From Brownfields to Greens Fees

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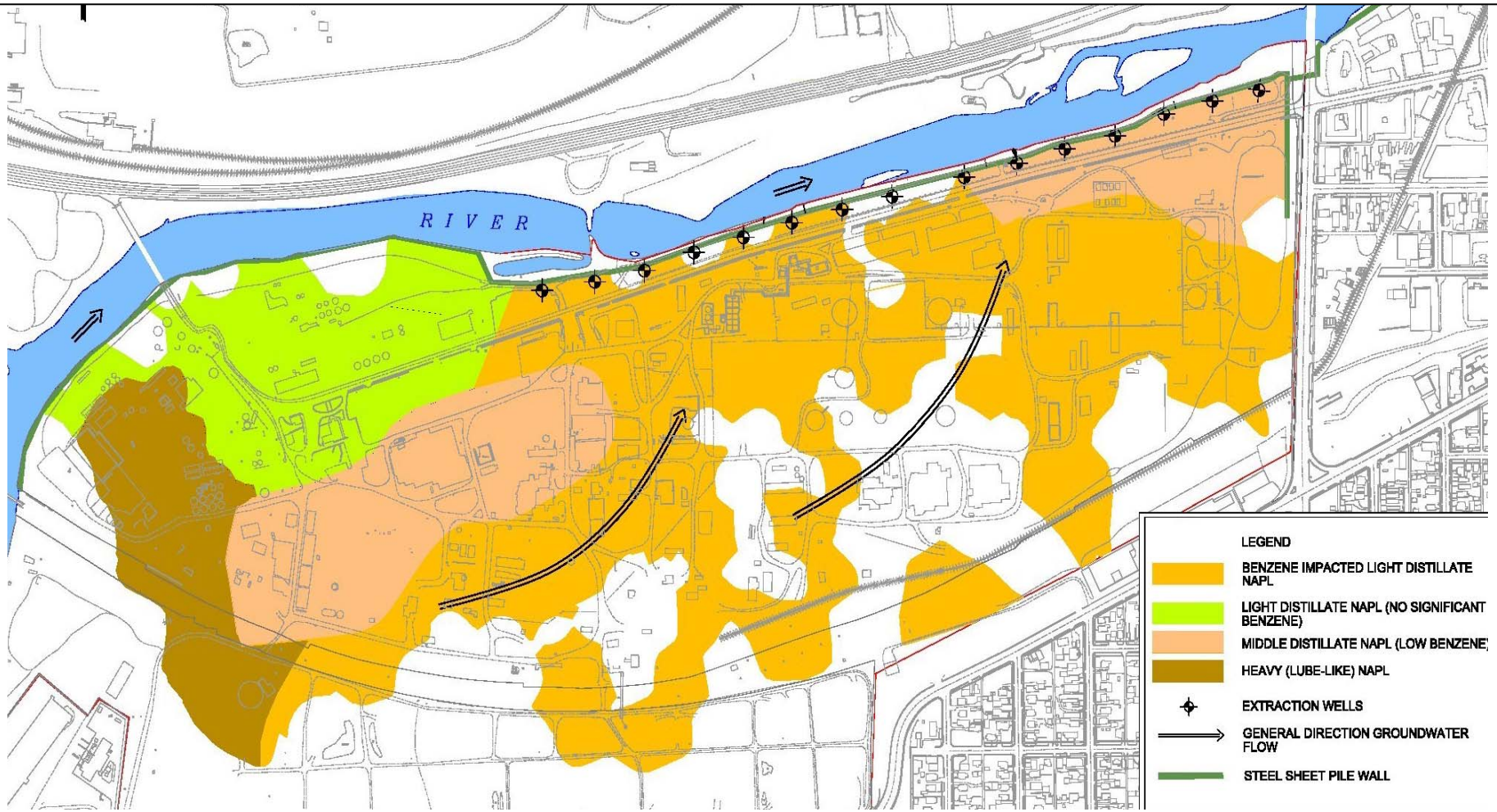
Casper WY Treatment Wetland
Former refinery (1912 – 1991)

- Extensive LNAPL with natural gradient toward river
- 1.5 mile long sheet pile wall with inward hydraulic gradient (6”)
  - 600 to 900 gpm needed (+Soda Lake = 1,200 to 2,200 gpm)



Reuse Plan
Golf course and commercial park

- Extensive use of vegetation and water features
- But, long, cold winters (-35 °C; high winds)

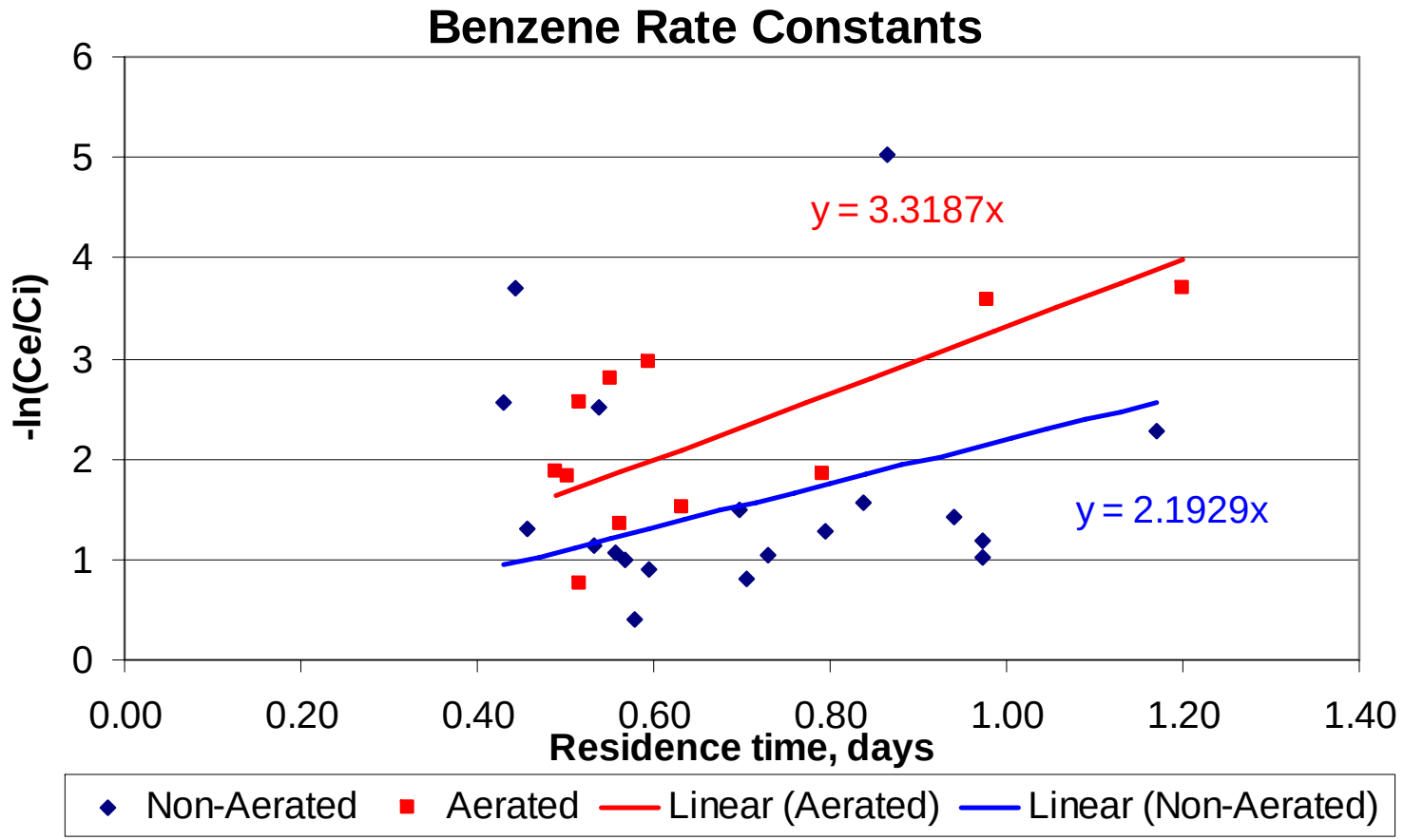
PLATTE RIVER COMMONS MASTER PLAN DRAFT
CASPER, WYOMING

MAY 2002

DESIGNWORKSHOP
Landscape Architecture • Land Planning • Urban Design • Tourism Planning

Pilot Study
Benzene results

- Mixed species:
  - *Cornus, Juncus, Phragmites, Salix, Scirpus, Typha*
- With and without aeration
- With and without insulation

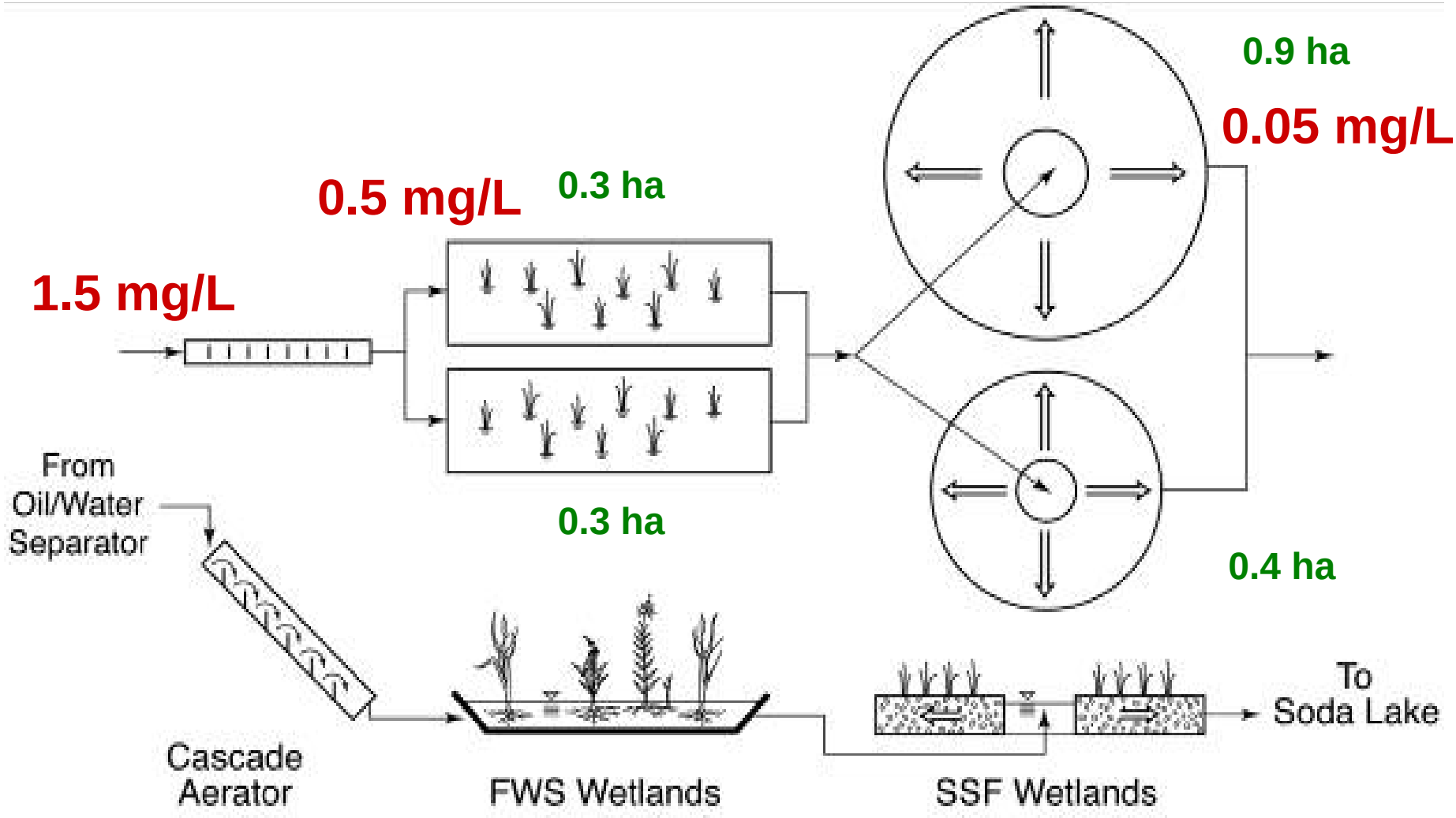


Rate Coefficients, K_A (m/yr)

$$\frac{C_o - C^*}{C_i - C^*} = \exp\frac{-K_A A}{Q} = \exp(-K_v t)$$

	Aeration		No Aeration	
Compound	**Mulch**	**No Mulch**	**Mulch**	**No Mulch**
Benzene	518	456	317	226
BTEX	356	311	257	244
TPH	1058	965	725	579
MTBE	64	60	35	22
Average Rate Increase	**2.1x**	**1.9x**	**1.3x**	**1.0x**

Full-Scale System Based on Pilot
Benzene as driver



Passive Stripping (Biofilter)

Sediment Basin

Radial Flow Aeration Wetland

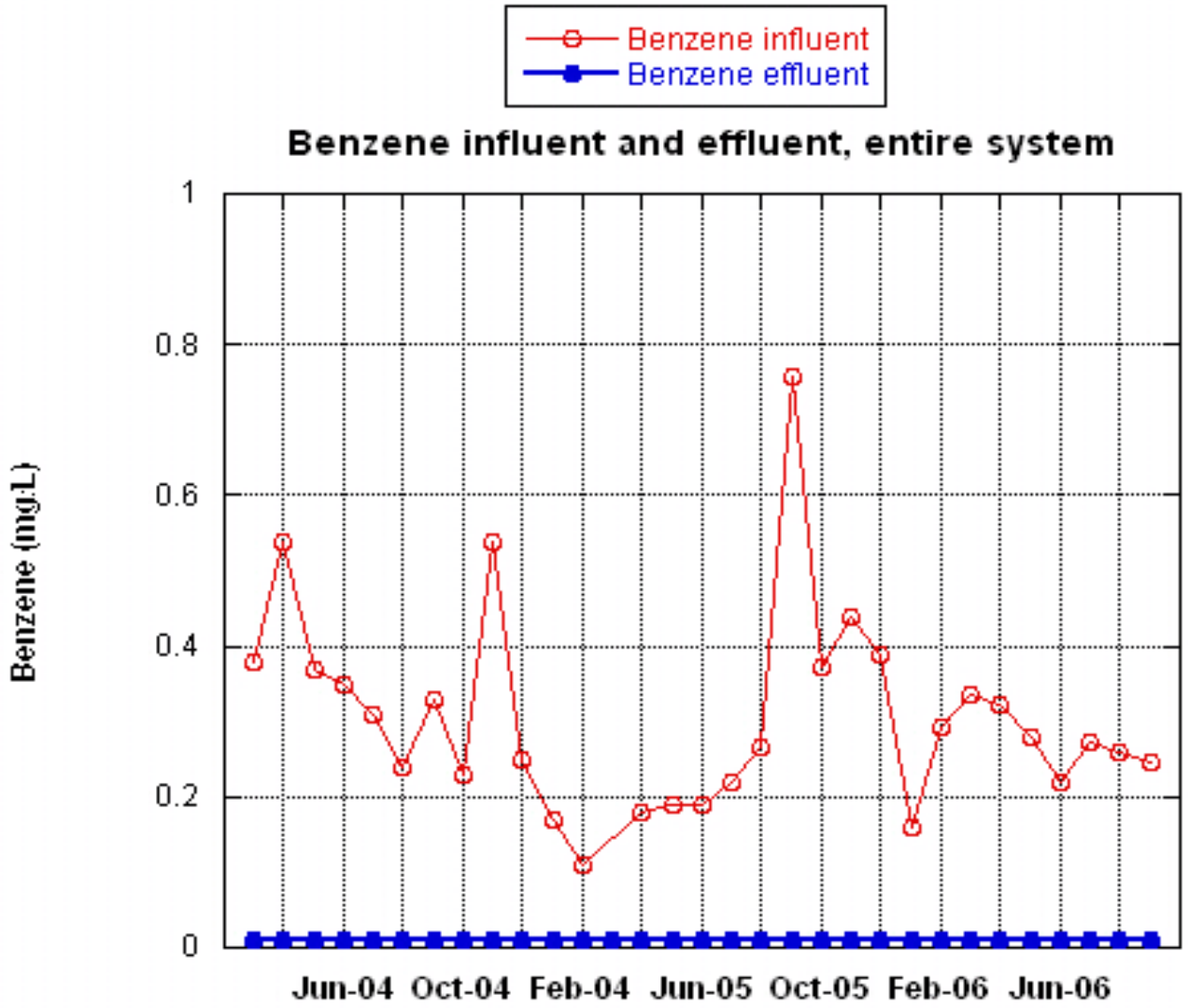
Radial Flow Aeration Wetland

During Construction

Post-Construction

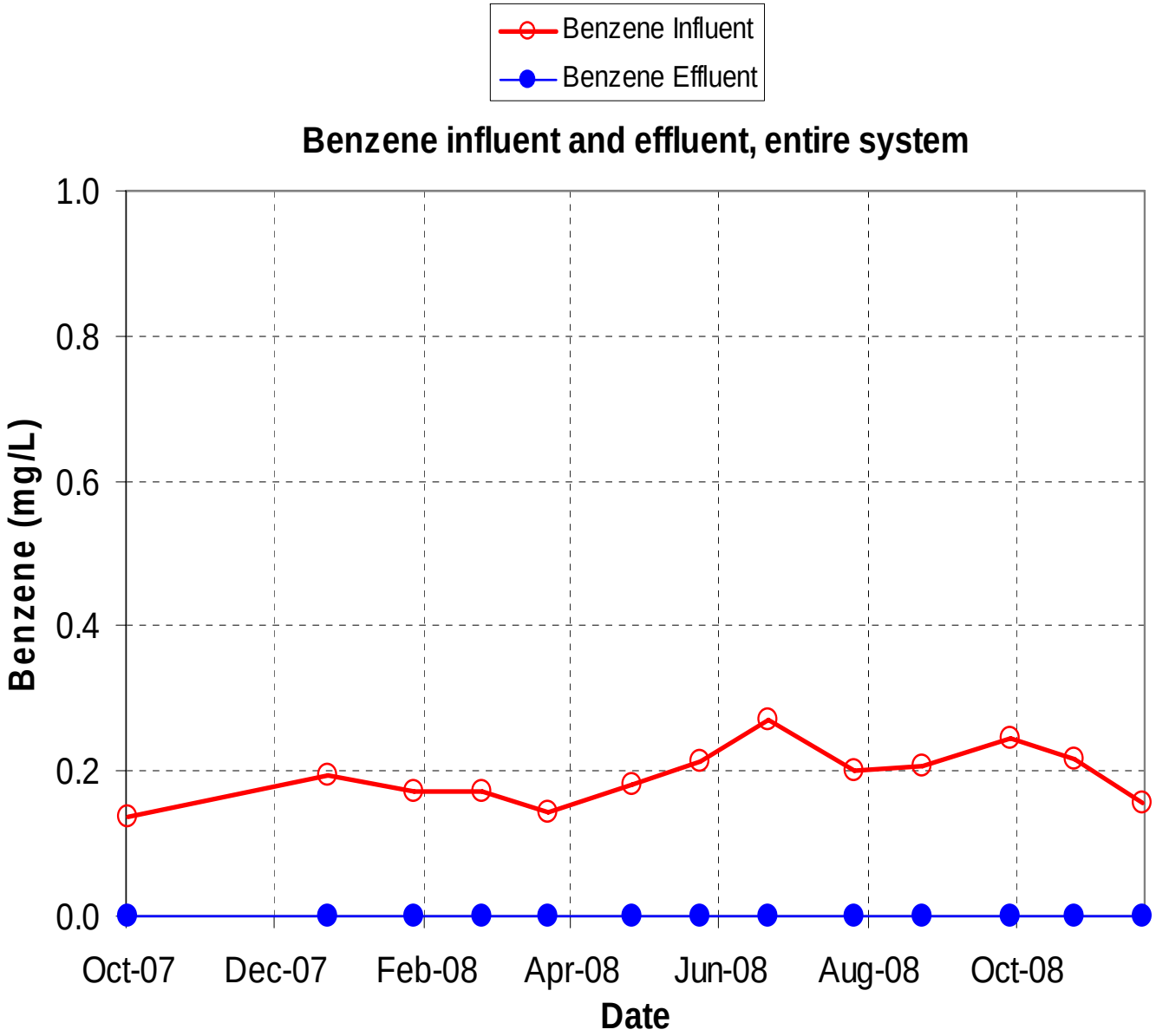
Opening Day

Benzene Treatment Results (2004 – 2006)



Outfall 001 Benzene below detection levels (<0.001 mg/L)

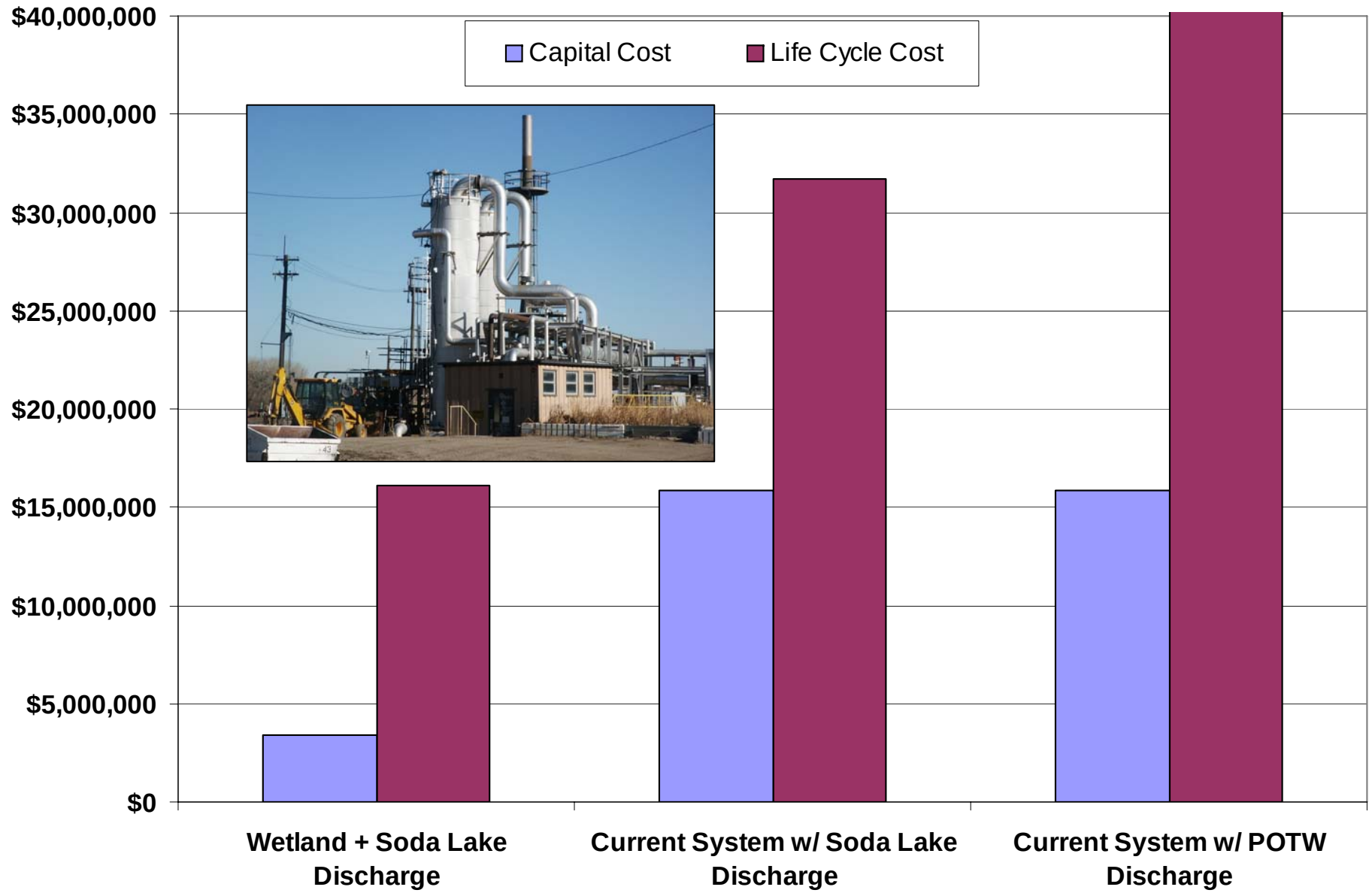
Operational Efficiency
(2007 – Current)



- Lime deposits plugging aeration lines in radial flow wetland
- Blowers turned off in late 2007
- Effluent targets still being met

Outfall 001 Benzene below detection levels (<0.001 mg/L)

Economic Considerations




Trees and grasses
© BP 2006

“Phytoscapes”
= Phytoremediation + Landscapes







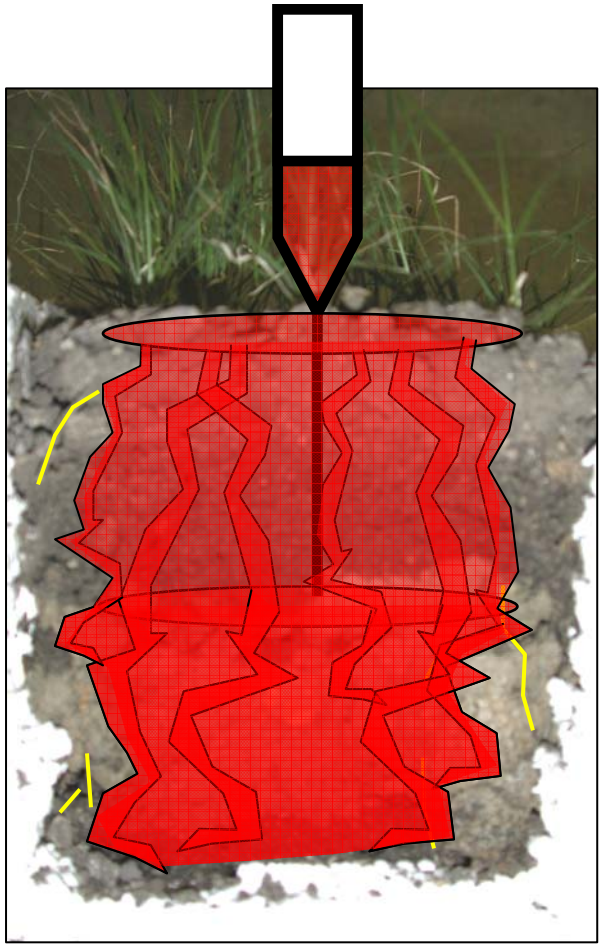

Phase 2 – Pure Gasoline Injections

Examined over **60 deep-rooted native prairie species** (grasses, forbs, wildflowers)

Injected pure gasoline (+/- 10% oxygenates) at various volumes

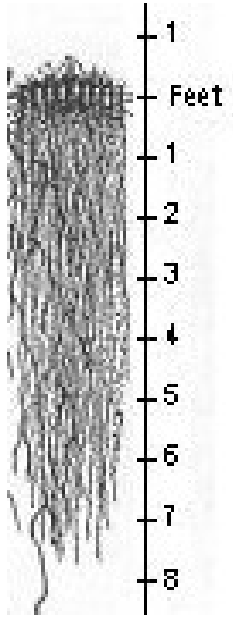
Measured gasoline **concentrations** over time (4-8 weeks)

Some species **VERY tolerant**; others more susceptible



Sub-irrigation only source of water

Confirmed roots growing through soil (yellow)



Clean topsoil

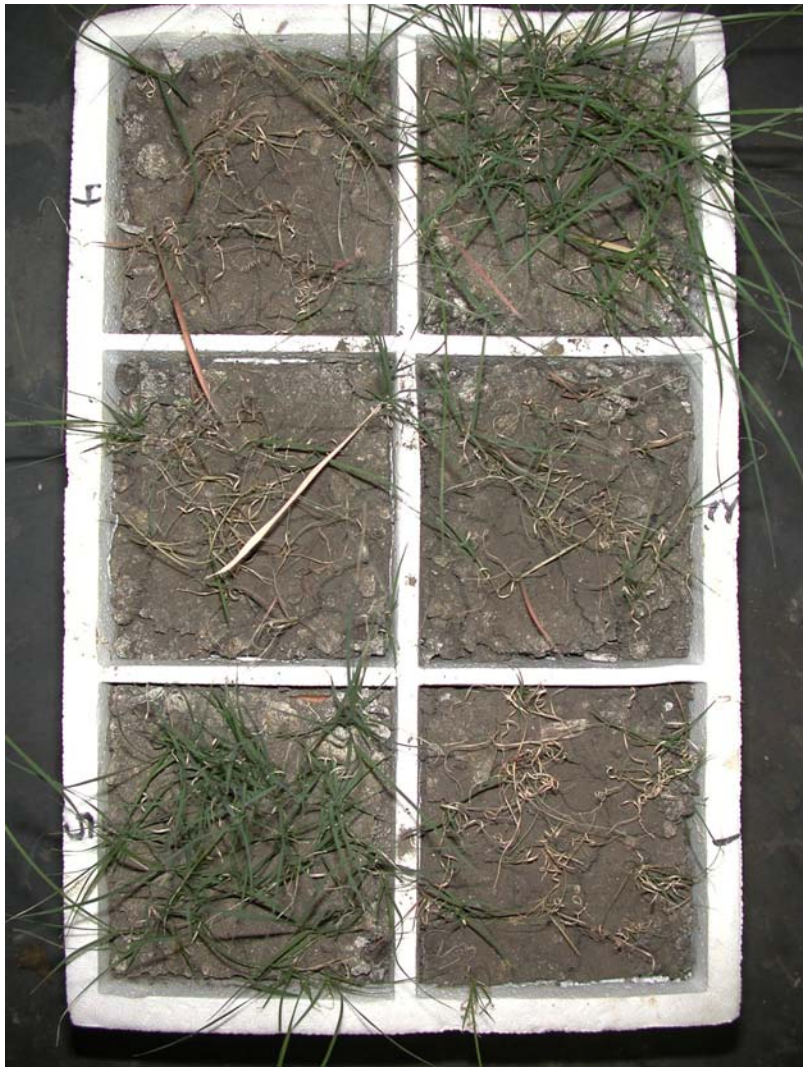
Clayey soil

1 L total soil volume

Phase 2 Gasoline Results

Not Only Tolerate, But Remediate

45 mls per 1 L cell (7.5% by wgt)



Final Soil Concentrations:

Unplanted Control Pots (not shown):

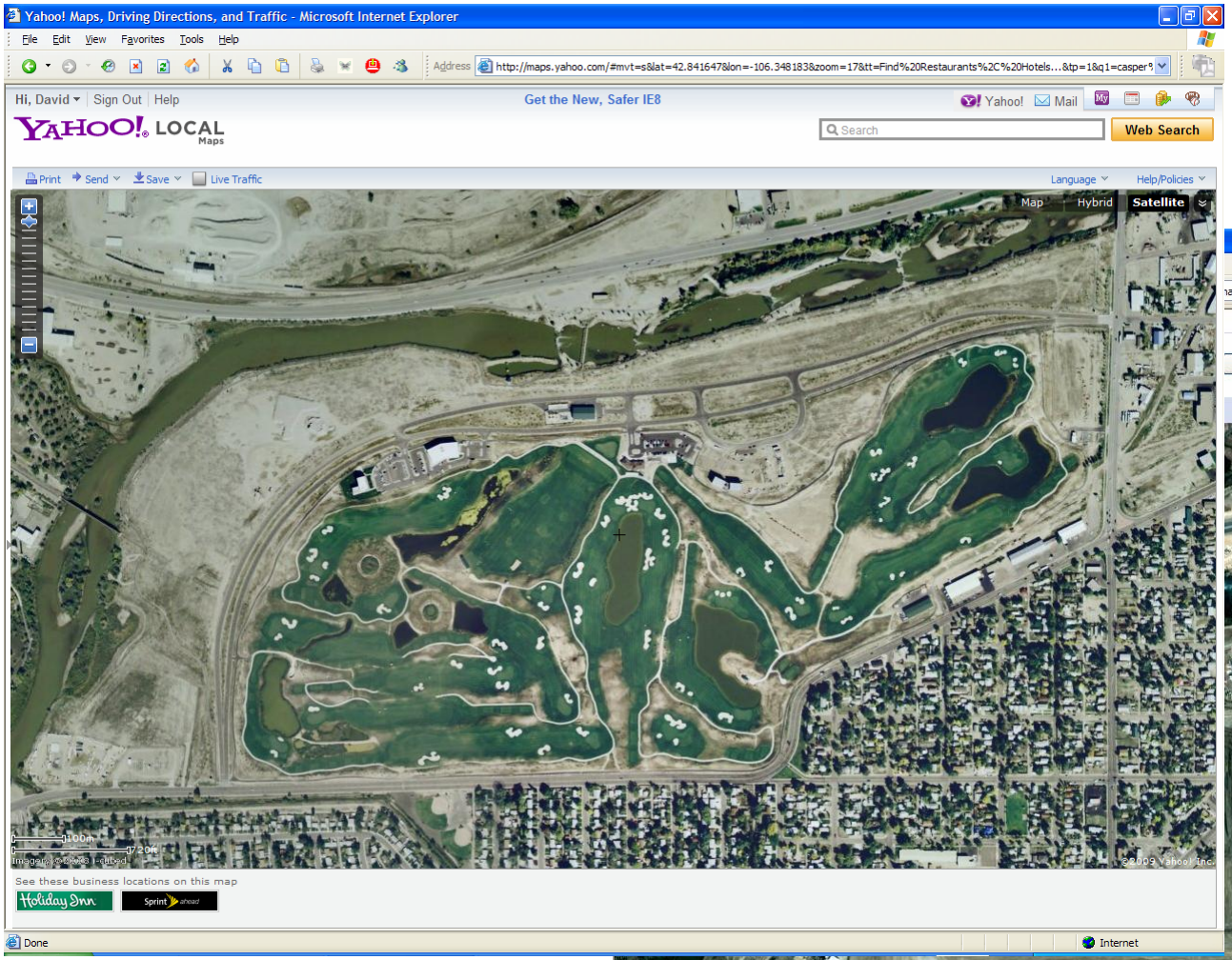
- BTEX **1,875 ug/kg**
- MTBE **2,700 ug/kg**

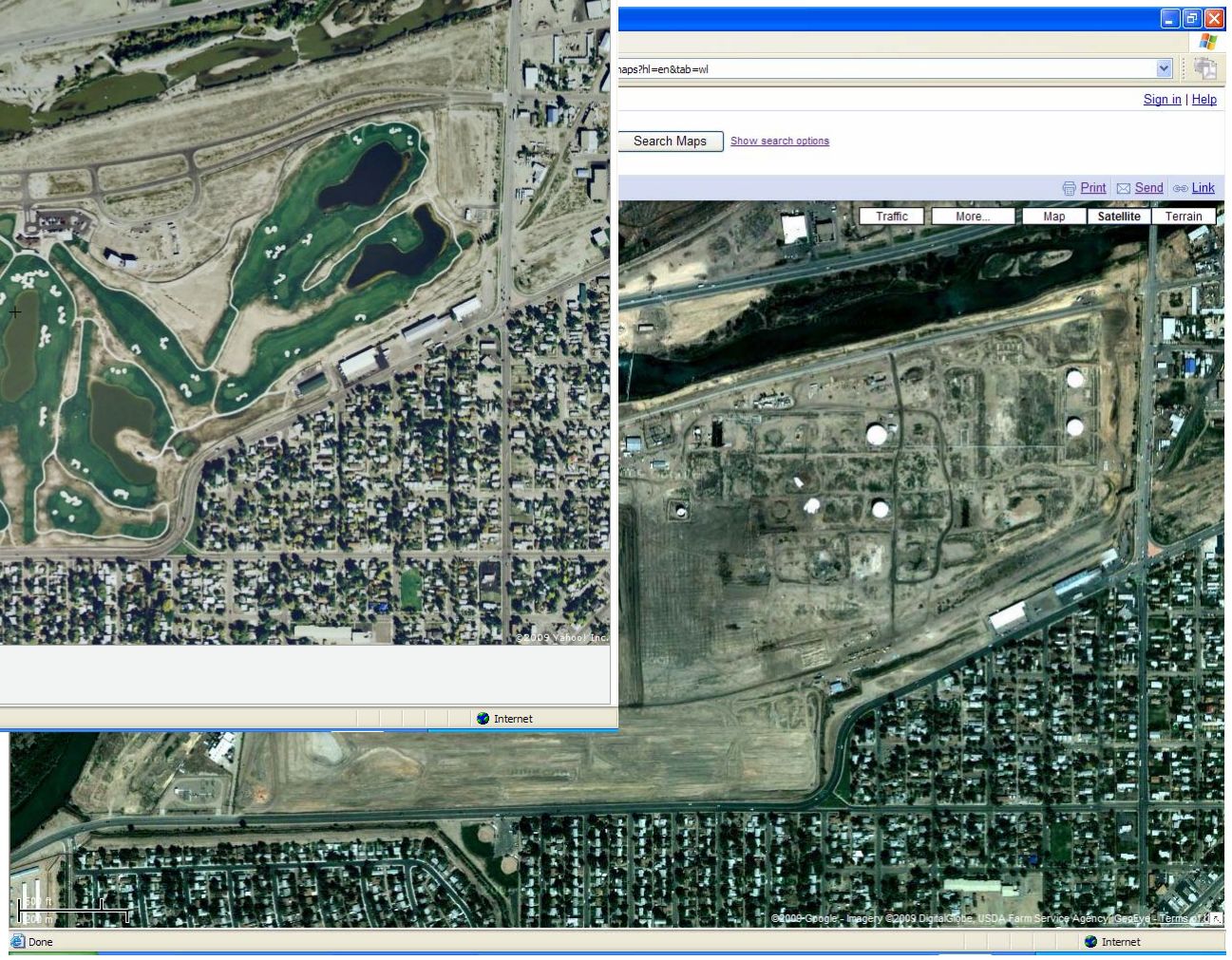
Planted Pots: Bottom Soil Layer

- BTEX **46 ug/kg (ND, 11, ND, 35)**
- MTBE **50 ug/kg**

orders of magnitude lower

Yahoo or Google Maps?





Both searched on November 23, 2009

Acknowledgements

- Joe Deschamp – BP Site Manager (retired)
- Chuck Stilwell – BP Site Manager
- Martin Johnson – BP Site Technical Point of Contact (former)
- Terry Moore – BP Site Technical Point of Contact
- Felix Flechas – U.S. EPA Region VIII
- Dr. Ari Ferro – Phytokinetics (pilot), now of URS
- Dr. Scott Wallace – North American Wetland Engineering (full scale), now of Naturally Wallace Consulting
- Dr. Gaylen Brubaker, et al. – RETEC, now AECOM