PLUME STOP®
Liquid Activated Carbon

# Frequently Asked Questions **(FAQs)**

## **PlumeStop®** Liquid Activated Carbon™


REGENESIS®

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## How it Works


**What is the basis for the technical design of PlumeStop treatments at a contaminated site? Is the application based on stoichiometry and/or pore volume occupancy?**
PlumeStop designs are based on the sorptive capacity of PlumeStop for the given contaminants (sorption isotherms) combined with a pore volume fill requirement to initiate good contact with the contamination.

**How is the distribution of PlumeStop through the subsoil determined?**
The presence of PlumeStop at a particular point is qualitatively indicated by its dark black color within the soil or groundwater. The actual concentration within soil and groundwater can be semi-quantified through analysis of the elemental carbon.

**How long will the water in the groundwater monitoring well remain black after treatment of a site with PlumeStop? What if the color of the water is a concern for my client? Will the soil be stained permanently?**
The water is expected to be black for the first 2-3 months. Over time, the water will clarify back to pre-injection conditions, and the time this takes depends on the soil type at the site. In general, soils with high cation exchange capacity (e.g., clay rich soils) will bind PlumeStop more quickly than those with lower capacity, thereby removing PlumeStop from the groundwater in a shorter period of time. As a result, clients will likely see variability on how long the water samples visually show PlumeStop within the treatment zone. If a client has serious concerns about this issue, REGENESIS® Remediation Services can implement well development procedures to clear the well. (Regardless of the soil type, soil samples collected from the treatment zone will remain black for a significant period of time.)

**What documentation is available to demonstrate biodegradation of the contaminants?**
An in-depth study on the contaminant degradation process is described in PlumeStop Technical Bulletin 3.1. In this study, the destruction of benzene in a biotic PlumeStop treated soil sample is compared to abiotic and soil-only control samples. Complete destruction of all benzene mass in the biotic PlumeStop sample compared to the control samples confirmed post-sorption contaminant degradation.

**How does PlumeStop distribute in the subsurface once pumping is stopped? How far is the material able to travel?**
PlumeStop is designed to achieve wide-area distribution through low-pressure injection. Surface treatment of the colloidal carbon particles alters the charge of the particles, thereby reducing their interactions with the soil matrix and increasing their distribution within the subsurface. PlumeStop deposits as it is injected to create a coating on the aquifer matrix, and the extent or distance of the coating will depend on the injection dose and volume as well as the soil type and groundwater flow rates. In permeable zones, it is expected to travel at least 10-15 feet. Once the injection pressure is stopped, PlumeStop will remain in the water column for a period of 1-3 months. See Technical Bulletin 1.1 on transport for more information.

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**Will PlumeStop change the hydraulic conductivity within the injection zone?**
PlumeStop will have minimal impact to hydraulic conductivity under typical loading rates.

**Is it certain that contaminant of concern (COC) removal at the beta sites is due to adsorption/ biodegradation and not simply dilution due to the volumes of fluids injected?**
The sorption capacity of PlumeStop is demonstrated in Technical Bulletins 2.1 and 2.2. Evidence for biodegradation of contaminants from the surface of PlumeStop is provided in Technical Bulletin 3.1. Furthermore, PlumeStop injection sequences alternate between sides of the treatment area to reduce net displacement. Note also that a 99-100% concentration reduction in a single injection event has never been achieved with a pump-and-treat system, which displaces significantly greater volumes over longer periods of time. This is because plumes generally mix and dilute more than they displace, and soil heterogeneity contributes to these competing processes.

**What causes the PlumeStop particles to stick to the soil?**
Surface modification of the colloidal PlumeStop particles create a negatively charged surface allowing them to transport through aquifer soils that are also predominantly negatively charged. In the primary method of PlumeStop deposition, these negatively-charged particles interact with pockets of permanent positive charge that are distributed throughout the aquifer matrix, resulting in irreversible deposition of the PlumeStop onto the soil. This process was demonstrated in Technical Bulletin 1.1 in which a column that was treated with PlumeStop was flushed with > 10 pore volumes of clear water with no washout of the deposited PlumeStop observed. A secondary deposition mechanism occurs over time *in situ* as the stabilizing polymer begins to degrade or interact with groundwater components, resulting in destabilized colloidal particles that cannot transport and permanently deposit on the soil.

**How long do the contaminant concentrations need to be kept down to achieve remediation goals?**
This depends on regulatory requirements. Some sites have reached risk-based regulatory remediation goals within 90 days of PlumeStop injection. However, it is more typical for regulatory agencies to require several quarters of groundwater compliance prior to closing a site.

**Is fouling of the carbon an issue?**
It is possible that the activated carbon will form a biofilm, much like biological activated carbon (BAC or Bio-GAC); however, this will continue to stimulate sorption and degradation of contaminants.

**What is the source of carbon?**
PlumeStop is manufactured using virgin activated carbon sourced from coconuts that can be used to treat potable water.

**What is the pH of the PlumeStop mixture?**
The pH for PlumeStop is between 8-9.

**How is the sorptive capacity of PlumeStop regenerated? Does the carbon lose its integrity?**
Regeneration of the sorption sites is achieved through the biodegradation of the sorbed contaminants. This process is described in depth in Technical Bulletin 4.1 via laboratory studies that demonstrate multiple cycles of regeneration without loss of activity.

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**Is it possible that within a long-term barrier, the carbon particles can themselves degrade as a result of their small size?**
Activated carbon is non-biodegradable and therefore is not subject to natural decay processes.

**What is responsible for the enhanced biodegradation?**
Sorption of the contaminants to the PlumeStop surface creates local areas of high contaminant concentration that are then colonized by contaminant-degrading bacteria. This co-localization of the contaminants and degrading bacteria on the PlumeStop surface greatly enhances the contact between the two components compared to solution-based bioremediation, thereby enhancing the efficiency of the degradative reactions. Technical Bulletin 3.1 provides a thorough discussion of the post-sorption contaminant biodegradation.

**If the seepage velocity was twice as fast, would the contaminants still have time to sorb?**
The adsorption of contaminants to the PlumeStop surface is a very fast, and almost immediate process, so even in a fast-moving aquifer, contaminants that make contact with PlumeStop should adsorb. However, if the seepage velocity is a concern, a longer PlumeStop barrier can be installed along the flow path to ensure sufficient contact time.

**Given the competition for adsorption sites on the carbon, how does PlumeStop respond to high TDS groundwater, for example, high dissolved sulfates?**
Sulfate is not adsorbed by the activated carbon used in PlumeStop and therefore sulfate will have no impact or competition for the adsorption of PFAS. This is true of other cations and anions typically found in groundwater.

**Liquid Activated Carbon spreads easily; isn't it spreading the contamination as well?**
LAC does transport easily, but as it is spreading, a layer of the PlumeStop will permanently deposit on the aquifer soil, and eventually all the PlumeStop will be deposited so that it does not transport any farther. A good analogy would be to compare it to a paintbrush stroke-if you paint a continuous line, eventually the paint will be used up and the line will end. PlumeStop allows us to inject a barrier of activated carbon *in situ*. Once in place, PlumeStop will continue to passively adsorb contaminants, just like a barrier.

## Contaminants Addressed

**What contaminants does PlumeStop work on?**

- Benzene (BTEX)
- Petroleum Hydrocarbons (PHC)
- Methyl tert-butyl ether (MTBE)
- Chlorinated solvents (cVOCs)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Aromatics
- Haloalkanes
- Pesticides and Herbicides
- Energetics
- Polychlorinated biphenyls
- Perfluorooctane Sulfonate (PFOS)
- Perfluorooctanoic Acid (PFOA)

See the *Range of Treatable Contaminants* in the resources menu for a complete list of chemicals that are compatible with PlumeStop.

**When treating PFAS compounds with PlumeStop, contamination remains with Liquid Activated Carbon, it's just retarded from distributing in the aquifer, isn't it?**
That is correct, in the case of contaminants like PFAS which do not have a destructive pathway available PlumeStop acts as an *in situ* containment or retardation strategy.

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## Performance

**How long does PlumeStop remain effective for groundwater remediation?**
PlumeStop is expected to provide treatment for decades as a result of its irreversible binding to the soil, the stability of the carbon to degradation, and the regeneration of the sorption sites via in-matrix biodegradation.

**What is the range of contaminant concentrations that can be treated?**
The range of concentrations that are most effectively treated with PlumeStop varies for each contaminant based on its sorption isotherm. These ranges are also influenced by flux rates.

**Do contaminants adsorb to the PlumeStop surface at different rates?**
The time it takes for PlumeStop to adsorb contaminants is expected to be very rapid in all cases.

**Are there any elements or conditions that could be present within the subsurface that would reduce the effectiveness of PlumeStop?**
Since there is no way to selectively adsorb only the contaminants, it is very important to know all of the organic species that are present at the site in order to apply the appropriate dose of PlumeStop. High levels of dissolved natural organic matter could also create competition with the contaminants for sorption sites. High levels of total dissolved solids (TDS) may slightly decrease the post-injection migration of PlumeStop, but they will not alter the sorptive and biodegradation properties.

**How is PlumeStop affected by extreme pHs?**
The pH of an aquifer will have minimal to no influence on the distribution of PlumeStop; only under very acidic conditions (< 4-5) might there may be a slight decrease in the post-injection transport of PlumeStop under natural flow conditions. In regard to the influence of pH on sorption, as with any activated carbon, a change in pH can alter the sorption of some compounds. No substantial changes in sorption are expected with contaminants like benzene or TCE. The largest changes are typically observed when the compound being adsorbed changes form with pH, eg. phenol, and a higher or lower pH can either improve or decrease the sorptive capacity depending on the compound.

**Any toxicity associated with the polymers used in the mixture that might have their own exposure risks?**
No, all additives used in PlumeStop are food grade and the polymer is completely biodegradable.

## Application

**How likely will PlumeStop be approved for injection in my State? Where has the product been applied so far?**
PlumeStop has been generally well-received by regulatory agencies across the U.S. PlumeStop has been applied on sites around the world.

**Why is it necessary to collect soil and groundwater samples before application?**
These samples are collected and analyzed to determine the total mass of contamination at the site. This includes the initial dissolved phase contamination plus the mass that will desorb/back-diffuse from the sorbed/immobile porosity. In addition, the total organic species that are present at the site are determined so that the appropriate dose of PlumeStop for all adsorbing species, not just the contaminant of concern, can be applied.

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**What happens if/when PlumeStop gets on the ground? How do I clean it off of concrete or equipment?**
PlumeStop will come off of most surfaces with standard pressure washer cleaning. Depending on the concrete porosity, this may take more effort on some surfaces than others. For all spills, it is best to first vacuum up the PlumeStop and then follow up with a soap and water pressure wash if needed.

**What are the important criteria in designing a remediation plan using PlumeStop?**
The most important design critical information is as follows:

A) Groundwater and soil data for contaminants of concern (COC's) and all other organic species present.

B) Continuous soil core (logged by REGENESIS) is collected prior to design application.

C) Clear water injection testing should be performed prior to application.

The test injection volumes should be comparable to the designed application volumes. This test should be performed by REGENESIS Remediation Services (RRS) with the appropriate injection monitoring system to the design application rates; this test should be performed by qualified personnel (RRS) with the appropriate injection – monitoring system that is downhole injection tools, pump metering/monitoring set.

**What percentage of the subsurface pore volume is used in the calculations to determine how much PlumeStop is injected?**
Typically 30%, which is similar to an ISCO injection.

**Does PlumeStop clog wells that are used for injection?**
No, PlumeStop behaves like a liquid, and the stabilized colloid (1-2 micron particles) does not clog wells.

**Why is it important to evaluate the concentrations of all contaminants at a site prior to PlumeStop application? For example, if benzene (BTEX) is the only contaminant of concern at a petroleum site, why do the Total Petroleum Hydrocarbons (TPH) concentrations in soil and groundwater also need to be determined?**
The sorption process of organic material to the PlumeStop surface is not selective for the contaminant of concern, and all dissolved organic compounds will compete for the sorption sites. For example, in the case of the petroleum site that is being treated for BTEX, the TPHs will occupy sorption sites, and if the dosage of PlumeStop was based solely on the BTEX concentrations, some BTEX will remain in the aqueous phase. It is therefore important that the total organic loading of the groundwater be quantified in order to determine the appropriate dosage of PlumeStop for the specific site.

**Is it possible to introduce PlumeStop via an existing well, or are injection points around the well always required?**
At some sites it may be possible to apply PlumeStop through an existing well.

**How is PlumeStop typically applied?**
PlumeStop is typically injected in the ground using direct push, application wells, or through gravity feed in both grid and barrier configurations.

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### If saturated soil data has never been collected at a site, can PlumeStop still be used?
Yes, if the site does not have saturated soil data, the recommended process would be to collect soil samples as part of the evaluation prior to applying PlumeStop in order to determine if there is additional mass not shown in the groundwater data.

### Has PlumeStop been applied at any sites with challenging subsurfaces?
Yes, many different and challenging subsurface environments have been successfully treated with PlumeStop. Examples include treatment of very heterogeneous media, high-flux sand/gravel aquifers, low permeability sites, fractured rock, among others.

### How much does PlumeStop cost?
To ensure project success, RRS takes responsibility for applying PlumeStop and will provide a "turn-key" project cost for including all aspects of the application (e.g. mobilization, direct push/drilling, injection, etc.).

### How is the material delivered to the site?
PlumeStop is delivered in 400 lbs drums or 2,000 lbs totes.

## Combined Approaches

### Can PlumeStop be co-applied with ORC Advanced® or HRC®?
Yes, successful co-application has been demonstrated for ORC Advanced and HRC.

### Can PlumeStop be used with Chemical Reducing Solution (CRS®)?
Yes, CRS can be applied in conjunction with PlumeStop, but the two products should be applied sequentially instead of being co-mixed.

### Can PlumeStop treatments be combined with enhanced aerobic biodegradation using an oxygen source, nutrients and bacteria?
Yes, ORC Advanced has been co-applied with PlumeStop as an oxygen source for aerobic biodegradation, and a mixture of nutrients is delivered with PlumeStop to stimulate the native bacteria population.

### Does PlumeStop increase the efficiency of sparge systems?
It depends upon the contaminant type. PlumeStop will bind dissolved contaminants from solution. If the contaminant is aerobically degradable, the bound contaminant will be rapidly biodegraded as a result of the oxygen from the air sparge system. However, if the contaminant is not aerobically degradable, PlumeStop will reduce the efficiency of the sparge by binding the contaminants in the subsurface and inhibiting their volatility.

### Related PlumeStop Information and Resources

- Tech Bulletins
- Spec Sheet
- White Paper
- Case Studies

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