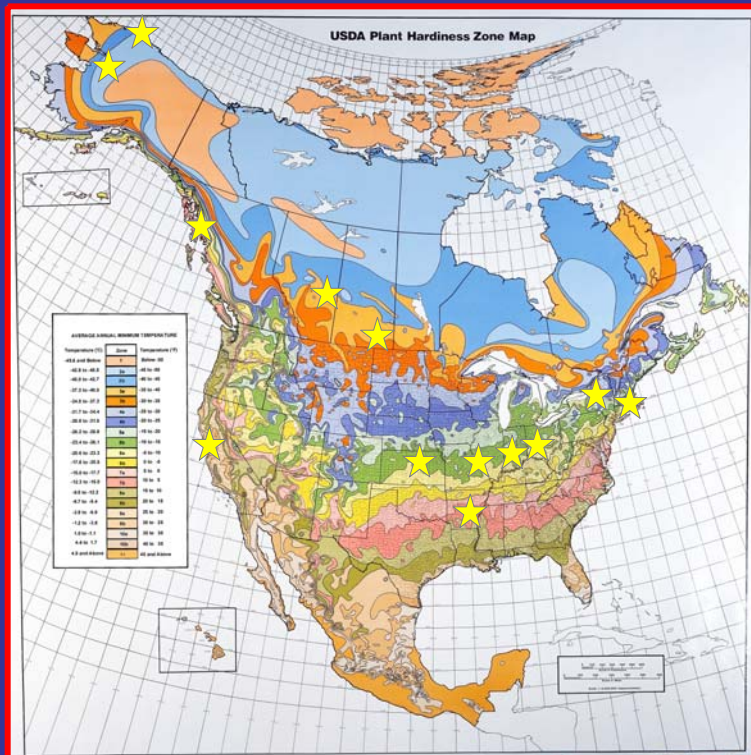


LESSONS LEARNED FROM THE RTDF/PERF PHYTOREMEDIATION FIELD TRIALS

The TPH Subgroup



Peter Kulakow
Kansas State University

RTDF/Cooperators

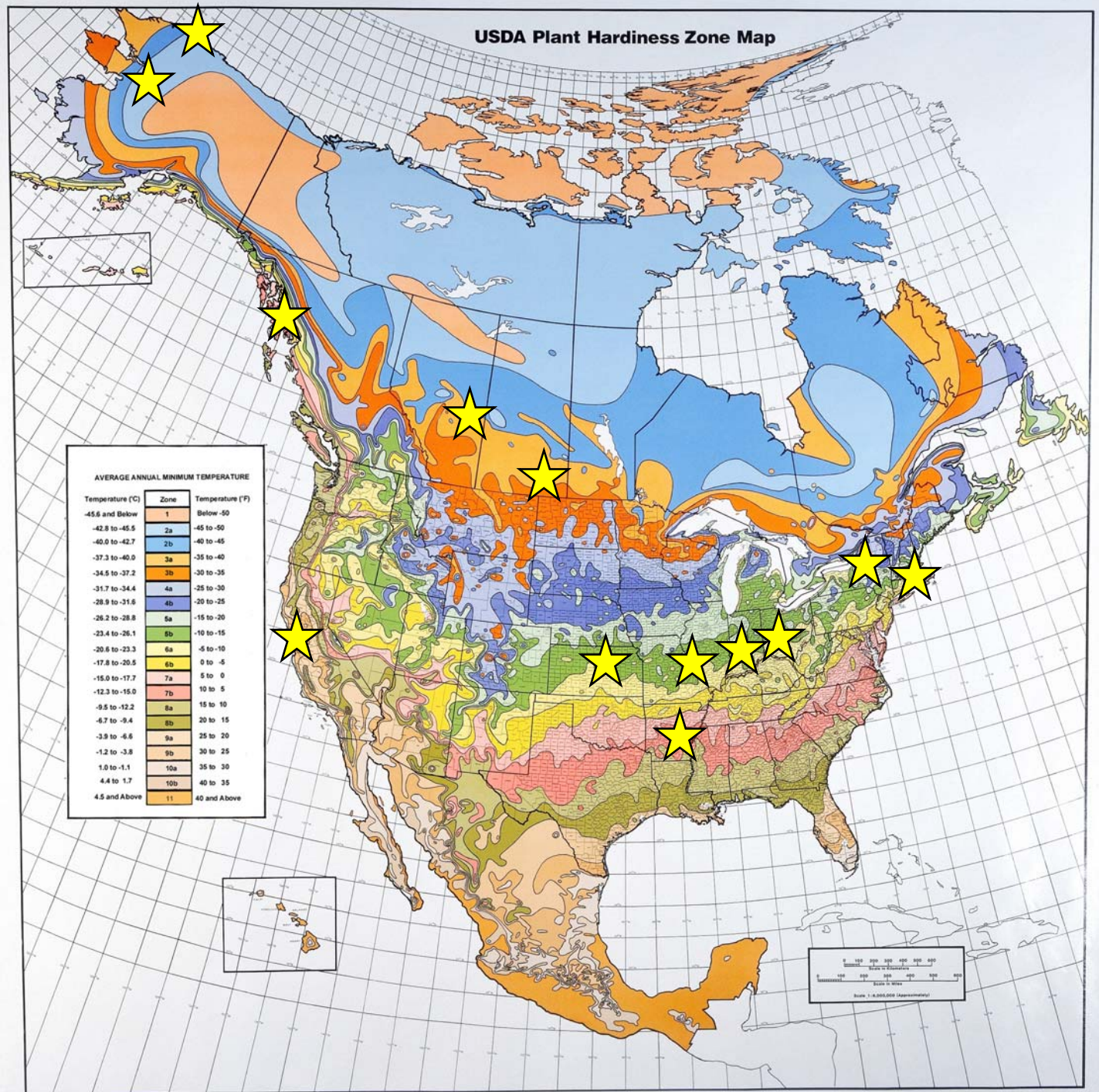
- USEPA
- PERF—Petroleum Environmental Research Forum
- Environment Canada
- Midwest HSRC
- Great Plains/Rocky Mountain HSRC
- ChevronTexaco
- University of Cincinnati
- U.S. Army-CRREL
- Syracuse University
- Niagara Mohawk Power Corporation
- Gas Research Institute
- The Retec Group
- U.S. Army, Fort Riley, Kansas
- Kansas State University
- South Dakota State University
- Atlantic Richfield Company, BP Corporation
- University of Arkansas
- Purdue University
- University of Saskatchewan
- ICF Consulting
- Naval Facilities Engineering Service Center
- Lockheed/Martin
- Lawrence Berkeley Laboratory



Goal

- Is vegetation useful for enhancing degradation of petroleum hydrocarbons in surface soil?
- Do we observe statistically significant reductions in petroleum hydrocarbon concentrations during a three year period comparing treatments with vegetation plus fertilizer with a control of no vegetation and no fertilizer?

Thirteen RTDF Field Site Locations





Types of RTDF Field Sites

- 3 Closed Refineries
- 2 Former Manufactured Gas Plants
- 3 Production Sites
- 5 Refined Product Sites

- 5 Sites in Cold Regions



Standardized Protocol

- Common experimental design and statistical analysis
 - Treatments with site specific adjustments
 - Standard grass/legume mixture
 - Local-optimized treatment
 - Unvegetated/unfertilized Control
- Sampling Plan for soil and vegetation
- Many TPH and PAH parameters analyzed, usually by the same laboratory

RTDF Lesson's Learned

1. Plants grew well on most of the petroleum impacted soils.

Site F – Manufactured Gas Plant



Willow/Poplar Mix



Natural Revegetation

Standard Mix

Site H – Closed Distribution Facility

Rhode Island

October 2002



Site I – Closed Refinery *Illinois*

October 2001



May 2002



Site K – Manufactured Gas Plant, *Indiana*



RTDF Lesson's Learned

2. It is crucial to characterize the source of the petroleum and the degree of weathering that has occurred prior to initiating phytoremediation.
 - Field sites with less prior biodegradation and aging of petroleum hydrocarbons showed the best results.

April 1999



**Site A – Refinery Site
PERF
Three Complete
Growing Seasons**

June 2000



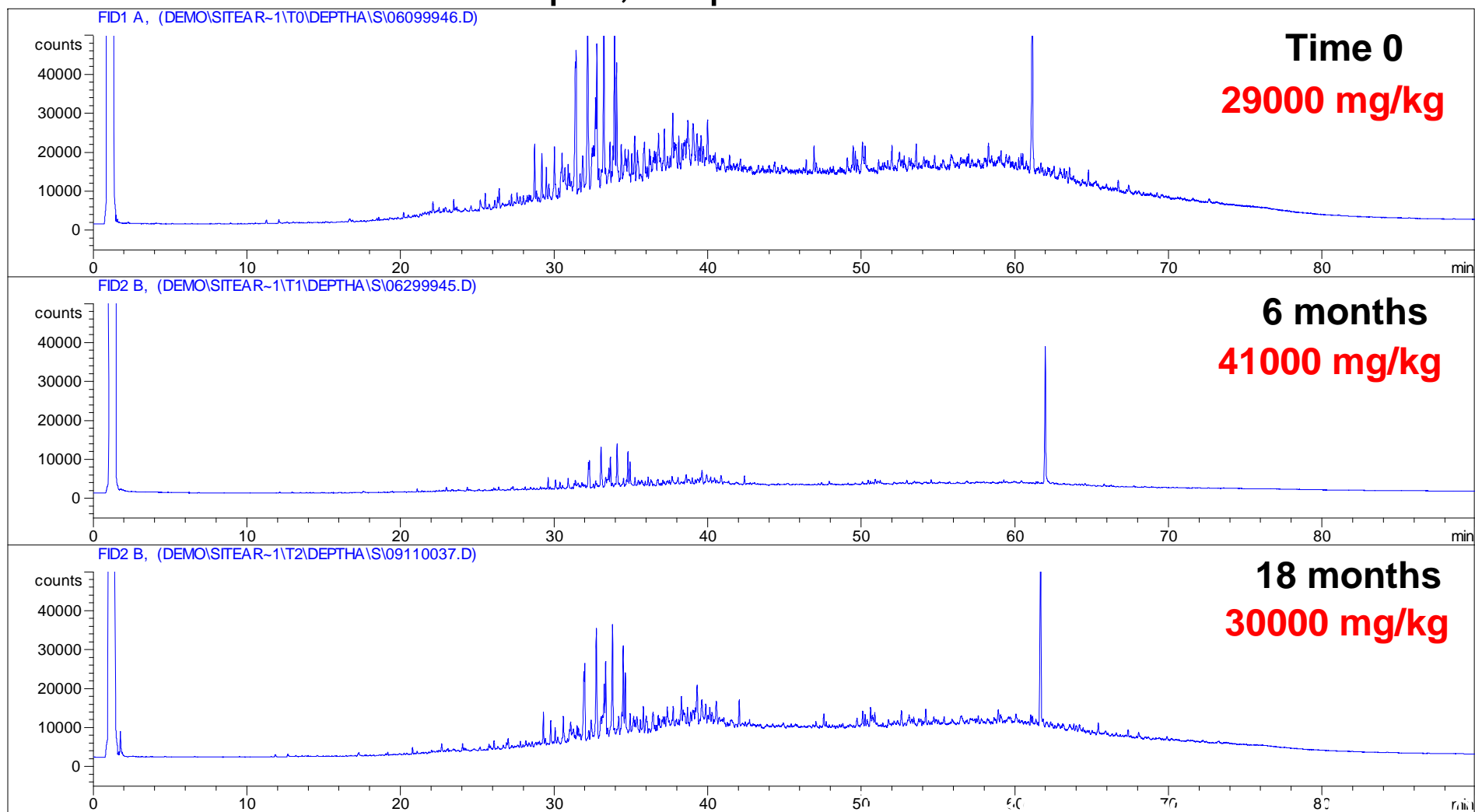
May 2001



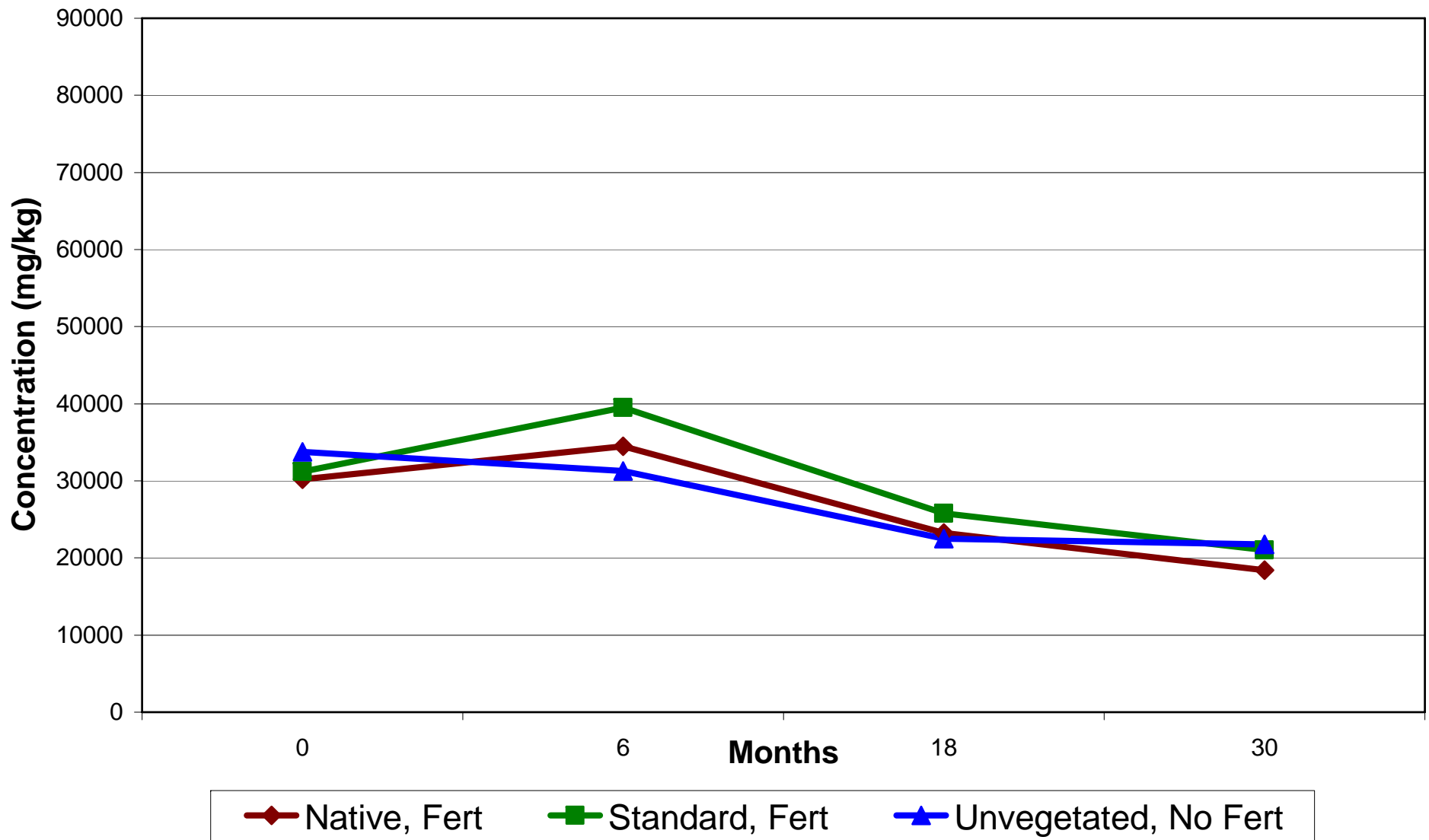
Site A RTDF Mixture Treatment Total Petroleum Hydrocarbons

EPA method 8015

Rep 2, Depth 0 - 15 cm



RTDF Trial Site A -- Total Petroleum Hydrocarbons -- 0 to 15 cm



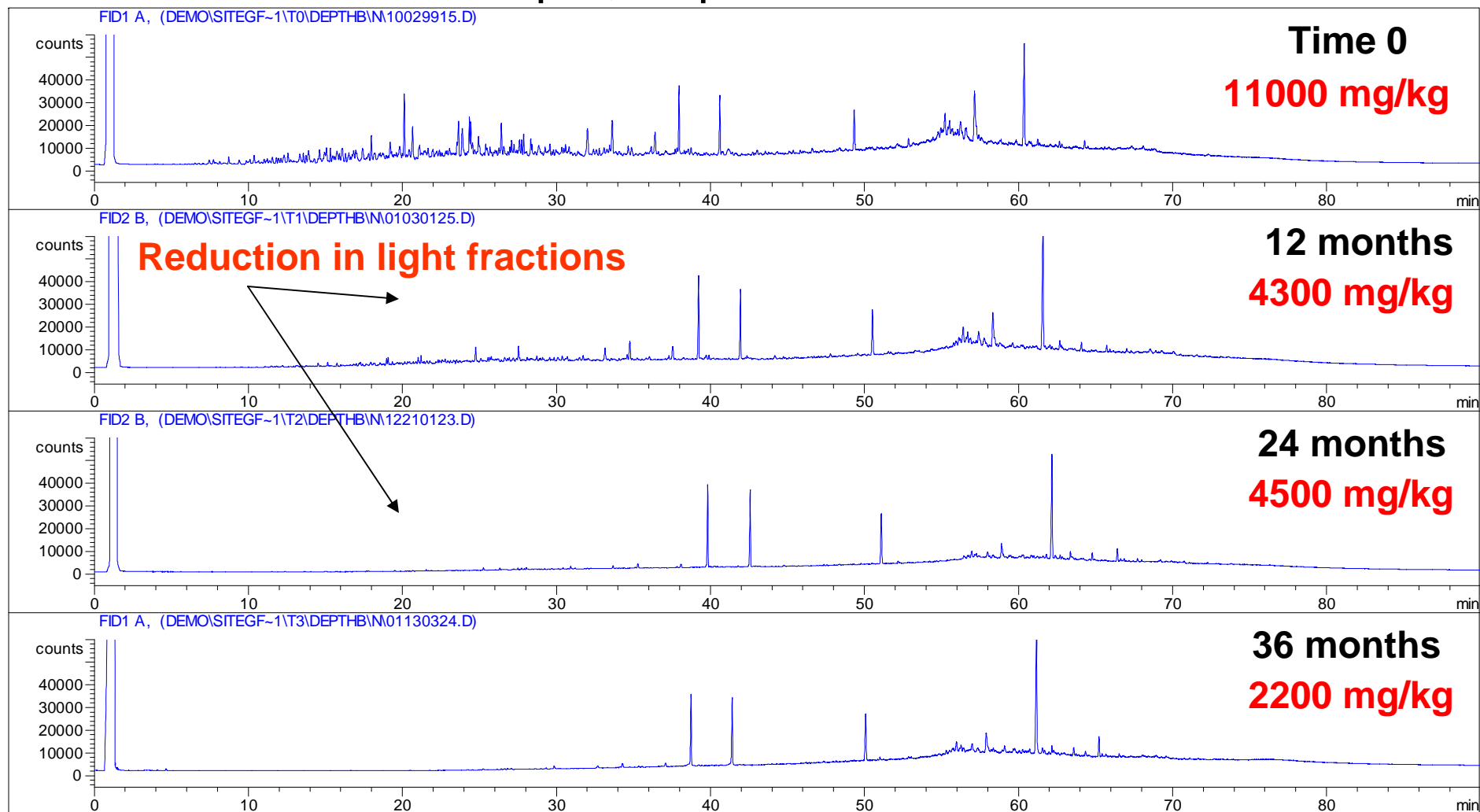
Site G – Kansas – Motor Vehicle Waste Lagoon Sediments



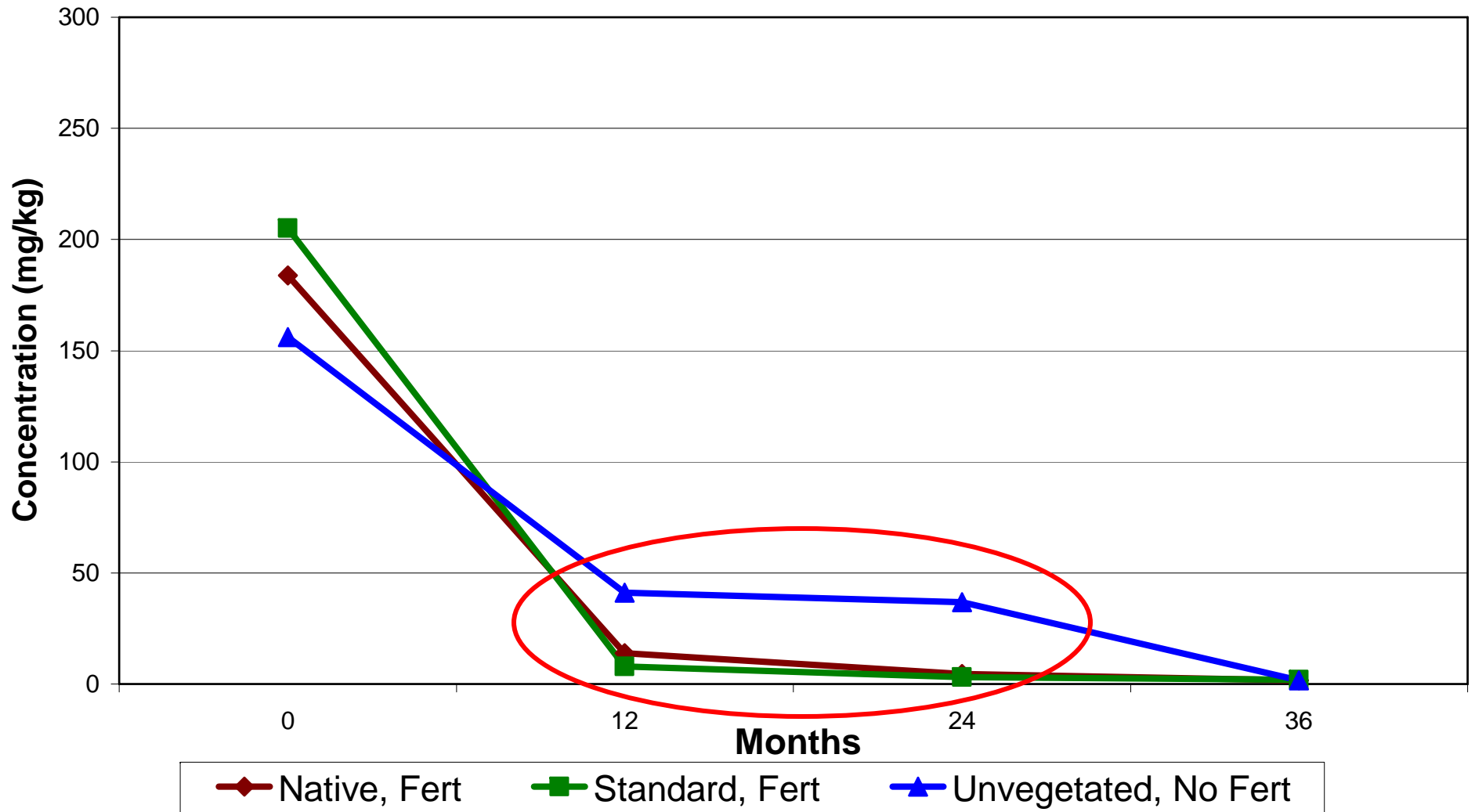
Site G Switchgrass Treatment Total Petroleum Hydrocarbons

EPA method 8015

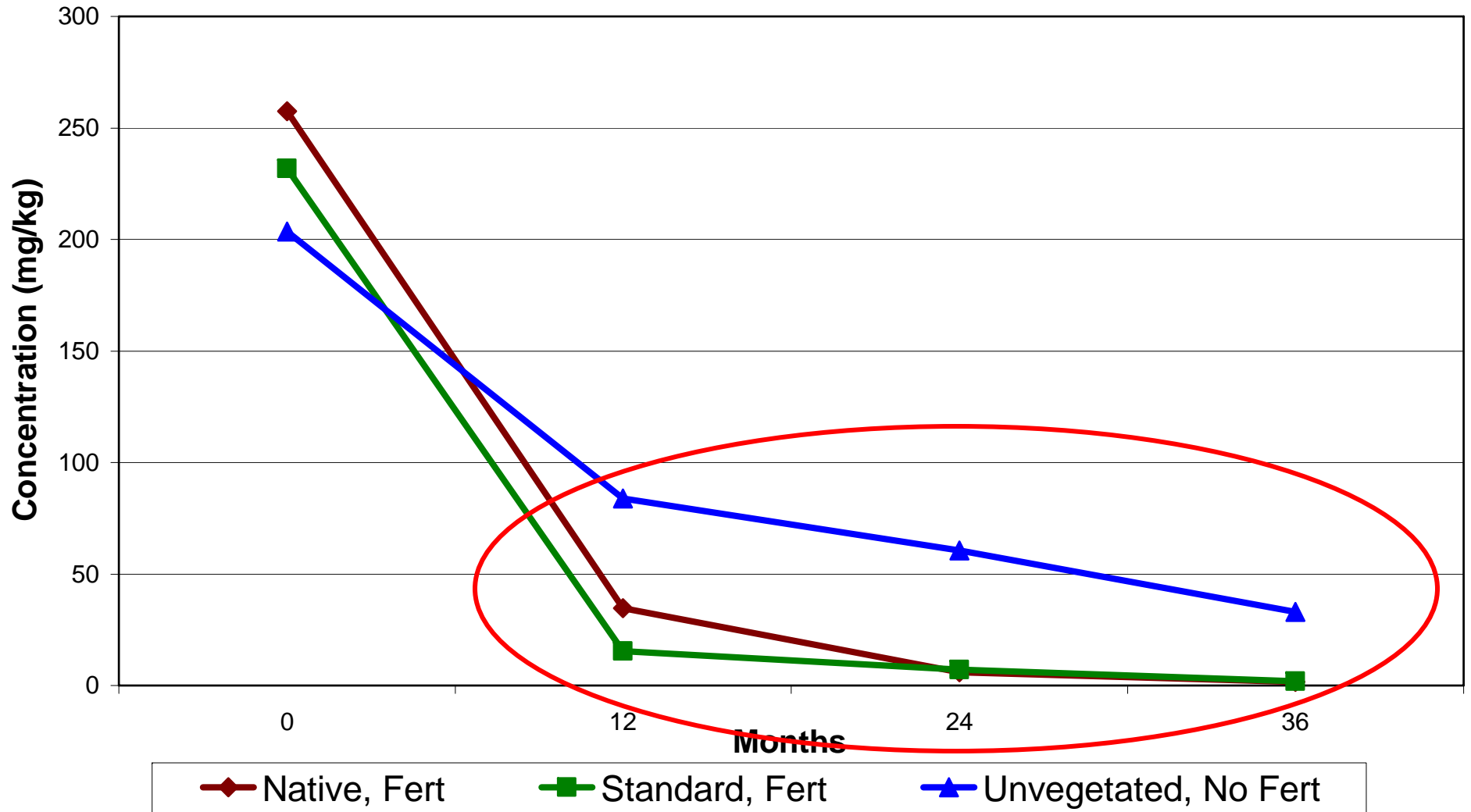
Rep 1, Depth 15- 45 cm



RTDF Trial Site G -- Total Polycyclic Aromatic Hydrocarbons -- 0 to 15 cm



RTDF Trial Site G -- Total Polycyclic Aromatic Hydrocarbons -- 15 to 45 cm



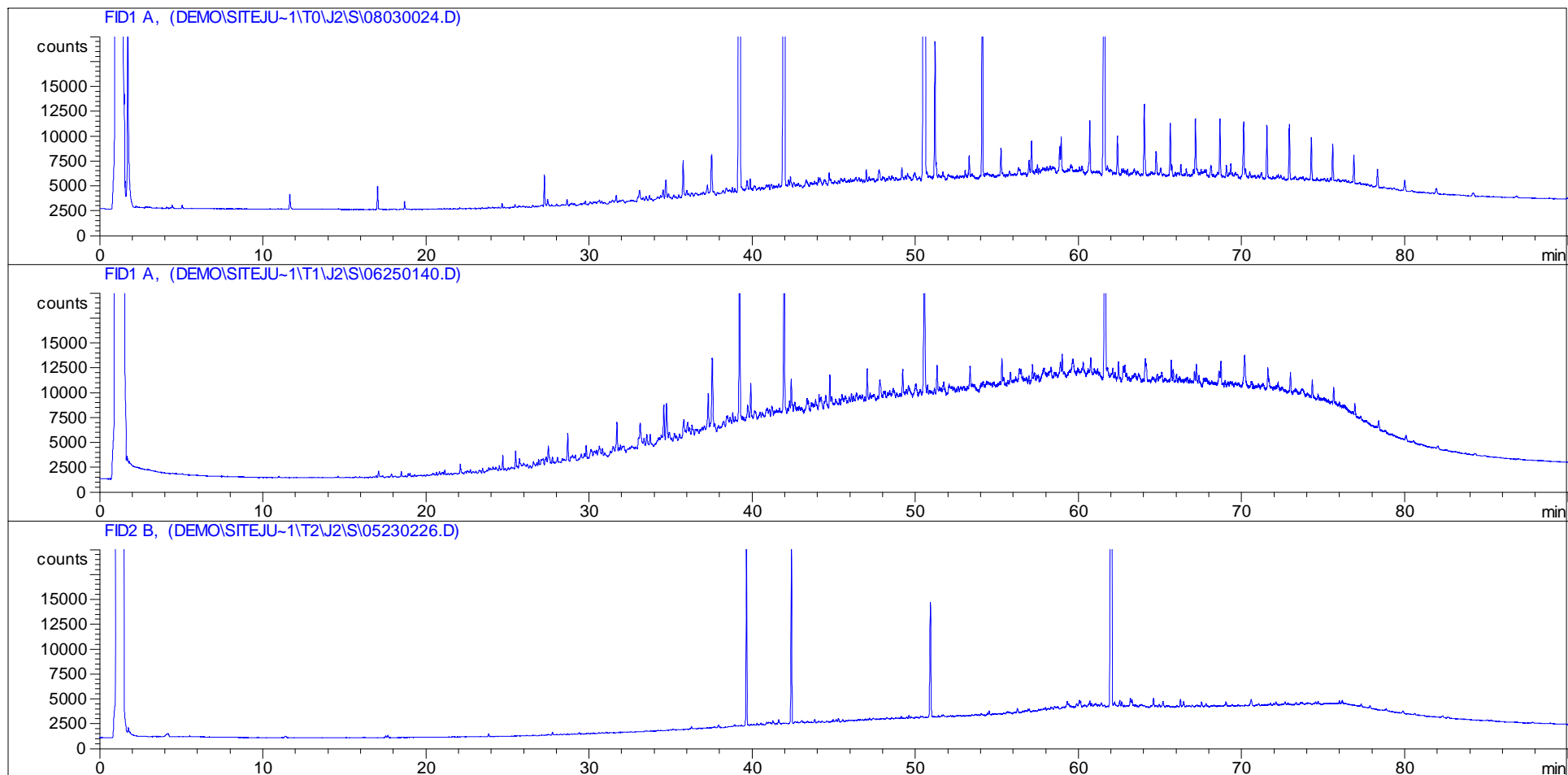
Site J – Production Site

Arkansas

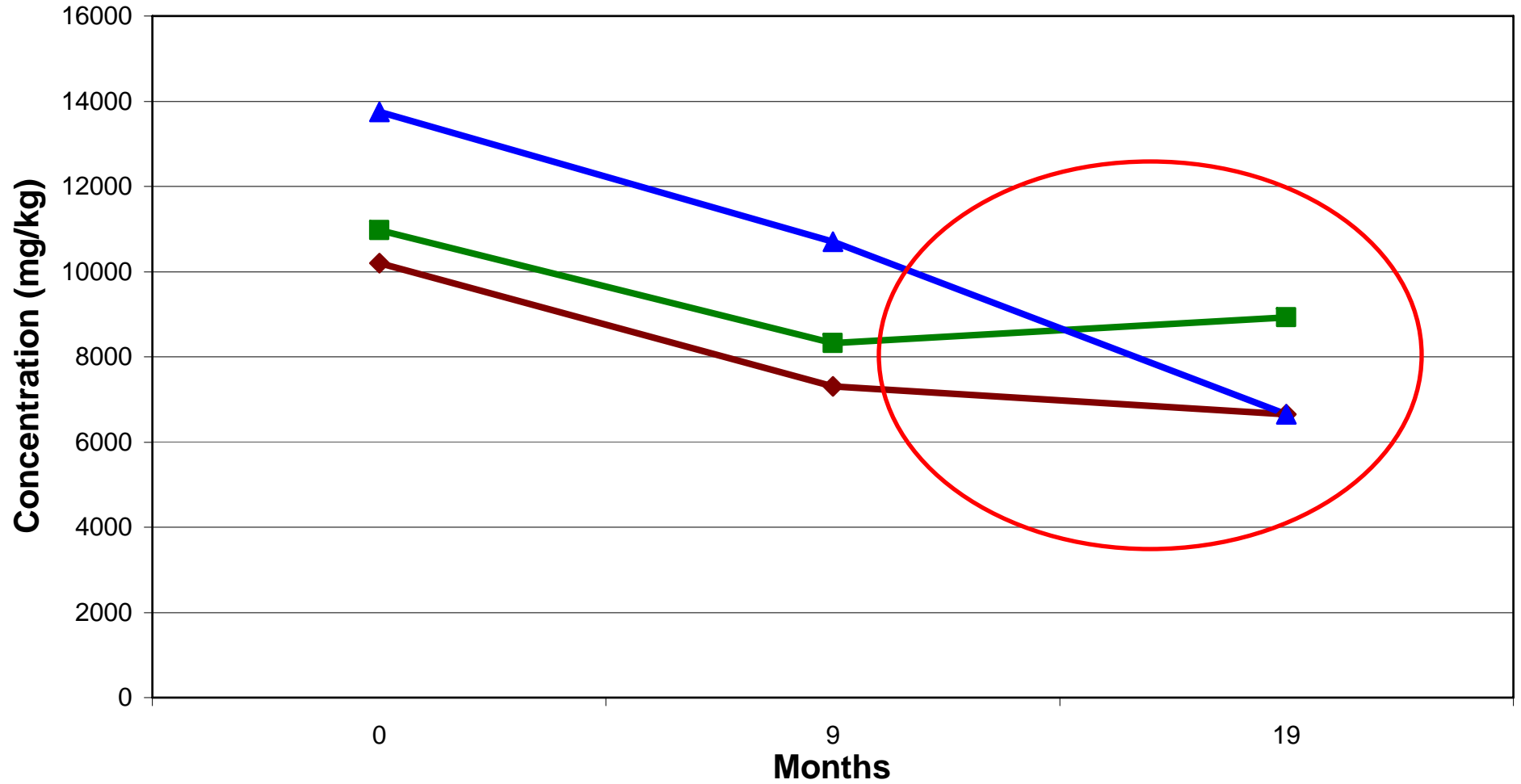


Site J - GC Chromatograms

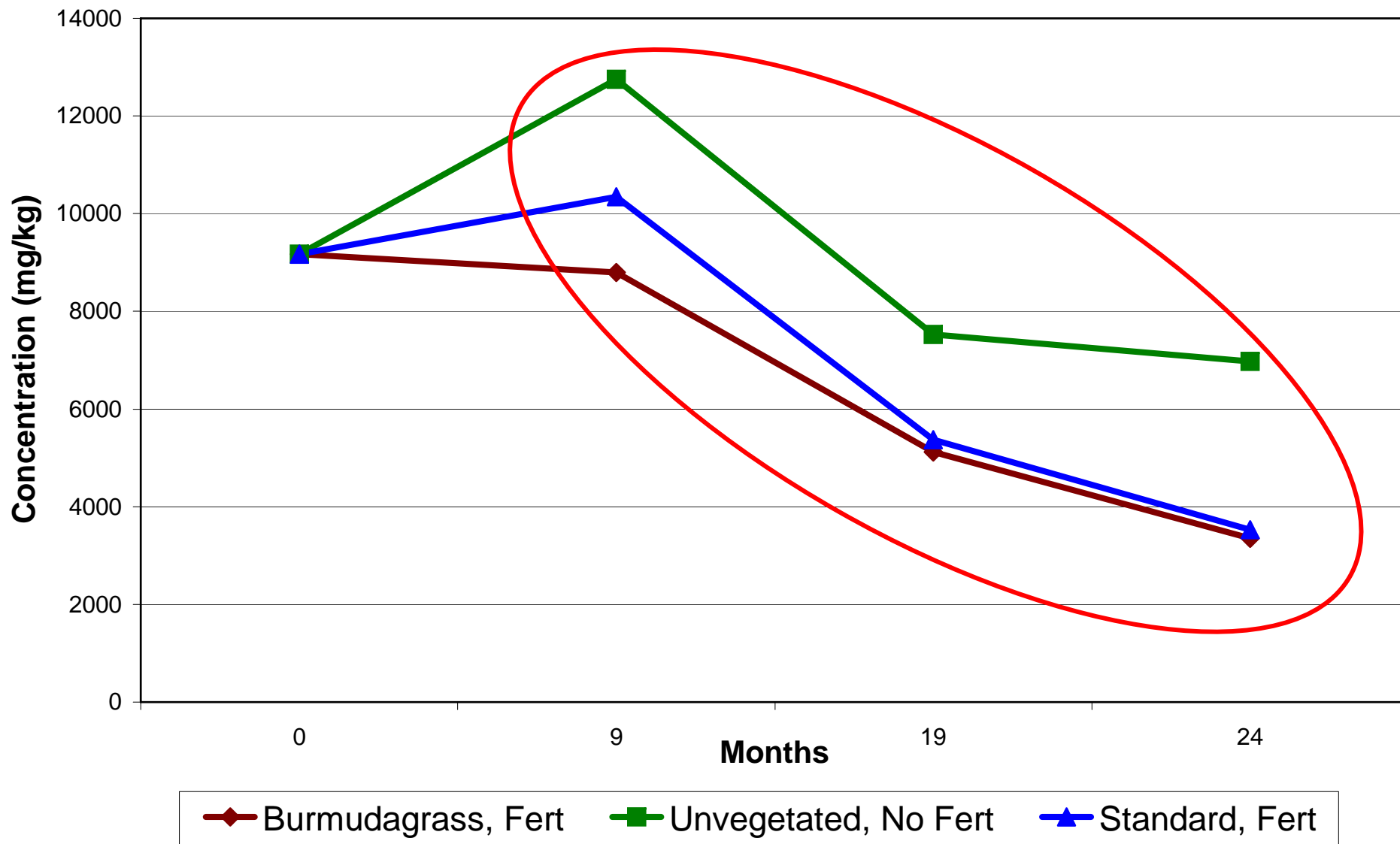
standard treatment plot, 0-15 cm, T0-T2
alternative sampling procedure – soil socks



RTDF Trial Site J -- Total Petroleum Hydrocarbons -- 0 - 15 cm composite RTDF sample method



RTDF Trial Site J -- Total Petroleum Hydrocarbons -- 0 - 15 cm buried samples method



RTDF Lesson's Learned

3. Phytoremediation may compare favorably to other bioremediation treatment systems in terms of cost and management requirements when the petroleum source is fresh or unweathered.

RTDF Lesson's Learned

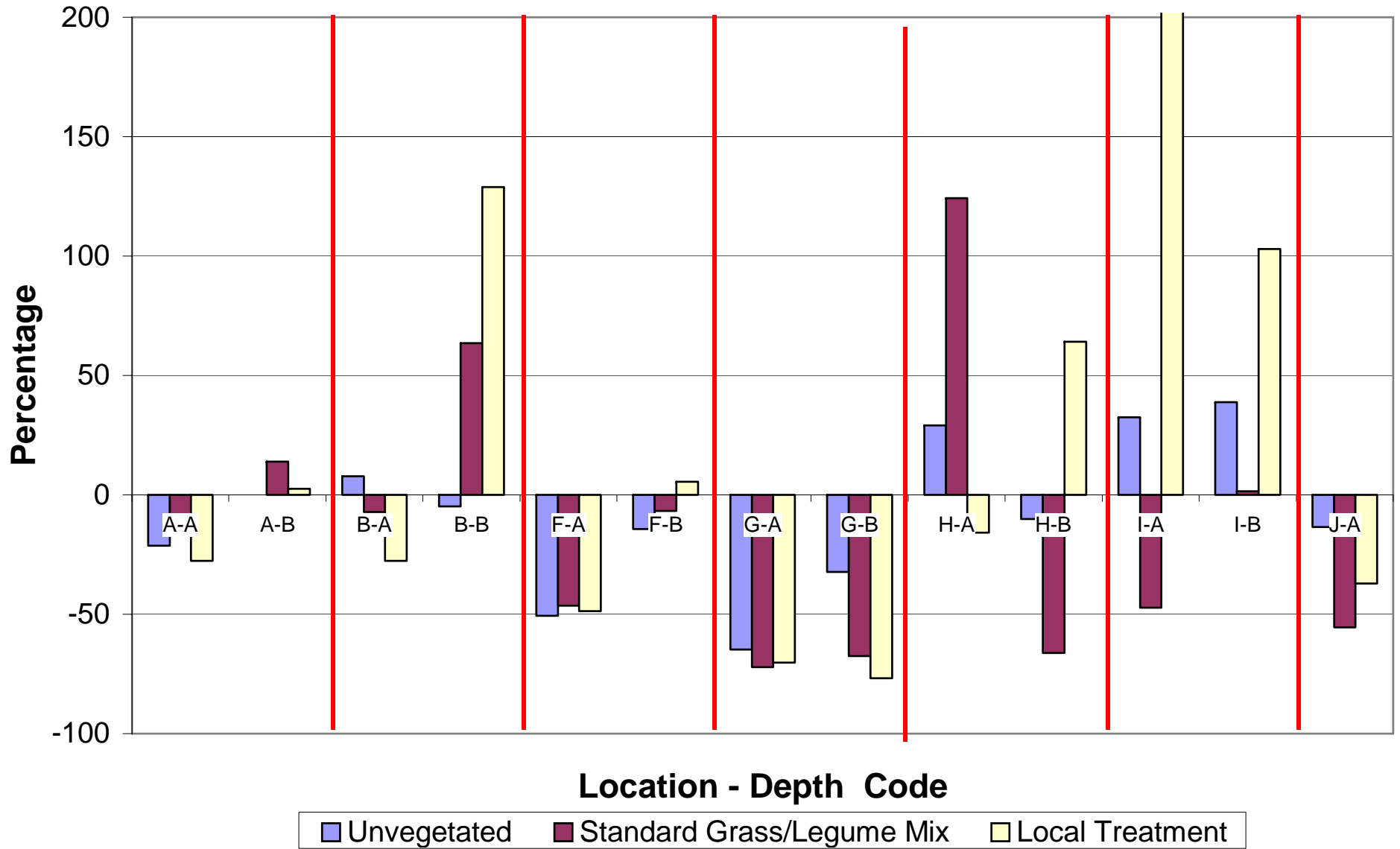
4. Soil characteristics are important for plant growth and phytoremediation potential.
 - soil texture
 - organic matter
 - salinity
 - pH
 - nutrients
 - water management

RTDF Lesson's Learned

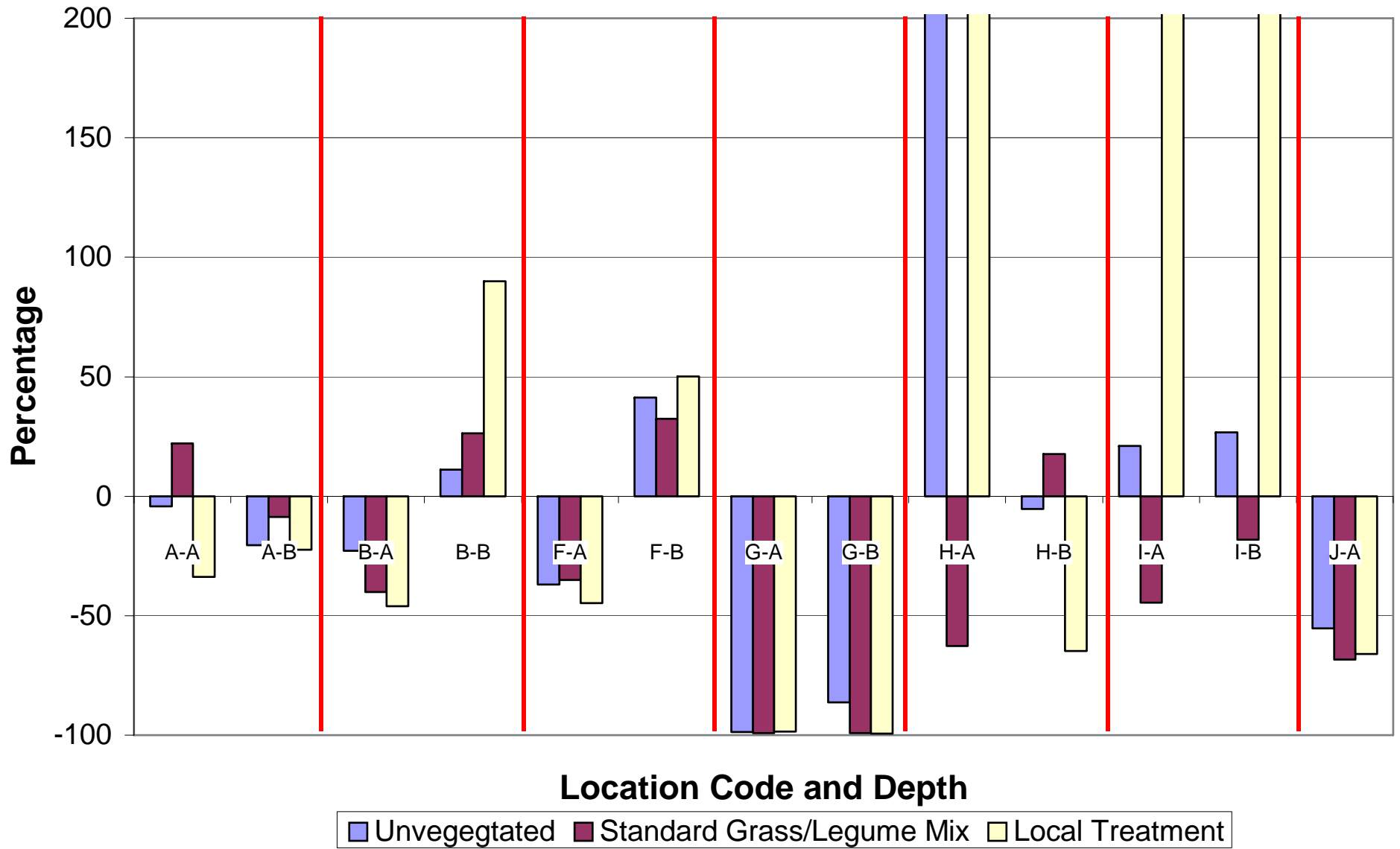
5. In most cases, it is sufficient to monitor a few target hydrocarbon parameters for monitoring of phytoremediation applications.

> 100 parameters estimated

TPH by 8015 - Percentage Change from Initial to Final



Total PAHs - Percentage Change from Initial to Final



RTDF Lesson's Learned

6. If cost savings are needed, a long treatment time is acceptable, and risk can be effectively managed using vegetation, then phytoremediation may be a suitable technology to consider at a site.