Technology Description

GBI's patented ***Butane Biostimulation Technologies™ (BBT)*** can be used to remediate a broad range of contaminants in soils and ground water quicker and at less cost than other technologies at many sites. Laboratory and field studies, as well as full-scale applications, have demonstrated the effectiveness of ***BBT*** for remediation of petroleum hydrocarbons, methyl-t-butyl ether (MTBE) and chlorinated solvents. Bench-scale data support the efficacy of ***BBT*** for reducing concentrations of PCBs, pesticides, PAHs, and 1-4 dioxane in the environment and perhaps perchlorate, nitrates, energetics and other contaminants as well.

Butane Biostimulation Technologies™ (BBT) involves injecting butane or a mixture of butane and air (or an alternative source of oxygen) into soil or groundwater to enhance the natural degradation of environmental pollutants by indigenous bacterial communities. The amount and frequency of butane and air injection is controlled using GBI's patented Injection panels which are modular to accommodate scaling. The delivery system is designed so that the volume of gas delivered can be varied, depending on the number of delivery points and optimization requirements. Typically, treatment is performed *in situ* using wells or temporary injection points. Because the butane is injected as a gas, which is highly soluble in water, it disperses and diffuses rapidly and broadly in the subsurface. Butane is the most soluble of the alkane gases, having four times the solubility of methane. GBI has seen radii of influence over 50 feet from a single injection well. Because of the high solubility of butane, ***BBT*** is also uniquely suited to the treatment of contaminant mass that has diffused into low-permeability soils, shales or even fractured rock. It is also ideal for reaching contaminants beneath structures with minimal disturbance.

One of the unique advantages of ***BBT*** is the ability to treat contaminants which degrade preferentially in either aerobic or anaerobic environments. When injecting butane and air the increased dissolved oxygen (DO) plus butane promotes the growth of butane degrading bacteria and the fortuitous cometabolism of contaminants. Increased DO also promotes biodegradation by indigenous microbes of contaminants that can be used as direct substrates for energy and growth. For sustainable reductive dechlorination of chlorinated organic compounds, anaerobic conditions and a source of electrons, typically hydrogen ions from an organic carbon source, is necessary. Butane provides this. Under aerobic conditions, butane utilizing microorganisms express a diversity of monooxygenase enzymes which mediate aerobic cometabolism of chlorinated methanes, chlorinated ethanes, chlorinated ethenes, MtBE and other contaminants. Studies comparing ammonia, methane, propane and butane as cometabolic substrates indicate that butane achieved the most effective transformations. Using ***BBT***, aerobic or anaerobic zones can be established to strategically degrade selected contaminants of concern (COCs) to manage potential risks to human health or the environment. It is also easy to switch from aerobic to anaerobic conditions within a matter of days at most sites as needed using GBI's patented control system.

It is noteworthy that butane-utilizing bacteria have been shown to fix nitrogen. Consequently they are able to produce their own nutrients. This capacity has not been observed in comparative studies using propane. In nutrient-limited environments the ability to fix nitrogen can substantially improve the sustainability of the remedial process.

Some advantages of *Butane Biostimulation Technologies*™

- ***BBT*** is unsurpassed in the variety of contaminants that can be addressed and the flexibility it provides to degrade contaminants through aerobic and anaerobic processes using simple infrastructure.

- The ability to degrade COCs aerobically and anaerobically using ***BBT*** provides a single technology that can be managed to provide complete mineralization of recalcitrant chlorinated aromatic hydrocarbons (CAHs), eliminating the common buildup of more toxic daughter products.

- ***BBT*** is great for mixed plumes.

- Using GBI's leased control panels it is easy to adjust the gas injection rate and mixture and to switch from aerobic to anaerobic conditions to optimize the system based upon performance monitoring data.

- ***BBT*** is generally less expensive than other technologies, in terms of capital investment and operational costs, as well as providing an expedited means to reach site closure, reducing monitoring costs. GBI has achieved site closures in less than 6 months.

- Because butane is a highly soluble gas, ***BBT*** provides a superior means of reaching contaminants in low permeability soils, beneath structures, and even in fractured rock, reducing costs and improving the effectiveness of treatment.

- ***BBT*** can be easily retrofitted onto air sparging or vapor extraction systems.

- GBI's modular control panels minimize engineering and installation costs, as well as capital costs through our leasing program.

- Operations and maintenance is minimal.

- Butane is non-toxic. It is used commonly in the food industry. It is also used as an aerosol propellant for health care products that contact the skin.

- Using ***BBT*** butane is typically injected at rates which result in concentrations in soil vapor of approximately 10 to 30 ppmv. This is well below the lower explosive limit of 14,000 to 19,000 ppm.

- Butane is quickly metabolized by microorganisms in soil and groundwater. Consequently, butane does not migrate away from the treatment area.

- Remediation-derived waste products are limited to soils and ground water from injection point installation.

- Using ***BBT*** there is no transfer media such as spent carbon from ground water treatment.

There are many more reasons to use ***BBT.*** We are not aware of any other technology that is as versatile and simple to implement while achieving comparable results. For case histories and additional information please visit our website.