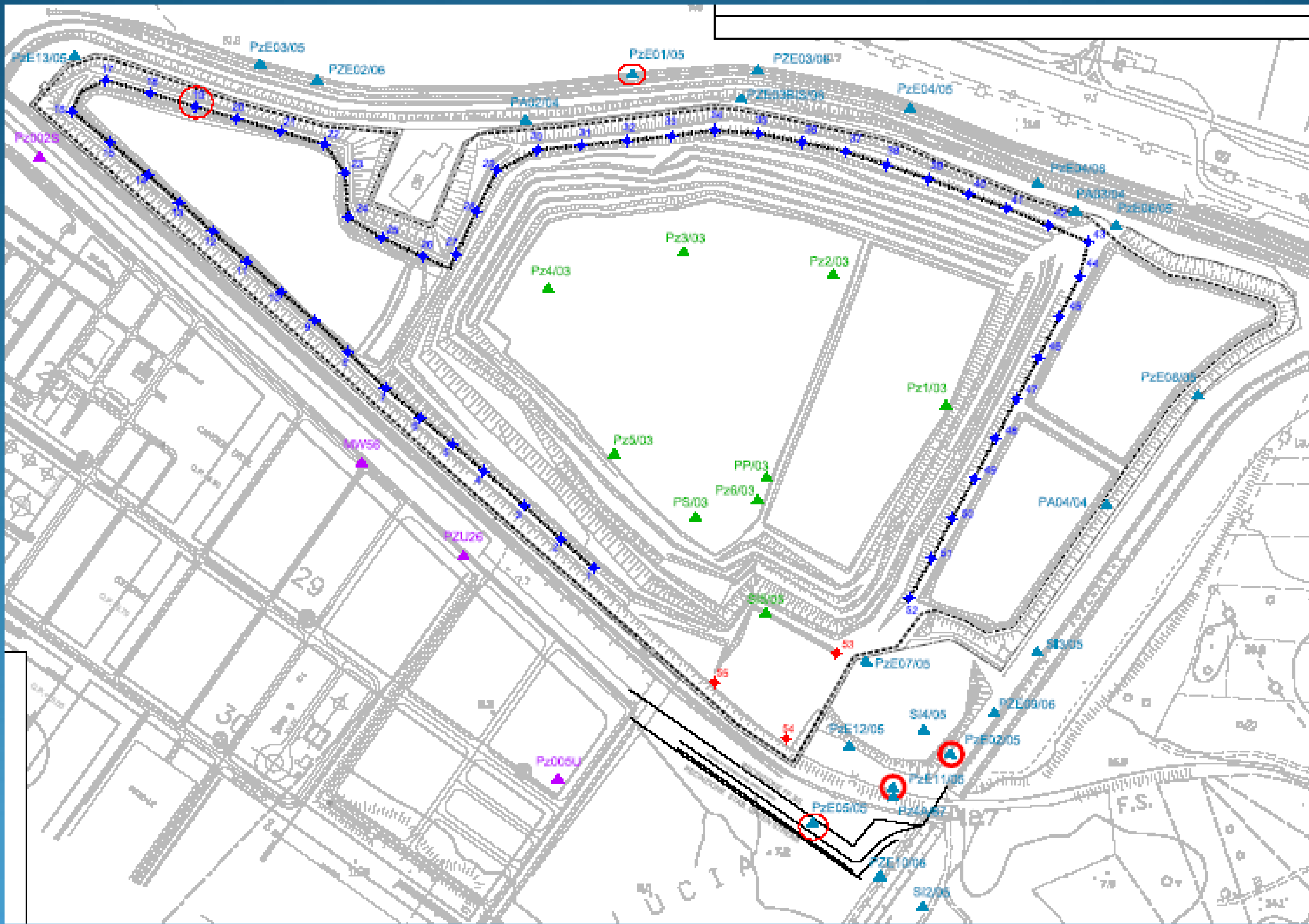
EMRAS II

NORM sub-group

January 2010

Vienna

Gela


PzE13/05
PzE03/05
PZE02/06
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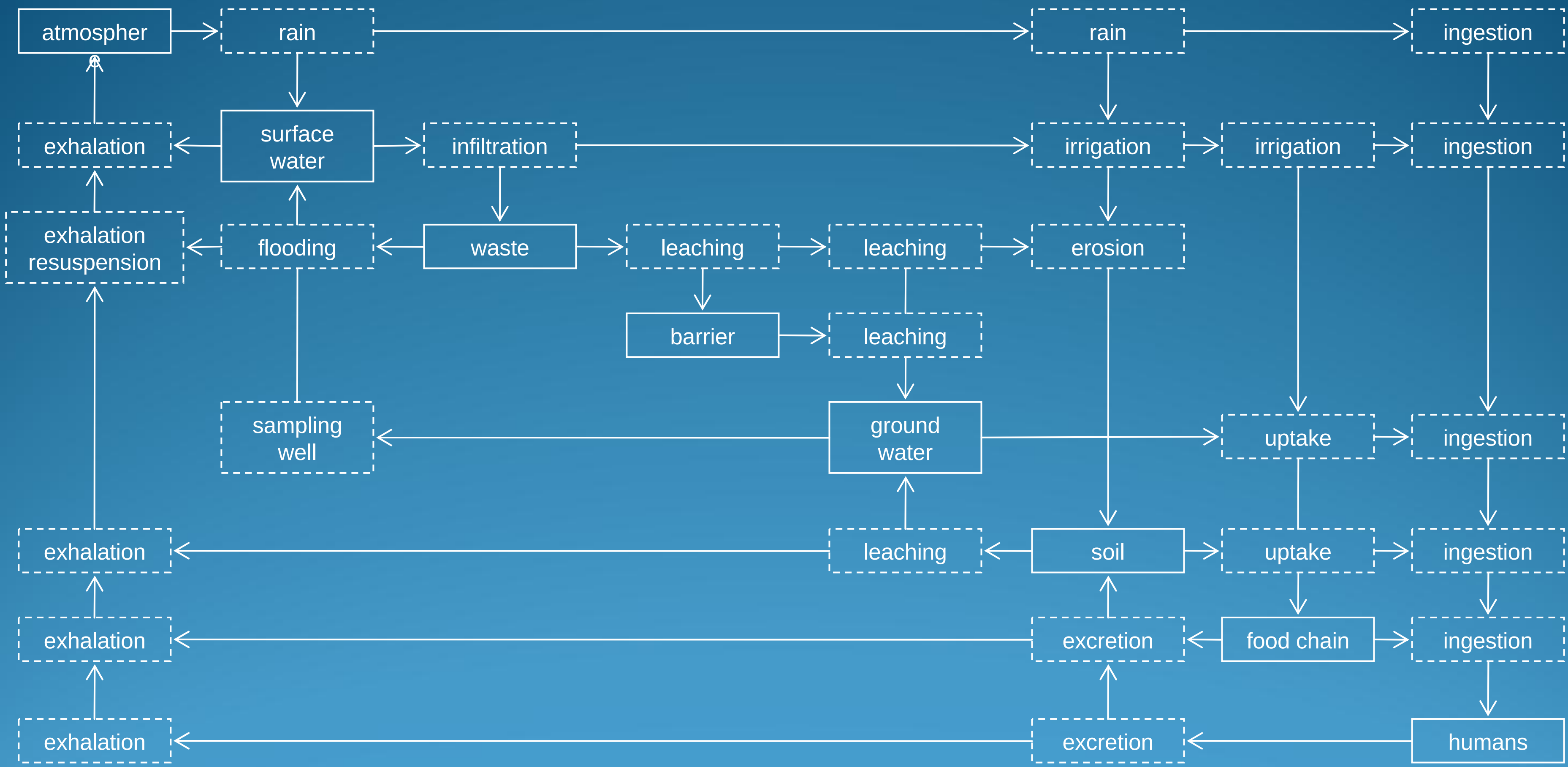
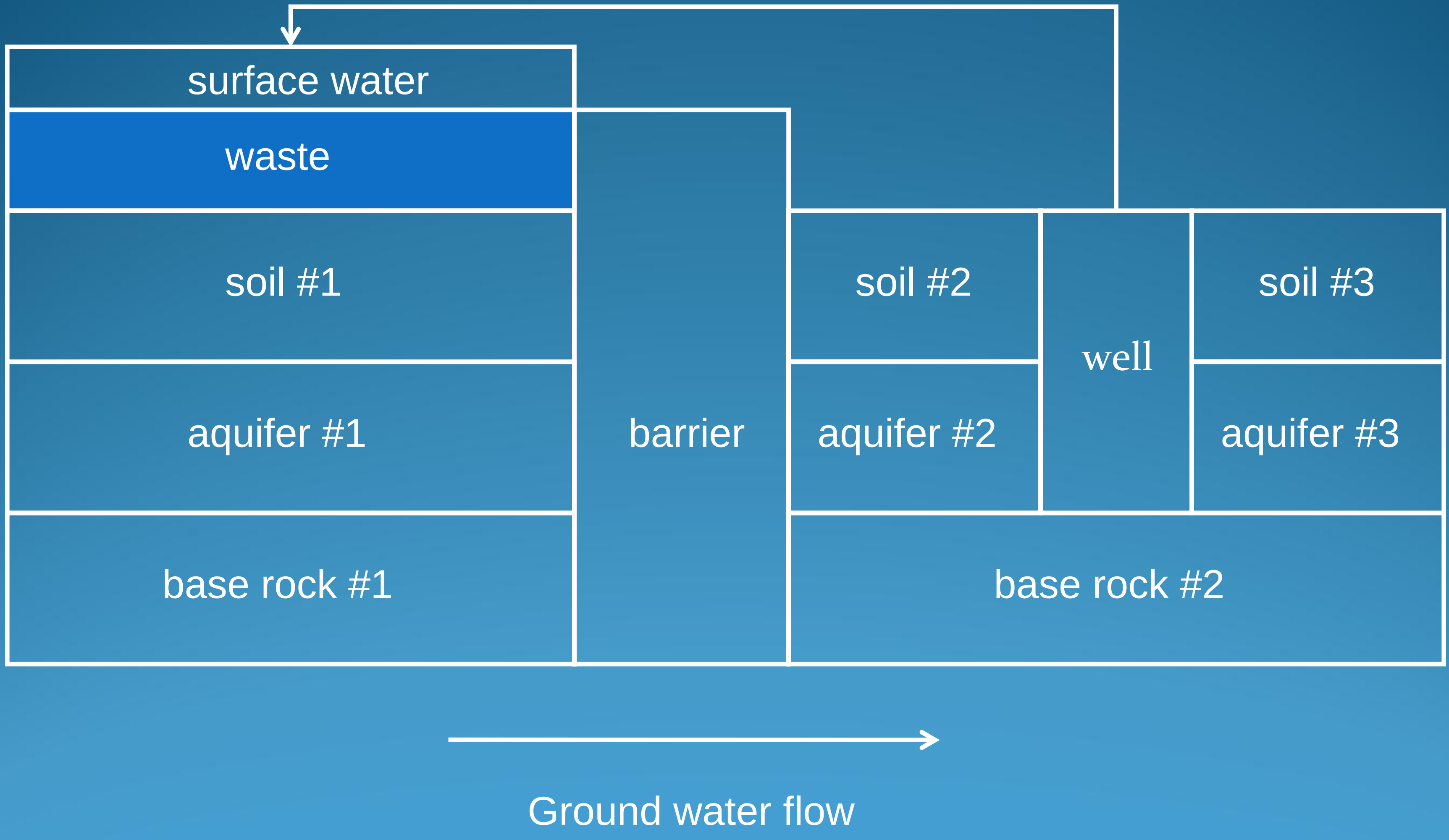
PA02/04
PzE04/05
Pz002S
Pz3/03
Pz2/03
Pz4/03
Pz1/03
PzE08/05
Pz5/03
PP/03
Pz6/03
PS/03
MW56
PZU26
PA04/04
PzE07/05
SI3/05
SI4/05
PzE09/06
PzE12/05
PzE02/05
PzE11/06
PzE05/05
PzE10/06
SI2/05
Pz006U

Characteristic matrix - Gela

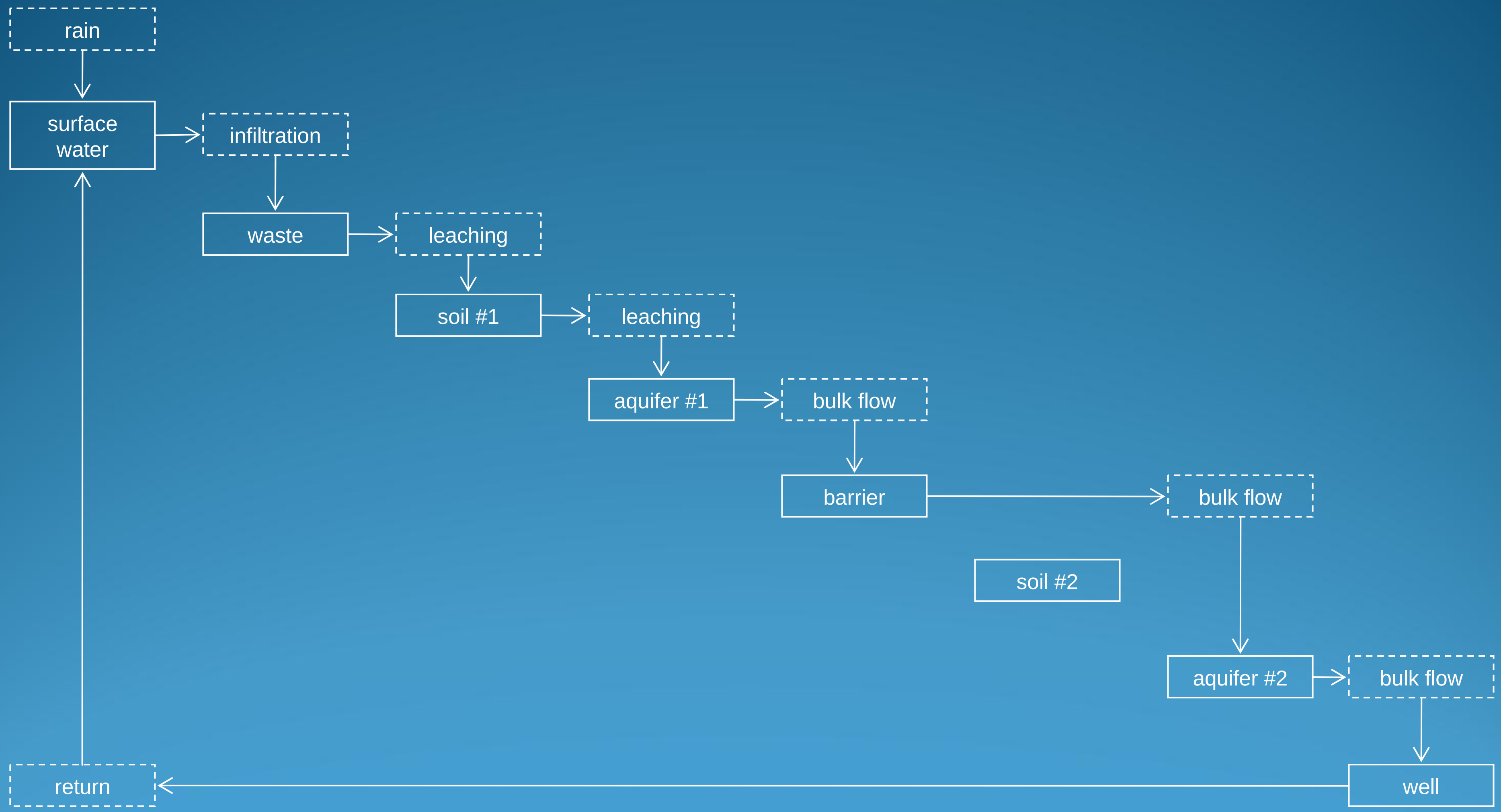


- This is obviously a complex problem in terms of detailed modelling
- Look for ways to simplify without losing the essesntial features
  - The barrier
  - The return of the leachate (percolate) to the top of the stack

Gela – simple 2D representation



Gela – simplified characteristic matrix



Compartment models

- General formulation

$$\frac{d\mathbf{C}}{dt} = A\mathbf{C}$$

- solution

$$\mathbf{C}(t) = \mathbf{C}(0)e^{At}$$

	surface water	waste	soil #1	aquifer #1	barrier	soil #2	aquifer #2	well
surface water			0	0	0	0	0	0
waste				0	0	0	0	0
soil #1	0	0			0	0	0	0
aquifer #1	0	0	0			0	0	0
barrier	0	0	0	0		0		0
soil #2	0	0	0		0			0
aquifer #2	0	0	0			0		
well		0	0	0	0	0	0	

Summary of available data:

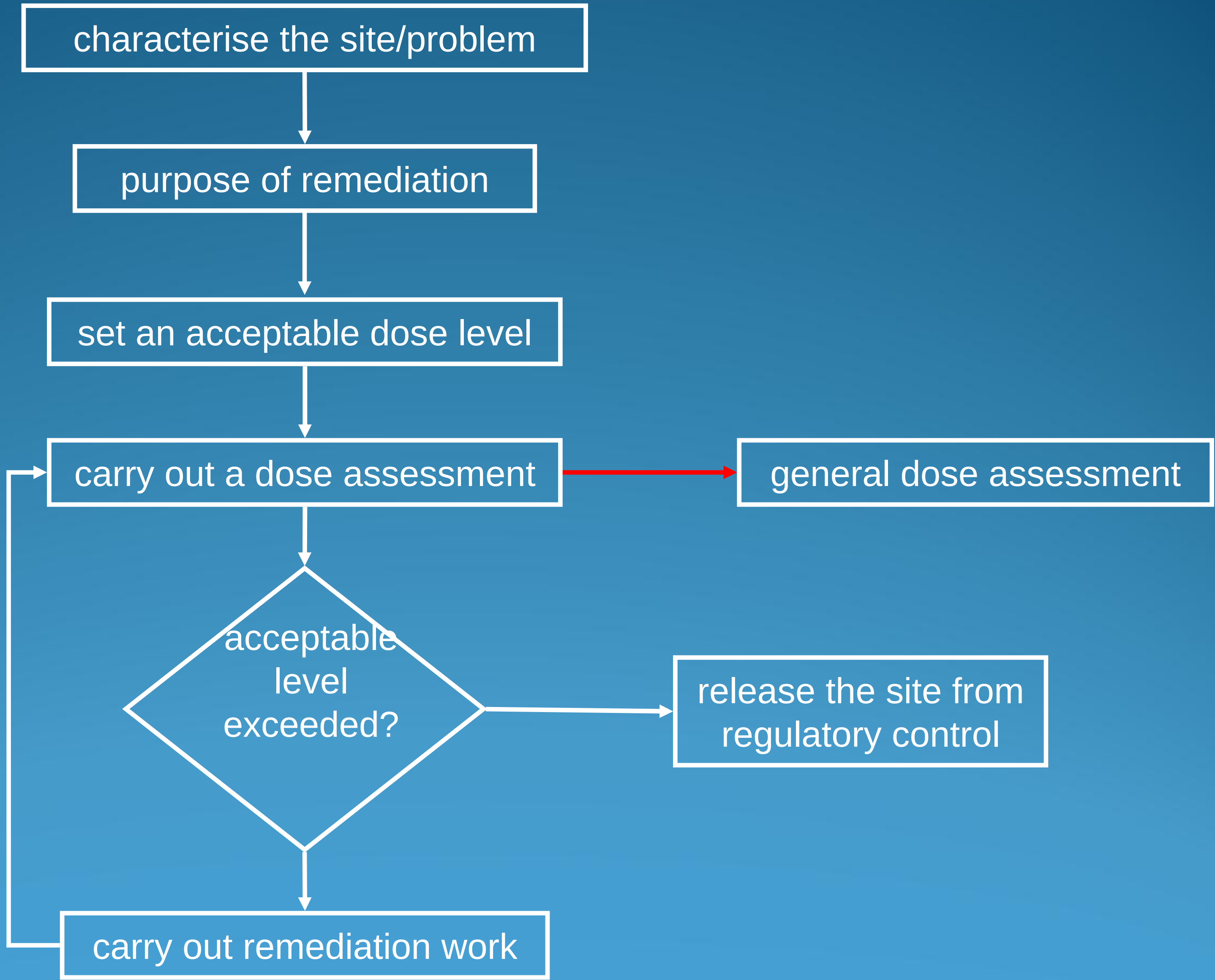
- the stack is positioned in an area where a bed of clay (hydraulic conductivity ~ 10-12×10-11 m s-1, thickness = 20-30 m, depth = 7-21 m) is present; the clay bed extends for hundreds of hectares; the hydraulic conductivity of phosphogypsum is 5×10-6 m s-1;
- the clay bed and the surrounding concrete retaining wall, inserted in the clay bed for 2-3 meters, should form a barrier for the superficial (i.e. over the clay bed) groundwater normally flowing from NW to SE; no investigation exists on presence of groundwater below the clay bed;
- the superficial groundwater is not permanent, i.e. it completely depends on rainfalls, which is very rare but intense; for long periods in a year piezometers and wells, outside the N-NW side of the stack are dry; therefore groundwater samples are not collected on a regular basis;
- in the SE corner outside the stack wall, where the sampling points Pz 02/05 and Pz 11/05 are, a lens of sand receives water from the superficial groundwater getting around the stack and from the surrounding hills; for this area information needed to model the dispersion of NORM is available:
- hydraulic conductivity: 2×10-4 m s-1
- Darcy velocity: 5 m a-1
- the depth of water is 6.25 m in Pz 11/05 which is at 12.30 m above sea level; the depth of water is 4 m in Pz 02/05, which is at 10.4 m above sea level

Hypothetical scenario – tailings dam

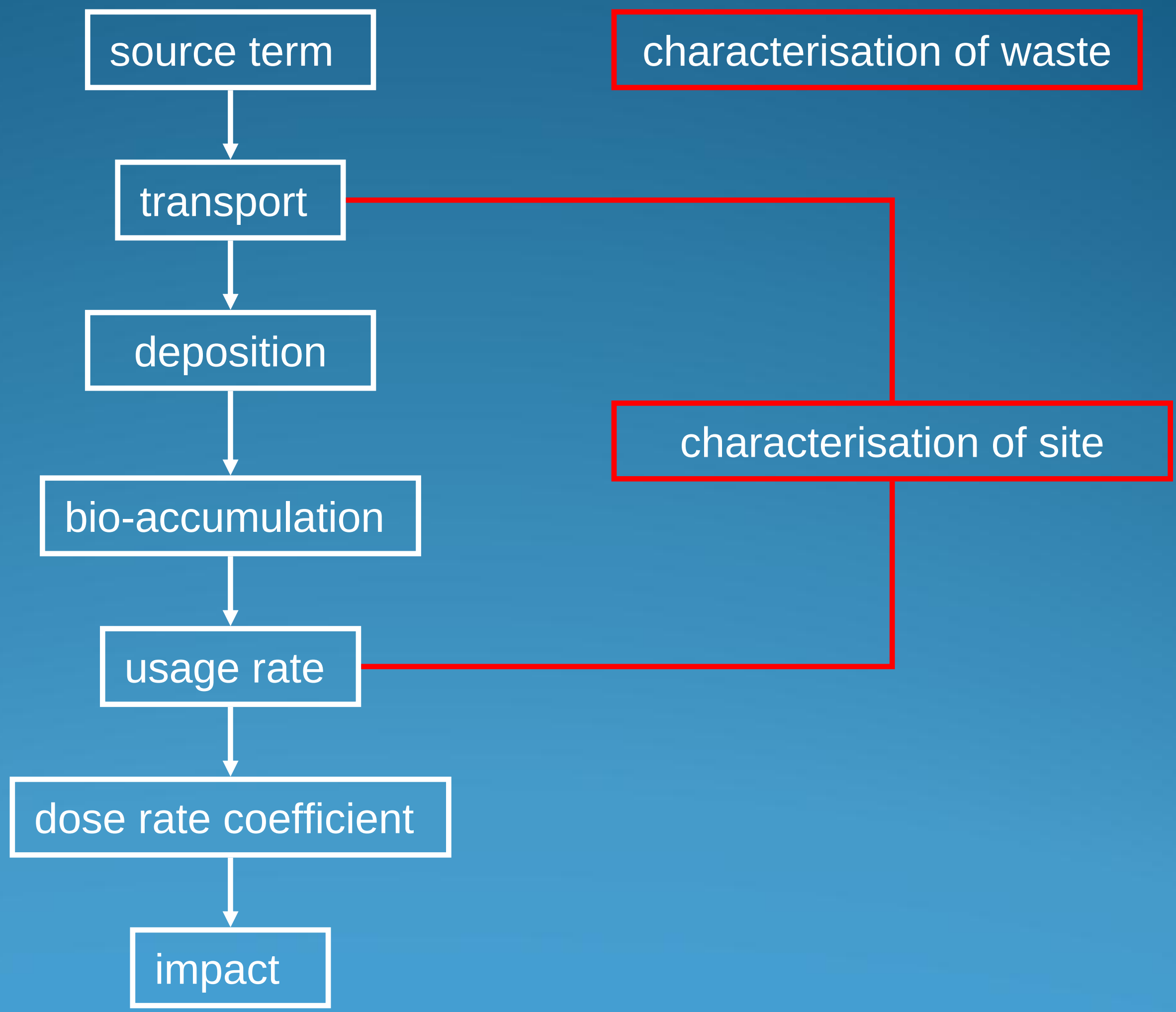
Remediation

- Purpose
  - Intervention (legacy site – remediation)
  - closure of an operational site
- Under regulatory control?

General remediation strategy



General dose assessment



Issues - problems

- Uncertainties in estimated doses
- Complexity of model(s)
- Effect of background
- Methods of remediation
- Demographics
- Doses to remediation workers
- Future land use
- On-going monitoring?
- How conservative? – realistic or worst case?
- Cost of remediation
- Stakeholder involvement

Monitoring

- Characterisation of waste
  - Radionuclide concentrations and profiles
  - Hydraulic conductivity
  - Rainfall, surface runoff (leaching)
  - Erosion

- Characterisation of site
  - Soil and rock types
  - Hydraulic conductivity
  - Radionuclide concentrations and profiles
  - Occupancy
  - Diet
  - Groundwater usage

Modelling – model development

- FEPS
- Characteristic matrix
- Choice of model type
  - Compartment model (emphasises features, transfer factors)
  - Diffusion/dispersion model (emphasises processes, transfer factors)
- Verification
- Validation