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BioNet™ & BioLuxing™ -A Technological System of In-situ Bioremediation

Foremost Environmental Solutions (FES) is an environmental remediation company in the business of preserving and improving our soils and water environment locally, nationally, and internationally by providing permanent and efficient solutions. FES focuses on providing cost-effective solutions using enhanced *in-situ* biosystems to remediate soil and groundwater contamination concerns for government and industrial clients.

FES and their professional staff and associates provide permeable reactive treatment systems and environmental consulting services to a broad client base that includes Federal government agencies, large Prime Contractors, commercial and industrial companies, the petroleum industry, and environmental consultants. These permeable reactive treatment systems are BioLuxing™ and BioWalls™ and provide *in-situ* treatment of petroleum hydrocarbons, chlorinated solvents, metals, and other compounds in soil and groundwater.

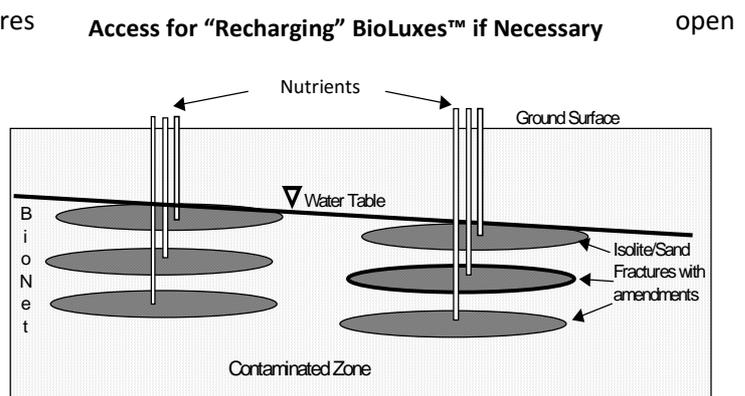
BioNet™

A system for in-situ bioremediation of contaminated soil and ground water wherein Isolite® CG (porous inorganic support spheres of diatomaceous earth pellets) are treated by inoculation with selected non-pathogenic microbes, i.e. bacteria, for converting or destroying the contaminants. The contaminants may be hydrocarbons, sulphides, frac flow back water, produced water, cyanides, nitrates, heavy metals and other chemicals. The porous cells of the Isolite® CG provide a home not only for the microbes but also for oxygen, water and other nutrients to help sustain the life of the augmented colonies of microbes introduced in the Isolite® CG.

BioNet™ Installation

The BioNet™ is created using hydraulic fracturing of the soil and injection of ISOLITE® CG, a porous ceramic that has been inoculated with bacterial cultures that degrade the chemical contaminants of interest. The fractures containing inoculated ISOLITE® CG are called BioLuxes™. The ISOLITE® CG serves as a proppant to hold the soil fractures and as a residence for the bacteria. The size and shape of the fractures is determined by the properties of the soil. However, fractures are normally circular in shape. They are ¾" thick at the center and decrease moving to the edge. Their size can be controlled, but is typically 30 to 40 feet in diameter. The Isolite® CG can be used with an EPA patented solid oxygen source (SOS) that is distributed throughout the BioLux™ for long-term supply. The ISOLITE® CG /SOS laden fractures create

a preferential pathway to the super support matrix (ISOLITE® CG /SOS) for the mitigation of the contaminant. Because of the long-term super-rich saturation of oxygen in the soil or water, very robust colonies of biodegrading bacteria are established and maintained.



US Patent #5,733,067 is a multi-purpose system for in situ remediation that we call The "X-PerT System." This patent can utilize permeable biologically and/or chemically reactive treatment sheets to destroy various contaminants. The X factor refers to all the variables at a specific site that they need to be accounted for and identified.

BioWall™ and ChemWall™, US patents #5,626,437 and 5,733,067, Methods for in situ Biological and Chemical treatments in contaminated soil and groundwater. Inventors Seth Hunt, Theodore Meiggs, Lawrence Murdoch and William Slack

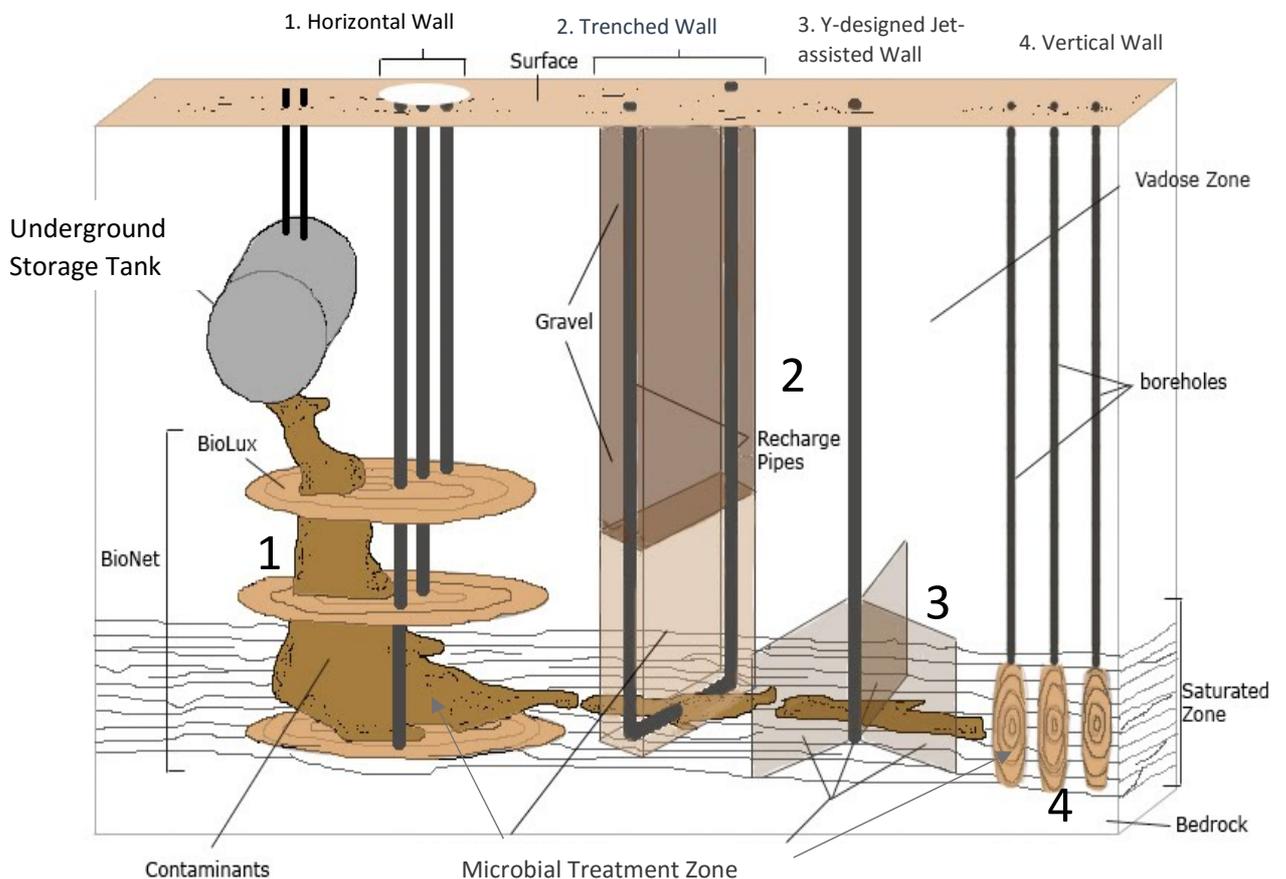
A method for in-situ bioremediation of contaminated ground water and surface water using a porous wall, filled with porous inorganic support spheres such as diatomaceous earth pellets treated by inoculation with selected non-pathogenic microbes, i.e. bacteria, for destroying or converting the contaminant. The contaminants may be petroleum hydrocarbons, chlorinated hydrocarbons and other chemicals. The internal porosity of the ISOLITE® CG provide a home for not only the oxygen supplied by EPA’s patented, long-term solid oxygen source (SOS) but a residence for water and nutrients to help sustain the life of the augmented colonies of microbes introduced within the pellets, creating an ideal bed and breakfast for microbes.

The method, in one embodiment, includes the digging of a trench perpendicular to the movement of the ground water and downstream from the contamination. The trench is dug below the level of the contaminated ground water and is filled with the porous inorganic support spheres creating the porous wall. Aeration pipes are installed at the bottom of the trench and gravel is used to fill the top of the trench. Also vent pipes may be installed in the trench for monitoring volatile contaminants emanating from the porous wall to monitor the progress of the bioremediation. Nutrients may be added in the form of aqueous solutions that are poured into the trench. The nutrients move by gravity downwardly feeding the microbes in the ISOLITE® CG. Also, nutrients may be fed into the trench using the aeration tubes.

Four Separate models of Biological (BioWalls) or Chemical (ChemWalls) are depicted below:

1. Horizontal BioWall (microbial slurry) or ChemWall (i.e. potassium permanganate)
2. Trenched BioWall (microbial slurry) or ChemWall (i.e. zero valent metal)
3. Designed “Y” jet-assisted BioWall (microbial slurry) or ChemWall (i.e. ZVM or potassium permanganate)
4. Vertical BioWall™ (microbial slurry) or ChemWall (i.e. Zero Valent Metal)

The compounds that will be selected depends on the contaminants to be treated.



BioWall™ - US Patent #5,733,067, "Method and System for Bioremediation of Contaminated Soil Using Inoculated Support Spheres" Inventors: Seth Hunt, Theodore O. Meiggs, Ph.D. of FOREMOST Solutions, Inc. and Lawrence C. Murdoch, Ph.D. and William W. Slack, Ph.D. of FRx, Inc.

A method used for in situ remediation of contaminated subsurface ground and subsurface water using chemically or biologically reactive sheets. The reactive or active sheets contain one or more selected compounds capable of recovering, destroying, degrading and immobilizing contaminants in the soil or water. The compounds that will be selected depends on the contaminants to be treated. The compound used is ISOLITE® CG (diatomaceous earth pellets), inoculated with selected non-pathogenic microbes, a zero-valent metal such as iron, tin, aluminum and zinc, a leachable compound such as sodium percarbonate or an adsorptive compound such as activated carbon and zeolite.

The contaminants may be petroleum hydrocarbons, chlorinated hydrocarbons and other hazardous chemicals. The sheets are formed by injecting a slurry of the selected compound into the subsurface, using hydraulic fracturing where the orientation of the fractures is influenced by cutting and preparing a bore hole prior to the injection of the slurry. Also the sheets may be formed by employing high velocity jet-assisted fracturing, using air, water and other fluids. The jet-assisted fracturing operates prior to or concurrently with an introduction of a slurry of the selected compound. The sheets may be formed horizontally, vertically and at angles dipping from the horizontal.

RESEARCH & DEVELOPMENT

For more than 15 years FOREMOST Environmental Solutions, Inc. (FES) has been demonstrating the viability and utility of its patented BioLuxing™ technologies. Considered to be ahead of its time, BioLuxing™ is the creative result of combining and enhancing proven bioremediation technologies in a synergistic manner. The research and development (R&D) challenge for FES has been to prove to industry, consultants, and government regulators that each part of the BioLuxing™ process is scientifically sound and that in terms of its flexibility and efficiency, the total value is greater than the sum of its parts.

Universities where research has been conducted for FES:

- Colorado State University
- University of Colorado
- Colorado School of Mines
- New Mexico State University
- University of New Mexico
- New Mexico Tech
- University of Texas
- University of Iowa
- Michigan Tech
- University of California @ Davis
- University of Southern California
- University of Cincinnati
- Clemson University
- Utah State University
- Montana State University

Some of FES' early clients/projects included:

- US General Service Administration in Denver; (EISB) cutting oil
- The US Air Force at Cape Canaveral in FL (Chem/ZVI); chlorinated solvents
- The US Army in Huntsville, in AL (Chem/ZVI); chlorinated solvents
- Army's Pueblo Chemical Depot in Pueblo (EISB); chlorinated solvents
- Gates Rubber Co. in Moncks Corner, in SC (EISB); chlorinated solvents
- The US EPA in Ronan, MT (EISB); leaking underground storage tanks with gasoline and MTBE
- A private Dry Cleaning Co. in GA, (EISB); chlorinated solvents
- A former Chromium Plating Co. in Glenwood Springs next to the Colorado River (EISB + Chem); hexavalent chrome
- State funded gasoline service stations with leaking underground storage tanks (EISB + BioWall); gasoline and MTBE

All of our projects were successfully remediated within budget and on schedule.

The following table shows the R&D activities that have been conducted to prove the concepts of BioLuxing™

Concept Needing Proof	Proof Needed	FES R&D Activities
Naturally occurring microbes can degrade contamination in the place where it is located; i.e., in situ.	Specific microbes can be identified, isolated, cultured and safely injected into contaminated zones.	Many tests completed in industrial and university labs to identify which microbes can degrade specific chemicals. Nine field tests (2 with EPA) completed with positive results.
Microbes perform more efficiently in a luxurious or optimal environment.	An in situ engineered environment can be constructed with porous pellets to enhance natural bioremediation.	Laboratory & field tests determined critical factors for maximum in situ microbial activity.
Microbes prefer to attach to protected matrices with ready access to nutrients and electron acceptors/donors.	Isolite® CG, the porous diatomaceous earth pellets, provides many key advantages in creating BioLuxes™ and BioWalls™.	Several inorganic amendments were tested and compared to Isolite® CG that is made with diatomaceous earth. Isolite® CG with its ideal internal pore sizes and strength proved most effective.
Preferential pathways can be created by hydraulic fracturing and filling with inoculated porous pellets to construct enhanced permeable reactive treatment zones.	Hydraulic fracturing creates controlled horizontal or vertical treatment lenses and a slurry of simultaneously injected ISOLITE® CG, SOS, and guar gum serves as a bio-carrier and proppant.	Isolite® CG was readily inoculated in labs and fractured into BioLuxes™ for field tests. Fractures were monitored for uplift and form. Tests were conducted for/by EPA, universities, and industries.
BioNet™, BioWall™ System is basically passive but can be “Recharged” from the surface.	Minimum equipment and little on-going maintenance required for “Recharging” for continued degradation of contaminants.	All phases of "Recharging" have been successfully demonstrated and O&M activities documented and compared to other methods.
BioLuxing™ is more flexible, less-expensive than most other methods and can actually enhance other bioremediation methods.	BioLuxing™ can be used at nearly any site, especially in tight soil conditions not conducive for many remediation methods.	BioLuxing™ successfully installed wherever attempted at less costs than others. Bids accepted by EPA and State Trust funds.
Fractures create much larger radius of influence than wells used for SVE & Bioventing.	Isolite® CG fractures enhance permeability of soil and remain open.	Rate of air flow increased by 10-100 times over conventional wells.
BioLuxing™ can replace soil vapor extraction (SVE), air sparging, and BioVenting by stacking Isolite® CG fractures (BioLuxes™).	Designs can include air to accommodate fluctuations of groundwater to treat vadose/saturated zones.	BioLuxing™ design out-performed comparative SVE system by 300% for removal of contaminants in NM.

Research and Development activities have been conducted by FES, EPA, 15 universities (see list above), 10 commercial research laboratories, Sumitomo Corporation and the Waste-management Educational and Research Consortium (WERC). WERC is a 10-year old consortium of universities and DOE labs in New Mexico, funded by the DOE and administered through New Mexico State University. Additionally, FES has had a three-year Cooperative Research and Development Agreement (CRADA) with EPA's R&D laboratories in Cincinnati, OH and Ada, OK.

Dr. William Mahaffey, Pelorus Environmental and Biotechnology Corporation; Leslie Thompson, Pintail Systems; and Judd Sundine of Sundine Enterprises Inc., have conducted considerable microbial related tests with Isolite® CG and its use in various bioremediation projects such as mine waste cleanup, re-mineralization of metals, and constructed wetlands. FES has shown success in using Isolite® CG in aerobic and anaerobic environments to degrade petroleum hydrocarbons, BTEX, MTBE, chlorinated solvents, hexavalent chromium, and nitrates at various mine wastes.

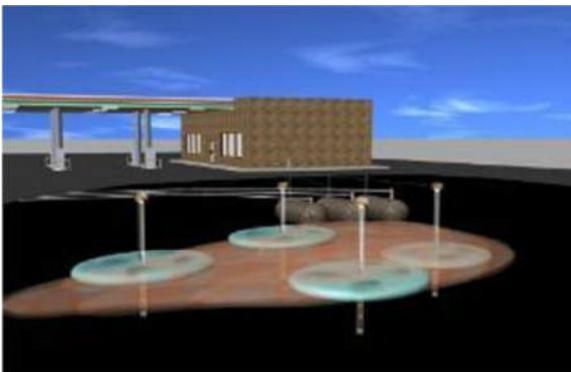
With assistance from FRx, Inc. and WERC, FES has designed and built a self-contained mobile hydraulic fracturing and microbial-slurry inoculating unit to emplace its patented BioLuxing™ technologies.

Properties:

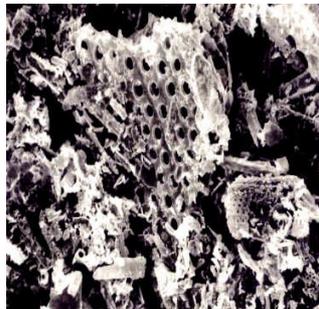
- Made from **diatomaceous earth** and a small amount of clay particles
- **Chemically inert particle density:** 2.27 (compared to 2.56 for sand)
- **Pore characteristics:** continuous, interconnected and open ended; thereby, permitting easy inoculation with microbes. Because of the internal pores, immobilized microbes are protected from shear kill.
- **Pore size:** 0.1 to 2 microns with 30% being over 1 micron
- **Life expectancy:** Isolite has an indefinite lifetime and can be reused.
- **Steam resistance:** does not break down or soften under steam.



BioNet™ is a system of in-situ bioreactors called BioLuxes™ that can be continually or periodically serviced to provide optimum conditions for bacterial degradation of chemical contaminants in the soil.



FES **now** manages the manufacturing and worldwide distribution of EPA’s patented, slow-release, Solid Oxygen Source pellets (SOS) which are extreme advancements to aerobic enhanced in situ bioremediation (EISB) for environmental remediation as well as “green enhancers” for soil, air and water issues.



1 gram of Isolite®CG supports 2×10^7 bacteria for colonization (200,000,000)

What makes FES Special and Unique?

From 1995 to 2013 we conducted several Cooperative Research and Development Agreements (CRADA) and co-authored and presented technical papers with EPA to test and prove our greatly enhanced in situ remediation technology FES patented and termed “BioLuxing™.”

By 2001, our system was working so well that Mitsubishi International Corp. (MIC) conducted an independent, worldwide evaluations of over 100 remediation technologies and selected our methodology as the “BEST of the BREED,” and signed a cooperative marketing agreement to assist their major clients with contamination issues. The [2002-2003, Mitsubishi International Corporation \(MIC\), Environmental Division](#) power point is available on our website, [www.foremostsolutions.com /our history/](http://www.foremostsolutions.com/our history/) under **International Attention & Endorsement** to read about our cooperative presentation we jointly prepared for major clients.

EPA recognized that in situ bioremediation was very dependent on providing an adequate supply of oxygen for most microorganisms and did something about it. They invented a long-term pellet as a solid oxygen source (SOS). FES cooperatively tested and proved that EPA’s SOS pellets were superior and easier to install using the BioLuxing™ system. EPA researchers determined that the SOS pellets provided the needed oxygen throughout the entire treatment zones for 22 months and were at least 30 % more effective than other oxygen supplied methods and cheaper in the long term.

Foremost Environmental Solutions’ Hydraulic Fracturing Unit



In 2013 EPA selected us to be their **Worldwide Exclusive Licensee** of the EPA advanced, Enhanced In Situ Bioremediation (EISB) patent (#7,252,986) that essentially evolved from our three earlier patents that Foremost Environmental Solutions cooperatively researched and demonstrated with EPA. Our long-term activities made us key pioneers and **now** partners with USEPA. Utilizing our Isolite®CG within our BioLuxing™ and BioNet™ technologies with the addition of EPA's patented SOS synergistically made both products significantly more effective and notably improved the EISB Bioluxing™ and BioWall™.

In December, 2013, EPA agreed that FES should use, promote and select sub-licenses of this technology to other remediation companies to be part of the "EPA/FES Team" for public benefit. **BioLuxing is too good, not to be used!** FES is **now** accepting applications from bioremediation companies interested in joining "the team" and becoming a sub-licensee to use the EPA patent. Please go to our home page at www.foremostsolutions.com and click on sub headings **Who We Are** and **What We Do** to learn how to apply for a sub-license and/or a non-exclusive distributorship for Isolite®CG and SOS. We anticipate to select only a limited number of sub-licensees and distributors in the USA and later expand to other countries who are in desperate need to protect their soil and water sources.

Foremost Environmental Solutions **has been** a successful Colorado-based environmental remediation company with 3 patents for soil and water, featuring enhanced in situ biological, chemical and physical remediation technologies. **Now, FES** have expanded its resources and opportunities in 2013 by being selected by the Sumitomo Corporation to become a global distributor of Isolite®CG. FES is the only distributor of Isolite®CG and SOS in the USA with opportunities worldwide Both Isolite®CG and SOS have multi-purpose capabilities and are extremely synergistic with each other as enhancers for both in situ bioremediation and the "green industry".



Bioremediation process Using Isolite® CG and SOS



Isolite®CG was initially developed for 50% water savings and soil conditions for golf courses and other "green industry" uses.



Constructed Wetlands using Isolite®CG and SOS

Some Typical ISOLITE®CG & SOS Uses

- in situ environmental clean up
- hydrophobic soils & localized dry spots
- anaerobic soils & drainage problem areas
- pre-mixed topdressing material
- compacted & high traffic areas
- drip irrigation
- sports turf safety / resiliency management
- tree transplanting & planting - seeding operations (Colorado Dept. of Transportation specified & Wyoming DOT specified Yellowstone Nat'l Park)
- other horticultural applications: bonsai, hydroponics, orchids, lawns, rooftop gardens, greenhouse plants, indoor plants
- matrix for the immobilization of microorganisms:
 - biological filtration
 - septic systems
 - wetland construction
 - bio-walls™