Attachment 6 - Water Cycle Assessment

Conceptual Water Cycle Management Study

For Proposed Rezoning of Lot 4 DP 834254, 510 Beach Road, Berry

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SEEC Reference 15000106-WCMS-02D

3rd April 2018

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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

3rd April 2018

Document Table

Issue Number	By	Reviewed by	Date
15000106-WCMS-02B	MP	BJ	26/10/2017
15000106-WCMS-02C	MP	Allen Price ASS	29/03/2018
15000106-WCMS-02C	MP	Allen Price ASS	03/04/2018

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1 Introduction

SEEC have been commissioned by Mrs. Enid Hall owner of Lot 4 DP 834254 (Figure 1) to prepare this Conceptual Water Cycle Management Study. It is required to accompany an application to rezone the property to permit large lot residential development over much of the site. The existing RU1 (Primary Production) zoned land would be rezoned to R5 (Large Lot Residential) with the existing E2 (Environmental Conservation) zoned land being rezoned to E1 (National Parks and Nature Reserves)
This WCMS shows how the requirements of Chapter 2 in Shoalhaven Council's DCP (2014) would be met. At this early stage, the WCMS is conceptual only; specific stormwater and wastewater management measures would be designed and presented at the Development Application Stage.

SEEC staff inspected the site on 5th May 2015. Weather on that day was cool and dry but the ground was sometimes wet following significant recent rainfall.

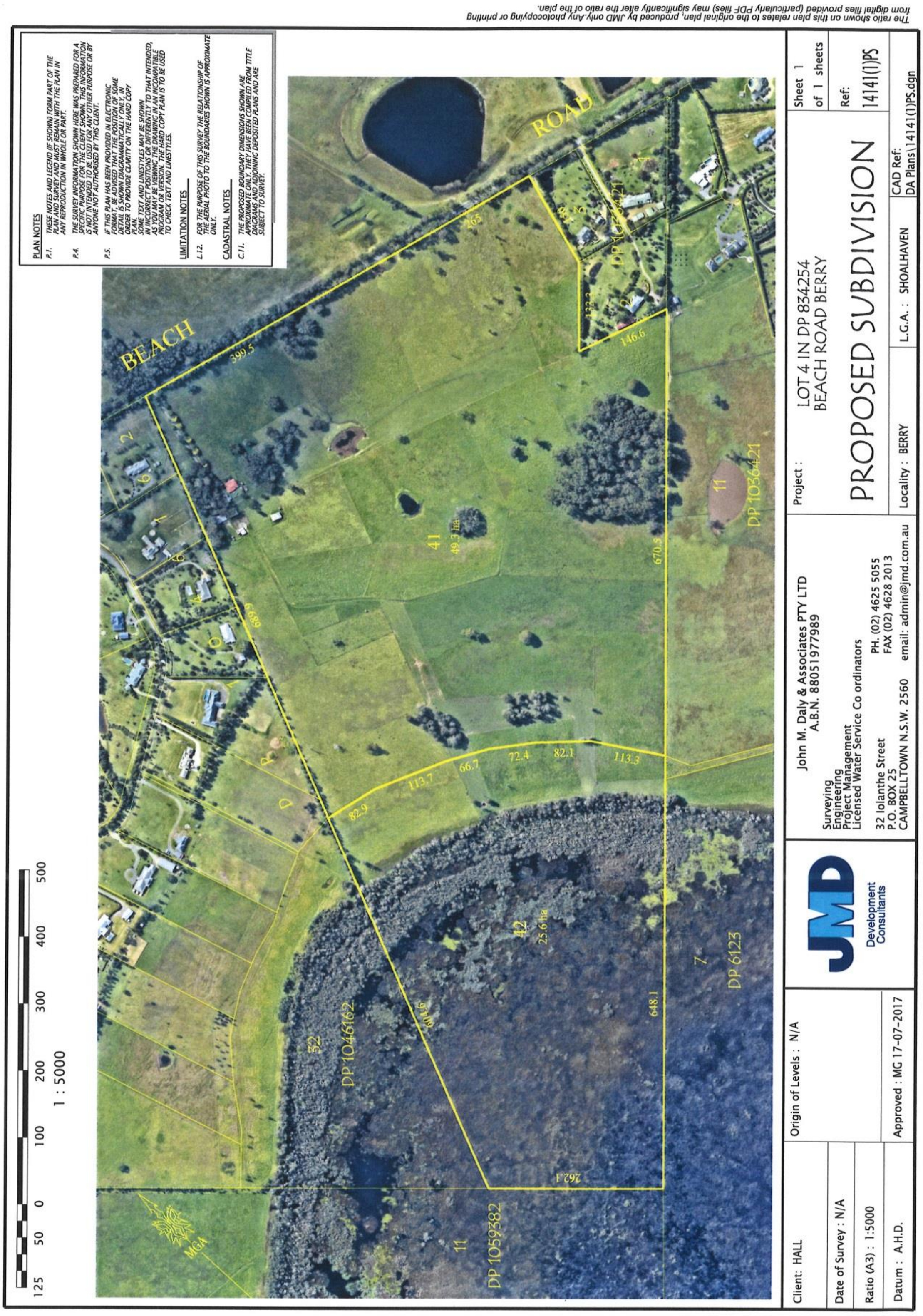

Figure 1 - Site Location

2 Project Description

It is proposed to rezone approximately 49.3Ha of the site from RU1 (Primary Production) to R5 (Large Lot Residential) and approximately 25.6Ha from E2 (Environmental Conservation) o E1 (National Parks and Nature Reserves).

Residential development would be confined to the R5 zoned land, and would be rural residential in nature, similar to neighbouring land to the west and the east (**Figure 1**). All the residential lots would require onsite wastewater management and rainwater tanks to supply potable water.

A road network would provide access to all residential lots. It is envisaged that it would drain to grassed table drains (swales), similar to the neighbouring developments to the east and west.

3 The Site

3.1 General Conditions

Lot 4 is a large rural property comprising about 55ha of pasture grass with the remainder (20ha) being part of Commonderry Swamp (Figure 1). At the time of inspection the pasture lands were used to graze cattle but in the past it has been used as a dairy farm. Other than Commonderry Swamp minor remnant native vegetation occurs in parts but generally the land has been cleared. Aerial photography of the site over a number of years from 1945 shows the site has been in a similar condition since that time.

A farm house and associated sheds are located in the northwest part of the property. The house is serviced by a septic tank to absorption bed located to the northwest and by a greywater trench located just to the east. **Figure 2** shows the typical conditions across the site.

Figure 2 - Looking south approximately along the alignment of a depression in the northwest corner of the site.

3.2 Topography and Drainage

Total relief is about 20 m and much of the land slopes at about 10–15%. A ridge divides the site into lands that drain to Beach Road (about 28.5 ha) and lands that drain to Commonderry Swamp. Approximately 20 ha of Lot 4 is Commonderry Swamp which is a SEPP14 Wetland. These lands would not be changed and so they are not discussed further in any detail.

Drainage on the southwest-facing slope (i.e. the land that slopes to Commonderry Swamp) is by sheet flow, there are no defined drainage depressions there. Drainage on most of the northeast-facing slope is via a broad depression which feeds two existing farm dams. A contour bank also feeds the northern-most of these dams. Although the depression is shown as a blue line on the Gerroa 1:25,000 topographic map, it does not have defined bed and banks (**Figure 5**) and so is not a watercourse that would require a controlled activity permit for any future works. On the map the depression is shown to discontinue north of Beach Road.

A third, small, dam is located in the far northwest. It is by-passed by the depression which drains just to its east and then enters the table drain of Beach Road. Finally, the depression drains under Beach Road through a culvert. A small portion of the northeast of the site also drains under Beach Road by another culvert; it then drains into a dam on a separate property.

3.3 Climate

The area has a warm temperate climate with summer-dominated rainfall. Nearby Berry has a mean annual rainfall of 1,423 mm and nearby Kiama has a mean 97 wet days a year. Pan evaporation is relatively high (approximately 1,671 mm/year measured at Nowra RAN station).

3.4 Soils

According to mapping by The Department of Conservation and Land Management (Hazleton P.A., 1992) the site has three soil landscapes (**Figure 3**):

- The Coolangatta Soil Landscape which is a residual soil landscape and occupies most of that part of the site to be developed;
- The Shoalhaven Soil Landscape which is an alluvial soil landscape in the far northwest of the site; and
- The Seven Mile Soil Landscape which is an estuarine soil landscape found in Commonderry Swamp.

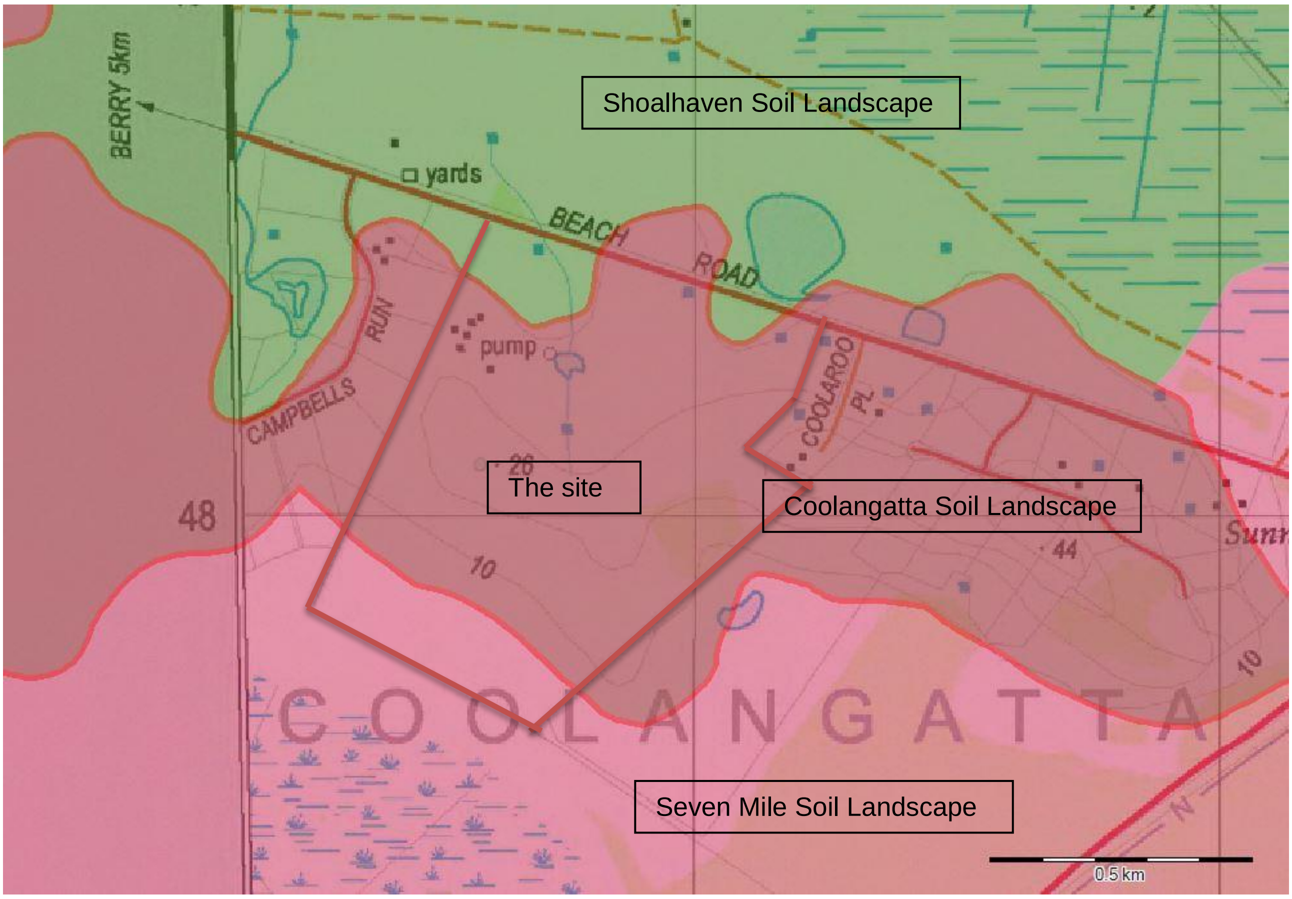

Figure 3 - Soil Landscape Mapping

A site specific soil investigation was undertaken by SEEC. A series of soil bores were taken where shown in **Figure 4.** The results of that investigation suggest the extent of the Shoalhaven Soil Landscape in the far northwest is slightly smaller than mapped; the Coolongatta Soil Landscape was present in this area too. Lands in the far southwest would not be developed and so were not investigated. All soil cores were taken on the Coolongatta Soil Landscape. The following soil profiles were observed:

Borehole 1:

0-200	Dark brown strongly pedal loam
200-400	Dark brown moderately pedal clay loam, sandy
400-900+	Light brown sandy clay loam with 10% fragments

Borehole 2:

0-150	Dark brown strongly pedal loam, saturated
150-600	Grey, weakly pedal, fine sandy clay loam to light clay
600-800	Mottled grey and orange brown sandy clay loam to light clay
800+	Bedrock (sandstone)

Borehole 3:

0-300	Dark brown strongly pedal loam
300-800	Dark brown moderately pedal clay loam to light clay, sandy
800-1,000	Dark brown moderately pedal clay loam, sandy with fragments
1,000+	Shale

Borehole 4:

0-200	Grey-brown loam
200-500	Brown light clay, moderately pedal
500-900	Mottled grey and orange medium clay, weakly pedal
900+	Shale

Borehole 5

0-100	Grey clay loam, weakly pedal
100-450	Grey mottled orange clay loam, moderately pedal
450-900	Grey mottled orange light to medium clay
900+	Shale

Figure 4 - Soil Core Locations

Soils were sent to NSW Department of Lands' Scone Research Laboratory and tested for a suite of effluent-disposal related tests. Topsoil and subsoil from BH2 and BH3 were composited separately and tested to give an indication of the average results. The results are given in **Table 1**. In summary, the boreholes and soil testing showed the soils at this site:

- Are consistently about 800 mm to 1,000 mm deep;
- Are moderately drained on the crest and higher side slopes but less well drained on footslopes where grey mottling occurs in the clay subsoil (*Minor to Moderate Limitation*[1]);
- Are slightly acidic, although this doesn't seem to affect grass growth (*Moderate Limitation*);
- Are not saline (*Minor Limitation*);
- Are not sodic (*Minor Limitation*);
- Are not significantly dispersive in the subsoil (EAT Class 2(1) *(Moderate Limitation);*
- Have good potential to sorb phosphorous *(Minor Limitation);*
- Have moderate cation exchange capacity (about 20 cmol(+)/kg) *(Minor Limitation)*.

Table 1 - Laboratory Soil Test results

Lab No	Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (cmol (+)/ kg)						C8B/1	P9B/2	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	EAT	Texture
1	15000106 BH 2 100 cm & 15000106 BH 3 100 cm	0.05	6.5	5.1	18.8	0.3	1.8	5.4	4.6	<0.5	290	8	Loam
2	15000106 BH 2 600 cm & 15000106 BH 3 500 cm	0.01	6.0	4.6	20.3	0.9	0.2	3.3	8.4	1.1	450	2(1)	Light clay

END OF TEST REPORT

[1] Limitations are those described in DLG (1998)

4 Land Surface Changes

4.1 Subdivision Stage

4.1.1 Introduction

The site is divided into:

- Land that will remain as part of Coomonderry Swamp (and so is not discussed further)
- Lands that will drain to Commonderry Swamp; and
- Lands that drain to Beach Road.

The following land surface changes would occur when the subdivision works are done.

4.1.2 Lands that drain to Commonderry Swamp

- Approximately 18.1 ha of land that is currently agricultural lands would become large-lot residential land. That would represent an improvement in water quality, as runoff from large-lot residential land has a better quality than runoff from agricultural land (CMA, 2010 and SCA, 2012).
- Approximately 5.7 ha of land that is currently agricultural lands would become zoned E1 (National Parks and Nature Reserves) and is proposed for dedication as an extension to Coomonderry Swamp Nature Reserve. That would represent an improvement in water quality, as runoff from an environmental zone would have a better quality than runoff from agricultural land (CMA, 2010 and SCA, 2012).

4.1.3 Lands that drain to Beach Road

- Approximately 29.7 ha of land that is currently agricultural lands would become large-lot residential land and the road network; none of the road network would drain to Commonderry Swamp. Runoff from large-lot residential land has a better quality than runoff from agricultural land (CMA, 2010 and SCA, 2012) but runoff from any new road might offset that to some extent.
- The two existing dams on the north-facing slope would be removed.

4.2 Dwelling Stage (Future DAs)

As each lot is developed there would be a slight increase in impervious surfaces (roofs, paving and driveways). However, as the lots are large, and it would be permissible to manage stormwater overflow in absorption trenches, the connectivity of these impervious surfaces to the stormwater drainage system would be minimal. CMA (2010) estimates the *effective* imperviousness[2] of these lots would only be about 5%.

5 Onsite Wastewater

5.1 Introduction

The site would not be connected to sewer and so wastewater generated in each new home would be managed on each lot. Much of the site is relatively unconstrained for wastewater management and most of the soils across the site are reasonably well suited to disposal of secondary treated effluent by either irrigation or absorption. However, there are some existing constraints and there would be others post development:

(i) Existing Constraints (Refer to Figure 5).

- There are areas of low-lying land along the frontage with Beach Road that are subject to poor drainage and high run-on; they represent the Shoalhaven Soil Landscape and would be avoided for the purposes of wastewater management.
- There is a drainage depression on the north-facing slope that drains to the far northwest corner of the site and thence under Beach Road; it requires a 40 m overland flow buffer from any effluent management area.
- The table drain(s) of Beach Road requires a 40 m buffer.

(ii) Post-development Constraints

- The new road network would, most likely, be drained using grass-lined drainage swales, similar to neighboring developments. Depending on their location and orientation, they might require a 40 m overland buffer from any future effluent management area.
- Buffers would also be required to lot boundaries and to the built environment on each lot; these would vary depending on each separate development application.

5.2 Conceptual Wastewater Design

5.2.1 Introduction

For the purpose of this early assessment, it is assumed irrigation would be adopted for wastewater disposal. Moderate slope gradients and the reasonably wet climate both dictate that subsurface irrigation be adopted on all lots. In addition, it is assumed wet weather storage is not desirable, as it is difficult for home-owners to manage. Assuming a five-bedroom home on tank water supply the design load is 900 L/day.

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

5.2.2 Nutrient Balances

Assuming the Effluent Management Areas consist of poorly managed lawns[3], to balance the input and uptake of nutrients, an area of 830 m^2 would be required[4] for a design life of 50 years (**Table 2**).

5.2.3 Hydraulic Balances

Chapter G8 in Council's DCP requires a monthly water balance to be done. The hydraulic *inputs* are retained median rainfall (i.e. median rainfall less an allowance for run-off) and applied effluent. The *outputs* are evapotranspiration (taken as pan evaporation reduced by a crop factor which varies through the year) and percolation (the ability of the soil to absorb water, 10L/m^2/day for a light clay soil (AS/NZS 1547:2012)). Median rainfall and pan evaporation values have been taken from Chapter G8.

The balance is shown in **Table 3**; a minimum Effluent Application Area (EAA) of 100 m^2 is required. Council require an area equivalent to this EAA to be set aside as a reserve in case it is ever required.

AS/NZS 1547:2012 gives an alternative, more conservative, method of calculating the required hydraulic area. The required area hydraulically is given as the daily effluent load (900L/day) divided by the Design Irrigation Rate (DIR) which, for light clay on a 10-20% slope, is 2.4L/m^2/day. By this method, the required EAA is 900/2.4 = 375 m^2. Again, Council require an area equivalent to this EAA to be set aside as a reserve, in case it is ever required.

5.2.4 Summary

Although, hydraulically, the EAA can (conservatively) be 375 m^2, the nutrient balance requires a total Effluent Management Area (EMA) of 830 m^2 to be set aside for effluent application and nutrient uptake.

Therefore, a total typical EMA for a five-bedroom home would consist of:

- 375m^2 of subsurface irrigation (the EAA)
- 455 m^2 of Nutrient Uptake Area (NUA) located immediately downslope of the EAA. Note: the NUA would include the reserve area.

Given the minimum lot size would be 10,000 m^2, incorporating an EMA of 830 m^2 would not be problematic (subject to a detailed assessment of existing and future constraints).

[3] i.e. lawns that are slashed with clippings not removed. The estimated plant nutrient uptakes would be 32.5 mg/m^2 and 3.25 mg/m^2 for nitrogen and phosphorous respectively (SCA, 2012). The insitu soil phosphorous sorption is estimated from site-specific soil testing to be 1861 kg/ha.
[4] Based on the nitrogen balance which is limiting.

Table 2- Nutrient Balances

Wastewater Volume 900 (L/day)

NOTE: The area required to uptake nutrients varies on what vegetation is adopted in the EMA.

Vegetation in EMA **Lawn - Unmanaged**

Nitrogen Balances

A = (C x Q) / Lx

Where:

A = Land Area (m2)

C = Concentration of Nutrient =	30	mg/L
Q = Wastewater Flow =	900	L/day
Lx = Critical Loading Rate =	32.5	(mg/m^2/day)

A = 831 m^2 of subsurface irrigation under Lawn - Unmanaged

Phosphorus Balances

Step 1: P Sorption Calculation

Psorb (topsoil)	loam	290	mg/kg	
Psorb (subsoil)	clay	450	mg/kg	
Bulk Density (topsoil)	loam	1500	kg/m3	
Thickness (topsoil)		200	mm	
Coarse Frags (topsoil)		0	%	
Bulk Density (subsoil)	clay	1300	kg/m3	
Thickness (subsoil)		800	mm	
Coarse Frags (subsoil)		5	%	
Calculated Psorb (topsoil)		870	kg/ha	
Calculated Psorb (subsoil)		4446	kg/ha	
Assumed P-sorb		1861	kg/ha	(insitu P-sorb is 35% calculated P-sorb)

Step 2: Determine the required area to sorb phorphorus (50 year design life) :

P absorbed	=	5316	x 0.35
	=	1861	kg/ha
	=	0.19	kg/m2
P uptake	=	3.25	mg/m2/day

Determine the amount of phosphorus generated over that time:

Concentration of phosphorus =		12	mg/L
Phosphorus generated =	Concentration x volume of wastewater =	197.1	kg

Area Required:

P generated / (P sorbed + P uptake) = 803 m^2 of Lawn - Unmanaged

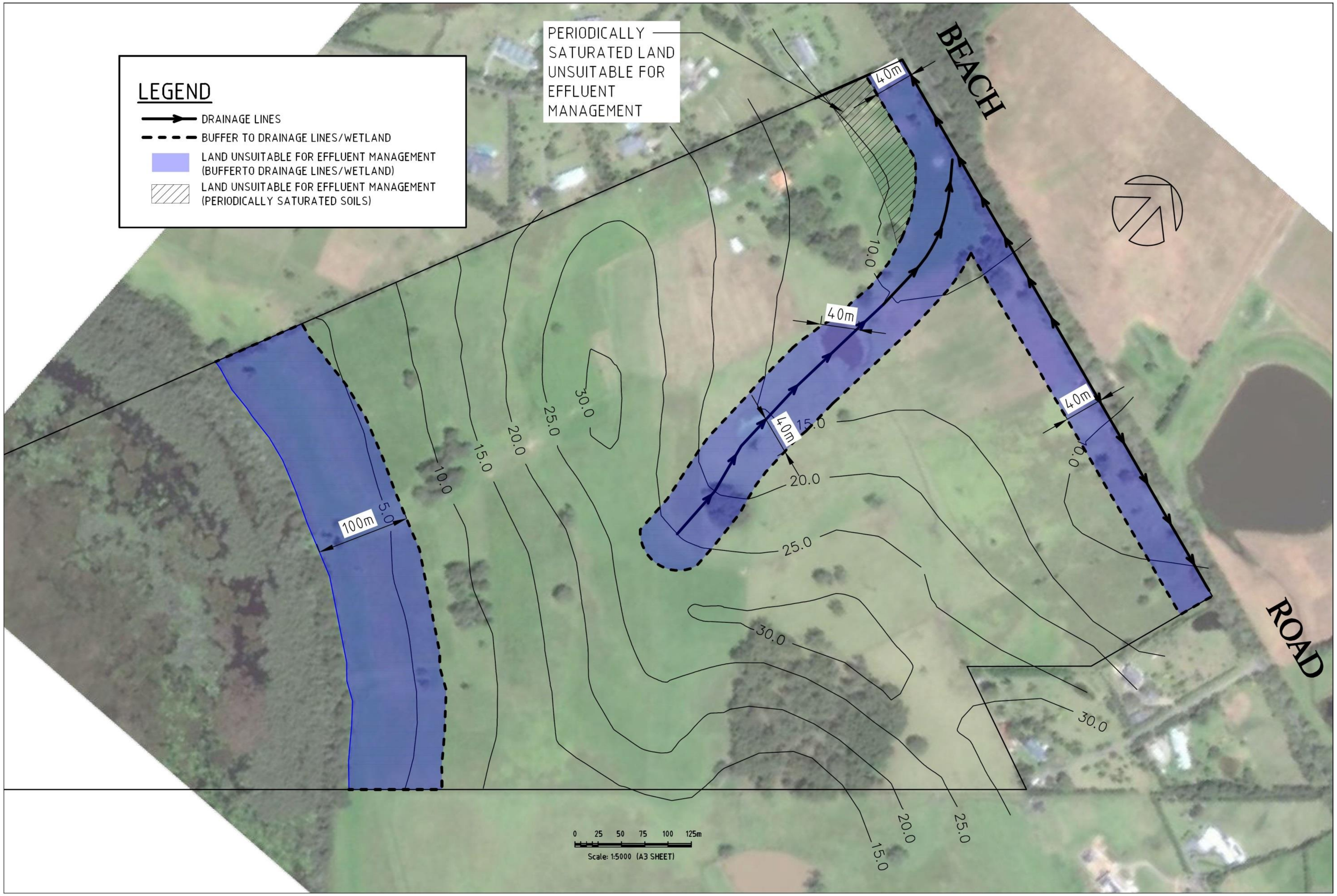

Figure 5 – Constraints to Effluent Management

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Table 3- Monthly Water Balance

Hydraulic Balance

	Rainfall Station	Berry		
	Evaporation Zone	Nowra		
	Wastewater Load	900	**L/day**	
	Percolation Rate	10	**mm/day**	
	Land Area	100	**m^2**	
	Storage Required	0	**m^3**	
Month	**Days in month**	**Median Precipitation (mm)**	**Evaporation (mm)**	**Crop Factor**
Jan	31	99.8	194.4	0.8
Feb	28	108.7	161.1	0.8
Mar	31	116.2	144.6	0.8
Apr	30	98.1	118.7	0.7
May	31	79.8	95	0.7
Jun	30	90.2	85.8	0.6
Jul	31	60	94.7	0.6
Aug	31	46.2	127.6	0.7
Sep	30	59.1	148.1	0.7
Oct	31	70.3	194.4	0.8
Nov	30	77.6	161.1	0.8
Dec	31	87.4	144.6	0.8
INPUTS				
	Retained Rainfall (mm)	**Effluent Irrigation (mm)**	**Total Inputs (mm)**	
Jan	79.84	279.00	358.84	
Feb	86.96	252.00	338.96	
Mar	92.96	279.00	371.96	
Apr	78.48	270.00	348.48	
May	63.84	279.00	342.84	
Jun	72.16	270.00	342.16	
Jul	48	279.00	327.00	
Aug	36.96	279.00	315.96	
Sep	47.28	270.00	317.28	
Oct	56.24	279.00	335.24	
Nov	62.08	270.00	332.08	
Dec	69.92	279.00	348.92	
OUTPUTS				
	Evapotranspiration (mm)	**Percolation (mm)**	**Outputs (mm)**	**Storage (mm)**
Jan	155.52	310.00	465.52	-106.68
Feb	128.88	280.00	408.88	-69.92
Mar	115.68	310.00	425.68	-53.72
Apr	83.09	300.00	383.09	-34.61
May	66.5	310.00	376.50	-33.66
Jun	51.48	300.00	351.48	-9.32
Jul	56.82	310.00	366.82	-39.82
Aug	89.32	310.00	399.32	-83.36
Sep	103.67	300.00	403.67	-86.39
Oct	155.52	310.00	465.52	-130.28
Nov	128.88	300.00	428.88	-96.80
Dec	115.68	310.00	425.68	-76.76

6 Stormwater Management

6.1 Introduction

Figure 1 in Chapter G2 of Council's DCP identifies the future development as a large scale development. The following sections describe a how a future Stormwater Management Plan would:

- Be consistent with:
  - Water Sensitive urban design (WSUD) principles; and
  - DCP Chapter G2 and its supporting technical guidelines.
- Achieve the relevant water quality objectives/targets.

A Stormwater Plan and a Soil and Water Management Plan would be developed to manage stormwater in a sustainable manner and comply with Council's DCP Chapter G2. The key outcomes identified in that document are to:

- Manage stormwater flow paths and systems to ensure the safety of people and property.
- Protect and enhance natural watercourses and their associated ecosystems and ecological processes.
- Maintain, protect and/or rehabilitate modified watercourses and their associated ecosystems and ecological processes towards a natural state.
- Mitigate the impacts of development on water quality and quantity.
- Encourage the reuse of stormwater.
- Integrate water cycle management measures into the landscape and urban design to maximise amenity.
- Minimise soil erosion and sedimentation resulting from site disturbing activities.
- Minimise the potential impacts of development and other associated activities on the aesthetic, recreational and ecological values of receiving water.
- Ensure the principles of ecologically sustainable development are applied in consideration of economic, social and environmental values in water cycle management.
- Ensure stormwater systems and infrastructure are designed, installed and maintained so as not to increase the risk to life or safety or people.

Council's key design objectives are listed in the sections below.

6.2 Hydrology Controls

The Key Objectives for hydrology controls for minor and major systems design are listed in **Table 4**, with reference to Council's DCP Chapter G2 and supporting document G2-2. The performance of any proposed stormwater system would be modelled in DRAINS stormwater software (or equivalent, approved, software) at the time of design.

Table 4 – Key Objectives: Hydrology Controls for Minor and Major Systems Design

Item	Source
Minor stormwater system – residential areas - 5 year ARI Major stormwater system - 100 year ARI Includes trunk stormwater systems e.g. open channels, large conduits and overland flow paths. Ensure a velocity depth product of less than $0.3m^2/s$ for a 100 year storm event.	Chapter G2: Clause 5.1.1
Stormwater retention – provide adequate retention storage volume (6-10mm[5] storage depth per m^2 increase in impervious surface area).	Chapter G2: Clause 5.3.2
Climate change impacts such as changes to rainfall intensities are incorporated into system design as per relevant policies and/or Australian Rainfall and Runoff (AR&R) Guidelines	Chapter G2: Clause 5.1.2
Onsite Stormwater Detention (OSD). OSD is to be sized to match pre-development peak flow rates for the 5, 20 and 100 year ARI rain events.	Chapter G2: Clause 5.1.3

6.3 Stormwater Reuse Controls

Stormwater re-use is encouraged on all new developments (**Table 5**). Rainwater tanks would be required on each new lot, their size being (at least partly) determined by BASIX.

Table 5 - Key Objectives: Stormwater Reuse Controls

Item	Source
Stormwater use within public open space (irrigation, street cleaning, and public amenities) is encouraged.	Chapter G2: Clause 5.2

[5] TBC by Council

6.4 Stormwater Quality Controls

Stormwater Controls would be considerate of the natural hydrological and ecological processes of the surrounding environment (**Table 6**). The performance of any proposed stormwater treatment train would be modelled in eWater's MUSIC software at the time of design.

The target pollutant reductions are high. Most likely the treatment train would consist of grass-lined swales for conveyance and water quality ponds and/or bioretention basins for onsite detention and water treatment. Such ponds would, most likely, be "end-of-pipe" structures located near Beach Road. They would be expected to be approximately 2-4% the size of the impervious areas that drain to them (CMA, 2010) and they would ultimately be handed over to Council, as they treat stormwater derived from a public asset (the road network). Consideration would be made to ensure adequate maintenance access.

Table 6 – Key Objectives: Stormwater Quality Controls

Item	Source
Develop an erosion and sediment control plan or soil and water management plan.	Chapter G2: Clause 5.3.1
Target pollutant load reductions: • Gross pollutants – 90% • Total Suspended Solids – 85% • Total Phosphorus – 65% • Total Nitrogen – 45% • Total Hydrocarbons – 90% The 1.5 year ARI pre-development peak discharge must be maintained. The duration of stream forming flows must be no greater than two-times the pre-development duration of stream forming flows at the site discharge point.	Chapter G2: Clause 5.3.4
Design and maintenance of stormwater structures: Ensure stormwater treatment measures for large scale developments are appropriately designed and are able to be maintained.	Chapter G2: Clause 5.3.5

7 Summary and Conclusion

It is proposed to rezone approximately 49.3Ha of the site from RU1 (Primary Production) to R5 (Large Lot Residential) and approximately 25.6Ha from E2 (Environmental Conservation) o E1 (National Parks and Nature Reserves).

Stormwater runoff from large lot residential lands and environmental zones has better quality than stormwater runoff from agricultural lands (CMA, 2010). Therefore, the land use changes would result in an improvement in stormwater quality.

All future residential lots would require onsite wastewater management and rainwater tanks to supply potable water. An assessment of the constraints and opportunities for onsite wastewater management has found that much of the site is unconstrained and so effluent management would not be problematic. However, there are some areas that are constrained and would be avoided (Figure 5); most notably:

- A 100m buffer from Commonderry Swamp.
- A 40m wide strip of land along Beach Road representing a buffer to Beach Road’s table drain (which carries significant flow in rainfall);
- A 40 m buffer from a depression on the north-facing slope (currently containing two farm dams); and
- An area of land in the far northwest representing the Shoalhaven Soil Landscape and which is low lying and prone to saturation.

Subsurface effluent disposal would be required because of the relatively wet climate and the moderately steep topography.

A new road network would be required to access the lots, although that is yet to be designed. The entire road network would be contained on the north-facing side slope that drains away from Commonderry Swamp. It is envisaged that stormwater from the road network would be drained by grass-lined swales, similar to the neighbouring developments. Measures would be provided to:

- Control the rate of stormwater flow (onsite detention, e.g. in rainwater tanks, bioretention basins) and
- Treat stormwater runoff from the road network to meet the target pollutant reductions.

It is envisaged that water quality ponds and/or bioretention basins would be required. Future stormwater design would meet Council DCP Chapter G2.

In conclusion, the change in land use from agricultural to large-lot residential would result in an improvement in stormwater quality. Issues of stormwater hydrology, stormwater quality and wastewater could be readily addressed in a future Development Application; none of these issues would preclude the proposed subdivision and re-zoning.

8 References

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