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#### Phytoremediation Feasibility for Brownfield Sites

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#### Overview



- Applicability to Brownfield Site Redevelopment
- What is Phytoremediation?
- Why Use Phytoremediation?
- Engineered systems: TreeWell System
- Case study

#### Applicability to Brownfield Redevelopment

- Soil remediation is commonly completed prior to brownfield reconstruction, but groundwater remediation can take years
- Groundwater remediation systems take many forms:

1. Many have mechanical aboveground components that operate 24/7/365,

2. Some mimic portable chemical mixing plants,

 Others can be more discreet (e.g. barrier walls, phytoremediation)



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#### Applicability to Brownfield Redevelopment

- Operations & Maintenance (O&M) of mechanical or chemical injection systems can be intrusive
- For some sites, intrusive remediation O&M is an is an issue

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- Phyto O&M:
  - makes less noise than most systems
  - makes less waste than most systems
  - requires less frequent O&M site visits
- As a best practice, phyto design can be planned in conjunction with the developers
  - Optimize placement of buildings and remediation vegetation areas
  - Resource for landscape designers: K. Krennan and N. Kirkwood. 2015. Phyto: Principles and Resources for Site Remediation and Landscape Design

# What is Phytoremediation?

What is it?

 Use of plants to degrade or contain contaminants from groundwater, soil, sediments and surface water

#### Mechanisms:

- Phytosequestration
  - Sequester contaminants in root zone (containment)
- Rhizodegradation
  - Microbial biodegradation within root zone (remediation by destruction)
- Phytohydraulics
  - Capture and evaporate water (containment)
- Phytoextraction
  - Uptake of contaminants into plant (remediation by removal)
- Phytodegradation
  - Uptake and breakdown of contaminants (remediation by destruction)
- Phytovolatilization
  - Uptake and transpire volatile contaminants (remediation by removal)

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Image: ITRC Phytotechnology Guidance (2009)

#### Why Use Phytoremediation?





Example contaminants – Petroleum hydrocarbons, CVOCs, Metals, MTBE, 1,4-Dioxane

#### Why use it?

- "Green & Sustainable" vs other more conventional technologies
- Low carbon foot print
- Potentially much lower cost than other treatment technologies
- Proven long-term track record when designed and implemented correctly
- Well accepted by regulatory community
- Improves with time (trees grow larger, use more water)
- Aesthetically pleasing

# Engineered Phytoremediation: The *TreeWell* System



- Active treatment in a passive manner
- Targets <u>specific</u> groundwater by directing root growth downward to capillary fringe

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- Groundwater is drawn upward through the soil column, then absorbed by plant roots
- Bioreactor effect both oxidizing and reducing zones in each unit
- Increases soil temps enhances biodegradation rates in vadose zone
- Patented, but available for use via specific contractors

#### Engineered Phytoremediation: The "Straw" *TreeWell* Unit



#### "Straw" TreeWell Design

- Targets deep confined aquifers
- Overcomes constructability challenges of shallower water-bearing zones above the aquifer of interest
- Hydraulic head drives target groundwater into the TreeWell unit through the double-screened "straw" piezometer

# Case Study: Central FL 1,4-Dioxane in Groundwater

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#### Site Background

- Fractured bedrock aquifer 5'-15' bgs
- Contaminant flux in a thin fractured zone from 10 - 15' bgs
- Initial Remedy: Long-term pump & treat system with UV/Peroxide
  - >\$300K/Year O&M costs
  - >10 Years to meet Remedial Goals

#### **Remedial Goals**

- Hydraulic Control
- Contaminant Treatment



# Case Study: System Installation

2013 Installation

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- 154 Units Installed
- 48" Borehole Drilled to 15' bgs
- · Set liner system to top of impacted zone
- Plantings set 20 feet on center
- Native trees:
  - Slash Pine (Pinus elliottii)
  - Sycamore (Platanus occidentalis)
  - Willow (Salix caroliniana)
  - Pond Cypress (Taxodium ascendens)



## Case Study: Impact on Groundwater Flow





- <u>Yellow</u> = initial GW flow (towards site boundary)
- Blue = GW flow <u>18 months</u> <u>after</u> Engineered Phyto System installed (gradient reversal/ hydraulic control; flow towards the Phyto System)
- GW Flow results have been consistently positive:
  - Some changes in flow were seen in the first season
  - By the end of the second season, groundwater flow had reversed

Demonstration of hydraulic capture enabled shutdown and decommissioning of the existing P&T system.

# Case Study: Monitoring Data





### Case Study: Cost Savings of Phytoremediation

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Note: Cost estimate provided by client

## Summary of Key Phyto Benefits

 Phyto can reduce contaminant concentrations and change groundwater gradients when applied with engineered design

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- Highly adaptable to specific site conditions and contaminants
- Applicable to many contaminants even at high concentrations
- Applicable to many sites even in cold climates
- A viable alternative to many P&T systems, using *TreeWell* technology
- Potential of significant cost-savings over conventional treatment options
- Stand-alone, green & sustainable technology

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