Interpreting Resistograph Readings.

A Manual for Users of the Resistograph Decay Detection Instrument

Prepared for IML

by

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Dunster & Associates Environmental Consultants Ltd.

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Interpreting Resistograph Readings

Since the introduction of the Resistograph decay detection system there has been widespread discussion among users about the "correct" interpretation of the charts produced during drilling. While it is not possible to define a set of interpretation rules that will apply in all cases, there are certain common characteristics in the results of Resistograph readings. This interpretation manual illustrates some of the results likely to be encountered, and provides a basic understanding of what the results are telling you about the internal conditions of the tree or wooden structure.

The Instrument

Instrument Mechanik Labor (IML) is a German company based in Wiesloch, just south of Heidelberg. IML specialises in the design and manufacture of precision instruments for use in a wide variety of different applications. The Resistograph, of which there are several models, was specifically designed to accurately detect decay and defects in trees, and wooden structures. The materials presented in this report have been obtained by using an F500 and F500 se models. The F series of Resistograph come in three sizes, with the F300, F400, and F500 representing optional drilling depths of 300, 400, and 500 millimetres.

The principle behind the Resistograph is quite simple. A very fine drill made of high quality steel, is fed into the wood at a predetermined rate, depending upon the species of wood, and the model in use. As the drill enters and passes through the wood, it encounters variable amounts of resistance. This resistance reflects:

- the structural condition of the cell walls,
- the variations between early and late wood in the annual growth ring,
- the species of wood and its typical cell layout (for example diffuse, or ring porous), and
- the manner in which the tree has developed in response to environmental conditions

The variation in resistance results in increases and decreases in the amount of torque applied to the drill shaft. By means of sophisticated mechanical and electronic sensors, variations in torque are translated into graphical output which depicts the internal conditions encountered by the drill at the specific point of drilling.

The Readings

The Resistograph produces two forms of output. One is a simple etched trace on a special waxed paper strip that slides in along the top of the instrument. In some models this can also be a printed line on a paper roll. In the more sophisticated models, readings can be stored in an on-board computer, and then downloaded to a desktop system for review, analysis, and printing. In either case the horizontal baseline of the chart is calibrated in inches or centimetres of drilling depth, moving from right to left. The vertical axis has no units, and is a measure of relative density within that one reading. For example a high point indicates a relatively higher density of wood (higher drilling resistance and therefore higher torque) than a lower point. Examples of both forms of output are included in this manual.

The manual contains sections dealing with the affect of annual ring widths, patterns of decay, and patterns of defect. Results using the wax paper strips and the digital printout are included to illustrate common patterns. A section looking at testing of wooden structures, uses power poles as the main example.

Interpreting the Results

Interpreting the charts requires practice and skill. Gross defects are relatively easy to recognise. The more subtle aspects of decay and defect require more time and experience. The examples in this manual should help you to better understand some of these aspects. The best approach to interpreting Resistograph results is to build up your own library of outputs charts. Whenever possible, take the time to obtain a section of wood at the point where you took a reading, and then match the output to the actual cross section. Copying the information derived from a waxed trace onto a clear acetate (overhead) permits the readings to be overlain onto a cross section of wood, so that the results are transparent. In this manner you can start to gain some confidence that what the Resistograph readings tell you, are in fact what will be inside the tree.

Readings taken with the 45° adapter in place, allow the user to explore the condition of the wood underground. On the F500se, for example, the tip of the fully extended needle would be about 35 cm down from the point where it entered the wood. However, at this angle the horizontal baseline is no longer a 1:1 ratio. To correct for the angle, multiply the horizontal reading by 0.71 which will give the actual horizontal depth.

Further Information

The information contained in this manual was produced by Dr. Julian Dunster. It is based on field work and subsequent dissection of many of the samples assessed. The charts reproduced show a range of different situations in a variety of species. If you would like more information about the Resistograph system please contact IML directly.

Caution

Many of the charts reproduced here have been shaded or coloured below the trace line in order to highlight the reading. Actual output is a single trace line. The charts reproduced have been scanned and shrunk down to fit this manual format.

 The materials, charts, and interpretations presented in this manual are based on analysis of the specific trees or structures discussed. They are provided as guidelines for interpretation. Users of the Resistograph system should know and understand the techniques involved in assessing standing trees, and the typical decay and structural problems likely to be encountered in wooden structures such as bridge timbers, power poles, and structural components in buildings.

Users of the manual and the Resistograph system are solely responsible for any interpretation or subsequent actions taken as a result of interpretations. Neither Instrument Mechanik Labor Inc. nor Dunster & Associates Environmental Consultants Ltd. accept any liability for the manner in which users choose to interpret their own data.

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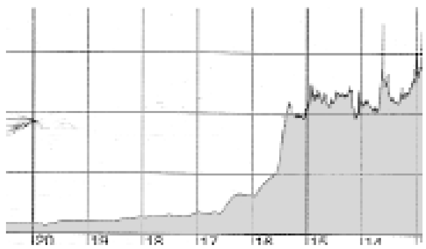
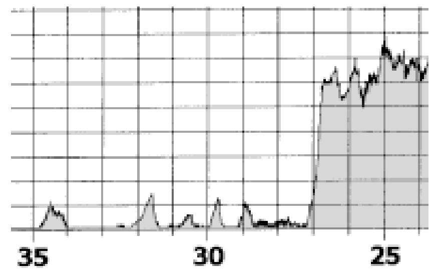
Patterns of Decay

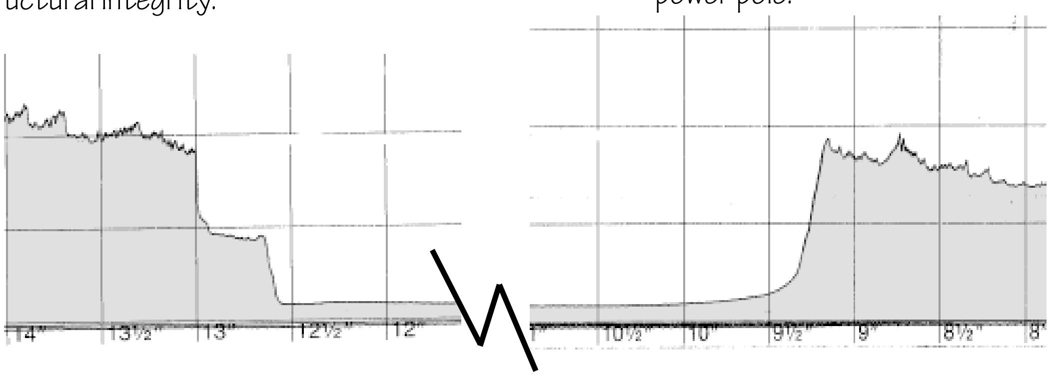
Wood decays in distinct stages. Sound wood has strong cell wall structure, but as decay organisms invade, physical and chemical changes occur within the individual cells. Incipient decay marks the beginning of changes in wood density. Once decay becomes well advanced, the wood structure breaks down and wood density decreases drastically. Changes from sound to incipient decay, and from incipient to advanced decay are detected by the Resistograph, although the extent to which this will show up also depends upon the species and growth patterns of the individual specimen. In the following charts typical decay patterns are shown.



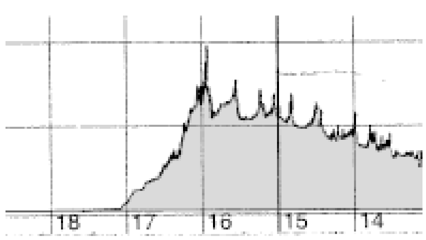
Decay in Douglas-fir. (*Pseudotsuga menziesii*). At 15.5 cm, the incipient decay starts, and moves rapidly into advanced decay by the 16 cm point. Drilling resistance (wood density) is low from then onwards indicating a large cavity which may have some rotting wood in it, but none of it has any structural integrity.



Decay in western redcedar (*Thuja plicata*). The edge of the decay zone is sharply defined at 26.8 cm. Resistance drops to zero, and then a few small bumps are seen. These are the last remnants of the late wood in individual rings. This reading is from the below ground part of a power pole.



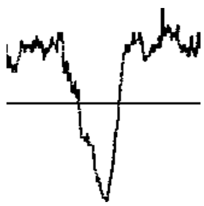
Decay in Red alder (*Alnus rubra*). The two sides of a cavity. The right side shows a very smooth decay curve, and is typical for hardwood species. The left side shows a pronounced step back up from no resistance to high resistance. The flat part in the middle of the step (about 0.75 inches) is the barrier zone between the sound and decayed wood.

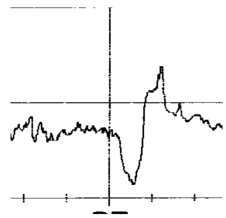


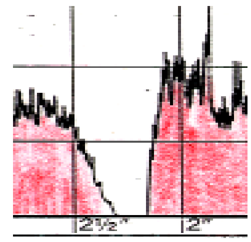
Decay in Big leaf maple (*Acer macrophyllum*). The decay curve is stepped down before the zero drilling resistance is reached. This is a transitional zone of incipient decay - the wood still has some structure, but gets progressively weaker as the drill gets closer to the cavity.

Cracks, and Other Issues

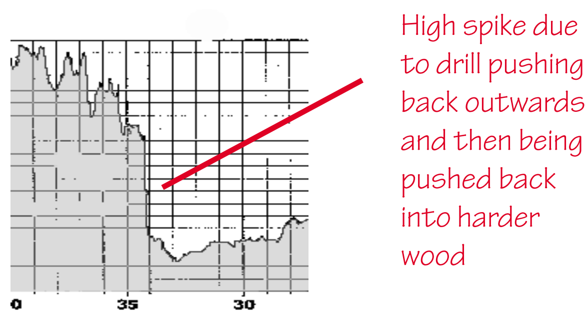
There are times when readings contain results that do not fit with anything else experienced. Cracks, can sometimes be difficult to separate from pockets of decay. Generally, a crack shows up as a sudden drop in resistance with sound wood on either side. In the examples below, note how the drop is characterised by continual resistance dropping down in jagged steps (albeit very small ones). This is quite different from decay, where the drop in resistance is more of a smooth curve.



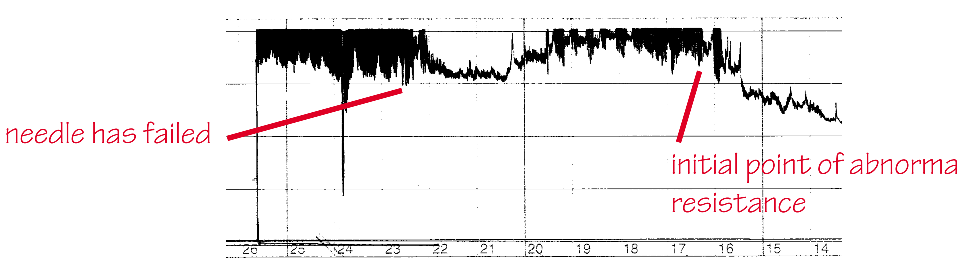




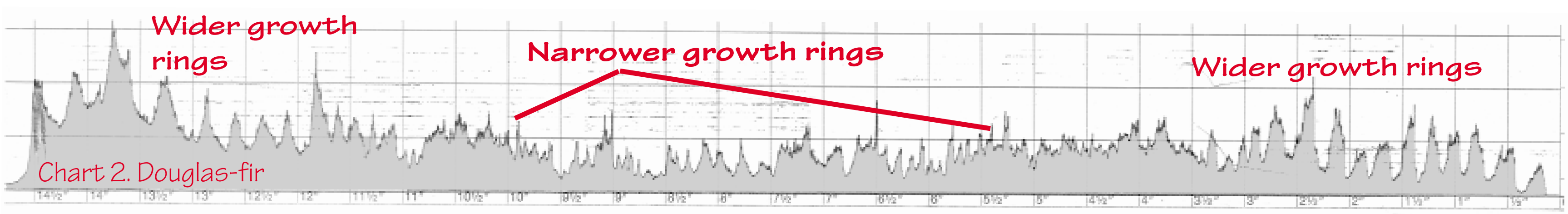
Sometimes the reading may not be related to the wood at all. The Resistograph utilises a clutch system to ensure that, in the event of the needle jamming, there is a mechanism for it to release, rather than ruining the entire instrument. Improper adjustment of the clutch may lead to slipping of the needle at a lower threshold torque. Typically, this shows up as a series of sudden vertical spikes, with the resistance on either side being quite different. The affect is caused by a build up of torque along the needle, which triggers the clutch to slip, and then recover, leading to a sudden "blip" in the measured resistance. Prior to the spike, resistance measured is declining as the clutch starts to slip. Once the clutch starts to grip again, the resistance measured is more accurately reflected in the reading. The example below left, shows this affect. Occasionally, the wood density may be very high and if the Resistograph is not held firmly against the wood, it will be pushed outwards. Correcting this by pushing back more firmly, gives a sudden high spike, as seen below right. This problem is overcome by holding the instrument firmly at all times.



In some cases, it is possible to encounter an extremely dense, and very hard piece of wood which gives an extremely high reading. This can lead to clipping of the results at the high end. It is also possible that the needle tip can fail in such circumstances, which then leads to an improper reading. Damage to the needle tip can also be caused by rocks (drilling underground), and pieces of metal in the tree or pole being tested. In the example below (Silver maple) the needle encountered some form of dense wood at 16 to 18 cm in, and then failed at 22cm. Needle tip failure is accompanied by a most unpleasant set of noises in the instrument, and a pronounced vibration. The reading should be stopped, and the needle withdrawn from the sample when this happens. Check the needle tip and install a new needle if required.



The Affect of Annual Ring Width



The Resistograph reading clearly shows the ring width variation and exactly matches the sampling point.

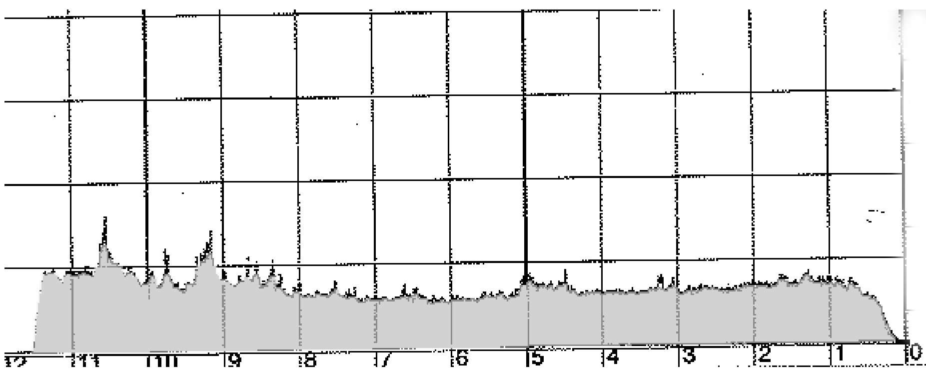
Chart 1 is a reading taken right through a Douglas-fir (*Pseudotsuga menziesii*) growing on Bowen Island. The trunk is sound throughout. Note how the outer ring widths are wide, and could be used to determine the age of that part of the tree. In some of the individual rings, the change in density between early wood and late wood is also apparent.The inner rings are very much smaller in width and consequently, form a much tighter grain. The resulting reading cannot differentiate individual rings.

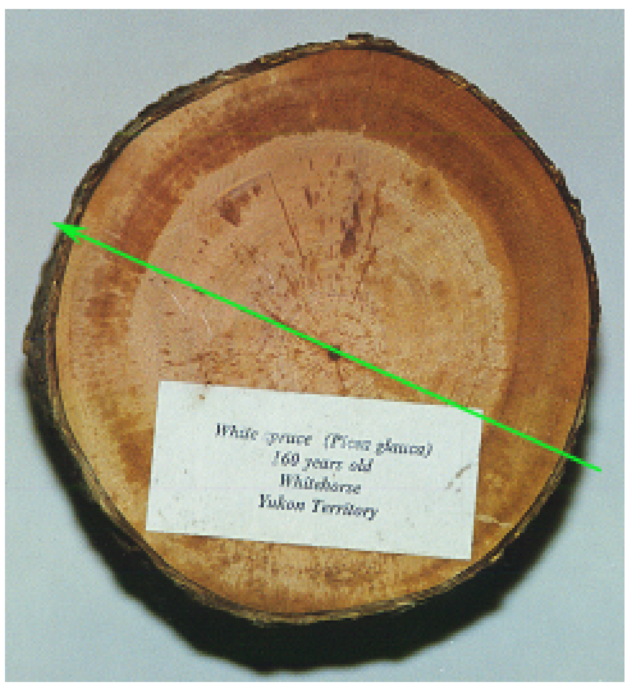
Chart 2 is a reading taken right through a Douglas-fir stem that had been dead for over two years. In this example the ring width is not so tight in the central area. The photograph shows the original chart laid across the sampling area.

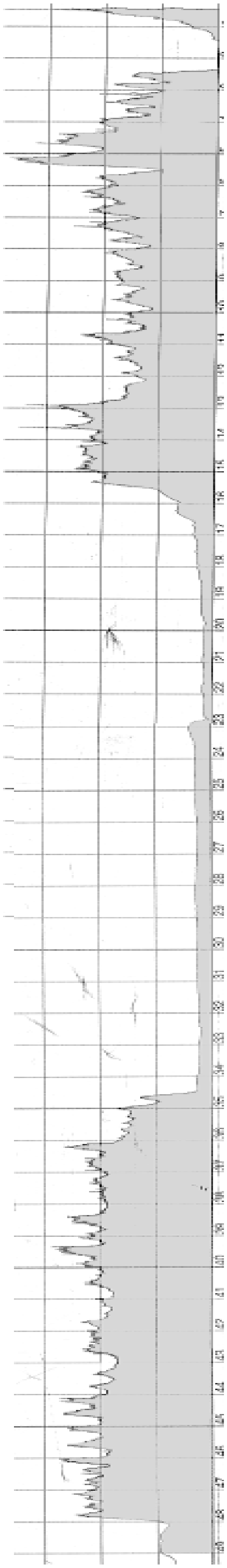
In both cases the wood is sound. Close examination of either chart shows that the lowest point of drilling resistance in the wide rings is similar to the higher point in the narrow ring widths.

The Affect of Annual Ring Width

This reading is taken across a white spruce (*Picea glauca*) growing in the Yukon Territory. The stem is only 11.5 centimetres in diameter, but contains 160 annual rings. This reflects the harsh climatic conditions where the tree grew; low moisture levels, poor soils, and a short growing season. The Resistograph reading shows a fairly continuous wood density right across the stem. The green line indicates the drilling path.







Analysing Patterns of Decay

The chart shown here is of a Douglas-fir (*Pseudotsuga menziesii*) that had been previously topped. This reading was taken across the top of the stem, about 20 centimetres below the point of topping. At this point the tree trunk was 48 centimetres in diameter. Five new leaders (one dominant and four sub-dominant) had regrown. The original cut surface was completely callused over with no external signs of decay visible. The Resistograph readings show that the trunk was hollow, with extensive advanced decay from 16 through to 35 centimetres. As this decay cavity expands it would eventually lead to structural failure of the regrown leaders.

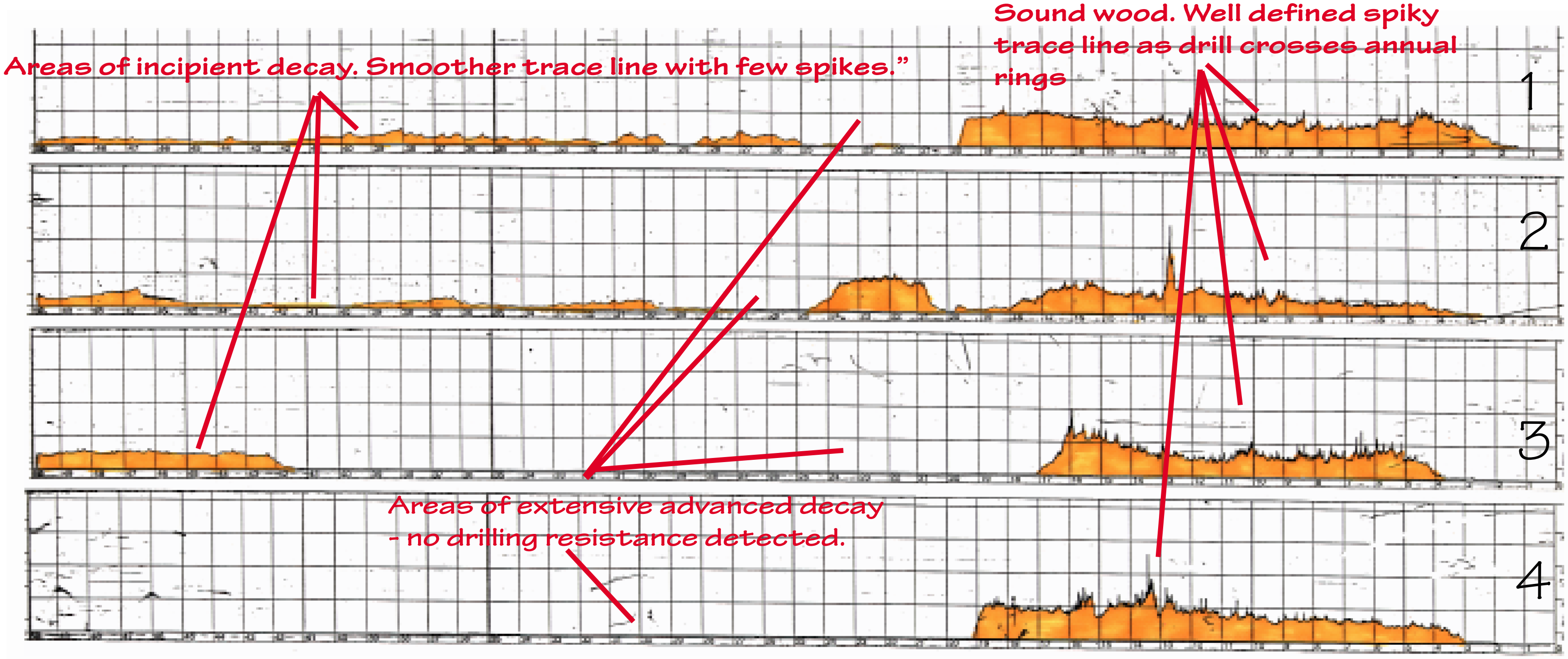
The extent of the charted cavity matches the cavity actually found after dissection. Note how the changes in wood quality (sound at15.5 centimetres, through incipient in the next centimetre, to advanced decay) are tracked by the Resistograph. This pattern on a chart is a very typical decay curve.

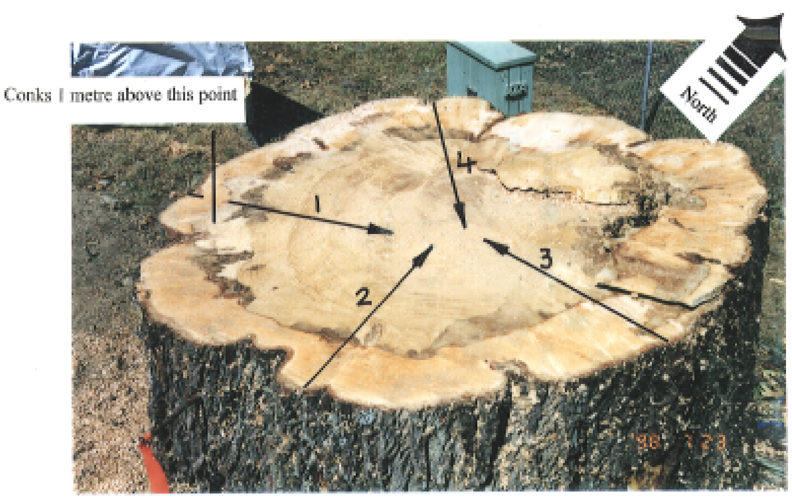
Note also how the baseline “zero” reading in the cavity is higher than the “zero” reading at the start of the drilling, and the baseline reading at the end of the drilling is higher yet, even though the drill has come right through the trunk. This elevated baseline reading is due to friction along the shaft of the drill which has wondered slightly off a straight line as it passed through the trunk. Note also the initial spike at the start of the reading. This is caused by the needle drilling through a hard plate of bark and then into a small gap underneath before it entered the cambium. The small spike at 23 centimetres in, was caused by stopping and the starting the drill.

Looking at the cavity just below the original point of topping

The top of the trunk showing the regrown leaders after the original topping work.

Analysing Patterns of Decay

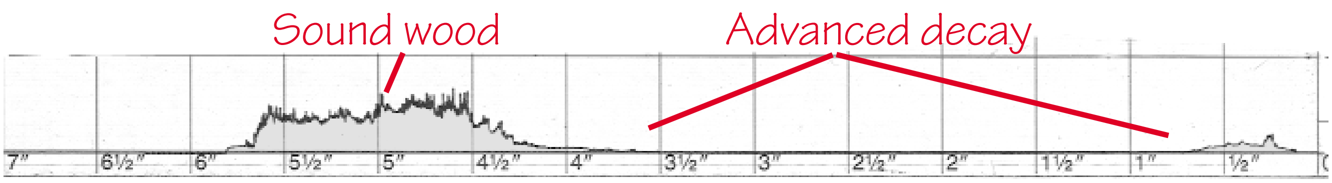




Big leaf maple (*Acer macrophyllum*) 134 cm in diameter. Large conks had been observed on the south face on either side of vertical bark cracks. Resistograph readings were taken at points 1 through 4 to determine shell thickness and the extent of suspected decay due to *Ganoderma applanatum* . The readings revealed very extensive advanced decay with shell thicknesses equating to less than 30% of the trunk radius. The cross section shown in the photograph is right at the plane of sampling. The central part of the trunk in readings 1, 2, and 3 still shows some drilling resistance, but note how the trace line at these central areas shows no "spikes", while the earlier trace in the sound outer wood shows quite distinct spikes as each ring is traversed. This is a typical reading and shows the difference between sound wood, and wood that has incipient decay.

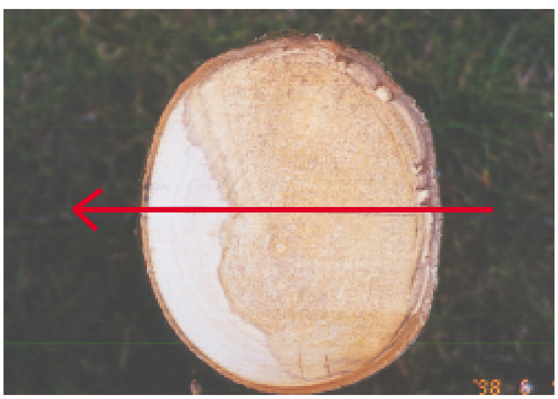
Analysing Patterns of Decay

A large branch (6.5 inches in diameter) fell from a big leaf maple without warning, on a calm day. There were no external indicators of defect on the tree at the point of failure. The failed branch exhibited extensive fungal mycelium at the failure point, subsequently analysed to be a saprobe, *Bjerkandera adjusta* (syn. *Polyporous adjustus*). Resistograph testing across the failure zone revealed that there was no structural capacity in most of the branch, with only a small part of sound wood on the upper zone (left of chart).



Top of branch

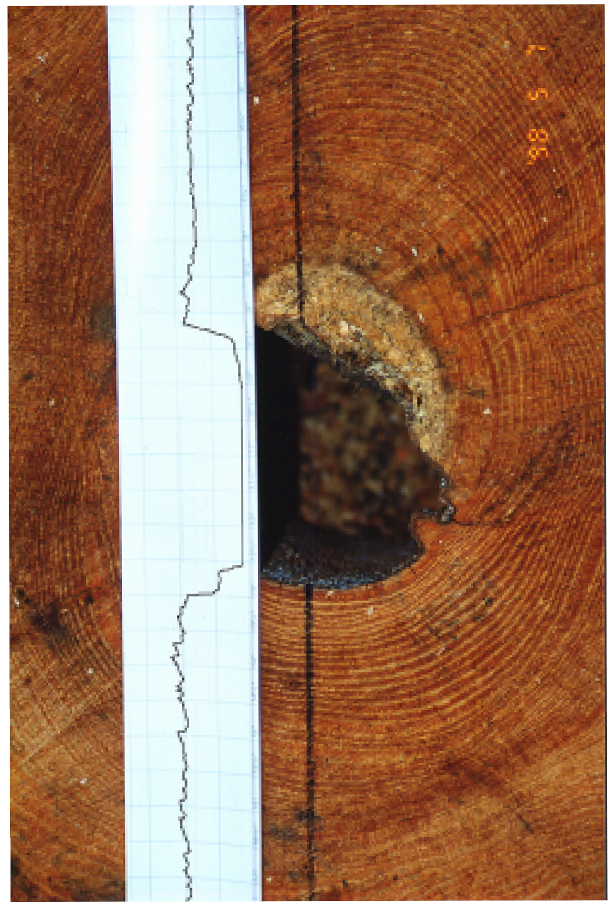
Underside of branch

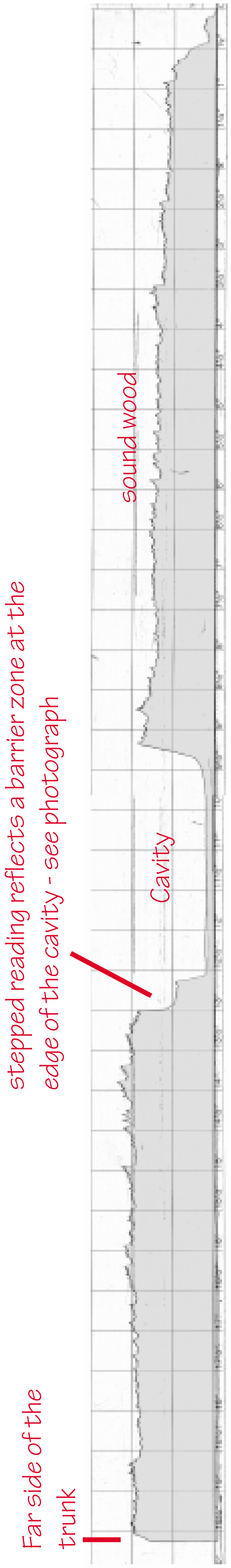


Cross section tested showing the small area of sound wood on the left (top) side

The failed branch at a point about 20 centimetres beyond the testing point. Note the extensive mycelium across the branch.

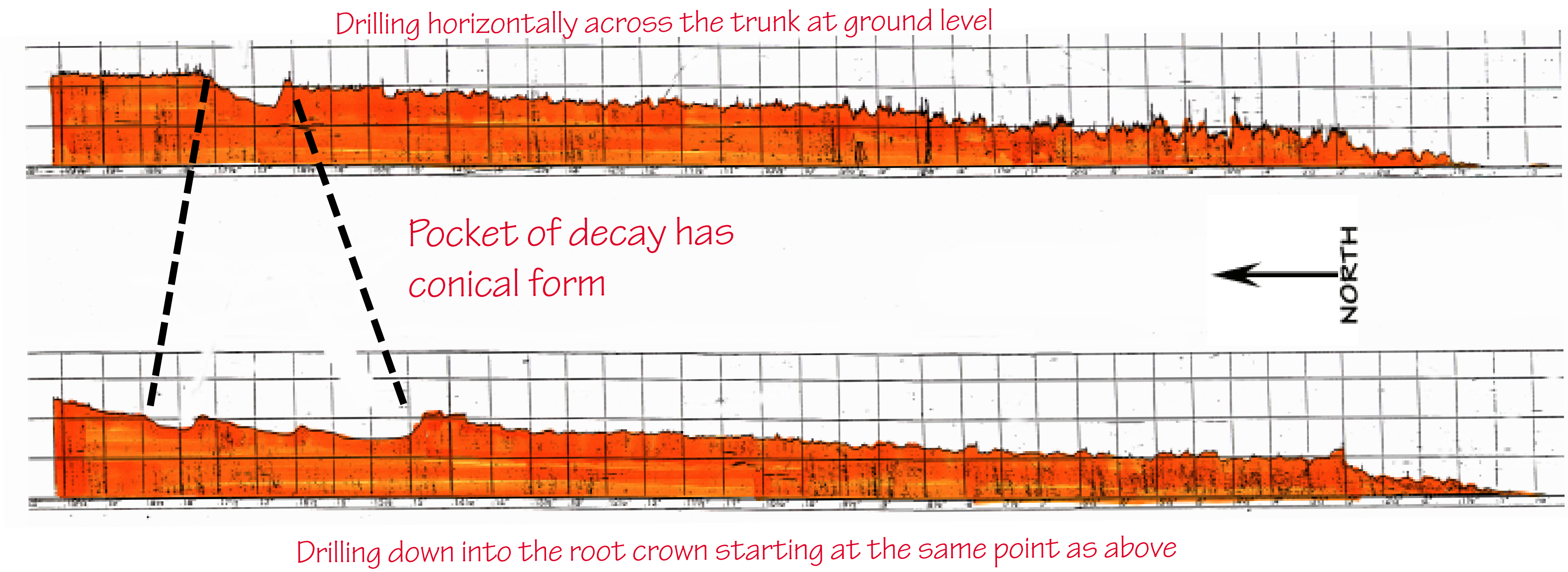
Analysing Patterns of Decay





Red alder (*Alnus rubra*) with an internal decay pocket that has compartmentalised quite well. The decay curve on the right side reflects a transition from sound wood, through incipient decay into a cavity. The stepped curve on the left side reflects a small barrier zone that had developed at the *edge of the cavity*, seen in the photograph. In this reading the wood density is very consistent across the trunk. The reading in the cavity area has almost *gone right back down to the zero baseline* indicating that the path of the drilling needle has remained straight and that there is no additional friction acting on the drill shaft as it passed through the wood. Although the annual rings are clearly seen in the photograph, they do not show up on the reading, indicating that the wood density is fairly even across the rings.

Analysing Patterns of Decay

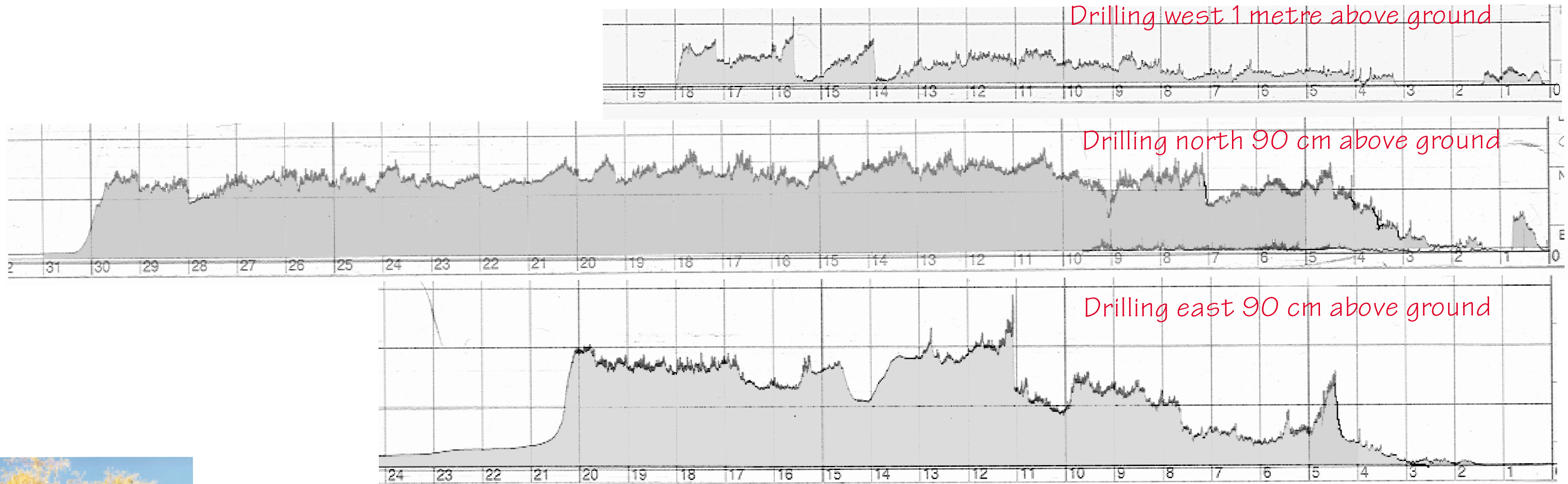


These two charts are taken from a red oak (*Quercus rubra*). The top reading was taken right across the base of the tree trunk and a small pocket of decay was noted, less than one inch across. A second reading (lower chart) was then taken drilling down into the root crown, starting at the same point as before.

The readings show that the pocket of decay is more extensive (about 3 inches) at an estimated depth of six inches underground.

The amount of decay was not considered to be a serious problem at the time of the assessment.

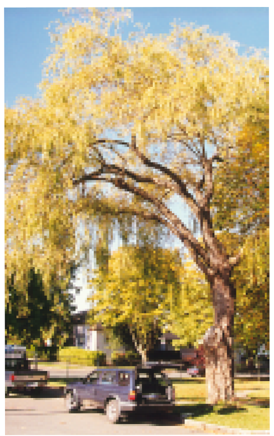
Analysing Patterns of Decay

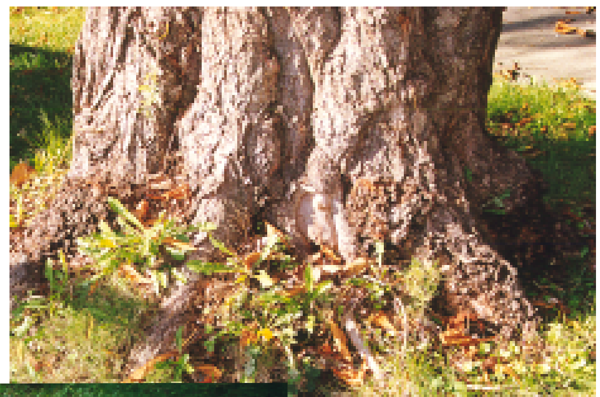


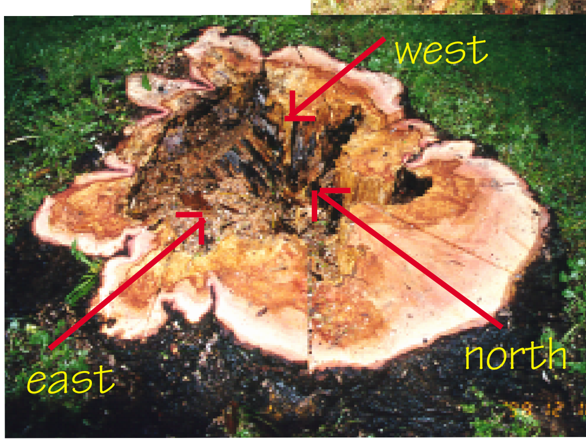
This willow (*Salix babylonica*) had a dbh of 100 cm, and had started to shed large limbs. Visual assessment revealed some decay in the areas of limb failure. Testing at the base revealed extensive decay throughout the trunk. The cut stump photograph was taken at about 80 cm below the point of testing. The decay patterns seen in the charts show that the decay was less extensive higher up the trunk, but still encompassed all of the central area.

Note how the relative drilling resistance varies between samples; the sample to the east showing much less resistance than the sample to the north and west. Given that these are all taken in relatively close proximity to each other, analysis of the charts would suggest that the wood in the east trace is much weaker, and indicates some internal problems.

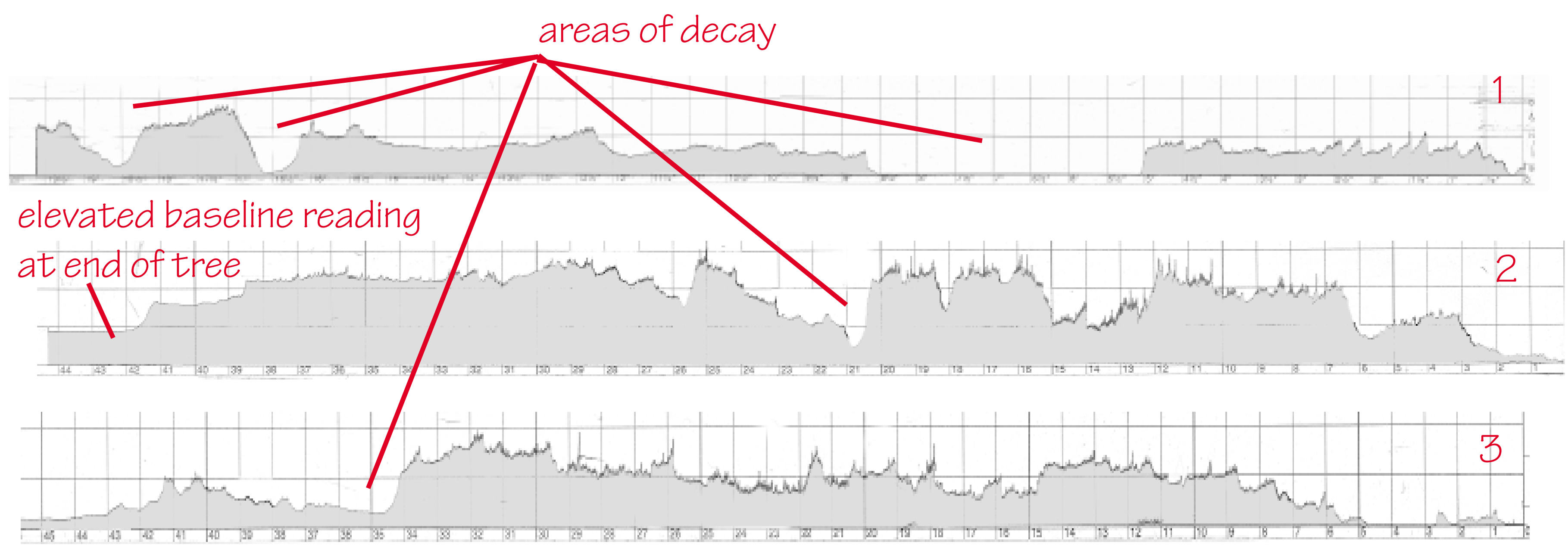
Note that the chart to the north has a very low trace under the main one. This resulted from using the hardwood setting first of all, which did not yield sufficient information. The drill was retracted and the setting changed to softwood, which then produced a reasonable result.







Analysing Patterns of Decay

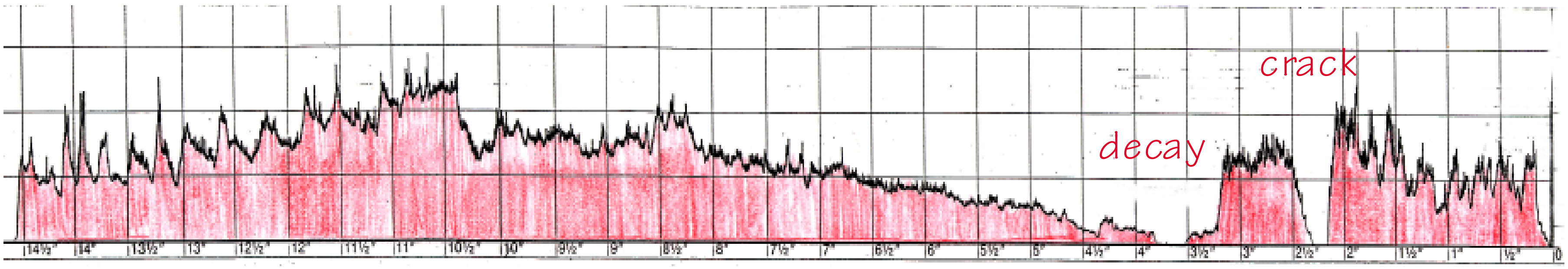


1 Western redcedar (*Thuja plicata*) 20 inches in diameter showing several distinct pockets of decay surrounded by sound wood. The decay pockets result from the pocket rot (*Postia sericeomollis*).

2 Horse chestnut (*Aesculus hippocastanum*) sampled at ground level. The chart shows the trunk to be generally sound but with a minor pocket of decay in the centre of the trunk. Note the end point is a high baseline zero due to friction on the drilling shaft.

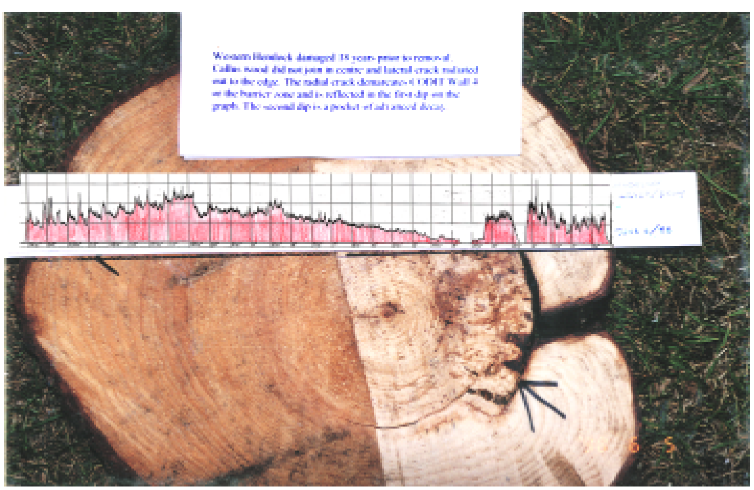
3 Cottonwood (*Populus trichocarpa*) sampled at the base of the trunk. The low resistance at the start and end of the of the drilling reflects extremely low density outer wood which is sound but very soft. An area of incipient decay is suspected at the 34 to 35 cm mark but would require additional sampling to confirm.

Analysing Patterns of Defect



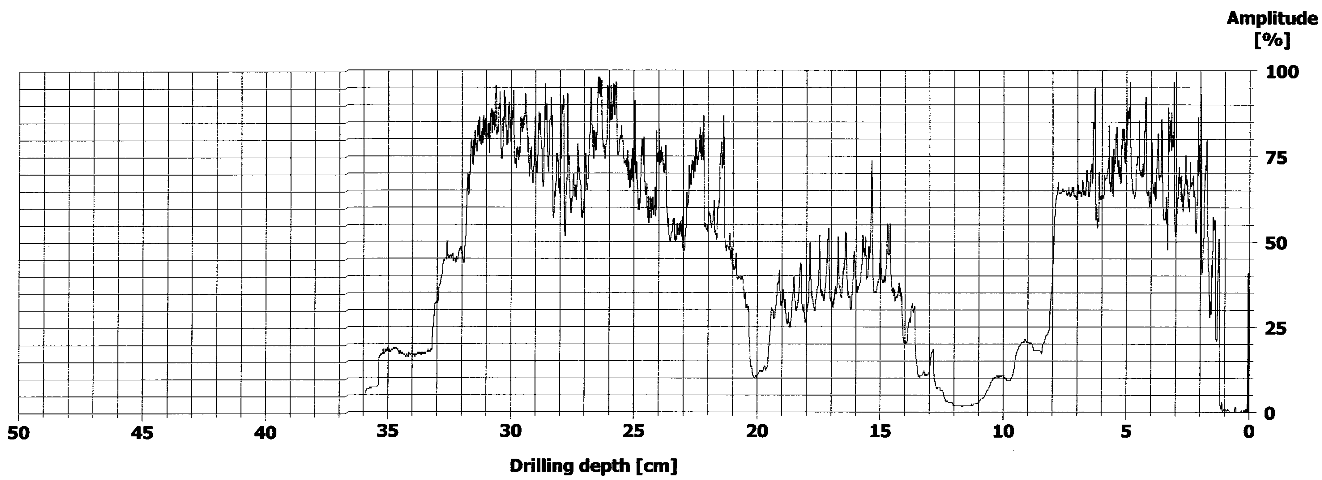
Western hemlock (*Tsuga heterophylla*) showing a reading across the entire trunk right next to a crack in the bark. The Resistograph reading was taken a few weeks after the tree was cut down, by which time the radial crack along the barrier zone (arrow) had dried out and opened up slightly. The photograph at left shows that the tree had been wounded about 18 years ago. The callus tissue closed over the wound leaving a well defined barrier zone. However, the callus tissue did not join together and after a strong winter wind the tree ruptured along the defect to produce a pronounced crack in the outer bark. This crack was weeping sap which then became a well defined black streak down the trunk - the visual indicator that triggered further assessment. The vertical section shows the column of decay which extended for 30 metres up the south face of tree, welll beyond the original wound area.

Note that the reading was taken off-centre, so the trace at around 5.5 inches in, is actually traversing along the rings, and not at 90° to them.



Readings Taken With The Electronic Option - F500se

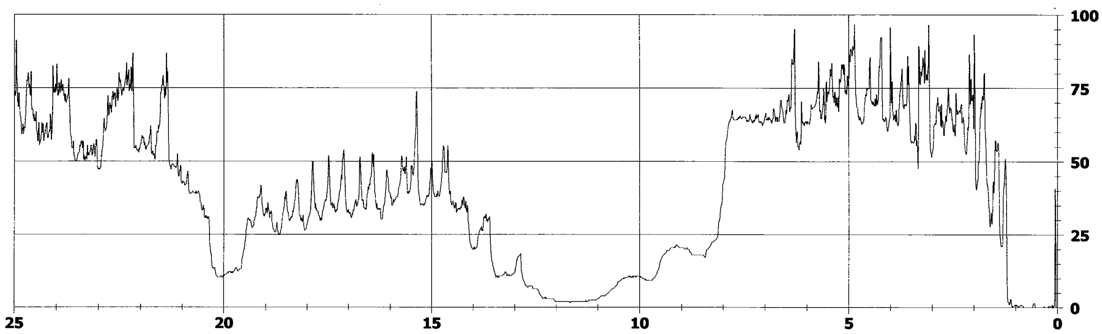
One of the options available for the F series of Resistographs is an on-board computer that permits storage of the readings in digital format. The results are then downloaded to a PC computer for subsequent analysis and annotation. In the digital formats, it is possible to alter the horizontal or vertical scales to have a closer look at the results. Examples of the different formats are shown on this and the next page. The charts following the examples are presented in the standard form for ease of viewing. The electronic option permits greater sensitivity in the reading, and allows for much more detailed analysis. However, the paper output is still an essential format since it allows for on the site interpretation, which in turn affects the extent of subsequent field checking.

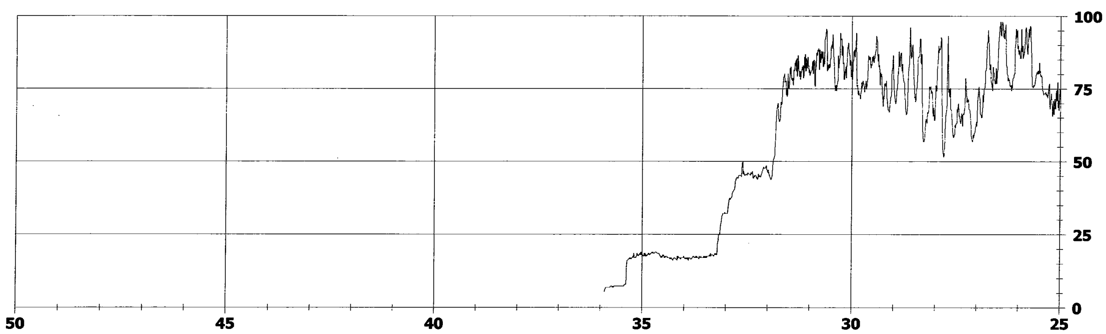


This is the standard format for electronic output.

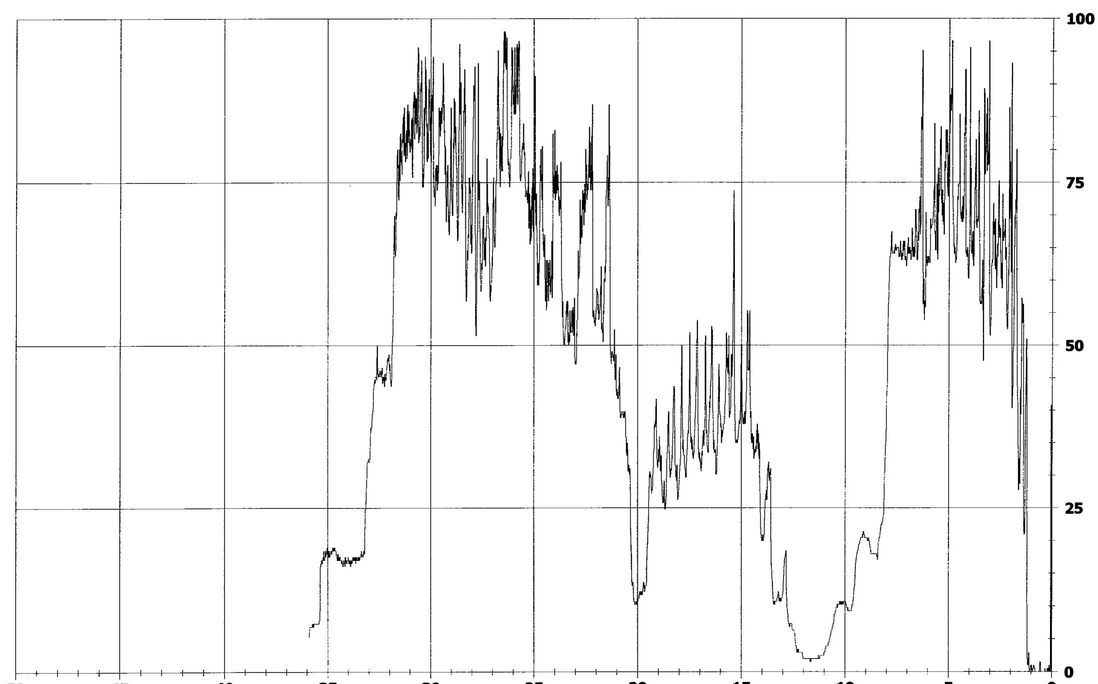
The electronic output option shown here mounted on an F500S Resistograph. Readings can be individually numbered through the keyboard.

Electronic Output Options.





Example of the same chart but extended horizontally into into two sections

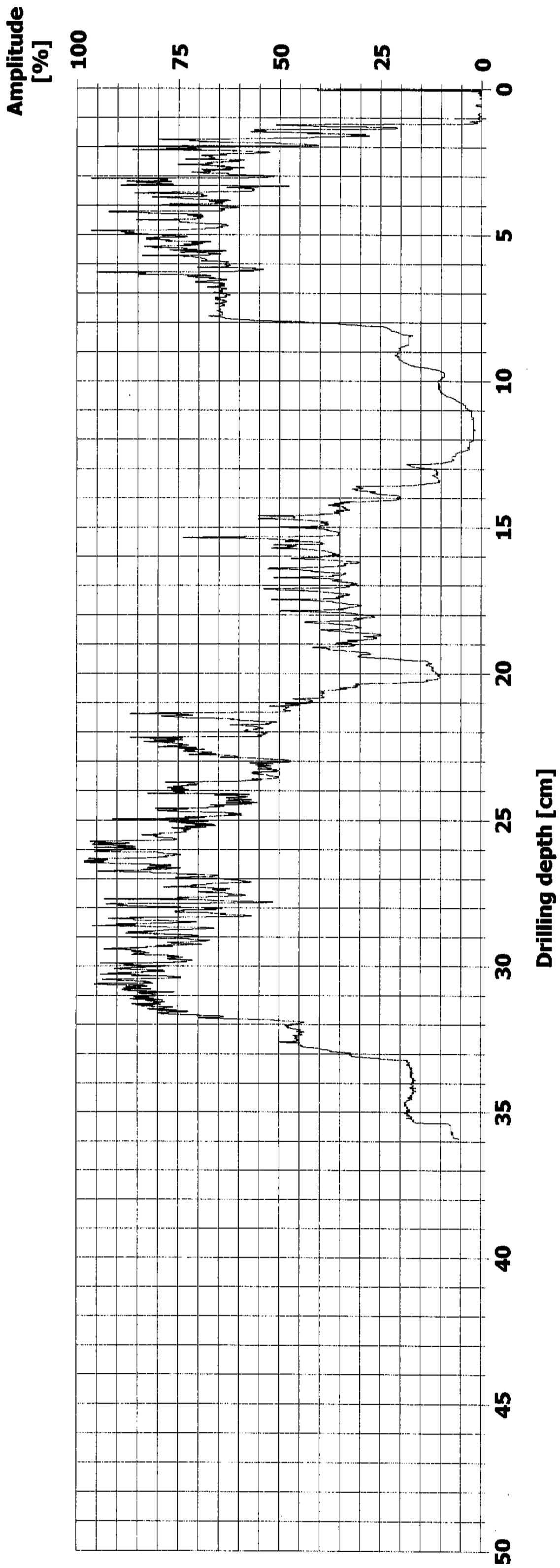


The same chart with the vertical axis extended

Decay in Douglas-fir

Measuring / tree data

Measurement no. : 1	Date : 20.08.1999	Direction : n/a
Drilling depth : 35.90 cm	Time : 18:59:59	Tree species : Douglas-fir
Wood species : Soft (1)	Diameter : 35.0 cm	Location : Bowen
ID-Number : 1	Measuring level :	Name :



Comment

Log sample. Past scars and decay inside, sound wood outside. Visible external indicators limited to unusual bark formation in a 3 m band up the trunk. Analysis at dissection confirms Resistograph readings.

Assessment

From	0.0 cm	to	1.0 cm	:	bark
From	1.0 cm	to	7.0 cm	:	sound wood
From	7.0 cm	to	14.0 cm	:	advanced decay
From	14.0 cm	to	19.0 cm	:	sound wood
From	19.0 cm	to	21.0 cm	:	crack / decay
From	21.0 cm	to	33.0 cm	:	sound wood

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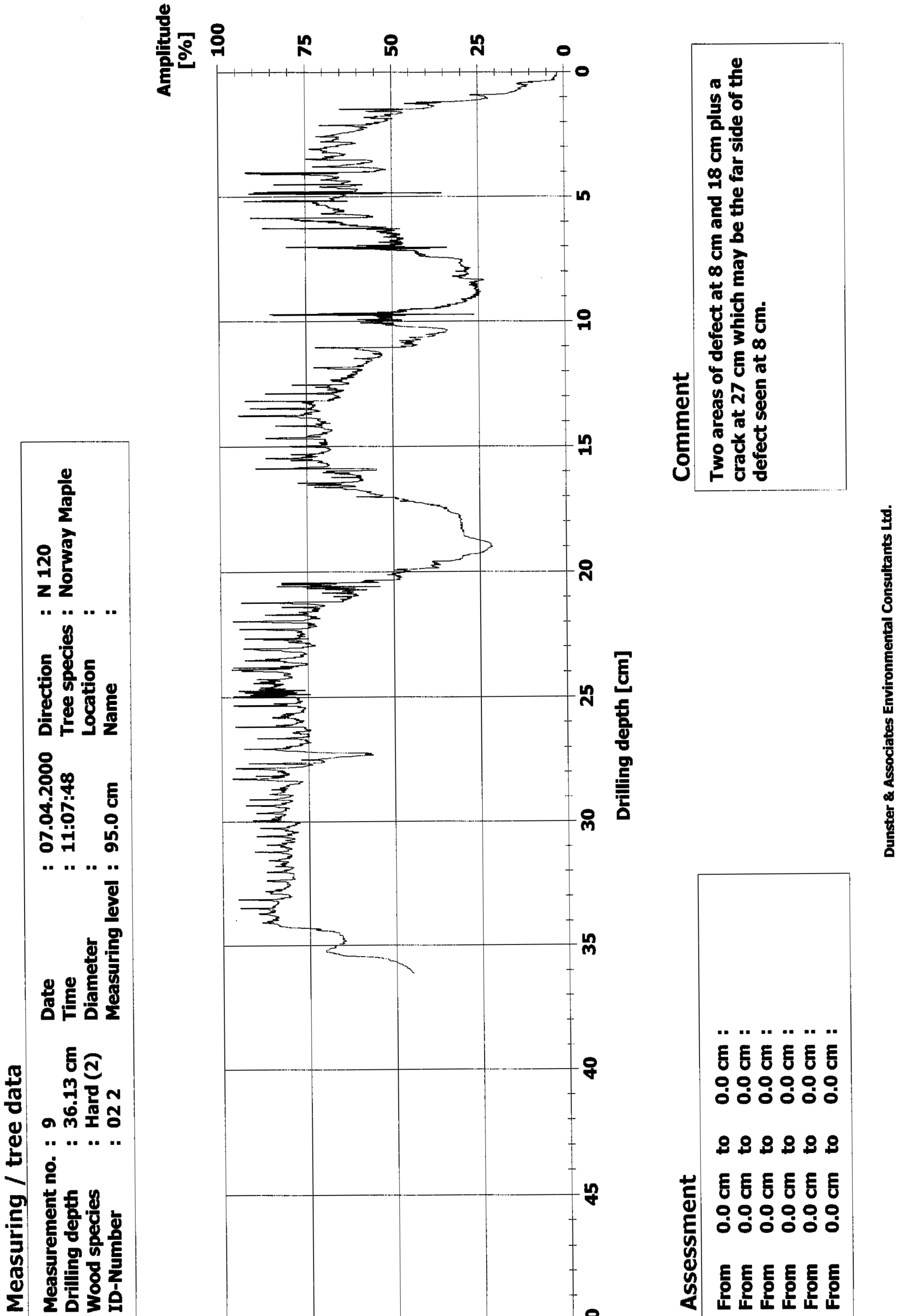
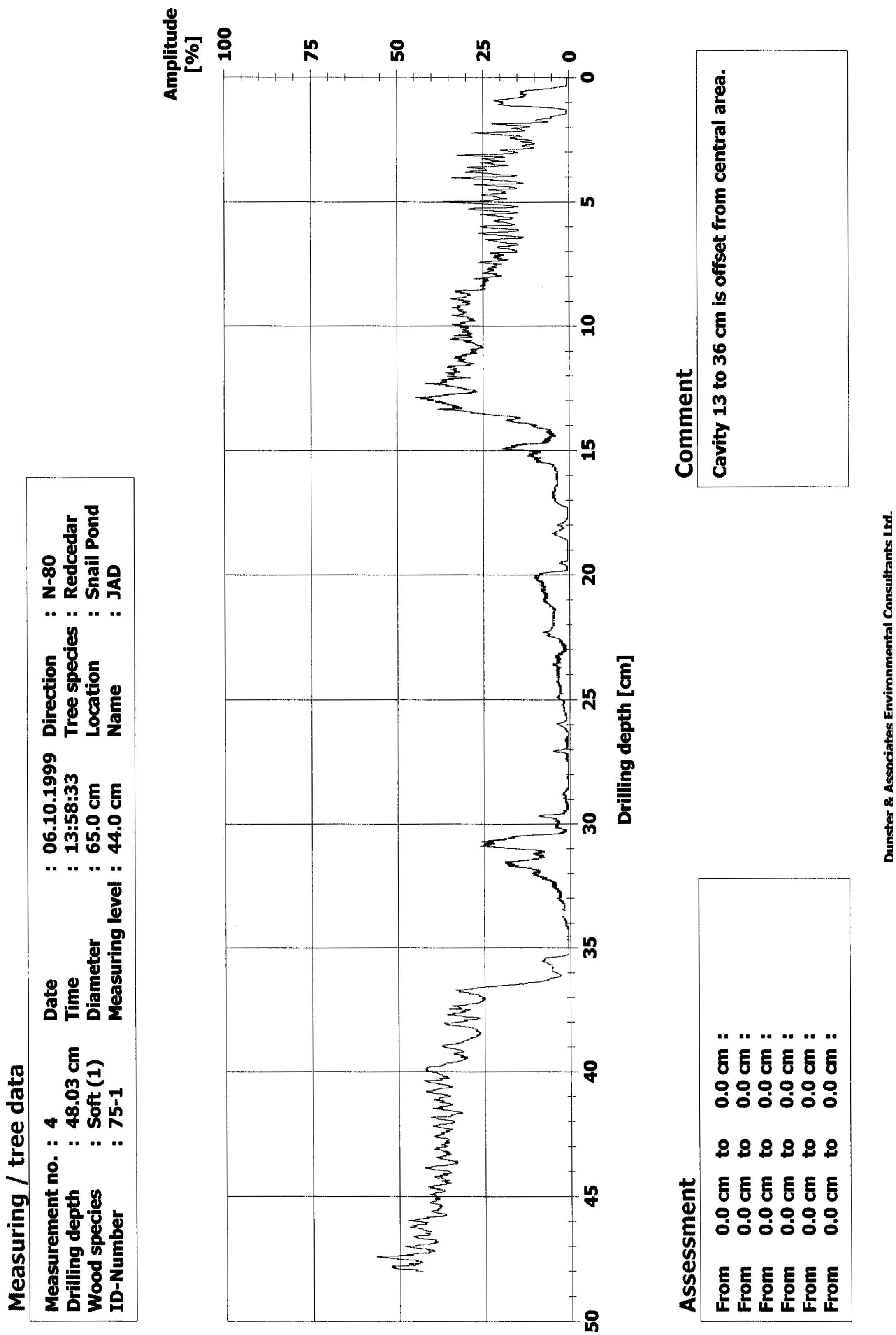
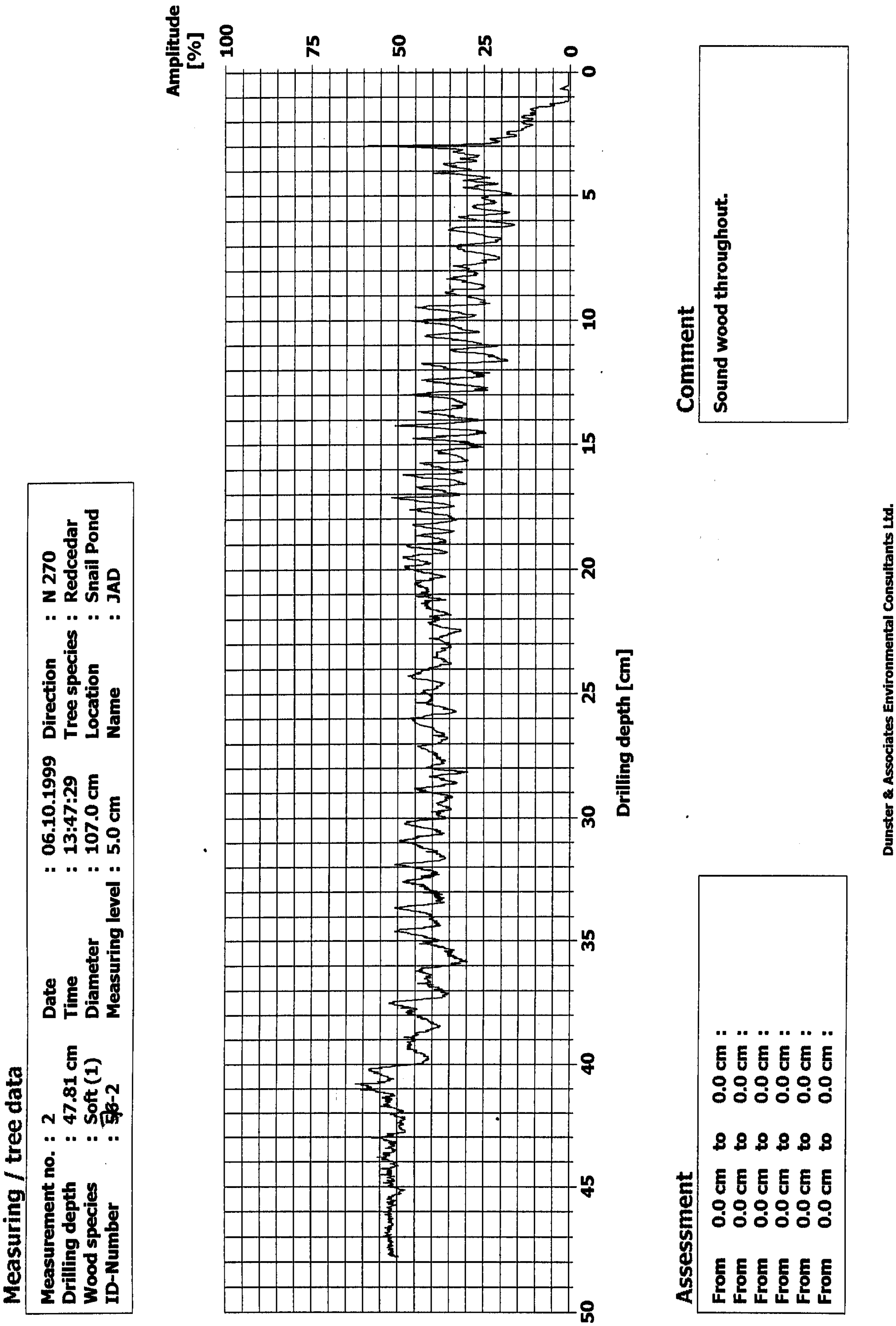
Ring of Decay in Norway Maple (*Acer platanoides*)



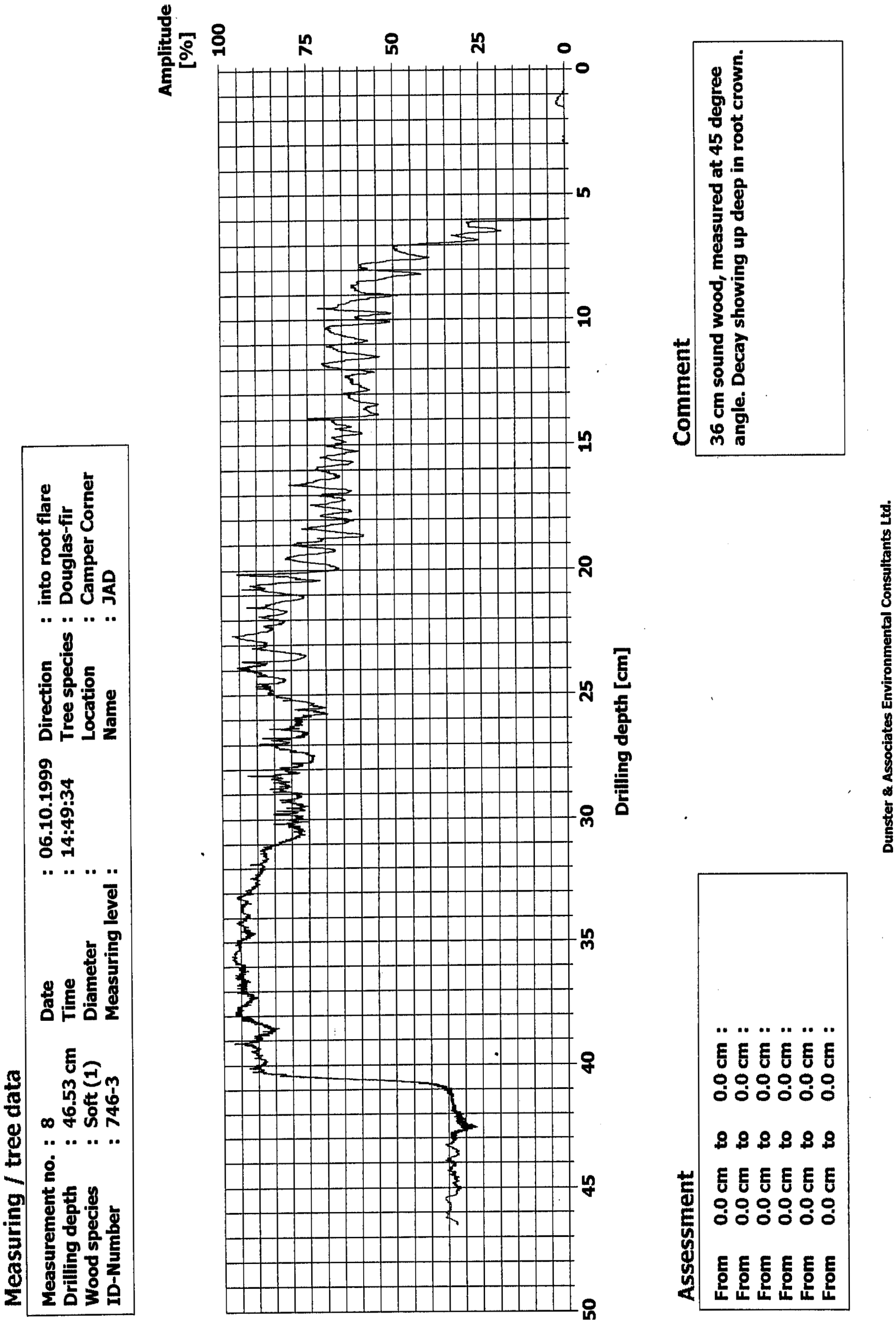
Decay in Western redcedar
Compare to chart on following page)



Western redcedar
(compare to previous chart)



Decay in Douglas-fir - underground test.

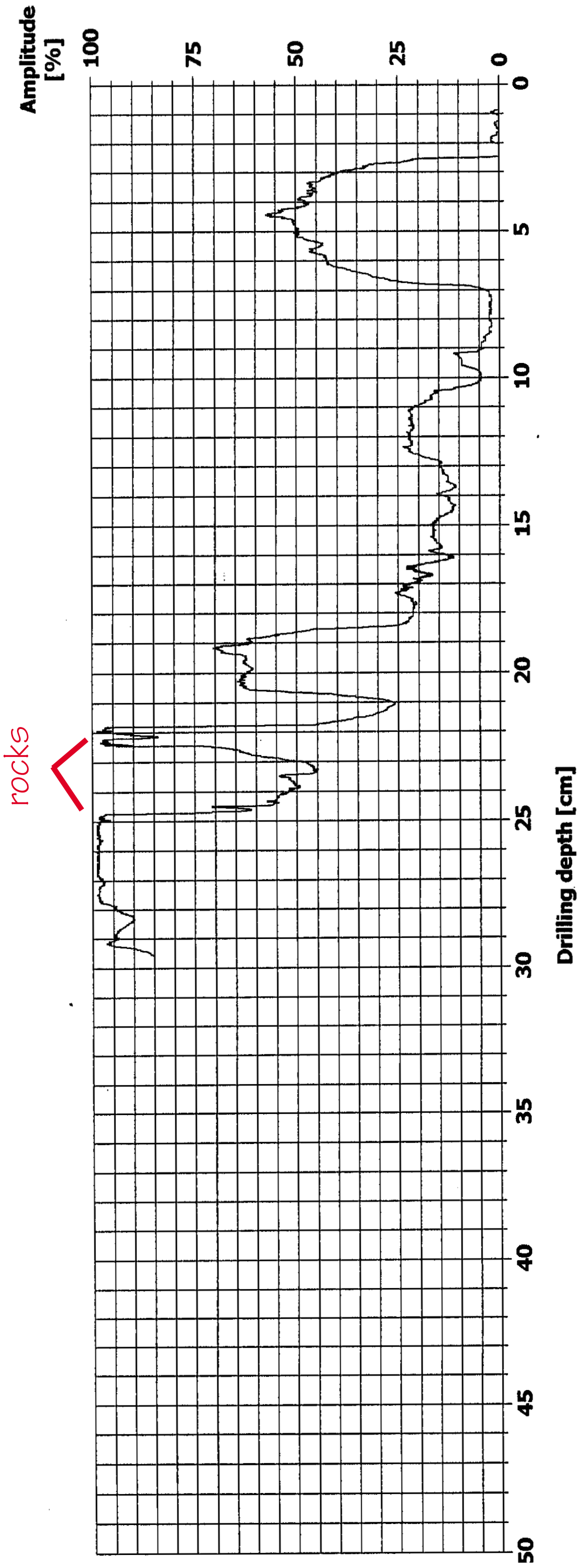


Using the 45° adapter , a reading was taken down into the root crown of a tree suspected to have root rot. The results clearly show the decay column. Because this reading is taken at an angle the drilling depth readings are elongated and are not a 1:1 match.

Decay in Douglas-fir - buttress root

Measuring / tree data

Measurement no.	: 9	Date	: 06.10.1999
Drilling depth	: 29.60 cm	Time	: 14:55:44
Wood species	: Soft (1)	Diameter	:
ID-Number	: 746-4	Measuring level	:
Direction	: root		
Tree species	: Douglas-fir		
Location	: Camper Corner		
Name	: JAD		



Comment

Drilling vertically into a buttress root 50 cm away from the trunk 7 to 17 cm seems doubtful. Increment core taken at this point shows decay in root. High resistance at 25 cm was rock (needle ruined at that point!).

Assessment

From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:

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The same tree as before but now assessing the condition of a large buttress root half a metre away from the main trunk.

Assessing Decay and Defects in Wooden Structures.

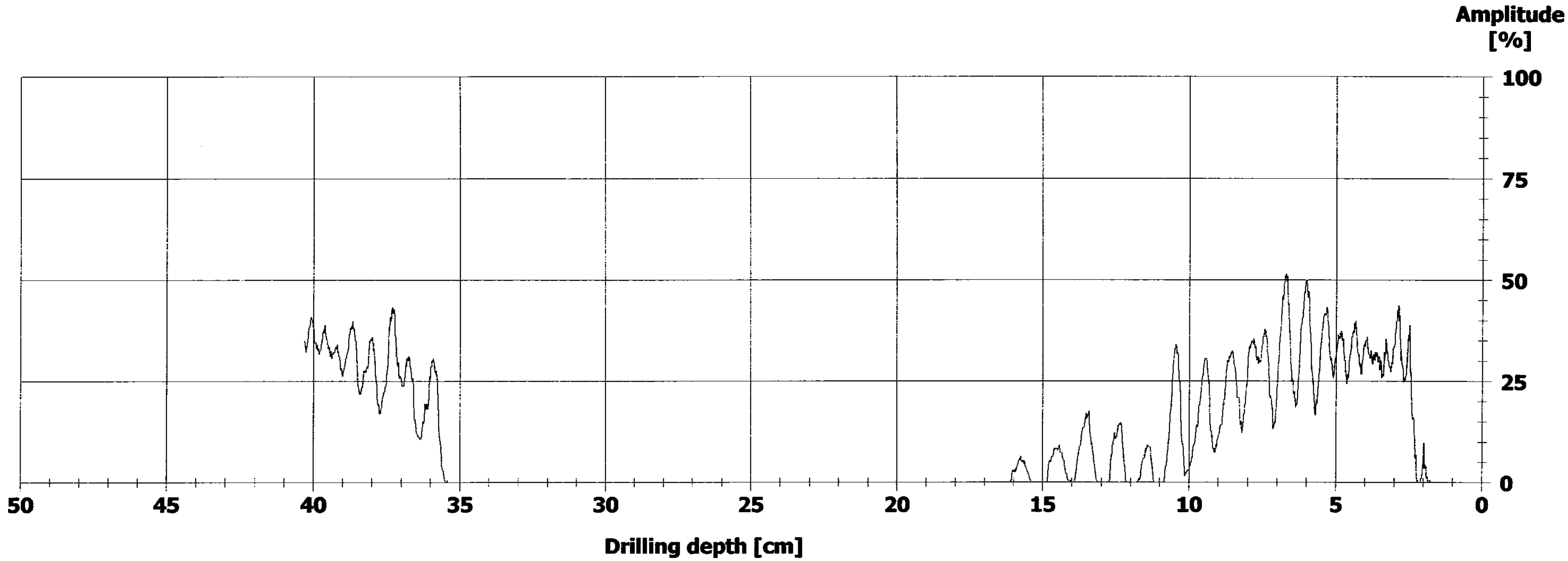
Unlike assessment of standing trees, where the wood is usually living, assessment of wooden structures deals with dead wood. In most cases the wood being tested has no bark, and the growth rings may be at almost any angle to the drill, and not necessarily at 90°. As a result, the Resistograph readings may show some complexities that require careful analysis. However, testing wooden structures with the Resistograph permits collection of extremely accurate records of decay and or defect, and allows comparison of condition at regular testing cycles. This is important where the replacement cycle has to be planned several years in advance, and where due diligence is an issue, in the event of a catastropic failure.

In the following charts, records of power pole testing are presented. Because power poles are buried in the ground, the most common decay problems occur at or close to the interface between the surface of the ground and the soil layers. In the following series of charts, two readings have been taken on each pole. The first one is taken using the 45° adapter to get a sense of what is happening below the ground surface. A second reading was then taken horizontally across the pole to gain a sense of any decay or defects that might be propagating up the pole. By comparing results from the two areas, the extent of the decay column can be evaluated to determine if the pole should be removed and replaced, or simply strengthened by addition of a support and bracing system.

Pole locations and identity numbers have been removed to protect confidentiality requirements. As with readings taken in live wood, the charts depict areas of incipient, and advanced decay.

Measuring / tree data

Measurement no.	: 1	Date	: 12.09.1999	Direction	: down into ground
Drilling depth	: 40.32 cm	Time	: 17:03:31	Tree species	: Douglas-fir
Wood species	: Soft (1)	Diameter	:	Location	:
ID-Number	: A-1	Measuring level	:	Name	:



Assessment

From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:

Comment

Pole is decayed in centre with cavity offset to north side.

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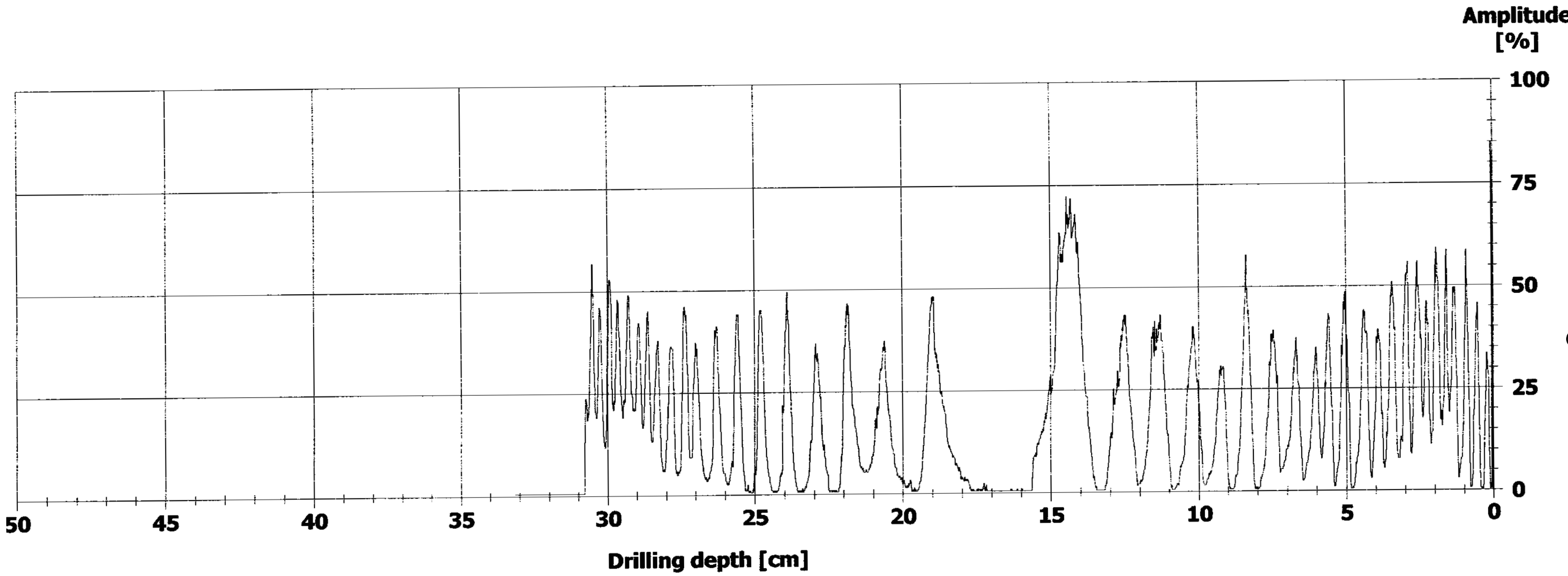
Pole A1. This is drilling down into the ground. The extensive decay shows up clearly. Because this drilling angle does not give a 1:1 horizontal reading it has to be corrected. In this example the decay extends from 11.36 cm through to 25.2 cm.

Measuring / tree data

Measurement no. : 2	Date : 12.09.1999	Direction : horizontally	
Drilling depth : 33.16 cm	Time : 17:06:02	Tree species : Douglas-fir	
Wood species : Soft (1)	Diameter :	Location :	
ID-Number : A-2	Measuring level :	Name :	



Assessment

From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:

Comment

Drilled 1 m above ground. Decay 15 to 19 cm. Well defined annual rings with clear early and late wood definition. Cavity 15.5 to 17.6 cm.

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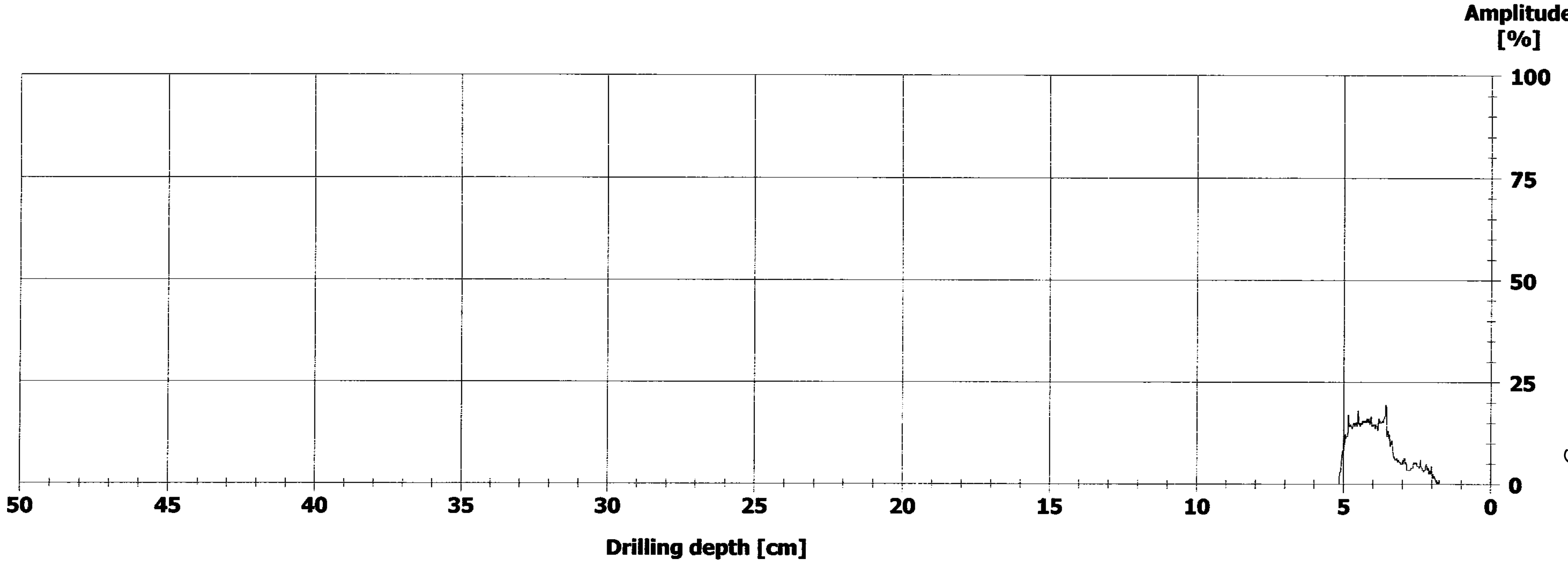
The same pole now drilled horizontally *above* ground, with the starting point being in the same vertical plane as the previous reading. The column of decay is now much smaller.

Measuring / tree data

Measurement no.	: 3	Date	: 12.09.1999	Direction	: into ground
Drilling depth	: 25.32 cm	Time	: 16:43:39	Tree species	: western redcedar
Wood species	: Soft (1)	Diameter	:	Location	:
ID-Number	: B-1	Measuring level	:	Name	:



Assessment

From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:

Comment

A few sound annual rings and then complete decay across the entire cross section

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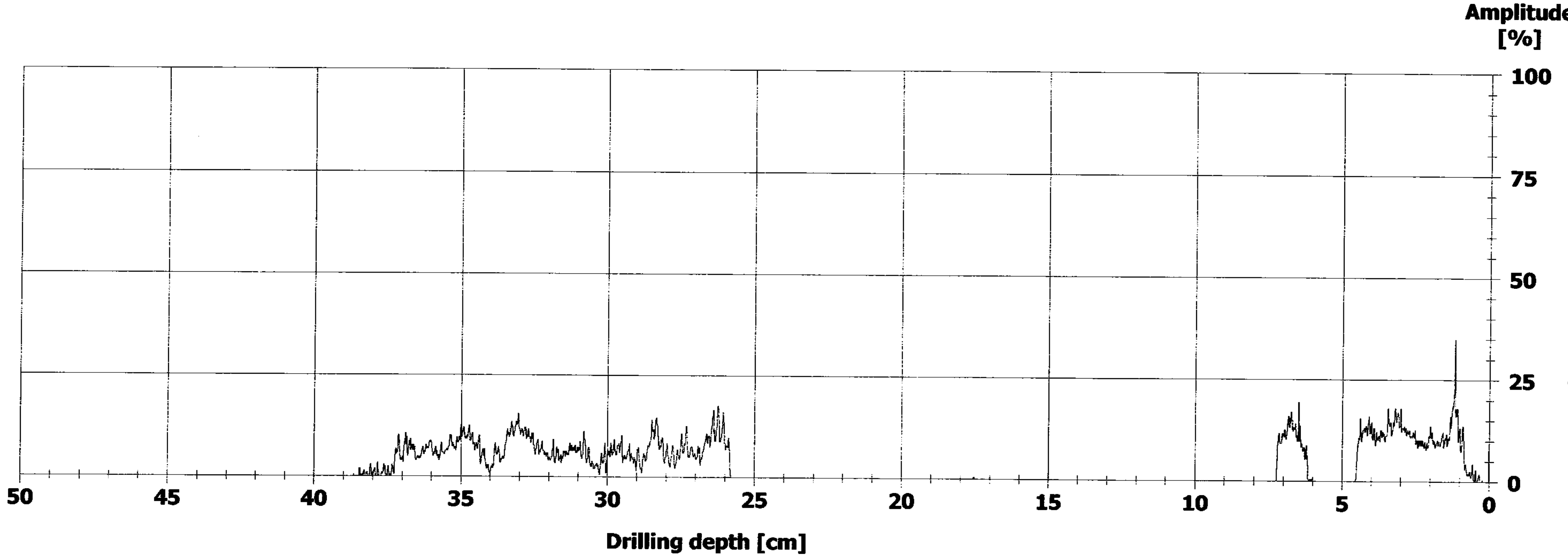
Western redcedar pole with very extensive decay in the below ground section. Apart from a 2 cm wide skin, the pole is almost completely rotted away.

Measuring / tree data

Measurement no.	: 4	Date	: 12.09.1999	Direction	: horizontally at 1m
Drilling depth	: 39.14 cm	Time	: 16:45:54	Tree species	: western redcedar
Wood species	: Soft (1)	Diameter	:	Location	:
ID-Number	: B-2	Measuring level	:	Name	:



Assessment

From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:
From	0.0 cm	to	0.0 cm	:

Comment

Extensive decay right through the central core and out towards the edge of the pole.

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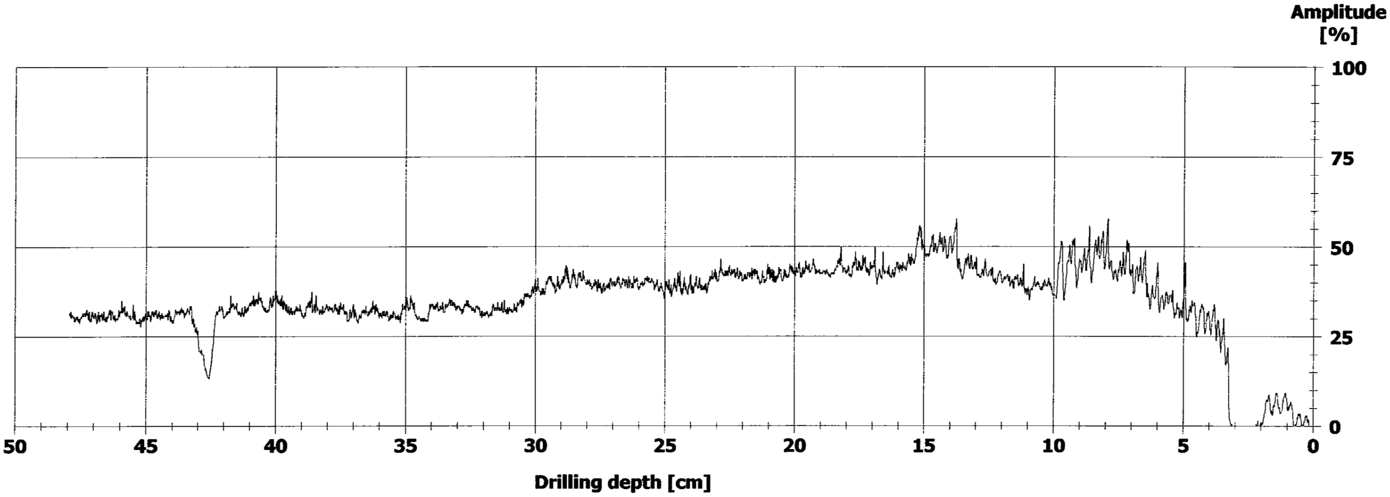
Drilling the same pole one metre above ground. The decay is still quite extensive, but some sound wood is seen as a thicker shell.

Measuring / tree data

Measurement no.	: 1	Date	: 13.09.1999	Direction	: vertically up
Drilling depth	: 47.93 cm	Time	: 08:30:04	Tree species	: redcedar
Wood species	: Soft (1)	Diameter	:	Location	: upstream stringer
ID-Number	: 1	Measuring level	:	Name	: jd



Assessment

From	0.0 cm	to	3.0 cm	:	decay
From	3.0 cm	to	42.0 cm	:	sound
From	42.0 cm	to	43.5 cm	:	crack or pitch
From	43.5 cm	to	47.0 cm	:	sound wood
From	0.0 cm	to	0.0 cm	:	
From	0.0 cm	to	0.0 cm	:	

Comment

Central stringer. Vertically up, centre line, 2 m from north abutment, upstream side. Minor decay on outside otherwise sound. Minor ring shake crack at 43 cm. Log diameter estimated to be 1.2 metres. Old growth cedar.

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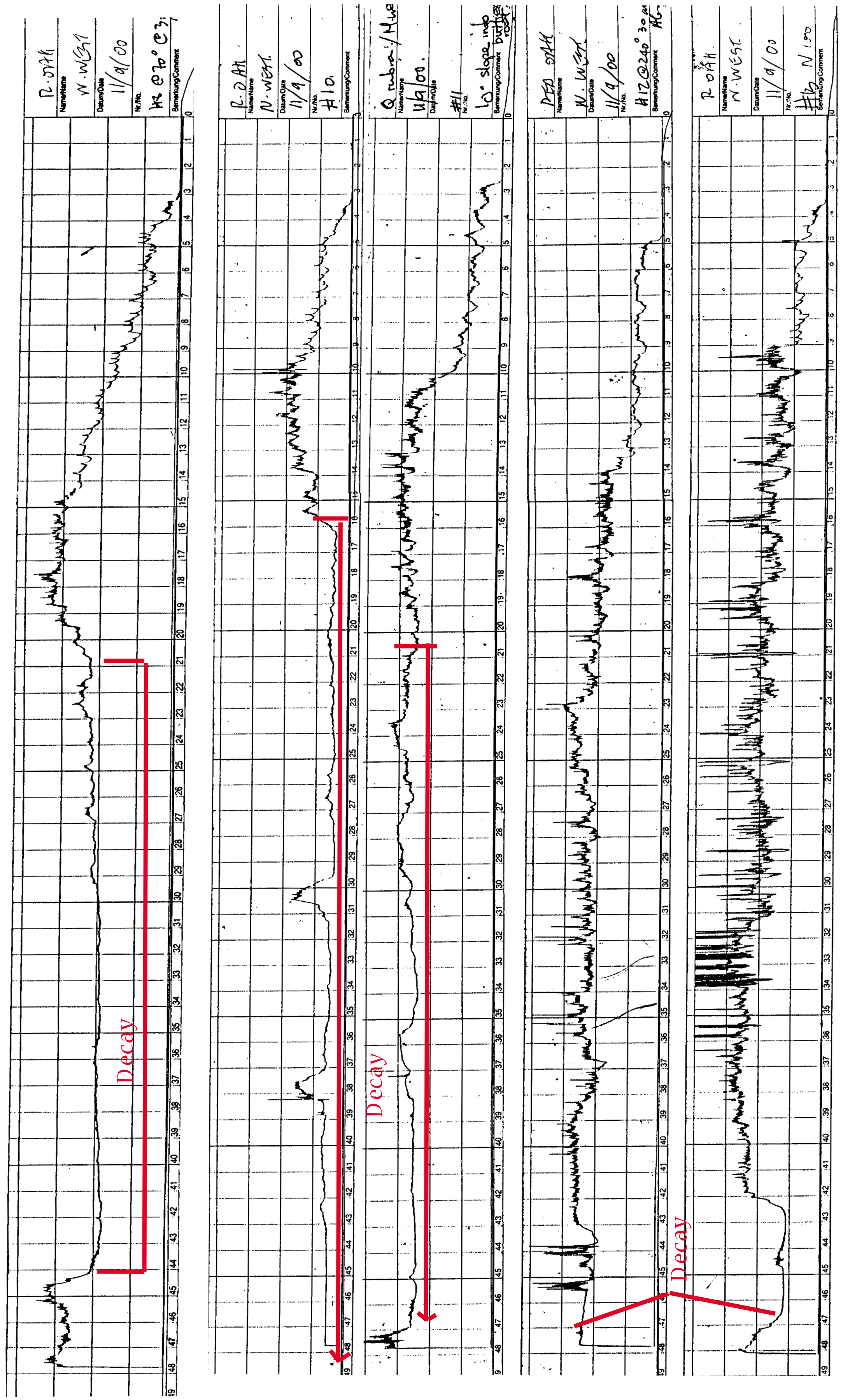
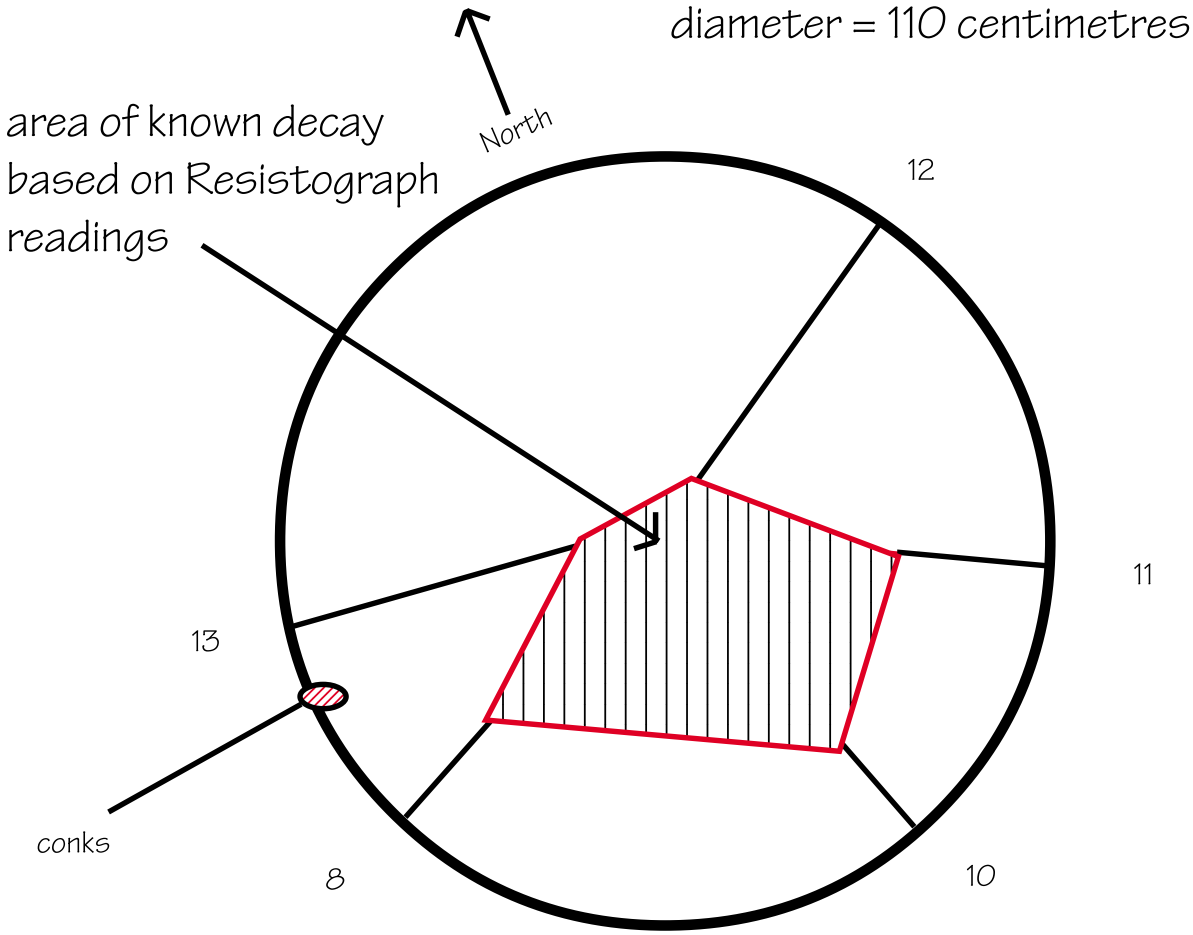
The Resistograph F500se with power pack adapter, seen here in use testing the main stringers on a log bridge. The results show the log to be sound. Use of testing records in this manner greatly facilitates proof of "due diligence" for structures that require proof of inspection.

Assembling a Comprehensive Assessment of Decay

In the previous pages various defects have been shown in an array of species and conditions. In many cases an area of decay may be suspected, but will require more readings before it can be accurately mapped out. In such cases the user should set up a systematic sequence for drilling so that decay can be mapped in a set of horizontal planes, or a vertical sections. The figure shown below illustrates a detailed analysis undertaken on a Red Oak (*Quercus rubra*). Three *Ganoderma applanatum* conks were noted. Initial Resistograph readings were taken at points in the plane 65 centimetres above ground. On the basis of the decay patterns noted in these first readings amore systematic gris was then laid out using drilling direction on a compass bearing at planes 10 centimetres apart. A detailed picture of the decay pattern was then built up in the horizonatl and vertical planes.

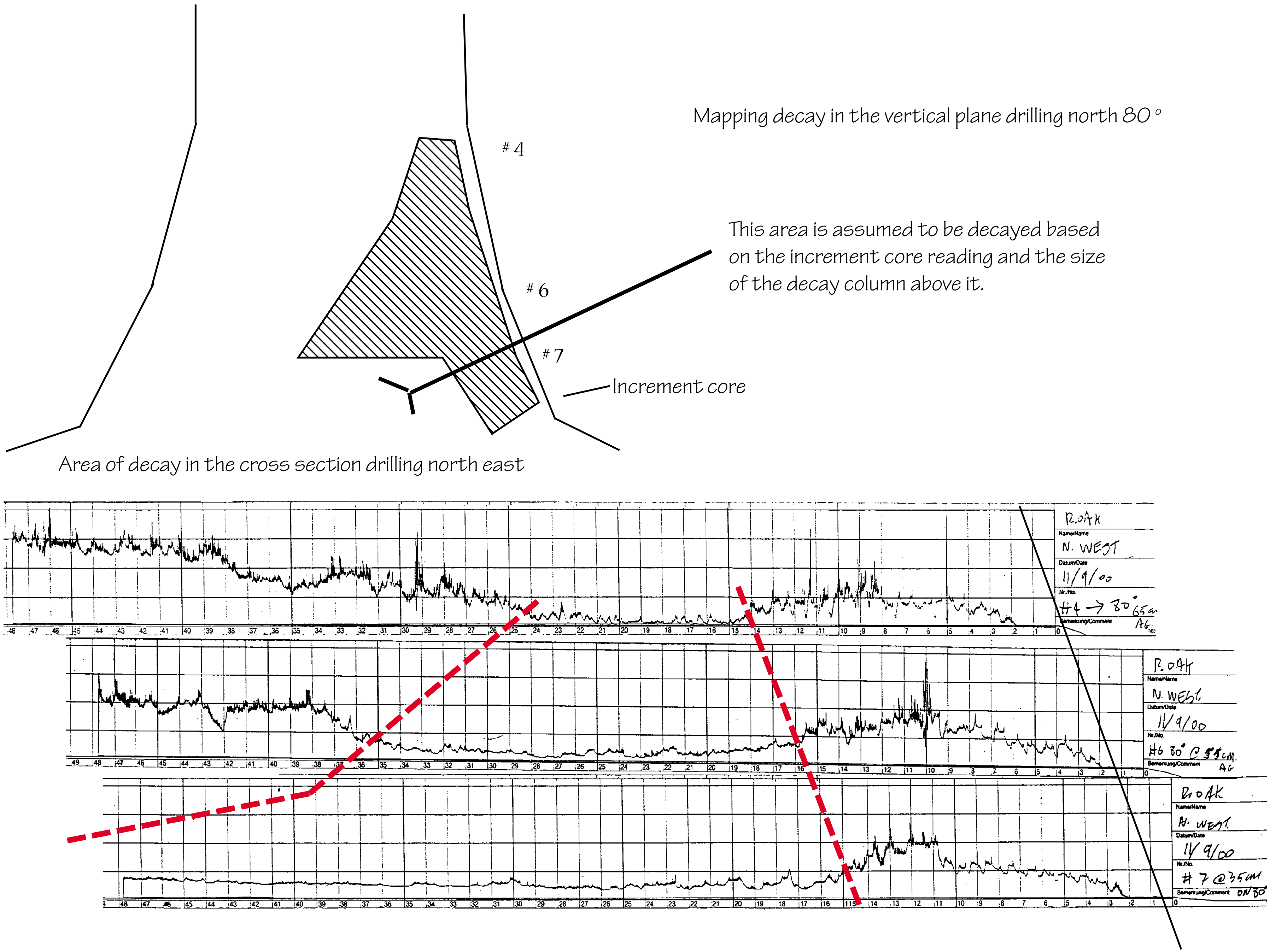


Readings 8, 10, 11, 12, and 13 taken in the horizontal plane 30 centimetres above ground. Knowing the drilling directions it is then possible to map out the extent of decay in this horizontal plane, as shown on the following page.



By plotting out the depths of sound and decayed wood it is possible to map the approximate extent of decay. In this case, the sampling plane used is below the conks. It can be seen that the column of decay is offset from the centre of the tree to the south side, but does not extend to the outside, leaving quite a wide shell of sound wood.

Sampling at higher planes revealed thinner shell thicknesses. Plotting the results out in a vertical plane (see next page) shows the extent of known decay up and down the trunk. By carefully analysing these horizontal and vertical readings it is now possible to define the present extent of the decay pocket and then make a decision about treatment. In this case, the tree is to be retained and annually monitored. It is expected that over time, the decay will extend out and become an open cavity, but the tree may live for many years yet.


Mapping decay in the vertical plane drilling north 80°
This area is assumed to be decayed based on the increment core reading and the size of the decay column above it.
4
6
7
Increment core
Area of decay in the cross section drilling north east

Conclusions

This manual has been prepared to allow for useful interpretations of Resistograph readings. The various sections portray a wide array of results and demonstrate that the Resistograph can accurately detect defects in all wood species. Areas of decay, cavities, and splits or cracks can all be detected and interpreted from the readings.

Experience in using and interpreting Resistograph readings is essential. To improve and hone your own skills with the Resistograph take the time to match readings with dissected trees , and if necessary practice on trees already cut down to prove to yourself that what the instrument is telling you, is what will be inside.

Above all, when using the Resistograph for live trees never forget that a sound understanding of visual tree assessment is vital, and a necessary prerequisite for effective use of the Resistograph. Similarly, for testing poles and wooden structures, it is essential to have confidence in your understanding of decay, both advanced and incipient in wooden structures - again, practicing on sample pieces of wood will enhance your skills.

We hope you find the manual useful and interesting. If you have any comments or suggestions please contact Julian Dunster at jdunster@bigfoot.com or your nearest IML dealer.

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