

Table 1
Nitrate Remediation Technology Matrix

Category	Technology	Technology Description	Technology Comparison							Technology Applicability												
			Costs			Time	Permitting	Waste	GW Impacts	Nitrate Concentration		System Size			Contaminant Depth			TDS	Aquifer Permeability	Reuse		
			Total Cost	Capital Cost	O&M Cost	Remediation Timeframe	Ease of Permitting	Amount Waste Generated	Potential for Secondary Impacts to Groundwater	Low (<10 mg-N/L)	High (>10 mg-N/L)	Very Small and Small Systems (< 0.25 MGD)	Medium Systems (0.25 to 1 MGD)	Large Systems (>1 MGD)	Shallow (<30 ft bgs)	Deep (> 30 ft bgs)	Very Deep (> 100 ft bgs)	High TDS Water	Low Permeability/Heterogeneous Aquifers	Nutrient Reuse	Non-Potable Water Reuse	Potable Water Reuse
Ex-Situ (Groundwater Extraction and Treatment followed by Re-Injection, Discharge to Surface Water, or Potable Reuse)	Reverse Osmosis with Brine Disposal to Brine Line	Pump water to surface, through RO membranes; pipe brine to brine line	-	-	-	-	+	-	+	-	+	-	-	+	+	+	+	+	NA	-	+	+
	Reverse Osmosis with Brine Concentration and Evaporation	Pump water to surface, through RO membranes; pipe brine to evaporation pond	-	-	-	-	+	-	+	-	+	-	-	+	+	+	+	+	NA	-	+	+
	Disposable Ion Exchange	Pump water to surface, through IX resin; Landfill or incinerate resin when exhausted	+/-	+/-	+/-	-	++	-	+	+	-	+	+/-	-	+	+	+	-	NA	-	+	+
	Regenerable Ion Exchange with Brine Discharge to Brine Line	Pump water to surface, through IX resin; Regenerate resin, pipe waste to brine line	+/-	-	+/-	-	+	-	+	+	-	+	+	+	+	+	+	-	NA	-	+	+
	Regenerable Ion Exchange with Brine Concentration and Evaporation	Pump water to surface, through IX resin; Regenerate resin, pipe waste to evaporation pond	+/-	+/-	+/-	-	++	-	+	+	-	+	+/-	+	+	+	+	-	NA	-	+	+
	Anoxic Fluidized Bed Bioreactor	Pump water to surface and treat using an anoxic fluidized bed bioreactor that uses bacteria to reduce nitrate to nitrogen gas. Treated water can be re-injected to promote in situ biodegradation.	+	+	+	+	+/-	+	+	-	+	+	+/-	+	+	+	+	-	NA	-	+	+
	Anoxic Fixed Bed Bioreactor	Pump water to surface and treat using an anoxic fixed bed bioreactor that uses bacteria to reduce nitrate to nitrogen gas. Treated water can be re-injected to promote in situ biodegradation.	+	+	+	+	+/-	+	+	-	+	+	+/-	+	+	+	+	-	NA	-	+	+
	Extraction without Treatment Followed Crop Irrigation	Pump water to surface, surface spread onto crops	++	++	++	+/-	+/-	++	++	+	+	+	+/-	-	+	+	+	-	NA	+	+	-
	Electrodialysis Reversal with Brine Disposal to Brine Line	Pump water to surface, through EDR system, pipe concentrate to brine line	-	-	-	-	+	-	+	-	+	-	-	+	+	+	+	+	NA	-	+	-
	Electrodialysis Reversal with Brine Concentration and Evaporation	Pump water to surface, through EDR system, send brine to evap ponds	-	-	-	-	++	-	+	-	+	-	-	+	+	+	+	+	NA	-	+	-
In Situ	Phytoremediation	Install plants or trees (e.g., poplars) for nitrate uptake from soil and shallow groundwater	+	+	++	+/-	++	++	++	+	+	+	-	-	+	+/-	-	-	+	+	-	-
	Permeable Reactive Mulch Biobarrier	Dig a trench transverse to groundwater flow and fill with sand and mulch. Anoxic conditions develop resulting in reduction of nitrate to nitrogen gas.	+	+	++	+/-	+	++	-	+	+	+	+/-	-	+	-	-	-	+	-	-	-
	Permeable Reactive Biobarrier with Injected Slow-Release Electron Donor	Inject substrate into aquifer downgradient of nitrate, allow groundwater to flow across	+	+	++	+/-	+	++	-	+	+	+	+/-	-	+	+	-	-	+/-	-	-	-
	Permeable Reactive Biobarrier with Continuously Injected and Recirculated Electron Donor	Install groundwater extraction and injection wells to create capture zone, add substrate to water prior to injection	-	-	-	+/-	+	++	-	+	+	+	+/-	-	+	+	-	-	+/-	-	-	-
	Groundwater Diversion Using Impermeable Cut-Off Walls	Excavate and install impermeable barriers, directing groundwater flow around nitrate plume	+/-	-	+	+/-	+	++	+	+	+	+	+/-	-	+	+/-	-	+	+	-	-	-
	Groundwater Diversion Using French Drains	Excavate and install trenches with french drains thus directing clean water around nitrate-impacted groundwater zones	+/-	-	+	-	+	++	+	+	+	+	+/-	-	+	+/-	-	+	+	-	-	-
	Source Treatment and Monitored Natural Attenuation	Remove high concentration sources of nitrate contamination using in situ bioremediation and then allow residual nitrate to be biodegraded naturally.	+	-	++	+/-	+	++	-	+	+/-	+	+/-	-	+	+	+	-	+/-	-	-	-
	Groundwater Diversion and Monitored Natural Attenuation	Install impermeable barriers such as sheet pile or soldier piles thus directing clean groundwater flow around nitrate-contaminated groundwater. Allow nitrate within contained area to biodegrade naturally	+	-	+	+/-	+	++	+/-	+/-	+/-	+	+/-	-	+	+/-	-	-	+	-	-	-
	Source Bioremediation Using Slow-Release Electron Donor Injection	Periodically inject slowly biodegradable organic compound (such as emulsified vegetable oil) into aquifer at or up-gradient of contamination to stimulate denitrification of nitrate to nitrogen gas	+	+/-	++	++	+	++	-	+	+	+	+/-	-	+	+	+	-	-	-	-	-
	Source Bioremediation Using Fast-Release Electron Donor Injection and Recirculation	Continuously inject quickly biodegradable organic compound (such as molasses) into aquifer at or up-gradient of contamination to stimulate denitrification of nitrate to nitrogen gas	+	+/-	+	++	+	++	-	+	+	+	+/-	-	+	+	+	-	-	-	-	-

Notes ++ Very Favorable
+ Favorable
-/+ Uncertain
- Unfavorable
NA Not applicable