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

Clay Research Group

Climate : Telemetry : Clay Soil : BioSciences : GIS & Mapping
Risk Analysis : Ground Remediation : Moisture Change
Data Analysis : Numeric Modelling & Simulations : Software

September 2014

Edition 112

The Clay Research Group

CONTENTS

Issue 112, September 2014

8 Years at Aldenham

Glenda Jones from Keele was the first person to instrument the Aldenham site as part of her PhD research into Electrical Resistivity Tomography. Glenda set up arrays leading from the willow and oak and took the first set of readings on 28th February, 2006 and then at monthly intervals.

Precise levels and site investigations commenced on 25th May 2006, over 8 years ago. Levels have been taken regularly since.

Site investigations were undertaken in May 2006, June 2007, April 2008 and November 2009 by MatLab Ltd. Disturbed and undisturbed soil samples were retrieved and tested in a variety of ways.

On the 4th August, 2006, a research team from Southampton University took moisture content readings using a neutron probe. Further readings were taken periodically through to May 2008.

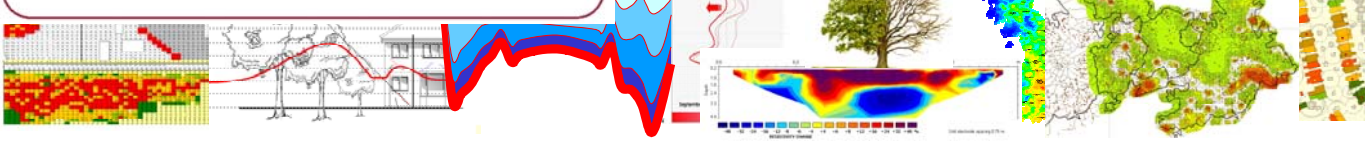
Other tests have been undertaken – TDR moisture sensors were buried and successfully transmitted data from 1m below ground to the web using telemetry.

Dr. Jon Heuch used ground penetrating radar to map the root distribution of the oak on 30th June 2006.

None of this would have been possible had it not been for the generosity of Aldenham School. When we first approached them towards the end of 2005, they were very supportive and allowed us to set up the various stations, arrays and so forth without hesitation.

That support has allowed us to further our understanding of how trees interact with climate and soil over time. The current research into electrokinesis osmosis by Tom Clinton from Birmingham University continues this theme.

THE CLAY RESEARCH GROUP
www.theclayresearchgroup.org
clayresearchgroup@gmail.com

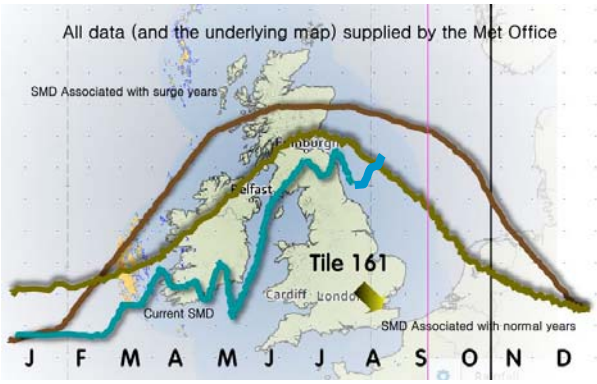


The Clay Research Group

Soil Moisture Deficit

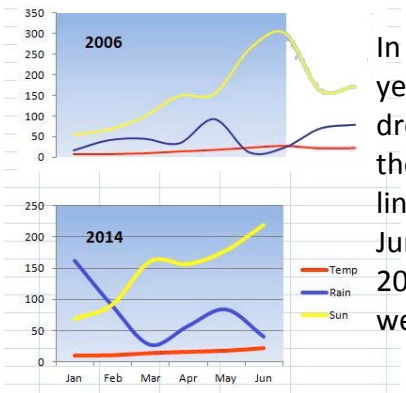
A late indication of some soil drying, although the deficit is still quite small in comparison to surge years and intermittent rainfall has no doubt contributed to the low number of claims notified so far this year.

SMD values are calculated at shallow depth and are not representative of conditions at peak root activity for mature trees – on average around 2mtrs bGL. It would take more than a few weeks of sunshine to trigger an increase in subsidence claims.



Weather Records

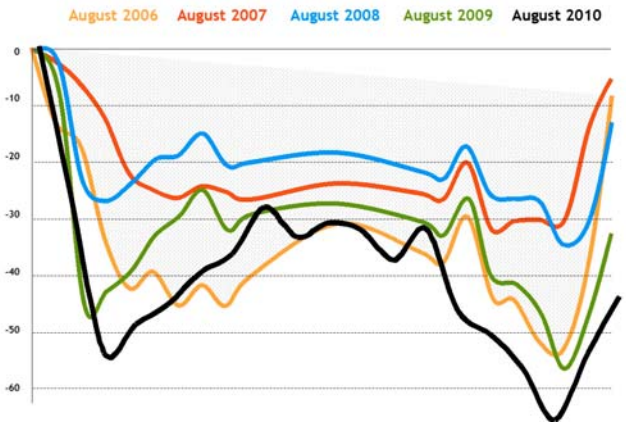
Weekly data from the Met Office for rainfall, temperature and hours of sunshine are shown below.



In 2006 (a surge year) rainfall dropped below the temperature line briefly in June. In contrast, 2014 was much wetter.

Levels over Time

Below, a plot of ground movement across the root zone of the Aldenham willow in August for the years noted.



The ground was at a low level in 2006, rose quite sharply in 2007 and 2008 before subsiding again in 2009 and 2010,the latter (black line) delivering the lowest profile.

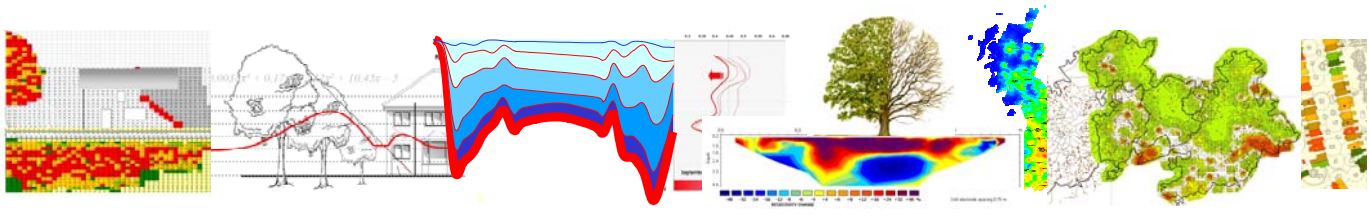
Persistent Deficits

How do we know there was(is) a persistent deficit in the vicinity of the willow? What sort of ground movement would take place if the willow were to be removed?

There was a persistent deficit in May 2006, but what is the situation today?

Did the heavy rainfall towards the end of 2012 and more recently rehydrate the desiccated zone?

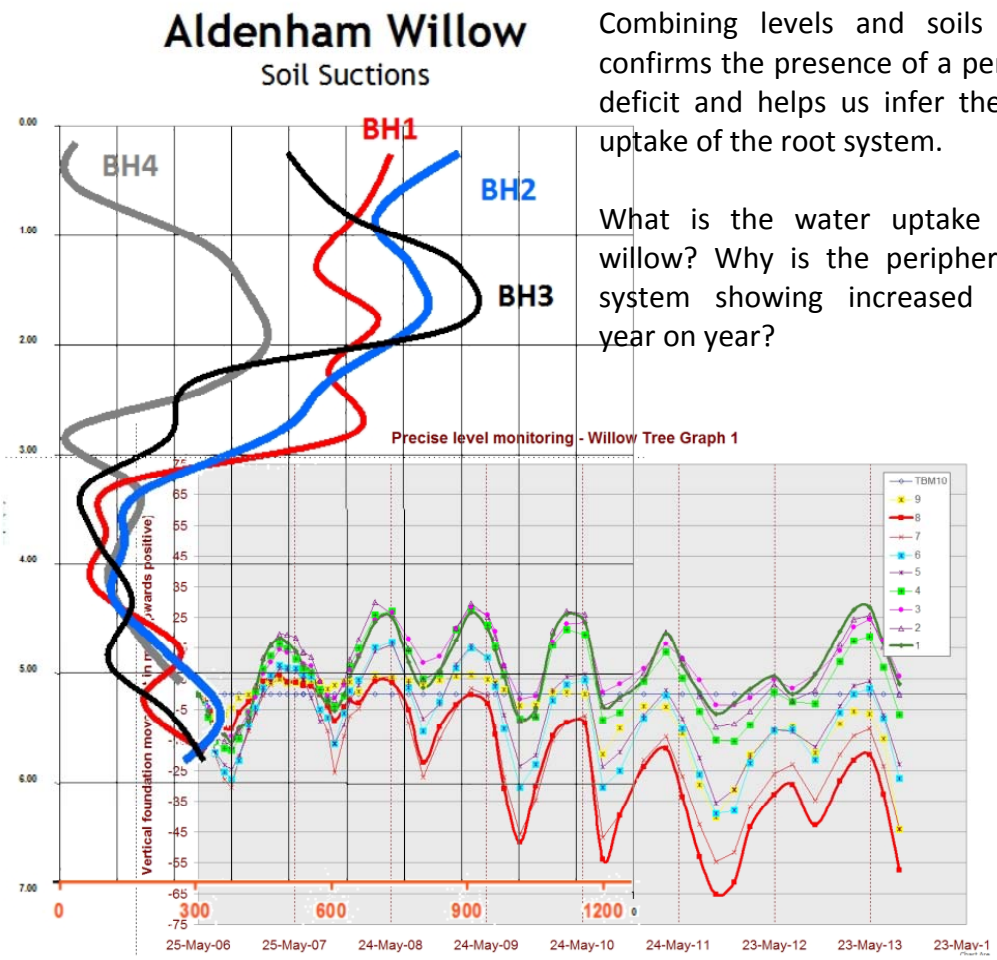
The following pages re-visit the soils and levelling data to try to answer the above.



The Clay Research Group

The Aldenham Willow - Levels and Soils

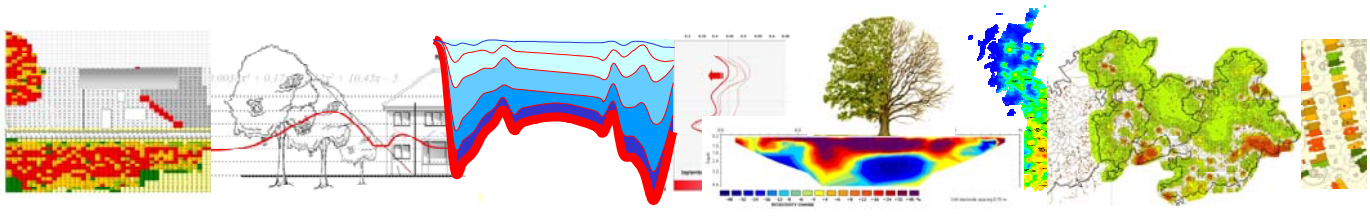
Monitoring the ground conditions beneath the Aldenham willow is probably something of a record in the field of domestic subsidence, both in terms of duration and the volume of information gathered from soil sampling and testing. The project has delivered some valuable results as can be seen on the following pages.



Combining levels and soils results confirms the presence of a persistent deficit and helps us infer the water uptake of the root system.

What is the water uptake of the willow? Why is the peripheral root system showing increased activity year on year?

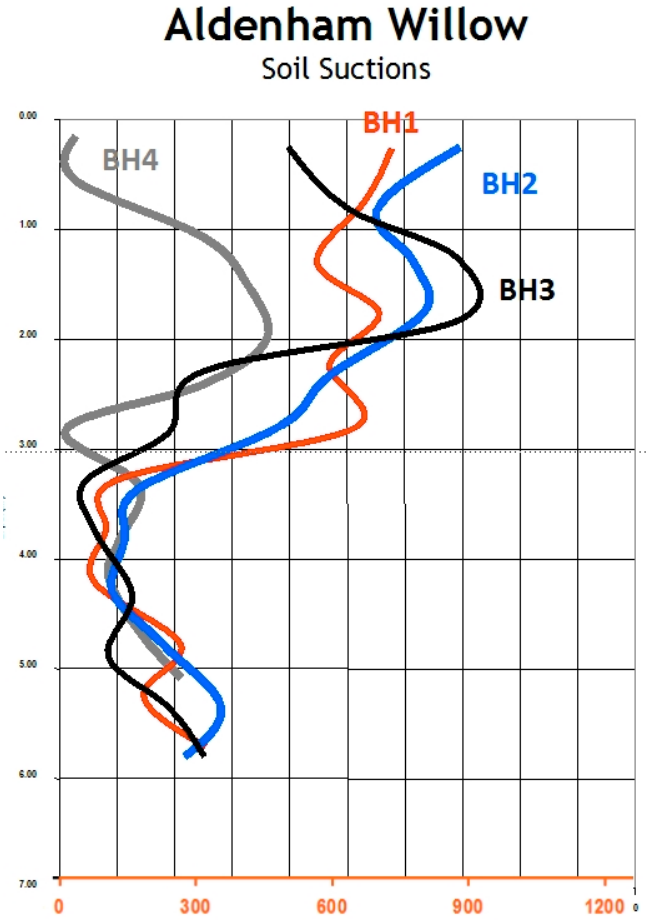
The link between soil desiccation and ground movement is illustrated as is the extent of root influence. As the ground closer to the tree develops a persistent deficit, so the peripheral system appears to compensate. Ground movement associated with moisture abstraction becomes more pronounced 20mtrs or more from the tree, than near to it. Testing soils throws light on what the levels are measuring, and vice versa. It also provides an opportunity to compare different soil tests and relate the movement that actually takes place with the estimates of swell.



The Clay Research Group

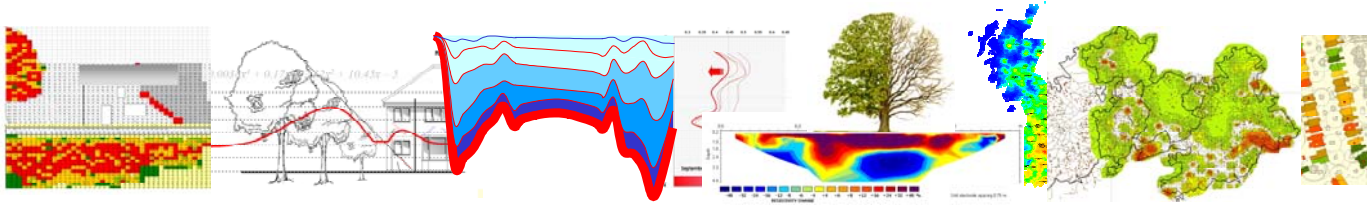
Persistent Deficit

When considering precise level data, reference is sometimes made to a persistent deficit in the vicinity of the Aldenham willow at the time the first reading was taken in May 2006.



Above, the results of soil testing from investigations undertaken on 25th May, 2006. The start of the growing season. Had the soil been fully rehydrated following winter rainfall, there would be no deficit. As it was, desiccation was recorded in the forms of negative porewater pressures using the filter paper suction technique and strains using the oedometer.

In addition, some precise levelling stations have subsequently risen above their start point indicating recovery from a dry state whilst we have recorded a developing deficit at others.



The Clay Research Group

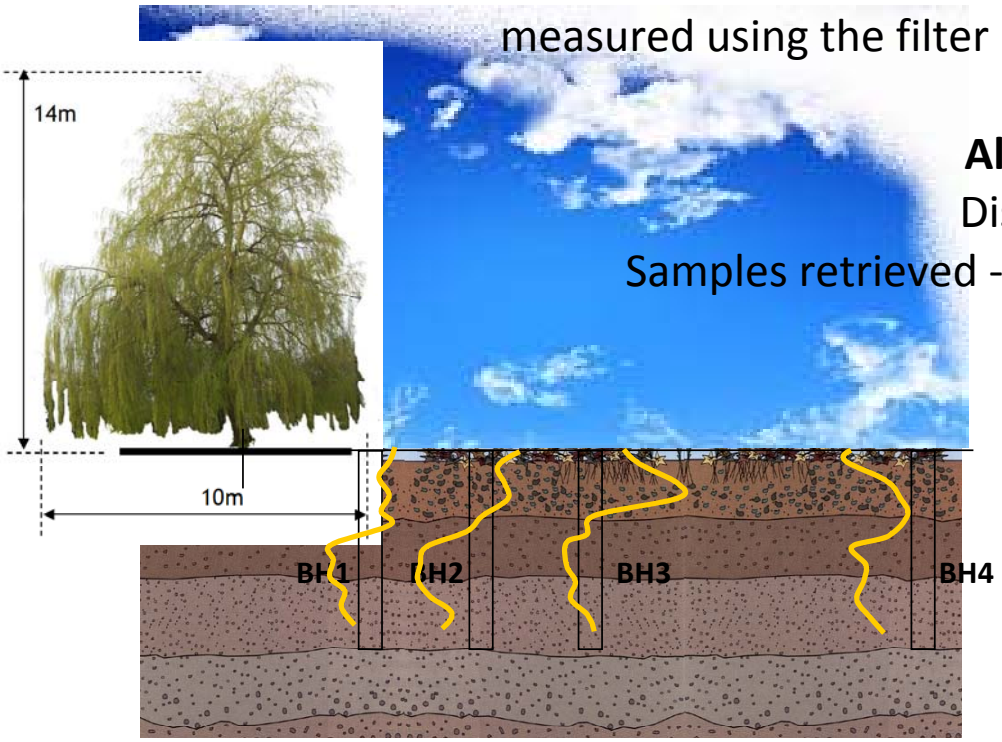
Soil Suctions

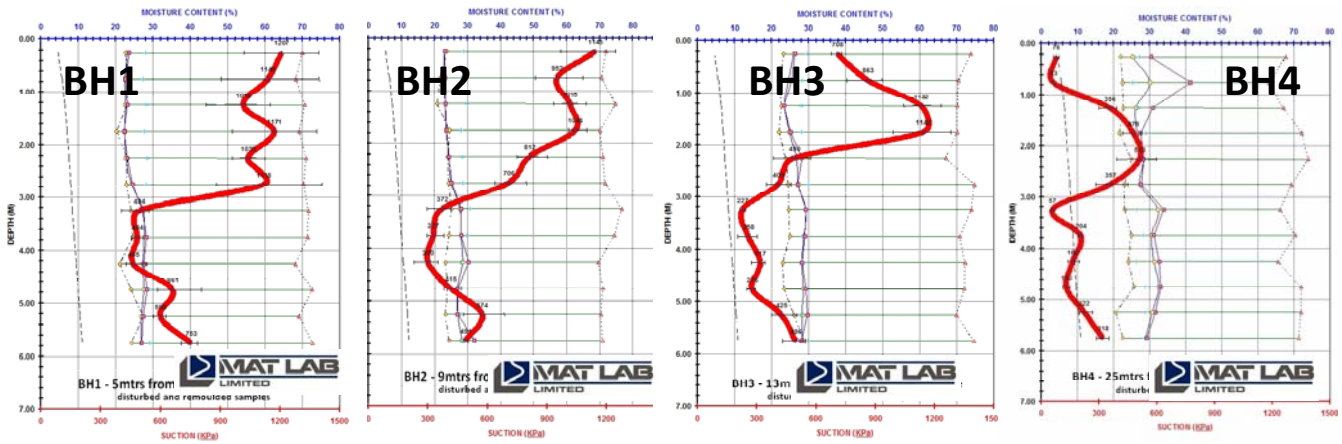
measured using the filter paper technique

Aldenham Willow

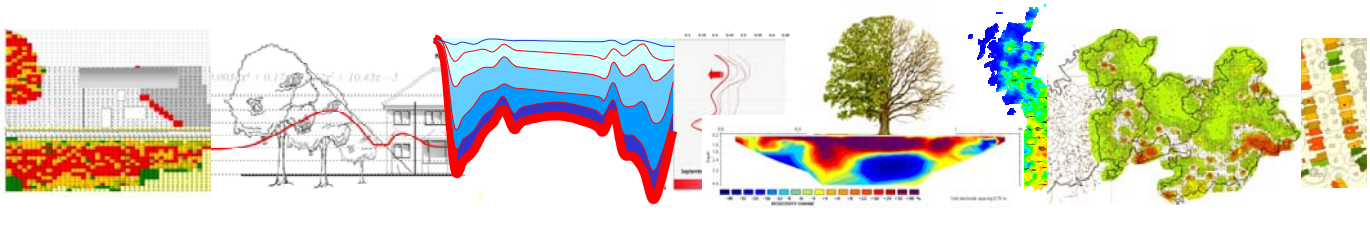
Disturbed samples

Samples retrieved - 25th May, 2006





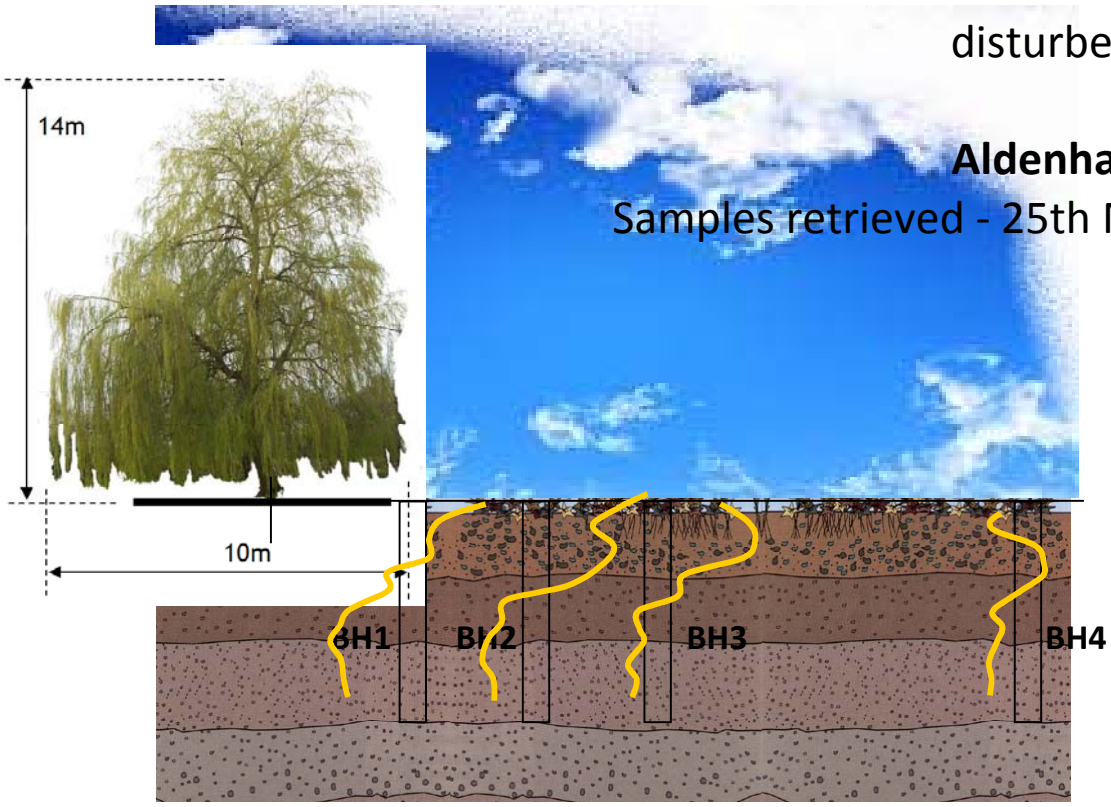
Diagrammatic section (top) showing the location of boreholes in relation to the Aldenham willow. Bottom, screenshots of the soils results tested using the filter paper method. All bores reveal desiccation to a depth of around 3.2mtrs bGL, even at BH4, furthest away from the tree. Peak suctions are recorded in BH1, closest to the willow, at 1,200kPa. The fact that these were recorded in late May confirm the presence of a persistent deficit.



The Clay Research Group

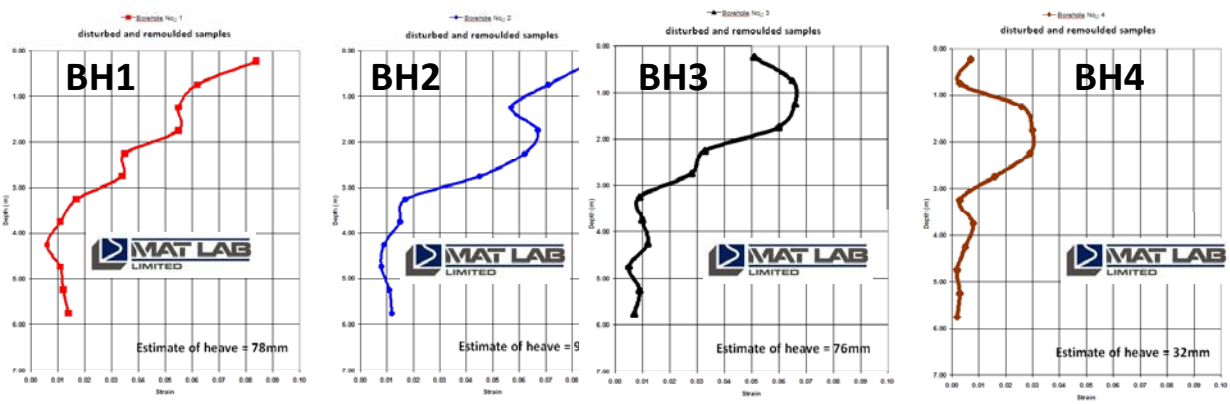
Oedometer

disturbed samples

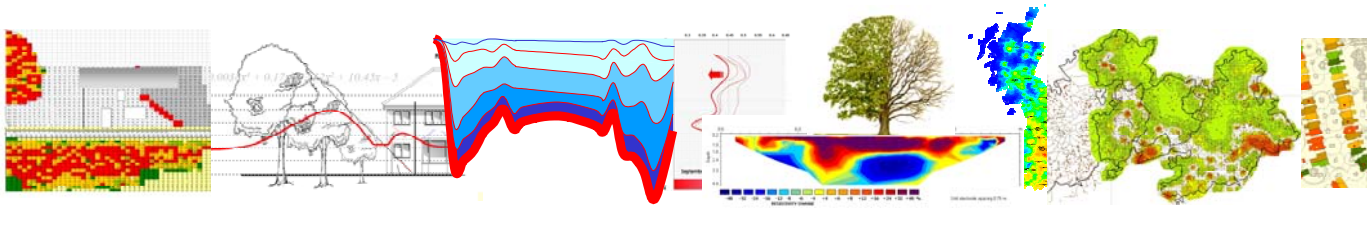


Aldenham Willow

Samples retrieved - 25th May, 2006

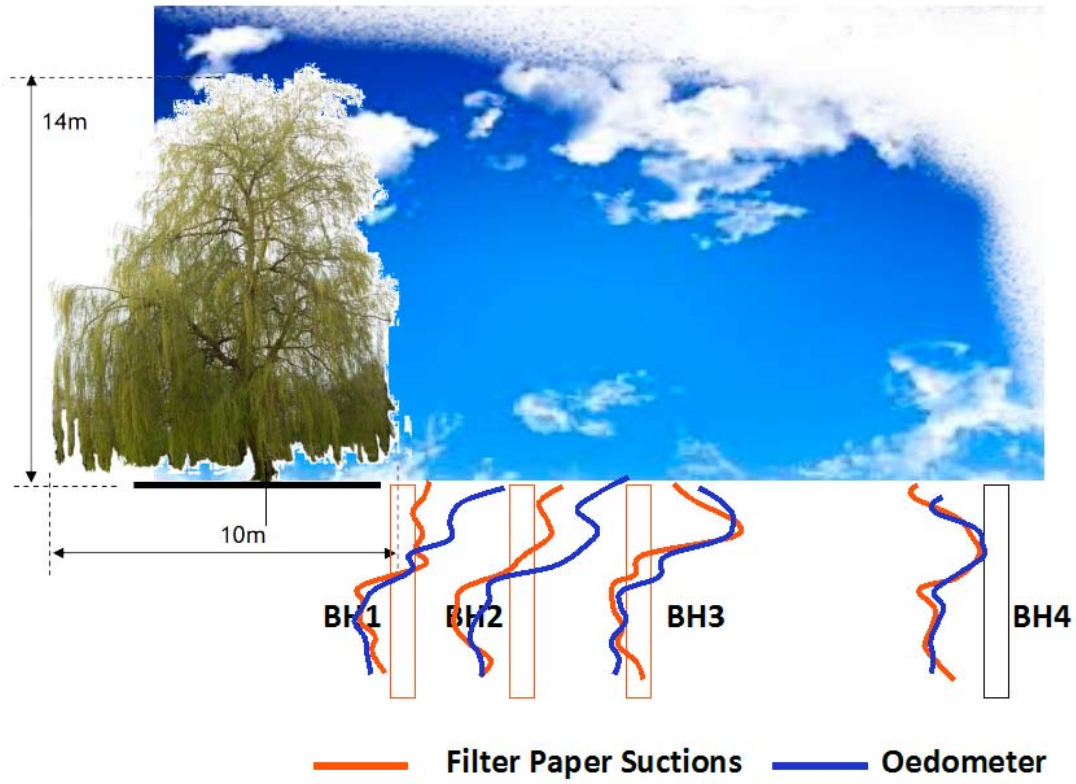


The testing laboratory, MatLab, were instrumental in developing the oedometer test for use with disturbed samples and subsequently gained UKAS accreditation. These early results revealed a close correlation to the filter paper results (previous page) and again, confirmed desiccated soil to 3mtrs. The estimates of heave are similar to those obtained using the filter paper method.

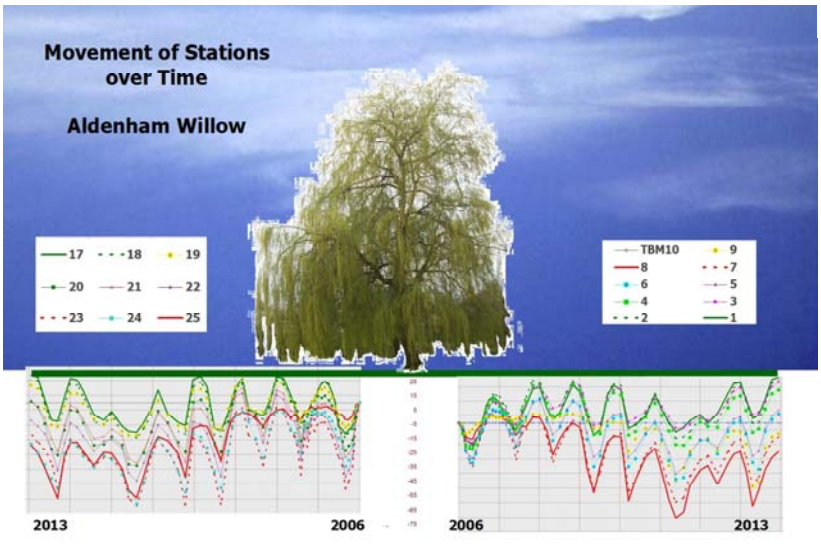


The Clay Research Group

Filter Paper Suctions –v- Oedometer Strains

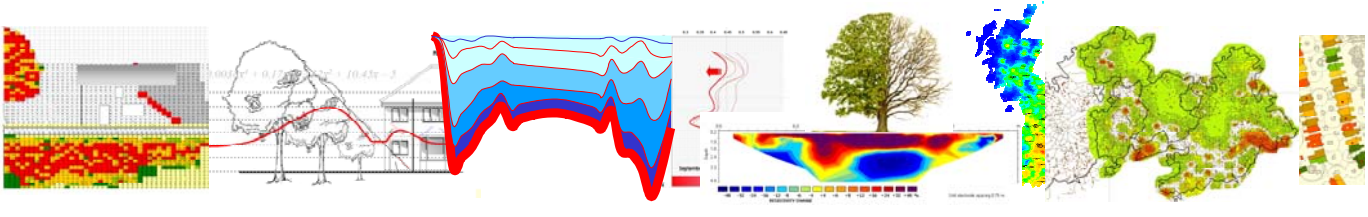


Superimposing oedometer strains onto the results of the filter paper test reveal similar patterns, as can be seen above. Estimates of heave are shown on the following pages, and correlate remarkably given the potential vagaries of soil testing.



Precise Levels

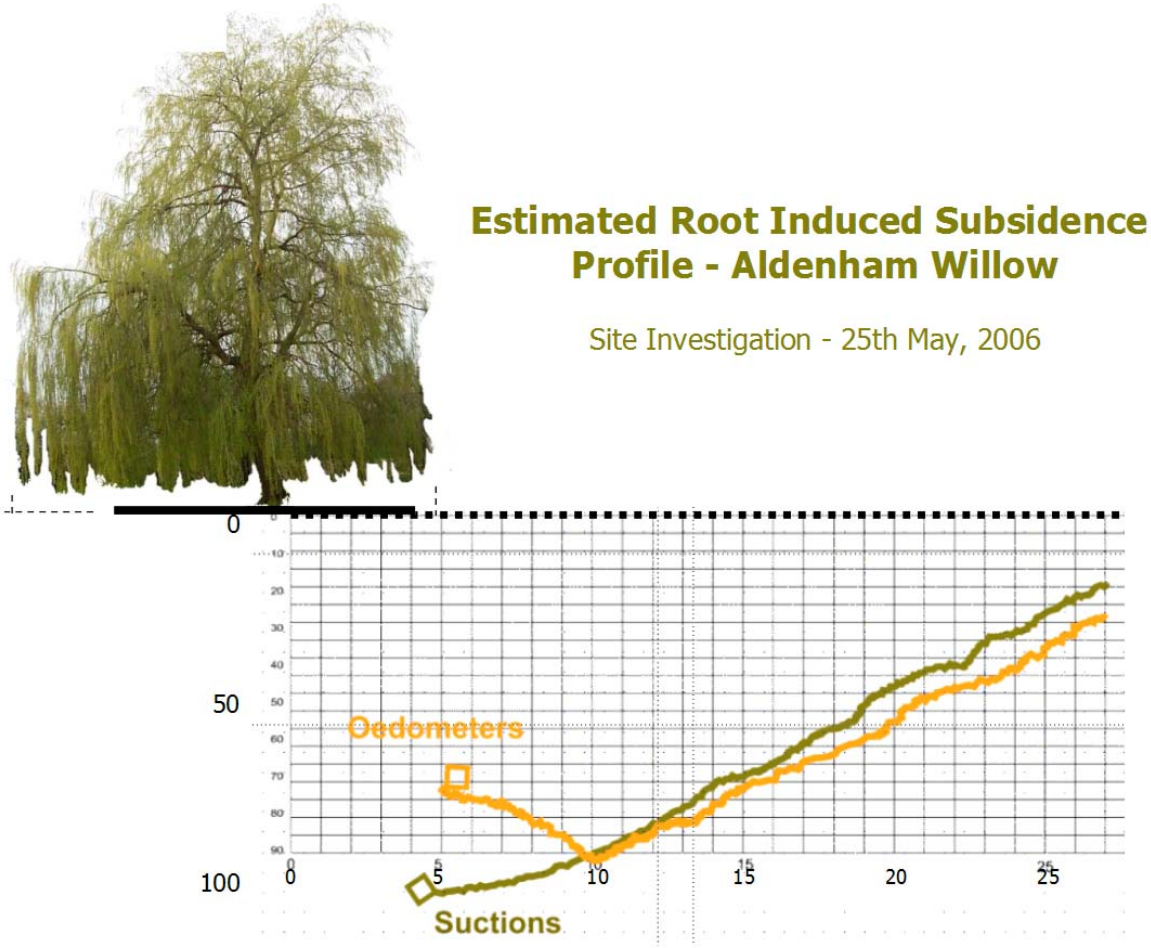
Precise levels, extending from 2006 to the current time plot the movement by station, increasing gradually over time with a greater amplitude further away from the tree than close to it – see Stations 8 and 25.



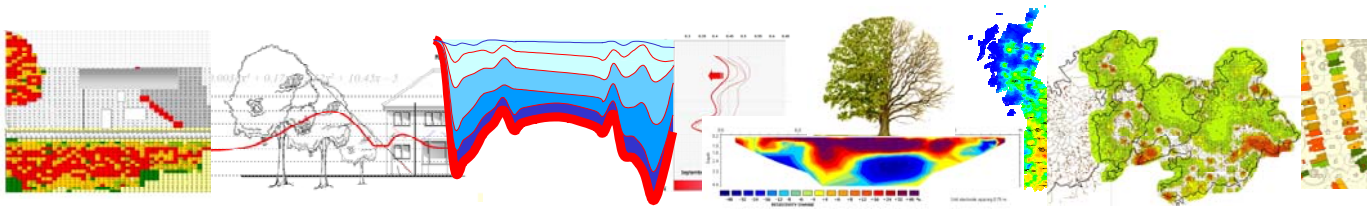
The Clay Research Group

Estimates of Heave

The estimates of heave from the filter paper test and oedometer strains are remarkably similar, differing only at BH1, 5mtrs from the tree. The heave potential here (in May 2006) was 100mm using the suction test, and 78mm using the oedometer.



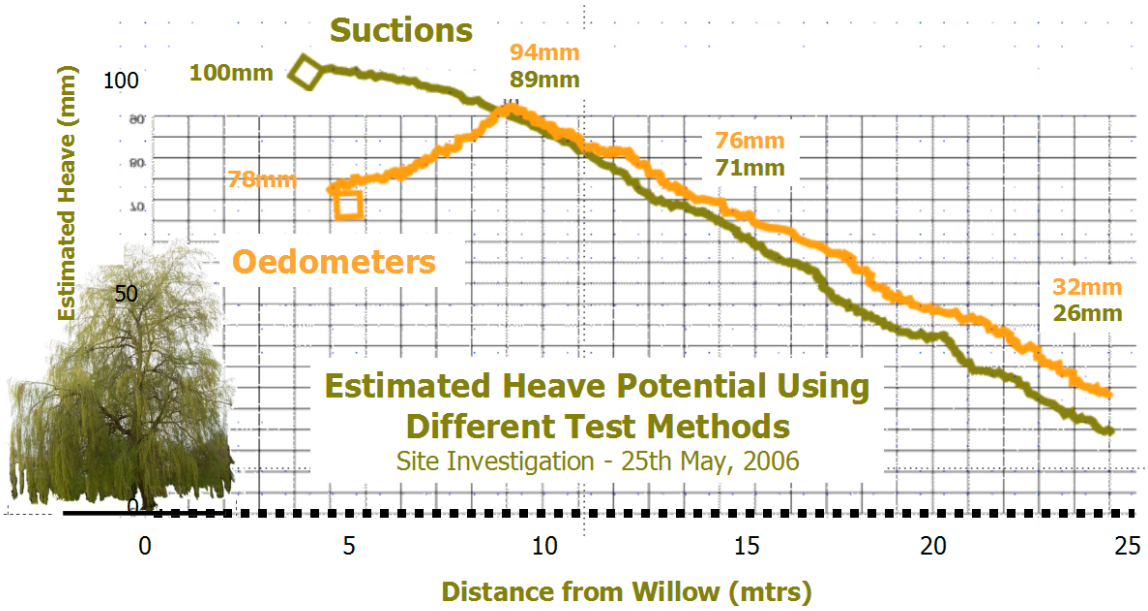
There was less variance between the results further away from the tree, at the remaining boreholes. At BH2, the figures were around 90mm, BH3, 70mm and at BH4, some 25mtrs from the 14m high willow, the estimate was 30mm. See following page for values.



The Clay Research Group

Looked at Another Way

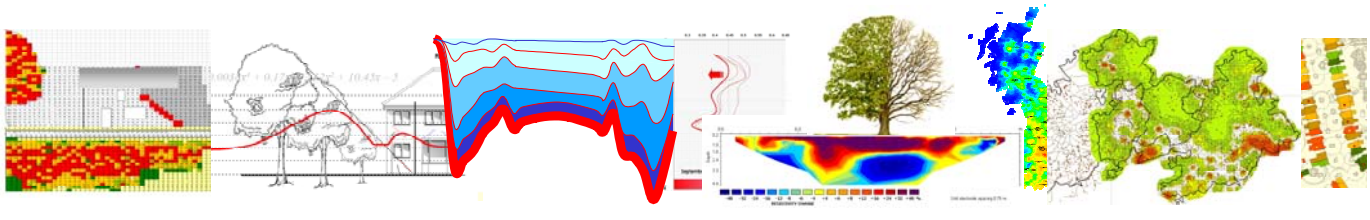
Inverting the figure from the previous page, the heave potential if the tree was removed.



Using the above values as a starting point, and adding movement recorded from precise levelling, it can be seen that furthest away from the willow, the deficit was say 30mm in May 2006, to which 60mm of seasonal movement would be added in the summer of 2013 = 90mm. Of the 90mm, around 20mm can be carried forward as a freshly developing persistent deficit, which means the ground 'takes forward' 50mm or so into 2014.

The 'persistent' element has been increasing steadily over the last 4 years, averaging 5mm per year. At a linear growth rate, it will take another 10 years or so to reach the levels of BH1. Assuming the roots have extended as far as they can go (25mtrs distance from a 14m high willow) and with very little knowledge of tree physiology, we can only assume it will be showing signs of stress shortly. Certainly suctions of 1,200kPa in late May must result in stress of the root zone closest to the tree.

That aside, a clear periodic signature has been evident even through fairly benign climatic years. The amplitude of seasonal movement is sufficient to cause damage to a domestic building.



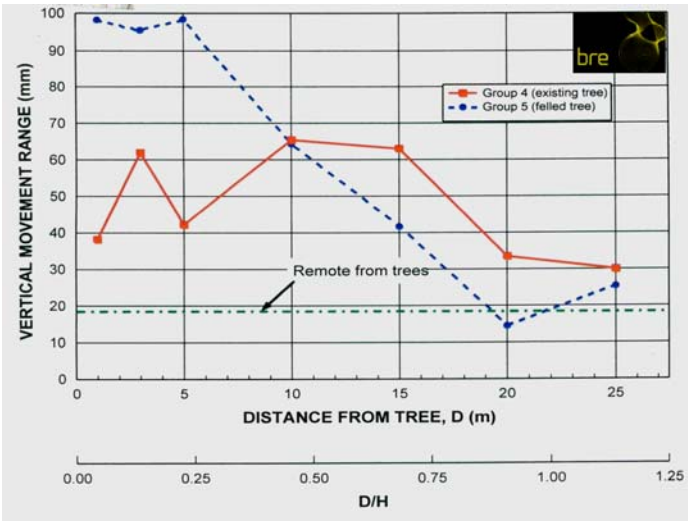
The Clay Research Group

The Chattenden Study

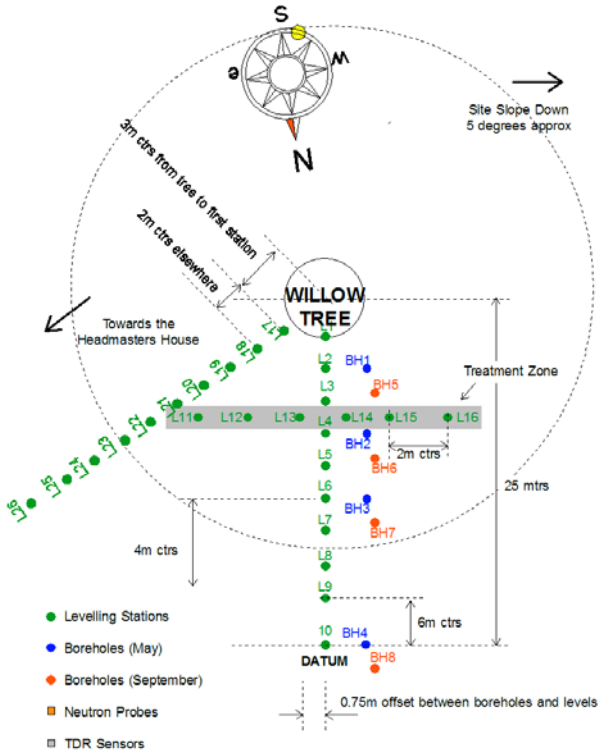
This record of ground movement at Aldenham compares with Mike Crilly's unpublished study undertaken when he was at the Building Research Establishment.

Precise levels taken at Chattenden revealed the pattern of movement shown right. Ground movement in the vicinity of mature poplars was plotted, and again following their removal.

Levels at 5m intervals revealed 100mm of recovery near to the tree, diminishing with distance linearly until it expired altogether at a distance equal to the tree height.



Chattenden, Kent, is a site owned by the MoD. The BRE were granted access to undertake research on ground movement over a number of years in the vicinity of a number of mature poplar trees, with some remote stations acting as datums.

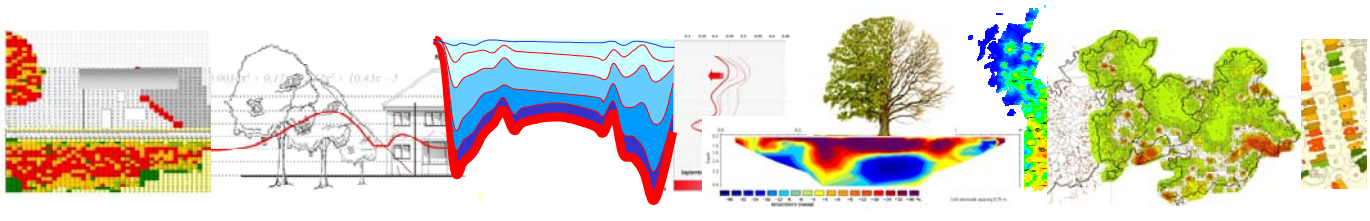


Aldenham Willow – the Site

The willow is situated on London clay with an average PI of around 48%. The soil PI is consistent over the depth of all bores.

The tree is 14m tall, and grows in the rear garden of the Headmaster's house. There is a gentle slope of around 5 degrees across the site, and both level arrays slope downwards towards the rear house wall.

The investigations that form the subject of this study are shown in blue on the sketch, left, and the levelling stations are green. Later site investigations (June 2007) are shown in red and further investigations were undertaken in April 2008 and November 2009.



The Clay Research Group

Northern Rail –v- Gateshead Metropolitan Borough Council

In the 110 edition, Rachel Bolt from Freeths provided details of a case describing the minimum steps an 'ordinary' (i.e. domestic) tree owner must take when instructing tree work.

The situation is different when commercial parties are involved. In this case, a council and a tree surgeon have been sentenced for safety failings after a worker was injured when a tree he had been felling landed on a railway line and was hit by a train.

Peter Wood acted as a sub-contractor to Mr Connelly who traded as Practical Conservation Management. Mr Connelly had been commissioned by Gateshead Metropolitan Borough Council to remove two poplar trees that were in danger of falling onto the track at Boat House Crossing near Ryton, next to the Newcastle to Carlisle railway line.

During the felling, one of the trees twisted and fell onto the railway line uprooting another tree on its way. Mr Connelly and Mr Wood tried to cut the tree away from the track, but while doing so failed to hear an oncoming Newcastle to Carlisle train.

Luckily the train was able to brake but couldn't avoid hitting the tree, injuring Mr Wood who sustained a fractured right ankle, a cut to the back of the head and bruising on his left arm, left thigh and right forearm.

The court was told the cost to repair the train by Northern Rail was more than £97,000.

A further £7,000 was incurred by Network Rail on callout, materials, machinery hire and delays to services. Network Rail had not been told about the felling operation near its line.

An investigation by the Health and Safety Executive (HSE) found that Gateshead Council failed to take reasonable steps to ensure that Mr Connelly was competent to carry out work on large trees, such as checking if he had the relevant qualifications.

Had it done so, it would have found that he was not qualified.

HSE also found Mr Connelly failed to put safety measures in place that would have prevented the tree from falling in the direction of the line.

Gateshead Metropolitan Borough Council was fined £40,000 and ordered to pay £5,854 in costs after pleading guilty to breaching Section 3(1) of the Health and Safety at Work etc Act 1974.

Mark Connelly was sentenced to 150 hours of unpaid work and ordered to pay £5,854 in costs after pleading guilty to breaching the same Act.

After the case, HSE Inspector Jonathan Wills said: "Mr Wood's painful injury and Northern Rail's unexpected bill for almost £100,000 could all have been avoided. Mr Connelly should have been able to determine that the large poplar trees represented a challenge which he was not really qualified to deal with safely and that the site presented factors which meant that special measures should have been taken."

Thanks to Dr. Jon Heuch for providing details of this case. Jon says www.trees.org.uk gives a list of contractors who should tick all the boxes.