TECHNICAL SESSIONS

Twelve technical sessions will take place from Tuesday afternoon until Thursday morning, with three sessions taking place concurrently. The abstracts within this section offer more insight into the topics that will be discussed.

Tuesday afternoon, December 4, 1:45 – 5:00 p.m.: Sessions 1A, 1B, and 1C
Wednesday morning, December 5, 8:30 – 11:45 a.m.: Sessions 2A, 2B, and 2C
Wednesday afternoon, December 5, 1:45 – 5:00 p.m.: Sessions 3A, 3B, and 3C
Thursday morning, December 6, 8:30 – 11:45 a.m.: Sessions 4A, 4B, and 4C

KEYNOTE ADDRESS
CHEMICAL DELIVERY AND MIXING: CHALLENGES AND OPPORTUNITIES

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In-situ remediation technologies have the potential to remove contaminants at low cost and without transferring contamination to a different medium. For example, though delivery of appropriate additives and removal of products that may impede reactions, one can stimulate indigenous microbial populations that can break down contaminants, thus working with nature. However, the rate of biogeochemical reactions in the field is almost always controlled by the rate of delivery and mixing of reactants. The severity of mass transfer limitations has unfortunately been often underestimated in the design of remediation projects, resulting in disappointing results. Mass transfer limitations need to be taken seriously into account when devising remediation schemes and must be diminished through appropriate technologies and engineering design. Even with improved technologies, mass transfer limitations impose constraints on the time it takes to achieve clean-up goals that must be considered when setting policy. This talk is a broad overview of mass transfer limitations in relation to chemical delivery and mixing; the challenges in achieving satisfactory reaction rates; and opportunities in developing enhanced and cost-effective in-situ remediation. The case of in-situ bioreduction of U(VI) at Oak Ridge, TN, is presented to illustrate some of the concepts. Also this talk will provide general background and key issues which will be discussed in greater detail throughout the session.

ENGINEERING DELIVERY OF SOLUBLE AMENDMENTS

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Soluble amendments for in situ remediation conventionally include products mixed in an aqueous solution; as opposed to solid, slurry, or immiscible fluid phase. The processes and variables are explored that are involved in the engineering design of delivery systems for fully miscible remediation amendments.

The design of subsurface amendment delivery systems requires a broad spectrum of issues to be addressed, including: (a) the chemical/physical properties of the amendment solution, (b) the concentration-dependent amendment reactions, sorption, and other chemical behavior in the subsurface, (c) the driving forces for amendment transport (advection, gravity, diffusion, dispersion), and (d) geologic heterogeneity, the injection boundary conditions, and a multitude of other natural and design variables that may control the amendment distribution. SERDP and ESTCP programs have contributed significantly to extending the knowledge of these factors. These results and those obtained in remediation practice have shown that for injection of reactive amendments, the amendment reaction pathways and kinetics have a profound influence on the subsurface amendment transport. Geologic heterogeneity is also critical because it can result in a non-uniform distribution of both contaminants and amendments, leading to diffusion-limitations for both amendment distribution and contaminant treatment.

Soluble amendments can include surfactants, cosolvents, oxidants, reductants, microbiological carbon-donors, or microbiological nutrients. Within each of these classes, there are different amendment formulations with unique delivery design considerations. Some amendments act as a primary treatment agent, while others react in situ to produce an intermediate product which is the active treatment agent. Other amendment formulations consist of two or more constituents that act together, each subject to different transport processes.

Injection geometry and tooling as well as the amendment injection concentration, volume, injection rate, and injection duration are ultimately the primary variables subject to design. Alternatives for injection include injection only, coupled injection-extraction, and continuous recirculation. Injection tooling alternatives include screened wells, direct push wells (top-down or bottom-up injection sequence), jetting-tools, and fracturing-tools. Each of these injection/delivery tools behaves differently in different geologic media and with different amendment characteristics and these differences are explored herein. Ultimately, the goal of the amendment delivery designer is to integrate the chemical, physical, and geological variables to develop a strategy which will deliver an adequate amendment concentration in contact with the contaminants for an adequate duration to achieve the treatment goals. It is shown that the optimum delivery design is highly technology-specific and site-specific.

ENGINEERING DELIVERY OF INSOLUBLE AMENDMENTS

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A variety of insoluble and/or low solubility amendments are being developed for in situ treatment including nano- and micro-scale Zero Valent Iron (ZVI), emulsified vegetable oil, emulsified ZVI, pH buffers, and sparingly soluble substrates. Potential advantages of 'insoluble' amendments include chemical reactivity and long-term performance. However, effectively distributing these materials in the subsurface can be challenging.

There are three common approaches for distributing 'insoluble' materials in aquifers: (a) injection of 'plugs' of the amendment; (b) mechanical mixing; and (c) injection of fine particulate suspensions/emulsions. Plugs of low solubility amendment can slowly dissolve over time, releasing aqueous reagents that are carried downgradient by the ambient groundwater flow. While this approach can be effective, transverse mixing is often very limited, requiring installation of very closely spaced plugs. In some cases, amendments can be distributed by physically distributing the amendment throughout the treatment zone by trenching, mechanical mixing, or fracturing.

There is increased interest in use of emulsions and suspensions containing tiny droplets (or particles) that can be transported through the sediment pores by groundwater flow. These particles are retained when they collide with sediment surfaces and stick. Collision frequency is a function of particle size and density. Sticking efficiency is controlled by the electrical, chemical and magnetic characteristics of the particles and prior saturation of the sediment surfaces. If particles flocculate, the large flocs that form will be rapidly removed.

Emulsified oils have been used at hundreds of sites throughout the world to stimulate anaerobic biodegradation processes. In heterogeneous aquifers with large spatial variations in hydraulic conductivity, uniformly distributing these materials can be difficult. Numerical model simulations were conducted using MODFLOW/RT3D to evaluate the effect of standard design variables (e.g. amount of oil and water, injection well spacing, injection pattern) on emulsion distribution in heterogeneous aquifers. Results of this analysis are presented as a series of curves relating different design variables to volume-weighted and flow-weighted contact efficiencies.

A spreadsheet based tool has been developed to assist in the design of efficient, lower cost injection systems. Users enter information on aquifer parameters and costs for labor, reagent and injection point installation. Results from the MODFLOW/RT3D simulations are incorporated, allowing the user to evaluate the effect of different injection approaches on contact efficiency. Using this tool, designers can easily evaluate the effect of different injection approaches on contact efficiency, initial capital cost and 30-year life cycle costs.

DNAPL SOURCE ZONES: CHALLENGES IN REMEDIAL DESIGN AND ASSESSMENT

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Despite substantial research and technology development over more than two decades, sites contaminated by dense nonaqueous phase organic liquids (DNAPLs) remain a distinct remedial and management challenge. DNAPL contamination remaining after aggressive mass removal may lead to persistent elution of dissolved-phase contaminants that pose risks to human health and the environment. This presentation summarizes research sponsored under SERDP Project ER-1293 that relate to source zone remedial design and performance assessment.

It is now widely recognized that natural subsurface heterogeneity tends to give rise to a high level of non-uniformity in DNAPL saturation distributions, leading to significant spatial variability in near-source downstream concentrations. Laboratory and mathematical modeling studies conducted under SERDP sponsorship have further revealed that DNAPL persistence under natural gradient conditions, as well as the performance of many source zone remedial technologies, will be closely linked to the spatial distribution of contaminant mass (i.e., the DNAPL 'architecture') within the source region. For example, research has demonstrated that greater mass removal efficiency can be achieved under scenarios with higher ganglia-to-pool (GTP) mass ratios. The impact of mass removal on downstream contaminant mass flux and plume evolution, however, has been much more difficult to predict. Recently, a number of simplified modeling tools for site management have been developed to predict the response of mass flux to mass removal, through the incorporation of source zone architecture metrics, such as GTP ratio. Although such models can represent early time behavior, they often fail to reproduce observed concentration tailing that typically occurs at large time or high mass removal levels. In addition, model calibration and prediction accuracy are largely dependent upon the quality and extent of site characterization data. These points are illustrated with example simulations of source evolution and mass flux behavior. Aggressive mass removal, coupled with monitored bio attenuation or remediation strategies, may offer significant promise for long term plume control at many sites. The complex interplay between spatial variability in formation properties (e.g. permeability) and a non-uniform distribution of contaminant mass, however, presents significant challenges for remedial technology design and implementation. The influence of heterogeneity and process coupling on remediation performance are illustrated with results of laboratory and modeling investigations involving in situ metabolic reductive dechlorination of PCE-DNAPL.

DELIVERING REACTIVE NANOPARTICLES TO SUBSURFACE DNAPL SOURCE ZONES

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Nanoscale zerovalent iron (NZVI) particles are proposed for in situ remediation of DNAPL source zones in contaminated groundwater aquifers. To be effective, NZVI must be reactive with target groundwater contaminants, and be mobile in the subsurface to enable emplacement in the source area. This is typically achieved through NZVI surface modification with polymers or surfactants. Several hydrogeochemical properties control the mobility of surface modified NZVI in the subsurface including, the particle surface coating properties and polydispersity, groundwater geochemistry, seepage velocity, and the grain size/type and the degree of sorting. Batch experiments were conducted to determine the effect of polymer coatings on NZVI reactivity with TCE, and the effects of TCE concentration and groundwater dissolved solutes. Dynamic light scattering, sedimentation, column and 2-D flow cell transport studies were conducted on polyelectrolyte-modified NZVI under a variety of hydrogeochemical conditions, and with varying polydispersity, to determine the effect of each of these parameters on their mobility in water-saturated sand columns. Finally, the resistance of polymer coatings to desorption and their ability to attach particles to the DNAPL/water interface was assessed. It was shown that modifiers that provide electrosteric repulsion, which are less likely to aggregate, are less sensitive to changes in ionic strength, and have a lower affinity for the sand grain surfaces, provide good mobility (10's to 100's of meters) in saturated sand columns for high particle concentrations (g/L) and under geochemical conditions representative of NZVI injection conditions. At low particle concentration (mg/L), mobility decreased with decreasing particle grain size, flow velocity, and in the presence of clay fines. This is consistent with colloid theory predictions. Mobility experiments conducted at high particle concentrations (1 to 6 g/L) and with polydisperse samples, and at geochemical conditions relevant to particle injection (10 mM Na^+, a pore water velocity of 3.2×10^{-4} m/s) showed that polydisperse samples containing large particles (several hundred nanometers) are less mobile than monodisperse samples containing only small particles (~100nm). The degree of deposition reversibility also decreased as polydispersity increases. The higher deposition rate of the polydisperse samples is attributed to increased aggregation from the magnetic attractive forces between particles which increase with r^6. This study emphasizes the important role of geochemistry and particle-particle interaction (aggregation) in the transport of concentrated NZVI dispersions in porous media. There is potential for controlled placement of NZVI in the subsurface because different surface coatings provide different mobility.

POLYMER ENHANCED DELIVERY OF CHEMICAL OXIDANTS AND BIOREMEDIATION AMENDMENTS

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Polymers can enhance the sweep efficiency of remedial fluids applied to low permeability zones that are result either from heterogeneities or lower relative permeability NAPL zones. Chemical oxidants and bioremediation are the focus of much research for remediation of NAPL-contaminated sites in ground water. This research investigates the compatibility of delivering food-grade polymers (Xanthan and HPAM) with potassium permanganate and sodium persulfate (chemical oxidants) and the KB-1 microbe (a microbe known to degrade PCE), and discusses fundamentals of polymer transport with application to remedial design. The results are generally applicable to remediation of both NAPL source zones and dissolved contamination. Experimental results from batch, column, and 2-D tanks studies will be presented, along with numerical-model simulation results. Permanganate and Xanthan is determined to be more a more robust polymer-oxidant pair. The polymer-oxidant mixture exhibits some oxidant demand, but the viscosity of the polymer solution and oxidizing capability of the oxidant are minimally influenced. PCE degradation rates during oxidation not significantly influenced by the polymer solution, but viscosity losses are observed during PCE oxidation that were not observed for polymer-oxidant solutions, nor for polymer-oxidant solutions with natural organic matter. This influences the design of polymer-enhanced chemical oxidation efforts. The KB-1 microbe is compatible with polymer-enhanced delivery. Preliminary results regarding the use of the polymer itself as an electron donor for PCE degradation by KB-1 are discussed. Design principles for delivering these remediation agents based on results of 2-D tank experiments and computer simulations are discussed.

KEYNOTE ADDRESS
SCIENTIFIC BASIS FOR SUSTAINING FOREST ECOSYSTEMS

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Sustainable forest management needs to provide for maintenance of critical ecological services and biodiversity as well as wood production. Natural models of forest disturbance and stand development provide an important scientific basis for developing silvicultural practices that accomplish all of these objectives, which is sometimes identified as ecological forestry. Major elements of ecological forestry are: (1) Structural retention at the time of regeneration harvest; (2) Manipulation of established stands to achieve and maintain desired forest conditions; and (3) Appropriate recovery periods between silvicultural treatment of stands. In addition, management needs to be planned and implemented at larger (landscape) spatial scales to be effective. Managers face major challenges to sustainable forest management in the 21st century as the result of global environmental change, globalization of the wood products industry, and exotic pests and pathogens.

SUSTAINABLE FOREST MANAGEMENT IN THE CONTEXT OF DOD FACILITIES

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In general terms, sustainable forest management aims to ensure that the goods and ecosystem services provided by forests are not diminished. On DoD lands, this must be accomplished in a manner that is consistent with the specific mission of each facility. Presented here is a case study of forest management needs and challenges in a specific location, the Marine Corps Base at Camp Lejeune (MCBCL), North Carolina. Management of diverse stands of longleaf pine at the MCBCL is particularly focused on maintenance of species diversity and habitat for the endangered red-cockaded woodpecker. Management strategies include frequent, low intensity prescribed fire and attention to the unique, uneven-aged structure of longleaf pine populations. Adaptive management is focused on unknowns associated with the behavior and reproduction of the woodpecker and the effects of different fire regimes on its habitat. Much of the MCBCL is dominated by second-growth; even-aged stands of loblolly pine that were planted on land once forested by both longleaf and loblolly pines. The primary management goals in these forests are restoration of historic forest composition, particularly longleaf pine, and restoration of woodpecker habitat where that is feasible and appropriate. Such restoration has historically included a range of practices including clear-cutting and forest thinning, usually associated with longleaf pine planting. Treatments may also include mechanical fuel manipulations to facilitate restoration of the natural low intensity, high frequency fire regime. In these situations, adaptive management focuses on uncertainties associated with effects of different harvest protocols on species diversity and habitat, and the challenges of restoring historical fire regimes. In both of these management situations, the impacts of military maneuvers, large-scale disturbance such as hurricanes and invasive non-native species are matters of concern.

ECOLOGICAL FORESTRY IN THE UPPER GREAT LAKES: WHY SELECTION SILVICULTURE IS NOT ENOUGH

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Northern hardwood forest types in the upper Great Lakes region have a long history of management using a single-tree selection approach. On the surface, this approach appears ecologically sustainable in that it maintains continuous forest cover and emulates an important natural disturbance regime, specifically individual tree blowdown. However, wide spread implementation of a selection approach has lead to a region-wide increase in sugar maple dominance in an otherwise species rich forest type. Alternative silvicultural approaches that better emulate the structural and compositional outcomes of larger scale canopy disturbances are being implemented in the region in an attempt to sustain the wider array of canopy species that occur in these forests. These approaches incorporate larger and more intense disturbances to regenerate mid-tolerant conifer and hardwood species, including yellow birch, northern red oak, white ash, eastern white pine. Ecological forestry approaches in the context of northern hardwood silviculture using case studies from the Wisconsin Department of Natural Resources and Menominee Tribal Enterprises will be discussed.

INTEGRATING FIRE AND SILVICULTURE: AN ECOLOGICAL BASED APPROACH TO MANAGEMENT OF SOUTHEASTERN PINE GRASSLANDS

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Three guiding principles of ecological forestry: incorporating legacies into silvicultural prescription, understanding intermediate stand development processes, such as fire, and incorporating appropriate recovery periods into management systems, form the basis for management that conserves, enhances and restores the high levels of diversity that southeastern pine grasslands have been noted for. Not only are these three aspects intimately linked to how the forest is managed through silviculture, but they also directly impact all management of the forest, including prescribed fire. Legacies affect fuels, largely through the patterns of longleaf distributed across time and space, since pine needles are the most critical fuels that allow for frequent fire. Frequent fire feedbacks in promoting vegetation that is pyrogenic, and its disruption in time or space results in development of fire sensitive species that often retard fire intensity or continuity. Harvesting can influence fire through distribution of fine fuels in the understory while removing needles from areas most impacted by harvesting operations (loss of fine fuels from grasses). The pine grasslands of the southeast provide an ideal opportunity by which the components of ecological management can be examined because these systems are tightly coupled to frequent fire and their species richness is among the highest in temperate forest globally when managed for long periods of time using these principles.

SUSTAINABLE FORESTRY FROM THE LAND MANAGER'S PERSPECTIVE: FORT BENNING CASE STUDY

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Fort Benning was established in 1918 -1920 with significant acreage added in 1941 to reach the current size of 183,000 acres. When acquired the property as a whole was fairly open due to past farming, and upland forests were dominated by shortleaf and loblolly pines but with some longleaf pine present in the mix. Early attempts to manage the forest resources met with limited success until the first full-time forester was hired in 1950. Early management focused primarily on the production of wood fiber and on fire suppression to protect resources and assets. This period also saw increasing disease and insect problems along with rising interest in management for the endangered red-cockaded woodpecker (RCW). The INRMP process in the late 1990s shifted resource management focus from fiber production to a broader interest in restoration and stewardship of the native longleaf pine ecosystem to benefit a comprehensive suite of ecosystem components while meeting the military mission. The Stoddard-Neel (S-N) approach to forest and wildlife management was adopted to pursue the new objectives, and Fort Benning personnel were mentored in the S-N approach through a collaborative effort.

Implementation of the S-N approach at Fort Benning resulted more in a change of guiding philosophy than drastic changes in on-the-ground operations. Specific changes in applied management include: increased use and higher priority of prescribed fire with greater attention to smoke management; operations guided by site-specific resource assessments and gradual manipulations to achieve long-term results; clearcutting only as a last resort and more emphasis on what is left behind rather than what is removed; and the use of an ecologically friendly cut-to-length harvesting system which causes little residual damage to harvested stands. Several challenges were encountered as management activities were modified. These include the need to reduce fuel loads, complaints about smoke and air quality issues from more frequent burning, ability to factor in long timeframes when others are looking for rapid changes, and educating hunters on the new philosophy and effects on wildlife habitat. Some successes to date include more longleaf pine and RCW on the installation, fewer wildfires, reduced insect and disease problems, better training areas, and higher biological diversity.

Though early in the process and with some questions still unanswered, we are confident this new approach to resource management will result in a unique, healthy, sustainable and productive forest (products as well as other values), while also providing quality training areas.

DECISION-MAKING TOOLS FOR IMPLEMENTING SUSTAINABLE FORESTRY

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The complexity of forest management is increasing with the scope of resources valued and the level of scrutiny from stakeholders. A wide variety of tools exist which can help managers deal with this complexity. These tools range from overarching principles, such as "resilience", to specific pieces of software which model tree growth or wildlife habitat. A few frameworks for defining sustainable forestry have become common starting points for forest managers today. The Montreal Process Criteria and Indicators are being used at the national level and by a number of states, while forest certification standards have been applied mainly to private lands and more recently to state and federal lands. These frameworks sketch out an ambitious array of themes to be considered but provide little guidance on specific methods for planning or management. An abundance of specific methods and tools exist; however, these tools are dispersed among different specialized domains (e.g. forest health, biodiversity, carbon sequestration) and require significant staff resources to find and implement. This talk will present a number of case studies on how different organizations have tried to integrate sustainable forestry analyses into their decision-making processes, and it will summarize strategies and resources available for bridging this implementation gap.

KEYNOTE ADDRESS
MCCLELLAN, THE ARMY DIDN'T LEAVE ANY ORDNANCE BEHIND!!

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The McClellan Joint Powers Authority (JPA) in Anniston, AL is charged with the cleanup of approximately 6,000 acres of mountainous land contaminated with unexploded ordnance (UXO) and munitions or explosives of concern (MEC) at former Fort McClellan. There have been many challenges which the JPA has faced while trying to redevelop McClellan starting with acquiring the funding through the Early Transfer process. This presentation will highlight who the JPA is, and how we acquired $211 million dollars in cleanup funding. We will identify exactly what there is to clean up at an eighty-two year old base, and how the program is structured to do the clean up. This study will look at the process and challenges we face integrating redevelopment with cleanup as well as the political issues of being within city limits.

A MINIATURE TOTAL FIELD MAGNETOMETER

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Magnetometers are one of the basic instruments used for the detection and discrimination of unexploded ordnance (UXO). Cesium vapor atomic magnetometers are commonly used since their readings are independent of the orientation of the sensor, which eliminates the noise problems due to rotation or even vibration of other types of sensors. In order to better discriminate UXO from clutter or scrap, a high spatial density of readings is desirable. In order to efficiently make such measurements, and to position such measurements accurately, arrays of sensing elements would be highly desirable. However, existing cesium vapor sensors are extremely large and consume a lot of power.

Recently, considerable advances have been made in total field magnetic sensors, as well as towards miniaturizing cesium clock technology using micro-electro-mechanical machining (MEMS) techniques. In this work, we are extending those techniques, and optimizing the design and operating principles used in MEMS clocks for magnetometry. In addition, potential exists for pursuing extremely sensitive devices operating at wide bandwidths. Such sensors could replace inductive coils currently used in electromagnetic (EM) devices for UXO detection and discrimination. In addition to their small size, measuring the magnetic field instead of its rates of change, as an inductive coil does, has considerable advantages.

The technical objective of this work is to produce a high sensitivity, total field magnetometer of extremely low power, small size, and capable of being mass-produced for low cost. In this paper, we will present extremely exciting results of our work prototyping and testing actual atomic magnetometers no larger than a grain of rice. Measured performance of better than 50 pT per root Hz under actual field conditions will be shown. Power consumption is a small fraction (less than 10%) of that used in existing systems.

We will also show results of our work at different cell temperatures, measuring the feasibility of working at higher bandwidths. This work will extend the MEMS technologies, allowing for a single sensor capable of making both a direct current (DC) magnetic field measurement as well as a high frequency measurement for use in a time domain EM system.

Significant progress is also being made towards commercializing these devices. Our design requires straightforward MEMs techniques, which are much less complicated, in fact, than some devices in commercial production today. Geometrics is working with commercial partners to begin producing such devices in the near future.

This research was funded by the U.S. Department of Defense under SERDP Project MM-1568.

EMI ARRAY FOR CUED UXO DISCRIMINATION

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With support from ESTCP, we have designed and constructed a vehicle-towed electromagnetic induction (EMI) sensor array to be used for cued discrimination of unexploded ordnance (UXO) from clutter. We envision the array will be used as part of a two-step process for identifying and discriminating buried metal targets. Step one of the process is to detect possible targets for further query; this presumably will be accomplished using a survey system. Step two is to position the array roughly over the anomaly and make EMI, and if required magnetometer, measurements. During the sensor measurement periods, the position and orientation of the array is determined to high precision by an array of Global Positioning System (GPS) antennas. The data collected, with near-perfect spatial correlation and no motion-induced noise, are then inverted (cooperatively if magnetometer measurements are made) for the desired target parameters. These inversions will be performed "on-the-fly" and the classification decision will be available in the field.

We have selected a time-domain sensor with a 35-cm diameter transmit loop and a 25-cm receive loop for the EMI portion of the array. Twenty-five transmit/receive pairs are arranged in a 5 × 5 array which is mounted on the Multi-Sensor Towed Array Detection System (MTADS) electromagnetic (EM) sensor trailer. We have begun to characterize the system at our Blossom Point test facility and the results to date are quite encouraging.

In this presentation we will briefly outline our deployment plans for the system, show examples of the initial sensor characterization results, and discuss our first field measurements with the array.

This research was funded by the U.S. Department of Defense under ESTCP Project MM-0601.

THE ALLTEM SYSTEM

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The ALLTEM system is an advanced multi-axis time-domain electromagnetic (TEM) induction system for detection and discrimination of unexploded ordnance (UXO). Design, construction and testing of the ALLTEM prototype have been supported by SERDP under Project MM-1328. ALLTEM has three orthogonal transmitting coils and an array of receiving induction coils as do some other TEM systems. ALLTEM differs from other multi-axis TEM systems in that it uses a continuous triangle-wave excitation. Mathematically, this is equivalent to measuring target step response rather than the more common impulse response. There are two resulting practical advantages. First, responses from ferrous and non-ferrous metal objects are of opposite polarities, providing a distinctive visual cue in the real-time waveform display that is clear to even an untrained operator. Second, at late times, the response for ferrous objects approaches a non-zero constant, rather than decaying toward zero. This improves late-time signal-to-noise ratio (SNR) -- an advantage for both detection and data inversion for target-identifying orthogonal polarizabilities. In May 2006, the U.S. Geological Survey operated ALLTEM with a Leica 1200 GPS over the Army's UXO Calibration Grid and Blind Test Grid at the Yuma Proving Ground (YPG), Arizona. ALLTEM multiplexes through all three orthogonal (H_x, H_y, and H_z axes) transmitting loops and records a total of 19 different transmitting and receiving loop combinations while in motion. Data are recorded at a constant 100 kilosamples/s rate with 24-bit precision. Filtering and processing remove almost all ground response and system drift effects from the data. The SNR improvements enhance detection of small or deep targets and inversion for target parameters. Our physics-based inversion algorithm was applied to YPG data with good results. Position errors from GPS and cart roll, pitch, and yaw were usually small enough that inversions provided good estimates of target position, depth, and orientation, and reproducible values for dipole polarizability moments of these targets, even though the system was moving. Thus it appears possible to obtain good multi-axis system target inversions and identifications from moving platform data even with some position "noise." A test stand with an automated positioning system has been developed and used to obtain high spatial density data over a number of UXO and clutter items. These new data have allowed us to further assess effects of spatial data density, position error, and sensor noise on target parameter calculations produced by the inversion algorithm.

This research was funded by the U.S. Department of Defense under SERDP Project MM-1328.

RECENT ADVANCES IN VECTOR EMI SENSORS

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Two current SERDP projects are advancing the state of the art for hand held Electromagnetic Induction (EMI) Sensors. The first is the Man-Portable Vector (MPV) time domain(TD) instrument with a 75cm transmitting coil and five triaxial receiver coils. This sensor acquires 15 data points (vector magnetic field at five locations) with each data shot. It operates in two modes: continuous mode for target detection and approximate location, and static mode for a series of high quality data suitable for discrimination. Geolocationing is accomplished by means of an arcsecond positioning system providing sub-centimeter accuracy.

The second instrument is the Geophex GEM-3D+ frequency domain instrument which incorporates a 55cm transmitter head and transverse receiver coils located slightly above instrument head in addition to the usual receiver coil located in the plane of the transmitter. This instrument records the inphase and quadrature components of the vector components of the magnetic field for a total of 6 data points per shot. Geolocationing for this instrument will be accomplished by secondary receiver coils (separate from the GEM-3D+ itself) which continuously measure the primary vector magnetic field and infer the location and orientation of the sensor head from that primary field. We refer to this as a "beacon" positioning system, and it also delivers sub-centimeter accuracy out to 2-3 meters from a central location.

Both of these instruments record the secondary vector magnetic field at one (GEM-3D+) or more (MPV) locations. The extra transverse components represent valuable new information about targets and enable novel methods aimed at rejecting environmental noise. Recent results regarding soil characterization and target classification and inversion will be presented.

This research was funded by the U.S. Department of Defense under SERDP Project MM-1443.

RESULTS OF AN AIRBORNE VERTICAL MAGNETIC GRADIENT DEMONSTRATION AT THE FORMER KIRTLAND PRECISION BOMBING RANGE, NEW MEXICO

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Vertical gradient configurations in magnetometer systems are common, and these are routinely used in ground-based unexploded ordnance (UXO) investigations. For boom-mounted airborne surveys, these configurations have the additional advantage of eliminating much of the rotor noise.

As a result of the successful prototype tests, Battelle developed two vertical magnetic gradient systems, and has completed several surveys with them. Both systems incorporate an integrated GPS-inertial navigation system for improved monitoring of aircraft orientation. The first is the VG-16 system, a 16-sensor (8 gradiometer) system with 12m swath width and 0.5 vertical separation between magnetometers. The second new system is the VG-22, a 22-sensor system with 7 gradiometers (14 magnetometers) deployed at 1m horizontal separation in the forward array, and two gradiometers in each side boom. With 6m swath width, VG-22 is intended for sites where greater resolution and sensitivity are required. Data acquisition and processing rates for the VG-16 are equivalent to those for the Arrowhead total field system, while the VG-22 requires roughly twice as much time to survey an equivalent area.

In addition to an assessment at Battelle's West Jefferson Ohio test site for airborne UXO systems, both VG-16 and VG-22 were validated at a blind test grid established by ESTCP at the Former Kirtland Precision Bombing Range (FKPBR) wide area assessment (WAA) site in New Mexico. The 88 seeded test items included 155mm, 105mm, 81mm, 60mm, 57mm, and 40mm ordnance distributed over a 521-acre site. Performance results were compiled by the Institute for Defense Analysis (IDA). Overall, VG-16 detected 67% of the seeded items, while VG-22 detected 90%, including 100% of the 40mm and 80% of the 57mm. Mean miss distances were 0.44m for VG-16 and 0.30m for VG-22. Both systems fell short in detecting 60mm, which were missing nose cones and tail fins. We conducted a review of the blind seed results after receiving the IDA analysis. This showed that most of the missed items produced distinct anomalies in the VG-22 data set and would have been detected had a lower picking threshold been selected. This would raise the Pd to 98% for VG-22, but would require approximately 10,500 picks, compared to 6400 picks (12 anomalies per acre) in the original VG-22 dig list.

The demonstration described in this presentation was supported by ESTCP under project MM-0633.

KEYNOTE ADDRESS
THE CANADIAN ARMY RANGE AND TRAINING AREA CHARACTERIZATION PROJECT

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In 2000, Director Land Environment (DLE) initiated a research and development (R&D) project on "Range and Training Area Characterization." The goal of the project is to understand the impacts of training and find solutions to mitigate the adverse impacts of training with live fire ammunition. All these efforts are done to ensure that our ranges will be sustainable in the future. Having a better understanding of the fate and transport of energetic materials, the project is now evolving at looking more closely at policies, procedures, and development of a new design for training ranges that seeks to reduce the impact of future munitions on the environment.

This project is still ongoing on active Canadian Army Bases and involves the collection of surface soils, biomass, surface water, and groundwater samples. Up to now, the major Army training ranges have been studied and protocols have been designed to ensure effective characterization of all types of Canadian Ranges.

The characterization work is a three-phased approach where samples are collected each year in order to better delineate the contamination pattern. Surface soil sampling, which is conducted in close collaboration with U.S. scientists, is part of the work involved. Groundwater surveillance wells are installed and geological formations also have been investigated.

The information obtained through this project is considered critical by DLE in order to better manage our training ranges in a sustainable manner. This presentation will cover DLE vision on Army training ranges, with the legacy from the past to the ranges that will prevail in the future.

RANGES, IMPACT AREAS, AND SDZS: THE CHALLENGES OF MONITORING AN ACTIVE RANGE COMPLEX

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Military installations primarily function to support the mission of training and readiness, thus limiting the availability of and access to these areas for other uses. This presentation will acquaint researchers and scientists with the challenges of conducting monitoring and research activities on an active military installation. Safety is a principal concern on any military installation, and understanding the basic types of land usage and associated terminology is necessary to understanding the complexity surrounding access to these lands for non-training activities. Terms like Range Complex, Impact Area, Surface Danger Zone, and Range Footprint will first be defined and explained, emphasizing their potential impact on research equipment location and site access. Proposed sampling, monitoring, and research activities on active installations may too heavily rely on the experience gained from work on inactive installations such as the Massachusetts Military Reservation (MMR). The presentation will highlight the critical distinction between conducting research activities on an active installation with some of the previous munitions constituents work at MMR. While these efforts have been invaluable, their use as a template for future work on an active range complex must be limited for several major reasons, which will be highlighted. Finally, the types of data and assistance that can typically be provided by an active installation to assist the researcher in accomplishing modeling and monitoring goals will be outlined. Throughout the presentation, Marine Corps Base Camp Lejeune will serve as an example of the complexities of working on an active installation, but these issues are by no means specific to Camp Lejeune or the Marine Corps.

OPERATIONAL RANGE MITIGATION NEEDS

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The use of munitions on operational ranges leaves residues of munitions constituents. These residues are mostly unexpended explosives, some metals, and perchlorate. Explosives come from high- and low-order detonations, unexploded ordnance that eventually fails and exposes their contents, and propellants. The lead comes from small arms use and perchlorate from missiles and training devices. Based on the physical conditions of where the range complex is located, these munitions constituents may migrate either vertically to groundwater or horizontally to streams. If a sufficient quantity migrates, it may pose a risk to human health and/or the environment.

There exist proven technologies to clean up these munitions constituents based on many years of work in the Installation Restoration Program. The problem is that the standard approach to applying these technologies in a cleanup scenario is not acceptable in an operational range environment. New technologies or methods are needed.

This presentation will examine the differences between cleanup applications and the needs and difficulties of dealing with an operational range environment.

RECENT ADVANCES FOR CHARACTERIZING ENERGETIC RESIDUES ON MILITARY TRAINING RANGES

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Energetic residues are heterogeneously distributed over military training ranges as particles of various sizes, shapes, and compositions. Moreover, most energetic residues are deposited on the surface, and the highest concentrations exist at firing positions, near targets, and where demolition activities are performed. To address the compositional and distributional heterogeneity associated with the deposition of particles and to obtain representative mean energetic residue concentrations, the sampling strategy must strive for the acquisition of samples that contain the constituents of concern in the same proportion to the bulk matrix as exists within the decision unit sampled. Likewise, to ensure that the subsample taken for analysis of energetic residues is representative of the sample, the field sample must be thoroughly processed.

To promote conformity among various government agencies in their efforts to characterize the amount and distribution of energetic residues on military training and testing facilities, ESTCP (ER-0628) facilitated the documentation of Method 8330B and published a sampling guide. The Office of Solid Waste - Environmental Protection Agency (OSW-EPA) posted Method 8330B on the SW-846 website in November 2006 (http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm#8330B). This method includes an appendix that describes recommended sampling and sample processing guidelines for soil samples collected on military training and testing facilities. ERDC-CRREL recently published a technical report that provides the information necessary to develop a conceptual site model and describes sampling strategies and designs that have been used to obtain representative surface soil samples on ranges (http://www.crrel.usace.army.mil/library/technicalreports/ERDC-CRREL-TR-07-10.pdf). These two documents represent several advances that are the product of the lessons learned during range studies at more than 30 installations over the last eight years. SERDP, the U.S. Army Corps of Engineers Distributed Source Program, the Army Environmental Center, and U.S. Garrison Army Alaska are funding these research activities.

This presentation will summarize the newly recommended laboratory sample processing and handling protocols and will give some examples of the sampling strategies and designs used to assess the surface loading of energetic residues. In addition, a summary of the current status of these new protocols will be provided.

USE OF AMENDMENTS AS A NEAR-TERM RANGE MANAGEMENT STRATEGY

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Currently, there is not an accepted technology for management of explosives and metals in active grenade range soils using non-invasive techniques. Two near-term management strategies currently under investigation include: (1) topical lime application for metals immobilization and explosives residues transformation, and (2) topical application of peat moss/soy bean oil (PMSO) for management of explosives residues.

The topical lime application project is based on the premises that increased alkalinity will result in decreased metals present in leachate and base-catalyzed transformation of explosives that will eliminate migration of RDX- and TNT-based explosives from the range area. The effects of continued range use and precipitation events have been addressed during in-situ lime treatment through surface and leachate water monitoring. Pre- and post-treatment assessments consisted of chemical analysis, soil characterization, contaminant leachability testing, and toxicity assessments at the demonstration site.

Treatability studies indicate that at a pH of 11.5 the RDX- and TNT-based explosives are quickly transformed. The degradation of these base-induced transformation products continues via biotic and abiotic reactions, mineralization of greater than 75% can be achieved within a few weeks. Mesoscale lysimeter studies where hydrated lime was applied to hand grenade range soils were used to evaluate the technology prior to application in the field.

The topical PMSO application project is based on a two-part premise—peat moss will reduce the leachability of explosives compounds and soy bean oil acts as an electron donor for biological degradation of explosives compounds.

Assessment of field application of the PMSO at an active hand grenade range also has been performed. Multiple grenade detonations within the treated area did not result in appreciable redistribution of the bulk of the material, thus indicating that the PMSO would remain in place and would serve as an effective treatment barrier. Further sampling and analysis will allow determination of the vertical mixing of the PMSO into the soil, as well as indicate range management practices that will allow effective deployment of this technology.

Proactive management of grenade ranges will help to mitigate potential range closures that could significantly impair military training and mission readiness. The potential DoD cost for soil remediation is also reduced via in-situ treatment and through elimination of explosives contaminant migration to water sources. These projects are funded by ESTCP.

PHYTOREMEDIATION: USE OF PLANTS AS A LONG-TERM RANGE MANAGEMENT STRATEGY

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The ultimate goal of current efforts is to bring phytoremediation one step closer to actual use at testing and training ranges for the continuous and long-term degradation of energetic compounds, enabling the sustainable use of ranges well into the future. Hybrid poplar is a "model plant" from the standpoint of genomics and as a commercially important species actually used in silviculture and phytoremediation. A case study is reported for applications to soils at Eglin Air Force Base (AFB) in Florida. In addition, we have examined native species and presently existing species of grasses and woody plants at Eglin AFB.

This presentation provides an overview of research utilizing techniques that span a wide range of scales from the use of range soils in the greenhouse to molecular tools (such as quantitative real-time reverse transcription-polymerase chain reaction and microarrays) to analyze gene expression in plants and bacteria for the degradation of the explosives compounds TNT, RDX, and HMX. We seek to answer the questions: (1) Does phytoremediation and rhizosphere degradation actually "work" under these conditions; and (2) How does it actually accomplish the task of degrading explosive contaminants in situ to innocuous end-products?

Organic chemicals that pass through membranes and translocate to stem and leaf tissues can be converted and solubilized by enzymes (e.g., cytochrome monooxygenase P450s or nitroreductase enzymes), conjugated by glutathione-S-transferase or sugars, and/or compartmentalized in vacuoles, cell walls, or the lignin of plants. These "bound residues" pose a potential problem if they become remobilized or engender ecotoxicity. In the Keck Laboratory, we have evidence of several genes that encode enzymes involved in the transformation of these chemicals in hybrid poplar. Major metabolites have been identified and pathways proposed.

KEYNOTE ADDRESS
COMBUSTION SCIENCE TO REDUCE PM EMISSIONS FROM MILITARY ENGINES: AN OVERVIEW OF FIVE NEW SERDP PROJECTS

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SERDP recently funded five projects (WP-1574, WP-1575, WP-1576, WP-1577, and WP-1578) that address Department of Defense (DoD) and national concerns about particulate (soot) emissions from gas turbine engines. These efforts involve fundamental research that will aid the DoD in meeting current and future PM2.5 regulations. Although these are independent programs, they are coordinated so that they work in concert to establish a science base for developing improved particulate models for designing low-soot, high-performance gas turbine engines.

There are many drivers for initiating such an extensive program. Current models cannot predict PM emissions to within one order of magnitude over the operating range from idle to full power. Furthermore, even the best fundamental models for soot formation in a single type of laboratory flame cannot predict measured soot levels better than a factor of 1.5 to 2 over a range of experimental conditions. Moreover, modeling and experimental research into soot formation has been dominated by studies at atmospheric and sub-atmospheric pressures. While useful for fundamental understanding, such studies do not address the typical operating conditions of gas turbine engines. Another factor motivating additional fundamental work on PM formation is the rapid movement by DoD to utilize alternate fuels; little is known about how PM emissions from military platforms will be affected by such fuels.

The array of programs funded under this SERDP initiative addresses the full scope of the problems summarized above. The program includes fundamental experiments on soot formation and oxidation, the development of enhanced soot models, and the creation of a database for soot formation in a number of combustion devices at atmospheric and elevated pressures for validation of robust soot models. In addition, the programs include the development of methods for applying the soot models to combustor design including advanced large eddy simulation (LES) methods. Perhaps the most important element of the overall Program is the coordination of all of the individual projects by the Air Force Research Laboratory. This coordination will result in the first ever effort to test the robustness of fundamental soot models across a wide range of conditions and combustion devices, which will greatly improve the chances that the models will produce accurate predictions of PM emissions from the complex combustion environments that exist in gas turbine and diesel engines.

SURROGATE FUELS FOR TRANSPORTATION FUELS

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A major factor in development of kinetic reaction mechanisms for hydrocarbon fuels is the demand for simulation tools for practical transportation and related systems. These systems include spark-ignition, diesel and homogeneous charge, compression (HCCI) engines, and gas turbines for aircraft and stationary power production. The fuels for these applications include gasoline, kerosene, diesel fuel and natural gas, as well as new candidates such as biodiesel fuels. All of these fuels consist of complex mixtures of many chemical species and many of the constituents are very large hydrocarbon species with as many as 15 - 20 carbon atoms. This talk will describe recent advances in kinetic reaction mechanisms, including mechanisms for n-hexadecane and other large n-alkanes, 2,2,4,4,6,8,8-heptamethyl nonane, methyl decanoate (a biodiesel surrogate), and cycloalkanes. Fundamental chemistry issues and needs involved with these new mechanisms will be emphasized.

EMISSIONS IMPLICATIONS OF ALTERNATIVE AVIATION FUEL COMBUSTION AND PRODUCTION

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The use of alternative (non-petroleum) aviation fuels can have emissions implications in two areas. The first is the obvious effect on aircraft engine emissions. The second area involves the emissions from the fuel production facility. The emissions of primary concern during fuel production are greenhouse gases, primarily CO_2. The primary alternative fuel of interest currently is a blend of Fischer-Tropsch isoparaffinic kerosene (IPK) and conventional jet fuel. Fuels produced directly from biomass (without going through the F-T process) are also of high interest.

In extensive emissions testing across a number of gas turbine engines, it has been found that Fischer-Tropsch fuel blends significantly affect only two engine emissions: particulates (soot) and sulfur compounds. The higher H/C ratio, relative to current jet fuels, and zero sulfur content of F-T IPK leads to significant reductions in soot and sulfur emissions. Data is currently available for T63, TF33, and T700 engines, with other engines planned for testing in the near future. The higher H/C ratio also leads to a slightly lower CO_2 emission index for F-T fuels, relative to petroleum, and a slightly higher H_2O emissions index.

In the aircraft equivalent of "well-to-wheels" CO_2 assessment, it is found that a F-T fuel plant increases CO_2 emissions by about 80% over petroleum fuels. However, carbon capture and storage/sequestration (CCS) can reduce the carbon footprint to a level roughly equivalent to that for petroleum-derived fuels. Recent reports and calculations have shown the co-feeding of biomass and coal to a F-T plant can reduce the fuel's carbon footprint significantly below petroleum, and in some cases can produce essentially a carbon-neutral fuel – where the CO_2 absorbed during production (through the use of biomass and CCS) completely offsets the CO_2 released during combustion. The CO_2-reduction potential of biomass-derived fuels is recognized in draft EU legislation for carbon taxes on jet fuel – where biomass-derived fuels are exempt from carbon taxes.

EXISTING AND EMERGING ENVIRONMENTAL CHALLENGES IN MILITARY PROPULSION: A EUROPEAN PERSPECTIVE

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Rapid developments are currently taking place in the area of petroleum-based fuels blended with Fischer-Tropsch (F-T) components and commercial approval is expected for some blends. There are also bio-derived jet fuel efforts in both the US and EU. However, a very limited amount of detailed data is currently available for F-T fuels and oxygenated compounds typically present even greater challenges and appropriate fuel specifications remain to be agreed. For both fuel families there is a distinct need to develop a comprehensive technology base that can support the development and optimization of propulsion devices. In terms of environmental emissions, it is becoming evident that, for example, different bio-derived fuels have different potentials to reduce particulate emissions depending on their chemical structure. Fischer-Tropsch based fuels also exhibit significantly different sooting propensities as compared to petroleum-derived fuels. In other application areas, the ignition characteristics of a fuel become of particular importance and, again, emerging fuels can show significantly different behaviour as compared to current alternatives. The highlighted issues can typically be expected to become more prevalent and of greater significance for combustion devices operating closer to stability limits where the sensitivity to the fuel chemistry can be expected to increase. Such conditions are often a direct consequence of a desire to reduce fuel burn and to lower combustion temperatures in order to reduce emissions. A proper representation of the fuel chemistry and the encapsulation of that understanding into calculations methods that are useful for design purposes is becoming a prerequisite even for the optimization of current engines operating on conventional fuels. The need for a significant research effort in this area is further emphasised by the fact that the results serve as a basis for the extension to the new fuel families. The talk will provide an overview of the emerging challenges associated with likely changes in fuels and operating conditions against a backdrop of current concerns with pollutants such as oxides of nitrogen and particulates. The talk will also cover potential new combustion regimes and the implications for calculations methods.

PREDICTING SOOT EMISSION FROM GAS TURBINES: FUNDAMENTAL EXPERIMENTS AND NUMERICAL SIMULATIONS

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The evolution of particle size distribution function (PSDF), morphology and chemical composition offers important insights into the kinetics of particulate soot nucleation and growth in combustion. Recently developed techniques, including small-angle X-ray scattering, small-angle neutron scattering (SANS), probe sampling/scanning mobility particle sizing (SMPS), and Particle Photo Ionization Mass Spectrometry (PIAMS), have been instrumental to achieving experimental resolutions necessary to follow particle kinetics. However, obtaining reliable data is by no means straightforward. A recent study demonstrated that a proper interpretation of the SANS, SMPS, PIAMS and TEM data can only be made if data from these measurements are considered jointly. The findings raise prospects of unambiguous and quantitative measurements of size distribution, chemical composition, and morphology for nanoparticles, from nucleation to aggregation in combustion. Likewise, simulation capabilities have also been advanced. The next generation of soot models will probably have the capability to provide detailed particle size distribution and chemical composition. The implications of these advances on gas turbine simulations will be discussed.

DEVELOPMENT OF SURROGATE FUELS FOR JP8

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The engineering and scientific community has been searching for the identification of surrogate fuels that can reasonably represent the performance and emissions behavior of jet fuels (e.g., Jet A, JP-8) in engines. Many proposals exist in the literature, but there has been no consensus of opinion. To help develop a common understanding for surrogate selection and their use, a working group created by AFOSR, ARO and NIST has been established. Furthermore, a multi-university research initiative (MURI) has been established by the AFOSR at Princeton University. During this presentation, the chemical kinetically limited processes within a gas turbine will be identified and target experimental parameters will be suggested for the development of a surrogate fuel. In addition, a palette of compounds is presented from which a surrogate fuel might be constructed. Recommendations for future efforts will be provided and a roadmap for the creation of surrogate fuel kinetics models proposed.

KEYNOTE ADDRESS
OPERATIONAL SUSTAINABILITY ISSUES IN IRAQ

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There is very high level emphasis for environmental concerns and sustainability programs. This is evidenced by their inclusion in the National Security Strategy, National Defense Strategy, National Military Strategy, numerous Joint Publications and Army Field Manuals. However, the implementation of these programs, regarding the environment and sustainability, appears to be lacking with regards to deployed situations.

Simply stated, the Army, and for that matter Department of Defense (DoD), does not have a consistent management approach regarding environmental and sustainability issues. There is a general sense of confusion as to what is the Army's policy (and DoD) regarding the environment during deployed operations and what if any sustainability issues should be or can be addressed. Commanders are not adequately being informed [or there is not adequate command emphasis] that environmental and sustainability training is not only directed but is also a necessity for mission execution. Without convincing mission commanders of the benefits of addressing environmental and sustainability issues you will not gain their support in implementation of environmental or sustainability programs. Without mission commanders' support, you will not be able to infuse the environmental and sustainability ethic into their units.

With a lack of policy and command emphasis, the natural result will be a lack of emphasis on training. Soldiers and deploying civilians across all levels lack general environmental training with regards to deployed operations. Specifically, this includes the understanding of their roles and responsibilities once deployed. Finally, when units and individuals do not understand their roles and responsibilities materiel/material solutions are not well addressed. Processes are continually being re-invented. Information is not shared from one area to the next or from one organization to the next. The requirements are not identified in a logical manner that can be addressed from an optimized and prioritized methodology.

Army Commanders need to realize that environmental and sustainability issues have the potential to impede the mission by creating safety problems, impacting resource allocation, impacting host nation relations, impacting public opinion, creating legal issues, and requiring unplanned costs. The first step to emphasizing these issues is to require Army's leaders to give environmental and sustainability issues the same importance as that of safety. Combatant commanders must be trained to look at deployed operations environmental and sustainability issues as something different than compliance mandated actions. It is extremely important they consider how environmental and sustainability conditions will affect their mission and their Soldiers. They must realize that as the environment has an impact on them, Soldiers have an impact on the environment and those impacts can affect the mission and Soldier health.

POWER & ENERGY ISSUES AND EMERGING SOLUTIONS

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Deployed bases are essential for the sustainment of overseas operational capabilities and readiness to serve and protect the nation and its interests. Deployed bases are small cities with a full spectrum of facility types and utility requirements that use large amounts of energy. The Army is developing a power and energy strategy for its CONUS installations to ensure war fighting mission readiness while also ensuring that installation energy is available, affordable, sustainable, and secure. These attributes are also relevant to deployed bases. Mission readiness for deployed bases also demands adaptability and scalability of power and energy for a diverse mix of missions. Power and energy security requirements and solutions need special attention for deployed bases.

This presentation describes CONUS Army Installation Energy Strategy and then highlights power and energy issues and emerging solutions for deployed bases. It offers a power delivery architecture concept that appears relevant to 21st Century deployed bases for assured mission accomplishment. Perspectives are also provided for increased penetration of renewables as an integral aspect of power delivery in a 24/7 OPTEMPO.

FLEXIBLE PV: AN ALTERNATIVE POWER SOURCE FOR MILITARY SYSTEMS

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The U.S. Army Natick Soldier Research Design and Engineering Center (NSRDEC) is the home for lightweight, highly mobile military shelter systems of all sizes that can be quickly deployed on the battlefield. As part of this effort, Natick has developed processes to laminate lightweight, flexible thin-film photovoltaic panels onto netting that can then be deployed as solar shades over these shelters to both reduce solar loading as well as generate power. The PV integrated solar shades, or "Power Shades" as there are more commonly known, reduce the surface temperature of the shelter significantly resulting in less power being needed to cool the shelter, and less fuel being consumed by the generators powering the shelter's environmental control units (ECU's). Other shelter items include existing tent fly designs that have had the PV modules laminated to the fly fabric thus creating integral pieces of the shelter that are now doing "double duty". Typical functions that are housed in these shelters include medical, command and control, billeting, soldier support, and maintenance. Many of the low power consumption tasks performed in these shelters such as lighting and the use of lap top computers can be met by the power generated by the PV on the Power Shade or shelter itself. This removes that electrical load from the traditional electrical grid resulting in reductions in fuel consumption and resupply requirements, maintenance requirements, and overall pollutant emissions.

Natick is also working on including the ability to recharge military batteries in the field where generator power is not an option due to mission requirements, or the high cost and complexity required to deliver fuel to remote locations makes generator use impossible. To do this, Natick is pursuing both raising the efficiency of the flexible PV that is used to minimize weight and packing volume of the electrical generating source, but also high efficiency battery charging electronics and microprocessor control algorithms.

Ultimately the Flexible PV program at Natick is driven to providing the Soldier of today, tomorrow, and beyond, with the ability to harness the clean energy of the sun and leaving the earth a little greener in the process.

MILITARY RESEARCH AND DEVELOPMENT APPLICATIONS FOR SAFE FIELD DRINKING WATER

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This presentation will address the R&D efforts by some of the DoD agencies pursuing the next generation of water purification equipment and the speaker's research at Penn State University with Dr. Brian Dempsey to optimize the use of coagulation pretreatment and ultrafiltration membranes for field water purification.

These research and development efforts present challenges and opportunities especially regarding informed and up-to-date application of the principles of health risk assessment and operational risk management to ensure safe drinking water for deployed troops.

MEETING CHANGING ENVIRONMENTAL REQUIREMENTS FOR A NAVY WITH CHANGING MISSIONS

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The Iraq war, the Global War on Terror, and other conflicts increase demands on Navy ships, extend deployments, force ships to spend more time in restricted waters, and place a larger burden on the environmental equipment and systems required to meet discharge regulations. As the Technical Warrant Holder and Program Manager for Shipboard Environmental Systems, NAVSEA 05P25 is responsible for ensuring that ships are equipped with the systems, processes, training, and documentation that enable the Navy to meet environmental policy, and domestic and international regulations. Currently, regulations or policies are in place for many wastes generated onboard ships, including oily waste, solid waste, sewage, and ballast water. However, regulations for graywater, hull coating leachate, deck runoff, compensated ballast and others are under developed by the Uniform National Discharge Standards Program.

The Navy uses a variety of equipments and processes to meet current regulations and faces challenges when integrating environmental technologies on Navy ships (limited space and manpower, hardening requirements, rotating operators, manning shifts, littoral operations, changes in food packaging, and increased use of synthetic oils/lubricants). New technologies are continuously being developed and integrated into the fleet to meet changing regulations and operational requirements. Through Acquisition Reform, there has been significant pressure to use commercial-off-the-shelf products. However, there is a growing recognition of the ILS and life cycle cost problems that result from having many different equipment commercial models and versions in the fleet. The Navy needs to finds ways to achieve commonality through acquisition of systems and components that are the best fit, at the best cost. To support this goal a strong research, development, test and evaluation program is needed to identify, evaluate and certify the right commercial systems for fleet use. NAVSEA, in cooperation with ONR and NAVFAC, are developing tools needed to accomplish this goal. The Technology Identification and Assessment Process (TIAP) was developed to provide a structured process to develop and maintain an environmental equipment knowledge base. Information gained on commercial technologies is stored in a Technology Matrix that is continually reviewed and revised. NAVSEA is investigating ways to use the matrix to down select equipment and systems to standardize systems and equipment provided to the fleet in new ship design and backfit.

NAVSEA, ONR and NAVFAC have also teamed to develop a formal process for identifying and prioritizing Navy ship and ship-to-shore environmental technology gaps based on current and future regulations, and current and future fleet operation requirements. The Needs process integrates input from personnel at all levels, and from different Navy organizations and customers. It provides a living database of prioritized needs for NAVSEA, ONR, NAVFAC and others to use in allocating and leveraging dwindling environmental RDT&E resources.

BASE CAMP 2025

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Beginning with a ground breaking meeting at MIT's Edicott House in 2005, the Army began to rethink the design principles of the base camp sustainability by envisioning Base Camp 2025 to support Army in the future. In the intervening period, the relevance of the ideas they developed increased from highly relevant to incredibly relevant. For example "On July 25, 2006 Al-Anbar commander and U.S. Marie Corps Maj. Gen. Richard Zilmer submitted an MNF-W priority 1 request pointing to the hazards inherent in American supply lines, and noted that many of the supply convoys on Iraq's roads (up to 70%, by some studies) are carrying fuel. Much of that fuel isn't even for vehicles – it's for diesel generators used to generate power at US bases et. al. In response, the document requests alternative energy solutions to power US forward operating bases… and the U.S. military looks like it will act on the request." (Defense Industry Daily, August 23, 2006)

This discussion will argue that the time has come to consider base camps as a component system of the system war fight. On the basic research side, the conversation will call for the application of habitation sciences as an enabler for the science and technology developers to allow the Army to project power around the globe in a manner that builds sustainable operational capability. Program interests cover a broad spectrum of habitation issues including scalability, modularity, interaction with terrain and climate, and force protection, broadly defined in the context of systems inhabited by soldiers. On a broader note, the discussion will challenge the audience to consider the potential of design optimizations of the entire base camp systems, modularity, and re-use. The discussion will end with examples of a few suggested capabilities for Base Camp 2025.

KEYNOTE ADDRESS
DIAGNOSTIC TOOLS FOR ASSESSING DIFFUSION IN FRACTURED SEDIMENTARY ROCKS: REMEDIATION IMPLICATIONS

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Field-focused research aimed at improved investigation methods and understanding organic contaminant source zones and plumes in fractured porous sedimentary rock, began in 1997 when intensive field studies were initiated at a TCE contaminated site on steeply dipping and faulted sandstone in California. This multidisciplinary program now includes three additional contaminated sites: a Wisconsin site on flat-lying sandstone and two sites in Ontario on flat-lying dolostone. These four sites have important differences so that they are broadly representative of sedimentary rock but they have several aspects in common, including: much site data from earlier conventional investigations, contamination initially caused decades ago by DNAPL flow into the rock, sufficient matrix porosity (2-20%) to allow diffusion-driven chemical mass transfer between fractures and the rock matrix causing strong influence on contaminant behavior, deep contaminant occurrence (greater than 350 m below ground surface at one site), and each site receives much regulatory attention. Based on the field results obtained to date, a general conceptual model for the formation and long-term evolution of source zones and plumes in fractured porous sedimentary rock is proposed. This conceptual framework is being tested and the various processes quantified through field investigations using a suite of high-resolution techniques referred to as the "Discrete-Fracture Network (DFN) investigation approach." This then allows application of DFN numerical models, such as FRACTRAN and HydroGeoSphere, to simulate flow and contaminant transport at these sites. Conventional field methods used in fractured rock studies are poorly suited for plume delineation or characterization because of mass storage in low-permeability zones, and therefore, new methods are being developed and used at all of the sites. In the DFN approach, emphasis for data acquisition is on data specific to individual fractures and the fracture network as well as the rock matrix blocks between fractures so that the characteristics and interactions between these two domains can be discerned. Rock core contaminant analyses at each site confirm that nearly all of the contaminant mass now resides in the low-permeability rock matrix although the down-gradient transport occurs in numerous, well-connected fractures. Therefore, quantifying the interactions between these domains is essential for improving the understanding of individual site conditions regarding prediction of plume behavior and responses to site remediation, which in sedimentary rocks, are strongly dependent on back-diffusion.

APPLICATION OF MOLECULAR TOOLS AND MICROARRAYS TO OPTIMIZE BIOREMEDIATION

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This talk will focus on the application of molecular tools to optimize the bioremediation of environmental contaminants by naturally occurring microorganisms. Bioremediation is a process that often relies upon mixed microbial communities to catalyze important biodegradation pathways. In order to understand and optimize bioremediation processes, there is a need to develop rapid, quantitative, non-culture based molecular and microbiological assays for use in characterizing microbial communities and activities in subsurface soils. This talk will describe a variety of detection and quantification techniques applied to both genes and transcripts of interest, including quantitative PCR (qPCR), reverse transcription qPCR, and whole-genome microarrays for comprehensive comparative genomics and transcriptomics. In addition, application of phylogenettic microarrays for identification of specific organisms in complex communities will be described. We have applied these tools to both laboratory samples for fundamental research, and to field samples for applied research in bioremediation of conventional and emerging contaminants.

COMPOUND SPECIFIC ISOTOPE ANALYSIS FOR ASSESSMENT AND QUANTIFICATION OF REMEDIAL PERFORMANCE

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Compound Specific Isotope Analysis (CSIA) – the characterization of stable isotope compositions of individual contaminant compounds dissolved in groundwater, sparked major advances in the application of isotope geochemistry to contaminant hydrogeology and remediation technologies. Stable isotope fingerprints, based first on carbon isotopes, and then rapidly incorporating hydrogen and chlorine isotope information as well, now provide diagnostic tools to identify and differentiate sources of contamination. Perhaps the most significant impact of CSIA however has been that it provides a powerful new method for investigation of remediation potential at contaminated sites, for both abiotic and biotic degradation processes. For organic contaminants such as chlorinated solvents, petroleum hydrocarbons and fuel additives, degradation can involve large and reproducible kinetic isotope effects, producing systematic changes in the delta 13C values of the residual contaminant as the light (12C) versus heavy isotope (13C) bonds are preferentially degraded, resulting in isotopic enrichment of the residual contaminant in 13C. This change in isotope ratios, or fractionation, can provide a diagnostic signal of degradation that can be used to monitor and evaluate performance. In many cases, stable isotope fractionation during degradation can be modeled by a simple Rayleigh distillation model that relates the change in observed stable isotope compositions to the extent of degradation in the system. Stable isotope analysis can therefore provide a direct indication of the effects of degradation on specific contaminants, as well as a novel independent means to quantify the extent of degradation and estimate degradation rates. A series of recent field studies will be highlighted that illustrate the range of potential applications for CSIA – including both examples of the use of CSIA for quantification of biodegradation, and the application of CSIA for diagnosis of degradation mechanisms.

THE ESTIMATION CONTAMINANT MASS DISCHARGE IN UNCONSOLIDATED GRANULAR AND FRACTURED ROCK AQUIFERS

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The estimation of water and solute mass discharges (or mean fluxes) from a distribution of measured local water and solute mass fluxes over transects in porous or fracture rock aquifers is a crucial task in assessing contaminated site parameters such as source strength, risk to potential receptors, compliance with legal standards and performance of remediation efforts. Moreover, the quantification of the uncertainty/reliability associated with these estimates is of no less importance and can be used for monitoring network optimization, risk assessment and decision making.

Typically, local flux measurements in unconsolidated porous flow formation are considered scalars. Discharge interpretations over transects are complicated by the fact that flux measurements are (1) not necessarily on a regular monitoring network, (2) produce skewed histograms for small to moderate amounts of data, and (3) statistically correlated in space. The first can result from preferential sampling patterns; however, various histogram declustering/updating techniques exist to address this complication. Asymmetric distributions are known to invalidate classic t-statistics based symmetric confidence intervals, but recent developments show a cubic transformation of the t-statistic allows for the estimation of asymmetric confidence intervals. The third issue invalidates the requirement of data independence in (2), but this can be compensated for by defining an equivalent number of independent data as a function of the data correlation structure using geostatistical principles. Thus, knowing the geostatistical properties of flux data from preliminary measurements, the cost of additional flux measurements can be directly related to a predicted reduction in estimated discharge uncertainty.

A local flux measurement in fracture rock represents the magnitude of the local discharge vector, whereas direction is defined in accordance to the fracture plane. For irregular monitoring patterns declustering weights can be applied to scale the magnitudes of local vectors, which are then geometrically added over a transect to estimate the contaminant or water discharge vector. Hemispherical projection plots are used to graphically represent the distributions of measured fracture orientations and local flux vectors as well as to estimate the direction of the ambient hydraulic gradient. The bootstrap method is considered for the quantification of the multivariate (magnitude plus direction) uncertainty space about the discharge estimate.

DIAGNOSING ABIOTIC DEGRADATION

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The abiotic degradation of chlorinated solvents in ground water can be difficult to diagnose. Under current practice, most of the "evidence" is negative; specifically the apparent disappearance of chlorinated solvents without any accumulation of vinyl chloride, ethane, ethylene, or acetylene. A better approach is to associate abiotic degradation with adequate quantities of an active iron mineral such as iron(II) sulfide or magnetite. Iron(II) sulfide can be estimated in sediment as acid volatile sulfide and magnetite can be recognized from the magnetic susceptibility of the sediment.

DIAGNOSTIC TOOLS FOR PERFORMANCE EVALUATION OF INNOVATIVE IN-SITU REMEDIATION TECHNOLOGIES AT CHLORINATED SOLVENT CONTAMINATED SITES

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The performance of remediation systems at chlorinated solvent contaminated sites has been historically evaluated using point measurements of dissolved contaminant concentrations in aquifers. Such an approach has significant limitations that may greatly impact the evaluation of technology effectiveness at contaminated sites. First, detailed monitoring of contaminant plumes in granular geologic media has shown that the distribution of dissolved contaminants is often spatially complex due to several factors including spatial variability of contaminant distribution in the subsurface source zone, variability of groundwater flow rate and direction, and variation in water level. This means that it may often be difficult for typical groundwater monitoring efforts, to determine where the majority of the contaminant mass is migrating and whether remediation systems are effective in reducing contaminant migration. Second, at sites with complex geologies, the evaluation of in-situ technology performance is even more complicated by contaminant migration through discrete fractures.

To better evaluate the success of in-situ remedial systems at chlorinated solvent contaminated sites, a set of diagnostic tools has been used at three hydrogeologically distinct sites employing in-situ chemical and biological treatment technologies over the past several years. These diagnostic tools include technology- and geology-specific tools, as well as those that can be used widely irrespective of the type of technology or site conditions. Mass flux measurement was used as a technology-wide metric of overall system performance since it has the potential to clearly demonstrate a reduction in the rate of contaminant mass release from the treated zone. Innovative technology-specific tools and geology-specific tools were tested for a real-time diagnosis of remedial technology success. Specific tools evaluated included rock core sampling, isotopic fractionation, molecular tools and integrated conventional techniques.

This presentation will provide an overview of the diagnostic tools evaluated during this ESTCP (ER-0318) funded study, as well as a synthesis of the results from the three sites as they pertain to comparability across different geologies. In addition, results from a comparative evaluation of various methods for measuring mass flux will be presented.

KEYNOTE ADDRESS
PANEL: ENVIRONMENTAL IMPACT OF FUEL USE IN ENGINES

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The FAA Office of Environment and Energy is responsible for addressing aviation environmental challenges such as noise, local air quality and greenhouse gas emissions. In response to stakeholder concerns about fuel supply security and the need for technologies to enable environmentally sustainable aviation growth, FAA has launched the Commercial Aviation Alternative Fuels Initiative (CAAFI) in partnership with airlines, airports, and manufacturers. The CAAFI process seeks to aggregate and communicate data needed by sponsors and stakeholders to allow them to develop and deploy alternative fuels for aviation use in the earliest possible timeframe. In this manner the CAAFI seeks to ensure an affordable and stable supply of environmentally progressive aviation fuels. A key part of the CAAFI process is the creation of roadmaps for its four process teams (R&D, Certification/Qualification, Environmental and Business and economics). The R&D and Environmental Roadmaps, highlight in place and planned efforts in those areas by CAAFI sponsors and Stakeholders. Efforts include FAA environmental life cycle, emissions measurement and fuel feasibility assessments. They also include current efforts and plans of the multiple government agencies and as well as private industry. These roadmaps, to be updated in November at CAAFI's annual meeting should be particularly useful to SERDP to assist in targeting the closure of R&D gaps in its proposed programs.

UPDATE OF FINDINGS ON SERDP MILITARY AIRCRAFT EMISSIONS RESEARCH PROGRAMS

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The demands on air travel and aviation support for commerce and military activities have been increasing over the past couple of decades and are not expected to slow down in the future. Contribution of military aircraft emissions to overall atmospheric burden of particulate matter and gaseous pollutants remains one of the major uncertainties in air quality research and air resources management. Emissions data on military aircraft are scarce due, in part, to technical complexity of aircraft emissions sampling and measurement. Under the auspices of SERDP, our team has been conducting research to probe particulate and gas emissions since 2005 using an array of in-situ and remote-sensing technologies for fixed- and rotating-wing aircraft currently used by U.S. military. These include T56, T33, T700-GE-700, T700-GE-701, and T700-GE-701C engines. Field measurements of the emissions were conducted; from the data sets emissions indices of various pollutants were derived. Formation of ultrafine and nanoparticles in exhaust plumes was observed under ambient conditions. Accurate measurements of particulate composition and size distribution were determined to a large extent by sampling conditions; sensitivity in measurement results appears to be particularly dependent on those that exist at low engine power conditions when emissions of air toxics were also at its maximum. Research needs for better emissions measurement and sampling were identified. We will update the community on our findings for the research program.

AN OVERVIEW OF GEA TAPS COMBUSTION TECHNOLOGY AND ALTERNATE FUELS

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GE Aviation (GEA) has been actively involved in the development of low-emissions propulsion engine combustion systems since the early 1970s under company as well as government sponsorship in many initiatives including NASA Experimental Clean Combustor, E^3, AST, UEET, Propulsion 21, and the U.S. Air Force and Navy supported TVC, an innovative high-performance low-emissions combustion concept which is covered in a SERDP presentation by Dr. Joseph Zelina. This presentation presents summary of the technology development and validation of TAPS, a Twin-Annular Premixing Swirl combustion system as applied to two engine classes, namely the CFM56 and GE90. The emissions characteristics of TAPS are compared with the most current technology (Low-Emission Combustor) LEC and pre-LEC combustors in certified commercial propulsion engines. The GEnx engine uses a TAPS technology based combustion system. Further TAPS technology enhancements continue for the LEAP56 propulsion system.

Interest in use of alternate fuels stems mainly from concerns about fuel availability, cost and potential impact of aviation on global warming. This presentation will cover GEA's involvement in recent "drop-in" replacement fuels from various sources including Fischer-Tropsch liquid from coal, bio-fuels and an innovative highly efficient bio-oil conversion to Jet fuel, a DARPS sponsored project.

LOW EMISSIONS COMBUSTION SYSTEMS USING TRAPPED VORTEX AND HIGH-G METHODS

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Meeting the conflicting requirements of higher compression ratio, high heat release rates, reduced weight and low emissions, with improved engine durability requires revolutionary combustion systems. For example, advanced combustors are becoming shorter and utilize non-metallic materials to meet the required thrust-to-weight ratio goals. Shorter residence times in the combustion chamber may reduce the NOx emissions, but the CO and UHC emissions then increase due to inadequate reaction time. Also, the unburned fuel could escape the combustion chamber and continue to burn in the turbine machinery, which could pose a series of rotating component challenges such as vane and blade durability, and pressure loss increases. Novel approaches to combustion system design have been underway to investigate compact combustion systems. These systems employ improved mixing devices, geometric features to expand combustor operability, special flame-holding mechanisms to cope with increased through-velocities, and dramatic changes to combustor flowfields to reduce combustor size and pollutant emissions. The term ultra-compact combustor (UCC), has been used to describe these novel concepts which will combine the combustor with the compressor exit guide vanes and the turbine inlet guide vanes. The UCC builds from previous work with trapped vortex combustor (TVC) work. This presentation focuses on vortex-stabilized combustor technologies that can enable the design of compact, high-performance combustion systems that can be used as a main combustor or an inter-turbine burner (ITB), where a secondary combustor is placed between the high pressure and low pressure turbine. The presentation highlights success stories with the trapped vortex combustor (TVC) in two specific real-world applications, and then presents the high-g UCC combustion technology under development for main combustors and ITBs.

NASA FUNDAMENTAL AERONAUTICS LOW-EMISSIONS COMBUSTION RESEARCH PROGRAM

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The NASA Fundamental Aeronautics Subsonics Fixed Wing and Supersonic Projects are conducting research to reduce emissions for both subsonic and potential supersonic aircraft. Reducing emissions from aircraft are critical in order to reduce the environmental impacts of aviation. Research objectives and plans for both of these projects will be presented. Highlights from some of the research areas will also be presented illustrating some of the research progress made to date. The research that NASA is also performing on Alternative Fuels for aircraft application will also be presented.

THE EFFECT OF HEAVY-DUTY DIESEL EMISSION STANDARDS ON U.S. ARMY GROUND VEHICLES

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Current 2007 compliant, on-road, heavy-duty diesel engines will not readily integrate into Army ground vehicles without modifications based on Army fuel and lubricant compatibility issues, Army mobility requirements, and Army cooling requirements. Such modifications include the removal of aftertreatment devices and the exhaust gas recirculation (EGR) system in-conjunction with recalibration of the engine for Army operating requirements. This presentation will provide an overview of Army ground vehicle requirements and the impact of current on-road emission standards on such vehicles.

KEYNOTE ADDRESS
STATE OF DISCRIMINATION TECHNOLOGY IMPLEMENTATION ON ACTIVE MMRP REMEDIATION PROJECTS

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Much effort and funds have been spent in the research and development of munitions or explosives of concern (MEC) discrimination technologies, i.e.: the ability to non-intrusively distinguish between buried munitions and non-munitions related items, typically by advanced analysis of geophysical data. Some results have shown promise. However, the experience in the National Association of Ordnance and Explosive Waste Contractors (NAOC) membership has generally been the implementation of discrimination technologies on active Munitions Management Response Program (MMRP) remediation projects has been slow and inconsistent. This presentation discusses instances where discrimination has been implemented, and identifies issues that have arisen that will be common to the MMRP remediation process in the future. These issues identify potential barriers that must be overcome for successful technology transfer of discrimination research and development. Such potential barriers include: method selection, method accuracy and reliability, ease of use, liability, landowner understanding, and regulator acceptance. Discrimination has the potential to enormously reduce the time and cost of the MEC remediation process by reducing the number of "digs". Thus, more ground could be covered for any given budget, and more land will be cleaned up. It should be recognized, however, that it is very likely that the discrimination process will also entail certain increase in risk by leaving some mis-discriminated ordnance items behind. Quantifying this risk, and reducing it to an acceptable level to contracting agencies, regulators and stakeholders is a major challenge to the successful transfer of this technology. A process must be initiated where certain discrimination techniques must be either "accepted" or "not accepted" by government contracting agencies, then the contractor and project manager can concentrate on the proper application of the accepted discrimination technique, rather than on re-proving its validity. If the method is properly applied, significant cost and time savings will be realized, and the residual risk will have been pre-identified and accepted by all stakeholders, prior to project commencement.

ESTCP DISCRIMINATION STUDY PILOT PROGRAM OVERVIEW

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The Environmental Security Technology Certification Program (ESTCP) was appropriated funds by Congress in FY 2006 for the "Development of Advanced, Sophisticated Discrimination Technologies for UXO Cleanup." In response to this direction, ESTCP carried out a Discrimination Pilot Program to (1) test and validate detection and discrimination capabilities of currently available and emerging technologies on real sites under operational conditions and (2) investigate how discrimination technologies can be implemented in cleanup operations in cooperation with regulators and program managers.

The pilot study was conducted on approximately 15 acres of a mortar target at former Camp Sibert, AL, and consisted of several combinations of data collection platforms and analysis approaches. Magnetometer and electromagnetic induction (both time- and frequency-domain) sensor data were collected with established and emerging sensor systems. In each data set, the Program Office team identified a complete list of anomalies that exceeded a threshold consistent with detecting the target of interest, a 4.2-in mortar, to a target depth of 11 times its diameter (117 cm). These *detection* lists may contain not only the mortars sought, but also munitions debris, cultural debris and geologic responses that must be discriminated.

In the *discrimination* phase of the program, each analysis team ordered target lists by likelihood of clutter to ordnance. The objective was to identify with high confidence items that could be safely left in the ground. Nearly 1,500 anomalies were intrusively investigated and documented allowing analysts at the Institute for Defense Analyses to assess the performance of each team. At the conclusion of this assessment, the target data were provided to the analysis demonstrators to serve as a resource for self-analysis and refinement of their algorithms and approaches.

This presentation will outline the overall program plan, provide highlights of the individual data sets, and set the stage for follow-on presentations by individual analysis teams.

COMPARISON OF MAGNETOMETER AND TEM DISCRIMINATION PERFORMANCE AT CAMP SIBERT

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We compare the discrimination performance of commercial of the shelf (COTS) magnetometer and time domain electromagnetic system (TDEM) sensors at the ESTCP discrimination study site at Camp Sibert, AL. The discrimination objective was to ensure 100% excavation of potentially hazardous 4.2" mortars. Surveys in different modes, using different sensors were conducted, including a standard EM-61 survey, Marine Towed Array Detection System (MTADS) magnetometer and EM-61 surveys, and an EM-63 cued interrogation survey. The EM data were inverted alone and cooperatively with the magnetometer data using the UXO-Lab software package. All survey modes met the primary objective of 100% discrimination performance, but there were significant differences in the false alarm rate (FAR), time required to survey and process the data etc.

Static dipole fits to the magnetometer data were generally are accurate to better than 20 cm in location and 5 cm in depth. The size of the dipole moment was diagnostic of 4.2" mortars and was used to prioritize the dig-sheet. For the EM-61 cart data, an instantaneous amplitude polarization model was fit to each anomaly. Due to the lack of attitude information and the separation between adjacent transects, positions and depths were significantly less accurate than the magnetometer data. A size-related feature and one related to the time-decay of the primary polarization were diagnostic. The limited data-quality of this survey required conservative discrimination thresholds, resulting in a high FAR. The MTADS EM-61 data were collected along both N-S and E-W transects. The higher data density and signal to noise ratio (SNR) of these data resulted in more accurate positions and depths, and significantly smaller spread in the polarization tensor parameters of 4.2" mortars. Consequently, more aggressive discrimination thresholds were set, reducing the FAR significantly. By using the magnetometer positions and depths as constraints in the MTADS inversions, the recovered polarization parameters displayed even less spread and improved discrimination performance. Additionally, by removing the depth ambiguity, we could constrain the fits to many marginal anomalies that could not be reliably inverted using the MTADS data alone. For the EM-63 data, the size of the primary polarization and it's time-decay properties were diagnostic of 4.2" mortars. An aggressive discrimination strategy was possible whereby all 4.2" mortars could be recovered with no false-alarms.

In terms of cost and performance, the magnetometer data appear to be the most attractive for this large object discrimination scenario. The EM-63 has the lowest FAR, but took significantly longer to collect, process, and interpret.

ANALYSIS OF ESTCP DISCRIMINATION STUDY DATA FROM CAMP SIBERT, AL

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In support of ESTCPs Discrimination Study Pilot Program at Camp Sibert, Alabama, SAIC analyzed electromagnetic and magnetic data collected in standard survey modes. The principal objective was to discriminate targets of interest (TOI) from non-TOI by identifying features that help separate the classes of objects, thereby reducing false alarms without impacting recovery of TOI.

We analyzed Marine Towed Array Detection System (MTADS) magnetometry data, MTADS EM61 MkII array data, MTADS GEM array, and standard cart EM61 MkII survey data. Typical industry standard equipment and procedures for navigation, geo-location, and data recording and reduction were used by others to collect the data.

The anomaly characterization algorithms used for our analysis assume a dipolar source and derive the best set of induced dipole model parameters that account for the spatial variation of the signal as the sensor is moved over the object. The model parameters are target X,Y,Z location, three dipole response coefficients corresponding to the principle axes of the target, and the three angles that describe the orientation of the dipole. The size of the target can be estimated from the sum of the targets' response coefficients. The shape can be estimated from the relative magnitudes of the three coefficients. In addition to utilizing the best-fit unconstrained model parameters, we constrained the model to reflect parameters obtained from labeled TOIs and compared fitted parameters.

We will discuss the inversion approach adopted for each data set, identify the features that were optimal based on the labeled training data, and report results of blind testing.

NEW DIGITAL GEOPHYSICS TECHNIQUES FOR UXO CLASSIFICATION

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The purpose of this project is to apply and evaluate classification algorithms on the Camp Sibert data set, to demonstrate that some non-UXO items can be classified correctly and hence left in the ground, while maintaining a given level of detection performance. The performance of seven different sensor combinations is compared. Moreover, for each combination, after the labeled data are defined for training, classification results will be obtained using two different classification approaches. The first approach will build a supervised classifier, using only the labeled training data, not accounting for the context provided by the unlabeled data. The second approach will be semi-supervised, this exploiting the unlabeled data when building the classifier. In addition to using the labeled data as provided by ESTCP to design the algorithms, for the EM61-magnetometer sensor combination we employ active learning to define the set of signatures for which acquisition of the associated labels would be most informative for classifier design. In this talk, the results of this study are reported.

BUD RESULTS FROM THE ESTCP DEMONSTRATION SITES

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Berkeley UXO Discriminator (BUD) is an optimally designed active electromagnetic system that not only detects but also characterizes UXO. The performance of the system is governed by a target size - depth curve. BUD was designed to detect UXO in the 20 mm to 155 mm size range for depths between 0 and 1.5 m, and to characterize them in a depth range from 0 to 1.1 m. The system incorporates three orthogonal transmitters and eight pairs of differenced receivers. BUD is mounted on a small cart to assure system mobility. System positioning is provided by state-of-the-art real-time kinematic global positioning system (RTK-GPS) receiver. The system has two modes of operation: (1) search mode, in which BUD moves along a profile and exclusively detects targets in its vicinity providing target depth and horizontal location, and (2) discrimination mode, in which BUD, stationary above a target, from a single position, determines three discriminating polarizability responses together with the object location and orientation.

While UXO objects have a single major polarizability coincident with the long axis of the object and two equal transverse polarizabilities, scrap metal has three different principal polarizabilities. This description of the inherent polarizabilities of a target is a major advance in discriminating UXO from irregular scrap metal. Our results clearly show that BUD can resolve the intrinsic polarizabilities of a target, and that there are very clear distinctions between symmetric intact UXO and irregular scrap metal. Moreover, UXO have unique polarizability signatures thus distinctions can me made between various UXO. Field surveys at the Yuma Proving Ground in Arizona and Former Camp Sibert in Alabama showed excellent detection and characterization results within the predicted size-depth range.

KEYNOTE ADDRESS
PERSPECTIVE AND RESEARCH ON BIOLOGICAL TREATMENT OF PERCHLORATE FOR POTABLE WATER

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Perchlorate has become a concern to drinking water utilities due to its presence at low concentrations in many raw drinking water sources. In the last few years a number of effective treatment methods have been employed for removal of this contaminant from raw water, and amongst the most useful is biological treatment. However, biological treatment of drinking water is not readily accepted in the United States. Whereas some countries are focused on production of biologically stable water and distribution of this water with no secondary disinfectant, the approach in the United States has been to provide a secondary disinfectant and essentially ignore biological stability of the water. Each approach has strengths and weaknesses, but little has been done to quantitatively measure the value and understand the risks and benefits of each approach. In the case of biological treatment of perchlorate, this results in a reluctance to use an effective treatment method. This and the fact that the treatment method is anaerobic only compounds acceptance concerns, especially that associated with possible carry-over of pathogens into the distribution system. Separately, water utilities in the United States are also addressing disinfectant by-product (DBP) formation and concerns associated with increased regulatory focus on DBPs. Formation of DBPs in the distribution system would be minimized if biologically stable was present in the distribution system, and at least partly for this reason there has been some growing interest in the use of biologically active filters in the U.S. For biological treatment of potable water to gain wider acceptance, a generally understood and widely accepted set of tools needs to be developed to allow for measurement and management of biological treatment and biologically stable water in a wide variety of circumstances, including perchlorate treatment. The prime technical issues and state of knowledge associated with biological treatment of perchlorate will be presented, as well as research activities to better understand and address these concerns.

STATE-OF-THE-ART OF BIOLOGICAL REACTORS FOR WELLHEAD TREATMENT OF PERCHLORATE

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The use of biological reactors (bioreactors) in treating perchlorate from groundwater wells is proving to be highly effective and economically attractive. Bioreactors are engineered systems that maintain biodegradative microorganisms at high densities, allowing for adequate contact with contaminant-laden groundwater. An electron donor (i.e., acetic acid, lactic acid, ethanol) is provided to the bioreactor where, under anoxic conditions, it is used in the denitrification/perchlorate reduction process. The byproducts of the process are nitrogen gas, chloride ions, carbon dioxide, heat generation, and additional biomass.

For well-head treatment, the state-of-the-art bioreactors are classified as fixed-film systems. The prevalent fixed-film systems include both packed bed and fluidized bed bioreactors. The packed bed bioreactors utilize bed materials ranging from coarse sand to plastic sheet or ring packing, and operate in a one-pass flow operation. The fluidized bed bioreactors are typically filled with sand or granular activated carbon, with the media hydraulically fluidized by a recirculating water stream.

Over the past ten years, numerous laboratory and field-pilot studies have been conducted to evaluate different bioreactor configurations and operational conditions for the effective treatment of perchlorate-contaminated groundwater. From these evaluations, several full-scale, fixed-film biological treatment systems are now operating throughout the United States. Currently, there are five full-scale bioreactors treating perchlorate-laden groundwater with concentrations ranging from approximately 2 to 400 ppm (to below 4 ppb), at flowrates from 200 gpm to 5000 gpm. In addition, both the packed bed and the fluidized bed bioreactors have recently been approved by the California Department of Public Health as permittable technologies for the treatment of perchlorate in drinking water. Currently, two pilot/full-scale systems are being demonstrated for the treatment of 50 ppb perchlorate laden-water to potable water standards.

This presentation will focus on the chronological development of fixed-film bioreactors for wellhead perchlorate treatment, the fundamental design principles, the operational advantages and concerns, and the economics of their operation. In addition, case histories detailing specific treatment conditions, performance, and lessons learned for the currently installed full-scale fixed-film bioreactor systems and the novel drinking water bioreactor systems will be presented.

LARGE-SCALE DEMONSTRATION OF PERCHLORATE REMOVAL USING WEAK BASE ANION RESIN

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Applied Research Associates, Inc. (ARA) will conduct a large-scale ion exchange demonstration for wellhead treatment of perchlorate. The ion exchange process being demonstrated was jointly developed by ARA and the Purolite Company (patent pending). The process employs a perchlorate-selective, regenerable weak base anion (WBA) resin (D-4170) made by Purolite. At low pH (<7), functional groups on WBA resins are ionized ($R\text{-}NH_3^+$) and capable of performing anion exchange. However, at pH (>7), the resin functional groups lose a proton and are uncharged ($R\text{-}NH_2$), which permits rapid and complete regeneration with very high chemical efficiency.

The WBA resin technology has been successfully demonstrated in pilot demonstrations for both groundwater remediation and drinking water treatment at two sites under ESTCP project *Perchlorate Removal, Destruction, and Field Monitoring Demonstration (ESTCP Project No. ER-0312).* At Redstone Arsenal in Huntsville, Alabama, perchlorate in groundwater was effectively reduced from 2,200 ppb to less than 4 ppb during a 15-week demonstration. Multiple regenerations were conducted without loss of performance. The volume of spent regenerating solution was limited to 0.02% to 0.05% of the treated water volume. Spent regenerating solution was effectively treated by either biodegradation or a zero-discharge scavenging process.

At well site F17 in Fontana, California, perchlorate in the water was reduced from 6-8 ppb to below the reporting limit (<0.10 ppb) of the analytical method. Treatment rates up to 4 gpm/ft^3 were demonstrated. The volume of spent regenerating solution was limited to less than 0.05% of the treated water. Perchlorate in the spent regenerating solution was reduced to below detectable limits using the zero-discharge scavenging process.

The scope of the large-scale demonstration includes engineering, installation, start-up, and permitting of a 1,000 gpm drinking water treatment system. Carollo Engineers will perform engineering and construction management for this demonstration. Selection criteria for the demonstration site included a well site in the Rialto-Colton basin with perchlorate contamination greater than 50 ppb. Due to the regenerable nature of the WBA process, this technology has the potential to reduce operation and maintenance costs 30 to 50% compared to single-use ion exchange processes. The cost savings for the WBA technology become greater as perchlorate contamination in the source water increases.

SURFACTANT-TAILORED GRANULAR ACTIVATED CARBON FOR PERCHLORATE REMOVAL FROM GROUNDWATER

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Pennsylvania State University developed the surfactant-tailored GAC technology and has collaborated with USFilter to improve its marketability. This technology involves pre-treating, or tailoring, GAC with alkyl quaternary ammonium or other active nitrogen groups. This tailoring extends the bed life of GAC for adsorbing perchlorate up to 35 times longer than conventional, non-tailored GAC. Based on this finding, tailored GAC has the potential to be very cost competitive against established perchlorate treatment technologies. Teamed with ARCADIS G&M, Inc., demonstrations have been conducted on pilot-scale field tests and by additional Rapid Small-Scale Column Tests in order to make more robust and broadly applicable. This presentation will discuss the extent to which a surfactant-tailored granular activated carbon has removed perchlorate from the Fontana, CA groundwater studies. It will also identify bed volumes to breakthrough at this site and at other sites; and it will present results of rapid small scale column tests.

PERCHLORATE REDUCTION USING THE HYDROGEN-BASED MEMBRANE BIOFILM REACTOR

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Among the most challenging pollutants for the remediation of groundwater are those whose common characteristic is that they are chemically oxidized. They include perchlorate along with nitrate, selenate, chromate, chlorinated solvents, and radionuclides. For all of the oxidized contaminants, microbiological reduction leads to innocuous products. For example, perchlroate is reduced to H_2O and Cl^-ion. This presentation describes a novel (hydrogen-based) biological treatment process called (Membrane Biofilm Reactor (MBfR)) able to reduce perchlorate and other oxidized pollutants. Hydrogen gas (H_2) is fed to the inside of hollow fiber membranes, diffuses through the membrane wall, and is then consumed by biofilm bacteria that use it as their electron-donor substrate while reducing one or more of the oxidized pollutants as their electron-acceptor substrate. This presentation addresses the conceptual basis for the MBfR, advantages of using H_2, and a status report on field testing of the MBfR. In addition, selected results for other oxidized contaminants, such as TCE will be provided. In short, the direct use of H_2 makes it possible to bio-reduce one or several oxidized contaminants to harmless or easily removed products.

ION EXCHANGE TECHNOLOGY FOR PERCHLORATE REMOVAL AND RECOVERY

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Ion exchange is one of the most promising treatment technologies for removing low levels of ClO_4^- at a relatively high flow rate. Currently, the most commonly used ion-exchange techniques include (i) selective but non-regenerable throwaway resins for single use, (ii) nonselective or low-selective resins with sodium chloride brine or acid regeneration, and (iii) selective and regenerable strong-base anion exchange resins with ferric chloride and acid regeneration. Each of these treatment options has its own advantages and disadvantages, and selection of these options depends upon, among other factors, the site-specific groundwater chemistry, the perchlorate contaminant concentration, secondary waste generation, and cost effectiveness. This presentation will discuss the fundamental mechanisms and selectivity issues related to ion exchange so as to better understand the pros and cons of various treatment options and the conditions under which the best treatment option is utilized. The presence of competing ions such as sulfate and nitrate will greatly diminish the treatment efficiency of non-selective or moderately selective anion-exchange resins, particularly for treatment of perchlorate contaminated water at low concentration levels. On the other hand, resins with high-selectivities show merits under these circumstances. Regeneration of highly-selective ion-exchange resins gives additional benefits, in which not only sorbed perchlorate can be quantitatively destroyed or recovered by eluting with as little as one bed volume of the regenerant solution but also the production of secondary wastes is minimized during treatment. The perchlorate recovery technology turns an environmental remediation liability into the reutilization of a valuable material and additionally allows for recovering trace quantities of perchlorate in water or sediments for isotopic forensics studies.

KEYNOTE ADDRESS
LIFECYCLE ENVIRONMENTAL IMPACTS ON CLOSE COMBAT MUNITIONS

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Project Manager Close Combat Systems (PM CCS) manages over 190 separate programs that meet Army Transformation goals of providing smaller, lighter, more lethal munitions to ensure increased mobility and countermobility to the full spectrum of Army forces. PM CCS managed munitions include: Networked Munitions, Countermine and EOD equipment, Demolitions, Non-Lethal equipment, Grenades, Pyrotechnics, Shoulder Launched Munitions, Counter IED equipment.

Implementing new munitions or making changes to existing munitions is a lengthy and difficult process. Rapid acquisition is necessary and requires a new paradigm to meet the changing needs of the warfighter. PM CCS has an aggressive in-stride modernization strategy that applies acquisition reform and product modernization principals to its management of newly assigned legacy munitions, some decades old. PM CCS relies on a strong relationship with RDTE community, as well as industry to meet performance and cost goals and to transition technology to the field.

PM CCS now emphasizes environmental, safety and occupational health (ESOH) lifecycle impacts as paramount when developing and implementing new weapon systems and as the driver for change in several existing systems. PM CCS responsibilities range from the development of a new munition to the production through use and/or demilitarization. PM CCS has targeted materials with adverse environmental and human health effects for potential replacement in weapon systems and has supported or endorsed programs to address these materials. Several projects are in place to find a replacement for perchlorate in weapon systems, most notably in the M115A2 Ground Burst Projectile Simulator and M116A1 Hand Grenade Simulator and the M117/M118/M119 Booby Trap Simulators. Environmentally benign colored smoke formulations are also necessary for continued soldier training, to include black, red, violet, and yellow smokes as well as a new system design for these munitions.

ENVIRONMENTAL LIFECYCLE INITIATIVES IN PYROTECHNIC MUNITIONS

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This presentation will discuss the many ammunition design and process initiatives taken to improve the environmental posture of pyrotechnic components and munitions throughout their lifecycle. This presentation will cover the environmental lifecycle considerations and actions taken on pyrotechnic munitions from concepts, R&D and production implementation. The speaker will cover tools and techniques used, program planning, process flow charts, testing and qualification requirements and team dynamics to making these initiatives a munitions and environmental success.

INTELLIGENT DESIGN OF ENERGETIC MATERIALS

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Energetic materials present a unique opportunity for the Army to incorporate green chemistry principles and "Materials by Design", or computational prescreening, into the design process to improve the Army's environmental footprint. As the Army is responsible for the entire life cycle of the materials from synthesis through demilitarization, potential benefits of "greener" energetic materials that maintain performance standards are far-reaching.

With this in mind, the U.S. Army Research Laboratory and collaborators have utilized significant advances in the development of computational methods to predict properties related to performance, sensitivity, and environmental impact of a new material.

Here we present a framework for integration and validation of emerging methods and models for energetic materials design. This presentation will discuss research into predictive toxicological modeling, progressive standards for conducting environmental health assessments, high-level efforts to foster a fundamental green chemistry ethic, and projects to seek alternative energetic materials.

ELECTROCHEMICAL SYNTHESIS OF ENERGETIC MATERIALS

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Electrochemistry is an important tool for synthesis of a variety of chemicals including organic compounds. To date only a small number of studies have investigated the use of electrochemistry to synthesize energetic materials. In some cases electrochemistry may provide a viable alternative to traditional chemical synthesis. When properly applied electrochemical reactions can be controlled precisely and can replace starting materials such as oxidizers. Further work in this area could lead to green synthesis routes for many energetic materials. A description of electrochemical synthesis, overview of past work, possible avenues for future work, and an example of recent work on oxidative nitration reactions will be presented.

BIOSYNTHESIS OF PRECURSORS TO ENERGETIC MATERIALS

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Microbial synthesis can offer an alternative to problematic chemical conversions. Two examples include 1,2,4-butanetriol (BT), which is the precursor to butanetriol trinitrate (BTTN) and phloroglucinol (PG), which is the precursor to 1,3,5-triamino-2,4,6-trinitrobenzene (TATB). Catalytic hydrogenation of malic acid requires elevated temperatures, elevated hydrogen pressures, and leads to a complex mixture of products from which BT is difficult to purify. Stoichiometric reduction of esterified malic acid employs sodium borohydride and leads to formation of multiple tons of borate salt byproducts for every ton of BT produced. By contrast, microbial synthesis of BT from xylose uses atmospheric pressure, temperatures not exceeding 37°C, and avoids generation of large quantities of salts as byproducts. Chemical synthesis of PG is similarly problematic. This multistep route uses TNT as the starting material, requires a stoichiometric oxidation employing carcinogenic chromium (VI), and generates large quantities of salts as byproducts. A microbial synthesis of PG has now been elaborated that enables this TATB precursor to be produced in a single step from glucose. Beyond BTTN and TATB, the use of microbial synthesis to produce precursors to other energetic materials will be discussed.

NEW HIGH-NITROGEN COMPOUNDS AS POSSIBLE REPLACEMENTS FOR RDX AND HMX

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The U.S. Army Ordnance Environmental Program seeks to reduce environmentally hazardous components utilized in the formulation and manufacture of rocket and missile propellants, explosives, and pyrotechnics. The focus of Army efforts is to find an environmentally benign high explosive composition that meets/exceeds the performance requirements for RDX, HMX, and TNT compositions.

RDX and TNT are commonly used because they are effective, cheap, and because current munitions and productions facilities are designed to use/make them. Over the years, many energetic materials have been developed to go beyond the performance of RDX, but to date, few to none have proven successful, except in niche applications.

The High-Nitrogen materials being explored theoretically by ARL and synthesized by LMU Munich present a great number of performance advantages over current energetics. They are 75-100% nitrogen and usually <10% carbon, resulting in combustion produces that are mainly nitrogen (N_2) and water. This means that the carbon footprint of these materials is extremely low. When utilized in Gun Propellants, high nitrogen materials have been shown to actually harden the gun barrel, extending the life of the gun barrel by more than 10 times. This is both a force enabler (fewer barrel changes), and a lifecycle environmental benefit. The fewer gun barrel changes, the less barrels need to be made, transported, and replaced. Early indications are that high nitrogen materials have favorable environmental and toxicity characteristics as well. The end result is an eventual reduction or elimination of potential contamination of soil and ground water on training/testing ranges and in Ammunition Plants and Depots by replacing current energetics with less/non-toxic energetics.

KEYNOTE ADDRESS
APPLICATION OF SURROGATE APPROACHES TO MANAGEMENT OF PUBLIC AND PRIVATE LANDSCAPES

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Management targets, whether species, assemblages, or ecosystem processes, often are difficult and expensive to measure directly. Surrogates can be defined as scientifically reliable, cost effective substitute measures of management targets. Management strategies at all scales use surrogates to maximize information return while minimizing expenditures of time and money. Surrogates are implicit or explicit in virtually all coarse filter, mesofilter, and fine filter strategies. Surrogate approaches assume that measurement or management of a surrogate facilitates broader inferences or management. Enabling conditions for use of surrogates typically include clear management objectives, criteria for success, triggers for changes in management, and opportunities for adaptive management. Several statistical, repeatable, and scientifically based methods exist to identify different types of surrogates, such as umbrella species and indicator species, a priori. I will illustrate these approaches using data from federal lands in the Great Basin. Ultimately, reliability of a surrogate is a testable hypothesis to be confronted with data. The ability of a potential surrogate to explain observed patterns and to predict conditions in new locations or time periods must be evaluated before surrogates are implemented. Whether a given surrogate is adequate depends on the decision making context and the reversibility of management actions.

USING SURROGATE SPECIES IN MANAGEMENT AND CONSERVATION

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Surrogate species and groups of species are used in management and conservation as proxies for broader sets of species when the number of species of concern is too great to consider them all individually. But surrogate approaches are not applicable to all situations. I discuss how the nature of the ecological system, the objectives and scale of management, and the level of knowledge available influence the decision about using a surrogate approach. I use species-area relationships to define a "surrogate zone" in which the approach may be most effective. Using a surrogate approach necessarily entails a tradeoff between management tailored to individual species and less precise practices that may apply to a broader array of species. Ultimately, the use of a surrogate approach depends on the level of uncertainty that is acceptable to conduct management or conservation activities.

BEHAVIORAL INDICATORS AS AN UMBRELLA APPROACH TO WILDLIFE CONSERVATION AND MANAGEMENT

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Fox squirrels and gray squirrels and their use of food patches illustrate how foraging behaviors can reveal the factors determining the distribution and abundance of two species from scales as small as meters to scales spanning continents. The feeding choices of Amani sunbirds reveal what trees must be saved to insure the success of this endangered bird whose world encompasses just 5 km^2 and whose very existence is threatened by other sunbird species of the Arabuko-Sokoke Forest, Kenya. Mule deer in Idaho reveal through their vigilance and habitat choices the whereabouts and threats of mountain lions. And, this knowledge of prey for their predators has allowed the first census and sightings of snow leopards in the Everest Range since the 1960s. Behaviors can and should be codified into tools for conserving habitats, species and communities. Behaviors have three potential advantages for assessing habitat quality, monitoring wildlife, and managing species of conservation concern. First, they provide a leading indicator of habitat quality. In response to degradation a species feeding behaviors should change predictably before this degradation manifests as changes in mortality and births. Second, vigilance behaviors and feeding behaviors at natural or experimental food patches can provide repeatable and inexpensive methodologies that complement more traditional techniques for monitoring population sizes and habitat suitability. Third, elusive and rare species such as large carnivores can often be monitored or detected through the more easily measured behaviors of their more abundant prey. Squirrels, sunbirds, deer, and large cats will show how these behavioral indicators emerge by joining theories of adaptive feeding with practical field techniques.

THE NORTHERN SPOTTED OWL AS AN UMBRELLA SPECIES FOR LATE SERAL FORESTS OF THE PACIFIC NORTHWEST

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Forest planning on public lands in the Pacific Northwest is largely based on the conservation strategy for the northern spotted owl (*Strix occidentalis caurina*), a species listed as threatened under the Endangered Species Act. Given a species-centric focus to forest planning, it is important to evaluate the extent to which management practices focused on the viability of spotted owls provide for other species dependent on late seral forest. My talk will address the adequacy of owl management practices as a surrogate for the habitat requirements of other unmeasured species. My approach is to independently develop conceptual models of spotted owls and late seral forest ecosystems. The owl model outlines the linkages between processes and key resources that collectively influence owl survival and reproduction. The late seral forest model includes the underlying physical and biological processes that produce the observed structural and compositional attributes that characterize this forest stage. The effectiveness of a species-based approach to forest management is assessed by comparing their conceptual models. The degree to which resources required for a viable owl population overlap the resources that characterize late seral forest measures the extent to which a single species can act as a surrogate for an entire ecosystem.

INSTALLATIONS AS ISLANDS: ISLAND BIOGEOGRAPHY AND ARCHIPELAGO APPROACHES TO SPECIES AND HABITAT MANAGEMENT

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DoD installations exist either as true islands or, most often, as "islands of habitats" within landscapes of distinct habitats and ecosystems, i.e., within "seas" of alternative land use types. Thus, optimal programs for managing their species and habitats requires a hierarchical, multi-scale approach that is informed by fundamental patterns and processes of many fields, including island biogeography. Rather than providing generic solutions to all management challenges, modern theory and tools of island biogeography can provide key insights for those attempting to design strategic field studies aimed at investigating both key patterns and their underlying processes.

I will use exemplary cases studies from our previous research, including those of island biogeography of vertebrates inhabiting true islands and those of montane forests, fragmented old-growth forests, and prairie dog towns, along with regional to global scale studies of geographic range collapse in endangered species. I will then illustrate how such investigations, i.e., those that focus on both large-scale patterns and their associated biogeographic processes, can be used to strategically manage public lands and their associated species and ecosystems. This will include demonstrations of how to estimate critical size, isolation or connectivity (including design of corridors), and landscape context (i.e., influence of adjacent lands) for managing the fundamental biogeographic processes—immigration, population survival (extirpation), and evolution.