Using Decision Support Tools to Improve Assessment and Clean-up

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- Robert Stewart, University of Tennessee
Why do we need Decision Support Tools?

- Integrate many different technologies: GIS/GPS/Data Bases/Visualization
- Effective way to communication to decision-makers and public about environmental problems and solutions
- Speed
- Clarity
- Repeatability
- Accuracy
- Standardization
- Dependability
What the Tools Do Not Provide

• Tools should be robust and not black-boxed
  ✓ Biologists, environmental scientists, geologists, risk assessors… are still needed.

• Good data are needed.
  • GIGO (Garbage In Garbage Out)

  Data QA/QC is essential
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FIELD ENVIRONMENTAL DECISION SUPPORT
FIELDS Services

Assistance for:
- Field Planning
- On site assistance
- Mapping
- Data Storage
- Monitoring
- Decision making
Where is FIELDS now?

- Over 75 Region 5 Superfund and Water Division sites
- Active participation on projects in Regions 2, 3, 5, 6, 7, 8, 9, and 10
- Training given to individuals from all regions, state and tribal government, and independent contractors
- Technology transfers in China and Latvia
- Contaminated soil and sediment
FIELDS Technology

DATABASE QUERY

GIS

VISUALIZATION

GPS
FIELDS System Components

ArcView based 2D Extensions
- Avenue, VB, and C++ dlls

F/S Plus

Standalone 2D/3D Viewer and Analysis Tools
FIELDS Methods

Contaminated Sediment Site Characterization Using the FIELDS Methodology

- Standardized characterization process
- Integration of FIELDS Decision Support Tools
The FIELDS approach:

- Gather historical data and perform preliminary data analyses
- Define an area or areas to be characterized
- Create a sampling plan (physical and chemical) using USEPA data quality methods
- Collect sample data using standard operating procedures
The FIELDS approach (cont’d):

- Use these sample data to model the extent of contamination
- Use modeled values to calculate mass and volume of contamination
- Develop remediation strategies based on clean-up goals
Methods

Gather available historical data:

1. Analytical data (ecological, chemical, human health)
2. GIS coverages
3. Aerial photographs
4. Physical characteristics (flow rates, sediment thickness, sediment type, etc.)
5. Historical and/or current contaminant sources
Historical Data

- Existing sample databases
- Current/historical images
- GIS coverages
- HH/Eco Studies
- Other information
Collect New Data

Bathymetry Surveys
Fall 1996

Spring 1999

1998 dredge area
1997 dredge area
Determine Sediment Thickness

- Manual probes
- GPR
- Seismic Profiling
- Chirp devices
Deer Lake: Sediment thickness profile from 294 sediment pokes performed in May 2000. The July 2000 sample design for mercury contamination was based on sampling areas with sediment less than 1.5 ft by Ponar dredge and greater than 1.5 ft by Vibrocores.

10 Jan. 01
Create Sample Designs

- Statistically based—when possible
  - hot spot search
- Collect accurate spatial information
- Determine spatial correlation of values
  - multi-staged sampling?
- Sediment detail for layer correlation
FIELDS
Sample Design Module

★ How many samples do I take?

★ Where should I take samples?

★ Consider data quality objectives
Statistically based Sample Design
Figure 3. Deer Lake: Sample design for mercury sampling July 2000. 100 cores were planned in areas with more than 1.5 ft of sediment, and 180 ponars were planned for areas with less than 1.5 ft of sediment. 10 Jan. 01
Data Collection
Data Query Tool

Query capabilities:

- **Criteria**
  - parameter, units

- **Options**
  - non-detects, results, dates

- **Total**
  - all results, etc.

- **User Defined 2D Interval**
  - all, maximum, DWA
Data Query Tool

Example query output, as shapefile
Deer Lake: Spatial distribution of all sediment samples taken in 1998 and 2000. A total of 317 unique locations were sampled with 196 ponnar samples and 121 cores, totaling 507 analyses (including duplicates). 10 Jan. 01.

Maximum mercury concentration per sample location:
- 0 - 1 ppm
- 1 - 2 ppm
- 2 - 3 ppm
- 3 - 5 ppm
- 5 - 10 ppm
- 10 - 20 ppm
- 20 - 50 ppm
Load to GPS

Clicking on this tool will convert your sampling locations into an ASCII file that can be exported to GPS.
Methods

Model extent of contamination

1. Incorporate bathymetric and sediment thickness data in order to define sediment layers

2. Employ the FIELDS tools to generate estimated contaminant values at unsampled locations
FIELDS

2D Modeling Module
Inverse Distance Weighting
and Natural Neighbor
"Best" power and neighbor for IDW

The cross validation for IDW algorithm finds the parameters (power and number of neighbors) with the lowest root mean square error.
Estimation Error Reporting

• Compares **interpolated** values with **original** values
• Useful for comparing different interpolation methods.
A FIELDS System Approach to Kalamazoo River Removal Assessment

- Interpolation of PCB Distribution -
- FIELDS Query and Natural Neighbor Tools
Methods

Use the FIELDS tools to calculate mass and volume of contaminant data
Four input categories:

Interpolated Concentration Grids

Interpolated Depth Grid

Concentration Ranges (e.g., TOSCA, non-TOSCA wastes)

Media Density
Mass and Volume

Interval 0-1 feet
Interval 1-2 feet
Interval 2-3 feet
Interval 3-4 feet
Interval 4-5 feet
Interval 5-6 feet
Interval 6-7 feet

Interpolated Concentration Intervals
Mass/Volume Tool

- Calculates mass of contaminant
- Calculates volume of contaminated media
Total mass = 2875 kg. 
= 6325 lb.

Figure 15. Deer Lake: Estimated total mass (grams) per 20x20 meter grid cell for all layers of sediment. Mass was determined from interpolated concentration, percent solid, and wet density. Greatest mass is found in the south lake section. 28 March 2001.
A FIELDS System Approach to Kalamazoo River
Removal Assessment

- Mass / Volume Calculations
Methods

Use the FIELDS tools to determine remediation strategies
Determine the action level (AL). In this case, the AL is based on risk from human consumption of contaminated fish.
Human Health Risk Assessment

- Estimate human health risks from exposure to pollutants

- Developed by SADA
- Utilizes ArcView Functionality
- Follows EPA RAGS (Risk Assessment Guidance For Superfund)
Ecological Risk Module

Developed by SADA

Uses sample values to identify locations or areas of a site that exceed or are predicted to exceed selected benchmarks (thresholds)

Follows Ecological Risk Assessors Forum (ERAF) guidelines

Data screening

Probability maps
**Remediation Tool**

- **Determine remediation areas**

  **Block-based**
  removes all cells with values \( \geq \) the removal concentration

  **Site-based**
  removes the highest, replaces it with the “Expected fill concentration”, and recalculates the average

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Remediation Tool:

- **Block-based**
- **Site-based**

Remediation Areas:
Remediation Tool Report and Table

Area units = Meters
Concentration = ppm
Total area is: 196678.0000 sq. Meters

Pre-remediation:
Average concentration over the entire remediation area was: 74.9313 ppm

Post-remediation:
Cleanup goal concentration: <= 10.00
Average concentration over the entire remediation area is: 9.9980 ppm
Remediation area is: 49231.0000 sq. Meters
Percentage of area remediated = 25.0313%

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<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>The Grid</td>
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<tr>
<td>The Area</td>
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<td>Meters</td>
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<td>Concentration Units</td>
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<td>Expected Fill Concentration</td>
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<td>Area Remediated</td>
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<td>Percent Area Remediated</td>
<td>25.0313%</td>
</tr>
</tbody>
</table>
Remediation zone scenarios (July 1999)

- 1997-98 dredged areas
- Remediation areas (10 ppm CUG, 1 ppm PRC) (17,418 cubic yards)
- Remediation areas (10 ppm CUG, 5 ppm PRC) (18,476 cubic yards)
- Remediation areas (10 ppm CUG, 10 ppm PRC) (20,368 cubic yards)

where CUG = Clean Up Goal
PRC = Post-Remediation Concentration

NOTE:
Remediation areas increase in size as the PRC value increases since more PCB is left in place.

IDW interpolation parameters:
10 meter radius
power of 4
1 meter grid cell size

Manistique Harbor
Final Products

- Maps
- Analyses
- Post-remediation (were goals met?)
- Communication with decision-makers
FIELDS Website:
www.epa.gov/region5fields/

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