DREDGING RESUSPENSION:

DEFINING THE ISSUES

Thomas D. Borrowman

thomas.d.borrowman@usace.army.mil

Topics

- Definitions
- Old issues
- Emerging issues
- Confounding factors
- Sources of uncertainty
- Conclusions

Why Does Resuspension Matter?

- **Fundamental determinant of impacts related to exposure to elevated suspended sediment concentrations, turbidity, and contaminants**
- **Longstanding concerns for a host of potentially sensitive receptors, including SAV, coral reefs, migratory fishes, etc.**
- **Critical consideration for the conduct of environmental/remedial dredging projects**
- **Substantial economic consequences**

The 4 R's

RESUSPENSION

RELEASE

RESIDUALS

RISK

DEFINITIONS

- **Resuspension – Dislodging of bedded sediment particles during the dredging process, and consequent transport and settlement of those particles at a new location**
- **Release – Transport of dissolved constituents of disturbed pore water or constituents desorbed from sediment particles**
- **Residuals – Disturbed sediments remaining after cessation of dredging**
- **Risk – Consequences of resuspension, release, and creation of residuals**

Old Issues

Unanswered questions 40 years after NEPA

- **What are the principal drivers affecting the rate of resuspension?**
- **What are the rates of resuspension associated with basic modes of dredging?**
- **What are the relevant spatial and temporal scales of resuspension?**

Old Issues

Unanswered questions 40 years after NEPA

- **What thresholds of suspended and deposited sediment exposure trigger biologically meaningful detrimental responses?**
- **What management practices and control measures actually provide protection benefits?**
  - **The current practice of resorting to environmental windows underscores a need to explore new approaches and technologies**

Emerging Issues

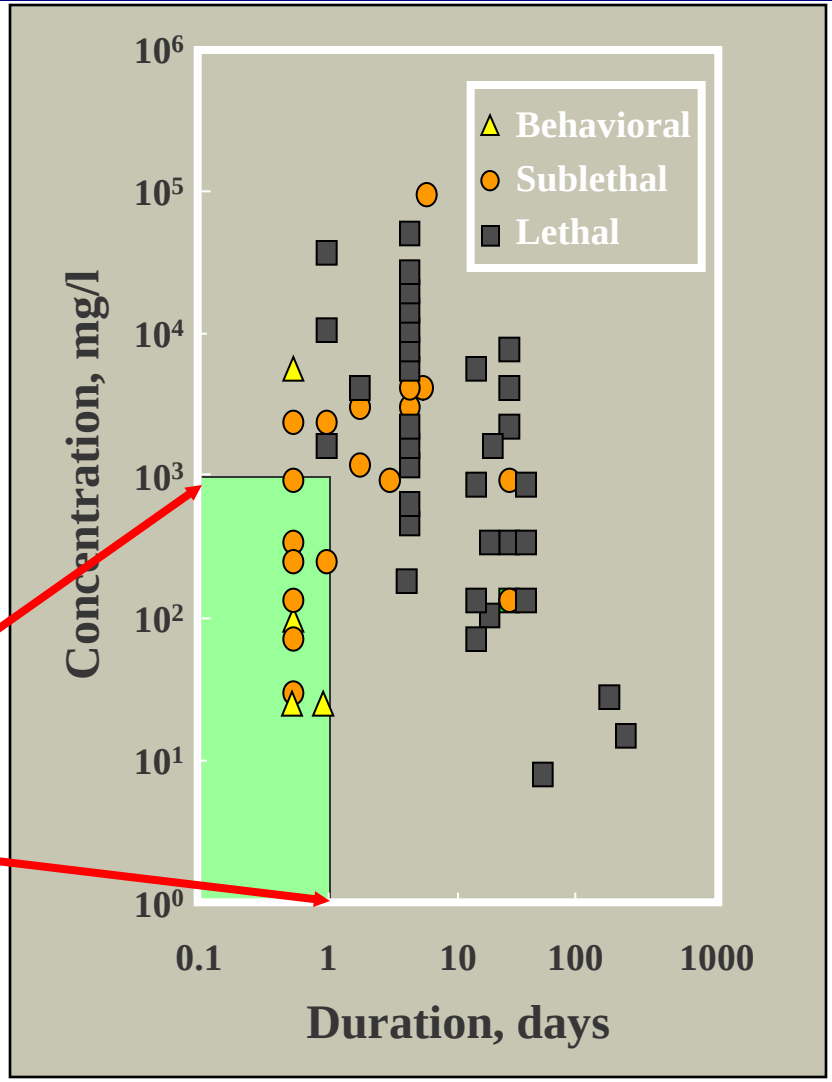
- **Concerns being extended to other sources, including ship traffic**
- **Increasing pressure for continuous, real time monitoring without established means of interpreting data or providing risk-based responses/controls**
- **Restrictions and controls applied to remedial projects are increasingly being incorporated into navigation dredging WQ certificates without a prior risk assessment or documented need**

Confounding Factors and Sources of Uncertainty

- Diverse receptors and pathways
- Lack of standardized methodologies
- Many physical factors influence resuspension
- Many operational factors influence resuspension
- Regulatory inconsistencies

Effects of TSS and Turbidity

Juvenile Salmonids



Dredging Exposure

Many studies have not used protocols that establish dose-response relationships.

Physical Factors That Influence Resuspension

- **Mode of dredging**
  - **Mechanical vs. hydraulic**
- **Hydrodynamics**
  - **Prevailing current velocities and vectors**
  - **Bathymetry**
- ***In situ* sediment properties**
  - **Grain size distribution**
  - **Water content/bulk density/liquidity**
  - **Atterberg Limits (Liquid and Plastic)**
- **Depth and salinity**

Operational Factors That Influence Resuspension (e.g., bucket dredge)

- Bucket type
- Size, volume, exposed surface area
- Ascent speed
- Descent speed
- Reset frequency
- Cycle time
- Production rate
- Sediment cohesion/adhesion
- Leakage from seals
- Debris
- Bottom sweeping/bed leveling
- Anchoring and spud movements
- Barge overflow
- Tug and tender maneuvering
- Operator skill

Perceptions vs. Reality

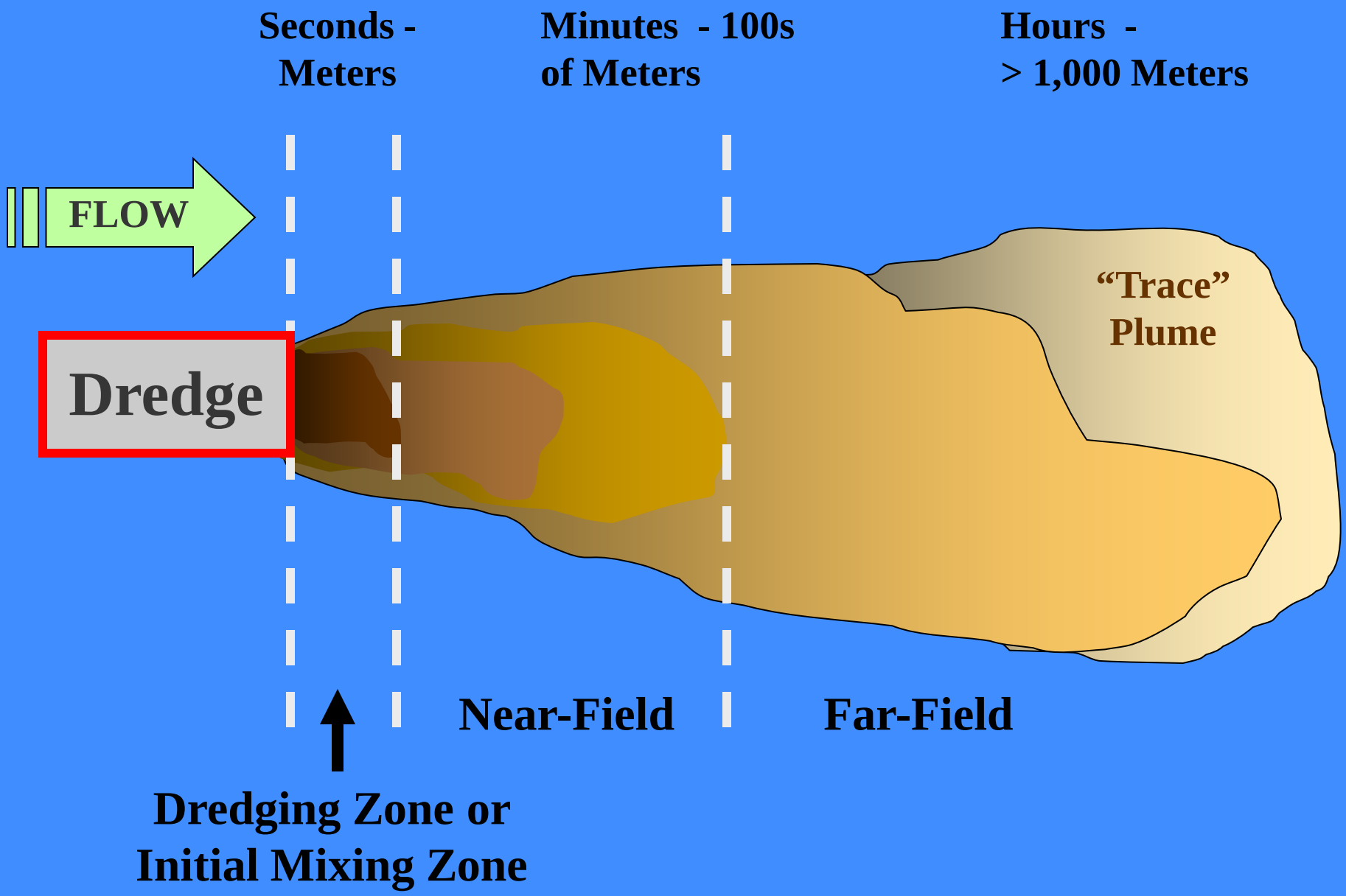
- **Perception**
  - ➢ **Resuspension controls provide environmental protection**

- **Reality**
  - ➢ **Controls frequently slow down production rates, but do not decrease mass loss**
  - ➢ **Tradeoffs are often ignored**
    - – **e.g., many critters tolerate short, intense exposures better than chronic exposures**
    - – **e.g., air quality effects due to prolonged emissions**

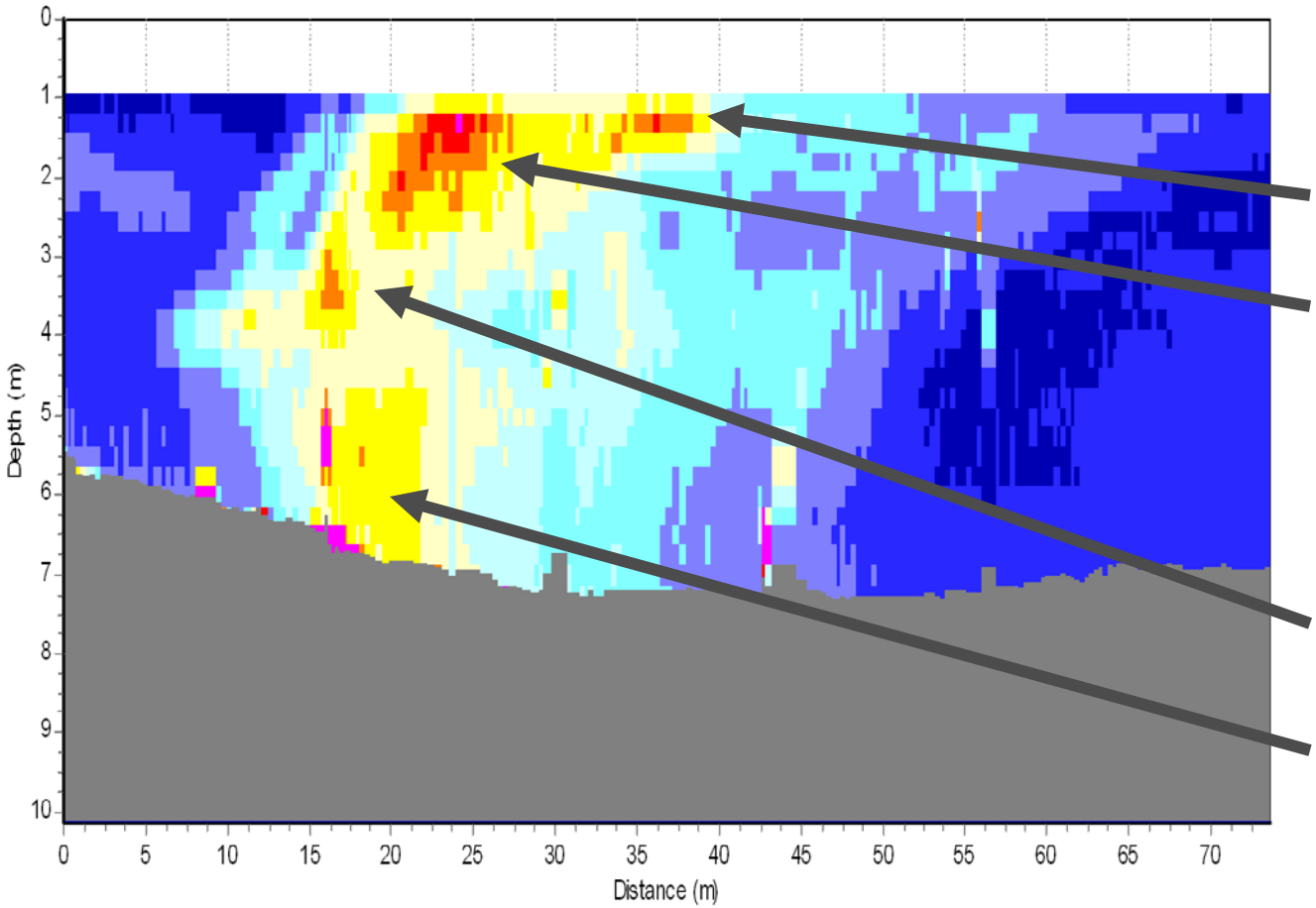
Evaluation of Resuspension

- Fate and transport models have become more sophisticated with improved understanding and handling of fundamental processes
- Uncertainty still surrounds source terms
- Empirically-derived source models exist only for a limited set of dredge types and equipment, site conditions, and sediment and operational characteristics
- Reliable, comprehensive dredging source models are needed for accurate assessment of risk associated with resuspension
- Monitoring is required to verify source term

Plume Spatial/Temporal Scales



Bucket Dredge Plume Components



- slewing
- exit and initial leakage
- hoisting
- bed impact and separation

Dredging Research Ltd

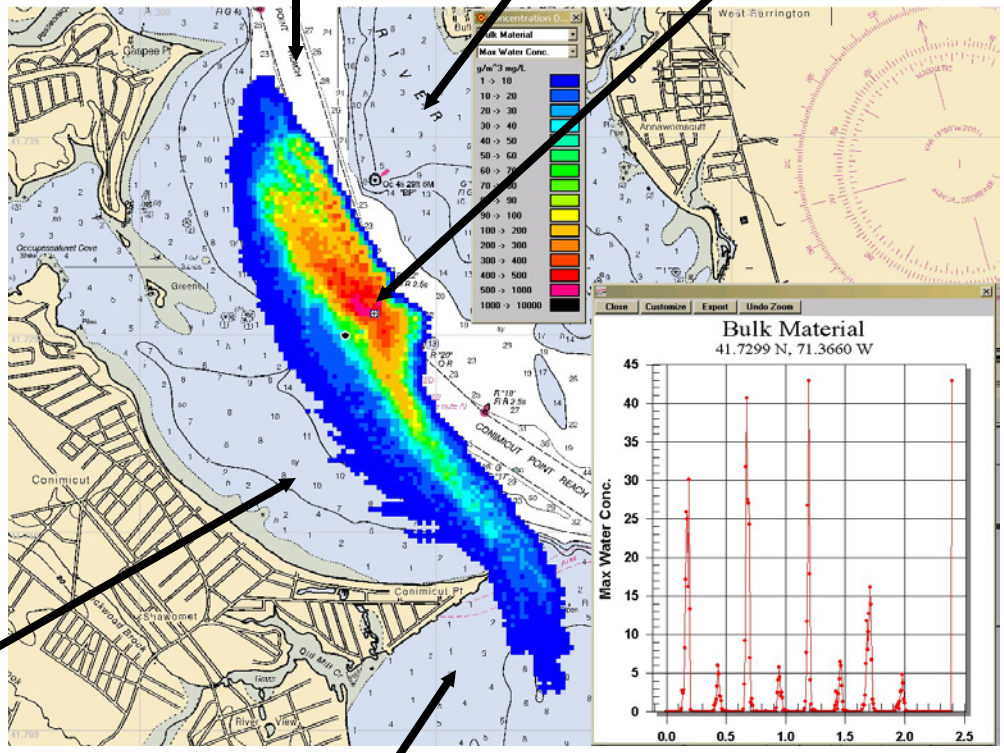
Characterization of Temporal Scales of Resuspension

- **Difficult but necessary step in determination of exposures**
- **Exposures for different receptors may vary by orders of magnitude based on location in relation to the source over time**
  - **Even mechanical dredges are not stationary, but advance at a certain rate**
  - **Receptors may be mobile or sessile, thus exposures may change substantially based on the dredging scenario**

Anadromous Fish Migratory Pathway

Shellfish Bed

Dredge



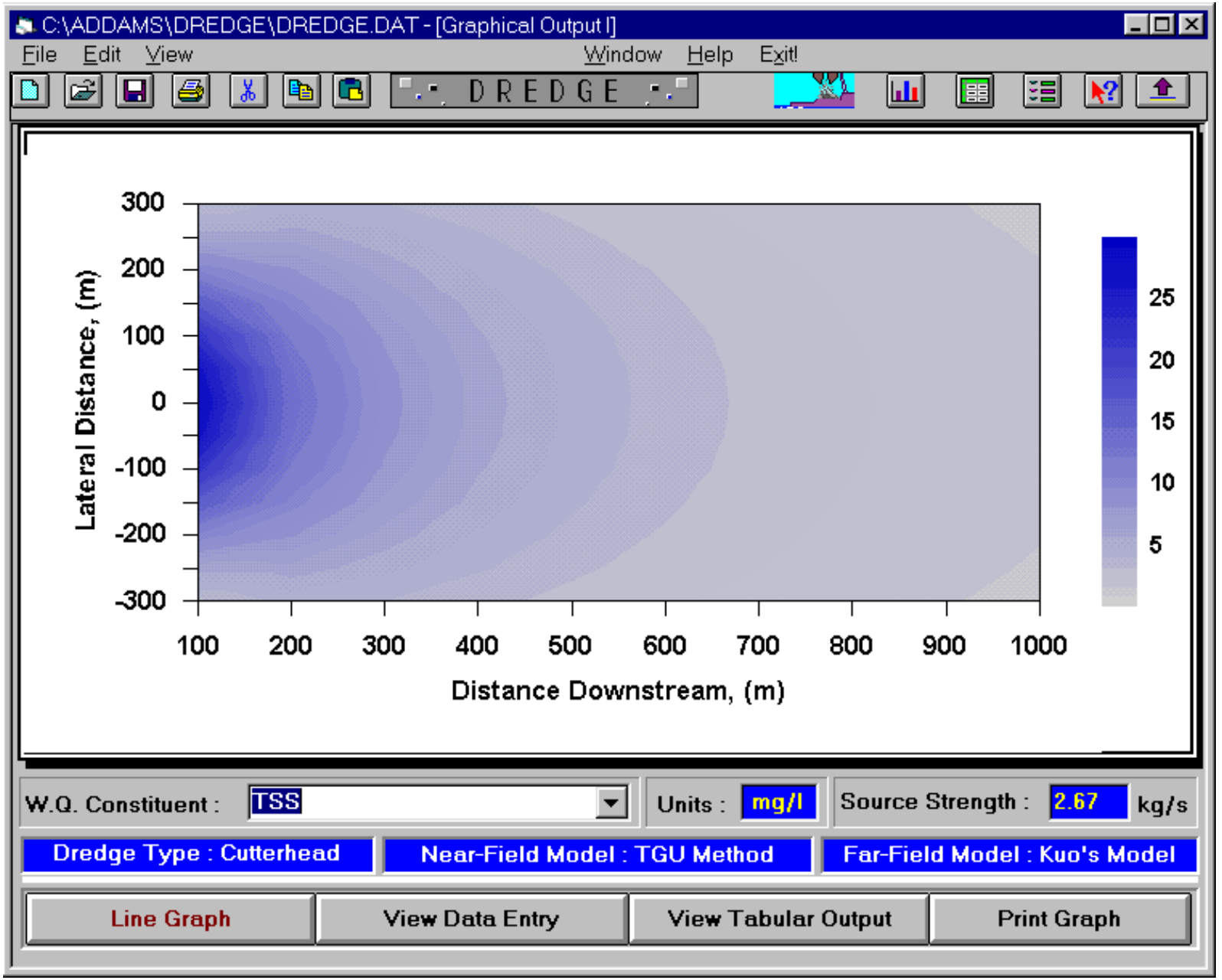
Spawning Habitat

Submerged Aquatic Vegetation

Technical Challenges

- **Resuspension is difficult to characterize quantitatively because acute effects are seldom observed**
  - **Harm, if any, occurs at sublethal levels**
- **Predictive near- and far-field models have many advantages in support of risk-informed decisions**
  - **Require validation, calibration, and verification**
  - **Very few empirical data sets exist**
  - **Data expensive to obtain**

DREDGE Model



DREDGE Post Processor Dissolved Contaminant Results: Copper

In Meters	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510
-36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000201
-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.000803
-28	0	0	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.001808	0.003013
-26	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.002209	0.004017	0.006829	0.010846
-24	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.00241	0.005021	0.009038	0.015063	0.023298	0.034545
-22	0	0	0	0	0	0	0	0.000201	0.001004	0.002611	0.005825	0.011448	0.020285	0.033139	0.050611	0.073102	0.101013
-20	0	0	0	0	0	0	0.000603	0.002008	0.005825	0.013457	0.02631	0.045791	0.073303	0.109045	0.153818	0.207418	0.269238
-18	0	0	0	0	0.000201	0.001004	0.00462	0.013457	0.03113	0.060451	0.103423	0.161046	0.233513	0.320414	0.420333	0.531856	0.653368
-16	0	0	0	0.000201	0.002008	0.010243	0.031532	0.073102	0.139564	0.232911	0.35212	0.495358	0.658988	0.839174	1.032285	1.234696	1.443389
-14	0	0	0.000201	0.003615	0.022093	0.073905	0.172891	0.323827	0.523641	0.765034	1.03851	1.334387	1.644212	1.960952	2.2788	2.593363	2.901461
-12	0	0	0.005021	0.046795	0.174497	0.412716	0.754218	1.174288	1.645454	2.142756	2.647133	3.144614	3.626074	4.085415	4.519347	4.925982	5.305409
-10	0	0.004017	0.091576	0.414523	0.999079	1.76524	2.618135	3.486114	4.32459	5.10899	5.828191	6.479025	7.063236	7.584498	8.047799	8.458667	8.82219
-8	0.000402	0.14619	0.990073	2.465427	4.151371	5.773734	7.217878	8.45544	9.49536	10.36022	11.07527	11.66436	12.14833	12.5447	12.86831	13.13099	13.34315
-6	0.093584	2.345148	6.263437	9.789349	12.46755	14.40153	15.77403	16.73886	17.40989	17.86779	18.1702	18.35763	18.45988	18.49803	18.48796	18.44149	18.36759
-4	4.914796	16.72463	22.97774	25.82036	27.0188	27.39988	27.35754	27.09031	26.70395	26.25707	25.78294	25.30091	24.82255	24.35461	23.90051	23.46236	23.04094
-2	49.93222	52.31394	48.97899	45.53323	42.54878	40.02067	37.86935	36.01907	34.40999	32.99579	31.74104	30.61876	29.60721	28.68951	27.85239	27.08448	26.37704
0	102.1554	75.22415	62.56336	54.78722	49.37892	45.33234	42.15485	39.57264	37.41963	35.58793	34.00461	32.61792	31.38999	30.29253	29.30394	28.40726	27.58888
2	49.93222	52.31394	48.97899	45.53323	42.54878	40.02067	37.86935	36.01907	34.40999	32.99579	31.74104	30.61876	29.60721	28.68951	27.85239	27.08448	26.37704
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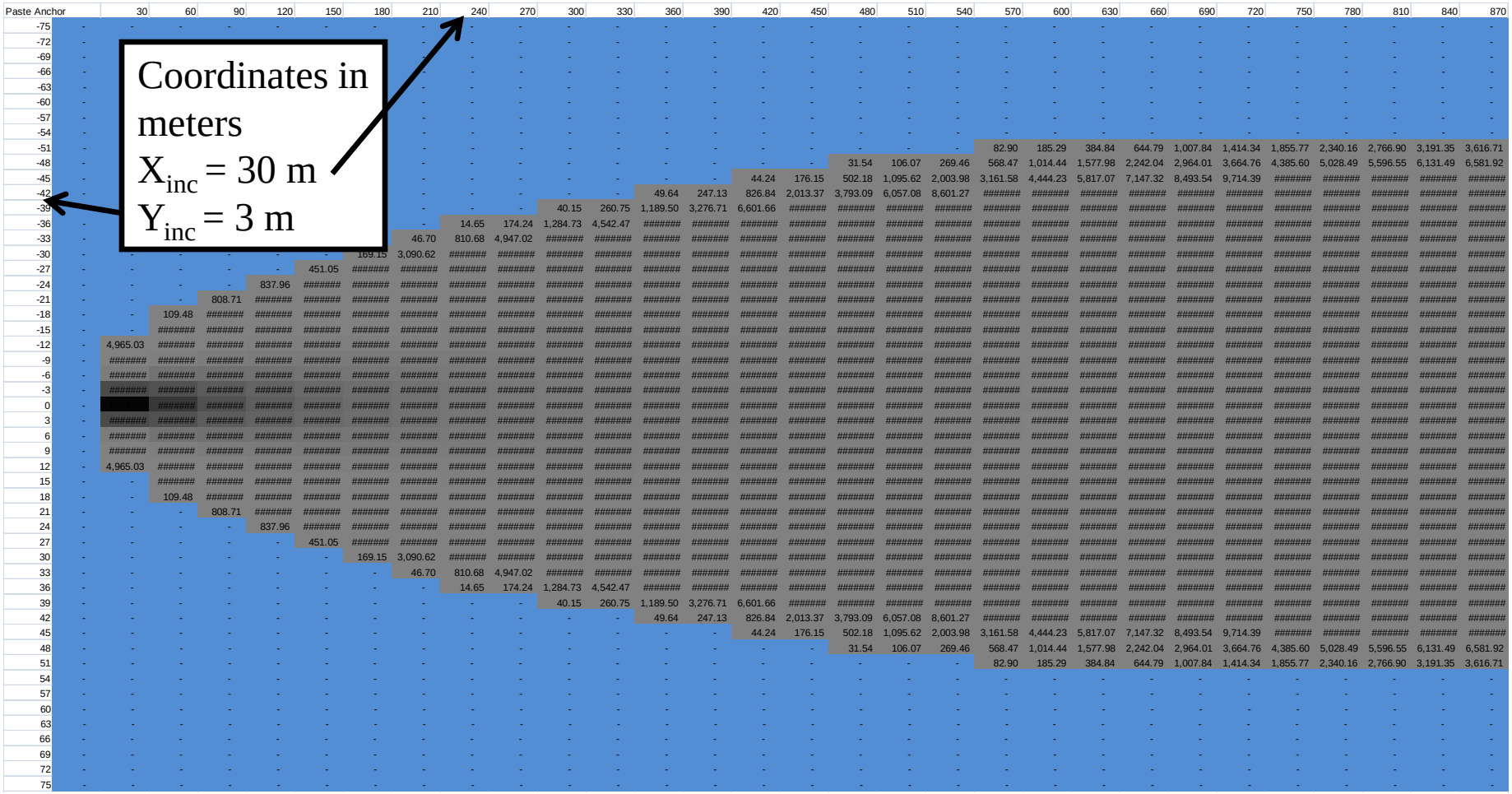
20	0	0	0	0	0	0	0.000603	0.002008	0.005825	0.013457	0.02631	0.045791	0.073303	0.109045	0.153818	0.207418	0.269238
22	0	0	0	0	0	0	0	0.000201	0.001004	0.002611	0.005825	0.011448	0.020285	0.033139	0.050611	0.073102	0.101013
24	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.00241	0.005021	0.009038	0.015063	0.023298	0.034545
26	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.002209	0.004017	0.006829	0.010846
28	0	0	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.001004	0.001808	0.003013
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000201	0.000402	0.000803
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000201
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

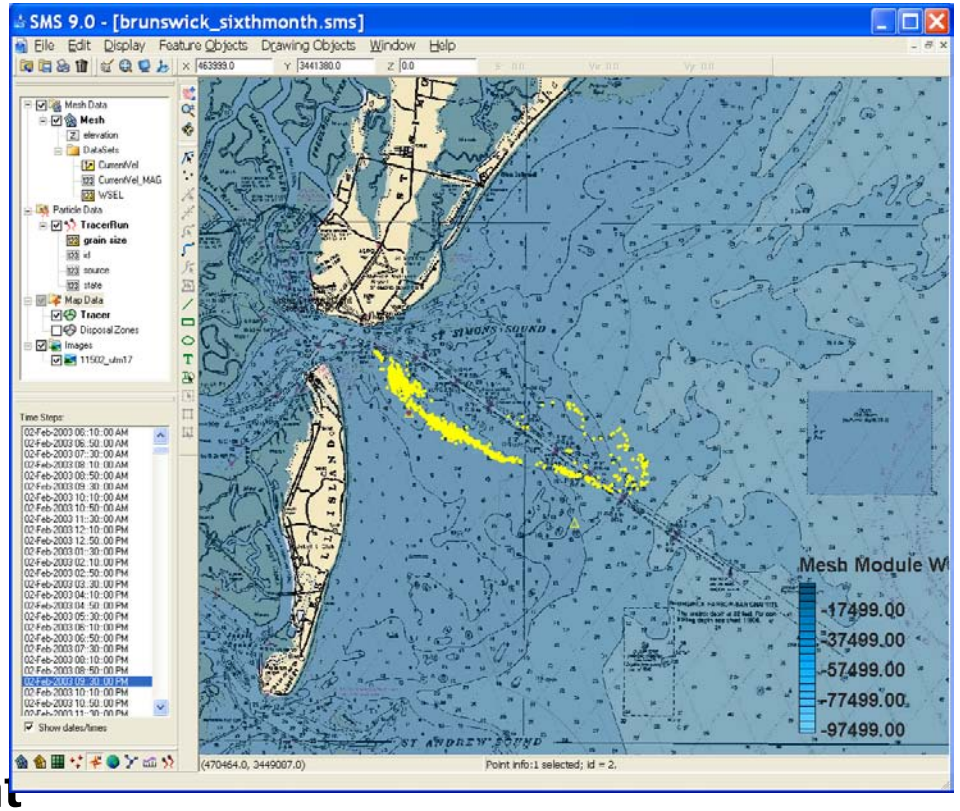
- 1% Loss
- Results from centerline concen-tration used for screening
- Copper Criteria 18 ug/L

Deposition of Resuspended Material

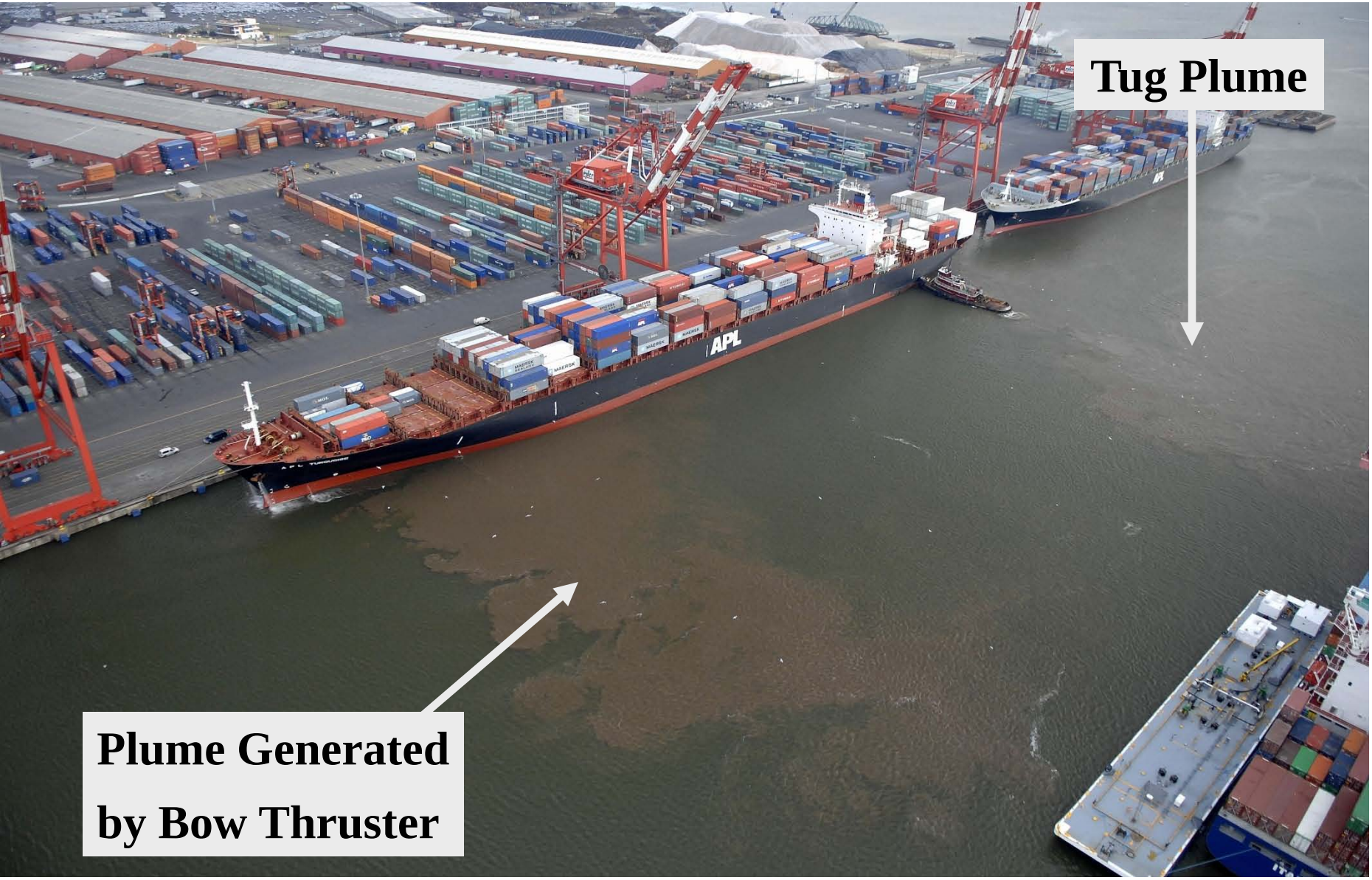


Particle Tracking Model (PTM)

- 3D dynamic transport
- Follows size classes of sediment through complex grids
- Accepts external source term
- Ability to compute sediment deposition and re-entrainment
- Adding modules to track water quality and contaminants
- Adding module to calculate exposures of organisms to suspended or deposited sediment



Ships as a Source of Resuspension



Conclusions

- **Resuspension issues form a basis for a majority of problematic environmental concerns associated with dredging and dredged material disposal**
- **These issues have proven to be exceedingly difficult to resolve**
- **Many sources of uncertainty exist regarding critical aspects of the process**
- **Risk-informed approaches represent a promising direction for instigating progress in an otherwise stagnant arena**

References

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