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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

October 2022
Issue 209

The Clay Research Group

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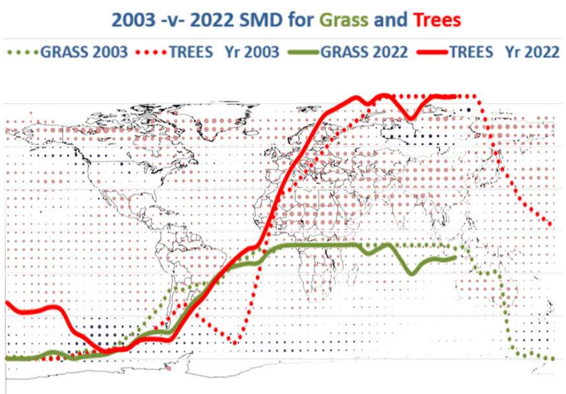
Issue 209, October 2022

Soil Moisture Deficit

Below, SMD values provided by the Met Office from the Heathrow weather station, for both grass and tree cover.



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

The 2022 profiles for both tree and grass cover continue to follow the 2003 event year.

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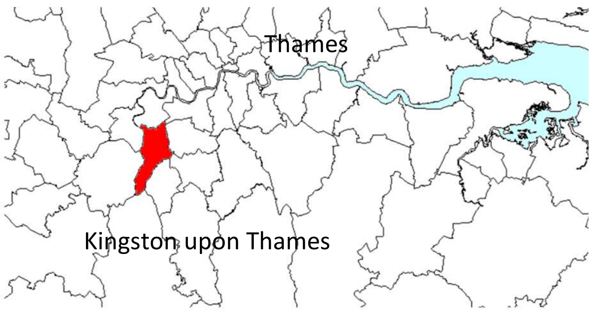
District and Sector Risk

Kingston upon Thames is the topic of the District Risk series in this month's edition and increased resolution is provided with examples at postcode sector level.

The study includes a review of cause and liability by season, providing a useful reference for underwriters, engineers and claim handlers.



Data Analysis

Different datasets are used to assess risk – some list claim numbers, others contain cause, perhaps settlement costs and date of notification.

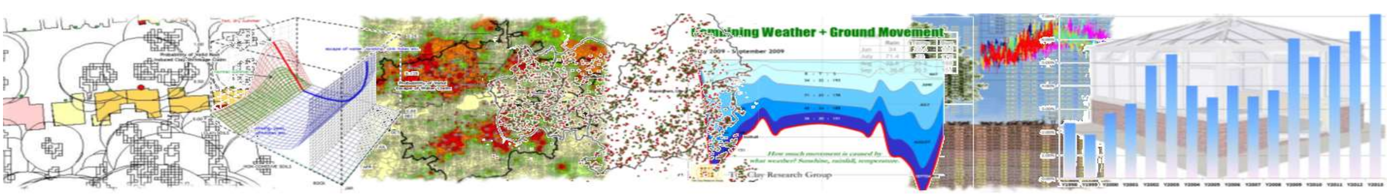
The risk maps in this newsletter access a database containing in excess of 100,000 claims, including notifications from both event and normal years.

Districts in the south east, on clay soil, are often rated as being at a much higher risk of subsidence which is a function of the geology. There are a similar number of claims across the remainder of the UK but spread over a larger area and with a variable geology that presents a reduced risk. The phrase 'the district presents a risk 'x' times greater than the average' should be read in this context.

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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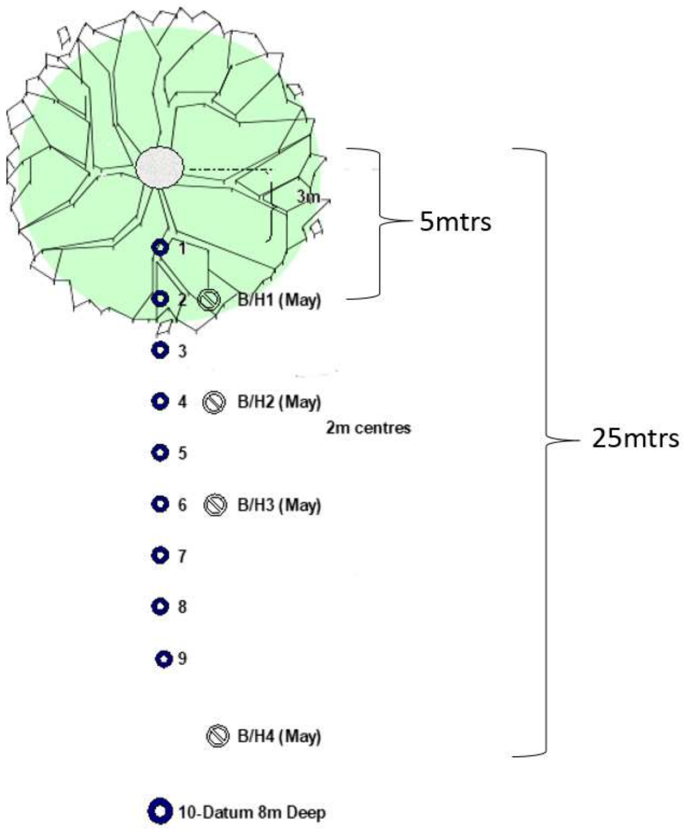
Tree Root Water Uptake – Aldenham Willow

Precise levels taken at the site of the Aldenham willow provide useful information determining water uptake across the root zone, how the root system develops over time and the response to seasonal changes.



Left, a plan showing the location of level stations 1 – 10 (station 10 is the 8m deep datum) established in May 2006.

Four boreholes were sunk in the same month. BH1 was 5mtrs from the tree, BH2 9mtrs, BH3 13mtrs and BH4 25mtrs.

Soil samples retrieved from the boreholes were tested using moisture content relative to plasticity index, oedometer and soil suctions.

The purpose of this exercise is to combine estimates of swell from the laboratory analysis with subsequent ground movement to try to improve our understanding of root activity.

For example, we know that soils tend to be drier closer to the tree, with the deficit diminishing with distance but what happens when soil suctions exceed the ability of roots to withdraw moisture from the ground? From the data gathered it appears the peripheral roots play an increasingly important role and the drier soils (those nearer the tree) are allowed to rehydrate, suggesting the roots near the tree are somehow 'switched off'.

The following pages illustrates a 'balancing out' across the root zone over time. Clearly this exercise applies to the Aldenham willow and the findings can't be used generically, but data gathered over time has provided an interesting insight into the dynamics of moisture uptake.

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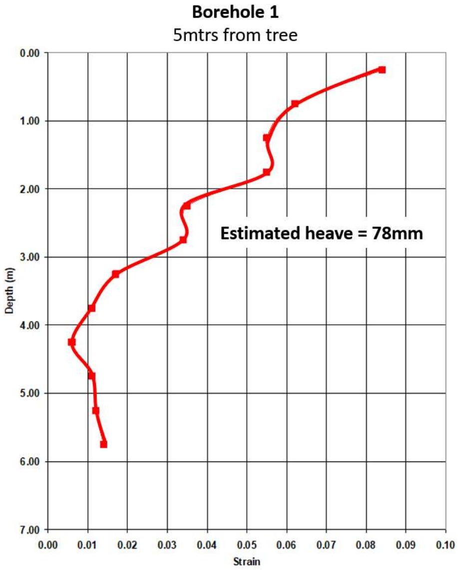
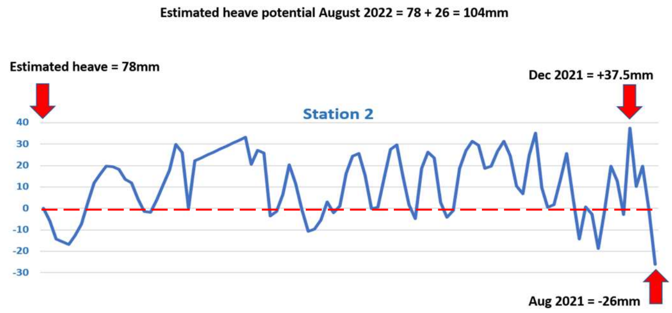
Tree Root Water Uptake

Borehole 1, sunk in May 2006 and 5mtrs from the willow, revealed significant desiccation to a depth of 4mtrs bGL with an estimated heave potential of 78mm. The borehole was situated toward the periphery of the canopy.

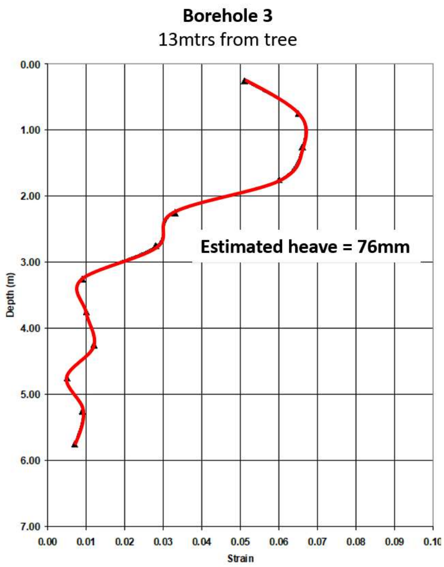


Monitoring by GeoServ Ltd., recorded seasonal movement at the nearest station (station 2 - see below) with maximum recovery from the initial datum of 37.5mm in December 2021 followed by subsidence of -26mm from the datum.

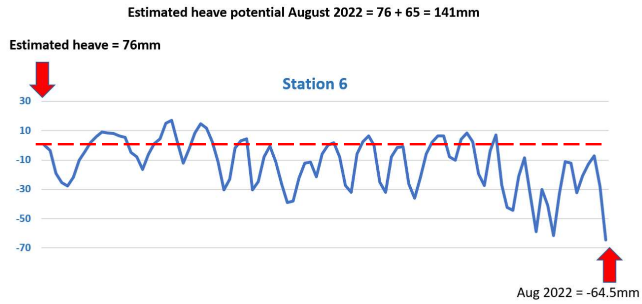
Taking into account the estimated heave potential from the initial site investigation undertaken in May 2006 (see left) the heave potential in August 2021 = 78 + 26 = 104mm.

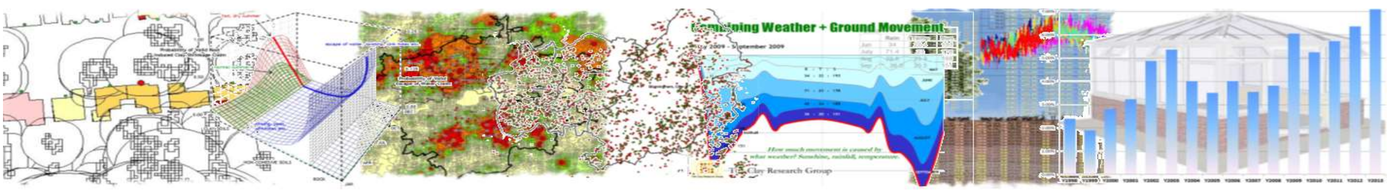


BH3 adjoins level station 6. The estimate of heave derived from testing the soil samples using the oedometer was 76mm in May 2006.



In August 2022, precise levels revealed the station had subsided 64.5mm from the starting point in May 2006, delivering a revised estimate of total heave on rehydration of around 140mm – the area of maximum potential recovery is around 13mtrs from the tree – close to its height.





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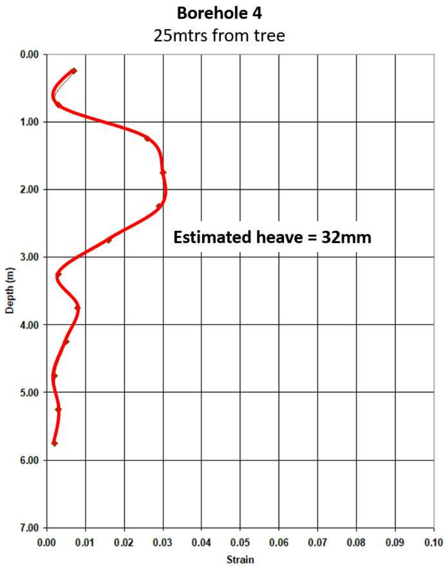
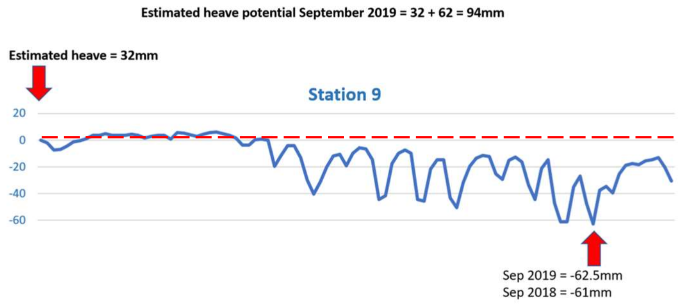
25mtrs from the tree at BH4 (below), the estimated heave in May 2006 using the oedometer test was estimated to be around 32mm.



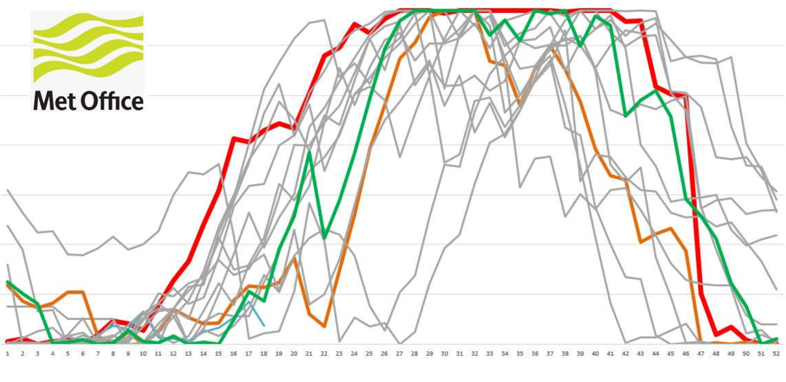
Precise levels (below) have shown gradual downward movement – root activity and water uptake have increased whereas movement nearer the tree (above – station 2) has generally been positive, suggesting root activity to have declined slightly.



Maximum subsidence of 121.3mm has been recorded at Station 25, 21mtrs from the tree in an adjoining array. In summary, soil tests in May 2006 revealed higher levels of desiccation closer to the tree, dissipating with distance towards the root periphery. There has been a general pattern of recovery closer to the tree, and increased subsidence towards the root periphery. The ground 13m from the tree (nearly matching its height) shows the maximum potential for movement of 140mm.

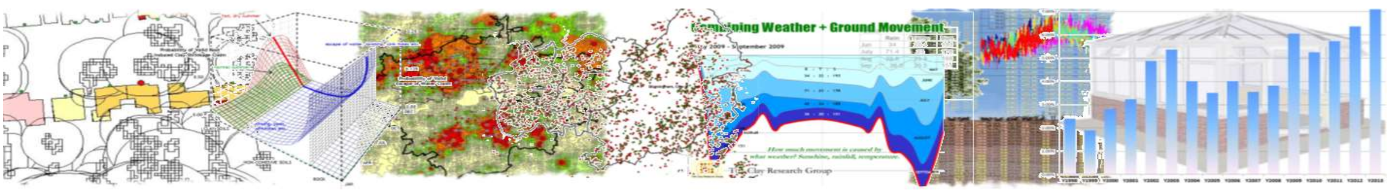
Soil Moisture Deficit and Event Years

Below, profiles of the SMD for years 2003 onwards for grass cover and medium available water capacity soil. Event years 2003, 2006 and 2018 are plotted against normal claim years. The three years peak at the maximum value for grass cover (134mm) in July. 2003 values began rising early in the growing season with little change throughout the summer, no doubt accounting for the high claim numbers.



All data provided by the Met Office from the Heathrow weather station.

2006 and 2018 follow similar profiles until August, when rainfall in 2006 reduced the SMD quite sharply. July appears to be significant in terms of a link between soil moisture deficit and claims, revealing the role of even short bouts of rainfall which reduce the risk as can be seen from plots of non-event years that reach a peak in July, but with a diminished influence due to short, intermittent spells of rainfall.



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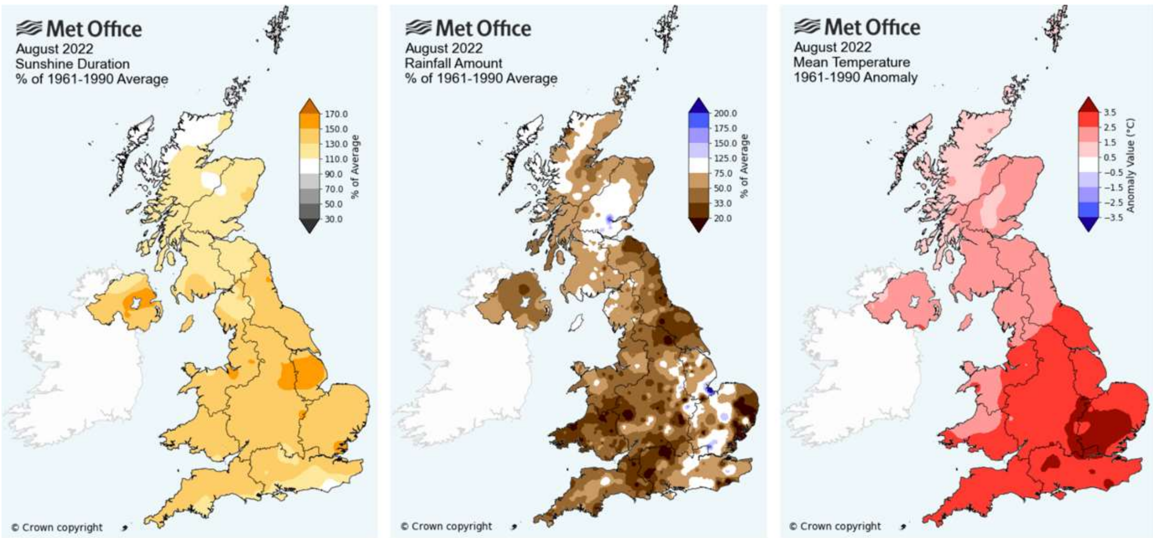
August Anomaly Maps

Below, Met Office anomaly maps showing sunshine, rainfall and temperature for August 2022, compared with the 1961 – 1990 average.

August had higher levels of sunshine duration, was much drier across most of the UK and far warmer, particularly in the SE.



The graphs, right, plot the annual weather data from the Met Office for the Heathrow weather station for the period 2003 to 2021.

Top, rainfall was particularly low in 2003 and the hours of sunshine particularly high in the surge years, 2003, 2006 and 2018.

The extended hours of sunshine are matched in the 'maximum temperature' graph, bottom right.

Rainfall data is shown for April to October and hours of sunshine and TMax for June through to September, inclusive.

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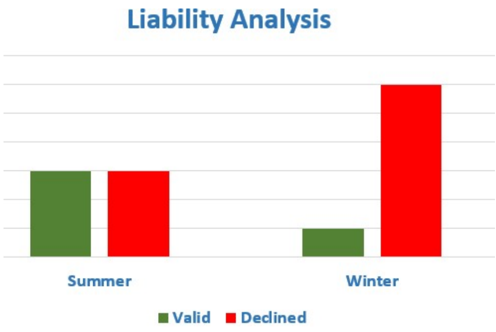
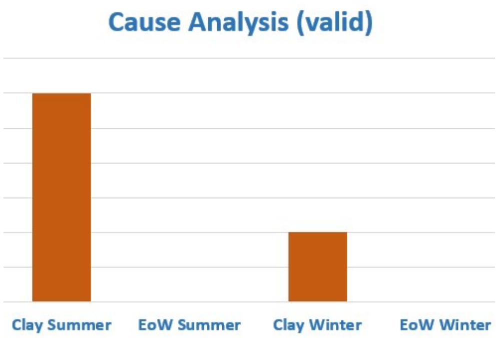
Using Past Claims Data to Infer Geology and Derive Probability of Cause and Liability
Sample Sector Level Analysis





KT3 4 – 50% of claims accepted as valid in the summer and around 14% in the winter. It is rated 6.5 times the UK average risk.

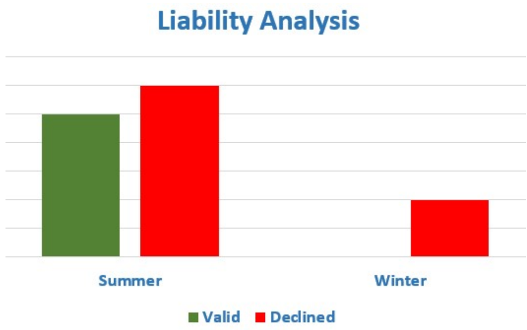
Clay shrinkage is the dominant cause of subsidence in the sector in both summer and winter. There are no claims related to escape of water in the winter or summer from the sample we hold.

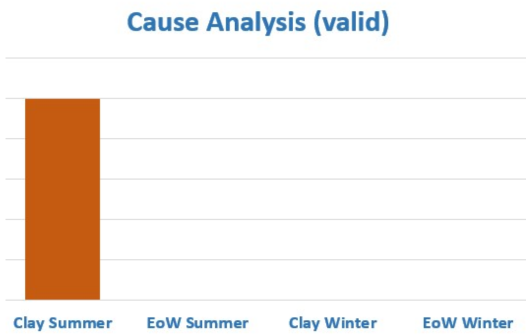
The BGS maps show a solid geology of outcropping London clay with drift deposits of River Terrace.

KT5 8 – Situated to the centre of the northern part of the district with predominantly clay shrinkage claims in the summer and escape of water claims in the winter.

The sector is rated 3.2 times the risk of the national average. This value seems perverse given the relatively low number of claims notified. This is due to the lower density of private housing and the use of frequency (claims/private housing population) to estimate risk.

Site investigations revealed outcropping clay soil with a PI of around 40% and superficial deposits of River Terrace.





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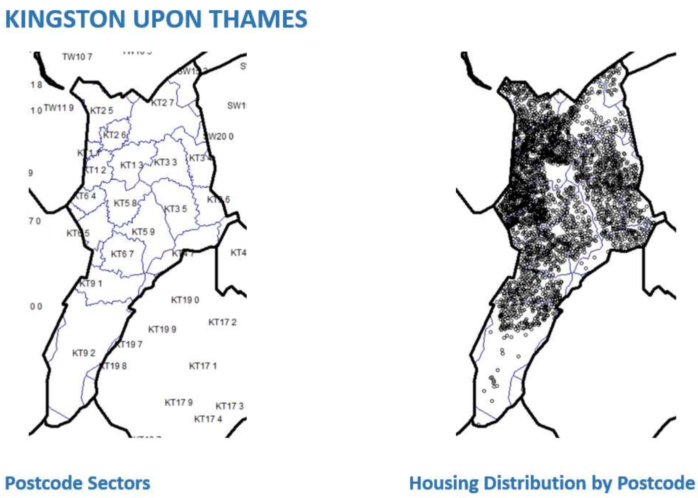
Subsidence Risk Analysis – KINGSTON UPON THAMES

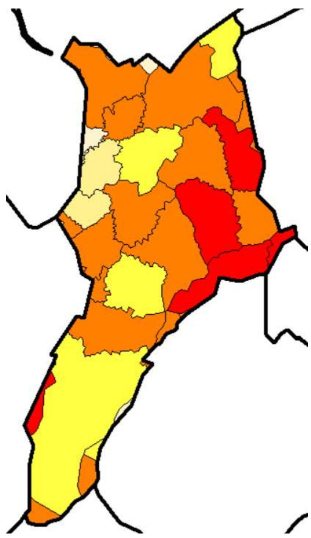
Kingston upon Thames is situated just south of the Thames and occupies an area of 37.25km^2 with a population of around 43,000.



Distribution of housing stock using full postcode as a proxy. Each sector covers around 2,000 houses and full postcodes include around 15 – 20 houses on average, although there are large variations.

Sector and 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 in a sector 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.

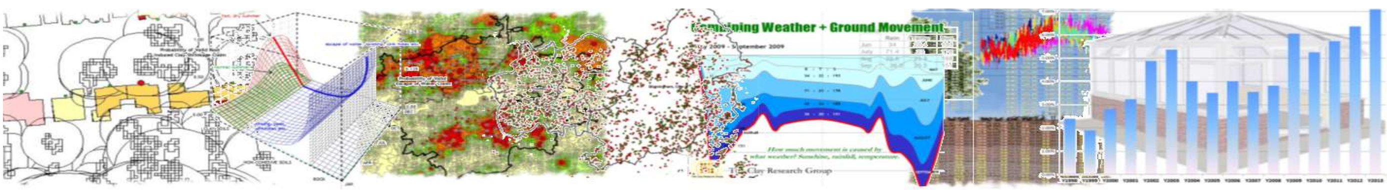


Kingston upon Thames district is rated around 2.6 times the UK average risk for domestic subsidence claims from the sample analysed. Above, risk by sector.

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

Kingston upon Thames is rated 9th out of 413 districts in the UK from the sample analysed and is around 2.6x the risk of the UK average, or 0.67 on a normalised scale.

There is an increased risk to the north of the borough as can be seen from the sector map, which broadly corresponds with housing distribution.



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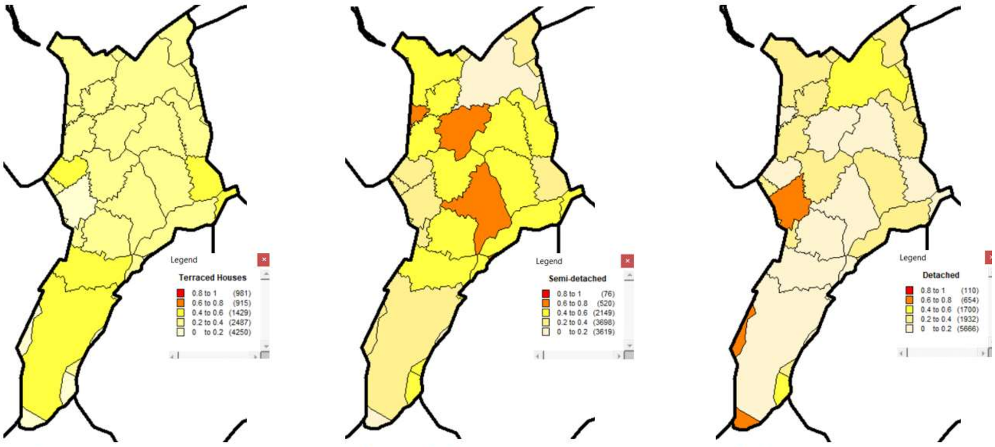
KINGSTON UPON THAMES - Properties by Style and Ownership

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 the model can be further refined if this information is provided by the homeowner at the time of application.

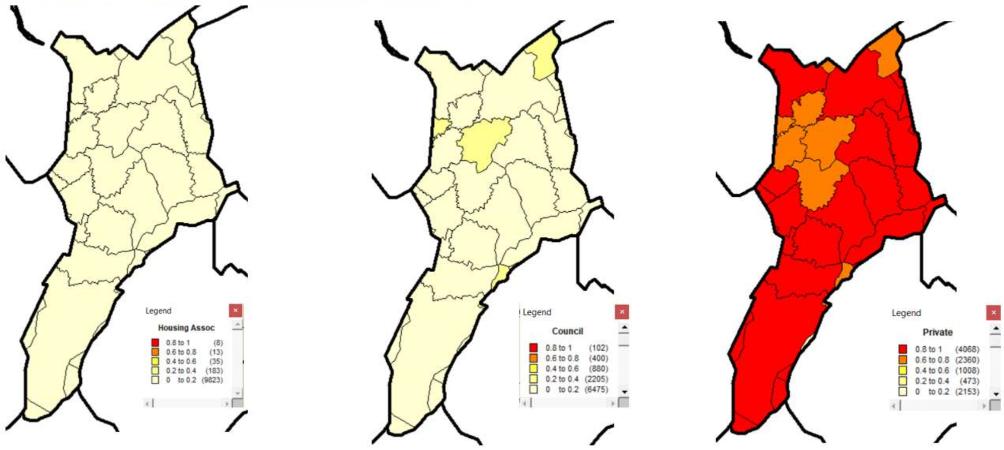
KINGSTON UPON THAMES - Distribution by House Type



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

Distribution by ownership is shown below. Privately owned properties are the dominant class and are spread across the borough. See page 10 for distribution of risk by ownership.

KINGSTON UPON THAMES - Distribution by Ownership



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

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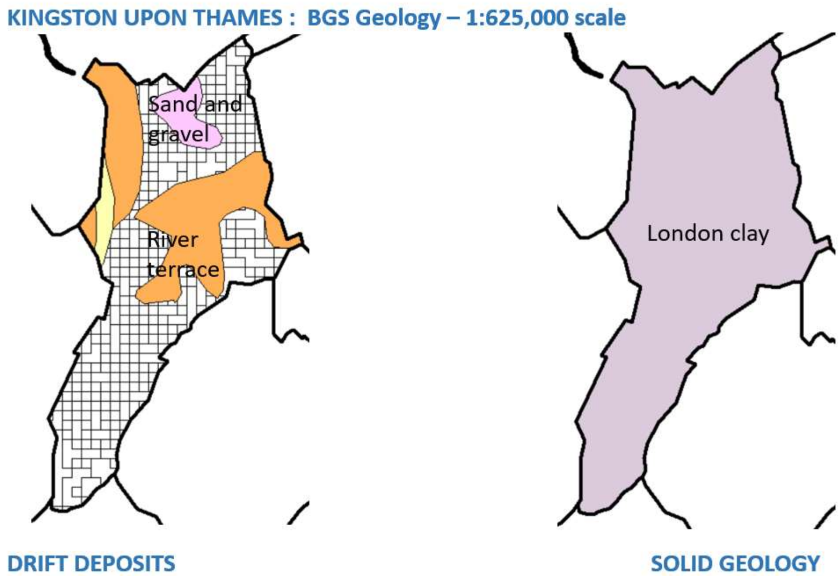
Subsidence Risk Analysis – KINGSTON UPON THAMES

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 of the sample we hold which reveals that, at district level, there is slightly less than 73% probability of a claim being valid in the summer and of the valid claims, there is a high probability (around 79% in the sample) that the cause will be clay shrinkage.

In the winter the likelihood of a claim being valid falls to around 45% - and if valid, there is an 80% probability the cause will be due to an escape of water. Maps at the foot of the following page plot the seasonal distribution.



1:625,000 series 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. Clay shrinkage is the dominant cause of valid claims in the summer and escape of water is the dominant peril in the winter months.

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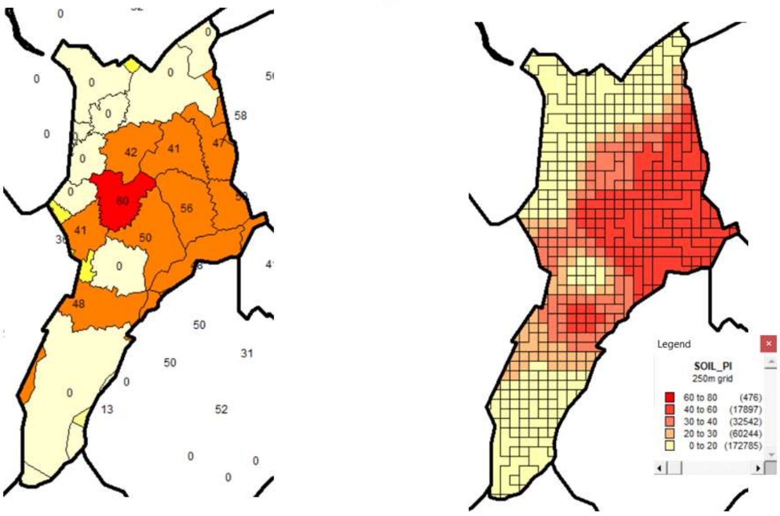
Liability by Geology and Season

Below, the average PI by postcode sector (left) derived from site investigations and interpolated to develop the CRG 250m grid (right). The higher the PI values, the darker red the CRG grid. The pattern doesn't agree with the BGS maps on the previous page due we imagine to claim distribution and the nature of investigations undertaken associated with the damage recorded.

KINGSTON UPON THAMES – Soil Plasticity Index

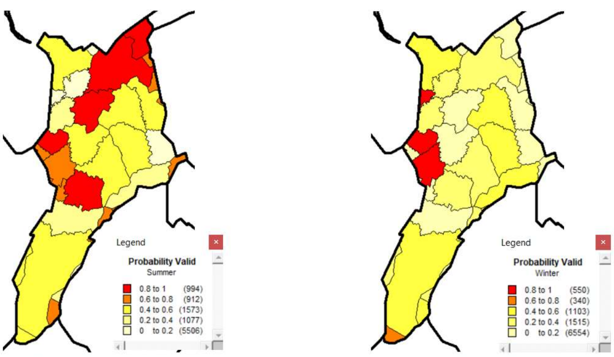


Soil PI Averaged by Sector

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. A single claim in an area with low population can raise the risk as a result of using frequency estimates.

KINGSTON UPON THAMES – by season



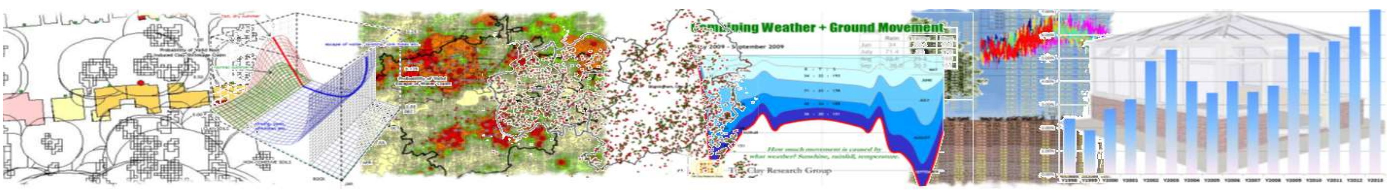
Probability Valid, Summer

Probability Valid, Winter

The maps, left, show the seasonal difference from the sample used.

Combining the risk maps by season combined with the table on page 12 is perhaps the most useful way of assessing the likely cause, potential liability and geology using the values listed.

The claim distribution and the risk posed by the soil types is illustrated at the foot of the following page. Escape of water related claims are associated with the superficial deposits or simply shallow foundations on poor ground and the dominant clay shrinkage claim, the outcropping clay. A high frequency risk can be the product of just a few claims in an area with a low housing density of course and claim count should be used to identify such anomalies.



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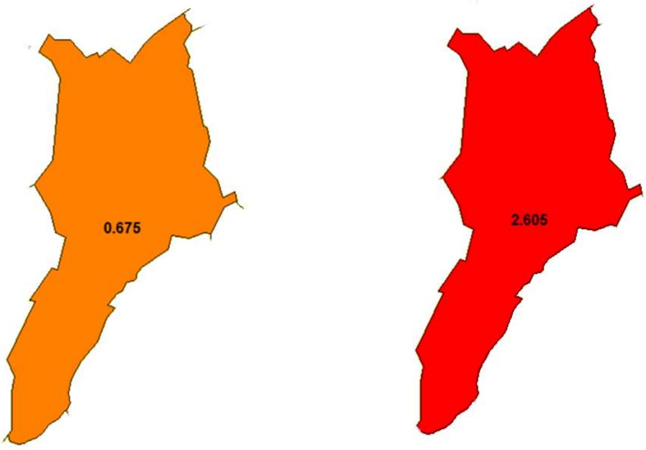
District Risk -v- UK Average. EoW and Council Tree Risk.

KINGSTON UPON THAMES - Subsidence Risk Relative to UK

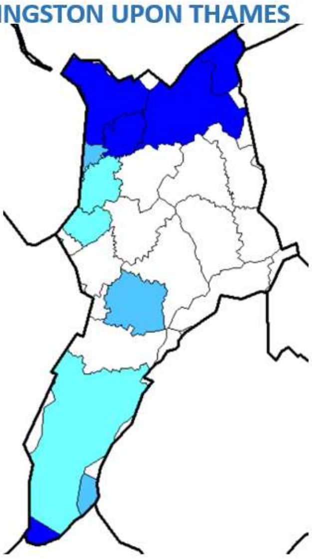


Normalised (0 – 1) Scale | Relative to UK Average

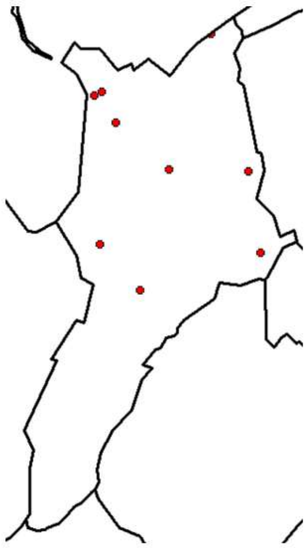
Below, left, mapping the frequency of escape of water claims usually reflects the presence of non-cohesive soils – alluvium, sands and gravels etc., although the pattern is less clear in this example. The absence of shading can indicate a low frequency rather than the absence of claims.

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.

KINGSTON UPON THAMES

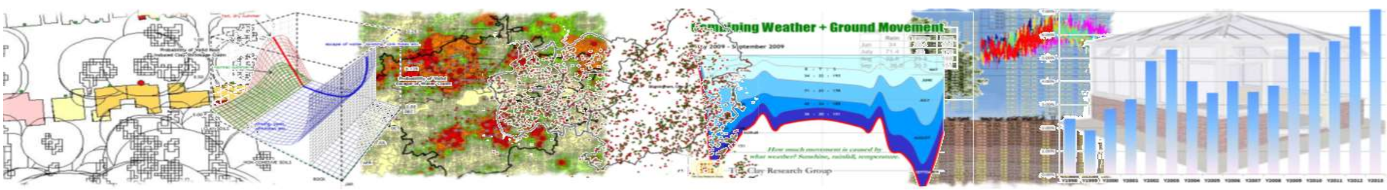


Higher Risk Escape of Water



Claims Involving Council Tree

(2,858 UK claim sample)



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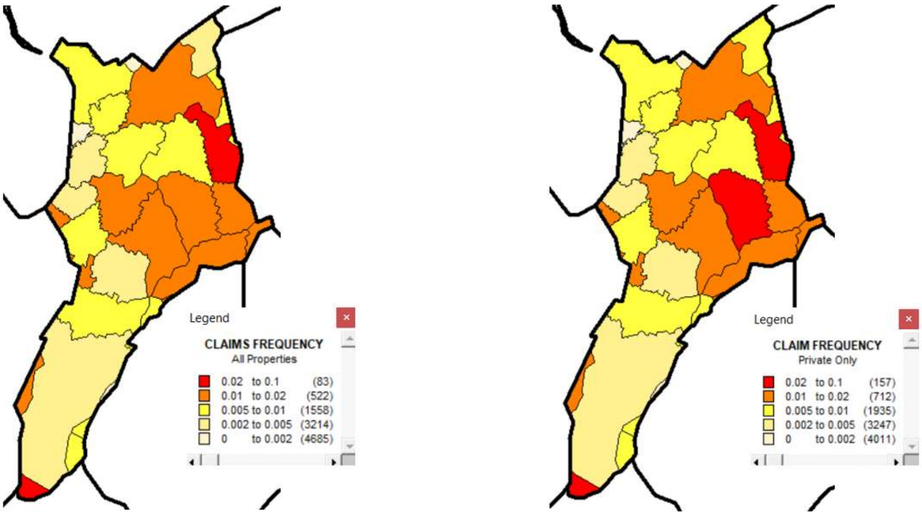
KINGSTON UPON THAMES - Frequencies & Probabilities

Mapping claims frequency against the total housing stock by ownership (left, private council and housing association combined and right, private ownership only revealing an increased risk), the importance of understanding properties at risk by portfolio.

KINGSTON UPON THAMES - Postcode Sector Subsidence Risk (frequency) by Ownership

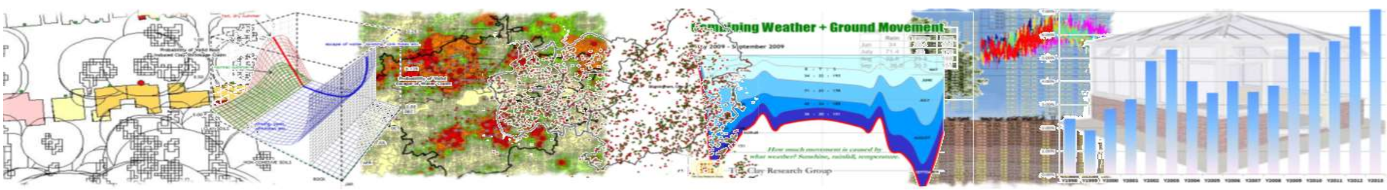


Combined Public and Private Frequency | Private Only

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 low, and in the winter, it is high. Valid claims in the summer are likely to be due to clay shrinkage, and in the winter, escape of water. For non-cohesive soils, sands gravels etc., the numbers tend to be steady throughout the year.

Liability by Season - KINGSTON UPON THAMES

District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Kingston upon Thames	0.584	0.149	0.267	0.09	0.36	0.55



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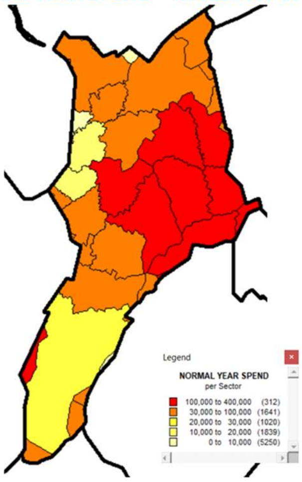
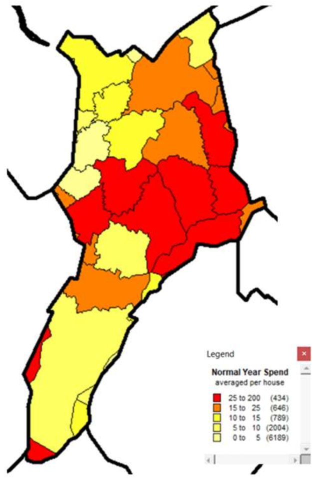
Aggregate Subsidence Claim Spend by Postcode Sector and Household in Surge & Normal Years

The maps below show the aggregated claim cost from the 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 – KINGSTON UPON THAMES



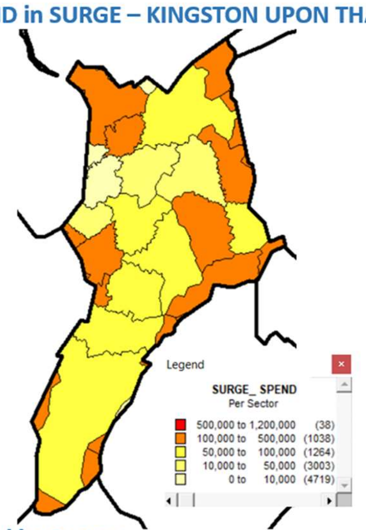
Spend by Sector



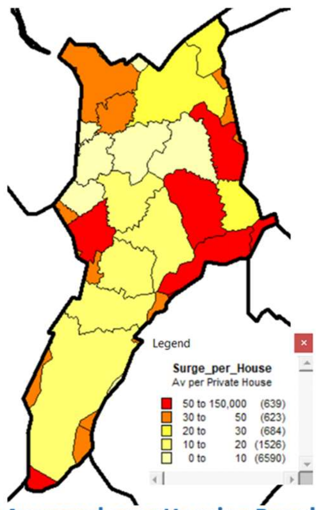
Spend Averaged over Housing Population

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.

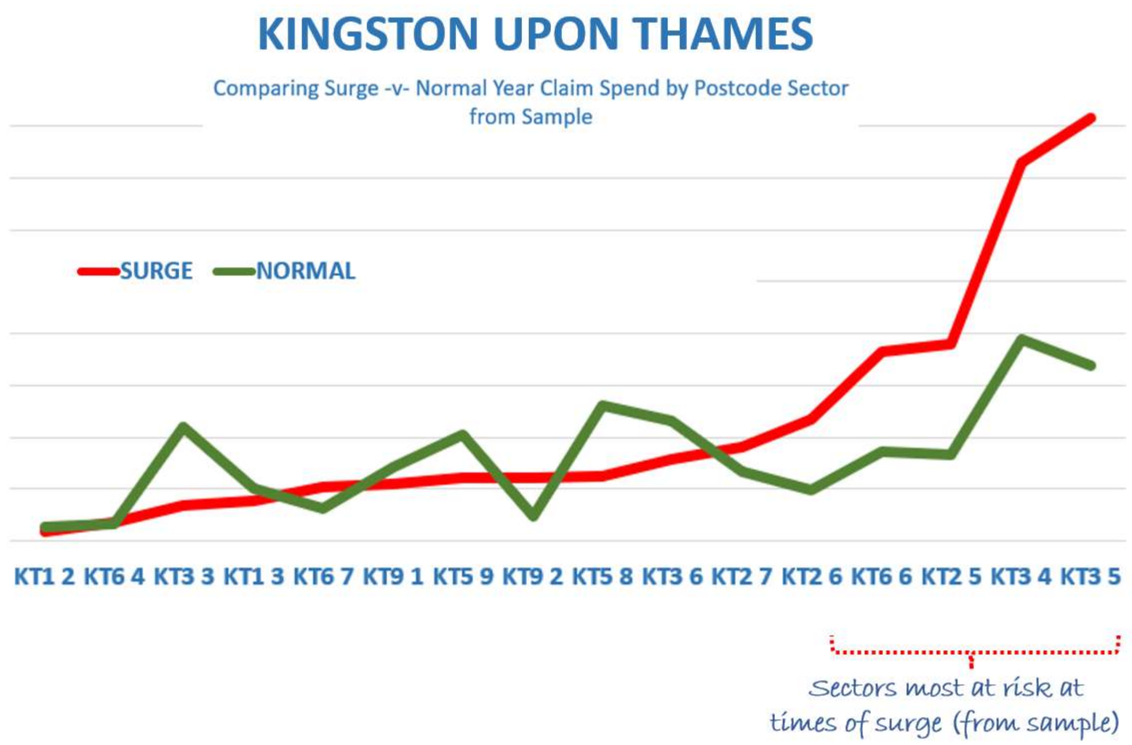
SPEND in SURGE – KINGSTON UPON THAMES



Spend by Sector



Spend Averaged over Housing Population



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.