ATTACHMENT 4 - WATER CYCLE MANAGEMENT STUDY

SEEC

Water Cycle Management Study

For Proposed Subdivision of Lots 102 & 104 DP 1018460, Lot 309 & 610 DP 751743, Boorga Road, Lake Wyangan, NSW

Prepared by: Mark Passfield

SEEC Reference 16000278-WCMS-01

30th January 2017

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Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects.

Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.

Mark Passfield
SEEC
30th January 2017

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Document Table

Issue Number	By	Reviewed by	Date
DRAFT 1	MP		
01	MP	Client, Council	30/01/2017

TABLE OF CONTENTS

1 Introduction

SEEC have been commissioned by ABR Farming Pty Ltd (owner) of Lots 102 & 104 DP 1018460, Lot 309 & Lot 610 DP 751743, Boorga Road, Lake Wyangan, NSW (Figure 1) to prepare this Water Cycle Management Study. It is required to accompany an application to ultimately subdivide the land into 114 new rural residential lots. The subdivision would be done in stages; Stages 1 to 3 (on Lot 102 DP 1018460) would comprise 34 new lots between approximately 1 and 2.5 ha. Further development would be the subject of future development applications.

This WCMS includes:

(i) An assessment of how the proposed development could affect the local water cycle; and

(ii) A conceptual plan for managing the water cycle to achieve target pollutant reductions for gross pollutants, sediment, phosphorus and nitrogen.

Figure 1 - Site Location (approx.)

2 Project Description

Initially it is proposed to subdivide Lot 10 DP 1018460 into 34 rural residential lots of between 10,125 m^2 and 25,048 m^2. Thereafter, the remaining lots would be subdivided into a further 80 lots (Appendix 1). Each lot would have access to reticulated irrigation water but would have a rainwater tank for potable water. The site would not be sewered - each lot would manage its own wastewater on site.

The new lots would be accessed by a new road network with an 11 m wide sealed road pavement in 24 m wide road corridor. The roads will drain to vegetated table drains with a piped drainage network[1] delivering runoff to a series of stormwater quality ponds for treatment before release to Lake Wyangan.

[1] Subject to engineering design

3 The Site

3.1 General Conditions

The lands slope gently westwards at about 2 to 4 percent towards Lake Wyangan. There is a buffer of undeveloped Crown Land between the lands and Lake Wyangan; it is between about 200 m and 430 m wide.

The land has been used for agricultural uses, mainly for pasture and cropping. The site currently has two irrigation water entitlements one being 76 ML of high security and the other 200ML of general security.

3.2 Topography and Drainage

Total relief from east to west is about 3 to 4 m. The site drains by sheet flow towards Lake Wyangan which is a man-made lake, a remnant from previous gypsum quarrying. The nearest natural named waterway is Mirrool Creek which is 15km to the south west of the site. There are also numerous irrigation supply canals, drainages and tile drains in the locale, two pass through the property draining cultivated lands from the east to Lake Wyangan (Figure 1).

Groundwater has been monitored by DM McMahon (2015); it is not a recognised constraint at the property.

3.3 Climate

The average rainfall is approximately 401.6 mm per annum, with the wettest months being March, August and October. Mean daily pan evaporation ranges from 1.4mm in June to 8.7mm in January. Griffith is characterised by cool wet winters and hot dry summers with mean maximum temperatures ranging from 14.5 °C in July to 33.0 °C in January and mean minimum temperatures ranging from 3.5 °C in July to 17.4 °C in February[2].

3.4 Soils

Soils are described in detail in DM McMahon (2015). In summary, they consist of loamy topsoil over clay loam to sandy clay loam subsoil (red earths) derived from sedimentary rocks. DM McMahon (2015) determined the soils are not saline or sodic. They are reasonably well-drained with good infiltration; runoff would be rare in the prevalent dry climate. The soils are well-suited to effluent disposal.

[2] This rainfall and temperature data is from Griffith Airport AWS 075041, 3.6km away and evaporation data from Griffith CSIRO 075028, 11km away (www.bom.gov.au).

4 Land Surface Changes

4.1 Subdivision Stages

4.1.1 Introduction

For the purpose of stormwater modelling (Section 6) the site is divided into Stages 1 to 3 and the remainder. The following land surface changes would occur when the subdivision works are done.

4.1.2 Stages 1 to 3

Stages 1 to 3 would comprise 34 new lots (Appendix 1). They would be accessed by a new looped, 11 m wide, sealed, access road within a 24 m wide corridor. There would also be a short cul-de-sac to service Lots 3, 4 and 5. Twelve of the new lots would drain directly towards Lake Wyangan; the remainder would drain to the new stormwater drainage system, although not all would do so directly.

4.1.3 The Remainder

The remaining stages would comprise 80 new lots (Appendix 1). They would be accessed by a series of new 11 m wide, sealed, access roads within 24 m wide corridors. Twenty two of the new lots would drain directly towards Lake Wyangan; nearly all the remainder would drain to the new trunk drainage system, although Lots 77 and 83 would drain to Boorga Road.

4.2 Dwelling Stage (Future DAs)

As the lots are developed with dwellings there would be a slight increase in impervious surfaces (roofs, paving and driveways) on each lot. However, as the rural residential lots are large and it would be permissible to manage stormwater in absorption beds, the connectivity of these impervious surfaces to the stormwater drainage system would be minimal. SMCMA (2010) recommends the *effective* imperviousness[3] of these lots be taken as 5% for modelling purposes (Section 6).

5 Onsite Wastewater

The site will not be connected to sewer and so wastewater generated in each new dwelling would be managed on each lot. The issue of onsite wastewater management is discussed in detail in DM McMahon (2015). Nearly all of the lots would be unconstrained for wastewater management and the soils across the site are well suited to disposal of secondary treated effluent by either irrigation or absorption. However, required buffers to existing drainage features would slightly constrain some lots, particularly in the later stages of development.

[3] i.e. the percentage of impervious surfaces that would be directly connected to the stormwater drainage system

6 Proposed Stormwater Drainage and Water Quality Measures

6.1 The Stormwater Treatment System

Reference has been made to The Lake Wyangan and Catchment Management Strategy (Water Technology, 2016) to develop a suitable, easily maintainable, stormwater treatment train. Given the size of the proposed lots, most runoff will be derived from the new road network. Appendix 2 details the proposed trunk drainage system. Pavement runoff will be directed into vegetated swales either side of the road. The swales will provide primary-treatment to the runoff by trapping sediment and associated phosphorous and nitrogen. Conceptually, the swales will have the following dimensions:

- Base width = 0.5 m
- Depth = 0.5 m
- Batter slope = 1H:4.5V
- Gradient = 1%

Grated inlets at regular intervals will allow the stormwater to be delivered to a piped network[4] and conveyed to a series of water quality ponds.

Where applicable (in future stages) stormwater up to at least the 1-year storm flow will be kept separate from offsite-derived flow in the two existing agricultural drains which drain lands to the east of the site. The latter would be directed straight through the site. Flows over the 1-year storm flow may enter the existing drains.

Stormwater from the development would be directed to six water quality ponds; two of which would be built in Stages 1-3. The approximate catchments to, and conceptual volumes of, these ponds are given in Table 1, together with catchments that would leave the site untreated. The catchments are shown in Appendix 2.

Table 1- Water Quality Ponds

Catchment Number	Catchment (lots) (ha)	Catchment (roads) (ha)	Pond Number	Pond Surface Area (m^2)[5]	Permanent Volume[6] (m^3)
1	18.79	2.92	1	300	120
2	15.12	2.90	2	450	180
3	8.66	0.88	3	180	70
4	31.37	3.08	4	720	290
5	18.35	3.23	5	510	200
6	13.29	1.92	6	320	130
7	10.32	0	-	-	-
8	44.49	0	-	-	-
Totals	**160.39**	**14.93**		**2480**	**990**

[4] Subject to engineering design
[5] Sized as 2% of the total effective impervious area draining to the pond (Melbourne Water, 2005)
[6] Taken as 0.4 times the area

The ponds will be designed to the requirements of Melbourne Water (2005) and might have a sediment trap at their inlet and will have fringing vegetation in the main pond volume.

6.2 Stormwater System Maintenance

Swales and water quality ponds and been adopted as they both have minimal maintenance requirements. The swales would periodically require slashing (mowing) and an annual inspection to ensure stormwater pits are not blocked and there is no scour/erosion, particularly at the outlets.

The water quality ponds could be owned by specific lot owners. An Operational Environmental Management Plan (OEMP) would be prepared to assist these new owners manage the ponds appropriately following established guidelines such as those published by Melbourne Water or Water-By-Design in Queensland. Interrogation of the MUSIC model shows the sediment load to the ponds will not be high (less than 50 kg/yr to each pond on average) and so sedimentation would not be problematic.

7 Stormwater Quality Modelling

7.1 Introduction

The estimated pre and post development sediment and pollutant loads are modelled using MUSIC (Model for Urban Stormwater Improvement Conceptualisation), developed by eWater. The model is appropriately calibrated as in **Tables 2, 3 and 4**. Statistics are produced in MUSIC for the following pollutants:

- TSS - Total Suspended Solids (kg/yr)
- TP - Total Phosphorus (kg/yr)
- TN - Total Nitrogen (kg/yr)
- Gross Pollutants (kg/yr)

The results of the modelling will be compared against the draft NSW Department of Environment and Climate Change's target pollutant reductions (DECC, 2007) which represents NSW's "Best Management Practice" for stormwater treatment. DECC (2007) gives pollutant reduction targets that apply to total suspended solids (TSS), phosphorous and nitrogen. Runoff from a proposed development must be treated to reduce these pollutants by (at least) the following percentages:

Table 2 – DECC Target Pollutant Reductions

Pollutant	Target Reduction
Total suspended solids (TSS)	85%
Total Phosphorous	65%
Total nitrogen	45%

7.2 Climate Calibration

Creation of a MUSIC catchment file requires an associated meteorological data file. Pluviograph data is available from two very nearby locations: Griffith Airport (Station number 75041) and Griffith CSIRO (Station number 75028). Although recent, the data from Griffith Airport was found to be incomplete and insufficient to obtain a 5-year data set for use in MUSIC. The data from Griffith CSIRO spans 1931 to 1989 and so offered a better opportunity to obtain a 5-year data set at six-minute intervals[7]. The best quality data was from the 1930s and so a data set was obtained from 01/06/1931 to 01/06/1936. Although the data is from the 1930s it is considered representative, as the mean annual rainfall modelled is 403 mm (compared to actual 401.6 mm, **Table 3**) and the pattern of rainfall would still be valid (**Figure 4**).

[7] A six-minute interval is considered appropriate as the runoff will be dominated by the road catchments which do not exceed 5ha and so have a time of concentration less than 15 mins.

Although pan evaporation data is available from the same weather station, MUSIC uses areal potential evapotranspiration data which is different[8]. Areal potential evapotranspiration data has been be estimated from graphs presented on the Bureau of Meteorology's website (average annual & monthly evapotranspiration).

Table 3 - Adopted Climate Statistics

Meteorological Data Statistics

	Rainfall/6 Minutes	Evapo-Transpiration
mean	0.005	3.319
median	0.000	2.550
maximum	8.240	6.010
minimum	0.000	1.200
10 percentile	0.000	1.410
90 percentile	0.001	5.320

	Rainfall	Evapo-Transpiration
mean annual	403	1213

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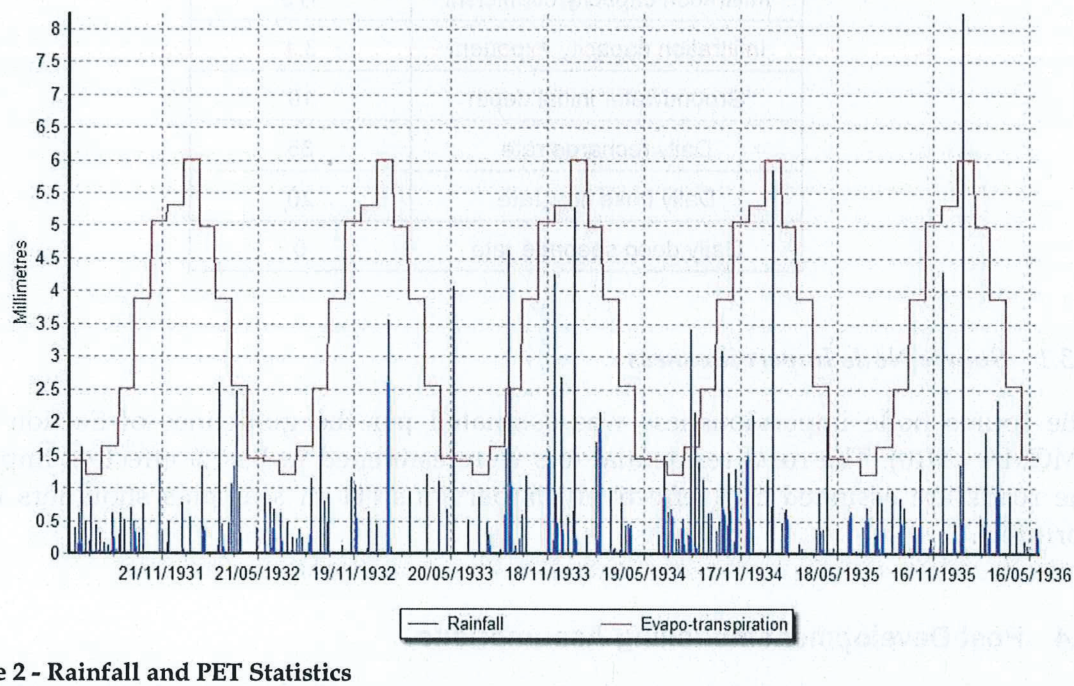


Figure 2 - Rainfall and PET Statistics

[8] **Areal potential ET** is the ET that would take place, under the condition of unlimited water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average.

7.3 Node Calibration

Table 4 presents the storm flow concentration calibrations for the MUSIC model. They are the program's default values.

Table 4 - Storm flow concentration calibrations used in MUSIC

	TSS mean (log mean)	TSS std dev (log std dev)	TP mean (log mean)	TP std dev (log std dev)	TN mean (log mean)	TN std dev (log std dev)
Rural residential land	89 (1.95)	2.1 (0.32)	0.22 (-0.66)	1.8 (0.25)	2 (0.3)	1.55 (0.19)
Sealed road	269 (2.43)	2.1 (0.32)	0.5 (-0.30)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)

The pervious area characteristics are calibrated as in **Table 5**. They are the values described in Section 3.6.3 of CMA (2010).

Table 5 - Pervious area calibrations used in MUSIC

Parameter	Value
Soil storage capacity	210
Initial storage	30
Field capacity	80
Infiltration capacity coefficient	175
Infiltration capacity exponent	3.1
Groundwater initial depth	10
Daily recharge rate	35
Daily base flow rate	20
Daily deep seepage rate	0

7.3.1 Source Node Imperviousness

The source node imperviousness was estimated per the guidelines of Section 3.6.4 in SMCMA (2010). The rural residential lots were estimated to be 5% effective impervious, the roads are assumed 50% effectively impervious (11 m seal plus shoulders in 24 m corridor).

7.4 Post Development Modelling Assumptions

The post-development model comprised source nodes and pond sizes based on the data in **Table 1**. The lengths of the swales was taken as double the length of roads (one either side). The MUSIC model is shown diagrammatically in **Figure 3**.

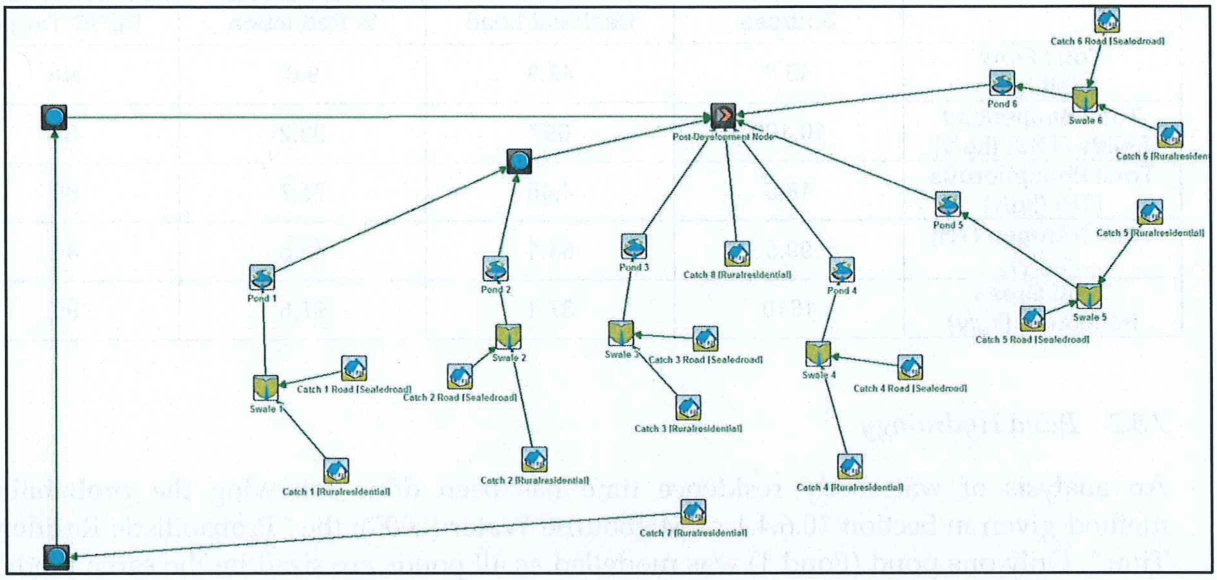


Figure 3 - MUSIC Model Schematic

7.5 Modelling Results

7.5.1 Treatment Train Effectiveness

<u>Stages 1, 2 and 3</u>

The predicted treatment train effectiveness for Stages 1, 2 and 3 is presented in **Table 6.** It shows the target pollutant reductions can be exceeded with the proposed water quality treatment measures[9].

Table 6 - Treatment Train Effectiveness (Stages 1, 2 and 3)

	Sources	Residual Load	% Reduction	DECC Target
Total Flow (ML/y)	15.4	14	8.7	NA
Total Suspended Solids (TSS) (kg/y)	3730	176	95.4	85
Total Phosphorous (TP) (kg/y)	6.71	1.43	78	65
Total Nitrogen (TN) (kg/y)	33.9	17.8	47.1	45
Total Gross Pollutants (kg/y)	547	0	100	90

<u>Whole Proposal</u>

The predicted treatment train effectiveness for the whole proposal is presented in **Table 7.** It shows the target pollutant reductions can be exceeded with the proposed water quality treatment measures.

[9] SEEC internal reference 16000278 Run 3

Table 7 - Treatment Train Effectiveness (whole proposal)

	Sources	Residual Load	% Reduction	DECC Target
Total Flow (ML/y)	46.8	42.3	9.6	NA
Total Suspended Solids (TSS) (kg/y)	10,100	697	93.2	85
Total Phosphorous (TP) (kg/y)	18.5	4.45	75.7	65
Total Nitrogen (TN) (kg/y)	99.5	54.1	45.5	45
Total Gross Pollutants (kg/y)	1510	37.1	97.5	90

7.5.2 *Pond Hydrology*

An analysis of waterbody residence time has been done following the probabilistic method given in Section 10.6.4.1 of Melbourne Water (2005); the "Probabilistic Residence Time". Only one pond (Pond 1) was modelled as all ponds are sized by the same method, i.e. a Pond's area is 2% of the effective impervious area draining to it and its volume is 0.4 times the area.

A MUSIC model was run using a daily time step from 1919 to 1989 (**Figure 4**)[10]. From within that, data was extracted from December 1939 to June 1989, a period of almost 50 years. The daily rainfall data was obtained at the BOM's Griffith CSIRO weather station. The same areal PET data used in Section 7.2 was used.

The data was exported to MS Excel for interrogation. The summer months (December to February inclusive) were selected in each year and the net summer inflow determined. If that was negative[11] then it was set to zero (no net inflow). The 20th percentile net summer inflow was then calculated and divided by the pond volume to give the 20th percentile probabilistic residence time (days). The result is 17 days, which is equal to the estimated maximum residence time (Figure 5) to minimise the risk of eutrophication and possible algal blooming (Melbourne Water, 2005) for a mean summer water temperature of 30^{o}C.

[10] SEEC internal reference 16000278 Run 4
[11] Happens if evaporation exceeds inflow

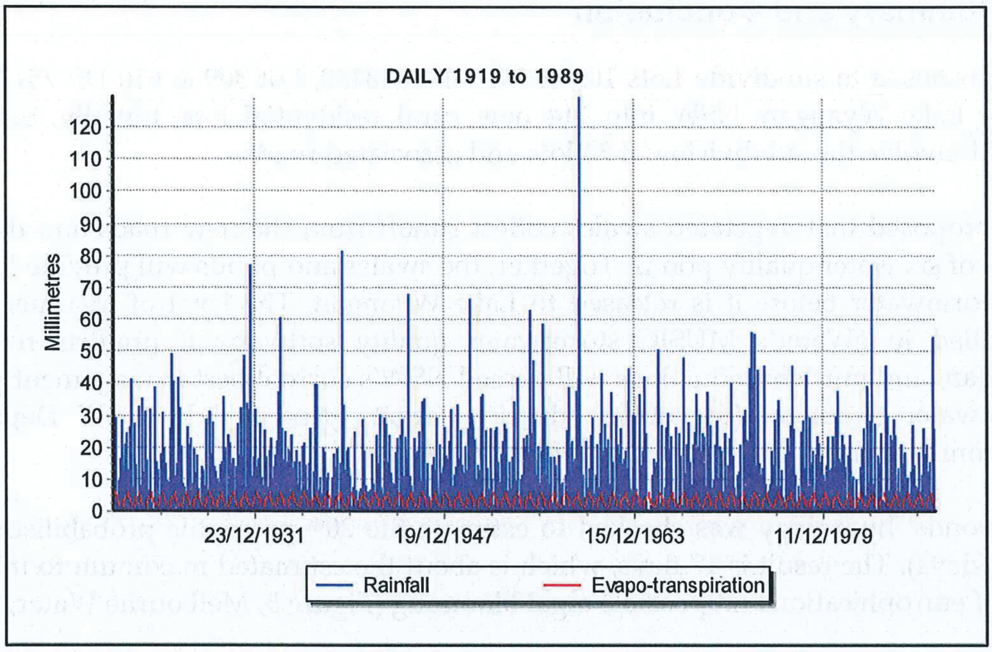
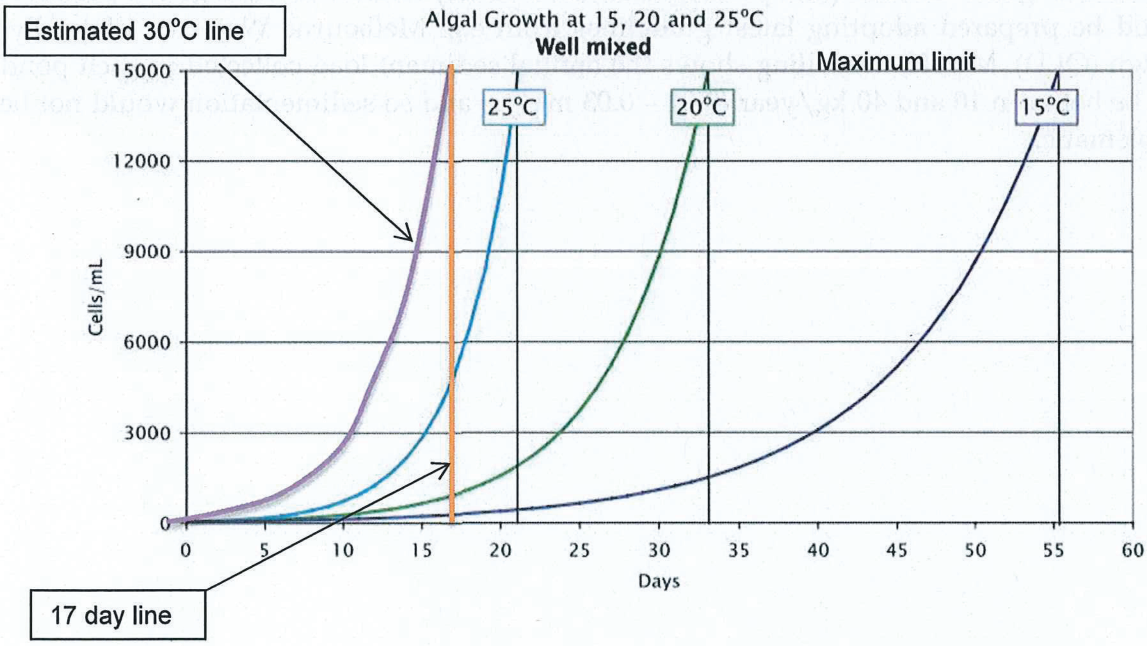


Figure 4 – Time-series graph for daily rainfall data



8 Summary and Conclusion

It is proposed to subdivide Lots 102 & 104 DP 1018460, Lot 309 & 610 DP 751743, Boorga Road, Lake Wyangan, NSW into 114 new rural residential lots. Initially, Stages 1 to 3 would involve the subdivision of 34 lots and associated roads.

It is proposed that vegetated swales collect runoff from the new roads and direct it to a series of six water quality ponds. Together, the swales and ponds will provide treatment to the stormwater before it is released to Lake Wyangan. The level of treatment has been modelled in eWater's MUSIC stormwater quality software; it predicts the levels of pollutant and nutrient reductions will exceed NSW's current best management practice for stormwater treatment (the draft reduction targets presented by NSW Department of Environment and Climate Change (DEC, 2007).

The ponds' hydrology was checked to estimate the 20th percentile probabilistic residence time (days). The result is 17 days, which is about the estimated maximum to minimise the risk of eutrophication and possible algal blooming (Figure 5, Melbourne Water, 2005).

Swales and ponds have been adopted as both have minimal and simple maintenance requirements. An Operational Environmental Management Plan (OEMP) would be prepared to guide Council (and possibly new lot owners) on how to manage the ponds. It would be prepared adopting latest guidelines from e.g. Melbourne Water or Water-By-Design (QLD). MUSIC modelling shows the annual sediment load collected in each pond will be between 10 and 40 kg/year (0.01 - 0.03 m^3/yr) and so sedimentation would not be problematic.

9 References

DECC (2007). *Managing Urban Stormwater, Environmental Targets (Draft).* NSW Department of Environment and Climate Change, Sydney.

DM McMahon (2015). *Land Capability Assessment: 2368 West Road & Lots 102 & 104 Boorga Road, Nericon, NSW 2680*

Melbourne Water (2005). *WSUD Engineering Procedures.* CSIRO, Collingwood, Victoria

SMCMA (2010). *Draft NSW MUSIC Modelling Guidelines.* Sydney Metropolitan Catchment Management Authority.

Water Technology (2016) Lake Wyangan and Catchment Management Strategy – Technical Report

10 Appendix 1 – Proposed Subdivision and Catchment Plan

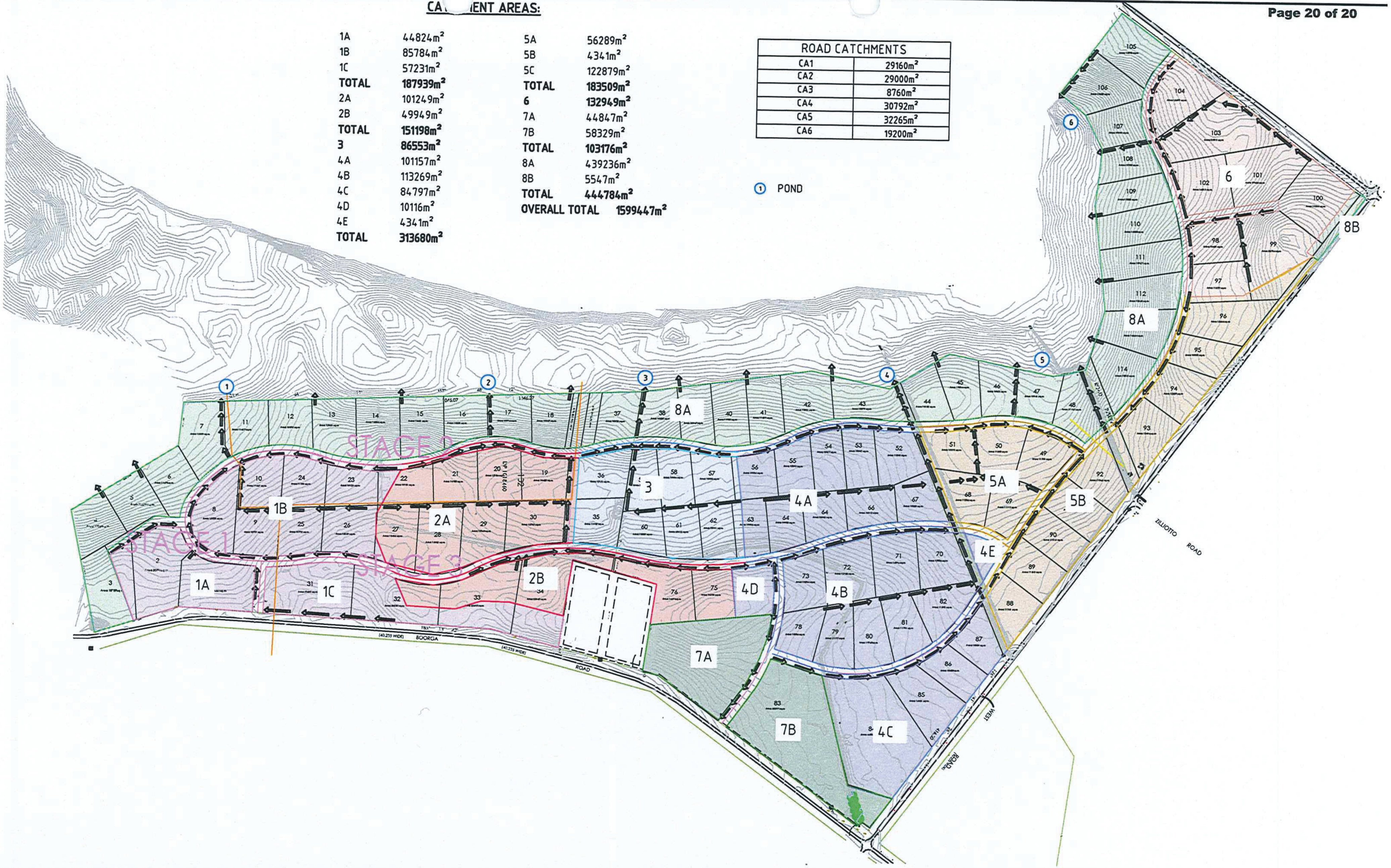
(Overpage)

CA[...]ENT AREAS:

1A	44824m²	5A	56289m²
1B	85784m²	5B	4341m²
1C	57231m²	5C	122879m²
TOTAL	**187939m²**	**TOTAL**	**183509m²**
2A	101249m²	**6**	**132949m²**
2B	49949m²	7A	44847m²
TOTAL	**151198m²**	7B	58329m²
3	**86553m²**	**TOTAL**	**103176m²**
4A	101157m²	8A	439236m²
4B	113269m²	8B	5547m²
4C	84797m²	**TOTAL**	**444784m²**
4D	10116m²	**OVERALL TOTAL**	**1599447m²**
4E	4341m²		
TOTAL	**313680m²**		

ROAD CATCHMENTS	
CA1	29160m²
CA2	29000m²
CA3	8760m²
CA4	30792m²
CA5	32265m²
CA6	19200m²

① POND



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