Contaminant Release and Transport

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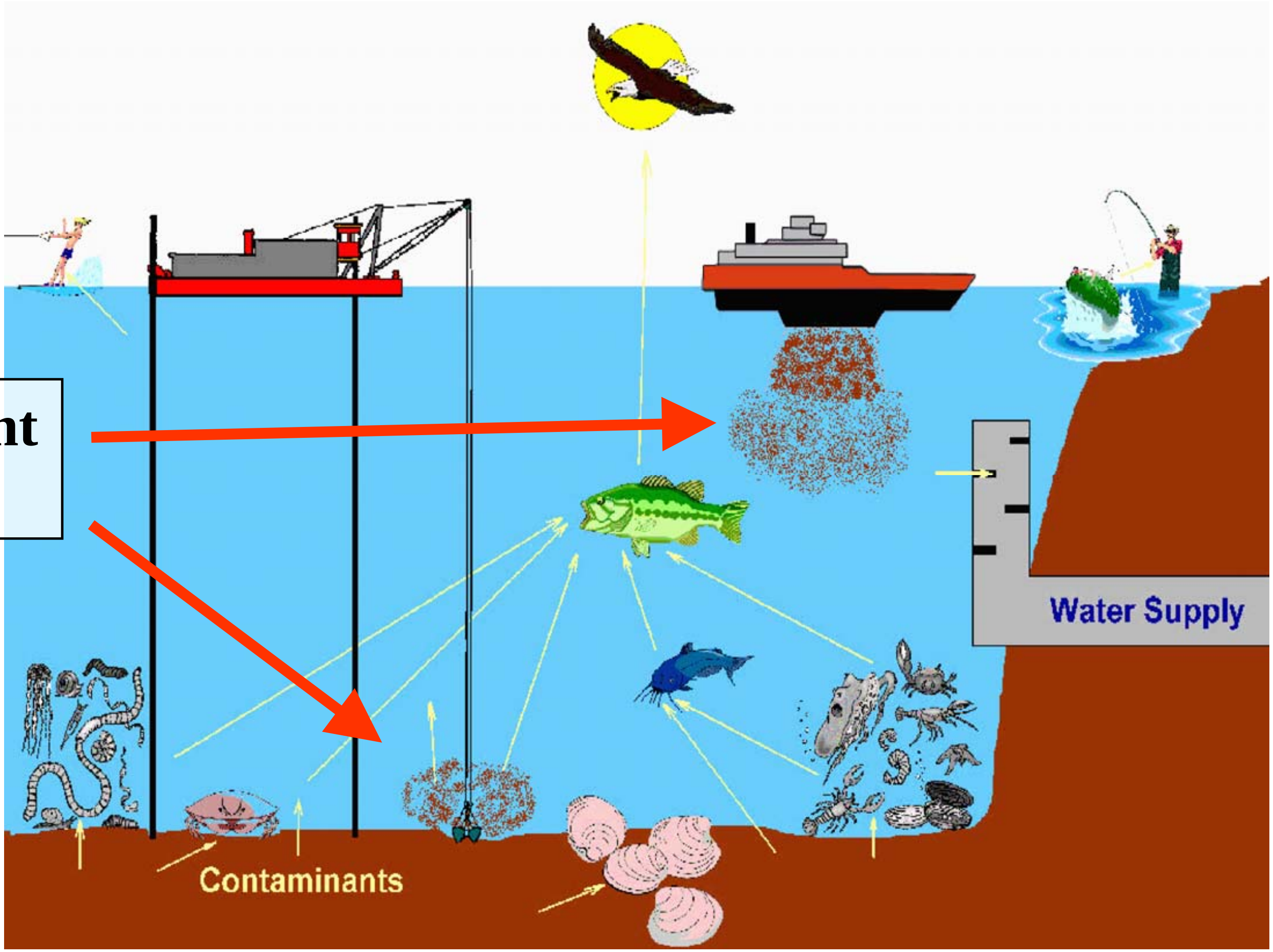
Why? Contaminant Releases Pose Risks

Contaminant Releases



Needs

- Contaminant release source model
  - Mathematical descriptions of processes
  - Protocols for parameterization/calibration
  - Parameterization tools
- Screening tools/model
- Contaminant fate and transport models

Approach

- Develop source description
- Identify contaminant release processes, and parameterize and quantify release factors
- Document evaluation protocol
- Formulate source model
- Develop screening tool
- Incorporate source model and release processes into fate and transport model
- Develop management approaches and document effectiveness

Source Description

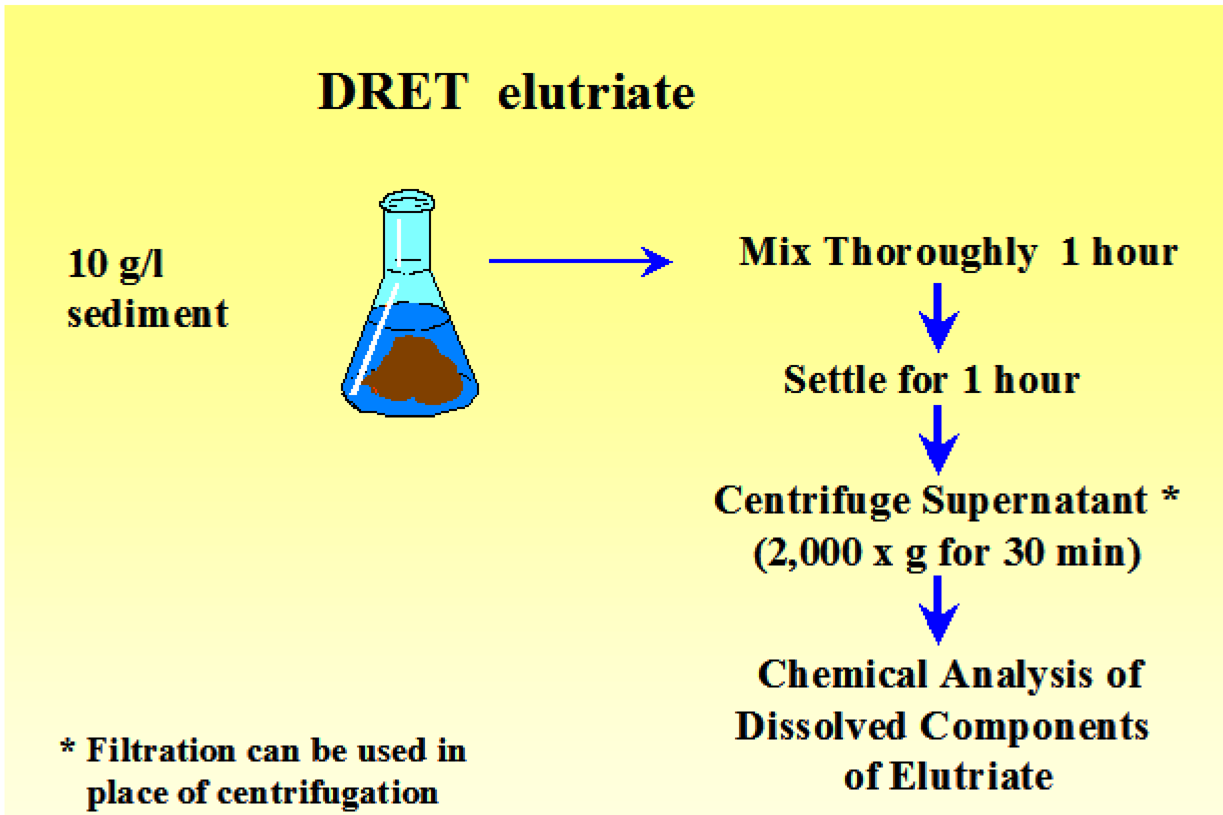
- Critical component of any evaluation
- Driver for any model and evaluation
- Critical Parameters: Rate of resuspension (kg of fine-grained TSS / sec), Volume of porewater release from residuals and Diffusion-induced flux from residuals
- Ranges from 0.01% to 10% of production, but typically 0.1% to 3%
- Residuals range from 2% to 9% of final pass
- Dissolved losses often just a fraction of resuspension and residuals

Contaminant Release Factors

- **Suspended particulate**
  - Equipment
  - Operation including overflow
  - Physical properties of sediment and debris
- **Dissolved**
  - Diffusion from residuals
  - Porewater releases from dredged material and residuals
  - Dissolution/partitioning from suspended solids
    - Function of variable contaminant properties
    - Availability
    - Kinetics

Release Characteristics

- Experimentally determined
- Dredging Elutriate Test (DRET)



Resuspension Source Evaluation

- **Partitioning coefficients from DRET test**
  - $Kd = Fss / Cw$ in L/kg
  - Fss is particulate concentration in mg/kg
  - Cw is dissolved concentration in mg/L
- **Fraction solids resuspended from TSS source model, R**
- **TSS from Flow Rate (L/sec) and Production Rate, Ms (kg/sec)**
  - $TSS = R \times Ms / Q$ in kg/L
- **Dissolved release by resuspension from bulk sediment concentration Cs, partitioning coefficient and TSS**
  - $Co = Fd \times Ct = TSS \times Cs$
  - Fd is the fraction dissolved $Fd = 1 / (1 + Kd \times TSS)$
  - $Mt = Ms \times Cs$
  - $Md = Mt \times Fd$

Documentation

- Source Evaluation documented in TN and spreadsheet
- Environmental Dredging TRD
- 4Rs Report
- Applied in DREDGE Model
- Source Model for PTM and other fate and transport models

Managing Releases

- **Solids controls**
  - Limit dispersion and advection
  - Promote sedimentation
  - Restrict releases to bottom of water column, reducing spreading
  - Silt curtains
- **Dissolved contaminant controls**
  - Reduce flow through area by barriers, thereby decreasing dissolved mass loss
  - Adsorbents

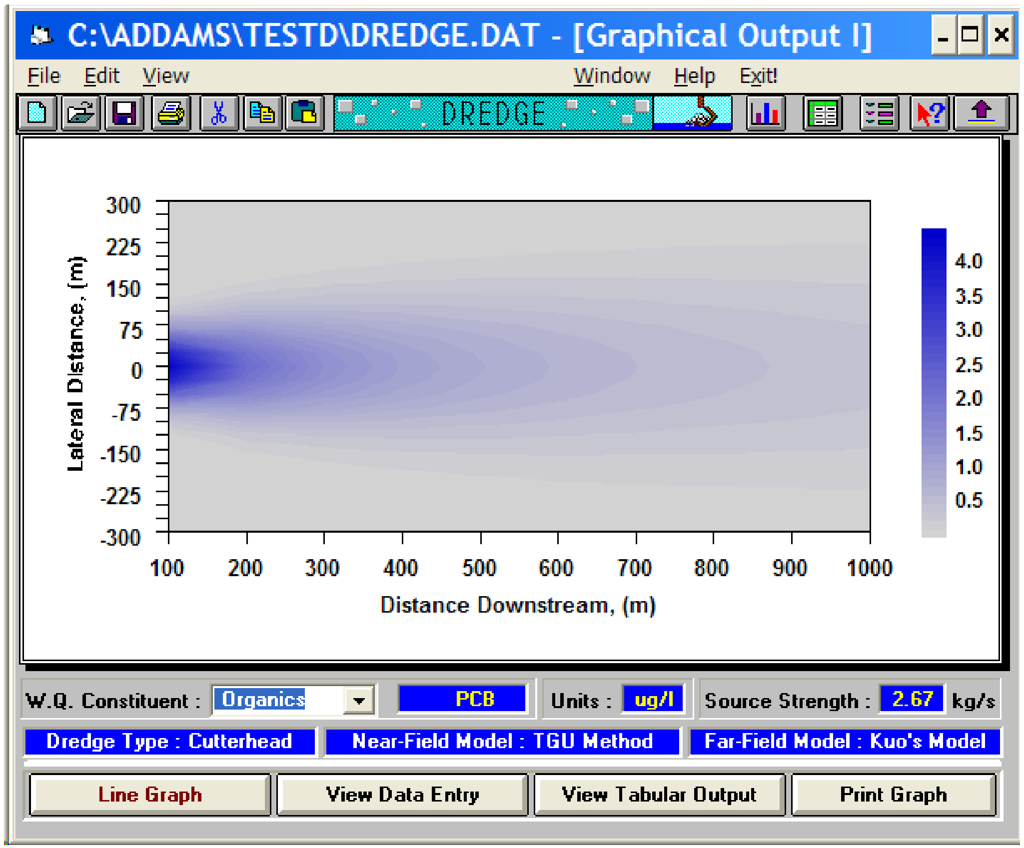
Screening Models

- A screening-level model refers to the use of simplified, quantitative, predictive methods that minimize time and effort for implementation.
- Assumptions can
  - Simplify complexity
  - Reduce input data requirements
- Screening-level models tend to produce conservative estimates of ambient impact.
- Screening-level models can be rapidly applied with minimal input data.

ADDAMS Screening Models

- **Mixing Models for Short-term, Near-/Mid-Field Water Quality and Toxicity Evaluations**
  - DREDGE - continuous resuspension
  - CDFATE / CORMIX - continuous discharge
  - STFATE - discrete discharges
- **1-D Models for Releases from Residuals and Sediment**
  - RECOVERY
  - CAP

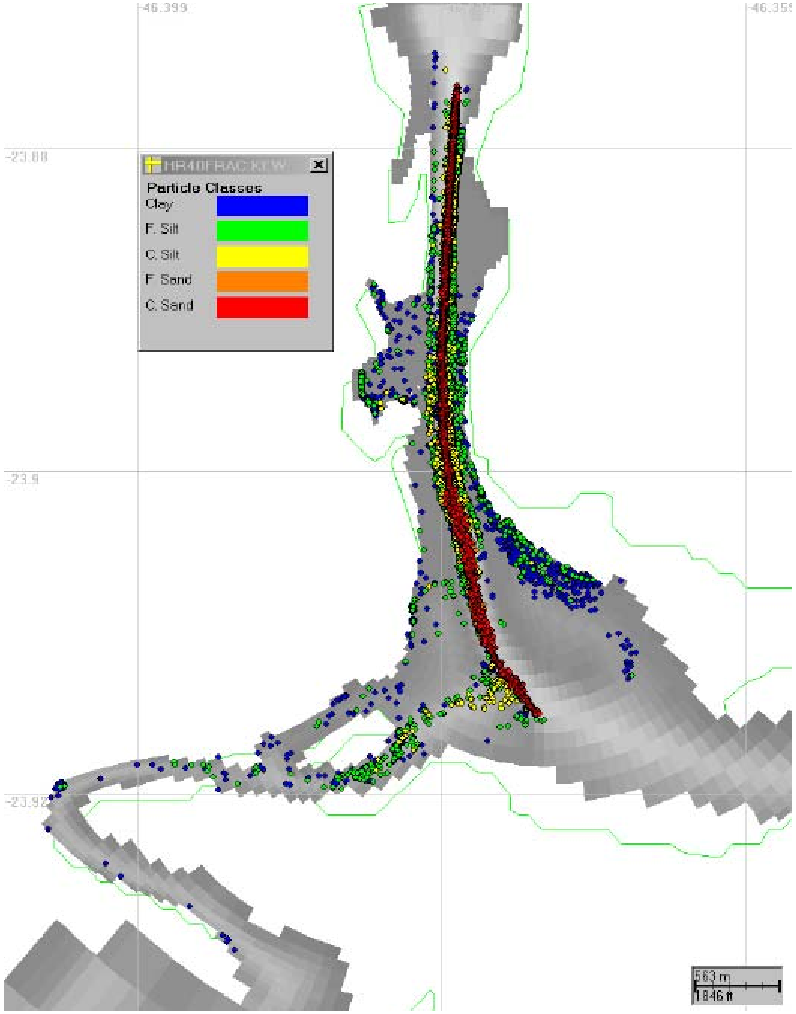
DREDGE



Prediction of Sediment Resuspension and Contaminant Release by Dredging

Comprehensive Dredging Models by Intregation with Surface-water Modeling System (SMS)

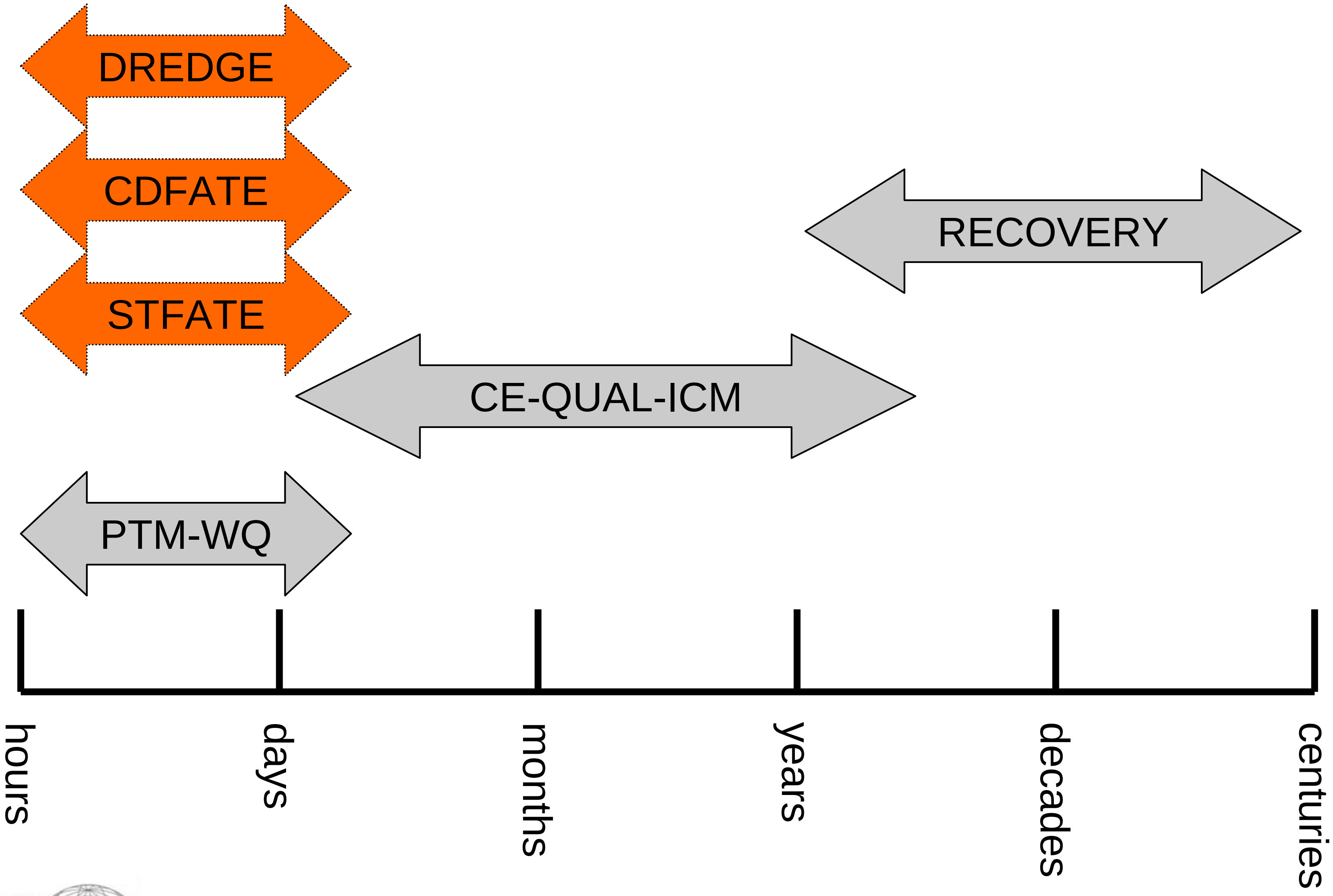
- Comprehensive set of processes and tools
- Hydrodynamics
- Sediment processes
- Pre-processing
  - Grids
  - Bathymetry
- Post-processing and visualization



Simulating Contaminant Release, Transport, and Fate from Dredging Operations

(part 2)

Modeling Efforts for Contaminant Release and Transport during Dredging



Interconnecting Models

PTM-WQ

Source/sink →

← Ambient concentration

CE-QUAL-ICM (TOXI)

- Passive transport
- First order decay
- Partitioning

- Eutrophication
- Sediment transport
- Toxic contamination

$$\frac{\partial C}{\partial t} = -\lambda C$$

$$\vec{r} = \vec{r}_0 + \vec{V}\Delta t$$

$$\frac{\partial C}{\partial t} + \vec{V} \cdot \nabla C = -\left(\nabla \vec{V}\right) C + S$$

kinetics (↑ S)

PTM-WQ

Motivation:

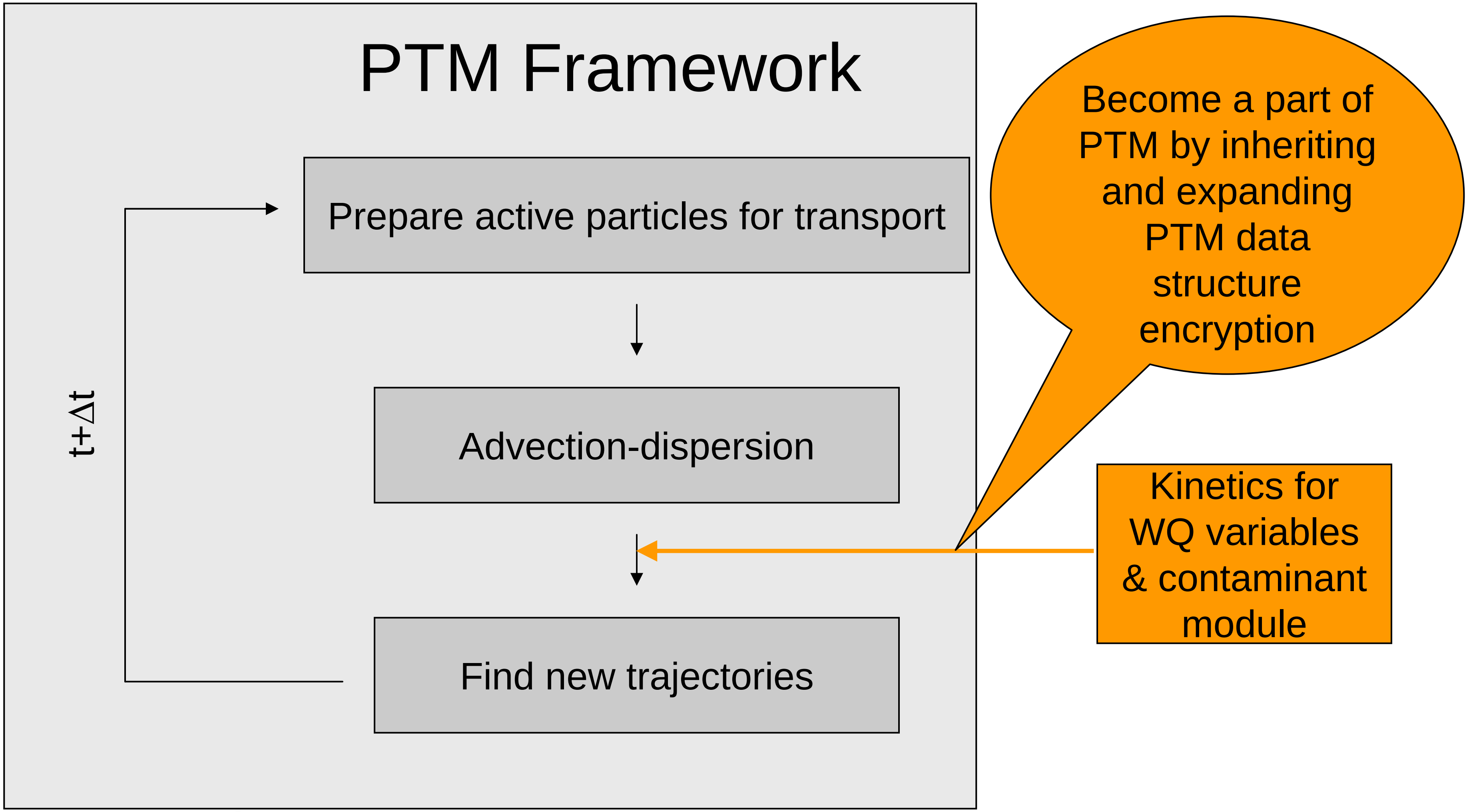
- Dredge plumes affect the environment on multiple temporal and spatial scales
- Grid size limits in handling full scales from a Eulerian model
- Lagrangian model such as PTM can handle high concentration gradient

PTM-WQ

Objectives/Approach:

- Improve an existing dredge plume model to account for fate and effects of non-conservative substances (i.e., contaminants)
- Create a module for PTM by incorporating basic water quality processes and kinetics, including adsorption/desorption, decay, and volatilization, as well as settling, deposition, and resuspension
- Pass output to larger scale model, CE-QUAL-ICM

Schematics of Contaminant Transport Module in PTM Frame



CE-QUAL-ICM (TOXI)

Motivation:

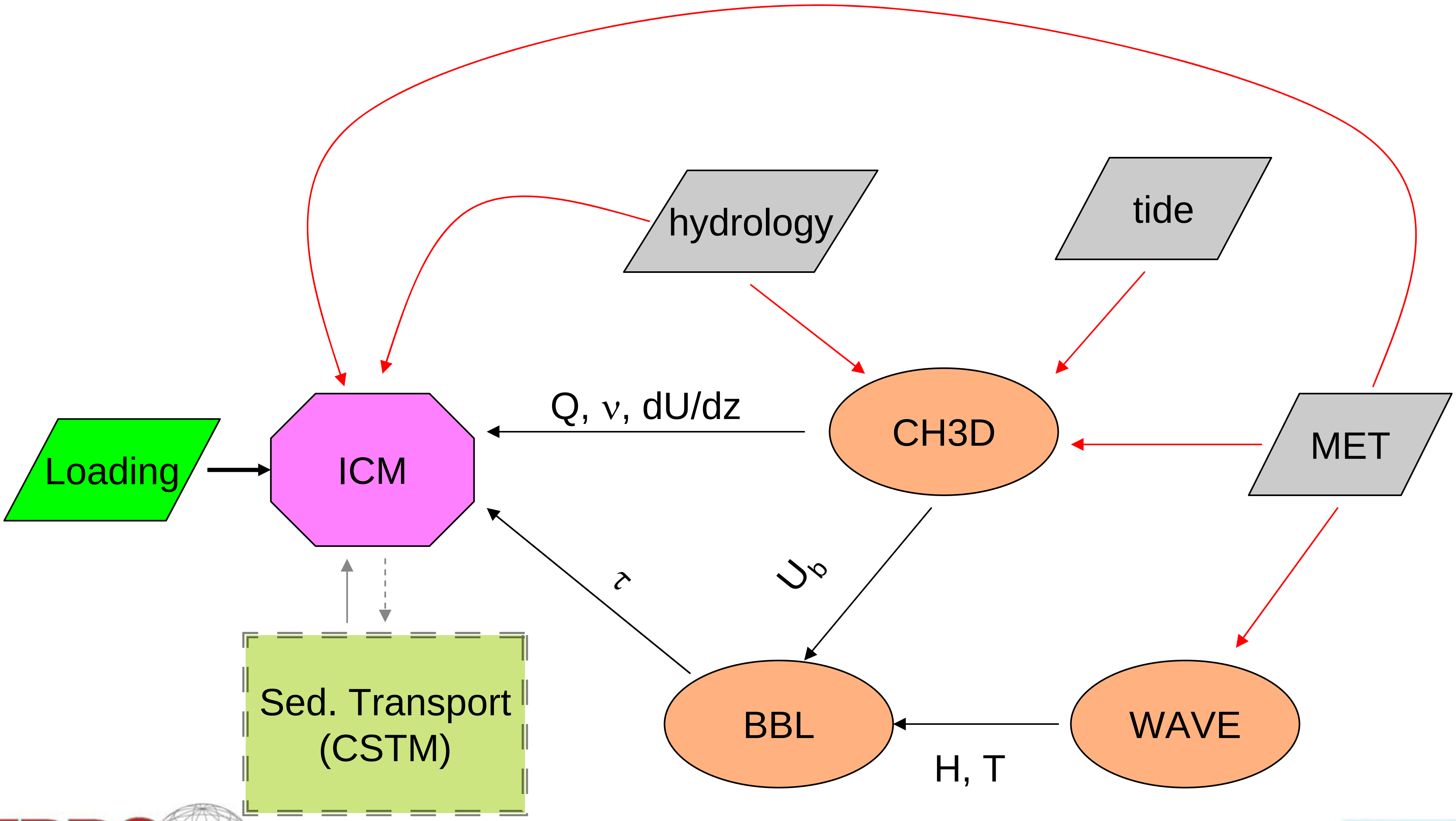
- Impacts of dredged material plumes occur over shorter and smaller temporal and spatial scales, whereas the effects of contaminated in-place sediments can be manifested over longer and larger scales
- Interacting set of predictive models is required that can act over multiple scales

CE-QUAL-ICM (TOXI)

Objectives/Approach:

- Develop a contaminant fate and transport model that will operate on spatial scales ranging from kilometers to system-wide and on temporal scales ranging from minutes to years
- Sediment transport algorithms will be adapted from SEDZLJ
- ICM will be coupled to any type of hydrodynamic model

Schematics for CE-QUAL-ICM



Benefits

- State-of-the-art, peer-reviewed evaluation protocols for contaminant releases and effects using sound science and verified methods
- State-of-the-art suite of tools and models for predicting contaminant exposures and risks
- Documented risk management techniques to control contaminant releases

Technology Transfer

Website:

http://el.erdc.usace.army.mil/dots/ccs/

http://el.erdc.usace.army.mil/dots/models.html

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