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

April 2021
Issue 191

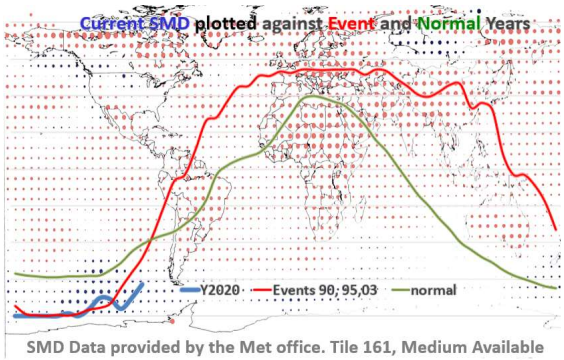
The Clay Research Group

CONTENTS

Issue 191, April 2021

SMD Update

The Soil Moisture Deficit remains one of the best criteria for assessing the probability of a summer surge early in the year although it is accepted that the probability of the forecast being correct has fallen to less than 75%.



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

This may seem too low to be of use but it matches weather forecasts in terms of reliability and given the factors involved, probably as good as we can hope for.

UKCRIC

Webinar relating to soil-foundation issues is scheduled for Monday, 19th April at 11.15am and lasting an hour, entitled 'The new UKCRIC National Facility for Soil-Foundation-structure interaction: research challenges and business opportunities', under the direction of Professor Anastasios Sextos.

"An introduction to this new laboratory currently under construction and due to open in Summer 2021. Join Professor Anastasios Sextos to understand the capability of this laboratory and hear about opportunities for collaboration."

To book, go to …

https://bristol-ac-uk.zoom.us/webinar/register/WN_rO86LdNZSL-WZ6dnQmo-dw

Risk Mapping - Southwark

This month's edition re-visits the Borough of Southwark, mapping the risk of domestic subsidence at postcode sector level. The original review appeared in edition 156, May 2018. This update takes into account seasonal changes affecting areas on shrinkable clay soil, spend by normal and surge years along with updated maps consistent with the current series.

Contributions Welcome

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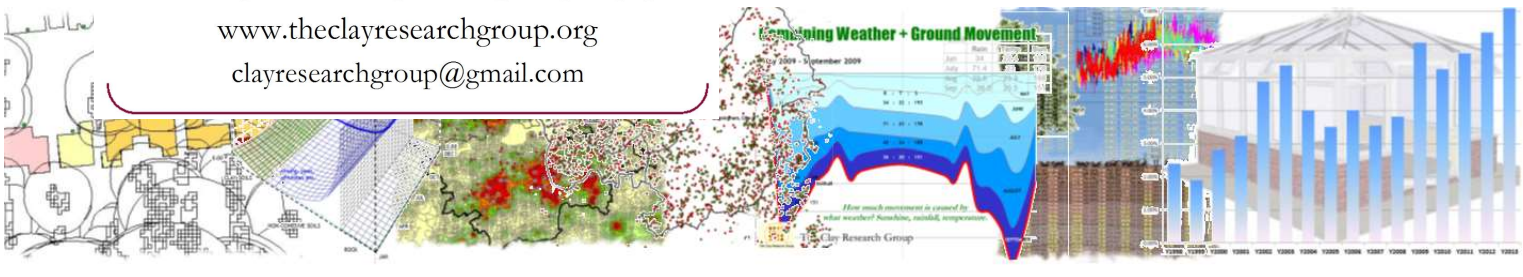

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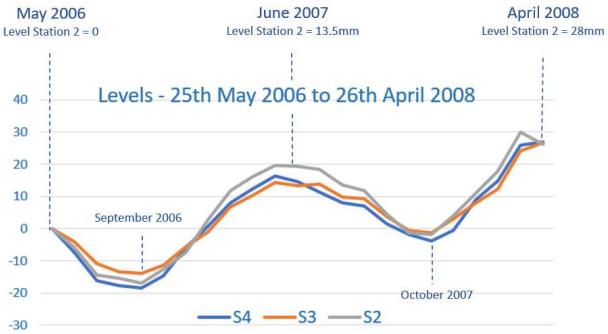
Estimated -v- Actual Swell

This article considers the usefullness of estimates of heave obtained from a range of soil tests. Disturbed and undisturbed soil samples were retrieved from the site of the Aldenham willow by C.P. Bennett Ltd., and tested using a variety of techniques by MatLab Limited. Estimates of swell made in May 2006, June 2007 and April 2008 are compared with precise level readings. How did the estimates compare with the actual ground movement?



For this exercise, precise level data from stations 2, 3 and 4, nearest the subject borehole, have been used.

This was gathered monthly from May 2006 through to May 2008, after which readings were taken bi-monthly.

Estimates of swell using filter paper and oedometer tests for disturbed and undisturbed samples are shown in the table, right. In May 2006 the oedometer suggested 78mm of swell and the filter paper, 101mm for disturbed samples.

Estimated Heave at Time of Sample Testing

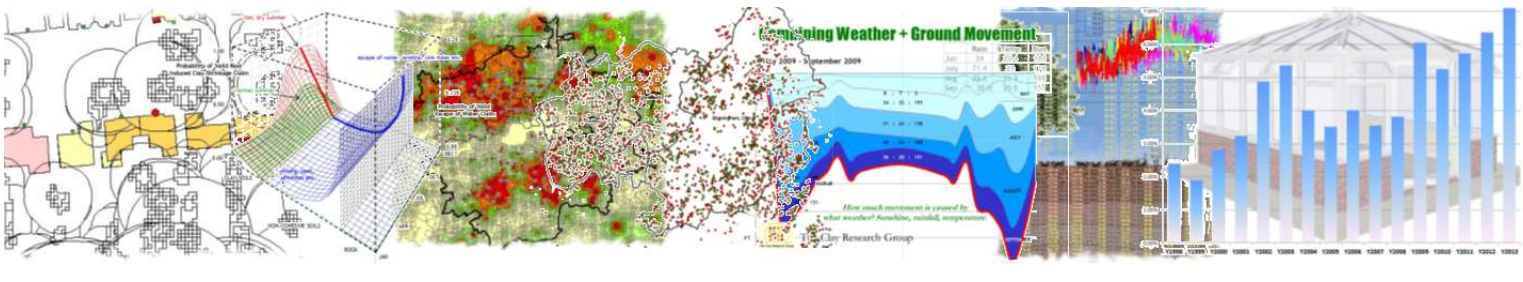
	May-06	Jun-07	Apr-08
OED (disturbed)	78	47	56
OED (undisturbed)		34	30
OED (remoulded)			18
Filter (disturbed)	101	55	56
Filter (undisturbed)		58	21

The difference between estimated heave for disturbed samples between May 2006 and April 2008 was 22mm (oedometer) and 45mm (filter paper). Precise levels show the actual recovery in that period was around 28mm.

In June 2007, the estimate of swell for the disturbed samples was 47mm and 55mm respectively and in April 2008, both tests delivered estimates of 56mm. Estimates for undisturbed samples, introduced in June 2007, are also shown. Although the estimated swell increased slightly, precise levels recorded recovery of 15mm.

Undisturbed samples from June 2007 and April 2008 estimated recovery of 4mm (oedometer) and 37mm (filter paper). Precise level readings recorded actual recovery of 14.5mm in the 10 month term.

The oedometer provided the most consistent results whereas results from both filter paper tests (disturbed and undisturbed samples) varied significantly.



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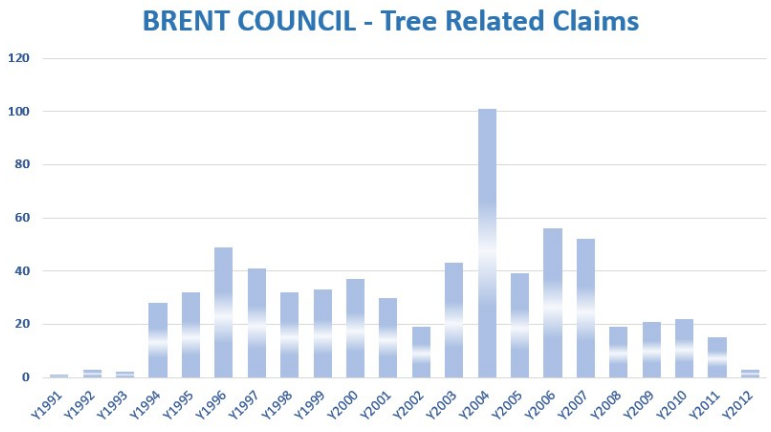
Count of Claims by Year Relating to Tree Root Nuisance Provided by Brent Local Authority

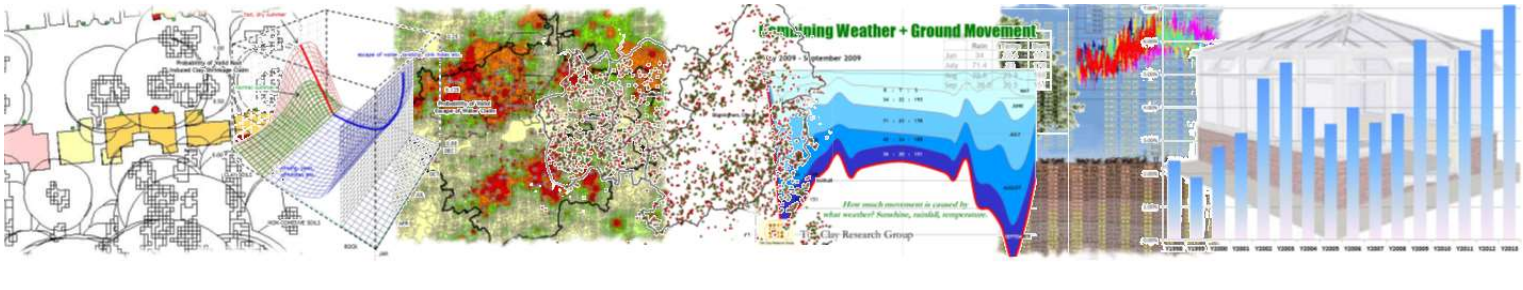
Interesting to see the low numbers following the 1990 surge in subsidence claim numbers, and the peak reaching 101 claims in 2004, following the 2003 surge year. The reduction in numbers follows the general decline in claim numbers.



Cumbria Sinkhole

Reported in the press, a farmer riding across a field on his quad bike fell into an 18m deep sinkhole in Cumbria. Fortunately, the signal from his mobile phone managed to reach emergency services and the fire department hauled him out. He was taken to hospital with chest and back injuries.

BBC reported “There are a number of early 19th Century disused iron ore mines in the area, making sinkholes an ever-present danger”



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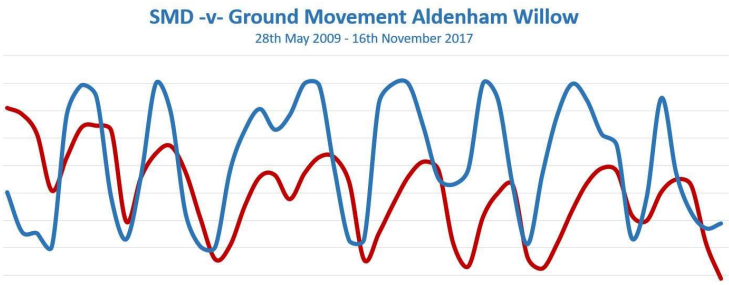
Graphs from the Past

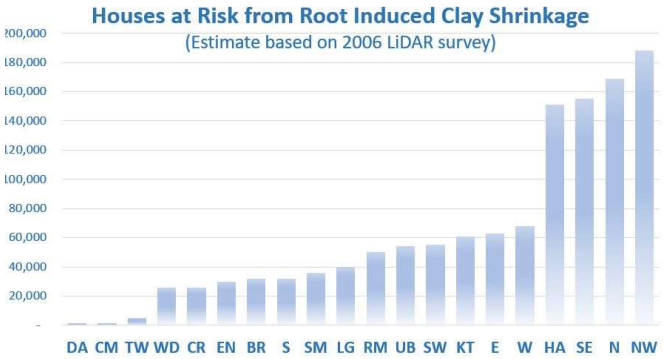
Well, the not too distant past. Given the 'working from home' environment we have been given the opportunity to review what we have learnt from analysing the data and reviewing some of the graphs that have appeared since the launch of the CRG.

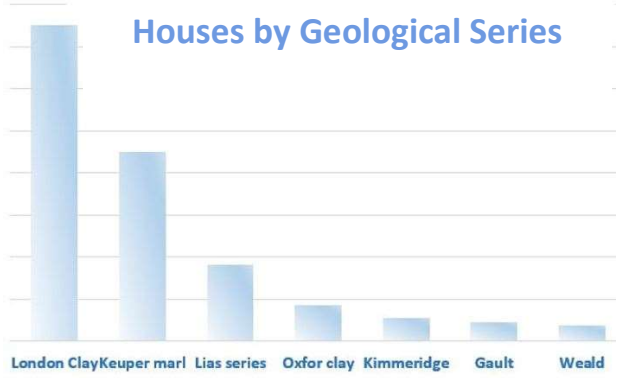


The link between ground movement (red) at the site of the Aldenham willow (station 23) and the Soil Moisture Deficit (blue).

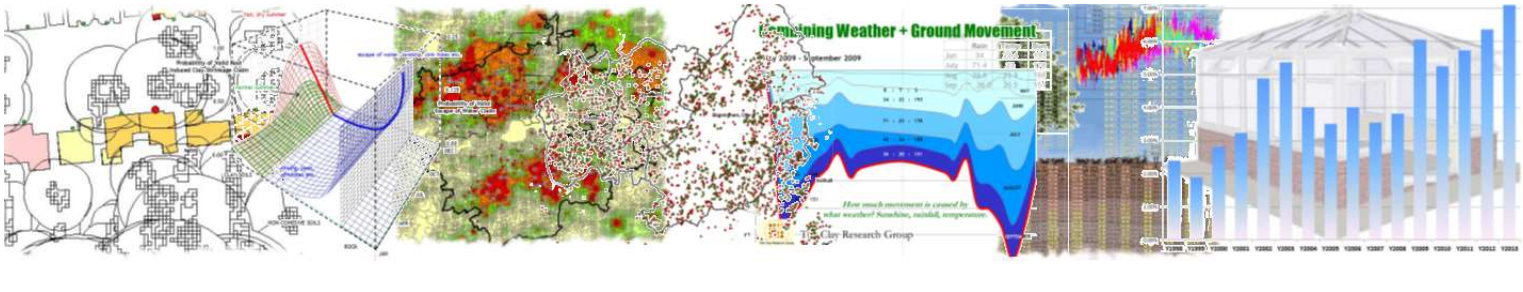
Some data missing in 2008, but the link between the two datasets is interesting with the SMD peaking just ahead of ground movement taking place.

Right, the exposure by postcode area in terms of the number of houses within the root zone of trees with a height greater than 4mtrs, using a modelled root radius of 1.2 x H. The model identifies trees on clay soils and the top four are NW, N, SE and HA.





Looking at exposure to the risk of subsidence in a different way, the graph left assesses risk based on claim frequency by clay series, with London clay presenting the highest risk (unsurprisingly given the housing population) followed by Mercia mudstone, Lias and Oxford clay series.



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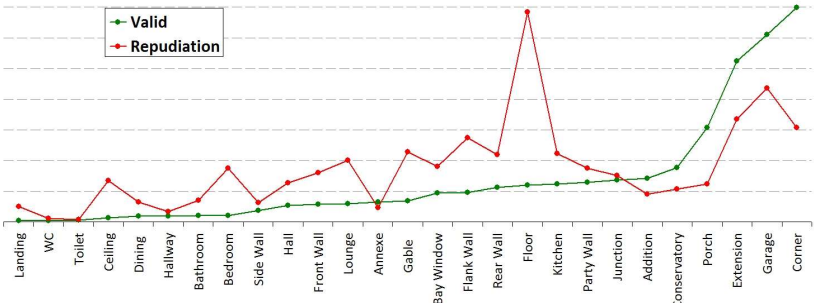
Graphs from the Past *... continued*

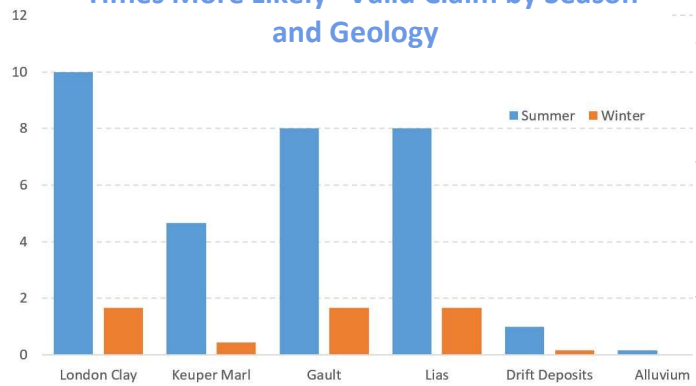
The graph, right, plots the location of damage and the likelihood of that claim being accepted or declined from a sample of around 34,000 records.

Crack damage to the corners of buildings have the highest count of acceptance whilst damage to a floor is more likely to be declined.

"Times More Likely" Valid Claim by Location



"Times More Likely" Valid Claim by Season and Geology

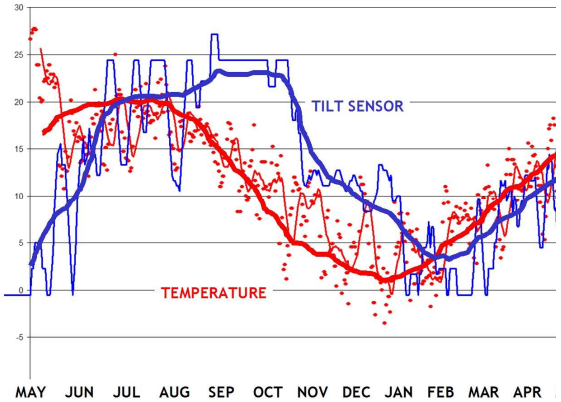


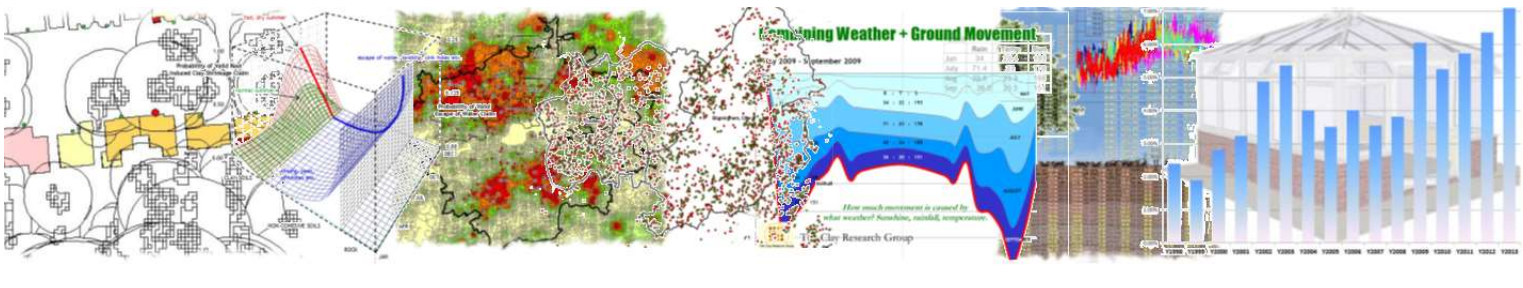
Left, a seasonal analysis of claim validity by geological series. The highest count of claims occurs on London clay, which also has the greatest difference between claim validity by season. Numbers increase substantially in the summer due to the presence of London clay and the link with vegetation.

Link between property movement on clay soil and temperature using tilt sensors.

Right, the link between temperature and ground movement on clay soil measured using remote sensors gathering data every hour and transmitting it via the web to both the engineer and homeowner.

Suitable interpretation software is needed to avoid movement of a few millimetres being misinterpreted as significant.





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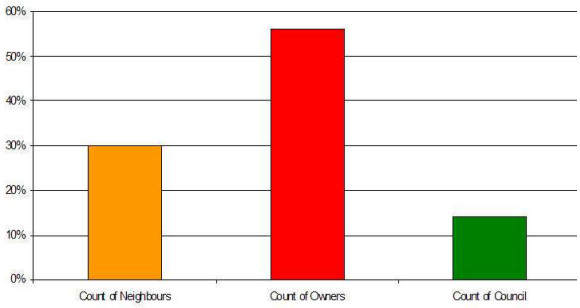
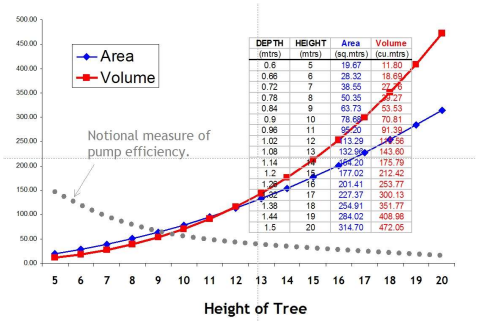
Graphs from the Past *... continued*

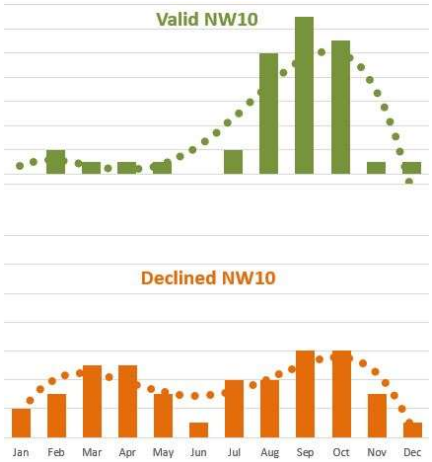


Of the trees involved in causing subsidence damage the graph left records ownership in terms of percentage.

The claimants own trees are most frequent, approaching 60% from our sample. Neighbours' trees are next, accounting for 30% and council owned trees come third.

Right, a graph linking tree height to water uptake. The graph is based on data that varies both by species and season and is designed to model potential ground movement associated with water uptake.

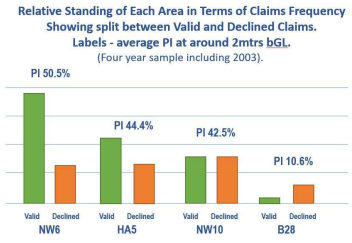


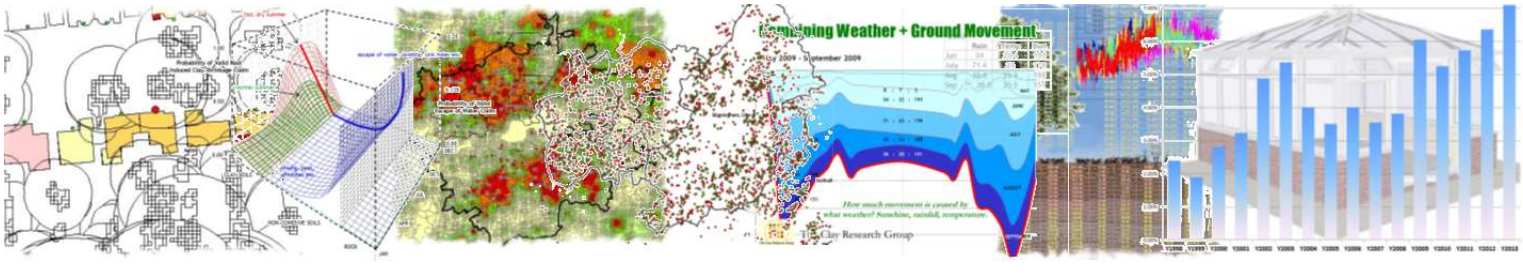


Another example of graphing seasonal movement by postcode in terms of the likelihood of claim validity and linked to both geology and climate.

The information forms one of the data series linking in to an intelligent system which, by merging with associated datasets (tree by species, height and distance, weather and soil PI) delivers a probability on causation and claim validity.

Continuing the theme from above, reviewing each postcode area in terms of the percentage of claims valid and declined by area in relation to the soils potential shrinkability. The risk increases along with the soil PI.





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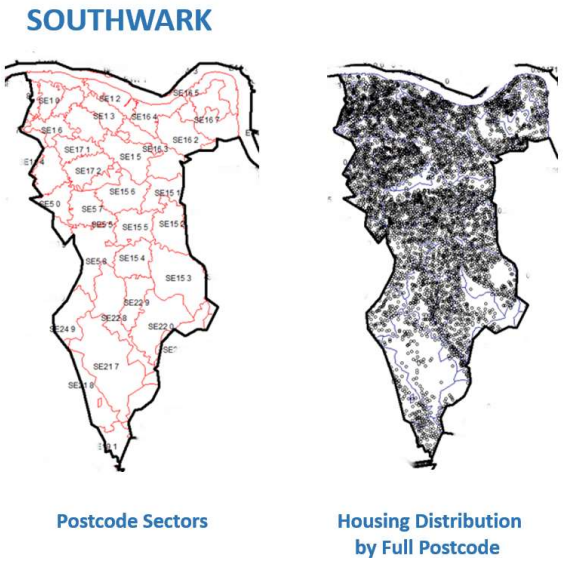
Subsidence Risk Analysis – SOUTHWARK

Southwark occupies an area of 28.85km^2 with a population of around 317,250. The district was originally covered in edition 156, May 2018 of the CRG newsletter. It is re-visited here to bring it in line with the current series and allow comparisons in terms of risk.



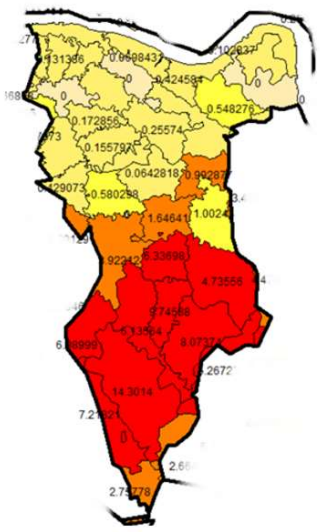
Postcode Layout
Left, postcode sector layout. Right, distribution of housing stock using full postcode as a proxy. UK postcodes cover on average 15 – 20 houses, although there are large variations.

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

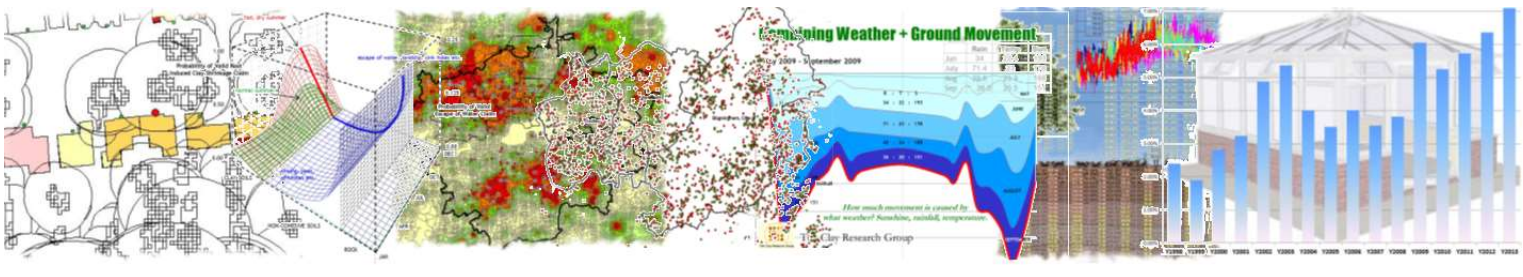
Southwark is rated as high risk and is 51st in the UK from the sample analysed, although the distribution across the borough varies considerably as can be seen from the sector map.

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.



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



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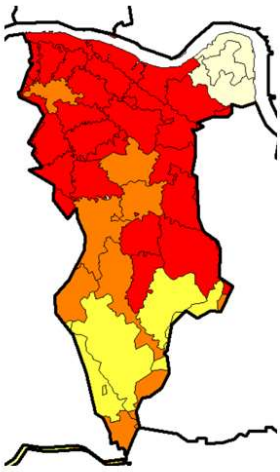
SOUTHWARK - Properties by Style and Ownership

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.



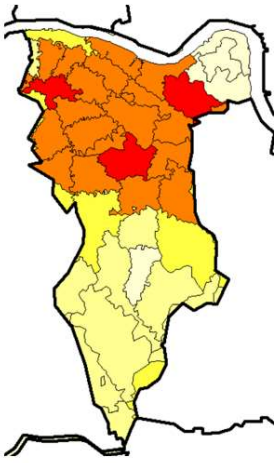
Terraced

Semi-Detached

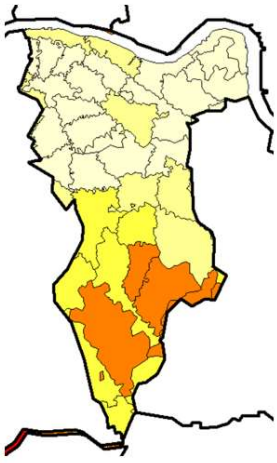
Detached

Distribution by ownership is shown below. The maps reveal a high frequency of terraced houses with council properties to the north of the borough and higher concentration of privately owned properties to the south, which will influence the outcome of the risk analysis.

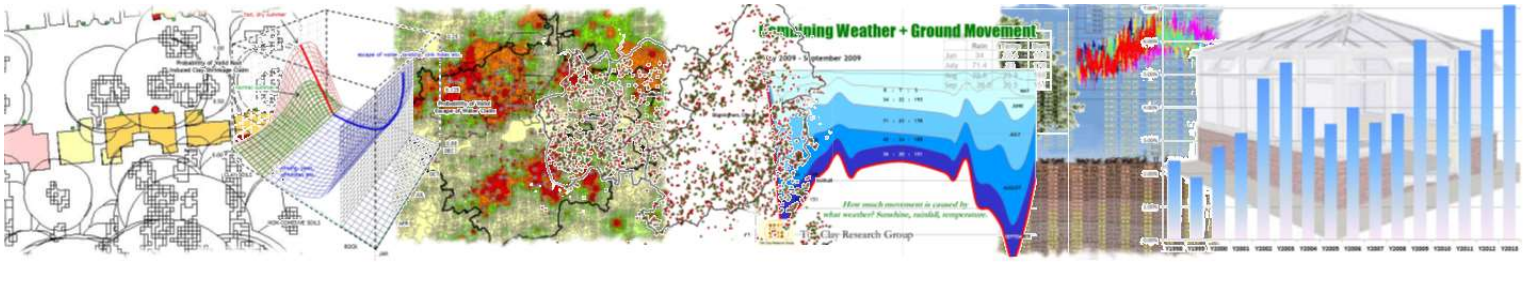
Housing Association



Council Ownership



Private Ownership



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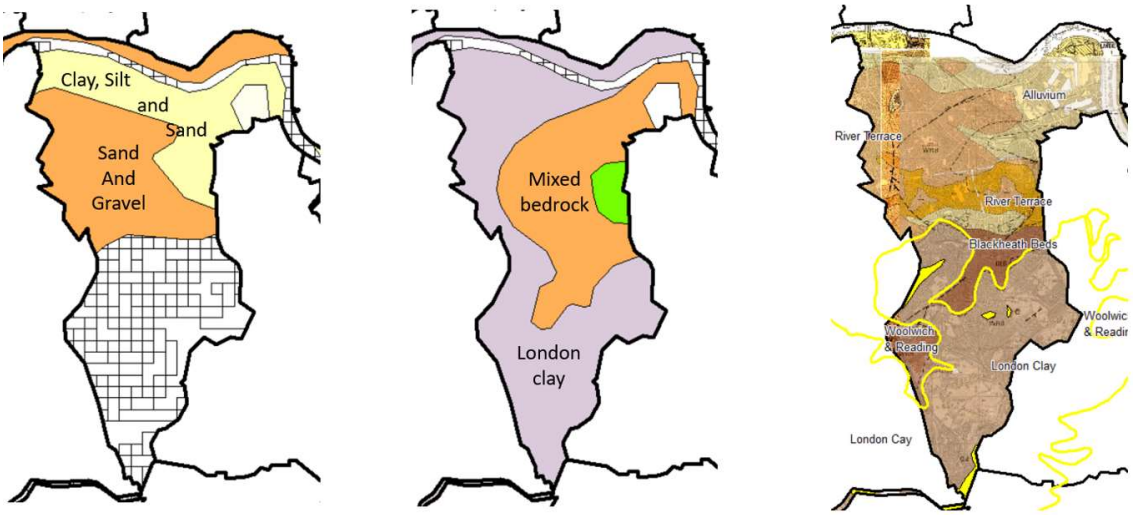
Subsidence Risk Analysis – SOUTHWARK

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.

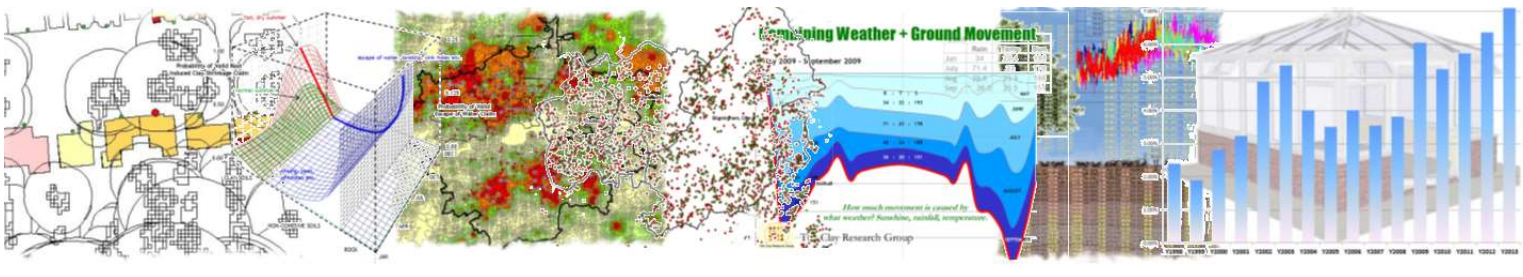
See page 12 for a seasonal analysis which reveals that in the summer there is around a 70% probability of a claim being valid, and of the valid claims, there is a high probability (greater than 90% in the sample) that the cause will be due to clay shrinkage. The sample is skewed to the south of the district due to a higher concentration of privately owned houses as well as the presence of London clay.

In the winter the situation reverses. The likelihood of a claim being declined is around 70%.

The analysis reflects the influence of the outcropping clay series and the apparent thickness of the superficial deposits.



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



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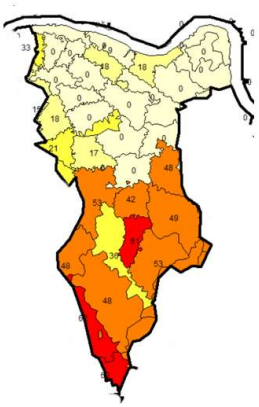
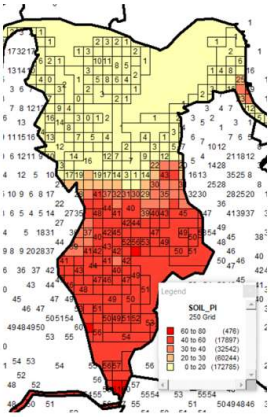
Liability by Geology and Season

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 matches the BGS maps on the previous page with clay having an average PI of around 50% where it exists. The higher the PI values, the darker red the CRG grid.

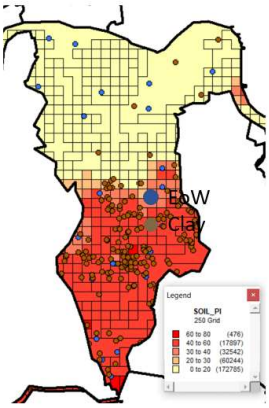
SOIL PLASTICITY INDEX – SOUTHWARK



Soil PI Averaged by Sector



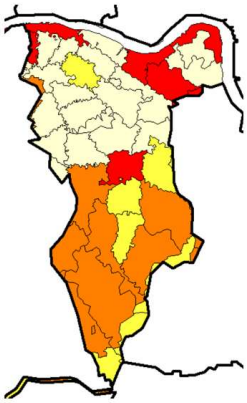
PI Interpolated on 250m CRG grid



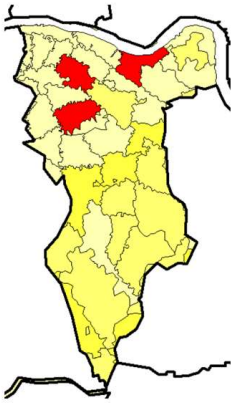
Claims by Cause Relative to Grid

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 - SOUTHWARK



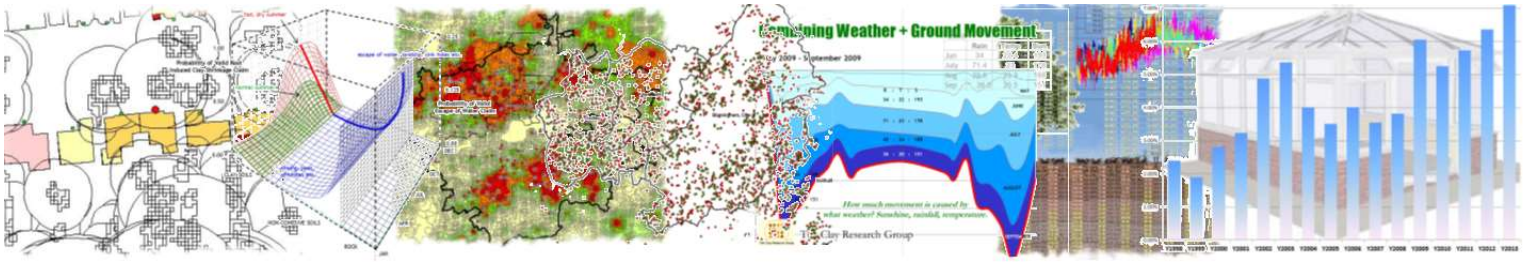
Probability Valid, Summer



Probability Valid, Winter

Mapping the risk by season (table on page 13) is perhaps the most indicative factor when assessing likely risk, causation and geology using following values.

Declinatures of 20% or less in the summer, and of the valid claims, around 70% or more in the summer relating to clay shrinkage.



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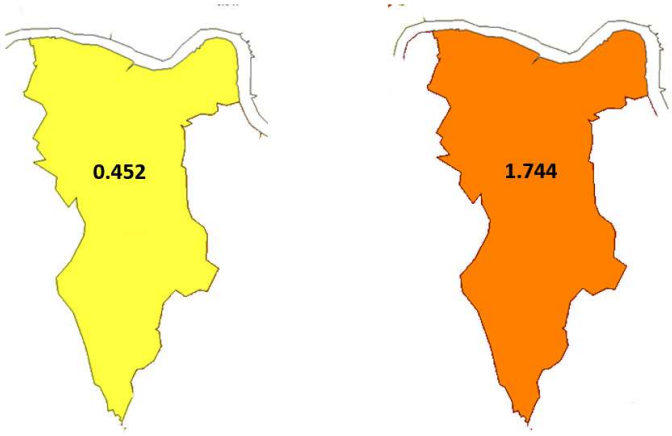
District Risk -v- UK Average. EoW and Council Tree Risk.

SUBSIDENCE RISK RELATIVE TO UK - SOUTHWARK

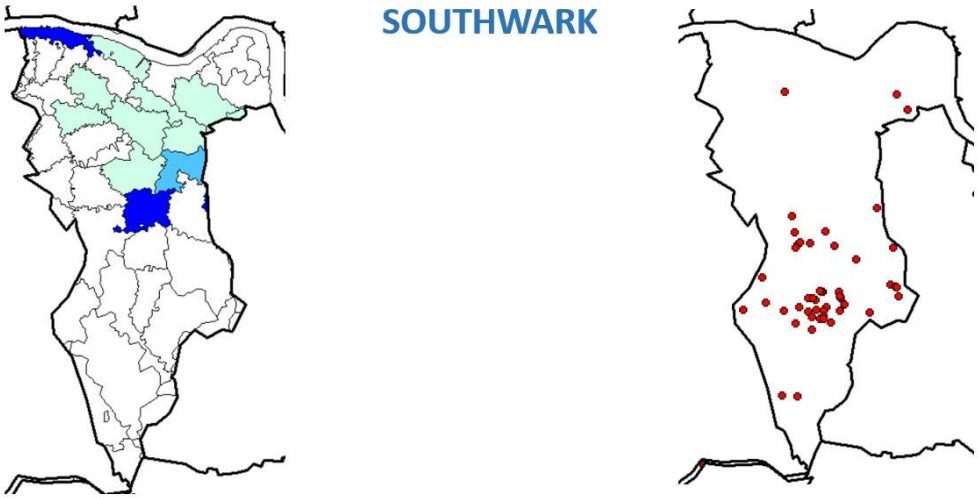


Normalised (0 – 1) Scale

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 north of the borough. The absence of shading does not indicate an absence of claims, but a low frequency. Such claims are often due to shallow foundations of older houses bearings onto disturbed ground or topsoil. Below, right, 'Council Tree Claims' map plotting claims from a small sample of around 2,700 UK claims where damage has been attributable to vegetation in the ownership of the local authority.

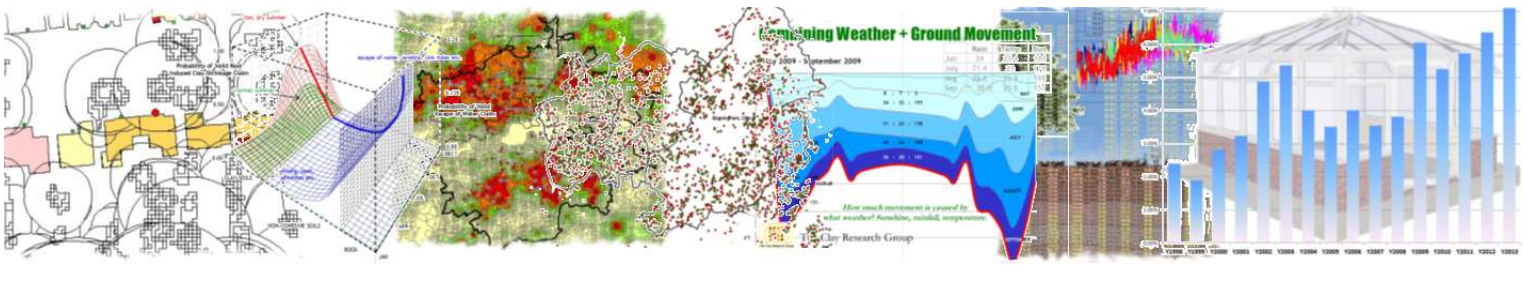
Escape of Water –v- Council Tree Claims
SOUTHWARK



Higher Risk Escape of Water

Claims Involving Council Tree

(2,700 UK claim sample)



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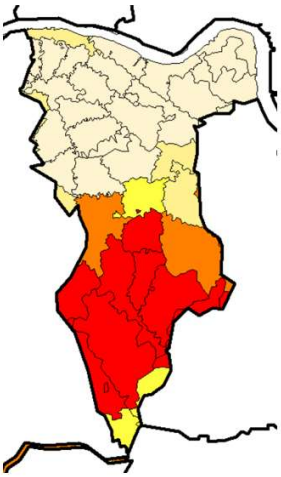
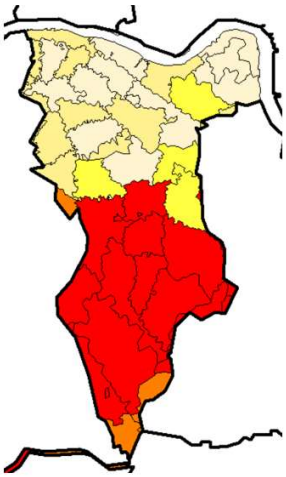
SOUTHWARK - Frequencies & Probabilities

Mapping claims frequency against the total housing stock, left (council, housing association and private) and private housing only, right, reveals the importance of understanding risk by portfolio.

POSTCODE SECTOR SUBSIDENCE RISK (FREQUENCY)
BY OWNERSHIP - SOUTHWARK



Combined Public and Private Frequency



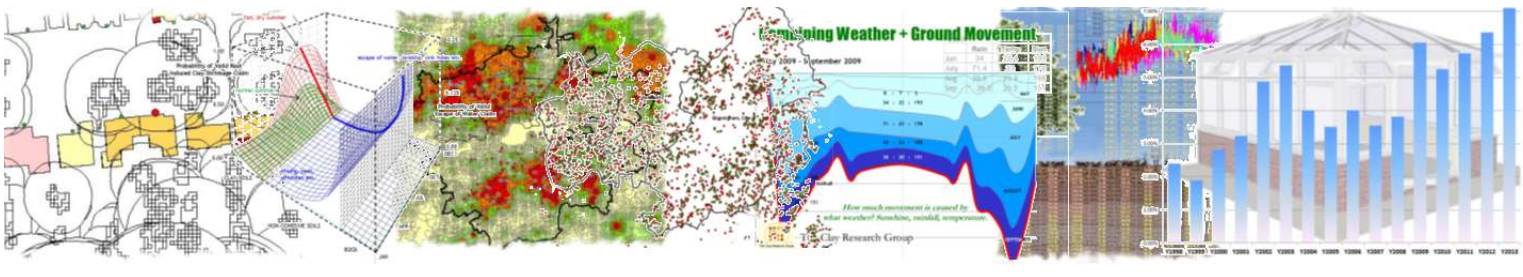
Private Only

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 valid in the summer is just under 80%, and in the winter, it falls to less than 20%. Valid claims in the summer are likely to be due to clay shrinkage, and in the winter, escape of water.

The probabilities of causation reverse between the seasons and the values are typical signatures of an outcropping, highly shrinkable, clay soil.

Liability by Season - SOUTHWARK

District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Southwark	0.683	0.096	0.221	0.04	0.27	0.69



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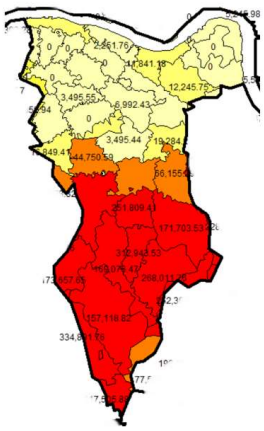
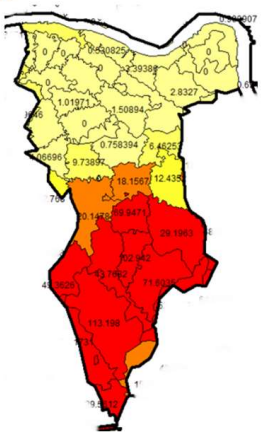
Aggregate Subsidence Claim Spend by Postcode Sector and Household in Surge & Normal Years

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
SOUTHWARK



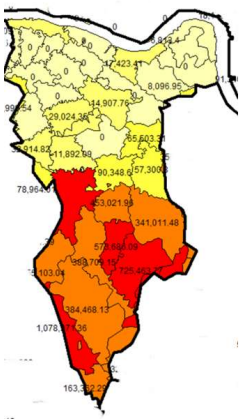
Spend by Sector



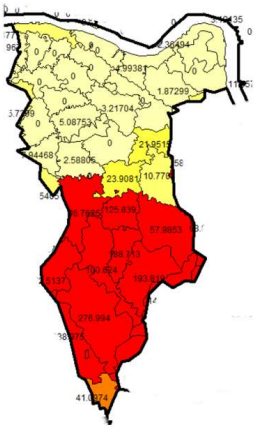
Spend Averaged over Housing Populatio

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.

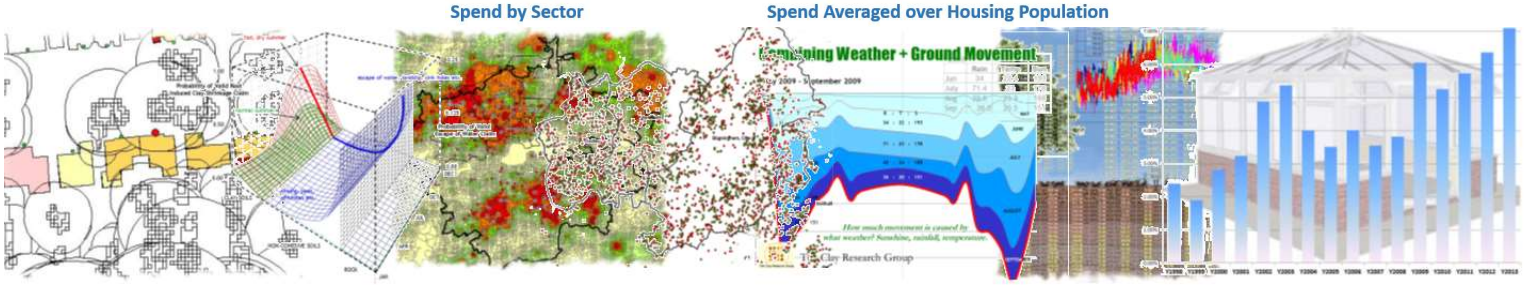
SPEND in SURGE – SAMPLE £419m
SOUTHWARK



Spend by Sector



Spend Averaged over Housing Population



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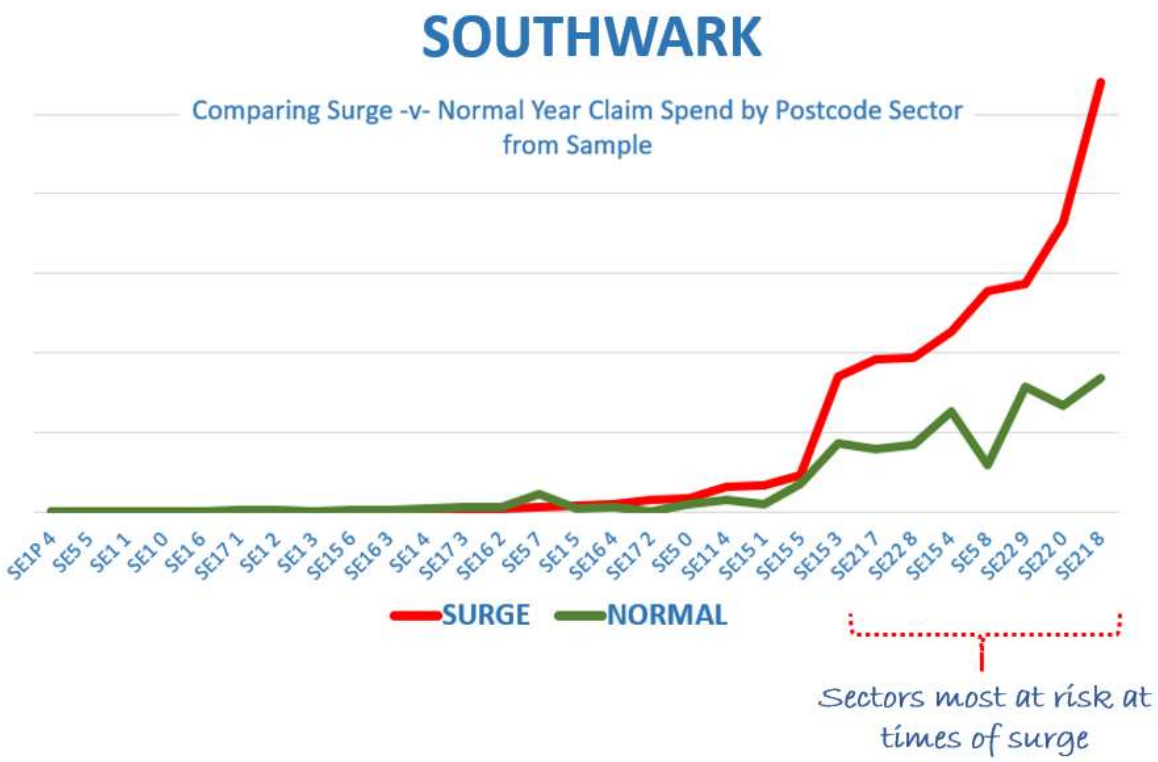
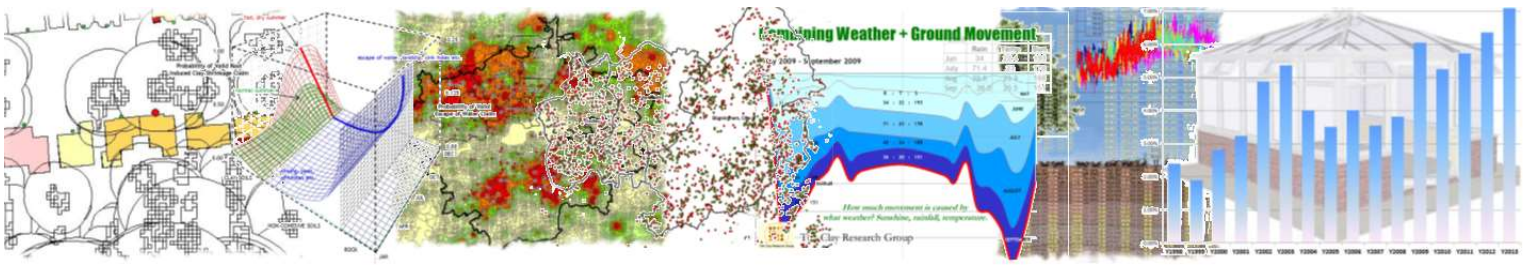


The above graph identifies the variable risk across the district at postcode sector level, distinguishing between normal and surge years. Divergence between the plots indicates those sectors most at risk at times of surge (red line).

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 can 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.



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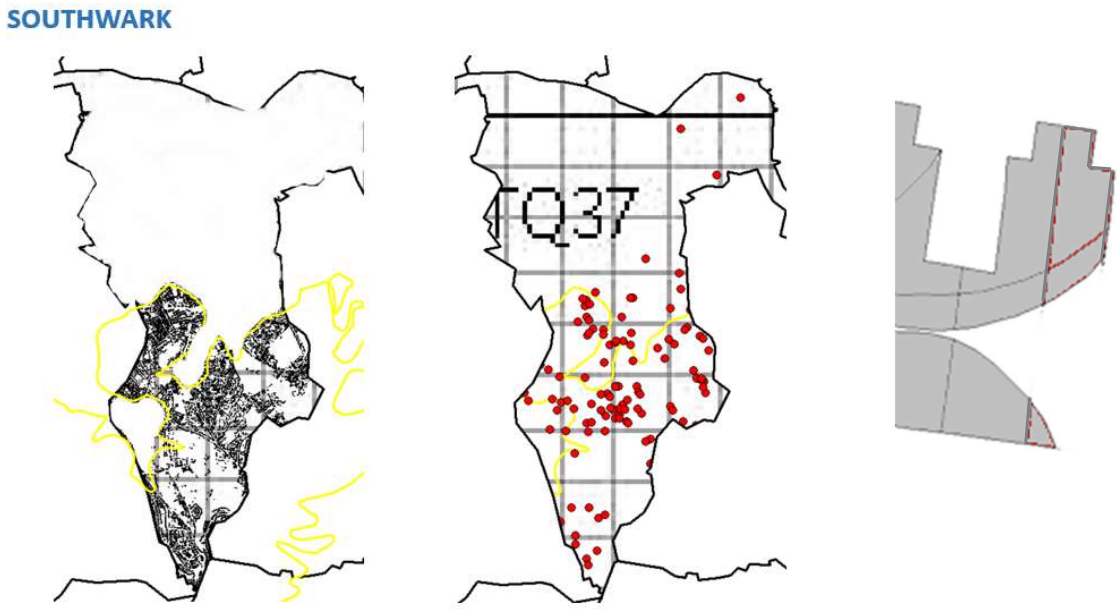
Modelled Root Overlap – Public and Private Trees

Below, left, a map showing the modelled root encroachment (grey shading - public and private trees) beneath domestic properties in Southwark using a root radius = 1.2 x the tree height.



Centre, red dots indicate valid, root induced clay shrinkage claims from a sample of 54k covering the UK.

Right, an enlarged portion of the root encroachment map. Only that area of the house with the modelled root zone beneath its footprint is shown.