REFERENCES

Acworth RI 1999, 'Investigation of dryland salinity using the electrical image method', *Australian Journal of Soil Research*, vol. 37, pp. 623–636.

Aldrick JM, Hook RA, van de Graaf RHM, Nicholson BM, O'Beirne D & Schoknecht NR 1984, *A study of the land in the catchment of the Gippsland Lakes*, Department of Conservation, Forest and Lands, Victoria.

Allen D & Merrick NP 2003, 'A floating electrode array for continuous geoelectrical imaging', paper presented to the ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Anderson-Mayes AM 1999, Enhancing interpretation of multivariate airborne geophysical data for dryland salinity studies, PhD thesis, University of Queensland.

Anon 2001, 'Electromagnetic Techniques for Agricultural Resource Management', unpublished paper presented on 3–5 July, Yanco, NSW Agriculture, CSIRO Land and Water, Canberra.

Annan AP 2003, *Ground Penetrating Radar principles, procedures, and applications*, Sensors and Software Inc, Mississauga, Ontario, Canada.

Auken E, Jorgensen F & Sørensen KI 2003, 'Large-scale TEM investigation for groundwater', *Exploration Geophysics*, vol. 34, pp. 188–194.

Auken E & Christiansen AV 2004, 'Layered and laterally constrained 2D inversion of resistivity data', *Geophysics*, vol. 69, pp. 752–761.

Australian National Audit Office (ANAO) 2003, *Management of scientific research and development projects in Commonwealth agencies: Better practice guide for senior management*, Commonwealth of Australia, Canberra.

Baddeley A, Fifield K & Minty B 2003, 'Scientific review of sodium-24 salinity mapping technology', Geoscience Australia consultancy report 2003/04, 22pp.

Baker P& Evans WR 2002, *Mid-Macquarie Salinity Prioritisation and Strategic Direction Project*, Bureau of Rural Sciences, Canberra.

Bell D 2002, *Measuring soil salinity using airborne multi-frequency polarimetric synthetic aperture radar and its application to the north Australian tropical coastal wetlands*, PhD thesis, Faculty of Science Information Technology and Education, Northern Territory University, Darwin, Australia.

Bennetts DA, Webb JA, Stone DJM & Hill DM 2005, 'Insights into dryland groundwater salinisation, south-eastern Australia, using hydrochemical and isotopic evidence', *Journal of Hydrology* (in press).

Bozon J & Matters J 1989, *Spotting soil salting: a Victorian field guide to salt indicator plants / text and diagrams*, Department of Conservation, Forests and Lands, Land Protection Division, Melbourne.

Bradd JM, Milne-Horne WA & Gates G 1997, 'Overview of factors leading to

dryland salinity and its potential hazard in New South Wales, Australia', *Hydrogeology Journal*, vol. 5, pp. 51–67.

Brady NC & Weil RR 2002, *The Nature and Properties of Soils*, 13th edn Prentice Hall, New Jersey.

Bride TF 1898, Letters from Victorian Pioneers, first printed and published for the Trustees of the Public Library, Museums, and the National Gallery of Victoria by Robert S Brain, Government Printer, Melbourne, new edition by William Heineman Ltd (1969), Port Melbourne.

Broadfoot K, Morris M, Stevens D & Heuperman A 2002, 'The role of EM38 in land and water management planning on the Tragowel Plains in Northern Victoria', *Exploration Geophysics*, vol. 33, pp. 90–94.

Bui EN & Henderson BL 2003, 'Vegetation indicators of salinity in Northern Queensland', *Australian Ecology*, vol. 28, pp. 539–552.

Butler KE, Russell RD, Kepic AW & Maxwell M 1996, 'Measurement of the seismoelectric response from a shallow boundary', *Geophysics*, vol. 61, pp. 1769–1778.

Carlson CA, Phillips FM, Elmore D & Bentley HW 1990, 'Chlorine-36 tracing of salinity sources in the dry valleys of Victoria land, Antarctica', *Geochimica et Cosmochimica Acta*, vol. 54, no. 2, pp. 311–318.

Chaplot V, Walter C, Curmi P & Hollier-Larousse A 2001, 'Mapping field-scale hydromorphic horizons using Radio-MT electrical resistivity', *Geoderma*, vol. 102, pp. 61–74.

Cheng X & Reid M 2001, *Groundwater monitoring summaries for the Sheep Pen Creek – Kialla East area; and Warrenbayne – Boho area*, Centre for Land Protection Research, Victorian Department of Natural Resources and Environment, Melbourne (brochures).

Chhabra R 1996, *Soil Salinity and Water Quality*, A.A. Balkema/Rotterdam/ Brookfield, New York, 284 pp.

Christensen NB & Sørensen K 2001, 'Pulled array continuous electrical sounding with an additional inductive source: an experimental design study', *Geophysical Prospecting*, vol. 49, pp. 241–254.

Christensen A, 2004, *Calibration of Honeysuckle Creek conductivity - depth imaging*, Geological Survey of Victoria unpublished report UR2004/1.

Christiansen AV & Christensen NB 2003, 'A quantitative appraisal of airborne and ground-based transient electromagnetic (TEM) measurements in Denmark', *Geophysics*, vol. 68, pp. 523–534.

Clarke CJ, George RJ, Argent RM, Hatton TJ & Bell RW 2001, 'A simple groundwater computer program for dryland salinity management in Australia', in K-P Seiler & S Wohnlich (eds), *Proceedings of New Approaches to Characterising Groundwater Flow*, 31st Intern, Congress of Intern. Assoc. Hydrogeologists, Munich, Germany, pp 279–282, Balkema, Rotterdam.

Commonwealth of Australia (CoA) 1996, *State of the Environment Australia, 1966*, CSIRO Publishing.

Cook SE, Corner RJ, Groves PR & Grealish GJ 1996, 'Use of airborne gamma radiometric data for soil mapping', *Australian Journal of Soil Research*, vol. 34, pp. 193–194.

Coram JE (ed.) 1998, *National Classification of Catchments for Land and River Salinity Control*, report for the RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program, Rural Industries Research and Development Corporation Publication No. 98/78, Canberra.

Coram J, Bond W, Dawes W & Stauffacher M 2000a, *Overview report: Groundwater and farming systems water balance modelling*, report to National Land & Water Resources Audit, CSIRO Land & Water, Canberra.

Coram JE, Dyson PR, Houlder P& Evans WR 2000b, *Australian Groundwater Flow Systems contributing to Dryland Salinity*, report by the Bureau of Rural Sciences for the Dryland Salinity Theme of the National Land & Water Resources Audit, Canberra.

Coram JE, Dyson PR & Evans WR 2001, *An Evaluation Framework for Dryland Salinity*, report prepared for the National Land & Water Resources Audit Dryland Salinity Project, Bureau of Rural Sciences, Canberra. Available at <http://audit.ea.gov.au/anra/land/docs/national/EvaluationFramework.pdf>

Council of Australian Governments (CoAG) 2000, *Our Vital Resources: A National Action Plan for Salinity and Water Quality*, Council of Australian Governments. Available at <www.napswq.gov.au/publications/vital-resources.html>.

Cresswell RG, Dent DL, Jones GL & Galloway DS 2004, 'Three-dimensional mapping of salt stores in the southeast Murray-Darling Basin, Australia. 1. Steps in calibration', *Soil Use and Management*, vol. 20, pp. 1–11.

Dehaan R & Taylor GR 2002, 'Field-derived spectra of salinized soils and vegetation as indicators of irrigation-induced soil salinization', *Remote Sensing of Environment*, vol. 80, pp. 406–417.

Dehaan R & Taylor GR 2003, 'Image-derived spectral endmembers as indicators of salinisation', *Intern. Journal of Remote Sensing*, vol. 24, no. 4, pp. 775–794.

Dent D 2003, *Five steps to tackling salinity*, Billabong Creek case study, Murrumbidgee catchment, New South Wales, Science for Decision Makers, Bureau of Rural Sciences, Canberra.

Deszcz-Pan M, Fitterman D & Labson V 1998, 'Reduction of inversion errors in helicopter EM data using auxiliary information', *Exploration Geophysics, Australian Society for Exploration Geophysics*, vol. 29, pp. 142–146.

Dickson BL & Scott KM 1998, 'Recognition of aeolian soils of the Blayney district, NSW: implications for mineral exploration', *Journal for Geochemical Exploration*, vol. 63, pp. 237–251.

Dickson BL & Taylor GM 2003, 'Quietening the noise: An evaluation of noise reduction methods applied to aerial gamma-ray survey data', *Exploration Geophysics*, vol. 34, pp. 97–102.

Ellis RG 1998, 'Inversion of airborne electromagnetic data', *Exploration Geophysics*, vol. 29, pp. 121–127.

English P, Richardson P, Glover M, Cresswell H & Gallant J 2004, *Interpreting airborne geophysics as an adjunct to hydrogeological investigations for salinity management: Honeysuckle Creek Catchment, Victoria*, CSIRO Land and Water Technical Report No 18/04. Available at <www.clw.csiro.au/publications/technical2004/>.

Emerson DW & Yang YP 1997, 'Effects of water salinity and saturation on the electrical resistivity of clays', *Preview*, vol. 68, pp. 19–24.

Fairbairn L 2002, 'Using salinity hazard mapping makes sense – Evaluation of EM31 system in assessing salinity hazard in south-west Victoria, saltland opportunities: profit for our communities and the environment', in *8th PUR$L National Conference & Workshop 2002 Conference Proceedings*, Promaco Conventions Pty Ltd, Canning Bridge, WA. Available at <www.promaco.com.au/conference/2002/pursl/>.

Ferdowsian R 1994, Technical Report, Department of Agriculture, Albany, Western Australia.

Ferdowsian R, Pannell DJ, McCarron C, Ryder AT & Crossing L 2001, 'Explaining groundwater hydrographs: Separating atypical rainfall events from time trends', *Australian Journal of Soil Research*, vol. 39, pp. 861–876.

Fitzpatrick RW, Merry RH, Cox JW, Rengasamy P & Davies PJ 2003a, 'Assessment of physico-chemical changes in dryland saline soils when drained or disturbed for developing management options', CSIRO Land & Water Technical Report 2/03. Available at <www.clw.csiro.au/publications/technical2003/tr2-03.pdf>

Fitzpatrick RW, Thomas M, Davies PJ &Williams BG 2003b, 'Dry saline land: an investigation using ground-based geophysics, soil survey and spatial methods near Jamestown, South Australia', CSIRO Land & Water Technical Report 55/03. Available from <www.clw.csiro.au/publications/technical2003/>.

Geonics 1998, *Applications of electromagnetic methods to soil salinity – Selected papers and examples*, Geonics Limited, Mississauga, Toronto, Canada.

George RJ, Bennett DL, Wallace K & Cochrane D 1996, 'Hydrologic systems to manage salinity at the Toolibin and Towerrinning lakes', in *Proceedings of the 4th National Workshop on the Productive Use and Rehabilitation of Saline Lands*, Albany, WA, March 1996, pp. 173–180.

George RJ, Beasley R, Gordon I, Heislers D, Speed R, Brodie R, McConnell C & Woodgate P 1998, *National Report: Evaluation of Airborne Geophysics for Catchment Management*, National Airborne Geophysics Project, The Department of Agriculture, Fisheries and Forestry and the National Dryland Salinity Program, Canberra, 81 pp. Available from <www.ndsp.gov.au/NAGP/nagp_nr.htm>.

George RJ, Speed RJ, Clarke CJ & Bennett DL 1999, 'Electromagnetics improves groundwater salinity assessments in shallow sedimentary and some weathered-basement aquifers in Western Australia', in C Barber, B Humphries and J Dixon (eds), *International Conference on Diffuse Pollution*, Perth, WA, May 1999.

George RJ, Campbell C, Woodgate P, Farrell SJ & Taylor P 2000, *Complementary data and cost benefit analysis of utilising airborne geophysics for salinity management purposes*, Project no. RM17, Land Water Research and Development Corporation, Canberra. Available from <www.lwa.gov.au/downloads/final_reports/RM17.pdf>.

George RJ & Woodgate P 2002, 'Critical factors affecting adoption of airborne geophysics for management of dryland salinity', *Exploration Geophysics*, vol. 33, pp. 84–89.

George R, Lawrie K & Woodgate P 2003, 'Convince me all your bloody data and maps are going to help me manage salinity any better', in *Geoscience frameworks and their application to salinity assessment and management: 2003 PUR$L conference*, 9th PUR$L National Conference, Yeppoon, Qld, QNRME04090.

Gilfedder M & Walker G 2001, 'A review of dryland salinity risk assessment methods', *Natural Resource Management*, vol. 4, no. 1, pp. 2–9.

Gordon I, Pearce B, Heiner I & Biggs A 2002, *Salinity hazard mapping in Queensland*, Department of Natural Resources and Mines, NRM Facts, Land Services, QNRM00270.

Grasty RL & Minty BRS 1995, 'The standardisation of airborne Gamma-ray surveys in Australia', AGSO Record 1995/60, AGSO, Canberra.

Green A 1998, 'Use of multivariate statistical techniques for the analysis and display of AEM data: AEM 98', *Exploration Geophysics*, vol. 29, pp. 77–82.

Green A & Lane R 2003, 'Estimating noise levels in AEM data', paper presented to ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Gunn P (ed.) 1997, 'Airborne magnetic and radiometric surveys', *AGSO Journal*, vol. 17, no. 2.

Hancock N & Raine S 2001, 'Advances in instrumentation', *Computers and Electronics in Agriculture*, vol. 31, pp. 211–212.

Howari FM 2003, 'The use of remote sensing data to extract information from agricultural land with emphasis on soil salinity', *Australian Journal of Soil Research*, vol. 41, pp. 1243–1253.

International Atomic Energy Agency (IAEA) 1991, 'Airborne Gamma-ray Spectrometer Surveying', Technical Series 323, IAEA.

Isbell RF 1996, *The Australian Soil Classification Revised Edition*, CSIRO Publication, Collingwood, Victoria.

Job JO, Gonzalez Barrios JL, Rivera Gonzalez M 1998, 'Effect of soil moisture on the determination of soil salinity using electromagnetic induction', *European Journal of Environmental and Engineering Geophysics*, vol. 3, pp. 187–199.

Lane R 2002, 'Ground and airborne electromagnetic methods', in E Papp (ed.), *Geophysical and remote sensing methods for regolith exploration*, CRC LEME Open File Report 144, Canberra.

Lane R, Brodie R & Fitzpatrick A 2003, *Constrained inversion of AEM data from St George, Queensland, Australia*, unpublished CRC LEME report, Canberra.

Lawrie K, Munday T, Dent D, Gibson D, Brodie R, Wilford J, Reilly N, Chan R & Baker P 2000, 'A geological systems approach to understanding the processes involved in land and water salinisation', *AGSO Research Newsletter*, May 2000, pp. 13–32.

Lawrie K, Pain C, Gibson D, Munday T, Wilford J & Jones G 2002, 'Regolith - a missing link in mapping salinity processes and predicting dryland salinity hazards', in N Phillips & K Ely (eds), *Victoria Undercover*, CRC LEME, pp. 167–173.

Lawrie K, Gray M, Fitzpatrick A, Wilkes P, & Lane R 2003, 'Reducing the acquisition costs of airborne electromagnetics surveys for salinity and groundwater mapping', *Preview*, vol. 106, pp. 31–38.

Lesch SM, Rhoades JD, Lund LJ & Corwin DL 1992, 'Mapping soil salinity using calibrated electronic measurements', *Soil Science Society of America Journal*, vol. 56, pp. 540–548.

Lide D (ed.) 2004, *CRC Handbook of Chemistry and Physics*, 85th edn, CRC Press, Boca Raton, Florida.

Lillesand TM & Keifer RW 1979, *Remote Sensing and Image Interpretation*, John Wiley and Sons, New York.

Macnae JC, Smith R, Polzer BD, Lamontagne Y & Klinkert PS 1991, 'Conductivity-depth imaging of airborne electromagnetic step-response data', *Geophysics*, vol. 56, pp. 102–104.

Macnae J 2003, 'Improving the accuracy of shallow depth determinations in AEM sounding', paper presented to the ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Martin L & Metcalfe J 1998, *Assessing the causes, impacts costs and management of dryland salinity*, LWRRDC Occasional Paper 20/98, Land & Water Resources R&D Corporation, Canberra.

Matters J & Bozon J 1989, *Spotting soil salting*, Victorian Department of Conservation, Forests and Lands, Melbourne, Victoria. Available from <www.dse.vic.gov.au/>.

McNeill JD 1980a, 'Electrical conductivity of soils and rocks', Technical Note TN5, Geonics Limited, Canada.

McNeill JD 1980b, 'Electromagnetic terrain conductivity measurement at low induction numbers', Technical Note TN6, Geonics Limited, Canada.

McNeill JD 1980c, 'EM34-3 survey interpretation techniques', Technical Note TN8, Geonics Limited, Canada.

McNeill JD 1980d, 'Use of EM-31 in-phase information', Technical Note TN11, Geonics Limited, Canada.

McNeill JD 1985, 'EM34-3 measurements at two intercoil spacings to reduce sensitivity to near-surface material', Technical Note TN19, Geonics Limited, Canada.

McNeill JD 1986, 'Geonics EM39 borehole conductivity meter – Theory of operation', Technical Note TN20, Geonics Limited, Canada.

McNeill SJ, Caccetta, PA, Campbell NA, Pairman D & Belliss SE 1999, 'Systematic spatial processing of a temporal Radarsat data set', in *Proceedings Image and Vision Computing '99*, Christchurch, New Zealand.

Metternicht GI & Zinck J2003, 'Remote sensing of soil salinity: potentials and constraints', *Remote Sensing of Environment*, vol. 85, pp. 1–20.

Møller I, Jacobsen BH & Christensen NB 2001, 'Rapid inversion of 2-D geoelectrical data by multichannel deconvolution', *Geophysics*, vol. 66, pp. 800–808.

Møller I & Sørenson KI 1998, 'A new approach for fast 2-D electrical mapping of near-surface structures', *European Journal of Environmental and Engineering Geophysics*, vol. 2, pp. 247–261.

Murray-Darling Basin Commission (MDBC) 1987, *Salinity and Drainage Strategy: Background Paper*, Background Paper 87/1, Murray-Darling Basin Ministerial Council, Canberra.

—— 1988, *Draft Salinity and Drainage Strategy: Discussion Paper No. 1*, Murray-Darling Basin Ministerial Council, Canberra.

Murray-Darling Basin Ministerial Council (MDBMC) 1999a, *Salinity and Drainage Strategy: Ten years on, 1999*, Murray-Darling Basin Commission, Canberra. Available at <www.mdbc.gov.au/naturalresources/policies_strategies/pdf/Strategy.pdf>

—— 1999b, *The Salinity Audit of the Murray-Darling Basin: A 100-year perspective*, Murray-Darling Ministerial Council, Canberra. Available at <www.mdbc.gov.au/naturalresources/policies_strategies/pdf/Final_Salt_Audit.pdf>

—— 2001, *Basin Salinity Management Strategy 2001-2015*, Murray-Darling Basin Ministerial Council, Canberra.

National Airborne Geophysics Project (NAGP) 1998, *Evaluation of airborne geophysics for catchment management*, AFFA and NDSP, Canberra. Available at <www.ndsp.gov.au/NAGP/nagp_nr.htm>

National Dryland Salinity Program (NDSP) 2003, *Practical Index of Salinity Models (PRISM)*, CD ROM, Land & Water Australia, Canberra. Available at <www.lwa.gov.au/ndsp/prism/>.

National Health and Medical Research Council (NH&MRC) 2004, *Australian Drinking Water Guidelines 2004*, National Health and Medical Research & Natural Resource Management Ministerial Councils. Available at <www.nhmrc.gov.au/publications/pdf/awgfull.pdf>.

National Land & Water Resources Audit (NLWRA) 2001, *Australian Dryland Salinity Assessment 2000: Extent, Impacts, Processes, Monitoring and Management options*, NLWRA, Canberra.

Noborio 2001, 'Measurement of soil water content and electrical conductivity by time domain reflectometry: a review', *Computers in Electronics and Agriculture*, vol. 21, pp. 213–237.

Norman C 1990, *Training Manual on the Use of the EM38 for Soil Salinity Appraisal*, Report No. 181. Department of Agriculture and Rural Affairs, Victoria.

Norman CP & Heslop K 1990, *Soil salinity of the Boort/West of Loddon salinity management area*, Research Report No. 125, Department of Agriculture, Victoria.

Phillips F, Hogan J & Hendrickx J, 2005, *Solute balance of the Rio Grande*, Available at

<www.sahra.arizona.edu/research/TA2/2_7.html>.

Powell J 2004, *Dryland Salinity: On-farm Decisions and Catchment Outcomes. A Guide for Leading Producers and Advisers*, Land and Water Australia, Canberra, ACT.

Prime Minister's Science, Engineering and Innovation Council (PMSEIC) 1999, *Dryland salinity and its impact on rural industries and the landscape*, PMSEIC Occasional Paper No. 1. Department of Industry, Sciences and Resources, Canberra.

Rayment GE & Higginson FR 1992, *Australian laboratory handbook of soil and water chemical methods*: Inkata Press, Port Melbourne.

Rhoades JD & Oster JD 1986, 'Solute content', in *American Society of Agronomy and Soil Science Society of America, Methods of Soil Analysis, Part-1, Physical and Mineralogical Methods*, Agronomy Monograph no 9, American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin.

Rhoades JD, Manteghi NA, Shouse PJ & Alves WJ 1989, 'Soil electrical conductivity and soil salinity: New formulations and calibrations', *Soil Science Society America Journal*, vol. 53, pp. 433–439.

Rhoades JD, Chanduvi F & Lesch S 2002, *Soil salinity assessment. Methods and interpretation of electrical conductivity measurements*, Food and Agriculture Organisation of the United Nations, Irrigation and Drainage Paper 57 (1999 first edition). Available at <ftp://ftp.fao.org/agl/aglw/docs/idp57.pdf>

Robins L 2004, *Dryland Salinity and Catchment Management – A Resource Directory and Action Manual for Catchment Managers*, Land and Water Australia, Canberra ACT.

Sattel D 2003, 'The resolution of shallow horizontal structure with AEM', paper presented to ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Schofield S & Jankowski J 1998, 'Sodium-bicarbonate waters – the danger of artesian flow from boreholes in the Ballimore region, central NSW', paper presented to Groundwater Sustainable Solutions, Intern, Groundwater Conference, IAH, University of Melbourne, Feb 8–10.

Slater K 1997, 'Clean and Green: The application of radiometric data for soil mapping', *Preview*, December, pp. 14–18.

Slavich PG & Read BJ 1994, 'Assessment of electronic induction measurements of soil salinity for indication of crop response', in E Humphries (ed.), *Root-zone Limitations in Clay Soils*, Soil Science Society, Riverina Branch, pp. 33–40.

Stace H, Hubble G, Brewer R, Northcote K, Sleeman J, Mulchahy M & Hallsworth E 1968, *A Handbook of Australian Soils*, Rellim Technical Publications, Glenside, South Australia.

Standards Australia 2004, *Risk Management*, Australian Standard AS/NZS 4360:2004, 3rd edition: Standards Australia, Sydney. Available at <www.standards.com.au/>.

Stauffacher M & English P 2002, 'Salinity: Where are we now?', paper presented to the 8th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Lands (PUR$L), Fremantle, WA, September 2002.

Street G (ed.) 2002, 'Salinity and Land Management (special issue)', *Exploration Geophysics*, vol. 33, no. 2.

Street GJ, Parsons S, Allen D & Hatch M 2003, 'Irrigation channel seepage investigations', paper presented to Australian Society Exploration Geophysics 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Sudduth KA, Drummond ST & Kitchen NR 2001, 'Accuracy issues in electromagnetic induction sensing of soil electrical conductivity for precision agriculture', *Computers and Electronics in Agriculture*, vol. 31, pp. 239–264.

Tassell GW 1995, *Geological factors influencing dryland salinity risk*, unpublished PhD thesis, Department of Geography, Australian National University, Canberra.

Taylor GR, Mah AH, Kruse FA, Keiren-Young KS, Hewson RD & Bennett B1995, 'The extraction of soil dielectric properties from AIRSAR and SIR-C imagery', in *Proceedings of the European Symposium on Satellite Remote Sensing II*, Paris, 25 – 28 September 1995, 2587, pp. 32 – 40.

Teskey DJ, Barlow R, Hood PJ, Lefebvre D, Paterson N, Reford M & Watson D 1991, *Guide to aeromagnetic specifications and contracts*, Geological Survey of Canada Open File 2349.

Torgersen T, Habermehl MA, Phillips M, Elmore D, Kubik P, Jones BG, Hemmick T & Gove HE 1991, 'Chlorine-36 dating of very old groundwater, Part 3. Further studies in the Great Artesian Basian, Australia', *Water Resour. Res.*, vol. 27, pp. 3201–3214.

Triantafilis J, Laslett GM & McBratney AB 2000, 'Calibrating an electromagnetic induction instrument to measure salinity in soil and irrigated cotton', *Soil Science Society of America Journal*, vol. 64, pp. 1009–1017.

Ulaby FT, Moore RK & Fung AK 1986, *Microwave remote sensing: Active and passive, Vol.III – From theory to applications*, Dedham, Massachusetts, USA.

Valla P & Yaramanchi U 2002, 'Surface Nuclear Magnetic Resonance. What is possible?', *Journal Applied Geophysics*, vol. 50, nos 1&2, pp. 1–229.

Van Beuren M & Price RJ 2004, *Breaking Ground – key findings from 10 years of Australia's National Dryland Salinity Program*, Land and Water Australia, Canberra, ACT.

Verboom WH & Pate JS 2003, 'Relationships between cluster root-bearing taxa and laterite across landscapes in south-west Western Australia: an approach using airborne radiometric and digital elevation models', *Plant and Soil*, vol. 248, pp. 321–333.

Ward SH 1990, 'Resistivity and induced polarization methods', in SH Ward (ed.), *Geotechnical and Environmental Geophysics*, vol. 1, Society of

Exploration Geophysics, Tulsa, Oklahoma.

Ward WT 1977, *Geomorphology and soils of the Stratford-Bairnsdale area, East Gippsland, Victoria*, Soils and Landuse Series, No 57, Australia.

Wilford J, Dent D, Braaten R & Dowling T 2001, 'Running down the salt in Australia 2: Smart interpretation of airborne radiometrics and digital elevation models', *The Land, Journal of the International Landuse Society*, vol. 5 no. 2, pp. 79–100

Wilson SM 2003, *Determining the full costs of dryland salinity across the Murray- Darling Basin – Final Project Report*, a Wilson Land Management Services Pty Ltd and Ivey ATP project report prepared for the Murray-Darling Basin Commission and National Dryland Salinity Program, Canberra.

Wolf PR 1974, *Elements of Photogrammetry*, McGraw-Hill Kogakusha.

Wolfgram PB, Christensen NB & Sattel D 2003, 'Approximate 2D inversion of AEM data', paper presented to the ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Other references not cited in text

American Society of Civil Engineers (ASCE) 1990, 'Agricultural salinity assessment and management', *ASCE manuals and reports on engineering practice*, No 71, New York, NY 10017, USA.

Briggs S 2003, 'Command and control in natural resource management: Revisiting Holling and Meffe', *Ecological management and restoration*, vol. 4, no. 3, pp. 161–162.

Bui E 2000, 'Risk assessment in the face of controversy: Tree Clearing and Salinisation in North Queensland', *Environmental Management*, vol. 26, no. 4, pp. 447–456.

Eklund PW, Kirby SD & Salim A 1998, 'Data mining and soil salinity analysis', *International Journal of Geographic Information Science*, vol. 12, no. 3, pp. 247–268.

Heany A, Beare S & Bell R 2001, 'Targeting reforestation for salinity management', *Australian Commodities*, vol. 7, no. 3, pp. 511–518.

Mues C & Kemp A 2001, 'Salinity management: Assessing priorities', paper presented at Outloook 2001, Managing Agricultural Resources, ABARE, Canberra.

National Land & Water Resources Audit (NLWRA) 2003, *Natural Resources Information Management Toolkit: building capacity to implement natural resources information solutions*, NLWRA, Canberra.

Webb A 2002, *Dryland salinity risk assessment in Queensland*, report prepared for the Consortium of Integrated Resource Management: CIRM Occasional Paper, Qld Department of Natural Resources and Mines, Brisbane, 45pp.

Williams BG & Baker GC 1982, 'An electromagnetic induction technique for reconnaissance surveys of soil salinity hazards', *Australian Journal of Soil Research*, vol. 20, pp. 107–18.

GLOSSARY[6]

Air photo interpretation (API)
The examination of photographic images for the purpose of identifying objects and patterns and judging their significance (Wolf 1974). API may involve mapping the features of interest from a single photo or from two photos (known as a stereo pair), in which case the interpreter has the benefit of seeing the features in three dimensions. API is both an art and a science, and in general the more experienced the interpreter the better the result. When used for salinity mapping API is seeking to map direct evidence of salt at the surface, or is seeking to infer its presence in the root zone through signs that the vegetation is suffering or through signs that salinity has caused actual changes in the type of vegetation over time.

Asset
A natural or human-made physical entity considered to be of value to humans or future generations, such as land used for cropping, pasture, agricultural produce, built assets, water supplies, and natural entities such as forest, rivers, lakes used for recreation or used to retain wilderness or biodiversity.

Biodiversity
The variety of all life forms—the differing plants, animals and microorganisms, the genes they contain and the ecosystems of which they form a part (CoA 1996). Australia's biodiversity is one of its most precious bequeathed assets and this asset is directly under threat ('at risk') as a result of salinity.

Biophysics
The science that deals with the application of physics to biological processes and phenomena.

Cadastral map
A map showing the parcels of land ownership.

Calibration
1. (Engineering) Adjustments made to an instrument or system so that it reads to the highest possible accuracy. A calibrated instrument should specify error bounds of the measurement.
2. (Geophysical surveys) To adjust processing parameters so that data from one type of survey (e.g. airborne) agree with data from another (e.g. surface and borehole measurements), sometimes by applying constraints in an **inversion** process.
3. (Resource Management) Often used in the sense of 'correlation', where one quantity is numerically related to another quantity. Linear regression is commonly used to derive this calibration relationship.

[6] Many of these definitions draw from the *Encyclopedic Dictionary of Applied Geophysics*, by RE Sheriff: Society of Exploration Geophysics, Tulsa USA, 2002.20d.; CRC LEME/Geoscience Australia, (Ken Lawrie, Matt Gray, Andrew Fitzpatrick, Paul Wilkes, Richard Lane, Colin Pain & Ian Lambert); *Assessing cost-effective salinity mapping strategies using a landscape-based approach to methodologies and technology selection* (see also Lawrie et al. 2003)

Digital elevation models (DEM)

Computer-based representations of the topography of the surface of the Earth. They usually comprise a grid of regularly spaced elevation values that can show the surface in three dimensions. They can be derived from a variety of techniques including:

- aerial photos using photogrammetric techniques;
- multispectral satellite imagery;
- airborne laser scanning; and
- airborne or satellite radar interferometry.

Modern systems can generate DEM with vertical accuracies of 1 to 5 m or better. In future vertical accuracies of around a few millimetres may be possible with new satellite-based radar techniques.

As a rule of thumb the vertical accuracy of a given DEM for any area should be about 1% of the total elevation range of the area. So if the area of interest has a total elevation range of 600 m the vertical accuracy should be approximately 6 m. They may also be known at digital terrain models (DTM).

Dryland salinity

The following description is taken from *Australian Dryland Salinity Assessment 2000* of the National Land and Water Resources Audit, 2001. Two broad forms of salinity are recognised in Australia.

- **Primary** or naturally occurring salinity is part of the Australian landscape, and reflects the development of this landscape over time. Examples are the marine plains found around the coastline of Australia, and the salt lakes in central and western Australia.

  Salts are distributed widely across the Australian landscapes. They originate mainly from depositions of oceanic salt from rain and wind. Salt stored in the soil or groundwater is concentrated through evaporation and transpiration by plants. In a healthy catchment, salt is slowly leached downwards and stored below the root zone, or out of the system.

- **Secondary** salinity is the salinisation of land and water resources due to land use impacts by people. It includes salinity that results from watertable rises from irrigation systems—**irrigation salinity—**and from dryland management systems—**dryland salinity**. Both forms of salinity are due to rising watertables mobilising salt in the soil. There is no fundamental difference in the hydrologic process.

  Where the water balance has been altered due to changing land use (e.g. clearing of native vegetation for broadacre farming or grazing) the excess water entering the watertable mobilises salt which then rises to the land surface. Movement of water drives salinisation processes and may move the stored salt towards the soil surface or into surface water bodies. It is the combination of the effects of salt and its movement by water through the landscape that leads to the creation dryland salinity.

Electrical conductivity (EC)

The ability of electrical current to pass through a substance. EC is commonly used to estimate the amount of soluble salt in solution. EC measurements can be made with a range of devices on ground and stream water, soils, and soil-paste extracts. Units of electrical conductivity are commonly given in mS/m, dS/m or µS/cm; 100 mS/m = 1 dS/m = 1000 µS/cm. Here, *S* is the symbol for siemens, and the prefixes *d* is deci (10^{-1}), *c* is centi (10^{-2}), *m* is milli (10^{-3}) and µ is micro (10^{-6}).

Geographic information system (GIS)

A computer-based mapping system that records information about objects at any point in the landscape. Such information includes the location, type, size, boundaries, neighbours, history, distances to other objects and many more data depending on the amount of information actually collected. The GIS offers an efficient storage, retrieval and analysis approach for any map-based information**.**

Geophysics

The study of the Earth by quantitative physical methods, such as magnetics, electromagnetics, gamma ray spectrometry (radiometrics), seismology and gravity.

Geophysical interpretation

Determination of the location, size, geometry and depth of bodies in the subsurface from spatial measurements of a geophysical field such as magnetics, electromagnetics, gravity. Multiple interpretations are often made based on different assumptions depending on the type of **model**. Interpretations should be constrained by known information from ground observations or drill hole data, and may use computer-based **inversion** techniques.

Geomorphology

The branch of geology and geography that deals with the study of the evolution and configuration of landforms.

Ground penetrating/probing radar (GPR)

A **radar** system used to map the shallow subsurface using electromagnetics waves, usually in the 10 to 1000 MHz band. The two-way travel times of reflected radar waves give the depths to where changes in electrical properties occur. The antennae of GPR systems are held in close contact with the ground to reduce surface reflections and maximise depth range.

Hazard

For the purposes of this book, a hazard is defined as anything that can potentially cause harm to an asset (NLWRA 2001). Salt becomes a hazard when it has the potential to move into a position where it has the ability to threaten an asset. Water is the means by which salt moves in the landscape. Thus a dryland salinity hazard will mean the combination of salt with the potential for movement by surface or groundwater.

The word threat can be used interchangeably with hazard in the context of this review.

Hydrogeology
The branch of geology that deals with the occurrence, distribution, and effect of groundwater. Groundwater is important in salinity studies, because it controls the mobilisation and movement of salt through the landscape.

Hydrology
The scientific study of the properties, distribution, and effects of water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hyperspectral imagery
A form of **remote sensing** that involves the acquisition of images at typically tens to hundreds of sensor wavelengths using an airborne or spaceborne imaging spectrometer that collects electromagnetic radiation, typically from visible light to the shortwave infrared (0.4 – 2.5 µm) and less commonly at thermal infrared (8 – 12 µm) wavelengths. Hyperspectral systems have continuous wavelength coverage (i.e. their wavelength channels are contiguous). Interpreted or derived information is usually presented using 'false-colour images' that use colours to show the spatial distribution of different mineral or environmental targets (see *multispectral remote sensing*).

Impact
The consequence of an occurrence (e.g. increasing salinity) on an asset such as a person, entity or the environment.

Information product
A map-based product that provides information of immediate use for decision making. Information products are derived from a range of data that may be in mapped form through a process of expert assessment. A typical information product may be a whole-of-farm map and plan that shows the location of assets such as productive pasture and the presence of salt somewhere below it.

Interpretation
The process of converting data to useable information. In a geoscientific context, interpretation is the derivation of a simple, plausible geological or other **model** that is compatible with all observed data. The model is never unique or complete and should be refined as more data comes to hand. Everything about an area should be considered when formulating an interpretation (see *air photo interpretation***,** *geophysical interpretation***)**

Inversion
Deriving from field data a geologically plausible **model** of the subsurface that is consistent with observed data (also known as inverse modelling).

Landscape processes
The complex interactions between the natural events of the environment and the impact of human land use. The natural events include the movement of water through gravity and other forces, solar irradiation, climate, weather, plant and animal growth, droughts and floods and so on. Human land

use includes the cultivation of land, construction of built assets such as roads and dwellings, irrigation, management of national parks, forestry, and other activities. It is the interaction of human activities and the natural processes that have led to the occurrence of dryland or secondary salinity in Australia.

Lidar (light detection and ranging)
A **radar** system that operates using visible, near infra-red or ultra-violet light. Lidar systems can measure surface material properties as well as deriving accurate DEM.

Mapping methods
In this book a salinity mapping method is any technique on its own, or in combination with another, that can be used to detect or infer the presence, concentration, location and extent of salinity at the time at which the techniques are applied. The extent is best defined by considering the breadth, width, and depth (the primary axes of an existing feature; the x, y and z axes) of a patch of salinity of consistent concentration. Salinity mapping methods range from soil sampling for salt concentrations to the use of satellite-based techniques for mapping vegetation that is indicative of salt in the root zone. Soils, groundwater, regolith, vegetation and other spatial data can also be mapped using mapping methods.

Model
A concept from which to deduce effects in comparison to observations. The 'model' may be conceptual, physical or mathematical. Models are essential in any **interpretation** or **inversion**.

Modelling
The process of developing a better understanding of observations.
1. The use of interpolating techniques to produce a contiguous picture of the Earth expressed in two and three dimensions from point-based data (put simply, the joining of the dots).
2. Forecasting into the future the likely extent, location and amount of a feature. In this book, modelling is often used in this context; as a forecasting technique for the likely location and concentration of salinity in the future. Therefore modelling introduces the fourth dimension, time.
3. The computer simulation of a mapping method over a particular scenario in order to determine whether that mapping method is suitable for the particular mapping task. Modelling in this sense is often used as a survey planning tool. (see also *numerical modelling*).

Multispectral remote sensing
A form of **remote sensing** that involves the acquisition of images at more than two and typically less than 20 sensor wavelengths using an airborne or spaceborne imaging spectrometer that collects electromagnetic radiation, typically from visible light to the shortwave infrared (0.4 – 2.5 µm) and less commonly at thermal infrared (8 – 12 µm) wavelengths. Multispectral systems do not have continuous wavelength coverage, or necessarily evenly spaced wavelength channels. The precise wavelengths of the channels are generally chosen to sense spectral features of specific targets. Interpreted or derived information is usually presented using 'false-colour images' that use colours to show the

spatial distribution of different mineral or environmental targets (see *hyperspectral imagery*).

Numerical modelling

1. Use of numerical techniques to calculate the theoretical response caused by an assumed set of subsurface parameters (also known as forward modelling).

2. Use of direct or iterative methods for deducing subsurface parameters from geophysical or other data (also known as inverse modelling (see *inversion)*.

Palaeochannel

An ancient water channel or stream bed, which has been covered by materials laid down by subsequent geological processes.

Prediction

A reasoning or statement about the future. The application of a modelling technique in the context of this report produces a prediction of the timing, location, extent, and concentration of future salinity, thereby permitting an analysis of the consequences of the prediction.

Radar

A system in which short-wavelength (radio and microwave) electromagnetic waves are transmitted and the energy scattered back from reflecting objects is detected. Acronym for 'radio detection and ranging'. The radar spectrum ranges from P-band (225 – 390 MHz) to V-band (46 – 56 GHz). Airborne and satellite radar systems employ a narrow beam reflected from the ground from which an image similar to air photos is derived. (see also *Lidar* and *ground probing radar*).

Regolith

The unconsolidated material between the surface and fresh bedrock, consisting of products of weathering, transport and deposition. Regolith often has a complex structure and can vary in thickness from a few centimetres to hundreds of metres.

Remote sensing

Remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation (Lillesand & Keifer 1979). In common usage, remote sensing refers to measurements made at a large distance, usually from high-flying aircraft or Earth satellites, although it can include ground based measurement systems as well. Especially refers to measurements of either natural electromagnetic radiation (**passive techniques**) or radiation from a source near the sensor (**active techniques**) that has been reflected back from the Earth's surface. While the most common data are available for Landsat, Spot and AVHRR, there are many other remote sensing data sources such as radar, airborne geophysics, and the hyperspectral instruments. The information is usually presented using false-colour imaging to create an image of the target species of interest.

Risk

The chance that a hazard will cause harm to an asset at some defined time in the future. Risk is classically defined as an impact (usually an unwanted impact) multiplied by its

likelihood of occurrence at some given time in the future. In effect, it is a way of weighting possible unwanted events by their likelihood. So a highly unlikely but serious impact may be regarded as presenting the same risk as a likely but minor impact (see Chapter 4).

Risk management

The systematic process of identifying, analysing and responding to potential project risk. Risk management includes maximising the probability and impact of positive events and minimising the probability and consequences of events adverse to project objectives (ANAO 2003).

Salinity

The presence of mineral salts such as sodium chloride (NaCl), potassium chloride (KCl), lime (calcium carbonate or $CaCO_3$), gypsum (calcium sulphate or $CaSO_4$), either in solution or as solids (see also *dryland salinity*).

Salt

The general term for mineral salts such as sodium chloride (NaCl), potassium chloride (KCl), lime (calcium carbonate or CaCO3), gypsum (calcium sulphate or $CaSO_4$).

Scale

The ratio of the dimensions of objectives in real life as represented on maps. They are mainly expressed as the following simple ratios.

1:10 000
1 mm on the map is equivalent to 10 m on the ground, and 1 square mm is equivalent to 0.01 ha. This is a useful scale for representing *paddock level* information.

1:50 000
1 mm on the map is equivalent to 50 m on the ground, and 1 square mm is equivalent to 0.25 ha. This is a useful scale for representing *subcatchment level* information.

1:100 000
1 mm on the map is equivalent to 100 m on the ground, and 1 square mm is equivalent to 1 ha. This is a useful scale for representing *subcatchment and catchment level* information.

1:250 000
1 mm on the map is equivalent to 250 m on the ground, and 1 square mm is equivalent to 6.25 ha. This is a useful scale for *regional* representations.

1:500 000
1 mm on the map is equivalent to 500 m on the ground, and 1 square mm is equivalent to 25 ha. This is a useful scale for *regional* and *State/ Territory* representations.

1:1 000 000
1 mm on the map is equivalent to 1 km on the ground, and 1 square mm is equivalent to 100 ha. This is a useful scale for *State/ Territory* representations. Forty-one 1:1 000 000 map sheets are required to cover Australia.

The larger the scale the closer one gets to the real life object. Thus 1:10 000 is considered to be large scale in relation to 1:1 000 000 which is considered to be small scale. Expressions of local, regional and national scales are also commonly used.

Sodicity
Measure of the proportion of exchangeable sodium ions in the soil. High sodicity weakens soil structure and increases susceptibility to erosion (erodibility).

Soil chemistry
The chemical composition, structure, properties, and reactions of a soil.

Soil salinity
The accumulation of salts in the environment. Saline soil is normally assumed to be non-alkaline. Where pH>8.5 the soil is referred to as saline-alkaline (see also *dryland salinity*).

Threat
Threat is considered to have the same meaning as hazard for this report.

Validation
The process used to verify the quality of the outcome of a mapping project. It usually needs to do so by using an independent source of information from that which was used to construct the original map.

INDEX[7]

[7] See also Glossary on p. 221.

D

E

F

G

N

O

P

R

S

T

V

W