APPENDIX 6.

HYDROGEOLOGY OF
SUNTOP AND
UPPER BUCKINBAH CATCHMENTS

Hydrogeology Case Studies

Suntop area. - T. Callen (2)

The Suntop area studied by Callan (2) is situated on in Canowindra Volcanics (Cudal Group). The major study areas were located on andesitic materials - mostly plagioclase feldspar quartz hornblende porphyry and sometimes siltstones. The types of minerals in the parent materials play a major role in the availability of ions which can from salts.

To the east are the Garra Formation (limestones) (Gregra Group) with the Hanover Formation (Cudal Group) to the west. A small unnamed area of the Cudal Gp (Scet) (rhyolitic tuff) and Cuga Burga Volcanics (Gregra Gp) are also found in the vicinity. The general area is characterised by major faults including the Cudal and Manildra Faults and numerous other more localised faults, all running approximately north - south. The beds dip sub-vertically (70 - 85^{o}) as a result of intense folding and deformation. This is typical of a significant band of country that runs north - south along the eastern side of the Little River plan area. It is within the Molong High.

This actual area studied by Callan does not have any dykes or faults which act as barriers to or conduits for groundwater movement. The Total Dissolved Solids (TDS) in the deep fractured rock aquifer is on average 2050 ppm, while the TDS in the surface aquifer is 3800 ppm. (These concentrations of solutes is not considered high enough to directly cause a dryland salinity phenomena at the soil surface.) This suggests that there is NOT a direct hydraulic connection between the deep aquifer and surface water table, and the water is sourced from different aquifers. In all piezometers, the Standing Water Levels (SWL) of the deeper aquifer in fractured rock was lower than the associated shallow piezometer, in the surface water table. This suggests there is no upward pressure head from the deep aquifer, and no intermixing. The head was always below surface level. i.e. they do not have a positive head. This deep (semi-confined) aquifer would seem to be a huge regional reservoir. The clay horizons in the soil at the soil bedrock interface are seen as semi-permeable layers between the two aquifers. This should prevent contamination of the fresher deep aquifer by deep drainage of the more saline surface water table.

Callan reasons that the groundwater process driving dryland salinity in the Suntop area is - local shallow aquifer waters sourced from upward movement (pressure head) in the recharge areas which are in lighter textured soils over weathered bedrock. This water is forced to rise upwards when it hits the heavy clays in the lower parts of the landscape. The hydraulic conductivity of the soils upslope where recharge is taking place is higher than the downslope clay soils in the discharge areas. The volumetric flow rates and transmissivity are also markedly lower. This means the clays act like dams, blocking the passage of the groundwater which is flowing more freely upgradient in gravelly recharge areas than it can move through. The clays act as sites for exchange of ions, and a membrane for filtering the much larger Cl anion, withholding it in the clay particles.

The clay soils also have poor drainage, resulting in ponding and consequent high soil water contents that end up becoming high water tables. The discharge areas exhibit as salt scalds and waterlogged areas in restricted corridors along ephemeral drains. Flownet analysis suggests that there might be a number of recharge and discharge sites down a slope, with one site studies exhibiting 3 recharge and 3 discharge sites over less than 4 kms. It also suggests that groundwater flow of the saline water table is within the soil zone above the bedrock contact.

The discharge water is high in sodium chlorite salts, which has been enriched by dissolving ions the along the groundwater flowpath. There is ample opportunity for ionic reactions involving Ca, Mg, Na and K. eg. the weathering of feldspars, common in andesitic prophyrys, releases sodium and results in the kaolin clays. The salt concentration is further increased through evaporation at discharge areas, resulting in salt scalds.

The presence of sinkholes may indicate that solution cavities along the jointing planes persist, resulting in the limestone being a relatively high hydraulic conductivity unit in the strata. i.e. rapid groundwater movement / high recharge.

Areas of banded rhyolite are very hard and highly resistant to weathering. They may act as barriers to groundwater flow.

The conclusion is that salinity in the Suntop area is a localized problem, particularly in the ephemeral drains, and not the result of a regional groundwater system. This makes remediation more feasible as the people in the local area can affect the local groundwater system, without requiring coordination over the whole regional catchment.

There is a site (Wamboyne) where the andesite tuff and siltstones meet. Upslope of the andesite tuff is limestone, which is likely to provide for rapid transmission of saline groundwater before meeting the tuff. The massive fine grained tuff has slightly lower hydraulic conductivity and may present a barrier to water movement ie. forms a retard deep below the surface. A salt scald has formed at the surface. This was found using ground magnetics.

Some intermittent monitoring of small creek known as Cumbungi Creek below the Suntop salinity sites showed very high salt levels (EC 5.2 dS/m) compared to Curra Creek (2.1 dS/m) and the Macquarie River in Wellington (0.3 dS/m). Pumping saline watertables is not an option as this could increase the salinity in the surface water system.

Joshua Chivers (Regional Water Quality Officer, Macquarie region) undertook some deep water sample testing up to and downstream of faults that ran into the Macquarie River. He concluded that the extensive north - south faulting that ran through the Suntop area did not significantly contribute salts to the Macquarie River. Electrical conductivity readings of the river water taken from either side of the band of faulting did not show any real differences. Callan also concludes that "transmission of saline groundwater along regional lineament structures in the Wellington district is not envisaged to be a major cause of dryland salinity in the Suntop catchment."

The salts in saline scalds in Suntop are dominantly NaCl salts, introduced by cyclic rain, with a secondary source from the salt in the marine environment.

<u>Buckinbah catchment - G. Kazemi (50)</u>

The Buckinbah catchment is situated on complex geology - bands of different lithologies running north south. These include from oldest to youngest: the Kabadah Formation (Cabonne Gp), Canowindra Volcanics and Burrawong Limestones (Cudal Gp), Wansey Formation, Burgoon Formation and Jews Creek Volcanics (Goonigal Gp), Maradana Shales (Gregra Gp), Gamble Granites, and Mesozoic Sandstones (Surat Basin) and recent Quaternary alluviums. The first four are the dominant rock types and are classed as volcanics (Canowindra), volcanoclastics (Kabadah and Wansey) and limestones (Burrawong).

There are two aquifer systems in the catchment - a deep confined groundwater flow system 10-25 metres deep and the shallow local aquifer. The two aquifers have quite different chemical composition and are from very different periods. The shallow water has been dated at less than 34 years, which would indicate that this aquifer has been created through land use change to cropping, which has allowed deep drainage. It is only found through the mid section of the catchment, mostly on the western side and on low lying flats. In comparison, the deep groundwater is from 970 years up to 13000 years.

The shallow aquifer is subject to seasonal fluctuations in depth, while the deep aquifer alters very little seasonally. The deep aquifer is located in fractured rocks of high hydraulic conductivity and large thickness and low TDS, while the shallow water table is perched above bedrock in the soil and alluvium. It appears that the two groundwater systems are quite separate and there is virtually no leakage between the two aquifers.

<u>Recharge</u>

Recharge to the shallow aquifer occurs through fractures in outcropping rocks, particularly in the upland areas as point recharge, along with some diffuse recharge along the flow path; the latter demonstrated by the quick response of the aquifer to rainfall. The creek also recharges the shallow aquifer during periods of high flow. When the water level in the shallow aquifer is high, it provides a source of baseflow to the creek.

Kazemi estimates that recharge to the shallow aquifer may be at least 20% of the rainfall. However, significant recharge only occurs during wet periods. In average to dry times, deep drainage is negligible, so there is minimal recharge of the shallow groundwater. The shallow water table, following the wet winter of 1998, was between 0.5 and 2.5 m below the surface through the middle section of the catchment. At these depths, saline water will rise to the surface by capillary action and discharge, particularly in clay soils.

Although the general water level of the surface aquifer and the topography are similar, on a local basis, there is flow towards the valleys and main stream of the Buckinbah creek, so salinity is exposed in low lying areas, or discharged into minor tributaries, where it remains as stagnant ponds.

On the other hand, recharge to the deep groundwater system probably occurs at the top of the catchment or even further away. This and other upper catchments are interconnected through regional faults and lithologies that run north - south along the Molong High. There is a long delay in response time between major rain events and apparent recharge.

Deep groundwater contributes to baseflow in the lower part of the Upper Buckinbah catchment. This is supported by similar chemistry in the stream and the groundwater. The

salinity of the deep aquifer is greater in the upper reaches than further down the catchment, where it contributes to stream baseflow. A fault or fracture may convey the water to the surface. It disappears back into the deep aquifer through limestone caves as the creek passes through the Burrawong limestones. Some water from this aquifer is abstracted through bores for stock and domestic uses.
The hydraulic heads in the deep bores are lower than the shallow bores, indicating a downward gradient. This means that if deep drainage occurs out of the saline surface aquifer it may ultimately contaminate the fresher deep aquifer.

Discharge
Discharge and associated dryland salinity appears to be controlled by changes in slope, and the inability of the groundwater surface to change as quickly, meaning that it gets closer to the groundsurface. Geological interfaces may exacerbate the problem in some areas as may hydraulic conductivity and soil texture. The Upper Buckinbah catchment is much narrower at the neck than in the catchment However, Kazemi does not suggest the small catchment outlet may contribute to the onset on dryland salinity. Even with average rainfall, some further salinity can be expected as the Buckinbah Creek catchment is in early stages of its salinisation cycle.

Geochemistry
Groundwater ions can mostly be accounted for by the concentration of NaCl in rainfall, with weathering processes an therefore rock composition have little influence on the geochemistry of the surface groundwater system. The samples have high to very high salinity hazard and low to medium sodium or alkalinity hazard. The main process controlling the chemistry of the groundwater and surface water chemistry is carbonate dissolution.