# REGOLITH-LANDFORM MAPPING: A TOOL FOR THE STRATEGIC MANAGEMENT OF DRYLAND SALINITY

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## INTRODUCTION

The relationship between regolith and underlying geology in upland areas is very strong; upland catchments in our study areas typically exhibit only a thin (< 5 m) regolith veneer (Harvey *et al.* 2002). Regolith-landform mapping in these areas is a useful tool for grouping areas of land with similar regolith characteristics and hence management needs. The information gathered from regolith-landform maps can be used to assist in determining Land Management Units (LMUs) and in the implementation of farm or catchment scale management plans (Southwell 2001).

Regolith is of great importance from a land management perspective, as it is the dominant media through which shallow fluid flow takes place and its characteristics help determine the types of agricultural practices that can be sustained (Southwell 2001). The make-up of regolith materials also has an influence on the types of landforms that are observed in an area (Ollier & Pain 1996). This means that the composition of the regolith influences geomorphology.

Regolith-landform mapping can be used in conjunction with other physical and chemical analyses to gain a better understanding of the physical features within the landscape that affect dryland salinity (Southwell 2001). This paper describes the Upper Hovells Creek catchment, which exhibits a range of symptoms of dryland salinity and waterlogging, including the presence of water and salt tolerant vegetation and areas with salt scalds (Muller *et al.* 1998).

## REGIONAL SETTING AND GEOLOGY

The Upper Hovells Creek catchment is located approximately 20 km NW of Boorowa, encompassing the town of Frogmore, on the central western slopes of NSW, Australia. A 1:20,000 scale regolith landform map was constructed over the upper reaches of Hovells Creek catchment and a section of the Boorowa River catchment. The study area covers 200 km$^2$ and lies within the eastern section of the Boorowa 1:100,000 map sheet and in the northwest of the Goulburn 1:250,000 map sheet.

Land in the Upper Hovells Creek catchment is mostly used for agricultural purposes such as cropping and grazing (Evans 1994). Cropping in the Upper Hovells Creek catchment is confined to the alluvial plains and fertile soils of the Kenyu Volcanics. Crops include wheat, canola, oats, lucerne, and a variety of vegetables and fruit. Much of the Upper Hovells Creek catchment is also used for meat production. Sheep and cattle are the animals most commonly grazed in the study area.

The major lithologies present are the Ordovician Cabonne, Adaminaby and Bendoc Groups; and the Silurian Wyangala Batholith and Douro Group (Johnston *et al. 2001*). At a regional scale, the Upper Hovells Creek catchment is located on the boundary between the Cowra-Yass Synclinorial Zone and the Molong-South Coast Anticlinorial Zone (Gilligan & Scheibner 1978). The boundary between these two zones is marked by a series of faults, where there is a contact between Siluro-Devonian and Ordovician rocks (Gilligan & Scheibner 1978).

## REGOLITH-LANDFORMS

There is no regolith-landform map for the Boorowa area, however, aspects of the regolith cover have been integrated as an overlay on the Boorowa 1:100,000 geology sheet (Johnston *et al.* 2001). Only three units are defined on this regolith overlay. They are:

- Quaternary alluvium below the break in slope;
- Colluvium above the break in slope;
- Residual material in areas which are resistant to weathering.
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This does not provide a comprehensive tool that can be used for farm scale management and planning.

## RESULTS

The Upper Hovells Creek regolith-landform map (Harvey 2003) shows the distribution of 22 units for the upland catchment. These units include *in situ*, colluvial and alluvial landforms, with a range of regolith lithology types and vegetation species present.

**IN SITU REGOLITH-LANDFORMS**

*In situ* regolith-landforms include all material that is weathered in place (Eggleton 2001). These materials have not undergone any form of transport. The majority of *in situ* material within the Upper Hovells Creek catchment is bedrock. It includes slightly weathered out-cropping and subcropping bedrock (Figure 1).

**Figure 1:** The typical way in which rock outcrop occurs in the Upper Hovells Creek catchment. Scattered areas of outcrop can be seen in the foreground ($SSeh_2$, $SSel_2$, $SSer_2$) with tors typically greater than 2 m in the background ($SSeh_1$, $SSel_1$, $SSer_1$)

**COLLUVIAL REGOLITH-LANDFORMS**

Colluvial regolith-landform units include all material, of a similar origin, that has been transported by means of gravity (Eggleton 2001). These units can include material that is presently being eroded down a slope, and that which is being deposited in a plain. These materials are usually found close to their source, and can include a variety of grainsizes and shapes, typically up to cobbles, and ranging from angular to well-rounded (Southwell 2001). The colluvial regolith-landform units in the Upper Hovells Creek catchment include erosional hills, erosional low hills, erosional rises and depositional plains (Figure 2). Nine colluvial erosional regolith-landforms, and one colluvial depositional regolith-landform was defined in the Upper Hovells Creek catchment.

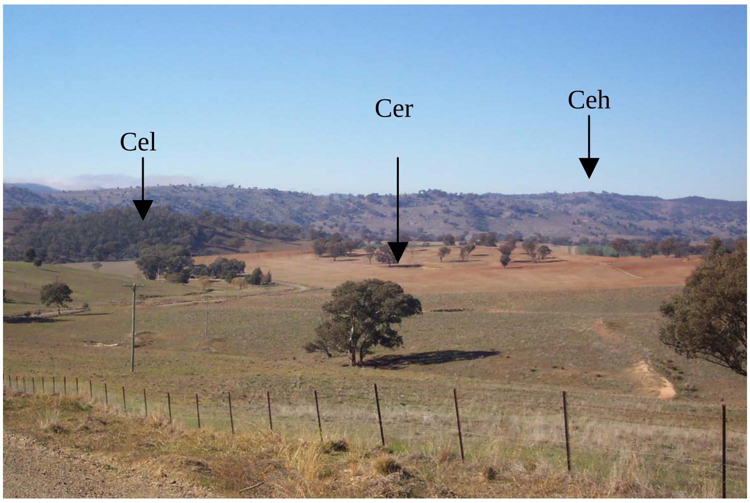


**Figure 2** In the background areas with high topographic relief can be seen $Ceh_1$, $Ceh_2$, $Ceh_3$). Areas with moderate topographic relief can also be observed ($Cel_1$, $Cel_2$, $Cel_3$), and those with low topographic relief in the foreground ($Cer_1$, $Cer_2$, $Cer_3$).

**ALLUVIAL REGOLITH-LANDFORMS**

Alluvial regolith-landforms can be defined as those where the material is dominantly transported by water (Eggleton 2001). Alluvial material can be transported some distance from origin, and generally consists of material that does not always reflect the underlying bedrock. The alluvial landforms present in the Upper Hovells Creek catchment include

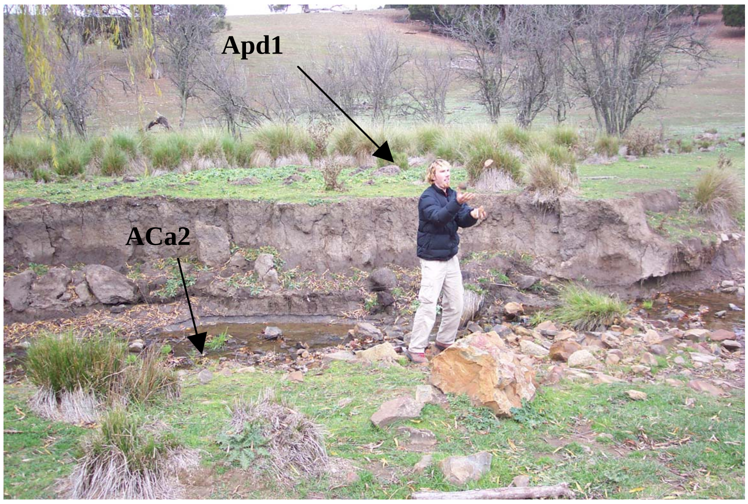


**Figure 3 (right):** This flat bottomed channel ($ACa_2$) is associated with a minor alluvial plain in the background ($Apd_1$).

drainage depressions, channels and plains (Figure 3)

## REGOLITH-LANDFORM DISTRIBUTION AND ASSOCIATIONS

Outcrop in the Upper Hovells Creek catchment is typically associated with the Wyangala Batholith. This area is dominated by outcropping and subcropping granitic bedrock (Figure 2). There is limited occurrence of alluvial plains in the Upper Hovells Creek catchment. Alluvial plains do not dominate the topographically lower areas of the catchment. Instead, the outcrop and steep slopes of the Wyangala Batholith dominate the northeastern part of the catchment. The main alluvial channel (Upper Hovells Creek) trends along the contact between the Wyangala Batholith and the metasediments of the Adaminaby group. This indicates that the presence of the batholith has had a strong control on the course and stream morphology of the Upper Hovells Creek. The colluvial regolith-landform units that are underlain by sedimentary rocks are typically shallow and stony. These units are also those that are used for grazing, or are dominated by remnant vegetation. Colluvial units overlying Ordovician mafic volcanics (Kenyu Volcanics) have a clay-rich regolith mantle up to 5 m thick and are typically cultivated for crops.

The regolith-landform map of the Upper Hovells Creek Catchment can be used to determine three land management units (LMU) within the catchment. The areas underlain by granite are dominated by outcrop, and exhibit waterlogging at the break in slope. There is some spring formation associated with subhorizontal jointing in the parent rock. Although these areas of outcrop are recognised zones of recharge they typically support native tree and shrub vegetation with some native and exotic grasses between tors. An associated study on a stretch of Hovells Creek, underlain by high-relief granite to the north, found that areas such as this were important regions of relatively fresh water influx to the catchment (Ratchford 2002). This is because the regolith veneer is thin and residence time in aquifers is short, resulting in less opportunity for groundwater to "see" salt as it passes through the high-relief granite. Best land management practice in this part of the catchment may not include establishing deep-rooted perennial vegetation, because it is preferable that this water enters the groundwater and surface water systems. This is contrary to appropriate management for adjacent regolith-landform units.

The areas underlain by Ordovician metasediments typically experience waterlogging in all low points of the landscape. Incipient to low grade metamorphism followed by weathering means that sandstone units are not necessarily the main aquifers in these bedded sediments. Shale beds are commonly highly cleaved with open fractures, and may be the focus of sub-surface fluid flow. Regolith lithologies in these areas have the highest salt load measured (EC up to 2500 μs/cm; Harvey 2003). Because the regolith is dominantly composed of lithic fragments, quartz and low cation exchange capacity (CEC) clay minerals, the regolith cannot chemically buffer saline groundwater (Moore *et al.* 1999). This is the principle salt source contributing to elevated salinity values in Hovells Creek. Traditional farming practices in these areas have resulted in widespread clearing of deep-rooted vegetation in all areas other than along rubbly ridgelines, that have limited grazing value, and laneways. Most riparian vegetation has also been removed. On these regolith-landform units salinity manifests in the landscape as crusts, scalds, areas of standing clear water, zones of poor feed and crop yield, tree death and presence of indicator species, particularly in low-lying areas. In these areas hazard mitigation includes revegetation of recharge and intercept zones, stabilisation of riparian zones, feed management using species that survive in saturated and salty ground, increased use of deep rooted perennial grasses and some farmers are exploring no-till techniques for cropping.

The areas dominated by Ordovician mafic volcanics (Kenyu Volcanics) exhibit few symptoms of waterlogging or dryland salinity. Regolith landform units in these areas have a thick regolith veneer (typically > 3 m), and have a high clay mineral and organic component. This regolith type has the lowest salt load measured (EC up to 235 μs/cm; Harvey 2003), and the presence of some high CEC clays allows the buffering of high pH fluids. This LMU is presently utilised for intensive cropping, fodder production and some grazing. These regolith materials can sustain longer periods of cropping than associated metasediments of the same age. This unit forms a discrete, and somewhat dissected, approximately north-south trending belt through the study area. Because of this, adjacent regolith units are commonly subjected to similar land use practices, but this management approach cannot be sustained without exacerbating the dryland salinity issues.

## CONCLUSIONS

The setting of regolith-landforms in the Upper Hovells Creek catchment is strongly geologically controlled. For example, the presence of the Wyangala Batholith has resulted in the limited presence of alluvial plains in the lower parts of this catchment. The 1:20,000 regolith-landform map (Figure 4)identifies areas with similar regolith characteristics and, hence, management needs. It is a useful tool for strategic land management, particularly dryland salinity hazard mitigation, in this area. The detailed scale of this regolith-landform map provides useful information for farm and catchment scale strategic land management planning.

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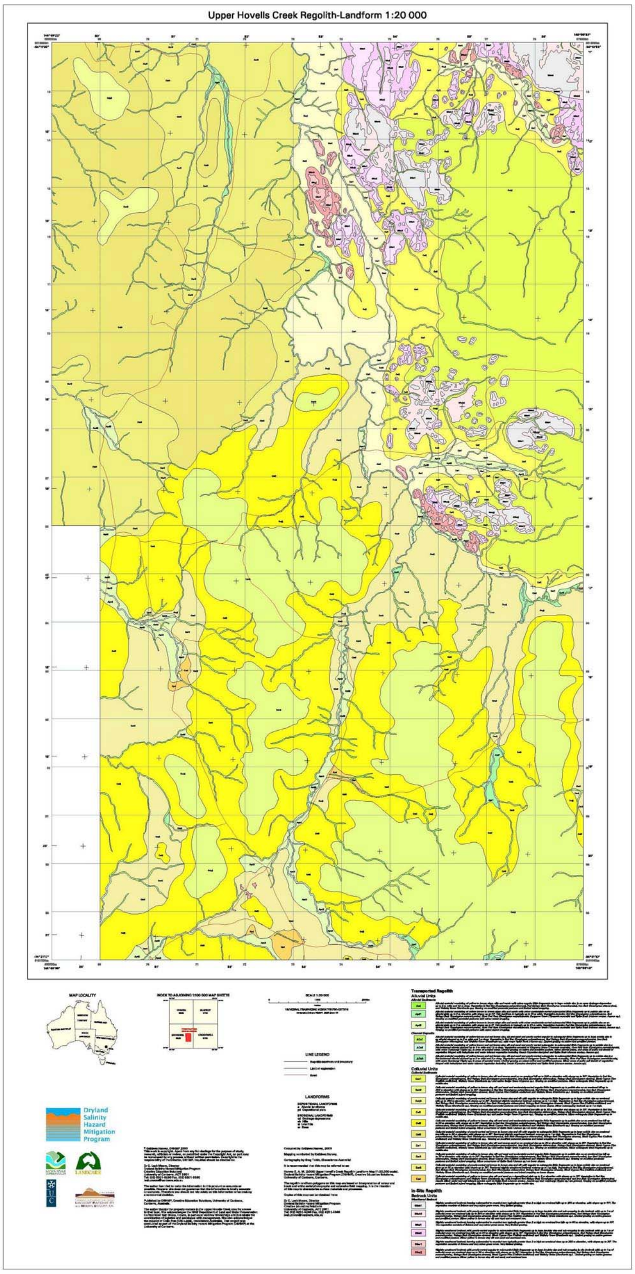


**Figure 4:** 1:20,000 regolith-landform map of the Upper Hovells Creek catchment. Not to scale.