Initial Success in Design and Modeling of a Landfill Cover using *Salix* on the Solvay Waste Beds in Syracuse, NY

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Presentation Outline

- Site history
- Project goal and objectives
- Vegetation selection and management
- Model selection and calibration
- Summary

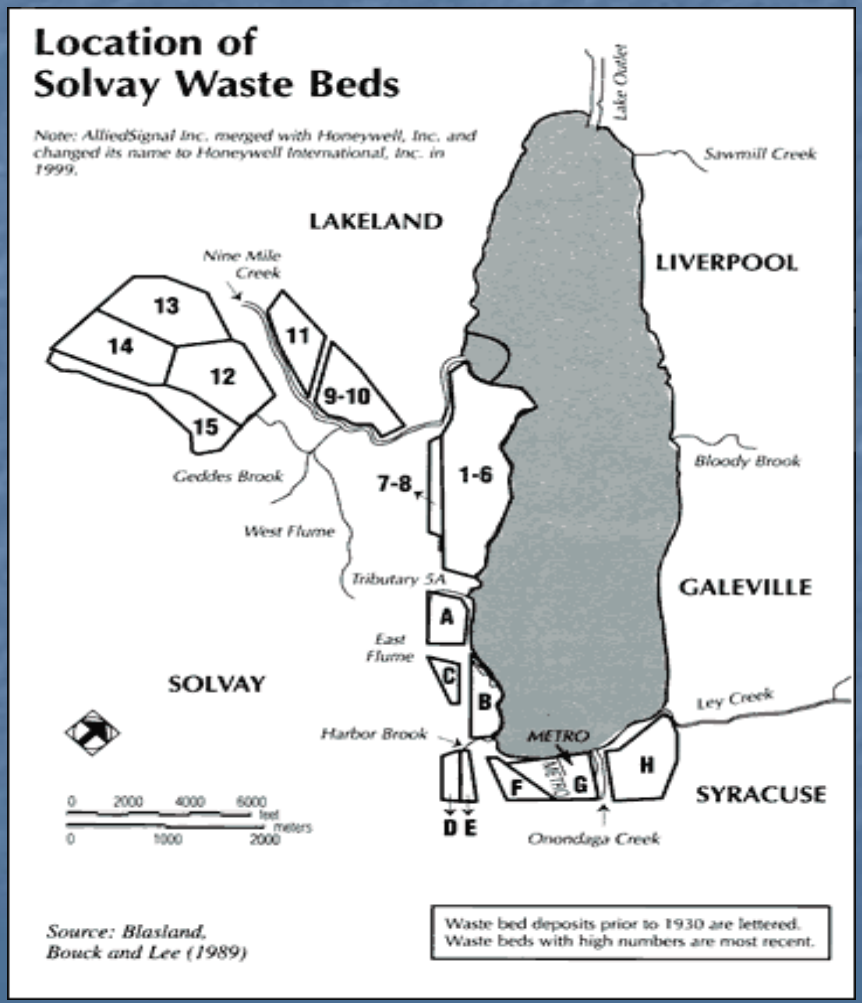
Site History

Solvay Process Company Facility and Erie Canal, early 1900s

- Soda ash manufacturing using the Solvay process (1887 – 1986)
- Raw materials locally available
  - limestone, brine (NaCl) and water
- 1907 – Solvay began operation of settling basins along Onondaga Lake
- Process residues discharged as a slurry (5% solids)

Site Location

Solvay Process Residues



- Waste Beds 9 to 15
  - 15 to 21 m deep
  - 270 ha (662 acres)
- Primarily a non-hazardous mixture of calcium, magnesium and sodium compounds
- Stressful growing conditions in shallow soil (<1m depth)
  - pH (8.0 – 12.3)
  - Electrical conductivity (0.5 – 9.2 dS/m)
  - Organic matter (0 - 3.9%)

Waste Beds 13 - 15

Project Goal and Objectives

- Determine the feasibility of using willow shrubs as part of a multipurpose landfill closure project.
  - Screen varieties suitable for wastebed environment.
  - Evaluate transpiration by willow shrubs.
  - Model the effect of evapotranspiration on leachate generation.
- Evaluate the feasibility of large-scale willow biomass crop production on the waste beds.
- Determine the value of the willow biomass crops for green fuel, bioproducts and recreation.

Willow Biomass Crop Management Challenges

- Water:
  - Select willow varieties that are productive on this site
  - Promote evaporation and transpiration to decrease deep percolation (leachate generation)
    - Vegetation interception
    - Low water use efficiency
    - Planting density and design
    - Understory vegetation management
- Soils:
  - Overcome harsh growing conditions
  - Incorporate organic matter to :
    - Enhance survival, growth and productivity
    - Improve soil water availability and capacity
    - Provide long-term beneficial use option for generators of biosolids and organic mulch

Vegetation Selection

Naturally established willow and poplar on the Solvay waste beds.

- Why willow?
  - one of the first woody species to establish naturally
  - tolerant of harsh conditions
  - high transpiration rates
  - high growth rates
  - genetic diversity

Greenhouse Screening Trials

Greenhouse screening trial of 40 willow and hybrid poplar varieties.

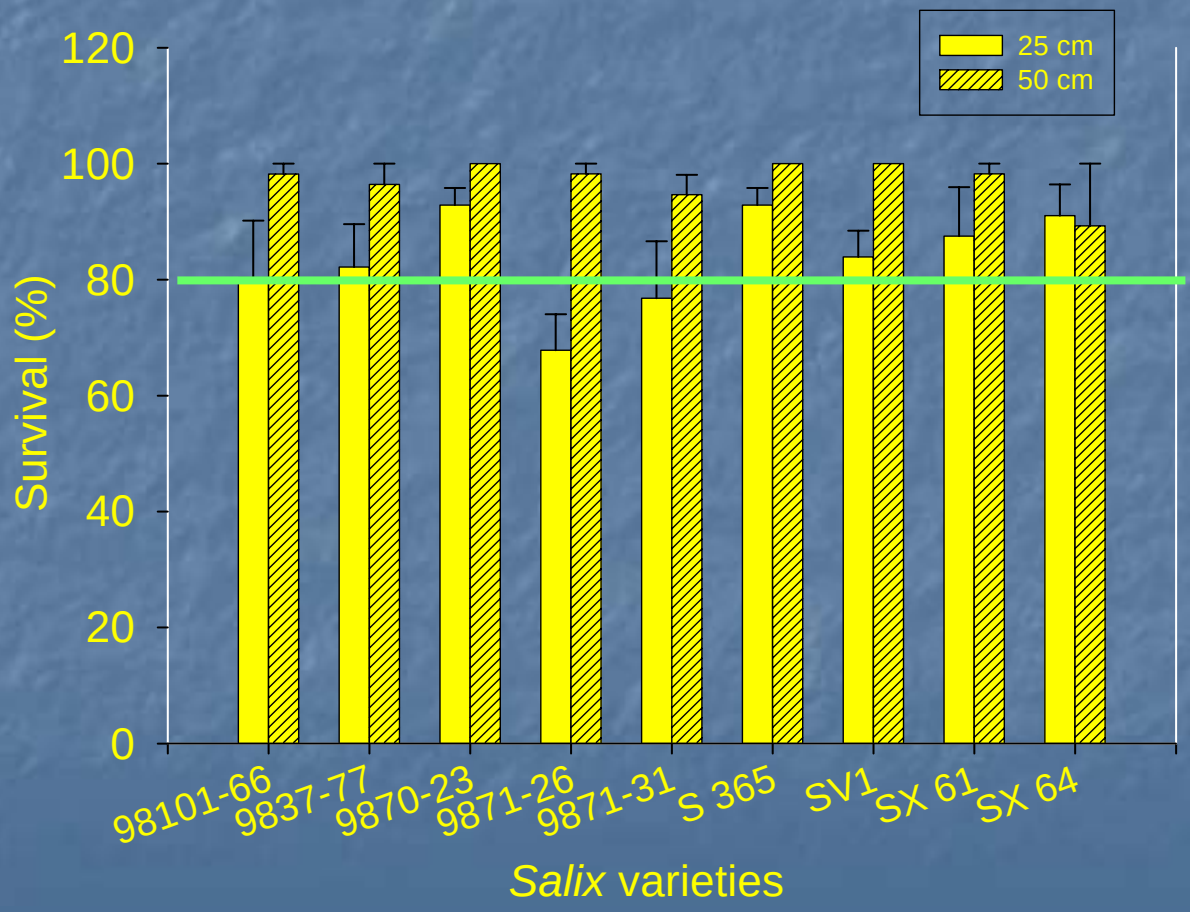
- Screened 40 varieties of willow and hybrid poplar from SUNY-ESF collection
- Used biosolids amended waste, unamended waste and a control
- Used aboveground and belowground growth results to select 10 varieties to test in field trials

Growth and Yield Trials

First-year growth of willow on biosolids-amended Solvay waste

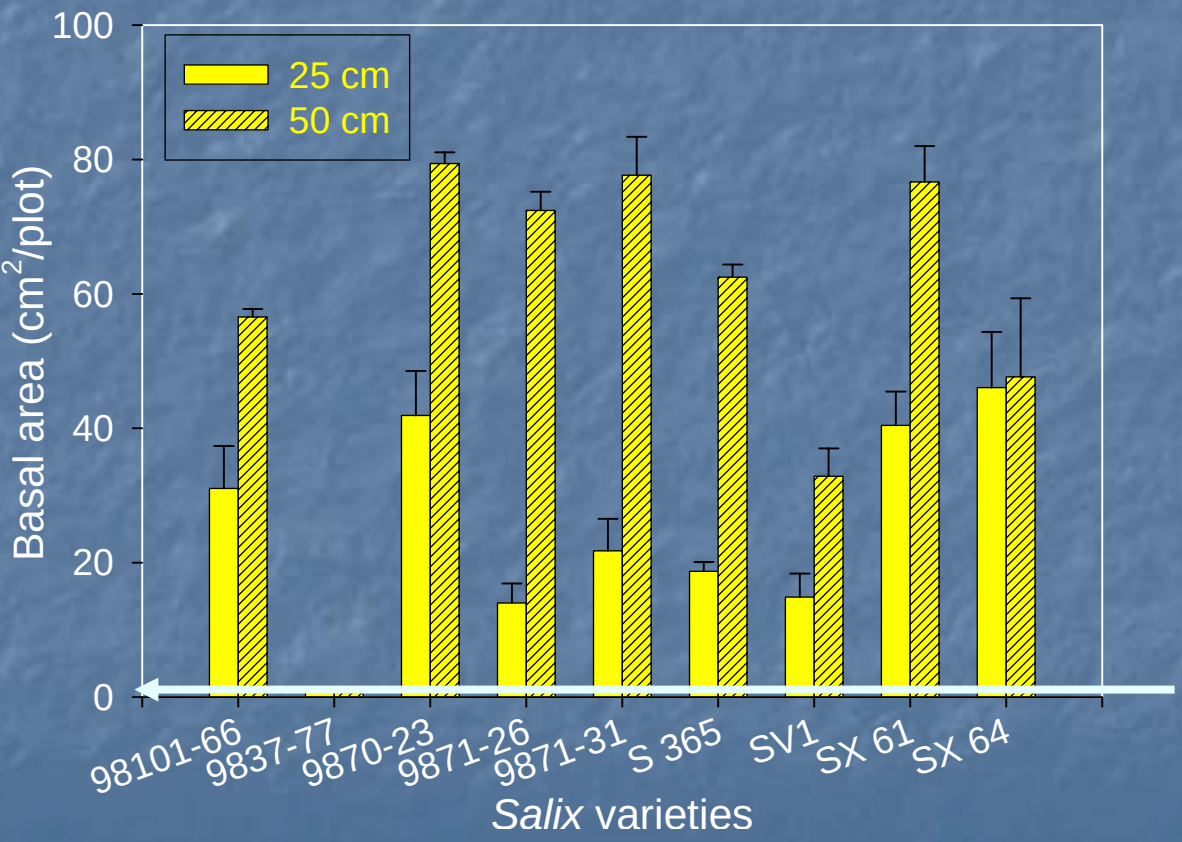
- Two plots (2004)
  - biosolids-amended (1986)
  - unamended waste
- Two cutting lengths (25 and 50 cm)
- Planting density
  - 15,000/ha (6,000/ac)

First-year Survival of Willow on Biosolids-amended Solvay Waste



80.1% survival on unamended waste (Field 2)

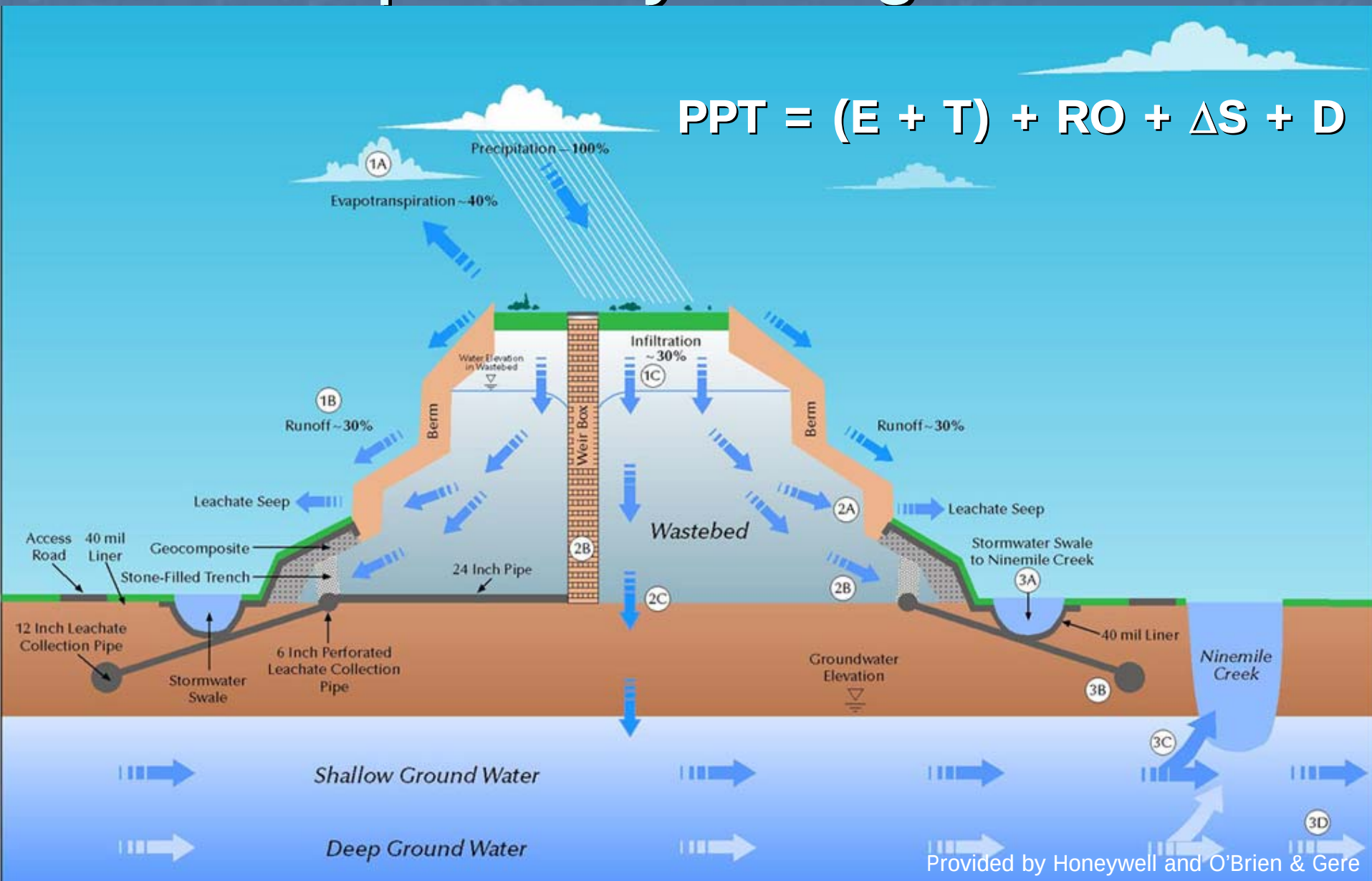
First Year Growth of Willow on Biosolids-amended Solvay Waste



Average basal area on Field 2 (unamended waste) (1.2 cm^2/plot)

Conceptual Hydrologic Model

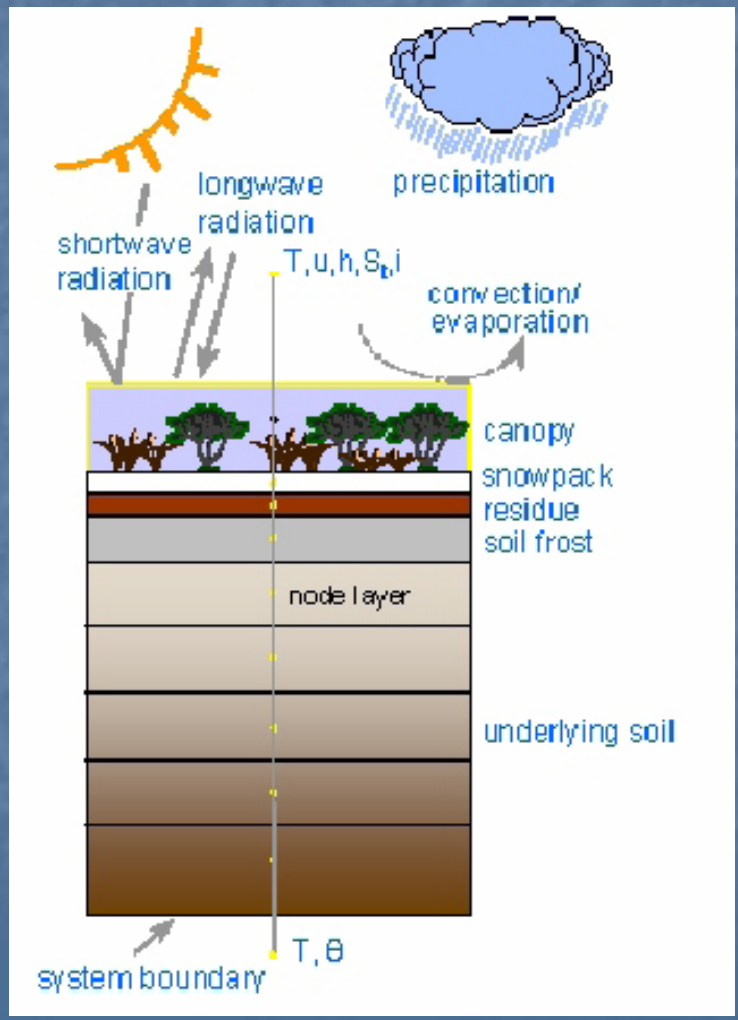
$$PPT = (E + T) + RO + \Delta S + D$$



Provided by Honeywell and O'Brien & Gere

Conceptual Heat and Water Model for a Willow Biomass Crop

- Climate
  - PPT = 1,018 mm annually
  - PPT = 560 mm (Nov – Apr)
  - Average temp. = 8.3^{o} C
- Crop Management
  - 3-year harvest rotation
  - Soil modifications with organic amendments & tillage
- Determine effect on percolation (leachate generation)



(Figure supplied by USDA)

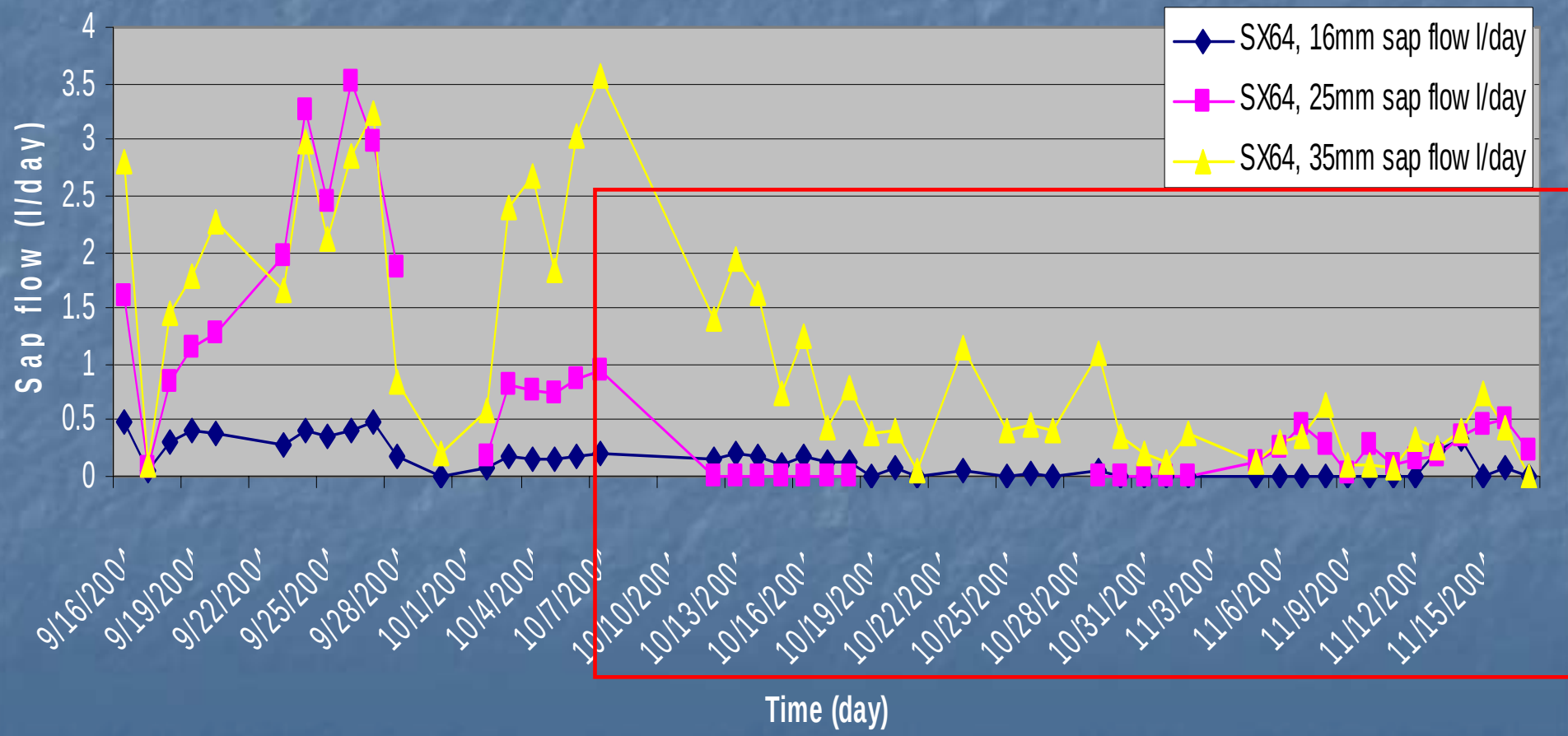
The Simultaneous Heat and Water (SHAW) Model

- One-dimensional model developed to simulate soil freezing and thawing.
- Simulates snow accumulation and snowmelt, transpiration and actual evaporation.
- Incorporates biomass and other crop management practices as input parameters.

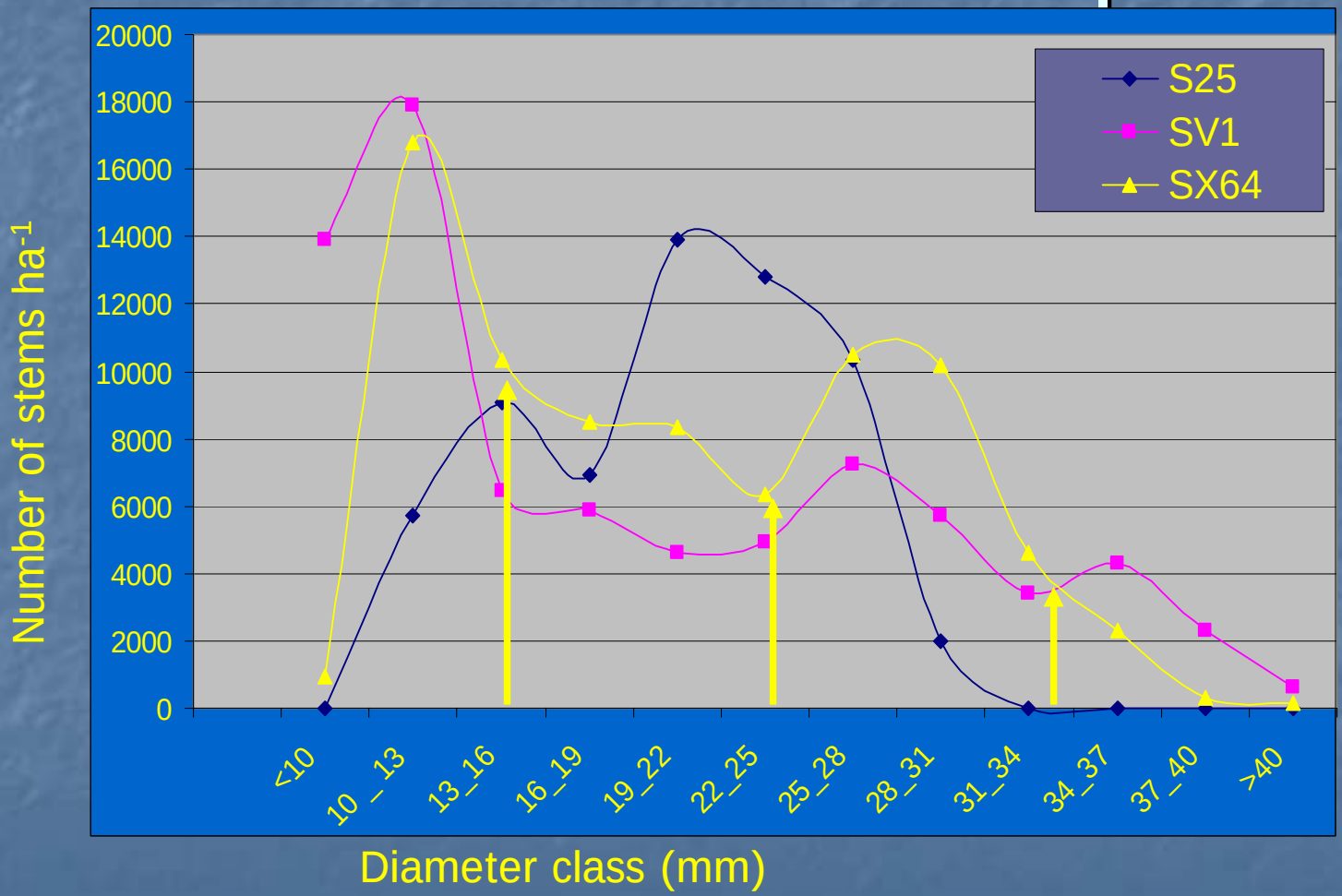
Model Calibration Using Sap Flow

- Stem heat balance method
  - Three-year old willow on mineral soil
  - Sensor sizes range from 10 - 35mm
- Measure: sap flow (g/hr/stem) and stem diameter distribution (stem/ha)
- Compute: Stand-scale sap flow (l/day)

Stem Size Differences in Late Season Sap Flow for One Variety



Stem Diameter Distribution to Determine Stand-level Sap Flow



Sensor sizes (16, 25, 35 mm)

Projected Late Season Sap Flow

Salix Variety	Sap Flow (mm)	Sap Flow (l/d/plant)
S25	180	3.4
SV1	65	1.2
SX64	131	2.5

October 8 – November 15, 2004

Summary

- Willow (*Salix*) can be successfully established when organic amendments are incorporated into wastebeds
- Late season transpiration by willow is important to the water balance
- Growth rates and transpiration rates vary amongst willow varieties
- Early modeling indicate that *Salix* minimizes deep percolation

Future Activities - 2005

- Monitor key soil and vegetation characteristics on the waste beds
- Begin trials on the waste beds with different organic amendments
- Quantify sap flow over entire growing season
- Complete initial model runs and identify key variables
- Calibrate and verify model output

Acknowledgements

- Honeywell International
- O'Brien & Gere Companies

Honeywell

O'BRIEN & GERE

SUNY-ESF

Short-Rotation Woody Crops Program

SUNY College of Environmental Science & Forestry

Selection of *Salix* for Field Trials

Greenhouse screening trial of 40 willow and hybrid poplar clones.

- Selection criteria:
  - Survival
  - Below-ground biomass (consider root : shoot ratio)
  - High water use “efficiency” (e.g. high water use : biomass ratio)