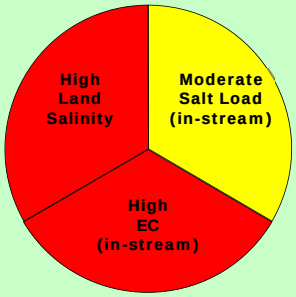
14. Majura Road Hydrogeological Landscape

LOCALITIES	**Majura Valley, Majura Road and Parkway, Canberra International Airport**
MAP SHEET	**Canberra 1:100 000**
CONFIDENCE LEVEL	**Moderate**



OVERVIEW

The Majura Road Hydrogeological Landscape (HGL) extends from the Federal Highway in the north to Lake Burley Griffin in the south. The catchment is bounded by Mt Ainslie and the change in geology on Mt Majura to the west (Figure 1). The HGL covers an area of 54 km^2 and receives 550 to 750 mm of rain per annum.

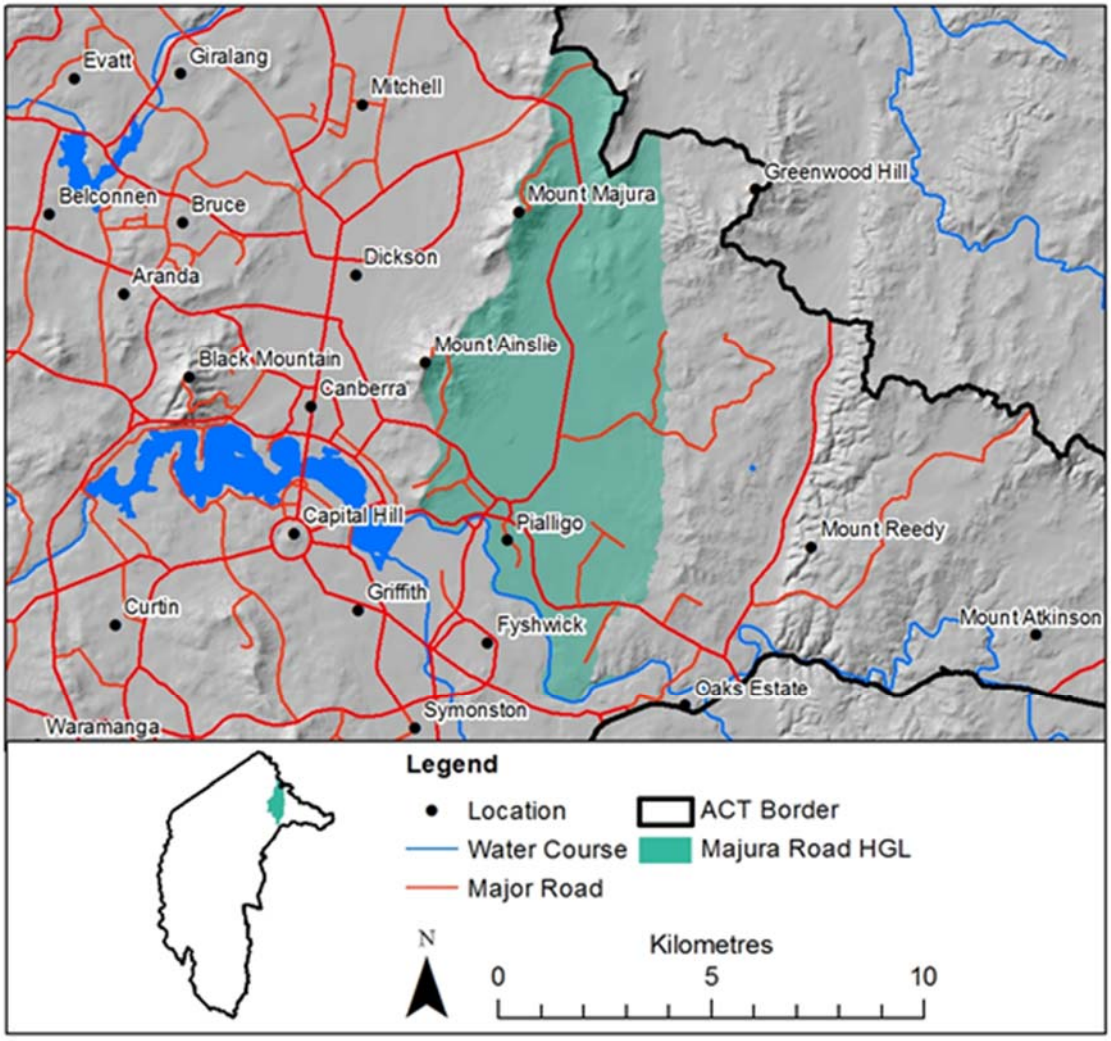


Figure 1: Majura Road HGL distribution map.

Majura Road HGL is a catchment based landscape in a broad valley bounded by steep hills (Silurian Mt Ainslie Volcanics) and a major fault line contact with the Ordovician Adaminaby Group (Figure 2). Lake Burley Griffin may influence water tables in the south of the HGL.

The area exhibits salinity via seasonal waterlogged patches and saline seeps with spike rush. On the western flanks there are saline springs in the upper slopes, as well as soils with severe salinity at 150 cm depth (43 dS/m). There is a history of saline sites in the lower reaches of the unit with former Salt Action demonstration sites established in early 1990s. Some recent salinity sites have remobilised after infrastructure development. Monitoring of bores and stream EC indicates moderate salinity levels.

Major infrastructure development is continuing within the HGL with the construction of the Majura Parkway and further development of the airport precinct. These developments are impacted by the local salinity and the soil conditions of the landscape. Pockets of acid sulfate soils impact on road embankments and batters in the higher landscape.

The land use of the area is highly variable with small areas of irrigated agriculture (vines and olives), grazing and cropping, defence lands, airport infrastructure including a large scale business park precinct, and reserve areas of native vegetation. There are important remnant grassland that act as biodiversity conservation areas in the lower landscape. Sand deposits (Pialligo Sands) in the lower landscape have previously undergone sand mining.

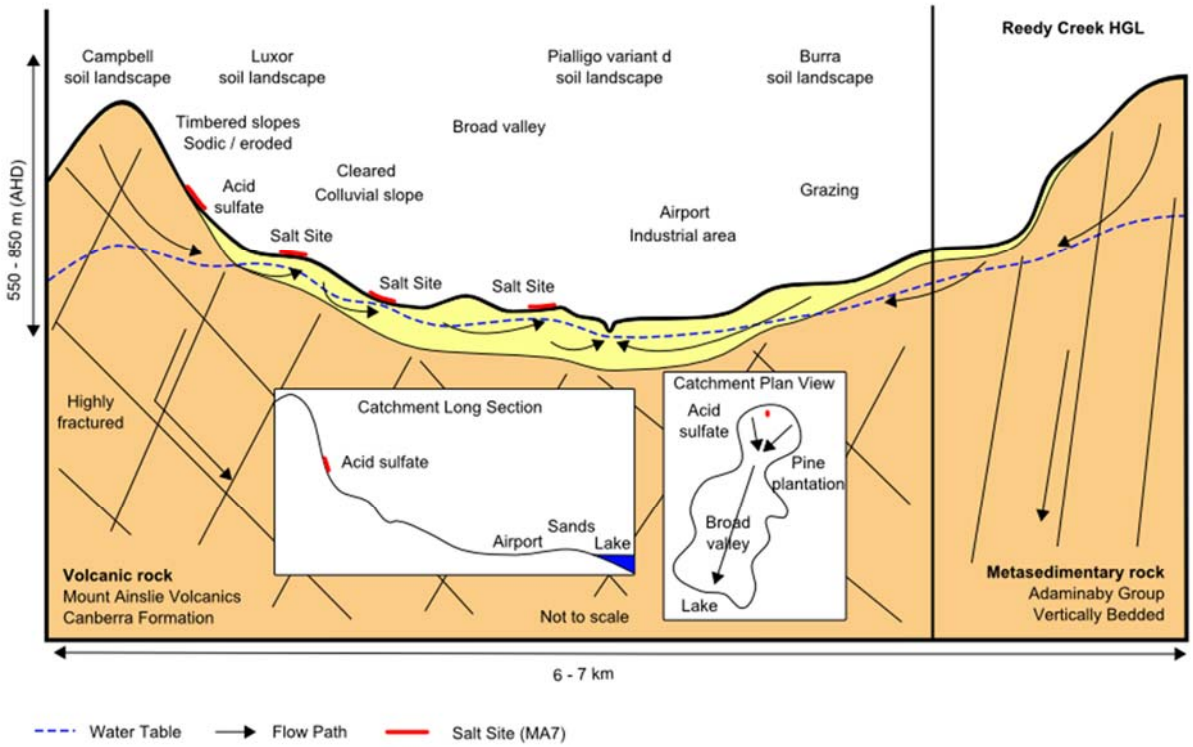


Figure 2: Conceptual cross-section for Majura Road HGL showing the distribution of regolith and landforms, salt sites if present, and flow paths of water infiltrating the system.

Salinity has been observed in this HGL in the form of land salinity and stream salt load and EC (Table 1).

Table 1: Majura Road HGL salinity expression.

SALINITY EXPRESSION	
Land Salinity (Occurrence)	High – minor seasonal saline outbreaks are common adjacent to drainage lines. Rare spike rush observed in main drainage lines
Salt Load (Export)	Moderate – surface water observed as brackish (1600–4800 µS/cm). Flow lines observed to have intermittent flows
EC (Water Quality)	High – surface water observed as brackish (1600–4800 µS/cm)

Salt store refers to the amount of salt stored in soil and geology materials. Salt availability refers to how easily this salt can be moved by water. Salt stored within Majura Road HGL has moderate mobility. There is a moderate salt store that has moderate availability (Table 2).

Table 2: Majura Road HGL salt store and availability.

SALT MOBILITY			
	Low availability	**Moderate** availability	**High** availability
High salt store			
Moderate salt store		**Majura Road**	
Low salt store			

Overall salinity hazard is based on the likelihood of salinity occurring and how much impact it would have. The overall salinity hazard in Majura Road HGL is high. This is due to the high likelihood that salinity issues will occur that have potentially significant impacts (Table 3).

Table 3: Likelihood of salinity occurrence, potential impact and overall hazard of salinity for Majura Road HGL.

OVERALL SALINITY HAZARD			
	Limited potential impact	**Significant** potential impact	**Severe** potential impact
High likelihood of occurrence		**Majura Road**	
Moderate likelihood of occurrence			
Low likelihood of occurrence			

LANDSCAPE FEATURES

The following photographs illustrate landscapes and specific features observed in this HGL. Information used to define the HGL is summarised in Table 4.

Photo 1: Photograph looking north over the flat lower colluvial and alluvial Majura valley landscape with Mount Majura Nature Reserve in the background (Photo: DPI / A Nicholson).

Photo 2: Majura Road landscape adjacent to commercial development (Photo: DPI / A Nicholson).

Photo 3: Construction works of Majura Parkway in lower Majura Valley, with Australian Defence Force Academy and playing fields in background (Photo: DPI / A Nicholson).

Photo 4: Mount Ainslie with Luxor soil landscape on the lower slope and foothills of Majura Valley (Photo: DPI / A Nicholson).

Photo 5: View from Mount Ainslie looking east over Canberra International Airport and associated developments of the Majura Valley (Photo: DPI / A Nicholson).

Photo 6: Mixed land use (grazing, defence, airport and light industrial) in the broad colluvial unit of Majura Road HGL (Photo: DPI / A Nicholson).

Photo 7: Steep upper elements and vegetation .assemblage in the upper part of Majura HGL adjacent to Majura Parkway (Photo: DPI / A Nicholson).

Table 4: Summary of information used to define Majura Road HGL.

Lithology *(Raymond et al. 2007; Geoscience Australia 2015)*	This HGL comprises Ordovician metasediments and Silurian volcanics. Key lithologies include: • Mount Ainslie Volcanics • Canberra Formation • Colluvium and alluvium The valley orientation of this HGL is fault controlled
Annual Rainfall	550–750 mm
Regolith and Landforms	Soil generally <1 m deep higher in the landscape and >1 m on lower slopes and in drainage lines. Deeper soil and imperfect drainage in the lower landscape provide moderate potential for salt store. Long colluvial slopes adjacent to a broad valley of relatively deep regolith leading up to steep hills Slopes generally 0–3% on valley bottoms; 3–10% on lower slopes; 10–32% in higher areas Elevation range is 550–900 m

Soil Landscapes *(Jenkins 1993; Jenkins 2000; Cook & Jenkins in prep)*	The following soil landscapes dominate this HGL: • Williamsdale • Pialligo (variant D) • Campbell • Luxor • Burra • Ginninderra Creek Clastic Rudosols or Leptic Tenosols (Lithosols) on crests generally confined to the western margin of this HGL. Red Chromosols and Red Kurosols (Red Podzolic Soils) and Red Kandosols (Red Earths) occur from crests to mid slope positions. Brown Chromosols and Magnesic-Natric Chromosols (Yellow Podzolic Soils) and Brown Kandosols (Yellow Earths) on drained lower slopes. Poorly drained Sodosols (Solodic Soils) in the undulating plain and drainage lines. Hydrosols and Stratic Rudosols (Alluvial Soils) occur on more active floodplain elements. Due to sodicity, catchment shape, geological boundaries and imperfect drainage the Sodosols within this HGL have a high potential for land degradation and dryland salinity. The Magnesic-Natric Chromosols (Yellow Podzolic Soils) also readily degrade and have salinity issues.
Land and Soil Capability	Class 6
Land Use	• mixed land use – grazing, airport, industrial, recreation and minor areas of horticulture
Key Land Degradation Issues	• water erosion (gullying and stream bank) • sodicity • damage to infrastructure
Native Vegetation *(Keith 2004; Gellie 2005; Dept. of Environment 2012)*	This HGL is situated within the IBRA7 South Eastern Highlands (Murrumbateman subregion).The HGL has been extensively cleared with remaining vegetation formations comprising Dry Sclerophyll Forest and Grassy Woodlands on lower slopes. Local vegetation is described by Gellie (2005)

HYDROGEOLOGY

Typical values for the hydrogeological parameters of this HGL are summarised in Table 5.

Table 5: Summary of values for typical hydrogeological parameters of Majura Road HGL.

Aquifer Type	Unconfined in fractured rock and unconsolidated alluvial and colluvial sediments on slopes and in flow lines
Hydraulic Conductivity	High Range: >10 m/day
Aquifer Transmissivity	Moderate Range: 2–100 m^2/day

Specific Yield	Moderate Range: <15%
Hydraulic Gradient	Gentle Range: <10%
Groundwater Salinity	Marginal to brackish Range: 800–>1600 µS/cm
Depth to Watertable	Shallow to intermediate Range: <2–8 m
Typical Sub-Catchment Size	Large (>1000 ha)
Scale (Flow Length)	Local Flow length: <5 km (short)
Recharge Estimate	High
Residence Time	Medium (years)
Responsiveness to Change	Medium (years)

MANAGEMENT OPTIONS

Overarching salinity management strategies have specific biophysical outcomes. These are achieved by implementing a series of targeted land management actions that take into account the opportunities and constraints of the particular HGL. The actions recognise the need for diffuse and specific activities within the landscape to impact on salinity. Further explanation of land management functions, strategies and actions can be found in Wooldridge *et al.* (2015).

Salinity is driven by interactions between water-use capacity of vegetation, physical soil properties and hydrogeological processes within the HGL.

Actions that influence the way water is used by vegetation or stored in the soil profile will impact on recharge. The influence of both continual and episodic recharge and the impacts of extreme weather events should be considered when deciding on appropriate management actions. Short and long-term climate cycles also should be considered as they have a bearing on salinity processes, particularly salt load and land salinity.

Landscape Functions – Majura Road HGL

Functions this landscape provides within a catchment scale salinity context:

- **D.** The landscape generates salt loads which enter streams and are redistributed in the catchment.
- **F.** The landscape generates high salinity concentration water.
- **G.** The landscape contains important land assets (including infrastructure and high value agricultural land) on which salinity processes impact.
- **H.** The landscape contains high hazard for generating sodic and saline sediments.
- **I.** The landscape contains high hazard for acid sulfate processes.

Landscape Management Strategies – Majura Road HGL

Appropriate strategies pertinent to this landscape:

- **Discharge rehabilitation and management (4)**: Discharge sites appear in the landscape during wet climate cycles. Improved management of these saline areas can reduce the impact of salinisation and prevent large negative impacts during wet cycles. Discharge management will also limit on-site land degradation.
- **Intercept shallow lateral flow and shallow groundwater (2)**
- **Stop discrete landscape recharge (3)**
- **Manage and avoid acid sulfate hazards (11)**

Key Management Focus – Majura Road HGL

Management focus is to recognise salinity impacts on infrastructure that will need to be planned for and taken into account in construction, particularly road construction. Grazing management is a major factor in landscape stability, as the soils are very sodic and are easily eroded. Past earthworks have failed due to grazing pressure on the landscape by an overpopulation of kangaroos on defence lands.

A balance between multiple land use and conservation issues should be obtained to satisfy the wide range of competing interests. The area is likely to become a major development area in the short term and a transport corridor into the future.

Specific Land Management Opportunities

Specific opportunities for this HGL:

- existing remnant grasslands can be a ‘seed bank’ resource
- planning frameworks into the immediate future.

Specific Land Management Constraints

Constraints on land management in this HGL include:

- acid sulfate and salinity impacts on infrastructure, particularly road construction and buildings
- total grazing pressure on government lands
- airport ‘envelope’ with regard to noise and height restrictions
- increased peri-urban development in competition with agricultural land.

Specific Targeted Actions

Management areas for this HGL are illustrated in Figures 3 and 4. The specific management actions for these areas are described in Table 6. Management actions for urban areas are given in Table 8.

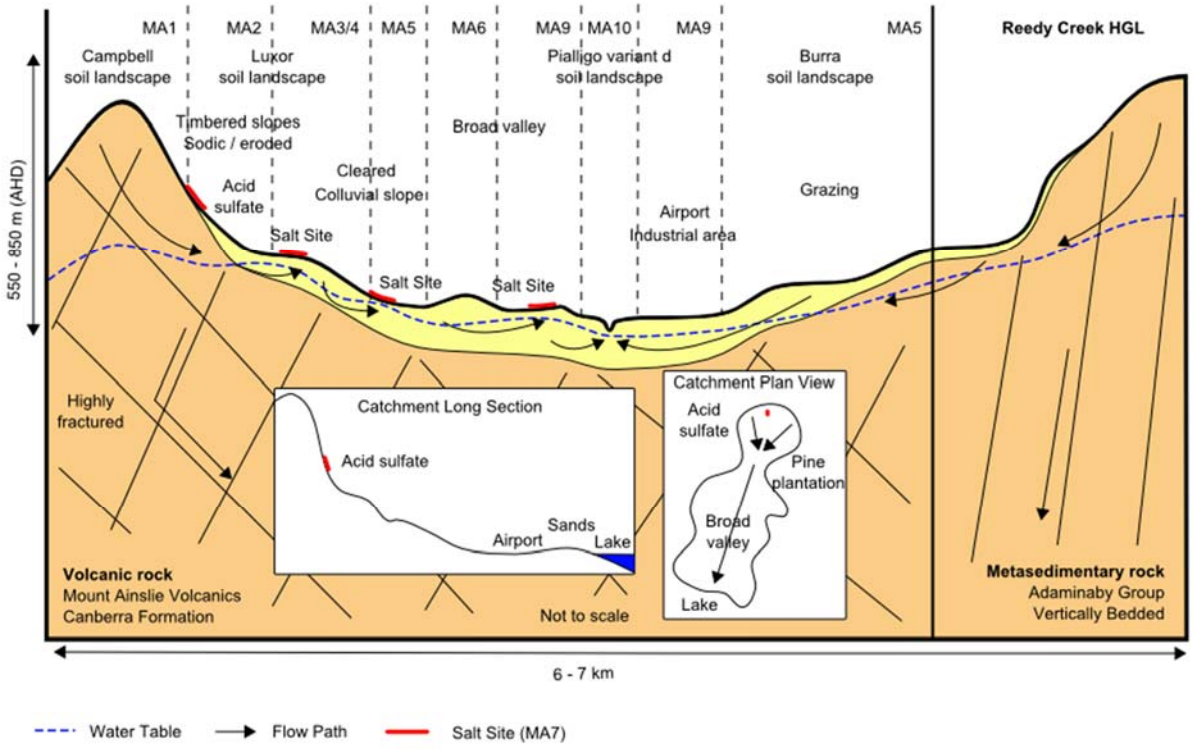


Figure 3: Management cross-section for Majura Road HGL showing defined management areas.

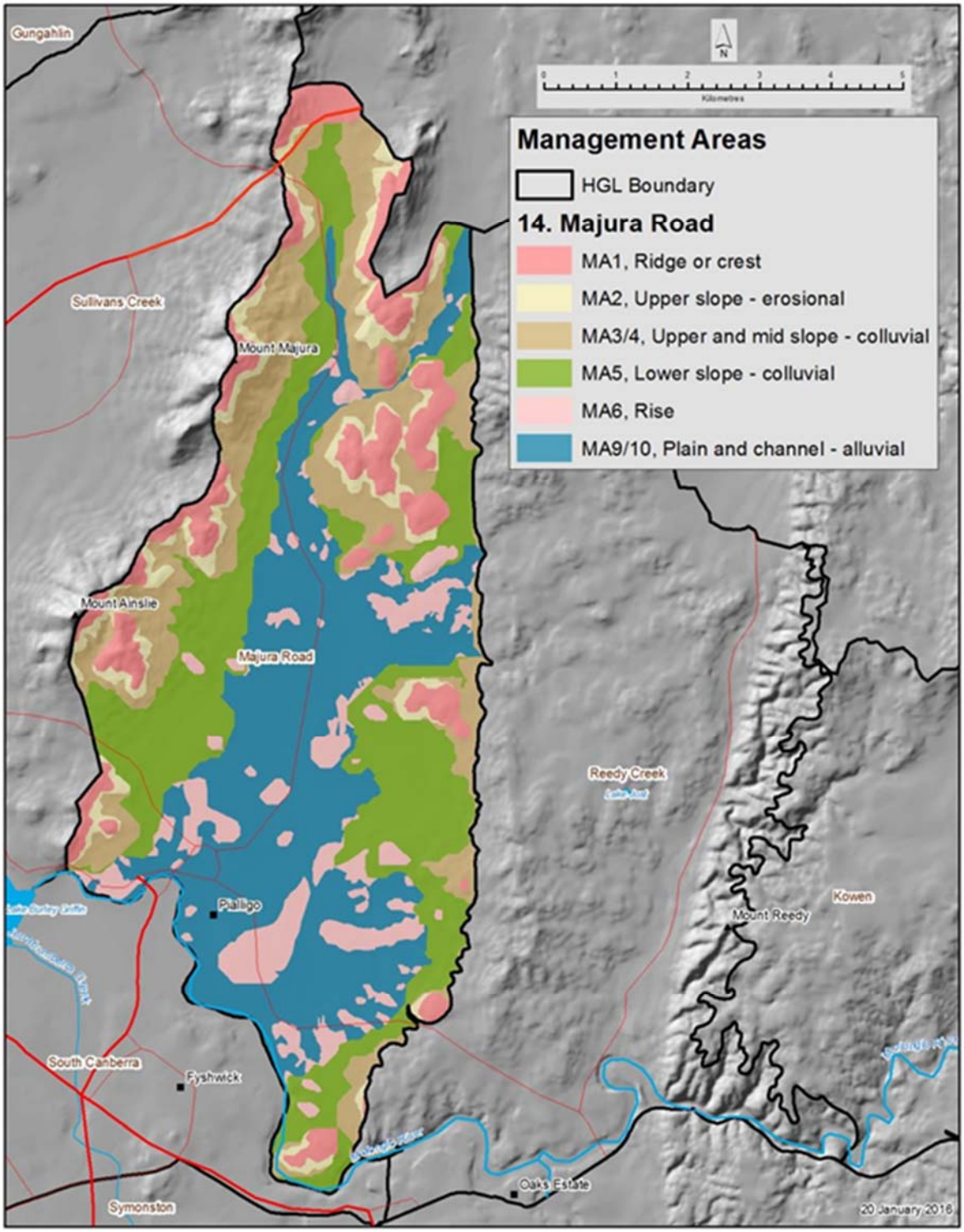


Figure 4: Spatial distribution of management areas for Majura Road HGL.

Table 6: Specific management actions for management areas within Majura Road HGL.

Management Area (MA)	Action
MA 1 (RIDGES)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Manage total grazing pressure to maintain and improve native vegetation for hydrology outcomes **(VE9)** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1)** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5)** Establish commercial forestry to manage recharge **(VP7)** **Acid Sulfate** Isolate and improve acid sulfate soil sites **(AS2)**
MA 2 (UPPER SLOPE – EROSIONAL) NB: INCLUDES MA7 – SALTLAND	**Vegetation for ecosystem function** Manage total grazing pressure to maintain and improve native vegetation for hydrology outcomes **(VE9)** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Establish and manage trees to integrate into existing farming infrastructure and logistics and for multiple outcomes including reduced recharge **(VE5)** Interception planting of trees to target shallow groundwater **(VE2)** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1)** Establish and manage perennial pastures to manage recharge **(VP2)** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5)** **Acid Sulfate** Isolate and improve acid sulfate soil sites **(AS2)** **Salt Land Rehabilitation** Fence and isolate salt land and discharge areas for saline site rehabilitation **(SR1)** Rehabilitation of salt land to minimise onsite and offsite degradation **(SR4)**

Management Area (MA)	Action
MA 3/4 (UPPER SLOPE – COLLUVIAL & MID SLOPES)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Establish and manage trees to integrate into existing farming infrastructure and logistics and for multiple outcomes including reduced recharge **(VE5)** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge**(VP1)** Establish and manage perennial pastures to manage recharge **(VP2)** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5)**
MA 5 (LOWER SLOPE – COLLUVIAL)	**Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1)** Establish and manage perennial pastures to manage recharge **(VP2)** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5)** **Irrigation Systems** Manage on-farm irrigation to achieve best practice **(IS1)**
MA 6 (RISES)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Establish and manage trees to integrate into existing farming infrastructure and logistics and for multiple outcomes including reduced recharge **(VE5)** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1)** Establish and manage perennial pastures to manage recharge **(VP2)** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5)**
MA 7 (SALINE AREAS)	**Salt land rehabilitation** Fence and isolate salt land and discharge areas to promote revegetation **(SR1)** Establish and manage salt land pasture systems to improve productivity **(SR2)** Establish forestry systems on salt land to improve productivity **(SR3)** Undertake rehabilitation to ameliorate land salinity processes and

Management Area (MA)	Action
	reduce land degradation **(SR4)** Mulch sites to reduce evaporation and promote pasture growth **(SR8)**
MA 9 (FLOWLINES, ALLUVIAL FLOODPLAIN)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Maintain and improve riparian native vegetation to reduce discharge to streams **(VE4)** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1)**
MA 10 (CHANNELS)	**Vegetation for ecosystem function** Maintain and improve riparian native vegetation to reduce discharge to streams **(VE4)**

High Hazard Land Use

There are some management actions that should be discouraged in this HGL as they will have negative impacts on salinity (Table 7). High hazard management actions for urban areas are given in Table 9.

Table 7: Management actions having negative salinity impacts in Majura Road HGL.

At Risk Management Areas	Action
MA 1, 2, 3, 4 & 5	Poor management of grazing pastures **(DLU2)** Clearing and poor management of native vegetation **(DLU4)** Locating infrastructure on discharge areas **(DLU7)** Deep ripping of soils to maximise water infiltration to subsoil **(DLU11)**
MA 6	Poor management of grazing pastures **(DLU2)** Clearing and poor management of native vegetation **(DLU4)**
MA 7	Poor management of grazing pastures **(DLU2)** Clearing and poor management of native vegetation **(DLU4)** Locating infrastructure on discharge areas **(DLU7)** Deep ripping of soils to maximise water infiltration to subsoil **(DLU11)** Poor targeting of land suitable for irrigation **(DLU14)**
MA 9	Poor management of grazing pastures **(DLU2)** Locating infrastructure on discharge areas **(DLU7)** Poor targeting of land suitable for irrigation **(DLU14)**

At Risk Management Areas	Action
MA 9/10	Poor management of grazing pastures **(DLU2)** Clearing and poor management of native vegetation **(DLU4)**

Urban Management Strategy Objectives – Majura Road HGL

The following list (in priority order) details the appropriate urban strategies pertinent to this landscape:

Highest priority

- **Urban Planning (UP)**: Planning of sub-division layout and design is required to manage salinity consequences. Development and re-development should not increase the salinity hazard of the natural and built environment. Layout and design should consider locations of roads, infrastructure and green-space as well as building allotments, and WSUD.
- **Urban Construction (UC**): Construction and re-development on saline land will require salt resistant/resilient materials. The salinities encountered in this HGL require careful consideration of construction method, depth of cut and location of roads, and all infrastructure including underground utilities.
- **Urban Investigations (UI**): The landscape contains salinity situations that predispose salinity development. Assessment of the location, intensity and scale of salinity is needed. There are areas of salinity throughout this HGL that need to be identified.

Medium priority

- **Urban Vegetation (UV)**: Maintain and enhance vegetation (including remnant vegetation) for the management of recharge and as a buffer to excess water input. Water-wise gardening should be encouraged in residential areas.
- **Urban Management (UM)**: The input of water into the landscape (from lawns, gardens, sporting fields) including the management of recycled water, requires careful management.
- **Riparian Management (RM**): Vegetation management in riparian areas will help minimise salt export to streams.

Specific Land Management Opportunities

There is a range specific opportunities for this HGL:

- water demand management can have a localised impact
- trees and salt tolerant vegetation are likely to have a moderate to high impact in this landscape if correct species are selected based on salinity/waterlogging tolerance. There is an abundance of shallow groundwater moving through the landscape.
- planning of mixed land uses can be complementary.

Specific Land Management Constraints

Constraints on land management in this HGL include:

- salt store in the upper landscape: need to limit impact of salinity on lower slopes
- sodic and dispersive subsoils
- avoid excessive water infiltration into soils
- total grazing pressure.

Table 8: Specific urban management actions for management areas within Majura Road HGL.

MANAGEMENT AREA (MA)	ACTION (URBAN)
MA 3/4/5/6	**Urban Planning** Prior to starting earthworks, sodic/saline soils should be identified **(UP1)** Minimise use of infiltration and detention of stormwater in hazard areas, consider lining detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management) **(UP2)** Identification of discharge sites should influence the size of the area to be developed **(UP3)** Maximise the size of impervious surfaces to prevent recharge of (perched) groundwater tables. Constructed pervious surfaces may need to be lined and drained to stormwater outlets **(UP4)** Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revise principles of WSUD where salinity effects are an issue **(UP5)** **Urban Construction** Deep drainage should be minimised by maximising surface water runoff and drainage **(UC2)** Ensure road construction is suitable for conditions **(UC5)** Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material interface is not saline (**UC1)** New houses, buildings or infrastructure (including roads, pathways and retaining walls) in current or potentially salt affected areas may need to be built to withstand the effects of salinity using industry accepted standards. In badly affected areas, consideration should be given to rehabilitating salt affected land, building above ground or choosing open space options **(UC6)** **Urban Management** Employ deficit irrigation principles to prevent over-irrigation of sports grounds, golf courses, parks, private gardens and lawns **(UM2)** Minimise leakage of standing water bodies, pools, lakes and service pipes (**UM1)** **Urban Vegetation** Develop native landscaping and water-wise gardens to reduce over-irrigation and water usage **(UV3)** Promote the retention and establishment of deep rooted vegetation that maximises water use in new urban development areas **(UV2)**

MANAGEMENT AREA (MA)	ACTION (URBAN)
MA 9	**Urban Planning** Prior to starting earthworks, sodic/saline soils should be identified **(UP1)** Minimise use of infiltration and detention of stormwater in hazard areas, consider lining detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management) **(UP2)** Identification of discharge sites should influence the size of the area to be developed **(UP3)** Maximise the size of impervious surfaces to prevent recharge of the (perched) groundwater table. Constructed pervious surfaces may need to be lined and drained to stormwater outlets **(UP4)** Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revise principles of WSUD where salinity effects are an issue **(UP5)** **Urban Construction** Minimise deep drainage by maximising surface water runoff and drainage **(UC2)** Ensure road construction is suitable for conditions **(UC5)** Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material interface is not saline (**UC1)** New houses, buildings or infrastructure (including roads, pathways and retaining walls) in current or potentially salt affected areas may need to be built to withstand the effects of salinity using industry accepted standards. In badly affected areas, consideration should be given to rehabilitating salt affected land, building above ground or choosing open space options **(UC6)** **Urban Management** Employ deficit irrigation principles to prevent over-irrigation of sports grounds, golf courses, parks, private gardens and lawns **(UM2)** Minimise leakage of standing water bodies, pools, lakes and service pipes (**UM1)** **Urban Vegetation** Develop native landscaping and water-wise gardens to reduce over-irrigation and water usage **(UV3)**
MA 10	**Riparian Management** Retain or re-establish effectively vegetated riparian buffer zones to manage discharge areas (preferably salt tolerant indigenous vegetation) **(RM1)** Maintain/re-establish effective vegetated riparian buffer zones **(RM2)**

Table 9: Urban management actions having negative salinity impacts in Majura Road HGL.

AT RISK MANAGEMENT AREAS	ACTION
MA 3, 4, 5, 6, 9,10	Avoid: • overwatering of parks and gardens • ponding water on lower landform units • deep cut and exposure of susceptible soils during development when establishing infrastructure and dwellings • input of extra recharge from delivery and stormwater systems

REFERENCES

Department of the Environment 2012, *Interim Biogeographic Regionalisation for Australia (IBRA), Version 7 (Regions),* Australian Government, Department of the Environment, Canberra, ACT

Gellie, N.J.H. 2005, Native vegetation of the Southern Forests: South-east Highlands, Australian Alps, South-west Slopes and Southeast Corner bioregions, *Cunninghamia 9(2)*, pp 219–253

Geoscience Australia, 2015, *Australian stratigraphic units database*, Canberra, ACT, (Accessed: 20 June 2015) http://dbforms.ga.gov.au/www/geodx.strat_units.int

Jenkins B.R. 1993, *Soil Landscapes of the Michelago 1:100 000 Sheet map and report*, Department of Conservation and Land Management, Sydney, NSW

Jenkins B.R. 2000, *Soil Landscapes of the Canberra 1:100 000 Sheet map and report*, Department of Land and Water Conservation, Sydney, NSW

Keith, D. A. 2004, *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*, NSW Department of Environment and Conservation, Hurstville, NSW

Raymond, O.L., Lui, S., Kilgour, P., Retter, A.J., Stewart, A.J. and Stewart, G. 2007, *Surface geology of Australia 1:1,000,000 scale, New South Wales – 2nd edition*, Geoscience Australia, Canberra, ACT

Wooldridge, A., Nicholson, A., Muller R., Jenkins, B. R., Wilford, J. and Winkler, M. 2015, *Guidelines for managing salinity in rural areas*, NSW OEH, Sydney, NSW [Accessed: 20 June 2015] http://www.environment.nsw.gov.au/resources/salinity/150241-HGL-salinity-rural.pdf