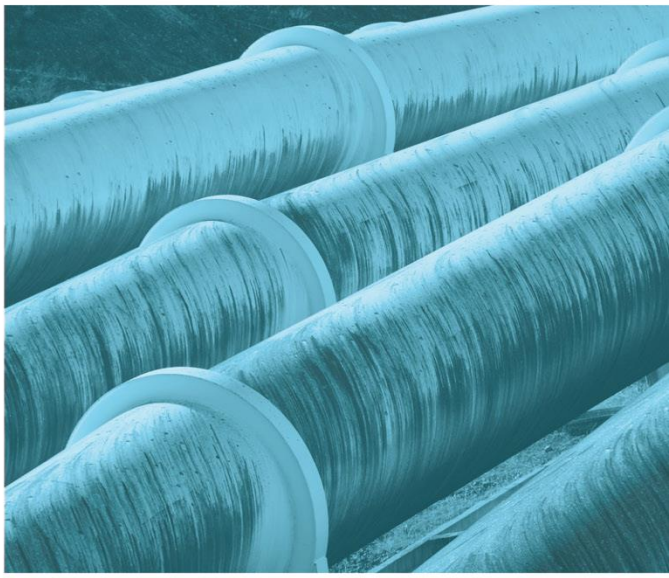



Daisy Hill Rural Residential Subdivision

Review of development plans

Prepared for Department of Planning, Industry and Environment
April 2020

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17 April 2020

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17 April 2020

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1 Introduction

1.1 Background

EMM Consulting (EMM) was engaged by New South Wales Department of Planning, Industry and Environment (DPIE) to carry out an independent review of the Vegetation Management Plan (VMP), the Salinity Management Strategy (SMS), the draft Development Control Plan (DCP) and the Dubbo Regional Council submission dated 16 August 2019, which aim to assess and manage the risk of salinity impacts from a proposed development at Daisy Hill, Eulomogo Road Dubbo NSW (the site).

The site is located in the Troy Gully catchment which is known to be at risk of impacts from shallow groundwater discharges, saline soil and scalding. The site is currently pasture/grazing and cropping land but is proposed to be rezoned to allow for a higher density of large lot residential development. The total area is approximately 430 hectares (ha) and the proposed subdivision will comprise 222 lots, with individual lot sizes varying from 0.6 ha to 3.0 ha.

1.2 Objectives

The objectives are to:

- review the VMP and determine whether the proposed actions for controlling salinity are appropriate and sufficient;
- review the SMS by tabulating the proposed actions for salinity management and provide commentary on whether the proposed actions and responses are deemed satisfactory, including additional recommendations where appropriate;
- review the draft DCP developed by the proponent, providing additional commentary associated with lot layout, landscaping, stormwater management and salinity;
- provide comment on the staging approach outlined in the documentation, and to review against the previous recommendations made by EMM (EMM, June 2018); and
- provide any further recommendations on how to assess and monitor the risk to salinisation going forward.

2 Review findings

The VMP has been reviewed against the overarching proposed actions for controlling salinity as stated in Section 1 of the VMP (Soilwater, April 2019). These are outlined in Table 2.1 along with EMM's review of the proposed strategies recommended to control ongoing salinity impacts.

The SMS developed by EnviroWest Consulting (Envirowest, December 2019) has been reviewed by tabulating the proposed actions for salinity management (Table 2 of Envirowest, December 2019), and providing EMM's review on whether the proposed actions and responses are satisfactory, including additional commentary where appropriate (Table 2.2). The review for each action is scored either as a:

- Yes - Actions and Responses are satisfactory (table cells are coloured green);
- Yes, but with future consideration - Actions and Responses are satisfactory but greater clarity, detail and/or transparency is recommended (table cells are coloured amber); or
- No - Actions and Responses are not satisfactory (table cells are coloured red).

Relevant sections of the draft DCP developed by the proponent have also been reviewed. The overall objective of the draft DCP is to provide an overarching document to provide developers guidance on how to develop the Daisy Hill Estate in a manner that minimises salinity impacts and promotes environmental, social and economic sustainability. Reviewed elements include Element 2- Lot layout (Table 2.3), Element 3- Landscaping (Table 2.4), Element 6- Stormwater management (Table 2.5) and Element 7- Salinity (Table 2.6).

As part of the review process, EMM paid particular attention to the strategies established to manage salinity risk, which largely consist of:

- the importance of smaller lot sizes overlying areas of low salinity risk and larger lot size overlying the areas of low-moderate salinity risk;
- fit for purpose plant species to manage water table heights;
- adequate drainage to manage stormwater; and
- the intent to develop a robust and fit-for-purpose Groundwater Monitoring Plan (GMP) and associated Trigger Action Response Plan (TARP).

Although the review commissioned by the Dubbo Regional Council indicated some reservations regarding the groundwater and salinity modelling conducted, namely the estimated lateral flows, the modelling is appropriate for this type of development in its early stages. The current modelling best aligns with characteristics of a Class 1 model, as described in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012), and more detailed modelling may follow in future if required, with the trigger to undertake such works being developed as part of the pending GMP and TARP.

Further recommendations and proposed actions going forward as an outcome of this review are summarised in Section 3 for consideration.

Table 2.1 Vegetation Monitoring Plan review

Salinity controlling action	EMM comment/recommendation on proposed strategies
Maximising the use of stored soil moisture to minimise groundwater recharge	Increased recharge to the groundwater system has the potential to raise water table/s and bring salt to the surface, causing salinisation. Minimising groundwater recharge is essentially controlled by two main strategies including: 1. Appropriate lot size; that is, smaller lots are proposed above the areas of deeper groundwater depths and higher salinity zones. 2. A selection of vegetation species planted in specific locations based on soil type, depth to groundwater and salinity to minimise future risk of salinisation. Soilwater states that, under this plan, the native vegetation area will increase from 0.2% to 12.6%. EMM essentially agrees with the proposed strategies, however as previously stated in the EMM 2018 report, the plan relies heavily on the chosen vegetation types being able to remove the required volumes of water from the phreatic surface to achieve this outcome. This is further discussed below.
Intercepting and reducing surface water flows to prevent the accumulation of surface water and generation of hydraulic gradients ie promote lateral flow.	The reports states that a 3 m wide table drain will be located on both sides of all roads to capture any surface water runoff from the road. A substantial table drain area of 13.0 ha is stated. It is assumed that the table drains will direct water naturally to the north-west in the direction of the natural topographic relief, with the road vegetation reserves absorbing any surface water excess. This seems logical and appropriate.
Lowering the watertable under the Daisy Hill Subdivision area	As stated above, the ability of the estate to manage shallow groundwater depths is highly dependent on the ability of the chosen vegetation species to transpire the required volumes at the required depths. Modelling results to date suggest that the vegetation plan can minimise groundwater recharge with some water logging likely to occur during wetter months. The modelling at this stage seems appropriate, and best fits a Class 1 model classification as described in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012). This class of model is appropriate to test conceptual ideas, for low risk projects and is suitable for small scale projects such as the Daisy Hill subdivision, especially at this early stage of development . Given there are limited measured data for a model/s to calibrate to (given the early stage), EMM recommends that the emphasis should be on a robust and fit-for-purpose Groundwater Monitoring Plan (GMP) and associated Trigger Action Response Plan (TARP). Further details on this recommendation are found in Section 3.2.

Table 2.2 Salinity Management Strategy review

Action	Response	Applicable HGL and management area	Strategic outcome	Are Actions and Responses satisfactory?	EMM comment/recommendation
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	Yes, but with future considerations identified in section 3.2	Areas of high salinity have been identified through an EM31 survey. Although not documented in detail within this report, 26 boreholes have also been analysed with depth to determine salinity profiles and soil classes. In general the top 6 m of the soil profile shows low salinity. An ongoing monitoring plan may be required to assess salinity impacts and if required, deploy mitigation strategies if the development starts to cause unacceptable salinity impacts in the future (related to Strategic outcome 5.1).
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	Yes, but with future considerations	The EM survey clearly shows the areas of high salinity. The supporting VMP and the SMS would be improved if the contact between the Pilliga Sandstone and the Purlewaugh Formation was clearly delineated. A simple conceptual model describing how salts are discharged and accumulated in this area would also be helpful within the VMP and reiterated in the SMS. The conceptual model could include the following: • Soil type / geology with depth • Salt distribution with depth, highlighting zones/areas of concern • Groundwater flow directions • Hydrogeological conditions under a low recharge and high recharge scenario • Process showing how rising water tables can either dissolve and subsequently mobilise salts in the vadose (unsaturated) zone and/or promote groundwater gradients, which mobilise salt down-gradient within the saturated zone.
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	Yes	No further comment.
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 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.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA1 Firgrove – MA2 Firgrove – MA3	2.3 3.2	Yes	No further comment.
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	Yes	No further comment

Table 2.2 Salinity Management Strategy review

Action	Response	Applicable HGL and management area	Strategic outcome	Are Actions and Responses satisfactory?	EMM comment/recommendation
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	Yes	A substantial table drain area of 13.0 ha is stated. It is assumed that the table drains will direct water naturally to the north-west in the direction on the natural topographic relief, with the road vegetation reserves absorbing any surface water excess.
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	Yes	No further comment, however the inclusion of the EM survey within the SMS would be helpful, with soil EC survey results overlaid
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	Yes	No further comment.
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	Yes, but with future considerations	The VMP outlines four revegetation areas that will target areas of high salinity including: 1) 3.3 ha vegetated buffer zone to the east to target the elevated salinity areas identified to exist at the interface between the Pilliga Sandstone and Purlewaugh Formation. 2) 3.2 ha of vegetated 45 m wide road reserve to target the generally higher salinity to the east, thought to be associated with the interface between the Pilliga Sandstone and Purlewaugh Formation. 3) 28.9 ha of vegetated 35 m wide road reserve for all other areas. 4) 5.7 ha of vegetation in the northern portion of the proposed subdivision to target shallow water tables and high salinity. Referring to Point 4 above, EMM would argue that this area is a natural groundwater discharge area, where salinity increases due to increased evapotranspiration from shallow groundwater. Given it is naturally, or currently, occurring it may not constitute an area of "impact". EMM also believes the reports would benefit from a vegetation species map, although this could form part of the development approval (DA) stage. The vegetation species figure could overly the EM32 salinity distribution for further transparency. This would allow a transparent review of the choice of vegetation species against the existing conditions (eg soil type, salinity and depth to groundwater) and objective to be achieved (eg lowering water table, intercepting lateral and/or vertical flow).
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 3 ha 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	Yes	No further comment.

Table 2.2 Salinity Management Strategy review

Action	Response	Applicable HGL and management area	Strategic outcome	Are Actions and Responses satisfactory?	EMM comment/recommendation
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	Yes	The report would benefit from a vegetation species map, overlying the EM32 salinity distribution as discussed above.
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 Firgrove – MA3	2.3 4.3	Yes	No further comment.
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 Regional Council.	Firgrove – MA3	2.5	Yes	No further comment.
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 Regional Council will be responsible for the management of vegetation along the road reserves.	Firgrove – MA3	2.5	Yes	No further comment.
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	Yes	Although not essential, the supporting VMP and the SMS would be improved if the contact between the Pilliga Sandstone and the Purlewaugh Formation was clearly delineated. This should at least be included at the DA stage.

Table 2.2 Salinity Management Strategy review

Action	Response	Applicable HGL and management area	Strategic outcome	Are Actions and Responses satisfactory?	EMM comment/recommendation
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 Regional 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	Yes, but with future considerations	The reports would benefit from a vegetation species map, which could overly the EM32 salinity distribution. This would allow a transparent review of the appropriate choice of vegetation species to the existing conditions (eg soil type, salinity and depth to groundwater) and objective to be achieved (eg lowering water table, intercepting lateral and/or vertical flow etc).
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 5.7 ha 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 Regional Council.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA3	2.5	Yes	No further comment.
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. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.	Richmond – MA1 Richmond – MA2 Richmond – MA3 Firgrove – MA2 Firgrove – MA3	1.1 2.1 2.2 2.4	Yes, but with future considerations –see section 3.2	The reports would benefit from a vegetation species map, which could overly the EM32 salinity distribution. This would allow a transparent review of the appropriate choice of vegetation species to the existing conditions (eg soil type, salinity and depth to groundwater) and objective to be achieved (eg lowering water table, intercepting lateral and/or vertical flow). This plot should at least be included at the DA stage. The effectiveness of vegetation to maintain water table depths and salinity should be managed via an appropriate GMP and TARP (see Section 3.2).

Table 2.3 Development Control Plan: Element 2 – Lot layout

Performance criteria ***The lot layout objectives may be achieved where:***	**Acceptable solutions** ***The acceptable solutions illustrate one way of meeting the associated performance criteria***	**EMM review/recommendations**
P1 Smaller lots overlay areas of low salinity risk; and larger lots overlay the areas of low-moderate salinity risk.	A1.1 The lot layout is generally consistent with the Conceptual Subdivision Plan (refer to SMS).	Agreed. However, smaller lot sizes are still maintained at the Firgrove Hydrogeological Landscape. This may still be appropriate if large water-table depths persist here. However, further explanation is warranted in the VWP and the SMS.
P2 The road pattern recognises the natural drainage patterns across the site so as to minimise the depth of earthworks in areas of saline subsoil.	A2.1 The road layout is generally consistent with the Conceptual Subdivision Plan (refer SMS).	Agreed.
P3 Vegetation zones are distributed strategically across the site.	A3.1 The subdivision layout is consistent with the Conceptual Subdivision Plan (refer SMS) and the VMP.	Agreed. However the documents would benefit from a vegetation species map, which could overly the EM32 salinity distribution to allow for more transparency of appropriate vegetation species.
P4 Lots are designed to optimise outlook to the semi-rural setting.	A4.1 There is no applicable Acceptable Solution to this Performance Criteria.	No comment.
P5 The design of lots provides vehicular access to the rear or side of lots where front access is restricted or not possible, particularly narrow lots where front garaging is not permitted.	A5.1 There is no applicable Acceptable Solution to this Performance Criteria.	No comment.
P6 A range of lot types (area, frontage, depth and access) is provided to ensure a mix of housing designs and styles.	A6.1 Within the Estate, the subdivision design shall provide varied lot frontages to promote a differentiation in design and housing product.	Agreed.
P7 Battle-axe lots are avoided.	A7.1 There is no applicable Acceptable Solution to this Performance Criteria.	No comment.
P8 Corner lots are of sufficient dimensions and size to enable residential controls to be met.	A8.1 Corner lots are to be designed to allow residential accommodation to positively address both street frontages.	Agreed.

Table 2.4 Development Control Plan: Element 3 - Landscaping

Performance criteria ***The landscaping objectives may be achieved where:***	**Acceptable solutions** ***The acceptable solutions illustrate one way of meeting the associated performance criteria***	**EMM review/recommendations**
P1 The road reserves and other public space within the estate are vegetated so as to promote an uptake of soil moisture and minimise groundwater recharge	A1.1 The public road network and other public space are landscaped with reference to the VMP. A1.2 The road reserve widths identified on the Conceptual Subdivision Plan are adopted so as to fully accommodate the proposed vegetation zones that are identified in the VMP. A1.3 The required landscaping is undertaken in line with the staged release of lots.	Agreed. However the documents would benefit from a vegetation species map, which could overly the EM32 salinity distribution to allow for more transparency of appropriate vegetation species.
P2 The landscaping includes a mix of both shallow and deep rooting plant species with good drought and waterlogging tolerance for water management.	A2.1 Landscaping is undertaken using the species and planting pattern/density identified in the VMP.	Yes, although refer to comment above.
P3 Vegetation zones are distributed strategically across the site.	A3.1 The subdivision layout is consistent with the Conceptual Subdivision Plan (refer SMS) and the VMP.	Agreed.
P4 Landscaping is undertaken in an environmentally sustainable manner which limits the time and costs associated with maintenance.	A4.1 Existing native trees are retained wherever possible. A4.2 Landscaping is undertaken using the species identified in the VMP, being native species that are suitable to the local area and require a minimal amount of watering.	Agreed.
P5 Street trees are selected to provide summer shading while not impeding solar access to dwellings in winter.	A5.1 Taller tree species nominated in the VMP are planted on the northern side of east-west aligned streets, while shorter species are planted on the southern side.	No further comment.

Table 2.5 Development Control Plan: Element 6 – Stormwater management

Performance criteria *The stormwater management objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
P1 The stormwater drainage system has the capacity to safely convey stormwater flows resulting from the relevant design storm under normal operating conditions, taking partial minor system blockage into account.	A1.1 Water sensitive urban design in the form of rain gardens, swales and absorption trenches are amalgamated into the design of the road network. A1.2 The design and construction of the stormwater drainage system is in accordance with the requirements of Australian Rainfall and Runoff 1987 and Aus-Spec (DCC version) Development Specification Series – Design and Development Specification Series – Construction. Construction Certificate plans for subdivisions shall show all minor and major stormwater systems clearly defined and identified. Minor systems for residential areas are designed to cater for the 1 in 100-year storm event. These systems are to be evident as 'self-draining' without impacting on flooding of residential houses etc.	Agreed. Documents may benefit from a figure show conceptual drainage direction and discharge locations of stormwater.
P2 Natural streams and vegetation are retained wherever practicable and safe, to maximise community benefit.	A2.1 Natural depressions and vegetation are incorporated into the stormwater drainage system for the subdivision and open space requirements.	Agreed.
P3 The system design allows for the safe passage of vehicles at reduced speeds on streets which have been affected by run-off from the relevant design storm	A3.1 The system allows for the safe passage of vehicles at reduced speeds on streets which have been affected by run-off from a 20% AEP event.	Agreed.
P4 Subdivision design and layout provides for adequate site drainage.	A4.1 Inter-allotment drainage via swales is provided to accept run-off from all existing or future impervious areas that are likely to be directly connected.	Agreed.
P5 Minimise the alteration of natural drainage patterns through construction of roads and drainage.	A5.1 The road layout is generally consistent with the Conceptual Subdivision Plan (refer SMS). A5.2 Road drains and outlets are designed to avoid large volumes of runoff infiltrating the ground at any one location. A5.3 Runoff from roads and other hard areas are discharged to a drainage network which is adjacent to the vegetation buffers. A5.4 Surface drains enable water to be moved off-site by the intermittent drainage lines across the site. These drainage lines are to follow the existing surface water flows.	Agreed. Documents may benefit from a figure showing conceptual drainage direction and discharge locations of stormwater. EMM recommends that this figure be included in the SMS.

Table 2.5 Development Control Plan: Element 6 – Stormwater management

Performance criteria *The stormwater management objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
P6 Surface water storages (dams) are restricted to reduce the potential for leaking and recharge of groundwater.	A6.1 The existing dams within the site are to be backfilled at the subdivision stage. A6.2 New dams are prohibited. A Section 88B Restriction on the Use of Land in favor of Dubbo Regional Council applies to each lot to this effect. A6.3 No on-site stormwater detention basins are to be installed.	No further comment.
P7 Drainage infrastructure is of a standard that limits the potential for leakage and recharge of groundwater.	A7.1 Works comply with the measures outlined in the SMS.	No further comment.

Table 2.6 Development Control Plan: Element 7 - Salinity

Performance criteria *The salinity objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
Lot Layout		
P1 The road pattern recognises the natural drainage patterns across the site so as to minimise the depth of earthworks in areas of saline subsoil.	A1.1 The road layout is generally consistent with the Conceptual Subdivision Plan (refer SMS).	No further comment.
P2 Smaller lots overlay areas of low salinity risk; and larger lots overlay the areas of low-moderate salinity risk.	A2.1 The lot layout is generally consistent with the Conceptual Subdivision Plan (refer SMS).	Agreed, however further discussion is warranted within the VMP and SMS as to why small allotments persist at the Firgrove Hydrogeological Landscape above the high salinity area. Generally speaking, larger lots are required to overlie areas of higher salinity risk due to the inherent lower irrigation density and hence lower recharge rates. Lower recharge rates reduce the risk of elevating the water table and mobilising salt beneath these allotments.
P3 Vegetation zones are distributed strategically across the site.	A3.1 The subdivision layout is consistent with the Conceptual Subdivision Plan (refer SMS) and the VMP.	Agreed.
Landscaping		
P4 The road reserves and other public space within the estate are vegetated so as to promote an uptake of soil moisture and minimise groundwater recharge	A4.1 The public road network and other public space are landscaped with reference to the VMP. A4.2 The road reserve widths identified on the Conceptual Subdivision Plan are adopted so as to fully accommodate the	Agreed. As discussed, the addition of a map showing planned vegetation species across the subdivision will promote further transparency and review of the appropriateness of species chosen commensurate with the local conditions and objectives.

Table 2.6 Development Control Plan: Element 7 - Salinity

Performance criteria *The salinity objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
	proposed vegetation zones that are identified in the VMP. A4.3 The required landscaping is undertaken in line with the staged release of lots.	
P5 The landscaping includes a mix of both shallow and deep rooting plant species with good drought and waterlogging tolerance for water management.	A5.1 Landscaping is undertaken using the species and planting pattern/density identified in the Vegetation Management Plan.	As above.
P6 Vegetation zones are distributed strategically across the site.	A6.1 The subdivision layout is consistent with the draft DCP Conceptual Subdivision Plan and the Vegetation Management Plan.	Agreed.
Infrastructure		
P7 Construction techniques are appropriate for the salinity risk and engineering solutions are implemented to minimise impacts on infrastructure	A7.1 Service lines and road construction works comply with the measures outlined in the SMS. A7.2 Site specific testing is to be undertaken to confirm exposure classification at the design stage for infrastructure. Note: Preliminary exposure classification of the *Richmond Estate Hydro-geological Landscape* based on soil samples collected at the expected footing depth of 500 mm is generally non-saline and classified as A1. A7.3 Salt protected materials for services, (eg salt resistant drainage pipes, casing of underground services) are used where relevant. A7.4 Design characteristic strength for concrete and the minimum reinforcement cover for concrete is to accord with Australian Standard AS2870: Residential Slabs & Footings, pertaining to aggressive soils, as summarised in SMS. A7.5 Imported fill is to be tested for salinity.	Agreed. Imported fill to be clean and non-saline.
Stormwater Drainage		
P8 Minimise the alteration of natural drainage patterns through construction of roads and drainage.	A8.1 The road layout is generally consistent with the Conceptual Subdivision Plan (refer SMS). A8.2 Road drains and outlets are designed to avoid large volumes of runoff infiltrating the ground at any one location. A8.3 Runoff from roads and other hard areas are discharged to a drainage network which is adjacent to the vegetation buffers.	Agreed. Documents may benefit from a figure show conceptual drainage direction and discharge locations of stormwater.

Table 2.6 Development Control Plan: Element 7 - Salinity

Performance criteria *The salinity objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
	A8.4 No on-site stormwater detention basins are to be installed. A8.5 Surface drains enable water to be moved off-site by the intermittent drainage lines across the site. These drainage lines are to follow the existing surface water flows.	
P9 Surface water storages (dams) and onsite stormwater detention are restricted to reduce the potential for leaking and recharge of groundwater.	A9.1 The existing dams within the site are to be backfilled at the subdivision stage. A9.2 New dams are prohibited. A Section 88B Restriction on the Use of Land in favor of Dubbo Regional Council applies to each lot to this effect. A9.3 No on-site stormwater detention basins are to be installed.	No further comment.
P10 Drainage infrastructure is of a standard that limits the potential for leakage and recharge of groundwater.	A10.1 Works comply with the measures outlined in the SMS. A10.2 No on-site stormwater detention basins are to be installed.	No further comment.
P11 Backwash water from swimming pools does not contribute to groundwater recharge.	A11.1 Swimming pools are regulated to utilize paper filters rather than sand filters. Paper filters do not require backwashing therefore reducing recharge to groundwater. A Section 88B Restriction on the Use of Land in favor of Dubbo Regional Council applies to each lot to this effect.	No further comment.
Staging, Monitoring & Revegetation		
P12 On-going monitoring of groundwater levels, staging, and revegetation is undertaken so that any impacts of development can be identified at an early stage and appropriate mitigation measures implemented if necessary.	A12.1 Lots are to be released in stages as outlined in the SMS to enable early identification and potential mitigation of any groundwater impacts. A12.2 On the downstream side of each stage of development, a monitoring well is to be installed and monitored bi-monthly A12.3 On-going monitoring of groundwater levels in existing monitoring bores on and within 1 km of the site is to be undertaken as a matter of course so that any impacts of development can be identified at an early stage and mitigation measures implemented if necessary.	The solutions proposed are required to support a robust and fit-for-purpose Groundwater Management Plan (GMP) and supporting Trigger Action Response Plan (TARP). At a minimum, physicochemical properties such as groundwater levels, EC and pH should be recorded bi-monthly, from all available monitoring wells. Planned monitoring wells to be installed within the subdivision should be installed as early as possible to allow for a baseline monitoring period prior to development. Consideration of dedicated monitoring wells located directly up-stream, downstream, at shallow groundwater areas to the north and more saline areas to the east should be made. EMM suggests that the development of a GMP supported by a TARP to assess groundwater quality and potential environmental impacts should be completed in accordance with the guidelines outlined by the Department of

Table 2.6 Development Control Plan: Element 7 - Salinity

Performance criteria *The salinity objectives may be achieved where:*	Acceptable solutions *The acceptable solutions illustrate one way of meeting the associated performance criteria*	EMM review/recommendations
		Science, Information Technology and Innovation (DSITI, 2017). The SMS should reference this framework and overall approach, however the development of such plans can occur at the DA stage, Further detail on this consideration is found in Section 3.2.
Salinity Management Strategy		
P13 Development satisfies the aims of the *Dubbo City Urban Salinity Management Strategy* and accord with the *Dubbo City Urban Salinity Implementation Plan.*	A13.1 Development meets the relevant aspects of the SMS.	No further comment.

3 Conclusion

3.1 Recommendations

As stated previously by EMM (2018), the VMP developed by Soilwater (Soilwater, April 2019) will play an important role in taking up excess moisture from the various land use types. As such, the SMS developed by Envirowest relies on the chosen vegetation species and areas to effectively transpire shallow groundwater and maintain groundwater depths to an appropriate level to minimise salinity impacts.

No further review comments are provided by EMM on the appropriateness of the groundwater modelling undertaken to date. However, EMM believes the coupling of the one-dimensional soil-water model with a 2-D (or 3-D) numerical groundwater flow model, to simulate the lateral movement of groundwater, would have been appropriate to demonstrate the ability of the proposed measures to achieve the required water management outcomes. Regardless, these models are conceptual in nature and are best described as Class 1 models as described in the Australian Modelling Guidelines classification system (Barnett et al, 2012). At this point, the level of modelling undertaken to date is adequate for this type of development in its early stages and EMM suggests that a focus on a robust and fit-for-purpose GMP and supporting TARP going forward would be more logical. Future and possibly more detailed modelling can be undertaken on a for-cause basis based on the recommendations outlined in the associated TARP and once more observation data are available to help reduce model uncertainty (see Section 3.2).

Other recommendations, which are not considered fatal flaws but would improve the current documentation, and can be included in the detailed Groundwater Monitoring Plan and Vegetation Management Plan at the development stage include:

1. spatial depth to groundwater contour maps for both the wet and dry seasons;

2. spatial vegetation map showing proposed species overlaid with the depth to groundwater maps and EM 31 salinity distribution;

3. monitoring wells to be installed across the subdivision as early as possible to promote a longer and more representative baseline monitoring dataset. High risk zones should be made the priority, including in the contact zone between the Pilliga Sandstone and Purlewaugh Formation;

4. the delineation between the Pilliga Sandstone and the Purlewaugh Formation should be more clearly documented;

5. smaller lot sizes are still maintained at the Firgrove Hydrogeological Landscape. This may still be appropriate if large water-table depths persist here but further explanation is warranted; and

6. a figure showing the conceptual drainage direction and discharge locations of stormwater. The SMS may benefit from the inclusion of this figure to support the reported text which explains how stormwater will drain from the roads toward dedicated roadside drains, which in turn will discharge stormwater into areas down-slope.

3.2 Groundwater Monitoring Plan considerations

The development of a robust and fit-for-purpose GMP is recommended to support the planned subdivision at Daisy Hill. The aim of the GMP would be to outline a framework to ensure that enough groundwater data are collected spatially and temporally, so site specific trends and groundwater trigger levels can be analysed and defined

respectively, to ensure salinity impacts at Daisy Hill are managed. With each trigger level tier, a list of trigger actions would be proposed as a mitigation strategy.

The GMP, including trigger level development and assessment methods, should be undertaken in accordance with relevant guidelines including DSITI (2017) and would include the following broad steps that can be provided in detail at the development stage:

- State the objective of the GMP.
- Describe the hydrogeological system and potential water affecting activities.
- Identify the environmental values (EV) of the aquifer and tabulate the relevant standard ANZECC guidelines for the type of receiving aquifer system.
- Design a monitoring well network including both regional wells and local wells. Preferably, wells should be chosen which have not been impacted by anthropogenic activities.
- Define the sampling suite, frequency and required length so a robust baseline dataset is developed. Relevant ANZECC guidelines generally recommend that a minimum of two years of baseline data is required to properly characterise the environment and assess natural variability.
- Calculate statistics of all bores including the mean, median, 5^{th}, 20^{th}, 80^{th}, 90^{th} and 95^{th} percentiles.
- Remove any outliers within the data set.
- Compare statistics with the ANZECC guidelines and through discussions with the regulator, determine an appropriate tiered trigger level framework.
- Compare time series of groundwater data to the trigger levels and investigate any breaches. If enough data are collected over time and throughout varying seasons, the DSITI (2017) guidelines recommend comparing the rolling median of the monitoring data being tested to the 80^{th} percentile for the first Tier trigger level, and three consecutive breaches to the 95^{th} percentile, representing a breach of the second Tier trigger level. This method reduces the risk of assigning false negatives to a trigger breach.
- Trend analysis using such methods as the Mann-Kendall approach should also be performed along with trigger level assessment to help detect whether any increasing salinity trends are significant or not. Trend assessments should be undertaken at both the Daisy Hill monitoring wells and background wells to help determine whether the salinity trends are caused by the subdivision activities or are naturally occurring.
- Determine an appropriate list of mitigation actions to be undertaken if either the first or second Tier trigger level is breached. This may include various actions such as increased monitoring frequency, vegetation species review and more detailed modelling for a first Tier trigger breach to more severe actions such as lot size amendments, lot staging period increase and installation of pumping bores for second Tier trigger breaches.

A commitment to undertake the development of a GMP and TARP should be included in the SMS. Reporting text can be updated within Section 4.3 of the SMS which can describe why a GMP and TARP is required and how it will be broadly implemented. An overview of the steps on how to develop these plans as outlined above can be included as an appendix.

3.3 Development Staging

As part of EMM's previous independent review of the groundwater and salinity modelling undertaken to assess off-site salinity impacts from the proposed development at Daisy Hill (EMM 2018), EMM recommended that a staged development of the site would enable early identification, and potential mitigation, of any groundwater impacts. Development of larger blocks (with expected lower irrigation density) first would provide a precautionary approach to development. Further, ensure a reconfiguration of smaller blocks to overly areas with greater depth to water table and larger blocks to the region of shallow water table in the west of the site, would reduce the risk of impacts in this higher risk area. A review of the Soilwater VMP report identifies that:

- the first stage release (Stage 1), is located on an elevated landscape, where groundwater depths range between 12 and 16 meters below ground level (mBGL); and

- Stage 1 has been determined by the location of available services such as power, water and telecommunications, however, have maintained a lot size that is dominated by the smaller areas being 0.6 ha in size. The larger lot sizes (seven 1.0 ha and six 1.5 ha) are generally located over the areas of slightly elevated salinity.

The plan for Stage 1 is consistent with EMM's initial recommendation on lot staging. Stage 1 presents a relatively low risk associated with salinisation, however staged vegetation planting will need to continue throughout the various stages and assessment of groundwater level and quality trends will need to be actively reviewed in line with the pending GMP and TARP.

3.4 Concluding remarks

In summary, the actions outlined in the VMP and SMS are likely to reduce salinity within the proposed Daisy Hill subdivision. The plans, however, rely on the chosen vegetation species and areas to effectively transpire shallow groundwater and maintain groundwater depths to an appropriate level to minimise salinity impacts. The SMS and VMP is adequate for the strategic purposes however at development stage, the preparation of a robust and fit-for-purpose GMP supported by an appropriate TARP and a detailed vegetation species overlay map is recommended to support the planned subdivision at Daisy Hill throughout the various stages to ensure early detection and subsequent mitigation of salinity impacts.

EMM believes that no fatal flaws exist within the Daisy Hill development documentation, however a number of recommendations are made to improve the quality of the documents and transparency of the planned actions.

4 References

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