REGENESIS®

Large TCE Plume Effectively Treated

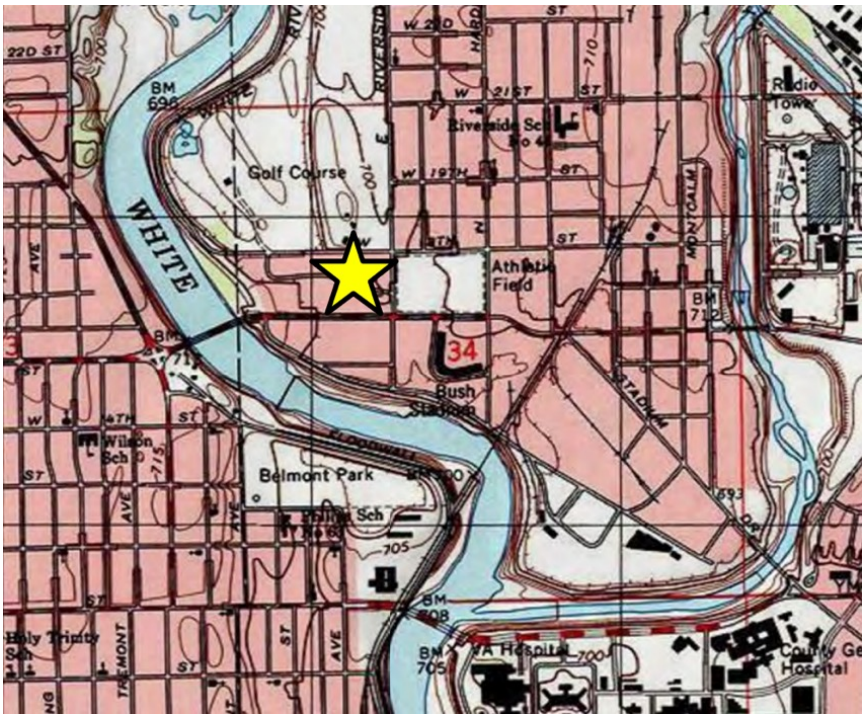
Combined *In Situ* Biogeochemical Reduction Solution Rapidly Mitigates Threat to River and Saves Client $380,000

Background

A Large TCE Plume Threatens to Impact the White River Near Downtown Indianapolis

Previous operations at a former manufacturing and warehouse facility outside of downtown Indianapolis released high levels of chlorinated solvents into the groundwater, creating a large groundwater plume extending to the White River. Figure 1

Figure 1 **Site Location**



The property was originally owned and operated by a chemical manufacturer who used the site as a paint shop and warehouse from 1955 until 1991. In 1994, a new tenant began manufacturing rubber plates used in photoengraving and eventually ceased operations in 2004, leaving the site vacant.

Wilcox Environmental Engineering, Inc., (Wilcox) a leading engineering consulting firm based in Indianapolis, was hired by the responsible party to investigate the site. In assessing the site, Wilcox determined that a significant trichloroethene (TCE) groundwater plume had migrated across several major thoroughfares toward the river.

"We have a fairly long, textbook cigar-shaped plume, with chlorinated VOCs that started at our source and are flowing towards the river.

–Scott Browne-Connors, LPG, RPG
Senior Geologist
Wilcox Environmental Engineering, Inc.

The plume was moving through shallow and deep aquifer zones as the sand unit carrying the contaminants thickened west to east across the site and offsite. The plume was underlain by a clay aquitard which prevented further vertical migration of the TCE but also served as a source for contaminant back-diffusion.

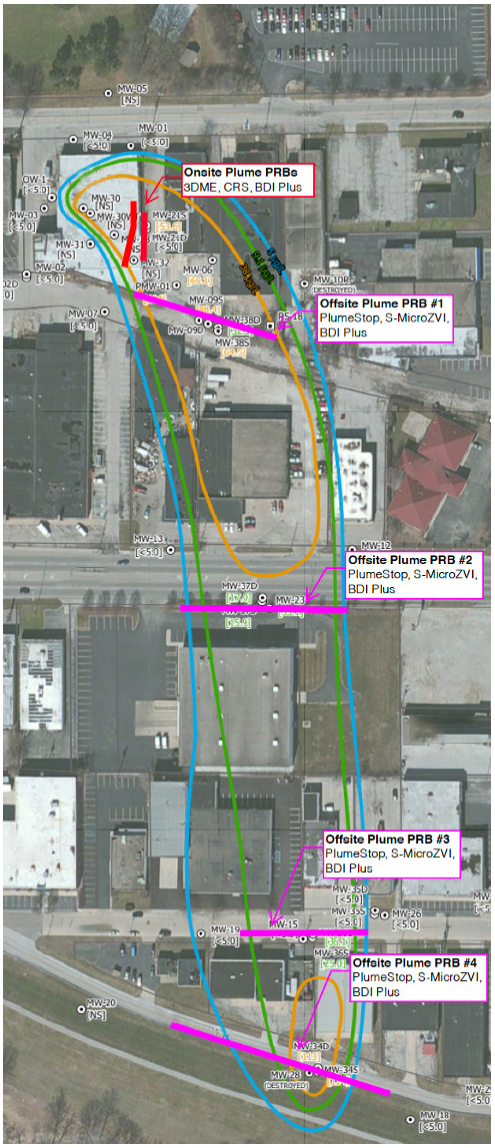
TCE concentrations typically ranged from 10 to 200 parts per billion outside the source zone. Except for the occasional detection of cis-1,2-dichloroethene, little to no chlorinated volatile organic compounds (CVOCs) were present in the plume body.

As the extent of the contamination came into focus, Wilcox considered effective remedial alternatives for treating the plume. An imminent treatment goal was to prevent contaminants from entering the river.

Remedial Design

Multi-faceted Approach Proposed to Treat the 2,000 feet-long TCE Plume

Figure 2



After evaluating the remedial options, Wilcox Environmental worked with REGENESIS on designing a solution for *in situ* remediation of the TCE plume using biogeochemical reduction in the onsite plume area and sorption-enhanced chemical reduction in the offsite plume. This approach would entail placing permeable reactive barriers (PRBs) perpendicular to groundwater flow in strategic plume areas.

3-D Microemulsion® (3DME), Chemical Reducing Solution®(CRS), Bio-Dechlor INOCULUM® Plus (BDI Plus), and magnesium sulfate (a sulfate source to enhance abiotic TCE reduction) would be injected into the onsite plume area, immediately downgradient of the source zone. And PlumeStop® Liquid Activated Carbon™ (PlumeStop), Sulfidated MicroZVI (S-MicroZVI), and BDI Plus would be injected as a series of PRBs in the offsite plume to passively treat TCE in the migrating groundwater. Figure 2

Like many urban chlorinated solvent plumes, remediation accessibility was confined by roadways, buildings, and other infrastructure, restricting PRB placement.

"This site presents quite a few challenges as it is a pretty large chlorinated solvent plume, covers a long distance, and crosses multiple very heavily traveled roads."

– Brett Hicks
Senior Technical Manager, REGENESIS

Using PlumeStop ensures that the biogeochemical reduction processes facilitated by S-MicroZVI and BDI Plus proceed to completion in the PRBs. PlumeStop increases the aquifer's sorption capacity, reducing contaminant velocity by magnitudes to allow complete TCE reduction to non-toxic end products like ethene, ethane, and carbon dioxide, with minimal to no daughter product formation within a barrier location. Further, the approach effectively addresses the back-diffusion of TCE from the lower clay aquitard.

The plume remedy was part of a comprehensive remedial strategy that included *in situ* thermal treatment of CVOCs in the source zone and sub-slab depressurization systems to prevent potential vapor intrusion into buildings above the plume.

Balancing the need for cost-effectiveness and speed, the team designed the multi-faceted remedy to immediately halt plume migration and eliminate potential impacts to the river while steadily eliminating TCE in the plume over time. Wilcox proposed an aggressive three-year timeframe for remediation completion. Bolstered by performance observed at similar sites treated by the Wilcox-REGENESIS team, the responsible party approved the treatment plan for implementation.

"This was not a tough sell to our Clients. We showed them the previous results on similar sites using these products and showed them what we had planned to do here. They liked it and authorized our proposal.

–Scott Browne-Connors, LPG, RPG
Senior Geologist Wilcox Environmental Engineering, Inc.

REGENESIS®

Design Verification Testing

Accurately Mapping CVOC Flux Zones Using FluxTracers Saves $380,000 in Project Costs

FluxTracer® Flux Mapping Tool

As part of Design Verification Testing (DVT) to ensure proper remedial placement and dosing, the team installed FluxTracer® devices in plume monitoring wells to delineate the contaminant flux zones. The information gained from these passive flux monitoring devices was used to accurately target the remedial amendments' application to the flux zones driving the plume's development. By shrinking the treatment to these flux zone, significant time and costs were saved for the project's implementation.

In discussing FluxTracer devices, Scott Browne-Connors, LPG, RPG, Senior Geologist with Wilcox, recalls, "We were able to save the Client about $380,000 in injectant material. It was time and effort well spent."

Other DVT activities included the collection of soil cores to confirm lithology changes and groundwater sampling to assess baseline biogeochemistry.

Application Details

Offsite PRB #1

Total PRB Length	280 ft
Treatment Interval	18-28 ft bgs
Injection Points	56
Application Volume	22,811 gal
PlumeStop	18,400 lbs
S-MicroZVI	6,800 lbs
BDI	8.5 L

Offsite PRB #2

Total PRB Length	245 ft
Treatment Interval	18-35 ft bgs
Injection Points	49
Application Volume	33,560 gal
PlumeStop	16,000 lbs
S-MicroZVI	5,900 lbs
BDI	7.5 L

Offsite PRB #3

Total PRB Length	180 ft
Treatment Interval	15-28 ft bgs
Injection Points	36
Application Volume	18,711 gal
PlumeStop	12,000 lbs
S-MicroZVI	4,400 lbs
BDI	11 L

Offsite PRB #4

Total PRB Length	255 ft
Treatment Interval	16-27 ft bgs
Injection Points	51
Application Volume	24,693 gal
PlumeStop	16,800 lbs
S-MicroZVI	6,200 lbs
BDI	8 L

Application

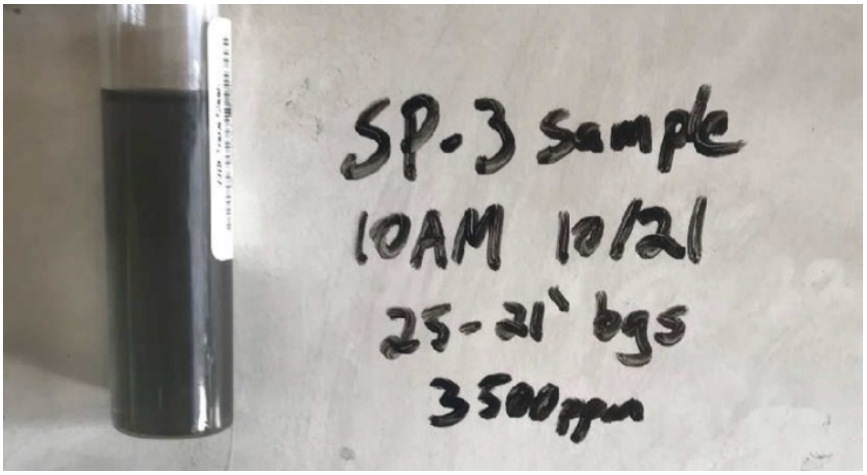
Safe and Efficient Installation Meets Time and Budget Requirements

In collaboration with Wilcox, REGENESIS Remediation Services (RRS) completed the PRB injections over 56 days from October to January 2023. A direct push drilling rig, equipped with 1.5-inch diameter drilling rods attached to a retractable screen or expendable tips, was used for amendment injection. The remediation amendments were prepared and applied using an RRS custom injection trailer containing mixing tanks, pumps, and a delivery system designed to connect to the injection points directly.

During the injection, the project team regularly verified amendment placement by collecting soil cores and water samples to assess visual changes. Figure 3 Periodic samples were also collected for assessing geochemical changes at wells/piezometers installed in the zones of PRB influence. The injection point depths were adjusted within each PRB based on the change in the lower confining layer (i.e., clay aquitard).

Approximately 110,000 gallons of remediation amendments were applied to the PRBs in total. The application was safely completed on time and within budget while working in highly visible and densely trafficked areas.

Figure 3



Sample taken from an SP-16 sample showing visual confirmation of amendments at the target depth of 25 to 21 feet. The concentration of the sample taken was 3,500 ppm.

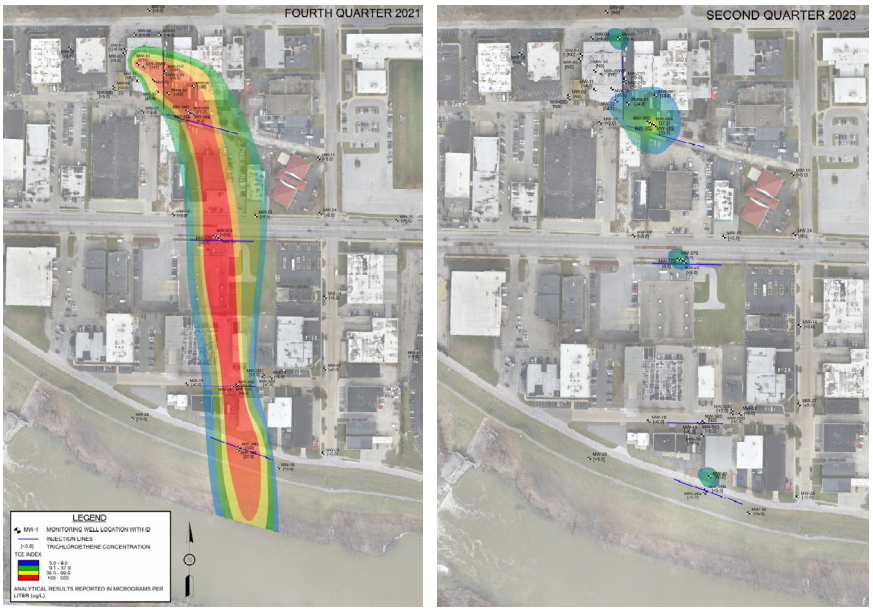
Results

Immediate Threat is Rapidly Mitigated

Following the *in situ* biogeochemical treatment, TCE concentrations in plume monitoring wells were quickly reduced (i.e., within three months), remaining consistent through two quarters of monitoring. Overall, the concentrations and areal extent of the TCE plume have been drastically reduced since the start of remediation. Figure 4

Figure 4

TCE Plume prior to remediation (left) and six months after *in situ* biogeochemical treatment (right).



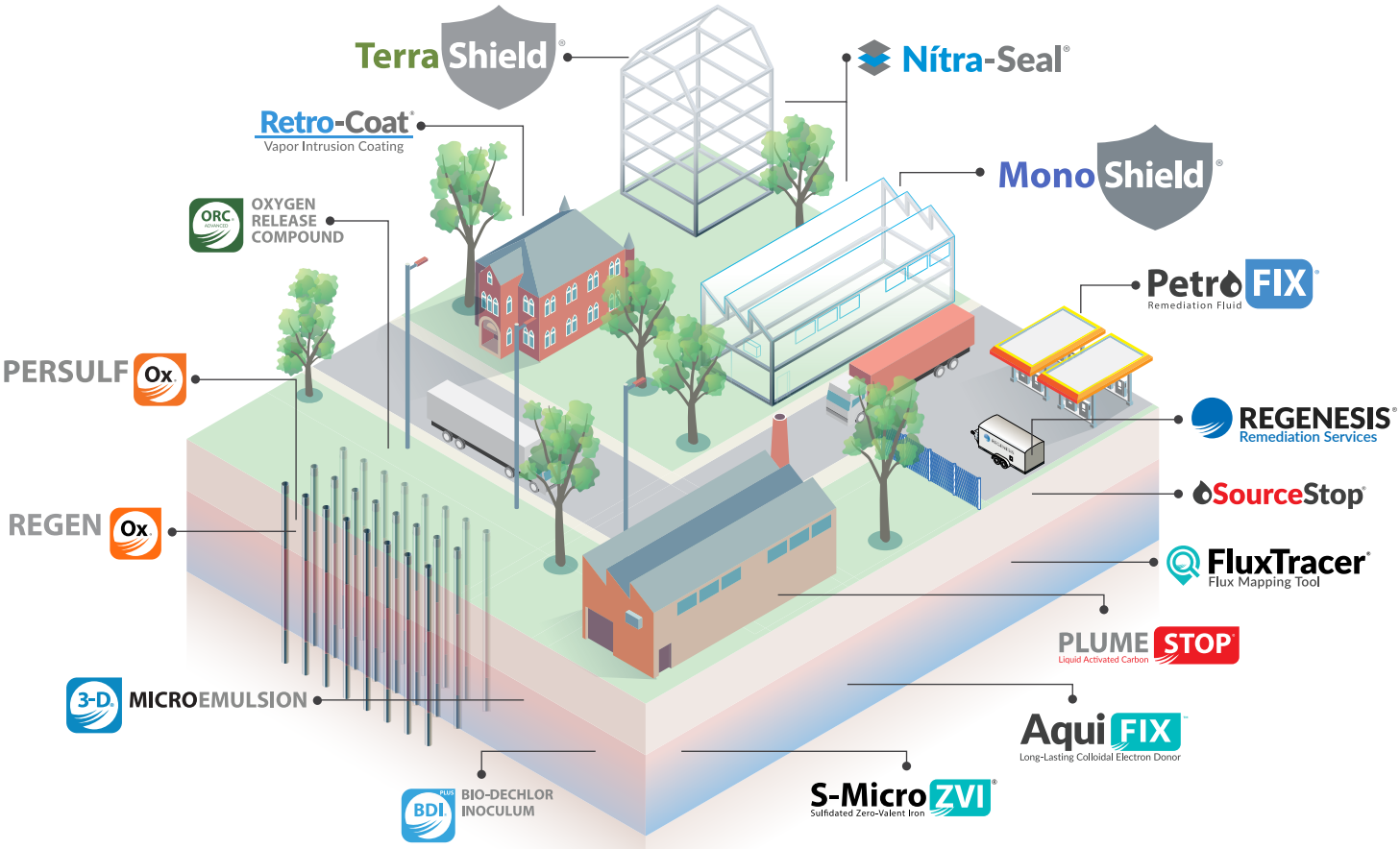
No daughter products have been detected in these wells post-treatment, indicating that the abiotic, chemical reduction of TCE is the dominant degradation process.

These results indicate that the remedy for treating the TCE plume is meeting expectations. Critically, the threat of TCE and other CVOC impacts on the White River has been severely diminished, achieving the near-term remediation goal.

Wilcox plans to continue post-application groundwater monitoring to track remedial progress. Further plume-wide reductions are expected as groundwater continues to bring contaminants into the PRBs to be eliminated.

"PlumeStop is the gold standard. It's proven to work, cleaning these chlorinated solvent plumes up quickly so that we can close sites out."

– Scott Browne-Connors, LPG, RPG
Senior Geologist, Wilcox Environmental Engineering, Inc.



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.

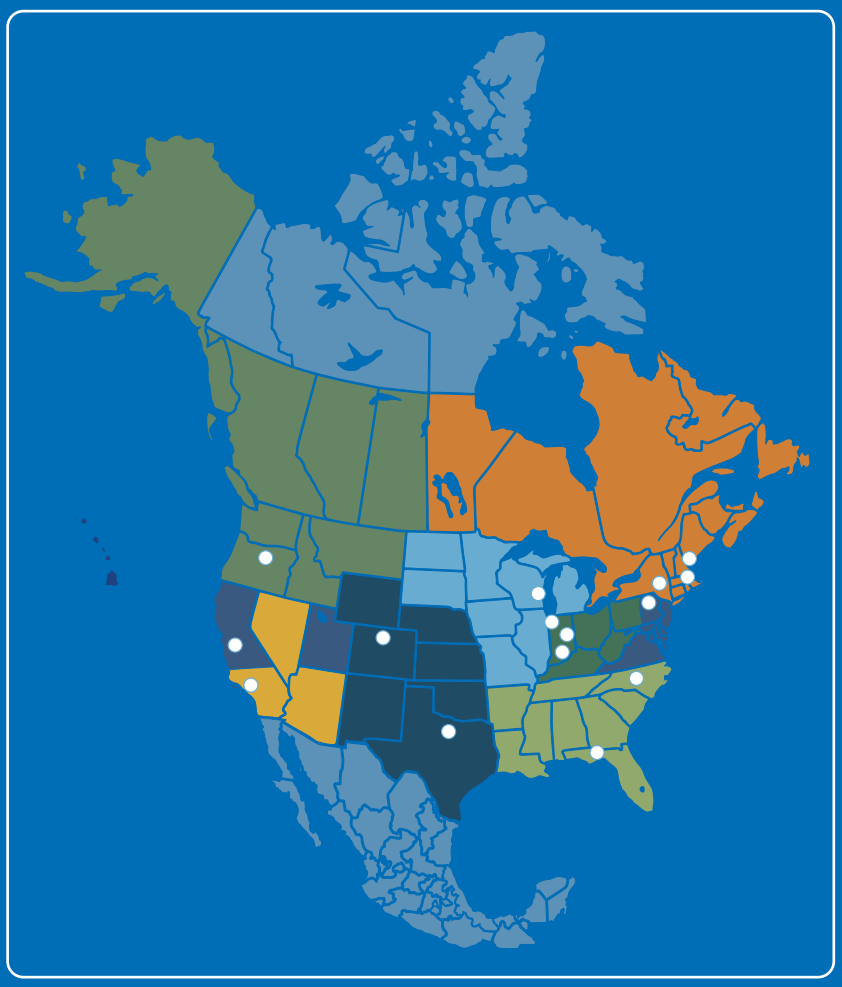
We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

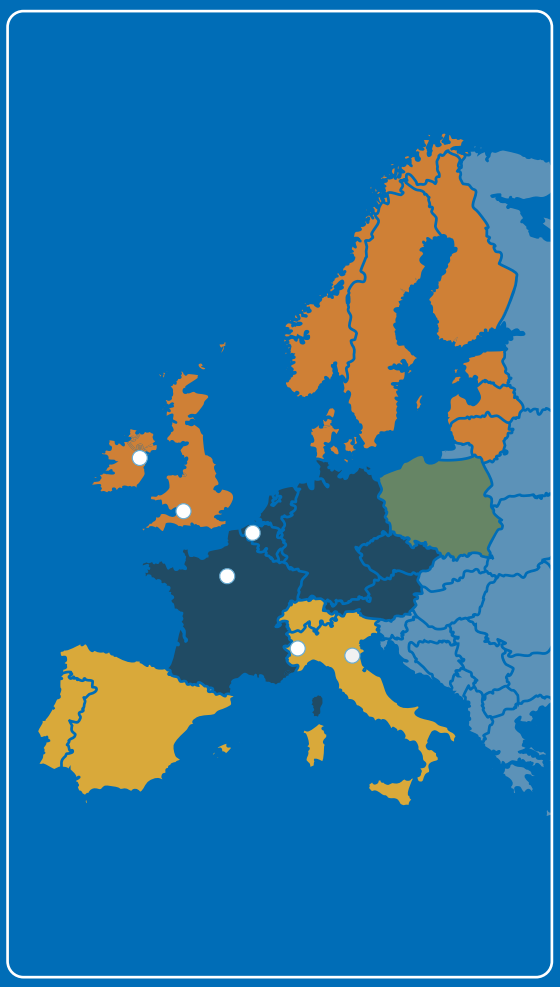
At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking 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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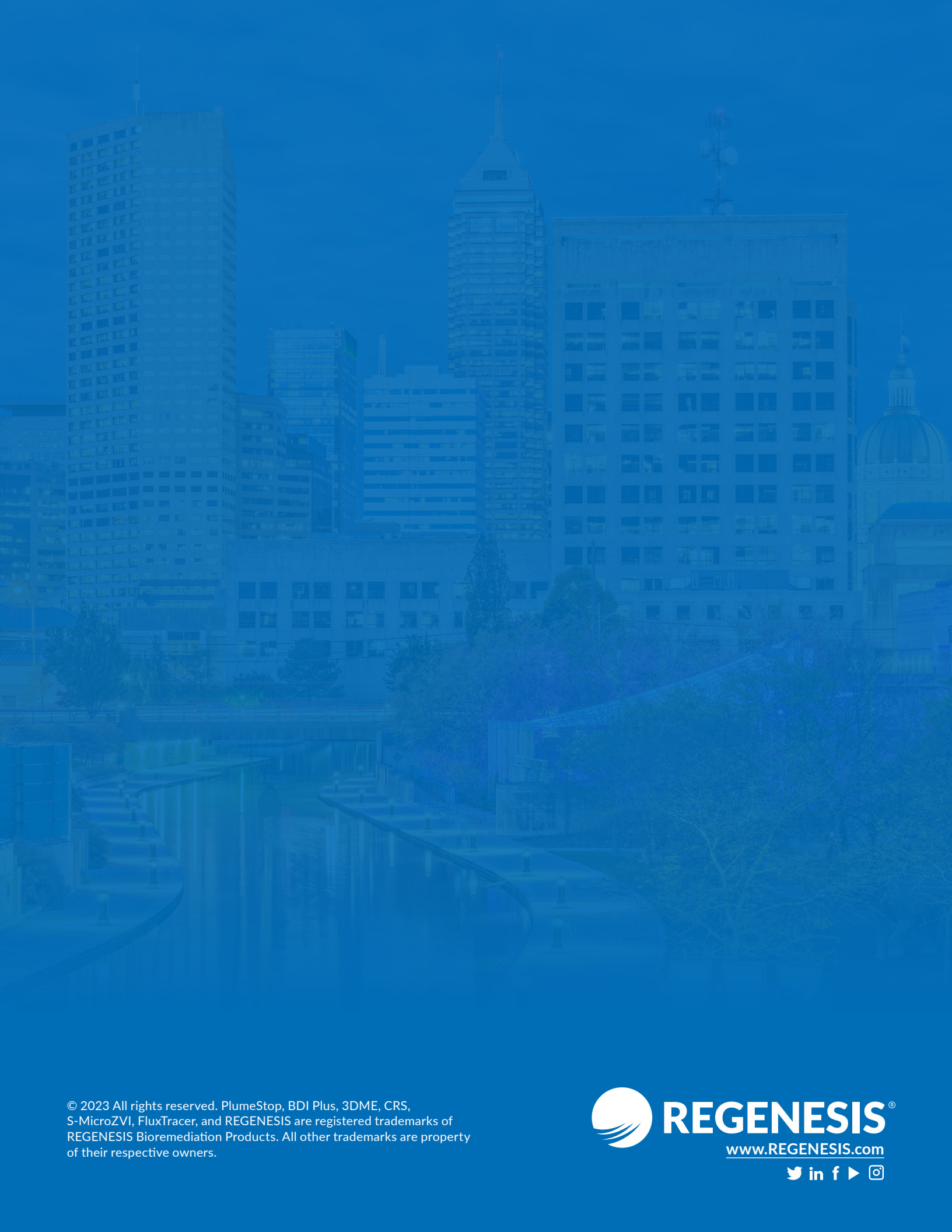
Visit www.REGENESIS.com to learn more.



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