In-Situ Remedial Method Evaluation of Petroleum-Impacted
OXY Well site 705-22-43

Remediation Option	Technology	Regulatory Requirements	Advantages	Disadvantages	Estimated Project Fee Range Per Site [1]	Comments	Estimated Project Duration
Soil Vapor Extraction (SVE)	A vacuum is applied to extraction wells to extract volatile petroleum constituents and introduce oxygen into the subsurface to enhance biodegradation	Work plan to COGCC for approval; May need an air permit for SVE system exhaust or treat with activated carbon; Monitor soil vapor exhaust and collect soil samples to verify method effectiveness	Use of existing wells as extraction wells; Time proven remedial method for remediating volatiles and gasoline range petroleum constituents (subsurface soil should be relatively transmissive); A trailer mounted SVE system can be used at other sites	Equipment O&M cost; Project duration a function of soil permeability; Expenditures for activated carbon disposal and replacement (if needed); Air permit for SVE equipment discharge could delay system activation; Not effective for removing diesel range and heavier hydrocarbons	$125,000 to $250,000	Pilot test needed to evaluate system feasibility and optimize system performance; Additional extraction and vent wells will increase method efficiency; Periodic soil samples should be collected in to evaluate method effectiveness; Blower equipment can be configured to operate on wellhead gas	6 months to 2 years
Bioventing	Introducing oxygen into the subsurface to enhance biodegradation of petroleum hydrocarbons by naturally-occurring soil bacteria. Air can be introduced t into the subsurface using injection or extraction wells	Work plan to COGCC for approval; Soil analysis to verify method effectiveness; EPA Rule Authorization Permit for air and nutrient injections	Use of existing wells as injection wells; Technology has been demonstrated effective to degrade mid-range hydrocarbons such as diesel range organics and jet fuel; An economic option for treating larger petroleum impacted soil areas; Air permit requirements are not anticipated	Equipment O&M cost; Project duration a function of soil permeability - subsurface soil conditions need to be relatively transmissive	$150,000 to $275,000	Pilot test needed to evaluate feasibility and optimize system performance; Periodic soil and soil vapor samples should be collected to evaluate method effectiveness; Blower equipment can be configured to operate on wellhead gas; Installation of additional injection wells would improve method effectiveness	Up to 3 years
In-Situ Thermal Desorption using wellhead natural gas for a heat source (Gas-Thermal Remediation)	Thermal desorption wells heat the surrounding soil , SVE used to remove contaminants; Condensed water vapor and extracted LNAPL collected for disposal and/or treatment	Work plan to COGCC for approval; Soil analysis to verify method effectiveness; Shorter estimated treatment time; potential need for an air permit	Extracted volatile vapors are routed through heaters as a supplemental fuel source; Scalable to fit small to large sites; Capable of being moved to other locations	Limit treatment area; High equipment and O&M expenditures; Requires electrical power to operate burner controls;	$900,000 to $1,000,000	Pilot test needed to evaluate system feasibility and optimize system performance; Soil samples will be collected to confirm method effectiveness; Wellhead gas can be used for heat source and to run SVE blower equipment	1 to 2 years
In-Situ Chemical Oxidation	Three injection events to apply PersulfOx™ (a catalyzed sodium persulfate compound) to chemically oxidize petroleum constituents	Work plan to COGCC for approval; EPA Rule Authorization for injections; Soil analysis following remedial injections to verify method effectiveness	Minimal disruption to site activities; Chemical oxidation reduces contaminant mass; Single remedial agent easily applied through existing injection wells	Sodium persulfate has been used extensively for petroleum remediation however PersulfOx™ is relatively new product (approximately 1 year)	$350,000 to $400,000	Pilot test needed to evaluate method feasibility; Installation of additional injection wells would benefit oxidant distribution and effective; Soil samples will be collected to confirm method effectiveness	1 to 2 years
Excavation with Landfill Disposal	Contaminant source removal by excavation	Work plan for COGCC approval; Waste characterization and manifesting for soil transport to landfill; Confirmation soil samples to assess method effectiveness	Minimal engineering; No equipment O&M cost; Time efficient; Visual and laboratory verification of completion	Potential long-term liability at disposal facility; High transportation costs; High disposal cost	NA	Excavation with landfill disposal is not considered to be a viable option due to depth of contamination, soil type, and hillside location of the site	NA
Passive/Assisted Passive Soil Vapor Extraction with Monitored Natural Attenuation (MNA)	Contaminant reduction using passive soil vapor extraction well and natural atmospheric/barometric pressure gradients and biodegradation by naturally-occurring soil bacteria	COGCC work plan for approval; Collection of periodic soil samples for laboratory analysis to assess method progress	Minimal equipment and O&M expenditures	Longer timeline to achieve regulatory closure; High soil moisture limits method effectiveness; Contaminant mass in source area could migrate during the time in which the technology is implemented	$50,000 to $100,000	Assessment of soil permeability to evaluate radius of influence; Installation of ventilation turbines, micro-blowers, and check valves will increase method effectiveness (assisted passive soil vapor extraction)	Up to 10 years

PersulfOx ™ manufactured by Regenesis. Note - Olsson Associates is not affiliated with any of the proposed equipment or chemical reagent manufacturers or vendors

[1] - Estimated project fees based on estimated project duration NA- Not Applicable