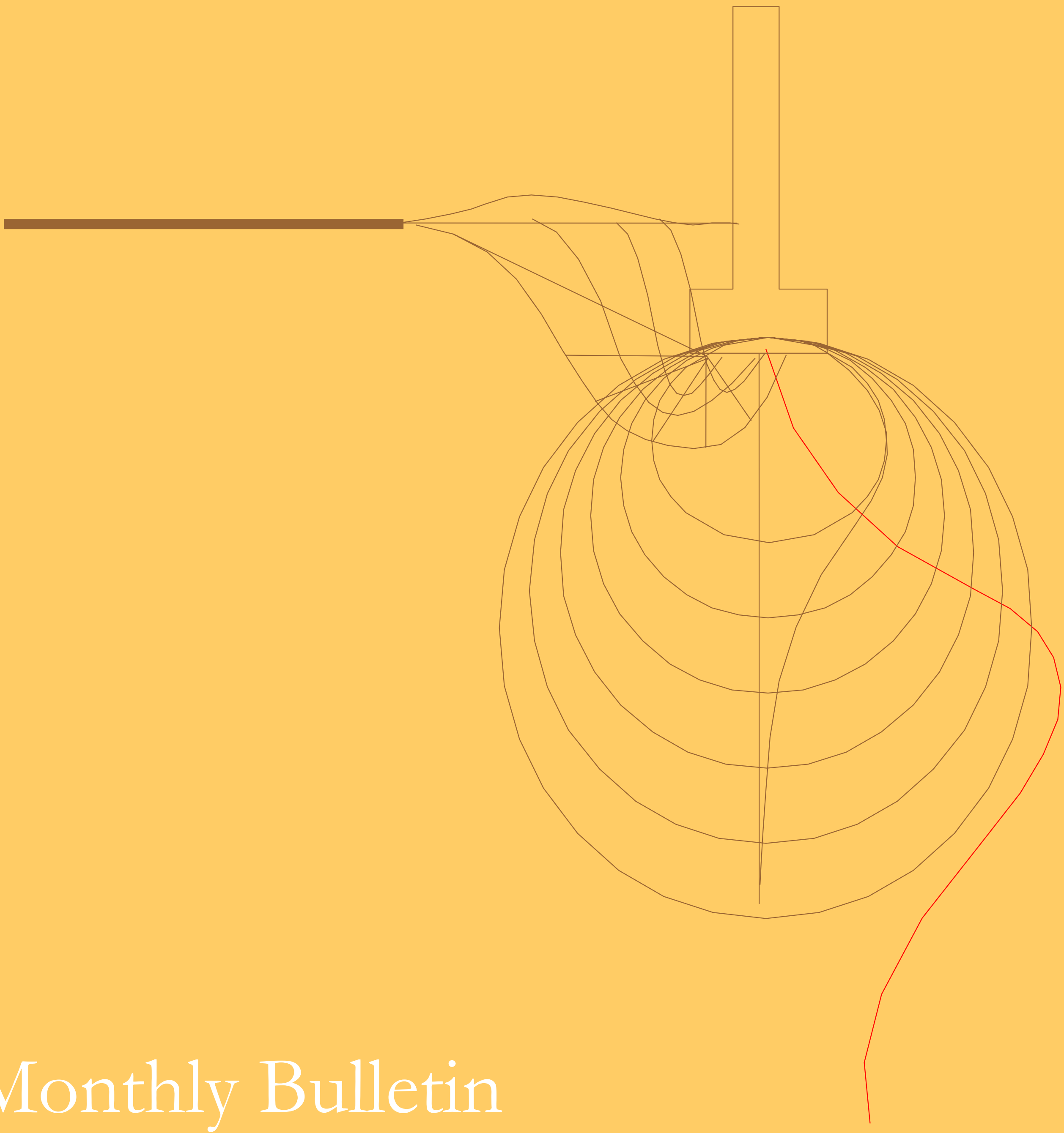
The Clay Research Group



Monthly Bulletin

The Clay Research Group

December 2006.

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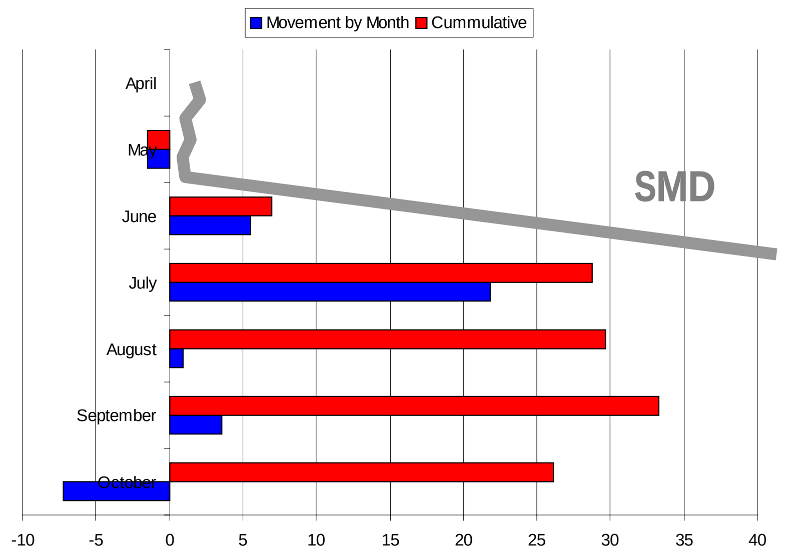
www.theclayresearchgroup.org

Movement by Month

Recording ground movement per month at the Oak tree site (blue) and using it as a proxy for moisture uptake provides food for thought. The Willow data, which is similar, is on Page 6.



These readings from Station 2 in 2006 at this site suggest that the tree takes a huge drink in July, and then pretty well 'switches off'. Little change is recorded in August and September, which is no doubt related to the competing suctions between the soil and the tree. This doesn't take account of the 'free water' – moisture that doesn't cause the ground to move – which would increase the figure for the July uptake.

The data show initial recovery of 1.5mm followed by subsidence over 4 months (maximum 21.8mm in July) and 7.2mm of recovery in October.

The cumulative effect is also plotted (red), and we see that this peaks in September, coincident with claim notifications.

Currently the weather model uses the Soil Moisture Deficit (SMD) values at the end of May to predict whether the year is likely to be an event or not. It refers to two values. The first is the recorded SMD at that time (the end of May) and the second is the difference between it and the lowest value recorded in the preceding months.

2005 and 2006 were both correctly predicted as being non-event years with higher than usual claim numbers as the SMD value increased rapidly in June. The prediction went against the 'common sense' view, as we were experiencing hot, dry weather and the reservoirs were dry.

This has implications in respect of our work on gene expression. If May 'sets the climatic scene' does July reveal the tree's response, with the cumulative influence experienced in September? August and September are almost secondary it would appear.

As ever, much more research is needed in this area, but the data has been invaluable in providing clues about how we might further refine the predictive capability of the application.

Electrolevels

MAT-LAB Site Investigations and Soil Testing

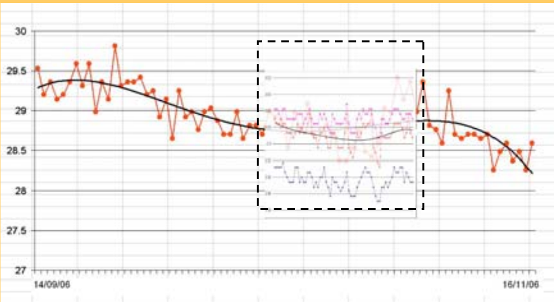
December 2006.

UK Data

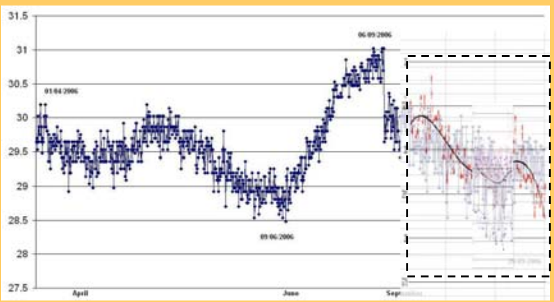
We receive data from sensors fitted to buildings in different parts of the country. Below, the underlying, larger graph plots the data from the Midlands, and the smaller superimposed graphs are taken from a property in the South East.

They use different equipment, from a different supplier, with differing geology, different trees etc. In the Midlands we have the Mercia Mudstone and London Clay in the South East.

Even with these differences, we are still able to match the general profiles and find good agreement best illustrated here by the trend lines.



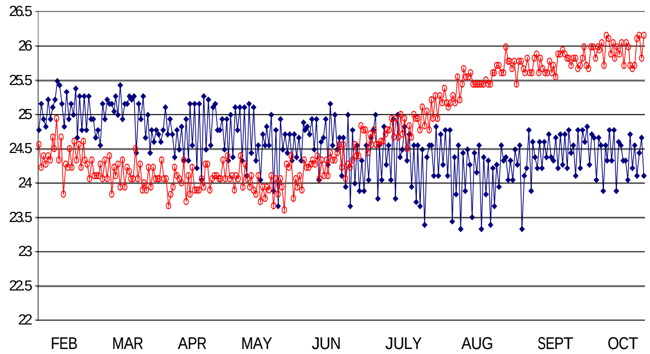
To illustrate the 'fit' we have merged several images. The patterns and correlations are clearly visible and agnostic of the units.



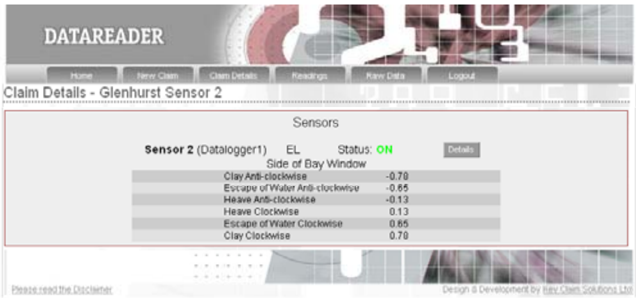
For example, one of the sensors (blue profile) is measuring in mm/m units, whilst the others are in degrees or radians.

The DataReader Application

Our web based application, built to interpret data from electrolevels, is undergoing rigorous testing and we have a wide variety of data to throw at it. Here is an example of a live case being investigated by Cyril Nazareth, our Project Co-ordinator. The instruments (2 sensors, one mounted each side of the bay, one measuring clockwise and the other measuring anti-clockwise movement – hence the mirror image) were activated on 17th February, 2006 and removed on the 9th September, 2006. They were measuring movement about 5mtrs away from a mature Lime tree.



The data was imported into the web based application, which then carried out various probability matches – see below. The DataReader correctly diagnosed root induced clay shrinkage as the most likely cause of movement.



The probabilities are listed as follows:-

Clay Shrinkage – 0.78
Escape of Water – 0.65
Heave – 0.13

This is a 7-month profile but the aim is to detect movement over a much shorter period and we have identified two targets. The first is the point of contraflexure in September and the second is recovery from September onwards. Only clay soils exhibit this profile, and detecting rotational movement in the correct plane should shorten the monitoring period significantly. By recording the direction of rotation we can understand the difference between recovery and subsidence.

Where monitoring is required over a longer term, the benefits of the 'fit and forget' technology are clear. As well as gathering better information quicker, we hope to reduce the significance of surge. Visiting the site quickly, installing a device of this sort and gathering evidence every day resolves the delays associated with soils testing and traditional monitoring.

The Clay Research Group

University of Southampton

Climate Change, Soil Moisture Profiling.

December 2006.

Ground Engineering

We were pleased to receive a mention in last months edition of Ground Engineering. The article referred to our work in developing telemetry, TDR sensors and remote sensing generally.

MONITORING

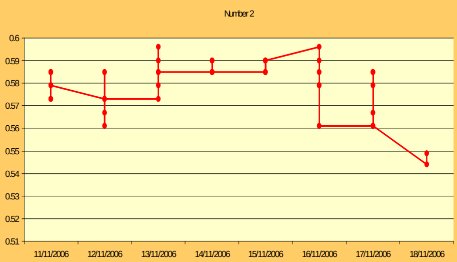
REMOTE CONTROL

Last month's annual Subsidence Forum heard how new developments are bringing down monitoring times. Francesca Breeze reports.

The article includes a quotation from Hilary Skinner's (B.R.E.) talk at the Aston Conference where she said "The Clay Research Group is undertaking one of the widest ranging clay research projects in the UK".

It also links in nicely to our connection with The Subsidence Forum, exploring innovative techniques in general. We understand there may be a more detailed article in January.

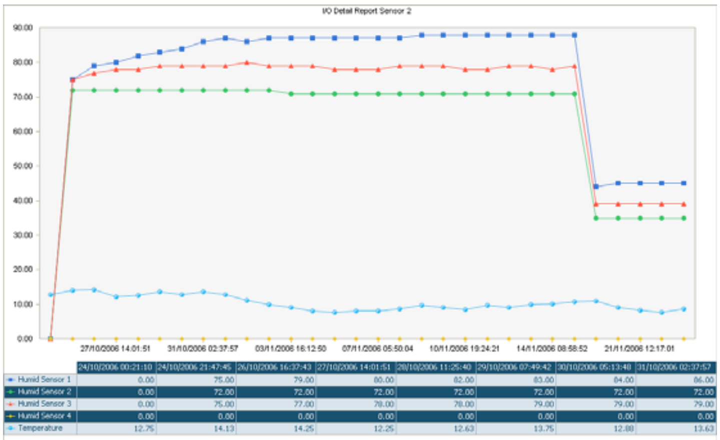
It's not all Perfect



No surprise to learn things don't always go the way we expect. Above we see an odd graph where the electrolevel sensors take as many as 6 readings in a day, leaving our interpretation software with an unusual pattern to detect. As it takes the mean from a series, it isn't thrown by odd data, occasional loss of power or the signal but testing continues as we gather more data.

TDR Sensor Installation

Below we have an update of the TDR output from Aldenham - the installation plan appears in earlier editions.



	24/10/2006 00:21:10	24/10/2006 21:47:45	26/10/2006 16:37:43	27/10/2006 14:01:51	28/10/2006 11:25:40	29/10/2006 07:49:42	30/10/2006 05:13:48	31/10/2006 02:37:57
Humid Sensor 1	0.00	75.00	79.00	80.00	82.00	83.00	84.00	86.00
Humid Sensor 2	0.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
Humid Sensor 3	0.00	75.00	77.00	78.00	78.00	79.00	79.00	79.00
Humid Sensor 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Temperature	12.75	14.13	14.25	12.25	12.63	13.75	12.88	13.63

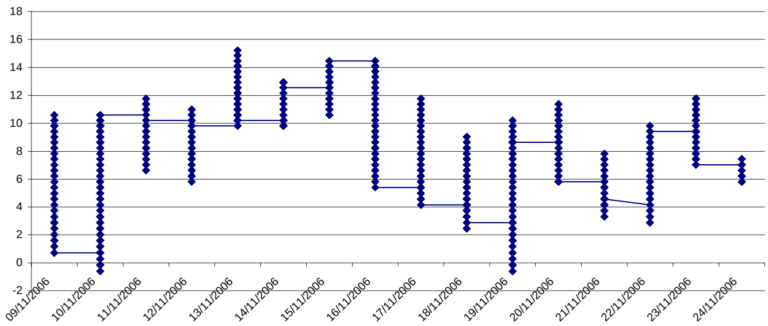
The system hadn't been calibrated on installation but using data from the neutron probe we were able to re-set the values from the offices here in the Midlands rather than have to drive a round trip of 200 odd miles to visit site, dig them up and re-code. Another major advantage.

The graph shows the moisture content at zero when 'in the box' and prior to installation, followed by a sharp increase in moisture content immediately after installation and then a gradual increase over 6 days as they reached equilibrium when buried in the ground.

To the extreme right of the picture we see the re-calibration exercise, with the last readings dropping sharply to the new calibrated level.

The values are nearing their anticipated optimum level and we should see a gradual increase over the next few months as rainwater enters the ground, followed by drying in May 2007.

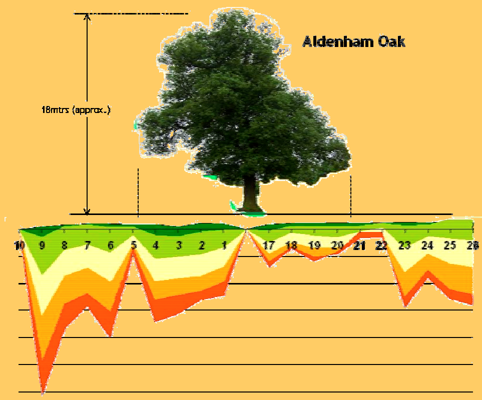
This data, combined with that from the weather station (see below), might reduce our reliance on external data and assist us in modelling the potential for an event year. It will be available via the web for individuals to view.



The weather station is taking readings every minute and needs to be adjusted, but at least it is working! Above we see the temperature plot for the period 09/11/06 to 24/11/06.

Question

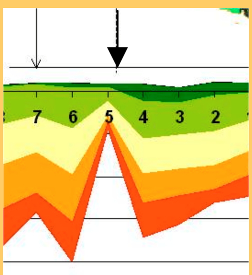
We know there is a persistent moisture deficit beneath both the Oak and Willow. This begs the question that if the soil is so dry we only record minor movement – around 20mm beneath the Oak, at Stations 6, 7 and 8 for example – how does it survive?



To build up this deficiency it has presumably consumed huge amounts of moisture in the past that account for over 100mm of movement if we take the modelled values.

We can see roots are exerting a significant influence at the periphery where there is a more plentiful supply of water, but what happens to the roots directly beneath the tree?

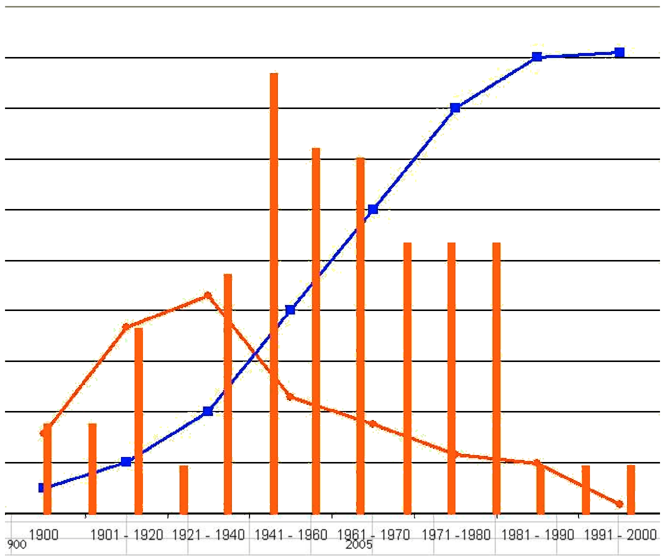
As we see from the ground movement, they are still active. They appear to be struggling to remove soil moisture, competing with the suctions exerted by the clay soil. Does there come a time when they die back, and does this indicate the onset of decline for the tree, leaving it vulnerable to infection? We know about the wilting point mechanism, but year on year does this deficiency threaten the health of the tree, or does it simply trigger a search for water?



Incidentally, the anomaly at Station 6 coincides with NP3 where gravel was encountered and we suspect they are influencing the readings to the right – Stations 14, 15 ….

Age of House -v- Risk

Plotting 'claims notified by age of construction' reveals that older properties are far riskier than homes built after 1960, as we might have expected.



Above is a comparison of claim notifications (red line) against house builds per period (red bar graph) – not to the same scale of course.

The cumulative total housing stock is shown diagrammatically as a blue line in the background and again, not to scale.

We can see the divergence between 'builds' and 'claims per age of house' and the size of this divergence is an indicator of risk by age of property.

Plotting this as frequency data we see the riskiest build period is between the 1920 - 40's where we have high claim notifications by age of property, and fewer builds.

The newer homes appear to be safer, as one would expect following the introduction of minimum foundation depths to comply with the Building Regulations and adoption of the NHBC research into tree related damage on clay soils.

Changes in drainage technology have also assisted, with flexible couplings and plastic pipes tolerating a greater degree of ground movement prior to cracking.

Modelling

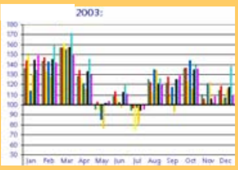
Birmingham University

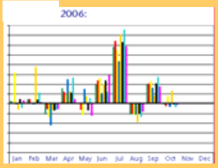
Weather Patterns

Data including rainfall, temperature and hours of sunshine etc., can be downloaded from the Meteorological Office web site at www.met-office.gov.uk.

Differences in views within the insurance industry revolve around whether we can use patterns early in the year to predict events, or whether the events are driven by changes in the summer and therefore are too close to act as predictors.

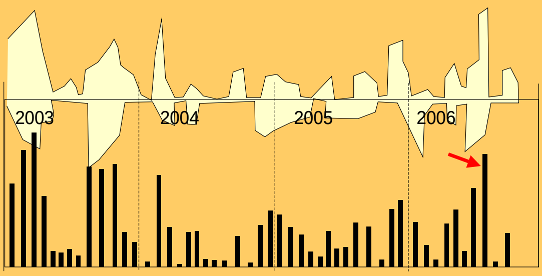
Much more information is needed before we can say – if indeed any link exists at all – but below we have reproduced samples from the Met Office web site for discussion. To the left is the sunshine anomaly graph for 2003. An event year.





To the right we have reproduced the graph for 2006 - a year with high claim numbers but not regarded as an event.

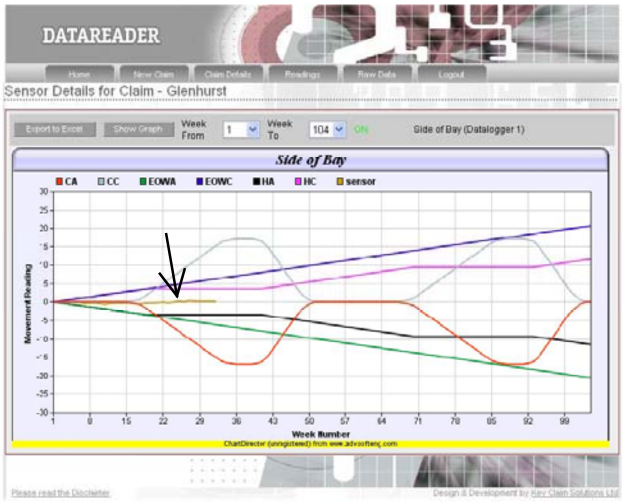
In contrast to 2003, we have a low increase in 'hours of sunshine' (when compared with the average) early in the year, and higher values – higher than 2003 – in June and July. Although this takes hours of sunshine in isolation, it is puzzling why, if events are driven by the 'immediate' weather, 2006 didn't reach the claim numbers of 2003.



We can build an envelope (above) encapsulating both the hours of sunshine and rainfall (anomaly data) to see how they combine. They are just two of several factors used to build the SMD data. The early months of May 2003 had both longs hours of sunshine, and a reduced rainfall pattern.

2006 probably matches 2003 in terms of overall differences in July. The idea that an event may be driven by 'immediate' weather patterns is less convincing looking at 2006 – arrowed – where we have high hours of sunshine and reduced rainfall from the average, and high claims numbers but not an event. Clearly, a dry May and July are indicators of a problem!

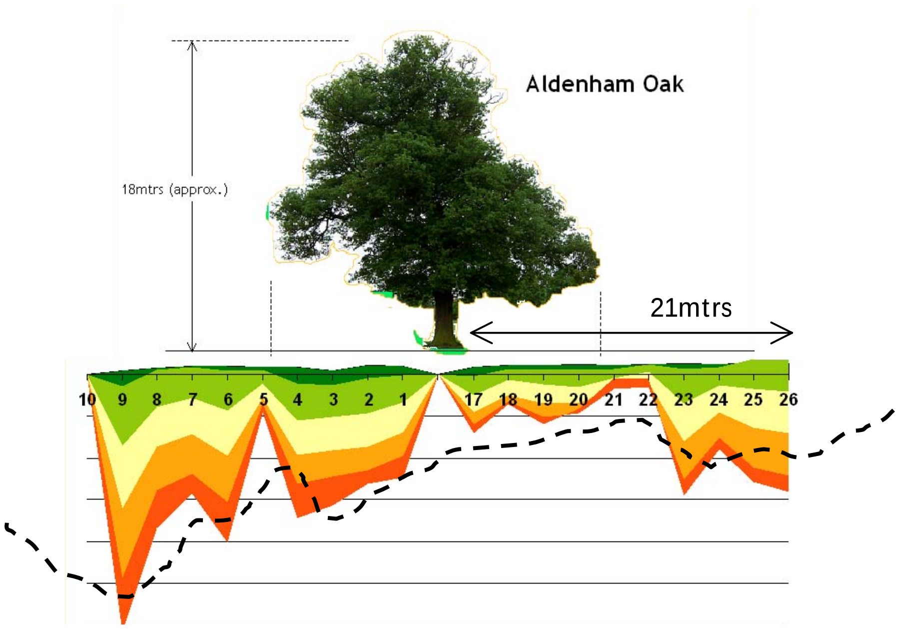
Detecting Fine Movement



Above we see how the application has detected a very fine trace – the mustard coloured line with the arrow pointing to it – to arrive at a match. Hence the term 'fuzzy matching'. The data doesn't have to be perfect as we saw on Page 3.

The Aldenham Oak

We can see the extent of tree root influence from the precise levels. The Oak is 16 - 18mtrs high and yet we are recording significant movement well over 24mtrs as we can see from the readings to the right of the ground profile image. Extending the root zone by extrapolating the contour suggests it could easily reach in excess of 30mtrs (see dotted line).



The Clay Research Group

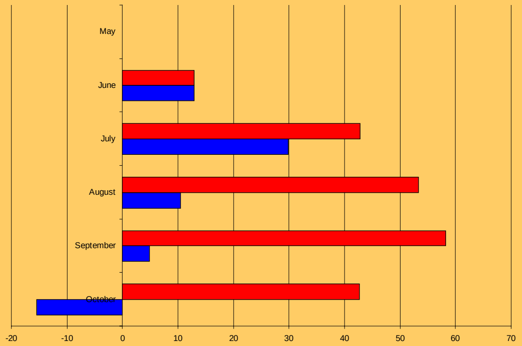
BRE Data Validation

December 2006.

Willow Moisture Uptake

Using ground movement as a proxy for moisture uptake, and accepting all of the problems associated with this, we see an apparent 'surge' in July corresponding with that of the Oak, described on Page 1.

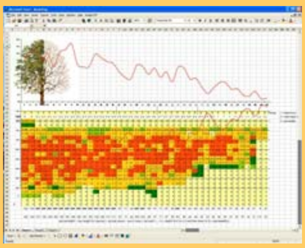
Of course, there isn't a direct or linear relationship between ground movement and moisture uptake. The tree will take up 'free water' in the clay soil initially, without causing movement. In the later phase it may be we see more movement with less water loss due to the mineralogy, but this provides a useful snapshot.



Again, as with the Oak tree, the following months show a significant reduction which may be a function of the persistent deficiency at the site. Much of the ground movement has already taken place.

We also see movement at the root periphery, and the influence extending beyond the tree height confirming both the Oak and Willow as aggressive species capable of causing damage to buildings at significant distances from buildings.

CRG Web Site II



Images of the 'disorder' modelling application have been tagged on to the end of the existing demonstration, and can be viewed by selecting "Software Applications".

Our Web Site

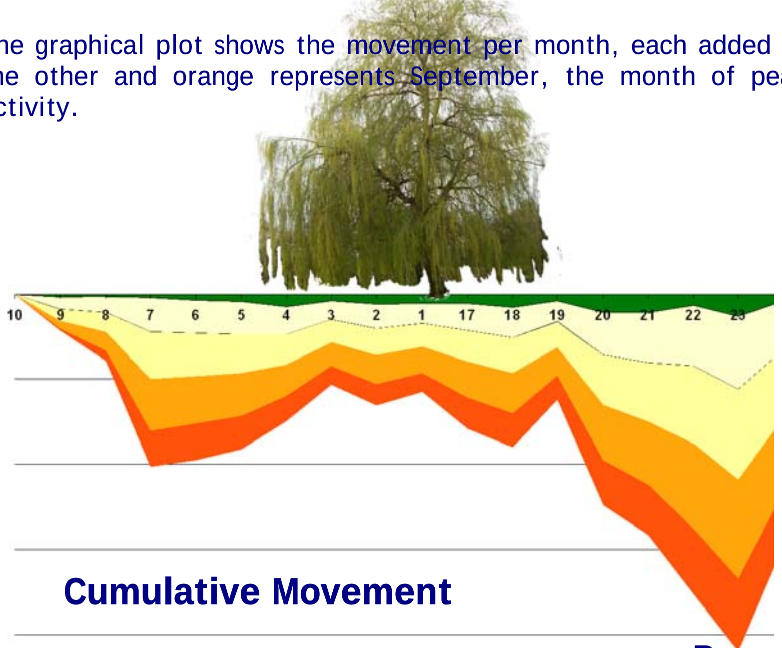
Copies of all newsletters are now available for downloading from our web site. Select 'monthly newsletter' from the toolbar to view index.

Aldenham Willow

The zone of root influence of the Willow as described by the precise levelling looks remarkably similar to the Oak with large movements at an outlying station on the root periphery.

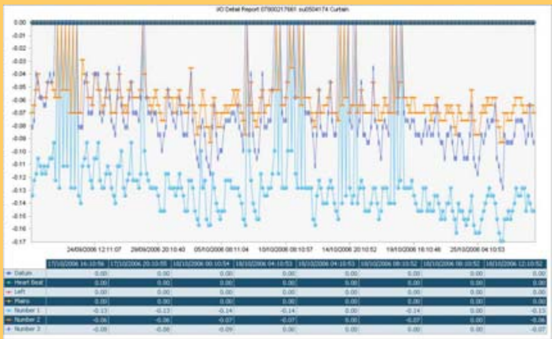
Maximum cumulative movement of 58.2mm was recorded in September at Station 23, and by month, the maximum value was 29.9mm in July. This compares with 33.3mm of cumulative movement on the Oak site at Station 9 and 21.8mm in July.

The graphical plot shows the movement per month, each added to the other and orange represents September, the month of peak activity.

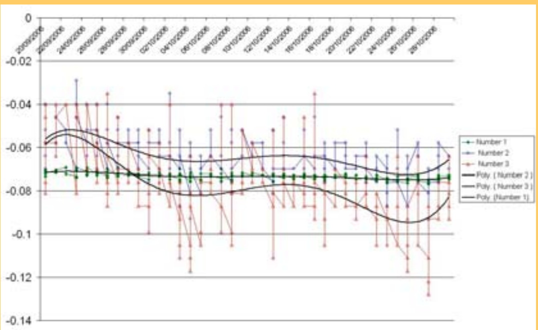


Trendline Analysis

The upper image shows how the data is delivered from the GSM site. We have lots of zero data as the signal is lost from time to time and with several sensors, interpretation can be difficult.



The intermediate phase is data cleansing and removal of 'odd' data. The 'lost signal' values and the wide range over a short period. Below we have plotted the outcome using trendline analysis.



There has been no movement at Station 1, which follows a horizontal line. Station 2 shows some movement, and Station 3 even more.

Station 1 is the datum – the one we use to compare output from the sensors closer to the trees maybe, as was the case here.

Stations 2 & 3 are a snapshot of the initial recovery phase extending from 20/09/06 through to 20/10/06, following after the peak in early September.

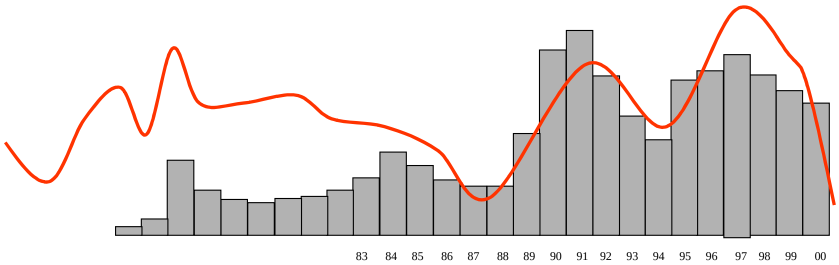
The data is then 'pattern matched' against characterised values for other perils to derive a probability.

Predicting Surge

Dr Richard Pugh's paper entitled "Some Observations on the Influence of Recent Climatic Change on the Subsidence of Shallow Foundations", published in Geotechnical Engineering, January 2002 reviewed the issues surrounding predicting high claim notifications, using variation from the mean rainfall plotted against claims.

Richard came to the conclusion "It is not considered possible to predict a claims surge until it is actually occurring".

We reproduce below some of the data in his paper, but presented slightly differently, with the variation from the mean rainfall pattern (red) inverted. Peaks on the red line are dry years.



We wonder if the model fails because of the early data in the series reflecting an immature market and the use of one measure of climate, rather than a combination?

Subsidence cover was only introduced in the early 1970's and it wasn't regarded as a major problem at that time. Houses moved and homeowners filled the cracks when they next decorated. Now the term 'subsidence' is used to describe even the most minor damage. Customers at that time had a natural reluctance to make a claim – something that has all but disappeared now. They didn't want to 'trouble the insurer'. We still see this reaction from time to time when visiting older claimants.

The awareness was no doubt heightened by the 1976 summer in which many more houses were damaged than claims made we suspect. Does the trend show the gradual uptake in an immature market? If so, it would suggest 'lack of fit' isn't a fault with the data, but socio-economic factors.

Evidence of this immaturity is provided by the number of houses that were underpinned then, compared with now. Prior to 1990 around half of the houses that had cracks were underpinned according to an unpublished survey undertaken by John Biller for Royal Insurance at that time. Today the figure for underpinning is probably 5%.

It appears from the data the market reached maturity in 1989/90 (where we see numbers stabilising) when knowledge of the policy grew along with house prices - then one may draw an approximate correlation between rainfall patterns and claims. Given that we are only looking at one element of the weather in this study and setting aside socio-economic factors that make earlier data less convincing, we may be missing something if we ignore the link.