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Robert Banks BSc Hons, Certified Professional Soil Scientist (CPSS), Dip Bus, PhD

Dr Paul Smith
Senior Environmental Planner
Upper Hunter Shire Council
Tuesday, 1 March 2022

Dear Paul,

Please find following this covering letter the peer review of the "HYDOGEOLICAL ASSESSMENT AND GROUNDWATER MANAGEMENT PLAN; 150 GUNDY ROAD. SCONE" (Martens, 2022).

Currently the document fails to indicate spatially any offsite potential salinity impacts or required management which may occur as a result of the proposed development. It does not indicate areas of affect nor does it propose mitigation measures. The study takes no account of existing salinity near or below the site, nor of salt stores in soils. Despite a large amount of real data available for the study area, very little of this appears to have been used. The impacts of increased run-on onto adjacent saline salt stores as a result of the proposed development are not considered.

Although MODFLOW was used to model groundwater changes instead of recommended salinity specific models, this has been done in other areas of Australia with some success. The groundwater data for the model was confined to just the proposed development site, instead of the whole catchment including the site. Existing monitoring bores and piezometer data from the model area were not included, and published information on salinity below the site have not been used.

As the document does not show the scale of potential salinity impacts within or downslope of the site, it is inadequate for planning purposes with respect to salinity.

I am more than happy to answer any questions regarding my review of the document.

Yours Sincerely

Robert Banks

Dr Robert Banks

Peer Review: "HYDOGEOLICAL ASSESSMENT AND GROUNDWATER MANAGEMENT PLAN; 150 GUNDY ROAD. SCONE" (Martens, 2022).

1. Introduction

This report was prepared at the request of Dr Paul Smith, Senior Environmental Planner for the Upper Hunter Shire Council. The brief of this report was to:

Carry out a peer review of the attached documentation to consider whether the salinity issue has been adequately investigated and the management plan would be sufficient to address the long term impacts of salinity in the catchment resulting from the development.

1.1 Code of Conduct

In preparing this report, I made all the inquiries I believed were necessary and appropriate and to my best knowledge no relevant matters were omitted from this report.

I believe that the facts within my knowledge that have been stated in this report are true.

The opinions I have expressed in this report are independent and impartial. I have read and understand *Schedule 7* to the *Uniform Civil Procedure Rules* and have used my best endeavours to comply with it.

I understand my duty to the Court and state that I have complied with it and will continue to do so. I believe I have the relevant expertise to provide such information as requested for this report. A copy of my Resume is included in Appendix 1.

1.2 Suitability for Undertaking Review

I have a PhD in Soil Physics (including Geomorphology and Pedology). Soil physics deals with the dynamics of physical soil components and their phases as solid, liquids and gases. It draws on the principles of physics, physical chemistry, engineering, and meteorology and applies these principles to address practical problems of agriculture, ecology, and engineering. Soil physics uses the same principles and equations as hydrogeology and the two fields are highly interrelated.

I have extensive experience in salinity research, mapping of soil, and salt loads and salinity risk from land use change at both a landscape scale local scale (Banks, 1995, 1998, 2001; Ringrose-Voase *et al.*, 2003), both as a government scientist and a private consultant.

2. Review of Document

2.1 Methods of Review.

To undertake this review, was read thoroughly with respect to the requirements of UHSC as well as the Planning Panels' "DETERMINATION AND STATEMENT OF REASONS" (30 September 2020) (Section 2.2 of this review). Of particular note, the Planning Panel requested a "salinity model" and that confident and satisfied that the reporting shows potential "onsite and offsite salinity impacts" and presents a plan as to how these impacts can be "minimised and mitigated."

Additional information was sought from public sources on soil mapping, salt loads and the nature of salt stores in the landscape using DPIE's E-Spade online soil profile and map viewer (Section 3.1 of this review)

Water use values for Scone are given in section 3.2 of this review.

2.2 Comments on Document

Page	Comments
1	Executive Summary. Many of the statements in this summary are incorrect as will be revealed as this review progresses. In particular: Point 1. Existing data has not been reviewed except for very broad backgrounding information Point 3. Pre and post development conditions were not assessed for offsite salinity conditions correctly, but the work that has been done indicates there is significant salinity risk within the proposed development footprint itself. Point 5: Groundwater impacts are not assessed correctly because of inadequate use of the model . Point 8: the groundwater management for the development is not sufficient for the purpose because of the way the investigation and modelling was conducted.
10 Para 4	The Planning Panel requested to have a groundwater salinity model to be developed for the site and surrounding areas ensure that the proposed development does not intensity existing salinity within the catchment. No maps are provided to indicate where this salinity might be, despite detailed maps being available. Unfortunately, further reading reveals that the modelling undertaken does not include adequate data from areas outside the proposed development footprint as requested by the Planning Panel.
11 Para 1	No map is provided of the saline areas adjacent to or below the proposed development. Salinity can also occur as a result of excess run-on to a site which saturates high salt bearing subsoils to the surface, creating an evaporation zone where salts can concentrate. This process has been ignored in the descriptions of mechanisms of

Page	Comments
	dryland salinity.
11, para 2 - 3	The impacts of saturation from increased run – on have not been factored into the model design. Note that the recommended models were not used. In addition to this, effects of increased water use for gardens is not included anywhere in the document. Last para. Continuous monitoring over 12 weeks is a very short timeframe for groundwater modelling data to be developed. Use of surrounding long-term monitoring would have been helpful in overcoming this limitation.
Pages 12 - 13	Point 7. Long term effects are not assessed. How many years was the model run for? None of this information is provided. Issues such as increased run-off, increased water use on land from lawns and gardens, as well as removal of deep-rooted perennial native grasses are not well considered as factors in the model design. If it is, then it is not mentioned clearly Surrounding land uses are inadequately described aside from the Aged Care Centre. Other assets down the catchment include the Scone High School, the Honeysuckle Urban area and downstream State-owned Infrastructure such as the highway and substation area which is already severely salt affected. The golf course below the highway is already salt affected.
14 last para	MODFLOW, used properly, can be used for urban salinity prediction purposes with some success. Unfortunately, by constraining the source of most groundwater data to the development footprint, and not using other available data for within the model boundary, predictions of offsite effects are unlikely to be precise or adequate. The model does not properly consider the catchment(s) of the site, make use of the multitude of public bore data and piezometer data, accessible on request, or salt load data which is available online. An example of MODFLOW being used correctly in this context is given in Matta and Cattlin (2000), where the whole catchment containing a town is used in the model with a high number of bores through the whole catchment above, below and including the town.
17	The reference to soils reveals nothing about the nature of the soils and reveals no understanding of how a Soil Landscape map is used. The consultants failed to include the latest soil mapping for the site available through E-SPADE. The newer mapping is at a much finer scale and is far more appropriate for the model. The 1:250 000 sheet Soil Landscapes presented, are, at best, background historical data. Please find the up to date soil landscape mapping relevant to the site in Section 3 of this review.
18	Soil texture has been confused with soil type on this page. The textural information provided is of very limited use. There are soil profiles available with real data surrounding the site as well as more up to date soil mapping available. Soil type should always be given using Isbell and NCST (2021), or an earlier version if the latter is not available.
19	Textures given in Table 3 are not national standard as per NCST (2009). Table 4. Despite the presence of some other bores with level data, and the proliferation of piezometers in the catchment of the development, it appears that only 2 external bores have been used in the modelling. This would have assisted the creation of a salinity groundwater model which covered the catchment area and predicting offsite effects.
21	Climate data is OK, but effects of watering of gardens and run-on effects offsite are not

Page	Comments
	correctly considered when this type of data is available. Instead of using a single set of climate data, a real set of climate data for the past 20-50 years may have been more suitable. Assuming average values in a salinity model is generally not useful as recharge is often pulsed and/or occurs only at a certain time of year. The pulsed recharge is highly significant north of Mediterranean Australia, where years of high rainfall result in large amounts of recharge. This recharge can take 1 – 10 years to be expressed as dryland or urban salinity even in a local small catchment.
22	Table 6 clearly shows that MW01a and b have groundwater levels within 2.3 m of the ground surface. No comment has been made about this being well within the zone of capillary rise of water to the surface. MW03, is also within the zone of capillary rise for silty soils. Both are sites of significant risk and are probably already saline. This is not stated clearly. Whilst it is good that extra bores have been placed within the proposed development footprint, they are all relatively high in the overall catchment and a connection with further bore and piezometer data needs to be included within the model from outside the development footprint is required.
23	Groundwater salinity levels given in Table 8 are all in the realms of poor quality water which cannot be used for agricultural (irrigation) or potable purposes (Hazelton & Murphy, 2007) (p110). Although this has a short comment, its significance in terms of groundwater processes is not given. Coupled with the water level from Table 6 for MW01a-b and probably MW03 this means that saline water is within the capillary zone of the surface and very highly likely to cause salinity if it has not already occurred. In terms of ranking salinity for potable purposes, none of the salinity values are low and some are not moderate but high.
26	Section 3.1.4: The assumption that discharge is continuous along creek-lines and depressions throughout the model domain is strange as it ignores break of slope salinity, salinity s a result of road compaction and restrictions and barriers. These need to be factored into the model and could have been added through seeking out this information which is freely available from DPIE.
28 - 29	Real textural information has not been used in the model. It is available and should have been used. Recharge rates for local soil types and soil materials have been extensively investigated and actually measured in the nearby Liverpool Plains (Ringrose-Voase *et al.*, 1989) these values for Recharge and ET could have been used if no closer data were available. They are the same soils in a very similar climate zone.
31para 2	Retention basins are generally leaky and promote hot zones of recharge if soil material used is saline. One assumes that the developer proposes to concrete line or heavy geotextile line these basins. All retention basins overflow in high rain, and all retention basins concentrates salts as they evaporate. If they are constructed with earth materials, they tend to wick water upslope via capillary rise which can be as high as 6 m in silty soils. The explanation of map 5 at the bottom of the page, is very confusing and appears not to make sense. Reference to this map shows that only older soil landscape mapping has been used when more detailed material is available.
32	Very large uncertainty is created by only constraining data for the exercise to within the proposed development boundaries.

Page	Comments
33	Section 6.1. Point 1. to say that no offsite bores will be affected is not justifiable. Point 3. As the modelling did not include nearby bores, it is highly unlikely that this statement can be justified. Salinity Impacts: stormwater impacts – putting extra water on already saline sites will increase local salinity through saturation.
36	Table 14. Trigger values are interesting. MW01a-b and MW03 are already saline and already within the zone for capillary rise. If they rise further, significant salinity will occur if it is not already there.
41	What consequence is there if monitoring during constructions finds a breach of trigger values in GW level? Apparently, there is none. As there is no post construction monitoring proposed, what consequences are there when salinity occurs after 2 years. Groundwater processes often have lead times in years to a decade even in local groundwater systems, these needs to be considered both in the model and poste development if it is approved. Post construction water use has not been considered.
42	GW modelling has been insufficient to correctly calculate offsite effects and the statements given in points 1 – 3 are not justifiable based on what has been presented. Apparently, according to paragraph 5, the controls suggested by other consultants are all valid. Are these the consultants who have suggested that salinity is an important issue for the site? No references given.
Map 07	Shows the extent of the model, but keep in mind measurements were only made within the development footprint. This is unacceptable. There are no groundwater data used in the model for the soil/geological/hydrogeological units outside of the proposed development footprint. To extrapolate outside the area of principal gw data used does not make sense. There are 13 active piezometers and one well adjacent to or below the development area all of which are monitored and have data which should have been incorporated into the model.
Maps 11, 13-14.	The pre and post-development groundwater surface transects appear to be identical. The scale needs to be such that change can be seen if it is there. Nonetheless. Transect B shows very high groundwater levels which are likely to be already causing salinity problems (to the left of the 400 m chainage mark in Map 11 and 14.

2.3 Summary, Comments on Document

In short, the document does not use available information, and the constraining of the study to data within the proposed development area does not answer questions regarding the potential offsite effects of the development on salinity and does not address the concerns raised by Council and the Planning Panel. In particular, the document does not present a plan as to how these impacts can be "minimised and mitigated."

Even despite this, the model does show that about one third of transect B already has saline groundwater within 2 m of the surface and will continue to do so post-development. This area is within the zone of capillary rise of water up through the soil to the surface and is already at risk of having actual surface salinity. Effects of increased water use for gardens is not included in the document and consequences of increased runoff to this area of the transect are not discussed.

The model has not been used adequately. Further salinity modelling *is* required to actually say what the offsite impacts are, indicate any potential impacts on maps and provide management solutions for potential salinity resulting from the proposed development.

3. Further information relevant to potential effects of the Proposed Development

As stated above, soil and landscape information used in the modelling is historical and has been replaced with mapping at 1:100 000 scale, which is far more suitable as a framework for planning within and around the site. Even with this scale of mapping, further details should be sought to meet the requirements of individual subdivision planning.

3.1 Use of E-Spade

Shows modern soil landscape mapping, which is available for download, with soil profiles which have salinity data (Figure 1). This data could have been used to calculate salt loading in areas receiving runoff or extra recharge/discharge from the proposed site. Full Soil Landscape descriptions are presented in Appendix 2. Soil Profile analytical data is available for each landscape in McInnes-Clarke (2004).

The salt loads provided in many of the soil data points, particularly below the development are very high to extreme. In addition to this, Vertosols under native grass vegetation, which dominate the lower slopes of the proposed development site, naturally have very high stored salt contents in subsoils (Banks, 1995, 1998; McInnes-Clarke, 2004; Tolmie *et al.*, 2011). These salts can be mobilised both through groundwater rise or saturation from changes in run-on through drainage or from garden over watering (Tolmie et al., 2011).

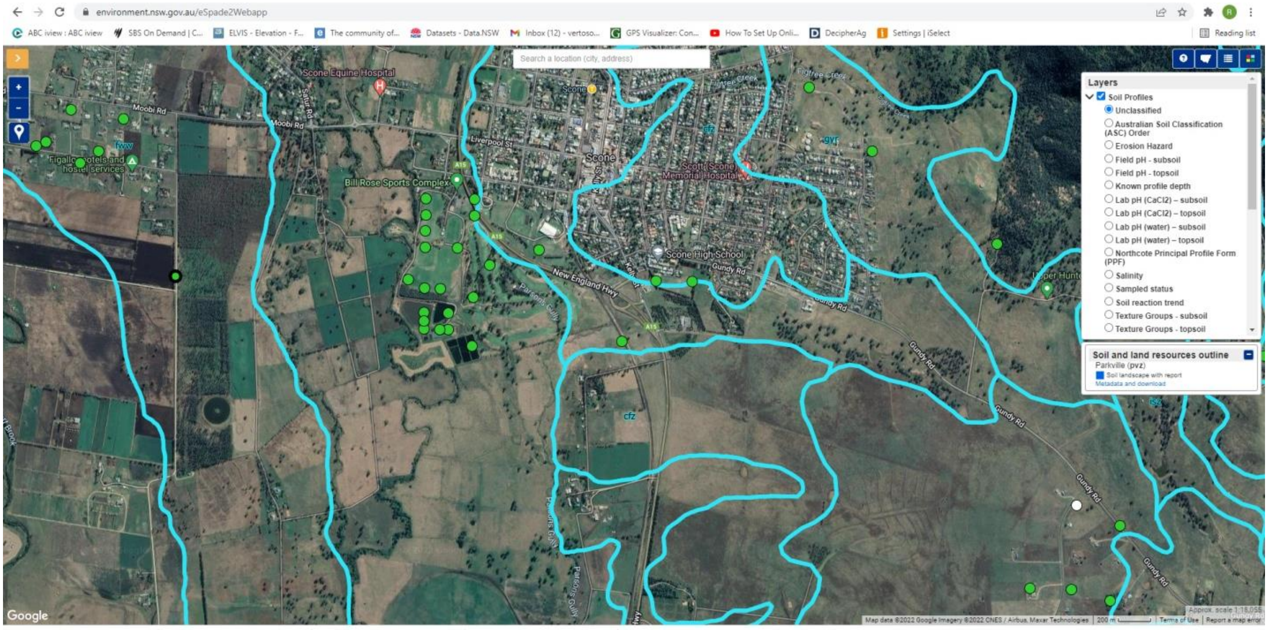

Figure 1: Screenshot from E-Spade showing modern soil landscape mapping and available soil profile data

3.2 Water use Data for Scone

Water use data is freely available from the UHSC. As Figure 2 illustrated, even small housing blocks can have very high water use per property. In terms of extra water, in addition to rainfall per hectare of land this can be over 3 megalitres per hectare (Figure 3). A significant portion of this water use is garden and lawn watering of shallow rooted plants. This contributes significantly to deep drainage which becomes extra recharge in urban areas. Real data such as this has not been included in the model.

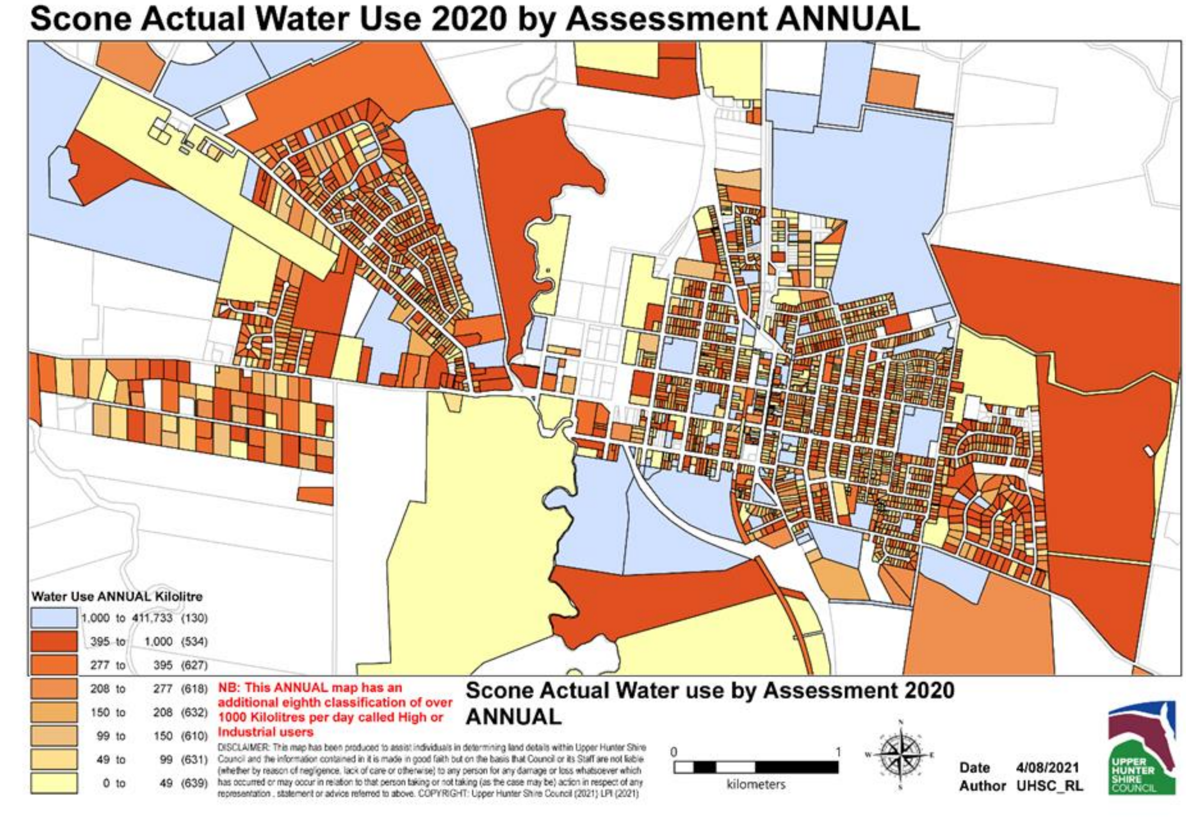

Figure 2: Annual Water use for Scone in kilolitres per household (UHSC)

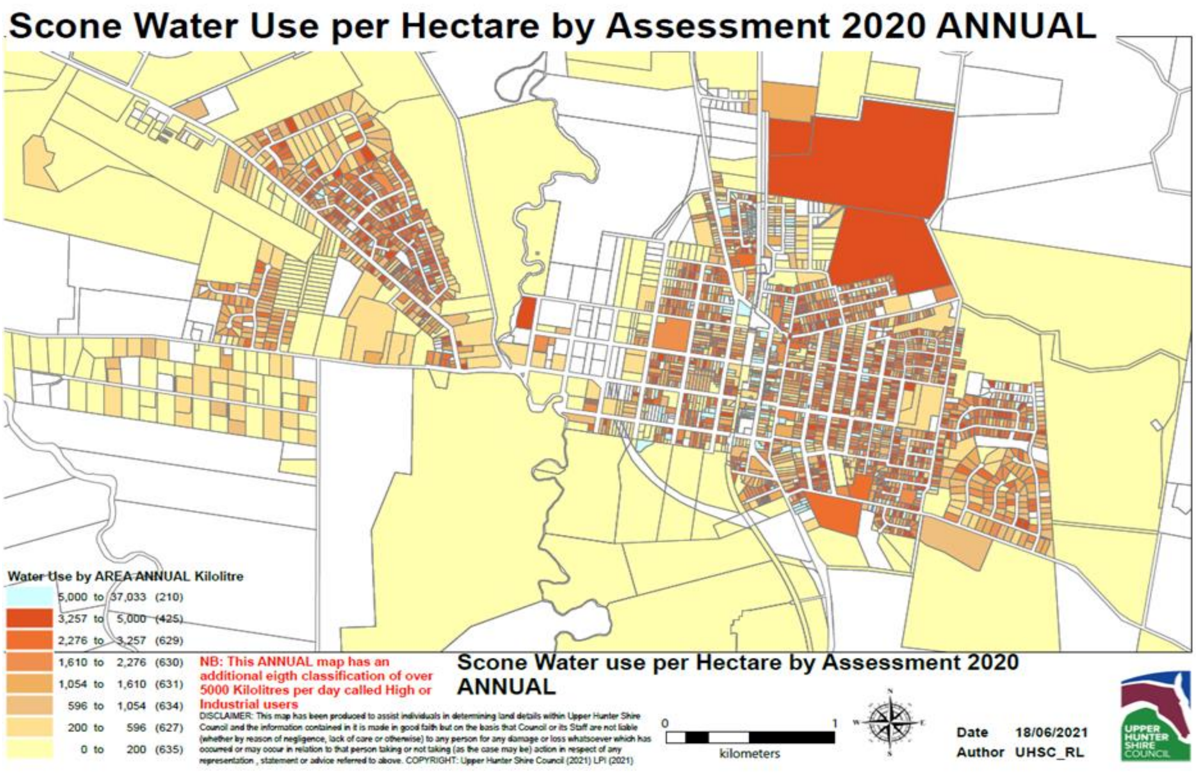

Figure 3: Annual Water use for Scone in kilolitres per hectare (UHSC)

4. Concluding Remarks and Recommendations

Although the model chosen for this work was not one which was recommended by the Planning Panel, it can be used for urban salinity planning if it is used in the correct manner and as much real data as possible is used for the model. Martens (2022) quote Littleboy *et al.* (2003) as a reason for choosing MODFLOW as the model of choice. In the quoted paper, Littleboy et al. (2003) state “There is little to be gained by using complex models with questionable estimates of input data (commonly referred to GIGO, Garbage-In Garbage-Out).” The amount of actual data available for Scone is more than sufficient to populate the model or use the suggested models with real data rather than assumptions.

Factors such as run-on have not been considered and the discharge section of the model has been constrained to drainage lines only, which is not a reflection of the way all salinity outbreaks occur in the region which must include breaks of slope, changes of soil type, constrictions in catchments as well as potential blockages such as the New England Highway.

The use of only bore data within the constraints of the development footprint makes the assessment of offsite impacts impossible. Interestingly, the bore water quality data which is used shows clearly that all the groundwaters are saline. The transect data provided also demonstrate that a significant portion of transect B is probably already affected by salinity to some extent.

In terms of the requirement of the study to show onsite and offsite salinity impacts and presents a plan as to how these impacts can be minimised and mitigated, this has not been achieved with any confidence.

It is therefore recommended that:

1. the study be re-done incorporating the appropriate available data which covers the whole model area and not just the development footprint. The model should be run for an appropriate time frame (multiple model runs over 20 – 50 years) using real historical data), using a model which can accommodate this data if MODFLOW cannot; and

2. The proposed development be denied consent until these issues are assessed correctly with clear geographical outcomes (on maps) and monitoring and management options that extend past the construction period for a timeframe that is equivalent to local catchment response times between pulsed recharge and actual salinity emergence.

5. References

Banks, R. G. (1995). *Soil Landscapes of the Curlewis 1:100 000 Sheet. Map and Report*. Sydney: NSW Dept. of Conservation and Land Management.

Banks, R. G. (1998). *Soil Landscapes of the Blackville 1:100 000 Sheet. Map and Report*. Sydney: NSW Dept of Land and Water Conservation.

Banks, R. G. (2001). *Soil Landscapes of the Tamworth 1: 100 000 Sheet. Map and Report*. Sydney: NSW Dept Land and Water Conservation.

Hazelton, P. A., & Murphy, B. W. (2007). *Interpreting soil test results: what do all the numbers mean?* Collingwood Victoria, Australia.: CSIRO publishing.

Isbell, R., & NCST. (2021). *The Australian Soil Classification. 3rd Edition.* (3 ed.). Melbourne: CSIRO Publishing.

Littleboy, M., Vertessy, R., & Lawrence, P. (2003). *An overview of modelling techniques and decision support systems and their application for managing salinity in Australia.* Paper presented at the Proceedings of 9th National Produce Use and Rehabilitation of Saline Land (PURSL) Conference, Queensland, Australia.

Martens. (2022). *HYDOGEOLICAL ASSESSMENT AND GROUNDWATER MANAGEMENT PLAN; 150 GUNDY ROAD. SCONE*. Retrieved from

Matta, J., & Cattlin, T. (2000). Groundwater modelling the Merredin Catchment: A tool to test groundwater management options with regards to rural urban salinity. *Hydro 2000: Interactive Hydrology; Proceedings*, 921.

McInnes-Clarke, S. K. (2004). *Soil Landscapes of the Murrurundi 1: 100 000 Sheet:(Parkville, Kars Springs, Murrurundi, Quirindi, Wallbadah)*: Department of Infrastructure, Planning and Natural Resources.

NCST. (2009). *Australian Soil and Land Survey Field Handbook. Third Edition* (3rd Ed.). Collingwood, VIC, Australia: CSIRO PUBLISHING.

Ringrose-Voase, A., Rhodes, D., & Hall, G. (1989). Reclamation of a scalded, red duplex soil by waterponding. *Soil Research, 27*(4), 779-795.

Ringrose-Voase, A., Young, R., Paydar, Z., NI, H., Bernardi, A., Cresswerll, H., Keating, B., Scott, J., Stauffacher, M., Banks, R., Holland, J., Johnston, R., Green, T., Gregroy, L., Daniels, I., Farquharson, R., Drinkwater, R., Heidenrecich, S., & Donaldson, S. (2003). *Deep drainage under different land uses in the Liverpool Plains catchment*: NSW Agriculture.

Tolmie, P. E., Silburn, D. M., & Biggs, A. J. W. (2011). Deep drainage and soil salt loads in the Queensland Murray–Darling Basin using soil chloride: comparison of land uses. *Soil Research, 49*(5), 408-423. doi:https://doi.org/10.1071/SR10172

6. Appendices

6.1 Appendix 1: Qualifications of Dr Robert Banks and suitability as Reviewer

Curriculum Vitae- Robert Banks

Personal Details

Name:	Robert Banks
Nationality:	Australian
Contact Details:	139 Blackjack Forest Road PO BOX 582, Gunnedah NSW 2380 Phone: (02) 67 427 489; mobile: 0427 431 512 e-mail: soilfuturess@clearmail.com.au

Tertiary Education

2019 **The University of Queensland, School of Agriculture and Food Sciences**
Doctor of Philosophy
Thesis Title: Rapid Soil Development in Response to Land Use Change. Case Studies from northern New South Wales Slopes, Plains and the New England Tablelands.

2004 **TAFE Gunnedah**
Diploma in Frontline Business Management

1989 - 1990 **Macquarie University, School of Earth Sciences**
BSc Hons Geomorphology and Soil
Research Hons. Thesis Title: *The Relationship between Floodplain Pollution and Exotic Weed Distribution in an Urban Floodplain: A Case Study of the Lane Cove River Valley.* Cross disciplinary study including fluvial geomorphology, soils, and plant ecology.

1986 – 1989 **Macquarie University, School of Biological Sciences**
BSc Ecology and Soils.

Honours and Awards – Accreditations

2019 **Senior Adjunct Research Fellow The University of Queensland.** Coordinator, UniQuest – UQ-International Development: Liverpool Plains component Australia. Awarded Fellowship for contribution to African short courses and mentoring local and overseas PhD students whilst enrolled for PhD at UQ.

2017 **Second best Research Presentation.**

Awarded at Meat and Livestock Postgraduate Conference, November 2017.

1994 - present **Certified Professional Soil Scientist.** Accreditation scheme run by Australian Soil Science Society Inc. ensuring appropriate standards and training are adhered to by accredited members.

2013 **Adjunct Research Fellow The University of Queensland.** Coordinator, UniQuest – UQ-International Development: Liverpool Plains component Australia. Awarded Fellowship for contribution to African short courses.

2012 **University Brawijaya School of Agriculture Medal**
Medal Presented by Dean of Faculty in recognition of training provided to local students, and procurement of EU funding for the soil science program at Uni Brawijaya, Java Indonesia

2011 **LandCare Award for Communication of Soil Science**
Presented by the Liverpool Plains Land Management Committee In recognition of publications, input to best management practice, and communication of soil science to members of the Liverpool Plains Community.

Employment History

2014 – 2018 **PhD Candidate. The University of Queensland.**

- Conducted research on significant soil type and characteristic changes which occur with common land use changes in northern NSW
- Presented findings to funding bodies and community groups as research was developed and subsequently completed
- Provided training and supervision to colleague post graduate students in field pedology and sampling
- Provided training and teaching to Honours students in pedology, field pedology and soil physics laboratory techniques.

2004 – 2022 **Director and Principal Consultant SoilFutures Consulting Pty Ltd.**

- Produced over 150 technical reports, maps and documents for national and international clients in agriculture, government and community groups
- Invited speaker at 150 (plus) Field Days (Australia)
- Supervised University students at University Brawijaya (Indonesia)
- Contributed to international training programs for professionals from 41 African countries and Iraq through UQ and Sydney University
- Contributed to national research programs with UNSW (Hydrogeology), Sydney University (Soil Science), Newcastle University, University of Queensland ANU (Soil Science and Geomorphology), and Wollongong University (Soil Engineering).
- Rice Paddy Soil research in Java / Indonesia with Technical University Munich, Bonn and Halle Universities (Field Pedology and Soil Physics)
- Established business and academic relationships with University Brawijaya (Indonesia) and EU funded research programs
-

1990 – 2004 **Senior Scientist/Soil Surveyor. Soil Conservation Service of NSW**

- conducted and published broad scale Soil Landscapes Surveys (maps and Reports)
- Supervised a team of regional soil survey staff and contributed locally and nationally to research particularly in salinity, hydrogeology, agronomy and new spatial analysis technologies
- Advising landholders, speaking at field days, supervising Honours
- Students from Australia and German Students from Gottingen, Hamburg and Berlin Universities.
- Two periods of 28 weeks Secondment to Hong Kong government as part of the Systematic Investigation of Features of the Territory (SIFT) project, mapping cut and fill slopes and ranking them in terms of hazard of failing in tropical storms

Publications

Peer Reviewed Publicaitons and Technical Papers/Conferences

Banks, R., Wendling, L., Basford, K., Ringrose-Voase, A., & Banks, V. (2020). Beneficial soil profile differences associated with tropical grass pastures on sodic texture contrast soils in Northern New South Wales. *Soil Research*, *58*(2), 207-218.

Banks, R. G. (2019). *Rapid soil development in response to land use change: case studies from the northern New South Wales slopes, plains and New England Tablelands.* (PhD), The University of Queensland, Brisbane.

Banks, RG 2017. Topical Pastures make beneficial changes to poor soils. *Grasslands Society Newsletter*, 32:3.5 – 7

Jin YZ, Huang, J., Banks, RG and Triantafilis, J. 2017. Scope to map soil landscape units at the district level from remotely sensed gamma ray spectrometry and proximally sensed EM induction data. *Soil Use and Management*. 4: 538 – 552.

NSW OEH (Office of Environment and Heritage) 2012. *Soil and Land Resources of the Liverpool Plains Catchment. Including the Liverpool Plains and Gunnedah Local Government Areas.* DVD-R .Natural Resources Unit. NSW OEH, Parramatta NSW. Robert Banks was principal author of this information and editor for the western portion of the Liverpool Plains.

A.J. Ringrose-Voase, R.R. Young, Z. Paydar, N.I. Huth, A.L. Bernardi, H.P. Cresswell,B.A. Keating, J.F. Scott, M. Stauffacher, R.G. Banks, J.F. Holland, R.M. Johnston,T.W. Green, L.J. Gregory, I. Daniells, R. Farquharson, R.J. Drinkwater, S. Heidenreich,S.G. Donaldson & C.L. Alston 2000. *Deep Drainage under Different Land Uses in the Liverpool Plains*. NSW Agriculture Technical Bulletin, CSIRO Land and Water Technical Report.

Banks, R.G. & McKane, D 1999. *Soil Carbon Storage Units of the NSW Interim Bioregions*. Series of maps and reports produced as a consultancy to the Australian Greenhouse, being incorporated into assessment of Australia wide soil carbon assessments. Australian Greenhouse Office, Canberra

Banks, R.G. 2001. *Soil Landscapes of the Tamworth 1:100 000 Sheet Map and Report*, Department Land and Water Conservation, Sydney

Ringrose-Voase, A.J., Paydar, Z., Huth, N.I., Banks, R.G., Cresswell, H.P., Keating, B.A., Young, R.R., Bernardi, A.L., Holland, J.F. & Daniels, I. 1999. *Modelling deep drainage of different land use systems. 2. Catchment wide application.* In Proceedings of the International Congress on Modeling and Simulation, Hamilton, New Zealand, December 1999, Volume 1. (Eds L. Oxley and F. Scrimgeour) pp. 43-48. University of Waikato, Hamilton, New Zealand.

Townsend, F.N., Lang, J.C. & Banks, R.G. 1999. *Dryland Salinity in the Liverpool Plains, NSW. Soil Mapping and Interpretation of Landscape Processes*. 6th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Land. Naracoorte, South Australia, 1 - 5 November 1999. Poster presentation summary in Conference Proceedings.

Banks, R.G. 1998. *Soil Landscapes of the Blackville 1:100 000 Sheet Map and Report*, Department Land and Water Conservation, Sydney

Keady, L.C. & Banks, R.G. 1998. *Field Guide to Soils of the Western Barwon Region Floodplains.*
Department of Land and Water Conservation, SYDNEY.

Keady, L.C., Banks, R.G, & Beasley, R. 1998. *Reconnaissance Soil Associations of the Collarenebri, Dungalear, Gwabegar, Mogil Mogil and Walgett 1:100 000 Map Sheets.* Department of Land and Water Conservation, SYDNEY

Banks, R.G. 1997. "Sols Profunds i Rentats" (Soils of the world temperate zone) In: R. Poch et al. (eds) *Encyclopedia Catalana* - Vol 6 Selves Temperades - Biosphera Edition pp31 - 36. BARCELONA, SPAIN.

Banks, R.G. 1995. *Soil Landscapes of the Curlewis 1:100 000 Sheet Map and Report*, Department of Conservation and Land Management, Sydney

Johnstone, R., Abbs, K., Banks, R., Donaldson, S & Greiner, R. 1995. *Unique Mapping Areas as the basis for Integrating Biophysical and Economic Modelling in the Liverpool Plain*s. MODSIM 95 Conference Proceedings

Kalaitzis P, Banks V & Banks R 2000. *Impacts Of Declining Shallow Ground Water Tables On The Health Of Terrestrial Native Vegetation In The Gunnedah Area*, NSW. LWWRDC Technical report for project No. NDW23.

Riley, SJ, Banks, RG. 1996. The Role of phosphorous and heavy metals in the spread of weeds in urban bushlands: an example from the Lane Cove Valley, NSW, Australia. *The Science of the Total Environment* 182: 32 – 52

Selected SoilFutures Consulting Publications/Reports

SoilFutures Consulting Pty Ltd 2020a. *Annual Soil Analyses and Report. Tamworth Effluent Re-Use Farm. Prepared for Tamworth Regional Council.* 9th in a series of Annual Monitoring reports focusing predominantly on rising salinity of wastewater irrigated lands.

SoilFutures Consulting Pty Ltd AND Hunt AG Solutions July 2020. *Soil Analyses for Tamworth Effluent Re-Use Farm with Comments on Site History and Salinity Management Options.* Client: Tamworth Regional Council.

SoilFutures Consulting Pty Ltd 2014a. *Great Artesian Basin Recharge Systems and Extent of Petroleum and Gas Leases. Revised Edition.* A spatial analysis of Gas lease extent and *critical recharge zones of the GAB with comments on potential risks*. 2nd edition peer reviewed prior to publication. Client: The Artesian Bore Water Users Association, NSW.

SoilFutures Consulting Pty Ltd 2013. *Potential for Oak Establishment and Truffle farming. Comboyne Plateau. An Investigation of Favourable Soil Conditions and climate.* Client: Dr Ken Adams, Gunnedah.

SoilFutures Consulting Pty Ltd 2015 *Electromagnetic Induction (EM31) Survey and Soil Investigation of Water Storage – "Jangaree"* . Prepared for Mr A Riordan, Piallaway.

SoilFutures Consulting Pty Ltd In conjunction with McKenzie Soil Management Pty Ltd 2011. Soil survey and Electromagnetic Induction Survey (em31) for Pecan Suitability. Jett Cottage, Pallamallawa, NSW. Cleint: Stahmann Farms.

SoilFutures Consulting Pty Ltd 2012. *Review of Soil Factors within Petroleum Exploration Licence 470 (PEL 470) in the Bellata-Gurley District with respect to risks associated with Coal Seam Gas Exploration and Production.* Client: Bellata-Gurley Action Group against Gas.

SoilFutures Consulting Pty Ltd 2011a. *Soil Description and Sampling, East Java (Ngawi), West Java (Sukabumi and Bogor). Indonesia.* Identification and selection of research sites for an EU funded collaborative project on rice soils of the tropics. Client: Technical University of Munich. Germany

SoilFutures Consulting Pty Ltd 2009. *Soil Landscapes and Soil Landscape Facets of the Hunter Councils* Region. A DVD Rom product showing all soil landscapes of the Hunter Councils catchments at 1:100 000 reconnaissance scale, broken into sub landscape sized facets. Client: Hunter Councils Incorporated, Maitland.

SoilFutures Consulting Pty Ltd 2009a. *Physical Environment Liverpool Plains. Geomorphology, Soil. Why is it unique in Australia? What are the community perceived threats from mining?* Client: Caroona Coal Action Group. Presentation to Senate Committee hearing on development and agricultural land

Namoi Catchment Management Authority 2008. *Reconnaissance Soil Landscapes of the Namoi River Catchment*. Digital product produced by SoilFutures Consulting Pty for the Namoi CMA.

SoilFutures Consulting Pty Ltd 2007 *Soil Description and Sampling for Effluent Re-use Investigation, Gilgandra.* Prepared for Hassall and Associates, Dubbo.

SoilFutures Consulting Pty Ltd 2006. *Consideration of Water Sources options for Groundwater Users in Upper Namoi Groundwater Zone 1. A geomorphic and hydrogeological Study.* Client: Zone 1 Upper Namoi Groundwater Users Group

SoilFutures Consulting Pty Ltd 2004. *South Wandobah Electromagnetic Induction Survey*- a report on soil salinity and irrigation potential. Client: Mr Don Hubbard, Spring Ridge, NSW.

SoilFutures Consulting Pty Ltd 2004. *South Wandobah Electromagnetic Induction Survey*- a report on soil salinity and irrigation potential. Client: Mr Don Hubbard, Spring Ridge, NSW.

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6.2 Appendix: Soil Landscape Descriptions (Source E-Spade, https://www.environment.nsw.gov.au/eSpade2Webapp 01/02/2022).

cfz	CRESSFIELD ROAD	Erosional

Landscape— Undulating rises to undulating low hills on the Wittingham Coal Measures in the central north of the Hunter Region. Slopes 3 - 10%, local relief 20 - 50 m (total relief 50 - 110 m), elevation 120 - 560 m. Extensively cleared open-woodland.

Soils— Very shallow to moderately deep (<25 - <100 cm), well to imperfectly drained Leptic and Bleached-Leptic Tenosols (Lithosols and Bleached Loams); moderately deep (50 - <100 cm), well-drained to imperfectly drained Red and Brown Chromosols (Red Podzolic Soils); moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red and Brown Sodosols (Solodic Soils and Soloths), Chromosols and Kurosols (Red and Brown Podzolic Soils); moderately deep (50 - <100 cm), poorly drained Grey Sodosols (Solodic Soils) and moderately deep to deep (50 - <150 cm), well to imperfectly drained Brown Dermosols (Brown Podzolic Soils and Non-calcic Brown Soils); moderately deep (50 - <100 cm), moderately well-drained Black Kandosols (Alluvial Soils); moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Brown and Black Vertosols (Brown Clays, Black Earths) and Brown and Black Dermosols (Prairie Soils); moderately deep to deep (50 - <150 cm), moderately well-drained Red Dermosols and Chromosols (Red Brown Earths); and moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red Dermosols and Chromosols (Red Brown Earths), Calcic Calcarosols (Terra Rossa Soils) and Red Vertosols (Red Clays).

Qualities and limitations— localised shallow soils, localised complex soils, localised poor moisture availability, localised productive arable land, widespread recharge zone, localised discharge zone, localised salinity hazard, localised gully erosion hazard, widespread sheet erosion hazard.

LOCATION AND SIGNIFICANCE

Widespread, undulating rises to undulating low hills on Permian sediments in the Central Hunter Lowlands extending from Muswellbrook in the south up to Murrurundi in the north. Type location is on Cressfield Road, north of Parkville (MGA grid reference 297000E, 6464000N, grid zone 56).

Variants

Cressfield Road variant a (cfza) - on the map has steeper slopes, generally 10 - 25%. Otherwise they have similar landscape features.

Included landscapes

Small areas of the Tinagroo (tgz) and Dunwell (dwz) soil landscapes have been included near to the boundary with these Triassic sediments. Small areas of Thompsons Creek (tcy) soil landscape have been included along drainage lines.

LANDSCAPE

Landform

Widespread, undulating rises to undulating low hills with slopes 3 - 10% (occasionally up to 15%). Slopes are typically long (1,000 m) to very long (2,500 m). Local relief 20 - 50 m (total relief 50 - 110 m) and elevation 250 - 470 m. Typical landform elements include broad rounded crests and simple sideslopes. Rock outcrop occasionally occurs as structural benches and low scarps (<0.5 m). Drainage patterns are tributary, both unidirectional and convergent.

Geology

Dominated by Wittingham Coal Measures, which consists of sandstone, conglomerate, siltstone, shale, tuff, coal and claystone. Also includes some Branxton Formation and Mulbring Sandstone from the Maitland Group, Wollombi Coal Measures and minor Greta Coal Measures. These sediments were deposited in environments ranging from marine to freshwater deltaic. Bedrock condition varies from moderately to strongly weathered. Depth to unweathered material was not determined.

Source: DMR (2002) and Geol Survey NSW and University of New England (1965).

Vegetation

Open-woodland, extensively cleared (approximately 90%) for grazing. Common tree species identified were Eucalyptus crebra (narrow-leaved ironbark), E. moluccana (grey box), E. melliodora (yellow box), and E. tereticornis (forest red gum). Other species include Angophora floribunda (rough-barked apple), E. albens (white box), Acacia verniciflua (varnish wattle), Acacia linifolia (flax wattle), Acacia implexa (hickory wattle), Acacia sp. (wattles) and Ficus sp. (fig). E. punctata (grey gum) occurs on sheltered sites and along drainage lines.

Typical grasses include Danthonia sp. (wallaby grasses), Dichanthium sericeum (Queensland blue grass), Stipa spp. (spear grasses), Stipa verticillata (slender bamboo grass), Cymbopogon refractus (barbed-wiregrass), Bothriochloa macra (red-leg grass), Chloris truncata (couch grass), Sporobolus creber (slender rats tail grass) and Eragrostis sp. (love grasses). Helichrysum apiculatum (yellow buttons) and Helichrysum semipapposum (clustered everlasting) are common and Juncus sp. (common rush) occurs in drainage lines. Foeniculum vulgare (wild fennel) and Verbena bonariensis (purple top verbena) commonly occur in disturbed areas and along roadsides.

Land use

Mostly used for grazing of beef cattle, horses and some sheep on native pastures. Also includes small areas of bentonite and coal mining and gravel quarries.

Land degradation

Moderate sheet, topsoil and occasionally subsoil erosion is widespread, especially in disturbed areas or with high stocking rates. Drainage lines and lower slopes exhibit past and present minor to moderate gully erosion.

Existing erosion

Land use	Non-concentrated flows	Concentrated flows	Wind
cultivation	high	very high	slight
grazing	slight	moderate	slight
urban	slight	moderate	slight

SOILS

Soil variation and distribution

Soils are often complex and controlled by landscape position and lithology. Very shallow to moderately deep (<25 - <100 cm), well to imperfectly drained Leptic and Bleached-Leptic Tenosols (Lithosols and Bleached Loams) and minor moderately deep (50 - <100 cm), well-drained to imperfectly drained Red and Brown Chromosols (Red Podzolic Soils) occur on crests and upper slopes. Dominating simple sideslopes are moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red and Brown Sodosols (Solodic Soils and Soloths), Chromosols and Kurosols (Red and Brown Podzolic Soils). Other minor soil types on simple slopes include moderately deep (50 - <100 cm), poorly drained Grey Sodosols (Solodic Soils) and moderately deep to deep (50 - <150 cm), well to imperfectly drained Brown Dermosols (Brown Podzolic Soils and Non-calcic Brown Soils). Moderately deep (50 - <100 cm), moderately well-drained Black Kandosols (Alluvial Soils) occur in drainage lines. Soil influenced by basaltic lithology include moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Brown and Black Vertosols (Brown Clays, Black Earths) and Brown and Black Dermosols (Prairie Soils). Soils with less basaltic influence, grade into moderately deep to deep (50 - <150 cm), moderately well-drained Red Dermosols and Chromosols (Red Brown Earths). On calcareous sediments, moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red Dermosols and Chromosols (Red Brown Earths), Calcic Calcarosols (Terra Rossa Soils) and Red Vertosols (Red Clays) can occur. Intergrades between these soils on calcareous sediments were observed during the survey and have been classified as No Suitable Group in the Great Soil Group classification system.

QUALITIES AND LIMITATIONS

Land capability

Urban Capability	B (C)	**Soil Regolith Class**	R3 (R4, R1)
Limitations to land use			
Grazing	slight to moderate	**Cultivation**	high to very high
Urban	slight to moderate		

Landscape

Steep slopes	not observed	**Mass movement hazard**	not observed
Rock outcrop	not observed	**Rockfall hazard**	not observed
Foundation hazard	not observed	**Woody weeds**	not observed
Complex terrain	not observed	**Productive arable land**	localised
Dieback	not observed		

Soils

Shallow soils	localised	**Complex soils**	localised
Poor moisture availability	localised	**Non-cohesive soils**	not observed

Hydrology

High run-on	not observed	**Poor drainage**	not observed
Permanently high watertables	not observed	**Permanent waterlogging**	not observed
Seasonal waterlogging	not observed	**Flood hazard**	not observed

Erosion

Wind erosion hazard	not observed	**Wave erosion hazard**	not observed
Gully erosion hazard	localised	**Sheet erosion hazard**	widespread
Streambank erosion hazard	not observed		

Salinity

Recharge zone	widespread	**Discharge zone**	localised
Salinity hazard	localised	**Seepage scalds**	not observed
Salt stores	high		

FACETS

cfz(1)— Crests and upper slopes

Soils

Very shallow to moderately deep (<25 - <100 cm), well to imperfectly drained Leptic and Bleached-Leptic Tenosol (Lithosols and Bleached Loams), with minor moderately deep (50 - <100 cm), well-drained to imperfectly drained Red and Brown Chromosols (Red Podzolic Soils).

Type Profile(s)

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 150

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 385

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 384

cfz(2)— Dominant soils on simple slopes

Soils

Moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red and Brown Sodosols (Solodic Soils and Soloths), Chromosols and Kurosols (Red and Brown Podzolic Soils).

Type Profile(s)

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 142

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 140

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 3

cfz(3)— Subdominant soils on simple slopes

Soils Moderately deep (50 - <100 cm), poorly drained Grey Sodosols (Solodic Soils) and moderately deep to deep (50 - <150), well to imperfectly drained Brown Dermosols (Brown Podzolic Soils and Non-calcic Brown Soils).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 153

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 139

Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 84

cfz(4)— Drainage lines

Soils Moderately deep (50 - <100 cm), moderately well-drained Black Kandosols (Alluvial Soils).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 8

cfz(5)— Slopes influenced by basalt and carbonaceous sediments

Soils Moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Brown and Black Vertosols (Brown Clays, Black Earths) and Brown and Black Dermosols (Prairie Soils). Soils with less basaltic influence, grade into moderately deep to deep (50 - <150 cm), moderately well-drained Red Dermosols and Chromosols (Red Brown Earths).

Type Profile(s) Soil landscapes of the Singleton 1:250 000 Sheet (1000216) profile 316

Soil landscapes of the Singleton 1:250 000 Sheet (1000216) profile 243

KAYUGA COAL SOIL SURVEY (1000889) profile 28

cfz(6)— Slopes influenced by calcareous sediments.

Soils Moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red Dermosols and Chromosols (Red Brown Earths), Calcic Calcarosols (Terra Rossa Soils) and Red Vertosols (Red Clays).

Type Profile(s) KAYUGA COAL SOIL SURVEY (1000889) profile 22

Ogilvies Hill Landcare (1000507) profile 12

REFERENCES

DMR 2002. New South Wales Statewide Geology coverage – 1:250 000 scale. Department of Mineral Resources, Sydney.

Geological Survey NSW and University of New England (1965), Tamworth 1:250 000 Geological Sheet Series Sheet SH 56-13, Department of Mines, Sydney.

NOTES

(1) This report describes reconnaissance soil landscape information mapped at 1:100,000 scale and does not negate the need for site assessment at a scale suitable to the land use or development under consideration.

(2) 'Not observed' means unlikely to be found. 'Localised' means observed to a level considered significant for land management. 'Widespread' means prevalent and significant over most of the landscape. 'None recorded' means no occurrence has been recorded. 'Not assessed' means no result has been recorded for this attribute and it may or may not be present in the soil landscape.

ilw	ILALA	Erosional (Residual)

Landscape— Undulating rises to rolling low hills on Carboniferous ignimbrites and volcanics in the central part of the Hunter Region. Slopes 5 - 20%, local relief 10 - 50 m, elevation 210 - 270 m. Completely cleared grassy woodland.

Soils— Shallow (25 - <50 cm), moderately well-drained Self-Mulching Black Vertosols (Black Earths); shallow to deep (25 - <150 cm), imperfectly drained Self-Mulching and Crusty Black Vertosols (Black Earths); and occasional Brown Sodosols (Solodic Soils).

Qualities and limitations— widespread shallow soils, widespread foundation hazard, localised productive arable land, localised recharge zone, localised discharge zone, localised gully erosion hazard, localised sheet erosion hazard, localised high run-on, localised poor drainage.

LOCATION AND SIGNIFICANCE

Broad cleared low rises in small disjunct areas in the Central Hunter Lowlands east of Scone and near Stanhope. Type location is rises southeast of Scone (MGA grid reference 300000E, 6449000N, grid zone 56).

Variants

None.

Included landscapes

Includes small areas of Gyarran (gyr) on steeper upper slopes, and Parkville (pvz) and Vacy (vaz) on drainage plains.

LANDSCAPE

Landform

Undulating rises to rolling low hills, with slopes 5 - 20%, local relief 10 - 50 m and elevation 210 - 270m. Crests are moderately broad (500 - 1,000 m) and residual, whilst sideslopes are rectilinear, moderately long to long (400 - 1,000 m) with slopes steepening to 20%, and lower slopes are short (50 - 100 m) and waning to linear open depressions. Rock outcrop and surface stones are absent. There is high run-on from upper slopes. Drainage is low-order and divergent.

Geology

Carboniferous ignimbrites and volcanics of the Kewell Creek Volcanics, consisting of rhyolitic ignimbrites, flows, agglomerate and resedimented rhyolitic siltstone, sandstone and conglomerate. Also occurs on the Newtown Formation's Hudsons Peak, Martins Creek and Johns Hill Ignimbrite Members), comprising rhyolitic and rhyodacitic ignimbrite and tuff; and the Mowbray Formation's Breckin and Lambs Valley Ignimbrite Members, consisting of rhyolitic and rhyodacitic ignimbrite, tuff and volcanic breccia.

Source: DMR (2002).

Vegetation

Completely creared, leaving a Rytidosperma bipartitum (wallaby grass) grassland. Original vegetation was probably a Eucalyptus crebra (narrow-leaved ironbark) - E. moluccana (grey box) - E. Blakelyi (Blakely's red gum) grassy woodland, with Corymbia maculata (spotted gum) and Paspalum dilatatum (paspalum) in the Stanhope area.

Source: McCauley (2006).

Land use

Completely cleared for grazing on native pastures.

Land degradation

Some localised gully erosion on lower slopes where drainage is concentrated.

Existing erosion

Land use	Non-concentrated flows	Concentrated flows	Wind
grazing	moderate	high	slight

SOILS

Soil variation and distribution

Dominated by shallow (25 - <50 cm), moderately well-drained Self-Mulching Black Vertosols (Black Earths) on crests, and shallow to deep (25 - <150 cm), imperfectly drained Self-Mulching and Crusty Black Vertosols (Black Earths) and occasional Brown Sodosols (Solodic Soils) on lower slopes.

QUALITIES AND LIMITATIONS

Land capability

Urban Capability	C	**Soil Regolith Class**	R2 (R3)

Limitations to land use

Grazing	low	**Cultivation**	moderate
Urban	moderate		

Landscape

Steep slopes	not observed	**Mass movement hazard**	not observed
Rock outcrop	not observed	**Rockfall hazard**	not observed
Foundation hazard	widespread	**Woody weeds**	not observed
Complex terrain	not observed	**Productive arable land**	localised
Dieback	not observed		

Soils

Shallow soils	widespread	**Complex soils**	not observed
Poor moisture availability	not observed	**Non-cohesive soils**	not observed

Hydrology

High run-on	localised	**Poor drainage**	localised
Permanently high watertables	not observed	**Permanent waterlogging**	not observed
Seasonal waterlogging	not observed	**Flood hazard**	not observed

Erosion

Wind erosion hazard	not observed	**Wave erosion hazard**	not observed
Gully erosion hazard	localised	**Sheet erosion hazard**	localised
Streambank erosion hazard	not observed		

Salinity

Recharge zone	localised	**Discharge zone**	localised
Salinity hazard	not observed	**Seepage scalds**	not assessed
Salt stores	not assessed		

FACETS

ilw(1)— Crests

Soils	Shallow (25 - <50 cm), moderately well-drained Self-Mulching Black Vertosols (Black Earths).
Type Profile(s)	Hunter Soil and Land Resources (1005268) profile 275

ilw(2)— Lower slopes

Soils	Shallow to deep (25 - <150 cm), imperfectly drained Self-Mulching and Crusty Black Vertosols (Black Earths) and occasional Brown Sodosols (Solodic Soils).
Type Profile(s)	Hunter Soil and Land Resources (1005268) profile 265

REFERENCES

DMR 2002. New South Wales Statewide Geology coverage - 1:250,000 scale. Department of Mineral Resources, Sydney.

McCauley, A. (2006). Vegetation Survey and Mapping of the Hunter, Central and Lower North Coast Region of NSW. A report prepared for the Hunter-Central Rivers Catchment Management Authority by the HCCREMS team at the Environment Division of Hunter Councils.

NOTES

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pvz	PARKVILLE	Transferral

Landscape— Gently undulating plain to undulating rises comprised of footslopes on alluvium and colluvium derived from adjacent Carboniferous conglomerates, sandstones and volcanics in the Parkville Valley in the central north of the Hunter Region. Slopes 2 - 7%, local relief <20 m, elevation 230 - 340 m. Extensively cleared open-woodland.

Soils— Deep (100 - <150 cm), slowly permeable and poorly drained Grey Dermosols (Grey Podzolic Soils); deep (100 - <150 cm), poorly drained Red Sodosols (Soloths); deep (100 - <150 cm), imperfectly drained Grey Dermosols (Alluvial Soils); and deep (100 - <150 cm), moderately well-drained Brown Sodosols (Solodic Soils).

Qualities and limitations— localised productive arable land, localised woody weeds, localised recharge zone, localised discharge zone, localised gully erosion hazard, widespread sheet erosion hazard, widespread high run-on, localised poor drainage, localised flood hazard.

LOCATION AND SIGNIFICANCE

Extends in all directions from the central Lake Glenbawn in the Hunter Valley on alluvium and colluvium. Type location is on the New England Highway, just north of Parkville (MGA grid reference 298000E, 6461000N, grid zone 56).

Variants

None.

Included landscapes

Small areas of Miranee Road (mrw) soil landscape may have been included on upper slopes.

LANDSCAPE

Landform

Very long footslopes on alluvium and colluvium. Slopes are typically 2 - 7% and >2000 m long. Local relief <20 m, elevation 230 - 340 m and total relief 40 - 70 m. Drainage lines are widely spaced, unidirectional, occasionally culminating in alluvial fans at the base of the slope.

Geology

Alluvium and colluvium derived from the Carboniferous Rossmore Formation and the Ayr Conglomerate (Cmr, Cma) - polymictic and tilloid conglomerates, lithic sandstones, acid volcanics and varves.

Source: Geological Survey NSW and University of New England (1965).

Vegetation

Open-woodland and possibly grassland, 95% cleared for agriculture. Remnant species include Eucalyptus moluccana (grey box), E. tereticornis (forest red gum), E. punctata (grey gum), E. creber (narrow-leaved ironbark), E. melliodora (yellow box) and occasional Notelaea sp. (native olive). Eucalyptus citriodora (lemon-scented gum) and Grevillea robusta (silky oak) have been planted along roadsides and near houses.

Grasses identified in the herb layer include Bothriochloa macra (red grass), Dichanthium sericeum (Queensland blue grass), Sporobolus creber (slender rat's tail grass) and Chloris ventricosa (tall windmill grass). Other species include Wahlenbergia sp. (bluebell) and Geranium sp. (cranesbill). In disturbed areas, introduced weeds such as Foeniculum vulgare (wild fennel) and Verbena bonariensis (purple top) are common.

Land use

Mostly used for grazing of beef cattle and horses on native and improved pastures. Historically, this area was extensively used for cropping, which resulted in widespread erosion. Today, cropping (such as for hay production) is a minor use. Includes intensive animal industries such as a piggery and chicken sheds, and the small township of Parkville. Very minor occurrences of the soil landscape intersect Mount Royal National and Barrington Tops National Park.

Land degradation

Historically, sheet and gully erosion were widespread, but rehabilitation has since occurred. Today, minor to moderate sheet erosion is widespread, occasionally resulting in the total removal of topsoil. Minor rill erosion is evident on exposed batters. Minor gully erosion occurs in some drainage lines.

Existing erosion

Land use	Non-concentrated flows	Concentrated flows	Wind
cultivation	high	very high	slight
grazing natural vegetation	moderate	high	slight
urban	moderate	high	slight

SOILS

Soil variation and distribution

Deep (100 - <150 cm), slowly permeable and poorly drained Grey Dermosols (Grey Podzolic Soils); deep (100 - <150 cm), poorly drained Red Sodosols (Soloths); deep (100 - <150 cm), imperfectly drained Grey Dermosols (Alluvial Soils); and deep (100 - <150 cm), moderately well-drained Brown Sodosols (Solodic Soils) are dominant. Individual soil types are diverse and vary over tens to hundreds of meters.

QUALITIES AND LIMITATIONS

Land capability

Urban Capability	C	**Soil Regolith Class**	R4 (R3)

Limitations to land use

Grazing	slight to moderate	**Cultivation**	slight to very high
Urban	moderate		

Landscape

Steep slopes	not observed	**Mass movement hazard**	not observed
Rock outcrop	not observed	**Rockfall hazard**	not observed
Foundation hazard	not observed	**Woody weeds**	localised
Complex terrain	not observed	**Productive arable land**	localised
Dieback	not observed		

Soils

Shallow soils	not observed	**Complex soils**	not observed
Poor moisture availability	not observed	**Non-cohesive soils**	not observed

Hydrology

High run-on	widespread	**Poor drainage**	localised
Permanently high watertables	not observed	**Permanent waterlogging**	not observed
Seasonal waterlogging	not observed	**Flood hazard**	localised

Erosion

Wind erosion hazard	not observed	**Wave erosion hazard**	not observed
Gully erosion hazard	localised	**Sheet erosion hazard**	widespread
Streambank erosion hazard	not observed		

Salinity

Recharge zone	localised	**Discharge zone**	localised
Salinity hazard	not observed	**Seepage scalds**	not observed
Salt stores	moderate		

FACETS

pvz(1)— Simple slopes

Soils Deep (100 - <150 cm), slowly permeable and poorly drained Grey Dermosols (Grey Podzolic Soils).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 168

pvz(2)— Simple slopes

Soils Deep (100 - <150 cm), poorly drained Red Sodosols (Soloths).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 171

pvz(3)— Open depressions

Soils Deep (100 - <150 cm), imperfectly drained Grey Dermosols (Alluvial Soils).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 169

pvz(4)— Simple slopes

Soils Deep (100 - <150 cm), moderately well-drained Brown Sodosols (Solodic Soils).

Type Profile(s) Soil Landscapes of the Murrurundi 1:100 000 Sheet (1000885) profile 167

REFERENCES

Geological Survey NSW and University of New England (1965), Tamworth 1:250 000 Geological Sheet Series Sheet SH 56-13, Department of Mines, Sydney.

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sgw	SINGLETON	Alluvial

Landscape— Level plain to gently undulating plain on Quaternary alluvium in the central part of the Hunter Region. Slopes <3%, local relief <10 m, elevation 10 - 200 m. Extensively cleared woodland, dominated by improved pastures.

Soils— Deep (100 - <150 cm), moderately well-drained Brown and Black Dermosols (Prairie Soils and Chernozems) and deep (100 - <150 cm), well-drained Red and Brown Kandosols (Red Earths and Brown Earths); deep (100 - <150 cm), imperfectly drained Haplic Epipedal Black Vertosols (Black Earths); deep (100 - <150 cm), well-drained Bleached Red Chromosols (Red Podzolic Soils and Red Soloths); and deep (100 - <150 cm), imperfectly to well-drained Stratic Rudosols (Alluvial Soils).

Qualities and limitations— localised complex soils, localised non-cohesive soils, widespread foundation hazard, widespread productive arable land, widespread recharge zone, localised wind erosion hazard, localised gully erosion hazard, localised sheet erosion hazard, widespread streambank erosion hazard, localised high run-on, localised poor drainage, localised permanently high watertables, localised permanent waterlogging, localised seasonal waterlogging, widespread flood hazard.

LOCATION AND SIGNIFICANCE

Mid section of the Hunter River alluvial plain, roughly comprising the section between Scone and Maitland. Includes the lower alluvial plains of Dart Brook, Kingdon Ponds and Parsons Gully in the Scone area. Type location is Hunter River alluvial plain, around the Singleton area (MGA grid reference 329352E, 6396801N, grid zone 56).

Variants

Small areas of Kingdon Ponds (kpw), Thompsons Creek (tcy) and Rothbury (ron) may occur where these alluvial soil landscapes join Singleton (sgw).

Included landscapes

None.

LANDSCAPE

Landform

Alluvial plain of variable width. Generally 200 - 1500 m wide, the plain is up to 4000 m wide in the Singleton area. Drainage is integrated and unidirectional. The channel is slowly migrating, with prominent meandering and relict ox-bow and chute cut-off channels occurring throughout. Both high and low terraces are present. Slopes 0 -3%, local relief <10 m and elevation 10 - 200 m.

Geology

Quaternary alluvium valley deposits consisting mostly of clays and silts with minor sands and gravels.

Source: DMR (2002) and Colquhoun GP et al (2015).

Vegetation

Extensively cleared woodland. Scattered trees include Eucalyptus tereticornis (forest red gum), E. melliodora (yellow box) and Angophora floribunda (rough-barked apple). Casuarina cunninghamiana (river oak) and C. glauca (swamp oak) occur along streambanks.

Source: Kovac and Lawrie (1991).

Land use

Extensively used for agriculture including vegetable and lucerne production, viticulture, dairying and other grazing on improved pastures. Some urban development, including much of Singleton and parts of Muswellbrook.

Land degradation

Minor land degradation apart from some streambank erosion. Gully erosion has been observed within the prominent terrace surface [facet sgw (5)].

Existing erosion

Land use	Non-concentrated flows	Concentrated flows	Wind
cropping	slight	moderate	slight
improved pasture	slight	moderate	slight
orchard/vineyard	slight	moderate	slight
urban	slight	moderate	slight

SOILS

Soil variation and distribution

Soil distribution is variable across this landscape due to differing episodes of sedimentation. Generally deep (100 - <150 cm), moderately well-drained Brown and Black Dermosols (Prairie Soils and Chernozems) and deep (100 - <150 cm), well-drained Red and Brown Kandosols (Red Earths and Brown Earths) throughout the alluvial plain. Deep (100 - <150 cm), imperfectly drained Haplic Epipedal Black Vertosols (Black Earths) occur on terraces and the alluvial plain. Deep (100 - <150 cm), well-drained Bleached Red Chromosols (Red Podzolic Soils and Red Soloths) occur on prominent terrace surface between Scone and Muswellbrook. Deep (100 - <150 cm), imperfectly to well-drained Stratic Rudosols (Alluvial Soils) occur on more recent sediment.

QUALITIES AND LIMITATIONS

Land capability

Urban Capability	B (D)	**Soil Regolith Class**	R1 (R3)

Limitations to land use

Grazing	slight to moderate	**Cultivation**	slight to high
Urban	slight		

Landscape

Steep slopes	not observed	**Mass movement hazard**	not observed
Rock outcrop	not observed	**Rockfall hazard**	not observed
Foundation hazard	widespread	**Woody weeds**	not observed
Complex terrain	not observed	**Productive arable land**	widespread
Dieback	not observed		

Soils

Shallow soils	not observed	**Complex soils**	localised
Poor moisture availability	not observed	**Non-cohesive soils**	localised

Hydrology

High run-on	localised	**Poor drainage**	localised
Permanently high watertables	localised	**Permanent waterlogging**	localised
Seasonal waterlogging	localised	**Flood hazard**	widespread

Erosion

Wind erosion hazard	localised	**Wave erosion hazard**	not observed
Gully erosion hazard	localised	**Sheet erosion hazard**	localised
Streambank erosion hazard	widespread		

Salinity

Recharge zone	widespread	**Discharge zone**	not observed
Salinity hazard	not observed	**Seepage scalds**	not observed
Salt stores	low		

FACETS

sgw(1)— Cracking clays of alluvial plain and terraces

Soils Deep (100 - <150 cm), imperfectly drained Haplic Epipedal Black Vertosols (Black Earths).

Type Profile(s) UPPER HUNTER VALLEY SOIL SURVEY (1000993) profile 1

sgw(2)— Structured dark earths of alluvial plains and terraces

Soils Deep (100 - <150 cm), moderately well-drained Brown and Black Dermosols (Prairie Soils, Chernozems).

Type Profile(s) Hunter Soil and Land Resources (1005268) profile 82

sgw(3)— Brown and red earths

Soils Deep (100 - <150 cm), well-drained Haplic Mesotrophic Red and Brown Kandosols (Red Earths and Brown Earths).

Type Profile(s) KAYUGA COAL SOIL SURVEY (1000889) profile 10

sgw(4)— Recent sediments of channels

Soils Deep (100 - <150 cm), imperfectly to well-drained Stratic Rudosols (Alluvial Soils).

Type Profile(s) Soil landscapes of the Singleton 1:250 000 Sheet (1000216) profile 258

sgw(5)— Prominent terrace

Soils Deep (100 - <150 cm), well-drained Bleached Red Chromosols (Red Podzolic Soils and Red Soloths).

Type Profile(s) KAYUGA COAL SOIL SURVEY (1000889) profile 1

REFERENCES

Colquhoun G.P., Phillips, G., Hughes, K.S, Deyssing L., Flitzherber, J.A., & Troedon, A.L. 2015. New South Wales Zone 56 Seamless Geology dataset, version 1 [Digital Dataset]. Geological Survey of New South Wales, Maitland.

DMR (2002) New South Wales statewide geology coverage - 1:250 000 scale. Department of Mineral Resources, Sydney.

Kovac, M and Lawrie J.W. (1991) Soil Landscapes of the Singleton 1:250,000 sheet. Soil Conservation Service of NSW, Sydney.

NOTES

(1) This report describes reconnaissance soil landscape information mapped at 1:100,000 scale and does not negate the need for site assessment at a scale suitable to the land use or development under consideration.

(2) 'Not observed' means unlikely to be found. 'Localised' means observed to a level considered significant for land management. 'Widespread' means prevalent and significant over most of the landscape. 'None recorded' means no occurrence has been recorded. 'Not assessed' means no result has been recorded for this attribute and it may or may not be present in the soil landscape.

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