Assessing and Managing Risks

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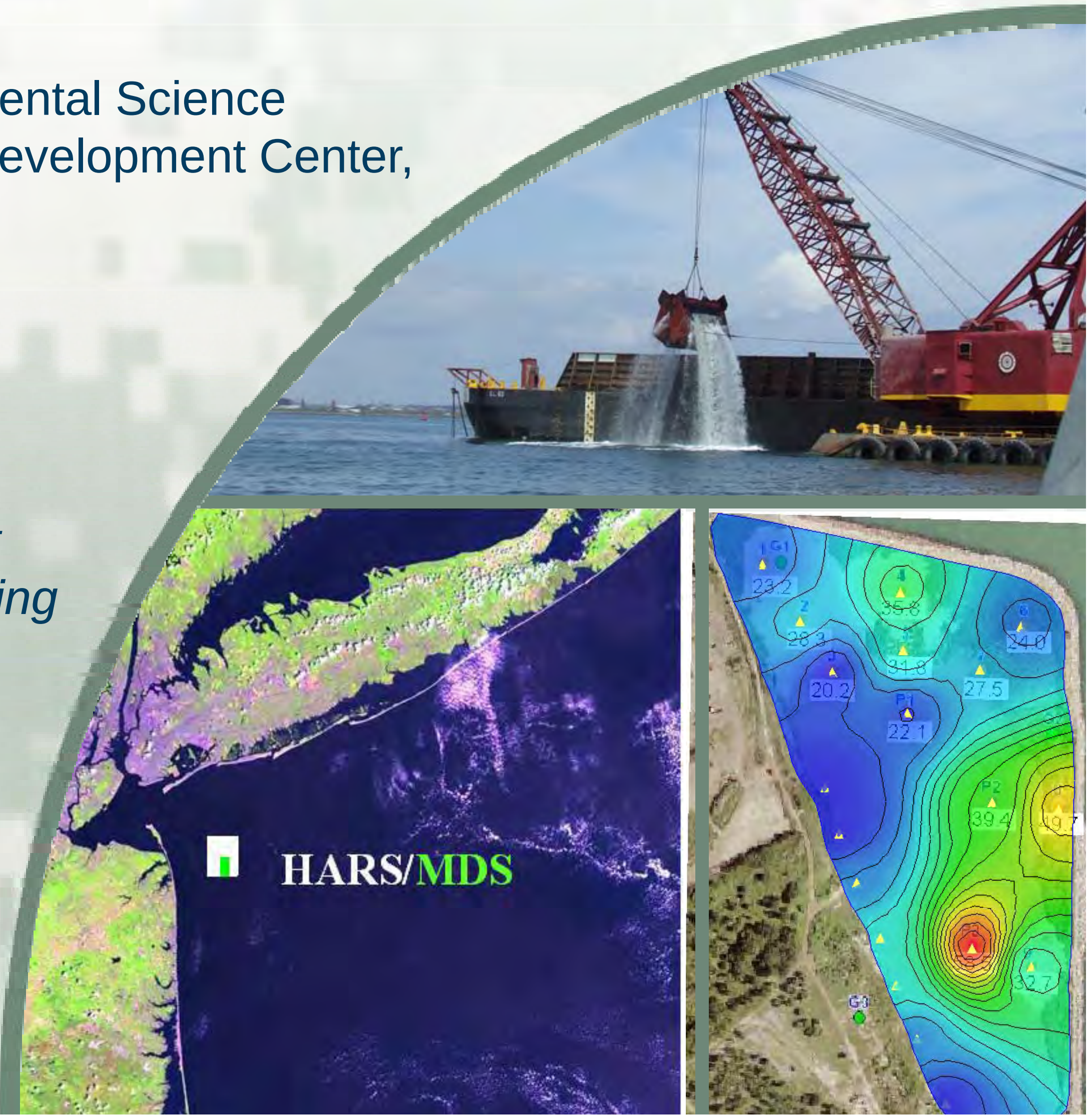
Engineers Australia

"Sustainable Dredging and Sediment Management: Assessing and Managing Environmental Effects and Benefits"

September 7-11, 2015



US Army Corps of Engineers

ERDC
Engineer Research and Development Center

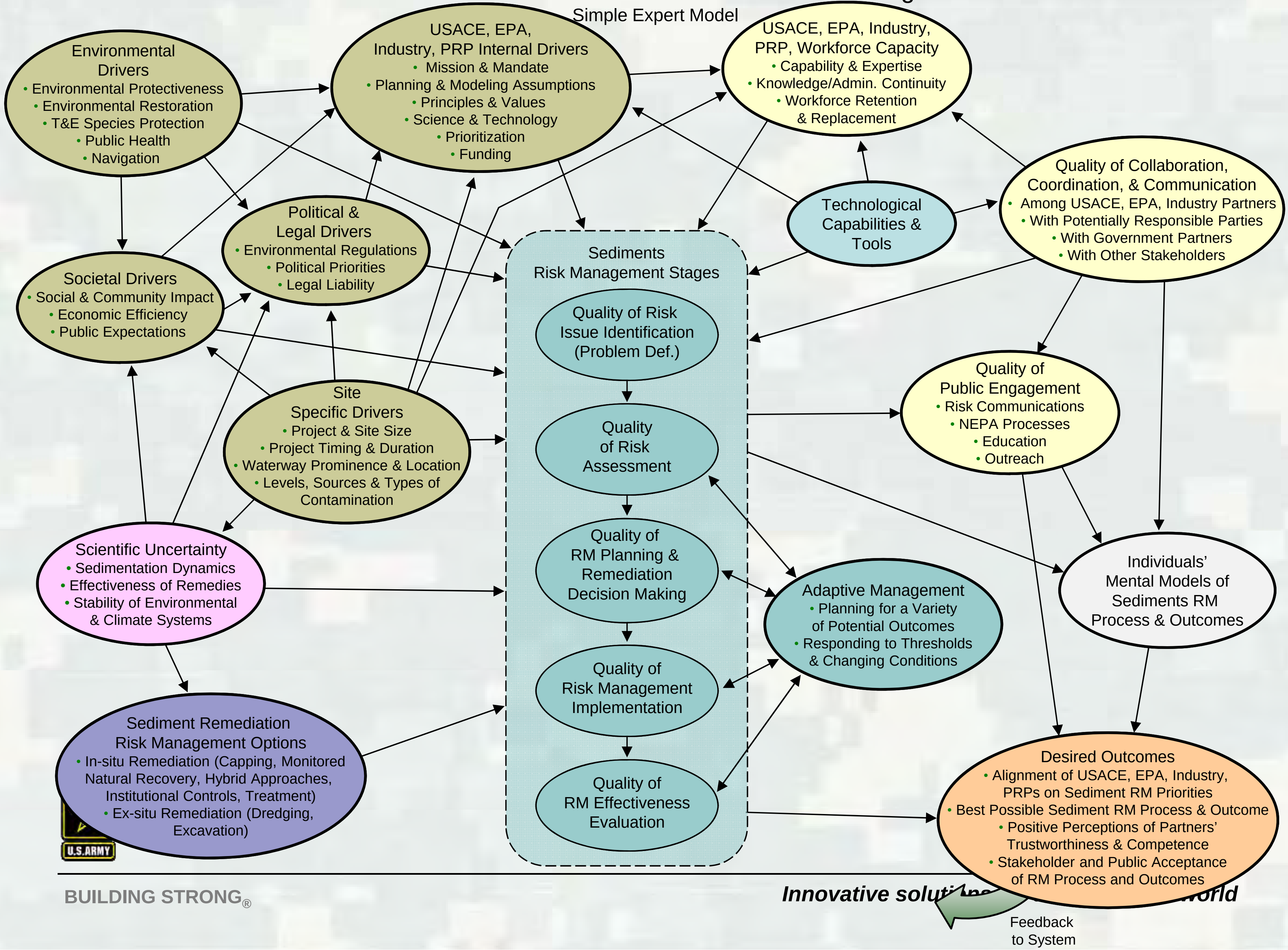
10 Guidelines for Robust Risk Management

1. **Risk management is undertaken through credible, scientific processes**
2. Risk management assumes a forward-looking posture
3. Specific and measurable objectives are developed in a transparent and rigorous manner
4. Risk management is accomplished through open, transparent and deliberative processes
5. Uncertainties are acknowledged and addressed through quantitative analysis
6. Risk management investments are commensurate with the magnitude of risks and uncertainties
7. Risk management is a system-scale activity
8. Risk reduction is most reliably achieved through the use of an integrated network of multiple remedial technologies and actions
9. Risk communication is integral to effective risk management
10. Risk management is achieved through formal application of adaptive management

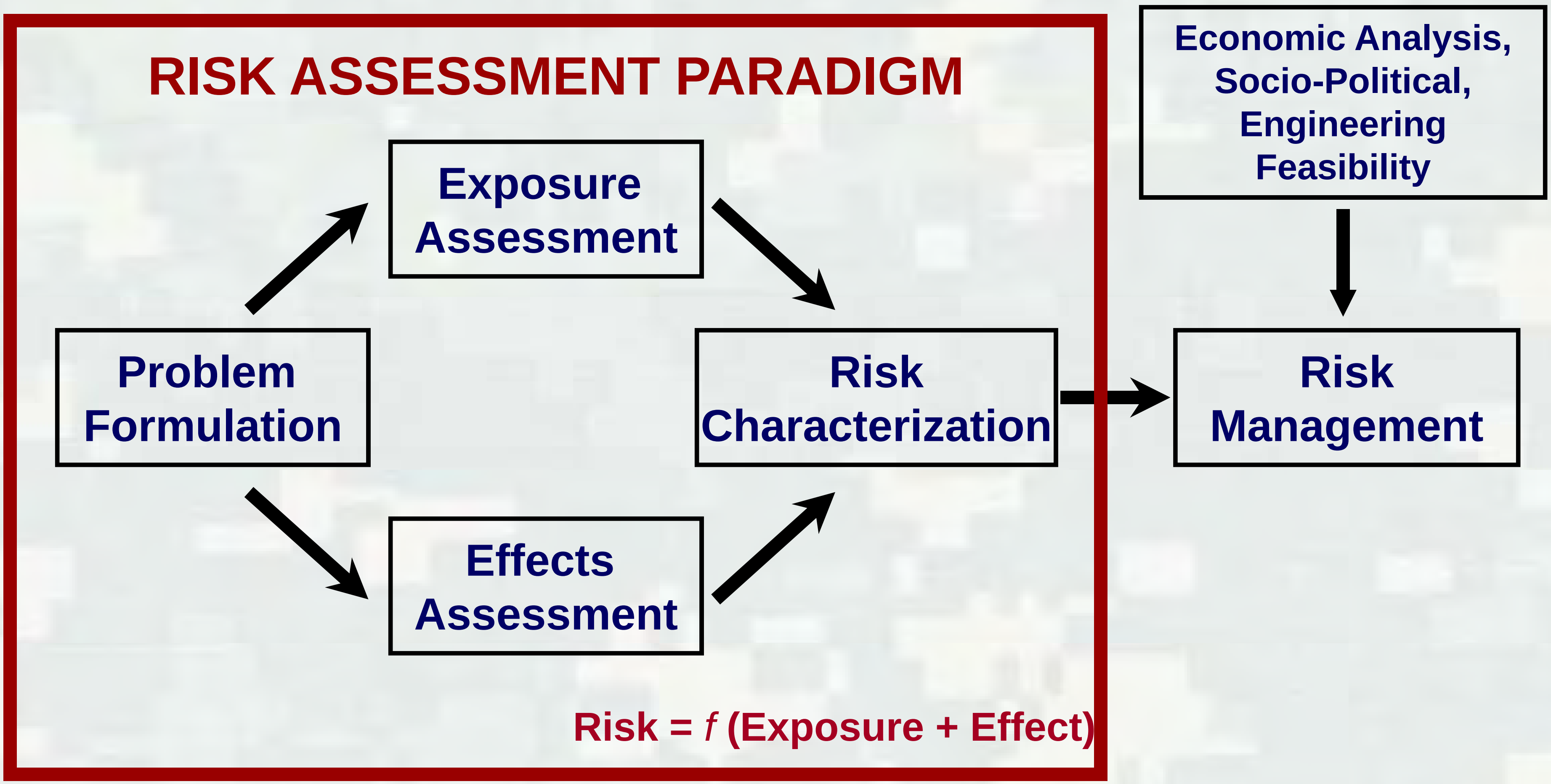
T. Bridges, K. Gustavson. 2013. Risk Management for Contaminated Sediments. In Reible D, ed, *Processes, Assessment, and Remediation of Contaminated Sediment*. Springer Science+Business Media, LLC, New York, NY, USA. pp 197-226.

Influences on Effectiveness of Sediment Risk Management

Simple Expert Model



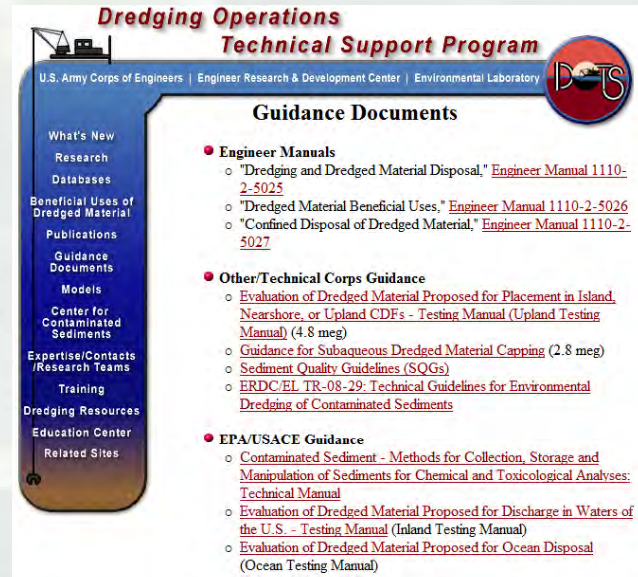
Risk Analysis Overview



Guidance Documents for Assessment and Management of Dredged Material

National Technical Guidance

- Technical Framework
- Inland Testing Manual
- Ocean Testing Manual
- Upland Testing Manual
- Beneficial Use Manual


Dredging Operations Technical Support Program

U.S. Army Corps of Engineers | Engineer Research & Development Center | Environmental Laboratory

What's New
Research
Databases
Beneficial Uses of Dredged Material
Publications
Guidance Documents
Models
Center for Contaminated Sediments
Expertise/Contacts /Research Teams
Training
Dredging Resources
Education Center
Related Sites

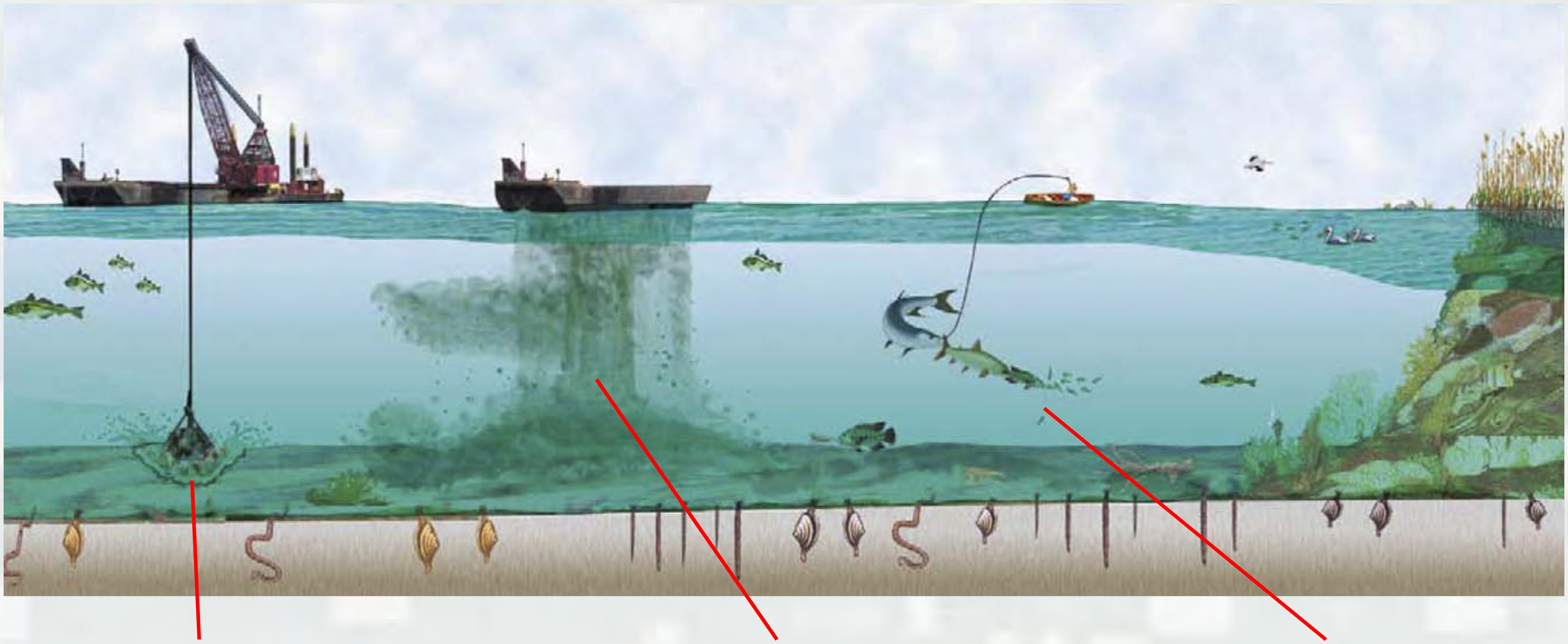
Guidance Documents

- Engineer Manuals
  - "Dredging and Dredged Material Disposal," Engineer Manual 1110-2-5025
  - "Dredged Material Beneficial Uses," Engineer Manual 1110-2-5026
  - "Confined Disposal of Dredged Material," Engineer Manual 1110-2-5027
- Other/Technical Corps Guidance
  - Evaluation of Dredged Material Proposed for Placement in Island, Nearshore, or Upland CDFs - Testing Manual (Upland Testing Manual) (4.8 meg)
  - Guidance for Subaqueous Dredged Material Capping (2.8 meg)
  - Sediment Quality Guidelines (SQGs)
  - ERDC/EL TR-08-29: Technical Guidelines for Environmental Dredging of Contaminated Sediments
- EPA/USACE Guidance
  - Contaminated Sediment - Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual
  - Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (Inland Testing Manual)
  - Evaluation of Dredged Material Proposed for Ocean Disposal (Ocean Testing Manual)

Found at:

el.erdc.usace.army.mil/dots/guidance.html

Potential Exposure/Effect Pathways



1. Releases during dredging

2. Biological effects during placement

3. Long term biological effects

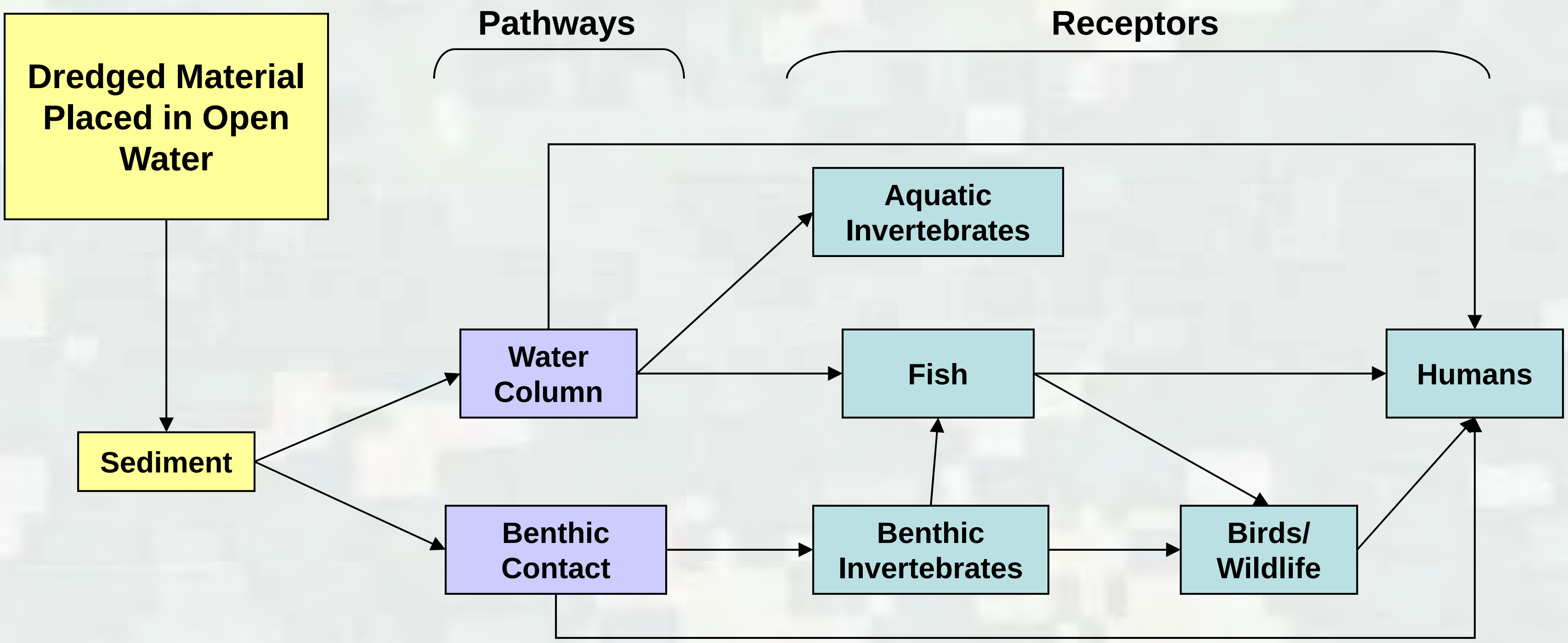
Management Options

Upland Placement

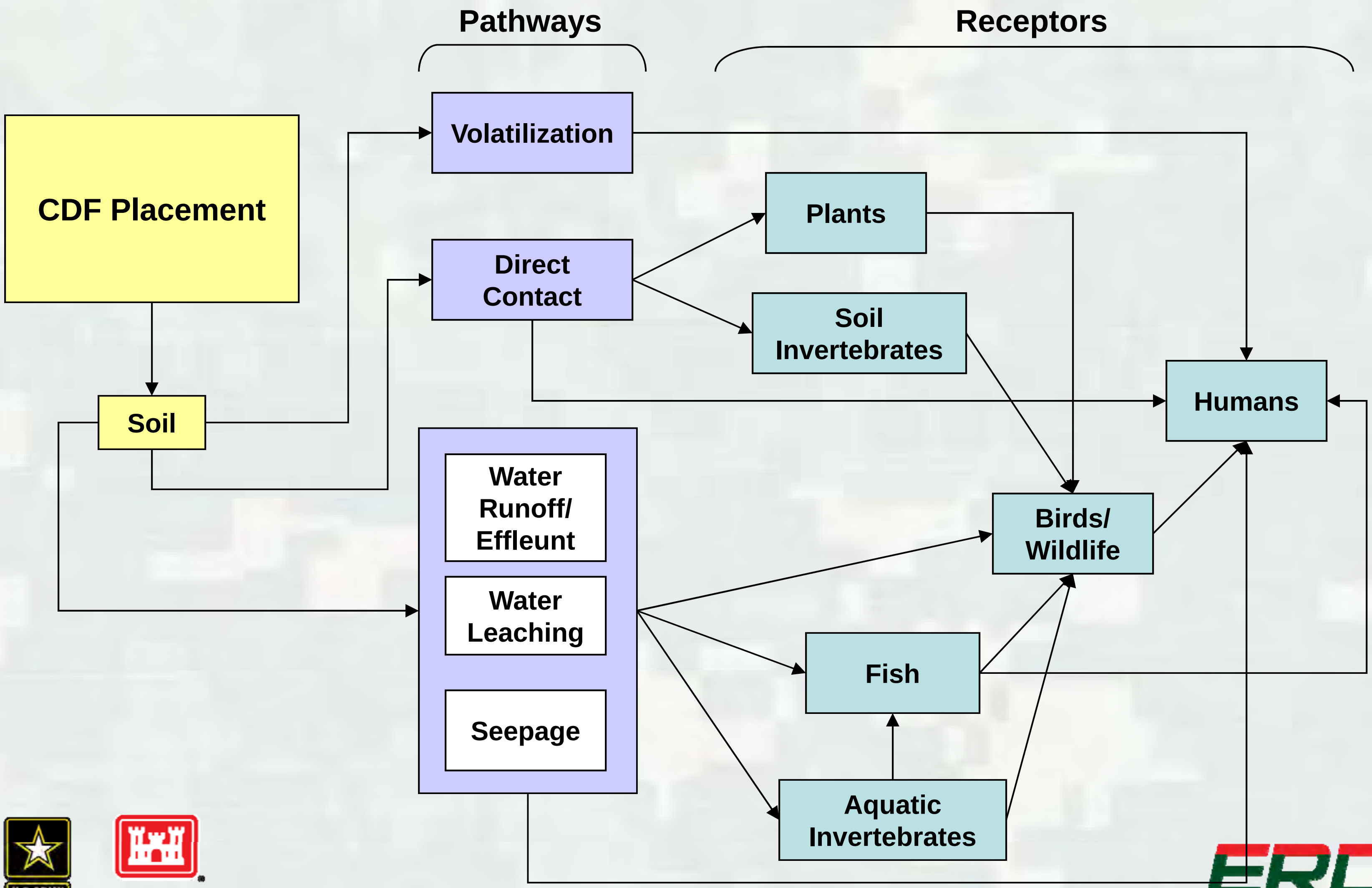
Open-Water Placement

Beneficial Use

Conceptual Model:
Open Water Placement of DM

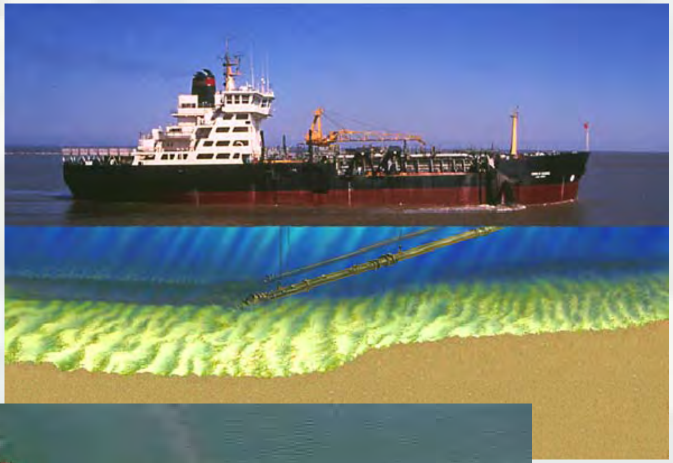


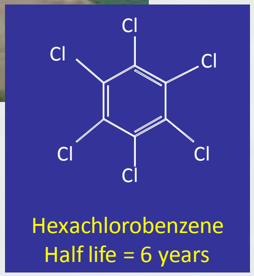
Conceptual Model: Upland (CDF) Placement of DM



Environmental Risks

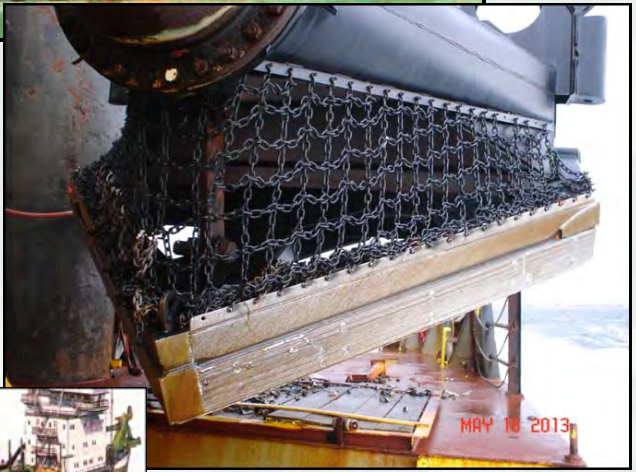
- Direct interactions with equipment, e.g.,
  - Vessel strikes
  - Entrainment
- Physical effects caused by sediment, e.g.,
  - Suspended sediment
  - Sediment deposition
- Contaminant effects, e.g.,
  - Direct toxicity
  - Bioaccumulation within food chains





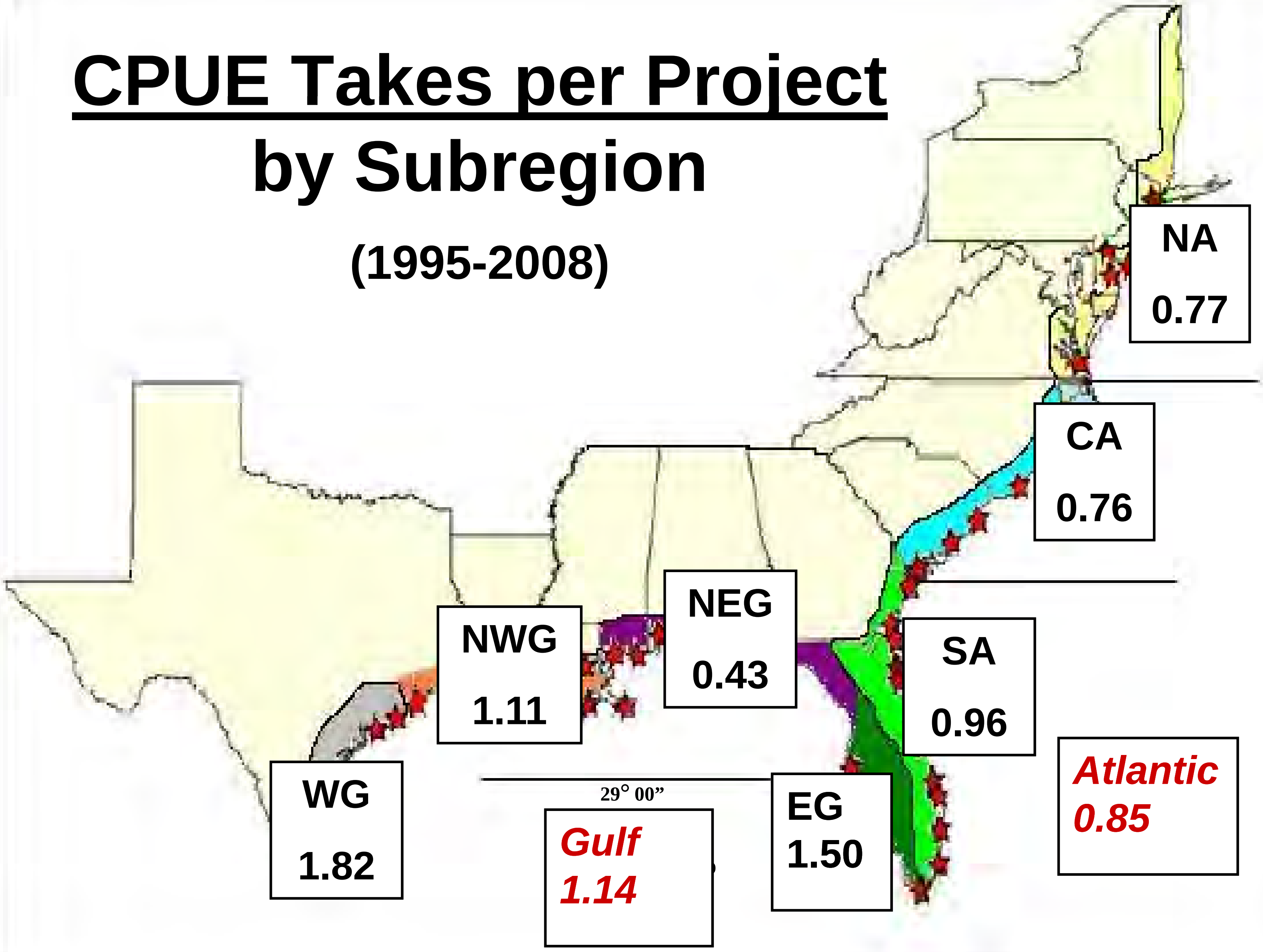
Direct Interaction: Dredge and Receptor

- Vessel strikes
  – E.g., Right Whale
- Entrainment
  - E.g., Sea turtles, fish
- Risk management includes a variety of engineering and operational controls
  - Which include trade-offs: turtle deflector produces 10-70% increase in fuel consumption

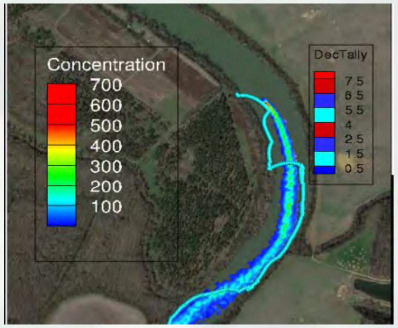


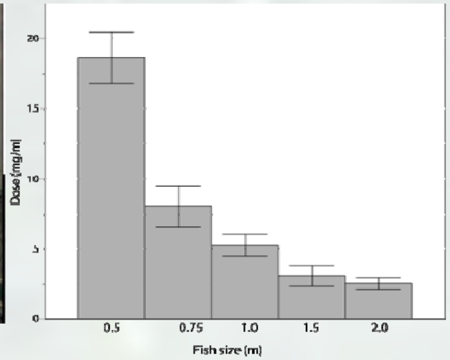
CPUE Takes per Project by Subregion

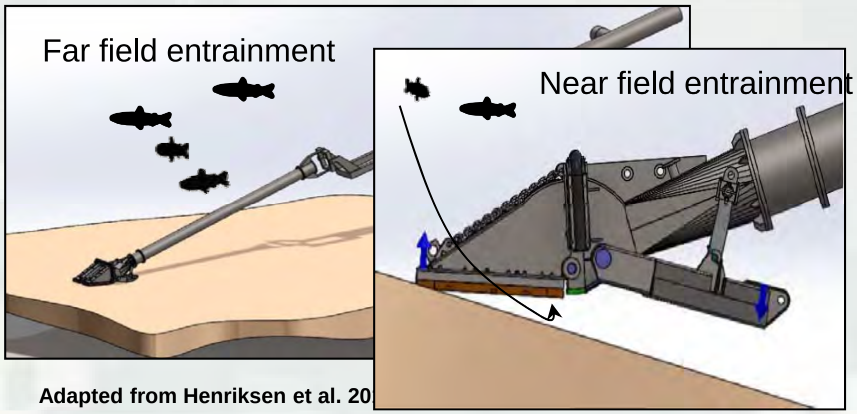
(1995-2008)



Exposure: Integrating physical data with models of fish movement







Adapted from Henriksen et al. 20

Purpose:

- Discern the behavioral mechanisms that govern sediment exposure and entrainments during dredging operations.

Results:

- Simulations of hypothetical dredge plume in advective environments and exposure estimates for various size classes of swimming fish.
- Conceptual model linking small temporal exposures to population outcomes.
- Workflow to link entrainment potential to fish swimming capacity and internal state near dredging operations.
- Laboratory and field capacity to verify simulation results and refine operations.

Payoff:

- ***Methods to account for behavior as part of exposure and entrainment assessment.***
- ***Reduced impacts to operating windows***

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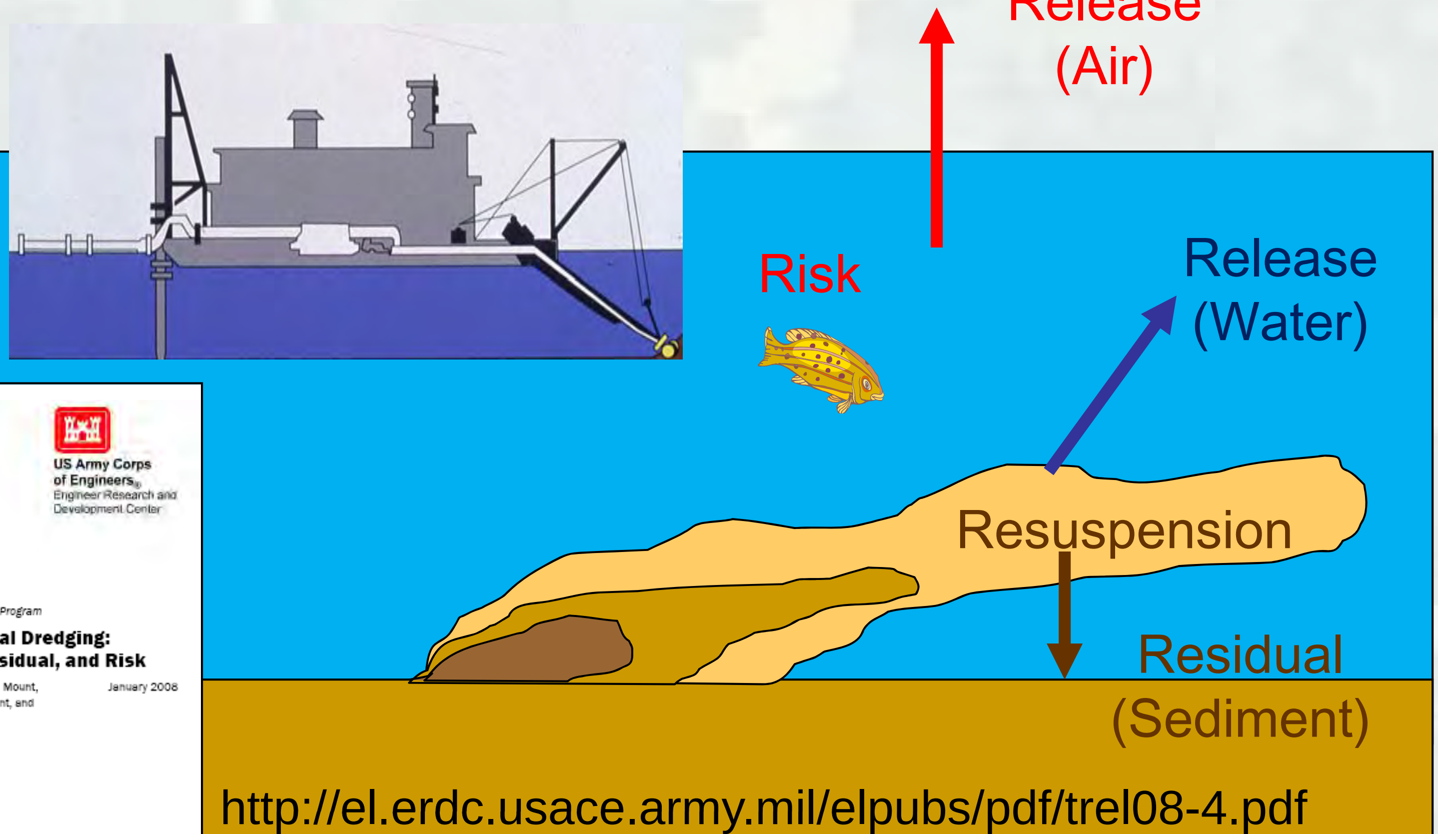
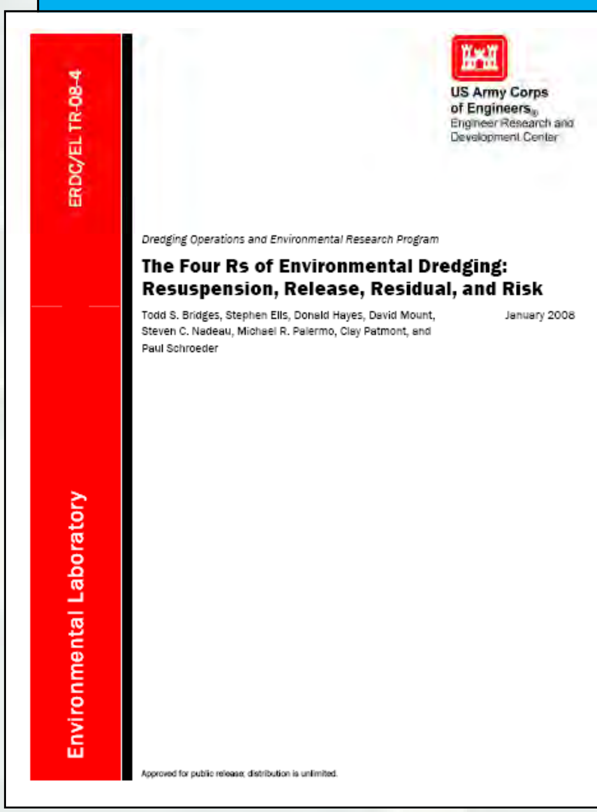
Innovative solutions for a safer, better world

The 4 Rs of Environmental Dredging




ERDC/EL TR-08-4

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Dredging Operations and Environmental Research Program

The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk

Todd S. Bridges, Stephen Ells, Donald Hayes, David Mount, Steven C. Nadeau, Michael R. Palermo, Clay Patmont, and Paul Schroeder

January 2008

Environmental Laboratory

Approved for public release; distribution is unlimited.

TS Bridges, KE Gustavson, P Schroeder, SJ Ells, D Hayes, SC Nadeau, MR Palermo, C Patmont. 2010. Dredging Processes and Remedy Effectiveness: Relationship to the 4 Rs of Environmental Dredging. *Integrated Environmental Assessment and Management* 6: 619-630.

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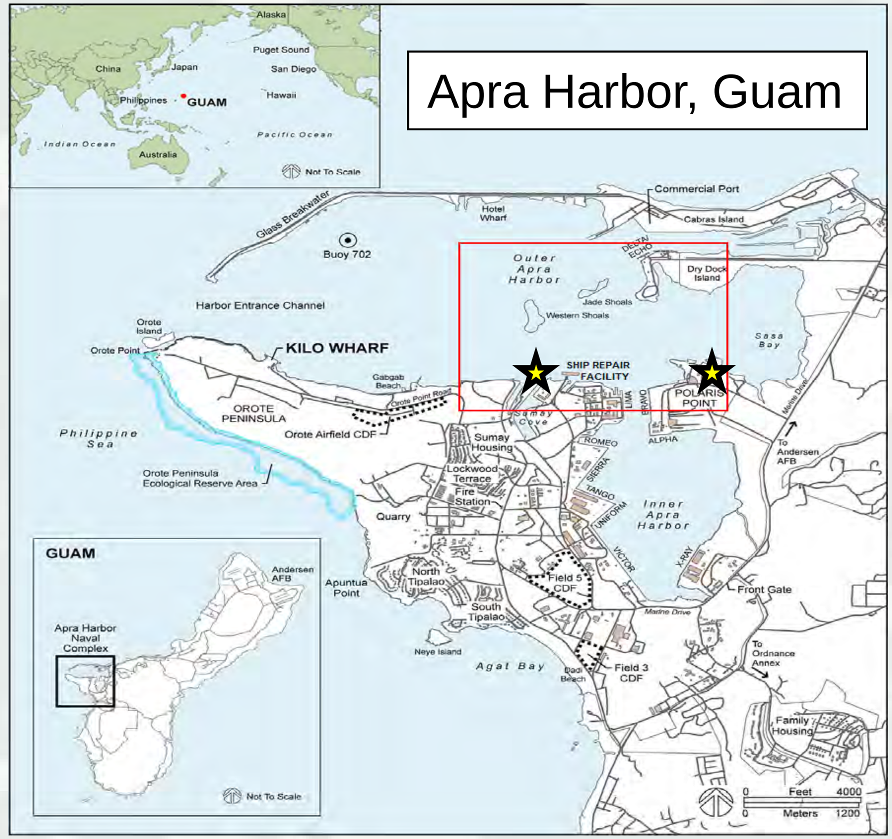
Innovative solutions for a safer, better world

Suspended Sediment: Case Example

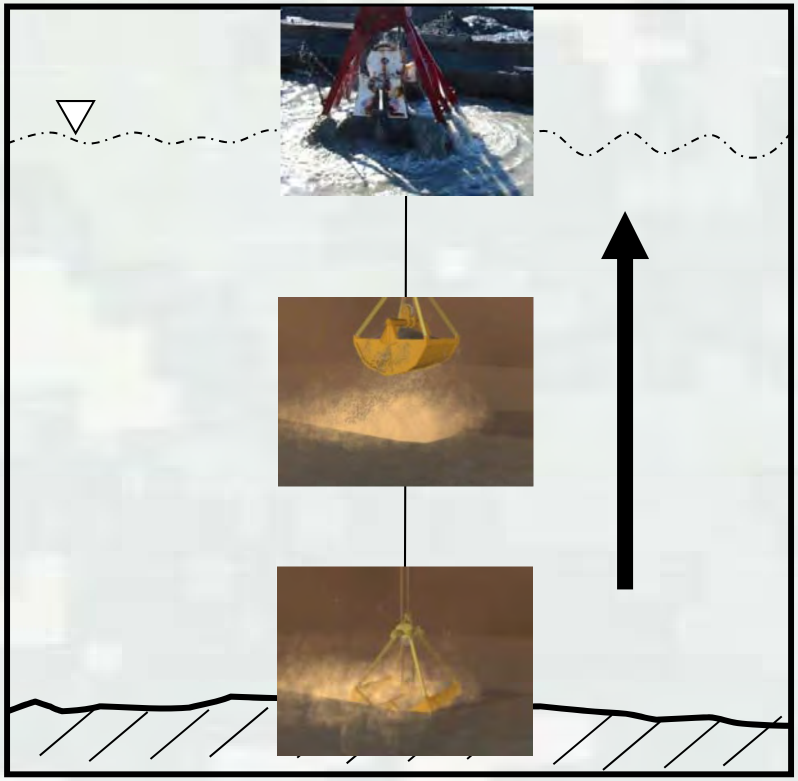
- The U.S. Navy is studying alternatives for the construction of a deep water wharf at Apra Harbor, Guam to provide a berthing site for nuclear powered aircraft carriers (CVN). Development of a site would involve extensive dredging.

- This work evaluated coral risks due to dredging at two of the considered sites: Polaris Point and Ship Repair Facility.



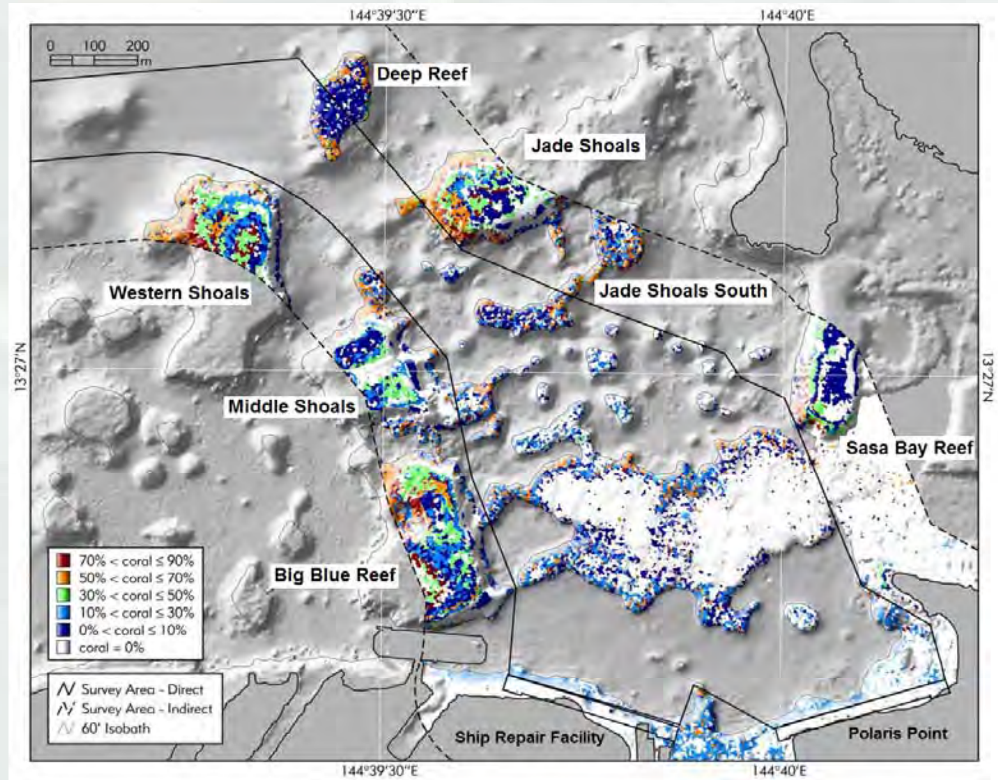
Gailani, Joseph, Tahirih Lackey, David King, Duncan Bryant, Sung-Chan Kim, and Deborah Shafer. "Predicting Dredging Effects to Coral Reefs in Apra Harbor, Guam, Part 1: Sediment Exposure Modeling " Accepted in *J. Envir. Mang.*
Shafer, Deborah, John McManus, Robert Richmond, David King, Joe Gailani, and Tahirih Lackey. "Predicting Dredging Effects to Coral Reefs in Apra Harbor, Guam, Part 2: Coral Effects ". Accepted in *J. Envir. Mang.*

Dredging Challenges



•Clamshell Resuspension Sources:

- ❑ Impact
- ❑ Ascent/Descent
- ❑ Slewing



Coral Density Map

•Chiseling Resuspension Sources:

- ❑ Major Release at bottom

Particle Tracking Model (PTM)

PTM is a Lagrangian particle tracker that models transport processes (advection, diffusion, deposition, etc) for representative parcels to determine constituent (sediment, contaminants, biologicals, etc) fate.

Input Requirements for Apra Harbor Case

- CH3D Grid/Bathymetry Data
- CH3D Hydrodynamic Data
- Released Sediment Characteristics
- Release Protocols
- Native Sediment Data

→

PTM

Time-dependent Particle Positions P(t,X,Y,Z)

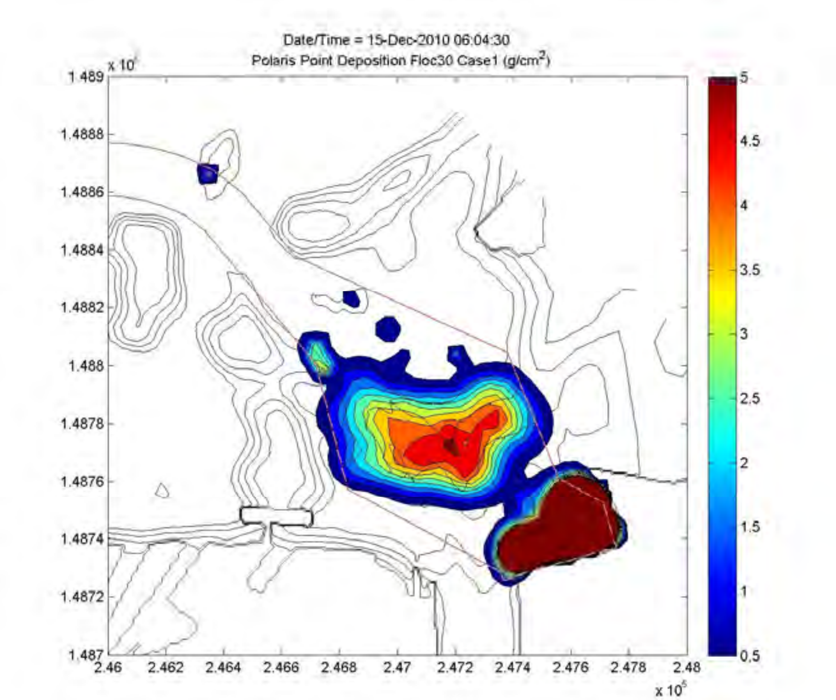
→

PTM/Surface-water Modeling System (SMS) Data Analysis Tools

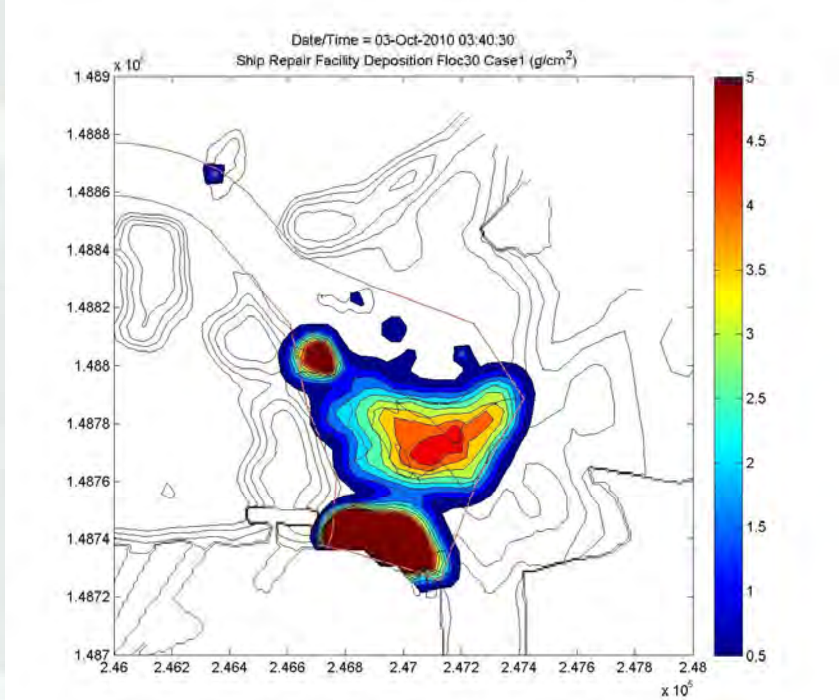
- Deposition
- Concentration
- Dose
- Exposure
- Accumulation
- Pathways

Example Output: Total Accumulation

Case 1: 1800 cyd - 2% loss - 90% effective silt curtain (Deposition in g/cm^2)



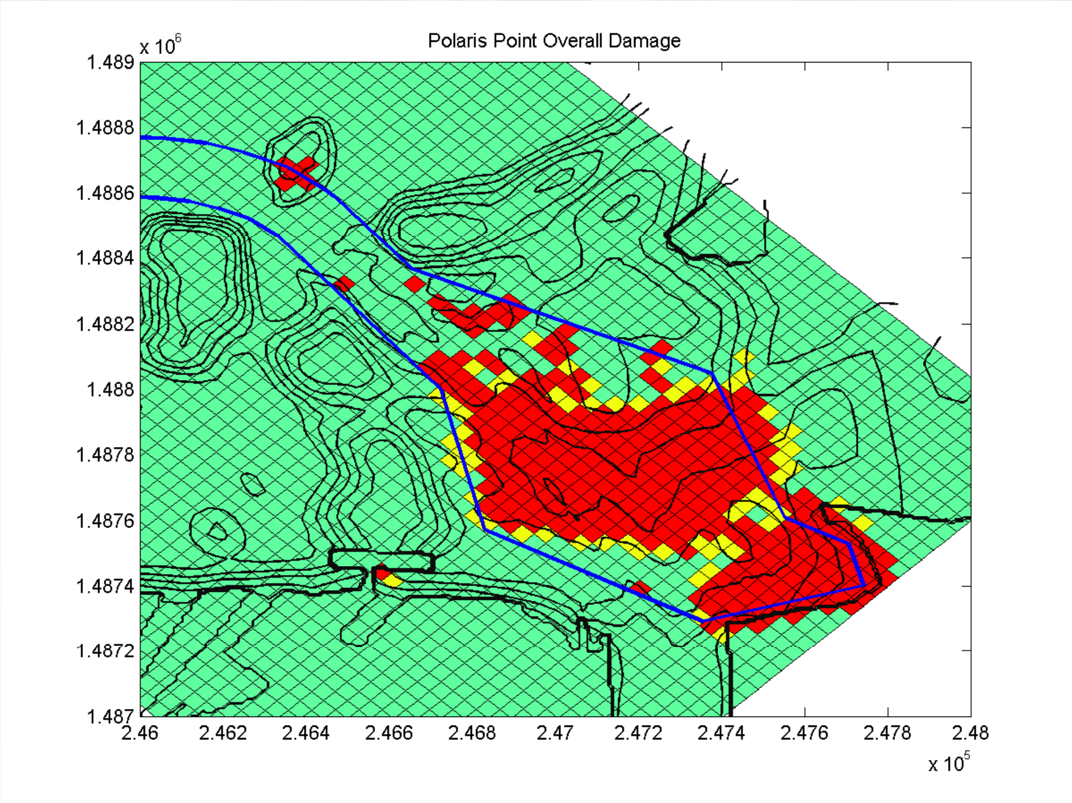
Polaris Point



Ship Repair Facility

- The majority of the sediment settles and accumulates within the dredging footprint.

Coral Reef Predicted Damage Plots



Green – Safe
Yellow – In danger
Red – Destroyed

By consulting with Coral Reef biologists, ultimately the goal is to take exposure information combined with effects information and predict risk.

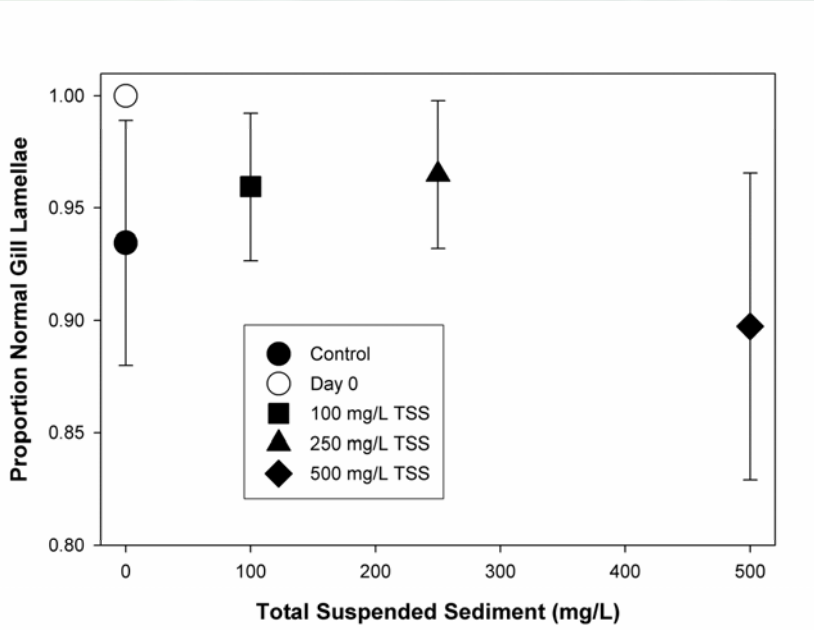
Data was gathered regarding the primary concerns:

- TSS
- Accumulation
- Deposition Rate

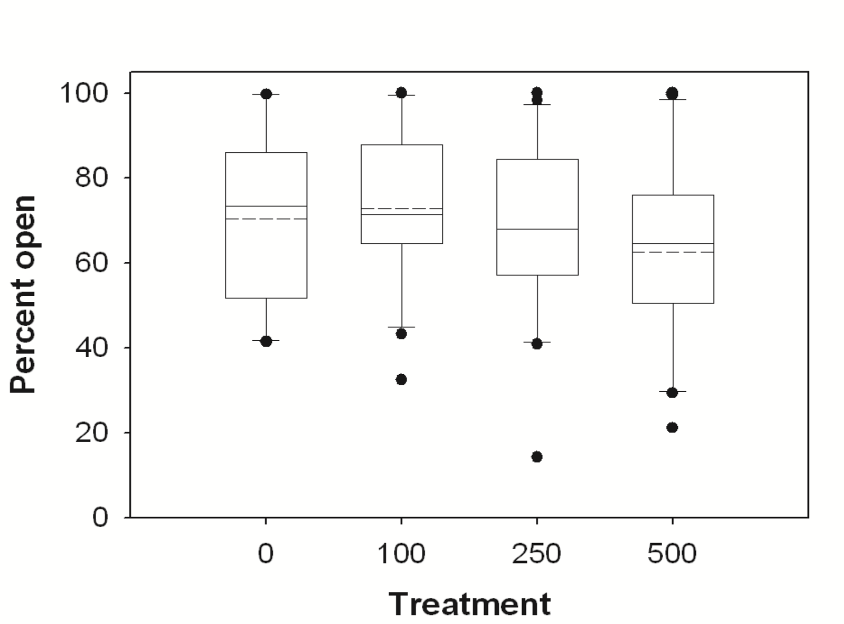
Data analysis was performed using the exposure information and the effects data. Damage plots were developed.

Suspended Sediment Effects Data

Walleye: Maumee Bay, OH



Oyster: James River, VA



Weight-of-Evidence for Contaminant Risks

Relies on three main lines evidence (LOE) to reach conclusions about the risks to receptors

Lines of Evidence

Sediment Toxicity and Bioaccumulation

Toxicity: Is sediment toxic to organisms that would colonize at the placement site?

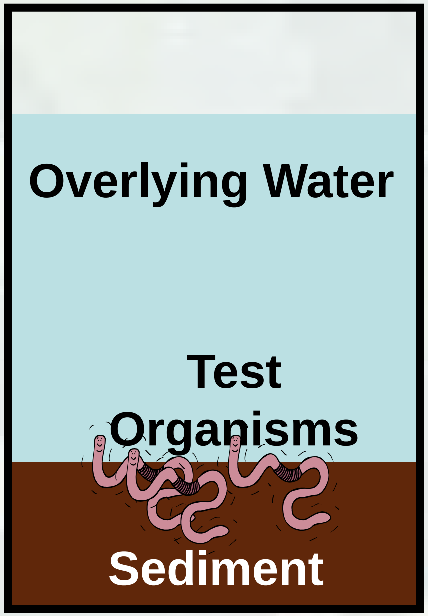
Bioaccumulation: Are contaminants accumulated in organisms to levels that might adversely affect food web?

Benthic Toxicity Bioassay

- Standardized EPA/ASTM protocols
  - Generally 10 day; 28 day chronic test
- Compare DM to reference and control sediments
- Use two sensitive species representing different life strategies
- Survival, growth, or reproduction of organisms as toxicological endpoint

Mortality in dredged material is 10% greater than reference (20% for amphipods), <u>and</u> statistically different from reference?

Bioaccumulation Bioassay

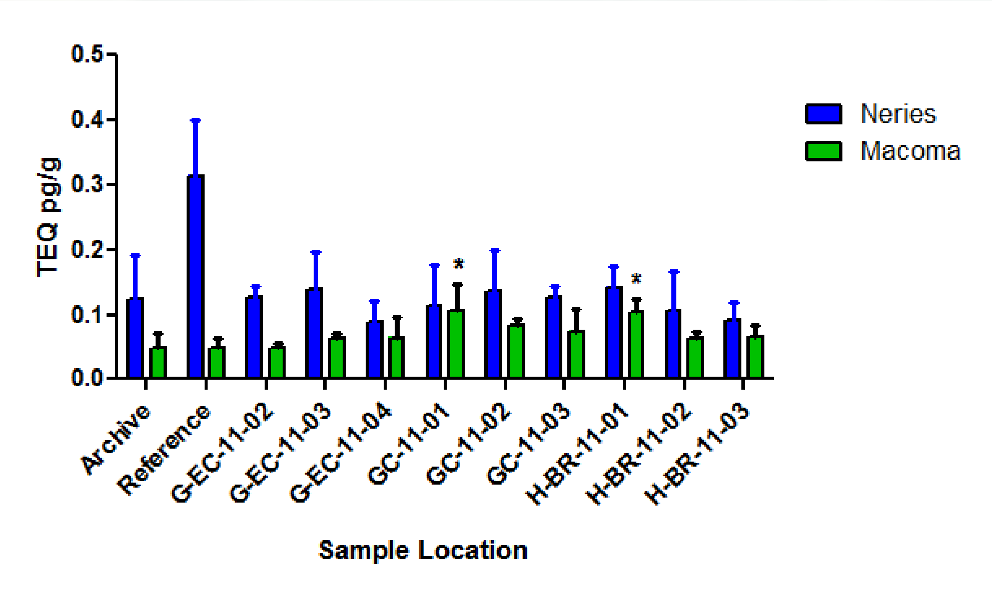


- Standardized EPA/ASTM protocol
  - 28-day exposure
- Use 2 different organisms
- Accumulation of chemicals of interest in organisms as endpoint
- Compare DM to reference sediment

Define potential for contaminants to move into food web and cause adverse effects to fish, birds, wildlife, and people

Drawing Conclusions

- Are unacceptable effects expected based considering relevant exposure conditions and toxicology data?



Example data from Houston Ship Channel

If no, options for placement are open
If yes, management controls evaluated

Risk Management through Engineering and Operational Controls

- Controls:
  - ► The equipment we use
    - i.e., dredge type, barge size, avoidance systems, etc.
  - ► When we operate
    - i.e., dredging windows
  - ► How we operate the equipment
    - i.e., disposal site selection, overflow, decanting, discharge rates, etc.
- Controls will affect project cost and schedule

Monitored Natural Recovery

- Natural recovery processes will operate at all sites
  - Chemical transformation
  - Reduced contaminant mobility and bioavailability
  - Physical isolation
  - Dispersion
- What additional engineering is needed to bring about acceptable risk reduction?
- How to develop lines-of-evidence to support decisions

DoD 2009 *Technical guide: Monitored natural recovery at contaminated sediment sites.* ESTCP-ER-0622.
http://www.epa.gov/superfund/health/conmedia/sediment/documents.htm

Dredging/Disposal/End-Use Process

Dredging/ Excavation → Staging/ Transport/ Rehandling → Treatment → Disposal or End-Use

- A removal remedy several parts/phases
  - Dredging/excavation
  - Transporting and rehandling
  - Treating or preparing the material
  - Transition to end-use or containment

http://el.erdc.usace.army.mil/elpubs/pdf/trel08-29.pdf


ERDC/EL TR-08-29

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Technical Guidelines for Environmental Dredging of Contaminated Sediments

Michael R. Palermo, Paul R. Schroeder, Trudy J. Estes, and Norman R. Francingues

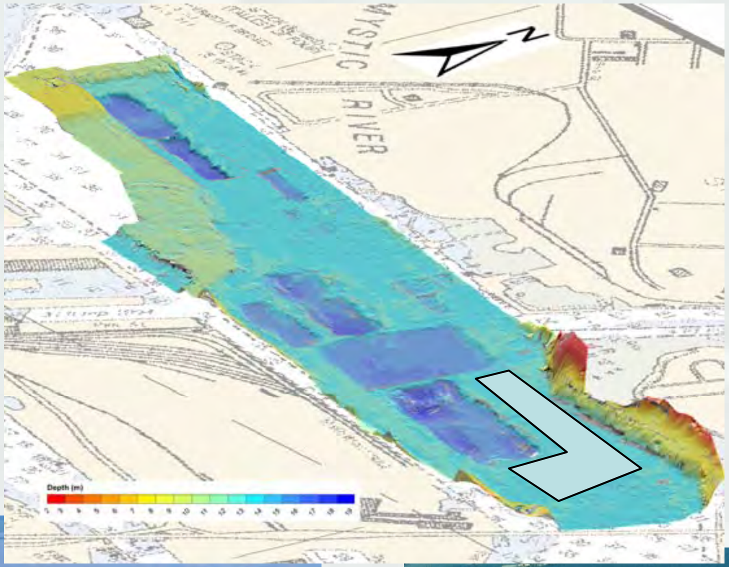
September 2008

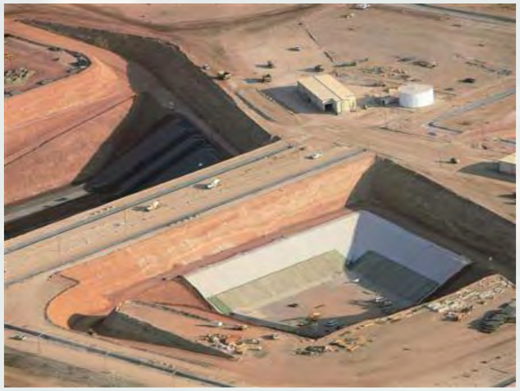
Approved for public release; distribution is unlimited.

Environmental Laboratory

Dredging Followed by Containment

- Confined Aquatic Disposal (CAD)
- Confined Disposal Facility (CDFs)
- Landfill (hazardous waste and otherwise)





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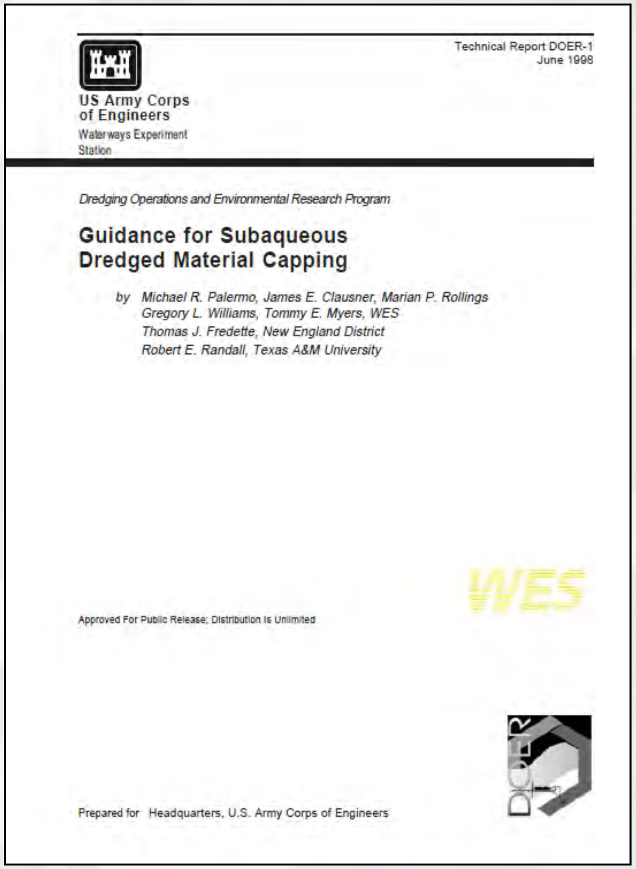
Capping

- Use of clean sediment to cover contaminated sediments
- Capping performed on in-place sediments as well as through Confined Aquatic Disposal (CAD)
- Has been used at numerous sites in the US and elsewhere
- ERDC currently updating national engineering guidance for USEPA



Technical Report DOER-1
June 1998

US Army Corps of Engineers
Waterways Experiment Station

Dredging Operations and Environmental Research Program

Guidance for Subaqueous Dredged Material Capping

by Michael R. Palermo, James E. Clausner, Marian P. Rollings
Gregory L. Williams, Tommy E. Myers, WES
Thomas J. Fredette, New England District
Robert E. Randall, Texas A&M University

WES

Approved For Public Release; Distribution Is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

Examples of Confined Aquatic Disposal

1981 – Rotterdam, Netherlands, 1.1 MCY

1981 – Norwalk Harbor, ~ 2,500 cu m

1984 – Seattle, WA Duwamish, 1100 cy

1987 – One Tree Island Marina, WA

1989 – New Bedford Harbor Pilot

1992 - Hong Kong, 13 MCY

1992 – Ross Island, Portland OR, 160 KCY

1997 - Newark Bay, 2 MCY

1997-2000 – Boston Harbor, 1,200,000 cu m

1998 – Hyannis Harbor, 57,000 cu m

2000 – Puget Sound Naval Shipyard, 377 KCY

2001 - Los Angeles, Energy Island, 100 KCY

2003 - Providence Harbor, 900,000 cu m

2005 – New Bedford Harbor – TBD

2006 - New London Harbor, 117,000 cu m

2006 – Oslofjord, Norway, 880 KCY

2006 - Norwalk Harbor, 27,000 cu m

2008-2010 – Boston Harbor

2008 - Port Hueneme, CA, 327 KCY

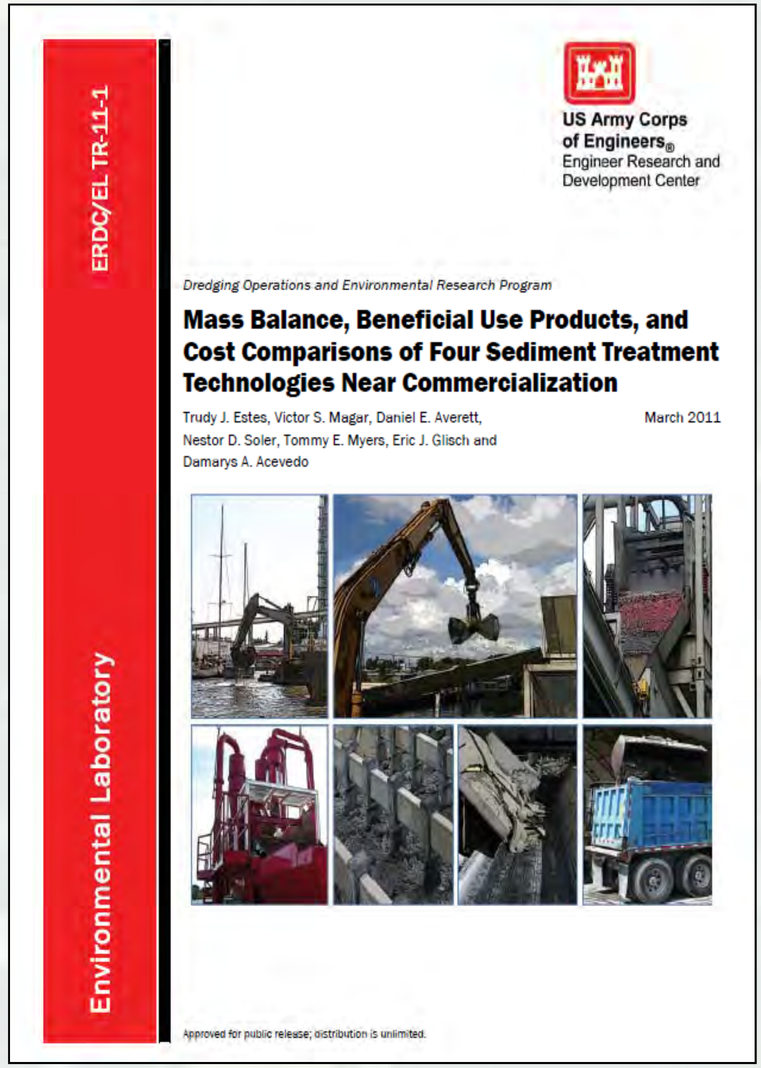
2008 – Melbourne, Australia, 23 MCY

2010 – Manila, Philippines

2010 – New London Harbor

Review and Analysis of Sediment Treatment Technologies

- Identify technologies near commercialization
- Evaluate performance based on published data
- Funded by EPA and USACE Dredging Operations Environmental Research Program (DOER)
- Estes et al 2011


ERDC/EL TR-11-1

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Dredging Operations and Environmental Research Program

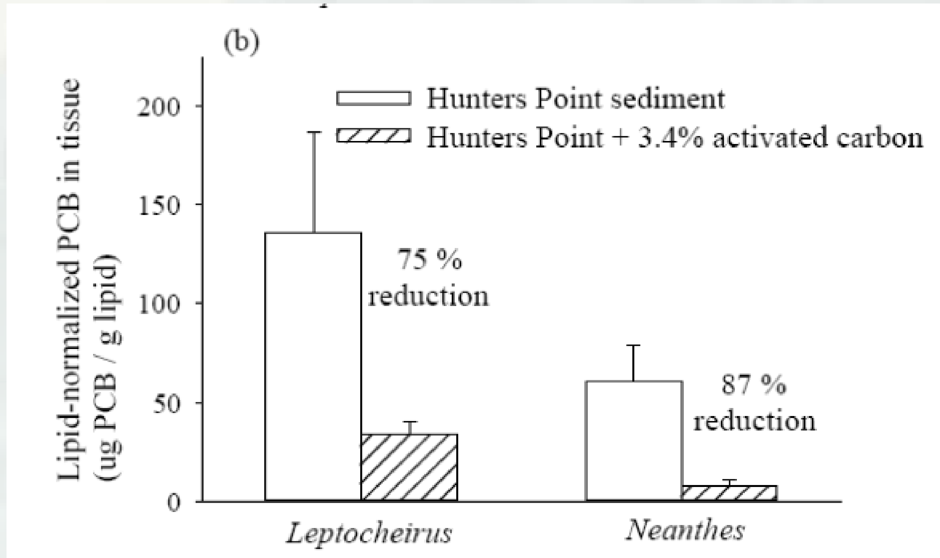
Mass Balance, Beneficial Use Products, and Cost Comparisons of Four Sediment Treatment Technologies Near Commercialization

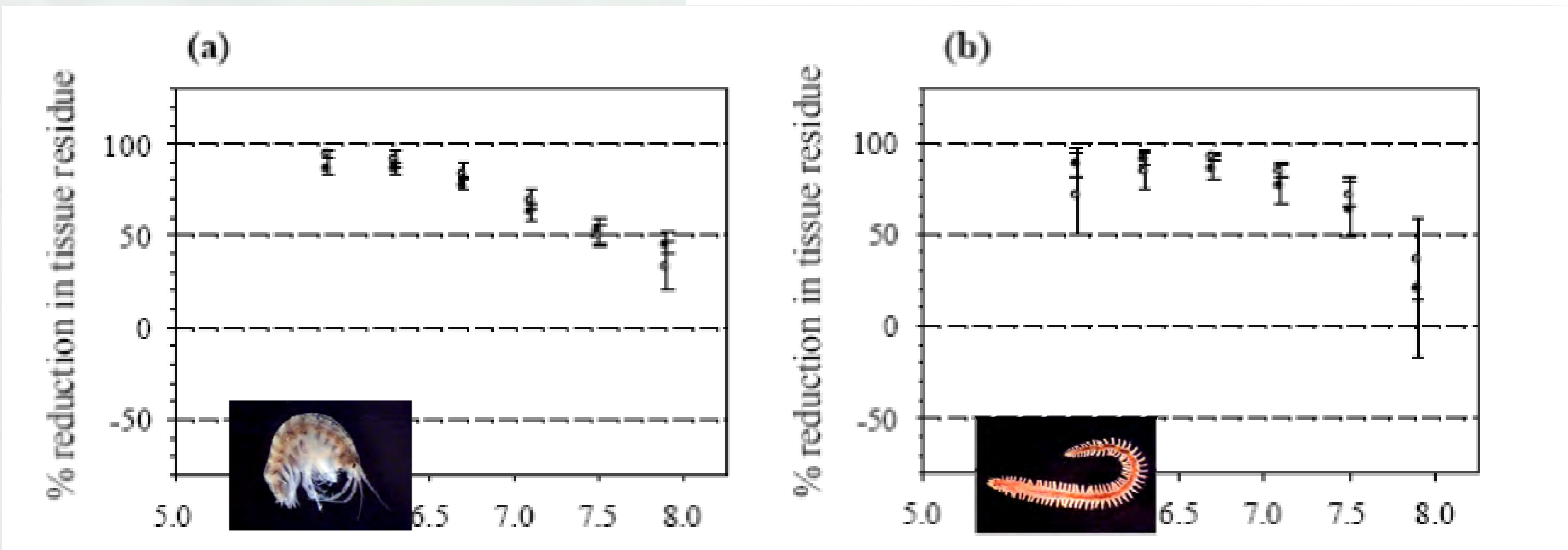
Trudy J. Estes, Victor S. Magar, Daniel E. Averett, Nestor D. Soler, Tommy E. Myers, Eric J. Glisch and Damarys A. Acevedo

March 2011

Approved for public release; distribution is unlimited.

Activated carbon reduces PCB bioavailability: Measured in terms of bioaccumulation





R. N. Millward, T. S. Bridges, U. Ghosh, R. J. R. Zimmerman ,G. Luthy. 2005. Addition of activated carbon to reduce PCB bioaccumulation by a polychaete (*Neanthes arenaceodentata*) and an amphipod (*Leptocheirus plumulosus*). *Environmental Science and Technology* 39:2880-2887.

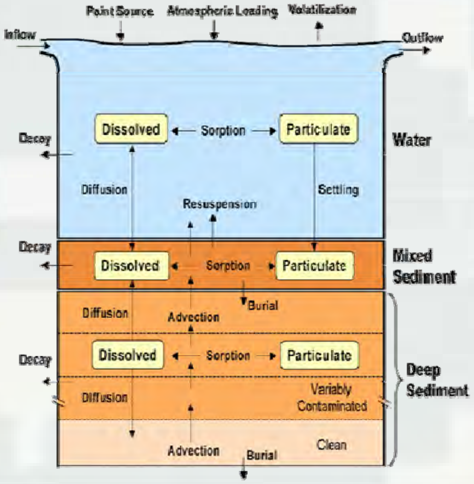
Evaluating Management Options for Contaminated Dredged Material

- Major steps
  - Determining what option or combination of options makes engineering sense
  - Use of strategic stakeholder engagement as a part of deliberation
- Major distinctions among the options
  - CAD: engineering is straightforward and proven; fewer processing steps; fewer exposure pathways; lower carbon footprint; least cost
  - CDF: engineering is well established; more steps and exposure pathways; larger carbon footprint; more costly
  - Landfill: engineering similar to CDF; can have much larger transportation step and carbon footprint; most costly

Sparrevik M, Saloranta T, Cornelissen G, Eek E., Magerholm Fet A, Breedveld GD, and Linkov I. 2011. Use of Life Cycle Assessments to Evaluate the Environmental Footprint of Contaminated Sediment Remediation. Environmental Science and Technology 45: 4235-4241

High Points

- Problem formulation / framing is a key step
- Risk-informed decision making is based on science, data and analysis
- Technology can provide a lot of data, but effective use of data depends on a robust decision-making framework



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