REGENESIS®

Colloidal Activated Carbon Flocculation Method Validation

PetroFIX® Remediation Fluid

PLUMESTOP® Liquid Activated Carbon

Description and Contaminant Analytical Impacts

Test Vial Settling Agent

Figure 1 – Two vials containing 2,000 mg/L of CAC. The recommended dose of settling agent was also added to the vial on the right, resulting in clear water.

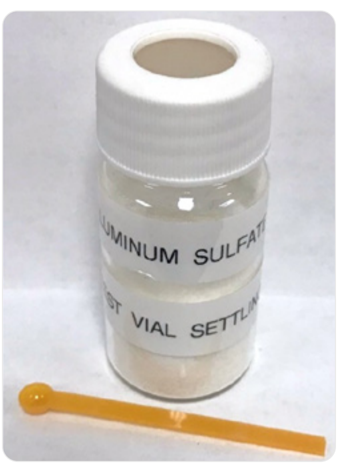


Figure 2 – ALUM kit with dosing scoop

After application of REGENESIS® colloidal activated carbon (CAC) products, groundwater and occasionally the water in monitoring wells will be impacted by the presence of suspended CAC. Within weeks or occasionally months, the CAC will fully attach to the aquifer matrix and the water will again become clear. The presence of CAC above approximately 100 mg/L (i.e.- water in a standard VOA vial too dark to see through) can have a negative impact on the methods and instruments used to quantify volatile organic compounds (VOCs) in water by standard methods like EPA 8260. To remove the CAC from analytical samples and permit VOC sampling, REGENESIS developed a method for flocculating suspended colloidal activated carbon directly in sampling vials **(Figure 1)**. For further information about the method and its use, please refer to the REGENESIS document: *Settling Agent for Test Vials*.

Verification of Settling Method: Effect on Aqueous VOC Concentrations

The objective for this method is to remove the suspended CAC from the water column while leaving the aqueous VOC concentration in the samples undisturbed. By adding a small amount of aluminum sulfate (ALUM) to a sample, the CAC will flocculate and fall to the bottom of the vial. This addition of a flocculant has minimal effect on any dissolved contaminants that may be present, as the ALUM does not affect the partitioning between the CAC and the water. A series of samples at various contaminant, ALUM, and CAC concentrations were evaluated to verify that ALUM does not cause changes in aqueous VOC concentrations.

About the Test Development

Effect of ALUM in the Absence of CAC

The presence of ALUM on the aqueous concentration for selected contaminants of interest was explored. Chlorinated volatile organic compounds and BTEX concentrations were tested after mixing with ALUM. Tetrachloroethylene, trichloroethylene, and cis-dichloroethylene were analyzed from 0.25 mg/L to 10 mg/L in the presence of 1 g/L ALUM. Analysis was performed via gas chromatography–mass spectrometry (GC-MS) using a head space sampling method. Samples were prepared in VOA vials with 40 mL of water and then spiked with CVOCs from a mixed 1000 mg/L stock to the concentrations listed. Alum was then added to each sample and the samples allowed to equilibrate for over 24 hours before aliquots were taken for analysis. The data showed that the addition of ALUM had a minimal effect on the contaminant levels vs control **(Table 1)**. The results were biased high and biased low with an average deviation of under 5% which is within the range of error for calibration and preparation. Benzene, toluene, ethylbenzene, and o-xylene were analyzed from 0.25 mg/L to 10 mg/L in the presence of 1 g/L ALUM via gas chromatography–mass spectrometry (GC-MS). Samples were prepared in VOA vials with 40 mL of water and then spiked with BTEX from a mixed 1000 mg/L stock to the concentrations listed. Alum was then added to each sample and allowed to shake for over 24 hours to equilibrate before aliquots were taken for analysis. The data showed that the addition of ALUM had a minimal effect on the contaminant levels vs control **(Table 3)**. The results were biased high and biased low with an average deviation of under 5% which is within the range of error for calibration and preparation.

Chlorinated Volatile Organic Compounds (CVOCs) with ALUM

Contaminant Concentration (mg/L)	Deviation from Control		
	PCE	TCE	Cis-DCE
0.25	-4.38%	-1.47%	4.32%
0.5	9.95%	0.76%	0.97%
2	-5.69%	-16.81%	-19.14%
5	5.87%	-4.82%	-8.62%
10	0.63%	0.38%	0.59%
Average	**-1.27%**	**-4.39%**	**-4.38%**

Table 1 – Effect of 1g/L ALUM on CVOC concentration analysis via GCMS.

Benzene, Toluene, Ethylbenzene, and O-Xylene with ALUM

Contaminant Concentration (mg/L)	Deviation from Control			
	Benzene	Toluene	Ethylbenzene	O-Xylene
1	0.24%	2.01%	3.77%	4.14%
2	-4.94%	-5.86%	-6.81%	-7.94%
5	-1.22%	-1.34%	-2.07%	-2.16%
10	-8.28%	-9.95%	-10.67%	-10.62%
Average	**-3.55%**	**-3.79%**	**-3.95%**	**-4.14%**

Table 3 – Effect of 1g/L ALUM on BTEX concentration analysis via GCMS.

Effect of ALUM in the Presence of CAC

Chlorinated volatile organic compound concentrations were analyzed with colloidal activated carbon after addition of ALUM to determine ALUM's effect on contaminant analysis. This experiment was performed using 500 mg/L CAC, 0.5 mg/L to 10 mg/L of CVOC, and 2 g/L ALUM in all samples with analysis via gas chromatography with an Electron Capture Detector (GC-ECD) by headspace. PCE and cis-DCE were selected to represent CVOCs as the contaminants with the highest and lowest sensitivity on GC-ECD respectively. To obtain 0.5 mg/L to 10 mg/L of contaminant in samples in the presence of CAC, isotherms were used to calculate the correct amount of neat contaminant to spike into each sample.

PCE and cis-DCE samples were prepared individually to match the isotherms calculated. Samples were prepared in VOA vials with 38 mL of 500 mg/L CAC and then injected with either neat PCE or cis-DCE to the concentrations listed. Then the samples were allowed to shake for 24 hours and then refrigerated for 24 hours to allow all contaminants to fully dissolve in solution. The samples were then injected with 2 mL of 35 g/L ALUM to obtain 2 g/L ALUM in the samples and allowed 2 hours to settle before aliquots were run on GC-ECD headspace. The data showed that the addition of ALUM had a minimal effect which caused the results to bias high for both contaminants **(Table 2)**. The data from this experiment support the notion that the addition of ALUM to flocculate CAC from aqueous samples may only slightly increase the measured CVOC concentrations, and that the use of ALUM as a settling agent is not leading to biased favorable results.

Chlorinated Volatile Organic Compounds (CVOCs) with Activated Carbon

Contaminant Concentration (mg/L)	Activated Carbon Concentration (mg/L)	Deviation from Control	
		PCE	Cis-DCE
0.25	500	29.41%	NA
0.5	500	34.87%	NA
2	500	31.47%	18.33%
5	500	8.3%	4.75%
10	500	NA	9.69%
Average		**26.01%**	**10.93%**

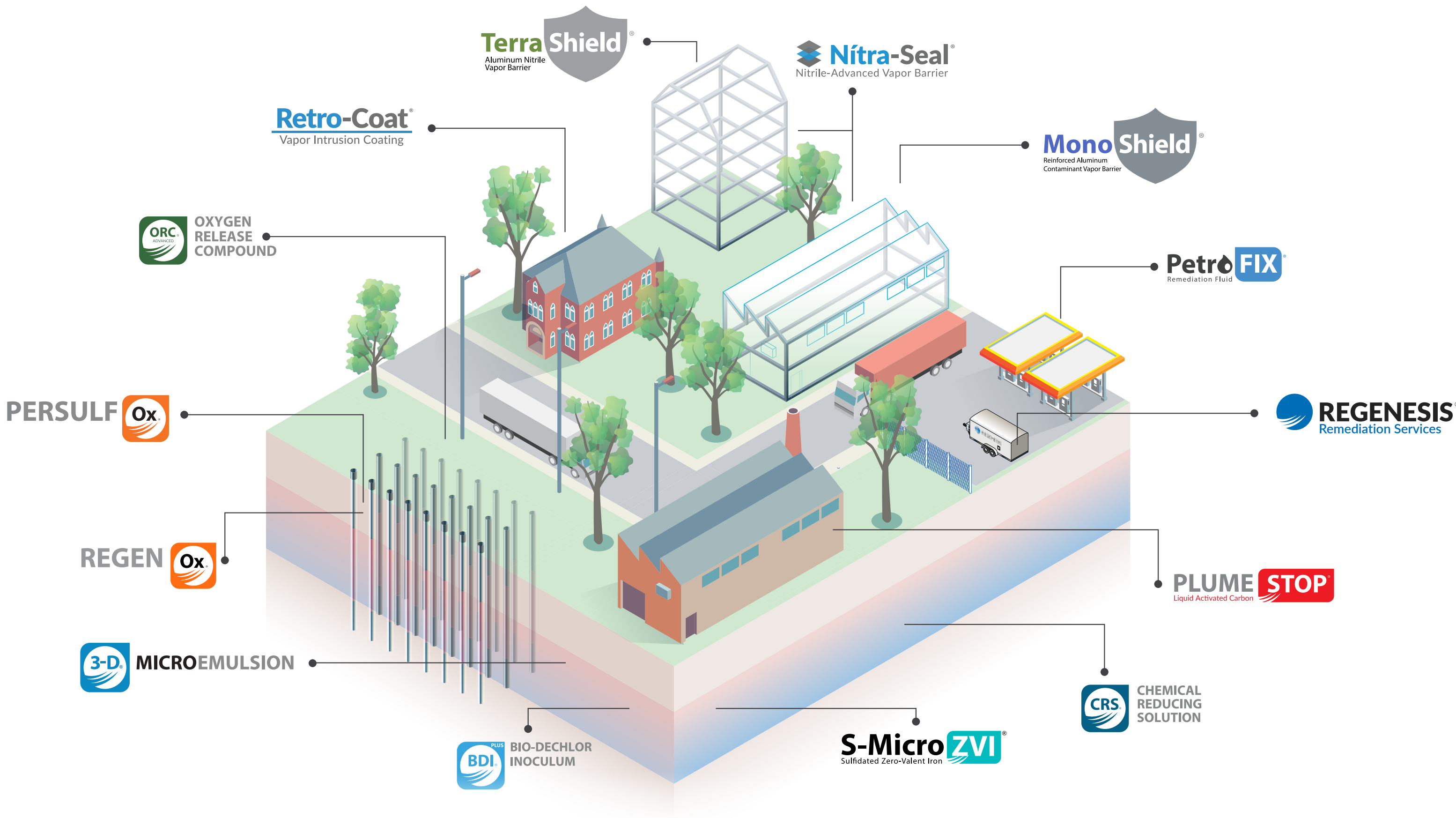
Table 2 – Effect of 2g/L ALUM on CVOC concentration analysis with 500 mg/L activated carbon analysis via GC-ECD.

Benzene and O-Xylene with Activated Carbon

Contaminant Concentration (mg/L)	Activated Carbon Concentration (mg/L)	Deviation from Control	
		Benzene	O-Xylene
1	500	24.31%	NA
2	500	2.99%	24.31%
5	500	2.87%	17.51%
10	500	15.09%	19.11%
Average		**11.32%**	**20.31%**

Table 4 – Effect of 2g/L ALUM on BTEX concentration analysis with 500 mg/L activated carbon analysis via GC-FID.

BTEX concentrations were analyzed with colloidal activated carbon after addition of ALUM to determine ALUM's effect on contaminant analysis. This experiment was performed using 500 mg/L CAC, 1 mg/L to 10 mg/L of BTEX, and 2 g/L ALUM in all samples with analysis via gas chromatography with a Flame Ionization Detector (GC-FID) by headspace. Benzene and o-xylene were selected to represent BTEX as the contaminants with the highest and lowest sensitivity on GC-FID respectively. To obtain 1 mg/L to 10 mg/L of contaminant in samples in the presence of CAC, isotherms were used to calculate the correct amount of neat contaminant to spike into each sample. Benzene and o-xylene samples were prepared individually to match the isotherms calculated. Samples were prepared in VOA vials with 38 mL of 500 mg/L CAC and then injected with either neat benzene or o-xylene to the concentrations listed. Then the samples were allowed to shake for 24 hours and then refrigerated for another 24 hours to allow all contaminants to fully dissolve in solution. The samples were then injected with 2 mL of 35 g/L ALUM to obtain 2 g/L ALUM in the samples and allowed 2 hours to settle before aliquots were run on GC-FID headspace. The data showed that the addition of ALUM had a minimal effect which caused the results to bias high for both contaminants **(Table 4)**. The data from this experiment support the notion that the addition of ALUM to flocculate CAC from aqueous samples may only slightly increase the measured BTEX concentrations, and that the use of ALUM as a settling agent is not leading to biased favorable results.



About REGENESIS

At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

Inherently, innovation imparts new and better ways of thinking and doing. For us this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

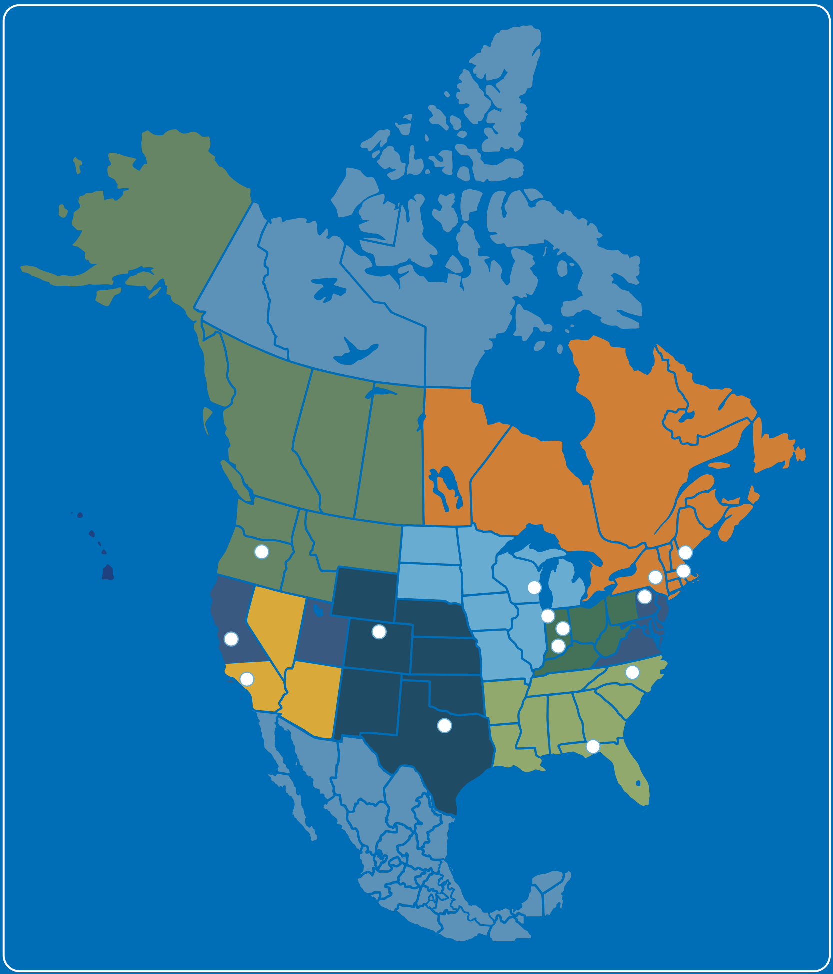
At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking time to understand the people we work with and their circumstances. We believe this is a key factor in achieving successful project outcomes.

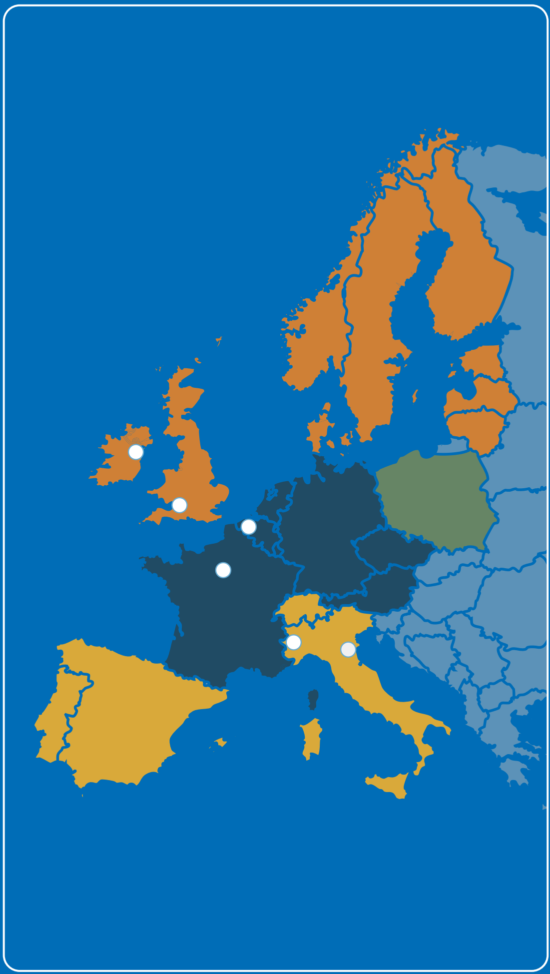
We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

REGENESIS®

We're Ready to Help You

Find the Right Solution For Your Site





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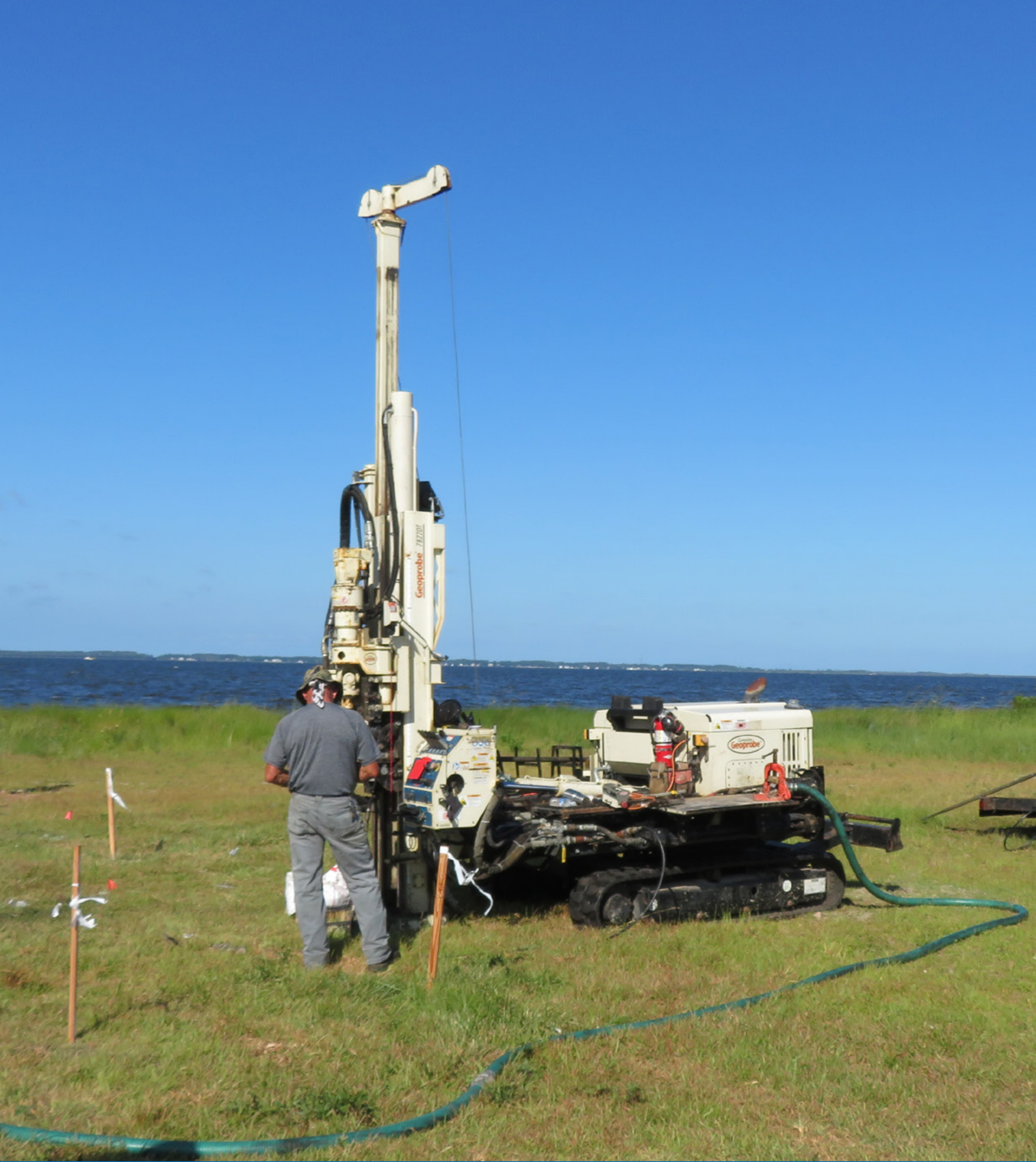
Visit www.REGENESIS.com to learn more.



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