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Water Ingress Into Mine Waste Storage Facilities:

How to Quantify a Key Closure Liability

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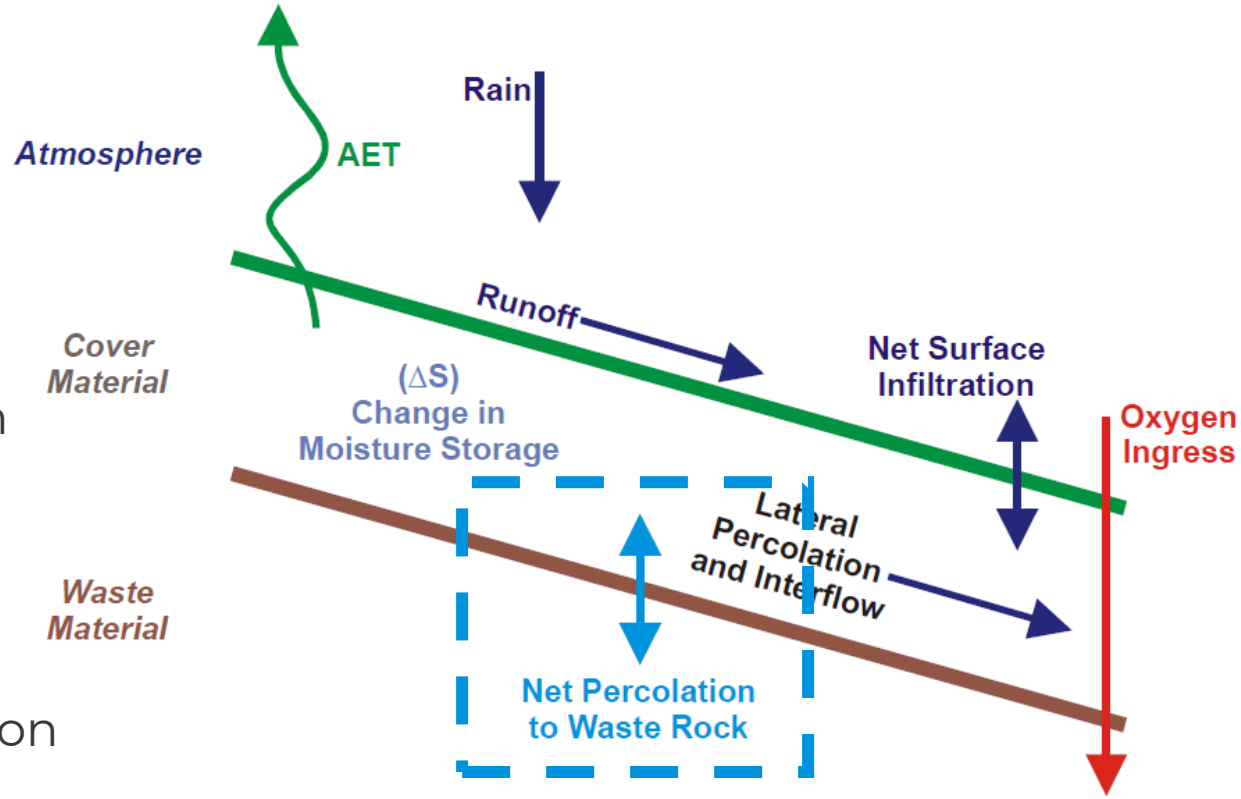
WHAT IS NET PERCOLAITON?

What is NP?

- Water that migrates beneath the ‘active zone’ into waste material.

Why do we care?

- NP is one of the main drivers of AMD load from *MWSFs seepage.
- Negatively impact SW + GW receptors.
- Understanding load helps inform AMD collection and treatment requirements.



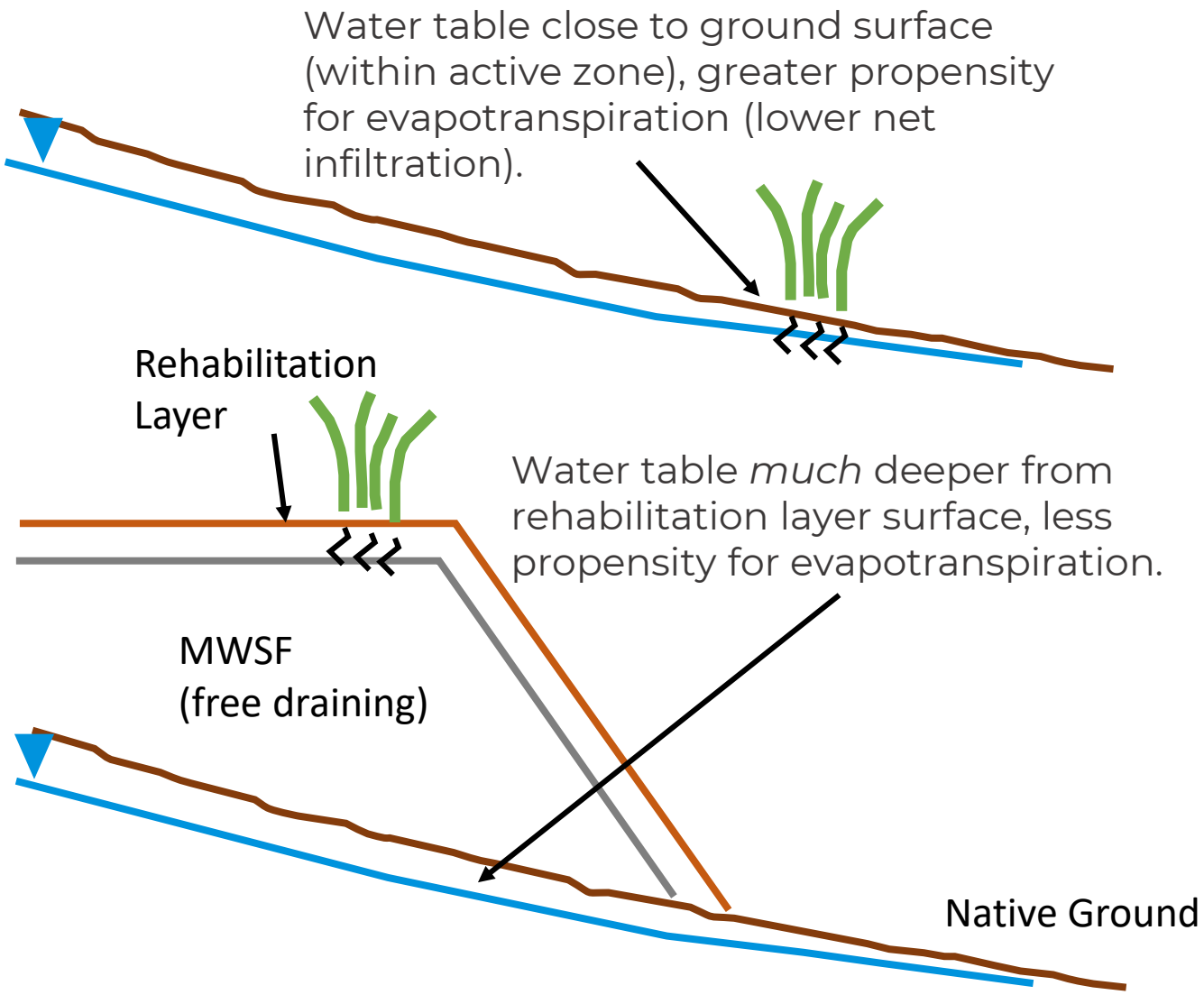
Source: MEND (2004)

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WHAT NP IS NOT

Often assumed to be equal to regional land surface recharge from GW Models, however:

- When we consider the differences in hydrological condition, a different picture emerges.
- MWSF, and WRDs in particular, are often free draining.
- The water table is much deeper and below the active zone of evapotranspiration (ET).
- So even with the same material used for rehab, NP into facility will be higher (since ET is lower).

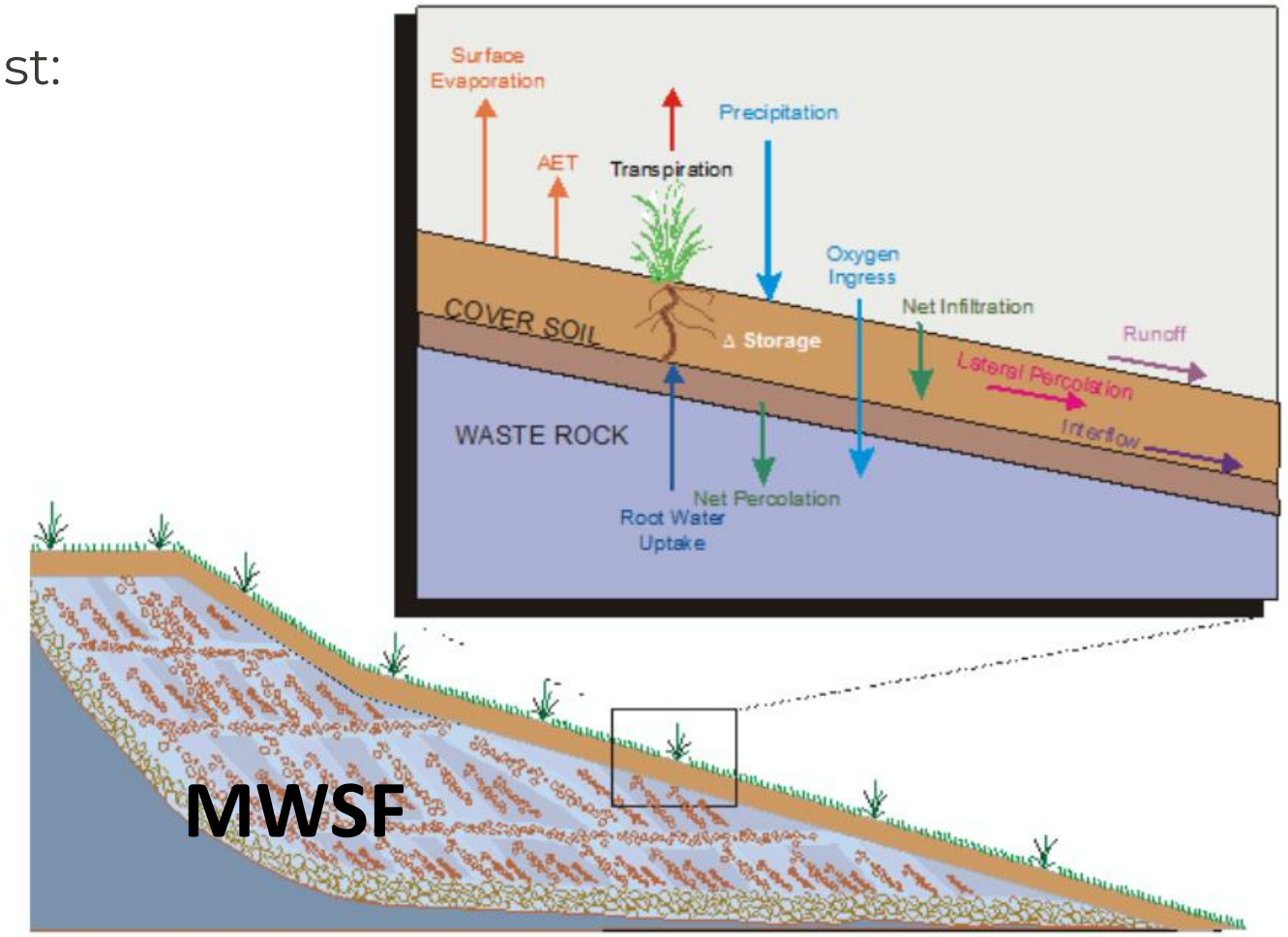


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ESTIMATION METHODS

A variety of quantification methods exist:

- Desktop approach
- Facility water balance
- Lysimeter measurements
- Near surface water balance
- Numerical simulations



Source: INAP

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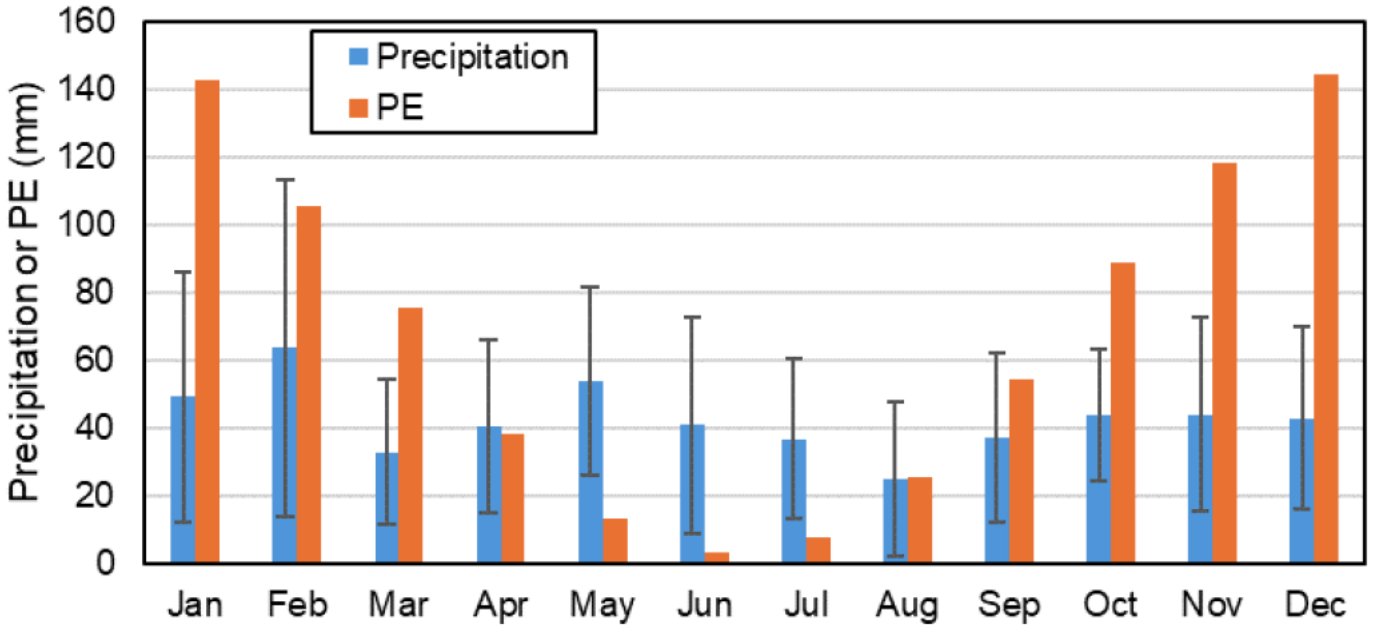
DESKTOP APPROACH

Approach

Conceptually evaluates the following controls on NP:

- Climatic conditions
- Cover system/capping (if present)
- Material properties
- Landform influences
- Vegetation influences

Compare with literature for sanity check.



Monthly precipitation and potential evapotranspiration from an undisclosed site.

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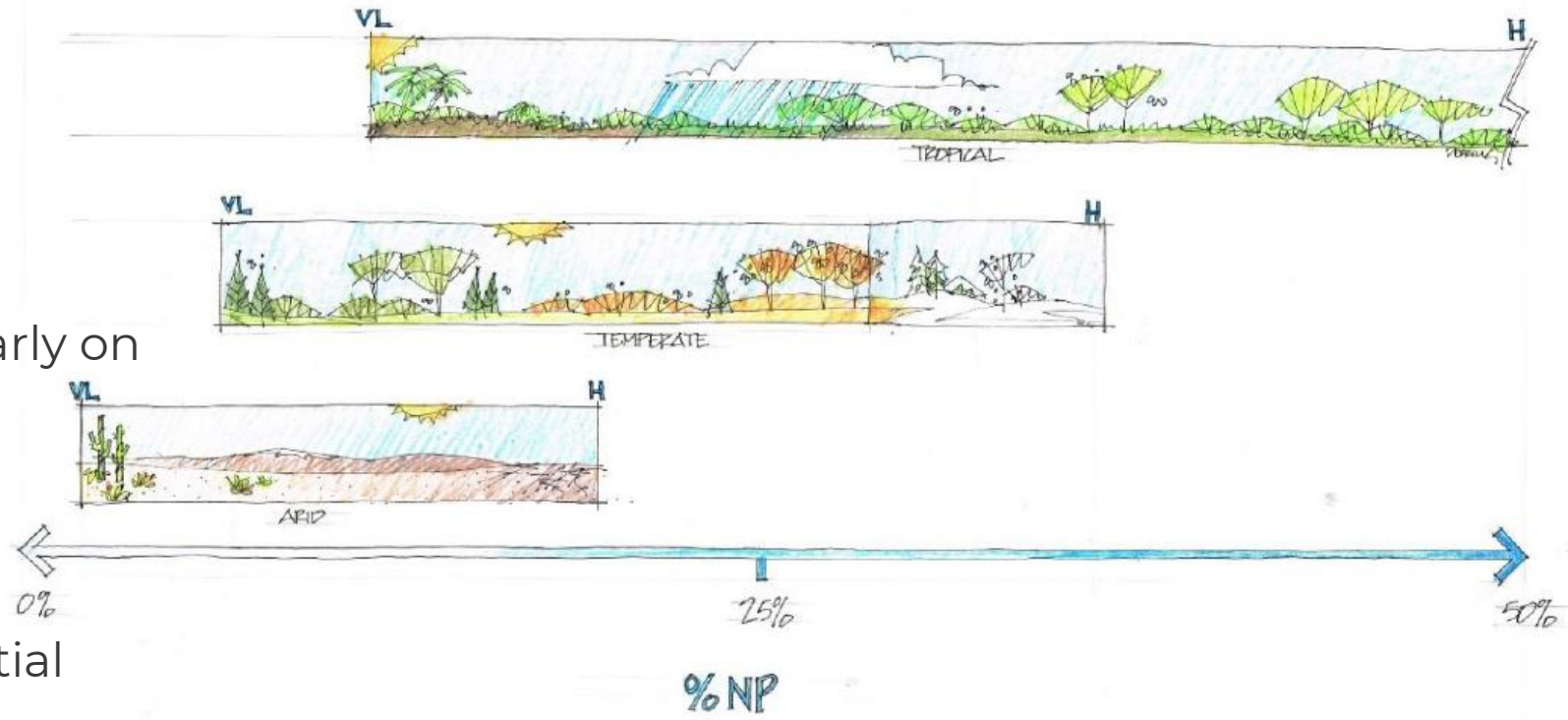
DESKTOP APPROACH

Pros

- Field investigation not essential
- Relatively modest in cost
- Can help inform the risk profile early on in project studies

Cons

- Best we can do is estimate potential range of NP*
- Further studies needed to narrow range

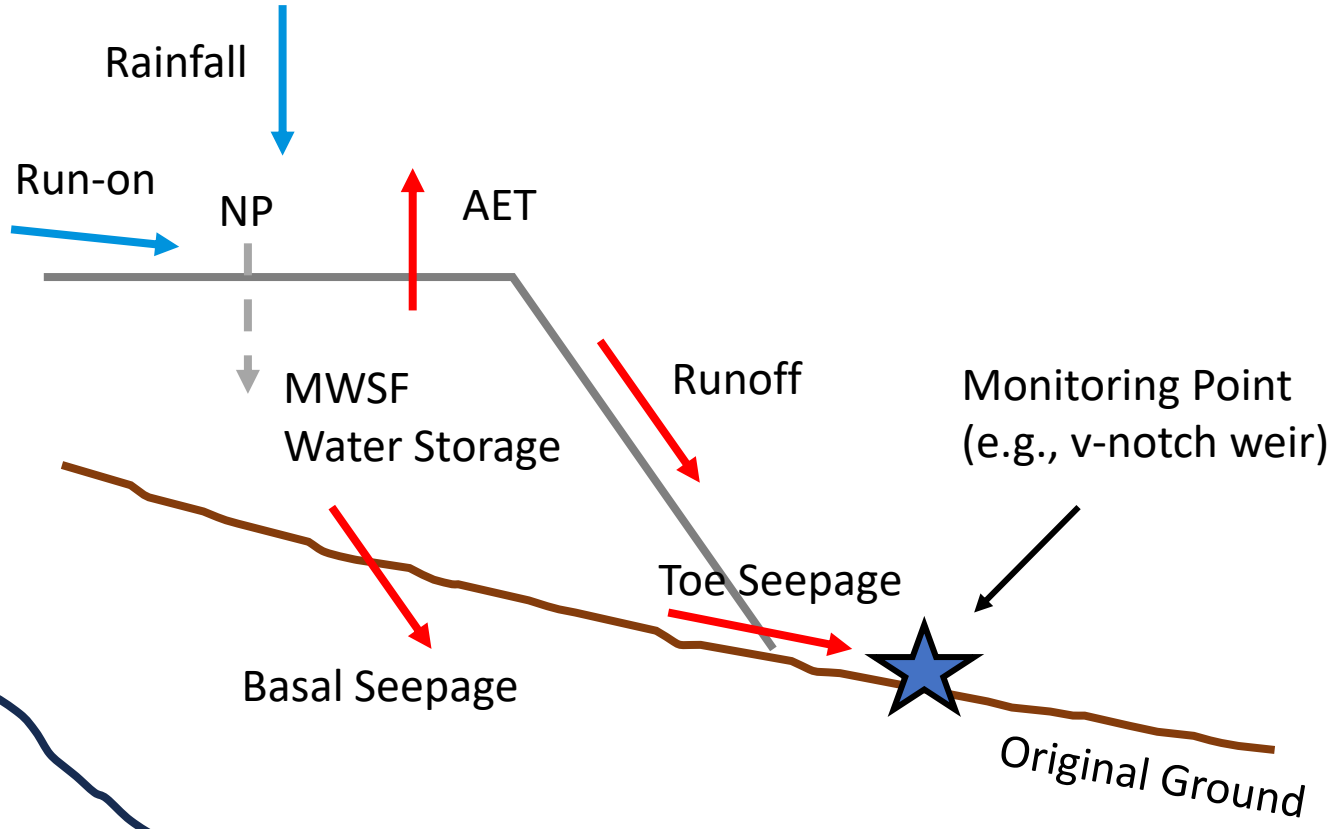


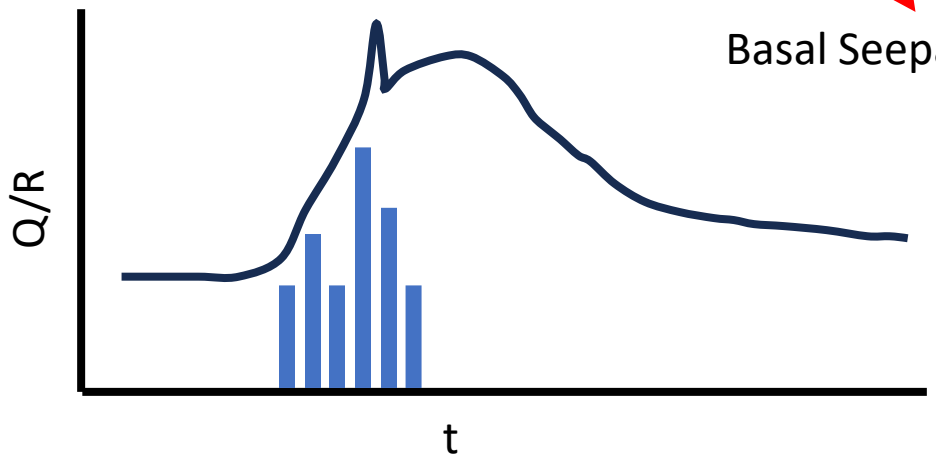
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FACILITY WATER BALANCE

Approach

- Measure and isolate as many inflow and outflow terms from MWSF as possible.
- Identify potion of flow record not influenced by runoff.
- Back calculate NP (area under curve).





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FACILITY WATER BALANCE

Pros

- Relatively modest in cost and easy to instrument*.
- Landform scale.

Cons

- Good understanding of flow paths needed.
- Not all terms in the water balance easily monitored (e.g., basal seepage, AET).



Source: Jewiss (2018)

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LYSIMETER

Approach:

- Install a collection ‘tub’ within MWSF and monitor outflow (= NP).
- Can be installed as facility is built, or afterwards.
- Although conceptually simple, careful design that considers unsaturated zone hydrology is essential to ensure measurements representative.



Source: INAP (2009)

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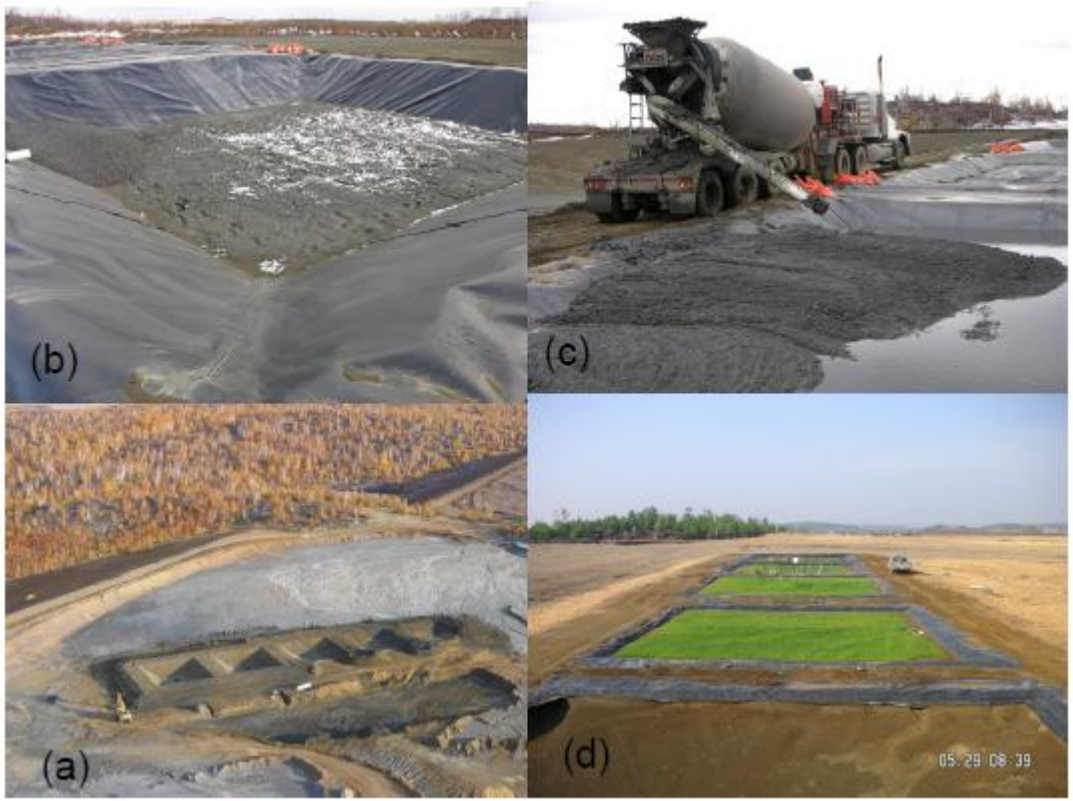
LYSIMETER

Pros:

- Actual record of water in MWSF (easy to interpret) if designed correctly.
- Also allows collection of water quality in addition to estimating NP.

Cons:

- Low to moderate investigation area.
- Can be expensive to design and install.



Source: Wilson et al. 2022

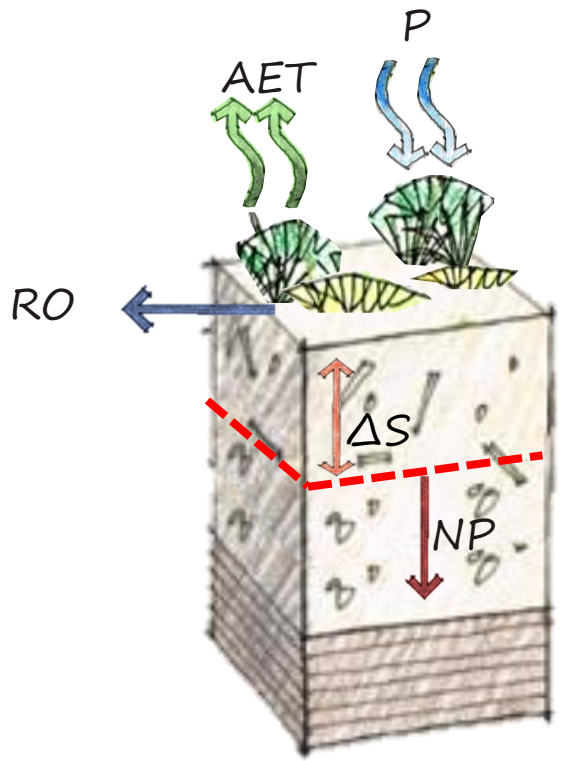
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NEAR SURFACE WATER BALANCE

Change in Storage $_{WB}$ = Precipitation – Actual Evapotranspiration – Runoff – Net Percolation ≈ Change in Storage $_{Measured}$

Approach

- Similar to Facility Water Balance, except focus on near surface and measure storage change in cover system (e.g., in soil).
- Install insitu soil monitoring system to measure storage change (and other properties, matric suction) .
- Adjust water balance terms within reasonable bounds to match measured and calculated change in storage over time.



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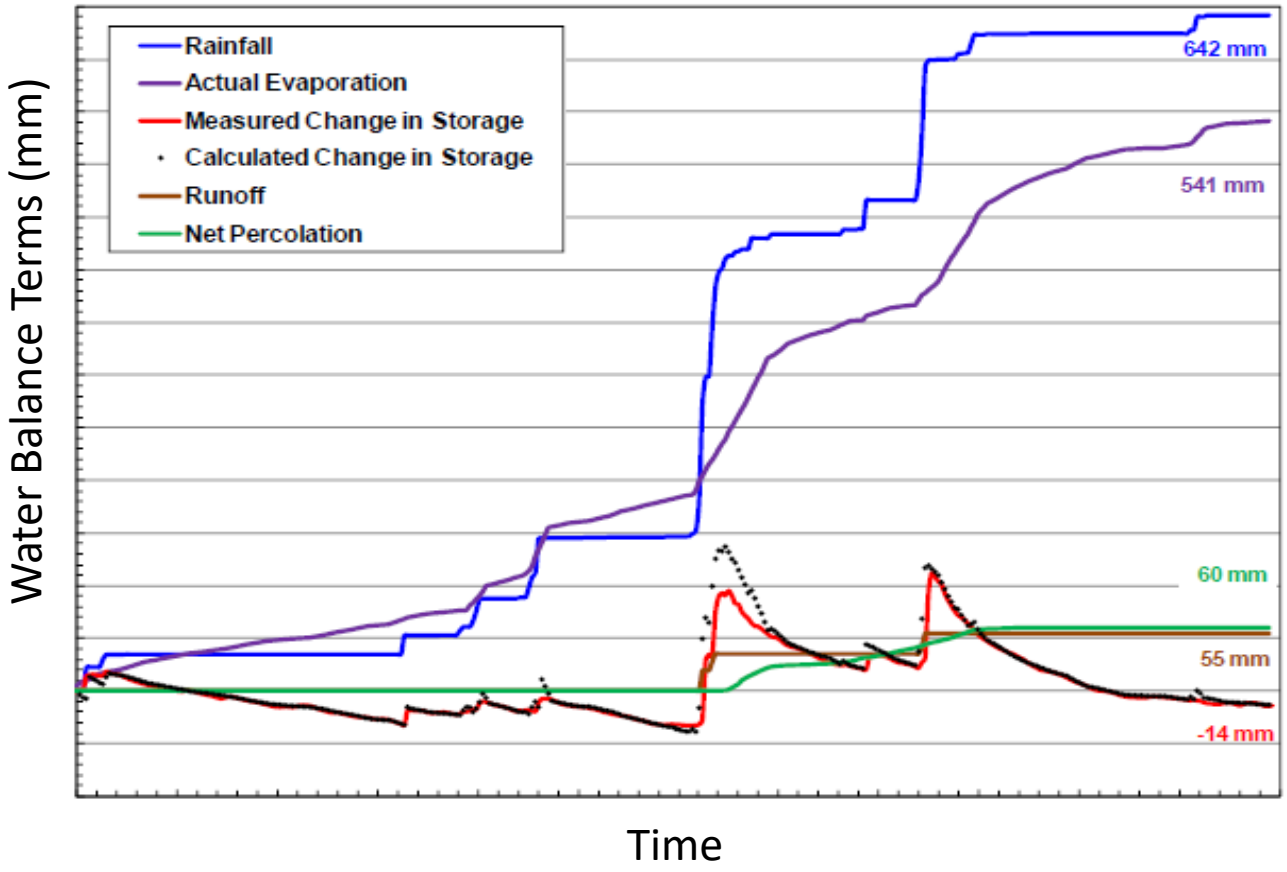
NEAR SURFACE WATER BALANCE

Pros

- Representative of actual field conditions.
- High resolution system dynamics.

Cons

- Moderate expense for instrumentation.
- Only representative of instrumented location. Multiple locations may be needed across MWSF landform.

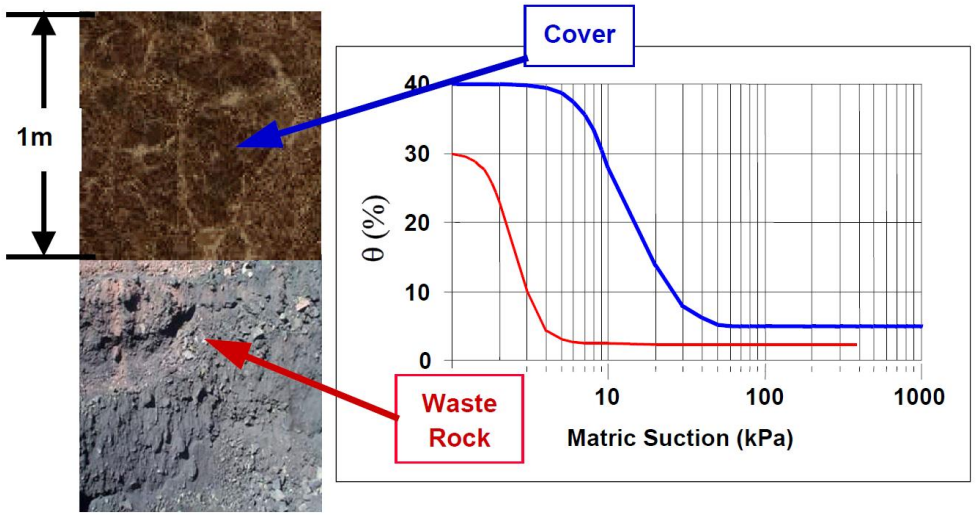


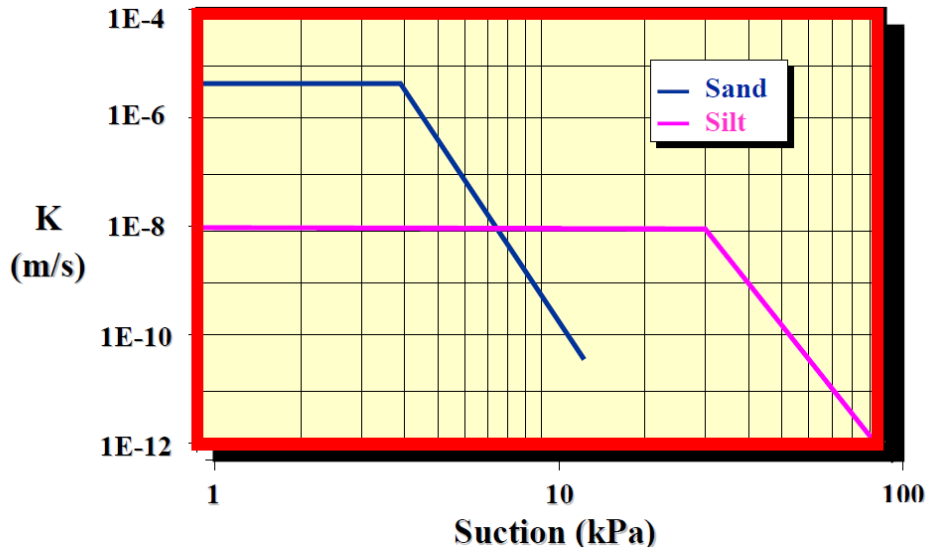
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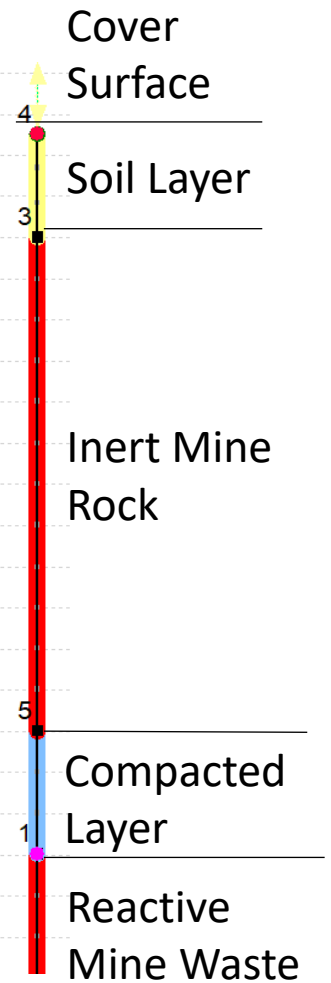
NUMERICAL SIMULATIONS

Approach:

- 1D (2D) unsaturated flow modelling.
- Inputs typically include:
  - Climatic dataset
  - Cover system construction/design
  - Material hydraulic properties
  - Vegetation characteristics
- Ideally be calibrated to field measurements.







Source: MEND (2004)

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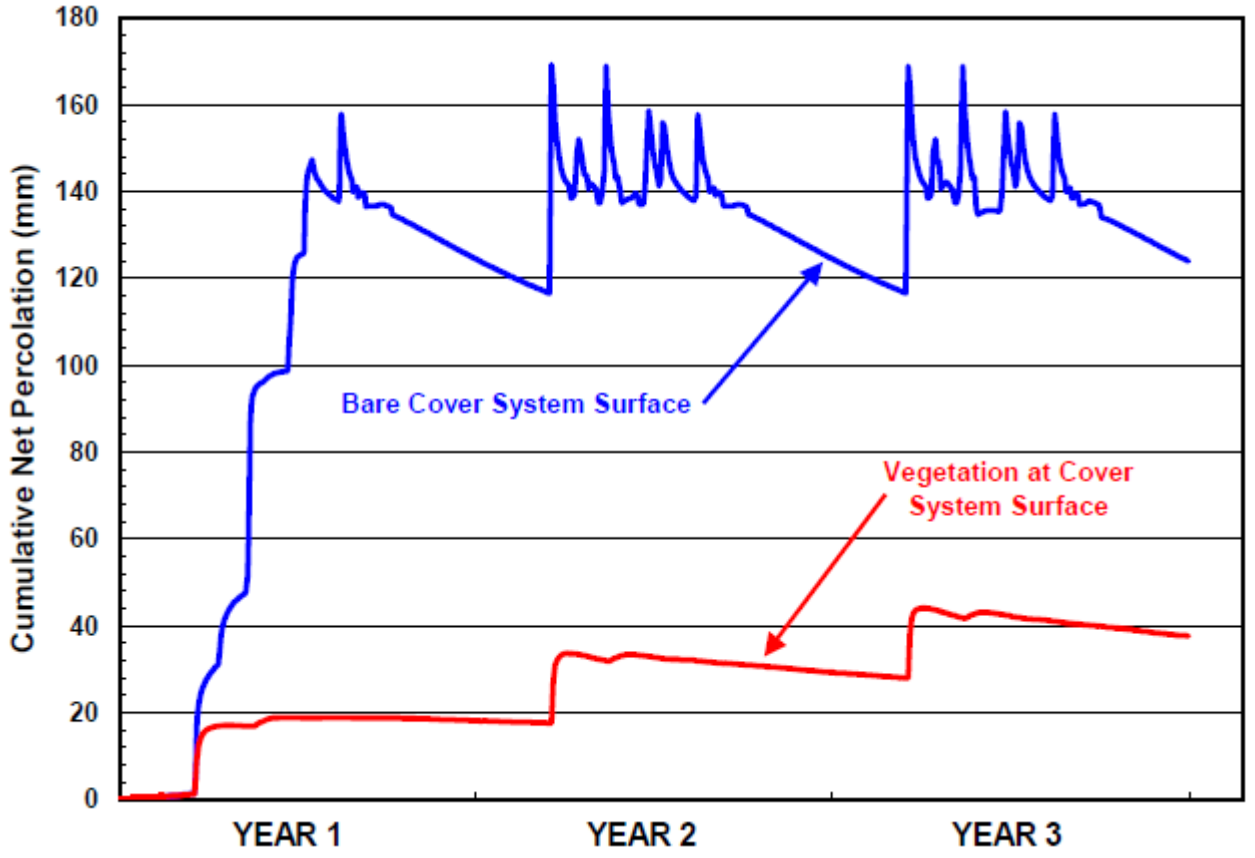
NUMERICAL SIMULATIONS

Pros:

- Allows investigation of what aspects of the system are most important to meeting performance objectives.
- Alternate cover systems can be evaluated

Cons:

- High data requirements
- Moderate to high costs
- Requires upscaling to landform



Source: MEND (2004)

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TAKE HOME POINTS

- NP is one of the primary controls on AMD collection and treatment requirements, and potentially a key closure liability.
- NP ≠ regional groundwater recharge rate
- A variety of methods exist to quantify NP, spanning a spectrum of complexity and cost.
- Each has their benefits and limitations.
- For more complex approaches, careful planning is required to maximise chances of getting accurate results representative of field conditions.

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