8/4/04 NWIRP RAB
1-30-003B-CU1

Proprietary

tierra technologies
A DIVISION OF AR UTILITY SPECIALISTS, INC.

Locus
TECHNOLOGY

THE CLOSED-LOOP *IN SITU* BIOREMEDIATION SYSTEM

Proprietary

Agenda

- Company Overview
- The Closed Loop *In-Situ* Bioremediation System
  - Description
  - Operation
  - Additives
  - Case Studies
  - Advantages
- NWIRP Bethpage Area of Concert (AOC) 22 Project Overview
- Questions and Discussion

ARUSI Company Overview

- Multi-Disciplined Environmental, Construction Management, Engineering and Design Firm
- 8(a) Certified Minority Owned and Operated with a Proven Track Record of Success
- Formed in 1987 and Have Completed Over $50 Million in Projects of Varying Scopes
- Headquartered in Phoenix, Arizona with Offices in Various Locations in the Southwest
- 2-Time Recipient of the Outstanding Minority Business Achievement Award from the City of Phoenix
- Selected as the Grand Canyon Minority Supplier of the Year in 2002

Locus Company Overview

- Highly Innovative Engineering News-Record (ENR) 200 Environmental Consulting and Engineering Firm
- Locus specializes in:
  - Consulting
  - Design
  - Construction
  - Information Management
  - Automation Services
- Headquartered in Walnut Creek, California with Offices throughout California, in Phoenix AZ, Boston MA, Asheville NC, and Paris France

Proprietary

Company Overview

Who we serve:

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

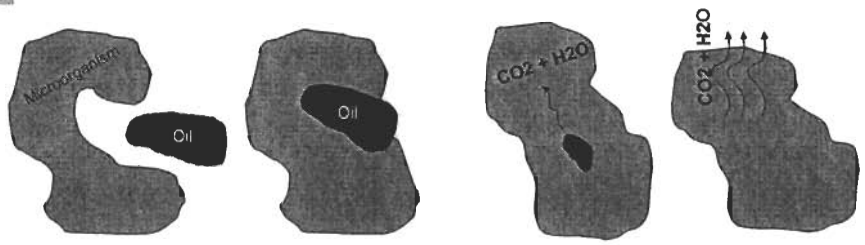
What is Bioremediation?

- A process that uses naturally occurring microorganisms to breakdown or degrade, hazardous substances into less toxic or nontoxic substances.
- A cost effective, natural process application to many common organic wastes, include hydro-carbon contaminates.
- Techniques that can be conducted on-site.
- Technology useful where rapid remediation is a high priority.

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

Schematic Diagram - Bioremediation



Microorganisms eat oil or other organic contaminant

Microorganisms digest oil and convert it to carbon dioxide (CO_2) and water (H_2O)

Mechanism for stimulating and maintaining the activity of these microorganisms includes a delivery system for providing:

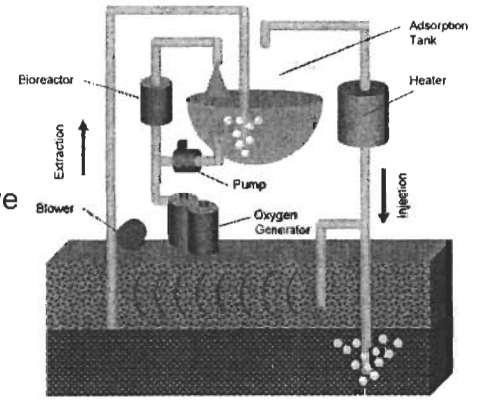
- electron accepter (oxygen, nitrate)
- nutrients (nitrogen, phosphorus)
- energy source (carbon)

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

System Description

- *In-Situ* Bioremediation
- Utilizes Indigenous Microorganisms
- Creates a Subsurface Environment Conducive to Biodegradation of Contaminants
- Continuous Monitoring of the Environment Using Above Ground Bioreactor

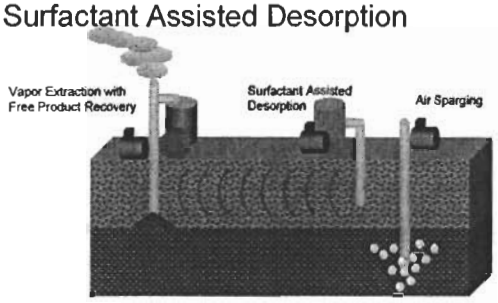


Proprietary

The Closed-Loop *In-Situ* Bioremediation System

System Description

- Combines Proven Technologies:
  - Vapor Extraction with Free Product Recovery
  - Air Sparging
  - Surfactant Assisted Desorption



Proprietary

The Closed-Loop *In-Situ* Bioremediation System

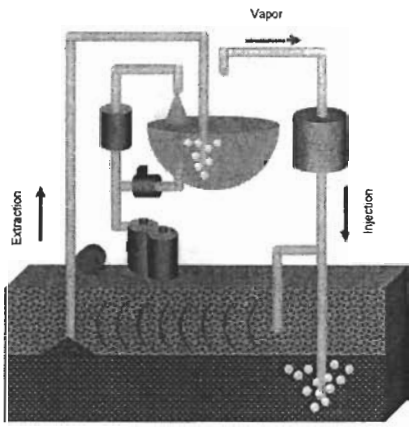
System Operation

Liquid media is recirculated through the bioreactor. O2 and nutrients are added to promote growth of desired microorganisms.

Soil vapor is sparged into the adsorption tank

Soil vapor is extracted from Subsurface bioreactor

Prior to starting the system, Any existing free product is recovered



Vapor containing the desired microorganism, moisture, nutrients and heat exits the adsorption tank

Nutrients, heat, and surfactant are added and injected into the subsurface environment

A subsurface bioreactor is created and maintained.

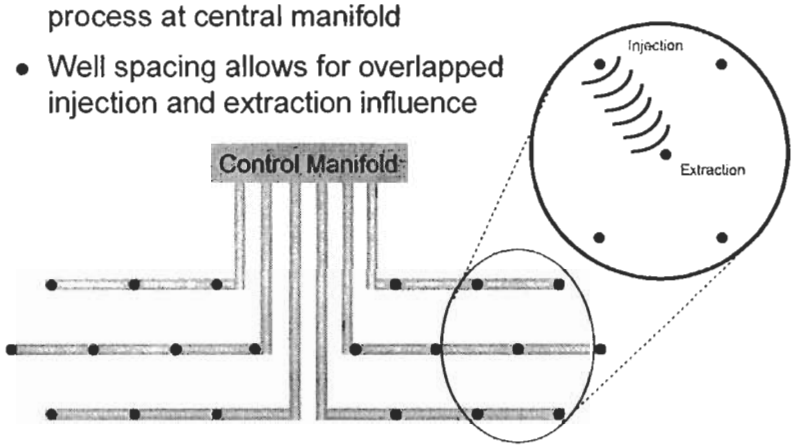
Vapor from the above-ground Bioreactor oxygenates the groundwater and volatizes the contaminant

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

System Operation

- Control of injection and extraction process at central manifold
- Well spacing allows for overlapped injection and extraction influence

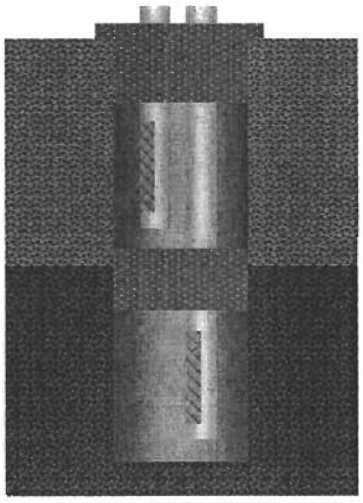


Proprietary

The Closed-Loop *In-Situ* Bioremediation System

System Operation

- Nested injection and extraction wells
- Targets treatment at a precise depth
- Accounts for heterogeneous soil strata



Proprietary

The Closed-Loop *In-Situ* Bioremediation System

The Biotreatment Additives

- Meta-Boost[SM] – Enhances the metabolic rate of bacteria
- Nitro-Boost[SM] – Provides nitrogen, phosphorus, and other nutrients
- Desorb-A[SM] – Foam surfactant that emulsifies adsorbed hydrocarbons, transports nutrients, oxygen, and microorganisms
- Deep-Treat[SM] – Provides an oxygen rich environment, removes competitive microorganisms
- All additives are completely biodegradable

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

Meta-Boost [SM]

- Metabolic and growth stimulator for bacteria
- Promotes bacteria reproduction
- Contains slow release carbons (humic and fulvic acids) and alkaloids
  - Slow release carbons provide a ready food source to support and promote bacterial growth
  - Alkaloids promote rapid cell growth resulting in accelerated bacterial reproduction
- Completely biodegradable

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

Nitro-Boost SM

- Nutrient solution for bacteria
- Provides nitrogen, phosphorus, and other nutrients
- Contains micro nutrients including ammonium nitrate, monoammonium phosphate
- Completely biodegradable

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

Deep-Treat SM

- Provides an oxygen rich environment, removes competitive microorganisms
- Contains hydrogen peroxide (H_2O_2) and mineral water
- Variable H_2O_2 concentration for different applications:
  - Fenton's Reagent – 5-20% H_2O_2 concentration with chelated iron
  - Oxygenating the subsurface – 2 ppm H_2O_2 concentration
  - Removing biomass build-up – 3% H_2O_2 concentration
- Completely biodegradable

The Closed-Loop *In-Situ* Bioremediation System

Key Ingredient

- Key ingredient in additives derived from Leonardite deposit aged 75 million years
- Optimum quality due to unique geologic history
- 12% Humic Acid
- 2-3% Fulvic Acid

Sealed Rock Cap Covering Humic Deposit

Humic Shale Deposit

The Closed-Loop *In-Situ* Bioremediation System

Desorb-A SM

- Biosurfactant wetting agent
- Foam surfactant that emulsifies adsorbed hydrocarbons
- Acts as the transport media for nutrients, oxygen, and microorganisms to the subsurface bioreactor
- Contains mixture of ionic and neutral surfactants including naturally generated surfactant from *pseudomonas aeruginosa* bacteria
- Completely biodegradable

Proprietary

The Closed-Loop *In-Situ* Bioremediation System

System Advantages

- Integration of Known Remediation Techniques
- Time Efficient = Cost Effective
  - Less Time On-Site for Remediation
  - Faster Return of the Property to Productivity
- Effective Remediation of Soil and Groundwater
- Closed-Loop – No Atmospheric Emissions or Effluent Streams Produced
- In-Situ Treatment – Minimizes Site Disruption

Proprietary

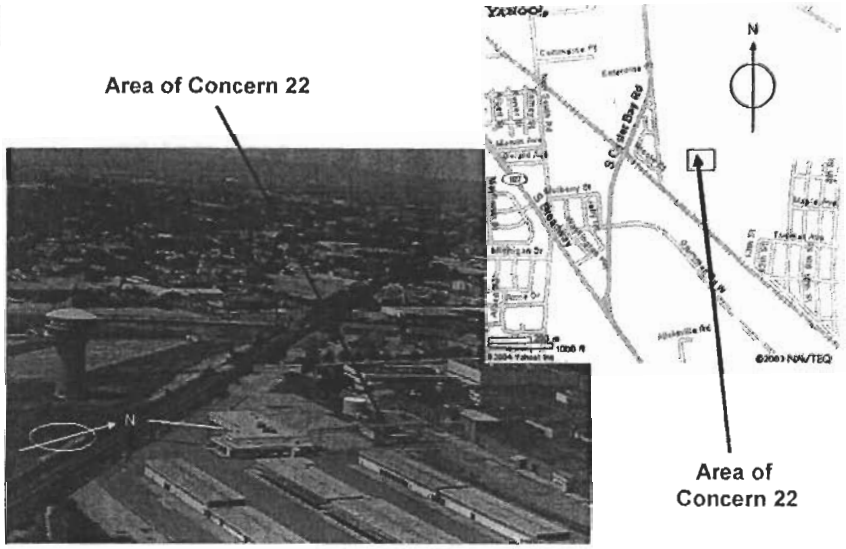
The Closed-Loop *In-Situ* Bioremediation System

System Advantages

- Demonstrated Effectiveness vs. Petroleum Fuels
- Accepted by Naval Facilities Engineering Service Center (NFESC) Under the Innovative Technologies Broad Agency Announcement
  - Abstract titled: "The Closed-Loop Bioreactor System for *In-Situ* Bioremediation of Contaminated Soil and Groundwater" is available for review

Proprietary

NWIRP Bethpage AOC 22 Project Overview



Proprietary

NWIRP Bethpage AOC 22 Project Overview

Project Background

- Former underground storage tank (UST) site located south of Plant 3.
- Investigations between 1997-2002 confirmed the presence of petroleum product in soils at 10-60 ft below ground surface (bgs)

NWIRP Bethpage AOC 22 Project Overview

Project Background

- The Navy has selected an active remediation approach based on New York State Department of Environmental Conservation (NYSDEC) comments.
- The pilot project objective is mass removal of fuel oil #4 and #6 from soil between 10-60 ft bgs.
- Volatile Organic Compound (VOC) impacted groundwater at AOC 22 is being addressed separately under another project.

NWIRP Bethpage AOC 22 Project Overview

Project Approach – Infrastructure

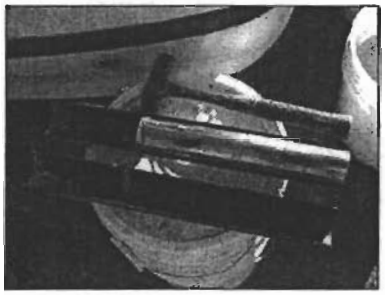
- Pilot Study Well Installation & Baseline Sampling
  - Soil samples
  - Groundwater samples
  - Microbiological samples
- Bench Testing
- Infrastructure Installation

Proprietary

NWIRP Bethpage AOC 22 Project Overview

Project Approach – Infrastructure

- The Closed-Loop Bioremediation System uses bacteria cultured from the contaminated site to achieve remediation.

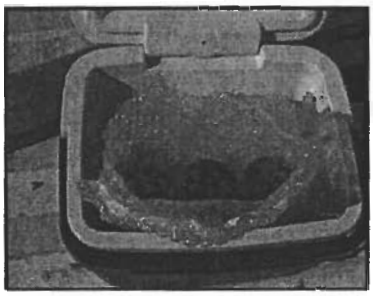


Proprietary

NWIRP Bethpage AOC 22 Project Overview

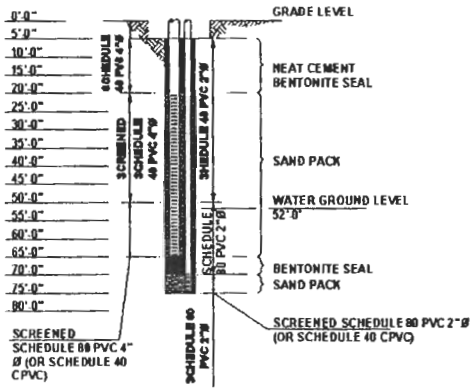
Project Approach – Infrastructure

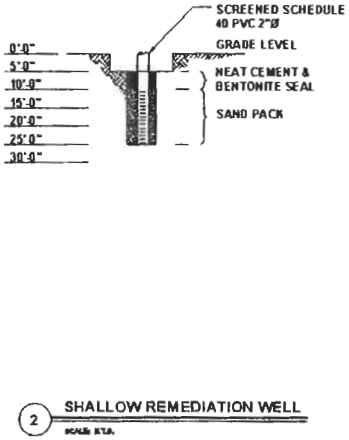
- Isolation of indigenous hydrocarbon degrading species
- Species identification



NWIRP Bethpage AOC 22 Project Overview

Project Approach - Infrastructure

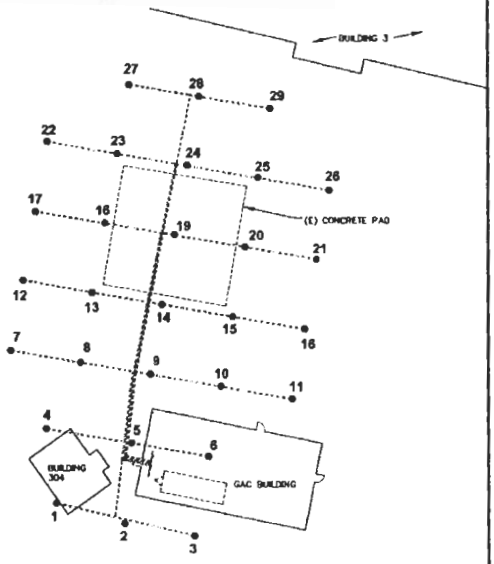




NWIRP Bethpage AOC 22 Project Overview

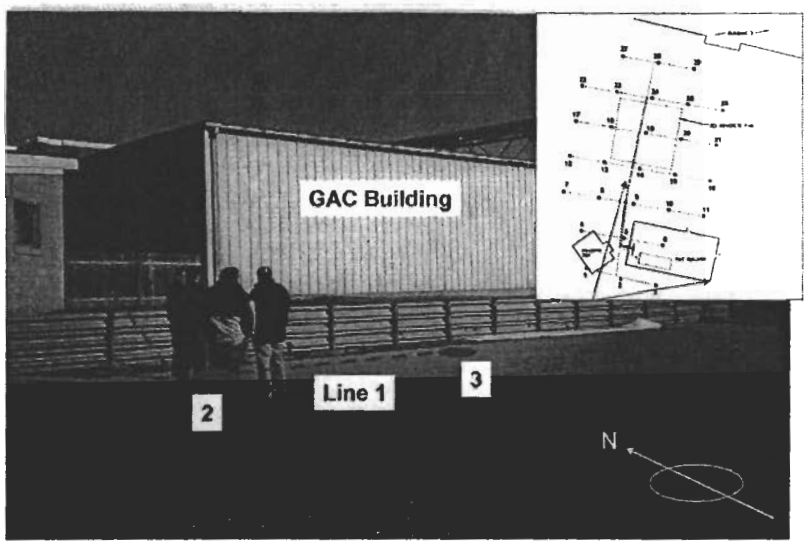
Project Approach - Infrastructure

Remediation Wells and Piping Design



Proprietary

NWIRP Bethpage AOC 22 Project Overview



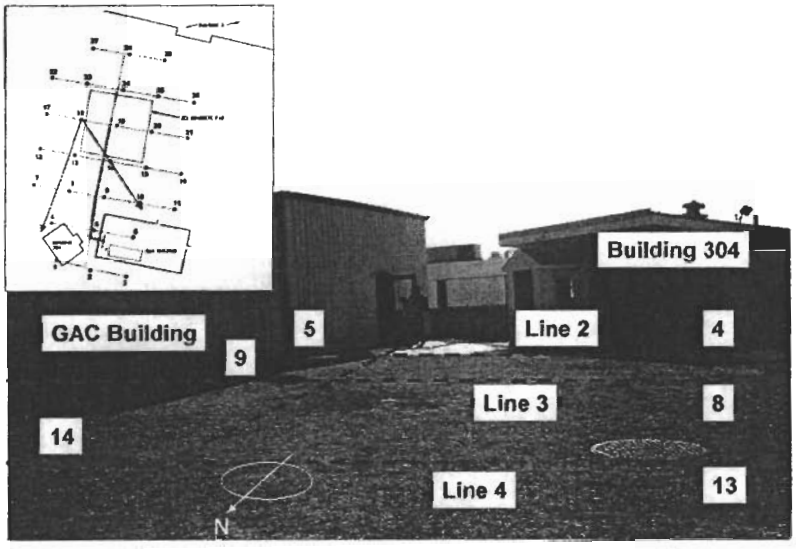
tierra technologies Locus

4 August 2004

29

Proprietary

NWIRP Bethpage AOC 22 Project Overview



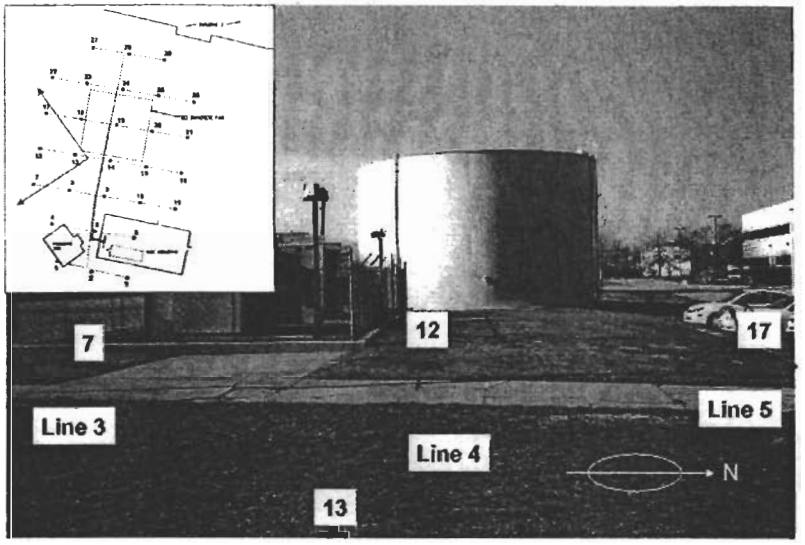
tierra technologies Locus

4 August 2004

30

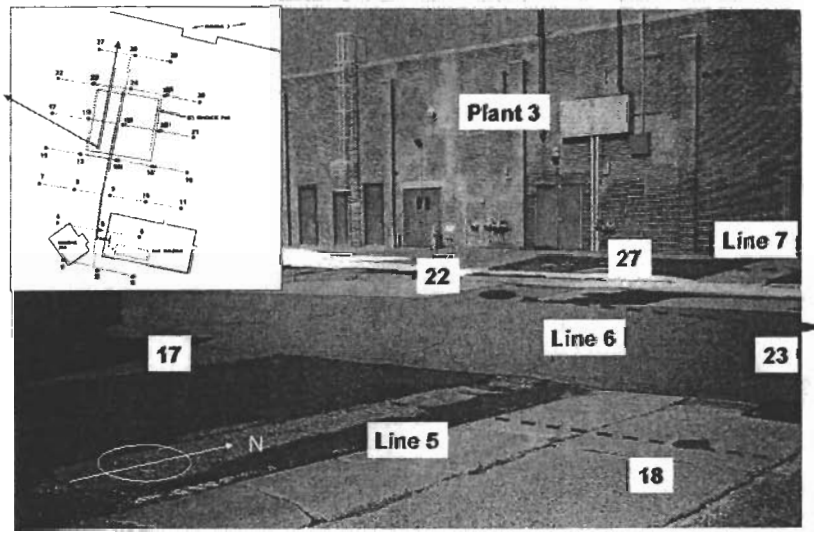
Proprietary

NWIRP Bethpage AOC 22 Project Overview



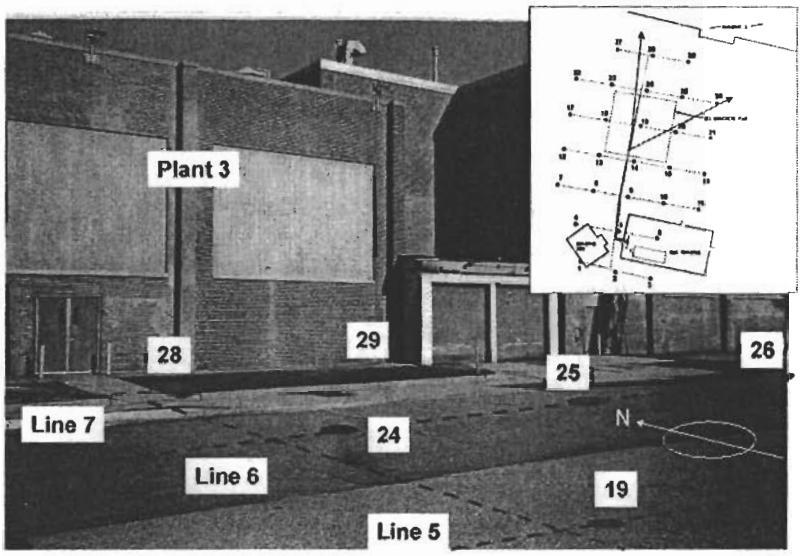
Proprietary

NWIRP Bethpage AOC 22 Project Overview



Proprietary

NWIRP Bethpage AOC 22 Project Overview



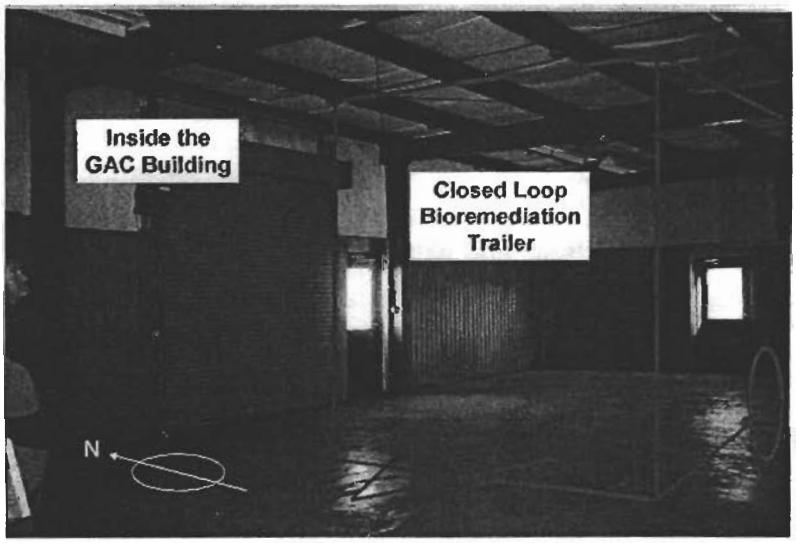
tierra technologies Locus

4 August 2004

33

Proprietary

NWIRP Bethpage AOC 22 Project Overview



tierra technologies Locus

4 August 2004

34

NWIRP Bethpage AOC 22 Project Overview

Project Approach- Startup and Operation

- Free Product Recovery
- Mobilization of Fuel Oil #6
  - Surfactant application to soil above water table
  - Hydrogen Peroxide (Fenton's Reagent) oxidation below water table
- Closed-Loop Bioremediation
  - Creation of subsurface bioreactor
  - 12 treatment cycles, 1 month each

NWIRP Bethpage AOC 22 Project Overview

Project Approach – Monitoring

- Groundwater Monitoring Program
  - Collect groundwater samples monthly
  - Analyze samples for VOCs, Semi Volatile Organic Compounds (SVOC), and total petroleum hydrocarbons (TPH), surfactants and nitrates
- Microbiological Monitoring Program
  - Collect monthly samples from selected monitor and remediation wells
  - Analyze samples for heterotropic plate counts and petroleum hydrocarbon degraders

NWIRP Bethpage AOC 22 Project Overview

Project Approach – Monitoring (cont.)

- Soil Sampling Program
  - Collect soil samples every other month
  - Analyze samples for VOCs, SVOCs, and TPH

NWIRP Bethpage AOC 22 Project Overview

Project Milestones

Design, Plans, Permits	2/04 – 7/04
Mobilization, System Installation	8/04 – 10/04
System Operation	10/04 – 9/05
- Groundwater Sampling & Analysis	Monthly
- Soil Sampling & Analysis	Every 2 Months
Final Report / Closeout	9/05 – 1/06
Site Restoration	2/06 – 3/06

Additional Questions & Discussion

File on eDOCs? ✓ Yes ____ No
Site Name I-30 003B-DU1
Site # NWIRP
County Nansemond
Town Suffolk
Foilable ____ Yes ____ No
Please Write The eDOC File Name Description AOC 22 Presentation