GERAGHTY & MILLER, INC.
Environmental Services

ENVIRONMENTAL PROTECTION

96 MAY 20 PM 1:07

mofile

a **heidemij** company

February 26, 1996
Project No. RC0174.003

Mr. Bob Cochran
Chevron U.S.A. Products Company
6001 Bollinger Canyon Road
San Ramon, California 94583-0804

SUBJECT: Remedial Approach, Chevron /Lonestar Facility, 333 - 23rd Avenue, Oakland, California.

Dear Mr. Cochran:

This letter presents the proposed remedial approach of enhanced bioremediation at the Chevron facility referenced above (Figure 1). Recent field sampling demonstrated very low levels of dissolved oxygen (DO), nitrate, phosphate, and ammonia (Table 1). During the November field sampling, DO concentrations ranged from 0.37 milligrams per liter (mg/L) to 1.49 mg/L. This indicates that aerobic biodegradation of petroleum hydrocarbons in the vicinity of these wells has resulted in the reduced DO concentrations observed during this sampling event. These low background DO concentrations suggest that future aerobic biodegradation is limited by the availability of oxygen.

A variety of indigenous organisms that live in the subsurface can convert contaminants into less toxic byproducts. In aerobic respiration, microbes transform organic contaminants into carbon dioxide by transferring electrons from the contaminant (oxidizing it) to oxygen (reducing it) or to a less-favored electron acceptor. DO is the most thermodynamically favored electron acceptor in the biodegradation of petroleum hydrocarbons, which are readily biodegradable under aerobic conditions. Ideally, aerobic biodegradation of petroleum hydrocarbons occurs when DO concentrations are greater than 2 mg/L. During aerobic biodegradation, DO levels are reduced as aerobic respiration occurs.

After DO has been depleted in the microbiological treatment zone, nitrate may be used as electron acceptor during anaerobic and anoxic biodegradation. Low levels of nitrate observed in the November field sampling indicate that this electron source is not sufficient to support microbiological activity. On behalf of Chevron, Geraghty & Miller proposes to install Oxygen Release Compound (ORC) formulated by REGENESIS Bioremediation Products (informational brochure attached) to increase the levels of DO and significantly enhance ongoing in-situ biodegradation. Additionally, Geraghty & Miller will install diammonium phosphate to increase levels of dissolved nitrogen and phosphorous, two key nutrients for aerobic bacteria.

1050 Marina Way South • Richmond, California 94804 • (510) 233-3200 • FAX (510) 233-3204

Geraghty & Miller proposes to add ORC and diammonium phosphate to Monitoring Wells MW-1, MW-7, MW-9, and MW-10. These wells were chosen due to their proximity to the original release (near MW-1), dissolved-hydrocarbon analytical concentrations, and low concentrations of DO. The monitor well locations are shown in Figure 2. Sections of ORC will be suspended below the groundwater surface from each selected wellhead. Approximately 5 pounds of diammonium phosphate will be added to each well. This will yield an average concentration of approximately 10 ppm within a 15-foot radius around the well. The dispersion and effects of DO, ammonia, and phosphate in surrounding wells will be monitored during quarterly groundwater monitoring events.

Geraghty & Miller appreciates the opportunity to be of service to Chevron U.S.A. Products Company. If you have any questions, please do not hesitate to call the undersigned at (510) 233-3200.

Sincerely,
GERAGHTY & MILLER, INC.

Aaron O'Brien
Engineer

Darryl B. Snow
Project Scientist/Project Manager

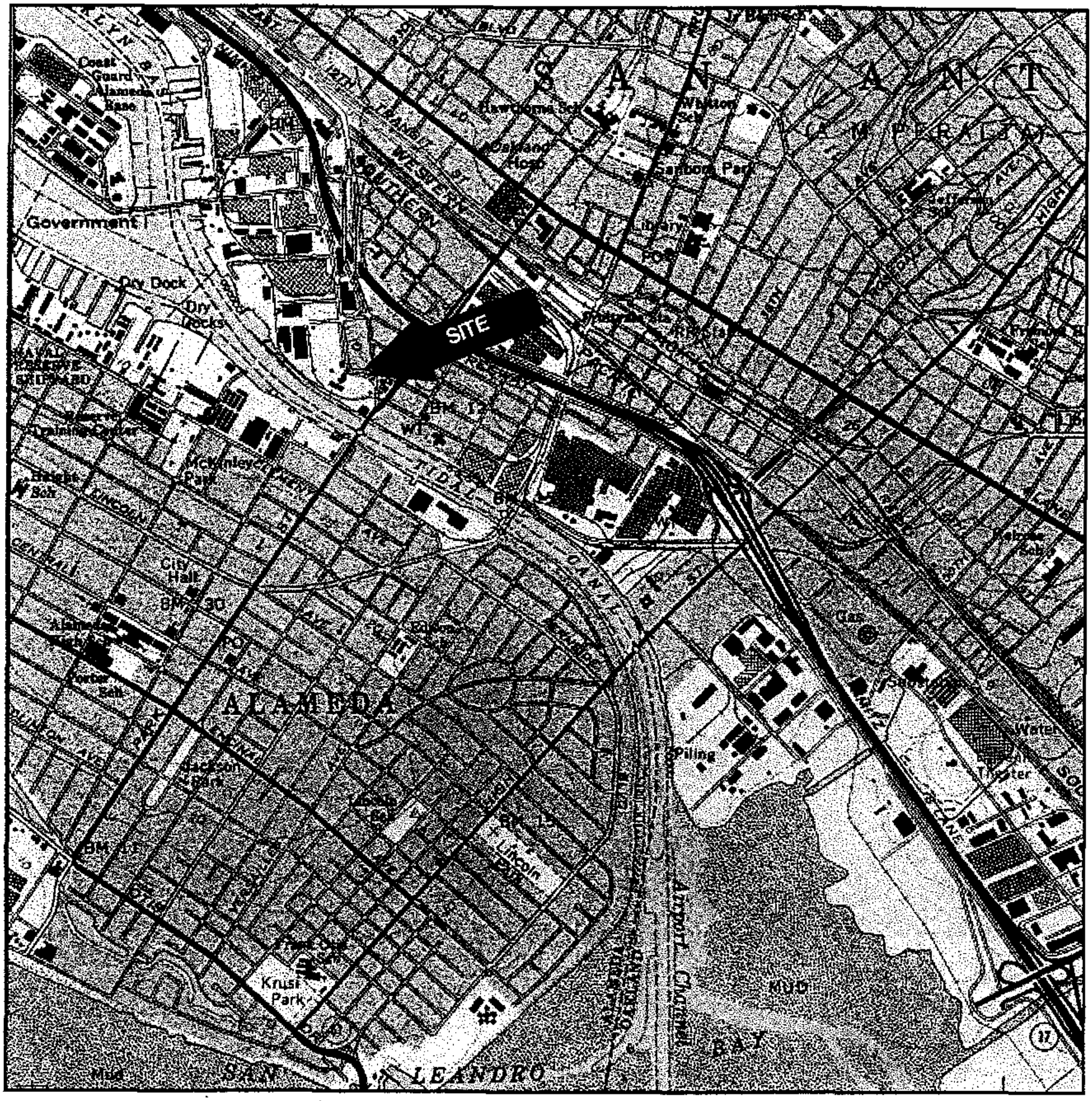
Gary W. Keyes, P.E.
Principal Engineer/Project Officer
Richmond, California Office Manager

Attachments:	Table 1	Summary of Field Parameters
	Figure 1	Site Location Map
	Figure 2	Site Plan
	Attachment 1	Copy of Oxygen Release Compound informational brochure

cc: Sumadhu Arigala, RWQCB

Table 1: Summary of Field Parameters
RMC Lonestar Facility
333 – 23rd Avenue, Oakland, California.

Well	Date	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)
MW-1	9-Nov-95	0.90	---	---	---
MW-2	9-Nov-95	(Abandoned prior to December 1992.)			
MW-4	9-Nov-95	0.37	0.2	0	0.1
MW-5	9-Nov-95	0.85	0.1	1.5	0.1
MW-7	9-Nov-95	0.42	---	---	---
MW-8	9-Nov-95	0.95	---	---	---
MW-9	9-Nov-95	0.58	---	---	---
MW-10	9-Nov-95	1.49	---	---	---
MW-11	9-Nov-95	0.52	0.2	5.0	0.1
MW-12	9-Nov-95	(Well filled with water.)			
MW-13	9-Nov-95	(Well not found.)			
R-2	9-Nov-95	0.44	0.6	0	0
A	9-Nov-95	0.42	1	0	4



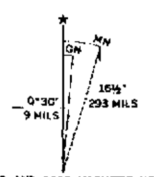
SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

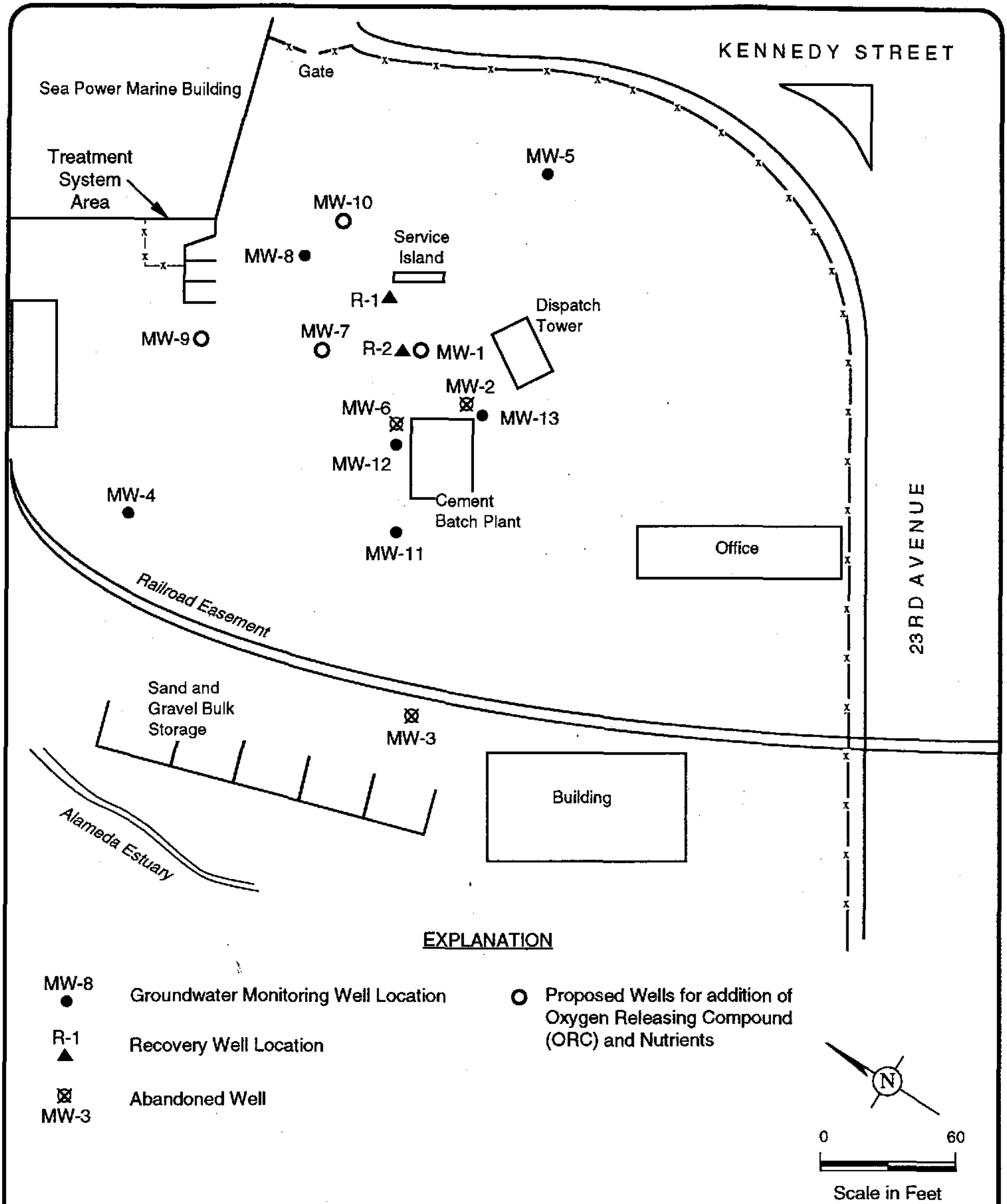
CONTOUR INTERVAL 20 FEET



UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Reference: U.S.G.S. 7.5-minute Quadrangle Oakland East California, 1959 photorevised 1980.

GERAGHTY & MILLER, INC. *Environmental Services* A **Heidemij** Company	**SITE LOCATION MAP** Lonestar Facility 333–23rd Avenue Oakland, California	FIGURE **1**
Project No. RC0174.000		



GERAGHTY & MILLER, INC.
Environmental Services
A **Heidemij** Company

Project No. RC0174.000

SITE PLAN
Lonestar Facility
333 – 23rd Avenue
Oakland, California

FIGURE
2

REVISION
2/07/96

ATTACHMENT 1

COPY OF OXYGEN RELEASE COMPOUND INFORMATIONAL BROCHURE

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:

$$MgO_2 + H_2O \rightarrow \tfrac{1}{2}O_2 \uparrow + Mg(OH)_2$$

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.

KINETICS OF OXYGEN RELEASE FROM ORC

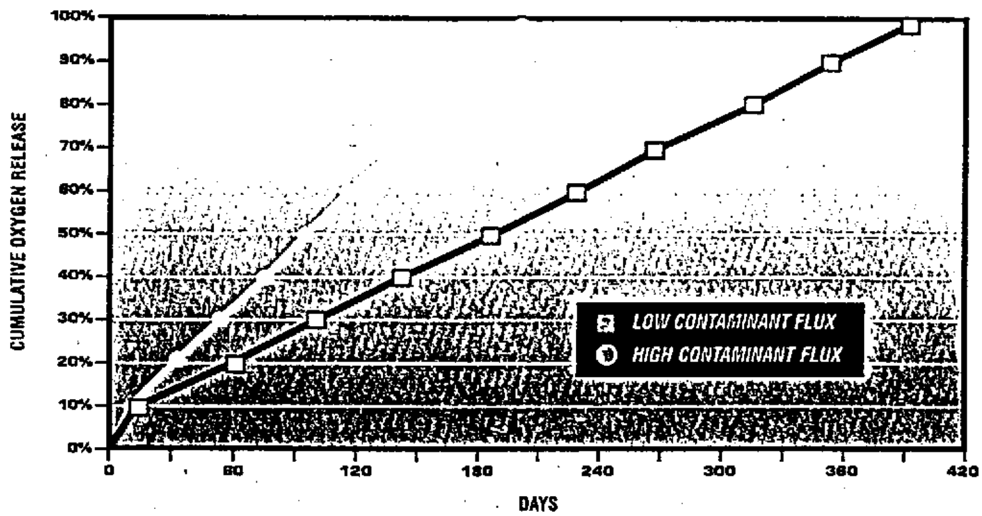


Figure 1 presents the oxygen release kinetics of ORC. The product releases about 10% of the available oxygen in the first few weeks and then releases the balance over a period of six months to a year depending on the level of contaminant flux.

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.

ORC OXYGEN BARRIER

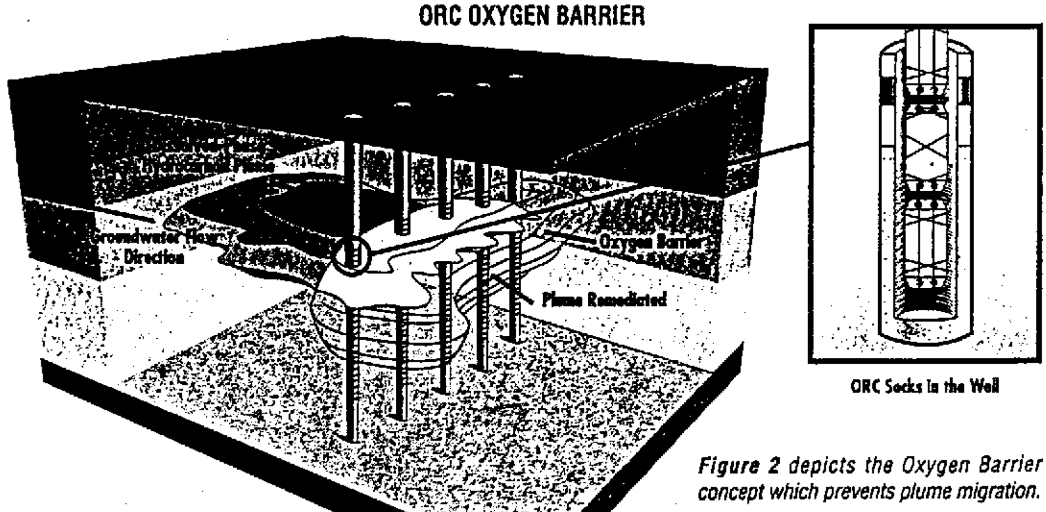


Figure 2 depicts the Oxygen Barrier concept which prevents plume migration.

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.**

TOTAL BTEX CONCENTRATIONS PARTS PER MILLION (PPM)

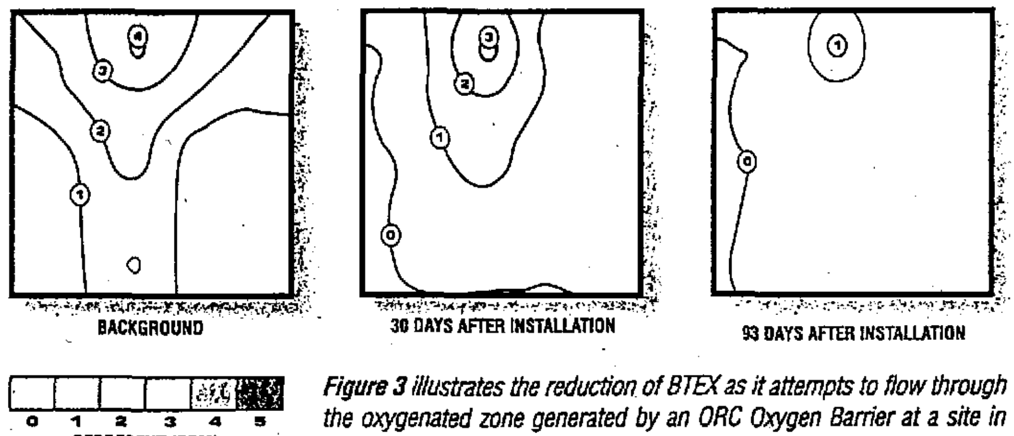


Figure 3 illustrates the reduction of BTEX as it attempts to flow through the oxygenated zone generated by an ORC Oxygen Barrier at a site in New Mexico. The view is presented as if one were in the saturated zone facing the barrier. The area represented here is 20' x 20'.

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).

16-SITE ORC PERFORMANCE EVALUATION

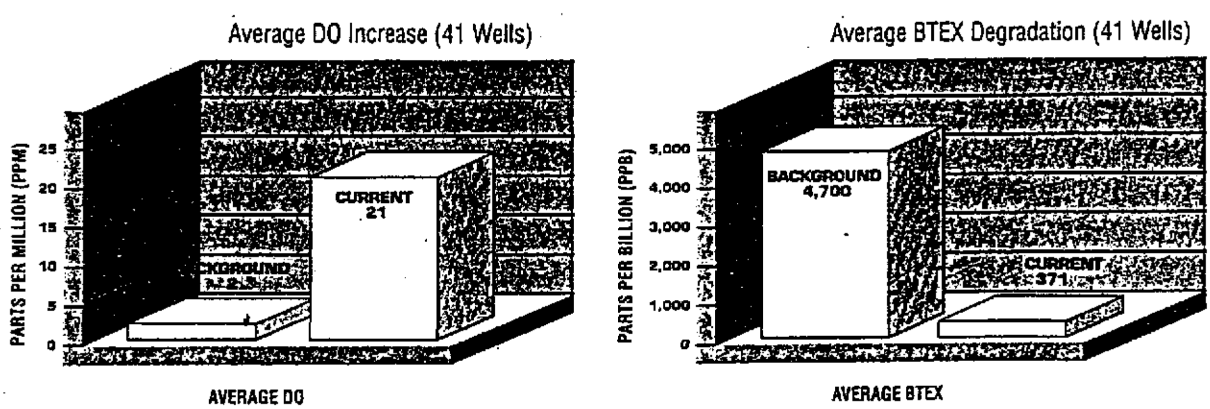


Figure 4 these graphs illustrate the results of the 16-site ORC Performance Evaluation program described above.

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