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
Artificial Intelligence

July 2021
Issue 194

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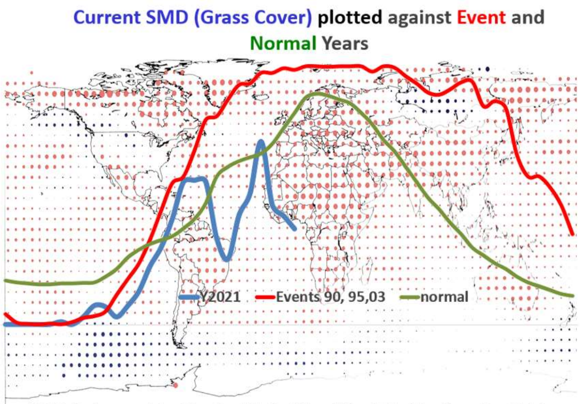
CONTENTS

Issue 194, July 2021

Soil Moisture Deficit

A dip in the SMD for grass cover recorded in the south east of England at tile 161 of the Met Office's national grid.



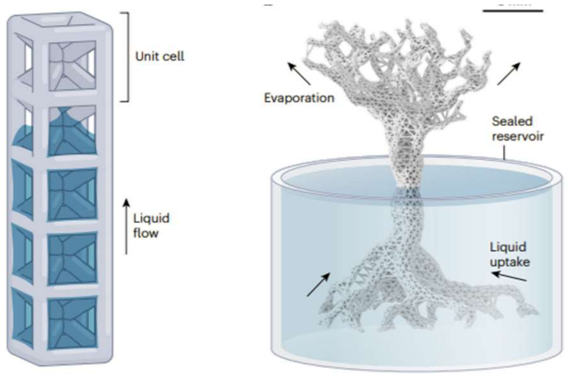
SMD Data provided by the Met office. Tile 161, Medium Available Water Capacity with grass cover

The relatively low values combined with intermittent heavy rainfall suggests a normal claims year ahead.

Modelling Water Uptake

Dudukovic *et al* from Lawrence Livermore National Laboratory, Livermore in California have had a paper published in the 1st July edition of the journal Nature entitled 'Cellular Fluidics'.

The paper describes their work using 3D printing methods to build a model of capillary flow that replicates water uptake in trees – see illustration below.



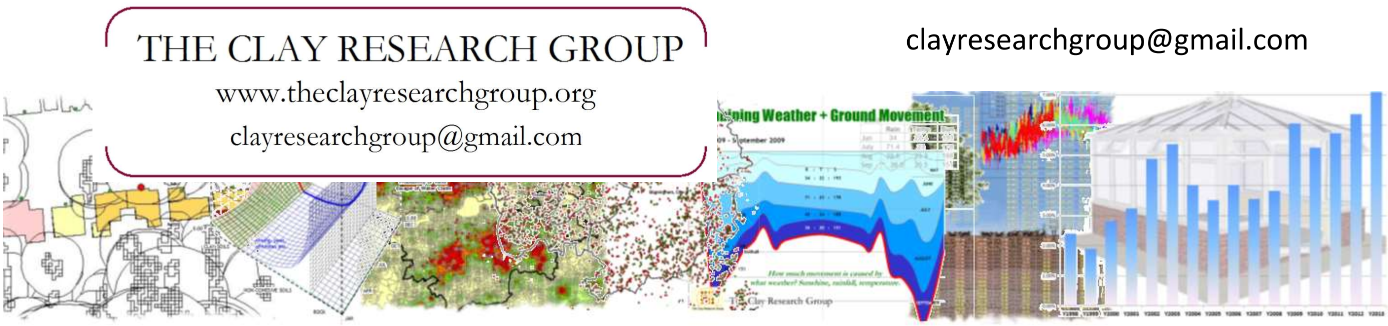
Above left, "*each of these unit cells is a millimetre-scale cube with internal empty spaces that are open to the surrounding atmosphere*". Right, "*a tree-like structure built from the unit cells continuously delivers liquid from a reservoir to the tips of the branches, where the liquid evaporates*".

https://www.nature.com/articles/s41586-021-03603-2.epdf?sharing_token=cRKZhUTbDkRfXcZEe8RgK9RgN0jAjWel9jnR3ZoTv0NPhAvvC_cTVbnq-PXWsBFvvuXqtkv2aTXgHJ_lGCHGk87T5iS5p-so4grUXoxk0NkY9TJ_Cne4OvLXTOp24rVgLD1dnm9X0IPDxFnthhiFa0HQ4qgFAlne7GNKqQqD2wI%3D Imagine setting up 3D machine printed models replicating claims.

Contributions Welcome

We welcome articles and comments from readers. If you have a contribution, please Email us at:

clayresearchgroup@gmail.com



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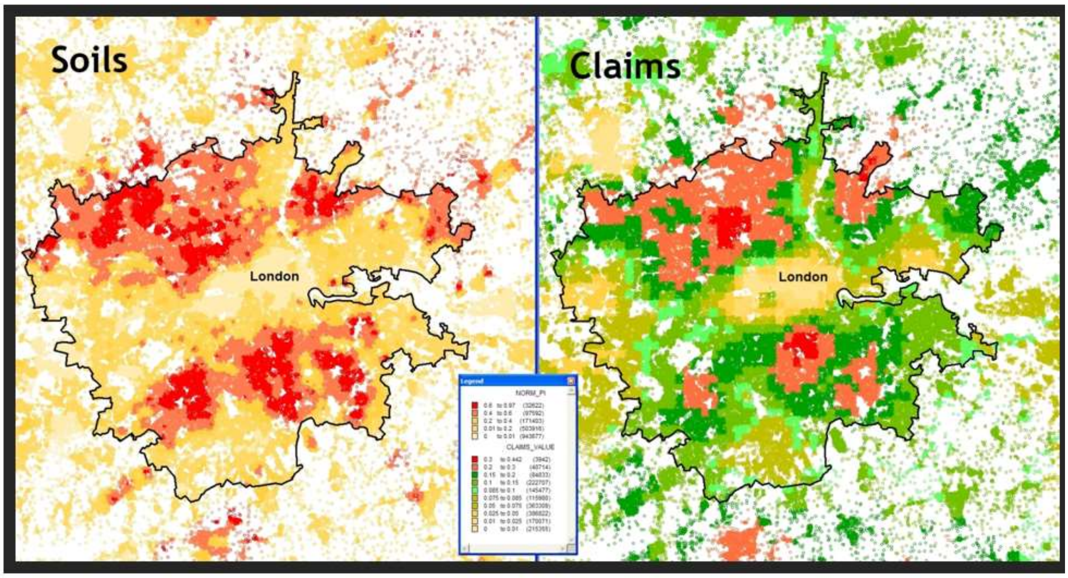
SUBSIDENCE - MODELLING FUTURE RISK

Last month's edition touched on the UK Climate Projection (UKCP) model, GeoClimate, developed by the British Geological Survey. The following pages provide an update of the CRG model outlining its derivation and a possible approach to modelling future changes in climate.

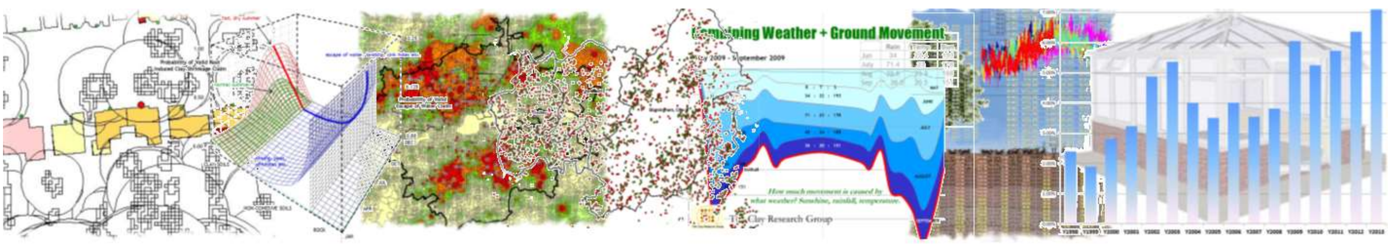
First of all, the benefit of visualising the risk allows those less interested in the domestic subsidence peril (after all, it only accounts for around 4 – 5% of insurers spend) to see the link between the geology and risk, as illustrated in the screenshot below.



A Geographic Information System (GIS) reveal the correlation between elements and provide a useful means of visually assessing risk in relation to location.

Left screen, soils rated by their shrink/swell potential – their plasticity index (PI) - and right, the frequency of subsidence claims.

Insurers spend a considerable sum of money annually undertaking site investigations to diagnose the cause of subsidence. Laboratory tests record the PI of clay soils where present and correlation analysis reveals the risk across the UK relative to claim frequency – see following page.



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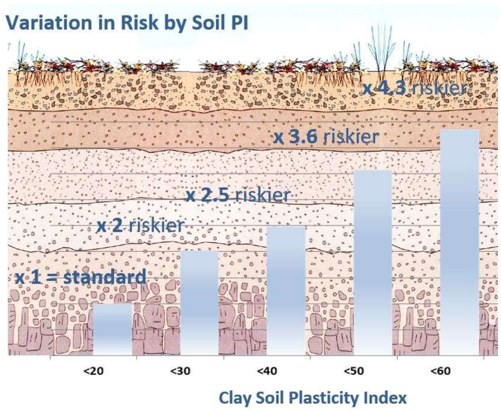
SUBSIDENCE - MODELLING FUTURE RISK

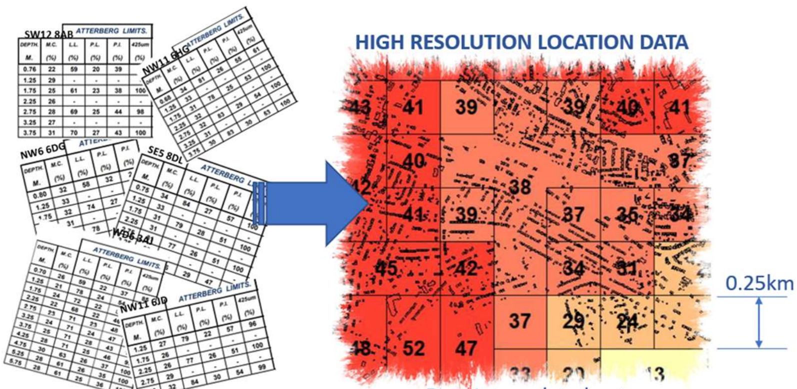
The image, right, estimates the risk by PI in 10% bands by relating it (the soil PI) to claim frequency. Not surprisingly, the risk increases the higher the shrink-swell properties.

These values are the basis for modelling risk in the event of climate warming. A significant mitigating factor in the UK is rainfall. Over recent years annual rainfall has been increasing, reducing the effect of warming.



The next step is to plot the soil PI at around 2mtrs bGL - the depth at which peak desiccation is most frequently encountered in cases of high value root induced clay shrinkage claims from a review of our records. The data is then interpolated between unit postcodes on a 250m grid. See left.

SITE INVESTIGATION RECORDS



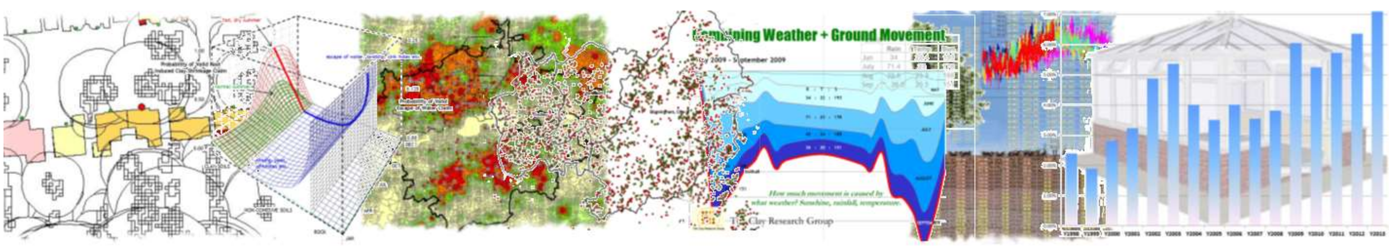
Data from around 2mtrs bGL from site investigations related to subsidence claims

Data interpolated onto 0.25km grid.

The output increases the granularity of the model when compared with postcode sector data as can be seen, right.

In summary, the data obtained from the investigation of subsidence claims directed our efforts and whilst there may be areas of clay missing from the final model, it reflects insurers experience taking into account additional factors such as age of property (i.e. modern estates with deeper foundations), tree planting frequency, species, H/D ratio etc.

Enhanced detail at postcode sector level.



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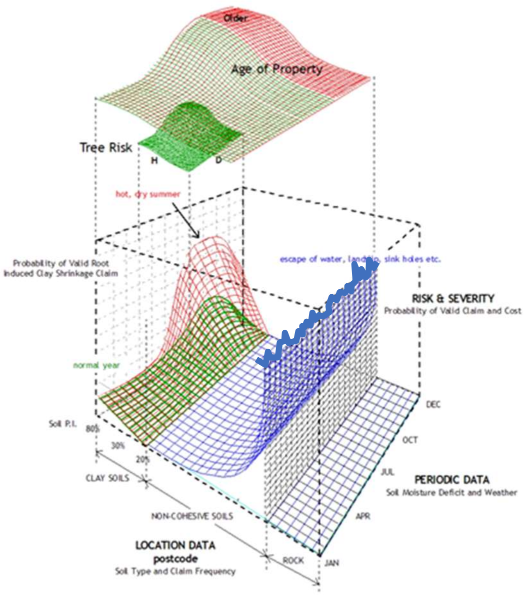
SUBSIDENCE - MODELLING FUTURE RISK

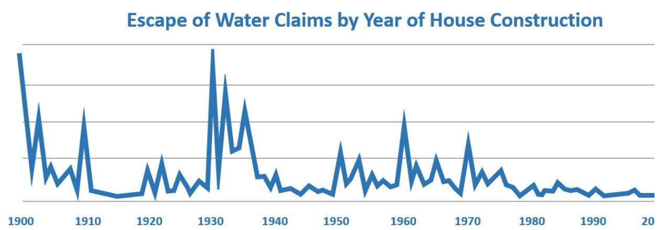
Correlation analysis reveals the link between claim frequency and soil type, but also any seasonal influence. The link changes seasonally for cohesive soils and the graph below illustrates the situation across the UK.

Climate Change -v- Subsidence Risk



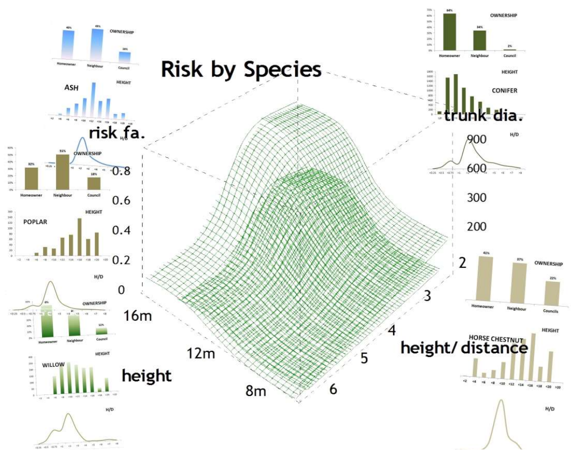
The graph illustrates the frequency and distribution of claims at postcode sector level across the UK by month. Exposure in surge (red) and normal (green) years can be adjusted to take account of climate change.

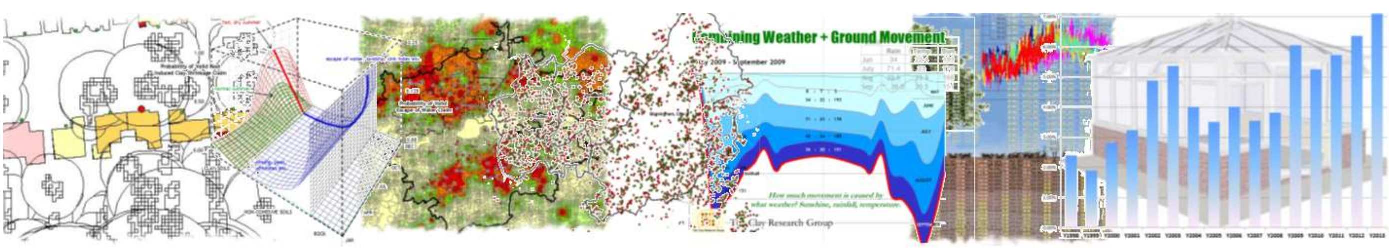
The blue mesh plots the risk associated with non-cohesive soils and varies by rainfall and property age. See below for risk in relation to property age.



Modelling the risk of subsidence caused by escape of water on non-cohesive soils – sands, alluvial soils etc., is based on past claims history rather than any attempt to rate the geology. Such soils are less vulnerable to increasing temperatures and drier weather.

Right, refining the model still further by superimposing the risk posed by trees within influencing distance onto the above graph taking account of species, height and distance from property as well as season where such data is available. Several applications have been developed providing information on trees including iTree, Treezilla, TreeTalk etc., as well as data from individual boroughs.





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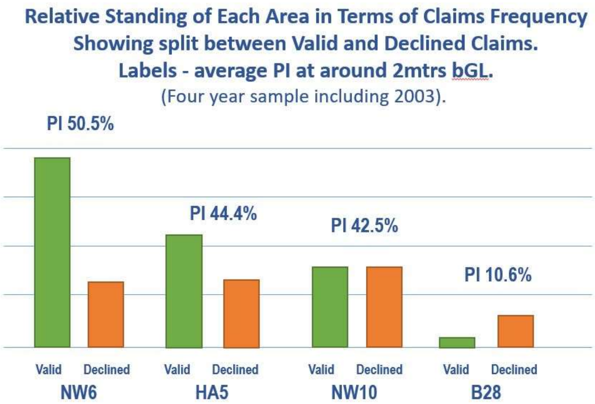
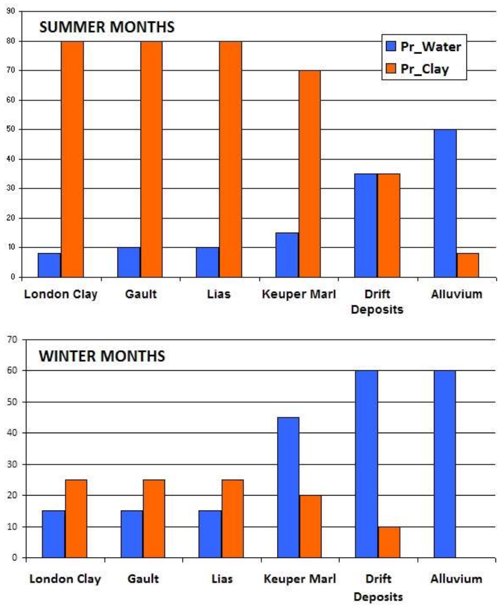
SUBSIDENCE - MODELLING FUTURE RISK

At a coarser level, the graph, right, plots the relationship between geological series and subsidence risk by postcode area.

NW6 has a high frequency of valid claims and a clay soil with a relatively high PI. In contrast, B28 has a much lower PI (around 10%) and a lower frequency of claims with more declinatures.



Seasonal Change in Risk of Subsidence by Soil Type



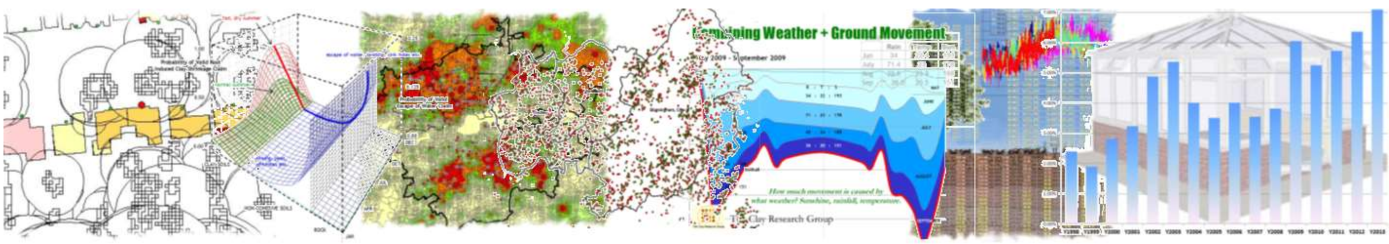
Seasonal fluctuation of risk by soil type showing the probability of a claim being valid in the summer and winter months.

On clay soil the probability of a claim being valid fluctuates seasonally and is far higher in the summer than the winter.

In contrast, the probability of a claim being valid and associated with an escape of water on drift and alluvial deposits remains fairly constant throughout the year.

This outline provides some idea of the data behind the model. Next month we look at how this can be used to take account of climate change – increases in temperature, hours of sunshine and rainfall etc.

The model concentrates on the clay series – the geology delivering the highest risk in terms of domestic subsidence. We have seen on page 3 that a higher PI delivers a higher risk, but how would we model that going forward? More in next month’s edition.



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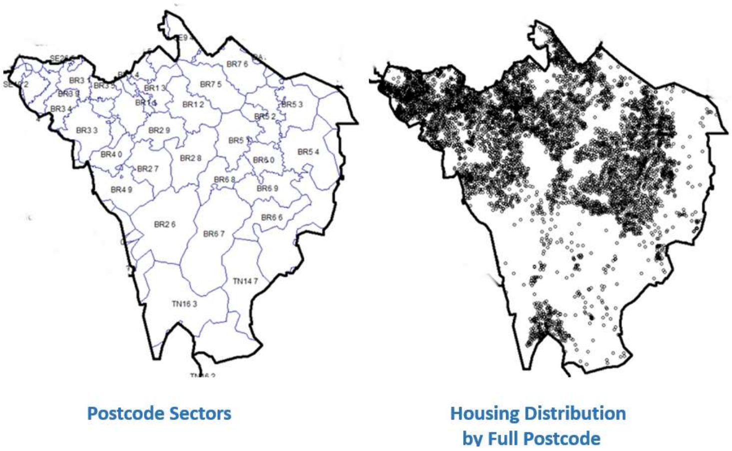
Subsidence Risk Analysis – BROMLEY

Bromley occupies an area of 150.2km^2 with a population of around 332,000 and was originally covered the October 2017 edition of the CRG newsletter, No. 149. It is re-visited here to bring it in line with the current series and allow comparisons between districts in terms of the risk of subsidence.



Distribution of housing stock using full postcode as a proxy. Each postcode in the UK covers on average 15 – 20 houses, although there are large variations.

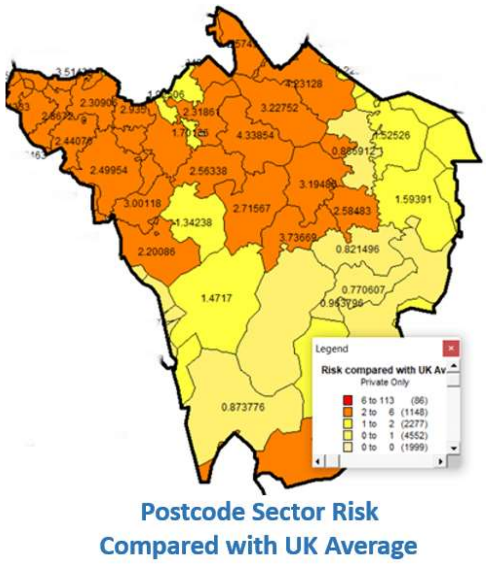
Housing distribution across the district (left, using full postcode as a proxy) helps to clarify the significance of the risk maps on the following pages. Are there simply more claims because there are more houses?

Using a frequency calculation (number of claims divided by private housing population) the relative risk across the borough at postcode sector level is revealed, rather than a ‘claim count’ value.

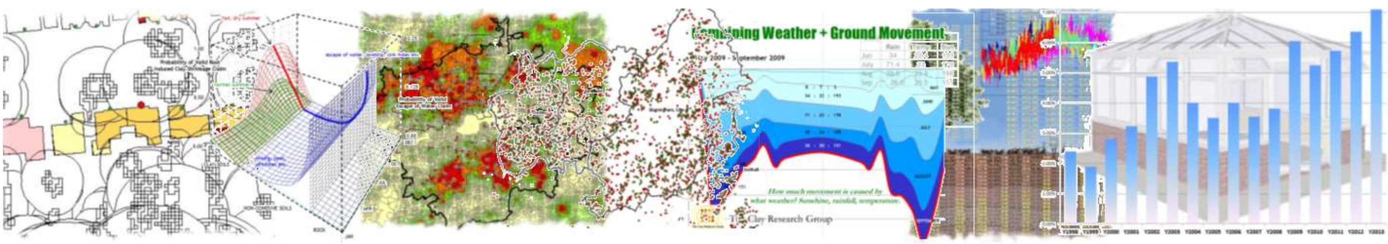
From the sample we have, sectors are rated for the risk of domestic subsidence compared with the UK average – see map, right.

Bromley is rated 80th out of 413 districts in the UK from the sample analysed and is 2.3x the risk of the UK average.

The distribution varies considerably across the borough as can be seen from the sector map.



Risk compared with UK Average.
Bromley is rated 2.3 times the UK average risk for domestic subsidence claims from the sample analysed based on the high frequency to the north of the borough. Above, values at postcode sector level compared with UK average.



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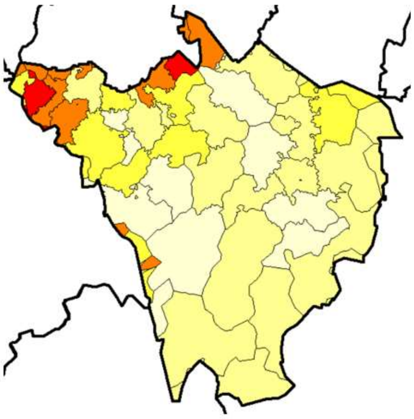
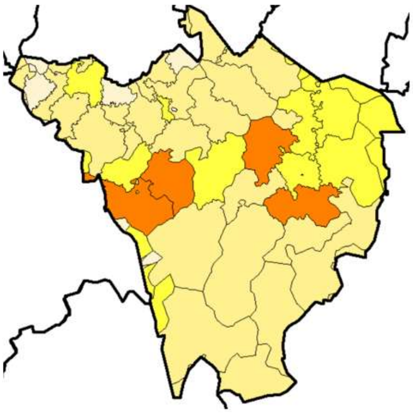
BROMLEY - Properties by Style and Ownership

Below, the general distribution of properties by style of construction, distinguishing between terraced, semi-detached and detached. Unfortunately, the more useful data is missing at sector level – property age. Risk increases with age of property and policies allow insurers to assign a rating to individual properties.

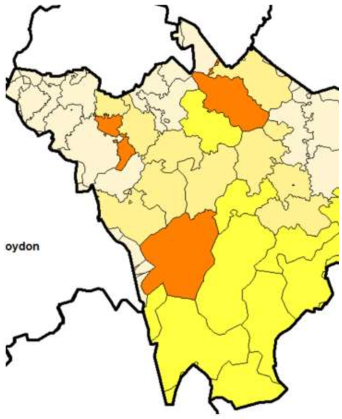
DISTRIBUTION BY HOUSE TYPE – BROMLEY



Terraced



Semi-Detached

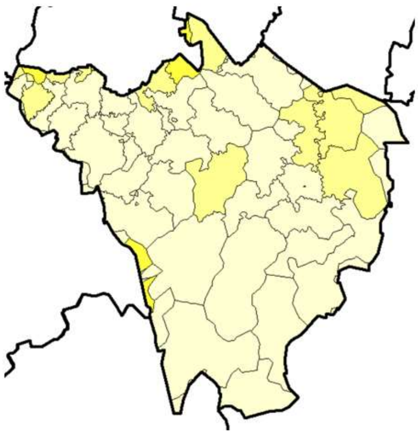


Detached

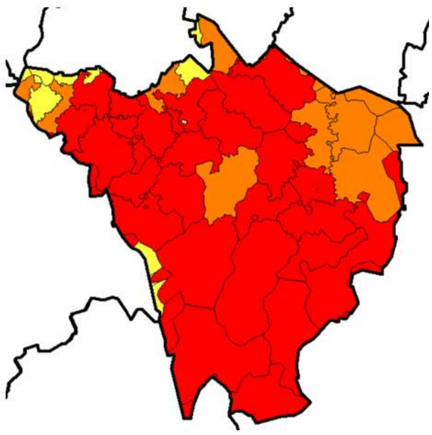
Distribution by ownership is shown below. The maps reveal a high frequency of privately owned properties across the borough.

DISTRIBUTION BY OWNERSHIP – BROMLEY

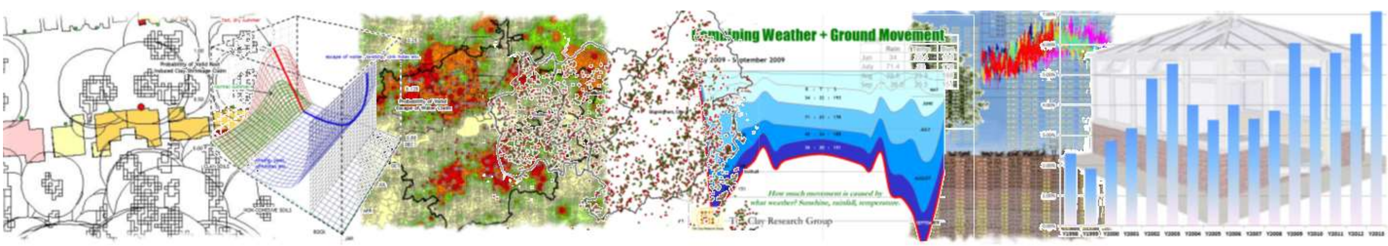
Housing Association



Council Ownership



Private Ownership

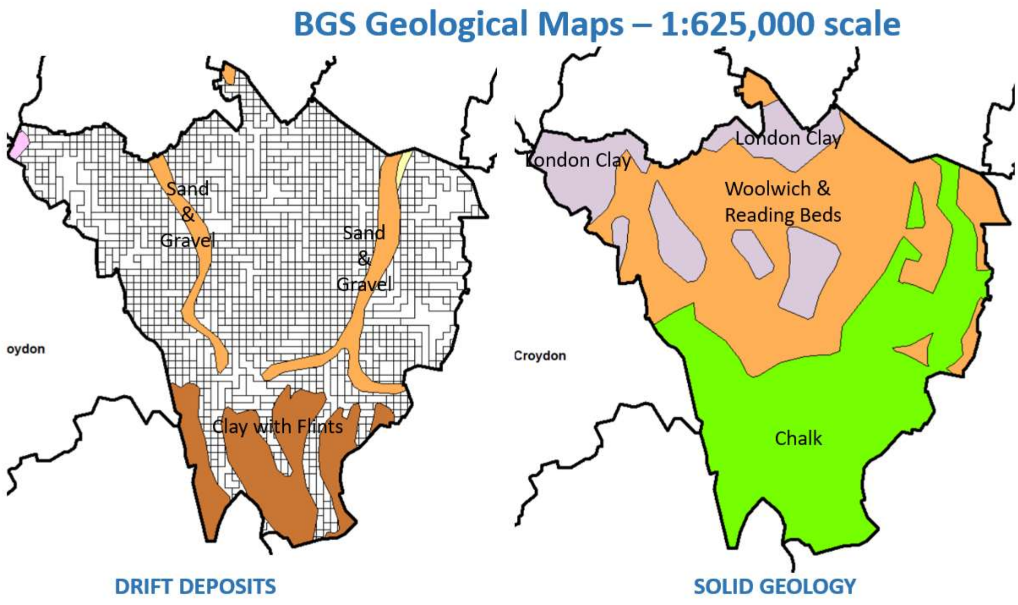


Subsidence Risk Analysis – BROMLEY

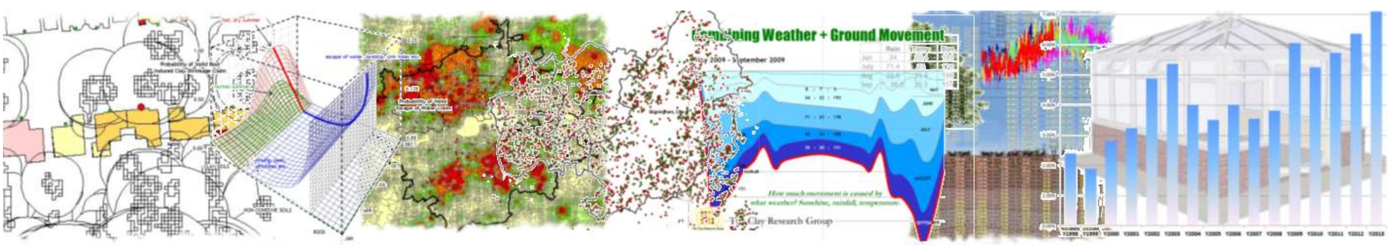
Below, extracts from the British Geological Survey low resolution 1:625,000 scale geological maps showing the solid and drift series. View at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html for more detail.

See page 10 for a seasonal analysis of the sample we hold which reveals that in the summer there is around 80% probability of a claim being valid, and of the valid claims, there is a high probability (greater than 80% in the sample) that the cause will be clay shrinkage.

In the winter the situation reverses. The likelihood of a claim being declined is around 55% and if valid, there is greater than 80% probability the cause will be due to an escape of water. The maps at the foot of Page 9 show the seasonal distribution.



1:625,000 and 1:50,000 series extract from the British Geological Survey maps. Working at postcode sector and referring to the 1:50,000 series maps deliver far greater benefit when assessing risk.



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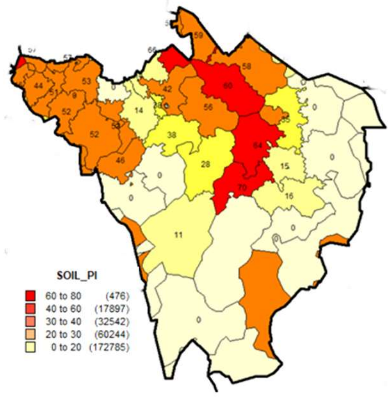
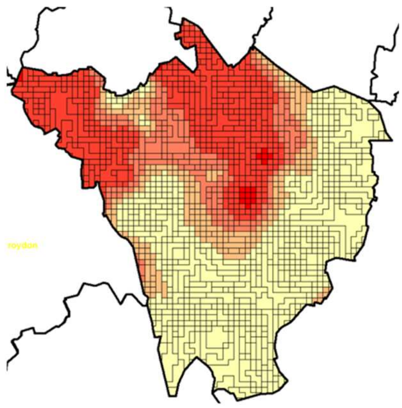
Liability by Geology and Season

Below, the average PI by postcode sector (left) derived from site investigations and interpolated to develop the CRG 250m grid (right). The presence of a shrinkable clay in the CRG model differs from the BGS maps on the previous page suggesting a variable thickness of drift and higher concentration of clay in some areas. Where it exists, the clay has a high PI – exceeding 50% in places and reaching 70% towards the centre of the borough. The higher the PI values, the darker red the CRG grid.

SOIL PLASTICITY INDEX – BROMLEY



Soil PI Averaged by Sector

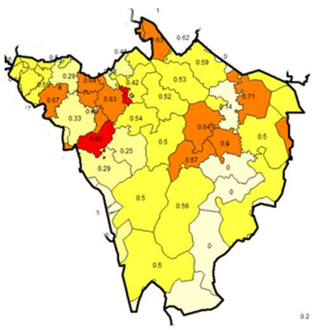


PI Interpolated on 250m CRG grid

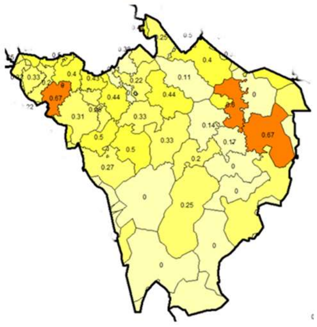
Zero values for PI in some sectors may reflect the absence of site investigation data - not necessarily the absence of shrinkable clay. The widespread influence of the shrinkable clay plays an important role in determining whether a claim is likely to be valid or declined by season. A single claim in an area with low population can raise the risk as a result of using frequency estimates.

PROBABILITY VALID by SEASON – BROMLEY

Distribution of domestic subsidence risk by season.



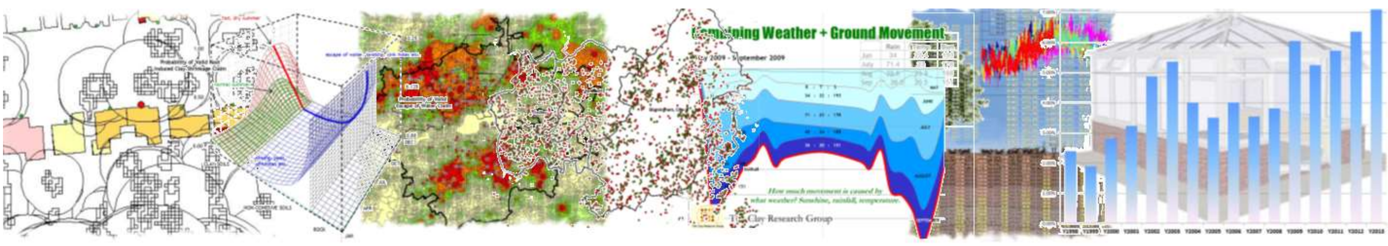
Probability Valid, Summer



Probability Valid, Winter

Mapping the risk by season (table at foot of page 11) is perhaps the most useful way of assessing the most likely cause, liability and geology using the values listed.

The maps left show the seasonal difference from the sample used. An enhanced version using a different approach is shown on the following page.



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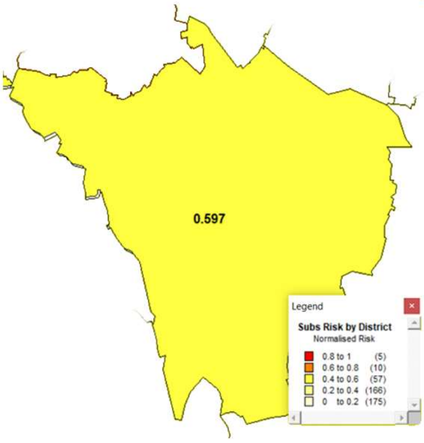
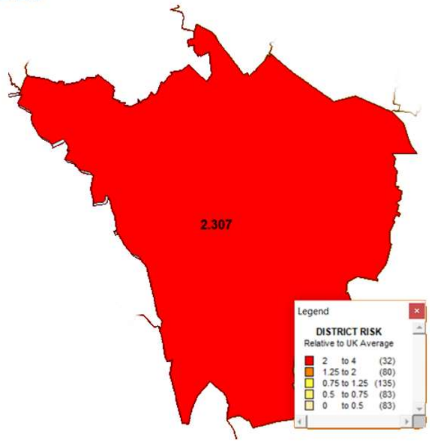
District Risk -v- UK Average. EoW and Council Tree Risk.

SUBSIDENCE RISK RELATIVE TO UK
BROMLEY



Normalised (0 – 1) Scale

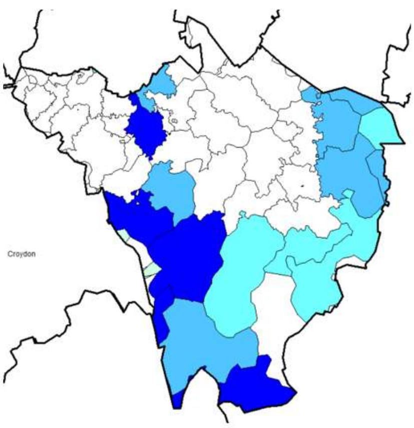


Compared with UK Average

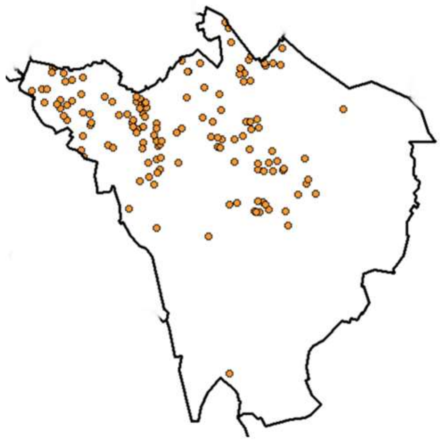
Below, left, mapping the frequency of escape of water claims from the sample reflects the presence of drift deposits (sands and gravels etc) to the south of the borough. The absence of shading does not indicate an absence of claims, but a low frequency.

Below right, map plotting claims where damage has been attributable to vegetation in the ownership of the local authority from a sample of around 2,858 UK claims.

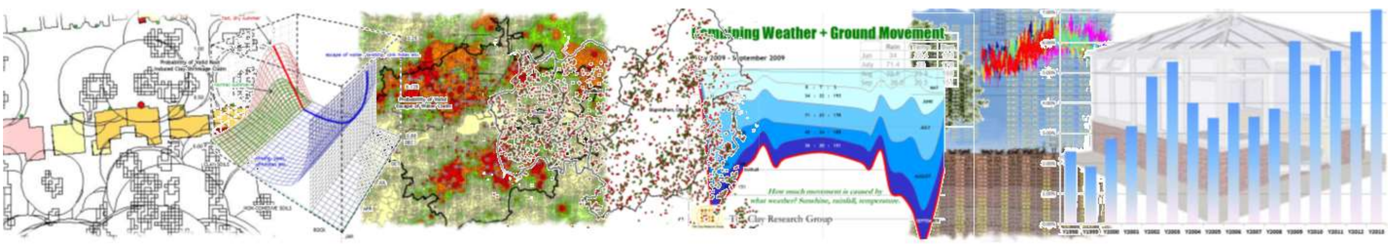
Escape of Water –v- Council Tree Claims
BROMLEY



Higher Risk Escape of Water
(17,852 claim sample)



Claims Involving Council Trees
(2,858 claim sample)



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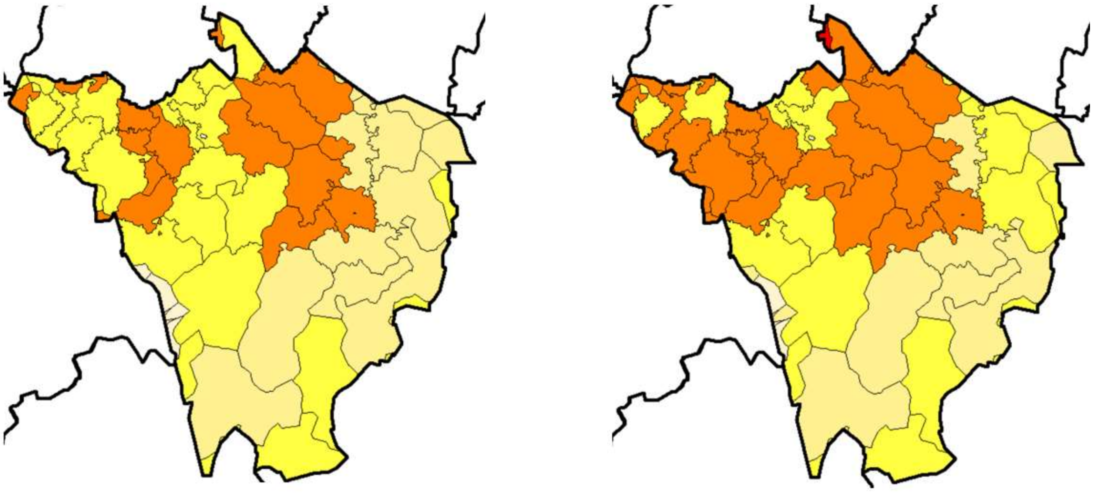
BROMLEY - Frequencies & Probabilities

Mapping claims frequency against the total housing stock by ownership, (left council and housing association combined and right, private ownership only), reveals the importance of understanding properties at risk by portfolio. There are several sectors in the 'private only' map with an increased risk.

POSTCODE SECTOR SUBSIDENCE RISK (FREQUENCY) BY OWNERSHIP - BROMLEY

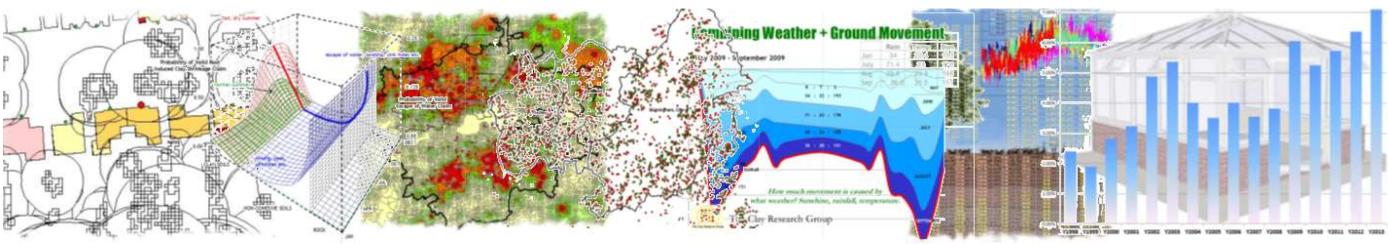


Combined Public and Private Frequency | **Private Only**

On a general note, the reversal of rates for valid-v-declined by season is a characteristic of the underlying geology. For clay soils, the probability of a claim being declined in the summer is just under 25%, and in the winter, it exceeds 50%. Valid claims in the summer are likely to be due to clay shrinkage, and in the winter, escape of water.

Liability by Season - BROMLEY

District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Bromley	0.626	0.136	0.238	0.08	0.37	0.55



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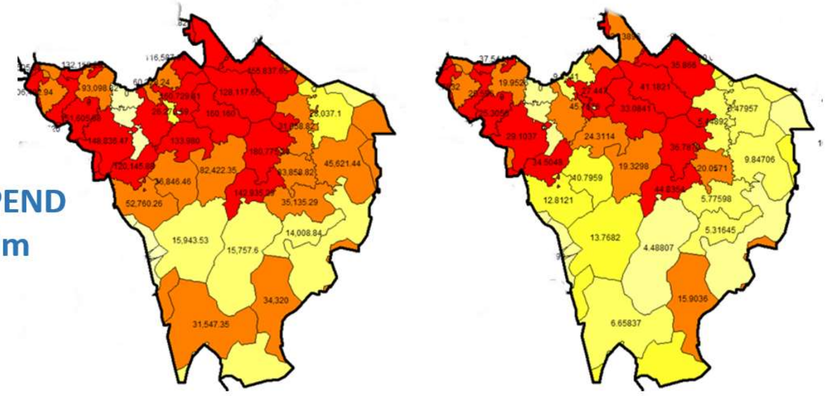
Aggregate Subsidence Claim Spend by Postcode Sector and Household in Surge & Normal Years

The maps below show the aggregated claim cost from the claim sample per postcode sector for both normal (top) and surge (bottom) years. The figures will vary by the insurer's exposure, claim sample and distribution.

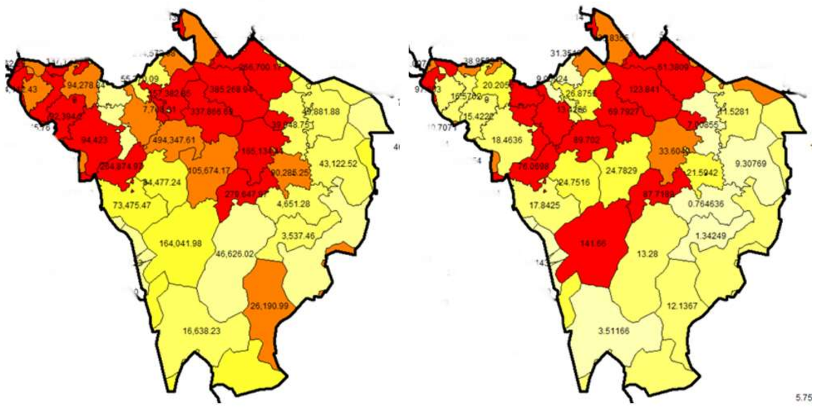
NORMAL YEAR SPEND – SAMPLE £200m BROMLEY



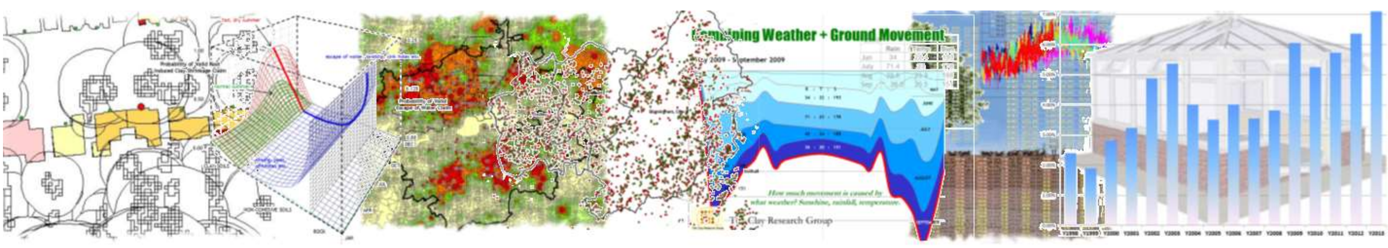
Spend by Sector | Spend Averaged over Housing Population

It will also be a function of the distribution of vegetation and age and style of construction of the housing stock. The images to the left in both examples (above and below) represent gross sector spend and those to the right, sector spend averaged across housing population to derive a notional premium per house for the subsidence peril. The figures can be distorted by a small number of high value claims.

SPEND in SURGE – SAMPLE £419m BROMLEY



Spend by Sector | Spend Averaged over Housing Population



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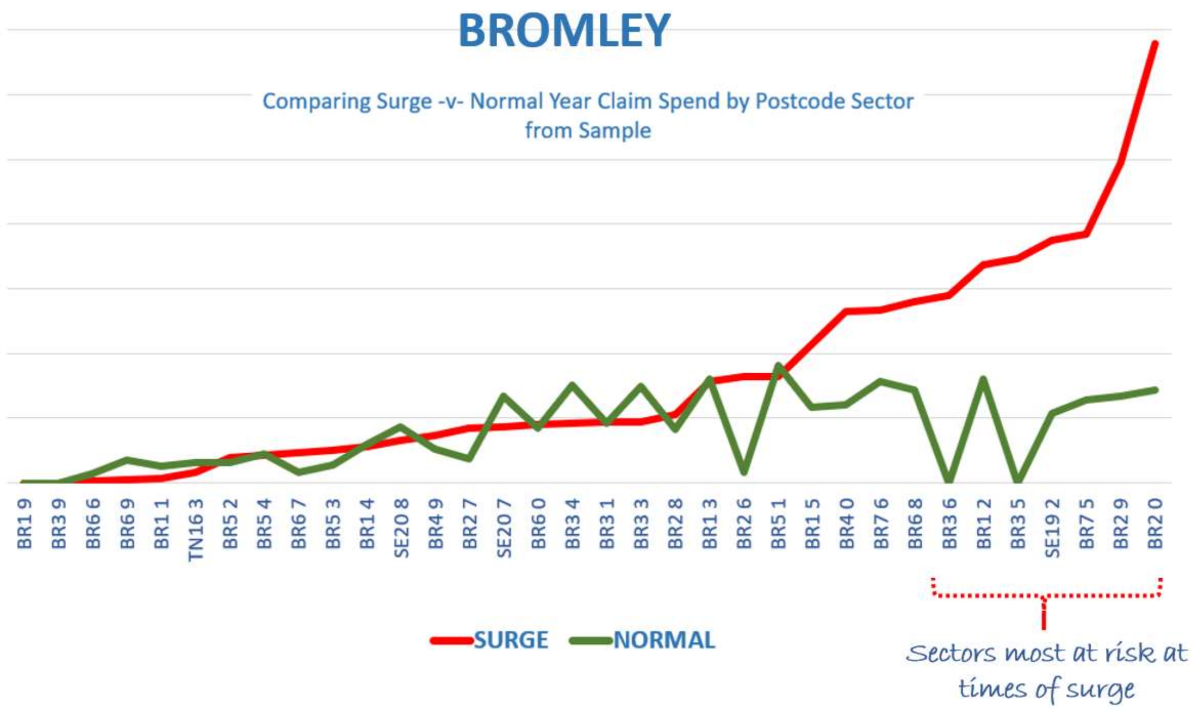

The above graph identifies the variable risk across the district at postcode sector level from the sample, distinguishing between normal and surge years. Divergence between the plots indicates those sectors most at risk at times of surge (red line).

It is of course the case that a single expensive claim (a sinkhole for example) can distort the outcome using the above approach. With sufficient data it would be possible to build a street level model.

In making an assessment of risk, housing distribution and count by postcode sector play a significant role. One sector may appear to be a higher risk than another based on frequency, whereas basing the assessment on count may deliver a different outcome. This can also skew the assessment of risk related to the geology, making what appears to be a high-risk series less or more of a threat than it actually is.

The models comparing the cost of surge and normal years is based on losses for surge of just over £400m, and for normal years, £200m.