Table A-3.C. Technical implementation considerations for vacuum-enhanced skimming

Data requirements	Site-specific data for technology evaluation	Vapor extraction rate and ROI	Vapor extraction rates and ROI determine whether adding vacuum to a skimming system is cost-effective.
		LNAPL conductivity, LNAPL transmissivity	LNAPL conductivity and transmissivity determine the LNAPL extraction rate that may be sustained by the LNAPL pump. These data may be obtained from LNAPL baildown tests or from predictive modeling.
		LNAPL characteristics	Low-viscosity LNAPLs are more amenable to pumping than higher-viscosity LNAPLs.
		Soil type/grain size	Granular soils (sands and gravels) experience higher airflows with lower operating vacuums. Fine-grained soils (silts and clays) experience lower airflows with higher operating vacuums.
		Safety precautions	Explosivity of LNAPL—potential need for bonding and grounding of metal equipment/containers and other associated safety requirements. Explosion-proof equipment and intrinsically-safe controls may be required. Storage areas must be secured.
		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 equipment.
	Bench-scale testing	N/A	
	Pilot-scale testing	LNAPL ROI/ROC	Establish LNAPL ROI/capture for different LNAPL pumping rates.
		LNAPL recovery rate, volume, chemical characteristics	Determine LNAPL recovery rate, volume, and chemical characteristics to assist with design of LNAPL storage, handling, and treatment/discharge options.
		Airflow and vacuum	Determine system airflow and vacuum and individual extraction wellhead airflows and vacuums.
		Induced vacuum ROI	Determine vacuum ROI by measuring induced vacuums on adjacent monitoring wells.
		Influent vapor concentrations	Assess influent vapor concentrations and system airflow rates to determine potential off-gas treatment requirements/permitting issues and to calculate vapor-phase LNAPL recovery.
	Full-scale design	Number of extraction wells	Determine number of extraction wells required to achieve adequate zone of LNAPL recovery consistent with LNAPL site objective(s).
		Conveyance piping	Determine locations, lengths, and materials for all horizontal conveyance piping to/from recovery/treatment system. Assess pipe insulation and heat tracing needs for winter conditions, if applicable.
		LNAPL ROI/ROC	
		Vacuum losses	Calculate potential vacuum losses due to conveyance pipe diameters, lengths, materials. Try to minimize losses between system and wellheads.
		Air permitting/off-gas treatment issues	Assess and design for air permitting and/or off-gas treatment requirements.
	Performance metrics	System uptime vs. downtime	
		Cumulative LNAPL recovery	
		Vapor-phase LNAPL recovery	
		Total LNAPL equivalent recovery cost metric	Cost per gallon of LNAPL recovered.
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.
Further information		Ground-Water Remediation Technologies Analysis Center. 1996. Bioslurping Technology Overview Report. TO-96-05. http://clu-in.org/download/toolkit/slurp_o.pdf	

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	LNAPL Distribution and Recovery Model (LDRM) (API): http://www.api.org/oil-and-natural-gas/environment/clean-water/ground-water/lnapl/ldrm