Coastal dune wetlands in England and Wales: Understanding rainfed groundwater dependent ecosystems to underpin conservation management

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Groundwater Dependent Ecosystems
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THE TEAM:
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• University of Southampton
• University of Groningen
• Natural England
• Countryside Council for Wales
• Ecological Surveys (Bangor)
• Geological Survey of Northern Ireland
• Sefton Borough Council

THE COASTAL DUNE WETLANDS:
• Sandscale – Furness
• Ainsdale – Sefton Coast
• Newborough Warren – Anglesey
• Whiteford Burrows – Gower
• Braunton Burrows – North Devon
• Holme – North Norfolk
• Magilligan – Co. Londonderry
The coastal dune wetlands of England and Wales

Masters of sand dune hydrology are the Dutch. Their dunes differ in that they are deeper with a saline wedge below and used to filter Rhine water for supply and as coastal defence structures.
Magilligan is different: thick and very big
I'm not licking any water off this beach!
Braunton Burrows coastal dune spit system. Classic groundwater ridge two thirds way inland towards estuarine marsh at estuary mouth. Carboniferous Limestone hills to the north...

...and a typical long-term dipwell record in dune slacks at Ainsdale, Sefton Coast
High frequency hydrograph data for Whiteford Burrows, Gower.

Note the TREES and NOT TREES issue (RED SQUIRRELS or RABBITS?)

- Hourly Rainfall
- Well 11 in open dunes
- Well 6 in trees
- Well 4 nearest beach

- Quiet response beneath trees
- Flashy open warren
- Moderated by beach as fixed head boundary
Whiteford Burrows
The great storm of April
1995
Percentage change due to long term decline in effective rainfall at Braunton Burrows, rapid storm event foreshore erosion at Whiteford Burrows, and long term foreshore erosion at Ainsdale
Whiteford Burrows: monitoring Tors Slack
Moisture content depth profiles for dipwells D2, D3 and D4 showing water table in D4 in December 2011 and February 2012.

Grain size profile D4. Hazen approximation gives K of ~10 m/d.
<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>RWL (mbgl)</th>
<th>Well depth (m bgl)</th>
<th>Temperature (°C)</th>
<th>SEC (µS/cm)</th>
<th>pH</th>
<th>DO (mg/l)</th>
<th>Eh</th>
<th>HCO₃ (mg/l)</th>
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</thead>
<tbody>
<tr>
<td>High dune</td>
<td></td>
<td></td>
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<tr>
<td>D&lt;sub&gt;new&lt;/sub&gt;</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>15/02/2012</td>
<td>5.93</td>
<td>9.2</td>
<td>10.4</td>
<td>804</td>
<td>7.9</td>
<td>13.4%</td>
<td>23</td>
<td>285</td>
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</tr>
<tr>
<td>5</td>
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<td>5.06</td>
<td>9.2</td>
<td>12.1</td>
<td>687</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25/02/2010</td>
<td>top of casing</td>
<td>1.97</td>
<td>7.9</td>
<td>719</td>
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<td>0.35</td>
<td>1.97</td>
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<td>7.7</td>
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<td>7</td>
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<td>7.6</td>
<td>0.5</td>
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<tr>
<td>Bedrock Borehole (Pilton Mudstone Formation)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>GC</td>
<td>14/11/2012</td>
<td>artesian</td>
<td>24 and 63</td>
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<td>7.2</td>
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</tbody>
</table>

Braunton Burrows
L and $\delta^2$H profiles. Peaks, if annual, suggest downward piston flow of $\sim$1 m/yr.
**Problem:** need downward piston flow of ~2 m/yr to shift all the effective rainfall down the unsaturated zone with porosity of 30% and moisture content of 13%.

**Cause:** perturbation of climate with wet summers and dry winters.

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Age dating with SF6. CFC not used as water in vadose and saturated zones tends to be depleted in oxygen and CFC may have become degraded.

<table>
<thead>
<tr>
<th>Dipwell</th>
<th>Site</th>
<th>Eastings</th>
<th>Northings</th>
<th>Sampling Date</th>
<th>SF6 (fmol/l)</th>
<th>Mean residence time 1.5 ccSTP/L EA ± 2 years</th>
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<td>135363</td>
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<td>(2004) 6</td>
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<td>(2003) 7</td>
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<td>14/11/12</td>
<td>1.310</td>
<td>(1992) 20</td>
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</table>
Moisture profiling – Braunton Burrows
So why monitor and measure?

To advise national strategy for conservation management.

What has it all got to do with the ecology anyway?

Plant species according to pH, depth to water, flooding, nutrient supply etc.

Hydrogeological and hydrological enquiry underpins ecological understanding and informs the managers.