%, the far-field predictions will vary by +/- 10% at most. The list shown in Table 4.3 is a brief guide for specification of Manning's *n* values; additional details are available in hydraulics textbooks.

7. The channel appearance can have an effect on the far field mixing by increasing turbulent diffusivity for the passive mixing process but will not significantly affect near-field mixing. Three channel appearance types are allowed in CORMIX. Type 1 are fairly straight and uniform channels. Type 2 have moderate downstream meander with a non-uniform channel. Type 3 are strongly winding and have highly irregular downstream cross-sections.

4.4.2 Unbounded Cross-section

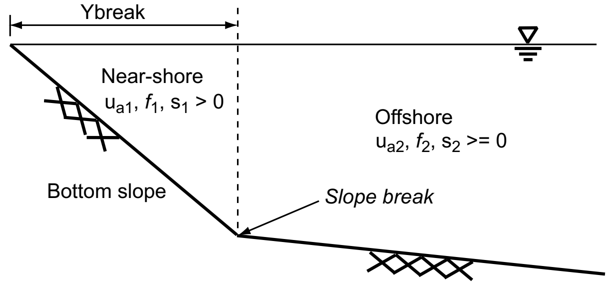
Hydrographic and geometric information are closely linked in unbounded cross-sections. The following comments apply:

1. From lake or reservoir elevation or tidal stage data, determine the water depth(s) for the receiving water condition to be analyzed.
2. For the given receiving water condition to be analyzed, assemble plots showing water depth as a function of distance from the shore for the discharge location and for several positions downstream along the ambient current direction.
3. If detailed hydrographic data from field surveys or from hydraulic numerical model calculations are available, determine the "cumulative ambient discharge" from the shore to the discharge location for the discharge cross-section. For each of the subsequent downstream cross-sections, determine the distance from the shore at which the same cumulative ambient discharge has been attained. Mark this position on all cross-sectional profiles. Examine the vertically averaged velocity and depth at these positions to determine typical values for ambient depth (HA) and ambient velocity (UA) input specifications. The conditions at, and close to, the discharge location should be given the most weight. The distance from the shore (DISTB) for the outfall location is typically specified as the cumulative ambient discharge divided by the product UA times HA.

Table 4.3 *Typical values for channel roughness*

Channel type	Manning's n
Smooth earth channel, no weeds	0.020
Earth channel, some stones and weeds	0.025
Clean and straight natural rivers	0.025 - 0.030
Winding channel, with pools and shoals	0.033 - 0.040
Very weedy streams, winding, overgrown	0.050 - 0.150
Clean straight alluvial channels	$0.031\ d^{1/6}$
(d = 75% sediment grain size in feet)	

Side View



Unbounded Cross-section for Brine/Sediment Effluents

1. Bounded laterally on one side only
2. Uniform ambient near-shore current field u_{a1} = constant$_1$; u_{a2} = constant$_2$
3. Positve near-shore slope s_1 with break to offshore slope s_2 at distance Ybreak
4. Near-shore Darcy friction factor f_1; offshore Darcy friction factor f_2
5. Uniform channel in downstream direction

Figure 4.5 *Offshore ambient schematization for brine and sediment effluent types. Near-shore slope s_1 must be > 0; offshore slope s_2 can be > or = 0.*

When detailed hydrographic data are unavailable, data or estimates of the vertically averaged velocity at the discharge location can be used to specify HA, UA, and DISTB. First, determine the cumulative cross-sectional area from the shore to the discharge location for the discharge cross-section. For each of the subsequent downstream cross-sections, mark the position where the cumulative cross-sectional area has the same value as at the discharge cross section. Then proceed as discussed in the preceding paragraph.

4. The specification of the actual water depth at the submerged discharge location (HD) in single ports and multiport diffusers is governed by considerations that are similar to those discussed earlier for bounded flow situations. Figure 4.4b shows an illustration of the schematization for a small buoyant discharge located on the side slope of a deep reservoir. The plume is expected to rise upward and stay close to one shore, with bottom contact and vertical mixing not expected. In this situation, no emphasis on replicating the mean reservoir depth and the actual width is necessary. However, care must still be taken to specify an ambient mean velocity that is characteristic of the actual reservoir and not determined using the reduced depth assumption.

   The specification of HD for shoreline or surface discharges is dictated by the depth condition some distance offshore from the discharge exit. HD does not describe the conditions immediately in front of the shoreline discharge channel exit. When in doubt, set HD equal to HA in the surface discharge case.

5. Either Manning's *n* or the Darcy-Weisbach friction factor *f* can be specified for the ambient roughness characteristics as described previously for the bounded case (see Section 4.4.1). If the unbounded case represents a large lake or coastal area, it is often preferable to use the friction factor *f*. Typical *f* values for such open water bodies range from 0.020 to 0.030, with larger values for rougher conditions. Table 4.3 shows typical Manning *n* values for various bottom materials.

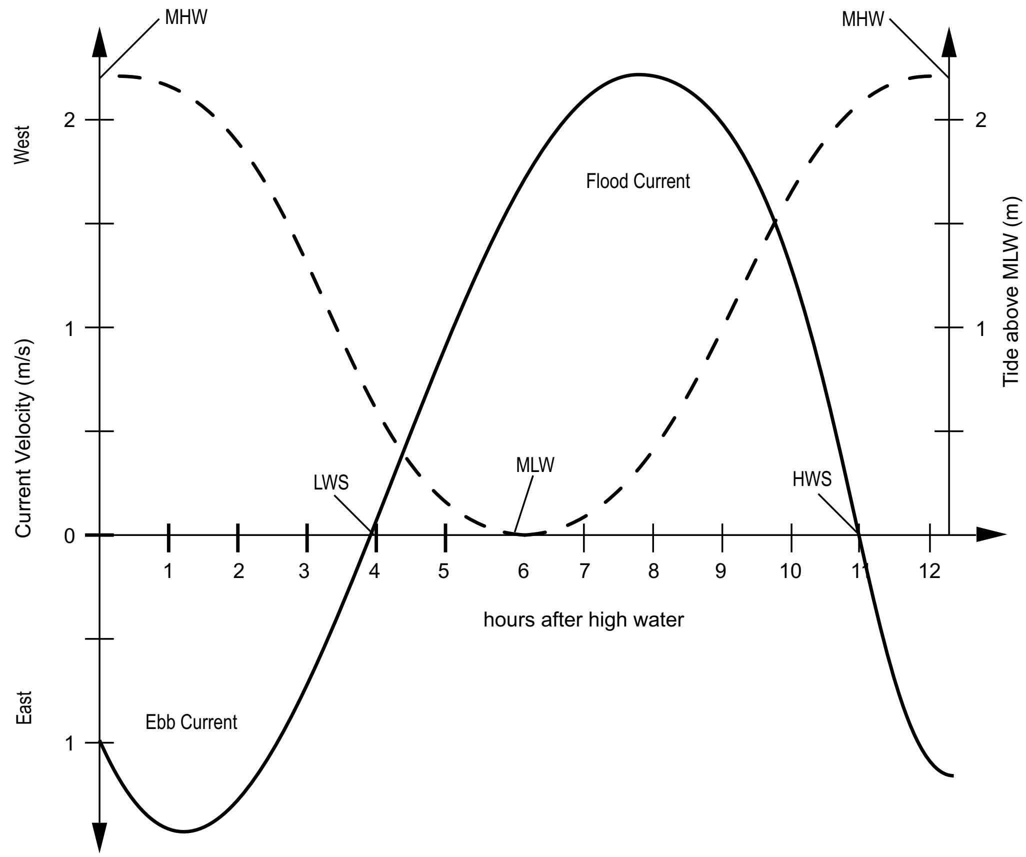


Figure 4.6 *Example of tidal cycle, showing stage and velocity as a function of time after Mean High Water (MHW).*

6. For brine and sediment effluent types, the discharge is assumed to occur in an unbounded coastal environment for simulation purposes. For these effluent types, an offshore bottom slope is assumed with the slope breaking perpendicular to the shoreline, as shown in Figure 4.5. Two slope values are specified - a near-shore slope s_1 and a far-shore slope s_2 - each with a corresponding velocity and roughness value. The change in bottom slope is specified by entering a value of YBREAK from the shoreline. Ambient roughness characteristics are specified as described previously for the bounded case (see Section 4.4). The depth at discharge value (HD) must be consistent with the values for slope and YBREAK or a warning message is issued.

4.4.3 Tidal Reversing Ambient Conditions

When predictions are desired in an unsteady ambient flow field, information on the tidal cycle must be supplied. In general, estuaries or coastal waters can exhibit considerable complexity with variations in velocity magnitude, direction, and water depth. For example, Figure 4.6 shows the time history of tidal velocities and tidal height for a mean tidal cycle a site in Long Island Sound. The tidal height varies between *Mean Low Water* (MLW) and *Mean High Water* (MHW).

The tidal velocity changes its direction twice during the tidal cycle at times called slack tide. One of these times occurs near, but is not necessarily coincident with, the time MLW and is referred to as *Low Water Slack* (LWS). The slack period near MHW is referred to as *High Water Slack* (HWS). The rate reversal (time gradient of the tidal velocity) near these slack tides is of considerable importance for the concentration build-up in the transient discharge plume, as tidal reversals will reduce the effective dilution of a discharge by re-entraining the discharge plume remaining from the previous tidal cycle (8). Hence, CORMIX needs some information on the ambient design conditions relative to any of the two slack tides.

The tidal period (PERIOD) must be supplied; in most cases it is 12.4 hours, but in some locations it varies. The maximum tidal velocity (UAmax) for the location must be specified; this can usually be taken as the average of the absolute values of the two actual maxima, independent of their direction. A CORMIX design case consists then of an instantaneous ambient condition, before, at or after one of the two slack tides. Hence, the analyst must specify the time (in hours) before, at, or after slack that defines the design condition, followed by the actual tidal ambient velocity (UA) at that time. The ambient depth conditions are then those corresponding to that time.

In general, tidal simulations should be repeated for several time intervals (usually hourly or bi-hourly intervals will suffice) before and after slack time to determine plume characteristics in unsteady ambient conditions.

Strongly unsteady conditions also occur in other environments, such as wind-induced current reversals in shallow lakes or coastal areas. In this case, any typical reversal period can be analyzed following an approach similar to the above.

4.4.4 Ambient Density Specification

Information about the density distribution in the ambient water body is very important for the correct prediction of effluent discharge plume behavior. CORMIX first inquires whether the ambient water is fresh water or non-fresh (i.e. brackish or saline). If ambient water is fresh and above 4^{o}C, the system provides the option of entering ambient temperature data so that the ambient density values can be internally computed from an equation of state. This is the recommended option for specifying the density of fresh water, even though ambient temperature per se is not needed for the analysis of mixing conditions. In the case of salt water conditions, Figure 4.7 is included as a practical guide for specifying the density if “salinity values” in parts-per-thousand (ppt) are available for the water body. Typical open ocean salinities range from 33 to 35 ppt.

The user then specifies whether the ambient density (or temperature) can be considered as uniform or as non-uniform within the water body and in particular, within the expected plume regions. As a practical guide, vertical variation in density of less than 0.1 kg/m^3 or in temperature of less than 1^{o}C can be neglected. For uniform conditions, the average ambient density or average temperature must be specified.

When conditions are non-uniform, CORMIX requires that the actual measured vertical density distribution be approximated by one of three schematic stratification profile types illustrated in Figure 4.8 for most effluent discharges. These are:

- Type A - linear density profile
- Type B - two layer system with constant densities and density jump
- Type C - constant density surface layer with linear density profile in bottom layer separated by a density jump
- Type D - 3-layer ambient density profile, available for coastal brine and/or sediment effluent types only

Corresponding profile types exist for approximating a temperature distribution when it is used for specifying ambient density distribution.

Note: When in doubt about the specification of the ambient density values it is reasonable to first simplify as much as possible. The sensitivity of a given assumption can be explored in subsequent CORMIX simulations. Furthermore,

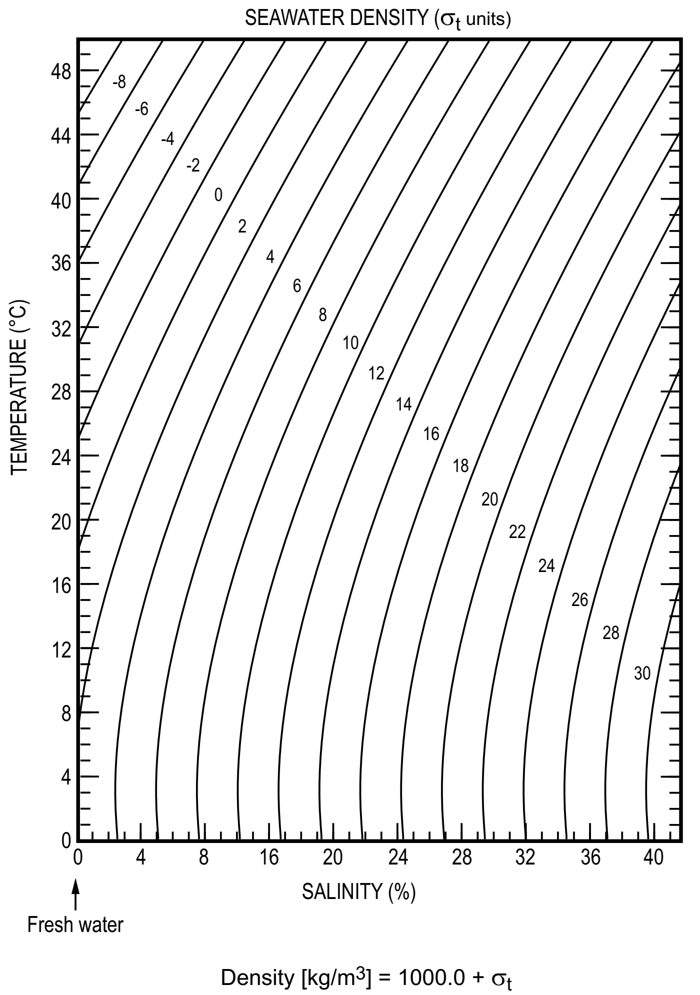


Figure 4.7 *Diagram for density of seawater as a function of temperature and salinity*

if CORMIX indicates a flow configuration (flow class) with near-field stability, additional studies with the post-processor option CorJet (see Section 6.1) can be performed to investigate any arbitrary stable density distribution.

After selecting the stratification approximation to be used, the user then enters all appropriate density (or temperature) values and pycnocline heights (HINT) to fully specify the profiles. The pycnocline is defined as zone or level of strong density change that separates upper and lower layers of the water column. The program checks the density specification to ensure that stable ambient stratification exists (i.e. density at higher elevations must not exceed that at lower elevations).

Note: A dynamically correct approximation of the actual density distribution should keep a balance between over- and under-estimation of the actual data similar to a best fit in regression analysis. If simulation results indicate internal plume trapping, then it is desirable to test - through repeated use of CORMIX- different approximations (i.e. with different stratification types and/or parameter values) in order to evaluate the sensitivity of the resulting model predictions.

4.4.5 Wind Speed

When specifying the **wind speed (UW)** at design conditions, it should be kept in mind that wind is unimportant for near-field mixing, but may critically

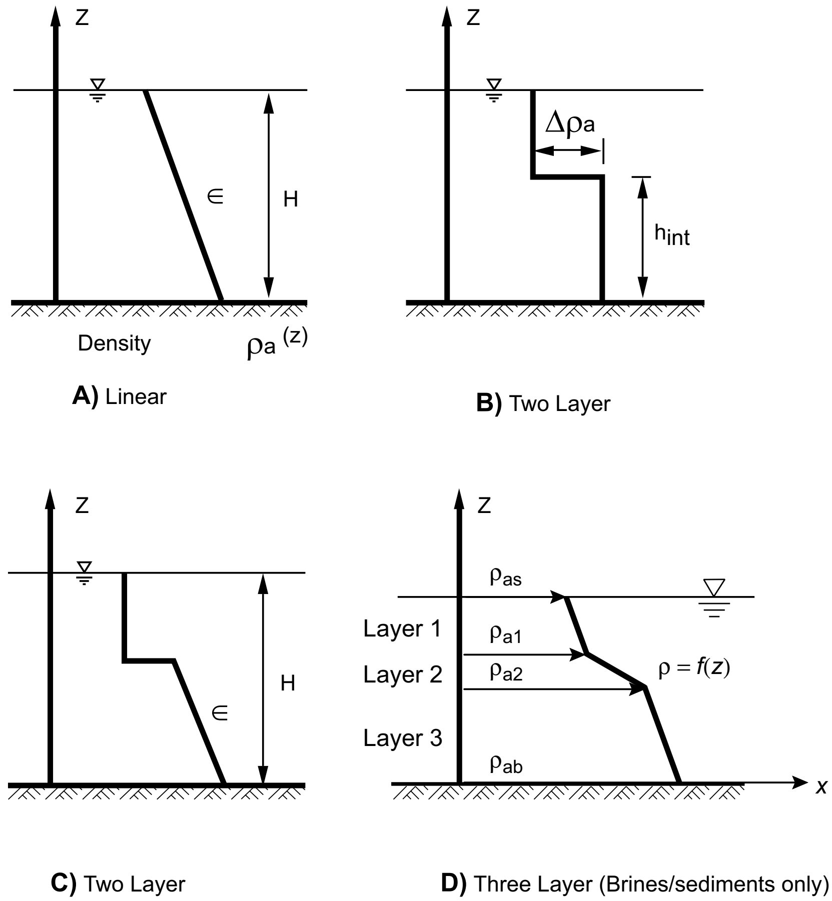


Figure 4.8 *Different approximations for representing ambient density stratification.*

affect plume behavior in the far field. This is especially important for heated discharges in the buoyant spreading regions. Wind speed data from adjacent meteorological stations is usually sufficient for that purpose. Wind is non-directional in CORMIX. Wind is used for surface heat transfer and ambient mixing only.

The following guidelines are useful when actual measured data are not available. The typical wind speed categories measured at the 10 m level are:

- Breeze (0-3 m/s)
- Light wind (3-15 m/s)
- Strong wind (15-30 m/s)

If field data are not available, use the recommended value of 2 m/s to represent conservative design conditions. An extreme low value of 0 m/s is usually unrealistic for field conditions, but useful when comparing to laboratory data. A wind speed of 15 m/s is the maximum value allowed in CORMIX.

4.5 Discharge Tab

Discharge properties are entered into CORMIX in the “Discharge” tab. The Discharge tab is shown in Figure 4.9 and has three options for single port, multiport diffuser, and surface (shoreline) source specification.

4.5.1 Discharge Data: Single Ports (CORMIX1)

Figure 4.10a is a definition sketch giving the geometry and flow characteristics for a submerged single port discharge within the schematized cross-

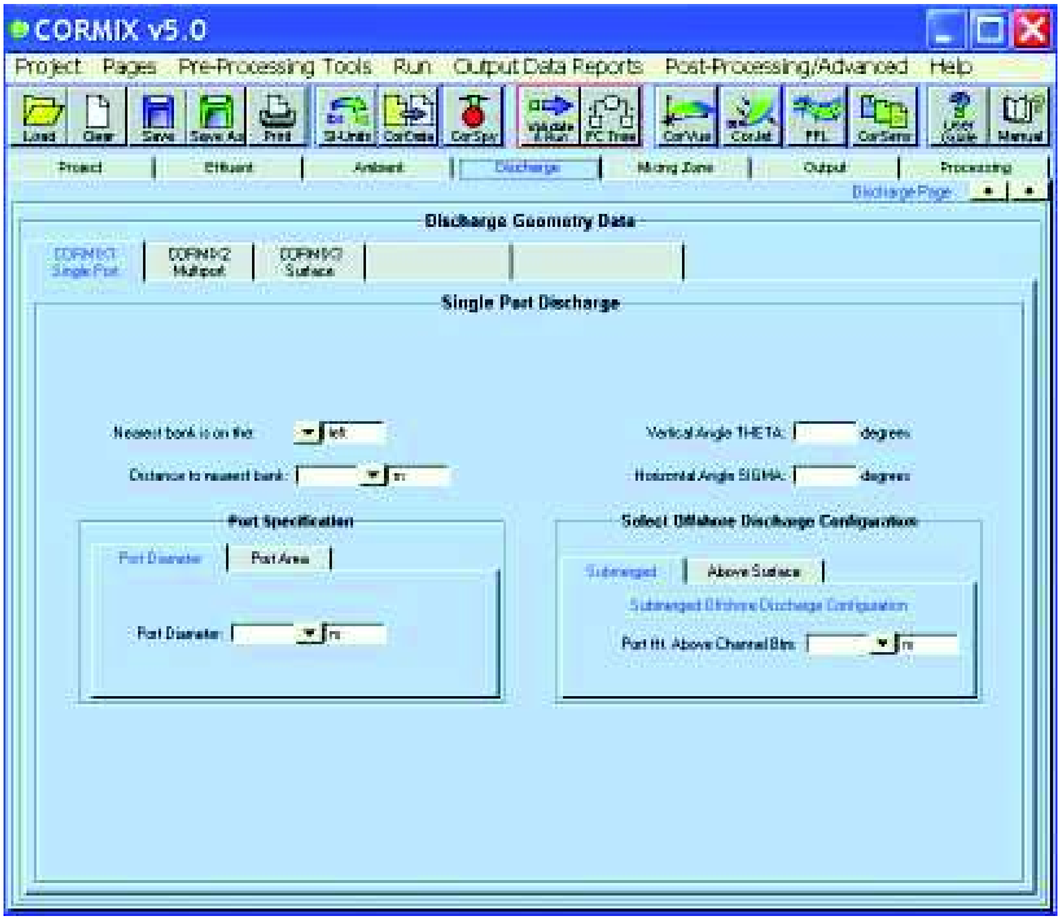


Figure 4.9 ***Discharge Data tab.*** *In this figure, the single port (CORMIX1) data tab is active. The "Effluent" tab controls options available for discharge specification in the Discharge data tab.*

section. Specification conditions for single port above surface discharges appears in Figure 4.11.

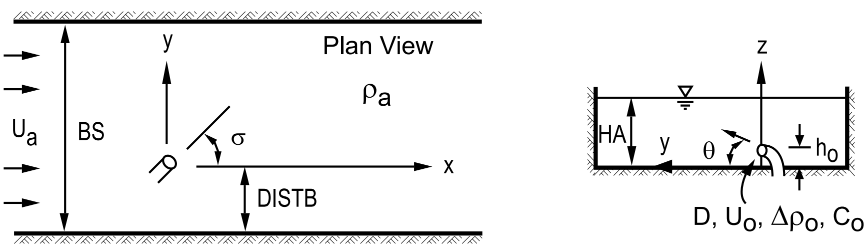
4.5.1.1 Discharge Geometry

To allow the establishment of a reference coordinate system and orient the discharge to that reference, CORMIX1 requires the specification of outfall geometry. These specifications are illustrated in Figures 4.10 and 4.11 and include:

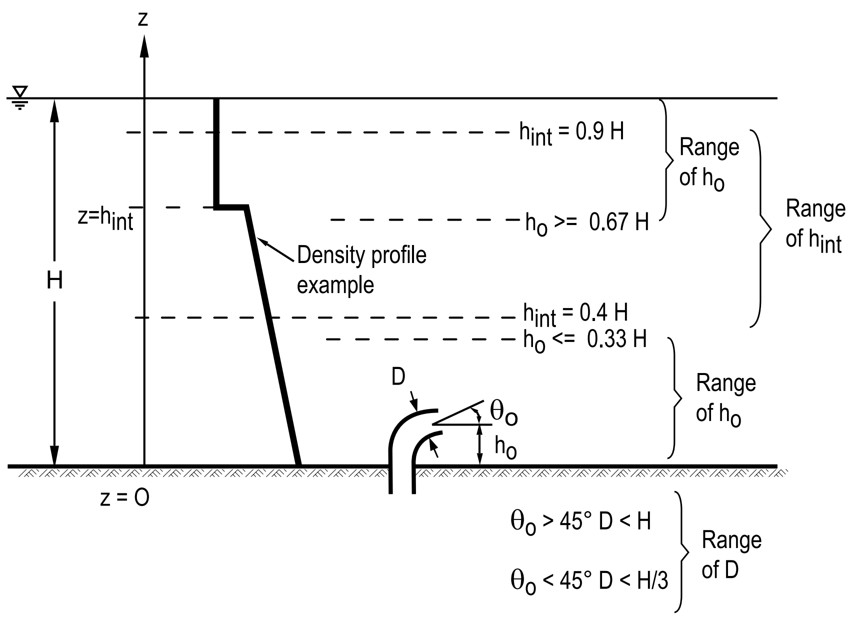
1. Location of the **nearest bank** (i.e. left or right) as seen by an observer looking downstream in the direction of the flow.
2. **Distance to the nearest bank (DISTB)**.
3. Port **diameter** (or **cross-sectional area** for non-circular shaped ports).

Note: The specification of the port dimension should account for any contraction effects that the effluent jet may experience upon leaving the port/nozzle.

4. For submerged discharges, **Height of the port (H0)** center above the bottom.
5. For above surface discharges, **Height of the port (H0)** center above the water surface as shown in Figure 4.11. In addition, the flow should be characterized as **jet-like**, **deflected jet**, or **spray-like**. For sediment discharges, a deflector plate is often used to distribute sediment around the discharge point as a deflected jet. For spray-like discharges, the area covered by the spray at the water surface is needed.



a) Definition Diagram Submerged Single Port Discharges
(Special case: HA = HD)



b) Limits of Applicability CORMIX1

Figure 4.10 *Submerged single port (CORMIX1) discharge geometry and restrictions.*

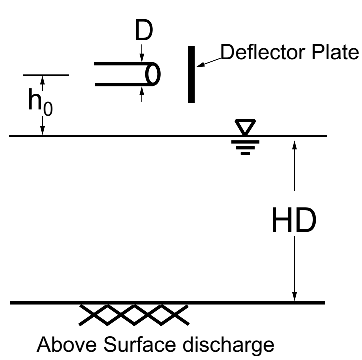


Figure 4.11 *Above surface discharge geometry for single port discharges.*

6. **Vertical angle of discharge (THETA)** between the port centerline and a horizontal plane.

7. **Horizontal angle of discharge (SIGMA)** measured counterclockwise from the ambient current direction (x axis) to the plan projection of the port centerline.

   Angle THETA may range between -45^o and 90^o. As examples, the vertical angle is 90^o for a discharge pointing vertically upward, and it is 0^o for a horizontal discharge. Angle SIGMA may range between 0^o and 360^o. As examples, the horizontal angle is 0^o (or 360^o) when the port points downstream in the ambient flow direction, and it is 90^o, when the port points to the left of the ambient flow direction.

In order to prevent an inappropriate system application, CORMIX1 checks the specified geometry for compliance with the three criteria illustrated in Figure 4.10b. These are:

1. The port height (H0) value must be less than one-third or greater than two-thirds of the local water depth (HD) value,
2. The port diameter value must not exceed HD's value for near-vertical designs, and one-third of HD's value for near-horizontal designs, and
3. The pycnocline value must be within the 40% to 90% range of HD's value.

In ordinary design practice, deeply submerged (near-bottom) implies a discharge close to the bottom, and not anywhere within the main water column or near the water surface. A slightly submerged (near-surface) discharge implies the port is close to the water surface. The port diameter restriction excludes very large discharge diameters relative to the actual water depth since these are unrealistic and/or undesirable. The distance separating the upper and lower layers of the ambient density profile type B or C is restricted in order to prevent an unrealistically thick plume relative to a thin upper or lower layer.

For those few extreme situations that would normally be limited by the above restrictions, Section 7.4 of Doneker and Jirka (11) contains a number of hints on how to conduct these difficult analyses. Only advanced users should carefully attempt these techniques.

4.5.2 Discharge Data: Multiport Diffusers (CORMIX2)

A generalized definition sketch showing the geometry and flow characteristics for a typical multiport diffuser installation is provided in Figure 4.12a. Due to the great number of complexities which may rise in describing an existing or proposed diffuser design, a few definitions are introduced prior to discussing actual data requirements of CORMIX2.

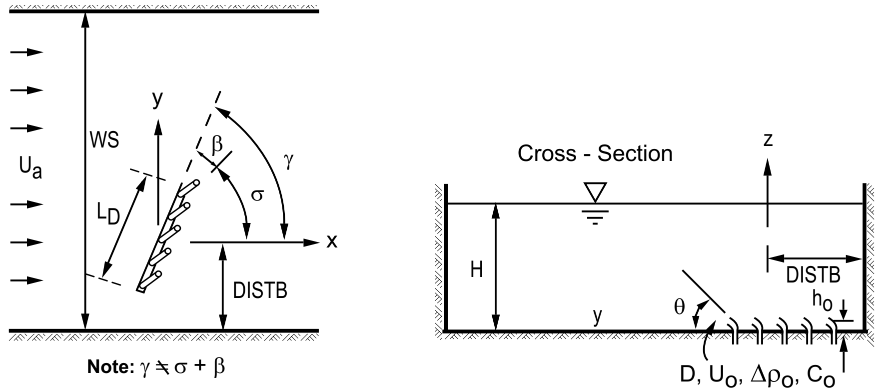
A **multiport diffuser** is a linear structure consisting of many more or less closely spaced ports or nozzles which inject a series of turbulent jets at high velocity into the ambient receiving water body. These ports or nozzles may be connected to vertical risers attached to an underground pipe, tunnel, or may simply be openings in a pipe lying on the bottom.

The **diffuser line** (or axis) is a line connecting the first port/nozzle and the last port/nozzle. Generally, the diffuser line will coincide with the connecting pipe or tunnel. CORMIX2 will assume a straight diffuser line. If the actual diffuser pipe has bends or directional changes it must be approximated by a straight diffuser line.

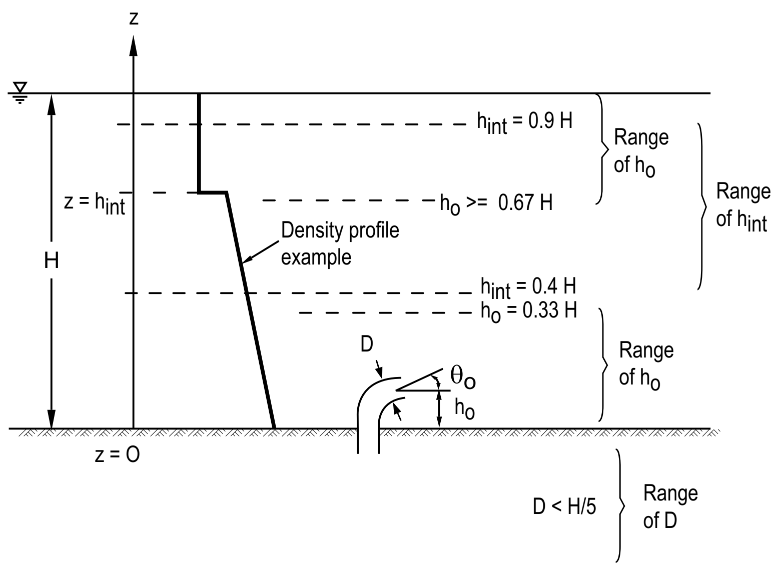
The **diffuser length** is the distance from the first to the last port/nozzle. The origin of the coordinate system used by CORMIX2 is located at the center (mid point) of the diffuser line. The only exception is when the diffuser line starts at the shore; then the origin is located directly at the shore.

CORMIX2 can analyze discharges from the three major diffuser types used in common engineering practice. These are illustrated in Figure 4.13 and include:

1. The **unidirectional diffuser** where all ports/nozzles point to one side of the diffuser line and are oriented more or less normally to the diffuser line and more or less horizontally (Figure 4.13a).
2. The **staged diffuser** where all ports point in one direction generally following the diffuser line



a) Definition Diagram CORMIX2



b) Limits of Applicability CORMIX 2

Figure 4.12 *CORMIX2 discharge geometry and restrictions*

with small deviations to either side of the diffuser line and are oriented more or less horizontally (Figure 4.13b).

3. The **alternating diffuser** where ports do not point in a nearly single horizontal direction (Figure 4.13c). This diffuser type produces no net horizontal momentum flux. In the this case, the ports may point more or less horizontally in an alternating fashion to both sides of the diffuser line or they may point upward, more or less vertically.

4.5.2.1 Diffuser Geometry

CORMIX2 assumes uniform discharge conditions along the diffuser line. This includes the local ambient receiving water depth (HD) and discharge parameters such as port size, port spacing, and discharge per port, etc. If the actual receiving water depth is variable (e.g. due to an offshore slope), it should be approximated by the mean depth along the diffuser line with a possible bias to more shallow near-shore conditions. Similarly, mean values should be used to specify variable diffuser geometry when it occurs.

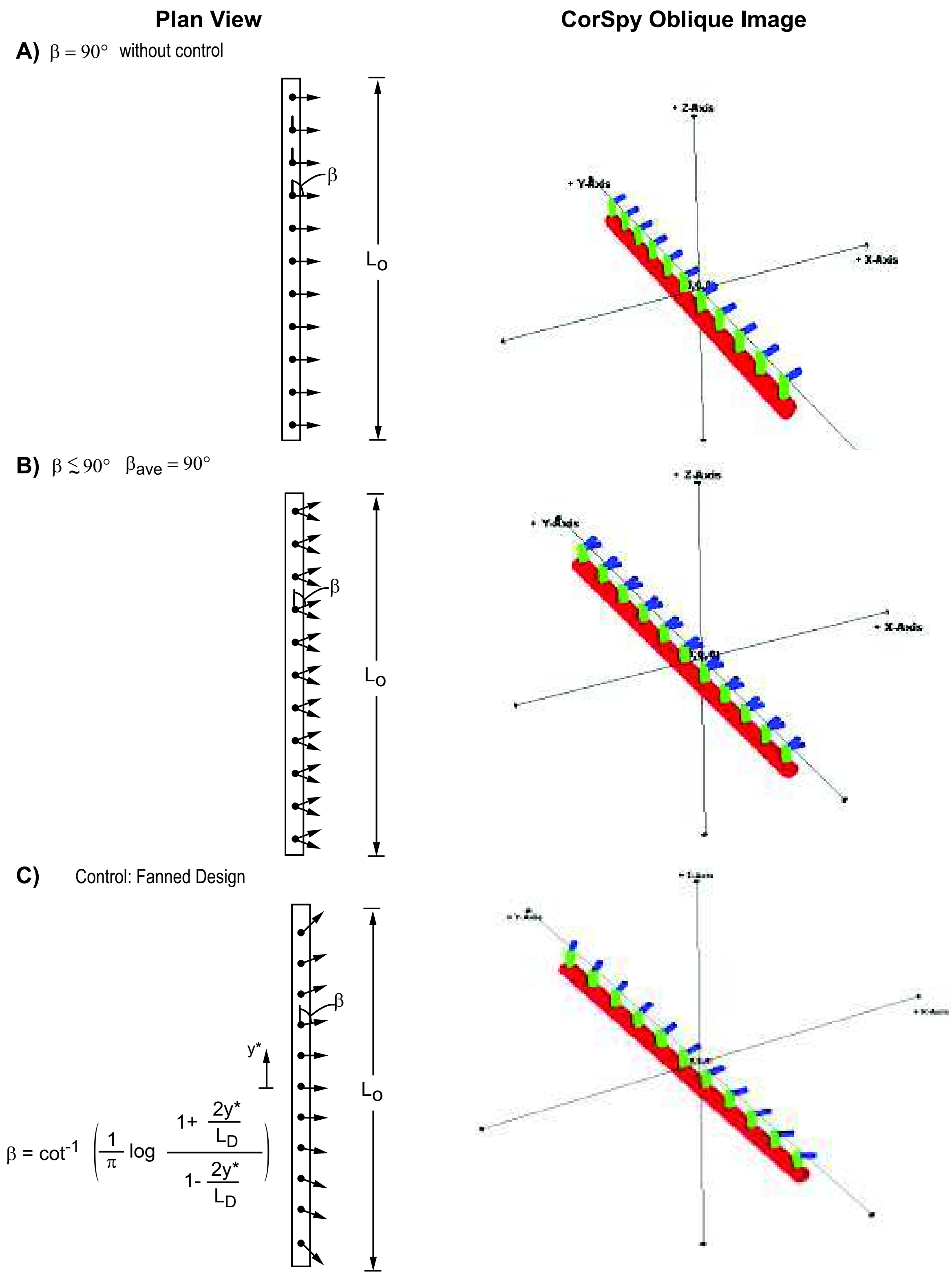
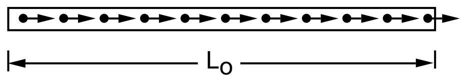
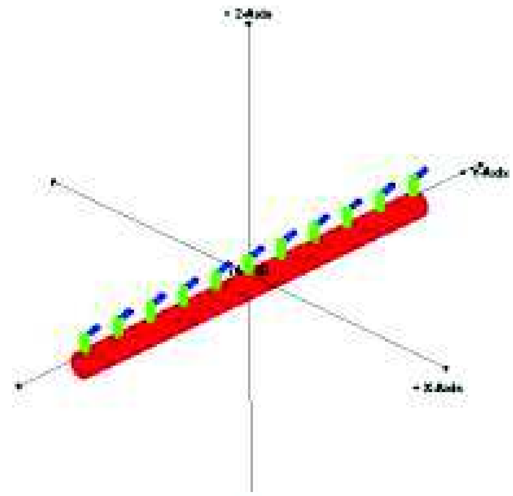


Figure 4.13.a *Unidirectional diffusers. These diffusers impart net horizontal momentum flux perpendicular to diffuser line. In CorSpy 3D view, g = 90^{o} (perpendicular) for all cases.*

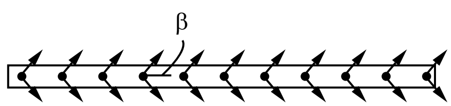
Plan View **CorSpy Oblique Image**

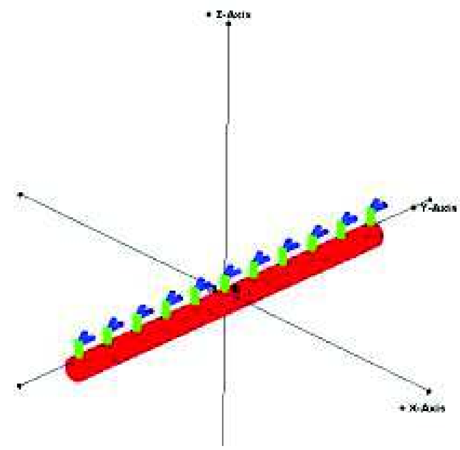
A) $\beta = 0°$



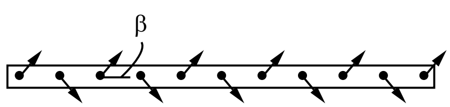


B) $\beta \lesssim 0°$ $\beta_{ave} = 0°$





C) $\beta \lesssim 0°$ $\beta_{ave} = 0°$



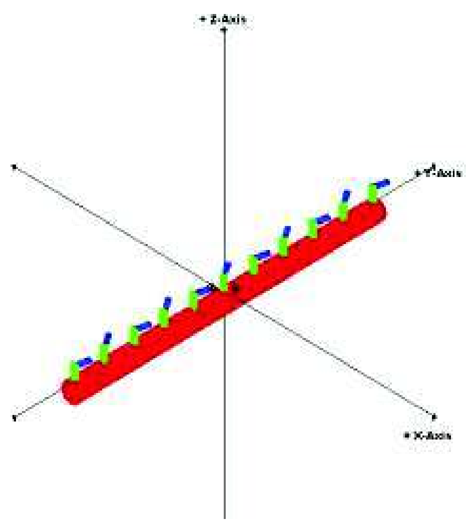


Figure 4.13.b *Staged diffuser designs. These diffusers produce net horizontal momentum flux parallel to diffuser line. In CorSpy 3D view,* g *= 90°* *(perpendicular) for all cases.*

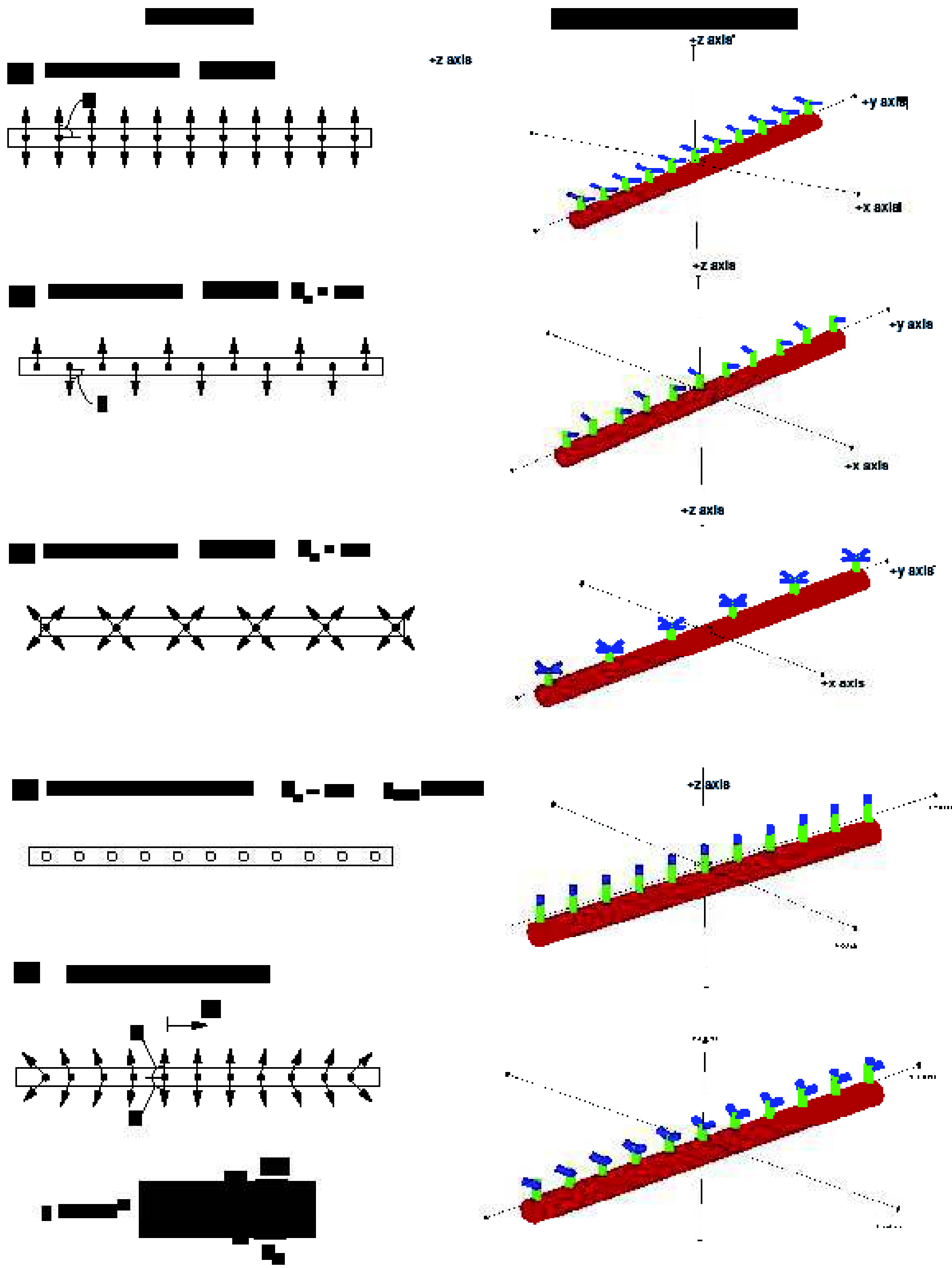


Figure 4.13.c *Alternating diffuser designs. These diffusers impart no net horizontal momentum flux. Note type D has vertical ports only. In CorSpy 3D view,* $g = 90^{o}$ *(perpendicular) for all cases.*

To allow the establishment of a reference coordinate system and orient the discharge to that reference, CORMIX2 requires the specification of the following entries. These specifications are illustrated in Figure 4.12a and include:

1. Location of the **nearest bank** (i.e. left or right) as seen by an observer looking downstream in the direction of the flow.
2. Average **distance to the nearest bank (DISTB)**.
3. **Average diameter (D0)** of the discharge ports or nozzles.
4. **Contraction ratio** for the port/nozzle is required. This can range from 1 for well rounded ports - usual value - down to 0.6 for sharp-edged orifices.
5. Average **height of the port centers (H0)** above the bottom.
6. Average **vertical angle of discharge (THETA)** between the port centerlines and a horizontal plane (45^{o} and 90^{o}).
7. For the unidirectional and staged diffusers only, the average **horizontal angle of discharge (SIGMA)** measured counterclockwise from the ambient current direction (x-axis) to the plan projection of the port centerlines (0^{o} to 360^{o}).
8. Approximate straight-line **diffuser length (LD)** between the first and last ports or risers.
9. **Distance from the nearest shore to the first and last ports or risers (YB1, YB2)** of the diffuser line.
10. Number of ports or risers and the number of ports per riser if risers are present.
11. Average **alignment angle (GAMMA)** measured counterclockwise from the ambient current direction (x-axis) to the diffuser axis (0^{o} to 180^{o}), and
12. For the unidirectional and staged diffusers only, **relative orientation angle (BETA)** measured clockwise or counterclockwise from the average plan projection of the port centerlines to the nearest diffuser axis (0^{o} to 90^{o}).

Note: CORMIX2 always assumes a uniform spacing between risers or ports, and a round port cross-sectional shape.

As examples of angle specifications, THETA is 0 degrees for a horizontal discharge and +90^{o} for a vertically upward discharge. SIGMA is 0^{o} (or 360^{o}) when the ports point downstream in the ambient flow direction and 90^{o} when the ports point to the left of the ambient flow direction. GAMMA is 0^{o} (or 180^{o}) for a parallel diffuser and 90^{o} for a perpendicular diffuser. BETA is 0^{o} for a staged diffuser and 90^{o} degrees for a unidirectional diffuser.

CORMIX2 performs a number of consistency checks to ensure the user does not make arithmetical errors when preparing and entering the above data. It also checks the specified geometry for compliance with three criteria to prevent an inappropriate system application. Figure 4.12b shows imposed limits of system application for CORMIX2. The imposed limits are:

1. Port height (H0) value must be less than one-third or greater than two thirds of the local water depth (HD) value.
2. Port diameter value must not exceed one-fifth of HD's value.
3. Pycnocline value must be within the 40% to 90% range of HD's value.

These restrictions are similar to those shown in Figure 4.12b for CORMIX1 with the exception of the diameter limit for each port.

4.5.3 Discharge Data: Surface (Shoreline) Discharges CORMIX3

A definition sketch for discharge geometry and flow characteristics for a buoyant surface discharge is provided in Figure 4.14. In general, CORMIX3 allows for different types of inflow structures, ranging from simple rectangular channels to horizontal round pipes that may be located at or near the water surface. In addition, three different configurations relative to the bank are allowed as illustrated in

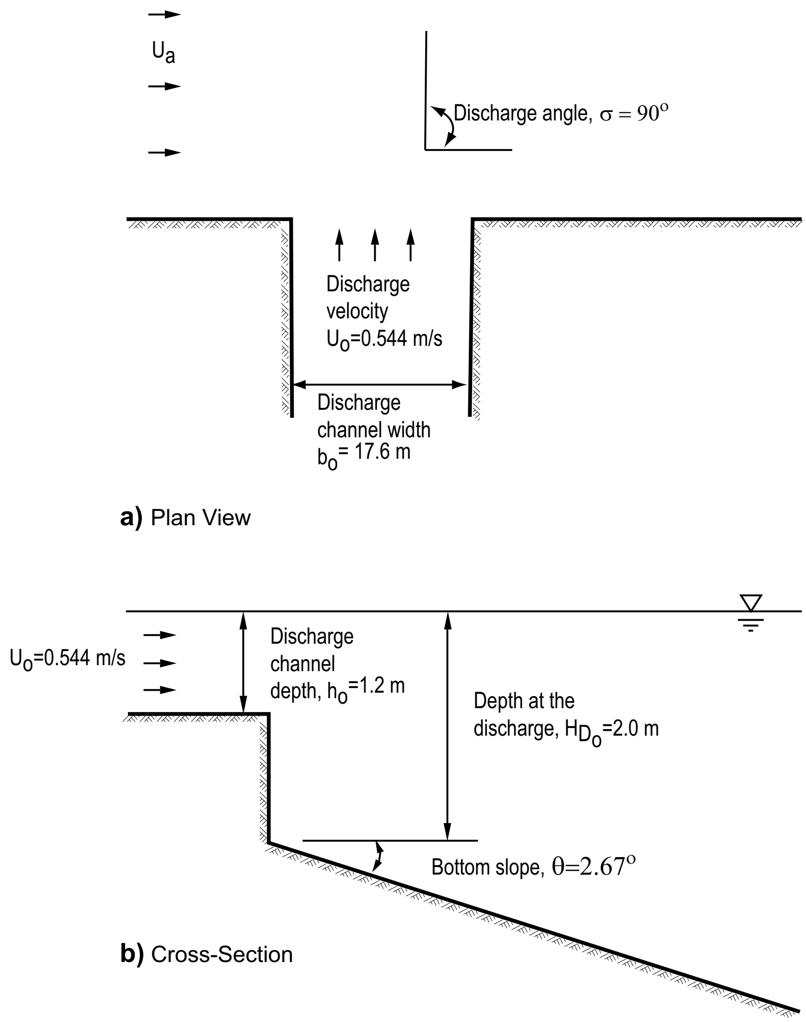


Figure 4.14 *CORMIX3 discharge channel geometry.*

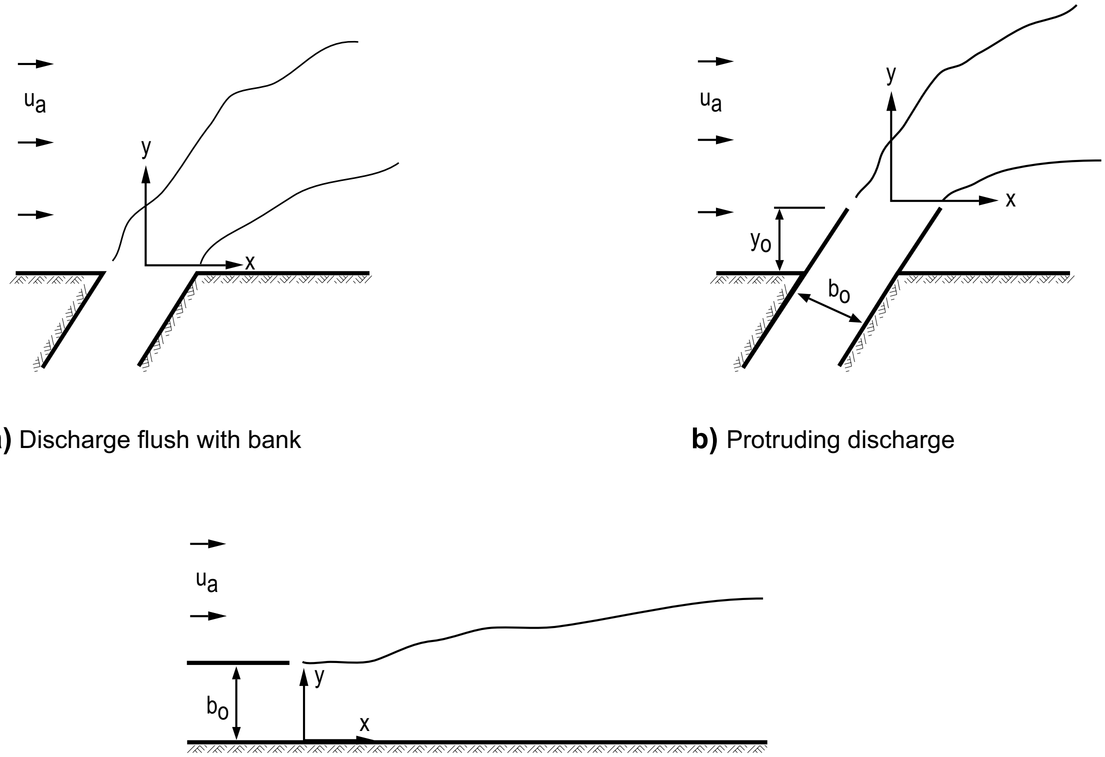
Figure 4.15. Discharge structures can be:

1. **Flush** with the bank/shore.
2. **Protruding** from the bank.
3. **Co-flowing** along the bank.

4.5.3.1 Discharge Geometry

To allow the establishment of a reference coordinate system and orient the discharge to that reference, CORMIX3 requires the specification of up to seven data entries. These specifications are illustrated in Figure 4.14 and include:

1. Location of the **nearest bank** (i.e. left or right) as seen by an observer looking downstream in the direction of the flow.
2. **Discharge channel width (B0)** of the rectangular channel.
3. **Discharge channel depth (H0)**.
4. **Actual receiving water depth at the channel entry (HD0)**.
5. **Bottom slope (SLOPE)** in the receiving water body in the vicinity of the discharge channel.
6. **Horizontal angle of discharge (SIGMA)** measured counterclockwise from the ambient current direction (x axis) to the plan projection of the port centerline. In the case of a **circular discharge pipe**, the **pipe diameter** and **depth of bottom invert** below the water surface (water surface to bottom edge of pipe) must be specified, respectively. In all cases, CORMIX3



a) Discharge flush with bank

b) Protruding discharge

c) Coflowing along downstream bank

Figure 4.15 *Possible CORMIX3 discharge configurations of discharge channel relative to bank/ shoreline.*

assumes the discharge is being issued horizontally.

CORMIX3 uses the variable HD0 for the actual water depth immediately in front of the discharge channel exit and requires an additional specification for the receiving water bottom slope, again immediately in front of the exit, extending into the receiving water body. These details are important for identifying cases where plume attachment to the bottom can occur.

In the case of a circular pipe discharge, CORMIX3 assumes the outlet is flowing full and is not submerged under the water surface by more than ½ of the outlet diameter. If the discharge outlet has an odd-cross sectional shape (e.g. a pipe flowing partially full) then it should be represented schematically as a rectangular outlet of the same cross-sectional area and similar channel depth.

For open channel discharges, considerable care should be exercised when specifying discharge channel depth since this parameter is directly linked to the ambient receiving water depth (stage). This is especially important for tidal situations.

To prevent an inappropriate system application, CORMIX3 only allows for a discharge channel depth-to-width aspect ratio of 0.05 to 5. This prohibits the use of extremely oblong discharge geometry.

In case of an **ambient background concentration,** it is important to treat all pollutant related data items in a consistent fashion. This includes the specification of any regulatory values as discussed in Section 4.6. All pollutant concentration in CORMIX should be entered as a concentration excess (DC) above background.

Example: Suppose the actual discharge concentration for a pollutant is 100 mg/l, and values of CMC and CCC for the pollutant are 20 mg/l and 10 mg/l, respectively. If the background ambient concentration for the same pollutant is 4 mg/l, the data entry into CORMIX for discharge concentration is C0 = 96 mg/l, CMC = 16 mg/l, and CCC = 6 mg/l, respectively. All concentration values listed in the various CORMIX output (see Chapter 5) must then be interpreted accordingly, and the actual downstream plume concentration values are computed by adding the background concentration value. For instance if the CORMIX predicted value downstream for one point happens to be 13.6 mg/l, then the total concentration value at that point would be 17.6 mg/l. Also, all program mixing zone messages would occur at correct regulatory concentrations because they are interpreted as excess plume concentrations above ambient.

4.6 Mixing Zone Data Tab

In the “Mixing Zone” tab the user must indicate:

1. Whether EPA’s toxic dilution zone (TDZ) definitions apply.
2. Whether an ambient water quality standard exists.
3. Whether a regulatory mixing zone (RMZ) definition exists.
4. The spatial region of interest (ROI) over which information is desired.
5. Number of locations (i.e. “grid intervals”) in the ROI to display output details.

Depending on the responses to the above, several additional data entries may be necessary as described in the following paragraphs.

When TDZ definitions apply, the user must indicate the *Criterion Maximum Concentration* (CMC) and *Criterion Continuous Concentration* (CCC) which are intended to protect aquatic life from acute and chronic effects, respectively. CORMIX will check for compliance with:

1. The CMC standard at the edge of the TDZ.
2. The CMC standard at the edge of the RMZ, providing a RMZ was defined.

See Section 2.2.2 for additional discussion.

When a *Regulatory Mixing Zone* (RMZ) definition exists, it can be specified by:

1. A distance from the discharge location.
2. The cross sectional area occupied by the plume.
3. The width of the effluent plume.

The *Region of Interest* (ROI), which is a user defined region where mixing conditions are to be analyzed, is specified as the maximum analysis distance in the direction of mixed effluent flow.

The grid Intervals for display controls how many lines of output data are written from the simulation model within each flow simulation module. This parameter’s allowable range is 3 to 800 and the chosen value does not affect the accuracy of the CORMIX prediction, only the amount of output detail. A low value (e.g. 4-10) should be specified for initial calculations to minimize printout lengths while a large value might be desirable for final predictions to resolve locations of mixing zone boundaries.

4.7 Output Control Tab

The “Output” tab form has radio control buttons to control CORMIX output in a simulation. The user can display, print, display and print, or have no output of the *prediction file* (fn.prd), *session report* (fn.ses), f*low class description* (fn.flw), *design recommendations* (fn.rec), and *processing record* (fn.jrn). In addition, the user can select radio buttons to show the rule-tree stem and leaf display of the rules used in data processing.

4.8 Processing Tab

The “Processing” tab allows the user to step through to CORMIX simulation or execute the entire simulation at once. The processing record is shown in the text display window as the rule bases and simulation models execute. This window displays important messages about the case under consideration and relates initial conclusions about flow behavior.

4.9 Units of Measure

CORMIX uses the metric system (SI) of measurement for all internal calculations and program reports. When data values are provided to the user in English mixed units, these are converted to equivalent metric measures internally by the program before simulation model execution. All CORMIX output is in SI (M-KG-S) units.

Pollutant concentrations can be entered in any conventional measure such as mg/L, ppb, bacteria-count, etc.

Considering the potential accuracy of CORMIX predictions, three to four significant digits are sufficiently accurate for most input data values. The only exceptions are the ambient and effluent density values. These may require five significant digits, especially when simulating the discharge to an ambient density-stratified receiving water body.