

12 OCT 1987

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BAUXITE HYDROLOGY UPDATE

ISSUE NO. 5

JULY 1987

Published by the Hydrological Research Section, Surface Water Branch, Water Authority of Australia in collaboration with the Department of Conservation & Land Management, Department of Mines and Alcoa of Australia.

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ESTIMATION OF FOREST LEAF AREA INDEX (Ian Colquhoun and Kim Whitford)

A study was conducted in April 1987 to compare non-destructive and easy to use methods of estimating LAI with the more tedious destructive method. An area of jarrah forest 25m x 25m was monitored using the sunlight transmittance method of Lang and Yeuquin (1986), the hemispherical photographic technique of B.M. Harper (Wollongong University pers. comm.) and a tree dimensions regression method of Whitford (pers. comm.). On completion of the field monitoring 60% of the trees were stripped of leaves from which Dr. J. Sommer (Curtin University) calculated the total leaf area of the plot. The results of the different methods are compared below.

<u>Method</u>	<u>Estimation of Leaf Area Index</u>
Destructive sampling	1.05 ± 0.1
* Lang method (includes area of woody tissue)	2.44 ± 0.06
Harper method (includes area of woody tissue)	1.80 ± 0.1
Whitford method	1.07

* The area of woody tissue was estimated to be equivalent to a leaf area index of 0.30.

The results indicate that further development of the Lang and Harper techniques are required before they can be used routinely in open jarrah forest sites. These methods may be appropriate to qualitatively assess changes in leaf area. The regression method of Whitford gave a very accurate result and on the basis of this experiment currently represents the best non-destructive method of leaf area estimation.

References

Lang A.R.G. and Xiang Yueqin (1986). Estimation of leaf area index from transmission of direct sunlight in discontinuous canopies. *Agric. For. Meteorol.* 37, 222-243.

TRANSPIRATION MODELLING (Ian Colquhoun and David Fox)

A model has been developed to estimate hourly and daily transpiration of E. resinifera and E. wandoo for autumn conditions when air temperatures and vapour pressure deficits are not high (Fox 1987). 95% of the variation is accounted for by the model. Only two meteorological factors are used in the model, namely cumulative solar radiation and average dry temperature. There was no significant difference in daily transpiration rates on a unit leaf area basis, between the two tree species at this time of year. This indicates that for three quarters of the year leaf area is the major factor controlling site water loss. Analyses of the ventilated chamber data from spring to summer is taking place.

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TRANSPIRATION MEASUREMENT (Ian Colquhoun)

The tree conductance of an E. resinifera tree was calculated using the ventilated chamber and the leaf porometer methods. During a 5 day period in autumn no significant difference was found between the estimates of both methods. A similar study was completed using an amphistomatous leaved tree (E. wandoo). Early analyses indicate that significant differences exist between the estimates of the two methods. This work is continuing to ensure that the ventilated chamber data can be used in the Penman-Monteith equation to calculate forest transpiration.

WATER RELATIONS OF JARRAH ON SITES INFECTED BY PHYTOPHTHORA CINNAMOMI (Stuart Crombie and Joanna Tippett)

Water relations of jarrah in the presence of the dieback fungus, Phytophthora cinnamomi, have been studied on fourteen sites in the northern jarrah forest over the summers of 1985/86 and 1986/87.

Stomatal conductances of jarrah on eleven of the fourteen dieback sites were significantly lower than in healthy jarrah trees on uninfected sites nearby in midsummer of 1986/87. Average predawn water potentials of trees on dieback sites were

significantly lower than those of trees on healthy sites nearby on seven of the fourteen sites in midsummer 1986/87. Differences between healthy and dieback affected jarrah were almost entirely absent in the spring or autumn periods when soils were moist and evaporative potential low. Midday leaf water potentials were less sensitive indicators of water stress than either dawn water potentials or stomatal conductances. Large basal lesions containing P. cinnamomi were found in 23 out of 90 trees examined in 1986/87.

Removing more than 60% and 80% respectively of the roots from healthy jarrah saplings resulted in levels of water stress similar to the mild (only stomatal conductances reduced) and severe (both stomatal conductances and predawn water potential reduced) water stress found in trees on dieback sites. These results suggest that jarrah surviving on old dieback sites may have lost in excess of 60% of their deep root systems. However reduced leaf area of trees which have been suffering dieback for several years may mask the effects of dieback on tree water supply because transpiration fluxes are reduced. Actual root loss on dieback sites may therefore be more severe than suggested by the above.

ELECTRO-MECHANICAL DENDROMETERS FOR MEASURING WATER STRESS IN JARRAH (Stuart Crombie)

The Davey electro-mechanical dendrometers were tested as a method for the automatic recording of water potentials in jarrah.

Dendrometers were mounted on jarrah trees growing on sites known to differ in water availability. Tree girth over this period was recorded at hourly or two-hourly intervals by computerised loggers. Tree water status was assessed using predawn water potentials measured at approximately monthly intervals from November 1986 to April 1987.

Shrinkage of tree boles was apparent one to two months before predawn water potentials began to fall. Shrinkage was less marked and occurred later in the summer on the wetter Havel S and P sites than on the drier Z site. Diameters of the bole and of large branches in the crown changed in synchrony suggesting low axial resistances to sap flow.

It is planned to continue monitoring girth changes to the three sites over the spring and summer of 1987/88, to instrument jarrah on thinned and unthinned sites and the transpirometer trees at Del Park. The phase relationships of changes in water potentials and trunk girth will be analysed so that tree water potentials can be obtained from dendrometer data.

The work is aimed at both verifying techniques and obtaining data from which the effect of forest thinning on tree and soil water status may be predicted.

YARRAGIL NORTH CATCHMENT : GROUNDWATER MONITORING NETWORK
(Peter Thorpe and Mike Martin)

The Geological Survey of Western Australia installed 43 monitoring piezometers at 18 sites on the Yarragil North catchment in early 1987 to investigate the hydrogeology of a small forested catchment in the intermediate rainfall zone (I.R.Z.). This research was initially planned to provide background hydrogeological data for a catchment subsequently to be part of a trial bauxite mining exercise to investigate the effects of bauxite mining in the I.R.Z. upon surface and groundwater salinity. However the 25 year mine plan for the Del Park mine has been withdrawn and a new mine plan for the Huntly mine introduced. This involves future mining in the Huntly area only with an eventual need to mine in the I.R.Z. east of Huntly, and about 25 km north of the Yarragil catchments.

Future mining in the Yarragil catchments is prohibited and alternative trial mining I.R.Z. catchments are being investigated. Long term monitoring of the Yarragil North catchment will allow an appraisal to be made of the scale and intensity of groundwater monitoring necessary to give a satisfactory understanding of the hydrogeological processes governing groundwater and stream salinity in the I.R.Z. If this scale of monitoring proves to be acceptable then a similar network will be recommended for the I.R.Z. trial mining catchment east of Huntly.

At each site in the Yarragil North catchment 1 to 3 piezometers were installed depending upon the saturated thickness above fresh bedrock. Each piezometer was slotted over a 3 m interval at its base, gravel packed and developed. At several sites the water table was below the boundary between regolith and fresh bedrock and drilling was continued into fresh bedrock to a maximum of 10 m to determine the presence of groundwater in fresh bedrock. Fractures within the fresh bedrock cores were common though of small size and often infilled with secondary minerals. The interconnection between fractures within fresh bedrock could not be estimated.

The degree of interconnection between the groundwater flow system in the regolith and fractures in bedrock will be investigated in the future by hydraulic testing of the bedrock piezometers and isotope dating of groundwater at the base of the regolith and in the fractures.

Pneumatic slug testing of piezometers in the regolith gave a catchment average hydraulic conductivity of 0.19 ± 0.15 m/d. Monitoring of water levels at monthly intervals by Alcoa staff is underway. The levelling of the piezometers will be undertaken by the Water Authority of WA in the near future. Monitoring of groundwater quality will be undertaken four times each year from both pumped and bailed samples.

The collaboration of other groups in this study would be beneficial, particularly in the investigation of unsaturated zone processes and soil and vegetation mapping of the catchment.

GROUNDWATER RECHARGE AT DEL PARK, DWELLINGUP

(Peter Thorpe and Mike Martin)

The effect of bauxite mining and rehabilitation upon groundwater recharge rates is a key factor in any models used to predict groundwater level responses, discharge rates and, in turn, stream salinity change in a catchment. The environmental tritium technique has been applied at two sites within the Del Park research catchment to investigate recharge and rates of groundwater movement in both an undisturbed location on the hillslope transect and down-gradient of a previously mined and rehabilitated area.

Tritium, the radioactive isotope of hydrogen, held within the water molecule, was injected in large quantities into the hydrological cycle in the mid-1950s and 1960s by above-ground nuclear bomb tests. Tritium measurements on groundwater can therefore distinguish a groundwater age of less than or greater than 32 years.

Detailed saturated zone tritium profiles to fresh bedrock were measured at the two sites using a multilevel piezometer. At both sites 'bomb' tritium was found to occur throughout the saturated zone. This indicates relatively rapid rates of recharge and groundwater movement in both situations, probably due to the relatively high hydraulic conductivity of the regolith and steep hydraulic gradients. Recharge rates can only be quantified from these sites in terms of a minimum value as the interface between tritium-containing and tritium-free groundwater was not intersected. Minimum recharge rates will be given when runoff information is available for the Del Park research catchment.

SAMPLING FOR ACCURATE SOIL PHYSICAL MEASUREMENTS IN LATERITIC SOILS (Nick Schofield)

Two techniques for extracting 'undisturbed' soil cores in lateritic soils have been tested, one involving a soil sampler and the other a rock sampler. The techniques have been assessed in four ways: measured design parameters, repeatability of results, comparison with an auger sampler, and comparison with a thin-walled sampler. As regards the design parameters, the soil sampler satisfies most criteria but has a rather high area ratio (necessary for good durability in lateritic soils). The high area ratio did not appear to cause compaction of the sample. One repetition of a large set of profiles indicated that, on the basis of bulk density data, the technique is moderately reliable. Comparison with bulk density

data from a hollow auger sampler showed that the soil sampler produced less variable results and a lower mean bulk density. The same conclusion was drawn when the soil sampler was compared to a thin-walled sampler. The supposedly better performance of the sampling techniques is attributed to lower internal friction, more accurate sample trimming, the use of the hydraulic ram for driving, and greater care in sample handling.

A REVIEW OF THE THEORY OF THE CONSTANT HEAD WELL PERMEAMETER METHOD (Nick Schofield)

The constant head well permeameter is a commonly used method for measuring the in situ saturated hydraulic conductivity of soils above the water table. The method essentially involves drilling a well, filling it with water to a prescribed depth, maintaining a constant head of water in the hole, and measuring the inflow rate to the hole. Theories of water flow from a well in these conditions date back in excess of 25 years and some of the formulae derived for saturated hydraulic conductivity are still in use today. Recently several more sophisticated numerical and analytical studies have been reported. However a number of simplifying assumptions are still common to all analyses, including neglect of soil heterogeneity, macropore flow and air entrapment. In all but two of the most recent analyses, no account is taken of flow in mixed saturated-unsaturated conditions.

A review and comparison of the numerous formulae that have been developed to date have been carried out. In the analysis involving only saturated flow, the important variables in the formulae are head of water (h) and radius of well (a) which are conveniently expressed as the ratio $\gamma = h/a$. Comparison of saturated flow formulae over a range of γ revealed moderately good agreement. Solutions became in closer agreement at higher γ (>20) but were subject to increasing potential error at lower γ (<20).

Two analyses included mixed saturated-unsaturated flow from the well. The major conclusion from both analyses is that the predicted saturated hydraulic conductivity values are significantly less than for the assumption of saturated flow alone, due to the effect of capillarity. Also both formulae for saturated hydraulic conductivity involve an additional variable, α , the sorptive number, a quantity not easy to determine. The effect of capillarity is least for coarse soils and greatest for fine soils.

Saturated-unsaturated unsteady flow model analyses identified a number of characteristics useful to the design and operation of the constant head well permeameter. It was found that its efficiency of operation would be maximised by minimising the water/soil contact area, which requires a small well diameter

and head of water. Two methods of terminating measurements prior to steady state infiltration being reached were suggested but these require further field evaluation.

HILLSLOPE STUDIES (Nick Schofield)

The Del Park hillslope is due to be cleared and mined from July 1987 and this signals the end of the 'Phase 1' pre-mining study. Infiltration studies that can only be carried out at the end of Phase 1 are currently taking place. Aquifer testing on a number of piezometers has also been completed. Extensive data sets from the site are now being prepared for analysis and reporting.

A second site in the Del Park catchment has been established. It is a 50m x 50m area named Davies Site. The purpose of this site is to (i) assess the hydrology of a good quality forest site (as opposed to the hillslope), (ii) test new equipment and methods, (iii) include measurements of litter leachate and transpiration, and (iv) improve 'control' monitoring for the hillslope during the mining and rehabilitation phase.

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