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Green Remediation Best Management Practices: Site Investigation and Environmental Monitoring

A fact sheet about the concepts and tools for using best management practices to reduce the environmental footprint of activities associated with assessing or remediating contaminated sites

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EPA's *Principles for Greener Cleanups* outline the Agency's policy for evaluating and minimizing the environmental footprint of activities involved in cleaning up contaminated sites.[1] Best management practices (BMPs) of green remediation involve specific activities to address the core elements of greener cleanups:

- Reduce total energy use and increase the percentage of energy from renewable resources.
- Reduce air pollutants and greenhouse gas emissions.
- Reduce water use and preserve water quality.
- Conserve material resources and reduce waste.
- Protect land and ecosystem services.

Overview

The need for site investigation is common to cleanups under any regulatory program. Investigative activities can occur at all points in the cleanup process, from initial site assessment through waste site closeout. A site investigation generally is undertaken to:

- Confirm the presence or absence of specific contaminants.
- Delineate the nature and extent of environmental contamination.
- Identify contaminant sources.
- Provide data for assessing potential risk to human health or the environment.
- Gather data for determining if a remedial or removal action should be taken.
- Identify site characteristics affecting remedial design, construction or operation.

Site investigation as well as long-term environmental monitoring typically involve a range of technologies and techniques to gather field measurements and collect analytical samples of soil and groundwater and often surface water, sediment, soil gas or indoor air. Investigation also may involve searching for underground storage tanks, drums or other buried objects, or evaluating demolition material containing asbestos, lead-based paint or other toxic products. Many of the same techniques and technologies may be used in later stages of a cleanup to evaluate ongoing performance of a remedy; determine the need for any modification to a remedial system; or track factors influencing anticipated closeout of a cleanup project. At certain points, site investigation and environmental monitoring both rely on data analysis or verification conducted by offsite laboratories.

Water monitoring at the New Idria Mercury Mine Superfund site in California involves use of time-interval sampling devices powered by solar energy. Collected sampling data are transmitted via satellite to a website accessible by project staff. This approach supplies a renewable source of onsite energy and reduces the frequency of staff visits to this remote site. Ongoing investigation of this site led to removal actions in 2011 and 2015.

Project Planning

Integration of green remediation BMPs early during the project design phase will help reduce cumulative environmental footprints of a cleanup. The BMP integration process involves selecting BMPs most suitable for the site's unique contamination scenario, potential remedies and anticipated site reuse. BMPs to be considered when planning a site investigation include:

- Schedule activities for suitable seasons to reduce the amount of fuel needed for heating or cooling equipment and supplies.
- Select service providers, product suppliers and analytical laboratories from the local area and consolidate the service and delivery schedules.

The ASTM *Standard Guide for Greener Cleanups* outlines a process for identifying, screening and selecting BMPs to minimize the environmental footprint of site-specific cleanup activities.[2]

- Identify local sources of trucks and machinery equipped with advanced emission controls and of cleaner alternative fuels.[3]
- Identify the nearest facility to be used for disposing of hazardous waste.
- Establish electronic networks for data transfers, team decisions and document preparation, and select electronic products through tools such as the Electronic Product Environmental Assessment Tool (EPEAT).[4]
- Reduce travel through increased teleconferencing and compressed work hours.
- Select facilities with green policies for worker accommodations and meetings.
- Integrate sources of onsite renewable energy to power hand-held devices, portable equipment, and stationery monitoring systems.

Product and service acquisitions provide opportunities to integrate BMPs when planning a site investigation. New contracts awarded by EPA for remediation environmental services at Superfund sites, for example, now require contractors to explore and implement strategies to reduce energy and water usage, promote carbon neutrality, promote industrial materials reuse and recycling, and protect and preserve land resources.[5]

Development of a well-conceived dynamic sampling plan can help assure that data truly representing a site are collected at the project onset, consequently minimizing remobilization of field crews and equipment. Systematic planning, which is a critical component of optimized strategies for investigating hazardous waste sites, involves identifying key decisions to be made, developing a conceptual site model (CSM) to support decision making, and evaluating decision uncertainty along with approaches for actively managing that uncertainty. The CSM combines analytical data with historical information to identify data gaps and allows for refinement as additional data become available.

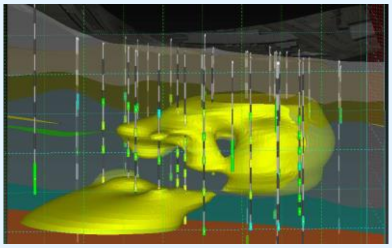
Field Activities

Fewer field mobilizations typically lead to reduced fuel consumption and associated air emissions and often less disturbance to the land and local ecosystems. BMPs that can help minimize mobilization during site investigation and environmental monitoring include:

- Use in situ data loggers to monitor water quality parameters and water levels, as an alternative to frequent sample collection or physical measurement.
- Install solar-powered telemetry systems to remotely transmit logging data.
- Use dynamic work plans involving real-time field measurements, which can immediately provide data to help determine the next activity during a given sampling event.

Technologies for collecting real-time data are typically non-invasive or minimally invasive; examples include:

- Direct sensing equipment such as the membrane interface probe, laser-induced or X-ray fluorescence sensors and cone penetration tests.
- Immunoassay, colorimetric and other field test kits to screen soil and groundwater contaminants.
- Portable vapor/gas detection systems using photoionization or flame ionization for screening purposes.
- Soil gas surveys involving instruments such as SUMMA canisters to determine the presence, composition and distribution of volatile organic compounds (VOCs) in the vadose zone and water table.
- Portable gas chromatography/mass spectrometry for analyzing fuel-related compounds and VOCs in soil and groundwater.
- Ground penetrating radar, magnetometers, and other geophysical survey instrumentation to locate metal objects and delineate disposal areas.



At Well 12A within the Commencement Bay-South Tacoma Channel Superfund site in Washington, high-resolution characterization data and 3D visualization were used to develop a robust CSM. The CSM helped quantify contaminant mass in soil and groundwater, delineate discrete treatment zones and prioritize remediation design approaches. This refined, minimally invasive strategy for site characterization significantly accelerated site cleanup, saving an estimated $1 million in treatment costs. Additionally, use of passive sampling devices for long-term monitoring avoided generation of purge water while saving more than $100,000 in the first five years of monitoring alone.

Other BMPs typically applying to site investigation and environmental monitoring focus on conserving and protecting water and using environmentally friendly products, such as:

- Deploy passive sampling devices, which involve no well purging.
- Use supplemental techniques to map the source and extent of a contaminated groundwater plume, such as analyzing core samples taken from rapid-growing trees.
- Employ a closed-loop graywater washing system to decontaminate trucks or machinery.
- Steam-clean or use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment.
- Use plastic sheeting or portable wash pads to contain and collect decontamination fluids and prevent their entrance into storm drains or groundwater.

- ♦ Treat potentially contaminated purge water through use of technologies such as activated carbon filtration prior to discharge to storm drains or waterways.
- ♦ Quickly restore disturbed areas of vegetation serving as stormwater controls.
- ♦ Use biodegradable lubricants and hydraulic fluids.
- ♦ Choose groundwater monitoring equipment made of noncorrosive material.

Yet other BMPs concern design and installation of groundwater wells to be used for sampling and monitoring. Relevant BMPs include:

- ♦ Design investigative wells in ways that allow for maximum reuse during remediation or to meet water demands of ongoing or future site activities.
- ♦ Integrate a horizontal well network where feasible as an alternative to a greater number of vertical wells.
- ♦ Choose a multi-port sampling system in wells intended for monitoring, to minimize the total number of wells needing to be installed.
- ♦ Use minimally invasive drilling techniques such as direct-push or sonic technology whenever feasible to reduce drilling duration, avoid or minimize use of water, and prevent or reduce generation of cuttings and associated disposal of investigation-derived waste (IDW).
- ♦ Use dual tube technology during drilling, which allows collection of continuous soil cores and later reuse of the same boreholes for site investigation, remediation or monitoring.
- ♦ Use an electric top drive system to minimize use of hydraulic fluids when rotary drills are used.
- ♦ Segregate and screen drill cuttings for potential use such as onsite backfill if allowed under applicable state or federal cleanup programs; use of an organic vaporizer analyzer may significantly improve or accelerate the screening process.
- ♦ Use environmentally friendly pipe dope for drill pipes and casings.
- ♦ Emplace mats to limit ground surface disturbance at drilling locations.

Use of passive diffusion bag (PDB) sampling techniques in 56 wells at the Joint Base Lewis McChord Superfund site in Washington significantly reduced the environmental footprint of sampling activities. When compared to using low-flow sampling techniques in other wells, PDB use achieved a:

- 54% reduction in energy used.
- 55% reduction in greenhouse gas emissions.
- 63% reduction in criteria pollutants.

The footprint reductions were driven by demonstrated reductions in the amount of field time, which leads to fewer vehicle miles traveled and associated fuel consumption. A two-person team was able to sample 12 of the wells per day when using PDBs but only five wells per day if using low-flow methods.[6]

Materials and Waste Management

Site investigation and environmental monitoring activities typically involve using an assortment of manufactured products such as personal protective equipment (PPE), sample containers and routine business materials. BMPs concerning green purchasing of such products include:

- ♦ Choose products with recycled and biobased contents such as agricultural or forestry waste instead of petroleum-based ingredients.
- ♦ Choose products, packing material and equipment that have reuse or recycling potential.
- ♦ Choose products manufactured through processes involving nontoxic chemical alternatives.

A comprehensive list of tools and resources for materials management decision-making is available in EPA's *Sustainable Materials Management in Site Cleanup* engineering issue paper.[7]

IDW generation and management frequently account for a significant portion of the environmental footprint of site investigation. IDW includes drill cuttings, well purge water, spent carbon from filtration equipment, reagents used with environmental field test kits, non-reusable or contaminated PPE and solutions for decontaminating non-disposable PPE and equipment. Reducing the volume of generated IDW will decrease the need for waste containers such as 55-gallon storage drums and for treating IDW onsite or disposing of it at a waste facility. Recommended BMPs to reduce the volume of routine waste or IDW, while often decreasing materials consumption, include:

- ♦ Compress the number of days needed for a given round of sampling.
- ♦ Minimize the need for disposable single-use items such as plastic bags.
- ♦ Designate collection points for items that are locally recyclable, such as metal, plastic or glass containers and paper or cardboard.
- ♦ Select test kits that generate less waste, such as soil samplers with reusable handles for coring syringes.
- ♦ Collect hydraulic fluids and lubricants for recycling at suitable local facilities.
- ♦ Maximize use of environmentally friendly additives such as ascorbic acid to preserve or stabilize collected samples, if compatible with target analytes and anticipated analytical methods.[10]

Use of EPA's *Spreadsheets for Environmental Analysis*[8] to estimate the footprint of cleanup activities at the Grants Chlorinated Solvents Plume Site indicated that laboratory analysis (including sample collection and preparation and offsite transport) accounted for approximately 10% of the energy- and carbon dioxide (equivalent)-related footprint of operating, maintaining and monitoring the remedy.[9] As a result, optimization of the sampling program is underway to reduce the frequency of sample collection and analysis.

Laboratory Support

Use of fixed-base laboratories for analytical services may significantly contribute to the environmental footprint of site investigation and environmental monitoring when considering offsite as well as onsite contributions. Green remediation BMPs concerning analytical support include:

- Use a mobile laboratory or portable analytical equipment, particularly for screening purposes and when rapid analytical results are needed.
- Specify EPA analytical methods involving procedures that need relatively low volumes of samples or solvents and generate less waste, such as solid phase micro extraction (SPME), pressurized fluid extraction, microwave extraction, and supercritical fluid extraction when possible. For example, SPME is a single-step process using little or no solvents and taking up to 70% less time.
- Choose fixed laboratories demonstrating a strong commitment to environmental performance, such as routine use of management practices identified by the International Institute for Sustainable Laboratories.[11]

Attributes of high-performing laboratories include:

- Optimized ventilation rates in light of the mixing factor of particular pollutants being removed from the laboratory; simply maximizing ventilation results in unnecessary energy expenditure (and may diminish safety conditions).
- Use of energy recovery devices and systems to reduce energy consumption for interior heating and cooling.
- Use of energy-efficient equipment for ventilation, refrigeration and lighting.
- Use of energy consumption controls such as programmable thermostats, window glass tinting and ample insulation.
- Cooling tower operation with a high concentration ratio, which increases the number of times water circulates before it is bled off and discharged; cooling accounts for an estimated 30-60% of water used in multipurpose laboratories.[12]
- Integration of solenoid valves, timers or other controls on equipment used in processes requiring flowing water.
- Use of less hazardous materials; for example, toluene may substitute for benzene as a solvent.
- Implementation of purchasing strategies and inventory controls that minimize disposal of excess materials.
- Recycling of liquid waste; for example, non-halogenated solvents may be used offsite as fuel blending feedstock.
- Recycling of materials such as clean glass or plastic containers, drums, electronics, and steel or aluminum instrumentation.

Acquisition of laboratory services supporting remedial investigation at the Diaz Chemical Corporation Superfund site in Holley, New York, included specifications meeting EPA greener cleanup policy. The selected laboratory employs practices such as:

- Recycling all paper products and shipping materials.
- Using energy-efficient lighting.
- Maintaining a paperless reporting and invoicing program.
- Minimizing waste through use of EPA-approved microscale methods.

Similar procurement requirements for subcontractor drilling activities reduced the investigative footprint by:

- Using direct-push technology.
- Deploying trucks equipped with advanced emission controls.
- Minimizing waste through waste oil and scrap recycling.

This fact sheet provides an update on information compiled in the December 2009 "Site Investigation" fact sheet (EPA 542-F-09-004), in collaboration with the Greener Cleanups Subcommittee of the EPA Technical Support Project's Engineering Forum.

To view BMP fact sheets on other topics, visit CLU-IN Green Remediation Focus: www.clu-in.org/greenremediation.

References

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