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# Dilution Studies

Examples and Insights from  
the San Francisco Bay Region

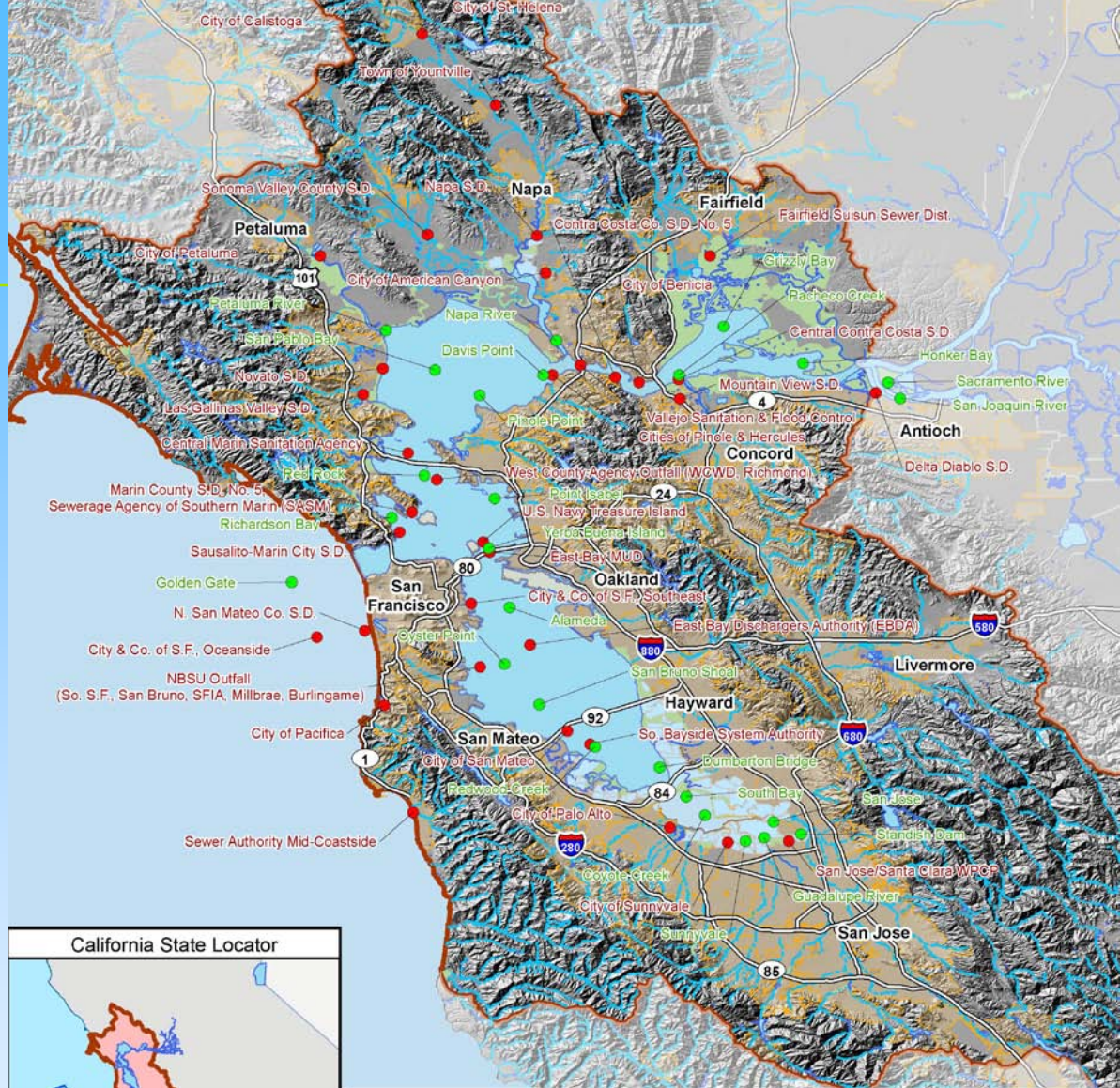


# Overview

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- A sense of scale – the Bay & your outfall
- Plume models
- So my dilution credit is...?
- Reality checks (dye studies, inspections)

# Outfalls & RMP Sites



**Map Features**

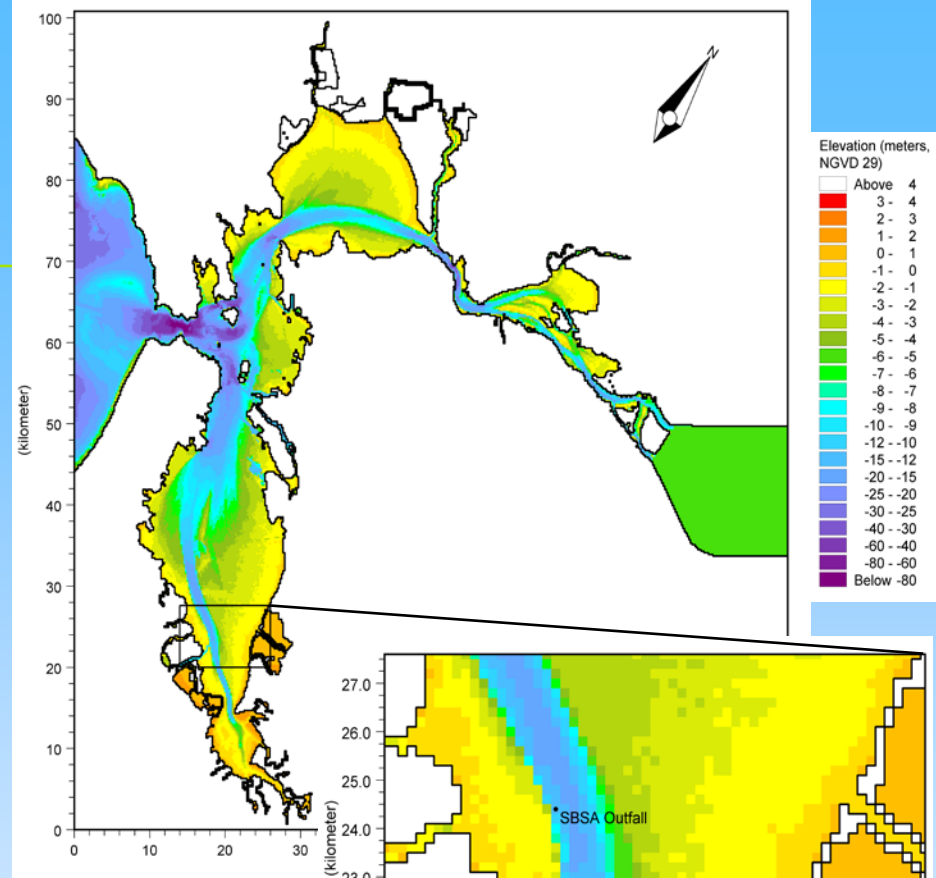
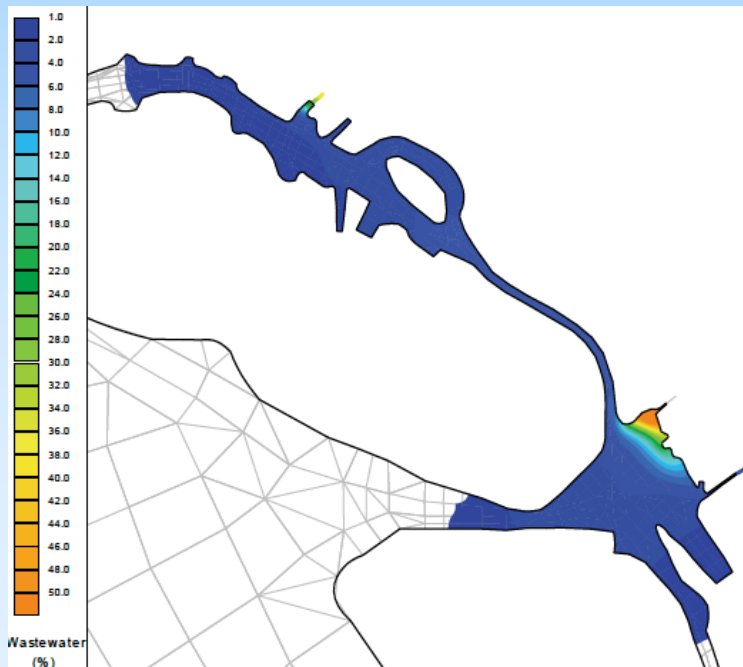
- Publicly Owned Treatment Works Discharge Location (POTW)
- Regional Monitoring Program Site (RMP)
- Regional Water Quality Control Board Region 2 (RWQCB)
- City Boundary
- Water Body
- Artificial Basins
- Swamp/Inundation Area
- Freeway System
- ~ Stream/River

0 10 20 40 Miles

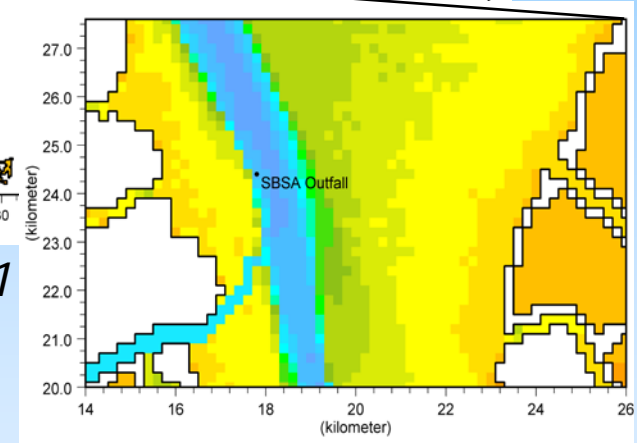
Map produced for LWA by SD 07062007  
 POTW locations from the San Francisco Bay Basin Plan  
 RMP locations from the San Francisco Estuary Institute  
 Hill shade produced from the National Elevation Dataset  
 All other data from the Environmental Systems Research Institute (ESRI)

# Bay Models

- 2-dimensions
- ~5-min time steps
- Can focus on any time or place

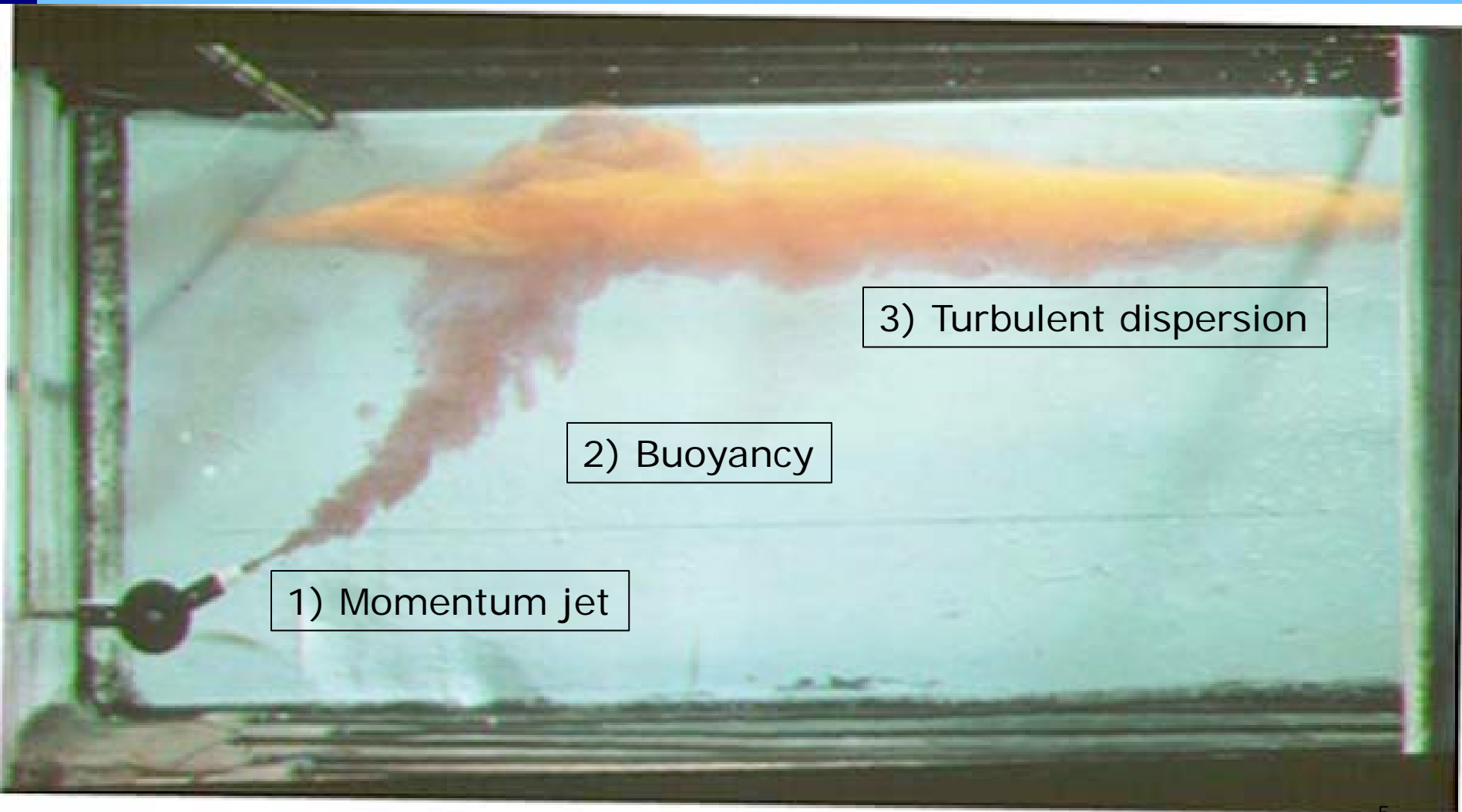


MIKE 21



RMA-2  
& -11

# Plume Mixing Processes

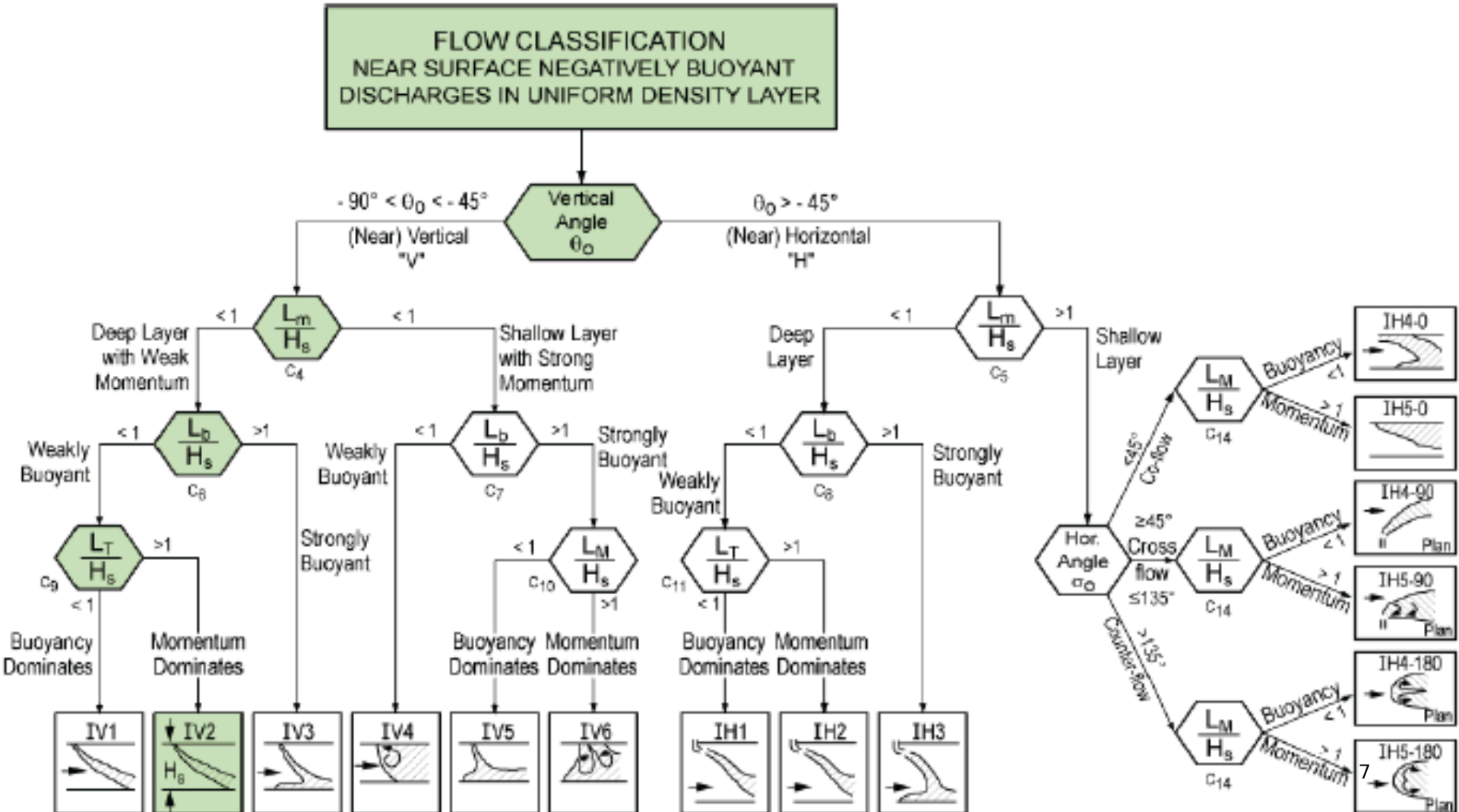


# Plume Model Components

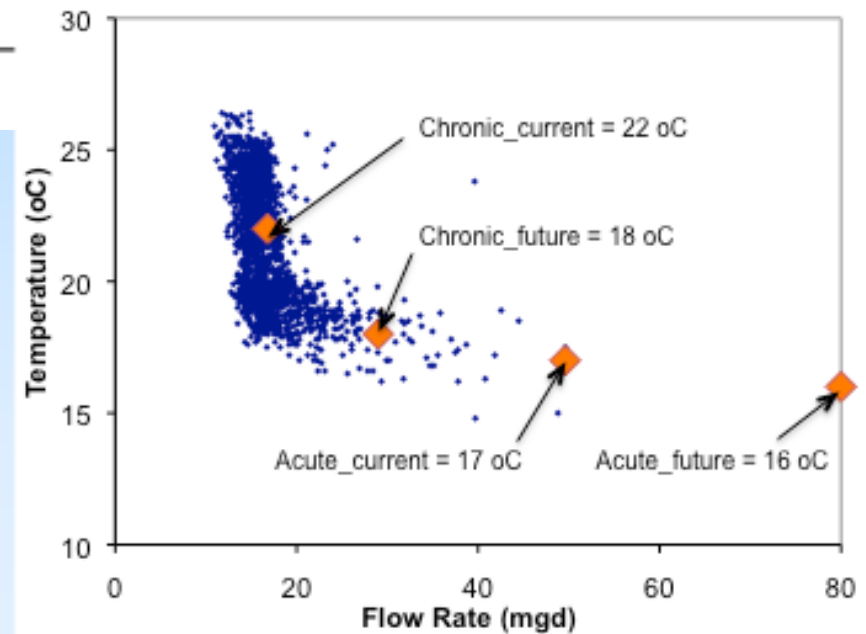
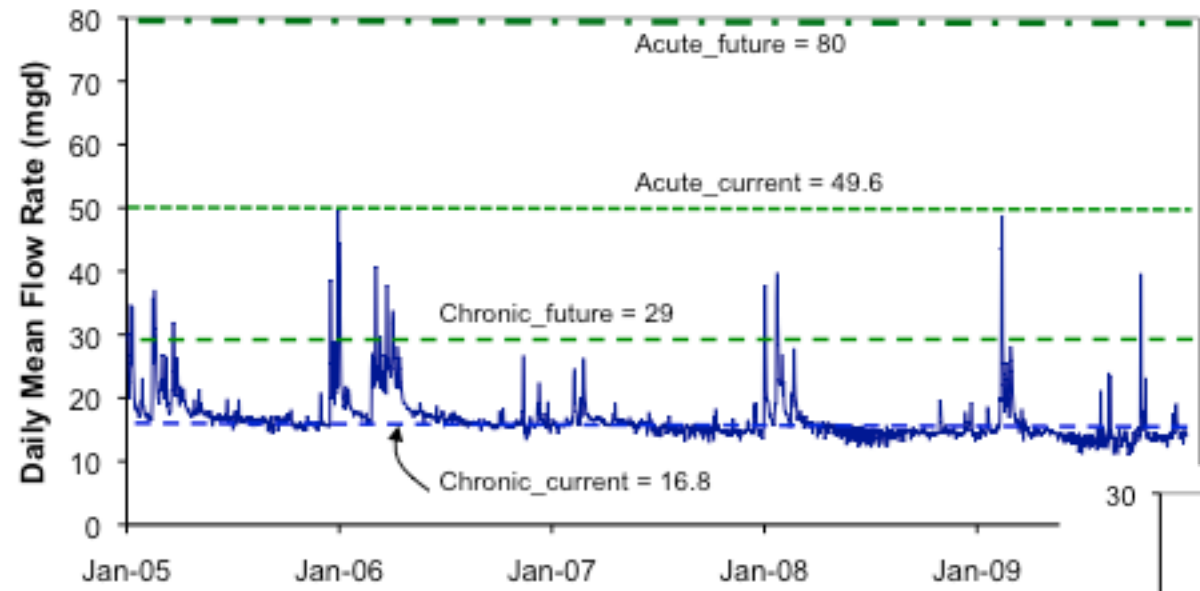
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- Effluent flow rate, density, concentration
- Diffuser geometry
- Receiving water currents, density, concentration
- Mixing zones & model output

# CORMIX: A Rule-based Expert System

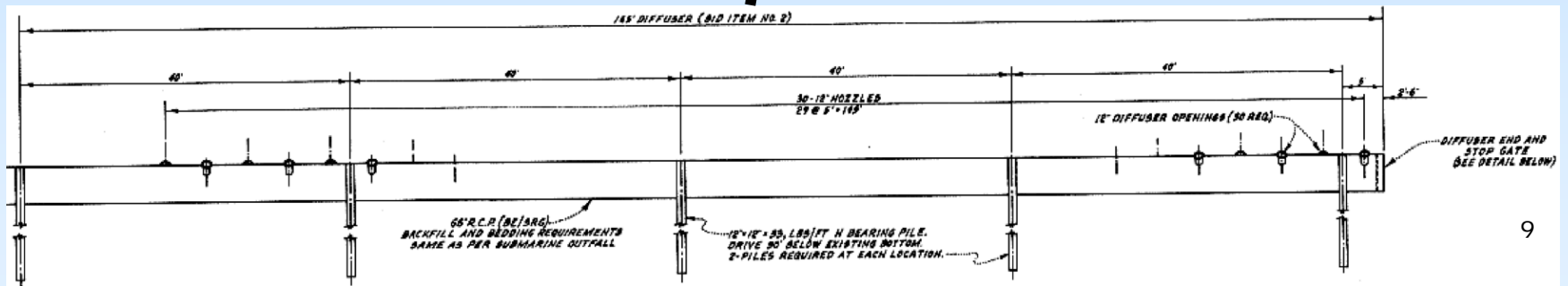
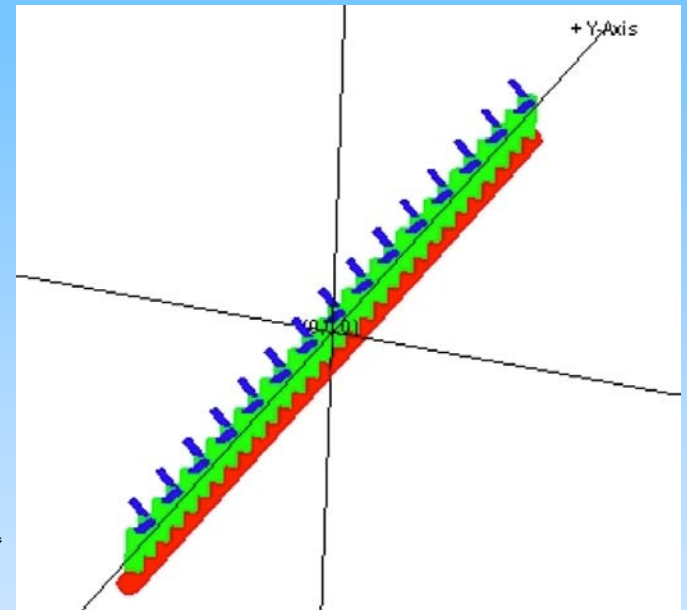
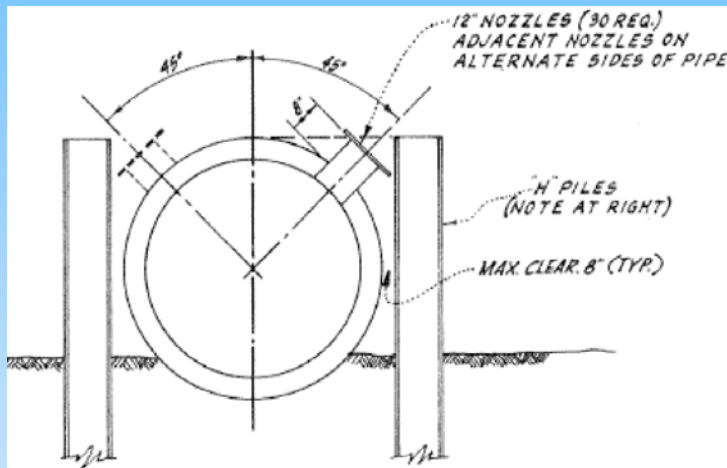


# Effluent Characterization



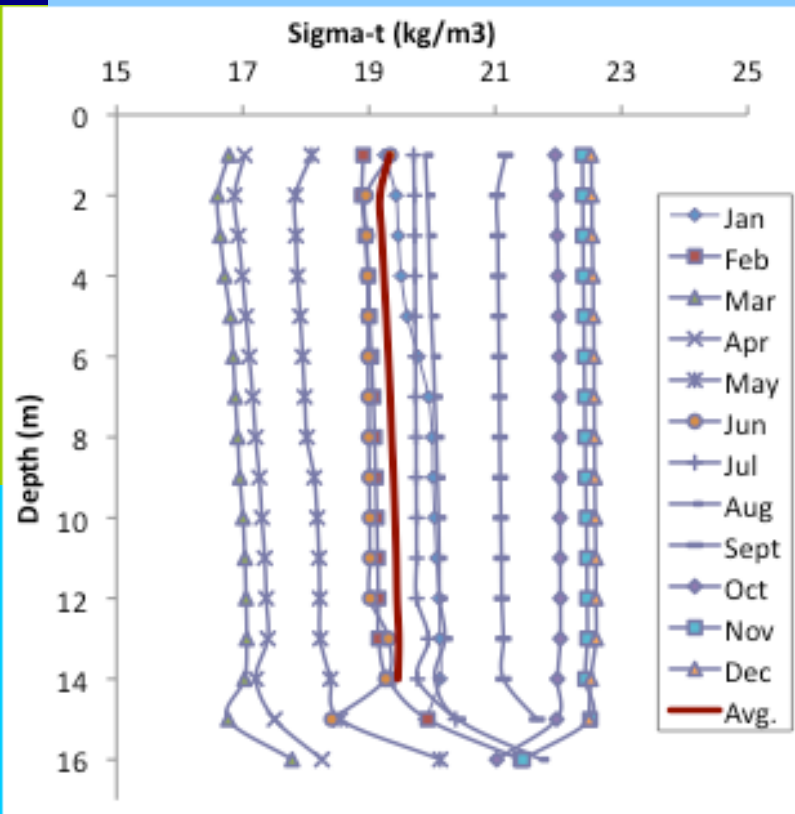


# Diffuser Geometry

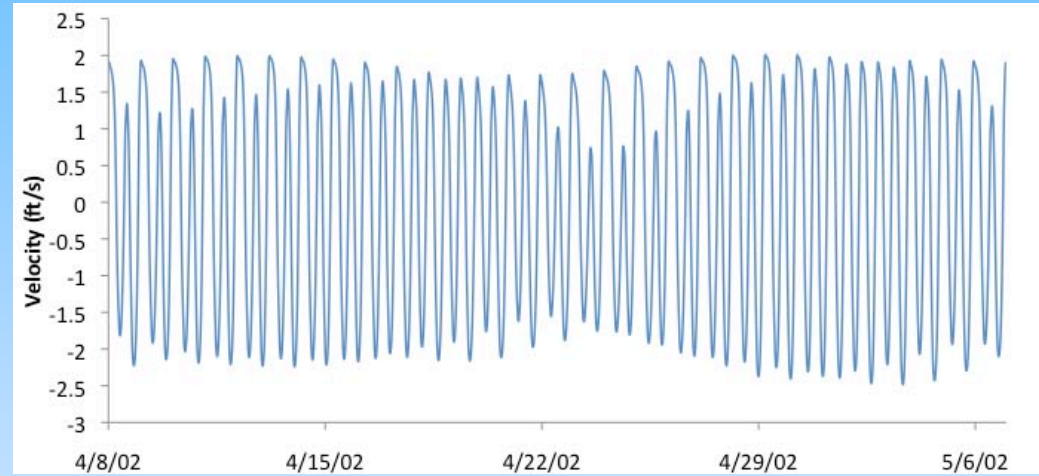


# Receiving Water Conditions

## Density Stratification



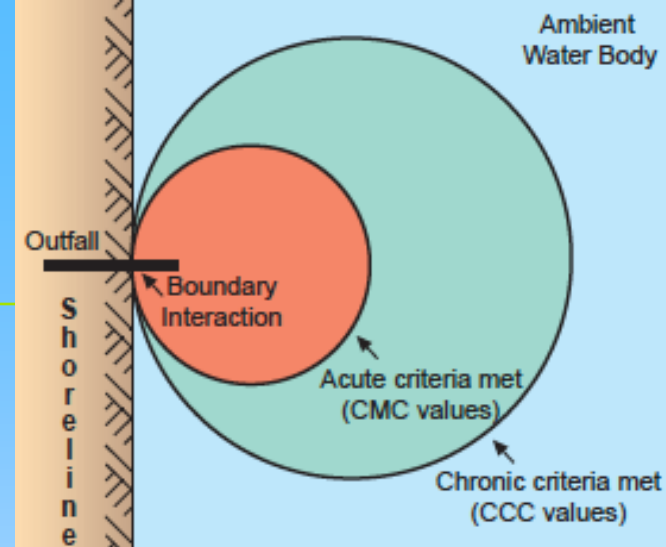
## Variable Velocity



## Boundaries



# “Critical Conditions” Vary



Condition	Acute	Chronic
Effluent	<ol style="list-style-type: none"> <li>1. Max daily</li> <li>2. Wet-weather design</li> <li>3. Wet-weather design</li> <li>4. Wet-weather design</li> </ol>	<ol style="list-style-type: none"> <li>1. Max 4-day avg.</li> <li>2. Wet-weather design</li> <li>3. Annual avg.</li> <li>4. Annual avg.</li> </ol>
Receiving Water	<ol style="list-style-type: none"> <li>1. Wet: Nov-Apr; Dry: May-Oct</li> <li>2. "Shortly before" max flood &amp; ebb</li> <li>3. Average ambient current</li> <li>4. Average ambient current</li> </ol>	

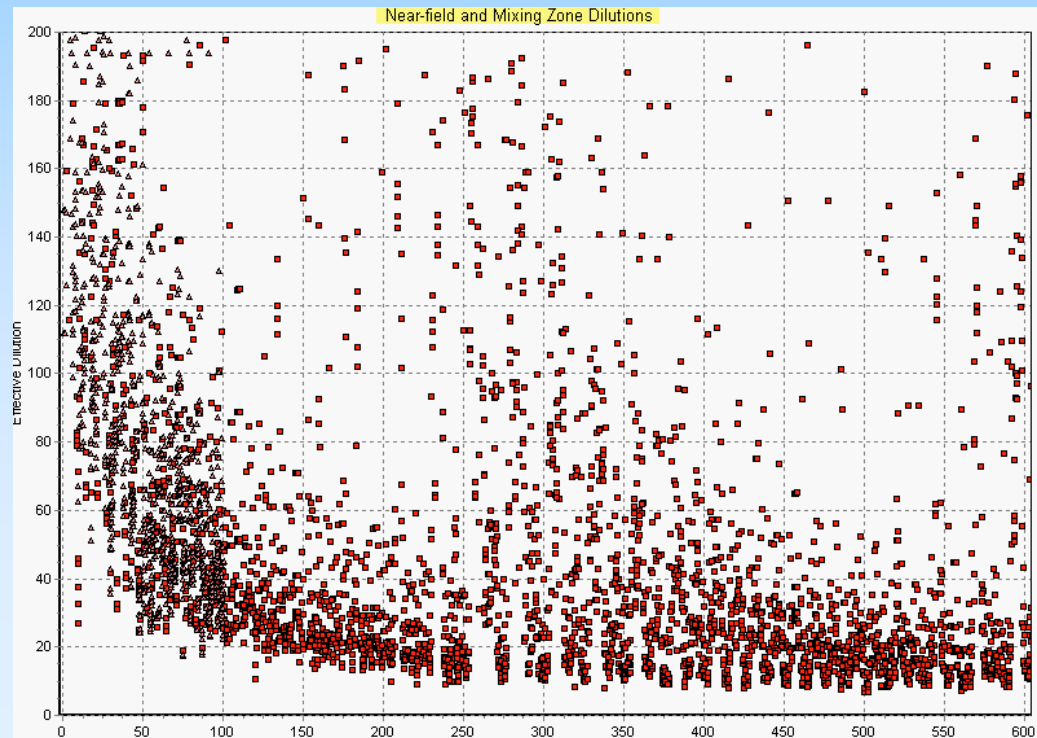
Or: Monte Carlo → 99.98<sup>th</sup> percentile dilution

EPA: "Use no current or slack tide"



# Multiple Test Cases

- Only VP allows batch runs
- CORMIX *accounts* for tides
- VP can *simulate* tides



# Plume Model Comparison

Model	Pros	Cons
CORMIX	<ul style="list-style-type: none"><li>• Delineates mixing effects</li><li>• Comprehensive text output</li><li>• Courses &amp; tech support available</li><li>• Represents diffuser</li><li>• Accounts for boundaries</li></ul>	<ul style="list-style-type: none"><li>• Costly</li><li>• Old-school interface</li><li>• Poor graphics</li><li>• Minimal output customization</li></ul>
Visual Plumes	<ul style="list-style-type: none"><li>• Physically-based</li><li>• Free</li><li>• Multiple models</li><li>• Used by Boards</li><li>• Batch process graphs</li><li>• Tidal buildup</li><li>• Customize text output</li><li>• Represents plume</li></ul>	<ul style="list-style-type: none"><li>• Minimal support</li><li>• Old-school interface &amp; graphics</li><li>• No boundary interactions</li></ul>

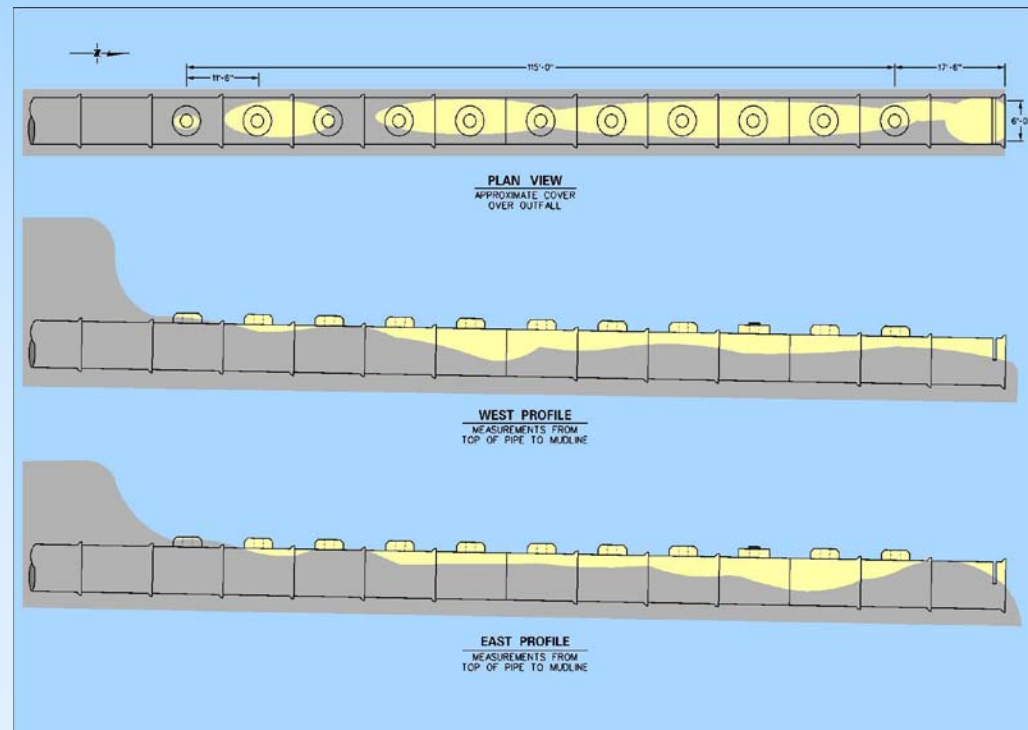
# So What's Your Credit?

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- CORMIX: Momentum & buoyancy dissipates
- VP: Not defined, choices include...
  - Hits surface?
  - “2 x depth” or “2 x width” from outfall?
  - Plumes merge?
  - <5-20% concentration variability?
  - Round number (e.g., 100 ft)?

# Reality Check #1: Diver Inspection

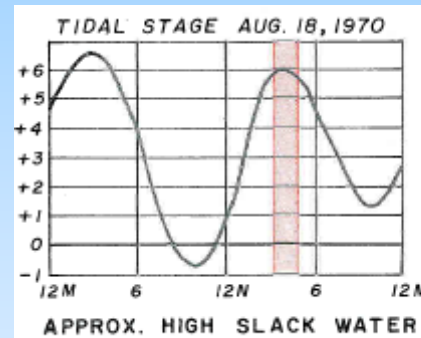
- Ports corroded or sealed?
- Sediment deposition or scour?
- Valves operating?
- Joints sealed?
- Anchors holding?
- Internal buildup?



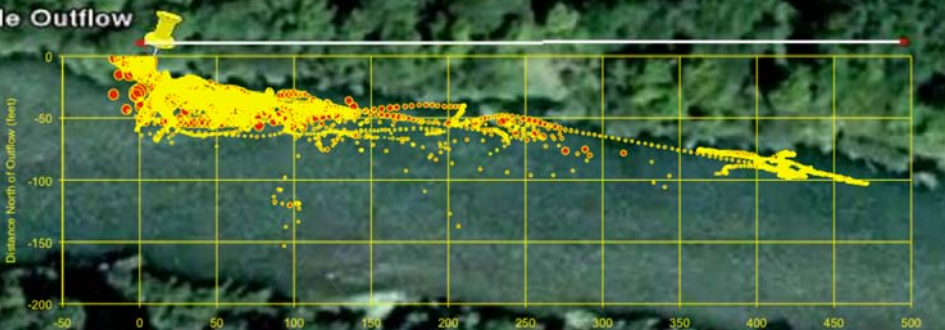
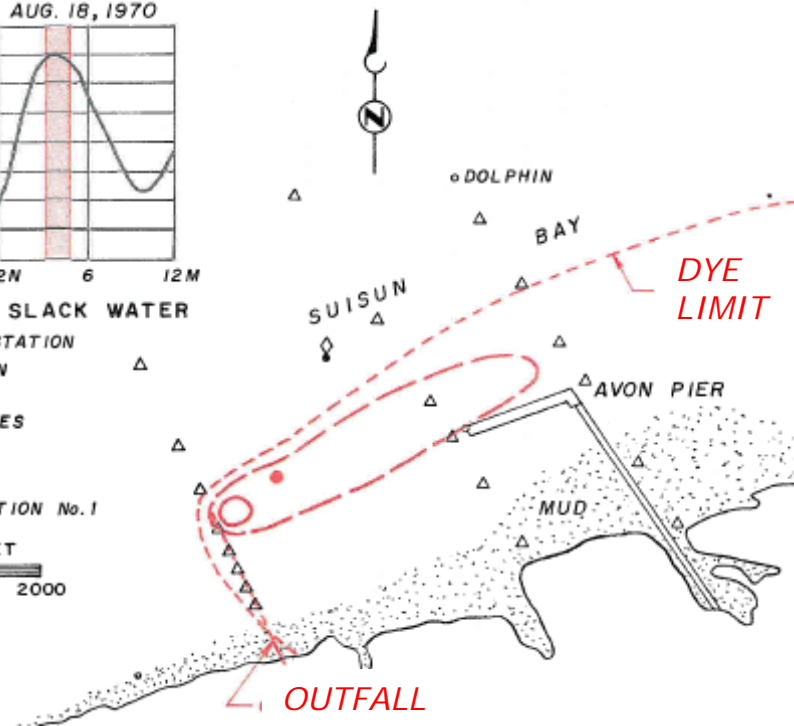


# Reality Check #2: Tracer (or Drogue) Study

- Many done in 1970s
- One-day events in lieu of models
- Calibrates Bay model



GRAB SAMPLE STATION  
MINIMUM DILUTION  
RECORDED = 1:78  
DILUTION LINES  
— 1: 500  
— 1: 100  
VERTICAL STATION No. 1  
SCALE IN FEET  
1000 2000



# QUESTIONS?

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# CORMIX Interface

**CORMIX v6.0.0.0** [ \_ ] [ □ ] [ × ]

Project Pages Pre-Processing Tools Run Output Data Reports Post-Processing/Advanced Help

Load Clear Save Save As Print lbs kg SI-Units CorHyd CorSpy Validate & Run FC Tree CorVue CorJet FFL CorSens User Manual CorHelp

Project Effluent **Ambient** Discharge Mixing Zone Output Processing

Ambient Page [ + ] [ - ]

### Ambient Geometry/Flow Field Data

Average Depth: [ ] m

Depth at Discharge: [ ] m

Wind Speed: [ ] m/s

**Bounded** | Unbounded

Width: [ ] m

Appearance: [ Uniform ]

**Steady** | Unsteady

**Flowrate** | Velocity

Flowrate: [ ] m<sup>3</sup>/s

**Manning** | Darcy

Manning's n: [ ]

**Ambient Flow Option**

### Ambient Density Data

**Fresh Water** | Non-Fresh Water

**Uniform** | Stratified

**Type A** | Type B | Type C

**Linear Density Profile**

[ ] Temperature (deg. C)

at Surface: [ ]

at Bottom: [ ]

# Visual Plumes Interface

Visual Plumes, Experimental PVD Version; U.S. Environmental Protection Agency, ERD-Athens, ORD, 4 Nov 02, 4 Mar 03

File Edit Models Stop Run Help



Diffuser: SAM-DDSD-brine-acute-ts.vpp.db Ambient: C:\Plumes\StephenM\DDSD\SAM-DDSD-brine-acute-ts.001.db Special Settings Text Output Graphical Output

## Ambient Inputs

	Measurement depth or height	Near-field current speed	Near-field current dir.	Ambient salinity	Ambient temperature	Background concentration	Pollutant decay rate(*)	n/r	n/r	Far-field diffusion coeff
Depth or Height		depth	depth	depth	depth	depth	depth	depth	depth	depth
Extrapolation (stc)		constant	constant	constant	constant	constant	constant	constant	constant	constant
Extrapolation (btm)		constant	constant	constant	constant	constant	constant	constant	constant	constant
Measurement unit	m	m	m	kg/m3	C	%	s-1	m/s	deg	m0.67/s2
	0	1	1	1000.5	15	0	0			0.0003
	8.4	7	7	1000.5	15	0	0			0.0003



UM3

### Ambient file list

#### Filename

SAM-DDSD-brine-acute-ts

### Time-Series Files (optional)

Borrow time-series files from project:

C:\Plumes\StephenM\SAM-DDSD-brine-acute-ts.001

Time-series filename		C:\Plumes\Step	C:\Plumes\Step	click for file	click for file	click for file	click for file	click for file	click for file	click for file
Time increment (hrs)		1.0000	1.0000							
Cycling period		696.0000	696.0000							
File measurement unit		m/s	deg							