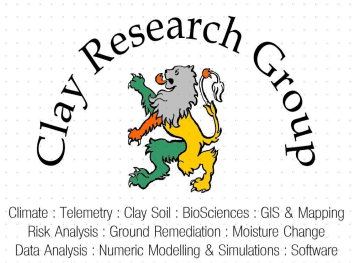
The
Clay Research Group

RESEARCH AREAS

Climate Change : Data Analysis : Electrical Resistivity Tomography
Time Domain Reflectometry : BioSciences : Ground Movement
Soil Testing Techniques : Telemetry : Numerical Modelling
Ground Remediation Techniques : Risk Analysis
Mapping : Software Analysis Tools
Electrokinesis Osmosis
Intelligent Systems



Edition 135

August 2016

The Clay Research Group

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Edition 135, August, 2016

Issues with Data

The difficulty interpreting data is well illustrated in this edition. The article on street trees by count and density (page 9) explores if there is a link to claims frequency. This seems a sensible project until we realise that we are only interested in street trees on clay soil and then, we only want to count street trees within influencing distance of houses. In any event, private trees are far riskier. It's far from straightforward and the data take no account of the age, metrics or species of the tree, or the maintenance program of the Borough. Deeper analysis next month.

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Surge Year Alert?

No sign of 2016 being anything other than a normal, or even low, claims year. Numbers have been declining steadily since 2006 and this is almost certainly associated with the increase in rainfall. "Bright spells followed by showers".

Valid? Or Declined?

Looking back over data gathered through both normal and surge years, there is a pattern linking geology with the likelihood of the number of claims that are either accepted or declined at postcode sector level.

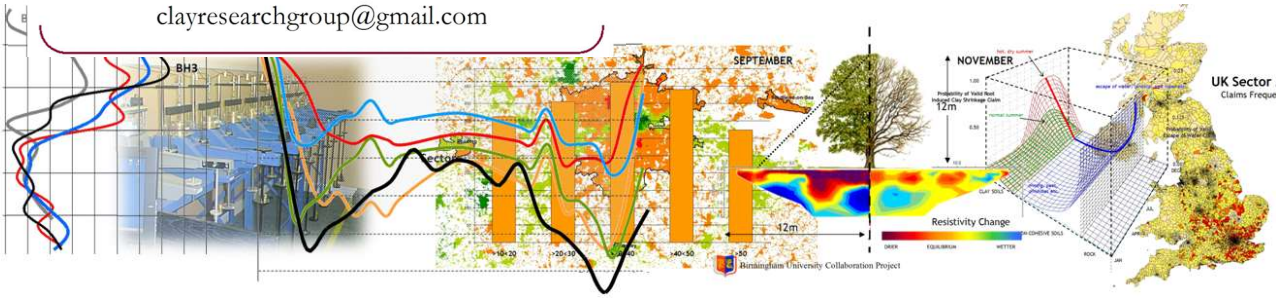
What are the odds of a claim being accepted and why is it linked to the weather?

The Lottery and Risky Trees

What are the chances of identifying which tree will cause what damage, and when? Better still, what are the chances of spotting the 100 or so trees that might vexatiously decide to drink so much water that the ground shrinks beneath the foundations of otherwise innocent houses?

After all, we have a rank order of risk for trees and a good idea of soil mechanics. Building vulnerability isn't a new concept. Don't mention the weather.

Just how difficult can it be? If the chances of winning the lottery are 1 in 14 million, what are the odds identifying which trees might 'go rogue'? More inside.



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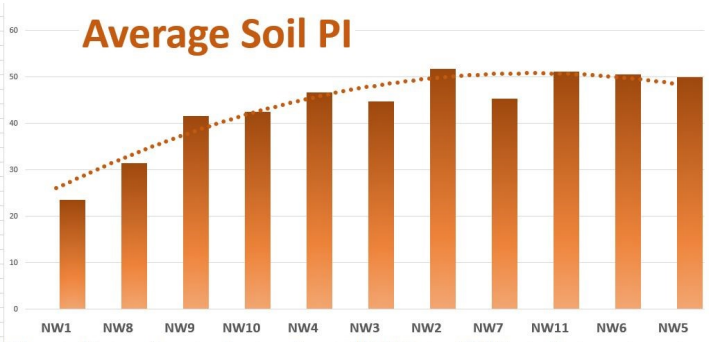
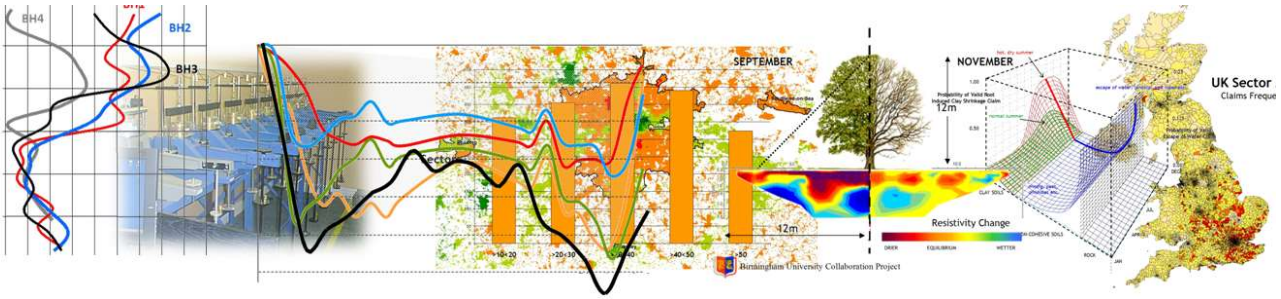
London - NW Area – Risk Analysis

Below, two graphs illustrating the variable risk across the North London NW postcode areas. Top (the blue bar chart) the claims frequency from our five-year sample (which includes one surge year) showing the significant differences between areas.

Below, with the area postcodes in the same sequence, the average plasticity index obtained from actual site investigations, and where possible taken at around 2mtrs below ground level to match the zone of peak root activity of mature trees.



The risk in both charts increases from left (NW1) to right (NW5). As the claims frequency increases, so does the soil PI and although the relationship isn't parallel there is a relatively high correlation – see following page.



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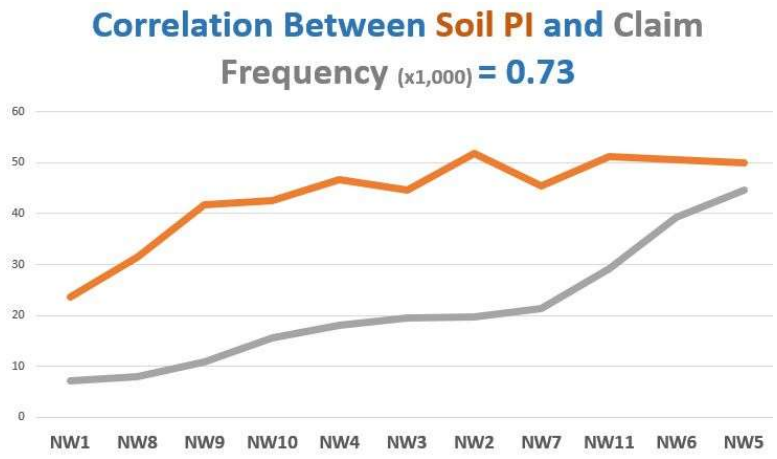
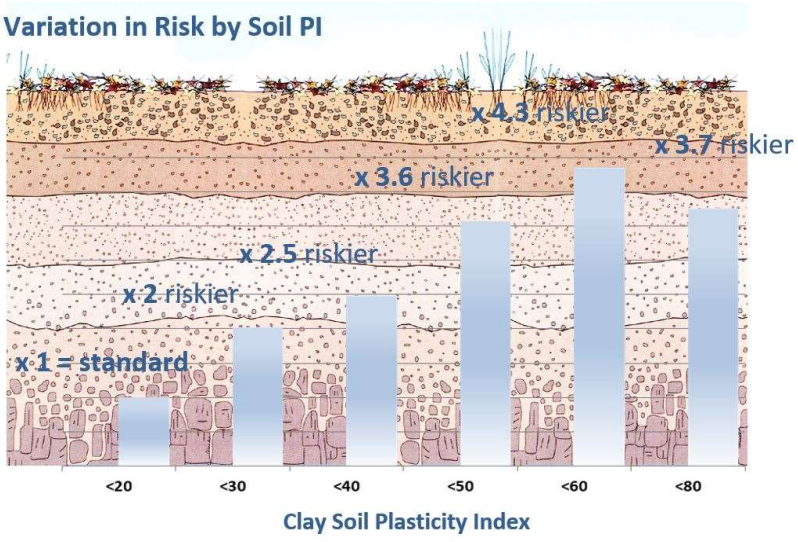
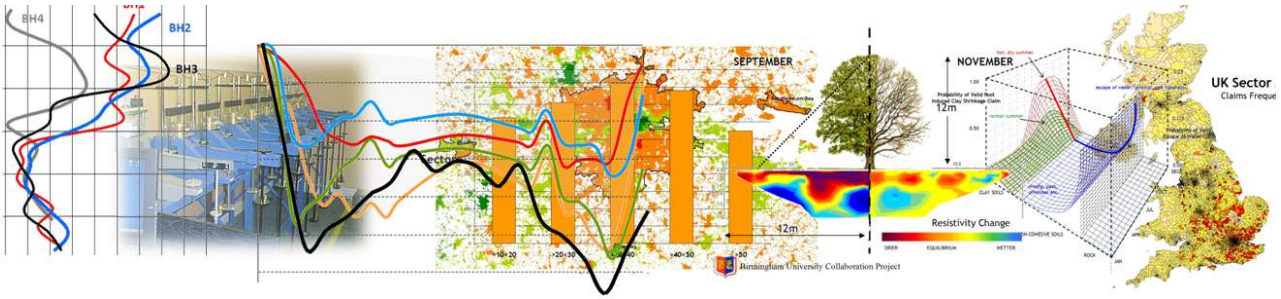
Correlation between soil PI and Claims.



The above graph plots the relationship between the PI of the clay soil and claims frequency for the postcodes shown – see page 2. the correlation between them is 0.73, revealing a strong relationship. The risk of subsidence increases with the plasticity index of the soil.

In more general terms and widening the scope of the analysis across various clay series, the following relationship with risk has been derived.





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Determining the Risk Factors using Correlation Techniques – 3 sectors compared

Below, three postcodes of variable risk in terms of claims/housing population. NW11 6 is the riskiest with a claims frequency (10,000 claim sample) of 0.0399 and N2 8 the safest of the three with a frequency of 0.0072. Location of these postcodes shown on the following page.

	NW11 6	N2 0	N2 8	r value
Claim Frequency	0.0399	0.0176	0.0072	
Riskier	5.54	2.4	1	
Av. Tree Height	10.95	11	8.27	0.734
Av. Overlap %	45	38	26	0.937
Soil	38	33	29.3	0.993
Houses Beyond Trees	15.4	18.2	27	-0.879

Analysis reveals that NW11 6 is 2.27 times riskier than N2 0 and 5.54 times riskier than N2 8.

N2 8 has 1.7 times more 'safe' houses than NW11 6 and 1.4 times more than N2 0.

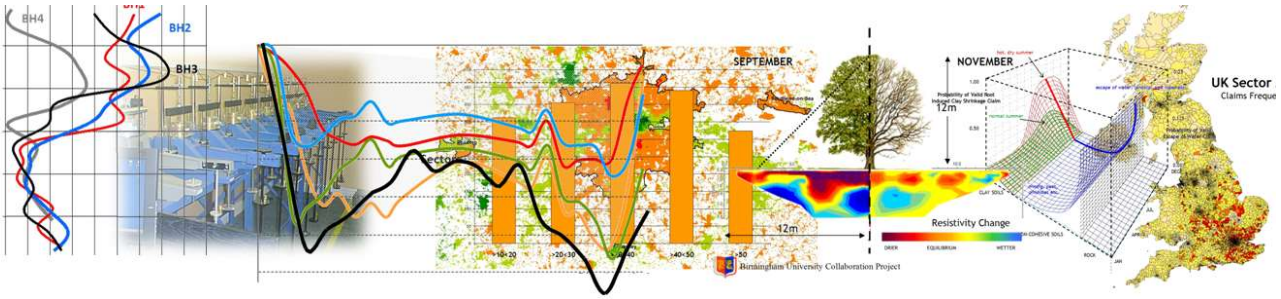
How do we establish if there is a link between risk and geology and trees? Here we have run a simple correlation to deliver the '*r*' value. The link between trees, clay soils and claims seems to be clear, although a correlation isn't evidence of causation.

The risk values have been standardised and the lowest risk sector (N2 8) is rated '1', bearing in mind this is only in relation to the three named sectors. N2 0 is rated 2.4 – over twice the risk of N2 8 and NW11 6 is the riskiest at 5.54.

First, the '*r*' value for soils is 0.986 which is exceptionally high. This isn't as useful as it might seem due to variability across the sectors and also with depth. No doubt if we sank boreholes elsewhere in each sector we would find different results, but these are the values held in our sample.

Trees also have a healthy '*r*' value. In terms of their height and '% root overlap' using the functions contained in our LiDAR risk model.

Finally, the percentage of houses within influencing distance of trees is an important factor – naturally. The table above lists houses estimated to be outside the influence zone of tree roots (expressed as a % of the total) and that delivers a '*r*' value of -0.856.



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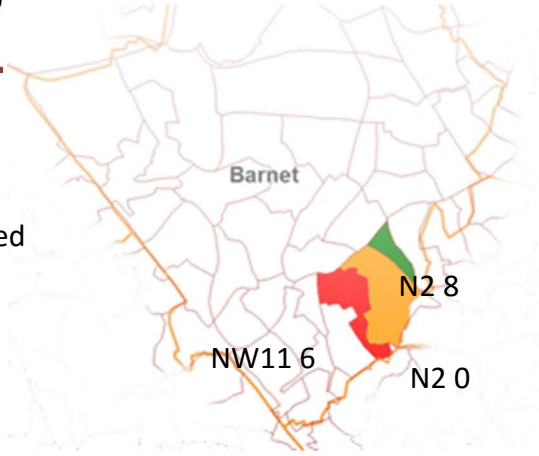
3 sectors compared … *continued*

Right, location of the 3 Barnet postcode sectors analysed on the previous page – NW11 6, N2 0 and N2 8.



Trees and Design Action Group

http://www.tdag.org.uk/

TDAG held a meeting on Tuesday, 19th July, 2016 at the Royal Horticultural Society (RHS) to review progress and plan future strategy. The meeting covered a wide range of topics including reports from regional meetings across the UK.

Amongst the items discussed was the Sheffield case which was reported in Issue 130 of the CRG newsletter.

We understand the next meeting is to be held at RHS, commencing at 3pm on 22nd November, 2016.

Contact Sue James for further information:
suejamesriba@gmail.com

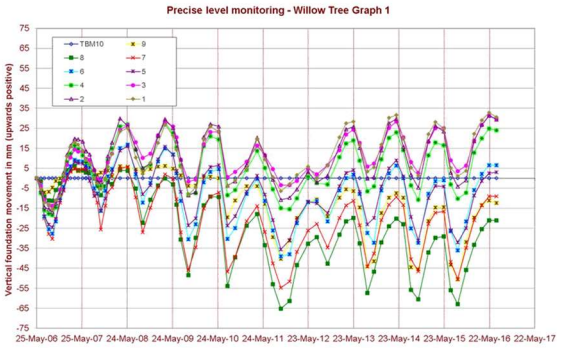
The TDAG bulletin includes the following link from Jon Heuch which may be of interest.

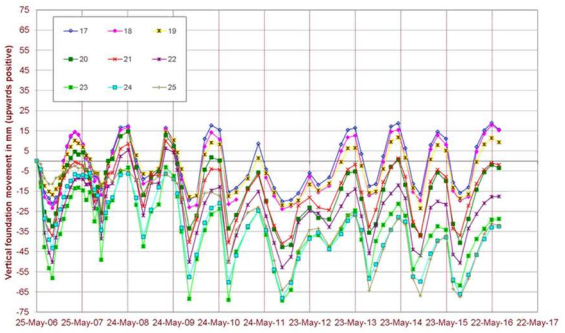
http://animalnewyork.com/2013/seurat-sans-all-the-trees/

The TDAG web site (address above) has links to a wide range of valuable resources.

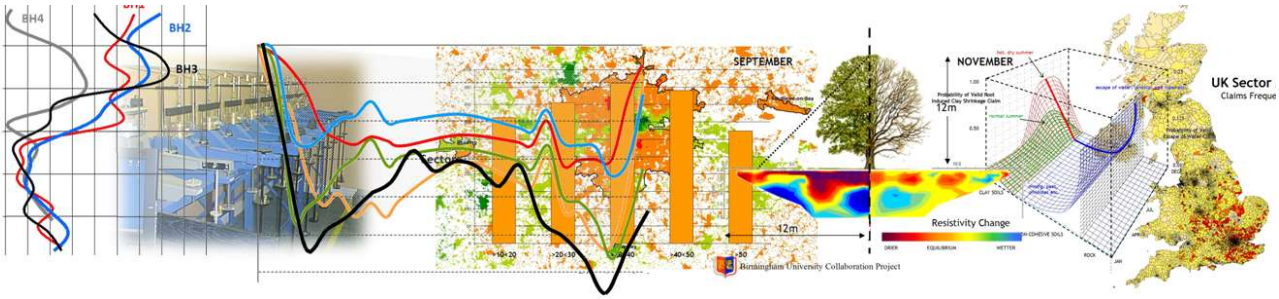
Aldenham Willow Levels

GeoServ have updated the levels taken from stations at the site of the Aldenham willow – see below. Best viewed on screen.





The divergence between the stations is increasing over time, with those furthest away from the tree recording the development of a persistent deficit.



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A Probabilistic View of Subsidence

Local Authority Tree Officers sometimes have a jaundiced view of 'foreseeability' and wonder how they might be expected to know which tree will cause what damage, and when. It's a good point.

Taking a Borough like Havering for example, containing around 100,000 houses, of which something like 80% are built on clay, it is estimated from our LiDAR survey that there are around 60,138 trees in the Borough, **within influencing distance of a property built on shrinkable clay,** 7,527 of which are in council ownership and 52,611 are privately owned**.**

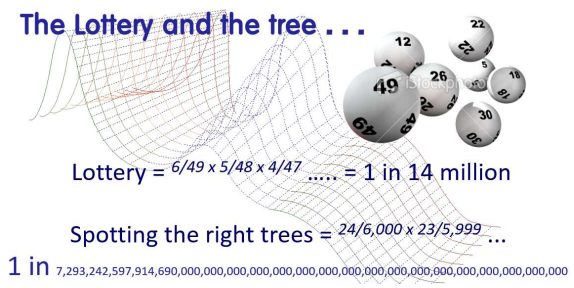
Incidentally, the analysis contains many 'something likes', 'arounds' and so forth but such is the nature of the problem. It has little bearing on the outcome.

As can be seen, by far the biggest risk is posed by privately owned trees in terms of numbers.

The annual UK claim frequency (averaged across all geologies) is estimated to be around 0.22%, or 2.2 houses in a thousand.

The odds of predicting which combination of houses will suffer what damage as a result of which combination of trees, and when, are impossibly small.

Of course, this isn't the legal interpretation, but we can see how frustrating it can be for Tree Officers.



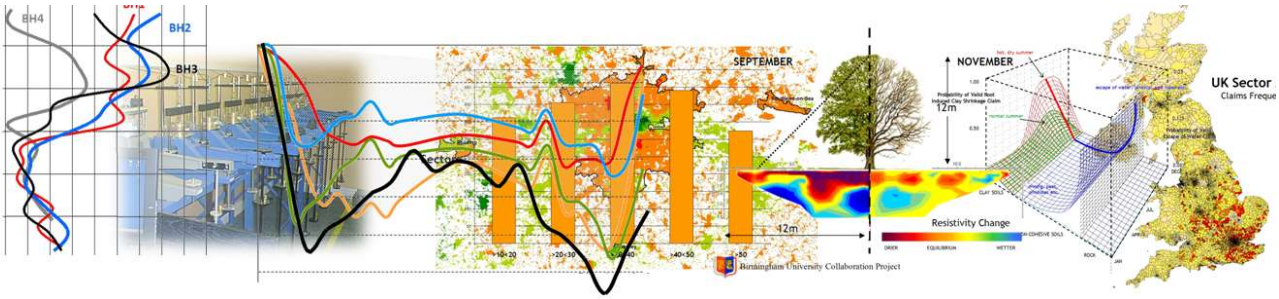
The impossible odds of guessing which tree will cause what damage, where and when.

There is no realistic prospect, as the picture above illustrates. The chances of winning the lottery are far better.

Over the 45-year period since the grant of domestic insurance cover, and taking averages, the number of houses damaged in the Borough could be something like 2.2 houses/thousand x 45yrs x 80,000 houses on clay soil = 8,000 properties. A conservative estimate given the presence of clay.

Our approach is based not on 'what is the chance of 'x' tree causing damage, and when', but 'when there is damage, what is the probability of the tree being involved?' This reduces the odds in our favour and simplifies the calculation.

We want to understand that, when a diagonal crack appears directed towards the drain or tree, and if that crack is wider at the top than the bottom, what are the odds that the tree is the cause, knowing its species, height, distance together with the soil properties and weather at the time of damage?



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What are the chances of that?

The analysis is further complicated by the changing risk from the weather and the probabilities varying by season and location.

Around 20% of claims will be repudiated in surge years, perhaps 50% or thereabouts in normal years and as many as 80% in the winter months. These are averages and they vary across the UK.

Instead of a 50% probability of being valid in a normal year, the figure is closer to 90% in some sectors, in a hot, dry year providing (a) the soil is clay and (b) there is a tree within influencing distance.

In contrast, the valid percentage remains fairly constant on 'other' soils across the UK at around 20% throughout the year.

The number of valid claims in surge years is biased towards the clay belt. Far more claims are valid in surge years in sectors underlain by clay.

Weather – particularly rainfall (or absence of) is a major determining factor.

Examples of valid claims not associated with vegetation on 'other' soils (not clay) might be houses with shallow foundations bearing onto fill or non-cohesive material where damage is caused by a leaking drain. Soil variability is another factor. Clay soils with a PI less than say 15% are generally regarded as non-plastic.

The reasons for a claim being declined has been analysed in earlier editions and includes historic movement, shrinkage, settlement, poor construction, wear and tear etc.

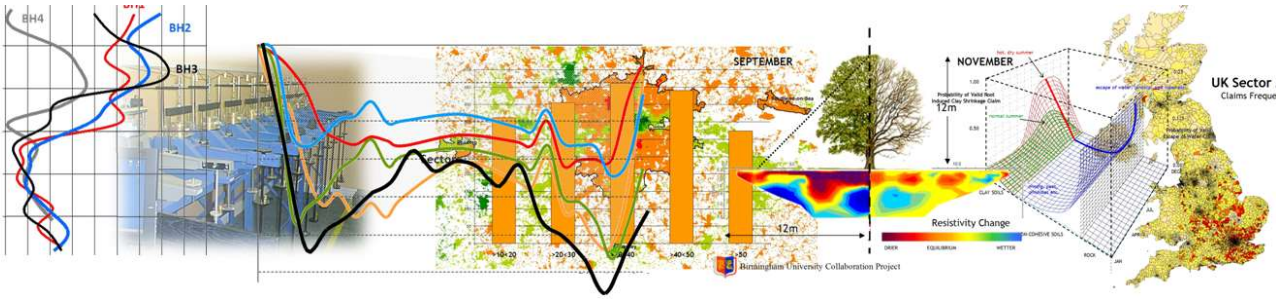
Arriving at a probability of whether a claim is valid or otherwise starts with examination of the damage. If we have a seemingly fresh diagonal crack, wider at the top than the bottom and inclined towards a tree or drain, the initial probability is based on the historic data for the location.

The probability varies with the risk posed by nearby vegetation. It increases if the H/D ratio is 2 - see graphs in previous editions. It also varies with the PI of the soil. The starting point in a surge year for a high risk sector might be 0.8 (80% valid claims). Multiply by 0.79 for London clay and then 0.8 for an H/D ratio of 2 = 0.506.

In the alternative, the values for a repudiation in this instance would be 0.2 x 0.21 x 0.2 = 0.0084.

The combined probability that this would be a valid claim would be 0.506/(0.506+0.0084) = 0.98, or 98%.

Clearly this is an exceptional value. In many instances the H/D ratio will give a smaller value and in a normal year the starting estimate might be less. More on the method of assessment on the following page.



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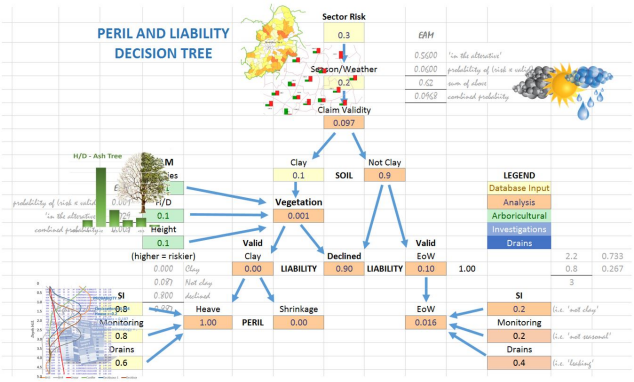
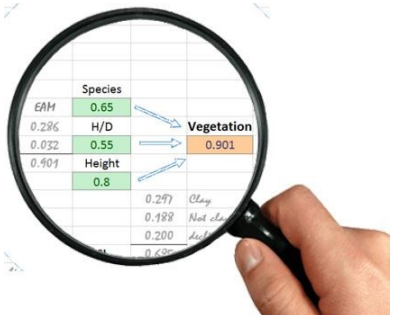
The A_i application

Right, the architecture of the Bayesian probability matrix, linking with the Environment Assessment Module (EAM) with the objective of deriving (a) the likelihood of the claim being valid and (b), if it is, the most likely peril.



The module refers to underlying databases and carries out an analysis of vegetation, soils, claims history (including validity – see pages 10 & 11) all by season.



Over the following months, each element will be explored, touching on both the calculation and the underlying logic.

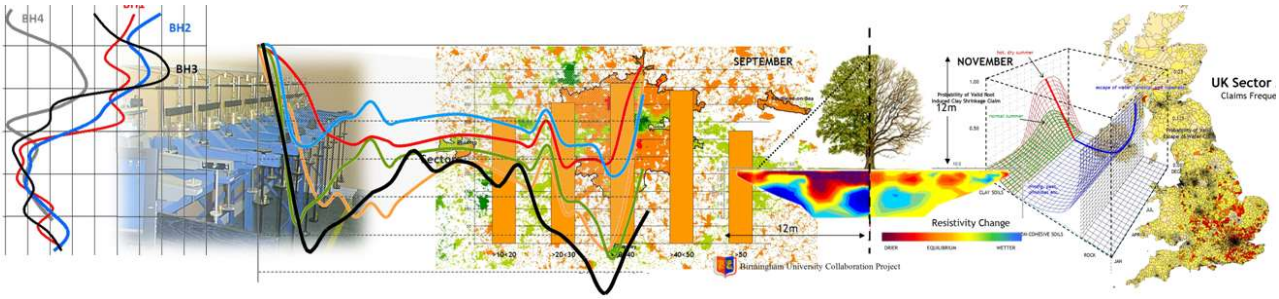
The example, left, looks at how the risk posed by vegetation is dealt with taking into account species, height and distance from the building.

The application is also able to handle input from site investigations, soil testing and monitoring, by referring to a library of characteristic signatures.

The objective is to develop a web based system that is able to receive input from the homeowner as well as experienced claims handler/engineer. By entering the address, the user will see historic claim numbers as a proxy for risk, the actual number of claims (for example, does the analysis refer to 1 past claim, or 100) and percentage that have been accepted.

The profile of this historic data will be represented on a seasonal timeline for the system to determine if there is a match. For example, if the postcode has a lot of valid claims in the summer, but few in the winter, the cause is likely to be root induced clay shrinkage. Conversely, a regular profile throughout the year with between say 20 – 50% valids might indicate problems associated with leaking drains etc. Heave would involve a clay soil, an absence of vegetation, with a higher probability of notification in the winter.

All parties associated with the claim (insured, insurer, handler, engineer, supplier etc.) will have access to screens specific to their needs. More in next month's edition.



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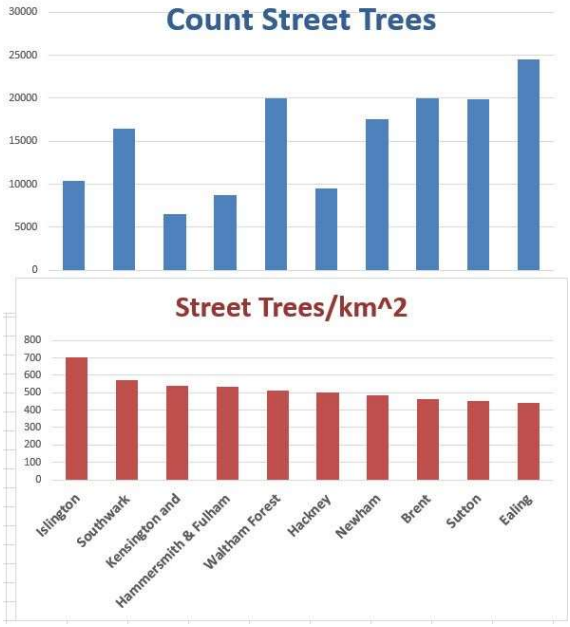
Trees by Borough – Density and Count

Below, a graph showing both the count of trees per borough and the number per square kilometre, taken from "Branching Out", issued by the GLA in April 2011.

Page 38 of the publication lists the numerous limitations of the dataset, to which we can add issues with our own analysis.

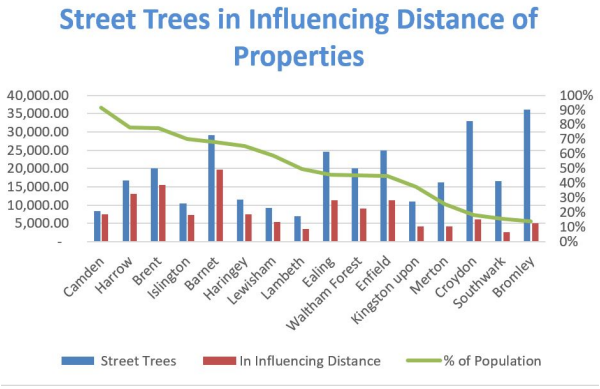


Islington has the highest density of trees in this category, and Ealing the lowest.

In terms of count, Ealing has the highest and Kensington the lowest. Interestingly, Islington, the borough with the highest density, has fewer trees than Ealing.

It appears that Ealing have been able to deliver urban greenery safely. They have more trees but fewer closer to houses.

The relative standing between the 16 boroughs using the published data (without qualification) listed in terms of the risk of root induced clay shrinkage is shown below, adding a "% of population" line.

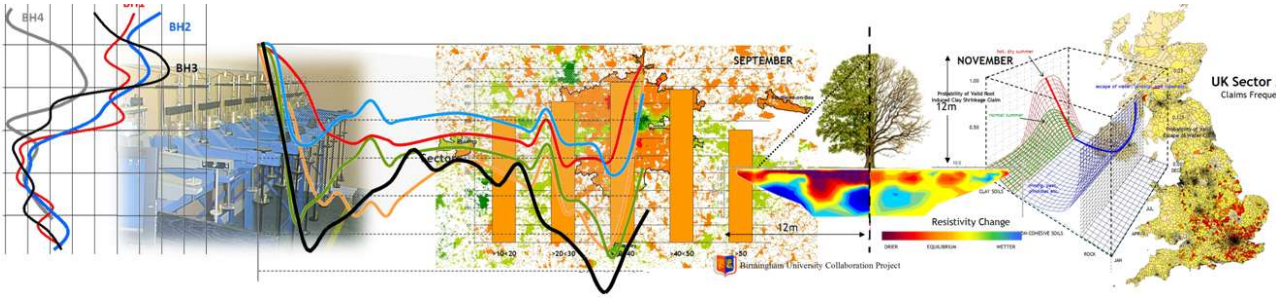


Bromley presents the lowest theoretical risk based upon the count of trees and their density of planting.

Camden are perhaps the riskiest using this form of analysis although it must be stated that this crude approach doesn't take account of housing stock (age or style of property), building vulnerability (extensions, bay windows etc.) or tree species, metrics, age and maintenance programs.

Also, a Local Authority may have reduced their risk by spending more maintaining trees under their control, which would influence their position in the league table.

A future edition of the newsletter will seek to refine this data by selecting trees, houses and claims on clay soil only, where modelled tree roots extend beneath a property.



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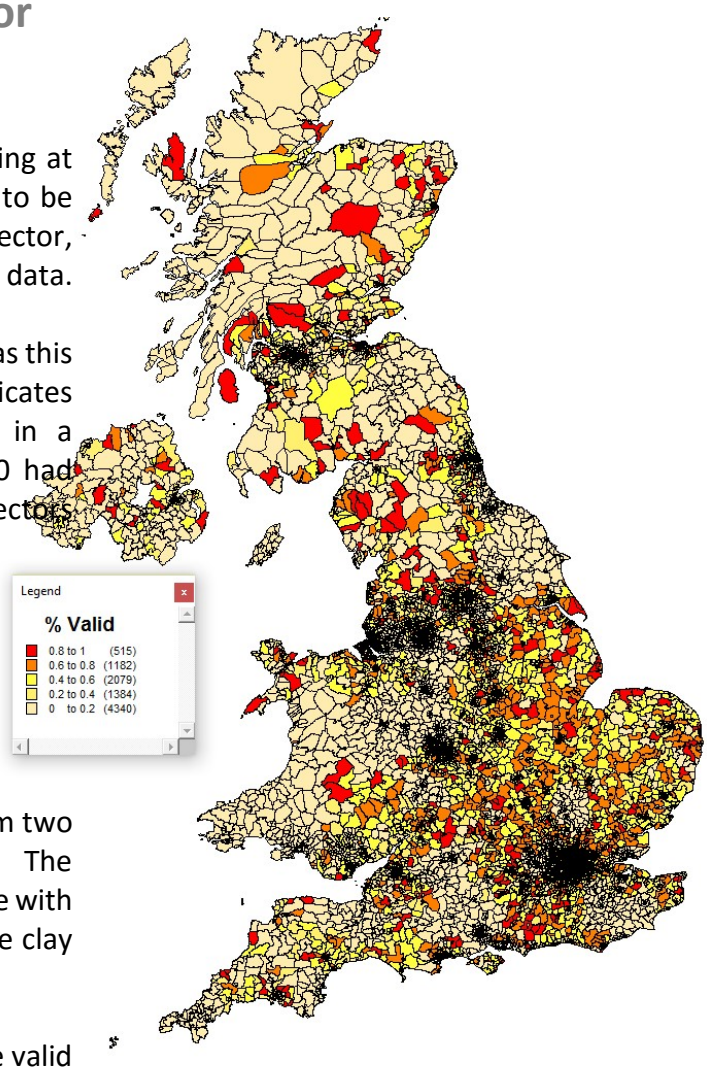
Probability of Valid and Declined by Postcode Sector - VALID -

Over the next few months we will be looking at the probability of whether a claim is likely to be accepted as valid or declined, by postcode sector, in 20% bands (see legend), based on historic data.

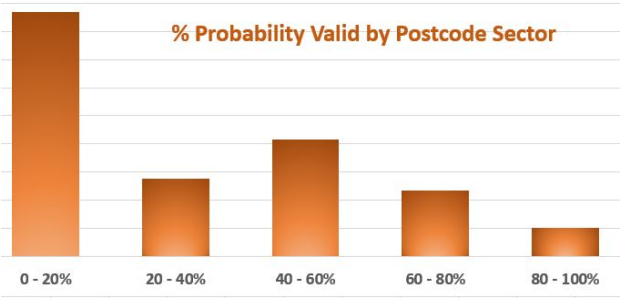
For example, the middle band (the legend has this as '0.4 to 0.6'), shown as dark yellow indicates that if say 100 claims had been made in a particular sector, then between 40 and 60 had been accepted as valid. There are 2079 sectors falling into this category.



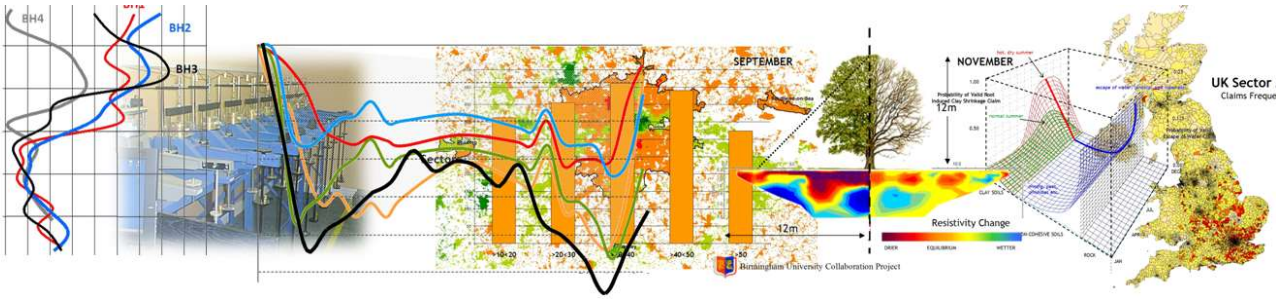
Sectors where claims have a greater than 80% record of being valid ('0.8 – 1') are coloured red and account for 515 in number.

Data consist of just over 60,000 records from two 'normal' claim years – i.e., not surge. The distributions and odds would change in surge with a higher number of 'likely to be valid' on the clay belt.

An 80% probability that a claim is likely to be valid using historic data is high given the imponderables of such claims in terms of weather, construction, vegetation and soils etc., and may also reflect demographics.



What are the drivers behind claim notification and what does the age of the property have to do with high percentages of valid or declined claims in certain sectors?



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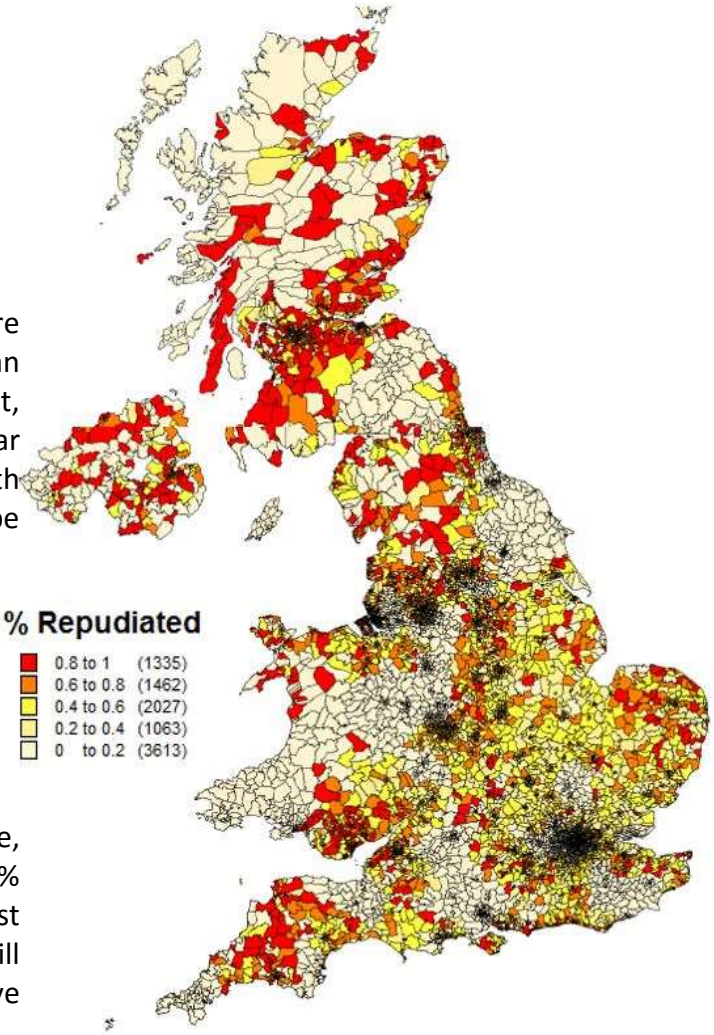
Probability of Valid and Declined by Postcode Sector

- DECLINED -

The number of postcode sectors where declinatures exceed 80% is higher than 'valids' as shown on the map, right, amounting to 1,335 sectors. There appear to be concentrations to the north, south west and Northern Ireland which may be a function of the variable geology.

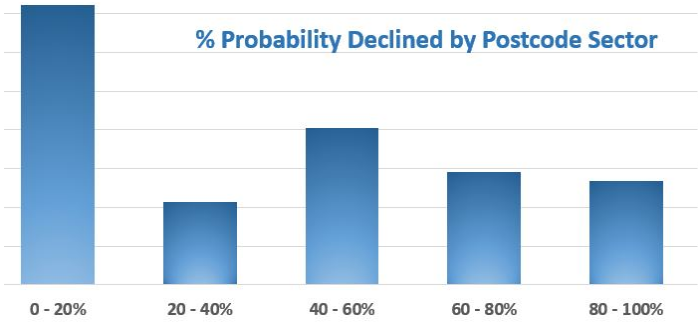


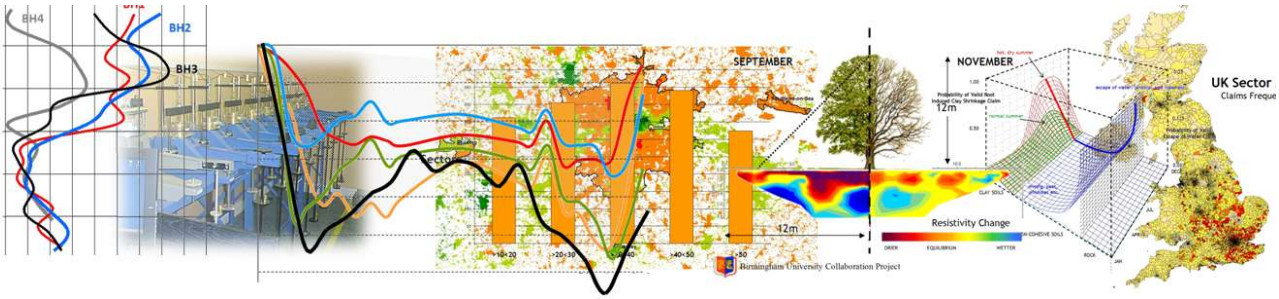
There are two and a half times the number of sectors where the sample database records repudiations exceeding 80%.

Bottom right and on the previous page, bar graphs showing distribution in 20% bands for valids and declined. The largest category is the 0 – 20% band which will include sectors where no claims have been lodged.

There are far more sectors across the UK where the declinatures exceed 80% as mentioned before, this would almost certainly change in a surge year.

The number of valids exceeding 80% would usually be associated with the clay belt and the above may be factored accordingly to deliver a higher resolution.





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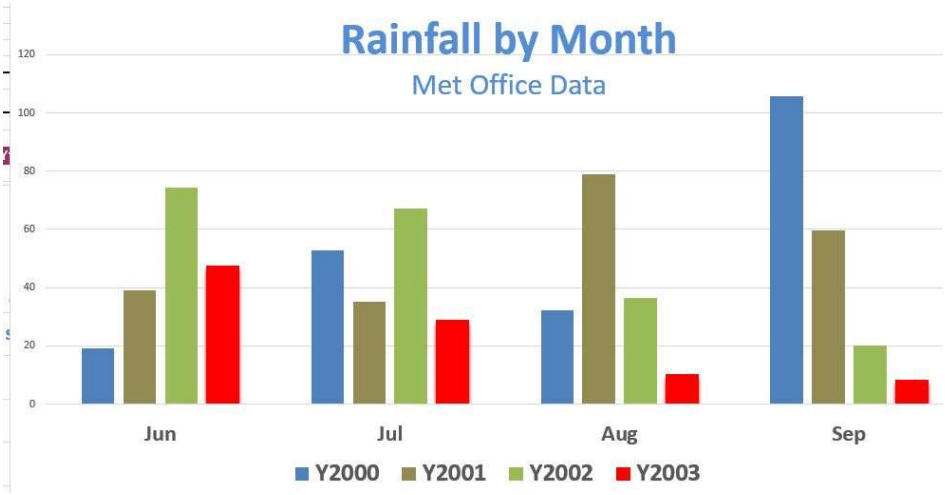
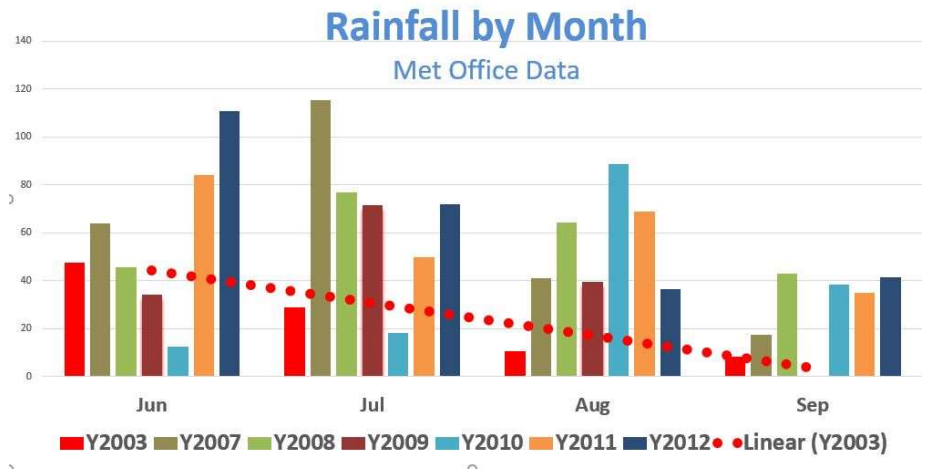
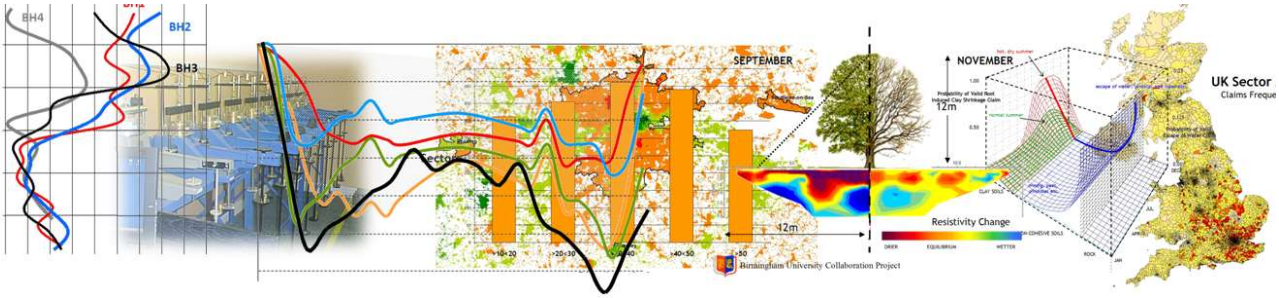
Influence of Rainfall on Claim Numbers



Above and below, 'rainfall by month' data comparing 2003 (a surge year) with the non-surge years listed for the months June through to September. Interestingly, rainfall in June, 2000 and 2001 and June and July of 2010 was lower than 2003. Heavy rainfall in August (2001 and 2010) and September (2000) appear to have 'saved the day', reducing claim numbers.

In all other years, rainfall exceeded the 2003 figures. 2003 became drier as the year progressed, as shown by the red dotted line.





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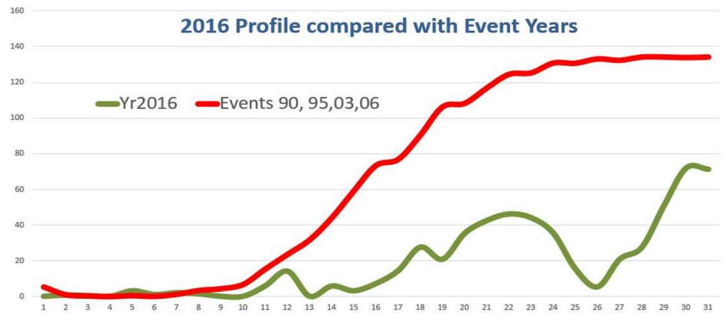


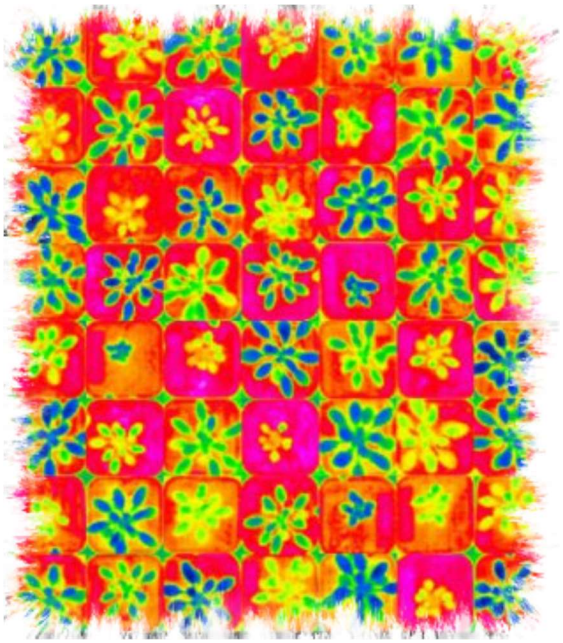
SMD Profiles

No suggestion of a surge in claims comparing the current SMD profile (green in both graphs) with the average for event years (top, red line).

Below left, the current profile plotted against 2006 to see if there is a prospect of a late surge.

Although there has been a small increase over the last month as we would expect, the current figure hasn't reached 100mm. It looks as though we will see a continuation of the low claim figures recorded over recent years.

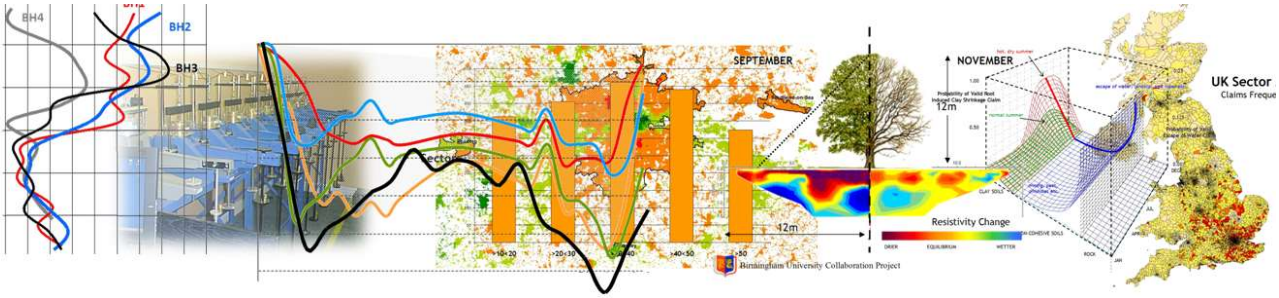
Plants Thriving on Less Water



Right, a thermogram of 40 day-old Arabidopis plants showing different growth and leaf temperatures indicated by false colours. Plants that combine low water consumption are indicated by green and yellow colours.

Researchers at the Technical University of Munich have been studying a plant hormone called abscisic acid, which is responsible for switching the water-saving mode on, saving as much as 40% of water.

Zhenyu Yang, *et al* "**Leveraging abscisic acid receptors for efficient water use in Arabidopsis**". *Proceedings of the National Academy of Sciences*, 2016



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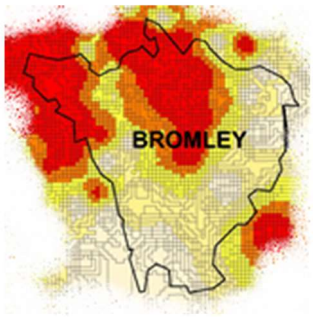
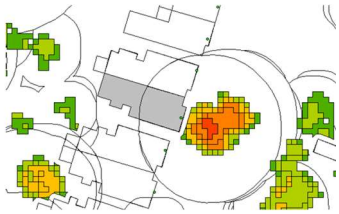
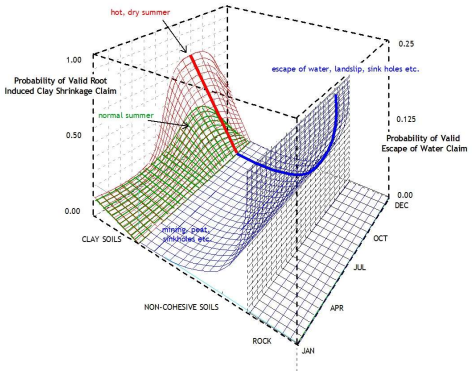
CRG REVIEW - 1



Mapping has been central to much of our work. Using a GIS, data has been plotted and analysed including claims by peril and geology, valid -v- declined, etc., and the geology from every site investigation recorded, which has enabled the construction of a unique 250m tiled grid showing the distribution of clay soils and their shrink/swell potential at around 2 – 2.5mtrs below ground, coincident with the peak root activity of larger, mature trees.

In 2006 Paul Stanley took the brave move (given the cost) of commissioning a LiDAR survey of London to map the location of all trees together with their height. The CRG were funded to map the data and undertake the analysis to deliver an advanced risk model when used in conjunction with the geological grid described above.



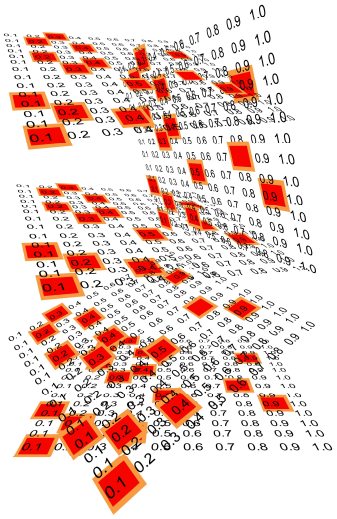


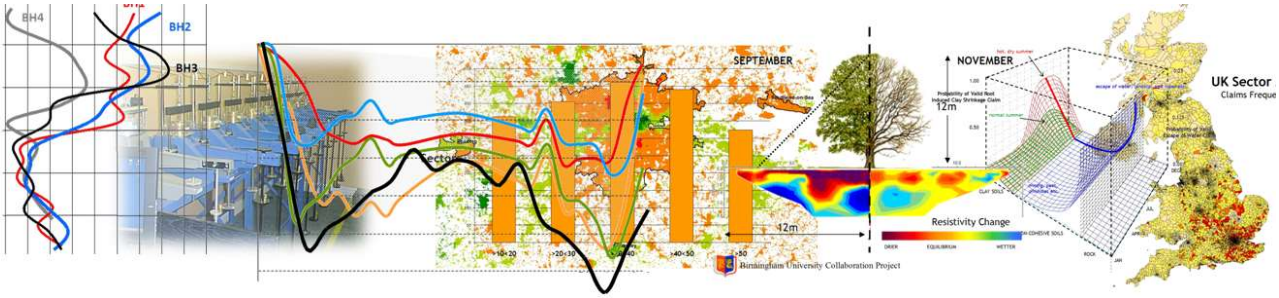
Improving our understanding of risk by combining location, geology and weather. The probability cube links all three and provides a simple visualisation tool accepting inputs from the Environmental Assessment Module – see elsewhere. Useful in Triage, underwriting and claims handling. As the cube has been built from actual claims experience, exceptions can be identified for audit purposes.

The underlying data has facilitated the development of a wide range of outputs. Data analysis has provided detailed information about the risk posed by clay soils by PI and vegetation by species, height and distance from the damaged building.

The risk posed by age of house, style of construction and area of damage by peril have all contributed to improving our understanding of risk.

The output is a probability model and an A_i system capable of constant updating.





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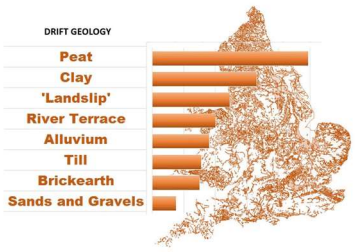
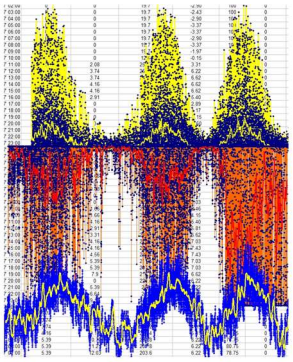
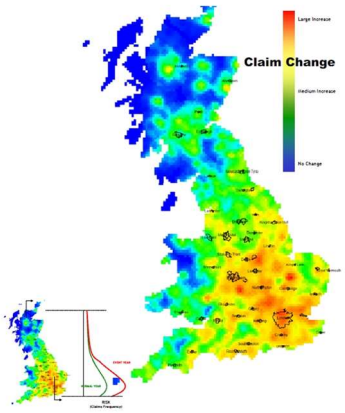
CRG REVIEW - 2



More recently the CRG have produced a 'risk by geology' analysis, listing exposure both by geological series and season to assist in triage, audit and underwriting. The benefit here is having relative values to set against the various elements, enabling modelling. Instead of knowing that London clay is riskier than say, sands and gravels, we now have values that tell us by how much, where and maybe when.



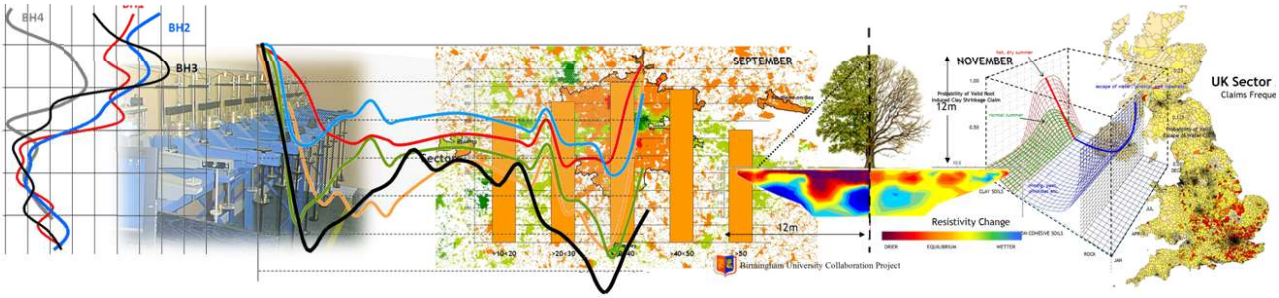
We have a better than 85% track record of predicting both surge and normal years sometime towards the end of May, beginning of June, using SMD data from the Met Office. This study commenced around 1992 and tracks the SMD against historic profiles, comparing current values with normal and surge year profiles. Our understanding of the role played by rainfall has improved – rather than simply saying "the wetter it is, the less the risk" – both by month and volume.



Climate change has been occupying the industry and perhaps perversely has had a different outcome than we might have anticipated. Warming has delivered fewer claims as a result of increased rainfall and although the global figures show a gradual warming, claim numbers have been reducing over the last 10 years. Our original model plotted the location of claim increases if the predictions were realised, together with claim numbers and exposure. The outcome may have been different due to an increase in rainfall but gathering and analysing data is essential to quantify change and where the results surprise us, measuring the error and understanding where/why it occurred.

Early trials of remote monitoring – sensors measuring tilt and moisture content change and transmitting data to the office – proved less successful than we had hoped.

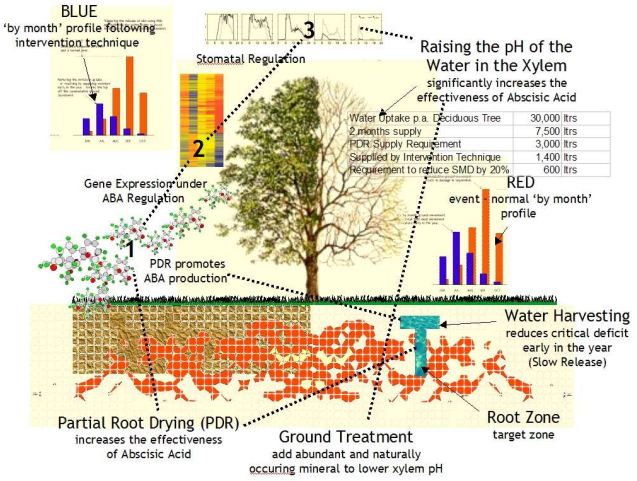
Dropped signals were the main problem and perhaps the situation has improved but there is little appetite at the moment despite interest in the 'Internet of Things' and 'connected home'.



The Clay Research Group

CRG REVIEW - 3

The Intervention Technique was developed following a detailed study of peak root activity in a range of trees over many years together with the published work of several plant physiologists including in particular Professor Davies from Lancaster University and his colleagues. Regulation of water uptake at times of drought stress is controlled by the hormone, abscisic acid (ABA). By triggering the hormone as early as possible, and reducing soil suctions, it is hoped that more trees may be retained and claims settled quicker.



ASTON UNIVERSITY
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The CRG haver organised the CPD accredited Annual Subsidence Conference, hosted by Aston University for over 10 years. A wide range of expert speakers have kept us up to date on case law, arboriculture, geology, claims handling, underwriting etc., and the venue has been a popular place for networking.

The newsletter, a resource providing access to data that hasn't been available in the past, has a steadily growing readership. Distributed via the CRG web site and links by associates and colleagues including the RICS, Subsidence Forum, OCA Ltd., etc., the newsletter hopefully contributes to the knowledge base of the industry, increasing the expertise of practitioners and improving our understanding of domestic subsidence. The 'visits per day' to the web site has increased gradually, reaching 82 in 2016.