List of Posters and Abstracts for SHC Topic 3 BOSC Meeting

November 2-4, 2016 – Cincinnati, OH

Locating Posters:

- The poster ID numbers are noted in red text below.
- Please refer to the red poster ID numbers and their associated location on the accompanying map.

SHC 3.61 Contaminated Sites

Task Posters:

1. Task 1 – Overview poster of ORD Technical Support Task – **John McKernan, ORD**
2. Task 2 – Overview poster of Contaminated Groundwater Research Task – **David Jewett, ORD**
3. Task 3 – Overview poster of Contaminated Sediments Research Task – **Lawrence Burkhard, ORD**
4. Task 4 – Overview poster of Vapor Intrusion Research Task – **Brian Schumacher & John Zimmerman, ORD**
5. Task 5 – Overview poster of Tools for Evaluating Spatio-Temporal Impacts of Contaminated Sites on the Environment – **Dave Jewett, ORD**

Topics Posters:

6. Evaluating the Relationship between Equilibrium Passive Sampler Uptake and Aquatic Organism Bioaccumulation – **Robert Burgess, ORD**
7. Geophysical decision support system (GDSS) – **Dale Werkema, ORD**
8. Flux-based site management with a focus on recent research related to measurement uncertainty – **David Jewett, ORD**
9. Sustainable Remediation of Arsenic and Chromium in Groundwater – **Diane Cutt, R2 & Richard Wilkin, ORD**
10. Remediation to Restoration to Revitalization Approach (R2R2R) for Great Lakes Areas of Concern: Methodologies, Metrics, and Indicators – **Marc Mills, ORD**
11. The Spatial and Temporal Distribution of contaminant vapors at and urban duplex – **Brian Schumacher/ John Zimmerman, ORD**
12. Mitigation and effectiveness of a vapor intrusion mitigation system – **Brian Schumacher/ John Zimmerman, ORD**
13. Geophysical methods for groundwater – surface water interactions – **Dale Werkema, ORD**
14. Contaminated sediments/remedy effectiveness – **Jim Lazorchak, ORD**
15. The Effect of Equilibration Time and Tubing Material on Soil Gas Measurements – **John Zimmerman, ORD**
16. ORD Technical Support and EPA Regions: Successful Partnerships in Cleaning up Communities – **Kira Lynch, R10**

17. Superfund Remedial Action Decision Process and Community Involvement Support with Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES) – **Brian Dyson, ORD**
18. RESES project: Understanding and Evaluating Ecosystem Services at Superfund cleanups and applying their benefits to sustainability for communities – **Kira Lynch, R10**
19. Regional Applied Research Effort (RARE) Urban Background study – **Robert Ford, ORD**
20. Measuring Contaminant Mass Flux and Groundwater Velocity in a Fractured Rock Aquifer Using Passive Flux Meters – **Diana Cutt, R2**
21. Tri-State Mining District Modeling, Technical and Decision Support – **Brian Dyson, ORD**
22. Updated lifecycle inventory data for Spreadsheets for Environmental Footprint Analysis (SEFA) Tool – **Paul Randall, ORD**

SHC 3.62 Environmental Releases of Oils and Fuels

Task Posters:

23. Task 1: Behavior, Fate and Effects of Oil and Spill Agents – **Robyn Conmy, ORD**
24. Task 2: National Contingency Plan Protocol Development – **Robyn Conmy, ORD**
25. Task 3: Research to Support Leaking Underground Storage Tank (LUST) Program Planning and Backlog Reduction – **Jim Weaver, ORD**

Topic Posters:

26. Petroleum Vapor Intrusion (PVI)Screen Tool – **Jim Weaver, ORD**
27. Wave Tank Oil Plume Simulations – **Robyn Conmy, ORD**

SHC 3.63 Sustainable Materials Management

Task Posters:

28. Task 1: Tools and Methods for Sustainable Materials Management Decision Analytics – **David Meyer, ORD**
29. Task 2: Beneficial Use of Materials – **Mark G. Johnson, ORD**
30. Task 3: Innovation and Long Term performance – **Teri Richardson, ORD**
31. Task 4: Net Zero – **Mike Nye, ORD**

Topic Posters:

32. The Sustainable Materials Management (SMM) Prioritization Tool – **Wes Ingwersen, ORD**
33. Tracking the Flow of Used Electronics in the U.S. – **Teri Richardson and Endalkachew Sahle-Demessie, ORD**
34. The Risk-Informed Materials Management (RIMM) Tool System for Determining Safe-Levels of Contaminated Materials Managed on the Land – **Justin Babendreier, ORD**
35. Specific Net Zero products – **Alex Lan, ORD**

36. Long-term Performance of containment systems at RCRA Subtitle C Landfills – **Thabet Tolaymat, ORD**
37. Implementation guidance for the next generation leaching tests – **Susan Thorneloe, ORD**
38. Techniques for Separating Organic Solvents to Facilitate Reuse and Remanufacturing – **Leland Vane, ORD**
39. State of the Practice of Construction and Demolition Debris Recycling – **Thabet Tolaymat, ORD**
40. Causes and mitigation of Subsurface Heat accumulation in Landfills – **Thabet Tolaymat, ORD**
41. Management of Wood from site clearing and storm debris – **Diana Cutt, R2**
42. Amending Jasper County, Missouri soils with biochar and other amendments following chat removal to facilitate soil restoration/revitalization and establishment of a soil-stabilizing plant cover: An ORD and Region 7 Collaboration – **Todd Luxton, ORD**
43. Updating the Hydrologic Evaluation of Landfill Performance (HELP) model – **Alice Gilliland, ORD**

Non-Project Posters:

44. EPA Sustainable and Healthy Communities Research – **Karen Chu, ORD**

Poster Abstracts for SHC Topic 3 BOSC Meeting

November 2-4, 2016 – Cincinnati, OH

These abstracts represent the 43 Topic 3 posters that will be present at the SHC BOSC meeting in November.

SHC 3.61 – Contaminated Sites

SHC 3.61 Task Posters:

Poster #1 – SHC 3.61, Task 1: ORD Technical Support

David Burden & John McKernan (ORD), and Felicia Barnett (ORD-R4)

In 1987, the U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD), Office of Land and Emergency Management, and EPA Regional waste management offices established the Technical Support Project. The creation of the Technical Support Project enabled ORD to provide effective technical assistance by ensuring ORD scientists and engineers were accessible to the Agency's Office and Regional decision makers, including Remedial Project Managers, On-Scene Coordinators, and corrective action staff. Five ORD Technical Support Centers (TSCs) were created to facilitate this technical assistance. Three of the five TSCs are supported by the Sustainable and Healthy Communities Research Program, and are summarized in the poster being presented:

- Engineering Technical Support Center (ETSC) in Cincinnati, Ohio
- Ground Water Technical Support Center (GWTSC) in Ada, Oklahoma
- Site Characterization and Monitoring Technical Support Center (SCMTSC) in Atlanta, Georgia

Over the past 29 years, the Technical Support Centers have provided numerous influential products to its internal Agency clients and to those at the State level (through the EPA Regions). These products include, but are not limited to the following: Annual TSC reports from the three Centers, a hard-rock mining conference every other year, PRO-UCL software development for site characterization statistics, groundwater modeling using state-of-the-art modeling software, numerical models and techniques, as well as highly influential publications on topics such as Rare Earth Elements, passive sampling techniques, in-situ treatment technologies, and determining 'background' concentrations for Superfund sites.

Poster #2 – SHC 3.61, Task 2: Contaminated Groundwater Research

Michael C. Brooks (ORD)

Groundwater accounts for approximately 30% of the global freshwater supply, and is an important source of both public and private drinking water. Contamination of the resource has resulted from a number of industrial and agricultural practices, and contaminated groundwater is found at 80% of Superfund sites. Once groundwater has become contaminated, clean up can take decades to complete. The U.S. EPA works to prevent human exposure to contaminants by ensuring groundwater quality meets federal and state drinking water standards. Consequently, Task SHC 3.61.2 is devoted to groundwater contaminant research, which supports the U.S. EPA's Fiscal Year 2014-2018 Strategic Plan Goal 3: "Cleaning Up Communities and Advancing Sustainable Development." Activities within the task were planned in consultation with other organizations within the agency (primarily the Office of Land and Emergency Management), and through the task's research coordination team. Areas of specific research include geophysics for site characterization, fate and transport of inorganic contaminants, permeable reactive barriers for inorganic treatment, flux-based site management at DNAPL impacted sites, organic contaminant modeling for site management purposes, groundwater impacts due to contaminant back diffusion, groundwater remediation using in-situ chemical oxidation, groundwater remediation using emulsified zero-valent iron treatment, and the development of an organics leaching assessment framework. Research within these activities will primarily be completed using laboratory studies, field studies, and model development and application. Assuming resource constraints are met, 14 products are planned under this task, and 8 have been proposed as key products. Selected accomplishments to date include the completion of a focused workshop on an organics leaching assessment framework, publication of a journal manuscript that guides effective and efficient in-situ chemical oxidation treatment, and completion of a book chapter that reviews application of additives used in bioremediation of chlorinated solvents and fuels for groundwater and soil remediation.

Poster #3 – SHC 3.61 Task 3: Contaminated Sediments Research

Task Lead: Lawrence Burkhard (ORD)

This poster will summarize the research efforts in the Contaminated Sediment Task within SHC–Contaminated Sites Project. The task is focused on providing knowledge, methods, tools, and guidance to OLEM-OSRTI (Superfund) and Great Lakes National Program Office (GLNPO) for use on sites with contaminated sediments. Task efforts are spread across six research areas:

1) Improving sediment toxicity testing methods;
2) Improving linkages between contaminant concentrations in sediment and fish;
3) Developing methods and guidance for the use of passive sampling;
4) Improving and developing remedy effectiveness methods, metrics, and guidance;
5) Developing methods and metrics for contaminant source identification; and
6) Developing methods and guidance for documenting restoration effectiveness.

For research area 1, extensive laboratory work with the sediment toxicity testing methods has been performed to improve the robustness of the methods in a contract laboratory setting. In

FY17, these improvements will be incorporated into EPA's *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates* (3rd edition). For research area 3, guidance on using passive sampling measurements for the deriving interstitial water remediation goals for the protection of benthic organisms from direct toxicity has been written. In addition, on-going research will assess the use of passive sampling to predict bioaccumulation by aquatic organisms in order to evaluate the use of passive samplers as organismal surrogates in some Superfund applications. For research areas 4, 5 and 6, field studies have and will continue to be performed to evaluate and validate new methods and metrics for documenting source identification, remedy effectiveness, and restoration effectiveness. To date, the use of benthic macroinvertebrates for documenting remedy effectiveness has been validated. In FY19, guidance for source identification at contaminated sediment sites and guidance for weight of evidence (WOE) approach for assessing remedy effectiveness and restoration effectiveness will be completed. The presentation will touch upon the research approaches, provide examples of the recent accomplishments, and future research direction for the Contaminated Sediment Task.

Poster #4 – SHC 3.61, Task 4: Vapor Intrusion Research

Brian Schumacher & John Zimmerman (ORD)

Vapor intrusion (VI) into occupied buildings is a serious and often difficult-to-evaluate problem, particularly at many Superfund sites where significant amounts of contaminants may remain in the subsurface for many years. Potential problems due to VI range from non-life-threatening odors to acute health impacts, explosions, or long-term chronic health effects.

Focus areas for Task 4 Vapor Intrusion includes research on:

- Vapor pathways: distribution and movement of VOCs from groundwater through soil to soil surface/subslab, and into a residence/building;
- Vapor sample collection techniques – passive sorbers;
- Sampling materials: influence of tubing type used to collect soil gas samples;
- Sampling probe/well installation: time required to reach dynamic concentrational gas equilibrium after installation;
- Short-duration screening to equilibration testing of the fan method to induce maximum vapor intrusion;
- Mitigation systems: effectiveness of mitigation systems to reduce or eliminate vapor intrusion;
- Timing of sampling events: using simple, inexpensive, and rapid measurement devices to predict when peak vapor concentrations will occur; and
- Use of soil vapor extraction system to prevent/reduce vapor intrusion.

Poster #5 – SHC 3.61, Task 5: Tools for Evaluating Spatio-Temporal Impacts of Contaminated Sites on the Environment

David Burden (ORD)

With population increases and increased frequency of extreme weather events due to climate change, there are stresses on aquifer-based water supplies, and the impacts of contaminated

sites may constrain community decisions on water supplies. At the decision-making level environmental considerations (SHC Project 3.61 – Tasks 1, 2, 3, and 4) are augmented by social and economic factors. One of the most challenging aspects of site remediation is the selection of a suitable contaminated site management strategy that incorporates both technical and economical feasibilities of available alternatives that include social variables and site reuse considerations. Research is needed to develop a knowledge base and decision tools to assess and predict temporal and spatial changes in aquifer based water supplies related to community water supplies. Task 5 emphasizes decision support tools, models, and software applications that scientists, technical staff, and communities can use to evaluate the temporal and spatial impacts that contaminated sites may have on the environment. And although funding for this task was delayed until FY 2016 because of resource reductions limiting research activities on the project, there are several proposed products for this task in the coming years. Proposed products for Task 5 include the spatial assessment of contaminated groundwater at hazardous waste sites near vulnerable drinking water supplies and a graphical user interface (GUI) for simulating the transport of volatile organic compounds in the vadose zone. The spatial assessment research will focus on conducting a GIS-based statistical analysis and/or develop a vulnerability index for the most vulnerable public drinking water sources in proximity of hazardous waste sites with groundwater contamination. The GUI tool will help evaluate temporal and spatial impacts of volatile organic contaminants on the subsurface environment. Products in other SHC Projects also link to the research objectives of this task. For example, two products proposed for SHC Project 2.63 link to SHC Project 3.61-Task 5: GIS-Mapping and Statistical Analyses to Identify Communities and Populations Disproportionately Impacted by Climate Change-Vulnerable Contaminated Sites, and Key Factors, and Exposure Assessment Case Study of a Community Disproportionately Impacted by Climate-Vulnerable Contaminated Sites. ORD is intent on focusing efforts on the development of models and decision support tools which are both spatially and temporally based.

SHC 3.61 Topic Posters:

Poster #6 – Evaluating the Relationship between Equilibrium Passive Sampler Uptake and Aquatic Organism Bioaccumulation

Robert M. Burgess & Abigail S. Joyce (ORD)

For decades, biomonitoring organisms have been used to assess the bioavailability of hydrophobic organic contaminants (HOCs) at contaminated sediment Superfund sites across the country. Specific applications include evaluating remedy effectiveness and pre- and post-remediation long-term monitoring. Recently, the use of equilibrium passive samplers as surrogates for biomonitoring organisms has been proposed for sites where organisms cannot be deployed or are not available. However, no comprehensive review has been performed to evaluate the relationship between equilibrium passive sampler uptake and organism bioaccumulation. For this task, a review of the scientific literature including water column and interstitial water exposures for a range of HOCs was conducted to address this question. Fifty-four studies were found where both passive sampler uptake and organism bioaccumulation were measured and 19 of these investigations provided direct comparisons relating passive sampler uptake and organism bioaccumulation. This review concludes that in many instances passive sampling had a strong predictive relationship to bioaccumulation and may serve as a reliable surrogate for biomonitoring organisms. When applied properly, passive sampling based estimates of bioaccumulation provide

useful information for making informed decisions about the bioavailability of HOCs at contaminated sediment sites.

Poster #7 – Geophysical decision support system (GDSS)

Dale Werkema (ORD)

One of the OLEM's primary priorities for the Contaminated Sites project is the continued technical support provided by ORD to Regional and Program Office staff at contaminated sites. Contaminated site cleanup is a complex process involving environmental fate and transport, biogeochemical reactions, remediation, and a host of important decision-making necessary to protect human health and the environment. EPA site managers usually do not have such broad expertise for all aspects of site cleanup and often lack the knowledge to make informed decisions. This product serves as a decision support tool for the application of geophysical techniques to contaminated sites. The geophysical decision support system (GDSS) provides a valuable link between research, the state of the science, and the application to contaminated site problems. The GDSS online presence is a textbook for the theory, a peer reviewed literature database, and decision guidance for environmental geophysics applications. The system queries the user on site objectives and site specifics. Once the user completes the array of questions, the GDSS generates a list of likely successful geophysical techniques with links to the technique description residing in the online textbook, as well as, a list of recent relevant peer reviewed literature. Furthermore, links are provided to pre-modeling tools whereby the user can test the applicability of the recommended geophysical tool(s) and generate a synthetic model showing the predicted geophysical response given the details of the site and the objective of the investigation. The GDSS and the integrated GTDSS will provide Program Office, Regional, Stakeholder, and others access to the environmental geophysics state of the science, provide recommendations, and generate predictive geophysical response models to their particular site and objectives. This product will provide users valuable, relevant, and current information on environmental geophysics to inform their decision making at contaminated sites.

Poster #8 – Flux-based site management with a focus on recent research related to measurement uncertainty

Michael C. Brooks (ORD)

Contaminant mass flux and mass discharge are useful measurements in contaminated site management because they combine two important features of contaminant risk: concentration and groundwater flow velocity. These measurements are useful for a number of purposes, and their application at contaminated sites is referred to as flux-based site management. Previous research within SHC has focused on the use of contaminant mass discharge for characterization of DNAPL contaminant source zones, and more recently on an evaluation of measurement uncertainty under simplified conditions. The latter research resulted in screening-level equations that can be used to facilitate reliable measurements of contaminant mass discharge. These previous efforts serve as a starting point for research that is proposed within the current FY16 to FY19 planning cycle. The first product planned under this activity will summarize research that has been completed to investigate effective field-scale approaches based on flux measurements that can be coupled with appropriate predictive models to better link characterization, prediction, and decision making.

This product includes research on the uncertainty of mass flux measurements under heterogeneous hydraulic conductivity conditions, and provides assistance in method selection. Another planned product will summarize research to modify a current technology for flux measurements (i.e., passive flux meter) so that the required laboratory based analysis of the technology can be replaced with a more rapid and less expensive field-based analysis, thus promoting high-resolution sampling. Another research activity planned is the completion of a RARE project investigating contaminant mass flux measurements in fractured rock settings.

Poster #9 – Sustainable Remediation of Arsenic and Chromium in Groundwater

Diana Cutt - ORD/Region 2, Richard Wilkin, ORD - NRMRL, Katherine Mishkin - Region 2

The presence of hexavalent chromium [Cr(VI)] and arsenic (As) in groundwater and soil is a global concern because these metals are classed as carcinogens and present a serious threat to human health. The remediation of Cr(VI) and As contamination in groundwater is mostly done by ex-situ methods – a costly, lengthy and often ineffective remediation approach. The focus of this research is to investigate more sustainable and effective cleanup methods for inorganic contamination in groundwater, including monitored natural attenuation and in-situ stabilization. This work addresses one of EPA Region 2's identified science needs – *conducting research to more fully understand natural degradation mechanisms and rates to aid in developing strategies to sustainably and cost-effectively remediate sites*. The research is being conducted at two Superfund sites in New Jersey – the Garfield Chromium Ground Water Superfund Site, a former electroplating facility that contaminated the community's groundwater with Cr(VI) from a tank rupture, and the Vineland Chemical Superfund Site, where a groundwater extraction and treatment remedy has attempted to treat arsenic for over 10 years at an annual cost of approximately $3 million per year.

At the Garfield site, spectroscopy and solid-phase extraction studies are being conducted to evaluate the natural capacity of subsurface materials to reduce Cr(VI) and form insoluble iron-chromium (Fe-Cr) hydroxide precipitates. At Vineland, in-situ stabilization of arsenic via air sparging is being evaluated. Using this technique, natural reducing conditions that transport ferrous iron and arsenic in groundwater are manipulated using air sparge techniques; this favors the formation of Fe hydroxide precipitates and the sequestration of arsenic.

Poster #10 – Remediation to Restoration to Revitalization Approach (R2R2R) for Great Lakes Areas of Concern: Methodologies, Metrics, and Indicators

Marc Mills (ORD)

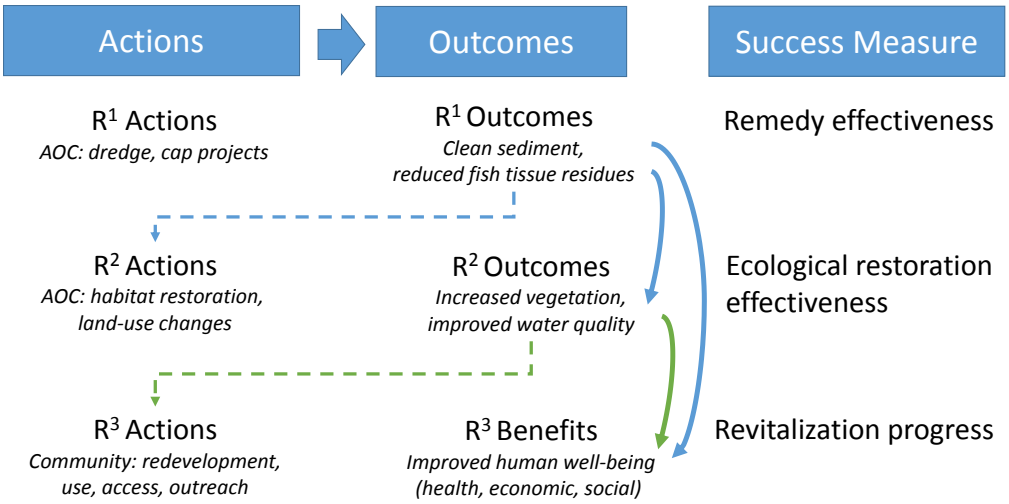
Research to support the management of contaminated sediments is being conducted under the SHC Contaminated Sites task. Waterways and their associated ports and harbors are vital to the economy, health, and identity of many communities. Historically, these waterways served as major transportation and economic hubs during the growth and development of these communities. During these early periods of rapid urbanization and economic growth, many of these waterways have been degraded by physical, biological, and chemical stressors. As communities have realized the inherent value of these waterways for transportation, recreation, aesthetics, sense of community identity, etc, efforts are underway to remediate, restore, and ultimately revitalize these waterways and, as a direct and indirect result, these communities. Within EPA, there are number of programs,

such as Superfund, Brownfields, and the Great Lakes Restoration Initiative, that are actively remediating and restoring contaminated sites and waterways to the benefit of local communities and the US, as a whole.

As a case in point, ORD is actively engaged with the Great Lakes National Program Office (GLNPO) to provide research and technical support to advance the restoration of the Great Lakes. GLNPO is responsible for restoring Areas of Concern (AOCs) as defined in the US-Canada Great Lakes Water Quality Agreement (GLWQA). Through the Great Lakes Restoration Initiative (GLRI), GLNPO utilizes programs focused on remediation of contaminated sediment sites and restoration of waterways within these designated AOCs. These programs directly benefit the local communities by serving as a catalyst for revitalization of the economy, health, ecosystem, and services of the waterways. Research suggests that the clean-up and protection of the Great Lakes will provide a significant economic benefit to the entire basin. Austin et al. (2007) estimated that a $31 billion investment in remediation, restoration and protection of the Great Lakes would yield at least $50 billion in economic benefits. Remediation and restoration of the AOCs would yield a wide range of public benefits, including increased public health through reduced exposure to pollutants such as mercury, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs); increased recreational opportunities such as swimming, boating, and fishing; increased coastal property values; and removal of dredging restrictions (International Joint Commission 2000, NEMI and NOAA 2001). The estimated economic cost of decreased human productivity due to exposure to mercury for the Great Lakes region has been estimated at $435 million (Krantzberg and de Boer 2006). In 2011, the estimated expenditures on Great Lakes recreational fishing was almost $2 billion dollars, with the average angler spending $1,180 annually (U.S. DOI et al. 2012). And finally, remediating and restoring AOCs is estimated to increase property values by $12 to $19 billion (Austin et al. 2007).

Though, the potential economic benefit of sediment remediation can be estimated and aggregated at a Great Lakes-wide scale, research is being developed in this Task to better predict how specific, local-scale remedial actions will benefit the public. GLNPO uses the term "R2R2R" to refer to the process of Remediating contaminated sediments and Restoring aquatic habitat to foster Revitalization in Great Lakes coastal communities (Fig. 1). In practice, GLNPO recognizes that community perceptions and use of the restored resource (e.g., reduced stigma, increased recreational use), as well as redevelopment within the AOC, are indicators of revitalization. However, the linkages between sediment remediation, habitat restoration, and community revitalization are not well understood and are the subject of this research. This Task is integrated with the ecosystems goods and services research occurring in SHC Project 2.61 (Task 2.61.5).

Figure 1. A framework for linking the community and ecosystem benefit of AOC restoration (sediment remediation [R1] + ecosystem restoration [R2]) to revitalization (R3) actions and community benefits. The outcomes of R1 and R2 actions are direct changes to the ecosystem which alter the ecosystem services. This results in an impact to the benefits of the R1 and R2 actions either directly or indirectly by influencing R3 actions. The arrows represented in the figure are areas of research activity.



Poster #11 – The Spatial and Temporal Distribution of contaminant vapors at and urban
Brian Schumacher and John Zimmerman (ORD)

Management of vapor intrusion (VI) sites can be complicated by spatial and temporal variability in indoor air, subslab, and soil gas contaminant concentrations. At an intensively monitored but unoccupied pre-1920 duplex in Indianapolis, IN, thousands of volatile organic compound (VOC) and radon measurements in soil gas and indoor and outdoor air have been collected over two years (three winter seasons) along with ancillary data (meteorological, differential pressure, and other related variables). The main volatile contaminants of concern at the Indianapolis test duplex were chloroform, tetrachloroethylene (aka perchloroethylene; PCE), and radon. Spatially, PCE, chloroform, and radon have distinctly different spatial distributions patterns at this site indicating potentially different sources. Temporally, there is a strong seasonal component to the PCE and chloroform indoor concentrations. The seasonal component appears to be correlated to the strength of the stack effect, but it is not the only variable that controls indoor air concentrations. Lower VOC concentrations were observed in indoor air during the summer months. During the winter months, indoor air peak concentrations were seen in different months of the 2011 winter for PCE (January) and chloroform (March) on the first floor of the Indianapolis test duplex. Temporal trends for chloroform and PCE differed markedly in fall 2011/winter 2012 between the heated and unheated sides of the duplex: the unheated side showed a much steeper decline in spring than the heated side.

Poster #12 – Mitigation and effectiveness of a vapor intrusion mitigation system
Brian Schumacher and John Zimmerman, ORD)

Vapor intrusion is the migration of subsurface vapors, including radon and volatile organic compounds (VOCs), in soil gas from the subsurface to indoor air. Vapor intrusion happens because there are pressure and concentration differentials between indoor air and soil gas. Indoor environments are often negatively pressurized with respect to outdoor air and soil gas. Subslab depressurization (SSD) is the predominant technology used for mitigating vapor intrusion. This research project investigated distributional changes in VOC and radon concentrations in the indoor air, subslab, and subsurface soil gas from an underground source (groundwater source and/or

vadose zone source) adjacent to a residence and to monitor the effects on the concentrations when a subslab depressurization mitigation system was installed and operated.

This study is conducted at a highly-instrumented pre-1920 residential duplex in Indianapolis, IN. To characterize the VOC and radon concentrations, seven conventional subslab ports, four wall ports similar to conventional subslab ports, seven external nested soil gas points (5 depths per point) and five nested soil gas points below the basement (4 depths per point) were installed. Additionally, continual monitoring of several independent variables that could influence VOC and radon concentrations including barometric pressure, soil moisture, soil temperature, water level, HVAC operation, and air temperature was performed.

The overall performance of the mitigation system in reducing indoor concentrations was better for radon than for VOCs. The estimated reduction for radon was approximately 91%. An average reduction of 68% in chloroform and 61% in PCE in indoor air was found. Concentrations of VOCs in some subslab and soil gas ports rose after mitigation began to levels not seen in more than a year of approximately weekly monitoring. This suggests that VOCs are being redistributed by the mitigation system and that concentrations close to the building may be enhanced by drawing higher concentrations of VOCs from greater depths.

Poster #13 – Geophysical methods for groundwater – surface water interactions

Dale Werkema, ORD - NERL

This research seeks to partially meet OLEM's research priority on groundwater characterization technologies and methodologies. Contamination may directly impact and limit water resources while influencing other routes of exposure, such as pathways to surface water bodies via groundwater-surface water interactions. Consequently, this effort is focused on the geophysical methods to characterize and monitor groundwater-surface water (GW/SW) interactions. These geophysical methods involve non-invasive, or very minimally invasive, surficial mapping of geophysical properties caused by, or affected by, this dynamic hydrogeological interface. The detection of temperature and electrical gradients between the groundwater and surface water enables rapid large area coverage of these interactions, guides the placement of remediation or capture systems before surface water bodies are impacted, can guide well placements, and monitor temporal variations as fluids move horizontally and vertically between this interface. The identification and monitoring of GW/SW interaction zones serves many of the Program Office needs where the understanding of subsurface processes (e.g., fate and transport and remediation effectiveness) is paramount to meeting their specific objectives.

In addition to journal articles, this research will produce analytical software to assess GW/SW interactions from hydrogeophysical data (e.g., temperature and electrical resistivity) and develop a module for the Geophysical Toolbox Decision Support System (GTDSS) to guide the selection of geophysical methods and to design of surveys for effective application to GW/SW problems. The GTDSS provides users a geophysical pre-modeling tool with capabilities to enable selection of appropriate and effective geophysical methods to use at a site, given project goals and site conditions. The GTDSS functions within the Geophysical Decision Support System (GDSS) and EPA's online Environmental Geophysics Textbook as described in SHC 3.61.1. Overall, the GTDSS is a downloadable geophysical pre-modeling tool that has applicability to a wide range of environmental issues. It is particularly suitable to problems where the objective is to understand the physical properties of the subsurface, both land and marine. These physical properties are the

summation of the solid and liquid components of the earth, which include biogeochemical reactions and interactions. The understanding of the spatial and temporal distribution of these properties is vital to protect human health and the environment and the GTDSS provides quantitative results to guide such investigations.

Poster #14 – Contaminated Sediments/Remedy Effectiveness

Jim Lazorchak (ORD)

The main objective of this research is to provide stakeholders with biological, chemical, and physical methods, indicators, and approaches to more effectively assess and manage contaminated sites, under the Great Lakes Legacy Act (GLLA), Great Lakes Restoration Initiative (GLRI), Superfund, and other EPA programs. ORD with its partners at the Great Lakes National Program Office (GLNPO), Superfund (SF), Regions (e.g. 4, 5 and 10), States (e.g. OH, MI, IN, MN, and WA) and other federal agencies such as USGS, NOAA, and USFWS has provided critical information and generalizable best practices derived from demonstration projects at multiple sites (5 Areas of Concern (AOCs) and 6 Superfund (SF)). The methods and indicators being developed are being used by project managers for: (1) identifying and tracking contaminant sources to sediments, (2) assessing risk management and remediation strategies at contaminated sediment sites using a weight of evidence approach and 3) possible delisting of AOC Beneficial Use Impairments (BUIs) and Superfund sites. The data and approaches from these place-based studies are being used by GLNPO and Federal, State, and local regulators, and disseminated to the broader sediment management community for characterizing environmental processes and managing risks and evaluating remediation and restoration of contaminated sediment sites. Addressing contaminated sediments more effectively will improve ecological and public health as communities move towards redevelopment and revitalization. The research and products produced under this task are incorporated directly into the site assessment, source identification and tracking, management, and monitoring programs by GLNPO, SF, and States. Also, innovative ORD technology for assessing contaminated sediments sites has been transferred and applied to Great Lakes AOCs (e.g Ashtabula AOC, Ottawa and Maumee Rivers in the Maumee River AOC, Manistique River AOC, Grand Calumet River, Niagara River, Saint Louis River , Milwaukee Estuary) and SF sites (e.g. Lower Duwamish Waterway, Washington Naval Yard, Lake Hartwell, Hunters Point). New approaches and technologies used by and/or transferred to stakeholders and partners were biological, chemical, and physical methods and approaches to assess ecological and human health risk at contaminated sites; approaches for design of remedies; weight of evidence approaches to assess, characterize, and evaluate remedy/restoration effectiveness, monitoring and delist Beneficial Use Impairments (BUIs) for ecological (e.g. benthic community) and human health (e.g. fish consumption). This research effort will yield: (1) improved understanding of the efficacy of sediment remediation for protecting human and ecological health as well as providing a "benefit production function" related to restoration of ecosystem services; (2) refined assessment methods to aid in selecting remedial goals and restoration techniques to reduce risk/impairment and sustainable ecosystems. (3) Improved ability for stakeholders on the Great Lakes AOCs (e.g. OH, MI, IN, NY, MN, NOAA, GLNPO) to assess chemical concentrations in fish, shellfish, and aquatic dependent wildlife (e.g., birds) from exposures to contaminated sediments and provide approaches for delisting of beneficial uses as well as providing certain "benefit indicators" for assessing ecosystem services . A key area for SHC research is to understand linkages between ecosystem goods and services (i.e., edible fish, clean water, so forth) and human health. The

methods and assessment in this research area allow ORD to explore other ways to link remediation and human health.

This research task focuses on developing methods and approaches to integrate qualitative and quantitative methods into a framework to assess remediation and restoration at contaminated sites. To assess these complex sites with many potential sources, receptors, and beneficial uses, a weight of evidence (WOE) framework using multiple lines of evidence (LOE) is required. Typically, biological, chemical, and physical lines of evidence are integrated to assess the performance on the remediation and restoration of the site by weighing the value of the information provided by multiple indicators across multiple LOE to assess the project as a whole. LOEs can be a combination of qualitative and quantitative indicators. The value of qualitative indicators versus quantitative indicators is an ongoing research area. In the end, the project manager and stakeholders need a framework to assess these multiple lines of evidence to reach conclusions on the degree of impact from a remedy or restoration.

Poster #15 – The Effect of Equilibration Time and Tubing Material on Soil Gas Measurements

John Zimmerman (ORD)

The collection of soil vapor samples representative of *in-situ* conditions presents challenges associated with the unavoidable disturbance of the subsurface and potential losses to the atmosphere. This research evaluates the effects of two variables that influence the concentration of volatile organic compounds in soil vapor samples: equilibration time and tubing material. The time for three types of soil vapor probes (i.e., macro-purge, mini-purge, and post run tubing probes [PRT]) to equilibrate with subsurface conditions was assessed by installing probes and collecting multiple samples over a 72 hour period. The effect of tubing material was evaluated by collocating soil vapor probes constructed with different tubing material and collecting samples over several months.

On average, the macro-purge probes reached 56, 68, 72, and 85 percent of the final TCE concentrations after 1, 2, 4, and 8 hours, respectively. Concentrations of TCE continues to increase slightly after 8 hours but stabilize after approximately 24 hours. Mini-purge vapor probes appeared to reach equilibrium within the first hour after installation. PRT probes generally reached 80 to 90 percent of their final concentrations within 1 to 2 hours after installation. It is recommend that soil vapor probes constructed with a sand filter-pack and bentonite seal (i.e., macro-purge probe) equilibrate for 24 to 48 hours prior to sample collection. Post-run tubing (PRT) probes equilibrated within 1 to 2 hours while a new probe design, (i.e., mini-purge probe) equilibrated and could be sampled after only 30 minutes for screening assessments.

Nylaflow, Teflon®, polyetheretherketone (PEEK), and stainless steel tubing had comparable trichloroethene (TCE) concentrations over all sampling time frames. Polyethylene tubing consistently yielded lower TCE concentrations than the other tubing materials except copper. Copper yielded significantly lower concentrations in the first days after installation, but performed similarly to other tubing after several months of exposure at the site. It is recommend that copper tubing be avoided and polyethylene only be used for screening assessments.

3.61 EPA Region/ORD Collaborations:

Poster #16 – ORD Technical Support and EPA Regions: Successful Partnerships in Cleaning up Communities

Kira Lynch (ORD-R10), Diana Cutt (ORD-R2), John McKernan (ORD)

The U.S. EPA ORD Technical Support Centers in the Sustainable and Healthy Communities Research Program and ORD researchers collaborate to provide important opportunities for successful partnerships that address the high priority science and research needs of the EPA Regions and Offices. This poster will present an overview of the types of specialized technical support and applied research that is currently taking place in all ten Regions. The specialized scientific expertise available to the regions through ORD play a critical role in helping the Regions to work toward goal 3 in the EPA Strategic Plan: Cleaning up Communities and Advancing Sustainable Development. The types of ORD expertise used most frequently that directly address Regional scientific support needs can be categorized as:

- Bringing Innovations to Site Characterization
- Improving Conceptual Site Models
- Facilitating Specialized Engineering Support – Advising on Remedy selection, Design, and Optimization
- Providing Statistical Analyses and Support
- Developing and Applying Decision Support Tools

For each of these categories, types of specialized expertise provided by ORD to the Regions, the relative abundance of projects requested by Regions, and a featured example will be presented to illustrate how ORD research is applied to clean up contaminated sites and help communities move towards sustainability.

Poster #17 – Superfund Remedial Action Decision Process and Community Involvement Support with Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)

Brian Dyson (ORD), Kira Lynch (ORD-R10), Diana Cutt (ORD-R2)

Superfund remedy decisions are often very complex and require consideration of input from a wide audience of stakeholders. The site RPM is required to understand and communicate the decision process with limited tools to transparently document how both technical and community values based factors are considered in the selection and optimization of alternatives. Structured decision making, which is supported through DASEES analysis, can be used by the site RPM to capture all of the factors that need to be considered when developing a Superfund remedial action approach that will result in protection of human health and the environment. The objective of this research is to evaluate the use of DASEES as a tool for Superfund project managers.

Poster #18 – RESES project: Understanding and Evaluating Ecosystem Services at Superfund cleanups and applying their benefits to sustainability for communities

Jewel Lipps, Carlos Pachon & Michele Mahoney (OLEM), Mike Kravitz (ORD), Kira Lynch (ORD-R10)

Superfund remediation projects are often large construction operations with a significant environmental footprint. Although Superfund has developed a methodology for quantifying the environmental footprint, there is no guidance on incorporation of ecosystem services. Superfund seeks to better integrate consideration of ecosystem goods and services when implementing its core mission of protecting human health and the environment at contaminated sites. This research is aimed at understanding how EGS can be incorporated into the site remediation and reuse planning. The research is also aimed at improving Best Management Practices (BMPs) to mitigate impacts on ecosystem services during contaminated site remedy construction and operations.

Poster #19 – Regional Applied Research Effort (RARE) Urban Background study

Barbara Alfano (R4), Glenn Adams (R4), Tim Frederick (R4), Felicia Barnett (ORD-R4), Brian Schumacher (ORD), Robert Ford (ORD)

Soils that have been heavily impacted by man for decades are likely to contain elevated levels of certain metals and/or polycyclic aromatic hydrocarbons (PAHs) due to human activity, industrial operations, and to infrastructure materials. Because these increased contaminant concentrations are due to urban activity and not site releases, it benefits EPA programs to have a better understanding of the extent that anthropogenic background contributes to environmental concentrations of these contaminants.

The purpose of this study is to collect data that will provide the necessary context to understand the background concentrations and distributions of urban contaminants in southeastern cities. Another goal of this project is to develop a consistent and robust data collection and analysis process that can be replicated in other states and regions. Background contaminant concentration data is especially useful for setting realistic clean-up levels for Brownfields redevelopment projects, Superfund projects, and other environmental restoration projects that aim to restore contaminated property to beneficial reuse.

Poster #20 – Measuring Contaminant Mass Flux and Groundwater Velocity in a Fractured Rock Aquifer Using Passive Flux Meters

Michael Brooks (ORD), Katherine Mishkin (R2), Diana Cutt (R2 ORD STL)

At contaminated groundwater sites, groundwater specific discharge and contaminant mass flux are important parameters used to understand the significance of contaminant loading to an aquifer, evaluate contaminant fate and transport, assess risk, design a groundwater remediation system, and assess remedial performance. The primary goal of the project was to improve the measurement of groundwater flow and flux in fractured bedrock systems. This project addresses one of Region 2's science needs – to develop cost-effective techniques for identifying contamination in fractured rock aquifers. The project evaluated the use of an innovative tool - the fractured rock passive flux meter - in determining contaminant mass flux and groundwater velocity in a contaminated aquifer in New Jersey.

Poster #21 – Tri-State Mining District Modeling, Technical and Decision Support

Brian Dyson/Souhail Al-Abed/Mohamed Hantush (ORD), Mark Doolan (R7), Rob Weber (ORD-R7)

The Tri-State Mining District includes four 'mega' Superfund sites, with a total effected land area of 2,500 square miles. The watershed in this area, the Spring River Basin, drains the effected land area in three states (Kansas, Missouri, and Oklahoma) where widespread lead and zinc mining contaminated the surrounding land. ORD NRMRL through the ETSC is assisting Region 7 (with partnering from Region 6 and other federal, state, and tribal stakeholders) to develop a decision-support watershed model to assist with the effective and efficient targeting of specific stream and lake areas for multi-site cleanup.

Poster #22 – Updated lifecycle inventory data for Spreadsheets for Environmental Footprint Analysis (SEFA) Tool
Paul Randall (ORD), Karen Scheuermann (R9), Carlos Pachon & Michele Mahoney (OLEM), Matthew Small (R9)

The updated SEFA tool includes cradle to gate life cycle inventories for the production of chemicals and materials. System boundaries include everything from the excavation of raw materials and recourse from the ground to the end of the production process or facility gate. Inventory analysis involved sorting and aggregation of relevant elementary flows into the environmental footprint categories considered in the SEFA tool. The material emission factors developed are intended for implementation in SEFA workbooks. For example, a user for a site may be using oxidants such as hydrogen peroxide or potassium permanganate as part of the site's remediation activities. The updated SEFA tool may now incorporate water use and updated emission factors for these chemicals to more accurately estimate how green a cleanup activity will be.

SHC 3.62 – Environmental Releases of Oils and Fuels

Task posters:

Poster #23 – SHC 3.62, Task 1: Behavior, Fate and Effects of Oil and Spill Agents
Robyn Conmy (ORD)

This task is dedicated to research on the biodegradation, weathering, dispersion, toxicity and behavior of oil and spill agents in support of the EPA Office of Land and Emergency Management (OLEM) and the Regions. Research efforts improve the understanding of their fate and transport to establish appropriate response, remediation and restoration methods. Awareness by emergency responders and scientists has been heightened on the capabilities and limitations of spill response methods available for use today, particularly for atypical spills (deep-water, high pressure, jet release, prolonged, under-the-ice spills). For impacted communities, ecological and

human health impacts associated with spilled oil and mitigation technologies (dispersants, surface washing agents, etc) are of concern. Research in this task will focus on spill preparedness and determining potential impacts of mitigation technologies to communities and ecosystems with respect to the behavior, transport, fate and effects of spilled oil and fuels. Further, the exploration, production and shipment of oils within the U.S. has drastically increased in recent years. Not only is the increased volume of concern, but also changes in oil type, where diluted and synthetic bitumen is produced from the Bakken Formation and Canadian oil sands formations. These products are particularly difficult to remediate and exhibit chemical and physical behavior unlike other crude oils. In order to be protective of communities and ecosystems, this task studies the effectiveness of the mitigation technologies on these unconventional oils.

Poster #24 – SHC 3.62, Task 2: National Contingency Plan Protocol Development

Robyn Conmy (ORD)

As mandated by the Oil Pollution Act (OPA 90) and the National Oil and Hazardous Substances Contingency Plan (NCP), EPA is responsible for maintaining the NCP Product Schedule (NCPPS) of commercially available spill countermeasure products (dispersants, solidifiers, surface washing agents, bioremediation products). New protocols for chemical agents and other additives, are developed by ORD and used to inform regulatory actions and provide guidance regarding product effectiveness. The latter assists in evaluating tradeoffs to potentially impacted communities and ecosystems. The private sector also uses these protocols to advance remediation / response technologies for various environmental conditions and oil products. Research products within SHC 3.62 Task 2 are dedicated to the development and refining of protocols in support of the EPA Office of Land and Emergency Management (OLEM) and as specified in the Federal Register 40 CFR § 300.900-920 Subpart J. ORD has developed a dispersant effectiveness protocol, the Baffled Flask Test, where Venosa et al., 2002, Holder et al., 2015 are citations within the proposed decision-rule for the 40 CFR. Currently, ORD is developing protocols for solidifiers (Sundaravadivelu et al., 2016) and surface washing agents. Research is also focused on the selection of new EPA Reference Oils for the NCPPS. ORD provides critical products to OLEM and the Regions in support of the NCP and through preparedness efforts to protect communities from exposures to environmental releases of oils and fuels.

Poster # 25 – SHC 3.62, Task 3: Research to Support Leaking Underground Storage Tank (LUST) Program Planning and Backlog Reduction

Jim Weaver (ORD)

Approximately 600,000 underground storage tanks are regulated by the EPA, where one third of the sites are located near population centers, putting indoor air and drinking water resources at potential risk. Leaks are common and, despite cleanup of more than 436,000 releases, there is a backlog of some 78,000 releases awaiting cleanup. Tanks research is focused on enhancing understanding and modeling transport of fuels and their constituent chemicals to reduce the number of sites that are backlogged because of poor understanding of contaminant fate and transport. Coupled with specific-site needs is the need to assess the potential threat to private domestic wells (PDW), which are one of the main impacted receptors at LUST sites. For program management, the spatial relationships between sources (LUSTs) and receptors (PDWs) are being

evaluated, as are methods of estimating the transport processes which determine the extent of contamination and potential for impacts. For this purpose and also for site management, an improved conceptual model, based on improved understanding of fuel behavior at and below the water table, is being developed for contaminant migration in groundwater and soil gas based on lab, field and modeling studies. Vapor intrusion assessment has been supported by development of the PVIScreen model, which will be merged with the groundwater modeling development. ORD supports the Office of Underground Storage Tanks (OUST) by coordinating research activities and program needs. Recent technical support has included contribution to vapor intrusion guidance, development of technical support documents and models, and providing workshops for state, regional and tribal partners.

SHC 3.62 Topic Posters:

Poster #26 – Petroleum Vapor Intrusion (PVI)Screen Tool

Jim Weaver (ORD)

Assessment of petroleum vapor intrusion (PVI) presents a number of technical and administrative challenges. Ambient air inside and outside of residences may contain petroleum hydrocarbons and building owners may not permit sampling, to name two examples.
In some cases impacts are minimized because the supply of oxygen from the atmosphere provides a large capacity for biodegradation. As a consequence of considerations like these, direct measurement of indoor air contamination is not always undertaken, and models are sought to provide lines-of-evidence to support an assessment. Environmental models, however, are dependent on values of empirical parameters. For PVI, determining these on a site-specific basis is often challenging or not possible within a reasonable-cost site assessment.

To provide a defensible, modeling-based line-of-evidence, a model called PVIScreen was developed to address parameter uncertainty in PVI modeling. PVIScreen applies the theory developed for the BioVapor model (DeVaull, 2007) to a lens of petroleum hydrocarbons, or zone of contaminated soil gas, which acts as a source of petroleum vapors. The PVIScreen model automatically conducts an uncertainty analysis using Monte Carlo simulations. The model is intended to make uncertainty analysis practical for application at petroleum vapor intrusion sites. Model simulations are in agreement with an EPA-sponsored analysis of field data that illustrate and document the attenuation of concentrations of petroleum compounds in soil gas with distance above the source of the vapors. Application has been made to sites in Oklahoma and Utah to demonstrate how the model is applied within the framework of EPA's PVI Guidance, and to compare with datasets containing indoor air and sub-slab soil gas measurements.

Poster #27 – Wave Tank Oil Plume Simulations

Robyn Conmy (ORD)

EPA has initiated and executed three Interagency Agreements (funds in to EPA) with Department of Interior's Bureau of Safety and Environmental Enforcement to conduct large scale oil dispersion experiments in collaboration with the Canadian Government (Department of Fisheries and Oceans Canada). Experiments have been conducted within a large scale wave tank facility (32 m long) in Dartmouth, Nova Scotia over the past 4 years. Oil plume simulations were

generated, some using high-pressure underwater jet releases of oils. These experiments were designed to gain a comprehensive perspective on factors influencing oil dispersion (oil type, dispersant type and concentration, temperature, salinity) and how field sensors and analytical chemistry methods detect these changes. This research is critical for the Agency's spill preparedness and response efforts, particularly for SSDU (Sub-Surface Dispersant Use) planning by the EPA Office of Land and Emergency Management, which coincides with the API (American Petroleum Institute) D3 Dispersant technical working group TAC efforts.

This poster will highlight recent publications produced from the oil plume simulation research. These include, Conmy *et al.,* 2016 dedicated to evaluation of *in situ* sensors used by response teams for oil tracking in water in support of the *Deepwater Horizon* oil spill data analysis and addressing uncertainties in detection limits of response tools. An approach for sensor assessment, calibration, and demonstrating appropriateness was developed, thus establishing that dispersed oil can be detected down to 300 ppb oil, refuting previous misconceptions of 1 ppm oil detection limit. These findings were published in Conmy *et al.,* 2014 in ES&T which is a citation within the Federal Register proposed decision-rule amendments to the 40 CFR § 300.900-920 subpart J for spill monitoring requirements. A recent EPA 600 series federal report will also be highlighted which utilized high-pressure jet oil releases, providing data for evaluating droplet fractionation and tuning the oil droplet formation numerical model, JETLAG. Further, a recent project on oil dispersions in hypersaline / brine waters will be showcased. This is in support the EPA Program Offices, Regions, the National Response Team (NRT), area contingency planning, and improving the Agency's technical readiness during spills and for litigation preparation. This work is critical for scientifically advancing the field and environmental protection with respect to various aspects of spill preparedness, response, and remediation, particularly during Spills of National Significance.

SHC 3.63 – Sustainable Materials Management

Task Posters:

Poster # 28 – SHC 3.63, Task 1: Tools and Methods for SMM Decision Analytics (SMMDA)
David E. Meyer (Task Lead), Wesley Ingwersen, Michael Gonzalez, Brian Dyson, Paul Randall, Justin Babendreier (All ORD)

The key objective of this research is to develop a sustainable materials management decision analytics (SMMDA) framework to inform stakeholders on how and when to apply environmental tools for sustainable materials management (SMM) and integrate the resulting knowledge with socioeconomic considerations to make the best-informed policy decisions. The framework will be capable of addressing decisions from a community to national scale by incorporating stakeholder preference as part of the process. The framework will encompass the entire decision process, including material prioritization based on stakeholder needs, baseline assessment to identify areas for improvement of material use, design and assessment of practical SMM strategies, and multi-attribute decision making within a stakeholder environment. As opposed to broader research on community decision making, this task will address the challenge

of applying product and/or chemical-centric tools like life cycle assessment (LCA) to the material-centric questions associated with SMM. The creation of this framework will provide sustainable materials management options for industrial, construction/demolition, and municipal materials, as well as enhance sustainable materials management to support community public health and development, revitalization and better management of materials. Four research sub-tasks have been created to organize the research necessary to support development of the framework: data generation, tool development, SMM strategy design, and demonstration case studies. The framework will require a broad range of knowledge and draw primarily on LCA methods, economic analysis (e.g., life cycle costing (LCC)), risk considerations, social impact assessment, sustainable chemistry and engineering design theory, and multi-criteria decision theory. Emphasis for data acquisition and tool development will be placed on developing open access tools and data that can be disseminated publically through the Federal LCA Commons. Data and methods for both the inclusion of social indicators and the application of multi-criteria decision making will incorporate outputs from other projects in SHC.

Poster #29 – SHC 3.63, Task 2: Beneficial Use of Waste Materials

Mark G. Johnson (Task Lead), Carolyn Acheson, Souhail Al-Abed and Ronald Herrmann, Mark G. Johnson, Tao Li, Sudhakar Takkellapati, Susan Thorneloe Leland Vane and Raj Varma (All ORD)

SHC Project 3.63, Task 2, "Beneficial Use of Waste Materials", is designed to conduct research and analyses to characterize and quantify the risks and benefits of using or reusing waste materials. There are 6 primary research areas in Task 2 that cover a broad spectrum of topics germane to the beneficial use of waste materials and address Agency, Office, Region and other client needs. The 6 research areas include: 1) Materials Recovery Technology, 2) Beneficial Use of Materials Optimization, 3) Novel Products from Waste Materials, 4) Land Application of Biosolids, 5) Soil Remediation Amendments and 6) Improved Leaching Methods for More Accurate Prediction of Environmental Release of Metals. The objectives of each research area, their intended products and progress to date will be presented. The products of this Task will enable communities and the Agency to better protect and enhance human health, well-being and the environment for current and future generations, through the reduction in material consumption, reuse, and recycling of materials.

Poster #30 – SHC 3.63, Task 3: Innovation and Long-Term Performance

Teri Richardson (ORD)

The fundamental goal of this project is to enable communities and the Agency to protect better human health and well-being, and the environment for current and future generations. This project focuses on methods of reducing the threats and impacts to public health and the environment associated with the use of materials across their life cycle. This goal is achieved primarily by reducing materials consumption, by increasing materials reuse and recycling, and by minimizing the environmental impacts associated with the manufacture, use and end-of-life disposition of products and materials. Specifically, the focus areas for this task are the management of used electronics and electronic waste and the long-term performance and adaptation to climate change of its materials management systems.

Although disparate from one another, the research projects included in Task 3 collectively reflects the response to the need to evaluate sustainable materials management options for electronic, industrial, construction/demolition, municipal materials, the evaluation of hazardous waste containment systems, open dumps, mapping of soil moisture and the adaptation to climate change.

To address the management of used electronics, an assessment of the flow of historic, current, and potential future used electronics and electronic waste is being conducted. The information gathered will be used to track the end-of-life flow of electronic waste and to establish a reliable estimate of the volume of material entering the collection, recycling, export, landfill and downstream treatment.

Evaluating the performance of different containment methods will inform the next generation management approaches for containment systems. Efforts will be made to finalize the design information on bioreactor landfill operational strategies, study the performance of hazardous facilities, develop approaches for materials management in climate change, and identify better practices for the demolition of buildings.

The resulting information and data will provide information that can be immediately used by the Agency to identify areas for the improvement of materials management.

Poster # 31 – SHC 3.63, Task 4: Net Zero
Mike Nye (ORD)

Net Zero (and more recently, net positive) waste strategies are comprised of five interrelated steps: reduction, re-purpose, recycling and composting, energy recovery, and disposal – with each step linking towards achieving net zero. As such these approaches can provide a framework for the application of ORD science and innovative technologies. The Army defines Net Zero Waste as follows: a Net Zero waste installation reduces, reuses, and recovers waste streams, converting them to resource values with zero solid waste to landfill. The overall purpose of this task is to demonstrate three case-studies towards achieving Net Zero waste to landfill through co-digestion and small-scale technologies. This task will not only focus on military installations, but surrounding non-military communities in order to catalyze public-private partnerships that embraces co-ownership and joint development and application of integrated solutions for sustainable outcomes. To the greatest extent possible, this task will strive to incorporate social and behavioral science, cost-benefit and other economic analyses through both internal expertise and external partnerships. Additionally, this task will aim to provide broadly-applicable tools and will disseminate lessons learned and best practices of Net Zero Waste approaches.

3.63 Topic Posters:

Poster #32 – The Sustainable Materials Management (SMM) Prioritization Tool
Wesley Ingwersen & David E. Meyer (ORD)

The public and private sectors, domestically and internationally are in the midst of a transition toward decision-making based on holistic sustainability considerations. The scientific foundations required to support those considerations will need to overcome our present artificial compartmental constructs to enable cross-discipline, cross-origin merging of information. In the report Sustainable Materials Management: The Road Ahead, EPA provided a definition for

sustainable materials management (SMM) which transcends historical lenses based on single impact, single life-stage (e.g., use, waste), political boundaries, or efficiency. The report also included a life-cycle assessment of the US consumption of goods and services to serve as an analytical framework for SMM. A draft life cycle based tool, the SMM Prioritization Tool, was developed under extramural contract for the Office of Land and Emergency Management (OLEM) based on the SMM framework to provide a faster, easier, and less costly way to incorporate life cycle information in decision-making, setting priorities, and engaging in strategic, system-level dialogue. Unfortunately, the original tool was created based on proprietary data in a platform that could not be easily distributed to stakeholders while the underlying model only addressed the manufacturing phase of the life cycle and did not include the ability to track materials in support of SMM policy development. To address these issues, the current research focuses on revising and expanding the tool. This includes: developing a new open-source environmentally-extended input output LCA model for the US (USEEIO); stratifying the national model to provide a multi-regional model describing a state a state of interest and the rest of US (ST-USEEIO, where ST = the state of choice); introducing the ability to track and assess key materials of interest; implementing a Python script called the IO Model Builder to automate the integration of the various data sources; extending the life cycle considerations to address use and end-of-life impacts; and developing a web-based platform to deploy the tool in a manner that enables users to customize the model for specific needs at varying geographic scales.

Poster #33 – Tracking the Flow of Used Electronics in the U.S.

Teri Richardson (ORD)

Electronic waste (e-waste) is the largest growing waste stream in the U.S. with an estimated amount of 3.1 million tons generated in 2013. The improper disposal of e-waste has environmental, economic, and social impacts, both domestically and internationally. The primary goal of this project is to conduct a national assessment of the flow for historic, current, and potential future used electronics and electronic waste. The critical information concerning the fate of used electronics and the effectiveness of current legislation and policies provided through the assessment is expected to offer an evaluation of the effectiveness of current regulatory policies. Methods of implementation and tracking employed by the research are essential for comparative purposes and the identification of operational and informational gaps.

At the current stage of inquiry, the research team is focusing on a Midwest states cluster to facilitate the data collection and discovery. The use-life and management of e-waste generated from the analysis of households, small and large businesses and other institutions is expected to differ significantly. This research is designed to track the end-of-life flow of e-waste to establish a reliable estimate of the volume of material entering the collection, recycling, export, landfill, and downstream treatment processes (such as smelting). The research results can enable the assessment of potential effects of the state-level electronics recycling requirements (e.g., benefits and drawbacks).

An e-waste flow model (eWFM) has been developed that helps us to provide estimates of the quantity of e-waste generated annually at the national level and currently for selected states. The model is capable of producing national-, regional-, and state-level estimates of the volume of electronic products entering end-of-life (EOL) management annually. The model's utility and functionality can be enhanced through an in-depth assessment of a single state's data to provide

the fine grain details required for the formulation of a tracking and reporting methodology and framework. The ability to conduct electronics life cycle tracking is anticipated to provide a significantly informed ability to manage the use and disposition of this electronic equipment more efficiently and facilitate environmentally sound use and disposition practices. An effort will be made to collaborate with states, local municipalities, stakeholders, and others that already have tracking and information systems in place. Once the framework for material flow analysis is established for the Midwest states cluster, the research will focus on other states and regions of the U.S. which will enable the comparison of model results with data to complete the picture of national electronics material flows and highlight areas of concern and improvement.

Poster #34 – The Risk-Informed Materials Management (RIMM) Tool System for Determining Safe-Levels of Contaminated Materials Managed on the Land

Justin Babendreier (ORD)

EPA's Risk-Informed Materials Management (RIMM) tool system is a modeling approach that helps risk assessors evaluate the safety of managing raw, reused, or waste material streams via a variety of common scenarios (e.g., application to farms, use as a component in road construction, landfilling, etc.). RIMM can be used to study one or more sites located in the conterminous United States, where it can estimate actual and relative chronic health risks of contaminants present in materials (e.g., toxic metals and organic chemicals). RIMM decisions can help communities reduce disposal costs and use of raw materials by facilitating safe redirection of waste streams to beneficial reuses. Directly serving the programmatic goals of EPA in Sustainable Materials Management (SMM), the RIMM Tool System is an open, free, and readily accessible multi-component platform of interoperable decision-support and -analysis tools. With its abilities to directly address uncertainty in exposure and risk from toxicants, RIMM is designed to concomitantly support: (a) SMM-based Agency policy analysis and rulemakings, (b) stakeholder driven decision-making for SMM, and (c) a broad array of research needed to further advance multimedia modeling and model evaluation research programs within and outside the Agency.

RIMM is both a methodology and technology for conducting integrated multimedia cumulative exposure and risk assessment of human and ecological receptors. RIMM uses or acquires best available site-scale scientific data to estimate ecological and human-health impacts created by placement of contaminated materials into landscapes. Site-specific assessments form the building blocks used to assess exposure and risk across multiple spatial-scales of interest (e.g. site, regional, national; county, state, tribal, Federal; etc.), where uncertainty and sensitivity in outcomes can also be assessed. A typical RIMM assessment has 3 steps: (Step 1) collect site-specific information at one or more sites across the U.S.; (Step 2) Run sets of multimedia modeling system runs across the site(s), tracking a range of scenarios; (Step 3): Evaluate exposure and risk results and decide safe-levels of contaminants in a material. RIMM allows users to study and compare one or more material management unit (MMU) types (e.g. landfill, pond or surface impoundment, roadway, pile, land application unit or farm, aerated tank). Against these options, users evaluate one or more metal and/or organic chemical contaminants in a given material.

Poster #35 – Specific Net Zero Projects

Alex Lan, ORD

Net Zero waste strategies are comprised of five interrelated steps: reduction, re-purpose, recycling and composting, energy recovery, and disposal – with each step linking towards achieving net zero. As such these approaches can provide a framework for the application of ORD science and innovative technologies. In many communities across the U.S., organic waste is the second highest component of landfills, which are the largest source of methane emissions. Through application of ORD science and tools, three case-studies are presented towards achieving Net Zero waste –particularly food waste- to landfill: co-digestion of food waste through wastewater treatment facilities; managing food waste in Columbia, South Carolina; and Comparison and evaluation of small-scale food technologies towards zero waste. A creation of a guidance document can be used by communities seeking to explore organics diversion strategies and co-digestion opportunities. This guidance document will include broadly applicable steps and methodologies for conducting a practical organics diversion plan and will include lessons learned from a broad range of case studies.

Poster #36 – Long-term Performance of containment systems at RCRA Subtitle C Landfills

Thabet Tolaymat (ORD)

The primary objective of this research study is to investigate the field performance of engineered containment systems based on data from Subtitle C landfills that have completed several years of PCC and to quantify actual leachate generation rates, liner performance (i.e., leakage), and leachate chemistry during PCC in relation to current industry "norms" and expectations. It is anticipated that this study will help the EPA assess and update field performance of Subtitle C landfills, specifically as reported and discussed in Chapter 5 and Appendix E of the previous study prepared for EPA titled "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" (EPA, 2002).

This research study focused on providing answers to questions outlined below.

1. What conclusions can be drawn regarding the hydraulic efficiencies of double liner systems (i.e., leakage rates through primary liners) at Subtitle C landfills based on available leachate collection and removal system (LCRS) and leakage detection system (LDS) data?
2. How much leachate is generated in closed Subtitle C landfills and what are the effects of site location (climatic region), cover system design, or waste type on leachate generation rates?
3. How do predictions of leachate generation using the EPA's Hydrologic Evaluation of Landfill Performance (HELP) Model compare to observed generation rates at these sites?
4. What is the leachate chemistry at these sites, and does it exhibit asymptotic behavioral trends over the long-term?

Poster #37 – Implementation guidance for the next generation leaching tests

Susan Thorneloe (ORD)

Next generation leaching tests have been validated to develop more accurate source terms for use in fate and transport models in support of both RCRA and CERCLA programs for

evaluating beneficial use, treatment technologies, and delisting. LEAF incorporates the major drivers that can vary and affect leaching of heavy metals including pH, the liquid-to-solid ratio of the test material and the leaching environment, and whether or not leaching is controlled by constituent aqueous-solid partitioning under chemical equilibrium or by the rate of mass transport through the material. For those factors that are not readily assessed in the laboratory (e.g., changing redox conditions and carbonation), software is available to evaluate geochemical speciation and scenario-based reactive transport models. This research is been closely coordinated with development of comparable methods in Europe.

The leaching test methods include batch equilibrium, percolation column and semi-dynamic mass transport tests for monolithic and compacted granular materials. By testing over a range of values for pH, liquid/solid ratio, and physical form of the material, one data set can be used to evaluate a range of management scenarios for a material representing different environmental conditions. LEAF results provide the ability to make meaningful comparisons of leaching between similar and dissimilar materials from national and international origins. Software (i.e., LeachXS-Lite) has been developed and is available at no cost for data management, evaluation, and visualization. A user's guide for LEAF implementation has been developed and is undergoing review prior to final release.

Poster #38 – Techniques for Separating Organic Solvents to Facilitate Reuse and Remanufacturing

Leland Vane (ORD)

The Remanufacturing Exclusion of the EPA's New Definition of Solid Waste rule is intended, in part, to promote the reuse/reprocessing of 18 industrial solvents in the pharmaceutical, paint and coating, plastic and resin, and basic organic chemical sectors. The technical challenge to solvent reuse/reprocessing is that replacing virgin solvents with reclaimed material requires the application of separation technologies to recover those solvents from their mixtures with the other processing materials, such as water, and to purify the solvents to meet reuse specifications. These separation technologies present an environmental opportunity but also an environmental challenge because they each have an environmental footprint, the largest usually due to the energy required in the process. As a result, the sustainability of many industrial sectors is linked to the efficiency of the separation technologies used in those sectors.

This research activity will provide scientific support regarding efficient separation technology options to EPA program and regional offices, states, tribes, and the regulated industries seeking to implement the remanufacturing exclusion or solvent reclamation in general. The activity will focus on the in-house review, development, and evaluation of advanced separation materials/technologies for energy-efficient solvent reprocessing. Solvent/water mixtures will be emphasized because, of the solvents identified in the new definition of Solid Waste rule, most form difficult-to-separate azeotropic mixtures with water. In addition, the migration of industries to less toxic and renewable solvents results in the use of solvents that is more prone to attract or mix with water. The research will leverage team members' experience successfully developing materials and processes to efficiently recover and dry alcohol-based biofuels, some of which are among the 18 industrial solvents targeted here.

The research activity will foster collaboration between separations technology developers, university researchers, solvent end-users, and regulators to promote solvent

recovery/reprocessing/reuse. For example, a cooperative research and development agreement (CRADA) with a membrane technology developer will be part of the activity. In addition, the activity lead is participating in the NIST-funded project *Accelerate Industrial Application of Less Energy-Intensive Alternative Separations* (ALTSEP), jointly led by the American Chemical Society and the American Institute of Chemical Engineers, to develop a roadmap for implementing efficient chemical separation processes.

Poster #39 – State of the Practice of Construction and Demolition Debris Recycling

Thabet Tolaymat (ORD)

Construction and demolition debris (CDD) represents one of the most substantial sources of discarded materials in the United States. Therefore, its management plays a critical role in developing national, state, and local sustainable materials management (SMM) initiatives. Consisting primarily of concrete, asphalt, wood, metal, gypsum, soil, and vegetative material, CDD offers strong potential for recovery and recycling, which in turn hold promise for a range of associated environmental, economic, and social benefits. ORD research in the area aimed at evaluating the state of the practice of the C&DD recycling industry. The initial evaluation suggested that construction and demolition contractors use several techniques to separate, recover, and recycle CDD materials. For example, some buildings are deconstructed to recover components that can be reused in new projects (e.g., dimensional lumber, bricks). Most recycled CDD finds its way to some type of CDD processing facility. While markets for recovered materials, and their associated market value, vary by material type. Economic, regulatory, and material-specific factors often contribute to the success of CDD recycling initiatives. The push toward green building programs has heightened awareness of the environmental issues associated with building materials and promoted CDD recycling.

The CDD recycling industry continues to grow. Some components (e.g., concrete) are commonly recycled for existing economic reasons. But others, especially those with low market value and that require processing to separate from the rest of the CDD stream, are often challenging to recycle. Many state and local governments have demonstrated that regulations and policies can play a major role in promoting CDD recycling, and municipalities or other entities interested in growing CDD recycling in their area should look to these successes as examples. A need remains to better track data on the amount, composition, and disposition of CDD in the United States, especially as related to CDD recycling, and to compile and disseminate successful strategies for CDD recycling and document resulting benefits.

Poster #40 – Causes and mitigation of Subsurface Heat accumulation in Landfills

Thabet Tolaymat (ORD)

The population of landfills in which part or all of the facility is operating at elevated subsurface temperatures appears to be more common than was previously understood. As such, understanding and preventing conditions that may lead to elevated subsurface temperatures in MSW landfills is of increasing interest for both operators and regulators. This research effort investigates the occurrence of sustained subsurface heating (SSH) events at landfills and summarizes the state of the science with regard to their detection, causes, effects, control, and long-term mitigation. There are several known and suspected underlying causal factors and

mechanisms that may contribute to SSH phenomena, including site-specific factors related to unique siting, geologic, and climatic conditions. It is recognized that multiple heat-generating processes may occur in parallel. As such, SSH events are often the result of a complex and interdependent combination of several processes rather than one process acting in isolation.

In developing strategies and operational practices to prevent SSH, it is important to understand techniques for detection and investigation of warning signs in the early stages of a SSH event, and to assess and characterize an event once it has been detected. Investigation of SSH events can be accomplished through a variety of direct or indirect methods. Direct investigation methods involve temperature readings taken from the waste mass, either from drill cuttings brought to the surface or down-hole measurements taken in boreholes or gas extraction wells and vents. Indirect methods, which have the advantage that temperature anomalies within the waste mass can be measured without potential air inflow to the hot zone via intrusive borings, include topographic changes indicating rapid or unusual settlement, infrared thermography to map heat distribution across the landfill surface (although this may not be effective at measuring heat accumulation at depth), geophysical measurements, monitoring changes in leachate temperature and composition, and monitoring localized changes in LFG temperatures and composition.

Remedial activities for addressing SSH events have to date often focused on careful monitoring without any real understanding of how to resolve, reverse, or impede the microbial and/or abiotic conditions that originally caused the situation. Furthermore, there is no long-term experience with successfully cooling a large waste mass. While gas injection appeared to be successful in one detailed case study examined, it was not successful in another. BMPs are needed for the design, evaluation, and performance monitoring of remedial activities at sites where elevated temperatures already exist. Standardized procedures for evaluating the technical feasibility and cost-effectiveness of various remediation techniques (e.g., liquid N2 or CO2 injection, smothering via capping, excavation and dousing, or adding pH amendments to the waste) would help to increase success rates and reduce the uncertainty currently surrounding different remediation strategies.

Poster #41 – Management of Wood from site clearing and storm debris

Steve Rock (ORD), Nicole DiForte (R2), Diana Cutt (ORD-R2)

Land clearing from contaminated site assessment and remediation operations and disaster recovery efforts can result in significant amounts of wood waste that must be managed. The Superfund program has increased its focus on the environmental footprint of cleanups through EPA's Office of Land and Emergency Management's (OLEM's) Greener Cleanups policy, Superfund's Green Remediation Strategy, and individual regional green remediation policies, such as EPA Region 2's Clean and Green Policy. Region 2's green remediation program has grappled with the issue of wood generated during cleanup activities. In addition, natural disasters can generate large amounts of vegetative and woody debris that present challenges in post-generation management. Hurricane Sandy, for example, generated more than 168,000 cubic yards of woody debris in New York City alone.

Currently, there is a lack of clarity with regard to how to best manage wood from site cleanup, land clearing, and debris management projects. There is a need for research into options for managing wood and evaluating the cost and life-cycle environmental impacts/benefits of these options. The objective of this research project was to evaluate a variety of wood management options from a cost and life-cycle assessment (LCA) perspective to help decision-makers identify

tradeoffs between options. The research also addressed other factors that may influence decisions about wood management, such as diversion of this waste stream from landfills and renewable energy targets.

Poster #42 – Amending Jasper County, Missouri soils with biochar and other amendments following chat removal to facilitate soil restoration/revitalization and establishment of a soil-stabilizing plant cover: An ORD and Region 7 Collaboration

Mark G. Johnson (ORD), Mark Doolan (R7), Rob Weber (R7 ORD STL)

Abandoned mines and the residuals from mining across the U.S. pose a considerable, pervasive risk to human health and the environment. Many soils in the Tri-State-Mining District (TSMD), located where Missouri, Kansas and Oklahoma meet, have been affected by the residuals of historic lead and zinc mining. Here we describe a research collaboration between ORD and Region 7 to investigate the use of customized soil amendments, which will include biochar, as a tool to provide both soil remediation and reestablishment of a soil-stabilizing native plant community at sites in the TSMD. Biochar is a charcoal-like, carbon-rich, porous by-product of thermal pyrolysis or gasification. A benefit of using biochar is the ability to engineer its properties to correspond to specific soil remediation needs. Specifically, it has properties that make it well suited for use in remediating mine soils and reestablishing vegetation, with studies indicating that biochar can complex and immobilize heavy metals. This is of critical importance for mining influenced sites. However, the optimized biochar properties for the remediation of acidic mine soils are not yet fully known. Biochar can be produced to have a range of pH values, depending upon feedstock and pyrolysis or gasification conditions, and post-production activation. Therefore, this material may be used as a liming agent to raise soil pH. Additionally, some biochars have been shown to improve soil water holding capacities and infiltration properties. Biochar can be produced with residual sorbed organics from the pyrolysis process that can provide a food source for soil microbial foodwebs, promoting healthy soil and plant growth. Collectively, biochar may serve as a useful component in the remediation of acid mine soils and mining influenced soils. While not a complete site remediation alone, amending mine soils with biochar may reduce immediate risks due to the leaching of heavy metals and off-site movement of pollutants from contaminated mine spoils. This project will initially produce a comprehensive set of biochars from a variety of local feedstocks, and through a targeted series of tests using soil from the TSMD, and more specifically Jasper County, Missouri will identify chemical and physical characteristics of biochar(s) with the most potential to remediate soils and reestablish native plant communities on the mining affected soils.

Poster # 43 – Updating the Hydrologic Evaluation of Landfill Performance (HELP) Model

Thabet Tolaymat (ORD)

The Hydrologic Evaluation of Landfill Performance (HELP) program was developed to estimate water movement across, into, and out of landfills. The program is applicable for evaluation of open and closed sites by both designers and permit writers. The program models the effects of hydrologic processes including rainfall, runoff, infiltration, and other water

pathways. Use of the model requires knowledge regarding landfill design, climate, and engineered conditions within the site.

All Subtitle C and D landfills use HELP to demonstrate compliance with a 30cm head on the liner requirement under 40 CFR 258. HELP v3.07 was last updated in 1995 and is currently available as a DOS executable program. An updated version of the HELP model, as a macro-enabled Microsoft Excel file, is currently under development and an alpha version of HELP v3.5 is expected in late 2016, with a public release at a later time. Updates will continue into 2017 to include modern standards of practice and new performance data regarding bottom liner systems, intermediate and final covers, leachate recirculation, as well as current meteorological and soil data.