TerraStryke® **Remediation Products LLC**
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TerraStryke® **TPHENHANCED™**

Product Highlights

TPHENHANCED™ passive aggressively *reduced* BTEX constituents **95.7**% from peak bioavailability in <4-months

TPHENHANCED™ represents a quantum leap forward in bioremediation practices

TPHENHANCED™ enhances native microbial populations and expedites natural attenuation

TPHENHANCED™ keeps the treatment area *anaerobic*

TPHENHANCED™ expedites residual mass solubilization by enhancing entire degrading community behavior

TPHENHANCED™ is sustainable, eliminating energy-consuming, emissions generating aboveground equipment

TPHENHANCED™ leverages existing Site conditions to realize *low-cost, low-risk, cost-effective* contaminant destruction.

TPHENHANCED™ is ideal for remote site locations with limited access and energy availability.

TerraStryke® TPHENHANCED™ Residual Source Mass Remediation

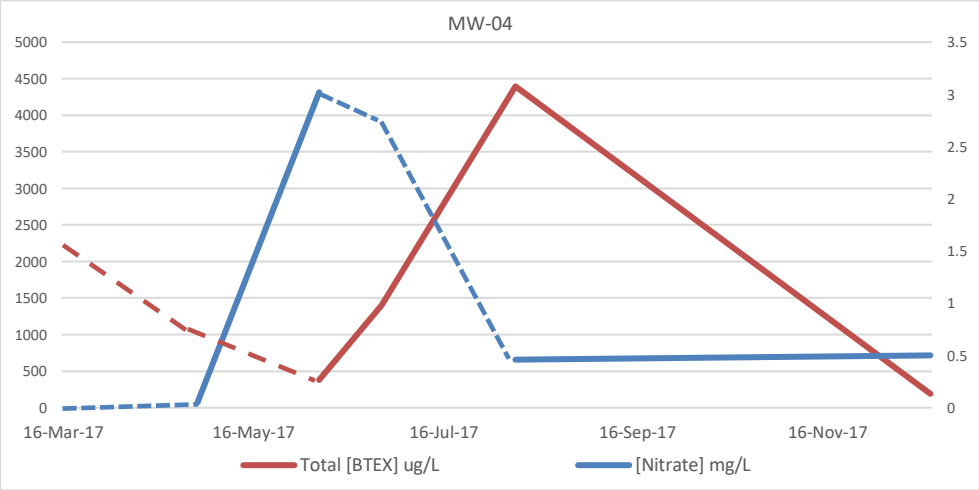
Abandoned Oil-Gas Production Facility – Petroleum Hydrocarbons, BTEX Legacy Production Water Retention Pond, Colorado

TerraStryke® Remediation Products LLC (*TerraStryke*®) develop and distribute biostimulation additives which cost-effectively enhance native microbials and are proven to expedite the natural attenuation and destruction of dissolved phase *and* residual source mass contaminants. Our additives represent a quantum leap forward in bioremediation practices.

PROCEDURES: The treatment area consists of an approximately 80x80ft (6,400 ft^2) area with an approximately 5-foot thick vertical zone of impact. 26 injection nodes, constructed of 2-inch OD PVC, were installed on approximately 10-foot centers within the treatment area. Groundwater was amended with **TPHENHANCED™** filled Passive Release Sock (PRS) deployment units installed at each node. Each PRS deployment unit is 5-ft long and contains ≈2-pounds of additive. Two deployment events (March 2017 and May 2017) were completed over a 9-month period. Two monitoring wells (MW-7 located within the treatment area, and MW-4 located downgradient of the treatment area) were periodically monitored/sampled to evaluate product efficacy. After biostimulation with **TPHENHANCED™**, the native microbial populations at MW-4 realized:

- An initial 84.2% decrease in dissolved-phase benzene, ethylbenzene, and xylenes (BEX); followed by,
- A >1,000% beneficial increase in BEX due to expedited source mass solubilization.
- During the solubilization period (June-August 2017), rapid additive utilization was observed.
- Continued reductions in BEX were observed after the additive availability was exhausted.

- Overall, *from peak bioavailability*, the following reductions were observed:
  - **>98%** decrease in Benzene after >1,000% increase
  - **>83%** decrease in Ethylbenzene, after initial 768% increase, and
  - **>97%** decrease in Xylenes after initial 2,500%+ increase
  - Toluene was BDL throughout the evaluation



TerraStryke® organically enriches groundwater biogeochemistry, cost-effectively enhancing contaminant destruction while minimizing Site impacts to realize your compliance objectives, leveraging Mother Nature's momentum to maximize your remediation dollar.

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This case study summarizes the superior performance of **TPH**ENHANCED™ to destroy bioavailable dissolved-phase contaminants. Furthermore, it demonstrates the four distinct phases of the remediation process using our biostimulation additives. ***First***, with increased additive availability we see increases in the Oxidation-Reduction Potential (ORP). ***Second***, we observe expedited destruction of the already available dissolved-phase contaminants. ***Third,*** we observe the expedited solubilization of residual mass that was previously unavailable to the microbial populations. ***Fourth***, is the enhanced destruction of the residual mass, having fluxed to a dissolved-phase.

We propose that microbial populations enhanced with **TPH**ENHANCED™ collectively secrete natural surfactants that increase the contaminants bioavailability. Additionally, the microbial efficiencies associated with nutrient and food source (PHC) utilization are optimized maximizing PHC degradation rates, sustainably and cost-effectively realizing long-term site compliance. These results are consistently observed and demonstrate that **TPH**ENHANCED™ is a quantum leap forward in bioremediation practices, providing a proven low-cost, low-risk strategy for the organic remediation of residual LNAPL and dissolved-phase contaminants.

THEORY: Additive enhanced bacterial populations utilized the **TPH**ENHANCED™ as an alternative electron acceptor to O_2 during respiration, and the dissolved-phase contaminant (BTEX) as electron donor; or food, an energy and carbon source providing cellular energy and building-block material to grow the PHC degrader community. PHC degradation continued as additive availability was exhausted, indicating the duality of the additive itself. The proprietary, patent pending additive formulation stimulates native heterotrophic microbial respiration; and in turn, PHC destruction. As the formulation is utilized the enhanced native microbial community, via endogenous decay, naturally 'recycle' supplied inorganics to maintain robust microbial communities which support continued PHC destruction even *after* the additive has been 'exhausted'.

In summary, data suggest that the unique combination of **TPH**ENHANCED™ components enhances the ability of unicellular organisms to combine their metabolic capabilities and degrade substrate(s) that neither could degrade alone. **TPH**ENHANCED™ stimulates microbial respiration (without O_2) and PHC destruction, organically, leveraging existing site biogeochemical conditions.

To determine if our additive is appropriate for an environmental management concern at your site, please consider our low-cost, low-risk PRS based pilot evaluation process described below

PRODUCT EVALUATION PROCESS: *TerraStryke*® established our Pilot program to provide practitioners a low-cost low-impact method to evaluate our additives under actual Site biogeochemical conditions. The process provides potential end-users a representative, yet conservative, 'Go-No-Go' evaluation that will confirm amendment efficacy and facilitate a more accurate determination of full-scale additive loading requirements, thereby allowing all Stakeholders a level of assurance prior to committing to full-scale deployment.

TerraStryke® evaluations are performed *in-situ,* using existing 2-inch diameter groundwater monitoring well(s) located proximate to source zone contaminants. Additive-filled deployment units are suspended in the screened interval of the test well and remain undisturbed for approximately 10-14 days. PRS units are replaced with performance groundwater monitoring/sampling performed each event. Typical evaluations require up to 6-8 deployment/replacement events, requiring a total of 6-9 weeks to complete. Additive efficacy is determined by comparing baseline results to performance data with a minimum 50% Performance Goal established to consider the evaluation a success and justify discussions regarding future full-scale additive deployment strategies. A Technical Memorandum presenting pertinent results relative to established Performance Goal(s), estimated costs, and remediation time-lines will be provided at the evaluation end.