IMTECO Ltd: Modelling the Hydrological Impact of Infrastructure Near Bog Pool Systems

Partner: Irene Tierney – Principal Ecologist, IMTECO Ltd
Email: irenetierney@imtecoltd.com

Context & Motivation Peatlands with **dense bog pool systems** are highly sensitive ecosystems. Infrastructure (e.g. wind farms, access tracks, buried cables) is usually prohibited in these zones — but even construction near the pools can affect their delicate **hydrology**. Impacts include drainage "shadows", altered connectivity between pools, or changes in hydroperiod (pool water duration and levels).

Currently, there is **no standard tool** for ecologists or regulators to quantify these risks or to define *evidence-based buffer zones*, as is done for other sensitive habitats like GWDTEs (Groundwater-Dependent Terrestrial Ecosystems).

The Challenge How can we **develop or adapt a hydrological modelling tool** that allows users (especially non-modellers like ecologists) to assess:

- How infrastructure might influence nearby **bog pool dynamics**.
- What buffer zones are necessary to minimise hydrological disruption.
- How to communicate these risks clearly to regulators and developers.

The tool should be:

- Scientifically credible.
- Flexible enough to incorporate field data.
- Simple enough to be used in practical consultancy settings.

Realistic Outcome for the Workshop This is a **broad and ambitious challenge**. A fully working model cannot be built in two days — but this group aims to:

- Identify key physical processes and modelling options
- Review what tools already exist (and their limitations)
- Discuss the **data requirements** and simplifications needed for consultants
- Propose a **roadmap** for developing a prototype tool, e.g. in Python/R or an interface for an existing model (like DigiBog or HEC-RAS)

The result would be a shared vision and technical outline that could seed a collaborative research or innovation project.

Modelling Approaches (for discussion) Below is a categorisation of possible modelling approaches, adapted from current research and industry practice. These should be discussed in terms of feasibility, input requirements, and applicability to bog pool systems.

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1. Physically-Based Distributed Flow Models (2D/3D)
Examples: **MIKE SHE**, **HydroGeoSphere**, **MODFLOW** (with UZF/SFR/LAK), **COMSOL**

- Simulate: water-table response to tracks/foundations, pool water levels, GW–SW (groundwater–surface water) exchange, culvert placement
- Inputs:
  - High-resolution LiDAR digital elevation model (DEM)
  - Peat layer stratigraphy and hydraulic properties (K, van Genuchten curves)
  - Drainage layout, rainfall/evaporation data
  - Logger data for calibration

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2. Surface Flow & Barrier Routing Models
Examples: **HEC-RAS 2D**, **TELEMAC-2D**

- Simulate: how roads, tracks, or berms act as **barriers**, causing ponding or fragmentation between pools
- Inputs:
  - Sub-metre DEM
  - Roughness maps (e.g. open water vs. Sphagnum mats)
  - Rainfall hyetographs
  - Water-level data from pool loggers

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3. Catchment-Scale Conceptual Screening Models
Examples: **TOPMODEL**, **HBV**, **GR4J** (with peat-specific parameters)

- Simulate: broader **seasonal drawdown risks**, "what-if" scenarios of cumulative impact
- Inputs:
  - Rainfall and evapotranspiration time series
  - Simplified soil and land cover types

- Outflow measurements or dipwell data

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4. Peatland-Specific Eco-Hydrological Models
Example: **DigiBog**

- Simulate: long-term interaction between **peat growth** and **hydrology**, particularly pool–ridge feedback
- Inputs:
  - Microtopography
  - Peat decomposition and productivity parameters
  - Historic water-table records
- Notes: DigiBog also includes a standalone hydrology module (*DigiBog_Hydro*)

More info: https://www.peatmothership.org/digibog

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5. Graph-Based & Cellular Automata Models (from LiDAR)

- Simulate: how **microtopography** and barriers affect **connectivity** between pools
- Can model thresholds for hydrological fragmentation and loss of function
- Inputs:
  - High-resolution DEM
  - Seasonal pool extents
  - Mapped pool network

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6. Water Quality & Export Models
Examples: **SWAT+**, **HYPE** (peat-parameterised)

- Simulate: how construction corridors affect **DOC (dissolved organic carbon)** or sediment exports
- Inputs:
  - Soil carbon maps, surface runoff patterns
  - Event-based water sampling of DOC and turbidity

Explanation of Key Terms

- **van Genuchten curves**: Describe how water is retained in soil/peat at different tensions — needed for accurate modelling of flow through porous media
- **GW–SW exchange**: The bidirectional flow between groundwater and surface water (like pools)
- **Hyetograph**: Graph of rainfall intensity over time
- **Hydroperiod**: Duration and frequency of pool inundation
- **Acrotelm/Catotelm**: The upper active and lower anoxic peat layers in bogs

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Final Aim The aim of this group is not to develop a working model immediately, but to outline:

- A **recommendation** for model type and structure
- A minimum data standard for ecological assessments
- Possible avenues for future development (student projects, grant proposals, open-source collaboration)