Impact assessment of wetlands:

a framework for the UK Environment Agency

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Environmental impact assessment

- EIA "… a means of drawing together, in a systematic way, an assessment of a project's likely significant environmental effects"
- "... enables environmental factors to be given due weight, along with economic or social factors, when planning applications are being considered"
- EU Directive 97/11/EC
- National legislation on EIA

European drivers for “water” EIAs

- **Habitats Directive (92/43/EEC)**
  - conservation of natural habitats - wild fauna and flora
  - Special Areas of Conservation (SACs)
  - maintain at, or restore to, 'favourable conservation status'

- **Birds Directive (79/409/EEC)**
  - special measures to conserve the habitats of listed species
  - Special Protection Areas (SPAs).

- **Water Framework Directive (2000/60/EC)**
  - achieve ‘good status’ in all water bodies

UK specific drivers for “water” EIA

- Wildlife and Countryside Act 1981
- Environment Act 1995
- Countryside and Rights of Way (CROW) Act 2000
- Catchment Abstraction Management Strategies (CAMs)
- Catchment Flood Management Plans (CFMPs)

Almost 100 key wetlands to assess

Staff not wetland experts

What drives the approach ?

Academics

- Detailed understanding
- Innovation
- Intellectual challenge
- Journal publications
- Peer review

Agencies

- Addressing legislation
- Consistency
- Fit for purpose
- Cost effectiveness
- Stakeholder responsibility

Impact Assessment of Wetlands

Stage 1 Hydrological impacts assessment (abstraction on wetland hydrology)

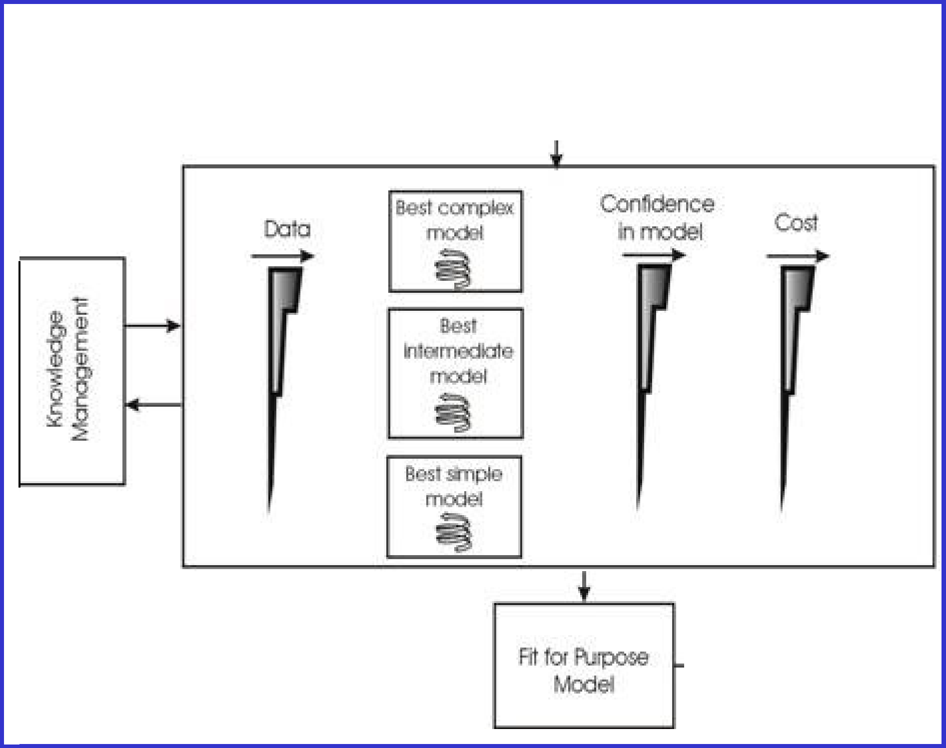
Stage 2 Ecological impacts assessment (hydrology on wetland biota)

Stage 1 Hydrological impact assessment

- **Level O**
  - Conceptual understanding
- **Level 1 Simple**
  - Water balance
- **Level 2 Intermediate**
  - one layer (aquifer) drawdown estimates
  - Theis/Hantush/Neuman
- **Level 3 Detailed**
  - Distributed modelling
  - MODFLOW, ISIS, MIKE-SHE

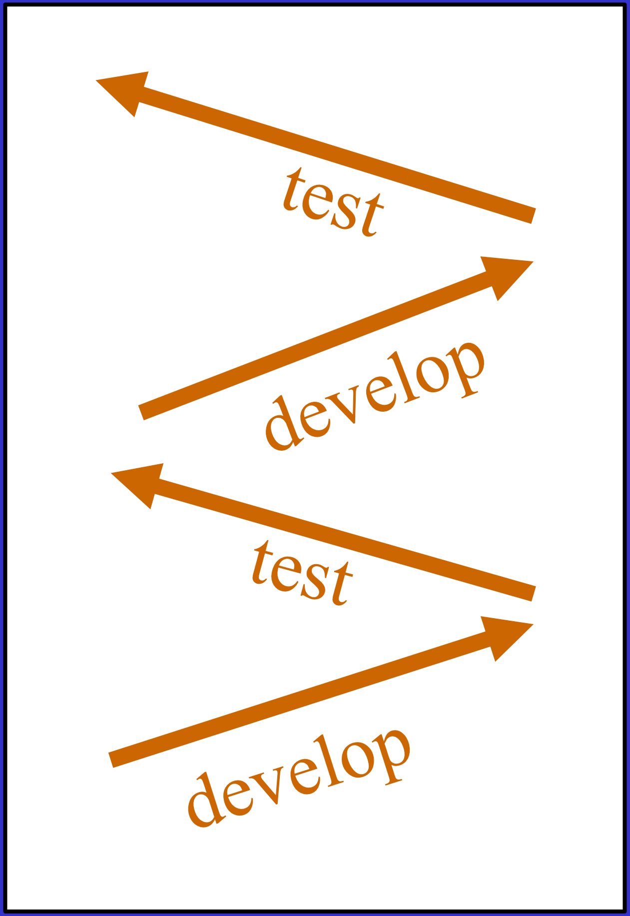
What level of assessment?

- Risk-based approach
- No right answer
- Use simplest approach that gives acceptable level of risk
- Move to higher level if results too uncertain



Model development

- Develop model
- Test with data
- Confirm or reject conceptual understanding



Level 0 Conceptual understanding

Understanding how the wetland interacts with the surrounding hydrological system; atmosphere, aquifer unit or catchment

Water transfer mechanisms

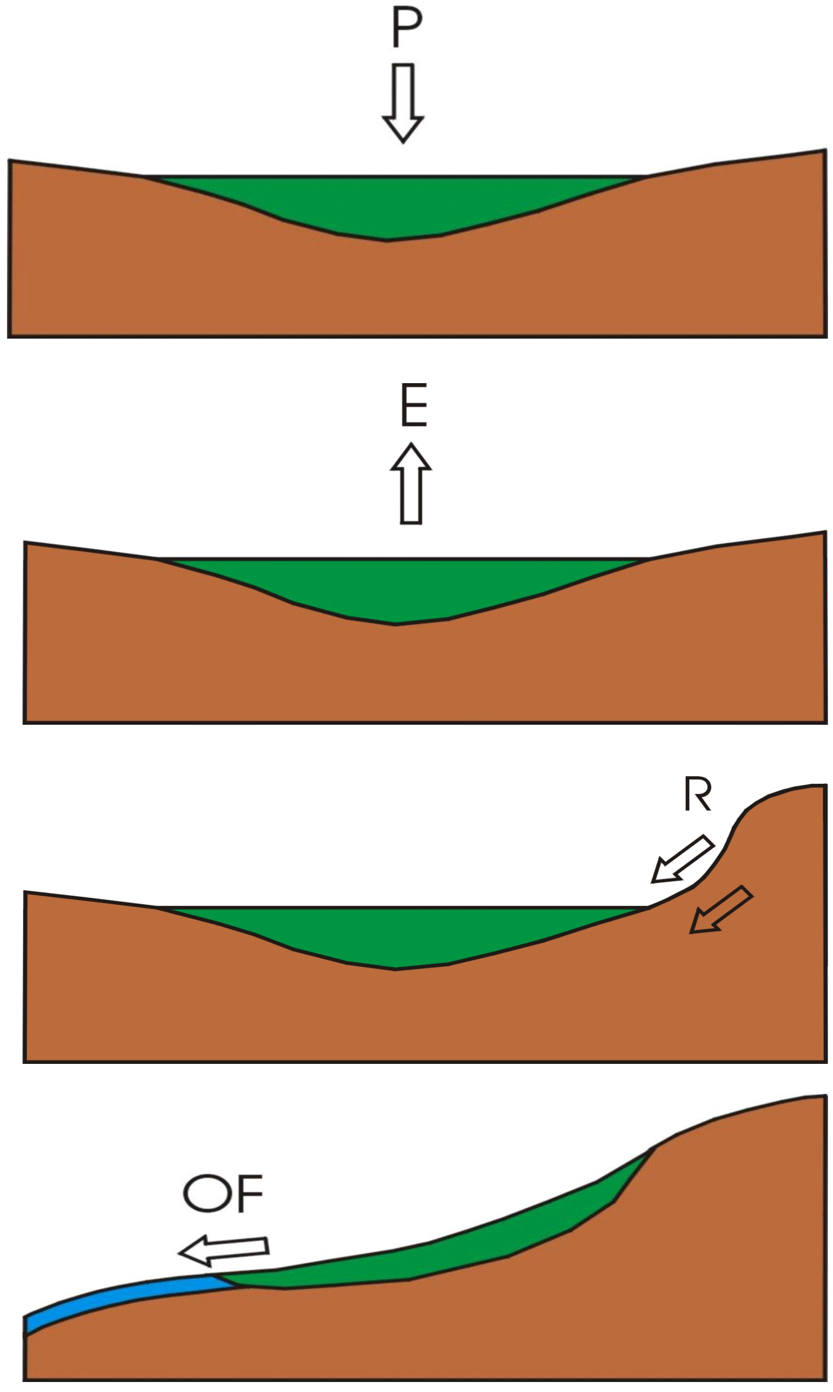
- How water moves into and out of wetlands
- How wetlands interact with rivers, aquifers, lakes, the sea
- How landscape location influences water transfer mechanisms

Precipitation

Evaporation

Runoff

Outflow

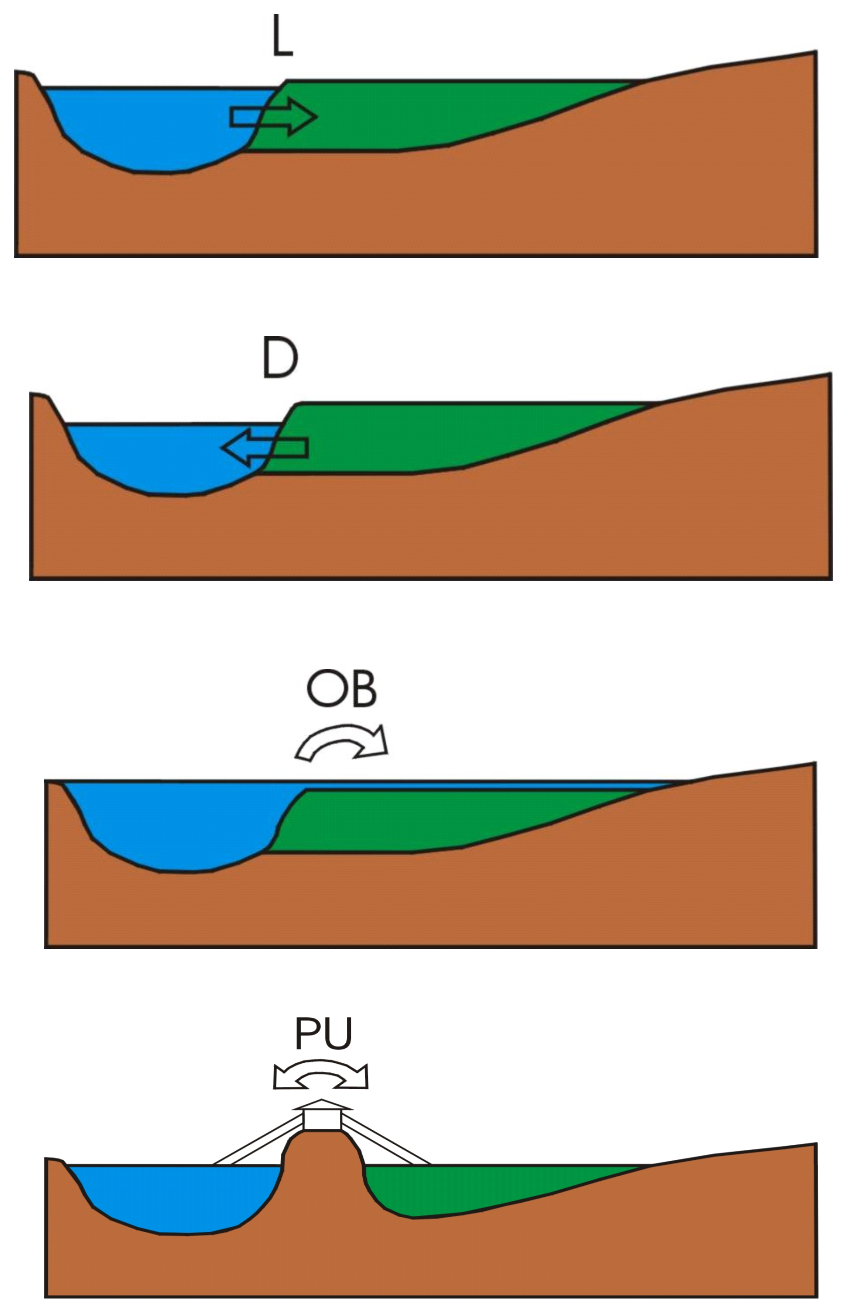


Lateral inflow

Drainage

Overbank flow

Pumping

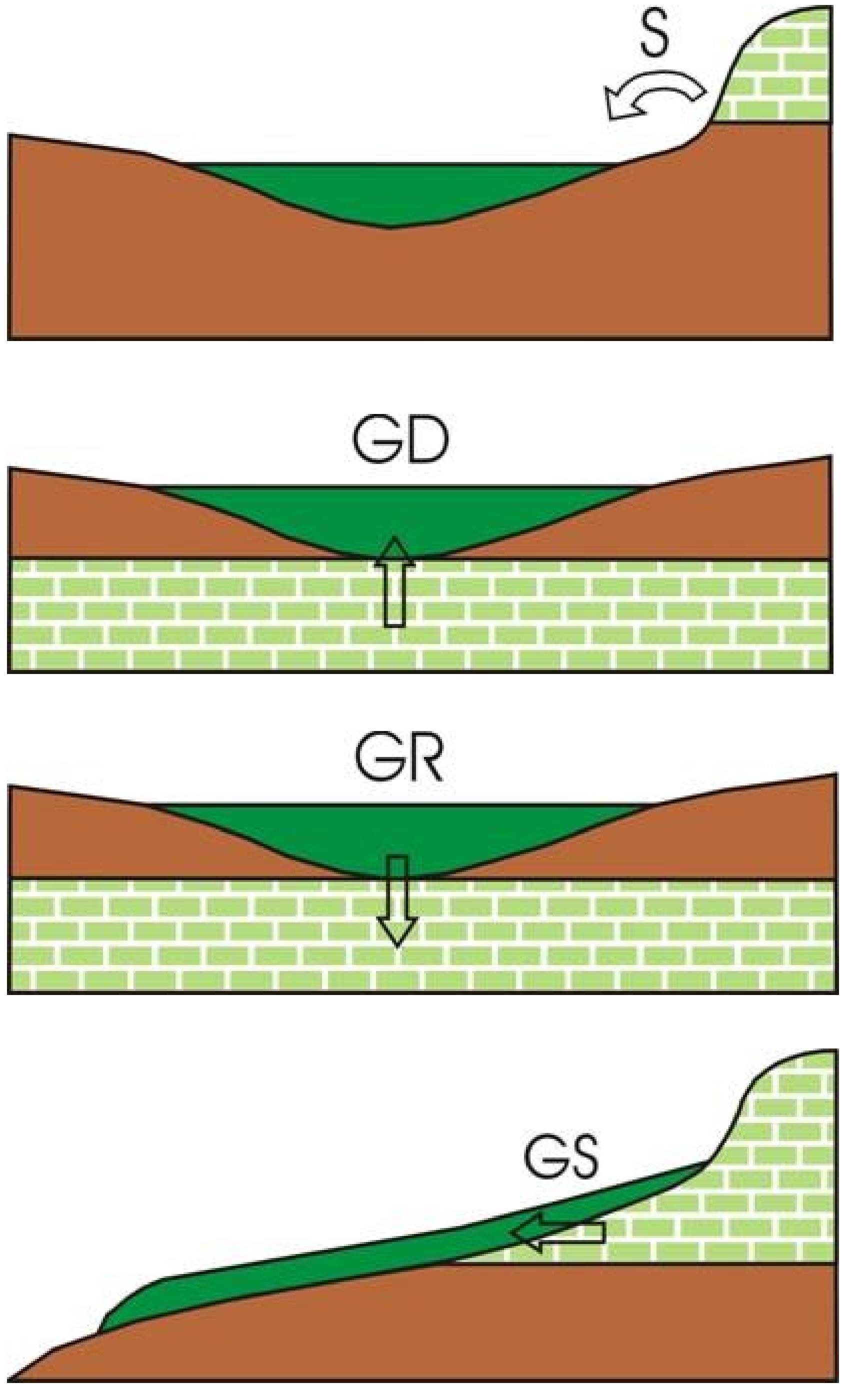


Spring flow

Groundwater discharge

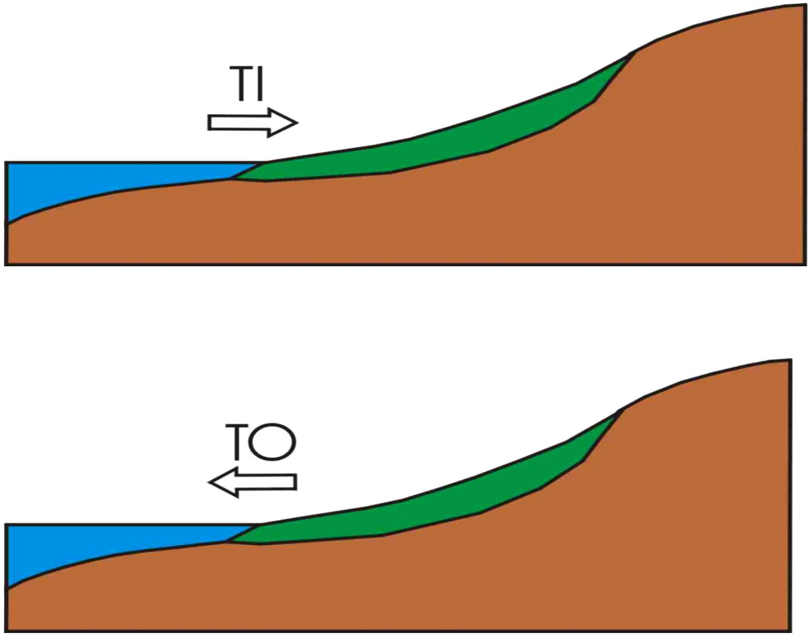
Groundwater recharge

Groundwater seepage

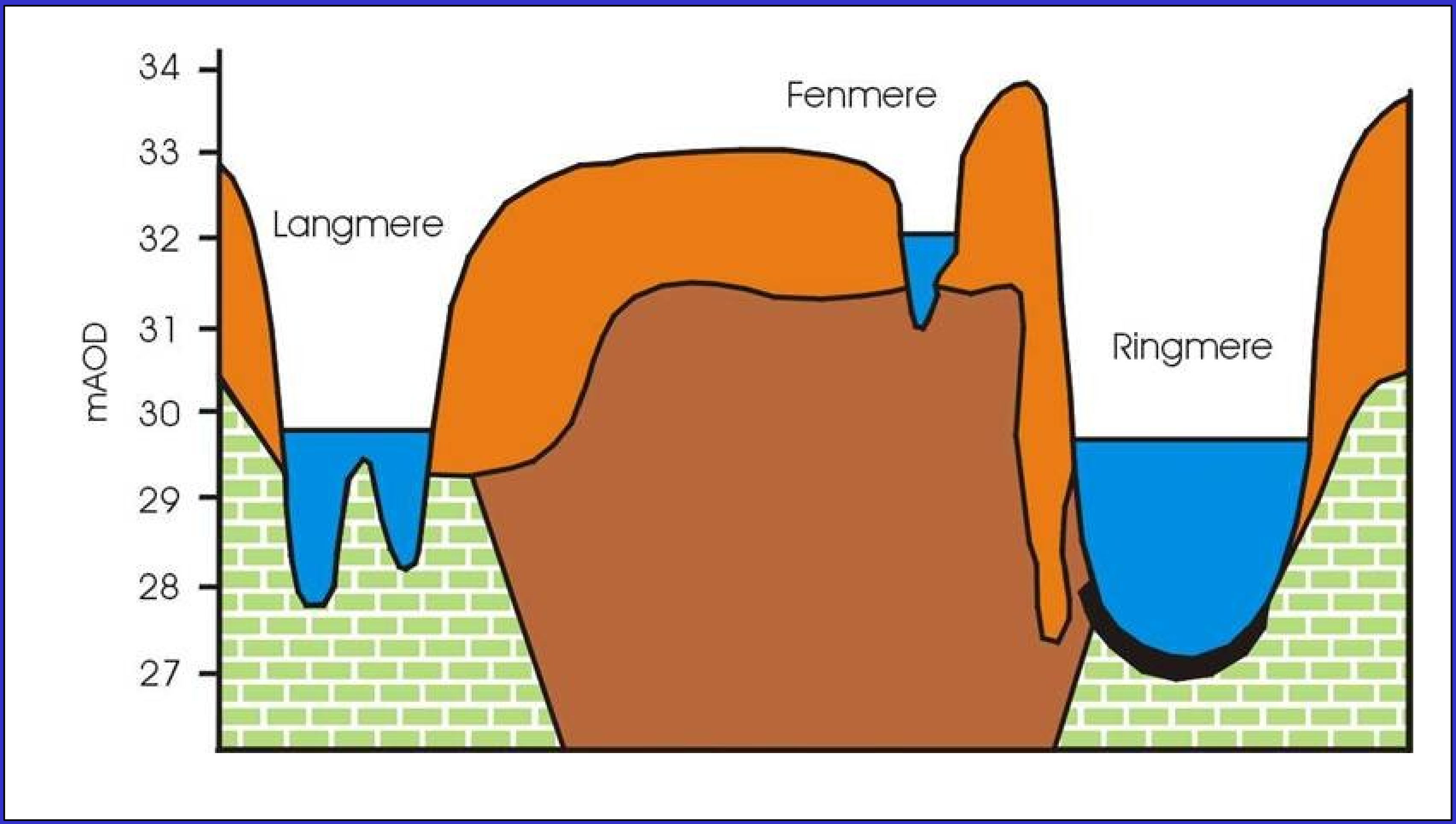


Tidal inflow

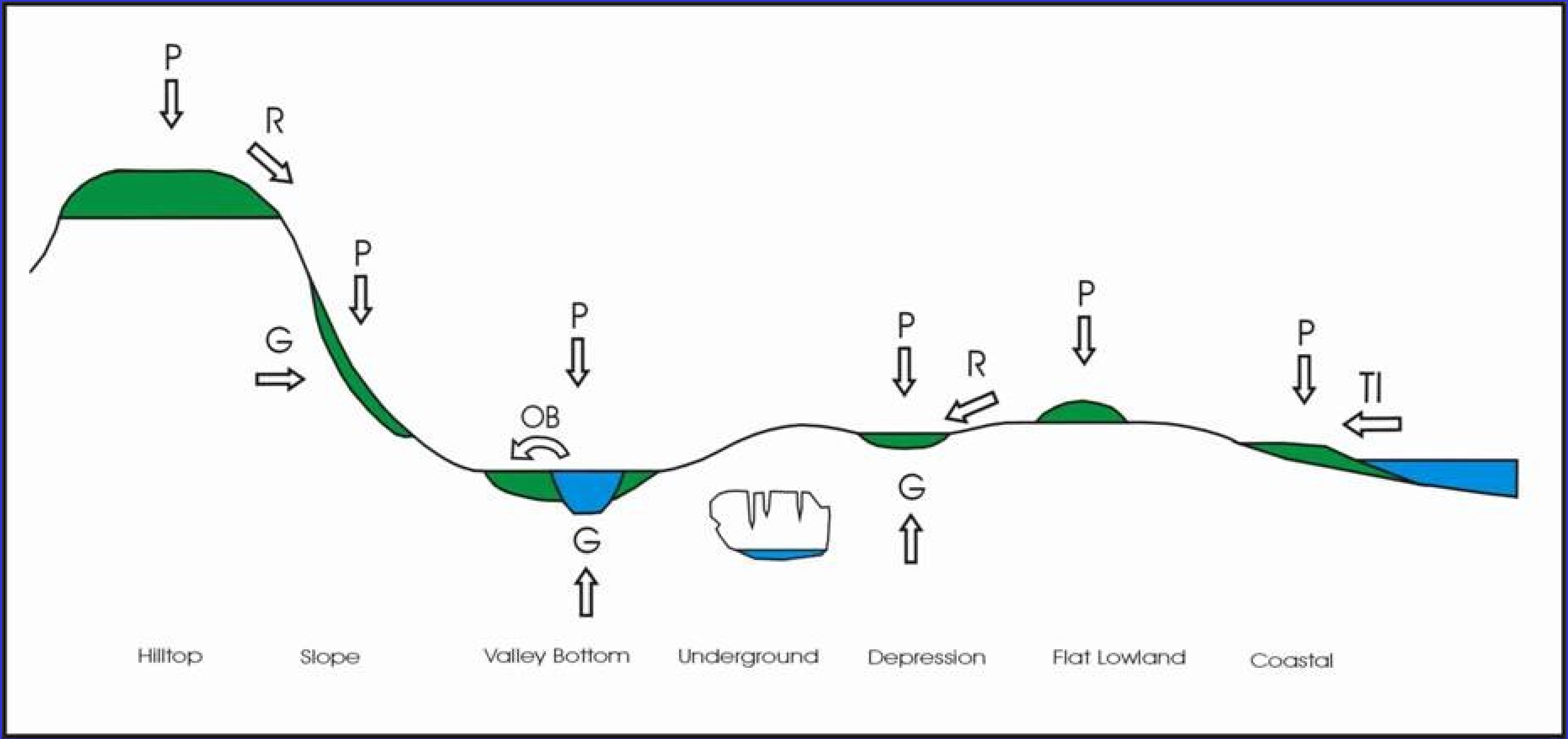
Tidal outflow



Differing contact with the aquifer

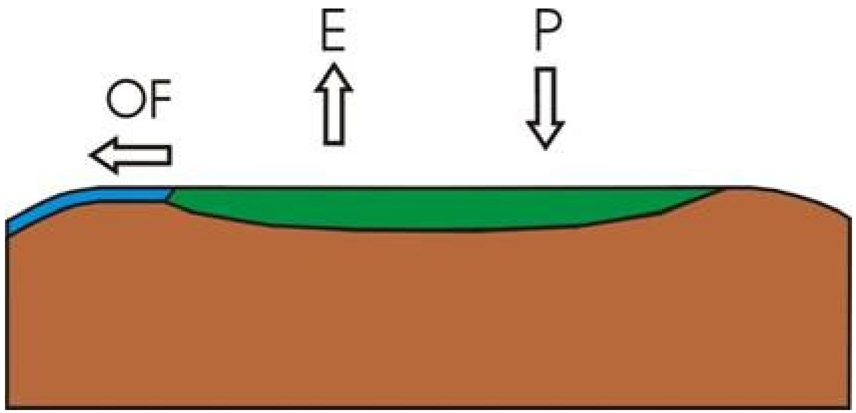


Wetland landscape location

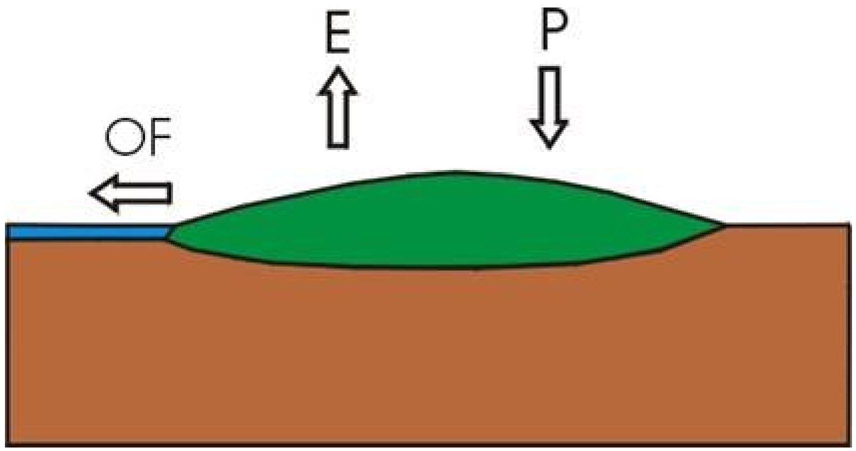


Flat area wetlands

Hill top

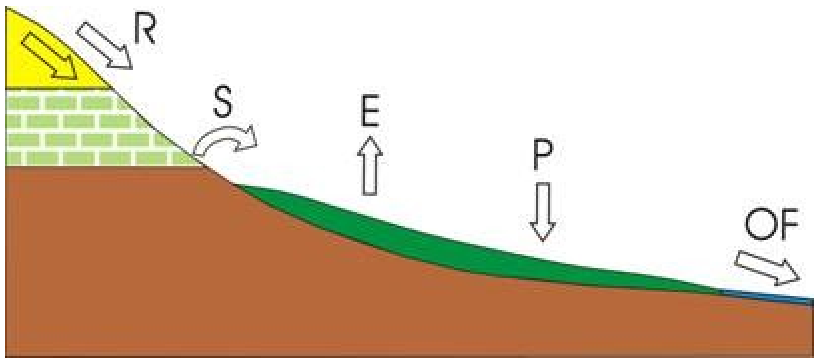


Low permeability layer

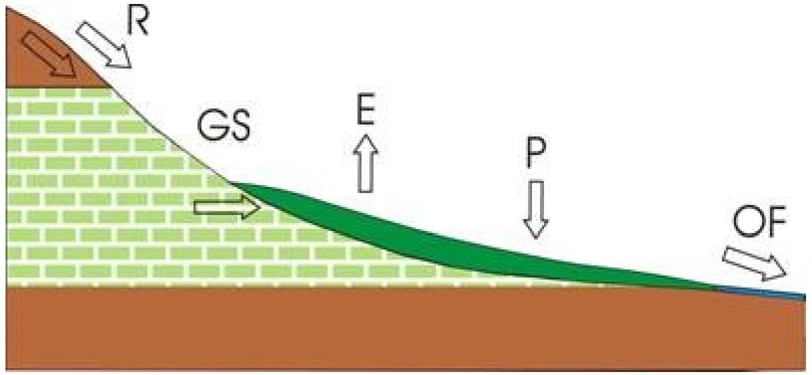


Slope wetlands

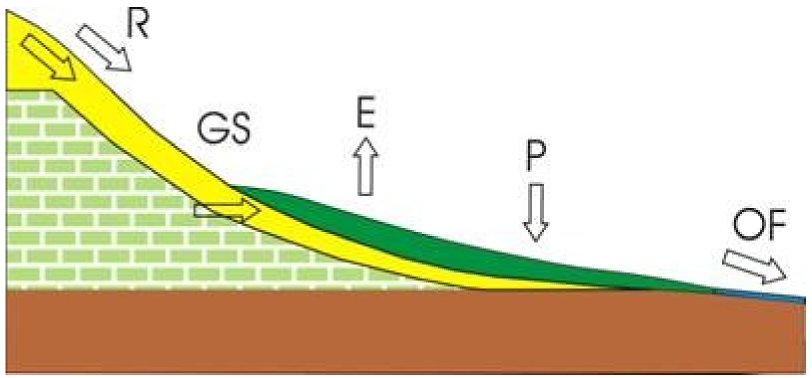
Spring-fed



Seepage-fed



Low permeability layer

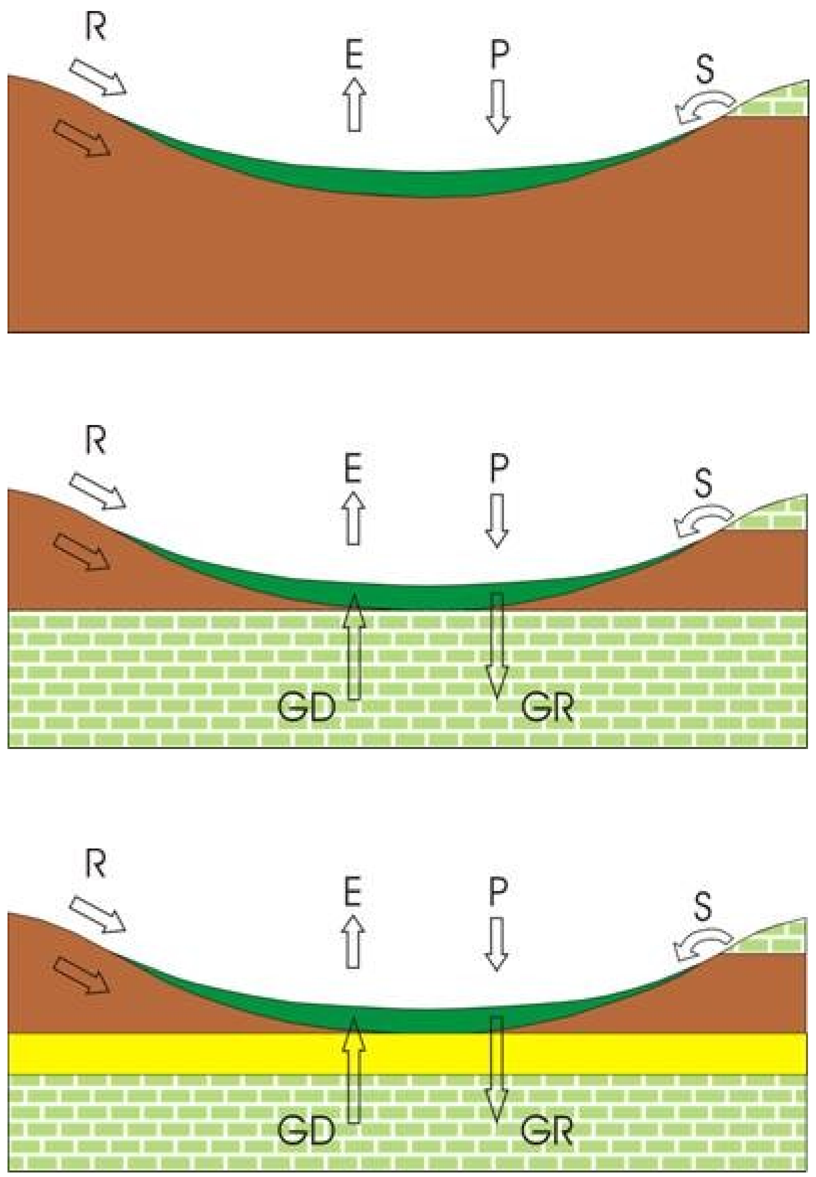


Depression wetlands

Spring-fed

Groundwater discharge

Low permeability layer

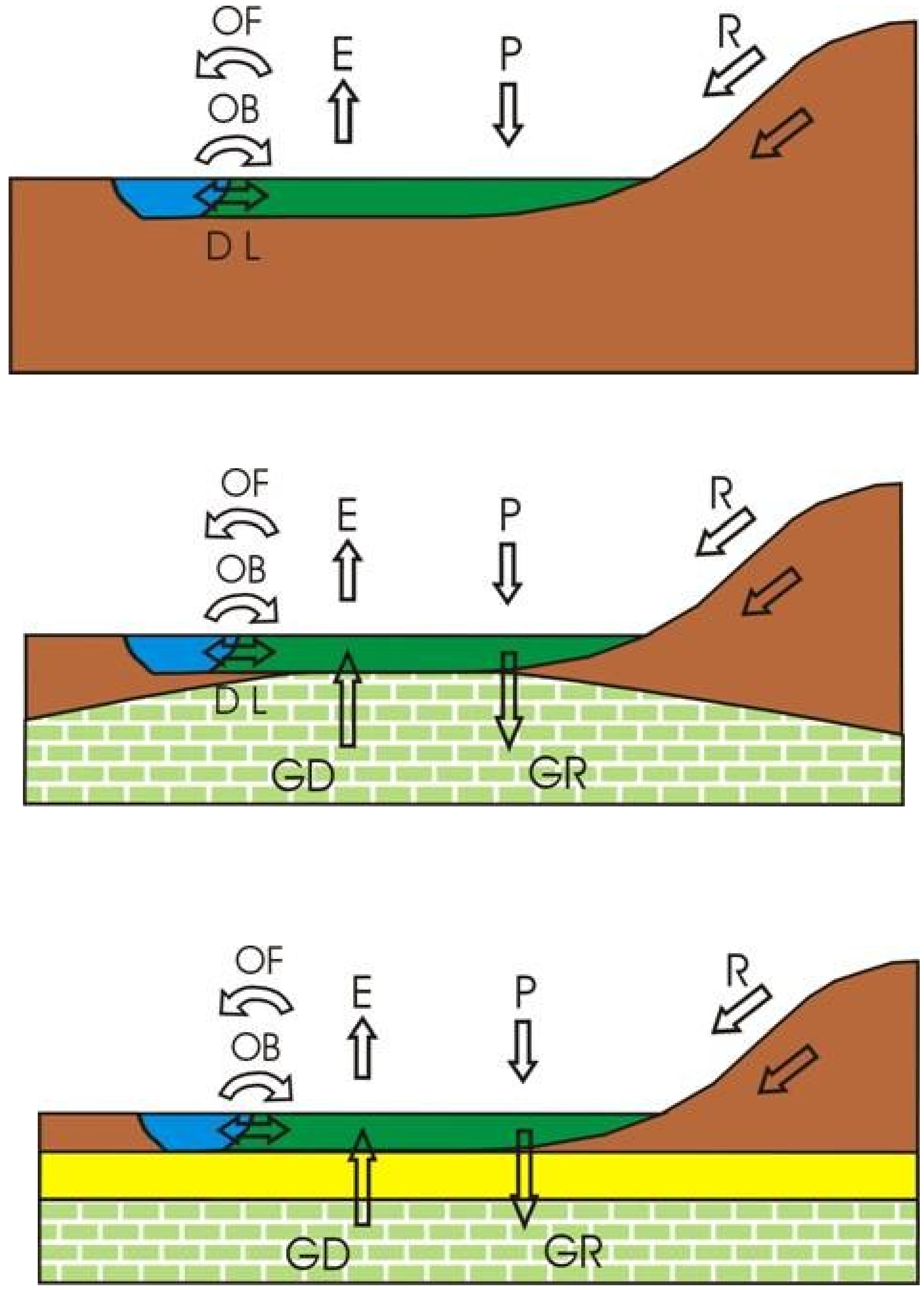


Valley bottom

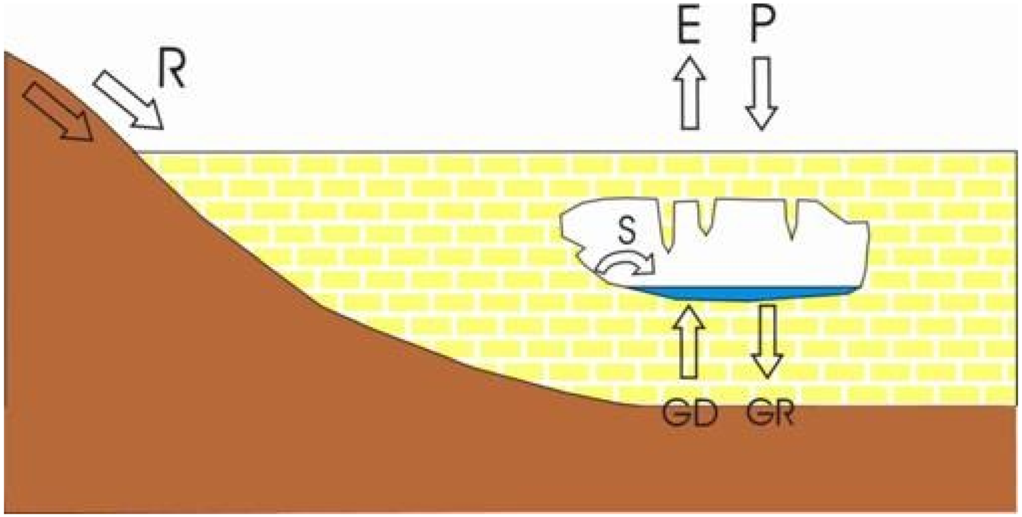
Spring-fed

Groundwater discharge

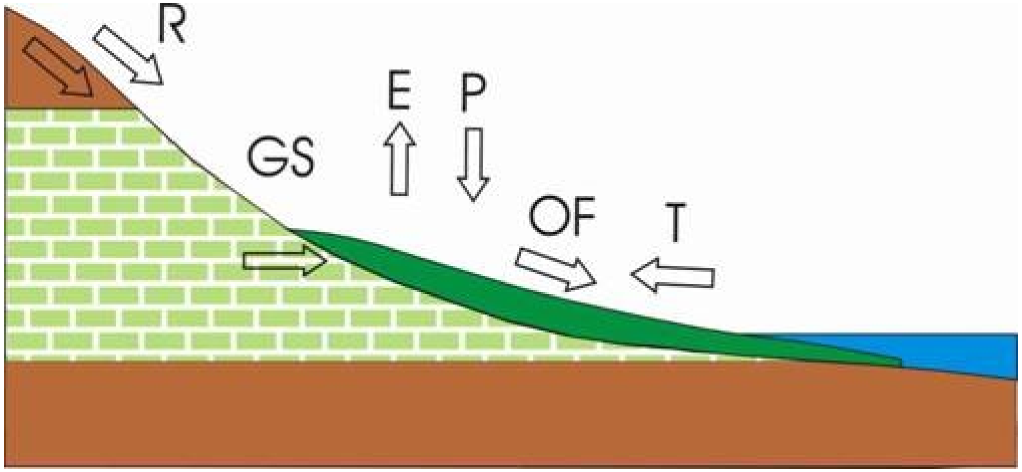
Low permeability layer



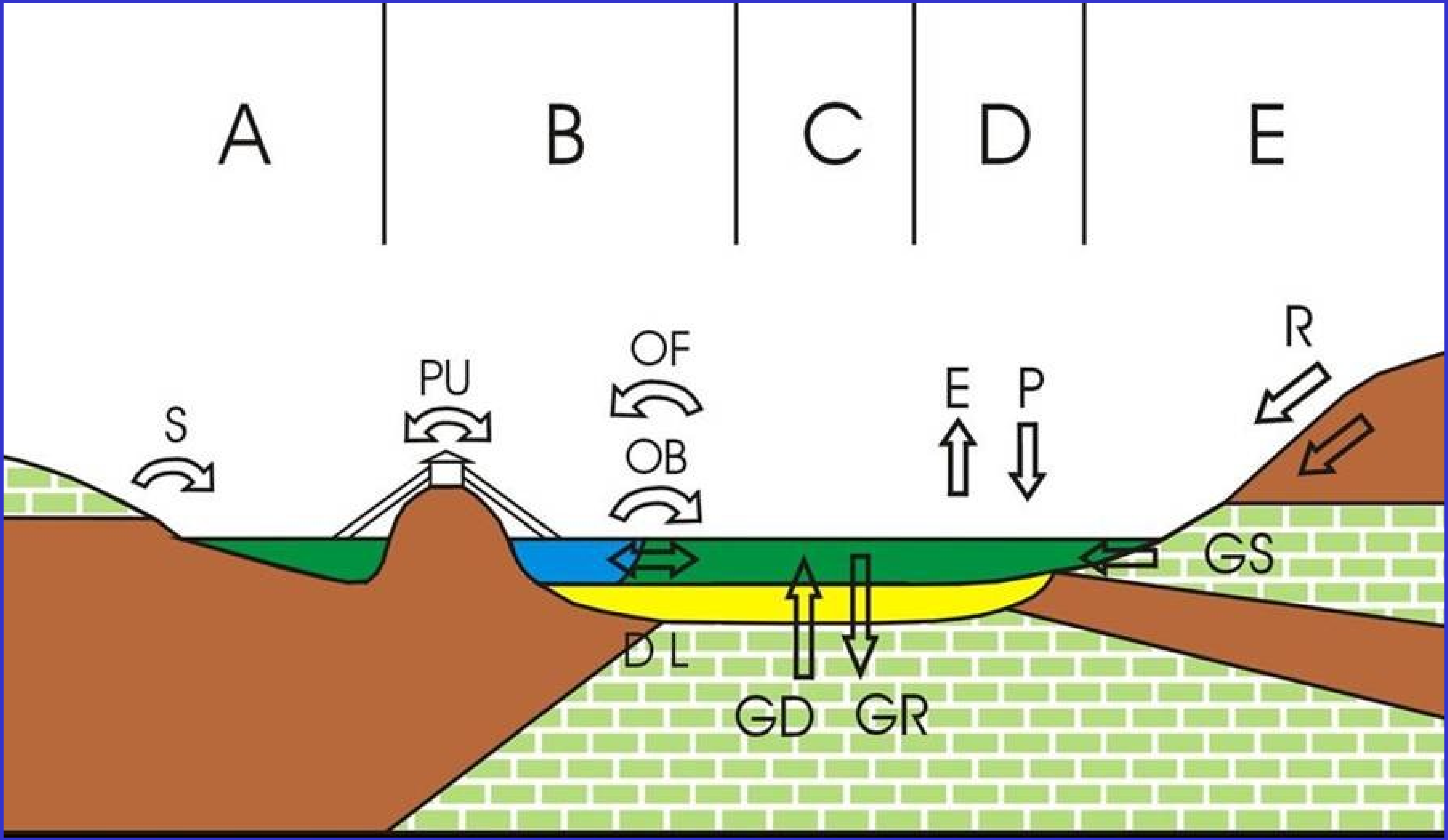
Underground



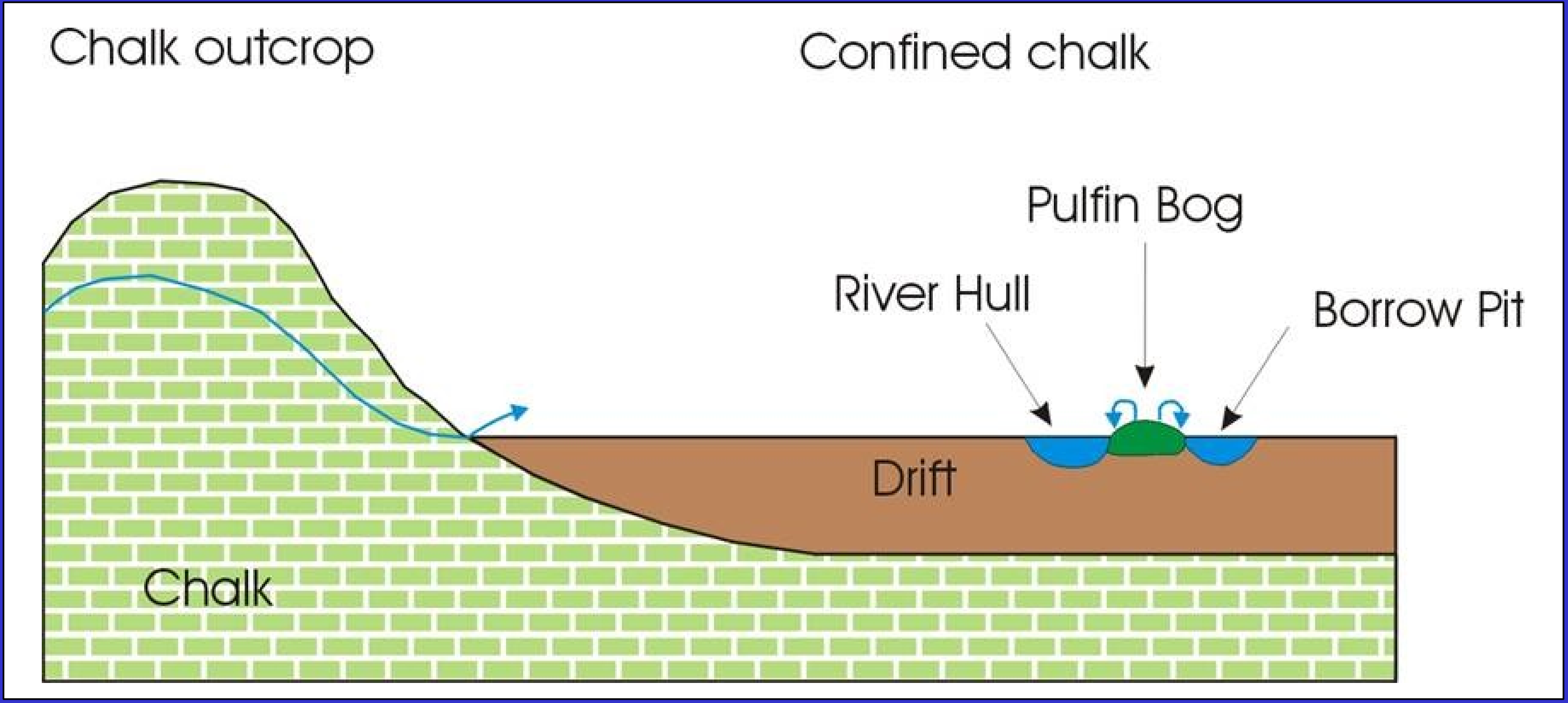
Coastal



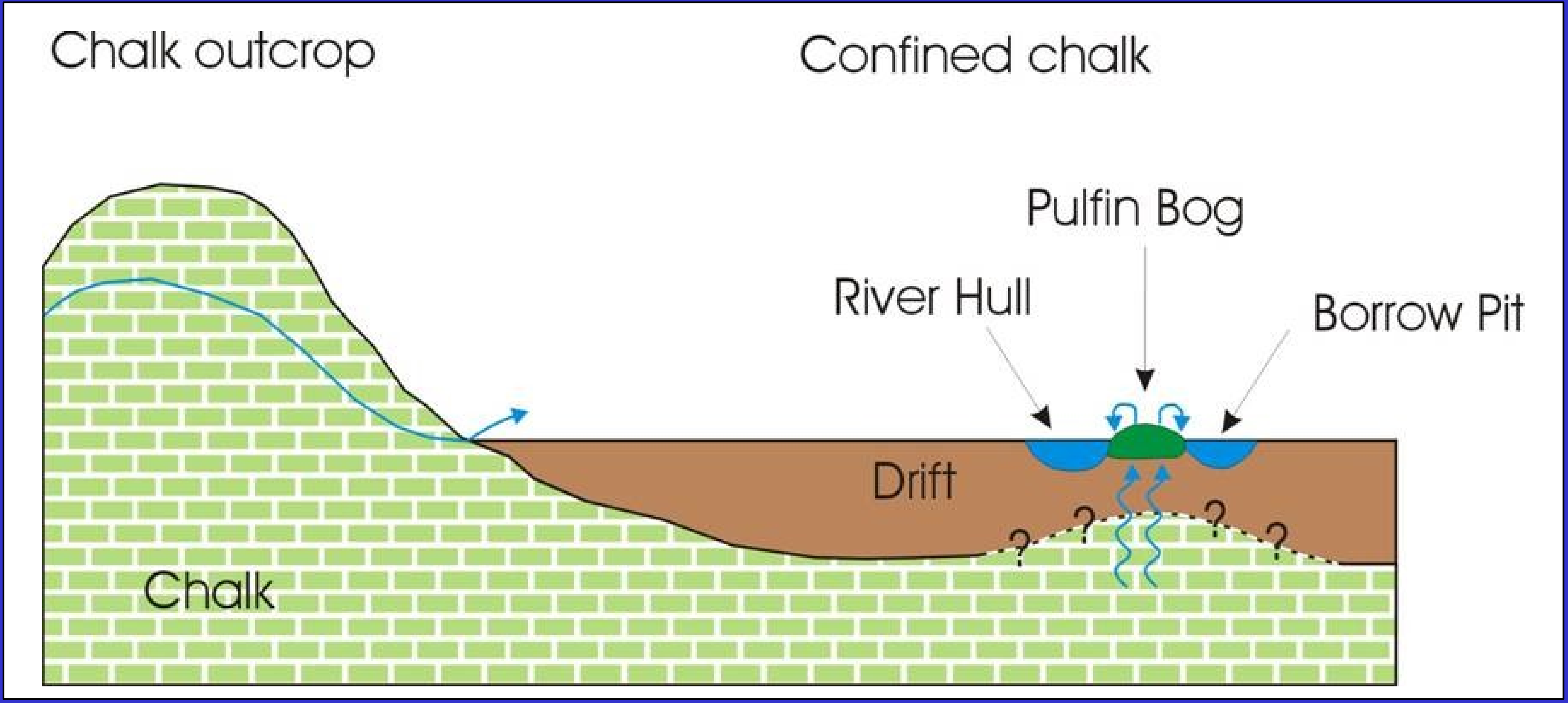
Conceptual understanding



Pulfin bog, Yorkshire



Pulfin bog, Yorkshire



Level 1 Simple

- Water balance approach
- Quantifying water transfer mechanisms
- Scenarios
- Uncertainty

Water balance of wetlands

Inputs to the wetland

P: precipitation (rainfall, snow, dew etc) directly on the wetland +

R: surface and shallow subsurface inflow to the wetland +

L: lateral inflow +

OB: over-bank inflow +

PUi: water pumped into the wetland +

S: spring flow +

GD: groundwater discharge into the wetland +

GS: groundwater seepage into the wetland

Outputs from the wetland

E: evaporation from the wetland +

δV: change in volume of water stored within the wetland +

D: drainage +

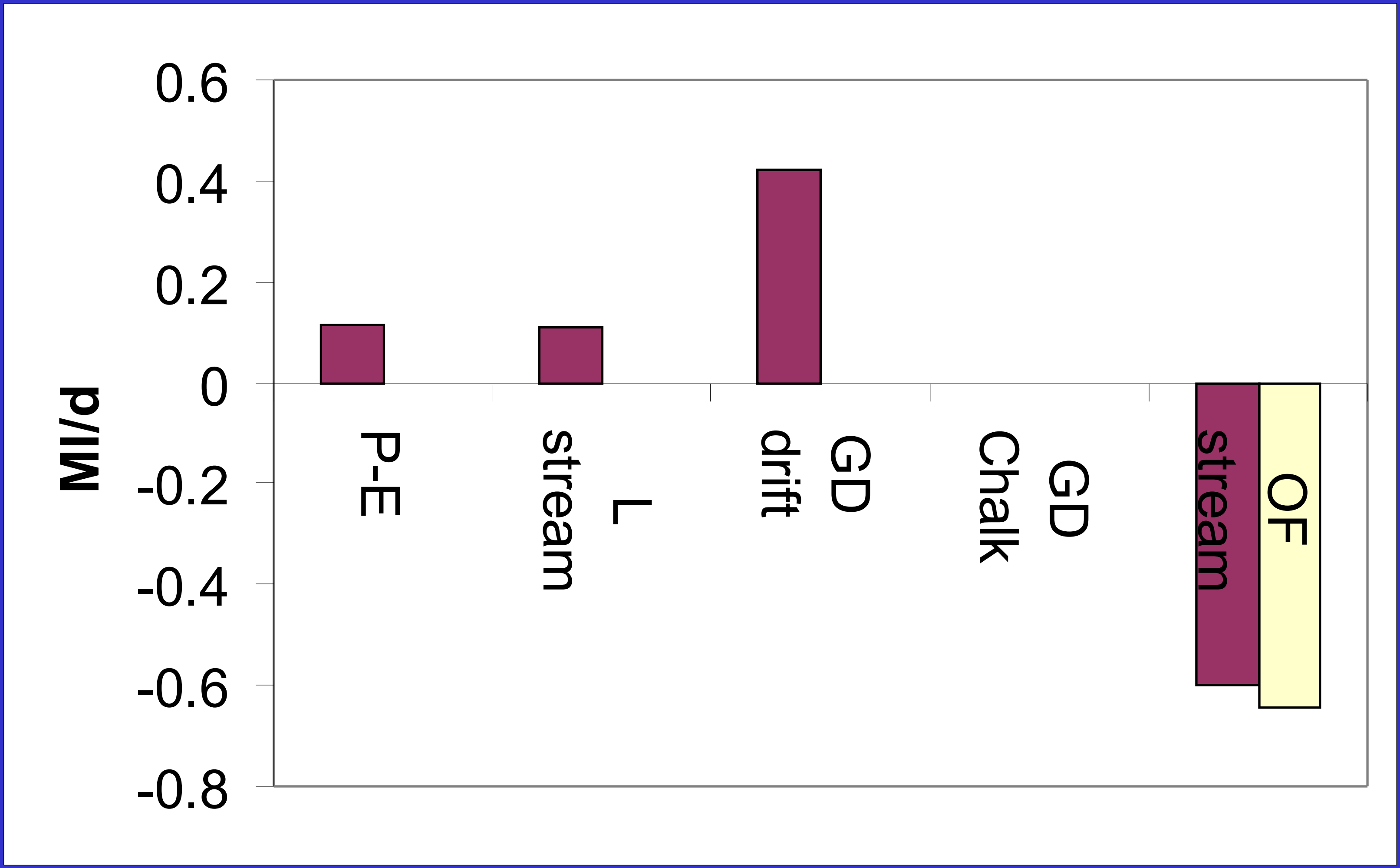
OF: overland outflow +

PUo: water pumped out of the wetlands +

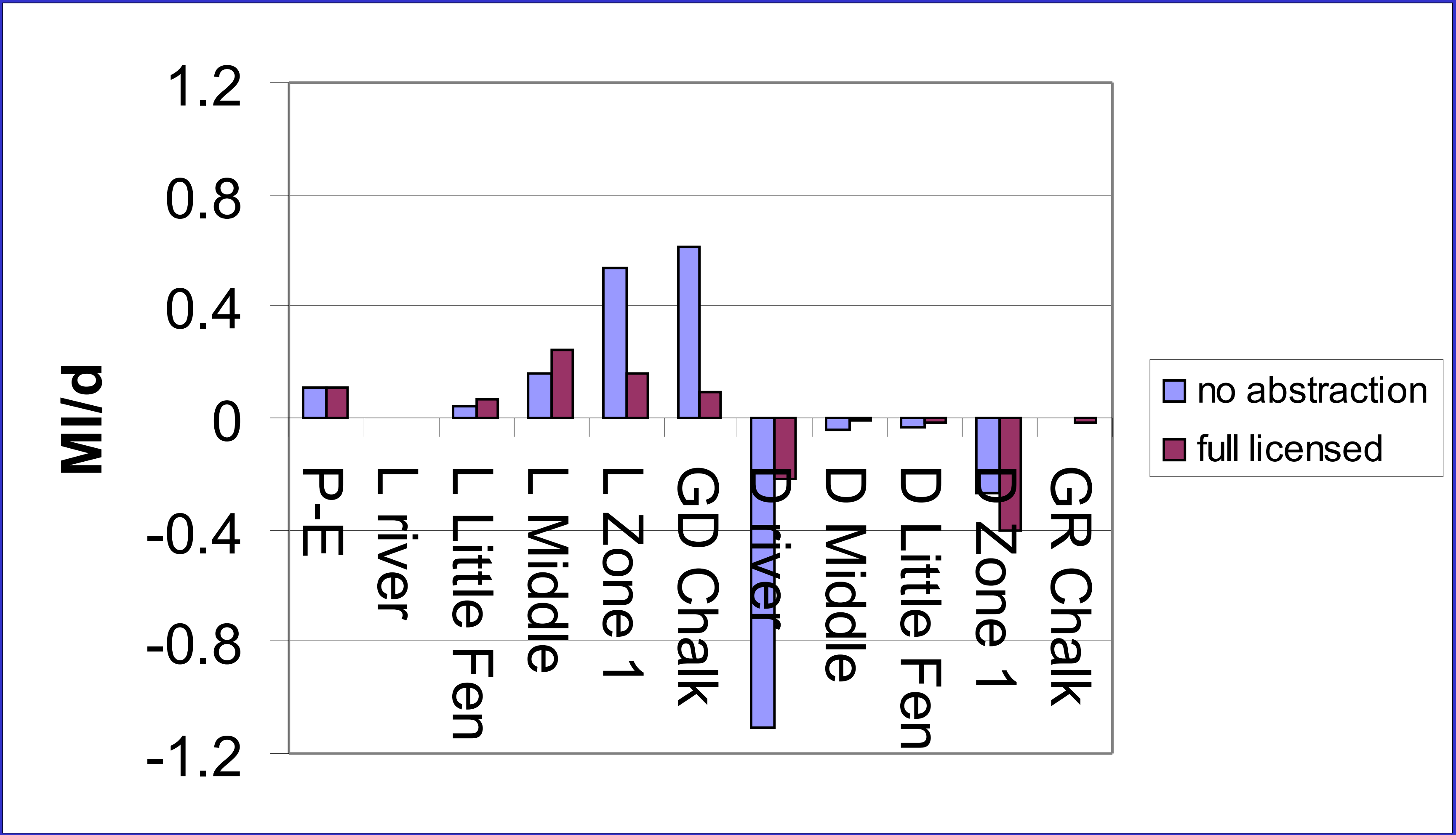
GR: groundwater recharge to aquifers +

where δV may be positive or negative

Sheringham Fen



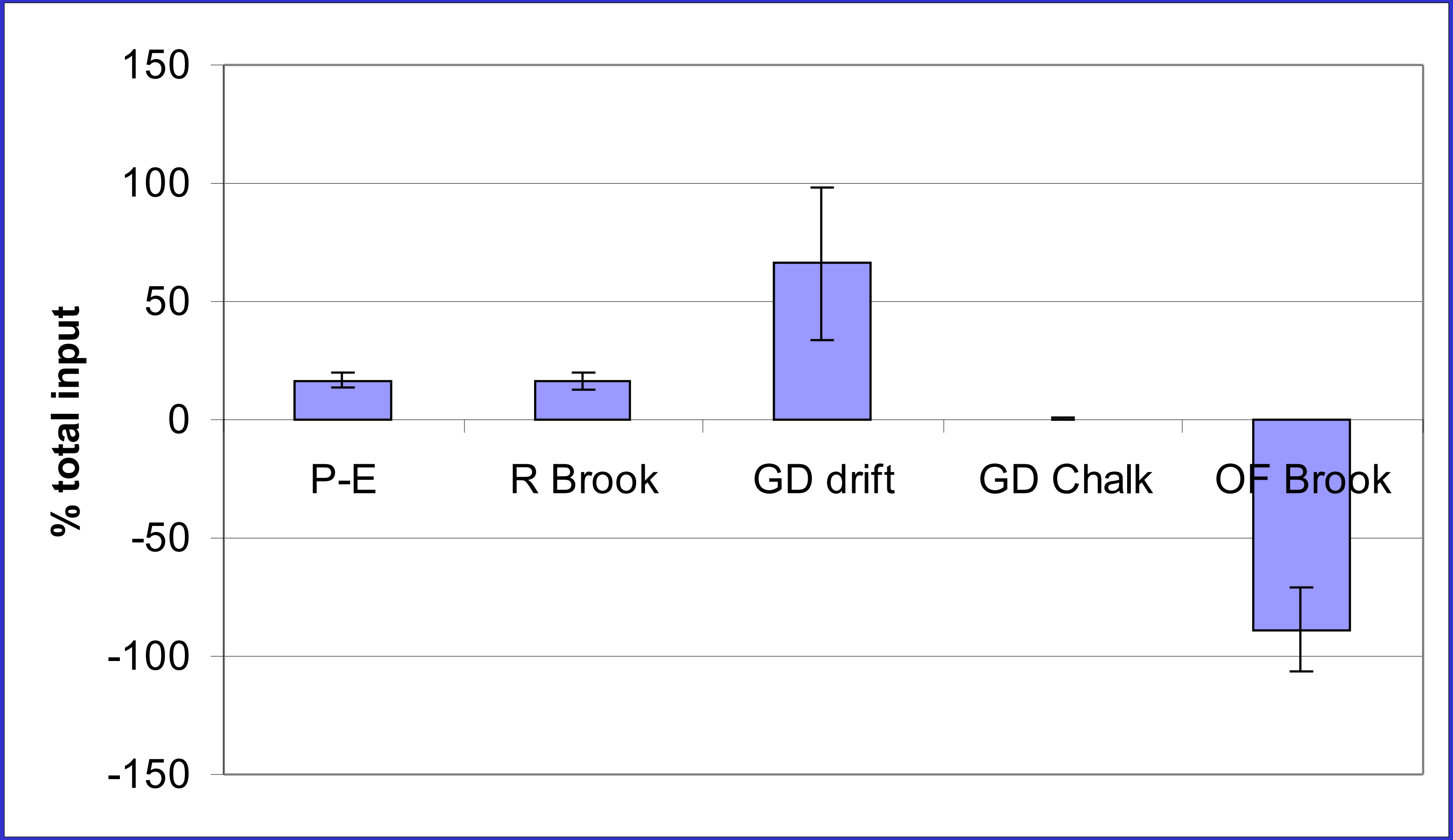
Scenarios for Lopham and Redgrave Fen



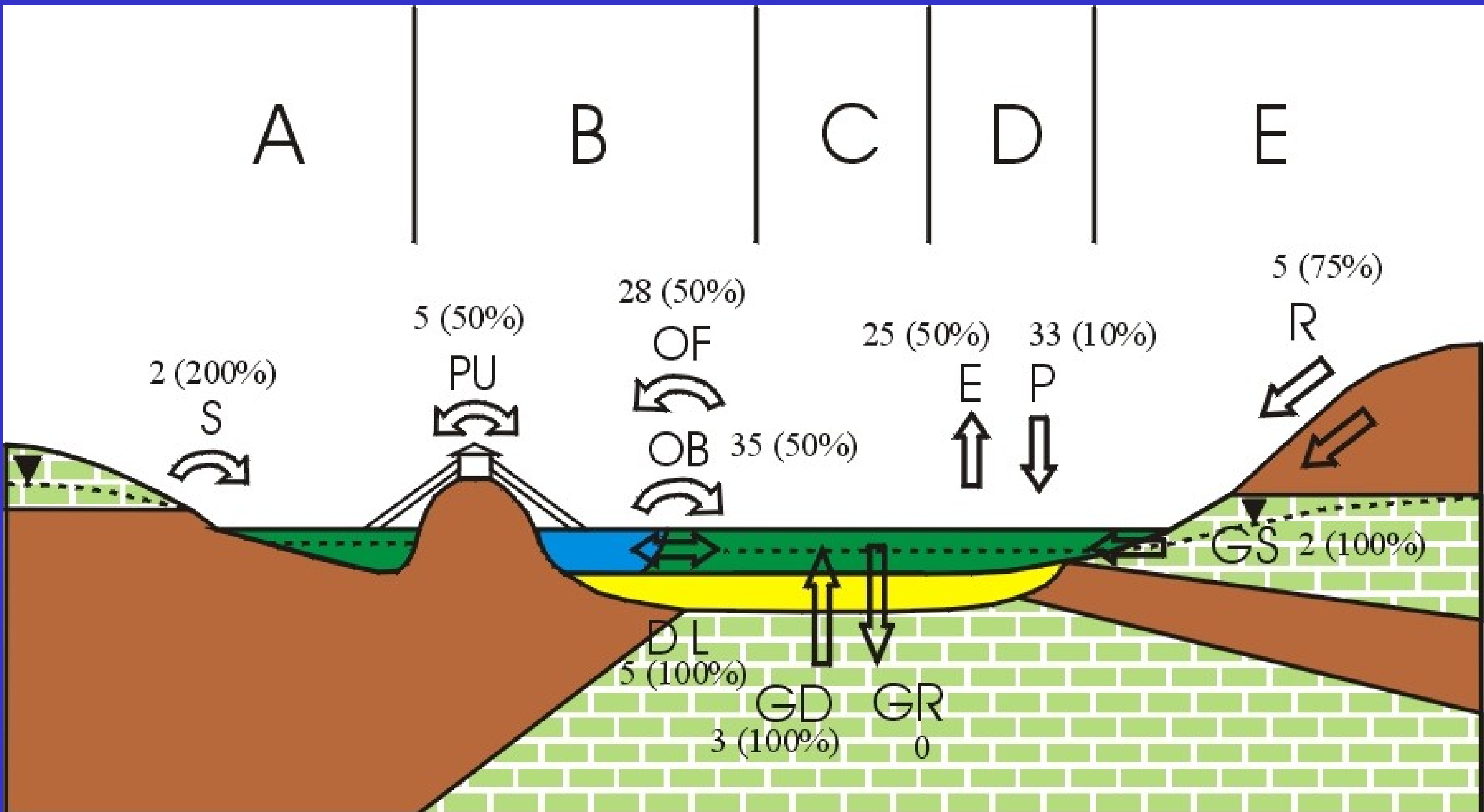
Uncertainty in modelling

- No measurement is exact
- All data are uncertain
- Need to assess the risk of being wrong
- Define acceptable level of uncertainty
- Improve data and models until "fit for purpose"

Sheringham Fen - uncertainty



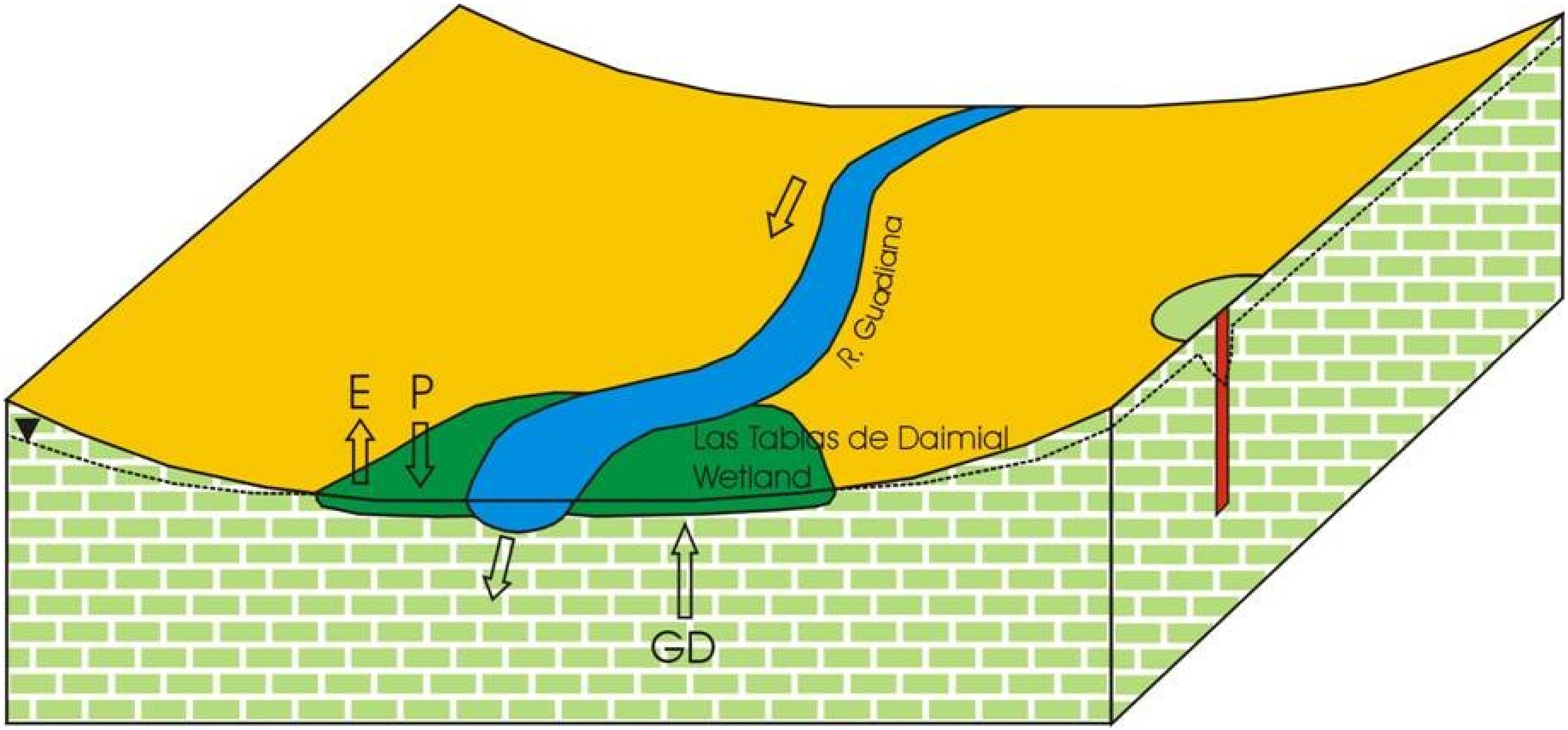
Quantified conceptual understanding



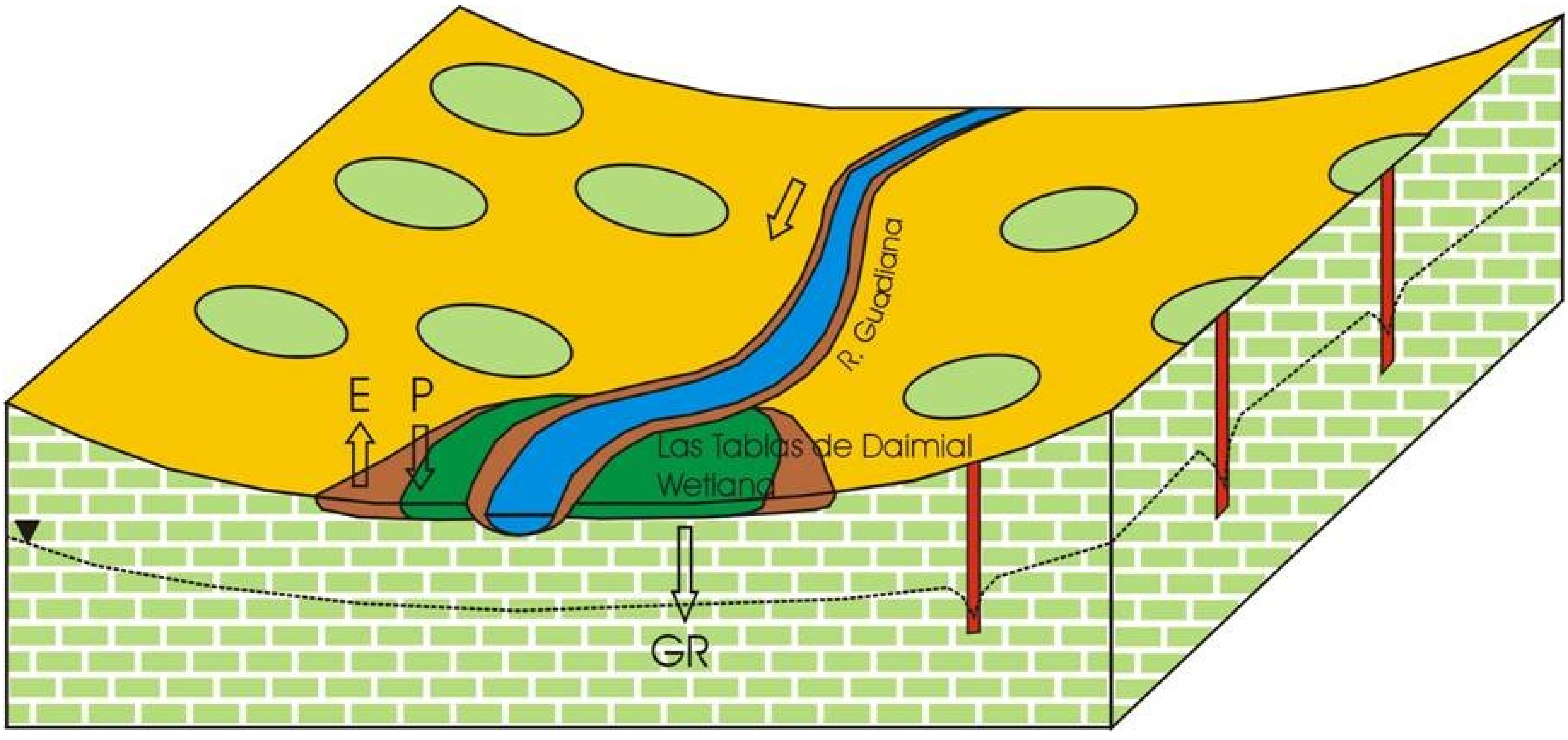
Water quality

- Wicken Fen drying out?
- Flooding from groundwater fed river
- Flood control
- Dominance of rainfall
- Change in pH
- Driven by water balance

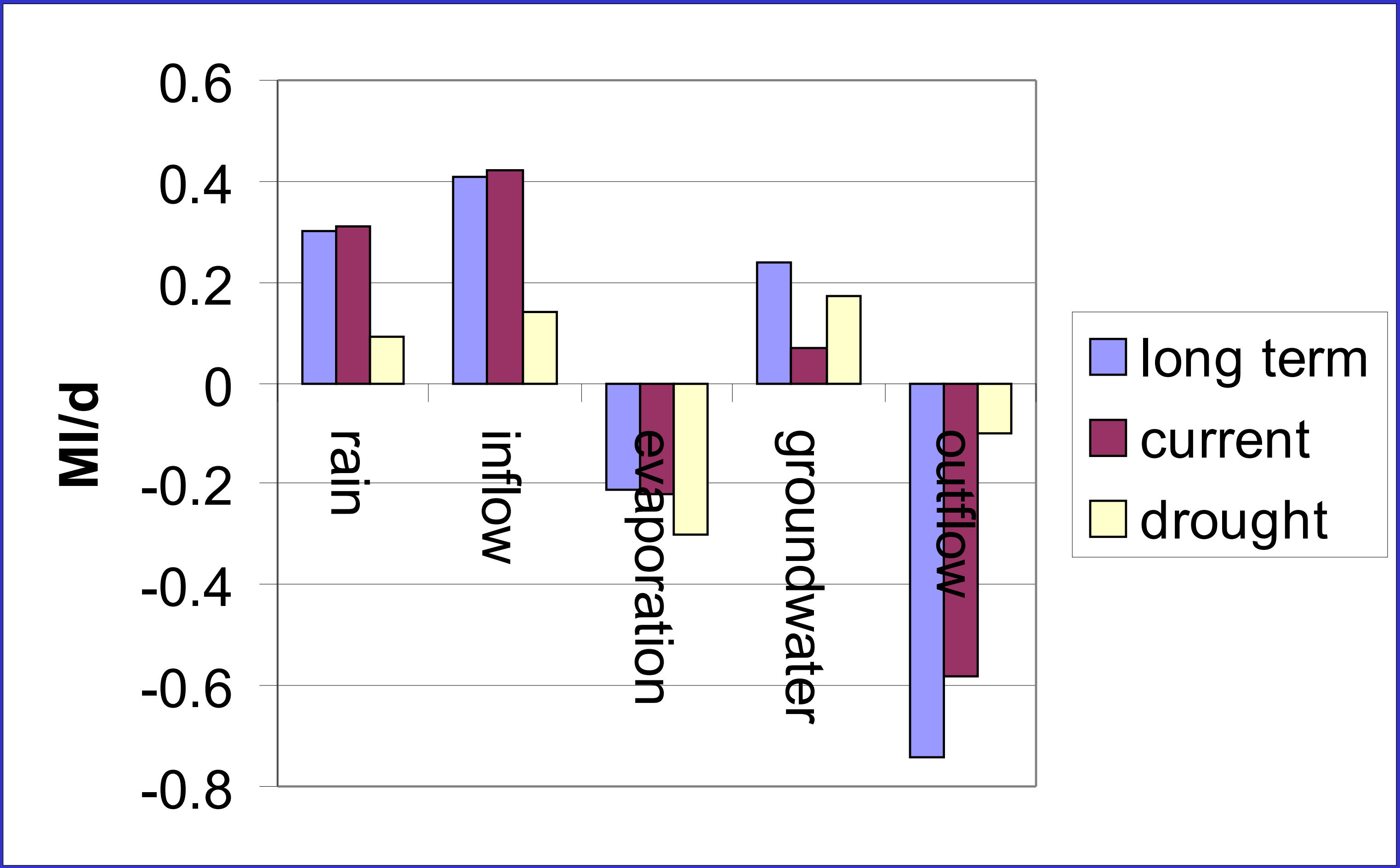
Las Tablas de Daimiel 1960s



Las Tablas de Daimiel 1990s



Sheringham Fen - scenario



Convert to water level

- Combine water balance model with specific yield of soil

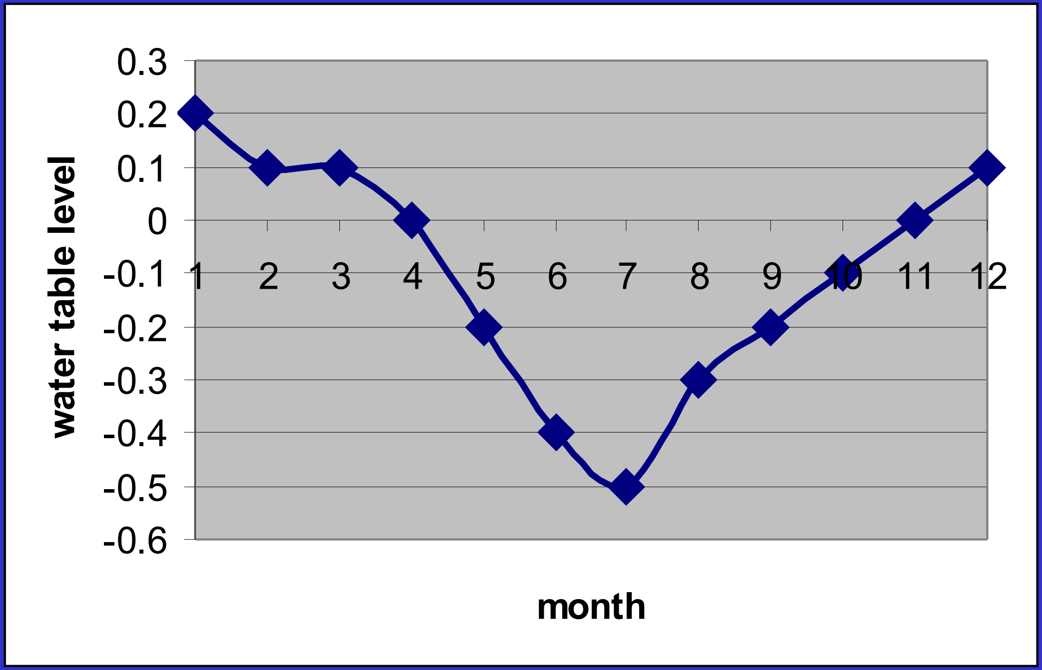
- $\delta s = SY\ \delta h$

where

δs = change in storage

SY = specific yield

δh = change in water level



Level 2 Intermediate approach

- Soil physics/drainage equations
- Hantush one layer leaky aquifer
- Draw down levels
- Rainfall-runoff model

Soil physics/drainage equations

H = f (DR, K, RH, R, E ..)

where

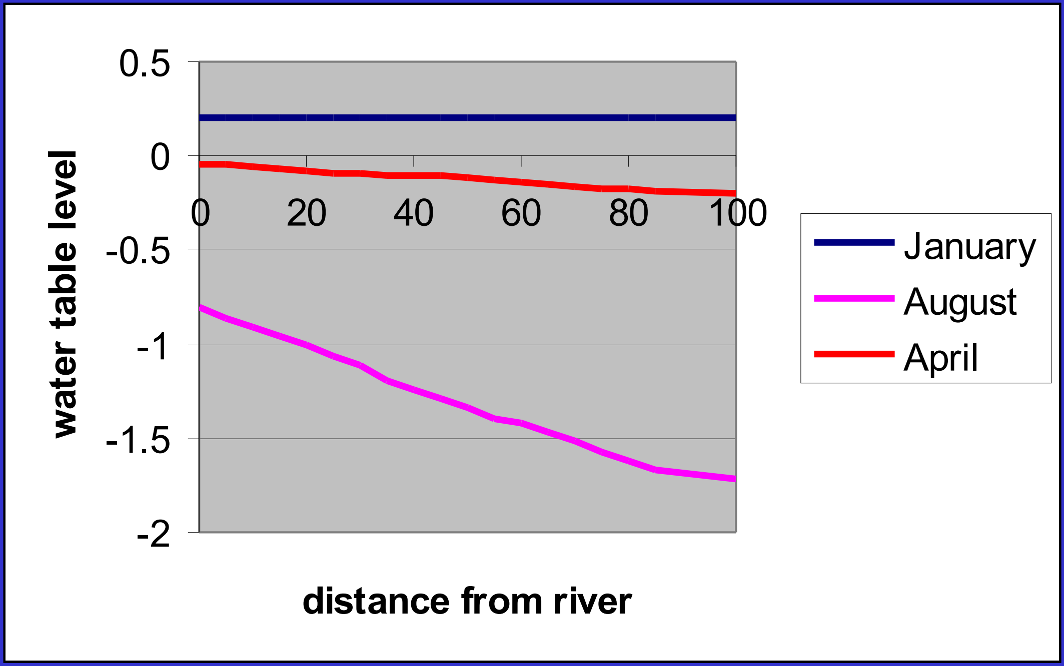
DR = distance from river

K = hydraulic conductivity

RH = river level

R = rainfall

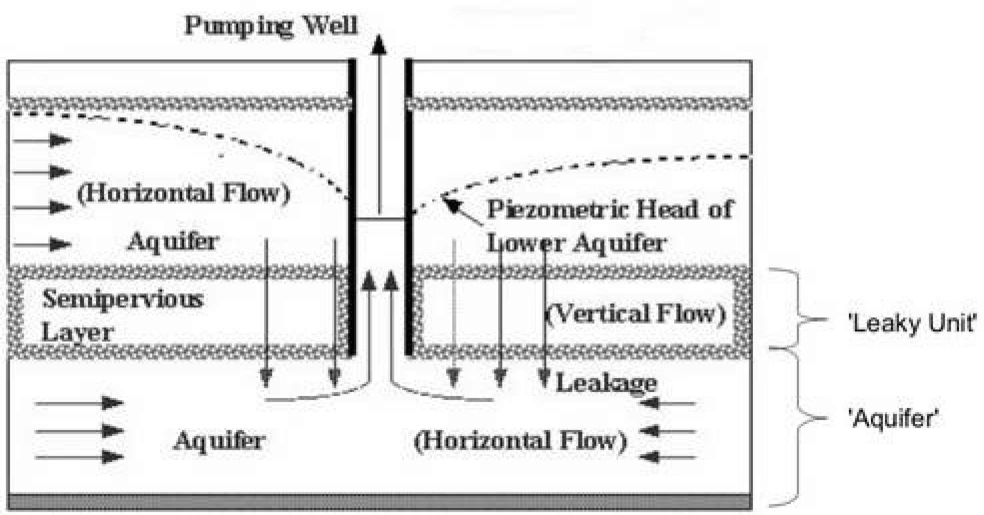
E = evaporation



Hantush leaky aquifer model

One Layer Leaky Aquifer System

Parameterised for Great Cressingham Fen



Thickness:	30 m
Vertical K:	0.0135 m/d
Thickness:	50 m
Horizontal K:	9 m/d
Transmissivity	**450 m^2/d**
Storativity	0.0001

Definitons (Hantush)

$$\beta = \sqrt{K_{aq} D_{aq} \cdot \left(\frac{D'}{K'}\right)} = \mathbf{1000}$$

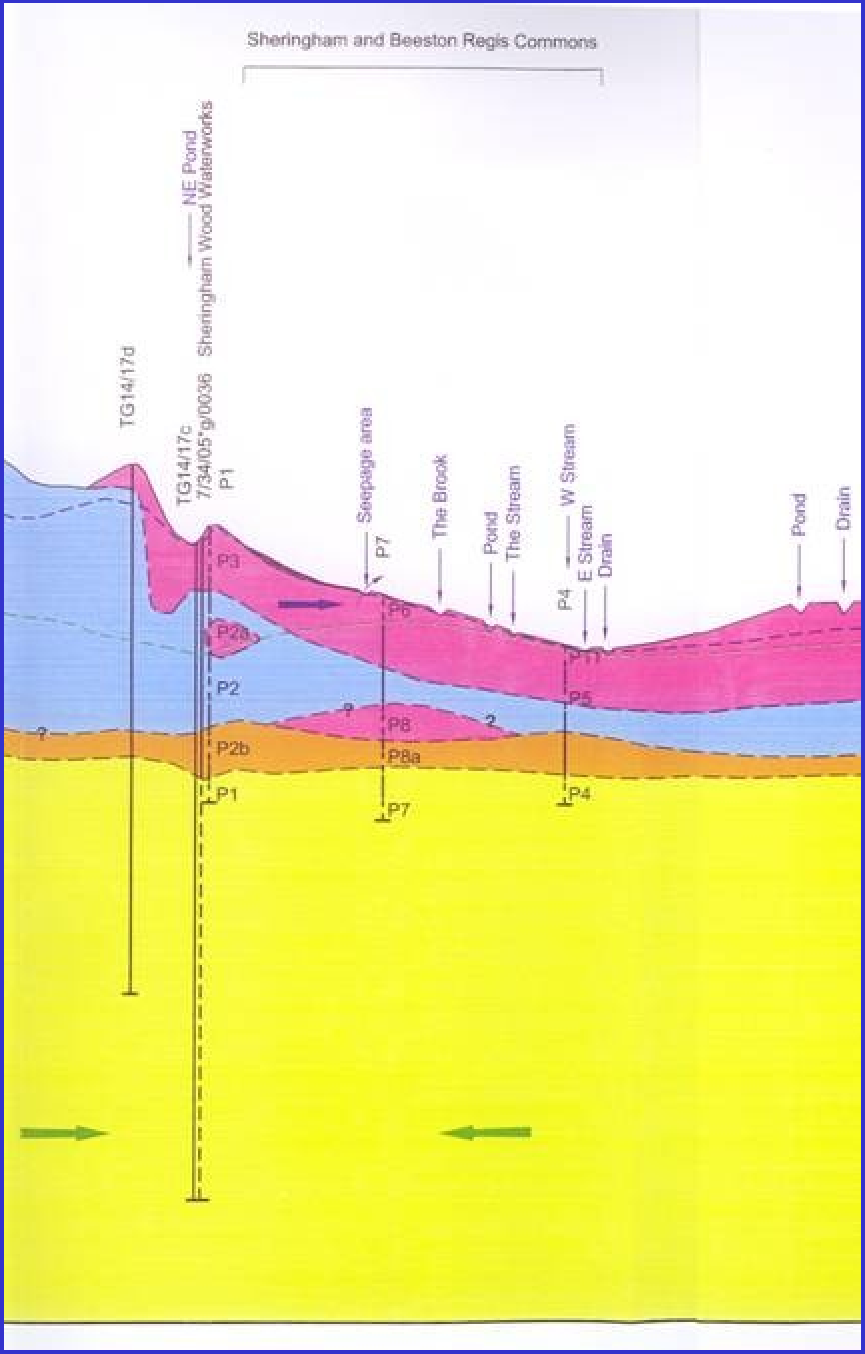
K_{aq}	Horizontal Hydraulic conductivity of aquifer
D_{aq}	Aquifer thickness
K'	Vertical Hydraulic conductivity of aquitard
D'	Aquitard thickness

Level 3 Detailed level

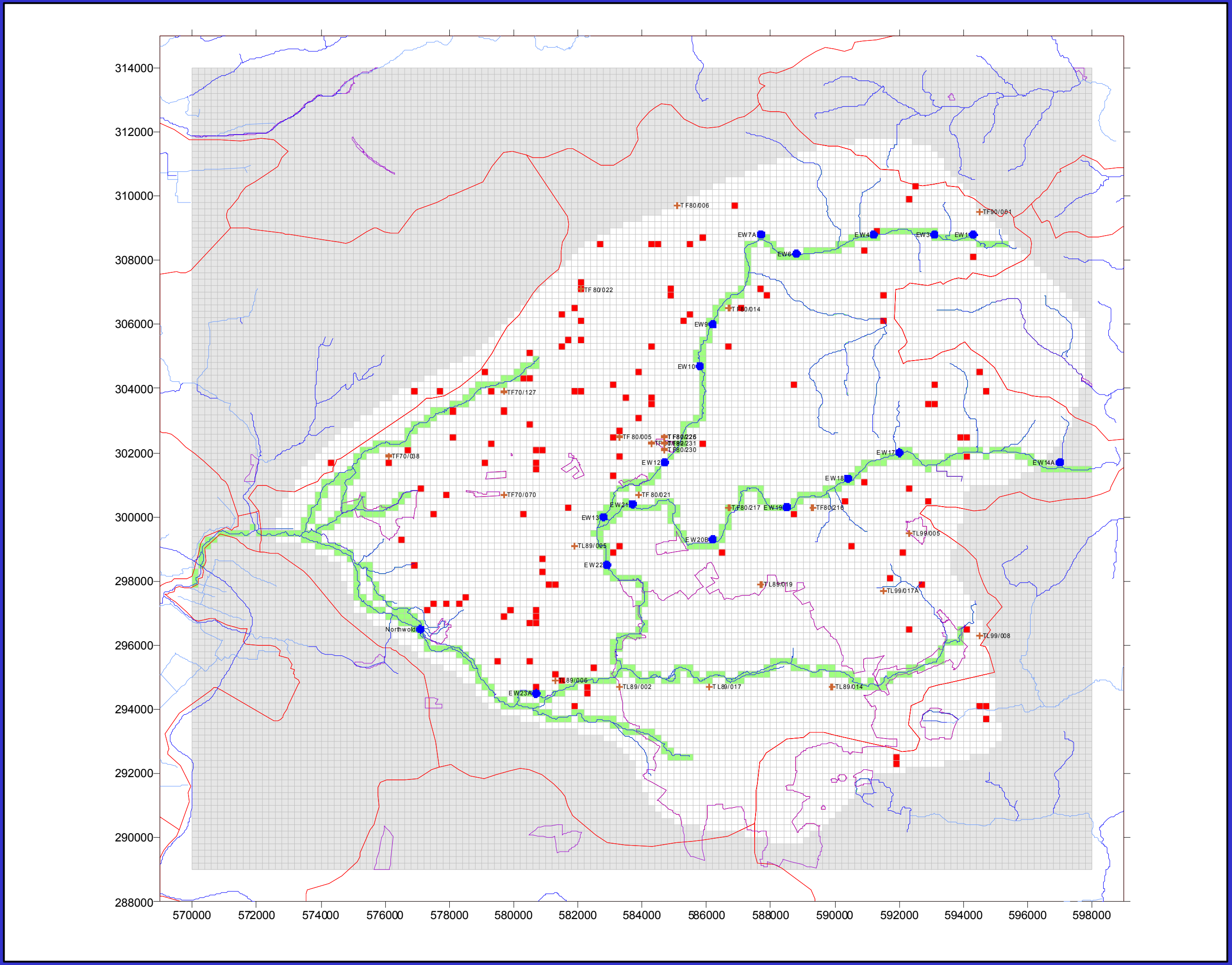
- Hantush gives 1-demensionl results – draw-down
- MODFLOW, ISIS, MIKE 11
- Hydraulics modelled
- Spatial data

Complex geology

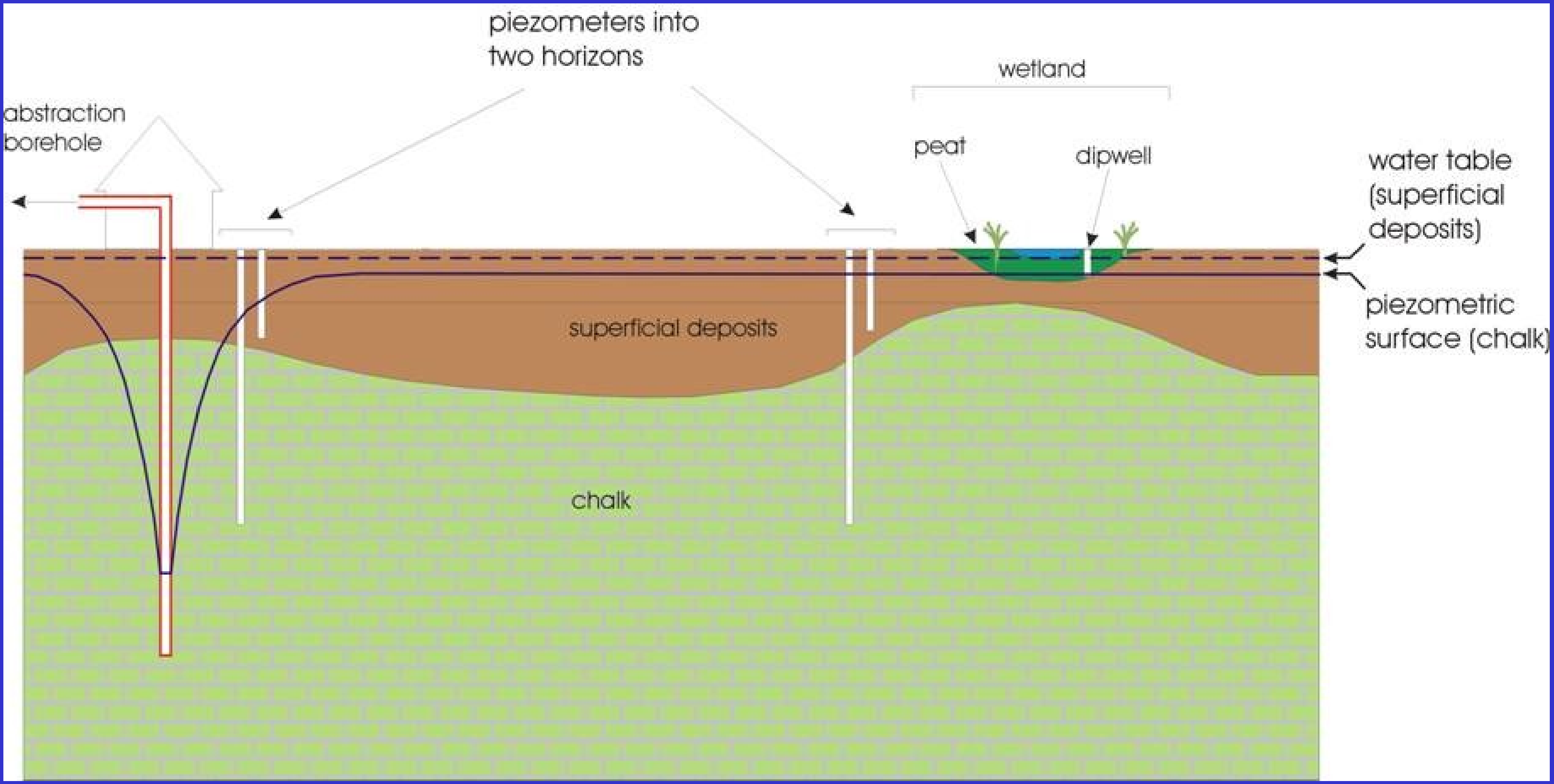
- Spatial variations in strata type
- Spatial variation in permeability of rocks (hydraulic conductivity)



Great Cressingham Fen MODFLOW map

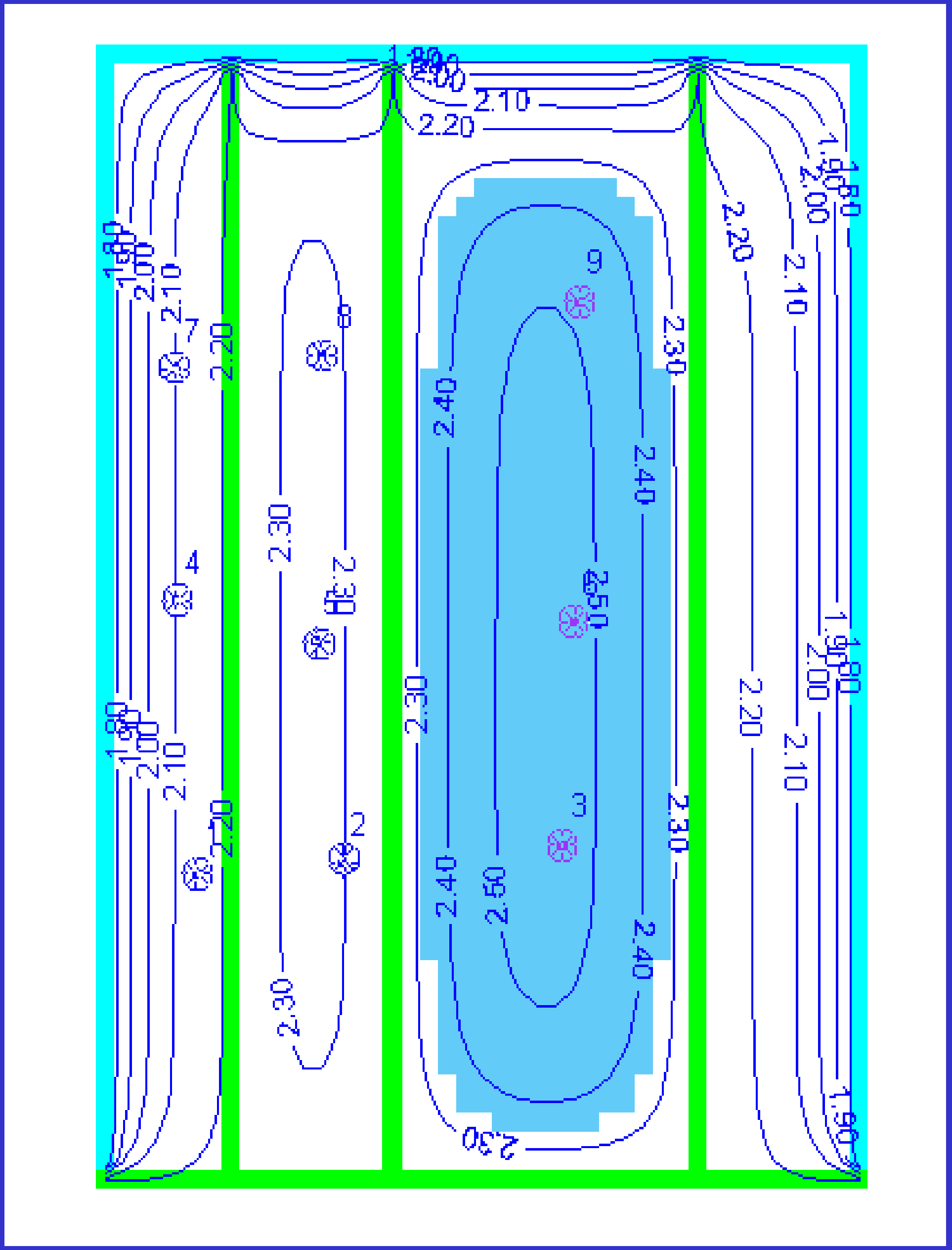


Groundwater data needs



Water table modelling

- MODFLOW groundwater model
- water table contours
- areas of inundation

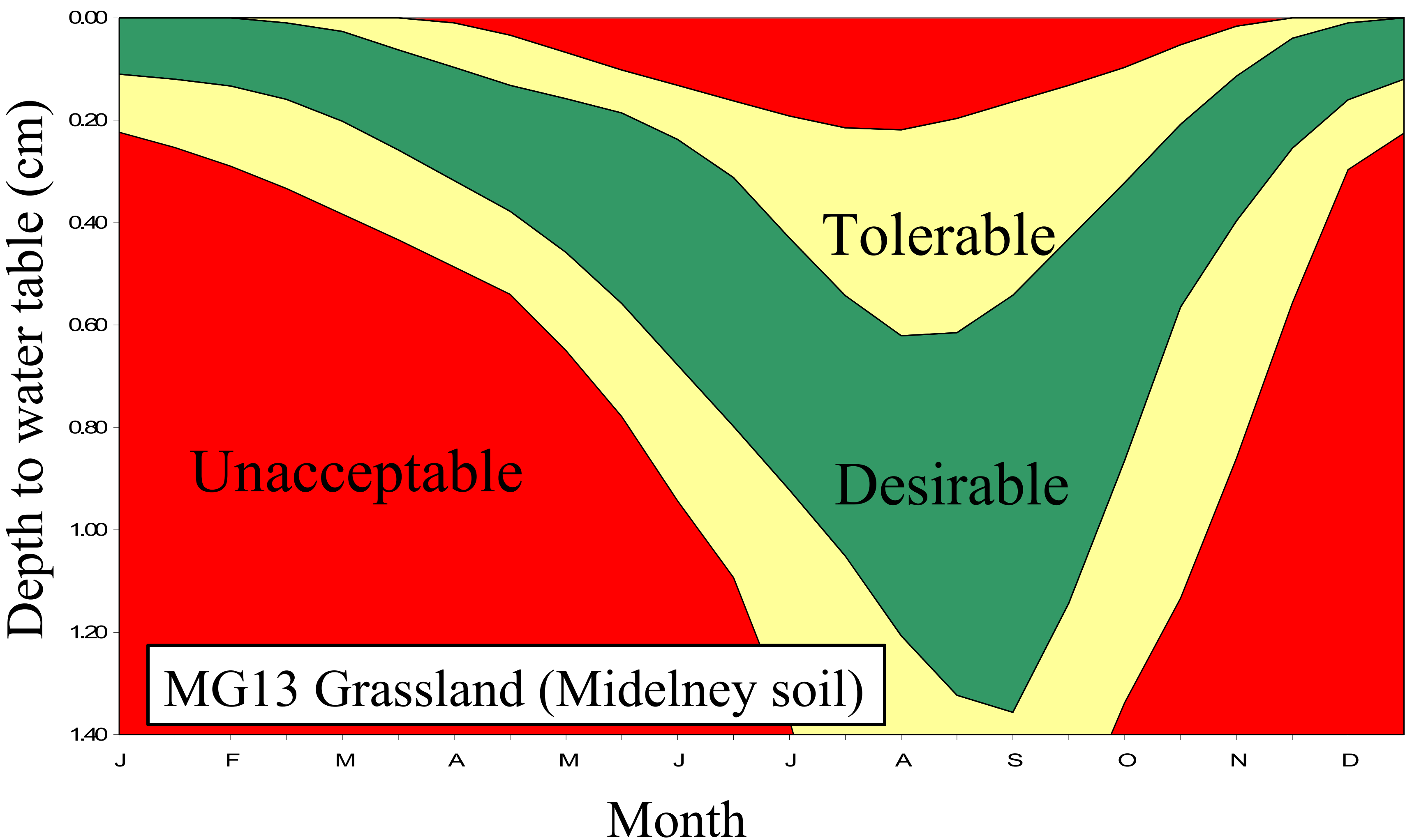


Impact Assessment of Wetlands

Stage 1 Hydrological impacts assessment (abstraction on wetland hydrology)

Stage 2 Ecological impacts assessment (hydrology on wetland biota)

Defining Thresholds/Needs



Great Cressingham Fen

Great Cressingham Fen - Summary

- The ADDITIONAL shallow water table drawdown related to an increase from natural (no abstraction) to full licensed abstraction is predicted to be around 11 cm

- Given the relative sensitivity of M13 to reduced water levels, an adverse effect cannot be ruled out at this stage.

Key concepts

- Conceptual understanding
- Fit for purpose
- Uncertainty
- Risk-based approach
- Stakeholder responsibility

http://www.uni-tuebingen.de/gracos/gif/eu.gif

EUROWET

Integration of European Wetland research in sustainable management of the water cycle

Hydrology Task Force review paper