Salinity Management Strategy

Daisy Hill Rural-residential Estate

Ref: R13365sms3
Date: 20 March 2020

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Environmental
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Services

Client:	Bourke Securities 30R Eulomogo Road Dubbo NSW 2830
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Report number:	R13365sms3
Date:	20 March 2020

Contents

1. Introduction

The Daisy Hill Salinity Management Strategy (SMS) has been prepared to support the rezoning and development process of the proposed Daisy Hill subdivision. Extensive research into current conditions on the site and downstream of the Daisy Hill precinct has produced the Daisy Hill Groundwater and Salinity Study dated August 2017, the Daisy Hill Vegetation Management Plan and the Daisy Hill On-site Effluent Management Study. These documents and the Dubbo City Urban Salinity Management Strategy and the Dubbo City Urban Salinity Implementation Strategy were used in preparation of this Salinity Management Strategy.

Daisy Hill Estate is a rural-residential subdivision proposed for Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW. Total development area is approximately 430 hectares. The conceptual plan includes 222 rural-residential lots ranging in size from a lot size of 0.6ha to 3ha. A single dwelling is proposed for each lot.

A groundwater and soil salinity assessment was undertaken and the report reviewed by Dubbo Regional Council. Dubbo Regional Council requested additional information. The planning proposal was referred to the Department of Planning and under Section 52 (2) of the Environmental Planning and Assessment Act 1979 it was determined the development should proceed subject to conditions including the preparation of a Salinity Management Strategy.

Following several technical workshops with the proponent and officers of the Department of Planning (DOP), Dubbo Regional Council (DRC), Department of Primary Industry (DPI) and the Office of Environment and Heritage (OEH) the DPI suggested water usage rates of 0.20 Megalitres/hectare be used for the Daisy Hill water balance modelling. Actual water usage for the 10 year period 2007 to 2017 were supplied by DRC. The water usage in Richmond Estate was 6.79mm/week (0.07ML/ha) and Firgrove Estate 7.72mm/week (0.08ML/ha). Simulation modelling of water usage on Daisy Hill was undertaken using irrigation rates up to 25mm/week (0.25ML/ha) to be conservative and enable robust predictions to be achieved. The simulation modelling demonstrated no increases in groundwater recharge will occur from the Daisy Hill.

The strategy addresses salinity management and describes procedures to be implemented in the development to prevent impacts on downstream salinity.

This report provides the Salinity Management Strategy to comply with the Dubbo Regional Council Salinity Policies.

2. Previous assessments

Extensive groundwater and salinity assessments have been undertaken to assess the occurrence of groundwater and salinity impacts on the site. The assessments also includes the potential for future impacts from the development on the site and within the Troy Gully catchment where salinity impacts have historically been observed and management actions implemented including tree planting.

The assessments have included input from the Department of Planning and Environment (DOP&E), Department of Primary Industries (DPI) and Office of Environment and Heritage (OEH). Government agency involvement has ensured an independent assessment and that all factors required by each department were addressed.

The following assessments and reports have been undertaken since March 2017.

- Terrabyte Services (March 2017) EM31 survey map

- Envirowest Consulting Pty Ltd (May 2017) *Hydraulic model simulations for Daisy Hill* (Report number L13365s12.1)
- Envirowest Consulting Pty Ltd (August 2017) *Hydraulic Model Simulations for Daisy Hill* (Report number L13365s12.2)
- Envirowest Consulting Pty Ltd (August 2017) *Updated groundwater and salinity study* (Report number R13365s6)
- Envirowest Consulting Pty Ltd (December 2017) *Hydraulic model simulations for Daisy Hill* (Report number L13365s13)
- EMM Consulting (March 2018) *Peer review* (requested by DOP&E)
- Soilwater Group (April 2018) *Peer review of the Groundwater and Salinity Study for the Proposed Daisy Hill Development* (Report number BSP-001-1-10)
- Envirowest Consulting Pty Ltd (April 2018) *Additional groundwater information Daisy Hill* (April 2018)
- EMM Consulting (June 2018) *Final findings and recommendations to the DOP&E*

The assessments and reports have been endorsed by:
Mr John Lawrie, Soil Science Society of Australia, Certified Professional Soil Scientist (Level 3)
Soilwater Consulting, 45 Gladstone Street, East Perth WA
EMM Consulting, engaged by DOP&E to undertake reviews

A range of assessment techniques were adopted to describe the development and determine salinity impacts including Electromagnetic (EM) survey, borehole and monitoring well construction, soil sampling, analysis and modelling. The EM survey was conducted over the whole site to provide information on the variability of soil apparent conductivity and to identify the location of the interface between the Pilliga Sandstone and Purlewaugh Formation geological units. The interface had been identified through review of hydrogeological landscapes as a potential area of higher soil salinity.

The EM results were validated by construction of 26 boreholes in areas of varying conductivity by soil sampling and analysis for electrical conductivity, pH, dispersion, soil texture and colour. The boreholes also enabled identification of other soil characteristics such as moisture and texture which may have influenced the survey results.

The soil analysis results indicated very low to low soil salinity in the upper 6m of soil across the majority of the site. Higher soil salinity levels were identified in one borehole in the eastern section of the site. The saline subsoils area was identified in the EM survey and determined to be the interface between the Pilliga Sandstone and Purlewaugh Formation geological units.

Eight groundwater monitoring wells were constructed across the site to a depth of up to 16m in 2017. Groundwater was identified at depths greater than 10m across the majority of the site with groundwater not detected at depths of 16m over at least half the site. Groundwater was identified at 1.4m below the surface in the central northern section of the site. The groundwater monitoring wells are suitable to be incorporated in the Dubbo Regional Council Salinity Network. The salinity network indicates groundwater varies with total rainfall.

Identification of the interface between the Pilliga Sandstone and Purlewaugh Formation geological units enabled the subdivision layout to be redesigned to allow for mitigation strategies to be implemented. The mitigation strategies include establishing deep rooted vegetation in road reserves and tree lots. Roads were designed to be located along the geological interface with a road reserve on the upper side of the road wide enough to enable a 30m wide vegetation buffer. Road reserves in other areas were designed to allow 10m wide vegetation buffers on either side of the road.

Water balance modelling was undertaken to predict impacts on soil and groundwater salinity following development of the site. The modelling results indicated that the proposed mitigation measures would prevent adverse impacts on soil and groundwater salinity both on the site and off-site within the Troy Gully catchment.

No visible preferential recharge or active discharge sites located within the development area. Some areas of salinity have been identified in the north eastern area section of the site. The areas of saline soil are from the interface with underlying sandstone rather historical seepage areas. The design of the subdivision avoids impacts on the saline areas.

3. Salinity management strategy

3.1 Strategy aim

The aim of the Daisy Hill Salinity Management Strategy is:

- To promote an integrated landscape management approach to urban salinity management consistent with the principles of ecologically sustainable development
- To manage the collection and use of reliable baseline data to quantify the saline status and ensure future monitoring, management and planning is adequate, effective, scientifically justified and cost effective.
- To ensure that urban salinity identification, management and education is in accordance with best practice and is central to sound, responsible environmental and land-use planning.

3.2 Strategies

The Dubbo City Urban Salinity Implementation Plan will be the planning tool for salinity management and guide the Daisy Hill Salinity Management Strategy actions.

The Dubbo City Urban Salinity Implementation Plan has been developed around five factors associated with the Dubbo City Urban Salinity Management Strategy. These are salt impact, groundwater recharge, land-use, infrastructure and monitoring. Outcomes for each factor have been developed to guide implementation of the strategies.

The adopted strategies and associated outcomes are described in Table 1.

Table 1. Salinity Management Strategies

Strategy	Outcome
1. Salt impact *To ensure the salt impact on the landscape is minimized and managed*	1.1 The discharge of salt into the groundwater system, river and streams is minimized 1.2 Salt stores are buffered to limit their interaction with shallow groundwater
2. Groundwater recharge *The volume of water with the potential to enter into and contaminate the natural system is minimised*	2.1 Lateral flow of shallow groundwater is intercepted and reduced 2.2 Excess soil moisture within the landscape is utilized 2.3 Ponding of water on discharge sites is minimised 2.4 Discharge to the groundwater system is minimised 2.5 Discharge of water into the landscape is minimised
3. Land use *Water usage and land-use activities are appropriate for the soil landscape in managing urban salinity and do not contribute to an increase in the assessed salinity hazard of the landscape*	3.1 The use of salinity affected land is undertaken in accordance with best practice management principles 3.2 Salinity risk is considered in the land-use planning process 3.3 The extent to which land-use activities and practices contribute to salinity hazard is understood

4. Infrastructure *Public and private infrastructure development and maintenance is consistent with the salinity hazard of the landscape*	4.1 Construction techniques are responsive and appropriate for the salinity risk of the landscape 4.2 Urban development on at risk landscapes specifically addresses the impacts on salinity 4.3 Existing infrastructure is maintained to minimize salinity impacts on the landscape and ongoing maintenance requirements.
5. Monitoring *The capacity to predict and monitor salinity affected land resources and biodiversity is maintained*	5.1 The impacts of development on groundwater are recognized, measured and monitored. 5.2 The overall situation of salinity at Daisy Hill is understood 5.3 Groundwater modelling is provided in a spatial capacity

3.3 Implementation

The Dubbo City Urban Salinity Implementation Plan provides salinity management actions for Hydrogeological Landscapes (HGLs) which are further divided into Management Areas (MAs) (based on topography) within each HGL.

The relevance of each strategy outcome is dependent on the characteristics of the HGLs and MA within each HGL. Figure 1 describes the location of each HGL and MA applicable to the site. Richmond Estate HGL occurs over the majority of the site on the northern side of Eulomogo Road with MA1 and MA2 in the eastern section and MA3 in the central and western sections. Firgrove HGL occurs on the southern side of Eulomogo Road and includes MA1 and MA1.

Implementation actions were adopted which targeted land management actions for each HGL and MA. Table 2 describes the actions to achieve the strategic outcomes, how the action will be adopted within the development design for Daisy Hill Rural-residential Estate and the HGL and MA relevant for each action.

Table 2. Actions for salinity management

Action	Response	Applicable HGL and management area	Strategic outcome (Table 1)
Urban investigations			
• Investigate concentration and composition of salts in the soil profile, groundwater and surface waters during initial site assessment to determine salinity hazard (UI1)	A soil and groundwater salinity assessment was undertaken over the site. The assessment comprised a visual inspection and desktop review. Boreholes were drilled and groundwater and soil samples collected from varying depths.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA3	4.2 5.1 5.2
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken over the site. The contact between the Pilliga Sandstone and Purlewaugh Formation. The contact was identified by high conductivity as well as soil analysis results. EM surveys were undertaken to indicate areas of high soil salinity.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1 Firgrove – MA2 Firgrove – MA3	4.2 5.1
Urban construction			
• Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material is not saline (UC1)	The final subdivision design will ensure depth of cut and exposure of susceptible soils is minimised. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be non-saline.	Richmond – MA2 Firgrove – MA2 Firgrove – MA3	3.2 4.1
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). The road	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1 Firgrove – MA2	2.3 3.2

	drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will be used by vegetation reserves. At times of high rainfall the surface drain will direct water off-site. No stormwater detention basins or ponds will be constructed. The existing farm dams will be backfilled. No farm dams will be constructed on the lots and enforced by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.	Firgrove – MA3	
• Consider the use of salt protected materials for services, e.g. salt resistant drainage pipes, casing of underground services (UC7)	Saline soils were generally not identified in the upper 1m of the site. Houses, buildings and infrastructure (roads and services) in areas of highly saline soil will be designed in accordance with building in saline areas.	Richmond – MA2	4.1
• Minimise the alteration of natural drainage patterns through construction of houses, roads, railways, channels etc. (UC8)	No defined drainage lines are present on the site. Surface water is directed by contours to the north west. The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance to natural flows.	Richmond – MA2 Richmond – MA3 Firgrove – MA2 Firgrove – MA3	3.2 4.1
Urban planning			
• Prior to commencement of earthworks sodic/saline soils should be identified (UP1)	Identification of sodic/saline soils was undertaken by EM survey and soil borehole sampling and analysis.	Richmond – MA2	4.2
• 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)	Standing water bodies are not proposed as part of the development. Existing farm dams will be backfilled. No farm dams will be constructed as implemented by a Section 88B instrument.	Richmond – MA3 Firgrove – MA1 Firgrove – MA2 Firgrove – MA3	2.3 3.2
• Identification of discharge sites should influence the size of the area to be developed (UP3)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.	Richmond – MA2 Firgrove – MA3	2.3 3.2
• 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)	The area containing MA2 is proposed to be rezoned as minimum 1.5ha and minimum 3ha blocks which will contain impervious areas to prevent recharge including dwellings, driveways and public roads. Stormwater runoff from the roads will be directed to roadside drains. The subdivision layout will be designed to allow the roadside drains in MA2 to discharge into areas downslope (MA3). The road drains will be designed to avoid large volumes of runoff infiltrating the ground at any one location.	Richmond – MA2	2.3
• Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revised principles of WSUD where salinity affects are an issue (UP5)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). Planting of deep rooted vegetation will utilise subsoil moisture and will reduce the occurrence of deep drainage.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1	3.1

Urban management			
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be backfilled. No farm dams will be constructed as implemented by a Section 88B instrument. No stormwater detention basins or ponds will be constructed.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1 Firgrove – MA2 Firgorve – MA3	2.3 4.3
• Employ deficit irrigation principles to prevent over-irrigation of sports grounds, golf courses, parks, private gardens and lawns (UM2)	No public open space areas or golf courses are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.	Firgrove – MA3	2.5
• Manage plant growth to maximise water usage. Consider harvesting mature zones of vegetation and replanting for ongoing water use efficiency (UM3)	Management of plant growth will be controlled by individual lot owners. Dubbo City Council will be responsible for the management of vegetation along the road reserves.	Firgrove – MA3	2.5
Urban vegetation			
• Retain or establish areas of deep-rooted salt tolerant indigenous vegetation to manage recharge or discharge site (UV1)	The majority of the site has been cleared. Existing vegetation is annual pastures. No additional tree clearing is expected to be undertaken. Deep-rooted vegetation comprising trees will be planted along road reserves using species recommended by DCC (no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation and areas of moderately saline soils in the central and western sections of the site. Promotion of deep-rooted vegetation plantings will be undertaken to future owners of the site.	Richmond – MA2 Richmond – MA3 Firgrove – MA2 Firgrove – MA3	1.1 1.2 2.1 2.2 2.4
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1 Firgrove – MA2 Firgrove – MA3	1.1 1.2 2.1 2.2 2.4
• Develop native landscaping and "waterwise" gardens to reduce over-irrigation and water usage (UV3)	Native landscaping will be undertaken within the road reserves using species recommended by DCC (no date). A 5.7ha public open space will be created in the central northern section of the site. Extensive native tree and shrub planting will be undertaken across the area. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA3	2.5
• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA2 Firgrove – MA3	1.1 2.1 2.2 2.4

	Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.		

4. Recommendations

4.1 Staging

Stage 1 of the development has been located on the elevated landscape on the southwestern side of the Daisy Hill precinct bordering Eulomogo Road. This location has access to all services (power, water and telecommunications) (Figure 2), more importantly there is no groundwater to 16 metres (depth of well MW2) at this site. It is proposed to transition future stages to the north/northwest where there is no groundwater to 12 metres (depth of hole MW1A, Figure 3).

The timing and make up of these stages will be influenced by market forces.

4.2 Re-vegetation mitigation measures

There are four scenarios (Figure 4) where re-vegetation will occur throughout the subdivision to achieve the outcomes of this Salinity Management Strategy and the Vegetation Management Plan.

4.2.1 Road reserves

Two types of road reserves are planned for the Daisy Hill subdivision (Figure 5) both containing vegetation zones. The make up and locations of these individual designs were the result of consultation with officers of the Department of Primary Industry and Environment and the Office of Environment and Heritage and were predicated on results of the extensive salinity research previously carried out.

- 35m Road Reserve: This is the dominant road network and has a total length of just over 15km. This road reserve consists of a 10 metre wide vegetation area either side of the road, giving a total vegetated area of 28.9ha.
- 45m Road Reserve: This is a minor road reserve, deliberately located over what is perceived as the interface between the Pilliga Sandstone and Purlewaugh Formation and has a total length of 1.1km. This road reserve consists of a 30 metre wide vegetation area located on the high side of the road, giving a total vegetated area of 3.2ha.

4.2.2 Road verges and table drains

A 3 metre wide table drain/verge will be located on both sides of all roads to capture any surface water runoff from the road. The table drains/verges in the development will have a total area of 13.0 Ha.

4.2.3 Vegetative buffer zones

The vegetation buffer zones are located on the eastern side of the proposed subdivision, once again overlaying the area thought to be the interface of the two hydro-geological landscapes and cover an area of 3.3ha.

Tree and shrub plantings in road reserves and buffer zones will be carried out at the completion of each stage. Deep rooted native tree and shrub selection will be tailored to individual site conditions at this time.

4.2.4 Targeted tree planting area

In the central northern portion of the proposed development, located over the area of shallowest groundwater, is a 5.7ha reserve dedicated to the planting of deep rooted native trees and shrubs.

It is envisaged that Stages 4 or 5 will identify, locate and service (water, roads, fencing) this area.

Timing for planting in the 5.7ha tree planting area will be as follows:

- Prior to the release of the Subdivision Certificate for the 55th lot (25%) in the subdivision, the tree planting area should be at least 25% (1.4ha) complete.
- Prior to the release of the Subdivision Certificate for the 110th lot (50%) in the subdivision, the tree planting area should be at least 50% (2.8ha.) complete.
- Prior to the release of the Subdivision Certificate for the 165th lot (75%) in the subdivision, the tree planting area should be 100% (5.7ha) complete.

The vegetation species will be selected from the attached Vegetation Management Plan.

4.3 Ongoing monitoring of salinity and groundwater

A salinity and groundwater monitoring action program has been development (Appendix 1). The plan describes responsibilities, type of monitoring, reporting periods, triggers and actions.

Dubbo Regional Council (DRC) has an extensive network of groundwater monitoring wells for the purpose of monitoring the levels of salinity and groundwater in and around the Dubbo city area (Figure 6). The wells are monitored and recorded on a bi-monthly basis.

Special attention will be paid to levels in the monitoring wells within a 1km radius of Daisy Hill for the purpose of detecting any extraordinary irregularities in salinity and/or groundwater.

Further, a monitoring well will be installed in the road reserve, at the low point of each stage of the development and introduced into the DRC Salinity Monitoring Network for this purpose.

It should be noted that climatic events such as periods of high rainfall and droughts affect and alter the groundwater levels dramatically (Figure 7). Mitigation measures would have to be triggered by impacts which can be attributed to the Daisy Hill development alone after removal of seasonal and rainfall influences.

Further benefits for the location of the early stages of the development was that, in the unlikely event of adverse impacts on salinity and/or groundwater being detected, there would be ample time and space to implement further mitigation measures such as a large tree planting area along the north western frontage to Pinedale Road and possible adjustment to lot sizes.

Any further mitigation measures would be administered and paid for by the developer.

4.4 Biodiversity

The developers are very aware that Biodiversity will have to be addressed during the Development Application phase of the Daisy Hill proposal and are currently seeking advice on this issue.

4.5 Urban sensitive design

The final subdivision plan will maintain the natural drainage pattern by minimising soil disturbance. The depth of cut will not expose susceptible soils. Earthworks in areas of saline subsoil will be restricted to depths of less than 500mm reducing the risk of exposure of saline subsoils. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be non-saline.

The existing trees along the unformed road on the site will be maintained. Additional trees will be established by individual landholders.

The building envelope for the lot in the north-eastern corner of the investigation area under the conceptual plan will be sited outside of higher saline areas as identified by the EM survey. Preliminary exposure classifications (Appendix 1) indicate the site is non-saline and A1 (Australian Standards, *AS 2870-2011*, 2011). Design characteristic strength for concrete is a minimum of 20MPa and minimum curing requirement is continuous curing for at least 3 days. Minimum reinforcement cover for concrete in soils is 40mm. Site specific testing should be undertaken to confirm exposure classification. Infrastructure including roads and buildings will be engineered with consideration of soil aggressiveness.

4.6 Reduce groundwater recharge

Existing dams will be backfilled and no new dams will be constructed in the development preventing leaking water recharging the groundwater. Runoff from roads and other hard areas will be discharged to a drainage network which is adjacent to the vegetation buffers. No stormwater detention basins or ponds will be constructed.

On-site effluent systems will be installed for each dwelling comprising secondary treatment and irrigated application systems. The effluent application system will sized to prevent percolation of water below the root zone.

Swimming pools will be regulated to utilise paper filters rather than sand filters. Paper filters do not require backwashing therefore reducing recharge to groundwater. The requirement for paper filters on pools will be enforced by a Section 88B instrument.

4.7 Rainwater reuse

All buildings will be connected to 45,000 rainwater tanks to reduce groundwater recharge. The rainwater will be used for garden watering at a time when it will be utilised by plants and not infiltrate into the soil. Collection of roof water will be enforced by a Section 88B instrument.

4.8 Waterwise gardening

Waterwise gardening will be promoted to future land owners throughout the development. This promotion will be undertaken by the developer. Dubbo Regional Council has a waterwise promotion program. Low water use gardens are achieved by reducing areas of irrigated lawn and the use of perennial native species. Community trends towards waterwise gardening are expected to become more common over time. Waterwise gardening will be further encouraged by enforcing restrictions on the extraction of groundwater at the site. Native species and waterwise gardening will result in minimal requirements for applications of fertilisers and herbicides.

5. References

DCC (2013a) *Richmond Estate Hydro-geological landscape* (Dubbo City Council)

DCC (2013b) *Firgrove hydro-geological landscape* (Dubbo City Council)

DCC (2013c) *Dubbo City Urban Salinity Management Strategy* (Dubbo City Council)

DCC (2013d) *Dubbo City Urban Salinity Implementation Plan* (Dubbo City Council)

Figures

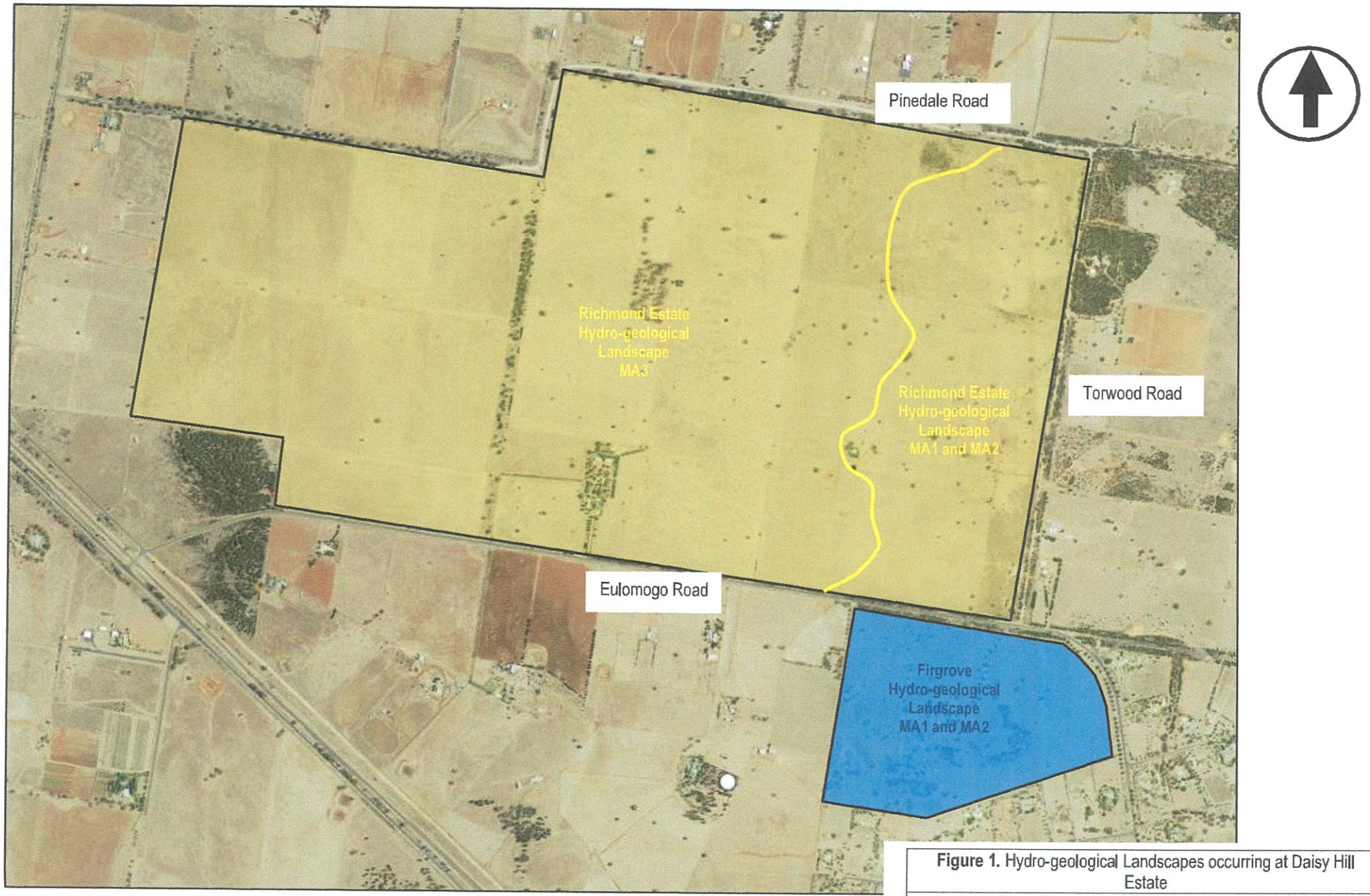

Figure 1. Hydro-geological Landscapes occurring at Daisy Hill Estate

Daisy Hill Estate, Eulomogo Road, Dubbo NSW

	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: LD	Date: 6/12/2019

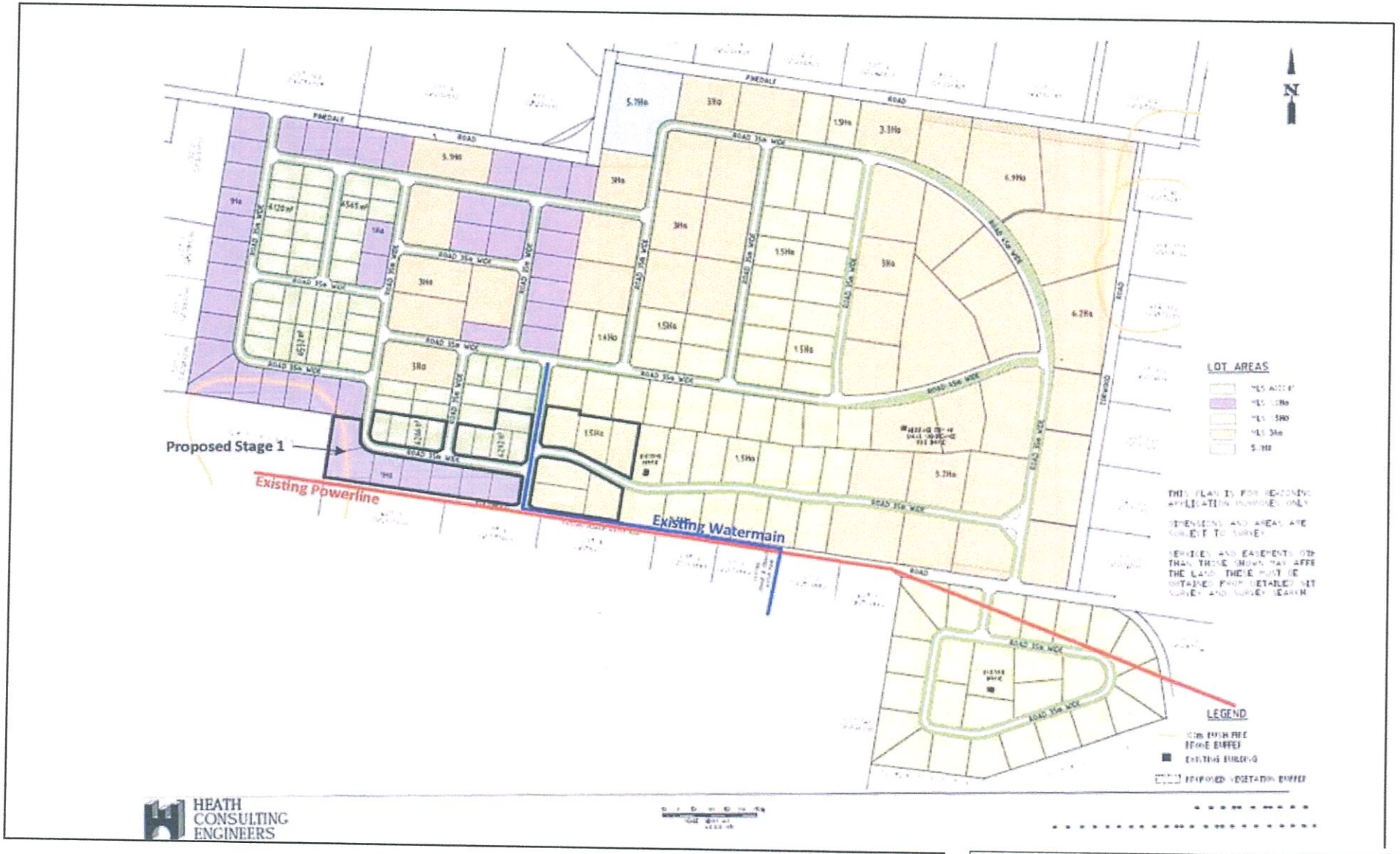

Figure 2. Existing service plan		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: -	Date: 6/12/2019

BOURKE SECURITIES PTY LTD	I : Surface elevation across the proposed Daisy Hill Subdivision, showing the southeast to northwest relief	soilwater GROUP
VEGETATION MANAGEMENT PLAN (VMP) FOR THE DAISY HILL SUBDIVISION		

Figure 3. Groundwater elevations		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: -	Date: 6/12/2019

BOURKE SECURITIES PTY LTD	Proposed Revegetation Areas for the Daisy Hill Subdivision	soilwater GROUP
VEGETATION MANAGEMENT PLAN (VMP) FOR THE DAISY HILL SUBDIVISION		

Figure 4. Road reserve revegetation

Daisy Hill Estate, Eulomogo Road, Dubbo NSW

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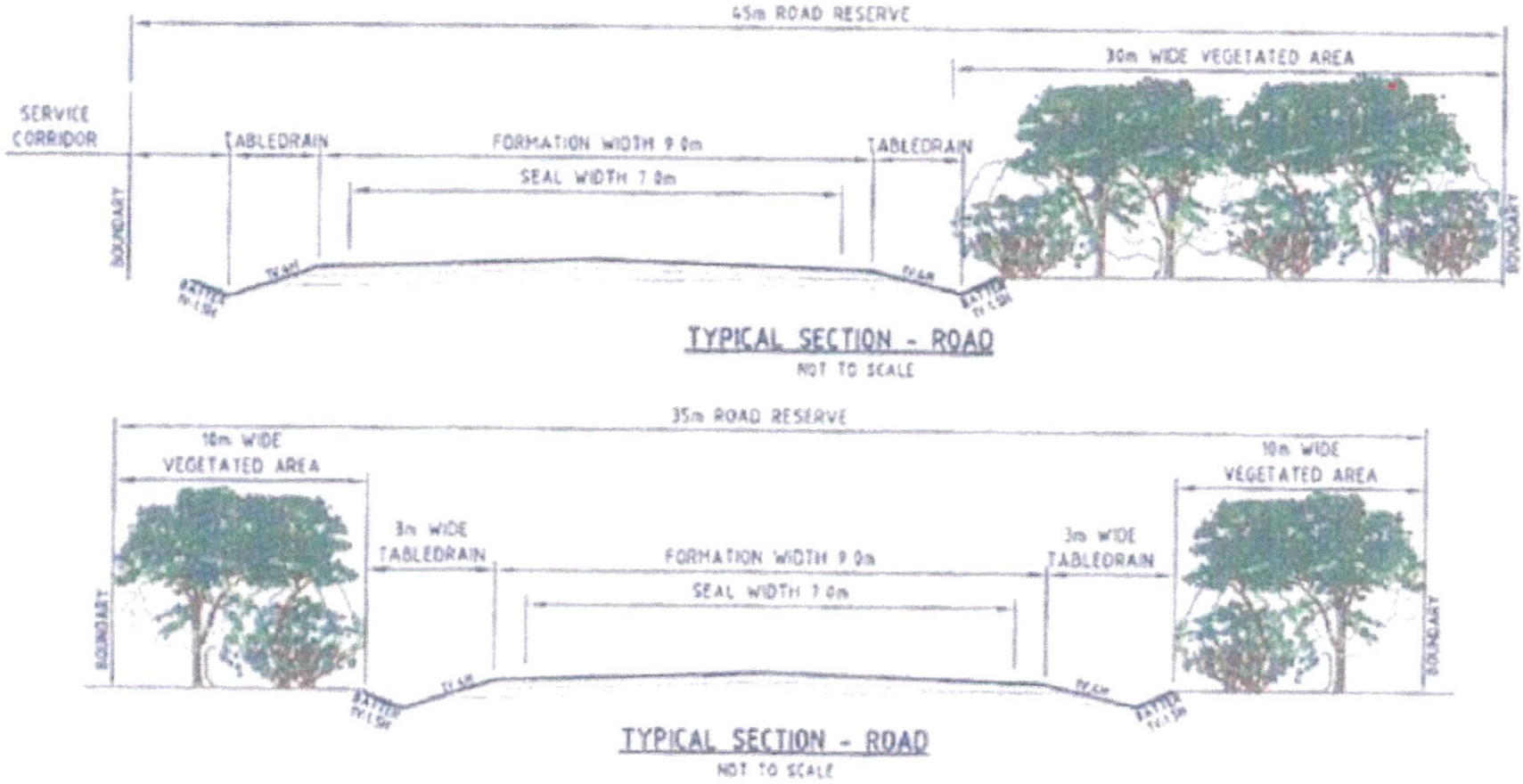
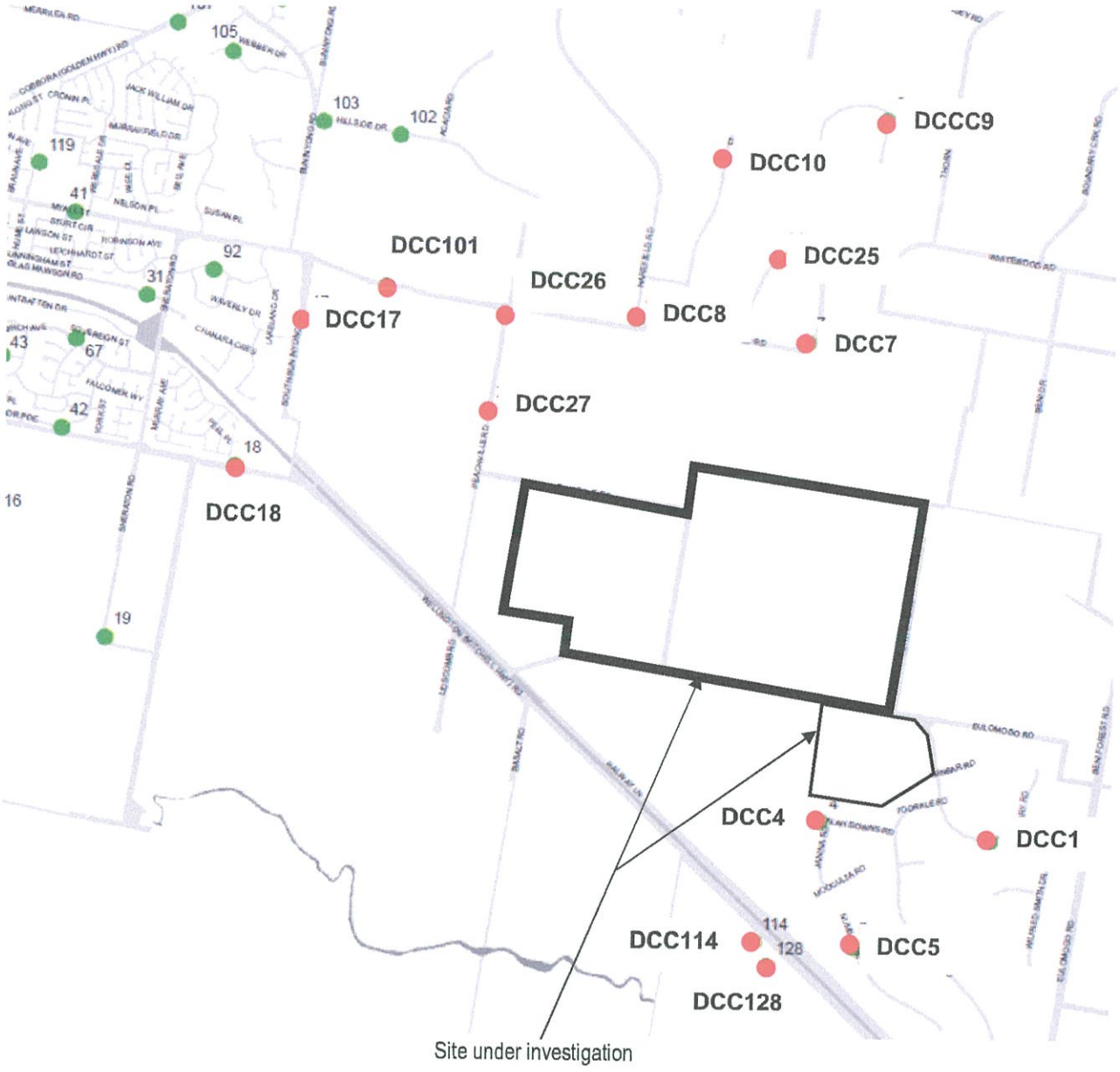


Figure 5. Road reserves planting design		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: -	Date: 6/12/2019



Legend

Dubbo City Council Salinity Network bores within 1km

Approximate Scale 1: 49,100

0 491 982 1,964m

Figure 6. Dubbo Regional Council Salinity Network		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: -	Date: 6/12/2019

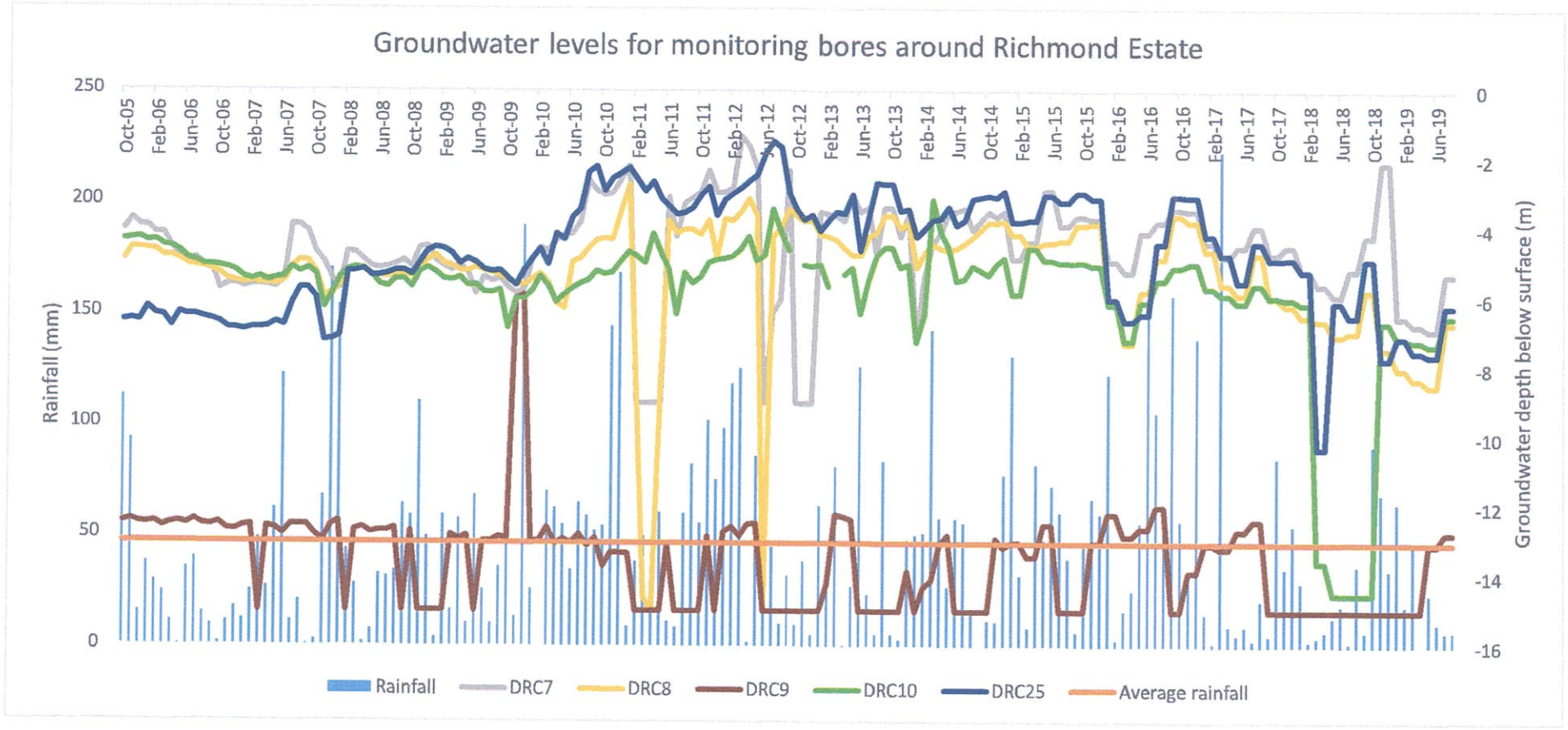


Figure 7. Groundwater levels for monitoring bores Richmond Estate 2005 to 2019		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13356sms3	Drawn by: LD	Date: 6/12/2019

Legend

MW02 Monitoring well

Approximate Scale

0 160 320 640m

Figure 8. Monitoring well locations		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13365sms3	Drawn by: LD	Date: 30/1/2020

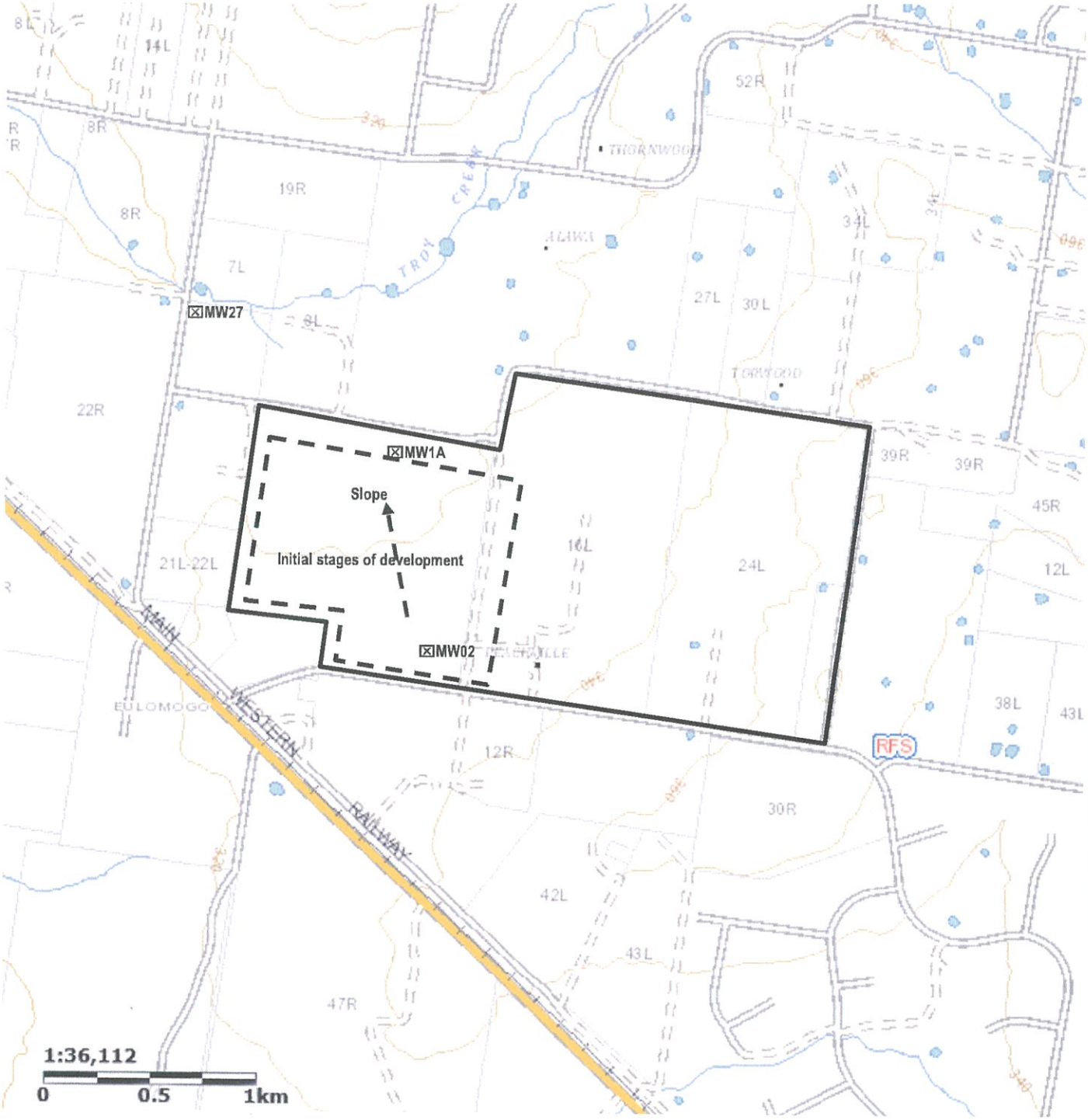


Figure 9. Monitoring well locations on topographic plan		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: R13365sms3	Drawn by: GM	Date: 14/2/2020

APPENDIX

Appendix 1. Salinity and groundwater monitoring action program, Daisy Hill Estate
Date prepared: 6 February 2020
Prepared by: Envirowest Consulting Pty Ltd
Ref: R13365sms1a1

1. Introduction

Daisy Hill Estate is a rural-residential subdivision proposed for Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW. The conceptual plan includes 222 rural-residential lots ranging in lot size from 0.6ha to 3ha. A single dwelling is proposed for each lot. The development will be undertaken in stages with the south western section developed first.

A Salinity Management Strategy (Envirowest Consulting Pty Ltd report number R13356sms3) has been developed for the site which describes the management and procedures to be implemented in the development to prevent impacts on downstream salinity.

Eight monitoring wells have been installed to depths of 10 to 16 metres over the site during the Salinity and Groundwater investigations. These wells have been identified by "in house" numbering of 1, 1A, 2, 3, 4, 4A, 5 and 6, however the wells will eventually be incorporated into the Dubbo Reginal Council's Salinity Monitoring Network and be allocated revised identification numbers.

Recharge has potential to occur on land from rainfall and other inputs. No preferential recharge areas have been identified in previous investigations. No active discharge areas have been identified on the site. Monitoring wells installed on and around the site indicate the groundwater levels. The groundwater levels have been observed to vary with rainfall events.

This Salinity and groundwater monitoring action program and Trigger Action Response Program (TARP) is required to identify and manage salinity and groundwater.

2. Salinity and groundwater monitoring program

2.1 Trigger action response program (TARP)

Monitoring wells MW1A, MW2 and DCC27 are located within and immediately downslope of the early stages of the Daisy Hill development and considered fair indicators of any changes in groundwater levels. Standing Water Levels will be obtained in MW1A, MW2 and DCC27 and results compared to adopted threshold levels (Section 2.5). Exceedance of the adopted threshold levels will trigger further investigations and actions.

2.2 Responsibilities

Council will make available to the developer, on request, any information from the Salinity Network. Until such time as the Daisy Hill monitoring wells are introduced into Council's Salinity Network the developer will monitor the Standing Water Levels in MW1A and MW2, also on a bimonthly (every two months) basis corresponding with council time frames. Dubbo Regional Council will be responsible for the assessment of Standing Water Levels in the monitoring wells in the salinity network. The assessment will be undertaken as part of the bimonthly monitoring (every 2 months) which Dubbo Regional Council undertakes for groundwater monitoring wells which form part of the Dubbo Council Salinity Network.

The developer will request the information from the council and then implement the salinity and groundwater monitoring action program. The developer will be responsible for review of the data and

comparison with the adopted thresholds. The developer will be responsible for undertaking an investigation program when threshold levels are exceeded and implementation of recommendations resulting from the investigation.

The developer will be responsible for construction of additional groundwater monitoring wells downslope of each stage of the *Daisy Hill Estate* development.

2.3 Type of monitoring

The groundwater levels will be assessed in the three indicator wells (MW1A, MW2 and DCC27). Other wells may be included in the monitoring program as stages of the development are completed. One additional bore will be installed in each new stage of the development. The Standing Water Levels will be the type of monitoring adopted.

The monitoring will be undertaken bimonthly (every 2 months). Monitoring procedures will be in accordance with the procedures currently undertaken by Dubbo Regional Council.

Groundwater monitoring is a more suitable indicator of salinity than soil moisture in the Daisy Hill development. Soil monitoring and the use of capacitance probes will be considered if groundwater triggers are exceeded as a method is identifying source of any impacts.

2.3.1 Spatial locations

A plan of the initial development stages and the location of proposed monitoring wells indicate MW1A and MW2 are located in the development area (Figure A1). The monitoring wells are in the direction of slope and are considered in the *zone of influence*. Additional monitoring wells installed at each of the individual development stages which will also be in the *zone of influence*. The development is expected to comprise at least 6 to 8 initial stages with new monitoring wells.

The new monitoring wells will be installed in accessible areas such as road reserves. It is not practical to install the wells prior to development as they could be destroyed in development activities. The location of viable areas cannot be defined until final plans are prepared.

Installation depth of proposed new monitoring wells is a maximum of 10m. The installation of the new monitoring wells will be at each new stage at the time of development. Monitoring wells at shallower depths is not considered necessary as the water bearing zone of the shallow aquifer extends over the 6 to 10m depth range.

2.3.2 Frequency of monitoring

Assessment of the monitoring wells on the Daisy Hill Development will be undertaken by the developer. Access will also be provided to Dubbo Reginal Council for inclusion in the Salinity Network.

Bimonthly morning will capture any trends in groundwater. Monthly groundwater monitoring is unlikely to provide any additional useful groundwater information compared with bimonthly monitoring.

If groundwater triggers are exceeded then monthly monitoring of groundwater may be implemented.

2.3.3 Data recording

All monitoring wells on Daisy Hill will be assessed by the developer bimonthly. Access will be provided to the Dubbo Reginal Council to assess the monitoring wells. If council opts not to assess the monitoring wells on Daisy Hill all data will be provided in the required format.

Historical review of groundwater data from the Salinity Network demonstrate seasonal rainfall can result in temporary elevated groundwater for up to four months. The objective of the Daisy Hill groundwater monitoring program is to identify increases in groundwater due to the development and not rainfall events. A period of 6 monthly (3 bi-monthly monitoring events) is an indicator period based on historical data in the Salinity Network catchment area.

2.3.4 Quality assurance

The required trigger for action is decreasing groundwater levels to less than a threshold level. All groundwater data collected will be available for review and quality checks.

The agreed plan will be followed and data obtained which only requires checking for completeness.

Monitoring well cover maintenance will be undertaken to enable access. No maintenance of the screen or casing of the monitoring well is expected to be required to enable ongoing use.

2.3.5 Soil moisture monitoring

Additional detailed monitoring of recharge and soil moisture will be investigated if groundwater trigger levels are achieved. It is not reasonable to implement an extensive monitoring program unless the thresholds are triggered. Extensive water balance modeling of the land-uses has been undertaken in a Salinity Assessment of the development which demonstrates no increase in water infiltration.

2.4 Reporting periods

Data from the monitoring will be collected and assessed bimonthly (every 2 months) from council's Salinity Network database. The developer will undertake to report any significant changes in groundwater levels and any threshold triggers exceeded. The reporting will include threshold exceedances, investigations and actions undertaken.

2.5 Thresholds

Threshold triggers are proposed for the three monitoring wells within and downslope of the early stages of the development (MW1A, MW2 and DCC27). One off-site monitoring well (DCC27) is considered an indicator of groundwater in the Daisy Hill Estate sub-catchment. The threshold level in DCC27 has been determined based on the historic data range over the monitoring period. Groundwater has previously been observed at a depth up to 1.84m. A 10% variation in the level is considered an estimate for natural variation hence a Standing Water Level of 1.65m in DCC27 is considered the appropriate trigger criteria.

Two monitoring wells on the site are also considered indicators of the groundwater levels downslope of the development (MW1A and MW2). These wells were selected as they are located within and downslope of the initial stages of the development and will provide an early indication of potential impacts from the *Daisy Hill Estate development*. Long term monitoring over a range of seasonal conditions has not been undertaken on MW1A or MW2. Since the installation of these two wells in June 2017, this area has been experiencing unprecedented drought conditions with no groundwater being present in either well. Given this scenario it is considered that a substantial depth of 8 metres will be accepted as an appropriate trigger at both locations.

Rainfall events have been observed to temporarily increase groundwater levels in the historical salinity monitoring network data. More than one observation time is required to confirm the groundwater levels are not impacted by seasonal rainfall events. Three consecutive observations are considered appropriate as a threshold trigger for groundwater levels.

Therefore thresholds trigger action are any of the following criteria occurring for three consecutive monitoring events:

- Monitoring well DCC27 – SWL<1.65m (below ground level)
- Monitoring well MW1A – SWL<8m (below ground level)
- Monitoring well MW2 – SWL<8m (below ground level)

The trigger depth of 2m is not considered appropriate for DCC27. The groundwater depth in DCC27 has previously been reported at 1.8m at times of high rainfall. A trigger depth of 1.6m in DCC27 is considered appropriate.

2.6 Actions

Exceedance of the adopted thresholds will trigger an investigation. The investigation will involve a review of historical rainfall and bore data to confirm the extent and significance of impacts. Possible causes of elevated groundwater are high rainfall, larger off-site catchment impacts or point sources unrelated to the development.

A range of actions are available to be implemented in the event of thresholds being exceeded. Mitigation actions may include:

- Expedite proposed tree planting in reserve areas
- Increase or add tree planting areas
- Redesign of lot layout
- Redesign of lot size

The actions will include an ongoing review to confirm the measures taken are adequate. Performance will be based on the groundwater triggers and additional action implemented until thresholds are within the desirable ranges.

Additional detailed monitoring of recharge and soil moisture can be included as an action if trigger levels and increasing groundwater is observed. It is not reasonable to implement an extensive monitoring program unless the thresholds are triggered. Extensive water balance modeling of the land-uses has been undertaken in a Salinity Assessment of the development which demonstrates no increase in water infiltration.

2.7 Responsible for actions and mitigations

The developer will be responsible for preparation of the action plan and implementation of the mitigation action as a result of any threshold exceedances.

3. Revision

The Salinity and groundwater monitoring action program may be revised as new information becomes available. The revision may include adjustment of the trigger thresholds and actions. Any revision will be based on sound scientific information.

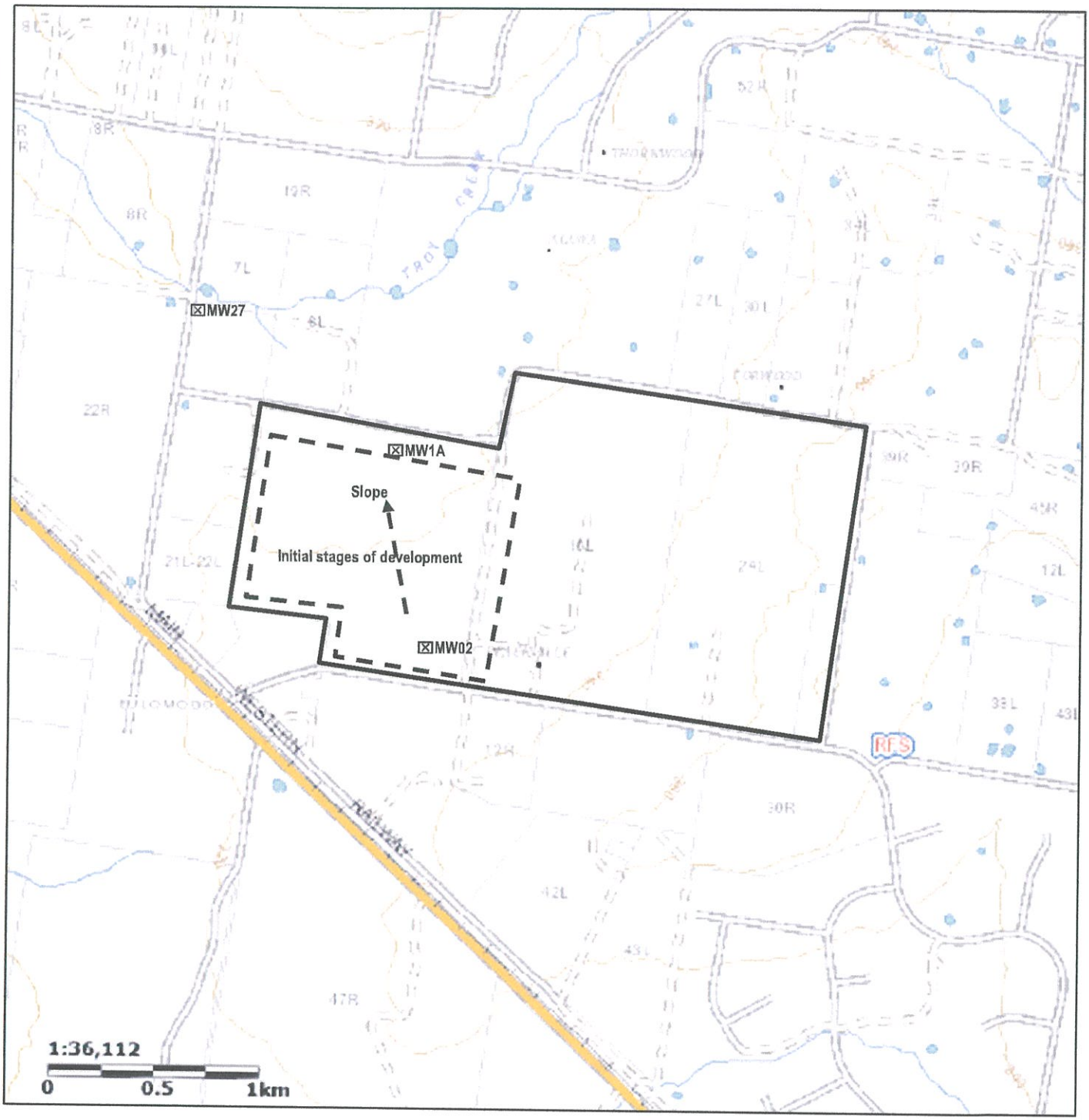


Figure A1. Monitoring well locations on topographic plan		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job: L13365s16	Drawn by: GM	Date: 14/2/2020