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
- DIFCD – DISPOSAL FROM A CONTINUOUS 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 1978 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

TIER II
NEED FOR TESTING

TIER II
WATER QUALITY

TIER III
TOXICITY
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

100 FT CONSTANT DEPTH GRID
0-3 ADDITIONAL WATER DENSITIES CAN BE SPECIFIED

WATER DENSITY PROFILE

NEAR SURFACE WATER DENSITY REQUIRED

ASSUMES LINEAR DENSITY VARIATION BETWEEN POINTS

0-3 ADDITIONAL WATER DENSITIES CAN BE SPECIFIED

NEAR BOTTOM WATER DENSITY REQUIRED
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**
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
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
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
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

![Dredged Material Description Data](image_url)

<table>
<thead>
<tr>
<th>Fraction Number</th>
<th>Description</th>
<th>Entire Load</th>
<th>Layer Fractions Total</th>
<th>Bottom Layer</th>
<th>Layer 2</th>
<th>Layer 3</th>
<th>Layer 4</th>
<th>Layer 5</th>
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<table>
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<th>Sediment Volume (cy)</th>
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<td>Moisture Content, %</td>
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<tr>
<td>X Barge Velocity (fps)</td>
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<tr>
<td>Z Barge Velocity (fps)</td>
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</table>

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>Fall Velocity (ft/sec)</th>
<th>Deposition Void Ratio</th>
<th>Critical Shear Stress (lb/ft²)</th>
<th>Cohesive?</th>
<th>Stripped During Descent</th>
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<tr>
<td>2.65</td>
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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
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

GRID SCHEMATIC
# Model Coefficients with Defaults

## Table of Coefficients

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>KEYWORD</th>
<th>DEFAULT VALUE</th>
<th>CURRENT VALUE</th>
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<td>Setting Coefficient</td>
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<td>Drag Coefficient For a Sphere</td>
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<td>Form Drag For Collapsing Cloud</td>
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<tr>
<td>Skin Friction For Collapsing Cloud</td>
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<td>Ratio-Cloud/Ambient Density Gradients</td>
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</table>

- **Calculate Vertical Diffusion Coeff (AKY0) using Pritchard Expression Instead of Using Current Value?**
OUTPUT DATA

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

Ammonia Concentration (mg/L)
DEPOSITION DEPTH WITHIN MODEL GRID