Variables & Parameters

Constant Coefficients

Term	Description	Unit of Measure	Value	Source
C_{diesel}	Diesel consumption coefficient	$\left[\frac{lbs-CO_2}{gal}\right]$	23.64	http://www.epa.gov/OMS/climate/420f05001.htm
C_{elec}	Electricity from grid (constant by State; potentially varying by region/zip code)	$\left[\frac{lbs-CO_2}{kWh}\right]$	0.54	eGRID2007 Version 1.1 State File (Year 2005 Data) http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
$C_{gasoline}$	Gasoline consumption coefficient (constant)	$\left[\frac{lbs-CO_2}{gal}\right]$	20.6	http://www.epa.gov/OMS/climate/420f05001.htm
$C_{propane}$	Propane fuel (including other fuel oils) consumption (constant)	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	139.2	http://www.eia.doe.gov/oiaf/1605/coefficients.html
C_{NG}	Natural gas fuel consumption	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	117.1	http://www.eia.doe.gov/oiaf/1605/coefficients.html
$C_{pot\text{-}wat}$	Potable water usage coefficient	$\left[\frac{kWh}{MG}\right]$	3950	California Energy Commission, California's Water-Energy Relationship, final staff report, 2005 (pg. 11) http://sfwater.org/detail.cfm/MC_ID/21/MSC_ID/156/C_ID/4621 (All water used was assumed to be potable water.)
$FE_{geo,bor}$	GeoProbe fuel economy (50 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	2.6	$FE_{rot} = \frac{50[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 2.6\left[\frac{gal_{diesel}}{hr}\right]$ Consistent with engineering estimate of 1-3 gal/hr Mike Casey Sonic Sampling, Richard Gotsch of CMECo (5/13/2009), & Margaret Haugen of Thein
FE_{rot}	Air or Mud rotary fuel economy (100 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	5.3	$FE_{rot} = \frac{100[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 5.3\left[\frac{gal_{diesel}}{hr}\right]$
FE_{mon}	Monitoring well drilling machine fuel economy (25 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	1.3	$FE_{rot} = \frac{25[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 1.3\left[\frac{gal_{diesel}}{hr}\right]$

Variables & Parameters

Term	Description	Unit of Measure	Value	Source
FE_{pilot}	Pilot or recovery well fuel economy (100 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	5.3	$FE_{rot} = \frac{100[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 5.3\left[\frac{gal_{diesel}}{hr}\right]$
FE_{rec}	Pilot or recovery well fuel economy (100 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	5.3	$FE_{rot} = \frac{100[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 5.3\left[\frac{gal_{diesel}}{hr}\right]$
FE_{FEL}	Front end loader fuel economy (100 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	5.3	$FE_{rot} = \frac{100[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 5.3\left[\frac{gal_{diesel}}{hr}\right]$
$FE_{borehole}$	Borehole clearance fuel efficiency (50 hp engine at 35% efficiency)	$\left[\frac{gal}{hr}\right]$	2.6	$FE_{rot} = \frac{50[hp]\frac{2545\left[\frac{BTU}{hr}\right]}{1[hp]}}{138{,}000\left[\frac{BTU}{gal_{diesel}}\right]0.35\%} = 2.6\left[\frac{gal_{diesel}}{hr}\right]$ 50 hp is the upper range of air knifing blower sizes (www.sonicairsystems.com)
FE_{hybrid}	Fuel efficiency of a hybrid	$\left[\frac{mi}{gal}\right]$	45	http://www.fueleconomy.gov/feg/FEG2009.pdf
FE_{econ}	Fuel efficiency of an economy	$\left[\frac{mi}{gal}\right]$	34	http://www.fueleconomy.gov/feg/FEG2009.pdf
FE_{sedan}	Fuel efficiency of a sedan	$\left[\frac{mi}{gal}\right]$	27	http://www.fueleconomy.gov/feg/FEG2009.pdf
FE_{van}	Fuel efficiency of a van	$\left[\frac{mi}{gal}\right]$	18	http://www.fueleconomy.gov/feg/FEG2009.pdf
$FE_{pick\text{-}up}$	Fuel efficiency of a pick-up truck	$\left[\frac{mi}{gal}\right]$	18	http://www.fueleconomy.gov/feg/FEG2009.pdf
FE_{semi}	Semi-truck or Dump-truck fuel economy	$\left[\frac{mi}{gal}\right]$	6	http://www.fueleconomy.gov/feg/FEG2009.pdf

Variables & Parameters

Term	Description	Unit of Measure	Value	Source
$PE_{gen-diesel}$	Diesel Generator	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	460	METHOD 1: Ranges from 0.071 to 0.08 gal-diesel/kWh (http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx) This electricity generation range is reported to include generator inefficiencies and assumes full-load operation. $PE_{gen-diesel} = 0.076\left[\frac{gal}{kWh}\right]\cdot 22.2\left[\frac{lbs-CO_2}{gal}\right]\cdot 293\left[\frac{kWh}{mmBTU}\right] = 494\left[\frac{lbs-CO_2}{mmBTU}\right]$ METHOD 2: (Number validation) Additionally, on average diesel engines are about 35% efficient (NOTE: thermodynamic limit for steel engines is 37%) --> $PE_{gen-diesel} = \frac{22.2\left[\frac{lbs-CO_2}{gal}\right]}{0.138\left[\frac{mmBTU}{gal}\right]\cdot 0.35} = 460\left[\frac{lbs-CO_2}{mmBTU}\right]$ (http://www.lpgasmagazine.com/lpgas/Technology/A-Deere-of-a-propane-engine / ArticleStandard/ Article/detail/24913)
$PE_{gen-propane}$	Propane Generator	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	398	http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx Propane generators are approximately 35% efficient (NOTE: thermodynamic limit for steel engines is 37%)
PE_{gen-NG}	Natural Gas Generator	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	335	http://www.naturalgas.org/overview/uses_eletrical.asp Propane generators are approximately 35% efficient (NOTE: thermodynamic limit for steel engines is 37%)
PE_{pump}	Power efficiency of free-product pump	$\left[\frac{gal}{hr}\right]$	0.08	$PE_{pump} = \frac{1.5[hp]\cdot 2545\left[\frac{BTU}{hr\cdot hp}\right]}{138{,}000\left[\frac{BTU}{gal}\right]\cdot 0.35} = 0.08\left[\frac{gal}{hr}\right]$ (approximate efficiency of a steel IC engine) Pump design equation: Q (gal/min)=3960*WHP (h.p.)/H(ft), where WHP was assumed to be 1.5 h.p. and H was assumed to be 20 ft.
PE_{skid}	Skid-mounted power efficiency	$\left[\frac{gal}{hr}\right]$	1.11	$PE_{skid} = \frac{21[hp]\cdot 2545\left[\frac{BTU}{hr\cdot hp}\right]}{138{,}000\left[\frac{BTU}{gal}\right]\cdot 0.35} = 1.11\left[\frac{gal}{hr}\right]$ Assumed average efficiency of a steel combustion engine to be 35% and a total of approximately 21 hp of engines within the system – one 10 hp extraction pump, three 2.0 hp process pumps, and one 5.0 hp air stripper.

Variables & Parameters

Term	Description	Unit of Measure	Value	Source
PE_{VAC}	Vac truck power efficiency	$\left[\frac{gal}{hr}\right]$	2.63	Engineering Estimate
$PE_{trailer}$	Trailer power efficiency	$\left[\frac{gal}{hr}\right]$	1.11	$PE_{skid} = \frac{21[hp] \cdot 2545\left[\frac{BTU}{hr \cdot hp}\right]}{138{,}000\left[\frac{BTU}{gal}\right] \cdot 0.35} = 1.11\left[\frac{gal}{hr}\right]$ Assumed average efficiency of a steel combustion engine to be 35% and a total of approximately 21 hp of engines within the system – one 10 hp extraction pump, three 2.0 hp process pumps, and one 5.0 hp air stripper
$PE_{GAC,water}$	GAC groundwater treatment	$\left[\frac{MMBTU}{year}\right]$	279	Assume one 5 hp transfer pump and one 7.5 hp steam generator 1 hp = 746 W --> 8760 hours/year --> operating 1 hp requires 6535 kWh annually (assuming 24/7 operation) --> 12.5 hp --> 81687.5 kWh/yr × 0.003412 mmBTU/kWh = 279 mmBTU/year
PE_{GAC}	GAC off-gas treatment	$\left[\frac{MMBTU}{year}\right]$	111	Assume 5 hp blower 1 hp = 746 W --> 8760 hours/year --> operating 1 hp requires 6535 kWh annually (assuming 24/7 operation) --> 5 hp --> 32675 kWh/yr × 0.003412 mmBTU/kWh = 111 mmBTU/year
$PE_{GAC\text{-}regen}$	GAC regeneration	$\left[\frac{MMBTU}{lb}\right]$	0.059	Virgin GAC is assumed to cost $1.50 per lb. Regenerated GAC costs 25% less than virgin GAC. Energy cost is estimated at $0.065/kWh. Assume the entire cost of regenerated GAC is associated with energy usage. --> $1.50 /lb * 0.75 / $0.065/kWh *0.003412 mmBTU/kWh = 0.059 mmBTU/lb
PE_{blower}	Off-gas blower	$\left[\frac{MMBTU}{year}\right]$	111	Assume 5 hp blower 1 hp = 746 W --> 8760 hours/year --> operating 1 hp requires 6535 kWh annually (assuming 24/7 operation) --> 5 hp --> 32675 kWh/yr × 0.003412 mmBTU/kWh = 111 mmBTU/year
$\Delta T_{ThermOx}$	ThermOx off-gas treatment	[°F]	1330	Off-Gas Treatment Technologies for Soil Vapor Extraction Systems: State of the Practice; EPA-542-R-05-028; March 2006
ΔT_{CatOx}	CatOx off-gas treatment	[°F]	730	Off-Gas Treatment Technologies for Soil Vapor Extraction Systems: State of the Practice; EPA-542-R-05-028; March 2006
Cp_{air}	Heat Capacity of air	$\left[\frac{BTU}{lbs°F}\right]$	0.24	www.Engineeringtoolbox.com
$\rho_{air\text{-}70F}$	Density of air	$\left[\frac{lb}{ft^3}\right]$	0.075	www.Engineeringtoolbox.com

Variables & Parameters

Term	Description	Unit of Measure	Value	Source
PE_{Therm}	Low-Temp Thermal Desorption	$\left[\frac{kWh}{ton}\right]$	443	It was reported that LTTD costs about $30-$70 per ton of soil, excluding transportation and excavation costs. The process includes a rotary dryer, asphalt plant aggregate dryer, a thermal screw, and a conveyor furnace The average value of $50/ton and assume all costs are associated with electrical consumption at ~$0.10 per kWh. In addition, this value falls within Mike Fetherling's (Midwest Soil) estimate of 0.69 to 2.99 mmBTU per ton with an average of 1.51 mmBTU/ton (443 kWh/ton). http://www.epa.gov/OUST/cat/LTTD.HTM#rotary
$E_{enclosure}$	Enclosure energy consumption	$\left[\frac{kWh}{ft^2}\right]$	8.2	2003 estimate of 8.2 kWh per square foot of "service" building (EIA, Table C21, 2006) http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howuseelec.htm
$R_{geo,bor}$	GeoProbe drilling rate	$\left[\frac{ft}{day}\right]$	100	Geoprobe = 100-150 ft/day for a 1" well HAS = 75-100 ft/day for a 2" well Engineering estimate (Mike Casey Sonic Sampling & Margaret Haugen of Thein)
R_{rot}	Air or Mud rotary drilling rate	$\left[\frac{ft}{day}\right]$	50	Aerotary/mudrotary = 50 ft/day for a 2" well
R_{mon}	Monitoring well drilling rate	$\left[\frac{ft}{day}\right]$	75	Geoprobe = 100-150 ft/day for a 1" well HAS = 75-100 ft/day for a 2" well Engineering estimate (Mike Casey Sonic Sampling & Margaret Haugen of Thein)
R_{pilot}	Pilot test well drilling rate	$\left[\frac{ft}{day}\right]$	75	Geoprobe = 100-150 ft/day for a 1" well HAS = 75-100 ft/day for a 2" well Engineering estimate (Mike Casey Sonic Sampling & Margaret Haugen of Thein)
R_{rec}	Recovery well drilling rate	$\left[\frac{ft}{day}\right]$	75	Geoprobe = 100-150 ft/day for a 1" well HAS = 75-100 ft/day for a 2" well Engineering estimate (Mike Casey Sonic Sampling & Margaret Haugen of Thein)
R_{aband}	Well over-drilling rate	$\left[\frac{ft}{day}\right]$	200	Engineering estimate (Mike Casey Sonic Sampling & Margaret Haugen of Thein)

Variables & Parameters

Variables Calculated by User Inputs

Technology	Term	Description	Unit of Measure	Default Value
Excavation	**PEexc,pilot**	Size of Excavator in Pilot Study	$\left[\frac{gal}{hr}\right]$	0
Excavation	**tpilot,exc**	Duration of Excavation Pilot Study	$[hrs]$	8
Excavation	**PEexc**	Size of Excavator during Operations	$\left[\frac{gal}{hr}\right]$	3.95
Excavation	**nexc**	Number of Excavators used during Operations	-	1
Excavation	**psoil**	COMPUTED from SoilType,exc selection that computes the Level of Effort (LOE)	$\left[\frac{tons}{yd^3}\right]$	1.3
Excavation	**soilmass**	Mass of the soil. $$\left(\frac{A_{soil}[ft^2]D_{soil}[ft]}{27\left[\frac{ft^3}{yd^3}\right]}\right)\rho_{soil}\left[\frac{tons}{yd^3}\right]$$	$[tons]$	241
Excavation	**nsemi**	Number of semitrucks used during excavation operations: $$\frac{soilmass}{15}$$	-	16
Excavation	**Qpotable,exc**	Amount of water needed for dust suppression. $soilmass[ton] \cdot 50\left[\frac{gal}{ton}\right]$	$[gal]$	12037
Excavation	**toperate,exc**	Duration of Excavation: $$\frac{n_{boring}C_{boring}h_{boring}}{R_{geo,bor}} + \frac{n_{mon,exc}C_{mon,exc}h_{mon,exc}}{R_{mon}} + \frac{n_{semi}}{10}$$	$[days]$	2.85
Excavation	**voperate,exc**	Frequency of personnel visits during system operation	$\left[\frac{1}{day}\right]$	1
SVE	**B,sve**	Electricity use in the enclosure, if any, for remediation system: B = 0 - no B = 1 - yes	-	1
SVE	**Aenclosure,sve**	Area of enclosure for remediation system	$[ft^2]$	300

Variables & Parameters

SVE	**nGAC,sve**	Number of Granular Activated Carbon (GAC) Vessels	-	2
SVE	**GAClbs,sve**	Size of each GAC vessel - If system energy use (PEi,operationsve) is < 390 $\frac{MMBTU}{year}$, then **GAClbs,sve = 500 lbs** = 390 thru 613 $\frac{MMBTU}{year}$, then **GAClbs,sve = 1000 lbs** >= 613 $\frac{MMBTU}{year}$, then **GAClbs,sve = 2000 lbs**	$[lbs]$	500
SVE	**GAC%,sve**	Percent of treatment that uses GAC. GAC%,sve = 1 - ThermOXpct,sve - CatOXpct,sve	%	100
SVE	**fGAC,sve**	GAC Regeneration Frequency	$\left[\frac{1}{year}\right]$	3.5
SVE	**vdelivery,sve**	Frequency of semi-truck deliveries to site during operation	$\left[\frac{1}{month}\right]$	5
SVE	**Foff-gastherm,sve**	Thermal oxidation off-gas flowrate - If system energy use (PEi,operationsve) is < 390 $\frac{MMBTU}{year}$, then **Foff-gastherm,sve = 100 cfm** = 390 thru 613 $\frac{MMBTU}{year}$, then **Foff-gastherm,sve = 200 cfm** >= 613 $\frac{MMBTU}{year}$, then **Foff-gastherm,sve = 500 cfm**	$[cfm]$	100
SVE	**Foff-gascat,sve**	Catalytic oxidation off-gass flowrate - If system energy use (PEi,operationsve) is < 390 $\frac{MMBTU}{year}$, then **Foff-gascat,sve = 100 cfm** = 390 thru 613 $\frac{MMBTU}{year}$, then **Foff-gascat,sve = 200 cfm** >= 613 $\frac{MMBTU}{year}$, then **Foff-gascat,sve = 500 cfm**	$[cfm]$	100
P&T	**Qpotable,sve**	Potable water use in million gallons per year	$[MGY]$	2.6
P&T	**FEYI,sve**	Fuel efficiency of a fork lift	$\left[\frac{gal}{hr}\right]$	6.6
P&T	**B,pt**	Electricity use in the enclosure, if any, for remediation system: B = 0 - no B = 1 - yes	-	1
P&T	**Aenclosure,pt**	Area of enclosure for remediation system	$[ft^2]$	300
P&T	**nGAC,watpt**	Number of Granular Activated Carbon (GAC) Vessels	-	4
P&T	**GAClbs,waterpt**	Size of each GAC vessel - If system energy use (PEi,operationpt) is < 390 $\frac{MMBTU}{year}$, then **GAClbs,waterpt = 500 lbs** = 390 thru 613 $\frac{MMBTU}{year}$, then **GAClbs,waterpt = 1000 lbs** >= 613 $\frac{MMBTU}{year}$, then **GAClbs,waterpt = 2000 lbs**	$[lbs]$	0

Variables & Parameters

P&T	GAC%,waterpt	Percent of treatment that uses GAC.	%	100
P&T	fGAC,waterpt	GAC Regeneration Frequency	$\left[\frac{1}{year}\right]$	3.5
P&T	vdeliverypt	Frequency of semi-truck deliveries to site during operation	$\left[\frac{1}{year}\right]$	5
P&T	Qpotable,pt	Potable water use in million gallons per year	$[MGY]$	2.6
P&T	FEYI,pt	Fuel efficiency of a fork lift	$\left[\frac{gal}{hr}\right]$	6.6
MPE	B	Electricity use in the enclosure, if any, for remediation system: B = 0 - no B = 1 - yes	-	1
MPE	Aenclosure	Area of enclosure for remediation system	$[ft^2]$	300
MPE	nGAC	Number of Granular Activated Carbon (GAC) Vessels	-	2
MPE	GAClbs	Size of each GAC vessel - If system energy use (PEi,operation) is <390 $\frac{MMBTU}{year}$, then **GAClbs = 500 lbs** = 390 thru 613 $\frac{MMBTU}{year}$, then **GAClbs = 1000 lbs** >= 613 $\frac{MMBTU}{year}$, then **GAClbs = 2000 lbs**	$[lbs]$	1000
MPE	GAC%	Percent of treatment that uses GAC. GAC% = 1 - ThermOXpct - CatOXpct	%	100
MPE	fGAC	GAC Regeneration Frequency	$\left[\frac{1}{year}\right]$	3.5
MPE	vdelivery	Frequency of semi-truck deliveries to site during operation	$\left[\frac{1}{year}\right]$	5
MPE	Foff-gastherm	Thermal oxidation off-gas flowrate - If system energy use (PEi,operation) is < 390 $\frac{MMBTU}{year}$, then **Foff-gastherm = 100 cfm** = 390 thru 613 $\frac{MMBTU}{year}$, then **Foff-gastherm = 200 cfm** >= 613 $\frac{MMBTU}{year}$, then **Foff-gastherm = 500 cfm**	$[cfm]$	200
MPE	Foff-gascat	Catalytic oxidation off-gass flowrate – If system energy use (PEi,operation) is < 390 $\frac{MMBTU}{year}$, then **Foff-gascat = 100 cfm** = 390 thru 613 $\frac{MMBTU}{year}$, then **Foff-gascat = 200 cfm** >= 613 $\frac{MMBTU}{year}$ then **Foff-gascat = 500 cfm**	$[cfm]$	200

MPE	**nGAC,wat**	Number of Granular Activated Carbon (GAC) Vessels	-	2
MPE	**GAClbs,water**	Size of each GAC vessel	$[lbs]$	1000
MPE	**GAC%,water**	Percent of treatment that uses GAC.	%	100
MPE	**fGAC,water**	GAC Regeneration Frequency	$\left[\frac{1}{year}\right]$	3.5
MPE	**Qpotable**	Potable water use in million gallons per year	$[MGY]$	2.6
MPE	**FEYI,mpe**	Fuel efficiency of a fork lift	$\left[\frac{gal}{hr}\right]$	6.6

Variables Entered by User

Technology	Term	Description	Unit of Measure	Default Value
General Assessment	**ddelivery**	Distance to site for deliveries	$[miles]$	37.5
General Assessment	**nexist**	Number of existing wells, constructed prior to current remediation project	-	5
General Assessment	**hexist**	Depth of existing wells	$[ft]$	75
General Assessment	**Vass**	Frequency of personnel visits during site assessment	$\left[\frac{1}{day}\right]$	2
General Assessment	**ngeo,ass**	Number of geoProbe borings	-	5
General Assessment	**Cgeo,ass**	GeoProbe boring diameter	$[in]$	2
General Assessment	**hgeo,ass**	Well depth	$[ft]$	25
General Assessment	**nmon, ass**	Number of wells for assessment	-	5
General Assessment	**Cmon,ass**	Well/boring Diameter	$[in]$	2
General Assessment	**hmon,ass**	Monitoring well depth	$[ft]$	25
General Assessment	**LOE**	Level of Effort (LOE) Coefficient	-	0.75

Variables & Parameters

General Assessment	tass	$t_{ass} = \frac{n_{geo,ass} C_{geo,ass} h_{geo,ass} LOE}{R_{geo,bor}} + \frac{n_{mon,ass} C_{mon,ass} h_{mon,ass} LOE}{R_{mon}} + 1$	$[days]$	3
General Assessment	dstaff	Distance to site for the personnel visits	$[miles]$	37.5
General Assessment	FEstaff,ass	Fuel efficiency of staff vehicle used during site assessment	$\left[\frac{mi}{gal}\right]$	18.01
General Assessment	Calt,ass	Alternative Transport Percent Use	%	100
Excavation	ntest-pits	Number of excavation test pits	-	1
Excavation	nboring	Number of borings	-	5
Excavation	Cboring	Well/boring Diameter	$[in]$	2
Excavation	hboring	Boring Depth	$[ft]$	25
Excavation	nmon,exc	Number of monitoring wells	-	5
Excavation	hmon,exc	Monitoring Well Depth	$[ft]$	0
Excavation	Asoil	Excavation Area	$[ft^2]$	500
Excavation	Dsoil	Excavation Depth	$[ft]$	10
Excavation	FEstaff,exc	Fuel efficiency of staff vehicle used during operations	$\left[\frac{mi}{gal}\right]$	18.01
Excavation	Calt,exc	Alternative Transport Percent Use	%	100
Excavation	Cover-drill,exc	Percent of monitoring wells that are over-drilled during abandonment	%	100
SVE	PEsve,pilot	Pilot Study Equipment Fuel Efficiency	$\left[\frac{gal}{hr}\right]$	1.11
SVE	tpilot,sve	Pilot Study Duration for Soil Vapor Extraction	$[days]$	4
SVE	nbor,sve	Number of bornings	-	25
SVE	Cbor,sve	Boring diameter	$[in]$	1
SVE	hbor,sve	Boring depth	$[ft]$	2.5
SVE	nmon,sve	Number of monitoring wells	-	5

Variables & Parameters

SVE	**Cmon,sve**	Well diameter	$[in]$	2
SVE	**hmon,sve**	Dept of monitoring wells	$[ft]$	25
SVE	**nrec,sve**	Number of recovery wells	-	5
SVE	**Crec,sve**	Diameter of recovery wells	$[in]$	4
SVE	**hrec,sve**	Depth of recovery wells	$[ft]$	25
SVE	**PEi,operationsve**	Annual energy use from SVE equipment	$\left[\frac{MMBTU}{year}\right]$	279
SVE	**Ci,operationsve**	Carbon content of power source	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	158
SVE	**Ci,supplimentsve**	Percent use of alternative electricity	$\%$	0
SVE	**toperate,sve**	Months of operation	$[months]$	36
SVE	**ThermOx%,sve**	Percent of treatment using Thermal Oxidation	$\%$	0
SVE	**CatOx%,sve**	Percent of treatment using Chemical Oxidation	$\%$	0
SVE	**Voperate,sve**	Frequency of personnel visits during system operation	$\left[\frac{1}{month}\right]$	2
SVE	**FEstaff,sve**	Fuel efficiency of personnel vehicle	$\left[\frac{mi}{gal}\right]$	18.01
SVE	**Calt,sve**	Alternative Transport Percent Use	$\%$	100
SVE	**tYI,sve**	Yellow Iron Operation Duration (Abandonment)	$[days]$	3.5
SVE	**Cover-drill,sve**	Percent of wells that are over-drilled during abandonment	$\%$	100
P&T	**PEpt,pilot**	Fuel efficiency of Pilot Study Equipment	$\left[\frac{gal}{hr}\right]$	1.11
P&T	**tpilot,pt**	Pilot Study Duration for Pump and Treat	$[days]$	4
P&T	**nbor,pt**	Number of borings for pump and treat	-	2.5
P&T	**Cbor,pt**	Boring Diameter	$[in]$	2
P&T	**hbor,pt**	Boring depth	$[ft]$	25
P&T	**nmon,pt**	Number of monitoring wells	-	5

Variables & Parameters

P&T	Cmon,pt	Monitoring well diameter	$[in]$	2
P&T	hmon,pt	Monitoring well depth	$[ft]$	25
P&T	nrec,pt	Number of recovery wells	-	5
P&T	Crec,pt	recovery well diameter	$[in]$	6
P&T	hrec,pt	Recovery well depth	$[ft]$	75
P&T	PEi,operationpt	Annual energy use from pump and treat equipment	$\left[\frac{MMBTU}{year}\right]$	279
P&T	Ci,operationpt	Carbon content of power source	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	158
P&T	Ci,suplimentpt	Alternative Electricity Percent Use	%	0
P&T	toperate,pt	Months of operation	$[months]$	72
P&T	Voperate,pt	Frequency of personnel visits during system operation	$\left[\frac{1}{month}\right]$	2
P&T	FEstaff,pt	Fuel efficiency of personnel vehicle	$\left[\frac{mi}{gal}\right]$	18.01
P&T	Calt,pt	Alternative Transport percent Use	%	100
P&T	tYI,pt	Yellow Iron Operation Duration (Abandonment)	$[days]$	3.5
P&T	Cover-drill,pt	Percent of wells that are over-drilled during abandonment	%	100
MPE	PEi,pilot	Fuel Efficiency of Pilot Study Equipment	$\left[\frac{gal}{hr}\right]$	1.11
MPE	tpilot	Pilot Study Duration for Multi-Phase Extraction	$[days]$	4
MPE	nbor	Number of borings	-	5
MPE	Cbor	Boring diameter	$[in]$	2
MPE	hbor	Boring depth	$[ft]$	75
MPE	nmon,mpe	Number of monitoring wells	-	5
MPE	Cmon,mpe	Monitoring well diameter	$[in]$	2
MPE	hmon,mpe	Monitoring well depth	$[ft]$	25

Variables & Parameters

MPE	nrec	Number of recovery wells	-	5
MPE	Crec	Recovery well diameter	$[in]$	4
MPE	hrec	Recovery well depth	$[ft]$	25
MPE	PEi,operation	Annual energy use from MPE equipment	$\left[\frac{MMBTU}{year}\right]$	502
MPE	Ci,operation	Carbon content of power source	$\left[\frac{lbs-CO_2}{MMBTU}\right]$	158
MPE	Ci,suppliment	Alternative Electricity Percent Use	%	0
MPE	toperate,mpe	Months of operation	$[months]$	36
MPE	ThermOx%	Percent of treatment using thermal oxidation	%	0
MPE	CatOx%	Percent of treatment using Chemical Oxidation	%	0
MPE	Voperate	Frequency of personnel visits during system operation	$\left[\frac{1}{month}\right]$	2
MPE	Festaff,mpe	Fuel efficiency of personnel vehicle	$\left[\frac{mi}{gal}\right]$	18.01
MPE	Calt,mpe	Alternative Transport Percent Use	%	100
MPE	tYI,mpe	Yellow Iron Operation Duration (Abandonment)	$[days]$	3.5
MPE	Cover-drill,mpe	Percent of wells that are over-drilled during abandonment	%	100
MNA	ngeo,pilot	Number of geoProbe borings	-	5
MNA	Cgeo,pilot	GeoProbe boring diameter	$[in]$	2
MNA	hgeo,pilot	GeoProbe boring depth	$[ft]$	75
MNA	nmon,pilot	Number of monitoring wells	-	5
MNA	Cmon,pilot	Monitoring well diameter	$[in]$	2
MNA	hmon,pilot	Monitoring well depth	$[ft]$	75
MNA	toperate,mna	Months of operation for Monitored Natural Attenuation	$[months]$	36
MNA	voperate,mna	Frequency of personnel visits during system operation	$\left[\frac{1}{year}\right]$	2

Variables & Parameters

MNA	**FEstaff,mna**	Fuel efficiency of personnel vehicle	$\left[\frac{mi}{gal}\right]$	18.01
MNA	**Calt,mna**	Alternative Transport Percent Use	%	100
MNA	**Coverdrill,mna**	Alternative Transport Percent Use	%	100