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

March 2020
Edition 178

The Clay Research Group

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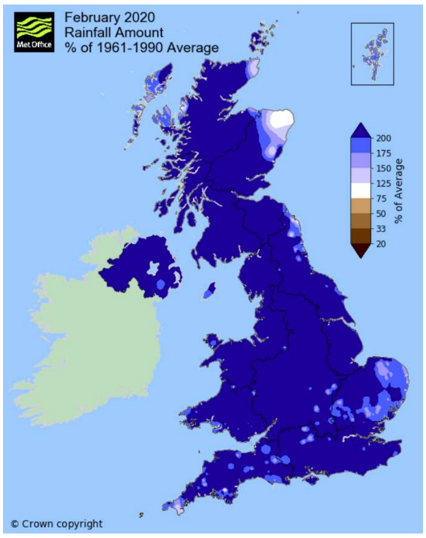
Issue 178, March 2020

Risk Modelling by District

The recent series of subsidence risk modelling extends to Bristol in this edition. Next month we compare the risk between districts with differing ratings to examine how the seasonal probability values link to the geology and compare the outcome for both liability and peril.

For example, how do Bristol and Leicester compare? Both have a variable geology and differ slightly in terms of risk rating. How do they compare with one of the London districts with predominantly outcropping clay?

February Rainfall



Rainfall anomaly map above, provided by the Met Office, plots rainfall for Feb 2020 compared with the 1961-1990 average. Apparently, it's been the wettest February on record.

Subsidence Forum Update

The Subsidence Forum Dissertation Prize scheme offers a cash prize of £500 for the best final year dissertation related to subsidence. For more information go to:

admin@subsidenceforum.org.uk

The closing date for submissions is Friday 4th September at 17:00.

This year's Subsidence Forum Training Day will be held on Thursday 15 October.

Contributions Welcome

Thanks to contributors who have spent time putting together articles on a range of subjects. Updates and comments etc., are welcome. Please Email us at clayresearchgroup@gmail.com.

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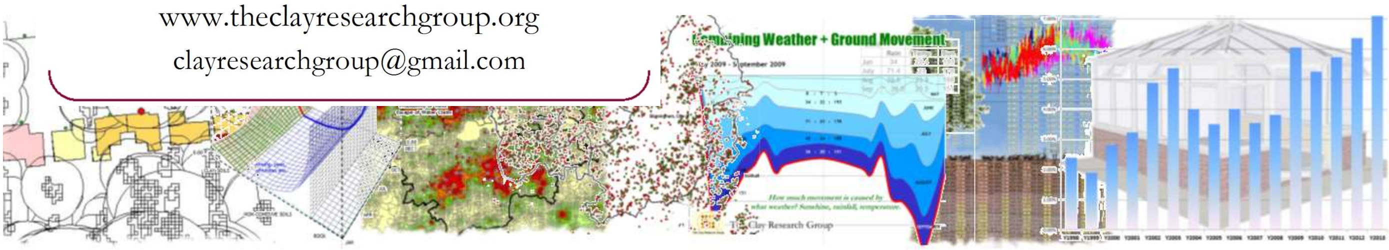

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Tree Research Update

Severing tree roots and irrigating street trees to reduce the risk of subsidence maybe? Just two articles from recent research papers that caught our eye. The paper on root severance entitled, "Responses of mature roadside trees to root severance treatments" was published in the journal Urban Forestry & Urban Greening, Volume 46, December 2019 and can be found on-line at https://www.sciencedirect.com/science/article/abs/pii/S1618866718308094

Amongst other findings, the abstract describes (a) root pruning reduced shoot elongation and leaf area one growing season after root severance including (b) the trunk diameters of trees closest to a road grew less than those further away and (c) root pruning in trenches should not be undertaken closer than 6 times DBH.

Green Stormwater Infrastructure Tree Trench

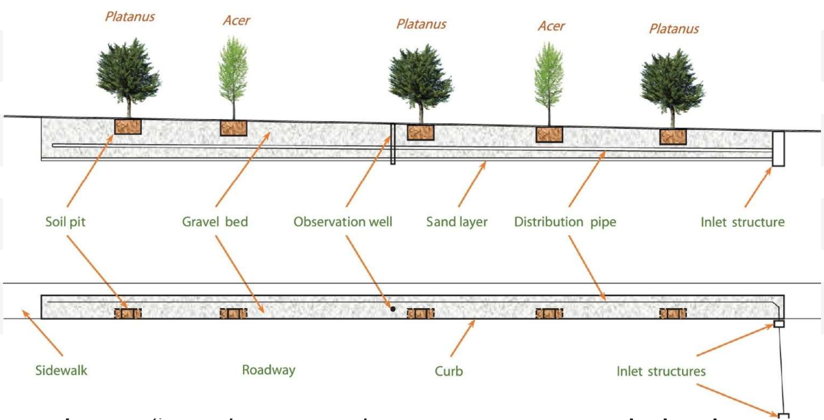
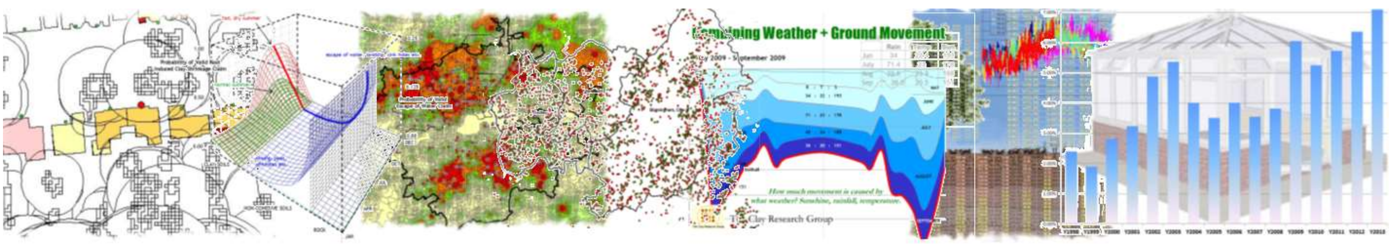


Image from the research paper on tree root irrigation undertaken in Philadelphia

An earlier edition (Volume 41) of the same journal published "Water relations of street trees in green infrastructure tree trench systems" by Caplan *et al.* The above illustration from the paper describes the various elements which include a soil pit to contain the tree root system and a gravel bed, hydrated by a distribution pipe – similar in many ways to the Intervention Technique. See: https://www.sciencedirect.com/science/article/abs/pii/S1618866718305910

The authors recommend that a subset from their experiment should be used – those suffering low levels of distress as a result of the installation.



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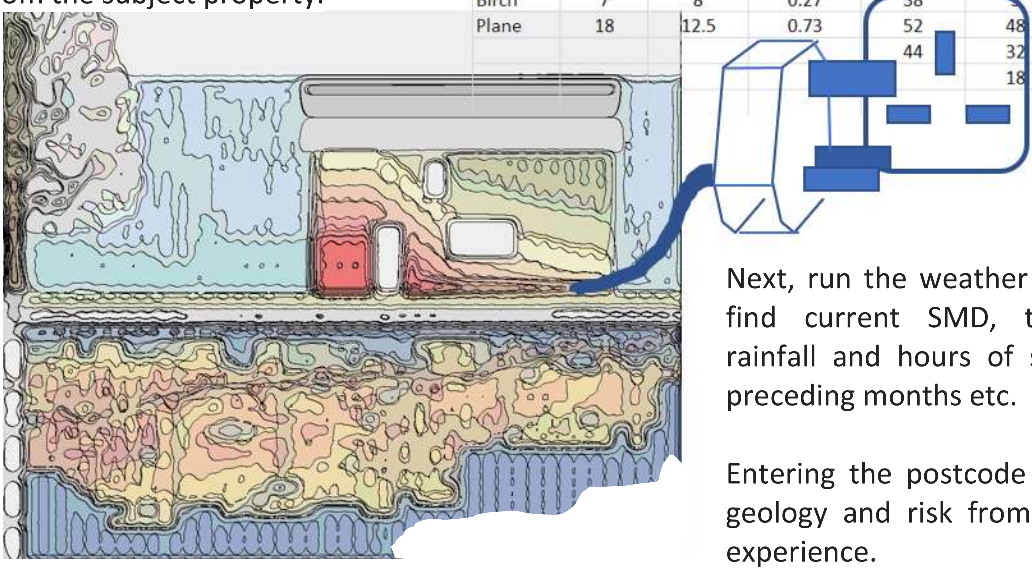
Intelligent Systems – Cracks and Trees

Returning to a topic that we have covered before, below is an illustration of how our 'intelligent system' deals with trees and how their involvement might be determined not by their mere presence but by taking into account their relationship to the damage observed – and the soil type, weather and building age.

First, we enter the properties of the tree - species, height and distance from the subject property.

SPECIES	HEIGHT (mtrs)	DISTANCE (mtrs)	WEATHER	SOIL P.I.	SWELL (mm)	RATING
Oak	22	12	0.58	45	45	0.68
Conifer	5	1.5	0.44	27	18	0.13
Birch	7	8	0.27	38	3	0.11
Plane	18	12.5	0.73	52	48	0.71
				44	32	0.3
					18	0.07
						0.42



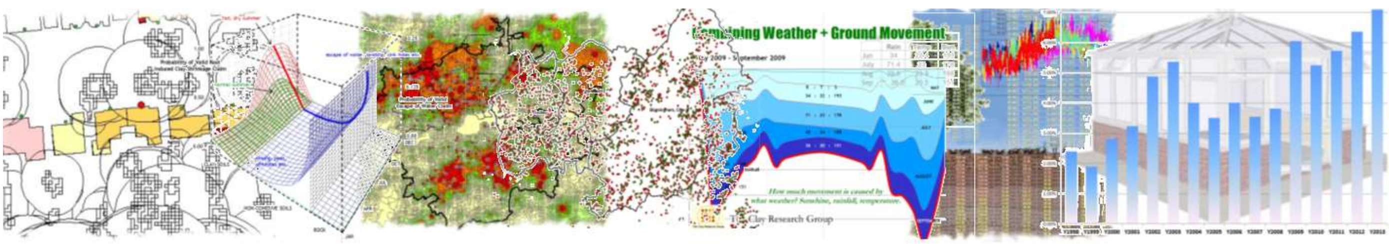
Next, run the weather database to find current SMD, temperature, rainfall and hours of sunshine for preceding months etc.

Entering the postcode delivers the geology and risk from past claims experience.

Then press the button and watch the image adjust to model a range of outcomes that suggest where, if the tree is involved, we might expect to find crack damage. The image above shows the most likely situation for crack damage for a given combination of the above elements, with the likelihood of the tree being implicated dissipating with distance away from their loci.

The database is built from past claims experience and the intelligent system combines the data to determine what has gone before. The outcome tells us the threat by species and metrics for each when they have been proven to be implicated following extensive studies involving precise levels, site investigations and soil sampling. That list has been published in earlier editions but how does the system deal with change? How does it learn?

This is where the sigmoid learning curve comes in. Rather than change every time some odd and conflicting result is encountered, it may (subject to pre-determined rules) change quite quickly at first, slowing as the change increases to make sure any amendments are warranted.



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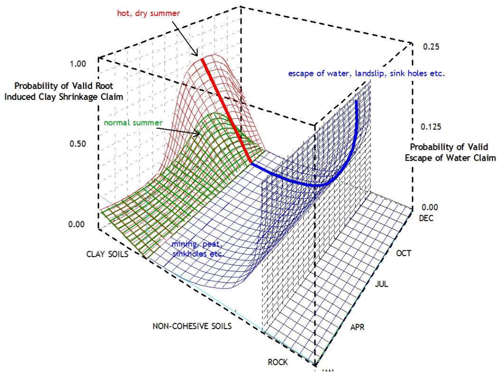
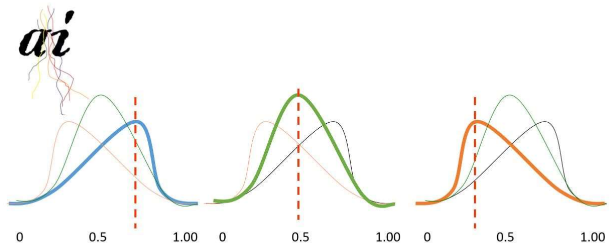
Change over time and Ai

If the vegetation is a potential cause of damage, the final step of this initial assessment is matching the location of the damage to the model. If they coincide then the likelihood of the claim being valid increases.

What degree of accuracy does the model deliver? If (a) the tree is implicated and (b) the damage coincides, then a probability of 0.5 or higher is a positive indicator. This may seem a low figure but given that we are examining the imponderables of the weather, vegetation and soils, it is a sensible value.

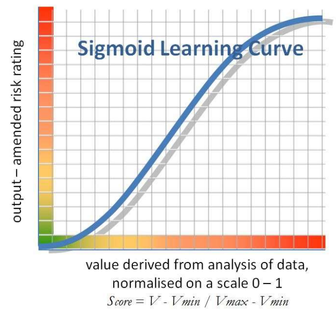
The probability cube resolves the issues of past experience including values for weather, geology, trees etc., all at postcode sector level and by month. See right. Simply link to the current weather module to derive an idea of risk.

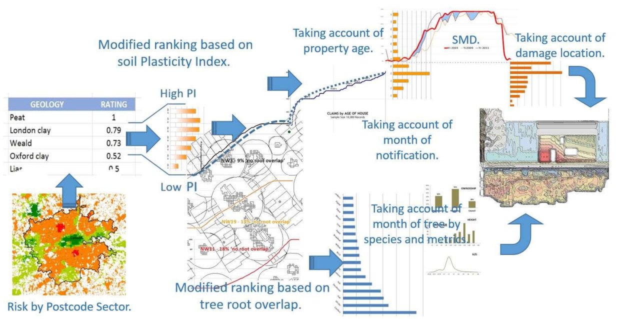




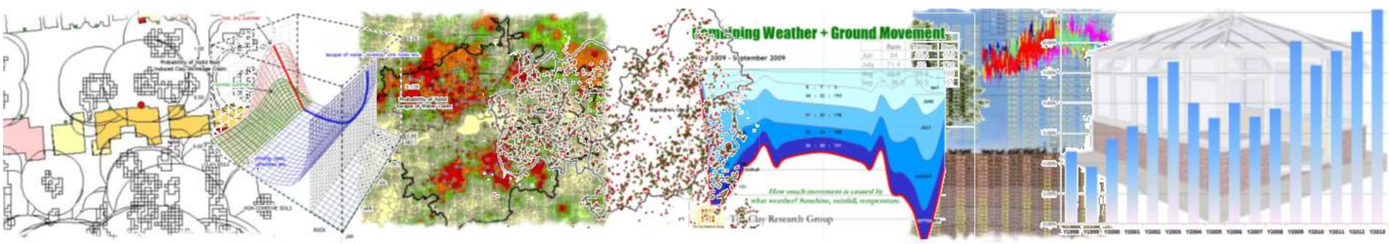
Account is taken of a changing world and climate change etc., (plus improved understanding of the risk posed by vegetation in response) by distribution graphs as shown left.

Distribution analysis leading to changes in the output need to be accounted for at differing rates and each has a unique sigmoid learning function. For example, does one dry summer change the view of risk for all? When a borough fell troublesome trees of a certain species, does that reduction in claims change the risk the tree species pose?





Linking them altogether is shown, left. How the weather influences the risk taking into account geology, tree species, height and distance from damaged building etc.



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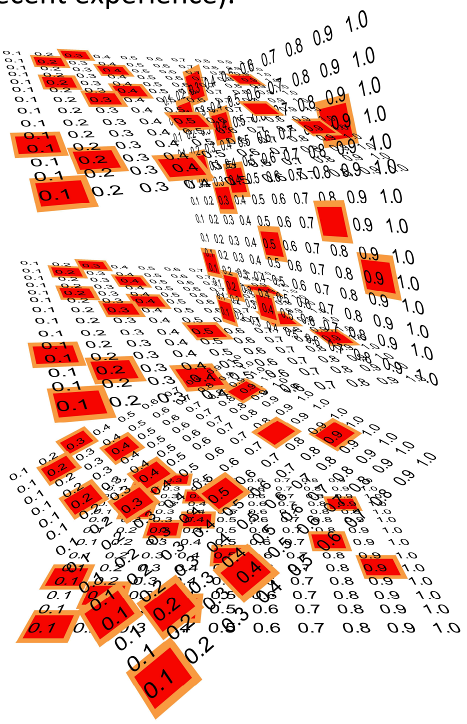
Data – Understanding the Value and Shortfalls when Mapping Risk

Our ‘subsidence risk by district’ mapping series refers to a specific claim sample and defines a risk which varies not only by year, but also by season and of course, by portfolio. Some of the maps plot frequency data, others, count, probability or cost. Others will describe the ratio – for example, house types (terraced, detached, semi-detached etc).

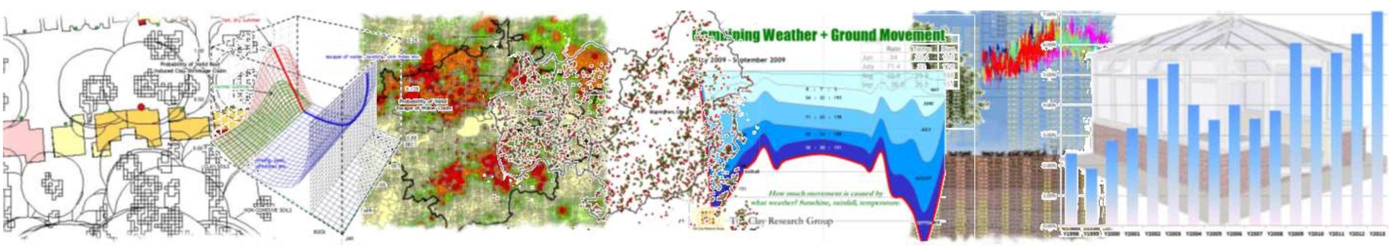
The risk in relation to the UK at district level in some instances may appear high but it has to be compared with the relatively low risk of the majority of UK sectors which are rated low risk. It’s also important to note that postcode sector risk values are graded on a national scale. For example, a score of say 0.3 relates to a national scale of 0 – 1 and is not restricted to the value for postcodes within the district under consideration.

Housing populations and claim ratings are a ‘snapshot in time’ estimate. Housing data is mostly taken from the 2011 census. Then there is the question of how the datasets compare – 2011 housing data may not compare with the year of the claim sample. The spend maps relate to a sample of 43,000 valid claims, perhaps spanning two or three years (more likely 4 years from recent experience).



The series seeks to outline a method of enhancing our understanding of the risk of domestic subsidence - where it is most often encountered and the link with the underlying geology. How claim numbers relate to population densities and most importantly, the seasonal element which can assist in triage and claims handling. What can we expect to find when asked to handle a claim in an area where we have little experience?

On the other hand, the risk is that we make decisions based not on our findings on site, but on what the system tells us, which is where the claims handlers and engineers expertise comes in.



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Subsidence Risk Analysis – Bristol

Bristol occupies an area of around 110km^2 and has a population of around 430,000.

Distribution of housing stock using full postcode as a proxy. Each postcode in the UK covers on average 15 houses, although there is significant variation.

Mapping housing distribution across the districts (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?

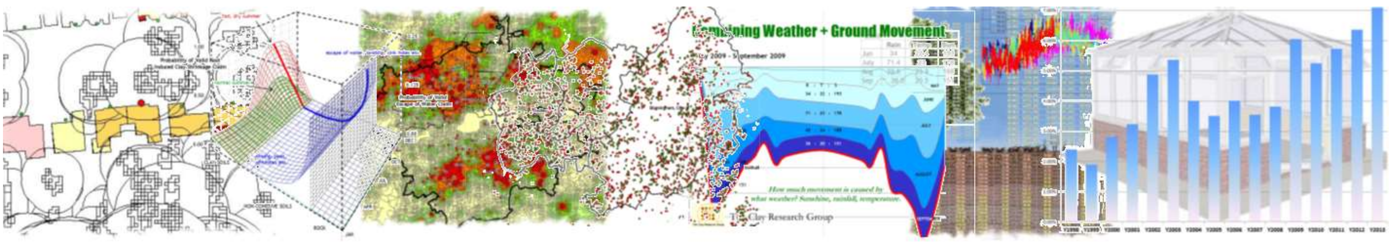
Using a frequency calculation (number of claims divided by private housing population) the relative risk across the borough at postcode sector level is revealed, rather than an absolute 'count of claim' value.

The areas are rated for the risk of domestic subsidence as shown on the map, right, in relation to the UK district average. The highest risk rating on the national scale is 4.

From the sample of claims, Bristol is ranked 35th in the UK - 1.87 x the national average.

It has a variable geology consisting of superficial drift deposits of alluvial soils overlying mudstones, limestones, Westphalian measures and clays of the Lower Lias series.

Layout of the district used for risk analysis above. Bristol has an estimated population of around 430,000 and an area of 110km^2.



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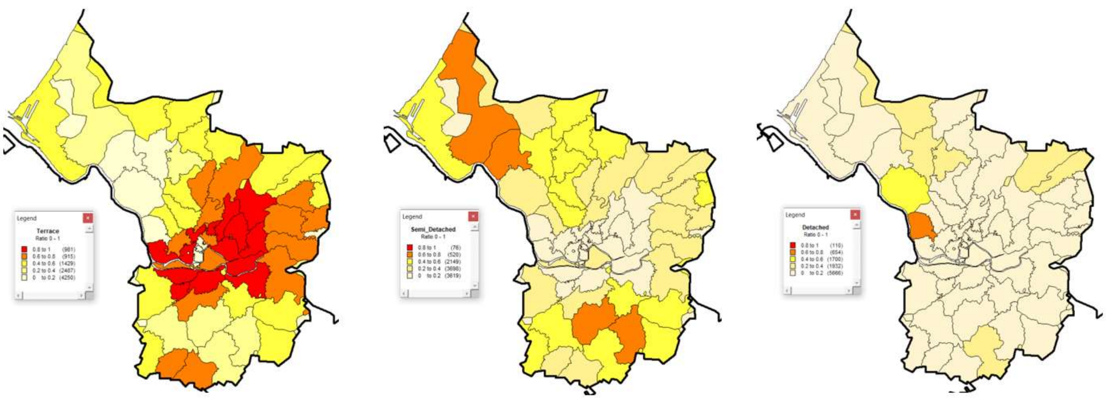
Bristol - Properties by Style and Ownership

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 – the age of the property. As we have seen from earlier studies, risk increases with age.

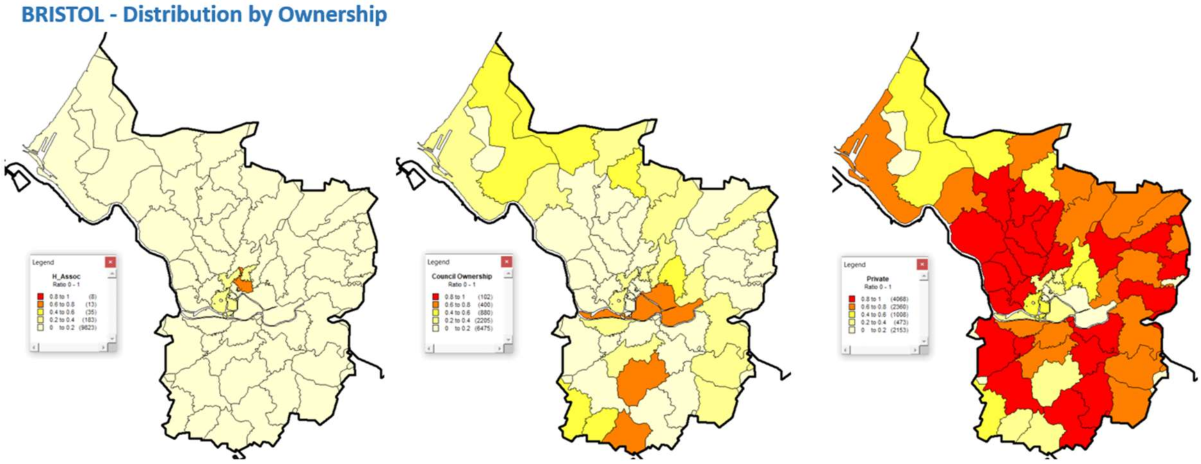
BRISTOL - Distribution by House Type



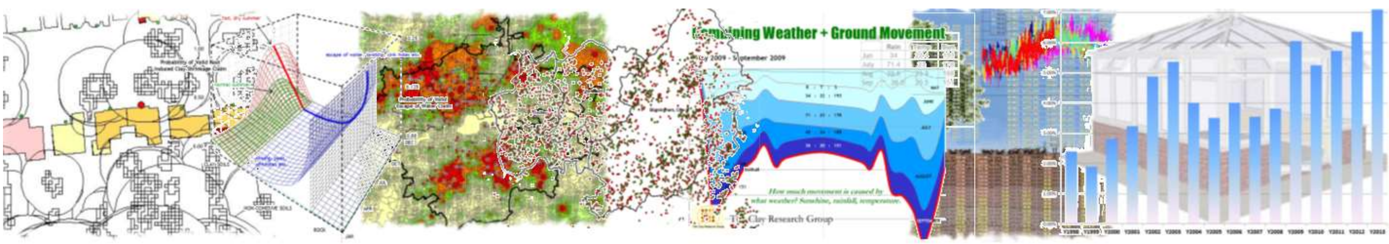
Terraced **Semi-Detached** **Detached**

Distribution by ownership is shown below. The maps reveal predominantly privately-owned properties across the borough, with a high concentration of terraced houses towards the centre.

BRISTOL - Distribution by Ownership



Housing Association **Council Ownership** **Private Ownership**



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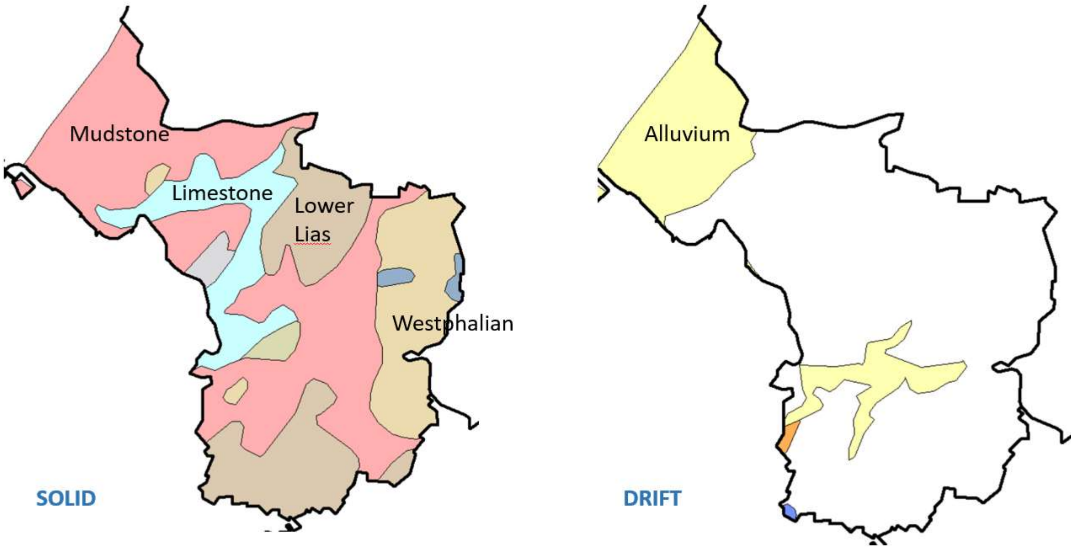
Subsidence Risk Analysis - Bristol

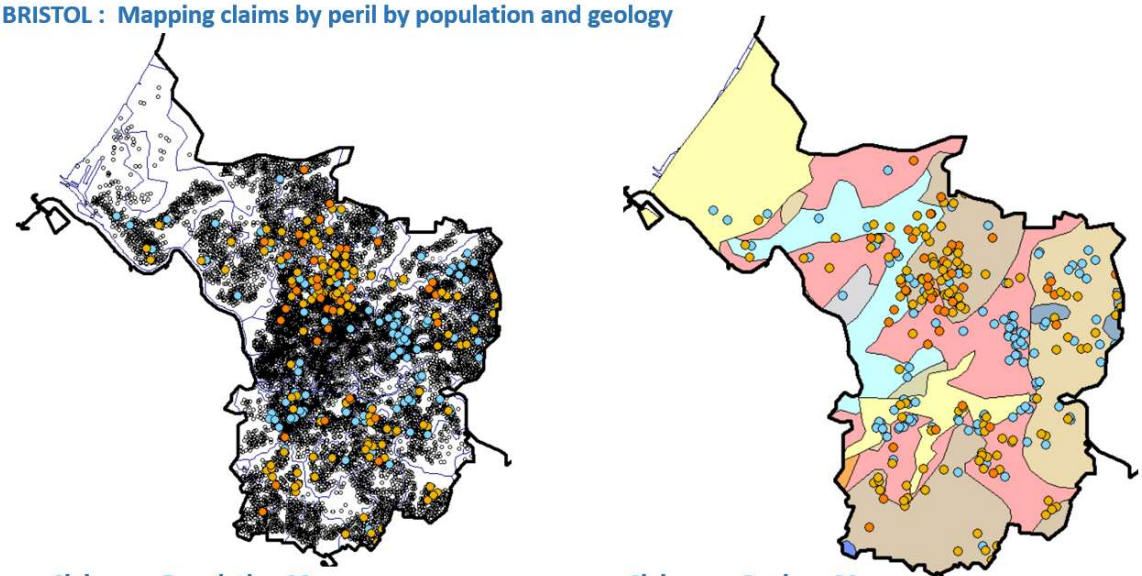
Below, extracts from the British Geological Survey maps showing the solid and drift series. View at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html

BRISTOL : BGS Geology – 1:625,000 scale low resolution mapping



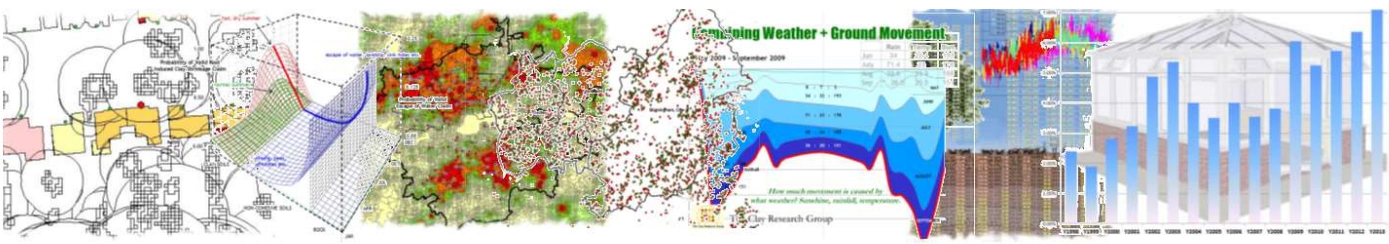
See page 12 for a seasonal analysis, which reveals a fairly balanced number of valid claims in the summer and winter, reflecting the variable geology.

BRISTOL : Mapping claims by peril by population and geology



Claims on Population Map

Claims on Geology Map



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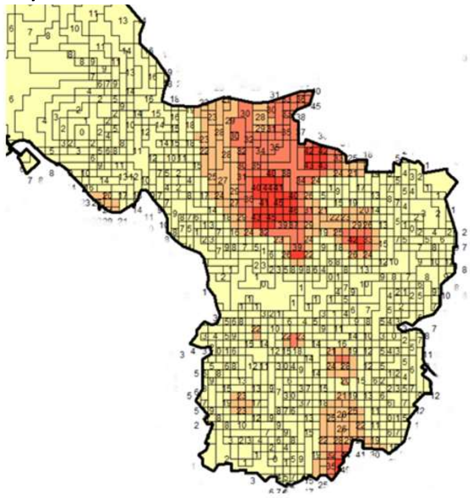
Liability by Season and Geology

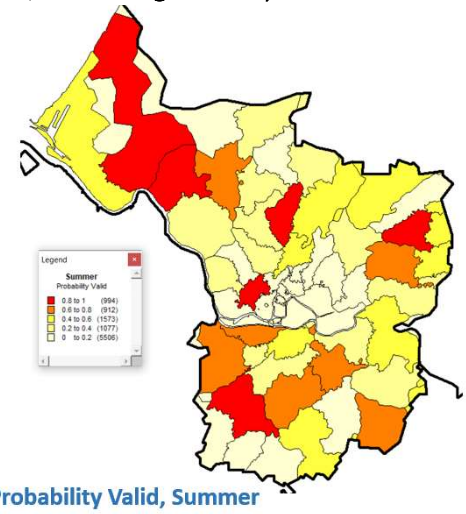
The average PI derived from site investigations by postcode sector (left, below) and interpolated on a 250m grid to deliver the CRG model (below, right). The presence of a shrinkable clay to the north of the district (compared with the alluvial soils shown on the BGS series) suggests the superficial deposits have a clay content.

Soil PI Averaged by Sector

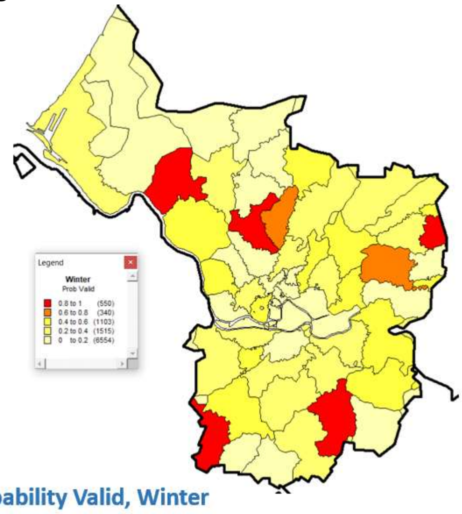


PI Interpolated on 250m CRG grid

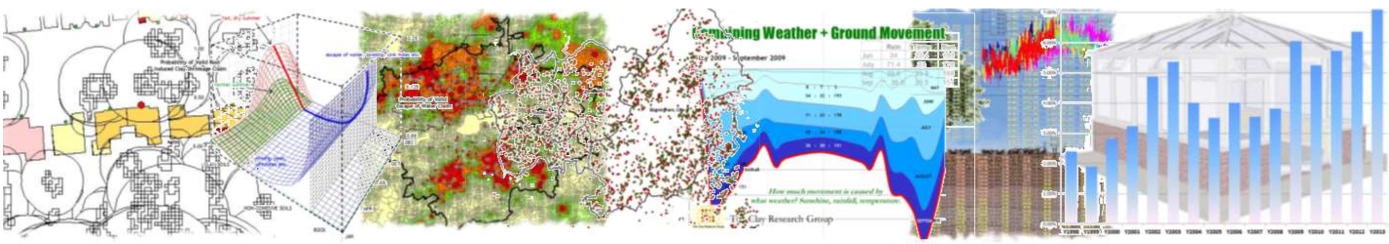
A borehole close to the M5 to the north of the district on the alluvial soils taken from the BGS web site records "stiff very closely fissured brown very silty clay with occasional dark brown very clayey silt inclusions" from ground level down to 1.45mtrs bGL. Below, the probability of whether a claim is likely to be valid or declined by season. There is little to choose between claim numbers seasonally. Valid claims are more likely in the summer months, reflecting the clay content of the underlying soils to the north and south west.



Probability Valid, Summer



Probability Valid, Winter



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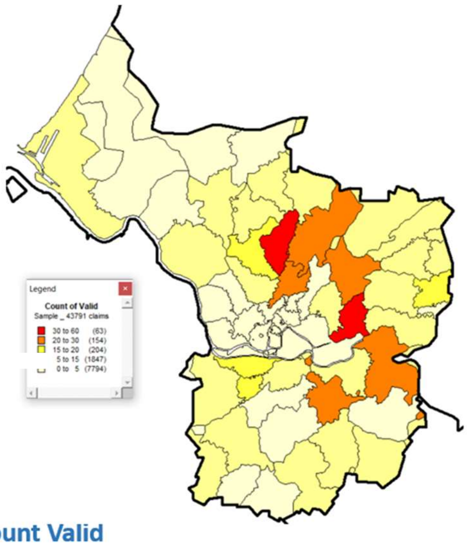
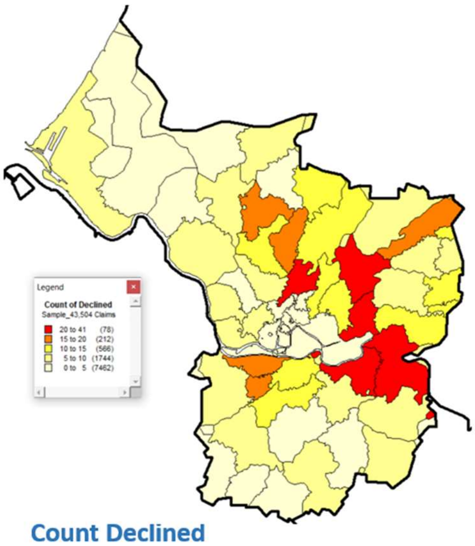
Liability by Sector.

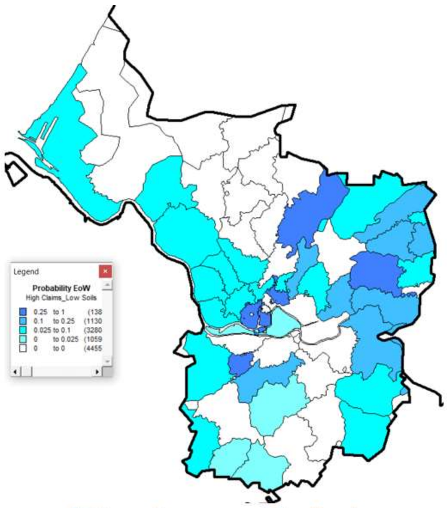


Count Valid

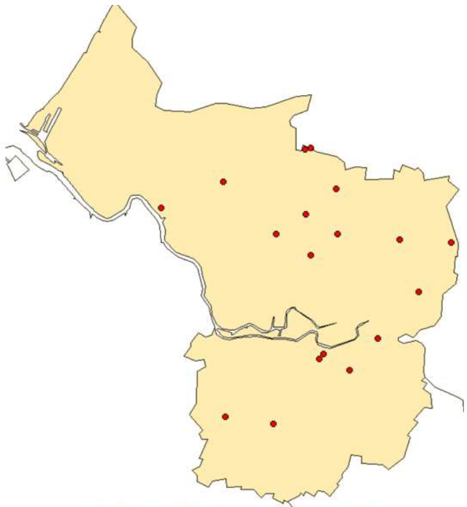


Count Declined

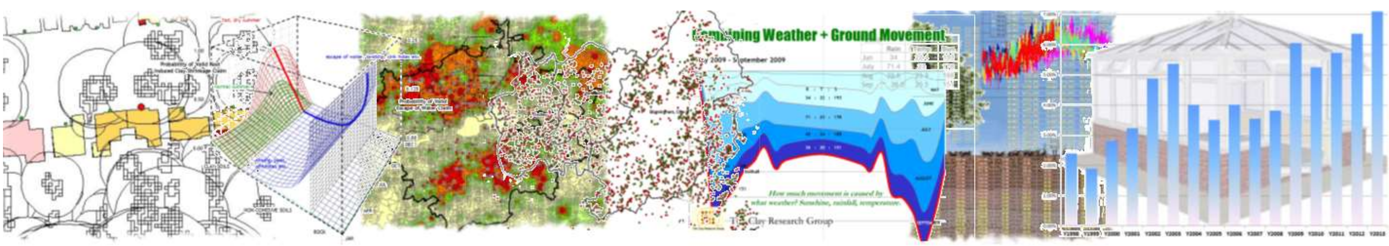
Above, mapping liability and plotting distribution of valid and declined claims for the sample size shown, not taking into account any seasonal influence. Below left, mapping the frequency of Escape of Water claims from the sample reflects the primarily non-cohesive drift deposits in the vicinity – Till, sand, sandy gravels and alluvial soils – and the population density. Below, right, dots on the 'Council Tree Claims' map, represent properties where damage has been attributable to vegetation in the ownership of the local authority.



Escape of Water Frequency Distribution



Local Authority Street Tree Claims



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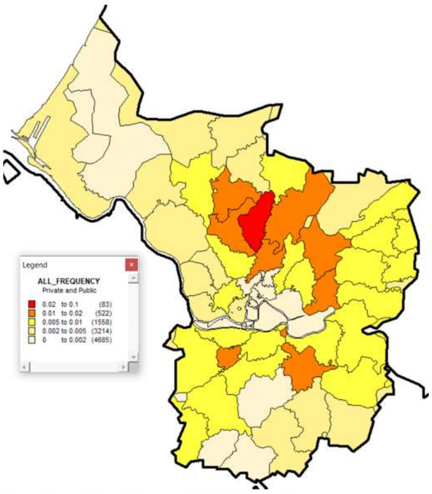
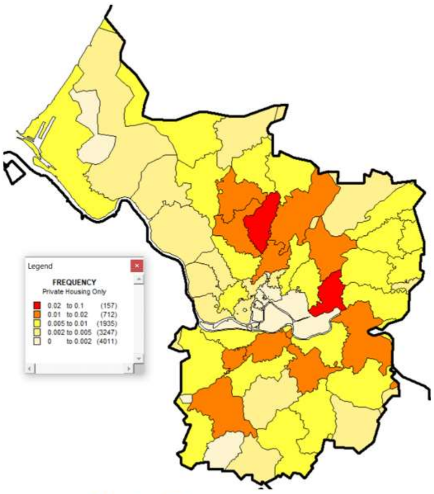
Bristol - Frequencies & Probabilities

BRISTOL - Postcode Sector Subsidence Risk (frequency) by Ownership



Combined Public and Private Frequency



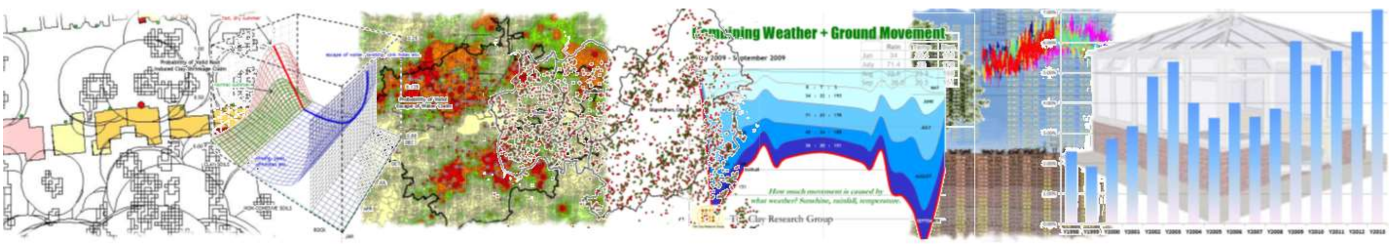
Private Only

Above, private housing map links risk with the CRG geological map on page 8. Below, the figures reveal a borough with a fairly balanced seasonal risk, reflecting the variable geology and the even and widespread distribution of private housing. The chances of a claim being declined in the summer are just under 40% and if it is valid, there is a slightly higher probability that the cause will be clay shrinkage. In the winter, the repudiation rate remains steady at around 37% and if the claim is valid, there is a slightly higher probability the cause will be water related. The probabilities of causation reverse between the seasons.

To improve our understanding a postcode sector analysis would be more useful.

Liability by Season - BRISTOL

District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Bristol, City of	0.341	0.277	0.382	0.28	0.35	0.37



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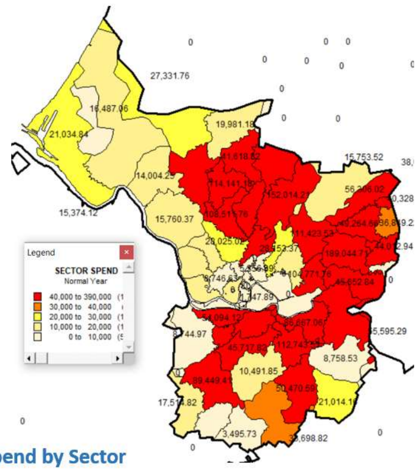
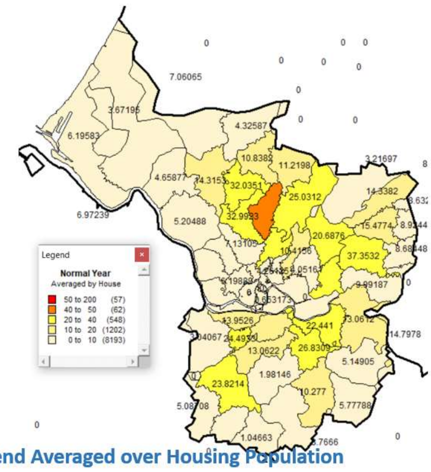
Aggregate Subsidence Claim Spend by Postcode Sector and Household to Derive Risk and Premium in Surge & Normal Years

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 reflect the study sample and will vary by the insurer's exposure and distribution.

NORMAL YEAR SPEND - BRISTOL



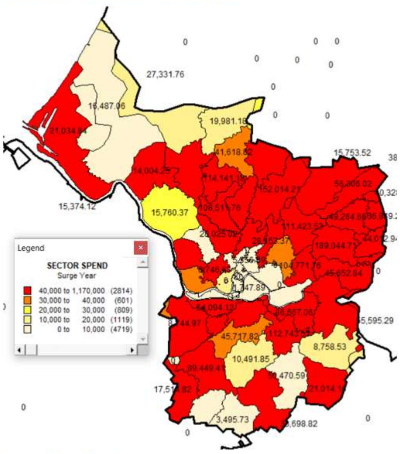
Spend by Sector



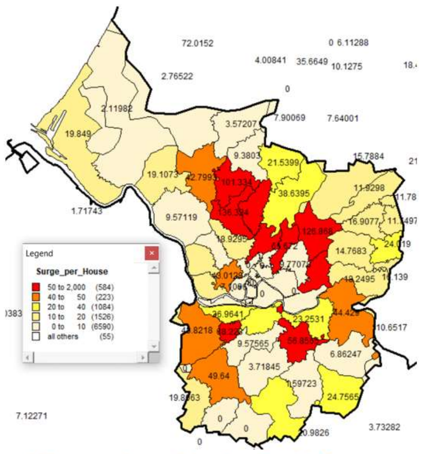
Spend Averaged over Housing Population

It will also be a function of the distribution of vegetation and age and style of construction of the housing stock. The image to the left in both examples represents sector spend and the figures to the right, sector spend averaged across housing population to derive a notional cost per house.

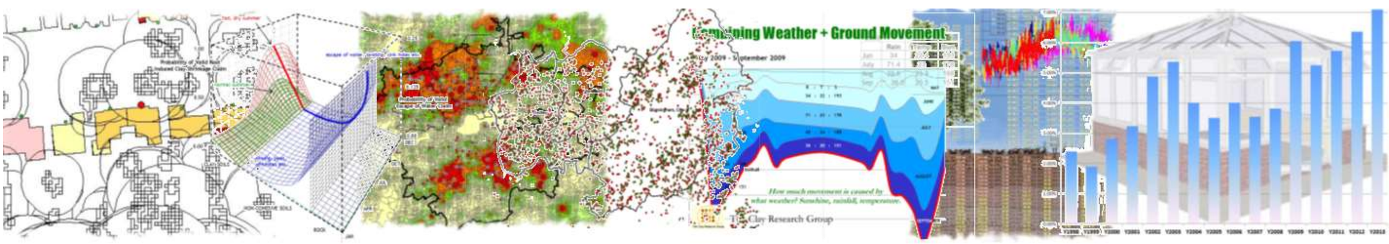
SPEND in SURGE - BRISTOL



Spend by Sector



Spend Averaged over Housing Population



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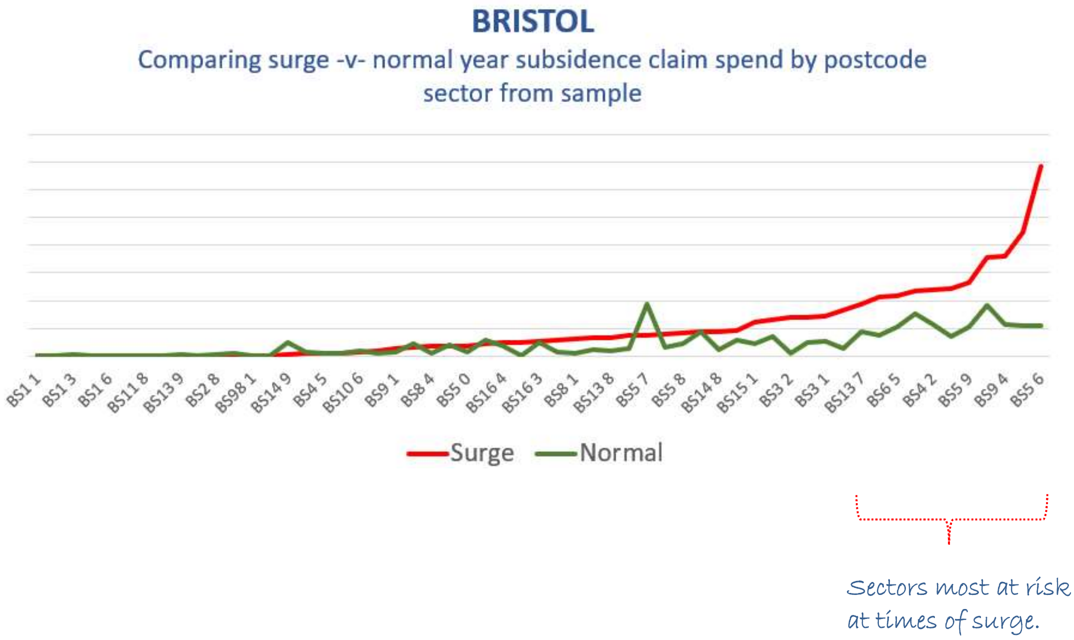

Identifying the variable risk across the district between normal and surge years by postcode sector. Divergence between the plots suggests those sectors that appear to be more at risk in surge.

In making an assessment of risk, housing distribution and count by postcode sector plays a significant role. One sector may appear to be a higher risk than another based on frequency, whereas basing the assessment on count might 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 appear less of a threat than it actually is.