Table A-12.A. In situ combustion/smoldering

Technology	In-situ combustion/smoldering (Self-sustaining Treatment for Active Remediation [STAR])	Smoldering combustion is a destructive remediation technique that uses the energy inherent in the contaminants being remediated to fuel the process in a self-sustaining manner. Once the process is initiated (ignited) through a short duration, low energy "ignition event", the energy of the reacting contaminants is used to pre-heat and initiate combustion of contaminants in adjacent areas, propagating a combustion front through the contaminated zone. The process is sustained by the addition of air through a well to the target treatment zone. The aboveground equipment used to implement the technology is similar to that used in AS/SVE systems and includes compressors for subsurface air delivery, blowers for vapor collection, and vapor phase activated carbon or a thermal oxidizer for vapor treatment. The process can also be implemented ex situ via engineered soil piles (STARx HottPad^{TM}).	
Remediation process	Physical mass recovery	No	N/A
	Phase change	Yes	1-2% of the mass remediated is volatilized ahead of the combustion front and captured and treated at ground surface.
	In situ destruction	Yes	Combustion to carbon monoxide (CO), carbon dioxide (CO_2), energy and water. 98-99% of mass remediated is destroyed in situ via smoldering combustion.
	Stabilization/ binding	No	N/A
Objective applicability	LNAPL saturation	Yes	Destruction (elimination) of LNAPL in treated areas. Broad range of applicability from moderate-concentration soils (>5,000 mg/kg TPH) to soils fully saturated with LNAPL.
		Example performance metrics	>99% reduction in contaminant concentrations in treated areas. Limited residual contaminant mass.
	LNAPL composition	Yes	Abate accumulation of unacceptable constituent concentrations in soil vapor and/or groundwater from an LNAPL source.
		Example performance metrics	LNAPL removal; soil and groundwater VOC concentrations to below regulatory standard; soil vapor plume concentrations to below regulatory standard.
Applicable LNAPL type	Best suited for low-volatility LNAPL; high volatility LNAPL likely requires the use of a surrogate fuel (e.g., emulsified vegetable oil) to act as the primary fuel to support combustion.		
Geologic factors	Unsaturated zone	Permeability	Effective when permeability of soils is sufficient to permit the minimum air flux required to support self-sustained smoldering combustion.
		Grain size	Best suited to silts to gravels. Clay materials will reduce the flux of air to the point where a smoldering reaction is reduced to impractical timescales or can no longer occur. Large void spaces cannot be tolerated as smoldering combustion requires a continuous porous matrix to facilitate the self-sustaining process.
		Heterogeneity	Can be used in heterogeneous soils. LNAPL combustion likely to proceed along preferential pathways where majority of LNAPL mass is located. Mass may remain following treatment in fringe areas that are below the lower concentration limit required for self-sustained smoldering, in disconnected blobs that are not identified during site investigation activities, and/or in low-conductivity lenses/areas where mass may be stored.

		Consolidation	Not typically a factor.
	Saturated zone	Permeability	Effective when permeability of soils is sufficient to permit the minimum air flux required to support self-sustained smoldering combustion.
		Grain size	Best suited to silts to gravels. Clay materials will reduce the flux of air to the point where a smoldering reaction is reduced to impractical timescales or can no longer occur. In soils coarser than gravel, the radius of influence (ROI) of an ignition well may be limited due to difficulties in sufficiently displacing groundwater (a heat sink) from the area around the well screen through the injection of air.
		Heterogeneity	Can be used in heterogeneous soils. LNAPL combustion likely to proceed along preferential pathways where majority of LNAPL mass is located. Mass may remain following treatment in fringe areas that are below the lower concentration limit required for self-sustained smoldering, in disconnected blobs that are not identified during site investigation activities, and/or in low-conductivity lenses/areas where mass may be stored. Combustion front can pass across "clean gaps" in the impacted zone depending on direction of air flow and the properties of the aquifer.
		Consolidation	Not typically a factor.