

SEP 09 1996

Environmental Consultants, Contractors & Engineers

September 5, 1996

MPCA, HAZARDOUS
WASTE DIVISION

Ms. Laura Hysjulien
Project Manager
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155

**RE: Oxygen Release Compound (ORC) Information, Former Conoco Store #23034
1126 South Robert, West St. Paul, Minnesota LEAK#00000858**

Dear Ms. Hysjulien:

Per our recent telephone conversation, enclosed is the information on oxygen release compound (ORC) I promised you. This information was recently presented to DAHL by Regenesi Bioremediation Products (Regenesi).

Earlier this year, DAHL proposed the installation of 6 groundwater ventilation (air sparging) structures within the current system's configuration to enhance remediation efforts at the site. Two of the structures were proposed to be installed on the west side of the site and four structures in the vicinity of the recovery well. However, since the submittal of the proposed upgrade, data collected have indicated that dissolved benzene concentrations have decreased to near MPCA established clean-up goals while concentrations of the other constituents are all below the clean-up goals in the vicinity of the recovery well. Concentrations on the west side of the site have remained below clean-up levels since December 1994. Based on this information, DAHL has been re-evaluating the necessity of the originally proposed upgrade.

It is evident that the system is adequately addressing the impact on the west side of the site. However, although lower, benzene concentrations just above clean-up levels are still present in the vicinity of the recovery well, thus it appears that enhanced remediation efforts are warranted in this area.

DAHL then evaluated the cost between installing groundwater vents or applying ORC by injection, both via Geoprobe. A cost savings of approximately \$300.00 to \$500.00 can be made immediately on the Geoprobe services by injecting ORC. Once the injection is completed, the "installation/up-grade" is completed and the monitoring schedule for the site can continue. Per the quote by Regenesi, the cost for the ORC would be \$7,262.00 (a total of 807 pounds @ \$9.00/lb). DAHL provided Regenesi with site specific information (depth to water, current concentrations, area of concern ~30'x30', etc.) for Regenesi to generate their quote. DAHL estimates the total cost for the ORC,

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Geoprobe services, and a DAHL geologist for the oversight of injection activities to be between \$9,000.00 and \$10,000.00.

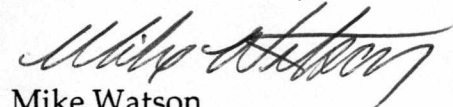
If groundwater ventilation structures are installed (4 total), the Geoprobe services would be approximately \$1,700.00. Parts and labor costs associated with the trenching and construction upgrade activities are estimated to be \$10,000.00 to \$12,000.00. Given that new equipment would be installed, the City of West St. Paul would have to grant approval for the upgrade. Costs for permitting and negotiating with City officials regarding the upgrade are not included. Furthermore, City approval for the existing system at the site took approximately one year after MPCA approval of DAHL's original corrective action design. Costs for equipment maintenance/replacement are also not included.

Based on the above cost comparison, DAHL recommends utilizing the ORC in lieu of installing groundwater ventilation structures. I have a video on ORC if you are interested upon your review of the enclosed information.

This correspondence and enclosed information serves as a brief introduction to ORC. There are many other benefits by utilizing ORC at this site, besides cost savings, that were not discussed that DAHL would more than happy to discuss with you. If you have any quesitons or would like to get together, please contact me at your convenience. In the event you would like to get together, DAHL can contact Regenesis to see if a representative would be available.

Sincerely,

DAHL & Associates, Inc.



Mike Watson
Project Manager

MPW

enclosures

cc: Mr. Mark Silverstone, Conoco Inc.

REGENESIS
Bioremediation Products

OXYGEN RELEASE COMPOUND (ORC®)

**ORC RELEASES
OXYGEN SLOWLY
TO ENHANCE
BIOREMEDIATION.**

OXYGEN RELEASE COMPOUND (ORC®)

BIOREMEDIATION – A NATURAL PROCESS

Bioremediation is a process by which microorganisms degrade certain hazardous substances. **REGENESIS'** products enhance the supply of oxygen to naturally occurring microbes which metabolically transform toxic organic compounds into harmless by-products. This carefully designed process can help to cleanup sites and inhibit the flow of polluted groundwater by creating permeable oxygen barriers.

A bioremediation system offers several advantages over other technologies. Other remediation methods may simply transfer the contaminants to another medium which requires removal, transportation, and possibly additional clean up. Bioremediation degrades contaminants on-site and has been shown to be more cost effective than other treatment technologies. The EPA actively promotes bioremediation as an ecologically sound, natural process.

Oxygen is often the limiting factor in aerobic bioremediation. Moisture and nutrients (such as phosphorus and nitrogen) are generally present in sufficient quantities, however, oxygen is rapidly consumed by microbes which thrive in an oxygen rich environment. Without adequate oxygen, contaminant degradation will either cease or may proceed by highly inefficient anaerobic processes. Thus, additional oxygen is needed to stimulate further aerobic microbial growth and activity.

OXYGEN RELEASE COMPOUND, ORC®

Oxygen Release Compound (ORC®) and methods of its application are innovative technologies which enhance bioremediation. ORC is a patented formulation of a very fine, insoluble peroxygen that releases oxygen at a slow, controlled rate when hydrated. Its use has been demonstrated to increase the remediation of hydrocarbon contamination in soil and groundwater.

FEATURES

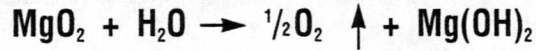
- Magnesium peroxide compound is activated by moisture
- Patented technology controls and prolongs the release of oxygen
- Moderate pH levels are maintained
- Fine particle size has stable, long shelf life
- No external coating of product is required to control rate of oxygen release
- Generates higher dissolved oxygen levels than possible with air

BENEFITS

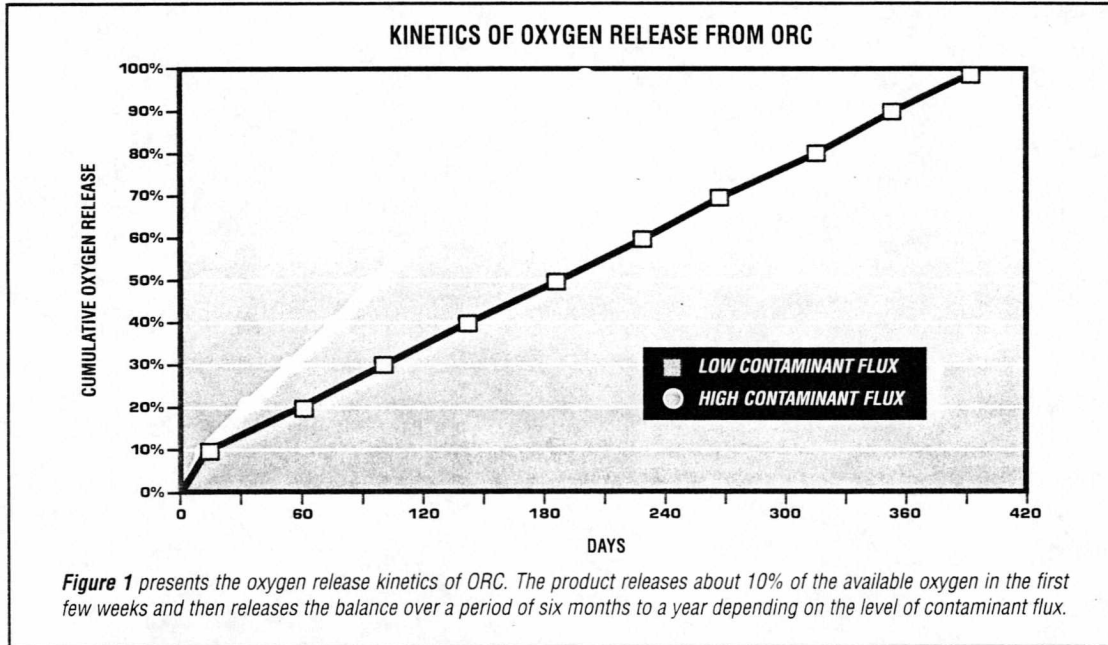
- Provides a passive, cost-effective, long-term oxygen source
- Does not generate harmful residue; environmentally safe
- Ideal for *in-situ* remediation where other methods are impractical
- Will not disturb the flow pattern of the contaminated plume
- Does not volatilize pollutants
- Can be used as a redox control agent

ORC TECHNOLOGY

The product releases oxygen when it comes in contact with water as shown by the following equation:

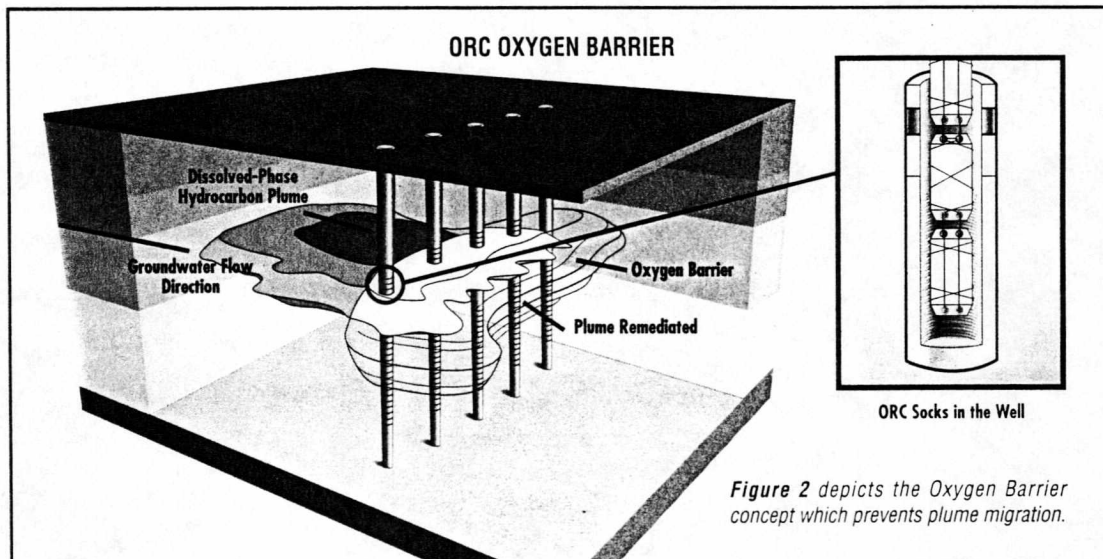


ORC will stop releasing oxygen when dry and will again release when rehydrated. The by-products of the reaction are oxygen and ordinary magnesium hydroxide, which make ORC environmentally safe to use.

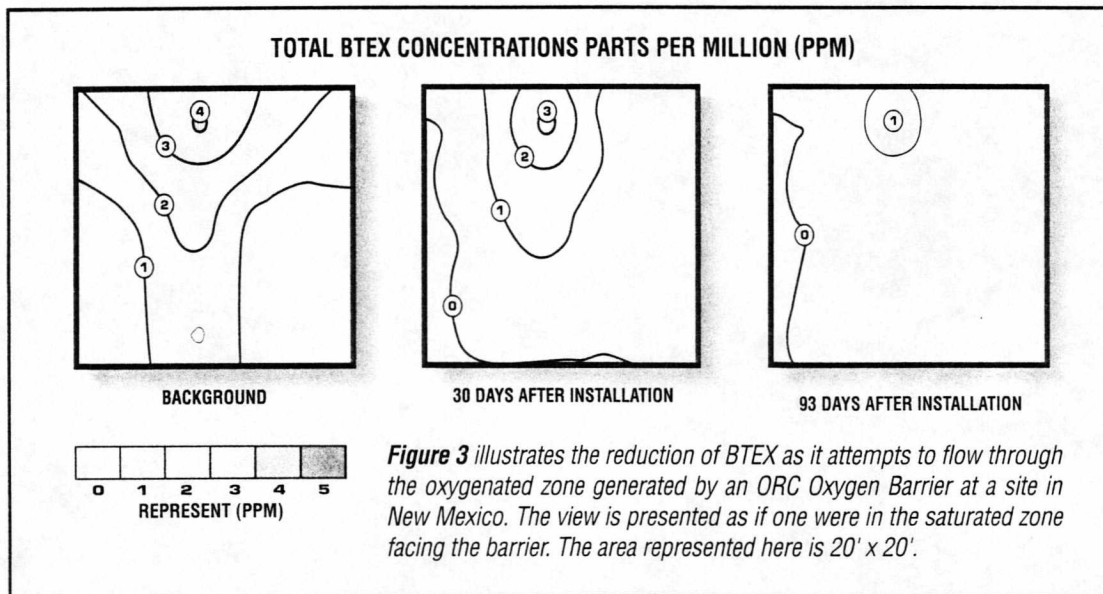


GROUNDWATER APPLICATION – THE "OXYGEN BARRIER"

ORC should be considered for contaminated groundwater sites where aerobic bioremediation is the appropriate treatment technology. For application, ORC powder is mixed in a carrier matrix and contained in inert filter socks. A string of ORC Filter Socks is laced together and lowered into a well through the length of the contaminated saturated zone where contact with groundwater will initiate the release of oxygen. ORC Filter Socks are configured for two-, four-, and six-inch diameter wells (see Figure 2). When the oxygen returns to background levels, the socks containing ORC are removed from the well and, if necessary, new charges of ORC are added.



Various applications of ORC can meet a wide range of remediation objectives. As a primary treatment system in groundwater applications, ORC can be configured to form an **Oxygen Barrier** across a contaminated plume. A properly placed row of wells or a trench containing ORC will slowly release oxygen, enhance bioremediation, and cut off the plume in the oxygenated zone (see Figures 2 and 3). The **Oxygen Barrier** concept was successfully demonstrated by the University of Waterloo in Canada and at sites in North Carolina, Alaska and New Mexico. BTEX compounds were significantly remediated at points downgradient from the **Oxygen Barrier**.



GROUNDWATER APPLICATION OPTIONS

Primary Treatment – ORC can be used as the primary treatment method at sites where groundwater contamination concentrations require active remediation. The goal is prevention of plume migration off-site.

Concurrent Treatment – At sites where another technology such as pump and treat is already installed, or planned for installation, ORC can be used to concurrently improve remediation results.

Follow-on Treatment – ORC can be used to continue groundwater remediation at sites where the primary technology is no longer cost effective – as when pump and treat operations reach an inefficient plateau.

Monitoring/Risk Reduction – This includes introducing ORC into existing monitoring wells at sites with groundwater contamination. ORC may reduce the required frequency and duration of monitoring by promoting degradation of low levels of contaminants and in certain situations may reduce source area contaminants enough to meet risk reduction objectives. Also this can be a cost effective method of performing a pilot study to determine how well ORC will work on a particular site before more extensive ORC treatment.

OTHER REMEDIATION OPTIONS

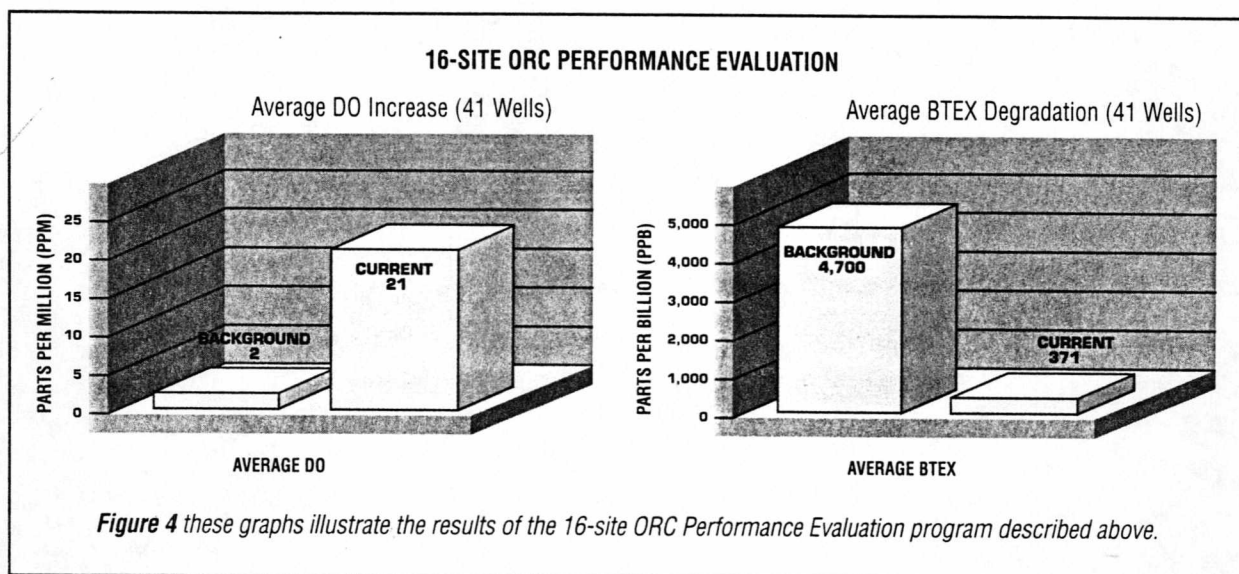
Soil Treatment – ORC can be mixed directly in soil to supply oxygen for remediation in biopiles and landfarming applications. This is particularly useful when soil conditions and/or physical location contraindicate mechanical aeration strategies. In some cases, ORC can be mixed into soil on the floor of an excavation, as clean fill is added, to prevent recontamination by groundwater as the table rises.

Odor Control – ORC has been successfully demonstrated to control odor in anaerobic impoundments.

ORC – PROVEN EFFECTIVENESS

In the early development of bioremediation formulations of ORC, several independent laboratories and universities participated in proof-of-concept studies indicating that ORC releases oxygen, enhances microbial activity, and promotes remediation. Subsequently, field applications demonstrated that ORC was effective in promoting bioremediation under "real world" conditions.

- **University of Waterloo** (published, *Groundwater Monitoring and Remediation*, Winter 1994) – Conducted at the widely studied Borden Aquifer in Ontario, Canada, the study indicates that an Oxygen Barrier generated by ORC released significant amounts of dissolved oxygen (DO). It concluded that the enhancement of DO by ORC led to the biodegradation of at least 4 mg/L each of benzene and toluene.
- **North Carolina Site** (published, *Proceedings from the Second International Symposium on In Situ and On-Site Bioreclamation*, San Diego, CA, 1993) – This study demonstrated that the use of ORC in an Oxygen Barrier dramatically reduced BTEX compounds downgradient from a UST generated gasoline spill.
- **Alaska Site** (presented at the I&EC Special Symposium, American Chemical Society, Atlanta, GA, 1995) – A pilot study showed the effectiveness of an ORC remediation compared to air sparging. Sparge points fouled in the high iron environment and there was evidence of channeling – a problem common with this technology. ORC was effective in remediation and a full barrier was installed. Benzene levels were reduced from 320 ppb to 9.8 ppb and total BTEX went from 1361 ppb to 17 ppb. Gasoline range organics went to ND (not detected) from 7.4 ppm. Diesel range organics rose from ND to .55 ppm, indicating there may have been an influx of hydrocarbons during the test.
- **New Mexico Site** (presented at The New Mexico Environment Department UST Bureau Bioremediation Conference, Santa Fe, NM 1995) – At this site, ORC was installed in 20 wells to form an Oxygen Barrier. There was a high contaminant flux at the site (5-15 ppm at 1-2 feet per day). DO increased from inadequate levels and was maintained at 10 ppm and greater for the first 30 days. After 93 days the estimates of the remaining oxygen indicated that a change out of ORC would not be required for six months. During this 93 day period, a significant reduction of BTEX mass was achieved in the treatment zone, such that concentrations of total BTEX in samples from the most downgradient well (measured at 120 feet from the barrier) declined to ND. At this well, assays of aerobic microbial degraders were two orders of magnitude higher than background, thus indicating the presence of oxygen from the ORC installation was driving bioremediation.
- **16-Site ORC Performance Evaluation** – ORC was placed in 41 existing wells on 16 sites and monitored for a 7 to 12 week period. The average dissolved oxygen levels were significantly increased; two-thirds of the readings were between 20 and 30 ppm, even while in the presence of dissolved phase BTEX. As expected, the BTEX levels dropped dramatically - between 80 and 100 percent in 75% of the wells - a third of those being fully remediated (see Figure 4).



CUSTOMER SERVICE

As part of our customer and product service, **REGENESIS** offers the following technical support at no additional charge:

- Analysis of your site for an ORC application to meet your remediation objectives
- Recommendation of ORC well placement and product replenishment
- Economic analysis and comparison of ORC to other remediation technologies
- Assistance with regulatory approval
- Technical Bulletins are available on a range of subjects

SAFETY, STORAGE AND HANDLING

ORC is an oxidizer. ORC should not come into contact with combustible materials. Though the material itself is not flammable, it can release oxygen to feed a fire. In the event of a fire, the area should be flooded with large volumes of water.

Since ORC can be mildly hazardous to human health, certain precautions should be taken when handling the material. Direct contact with the skin and eyes should be avoided, as irritation may occur. Rubber gloves and protective goggles should be worn as a preventative measure. Should contact with skin occur, wash immediately with soap and water. Flush eyes thoroughly and repeatedly for 15 minutes and contact a physician, if necessary.

Inhalation may also cause mild irritation to the lungs, nose, and throat, but should not result in significant, long-term hazard. When ORC is packaged in filter socks for use in wells or trenches, the free-powder related hazards are significantly limited. A proper dust mask or breathing apparatus should be used when the product is handled in the powder form. If inhalation irritation occurs, move to a well ventilated space, or outside to fresh air.

ORC is a very stable compound. Though it is designed to release oxygen when in contact with water, it will remain stable at up to 3% moisture which facilitates storage. Storage areas should remain dry. Avoid areas with high humidity. Store the product away from combustible material. Keep containers closed when not in use.

An MSDS is shipped with every order and copies are available upon request.

REGENESIS - THE COMPANY

REGENESIS Bioremediation Products was formed to continue the development and marketing of ORC®. Oxygen Release Compound was first sold commercially in 1994 after three years of development. The inventors originally began working on a similar product used to facilitate the growth of plants in oxygen-poor soils. Formulations of ORC more appropriate to bioremediation applications were successfully tested in the laboratory and followed by several field demonstrations. The company is now in the commercialization phase, working with clients to meet their specific remediation needs.

The Scientific Advisory Board and Board of Directors of **REGENESIS Bioremediation Products** are composed of recognized leaders from industry, academia and government.

For further information or technical assistance, please contact:

REGENESIS Bioremediation Products

27130A Paseo Espada ■ Suite 1407 ■ San Juan Capistrano ■ CA 92675 ■ Voice: (714) 443-3136 ■ Fax: (714) 443-3140

SOURCE TREATMENT IN THE EXCAVATED TANK PIT

An ORC® *Excavated Tank Treatment* offers a unique, one-time opportunity to provide a large treatment area across the floor of a tank excavation. Applying a long-lasting oxygen source into the system creates a zone of remedial activity which protects the lower region of the pit. When groundwater is present in the pit, preventing additional excavation, ORC may be the only viable treatment option. An ORC *Excavated Tank Treatment* can also be a more cost-effective remediation alternative to excavation, transportation, and disposal of the soil at the bottom of a tank pit.

After tank removal and remedial excavation, an ORC *Excavated Tank Treatment* can be used in-situ to remediate the residual levels of hydrocarbon in the soil and at the soil/groundwater interface. In this application, pure ORC powder is physically mixed with contaminated media; typically, 0.1% to 1% of ORC is used in the soil on a wt/wt basis. As seasonal fluctuations occur in the water table, contact with the ORC treated area promotes biodegradation. This protects clean groundwater from residual sorbed material and protects clean fill from contaminated groundwater.

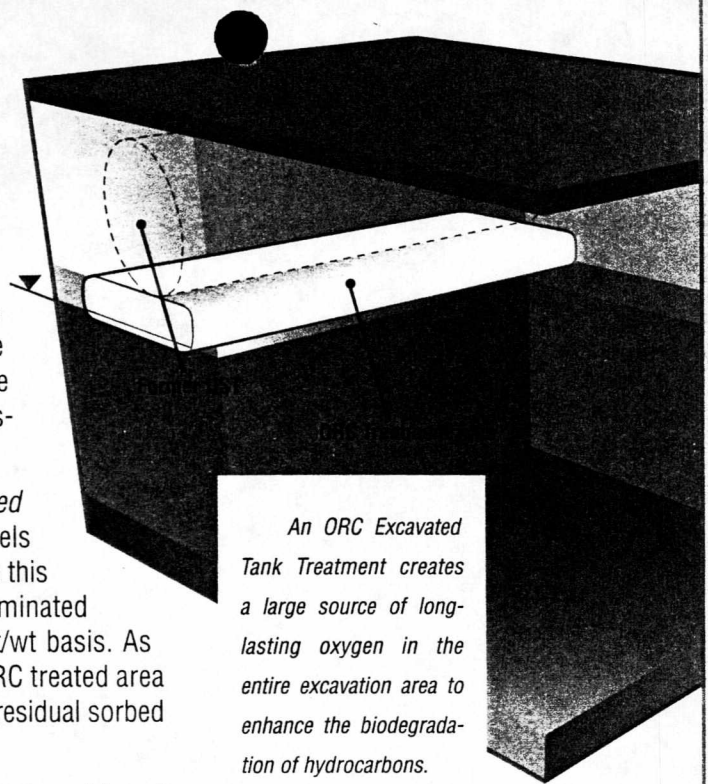
In a typical 30' by 30' tank pit, a three foot .3% ORC application would cost only \$7,200 and would treat 100 ppm TPH. At \$72 per cubic yard, this long-lasting ORC treatment may be less expensive than physical excavation, transportation and disposal.

Detailed application instructions are available for both the saturated zone and tank pit treatments. If you have any questions about the ORC Source Treatments, please contact the **REGENESIS** headquarters or your regional representative nearest you.

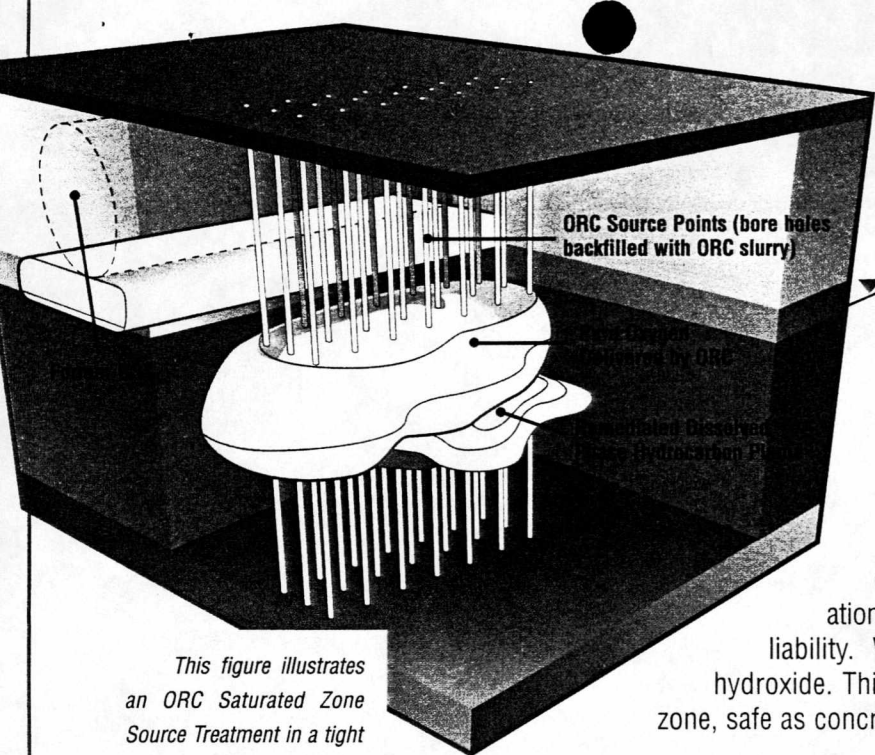
REGENESIS Bioremediation Products

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Mr. Mark Silverstone
Dahl and Associates
4390 Mcmenemy St
Attn: Michael Watson Jim Coletta
Saint Paul MN 55127-6004



An ORC Excavated Tank Treatment creates a large source of long-lasting oxygen in the entire excavation area to enhance the biodegradation of hydrocarbons.



SOURCE TREATMENT OF THE SATURATED ZONE

The ORC® *Saturated Zone Source Treatment* targets dissolved phase contamination plus sorbed material within the saturated zone and capillary fringe. In this new, low-cost application, ORC powder is mixed with water to create a smooth slurry that is pumped or poured into narrow, inexpensive direct-push or augered bore holes that have been placed in an array in and around the contaminant source area. This creates a highly oxygenated zone.

The permanent ORC source points slowly release oxygen for about six months to enhance aerobic bioremediation, degrading the contaminant mass and reducing risk and liability. When the oxygen exhausts, the ORC is inert magnesium hydroxide. This ORC residue may be used as a grout, in the saturated zone, safe as concrete.

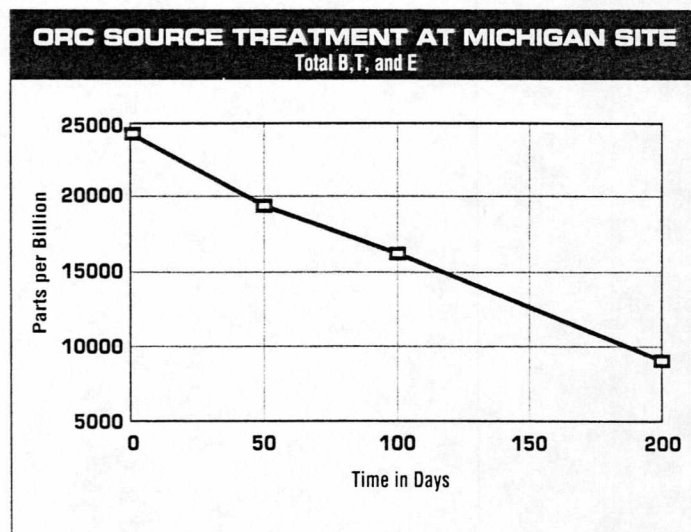
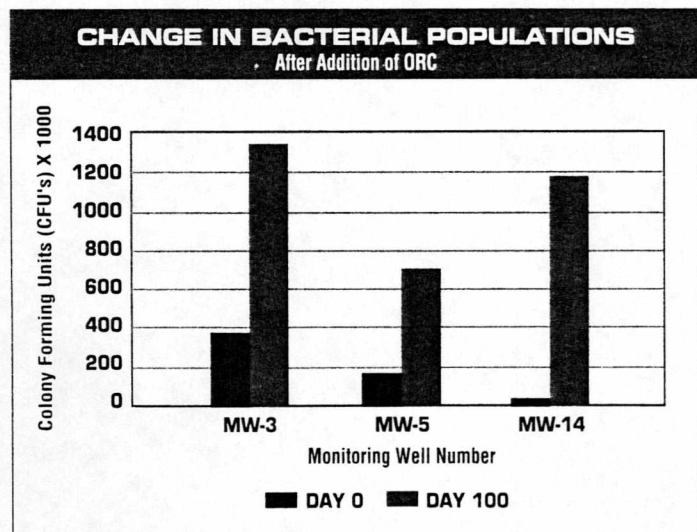
This figure illustrates an ORC Saturated Zone Source Treatment in a tight array of low cost bore holes around the contaminant source. The ORC points deliver pure oxygen for about six months to enhance aerobic bioremediation.

The ORC Saturated Zone Source Treatment saves time and operating expense:

- ◆ Continuous mechanical operation or maintenance is no longer required after source points are installed.
- ◆ ORC delivers higher levels of useable dissolved oxygen than mechanical methods because it provides a chemical source of pure molecular oxygen, not just air.
- ◆ The elevated dissolved oxygen level environment degrades the contaminant 10 to 100 times faster than the anaerobic process.
- ◆ ORC's molecular oxygen disperses easily through a tight media and uses the same migratory pathways as the contaminants. Sparged air may channel, particularly in tight soils.

FIELD RESULTS

An ORC *Saturated Zone Source Treatment* was applied in Michigan where a leaking UST created a static plume with 25 ppm of benzene, toluene and ethylbenzene contamination in the groundwater. Fifty-seven bore holes were drilled with a 5.25 inch outer-diameter hollow stem auger in an array throughout the source area and each was backfilled with ORC. After 200 days, the monitoring wells showed a significant reduction in the contaminants which correlated with a rise in the microbial degrader populations.



LOWER COST OF ORC® SATURATED ZONE SOURCE TREATMENT COMPARED TO AIR SPARGING

Costs Comparison at an Oklahoma Site

ORC Saturated Zone Source Treatment versus Air Sparging with Soil Vapor Extraction		
COST CATEGORY	ORC	AIR SPARGING W/SVE
System Installation		
ORC®	\$11,943	N/A
Geoprobe®	11,168	N/A
Labor/Materials	5,220	\$49,734
Capital Equipment	0	36,800
Subtotal	\$28,331	\$86,534
Monitoring	11,055	40,200
System Maintenance	6,900	32,100
Total	\$46,286	\$158,834

NOTES: The treatment area at this site is 9,146 square feet and the treatment thickness is 11 feet. The ORC system is designed to treat a plume with a peak BTEX concentration of 25 ppm and close the site in one year. The values for the air sparge system were derived independently by the site consultant and site closure is expected in three years.

Cost Analysis	
Cost Category	ORC Saturated Zone Source Treatment Cost Compared to Air Sparging
Capital Costs	ORC does not require capital investment
Maintenance Costs	ORC does not incur extended maintenance and monitoring costs
Total Cost	ORC has 70% lower overall cost

CONCLUSION

An ORC Saturated Zone Source Treatment can be more cost-effective than air sparging.

LOWER COST COMPARED TO MONITORING ONLY

An ORC Saturated Zone Source Treatment, if properly applied, can result in site closure in as little as one year. The highly oxygenated aerobic process is 10 to 100 times faster than the anaerobic process. Applying ORC can avoid on-going monitoring costs as well as potential future liability.

Using the draft ASTM monitoring protocol for bioremediation to estimate the five year monitoring costs at the 12 wells on the Oklahoma site, projected monitoring costs are:

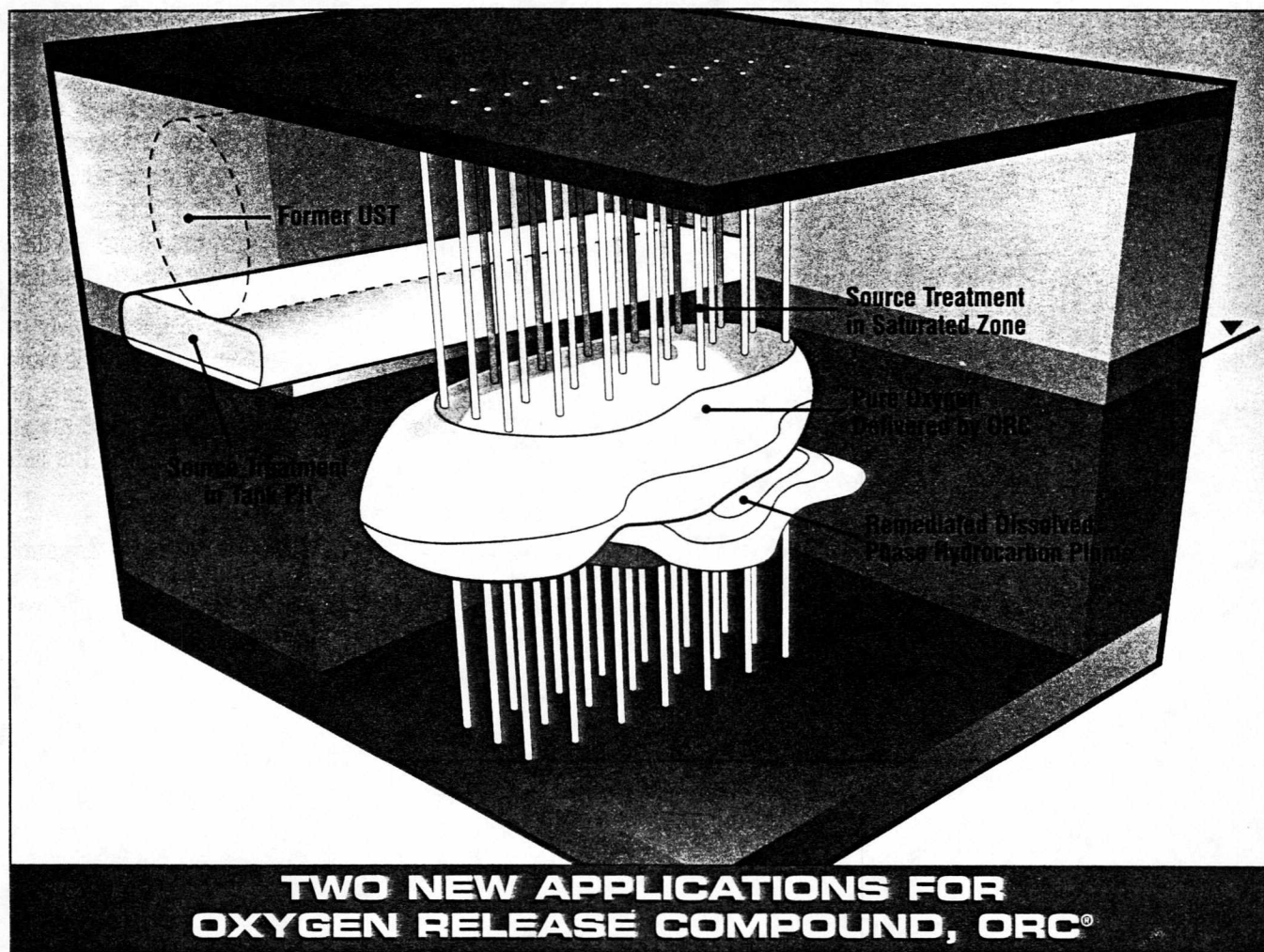
First year quarterly monitoring at \$500/well/monitoring event	\$24,000
Second year semi-annual monitoring at \$500/well/monitoring event	\$12,000
Third through fifth annual monitoring costs at \$500/well/monitoring event	\$18,000
Cost of Monitoring Only	\$54,000
Costs of ORC Saturated Zone Source Treatment	\$46,286

NOTE: At the end of five years, at anaerobic degradation rates the peak BTEX levels would still be 17 ppm, which may require further monitoring due to downgradient receptors. With the ORC treatment the site should be closed in one year.

CONCLUSION

An ORC Saturated Zone Source Treatment will close the site sooner and more cost effectively than just monitoring the site.

FASTER SITE CLOSURE AT LOWER COST WITH ORC® SOURCE TREATMENTS



TWO NEW APPLICATIONS FOR OXYGEN RELEASE COMPOUND, ORC®

IN THE CONTAMINATED SATURATED ZONE

Reduce contaminant mass and meet RBCA compliance standards with an ORC *Saturated Zone Treatment*:

- ◆ ORC direct push or augered bore holes throughout the contaminated saturated zone provide rapid, economic closure.

IN AN EXCAVATED TANK PIT

Eliminate the toughest source of contamination with an ORC *Excavated Tank Treatment*:

- ◆ ORC powder mixed in the bottom of an excavated tank pit provides economic, prolonged soil and groundwater treatment.

NEW APPLICATIONS FOR OXYGEN RELEASE COMPOUND, ORC®

Oxygen Release Compound has demonstrated rapid, cost-effective results as a source treatment to remediate contaminant hydrocarbons in the saturated zone near the original source and in excavated tank pits.

To enhance aerobic bioremediation, ORC Source Treatments deliver time released dissolved oxygen for about six months. These new ORC applications can reduce the contaminant mass at the source and attenuate the dissolved phase plume, significantly lowering risk and achieving compliance standards at required downgradient points.