NEWMOA Ecological Risk Assessment Workshop

Westford, MA & Danielson, CT

September 2011

Principles of Ecological Risk Assessment

September 2011

Introduction to Your Instructor

- Charles “Chuck” Harman
- Principal Ecologist with AMEC Earth & Environmental
- Professional Wetland Scientist
- BS in Wildlife Ecology, MA in Biology
- 25 years as an environmental consultant in the Northeastern United States
- Completed Ecological Risk Assessments at over 50 CERCLA/RCRA sites and countless major state-lead sites

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Why Ecological Risk Assessments?

- Not all hazardous waste sites have human exposure components
- Ecological receptors behave much differently than human receptors
- HHRA addresses a single, well studied receptor; while ERA addresses multiple receptors, which are often not well studied
- When to conduct ecological risk assessments?

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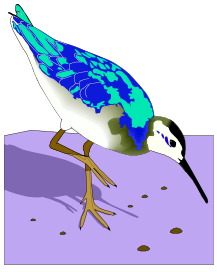
Ecological Risk Assessment

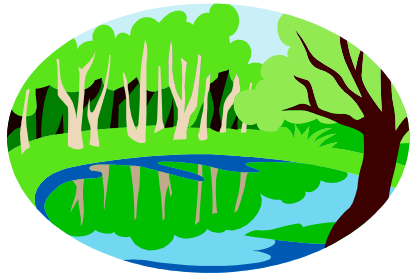
Evaluation of the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors

EPA, 1992



Stressors

- Chemical
- Physical
- Biological



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Ecological Risk Assessment

- Multi-disciplinary process for collecting, organizing and analyzing information to estimate the probability of adverse impacts to ecological receptors
- Tiered approach
  - Lower tiers protective, higher tiers predictive
  - Lower tiers use conservative assumptions, higher tiers use site-specific data and mechanistic models
  - Evaluate each tier to decide if the next is needed
  - Objective is to progressively reduce uncertainty

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Unique Aspects Of Ecological Risk Assessment

- Focus of ERA should be primarily on the population, community or ecosystem rather than the individual, unless receptor is endangered species
- Some routes of exposure are unique to nonhuman species
- Nonhuman organisms may be indirectly affected by loss of food or habitat associated with chemical exposure

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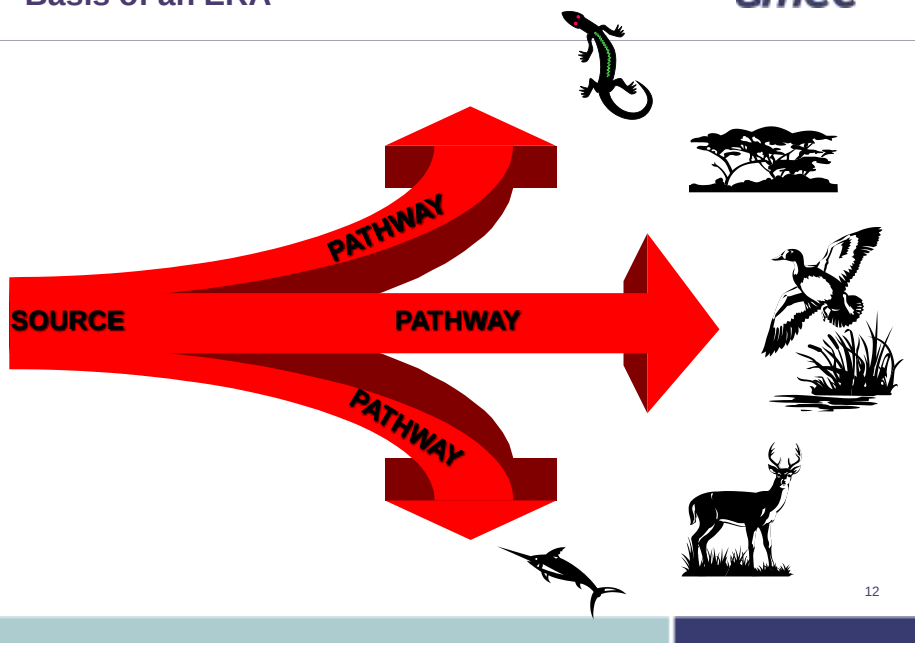
Basis of an ERA



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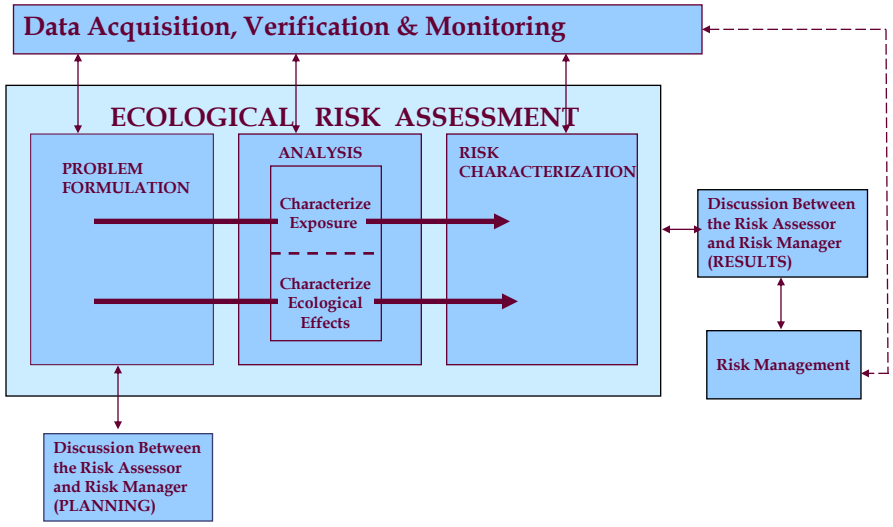

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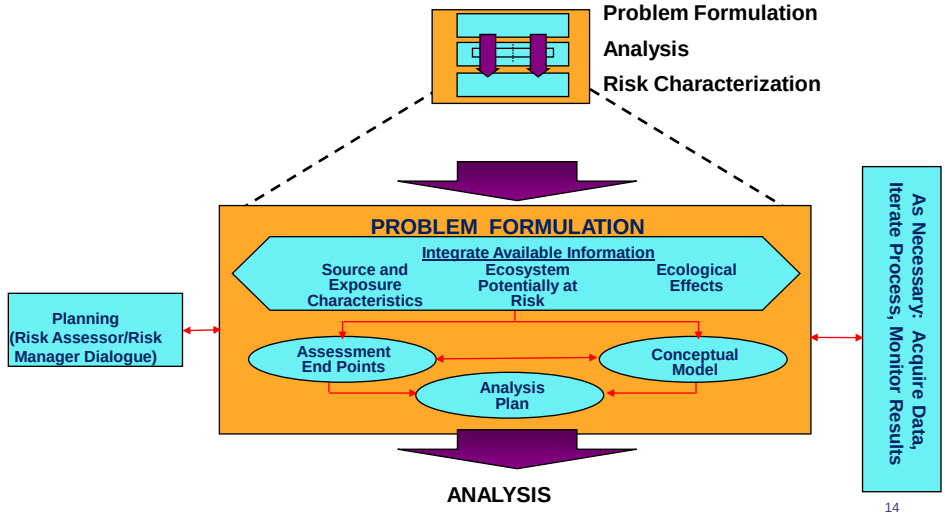
Problem Formulation Phase



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Problem Formulation

- Defines the nature of the problem and the characteristics of the risk assessment needed to solve it
  - Identify ecosystem at risk
  - Identify potential ecological effects
  - Select assessment/measurement endpoints
  - Conceptual Site Model

- Considers established management goals for site
- Risk assessors' first opportunity to incorporate "perspectives" into the assessment
- First evaluation of comparative risks at a site

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Problem Formulation (Questions Asked)

- What are the stressors?
- What is the area of concern?
- Who are the interested parties?
  - Responsible parties
  - Governments – Federal, State, Local
  - Tribes
  - NGOs
  - Local interests

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Identification of Stressors

- Chemical
  - Site uses and sources of contamination
  - Primary sources
  - Secondary sources
- Physical
  - Construction
  - Fire
  - Invasive species
- Biological
- Combination

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Assessment Endpoints

- Neutral expressions of the actual environmental goals to be protected
- Not management goals
- Defined by:
  - Ecological entity (species, species groups, community, ecosystem)
  - Attributes of the ecological entity (growth, survival, species diversity)

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Assessment Endpoints

- Ecosystem
  - Productive capability
- Population
  - Extinction
  - Abundance
  - Yield/production
  - Age/Size class structure
- Community
  - Sport value
  - Recreation quality
  - Biological stability
  - Desirability

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Measurement Endpoints (Measures of Effects)

- Ecosystem
  - Biomass
  - Productivity
  - Nutrient dynamics
- Population
  - Occurrence
  - Abundance
  - Age/class structure
  - Reproductive success
- Community
  - Number of species
  - Dominance
  - Diversity
- Individual
  - Death
  - Growth
  - Fecundity
  - Behavior

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Selection of Endpoints

- Assessment Endpoints
  - What component of the environment is at risk?
  - How should efforts be defined
    - Legal
    - Regulatory
    - Public concerns
- Measurement Endpoints
  - Directly related to assessment endpoints
  - Consistent relationship

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Characteristics of Good Endpoints

- Social relevance
- Biological relevance
- Unambiguous
- Measurable or predictable
- Susceptible to the hazard
- Logically related to the decision process

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Conceptual Site Model

- Describes predicted relationships among stressors, exposure, and assessment endpoint responses
- Identifies potential sources
- Identifies complete and incomplete exposure pathways
- Identifies potential receptors (primary and secondary)

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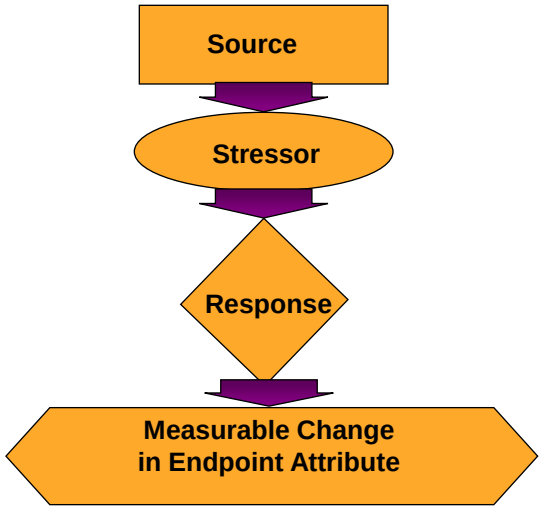
Elements of a CSM



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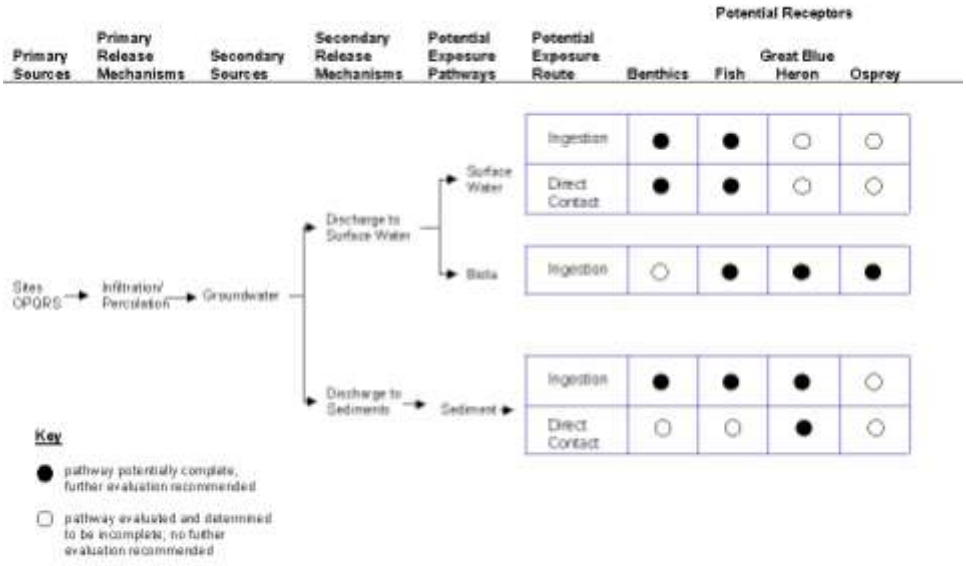
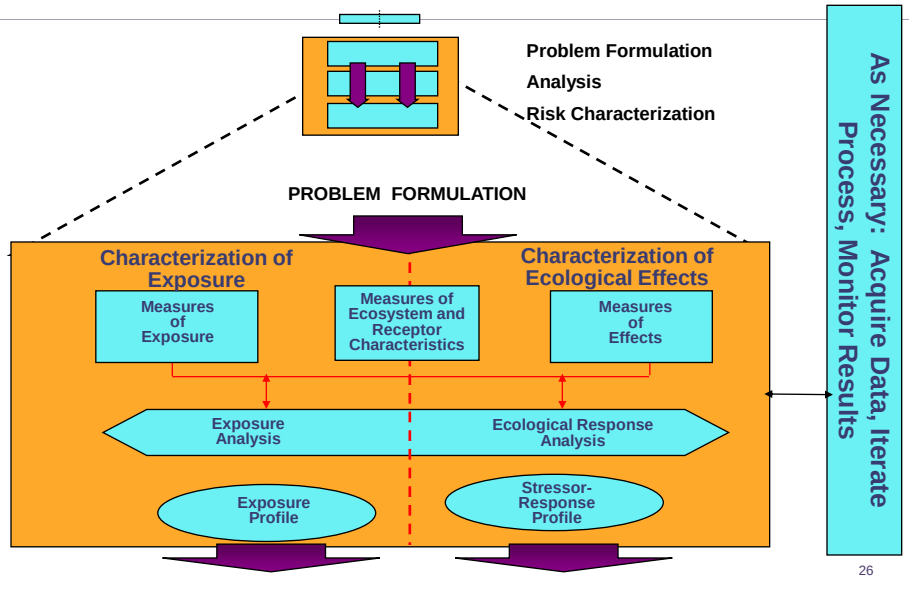


Figure 1A
Aquatic Conceptual Site Model for the Mississippi River Ecological Risk Assessment
Sauget Area 2 RI/FS SSP
Sauget Area 2 Sites Group

Analysis Phase



Analysis

- Exposure Characterization/Assessment
  - Stressor characterization
- Effects Assessment
  - Use of limited data on ecological effects can result in highly uncertain and overly conservative risk estimates
  - Safety factors for taxonomic extrapolations
  - Agencies prefer use of most conservative values

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Analysis (continued)

- "Top down" evaluation can complement the results of a "bottom up" effects assessment
- Exposure assessment becomes the primary mechanism for reducing the uncertainty of the effects assessment
  - Site-specific information
  - Reasonably definable

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Exposure Characterization

- Type: Chemical, physical, or biological
- Intensity: Concentration
- Duration: Acute (short-term) or chronic (long-term)
- Frequency: Single event, episodic or continuous
- Timing: Relative to ecological/biological cycles
- Occurrence: Homogenous or heterogeneous
- Scale: Geographic extent

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Tools for Conducting Exposure Assessments

- Chemical data from site-related matrices
- Tissue residue data
- Bioaccumulation/food web modeling
- Biomarkers
- Life history information

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Effects Assessment

- Determination of the nature of the effects and their magnitude as a function of exposure
- Assessments made using
  - Literature studies/review
  - Laboratory toxicity tests
  - Ambient media toxicity tests
  - Field studies
  - Biological surveys

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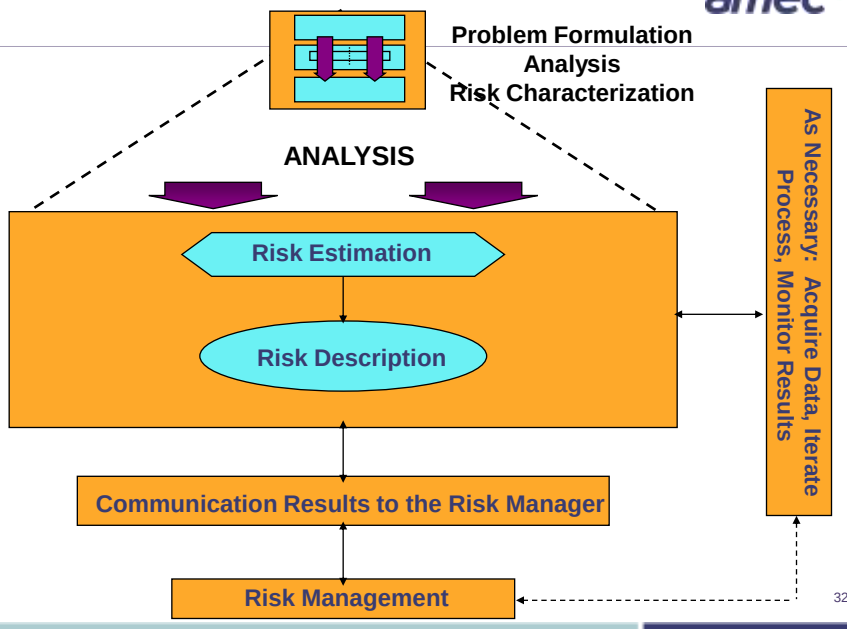
Risk Characterization



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Risk Characterization

- Characterize type, nature, extent and the strength of adverse ecological risks associated with chemicals identified at your site based on evaluation of data collected in Analysis phase
- Statistically compare data from area of concern with data from reference area
- Compare toxicological benchmarks with representative estimated doses
- Evaluate stressor-response relationships

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Uncertainty Evaluation

- Built into discussions on measures of exposure and effects
- Subject to professional judgment and scrutiny
- Often qualitative
- Provides perspective on soundness of lines of evidence

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ERA Process for Superfund - Objectives

- Document whether actual or potential ecological risks exist at a site
- Identify which contaminants present at a site pose an ecological risk
- Generate data to be used in evaluating cleanup options

Eight Step Process

- Screening-Level Ecological Risk Assessment
  - Step 1 – Screening Level Problem Formulation/Effects Evaluation
  - Step 2 – Screening Level Exposure Estimate/Risk Characterization*

* - SMDP

SMDP's

- Scientific Management Decision Points
- Points in the ERA process at which the risk assessor and risk management team are required to meet
- Purpose is to reach agreement between all parties on the approach and activities necessary for that stage of the ERA process

Eight Step Process (Continued)

- Baseline Ecological Risk Assessment (BERA)
  - Step 3 – Problem Formulation*
  - Step 4 – Study Design/Data Quality Objectives*
  - Step 5 – Field Verification of Sampling Design*
  - Step 6 – Site Investigation and Analysis of Exposure and Effects*
  - Step 7 – Risk Characterization
  - Step 8 – Risk Management*

* - SMDP

Screening Level Ecological Risk Assessment (SLERA)

- Objectives
  - Eliminate endpoints/exposure routes/media
  - Eliminate contaminants of no concern
  - Focus study on short list of contaminants
  - Cost-effective
- Actions
  - Chemical analyses
  - Comparison of data to benchmarks
  - Focus future study on short list of contaminants
  - Survey of biological resources
  - Development of species/site-specific toxicity benchmarks
  - Food web evaluation

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Baseline Ecological Risk Assessment (BERA)

- Full weight of evidence risk characterization
- Additional matrix sampling
- Biological sampling
- Ecological community/population survey/assessment
- Toxicity testing

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Step 1 – Screening Level Problem Formulation/Effects Evaluation

- Identify environmental setting and known/suspected contaminants
- Evaluate potential contaminant fate and transport
- Identify mechanisms of toxicity and likely categories of receptors that can be affected
- What are the complete exposure pathways?
- Select endpoints to screen

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SLERA Problem Formulation Assumptions

- Total concentration is bioavailable
- Diverse community is present
- Healthy populations are present
- Use conservative ecological risk criteria to screen risks
- Exposure scenario is worst case
- Chemical exposure and effects data can be used to evaluate potential ecological risks

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Step 1 – Screening Level Problem Formulation/Effects Evaluation

- Identification of screening ecotoxicity values
  - Conservative thresholds for determining adverse ecological effects
- Should represent lowest effect values
- Look at toxicity data
  - Exposure duration
  - Exposure route
  - Field versus laboratory data
- Population level ecological effects (reproduction/survivorship)

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Step 2 – Screening Level Exposure Estimate/Risk Characterization

- Maximum concentrations (also use a central statistic)
- Conservative Exposure Factors
- AUF & SUF – 100%
- Bioavailability – 100%
- Body weight/food ingestion
  - Minimum body weight
  - Maximum food ingestion
- Dietary composition – 100% consists of the most contaminated dietary component

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Step 2 – Screening Level Exposure Estimate/Risk Characterization

- Hazard Quotient
  - HQ = Exposure Concentration/Benchmark
- HQs less than one indicate the potential for an adverse ecological risk is minimal
- HQ of one or greater is not confirmation of an impact, just indication of the potential for an adverse ecological risk

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SLERA Activities

- Identify Type and Extent of Stressors
  - Chemical sampling for COPECs
  - Surface water
  - Surface soil
    - Grid versus biased sampling
  - Surface sediment – BAZ
    - Depositional areas
    - Single line sampling
    - Transect sampling
    - Deep sampling

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SLERA Activities (Continued)

- Define site setting and ecological resources
- Lines of evidence
  - Simple screening of chemical data against benchmarks
    - Benchmarks are values that if exceeded suggest the potential for an ecological effect – measure of effect
  - Conservative food chain modeling

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Step 3 – BERA Problem Formulation

- Refine preliminary contaminants of concern
- Further characterize ecological effects of contaminants
- Review and refine information on contaminant fate and transport, exposure pathways, ecosystems at risk
  - Refine ecological setting, magnitude/distribution of contaminants
  - Degradation, ionization, adsorption, erosion, volatilization
- Select additional assessment endpoints
- Refine conceptual site model

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Step 4 – Study Design and Data Quality Objective Process

- Establish measurement endpoints
- Complete the conceptual model
- Establish the study design for field work to support the BERA
  - Lines of evidence?
  - Bioaccumulation studies/tissue studies?
  - Toxicity testing?
  - Population/community evaluations
- Establish the data quality objectives

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Step 4 – Study Design and Data Quality Objective Process (Continued)

- DQO process
  - Series of planning steps
  - Clarify the study objectives
  - Determine the most appropriate time for data collection
  - Establishing quantity and quality of data
- Results of Step 4
  - Work Plan (WP)
  - Sample and Analysis Plan (SAP)
    - Field Sampling Plan (FSP)
    - Quality Assurance Project Plan (QAPP)

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ERA Work Plan

- Introduction
- Description of Ecological Risk Assessment Process
- History of Site Investigations
- Problem Formulation
  - Ecological Setting
  - Conceptual Site Model (CSM)
  - Selection of COPECs
  - Identification of Receptors and Endpoints
  - Assessment and Measurement Endpoints
- Analysis
  - Ecotoxicological Benchmarks
  - Wildlife Toxicological Benchmarks
- Risk Characterization
- Uncertainty Analysis
- Conclusions

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BERA Final Steps

- Step 5 – Field Verification of Sampling Design
- Step 6
  - Site Investigation – Implementation of study
  - Analysis of ecological exposure and effects
    - More detailed version of Step 1
    - Characterize exposures
    - Characterize ecological effects – exposure/response analysis
    - Evidence of causality
- Step 7
  - Risk estimation and risk description
  - Uncertainty

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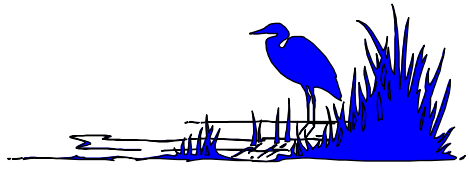
Step 8 – Risk Management

- Different process from risk assessment
- Variety of risk management issues established under the NCP
  - Ecological impact of remedial options
  - Monitoring



Vegetative Impact Considerations

- Direct loss of plants specimens and communities
- Change in vegetative classes
- Modification in structural diversity
- Change in successional stages
- Change diversity/frequency/abundance
- Loss of seed banks and litter layers

Potential Faunal Components

- Species list
- Wildlife habitats and niche requirements
- Feeding guilds
- Predator-prey relationships
- Reproductive success, dispersal rates, migration
- Population natality, mortality, longevity
- Population growth rates

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Faunal Impact Considerations

- Direct loss of life
- Loss of habitat
- Migration/dispersal obstructions
- Changes in feeding behaviors
- Aerial deposition
- Chemical exposure

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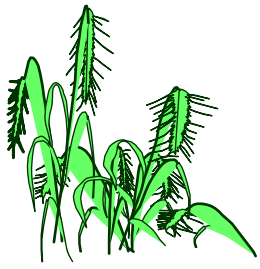
Faunal Characterization Techniques

- Paper studies (HEP)
- Cruise methods (tracks, signs, scat, calls)
- Populations studies (mark-recapture, spotlight surveys)
- Direct sampling – Permits may be required
  - Sweep nets
  - Drop-in traps
  - Drift lines
  - Mist nets
  - Live traps
  - Snap traps



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Aquatic Resources

- Phytoplankton
- Zooplankton
- Macrophytes
  - Floating
  - Rooted
- Benthic Invertebrates
- Fish

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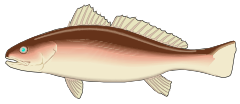
Aquatic Habitat Characterization



- Lotic – running water
- Lentic – standing water
  - Littoral – well lit shallow water region
  - Limnetic – open water/region of light penetration
  - Profundal – open water/below point of light penetration
- Benthic – sediment
- Nekton – free swimmers in water column
- Periphyton – surface of rocks, aquatic vegetation
- Neuston – surface water film

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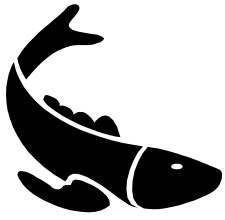
Fish Community Assessment



- Electro-fishing
- Gill netting
- Seining
- Measured parameters
  - Number of species
  - Length/weight
  - Condition
  - Reproductive state
  - Presence of disease/parasites
  - Fish tissue

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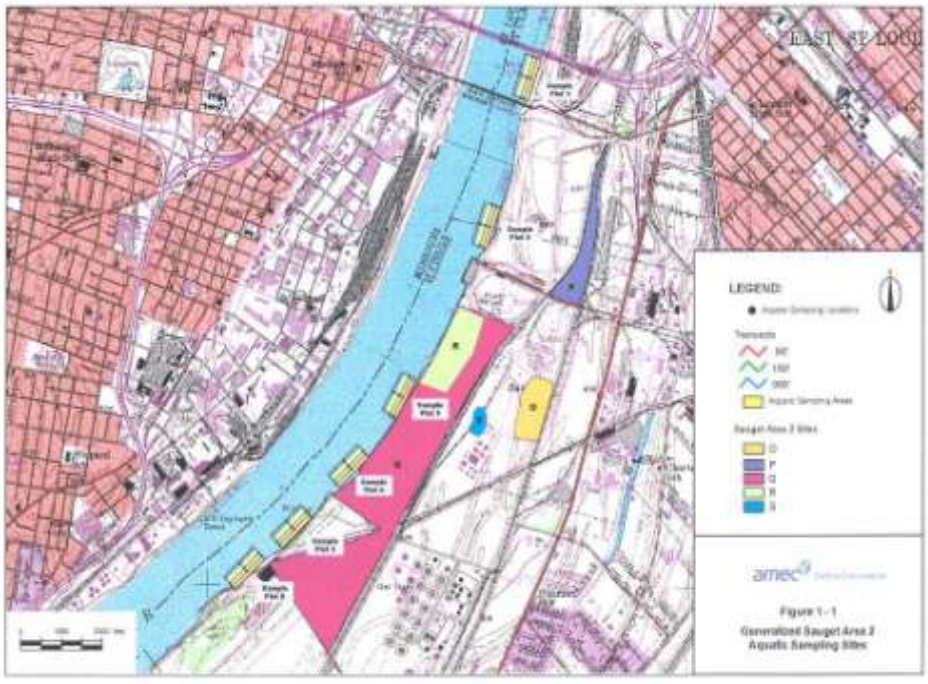
Description

- Located adjacent to the Mississippi River
- Includes approximately 14,000 feet of riverbank and over 250 acres of total area, including floodplains below a U.S. Army Corp of Engineers flood control dike
- The terrestrial portion includes five former disposal sites identified as Sites O, P, Q, R, and S



Description (Continued)

- Site O
  - Approximately 20 acres, sewage sludge dewatering, PCBs up to 1,900 ppm, dioxins at 170 ppb
- Site P
  - Approximately acres 20 acres, municipal/industrial waste disposal
- Site Q
  - Approximately 90 acres, municipal/industrial waste disposal, site of USEPA emergency removal, PCBs up to 16,000 ppm, contains two large ponds
- Site R
  - Approximately 36 acres, industrial waste disposal, closed landfill, covered with clean fill
- Site S
  - Chemical reprocessing waste disposal, very small

Aquatic Ecological Risk Assessment

- Sampling conducted in 6 locations, sampling plots established such that three samples set in a transect 50' from shore, 3 samples 150' from shore, and 1 sample 300' from shore
- At each sampling location collect surface water and sediment samples
- Sediment samples
  - Surface grab
  - Chemical analysis (VOCs, SVOCs, metals, pesticides/herbicides dioxin), bioassay, sediment bioaccumulation
- Surface Water
  - Collected above sediment/surface water interface using pump/hose rig attached to sediment sampler frame
  - Chemical analysis (VOCs, SVOCs, dissolved metals, filtered metals, pesticides/herbicides dioxin), bioassays

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Floodplain Ecological Risk Assessment

- Collected surface soil samples
- Ecological characterization of the Sites
- Collect plant tissue for chemical analysis (SVOCs, dioxin, PCBs, pesticides/herbicides, metals)
- Collect insects for chemical analysis (SVOCs, dioxin, PCBs, pesticides/herbicides, metals – some variation in analytes depending upon amount of tissue collected)
- Earthworm bioaccumulation tests

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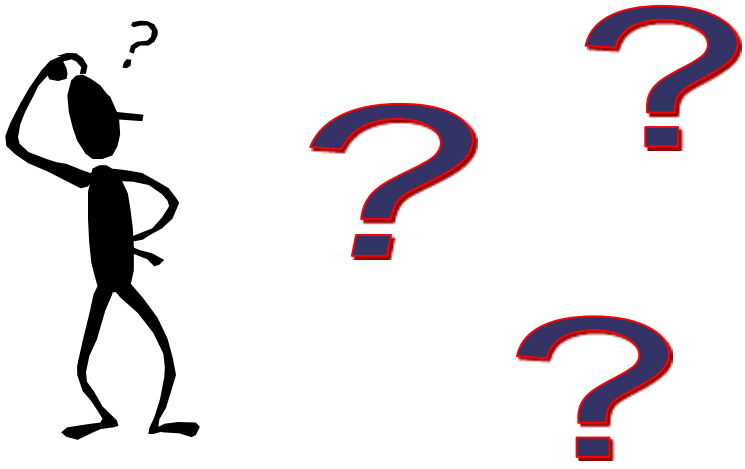

Charles Harman, P.W.S.
AMEC Earth & Environmental
285 Davidson Avenue, Suite 405
Somerset, NJ 08873
732-302-9500 ext. 127
732-302-9504
charles.harman@amec.com