Table A-4.C. Technical implementation considerations for total liquid extraction

Data requirements	Site-specific data for technology evaluation	Hydraulic conductivity, transmissivity	Hydraulic conductivity and transmissivity data help determine the appropriate groundwater extraction rate that may be sustained by the groundwater pump. These data may be obtained from slug tests or groundwater pumping tests or from predictive modeling. Relatively tight formations with low-conductivity/transmissivity soils may require the use of low-flow pneumatic pumps, as opposed to higher-flow submersible pumps.
		LNAPL conductivity, LNAPL transmissivity	LNAPL transmissivity data indicate the LNAPL extraction rate. Transmissivity data may be obtained from LNAPL baildown tests or predictive modeling.
		LNAPL characteristics	Low-viscosity LNAPLs are more amenable to pumping than higher-viscosity LNAPLs. Hence, lighter-end, low-viscosity LNAPL such as gasoline, kerosene, jet fuel, diesel and No. 2 fuel oil are more amenable to pumping than a No. 6 fuel oil or Bunker C.
		Soil permeability (to air, e.g., in unsaturated zone)	Coarser-grained, more-homogeneous soils allow larger ROI to develop. Finer-grained soil interbeds impede or lessen capture.
		Safety precautions	Explosivity of LNAPL—potential need for bonding and grounding of metal equipment/containers and other associated safety requirements.
		Available power/utilities	The power source must be determined. Drop-line power may be readily available. Alternatively, on-site sources such as generators or solar power may be needed. Power supply must be compatible with skimmer pump demand. Air compressors can operate pneumatic pumps to alleviate explosive-atmosphere concerns.
	Bench-scale testing	N/A	
	Pilot-scale testing	Groundwater ROI/ROC	Establish groundwater ROI/ROC for different groundwater pumping rates. For continuous pumping systems, determine acceptable pumping rate that may be sustained for optimal groundwater drawdown. Excessive groundwater drawdown may smear LNAPL into formerly submerged soil and reduce LNAPL recovery.
		LNAPL ROI/ROC	Establish LNAPL capture for different LNAPL pumping rates. For continuous pumping systems, determine acceptable pumping rate that may be sustained.
		Groundwater recovery rate, volume, and influent concentrations	Determine groundwater recovery rate, volume, and influent concentrations to assist with design of water handling, treatment, and discharge options.
		LNAPL recovery rate, volume, and chemical characteristics	Determine LNAPL recovery rate, volume and chemical characteristics to assist with design of LNAPL storage, handling, treatment, and discharge options.
		LNAPL emulsification issues	Disposal of recovered liquids, often emulsified, must be considered.
	Full-scale design	Number of extraction wells	Determine number of required wells necessary to achieve adequate zone of LNAPL recovery consistent with LNAPL site objective(s).
		Conveyance piping	Determine locations, lengths, materials for all horizontal conveyance piping to/from extraction wells and recovery/treatment system. Assess pipe insulation and heat tracing needs for winter conditions, if applicable.
		Groundwater ROC	Establish groundwater capture for different groundwater pumping rates. For continuous pumping systems, determine acceptable pumping rate that may be sustained.

		LNAPL ROC	Establish LNAPL capture for different LNAPL pumping rates. For continuous pumping systems, determine acceptable pumping rate that may be sustained without creating unacceptable drawdown.
		LNAPL emulsification issues	Oil/water separation with resulting sediment accumulation and biogrowth may create maintenance issues. Chemical treatments to inhibit biogrowth or "break" emulsified oil may be necessary to meet discharge standards.
	Performance metrics	Groundwater/LNAPL recovery rates and volumes	Basic system performance monitoring
		System uptime vs. downtime	
		Cumulative groundwater/LNAPL recovery	
		LNAPL recovery vs. groundwater recovery	LNAPL/water ratio
		LNAPL recovery cost	Cost per gallon of LNAPL recovered
		LNAPL thickness	
		Mass removed	
Modeling tools/ applicable models		Projected future LNAPL recovery	Use of decline curve analysis, semi-log plots, etc. to predict future LNAPL recoveries and help determine when LNAPL recovery is approaching asymptotic.
			LNAPL Distribution and Recovery Model (LDRM) (API)
		Groundwater aquifer testing and modeling software (drawdown and capture)	Commercially available
Further information		EPA. 1996. How to Effectively Recover Free Product at Leaking Underground Storage Tank Sites: A Guide for State Regulators. Office of Underground Storage Tanks. EPA 510-R-96-001.https://www.epa.gov/ust/how-effectively-recover-free-product-leaking-underground-storage-tank-sites-guide-state	
		LNAPL Distribution and Recovery Model (LDRM) (API): http://www.api.org/oil-and-natural-gas/environment/clean-water/ground-water/lnapl/ldrm	
		EPA. 2005. Cost and Performance Report for LNAPL Recovery: Multi-Phase Extraction and Dual-Pump Recovery of LNAPL at the BP Former Amoco Refinery, Sugar Creek, MO. EPA-542-R-05-016. https://www.epa.gov/sites/production/files/2015-04/documents/cpbpsugarcreek.pdf	