

**Table A-4.A. Total fluid extraction**

Technology	Fluid recovery (total fluids)	Total liquid extraction removes both groundwater and LNAPL from a well using either one pump to collect both liquids, or two pumps (dual pump system) to collect each liquid separately. The pump(s) may be electric submersible or pneumatic (or a belt skimmer could be used to recover LNAPL). Single pump systems may emulsify LNAPL and require LNAPL/water separation, and they usually involve less groundwater recovery (i.e. fine-grained soils). Dual pump systems are usually employed where significant groundwater extraction is expected or treatment to "break" emulsions are not possible or cost-effective. In both cases, a cone of groundwater depression is created that induces LNAPL flow into the well through an increased hydraulic gradient. Groundwater drawdown may expose submerged LNAPL thereby increasing LNAPL mobility and LNAPL recovery rate. Groundwater extraction may also provide hydraulic containment of potentially migrating LNAPL. <i>(See illustrations for potential configurations.)</i>	
Remediation process	Physical mass recovery	Yes	Removes mobile LNAPL at the groundwater surface with a capture zone dictated by the cone of groundwater depression; does not affect residual LNAPL mass.
	Phase change	No	N/A LNAPL remains in original liquid phase.
	In situ destruction	No	N/A
	Stabilization/binding	No	N/A
Objective applicability	LNAPL saturation	Yes	LNAPL recovery reduces LNAPL saturation toward residual saturation; does not typically improve dissolved-phase concentrations due to residual LNAPL mass left behind.
		Example performance metrics	Direct analysis of soil to indicate changes in formation LNAPL saturations, LNAPL transmissivity/LNAPL conductivity, LNAPL-to-water ratio, asymptotic recovery of a well-operated and -maintained system.
	LNAPL composition	No	N/A
		Example performance metrics	N/A
Applicable LNAPL type	All LNAPL types; however, lower-viscosity LNAPL (0.5–1.5 cP) is much more recoverable than high-viscosity LNAPL (>6 cP).		
Geologic factors	Unsaturated zone	Permeability	Technology is not applicable to LNAPL in the unsaturated zone.
		Grain size	
		Heterogeneity	
		Consolidation	
	Saturated zone	Permeability	Soil permeability is proportional to LNAPL recovery rate—higher LNAPL recovery and saturation reduction in higher permeability soils. Permeability affects the ROI of a recovery well. Another key factor is the ratio between LNAPL transmissivity to aquifer transmissivity. Low-conductivity materials ( $K_w < 10^{-6}$ cm/sec) may experience poor total fluid recovery.
		Grain size	LNAPL within fine-grained soils may not be feasible to remove by total liquid extraction.
		Heterogeneity	Moderately sensitive to heterogeneity; affects the ROI of a recovery well. Focuses on LNAPL at the groundwater surface and LNAPL that can drain with a depressed groundwater surface. Excellent applicability for confined LNAPL conditions since little to no additional smearing occurs; not applicable to thin, perched LNAPL layers, from which drawdown is limited; moderately applicable to unconfined LNAPL conditions.
		Consolidation	Not typically a factor
Cost	Per well, the capital costs of single pump systems are higher than those of active skimming or vacuum enhanced skimming, but lower than those of dual pump systems. However, fewer wells are required to achieve the same goal within the same time frame as skimming.		