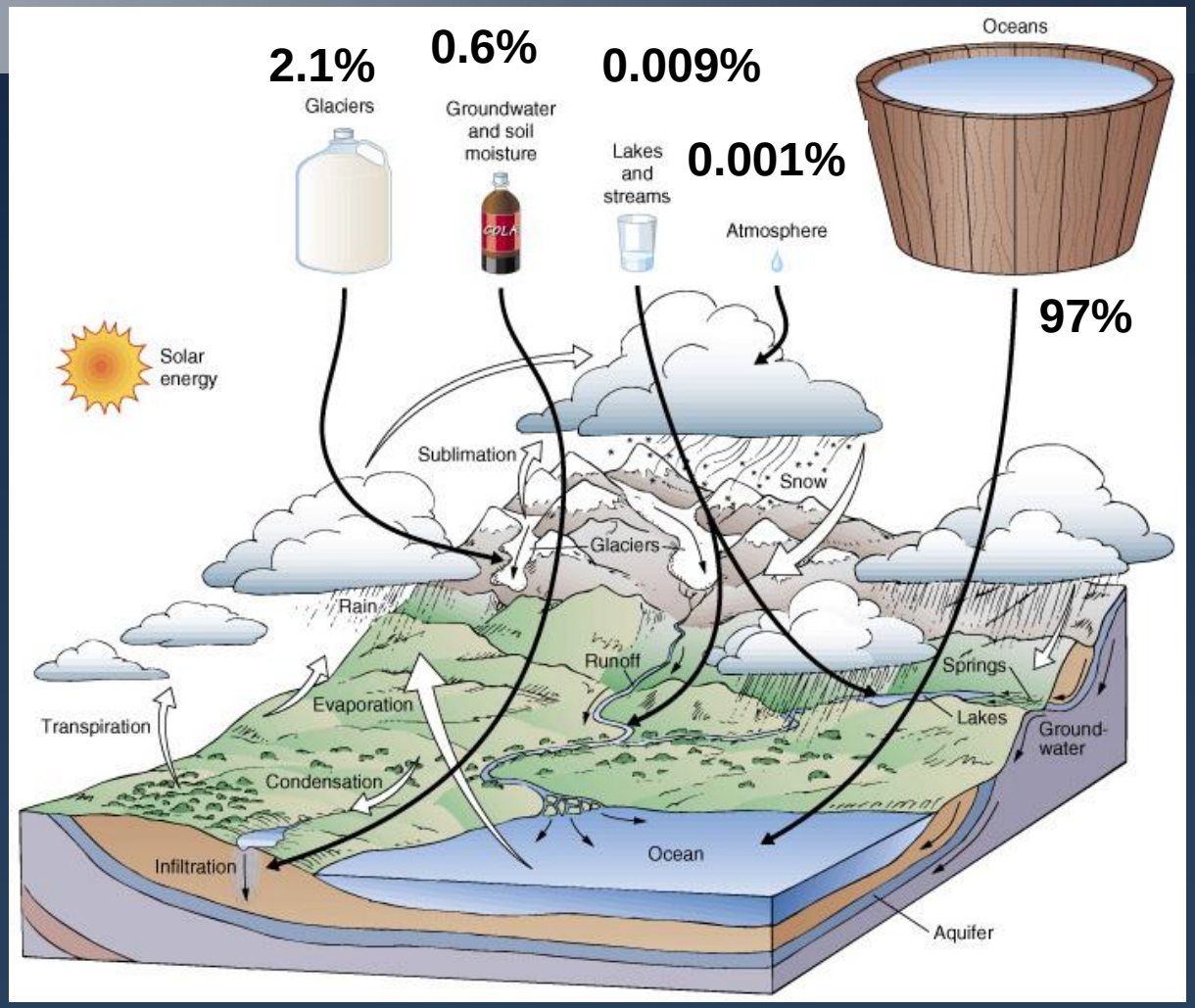
A Brief Summary of the Site Assessment, Investigation and Cleanup Process

EEC Environmental

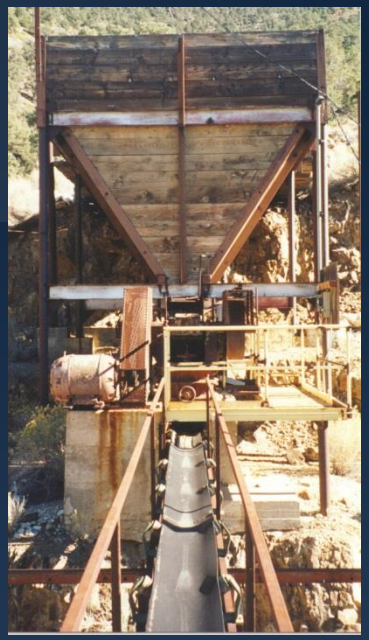
The Hydrologic Cycle and Relative Quantity of Water in Each Resource

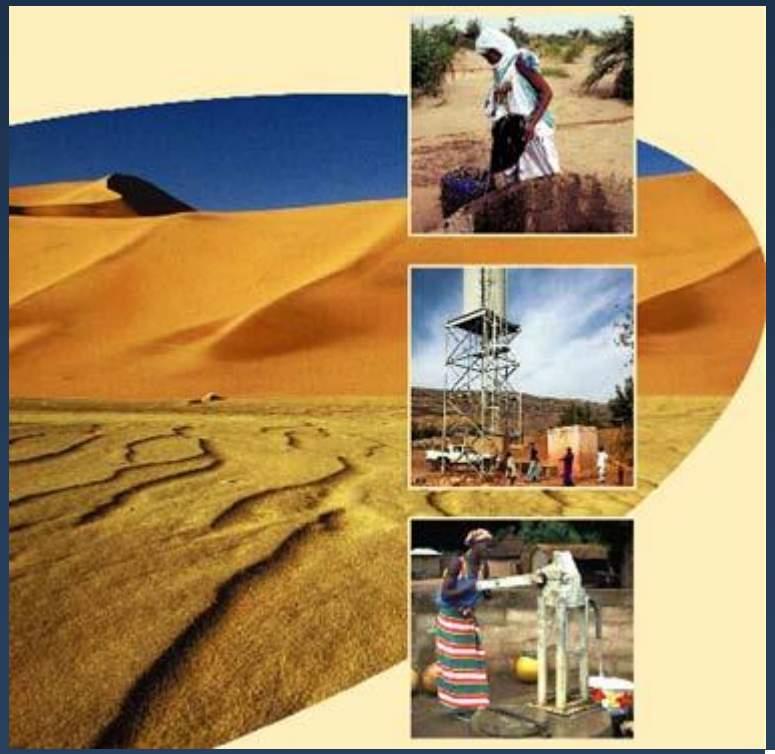


EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Uses of Groundwater

- Drinking water
  - Private
  - Municipal
- Industrial
- Agriculture
- Mining





EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Soil & Groundwater Contamination

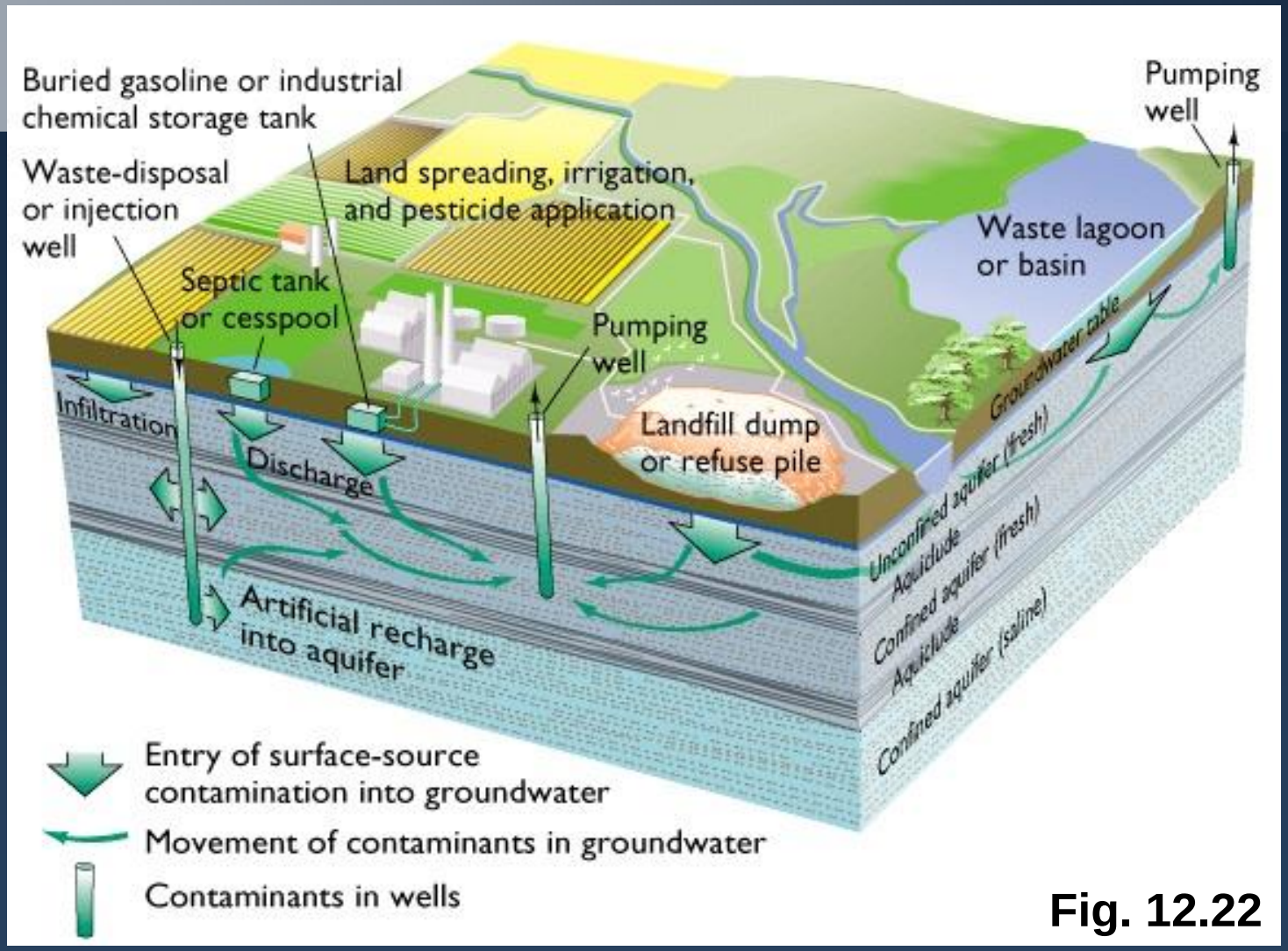


Fig. 12.22

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Surface and Groundwater Pollution Leads to Health Problems, Water Shortage

- Mining
  - Acid mine drainage
  - Heavy metals – Hg, Cr, Pb
- Industrial / Commercial Pollution
  - Dyes and pigments
  - Petroleum / gasoline
- Agricultural runoff
  - Pesticides
  - Nutrients – nitrates, phosphates
  - Salinization – Sodium, chloride
- Sewage
  - Pathogens - Enteric
  - Nutrients – Nitrates, phosphates
  - Polluted animal feed

Textile Waste

Gasoline

Mining Waste

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Environmental Site Assessment & Cleanup Process

- Phase I: *Initial Review.* Historical records review, site reconnaissance, and interviews.
- Phase II: *Confirm or discount.* Sampling, testing, and data analysis to identify pollution. Define the vertical and horizontal limits of the extent of pollution.
- Phase III: *Delineation and Remediation* Evaluate risks to human health and environment; pilot testing; cleanup technology selection; cleanup of pollution

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Phase I Site Assessment

- *Why are Phase I ESA's Performed?*
  - Evaluate the property for potential environmental pollution.
  - Assess source and responsibility for pollution.
  - Evaluate potential investigative steps.

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Where are Phase I ESA's Performed?

- Phase I ESA's are performed on any piece of property, which can include:

Major Industrial Properties

Gas Stations

Undeveloped or agricultural land

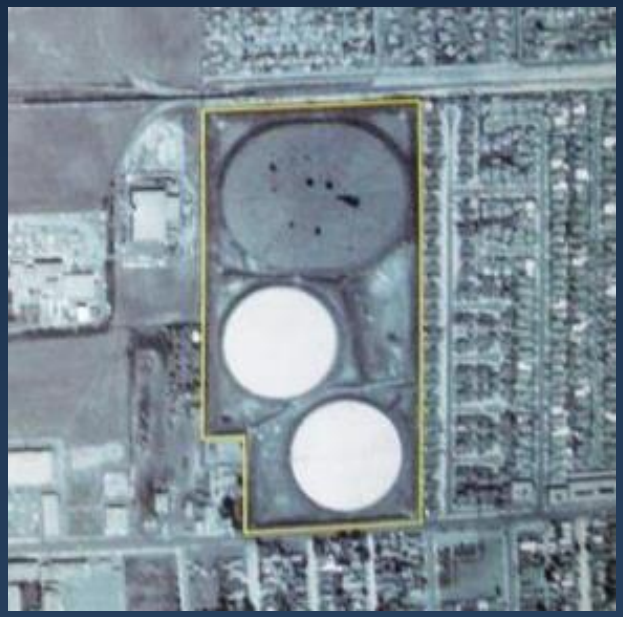
Industrial or Commercial Buildings

Shopping Centers

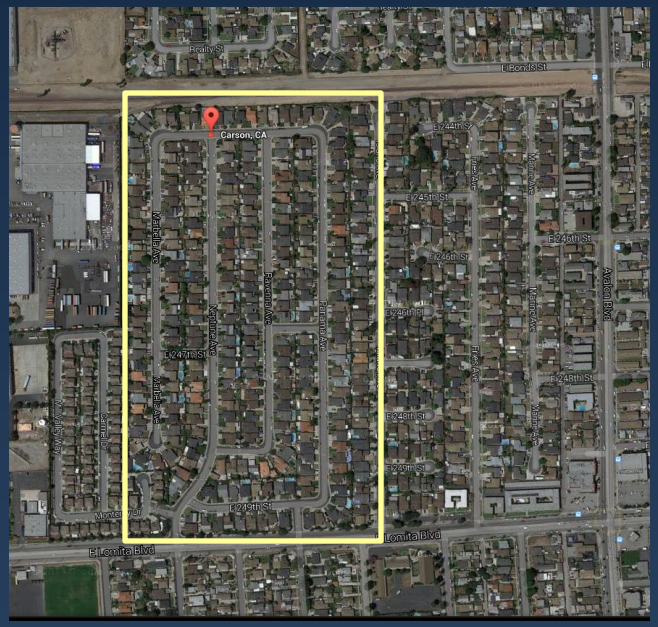
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Phase I Site Assessment

- *Obtain Background Information from Existing Data*



Historic Oil Tank Farm (1965)



Current Residential Homes (2014)

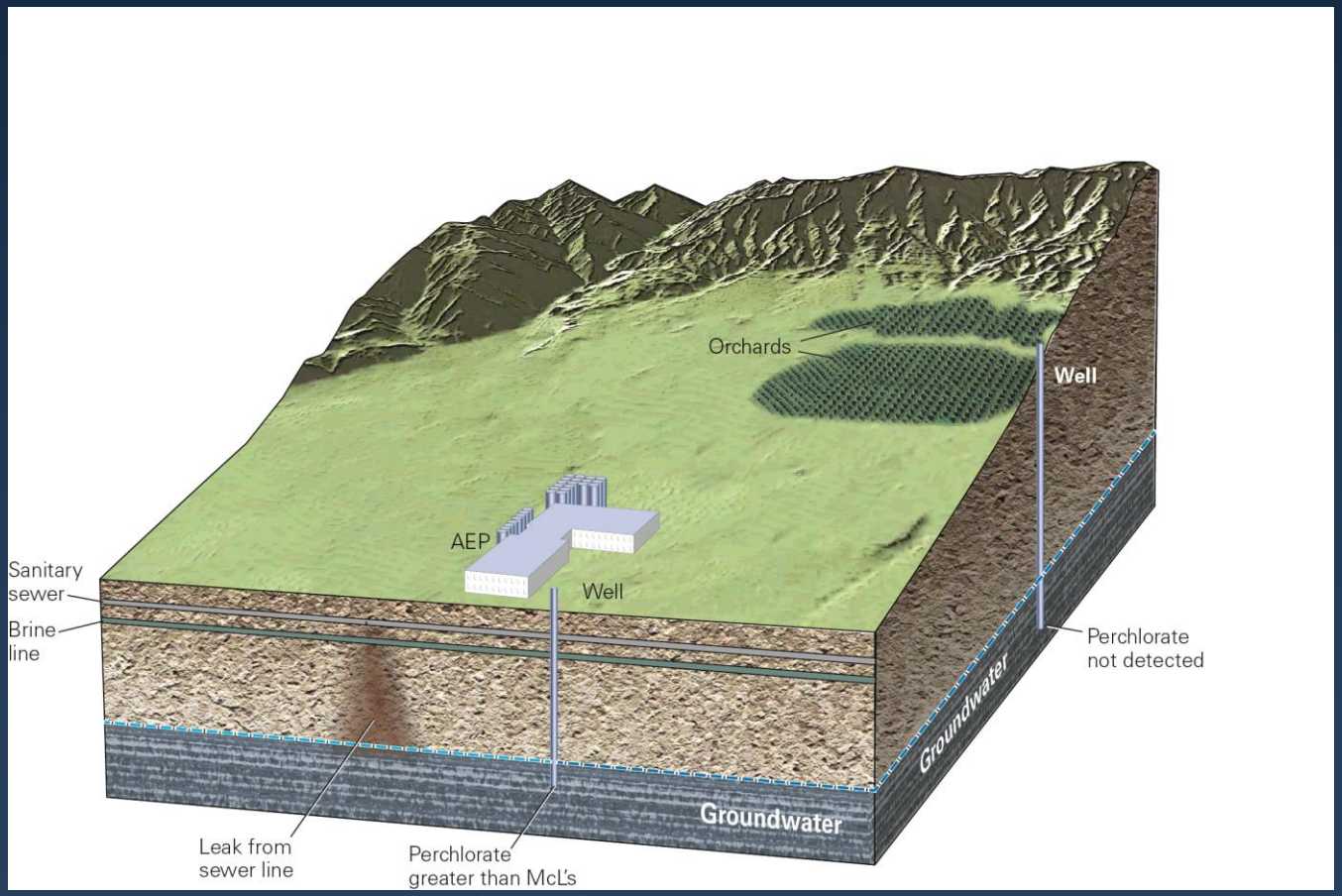
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Phase II Site Investigation

- Sampling to Identify the Type, Quantity, and Extent of the Pollution
  - Soil
  - Groundwater
  - Soil Vapor
- Laboratory Testing

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Sources of Contamination are Not Always Obvious

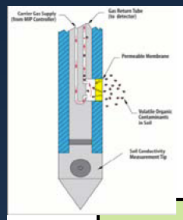


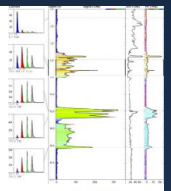
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Tools of Assessment

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

High Resolution Site Characterization (HRSC)



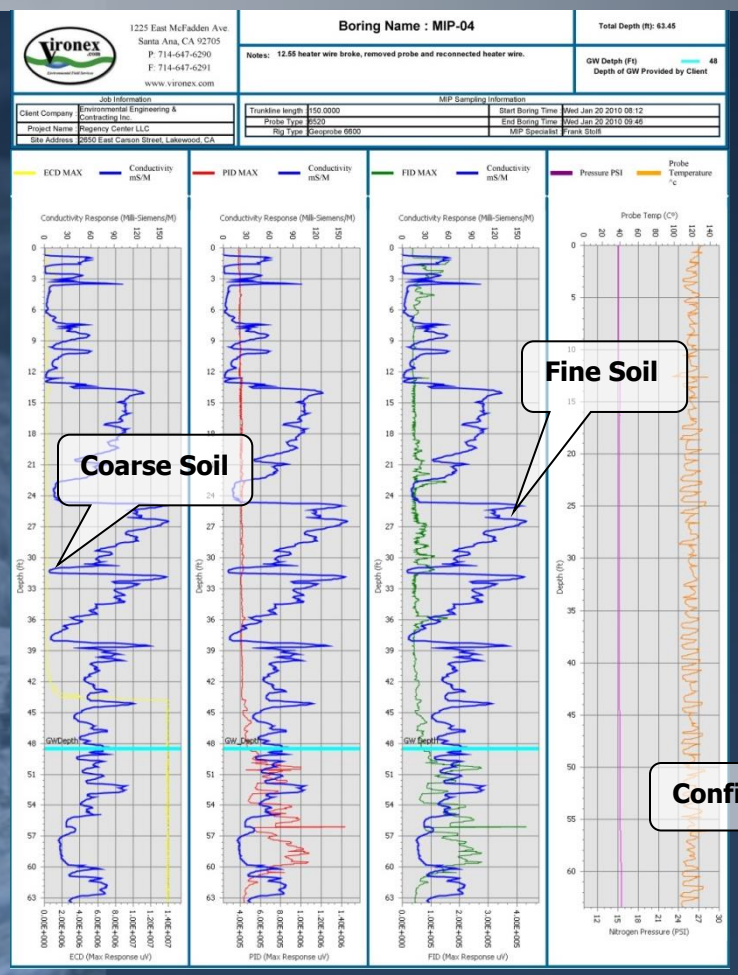


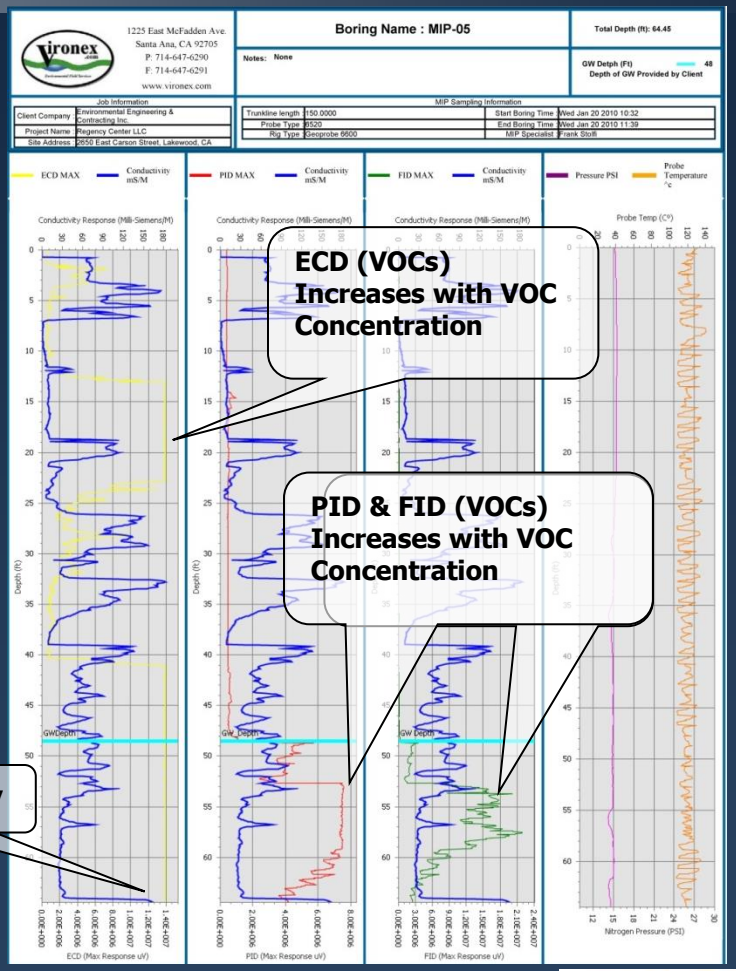
Examples of tools that provide real-time data

Technology	Matrices	Data Provided
LIF/UV methods (Lasers, UV lamp)	Water, soil	TPH, PAH, Coal Tar
Geophysical tools – surface EM, Resistivity, GPR , acoustic	Soil, fill, bedrock	Sources, pathways, macro-stratigraphy, and buried objects
XRF (screening and definitive)	Soils, material surfaces	Metals
MIP (ECD, PID, FID, ECD, XSD)	Soil, water	VOCs, hydrocarbons, and DNAPL
Neutron Gamma Monitors	Soil, water, material surfaces	Radiation
Hydraulic conductivity profilers	Soil, water	Hydraulic conductivity, lithology
Geophysics – downhole (natural gamma ray, self potential, resistivity, induction, porosity/density, and caliper)	Soil, fill, bedrock	Lithology, groundwater flow, structure, permeability, porosity, and water quality
CPT, high-resolution piezocone	Soil, water	Lithology, groundwater flow

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

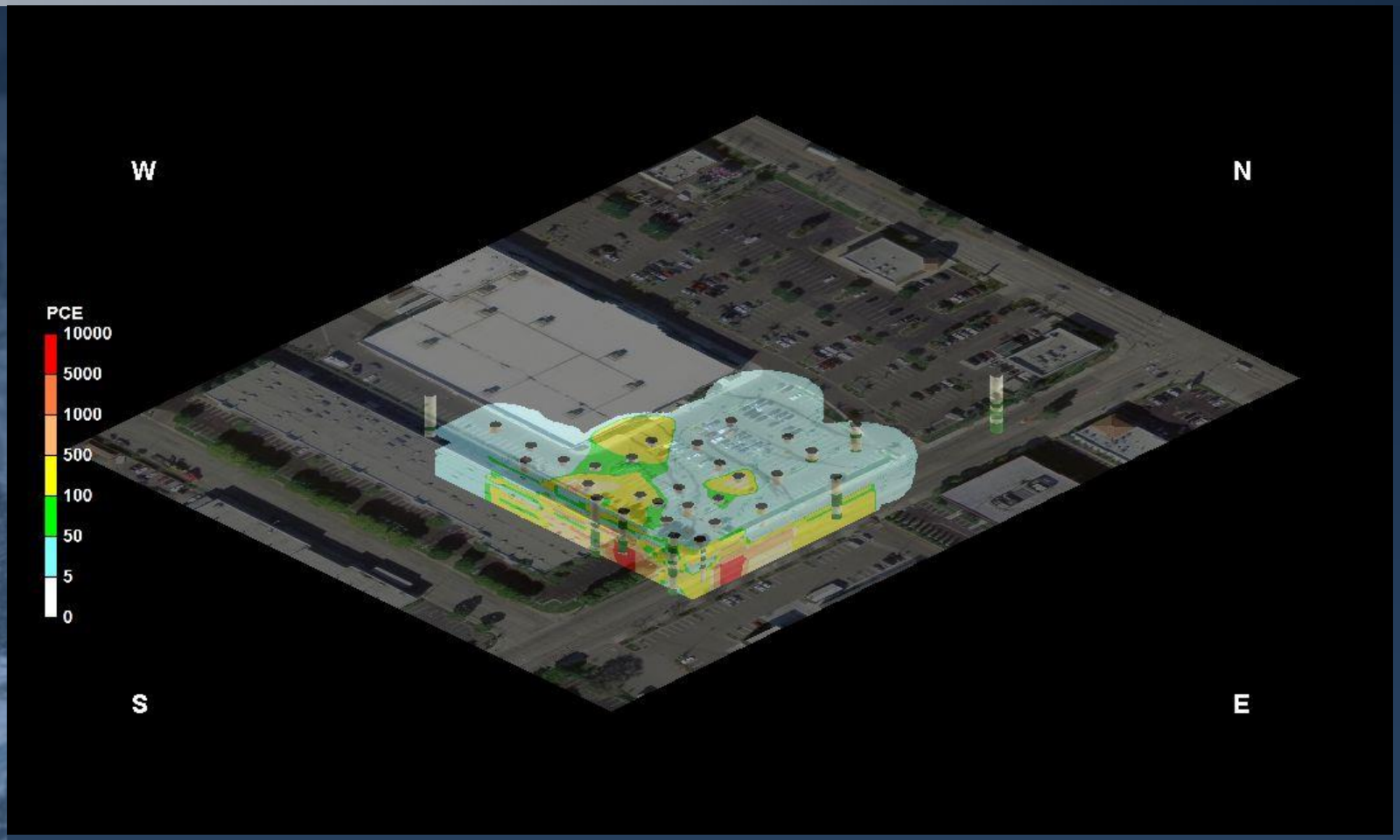
High Resolution Site Characterization (HRSC)





EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

High Resolution Site Characterization (HRSC)



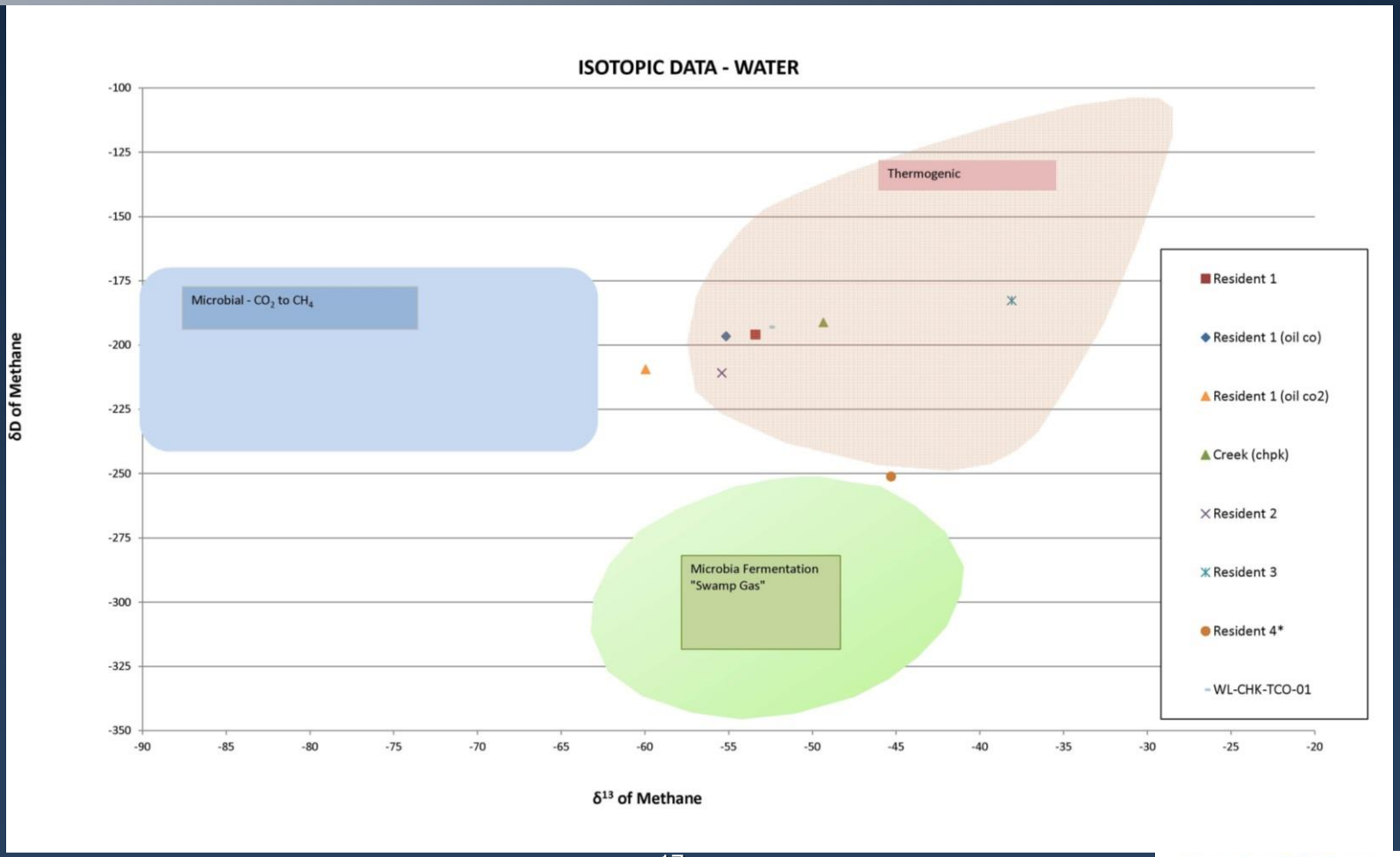
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Types of Testing

- Soil testing. Allows for a test of chemicals within the soil underlying a site.
- Picture is a rig drilling a sample of soil for testing.

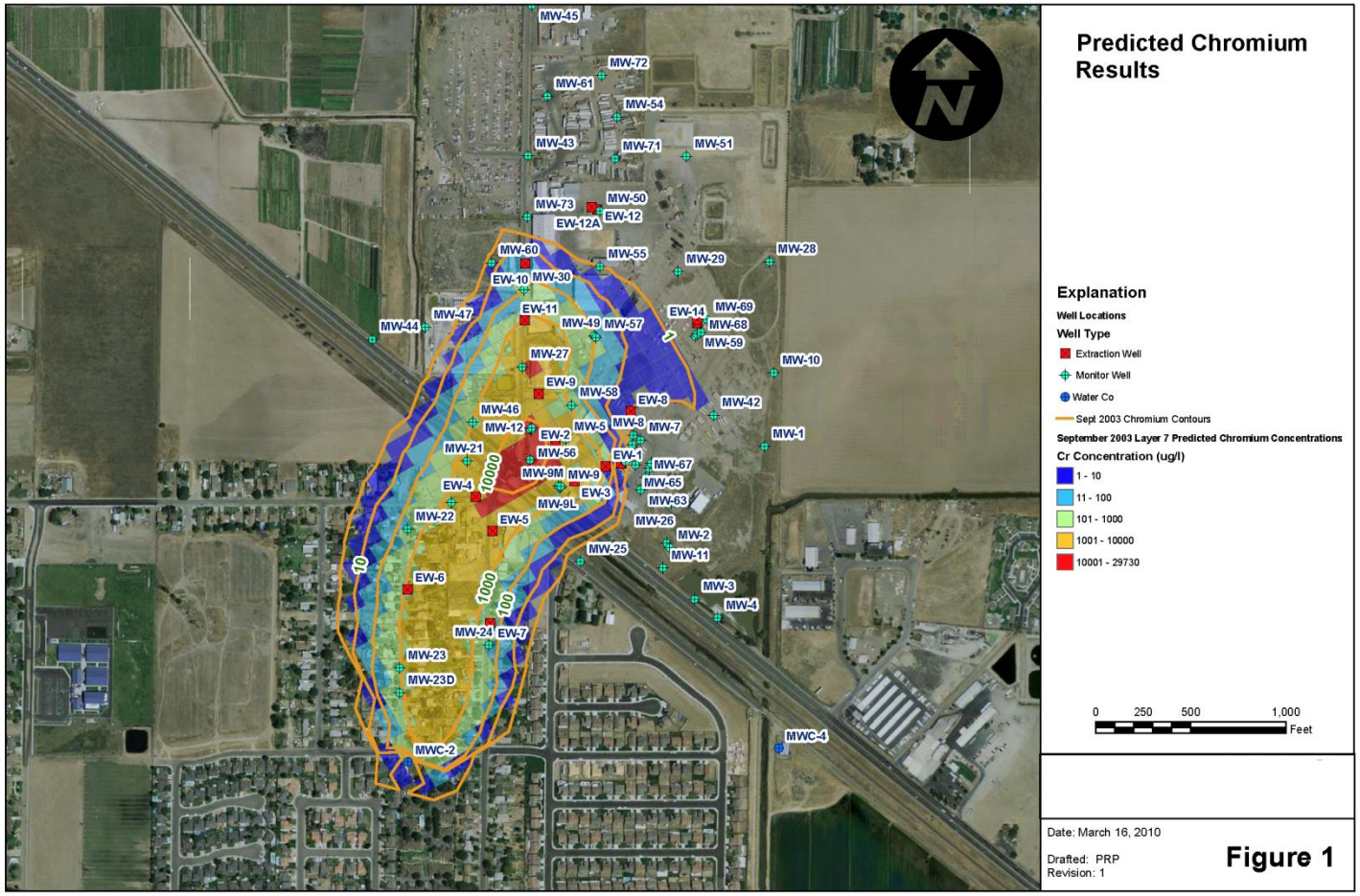
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Forensic Analysis



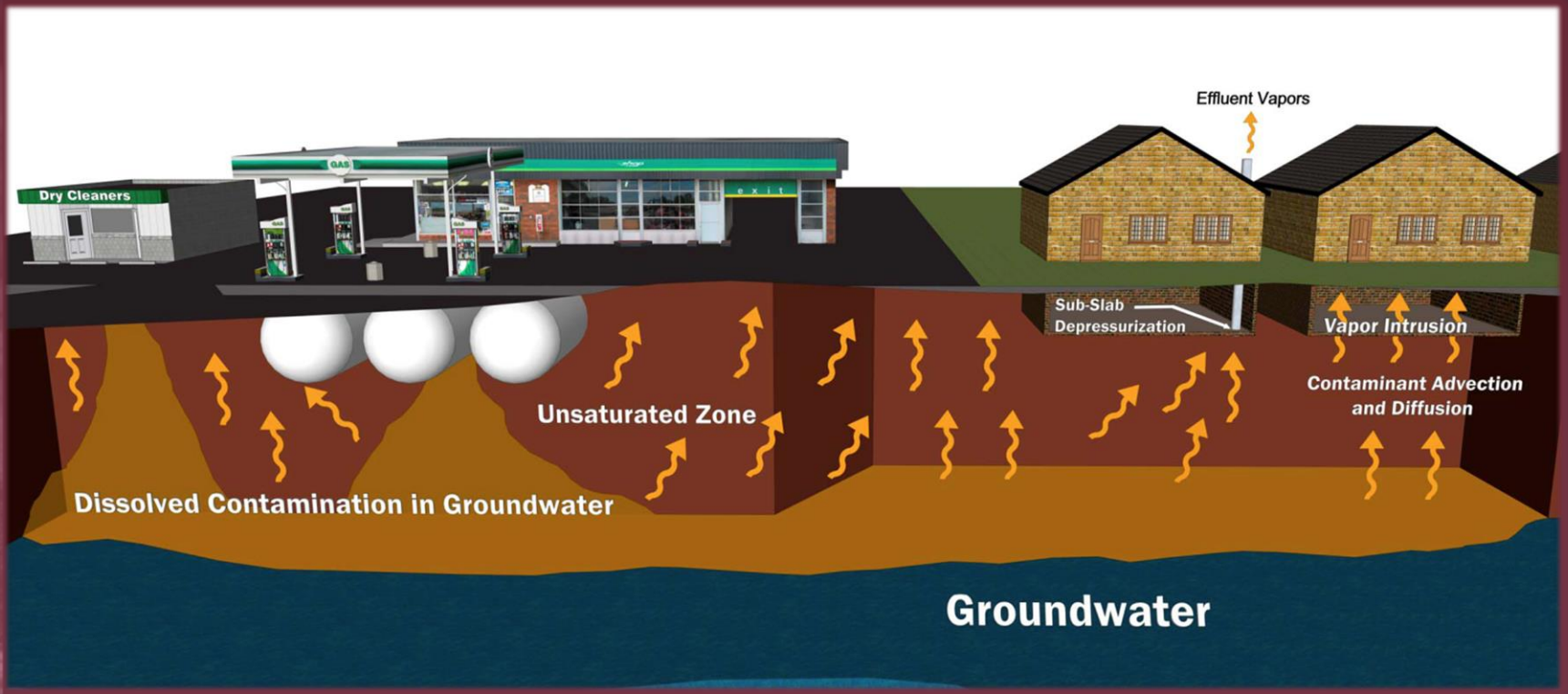
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Groundwater Modeling



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Vadose Zone & Vapor Modeling



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Examples of Pollution in Soil and Groundwater

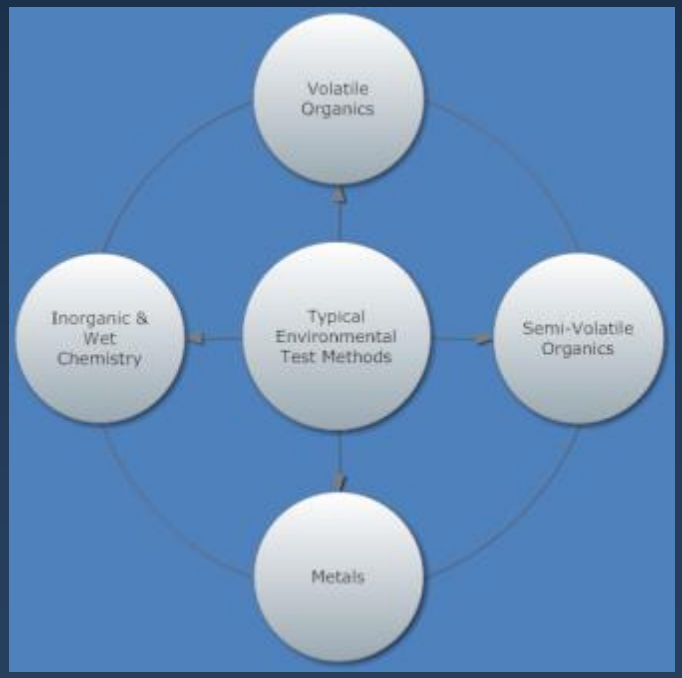
Example of Impregnated Oil in Unsaturated Soil

3.5 Meters of Oil Found on the Groundwater Surface

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

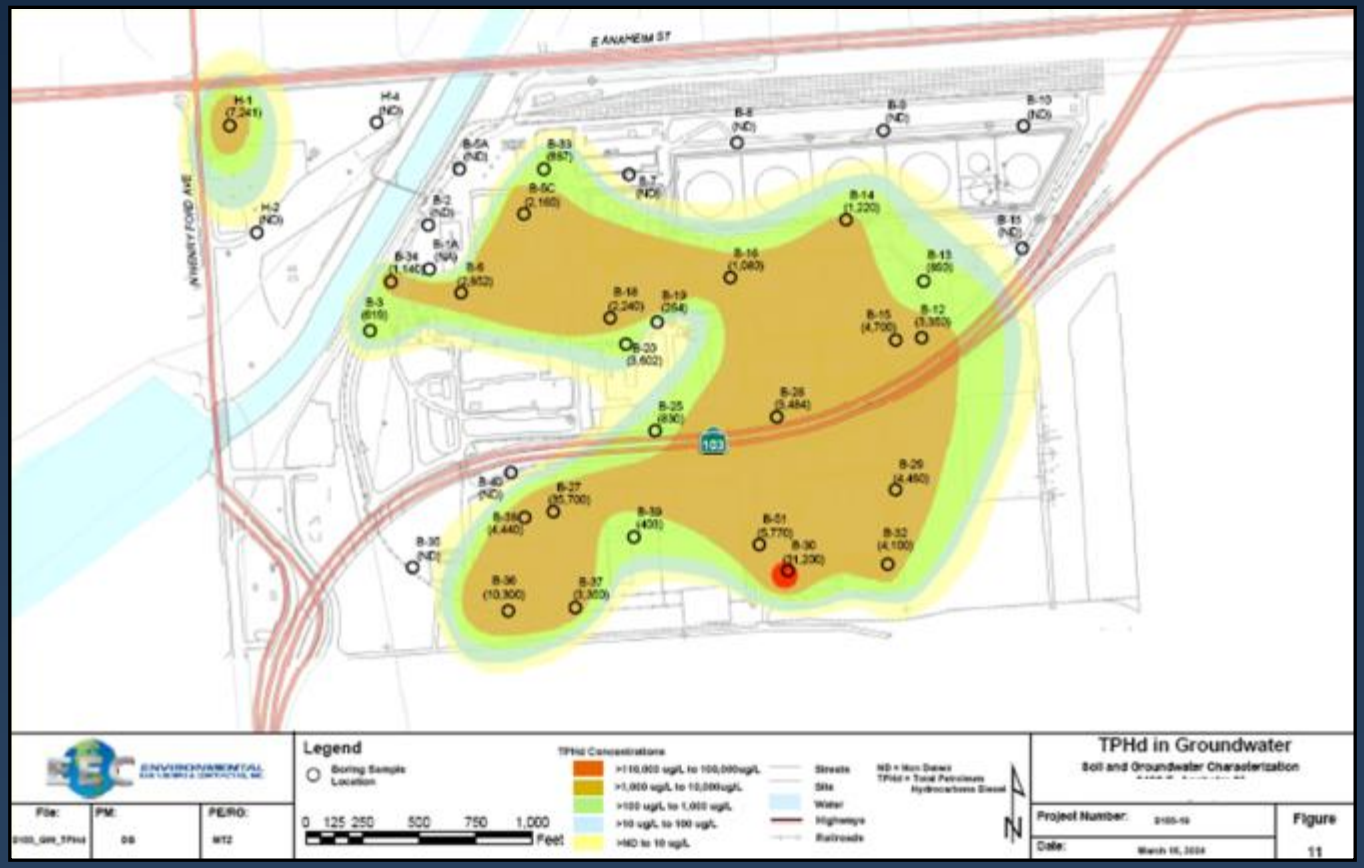
Typical Environmental Laboratory Tests

- Volatile Organics
  - Gasoline
  - Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)
  - Aromatics / Oxygenates
- Semi-Volatiles
  - Diesel
  - Pesticides and PCB's
  - Pesticides and Herbicides
- Metals
  - 20+ standard metals
  - Hexavalent Chromium
  - Organic Lead
  - Mercury



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Pollution Distribution Based on Site Assessment

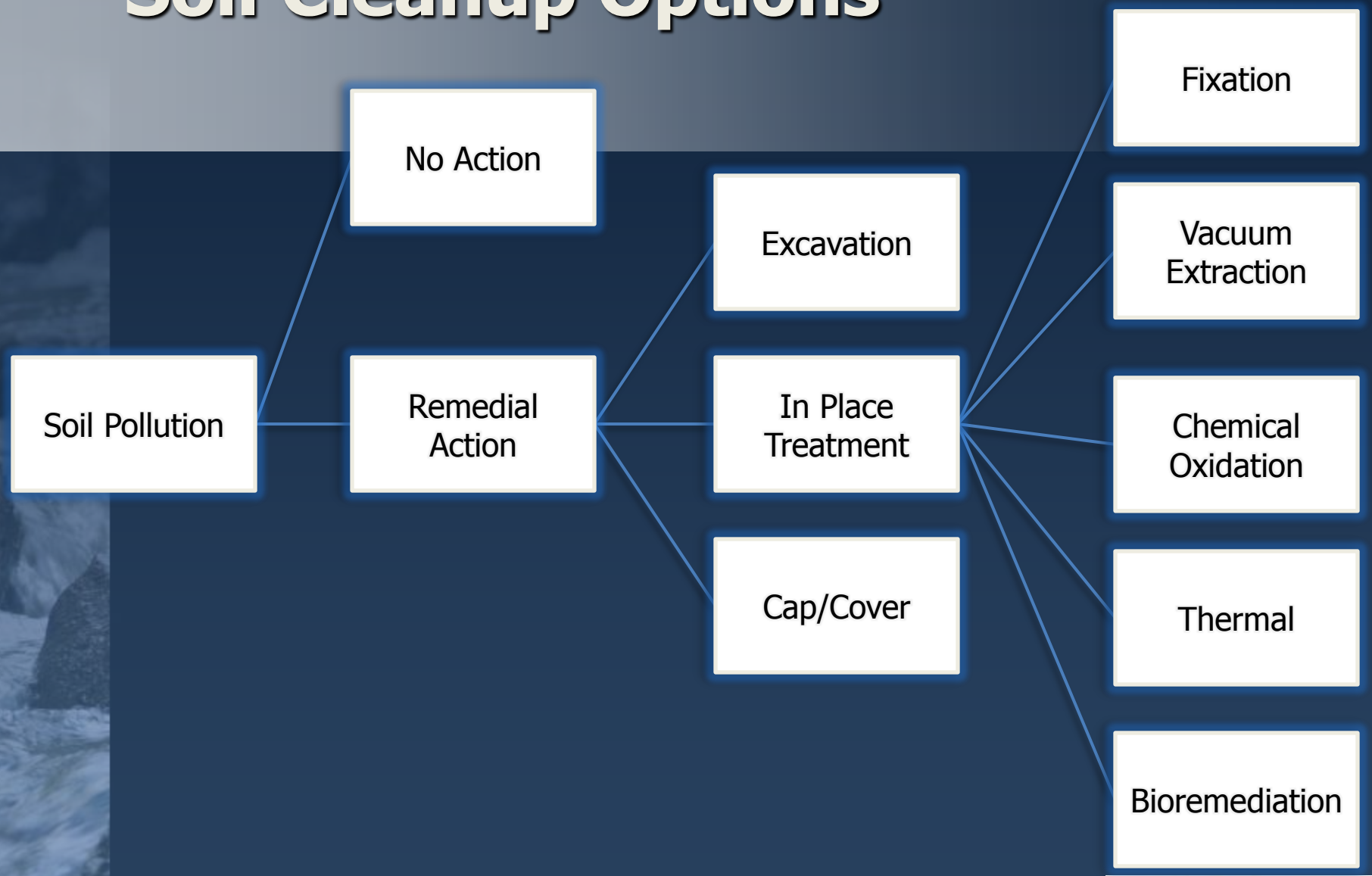


Phase III – Site Cleanup

- Evaluate risks to human health and environment, and propose cleanup actions.
- *Cleanup:* Review and Evaluate Cleanup Alternatives (Cost and Technical Feasibility)

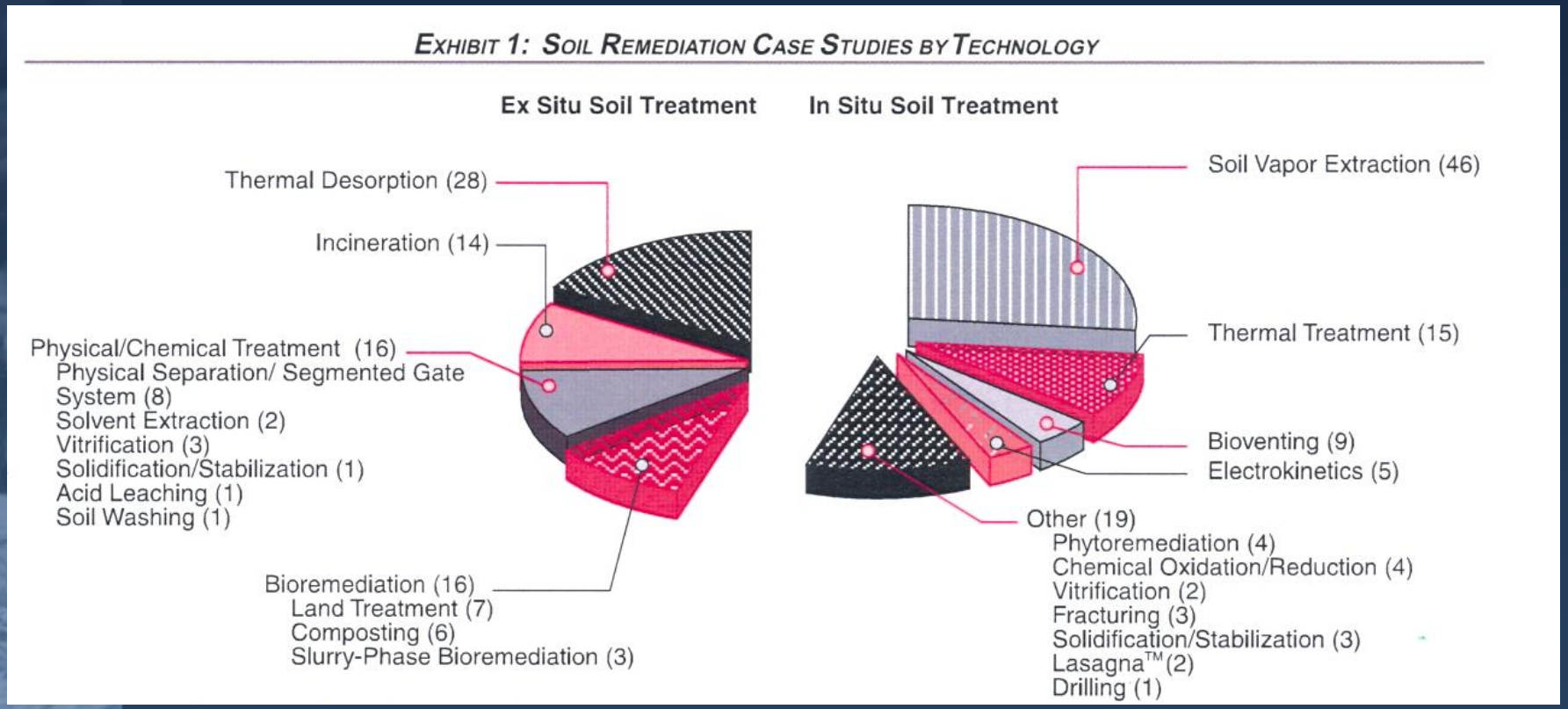
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Soil Cleanup Options



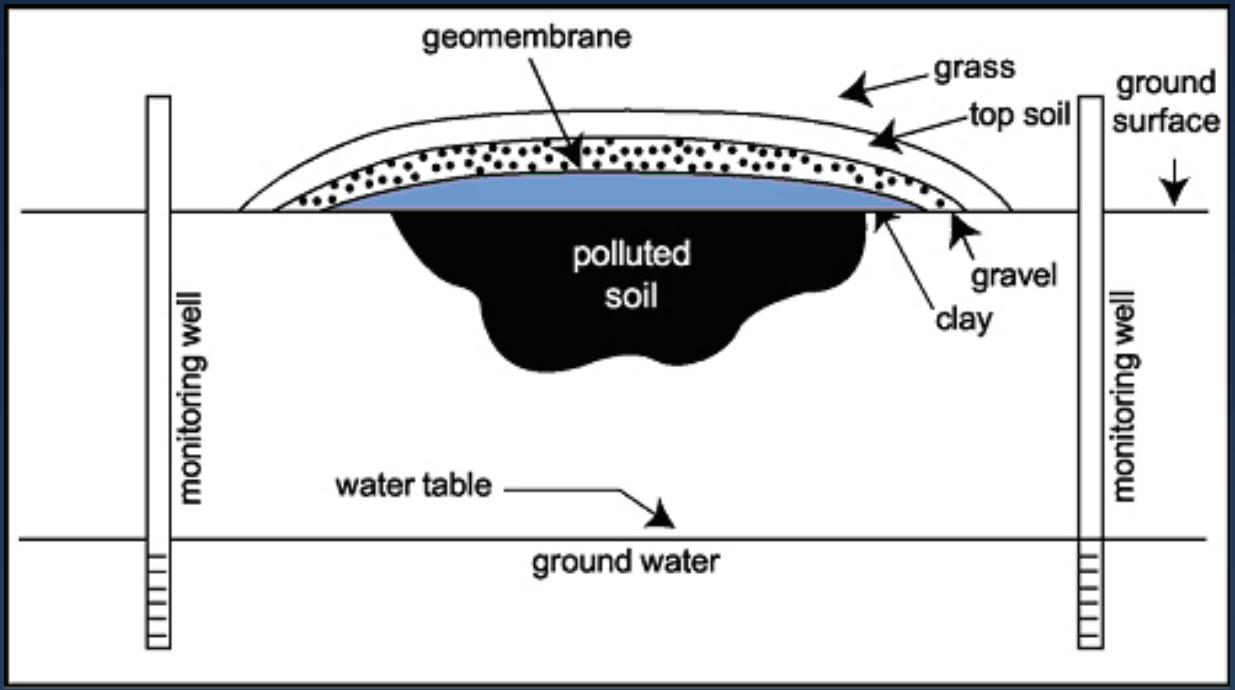
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Different Technologies used for Soil Remediation



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

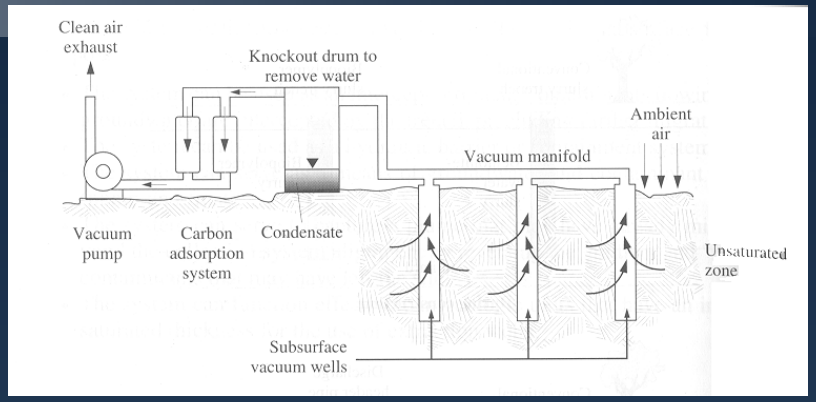
Capping Containment and Drain

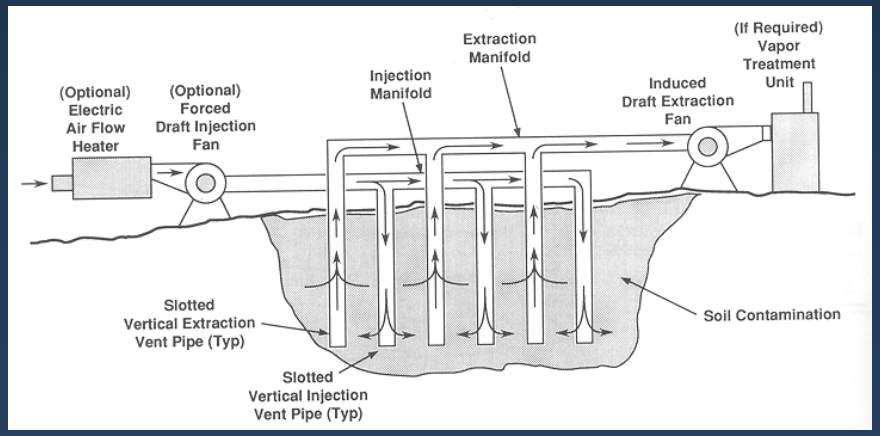


EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Soil Vapor Extraction (SVE)

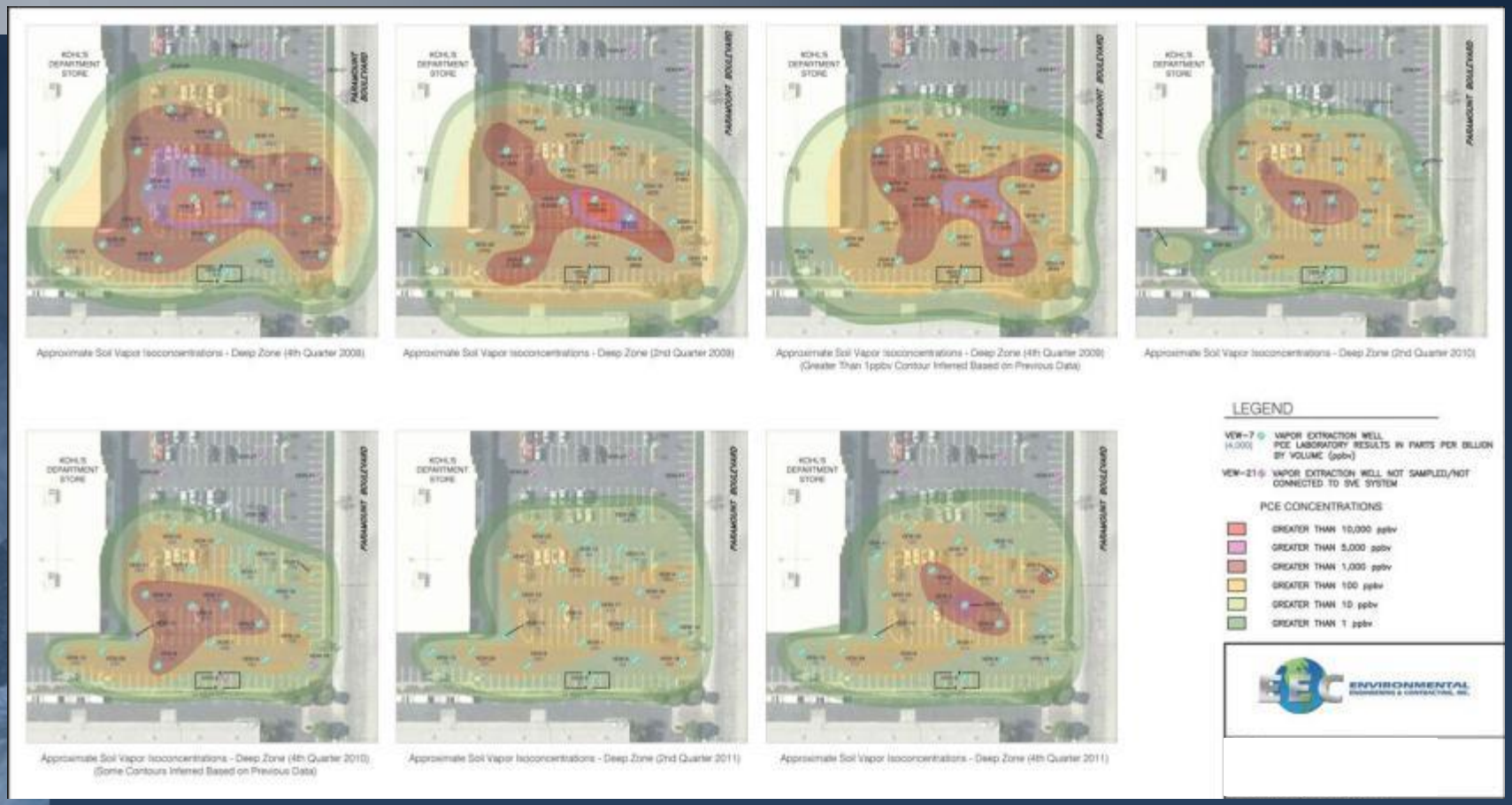
- Volatiles captured or treated at surface
- Optional air sparge, Sweeps volatiles from groundwater





EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

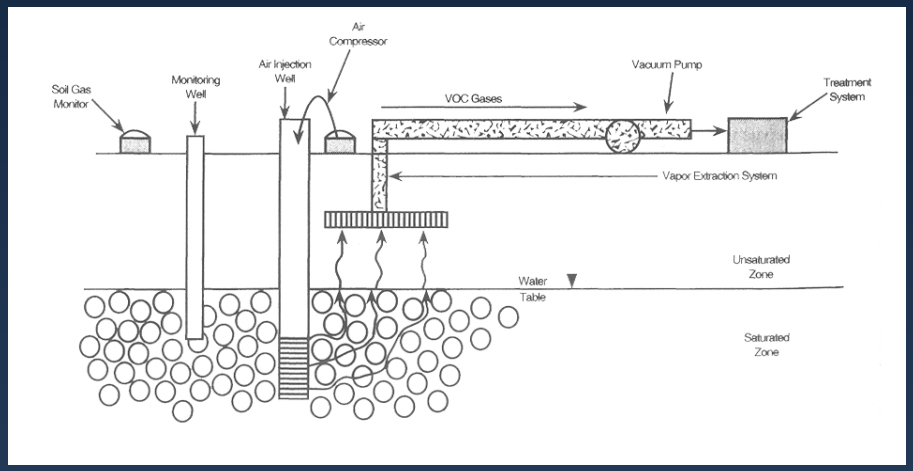
Positive Results from Soil Cleanup

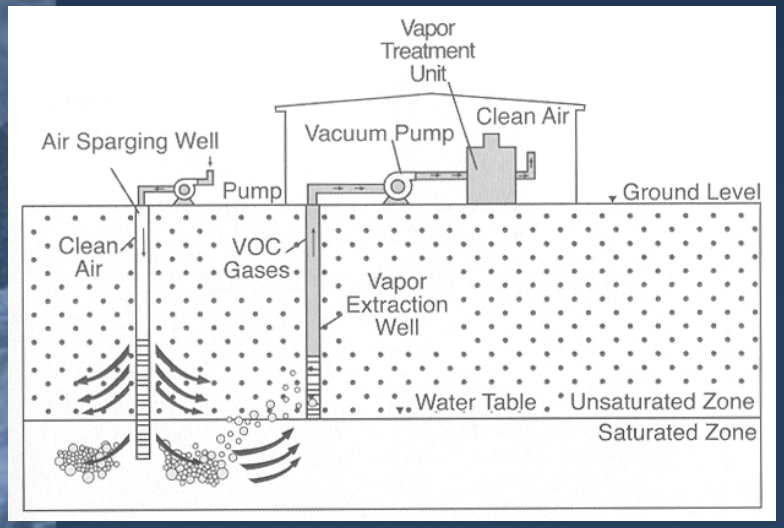


EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Air Sparging Enhanced SVE

- SVE commonly enhanced with air sparging.
- Air sparging involves the active pumping of ambient air into the subsurface soil and groundwater to enhance the collection of volatiles through the SVE system.





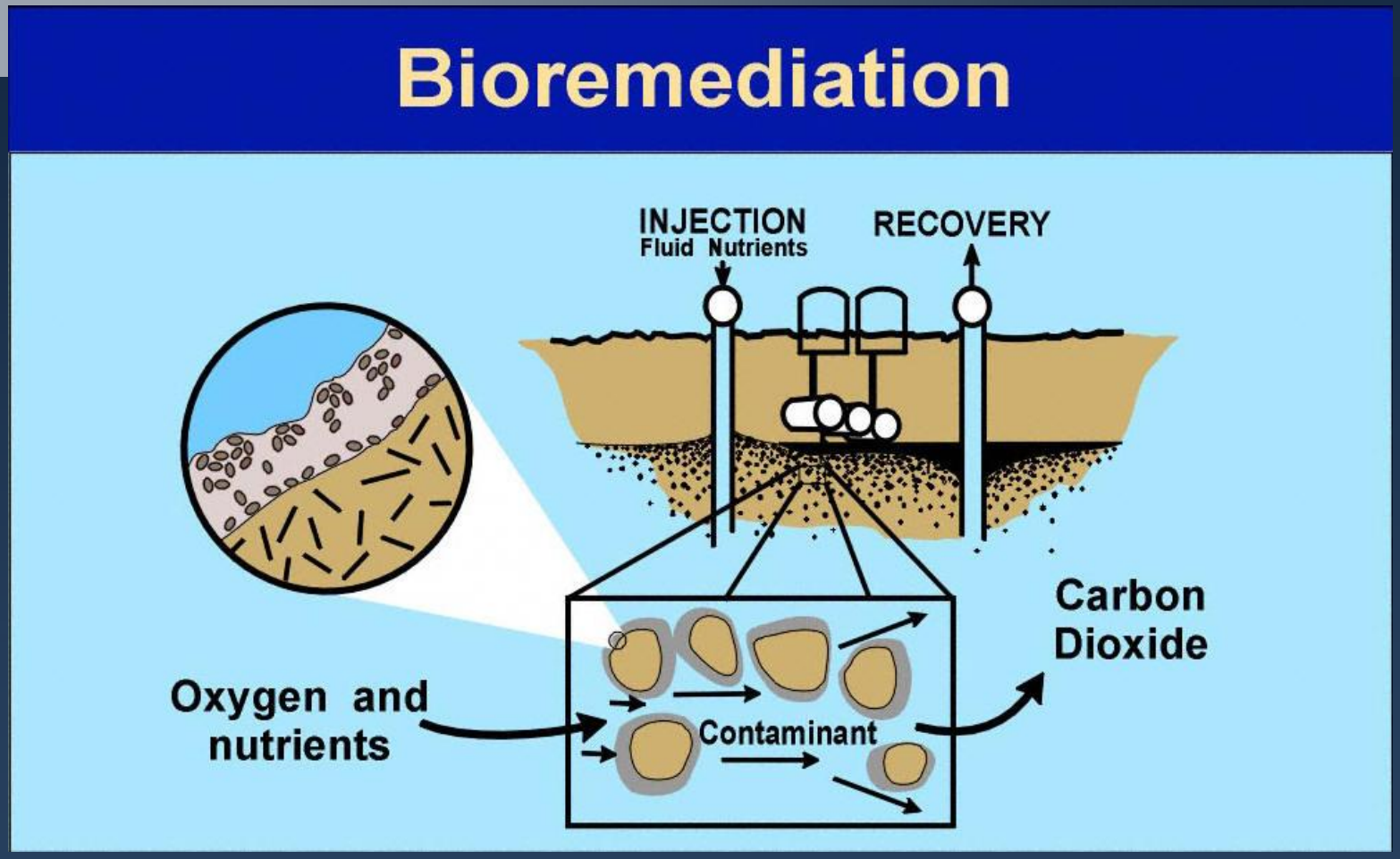
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Bioremediation can Occur In-situ or Ex-situ

- In-situ typically enhances naturally occurring biological activity
  - circulating nutrient and oxygen-enriched water-base solution
  - forced air movement provides oxygen to enhance naturally occurring microbes.
- Bioventing has air flow rate lower than Soil Vapor Extraction (SVE)
  - deliver oxygen
  - minimizing volatilization
- In-situ biological treatment is effective for non-halogenated volatiles and fuel hydrocarbons
- Technology is less effective for non-biodegradable compounds and for soils with low permeability

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

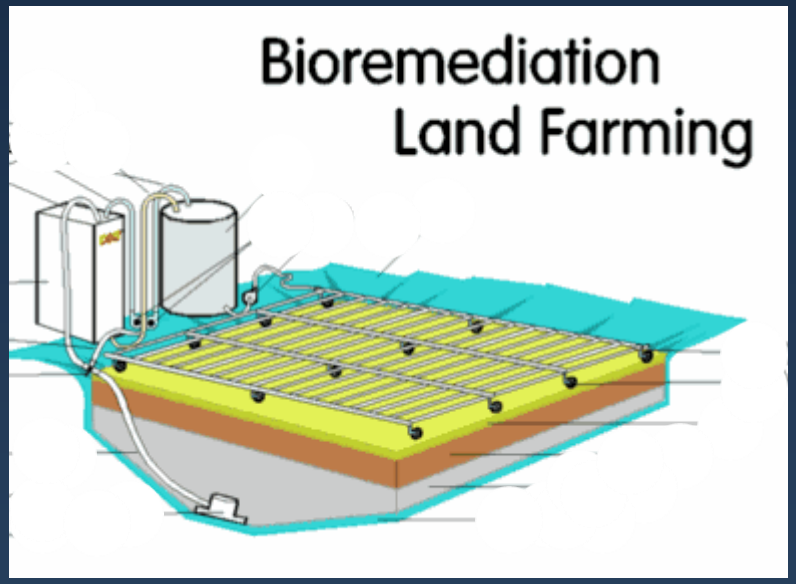
In-situ Bioremediation



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

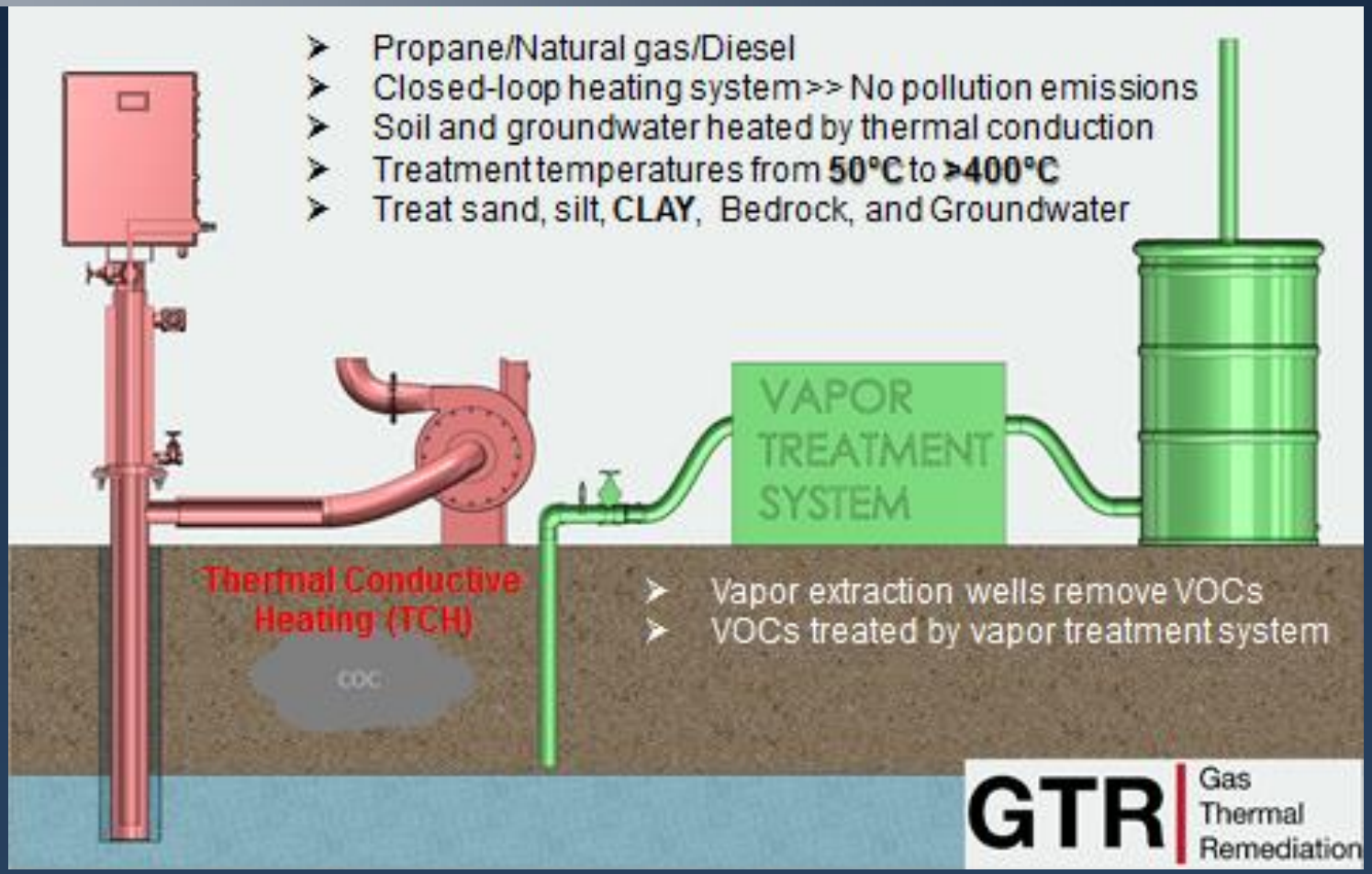
Bioremediation for Petroleum Waste (Ex-situ)

- Ex Situ bioremediation involves excavating the contaminated soil
- Placing it into biotreatment cells
- Adding nutrients to enhance biological activity
- Periodically turning it over to aerate the water.
- The moisture, heat, nutrients, oxygen, and pH are usually controlled in the process.
- Separation of decontaminated solids



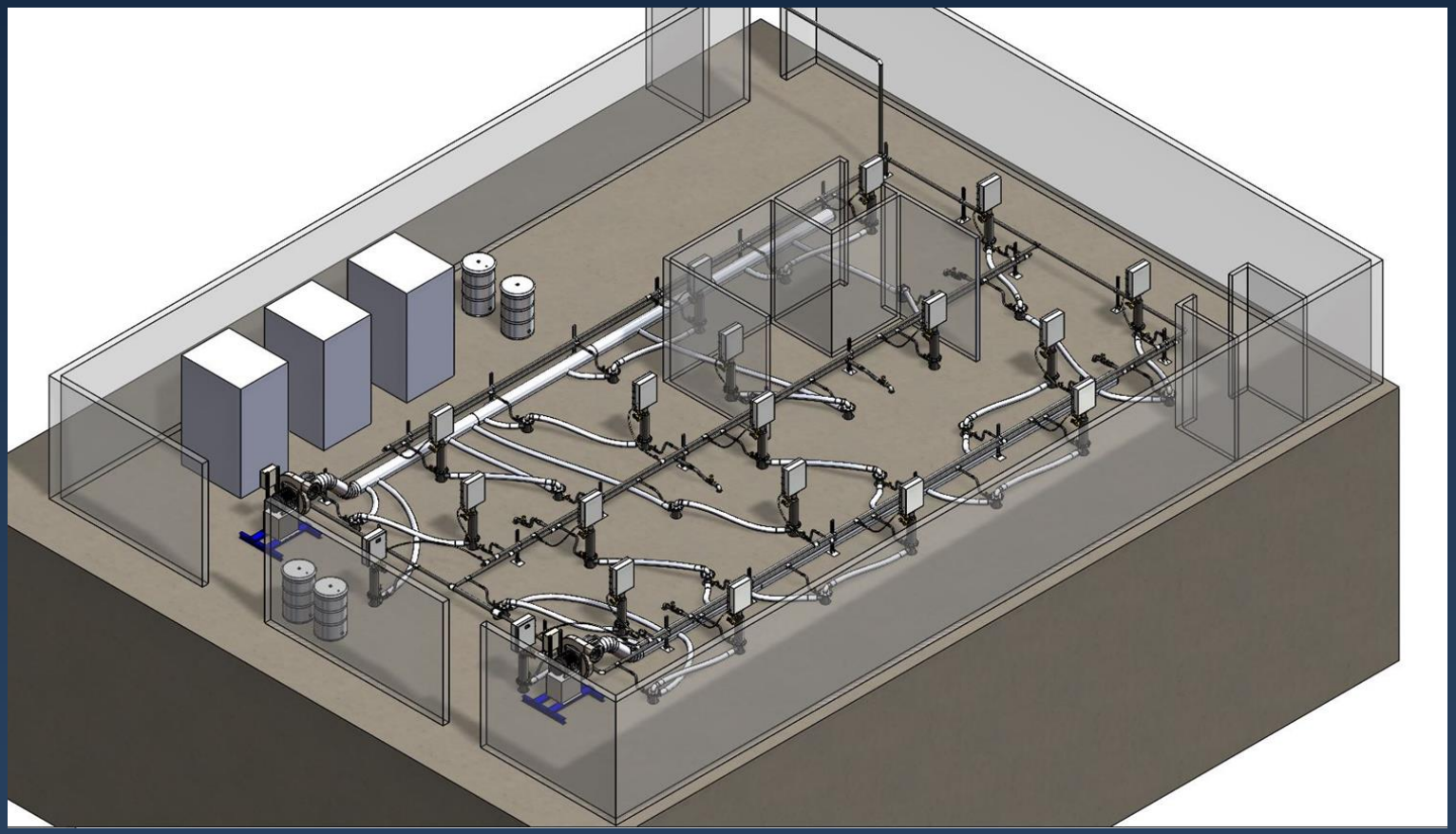
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Gas Thermal Remediation



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Gas Thermal Remediation Layout

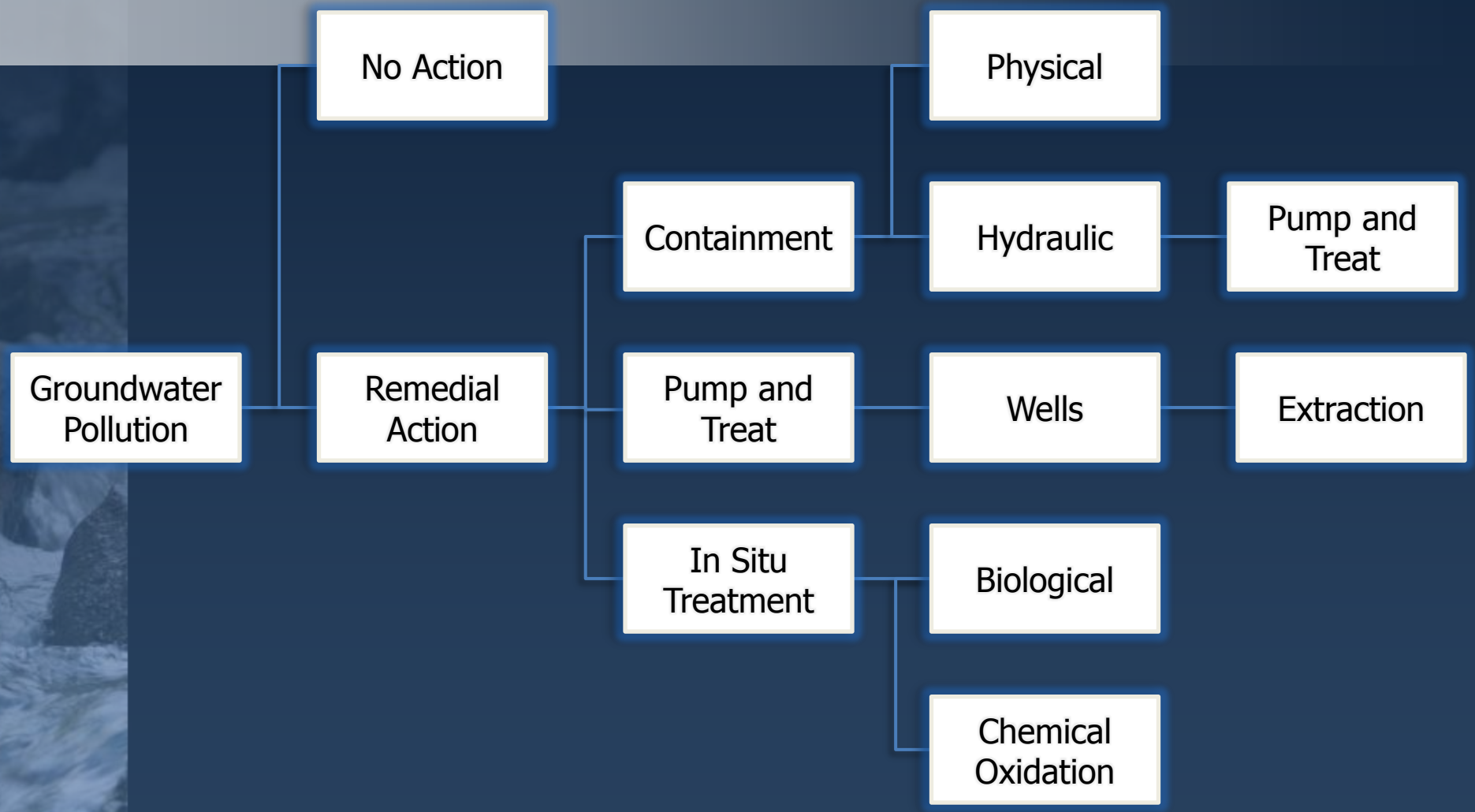


EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Cement Stabilization (Ex-situ)

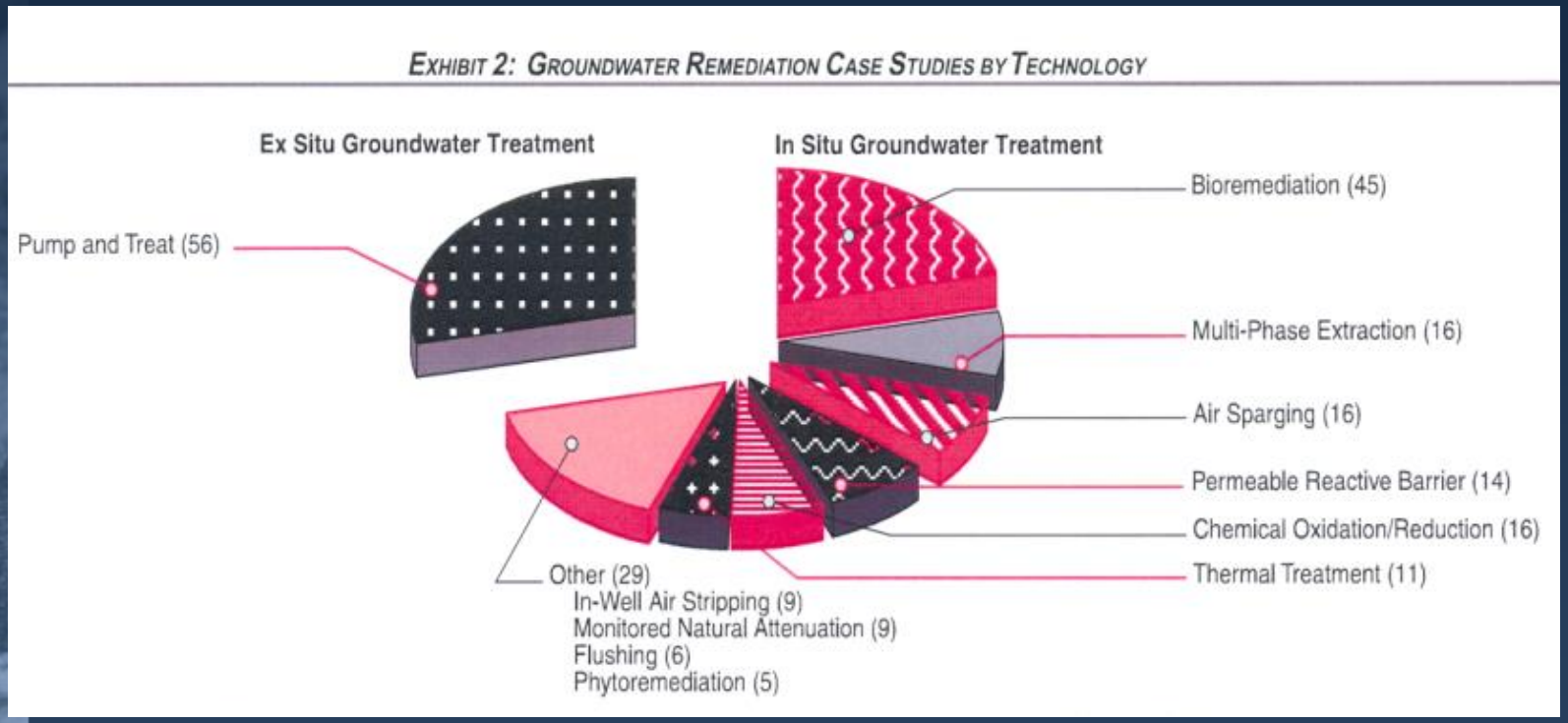
- Description
  - Slurry of wastes and water is mixed with portland cement to form a solid.
- Advantages
  - Low cost
  - Readily available mixing equipment
  - Relatively simple process
  - Suitable for use with metals
- Disadvantages
  - Solids are suspended, not chemically bound
    - subject to leaching
  - Doubles waste volume
  - Requires secondary containment
  - Incompatible with many wastes
    - Organics, some sodium salts, silts, clays, and coal or lignite.

Groundwater Cleanup Options



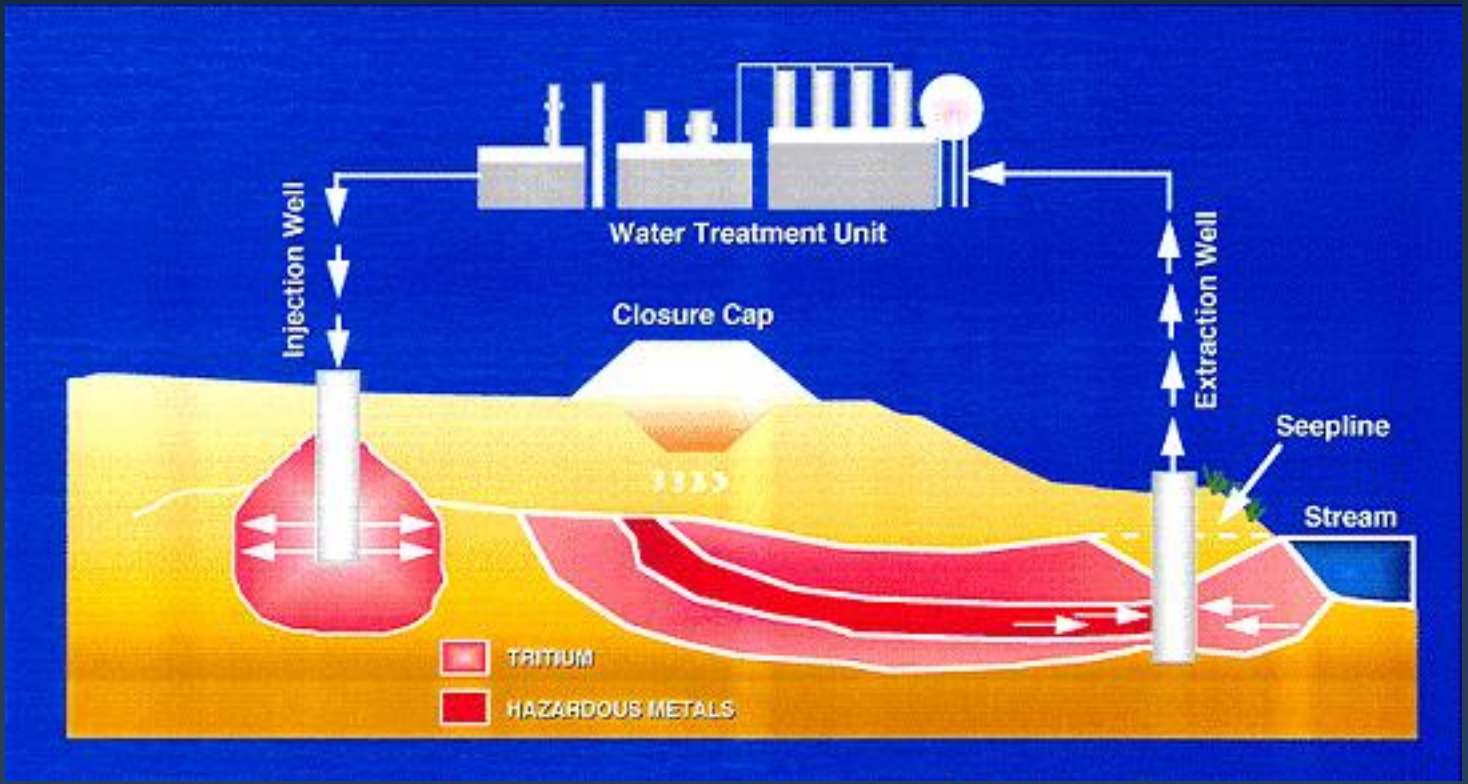
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Different Technologies used for Groundwater Remediation



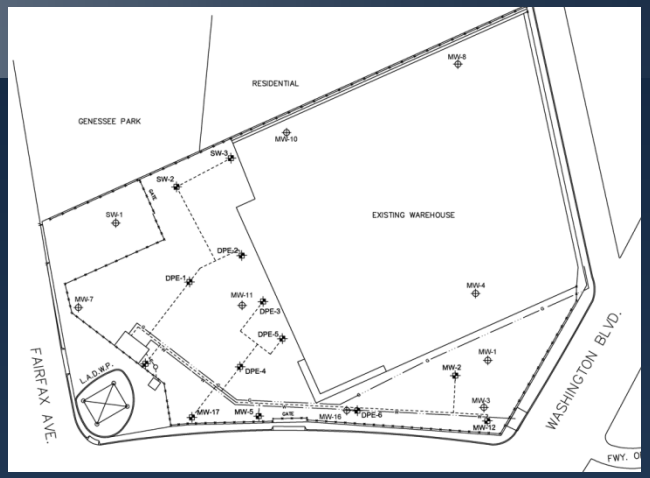
EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 567-2300
Fax: (714) 567-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Pump and Treat Technology



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Pump and Treat Technology

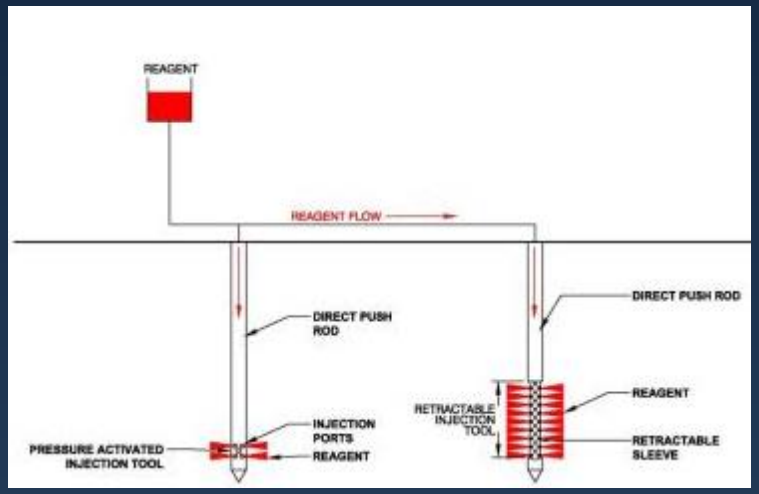


EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Injection of Oxidants or Biological Compounds

Custom Designed Injection Rigs

Injection Rig Mixing Systems



2.125" Bottom-Up Injection Tool With 1 Foot Screen

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

In-Situ Injections

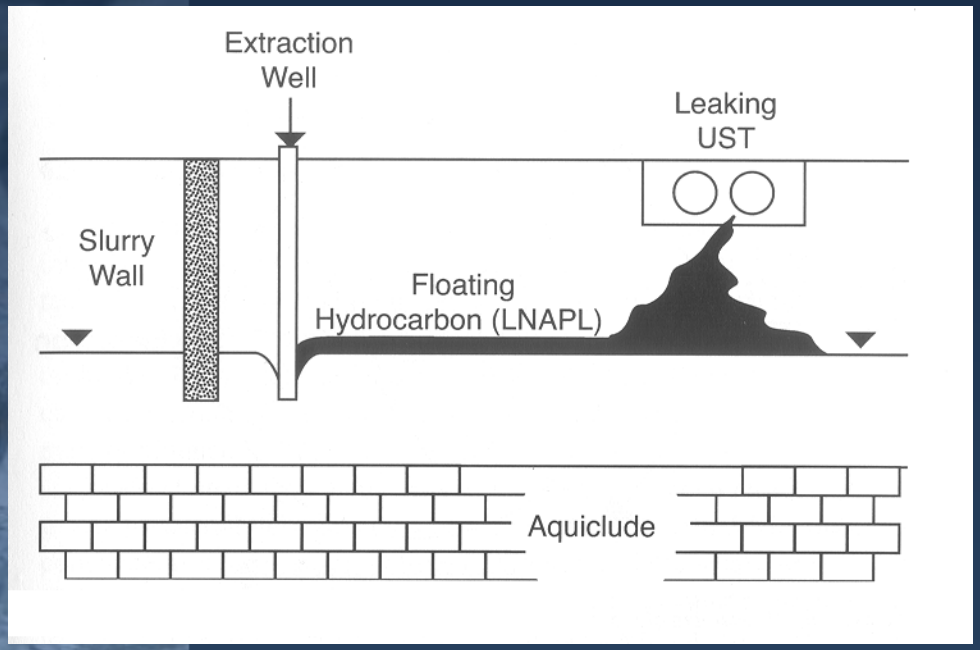
ISCO injection at IP4

Preparing persulfate in mixing tank

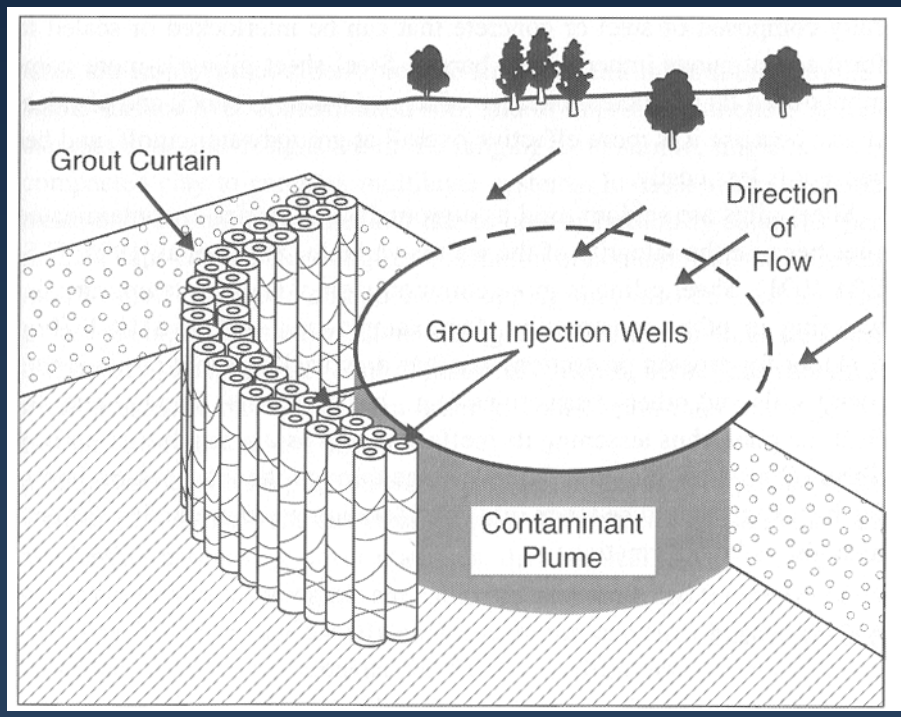
Injection tool

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

Slurry Walls and Grout Curtains are Containment Technologies



Slurry Wall

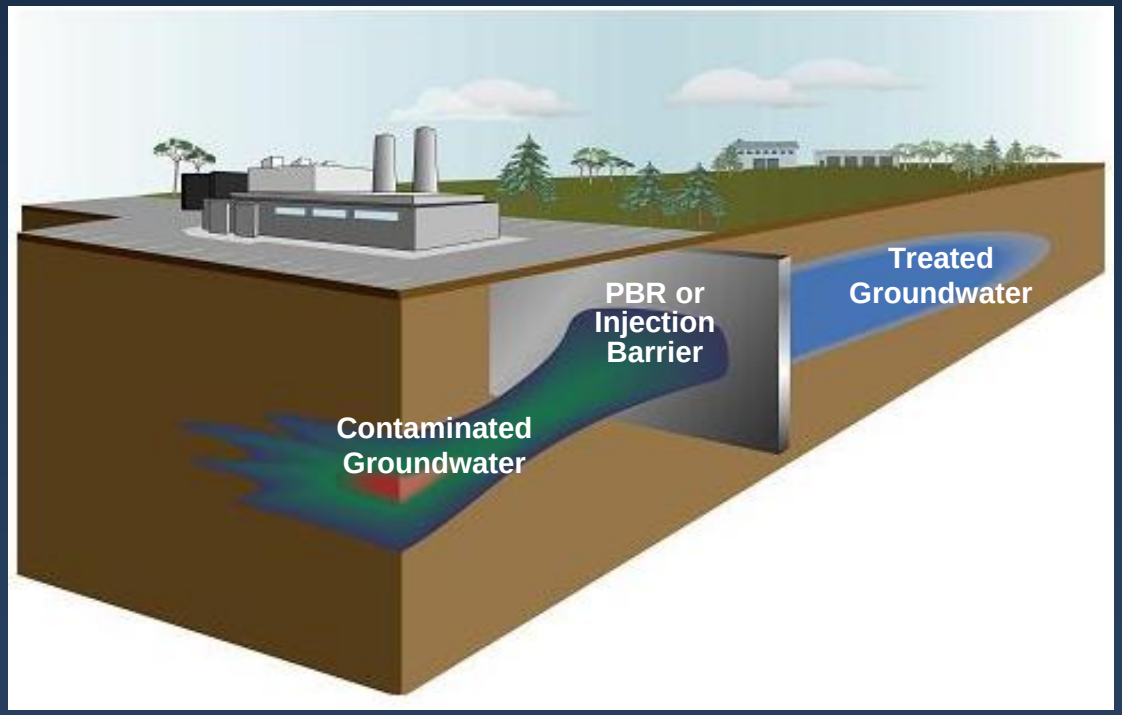


Basic Grout Curtain Containment System

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

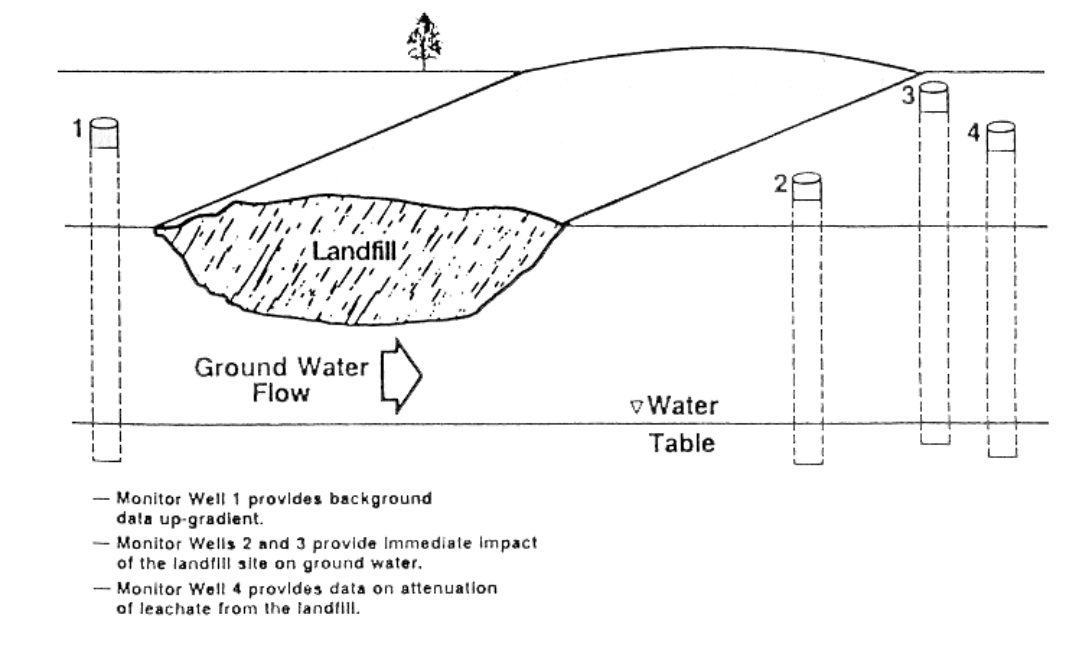
Examples of Remedial Technique – Reactive Barrier

- Permeable Reactive Barrier or Injection Barrier



EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

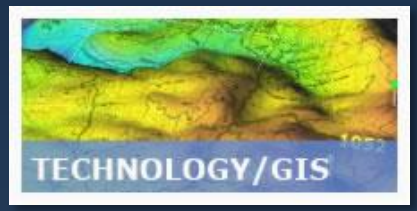
Groundwater Monitoring is Necessary to Protect Drinking Water



- **All containment remedies are accompanied by an extensive groundwater monitoring program.**

EEC ENVIRONMENTAL
Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com

EEC ENVIRONMENTAL



Corporate Headquarters
One City Boulevard West
Orange, California
Phone: (714) 667-2300
www.eecworld.com
mzeko@eecenvironmental.com

Mid-Atlantic Office
Annapolis, Maryland

Northwest Office
San Francisco, California

EEC ENVIRONMENTAL

Corporate Office
Tel: (714) 667-2300
Fax: (714) 667-2310
One City Boulevard West, Suite 1800
Orange, California 92868
www.eecenvironmental.com