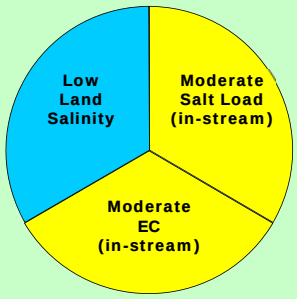
23. Sullivans Creek Hydrogeological Landscape

LOCALITIES	**Civic, Canberra Central, Mitchell, Watson, Dickson, Black Mountain, Hackett, Lyneham**
MAP SHEET	**Canberra 1:100 000**
CONFIDENCE LEVEL	**High**



OVERVIEW

The Sullivans Creek Hydrogeological Landscape (HGL) extends from Central Canberra in the south to Mitchell and past Horse Park Drive in the north. The area also extends from Black Mountain to Mt Majura Nature Reserve. The area is mostly urbanised with extensive new urban development in the north in Gungahlin (Figure 1). The HGL covers an area of 72 km^2 and receives 600 to 750 mm of rain per annum.

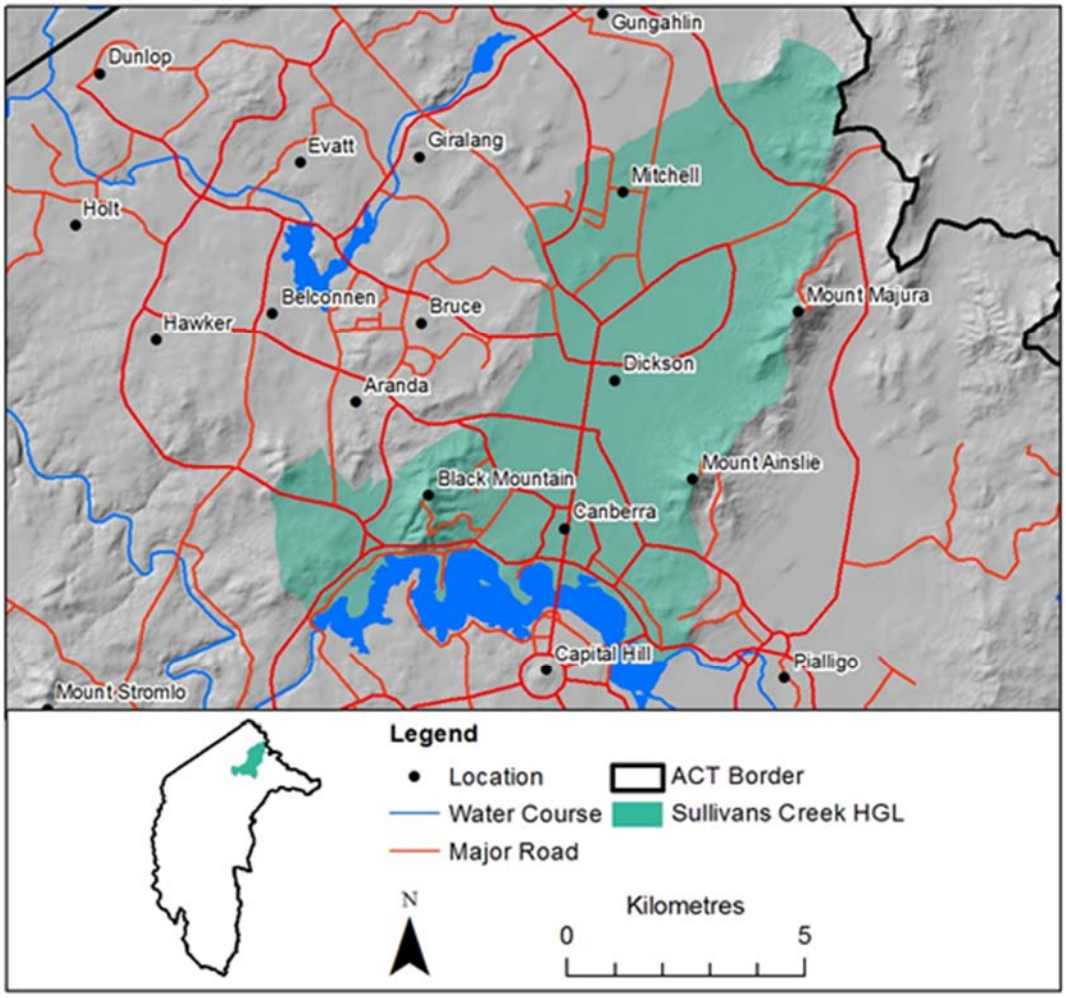


Figure 1: Sullivans Creek HGL distribution map.

Sullivans Creek HGL is a catchment based landscape in a broad valley (bowl shaped), bounded by steep hills, with Silurian Mt Ainslie Volcanics to the east, and mixed Silurian and Ordovician metasediments to the west (Figure 2). Lake Burley Griffin forms the southern boundary.

A low rise (bench) of Franklin Soil Landscape material on the western margin is also a major feature in the adjoining Gungahlin HGL. The drainage pattern has been altered, with constructed channels, flood retention structures and wetlands to cater for the increased runoff in the urbanised landscape. Ovals have been constructed on the floodplain/alluvium adjacent to flow lines in the bowl shaped landscape. There is a high level of irrigation on the sports assets, and in some areas the creek runs under sports fields in pipes.

Major infrastructure development is continuing within the HGL with the construction of new housing in the Gungahlin suburbs of Harrison and Franklin.

The land use of the area is highly variable, with small areas of irrigated ovals and sporting fields, grazing lands in the upper landscape elements and reserve areas of native vegetation in the Black Mountain area. Important remnant grassland areas act as biodiversity conservation areas in the mid-upper landscape (Gungaderra Grasslands Nature Reserve).

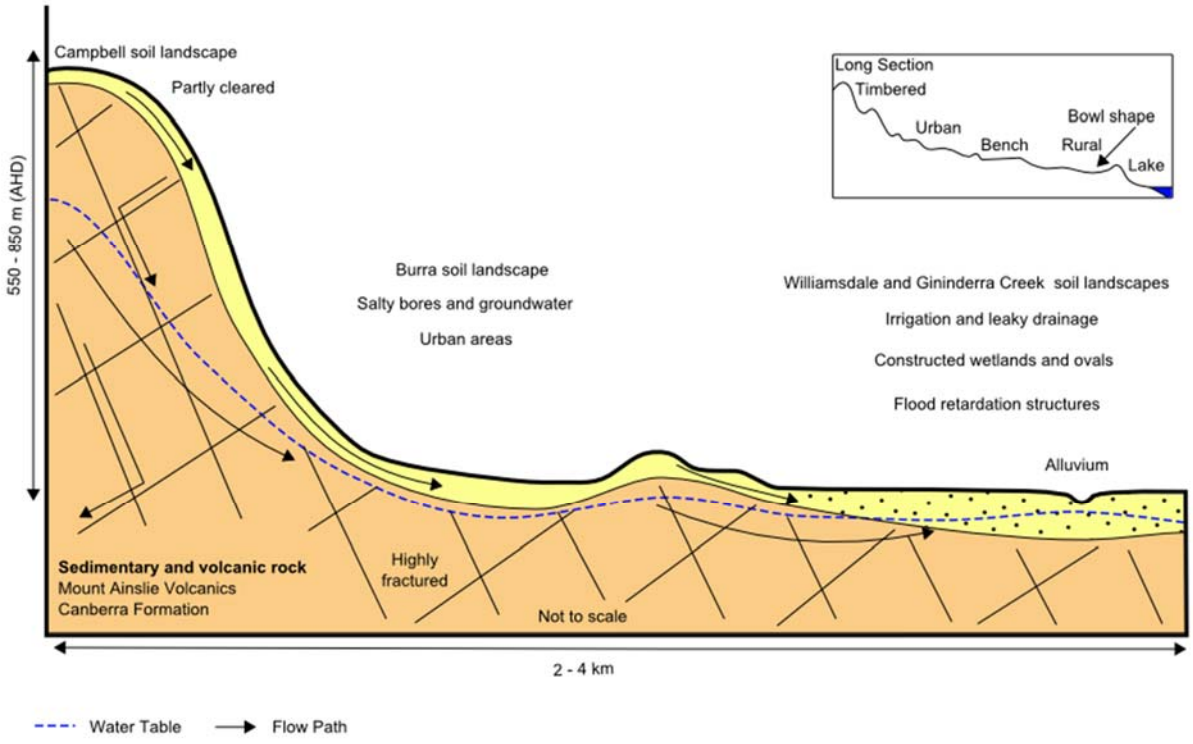


Figure 2: Conceptual cross-section for Sullivans Creek HGL showing the distribution of regolith and landforms, salt sites if present, and flow paths of water infiltrating the system.

Salinity expression in this HGL is in the form of stream salt load and EC (Table 1).

Table 1: Sullivans Creek HGL salinity expression.

SALINITY EXPRESSION	
Land Salinity (Occurrence)	Low – no land salinity observed.
Salt Load (Export)	Moderate – marginal (800–1600 µS/cm) bore water observed suggesting salt in base flow.
EC (Water Quality)	Moderate – marginal (800–1600) salt in base flow.

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 Sullivans Creek HGL has moderate mobility. There is a moderate salt store that has moderate availability (Table 2).

Table 2: Sullivans Creek HGL salt store and availability.

SALT MOBILITY			
	Low availability	**Moderate** availability	**High** availability
High salt store			
Moderate salt store		**Sullivans Creek**	
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 Sullivans Creek HGL is low. This is due to the moderate likelihood that salinity issues will occur and that they would have potentially limited impacts (Table 3).

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

OVERALL SALINITY HAZARD			
	Limited potential impact	**Significant** potential impact	**Severe** potential impact
High likelihood of occurrence			
Moderate likelihood of occurrence	**Sullivans Creek**		
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: Constructed wetland in Sullivans Creek HGL (Photo: OEH / R Muller).

Photo 2: Constructed channel with ovals adjacent to drainage line in the mid-section of HGL (Photo: OEH / R Muller).

Photo 3: Stabilized gully adjacent to Horse Park Drive (Photo: DPI / A Nicholson).

Photo 4: Natural vegetation north of Horse Park Drive indicating rises and hills of upper landscape units (Photo: DPI / A Nicholson).

Photo 5: Horse Park Drive adjacent to Majura HGL indicating steep hills of upper landscape units (Photo: DPI / A Nicholson).

Photo 6: Mid-slope landscape of Sullivans Creek HGL in the vicinity of Mitchell (Photo: DPI / A Nicholson).

Photo 7: Civic and Lake Burley Griffin in the lower section of Sullivans Creek HGL (Photo: DPI / A Nicholson).

Photo 8: View to the west from Mt Ainslie across the broad lower landscape units of the urbanised component of Sullivans Creek HGL (Photo: DPI / A Nicholson).

Photo 9: Intersection of Northbourne Avenue and Antill Street in Dickson, indicating the heavily urbanised area of Sullivans Creek HGL (Photo: DPI / A Nicholson).

Table 4: Summary of information used to define Sullivans Creek HGL.

Lithology *(Raymond et al. 2007; Geoscience Australia 2015)*	This HGL comprises a range of rock types including felsic volcanics, sedimentary rocks and unconsolidated sediments. Key lithologies include: • Canberra Formation • Mount Ainslie Volcanics • Mount Painter Volcanics • Colluvium and alluvium
Annual Rainfall	600–750 mm
Regolith and Landforms	Soil generally <1 m deep higher in the landscape and >1 m deep on lower slopes and in drainage lines. Deeper soil and imperfect drainage in the lower landscape provide moderate potential for salt store. Slopes generally 10–32%; 0–10% in wide and flat valley bottoms. Elevation range is 550–850 m

Soil Landscapes *(Jenkins 1993; Jenkins 2000; Cook & Jenkins in prep)*	The following soil landscapes are dominant in this HGL: • Williamsdale • Burra • Ginninderra Creek • Campbell Normal distribution of soils in this HGL has been modified by earthworks in urban areas. The following classifications describe the soil types in their undisturbed (pre-urbanised) condition. Many of the properties attributed to these soil types will remain despite the high degree of disturbance. Clastic Rudosols occur on crests generally along the catchment divide that forms the margin of this HGL. Well drained Red and Brown Kandosols (Red and Yellow Earths) are found on upper slopes. Red Chromosols and Red Kurosols (Red Podzolic Soils) occur on mid slopes. Brown Chromosols (Yellow Podzolic Soils and Brown Kandosols (Yellow Earths) on better drained lower slopes. Poorly drained Sodosols (Solodic Soils) and Sodic Brown Chromosols (Brown and Yellow Podzolic Soils) on lower slopes adjacent to drainage lines. Deep Stratic Rudosols (Alluvial Soils) on floodplain elements.
Land and Soil Capability	Class 5
Land Use	• urban development • nature reserves • grazing
Key Land Degradation Issues	• water erosion • sodicity
Native Vegetation *(Keith 2004; Gellie 2005; Dept. of Environment 2012)*	This HGL is situated within the IBRA7 South Eastern Highlands (Murrumbateman subregion). The HGL is extensively cleared with remaining vegetation formations comprising Grassy Woodland and Dry Sclerophyll Forest. 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 Sullivans Creek HGL

Aquifer Type	Unconfined to semi-confined in fractured rock and saprolite Lateral flow through unconsolidated colluvial and alluvial sediments on lower slopes and in flow lines
Hydraulic Conductivity	Moderate Range: 10^{-2}–10 m/day

Aquifer Transmissivity	Moderate Range: 2–100 m^2/day
Specific Yield	Moderate Range: 5–15%
Hydraulic Gradient	Gentle Range: <10%
Groundwater Salinity	Fresh to marginal Range: <800–1600 µS/cm
Depth to Watertable	Intermediate Range: 2–8 m
Typical Sub-Catchment Size	Medium (100–1000 ha)
Scale (Flow Length)	Local to intermediate Flow length: <10 km (short to intermediate)
Recharge Estimate	Moderate
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 have impacts 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 – Sullivans Creek 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.
- **E.** The landscape receives and stores salt load through irrigation or surface flow.
- **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.

Landscape Management Strategies – Sullivans Creek HGL

Appropriate strategies pertinent to this landscape:

- **Stop discrete landscape recharge (3).**
- **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.
- **Dry out the landscape with diffuse actions over most of the landscape (6)**: Encourage plant growth and increase plant water use in order to use excess soil moisture and shallow groundwater. Healthy, actively growing vegetation will also buffer groundwater accessions in wet seasonal conditions.
- **Minimise recharge in lower parts of the landscape and maximise runoff to streams (9).**

Key Management Focus – Sullivans Creek HGL

This landscape has a drainage system dominated by urban storm water management with flood detention structures, constructed channels and constructed wetlands. Recent efforts to create functioning wetland systems can be seen.

In the northern area near Horse Park Drive, water-sensitive design principles will be important in new suburbs. In the southern area, in suburbs such as Lyneham and Dickson, existing water management infrastructure is based on control and disposal of storm water with little ecological function. Newly constructed wetlands are adding ecological function to these older systems (e.g. David Street Wetland).

Salinity management will include management of irrigation of public and private areas and vegetation management across the landscape.

Specific Land Management Opportunities

Specific opportunities for this HGL:

- some high recharge zones have native tree vegetation on them – Black Mountain, Bruce Ridge and Mount Majura
- comparatively small areas of irrigated private lawns
- conservation areas throughout landscape.

Specific Land Management Constraints

Constraints on land management in this HGL include:

- pace of development adjacent to Gungahlin
- old constructed channels in earlier developments which are hard to modify.

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.

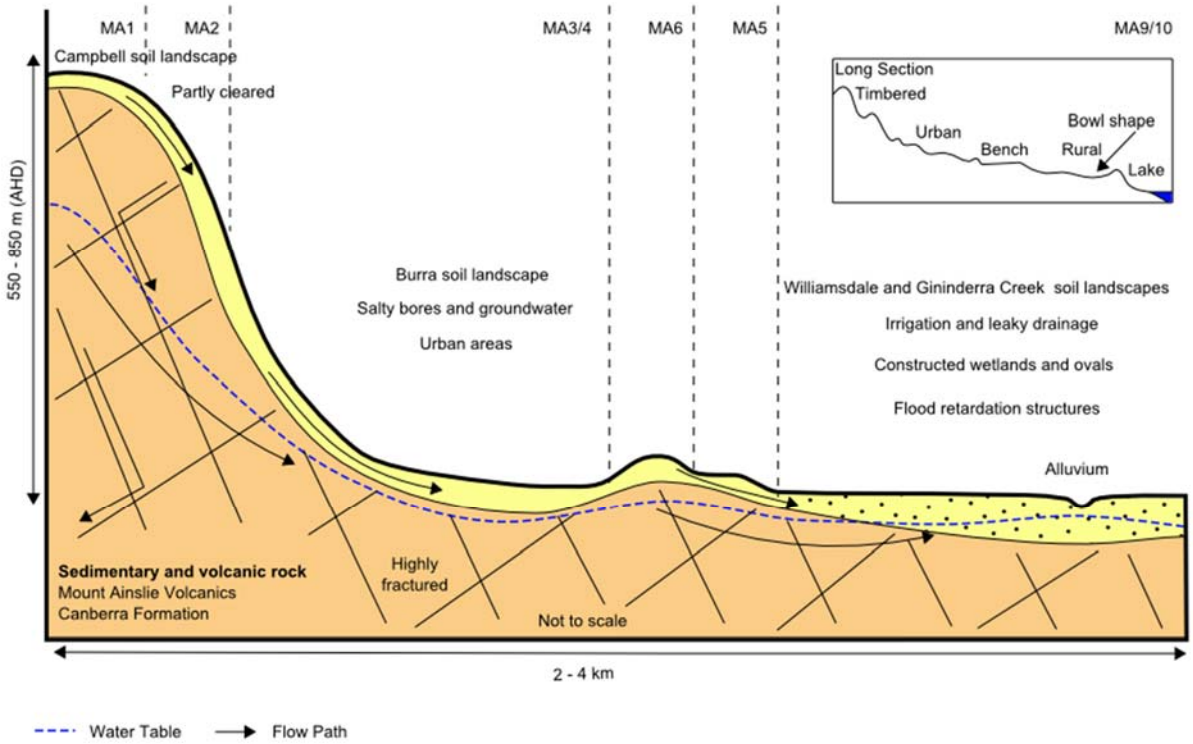


Figure 3: Management cross-section for Sullivans Creek HGL showing defined management areas.

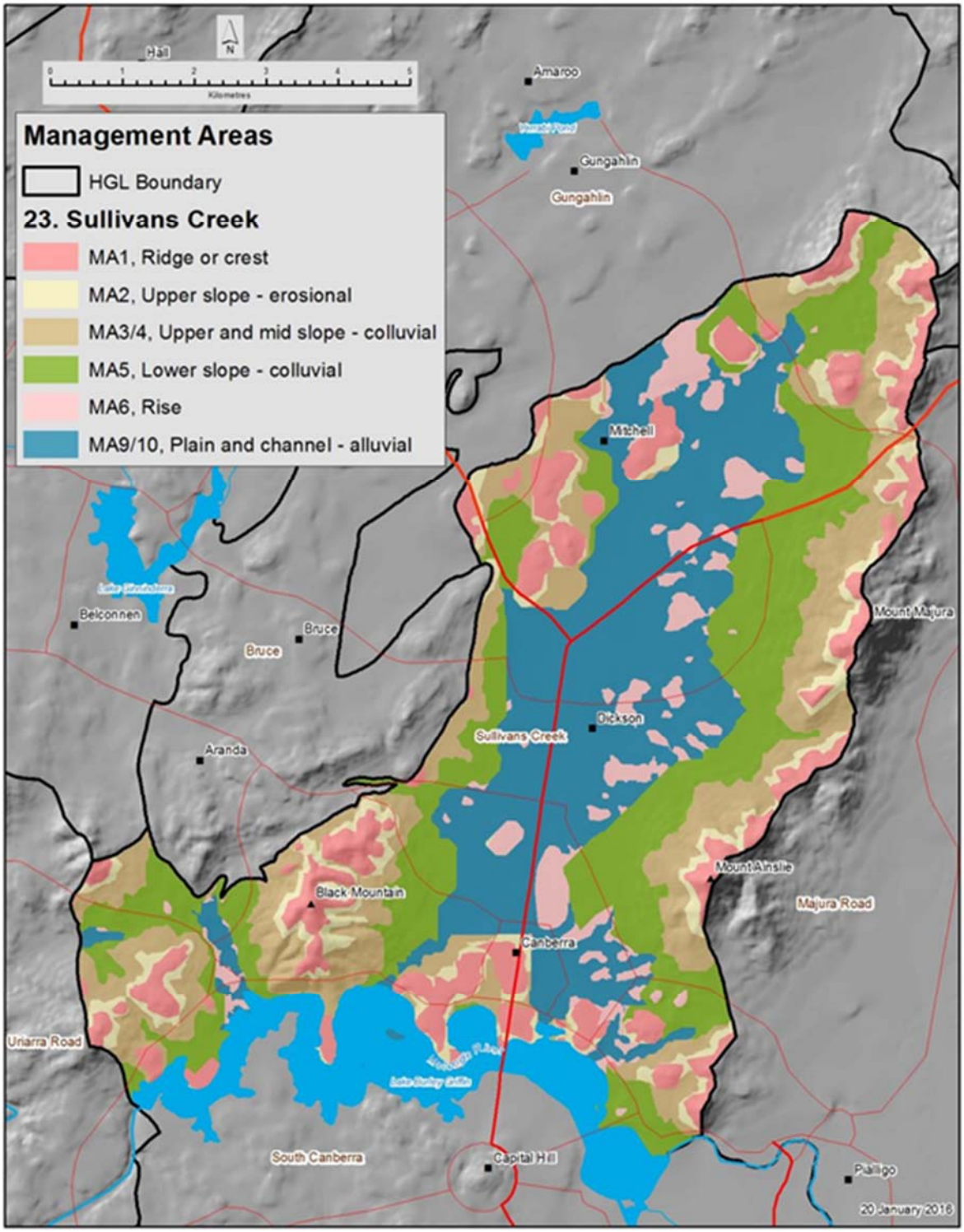


Figure 4: Spatial distribution of management areas for Sullivans Creek HGL.

Table 6: Specific management actions for management areas within Sullivans Creek HGL

Management Area (MA)	Action
MA 1 (RIDGES)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** **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)**
MA 2 (UPPER SLOPES – EROSIONAL)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** **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)**
MA 3/4 (UPPER SLOPE – COLLUVIAL)	**Urban management actions as appropriate** **Vegetation for ecosystem function** Interception planting of native woody species to target shallow groundwater **(VE2)** **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)**
MA 6 (RISES)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** **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)**
MA 5 (LOWER SLOPE – COLLUVIAL)	**Urban management actions as appropriate** **Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3)** Interception planting of native woody species to target shallow groundwater **(VE2)** **Vegetation for production** Improve grazing management of existing perennial pastures to

Management Area (MA)	Action
	manage recharge **(VP1)** 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 9 (ALLUVIAL)	**Urban management actions as appropriate** **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)** **Irrigation Systems** On farm (site) Irrigation management BMP**(IS1)** Establish effective effluent disposal systems specific to site conditions **(IS3)**
MA10 (CONSTRUCTED RIPARIAN)	**Urban management actions as appropriate** **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)** **Irrigation Systems** Establish effective effluent disposal systems specific to site conditions **(IS3)**

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 Sullivans Creek HGL.

At Risk Management Areas	Action
MA 1, 2 ,3, 4 & 6	Clearing and poor management of native vegetation **(DLU4)** Poor management of grazing pastures **(DLU2)**
MA 5	Poor management of grazing pastures **(DLU2)** Clearing and poor management of native vegetation **(DLU4)** Poor targeting of locations suitable for irrigation **(DLU14)**

At Risk Management Areas	Action
MA 9 &10	Clearing and poor management of native vegetation **(DLU4)** Locating infrastructure on discharge areas **(DLU7)** Poor irrigation practises **(DLU13**) Loading of soils with salt through irrigation and flow management (**DLU15)**

Urban Management Strategy Objectives – Sullivans Creek 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.
- **Riparian Management (RM**): Vegetation management in riparian areas will help minimise salt export to streams.
- **Urban Management (UM)**: The input of water into the landscape (from lawns, gardens, sporting fields) including the management of recycled water, requires careful management.

Medium priority

- **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 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 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 some salinity throughout this HGL that need to be identified.

Specific Land Management Opportunities

There is a range of 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.

Specific Land Management Constraints

Constraints on land management in this HGL include:

- there is some salt store in the upper landscape from which the impact of salinity on lower slopes should be limited
- sodic and dispersive subsoils

- avoid excessive infiltration water of into soils.

Table 8: Specific urban management actions for management areas within Sullivans Creek 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 of 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 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** 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 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 use **(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 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 Sullivans Creek HGL.

AT RISK MANAGEMENT AREAS	ACTION
MA 2,3,4,5,6,9,10	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 South-east 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