COST-EFFECTIVE REMEDIATION TECHNOLOGY FOR PFAS IN SOIL UTILIZING A PROPRIETARY RAPID LEACHING AND DEWATERING TECHNOLOGY

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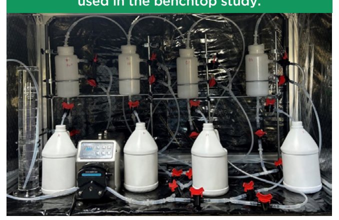
ABSTRACT

HRP Associates, Inc. (HRP) and Next Earth Environmental, Inc. (NEE) have developed a soil remediation approach that utilizes a proprietary and patent pending (application number 63/608,515) technology to remediate PFAS in soil. The remediation technology mobilizes contaminants from a solid state (soil) to a liquid state resulting in clean soil. The technology is easily scalable and can be designed to manage any weekly throughput (i.e., <100 cubic yards or >1,000 cubic yards). The technology uses a unique and patented filtration system that allows soil to be fully saturated with water and then rapidly dewatered in a watertight containment cell constructed from geomembrane and geosynthetic clay liners. The leachate is collected in a secondary watertight cell that is similarly constructed and then pumped through a wastewater treatment system to remove PFAS for future destruction or disposal.

This PFAS remediation process is referred to as Rapid Leaching and Dewatering Technology (RLDT). Once the soil is saturated, the highly soluble PFAS contaminates within the soil matrix are partitioned into a liquid phase. Once in a liquid phase, the PFAS analytes can be easily removed and consolidated through a wastewater treatment process. The soil is then resaturated with the treated water within the containment cell as necessary until the desired PFAS removal limits have been obtained (i.e., EPA Regional Screening Levels). Once the appropriate number of rinses have been completed to meet the applicable PFAS standards, the soil is left to dry for 24 hours. After 24-hours, the soil will reach an appropriate moisture content (i.e., non-saturated and can be removed for reuse or disposal.)

Setup of the four test cells (A1, B1, C1, D1) used in the benchtop study.



Two separate benchtop studies of the remediation technology have documented average total PFAS (sum of all reported analytes using EPA Method 1633) removal ranging from 89 to 93 percent. The technology removed 94 to 100 percent of the five PFAS analytes regulated by the EPA. Additional rise cycles can be incorporated into the technology to achieve additional PFAS removal to meet the target site concentrations. The benchtop studies used three and four rinse cycles to determine the effectiveness.

The benchtop study successfully demonstrates the capability of our patent-pending technology to transfer (partition) PFAS from soil to a liquid state. Once liquefied, the contaminants are destroyed using sorption with high temperature destruction and regeneration, sonication, or other innovative destructive methods. A treatability study similar to the one described above is completed with PFAS impacted site specific soil to determine the required number of rinse cycles and appropriate pH needed to mobilize PFAS.

The leachate results are then used to design a site-specific wastewater treatment system resulting in PFAS destruction. A cross-section of a full-scale RLDT system is shown below along with a photograph of the drainage layer, a cost comparison, and cross-section of the patented drainage layer. The use of RLDT can result in significant cost savings when compared to excavation and disposal at a Subtitle C landfill. A cost comparison that was completed as part of a feasibility analysis at an active AFFF site that HRP is working on is below the cross-section.

TEST METHODOLOGY

Each of the HDPE test cells in the photograph (top rack) is equipped with a specialty filter cell that represents the proprietary patented drainage layer. The valves depicted in the photograph allow each HDPE test cell to operate independently, using a measured volume of water from the graduated cylinder (left side of photo). The water is pumped from the graduated cylinder at a consistent flow rate through a peristaltic pump (center of photograph) into the desired HDPE test cell. Two benchtop studies were completed. Test 1 used AFFF concentrate consisting of a 50:50 mixture of Chemguard C301MS and Ansulite AFC-5-A AFFF. The AFFF concentrate was spiked into four, 250-gram aliquots of soil. The aliquots of soil were homogenized, and the tests completed. Four different rinse waters were used for each test to evaluate the leaching under different pH conditions.

Test 2 used a specialty PFAS standard manufactured by Cambridge Isotope that contained 40 of the 1633 PFAS analytes at a known concentration. The spike solution was added into four, 300-gram aliquots of soil.

The aliquots of soil were homogenized, and the tests completed. Three different rinse waters were used for each test to evaluate the leaching under different pH conditions. The benchtop studies included the collection of 48 samples for laboratory analysis of PFAS via EPA Method 1633 at Alpha Analytical, a Pace laboratory located in Massachusetts. A description of the test set up and sampling protocol for each test are shown in the accompanying tables.

WIP Drain filter inside the reactor prior to soil addition.

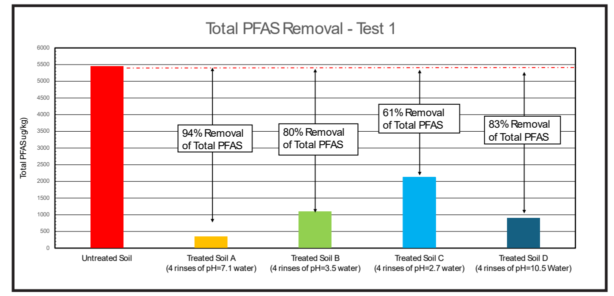
RESULTS

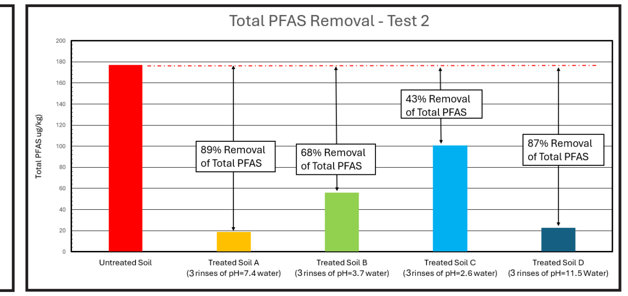
The pH neutral PFAS free water (pH =~7) yielded the highest removal efficiency in both tests, achieving 89% to 94% removal of total PFAS and 99% of PFOA. The pH adjustment is necessary in determining the most efficient way to partition PFAS from soil based on the unique chemical properties of Site-specific soil (i.e., total organic carbon). The graphs to the right show how pH adjustment of the rinse water affected total PFAS removal during each of the rinses.

The untreated soil ("Spiked Soil") is the initial PFAS concentration before treatment. Varying combinations of neutral and pH adjusted water can be used to increase PFAS removal efficiencies. The benchtop study successfully demonstrates the capability of the patent-pending technology to transfer (partition) PFAS from soil to a liquid state. Once liquefied, the contaminants are destroyed using sorption with high temperature destruction and regeneration, sonication, or other innovative destructive methods.

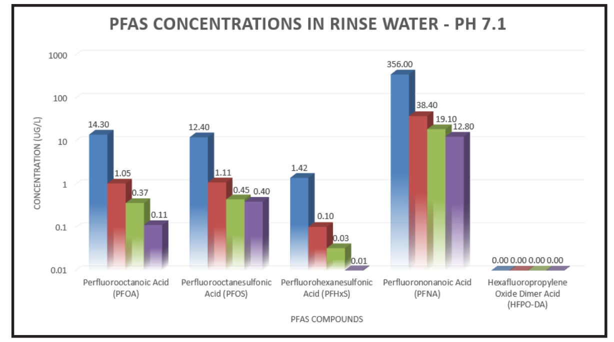
A treatability study similar to the one described above is completed with PFAS impacted site specific soil to determine the required number of rinse cycles and appropriate pH needed to mobilize PFAS. The leachate results are then used to design a site-specific wastewater treatment system resulting in PFAS destruction. A field study can also be implemented using a one cubic yard scale model of the RLDT as shown here.

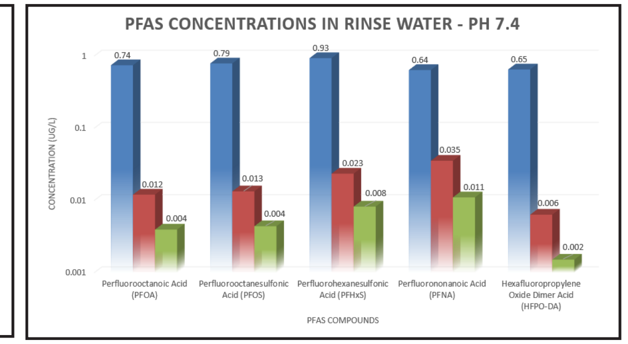
DATA RESULTS





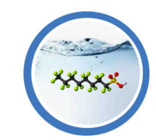
	Test 1	Test 2
Soil Sample	Soil spiked with 10 milliliters of the 50:50 AFFF concentrate	Soil spiked with 10 milliliters of Cambridge Isotope PFAS Spike Standard
Number of Rinses	4 rinses at 1.5 L / rinse	3 rinses at 2.25 L / rinse
Reactor A	pH 7.1 PFAS Free Water	pH 7.4 PFAS Free Water
Reactor B	pH 3.5 PFAS Free Water	pH 3.7 PFAS Free Water
Reactor C	pH 2.7 PFAS Free Water	pH 2.6 PFAS Free Water
Reactor D	pH 10.5 PFAS Free Water	pH 11.5 PFAS Free Water





STEP 1: PFAS impacted soil is excavated and then placed into the double lined soil containment cell with drainage system.

STEP 2: The soil containment cell is flooded with water and then the soil is agitated with large air bubbles.

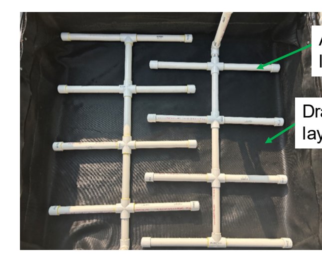


STEP 3: PFAS leaches from the soil and mobilizes into the water.

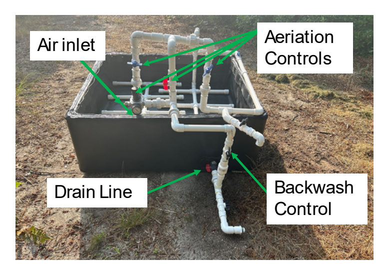
STEP 4: PFAS impacted water is pumped through a treatment system. Resulting clean water is transferred back to the soil containment cell and Steps 2-4 are repeated.

STEP 5: Once desired contaminant removal level is reached, clean soil is removed from the containment cell and Steps 1-4 are repeated, as necessary.

STEP 6: Clean water is dis-charged or recycled after the project is completed and all soil has been cleaned.



SCAN TO WATCH >



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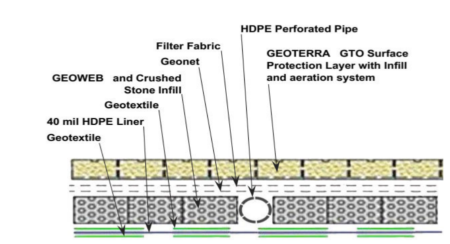
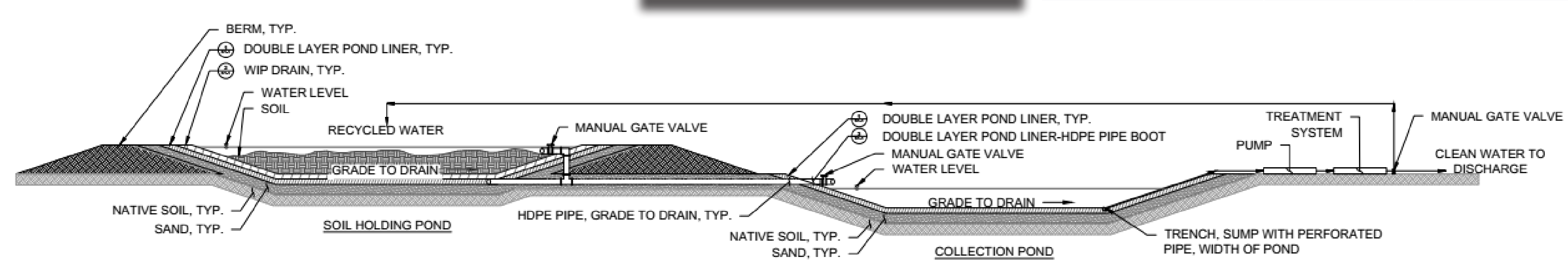


Excavation of 35,000 yd^3 Between 2-5 ft below ground surface	Rapid Leaching Technology	Soil Excavation and Disposal (Subtitle C Landfill)
	100'X100' Cell	500 tons per week, 70 weeks
Leachability/Benchtop Testing	$55,000 to $65,000	N/A
Soil Disposal Characterization for Landfill (One sample per 500 cubic yards)	Not Applicable	$100,000 to $120,000
Civil Engineering Design Costs	$70,000 to $100,000	$70,000 to $100,000
Environmental Engineering Design Costs (Water Treatment Design)	$25,000 to $35,000	N/A
Reactor Cell Construction	$1,560,000 to 1,700,000	N/A
Wastewater Treatment System Mobilization	$40,000 to $80,000	N/A
Construction Oversight /Equipment Costs	$6,400,000 to $6,600,000	$2,800,000 to $3,000,000
PFAS Post Treatment Sample Collection (one per 500 cubic yards)	$35,000 to $45,000	NA
Soil Import and Placement	N/A	$3,150,000 to $3,250,000
Soil Borrow Source Testing	N/A	$50,000 to $55,000
Soil Disposal	N/A	$63,000,000 to $63,200,000
TOTAL COST	**$8,185,000 to $8,625,000**	**$69,170,000 to $69,725,000**



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