Environmental Technology

Refinery Redevelopment

A Rags to Riches Brownfields Story

"How to Build a Golf Course"

David Tsao, Ph.D.

BP Group Environmental Management

- **OVERVIEW**
  - ➔ Site History
  - ➔ Redevelopment Plans
  - ➔ Phytotechnology Solutions
  - ➔ Beneficial Outcomes
  - ➔ Next Steps

Site History

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- **Former Amoco Refinery**
  - ➔ Main process areas = 350 contiguous acres
  - ➔ Ceased operations in 1991 after 77 years of operation
  - ➔ Dismantled in 1993 (underground pipe removal later)
  - ➔ **Came under "new" management in 1998 (merger with BP)**
- **Environmental / Ecological Issues:**
  - ➔ **Groundwater and soils** impacted with **petroleum hydrocarbons**
  - ➔ "Light" to "heavy" hydrocarbons; relatively sandy geology
  - ➔ **Receptor: site adjacent to a major river**
- **Solutions:**
  - ➔ Barrier Wall **(length = 8,600 ft)** to eliminate pathway to the river
  - ➔ Groundwater extraction to maintain inward gradient **(600 to 900 gpm)**
  - ➔ Extracted groundwater processed through a oil / water separator
  - ➔ Aqueous stream treated with air strippers before being sent to POTW
  - ➔ **Permit discharge to POTW = 0.05 mg/L benzene**

Site Map

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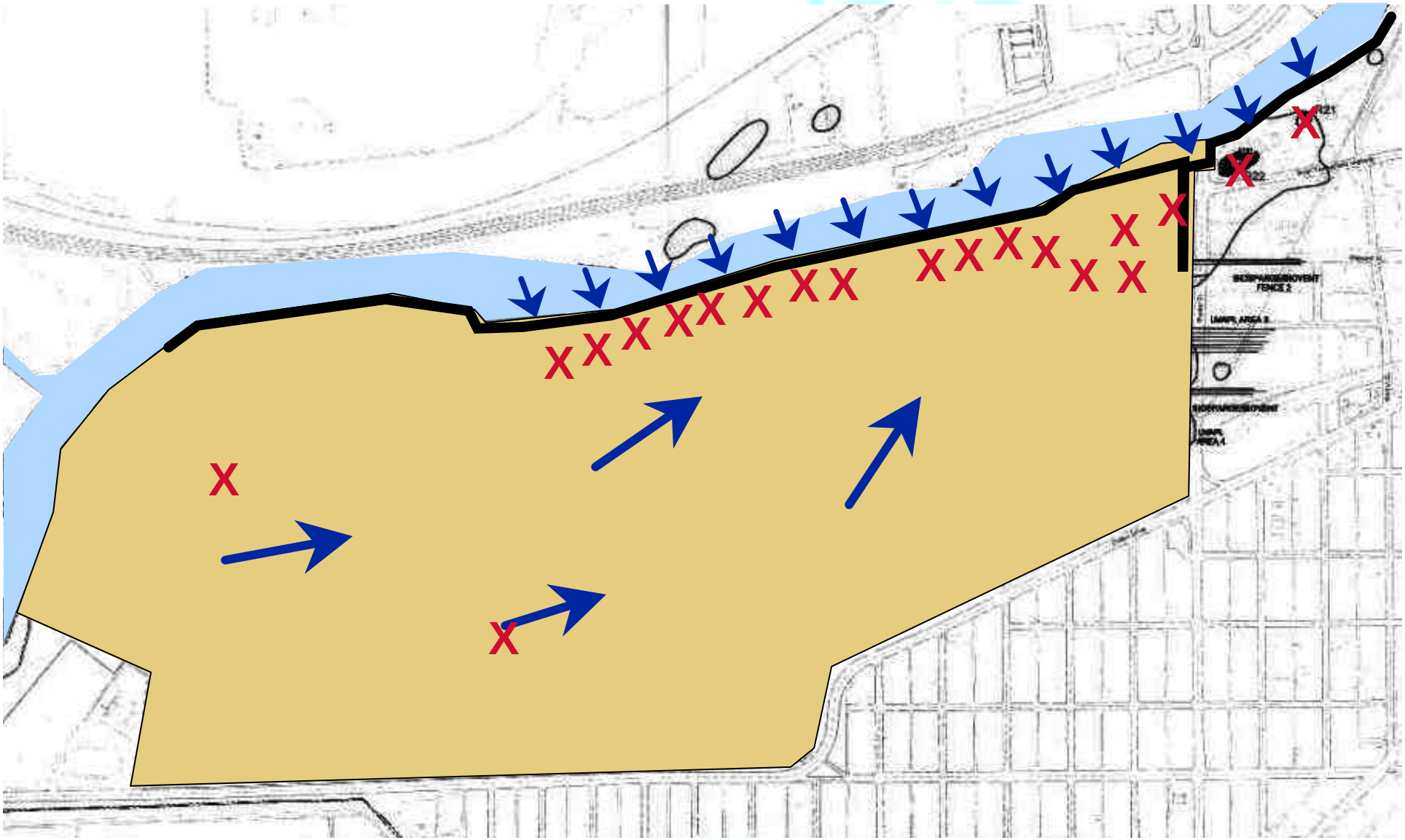

Other Issues

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- **Other Environmental / Ecological Issues:**
  - ➔ Former process water settling pond (associated with natural lake nearby)
  - ➔ Serving as a **wildlife habitat** (250+ bird species)
  - ➔ Additional 600 to 1,300 gpm of water needed to maintain lake size
    (total capacity needed: 1,200 to 2,200 gpm)

- **Social Issues:**
  - ➔ Un-used / under-utilized property needing revitalization
  - ➔ Environmental stigma, job loss, property values, **affected livelihoods**
  - ➔ Improve community relations

- **Financial Issues:**
  - ➔ High Water Treatment Costs (air stripping, POTW): **$1.0 million per year**
  - ➔ Groundwater extraction for 99 years **(long-term O&M required)**
    (words you don't like to hear in the remediation business)

Defining a Beneficial End Use

Win, Win, Win Situation

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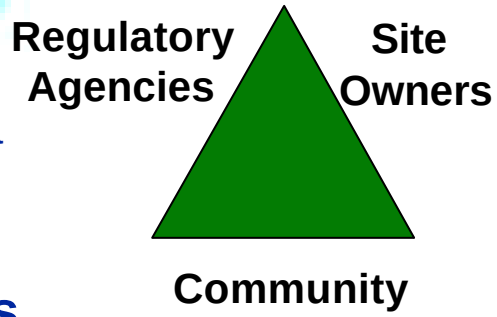
- **First and foremost: Make human health and environmental risks acceptable**
  - ➔ **GOALS:** Containment vs. Remediation vs. Both
  - ➔ **Restrict direct interactions** with contaminated media
  - ➔ Understand plant-contaminant **fate and transport**



- **Financial, Social, and Environmental Bottomlines**
  - ➔ **FINANCIAL:** **Positive cash flow** for local community (tax revenues, property value, etc.)
  - ➔ **SOCIAL:** **Recreational**, educational, aesthetics
  - ➔ **ENVIRONMENTAL:** **Risk reduction**, ecological improvement, site restoration, enhanced biodiversity
- **What options for end uses if considering phytotechnologies?**
  - ➔ **Small Properties:** Ornamental Gardens
  - ➔ **Large Properties:** Golf Courses, Sports Complexes, Bike/Exercise Trails, Wildlife Observatories, Seed Farms, Bio-Fuel Farms

Reuse Plan

Golf Course (of course)

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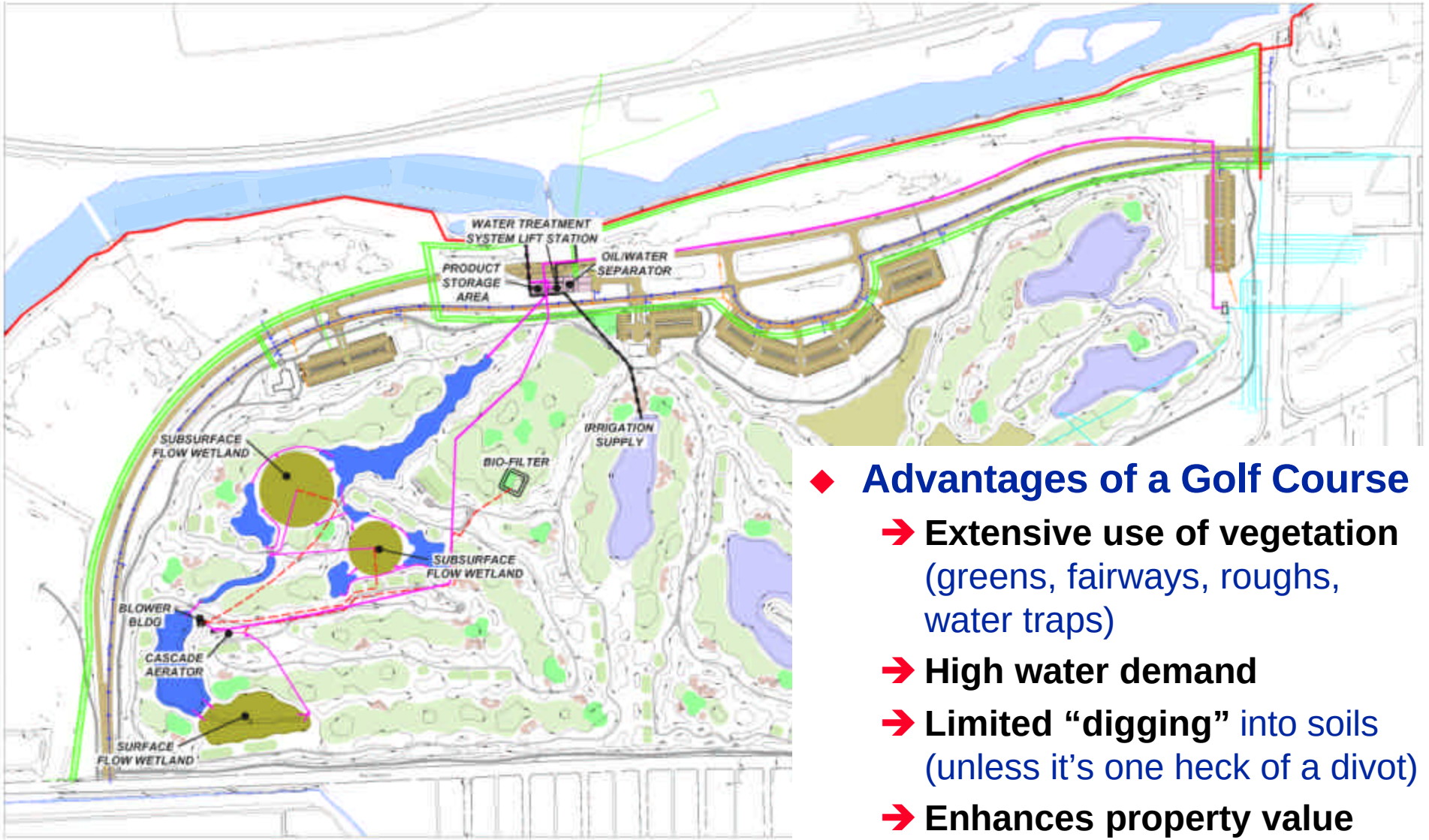
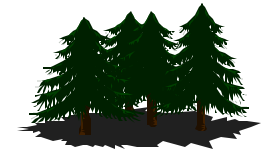


- **Advantages of a Golf Course**
  - ➔ **Extensive use of vegetation** (greens, fairways, roughs, water traps)
  - ➔ **High water demand**
  - ➔ **Limited "digging"** into soils (unless it's one heck of a divot)
  - ➔ **Enhances property value**

Types of Phytotechnology Systems to Consider



- **Treatment Wetlands**
  - ➔Ex-situ groundwater remediation, non-point source pollution control
- **Hydraulic Barriers**
  - ➔Reduce groundwater pumping and physical / chemical processing
- **Vegetative Covers**
  - ➔Soil remediation, soil stabilization, infiltration control

Wetlands Basics

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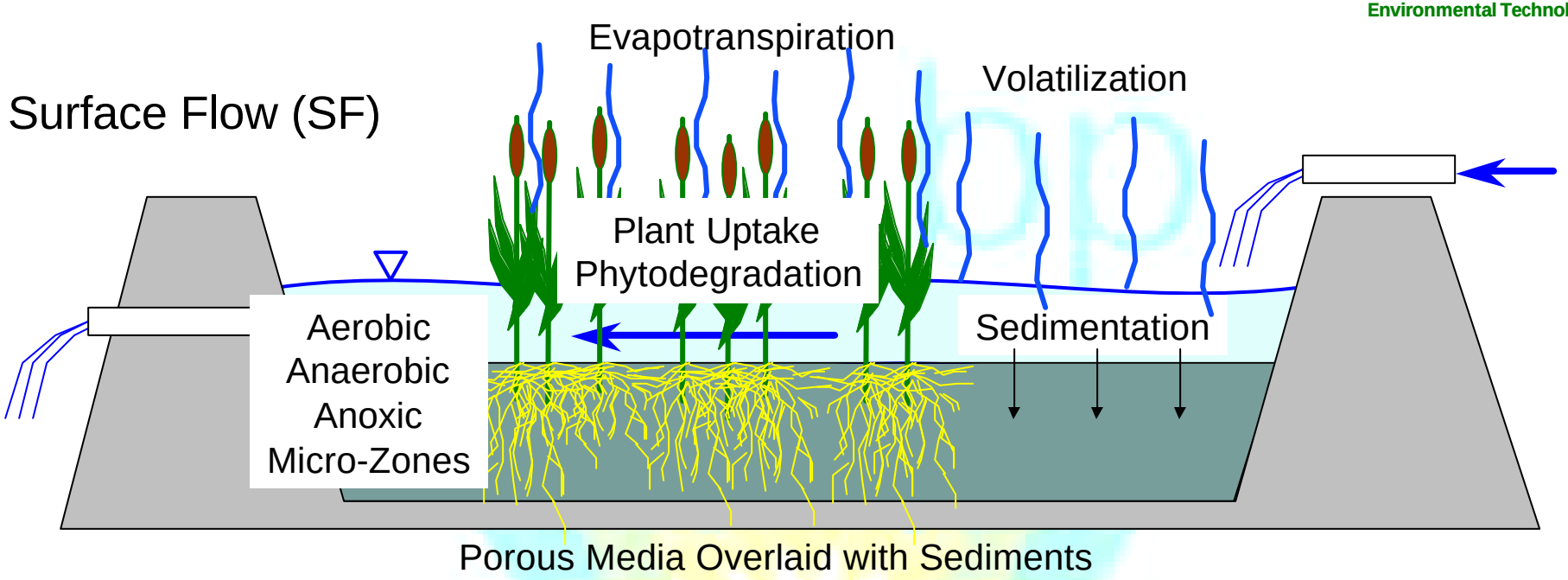

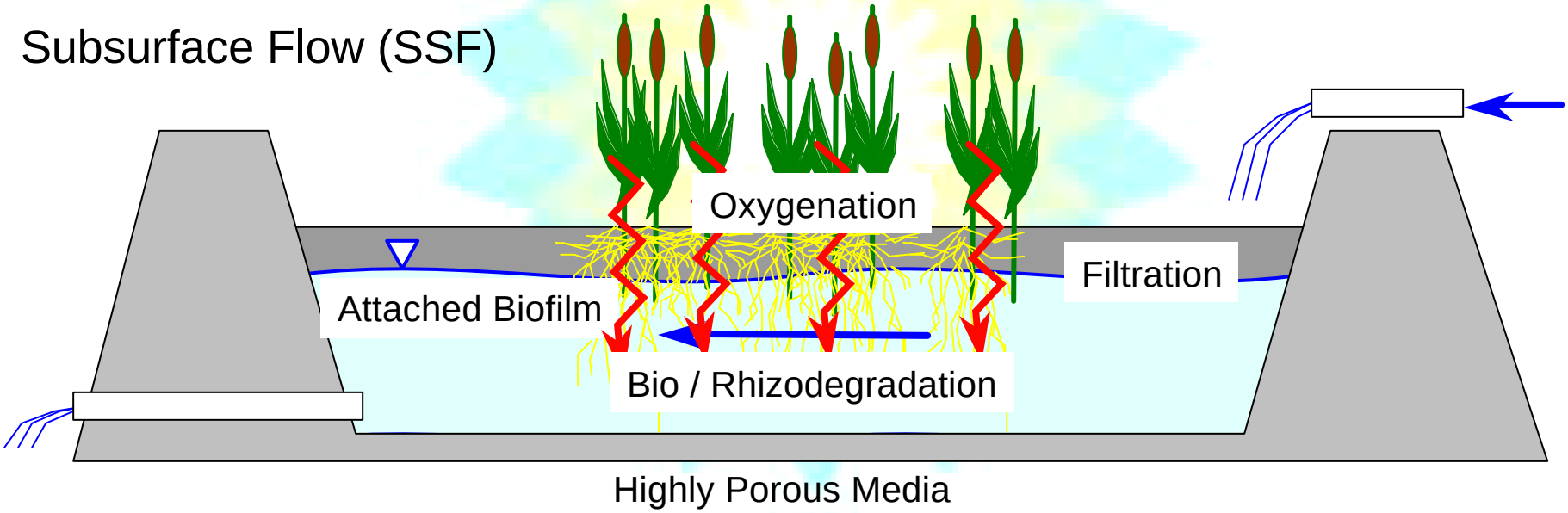

Pilot Wetland Study

Phytokinetics, NAWE, RETEC

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- **Constituent of Concern = Benzene**
  - ➔ 1.5 mg/L inlet; **<0.05 mg/L target outlet**
  - ➔ Utilize SSF design to reduce risks from exposure pathways
- **Issue 1:** Preliminary sizing w/o aeration – **too large (25+ ac SSF only)**
  - ➔ Utilize passive air stripping ?
  - ➔ Design forced aeration into the SSF system ?
- **Issue 2:** High Fe and Ca content (92.5 mg precipitate per L)
  - ➔ Precipitate out first or else **extensive fouling** of SSF system
- **12 Wetland Species Examined:**
  - ➔ *Cornus, Juncus, Phragmites, Salix, Scirpus, Typha*

- **Pilot Study Results Used for Final Design:**
  1. Enclosed cascade aerator (w/ bio-filter): 1.5 mg/L → 0.5 mg/L
  2. Sedimentation ponds and SF wetland: Fe/Ca precipitation
  3. Forced aeration SSF wetland: >95% benzene removal (0.5 mg/L → **<0.05 mg/L**)

Final Design Schematic

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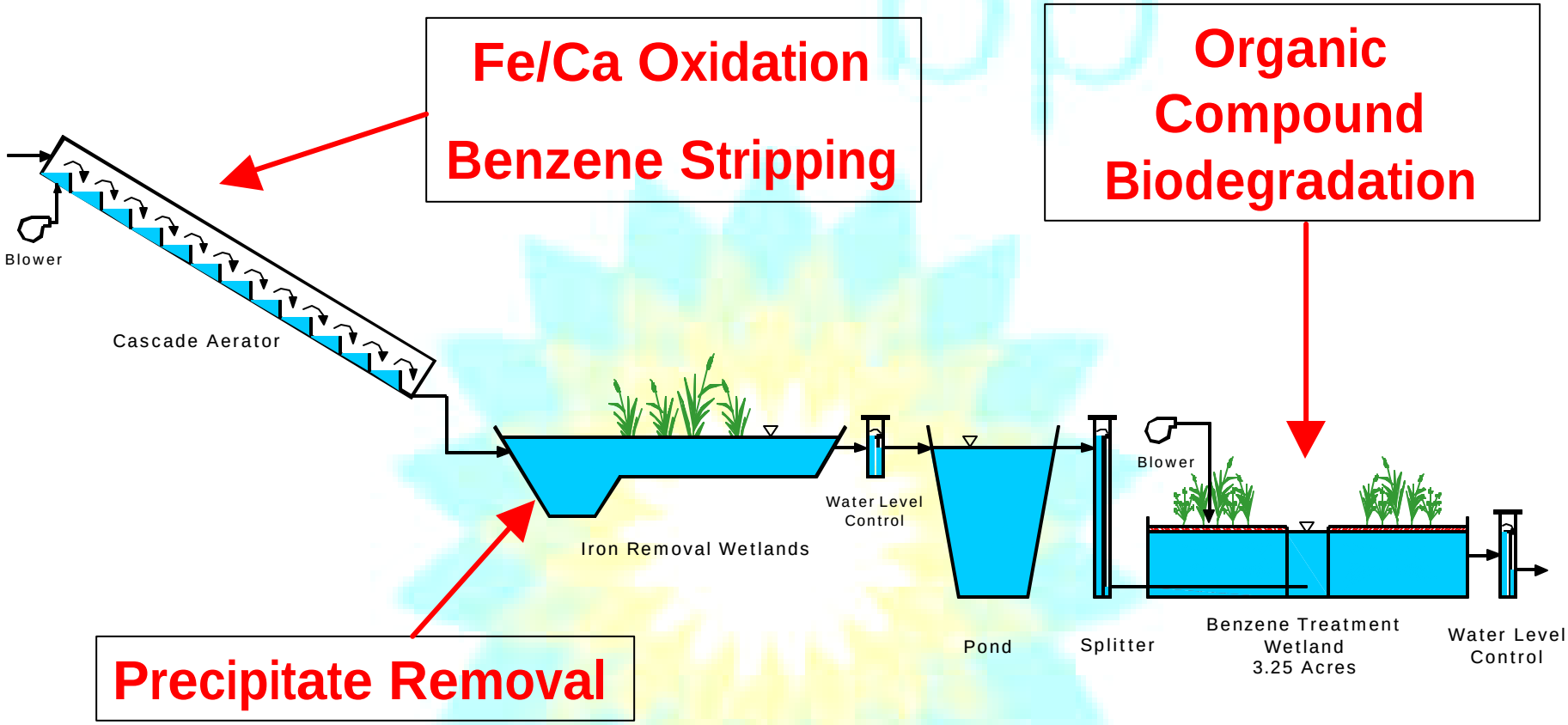

Reuse Plan

Incorporating Wetlands (into the Back 9)

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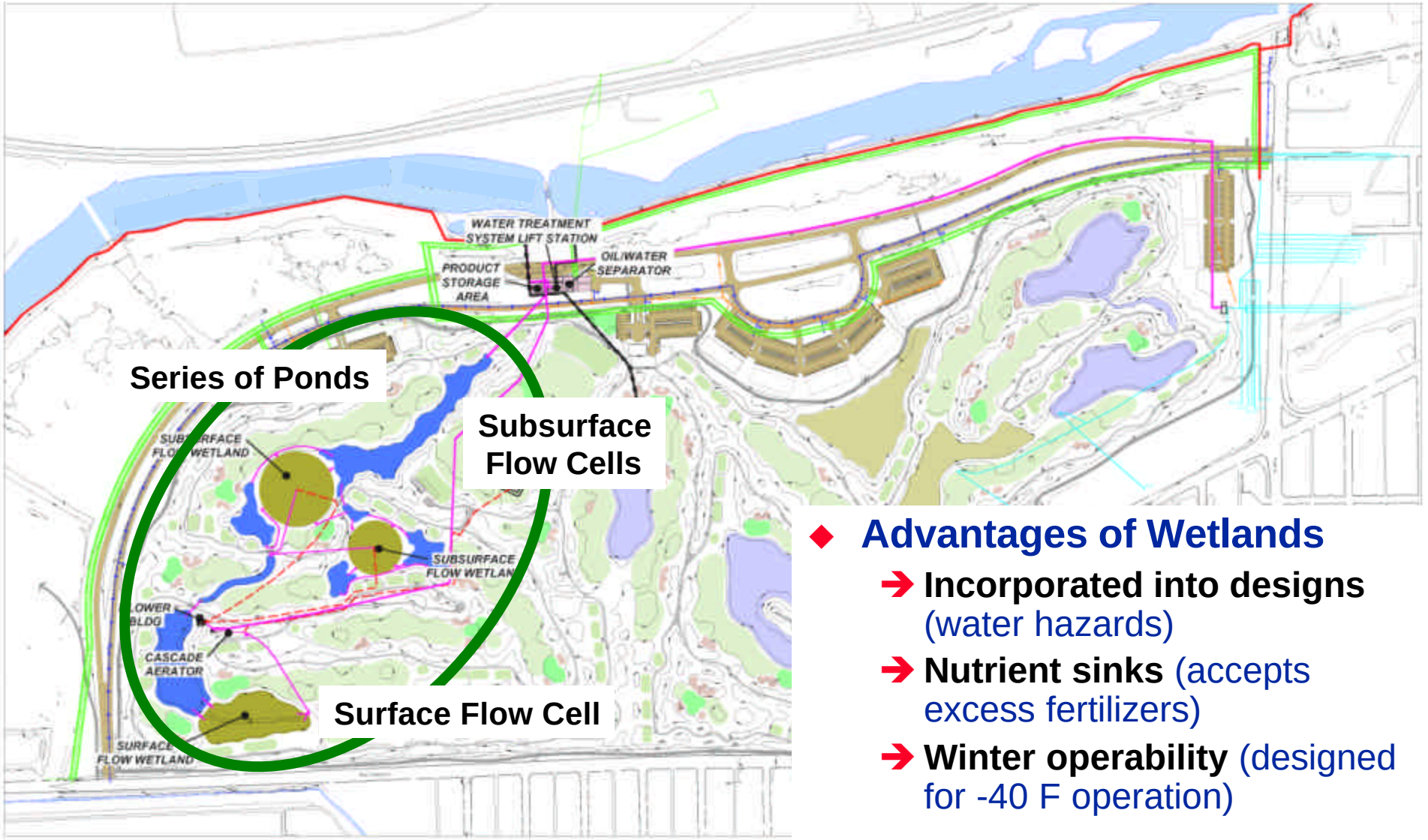

- **Advantages of Wetlands**
  - **Incorporated into designs** (water hazards)
  - **Nutrient sinks** (accepts excess fertilizers)
  - **Winter operability** (designed for -40 F operation)

Hydraulic Control Basics

Cone of Depression

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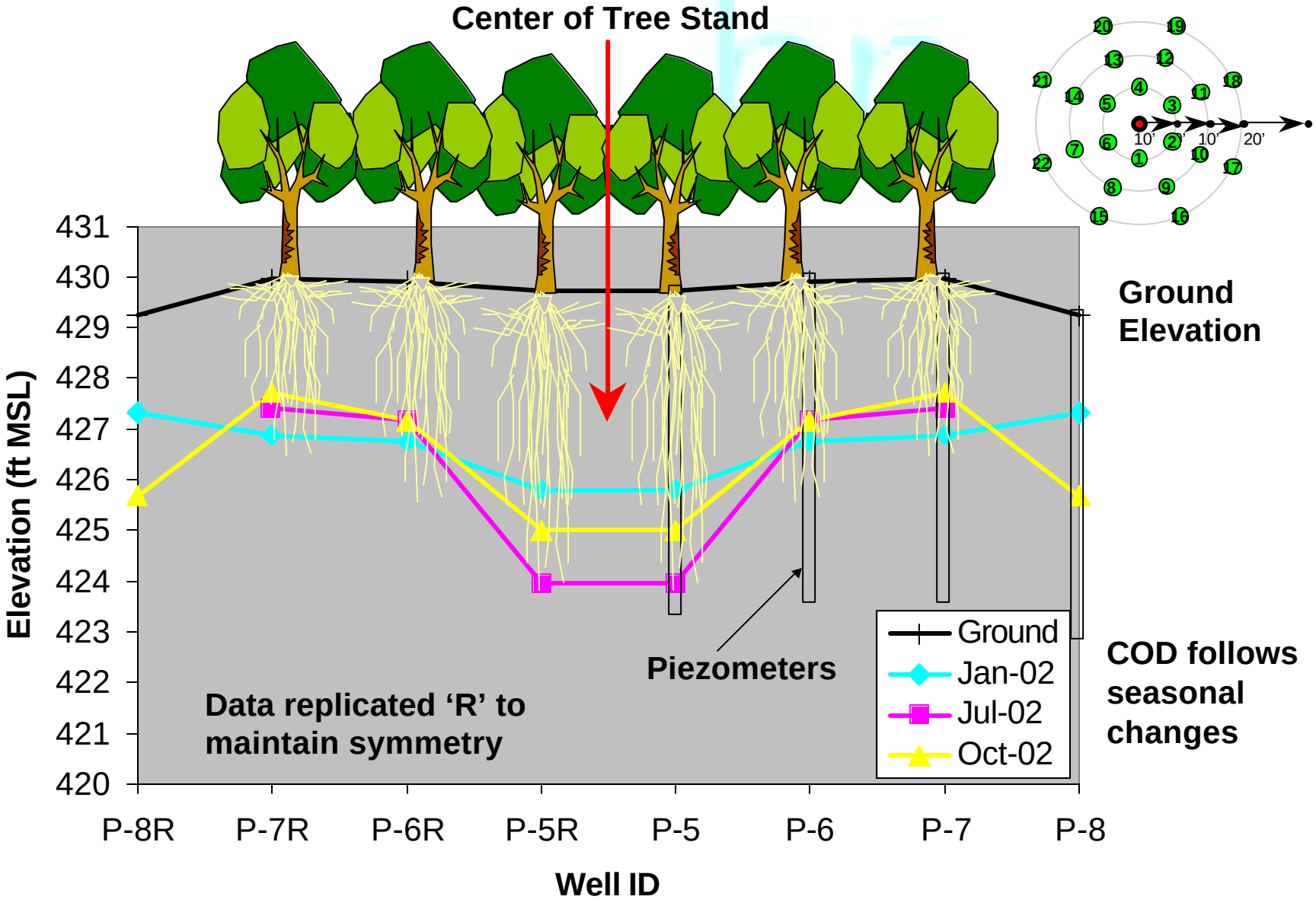

Projecting Water Usage

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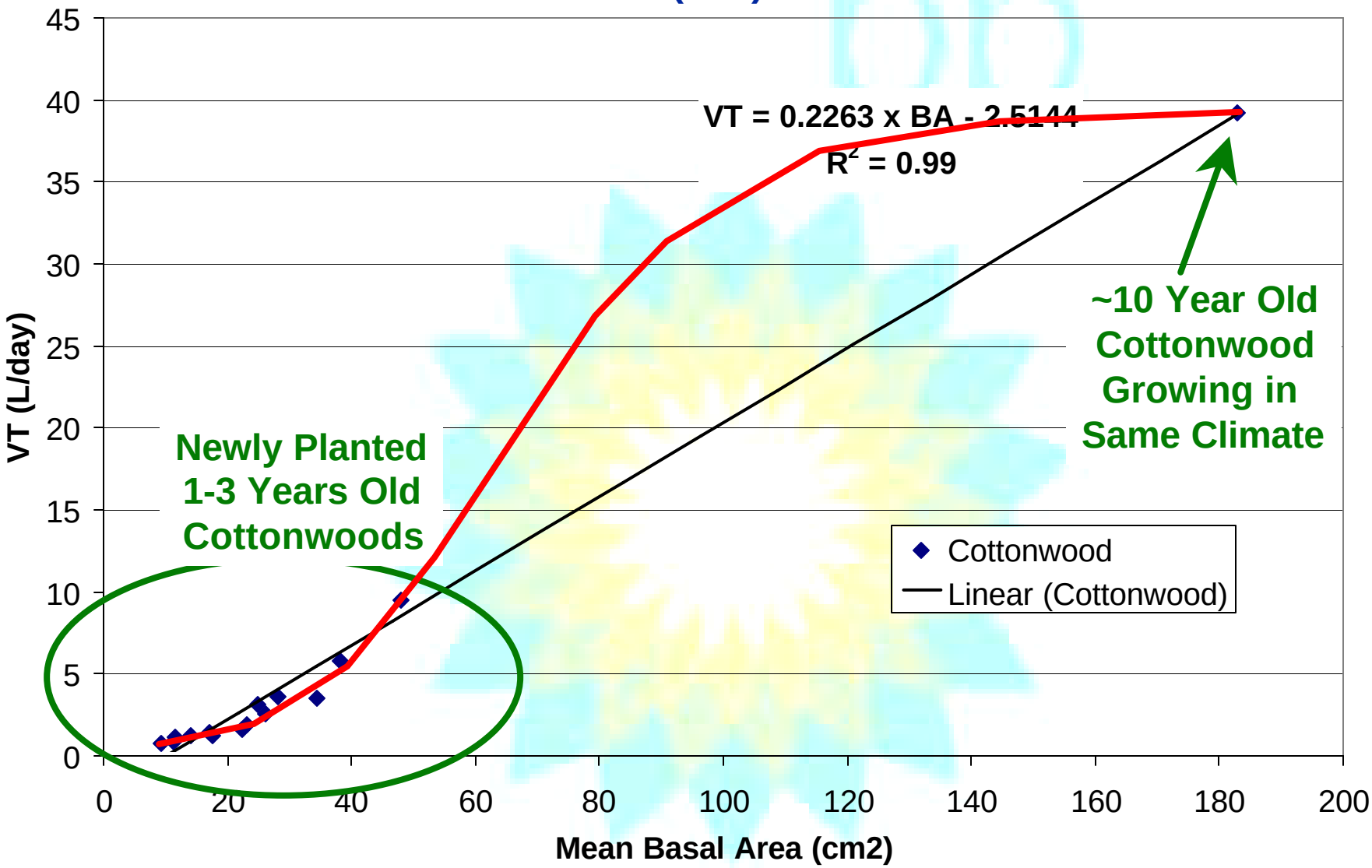
VT = Water Usage (L/day)
BA = Basal Area of Trunk (cm^2)



Reduce Physical GW Extraction

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- **Net Water Loss**
  - ➔ Pan Evaporation = **minus** 40 – 60 inches/year
  - ➔ Precipitation = **plus** 10 – 15 inches/year
  - ➔ **Overall loss = net 75% of pan evaporation**
  - ➔ **Good indicator** of the applicability of tree hydraulic barriers
- **Incorporate nature trails / park area next to river**
  - ➔ 20 acres planted at 800 trees/ac: 16,000 trees
  - ➔ At 10 years old (canopy closure): 10 gal/day per tree
  - ➔ 120 day growing season: 19.2 million gal/yr
  - ➔ Account for precipitation: **14.4 million gal/yr**
- **Natural groundwater reduction**

Reuse Plan

Incorporating Tree Barriers

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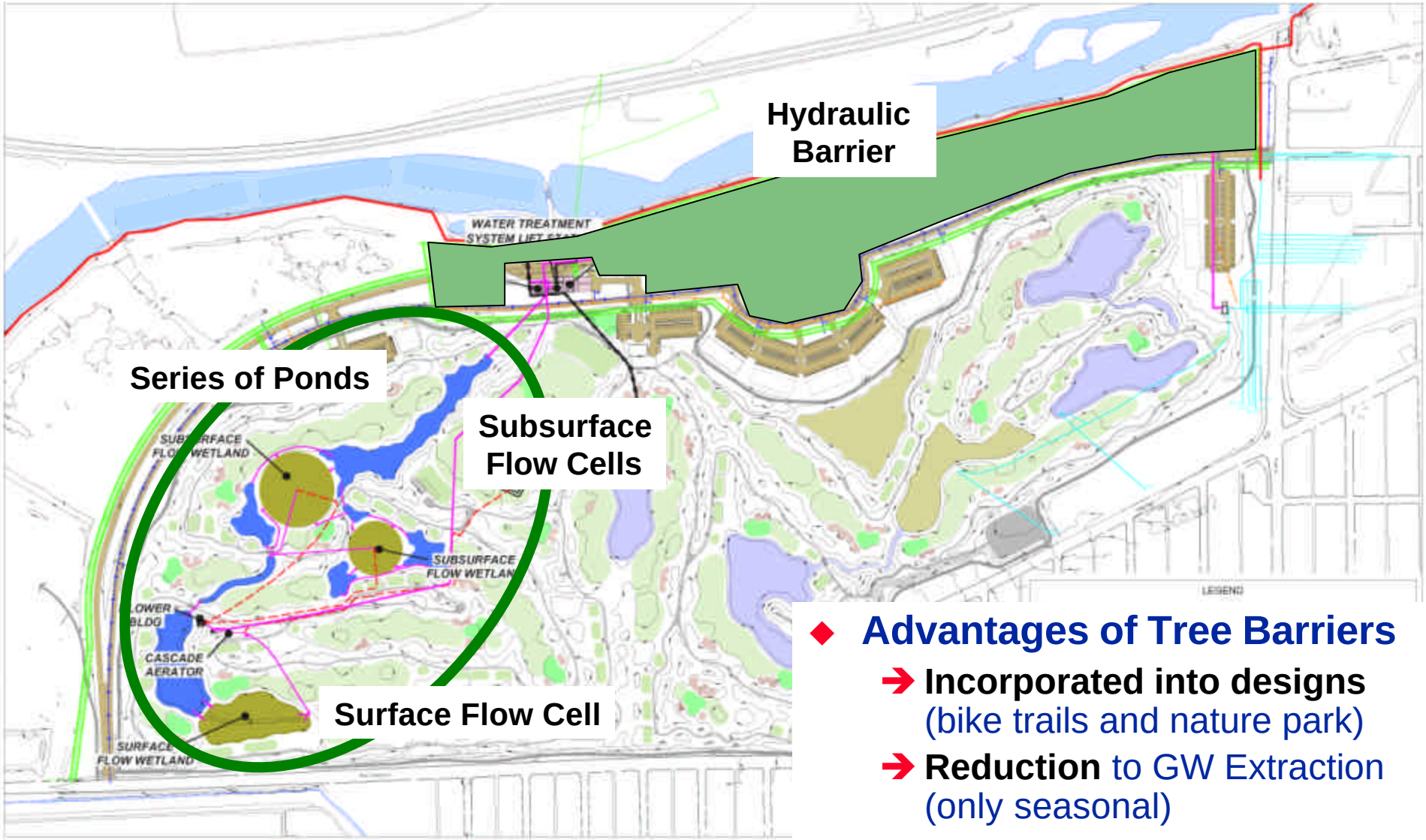

- **Advantages of Tree Barriers**
  - ➔ **Incorporated into designs** (bike trails and nature park)
  - ➔ **Reduction** to GW Extraction (only seasonal)

Vegetative Covers

Deep-Rooted Species

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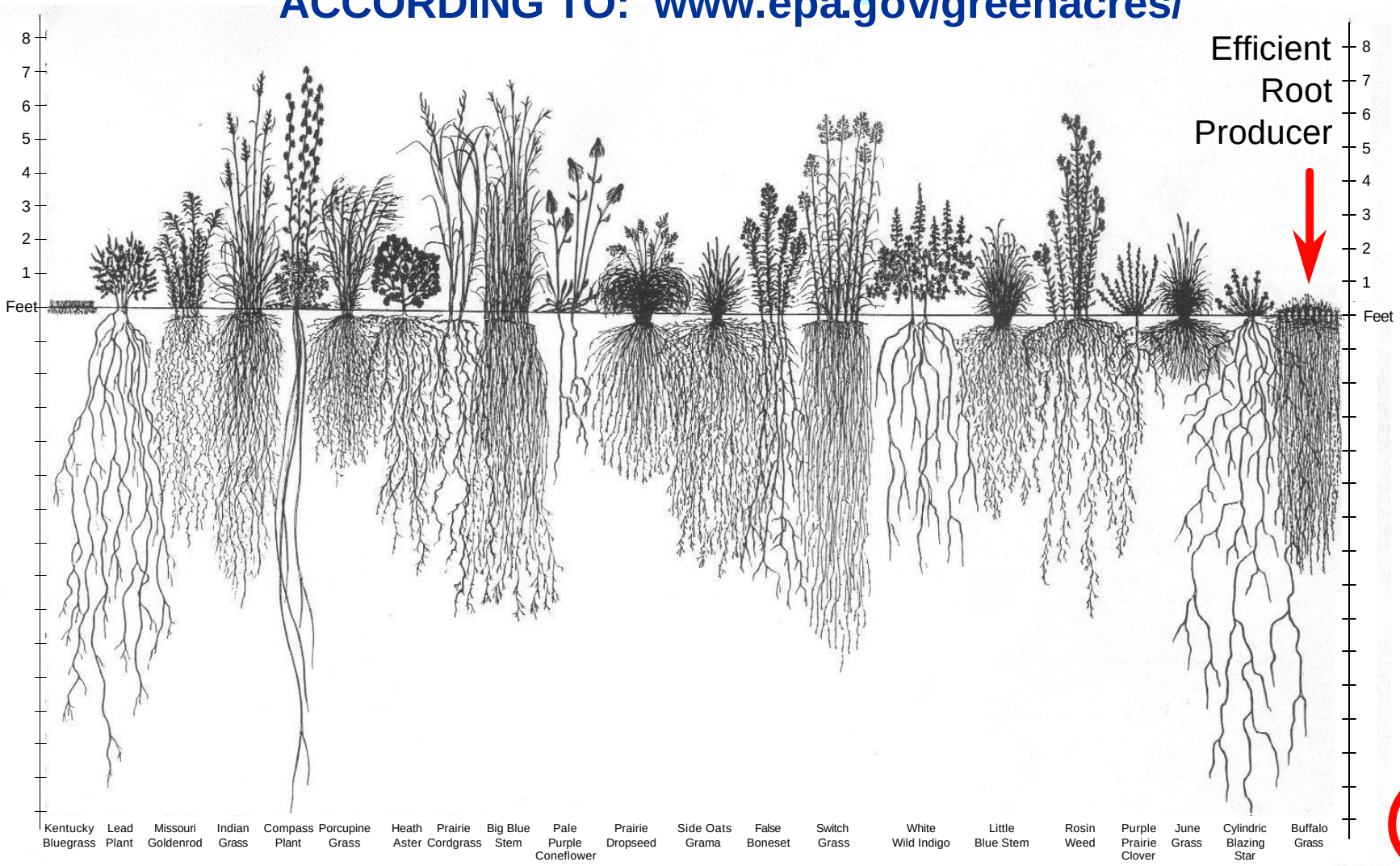
ACCORDING TO: www.epa.gov/greenacres/



Root Systems of Prairie Plants - From the U.S. EPA Handbook on Natural Landscapes

Conservation Design Forum, Inc.
Heidi Natura 1995 ©

Remedial Capabilities of Buffalo Grass

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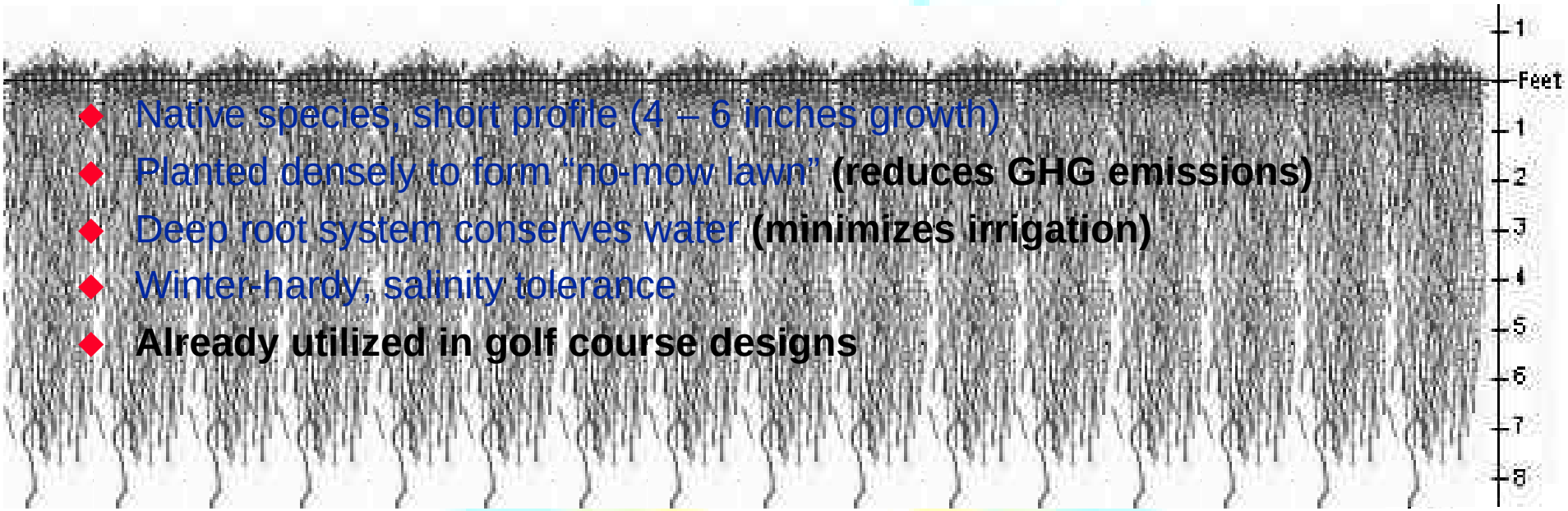

- Native species, short profile (4 – 6 inches growth)
- Planted densely to form "no-mow lawn" **(reduces GHG emissions)**
- Deep root system conserves water **(minimizes irrigation)**
- Winter-hardy, salinity tolerance
- **Already utilized in golf course designs**

- **Potential for Rhizodegradation**
- **Screening Experiments (gasoline dissolved in irrigation):**
  - ➔ Tested increasing concentrations: up to saturation
  - ➔ Max concentration in irrigation: **60.3 mg/L BTEX, 2,400 mg/L MTBE**
  - ➔ **RESULTS:** **Buffalo Grass remained healthy**

Phase 2 - Gasoline Injections

+/- 10% MTBE

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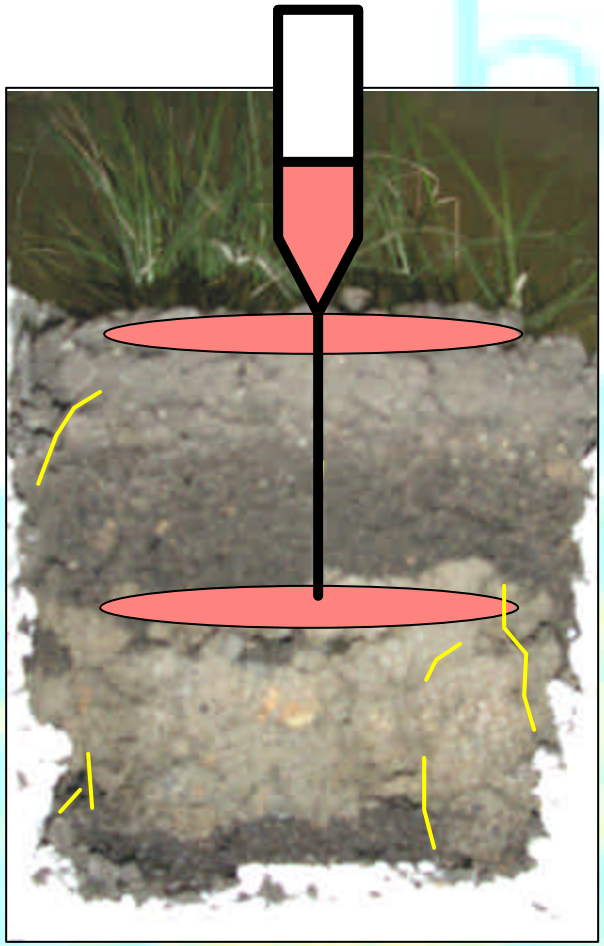
WEEK 1: **Injected 5 ml** gasoline

WEEK 2: **Injected 10 ml** gasoline

WEEK 3-5: **Surface applied 10 ml** gasoline per week

WEEK 6: **Harvested and sampled soils**



Cut open pots to confirm roots were growing throughout soil (yellow highlights)

1 L total soil volume

Some signs of stress, NO mortality

Buffalo Grass

Screening Results

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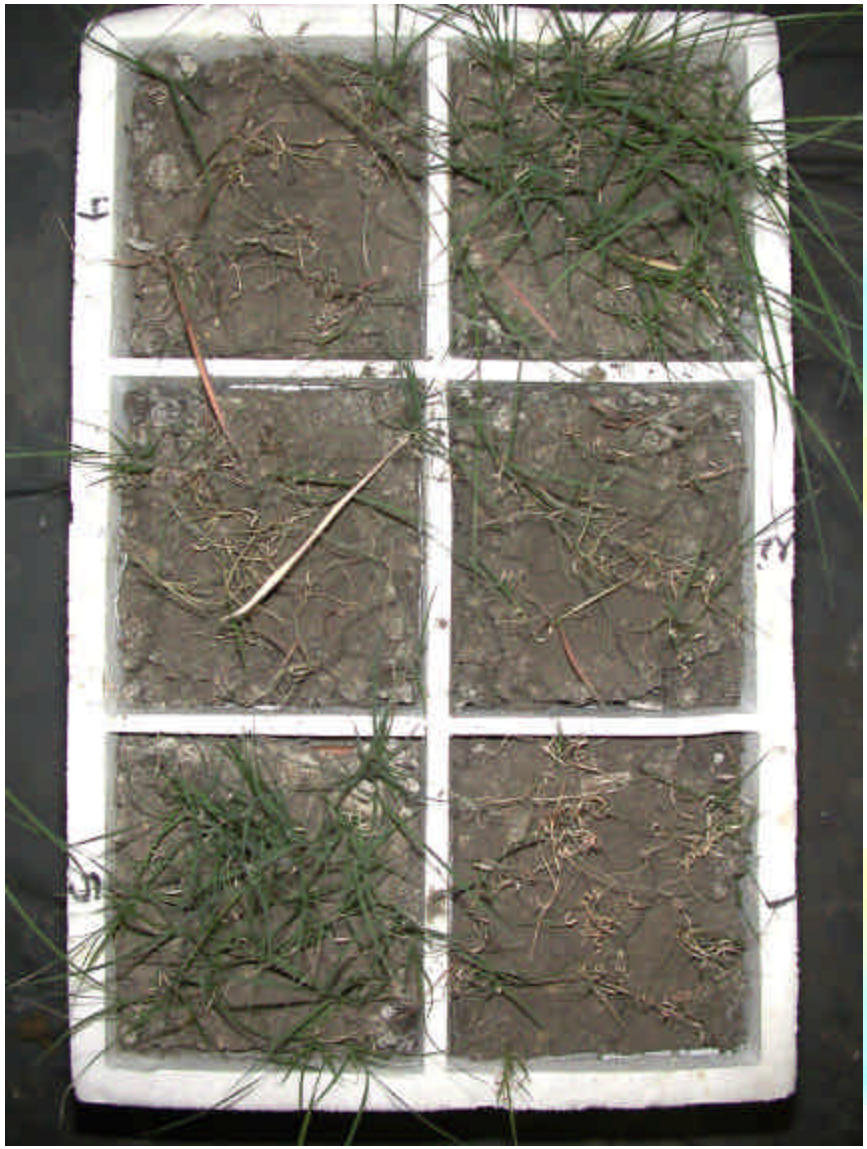
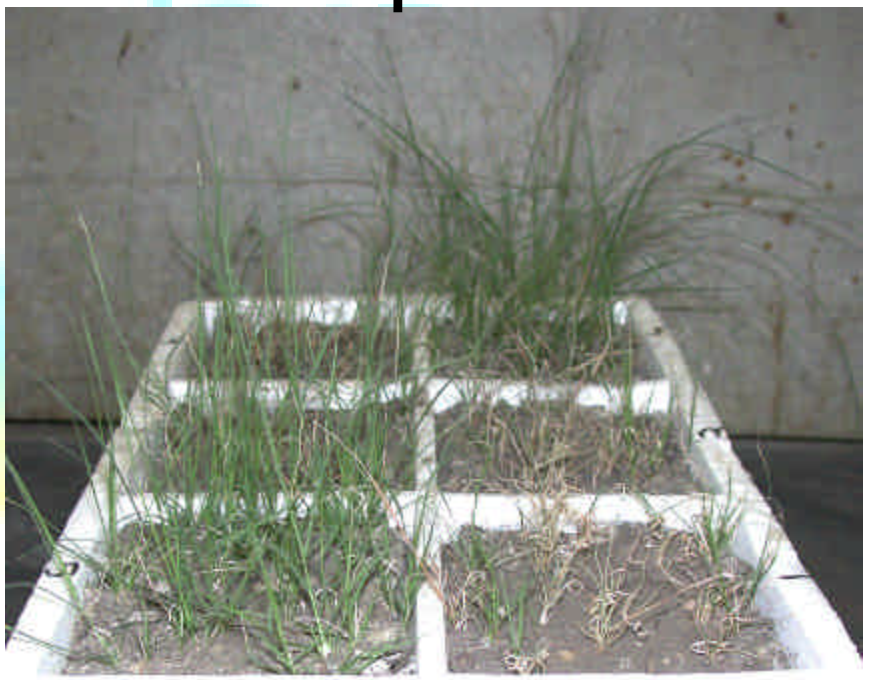
45 mls per 1 L cell





Final Soil Concentrations:

Top Layer: above injection

- BTEX **All Non-Detect ***
- MTBE **13 ug/kg**

Bottom Layer: below injection

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

Potential Fates of Gasoline and MTBE

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- **45 ml total volume of gasoline introduced**
- **Known Fate and Transport Mechanisms:**
  - → Some loss through **(phyto)volatilization** (noticeable odor)
  - → **Sorbed** onto soils (visible NAPL while sampling)
  - → **NONE leached** down (all water samples throughout were ND)
- **Other Suspected Mechanisms:**
  - → **Rhizodegradation: plant rhizosphere** built under slowly increasing gasoline (MTBE) concentrations
  - → **Phytodegradation: plant photosynthesis** produces very strong oxidants (oxidize water)
    - i.e. Advanced Oxidation Process

Reuse Plan

Incorporating Vegetative Covers

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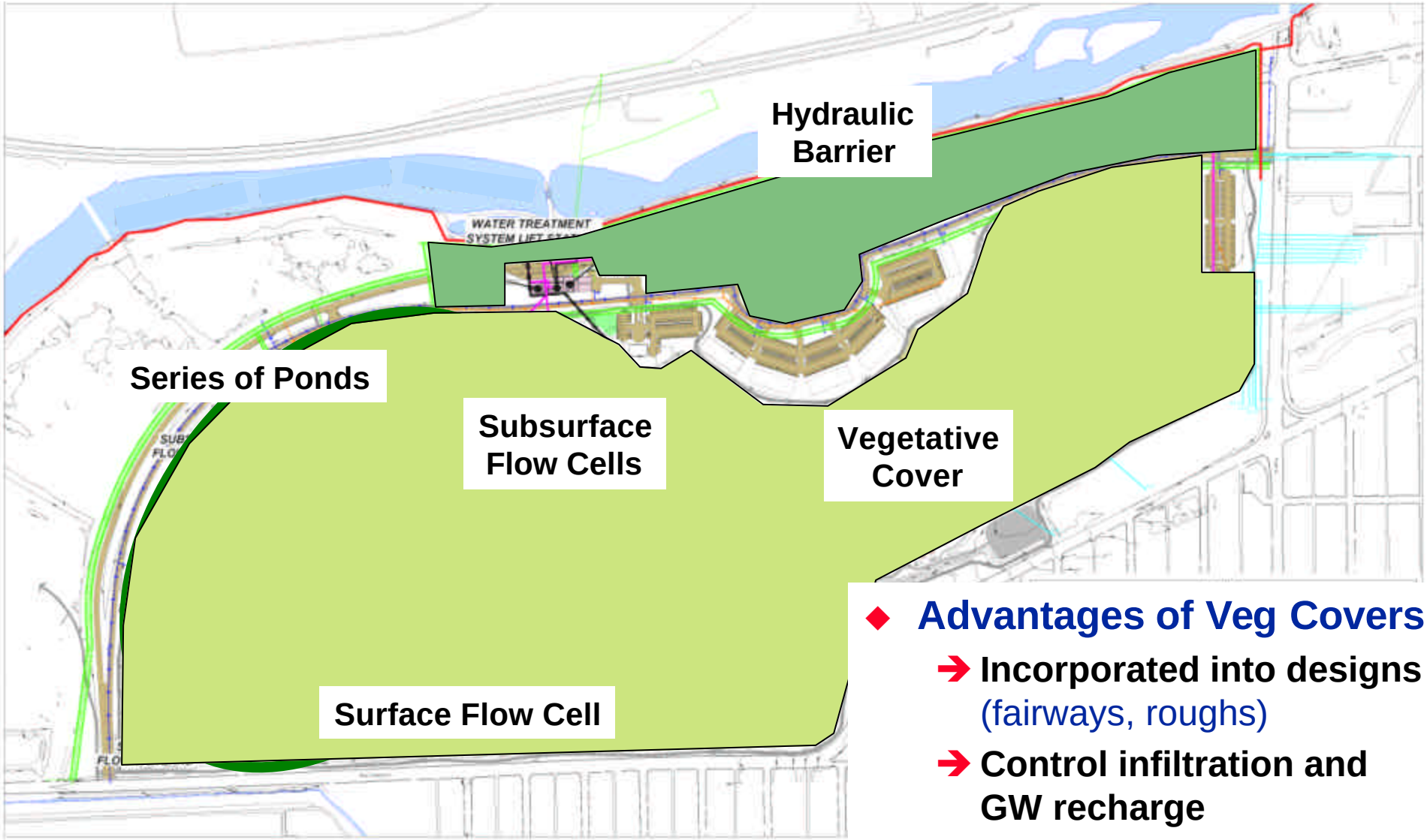
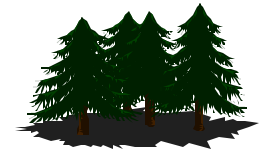


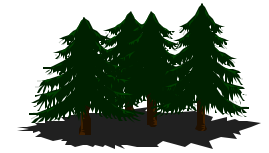
- **Advantages of Veg Covers**
  - ➔ **Incorporated into designs** (fairways, roughs)
  - ➔ **Control infiltration and GW recharge**

Conclusions



- **ENVIRONMENTAL WIN:**
  - ➔ Contaminant reduction: **Treatment Wetlands**
  - ➔ River protection: Barrier Wall, Extraction Wells, **Tree Hydraulic Barrier**
  - ➔ Mitigate soil/GW pathways: **Vegetative Cover**
  - ➔ Air emissions pathway: Bio-Filter
- **SOCIAL WIN:**
  - ➔ Increased revenue, tax base, property value, **livelihoods**
  - ➔ Enhanced community relations **(working together)**
  - ➔ Golf course **construction commencing in 2003**
  - ➔ Golf course opens 2004 **(Fore for '04)**
- **FINANCIAL WIN:**
  - ➔ Capital Costs $16 million reduced to **$3.5 million**
  - ➔ **Total Life Cycle Costs** $40+ million reduced to **$16 million**

Phytotechnology Resources



- **US EPA Citizen's Guide to Phytoremediation**
  - ➔ **http://www.epa.gov/swertio1/products/citguide/phyto.htm**
- **US EPA Remediation Technology Development Forum**
  - ➔ **http://www.rtdf.org/public/phyto/default.htm**
- **US EPA Use of Natural Landscapes**
  - ➔ **http://www.epa.gov/greenacres/**
- **US Interstate Technology and Regulatory Cooperation**
  - ➔ **http://www.itrcweb.org/reports/phyto**
  - ➔ **Phyto Decision Tree, Tech & Reg Guidance Document**
- **International Phytoremediation Electronic Network**
  - ➔ **http://www.dsa.unipr.it/phytonet/**
- **USDA PLANTS National Database**
  - ➔ **http://plants.usda.gov/**
- **AEHS - International Journal on Phytoremediation**