

Problem and Research Objectives:

The proposed research will develop an Enhanced Life-Cycle Assessment (ELCA) framework for the assessment of environmental technologies that will be demonstrated by assessing the life-cycle costs and benefits, risks, and stakeholder acceptability of using treatment wetlands for cleanup and restoration at the Tar Creek Superfund site.

Our overall objective is to develop a systematic process for environmental technology assessment that accounts explicitly for the interdependence among changes in releases of pollutants, human health risks, and economic impacts throughout the technology life cycle, and that is guided by stakeholder concerns and preferences regarding environmental management and pollution control. **Specific goals of the proposed research** include: i) development of methods of assessing stakeholder concerns and preferences suitable for guiding policy-relevant analyses; ii) to integrate risk assessment and benefit-cost analysis methods with life-cycle assessment techniques; iii) to demonstrate the ELCA framework by producing policy-relevant data regarding the costs, benefits, risks, and stakeholder acceptability of using treatment wetlands at the Tar Creek Superfund site; and iv) to identify priority information needs of the decision-making process to help guide future scientific research.

Methodology:

The process of making environmental decisions involving health, societal, and economic issues is most commonly supported by three types of analysis: benefit-cost analysis (BCA), life-cycle assessment (LCA), and human health risk assessment. This project is advancing these analytic methods by integrating them into a coherent ELCA framework. The ELCA framework is both an integrated set of analysis tools that support the policymaking process as well as a procedure that involves stakeholders in defining the analysis process and therefore involves them in a critical part of policymaking. Involving stakeholders in the analysis process is important because stakeholders will not support a policy decision that they do not feel is fully legitimate.

The ELCA framework is being used to assess the technical effectiveness of the enhanced wetland technology in reducing human health risk through an integrated LCA and risk assessment process. The risk assessment process is guided by input from stakeholders gathered through survey and interviews. Benefit-Cost Analysis (BCA) is being used to assess the net benefit of the proposed use of treatment wetlands at the Tar Creek site. Incorporating BCA within the ELCA framework assures that the market and non-market site characteristics that are evaluated and included in the analysis are those that are important to the stakeholders and not simply those that an analyst thinks should be important. The BCA is also guided by the results of stakeholder interviews, Q sorts, and surveys. Stakeholder acceptability is being assessed from interviews with stakeholders residing or working near the proposed project site. Statements from these interviews are being Q sorted by stakeholders in a subsequent interview, and these Q sorts are being factor analyzed to reveal general perspectives on the technologies and to determine whether a conflict exists among these perspectives. Finally, the information regarding stakeholder concerns and preferences regarding the proposed remediation technology being developed from narrative analysis of the open-ended interview transcripts, Q methodology, and preference ranking are being used to develop a survey instrument.

Survey responses are being analyzed using descriptive statistics and regression to determine stakeholders' concerns and judgments of the acceptability of the proposed remediation technology as well as their willingness to tradeoff benefits and costs to implement the technology. The information regarding stakeholder preferences and concerns is being fed back to guide and inform the three assessment processes (LCA, BCA and risk assessment).

Principal Findings and Significance:

Of the three assessment exercises in this project (social impact assessment; economic impact assessment; environmental risk assessment), the social impact assessment effort needed to be completed first, since it is used to help frame the conduct of the other components. This assessment was conducted by interviewing selected stakeholders who are nearby residents, regulatory officials having responsibility for site remediation, experts who have or are conducting studies of the site, and representatives of various interest groups who perceive that they have a stake in site remediation. The social impact assessment was conducted via two rounds of face-to-face stakeholder interviews conducted in the Picher-Cardin-North Miami area surrounding the Tar Creek site.

Careful analysis of the cognitive maps from the first round of interviews resulted in the construction of an aggregate map which incorporates features of all ten maps. Aggregate maps provide a unique perspective by summarizing the schema of a whole social system into one map. Therefore they are characteristic of the social system and not attributable to any individual participant. This map serves to inform our understanding of the stakeholders' perspectives and the preparation of the interviews regarding the wetland treatment systems.

The remaining task under the social impact assessment activity is eliciting the stakeholders' reactions to the new wetlands technology and assessing their health concerns through a knowledge assessment. An influence diagram has been prepared for use as the standard for assessing participant knowledge. The results of social impact assessment have been used to frame the economic and technological effectiveness assessments that are now underway.

The economic assessment task has developed an economic valuation method based on the benefit transfer approach. The model for Tar Creek has been completed but has not yet been populated with data representing treatment wetland performance. This is the remaining task.

The risk assessment task was begun by developed in expert mental model of the Meyer Ranch site at Tar Creek. Influence diagrams were created to represent the movement of contaminants from mine drainage and the possible exposure pathways of those contaminants to humans. In addition, influence diagrams included socioeconomic factors, future sediment removal of wetlands, and future development as probable sources of risk to humans. Three influence diagrams were created. The first one represents the movement of contaminants from mine drainage without implementation of an alkaline wetland treatment system. The second represents movement of contaminants through an alkaline wetland treatment system until reaching humans, and the third diagram

represents the interactions among elements within an alkaline wetland system. The arrows symbolize direct pathways of contaminants to different medias (air, soil, and water), and receptors (animals, plants, microorganisms, and humans) which are represented by squares. The oval boxes are some of the transport and exposure mechanisms of contaminants. The three diagrams provided a general overview of the elements affecting the water quality of Mayer Ranch, North Miami, Oklahoma, and therefore, affecting human health.

Several experts on different areas, such as toxicology, wetland science, and water quality among others, were identified and interviewed. Dr. Mary Jane Calvey, a toxicologist, wetland specialists: Dr. Robert Nairn and Dr. Aisling O'Sullivan, Dr. Dennis Datin and Mr. David Cates, environmental engineers, and Ms. Denae Athay, an environmental scientist were interviewed. Their input, suggestions, and comments helped improve influence diagrams.

All available information from interviews and influence diagrams were collected and reviewed to complete the final expert mental model of Mayer Ranch, North Miami Oklahoma. In addition, influence diagrams representing the existing risk and new risks created by wetland treatment systems were incorporated in the final expert mental model.

Without a doubt, the Mayer Ranch system has a high level of complexity, and so does its expert mental model. It is evident that gaps of knowledge exist when trying to explain both transport mechanisms of metals in different media, and the mechanisms of action within wetlands. The resulting expert mental model takes into account exposure pathways of metals until they find their way to humans, but it does not comprise the magnitude of each pathway. Although pathways of metal exposure to humans may always exist regardless of the presence of a wetland treatment system, the difference lies in the degree of exposure. For instance, metal concentration moving from a wetland treatment system to humans may be lower in comparison with metal concentrations getting to humans without passing through wetland treatment systems. In addition, human health risks due to creation of wetlands, future development and socioeconomic factors influence human exposure pathways. This expert mental model tries to incorporate all elements affecting the system in question. It also provides an image of the interactions of humans within the Mayer Ranch ecosystem, which become highly important when assessing human health and environmental impacts.

References

Atman, C., Bostrom, A., Fischhoff, B., and Morgia, G., "Designing Risk Communication: Completing Mental Models of Hazardous Processes, Part I", Risk Analysis, Vol. 14, No. 5, 1994, pp. 779-788.

Howard, R., Knowledge Maps. The Institute of Management Sciences. 1981, pp 903-922.

Morgan, M., Risk Communication: A Mental Model Approach, New York, 2002.

Region VI- Environmental Protection Agency, "Work Plan Mining Waste Remedial Investigation/ Feasibility Study, Tark Creek Superfund Site, Ottawa County, Oklahoma", Technical Report, Brown & Root Environmental, Houston, Texas, July 1995.