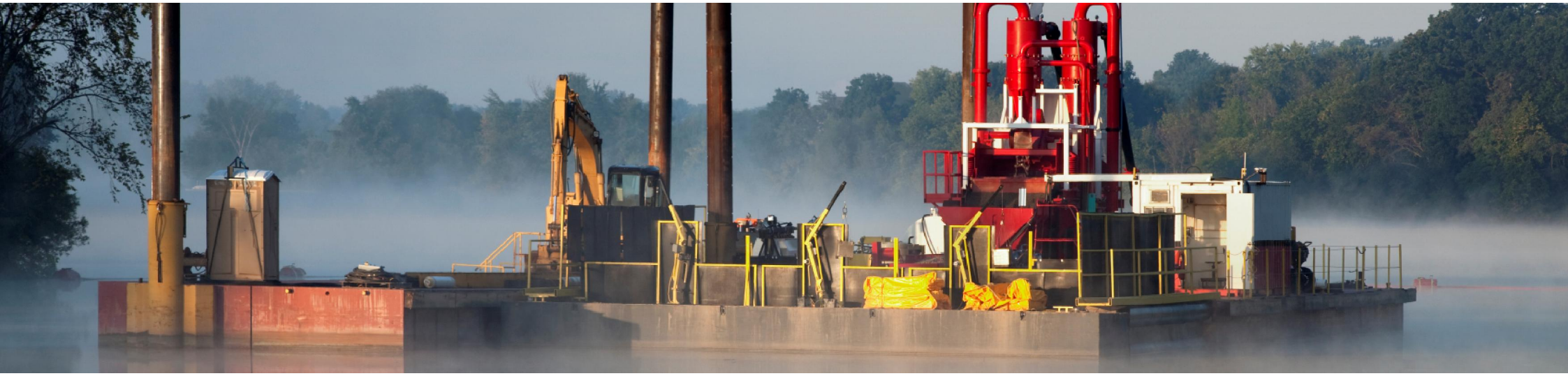


STRATEGIE DI INTERVENTO PER SEDIMENTI CONTAMINATI: CASI STUDIO ED ESPERIENZE DAL PANORAMA INTERNAZIONALE

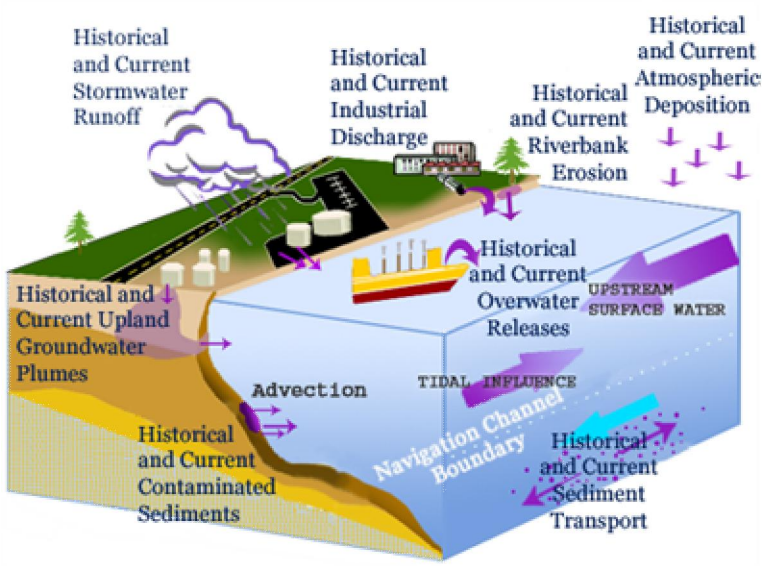
FABIO COLOMBO, ELISA BIZZOTTO - RAMBOLL ITALY

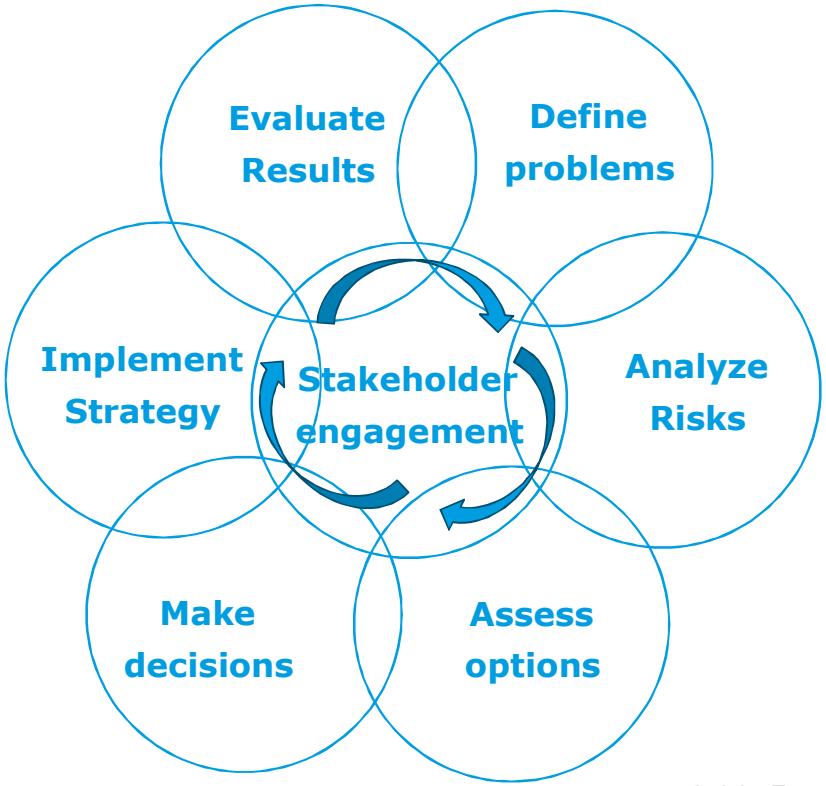
RAMBØLL

QUALI SFIDE?

- Contaminazione storica
- Presenza di aree di pregio ecologico e/o culturale
- Contaminazione diffusa
- Complessità delle matrici
- Variabilità sito specifica
- Influenza congiunta di diverse attività antropiche, emissioni di varia natura
- Assenza di legislazioni specifiche e di un approccio consolidato
- Elevati costi di gestione e di bonifica
- Elevato impatto delle attività di bonifica

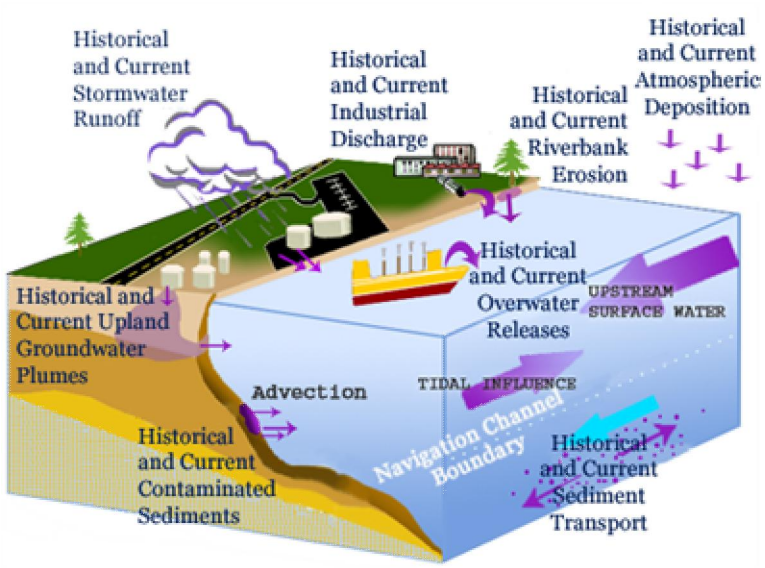
PROCESSI DECISIONALI E GESTIONE DEL RISCHIO





NRC 2015

PROCESSI DECISIONALI E GESTIONE DEL RISCHIO



NRC 2015

PROCESSI DECISIONALI E GESTIONE DEL RISCHIO

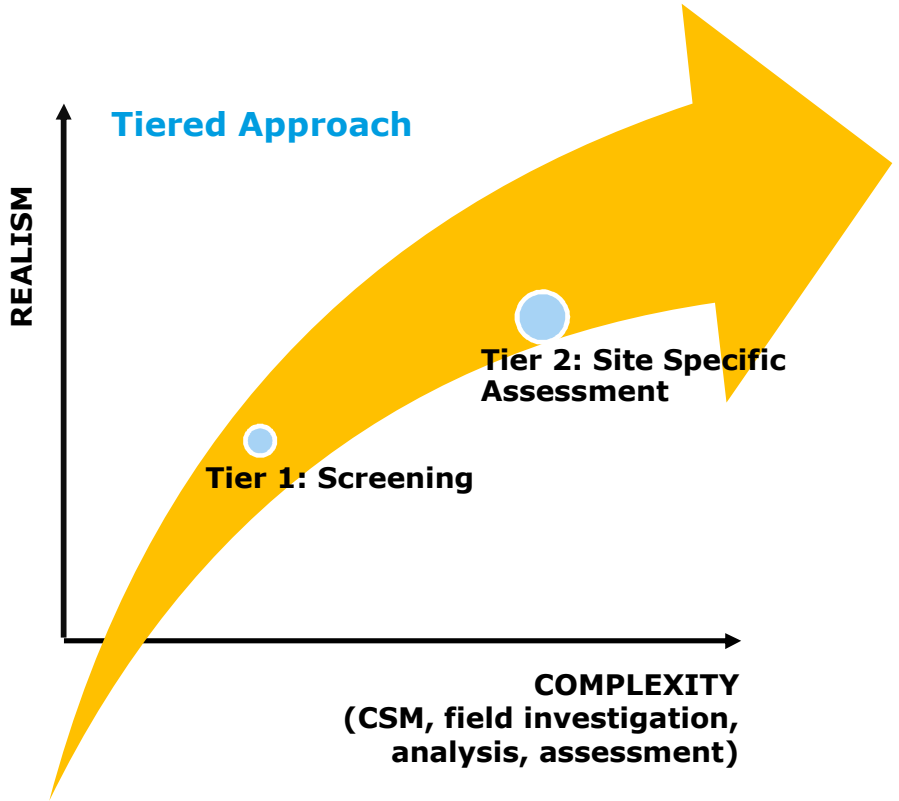
Necessità di azioni di bonifica?
Quale opzione permette di ottenere il maggiore beneficio ambientale, considerando la fattibilità e l'efficacia?
Obiettivi e livelli da raggiungere per il recupero ambientale?
Sono richieste azioni di compensazione o mitigazione?

Rischi per la salute umana?
Rischi per i recettori ecologici e gli ecosistemi (acquatici e terrestri)?
Impatti sui servizi ecosistemici?
Le condizioni sono stabili? Trend temporale?

Contesto ambientale e problematiche?
Contaminanti di interesse? Percorsi di esposizione?
Recettori ecologici e valori ambientali da proteggere?
Distribuzione spaziale e verticale dei CoC nelle matrici ambientali? Processi idrodinamici, tassi di sedimentazione e fenomeni di trasporto? Sorgenti primarie e secondarie e relativo impatto sui sistemi acquatici?
Processi di bioaccumulo e biomagnificazione?

RAMBOLL

PROCESSI DECISIONALI E GESTIONE DEL RISCHIO



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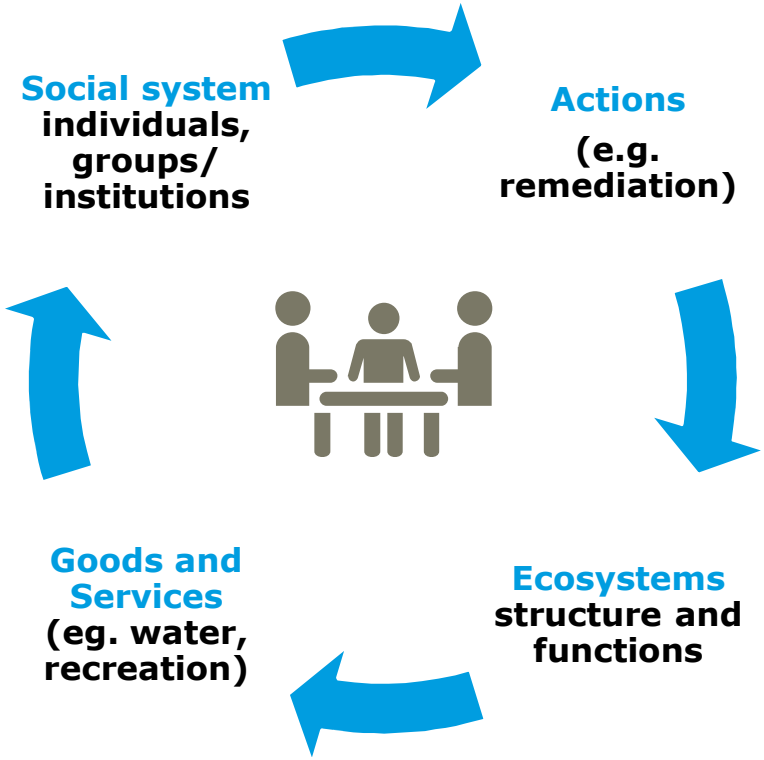
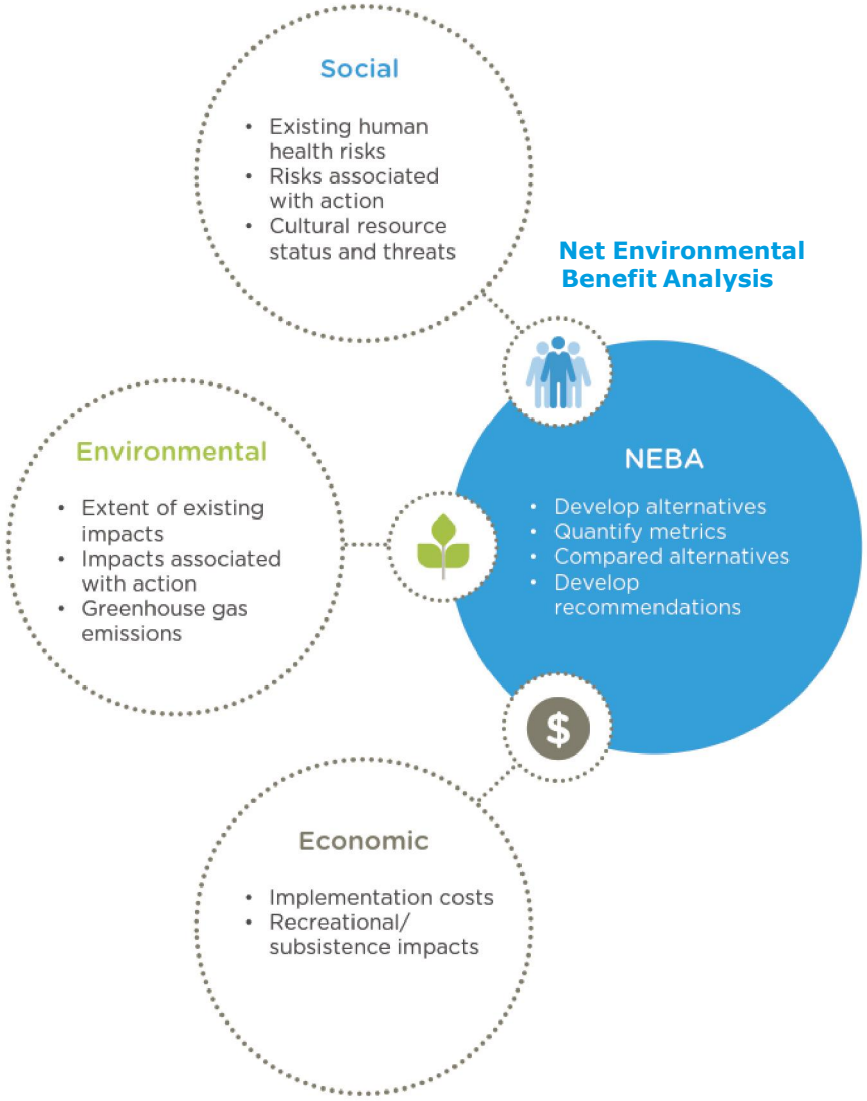
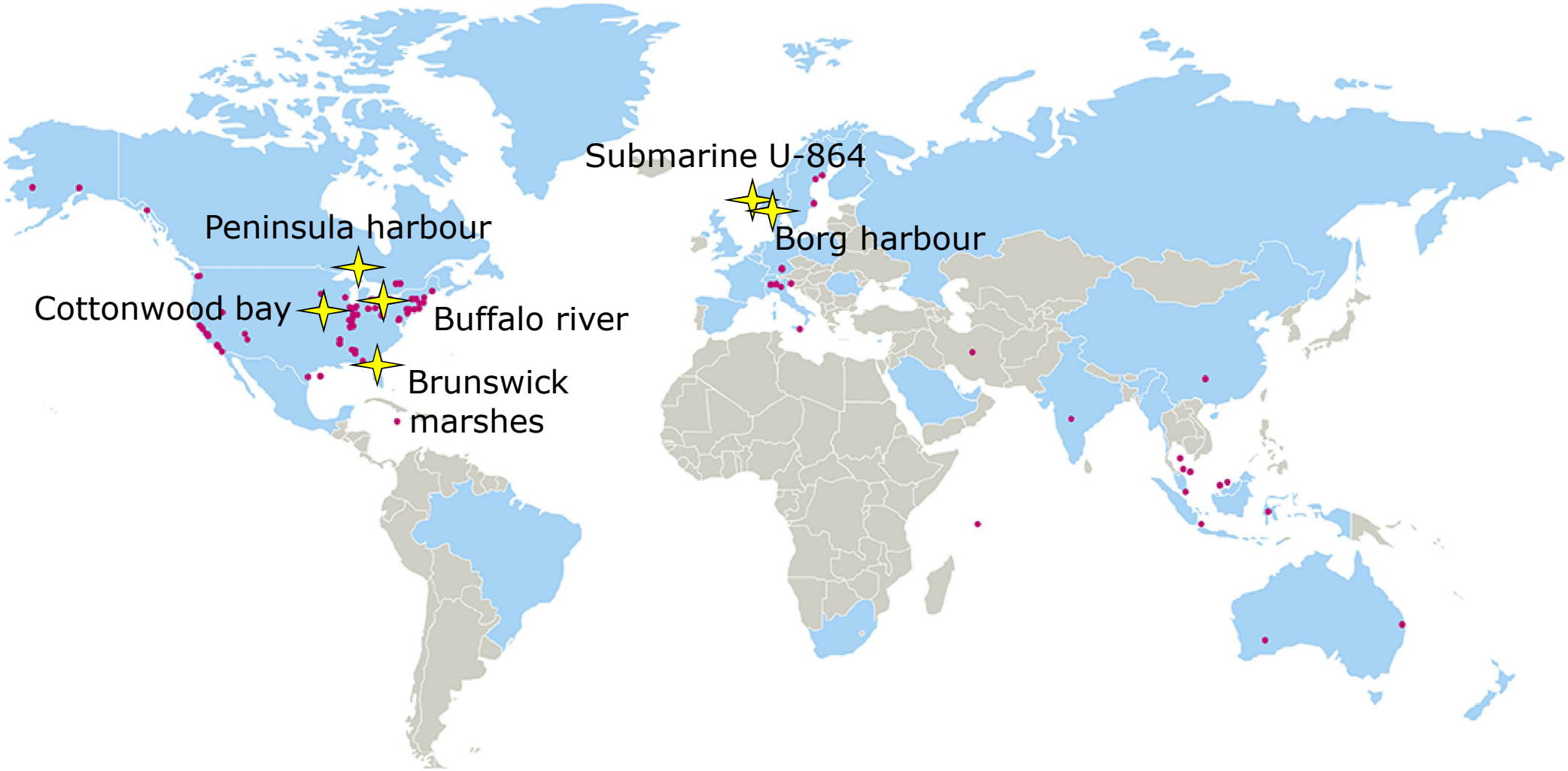




RAMBOLL

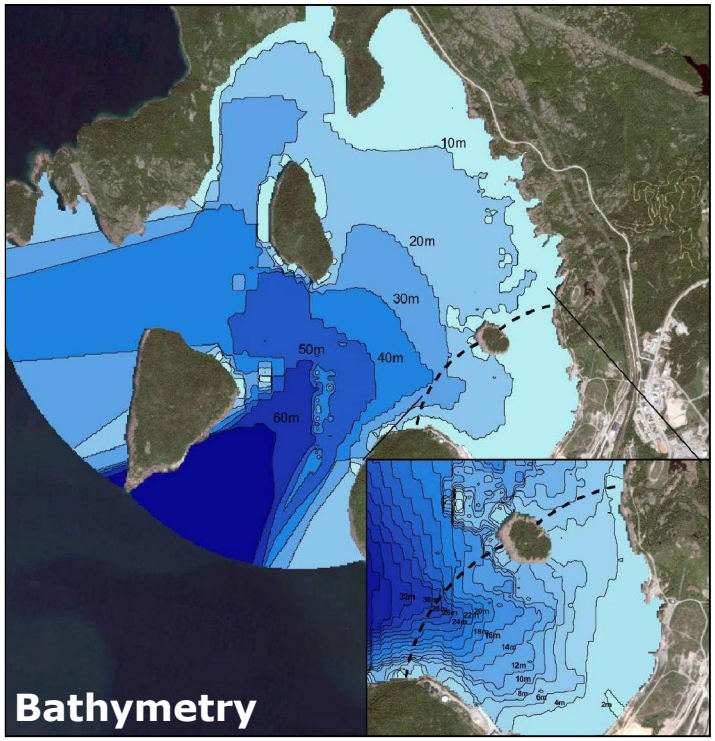
ESPERIENZA NELLA GESTIONE DI SITI CON SEDIMENTI CONTAMINATI DA MERCURIO

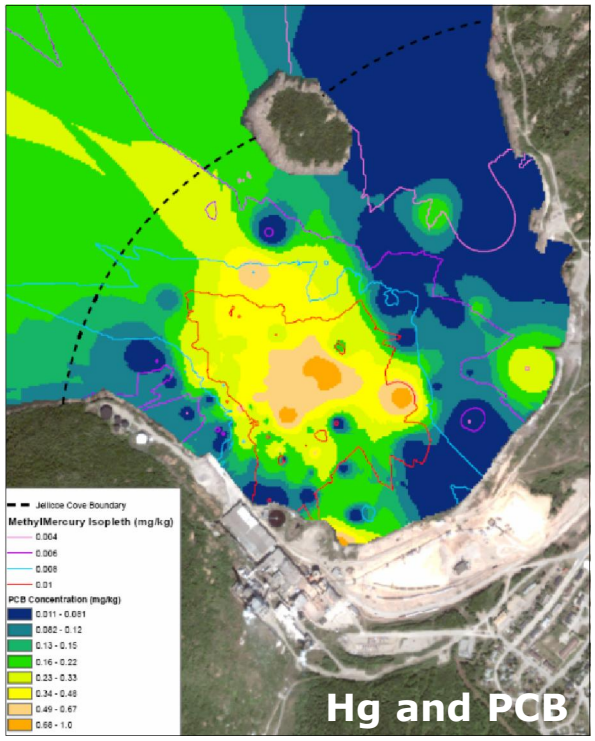


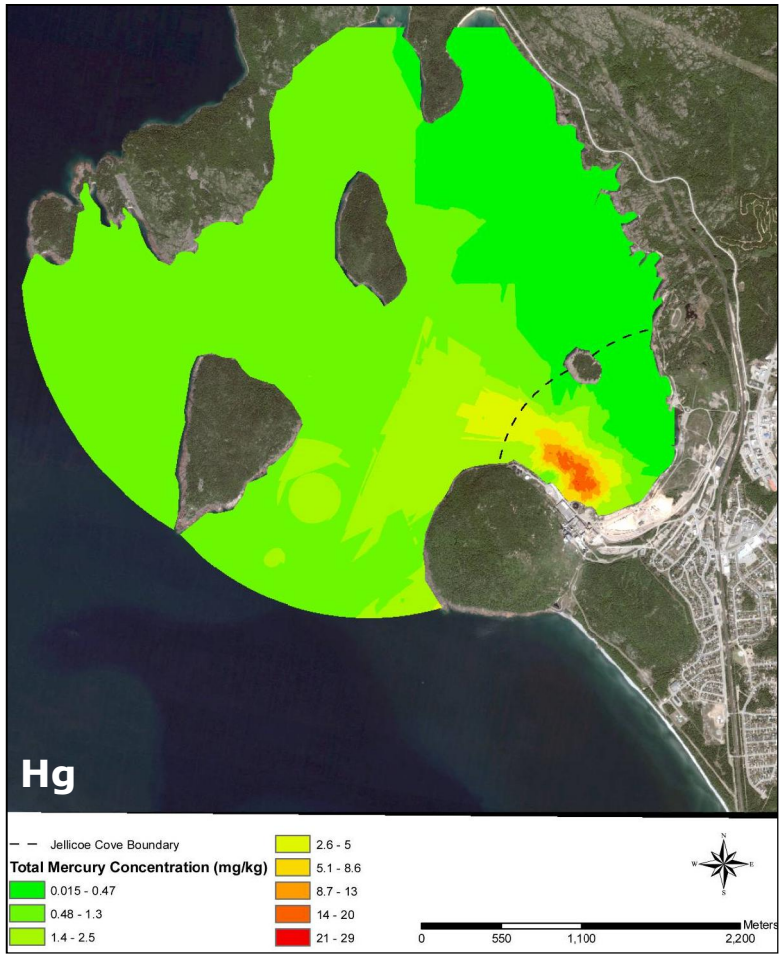
PENINSULA HARBOUR, MARATHON, ONTARIO

- Peninsula Harbour: Lake Superior, approximately 3 km wide and 4 km long
- Presence of historical industrial production
  - bleached kraft pulp mill (effluent discharged directly to the cove in the period 1946-1983)
  - chloro-alkali plant built adjacent to the mill in the 1952 (active until late 1977, effluent treated until 1984)
- COC: Mercury and PCB

PENINSULA HARBOUR, MARATHON, ONTARIO



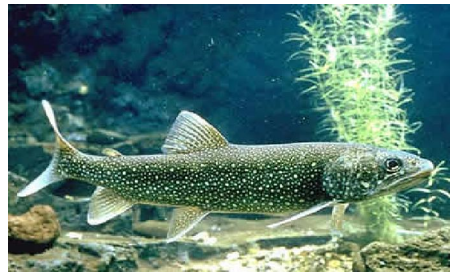




Sediment Mercury and PCB Concentrations Delineated by Inverse Distance Weighting

RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
SCOPO DEL LAVORO

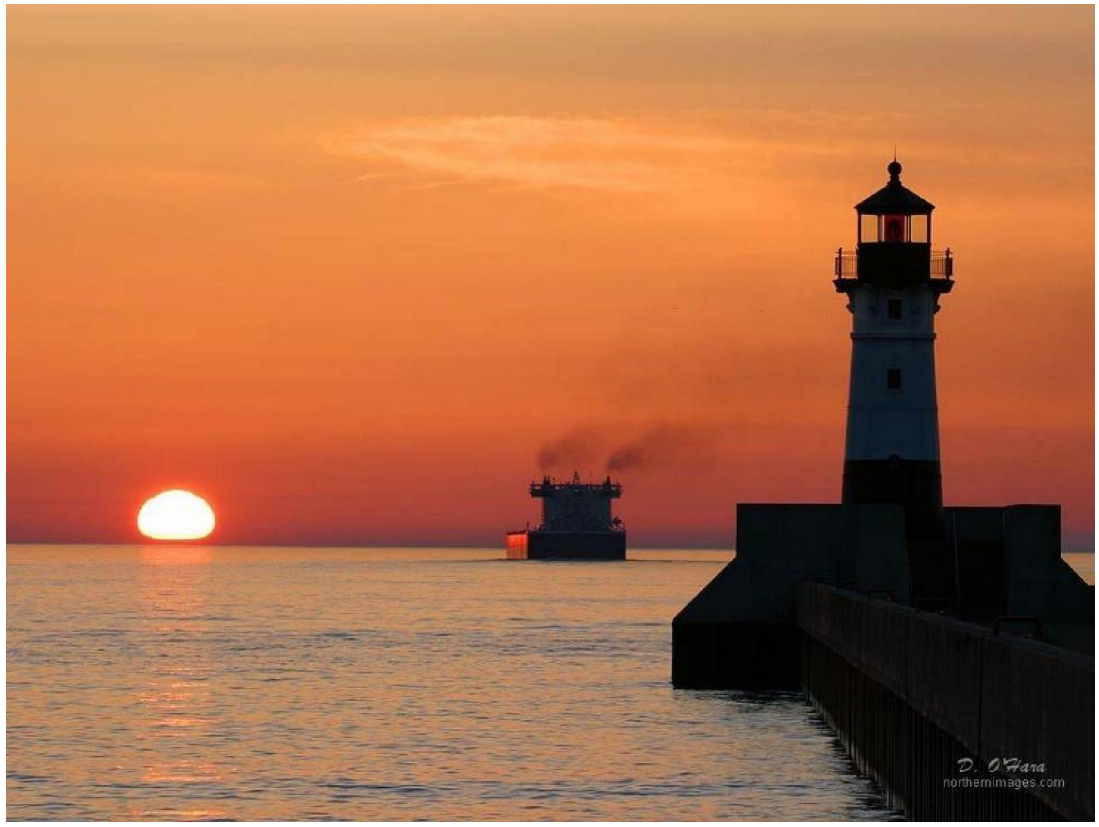


- **Environmental risk assessment** to characterize and quantify risks related to chemicals in the Areas Of Concern
  - Ecological Risk Assessment
    - Receptor characterization (benthos, fish, wildlife)
    - Exposure assessment, Effect assessment, Risk characterization
  - Human Health Risk Assessment
- Develop and evaluate **Sediment Management Options** that address mercury and PCBs in Peninsula Harbour Area of Concern, in order to
  - Reduce the potential for offsite migration of mercury from the hot spot area
  - Reduce the potential for future exposure to sediment-associated methylmercury and PCBs

RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
VALUTAZIONE DELLE DIVERSE OPZIONI DI GESTIONE DEI SEDIMENTI

- Screening Phase - Identify and evaluate General Response Actions based on
  - Effectiveness
  - Implementability, and
  - Cost
- Create short-list of remedial alternatives retained after preliminary screening
- Evaluate remedial alternatives in detail
- Develop conceptual designs for remedial alternatives



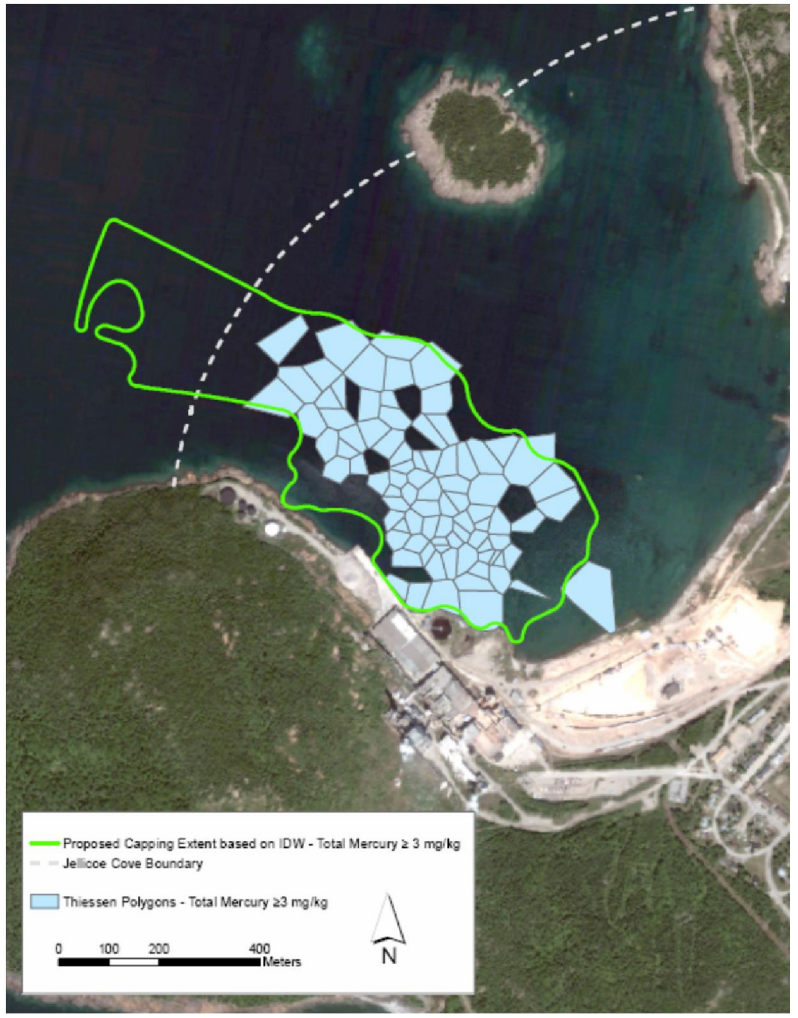
RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
VALUTAZIONE DI SCREENING

General Response Action	Screening Result
No Action	Reject
Institutional Controls	Reject as stand-alone remedy
Monitored Natural Recovery	Reject for source control Applicable to residual sediment
Sediment Capping - Isolation - Thin Layer - Reactive	 Reject Retain Consider during detailed design
Sediment Removal - Hydraulic Dredging - Mechanical Dredging	 Retain Reject
Removal Process Options	Dewatering, transportation, onsite (inland) or offsite disposal
In Situ Treatment	Consider reactive cap materials during detailed design
Ex Situ Treatment	Consider solidification/stabilization if TCLP results suggest leachable constituents

PENINSULA HARBOUR, MARATHON, ONTARIO
DEFINIZIONE DELL'AREA DI INTERVENTO

- On the basis of site specific conditions (bioavailability, toxicity test results) and RA results, refined delineation of cap area
  - 3 mg/kg Mercury Hotspot Delineation. For the thin layer cap, use of Thiessen polygons to define cap outline allows for cost effective placement of cap materials over well characterized sediment
- Identification of remedial alternatives
- Conceptual design of remedial alternatives
- Detailed evaluation of remedial alternatives
- Consideration of Monitored Natural Recovery
- Engineering design work plan



RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
SELEZIONE DELLA METODOLOGIA DI INTERVENTO

- **Remedial Alternative 1:**
  Thin layer capping > 3 mg/kg Hg
- **Remedial Alternative 2:**
  Hydraulic dredging, thin layer capping, offsite sediment disposal
  - Alt 2a: Dredge > 17 mg/kg Hg & thin layer capping > 3 mg/kg
  - Alt 2b: Dredge > 14 mg/kg Hg & thin layer capping > 3 mg/kg
- **Remedial Alternative 3:**
  Hydraulic dredging, thin layer capping, consolidation of dredged sediments in a inland CDF
  - Alt 3a: Dredge > 17 mg/kg Hg & thin layer capping > 3 mg/kg
  - Alt 3b: Dredge > 14 mg/kg Hg & thin layer capping > 3 mg/kg

RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
SELEZIONE DELLA METODOLOGIA DI INTERVENTO: MATRICE DI VALUTAZIONE

Criteria	Relative Importance	Thin Layer Capping	Hydraulic Dredging	Combined Thin Layer Capping and Hydraulic Dredging
Effectiveness	High	Better	Good	Best
Technical Feasibility	Medium	Best	Good	Better
Community Acceptance	Medium	Good	Better	Best
Risk	High	Better	Good	Best
Monitoring Needs	Low	Good	Best	Better
Compliance with Regulations	Medium	Good	Good	Good
Cost Effectiveness	High	Best	Good	Better
SCORE		**2.0**	**1.3**	**2.4**

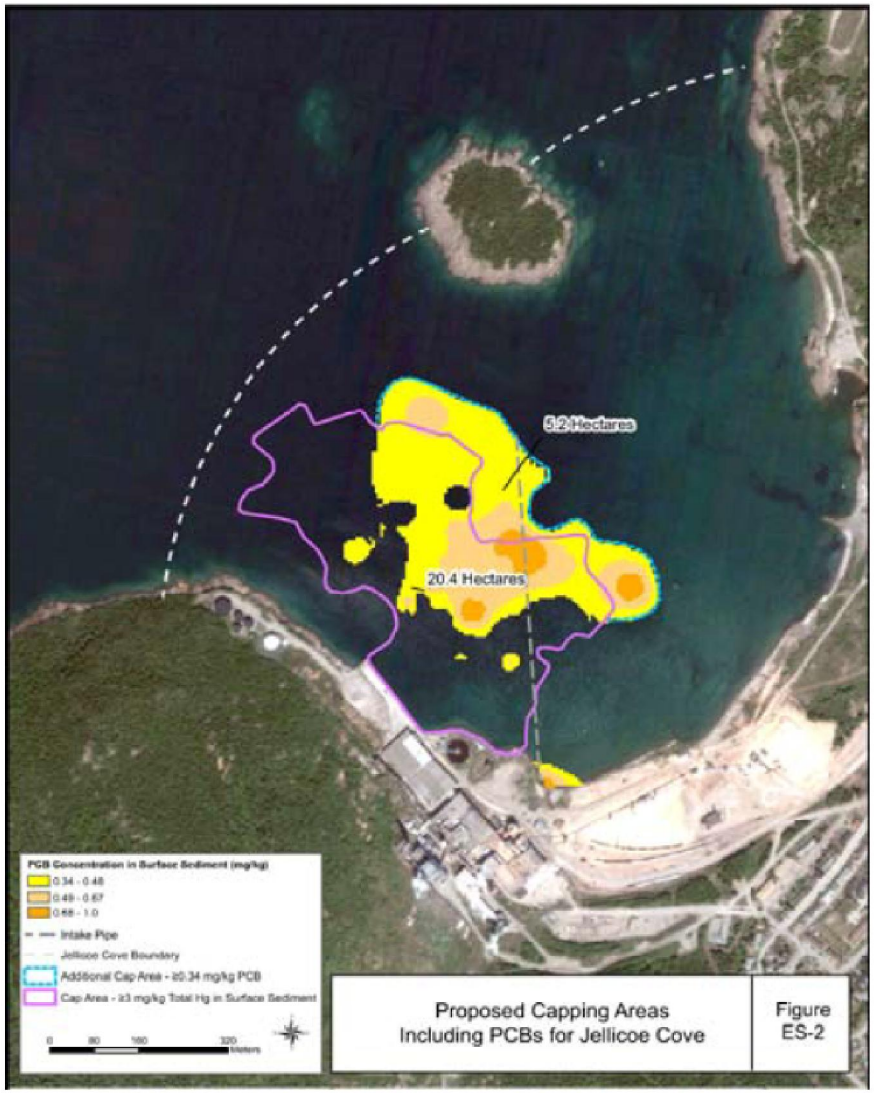
RAMBOLL

PENINSULA HARBOUR, MARATHON, ONTARIO
PROGETTO PRELIMINARE

Conceptual designs focus the discussion of sediment remediation by defining specific targets for thin layer capping and hydraulic dredging.

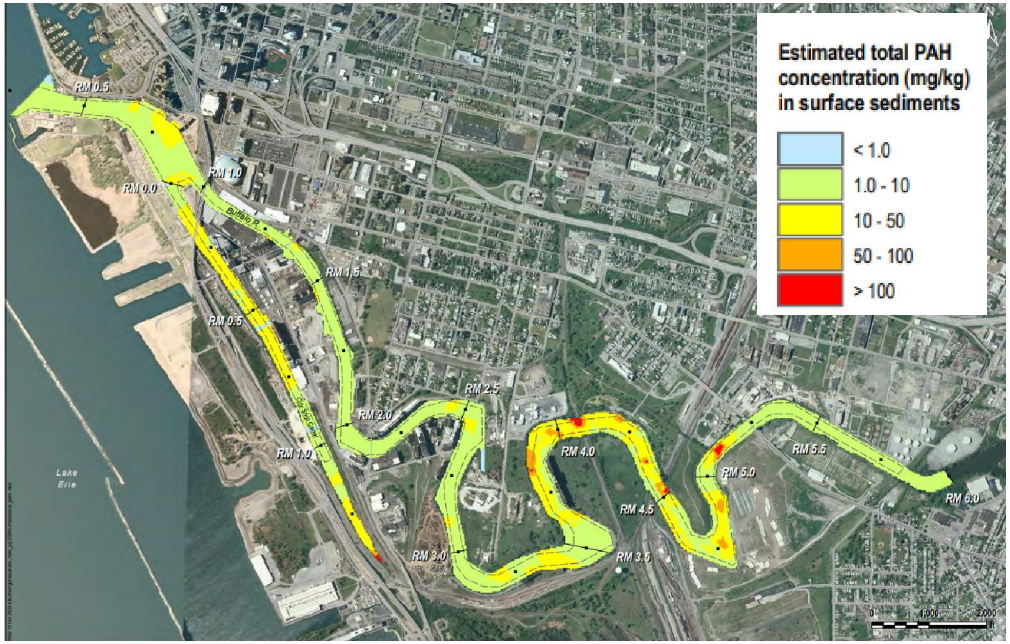
- The remedial target for **thin layer capping** is defined by surface sediment with Hg > 3 mg/kg
- The remedial targets for **hydraulic dredging** are defined by surface sediment with Hg > 14 mg/kg or 17 mg/kg

Conceptual designs also highlight site-specific information such as the slope of the cove bottom and potential placement locations for dredging pipelines, silt curtains, shore-side staging areas, and dredged sediment dewatering operations.



BUFFALO RIVER, BUFFALO, NEW YORK

- The Buffalo River discharges into Lake Erie
- Served as an industrial, commercial, and urban waterway for almost two centuries, beginning with the Erie Canal in 1825
- Widespread sediment contamination, mainly related to **PAH, PCB, Mercury and Pb**
- **Ramboll was the lead technical consultant**, coordinating a team of scientists and engineers from different agencies
- Developed the **Remedial Investigation** and **Feasibility Study of alternatives**



Collaboration with US Environmental Protection Agency (USEPA), US Army Corps of Engineers (USACE), NY State Department of Environmental Conservation (NYSDEC), and Buffalo Niagara Riverkeeper

RAMBOLL

BUFFALO RIVER, BUFFALO, NEW YORK
VALUTAZIONE DELLE DIVERSE OPZIONI DI GESTIONE DEI SEDIMENTI

- Conceptual designs were prepared for the remedial alternatives for sediment risk management. The alternatives include various combinations of targeted removals, monitored natural recovery, and sediment capping:

- **Alternative 1 - No action**
- **Alternative 2 - Monitored Natural Recovery** (multiple lines of physical and biological evidence)
- **Alternative 3 – Basic dredging + capping** (removal PAH TU > 1, large volume, 5-6 years to implement)
- **Alternative 4 - Protectiveness Dredging Remedy** (removal of surficial sediments (0–30 cm) **+ capping**. Small volume of sediment to be dredged, 2-3 years to implement)
- **Alternative 5 – Enhanced Protectiveness Dredging** (removal PAH TU > 1 in surface sediment (0–30 cm) and additional areas impacted by PCBs, metals and grease)

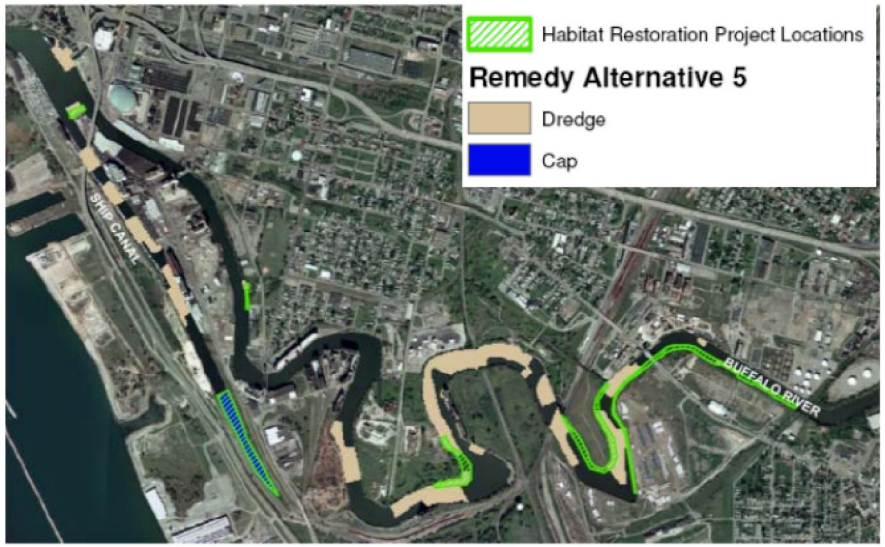
Criteria adopted to evaluate remedial alternatives:

- Overall protection of the Human Health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements
- Short-Term Effectiveness
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume
- Implementability
- Cost
- State and Community Acceptance

RAMBOLL

BUFFALO RIVER, BUFFALO, NEW YORK

- Selected remedy: capping, dredging, and MNR
  - 32 hectares of sediment remediation, including over 380 000 m^3 dredging
  - Placement of a cap in the City Ship Canal, and cover placement at selected locations that could not be dredged safely
  - Habitat restoration in five project areas
- The remedy was completed in 2015
- Ramboll led the identification and design of **habitat mitigation and restoration alternatives**; restoration projects helped accelerate permitting and the resolution of mitigation requirements
- **Negotiations with the agency team and strong scientific basis** helped avoid a bank-to-bank removal of the 10-km river, as originally proposed

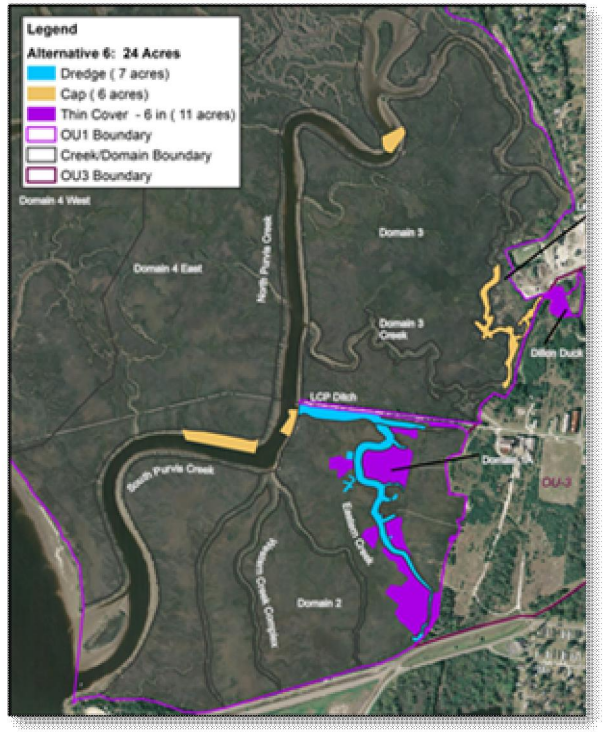


Potential Habitat Restoration Areas

RAMBOLL

BRUNSWICK, GEORGIA

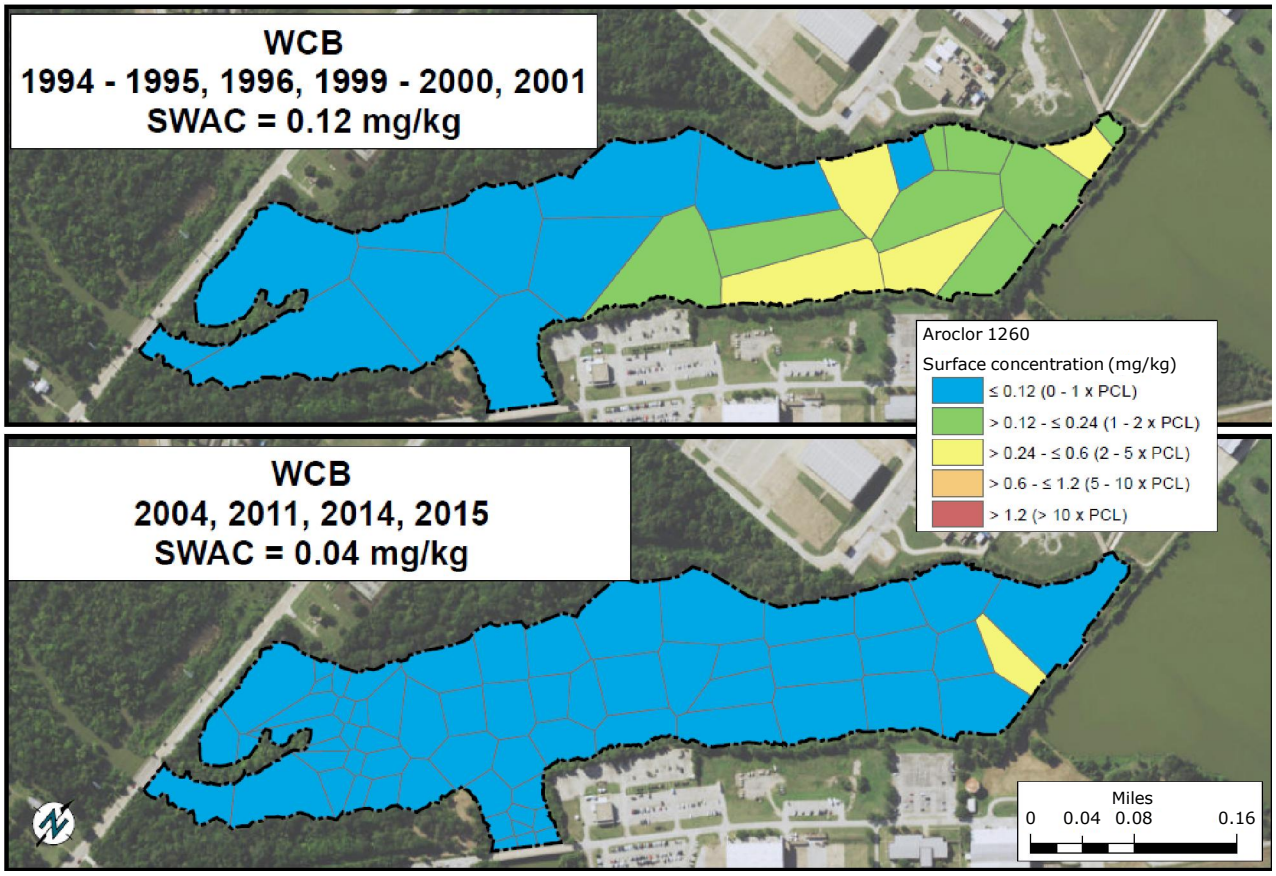
- Shallow estuary sites (270 hectares) with large tidal ranges and extensive stable wetlands, with presence of mercury, PCB, lead, and PAH
- Ramboll completed all aspects of work to prepare the Feasibility Study
- "Risk- of-Remedy" analysis considered whether the "cleanup [could] cause more ecological harm than the current site contamination" (EPA 1999)
- **The impacts of remediation on the marsh were weighed against the benefits of risk reduction**
- Ramboll led negotiations with regulatory agencies to develop an integrated remedy that included MNR, enhanced MNR (EMNR) using a 15-cm sand cover for vegetated marsh areas, capping, and removal in non-vegetated channels



RAMBOLL

COTTONWOOD BAY SITE, DALLAS TEXAS, USA
MONITORAGGIO DEL RECUPERO NATURALE

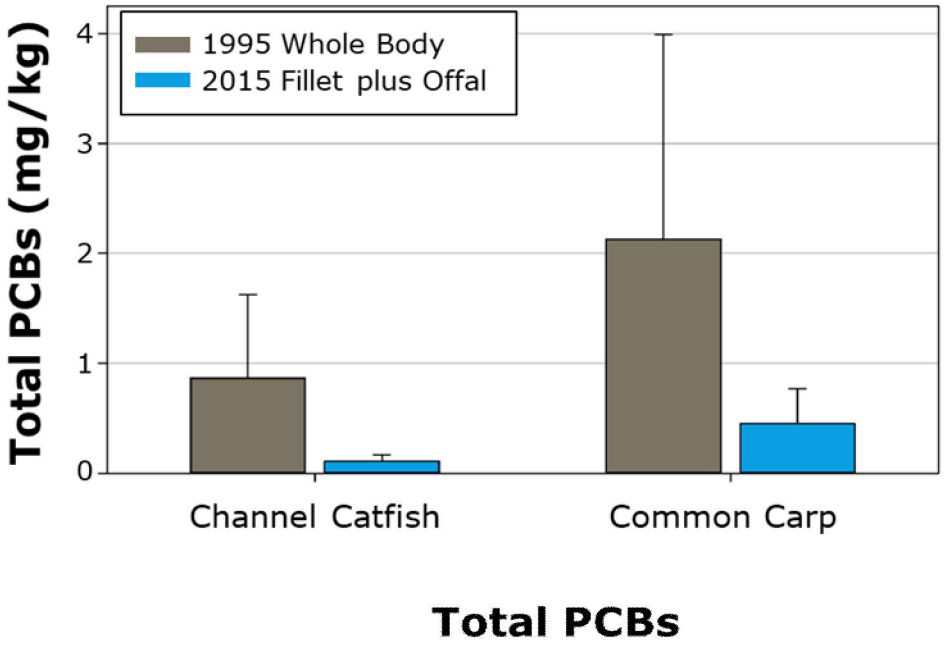
- Public reservoir – 1092 hectares
- Former US Navy-related facilities located on the shore
- 2011 Texas Commission on Environmental Quality (TCEQ) identified dredging as the remedial action for sediments
- 2013-14 sediment sampling demonstrated decreasing surface sediment concentrations
- Ramboll led the 2015-2017 MNR investigation



COTTONWOOD BAY SITE, DALLAS TEXAS, USA
MONITORAGGIO DEL RECUPERO NATURALE

Lines of Evidence Demonstrate MNR

- Recovering surface sediment COC concentrations
- Sediments are stable
- COC bioavailability in sediments is minimal
- COC concentrations in fish tissue have decreased since the mid-1990s



COTTONWOOD BAY SITE, DALLAS TEXAS, USA
MONITORAGGIO DEL RECUPERO NATURALE E LINEE DI EVIDENZA

Sampling, Analyses, and Risk Evaluations	Corresponding MNR Line of Evidence
Review of historic contaminant sources and current source control measures	Source control
Sediment coring and chemistry analyses	Surface sediment recovery
Sediment geochronology analyses	Sediment deposition/sediment stability
Surface sediment sampling and AVS/SEM	Bioavailability of metals in sediments
Fish tissue chemistry	Temporal trends in fish
Ecological and human health risk evaluations	Current risk and risk reduction over time

In 2018, TCEQ approved the MNR remedy for Cottonwood Bay. The revised and updated Remedial Action Plan (2018) requires 15 years' monitoring to demonstrate MNR can achieve site-specific risk-based cleanup levels.

RAMBOLL

DRAGAGGIO NAVIGAZIONALE PORTO DI BORG

- Hvaler Marine National Park
- Presence of valuable natural habitats/species

RAMBØLL

DRAGAGGIO NAVIGAZIONALE – PORTO DI BORG

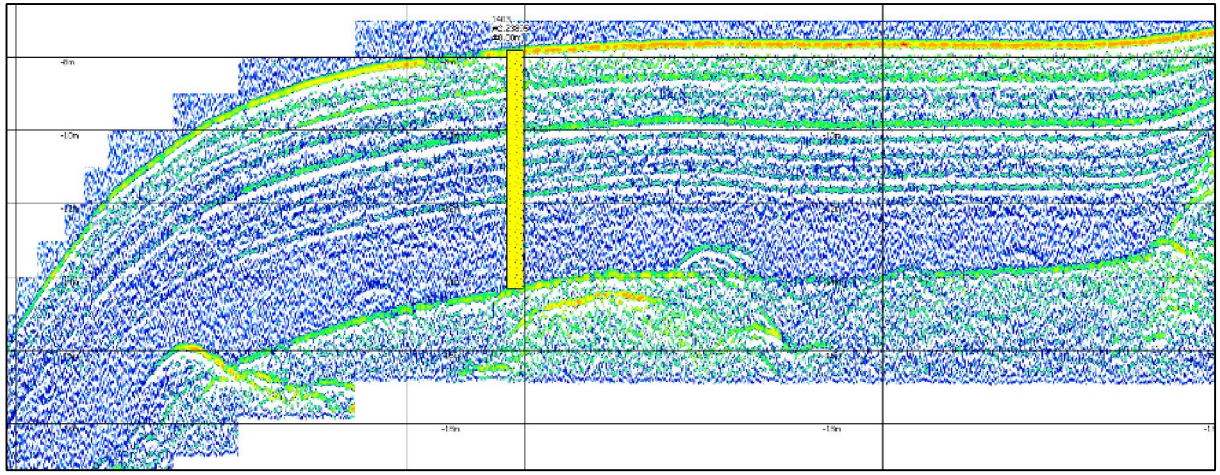
- 3 mill m^3 sediments to be dredged
  - 0,5 mill m^3 polluted sediments. Mercury, copper, PAH, PCB from several industries along the river Glomma (621 km long)
  - 2,5 mill m^3 non-polluted sediments
- Ramboll services
  - Base line investigations: sediment extent, sediment chemistry, geotechnical stability, valuable natural habitats
  - 3D modelling and excavation plan
  - Environmental Impact Assessment
  - Monitoring and Public communication

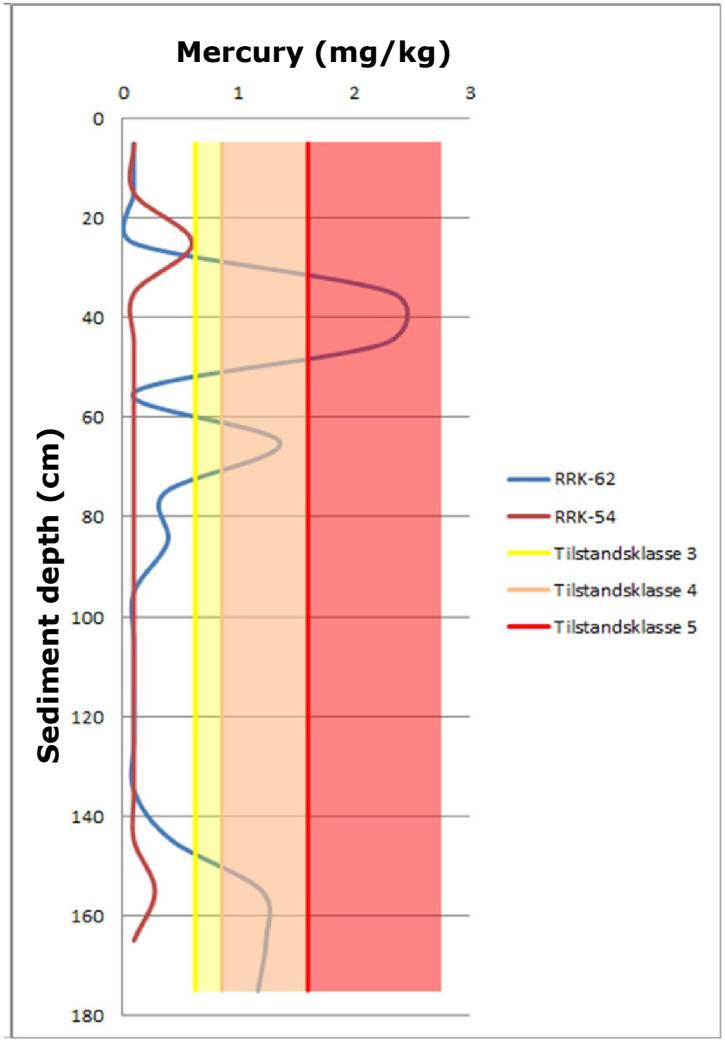
Borregaard Industry ©*Store Norsk Leksikon*

RAMBØLL

DRAGAGGIO NAVIGAZIONALE – PORTO DI BORG

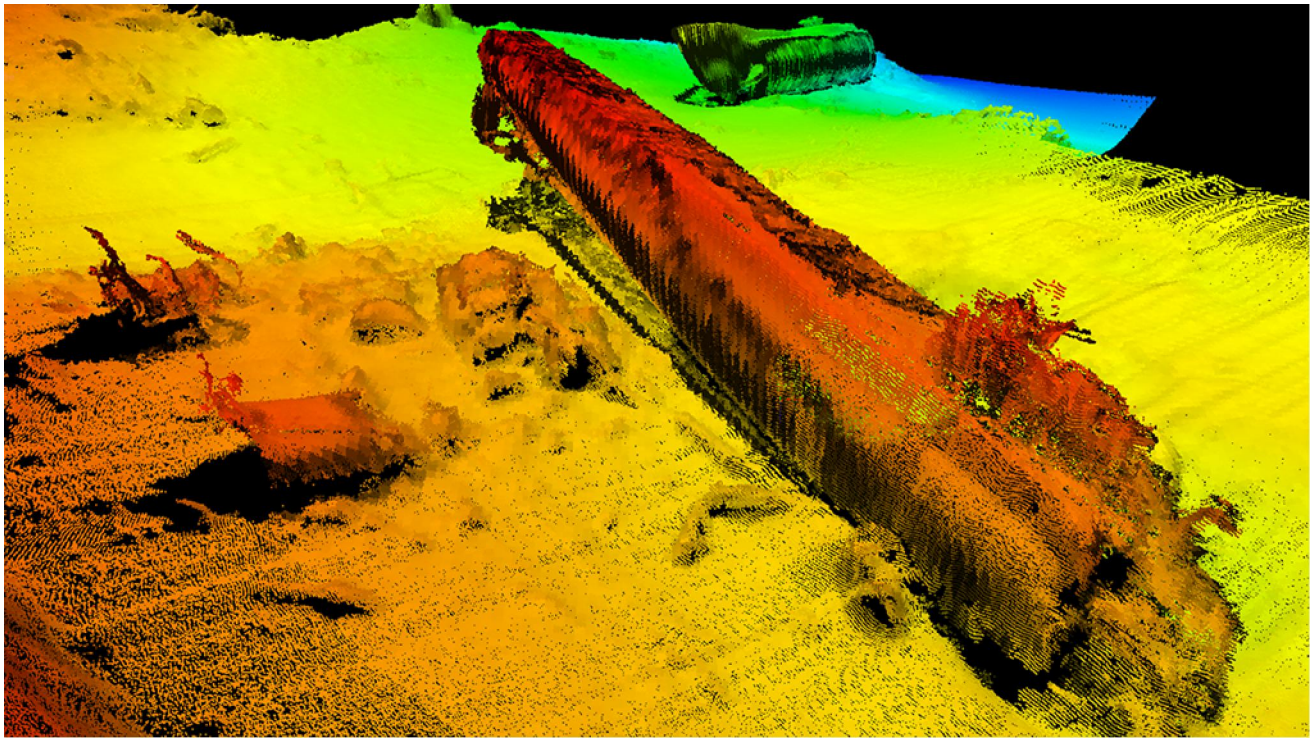
- 3D excavation model, based on
  - Detailed bathymetry
  - Detailed «layer» information (Polluted / Non-polluted)
- Terrain model based on
  - Sub bottom profiling
  - Verified by sediment core sampling and
  - Detailed chemical analysis





IL RELITTO DEL SOTTOMARINO TEDESCO U-864, AFFONDATO DURANTE LA II GUERRA MONDIALE

- 67 tons of Hg stored in the keel of the submarine
- Sunk to 150 m water depth at the west coast of Norway after been torpedoed in 1945
- Discovered by the Norwegian Navy in 2003
- One of the most extensively studied and surveyed wreck in Norwegian history
- Concerns for Arctic ecosystems and sea waters



RAMBØLL

IL RELITTO DEL SOTTOMARINO TEDESCO U-864, AFFONDATO DURANTE LA II GUERRA MONDIALE

- Geotechnical analyses have shown that the seabed in the area around U-864 is unstable
- A counter-filling has been established to stabilize the seabed and reduce the risk of movement by unconsolidated sediments and mitigate any associated pollution
- The counter-filling operation involves laying some 100 000 cubic meters of sand and rock in a controlled and precise manner from a specially designed ship

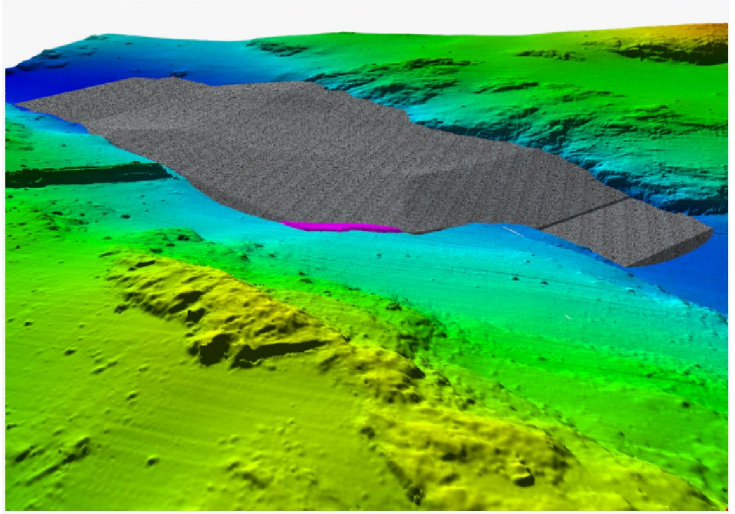


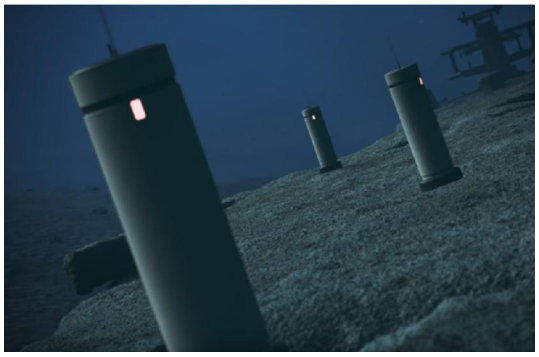
Illustration of the counter fill by Van Oord.

RAMBØLL

IL RELITTO DEL SOTTOMARINO TEDESCO U-864, AFFONDATO DURANTE LA II GUERRA MONDIALE

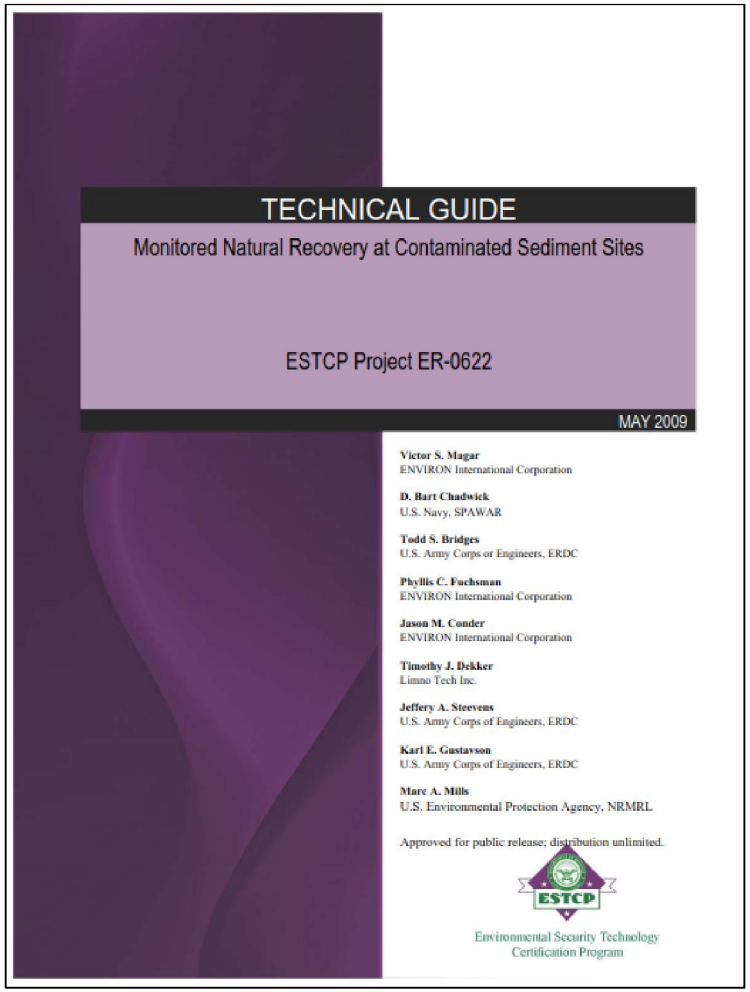
MONITORAGGIO AMBIENTALE ED ATTIVITÀ FUTURE

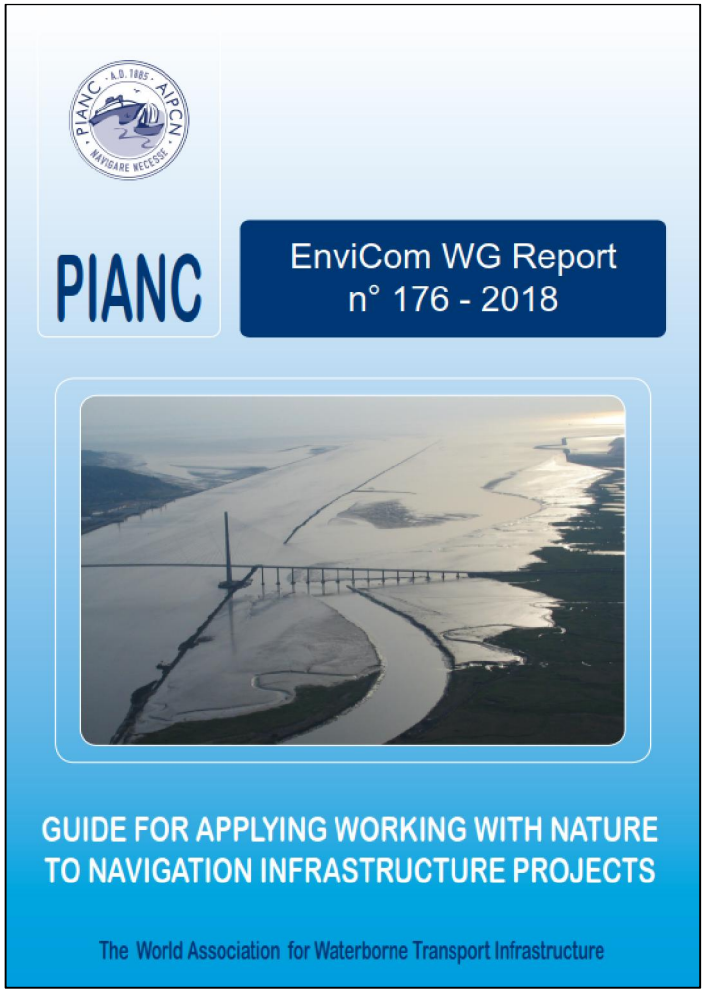
- Ramboll was commissioned to perform the third-party control of the monitoring of the counter-fill implementation, to ensure that the project meets all relevant environmental requirements
- The project has much public attention
- Discussions about raising the wreck or cap it. Not decided yet. Most specialist communities support in-situ capping
- Mercury in biota is continuously monitored



RAMBØLL

LINEE GUIDA E PUBBLICAZIONI SCIENTIFICHE RELATIVE AI SITI CON SEDIMENTI CONTAMINATI





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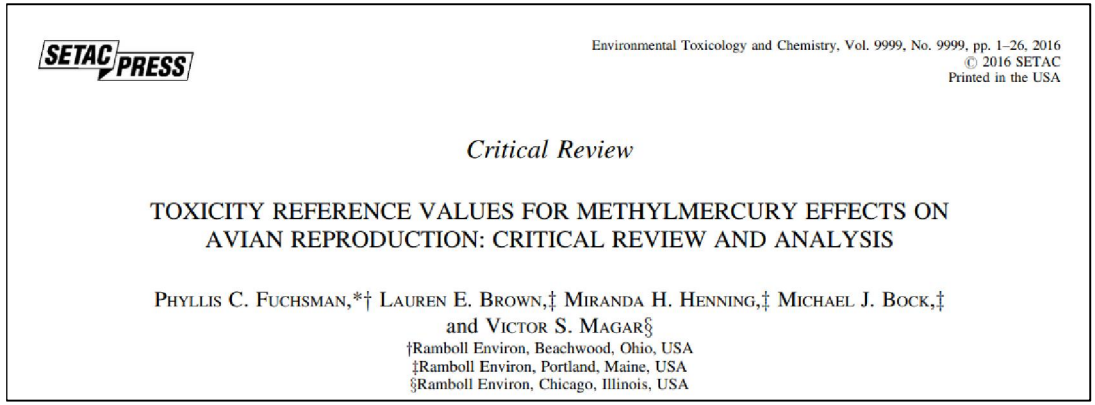

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Critical Review

TOXICITY REFERENCE VALUES FOR METHYLMERCURY EFFECTS ON AVIAN REPRODUCTION: CRITICAL REVIEW AND ANALYSIS

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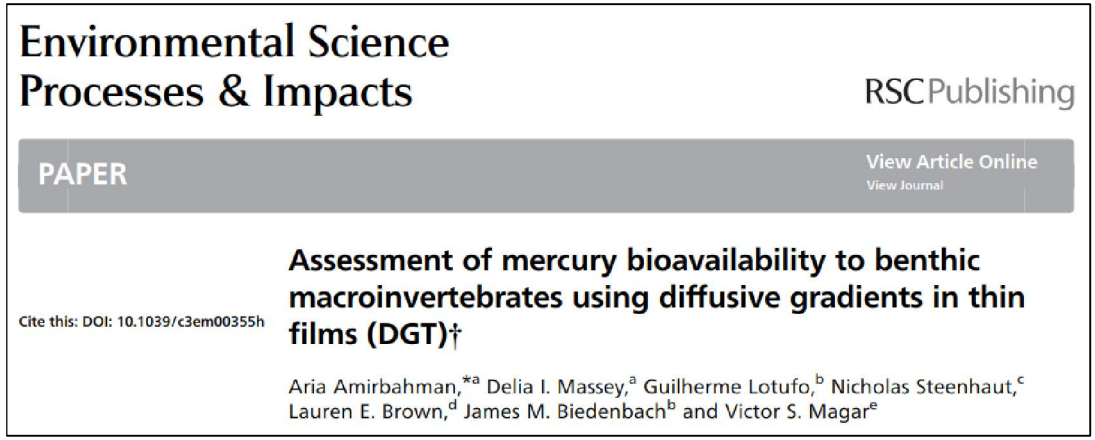

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Assessment of mercury bioavailability to benthic macroinvertebrates using diffusive gradients in thin films (DGT)†

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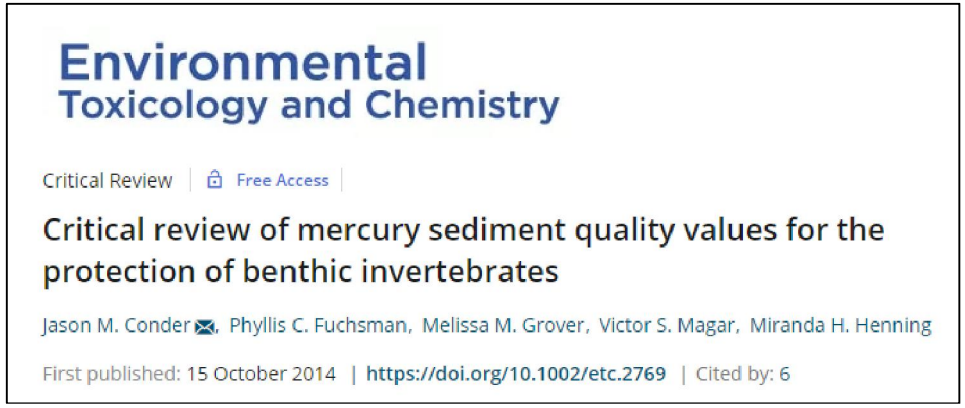
RAMBOLL



Environmental Toxicology and Chemistry

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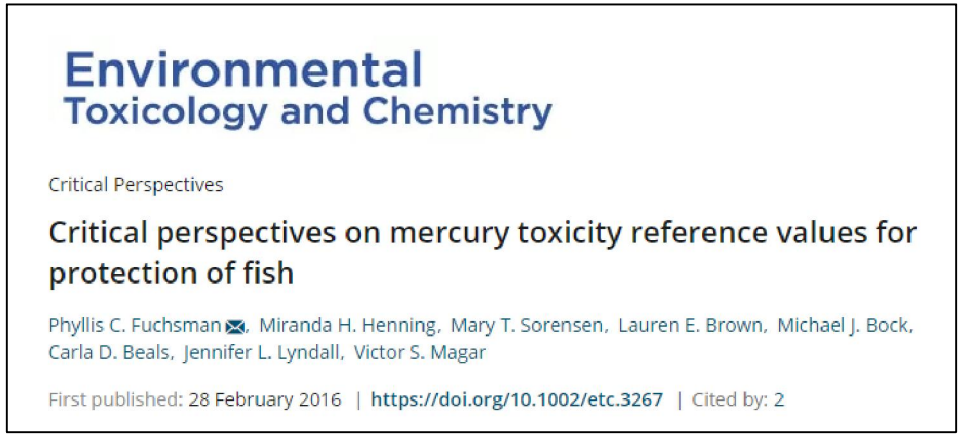
Jason M. Conder, Phyllis C. Fuchsman, Melissa M. Grover, Victor S. Magar, Miranda H. Henning

First published: 15 October 2014 | https://doi.org/10.1002/etc.2769 | Cited by: 6



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Critical Perspectives

Critical perspectives on mercury toxicity reference values for protection of fish

Phyllis C. Fuchsman, Miranda H. Henning, Mary T. Sorensen, Lauren E. Brown, Michael J. Bock, Carla D. Beals, Jennifer L. Lyndall, Victor S. Magar

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GRAZIE PER L'ATTENZIONE!

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