



British
Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our
changing Earth

Moray Ness GSI3D ZOOMing in ?

GSI3D Consortium Workshop 1-2 March 2011, BGS Keyworth



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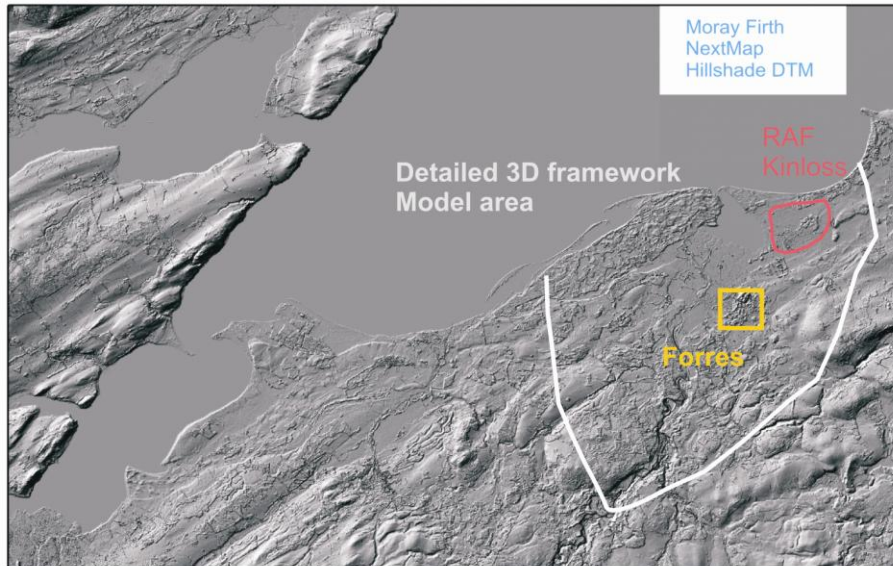
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Outline

- Background ~ Where? Context? Drivers?
- Designing the work Programme ~
Multidisciplinary team work (field and office)
- Making the framework models (local detailed
framework, nested in a regional generalised
framework)
- Reattributing the detailed model/How much
detail do we need?
- The future

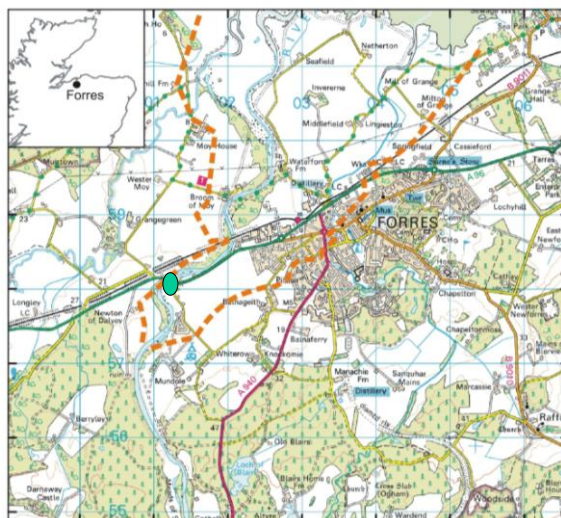
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Background Flooding in Forres



A large part of the town flooded 1997, 2001

Muckle Spate of August 1829

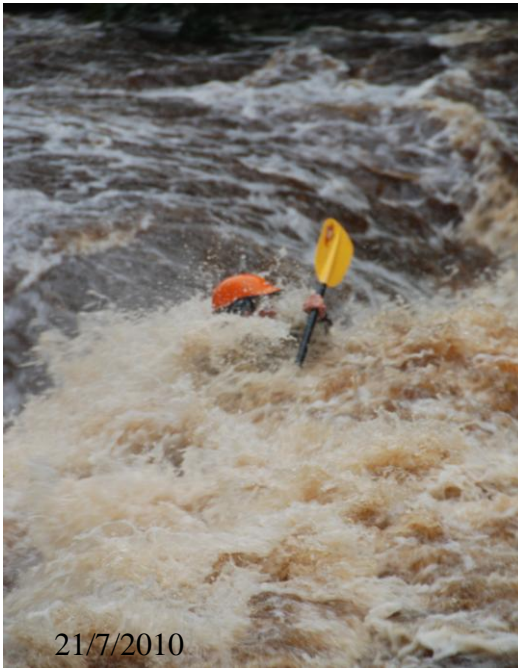
In parts of the catchment flow was estimated as >20 times the normal discharge at the mouth of the Thames

At Findhorn Bridge  flow was >7 times the Thames

New Flood Alleviation Schemes being designed

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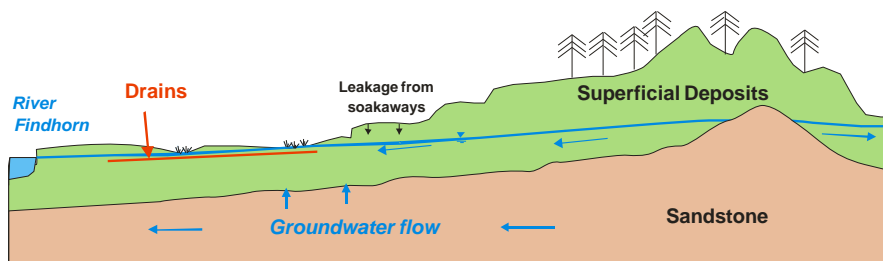
Before it reaches the sea the River Findhorn flows within a narrowly confined valley or numerous gorges cut into bedrock

The Findhorn flowing across psammites of the Dava Subgroup up-stream of Mains of Sluie

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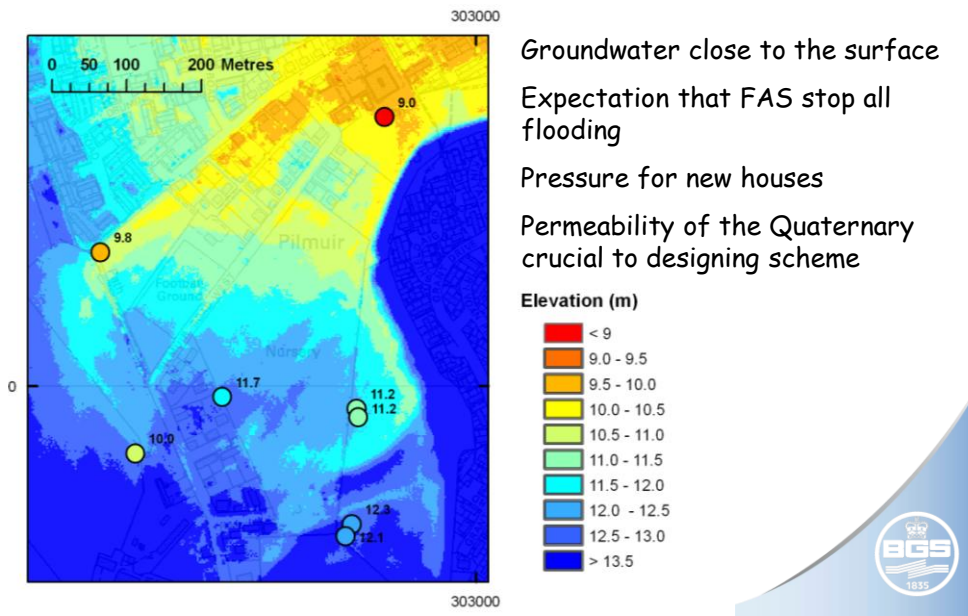
Background Flooding in Forres



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Background Flooding in Forres



Construction of flood defences at Chapleton Moss, Forres
Cost £20 M

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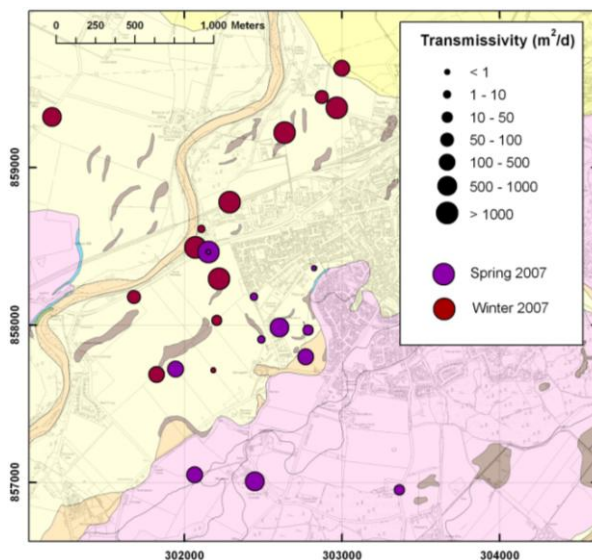


Estimating permeability

1. Pumping tests
2. Particle size distribution
3. Slug tests
4. Geology and modelling: putting it all together



Pumping tests: transmissivity



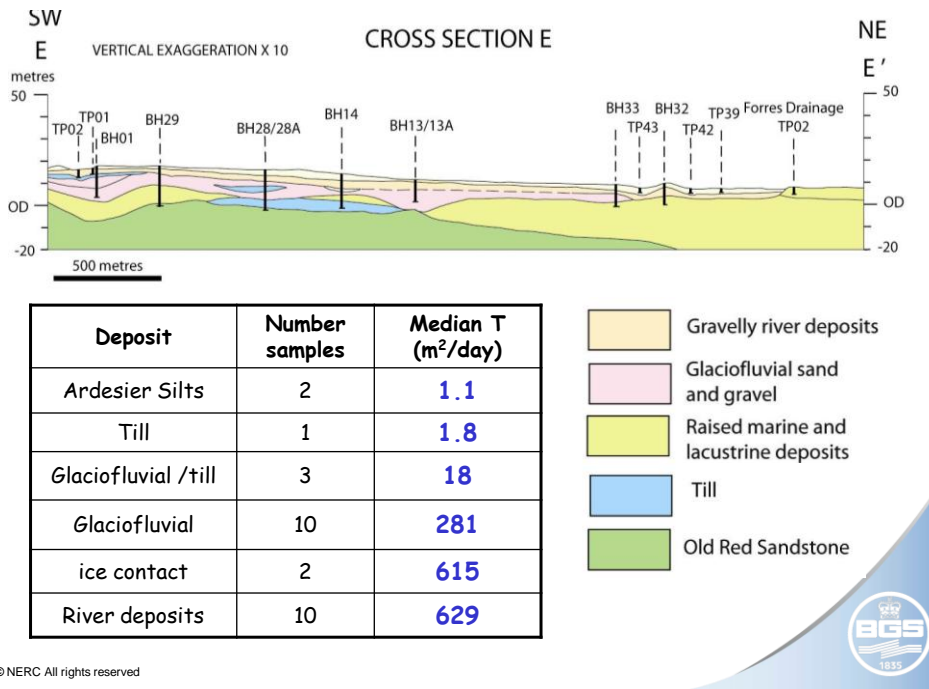
high $T > 1000 \text{ m}^2/\text{d}$

Great variability

No obvious pattern

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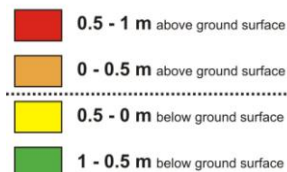


Modelled groundwater flooding



ZOOM modelling incorporating some novel techniques

Colours represent the modelled groundwater levels with respect to the ground surface.



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Measuring permeability at outcrop



Hydrogeologists - test permeability *in situ*
Geologists - tell us exactly what unit we are in.
Engineering geologists - do standard tests
and descriptions

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Guelph permeameter

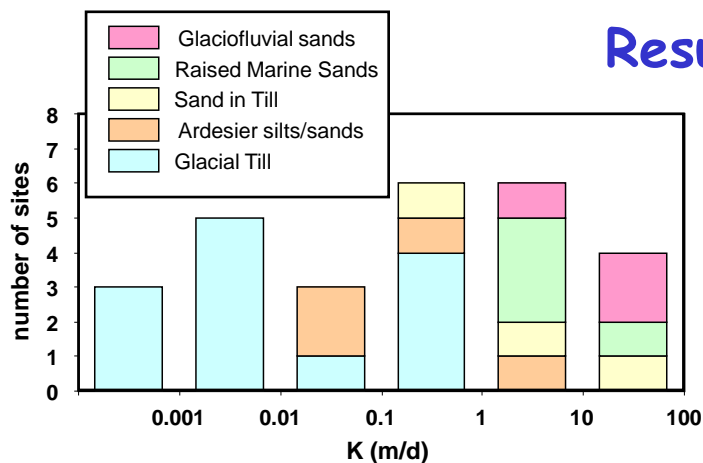
Make auger hole 10 cm deep

Difficult due to location of outcrops

Carry out test (<1 hour)

Range 0.001 - 20 m/d





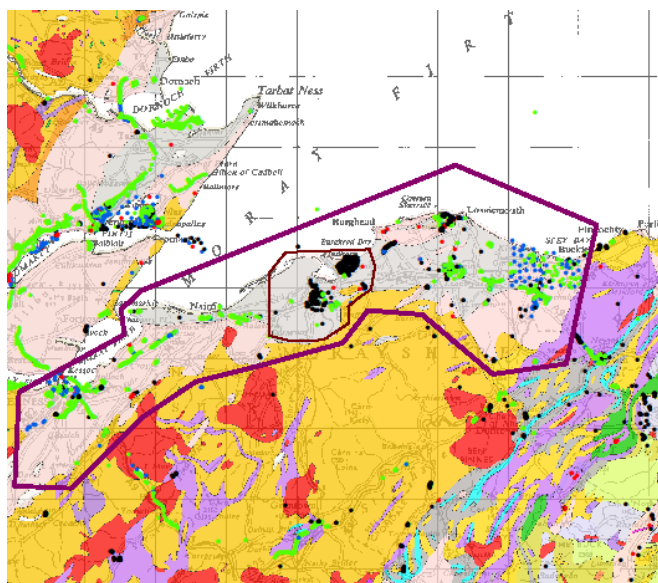
Wide range over all deposits, but there is a statistically significant correlation between engineering parameters and hydraulic conductivities

Relating *in-situ* permeability, particle size and relative density of superficial deposits in a heterogeneous catchment. MacDonald et al. *Journal of Hydrology* (submitted)

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The Regional model and the Forres Model



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Regional Model

Simple 6 layer model

Superficial Deposits (Glacial & Postglacial
unconsolidated materials)

Sedimentary rocks

Jurassic (mudstones & sandstones)

Permian/Triassic (sandstones)

Devonian (Old Red Sandstone)

Major igneous intrusions (mainly granites)

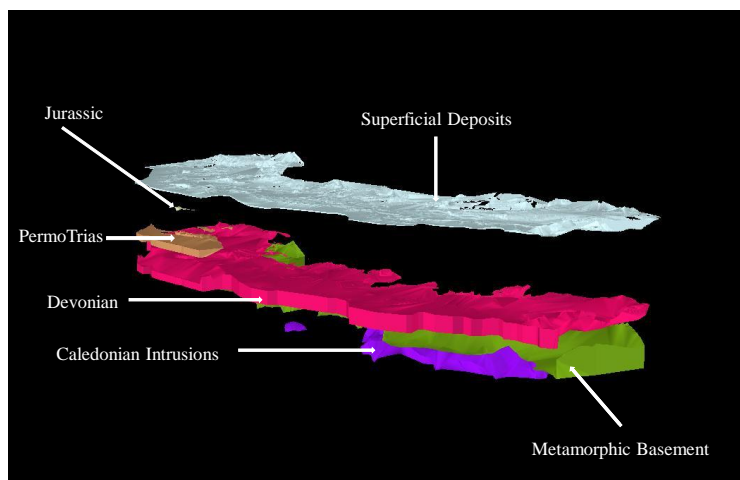
Ancient crystalline metamorphic basement

Extends on the southern flank of Moray Firth from
Buckie to Inverness

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Exploded regional model



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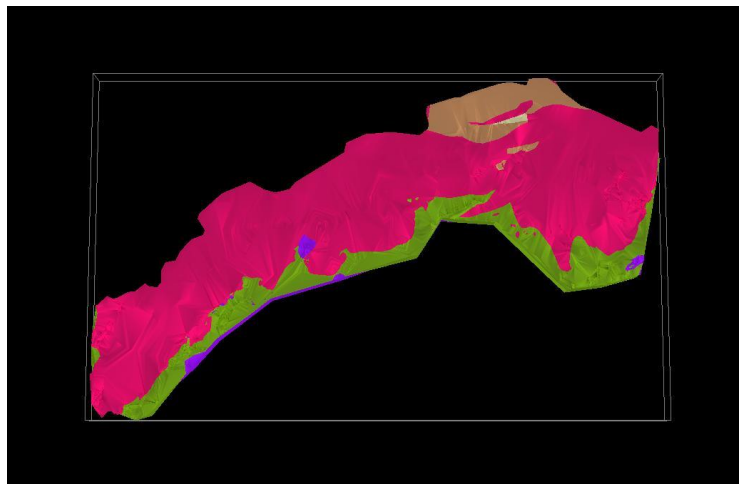
Distribution of Superficial Deposits



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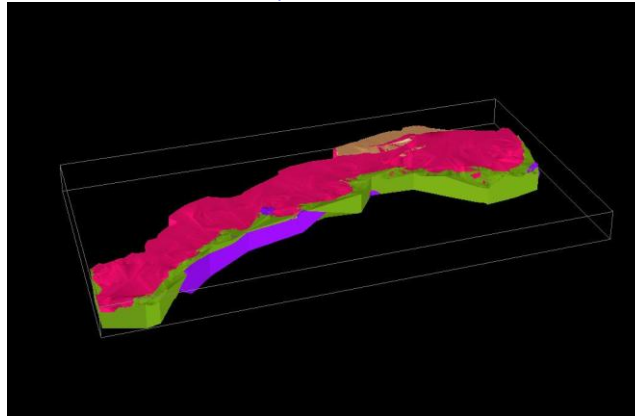
Sedimentary Rocks viewed from above



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Complete model

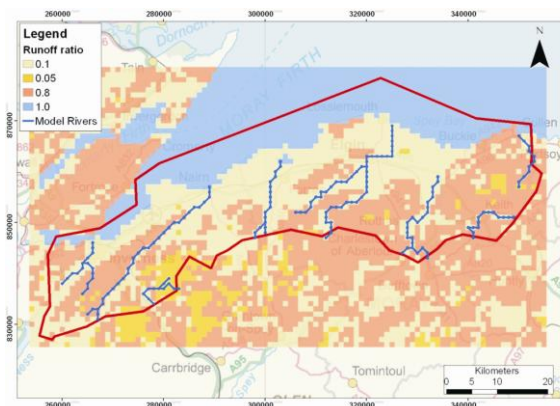


A multilayer Zoom Regional Groundwater Model has been created for this area incorporating this data

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Extent of model with rivers and runoff ratio



- Recharge model over the Moray region generated using ZOODRM

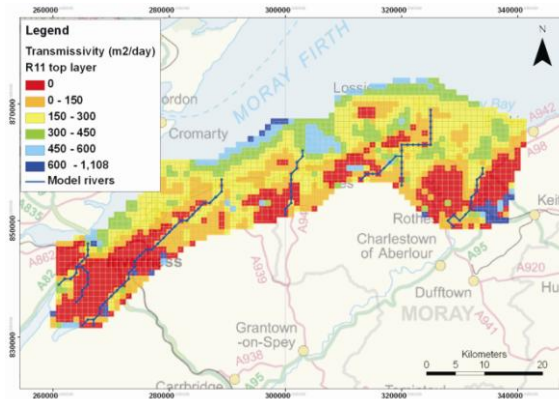
- Runoff ratio was calculated from the extent and nature of the surface deposits

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Transmissivity in the model

3 layer model: Superficial deposits,
Sedimentary & Crystalline rocks



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• Transmissivity =
thickness x permeability

• Thickness from GSI3D
model; permeability from
field measurements

• Results: plausible
groundwater levels in
superficial deposits
and flows in rivers



Forres Model

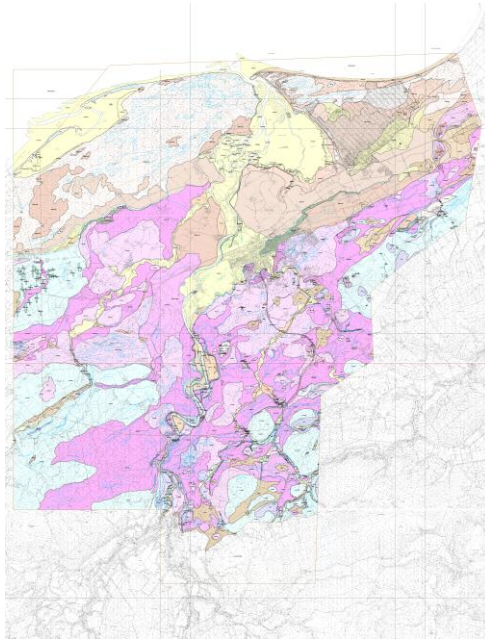
Complex model 47 layers including lenses

Bedrock ~ Crystalline basement (no distinction
between country rock and intrusions: basal
conglomerate, sandstone - but no faulting
(modelled as 'stepped' profiles)

Remaining 44 layers are Quaternary (Superficial
Deposits) + Artificial deposits (Flood
prevention embankments are important)

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The new geological map is the starting point

150 km² of ground covering all of the Forres urban area and the lower reaches of the River Findhorn to the coast

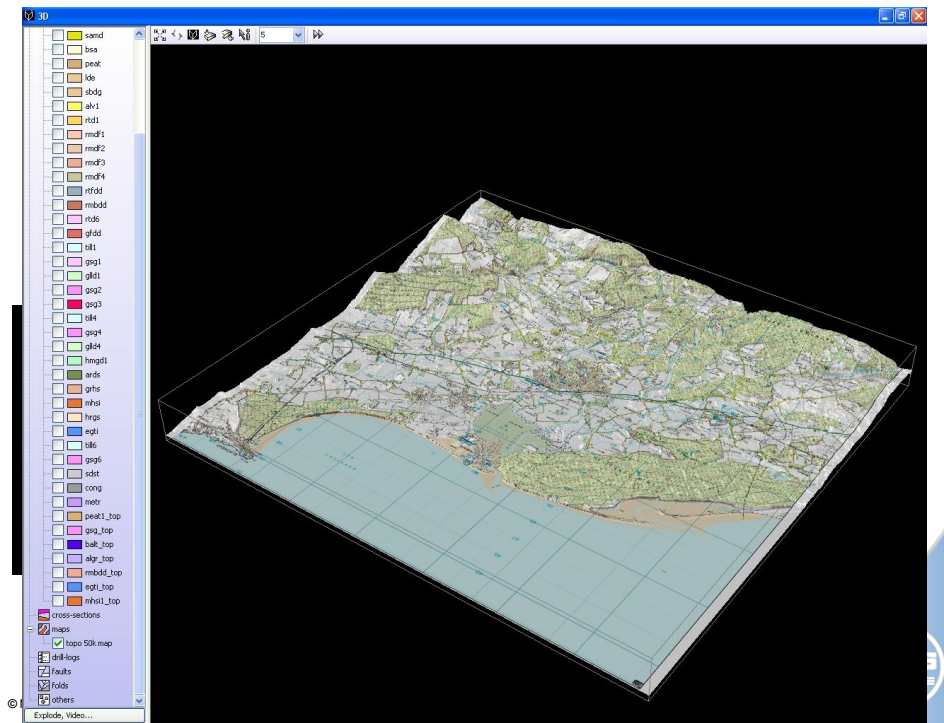
A complex, locally thick, sequence of aeolian, marine, glaci-marine, fluvial, glaciofluvial and glacial sediments overlying Middle & Upper ORS and crystalline basement rocks

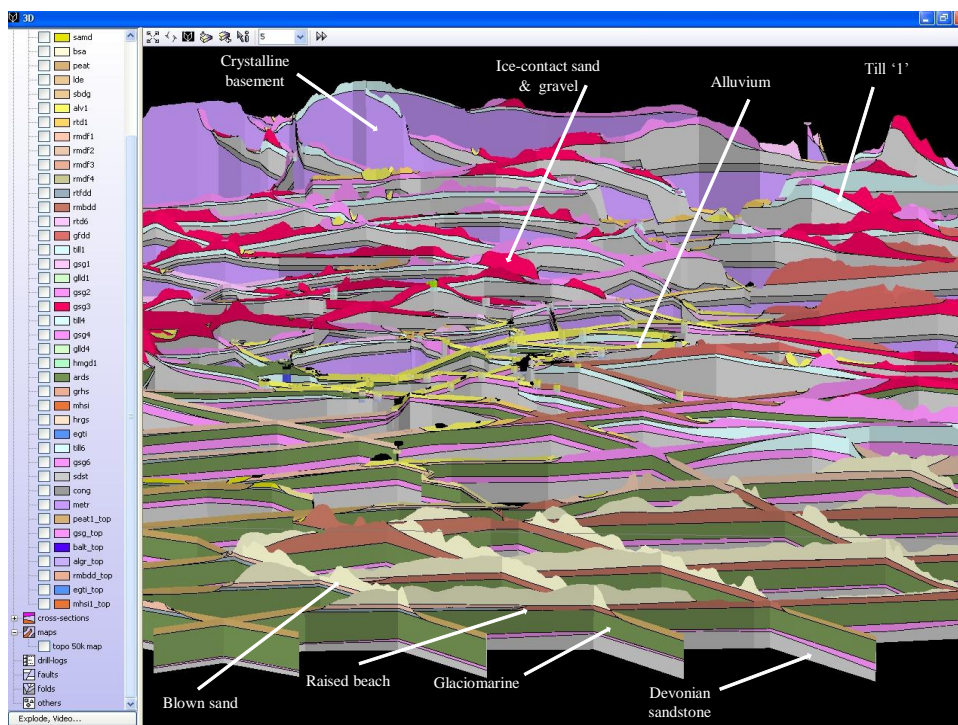
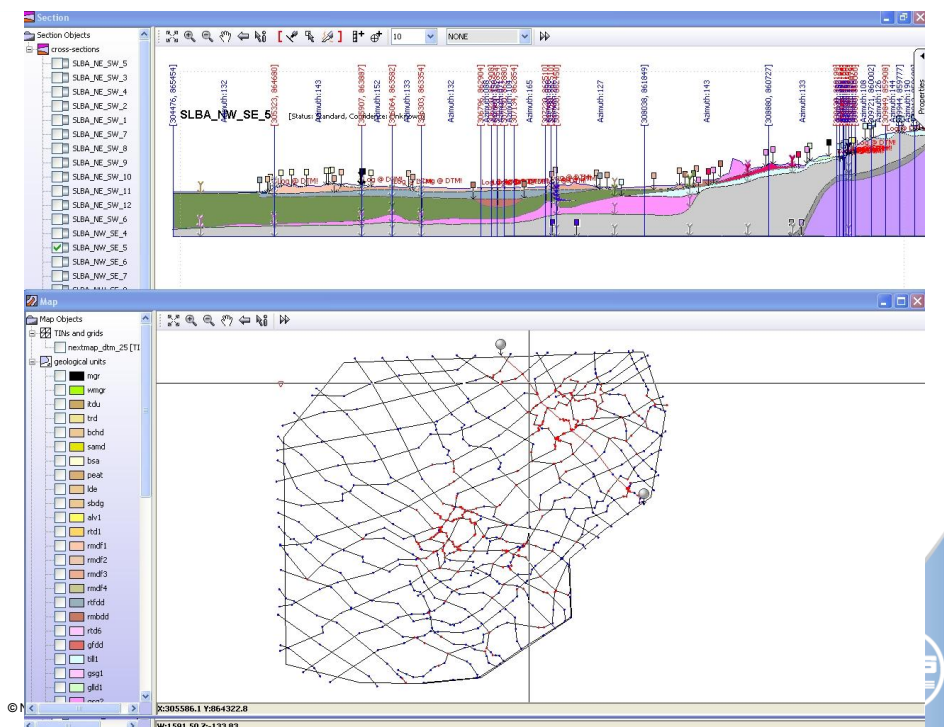


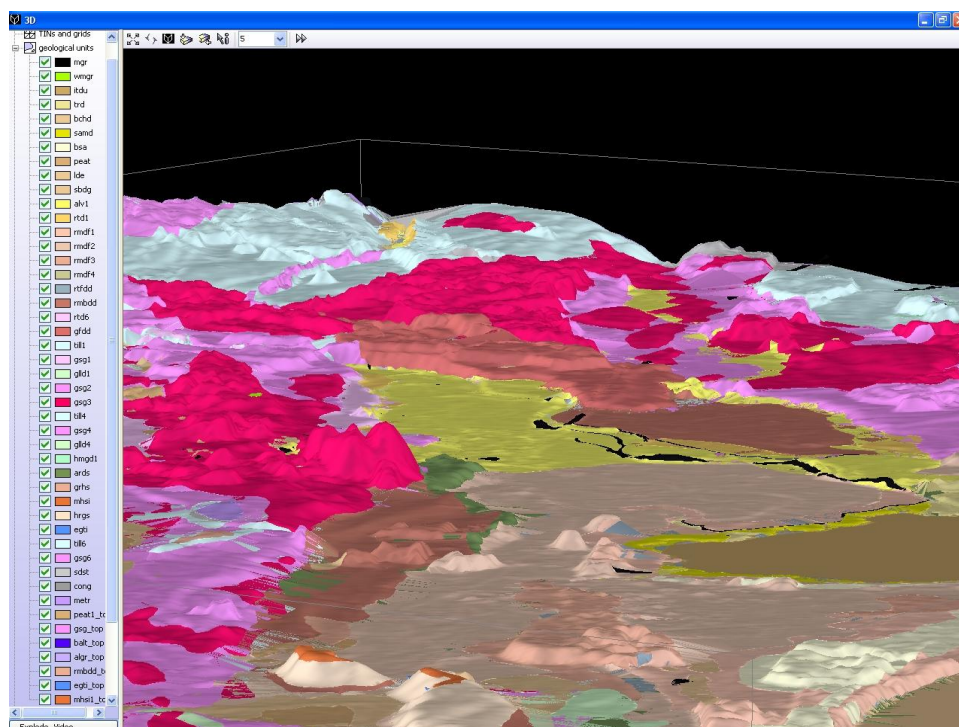
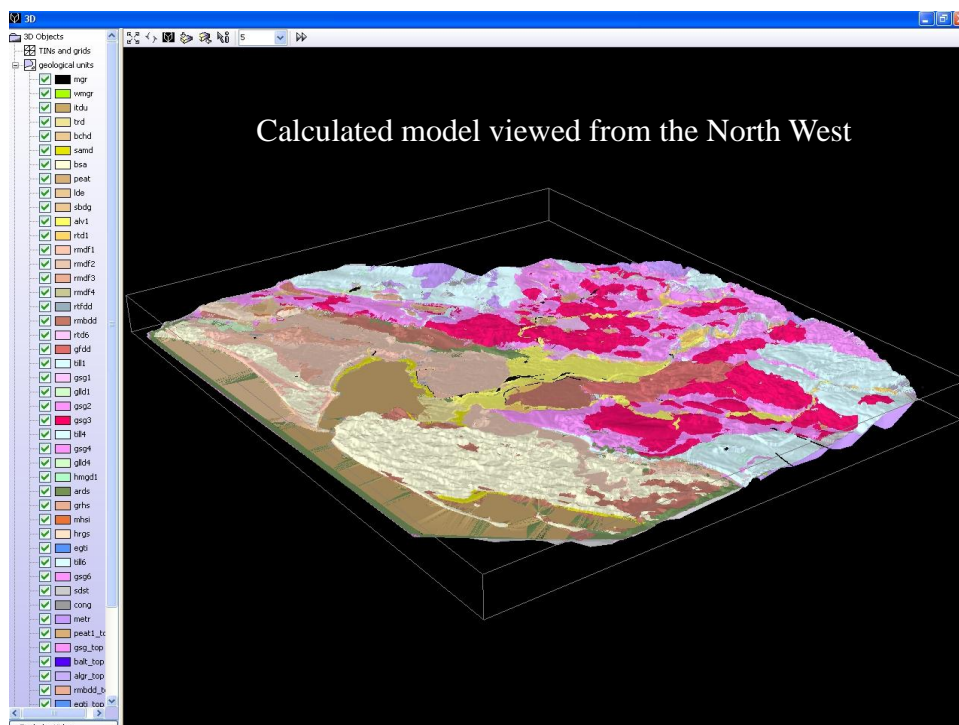
> 480 data points: boreholes, wells, trial pits and logged sections

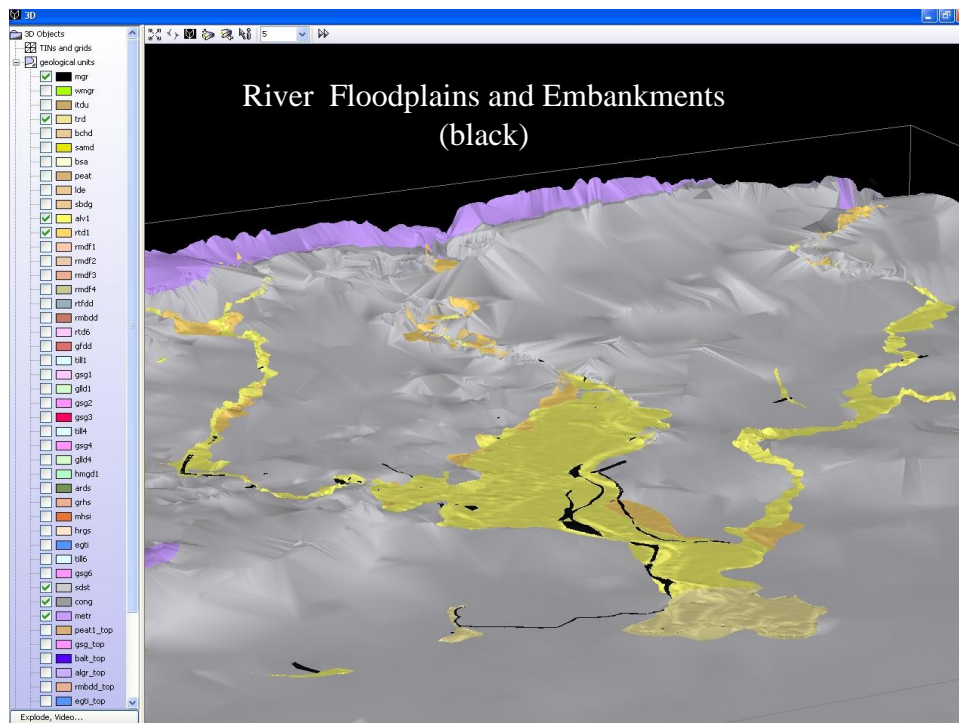
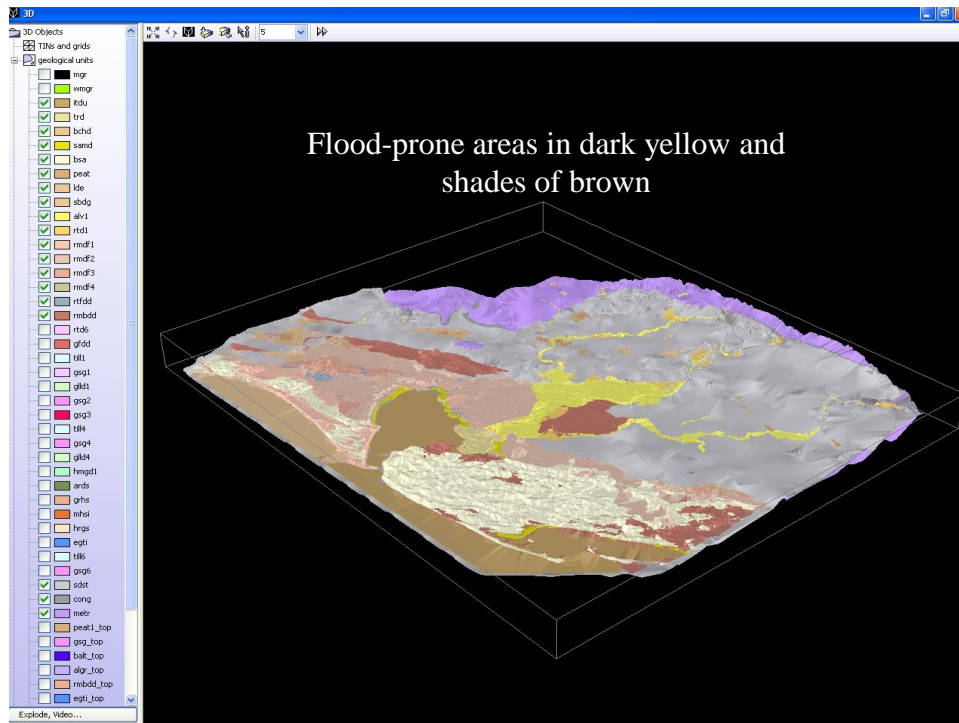


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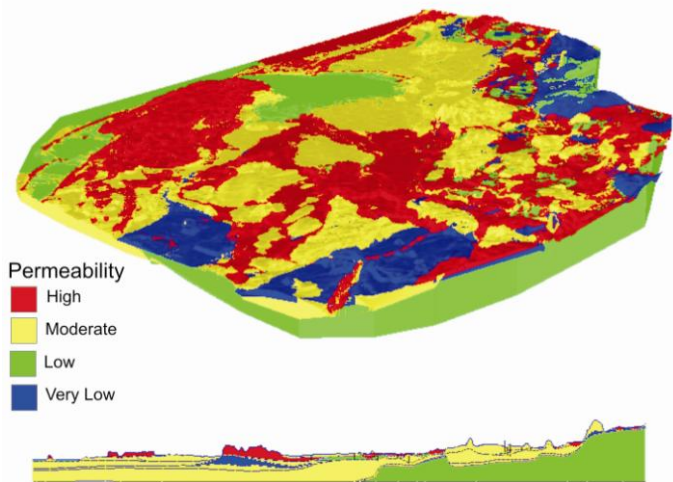








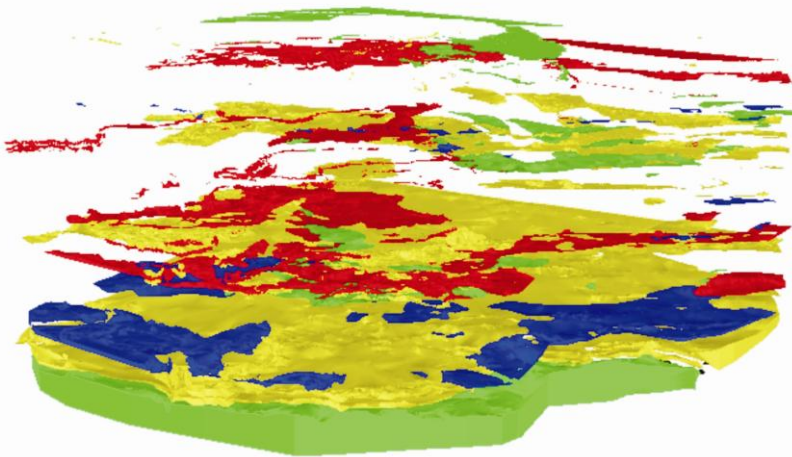
GSI3D reattributed for permeability



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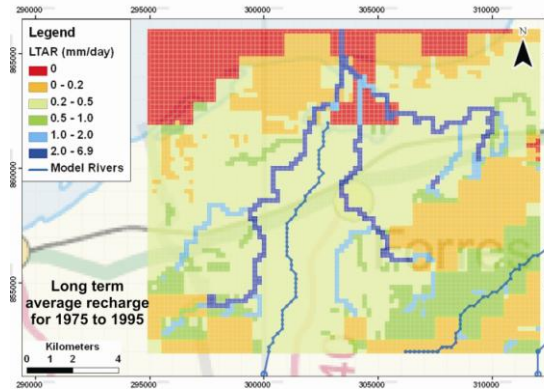
The complexity of permeability in 3D for the Forres area



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Local Forres ZOOM Model



- 3 layer model – shallow superficial, deep superficial, bedrock in hydraulic connection

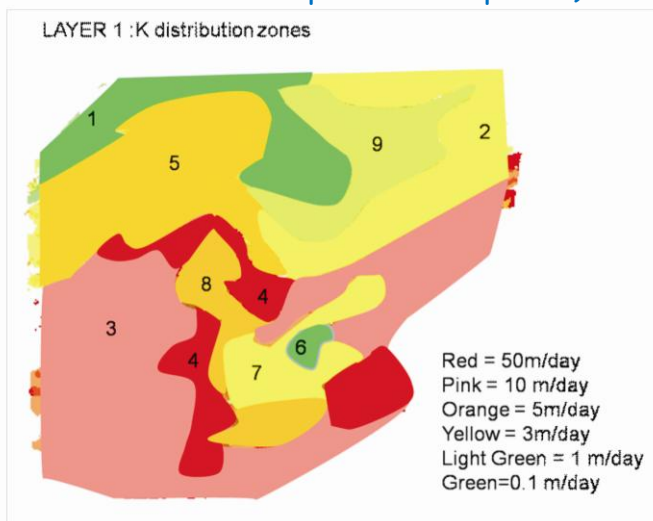
- based on GSI3D model simplified according to permeability from field measurements

- Innovative – the layer topography is included from GSI3D

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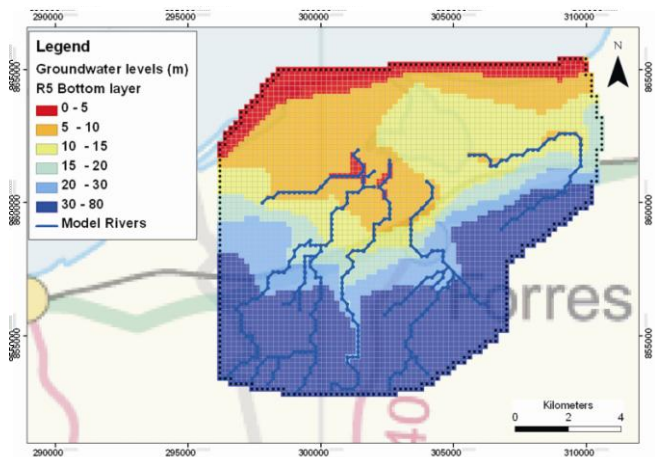


Hydraulic Conductivities for Layer 1 (Shallow Superficial Deposits)



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Groundwater
Results from the
local model

- Groundwater levels close to surface in Forres – groundwater flooding
- Some Superficial deposits on higher ground are dry
- Small groundwater flow cells caused by discharges to local rivers

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2011 and beyond

ONGOING

Reattribution of Forres model with geotechnical properties – end March 2011. Licence negotiations with consultants for Lithoframe of portion of detailed model.

NEW START

GSI3D framework building will focus on Inverness city and the surrounding Great Glen Area; baseline data collection started Winter 2010-11

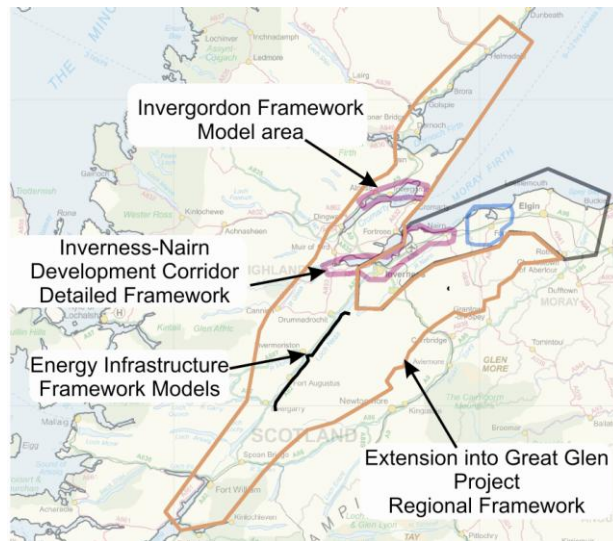
Drivers:

1. Last major urban area in the Scottish Highlands without updated geological coverage (land contamination issues)
2. Major Energy Infrastructure and Transport Improvement projects
3. Flood and slope stability risk

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Extending the framework models



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