Hydraulic Containment, Natural Attenuation and Phytoremediation as a Combined Remediation Strategy for an Industrial Waste Site in South Africa

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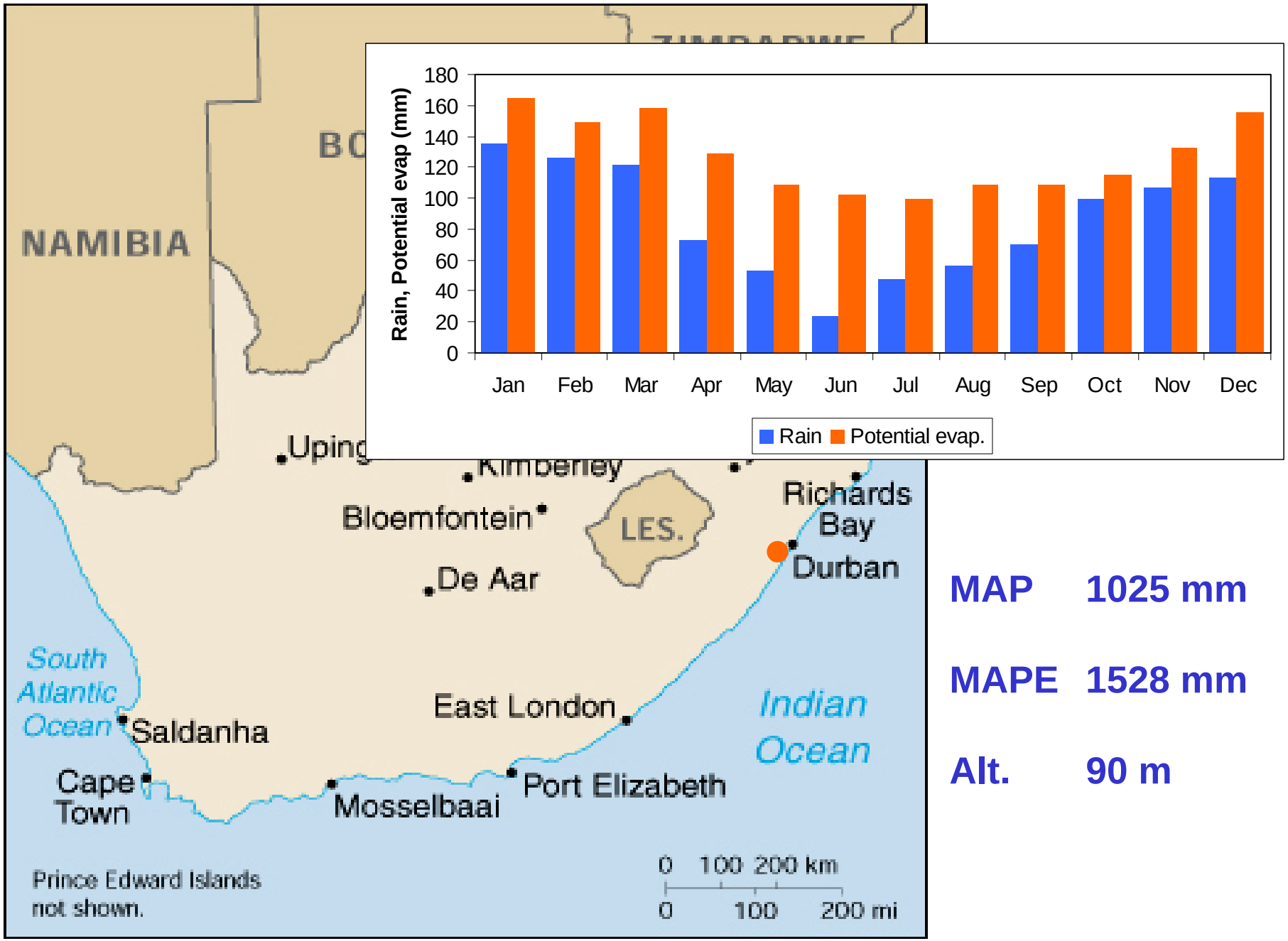
Outline

- Introduction
- Remediation strategy
- ET cover performance
- Conclusion



MAP **1025 mm**

MAPE **1528 mm**

Alt. **90 m**

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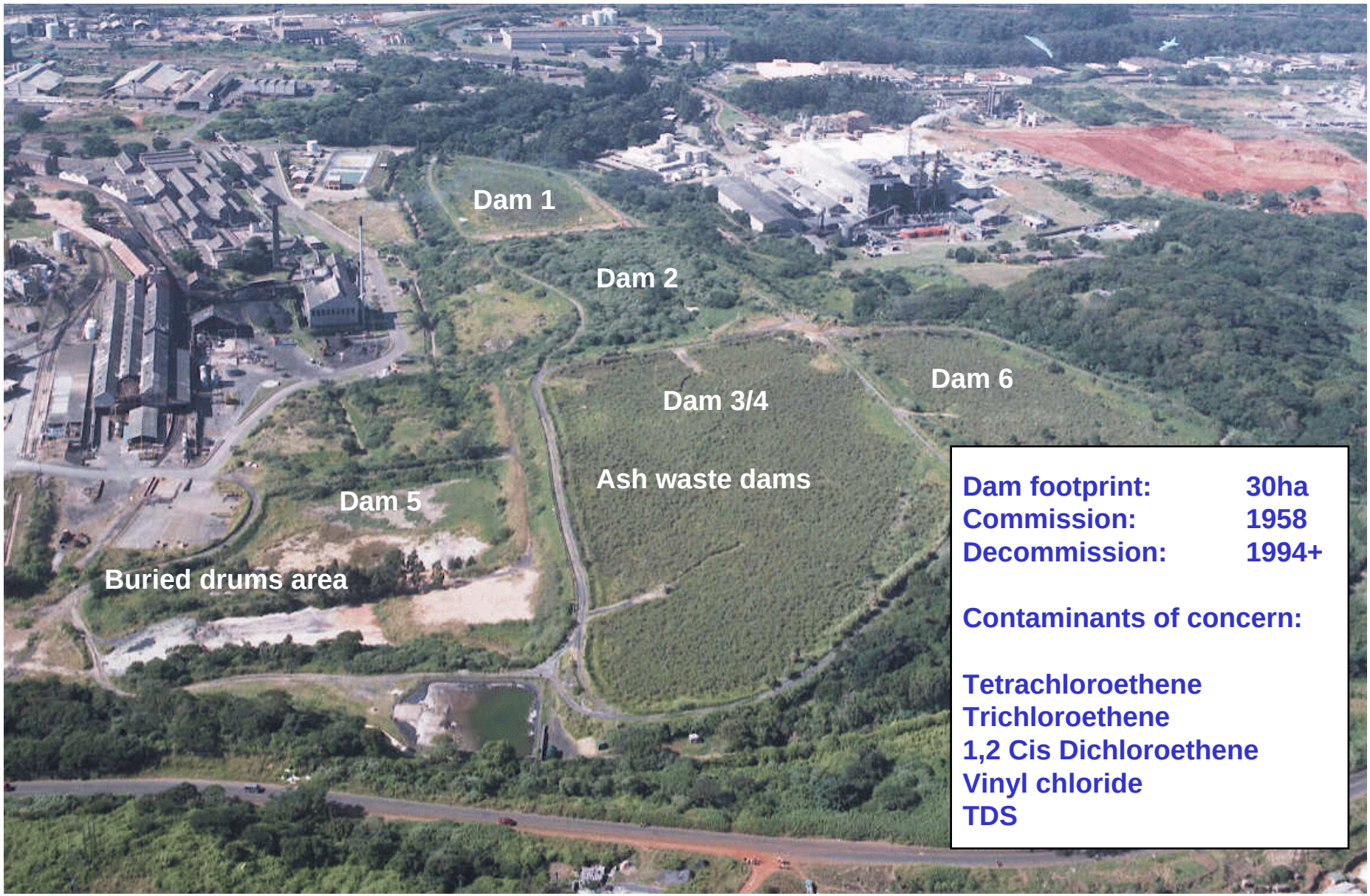
Aerial view of the dams and buried drums area



Remediation Strategy

- **Management intervention:**

  - **Alternative water supply** to the KwaMakutha village and reversal of off-site contamination by groundwater drawdown,

  - **Dewatering of the slimes dams** by drawdown of phreatic surface below the dams,

  - **Surface water control** by installation of drainage works,

  - **Seepage water control** by subsurface drains around the dams and in Kwamakutha.

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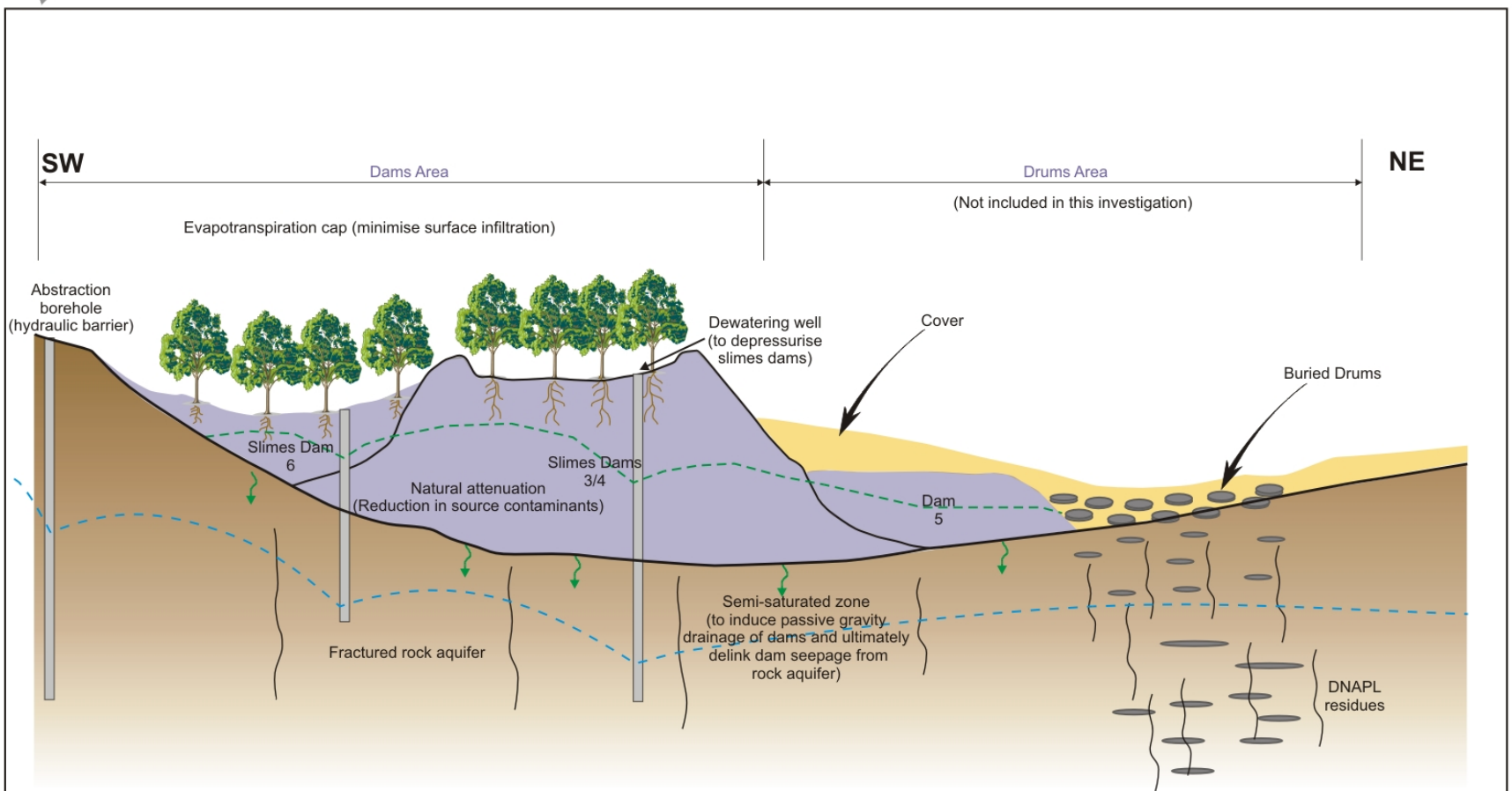
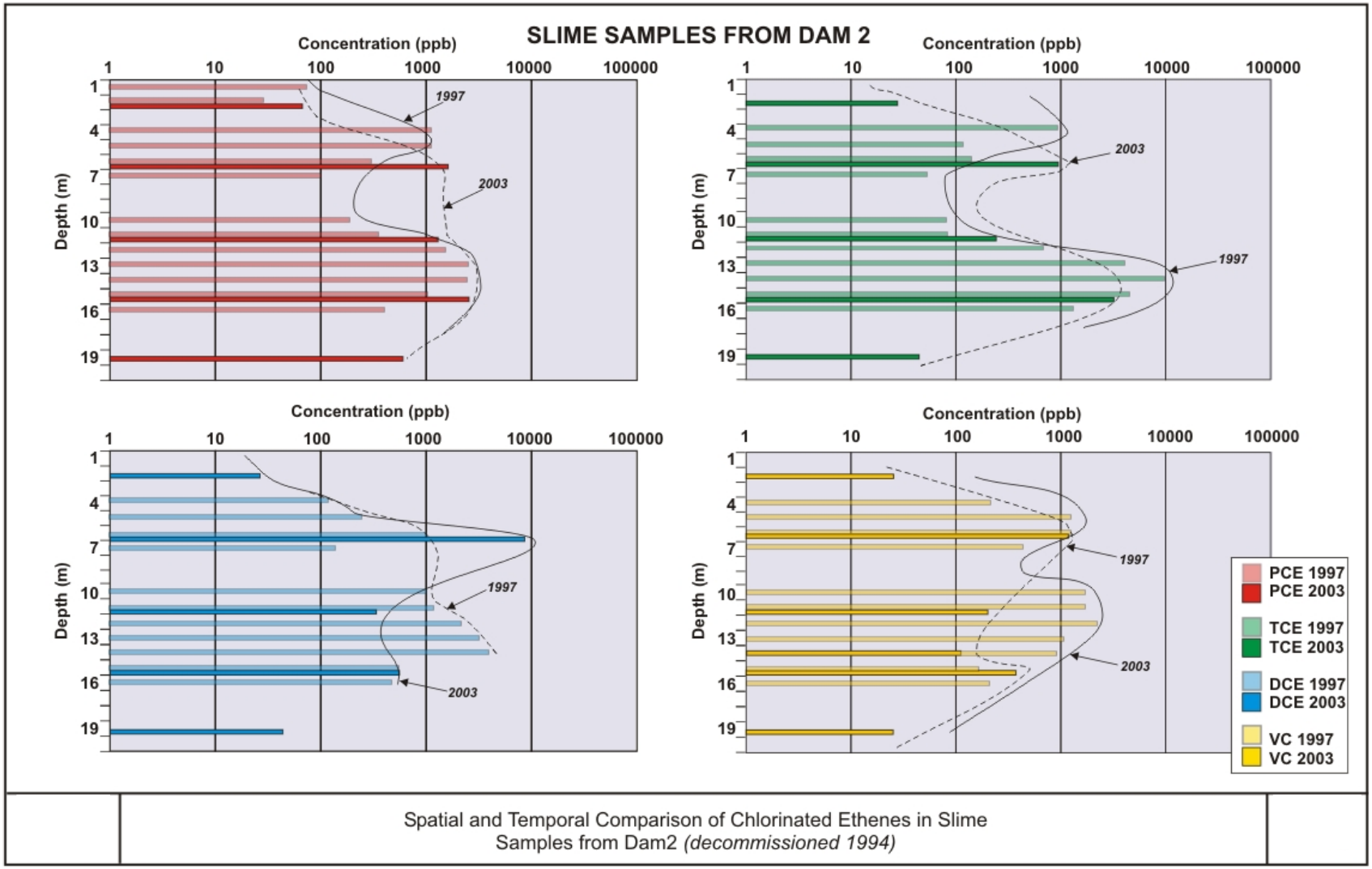
- **Proposed remediation:**
  - **Hydraulic containment** by groundwater gradient control and surface runoff control,
  - **Monitored Natural Attenuation** and possibly enhanced attenuation by recirculation in the groundwater and
  - **Evapotranspiration cover.** Planting of some 1600 indigenous species to limit fluxes through the slimes and promote natural attenuation.



SCHEMATIC SECTION THROUGH NWWS SHOWING MAIN REHABILITATION COMPONENTS OF THE DAMS AREA

Source attenuation in the slimes profile

SRK Consulting
Engineers and Scientists



Spatial and Temporal Comparison of Chlorinated Ethenes in Slime Samples from Dam2 *(decommissioned 1994)*

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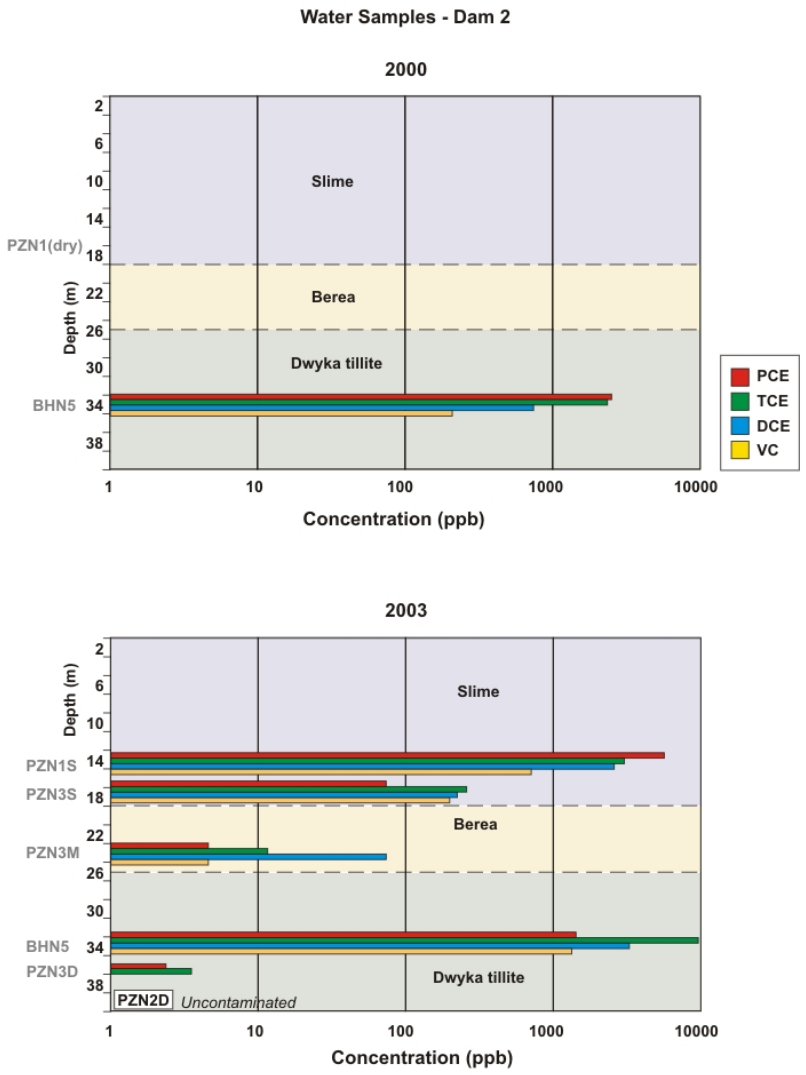

Spatial and Temporal Comparison of Chlorinated Ethenes in pore Water Samples and ground water from underlying aquifer - Dam 2 *(decommissioned 1994)*

Contaminant concentrations in the groundwater in and bellow the slimes dam

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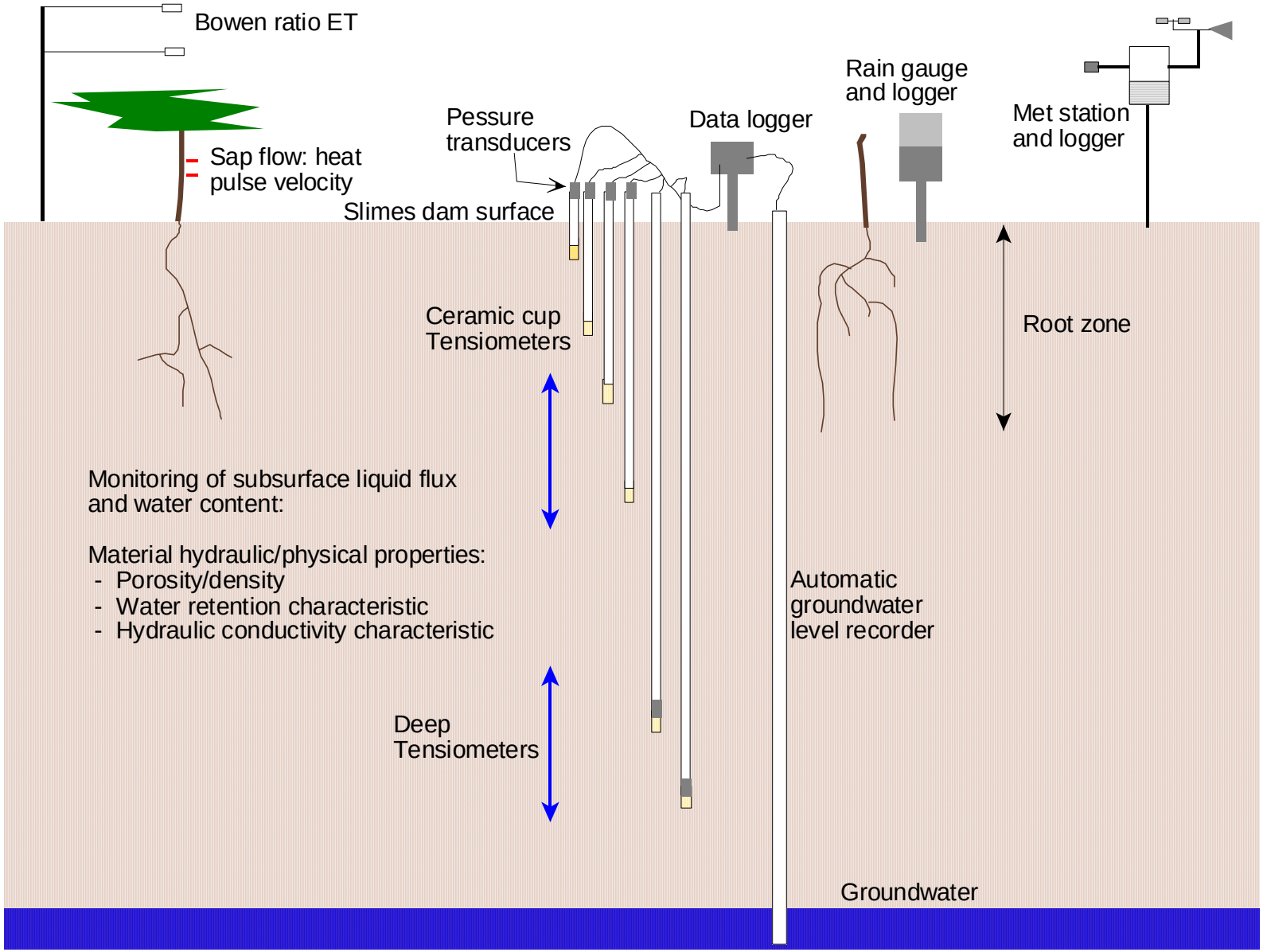
Schematic of instrumentation for measurement of components of the slimes dam water balance



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Vegetation on slimes dam 2

Shallow rooting system of the Natal Fig

Grass growth on slimes dam 2

Slimes Dams Water Balance Modelling

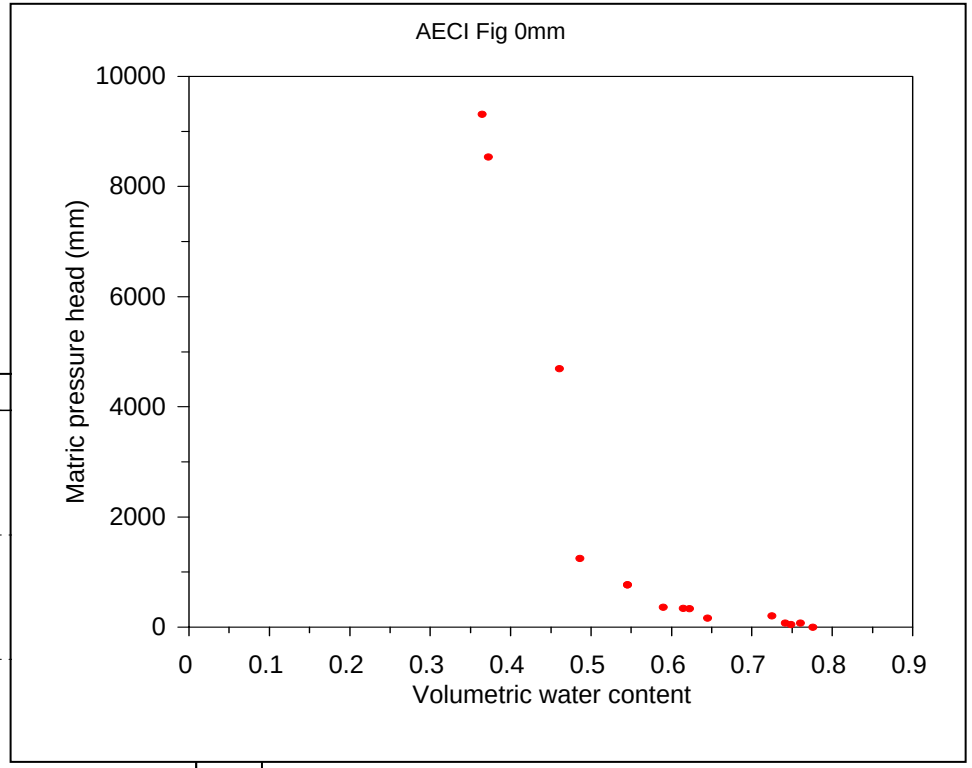
- Since the groundwater recharge component **flux** cannot be measured directly, as is the case in lysimeter experiments, the observations and material properties are combined to calculate this flux.

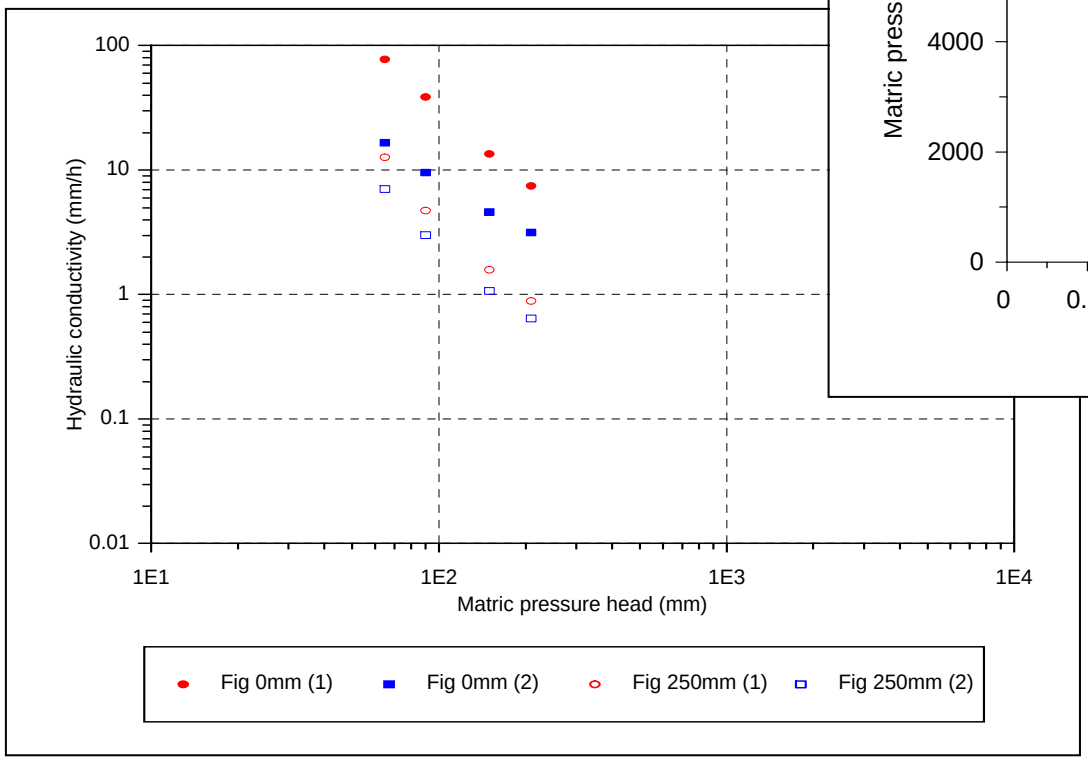
- We also wish to evaluate the potential of the full slimes profile (15m) in absorbing peak rainfall events, retarding fluxes to the groundwater and releasing water back up to the root zone during dry periods.

- These calculations are best performed using the soil water physics inherent in the HYDRUS2D software. Once calibrated against the observations over three years, HYDRUS2D is used to predict long-term performance of a full canopy cover

HYDRUS2D inputs: hydraulic characteristics of the slimes materials

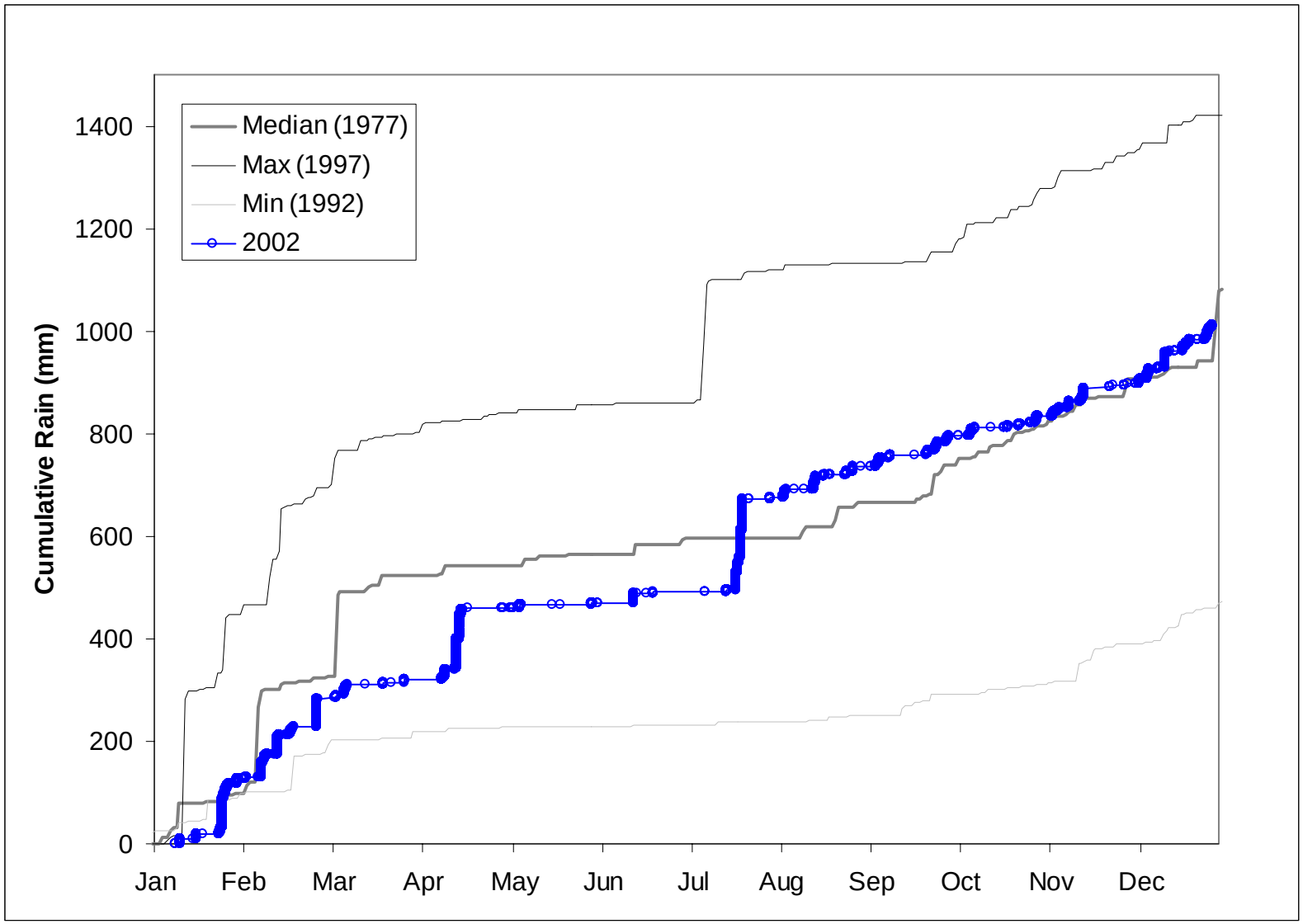
Water retention characteristic



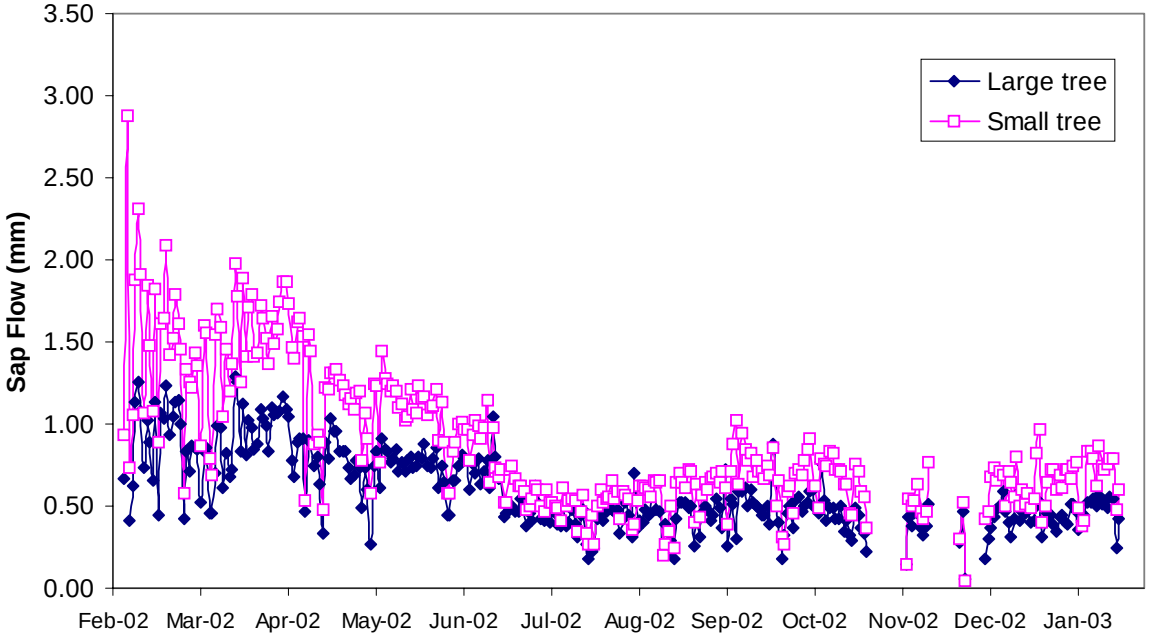


Hydraulic conductivity characteristic

HYDRUS2D inputs: rainfall characteristics (short & long term)

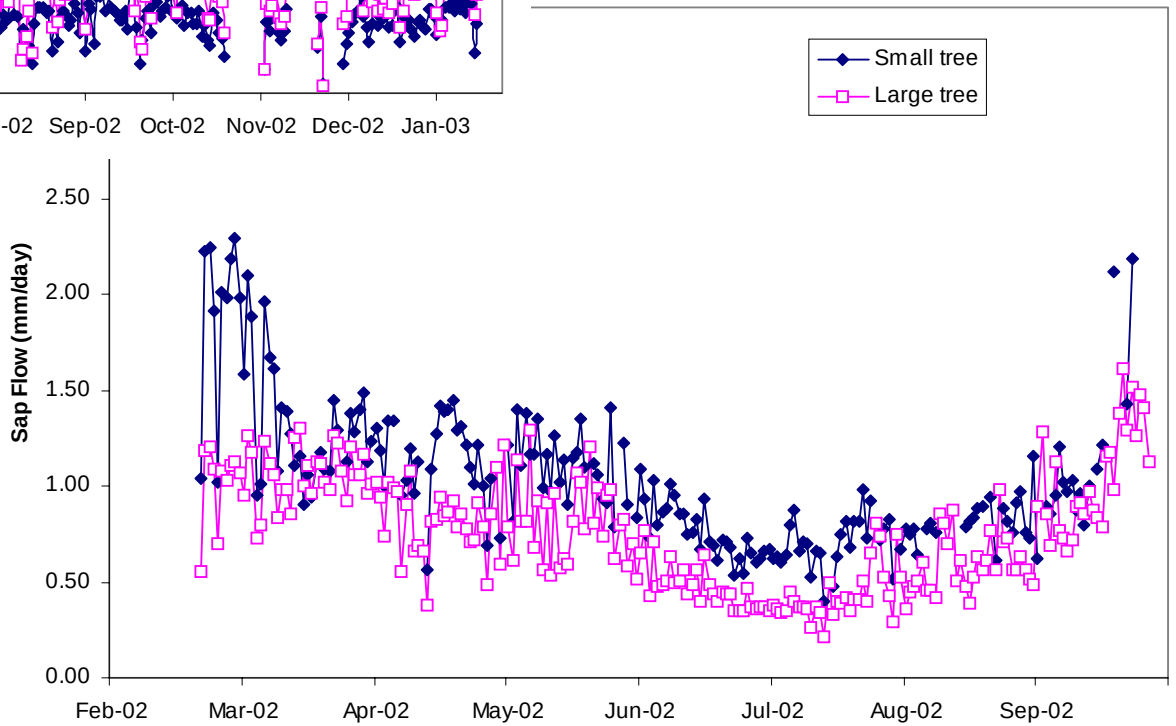


HYDRUS2D inputs: Transpiration

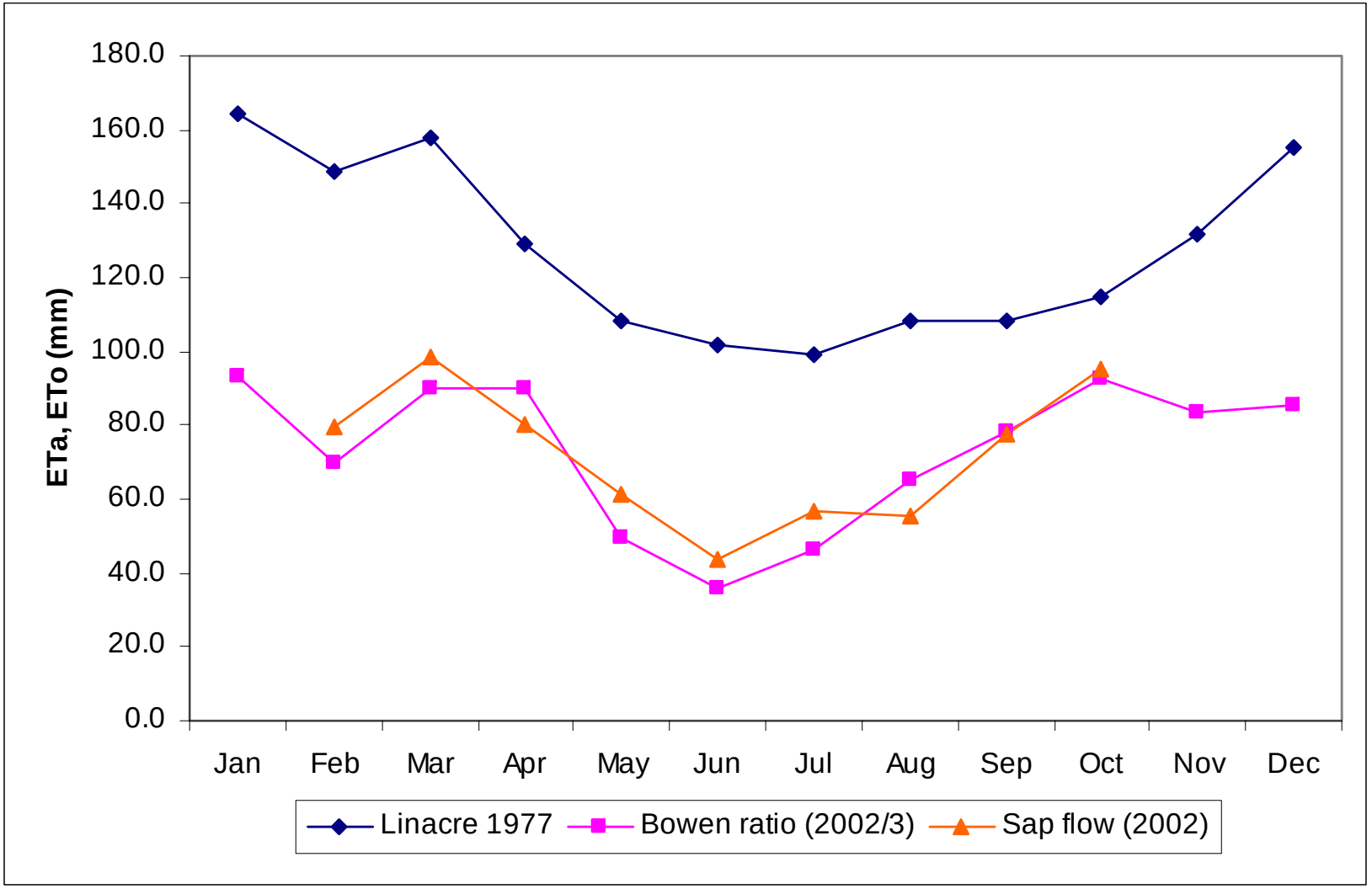


Sap flow rates for Bugweed trees (2002)

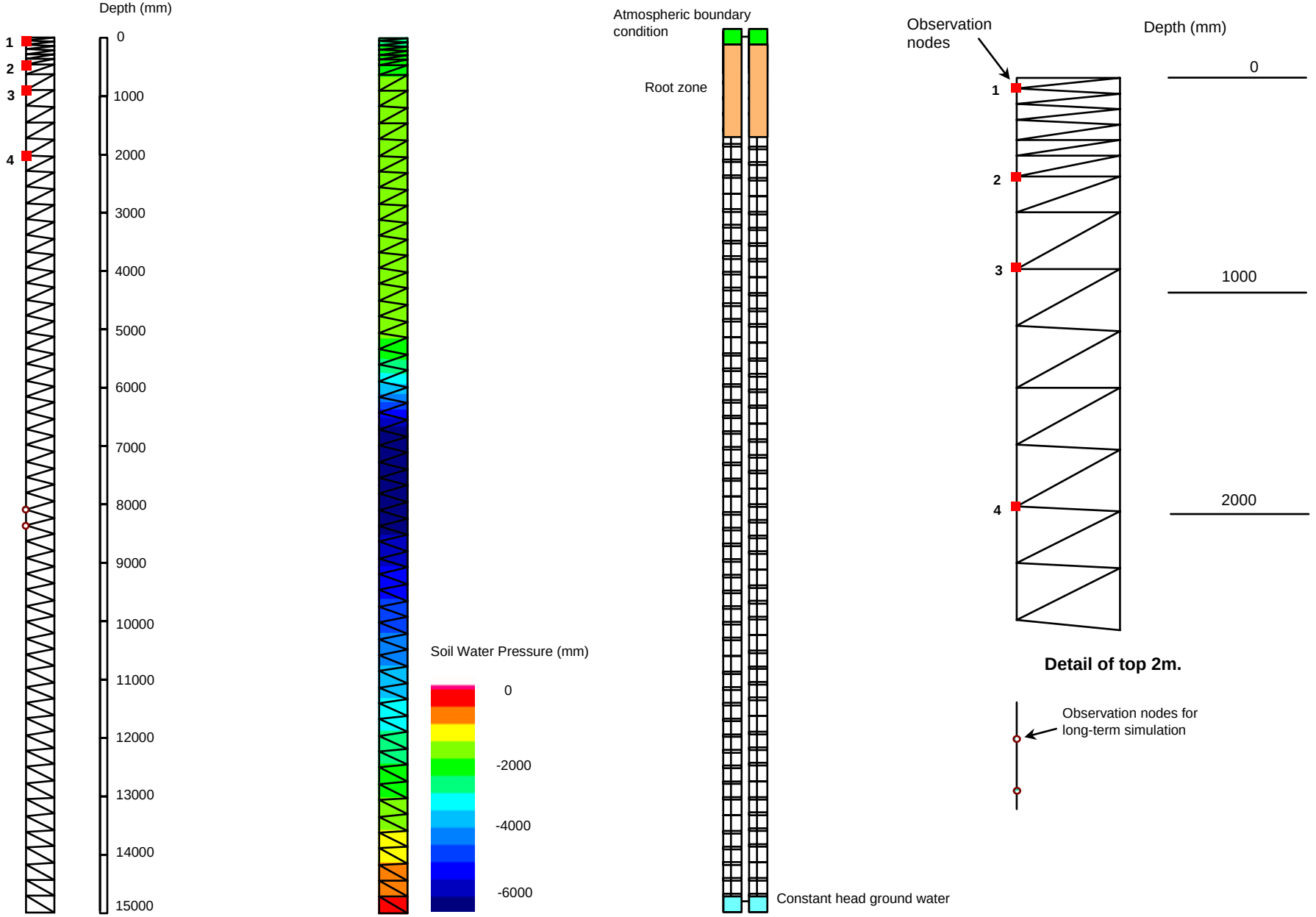
Sap flow rates for Pigeonwood trees (2002)



HYDRUS2D inputs: potential evaporation and transpiration

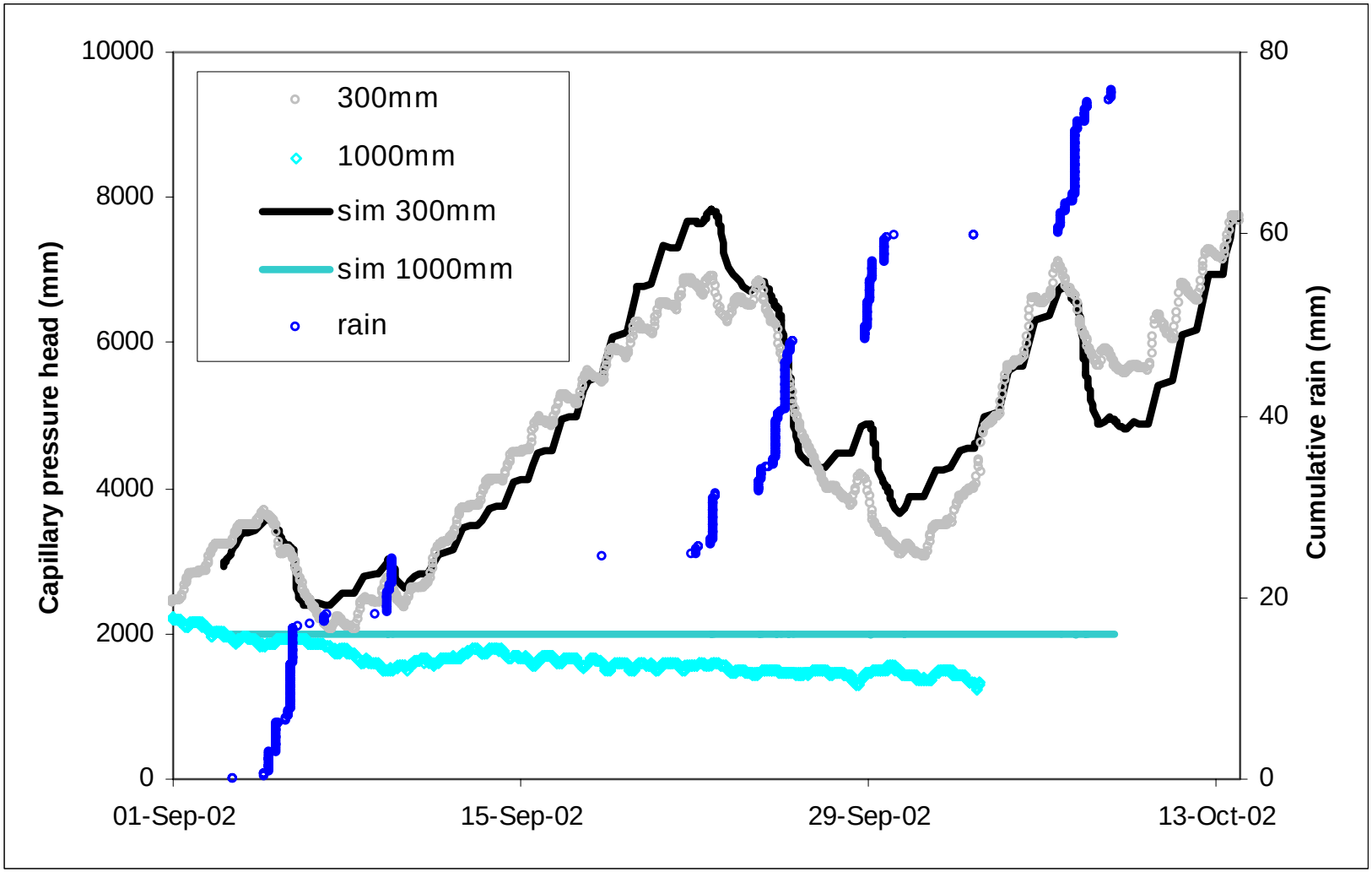


HYDRUS2D finite element configuration

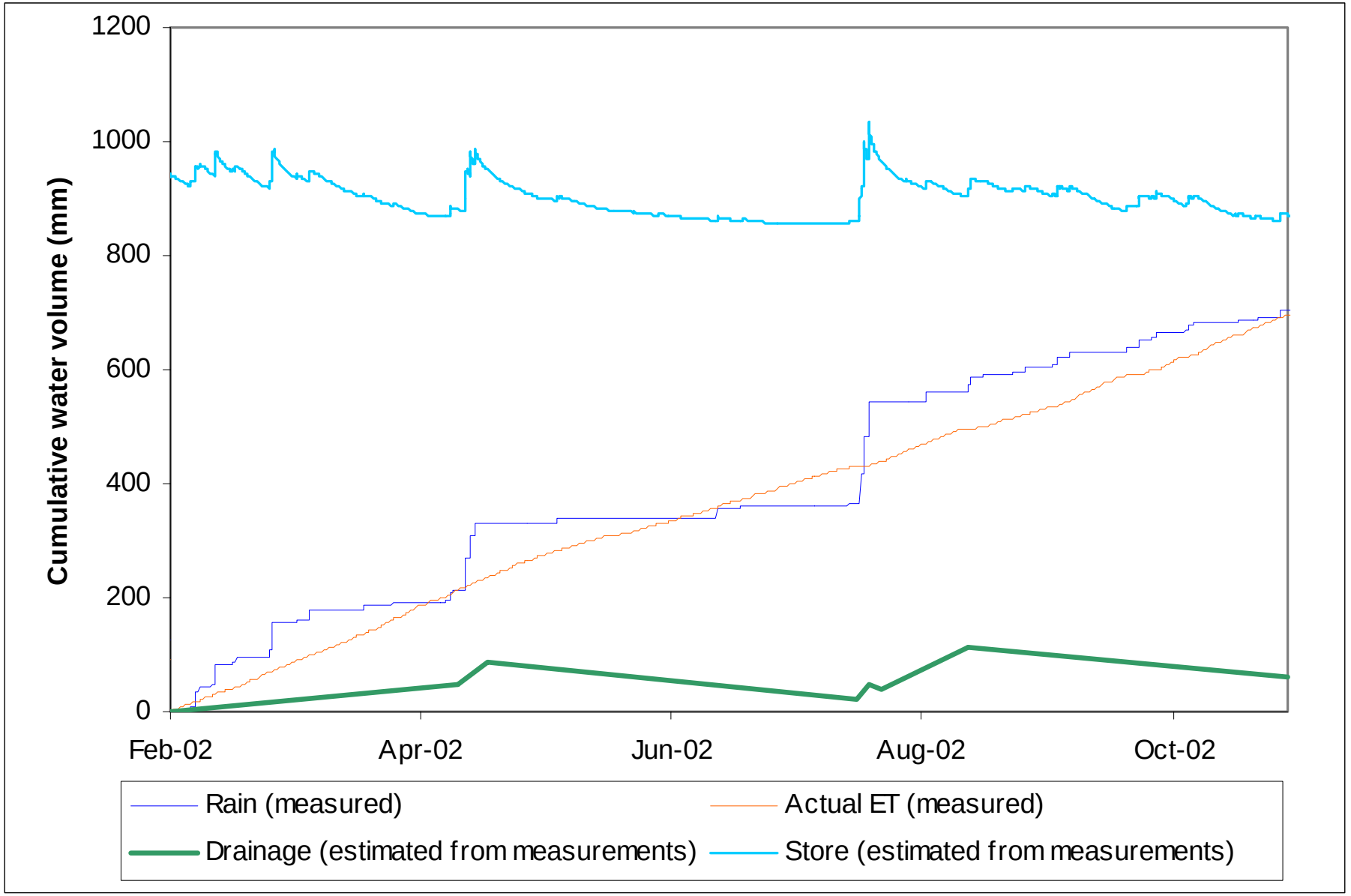


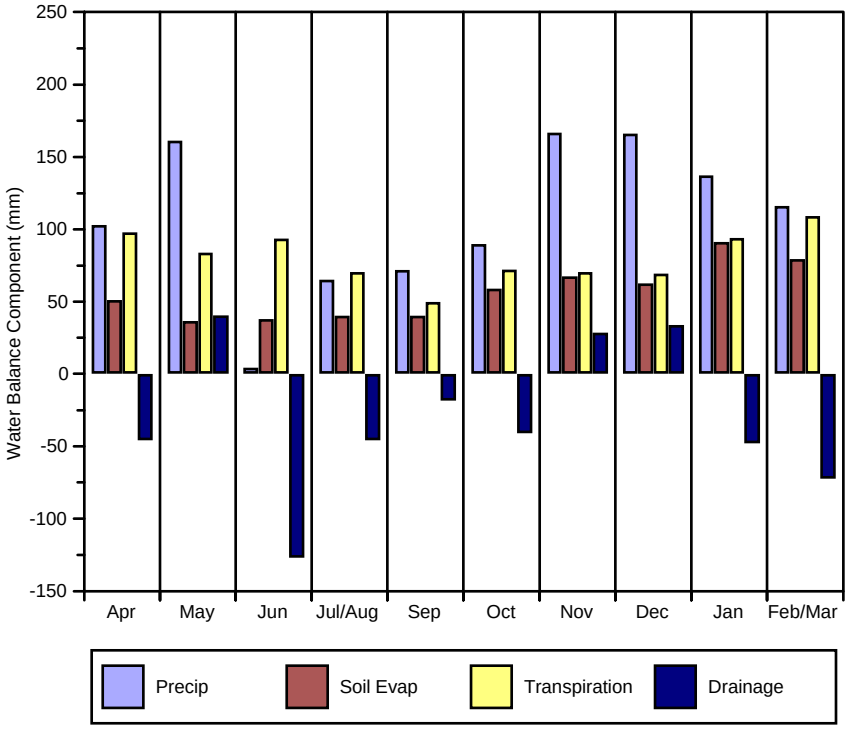
HYDRUS-2D Finite Element Mesh **Initial Conditions** **Boundary conditions**

Typical comparison of measured and simulated soil water tension from which fluxes are derived



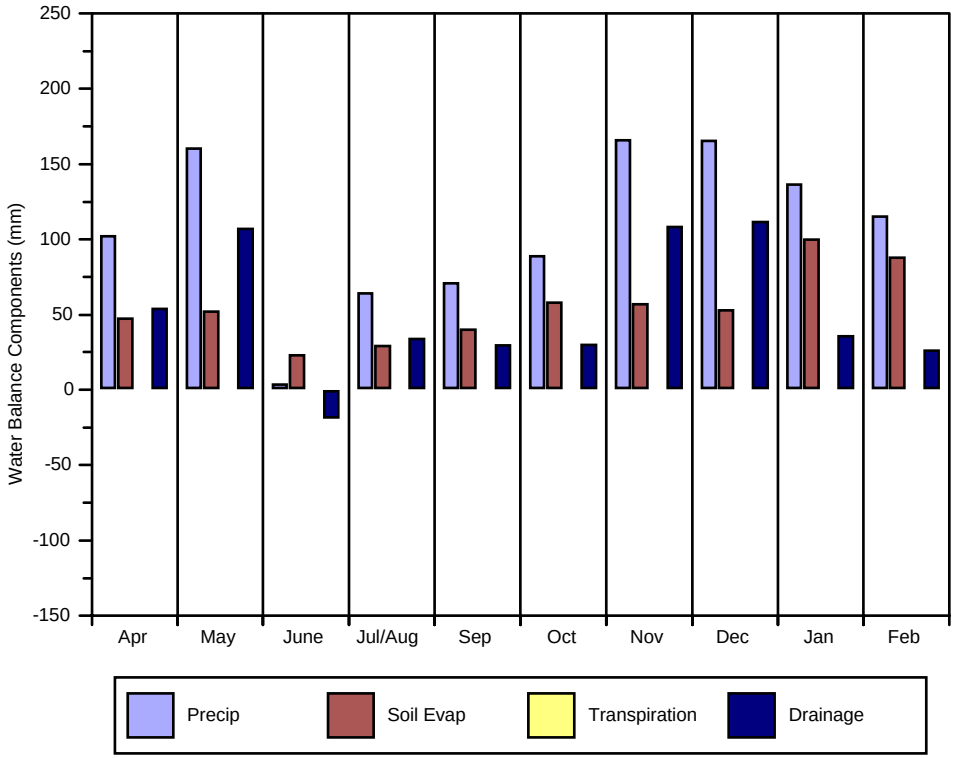
Components of the root zone water balance for the monitored period





Simulated root zone water balance for monitored period for Fig Tree site.

Simulated water balance for monitored period for Bare site (2000mm depth)



Long term slimes dam water balance simulation

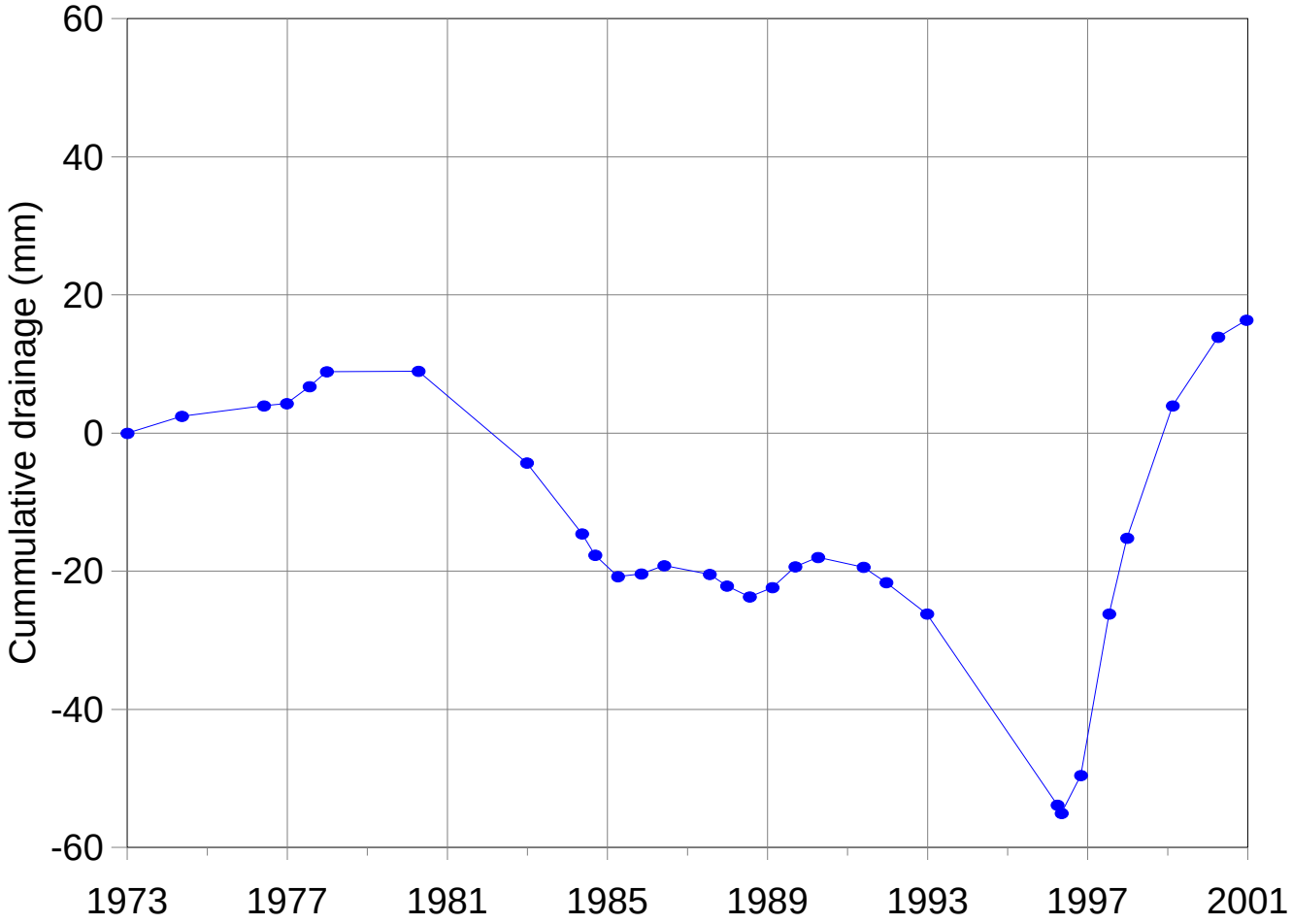
- Long term ground water recharge fluxes are simulated by

  - Correlating meteorological parameters for short term records between stations at the site and Durban International Airport,

  - Simulating full vegetation cover performance using HYDRUS2D with adjusted long term inputs of rainfall and potential evaporation (28yr record),

  - Extracting the discharge time series for groundwater recharge from the base of the slimes dam.

Results of simulated fluxes to groundwater



Cumulative simulated long term recharge to groundwater: Vegetated scenario

Scope of current investigations

- Groundwater hydraulic control and Natural Attenuation assessment
    - Groundwater tracer study.
    - Assess natural attenuation capacity
    - quantify recirculation water and mass balance
- Phytoremediation assessment
    - Improving ET estimates using scintillometry
    - Characterizing spatial distribution of hydraulic performance
    - Evaluating capacity of slimes profile for natural attenuation
- Surface hydraulic control
    - Evaluation and design of cap for buried drums area
    - Design of surface runoff and seepage controls

Conclusions

- Natural attenuation has been observed in the slimes profile and groundwater

- A combined train of technologies, comprising

    - hydraulic control (surface and subsurface)
    - phytoremediation and
    - managed natural and enhanced attenuation

has been defined for long term management of the site

- Phytoremediation is a valuable component in the system of remediation:

    - limiting groundwater recharge to less than 0.3% of rainfall and
    - providing an environment for natural attenuation of VOC's