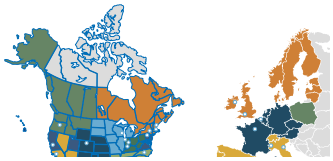
REGENESIS®

PlumeStop and PFAS Treatment

Frequently Asked Questions and Answers

REGENESIS®

PFAS Contaminants – An Emerging Concern



Per- and polyfluorinated alkyl substances (PFAS) are a group of thousands of manmade chemicals used for decades in a wide variety of residential, commercial, and industrial applications and products. Stain-resistant carpets, water-resistant clothing, non-stick cookware, food packaging, and aqueous film-forming foam (AFFF) are known to contain PFAS. Their abundant use has led to pervasive environmental contamination including drinking water, surface water, groundwater, soil, sediment, and air contamination. Due to their toxicological properties, many states have begun restricting wild game and fish consumption due to detections of PFAS in wildlife.

PFAS are highly soluble in water and have a very strong carbon-fluorine backbone making them resistant to traditional remediation technologies and natural attenuation. PFAS that enter groundwater are known to be persistent and travel long distances. Fate and transport of PFAS in groundwater depends on the environment which they were released and the physical properties of the PFAS being examined (e.g., carbon chain lengths, linear/branched isomers, functional groups, and degree of fluorination). This discussion will focus on the challenges of understanding fate and transport of PFAS.

Frequently Asked Questions

PFAS Treatment Using Colloidal Activated Carbon Technology

PLUME STOP® Liquid Activated Carbon

PlumeStop® Colloidal Activated Carbon is an innovative groundwater remediation technology designed to address the challenges of excessive time and end-point uncertainty in the *in situ* remediation of groundwater contaminants. PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material binds to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

Scan Here to Read Grant Carey's Article on This Topic

Scan Here to See a Short Technical Video

When treating PFAS compounds with PlumeStop, is there any destructive mechanism?

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.

What is the anticipated longevity of a PlumeStop barrier and when would reinjection be necessary for the longer term protection of downgradient wells or receptors?

The longevity of a PlumeStop® barrier is determined by several factors. First is the characteristics of the contaminant plume, including rate of contaminant flux, contaminant species present, other organics present that could competitively sorb, if the contaminants are biodegradable or not. Second is the installation design itself which includes the amount of PlumeStop applied per unit volume of aquifer flux zone, and the barrier thickness (the distance of PlumeStop treated aquifer that the plume will have to migrate through).

To evaluate these factors, we use a competitive sorption model to help us estimate how much carbon is required to capture the estimated PFAS flux and any other organic compounds coming through the barrier over time. Under most circumstances the estimated longevity of a PlumeStop barrier meeting regulatory objectives is on the order of many decades. If the source has been removed and the incoming flux is diminishing, the longevity of a single PlumeStop barrier may be greatly extended. The QR code to the left links to a short technical video that provides a more in-depth explanation on this.

Does PlumeStop get spent over time and have to be replenished?

PlumeStop never gets "spent" in the sense that it will remain as part of the aquifer and will continue to adsorb contaminants. It will however potentially become "filled up" with PFAS if there is a continuous incoming flux. This is because PFAS compounds do not biodegrade like BTEX or chlorinated compounds can. If an existing PlumeStop barrier becomes saturated with PFAS, an additional barrier can be installed just downgradient of the first.

Can other non-target compounds block available adsorption sites for PFAS?

Yes, hydrophobic contaminants or natural organic matter can and will compete for sorption sites on the PlumeStop particle. Therefore, when we are evaluating PlumeStop for a site, we typically request TOC levels, and all analytical contaminant data that is available. We are able to use this data in the PlumeStop competitive sorption model to view the expected impact.

Is PlumeStop more effective for short or long chain PFAS?

The more hydrophobic the contaminant is, the more sorptive it is to colloidal activated carbon. Therefore, the least sorptive species are the short chain PFAS such as perfluorobutanoic acid (PFBA). However, PlumeStop is effective at treating PFBA-it's just a matter of how much PlumeStop is applied and how long of a PlumeStop treatment zone that can be created.

What concerns do you see with the US EPA creating formal regulation of PFAS that would require concentration and/or destruction methods of treatment?

With PlumeStop, the waste is never "generated" in regulatory terms. Therefore the practitioner using PlumeStop does not have to worry about transport to a permitted Transportation, Storage, Disposal Facility (TSDF). Use of PlumeStop would be a most elegant, and cost effective solution under the scenario of EPA creating formal designation of PFAS as a hazardous material (waste).

Scan here to review ITRC's PFAS standards information

What are the regulatory standards for PFAS?

This is a complex question as there are no federal standards for PFAS, simply health advisory levels. Many states have promulgated their own standards. A good reference is the ITRC.

When a No Further Action (NFA) is issued, are institutional or engineering controls typically implemented after the use of PlumeStop for PFAS?

Our discussions with regulatory agencies have all included the notion of having a sentinel well(s) downgradient of the PlumeStop barrier being used for PFAS remediation that is analyzed periodically (i.e. once a year) to ensure that the PlumeStop is working as designed. This is a form of institutional control that would go with the NFA.

Do high levels of metals in groundwater impact the effectiveness of PlumeStop for PFAS or other target contaminants?

No, most metals have limited sorption to colloidal activated carbon, and therefore do not effectively compete for adsorption sites with the target contaminants.

About PlumeStop Technology

What is the basis for the technical design of PlumeStop treatments at a contaminated site and 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 (using sorption isotherms and a competetive model), combined with a pore volume fill requirement to initiate good contact with the contamination.

How is the distribution of PlumeStop through the subsoil confirmed?

The presence of PlumeStop at a particular point is qualitatively indicated by its dark black color within the soil or groundwater. Field tests are performed in real time by REGENESIS Remediation Services to monitor distribution during injection events.

How long will the water in the groundwater monitoring well remain black after treatment of a site with PlumeStop and 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 primarily depends on the soil type and groundwater movement 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?

Scan Here to Download PlumeStop Technical Bulletins

PLUME STOP Liquid Activated Carbon

An in-depth study on the contaminant degradation process is described in **PlumeStop Technical Bulletins 3.1 and 3.4**. In those studies, the destruction of benzene and TCE, respectively, in a bio-stimulated, PlumeStop treated batch reactor is compared to abiotic and soil-only control samples. Rapid and complete destruction of all the contaminant mass in the PlumeStop sample compared to the control samples confirmed post-sorption contaminant degradation.

How is the sorptive capacity of PlumeStop regenerated and 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.

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.

Scan Here to Read Rick McGregor's Article That Covers This Topic

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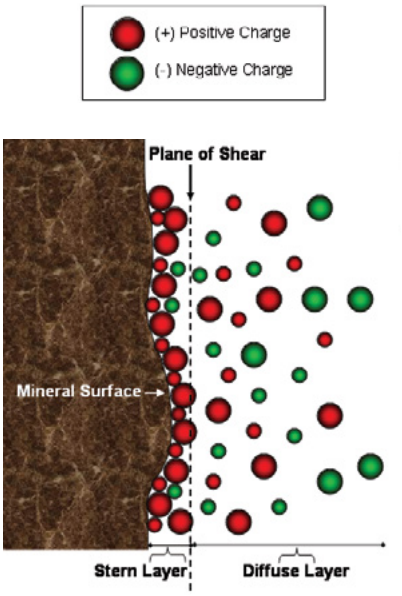
Will PlumeStop change the hydraulic conductivity within the injection zone?

PlumeStop will have minimal impact to hydraulic conductivity under typical loading rates.



What causes the PlumeStop particles to stick to the soil and what is the fate of the polymer coating?

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 wash away, which typically occurs within three months of the application, resulting in destabilized colloidal particles that cannot transport and permanently deposit on the soil.

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.

If the seepage velocity was twice as fast, would the contaminants still have time to sorb?

The adsorption of contaminants to the micron-scale PlumeStop surface is very fast, an almost immediate process, so even in a fast-moving aquifer, contaminants that make contact with PlumeStop will 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.

Is PlumeStop impacted by high TDS in 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.

Is the performance of PlumeStop affected by extreme pHs?

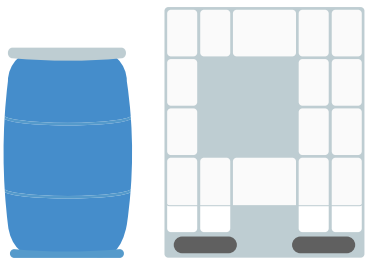
As with any activated carbon, a change in pH may alter the sorption of some compounds. No substantial changes in sorption are expected with contaminants like benzene or TCE because they do not change form at different pH values. The largest changes are typically observed when the compound being adsorbed changes form, e.g. changes from neutral to charged, depending on the pH. That change can either improve or decrease the sorptive capacity depending on the compound.

Colloidal Activated Carbon spreads easily; isn't it spreading the contamination as well?

CAC 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, preventing further migration.

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 colloidal activated carbon to degradation, and the regeneration of the sorption sites via biodegradation for species that are degradable.



How is the material delivered to the site?

PlumeStop is delivered as a concentrate in 400 lbs drums or 2,000 lbs totes. It is then diluted on site prior to application.

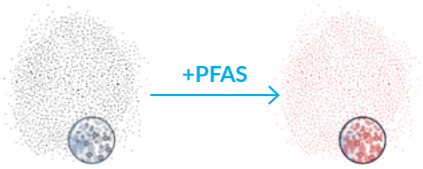
Do contaminants adsorb to the PlumeStop surface at different rates?

The time it takes for PlumeStop to adsorb contaminants is expected to be very rapid in all cases.

Carbon Particle Sorption Comparison

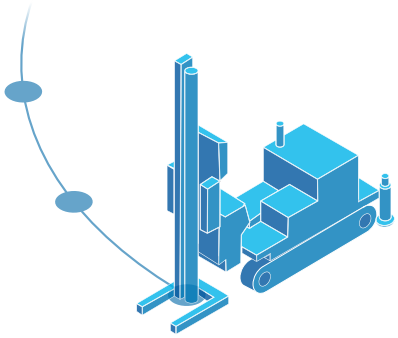
Granular Activated Carbon (>500µm):
Slow sorption due to limited surface area exposed to solute

Collloidal Activated Carbon (1-2µm):
Rapid sorption and more complete use of sorption sites



Any toxicity associated with the polymers used in the mixture that might have their own exposure risks?

No, additives used in PlumeStop are food grade and the polymer is completely biodegradable.



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.

Is it possible that within a long-term barrier, the activated carbon particles can themselves degrade as a result of their small size?

Unlike organic carbon, activated (or elemental) carbon is non-biodegradable and therefore is not subject to natural decay processes. The activated carbon particles will therefore permanently become a part of the aquifer material.

Contaminants Addressed

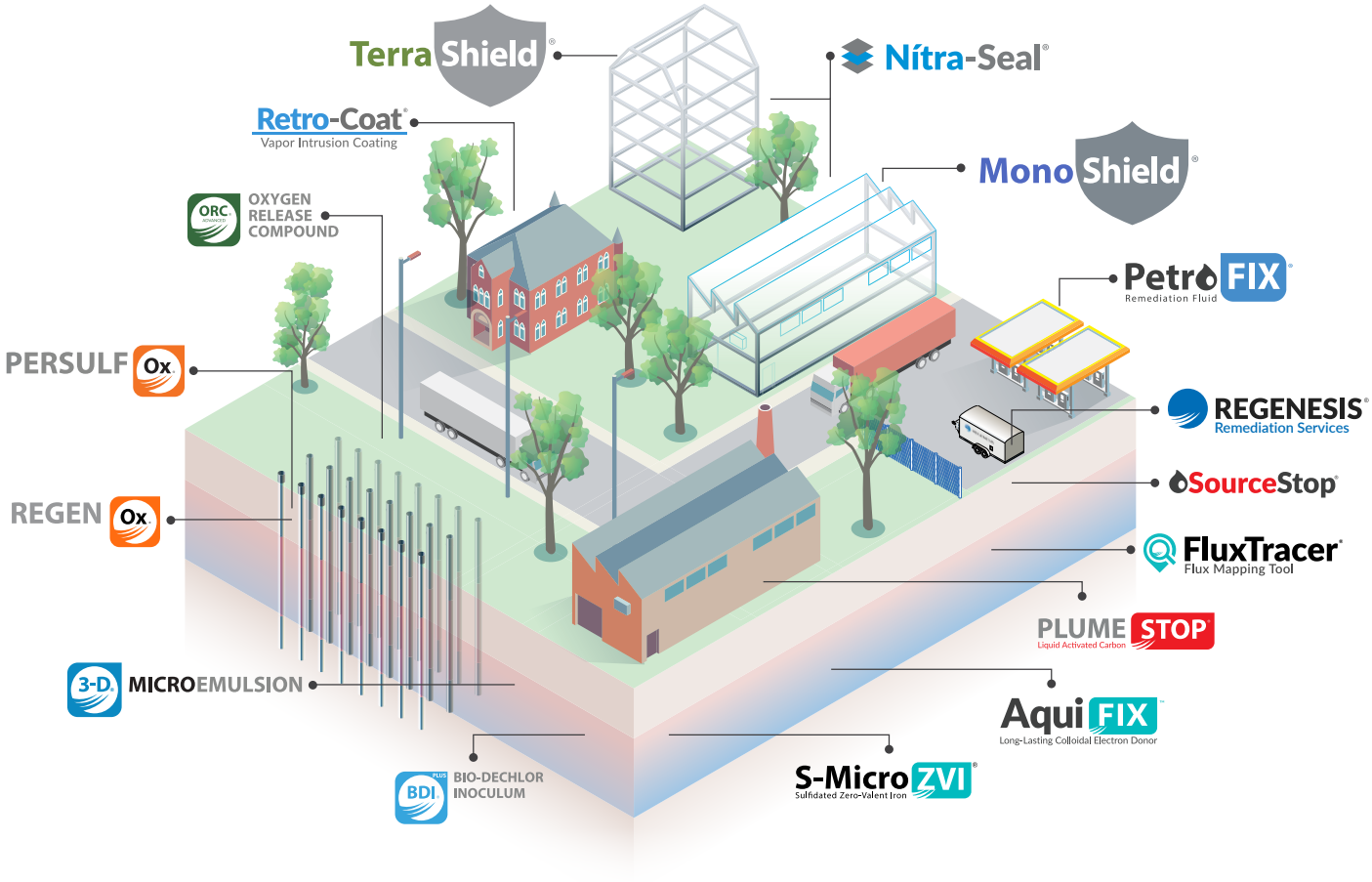
Scan here to view the full range of treatable contaminants

What contaminants does PlumeStop work on?

- Chlorinated solvents (cVOCs)
- Per- and polyfluorinated alkyl substances (PFAS)
- Benzene, toluene, ethylbenzene (BTEX)
- Petroleum Hydrocarbons (PHC/TPH)
- Methyl tert-butyl ether (MTBE)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Aromatics
- Haloalkanes
- Pesticides and Herbicides
- Energetics
- Polychlorinated biphenyls

What is the range of contaminant concentrations that can be treated?

PlumeStop can treat a wide range of concentrations, however it is the contaminant flux that is most important to consider. The contaminant flux, along with the specific contaminants, will strongly dictate the likelihood of success and the longevity of a treatment. We strongly recommend measuring contaminant flux using a passive flux meter, such as FluxTracers, ahead of all PlumeStop applications.



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.

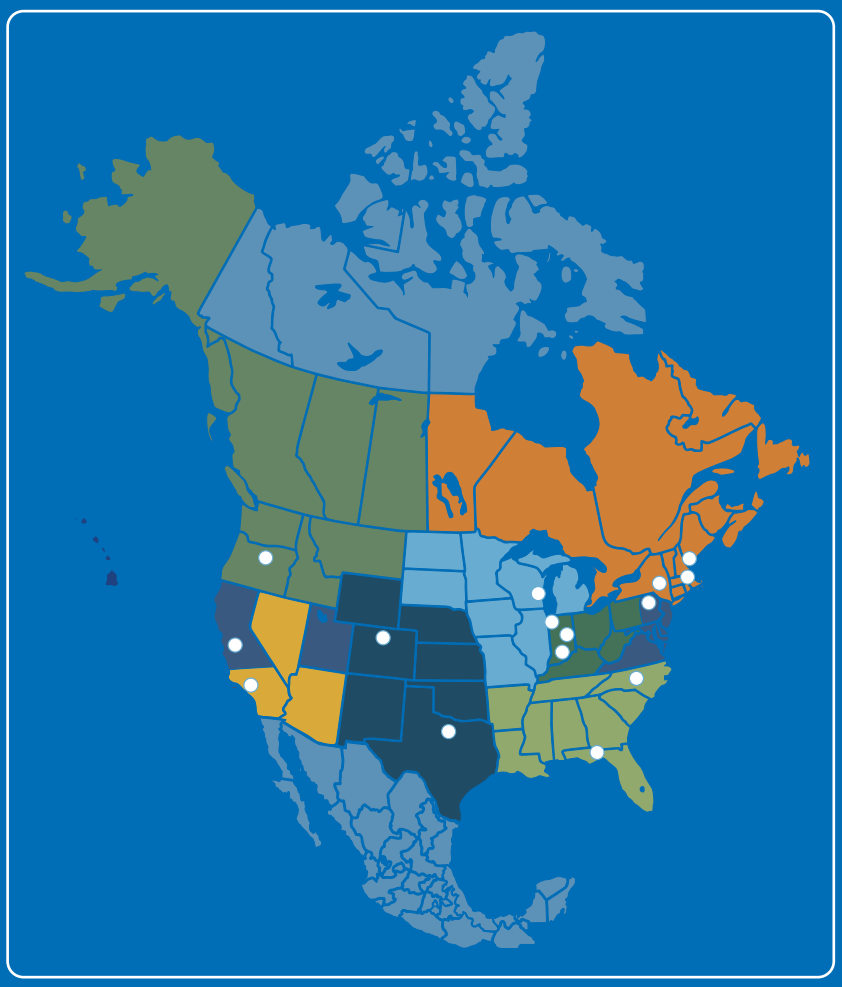
Inherently, innovation imparts new and better ways of thinking and doing. For us this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

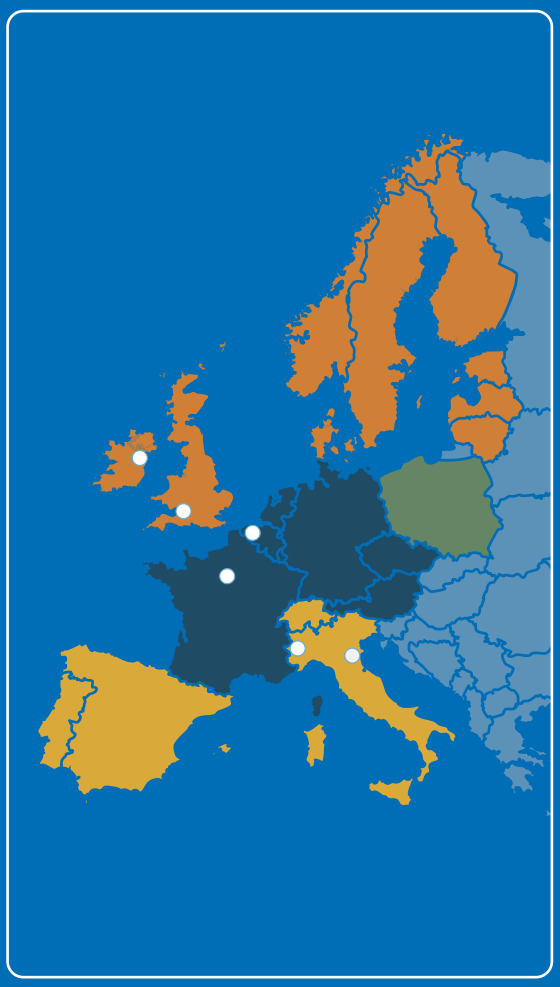
We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

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.

We're Ready to Help You Find the Right Solution For Your Site





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