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Environmental Fact Sheet

CONTROLLING THE IMPACTS OF REMEDIATION ACTIVITIES IN OR AROUND WETLANDS

Remediation of hazardous waste sites is accomplished under both the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund). The remediation process at RCRA and Superfund sites uses a variety of technologies on hazardous constituents in the air, surface and ground water, soils, and sediments. Some of these technologies, involve either removal or containment, and can be performed *in situ*. Others are implemented through excavation, extraction, and in some cases, on-site treatment and replacement. During clean-up operations that involve a surface or subsurface reconfiguration of a site, pre-existing conditions can be disturbed, and the disturbance may result in physical and chemical changes to the site and to the adjacent areas. In some cases, the site or the adjacent areas may contain wetlands. Special considerations are warranted when remediation sites are in or adjacent to wetlands because clean-up efforts have the potential to negatively impact a wetland's ecosystem and its functions.

This fact sheet provides technical information that can be used to protect wetlands from the potential negative impacts caused by the more common technologies used to remediate hazardous waste sites.

Waste Excavation and Surface Reconfiguration

At many sites, contaminated sediment and debris are excavated, treated on site (through incineration or soil washing) and returned to the excavated area (e.g., back into a landfill). In other scenarios, all wastes removed from the site are disposed of somewhere else on- or off-site.

Various surface reconfigurations can result from site activities. Elevations can be lowered and slopes may be regraded following excavation. To minimize water contact with exposed contaminants and to contain spills, water may be rechanneled or diverted from existing drainage patterns and dikes, and embankments may be built. Waste piles may be created to temporarily store contaminated media for treatment, or to store treated media to be deposited on-site. Stabilization methods to minimize migration of hazardous contaminants by reducing surface infiltration to ground water can include clay caps or other ground cover systems. All of these changes can affect shallow ground water and the flow rates and chemical makeup of precipitation runoff.

Impacts from Surface Reconfiguration and Excavation

Remedial technologies that require surface reconfiguration will usually result in some degree of environmental change to surrounding areas if proper precautions are not taken. Impacts to nearby wetlands from remediation activities at hazardous waste sites can result from sedimentation due to increased erosion rates, contamination from fugitive dust emissions, and disruption of the water table due to the creation of earthen structures.

Erosion

When construction activities bare or create slopes, surface erosion from rainfall and flowing water can result. Even on well-designed slopes, some soil loss will result from certain mechanical and chemical processes that transport sediment and contaminants downslope into nearby low-lying areas, including wetlands. Mechanical processes include sheet, rill, and gully erosion. Colloidal erosion and erosion rates of some soils are influenced by chemical processes.

The velocity of a raindrop has been measured to be about 20 miles per hour, and impact energy increases with drop size. Mechanical processes of soil erosion begin when falling rain impacts the soil at high velocities and detaches soil particles from the ground. The loosened soil particles can then be transported by shallow overland (or sheet) flow of rainwater across the land surface causing sheet erosion.

Progression of sheet erosion can eventually lead to the development of small shallow channels in the soil, called rills. Rill erosion occurs as a portion of the overland flow becomes concentrated into rills. As the channelized flow increases in velocity, soil particles are detached by the shearing energy of the runoff, and by slumping due to channel undercutting (e.g., headward erosion). If slopes are steep and long, and runoff velocity increases, larger and deeper channels or gullies can develop. Erosion in gullies can have a correspondingly higher rate of erosion, but rill and sheet erosion (over bare slopes) can cause the loss of more soil. While larger particles may be transported only short distances, small particles such as clay and silt may become suspended in water and transported for large distances until they settle out of the water column in a quiescent setting.

The potential for erosion also depends on the type of material exposed at the surface. Soils high in silt or very fine sand generally have the highest potential for erosion relative to other soil textures. At hazardous waste remediation sites, clay materials are often used to form low-permeability barriers separating waste and moisture. Clays can be eroded through mechanical processes such as those described above, but the rate at which some clays erode is highly dependent on their pore water chemistry. Erosion rates in unsaturated montmorillonite clays used in embankments and landfill caps can vary by a factor of 200 due to pore water chemistry at the surface. Uniformly maintaining the optimum moisture content during construction of embankments and caps can control the erosion caused by pore moisture chemistry.

Erosion of fine soil materials can also occur from *slaking*, which occurs when soil aggregates break down from immersion in water (e.g., due to cation exchange), and are transported by running water. Slaking is common in clay soils.

Another form of erosion occurs through dispersivity or colloidal erosion. As water runs over the surface of fine soils, the texture of the soil contributes to uneven flow and mixing. Colloidal particles, or clay and organic particles that are so small that they tend to remain suspended in water, are washed out of the surface soil. Since colloidal particles are probably the primary carriers of chemical compounds in the soil (i.e., contaminants), the chemistry of the runoff can change. For example, the runoff may become more alkaline or acidic.

Wetlands can be disrupted as a result of increased deposition from changes in rates of soil erosion, and due to chemical changes in runoff. Although natural rates of deposition in wetlands are generally beneficial, increased depositional rates in wetlands due to human activities can accelerate changes of such a magnitude that some organisms cannot adapt. Rapid changes may raise the bottom of the wetland, and alter water depth, circulation, light, and temperature. The disappearance of some species and the potential entrance of other species may cause a chain reaction that completely alters the original ecologic association. In addition, flood storage capacity of a wetland may be reduced or lost.

Chemical changes in runoff that enters wetlands can similarly affect sensitive plant and animal species, and result in ecologic upset. Chemical changes also create the potential for significant reductions in contaminant or nutrient removal efficiencies from the water, and the accumulation of toxic materials.

Erosion Control

There are many sources of information concerning the control of erosion. Engineering handbooks on this topic have been developed by government entities such as the Soil Conservation Service, the U.S. Army Corps of Engineers, and the Federal Highway Administration. Topical areas such as runon and runoff control, dam construction, and open channel hydraulics may provide additional design information.

Preventative measures for erosion control are listed below

- As a precursor to erosion control measures, estimate the average soil loss annually from sheet and rill erosion for the disturbed area. The Universal Soil Loss Equation (USLE) from the U.S. Department of Agriculture can be used for such purposes, and to determine whether there is an appropriate vegetative cover to protect exposed areas. The USLE is composed of factors that estimate the inherent erosion potential at the site, and potential reductions of soil losses through compensation factors such as erosion control.
- EPA recommends that landfill covers, for example, be designed such that the rate of soil erosion is no more than 2 tons per acre per year as calculated by using the USLE. This number should be adjusted according to the potential effects of the runoff on wetlands.

- Implement contoured grading to break up long, steep slopes and to reduce the velocity of runoff before the flows have a chance to form gullies. For example, performance standards to protect wetlands in Florida require that slopes are no steeper than a three to one (horizontal to vertical) ratio.
- Construct crown ditches at the tops of slopes or interceptor ditches perpendicular to slopes to capture and convey water to the ends of the slope or into reinforced (rip rap) channels leading downslope and away from the wetland.
- Construct retaining walls of resistant material, such as sand bags or grout bags.
- Seed or plant vegetative cover that is suited to the site's soil and climatic conditions so that it can protect soil from raindrop impacts and provide soil stability.
- Apply porous geotextile fabrics or erosion control mats to slopes to reduce erosional impacts while still allowing surface drainage and infiltration. Nonporous geomembranes and liners to be used in water retainment systems, such as ditches and ponds, and as siltation devices.
- Increase slope stability and temporarily reduce erosion potential by adjusting soil moisture for optimal compaction during fill emplacement.
- Coordinate activities during construction to prevent unnecessary erosion. For example, compacting soil immediately after grading it will reduce soil erosion.
- Alter the soil water chemistry of surface clays to reduce their erosion potential. Calcium montmorillonite clays, for example, can be treated with sodium salts such as Na_2CO_3.
- Design a storm-water catch basin to equalize and neutralize runoff.

Fugitive Dust Emissions

Fugitive dust can become a significant factor during remediation of hazardous waste sites where surface construction activities are involved. Wind-induced erosion of unprotected soil and such activities as earth-moving or stockpiling, excavation, and moving vehicles, can suspend fine particles into the atmosphere. These particles may be widely dispersed, and may settle over nearby areas depending upon precipitation and wind-speed.

In a dry spell, fugitive dust emissions may cover the leaves of wetland vegetation, disabling or reducing their photosynthesis efficiency. Loss of some wetland vegetation may occur due to excessive dust emission in a dry season.

Fugitive Dust Emission Control

Impacts from fugitive dust emissions on wetlands can be prevented by spraying water or special dust-control formulations over the construction area(s). Basic control strategies can be adopted to minimize fugitive dust emissions. For remediation activities at hazardous waste sites, these strategies can involve engineering and operational controls that are similar to soil erosion controls, but limit the amount of dust that may become suspended. To reduce fugitive dust emissions the following techniques may be considered.

- *Road Maintenance.* Paved roads within the hazardous waste sites can be cleaned by water flushing to dis lodge road dust. Cracked or abraded roads can be resurfaced with non-erodible materials to minimize dust accumulation. Wet unpaved roads to suppress dust.

- *Traffic controls.* To minimize dust emission, site coordinators could apply a practical limit to the use of unpaved roads to low-weight vehicles, require lower travel speed, and require washing of excavation/moving equipment prior to leaving the site.
- *Stabilization.* Disturbed surfaces and/or storage piles could be stabilized by: (1) wet suppression (similar to wetting unpaved roads) to agglomerate small particles into larger particles; (2) vegetative cover to reduce wind velocity and bind soil particles; and (3) covering the disturbed surface with hay mulch.
- *Dust barriers.* Create windscreens of fabric, wood, or other light-weight materials to reduce surface winds or to trap particles downwind of disturbed areas, waste storage piles, and construction activities.

Pumping and Treating Ground Water

Pumping contaminated ground water to the surface for treatment is a common clean-up technology at many hazardous waste sites and RCRA facilities. Pump-and-treat technology extracts contaminated ground water and treats it on the land surface. The treated water is then discharged either on- or off-site, or reinjected into the soil.

Generally, surface activities at hazardous waste sites or shallow burials of waste are more likely to contaminate ground water in the uppermost aquifers. Contaminated ground water from the upper aquifers also recharges into surface streams, creeks, rivers, and wetlands. Aquifers from which the ground water is withdrawn can be composed of consolidated bedrock or soft, unconsolidated sediments. These characteristics influence the rate and likelihood of contamination, as well as the extent to which the subsurface responds to disturbances by various remedial technologies.

Depending upon the site-specific circumstances, ground water that has been pumped to the surface and treated may either be discharged on the surface (e.g., to a stream or publicly owned treatment work), or it can be reinjected into the subsurface. Frequently, the ground water will be reinjected into the same aquifer from which it was withdrawn to enhance further ground-water recovery.

Impacts from Pumping

Overpumping for the removal of contaminated ground water without adequate recharge can result in two potentially deleterious effects on wetlands: dewatering and land subsidence. The two effects are not independent from one another. In the first case, removal of ground water at a greater rate than it can be replenished can cause a significant drop in the water table, which is called *drawdown.* Since the water table in wetlands is usually at or near the surface, drawdown of the local water table can severely dewater wetlands that depend on a shallow water table for moisture. Even in situations in which wetlands are fed by surface water sources, dewatering as a result of drawdown can occur as surface water is lost to the subsurface.

In the second case, excessive drawdown of the water table or lowering of piezometric levels as a result of fluid extraction can trigger land subsidence. Subsidence typically occurs very slowly over a wide area, particularly in areas that contain thick layers of soils with high concentrations of clay, which is typical of some wetland environments. Consequently, subsidence introduces potential long-term impacts to wetlands.

Subsidence as a result of ground water pumping is widely documented. As underground pore fluids separating individual soil particles are removed, underground stresses are redistributed, and the effective pressure from the overburden increases. In response to these new stresses, soil particles adjust and consolidate into a smaller volume. As the effects from this phenomena move through the subsurface, the surface expression may result in subsidence over a large area. The potential for subsurface strata to compress increases as the piezometric head is lowered. Subsidence from ground water withdrawal is generally lenticular-shaped at the surface, with decreases in elevation that can range from a few millimeters in stiffer underground formations to several meters in soft unconsolidated soils. Organic and peat soils commonly found in wetland environments are especially prone to large amounts of settlement.

The long-term effects of subsidence in wetlands can result in changes to wetland hydrology. As elevations and slopes are altered, stream courses, stream gradients, and the amount of surface flow into the wetland can be increased, decreased, or reversed to upset the delicate water balance of the wetland. An increase in the volume or velocity of flow into the wetland can lead to increased flooding and sediment deposition, potentially smothering benthic organisms. Conversely, a decrease in flow to the wetland may result in desiccation and loss of function. Similarly, wetlands along large water bodies that experience subsidence may become susceptible to permanent flooding, and develop into deepwater habitats. The extent of flooding depends upon the differences in elevation between the water body and the wetland, including tidal influences. In cases where wetlands become deepwater habitats, wetland functions and species that use air as the principle medium would be replaced by functions and species that primarily use water.

Control of Water Loss

The surest way to prevent water loss and subsequent subsidence of wetlands is to prevent over-extraction of ground water. The water table will not drop and subsidence will not occur if the recharge rate equals the rate of fluid withdrawal.

When implementing a pump-and-treat operation, the following factors should be considered to avoid unnecessary impacts to wetlands:

- Optimize pumping rates and quantities based on a water-balance relationship between the natural (or artificial) recharge rate and the maximum rate of withdrawal.
- Estimate tolerance limits for drops in the water table or piezometric level that will not cause adverse impacts to the wetland.
- Estimate tolerance limits for the magnitude of subsidence that can occur without significant adverse impacts on the wetland for various drops in the water table.
- Estimate the maximum amount of subsidence that could occur based on planned pumping rates, and aquifer and soil characteristics for given

drops in water levels and surface elevations.

- Place an impervious barrier, such as a slurry wall, between the pumping or dewatering system and the wetland.
- Monitor ground-water levels and surface elevations.

Landfill Capping and Runoff Diversions

Installation of impermeable cover systems on top of RCRA or CERCLA landfills may cause additional surface runoff from the landfill area. The associated diversion berms/ditches also are sometimes routed differently than pre-existing conditions. A general decline in the water table for an adjacent area may occur from preventing direct seepage or by recharging a shallow water table. If the adjacent area happens to be a wetland, a decline in the wetland's water table may result from caps and runoffs.

Impacts from Routing Runoff Control Ditches in a Landfill Cover System and Control

Major activities involved in the construction of landfill cover systems include earth-moving and surface reconfiguration. Impacts on wetlands from such activities at landfills are addressed under "Waste Excavation and Surface Reconfiguration."

Construction of landfill cover systems also may include construction of runoff control/diversion ditches. These systems usually cause some degree of change in the shallow water table. For example, if the runoff control ditches are diverted away from the adjacent wetland where the water enters a stream at a distant location, quite a bit of water from the diversion ditches will be lost to evaporation. Obviously, more water loss to adjacent wetlands will occur from a large landfill, and less will occur from a small one.

Measures to minimize adverse impacts involve routing stormwater runoff from the ditches through an emergent pool for sedimentation, and erosion control prior to discharge into the low-lying marsh or wetland areas.

More Information

RCRA Hotline: Accepts calls Monday-Friday, 8:30 a.m. to 7:30 p.m. EST. The national, toll-free number is: (800) 424-9346; TDD (800) 553-7672. In Washington, D.C., the number is: (703) 412-9810; TDD (703) 412-3323.

Wetlands Protection Hotline: Accepts calls Monday-Friday, 9:00 a.m. to 5:30 p.m. EST. The national, toll-free number is: (800) 832-7828

RCRA Docket: For copies of other documents on solid waste issues, or to receive a catalogue of solid waste documents, write: RCRA Information Center (RIC), U.S. Environmental Protection Agency, Office of Solid Waste (OS-305), 401 M Street, SW, Washington, D.C. 20460.

U.S. Environmental Protection Agency
401 M Street SW (OS-305)
Washington, DC 20460