

STFATE

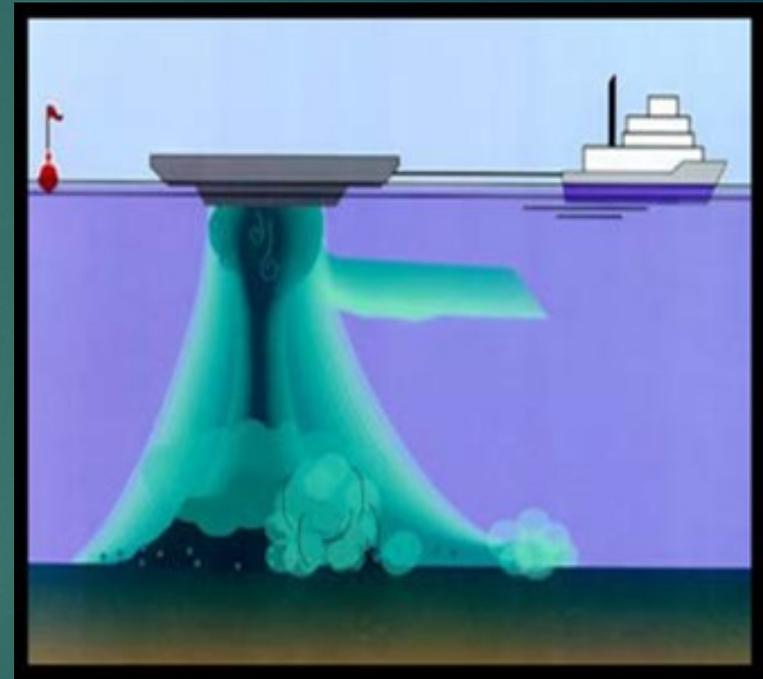
(SHORT-TERM FATE OF DREDGED MATERIAL DISPOSAL IN OPEN WATER MODELS)

OPEN WATER DISPOSAL MODELS FOR PLUME DISPERSION AND INITIAL DEPOSITION FROM DUMP SCOWS AND HOPPER DREDGES

(DISCRETE, NON-CONTINUOUS DISCHARGES)

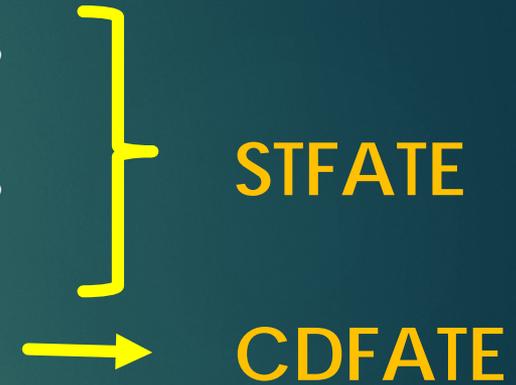
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MODELS FOR DREDGED MATERIAL DISPOSAL IN OPEN WATER

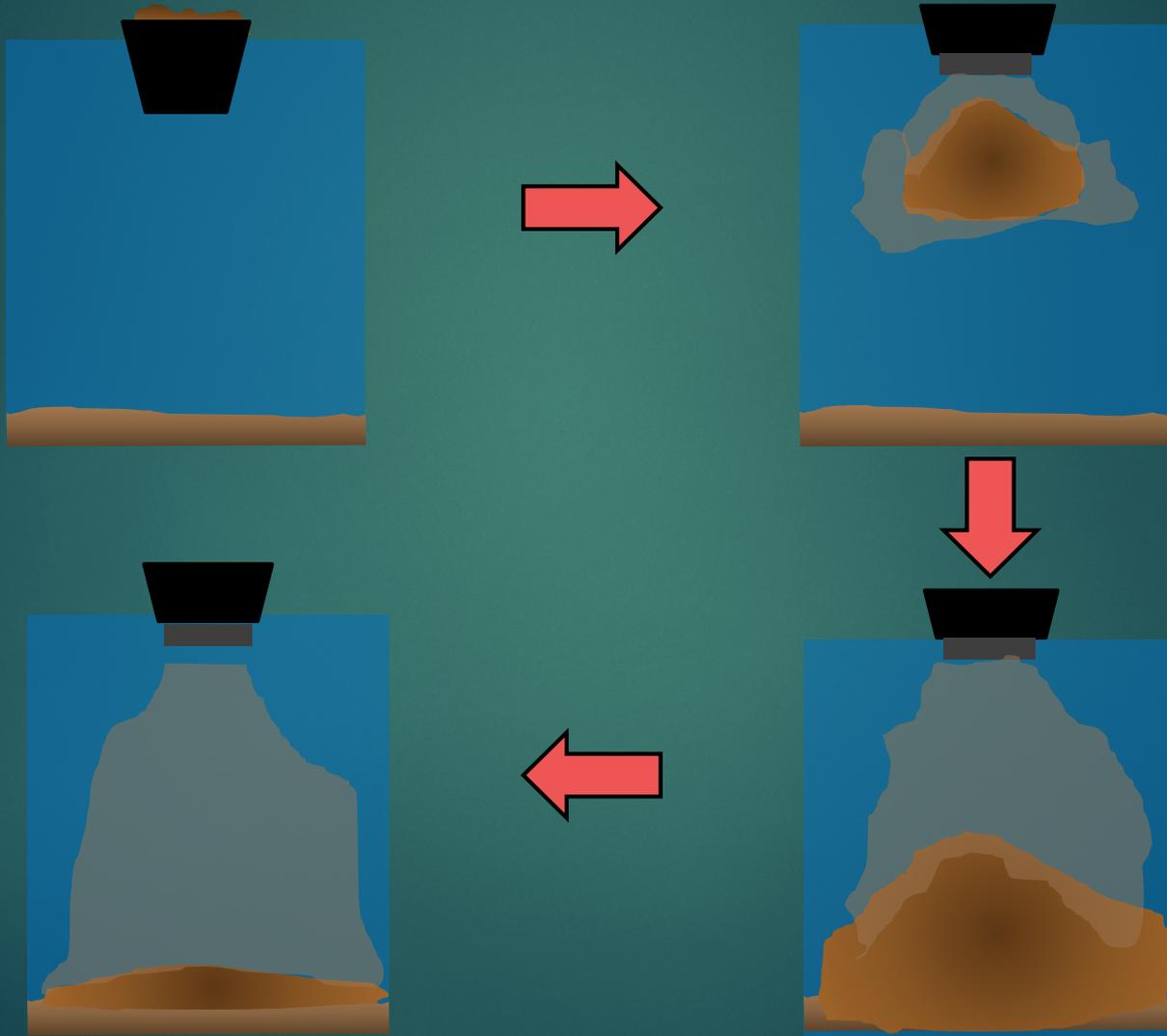
- ▶ DIFID – DISPOSAL FROM AN INSTANTANEOUS DISCHARGE
- ▶ DIFID – DISPOSAL FROM AN INSTANTANEOUS DISCHARGE
- ▶ DIFCD – DISPOSAL FROM A COUNTINUOUS DISCHARGE
- ▶ ORIGINAL MODELS DEVELOPED BY EPA (KOH AND CHANG 1973)
- ▶ MODIFIED AND REFINED BY WES (BRANDSMA AND DIVOKY 1976 AND JOHNSON 1990)
- ▶ VERIFIED BY DATA AT SEVERAL SITES (BOKUMIEWICZ 1078 AND JOHNSON 1978)



PURPOSE

- ▶ Simulation of dredged material descent, collapse, and transport by advection and dispersion
- ▶ Prediction of water quality in water column considering the effects of initial mixing
- ▶ Comparison of contaminant concentration in water column with water quality standard at edge of disposal site
- ▶ Prediction of mixing zone required for open water disposal of dredged material
- ▶ Prediction of initial deposition of dredged material

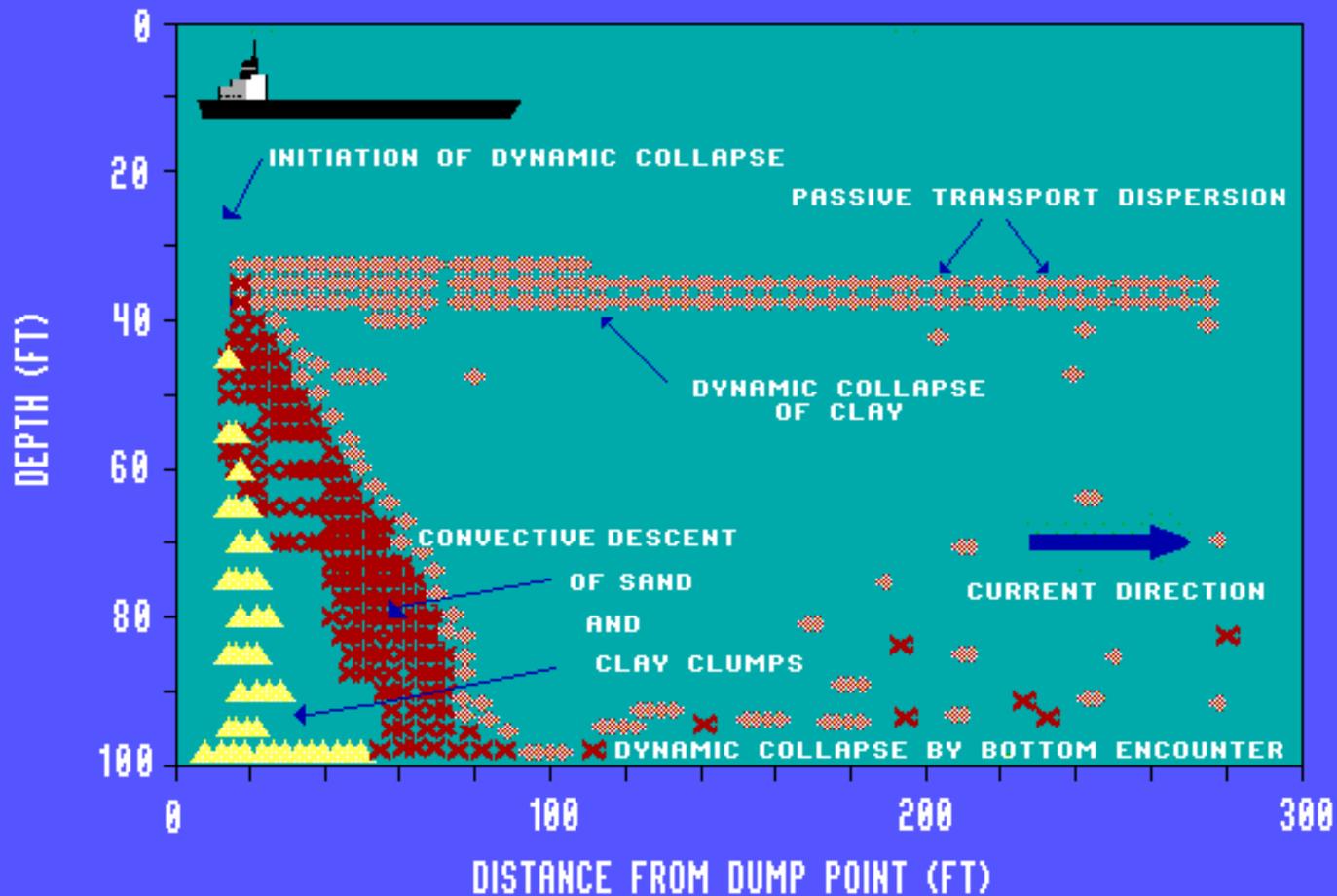
DISPOSAL SEQUENCE



PHASES MODELED

- ▶ Convective descent – controlled by gravity and momentum
- ▶ Dynamic collapse – bottom encounter, spreading dominates
- ▶ Passive transport dispersion – currents and turbulence dominate

EXAMPLE PLUME GENERATION AND TRANSPORT

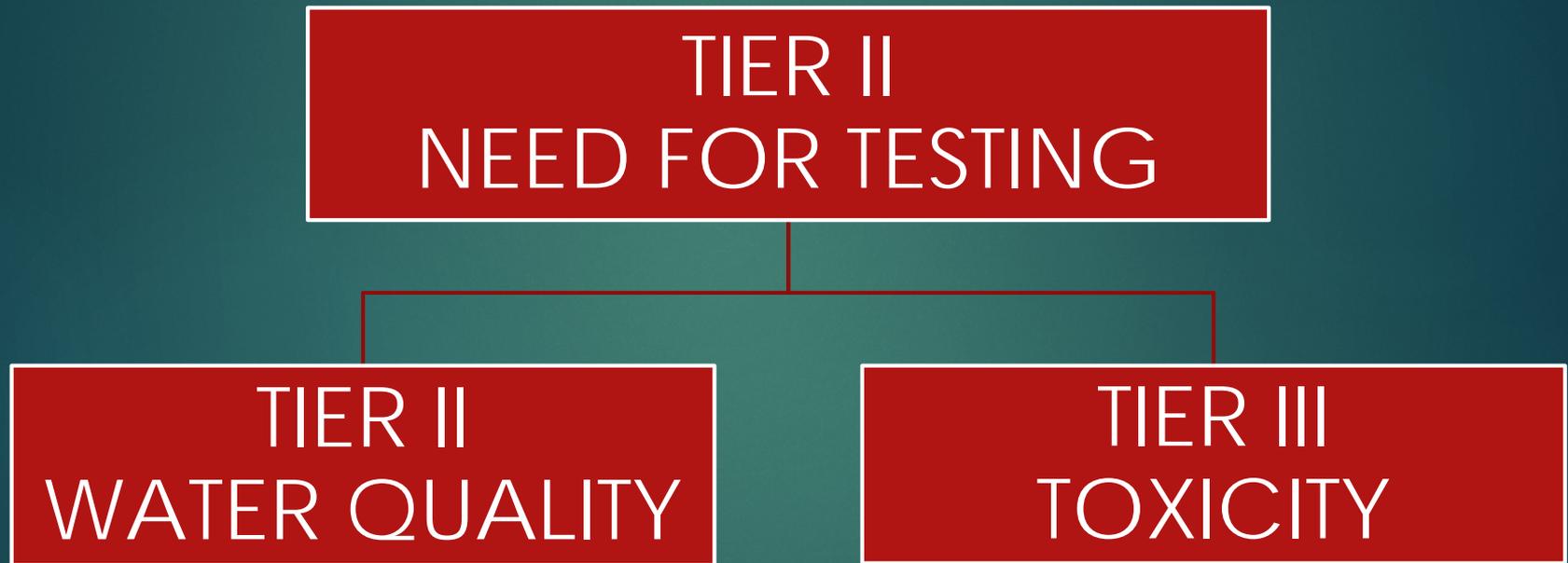


APPLICATIONS



- ▶ Regulatory evaluation under Section 103 of the Marine Protection Research and Sanctuary Act and Section 404(b)(1) of the Clean Water Act
- ▶ Evaluation of sediment mound development
- ▶ Plume generation and transport evaluations

REGULATORY EVALUATION USES TIERED APPROACH



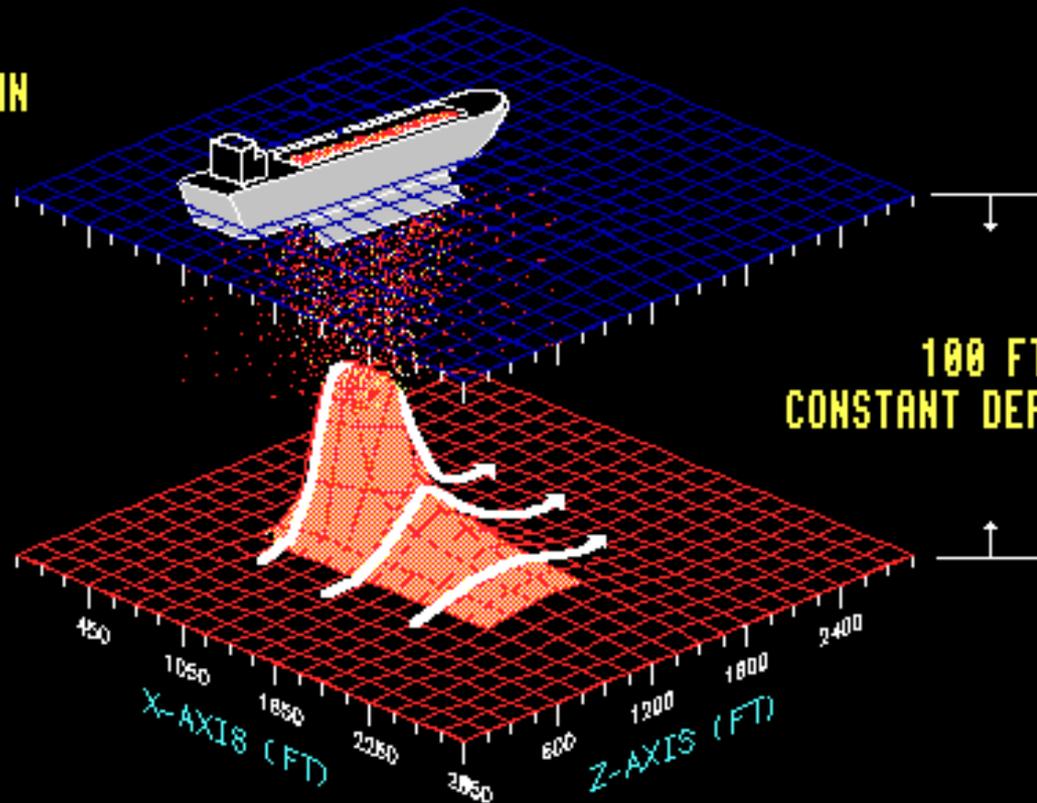
INPUT REQUIREMENTS



- ▶ DISPOSAL SITE DESCRIPTION
- ▶ VELOCITIES AT DISPOSAL SITE
- ▶ INPUT/OUTPUT/EXECUTION CONTROLS
- ▶ DREDGED MATERIAL DESCRIPTION
- ▶ DISPOSAL OPERATION
- ▶ MODEL COEFFICIENTS

DISPOSAL SITE DATA

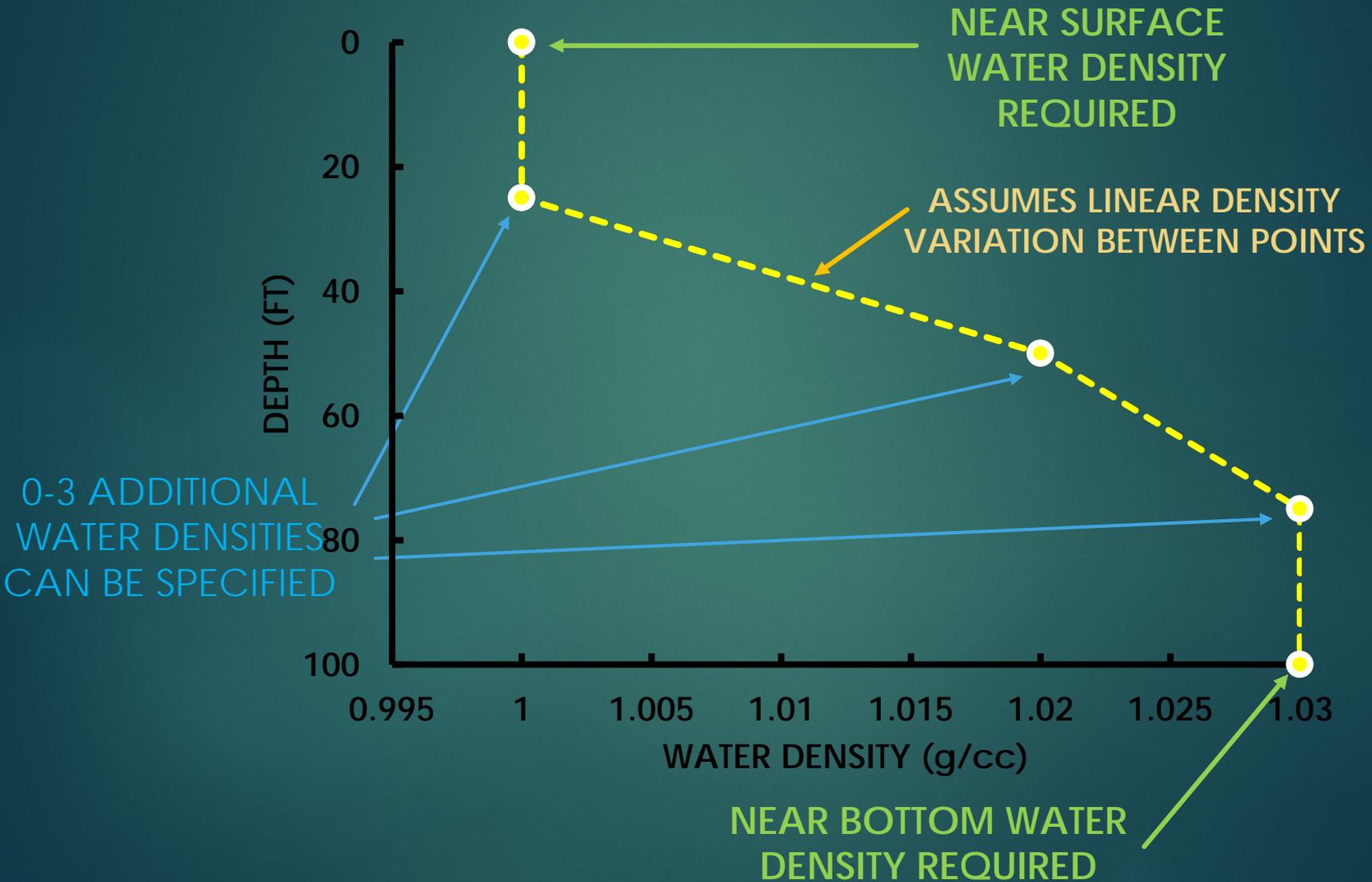
20X20 GRID
150 FT GRID SPACING IN
X AND Z DIRECTION



BOTTOM SLOPE = 0

BOTTOM ROUGHNESS .01 FT

WATER DENSITY PROFILE



DISPOSAL SITE WATER VELOCITY OPTIONS

- ▶ SINGLE DEPTH-AVERAGED VELOCITY
 - ▶ Uniform velocity profile
 - ▶ Logarithmic velocity profile
- ▶ 2-POINT VELOCITY PROFILE
(Constant Depth Grid Only)
- ▶ VARIABLE VELOCITY FIELD FOR ENTIRE GRID
- ▶ UNSTEADY VELOCITY FOR SINGLE DEPTH
(Tidal Velocity Profile)

DEPTH AVERAGED VELOCITIES (SINGLE VALUE)

- ▶ UNIFORM VELOCITY PROFILE
- ▶ LOGARITHMIC VELOCITY PROFILE

Velocity Profile Data

Velocity Profile Type

- Single Depth Averaged Velocity
- 2-Point Velocity Profile for a Constant Depth Grid
- Variable Velocity Field for Entire Grid
- Unsteady Velocity for Single Depth (Tidal Velocity Profile)

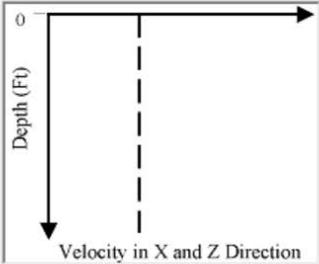
Single Depth Velocity

0.0 X-Direction Velocity (fps)

0.0 Z-Direction Velocity (fps)

Use a Logarithmic Velocity Profile?

0.0 Depth (ft) of Velocity



Single Point Velocity

STFATE treats positive velocities in the X-Direction as moving from the top of the grid towards the bottom. Positive velocities in the Z-Direction move from left to right.

OK Cancel Help

2-PT VELOCITY PROFILES

- ▶ User Enters X and Z Velocities at 2 Depths
- ▶ STFATE Extrapolates Velocity with Depth as:
 - ▶ Constant velocity between water surface and shallowest depth
 - ▶ Linear variation between shallowest and deepest depth
 - ▶ Linear variation between deepest depth and velocity = 0 at bottom
- ▶ Velocities Assumed Constant Throughout Simulation

Velocity Profile Data

Velocity Profile Type

- Single Depth Averaged Velocity
- 2-Point Velocity Profile for a Constant Depth Grid
- Variable Velocity Field for Entire Grid
- Unsteady Velocity for Single Depth (Tidal Velocity Profile)

2-Point Profile

	X-Depth	X-Velocity	Z-Depth	Z-Velocity
Upper Point	8.2	0.52	8.2	0.21
Lower Point	40	0.31	40	0.12

Constant Water Depth Must Be Specified in Site Data
X - Direction Velocity (+) is from top to bottom
Z - Direction Velocity (+) is from left to right

2-Point Velocity Profile for a Constant Depth Grid

STFATE treats positive velocities in the X-Direction as moving from the top of the grid towards the bottom. Positive velocities in the Z-Direction move from left to right.

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VARIABLE VELOCITY PROFILE

- ▶ User enters x and z velocity vectors for each cell
- ▶ Allows detailed flow field
- ▶ Typically derived from hydrodynamic model output
- ▶ Velocity assumed constant throughout simulation

Velocity Profile Data

Velocity Profile Type

- Single Depth Averaged Velocity
- 2-Point Velocity Profile for a Constant Depth Grid
- Variable Velocity Field for Entire Grid
- Unsteady Velocity for Single Depth (Tidal Velocity Profile)

Variable Velocity Field

Initialize the X-Direction Velocity field to a constant? 0.00

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
Row 1	0	0	0	0	0	0	0	0	0
Row 2	0	0	0	0	0	0	0	0	0
Row 3	0	0	0	0	0	0	0	0	0

Initialize the Z-Direction Velocity field to a constant? 0.00

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
Row 1	0	0	0	0	0	0	0	0	0
Row 2	0	0	0	0	0	0	0	0	0
Row 3	0	0	0	0	0	0	0	0	0

Velocity in Z-Direction

Variable Velocity Field for Entire Grid

STFATE treats positive velocities in the X-Direction as moving from the top of the grid towards the bottom. Positive velocities in the Z-Direction move from left to right.

OK Cancel Help

UNSTEADY VELOCITY (SINGLE POINT, TIDAL VELOCITY)

- ▶ CONSTANT VELOCITY WITH DEPTH
- ▶ MAGNITUDE AND DIRECTION CHANGE OVER A FIXED PERIOD
- ▶ TIME PERIOD REPEATS DURING SIMULATION
- ▶ TYPICAL OF TIDAL CYCLES
- ▶ COULD BE USED FOR OTHER SIMULATIONS

Velocity Profile Data

Velocity Profile Type

- Single Depth Averaged Velocity
- 2-Point Velocity Profile for a Constant Depth Grid
- Variable Velocity Field for Entire Grid
- Unsteady Velocity for Single Depth (Tidal Velocity Profile)

Unsteady Velocity Profile

0.0

Simulation Duration (Hrs)

0.00

Depth Where Velocity Profile is Applied (Ft)

0.00

Start Time Within Velocity Profile (Hrs)

0.0

Average X-Velocity (Ft/Sec)

0.0

Average Z-Velocity (Ft/Sec)

	X-Velocity	Z-Velo
▶ Point 1 (t=0 Hrs)	0	0
Point 2 (t=0.5 Hrs)	0	0
Point 3 (t=1.0 Hrs)	0	0
Point 4 (t=1.5 Hrs)	0	0
Point 5 (t=2.0 Hrs)	0	0
Point 6 (t=2.5 Hrs)	0	0
Point 7 (t=3.0 Hrs)	0	0
Point 8 (t=3.5 Hrs)	0	0
Point 9 (t=4.0 Hrs)	0	0
Point 10 (t=4.5 Hrs)	0	0
Point 11 (t=5.0 Hrs)	0	0
Point 12 (t=5.5 Hrs)	0	0
Point 13 (t=6.0 Hrs)	0	0

Velocity (Ft/Sec)

Time

Unsteady Velocity for Single Depth (Tidal Velocity Profile)

STFATE treats positive velocities in the X-Direction as moving from the top of the grid towards the bottom. Positive velocities in the Z-Direction move from left to right.

Unsteady Velocity Information

Ok Cancel Help

INPUT, EXECUTION, AND OUTPUT CONTROLS

- ▶ Phases To Be Modeled
- ▶ Level of Evaluation (Tier)
- ▶ Disposal Site/Mixing Zone Location
- ▶ Contaminant Description, Concentrations, and Criteria
- ▶ Depths Where Output Desired
- ▶ Duration of Simulation
- ▶ Size of Long-Term Time Step for Diffusion
- ▶ Selection of Output Types

DREDGED MATERIAL DESCRIPTION

- ▶ NUMBER OF LAYERS (MAX 6) AND VOLUMES
- ▶ X & Z VELOCITY VECTORS OF BARGE/HOPPER
- ▶ NUMBER OF SOLID FRACTIONS (Max 4)
 - ▶ e.g. Clumps, Sand, Silt, Clay
- ▶ PROPERTIES OF SOLID FRACTIONS
 - Specific Gravity
 - Volumetric Concentration
 - Fall Velocity
 - Void Ratio
 - Critical Shear Stress
 - Cohesiveness
- ▶ DREDGING SITE WATER DENSITY

DREDGED MATERIAL DESCRIPTION

Material Description Data

Sediment Information Define STFATE Sediment Fractions

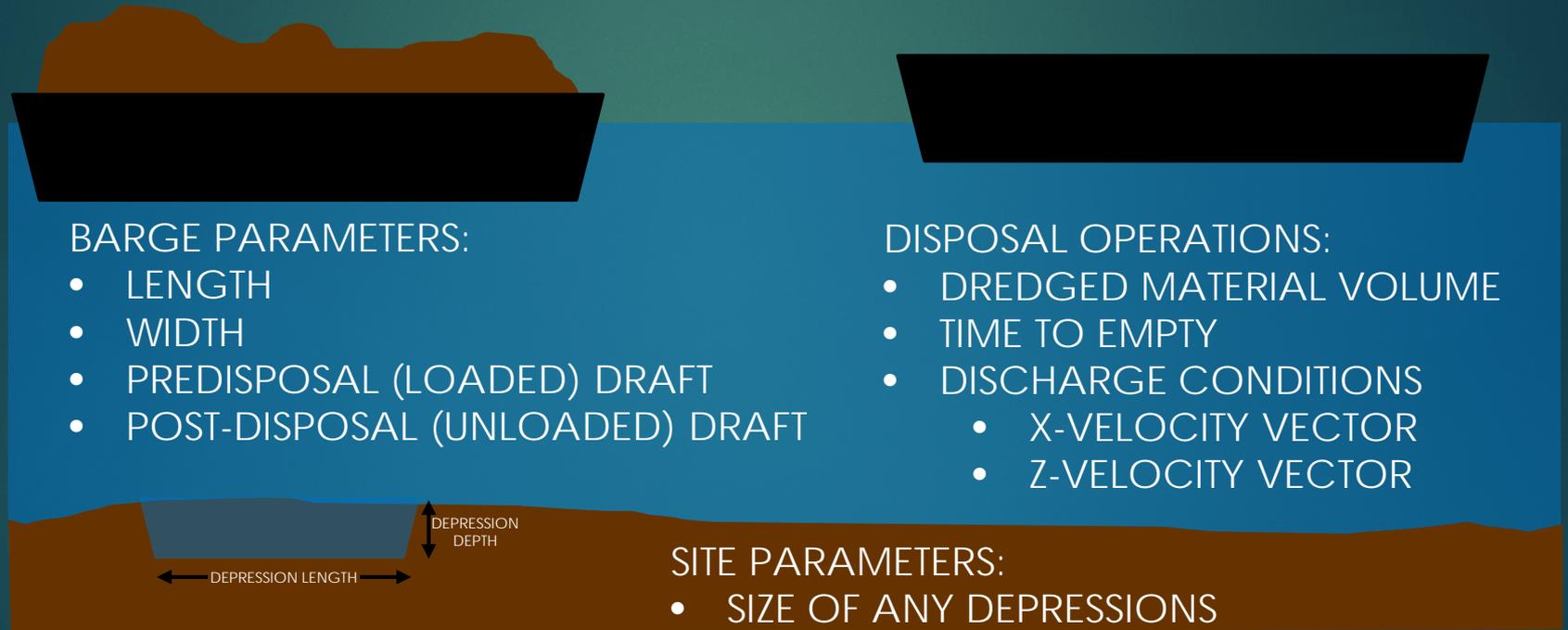
Dredged Sediment Volumetric Fractions Table

Fraction Number	Description	Entire Load	Layer Fractions Total	Bottom Layer	Layer 2	Layer 3	Layer 4	Layer 5	Top Layer	Specific Gravity	Fall Velocity (ft/sec)	Deposition Void Ratio	Critical Shear Stress (lb/ft ²)	Cohesive?	Stripped During Descent
1	Silt	0.010								2.65	0.01	4.5	0.0085	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2	Clay	0.031								2.65	0.002	7.5	0.0038	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3	SAND	0.002								2.7	0.1	0.6	0.025	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4	SAND	0.001								2.7	0.1	0.6	0.025	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Water	0.956													
	Total	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
	Sediment Volume (cy)	13500													
	Moisture Content, %	0.0													
	X Barge Velocity (fps)	0.00													
	Z Barge Velocity (fps)	0.00													

3 Sediment Layers (Barge 1-6; Hopper - only 1 layer allowed) Example Settling Properties

OK Cancel Help Volumetric Fraction Assistance

BARGE PARAMETERS AND DISPOSAL OPERATIONS DATA



BARGE PARAMETERS:

- LENGTH
- WIDTH
- PREDISPOSAL (LOADED) DRAFT
- POST-DISPOSAL (UNLOADED) DRAFT

DISPOSAL OPERATIONS:

- DREDGED MATERIAL VOLUME
- TIME TO EMPTY
- DISCHARGE CONDITIONS
 - X-VELOCITY VECTOR
 - Z-VELOCITY VECTOR

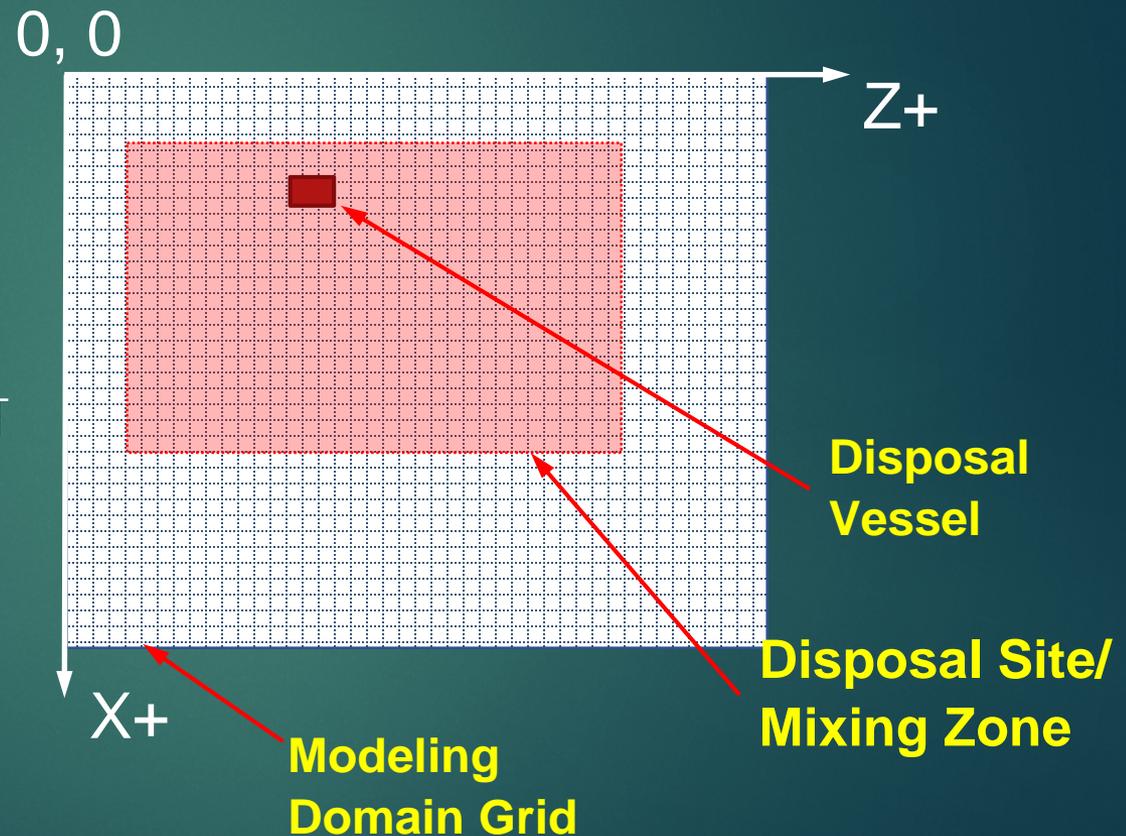
SITE PARAMETERS:

- SIZE OF ANY DEPRESSIONS
 - LENGTH
 - WIDTH
 - DEPTH

GRID SCHEMATIC

REQUIRED:

- DISPOSAL SITE/MIXING ZONE LOCATION
 - X,Z OF UPPER LEFT CORNER
 - X,Z OF LOWER RIGHT CORNER
- DISPOSAL LOCATION
 - X,Z OF VESSEL CENTER



MODEL COEFFICIENTS WITH DEFAULTS

Table of Coefficients

Coefficient Set: Default

	DESCRIPTION	KEYWORD	DEFAULT VALUE	CURRENT VALUE
▶	Settling Coefficient	BETA	0.0000	0.0000
	Apparent Mass Coefficient	CM	1.0000	1.0000
	Drag Coefficient For a Sphere	CD	0.5000	0.5000
	Form Drag For Collapsing Cloud	CDRAG	1.0000	1.0000
	Skin Friction For Collapsing Cloud	CFRIC	0.0100	0.0100
	Drag For an Ellipsoidal Wedge	CD3	0.1000	0.1000
	Drag For a Plate	CD4	1.0000	1.0000
	Friction Between Cloud and Bottom	FRICTN	0.0100	0.0100
	4/3 Law Horiz. Diff. Dissipation Factor	ALAMDA	0.0010	0.0010
	Unstratified Water Vert. Diff. Coefficient	AKY0	0.0250	0.0250
	Ratio-Cloud/Ambient Density Gradients	GAMA	0.2500	0.2500

Calculate Vertical Diffusion Coeff (AKY0) using Pritchard Expression Insead of Using Current Value?

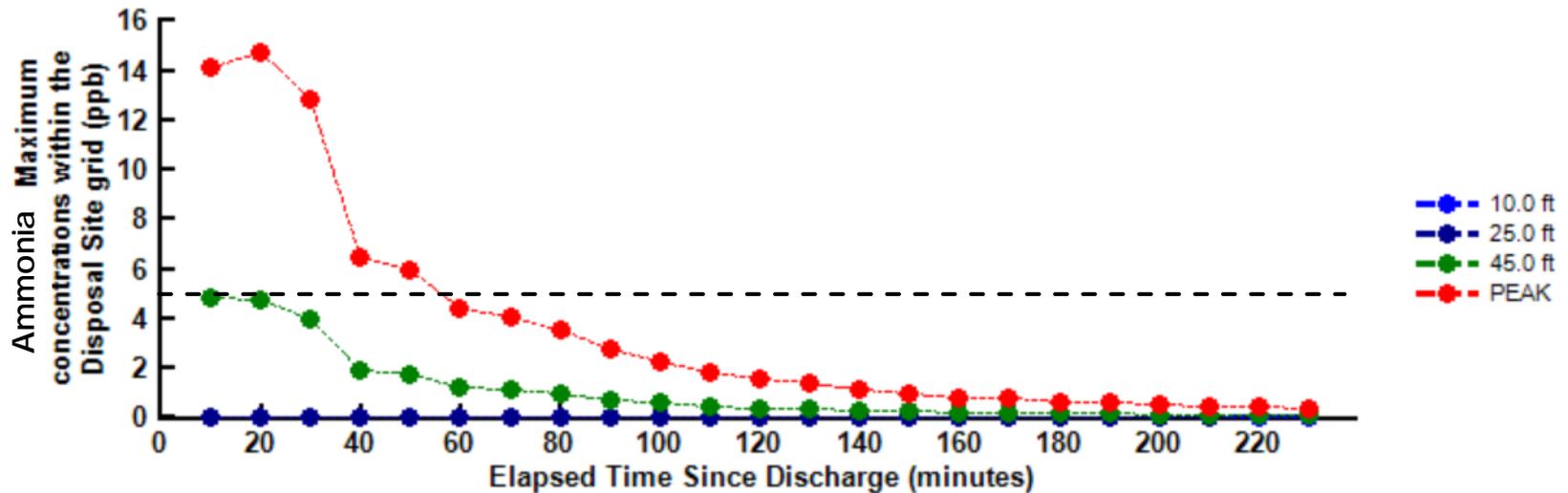
OK Cancel Save Help Default

OUTPUT DATA

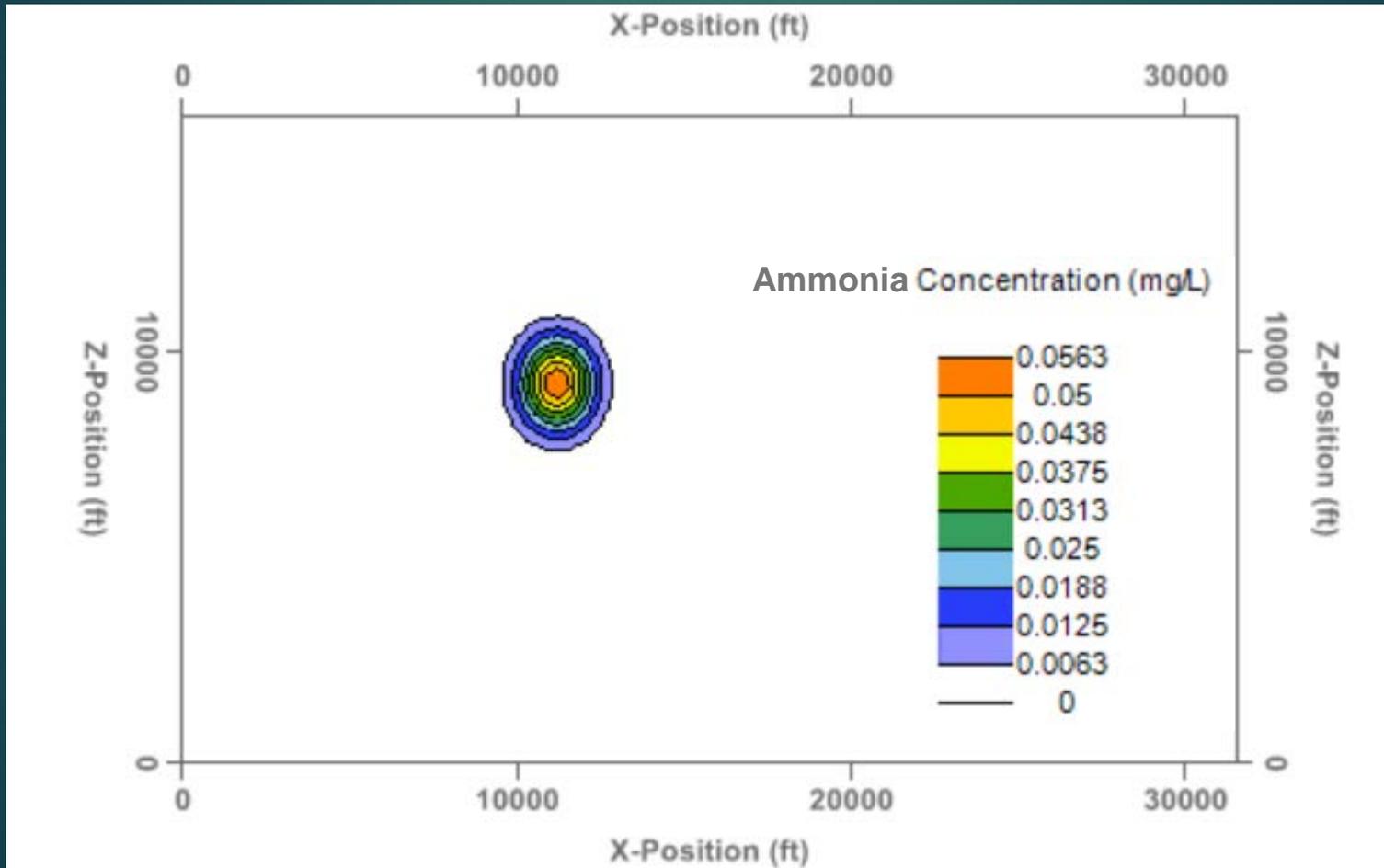
- ▶ Time History of Descent and Collapse Phase
- ▶ Plume Concentrations by Time/Depth
- ▶ Accumulation of Material on Bottom
- ▶ Maximum Concentrations

MAXIMUM WATER COLUMN CONCENTRATIONS

Maximum Computed Water Column Concentrations of AMMONIA within Model Grid



WATER COLUMN CONCENTRATIONS



DEPOSITION DEPTH WITHIN MODEL GRID

