OVERVIEW OF NATURAL SYSTEMS FOR WASTEWATER TREATMENT

December 14, 2011

Presented by
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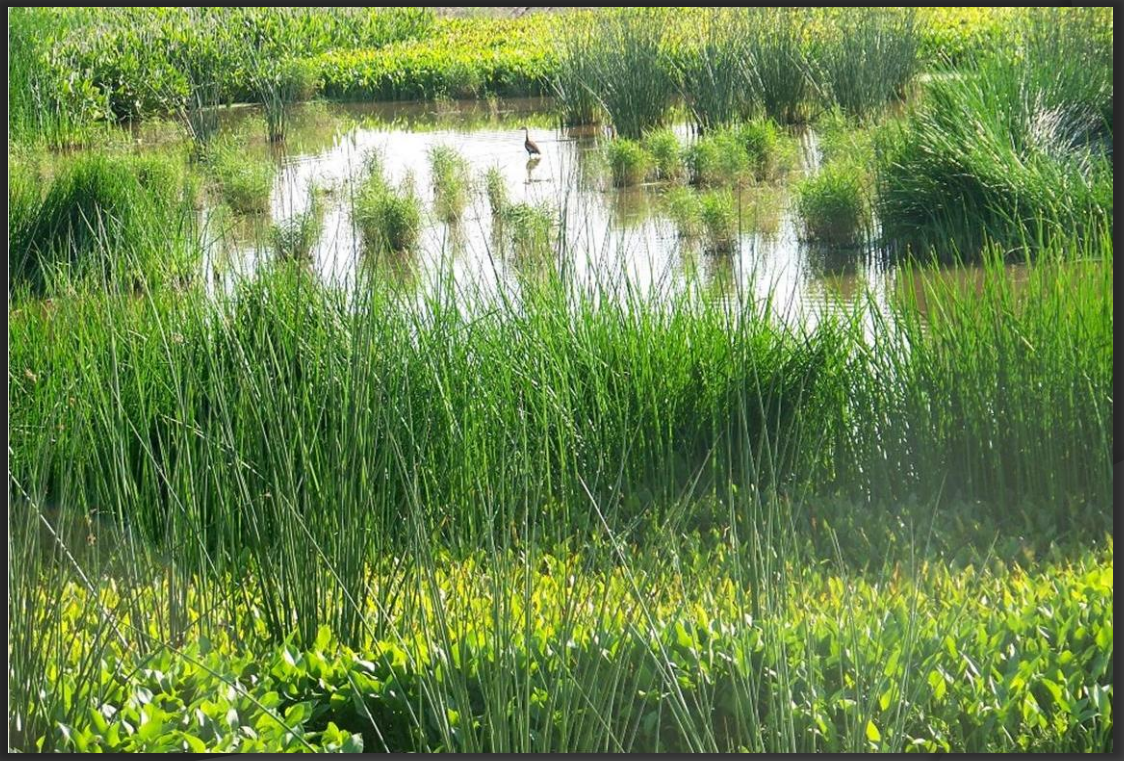
What Are Natural Systems?

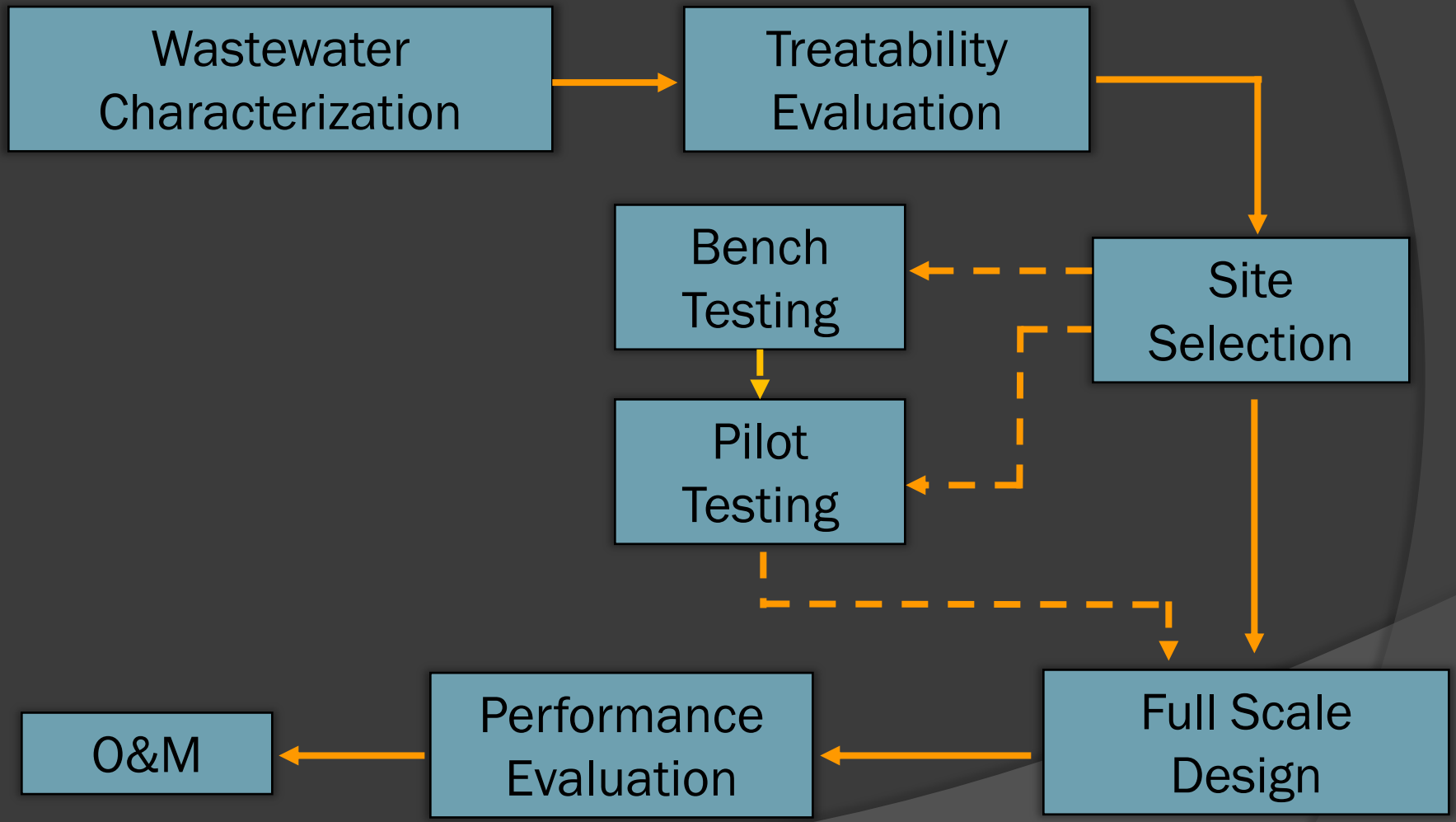
- Technologies that optimize natural processes to clean contaminated soils and water
  - Sustainable
  - Low Cost
  - Low Impact
  - Long Life
  - High PR



Natural System Technologies

- Constructed Treatment Wetlands
- Natural Media Filters
  - Engineered Soil Profiles
  - Compost Filters
  - Sand Filters
- Phytotechnology
  - Hydraulic Control
  - Biodegradation
- Low Impact Development
  - Bioretention/Rain Gardens
  - Vegetated Filter Strips
  - Grass/Vegetated Swales
  - Porous Pavement

Design Elements

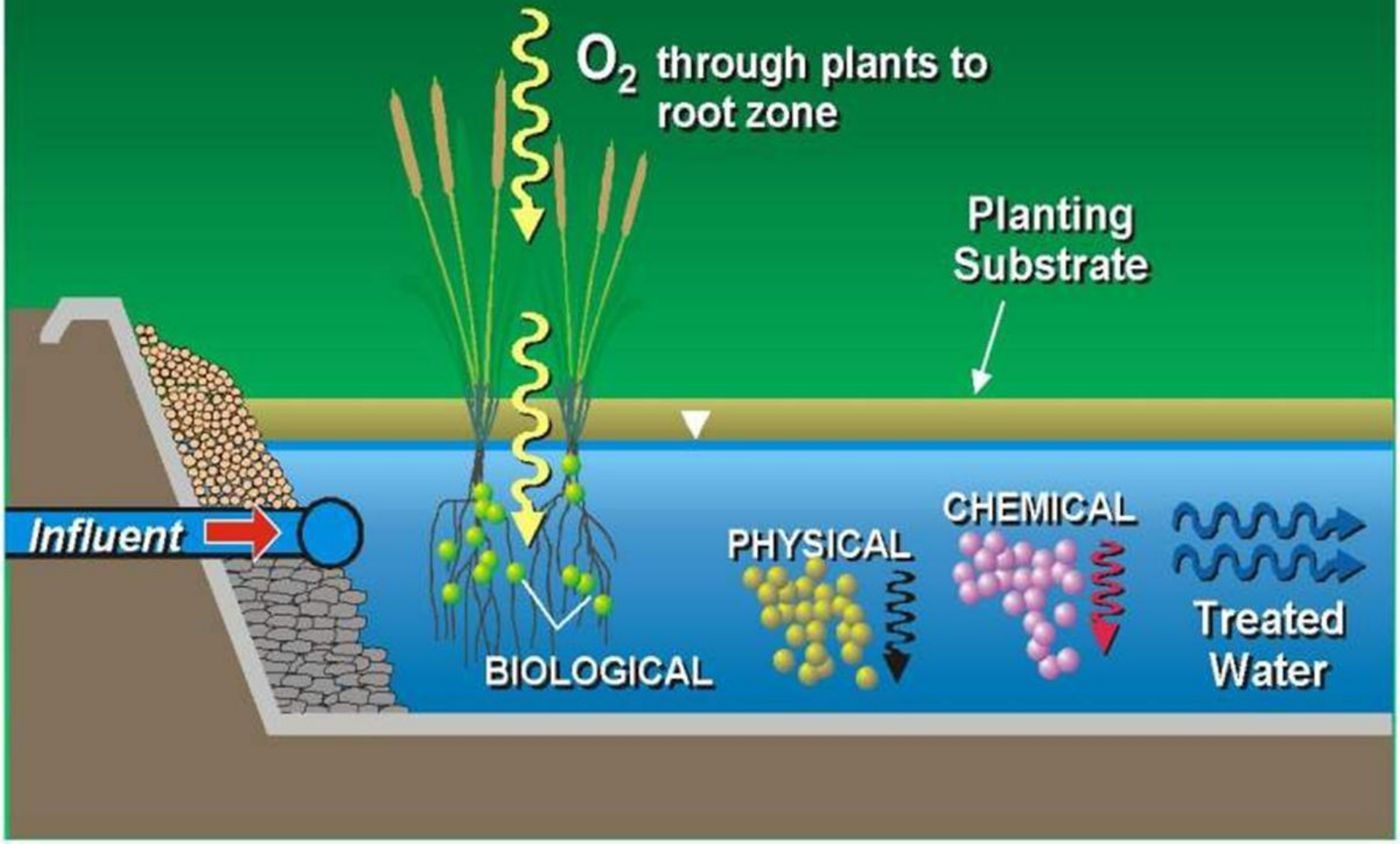


Constructed Treatment Wetlands

Engineered treatment system designed to achieve water quality improvements by maximizing processes that occur in natural wetlands

- Acid Mine Drainage
  - Metals
  - TSS
  - pH
- Municipal Wastewater
  - Nutrients
  - Pathogens
- Landfill Leachate
  - Metals
  - Ammonia
- Agricultural Runoff
  - TSS
  - Nutrients
- Urban and Industrial Stormwater
  - Metals
  - Nutrients
  - Solids
  - PCBs
- Industrial Wastewater
  - Metals
  - BTEX
  - PAHs
- Groundwater Remediation
  - Metals
  - BTEX
  - PAHs
  - Chlorinated Solvents

Contaminant Removal Mechanisms:
Multiple Processes At Work



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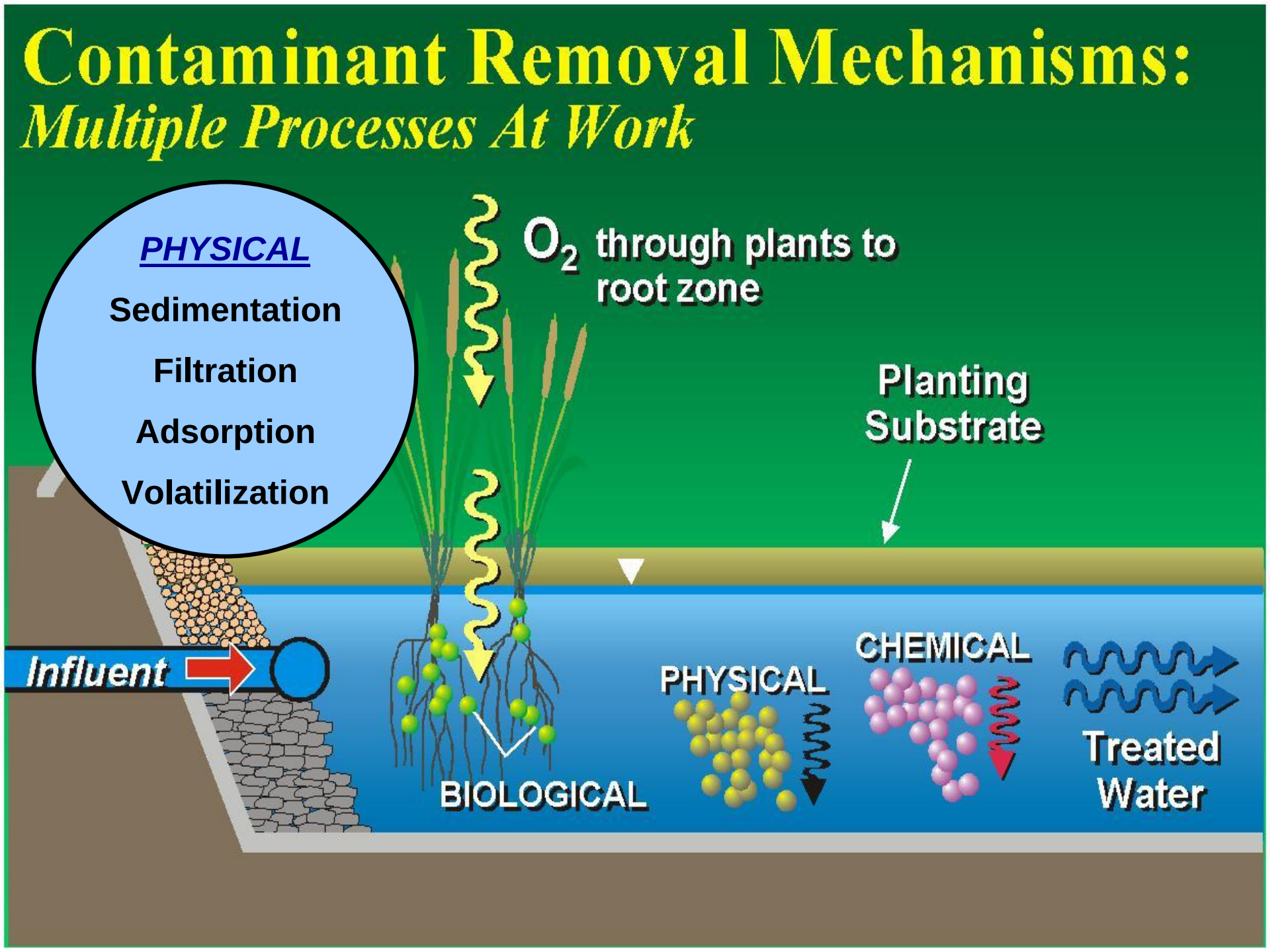
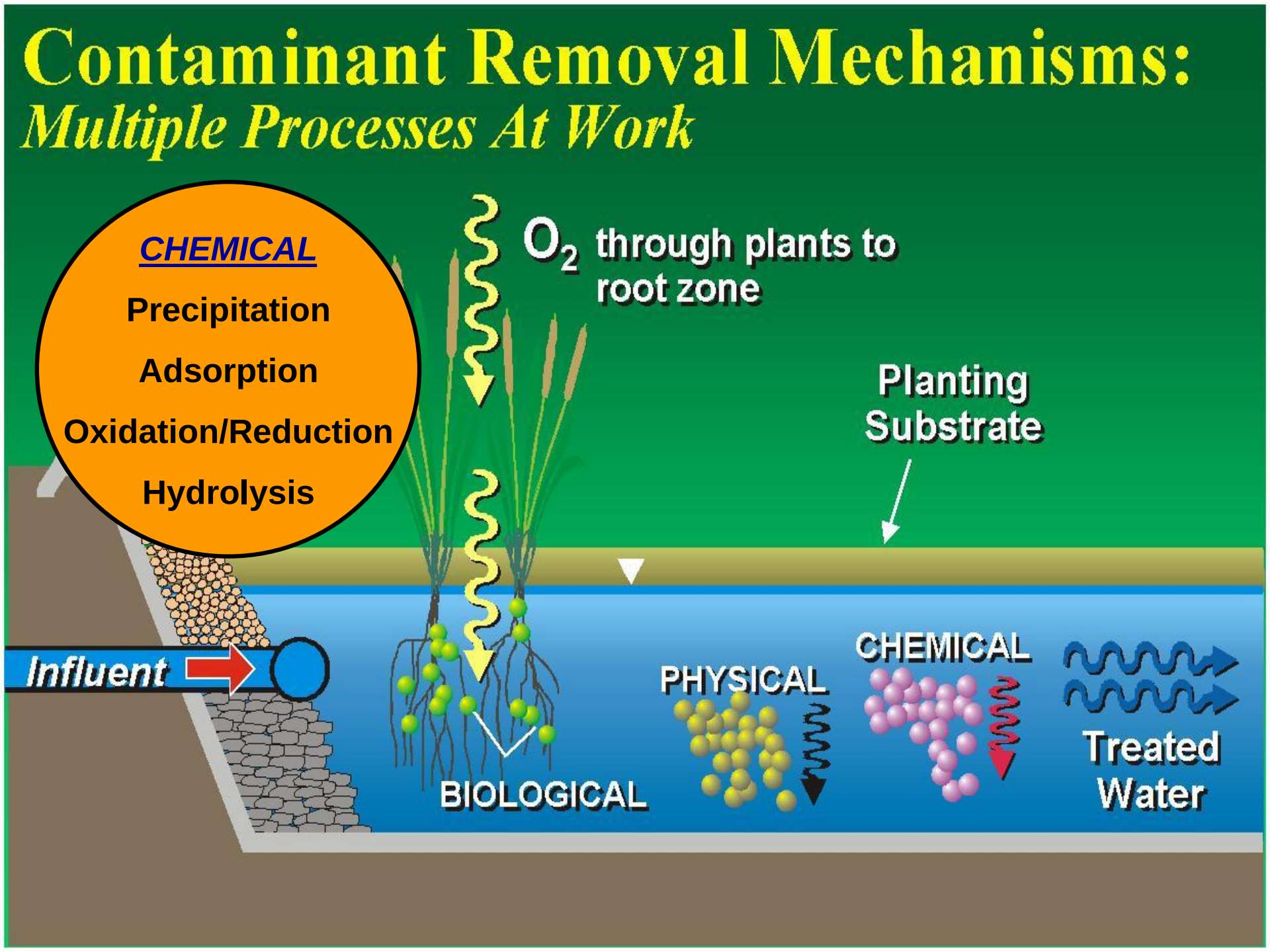
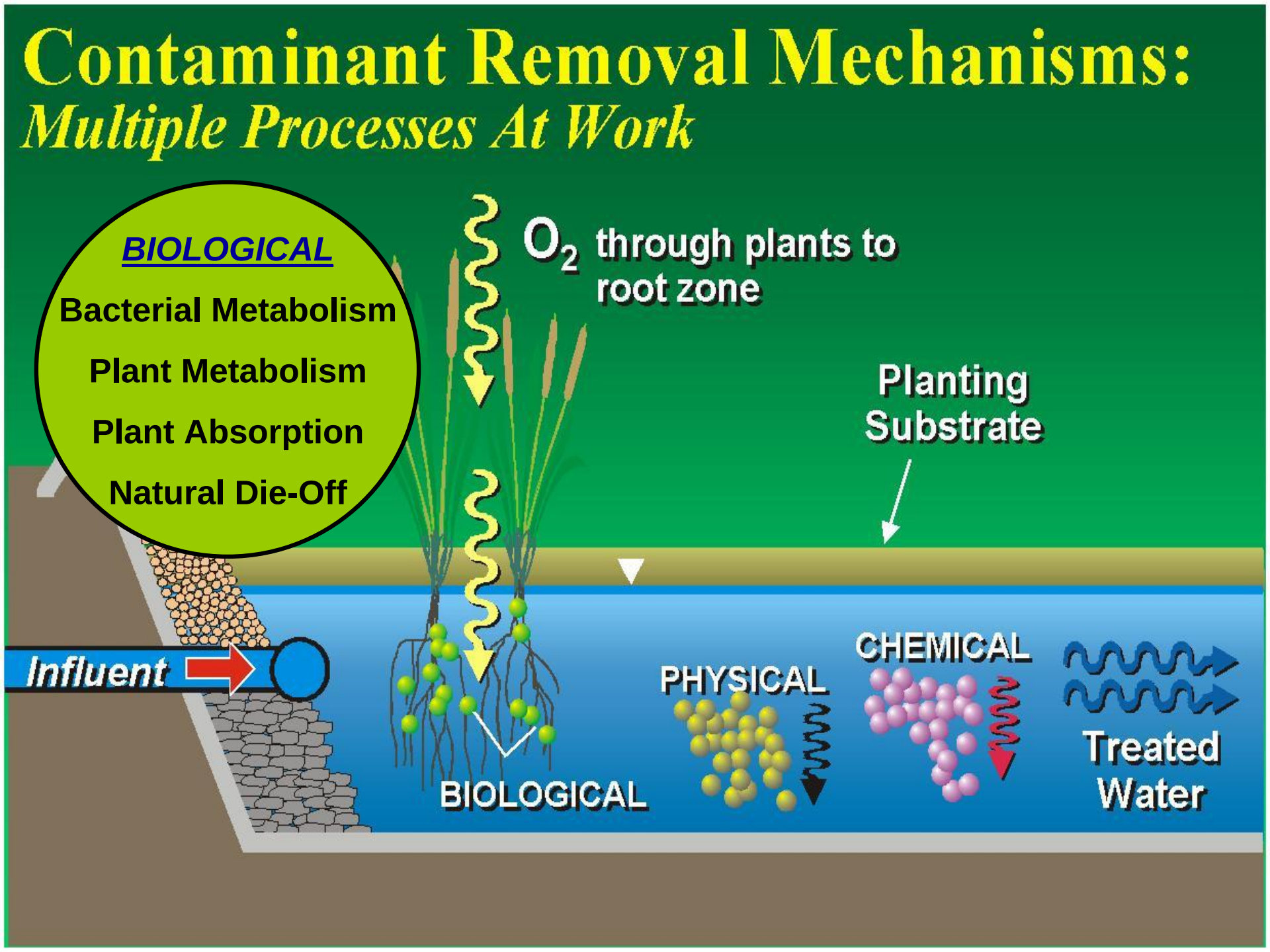


Contaminant Removal Mechanisms:
Multiple Processes At Work

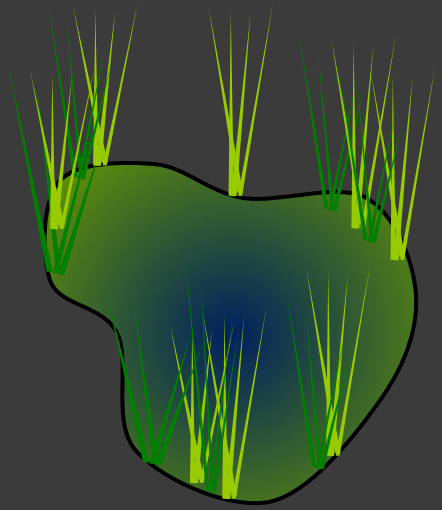


Contaminant Removal Mechanisms:
Multiple Processes At Work

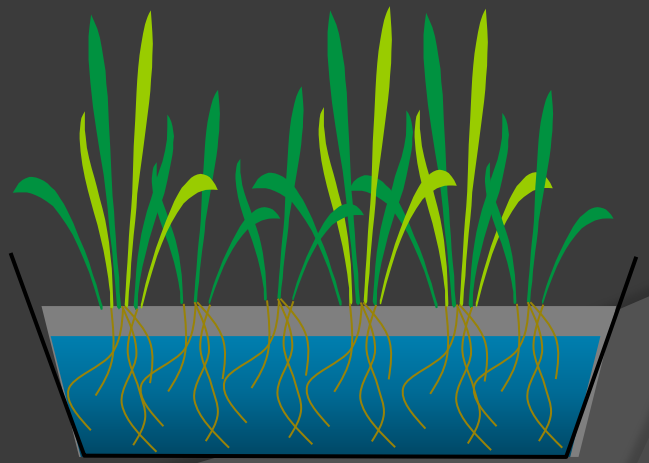


Constructed Treatment Wetlands

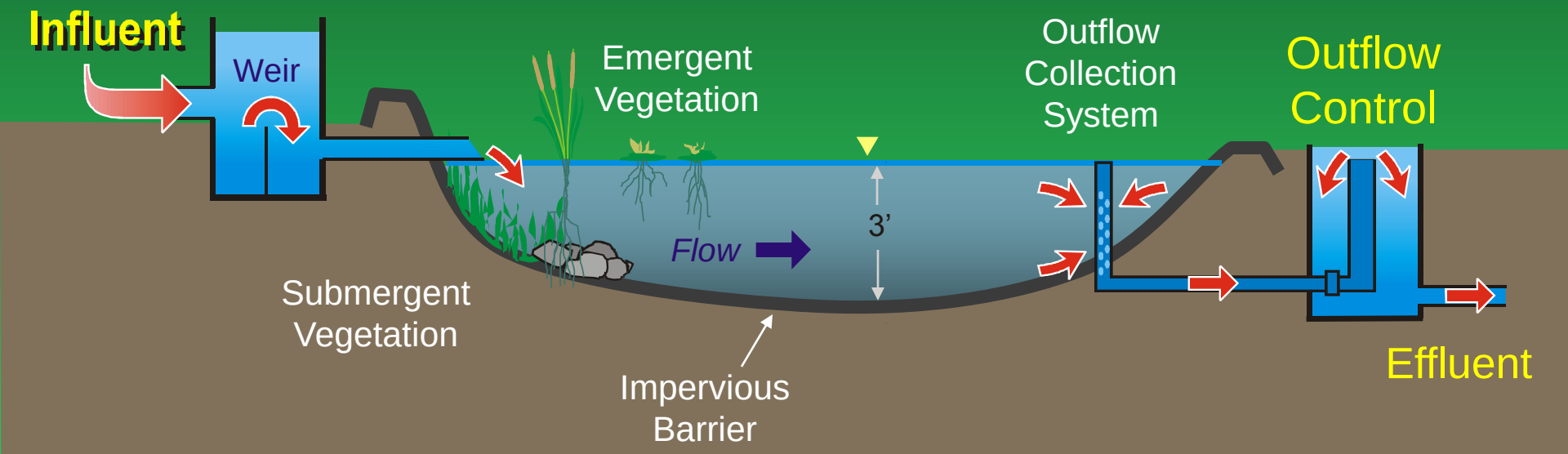
- Surface Flow
  - *Forebay*
  - *Shallow Marsh*
  - *Micropool*



- Subsurface Flow
  - Horizontal
  - Vertical
  - Batch
  - Enhanced



Free Water Surface



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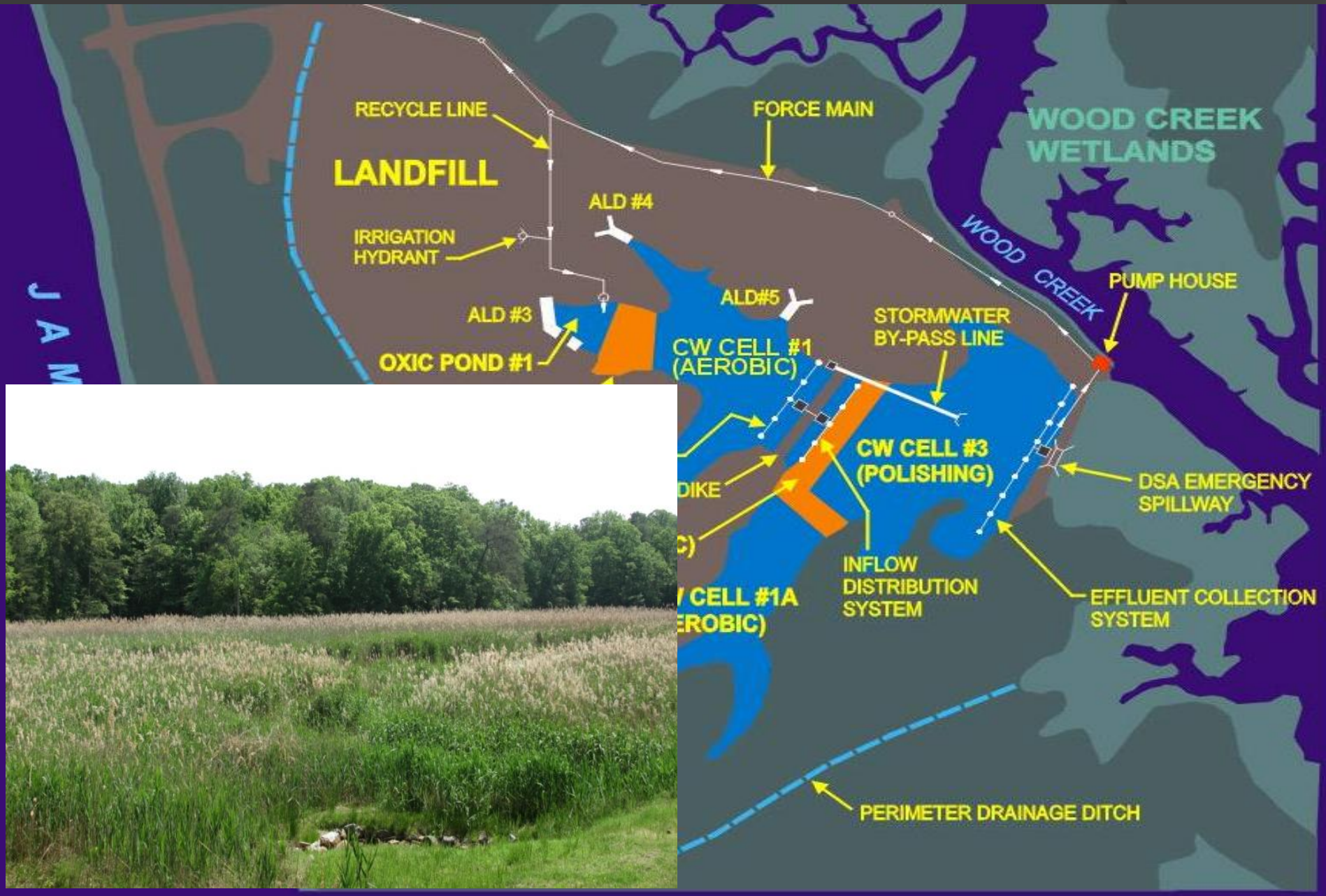
Landfill Leachate, VA



Metal Refinery Runoff, TX

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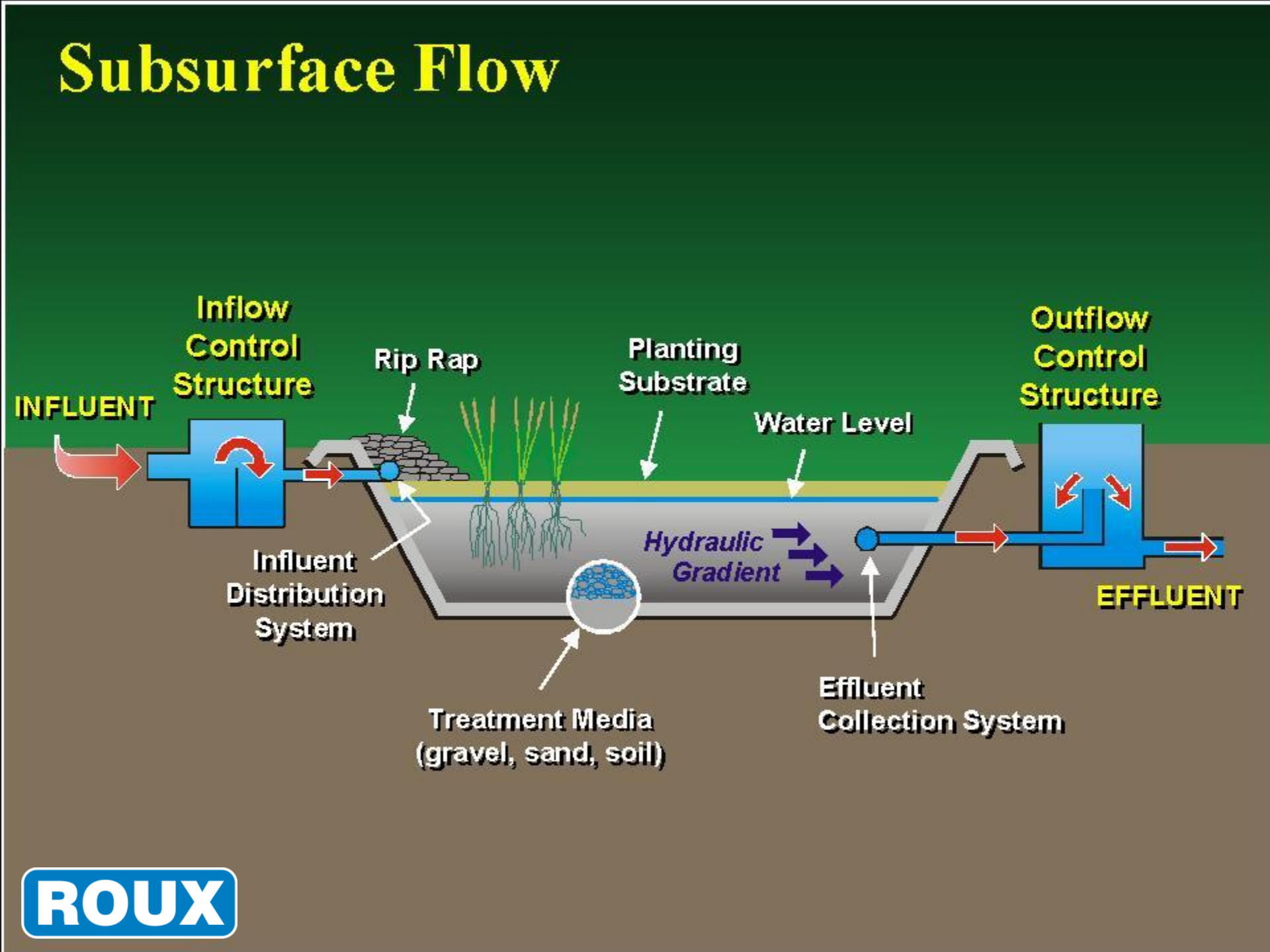
Steel Mill Runoff, NJ

Subsurface Flow



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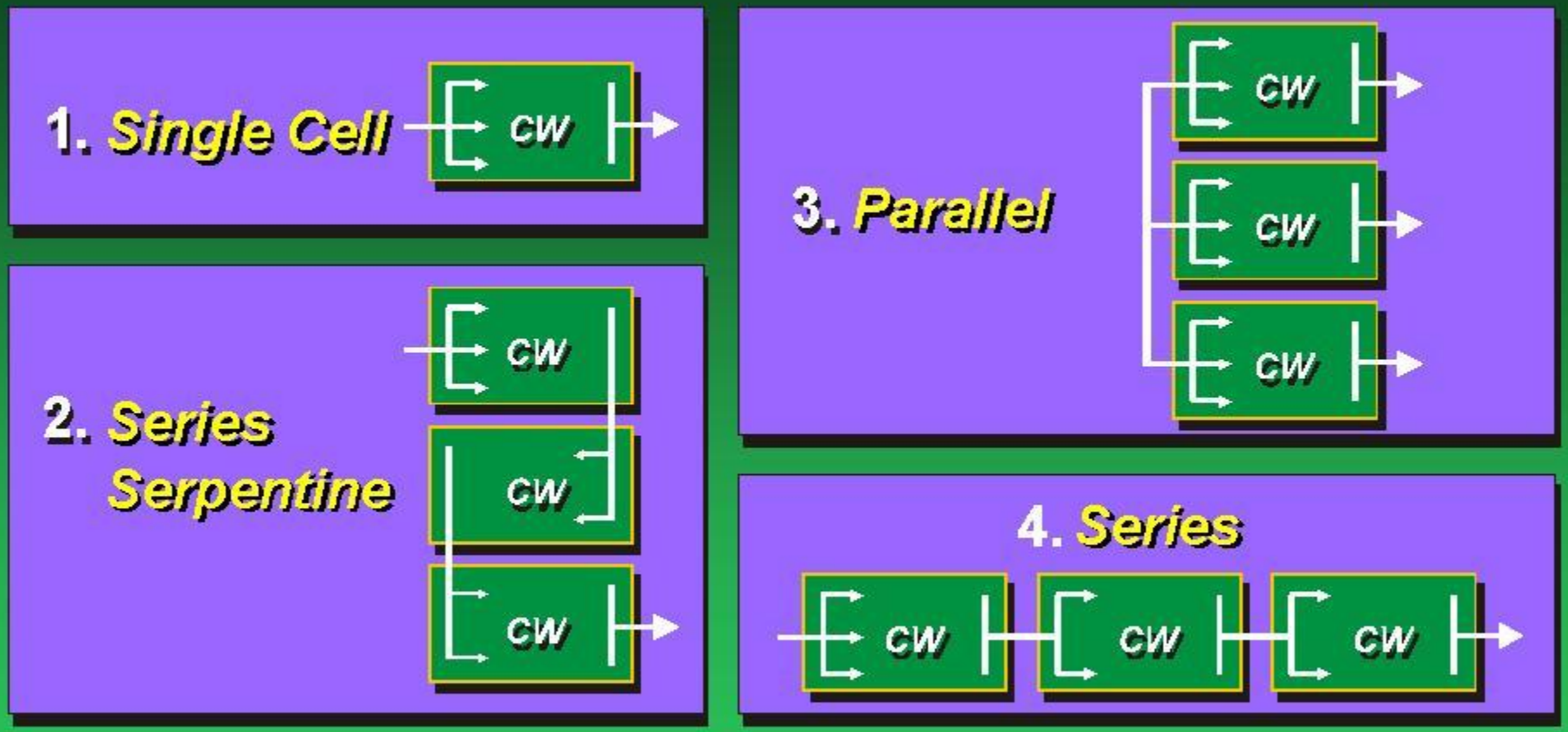
Subsurface Flow



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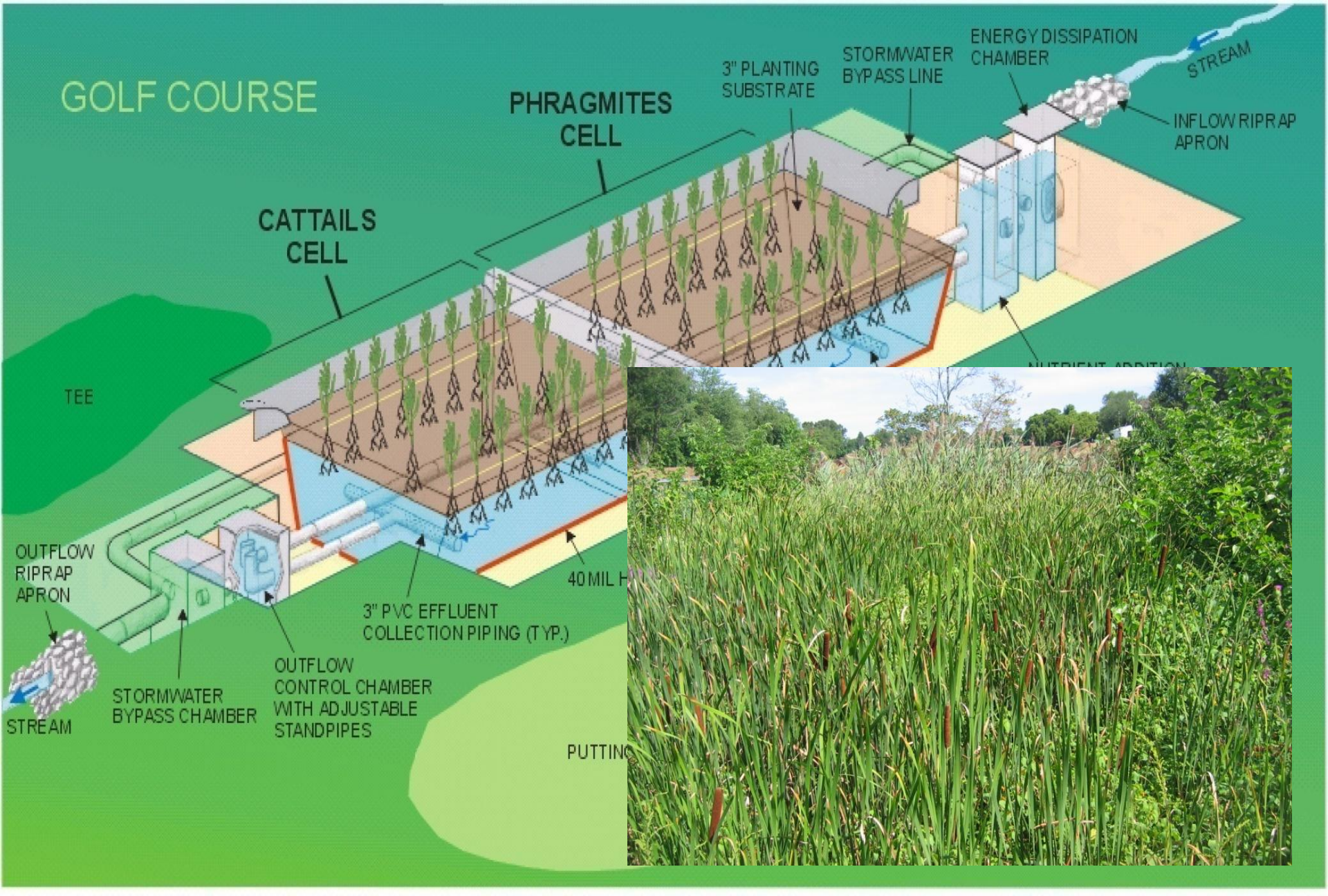
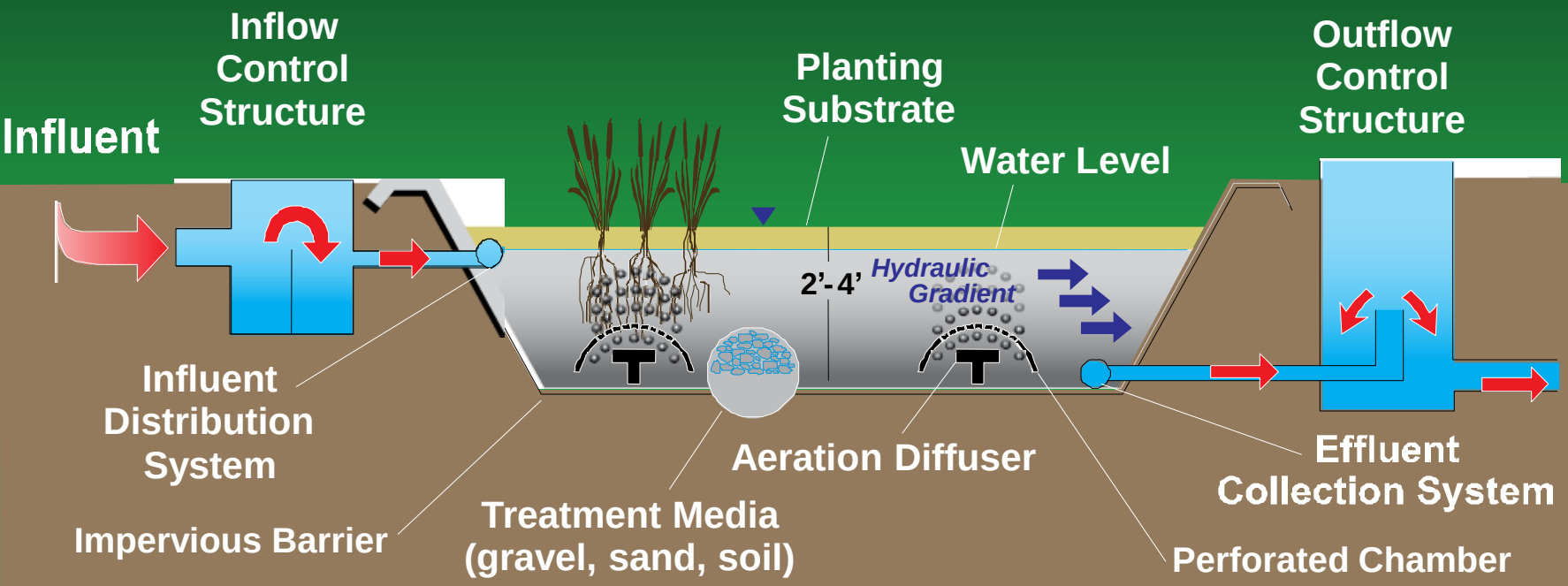
BTEX Removal, RI



Smelter Runoff, SC

Residential Sanitary, WV

Enhanced Subsurface Flow



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Enhanced Sanitary, PA

ROUX

Enhanced Sanitary, PA

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Natural Media Filtration

The use of natural materials to filter, adsorb and sequester contaminants from groundwater, process water, and/or stormwater.

- Media Types
  - Compost
  - Sand
  - Gravel
  - Peat
- Removal Mechanisms
  - Sedimentation
  - Filtration
  - Adsorption
  - Ion Exchange
  - Decomposition
  - Microbial Metabolism

PCB Removal, IN

Natural Media Filter

Zinc Removal, VA

Zinc Removal, VA

Zinc Removal, VA

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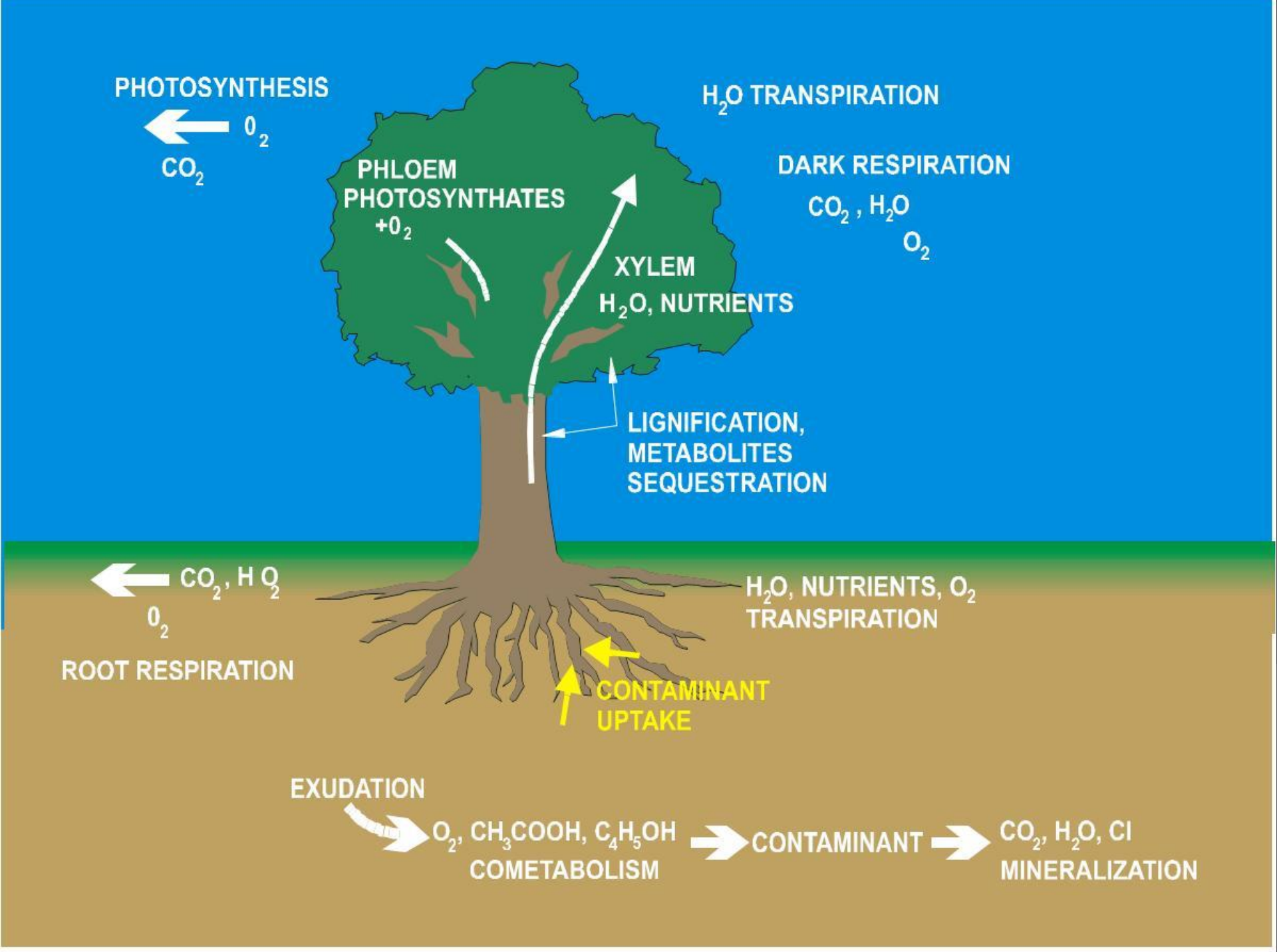
Phytotechnologies

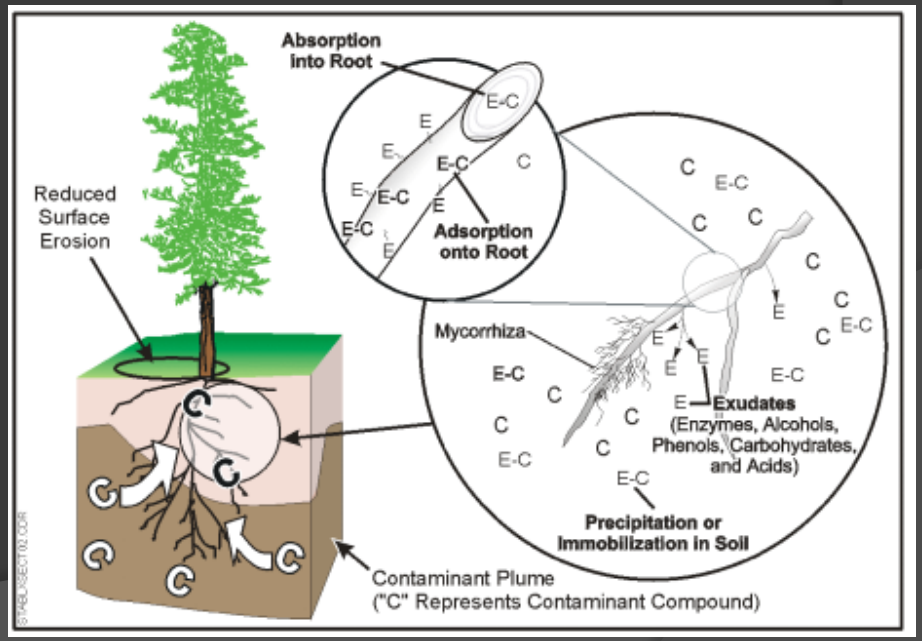
Use plants to remediate soil, sediment, groundwater, surface water

- Constituents Treated
  - BTEX
  - PAHs
  - PCBs
  - Chlorinated Solvents
  - Metals
  - Pesticides
  - Nutrients
- Mechanisms
  - Evapotranspiration
  - Rhizodegradation
  - Phytostabilization
  - Phytoextraction
  - Phytovolatilization
  - Phytodegradation


PHOTOSYNTHESIS
O_2
CO_2
H_2O TRANSPIRATION
DARK RESPIRATION
CO_2 , H_2O
O_2
PHLOEM
PHOTOSYNTHATES
$+O_2$
XYLEM
H_2O, NUTRIENTS
LIGNIFICATION,
METABOLITES
SEQUESTRATION
CO_2, H_2O
O_2
ROOT RESPIRATION
H_2O, NUTRIENTS, O_2
TRANSPIRATION
CONTAMINANT
UPTAKE
EXUDATION
O_2, CH_3COOH, C_4H_5OH
COMETABOLISM
CONTAMINANT
CO_2, H_2O, Cl
MINERALIZATION

Phytostabilization

- The immobilization of a contaminant through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants.

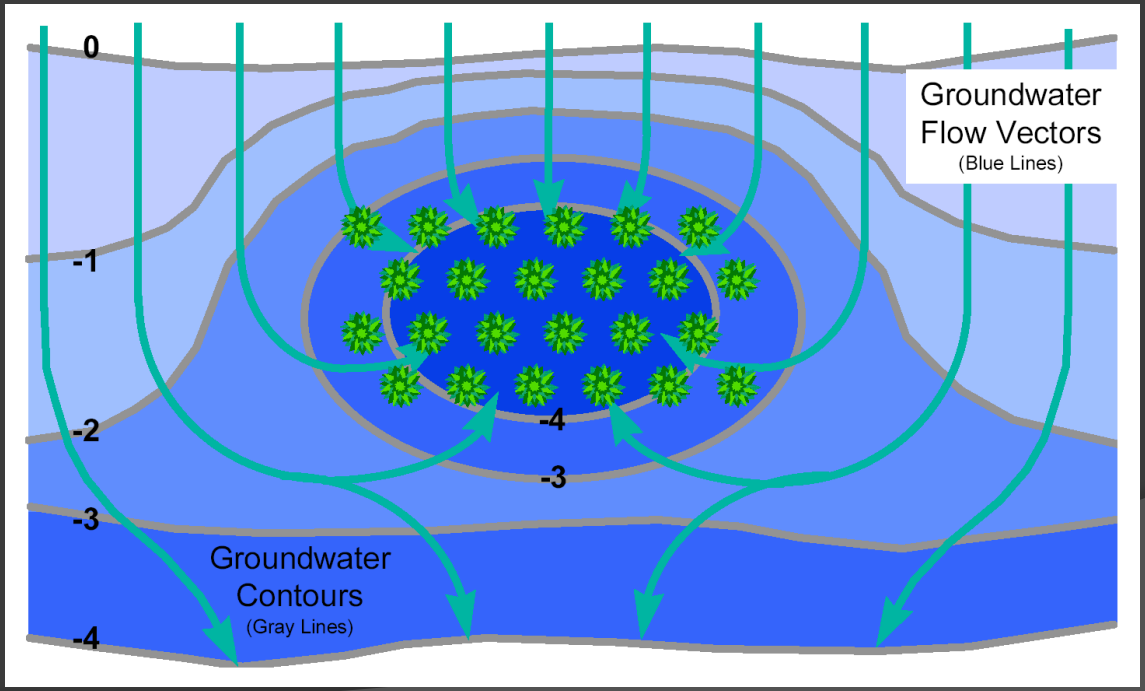


Evapotranspiration

- Combination of direct evaporation and plant transpiration
  - The ability of plants to intercept, take up and transpire large volumes of rainfall and/or groundwater.
- Benefits Include:
  - Green alternative that is functionally equivalent to the standard pump-and-treat system and conventional landfill cap.
  - Hydraulic influence induced by plant roots is more uniformly distributed than with a pumping well.
  - Low installation and operational costs.

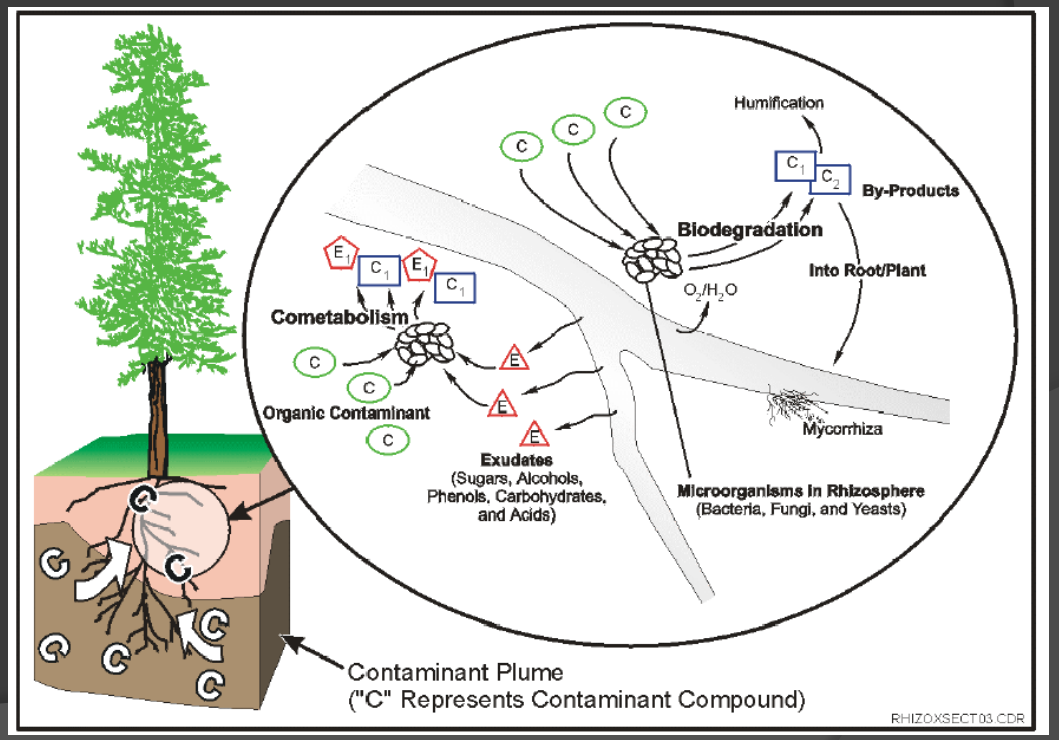
Hydraulic Control

- The use of plants to uptake large volumes of water to contain or control the migration of groundwater.

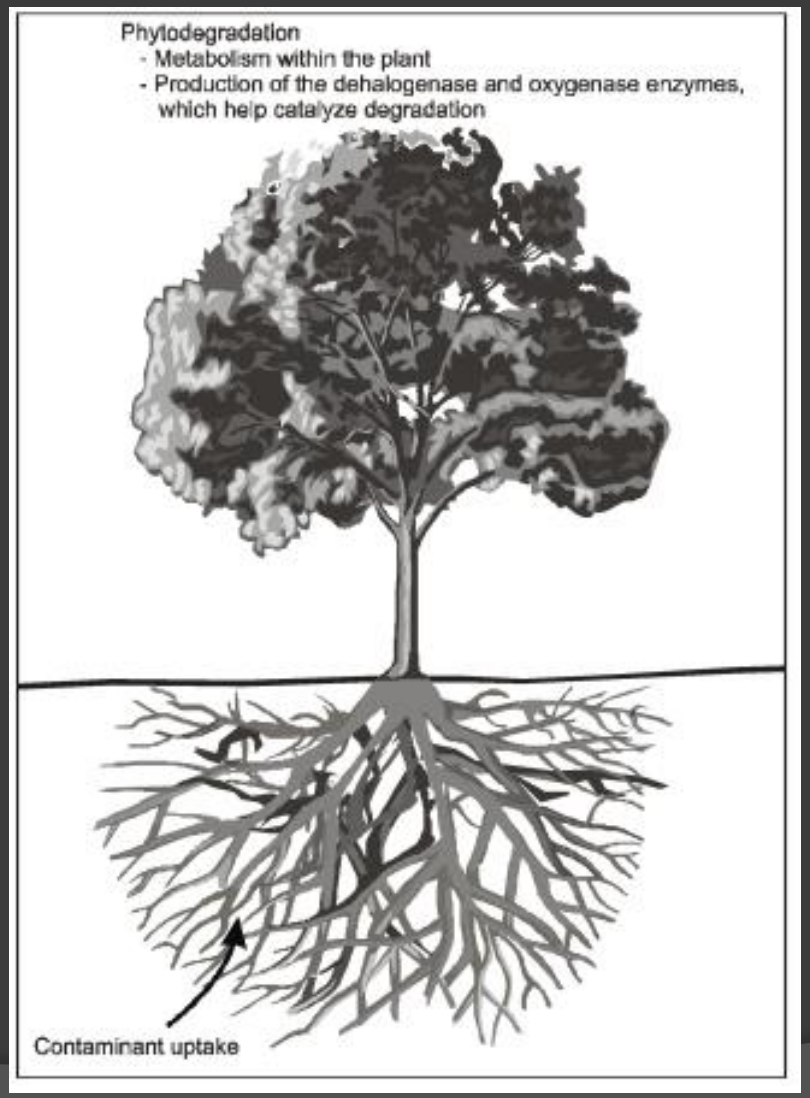


Rhizodegradation

- The breakdown of a contaminant in soil through microbial activity that is enhanced by the presence of the root zone
- TPH, PAHs, BTEX, PCBs, Pesticides, chlorinated solvents



Phytodegradation



- The breakdown of contaminants taken up by the plant through metabolic processes within the plant or through the effect of compounds (i.e., enzymes) produced by the plant.

Bare Root Hybrid Poplars

Planting

Bare Root Black Willows

Irrigation with constructed waters

Phyto Plot Growth

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Landfill Isolation, MI

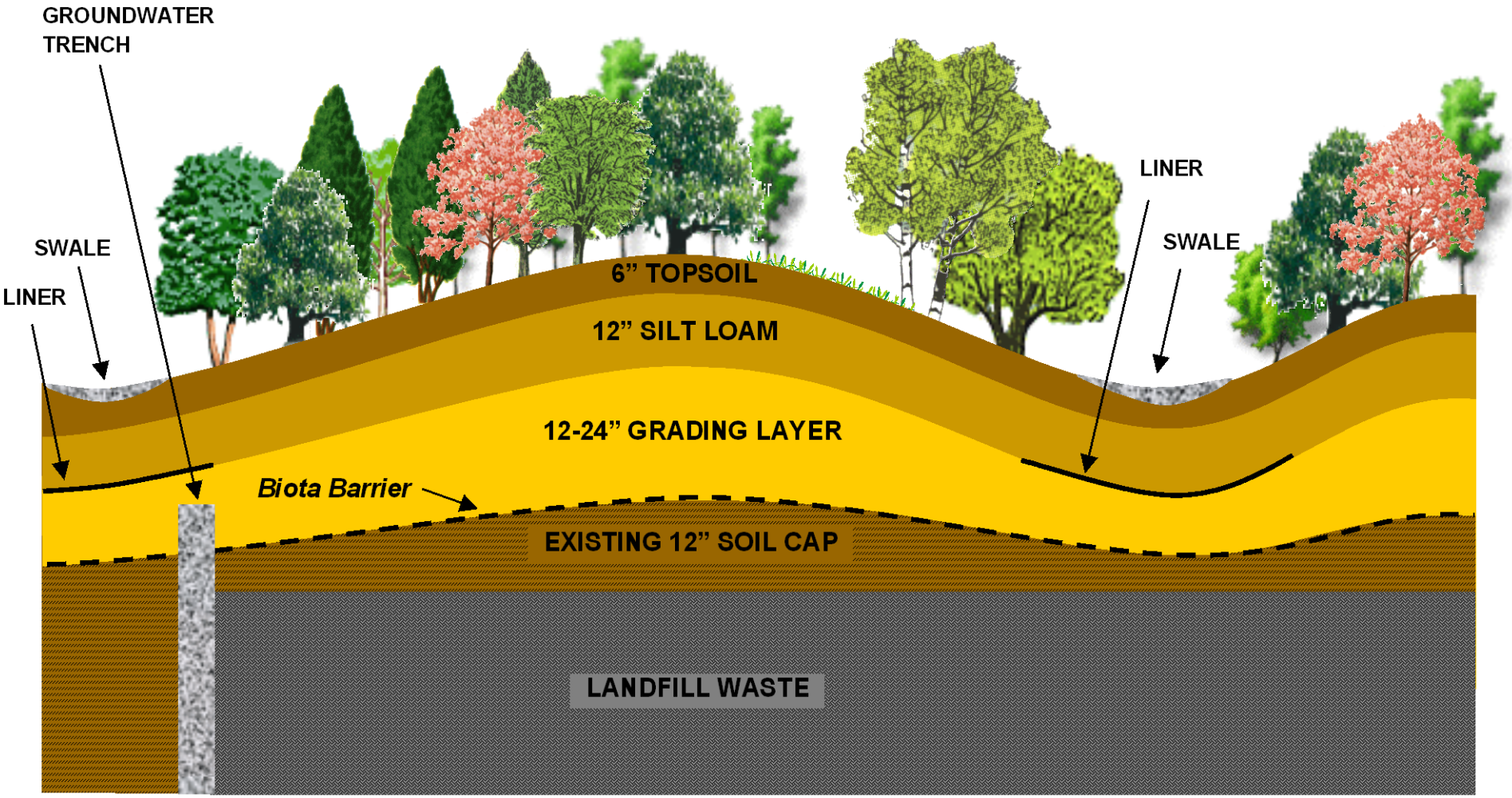
Landfill Isolation, MI

Wildlife Habitat Landfill Cover, NY

ROUX

Wildlife Habitat Landfill Cover, NY

ROUX



Wildlife Habitat Landfill Cover, NY

ROUX

Wildlife Habitat Landfill Cover, NY

ROUX

Superfund Lagoon Closure, NJ

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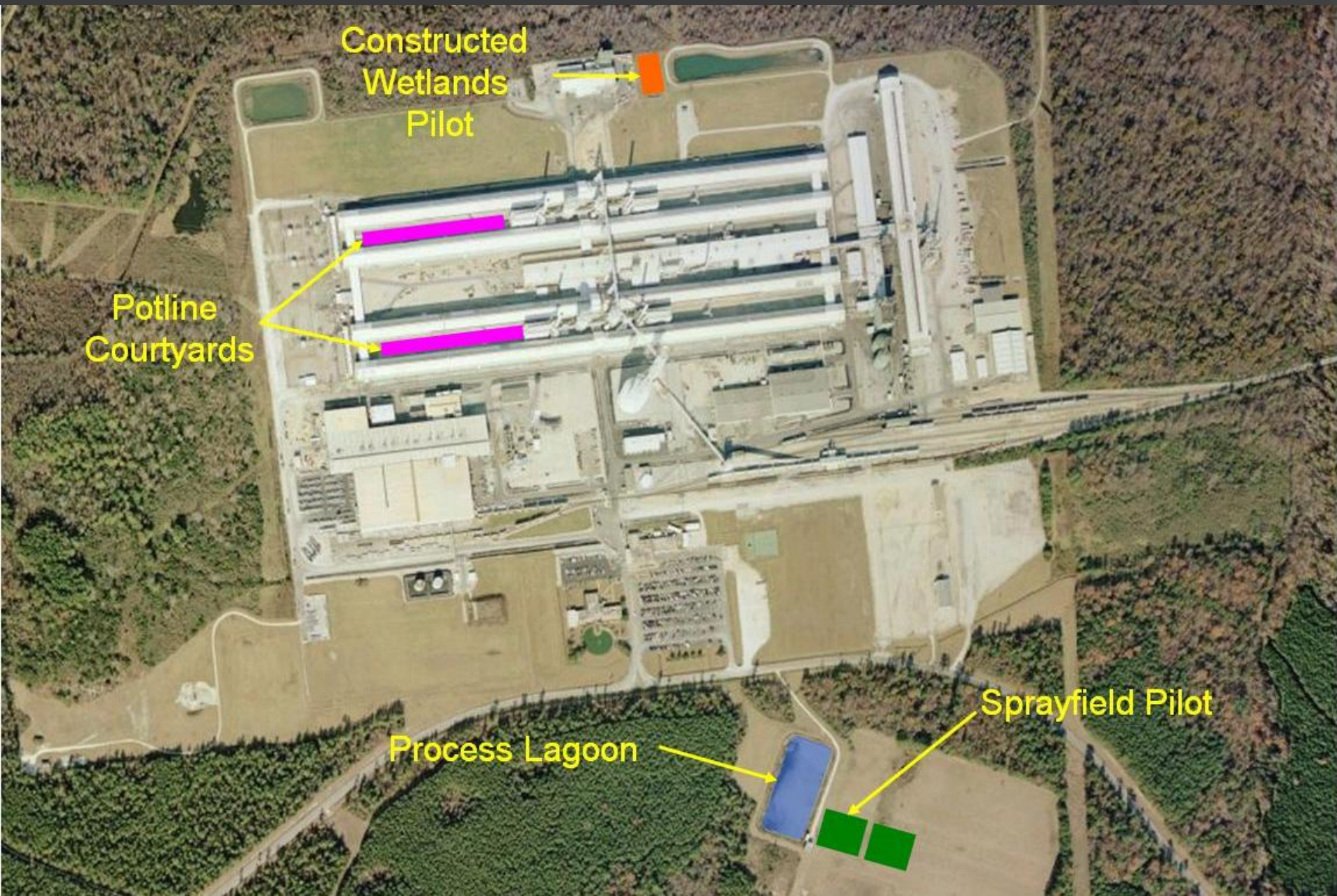
Superfund Lagoon Closure, NJ

Process Water Discharge, SC

Process Water Consumption, SC



Process Water Consumption, SC

Process Water Consumption, SC

Landfill Cover, VA

Landfill Cover, VA

Pros & Cons

- Advantages
  - Passive Operation
  - Competitive Capital
  - Low O&M
  - Shock Absorber
    - Chemical
    - Hydraulic
  - High Public Acceptance
  - Provides Habitat Benefits
  - Beneficial Reuse Opportunities
- Disadvantages
  - Site Specific
  - Large Land Area
  - Timeframe (i.e., phyto)
  - Vector Concerns (i.e., FWS)

VS.