



ISCO Soil Mixing Program: TCE Treatment

Site

- Former Manufacturing Facility; Wisconsin.

Contaminants of Concern

- TCE soil levels as high as 140,000 ug/kg.

Geology/ Hydrology

- Site geology consists of mostly clay from 0-15 feet bgs underlain by a mostly sand unit from 15-30 feet bgs.
- Depth to water is approximately 25-30 feet bgs.

ISCO Soil Mixing Program

- Sodium Hydroxide Activated Sodium Persulfate (ALK-ASP) at concentration of 15%.
- ~13,500 sq. ft area from 0-15 ft bgs within the upper clay unit and ~11,700 sq. ft area from 15-30 ft bgs within the lower sand unit.
- Treatment areas broken down into 10 x 10 ft cells based on pre-treatment TCE values.
- Treatment approach included initial excavation and stockpiling of upper clay unit; treatment of the lower sand unit; re-placement of the stockpiled upper clay unit into specific groups based on pre-treatment TCE concentration followed by treatment of the lower sand unit.
- Approximately 194,973 gallons of ALK-ASP were mixed into both soil units utilizing the Lang Tool dual axis blender over 31 days.
- Reagent included 270,600 lbs. sodium persulfate activated by approximately 54,300 gallons of 50% sodium hydroxide.
- Confirmatory sampling conducted throughout the soil mixing program to gauge project effectiveness and allow for any field changes if necessary.

Results

- Post-treatment data confirmed that 36 of 37 samples collected were below the remediation target goal of 1.5 mg/kg. Client was awarded the Wisconsin Business Friend of the Environment, Large Business Environmental Stewardship Award for 2012.

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ISOTEC Case Study No. 65

ISCO SOIL MIXING PROGRAM: TCE TREATMENT UTILIZING SODIUM HYDROXIDE ACTIVATED SODIUM PERSULFATE

Former Manufacturing Facility
Northern Wisconsin

INTRODUCTION

ISOTEC was retained to provide technical support during implementation of a in-situ chemical oxidation (ISCO) soil mixing treatment program utilizing sodium hydroxide activated sodium persulfate (ALK-ASP) at a former manufacturing facility in northern Wisconsin to address trichloroethene (TCE) impacted soils. Concentrations of TCE in site soils were as high as 140,000 micrograms per kilogram (ug/kg) within the upper clay unit and as high as 27,500 ug/kg within the lower sand unit. Designation of the target treatment areas and initial reagent dosage was calculated by the functioning engineer for the site hired by the property owner.



SITE BACKGROUND/GEOLOGY

Past business operations at the site have resulted in soil impacts with TCE. The site is currently unoccupied and all above structures were removed prior to implementing the ISCO soil mixing treatment. The areas of concern (AOC) requiring treatment consisted of an approximately 13,500 square feet (ft²) upper clay unit targeting the 0-15 feet (ft) below ground surface (bgs) interval and an approximately 11,700 ft² lower sand unit targeting the 15-30 ft bgs interval. Permitting for the ISCO mixing activities was governed by the Wisconsin Department of Natural Resources (WDNR).

Site geology consisted of mostly clay from 0-15 ft bgs underlain by a mostly sand unit from 15-30 ft bgs. Depth to groundwater is generally encountered from 25-30 ft bgs.

ISCO TREATMENT PROGRAM AND IMPLEMENTATION

The ISCO soil mixing treatment program was implemented using the ALK-ASP process. Prior to implementing the soil mixing program, the treatment area was accurately delineated by a surveying company and the information was stored within the Lang LTC dual axis blender (LTC blender) equipped with a global positioning system (gps) device. The LTC blender gps device is equipped to show real-time location and depth during the soil mixing process to ensure that the entire treatment area was accurately and thoroughly mixed. Two treatment zones were targeted for remediation; the upper clay unit from 0-15 ft bgs and the lower sand unit from 15-30 ft bgs. Prior to implementing soil mixing activities,



each unit was broken down into 10 ft x 10 ft treatment cells. Within each unit, the treatment cells were further categorized into pre-treatment TCE concentration groups for the purpose of reagent dosing. Three (3) contaminant concentration groups were designated in the lower sand unit and four (4) groups within the upper clay unit. A total of 311 treatment cells were treated within both of the target units.

The lower sand unit was treated first with soil mixing activities. Prior to do doing so, the upper clay unit had to be excavated and stockpiled within designated areas in order to access the lower sand unit. The soils were stockpiled and grouped based on the pre-treatment TCE groupings discussed above. Once the mixing activities in the lower sand unit were completed, the stockpiled upper clay unit soils were backfilled within the excavated area on top of the treated lower sand unit. As much as possible, compaction activities were completed in the backfilled area. During the soil backfilling activities, the previously stockpiled soil was positioned in such a way that the designated groupings were placed within the same general areas (as much as possible) to allow for more efficient mixing of the upper clay zone and to more accurately ensure that the proper dosing was being applied to each treatment cell. Once all of the soil was put back in place, the upper clay unit was treated with the soil mixing activities.

A total of 194,973 gallons of ~15% ALK-ASP were mixed into both units within the 311 designated treatment cells over 31 days (actual mixing days). The reagent was prepared within a designated chemical mixing area that included mixing tanks, chemical storage tanks, transfer pumps and hoses, safety shower/eyewash, secondary containment pad and dry chemical storage containers. A total of 270,600 pounds of sodium persulfate oxidant and ~54,260 gallons of 50% sodium hydroxide activator were utilized during the ISCO treatment program.



Majority of reagent (~63%) was mixed within the upper clay unit due to significantly higher pre-treatment TCE

concentrations and higher natural soil oxidant demand; while the lesser impacted lower sand unit received a much less volume (~37%).

The ALK-ASP was applied to the impacted soil units as a liquid solution containing a mixture of sodium persulfate and a portion of the sodium hydroxide (varied between 10-20% of the sodium persulfate liquid volume) required for activation followed by the remaining volume of sodium hydroxide calculated for each treatment zone. The rationale for this approach is to first raise the pH of the ~15% stock solution within the mixing tank immediately prior to injecting into the LTC Blender assembly such that any sulfuric acid produced from persulfate decomposition is immediately neutralized and not corrosive to the blending equipment. The remaining sodium hydroxide was blended in directly as a polishing step primarily to maintain the pH above 10.5 within the just completed mixing zones to ensure that continued activation of the sodium persulfate would occur.

Confirmatory sampling activities were completed within (randomly selected cells) cells after treatment occurred to ensure that proper pH was being maintained (107 samples were collected); and to measure the residual sodium persulfate concentration at different time intervals following treatment to determine if additional oxidant was required to ensure continued and complete treatment within a given cell was occurring. Data collected from the initial days of sampling within the lower sand unit proved to be of significant importance when it was determined that additional sodium persulfate was required to prolong the treatment longevity to ensure increased TCE reduction success. At the same time, the volume of sodium hydroxide that was added to the liquid persulfate mixture was reduced because of high pH readings recorded 1-day after sampling. In a few instances, data collected from select cells showed either low levels or non-detect levels of sodium persulfate following treatment. In such cases, the cells were re-treated (if still accessible) with additional mixing of sodium persulfate.



CURRENT PROJECT STATUS

The objective of the ISCO treatment program was to blend ALK-ASP into both the upper clay and lower sand units in an effort to reduce TCE concentrations to below 1,500 ug/kg in site soils. Majority of data collected during the confirmatory sampling activities showed post-treatment TCE concentration to be below the target value of 1,500 ug/kg designated for the site. Post-treatment verification sampling data confirmed that 36 of 37 samples collected at 13 locations were below the treatment goal of 1,500 ug/kg. Average TCE concentration in the upper clay unit was reduced from a pre-treatment value of 13,300 ug/kg to a 84 ug/kg following treatment, a >99% reduction. Average TCE



concentration in the lower sand unit was reduced from a pre-treatment value of 10,200 ug/kg to a 321 ug/kg following treatment, a >96% reduction.

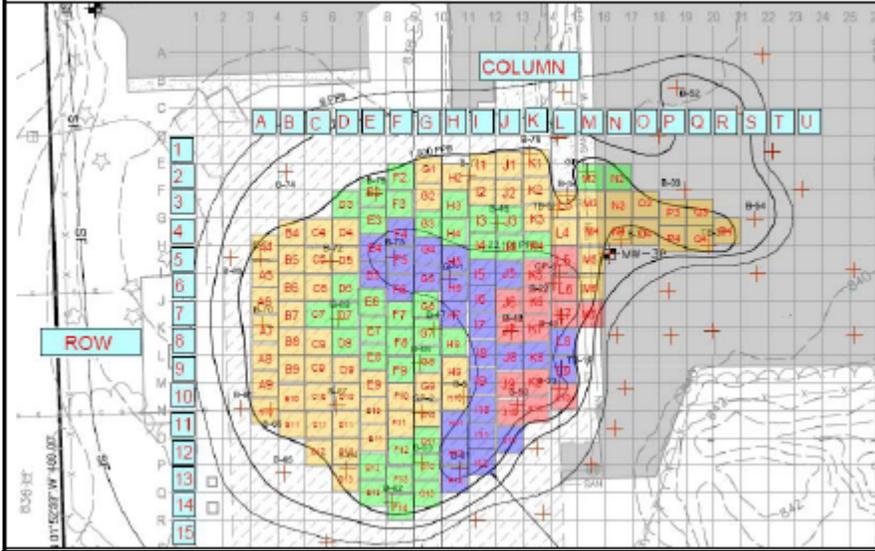
Soil Verification Sampling Results

Boring Location	Sample ID	Sample Depth Interval (feet bgs)		TCE (ug/kg)
VS1	VS1A	2	4	<32
	VS1B	10	12	240
	VS1D	24	26	470
VS2	VS2A	2	4	130 J
	VS2B	10	12	<30
	VS2C	24	26	2,800
VS3	VS3A	2	4	<32
	VS3B	11	13	<29
	VS3E	25	27	<31
VS4	VS4A	2	4	<35
	VS4B	10	12	<29
	VS4C	24	26	<30
VS5	VS5A	2	4	<30
	VS5B	11	13	260
	VS5E	25	27	<29
VS6	VS6A	2	4	<31
	VS6B	11	13	520
	VS6C	25	27	<28
VS7	VS7A	2	4	<31
	VS7B	9	11	<30
	VS7D	23	25	<28
VS8	VS8A	2	4	<30
	VS8B	10	12	85 J
	VS8C	24	26	<25
VS9	VS9A	2	4	<34
	VS9B	11	13	34 J
	VS9D	25	27	<29
VS10	VS10A	2	4	63 J
	VS10B	10	12	280
	VS10D	24	26	<29
VS11	VS11A	2	4	<30
	VS11B	8	10	<29
VS12	VS12A	2	4	<30
	VS12B	8	10	<32
MW-3PR	MW-3PRA	2	4	<30
	MW-3PRB	11	13	43 J
	MW-3PRC	25	27	<29

Additional treatment in the form of direct-push injections using the ALK-ASP process was implemented at the site to target the lone sample location that came back above 1,500 ug/kg following the treatment program. No further remediation work was required at the site and restoration activities were implemented. The client was awarded the Wisconsin Business Friend of the Environment, Large Business Environmental Stewardship Award for 2012.

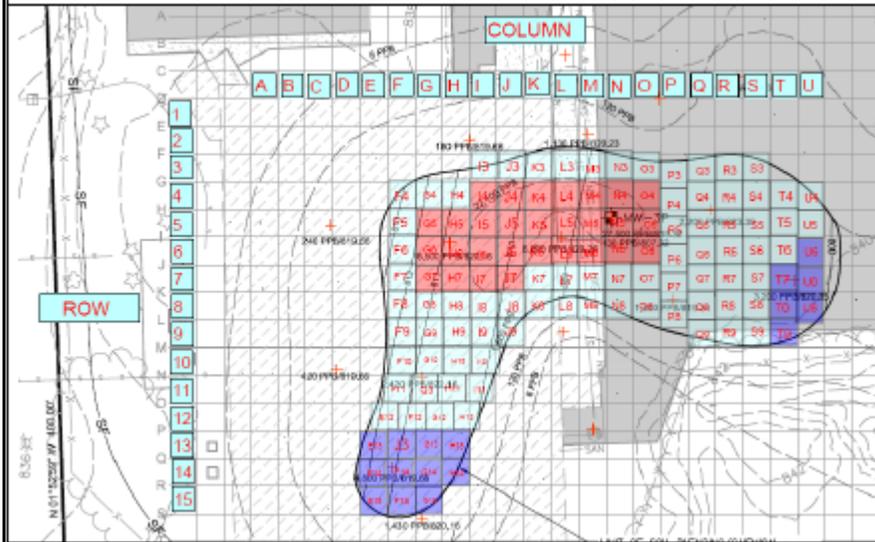
Original Design Layout of Treatment Zones

UPPER CLAY ZONE – ORIGINAL LAYOUT



- A4 Individual Cell Location Indicator w/ corresponding column designation and row number.
- Pre-Treatment TCE Concentrations < 7,000 ppb.
- Pre-Treatment TCE Concentrations between 7,000-20,000 ppb.
- Pre-Treatment TCE Concentrations between 20,000-25,000 ppb.
- Pre-Treatment TCE Concentrations > 25,000 ppb.

LOWER SAND ZONE – ORIGINAL LAYOUT



- S8 Individual Cell Location Indicator w/ corresponding column designation and row number.
- Pre-Treatment TCE Concentrations < 3,000 ppb.
- Pre-Treatment TCE Concentrations between 3,000-8,000 ppb.
- Pre-Treatment TCE Concentrations > 8,000 ppb.



Actual Design Layout of Treatment Zones

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V		
1																								
2	1	Figure 4						SP 255 Na 180		SP 278 Na 196	SP 278 Na 196	SP 278 Na 196						Upper Clay Unit Reagent Quantities						
3	2				SP 268 Na 180	SP 337 Na 361	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 537 Na 392		SP 586 Na 394	SP 586 Na 394									
4	3				SP 537 Na 361	SP 537 Na 361	SP 537 Na 361	SP 586 Na 394	SP 776 Na 399	SP 776 Na 399	SP 776 Na 399	SP 841 Na 432												
5	4	SP 278 Na 196	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 712 Na 365	SP 537 Na 361	SP 537 Na 361	SP 537 Na 361	SP 510 Na 359	SP 510 Na 359	SP 712 Na 365	SP 712 Na 365	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 776 Na 399	SP 776 Na 399	SP 776 Na 399	SP 841 Na 432	SP 938 Na 442	SP 938 Na 442	
6	5	SP 557 Na 392	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 712 Na 365	SP 537 Na 361	SP 537 Na 361	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 712 Na 365	SP 712 Na 365	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 776 Na 399	SP 776 Na 399	SP 776 Na 399	SP 841 Na 432	SP 938 Na 442	SP 938 Na 442	
7	6	SP 557 Na 392	SP 557 Na 392	SP 510 Na 359	SP 537 Na 361	SP 712 Na 365	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 510 Na 359	SP 790 Na 374	SP 862 Na 408	SP 586 Na 394	SP 776 Na 399	SP 776 Na 399	SP 776 Na 399	SP 841 Na 432	SP 938 Na 442	SP 938 Na 442					
8	7	SP 557 Na 392	SP 557 Na 392	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 586 Na 394	SP 862 Na 408	SP 862 Na 408	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 841 Na 432	SP 841 Na 432	SP 1294 Na 432	SP 841 Na 432	SP 938 Na 442	SP 938 Na 442	
9	8	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 586 Na 394	SP 586 Na 394	SP 586 Na 394	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 586 Na 394	SP 586 Na 394	SP 776 Na 399	SP 776 Na 399	SP 586 Na 394	SP 586 Na 394	SP 603 Na 424	SP 841 Na 432	SP 841 Na 432	SP 841 Na 432	SP 841 Na 432	SP 938 Na 442	SP 1005 Na 476	
10	9	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 586 Na 394	SP 634 Na 426	SP 975 Na 457	SP 650 Na 457	SP 634 Na 426	SP 862 Na 408	SP 862 Na 408	SP 776 Na 399					SP 420 Na 216	SP 1262 Na 432	SP 841 Na 432	SP 906 Na 455	SP 1005 Na 476		
11	10	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 557 Na 392	SP 650 Na 457	SP 650 Na 457	SP 603 Na 424	SP 603 Na 424	SP 683 Na 459	SP 862 Na 408	SP 862 Na 408	SP 933 Na 442	SP 933 Na 442										
12	11	SP 325 Na 228	SP 650 Na 457	SP 603 Na 424	SP 603 Na 424	SP 603 Na 424	SP 603 Na 424	SP 732 Na 492	SP 732 Na 492	SP 1005 Na 476	SP 1005 Na 476	SP 568 Na 288						Pre-Treatment TCE Concentration <7,000 ppb						
13	12		SP 650 Na 457	SP 650 Na 457	SP 634 Na 426	SP 634 Na 426	SP 732 Na 492	SP 684 Na 460	SP 906 Na 455	SP 453 Na 232								Pre-Treatment TCE Concentration 7,000- 20,000 ppb						
14	13			SP 650 Na 457	SP 603 Na 424	SP 603 Na 424	SP 634 Na 426	SP 906 Na 455	SP 453 Na 232									Pre-Treatment TCE Concentration 20,000- 25,000 ppb						
15																	Pre-Treatment TCE Concentration >25,000 ppb							

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
1																		
2																		
3					SP 381 Na 217	SP 381 Na 217	SP 381 Na 217	SP 508 Na 290	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 423 Na 482	SP 423 Na 482	SP 317 Na 362			
4		SP 550 Na 314	SP 550 Na 314	SP 550 Na 314	SP 639 Na 312	SP 639 Na 312	SP 639 Na 312	SP 590 Na 288	SP 737 Na 360	SP 737 Na 360	SP 737 Na 360	SP 635 Na 362	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 212 Na 241	
5		SP 593 Na 338	SP 688 Na 336	SP 590 Na 288	SP 737 Na 360	SP 737 Na 360	SP 737 Na 360	SP 635 Na 362	SP 423 Na 482									
6		SP 593 Na 338	SP 688 Na 336	SP 590 Na 288	SP 737 Na 360	SP 737 Na 360	SP 737 Na 360	SP 635 Na 362	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 437 Na 482					
7		SP 593 Na 338	SP 688 Na 336	SP 688 Na 336	SP 688 Na 336	SP 688 Na 336	SP 593 Na 338	SP 508 Na 290	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 437 Na 482	
8		SP 593 Na 338	2120 Na 290	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 423 Na 482	SP 328 Na 362						
9		SP 635 Na 362							SP 317 Na 462	SP 423 Na 482	SP 423 Na 482	SP 219 Na 241						
10		SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362		Lower Sand Unit Reagent Quantities											
11		SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362													
12		SP 635 Na 362	SP 635 Na 362	SP 635 Na 362	SP 635 Na 362													
13		SP 656 Na 362	SP 656 Na 362	SP 656 Na 362	SP 656 Na 362												Pre-Treatment TCE Concentration <3,000 ppb	
14		SP 656 Na 362	SP 656 Na 362	SP 656 Na 362	SP 656 Na 362												Pre-Treatment TCE Concentration 3,000- 8,000 ppb	
15		SP 656 Na 362	SP 656 Na 362	SP 656 Na 362													Pre-Treatment TCE Concentration >8,000 ppb	