



National Parks & Wildlife Service

Simulating the Impact of Regional Groundwater Changes on Raised Bog Ecohydrology

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Supporting Conditions for Irish Raised Bogs

Vital Elements for healthy bog ecohydrology

1. Nutrient-poor water supply-
Rainfall.
2. Water logging – water table close to, or at ground surface – How?
 - A. Frequent rainfall
 - B. Gentle topographic gradients (<0.5%)
 - C. Low downward seepage rates

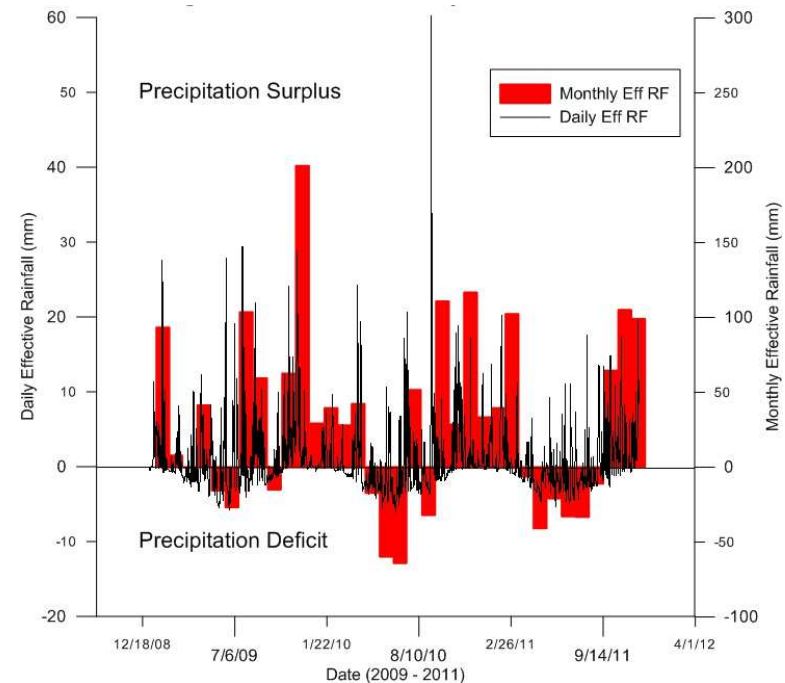
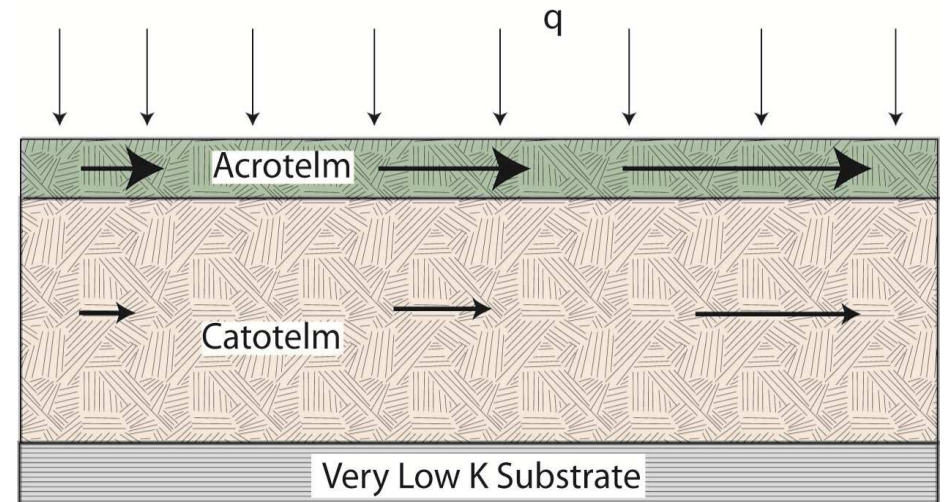
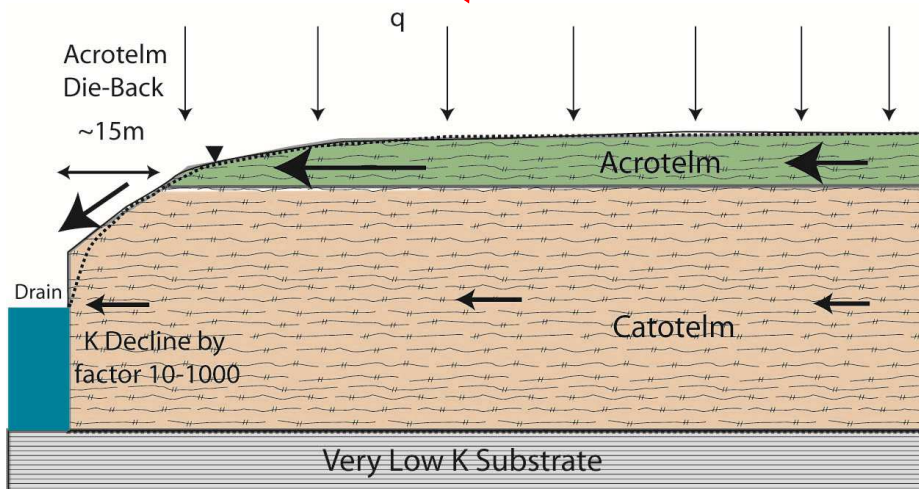
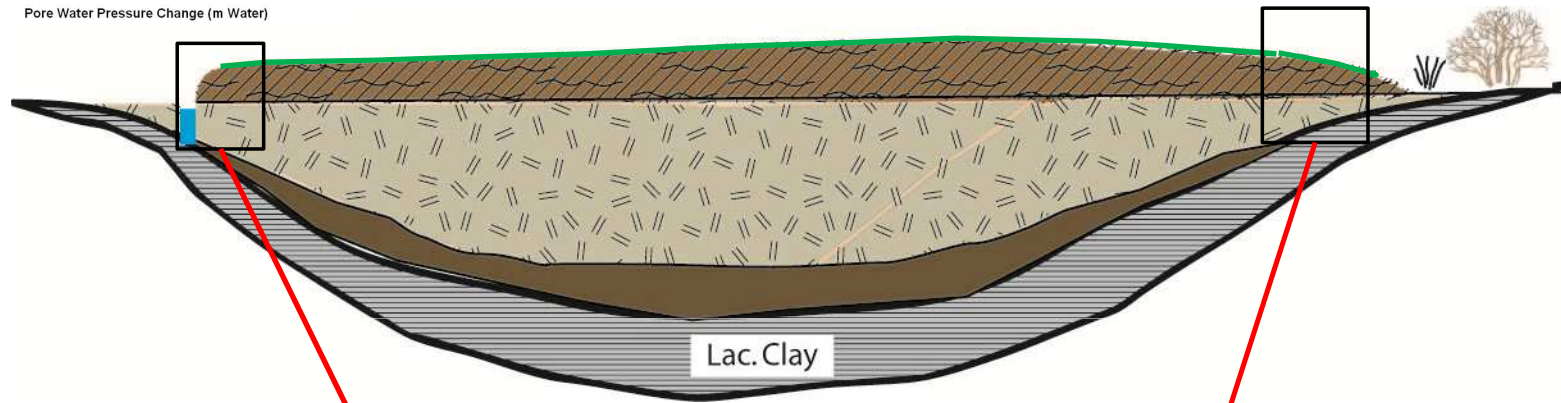
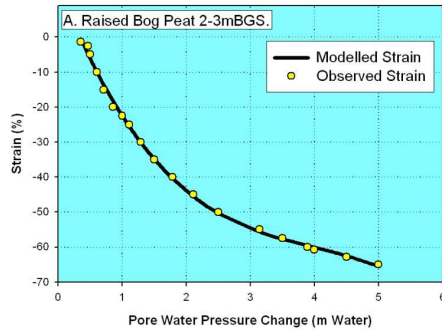


Image: Ballynahone Bog – Alastair Ruffel, QUB.

Conventional View of Marginal Drainage



Clara Bog: Example from Irish Midlands

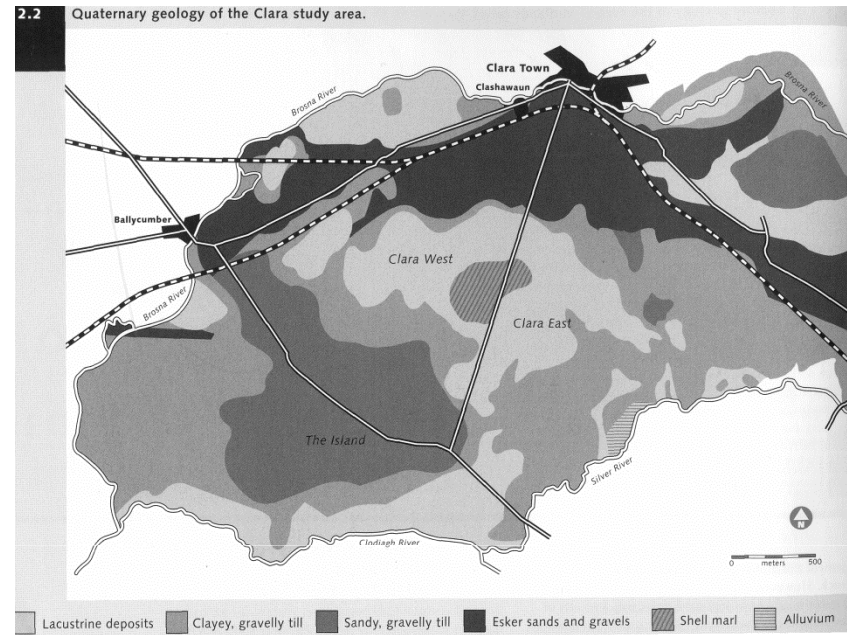
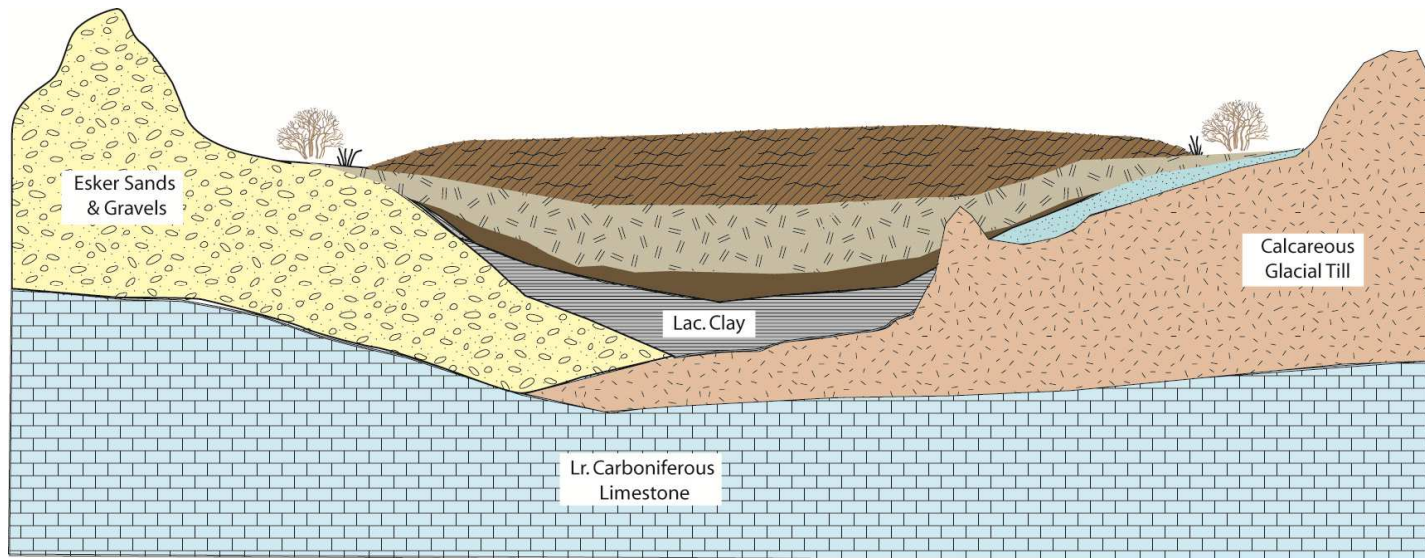
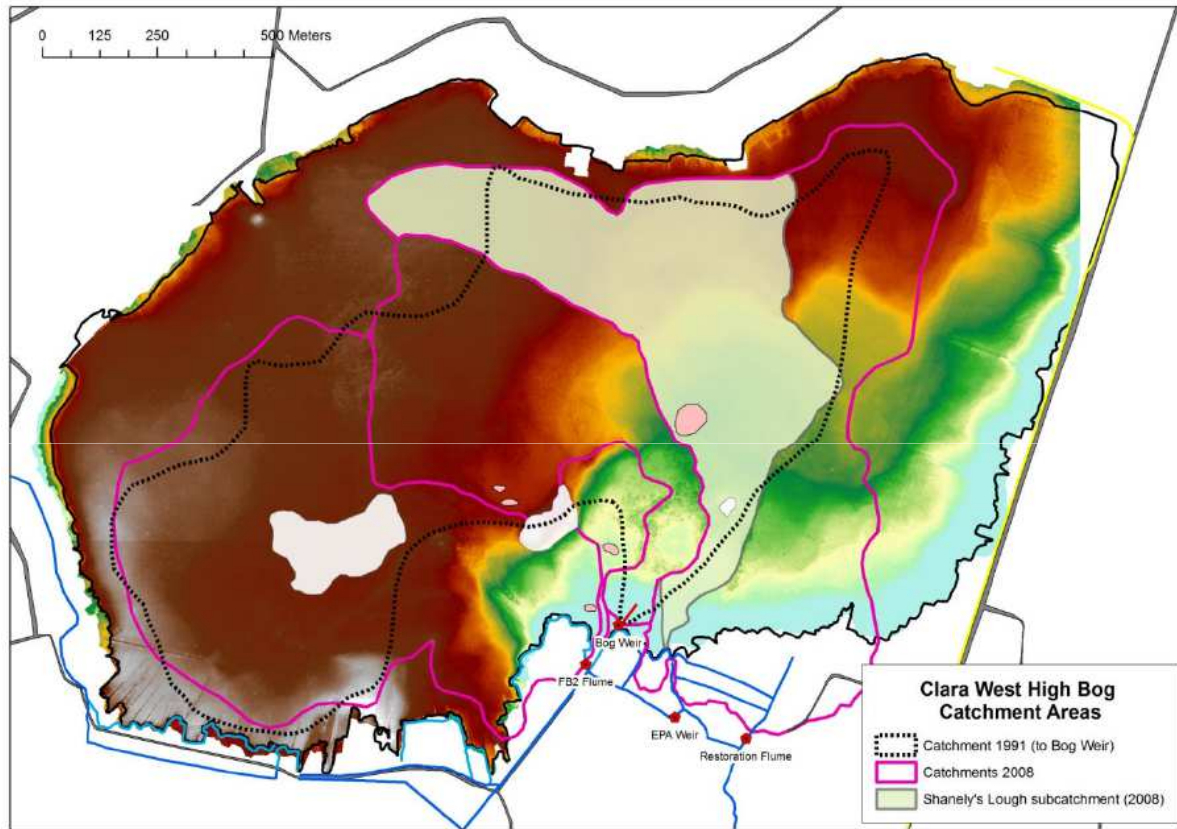


Image: From Schouten et al., 2002



Subsidence



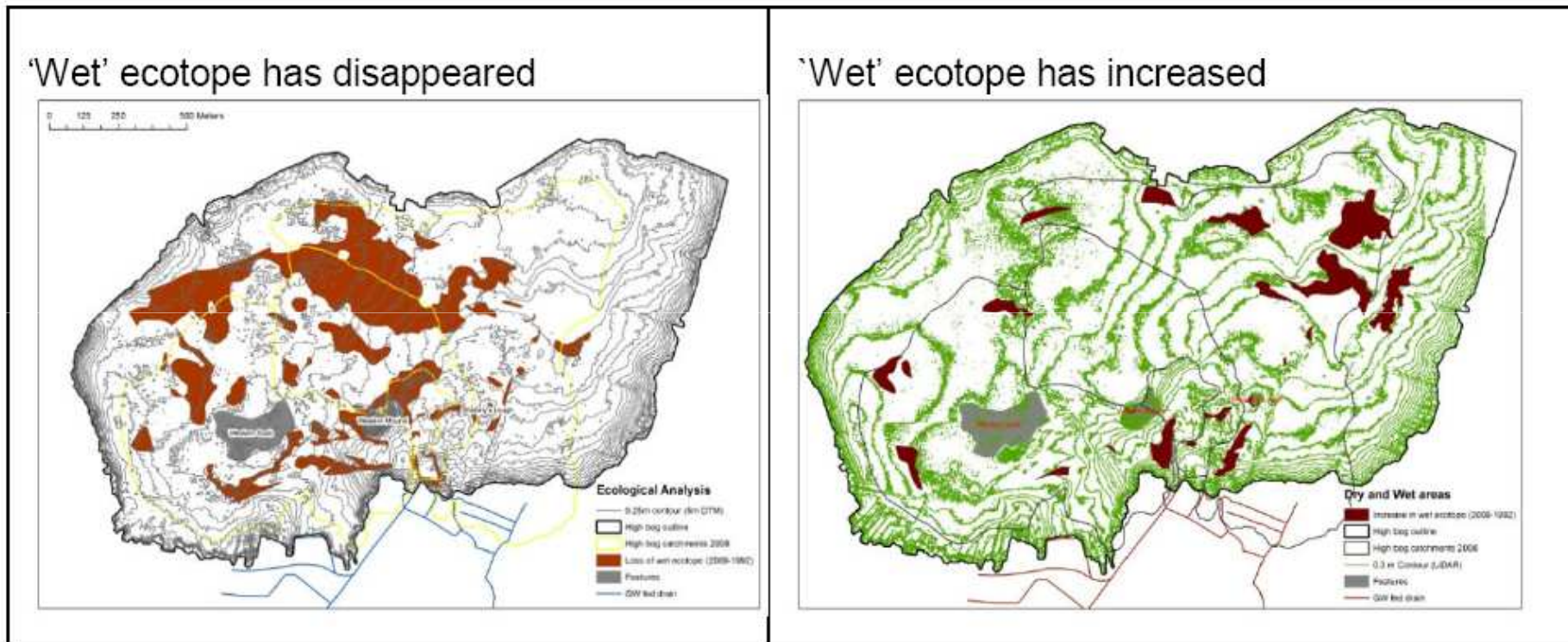
Photos: Colm Malone, NPWS.
Image: Regan (2012)

Hydro-ecological effects of Subsidence



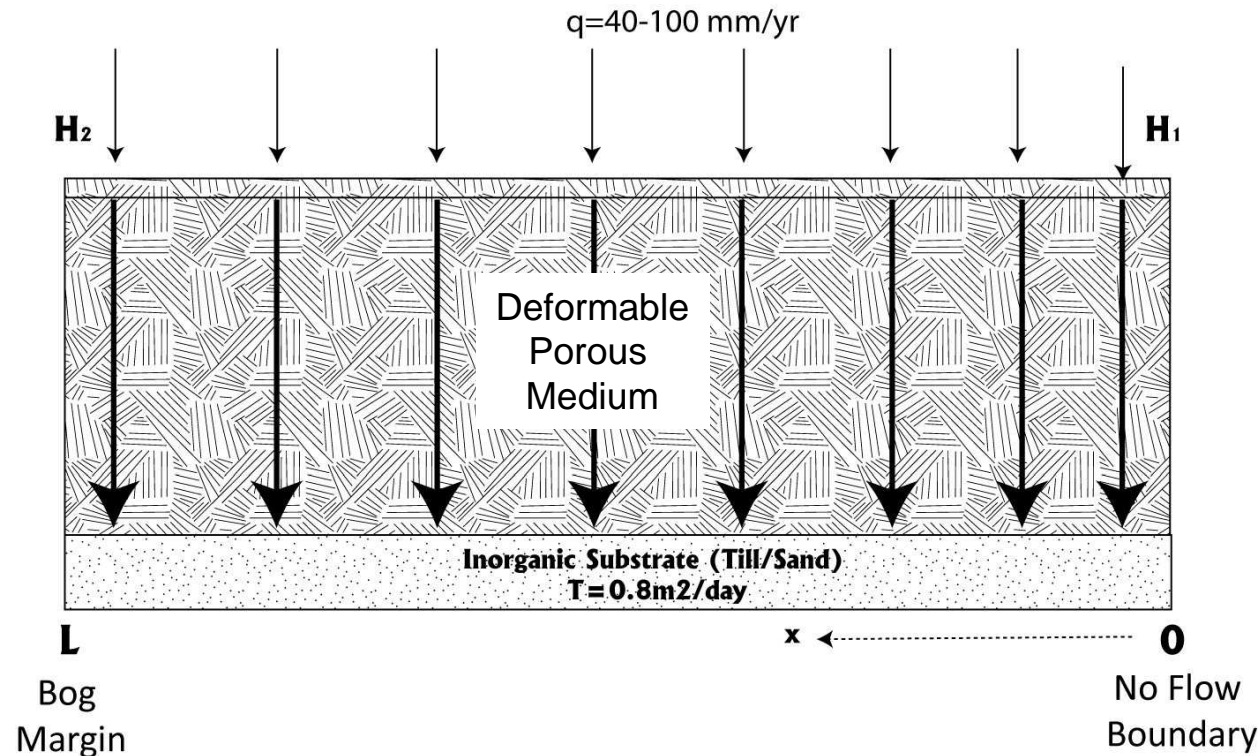
High bog topographic catchment areas and 'wet' ecotope distribution in **(A)** 1992 and **(B)** 2009 (Regan & Johnston, *Catchment fragmentation and hydro-ecological modification of a raised bog wetland*, IAHS red book series, 2013; *in press*)

Ecological Effects of Subsidence



Images: Regan (2012)

Simulating drainage-related subsidence



Steady State
 1D Confined Aquifer
 At $t=0$, $H_2=H_1=60\text{mAD}$
 At $t>0$, $H_2=57\text{mAD}$
 Head drop converted to stress
 Uniform deformation
 (over full peat thickness)

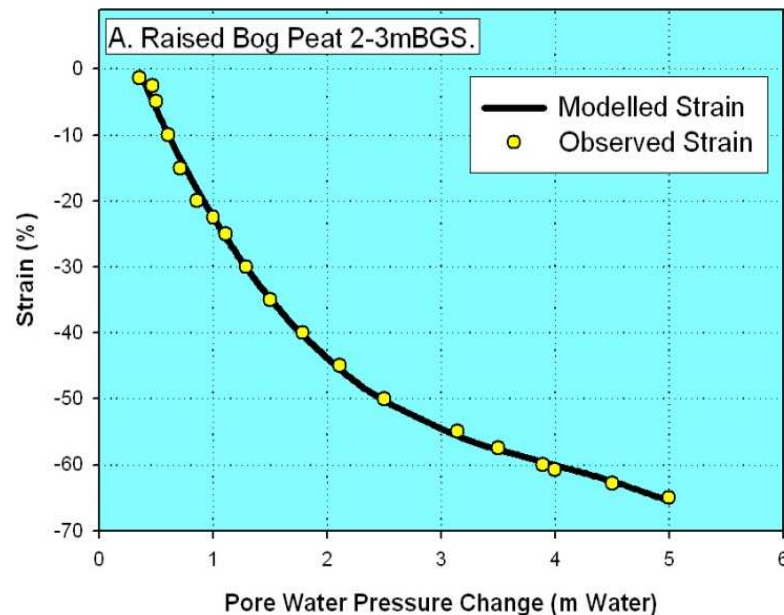
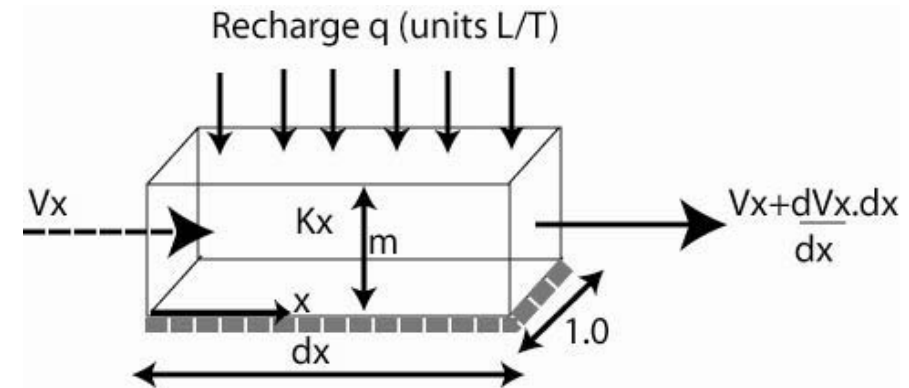
Model inputs:
 Recharge: From flow balance/
 Hydrograph separation from EMMA
 Transmissivity: From slug testing
 Heads: Field measurements

Incorporating Geotechnical Properties

- One dimensional flow for confined aquifer with recharge.

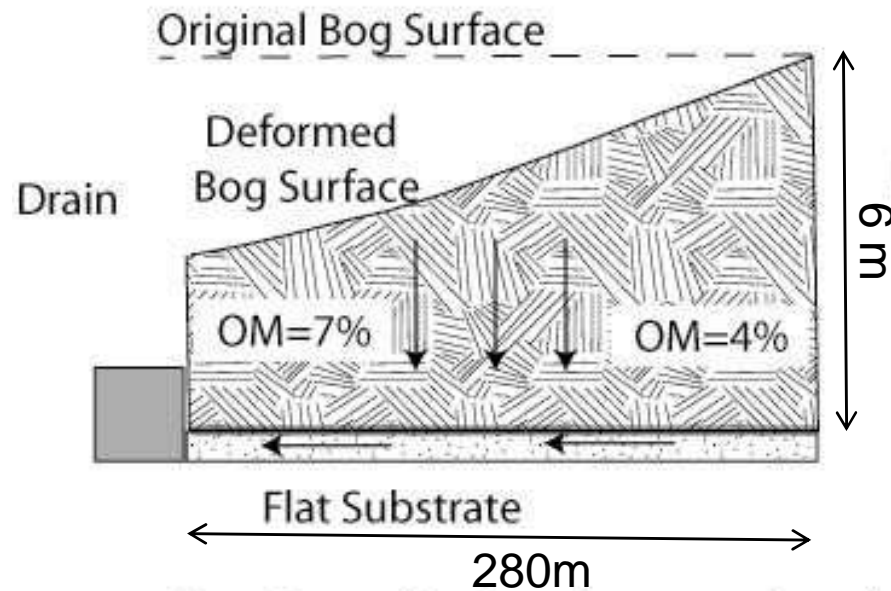
$$\frac{d^2 h}{dx^2} = -\frac{q}{T}$$

- Change in head used to calculate strain.
- Strain applied over whole peat column
- Change in thickness calculated and resulting topography simulated.

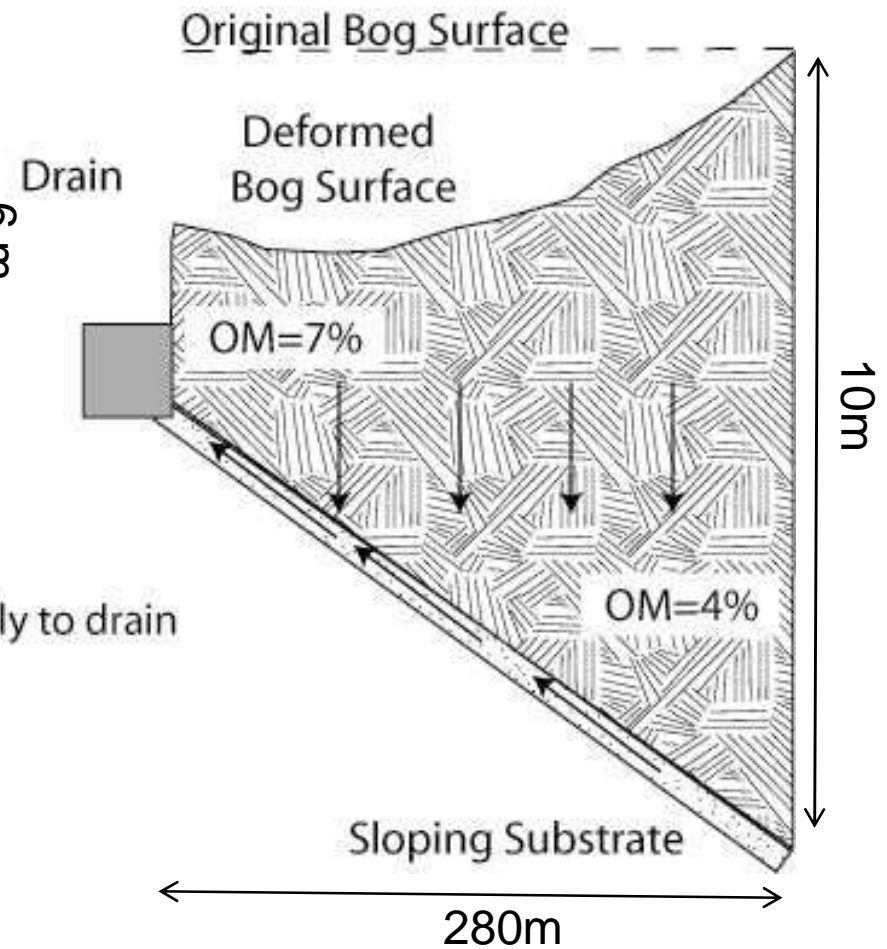


Simulated Topographic Profiles of Bog Surface

A. Flat Planar Substrate

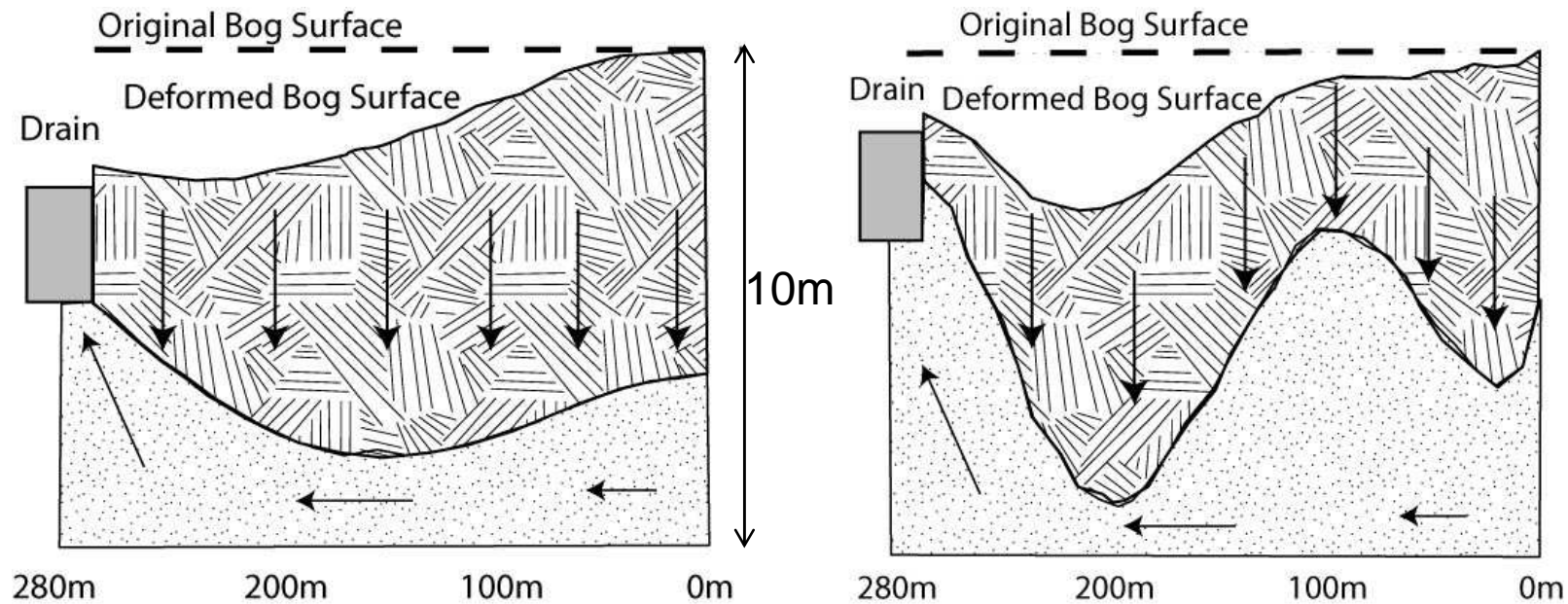


B. Sloping Substrate

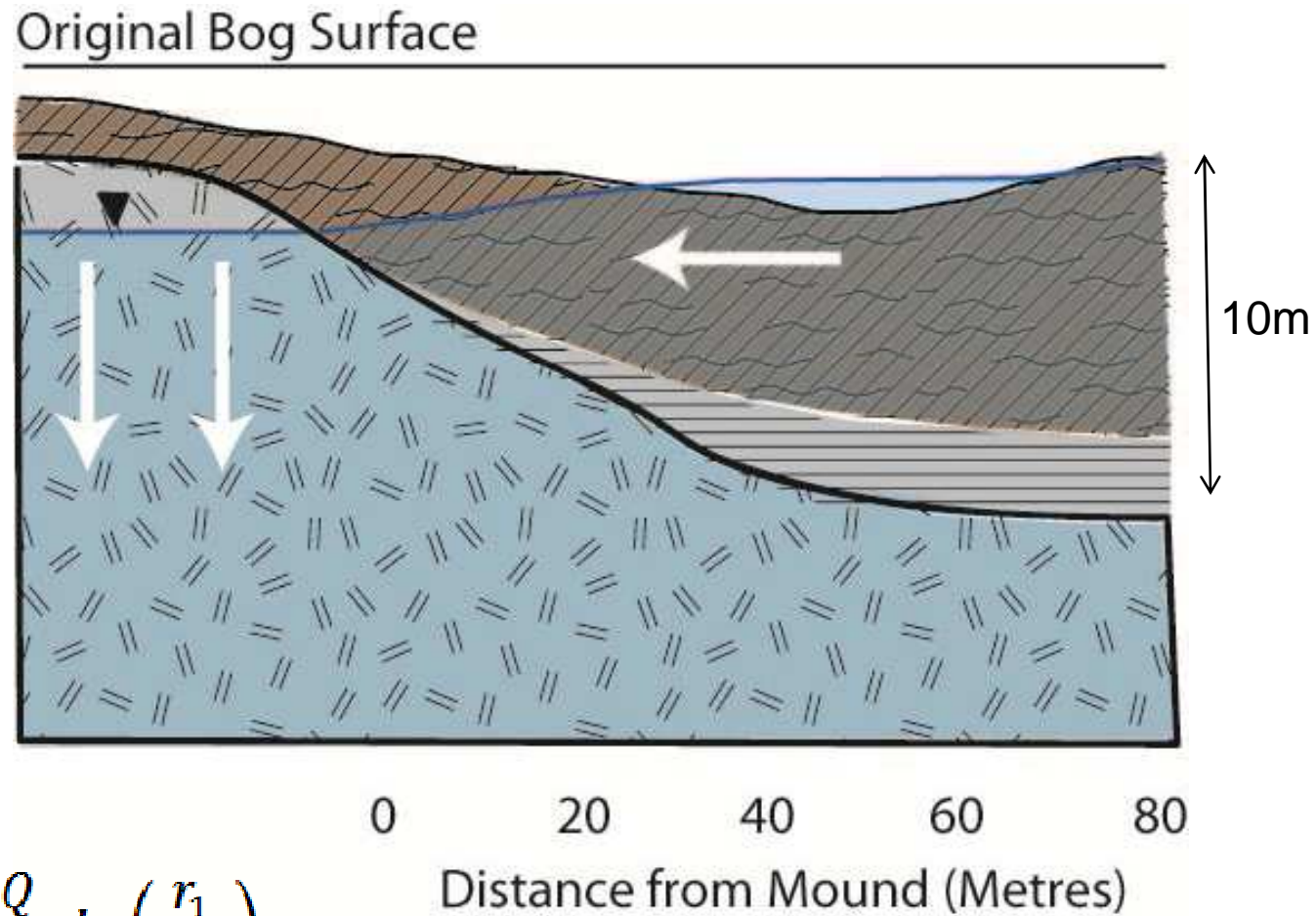


Note: Ground Surface slopes consistently to drain where (A) substrate is planar. Ground Surface has a trough before margin where (B) substrate slopes.

Simulated Profiles 2 – More Complex Substrate



Centre of Bog: Till Windows

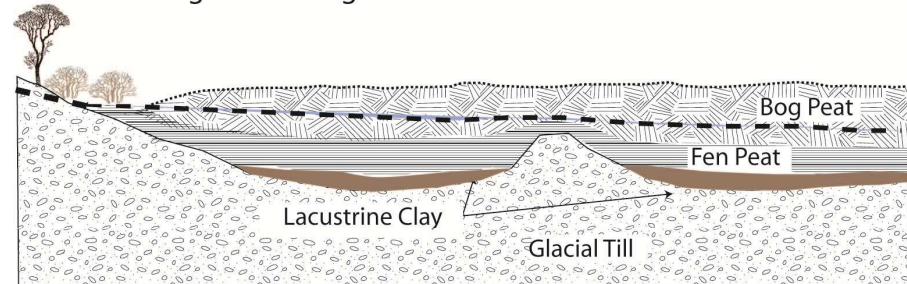


$$s_1 = s_{Till} - \frac{Q}{2\pi T} \ln\left(\frac{r_1}{r_{till}}\right)$$

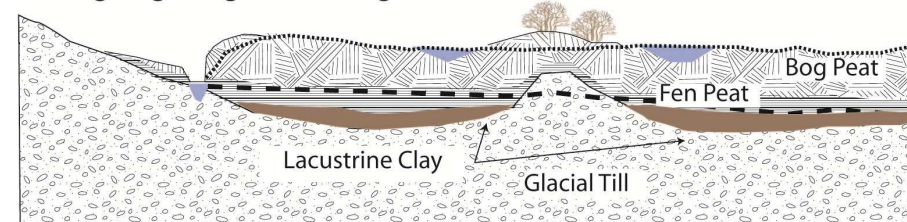
Perspectives

- 1D confined flow with recharge for marginal drainage.
- Situation with windows through lac clay more complex - radial.
- Effects of lowered water levels resemble pumping
- Same phenomena observed as simplified simulation (Lakes, desiccated areas).
- Peat thickness / compressibility and substrate composition are crucial controls in response to subsidence.

A. Before Marginal Drainage



B. On-going Marginal Drainage



Conclusions

- Raised Bogs can be GWDTEs.
- Drains cutting through the peat substrate can have comparable impacts to groundwater abstraction.
- This causes subsidence in (compressible) peat.
- Subsidence impacts bog ecohydrology by altering flow directions / catchments/ residence time.
- The nature and configuration of peat substrate influences ecotope fate during/after subsidence in marginal areas.
- Impacts decline moving away from margins suggesting other processes responsible for decline in more distal parts of bog.
- Drainage can result in certain areas becoming wetter (, although overall effects lead to drying out).