Table A-11.A. Electrical resistance heating

Technology	Electrical resistance heating	Electrical resistance heating is a polyphase electrical technique used to resistively heat soil and mobilize and volatilize LNAPL. Electrodes are typically installed using standard drilling techniques to carry the electrical power to the subsurface. Electrical current flows within the pore water from each electrode to the other electrodes out of phase with it. The soil matrix is heated due to the soil's resistance to electric flow. Generally imparts uniform heating to the treatment zone. Mobilized LNAPL is recovered from extraction wells, and volatilized LNAPL is collected via vapor extraction wells. Because the presence of water in the pore spaces is required for current to flow, the technology is limited to temperatures of 100C, or the boiling point of water.	
Remediation process	Physical mass recovery	Yes	Heating reduces viscosity of LNAPL and increases mobility and recoverability.
	Phase change	Yes	The heating volatilizes the LNAPL.
	In situ destruction	No	Not generally important. LNAPL may undergo thermal degradation or hydrous pyrolysis but with limited effect.
	Stabilization/ binding	No	N/A
Objective applicability	LNAPL saturation	Yes	Enhances LNAPL fluid flow, reducing LNAPL saturations to residual saturation; mass loss also by volatilization.
		Example performance metrics	Reduced LNAPL transmissivity; reduction or elimination of measurable LNAPL in wells.
	LNAPL composition	Yes	Abate accumulation of unacceptable constituent concentrations in soil vapor and/or groundwater from an LNAPL source.
		Example performance metrics	LNAPL composition change; soil and groundwater VOC concentrations to below regulatory standard; soil vapor concentrations to below regulatory standard.
Applicable LNAPL type	All LNAPL types, though higher-viscosity and/or lower-volatility LNAPL will take longer to treat and/or achieve less remedial effectiveness.		
Geologic factors	Unsaturated zone	Permeability	Effective in lower-permeability materials where heat loss to groundwater flux is low but electrical conductivity is high.
		Grain size	Fine-grained soils (silts and clays) are typically more electrically conductive than coarse-grained soils and can be more efficiently heated.
		Heterogeneity	Can be employed at sites with widely varying heterogeneity. Moisture content of the individual layers is the key determining factor for soil heating efficiency. LNAPL mobilization along preferential pathways is most likely.
		Consolidation	Can be effective in fractured and weathered bedrock, however if bedrock material exhibits high electrical resistivity, ERH application becomes problematic.
	Saturated zone	Permeability	Most effective in lower-permeability materials, where fluid flow is reduced.
		Grain size	Fine-grained soils (silts and clays) are typically more electrically conductive than coarse-grained soils and can be more efficiently heated.
		Heterogeneity	Can be employed at sites with widely varying heterogeneity. Increased moisture content of the individual coarse layers and the electrical conductivity of fine-grained soils layers result in heating and increasing mobility over a wide range of soil conditions.
		Salinity/Dissolved Solids	High concentrations of dissolved solids as well as saline groundwater conditions (above 10,000-µS) can lead to decreased resistivity, and less effective heat generation.
		Consolidation	Can be effective in fractured and weathered bedrock, however if bedrock material exhibits high electrical resistivity, ERH application becomes problematic.