Narara Eco Village

Water Reservoir

Initial Sampling Report

Appendix 4.1.1.1
A0072

25th November 2014

Aquacell Pty Ltd
Unit 1/10b Production Place, Penrith NSW 2750, Australia
PO Box 7091, Leura NSW 2780, Australia
P: +61 2 4721 0545 F: +61 2 4721 2761
www.aquacell.com.au
ABN 79 072 487 015

Revision	Date	By	Checked	Status	Amendments
1	25/11/14	B. Layson/W.Johnson	W. Johnson	Issued to NEV	

1. Summary

This report has been prepared following the completion of a 12-week water sampling period, conducted to build a more complete knowledge of the water quality in the dam to be used as the water source to the Narara Ecovillage. The results indicate that the water is low in alkalinity, pH and hardness, and high in colour, iron, manganese and aluminium.

The treatment objectives could be met by the addition of chemical dosing ahead of the filtration process to remove colour, iron and manganese, as well as post treatment to increase hardness and alkalinity. This should produce a water that meets the ADWG and is less corrosive towards pipework and fittings in the distribution system and homes.

It is recommended that the current weekly sampling program continue for the immediate future, with the addition of phosphorus to the analysis list.

Additional sampling for blue-green algae and associated toxins should commence as soon as practical. Aquacell will prepare a separate quote for this for approval by NEV before commencing. As the potential for blue-green algae blooms cannot be eliminated at this stage, an additional process step (granular activated carbon) will be included in the design as a precaution.

2. THE SAMPLING SCHEDULE

The sampling schedule was comprised of 2 different sampling assays. An extensive monthly test, and a targeted weekly sampling test.

The weekly samples were tested for specific parameters that would typically impact on the treatment plant design. These were taken every week over the 12 week period, excluding the weeks of the monthly sampling. This is due to the fact that the monthly sampling assays included all of the analytes in the weekly sampling assays. This means that over the 12 weeks 9 weekly samples and 3 monthly samples were be taken.

The monthly sample assays included a wide range of analytes. The purpose of this was to examine a broader range of potential contaminates to determine if any of these required further investigation. This included trace metals, chemicals, radioactivity, organics and pesticides. These samples were taken at the beginning, middle and end of the 12 week sampling period.

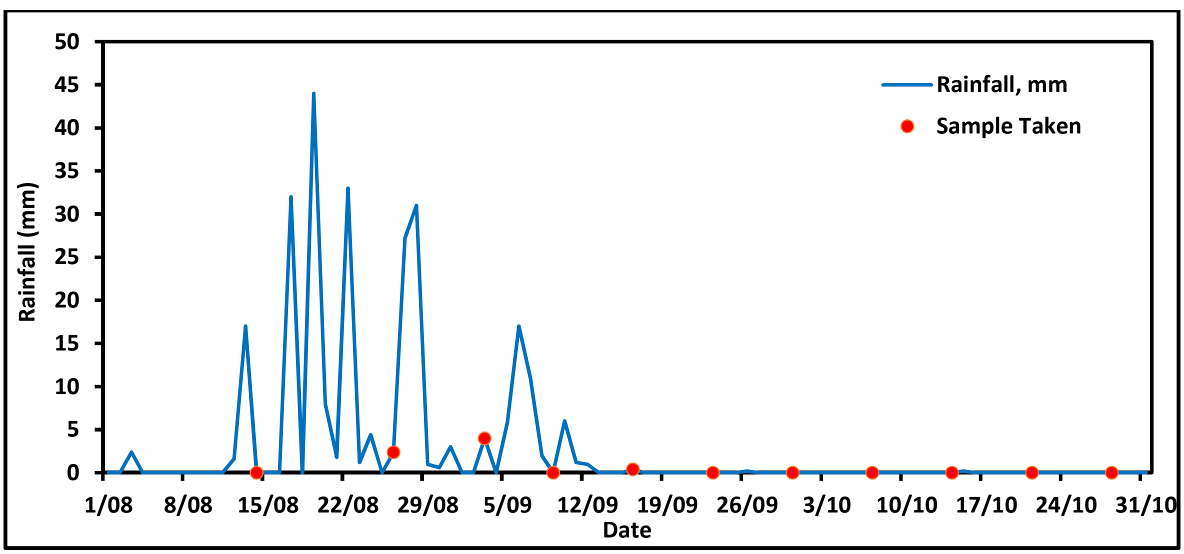
The sampling schedule is summarized in Table 1.

Table 1 Sample Schedule

Sample	1	2	3	4	5	6	7	8	9	10	11	12
Monthly Analysis	X					X						X
Weekly Analysis		X	X	X	X		X	X	X	X	X	

Rainfall was also checked from the Bureau of Meteorology website and is recorded to provide an indication of when samples were rain affected. These results are provided in figure 1.

Figure 1 Rainfall and sample days



3. Sampling Results

The results for "weekly" test parameters are presented in table 2, along with the Australian Drinking Water Guidelines (ADWG) recommended limits. The monthly results are presented in table 3. Those parameters that returned results that were outside the ADWG recommend limits are highlighted.

Table 2 Weekly Sampling Results

	Sample / Units	Month 1 14/08	Week 1 26/08	Week 2 3/09	Week 3 9/09	Month 2 16/09	Week 4 16/09	Week 5 23/09	Week 6 30/09	Week 7 7/10	Week 8 14/10	Week 9 21/10	Month 3 28/10	ADWG See PQL	Health (H) Aesthetic (A)
Rain Fall, Day of Sample	mm	0.0	2.4	4.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0		
Rain Fall, Week of Sample	mm	18.6	50.8	39.6	39.8	8.6	8.6	0.0	0.2	0.0	0.0	0.2	0.0		
Characteristics															
Bicarbonate Alkalinity	mg/L	12	7	<5	6	6	6	6	6.3	6.9	6	49	6		
Carbonate Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	Pt/Co	55	85	100	85	50	50	<5	40	45	40	55	50	15	A
Electrical Conductivity	µS/cm	170	140	135	140	160	140	140	155	156.05	140	130	190		
Hardness	$mgCaCO_{3/L}$	19	17	15	17	16	16	18	18	18	16	17	16	<200	A
Hydroxide Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
pH	pH Units	7.3	6.1	4.9	5.9	6	6.1	6.2	6.1	6.3	6.4	6.2	6.4	6.5-8.5	A
Total Alkalinity	mg/L	12	7	<5	6	6	6	6	6.3	6.9	6	49	6		
Total Dissolved Solids	mg/L	110	98	11	78	87	82	81	91	119	100	90	110	600	A
Total Organic Carbon	mg/L	5	7	8	7	7	7	7	6.4	6.503	6	8	7		
Turbidity	NTU	3.4	3.6	4.85	3.4	2.4	2.5	3.5	1.6	1.2	1.4	2.6	2.5	5	A
Microbial Contents															
E.coli	CFU/100mL	11	32	38	19	17	8	22	<1	40	200	53	13	<1	H
Chemical Contents															
Aluminium	µg/L	40	240	230	320	220	220	210	687	106.3	90	150	110	200	A
Calcium	mg/L	1.8	1.5	1.2	1.5	1.4	1.4	1.45	1.56	1.5	1.4	1.5	1.4		
Iron Total	µg/L	1200	1000	700	730	570	550	640	1006	629.5	670	780	660	300	
Magnesium Dissolved	mg/L	3.5	3.1	2.8	3.3	3.1	3.1	3.4	3.5	3.4	3.1	3.2	3.0		
Manganese	µg/L	32	26	1700	30	26	26	28	1860	20.7	28	31	22	500, 100	H, A

Table 3: Monthly Test Results

	PQL	Units	Month 1 14/08/14	Month 2 16/09/14	Month 3 28/10/14	ADWG See PQL	Health (H) Aesthetic (A)
Rain Fall, Day of Sample		mm	0.0	0.4	0		
Rain Fall, Day Before Sample		mm	17.0	0	0		
Characteristics							
Ionic Balance		%	-3.1	3.1	-2.8		
Total Suspended Solids	5	mg/L	<5	<5	<5		
Microbial Contents							
Total coliforms	1	CFU/100mL	150	40	17	<1	H
Chemical Contents							
Antimony	1	µg/L	<1	<1	<1	3	H
Arsenic-Total	1	µg/L	<1	<1	<1	10	H
Barium	1	µg/L	15	13	12	2000	H
Boron Total	5	µg/L	21	15	18	4000	H
Cadmium	0.1	µg/L	<0.1	<0.1	<0.1	2	H
Chloride	1	mg/L	39	36	35	250	A
Chromium	1	µg/L	<1	<1	<1	50	H
Colbalt	1	µg/L	<1	<1	<1		
Silicon- Total	0.2	mg/L	1.8	1.7	1.2		
Total Cyanide	0.004	mg/L	<0.004	<0.004	<0.004	0.08	H
Vanadium-Total	1	µg/L	<1	<1	<1		
Copper	1	µg/L	<1	<1	<1	2000, 1000	H, A
Fluoride, F	0.1	mg/L	<0.1	<0.1	<0.1	1.5	H
Iron Dissolved	10	µg/L	1200	350	430	300	A
Lead	1	µg/L	<1	<1	<1	10	H
Mercury-Total	0.05	µg/L	<0.05	<0.05	<0.05	1	H
Molybdenum	1	µg/L	<1	<1	1	50	H
Nickel	1	µg/L	<1	<1	<1	20	H
Nitrate as N in water	0.005	mg/L	0.03	0.021	0.012	50	H
Nitrite as N in water	0.005	mg/L	<0.005	<0.005	<0.005	3	H
Phosphorus - Total	0.05	mg/L	<0.05	<0.05	<0.05		
Potassium - Dissolved	0.5	mg/L	1.9	1.3	1.5		
Selenium-Total	1	µg/L	<1	<1	<1	10	H
Silver-Total	1	µg/L	<1	<1	<1	100	H
Sodium - Dissolved	0.5	mg/L	21	23	19	180	A
Sulphate, SO4	1	mg/L	5	8	6	500, 250	H, A
Tin	1	µg/L	<1	<1	<1		
Zinc	1	µg/L	19	3	<1	300	A
Radiation - Radium-226, Radium-228							
Alpha	5	mBq/L	<5			500	
Beta	10	mBq/L	<10			500	

	PQL	Units	Month 1 14/08/14	Month 2 16/09/14	Month 3 28/10/14	ADWG See PQL	Health (H) Aesthetic (A)
Rain Fall, Day of Sample		mm	0.0	0.4	0		
Rain Fall, Day Before Sample		mm	17.0	0	0		
Organic Pesticides							
Organochlorine Pesticides (OCP)							
Aldrin + Dieldrin	0.2	µg/L	<0.2	<0.2	<0.2	0.3	H
alpha-BHC	0.2	µg/L	<0.2	<0.2	<0.2		
alpha-Chlordane + gamma-Chlordane	0.2	µg/L	<0.2	<0.2	<0.2	2	
beta-BHC (b-BHC)	0.2	µg/L	<0.2	<0.2	<0.2		
delta-BHC (d-BHC)	0.2	µg/L	<0.2	<0.2	<0.2		
Dieldrin (See Aldrin)	0.2	µg/L	<0.2	<0.2	<0.2	-	
Endosulfan I (a) and II (b)	0.2	µg/L	<0.2	<0.2	<0.2	20	H
Endosulfan II (See Endosulfan I)	0.2	µg/L	<0.2	<0.2	<0.2	-	H
Endosulfan Sulphate (See Endosulfan I)	0.2	µg/L	<0.2	<0.2	<0.2	-	H
Endrin	0.2	µg/L	<0.2	<0.2	<0.2		
Endrin aldehyde	0.2	µg/L	<0.2	<0.2	<0.2		
gamma-BHC (lindane)	0.2	µg/L	<0.2	<0.2	<0.2		
gamma-Chlordane (See alpha-Chlordane)	0.2	µg/L	<0.2	<0.2	<0.2	-	
HCB	0.2	µg/L	<0.2	<0.2	<0.2		
Heptachlor	0.2	µg/L	<0.2	<0.2	<0.2	0.3	H
Heptachlor Epoxide	0.2	µg/L	<0.2	<0.2	<0.2		H
Methoxychlor	0.2	µg/L	<0.2	<0.2	<0.2	300	H
pp-DDD	0.2	µg/L	<0.2	<0.2	<0.2		
pp-DDE	0.2	µg/L	<0.2	<0.2	<0.2		
pp-DDT	0.2	µg/L	<0.2	<0.2	<0.2	9	H
Organophosphate Pesticides (OP's) – Standard 12 list							
Azinphos-methyl	0.2	µg/L	<0.2	<0.2	<0.2	30	H
Bromophos Ethyl	0.2	µg/L	<0.2	<0.2	<0.2	10	H
Chlorpyriphos	0.2	µg/L	<0.2	<0.2	<0.2		
Chlorpyriphos-methyl	0.2	µg/L	<0.2	<0.2	<0.2		
Coumaphos	0.2	µg/L	<0.2	<0.2	<0.2		
Diazinon	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Dichlorovos	0.2	µg/L	<0.2	<0.2	<0.2		
Dimethoate	0.2	µg/L	<0.2	<0.2	<0.2	7	H
Disulfoton	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Ethion	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Fenitrothion	0.2	µg/L	<0.2	<0.2	<0.2	7	H
Malathion (Maldison)	0.2	µg/L	<0.2	<0.2	<0.2	70	H
Methidathion	0.2	µg/L	<0.2	<0.2	<0.2	6	H
Methyl Parathion	0.2	µg/L	<0.2	<1	<0.2	20	H
Mevinphos	0.2	µg/L	<0.2	<0.2	<0.2	5	H
Naled	0.2	µg/L	<0.2	<0.2	<0.2		
Phenamiphos	0.2	µg/L	<0.2	<0.2	<0.2		
Phorate	0.2	µg/L	<0.2	<0.2	<0.2		
Phosalone	0.2	µg/L	<0.2	<0.2	<0.2		
Ronnel (fenchlorphos)	0.2	µg/L	<0.2	<0.2	<0.2		
Polychlorinated Biphenyls (PCB's)							
Aroclor 1016	2	µg/L	<2	<2	<2		
Aroclor 1021	2	µg/L	<2	<2	<2		
Aroclor 1032	2	µg/L	<2	<2	<2		
Aroclor 1042	2	µg/L	<2	<2	<2		
Aroclor 1048	2	µg/L	<2	<2	<2		
Aroclor 1054	2	µg/L	<2	<2	<2		
Aroclor 1060	2	µg/L	<2	<2	<2		

4. DISCUSSION

Of the extensive analyte testing completed of the 12 week sampling period, there were 7 analytes that lie outside the ADWG. These are *E. coli*, total coliforms, colour, pH, aluminium, manganese, and iron. In addition to these, alkalinity and hardness are also very low, which although not specifically highlighted in the ADWG, make the water potentially corrosive to metals and therefore requires addressing in the treatment process.

The remaining characteristics and chemical contaminates were all below the ADWG (where limits are provided). The results of the radiation tests returned no radiation concerns. All of the results from the organic pesticide testing returned concentrations below the detectable limit. The tested polychlorinated biphenyls all returned concentrations below the detectable limit of 2.0 µg/L.

Microbiological contaminates

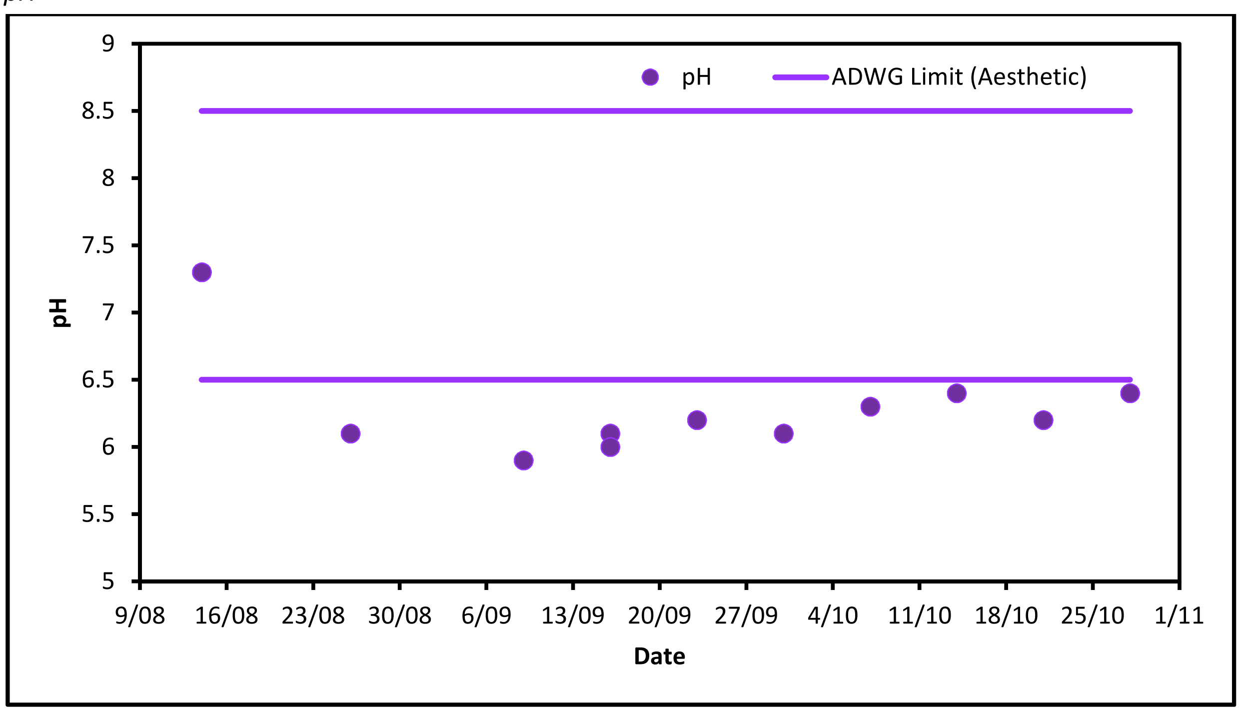
The ADWG requires no detectable concentration of *E. coli* or coliforms in drinking water. The presence of both these indicator organisms in the raw confirms that disinfection is required.

The proposed treatment train includes microfiltration and chlorination, which provides for multiple disinfection barriers and should adequately deal with any bacteria, viruses, or protozoa.

pH and Alkalinity

Both the raw water pH and alkalinity are low and will require adjustment. Alkalinity is a measure of a waters ability to buffer changes in pH. A low pH and alkalinity (especially in combination with low hardness) can mean the water has an unstable pH during treatment and distribution and may also be corrosive to metals.

pH



Hardness (calcium and magnesium)

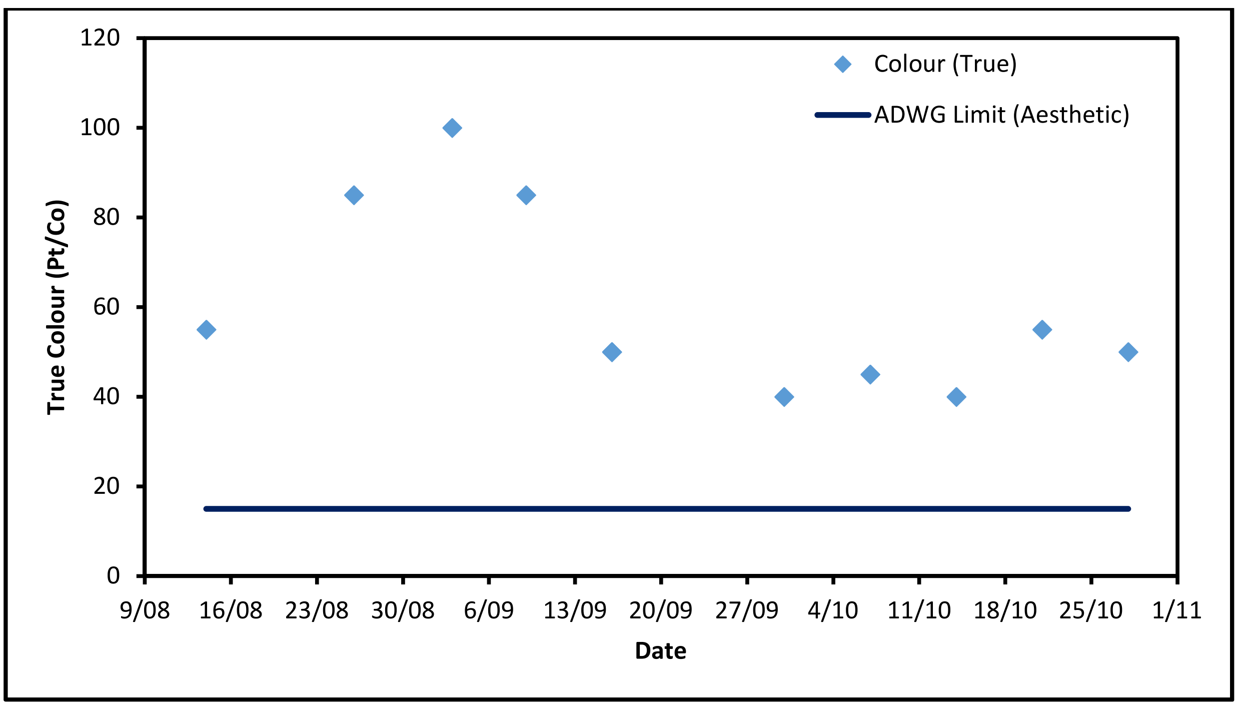
High levels of hardness can result in formation of scale on hot water pipes and fittings, whereas very low levels may indicate a water that is potentially corrosive to metal pipework and fittings or concrete lined pipes. The dam water is particularly soft (low hardness).

True Colour

The dam water contains an appreciable amount of true colour (40 to 100 HCU). This is well above the ADWG acceptable value of 15 HCU. This is largely an aesthetic issue, although high levels of colour can also lead to the formation of unacceptable levels of disinfection by-product following chlorination. It is therefore a treatment objective to reduce the colour to a level below 15 HCU.

There are various methods available to remove colour including oxidation (e.g. using ozone), membrane filtration (NF), absorption using activated carbon, or coagulation through the addition of chemical coagulants that precipitate colour that is subsequently removed by filtration. All these methods will be considered, however the most cost effective is likely to be coagulation.

True colour

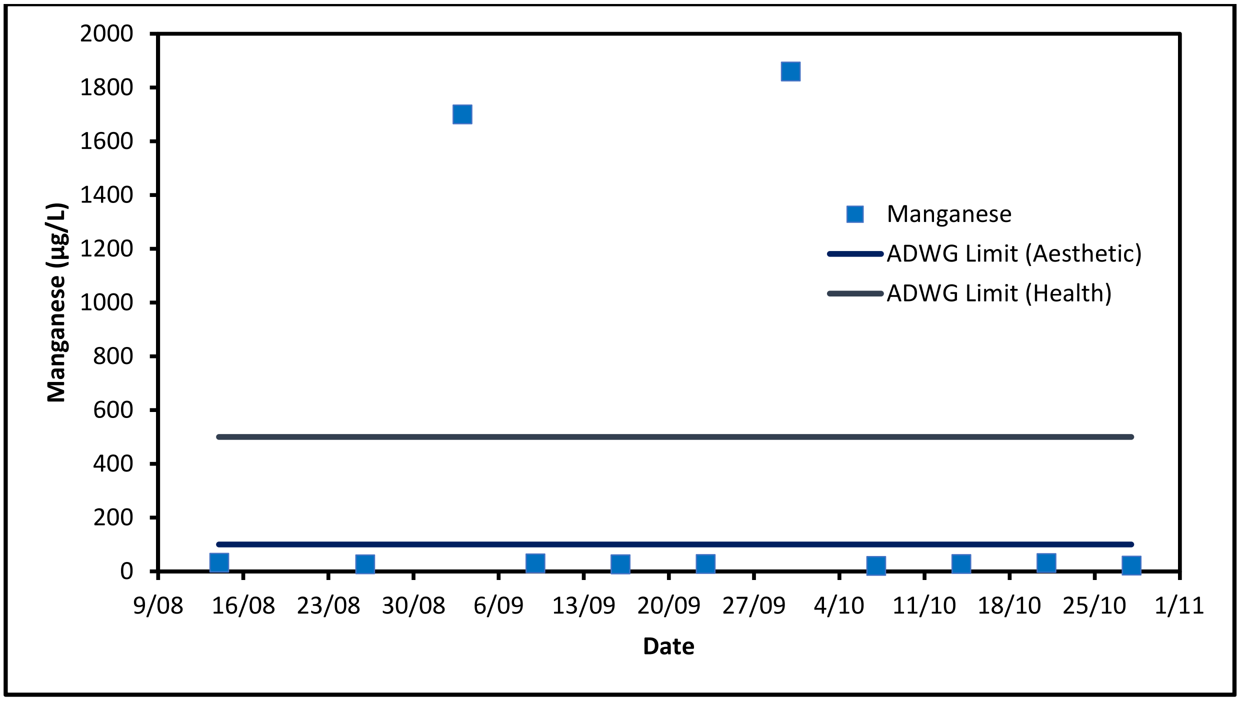


Manganese

The ADWG state that "At concentrations exceeding 0.1 mg/L, manganese imparts an undesirable taste to water and stains plumbing fixtures and laundry. Even at concentrations of 0.02 mg/L, manganese will form a coating on pipes that can slough off as a black ooze. Some nuisance microorganisms can concentrate manganese and give rise to taste, odour and turbidity problems in distribution systems. A discretionary target of 0.01 mg/L is suggested at the treatment plant.

The manganese levels found ranged from 0.022 mg/L to 1.86 mg/L. This is no doubt partly due to the low pH which increases solubility of manganese, and may well be partially removed by increasing the pH and alkalinity. However, the very high levels observed in some samples means that it must be a consideration in the treatment process.

Manganese concentration



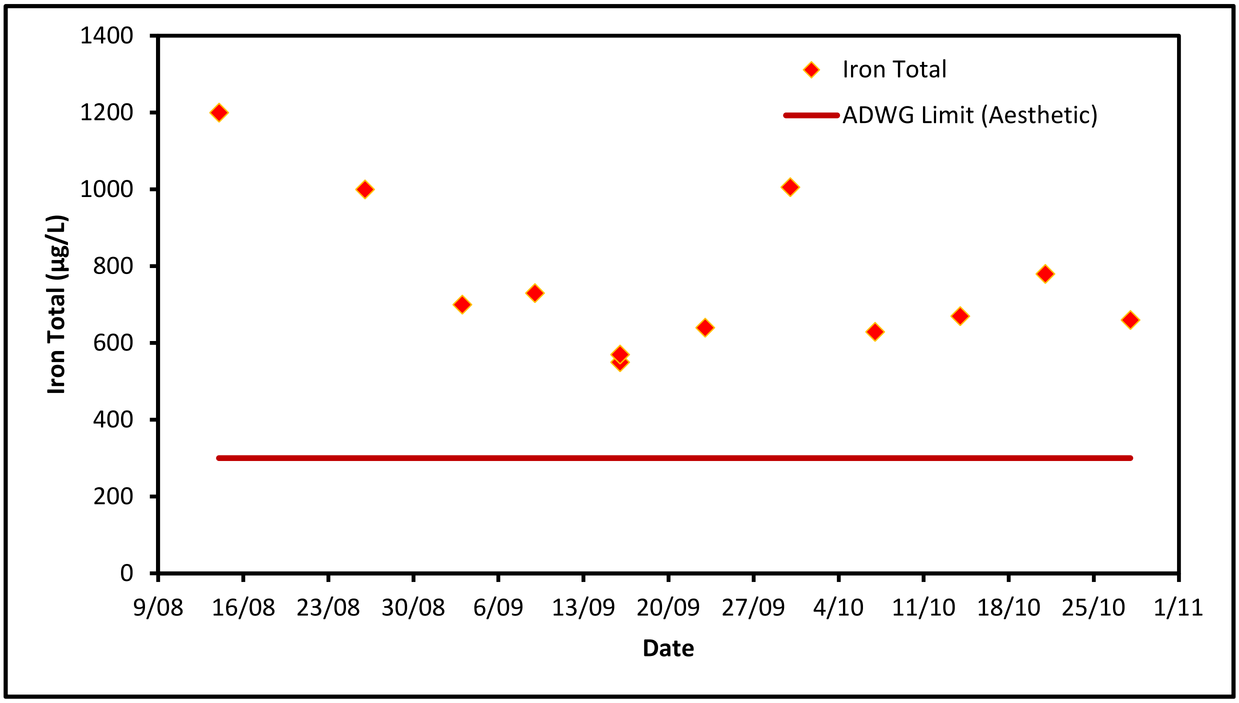
The most effective methods for removing manganese involve oxidation to manganese dioxide (which has very low solubility) with subsequent filtration. This can be achieved using a range of oxidants, but the most cost effective will likely be the addition of potassium permanganate. This is a strong oxidant and is dosed into the water at the beginning of the treatment process.

Iron

Iron levels ranged from 0.55 mg/L to 1.2 mg/L. Iron has a taste threshold of about 0.3 mg/L in water, and becomes objectionable above 3 mg/L. High iron concentrations give water an undesirable rust-brown appearance and can cause staining of laundry and plumbing fittings, fouling of ion-exchange softeners, and blockages in irrigation systems. (ADWG). It is therefore a treatment objective to reduce iron to < 0.3 mg/L in the treated water.

Methods for removal of iron are similar to manganese, and involves oxidation of soluble iron to solid iron oxide or hydroxide which can be removed by filtration. The same treatment process implemented for manganese should also manage the iron levels.

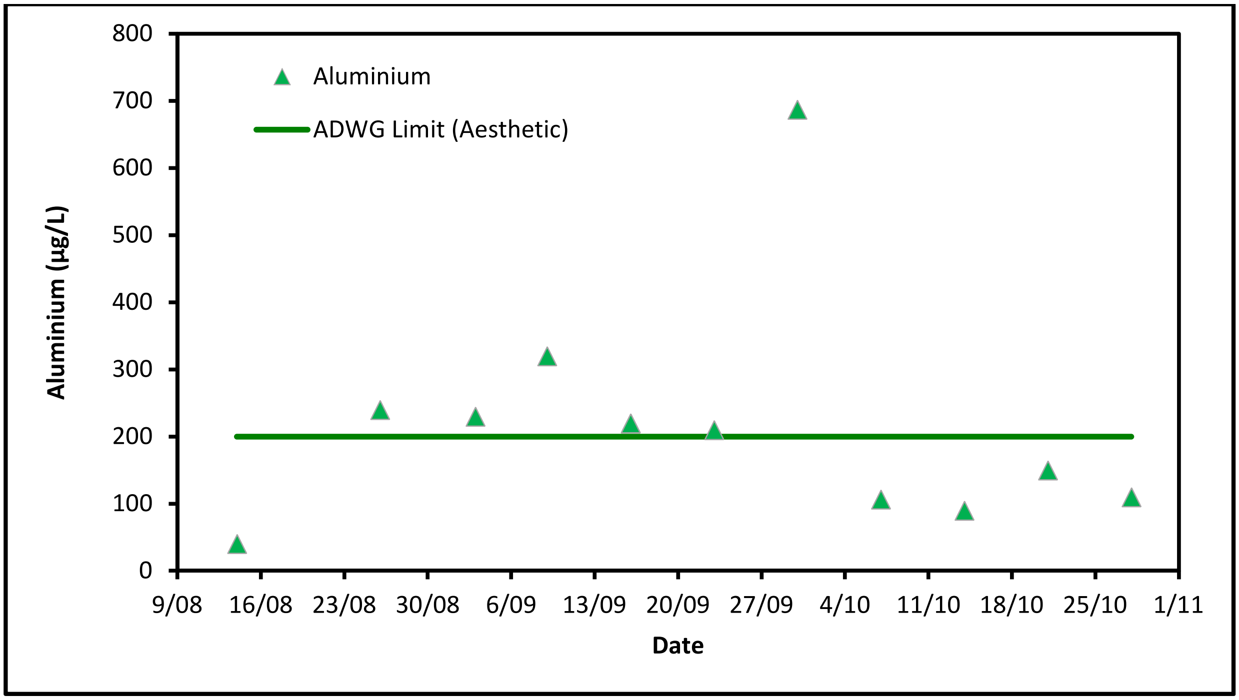
Iron concentration



Aluminium

The recommended limit for aluminium is based on the potential for post-precipitation in the distribution network and is it therefore recommend that the concentration be < 0.2 mg/L. This is therefore a treatment objective to reduce aluminium to < 0.2 mg/L. This is achieved through the coagulation/filtration process required for colour removal.

Aluminium concentration



Wet Weather

Several samples occurred during rain events or shortly after. Turbidity, colour and iron were elevated in the late August to early September samples associated with higher rainfall. Manganese was high in week 2 and week 6, which were also periods where rainfall was recorded, although week 6 falls were very low (0.2mm). Bacteria levels were not significantly altered. Alkalinity and pH were also lower during the rainfall in early September, which is consistent with high iron and manganese results.

In summary, it appears that there is a measurable impact on key water quality parameters during and following rainfall. This should not alter the treatment process, but does mean careful attention to process monitoring and control will be required to ensure water quality is maintained during and following these events.

5. Conclusion

The results of the sampling program so far indicate that the water is low in alkalinity, pH and hardness, and high in colour, iron, manganese and aluminium.

The treatment objectives could be met by the addition of chemical dosing ahead of the filtration process to remove colour, iron and manganese, as well as post treatment to increase hardness and alkalinity. This should produce a water that meets the ADWG and is less corrosive towards pipework and fittings in the distribution system and homes. As the potential for blue-green algae blooms cannot be eliminated at this stage, an additional process step (granular activated carbon) will be included in the design as a precaution.

6. Further sampling recommendations

The weekly regime meets the ongoing requirements for water quality monitoring and is currently being continued as is. However, it is recommended we add phosphorus analysis to the list. The latter is important for assessing the risk of algal blooms. The phosphorus levels in earlier samples were below the detection limit of 50 ppb, however we need to establish that this is below 10 ppb. The method therefore needs to be reviewed to lower the detection limit and confirm whether algal blooms are a potential risk in the dam. Aquacell have arranged to conduct this sampling at Sydney Water, through the lab currently used for testing. The sampling procedure and subsequent delivery to the lab, will therefore not change.

Algal counts and algal toxins have yet to be considered quantitatively, and with warmer weather approaching we should begin sampling for the presence of cyanobacteria cells (blue-green algae) and associated toxins. It is recommended that we commence some additional tests for these toxins. This would include cylindrospermopsin, microcystin, nodularin, and Saxitoxin. Aquacell will prepare a separate quote for this for approval by NEV before commencing.

As no other chemicals of significance were identified in the more comprehensive sampling, there is no need to pursue any of these contaminates further.

Narara Eco Village

Water Reservoir

Follow Up Sampling Report

Appendix 4.1.1.2

A0072

18th August 2015

Revision	Date	By	Checked	Status	Amendments
1	18/08/15	J. Taylor	W. Johnson		

1. Summary

This report has been prepared following the completion of a second sampling regime on the Narara Ecovillage dam. The dam is the water source for a proposed potable water treatment plant to supply the residents of the village. It is also a part of water industry infrastructure which is currently the subject of an application for a Water Industry Competition Act (WICA) Network Operators and Retail Supply licence.

An initial 12 week sampling program was undertaken on the dam. This sampling was conducted between August and October in 2014, with the report presented in November 2014. The report found the dam water was low in alkalinity, pH and hardness, and high in colour, iron, manganese and aluminium.

To continue to build knowledge about the dam's water quality, a further 16 samples were taken between November and April to confirm the original observed trends and identify any seasonal changes. In line with the recommendation of the initial sampling report, the additional testing has been undertaken with the addition of phosphorus to the analysis list as an indicator of the propensity of algal blooms.

This report should be read in conjunction with the initial sampling report from November 2014. Many of the conclusions from that report are referred to here. For the purpose of expediency the description and analysis has not been repeated here.

2. The Sampling Schedule

The initial sampling of the dam water consisted of two different sampling assays; an extensive monthly test, and a targeted weekly sampling test. The extensive monthly tests did not indicate or highlight any specific areas of concern, so the follow up sampling regime continued the weekly targeted tests as it measured parameters that typically impact on the design of the treatment plant.

An additional 16 samples were taken and the sampling dates are shown in **Table 1**. The first four samples were taken approximately weekly from mid-November, while the next 11 were taken weekly from mid-January.

The final sample was taken on 22nd April 2015. This was taken in response to a unique rain event which occurred at Narara. This sample is discussed separately later in this report.

Sample	Date
1	18/11/14
2	2/12/14
3	9/12/14
4	16/12/14
5	20/01/15
6	27/01/15
7	3/02/15
8	10/02/15
9	17/02/15
10	24/02/15
11	3/03/15
12	10/03/15
13	17/03/15
14	24/03/15
15	31/03/15
16	22/4/15

Table 1 Sample Schedule

Rainfall was also checked from the Bureau of Meteorology website and is recorded to provide an indication of when samples were rain affected. These results are provided in **Figure 1**.

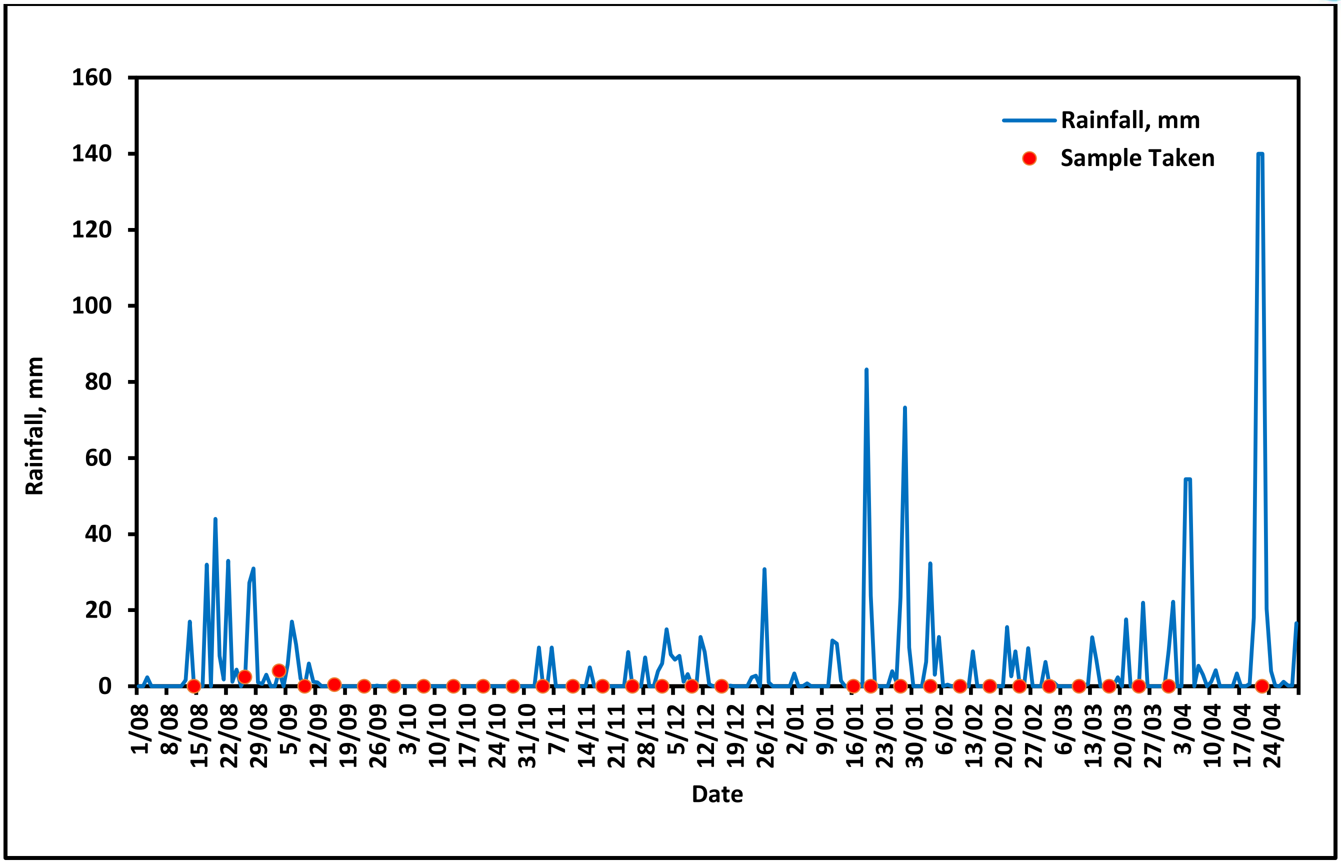


Figure 1 Rainfall and sample days

3. Sampling Results

The results for test parameters for the first 8 samples are presented in Table 2, and the result for the final 8 samples are presented in **Table** 3. The Australian Drinking Water Guidelines (ADWG) recommended limits are also presented in the tables. Those parameters that returned results that were outside the ADWG recommend limits are highlighted.

Table 2 Results for Samples 1 - 8

	Sample	1	2	3	4	5	6	7	8	ADWG	Health (H)
	Units	18/11	2/12	9/12	16/12	20/1/`5	27/01	3/02	10/02	See PQL	Aesthetic (A)
Rain Fall, Day of Sample	mm	0.0	0	0.0	0.0	0	0	0.0	0.0		
Rain Fall, Week of Sample	mm	5.2	17.6	42.9	24.6	107.9	29	122.2	17.4		
Characteristics											
Bicarbonate Alkalinity	mg/L	7	8	8	8	11	8	8	8		
Carbonate Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	Pt/Co	40	40	50	50	30	25	60	60	15	A
Electrical Conductivity	µS/cm	140	140	150	140	160	150	130	120		
Hardness	mgCaCO$_{3/L}$	17	18	17	16	16	16	15	14	200	A
Hydroxide Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
pH	pH Units	6.1	6.5	6.5	6.5	6.4	6.3	6.3	6.1	6.5-8.5	A
Total Alkalinity	mg/L	7	8	8	8	11	8	8	8		
Total Dissolved Solids	mg/L	75	98	93	90	89	82	78	100	600	A
Total Organic Carbon	mg/L	8	7	6	7	6	7	10	11		
Turbidity	NTU	1.6	2.5	2	1.4	2	3.2	2.9	18	5	A
Microbial Contents											
E.coli	CFU/100mL	70	110	10	40	308	330	180	310	<1	H
Chemical Contents											
Aluminium	µg/L	70	60	50	90	50	120	420	350	200	A
Calcium	mg/L	1.5	1.6	1.5	1.4	1.4	1.4	1.3	1.3		
Iron Total	µg/L	660	780	510	550	530	1200	920	1200	300	
Magnesium Dissolved	mg/L	3.2	3.3	3.2	3	3.1	3	2.8	2.7		
Manganese	µg/L	12	19	10	13	22	49	57	98	500, 100	H, A
Phosphorous	mg/L		0.02	0.014	0.01	0.02	0.02	0.02	0.1		

Table 3 Results for Samples 9 - 16

	Sample	9	10	11	12	13	14	15	16	ADWG	Health (H)
	Units	17/02	24/02	3/03	10/03	17/03	24/03	31/03	22/04	See PQL	Aesthetic (A)
Rain Fall, Day of Sample	mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	140.0		
Rain Fall, Week of Sample	mm	9.2	27.4	16.4	1.0	20.4	20.0	31.4	302.0		
Characteristics											
Bicarbonate Alkalinity	mg/L	8	6	10	7	6	10	6	6		
Carbonate Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	Pt/Co	60	60	45	50	70	68	210	92	15	A
Electrical Conductivity	µS/cm	130	130	140	140	210	260	130	110		
Hardness	mgCaCO$_{3/L}$	16	13	15	15	12	13	14	11	200	A
Hydroxide Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
pH	pH Units	6.2	5.9	6.9						6.5-8.5	A
Total Alkalinity	mg/L	8	6	10	7	6	10	6	6		
Total Dissolved Solids	mg/L	83	91	92	77	120	110	75	68	600	A
Total Organic Carbon	mg/L	15	12	13	10	8	9	9	15		
Turbidity	NTU	6.4	11	4	37	2	1.4	3.3	6.7	5	A
Microbial Contents											
E.coli	CFU/100mL	62	180	24		82	16	130	70	<1	H
Chemical Contents											
Aluminium	µg/L	530.0	160	140	190	110	90	110	690	200	A
Calcium	mg/L	1.3	1.1	1.3	1.2	0.8	0.9	1	1		
Iron Total	µg/L	2100.0	610	600	1200	580	410	390	1000	300	
Magnesium Dissolved	mg/L	3.0	2.5	2.9	2.8	2.5	2.5	2.8	2		
Manganese	µg/L	200.0	15	31	63	35	19	29	56	500, 100	H, A
Phosphorous	mg/L	0.02	0.1	0.04		0.04	0.021	0.024			

4. DISCUSSION

Of the extensive analyte testing completed, there are 7 analytes that lie outside the ADWG. These are *E. coli*, total coliforms, colour, pH, aluminium, manganese, and iron. In addition to these, alkalinity and hardness are also very low, which although not specifically highlighted in the ADWG, make the water potentially corrosive to metals in the distribution system and therefore requires addressing in the treatment process.

The remaining characteristics and chemical contaminates were all below the ADWG (where limits are provided).

The results of the all 26 samples (12 samples from the first test schedule and 16 from the second test regime) have been combined and presented in the analysis below.

Microbiological contaminates

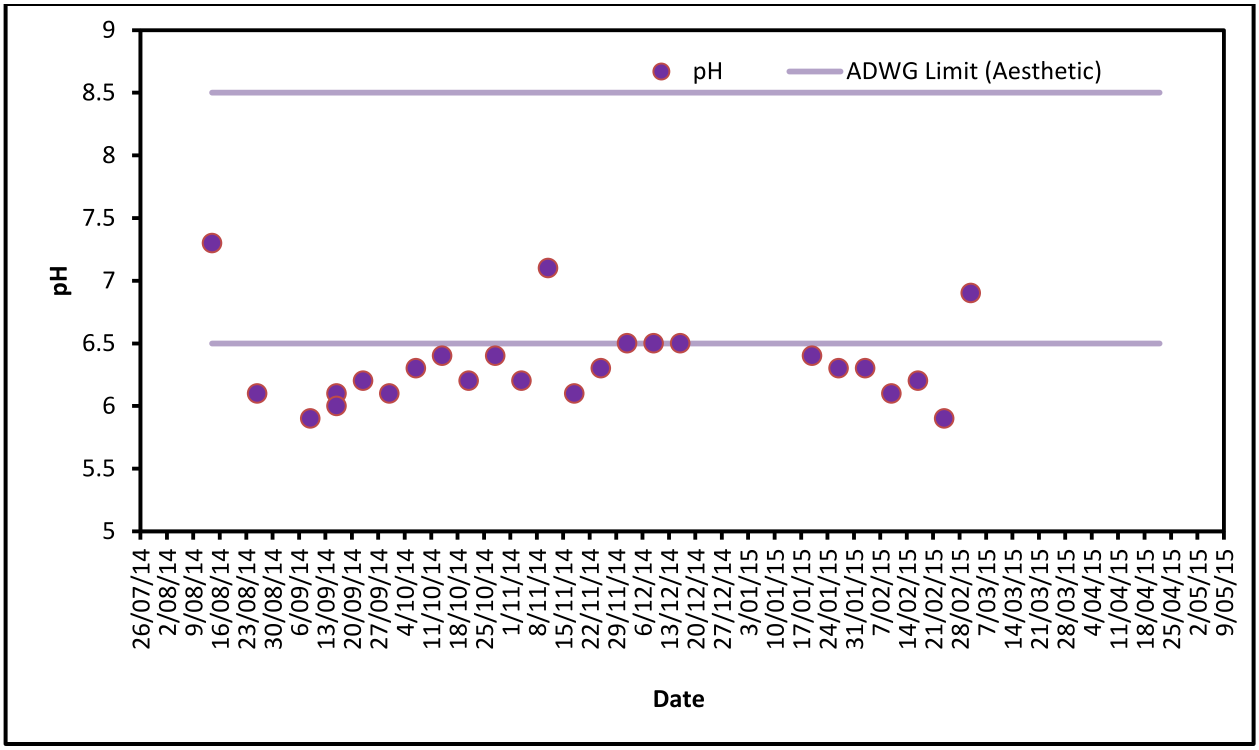
The results of the second test regime indicate the ongoing presence of *E. coli.* Disinfection remains a key objective of the treatment process to address the possible presence of pathogenic bacteria, protozoa and viruses.

The conclusion in the original sample report was that the proposed treatment train which included ultrafiltration, nanofiltration and chlorination, would adequately deal with any bacteria, viruses, or protozoa. There are no sampling results which require this conclusion to be re-assessed.

pH and Alkalinity

The raw water pH and alkalinity remained consistent with the initial sampling results and confirm that the raw water pH and alkalinity will require adjustment in the treatment process. This is consistent with the original report.

pH



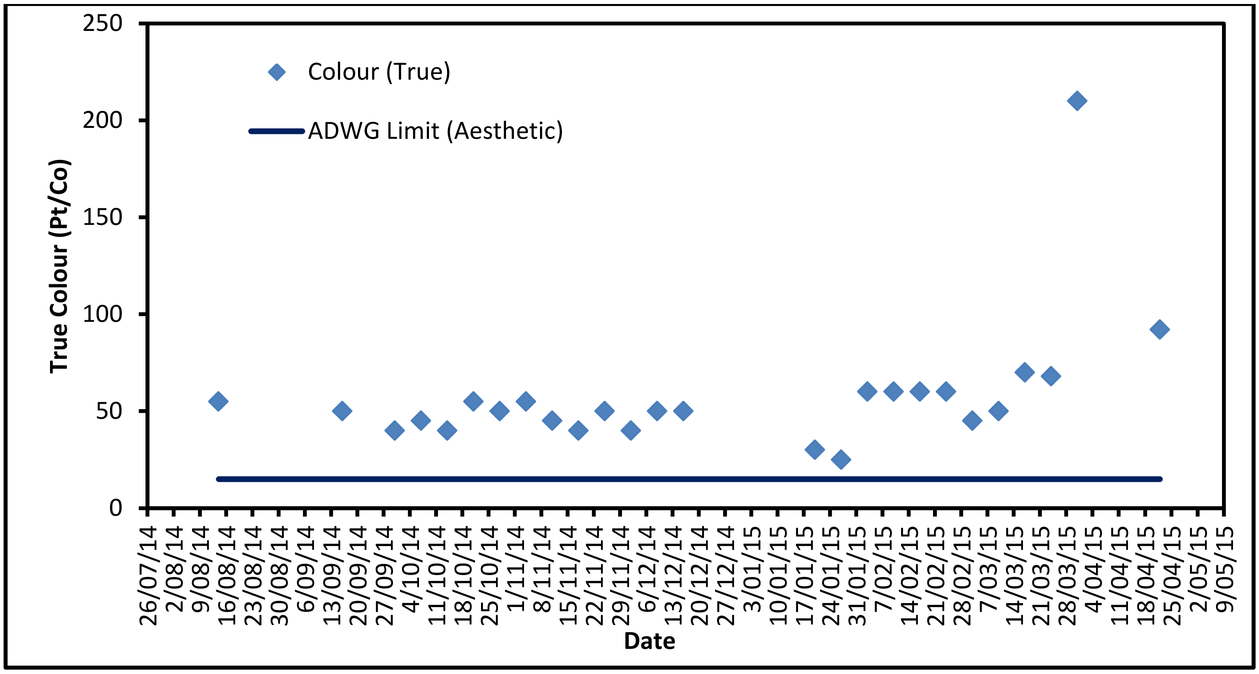
Hardness (calcium and magnesium)

The levels of calcium and magnesium are consistent across all sampling and confirm that the dam water is soft (low hardness) and may be potentially corrosive to metal pipework and fittings, or concrete lined pipes.

True Colour

The dam water continued to show true colour typically between 40 and 100 HCU, which is well in excess of the ADWG aesthetically acceptable level of 15 HCU. As described in the original dam sampling report, oxidation using ozone, membrane filtration, absorption using activated carbon, or coagulation and filtration are the methods being considered to remove the colour.

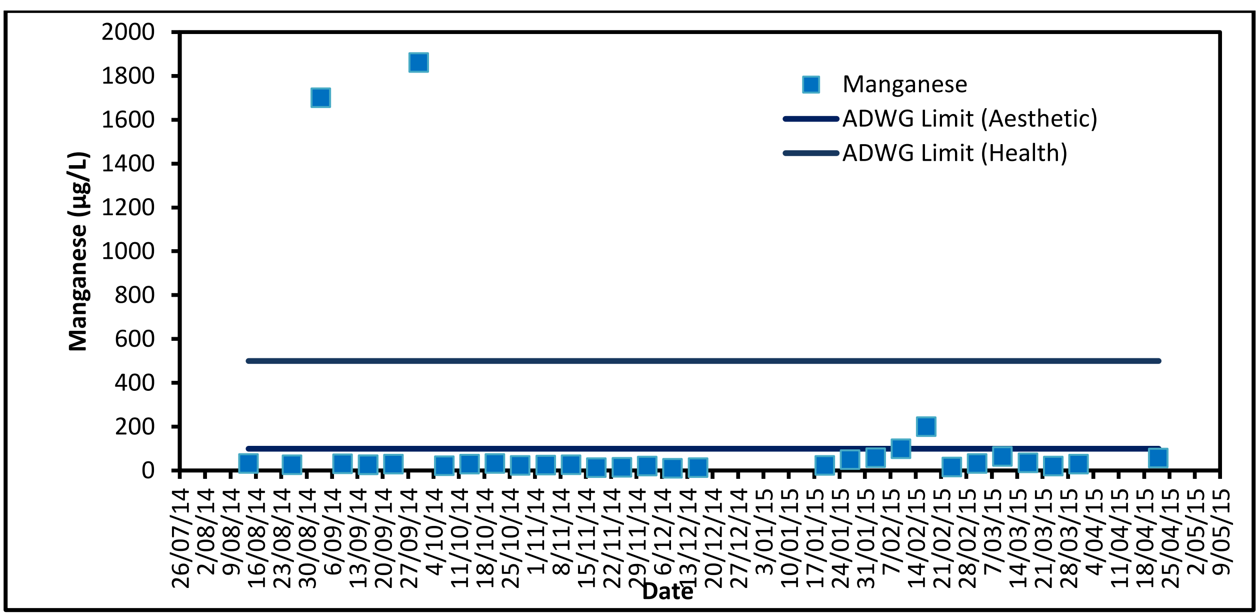
True colour



Manganese

High concentrations of manganese were present in all samples confirming that manganese removal will need to be incorporated into the water treatment train as identified in the original water sampling report.

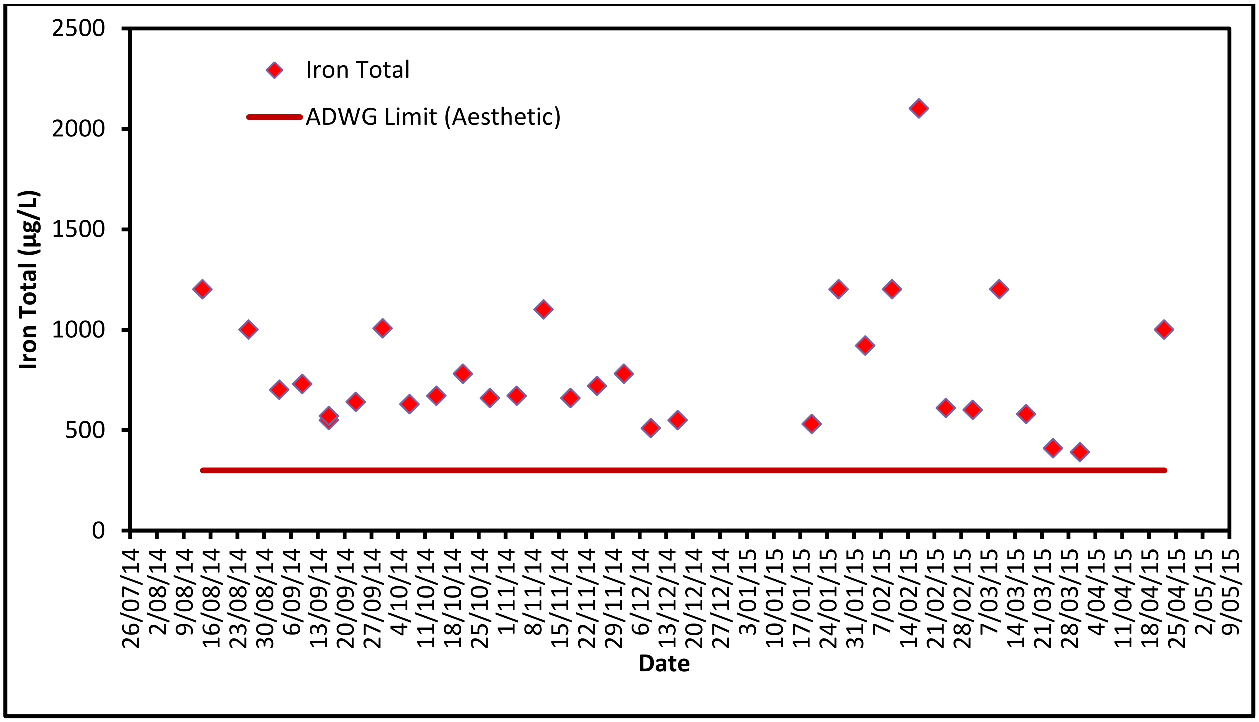
Manganese concentration



Iron

The levels of iron concentration in the second 16 samples closely reflected the results from the initial sampling indicating that the water is likely to have a rust-brown appearance and cause staining of laundry and plumbing fittings. Removal of iron to levels below 3mg/L will need to be included as part of the treatment train.

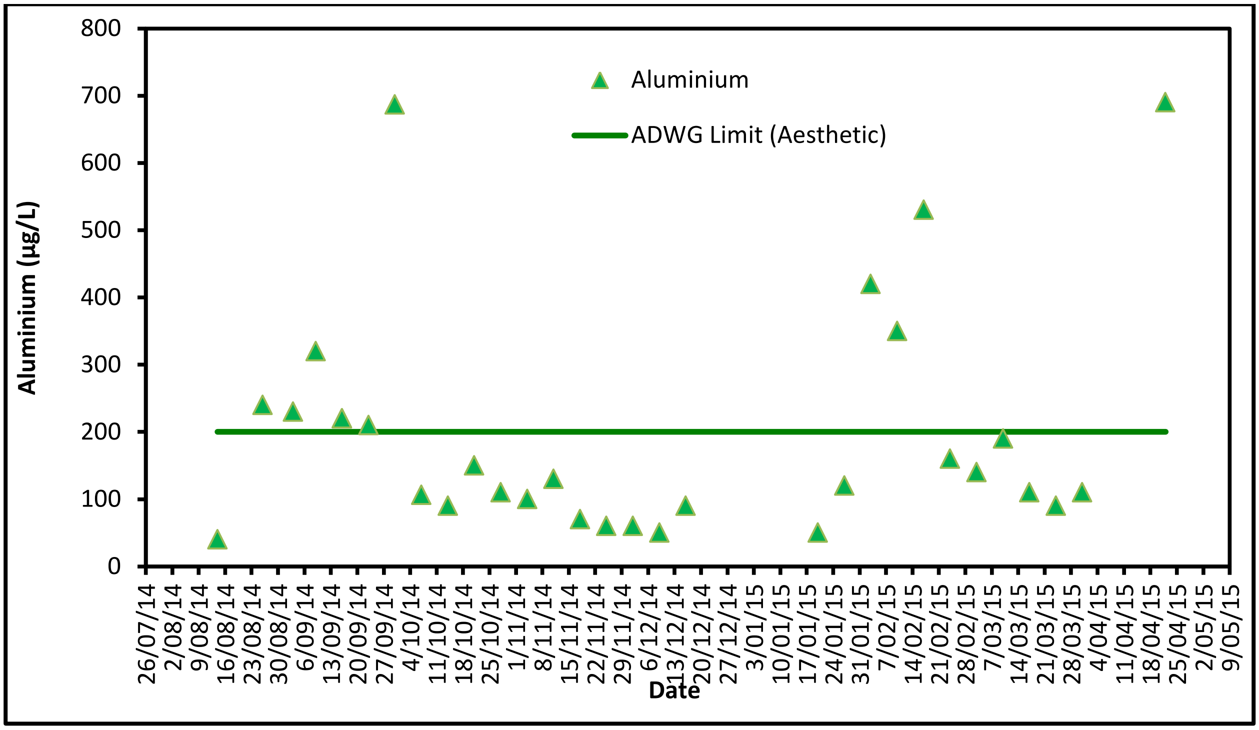
Iron concentration



Aluminium

Aluminium continues to be sporadically above the treatment objective of 0.2mg/L confirming that the treatment train will need to reduce aluminium.

Aluminium concentration



Wet Weather

The first sampling program showed there is a measurable impact on key water quality parameters during and following rainfall.

The results from the second sampling program include a sample taken on 22nd April 2015. This was taken during a significant rain event where 140mm of rain fell on both the 21st and 22nd April. In total, 318mm of rain fell over four days according to Bureau of Meteorology records. Narara has a median rain fall of 1067mm per year and a mean rail fall of 1213mm per year. The rain event experienced in April 2015 is significant in that approximately 25% of the expected annual rain fall came within four days.

The sample results from the 22nd August indicate higher levels of true colour, turbidity and aluminium. Generally, these results are no higher than other samples taken during the sampling period, and indicate the event did not cause dam water quality outside what is typically experienced on site.

Sampling for Phosphorous

Phosphorus was measured during the first sample program however the test resolution was not low enough to be a useful in assessing the risk of algal blooms. In the period of testing covered by this report the detection limit was reduced to 0.002 mg/L by using the Sydney Water laboratory to carry out the analysis.

The test results for these samples show a maximum phosphorus level of 0.100 mg/L and an average of 0.035 mg/L Based on table 6 of *"Management Strategies for Cyanobacteria (blue-green algae): a Guide for Water Utilities"* (WQRA, 2010), the water is classed is a moderate to high risk for potential for cyanobacterial growth. As such, strategies need to be developed for monitoring the dam for signs of algal blooms, and considering the need for algal toxin and taste and odour removal in the treatment process.

The proposed treatment process incorporates oxidation processes and well as a low molecular weight cut-off nanofiltration membrane (< 300 Dalton) that is capable of high levels of rejection of various algal toxins.

5. Conclusion

The results of the initial 12 week sampling program indicated that the water is low in alkalinity, pH and hardness, and high in colour, iron, manganese and aluminium. The results of the second sampling program confirm this to be the case and there are no noteworthy difference between the results of the first sampling program and the results of the second sampling program. The conclusions drawn for these parameters in the first sampling result remain valid.

Low detection limit testing for phosphorus identified that the dam is in the moderate to high risk category for potential for cyanobacterial growth. The treatment process must be capable of removing algal toxin in the event of a blue-green algae outbreak, and the dam management strategy needs to include monitoring for signs of algal blooms.

With a total of 26 samples taken over 8 months, there is no clear indication of any seasonal trending of the data. This is not to say that no season effects may occur, and ongoing monitor will determine if there are any seasonal or long term trending of the water quality parameters

6. Further sampling recommendations

Ongoing sampling should continue to assess any seasonal trends. It is also recommended that a series of samples be taken at various locations around the dam and at different depths to assess variability in the water quality within the dam and the presence or extent of any stratification.

Pells Consulting

Narara Ecovillage Cooperative Ltd

REPORT ON THE SAFETY INSPECTION OF NARARA DAM

Appendix 4.1.1.3

M010.R1 Rev1
22 October 2015

Report Title	REPORT ON THE SAFETY INSPECTION OF NARARA DAM
Authors	Steven Pells; Philip Pells
Job No.	M10
Report No.	R1
Client	Narara Ecovillage Cooperative Ltd
Contact	M Fisher

Date	**Revision**	**Comment**
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1 INTRODUCTION

The dam at the Narara Ecovillage (NEV) site was designed by the Water Resources Commission NSW and was constructed in the mid- to late 1980's in accordance with approval of Development Application 5971 by Gosford Council dated 30 May 1985.

It is understood the embankment dam was constructed for irrigation purposes within the Gosford Primary Industries Institute, which was part of the NSW DPI's Centre of Excellence for Market Access and Greenhouse Horticulture.

The site is now managed by the Narara Ecovillage Cooperative, and the dam is proposed to be used as water supply to the Narara Ecovillage.

With respect to the change of proprietorship and recommissioning of the dam, this report provides a Dam Safety Review for the Narara EcoVillage Dam, as per ANCOLD 2003. The report addresses the following issues:

- a formal dam safety inspection (the last dam safety inspection was undertaken by the Department of Commerce in March 2006), including documentation of any remedial measures necessary to comply with current ANCOLD guidelines,
- a revised analysis of stability of the embankment,
- a qualitative risk assessment in accordance with ANCOLD Oct 2003, and
- an assessment of erosion of the spillway which has been observed to develop

Issues related to dam break safety have been addressed in the recent reports (2012 and 2014) by the NSW Department of Public Works, and do not require revision.

In order to undertake a meaningful dam safety assessment it is necessary to have a reasonable understanding of the existing facility, including: the internal structure of the embankment; spillway design and hydraulics, and; monitoring records of the embankment (eg seepage, pore pressures, cracking etc). Typically, such data are presented in published reports and drawings, but were unavailable for this dam. This report therefore also provides a summary of additional investigations undertaken to obtain this data, including:

- Review of historical site records and correspondence with personnel with previous involvement with the dam construction.
- Installation of three standpipe piezometers in the embankment and measurement of standing water levels.
- Geological mapping / appraisal of the spillway.
- Hydraulic analysis of the spillway.
- Ground surveys of the embankment and spillway.

1.1 Inspection program

The following inspections were undertaken by Pells Consulting prior to issue of this report:

1. On 19 May 2015 Philip Pells undertook an initial inspection of the embankment and spillway.
2. On 16July 2015 Philip Pells and Steven Pells:
    - o undertook optical ground surveys of the spillway, and;

- o inspected the spillway and the outlet structure.

3. On 24 July 2015 Steven Pells installed three (3) standpipe piezometers in the downstream face of the embankment.
4. On 29 July 2015 Philip Pells and Steven Pells undertook:
   - o ground surveys to confirm the 1V:3H slope of the upper face of the embankment;
   - o geological mapping within the spillway;
   - o measurements of the water levels in the standpipe piezometers;
   - o purged water from the piezometers (to allow subsequent readings that were unaffected by the installation process), and;
   - o installed an automatic water level logger in BH2.
5. On 6 August 2015, Philip Pells measured standing water levels in the standpipe piezometers

2 DESCRIPTION OF THE DAM

2.1 Physical Details

2.1.1 Location

The dam is located on land owned by the NEV, in the suburb of Narara, near Gosford in NSW. The location of the dam, the catchment and regional topography is shown in Figure 1.

2.1.2 General Arrangement

The arrangement of the dam embankment, spillway and outlet structure is shown in Figure 2.

2.1.3 Embankment

The embankment has a relatively flat downstream face (~1H:5V) and a narrow crest which seems indicative of original crest being raised by almost a metre (see Figure 3).

Documentation accompanying the dam safety assessment of March 2006 (Department of Commerce, 2006) states that the embankment as originally constructed was overtopped in 1985 and 1990, and the spillway was therefore widened to increase its capacity. The extent of the widening is visually obvious (see Section 2.1.5 below), and discussions between Pells Consulting and an officer of the NSW Office of Water, revealed that the widening was undertaken by the Soil Conservation Service of NSW sometime in the 1990's.

The documentation accompanying the dam safety assessment of March 2006 (Department of Commerce, 2006) also indicates that the embankment is a homogeneous earthfill construction.

Test boreholes installed by Pells Consulting encountered a layer of crushed rock material of approximately 1m thickness covering the downstream face of the embankment. The nature of this material appeared to be consistent with the sandstone / claystone in the widened section of spillway. It is postulated that material won from the spillway widening was placed onto the downstream embankment slope.

Ground surveys provided to Pells Consulting by NEV confirmed the downstream embankment to have a slope of approximately 1V:5H. The crest height was reported at 17.195 m AHD, which is less than the value of 17.45 m AHD presented in NSW Public Works (2012). Depth measurements, accompanied by optical surveys, undertaken by Pells Consulting indicated the upstream slope to be approximately 1V:3H. This accords with original design plans, which are shown overlaying aerial photographs in Figure 24 below.

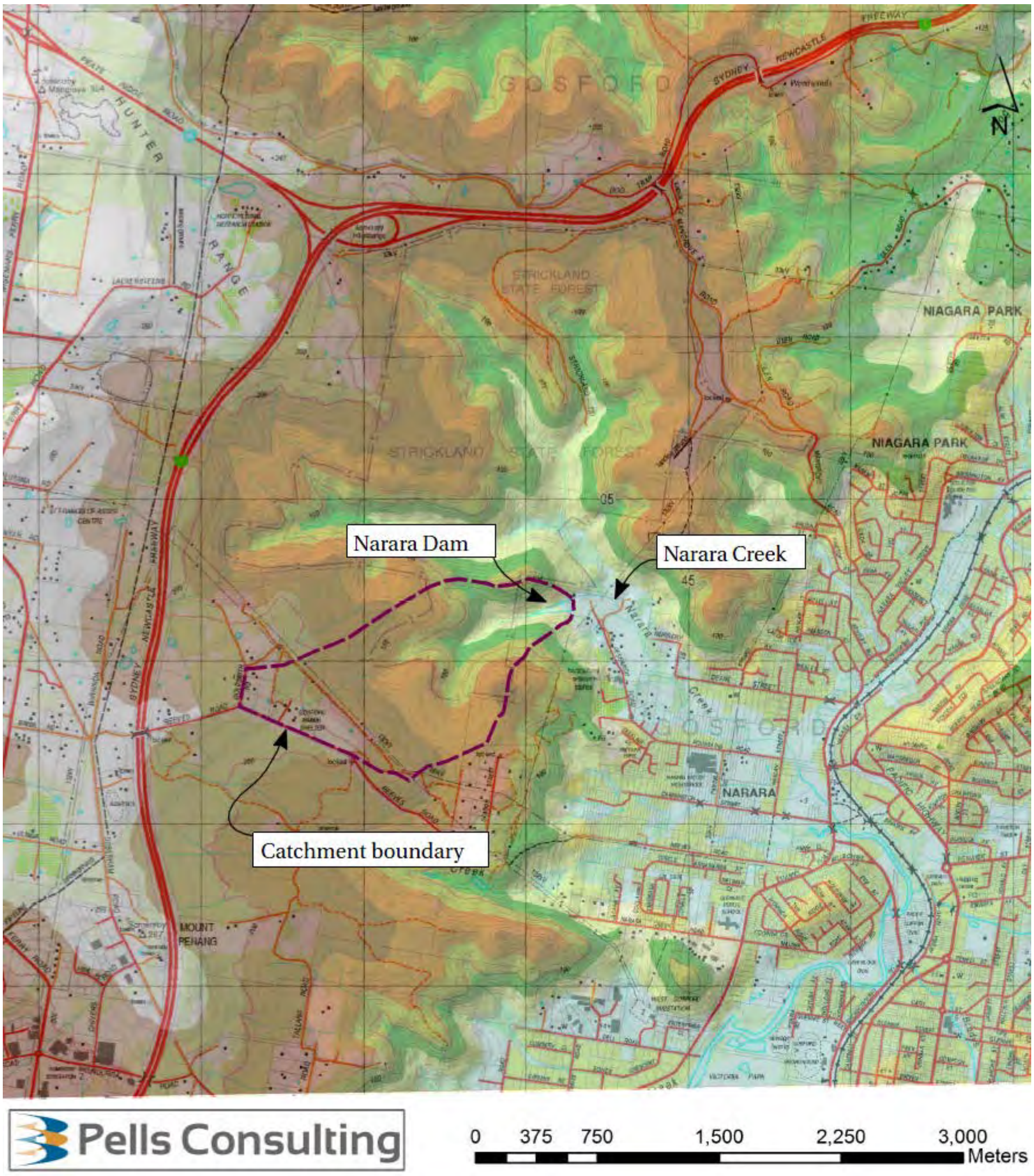


Figure 1 - Location of Narara Dam

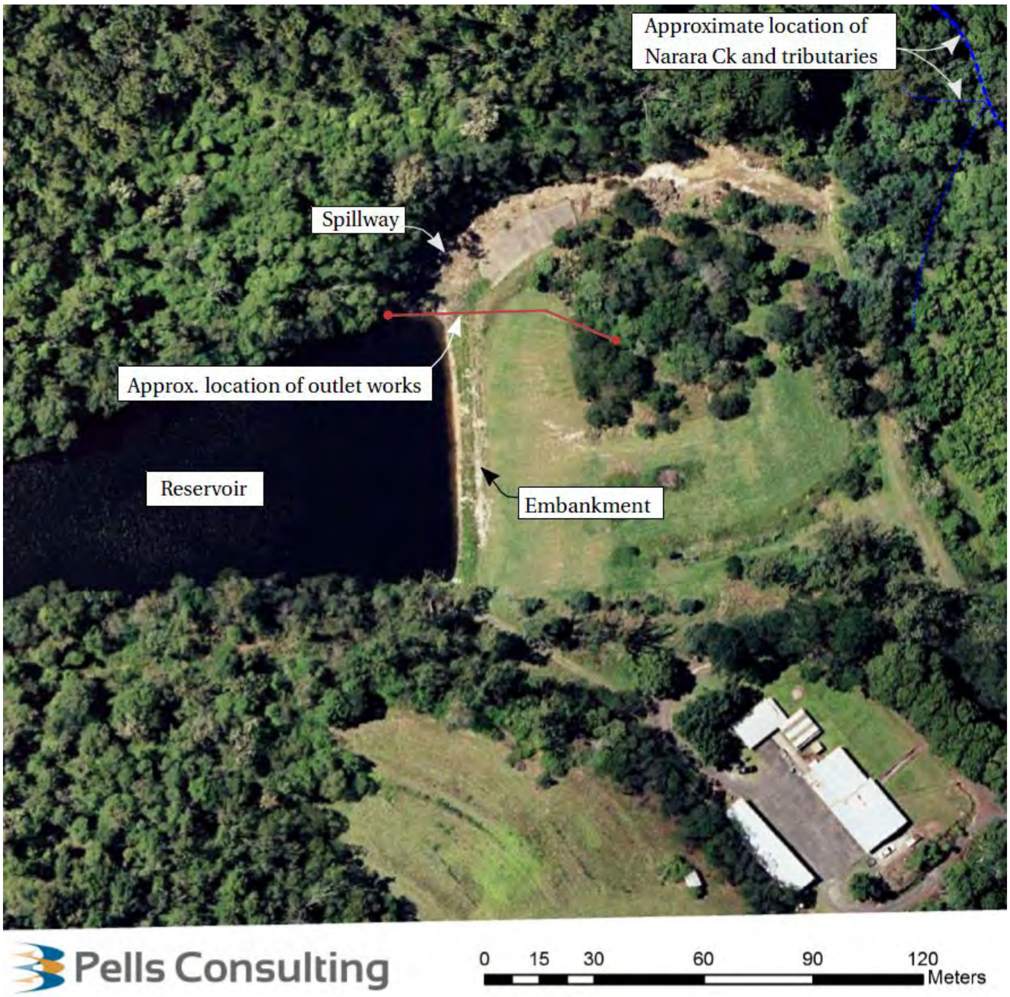


Figure 2 - General arrangement

Figure 3 - Raised crest and gentle (approx. 1V:5H) downstream face

Figure 4 - View of reservoir from embankment

2.1.4 Outlet Works

The outlet works shown in plan in Figure 2 comprises a 1200mm diameter glory-hole inlet located near the entrance to the side channel spillway (Figure 5). A close up photograph of the gloryhole is shown in Figure 6. This gloryhole feeds a 400 mm diameter pipe, which exits via a similar 1200mm riser (Figure 7) amongst trees on the left side of the downstream face (Figure 8).

Figure 5 - View along crest toward spillway entrance and glory-hole inlet

Figure 6 - Close-up photograph of the glory-hole inlet

Figure 7 - Photograph of the outlet of the outlet works

Figure 8 – The end of the outlet works is within the trees / scrub on the right hand side of this photograph

A schematic of the outlet system is shown in Figure 9. A stage-discharge relationship for the outlet system was modelled by assuming sharp-crested weir flows over the rim of the gloryhole, pipeline friction losses (Colebrook-white equation) and minor losses consistent with the schematic. The results are presented in Figure 10, and indicate that the outlet system could convey up to (approximately) 400 litres per second.

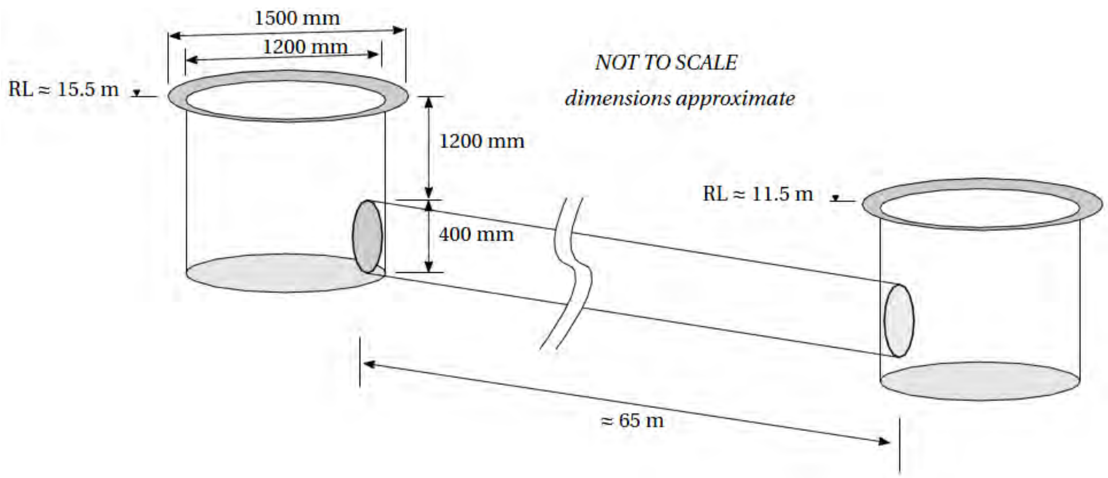


Figure 9 - Schematic of the Outlet Works

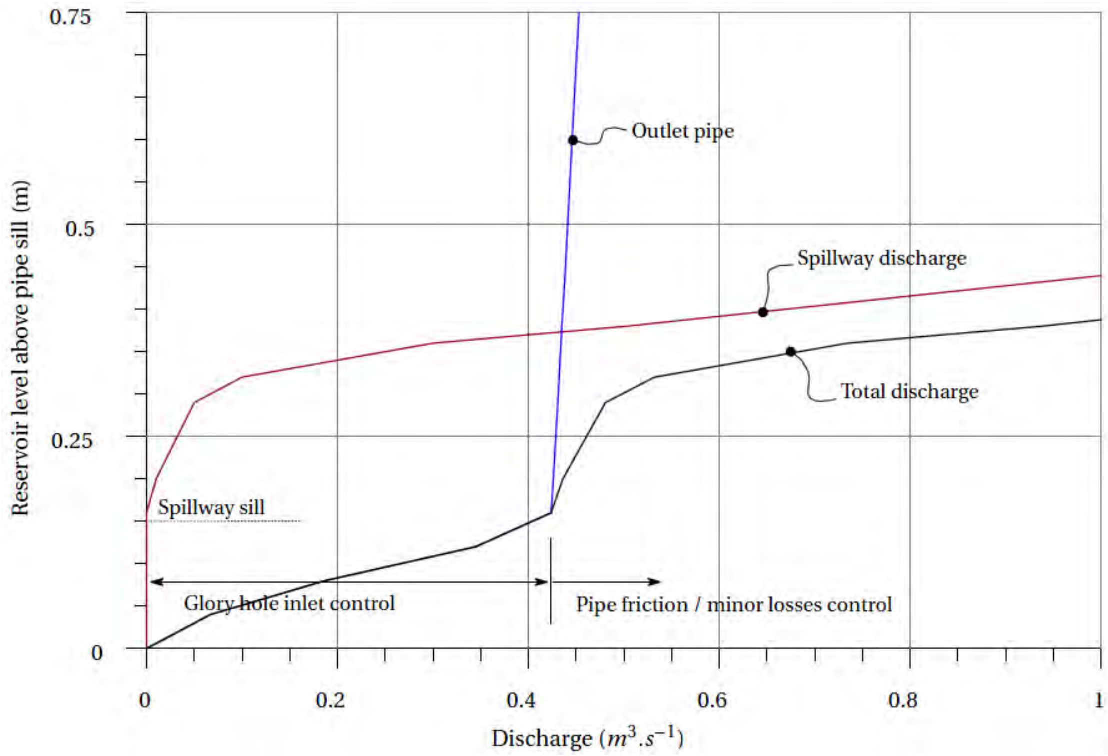


Figure 10 - Modelled stage-discharge relationship for the outlet works

2.1.5 Spillway

A side channel spillway is cut into the left abutment. As stated above, it is understood that this channel was widened sometime in the past. Approximately half the width of the channel (on the embankment side) from 16 to 45 m downstream of the channel entrance is covered with shotcrete. The remainder of the spillway is unlined. Photographs of the spillway, progressing downstream, are presented in Figure 11 to Figure 16.

Figure 11 - Entrance to the side-channel spillway

Figure 12 - View of the upper spillway from the embankment.
Note the concrete lined section may be indicative of the width of the original spillway (i.e. before widening)

Figure 13 - Looking downstream toward the end of the lined section

Figure 14 – Looking upstream toward the end of the lined section

Figure 15 - Looking downstream toward the spillway exit

Figure 16 - Section of Narara Creek just below the spillway

Note, the creek is flowing from left to right. Spillway flows enter the creek from the right hand side, at the far downstream side of this photograph

Ground surveys of the spillway topography were undertaken by Pells Consulting using optical surveying techniques. The surveyed points are shown in Figure 17. Based on these surveys, and site inspections, an approximate digital terrain model of the spillway was assembled, as shown in Figure 17.

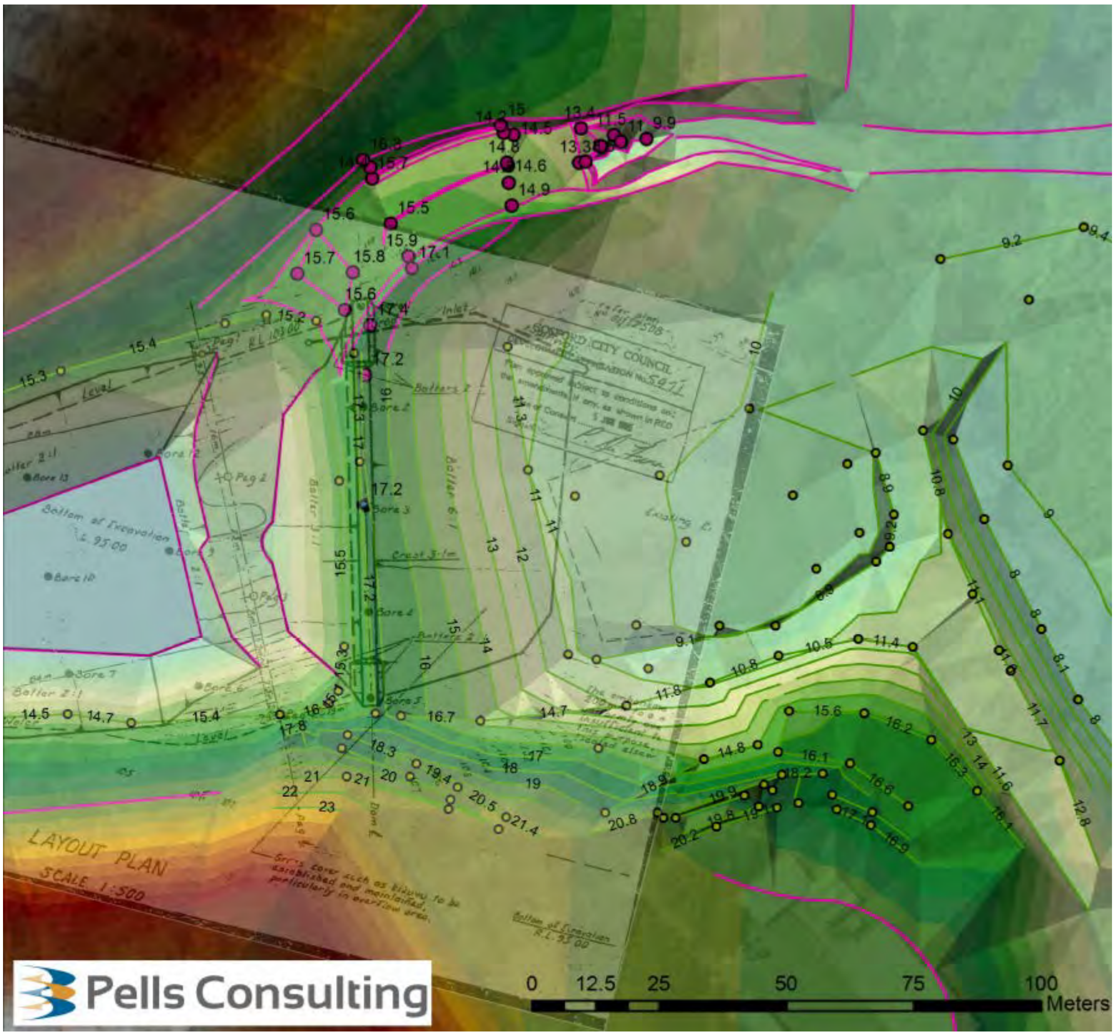


Figure 17 - Interpreted spillway topography

Note: pink data points show ground surveys undertaken by Pells Consulting. Pink breaklines were interpreted based on the site inspection.

A 1-D hydraulic model of the spillway was constructed using HEC-RAS (USACE, 2010). This model was assembled over the digital terrain model, as shown in Figure 18.

A stage-discharge relationship for the spillway was estimated using the HEC-RAS model, as shown in Figure 19. The relationship was relatively insensitive to assumed model roughness.

It is noted that the spillway discharge for a reservoir level of RL17.2 (ie the dam crest) is approximately 60 m^3s^{-1}. Despite the lower crest level than previously reported, this “dam crest flood” (DCF) is larger than the value of adopted in NSW Department of Commerce, 2006. This analysis suggests that a higher return period may be applicable to the DCF than previously decreed.

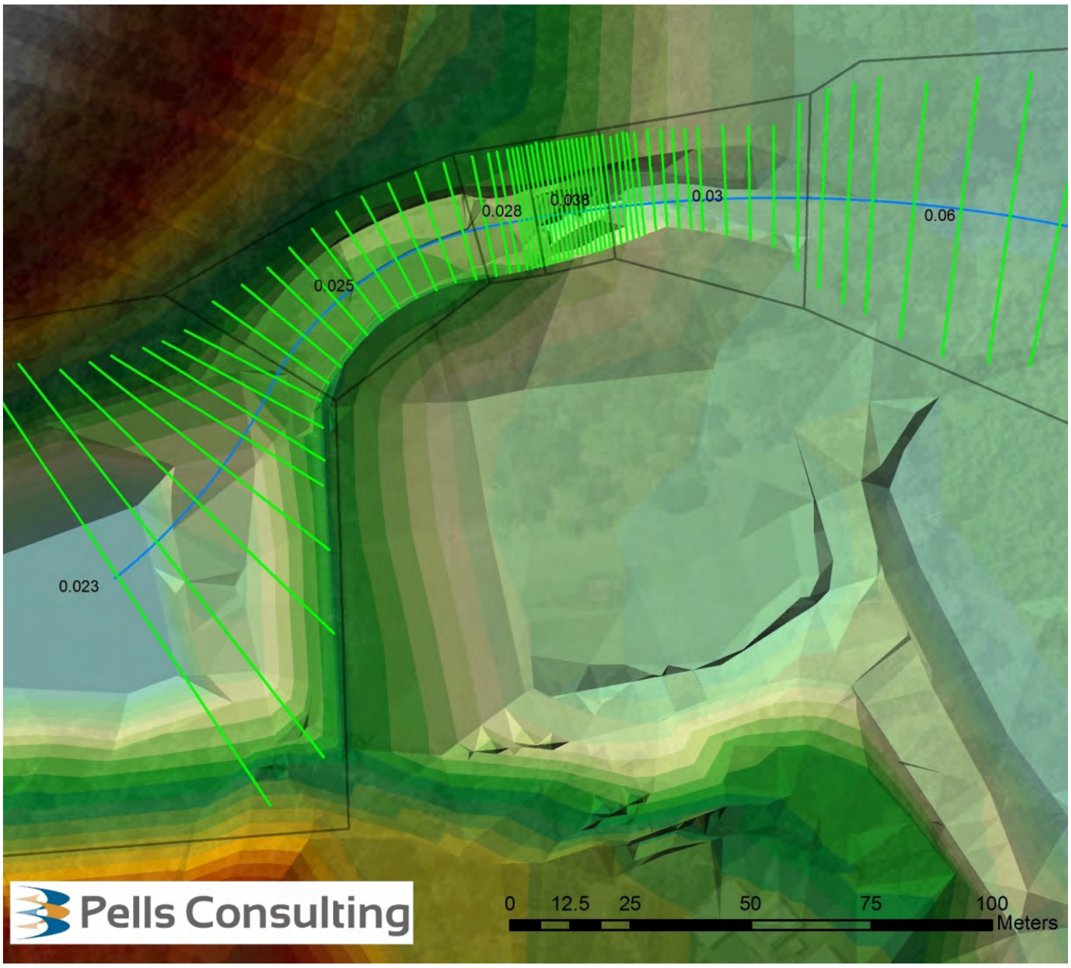


Figure 18 - Overview of HEC-RAS model of the spillway.
Annotations shown regions of assumed roughness values (Manning's `n')

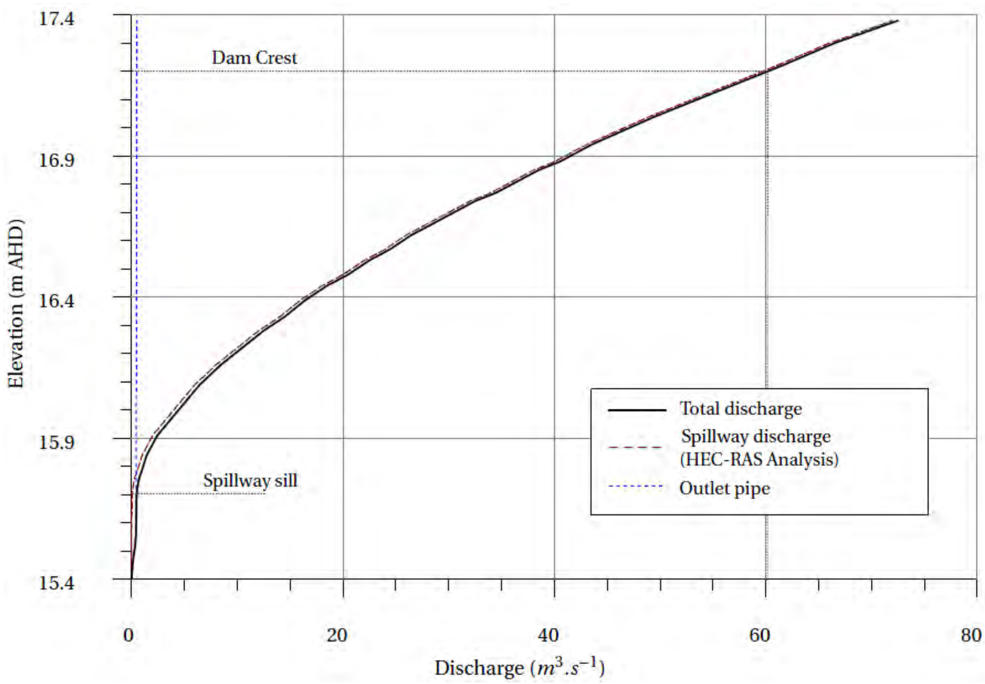


Figure 19 – Stage-discharge relationship for the spillway and outlet works

2.2 Geological Setting

The dam is located in the lower part of the Terrigal Formation of the Triassic Narrabeen Group. This Formation comprises interbedded sandstones and shales.

The overlying Hawkesbury Sandstone forms the crests of the hills surrounding the site (above about RL130m to RL150m).

A number of factors have led us to conclude that the base of the embankment is close to or is within the Patonga Claystone that underlies the Terrigal Formation. Available evidence suggests that the particular flat valley shape of Narara Creek within and downstream of the Eco Village is characteristic of the geomorphology of the Patonga Claystone, viz:

"…. broad, flat and swampy valley floors or hummocky footslopes in the Patonga Claystone"

McNally,1995

However, if further investigation shows that the claystone revealed in the lower part of the spillway channel is not the top of the Patonga Claystone, it is certainly the thick siltstone/claystone stratum that occurs in the lower part of the Terrigal Formation (see Figure 20 and Figure 34)

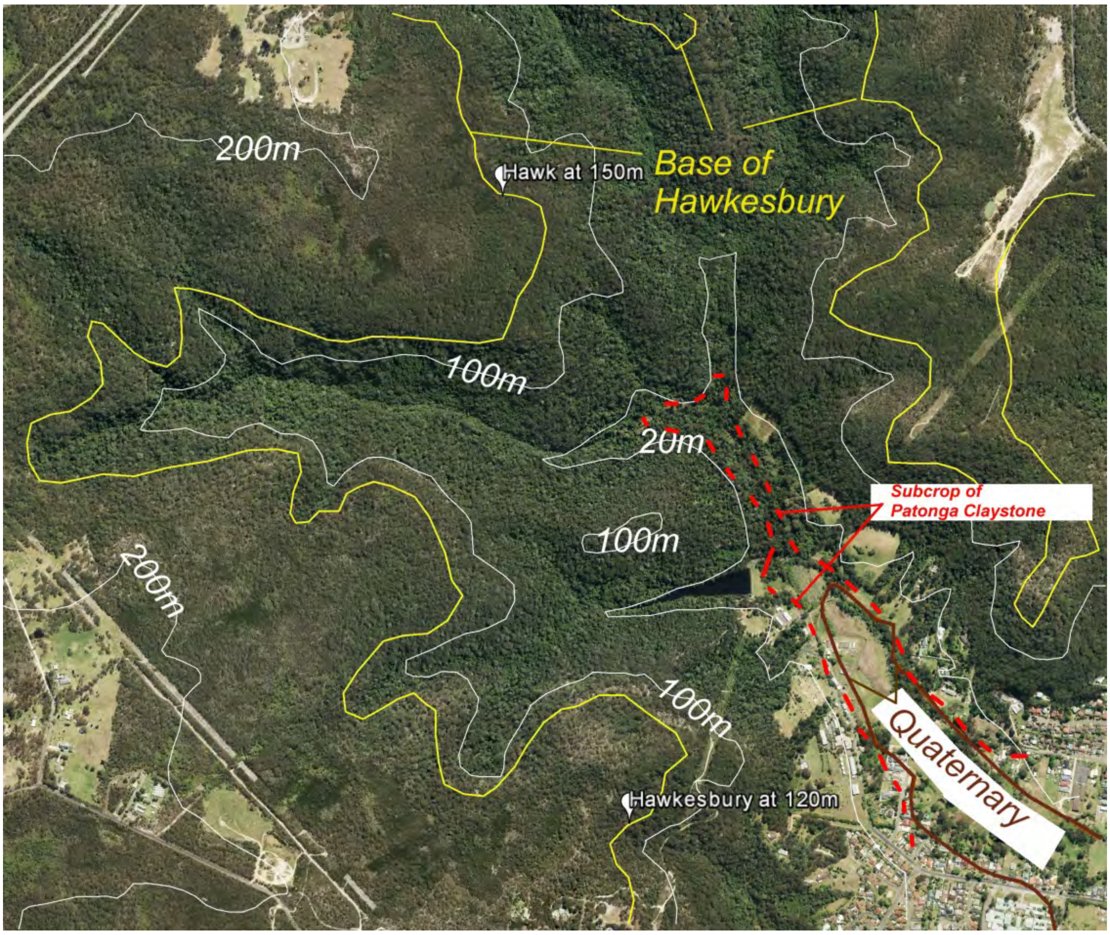


Figure 20 - Geology from 1:25000 geological map with our interpretation of the possible upper surface of the Patonga Claystone.

2.3 Hydrology

Hydrological studies accompanied dam-break studies presented in NSW Department of Commerce (2006). NSW Public Works (2012) made reference to revised hydrological studies, as per the excerpt in Figure 21:

Narara Farm Dam's latest Flood Hydrology was carried out by the Hydrology Group of NSW Public Works in 2011. This Hydrology Study includes the PMF and 1 in 100,000 AEP flood hydrographs with storm durations ranging from 15 mins to 6 hours. Refer to Appendix A for the Hydrology Report. Results from the initial dam routing are presented in Table 2-1.

Table 2-1 Initial Dam Routing Results

Storm Event	Worst Storm Duration*	Max. Dam Flood Level	Max. Dam Inflow	Max. Dam Outflow	Overtopping Height
1 in 100 AEP	6 hour	RL 16.90 m-AHD	29 m^3/s	28 m^3/s	No overtopping with 0.55 m Freeboard
1 in 1,000 AEP (DCF)#	6 hour	RL 17.40 m-AHD	47 m^3/s	41 m^3/s	No overtopping with 0.05 m Freeboard
1 in 100,000 AEP	1 hour	RL 17.80 m-AHD	106 m^3/s	104 m^3/s	Overtopped by 0.35 m
PMF	30 min	RL 18.13 m-AHD	178 m^3/s	172 m^3/s	Overtopped by 0.73 m

* In terms of the highest modelled floodwater level in dam;

\# Examined in the 2006 Dambreak Study.

Figure 21 - Excerpt from NSW Public Works, 2012

The results presented in Figure 21 indicate an outflow discharge of 41 m^3s^{-1} from the DCF. As stated above, this is lower than the estimate of approximately 60 m^3s^{-1} made in the present study.

2.4 Hazard Category

The 'hazard category', as defined in ANCOLD (2000), reflects the severity of potential damage and loss, in conjunction with the population at risk (PAR), for a 'sunny day' failure with reservoir full, or flood failure conditions.

The dam safety assessment of 2006 assigned a hazard category, based on flood-consequence, of "High-C" to the Narara Dam. This was re-categorised to LOW by NSW Public Works, 2012. This re-categorisation was validated in NSW Public Works, 2014. Following this re-categorisation, the possibility of de-prescribing the dam was mooted in a letter from NSW Public Works to NEV (12 May 2014). The NSW Dam Safety Committee (DSC) accepted the de-prescription, and provided official notice of the fact to NEV in a letter of 27 June 2014.

2.5 Dam data summary

As summary of dam data from NSW Public Works, 2012 is reproduced in the excerpt in Figure 22. Following the discussions above, it is envisaged that this data should be formally updated, as per the annotations shown.

Table 1-1 Narara Farm Dam Data

Narara Farm Dam	
Ownership	~~State Property Authority~~ NEV
Dam Type	Earthfill Embankment
Catchment Area	159.20 ha
Storage Capacity	43.30 ML
FSL	~~RL 15.90 m-AHD~~ 15.6 m AHD*
Stream Bed Level	RL 7.90 m-AHD
Dam Crest Level	~~RL 17.45 m-AHD~~ 17.2 m AHD
Dam Height	9.55 m
Available Freeboard	1.55 m
Crest Length	100.00 m
Spillway Crest Level	At FSL
Spillway Type	Earth Channel Spillway
Spillway Length	18.20 m
Return Period of Dam Crest Flood (DCF)*	1 in 1,000 AEP may require revision
Sunny Day Dambreak PAR*	12
Sunny Day Consequence Category*	HIGH C
DCF Dambreak PAR*	30
Flood Consequence Category*	HIGH C
Acceptable Earthquake Capacity*	1 in 1,000 AEP Event
Acceptable Flood Capacity*	1 in 100,000 AEP Event

* Assessed and reported in the 2006 Dambreak Study

*based on coarse survey data, requires confirmation

Figure 22 – Dam data summary from NSW Public Works, 2012, showing possible revisions

3 EMBANKMENT STABILITY

Investigations and analyses were undertaken to assess the stability of the embankment.

3.1 Boreholes and piezometers

To assist with appraisal of the embankment, three boreholes, with standpipe piezometers (Figure 23), were installed by Pells Consulting on 24 June 2015. A summary of bore construction details is given in Table 1, and field-logs of the boreholes are attached in Appendix B. Measurements of standing water levels in the standpipes are also summarised in Table 1.

The location of bores is shown in Figure 24.

Figure 23 - Three boreholes with standpipe piezometers were installed in the embankment

Table 1- Bore construction details

ID	Location			RL ToC[1.]	Depth	Standing water level (m AHD)		
	Description	*mE*	*mN*	*m AHD*	*m*	*24/7/15*	*29/7/15*	*6/8/15*
BH1	Near crest	344297.2	6304335.7	16.26	3.53	15.70	15.21	15.23
BH2	Mid-embankment	344306.2	6304336.6	14.65	3.14	13.75	13.88	13.63
BH3	Near toe	344321.0	6304337.6	12.22	3.485	10.52	11.49	11.39

1. Top of casing

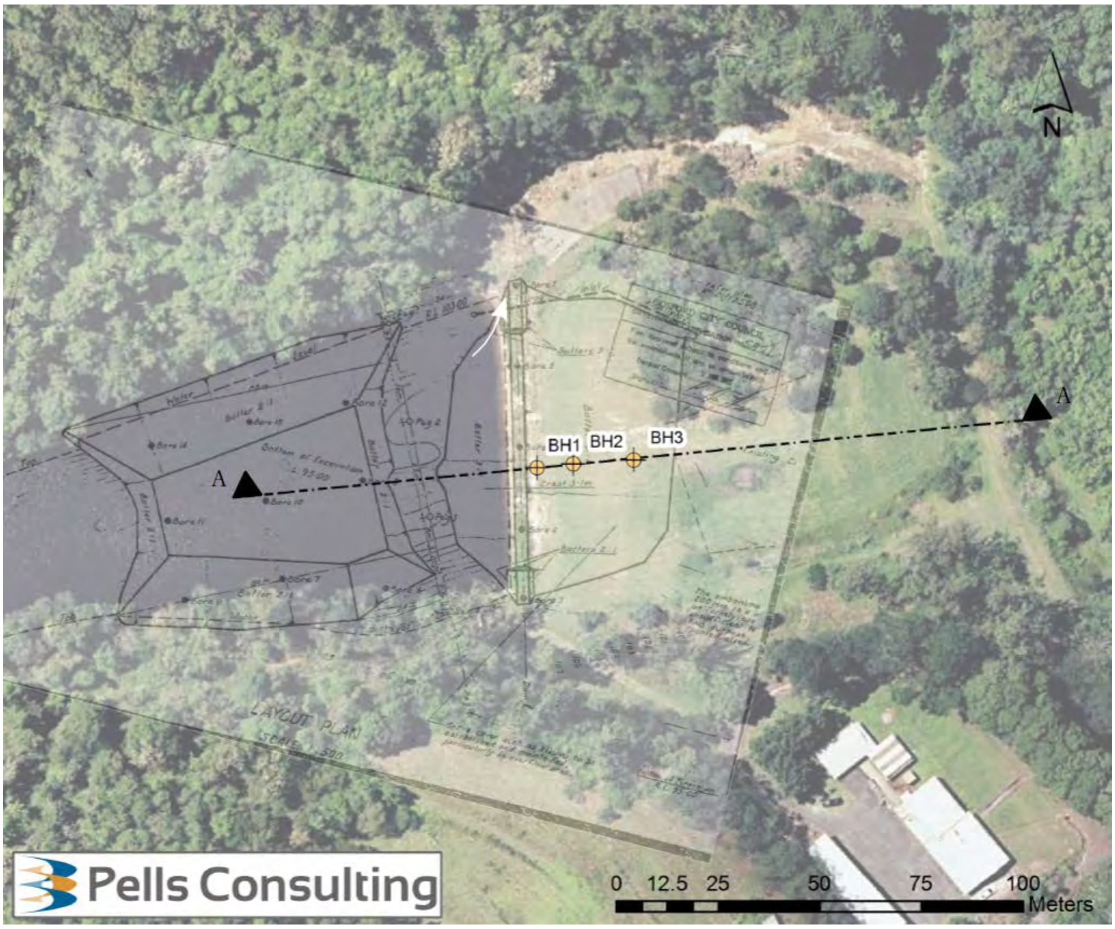


Figure 24 - Plan of dam showing original embankment design, location of boreholes (piezometers) and location of embankment cross-section

3.2 Embankment cross-section

A cross-section through the embankment along alignment A-A (Figure 24) is shown in Figure 25. This cross-section is based on available ground survey data, original construction plans, and the bore logs.

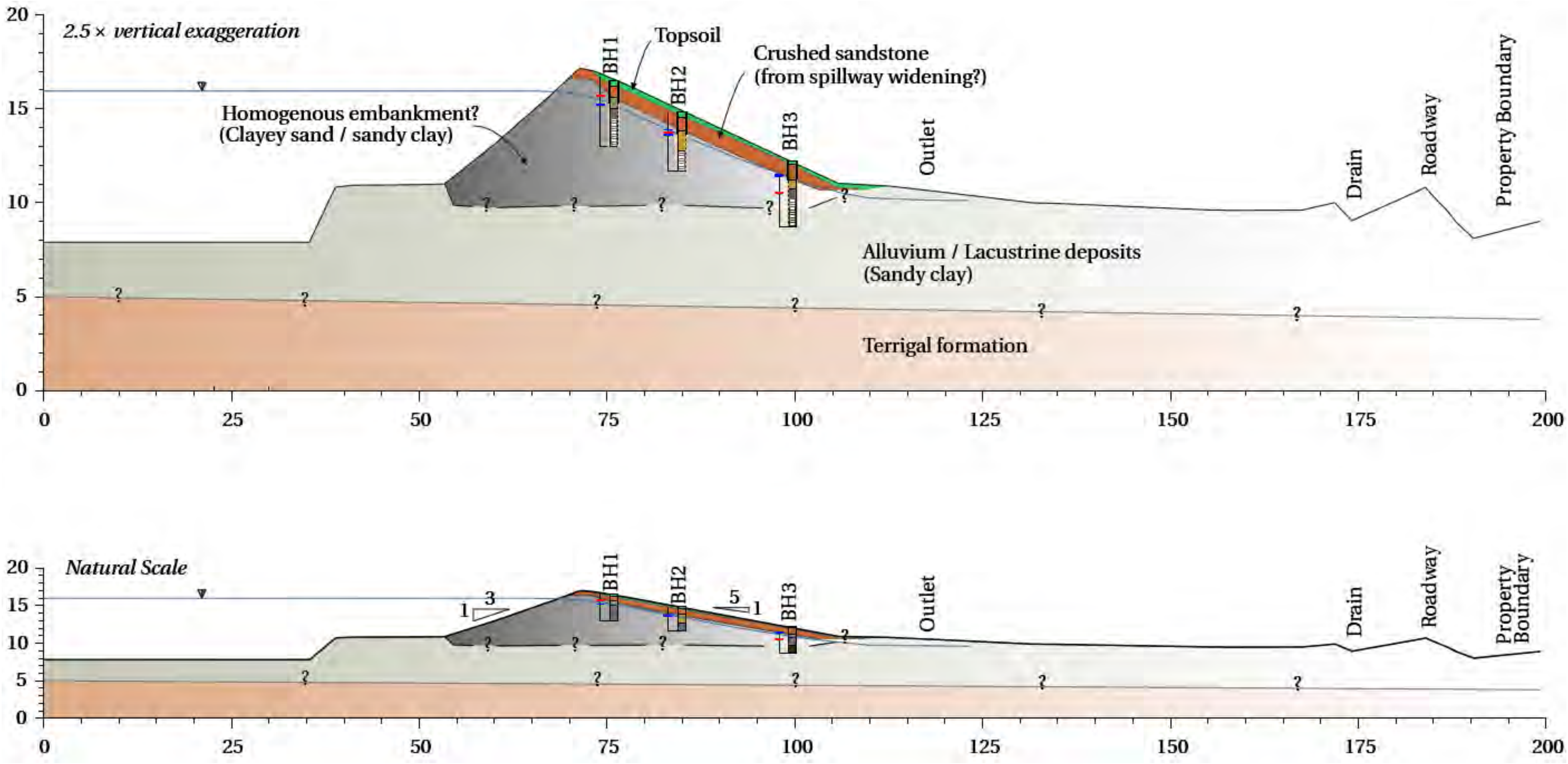


Figure 25 - Interpreted cross-section through the embankment (along line A-A shown in Figure 24)

3.3 Stability analysis

A slope-stability analysis, based in the cross-section A-A (Figure 25) was undertaken using the software Slide^{TM} (Rocscience). An overview of the model is shown in Figure 26.

The analyses adopted estimates of soil strength and groundwater parameters as shown in Table 2 (Case 1) and Table 3 (Case 2). The results from the analysis of Cases 1 and 2 are shown in Figure 27 and Figure 28, respectively. The results indicate a factor of safety for the embankment of greater than 2. It is considered that the adopted strength values are conservative (ie. actual strength is considered to be higher than the modelled values).

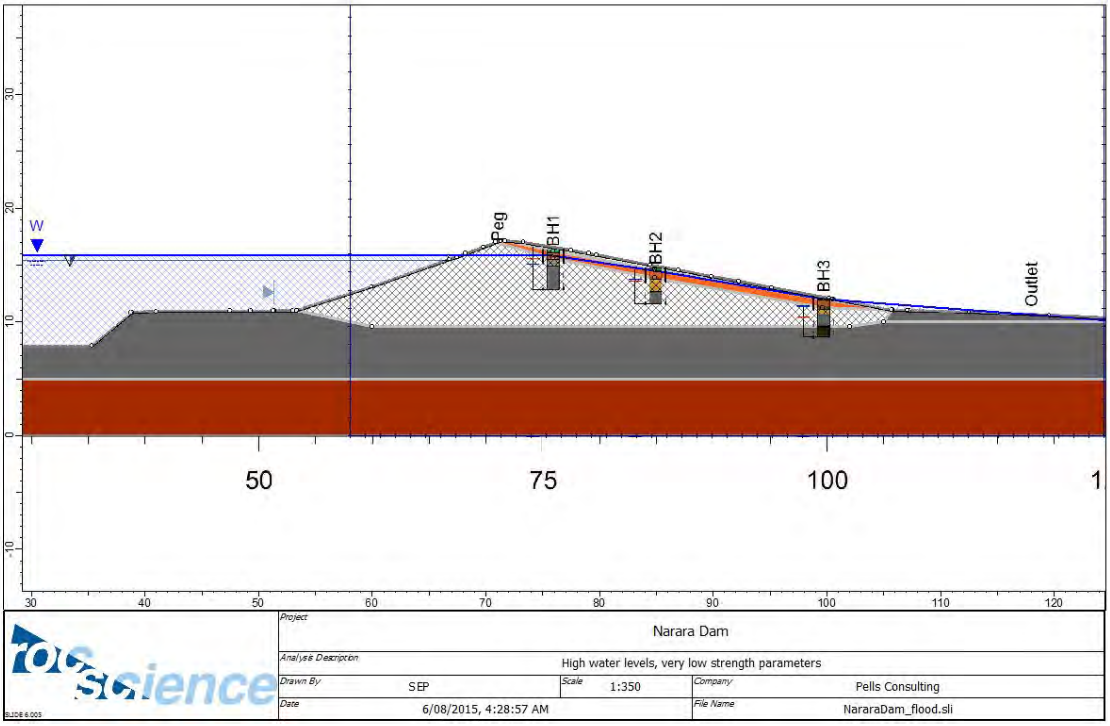


Figure 26 - Example of stability analysis along cross-section A-A

Table 2 - Embankment strength indices, Case 1

Material	Unit weight (kN/m^3) *Unsaturated*	*Saturated*	Cohesion c' *kPa*	Friction angle ϕ' *Deg.*	Groundwater level
Topsoil	16	18	0	25	As measured
Crushed sandstone	20	22	0	35	
Clayey sand embankment	20	22	5	32	
Alluvium / lacustrine	20	22	5	26	
Terrigal formation	21	23	50	30	

Table 3 - Embankment strength indices, Case 2

Material	Unit weight (kN/m^3) *Unsaturated*	*Saturated*	Cohesion c' *kPa*	Friction angle ϕ' *Deg.*	Groundwater level
Topsoil	16	18	0	22	
Crushed sandstone	20	22	0	34	
Clayey sand embankment	20	22	2	28	As measured plus 1 metre
Alluvium / lacustrine	20	22	5	26	
Terrigal formation	21	23	50	30	

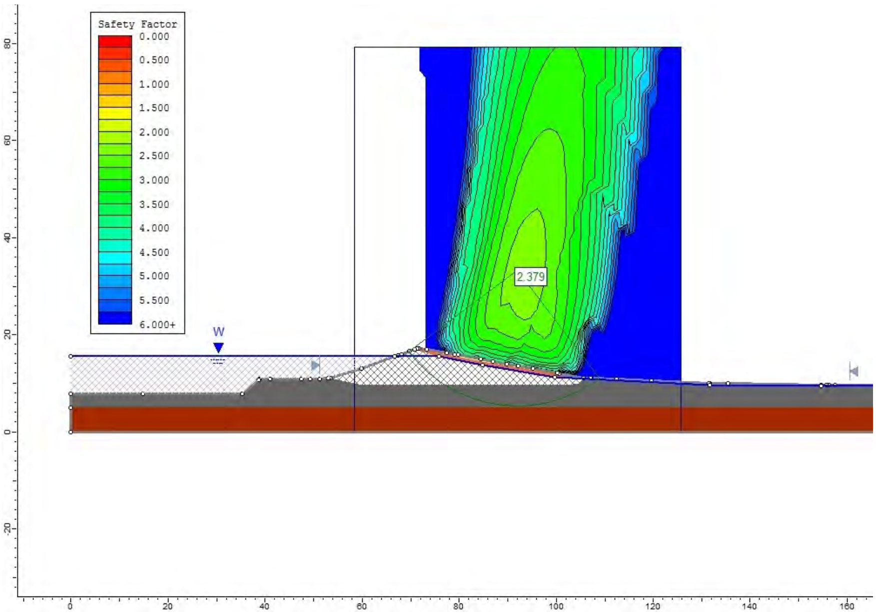


Figure 27 - Results of slope stability assessment - Case 1

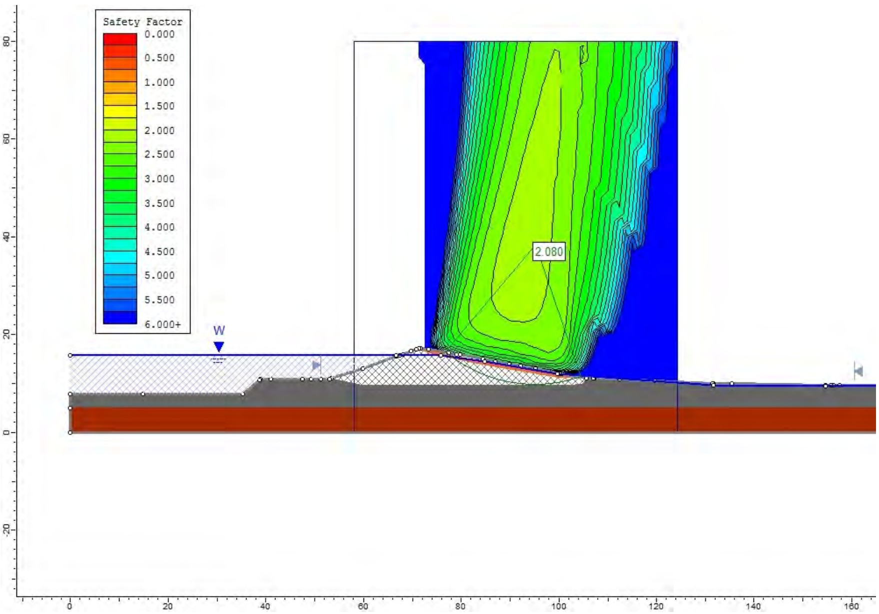


Figure 28 - Results of slope stability assessment - Case 2

4 SPILLWAY EROSION

4.1 Observed Erosion

For assessment of erosion, the spillway was considered as four separate regions, as described in Table 4. These regions are shown in photographs in Figure 29 to Figure 33.

Table 4 - Summary of erosion areas

ID	Location *Desc.*	 *m d/s sill*	Observed erosion
HA1	Upper spillway and adjacent to lined section	< 40m	Mild gullying on spillway LHS, < 0.3 m depth
HA2	End of lined section	45m	Erosion of soft rock at end of concrete. Some channelization. <0.4 m depth
HA3	End of rock	60 - 70 m	Formation of channel headcut, likely to progress upstream. Up to 1.5 m depth Undermining of rock strata, plunging flows, toppling of corestones. Erosion depth up to 3 m
HA4	Alluvium / colluvium	70m to end (~115m)	Active erosion of alluvium / colluvium

Figure 29 - Unlined widened section of spillway adjacent to concrete (Region "HA1" ~10 to 40 m from spillway entrance)

Figure 30 – Erosion of soft rock at end of lined section (Region "HA2" ~ 45 m from spillway entrance)

Figure 31 - Headcutting erosion channel at end of rock spillway (Region "HA2/HA3" ~60m from spillway entrance)

Figure 32 - Erosion of soft, highly weathered claystone, causing plunging flows and toppling of sandstone corestones (Region "HA3" between 60 and 70 m from spillway entrance)

Figure 33 – Erosion of soil (alluvium / colluvium) (Region "HA4" - 70 to 100 m from spillway entrance)

4.2 Spillway Geology

The displaced sandstone blocks shown in Figure 34 are typical of the Terrigal Formation, as illustrated in Figure 35 from McNally, 1995.

Geological mapping characterising the rock mass is presented in Figure 36. Field observations of rock mass in are presented in Figure 37.

Interpreted rock-mass indices characterising the eroding rock mass at each location are presented in Table 5 to Table 7.

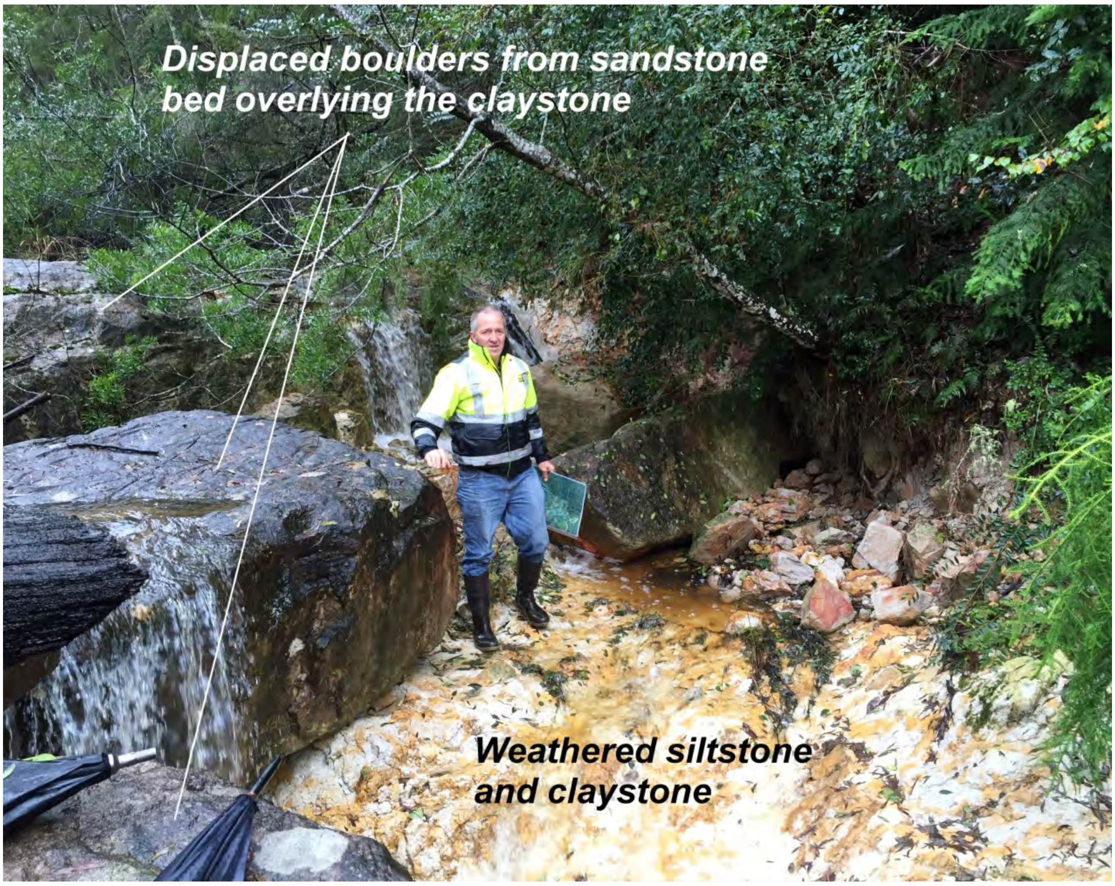


Figure 34 - Siltstone/claystone bed in lower part of spillway.

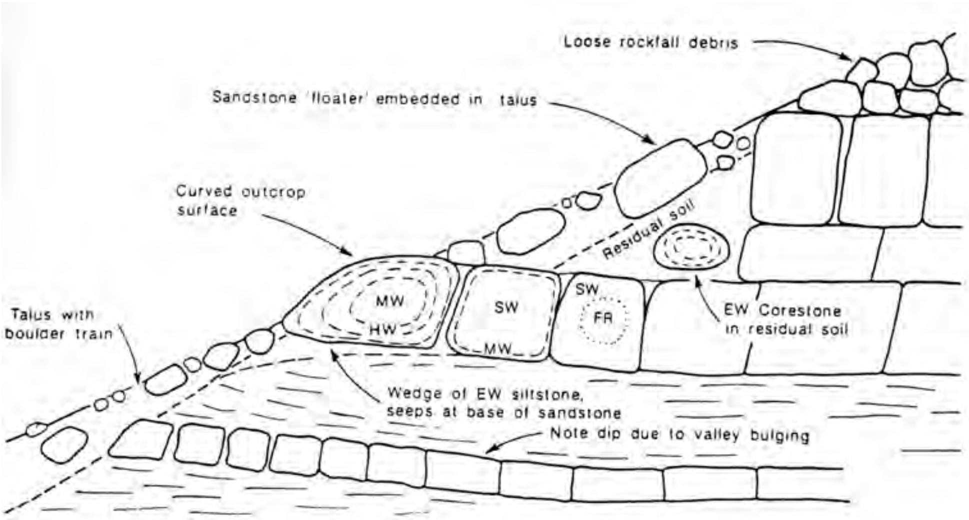


Figure 6. Typical weathering patterns and colluvial deposits in Terrigal Formation.
Note that weathering processes penetrate further into sandstone units than into shales.

Figure 35 - Terrigal Formation weathering.

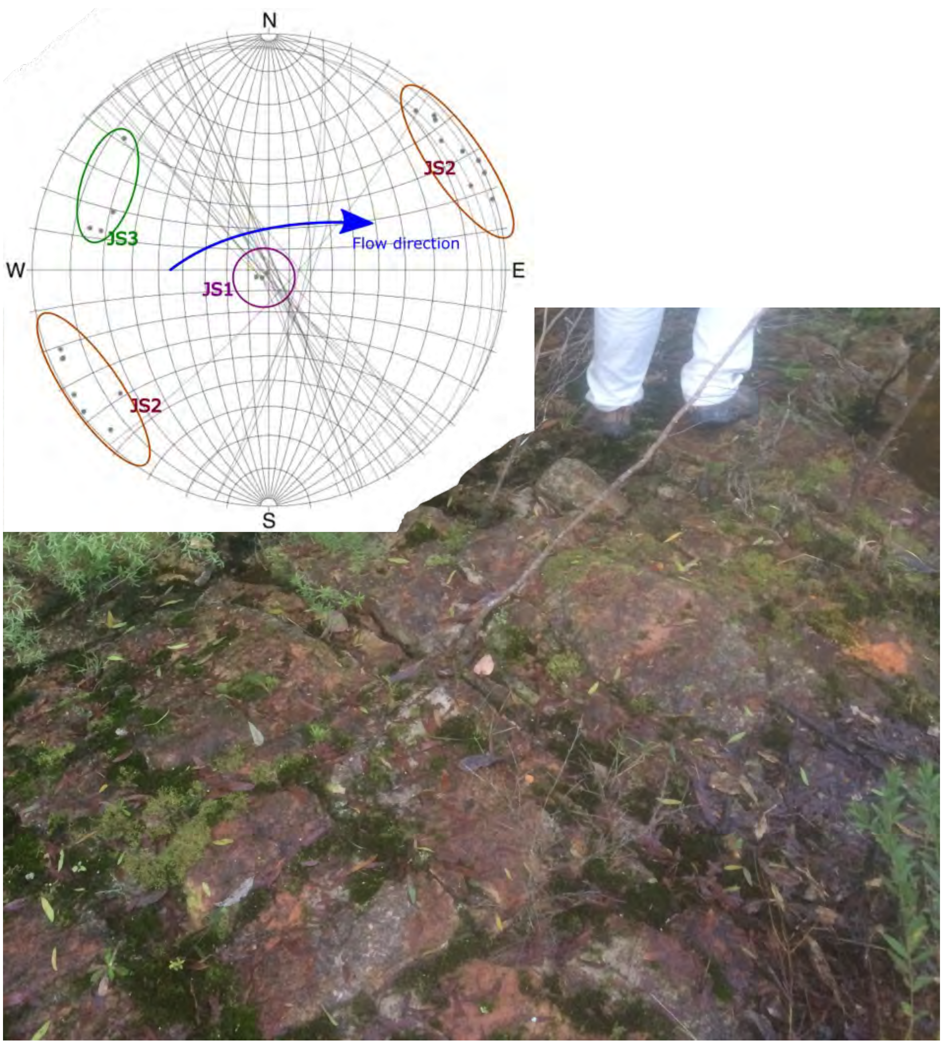


Figure 36 - Geological map representation of spillway rock mass

SITE		STRUCTURAL REGION				ROCK TYPE AND STRATIGRAPHY					
Narara		***HA1 - upper channel***				***Sandstone fascies of the Terrigal formation***					
Rock Quality Designation		**Strength of intact rock**									
RQD		**Classification**		**UCS** MPa		**CONTINUITY**		**JS1**	**JS2**	**JS3**	
		Very high		>250		Very low	<1m				
90%-100%		High		100-250		Low	1m-3m				
75%-90%		Medium		50-100		Medium	3m-10m				
50%-75%		Moderate		25-50		High	10m-20m				
25% - 50%		Low		5-25		Very high	>20m				
<25%		Very low		1-5		**DEFECT APERTURE**					
DEFECT ORIENTATIONS		**JS1**	**JS2**	**JS3**		Very tight	<0.1mm				
Description		***Bedding***	***N/S sv***	***E/W sv***		Tight	0.1-0.5mm				
Dip (degrees)		**0**				Moderately open	0.5-2.5mm				
Dip Direction (degrees TN)		**-**				Open	2.5-10mm				
SPACINGS						Very wide	>10mm				
Very wide	>2m					**DEFECT INFILL**					
Wide	0.6-2m					Clayey	Soft/hard				
Moderate	0.2-.6m					Sandy	Dense/loose	Dense	Dense	Dense	
Close	.06-.2m					Breccia	Dense/loose				
Very close	<60mm					**ROUGHNESS**					
JOINT WALL WEATHERING						Very rough/stepped					
Fresh to Slight						Rough/undulating					
Moderate, Mod strength						Slightly rough					
Highly, Low strength						Smooth, planar					
Completely, V.Low strength						Slickensided					
ADDITIONAL INFORMATION											

SITE		STRUCTURAL REGION				ROCK TYPE AND STRATIGRAPHY					
Narara		***HA2 - end of concrete***				***Sandstone fascies of the Terrigal formation***					
Rock Quality Designation		**Strength of intact rock**									
RQD		**Classification**		**UCS** MPa		**CONTINUITY**		**JS1**	**JS2**	**JS3**	
		Very high		>250		Very low	<1m				
90%-100%		High		100-250		Low	1m-3m				
75%-90%		Medium		50-100		Medium	3m-10m				
50%-75%		Moderate		25-50		High	10m-20m				
25% - 50%		Low		5-25		Very high	>20m				
<25%		Very low		1-5		**DEFECT APERTURE**					
DEFECT ORIENTATIONS		**JS1**	**JS2**	**JS3**		Very tight	<0.1mm				
Description		***Bedding***	***N/S sv***	***E/W sv***		Tight	0.1-0.5mm				
Dip (degrees)		**0**				Moderately open	0.5-2.5mm				
Dip Direction (degrees TN)		**-**				Open	2.5-10mm				
SPACINGS						Very wide	>10mm				
Very wide	>2m					**DEFECT INFILL**					
Wide	0.6-2m					Clayey	Soft/hard				
Moderate	0.2-.6m					Sandy	Dense/loose	Dense	Dense	Dense	
Close	.06-.2m					Breccia	Dense/loose				
Very close	<60mm					**ROUGHNESS**					
JOINT WALL WEATHERING						Very rough/stepped					
Fresh to Slight						Rough/undulating					
Moderate, Mod strength						Slightly rough					
Highly, Low strength						Smooth, planar					
Completely, V.Low strength						Slickensided					
ADDITIONAL INFORMATION											

SITE		STRUCTURAL REGION				ROCK TYPE AND STRATIGRAPHY					
Narara		***HA3 - headcut / weathered slot***				***extremely weathered / leached sandstone***					
Rock Quality Designation		**Strength of intact rock**									
RQD		**Classification**		**UCS** MPa		**CONTINUITY**		**JS1**	**JS2**	**JS3**	
		Very high		>250		Very low	<1m				
90%-100%		High		100-250		Low	1m-3m				
75%-90%		Medium		50-100		Medium	3m-10m				
50%-75%		Moderate		25-50		High	10m-20m				
25% - 50%		Low		5-25		Very high	>20m				
<25%		Very low		1-5		**DEFECT APERTURE**					
DEFECT ORIENTATIONS		**JS1**	**JS2**	**JS3**		Very tight	<0.1mm				
Description		***Bedding***	***N/S sv***	***E/W sv***		Tight	0.1-0.5mm				
Dip (degrees)		**0**				Moderately open	0.5-2.5mm				
Dip Direction (degrees TN)		**-**				Open	2.5-10mm				
SPACINGS						Very wide	>10mm				
Very wide	>2m					**DEFECT INFILL**					
Wide	0.6-2m					Clayey	Soft/hard				
Moderate	0.2-.6m					Sandy	Dense/loose	Dense	Dense	Dense	
Close	.06-.2m					Breccia	Dense/loose				
Very close	<60mm					**ROUGHNESS**					
JOINT WALL WEATHERING						Very rough/stepped					
Fresh to Slight						Rough/undulating					
Moderate, Mod strength						Slightly rough					
Highly, Low strength						Smooth, planar					
Completely, V.Low strength						Slickensided					
ADDITIONAL INFORMATION											

Figure 37 – Field observations of rock masses

Table 5 – Interpreted Barton Q' value at selected areas

Location	Area considered	Q factors				Q'
		RQD	Jn	Jr	Ja	
HA1/HA2	Unlined rock adjacent to concrete	75	9	2.5	3	6.9
HA2	End of concrete	35	12	3	4	2.2
HA2/HA3	Headcut / channel	35	12	3	4	2.2
HA3	Plunge pool	5	12	3	5	0.3
HA4	End of spillway	-	-	-	-	-

Table 6 – Interpreted Kirsten Index at selected areas

Location	Area considered	Factors					K
		Ms	Jn	Jr	Ja	Js	
HA1/HA2	Unlined rock adjacent to concrete	8.39	2.76	2.5	3	1	190
HA2	End of concrete	3.95	3.39	3	4	1	31
HA2/HA3	Headcut / channel	3.95	3.39	3	4	1	31
HA3	Plunge pool	3.95	3.39	3	5	1	3
HA4	End of spillway						

Table 7 – GSI values at selected areas

Location	Area considered	Strength rating	RQD rating	Discont. spacing	Discont. Cond.	GSI	GSI Lookup
HA1/ HA2	Unlined rock adjacent to concrete	2	15	15	12	54	50
HA2	End of concrete	1	9	12	8	40	40
HA2/ HA3	Headcut / channel	1	9	10	8	38	40
HA3	Plunge pool	0	3	5	6	24	25
HA4	End of spillway	-	-	-	-	-	-

4.3 Spillway Hydraulics

The HEC-RAS model of the spillway (described above) was utilised to report hydraulic characteristics along the spillway profile for discharges up to 100 m^3s^{-1}. Profiles of the spillway hydraulics are presented for discharges in 10 m^3s^{-1} and 60 m^3s^{-1} in Figure 38 and Figure 39, respectively.

Plots of the hydraulic characteristics of spillway flows are presented in Figure 40.

Hydraulic indices relevant to each of the erosion areas are presented in Table 8.

Table 8 - Estimated hydraulic indices for DCF at selected areas

Location	Area considered	Discharge 60 m^3s^{-1}		
		Π_{UD} *(kW/m2)*	u *(m/s)*	τ_o *(kPa)*
HA1/HA2	Unlined rock adjacent to concrete	0.6	3.6	0.09
HA2	End of concrete	0.9	1.6	0.17
HA2/HA3	Headcut / channel	1.5	5.1	0.22
HA3	Plunge pool	8.3	6.5	0.76
HA4	End of spillway	1.9	6	0.35

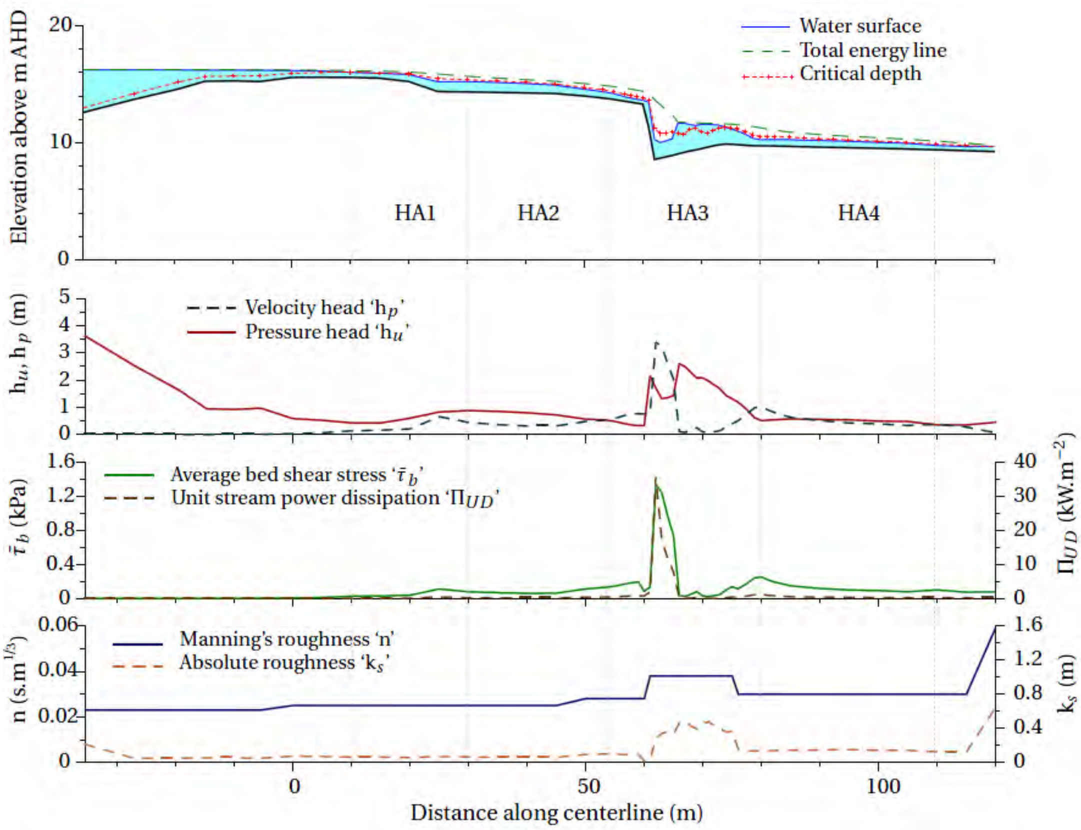


Figure 38 – HEC-RAS model of spillway hydraulics, discharge of 10 m^3.s^{-1}

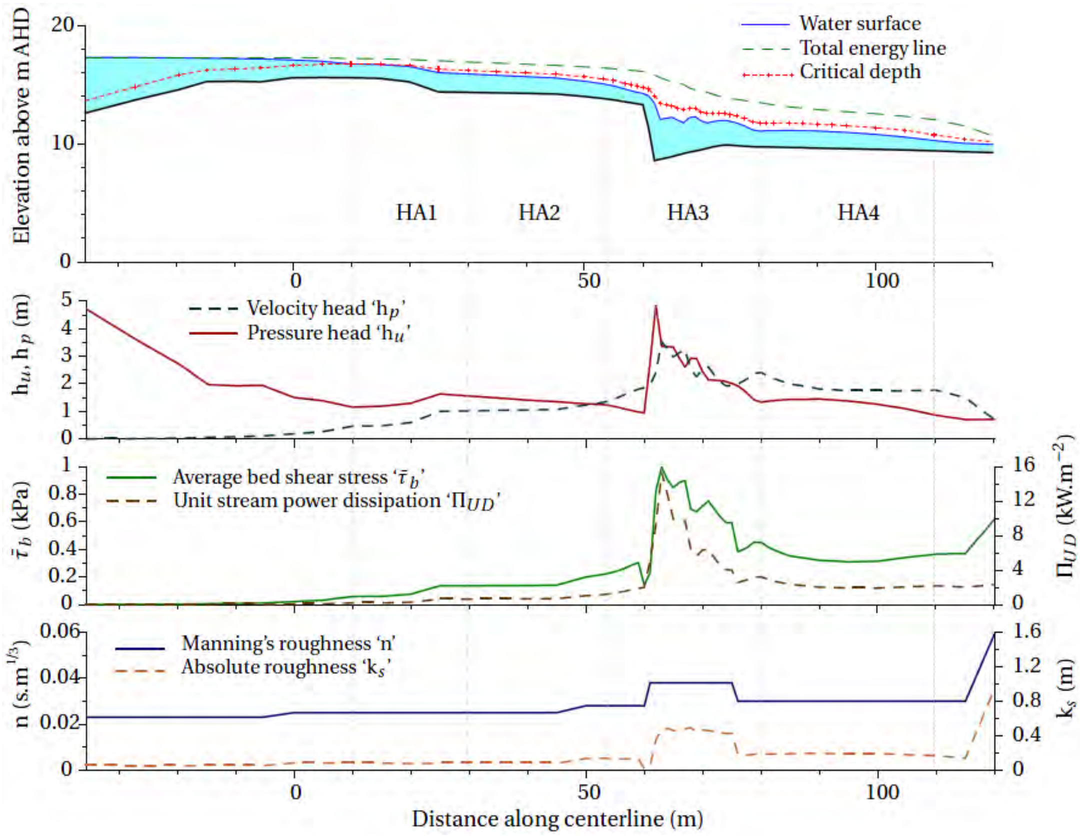


Figure 39 - HEC-RAS model of spillway hydraulics, discharge of 60 m^3.s^{-1}

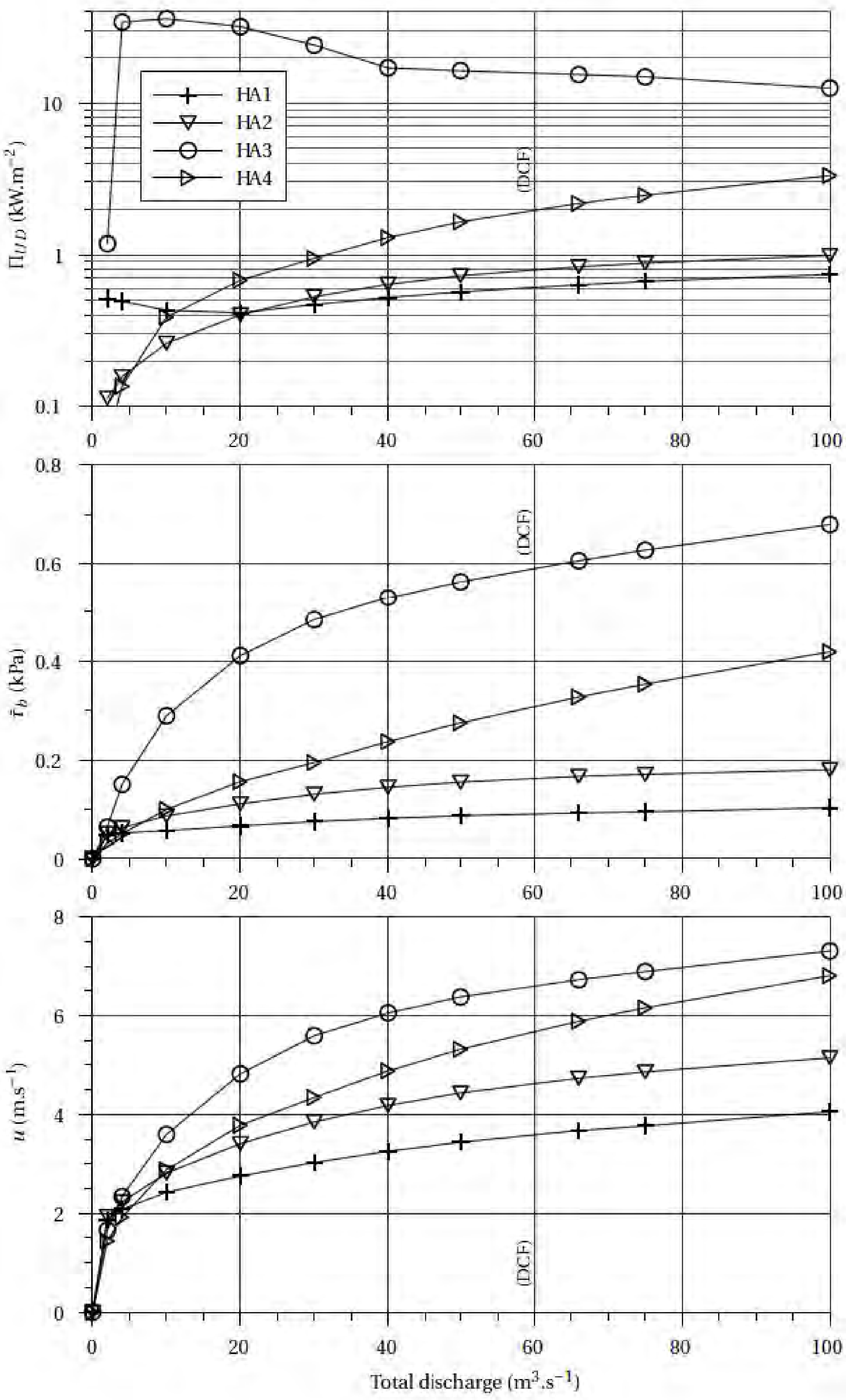


Figure 40 - Discharge characteristics

4.4 Assessment of Erosion Risk

The risk of erosion of unlined dam spillways is commonly assessed by comparison to the observed erosion at other case studies. Various "thresholds" of erosion, or erosion risk categories have been presented by van schalkwyk, et al 1994; van schalkwyk 1994; Annandale, 1995 and Kirsten et al 2000 based on these case studies. In these methods, the hydraulic loading on the spillway was characterised using the unit stream power dissipation "Π_{UD}" (kW.m^{-2}), and the erodibility of the rock mass was characterised using the Kirsten rock-mass index. The various thresholds from these authors are summarised in Figure 41.

The values for Π_{UD} and Kirsten index assessed for the various regions in the Narara Dam spillway are plotted on Figure 41. The position of the plotted data points confirm that, in comparison to other case studies, the conditions at the plunging step (HA3) at Narara are characteristic of potentially serious erosion, whereas the characteristics at the upper spillway (HA1) are indicative of low erosion risk. The conditions for the section of spillway between the end of the concrete and the start of the plunge are indicative of minor to moderate erosion risk. This accords with the observations and views the writer.

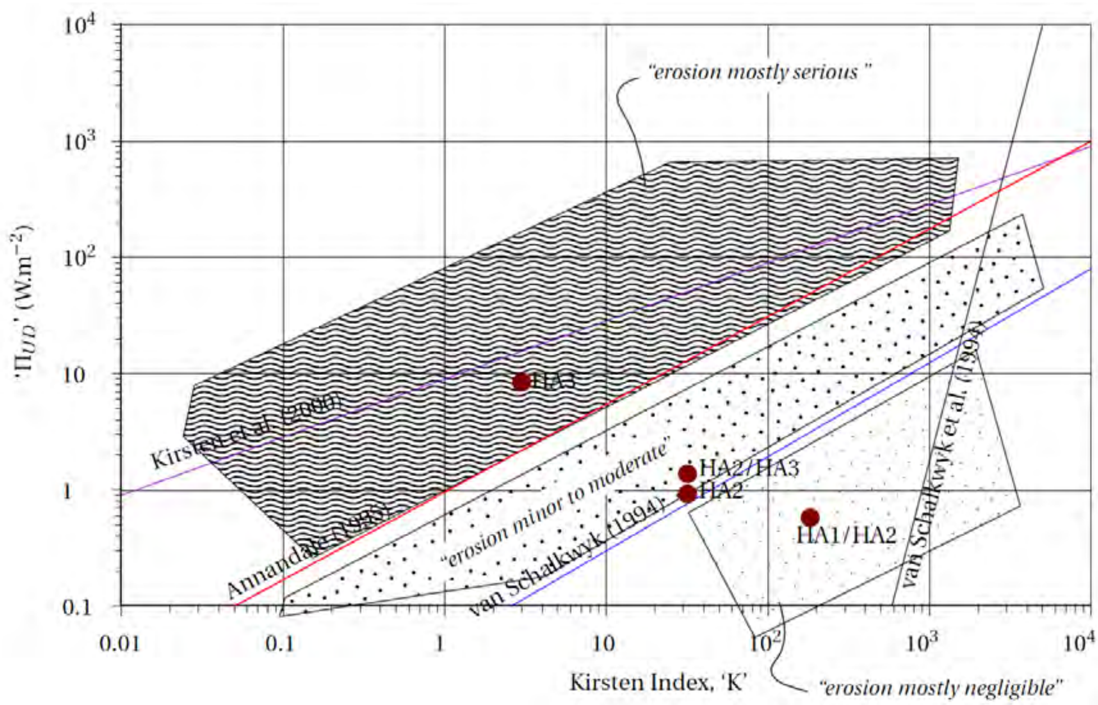


Figure 41 – Comparison of Narara erosion points versus published observations

It is expected that, during spillway flood events, the spillway downstream of the plunge section will continue to erode away the loose alluvium / colluvium. This represents a potential issue with unstable slopes and falling trees that may affect development plans at the site, but is considered to have no impact on dam safety.

The erosion forming the plunge at HA3 is expected to advance upstream, over subsequent flow events (ie "head-cutting"). In particular, the erosion channel just upstream of the plunge (Figure 31) will develop and will advance upstream. However, more resistant material is encountered in the upstream direction, which is expected to impede the development of erosion. Eventually, if the erosion-channel progresses far enough upstream, it can present a risk to the safe operation of the spillway. At such a time, remedial measures, such as dental concrete or chute lining may be required. However, it is considered that the rate of erosion will be slow enough such that is can be monitored over time, through various flood events. It is not expected that the erosion will progress to a critical state over the course of one or two flow events. Hence this erosion will remain an issue for monitoring over time, but does not constitute a present risk to dam safety.

The erosion at the end of the lined section may develop, undermining the concrete. This location should similarly be monitored.

The risk of erosion developing in the upper spillway is considered to be very low in accordance with the relatively wide and flat slope in this vicinity, and the sufficiently erosion-resistant nature of the rock mass in this region.

5 RISK ASSESSMENT

A qualitative risk assessment has been undertaken in accordance with the ANCOLD Guidelines of October 2003. These guidelines reference Australian Standard AS4360:1999. The Australian Standard sets out general guidelines for definitions of Likelihood, Consequences and Risk but advises that these should be tailored to a particular dam or site. We have followed this procedure.

Table 9 sets out the definitions of Likelihood, and Table 10 gives the definitions for Consequence, specifically directed to the Narara Dam.

Table 11 sets out the Risk Matrix.

Using the guidelines of ANCOLD, October 2003 we have considered Hazard Scenarios for which we have determined risk according to Tables 9, 10 and 11.

Table 12 sets out the Hazards we have considered and the computed risk levels. It must be noted that one could consider many trivial risks which by inspection would be Low or of no consequence and we have not included such trivial matters in Table 12.

The risk levels in Table 12 are consistent with the discussions given earlier in this report and provide the basis for formulation of the Operation and Maintenance Manual which is in a separate document M10.R2.

Table 9 – Definitions of Likelihood

MEASURE OF LIKELIHOOD		
LEVEL	**TERM**	**DESCRIPTOR OF LIKELIHOOD, AND/OR PROBABILITY OF OCCURRENCE AT NARARA DAM**
E	**Very Improbable**	Not reasonable to expect within 100 years; AEP $<10^{-3}$.
D	**Unlikely**	Not reasonable to expect within 50 years, but may occur with subsequent passage of time with passage of time and failure to implement Dam Management Plan; AEP$<10^{-3}$.
C	**Possible**	May occur any time in the next 50 years and more likely in the next 100 years
B	**Likely**	Will probably occur sometime in the next 100 years.
A	**Almost certain**	Likely to occur at any time. Or within hours or a few days of extreme triggering event, or combination of events, being flood with AEP$>10^{-3}$; earthquake with AEP$>10^{-6}$; spillway blockage; uncontrolled piping; deep seated instability of upstream or downstream face.

Table 10 – Definitions of Consequence

CONSEQUENCE		
LEVEL	**TERM**	**DESCRIPTION RELEVANT TO NARARA DAM**
1	**Insignificant**	No loss of stored water and no threat to stored water, no injuries, insignificant impact on local environment of the dam and downstream of the dam.
2	**Minor**	No loss of stored water but threat of loss if maintenance works not implemented, minor impact on design capacity of spillway requiring remedial works within period of weeks, loss of freeboard, loss of embankment width at or near full supply level by virtue of face erosion or local instability; no injuries.
3	**Moderate**	Imminent loss of stored water due to embankment instability, and/or piping, and/or overtopping; immediate remedial works required; SES and Police notified via Emergency Action Plan; clear and present danger of major downstream flooding and possible injury or loss of life.
4	**Major**	Loss of the stored water by instability of embankment, piping in or around embankment, overtopping due to loss of, or inadequate, spillway capacity; Dambreak scenario; SES and Police notified via Emergency Action Plan; major flooding downstream; evacuation plan initiated; potential for loss of life.
5	**Catastrophic**	Multiple deaths, off-site toxic contamination release, financial losses >$50 million; flood levels greater that AEP 10^{-2} natural floods.

Table 11 – Risk Matrix

LIKELIHOOD		CONSEQUENCE				
		1	**2**	**3**	**4**	**5**
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
E	**Very Improbable**	**L**	**L**	**L**	**M**	**H**
D	**Unlikely**	**L**	**L**	**M**	**M**	**E**
C	**Possible**	**L**	**M**	**M**	**H**	**E**
B	**Likely**	**M**	**M**	**M**	**H**	**E**
A	**Almost certain**	**M**	**M**	**H**	**H**	**E**

Table 12 – Assessed Hazards

HAZARD		ASSESSED LIKELIHOOD	ASSESSED CONSEQUENCE	RISK	BASIS OF ASSESSMENT
Number	Description				
1	Flood with AEP>10^{-3}, no spillway blockage, no loss of freeboard due to other events; erosion failure of embankment	Very improbable	Major	M	Spillway designed for AEP 10^{-3}; dam would overtop; if dam failed the Dambreak study indicates Sunny Day Consequence Category of LOW and Flood Consequence category as LOW; dam has withstood two overtopping occurrences prior to spillway upgrade.
2	Flood with AEP >10^{-3} with spillway already partly blocked by debris or a rock fall	Very Improbable	Major	M	As above coupled with assumption the Operation and Maintenance manual requirements have NOT been followed.
3	Flood with AEP>10^{-3} with loss of freeboard having occurred due settlement or crest erosion or slumping	Very Improbable	Moderate	L	Spillway designed for AEP 10^{-3}; dam would overtop to a greater extent that per item 1 but would require that Operation and Maintenance Manual has been ignored; if dam failed the Dambreak study indicates Sunny Day Consequence Category of LOW and Flood Consequence category as LOW.
4	Flood with AEP <10^{-3} but with spillway blockage and/or loss of freeboard such that overtopping occurs	Very Improbable	Moderate	L	Spillway designed for AEP 10^{-3}; dam would overtop to a greater extent that per item 1 but would require that Operation and Maintenance Manual has been ignored; if dam failed the Dambreak study indicates Sunny Day Consequence Category of LOW and Flood Consequence category as LOW
5	Deep seated instability of downstream face cutting through crest	Very Improbable	Moderate	L	Computed factor of safety >2 based on monitored existing high pore pressures in downstream face which has slope of 1(V):5(H)

HAZARD		ASSESSED LIKELIHOOD	ASSESSED CONSEQUENCE	RISK	BASIS OF ASSESSMENT
Number	Description				
6	Deep seated instability of upstream face cutting through crest	Very Improbable	Moderate	L	Rapid drawdown of reservoir not possible; no evidence of instability in >35 years of operation
7	Piping failure through embankment or along low flow outlet pipe	Very Improbable	Moderate	L	No evidence of piping in >35 years of operation; dam has always stored fresh water.
8	Collapse of low flow outlet pipe leading to piping failure	Very Improbable	Moderate	L	Concrete pipe; no evidence of any issues in 35 years of operation
9	Progressive erosion of spillway leading to undercutting of spillway entry	Unlikely	Moderate	M	Erosion has occurred and will continue to occur; specifically addressed in Operation and Maintenance Manual; remedial works expected within next one or two decades
10	Erosion of upstream face by wave action leading to slot breakthrough somewhere along the crest	Unlikely	Moderate	M	Embankment upstream face not covered with rip rap; however, reservoir has a short fetch and only minor erosion due to wave action has occurred during the past ~30 years; specifically addressed in Operation and Maintenance Manual; remedial works expected within next two decades
11	Settlement of embankment leading to loss of freeboard	Unlikely	Moderate	M	Insignificant settlement (probably <<100mm) has occurred over the past ~30 years.
12	Settlement of embankment following earthquake leading to loss of freeboard	Very improbable	Moderate	M	Embankment constructed of high clay content soil, with dirty rockfill over downstream face - liquefaction verging on impossible under Maximum Credible earthquake.

6 CONCLUSIONS

Based on the studies presented above, it is considered that there are no immediate issues of dam safety at the NEV dam.

The stability of the embankment is considered to be consistent with normal requirements for such a structure, and while there is evidence of persistent dampness at the embankment toe, no indications of piping failure were observed or have been reported over the 30+ years of operation of the dam.

There is evidence of erosion in the dam spillway. The erosion is expected to continue developing, and must be monitored. At some stage in the future, depending of flood events encountered, some remedial work is expected, but it is not considered to be critical at this stage, nor is expected to become critical suddenly over the course of a single event.

The Hazard scenarios assessed in this report are addressed in the the Operation and Maintenance Manual in Pells Consulting report M010.R2.

7 REFERENCES

7.1 Site-specific references

DA5971 /1985: file of Development Applications of Narara Horticultural Dam held by Gosford City Council

NSW Department of Commerce 2006 “Dam Safety Evaluation of Farm Dam on the Narara Horticulture Research Station” Report No., DC05243 **Feb 2006**

NSW Dams Safety Committee, 2006. Narara Horticultural Dam Surveillance Report – attachment to Letter from Norm Himsley Dams Safety Committee to Paul Anderson NSW DPI Gosford Horticultural Institute **5 May 2006** “Re: Narara Horticultural Dam – surveillance report (March 2006)”.

NSW Public Works 2012 Narara Farm Dam - Dambreak Study Report No. DC11146 **Jan 2012**

NSW Public Works, 2014. Narara Horticultural Dam – Dambreak sensitivity analysis addendum report. **7th May 2014** Report No. DC14046 Final.

Letter from Klay Chan NSW Public Works, **12 May 2014**, to John Talbott Narara Ecovillage Cooperative “Ref: Narara Horticultural Dam – Dambreak sensitivity analysis Addendum Report”

Letter from Narara ecovillage cooperative, **20 May 2014**, to Steve Knight NSW Dam Safety Committee “Re: Dambreak sensitivity analysis – Narara Horticultural Dam”

Letter from Steven Knight at NSW Dam Safety Committee, **27 June 2014** to Mark Fisher of Narara Ecovillage Cooperative “Re: Narara Horticultural Dam” ref: NararaHort

7.2 Other references

Australian National Committee on Large Dams (ANCOLD), 2000. Guidelines on assessment of the consequences of dam failure. May 2000

Australian National Committee on Large Dams (ANCOLD), 2003. Guidelines on dam safety management. August 2003

USACE Hydrologic Engineering Centre, 2010. HEC-RAS River Analysis System Hydraulic Reference Manual (computer program documentation No. Version 4.1). USACE, Hydrologic Engineering Centre.

APPENDIX A

HISTORICAL DOCUMENTATION OF DAM CONSTRUCTION

A.1 SPECIFICATIONS FROM WRC

The dam was to be constructed in accordance with Specifications by Water Resources Commission as attached to DA 5971. These included the following important facets:

Site Clearing

The area to be covered by the embankment, and associated works together with an area extending beyond the limits of each for a distance of 5 metres all round shall be cleared of all trees, scrub, stumps, roots, dead timber and rubbish, all of which shall be removed from the vicinity of the work and burned or otherwise disposed of in a manner approved by the Supervising Officer.

Cut-off Trench

The trench for the clay cutoff shall be excavated as a minimum to the dimensions shown on the Plans. The trench shall extend downwards into impervious material or rock, as the case may be, for a distance of at least 300 mm and along the full length of the embankment but not the bywash.

All water, loose rock, loose soil, and soil whose moisture content is higher than the surrounding insitu moisture content shall be removed from the trench before backfilling commences.

Borrow Area

The material for the construction of the embankment shall as far as possible be excavated from within the area to be covered by the stored water.

Overflow Pipe and Spillway

The dam will have an overflow pipe installed in the wall to ensure the creek continues to flow. During periods of normal flow in the creek when the dam is at full capacity this will take most of the flow away from the spillway. The dam will be full to capacity during normal seasonal conditions and the water level will only drop during extended dry periods.

The pipes forming the inlet and outlet chambers shall each consist of a total of 3.50 metres of diameter Class S reinforced concrete butt jointed precast pipes. These pipes are to be set on concrete bases as dimensioned on the plans. The concrete bases are to be finished with a steel trowel to give a smooth surface.

Holes are to be neatly cut in the walls of the inlet and outlet chambers to receive the ends of the spillway pipe. Alternatively, precast pipes of approved make and of correct dimensions which have outlets formed for connection to the spillway pipe, may be used for the two chambers.

The inlet chamber shall be set into the ground with its top edge level at R.L. 103.00 so that water will flow uniformly over it when the spillway is in operation. It shall be so positioned on the side of the gully so that the top edge is not less than 300 mm and not more than 500 mm above the natural surface.

The outlet chamber is to be positioned with its top edge set level and about 150 mm below the surrounding natural surface which is to be evenly sloped into the crest of the outlet. Stone pitching shall be placed around the outlet chamber to protect the surface of the ground against erosion. The stones shall be closely handpacked with their top surfaces flush with the top of the outlet pipe and evenly sloped from the crest of the outlet to the surrounding natural surface.

The spillway pipe is to be laid with the bottom 500 mm of the pipe barrel evenly and firmly bedded throughout its length, the ends of the individual pipes being free from bearing to facilitate jointing operations.

The spillway pipes shall be jointed with rubber rings or gaskets. Before jointing is commenced the ends of the pipes to be jointed and the inner surfaces of the socket or coupling shall be clean and dry. In making the joint care shall be taken to ensure the rings or gaskets are correctly placed and are not forced out of position during the operation. The pipes shall be pushed or levered home to the witness grooves or guide marks so that an even line shall occur at the inverts. If the leverage is applied with a crowbar, a wooden block is to be inserted between the end of the pipe and the crowbar.

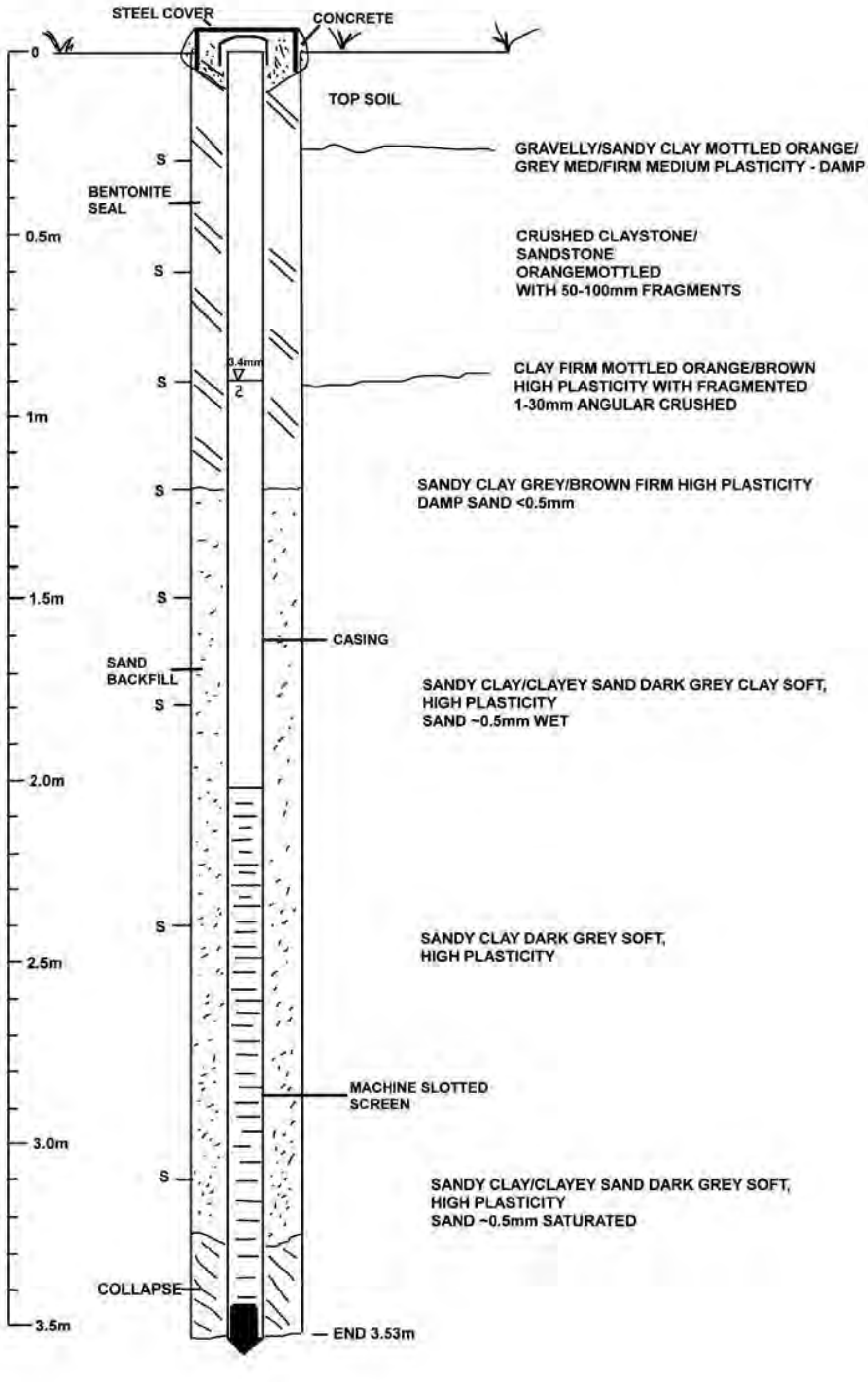
After the pipe has been approved by the Supervising Officer the spaces under the pipe joints shall be filled with impervious material to complete the bedding.

One cutoff collar shall be cast in situ around the pipe to the dimensions and in the position shown on the plans. The cutoff collar is to be bonded to the pipe with a suitable sealing compound or bitumastic filler.

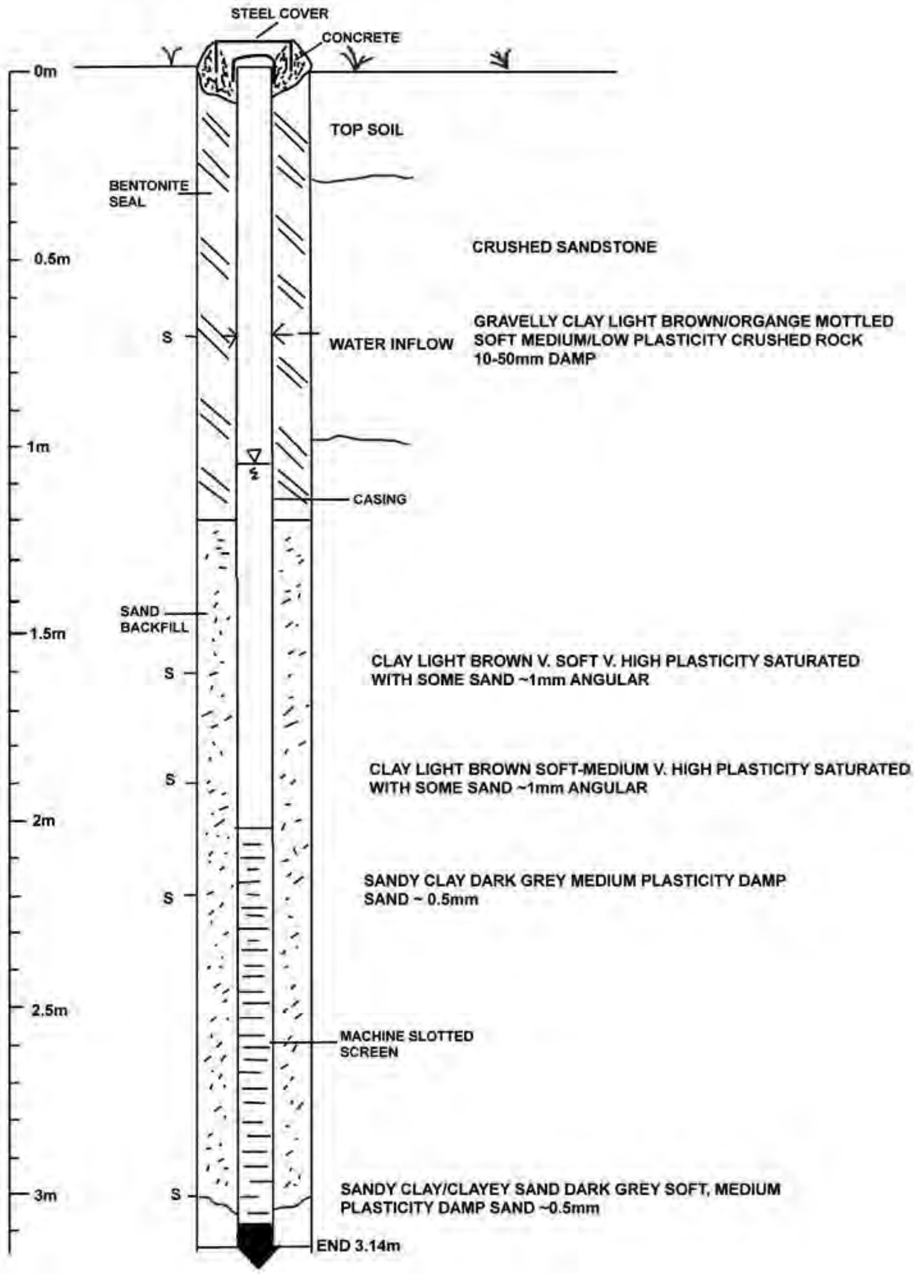
APPENDIX B

FIELD LOGS OF STANDPIPE PIEZOMETERS

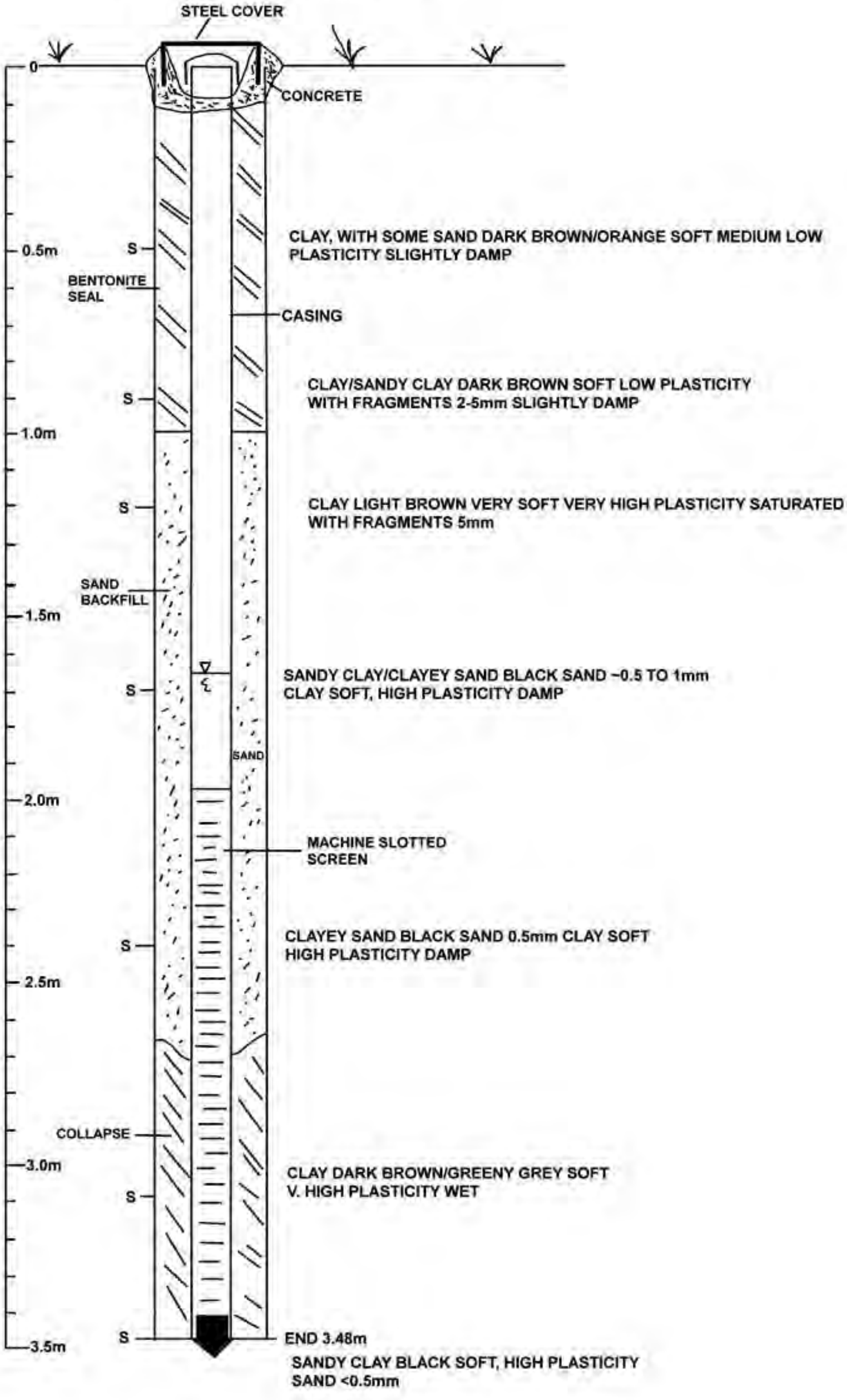
BOREHOLE 1 - 24 JULY 2015



BOREHOLE 2 - 24 JULY 2015 (CENTRE)



BOREHOLE 3 - 24 JULY 2015 (TOE)



Narara Ecovillage Cooperative Ltd

NARARA ECOVILLAGE DAM
DAM SAFETY MANAGEMENT SYSTEM

Appendix 4.1.1.4

M010.R3 Draft
27th October 2015

Table 1 – Revision History

REV	DATE	DESCRIPTION	PREPARED	APPROVED
A	27 Oct 2015	Draft	S.Pells / PJN Pells	

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1 INTRODUCTION

This report has been prepared to establish, in one controlled document, official guidance for the ongoing safe management of the Narara EcoVillage (NEV) Dam.

The NEV dam is an 8 m high earth embankment dam what withholds approximately 45 ML storage. It is therefore a relatively small dam, and is no longer a prescribed facility so there are no formalised procedures for inspection and reporting that apply to the facility. However, the dam is critical to the viability of the Narara Village. Therefore, operation and safety management is being undertaken according to the guidance in ANCOLD, 2003 applicable to a LOW hazard category dam and the Dam Safety Management System (SMS) outlined in document DSC2A, published by the NSW Dam Safety Committee.

In addressing these matters, this report also address Operations and Maintenance matters relevant to dam safety, as per the requirements of ANCOLD 2003.

This report is therefore developed to take the role of a manual, which provides all information and instructions necessary for safe surveillance, operation and maintenance of the dam, outlet and spillway.

1.1 Document Control

This Manual should be reviewed at least every 5 years, and should also be revised whenever there are major upgrade works, changed practices or new studies which provide updated findings of relevance.

The electronic form of this document should be saved as a `read only file' so that changes can only be saved by selecting 'Save As' from the drop down 'File' menu and saving to another name or location. Users may print hard copies of the document, however these are uncontrolled and are must be clearly marked as such.

1.1.1 Procedure for Revising the Manual

Approval from the owner (Narara EcoVillage Dam) is required before any changes/revisions are made to this document. To make any changes or revisions, the procedure given below must be followed:

1. The Planning Manager must be notified before any alterations are made to the document,
2. 'Track changes' should be turned on in MS Word before the document is edited. This is done by clicking on 'Track Changes' which is found in the 'Tools' drop down menu. This should then show all changes made to the document in a different colour.
3. Once all the necessary changes have been completed, the Planning Manager should be notified. The person who made the changes to the Manual should <u>not</u> accept the tracked changes.
4. The Planning Manager will review the edited document accepting or rejecting the new changes. If the Planning Manager thinks that there has been an accidental change, he/she should clarify these changes with the person who made them, ensuring that the changes made were necessary.
5. The Table 1 – , located on the front cover of this document, should be updated to reflect the revisions made.
6. Once the Planning Manager has accepted all the new changes, they will then replace the existing controlled electronic version with the new version.

2 GENERAL INFORMATION

2.1 Ownership

The dam at the Narara Ecovillage (NEV) site was designed by the Water Resources Commission NSW and was constructed, in the mid- to late 1980's, in accordance with approval of Development Application 5971 by Gosford Council dated 30 May 1985. It is understood the embankment dam was constructed for irrigation purposes within the Gosford Primary Industries Institute, which was part of the NSW DPI's Centre of Excellence for Market Access and Greenhouse Horticulture.

The dam is now managed by the Narara Ecovillage Cooperative, and the dam is proposed to be used as water supply to the Narara Ecovillage.

2.2 Location and Access

The dam is located on land owned by the NEV, in the suburb of Narara, near Gosford in NSW. The location of the dam, the catchment and regional topography is shown in Figure 1.

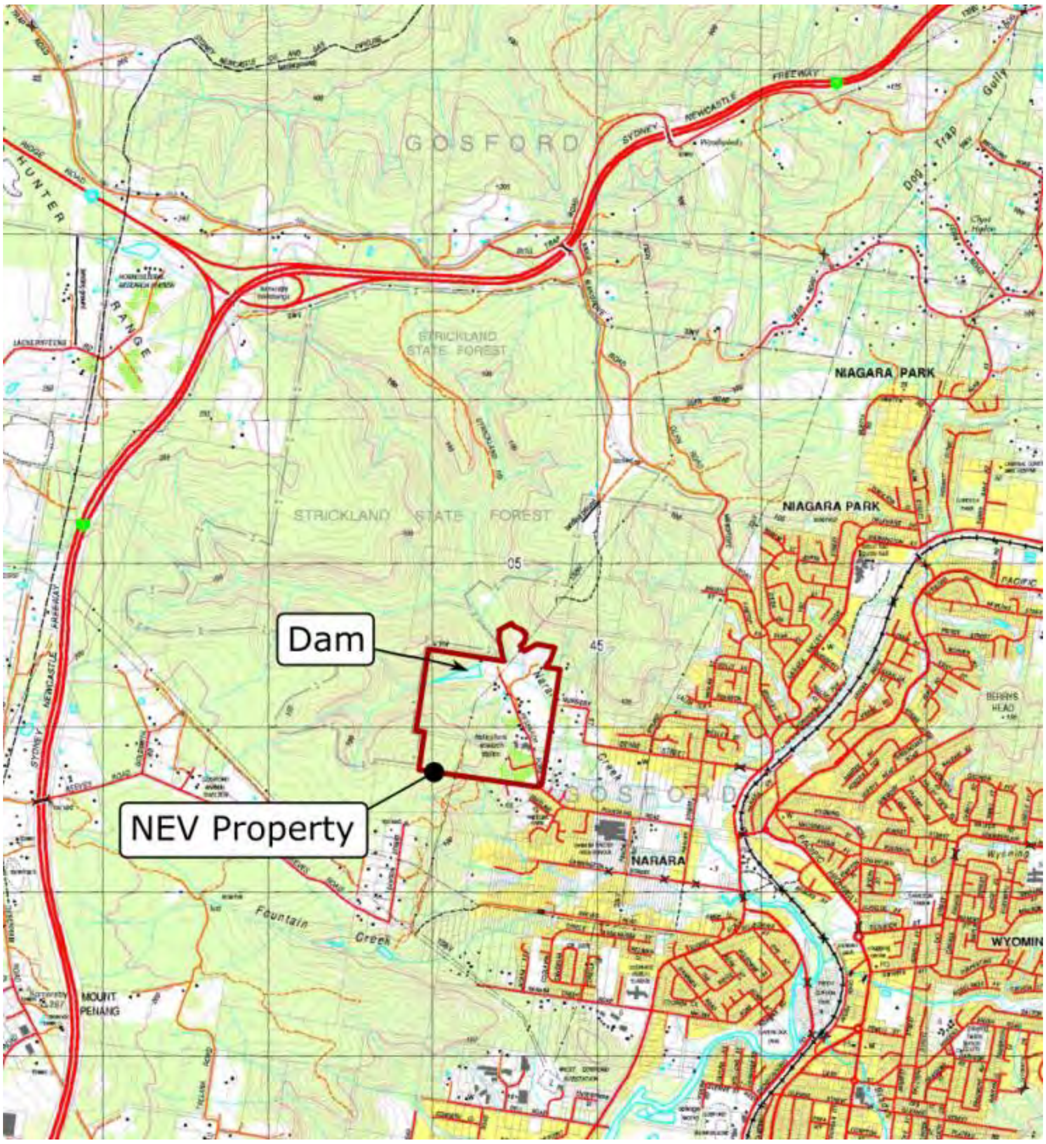


Figure 1 - Location of Narara Dam

2.2.1 Access Authorisation

Access to the NEV site is currently controlled. No additional controls to authorise access to the dam are required at this stage.

2.2.2 Access Routes

Access to the NEV site is via Research Road, as shown on Figure 2. Once on the site, access to the embankment wall is via the existing road, shown on Figure 3.

The spillway can be accessed by walking along the crest of the embankment.

2.2.3 Access under Adverse Weather Conditions

A sunny-day dambreak scenario (SDD) model was presented in Public Works (2014). In Figure 4 the predicted flood extents from the SDD are overlayed on the 1:25000 topographic map. Based on this model, site access is not expected to be compromised under the dam break scenario.

Vehicular access may be restricted under >10% AEP flood conditions in Narara Creek, due to inundation of the approach roadways (see Figure 5). Once on site, further vehicular access may be incurred (Figure 6), and caution is required. Foot access may be required during flooding of Narara Creek.

A dam break occurring during flood conditions was shown to cause only a small increase to flood extents.

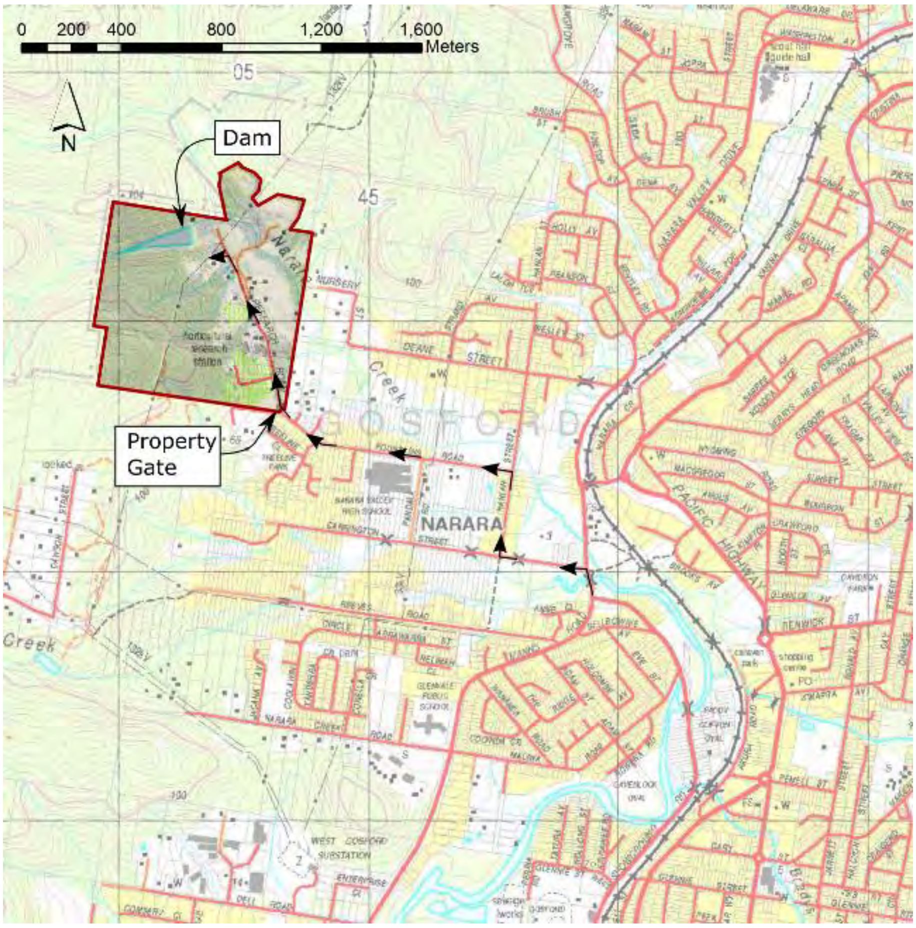


Figure 2 – Access to NEV site

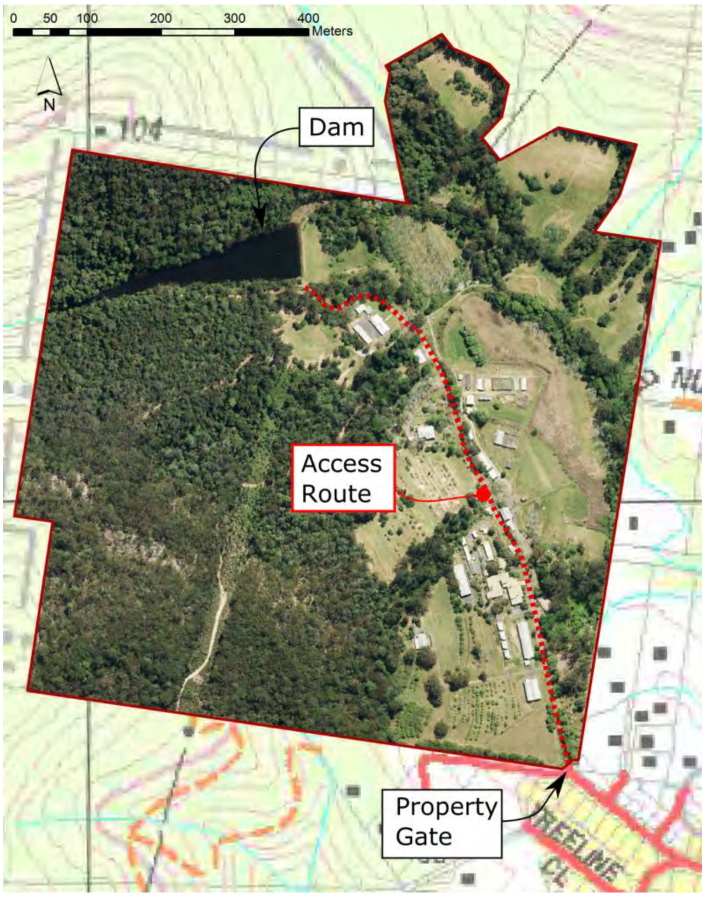


Figure 3 – Dam access.

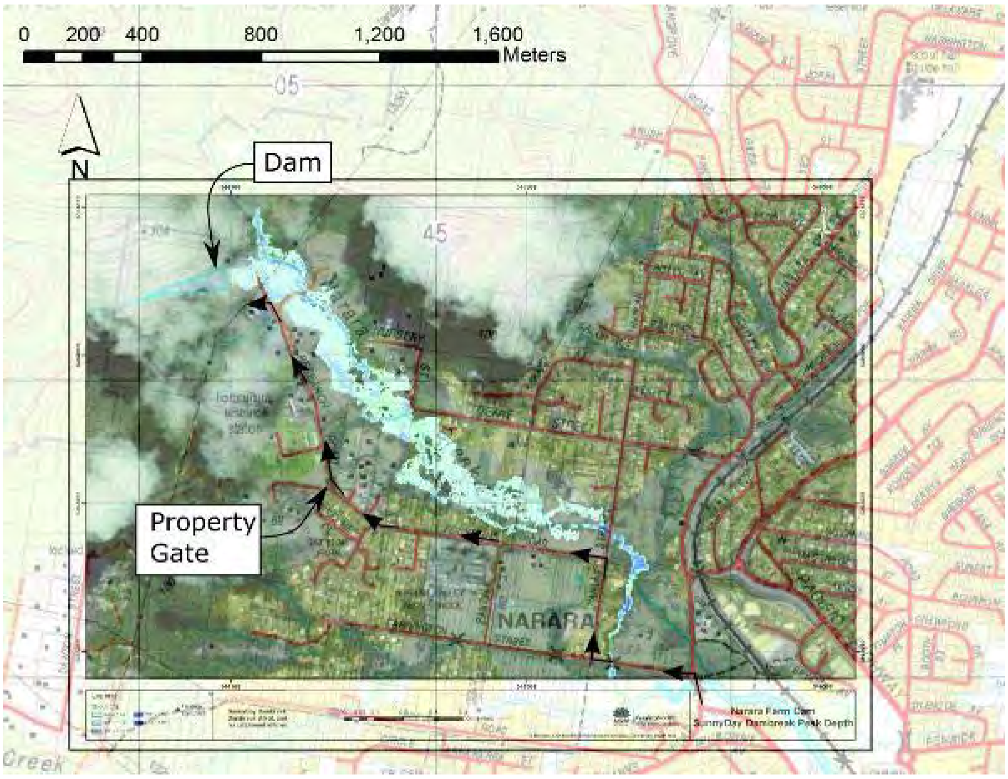


Figure 4 – Access during sunny day dam break (based on Public Works, 2014).

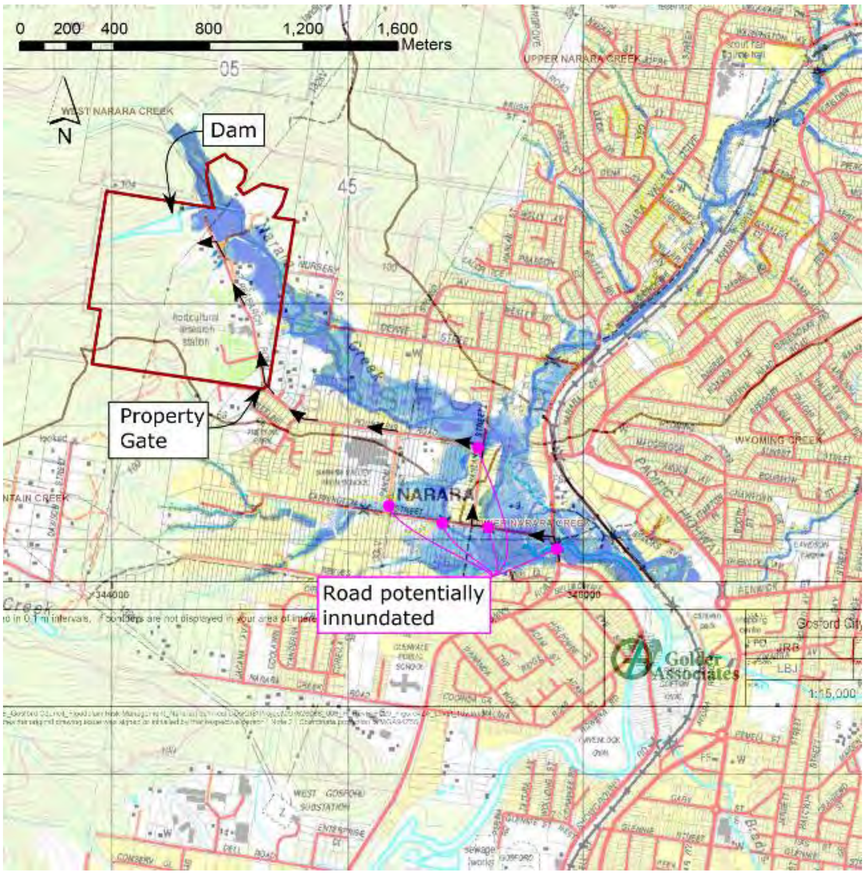


Figure 5 –Site access under 10% AEP flood in Narara Creek (Golder, 2013).

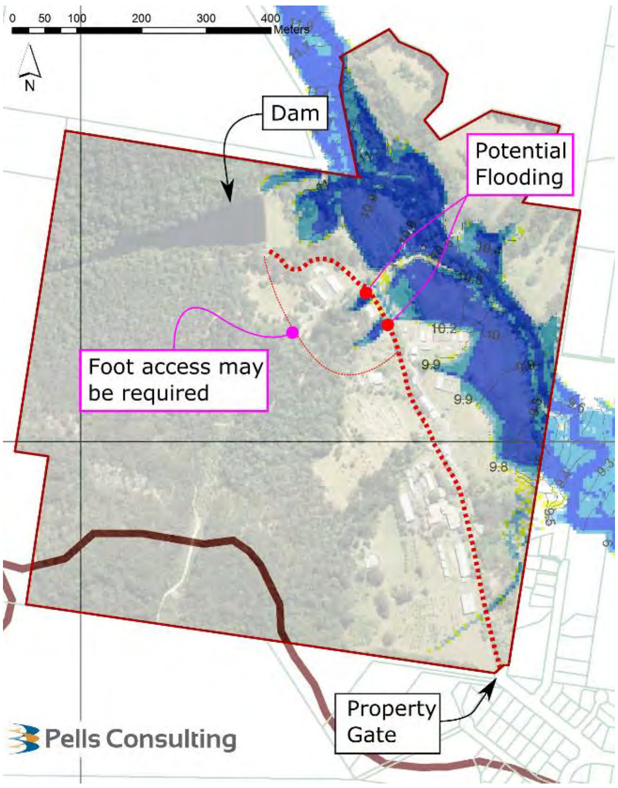


Figure 6 – Dam access under 10% AEP flood in Narara Creek (Golder, 2013).

2.3 Attendance, Communications and Warnings

The dam is not manned by a dedicated staff member. However, the NEV site office is generally attended, and can be contacted on:

Postal and Physical Address
Narara Ecovillage
25 Research Road
Narara NSW 2250
Australia

Telephone
TBA

NEV dam does not have a flood warning system. If a telemetered reservoir level monitoring is installed, an automated notification system may be considered. Such a system could be configured to provide notification of various reservoir trigger levels.

There is no seepage measurement at the NEV dam. Seepage will be monitored visually through routine inspections.

There is no seismic warning system at the NEV dam.

2.4 Responsibilities

NEV has ownership of the dam, spillway and reservoir.

Responsibility in the chain of command with respect to the operation and maintenance of the Dam is summarised in Table 2.

Table 2 - Responsibilities

Area of Responsibility	Personnel Responsible	Contact Details
Emergency action	TBA	
Reservoir level monitoring	TBA	
Dam safety and surveillance	TBA	
Dam maintenance	TBA	
Vegetation management	TBA	

2.5 Contacts

Key stakeholders are summarised in Table 3.

Table 3 - Contacts

Stakeholder	**Contact**	
Emergency Services	**State Emergency Services** Phone: 132 500 02 4365 4055 (Gosford) http://www.ses.nsw.gov.au/ **Fire and Rescue** Wyoming Fire Station Lot 2 Laycock Street, Wyoming NSW 2250 Phone: 02 4325 3624 http://www.fire.nsw.gov.au/ **Fire – Rural / Bush** Narara Rural Fire Brigade 2 Manns Rd, Narara NSW 2250 Phone: 02 4340 2911 http://www.rfs.nsw.gov.au/ **Police** 1, 9-11 Mann St, Gosford NSW 2250 Phone: 02 4323 5599	**Medical** Gosford Hospital Holden St, Gosford NSW 2250 Phone: 02 4320 2111
Insurers	**TBA**	
Regulator	**Dam Safety (unofficial)** NSW Dam Safety Committee Mr. Steve Knight, Executive Engineer Phone: 02 9842 8070 Mob: 0403 681 645 steve.knight@damsafety.nsw.gov.au http://www.damsafety.nsw.gov.au/ **Water Supply** IPART Phone: 02 9290 8400 http://www.ipart.nsw.gov.au/	
Water Quality and Supply	**Aquacell** Contact person Phone: 02 4721 0545	
Dam Safety Engineer	**Pells Consulting** 49 Lakeside Drive, MacMasters Beach 2251 Phone: 0243812125 Steven Pells, Associate Mobile: 0409 155 946 Philip Pells, Director Mobile: 0408 418 296	
Flora and Fauna	**TBA**	
Meteorology	**Bureau of Meteorology** Emergencies - forecasts & warnings http://www.bom.gov.au/	
Fishery	**NSW Department of Primary Industries** Phone: 1300 550 474 http://www.dpi.nsw.gov.au/fisheries	
Neighbouring Landowners	**Forestry Corporation -** Strickland State Forest 02 9872 0111 http://www.forestrycorporation.com.au/	

2.6 Operational Data and Log

There is no current requirement for an operational data recording or operations log, as there are no structures or instrumentation on the dam requiring operation.

Additional infrastructure will be installed as part of the proposed water supply system. This infrastructure will be subject to specific operation and maintenance guidelines that are yet to be developed.

2.7 Public Health and Safety

The dam shall be subject to safety policies applicable to the NEV site.

Potential hazardous situations that can arise on the dam site are as follows:

- Exposure to drowning.
- Falls into reservoirs or to the outlet works.
- Aggressive wildlife
- Injury from slipping/falling.
- Vehicle accident on embankment wall.
- Unstable slopes within and adjacent to spillway.
- Hazards from spillway flows

The above list is NOT complete and should only be used as a guide.

2.8 Staff training

Training is required for staff to undertake routine inspections. Records of staff training shall be logged here.

Until selected staff are suitably trained, routine inspections will be undertaken by qualified external dam engineers.

2.9 Supporting Documents

An up to date list of relevant documents should be maintained in Table 4.

Table 4 – Supporting documents

Document type	Date	Reference
Dam break Study	Jan 2012	*NSW Public Works State Property Authority 2012 Narara Farm Dam Dambreak Study Report Number: DC 11146*
Dam break Study	May 2014	*NSW Public Works 2014 Narara Horticultural Dam Dambreak Sensitivity Analysis Addendum Report Number: DC14046 (FINAL)*
Dam safety review	Oct 2015	*Pells, S.E. & Pells, P.J.N. 2015 Report on the safety inspection of Narara Dam Consultants report by Pells Consulting for Narara Ecovillage Cooperative. Ref M10.R1 Oct 2015.*

A dam 'databook' should be developed, in which various historical documents and relevant correspondence is kept. Details of where the databook is kept should be entered here.

3 DAM

3.1 Description and General Arrangement

The arrangement of the dam embankment, spillway and outlet structure is shown in Figure 7.

The embankment has a relatively flat downstream face and a narrow crest which seems indicative of original crest being raised by almost a metre (see Figure 8).

Documentation accompanying the dam safety assessment of March 2006 (Department of Commerce, 2006) states that the embankment as originally constructed was overtopped in 1985 and 1990, and the spillway was therefore widened to increase its capacity. The extent of the widening is visually obvious (see Section 6.2 below), and discussions between the Pells Consulting and an officer of the NSW Office of Water, revealed that the widening was undertaken by the Soil Conservation Service of NSW sometime in the 1990's.

The documentation accompanying the dam safety assessment of March 2006 (Department of Commerce, 2006) indicated that the embankment is a homogeneous earthfill construction.

Test boreholes installed by Pells Consulting encountered a layer of crushed rock material of approximately 1m thickness covering the downstream face of the embankment. The nature of this material appeared to be consistent with the sandstone / claystone in the widened section of spillway. It is postulated that material won from the spillway widening was placed onto the downstream embankment slope.

Ground surveys provided to Pells Consulting by NEV confirmed the downstream embankment to have a slope of approximately 1V:5H. The crest height was reported at 17.195 m AHD, which is less than the value of 17.45 m AHD presented in NSW Public Works (2012). Depth measurements, accompanied by optical surveys, undertaken by Pells Consulting indicated the upstream slope to be approximately 1V:3H. This accords with original design plans, which are shown overlaying aerial photographs in Figure 10 below.

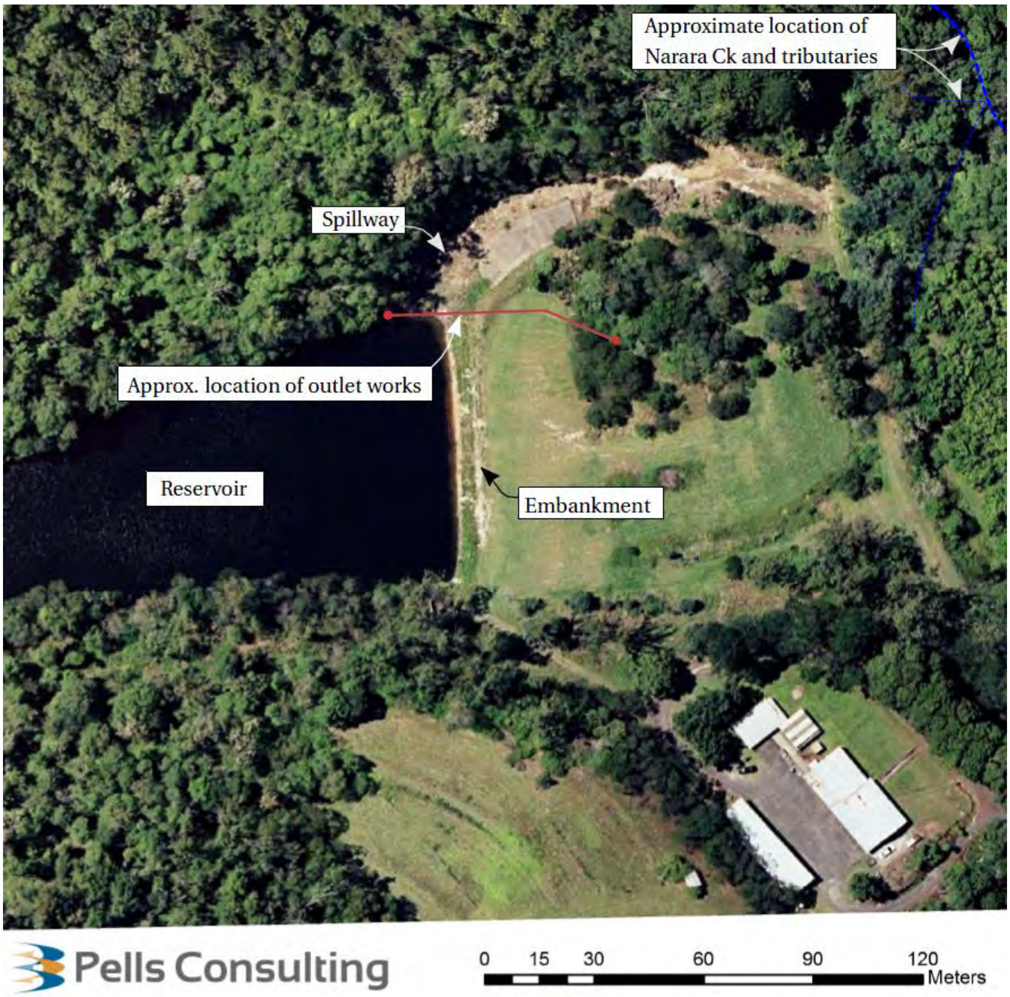


Figure 7 - General arrangement.

Figure 8 - Raised crest and gentle (approx. 1V:5H) downstream face.

Figure 9 - View of reservoir from embankment.

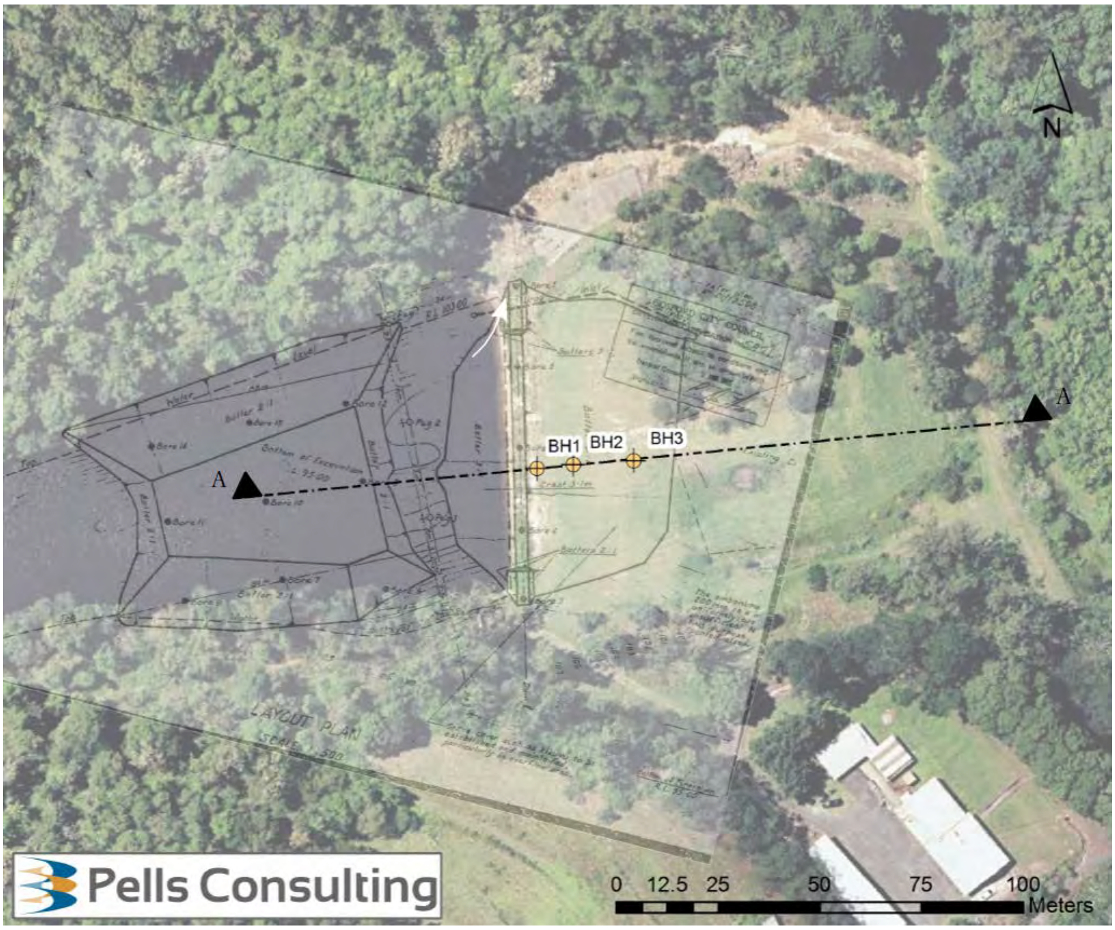


Figure 10 - Plan of dam showing original embankment design, location of boreholes (piezometers) and location of embankment cross-section.

3.2 Hazard Category

The 'hazard category', as defined in ANCOLD (2000), reflects the severity of potential damage and loss, in conjunction with the population at risk (PAR), for a 'sunny day' failure with reservoir full, or flood failure conditions.

The dam safety assessment of 2006 assigned a hazard category, based on flood-consequence, of "High-C" to the Narara Dam. This was re-categorised to LOW by NSW Public Works, 2012. This re-categorisation was validated in NSW Public Works, 2014. Following this re-categorisation, the possibility of de-prescribing the dam was mooted in a letter from NSW Public Works to NEV (12 May 2014). The NSW Dam Safety Committee (DSC) accepted the de-prescription, and provided official notice of the fact to NEV in a letter of 27 June 2014.

3.3 Dam data summary

As summary of dam data from NSW Public Works, 2012 is reproduced in the excerpt in Figure 11. Following the discussions above, it is envisaged that this data should be formally updated, as per the annotations shown.

Table 1-1 Narara Farm Dam Data

Narara Farm Dam	
Ownership	~~State Property Authority~~ NEV
Dam Type	Earthfill Embankment
Catchment Area	159.20 ha
Storage Capacity	43.30 ML
FSL	~~RL 15.90 m-AHD~~ 15.6 m AHD*
Stream Bed Level	RL 7.90 m-AHD
Dam Crest Level	~~RL 17.45 m-AHD~~ 17.2 m AHD
Dam Height	9.55 m
Available Freeboard	1.55 m
Crest Length	100.00 m
Spillway Crest Level	At FSL
Spillway Type	Earth Channel Spillway
Spillway Length	18.20 m
Return Period of Dam Crest Flood (DCF)*	1 in 1,000 AEP may require revision
Sunny Day Dambreak PAR*	12
Sunny Day Consequence Category*	HIGH C
DCF Dambreak PAR*	30
Flood Consequence Category*	HIGH C
Acceptable Earthquake Capacity*	1 in 1,000 AEP Event
Acceptable Flood Capacity*	1 in 100,000 AEP Event

* Assessed and reported in the 2006 Dambreak Study

*based on coarse survey data, requires confirmation

Figure 11 – Dam data summary from NSW Public Works, 2012, showing possible revisions.

3.4 Embankment

A cross-section through the embankment along alignment A-A (Figure 10) is shown in Figure 12. This cross-section is based on available ground survey data, original construction plans, and the bore logs.

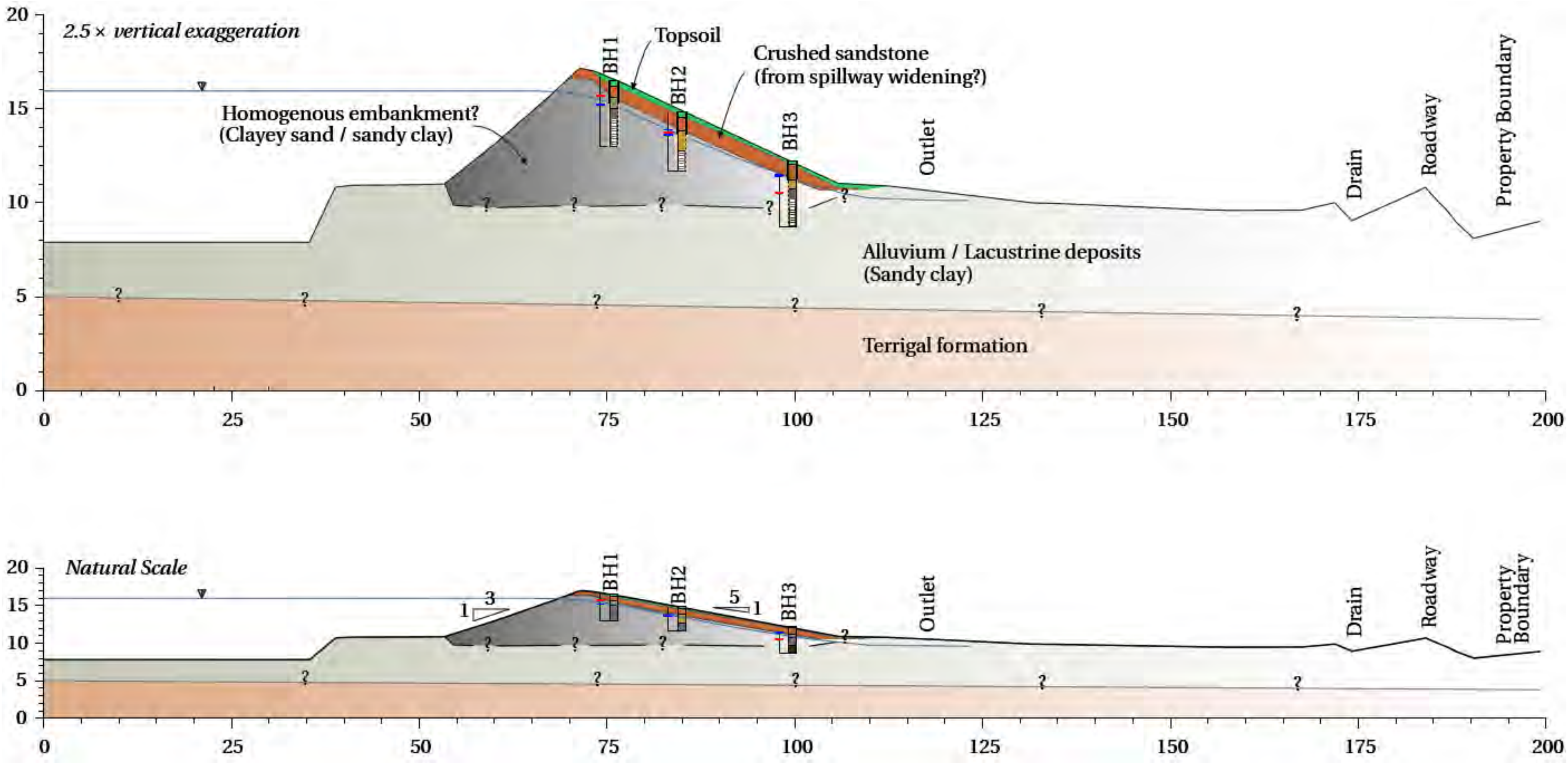


Figure 12 - Interpreted cross-section through the embankment (along line A-A shown in Figure 10).

3.5 Vegetation Management

Vegetation management on the embankment is required for the following reasons:

- Vegetation can visually obscure features of the dam which need to be observed during routine inspections.

- Trees and shrubs may introduce roots into the embankment which will grow towards the water source and may damage the embankment through the creation of seepage paths.

In general, vegetation growing in the embankment that is greater than 0.3m in height should be removed.

The large trees that currently exist around toe of the embankment, near the outlet works, are at the extremities of the embankment, and may be left in place as their removal would cause significant disturbance. This area of tree growth must not be allowed to spread to the west or south.

Selected trees should be removed, as required, to create a clear access path for inspection of the outlet works.

The method of vegetation removal should minimise risks to the dam. The preferred method for removal is to cut and poison, or some compatible method that does not require ground disturbance. If this is not possible, void from removal of roots needs to be refilled with soil and re-compacted.

4 SURVEILLANCE, MONITORING AND SAFETY REVIEWS

The NEV Dam is no longer a prescribed facility so there are no formalised procedures for inspection and reporting that apply to the facility.

However, the dam is critical to the viability of the Narara Village. Therefore, inspection and reporting procedures cognisant of the guidance in ANCOLD, 2003 applicable to a LOW hazard category dam have been elected.

4.1 Requirements

The ANCOLD 2013 requirements for surveillance of low hazard category dams are summarised in Table 5. Requirements for monitoring of low hazard dams are summarised in Table 6. Dam Safety Reviews are additional to routine surveillance / reporting, an, unless triggered by some other circumstance, should be undertaken every 10 or 20 years.

Table 5 - Dam safety inspection requirements for a Low hazard category dam, as per ANCOLD 2003, *Guidelines on Dam Safety Management*

ANCOLD Type of Inspection	Personnel Competency	Purpose	Frequency
Routine Visual	Operations Personnel[1.]	The identification and reporting of deficiencies by visual observation of the dam by operating personnel as part of their duties at the dam.	Monthly
Intermediate	Dams Engineer	The identification of deficiencies by visual examination of the dam and review of surveillance data against prevailing knowledge with recommendations for corrective actions.	Every 5 years
Comprehensive	Dams Engineer and Specialists (where relevant)	The identification of deficiencies by a thorough onsite inspection; by evaluating surveillance data; and applying current criteria and prevailing knowledge Equipment should be test operated to identify deficiencies. For Safety Review (every 20 years) consider: • Draining of outlet works for internal inspection • Diver inspection of submerged structures	Not required
Special / Emergency	Dams Engineer and Specialists.	The examination of a particular feature of a dam for some special reason (e.g. after earthquakes, heavy floods, rapid drawdown, emergency situation) to determine the need for pre-emptive corrective actions.	As required

1. Dam owners should ensure that all operational personnel are suitably trained

Table 6 - Dam safety monitoring requirements for a Low hazard category dam, as per ANCOLD 2003, *Guidelines on Dam Safety Management*

Monitoring Type	Monitoring Frequency for LOW hazard dam
Rainfall	Monthly
Storage level	Monthly
Seepage	Monthly
Chemical analysis of seepage	Not required
Pore pressure	Consider
Surface movement, control	Not required
Surface movement, normal	Consider
Internal movement / stresses	Not required
Seismological	Not required

4.2 Inspection, Monitoring and Safety Review Program for NEV Dam

4.2.1 Instrumentation and measurements

There is no instrumentation in the dam or embankment requiring specialist maintenance or observation.

Reservoir levels shall be observed from reading a water level staff that will be installed.

Seepage will be reviewed by visual examination of ground conditions over the embankment and toe of embankment.

There are no hydraulic control structures on the spillway or outlet works.

Pore pressure will be monitored by dip readings undertaken on the three standpipe piezometers, as shown in Figure 10 and Figure 12.

Observations of reservoir levels, seepage and pore pressures shall be made monthly during routine inspections.

NEV may elect to undertake reservoir and rainfall monitoring on a more frequent basis to assist with operations. Data from such monitoring will assist with dam safety studies, but are not a requirement for dam safety.

4.2.2 Routine Inspections

Site staff inspections shall be undertaken monthly and after flood events involving flow depths of greater than 300mm over the upstream lip of the spillway. These inspections shall involve walkover examination of the embankment and spillway and completion of the proforma given in Appendix A. The completed proforma, together with any appropriate photographs shall be forwarded to Pells Consulting by post.

This proforma stipulates recording or reservoir water levels, standpipe piezometer water levels and rainfall, fulfilling the monitoring requirements of ANCOLD 2003.

The person undertaking dam inspections should have adequate training as per the requirements of the NSW Dam Safety Committee (DSC).

4.2.3 Annual Dam Safety Inspections

Visual inspections by Pells Consulting shall be undertaken annually, or after any significant damaging flood events, as reported to Pells Consulting by NEV. An annual report will be submitted by Pells Consulting to NEV.

4.2.4 Intermediate Inspections

An intermediate dam inspection report will be prepared by Pells Consulting, or similar designated organisation, every 5 years, and submitted by NEV to the appropriate authority.

4.2.5 Comprehensive Surveillance Report

There is no requirement for comprehensive surveillance reporting

4.2.6 Special Inspection Reports

Special investigation reports may be required at anytime to examine a particular feature of the dam in response to special circumstances (eg earthquakes, heavy floods or some emergency situation). The report would be undertaken by specialists relevant to the point of enquiry.

4.2.7 Dam Safety Reviews

A Dam Safety Review is described in ANCOLD 2003 as:

> “a procedure for assessing the safety of a dam, and comprises, where relevant, a detailed study of structural, hydraulic, hydrologic and geotechnical design aspects and of records and reports from surveillance activities. A Safety Review should assess the integrity of a dam against known failure modes and mechanisms” (pg 29)

The frequency of Dam Safety Reviews are:

> “normally be based on a deficiency or weakness identified during the surveillance program or by other means … a Safety Review may also be required by the dam owner at any time as an independent and external examination to satisfy the dam owner or a higher authorities as to the dams safety … if nor undertaken for [these reasons], periodic Safety Reviews at 10 to 20 year intervals are considered appropriate” (pg 30)

A Dam Safety Review was commissioned by NEV in 2015 (Pells Consulting, 2015). This was done to review the dam subsequent to purchase of the site.

5 RESERVOIR OPERATION

5.1 Description

The NEV dam impounds water from a tributary of Narara Creek. The catchment area shown in Figure 13 - Narara Dam and Catchment has an area of approximately 142 ha. The reservoir surface area at FSL has an area of approximately 1.05 ha, and, based on a reservoir depth of 7.5 metres, the estimated storage volume at FSL is approximately 45 ML.

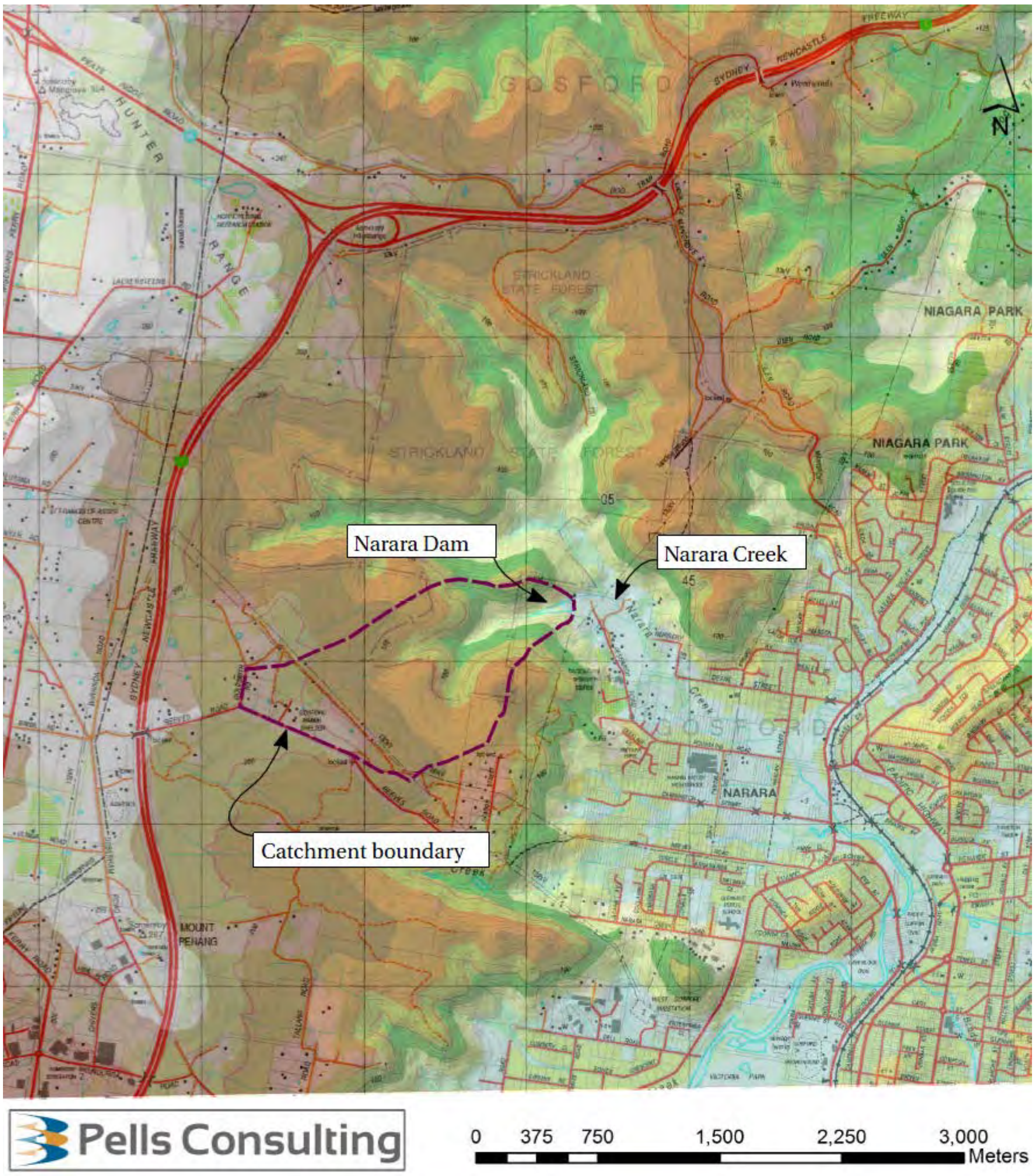


Figure 13 - Narara Dam and Catchment

5.2 Design Flood

Hydrological studies accompanied dam-break studies presented in NSW Department of Commerce (2006). NSW Public Works (2012) made reference to revised hydrological studies, as per the excerpt in Figure 14:

Narara Farm Dam's latest Flood Hydrology was carried out by the Hydrology Group of NSW Public Works in 2011. This Hydrology Study includes the PMF and 1 in 100,000 AEP flood hydrographs with storm durations ranging from 15 mins to 6 hours. Refer to Appendix A for the Hydrology Report. Results from the initial dam routing are presented in Table 2-1.

Table 2-1 Initial Dam Routing Results

Storm Event	Worst Storm Duration*	Max. Dam Flood Level	Max. Dam Inflow	Max. Dam Outflow	Overtopping Height
1 in 100 AEP	6 hour	RL 16.90 m-AHD	29 m^3/s	28 m^3/s	No overtopping with 0.55 m Freeboard
1 in 1,000 AEP (DCF)#	6 hour	RL 17.40 m-AHD	47 m^3/s	41 m^3/s	No overtopping with 0.05 m Freeboard
1 in 100,000 AEP	1 hour	RL 17.80 m-AHD	106 m^3/s	104 m^3/s	Overtopped by 0.35 m
PMF	30 min	RL 18.13 m-AHD	178 m^3/s	172 m^3/s	Overtopped by 0.73 m

* In terms of the highest modelled floodwater level in dam;

Examined in the 2006 Dambreak Study.

Figure 14 - Excerpt from NSW Public Works, 2012

The results presented in Figure 14 indicate an outflow discharge of 41 m^3s^{-1} from the DCF. As stated above, this is lower than the estimate of approximately 60 m^3s^{-1} made in the study by Pells Consulting (2015).

5.3 Inflows forecasting

There is no inflow forecasting system established for the NEV dam.

5.4 Operating Criteria

The outlet and spillway works are uncontrolled, and no operation criteria are required.

Water supply outlet works, once they are developed, with be subject to operational rules that are yet to be developed.

5.5 Recreational usage

The dam will not be used for recreational purposes. As part of the development, signage should be installed to reflect the permitted usages of the reservoir.

6 SPILLWAY AND OUTLET OPERATION AND MAINTENANCE

6.1 Outlet Works

6.1.1 Description

The NEV dam has an outlet pipe as shown in plan in Figure 7. The outlet comprises a 1200mm diameter glory-hole inlet located near the entrance to the side channel spillway (Figure 15). A close up photograph of the gloryhole is shown in Figure 16. This gloryhole feeds a 400 mm diameter pipe, which exits via a similar 1200mm riser (Figure 17) amongst trees on the left side of the downstream face (Figure 18).

Figure 15 - View along crest toward spillway entrance and glory-hole inlet.

Figure 16 - Close-up photograph of the glory-hole inlet.

Figure 17 - Photograph of the outlet of the outlet works.

Figure 18 – The end of the outlet works is within the trees / scrub on the right hand side of this photograph.

6.1.2 Outlet Hydraulics

A schematic of the outlet system is shown in Figure 19. A stage-discharge relationship for the outlet system was modelled in Pells Consulting (2015). The results are presented in Figure 20, and indicate that the outlet system could convey up to (approximately) 400 litres per second.

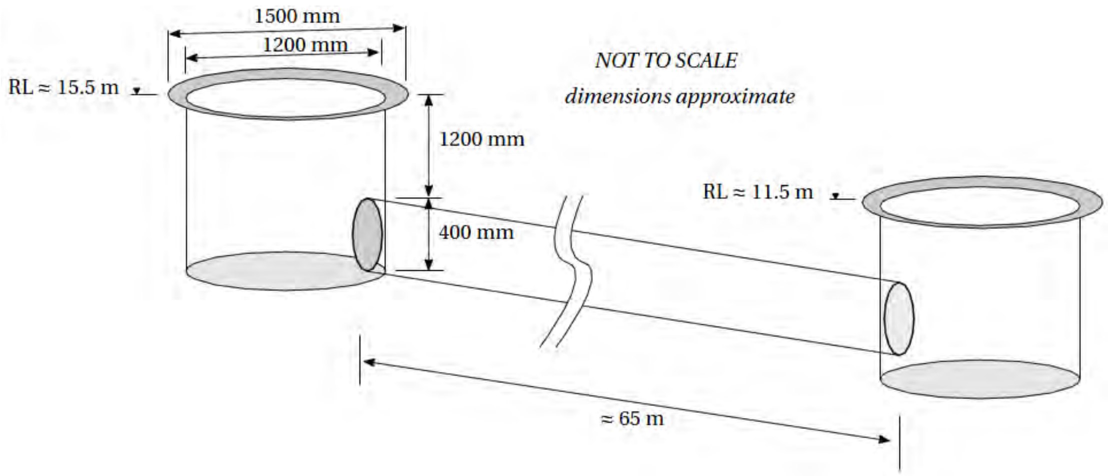


Figure 19 - Schematic of the Outlet Works.

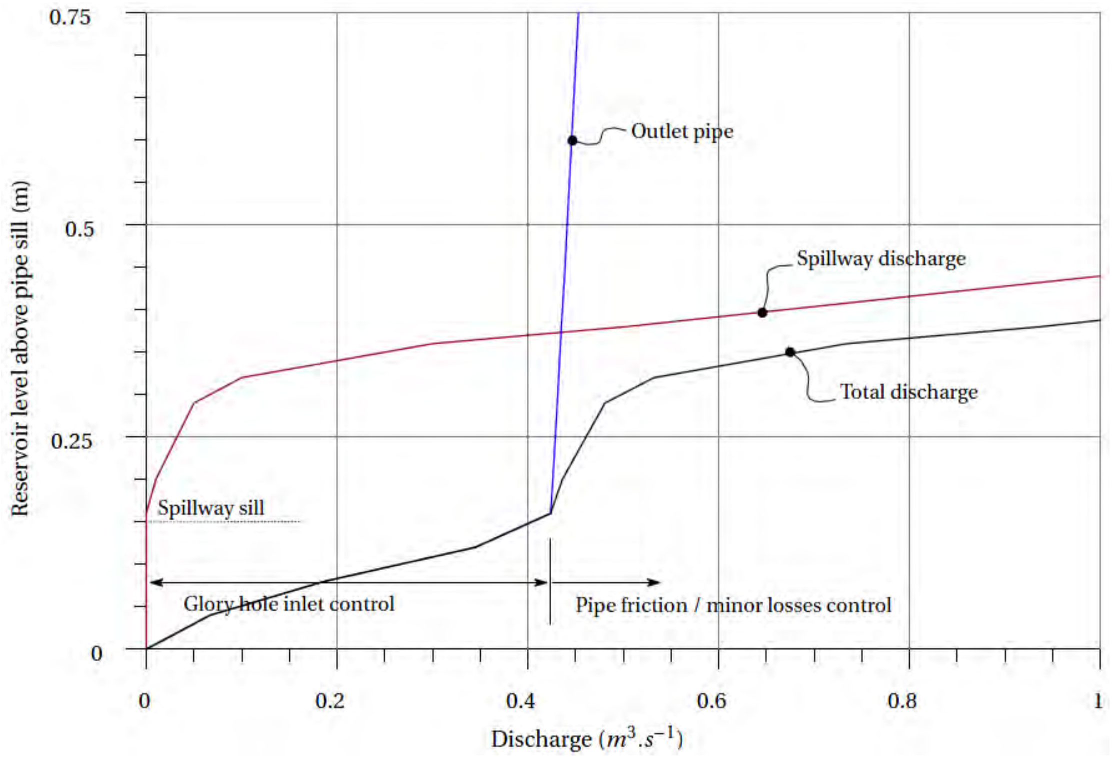


Figure 20 - Modelled stage-discharge relationship for the outlet works.

6.1.3 Outlet Operation

The outlet does not require any manual operation.

6.1.4 Outlet Works Maintenance

Routine maintenance should ensure that the outlet does not become subject to blockage from vegetation or debris.

The inlet also currently exhibits a slight tilt. Routine inspections should verify that the inlet is stable over time, does not appear to be moving / tilting any further.

6.2 Spillway

6.2.1 Description

A side channel spillway is cut into the left abutment. As stated above, it is understood that this channel was widened sometime in the past. Approximately half the width of the channel (on the embankment side) from 16 to 45 m downstream of the channel entrance is covered with shotcrete. The remainder of the spillway is unlined. Photographs of the spillway, progressing downstream, are presented in Figure 21 to Figure 26.

Ground surveys of the spillway topography were undertaken by Pells Consulting using optical surveying techniques. The surveyed points are shown in Figure 27. Based on these surveys, and site inspections, an approximate digital terrain model of the spillway was assembled, as shown in Figure 27.

Figure 21 - Entrance to the side-channel spillway.

Figure 22 - View of the upper spillway from the embankment.
Note the concrete lined section may be indicative of the width of the original spillway (i.e. before widening).

Figure 23 - Looking downstream toward the end of the lined section.

Figure 24 – Looking upstream toward the end of the lined section.

Figure 25 - Looking downstream toward the spillway exit.

Figure 26 - Section of Narara Creek just below the spillway.
Note, the creek is flowing from left to right. Spillway flows enter the creek from the right hand side, at the far downstream side of this photograph.

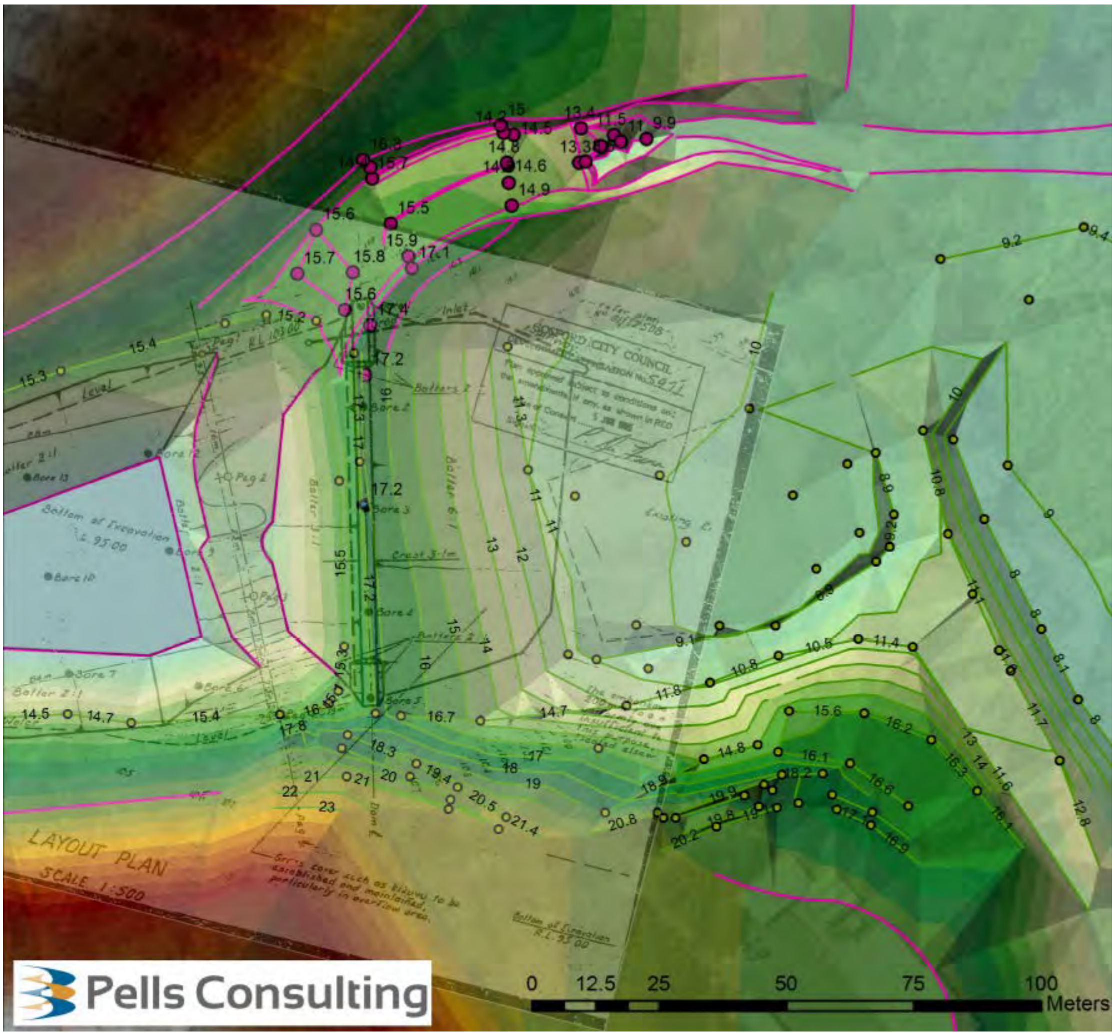


Figure 27 - Interpreted spillway topography.

Note: pink data points show ground surveys undertaken by Pells Consulting. Pink breaklines were interpreted based on the site inspection.

6.2.2 Spillway Hydraulics

A stage-discharge relationship for the spillway was estimated in Pells Consulting (2015), as shown in Figure 29.

It is noted that the spillway discharge for a reservoir level of RL17.2 (ie the dam crest) is approximately $60m^3s^{-1}$. Despite the lower crest level than previously reported, this “dam crest flood” (DCF) is larger than the value of adopted in NSW Department of Commerce, 2006. This analysis suggests that a higher return period may be applicable to the DCF than previously decreed.

6.2.3 Spillway Operation

The spillway does not require any manual operation.

6.2.4 Spillway Maintenance

Ongoing spillway maintenance should ensure that the spillway channel is clear and free from debris and blockages.

Routine inspections should monitor the development of the erosion knickpoint and erosion channels.

At some stage in the future, it is possible that remedial works shall be required to address ongoing erosion. This is not an emergency matter. The nature of remediation required will depend on the nature of the development of erosion.

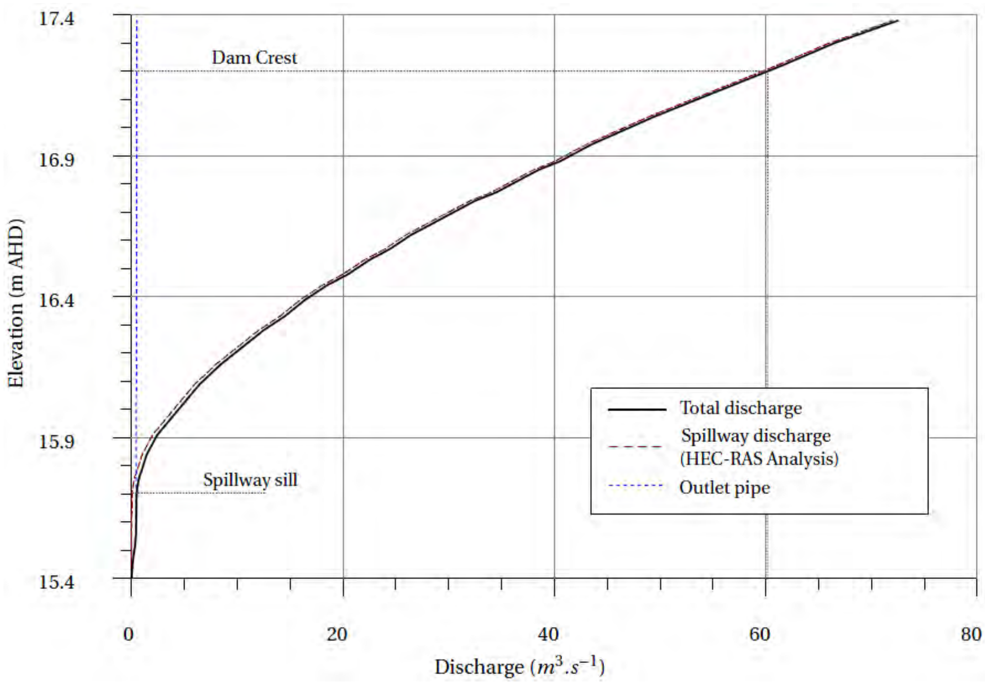


Figure 28 – Stage-discharge relationship for the spillway and outlet works.

6.2.5 Vegetation Management

Vegetation management on the spillway is required for the following reasons:

- Vegetation within the spillway channel will reduce the spillway discharge capacity, increasing the possibility of embankment overtopping.
- Trees within the spillway may form locations of flow velocity concentration, causing erosion to initiate.
- Roots from trees may also cause cracking of the shotcrete lining in the spillway.

Trees and shrubs greater than 0.3m in height should be removed from the spillway channel, leaving a clear flow path. The deposition of any large logs or obstructions in the spillway mouth or channel should be removed. Trees along the edge of the spillway channel, whose roots are causing or could cause damage to the shotcrete lining should be removed.

The glory hole inlet and outlet should be routinely cleared of growth and debris.

7 EMERGENCY MANAGEMENT

The following emergency management plan relates directly to the NEV site and the role of its owners in responding to concerns over the integrity of the dam embankment. It does not override any existing disaster plan developed by SES for the case of flooding in Narara creek.

7.1 Emergency Identification, Evaluation and Classification

A dam safety emergency includes events that could potentially lead to failure of a dam, as well as events where dam failure in imminent or has already occurred.

In general terms, events that could result in a dam safety emergency include:

- Large floods.
- Earthquakes.
- Explosions.
- Cracks appearing in the embankment.
- Landslide/slippage.
- Unexplained increases in seepage.
- Operational incidents.
- Vandalism / Sabotage.

For the NEV dam, the Emergency Categories set out in Table 7 are adopted.

The observer of the emergency is required to assess the level of emergency according to the descriptions in Table 7 and follow the notification procedures for the appropriate category as set out in Section 7.2.

7.2 Notification

Contact details for the NEV site office are given in Section 2.3 on Page 6.

Contact details for NEV staff are given in Table 2 of Section 2.3 and Page 6.

Contact details for external entities are given in Table 3 of Section 2.5 and Page 6.

For a LEVEL 1 emergency category, the following notification should be made:

1. The person responsible for “Emergency Action” as listed in Table 2 of Section 2.3 should be notified.
2. The “Emergency Action” staff member should then contact the Dam Safety Engineer (Table 3 of Section 2.5) (or equivalent appointed by NEV) and make arrangements for a dam inspection.
3. Further actions, while a LEVEL 1 emergency remains in place, will be subject to the outcomes of the emergency inspection.

For a LEVEL 2 emergency category, the following notification should be made:

1. The person responsible for “Emergency Action” as listed in Table 2 of Section 2.3 should be contacted immediately.

2. The “Emergency Action” staff member should then contact the Dam Safety Engineer (Table 3 of Section 2.5) (or equivalent appointed by NEV) and make arrangements for an emergency dam inspection as soon as possible. If the Dam Safety Engineer is uncontactable or unavailable for an emergency inspection, the Dam Safety Committee should be contacted.
3. Further actions, while a LEVEL 2 emergency remains in place, will be subject to the outcomes of the emergency inspection.

For a LEVEL 3 or LEVEL 4 emergency category, the notification flowchart from the NSW Dam Safety Committee publication DSC12-1 Annex A shall be followed, as per Figure 1.

In the case of a bomb threat, or suspicion of illegal activity, police must be notified.

Table 7 – Emergency Categories

Emergency Category	Condition	Examples
Level 1	Failure of embankment would be unlikely. Generally category represents threats to safe/efficient operation of dam and/or areas requiring maintenance.	• Noticeable increase in seepage flows • Standing water level in bores near or above ground surface • wave erosion of upstream face • cracking observed in the embankment
Level 2	Dam embankment and spillway intact but there is basis for concern that dam safety is compromised and a failure condition may arise if actions are not taken.	• Large unexplained seepage flows • very large flows through spillway • concern that reservoir level will rise above the embankment level • active wave erosion of upstream face that may breach embankment crest • slumping or evidence of landslide risk in embankment or small slide mid-embankment
Level 3	Dam embankment and spillway intact but there is basis for concern that dam may fail within 24 hrs	• Embankment overtopping • gushing seepage occurring through the embankment or toe • high spillway discharges with evidence of rapidly progressing erosion that may lead to breach • landslide / slippage of embankment than compromises crest width, water flowing through failure
Level 4	Failure of embankment is imminent, or dam currently undergoing failure or has failed	• Embankment breach is imminent, or; • Embankment has been breached and the reservoir storage is rapidly discharging.

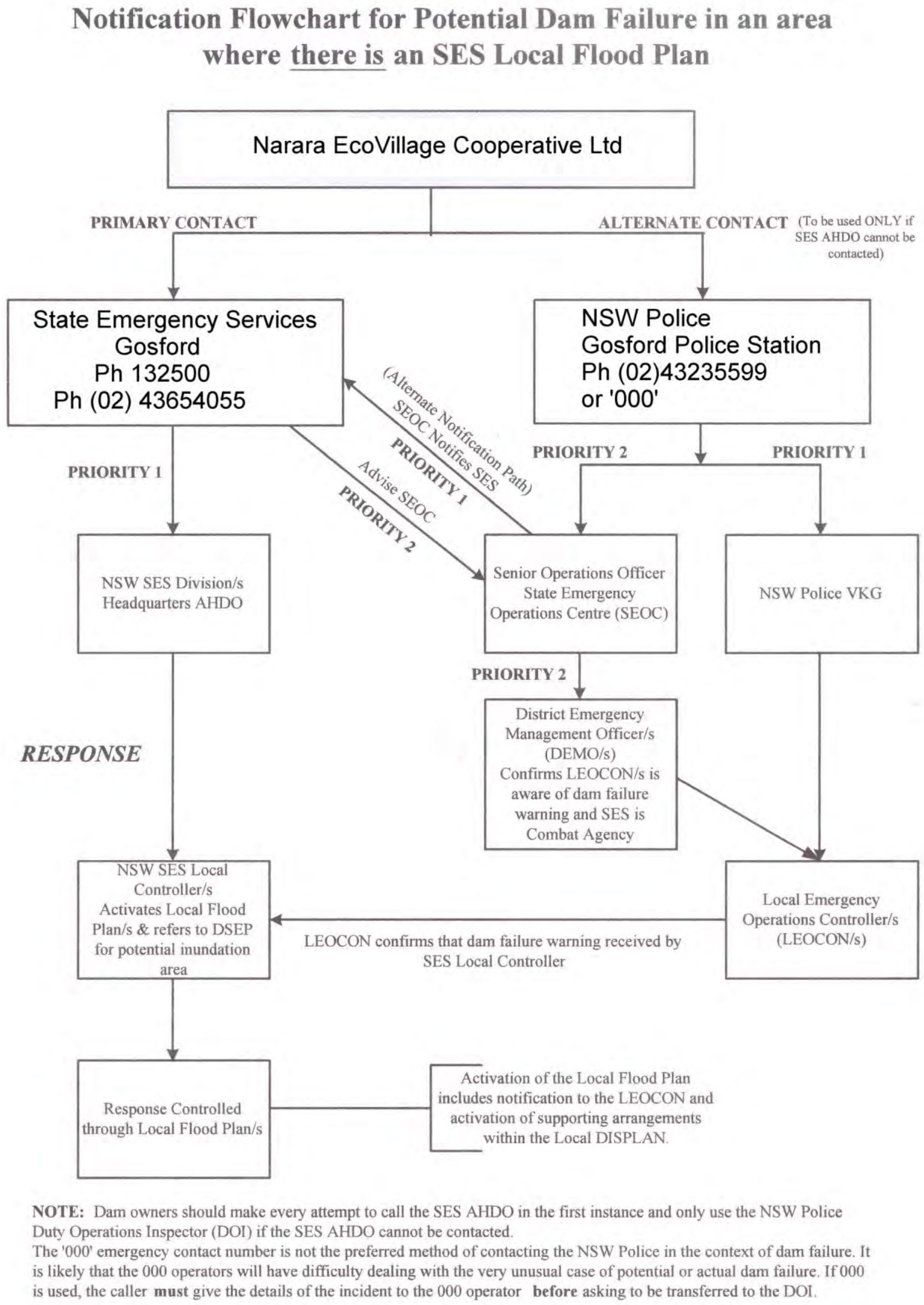


Figure 29: Emergency Notification Flowchart.

7.3 Inundation Maps

An inundation map for the case of a sunny dam dam break is shown in Figure 30 Dam break during flood conditions is shown in Figure 31. Note that the dam breach during flood conditions has been modelled to only have a mild effect of the flood extents.

7.4 Preventative Actions

The dam does not have a hydraulic control structures to regulate spillway flows or to initiate drawdown of the water levels.

It is recognised that NEV have very limited resources to undertake emergency remedial works.

For LEVEL 3 or LEVEL 4 emergency categories, there are no preventative actions that can or should be attempted by NEV staff.

For some of the events it would be necessary to mobilise earthmoving equipment on an emergency basis and such mobilisation will be advised by the SES and/or Pells Consulting (or the designated equivalent specialist consultants). At some stages for some of the events it will be appropriate for the SES to initiate the SES local flood plan.

Preventative measures may be undertaken for a LEVEL 1 or LEVEL 2 emergency category, *subsequent to undertaking notification procedures as described above*, are listed below.

Table 8 – Example remedial Actions, subsequent to notification, for low level emergency events

<table>
<tr><th>EVENT</th><th>REMEDIAL / PREVENTION MEASURES</th></tr>
<tr><td>Initiation of Piping, meaning dirty or excessive seepage water from downstream face or in downstream area below embankment</td><td>Increase surveillance frequency to daily. Prepare to lower water level by emergency pumping subject to advice of the above.</td></tr>
<tr><td>Wave erosion of upstream face</td><td>Dumping of gravel, rocks and sandbags into the eroded area.</td></tr>
<tr><td>Blockage of spillway channel by erosion of batters, slumping of batters or debris washed / fallen into channel.</td><td>Clear debris immediately</td></tr>
<tr><td>Slumping/bulging of embankment face(s)</td><td rowspan="3">Increase monitoring/inspection regime to twice weekly</td></tr>
<tr><td>Cracking of the embankment crest and/or embankment batter faces.</td></tr>
<tr><td>Standing water level in bores near or above ground surface</td></tr>
</table>

In the case of a bomb threat, or suspicion of illegal activity, the police will be responsible for the actions taken.

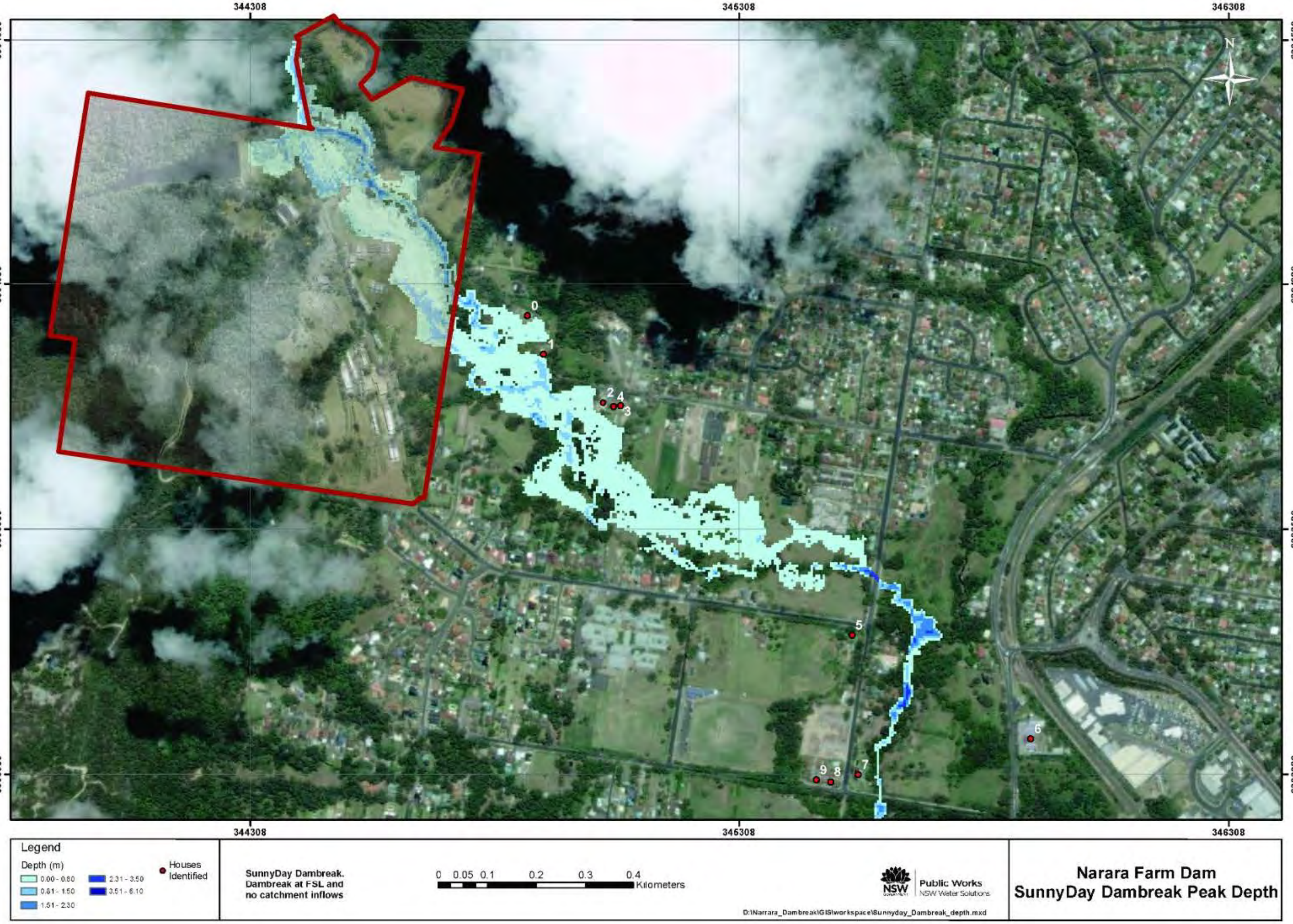


Figure 30 - Sunny day dam break inundation.

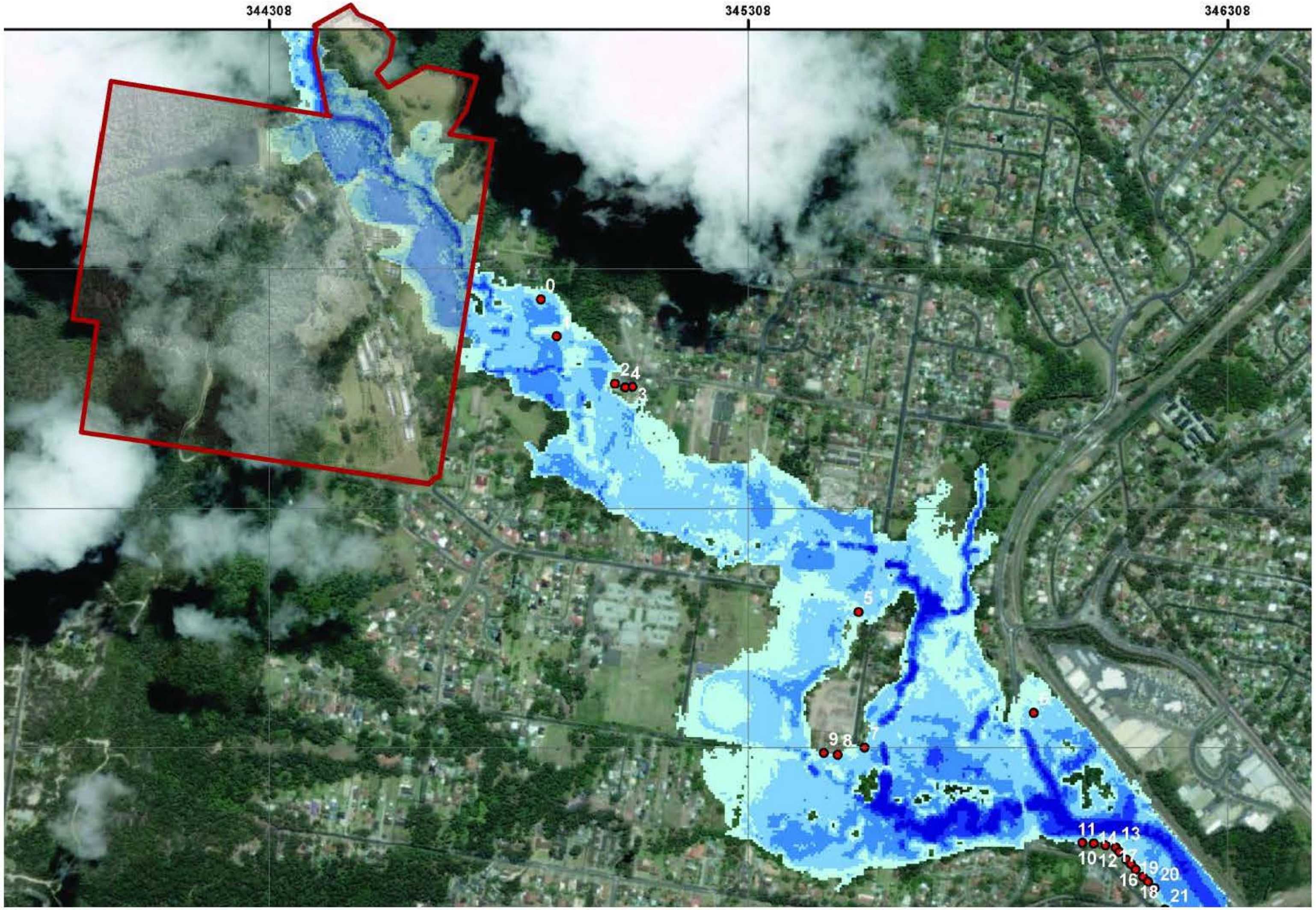


Figure 31 - Dam break inundation during 100 yr ARI flooding event.

8 REFERENCES

NSW Public Works 2012 Narara Farm Dam - Dambreak Study Report No. DC11146 **Jan 2012**

NSW Public Works, 2014. Narara Horticultural Dam – Dambreak sensitivity analysis addendum report. **7th May 2014** Report No. DC14046 Final.

Australian National Committee on Large Dams (ANCOLD), 2000. Guidelines on assessment of the consequences of dam failure. May 2000

Australian National Committee on Large Dams (ANCOLD), 2003. Guidelines on dam safety management. August 2003

USACE Hydrologic Engineering Centre, 2010. HEC-RAS River Analysis System Hydraulic Reference Manual (computer program documentation No. Version 4.1). USACE, Hydrologic Engineering Center.

APPENDIX A

DAM INSPECTION PROFORMA

INSPECTION PROFORMA

ROUTINE QUARTERLY DAM SURVEILLANCE AND MONITORING, NARARA DAM

General Conditions at time of inspection

Date	
Weather	
Reservoir level	
Date and depth (mm, if available) of most recent rain	

Embankment

Upstream face

General condition	
Location and extent of any cracks, slips, wave-erosion or subsidence	
Nature of vegetation	

Downstream face

General condition	
Location and extent of any cracks, slips, seepage or subsidence	
Nature of vegetation	

Downstream toe

General condition	
Location and extent of any slips or subsidence	
Describe any seepage / leakage (location, quantity, clear or coloured)	
Nature of vegetation	

Spillway

Highest reservoir level since last inspection (m RL)	

Inlet and upper channel

General condition / note changes since last inspection	
Location and extent of any erosion	
Location and extent of any obstructions to flow	

Mid-channel (concrete lined section and adjacent)

General condition / note changes since last inspection	
Location and extent of any erosion	
Location and extent of any obstructions to flow	

End of rock (plunge section and headcutting)

General condition / note changes since last inspection	
Location and extent of any erosion	
Location and extent of any obstructions to flow	

End section (flat, soil section)

General condition / note changes since last inspection

Location and extent of any erosion

Location and extent of any obstructions to flow

Outlet works

Glory-hole inlet

General condition

Outlet

General condition

Standpipe piezometers

BH1 - near crest

Condition

Standing water level (DIP) (m below lip of PVC casing)

Time of DIP

BH2 - mid-embankment

Condition

Standing water level (DIP) (m below lip of PVC casing)

Time of DIP

BH3- near toe

Condition

Standing water level (DIP) (m below lip of PVC casing)

Time of DIP

Other matters

Are there any other matters in the owner's knowledge which could affect the safety of the dam?

Is the dam considered to be in a safe condition? Indicate any measures necessary to make the dam safe.

Certification

This is to certify that the information submitted in this report is true and is based on a recent inspection of the dam and its associated works and is, to the best of my knowledge, true and correct.

Signature:

Name:

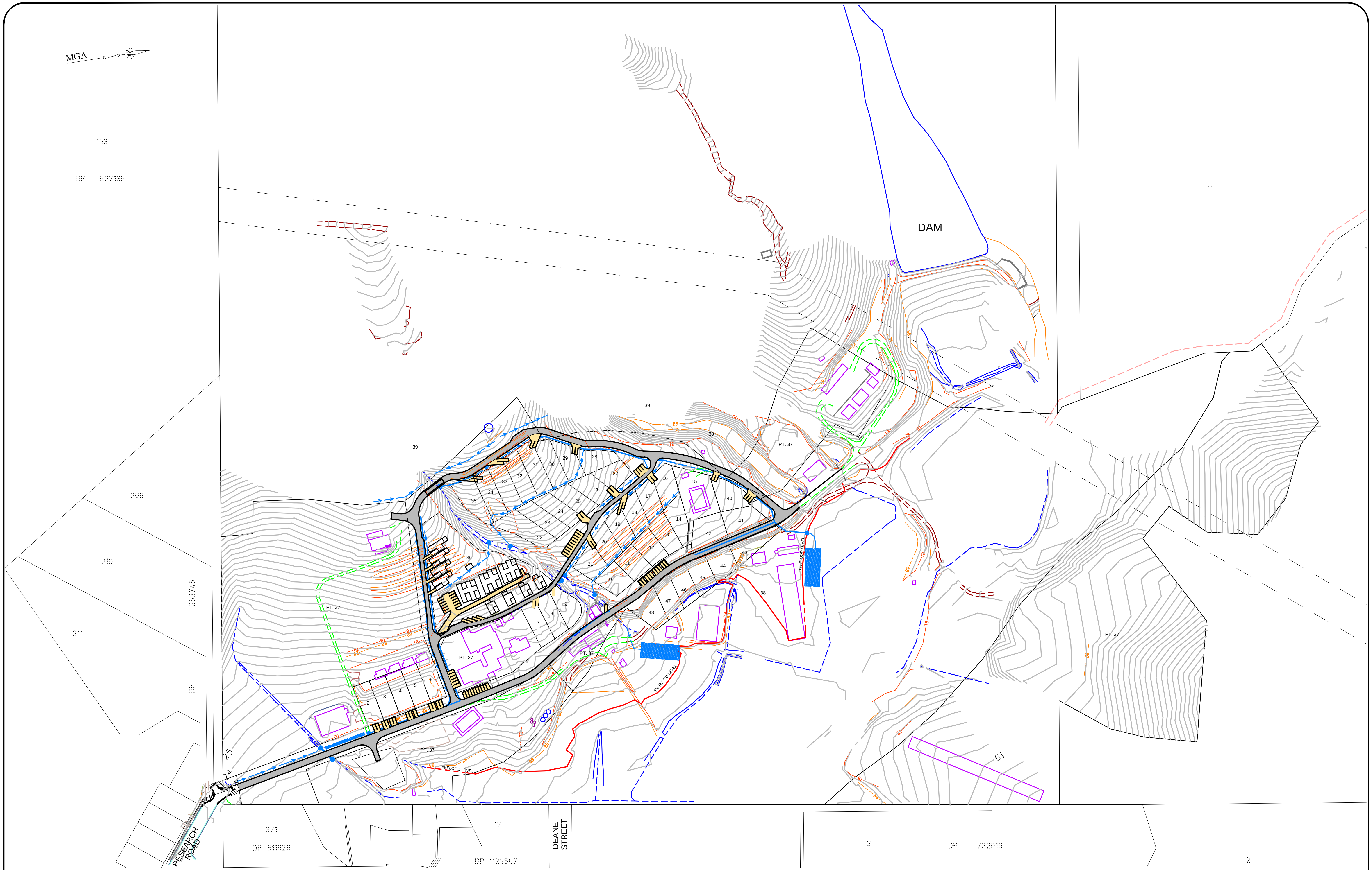
Date:

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix 4.1.1.4B

1 in 100 AEP Study Plans

Document Name:	1 in 100 AEP Study Plans	Revision Number & Date:	1 – 1/12/2015	Narara Ecovillage Co-operative Ltd
Date of Issue:	1-Dec-2015	Controlled Document:	Yes	



07/12/2015 AUTHORISED OFFICER / DATE	REV	REVISION DETAILS	DATE
CONCEPT ONLY NOT FOR CONSTRUCTION	-	-	-
DRAWING No: BB12242			

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REDUCTION RATIO 1:1500 @ A1 & 1:3000 @ A3

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REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	0.5m
DATUM:	AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS:	SSM 67141
R.L.:	23.675

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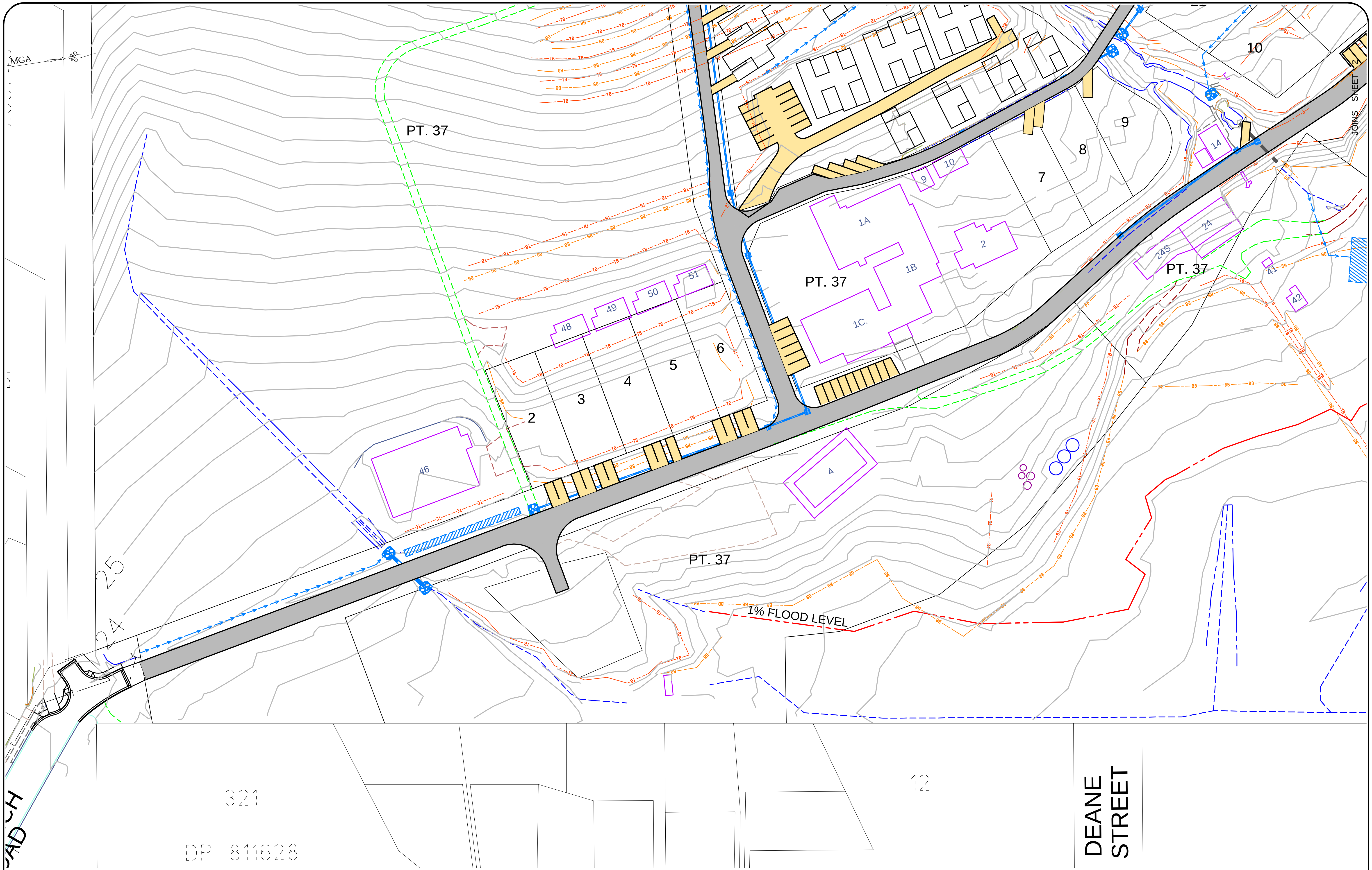
CHASE BURKE HARVEY

PLAN SHOWING PROPOSED STORMWATER INFRASTRUCTURE FOR NARARA ECO VILLAGE LOT 13 IN DP 1126998 RESEARCH ROAD, NARARA

SHEET No.	1
No. of SHEETS:	5
DRAWING No:	BB12242
REV:	-



AUTHORISED OFFICER	DATE	REV	REVISION DETAILS	DATE
	07/12/2015	-	-	-

CONCEPT ONLY
NOT FOR CONSTRUCTION

DRAWING No: BB12242

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REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL: 0.5m
DATUM: AHD
AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS: SSM 67141
R.L.: 23.675

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Erina: (02) 4367 7334
Hornsby: (02) 9482 9498
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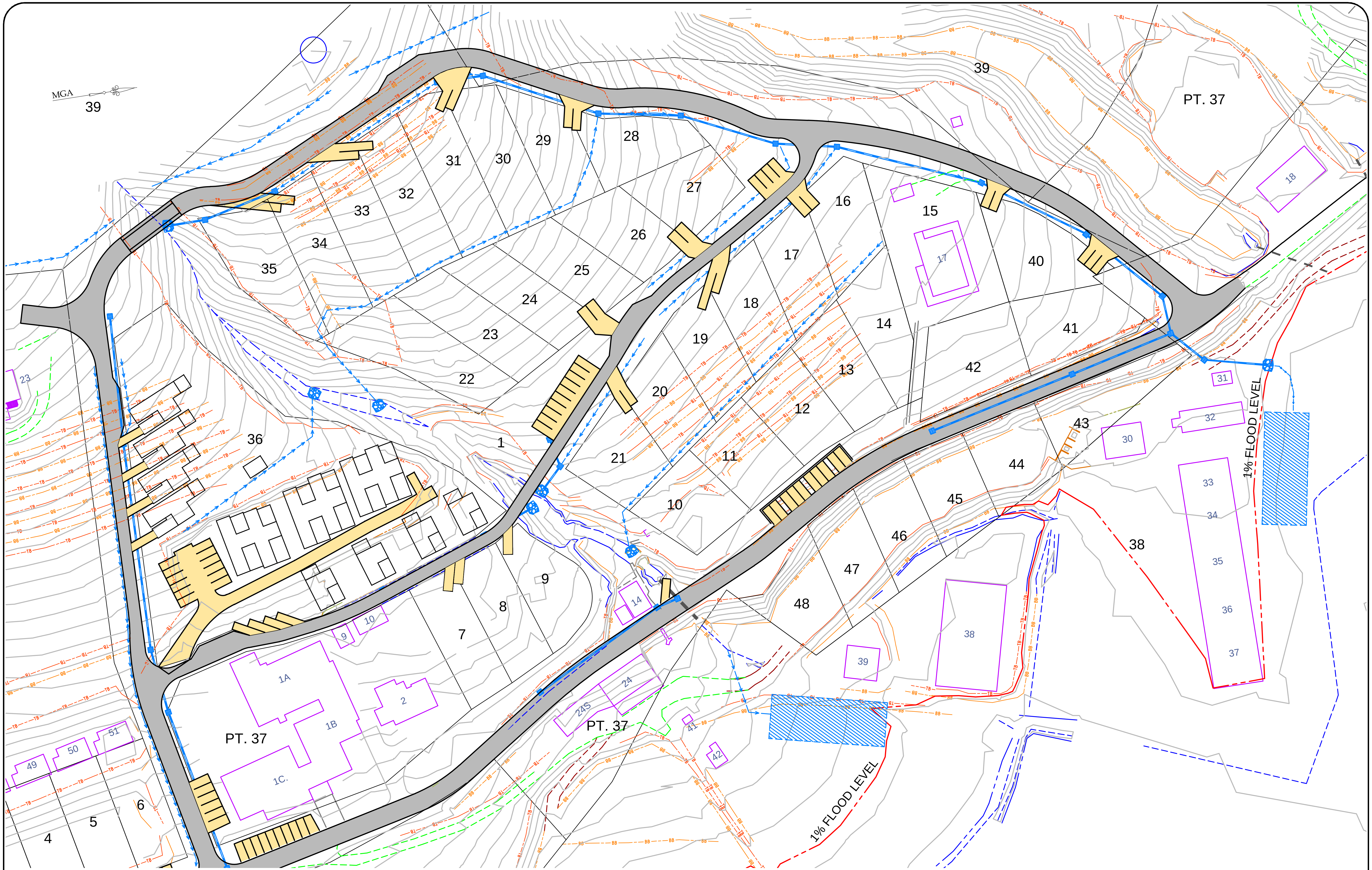
PLAN SHOWING PROPOSED STORMWATER INFRASTRUCTURE FOR NARARA ECO VILLAGE
LOT 13 IN DP 1126998
RESEARCH ROAD, NARARA

SHEET No. 2
No. of SHEETS: 5
DRAWING No: BB12242
REV: -



07/12/2015 AUTHORISED OFFICER DATE	REV	REVISION DETAILS	DATE
CONCEPT ONLY NOT FOR CONSTRUCTION	-	-	-
DRAWING No: BB12242			

0 5 10 20 30 40 50
REDUCTION RATIO 1:500 @ A1 & 1:1000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd		LOT No.	13
REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2	SECTION	–
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS	PLAN No.	DP 1126998
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK	SUBURB	NARARA
		LGA	GOSFORD
		PARISH	GOSFORD
		COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	0.5m
DATUM:	AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS:	SSM 67141
R.L.:	23.675

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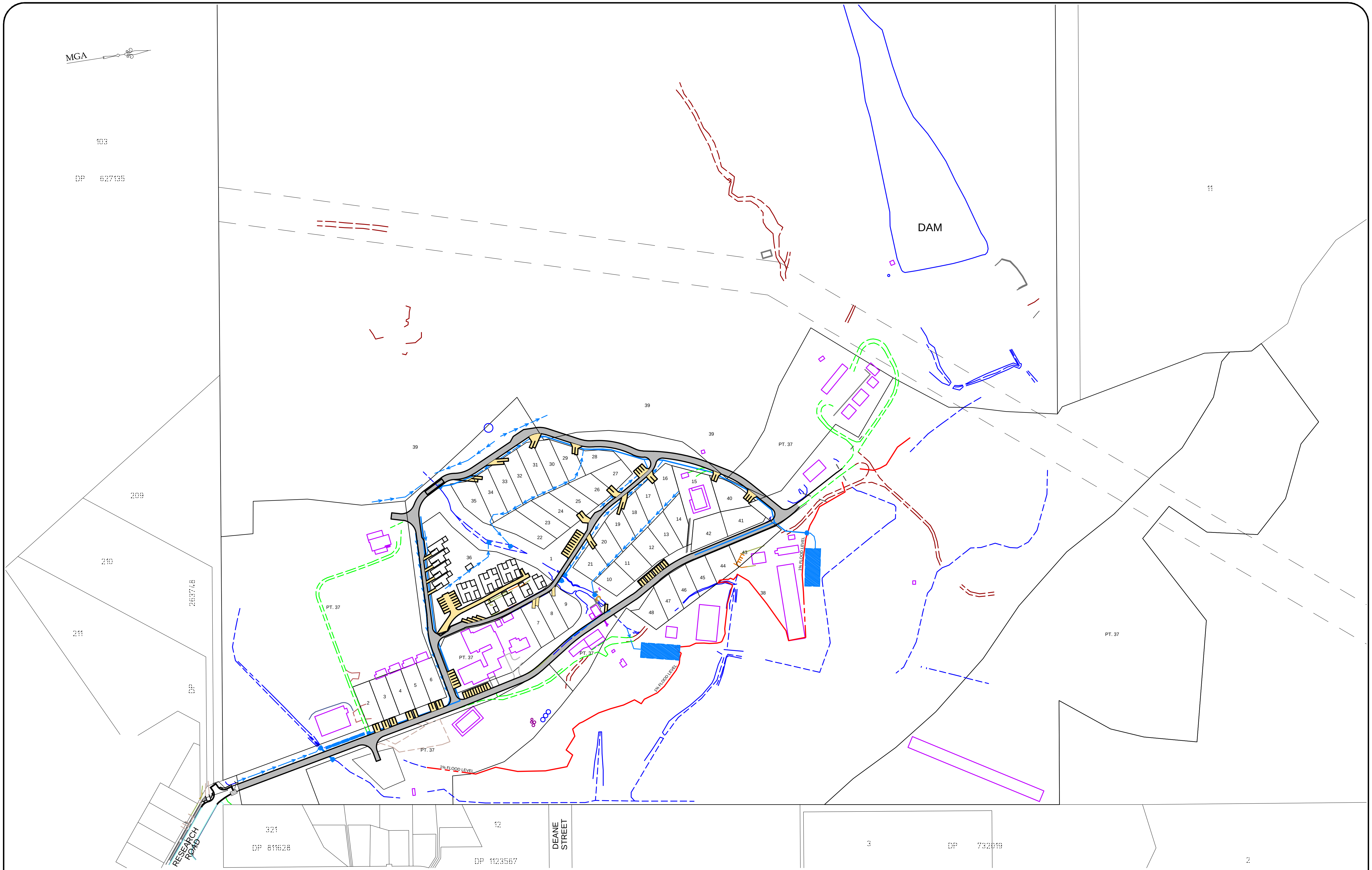
Hornsby: (02) 9482 9498
www.cbhsurvey.com.au

CHASE BURKE HARVEY

PLAN SHOWING PROPOSED STORMWATER INFRASTRUCTURE FOR NARARA ECO VILLAGE
LOT 13 IN DP 1126998
RESEARCH ROAD, NARARA

SHEET No.	3
No. of SHEETS:	5
DRAWING No:	BB12242
REV:	-



AUTHORISED OFFICER	DATE
[signature]	07/12/2015

CONCEPT ONLY
NOT FOR CONSTRUCTION

DRAWING No: BB12242

REV	REVISION DETAILS	DATE
-	-	-

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REDUCTION RATIO 1:1500 @ A1 & 1:3000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd	
REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	0.5m
DATUM:	AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS:	SSM 67141
R.L.:	23.675

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CHASE BURKE HARVEY

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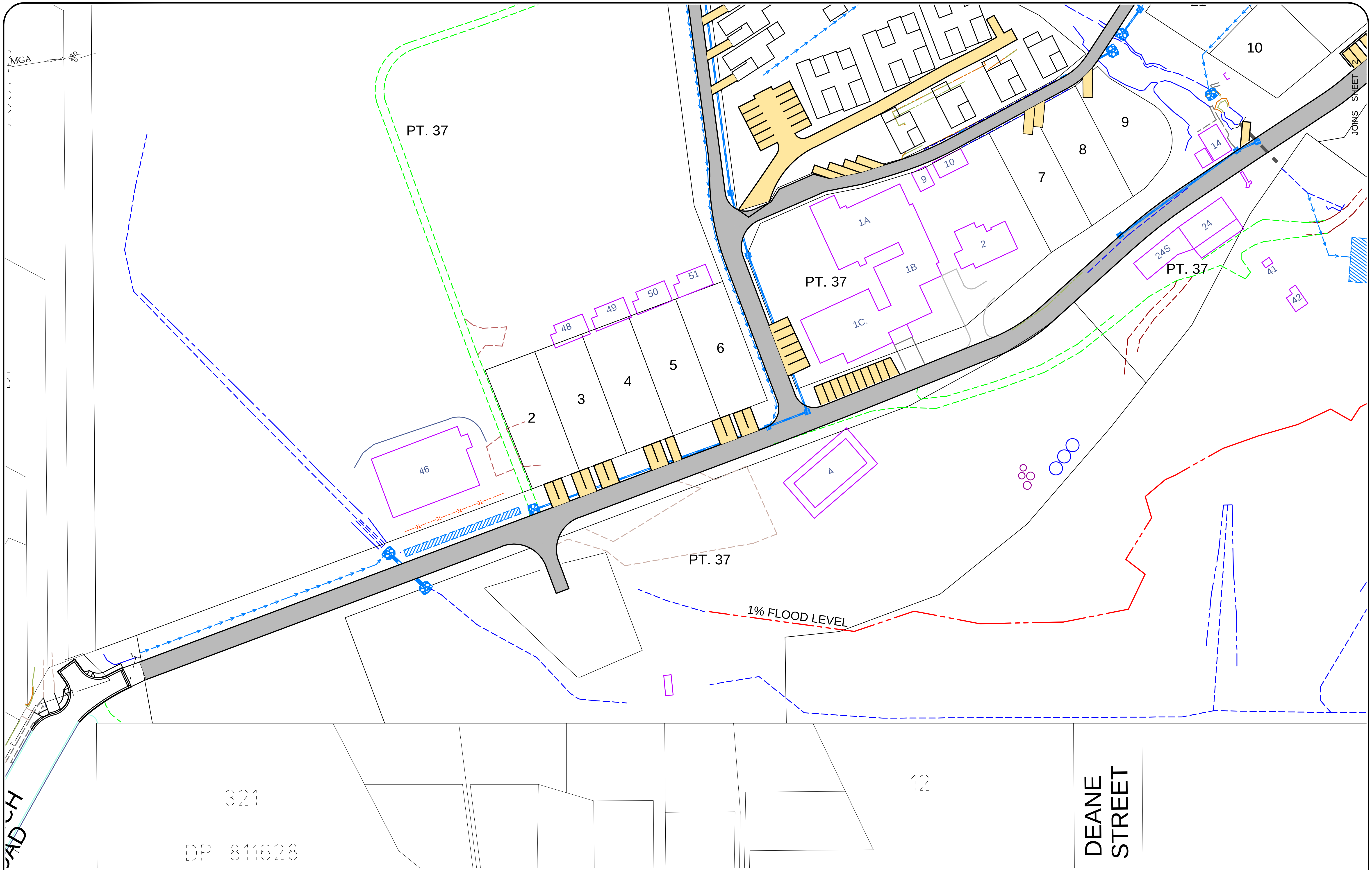
LOT 13 IN DP 1126998
RESEARCH ROAD, NARARA

SHEET No.	4
No. of SHEETS:	5
DRAWING No:	BB12242
REV:	-



AUTHORISED OFFICER	DATE 07/12/2015
CONCEPT ONLY NOT FOR CONSTRUCTION	
DRAWING No:	BB12242

REV	REVISION DETAILS	DATE
-	-	-

0 5 10 20 30 40 50
REDUCTION RATIO 1:500 @ A1 & 1:1000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd	
REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	0.5m
DATUM:	AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS:	SSM 67141
R.L.:	23.675

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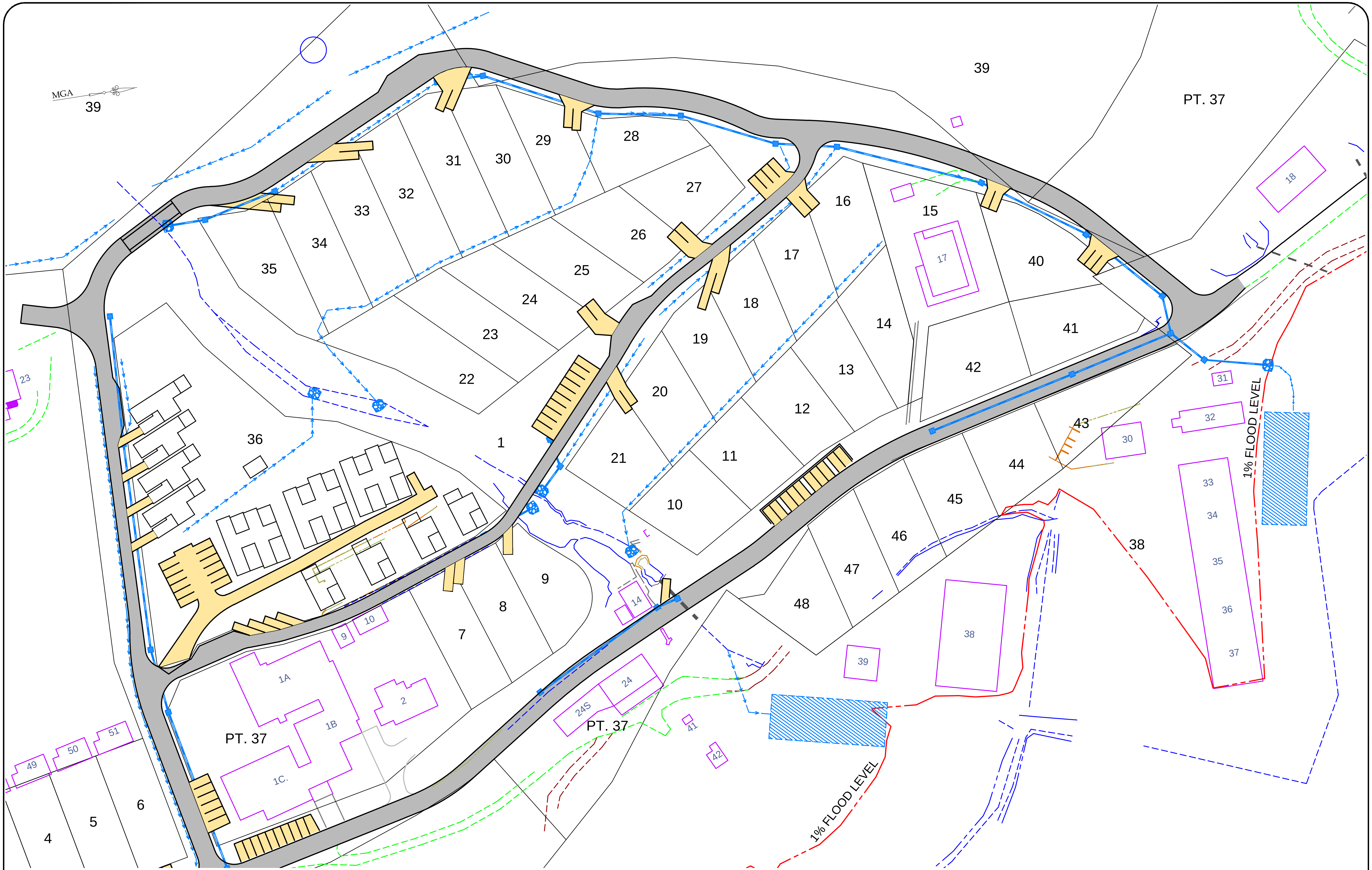
PLAN SHOWING PROPOSED STORMWATER INFRASTRUCTURE FOR NARARA ECO VILLAGE
LOT 13 IN DP 1126998
RESEARCH ROAD, NARARA

SHEET No.	5
No. of SHEETS:	5
DRAWING No:	BB12242
REV:	-



PLAN SHOWING PROPOSED STORMWATER INFRASTRUCTURE FOR NARARA ECO VILLAGE
LOT 13 IN DP 1126998
RESEARCH ROAD, NARARA

AUTHORISED OFFICER	07/12/2015
CONCEPT ONLY NOT FOR CONSTRUCTION	
DRAWING No:	BB12242

REV	REVISION DETAILS	DATE
-	-	-

0 5 10 20 30 40 50
REDUCTION RATIO 1:500 @ A1 & 1:1000 @ A3

CLIENT:	Narara Ecovillage Co-operative Ltd		
REF:	2012242	SURVEY FILE:	12-24ENG-STG1-S96-CC-end2
SURVEYED BY:	CBH	DATE OF SURVEY:	VARIOUS
DESIGNED BY:	R FLETCHER	DRAWN BY:	E JACK

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	0.5m
DATUM:	AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS:	SSM 67141
R.L.:	23.675

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CHASE BURKE HARVEY

SHEET No.	6
No. of SHEETS:	5
DRAWING No:	BB12242
REV:	-

Appendix 4.1.1.4C

Draft Dam Safety Management Policy

Date Adopted:

Details of Board Meeting: December 2015 or soon thereafter

Moved by:

Seconded by:

CONTEXT

Lot 13, DP 1126998, No 25 Research Road, Narara NSW - Community Title Subdivision

This policy applies to all directors and managers who make decisions affecting the safety and maintenance of the village supply dam and the associated floodplain along Narara Creek.

Dam safety improvements require judgement and must be evaluated in the context of community safety and customer price impacts on potable water supply.

Risk Management Policy Framework for Dam Safety (Endorsed by NSW Cabinet 22 August 2006)

PURPOSE

Policy for overall dam safety management objectives at Narara Ecovillage development.

DEFINITIONS and ABBREVIATIONS

ANCOLD means the Australian National Committee on Large Dams.

ALARP – Achieving an acceptable or tolerable level of risk, (often taken as 1 in 1,000,000 per year) with the broad aim to 'avoid avoidable risk'.

Limit of Tolerability - A limit set by ANCOLD to assess safety requirements for dams. The limit is plotted on F-N charts that plot the cumulative probability of failure (F) against the number (N) of deaths, and the plot of failure modes for a dam can be compared to this limit. If any section of the plot falls above the Limit of Tolerability, remedial solutions are required.

SDCC – Sunny Day Consequence Category – LOW following studies 2012 & 2014

FCC – Flood Consequence Category – LOW following studies 2012 & 2014

RWMP – Reservoir Water Management Plan, comprising the 12 Elements of the Australian Drinking Water Guidelines and NSW Health requirements

DSMS – Dam Safety Management System, comprising structural integrity of the dam as water infrastructure and supply guarantee under WICA

WICA – Water Industry Competition Act

Policy

Narara Ecovillage Co-operative Ltd:

1. Undertakes to preserve its dam at "Upper" Narara Creek;
2. Recognises its contribution to village businesses and the surrounding communities;
3. Will not expose the community to unacceptable risks from the existence and operation of the dam;
4. Commits to using recognised prevailing good practice and technology suitable for a small 43mL capacity dam;
5. Accepts ANCOLD Guidelines for low consequence category dams as the industry standard for dam safety management;
6. Will manage dam safety risks by a program of inspection, maintenance, surveillance, safety reviews, training, reporting, emergency management and remedial work;
7. Commits to liaising with local council officers to ensure community best practice is maintained with regard to flood studies and local infrastructure;
8. Will periodically audit dam safety as required under its development approvals and licensing arrangements under the DPI Water Approvals, the Water Industry Competition Act or Dam Safety Act and so that the risks of dam failure is maintained below the 'Limit of Tolerability';
9. Will assess dam safety improvements to further lower risks to ALARP (as low as reasonably practicable);
10. Endeavours to source dam design, construction and operational history through the GIPA process (Government Information (Public Access) Act 2009) from all likely sources – predominantly government agencies.

Procedure

Policy endorsed by the Board, adopted by Project Director, Dam Safety and Reservoir Managers (when appointed), Water (Infrastructure) Network Manager and Land Team.

Notes

Approvals and Licensing

Gosford City Council – Notice of Determination of Development Application, DA 44994/2013 Part 1

Independent Pricing and Regulatory Tribunal – Network Operator's and Retail Supplier's Licences issued for Narara Ecovillage Co-operative Ltd (to be issued 2016)

For more information on this policy, contact the Chairman of the Board, Narara Ecovillage Co-operative Ltd

References

Dams Safety Committee Guidance Notes relating to risk management such as DSC2A Guidance Note – Dam Safety Management Systems;

For details of definition and determination of SDCC and FCC, refer to DSC3A Guidance Note - Consequence Categories for Dams;

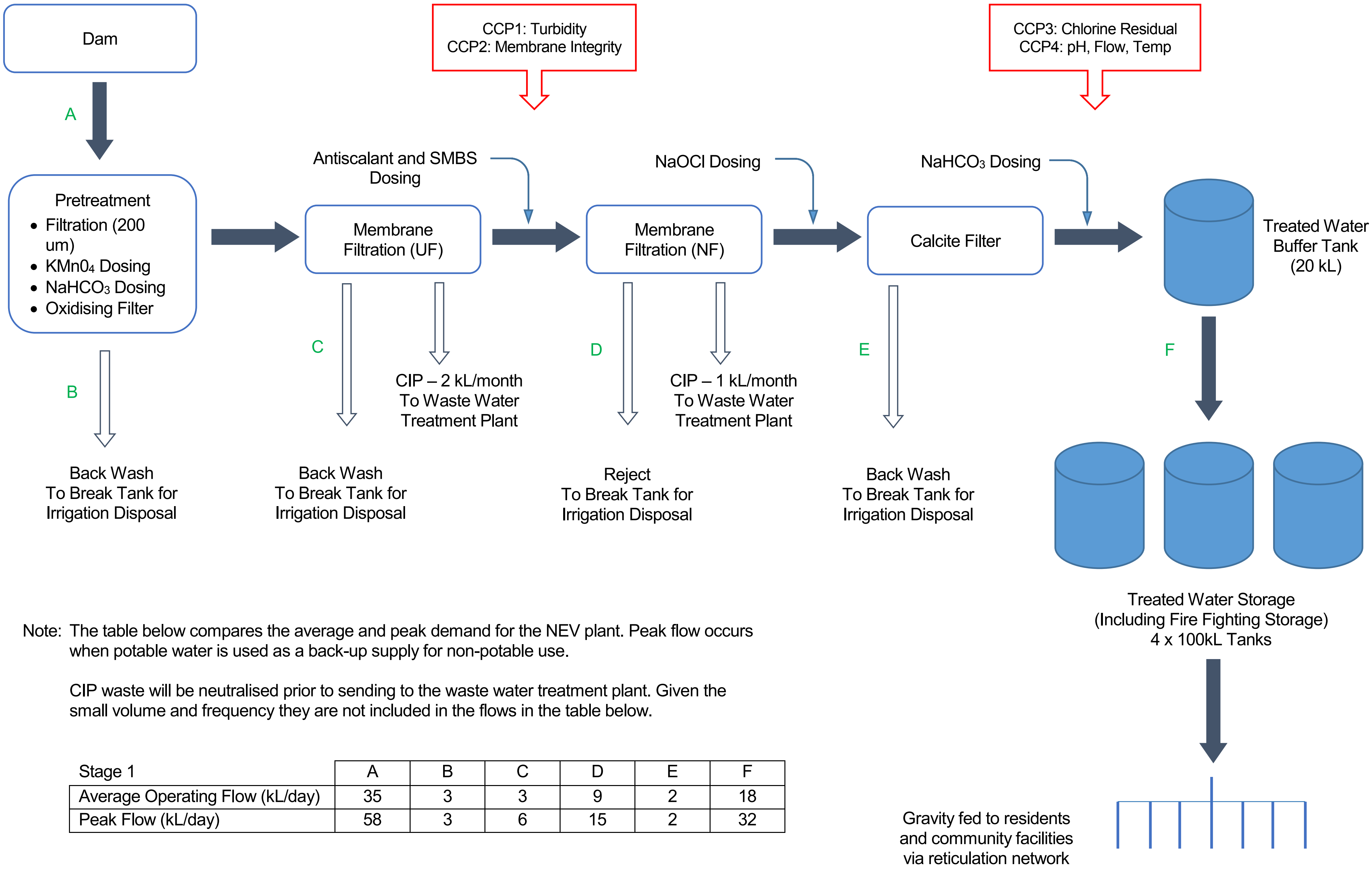
Interpretive Guideline —Model Work Health and Safety Act - the meaning of ‘reasonably practicable ’ – Safe Work Australia.

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix - 4.1.1.5

WTP Block Diagram - Stage 1

Stage 1 Potable Water Treatment Plant – Capacity 2 x 70kL/day (Treated Water)



Note: The table below compares the average and peak demand for the NEV plant. Peak flow occurs when potable water is used as a back-up supply for non-potable use.

CIP waste will be neutralised prior to sending to the waste water treatment plant. Given the small volume and frequency they are not included in the flows in the table below.

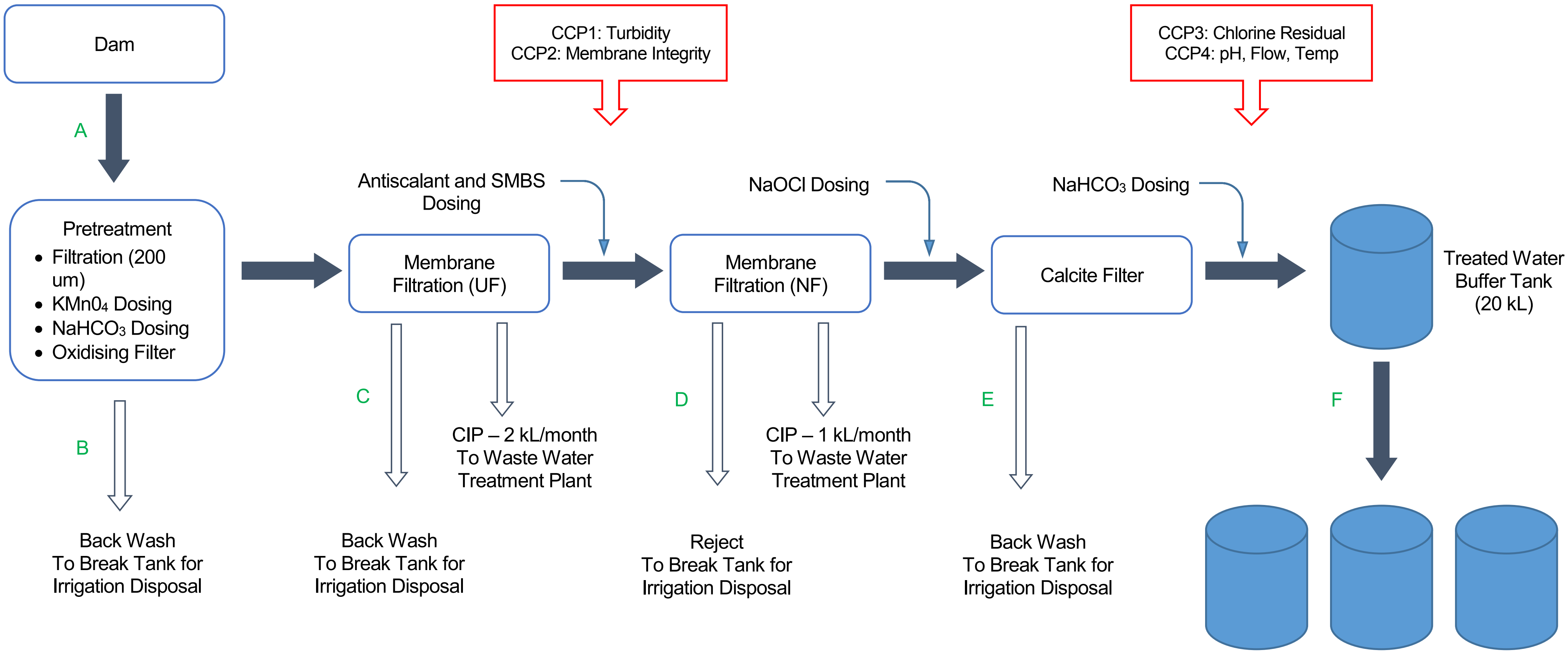
Stage 1	A	B	C	D	E	F
Average Operating Flow (kL/day)	35	3	3	9	2	18
Peak Flow (kL/day)	58	3	6	15	2	32

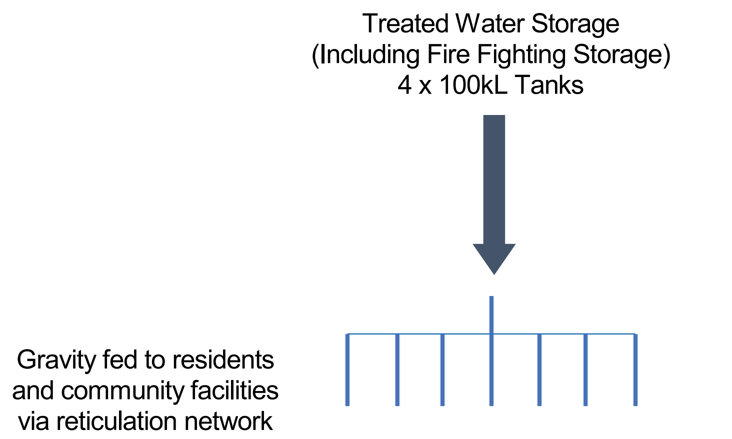
Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix - 4.1.1.6

WTP Block Diagram - Stage 2

Stage 2 Proposed Potable Water Treatment Plant – Capacity 2 x 70kL/day (Treated Water)





Note: The table below compares the average and peak demand for the NEV plant. Peak flow occurs when potable water is used as a back-up supply for non-potable use.

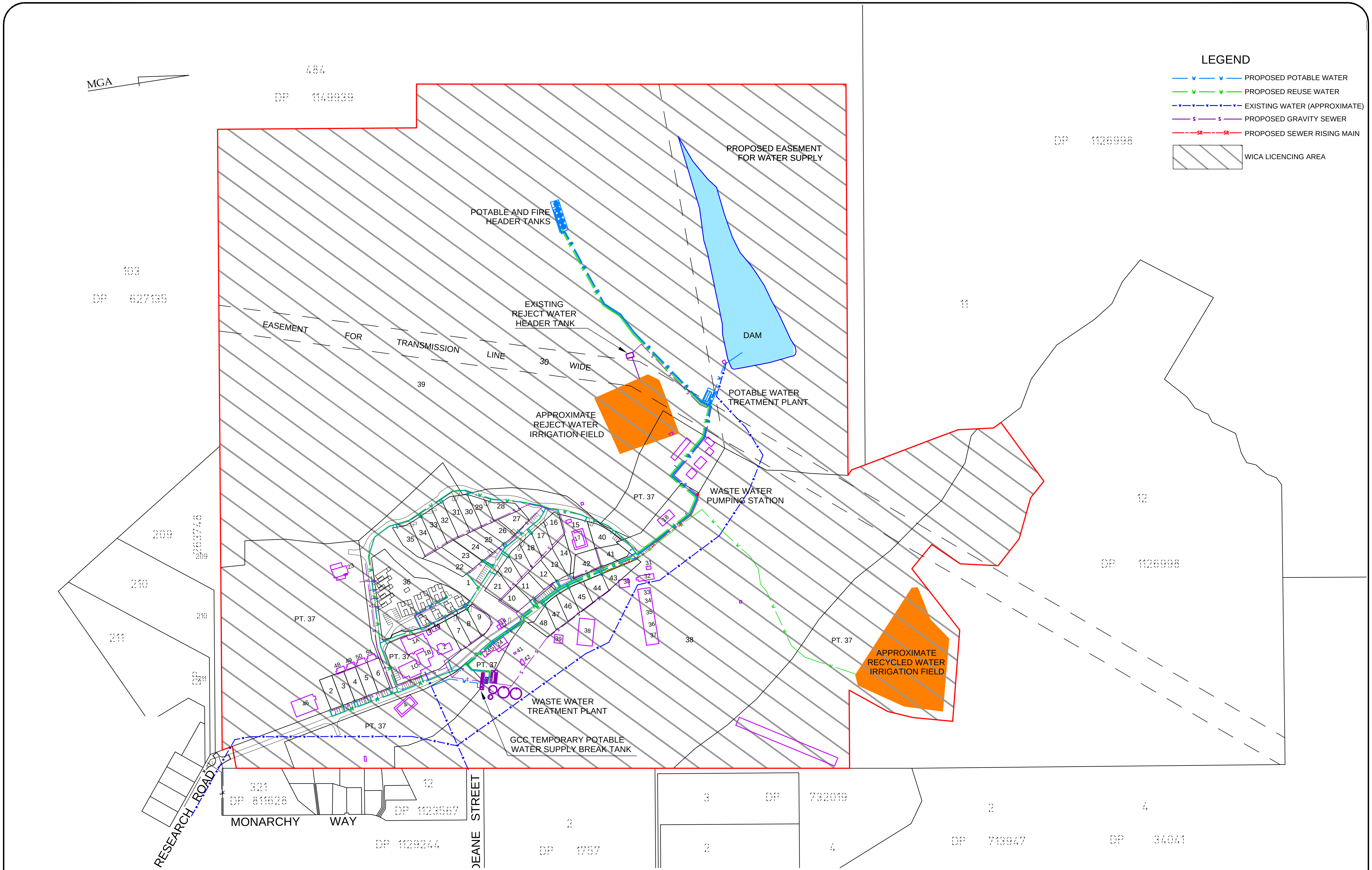
CIP waste will be neutralised prior to sending to the waste water treatment plant. Given the small volume and frequency they are not included in the flows in the table below.

Stage 2 Proposal	A	B	C	D	E	F
Average Operating Flow (kL/day)	72	4	4	18	4	42
Peak Flow (kL/day)	133	8	8	33	8	76

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix - 4.1.3.1

Water Infrastructure Plan



REV	REVISION DETAILS	DATE
A	LEGEND	7/12/15
B	UPDATE LAYOUT AND NOTES	4/03/16

AUTHORISED OFFICER 04/03/2016 DATE

DRAWING No: WICA12242-B

0 15 30 60 90 120 150
REDUCTION RATIO 1:1500 @ A1 & 1:3000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd		LOT No.	13
REF: 2012242	SURVEY FILE: 12-24ENG-STG1-S96-CC-end2	SECTION	–
SURVEYED BY: CBH	DATE OF SURVEY: VARIOUS	PLAN No.	DP 1126998
DESIGNED BY: R FLETCHER	DRAWN BY: E JACK	SUBURB	NARARA
		LGA	GOSFORD
		PARISH	GOSFORD
		COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL: 0.5m
DATUM: AHD AUSTRALIAN HEIGHT DATUM
ORIGIN OF LEVELS: SSM 67141
R.L.: 23.675

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Hornsby: (02) 9482 9498
www.cbhsurvey.com.au
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SHEET No. 1
No. of SHEETS: 1
DRAWING No: WICA12242-B
REV: B

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix 4.1.3.2

Plan Showing Proposed Community Title Subdivision

Document Name:	Plan Showing Proposed Community Title Subdivision	Revision Number & Date:	1 – 1/12/2015	Narara Ecovillage Co-operative Ltd
Date of Issue:	1-Dec-2015	Controlled Document:	Yes	

REV	REVISION DETAILS	DATE
-	-	-

REGISTERED SURVEYOR 9/12/2013 DATE

THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242

DRAWING No: S12242

0 20 40 80 120 160 200

REDUCTION RATIO 1:2000 @ A1 & 1:4000 @ A3

CLIENT:	Narara Ecovillage Co-operative Ltd
REF: 12/242	SURVEY FILE: Stage1-Lots
SURVEYED BY: -	DATE OF SURVEY: -
DRAWN BY: E JACK	CHECKED BY: S BISHOP

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Hornsby: (02) 9482 9498

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CHASE BURKE HARVEY

Plan Showing Proposed
Community Title Subdivision
of Lot 13 in DP 1126998
Research Road, NARARA

SHEET No.	1
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

REGISTERED SURVEYOR	9/12/2013 DATE	
THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242		
DRAWING No: S12242		

REV	REVISION DETAILS	DATE
-	-	-

0 10 20 40 60 80 100
REDUCTION RATIO 1:1000 @ A1 & 1:2000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd		LOT No.	13
REF: 12/242	SURVEY FILE: Stage1-Lots	SECTION	–
		PLAN No.	DP 1126998
SURVEYED BY: -	DATE OF SURVEY: -	SUBURB	NARARA
		LGA	GOSFORD
DRAWN BY: E JACK	CHECKED BY: S BISHOP	PARISH	GOSFORD
		COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Hornsby: (02) 9482 9498
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CHASE BURKE HARVEY

Plan Showing Proposed
Community Title Subdivision
of Lot 13 in DP 1126998
Research Road, NARARA

SHEET No.	2
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

REV	REVISION DETAILS	DATE
-	-	-

REGISTERED SURVEYOR — 9/12/2013 — DATE

THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242

DRAWING No: S12242

0 10 20 40 60 80 100

REDUCTION RATIO 1:1000 @ A1 & 1:2000 @ A3

CLIENT:	Narara Ecovillage Co-operative Ltd
REF: 12/242	SURVEY FILE: Stage1-Lots
SURVEYED BY: -	DATE OF SURVEY: -
DRAWN BY: E JACK	CHECKED BY: S BISHOP

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Hornsby: (02) 9482 9498

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CHASE BURKE HARVEY

Plan Showing Proposed Community Title Subdivision of Lot 13 in DP 1126998 Research Road, NARARA

SHEET No.	3
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

REGISTERED SURVEYOR 9/12/2013 DATE	REV	REVISION DETAILS	DATE
THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242	-	-	-
DRAWING No: S12242			

0 10 20 40 60 80 100
REDUCTION RATIO 1:1000 @ A1 & 1:2000 @ A3

CLIENT: Narara Ecovillage Co-operative Ltd		LOT No.	13
REF: 12/242	SURVEY FILE: Stage1-Lots	SECTION	–
SURVEYED BY: -	DATE OF SURVEY: -	PLAN No.	DP 1126998
DRAWN BY: E JACK	CHECKED BY: S BISHOP	SUBURB	NARARA
		LGA	GOSFORD
		PARISH	GOSFORD
		COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Plan Showing Proposed
Community Title Subdivision
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Research Road, NARARA

SHEET No.	4
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

REGISTERED SURVEYOR 9/12/2013 DATE

THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242

DRAWING No: S12242

REV	REVISION DETAILS	DATE
-	-	-

0 5 10 20 30 40 50

REDUCTION RATIO 1:500 @ A1 & 1:1000 @ A3

CLIENT:	Narara Ecovillage Co-operative Ltd
REF: 12/242	SURVEY FILE: Stage1-Lots
SURVEYED BY: -	DATE OF SURVEY: -
DRAWN BY: E JACK	CHECKED BY: S BISHOP

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Erina: (02) 4367 7334

Hornsby: (02) 9482 9498

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CHASE BURKE HARVEY

Plan Showing Proposed Community Title Subdivision of Lot 13 in DP 1126998 Research Road, NARARA

SHEET No.	5
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

REV	REVISION DETAILS	DATE
-	-	-

9/12/2013
REGISTERED SURVEYOR DATE
THIS PLAN TO BE READ IN CONJUNCTION WITH CBH REPORT WITH REFERENCE: 12/242
DRAWING No: S12242

0 5 10 20 30 40 50
REDUCTION RATIO 1:500 @ A1 & 1:1000 @ A3

CLIENT:	Narara Ecovillage Co-operative Ltd
REF: 12/242	SURVEY FILE: Stage1-Lots
SURVEYED BY: -	DATE OF SURVEY: -
DRAWN BY: E JACK	CHECKED BY: S BISHOP

LOT No.	13
SECTION	–
PLAN No.	DP 1126998
SUBURB	NARARA
LGA	GOSFORD
PARISH	GOSFORD
COUNTY	NORTHUMBERLAND

CONTOUR INTERVAL:	-
DATUM:	-
ORIGIN OF LEVELS:	-
R.L.:	-

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Plan Showing Proposed
Community Title Subdivision
of Lot 13 in DP 1126998
Research Road, NARARA

SHEET No.	6
No. of SHEETS:	6
DRAWING No:	S12242
REV:	-

Appendix 4.1.4

Maddocks

Lawyers
Level 27, Angel Place
123 Pitt Street
Sydney New South Wales 2000 Australia

GPO Box 1692
Sydney New South Wales 2001

Telephone 61 2 9291 6100
Facsimile 61 2 9221 0872

info@maddocks.com.au
www.maddocks.com.au

DX 10284 Sydney Stock Exchange

Date:

Deed of Agreement - Interim WaterConnection

The Council of the City of Gosford
ABN 78 303 458 861
and

Narara Ecovillage Co-Operative Ltd
ABN 86 789 868 574

Interstate offices
Canberra Melbourne

Affiliated offices around the world through the Advoc network - www.advoc.com

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Deed of Agreement - Interim Water Connection

Dated

Parties

Name	**The Council of the City of Gosford ABN 78 303 458 861**
Address	49 Mann Street Gosford
Facsimile	(02) 43232477
Contact	Attention: Richard Brocklehurst
Short name	**Council**

Name	**Narara Ecovillage Co-Operative Ltd ABN 86 789 868 574**
Address	
Facsimile	
Contact	
Short name	**Owner**

Background

A. The Council is a water supply authority under the *Water Management Act 2000* (**WM Act**).

B. The Owner is the registered proprietor of Lot 13 DP 1126998 being 25 Research Road Narara 2250 (**Property**)

C. The Owner has applied to the Council for the retention of an existing connection to Council's water reticulation system as an interim arrangement during the development of Stage One of DA44994/2013 (**Development Consent**) and construction of water industry infrastructure under the *Water Industry Competition Act 2006* (**WICA**).

D. Council has agreed to consent to the Owner's temporary retention of its connection to Council's water reticulation system on the terms and conditions set out in this Deed.

This Deed Witnesses

1. Definitions

In this Deed:

Authorisation means:

(a) an approval, consent, declaration, exemption, accreditation, notarisation, licence, permit, certificate, waiver or other authorisation, however described, required by any law; and

(b) in relation to anything that could be prohibited or restricted by law if an Authority acts in any way within a specified period, the expiry of that period without that action being taken,

including any variation, modification, renewal or amendment with any Authority.

Authority means any:

(a) government, government department, government agency or government authority;

(b) governmental, semi-governmental or judicial person carrying out any statutory authority or function; or

(c) other person (whether autonomous or not) who is charged with the administration of a Law.

Business Day means a day other than a Saturday, Sunday or public holiday in New South Wales.

Claim means any action, claim, demand or proceeding (including based in contract, tort or statute or under any indemnity, and including any action based on personal injury or death) made against the person concerned however it arises and whether it is present or future, fixed or unascertained, actual or contingent.

Consequential Loss means any special, indirect or consequential loss, whether or not a Party has been advised of or is aware of that loss, including:

(a) any loss of revenue, profit, data, opportunity, business, goodwill or future reputation, any failure to realise anticipated savings, any downtime costs, any damage to credit rating, and any penalties payable under contracts other than this Deed; and

(b) any other loss or damage which does not naturally or directly result in the ordinary course of events from the breach, action or inaction in question.

Contribution Amount means a security amount to be paid to Council by the Owner in lieu of water headworks and augmentation contributions payable under section 306(2)(a) of the WM Act and calculated to be $65,439 in accordance with section 306(3) of the WM Act and Council's policy: *WS5.03 Water Supply and Sewerage Development Charges*.

Controller means, in relation to a person's property:

(a) a receiver or receiver and manager of that property; or

(b) anyone else who (whether or not as agent for the person) is in possession, or has control, of that property to enforce an encumbrance.

Council means Council of the City of Gosford.

Council's Water means all water supplied through Council's water reticulation system.

Development means the development permitted by the Development Consent.

Development Consent means DA4994/2013 approved by Council 8 August 2013, as amended from time to time under the EP&A Act.

Disconnection Date means the date that Council issues a written notice to the Owner confirming that the Owner's Water Supply System has been disconnected from Council's water reticulation system.

EP&A Act means the *Environmental Planning and Assessment Act 1979*.

Insolvency Event means, in respect of a person:

(a) an order is made, or the person passes a resolution or takes any steps to pass a resolution, for its winding up;

(b) an administrator is appointed to the person;

(c) the person resolves to appoint or takes any other steps to appoint a Controller, provisional liquidator, trustee for creditors or in bankruptcy or analogous person to the person or any of the person's property;

(d) the appointment of a Controller, provisional liquidator, trustee for creditors or in bankruptcy or analogous person to the person or any of the person's property;

(e) a bank or other financier taking possession of any of the person's property;

(f) the person entering into a compromise or arrangement with, or assignment for the benefit of all of its members or creditors;

(g) the person informs the Council in writing or creditors generally that the person is insolvent;

(h) the person has a meeting of its creditors for the purpose of:

  (i) entering a scheme of arrangement or composition with creditors; or

  (ii) placing it under official management;

(i) execution is levied against a material part of its assets by creditors, debenture holders or trustees under a floating charge; or

(j) where the person is a company, the company is or becomes unable to pay its debts when they are due or is or becomes unable to pay its debts within the meaning of the *Corporations Act 2001* (Cth) as amended or replaced or is presumed to be insolvent under the *Corporations Act 2001* (Cth) as amended or replaced,

unless this takes place as part of a solvent reconstruction, amalgamation, merger or consolidation that has been approved by the Council.

Law includes any legislation or any rule, principle, duty or requirement of or under common law or equity, and for the avoidance of doubt includes any Authorisations and the lawful requirements of Authorities.

Owner means Narara Ecovillage Co-Operative Ltd, the registered proprietor of the Property.

Owner's Water Supply System means the internal water supply system on the Property, including a 100kL product tank and pumping station.

Party means a party to this Deed.

POM means the Plan of Management referred to in clause 3.

Property means Lot 13 DP 1126998 being 25 Research Road Narara 2250.

Subdivision Certificate means a subdivision certificate issued under Part 4A of the EP&A Act in respect of the Development.

Stage One means Stage 1 as set out in the Development Consent.

Temporary Water Commencement Date means the date that either or both of the following events have occurred:

(a) the Subdivision Certificate is issued; and

(b) at least thirty dwellings are occupied within the Property as part of the Development.

Temporary Water Disconnection Date means the date that is the earlier of:

(a) the date that is 18 months after the Temporary Water Commencement Date; and

(b) the date that:

(i) a WICA Licence is granted in relation to the Development; and

(ii) the water industry infrastructure that is the subject of the WICA Licence is operational, as verified by an approved auditor under the WICA Act.

WICA means *Water Industry Competition Act 2006*.

WICA Licence means a licence granted under section 10 of the WICA Act.

WM Act means *Water Management Act 2000.*

WM Regulations means *Water Management Regulations 2011*.

2. Retention of temporary water supply

The Council agrees to:

2.1.1 allow the Owner to retain the temporary connection from Council's water reticulation system to the boundary of the Property; and

2.1.2 continue to supply Council's Water to the Owner's Water Supply System to service the Development, until the Temporary Water Disconnection Date.

3. Disconnection of temporary water supply

3.1.1 The Owner must notify the Council in writing as soon as reasonably practicable and in any case within 2 Business Days after:

(a) a WICA Licence is granted in relation to the Development; or

(b) the water industry infrastructure that is the subject of the WICA Licence is operational, as verified by an approved auditor under the WICA Act.

3.1.2 The Owner must disconnect from and submit a written application to the Council to remove all water supply connections from the Property to Council's water reticulation system within 10 Business Days after the Temporary Water Disconnection Date.

4. Plan of Management

4.1 Owner to submit draft POM

4.1.1 On or before the date of this Deed the Owner must prepare and submit a draft POM to Council.

4.1.2 The draft POM must comply with the terms of this Deed and include emergency water supply arrangements for each of the following circumstances:

(a) where the temporary supply of Council's Water is interrupted through system maintenance or failure; and

(b) where the water quality within the Property is not at a potable standard or is otherwise compromised.

4.2 Review by Council of draft POM

4.2.1 Within 10 Business Days of receiving the draft POM, Council must give the Owner written notice:

(a) accepting the draft POM;

(b) rejecting the draft POM; or

(c) otherwise commenting on, or requiring amendments to the draft POM.

4.2.2 If Council issues a notice under clause 4.2.1(b) or clause 4.2.1(c), the Owner must promptly re-submit an amended draft POM, in which case clauses 4.1 and 4.2 will reapply.

4.2.3 If in respect of a draft POM the Council issues a notice under clause 4.2.1(a), that version of the draft POM will become the final POM.

4.2.4 The Owner must ensure that the final POM is in place within 30 Business Days after the date of this Deed.

4.2.5 Any alteration to the final POM requires the Council's approval in writing.

4.3 No duty of care, responsibility or obligation etc.

4.3.1 The Council does not owe or assume a duty of care or other responsibility or obligation to the Owner to review or check the draft POM for its suitability, or for errors, omissions, inconsistencies, ambiguities, discrepancies or compliance with this Deed.

4.3.2 No review of, comment upon or approval or rejection of, or failure to review, comment upon, approve or reject, any draft POM by or on behalf of the Council will:

(a) relieve the Owner from, or otherwise limit, alter or affect, the Owner's liabilities or responsibilities under this Deed; or

(b) prejudice the Council's rights against the Owner under this Deed.

4.4 Failure to comply is breach of Deed

4.4.1 The Owner must ensure that the final POM is complied with at all times until the Disconnection Date.

4.4.2 A failure by the Owner or any other person to comply with, or implement, any term or condition of the POM will be a breach of this Deed.

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5. Contribution Amount

5.1 Contribution Amount

On or before the commencement of this Deed the Owner must pay the Council the Contribution Amount as security for the disconnection of the Owner's Water Supply System from Council's water reticulation system at the Temporary Water Disconnection Date.

5.2 Council Refund

5.2.1 Subject to clause 5.2.2, if the Owner has complied with all of its obligations under this Deed, the Council agrees to refund the Contribution Amount to the Owner within 20 Business Days after the Disconnection Date.

5.2.2 Despite clause 5.2.1, the Council may retain the Contribution Amount and apply the Contribution Amount for any purpose in its discretion if the Owner's water supply system has not been disconnected from Council's water reticulation system by the date that is 60 Business Days after the Temporary Water Disconnection Date.

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6. Owner’s Water Supply System – general obligations

6.1.1 The Owner must maintain water quality to a potable standard within the Owner's Water Supply System.

6.1.2 The Council's Water supplied under this Deed must only be used to service lots within the Development.

6.1.3 The Council's Water may only be used to fill the product tank forming part of the Owner's Water Supply System between the hours of 10pm to 7am daily, and must not be used for that purpose at other times.

6.1.4 The Owner must ensure that appropriate backflow prevention devices are installed at the Property boundary meter by a licensed plumber so that cross-contamination does not occur from the Property to Council's Water.

7. Fire safety

7.1.1 The Owner acknowledges that Council's Water Supply is insufficient to meet all fire safety requirements required by Law at the Property.

7.1.2 As between the Council and the Owner, the Owner assumes all responsibility and liability for:

(a) ensuring that there is adequate fire safety infrastructure and associated water supply at the Property; and

(b) complying with all applicable fire safety requirements at the Property required by Law,

and releases the Council accordingly.

8. Release and indemnity

8.1 Risk

The Owner uses Council's Water and connects to Council's water reticulation system at its own cost and risk.

8.2 Release

The Owner releases Council from all Claims resulting from any damage, loss, death or injury in connection with:

8.2.1 the supply of Council's Water to the Owner's Water Supply System;

8.2.2 the quality of Council's Water beyond the water meter on the Property;

8.2.3 the use of Council's Water at the Property;

8.2.4 the need for or adequacy of fire protection infrastructure and associated water supply in relation to the Property; or

8.2.5 the connection or disconnection of Council's water reticulation system to the Property.

8.3 Indemnity

8.3.1 The Owner must indemnify the Council against:

(a) any Claim made, threatened or commenced against the Council; and

(b) any liability, loss (including Consequential Loss), damage or expense (including legal costs on a full indemnity basis), and cost suffered or incurred by Council,

arising in connection with:

(c) the supply of Council's Water to the Owner's Water Supply System;

(d) the connection of Council's water reticulation system to the Owner's Water Supply System, including any contamination caused to Council's Water due to the connection;

(e) the quality of Council's Water beyond the water meter on the Property;

(f) the use of Council's Water at the Property;

(g) the need for or adequacy of fire protection infrastructure associated water supply in relation to the Property;

(h) the disconnection of Council's water reticulation system to the Property, including the failure by the Owner to comply with its obligations under clause 3.1.2; or

(i) a breach of the Deed by the Owner.

8.3.2 The indemnity in clause 8.3.1 does not apply to the extent that a breach of this Deed by Council directly contributed to the circumstances giving rise to the Claim, liability, loss, damage, expense or cost.

8.4 No compensation

Council is not liable to the Owner for any loss or damage incurred by the Owner in connection with the subject matter of this Deed, or acts or omissions of the Owner, including:

8.4.1 any damage to the Owner's Water Supply System or any water supply system;

8.4.2 any damage or loss to any property of any person;

8.4.3 any loss arising from death, disability or any injury to any person,

no matter how it happens.

8.5 Survives termination

8.5.1 The release in this clause survives termination of this Deed.

8.5.2 The indemnity in this clause survives termination of this Deed.

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9. Termination of Deed on default

9.1 Default

9.1.1 The Council may, by notice in writing to the Owner, terminate this Deed immediately and exercise any other legal right, if:

(a) the Owner commits a breach of this Deed which is not rectifiable (as reasonably determined by the Council);

(b) any payment required to be paid under this Deed from the Owner to the Council is in arrears for 20 Business Days, whether or not the Council has demanded payment;

(c) the Owner fails to rectify a breach of this Deed which is rectifiable within 10 Business Days after receiving a written notice from the Council specifying the breach and requiring the Owner to rectify it;

(d) the Owner repudiates its obligations under this Deed; or

(e) an Insolvency Event occurs in respect of the Owner.

9.1.2 If the Council ends this Deed under this clause, the Owner shall not be released from liability for any prior breach of this Deed and other remedies available to the Council to recover loss, damage or amounts owing under this Deed shall not be prejudiced.

9.1.3 Demand or acceptance of any other moneys due under this Deed by the Council after termination does not operate as a waiver of the termination.

9.2 Damages following termination

If the Council terminates this Deed under clause 9.1, the Owner must compensate the Council for any loss or damage the Council suffers in connection with the event that gave rise to the termination.

10. No fetter of discretion

10.1.1 Nothing in this Deed will be taken to require Council to act in a manner that contravenes the *Local Government Act 1993* (NSW) or the WM Act or to unlawfully fetter the discretions of Council and the provisions of this Deed will be interpreted accordingly.

10.1.2 Without limiting clause 10.1.1, the Owner acknowledges that:

(a) Council may have a role as consent authority in respect of the Property and may charge inspection fees, and the Council cannot fetter its discretion when performing any function as a consent authority; and

(b) Council will not be liable to the Owner under this Deed for any acts or omissions of the Council undertaken in exercising any of its statutory rights, duties or powers under the EP&A Act, WM Act or the *Local Government Act 1993* (NSW) or the exercise of any other statutory right, power or duty that the Council may lawfully exercise.

11. GST

11.1 GST Act

In this clause words that are defined in *A New Tax System (Goods and Services Tax) Act 1999* have the same meaning as their definition in that Act.

11.2 Exclusive of GST

Except as otherwise provided by this clause, all consideration payable under this Deed in relation to any supply is exclusive of GST.

11.3 Recipient must pay

If GST is payable in respect of any supply made by a supplier under this Deed, subject to clause 11.4 the recipient will pay to the supplier an amount equal to the GST payable on the supply at the same time and in the same manner as the consideration for the supply is to be provided under this Deed.

11.4 Tax invoice

The supplier must provide a tax invoice to the recipient before the supplier will be entitled to payment of the GST payable under clause 11.3.

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12. Notices

12.1 Delivery of notice

12.1.1 A notice or other communication required or permitted to be given to a Party under this Deed must be in writing and may be delivered:

(a) personally to the Party;

(b) by leaving it at the Party's address;

(c) by posting it by prepaid post addressed to the Party at the Party's address; or

(d) by facsimile to the Party's facsimile number.

12.1.2 If the person to be served is a company, the notice or other communication may be served on it at the company's registered office.

12.2 Particulars for delivery

12.2.1 The address and facsimile number of each Party are set out on page 1 of this Deed under the heading 'Parties' (or as notified by a Party to the other Parties in accordance with this clause).

12.2.2 Any Party may change its address or facsimile number by giving notice to the other Parties.

12.3 Time of service

A notice or other communication is deemed delivered:

12.3.1 if delivered personally or left at the person's address, upon delivery;

12.3.2 if posted within Australia to an Australian address, 2 Business Days after posting and in any other case, 5 Business Days after posting;

12.3.3 if delivered by facsimile, subject to clauses 12.3.4 and 12.3.5, at the time indicated on the transmission report produced by the sender's facsimile machine indicating that the facsimile was sent in its entirety to the recipient's facsimile;

12.3.4 if received after 5.00pm in the place it is received, at 9.00am on the next Business Day; and

12.3.5 if received on a day which is not a Business Day in the place it is received, at 9.00am on the next Business Day.

13. Governing law

This Deed is governed by the law applying in New South Wales and the Parties submit to the non-exclusive jurisdiction of the courts of New South Wales.

14. Interpretation

14.1 Words and headings

In this Deed, unless expressed to the contrary:

14.1.1 words denoting the singular include the plural and vice versa;

14.1.2 the word 'includes' in any form is not a word of limitation;

14.1.3 where a word or phrase is defined, another part of speech or grammatical form of that word or phrase has a corresponding meaning;

14.1.4 headings and sub-headings are for ease of reference only and do not affect the interpretation of this Deed; and

14.1.5 no rule of construction applies to the disadvantage of the Party preparing this Deed on the basis that it prepared or put forward this Deed or any part of it.

14.2 Specific references

In this Deed, unless expressed to the contrary, a reference to:

14.2.1 a gender includes all other genders;

14.2.2 any legislation (including subordinate legislation) is to that legislation as amended, re-enacted or replaced and includes any subordinate legislation issued under it;

14.2.3 any document (such as a deed, agreement or other document) is to that document (or, if required by the context, to a part of it) as amended, novated, substituted or supplemented at any time;

14.2.4 writing includes writing in digital form;

14.2.5 'this Deed' is to this Deed as amended from time to time;

14.2.6 'A$', '$', 'AUD' or 'dollars' is a reference to Australian dollars;

14.2.7 a clause, schedule or attachment is a reference to a clause, schedule or attachment in or to this Deed;

14.2.8 any property or assets of a person includes the legal and beneficial interest of that person of those assets or property, whether as owner, lessee or lessor, licensee or licensor, trustee or beneficiary or otherwise;

14.2.9 a person includes a firm, partnership, joint venture, association, corporation or other body corporate;

14.2.10 a person includes the legal personal representatives, successors and permitted assigns of that person, and in the case of a trustee, includes any substituted or additional trustee; and

14.2.11 any body (**Original Body**) which no longer exists or has been reconstituted, renamed, replaced or whose powers or functions have been removed or transferred to another body or agency, is a reference to the body which most closely serves the purposes or objects of the Original Body.

15. General

15.1 Variation

This Deed may only be varied by a document executed by the Parties.

15.2 Counterparts

This Deed may be executed in counterparts, all of which taken together constitute one document.

15.3 Entire agreement and no reliance

15.3.1 This Deed:

(a) constitutes the entire agreement between the Parties; and

(b) supersedes and cancels any contract, deed, arrangement, related condition, collateral arrangement, condition, warranty, indemnity or representation imposed, given or made by a Party (or an agent of a Party) prior to entering into this Deed.

15.3.2 The Owner acknowledges that in entering into this Deed the Owner has not relied on any representations made by the Council (or its agents or employees) other than matters expressly set out in this Deed.

15.4 Liability

If a Party consists of 2 or more people or entities, an obligation of that Party binds each of them jointly and severally.

15.5 Severability

15.5.1 Any provision of this Deed that is held to be illegal, invalid, void, voidable or unenforceable must be read down to the extent necessary to ensure that it is not illegal, invalid, void, voidable or unenforceable.

15.5.2 If it is not possible to read down a provision as required by this clause, part or all of the clause of this Deed that is unlawful or unenforceable will be severed from this Deed and the remaining provisions continue in force.

15.6 Waiver

The failure of a Party at any time to insist on performance of any provision of this Deed is not a waiver of the Party's right at any later time to insist on performance of that or any other provision of this Deed.

15.7 Further assurance

Each Party must promptly execute and deliver all documents and take all other action necessary or desirable to effect, perfect or complete the transactions contemplated by this Deed.

15.8 Legal costs and expenses

15.8.1 The Owner must pay its own and the Council's legal and administrative costs and expenses (on a full indemnity basis) in relation to the negotiation, preparation and execution of this Deed, unless expressly stated otherwise.

15.8.2 The Parties acknowledge and agree that the total liability of the Owner under clause 15.8.1 is equal to $4,500.

15.8.3 The Owner must pay the costs and expenses of Council that are required to be paid under clause 15.8.1 within 10 Business Days after the Owner receives a tax invoice for those costs and expenses.

15.9 Survival and enforcement of indemnities

15.9.1 Each indemnity in this Deed is a continuing obligation, separate and independent from the other obligations of the Parties and survives termination of this Deed.

15.9.2 It is not necessary for a Party to incur expense or make payment before enforcing a right of indemnity conferred by this Deed.

15.10 No merger

The warranties, undertakings, agreements and continuing obligations in this Deed do not merge on completion of the transactions contemplated by this Deed.

15.11 Business Day

If a payment or other act is required by this Deed to be made or done on a day which is not a Business Day, the payment or act must be made or done on the next following Business Day.

Signing Page

Executed by the Parties as a deed

Signed for and on behalf of **The Council of the City of Gosford ABN 78 303 458 861** by General Manager in the presence of:	))	.... Print Title:

....
Witness

Executed by **Narara Ecovillage Co-Operative Ltd ABN 86 789 868 574** in accordance with section 127(1) of the *Corporations Act 2001*:	))))

.... Signature of Director	.... Signature of Director (or Company Secretary)
.... Print full name	.... Print full name

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix - 4.1.9.1

NEV Potable Water Risk Register RevD

Document Control Information

Document:	Narara Ecovillage Potable Water Risk Assessment Register
Date Created:	This format created 23 February 2016
Created by:	Annette Davison (consultant to Narara Ecovillage)
Date last Modified:	16-Mar-16
Modified by:	Annette Davison
Modifications Made:	Rev B: Modifications made post review by John Talbott and Annette Davison, 22 February 2016. RevC: Modifications made post risk review by Geoff Cameron, Mark Fisher and Annette Davison, 14 March 2016. RevD: Modifications and additions made 16 March 2016 by Annette Davison. Sent to Geoff Cameron and Mark Fisher, 16 March 2016.
Version :	Rev D
Status:	For Narara Ecovillage internal use only, not for circulation (will require update schedule to be added here once adopted)
Document Number:	Appendix 4.1.9.1 (Stage 1 WICA Licence)
Update Required:	TBD by NEV.
Document Controller:	TBD by NEV.

Risk Review Details

Date	Location	Attendance	Purpose	Outcomes
24-Mar-14	Syndicate Room 9, MGSM Conference Centre, Level 7, 37 Pitt Street, Sydney	John Talbott Narara Ecovillage Geoff Cameron Narara Ecovillage Katrina Wall NSW Health Kerry Spratt NSW Health Maria Morahan IPART Warren Johnson Aquacell Belinda Layson Aquacell Colin Fisher Aquacell Annette Davison Risk Edge Sarah Loder City Water Technology	Initial risk analysis	Register developed of initial catchment to tap system and water treatment plant concept design.
14-Mar-16	Risk Edge Head Office, 1/7 Highfield Road, Lindfield	Mark Fisher (Director, NEV) Geoff Cameron (Director, NEV) Annette Davison (Director and Principal, Risk Edge)	Risk review	Events, controls and scores reviewed. Break tank risk event removed as no longer part of system. UV events removed as UV no longer a disinfection step in the system design. Remove microfiltration event: "Biological and physical hazards Excessive turbidity interfering with the efficiency of the UV disinfection system" as UV no longer a part of the system. Add nanofiltration events.
16-Mar-16	Risk Edge Head Office, 1/7 Highfield Road, Lindfield	Annette Davison (Director and Principal, Risk Edge)	Editing of spreadsheet	Reality check of review and formatting consistency modifications undertaken. 'DeletedRisks' sheet added.

Risk Register Potable Water Supply

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk L	Maximum Risk C	Max. Risk Score	Preventative Measures	Residual Risk L	Residual Risk C	Resid. Risk Score	Uncertainty	Comments	Further Actions
Catchment	C1	Biological and physical hazards Recreation and camping (residents and public) leading to raw water quality that is difficult to treat	3	5	8	Water treatment plant (design concept developed and technology assessment conducted by Water Futures 2015) Residents aware that dam is water source Community rules Dam Recreation Policy (no primary contact, no motorised watercraft) Residents bound by Community Management Statement. Some inherent mitigation in dam.	1	4	5	Uncertainty low	ALARP 14/3/2016: Max risk changed to 3 from 4 for likelihood. Residual C changed to 4. Score reduced and therefore not considered ALARP.	14/3/16: No actions added.
Catchment	C2	Biological, physical and chemical hazards Faecal matter (including feral animals) and erosion products from agriculture (horticulture and animal husbandry) and forestry reaching waterways and causing a water quality problem in dam	3	5	8	Water treatment plant (design concept developed and technology assessment conducted) Some inherent mitigation in dam. Landuses in catchment understood and now mapped.	1	4	5	Uncertainty low	14/3/2016: There is only a small level of agriculture at the top of the catchment. NEV checked with Strickland State Forest and there is no feral animal baiting program in place (not seen as a priority forest for this activity). Max risk changed to 3 from 4 for likelihood. Residual C changed to 4. Score reduced and therefore not considered ALARP.	14/3/2016: No actions added.
Catchment	C3	Biological and physical hazards Periodic changes in raw water quality leading to difficulty in treating raw water and increased chlorine demand	3	4	7	Water treatment plant (design concept developed and technology assessment conducted by Water Futures 2015) Residents aware that dam is water source Community rules Dam Recreation Policy (no primary contact, no motorised watercraft) Residents bound by Community Management Statement. Some inherent mitigation in dam.	2	4	6	High uncertainty due to lack of historical data. 16/3/2016: See comments on WQ which now reduce the uncertainty.	14/3/2016: WQ monitoring report from August 2015. Water appears of good quality. Water will need to be monitored over time to get more historical information. 16/3/2016: Risk scored by Annette Davison.	Aquacell to establish raw water sampling program (capture a range of weather conditions, seasonal changes as much as possible). Include TOC/DOC and dissolved iron and aluminium, colour, turbidity, nutrients plus gross alpha and gross beta (one-off). Refer to Woodlots and Wetlands report for hydrogeology.
Catchment	C4	Biological, physical and chemical hazards Eutrophication resulting in low DO, high nutrients, increased possibility of algal blooms causing taste and odour, toxin production, mineral mobilisation resulting in poor water quality	2	4	6	Water treatment plant (design concept developed and technology assessment conducted by Water Futures 2015) Residents aware that dam is water source Community rules Dam Recreation Policy (no primary contact, no motorised watercraft) Residents bound by Community Management Statement. Some inherent mitigation in dam.	1	4	5		Not considered to be a problem for this system	
Catchment	C5	Physical and chemical hazards Bushfire followed by heavy storm resulting in ash, nutrients washing into the dam	1	5	6	Water treatment plant (design concept developed and technology assessment conducted) Some inherent mitigation in dam. Landuses in catchment understood and mapped. Ability to cart water in.	1	4	5	WTP would only be a control if minor impact (process should be able to manage float ash on dam, not wholesale contamination)	14/3/2016: Historical information is that there has been no fire in the catchment in living memory. Max. risk scores not changed residual risk consequence reduced to 4 as water can be carted in.	14/3/2016: Bushfire Management Plan to be developed (liaise with Strickland State Forest, RFS and GCC). Ensure that assets etc are mapped as part of this plan.
Catchment	C6	Physical and chemical hazards Road crossings, accidents and spills, unsealed roads leading to water quality issues	2	4	6	Water treatment plant (design concept developed and technology assessment conducted by Water Futures 2015) Residents aware that dam is water source Some inherent mitigation in dam.	2	3	5	Pending catchment boundary. 16/3/2016: Uncertainty reduced as catchment now mapped - few if any crossings.	16/3/2016: Catchment boundary and landuses now mapped and understood. Risk scores added by Annette Davison.	NEV to define catchment area NEV to identify relevant stakeholders in incident management plan (HAZMAT, EPA, Police, Fire, NSW Health)

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
Catchment	C7	Biological hazards Failing onsite sewage management systems in catchment leading to high levels of pathogens in source water	3	4	7	Water treatment plant with multiple barriers in process train	2	4	6		Do not appear to be neighbouring onsite sewage management systems close to waterway Note that there is an animal shelter on Reeves St which might have a treatment plant The site does have some onsite sewage management systems at NEV downstream of dam. 16/3/2016: Landuses and catchment boundary are now mapped and understood.	NEV to identify on site sewage management systems - liaise with GCC
Source Water (Dam)	S1	Biological hazards Dead animals decaying and leaching nutrients resulting in poor water quality entering dam	2	4	6	Water treatment plant with multiple barriers in process train Dam Management Plan (service to be provided by external contractor)	1	4	5			Dam management plan to be developed by NEV/Aquacell including how this fits with WICA licence
Source Water (Dam)	S2	Chemical and physical hazards Dam stratification/ inversion leading to release of Fe and Mn and turbidity	3	3	6	Shallow dam Water treatment plant with multiple barriers in process train Dam Management Plan (service to be provided by external contractor - no destratification planned)	2	3	5		Iron and aluminium were elevated in the one sample. To be scored once more data has been obtained. 16/03/2016: New WQ data set obtained (August 2015). Some issues noted with Mn levels. Pretreatment has now been designed in.	NEV to liaise with previous site manager regarding this (including instances of T&O)
Source Water (Dam)	S3	Biological, physical and chemical hazards Potential stormwater entry into dam	1	3	4	Stormwater from NEV site will not flow to dam (to Narara Creek) Dilution Water treatment plant (proposed)	1	2	3			
Source Water (Dam)	S4	Biological, physical and chemical hazards Short-circuiting and rapid mixing and/or reduced detention time in the dam leading to poor quality water	2	4	6	Water treatment plant with multiple barriers in process train Monitoring of raw water Average residence time in excess of 25 days (98%ile) in dam	2	2	4		14/3/2016: Woodlots and Wetlands study (Reservoir Water Management Plan V5.3 2015) states 25 day average residence time. Scores added, N/A before.	14/3/2016: Review Woodlots and Wetlands recommendation (Reservoir Water Management Plan V5.3 2015) to include a variable offtake level for the dam.
Source Water (Dam)	S5	Biological, physical and chemical hazards Algal blooms (toxic and non-toxic strains) resulting in poor water quality	1	5	6	Water treatment plant with multiple barriers in process train Monitoring of raw water Good quality of catchment and runoff.	1	4	5		Carbon (adsorption) not to be considered unless catchment management studies and WQ monitoring indicate otherwise. 14/3/2016: There is only a small level of agriculture at the top of the catchment. Low phosphorus levels in raw water (August 2015). No historical algal blooms.	NEV to liaise with previous site manager regarding this (including instances of T&O) Refer to Water Directorate website for algal management protocols 14/3/2016: Review Woodlots and Wetlands recommendation (Reservoir Water Management Plan V5.3 2015) to include a variable offtake level for the dam.
Source Water (Dam)	S6	Biological, physical and chemical hazards Use of the dam for firefighting resulting in water quality contamination	2	3	5	Water treatment plant with multiple barriers in process train Monitoring of raw water Fire hydrants designed into system. 300 KL for firefighting in gravity fed tanks. Inherent dilution in dam.	2	2	4		14/3/2016: Risk scores added, N/A before.	NEV to include use of dam for firefighting in bushfire management plan
Pre-treatment	PT1	Failure of pre-treament to remove colour, DOC/TOC			Not scored	Currently no detail on control for this component of the system			Not scored			14/3/2016: Review O&M of pre-treatment system with Aquacell.
Microfiltration	MF1	Biological hazard Membranes may be compromised by cleaning resulting in reduced pathogen removal.	3	4	7	Maintain membranes under a regular schedule. Ensure all membranes are replaced periodically. Pressure differential alarm. Pressure decay testing. Still have chlorine. Filter to waste after clean and can divert off-spec water. Verification monitoring (when developed)	1	2	3			14/3/2016: Review how membrane replacement schedule will be managed (possibly through the service agreement/asset management plan).
Microfiltration	MF2	Biological hazard Membrane breach resulting in pathogen breakthrough	3	4	7	Pressure decay testing. Still have Cl2. Preventative maintenance program for membranes. Filter to waste after clean and can divert off-spec water.	1	2	3	Decision is based on pressure decay testing being in place		Review the log reductions provided by current process train

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
Nanofiltration	NF1	Biological hazard Membranes may be compromised by cleaning resulting in reduced pathogen removal.	3	4	7	Maintain membranes under a regular schedule. Ensure all membranes are replaced periodically. Pressure differential alarm. Pressure decay testing. Still have chlorine. Filter to waste after clean and can divert off-spec water. Verification monitoring (when developed)	1	2	3		14/3/2016: Risk scores same as for microfiltration as even though only one disinfection barrier now, there are two sets of membranes and a pre-treatment step in the design.	Review where off-spec water will be diverted to and/or retreated
Nanofiltration	NF2	Biological hazard Membrane breach resulting in pathogen breakthrough	3	4	7	Pressure decay testing. Still have Cl2. Preventative maintenance program for membranes. Filter to waste after clean and can divert off-spec water.	1	2	3	Decision is based on pressure decay testing being in place	14/3/2016: Risk scores same as for microfiltration as even though only one disinfection barrier now, there are two sets of membranes and a pre-treatment step in the design.	Review the log reductions provided by current process train
Nanofiltration	NF3	Biological and physical hazards Excessive turbidity interfering with the efficiency of the chlorine disinfection system	3	5	8	Filter to waste after clean and can divert off-spec water. Turbidity meter is alarmed - high alarm diverts off-spec water. Online turbidity meter. UVI is alarmed and will shut down plant for high alarm.	1	3	4			Clarify what will happen to off-spec water in this case. Need to develop an incident response plan in consultation with NSW Health which includes notification to NSW Health when a CCP is breached.
Chlorine Disinfection (chlorine, dosing pump)	CD1	Biological hazard Insufficient chlorine dose leading to inadequate Ct (contact time X dose) and poor disinfection by chlorine system.	4	5	9	Upstream MF and UV System designed to USEPA Guidelines Alarms on Chlorine dosing system (low dose, high dose, high back pressure) Flow paced chlorine dosing system Flow switch through dosing cell Free residual chlorine monitoring Process interlocks (out of spec water diverted).	2	2	4		Note temperature may also affect disinfection efficiency	Aquacell to confirm which guidelines this process is being designed to. CCP procedures to be developed in conjunction with NSW Health.
Chlorine Disinfection (chlorine, dosing pump)	CD2	Biological hazard Insufficient contact time leading to inadequate Ct (contact time X dose) leading to poor disinfection by chlorine system.	4	5	9	Upstream MF and UV System designed to USEPA Guidelines Design tanks so that minimum operating level provides required contact time. Baffle design in chlorine contact tank. Free residual chlorine monitoring	2	2	4		Has a non-conforming water protocol been written?	
Chlorine Disinfection (chlorine, dosing pump)	CD3	Biological hazard Underdosing from insufficient chemical in dosing tank or equipment failure	4	4	8	Online chlorine level monitoring (alarmed) and visual indicator in dosing tank. Training of service technician. O&M program. Verification monitoring downstream. Process interlocks.	2	2	4		Roles and responsibilities currently being defined.	
Chlorine Disinfection (chlorine, dosing pump)	CD4	Chemical hazard Overdosing of chlorine	4	5	9	Free residual chlorine monitoring Process interlocks Training of service technician. Customer complaints monitoring.	2	2	4			CCP information will need to consider whether water can be retreated. Talk to EPA about environmental discharges and if necessary consider sending out of spec water to Break Tank instead of dam.
Chlorine Disinfection (chlorine, dosing pump)	CD5	Biological and physical hazards High pH in the water causing reduced disinfection efficiency	4	3	7	On-line pH meters on raw, contact tank and treated water and shut down and divert treated water delivery once pH out of range Pre-treatment where pH can be adjusted (NaHCO3) Still have MF Verification monitoring downstream (program to be developed)	2	3	5	Await further data	From available data, pH was quite low but this is to be confirmed through additional monitoring 14/3/2016: pH of raw water is slightly acidic (August 2015 report).	14/3/2016: Review chlorine contact tank with Aquacell (currently not drawn on Appendix 4.1.1.5). Max scores added and residual scores changed to 2/3 from 1/2.
Calcite Filter	CF1	Chemical hazard Failure of pH stabilisation leading to potential problems in distribution system	3	2	5	pH monitoring in potable water storage Visual monitoring of Calcite filter No Ductile Iron Cement Lined pipes New system Operator training Verification monitoring downstream	1	2	3	Await further data	Distribution system materials still to be determined (likely poly mains, copper internals). 14/3/2016: Max risk scores added (N/A previously). Water quality report (August 2015) suggests water slightly acidic.	
Potable Water Storage Tanks	PWST1	Biological, physical and chemical hazards Contamination of reservoirs by pests (possums etc.), infiltration from roof, illegal access, corrosion or sediment build-up resulting in poor water quality	4	5	9	Covered reservoir Good roof design Chlorine residual Verification monitoring Reservoir inspection program (to be developed) Customer complaint monitoring	2	4	6		Currently there is overhanging vegetation. 14/3/2016: Note that the new design has four potable storage distribution reservoirs (from 1 originally) with booster chlorination designed in.	Develop a response protocol (including hand-dosing reservoir) Vegetation reduction and ongoing vegetation management program to be developed Determine appropriate monitoring point for chlorine residual in distribution system

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
Potable Water Storage Tanks	PWST2	Biological, physical and chemical hazards Poor water quality due to low turnover (including loss of residual disinfectant)	3	4	7	Covered reservoir Good roof design Chlorine residual Verification monitoring Reservoir inspection program (to be developed) Customer complaint monitoring	2	4	6		Reservoir inspection program will be developed including operator training and records. Scored based on staging approach. 14/3/2016: Note that the new design has four potable storage distribution reservoirs (from 1 originally) with booster chlorination designed in.	Develop a response protocol (including hand-dosing reservoir) Need to consider reducing potential for stagnation in the reservoir Develop CCPs in consultation with NSW Health. Refer to DWMS examples.
Potable Water Storage Tanks	PWST3	Low mixing causing dead spots/short circuiting (common inlet outlet) exacerbates water age problems and causing poor water quality	3	4	7	Chlorine residual Verification monitoring Reservoir inspection program (to be developed) Customer complaint monitoring	2	4	6		14/3/2016: Note that the new design has four potable storage distribution reservoirs (from 1 originally) with booster chlorination designed in.	Ensure that reservoir design considers mixing
Potable Water Storage Tanks	PWST4	Reservoir cleaning while reservoir is online resulting in risks to water quality	4	4	8	Good quality water with pre-treament and two sets of membranes. Buffer (multiple tanks) to be able to take a reservoir offline for cleaning. Verification monitoring (when developed) Customer complaints monitoring (to be developed)	3	4	7	14/3/2016: Residual risk rated as high for now until procedures are in place.	14/3/2016: Hydraulic considerations now finalised. Note that the new design has four potable storage distribution reservoirs (from 1 originally) with booster chlorination designed in.	14/3/2016: Ensure that reservoir cleaning (e.g. through Aqualift or other contractor) and O&M in general is included in the Asset Management Plan.
Distribution System (lines, end use)	DS1	Water age in mains resulting in chlorine residual decline and potential for regrowth (discoloured water etc.)	3	3	6	System designed with ring mains to reduce dead ends etc Good practice design being followed for distribution system Design of plant and storage tanks considers demand and water age Potential to adjust chlorine levels at plant and in storage.	2	3	5		14/3/2016: Scores added (N/A before).	
Distribution System (lines, end use)	DS2	High chlorine demand due to DOC/TOC leading to inability to maintain residuals	3	3	6	Assessment of total organic carbon and colour (August 2015) Pretreatment (200 um filter, KMnO4, NaHCO3, oxidising filter) Membranes (ultrafiltration and nanofiltration)	2	3	5		14/3/2016: Scores added (N/A before).	Undertake sampling and analysis for DOC/TOC and colour
Distribution System (lines, end use)	DS3	Seasonal conditions affecting water temperature in the raw and treated water and longevity of chlorine residual in the distribution system	2	4	6	System designed with ring mains to reduce dead ends etc Good practice design being followed for distribution system Design of plant and storage tanks considers demand and water age Potential to adjust chlorine levels at plant and in storage. Mixing in the tanks.	2	3	5		14/3/2016: Scores added (N/A before).	Include temperature in raw water monitoring program and distribution (to better understand temperature variations)
Distribution System (lines, end use)	DS4	Delivery pipes and fittings leaking or bursting	3	4	7	Plumbing installed according to AS/NZS 3500 Use licensed plumbers Materials from reputable suppliers	2	3	5			Develop handover protocols to householders and plumbing inspection of buildings before occupancy (noting that this will be crucial to granting of licence) NEV to consider including plumbing requirements in by-laws
Distribution System (lines, end use)	DS5	Cross contamination from non-quarantining of sewer and water equipment including CCTV during mains work	3	4	7		N/A		Not scored		14/3/2016: Procedures will need to be developed post construction phase. Therefore, residual risk not yet scored.	14/3/2016: Leve this action in: "Develop procedures for mains work including separate equipment and clothing, hygiene procedures for water and sewer."
Distribution System (lines, end use)	DS6	Cross connections with recycled water system or any other non-potable sources	5	5	10	Plumbing audit Coloured piping Aquacell has a backflow prevention procedure in place Customer complaints monitoring system (to be developed) Complaints Handling and Dispute Resolution Policy Retail Supply Managment Plan. Verification monitoring Education Higher pressure in potable system than recycled system	2	5	7		ALARP 14/3/2016: Not considered ALARP until the issue of plumbing audit and customer complaint monitoring is addressed.	14/3/2016: Keep these actions: "Review backflow prevention/ cross connection policies in place for this scheme. Review risk once recycled water treatment plant finalised." Develop a customer complaints monitoring system.

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
Distribution System (lines, end use)	DS7	Backflow from various sources causing water quality problems	3	5	8	RPZ (reduced pressure zone), air gaps Plumbing audit Coloured piping Aquacell has a backflow prevention procedure in place Customer complaints monitoring Verification monitoring Education Plumbing controls Zero Chemicals Policy for site management Community Management Statement (binds residents to chemical use policy)	3	4	7		Unlikely to be any high risk activities on site. 14/3/2016: Perhaps small café and/or dairy farm. 14/3/2016: Still some controls to put in place therefore consequence not yet as low as could be - but, it is considered a low risk site for backflow.	14/3/2016: Keep "Review backflow prevention/ cross connection policies in place." 14/3/2016: Develop trade waste policy if/as required.
Distribution System (lines, end use)	DS8	Reduced water quality from growth of biofilms	3	4	7	Assessment of total organic carbon and colour (August 2015) Pretreatment (200 um filter, KMnO4, NaHCO3, oxidising filter) Membranes (ultrafiltration and nanofiltration)	2	2	4		14/3/2016: New process design incorporates a pre-treatment step to remove tannins/TOC. There are now two sets of membranes - UF and NF which are different to the original design (previously only UF). Water has high colour from tannins.	14/3/2016: Clarify with Aquacell whether the oxidising filter for pretreatment is the same as sodium metabisulphite addition.
Distribution System (lines, end use)	DS9	Reactive cleaning of mains resulting in reduced water quality			Not scored				Not scored		14/3/2016: No measures yet in place therefore not yet scored.	14/3/2016: Develop distribution system cleaning/ maintenance proceudres (to be prepared prior to operation)
Distribution System (lines, end use)	DS10	Turnover in water direction, pressure, system operation resulting in reduced water quality	3	4	7	Design of reticulation system does not have bi-directional flows.			0		14/3/2016: Consider removing this event as bi-directional flows do not appear to be planned into this system.	Ensure that this event is covered in distribution system maintenance plan/procedures
Distribution System (lines, end use)	DS11	Reduced water quality from use of water carter connections by approved users	3	4	7	System design. One dedicated access point. Five appropriate (i.e. licence from Gosford Council) water carter providers have been identified.	2	4	6		Unlikely that water carters will be allowed to connect to the system. 14/3/2016: System has been designed to allow water carter access at one dedicated point on the main road. The design has been submitted to the civil contractors. Risk scores changed from N/A to adding in max and residual scores.	14/3/2016: Ensure that water carters have current licence if/when used.
Distribution System (lines, end use)	DS12	Use of fire hydrants stirring up the system and causing water quality issues	4	3	7	Upstream water treatment plant (good water quality) Ring main designed with fire hydrants (in accordance with Plumbing Code of Australia and Bushfire Protection Assessment (Australian Bushfire Protection Planners 2013)). Verification monitoring will be in place as part of the Infrastructure Operating Plan. Complaints Handling and Dispute Resolution Policy (customer complaints monitoring to be developed)	2	3	5		14/3/2016: Residual risk scores added.	14/3/2016: Ensure that a water quality monitoring plan is developed for verification purposes (for drinking and recycled water).
Distribution System (lines, end use)	DS13	Main break resulting in entry of contaminants into the system	3	4	7	Customer complaints monitoring (to be developed) New pipes therefore unlikely to have mains breaks happening initially Chlorine residual Verification monitoring Positive pressure	2	3	5		Likely that potable and recycled water pipework will be in same trenches but sewers separate 14/3/2016: Residual risk scores added.	Ensure that this event is covered in distribution system maintenance plan/procedures
Distribution System (lines, end use)	DS14	Illegal/unknown connections resulting in introduction of unknown hazards	3	5	8	All residents will be part of NEV owners association Education plan Monitoring through water balance (proposed) Chlorine residual Verification monitoring program Customer complaints monitoring Maintain positive pressure in the distribution system Backflow prevention at property boundary	2	5	7		ALARP 14/3/2016: Still comfortable with ALARP. Score not changed.	

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
Distribution System (lines, end use)	DS15	Contamination introduced during laying of new mains by operator and/or other party			Not scored				Not scored		14/3/2016: New main is part of Stage 2 infrastructure rollout and therefore covered by separate WICA licence application for Stage 2. Not scored at this stage as not relevant yet.	
Distribution System (lines, end use)	DS16	Dead ends in reticulation systems leading to stagnation and water quality issues	3	4	7	Dead ends to be designed out where possible Verification monitoring Customer complaints monitoring Chlorine residual	2	3	5			Consider how this issue is dealt with during the staging process
Distribution System (lines, end use)	DS17	Lack of chlorine residual at system extremities	4	4	8	Verification monitoring program including checking chlorine residual in distribution system. Ring main system has been designed to minimise dead ends. Small system. Customer complaint monitoring Ability to adjust dosing	2	4	6		Distribution system design not yet finalised Currently going through re-zoning process which will impact upon distribution system for following stages. 14/3/2016: System design now finalised. Dead ends have been minimised, ring mains used. Residual likelihood changed to 2 from 3.	14/3/2016: Keep "This event to be considered in chlorination CCP. Develop verification monitoring program with consideration of NSW Drinking Water Monitoring Program (available online)."
General/ Whole of System	WoS1	Use of non-potable water (e.g. recycled water) as though it were treated drinking water	4	4	8	Signage Education brochure Coloured pipes Customer complaint monitoring Robust recycled water treatment process	2	4	6		ALARP. Aquacell will develop a program that's tailored for NEV. Scored assuming recycled water plant process OK.	NEV to review program. Consider liaison with PHU regarding this event.
General/ Whole of System	WoS2	Incorrect or reduced quality of materials or chemicals resulting in potential for water quality contamination	3	4	7	Computerised asset planning system Inventory control system for chemicals Buy chlorine as required. Only deal with reputable manufacturer. Install to manufacturer's specifications. Can divert out of spec water if at WTP and if detected	2	3	5		Aquacell will develop a program that's tailored for NEV	NEV to review program. System for storing materials to be developed and covered in contract. Aquacell to review chemical specifications/ certificates and verify OK for drinking water.
General/ Whole of System	WoS3	Chemicals being delivered to incorrect storage resulting in process contamination or incorrect dosage	2	4	6	Training of operators Chlorine is the only liquid chemical which will be stored onsite	1	4	5			Consider designing in different fittings for different chemicals
General/ Whole of System	WoS4	Prolonged power outages	4	4	8	Connection grid for foreseeable future. Running on PV and batteries. UPS for all critical alarms and monitoring systems. Electricity design in place for Stage 1. Gravity feed. Five days backup storage for potable water. Water carting plan.	2	4	6		14/3/2016: NEV may ultimately be off grid. Max and residual risk scores added.	14/3/2016: Change to Consider establishing a list of local generator suppliers. Make sure this is covered in the Incident and Emergency Response Plan.
General/ Whole of System	WoS5	Catastrophic system failure, e.g. bushfire, flood or earthquake taking out key infrastructure e.g. WTP or pump station	1	5	6	UPS for all critical alarms and monitoring systems. Gravity feed. Five days backup storage for potable water. Water carting plan.	1	5	6		ALARP	14/3/2016: Keep "Ensure that WQ impacts are covered within incident management plan/procedures." Add "Ensure that this event is covered also in the Business Continuity Plan when developed."
General/ Whole of System	WoS6	Human actions (sabotage)	1	5	6	NEV site security (but not near dam) Password protection on SCADA	1	5	6		ALARP	14/3/2016: Keep "Security around dam and WTP to be reviewed. Security checks to be included in reservoir and site inspection programs." Add "Ensure that this event is covered also in the Business Continuity Plan when developed."
General/ Whole of System	WoS7	Significant operator/ contractor error resulting in poor water quality	3	5	8	Operator training Remote monitoring Password protection on SCADA (including restriction on changing CCPs - only by Aquacell Technical Manager) Position descriptions for NEV Water Utility Staff. Verification monitoring (when developed)	2	4	6			14/3/2016: Keep "Review method for ensuring skills currency and competency for drinking water quality. Consider water quality awareness and training for contractors also (NWP279 (Cert II)). Ensure that IPART and NSW Health are involved in any changes to CCPs (once in place)" 14/3/2016: Ensure that NWP279 (Cert II) is required for operators.

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk			Preventative Measures	Residual Risk			Uncertainty	Comments	Further Actions
			L	C	Max. Risk Score		L	C	Resid. Risk Score			
General/ Whole of System	WoS8	Lack of resources resulting in reduction of proactive management work leading to system issues (e.g. control measures not being implemented appropriately)	3	4	7	Service Agreement is now in place between Aquacell and NEV specifying roles and responsibilities. Monthly performance reports from Aquacell to NEV. Performance level KPIs set into the agreement. Ability to rescind agreement if performance not met. Verification monitoring (when developed)	2	3	5		Remote monitoring will be by Aquacell Onsite O&M tasks probably by Aquacell but to be determined Day to day operations to be by NEV personnel	14/3/2016: Remove "Roles and responsibilities" to be further developed and training and records management to be covered in this. Add: Ensure that records management is developed to help review and monitor this event. Risk scores added.
General/ Whole of System	WoS9	Lack of training/awareness of key staff resulting in potential for poor water quality through incorrect operation of the water supply system	3	4	7	Service Agreement is now in place between Aquacell and NEV specifying roles and responsibilities. Monthly performance reports from Aquacell to NEV. Performance level KPIs set into the agreement. Ability to rescind agreement if performance not met. Verification monitoring (when developed)	2	3	5			14/3/2016: Remove "Roles and responsibilities" to be further developed and training and records management to be covered in this. Add: Ensure that records management is developed to help review and monitor this event. Risk scores added.
General/ Whole of System	WoS10	Resourcing issues due to greying of the workforce, unavailability of appropriately qualified staff, staff turnover leading to water quality issues	4	3	7	NEV members are the workforce. Plan to increase education and training in the NEV Water Utility arm. Ability to contract in resources as required.	3	3	6		14/3/2016: Remove "Not considered an issue for this system" Risk scores added.	
General/ Whole of System	WoS11	Failure of critical monitoring devices resulting in unknown water quality	3	5	8	Instrument selection (fit for purpose and capable of holding calibration) Verify calibration through operator checks Calibration schedule Process validation programmed into control system	1	4	5		Low and high warning alarms Low low and high high	Consider having critical spares available

Risk Register Potable Water Supply

Process Step	Risk #	Potential Hazards and Hazardous Event	Maximum Risk L	Maximum Risk C	Max. Risk Score	Preventative Measures	Residual Risk L	Residual Risk C	Resid. Risk Score	Uncertainty	Comments	Further Actions
3. Break Tank		Biological, physical and chemical hazards Water quality deterioration in Break Tank	2	3	5	Good flow-through and not excessive storage Covered, physically secure Water treatment plant (proposed)	1	2	3			Cover Break Tank in distribution reservoir management plan 14/3/2016: Remove this event as the new system design does not have a break tank but goes straight to pre-treatment.
4. Microfiltration		Biological and physical hazards Excessive turbidity interfering with the efficiency of the UV disinfection system	3	5	8	Filter to waste after clean and can divert off-spec water. Turbidity meter is alarmed - high alarm diverts off-spec water. Online turbidity meter. UVI is alarmed and will shut down plant for high alarm.	1	3	4			Clarify what will happen to off-spec water in this case. Need to develop an incident response plan in consultation with NSW Health which includes notification to NSW Health when a CCP is breached.
5. UV disinfection		Biological hazard Low UV dose leading to poor UV disinfection or UV lamp failure or a fault with the system	3	4	7	UV intensity meter - alarmed (UVI) Lamp replacement program Lamp run hours meter Operator training. Fault alarms (e.g. ballast failure) Still have chlorine for chlorine sensitive pathogens.	1	4	5			Develop CCP procedure
5. UV disinfection		Biological hazard Excessive micro-organisms in filtrate, above the design value. (Biological contaminants pose a risk to humans via skin contact, inhalation or accidental ingestion). Lamp tube fouling	3	4	7	Controls on MF including pressure decay testing. Online turbidity meter. UVI sensor - alarmed, system shuts down for high alarm. Locate UV after MF Verification monitoring downstream. Chlorine dosing for chlorine sensitive pathogens.	1	4	5			
5. UV disinfection		Physical hazard Poor hydraulics through the UV (lack of mixing) leading to short circuiting, high flows through the UV above the design flow.	2	4	6	Verification testing Equipment and installation compliant with certification of system. Limiting maximum flow through UV unit to flow capacity of unit. Chlorine dosing for chlorine senstive pathogens.	1	4	5			
5. UV disinfection		Biological hazards Lamp breakage leading to disinfection failure	3	4	7	On-line monitoring of the UVI. Production stopped. Reputable supplier. Operator training. Chlorine dosing for chlorine sensitive pathogens.	2	4	6		Risk based on use of amalgam lamps from reputable supplier.	
5. UV disinfection		Biological hazard UVT outside of validated range leading to water not meeting log removal requirements	N/A		#VALUE!	Factory calibrated standard sensor. Regular checks. Chlorine disinfection			0		UVT will not be monitored.	Obtain RWQ data for colour.
Distribution System (lines, end use)		Reduced water quality from unlined fittings			0				0			14/3/2016: Remove event - not an issue for this system.
Distribution System (lines, end use)		No backup potable water available	N/A		#VALUE!				0			Consider alternate sources of potable water e.g. keeping GCC water to one building. Liaise with GCC. 14/3/2016: This event is dealt with in the Retail Supply Risk assessment. Agreement has been reached with Gosford Water to provide a source of potable water to NEV for Stage 1. Remove event from register.

Risk Matrix

Amended to fit risk management policy key

		Consequence				
		1	2	3	4	5
Likelihood	A	Low	Low	Low	Moderate	High
	B	Low	Low	Moderate	High	Very High
	C	Low	Moderate	High	Very High	Very High
	D	Low	Moderate	High	Very High	Very High
	E	Low	Moderate	High	Very High	Very High

Qualitative measures of likelihood

Level		Descriptor	Example of Description	Specifics
A	1	Rare	May occur only in exceptional circumstances	very rarely > annual
B	2	Unlikely	Could occur in unusual circumstances	chance of annual occurence
C	3	Possible	Might occur or should be expected to occur under certain circumstances	chance of monthly occurence
D	4	Likely	Will probably occur	chance of weekly occurence
E	5	Almost Certain	Is expected to occur	chance of daily occurrence

Qualitative measures of consequence

Level	Descriptor	Example of Description		
		Health	Financial	Environment
1	Insignificant	Insignificant impact or not detectable		
2	Minor	Minor impact on contact population, first aid treatment	> $10k Delay > 1 week	Minimal and short term harm to the environment
3	Moderate	Moderate impact on contact population, medical treatment required	> $200k Delay > 1 month	Significant harm to the local environment for a short period
4	Major	Major impact on contact population, extensive injuries	> $1m Delay > 6 months	Significant harm to the environment
5	Catastrophic	Potentially lethal on contact population, death	> $5m Indefinite delay	Significant, widespread harm outside local area

Risk Matrix

In line with Aquacell risk management policy

Likelihood	Consequence 1	2	3	4	5
1	Low	Low	Low	Low	High
2	Low	Low	Low	Moderate	High
3	Low	Low	Moderate	Significant	High
4	Low	Moderate	Significant	High	High
5	Moderate	Significant	High	High	High

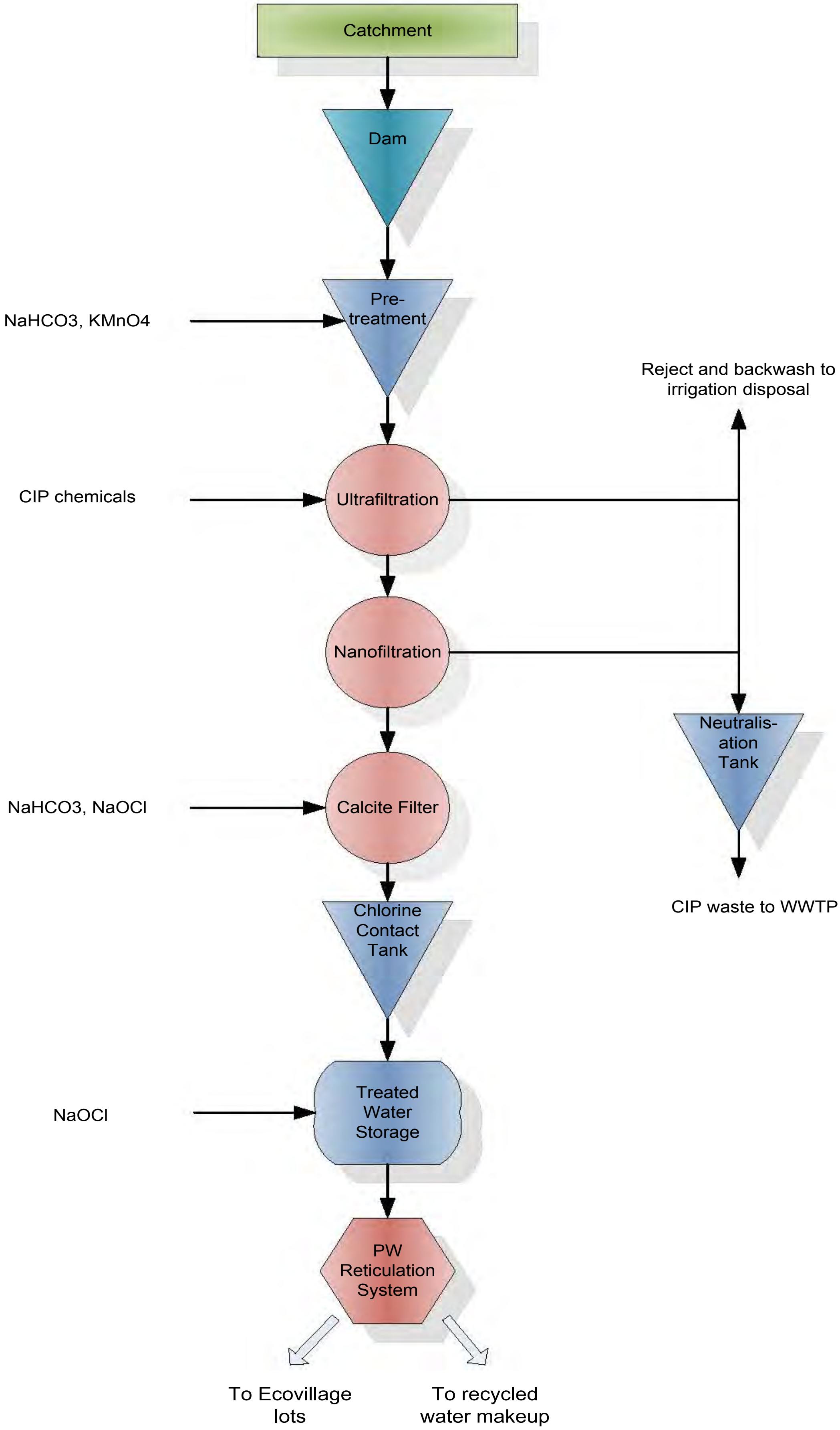
Qualitative measures of likelihood

Level	*Descriptor*	*Example of Description (ADWG 2011)*	
1	Rare	May occur only in exceptional circumstances	very rarely > annual
2	Unlikely	Could occur at some time	chance of annual occurence
3	Possible	Might occur or should be expected to occur at some time	chance of monthly occurence
4	Likely	Will probably occur in most circumstances	chance of weekly occurence
5	Almost Certain	Is expected to occur in most circumstancces	chance of daily occurrence

Qualitative measures of consequence

Level	*Descriptor*	*Example of Description* *Customer Service (Aquacell 2011)*	Regulatory/ Legal *(Aquacell 2011)*	Water Quality *(ADWG 2011)*
1	Insignificant	Individual customer effected	Insignificant legal, regulatory or internal policy failure	Insignificant impact, little disruption to normal operation, low increase in normal operation cost
2	Minor	Separate group(s) of customers effected	Minor legal, regulatory or internal policy failure	Minor impact for small population, some manageable operation disruption, some increase in operating costs
3	Moderate	Customer or community segment effected	Major legal, regulatory or internal policy failure Imposition of licence conditions	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
4	Major	Significant portion of customers effected	Major legal, regulatory or internal policy failure Imposition of licence conditions	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required
5	Extreme	Virtually all customers are effected	Significant legal, regulatory or internal policy failure Loss of licence(s)	Major impact for large population, complete failure of systems

Narara Potable Water Process Flow Diagram



Appendix 4.1.9.2 Drinking Water Management Improvement Plan

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A1	3.1	Prepare a recreational management policy for reservoir	NEV	Cmt1	Jun-15	Closed	Recreational Policy has been written
A2	2.1	Liaise with Strickland State Forest managers regarding location of walking tracks, feral animal populations and associated baiting programs, etc.	NEV	Cmt1, Cmt2	Feb-15	Open	Liason is ongoing
A3	2.1	Define catchment area including aerodrome etc.	NEV	Cmt1, Cmt6	Jan-15	Closed	Catchment map has been prepared
A4	2.1	Double-check land use in area (including agriculture).	NEV	Cmt2	Jan-15	Closed	Agricultural area at extereme Western limit of catchment of less than 1 ha.
A5	2.1	Establish raw water sampling program (capture a range of weather conditions, seasonal changes as much as possible). Include temperature, TOC/DOC, dissolved iron and aluminium, colour, turbidity, nutrients plus gross alpha and gross beta (one-off). Refer to Woodlots and Wetlands report for hydrogeology.	Aquacell	Cmt3, UV5, Cl5, Dst2, Dst3	Jan-15	Closed	Reservoir sampling program has been done and documented.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A6	6.2	Consider water quality issues in bushfire management plan including use of dam for firefighting and alternate sources of potable water. Liaise with Strickland State Forest, RFS and GCC.	NEV	Cmt5, Dam6		Closed	Alternate potable water source will be tankering water in and topping up the potable water header tanks. NEV to liaise with RFS to determine potential frequency.
A7	6.2	Prepare incident management plan/ procedures which includes water quality impacts, identifies relevant stakeholders (HAZMAT, EPA, Police, Fire, NSW Health) and also includes notification to NSW Health when a CCP is breached.	NEV	Cmt6, Flt3, Gen5	Jun-16	Open	This information has been addressed in the draft Drinking Water Quality Management Plan. It will be finalised before the plant is bought into commercial operation.
A8	2.1	Identify onsite sewage management systems by liaising with GCC.	NEV	Cmt7	Feb-15	Closed	Existing septic system has been upgraded to GCC requirements under conditions of consent for occupation of existing buildings
A9	3.1	Dam management plan to be developed with consideration as to how this fits with WICA licence.	Aquacell/ NEV	Dam1	Completion within 6 months from licence issue	Open	The dam has been de-prescribed. Safety Assessment and Draft Management plan has been prepared.
A10	2.1	Liaise with previous site manager regarding evidence of dam stratification/inversion and algal blooms (including instances of taste and odour).	NEV	Dam2, Dam5	Feb-15	Closed	No significant events were noted. Taste and odour were not recorded as dam has only previously been used for irrigation purposes. Former staff report dam was stocked with edible native fish species and was productive throughought the period since its construction.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A11	2.1	Check time from entry into dam to dam wall (refer Woodlots and Wetlands study).	Aquacell	Dam4	Mar-16	Open	
A12	3.1	Refer to Water Directorate website for algal management protocols.	Aquacell	Dam5	Sep-15	Open	Algal monitoring, management and CCP are covered in the Reservoir Water Management Plan
A13	4.3	Review where off-spec water will be diverted to and/or re-treated. Consult EPA about environmental discharges or send out of spec water to Break Tank instead of dam.	Aquacell/ NEV	Flt1, Flt3, Cl4	-	Closed	Off-spec water will go to irrigation disposal
A14	9.2	Review the log reductions provided by current process train.	Aquacell	Flt2	Mar-16	Open	For application, develop indicative list of log reductions for process units in place with further detail to be feshed out later. Need to know chlorine C.t, UVT and UV dose. Will take a multi-barrier approach to design. Refer to the 6 guiding principles in ADWG.
A15	3.2	Develop CCP procedure for UV disinfection.	Aquacell/ NEV	UV1	Mar-16	Open	Current design no longer has UV. Leave action open and review in Mar-15 once final design is known to ensure UV is not bought back in without this risk being considered.
A16	9.3	Confirm which guidelines the chlorine system is being designed to.	Aquacell	Cl1	Done	Closed	Chlorine system will be designed to USEPA standards.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A17	3.2	Develop CCPs in consultation with NSW Health. Refer to DWMS examples available online.	Aquacell/NEV	Cl1, PWT2	Jun-14	Closed	CCPs are addressed in the Drinking Water Management System Development Plan
A18	3.2	Consider whether water can be re-treated and prepare CCPs procedure accordingly.	Aquacell/NEV	Cl4	Jan-15	Closed	Off-spec water will go to the Break Tank.
A19	3.2	Consider chlorine residual at extremities in chlorination CCP.	Aquacell	Dst18	Jun-16	Open	Part of R&D/commissioning. Informed by seasonal and usage patterns.
A20	3.2	Ensure that IPART and NSW Health are involved in any changes to CCPs (once in place).	Aquacell /NEV	Gen7	Ongoing	Open	Aquacell will only change CCPs and CCP conditions in consultation with IPART and NSW Health.
A21	4.5	Determine distribution system materials.	Aquacell	Cct1	Mar-16	Open	To comply with AS3500 and AS4020.
A22	6.2	Develop a response protocol for reservoir contamination and/or loss of residual disinfectant (including manual chlorine dosing to reservoir).	Aquacell	PWT1, PWT2	Sep-15	Closed	The header tanks will have residual chlorine monitoring and dosing systems and a recirculation system to ensure residual chlorine levels remain within required limits.
A23	3.1	Reduce vegetation and develop ongoing vegetation management program.	NEV	PWT1	Aug-15	Open	Vegetation has been removed from dam crest and spillway areas. Draft Dam Management Plan has been prepared.
A24	5.1	Determine appropriate monitoring point for chlorine residual in distribution system.	Aquacell /NEV	PWT1	Mar-16	Open	Will be done as part of R&D/commissioning. Will have zones - refer to NSW Health guidance in developing monitoring program (element 5). Will be part of specification for reticulation design.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A25	9.3	Ensure that reservoir design considers mixing and considers reducing potential for stagnation.	Aquacell/ NEV	PWT2, PWT3	Sep-14	Open	The header tanks will have residual chlorine monitoring and dosing systems and a recirculation system to ensure residual chlorine levels remain within required limits.
A26	4.4	Determine reservoir inspection/ cleaning program once hydraulic considerations are finalised and also include Break Tank in this.	Aquacell/ NEV	PWT4, BTk1	Jun-16	Open	External inspection will be part of monitoring for Distribution Reservoir CCP. Internal inspection and cleaning will be a supporting program - NEV and Aquacell will liaise with reputable contractors such as Aqualift to determine the best way forward.
A27	3.1	Develop handover protocols to householders and plumbing inspection of buildings before occupancy (noting that this will be crucial to granting of licence).	NEV	Dst4	Jun-16	Open	Will be included in customer service supply contract.
A28	1.2	Consider including plumbing requirements in by-laws.	NEV	Dst4	Sep-15	Closed	Will be included in customer service supply contract.
A29	4.1	Develop procedures for mains work including separate equipment and clothing, hygiene procedures for water and sewer.	NEV	Dst5	Completion within 6 months from licence issue	Open	Procedures will be prepared and staff trained prior to commencement of operation. Water quality awareness training will be ongoing.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A30	3.1	Review backflow prevention/ cross connection policies in place for this scheme.	NEV	Dst6, Dst7	Completion within 6 months from licence issue	Open	Will be included in customer service supply contract. Appropriate auditing procedures (refer examples available on the web) for ongoing management will be prepared prior to commencement of operation. Water quality awareness training will be ongoing.
A31	2.3	Review cross connection risk once recycled water treatment plant finalised.	Aquacell/ NEV	Dst6	Post-commissioning of plant	Open	
A32	3.1	Develop trade waste policy.	Aquacell/ NEV	Dst7	N/A for Stage 1	Closed	In Stage 1 there will not be trade waste. Trade waste policy to be developed should they become part of future stages.
A33	7.1	Increase awareness of the DWMS process (See Public Health Act/ NSW Health Guidelines for DWMS available online).	Aquacell/ NEV	Dst7	Completion within 6 months from licence issue	Open	In developing reservoir CCP this will help from a distribution perspective. Will develop a handout/ awareness document. To be incorporated into Aquacell's current training procedures. Consider NWP279.
A34	6.2	Consider alternate sources of potable water e.g. keeping GCC water to one building, carting water. Liaise with GCC.	NEV	Dst8		Closed	Back up water will be supplied by carting water.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A35	4.1	Develop distribution system cleaning/ maintenance procedures (currently in progress). Ensure that mains breaks and turnover in water direction, pressure, system operation are covered.	NEV	Dst10, Dst11, Dst14	Completion within 6 months from licence issue	Open	Will be finalised prior to commercial operation.
A36	3.1	Consider water carting access and whether it will be appropriate for this system.	NEV	Dst12	Before commercial operation	Open	NEV to liase with local water carters and put processes into place to ensure propective carters do not contaminate water supply
A37	9.3	Determine how firefighting water supply will be provided.	NEV	Dst13		Closed	Water for fire fighting will be stored in 400 kL buffer tanks and reticulated in common with drinking water and delivered via hydrants located within road reserves.
A38	4.1	Ensure that mains breaks are covered in distribution system maintenance plan/procedures.	NEV	Dst14	Completion within 6 months from licence issue	Open	Will be finalised prior to commercial operation.
A39	3.1	Consider backflow prevention devices at water meters.	NEV	Dst15		Closed	Will be installed.
A40	9.3	Consider how dead ends in the reticulation are dealt with during the staging process.	Aquacell/ NEV	Dst17	Mar-16	Open	To be included in specifications. Also consider chlorine residual.
A41	5.1	Develop verification monitoring program with consideration of NSW Health Drinking Water Monitoring Program (available online).	Aquacell/ NEV	Dst18	Mar-16	Open	Will be finalised prior to commercial operation.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A42	8.2	Review notification regarding accidental consumption of non-potable water once program completed by Aquacell. Liaise with PHU regarding this.	NEV	Gen1	Mar-16	Open	Will be finalised prior to commercial operation.
A43	4.5	Review program for management of materials and chemicals once completed by Aquacell.	NEV	Gen2	Prior to Commercial Operation	Open	Detailed design to be completed first to understand types and volumes of chemicals required
A44	4.5	Develop a system for storing materials and cover in contract.	Aquacell/NEV	Gen2	Mar-16	Open	Cover in plant construction and operation contract and ongoing. Consider storage in plant design and cover in O&M manual.
A45	4.5	Review chemical specifications/ certificates and verify OK for drinking water.	Aquacell	Gen2	Completion within 6 months from licence issue	Open	Chemicals handling protocol to be developed. Will only buy from reputable suppliers e.g. Orica/Elite (need to check no UV stabilisers etc - confirm suitable for drinking) etc.
A46	9.3	Consider designing-in different fittings for different chemicals.	Aquacell	Gen3	N/A	Closed	Only sodium hypochlorite plus CIP chemicals. No bulk deliveries. All points labelled and operators trained and aware.
A47	6.2	Consider establishing an agreement with a local generator supplier.	NEV	Gen4	Prior to site occupancy	Open	Permanent back up generator will be provided for WWTP. Back-up power will be part of smart grid design for whole of site.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A48	3.1	Review security around dam and WTP.	Aquacell/ NEV	Gen6	Completion within 6 months from licence issue	Open	Dam - will be part of dam management plan. WTP - to be part of design (form of security to be determined down the track e.g containerised/fenced).
A49	4.1	Include security checks in reservoir and site inspection programs.	Aquacell/ NEV	Gen6	Completion within 6 months from licence issue	Open	Will include checklist for security and have regard to inspection checklist in DWMS materials.
A50	7.2	Review method for ensuring skills currency and competency for drinking water.	Aquacell/ NEV	Gen7	Sep-15	Closed	Covered in the relevant position descriptions.
A51	7.2	Consider water quality awareness and training for contractors also.	Aquacell/ NEV	Gen7	Feb-16	Open	Include in site induction process.
A52	7.1	Develop roles and responsibilities further (including for training and records management).	Aquacell/ NEV	Gen8, Gen9	Completion within 6 months from licence issue	Open	Covered in position descriptions and responsibilities and authorities matrix included in the DWMS.
A53	4.4	Consider having critical spares available.	Aquacell/ NEV	Gen11	Before commercial operation	Open	List critical spares in O&M manual. Update list of inventory.
A54	1.2	Update the position descriptions and IMS to include drinking water specific requirements.	Aquacell	-	Before commercial operation	Open	
A55	4.1	Liaise with reputable contractors such as Aqualift to determine the best way forward for internal inspection and cleaning of reservoirs.	Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A56	4.2	Develop service inspection sheets	Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A57	4.2	Develop operational monitoring program	Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A58	4.5	Develop chemical handling protocol	Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A59	5.1	Determine the first point of contact for customers and associated training/awareness program.	NEV	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A60	5.3	Determine how water quality results will be communicated for this scheme.	Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A61	6.1	Review incident and emergency management documents in IMS specifically for this project.	NEV / Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A62	6.2	Develop specific emergency response procedures for this site, based on existing Incident and Emergency Management Procedure IE010-3.	NEV / Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.
A63	7.1	Adapt existing training documents (plans, procedures and records) for this scheme	NEV / Aquacell	-	Prior to plant commissioning	Open	Prior to plant commissioning
A64	7.2	Review available National Water Package training units for suitability and consider putting staff through NWP279.	NEV / Aquacell	-	Prior to plant commissioning	Open	Prior to plant commissioning

Action #	ADWG Framework	Task/ Activity	Responsibil	Risk #	Timing/ Priority	Status	Comments/ Notes
A65	10.2	Review/adapt standard reporting protocols will be refined for this scheme.	NEV / Aquacell	-	Before commercial operation	Open	Will be finalised prior to commercial operation.

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Narara Ecovillage
Potable Water Scheme

Drinking Water Management System Development Plan

ADWG Framework Compliance and Critical Control Points

12 June 2014

Aquacell Project A0072

Prepared by:
City Water Technology Pty Ltd and RiskEdge Pty Ltd
on behalf of Aquacell Pty Ltd

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Revision 2, 16 June 2014

Aquacell Pty Ltd
Unit 1/10b Production Place, Penrith NSW 2750, Australia
PO Box 7091, Leura NSW 2780, Australia
P: +61 2 4721 0545 F: +61 2 4721 2761
www.aquacell.com.au
ABN 79 072 487 015

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1 Compliance with Australian Drinking Water Guidelines

The table below lists the 12 elements of the *Framework for Management of Drinking Water Quality* (as per the ADWG) and shows how the NEV scheme will meet the various elements. Actions to improve compliance have been included on the Drinking Water Quality Management System (DWMS) Improvement Plan.

Table 1-1: ADWG Framework Elements

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 1: Commitment to responsible use and management of recycled water quality		
1.1 Drinking water quality policy: - Formulate a drinking water quality policy, endorsed by senior executives, to be implemented throughout the organisation. - Ensure that the policy is visible and is communicated, understood and implemented by employees.	- Drinking water quality has been integrated into Aquacell's existing Recycled Water Policy (IMS Document EM010). - Aquacell's policies are communicated as part of the induction program and are available via IMS/intranet.	- Aquacell draft Water Quality Policy. *IMS Document EM010.*
1.2 Regulatory and formal requirements: - Identify and document all relevant regulatory and formal requirements. - Ensure responsibilities are understood and communicated to employees. - Review requirements periodically to reflect any changes.	- Legal requirements are mentioned in the position descriptions and 'Regulatory and Legal' section of IMS which is available via Intranet. The position descriptions and IMS will be updated to include drinking water specific requirements. - There is an automatic notification to staff when these documents are updated. The Managing Director is responsible for ensuring that updates are communicated to the relevant staff. - Aquacell is currently in the process of reviewing all of its regulatory and formal requirements (the Managing Director is responsible for ensuring currency).	- WICA Application - Gosford City Council DA - Appendix 4 of this document.

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
1.3 Engaging stakeholders: - Identify all stakeholders who could affect, or be affected by, decisions or activities of the drinking water supplier. - Develop appropriate mechanisms and documentation for stakeholder commitment and involvement. - Regularly update the list of relevant agencies.	- Communication with stakeholders is covered in Community Engagement Procedure CS020-3. Specific stakeholders to be identified in a separate register for each project (located in management plan). - Aquacell will include a note in IMS to refer to the relevant management plan. The management plan will be reviewed as part of review of the DWMS. - The NEV Co-operative Ltd actively involves all its members in the planning and approval of the development and its infrastructure. The Co-operative operates under Dynamic Governance, which seeks to achieve fair, inclusive, transparent, accountable and creative decision-making processes. A working group of interested members has been involved from the early stages of the project looking at the technical aspects of the project and helping to choose technology options. - The NEV has a website which contains information on the proposed development with contact details and invitation for comment and further information.	- Aquacell's existing Community Engagement Procedure CS020-3 - NEV website - NEV Community Management Statement (draft)
Element 2: Assessment of the drinking water supply system		

2.1 Water supply system analysis:
- Assemble a team with appropriate knowledge and expertise.
- Construct a flow diagram of the water supply system from catchment to consumer.
- Assemble pertinent information and document key characteristics of the water supply system to be considered.
	- For each Aquacell project, a person with specific responsibility for that project is assigned. There will be a detailed table of roles and responsibilities developed for this scheme. The core water quality team consists of:
	  - Technical Manager
	  - Project Manager
	  - Operations Manager
	  - Environmental Officer
	  - Service Engineers/ Technicians
	- A flow diagram has been developed for the scheme.
	- Key characteristics of the water supply have been documented in *Narara Eco-Village - Water Management Systems Overview* (Appendix 1.1 to the application) and the *Risk Assessment Summary Paper for the proposed potable water supply system at Narara Ecovillage* (CWT, March 2014).
		- Project organisational chart (appendix 3.4.2 of the application).
		- System process flow diagram (appendix 4.1.1.1 of the application).
		- *Narara Eco-Village - Water Management Systems Overview*
		- *Risk Assessment Summary Paper for the proposed potable water supply system at Narara Ecovillage* (CWT, March 2014)

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
2.2 Assessment of water quality data: - Assemble historical data from source waters, treatment plants and finished water supplied to consumers (over time and following specific events). - List and examine exceedances. - Assess data using tools such as control charts and trends analysis to identify trends and potential problems.	- The raw water monitoring program will commence in July 2014. Other monitoring will be carried out as per Element 4 (operational monitoring) and Element 5 (verification monitoring). - CCP exceedences will show up on SCADA interface. All other exceedences will be monitored and reported manually. - Aquacell's Technical Manager will be responsible for ongoing data assessment and analysis at a frequency specified in the monitoring program(s).	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT

2.3 Hazard identification and risk assessment:
- Define the approach and methodology to be used for hazard identification and risk assessment.
- Identify and document hazards, sources and hazardous events for each component of the water supply system.
- Estimate the level of risk for each identified hazard or hazardous event.
- Evaluate the major sources of uncertainty associated with each hazard and hazardous event and consider actions to reduce uncertainty.
- Determine significant risks and document priorities for risk management.
- Periodically review and update the hazard identification and risk assessment to incorporate any changes.
	- A risk assessment has been conducted (24th March 2014). The Summary Paper includes:
	  - the methodology used for hazard identification and risk assessment
	  - the Risk Register, containing:
	    - identified hazards and hazardous events
	    - estimated levels of risk for each hazardous event
	    - sources of uncertainty and actions to reduce uncertainty
	    - identification of significant risks
	    - existing control measures in place
	    - additional control measures proposed or actions to reduce the residual risk as required
	- The Risk Register will be reviewed at the following stages:
	  - Design
	  - Construction
	  - Commercial operation
	  - Prior to audits (according to ongoing audit schedule)
		- *Risk Assessment Summary Paper for the proposed potable water* supply *system at Narara Ecovillage* (CWT, March 2014)

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 3: Preventative measures for drinking water quality management		
3.1 Preventative measures and multiple barriers: - Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk. - Evaluate alternative or additional preventive measures where improvement is required.	- Existing preventive measures were captured at the Risk Assessment Workshop and are detailed within the Risk Register. Where gaps were noted with the existing system, actions to address the gaps were logged in the Risk Register and transcribed to the Action Plan. - Preventative measures will be reviewed upon review of the Risk Register (as outlined for component 2.3 above).	- *Risk Assessment Summary Paper for the proposed potable water* supply *system at Narara Ecovillage* (CWT, March 2014)
3.2 Critical control points: - Assess preventive measures from catchment to consumer to identify critical control points. - Establish mechanisms for operational control. - Document the critical control points, critical limits and target criteria.	- Preliminary critical control points (CCPs) have been identified, as summarised in Section 2.2 below. - Once approved, Aquacell will only change CCPs and CCP conditions in consultation with IPART and NSW Health.	- Section 2.2 of this document.

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 4: Operational procedures and process control		

4.1 Operational procedures:
- Identify procedures required for processes and activities from catchment to consumer
- Document all procedures and compile into an operations manual.
	- Aquacell will develop an O&M Manual.
	- Aquacell and NEV will prepare a dam management plan.
	- Standard Operating Procedures/ Work Instructions will be prepared for the following tasks:
	  - Plant security and maintenance
	  - Filter and backwash inspections
	  - Walkaround and visual inspections
	  - Reservoir Inspections
	- Other plans/procedures will be prepared for the following:
	  - Backflow and cross connection prevention
	  - Blue-green algae management
		- Operations and Maintenance Manual (to be compiled prior to commencement of operation)
		- Aquacell Trouble Shooting Guide (IMS Document OM070)
		- Aquacell Work instructions (to be prepared prior to commencement of operation)

4.2 Operational monitoring: - Develop monitoring protocols for operational performance of the water supply system, including the selection of operational parameters and criteria, and the routine analysis of results. - Document monitoring protocols into an operational monitoring plan.	- Log sheets will be developed for raw and treated water quality monitoring. - Aquacell's Operations Manager will be responsible for reviewing results and reporting. - Water quality performance reports will be supplied with bills. - SCADA and telemetry will also be used to monitor the system. - Service inspection sheets will be developed for this project. - An operational monitoring plan will be developed for this project.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
4.3 Corrective action: - Establish and document procedures for corrective action to control excursions in operational parameters. - Establish rapid communication systems to deal with unexpected events.	- Corrective actions are included in CCP tables (see Section 2.2 of this document). - Refer to Element 6 below for incident management.	- Section 2.2 of this document

4.4 Equipment capability and maintenance:
- Ensure that equipment performs adequately and provides sufficient flexibility and process control.
- Establish a program for regular inspection and maintenance of all equipment, including monitoring equipment.
	- Treatment equipment will be of standard and reliable design and will be maintained by qualified suppliers.
	- Instrument capability and maintenance will be via:
	  - Instrument selection (fit for purpose and capable of holding calibration)
	  - Operator checks to verify calibration
	  - Calibration schedule
	  - Process validation programmed into control system
		- A service agreement (to be finalised) will exist between NEV Co-op and Aquacell for the maintenance and service of the recycled water treatment system.

4.5 Materials and chemicals: - Ensure that only approved materials and chemicals are used. - Establish documented procedures for evaluating chemicals, materials and suppliers.	- All plumbing and drainage work is conducted in a manner conforming to AS/NZS 3500. - All materials will comply with AS 4020. - All chemicals will be purchased from reputable suppliers (e.g. Orica/Elite) and will be checked to confirm suitable for drinking (e.g. no UV stabilisers etc). - A chemicals handling protocol will be developed.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 5: Verification of drinking water quality		
5.1 Drinking water quality monitoring: - Determine the characteristics to be monitored in the distribution system and in water as supplied to the consumer. - Establish and document a sampling plan for each characteristic, including the location and frequency of sampling. - Ensure monitoring data is representative and reliable.	- The verification monitoring program will be developed as part of the R&D/commissioning phase of the project. This will be informed by the specification for the reticulation design. - The monitoring program will be developed in consultation with NSW Health.	
5.2 Customer satisfaction: - Establish a consumer complaint and response program, including appropriate training of employees	- Aquacell has a Complaints Handling and Dispute Resolution Policy CS030-3. Requests are logged and reviewed in weekly operations meeting. - The first point of contact for customers and associated training/awareness program will need to be determined in association with NEV. - Aquacell's Customer Services Charter has been updated to include drinking water.	- Aquacell's Complaints Handling and Dispute Resolution Policy CS030-3 - Aquacell's draft Customer Services Charter
5.3 Short term evaluation of results: - Establish procedures for the daily review of drinking water quality monitoring data and consumer satisfaction. - Develop reporting mechanisms internally, and externally, where required.	- On a day-to-day basis, the system will be monitored remotely via prioritised alarms and interlocks. - Water quality issues will be discussed at a weekly operations meeting. - Trends will be reviewed on a monthly basis or more frequently as required. - CCPs and other water quality alarms will be distributed automatically and corrective actions applied as per CCP tables. Any parameter outlier will be referred to Aquacell's Technical Manager.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
5.4 Corrective action: - Establish and document procedures for corrective action in response to non-conformance or consumer feedback. - Establish rapid communication systems to deal with unexpected events.	- Aquacell has a Complaints Handling and Dispute Resolution Policy CS030-3. Requests are logged and reviewed in weekly operations meeting..	- Aquacell's Complaints Handling and Dispute Resolution Policy CS030-3
Element 6: Management of incidents and emergencies		
6.1 Communication: - Define communication protocols with the involvement of relevant agencies and prepare a contact list of key people, agencies and businesses. - Develop a public and media communications strategy	- Incidents and emergencies are covered in Aquacell's IMS and will be reviewed specifically for this project.	
6.2 Incident and emergency response protocols: - Define potential incidents and emergencies and document procedures and response plans with the involvement of relevant agencies - Train employees and regularly test emergency response plans - Investigate any incidents or emergencies and revise protocols as necessary	- Specific emergency response procedures will be developed for this site, based on existing Aquacell Incident and Emergency Management Procedure IE010-3.	- Aquacell's Incident and Emergency Management Procedure (IMS Document IE010)

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 7: Employee awareness and training		
7.1 Employee awareness and involvement - Develop mechanisms and communication procedures to increase employees awareness of and participation in drinking water quality management	- Aquacell has a Training Register in place. Any new training requirements are reviewed at the annual performance review, unless identified in the interim. These procedures will be adapted to include this scheme.	
7.2 Employee training: - Ensure that employees, including contractors, maintain the appropriate experience and qualifications - Identify training needs and ensure resources are available to support training programs - Document training and maintain records of all employee training	- Aquacell will develop a training plan for this scheme and ensure that personnel are trained to carry out procedures. Roles and responsibilities will be further developed and training and records management to be covered in this. - Records will be maintained in the training register. The HR Manager is responsible for maintaining training records. - Aquacell maintains selection criteria and job descriptions to ensure that new staff have appropriate skills and qualifications. - Aquacell will use manufacturer training for the relevant process units. - Aquacell will review available National Water Package training units for suitability. - Aquacell has the following procedure in place: Training Procedure HR120-2. The training register is a component of this.	- Aquacell's Training Procedure HR120-2
Element 8: Community involvement and awareness		
8.1 Community consultation: - Assess requirements for effective community involvement. - Develop a comprehensive strategy for community consultation.	- In the NEV Ecovillage development, the key stakeholders are the members of the village community. The community consultation process is therefore similar to the stakeholder consultation process described in Element 1. This includes community education and a Dynamic Governance process that seeks to involve all the members in decision making. - Aquacell has a Community Engagement Procedure CS020-3 in place. - Specific community engagement for NEV will be included in the Community Management Statement (Appendix 4.1.4 to this application).	- Aquacell's Community Engagement Procedure CS020-3 - Community Management Statement - NEV website - NEV Community Association Charter

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
8.2 Communication: - Develop an active two-way communication program to inform consumers and promote awareness of drinking water quality issues.	- Communication will be included in the Community Engagement Procedure CS020-3 and Community Management Statement (Appendix 4.1.4 to this application).	- Aquacell's Community Engagement Procedure CS020-3 - Community Management Statement
Element 9: Research and development		
9.1 Investigative studies and research monitoring: - Establish programs to increase understanding of the water supply system. - Use information to improve management of the water supply system.	- Aquacell has a formalised R&D approach to all of its schemes. Active discussion by the team takes place in the form of workshops and detailed R&D plans. - Risk assessment review and weekly operational meetings will be used to identify areas for further investigation and research specifically for the NEV scheme. Depending on the scope and nature of the study, this would be included in either the Drinking Water Quality Improvement Plan or Aquacell's R&D Plan.	
9.2 Validation of processes: - Validate processes and procedures to ensure that they are effective at controlling hazards. - Revalidate processes periodically or when variations in conditions occur.	- Short and long term evaluation of data is used to assess the effectiveness of existing processes. See Element 5 and 11 above. - Processes will be revalidated as future stages in the project come online. This will include a review of capacity and a review of the risk register for drinking water quality.	
9.3 Design of equipment: - Validate the selection and design of new equipment and infrastructure to ensure continuing reliability.	- Selection and design of new equipment is subject to Aquacell's design process which include reviews, approvals, HAZOP and HACCP phases.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 10: Documentation and reporting		
10.1 Management of documentation and records: - Document information pertinent to all aspects of drinking water quality management. - Develop a document control system to ensure current versions are in use. - Establish a records management system and ensure that employees are trained to fill out records. - Periodically review documentation and revise as necessary.	- Aquacell's procedures are stored in its IMS and records are stored in the CMMS. - SCADA is also used to record and store data. - All documents and records are backed up to external drives and 'the cloud'. - Review dates are included in the footer on individual documents.	
10.2 Reporting: - Establish procedures for effective internal and external reporting. - Produce an annual report to be made available to consumers, regulatory authorities and stakeholders.	- Water quality and plant performance will be reported to NEV on a monthly basis. Aquacell's standard reporting protocols will be refined for this scheme. - Senior members of Aquacell discuss relevant water quality issues on a frequent basis. Decisions on improvements in operational equipment and infrastructure issues will arise from these discussions. The NEV scheme will be included as part of these discussions. Aquacell will communicate the outcomes to the NEV team where relevant. - Aquacell generally undertakes at least an annual review meeting with each of its scheme clients. Reporting requirements will also be determined as part of the contractual requirements with NEV. - Aquacell will report to IPART as per licence conditions.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
Element 11: Evaluation and audit		
11.1 Long-term evaluation of results: - Collect and evaluate long-term data to assess performance and identify problems. - Document and report results.	- Aquacell's Technical Manager will be responsible for review of data and long-term evaluation of results. - Results will help to inform risk assessment reviews. - As outlined above, senior Aquacell personnel discuss and review issues. - Reporting will be as outlined in component 10.2 above.	
11.2 Audit of drinking water quality management: - Establish processes for internal and external audits. - Document and communicate audit results.	- Aquacell will be subject to WICA licence audits. - Internal audits will be scheduled to precede the licence audit by approximately two months. - Informal inspections will be undertaken by operators.	
Element 12: Review and continual improvement		

12.1Review by senior executive:
- Senior executive review of the effectiveness of the management system.
- Evaluate the need for change.
	- Aquacell's Technical Manager, Project Manager, Managing Director, Operations Manager, HR Manager review the effectiveness of the management system on a project-by-project basis. Aquacell's current method for review of the management system is:
	  - Pre-audit (with minutes of meeting)
	  - Risk assessment review (action plan)
	- This approach will be reviewed for the NEV scheme.
	- As outlined for Component 10.2 above, senior members of Aquacell discuss relevant water quality issues on a frequent basis.	

FRAMEWORK ELEMENT	ACTIVITY	REFERENCE DOCUMENT
12.2 Drinking water management improvement plan: - Develop a drinking water quality management improvement plan. - Ensure that the plan is communicated and implemented, and that improvements are monitored for effectiveness.	- Actions to improve risk management in the water supply system were identified in the risk workshop of 24th March 2014. - An Improvement Plan, including the assignation of responsibilities and priorities, has been developed for implementation of the actions. - Actions continue to be added to the Improvement Plan as they are identified.	- Improvement Plan

2 Operational monitoring and process control

The following CCPs are based on prior experience and are expected to arise out of the HACCP review once this has been formally held. Any changes or additions that arise from the review will be included in the document prior to commissioning.

The critical control points and responses are outlined below:

Raw Water Pump Station	Membrane Filtration	UV Disinfection	Chlorine Disinfection	Distribution Reservoirs
CCP 1	CCP 2	CCP 3	CCP 4	CCP 5

2.1 Water quality monitoring

Aquacell will develop a drinking water quality monitoring program in consultation with NSW Health. This may be based on *NSW Health Drinking Water Monitoring Program December 2005* or Chapter 9 of *Australian Drinking Water Guidelines 2011.*

2.2 Critical control points

2.2.1 CCP1 – Algal Management

Observation of the raw water source for algal scums will form part of the operator checks.

Quantitative limits for this critical control point cannot be established until the raw water sampling has been completed. This action is identified in the Drinking Water Improvement Plan.

CCP1	**Algae Management**
	Cells or biovolume
Critical limits/Alert limits	
Alert	Aquacell TBD if this CCP will be used
Critical	Aquacell TBD if this CCP will be used
Monitoring procedures	
What	Aquacell TBD if this CCP will be used
How	Aquacell TBD if this CCP will be used
When	Aquacell TBD if this CCP will be used
Where	Aquacell TBD if this CCP will be used
Who	Aquacell TBD if this CCP will be used
Corrective actions	
What	Aquacell TBD if this CCP will be used
How	Aquacell TBD if this CCP will be used
When	Aquacell TBD if this CCP will be used
Where	Aquacell TBD if this CCP will be used
Who	Aquacell TBD if this CCP will be used

2.2.2 CCP2 – Membrane Filtration

CCP2	**Membranes**	
	Filtrate Turbidity	**Pressure Decay Rate (PDR)**
Critical limits/Alert limits		
Alert	> 0.2 NTU	TBA kPa/min
Critical	> 0.5 NTU	TBD kPa/min
Monitoring procedures		
What	Turbidity	Pressure decay
How	Sensor	Automatic test cycle
When	Continuous, Online	Daily
Where	Filtrate line	Membrane modules
Who	Aquacell/Automatic	Automatic
Corrective actions		

What	Recirculation mode	Shutdown if above critical level
How	Open recirculation valve	Close valves and turn off pump
When	Immediately if turbidity exceeds 0.5 NTU	Immediately
Where	Filtrate line	Membrane skid
Who	Aquacell/Automatic	Automatic

Turbidity

If the turbidity exceeds the critical level the filtrate flow is diverted from treated water to recirculation back to the Break Tank. If after 30 minutes the filtrate turbidity is still above the critical level, the membrane system will go to standby and a "shutdown on high turbidity" alarm will be generated.

Production resumes when the operator resets the turbidity alarm after the cause has been identified and addressed.

Pressure Decay Rate:

The PDR for this unit is chosen based on the application of theory as described in the US EPA Membrane Filtration Guidance Manual (USEPA, 2005). The critical PDR is based on achieving an LRV of 4 for bacteria/protozoa (≥ 1 µm).

A pressure decay test is carried out daily at a set time automatically by the PLC. If the resulting decay rate exceeds the critical value the plant will shutdown and alarm. The operator must then investigate the problem and retest the unit before processing water to storage.

2.2.3 CCP3 – UV Disinfection

CCP3	**UV disinfection**		
	UV RED	**Lamp status**	**Water flow**
Critical limits/Alert limits			
Alert	75 mJ/cm^2	12,000 hours or failure	≥ 3,800 L/h
Critical	71 mJ/cm^2	Lamp fail	≥ 4,000 L/h
Monitoring procedures			
What	UVI	Lamp life and lamp fail	Water flow
How	Sensor	PLC record and UV unit control module	PLC
When	Continuous, Online	Continuous, Online	Continuous, online
Where	UV	UV	Before UV
Who	PLC/Automatic	PLC/Automatic	PLC/Automatic
Corrective actions			
What	Treated water is recycled to before UV	UV unit stopped on lamp fail, and treated water diverted to Break Tank	UV unit stopped, and treated water diverted to Break Tank
How	Recycle Valve	UV off signal from PLC stops UV, PLC closes inlet valve to UV	UV off signal from PLC stops UV, PLC closes inlet valve to UV
When	Immediate	Immediate	Immediate
Where	After chlorine contact system	UV Control module and PLC	PLC
Who	PLC/Automatic	PLC/Automatic	PLC/Automatic

UV dose
If the UV dose drops below alert level an alarm is triggered to warn the operator that the UV system is approaching low UV dose. Operator can then check unit operation and rectify before UV dose reaches critical level. If the critical level is reached the UV unit diverts treated water production back to the Break Tank. Return to production requires the UV fault to be rectified and recirculation of water post chlorine contact for at least 30 minutes.

Lamp Status
Lamp status is monitored continuously by the UV control module. If a lamp failure is detected an alarm output is sent to the PLC and production of treated water to storage is stopped immediately by closing the inlet valve to the UV unit and stopping the unit. The UV unit remains shutdown until the failed lamp is replaced and treated water is diverted to the Break Tank.

Water Flow
The water flow to the UV must be at least equal to the minimum flow to avoid overheating, and below the maximum validated flow for the unit to ensure disinfection performance is not compromised.

If the flow is outside the alert range an alarm is generated (UV high flow or UV low flow).

If it is outside the critical range an alarm is raised (UV shutdown on low flow, or UV shutdown on high flow) and the UV unit is shutdown. In both cases, treated water is diverted to the Break Tank.

Impact of measurement time delay
Delays between the point of measurement and the control system response could occur due to signal transmission time delays, PLC delays including noise filtering on alarms, output response delays and valve opening and closing time. In total this might between 10 seconds and 30 seconds. The NEV system is designed such that the UV system is directly upstream of the chlorine contact system. The recirculation valves to return out of specification water back to the Break Tank are downstream of the chlorine contact system. Therefore, if a UV fault is detected that requires the UV to shutdown, the comparatively long residence time in the chlorine contact systems ensures that no untreated water will be sent to storage.

There is a time delay in starting up the UV in which partially treated water passes through the UV to the Chlorine Contact Tank. Transfer of treated water to storage will be delayed following UV start up by an amount of time calculated to be equal to the detention time in the chlorine system at the set flow.

2.2.4 CCP4 – Chlorine Disinfection

CCP4	**Chlorine disinfection**			
	Residual free chlorine	**Water pH**	**Water temperature**	**Water flow**
Critical limits/Alert limits				
Alert	< 0.6 mg/L	pH < 6.6 or pH > 7.4	≤ 12°C	> 3,800 L/h
Critical	< 0.5 mg/L	pH <6.5 or pH > 7.5	≤ 10°C	> 4,000 L/h
Monitoring procedures				
What	Free Residual Chlorine (FRC)	pH	Temperature	Water flow
How	Sensor	Probe	Thermocouple	Inline flow meter
When	Continuous, Online	Continuous, Online	Continuous, Online	Continuous

Where	At the end of the chlorine contact pipe	At the end of the chlorine contact pipe	At the end of the chlorine contact pipe	Inlet to UV and chlorine contact system
Who	PLC/Automatic	PLC/Automatic	PLC/Automatic	PLC/automatic
Corrective actions				
What	Treated water is recycled to the Break Tank/ before UV	Treated water is recycled to the Break Tank/ before UV	Treated water is recycled to the Break Tank/ before UV	Shutdown and check flow control elements (VSD and flowmeter)
How	Recycle Valve	Recycle Valve	Recycle Valve	Shutdown filtration unit
When	Immediate	Immediate	Immediate	Immediate
Where	After chlorine contact system	After chlorine contact system	After chlorine contact system	Membrane skid
Who	PLC/Automatic	PLC/Automatic	PLC/Automatic	PLC/Automatic

Residual Free Chlorine:
The disinfection is based on the World Health Organization's recommendation that effective disinfection can generally be achieved by applying a 30 minute contact time to a free chlorine concentration of 0.5 mg/L (WHO 2011). This target will be reviewed and adjusted if necessary as part of the HACCP review.

If the free residual chlorine level drops below the critical level then the treated water is recycled back to the break tank until the chlorine residual is above the critical level. An alarm is raised to make the operator aware that delivery of treated water has ceased due to chlorine residual out of range.

Treated Water pH:
If the pH of the treated water measured at the outlet of the chlorine contact system drops below the critical level or rises above the maximum level then the treated water is recycled back to the break tank until the pH is within the required range. An alarm is raised to make the operator aware that delivery of treated water has ceased due to pH out of range.

Water Temperature:
The chlorine contact system has been designed based on a minimum temperature of 10°C. It is important to ensure that chlorine contact occurs above this temperature so as to ensure effective inactivation of pathogens.

If the temperature of the treated water measured at the outlet of the chlorine contact pipe drops below the critical level of 10°C the treated water is recycled back to the Break Tank until the temperature is above 10°C. An alarm is raised to make the operator aware that delivery of treated water has ceased due to temperature out of range.

Water Flow:
The chlorine contact system has been designed based on a maximum flow of 4,000 L/h. It is important to ensure that the treated water flow remains below this figure so as to ensure effective inactivation of pathogens. The water flow to the chlorine contact system will be controlled manually by a valve, but monitored by inline flow meter.

2.2.5 CCP 5 – Distribution Tank

CCP5	**Distribution Tank**
	Security and integrity
Critical limits/Alert limits	
Alert	Evidence of security or integrity breach
Critical	Security or integrity breach not rectified, or serious breach
Monitoring procedures	
What	Reservoir integrity
How	Observation by operators (external only)
When	Weekly
Where	Potable Water Storage
Who	Aquacell
Corrective actions	
What	Assess risk of the damage or breach impacting quality of water supply. If risk is present, ensure chlorine residual is at least 1ppm and hold for 1-hour. Isolate tank and repair or reinstate integrity.
How	Operator intervention
When	Immediately following discovery of breach
Where	At storage tank
Who	Aquacell staff or delegate

References

1. NHMRC/NRMMC 2011. *Australian Drinking Water Guidelines 6*, Version 2.0, Updated December 2013

2. NSW Health 2005, Drinking Water Monitoring Program, December, ISBN: 0 7347 3880

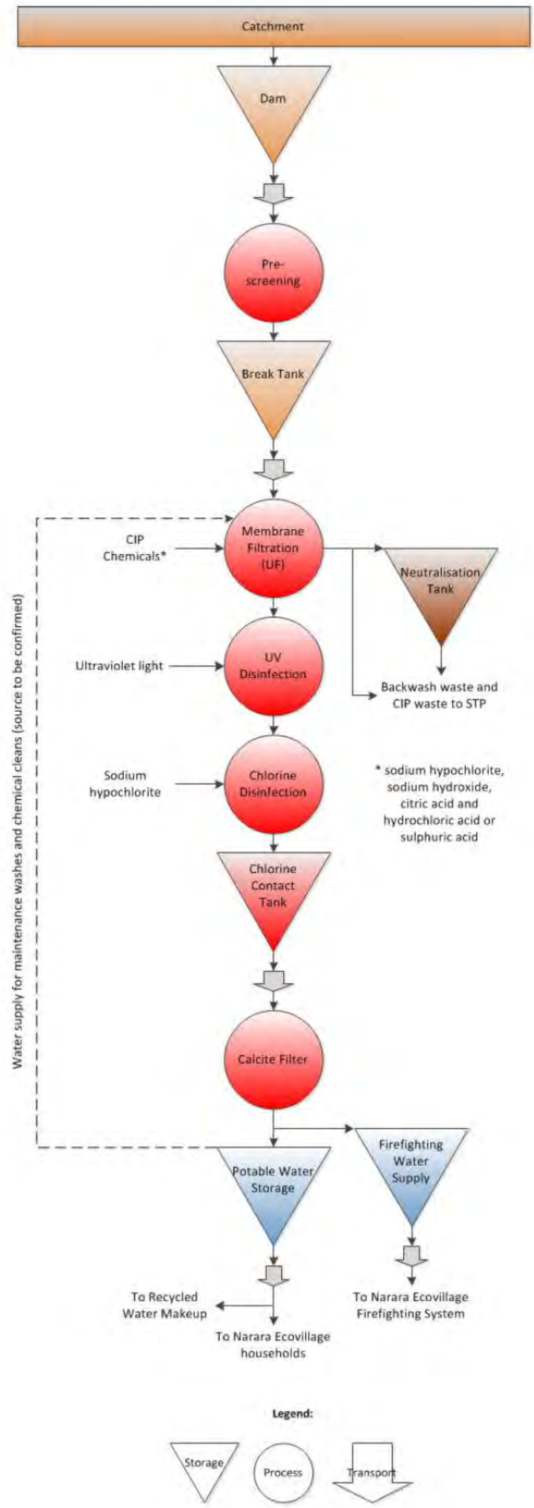
3. Woodlots and Wetlands Pty Ltd 2013, *An integrated water cycle management strategy for the proposed Eco-village at Lot 1 DP 1087535 Research Road Narara*

3 Appendices

Appendix 1 System Overview Description

SYSTEM COMPONENT	DESCRIPTION
Population Supplied	To be confirmed. Note: Stage 1 Development Application includes 60 dwellings and the full development is expected to include some 100 to 130 dwellings. Assuming 5 people per dwelling, estimated population is up to 300 for Stage 1 and up to 650 at full development.
Proposed Water Source	Dam
Proposed Water Storage (Before Treatment)	Break Tank (pumped from dam)
Proposed Water Treatment	Proposed Water Treatment Plant (70 kL/day): - Membrane filtration (ultrafiltration) - Ultraviolet disinfection - Chlorine disinfection (sodium hypochlorite) (provides an additional disinfection step as well as providing a distribution system chlorine residual) - Stabilisation and corrosion control (Calcite filter)
Proposed Water Storage (After Treatment)	Potable Water Storage Tank (roofed, capacity to be determined)
Proposed Distribution of Product	Pumped supply to households and other dwellings within Narara Ecovillage as drinking water (53 kL/day) as well as to recycled water plant for use as make-up water (up to 17 kL/day)
Any Special Controls Required	Quality of chemicals, materials etc used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention. Operation and maintenance of all infrastructure to prevent recontamination.

Appendix 2 Simplified Process Flow Diagram



Appendix 3 Preliminary stakeholder register

Stakeholder	Role in Drinking Water Management	Communication Between Utility and Stakeholder	Current Contact	Current Contact Details	Key Contact from WSC
Aquacell staff	Carriage and ownership of essential activities of the Drinking Water Management System	Communication on operations, maintenance	Warren Johnson (Technical Manager)	E: warrenj@aquacell.com.au P: 02 47210545 M: 0428 529 181	
NEV staff	Carriage and ownership of essential activities of the Drinking Water Management System	Communication on operations, maintenance			
NSW Health (Head Office)	General advice on drinking water management and retrospective powers under the *Public Health Act 2010 (NSW)*	General advice sought on drinking water management	Public Health Unit	BH (02) 9382 8333 AH (02) 9382 2222 and request the Public Health Officer	
NSW Health (PHU)	Local advice on drinking water management and retrospective powers under the *Public Health Act 2010 (NSW)*	Local advice sought on drinking water management and liaison on disease outbreaks (if possible link to drinking water borne route)	John James / Kerry Spratt		
NSW Office of Environment and Heritage	Polluting activities regulator, advice on spills in catchment, environmental flows advice	Referral of concerns relating to pollution in source waters and environmental flows			

Stakeholder	Role in Drinking Water Management	Communication Between Utility and Stakeholder	Current Contact	Current Contact Details	Key Contact from WSC
Metropolitan Water Directorate	Water planning, policy advice; water recycling funding and support; water education and engagement				
IPART	Pricing of water	Representations on specific aspects of water management	Program Manager Compliance	(02) 9290 8477	
National Health and Medical Research Council and National Resource Managers Ministerial Council	National drinking water guideline authors	Review and comment on revisions to guidelines			
Water Services Association of Australia (WSAA)	Professional body	Use of, and contribution to the development of, standards and codes of practice			
Research and technical organisations (CRCs, universities, technical experts)	Sources of technical expertise and services	Maintain professional relationships Procure services			
Industry peers (e.g. other corporations)	Sources of technical expertise, peer review and benchmarking	Maintain professional relationships Procure services			

Stakeholder	Role in Drinking Water Management	Communication Between Utility and Stakeholder	Current Contact	Current Contact Details	Key Contact from WSC
Police	Control of emergency spills and site security issues	Support in control of site security Response to spills and bursts			
Rural Fire Service	Response to emergencies (in particular bushfires)	Response to spills and bursts Response to emergencies such as bushfires			
State Emergency Services	Response to emergencies	Response to spills and bursts and coordinate evacuations			
Committee on Uniformity of Plumbing and Drainage Regulations	Plumbing Regulator	Comment on plumbing regulations			
Standards Australia	Professional body	Use of, and contribution to the development of, standards and codes of practice			
Central Coast Community Environment Network	Promotion of catchment management and community education	Liaison regarding catchment management			

Stakeholder	Role in Drinking Water Management	Communication Between Utility and Stakeholder	Current Contact	Current Contact Details	Key Contact from WSC
Residents/ businesses within Catchment areas	Notify NEV of changes in catchment. Potential to impact of source water quality.	Information sharing and education			
Narara Ecovillage residents	Those to whom safe, quality water is to be provided	Customer complaint follow up Customer contract Water Bills Internet			
NSW Office of Fair Trading	Water fitness for purpose and related trading issues. Administrator of the *Plumbing and Drainage Act 2011*	Liaison over water product issues			

Appendix 4 Preliminary register of legal and formal requirements

Instrument	Jurisdiction	Type	Relevance
Australian Drinking Water Guidelines 2011	National	Guideline	Sets frameworks and guidance for the provision of safe, quality drinking water
Catchment Management Authorities Act 2003	NSW	Statute	Catchment management
Competition and Consumer Act 2010	Commonwealth	Statute	Fitness for purpose of drinking water
Dams Safety Act 1978	NSW	Statute	Impacts of dam safety on water quantity and potentially water quality
Environmental Planning and Assessment Act 1979	NSW	Statute	Planning activities which require assessment
Environment Protection and Biodiversity Conservation Act 1999	Commonwealth	Statute	Catchment management in particular for areas of national environmental significance
Fair Trading Act 1987	NSW	Statute	Includes provisions for goods (and services) to be fit for purpose
Fisheries Management Act 1994	NSW	Statute	Protection of fish habitats (including threatened and protected species management) and aquaculture management
Food Act 2003	NSW	Statute	Need to maintain water quality
AS ISO 22000-2005 Food safety management systems-Requirements for any organization in the food chain	National	Standard	Analogous to the ADWG Framework but would allow certification to that standard if sought
Forestry Act 1916	NSW	Statute	Management of State Forests
Heritage Act 1977	NSW	Statute	Protection of state and/or locally significant heritage (important to be cognisant of in planning new infrastructure)
Independent Pricing and Regulatory Tribunal Act 1992	NSW	Statute	Impacts of pricing on the provision of infrastructure and consequent potential impacts on water quality.

Instrument	Jurisdiction	Type	Relevance
National Parks and Wildlife Act 1974	NSW	Statute	Protection of natural, social and cultural value (important to be cognisant of in planning new infrastructure)
NSW Health Drinking Water Monitoring Program	NSW	Guidelines	Includes NSW Health Response Protocols for chemical and microbial quality, treatment failure and *Cryptosporidium* and *Giardia*.
Plumbing and Drainage Act 2011	NSW	Statute	Largely for management of the distribution system including legislative requirements for plumbing and drainage works
Plumbing and Drainage Regulation 2012	NSW	Regulation	Largely for management of the distribution system including legislative requirements for plumbing and drainage works
Plumbing Code of Australia 2004	National	Best practice	Largely for management of the distribution system including standards for plumbing and drainage issues
AS/NZS 3500 Plumbing and Drainage Set	National	Standard	Largely for management of the distribution system including standards for plumbing and drainage issues
AS 4020 Products for use in contact with drinking water	National	Standard	Materials and other products suitable for use with drinking water.
Protection of the Environment Operations Act 1997	NSW	Statute	Environmental protection including licensed discharges.
Protection of the Environment Operations Regulation 1998	NSW	Regulation	Submit annual National Pollutant Inventory (NPI) returns if any of the specified reporting thresholds are exceeded (water contamination issues)
Public Health Act 2010	NSW	Statute	Protection of public health, follow any advice issued from the Chief of Health regarding drinking water safety to the public; sample drinking water in accordance with NSW Health recommendations. Prepare a drinking water management system.
Public Health Regulation 2012	NSW	Regulation	Requirement to prepare a drinking water management system in accordance with the ADWG Framework for Management of Drinking Water Quality. Requirement to keep records of all water carters supplied.

Instrument	Jurisdiction	Type	Relevance
AS/NZS 4360:2004 Risk Management	National	Standard	Includes guidance on the use of risk assessment and management. Note that the risk assessment matrix in the Framework for the Management of Drinking Water Quality is based on AS/NZS 4360.
Soil Conservation Act 1938	NSW	Statute	Soil management (in the context of catchment management)
US EPA Surface Water Treatment Rules	International	Legislation	Includes information and guidance (as well as other things) on the levels of treatment (in log reduction terms) from water sourced from catchments with varying levels of protection. Not yet included in concept in the ADWG but likely to be included in revisions.
Water Industry Competition Act 2006	NSW	Statute	Licence sought under this Act to construct, maintain and operate water infrastructure and supply potable water as a corporation.
Water Services Association of Australia Water Supply Codes	National	Best practice	Includes methodologies for undertaking a range of water supply works including distribution system management
World Health Organization's Water Safety Plan	International	Guideline	Analogous to the ADWG Framework
Contract between Aquacell and Narara Ecovillage Cooperative	Project	Contract	

Hopkins Correctional Centre
Rainwater Supply Scheme

Rainwater Quality Management Plan

24th June 2014

Prepared by:
Warren Johnson; Martin Hoogland (02) 4721 0545
warrenj@aquacell.com.au

Aquacell Pty Ltd
Unit 1/10b Production Place, Penrith NSW 2750, Australia
PO Box 7091, Leura NSW 2780, Australia
P: +61 2 4721 0545 F: +61 2 4721 2761
www.aquacell.com.au
ABN 79 072 487 015

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Abbreviations	
ADWG	Australian Drinking Water Guidelines
Bq	Becquerel, SI unit of radioactivity = 1 disintegration per second
BSN	Basin
CAW	Class A Water
DCW	Domestic cold water (municipal mains supply)
E. coli	Escherichia coli
HAZOP	Hazard and operability study
HACCP	Hazard analysis and critical control point study
HCC	Hopkins Correctional Centre
ITP	Inspection and Test Plan
kL	Kilolitre = 1000 litres = 1 m3
NTU	Nephelometric turbidity unit, a standard unit of turbidity measurement
PFM	Programmed Facility Maintenance Pty Ltd
PPE	Personal protective equipment
RPZD	Reduced Pressure Zone Device, a form of backflow prevention shown on some HCC drawings
RQMP	Rainwater Quality Management Plan
RWQMP	Recycled Water Quality Management Plan
S	Siemens, SI unit of electrical conductance = 1 mho
SH	Shower
SK	Sink
SS	Suspended solids
Sv	Sievert, SI unit of effective radiation dose
THMs	Trihalomethanes
TOC	Total organic carbon
TRW	Treated Rainwater
WC	Toilet (water closet)

1. Introduction

The Hopkins Correctional Centre (HCC) is designed to make the most economical use of all readily available water resources: municipal "mains supply" water, rainwater, and Class A recycled water. These water resources are reticulated in separate, dedicated ring mains around the site for different purposes. Class A recycled water is used for irrigation, laundry and toilet flushing, except in some of the older buildings where retrofit was uneconomical and treated rainwater is used. Treated rainwater is used for sinks, basins and showers throughout the site, except for the new kitchen and health buildings which use mains water (designated "DCW" for "domestic cold water" on drawings and in some documentation).

Provision is made for redundancy by supply of the lower quality grades of water from higher quality sources. The reticulation ring main for Class A water can be supplied with treated rainwater from its reticulation system, and similarly the reticulation ring main for treated rainwater can be supplemented with mains water, either from its site storage and reticulation pump set or direct from mains pressure water. Substitution of poorer-quality water for higher quality water must be avoided, and backflow prevention equipment is installed in the connecting pipework.

Water falling as rain is very pure and usually suitable to drink. It can become contaminated even as it falls from the sky, by airborne pollutants and dust, although this is unusual under best practice pollution control regimes such as in Australia. The typical sources of contamination of rainwater in domestic systems are from within the collection and storage systems. It is important that the rainwater system at HCC be properly designed, and regularly inspected and maintained, and corrective action be taken if problems are found.

1.1 Purpose of this Rainwater Quality Management Plan

At HCC, treated rainwater is reticulated to sinks, basins and showers. The resulting exposure levels mean that it will be effectively, if not literally, used for drinking and should comply with the *Australian Drinking Water Guidelines* ("ADWG"). This Rainwater QMP ("RQMP") states the water quality objectives for the rainwater component of the water supply scheme and describes risks and mitigation measures to ensure those objectives are achieved and maintained. The document includes:

- An outline of the preventative risk management approach adopted in the *Australian Drinking Water Guidelines* (NHMRC, NRMMC 2013), and its application to the HCC rainwater system to supply drinking water;
- A description of the rainwater catchment, storage, treatment and distribution system;
- A summary of the relevant hazards and appropriate risk mitigation presented in *Guidance on use of rainwater tanks* (enHealth 2011) and outcomes of a risk workshop undertaken for the HCC system (pending).
- An outline of the inspection and monitoring program to ensure the treated rainwater meets the required quality for end use.

This RQMP provides the framework for operation and management of the rainwater system, from which standard operating procedures, logs and reporting requirements are established. It should be used by the site operator as the reference document for decision making in relation to safe operation of the rainwater supply system, including providing sufficient resources to monitor the system, manage risks and generate reports. Quality management principles dictate that review and continuous improvement should be applied, so that this document should be reviewed regularly and updated as needed.

1.2 Preventative Risk Management

1.2.1 What is it?

Hazards can be thought of as the causes of unwanted incidents. The risk of an incident is the combination of the likelihood of its occurrence (ranging from rare to almost certain) and the consequences of its occurrence (minor to catastrophic). Risk management usually focuses on incidents with the highest risk (combined likelihood and consequence), but the health effects of supply of poor quality drinking water can have such severe consequences that minimisation of the likelihood is essential. The guiding principle of the ADWG is to identify significant contamination hazards and provide multiple "barriers" to minimise the likelihood of occurrence of contamination, so-called "preventative risk management". In the application of the ADWG, it effectively means elimination or minimisation of the sources of contamination.

1.2.2 How is Preventative Risk Management implemented in the ADWG?

The ADWG specify a Framework for management of drinking water quality with twelve essential elements:

1. Commitment to drinking water quality management
2. Assessment of the drinking water supply system
3. Preventative measures for drinking water quality management
4. Operational procedures and process control
5. Verification of drinking water quality
6. Management of incidents and emergencies
7. Employee awareness and training
8. Community involvement and awareness
9. Research and development
10. Documentation and reporting
11. Evaluation and audit
12. Review and continual improvement

All of these elements should be addressed in operating the rainwater supply system (see ADWG Section 3). Section 13 Compliance with Australian Drinking Water Guidelines below describes how these are addressed at HCC in relation to the rainwater supply.

In combination with the ADWG, the Australian government publication *Guidance on use of rainwater tanks* (enHealth 2011) provides a guide for implementing best practice in rainwater systems. *Guidance on use of rainwater tanks* identifies system analysis and management (items 2 and 3 above) as the most important areas for rainwater systems. The generic hazards and associated preventative measures and corrective actions from this document are presented in Sections 4. Hazard Identification and Risk Assessment and 5. Control Measures of this RQMP.

The ADWG present the recommended maximum (or minimum) value of a water quality parameter as a Guideline, rather than a limit. Many of the common water quality parameters have both health and "aesthetic" guideline values because the water may become unpalatable (unpleasant to drink) before it becomes unhealthy (with increasing concentration), for example. The better of the two values is used as the recommended guideline value. With the notable exception of microbial indicators, the health values adopted in the ADWG for most contaminants do not result in any significant risk to the health of the consumer over a lifetime of consumption, according to present knowledge. Therefore, short-term exposures to levels outside the guidelines are usually not a cause for concern for most quality parameters.

An exceedance of the recommended value during monitoring triggers a corrective action or incident response under this RQMP, which includes investigation and identification of the source. Knowledge about exposure of humans to chemicals is continually evolving, and expensive treatment to address a particular chemical species may not be warranted. For example, some sectors of the community are more susceptible than others to particular contaminants, like infants and breast-feeding mothers, and HIV-positive people, which may have limited relevance to this site. Under the hierarchy of controls (elimination, substitution, engineering, administrative, PPE), and in consultation with stakeholders, there may be a more effective solution without resort to expensive treatment processes.

Another useful source of information is the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks* (2008). This details the methodology for assessment of health-related outcomes of exceedances of the guideline values. However, this type of assessment should not be necessary for the HCC rainwater system unless unusual contaminants are found whose source cannot be identified or easily controlled.

2. Organisational Commitment

AEGIS Correctional Partnership (Aegis) is the Owner of the scheme at HCC. Aegis is committed to ensuring the system is maintained and operated in compliance with relevant guidelines, regulations and standards at all times.

Aegis has subcontracted responsibility for the maintenance of the prison precinct to Programmed Facility Maintenance (PFM). PFM will provide maintenance and operation services for the rainwater system and treatment plant. PFM is committed to maintaining and operating the system in compliance with relevant guidelines, regulations and standards at all times.

Note that according to the Victorian Department of Health publication *Rainwater use in urban communities: Guidelines for non-drinking applications in multi-residential, commercial and community facilities* (2013, p3):

> "The quality and acceptable uses of rainwater are not subject to specific regulation in Victoria. Despite this, individuals or organisations responsible for rainwater systems should demonstrate due diligence by ensuring that rainwater is safe for its intended use. The quality of rainwater and the associated management controls need to be proportional to the level of exposure to rainwater – the more likely it is that rainwater will be ingested, the higher the water quality and more stringent the management controls should be."

Section 4 of the ADWG recognises that smaller systems (defined as supplying less than 1000 people) may be able to simplify or relax some of the more-onerous/expensive requirements such as sampling and analysis for monitoring. However, this reduced sampling would introduce more risk and should not be implemented until justified by results of the monitoring program over a significant period (6 months or more under full capacity operation).

The various roles and responsibilities of the ownership and management parties are outlined in section 8 of this document.

3. Description of the Rainwater System

3.1.1 Site description

A plant layout for the Hopkins Correctional Centre Scheme is shown in Appendix 1. The site is located in Warrak Road, Ararat, Victoria.

3.1.2 Rainwater system function

Rainwater is collected from the roofs of the buildings around the site. It flows by gravity from gutters and downpipes to a number of collection tanks (with volumes ranging from 25 to 40 kL) situated close to the buildings (External Stores, East Satellite and West Satellite, Gate House East, 2 tanks at Gate House West). Pump sets deliver from the collection tanks to two 200 kL rainwater storage tanks which serve as feed tanks to the rainwater treatment plant. The tanks can be isolated so that only one is online, to allow maintenance and cleaning of a tank when required.

The rainwater treatment plant is supplied by AKS Industries, consisting of a fine screen, ultrafiltration membranes, an ultraviolet light disinfection unit and ancillary systems including chemical dosing, backwash and recirculation pumps and controls. Nominal capacity of the treatment plant is 135 kL/ day. A feed pump delivers the water from storage through a 100 µm screen to a membrane filtration array. The membrane filtrate passes through the UV disinfection unit and into two 35 kL treated rainwater tanks. Similar to the storage tanks, each treated rainwater tank can be isolated to allow maintenance and cleaning. Sodium hypochlorite is dosed into a recirculation loop on the treated rainwater tanks for residual disinfection. Backwash water for the membrane array is drawn from the treated rainwater tanks and dosed with appropriate chemicals for membrane cleaning when required. Waste from the fine screen, membrane backwash and chemical cleaning is discharged to the site sewer.

Membrane ultrafiltration is implemented, using Inge "dizzer® XL 0.9 MB 60 W" membrane modules from Germany with a nominal pore size of 0.02 µm. This is sufficiently small to reject protozoa and bacteria to a high degree, and even some virus particles, as well as almost all atmospheric particulates. Turbidity of the filtrate is normally less than 0.1 NTU, with a maximum of 0.3 NTU. This low turbidity is well suited to disinfection by UV irradiation where higher turbidity reduces the effectiveness of treatment.

The Viqua Sterilight SPV-950 "Healthshield" UV disinfection unit uses electromagnetic radiation of suitable intensity and wavelength to cause disruption of cellular matter and DNA/ RNA, thus inactivating or killing microorganisms including viruses. The unit incorporates a UV intensity detector and flow-paced control to ensure optimum energy usage and an appropriate UV dose, estimated to be about 40 mJ/cm^2.

Sodium hypochlorite solution is dosed to the treated rainwater in a recirculation loop from the treated rainwater tanks. A free chlorine residual provides a further barrier to pathogen contamination and prevents growth of microbial contaminants in the distribution system. The ADWG require a minimum of 0.5 mg/L free chlorine residual. The maximum from a health perspective is 5 mg/L free chlorine, but the aesthetic limit is set at 0.6 mg/L because of taste sensitivity for some individuals.

A reticulation pump set draws from the treated rainwater tanks and pressurises the distribution ring main. Branches off the ring main deliver to individual buildings for reticulation.

Some relevant drawings which illustrate the scheme are included in Appendix 1:

Aegis-NDY	HN-AA032	HCC: Hydraulic Services: Treated Rainwater Schematic

Aegis-NDY	HN-AA034	HCC: Hydraulic Services: Untreated Rainwater and Domestic Cold Water Schematic
Aegis-NDY	HN-HPA800	HCC: Hydraulic Services: Plant Schematic
AKS Industries	WF_APA_PID_001	Ararat Prison – AKS: Piping and Instrumentation
AKS Industries	WF_ARA_GA_001	Ararat Prison – AKS: Indicative General Arrangement

4. Hazard Identification and Risk Assessment

A HAZOP and Environmental Risk Assessment, and a Hazard Analysis and Critical Control Point (HACCP) analysis of the Hopkins Correctional Centre Rainwater Scheme have yet to be completed. These will form Appendices 2 and 3 respectively. The methodology will be in accordance with ADWG and Aquacell's documented risk procedures.

A table of generic hazards and controls for rainwater tank systems is presented at the end of section 5.

4.1 Water quality objectives

Rainwater is used to supply rural and remote communities in Australia, and has been safely used by mankind for millennia. Experience has shown that proper design and regular inspection and maintenance can produce safe, good-quality water for human consumption. Main issues to be aware of are the potential for contamination with airborne chemicals, dusts and aerosols, occupation by small animals, mosquitoes and microorganisms, and eliminating areas in the collection system (gutters, downpipes, etc) where stagnant water can lie open to the atmosphere, thereby creating conditions for microbial growth and decay.

First flush diversion and maintenance of the preventative measures will normally suffice to produce good quality water. The ultrafiltration membrane and UV irradiation in the rainwater treatment plant could be considered excessive, but form prudent extra barriers to contamination in a drinking water application.

The ADWG provide guideline values for microbial, chemical, physical and radiological characteristics of drinking water.

4.2 Microbial hazards

Rainwater collected and stored in tanks will contain a range of microorganisms, just as the air around us does, but virtually all of them are harmless in a properly maintained system.

Under the ADWG, microbial quality of drinking water is determined by the presence or absence of enteric pathogens (disease-causing organisms usually found in the intestine), such as *E. coli*. The presence of *E. coli* is indicative of the presence of faecal matter, which must be addressed. The performance measure for acceptance in the distribution system is *E. coli* should not be detected in a minimum 100 mL sample. Corrective action must be taken immediately if any is detected.

Potential sources of faecal matter are small animals such as birds, reptiles, amphibians and mammals that have access to the roof, its drains, or tanks, and other free-living organisms. Access to roofs and tanks should be minimised by preventative measures such as insect screens on all tank openings, "gutter guards" and trimming overhanging and nearby branches.

Some other (non-enteric) pathogens can grow within tanks provided that there are sufficient nutrients and/ or light. The ultrafiltration membrane in the treatment plant provides a barrier to contamination from bacteria and protozoa, but an additional control measure (especially for algae) is to use opaque materials for the tanks and pipework.

One non-enteric, free-living pathogen which is highlighted in the ADWG after having caused unexpected disease from Australian water supplies is the amoeba *Naegleria fowleri*, which can cause primary amoebic meningoencephalitis ("PAM"). The route of infection is intra-nasal and PAM is associated with bathing rather than ingesting water. Maintaining a chlorine residual is effective in inactivating *N. fowleri*, but testing for any members of the *Naegleria* genus should be conducted in screening/ baseline studies and quarterly monitoring. If found, frequent testing should be implemented and the source identified, and specific corrective action taken to eliminate the source.

4.3 Chemical hazards

The ADWG provide guidelines for a wide variety of organic and inorganic chemicals. However, most of these are unlikely to occur at significant levels in a well-designed and maintained rainwater system. Chemical inputs to the rainwater collection system are limited to airborne contaminants from dust, smog, vehicular exhaust, smoke from bushfires, decay of leaf litter, discharges from roof-mounted appliances, and possibly from spraying of horticultural or agricultural chemicals. Another potential source is the materials of construction used on the roof and in the rainwater system, but at HCC, these have been selected for compatibility with drinking water. Any repairs or modifications to the system should use materials approved for contact with drinking water, or similarly-approved coatings.

The first flush system should divert the great majority of the residues from the roofs and collection pipework contained in the initial flow during a rain event. In the event of a major dust storm or nearby bushfire, or after a prolonged period of drought, it would be prudent to thoroughly hose down the roofs, with the first flush system set to divert, to avoid flushing of residual deposits into the collection tanks and subsequent dissolution of soluble components. The treatment system should cope with some particulate matter, but it has not been designed to deal with dissolved chemical species which could result from dissolution or decay of sediment in tanks.

Sodium hypochlorite is the only chemical added to the treated rainwater, for residual disinfection to prevent growth of microorganisms in the reticulation system.

4.4 Physical quality parameters

Physical quality parameters addressed in the ADWG include colour, turbidity, hardness, total dissolved solids, pH, temperature, taste and odour, and dissolved oxygen. None of these parameters should exceed their guideline values in a properly-maintained rainwater system.

Assuming that the system is properly maintained, one parameter which could be of concern is hardness (which is the sum of dissolved calcium and magnesium ions), which is expected to be so low as to potentially cause corrosion, unless materials of construction in contact with the water are carefully selected. This applies also to the materials of construction used in the sewer (wastewater collection) system.

Another potential issue with the rainwater system is alkalinity and the related parameter pH. Being so pure, rainwater has very little alkalinity, essentially only that from atmospheric carbon dioxide which has been absorbed during its fall. With limited alkalinity, the water can change pH significantly due to incidental chemical reactions such as dissolution of metallic ions from materials of construction. A change in pH to a value outside the ADWG guideline of 6.5 to 8.5 can affect the solubility of metals in pipes and fittings, allowing further changes in pH in a "runaway" sequence. Municipal water treatment plants commonly add lime and carbon dioxide, or limestone, to increase both alkalinity and hardness if required. At HCC, there is no process equipment installed to control these parameters. However, as long as appropriate materials have been used throughout the system, pH may not be adversely affected. However, it corrosion should be monitored and corrective action taken if required.

Colour, turbidity, taste or odour, as well as chemical contamination, could also become a short-term issue if a large quantity of dust or ash was washed into the collection tanks after the first flush, or with failure of the first flush system. Hence, flushing or washing of the roofs and collection systems after a significant airborne dust or ash event is recommended.

4.5 Radiological quality

According to the ADWG (2013 update, §7.5.3), Australians receive an effective radiological dose of about 2 mSv/year on average, with less than 10% from the ingestion of food and drinking water, the remainder being "background radiation". The guideline value for effective dose from drinking water is 1 mSv/year. This is very unlikely to occur naturally in a rainwater system. So-called "screening", or baseline studies, to determine whether further investigation and/or treatment is necessary, should be conducted for gross alpha and beta emitters, initially and annually thereafter unless high levels are found.

4.6 Mosquitoes

An additional water quality issue that is particularly relevant to rainwater systems is mosquitoes. Rainwater tanks provide breeding sites for mosquitoes, which can transmit disease. Mosquito access through tank penetrations (inlets, vents) should be avoided by using suitable insect screens. Breeding sites in the form of water ponding in the collection system should also be avoided.

5. Control Measures

For any contamination hazards identified, some sort of control measure, or "barrier", should be implemented to minimise the likelihood of its occurrence. Multiple barriers should be considered, especially if there is concern about the reliability of a selected control measure.

Control measures are listed here, broken down into five categories:

- Roof catchment protection and maintenance
- Correct material selection and installation of the rainwater storage
- Correct material selection and installation of the distribution and plumbing
- Treatment system
- Regular inspection and maintenance of the supply system

Some of the control measures listed here may not be relevant to the current HCC Rainwater system, but could be relevant to a future extension or modification of the scheme. Some of the issues listed are more-appropriately considered during design than operation, but they also serve to highlight things to look for during inspections, which may require corrective action in the form of repairs or modifications. For further information, the references should be consulted.

The treatment system HAZOP and HACCP analysis outcomes, when available, will provide other control measures to be implemented.

5.1 Roof catchment protection and maintenance

Using correctly designed and maintained roof catchments is a key step to protecting rainwater from contamination. For the HCC catchment systems, the following should be implemented.

- Overhanging vegetation should be cut back.
- Gutter shielding devices ("gutter guard") should be installed where roof catchments are adjacent to trees and vegetation, to reduce the amount of debris entering gutters and storage tanks.
- Gutters should have sufficient and continuous fall to downpipes to prevent pooling of water, which could accumulate debris, lead to algal growth and possibly provide a site for mosquito breeding. A fall of 1:200 should be sufficient.
- Chemicals used for any roof cleaning should be carefully selected to ensure they do not pose a risk to human health or the environment.

The following measures are generally considered good practice, but are most important where rainwater is used for purposes with a high risk of ingestion, such as HCC.

- First-flush diverters or by-pass devices (also called "interceptors") should be installed to reduce the entry of contaminants, which build up on roofs and in gutters during dry spells, to the storage tank. The diversion device should be inspected after each rainfall event, and re-set/ drained/ cleaned if required.
- Roof access should be restricted to maintenance activities only.
- Structures that provide a perching place for birds should be removed or modified.

5.2 Rainwater storage

Tanks should have impervious covers and all access points, except for the inlet and overflow, should be provided with close-fitting lids which should be kept shut unless in use. The inlet to the tank should incorporate a screen to prevent solid material being washed into the tank, and a mesh covering to prevent access of mosquitoes and other insects. Overflow openings should also be covered with insect-proof mesh.

Tank overflows and run-off that is not collected in the tank must be diverted into the stormwater drain. It must not be allowed to pool or to cause a nuisance to neighbouring properties or to areas of public access. The overflow should be designed to prevent stormwater from flowing back into the tank.

5.3 Rainwater distribution and plumbing

To prevent cross-connections between the rainwater and other site water supplies, rainwater distribution pipes should be clearly labelled 'RAINWATER' in a contrasting colour, in accordance with AS/NZS 3500 *National plumbing and drainage code*. In addition, as-built drawings of the distribution system should be available and protocols developed to ensure modifications and maintenance on the distribution system do not result in a cross-connection.

Backflow prevention devices, also known as "RPZD"s, complying with Australian Standards must be used to prevent the risk of rainwater siphoning back into and contaminating the drinking water supply. These should be regularly inspected and tested.

5.4 Rainwater treatment plant

Treatment options for rainwater systems most commonly include:
• filtration
• disinfection (usually chlorine or ultraviolet light).

Both of these processes are installed at HCC, with disinfection by both chlorine (for residual, delivered and stored as aqueous sodium hypochlorite solution) and UV. The treatment train is driven by the feed pump which delivers the water from the storage tank with sufficient pressure to force membrane filtrate through the UV system and into the treated rainwater tanks (refer section 3.1.2 above).

Typical monitoring and control measures for the plant are outlined below. Further detail will come through the HACCP workshop.

Table 1: Control measures for treatment plant operation

Treatment hazard	Cause	Preventative measure	Monitoring	Corrective action
Loss of membrane barrier	Membrane Failure	Check integrity	Turbidity and integrity monitoring	Shut down plant and repair or replace membrane
Loss of UV barrier	Failed UV lamp	UV lamp fail alarm	Alarm triggers plant shutdown	Replace lamp
	UVT high	Control water quality	UV intensity	Shutdown plant and investigate cause of high UVT.
Chlorination ineffective	Low chlorine	Free chlorine >0.5 ppm	Free chlorine monitored online	Shutdown and correct low chlorine
	pH out of range	pH between 6.8 and 8.5	Monitor pH	Shutdown and investigate cause

Operation of the treatment plant is addressed in the Operation and Maintenance Manual for the equipment supplied by AKS. (pending) This should be consulted for details of standard operating procedures, troubleshooting and corrective actions to rectify equipment faults and treatment issues. These are summarised in the table above.

5.5 Hot water services

Generally, domestic water heating systems are not designed to provide thermal disinfection such as pasteurisation. *Rainwater use in urban communities* (Vic. DoH 2013) states:

> "However, hot water services are currently designed to address Legionella risks from water (consistent with the requirements in AS/NZS 3500 *National plumbing and drainage code*). Hot water services should not be relied on to inactivate enteric pathogens (pathogens found in the gut) as they may not heat water to a high enough temperature for long enough to act as appropriate treatment"

Hot water services should be set to reach a reasonably high temperature (>50°C); warm temperatures around 35 - 40°C are ideal for growth of enteric pathogens.

5.6 End-use controls

As a reminder to staff and in case of visitors, external taps supplying rainwater should be identified with a safety sign labelled 'RAINWATER'. Signs should comply with AS1319 *Safety signs for the occupational environment*, with black writing on a yellow background. Where signs could be encountered by sensitive groups who may not be able to read (for example children visiting inmates), additional controls should be considered such as using taps with removable handles or locating taps 1.5 metres or more above the ground.

Internal rainwater outlets should be identified, for example via a 'RAINWATER' label on tap buttons.

5.7 General controls for rainwater tanks

A summary of general preventative measures and corrective actions for health and aesthetic hazards in rainwater systems, taken from *Guidance on use of rainwater tanks*, is presented in the two tables below. Some of the frequencies of inspection are increased because of the relatively-large population relying on this rainwater source.

5.7.1 Preventative measures and corrective actions for Health hazards

Table 2: Control measures for Health hazards

Health hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Faecal contamination from birds and small animals	Overhanging branches on roof	Prune tree branches.	Check tree growth every three months.	Prune branches.
		Install first flush device.	Check device after rainfall	Empty contents of device after rainfall.
	Animal access to tank	Protect all inlets, overflows and other openings to prevent entry by small animals and birds.	Check access covers are kept closed. Check inlets, overflows and other openings every week.	Repair gaps. Secure access cover. If animal access suspected disinfect tank using chlorine.
		Maintain integrity of tank roof and body to prevent access points.	Check structural integrity of tank.	If a dead animal is found, empty and clean tank. If this has to be delayed, remove animal remains and disinfect tank using chlorine.
Faecal contamination from humans (above-ground tanks)	Human access to tank	Prevent access. Ensure tank is roofed and access hatches are secured.	Check access covers are secured, particularly in hot weather.	Secure access cover.

Health hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Faecal contamination from humans (buried pipework)	Ingress of contaminated water, potential cross-connections	Ensure that pipework is protected from cross-connections, that pipework is impervious and is separated from septic and sewage pipes. All plumbing work on site to be performed by suitably-qualified tradesmen who have had thorough site induction	Check (isolate TRW reticulation pump set and mains supplies, check for flow from rainwater system taps) after any plumbing work has been done on site and at least every three months (when inmates are confined e.g. at night?) Also check backflow prevention systems	Remove cross-connections, repair or replace pipework.
Mosquitoes	Access to stored water	Protect all inlets, overflows and other openings with mosquito-proof mesh.	Inspect water for presence of larvae at least every three months.	Repair screening of inlets and openings to prevent access, and if larvae are present, to prevent escape of mosquitoes. Treat tanks with a small amount of kerosene or medicinal paraffin.
Fe, Zn, Cu … contamination	Increased corrosion of metals due to low pH from long periods of contact between rainwater and leaves	Keep gutters clean. Install leaf protection devices on gutters.	Inspect gutters every three months.	Clean gutters. If large amounts of leaves are detected on regular inspections clean more often.
Chemical contaminants from tanks, pipework etc.	Water standing in metal pipes overnight or longer periods	Use plastic pipes	Inspect plumbing to identify pipe materials	Flush pipes in the morning for long enough to bring new water from the tank (several minutes).
	Re-suspension of accumulated sediment	Regularly clean tank to remove accumulated sediment. Reduce amount of sediment by keeping roof catchments and gutters reasonably clean. Protect inlet to tank using a leaf filter. Install a first flush diverter.	Inspect tank every 3 months. Inspect roof and gutters and inlet filter every month.	Clean tank if required. Clean roof, gutters and inlet filter as necessary. Ensure filter is in place.
Other contamination from roof materials	Preservative-treated wood Bitumen based materials	Do not collect rainwater from roofs covered with exposed treated wood. Do not collect rainwater from roofs with bitumen-based products.	Inspect roof before installing tank.	If treated wood present it could be sealed or covered to prevent exposure to rainwater.

Health hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Chemical contaminants from tanks, pipe work etc.	Inappropriate material that does not comply with Australian or Australian/New Zealand Standards relating to food grade products or products for use in contact with drinking water	Use only approved materials.	Check suitability of product with retailer or supplier.	Remove or replace product.
Dangerous plants	Overhanging branches (check identity of suspect plants with horticulturist)	Prune tree branches.	Check tree growth every three months.	Prune or remove plant.
Drowning	Access to tank roof Hatches open or roof in poor state of repair	Prevent access to tank roof by humans.	Check access covers are kept closed and roof is intact. Ensure that trellises and trees do not allow ready access to tank roofs.	Repair gaps. Secure access cover. Prune tree branches.

5.7.2 Preventative measures and corrective actions for Aesthetic hazards

Table 3: Control measures for Aesthetic hazards

Aesthetic hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Sulphide/rotten egg/ sewage odours	Anaerobic growth in accumulated sediment at the bottom of tanks	Regularly clean tank to remove accumulated sediment.	Inspect tank every 3 months.	Clean tank if required. If cleaning not practical (for example in the middle of summer) disinfect tank with chlorine and flush chlorinated water through all pipework. If practical, pumping air into the tank, to add oxygen to the water, may also help to minimise tastes and odours.
	Slimes and stagnant water in pipe work	Avoid u-bends or underground pipework that can hold stagnant water. Install drainage points on buried pipework		
Musty or vegetable type taste and odours (no light penetration)	Accumulated material on roofs and gutters. May possibly include pollen.	Remove overhanging branches from trees. Keep gutters clean. Install leaf protection devices on gutters.	Inspect gutters at least every month.	Clean gutters. If large amounts of leaves (or pollen) are detected on regular inspections clean more often. If practical, pumping air into the tank, to add oxygen to the water, may also help to minimise tastes and odours.

Aesthetic hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Coloured water	Accumulated damp leaves in gutter	Keep gutters clean. Install leaf protection devices on gutters.	Inspect gutters at least every month.	Clean gutters. If large amounts of leaves are detected on regular inspections clean more often.
Musty, vegetable or fishy type taste and odours (light penetration)	Algal growth due to light penetration into tank or pipe work	Make sure tank is completely roofed and is impervious to light.	Inspect water every three months.	Repair roof. If practical, pumping air into the tank, to add oxygen to the water, may also help to minimise the tastes and odours.
		Ensure pipework, including inlets to tanks, are impervious to light (white pipes can allow light penetration).		Paint pipework with dark colour.
Bitter taste (concrete tanks) Metallic taste (galvanised tanks) Plastic taste (plastic tanks)	New tank	Use water from first fill for non-potable purposes. Taste will diminish in subsequent fills.	Water quality/taste will improve with tank age.	Use water from first fill of new tanks, or water collected from newly painted roofs for non-potable purposes. Problem will diminish with time
Detergent taste or water frothing	Newly painted roof	Do not collect water from first 2-3 rain events after painting.	Water quality/taste will improve with paint age.	Use water from first fill of new tanks, or water collected from newly painted roofs for non-potable purposes or divert to stormwater. Problem will diminish with time.
Hydrocarbon or preservative taste	Deposits from agricultural/ horticultural spraying	Negotiate with sprayers for spraying only in appropriate wind direction. Otherwise arrange for roof cleaning after upwind spraying events	TOC analysis of storage tank/s every 3 months and after spraying	Roof cleaning with diversion to stormwater
Insects/water boatmen etc.	Access to stored water	Protect all inlets, overflows and other openings with insect proof mesh.	Inspect water for presence of insects and/or larvae every three months.	Repair screening of inlets and openings to prevent further access. Use simple coarse filter to remove remaining insects.

Aesthetic hazard	Possible cause	Preventative measure	Monitoring	Corrective action
Small white flakes in water	Microbial growth	Keep gutters clean. Growth encouraged by nutrients contained in plant and soil material accumulated in gutters or at the bottom of tanks. Install leaf protection devices on gutters	Inspect gutters at least every month. Inspect tank every 3 months.	Clean gutters and tank if necessary. Disinfect tank using chlorine.
Slime on the inside of tanks	Microbial growth	All containers that continuously hold water will develop biofilms on surfaces below the water level.	None required.	None required. These are naturally occurring and not harmful to the general population.
White deposits on the surface of metal tanks (slimy or waxy feel)	'White rust'. A corrosion product containing zinc-rich oxide	Not required.	None required.	None required, the deposits are not harmful. Physical removal could damage the surface of the tank and increase the potential for corrosion.

6. Monitoring and Corrective Actions

The rainwater system at HCC needs pro-active oversight to ensure that the water delivered from it is safe. As well as regular inspection and maintenance of the collection system and treatment plant, routine measurement and monitoring of critical water quality parameters is an essential component because of the potential health impacts of supply of unsafe water. Another essential component under the ADWG is the validation of preventative measures and treatment processes ("barriers"), to ensure that the contamination barriers are properly installed and operated, and verify the level of protection they provide.

6.1 Water Quality Sampling and Analysis

According to the Victorian Department of Health's *Rainwater use in urban communities*:

> "Monitoring the rainwater system is an essential part of the multiple barrier approach. The results of monitoring show whether the risk control measures are working properly. Employ corrective actions when monitoring indicates that a control measure or barrier has not been operating effectively.
>
> Whether the water is treated or not, a full rainwater system inspection should be undertaken at least quarterly."

The ADWG state (§ 3.5.1):

> "Key characteristics related to health include:
> • microbial indicator organisms;
> • disinfectant residuals and any disinfection by-products;
> • any health-related characteristic that can be reasonably expected to exceed the guideline value, even if occasionally;
> • potential contaminants identified in analysis of the water supply system and hazard identification.
> …

Frequency of testing for individual characteristics will depend on variability, and whether the characteristics are of aesthetic or health significance. Sampling should be frequent enough to enable the monitoring to provide meaningful information. Sampling and analysis are required most frequently for microbial constituents, and less often for organic and inorganic compounds. This is because even brief episodes of microbial contamination can lead to immediate illness in consumers, whereas, in the absence of a specific event (e.g. chemical overdosing at a treatment plant), episodes of chemical contamination that would constitute an acute health concern are rare. Guideline values for most chemical parameters are based on impacts of chronic exposure."

Also from the ADWG (§ 9.2):

> "Developing a monitoring program is not a static activity, but part of an ongoing, iterative process of system management that seeks to understand the challenges and risks, plan and implement measures to prevent contamination (appropriate to the level of risk), monitor and assess the effectiveness of these barriers, plan improvements, and adjust preventive measures and monitoring programs as required."

An initial, draft, summary of the quality parameters, sampling location and frequency of sampling is shown below in Table 4. The table is subject to ongoing revision of frequencies and analytes based on screening for analytes of concern, and level and variability of the results. Also, the sampling locations may change as a result of the HACCP study. The following paragraphs describe the logic for the preliminary selection of sampling locations and analytes.

The quality of the rainwater delivered from any basin, sink or shower tap at HCC should comply with the ADWG guidelines at all times. Therefore, monitoring samples should be collected from delivery points within the buildings connected to the rainwater supply. This ensures that issues relating to the distribution network, such as long detention times and insufficient chlorine residual, can be detected. Initially, samples for pH and chlorine residual from a number of taps in each building should be used to determine a "canary" or early-warning location; the lowest chlorine residual is indicative of the longest hydraulic detention time, which may also see the greatest change in pH. Initially, sampling points in each building should be selected based on a combination of least flow and longest distance from the ring main, based on the reticulation piping arrangement, to target the longest hydraulic detention time. Usually, this will be a basin or rarely-used appliance on the end of a branch.

If a health-related guideline is breached at any location, corrective action should be implemented to improve the water quality delivered to that point. Routine weekly samples should be collected from that "canary" location until the fault is rectified. Subsequent sampling should use the "canary" location for every second weekly sample, and rotate through other selected taps in other buildings. If over time a more-critical delivery point is found, it should become the "canary" location for sampling. If the water quality results at a particular location cannot be made to comply with the guidelines, it is often because of extremely long detention time and special control measures may be needed, such as an actuated valve on a timer to regularly flush the supply pipe to sewer (via free discharge to avoid possible backflow).

Weekly monitoring of health parameters is required according to the guidelines. Analytes for weekly measurement include *E. coli*, pH, temperature, conductivity, alkalinity, chlorine residual, copper, iron and manganese. Any contaminants found to be of concern from screening or "baseline" analysis should also be analysed, for investigation of the source and until satisfactory control measures have been implemented and validated. Additional parameters for monthly analysis (after initial weekly screening to establish a baseline) are total coliforms, *Naegleria*, total organic carbon ("TOC"), trihalomethanes ("THMs"), colour, turbidity, dissolved oxygen and hardness. Frequency of analysis for less-critical analytes, such as alkalinity, copper, iron and manganese, can be reduced if their levels are low and show little variation. Conversely, frequency should be increased for any of the monthly analytes if their levels are relatively high or highly variable (at the same sampling location) with no obvious explanation. After annual review with stakeholders and relevant authorities, some monthly monitoring parameters may be reduced to quarterly or annual monitoring.

Additional sampling from points within the collection and treatment system are required for the purposes of validation monitoring, understanding the system, and identification of the source of any contamination. Recognising that sample analysis is not cheap, a limited number of locations providing "bang for buck" should be targeted, noting that additional critical control points ("CCP"s) still may be identified.

The rainwater storage tanks, before the treatment plant, are an obvious location; a sample from the online tanks as the water enters the treatment plant should be collected. These samples should be analysed for E. coli, pH, temperature, conductivity, total coliforms, total organic carbon and suspended solids, and any water quality parameters found to be of concern. For parameters of concern, samples should also be taken from the individual collection tanks and analysed to aid in identification of the source.

For the purpose of validation, weekly treated rainwater samples should be collected. These samples should be analysed for E. coli, pH, temperature, conductivity, total coliforms, total organic carbon and suspended solids.

To identify problems in the distribution system, a sample from the treated rainwater tanks should be collected, from the recirculation loop before the water passes the hypochlorite dosing point. These samples should be analysed for E. coli, pH, temperature, conductivity, total coliforms, total organic carbon, chlorine residual, copper, iron, manganese, trihalomethanes ("THMs"), colour, turbidity, dissolved oxygen and hardness.

For a rainwater system providing drinking water, an initial screening or "baseline" analysis for possible contaminants of concern is warranted. Screening analysis of total organic carbon, ammonia, nitrate, fluoride, hydrogen sulphide, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, tin, uranium, zinc, gross alpha and gross beta is recommended. These should also be analysed quarterly for the first year, but their testing can subsequently be reduced in frequency provided that no elevated levels are found. It would be desirable to re-test for these whenever sediment is found in the bottom of a collection tank, as a precautionary measure.

Additional monitoring is required for incident and emergency response, which, by its nature, depends on the specific circumstances of the incident or emergency. An understanding of the system and the nature of the incident is required to develop a suitable short-term monitoring plan and aid in investigating the cause of the incident. After an incident or emergency, the routine monitoring plan will be modified, at least until the parameter/s of concern are brought back to an acceptable level.

The ADWG recommend that taste and odour be tested annually. However, if HCC users are encouraged to register concerns about these issues if they occur, which can provide early warning of a problem, there should be no need for expensive external testing.

Monitoring data should be representative, reliable and fully validated. Procedures for sampling and testing should also be documented. Sample identification and reporting of results must be comprehensive, including date, time, location, sampling method, name of person taking sample, chain of custody records, analysis methods and details, etc. Records of sampling and analysis should be stored for future retrieval if required.

Results of analyses should be entered into a spreadsheet or database system with sample ID, date and location, to allow statistical analysis, validation of treatment processes, graphing and trending, and reporting.

The quality parameters and sampling locations which have been identified above are consolidated in the following table. All of these parameters should be analysed initially for screening/ baseline purposes at the storage tanks. It is important to note that this table should be updated as required and as more information allows sampling frequencies to be reduced, or poor results force frequencies to increase.

Table 4: Sampling frequency and locations for Monitoring

Quality Parameter			Location		
Analyte	Guideline		End user ("Canary")	Storage tanks	Treated rainwater tanks
	Health	Aesthetic			
E. coli /100mL	No detect		W	S, W	W
Naegleria /100mL	No detect			S, Q>A	
Chlorine residual mg/L	> 0.5, < 5	< 0.6	W		W
pH = -log[H^+]		6.5-8.5	W	S, W	W
Temperature, °C			W	S, W	W
Conductivity, µS/cm		< 1200	W	S, W	W
Alkalinity			W	S, W	W
Cu	< 2	< 1	W>M	S, W>M	W>M
Fe		< 0.3	W>M	S, W>M	W>M
Mn	< 0.5	< 0.1	W>M	S, W>M	W>M
Thermo coli /100mL			W>M	S, W>M	W>M
TOC			W>M	S, W>M	W>M
THM	< 0.25		W>M	S, W>M	W>M
Colour, Hazen		< 15	W>M	S, W>M	W>M
Turbidity, NTU		< 5	W>M	S, W>M	W>M
Dissolved O_2		> 85%	W>M	S, W>M	W>M
Hardness as CaCO3		< 200	W>M	S, W>M	W>M
SS				S, W>M	W>M
NH_3-N		< 0.5		S, Q>A	
NO_3^-	< 50 infants, < 100			S, Q>A	
F	< 1.5			S, Q>A	
H_2S		< 0.05		S, Q>A	
As	< 0.01			S, Q>A	
Ba	< 2			S, Q>A	
Be	< 0.06			S, Q>A	
Cd	< 0.002			S, Q>A	
Cr(VI)	< 0.05			S, Q>A	
Pb	< 0.01			S, Q>A	
Hg	< 0.001			S, Q>A	
Mo	< 0.05			S, Q>A	
Ni	< 0.02			S, Q>A	
Se	< 0.01			S, Q>A	
Ag	< 0.1			S, Q>A	

Quality Parameter			Location		
Analyte	Guideline		End user ("Canary")	Storage tanks	Treated rainwater tanks
	Health	Aesthetic			
Sn				S, Q>A	
U	< 0.017			S, Q>A	
Zn		3		S, Q>A	
Gross α, Bq/L	< 0.5			S, Q>A	
Gross β, Bq/L	< 0.5			S, Q>A	

Frequency: S = screening/ baseline, W = weekly, M = monthly, Q = quarterly, A = annually. "W>M" means weekly for the first month and then monthly provided low level and variability, "Q>A" means quarterly for the first year and then annually provided low level and variability; monthly analyses may be reduced to quarterly or annual subject to results and HACCP

Some of the quality parameters in Table 4 have no guideline values but can be useful in diagnosing the source of a problem.

When monitoring shows a water quality parameter value outside of the guidelines, corrective action is required. One of the first priorities is to re-test with another sample, or have the laboratory re-analyse the original sample if available and properly preserved, but meanwhile, corrective actions identified in the risk assessment process and documented in Section 5. Control Measures should be implemented.

Validation of the preventative measures and treatment processes as suggested in the ADWG can be obtained from the regular sampling and analysis of the storage tanks, membrane filtrate, UV effluent, treated rainwater and delivered tap water. The contaminants of concern for a well-designed and maintained rainwater system are difficult to identify, and the levels of treatment required to assure safety, and therefore required for validation, are unclear. The ADWG suggest that "desktop", or theoretical, validation can be sufficient, without the use of plant data. However, until more is known about the quality of water collected in the HCC rainwater system, validation of the treatment processes is not possible.

6.2 Inspection

It is expected that the rainwater treatment plant will have its own inspection protocols and Inspection and test plans ("ITP"s) or checksheet forms incorporated into its operation and maintenance regime, provided by the vendor under the supply contract. The inspections and maintenance undertaken on the treatment plant should be reported by the contractor and viewed as part of the overall system operation.

Checksheet forms should be developed to document the routine inspections for all parts of the collection and distribution system. Items to be inspected include roofs and any surrounding vegetation, gutters and their guards, collection tanks and first flush devices, storage tanks, treated rainwater tanks, and distribution system including RPZDs and possible cross-connections, incorporated into 2 or 3 checksheet forms. The inspection forms can include items for associated equipment, such as collection tank water level and pump set operational status. Sample forms, which will need to be updated as experience is gained and other issues arise, as well as incorporating any HACCP issues when available, are included in Appendix 4.

7. Incident Management

In the ADWG, an incident is an occasion when water quality outside of the guidelines is delivered to consumers. In other words, the monitoring and corrective actions have failed to prevent distribution of poor quality water. Under the guidelines, consumers should be notified as soon as possible.

In the HCC situation, being a relatively small community with institutional structures in place, the scale and logistics of incident management should be easily managed. The provision of backup mains supply water enables the reticulation of mains water while the incident is investigated to identify the cause or source of the problem, and corrective action is taken. Thus, the first response to an incident with the rainwater system will be to shut down the treated rainwater reticulation pump set and isolate the treated rainwater tank, and ensure that the backup potable reticulation pump set or mains pressure supply is operational. Flushing of the affected pipework after an incident, to remove any remaining contamination or to provide increased disinfection, is likely to be required. Procedures specific to the problem may also be required, such as flushing out a collection or storage tank, chemical cleaning of a section of roof, or optimisation of treatment plant operating parameters such as chlorine dosing.

The scheme manager and scheme operator should be involved in developing appropriate incident and emergency response protocols for the HCC rainwater supply scheme. To avoid further incidents in the short term, basins, sinks and showers in a particular building or area could be isolated while flushing is carried out, for example, subject to management of inmates and time of day.

8. Roles and Responsibilities

8.1 Scheme Manager

The scheme manager has overall responsibility for the installation and operation of the rainwater system. The scheme manager should demonstrate due diligence and ensure that the legal risks associated with the use of rainwater are appropriately addressed. To fulfil this responsibility, the scheme manager should ensure that this management plan is properly implemented and reviewed, and ensure communication and training needs are adequately met.

Aegis is the manager of the HCC rainwater scheme.

8.2 Scheme Operator

The scheme operator operates and maintains the HCC rainwater scheme on behalf of Aegis.

PFM is the operator of the HCC rainwater supply scheme.

9. Communication

Key messages to be communicated to users of the system should address:

- How to identify rainwater pipes and outlets (as distinct from other outlets)
- Where to get further information and advice
- How to report rainwater supply or quality issues

Residents and staff should receive written information. After the scheme has been in operation for some time, it may be considered necessary to improve signage or introduce a site induction program relating to water use. Staff of the facility should have some induction into the multiple water sources in use, and training in the relevant aspects of the quality management plans and how they affect the running of the facility.

The Department of Justice established the Ararat Correctional Precinct Development Community Advisory Group (CAG) to engage the community on the development plans and allow opportunity for input. This is an ongoing process.

A complaints handling procedure should be developed. Noting that complaints can provide early warning of developing problems, signage in appropriate locations should inform users of the steps to take and how to report any issues with the water quality or hardware of the system.

Regular communication within the staff of the facility, such as handover documentation between shifts as well as management planning meetings, should include information about the rainwater system. It is important that shift supervisors are aware of any current issues, such as an outage due to incident response, system maintenance or regular inspections. Similarly, management should be aware of upcoming activities which could involve contractor site access or special arrangements for inmates and users of the system.

10. Training

This generally applies to the operators and managers of the rainwater supply scheme. The level of skill appropriate to operating the system is substantially higher than that appropriate to general staff of the facility.

The ADWG state(§ 3.7):

> “The knowledge, skills, motivation and commitment of employees and contractors ultimately determine a drinking water supplier’s ability to operate a water supply system successfully. It is vital that awareness, understanding and commitment to performance optimisation and continuous improvement are developed and maintained within the organisation.”

Training opportunities provide a means to engage personnel and up-skill the workforce, and a KPI for an individual’s performance evaluation. Water industry operator certification is becoming more recognised and desirable. The Australian Water Association (“AWA”) organises operator conferences annually, and can provide details of training opportunities and contacts for training organisations. One popular training provider is the International Water and Environment School (“IWES”) which runs multiple concurrent courses in water and wastewater treatment, events which provide an opportunity for information exchange and networking with people of all skill levels.

11. Documentation

As built drawings, O&M manuals for treatment plant, data logging, Inspection records, Monitoring plan, Monitoring results

(3.10.1 Management of documentation and records)

- Document information pertinent to all aspects of drinking water quality management.
- Develop a document control system to ensure current versions are in use.
- Establish a records management system (database or systematic storage) and ensure that employees are trained to fill out records.
- Periodically review documentation and revise as necessary.

(3.10.2 Reporting)

- Establish procedures for effective internal and external reporting.
- Produce an annual report to be made available to consumers, regulatory authorities and stakeholders.

12. Review and Improvement

(Evaluation & audit E11)
• Collect and evaluate long-term data to assess performance and identify problems.
• Document and report results
• Establish processes for internal and external audits.
• Document and communicate audit results
(Review and continuous improvement E12)
• Senior executive review of the effectiveness of the management system.
• Evaluate the need for change.
• Develop a drinking water quality management improvement plan.
• Ensure that the plan is communicated and implemented, and that improvements are monitored for effectiveness

13. Compliance with Australian Drinking Water Guidelines

The table below lists the 12 elements of the framework for managing drinking water quality and use (as per the ADWG) and shows how the scheme meets the various elements.

Table 5: 12 Framework Elements

Framework element	Activity	Reference Document
Element 1: Commitment to drinking water quality management		
Components: Drinking water quality policy	• The project parties, Aegis and PFM are all committed to the responsible use of rainwater as indicated in section 1.3.	Policy statements from PFM and Aegis will be available.
Regulatory and formal requirements	• None required according to DoH • Recommend following ADWG because of level of exposure	
Engaging stakeholders	• The Department of Justice established the Ararat Correctional Precinct Development Committee Advisory Group (CAG) to ensure that the community has the opportunity to participate in plans for the development. The CAG provides ongoing information sharing between the Department of Justice, the community, and the Ararat Rural City Council. • One of the key issues raised by the community was the requirement for sustainable development, particularly around water. This led to the water saving and recycling initiatives that are part of the development. • The Department of Justice has published the Ararat Correctional Precinct Development Plan, which outlines the project and the community and other stakeholder involvement.	Ararat Correctional Precinct Development Plan
Element 2: Assessment of the drinking water supply system		
Components: Water supply system analysis	• Uses are for basins, sinks and showers, as well as toilet flushing in older buildings. • Water source is rainwater collected and treated on site	This RQMP
Assessment of water quality data	• Raw rainwater quality is estimated from typical analyses. Contaminants specific to the HCC site are yet to be determined • Treated water quality from the treatment plants will be tested in accordance with a specified monitoring regime.	This RQMP, and ADWG

Framework element	Activity	Reference Document
Hazard identification and risk assessment	Human health Given the use of the water in basins, sinks and showers, the level of exposure will be equivalent to drinking A HACCP and HAZOP will be conducted with stakeholders once the design of the process has developed to suitable point, and will form appendix 4 of this document. The proposed stakeholders are listed in the HEMP.	HACCP and HAZOP Appendices 3 & 4
Element 3: Preventative measures for drinking water quality management		
Components: Preventative measures and multiple barriers	Human health Preventative measures to manage risks to human health include: • Membrane filtration, UV disinfection and chlorine disinfection; • Pipework and signage at site of use indicating that rainwater is being used; • Signage at site to alert plumbers to multiple water systems (potable, rain and recycled) and co-ordination of plumbers through site management; • Backflow prevention and cross-connection control; • Education programme for prisoners , staff, visitors, and contractors • A list of detergents considered appropriate for use on roofs made available to maintenance personnel and updated annually;	This RQMP
Critical control points	Critical control points will be confirmed during the HACCP risk assessment.	HACCP (to be completed) Appendix 4.

Framework element	Activity	Reference Document
Element 4: Operational procedures and process control		
Components: Operational procedures	• Operational procedures were identified for all processes and activities associated with the system, including operation of treatment processes and auditing procedures for cross-connections. • Documented procedures must be available to operations personnel and for inspection at any time. • Operators are proficient and are able to recognize the significance of changes in the rainwater treatment plant and water quality. They are able to respond appropriately according to established procedures.	This RQMP Treatment plant O+M Manual This RQMP
Operational monitoring	Monitoring includes: • Trans-membrane pressure ("TMP") • UVI, power and lamp failure (continuous) • Free chlorine residual (continuous) • Turbidity in treated water recirculation loop (continuous) • pH in treated water recirculation loop (continuous) • Regular inspection of tank controls (gutters, screens, etc);	Treatment plant O+M Manual This RQMP (after incorporation of HAZOP and HACCP outcomes)
Corrective action	Corrective actions include the following: • Noncompliance with critical limits results in the system being stopped and/or treated water transfer to storage is prevented. • If cross-connections detected, flow to ring main stopped until repairs completed. Site switches to potable water backup until cross connection is eliminated.	This RQMP
Equipment capability and maintenance	• Treatment plant and disinfection systems of standard and reliable design. Maintained by qualified supplier.	PFM have been engaged by Aegis to manage to operation and maintenance of the system.

Framework element	Activity	Reference Document
Materials and Chemicals	• All plumbing and drainage work is conducted in a manner conforming to AS/NZS standard 3500. • All chemical used in the plant are obtained from credible suppliers.	The plant design is approved prior to construction. Contractor inductions are performed prior to commencement of work MSDS are supplied for each chemical
Element 5: Verification of drinking water quality		
Components: Drinking water quality monitoring	Human health • Monitoring of defined parameters is undertaken. • Any complaints are recorded and investigated.	Section 6 of this RQMP
Consumer satisfaction	• Complaints handling process is outlined in Section 9.	This RQMP.
Short-term evaluation of results	• Monitoring analysis results provided to scheme operator by laboratory	Service Report to Aegis regarding plant operation and performance indicators
Corrective action	• Corrective action depends on the incident. As a minimum, it involves investigation of plant performance records to confirm normal operation, and additional testing to confirm the result and identify the source. • If target criteria for quality parameters are exceeded, preventative measures need to be reassessed and corrective action taken to ensure performance is improved.	Corrective actions are addressed in section 6 of this RQMP
Element 6: Management of incidents and emergencies		
Components: Communication	• In the case of an incident or emergency that requires a media response, only the CEO is authorized to make any public comment.	Records of incidents or emergencies kept by Aegis / PFM

Framework element	Activity	Reference Document
Incident and emergency response protocols	• (Yet to be developed in coordination with HCC/Aegis) • Employees are trained in emergency response and incident protocols. • Training records are kept. • In the event that the rainwater treatment plant is unable to supply treated water, potable water backup is available.	This RQMP
Element 7: Employee awareness and training		
Components: Employee awareness and involvement	• Operator of treatment plant to be sufficiently skilled to run the plant and investigate any faults • Develop mechanisms and communication procedures to increase employees' awareness of and participation in drinking water quality management. • • Contractors inducted to site are told of the presence of multiple pipe systems and the precautions required.	Technician induction on commencement of employment, operating manuals, supervision from experienced engineers. Induction records for those coming on site to work. End user awareness brochure (to be produced) HCC website describing the water use features of HCC.
Employee training	• Operators to be aware of approval conditions and instructed on occupational health and safety requirements • Ensure that employees, including contractors, maintain the appropriate experience and qualifications. • Training needs for individual employees are identified and adequate resources made available during the induction phase. Annual performance reviews identify additional training requirements and set performance targets. Training records are kept.	Site Induction program Contractor induction records Annual reviews

Framework element	Activity	Reference Document
Element 8: Community involvement and awareness		
Components: Community consultation	• The Department of Justice established the Ararat Correctional Precinct Development Community Advisory Group (CAG) to engage the community on the development plans and allow opportunity for input. This is an ongoing process.	Community Advisory Group records Ararat Correctional Precinct Development Plan (2010)
Communication	• Various documents on the development proposal and activities have been produced to promote public awareness and education. This information is available online through the Department of Justice website.	Ararat Correctional Precinct Development Plan (2010).
Element 9: Research and development		
Components: Investigative studies and research monitoring	• As the depth of operational knowledge regarding this and similar water treatment technologies increases, so the understanding of the weaknesses increases. This results in better opportunity to be proactive regarding operational control and maintenance of the plant.	This RQMP will be reviewed in 12 monthly intervals as part of the process of continual improvement.
Validation of processes	• Ongoing investigations into rainwater quality and treatment plant performance to refine assessments. This may enable less conservative critical control points to be adopted or treatment requirements reduced.	Validation according to section 6 of this RQMP
Design of equipment	• The design of the plant is based on experience with individual and community rainwater schemes. Specific design features for dealing with issues in a Correctional Centre setting could be developed	Section 5 of this RQMP

Framework element	Activity	Reference Document
Element 10: Documentation and reporting		
Components: Management of documentation and records	• Design of treatment plant and reticulation system documented; • Operating procedures documented; • All results to be recorded and stored; • Included in this RQMP and the Operations and Maintenance Manual is information pertaining to preventative measures employed, target and critical limits, critical control points, operating and corrective action procedures. • These documents, along with the incident and emergency response plans, training programs and reporting protocols ensure that the plant is operating within set limits at all times. • The document control system, ensures that only the most current version of any document is available for use. All documents are reviewed on an annual basis.	This RQMP, Incident and Emergency Management Procedure, Performance reviews, AKS Operations and Maintenance Manual
Reporting	• Internal reporting consists of verbal communication between the operator and the site service technician and written reports from the technician to the operator. • The owners of this treatment plant receive a monthly report detailing all operational and performance parameters and the maintenance performed during that month. • An annual report is prepared and submitted to the owner. • Noncompliance breaches are reported immediately to PFM/ Aegis.	Monthly reporting to Aegis. An annual report to Aegis
Element 11: Evaluation and audit		
Components: Long-term evaluation of results	• Annual report on compliance with ADWG, including test results.	Annual report to Aegis
Audit of drinking water quality management	• Audit after the first 12-months then ongoing at least every 3 years by third party auditor.	Audit reports

Framework element	Activity	Reference Document
Element 12: Review and continual improvement		
Components: Review by senior managers	• Performance of treatment plant, customer complaints/satisfaction reviewed annually as part of compliance reporting. Annual report Aegis signed off by senior staff member from PFM.	Annual report signoff
Drinking water quality management improvement plan	• RQMP reviewed at least annually. • Any opportunities for improvement identified through staff, customers, or auditors are reviewed and implemented as appropriate.	Improvement actions from audit reports or annual reviews are reviewed and implemented where appropriate.

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4. NHMRC, NRMMC 2008, National Water Quality Management Strategy; Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (2008). Accessed from http://www.environment.gov.au/resource/national-water-quality-management-strategy-overview-australian-guidelines-water-recycling on 5/2/2014

Appendices

Appendix 1 Site plan and relevant drawings

Aegis-NDY	HN-AA032	HCC: Hydraulic Services: Treated Rainwater Schematic
Aegis-NDY	HN-AA034	HCC: Hydraulic Services: Untreated Rainwater and Domestic Cold Water Schematic
Aegis-NDY	HN-HPA800	HCC: Hydraulic Services: Plant Schematic
…		
AKS Industries	WF_APA_PID_001	Ararat Prison – AKS: Piping and Instrumentation
AKS Industries	WF_ARA_GA_001	Ararat Prison – AKS: Indicative General Arrangement

Appendix 2 HAZOP and Environmental Risk Assessment (pending)

Appendix 3 HACCP (pending)

Appendix 4 Draft Inspection checksheet forms

Hopkins Correctional Centre
Rainwater Quality Management Plan
Draft Collection System Inspection Record

Date: ____/____/____ Time: _________
Inspector name: ________________________
Inspection frequency: Weekly

Roofs and gutters

Issue	Building							Comments
	West	GH W	GH E	Ext Store	East			
Roof clear of debris, branches, leaves, bird droppings, dead animals, etc								
Roof free of obvious ash or dust								
Gutter guard intact and properly installed								
Gutters and guards free of sediment, leaves, dead animals, etc								

Tanks

Issue	Collection tanks						Storage Tanks		Comments
	West Sat	GH W1	GH W2	GH East	Ext Stor	East Sat	1	2	
First flush device clear of debris									
First flush device operational									
First flush device drained									
Inlet screen intact									
Inlet screen clear of debris									
Overflow screen intact									
Overflow screen clear of debris									
Vent screen intact									
Vent screen clear of debris									
Drain for overflow clear of debris									
Access covers secured									
Outlet valve open									
Drain valve closed									
No obvious leaks									
Pump set power available									
Pump set operational									
Tank water level reading									

Date: ____/____/____ Time: _________
Inspector name: ______________________
Inspection frequency: Monthly

Ring main

Issue	Building/ branch									
Isolation valve fully open										

Pump sets, RPZD and mains supply connection

Issue	Y/N	Comments
TRW Pump set power available		
TRW Pump set fully operational		
Mains pressure RPZD operational		
Potable reticulation RPZD operational		
Mains supply valve operational		
Potable supply valve operational		
Potable Pump set power available		
Potable Pump set fully operational		

Hopkins Correctional Centre
Rainwater Quality Management Plan
Draft Collection System Inspection Record

Date: ____/____/____ Time: _________
Inspector name: ______________________
Inspection frequency: Quarterly

Roofs and gutters

Issue	Building							Comments
	West	GH W	GH E	Ext Store	East			
No vegetation within 1m								

Tanks

Issue	Collection tanks						Storage Tanks		Comments
	West Sat	GH W1	GH W2	GH East	Ext Stor	East Sat	1	2	
No obvious damage, roof & walls intact									
No obvious sediment on bottom									
No bugs/ mosquitoes netted									

Distribution system

Issue								Comments
No cross-connections								

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix 4.1.12.2

Reservoir Water Management Plan 6

Document Name:	Reservoir Water Management Plan	Revision Number & Date:	1 – 1/12/2015	Narara Ecovillage Co-operative Ltd
Date of Issue:	1-Dec-2015	Controlled Document:	Yes	

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook 2126

Mr Geoff Cameron,
Chair,
Water and wastewater Management Team,
Narara Ecovillage

Dear Mr Cameron,

Please find below the revised Reservoir Water Quality Management Plan.

The plan has been revised to clearly identify its strong linkage with the 12 elements in the Australian Drinking Water Guidelines (2011).

Considerable emphasis is placed on identifying catchment conditions, especially via a Sanitary Survey, a Vulnerability Assessment and a Microbial Indicator Assessment as per the Water Services of Australia publication (WSAA, 2015):

Drinking Water Source Assessment and Treatment Requirements: Manual for the Application of Health Based Treatment Targets.

A key aim of the plan is to identify the extent to which the water is the reservoir is ‘Fit-for-Purpose’ as feedstock for the water treatment plant.

A risk analysis identifies the extent to which catchment conditions and activities create risks to the fit-for-purpose requirements. These are then addressed via appropriate mitigating actions and precautions.

Please feel totally free to contact me should you require further comment or clarification.

Yours sincerely

Peter Bacon.

Dr Peter Bacon
Director
4.12.2015

RESERVOIR WATER MANAGEMENT PLAN
for

NARARA ECO VILLAGE

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

Reservoir

Client	Narara Eco Village
Prepared By	Woodlots & Wetlands Pty Ltd 220 Purchase Road Cherrybrook NSW 2126 Telephone (02) 94842700 Mobile 0427905440 E mail woodlots3@bigpond.com
Date Issued	7 December 2015
Document File name	*Reservoir Management Plan Narara Ecovillage V6*
Document Title	**RESERVOIR WATER MANAGEMENT PLAN** **for** **NARARA ECO VILLAGE**
Document Registered By	Peter Bacon Principal Consultant

Acknowledgement

The assistance of Narara Eco Village members, especially David Roberts, Mark Fisher and John Talbott is gratefully acknowledged. The input of Aquacell Technology and City Water are also appreciated.

The example Risk---based Drinking Water Management System Central River and Little Bore water supply systems (NSW Office of Water, 2012) and Drinking Water Source Assessment and Treatment Requirements : Manual for the Application of Health Based Treatment Targets (WSAA, 2015) have been used as guides in portions of the current document.

Glossary

Abbreviation or acronym	Explanation
ADWF	Average Dry Weather Flow (cubic m/day)
ADWG	Australian Drinking Water Guidelines (ADWG) (NHMRC/NRMMC, 2011).
AEP	Annual Exceedance Probability: A 1 in 1,000 AEP event has a 1 in 1,000 Y average recurrence frequency
Al	Aluminium
ALARP	As Low As Reasonably Possible (an acronym used in risk assessment)
AWTS	Aerated Wastewater Treatment System
BOD	Biological Oxygen Demand
C	Carbon
Ca	Calcium
CANRI	Community Access Natural Resource Information
CFU	Colony Forming Units. A measure of microbial population. It is sometimes referred to as MPN (Most Probable Number)
cm	Centimetres
DALY	Disability Adjusted Life Years. A World Health Organisation sponsored system of assessing the impact of accidents or disease on a population. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for incident cases of the health condition (WHO web site, accessed 2013). The minimum tolerable health risk is typically 10^{-6} DALY (NRMMC/ EPHC/ AHMC (2006).
dB	dB decibel. A measure of noise intensity.
Denitrification	A key nitrogen removal process in wetlands. It involves oxidation then gaseous loss of nitrate-N and nitrite-N to the atmosphere.
DIPNR	Department of Planning Infrastructure and Natural Resources in May 2012, the environmental components had been transferred to the Office of Water (NOW) and OEH)
dS/m	decisiemens/metre A measure of electrical conductivity (1 dS/m=1000 microsiemens/cm)

Abbreviation or acronym	**Explanation**
DWMS	Drinking Water Management System
Effective risk management	The identification of all potential hazards, their sources and hazardous events, and an assessment of the level of risk presented by each.
Effluent	Treated wastewater from a sewage treatment plant (STP)
EMP	Environmental Management Plan
ESCP	Erosion and Sediment Control Plan
Field capacity (water holding capacity)	The amount of water held in soil once gravitational water has drained from the profile. Typically, it is reached approximately 48 hr. after saturation. It can be expressed as a variety of units. In the current report, it is in mm of water stored in the plant root zone.
Fit for Purpose	Raw material or product that is suitable for conversion to a desired end product utilising a proposed methodology. For example, converting raw water from Narara Reservoir to water with qualities consistent with the ADWG via the proposed treatment train.
Faecal coliforms	Bacteria that are indicative of faecal contamination. E coli population density as CFU/100 mL is used as the key water quality criteria.
FSL	Full Surface Level in a reservoir
g	Grams
K	Potassium
ha	hectare (1 ha=100m*100m)
HACCP	HACCP is the Hazard Analysis and Critical Control Point system. (That is: What can we do to reduce hazards)
Hazard	HAZARD=probability*consequences A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard. (What can happen and how)?
HRT	Hydraulic Retention Time – the average travel time for water to pass through a system such as a dam, wetland, maturation pond or reaction chamber.
kg	Kilograms
kL	Kilolitres (1000 L)
km	Kilometres
L	Litres

Abbreviation or acronym	Explanation
LEP	Local Environment Plan. The key planning and zoning instrument used by Councils. The 2014 LEP is the current one in the Gosford City Council LGA.
LGA	Local Government Area
mg	milligrams (10^{-3}g)
Mg	Magnesium
mL	millilitres (10^{-3}L)
ML	megalitres (10^{6}L)
MSDS	Material Safety Data Sheets
MUSIC	Model for Urban Stormwater Improvement Conceptualisation; A stormwater management model widely used in Australia for prediction stormwater quality.
N	Nitrogen
Na	Sodium
NEV	Narara Eco Village
NEV Ltd.	Narara Eco Village Limited. The legal entity which owns NEV
OWL	Operating Water Level
OH&R	Occupational Health and Rehabilitation
P	Phosphorus
PET	Potential Evapotranspiration: Rate of loss of water from plants and soil when there is an unlimited supply.
pH	A measure of acidity
PHU	Public Health Unit of Health NSW.
PQL	Practical Quantification Limit
REF	Review of Environmental Factors
Risk	The likelihood of identified hazards (see definition above) causing harm in exposed populations in a specified timeframe, including the severity of the consequences. (How likely is it to happen? How serious are the consequences?) Risk is maximum risk in the absence of preventive measures Residual risk is the risk after consideration of existing preventive measures.
SAR	Sodium Adsorption Ratio. A measure of the ratio of sodium to calcium plus magnesium. It is used in conjunction with salinity data to determine the stability of

Abbreviation or acronym	Explanation
	irrigation water.
Stormwater	Rainfall runoff derived water arising from roof or ground surfaces.
STP	Sewage Treatment Plant
TWL	Top water level (m)
WTP	Water Treatment Plant

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1. INTRODUCTION

1.1 BACKGROUND

This Reservoir Water Management Plan addresses the 12 elements in the Australian Drinking Water Guideline.

The Plan was prepared in response to a request by the Independent Pricing and Regulatory Tribunal (IPART) as part of the Licence Application under the Water Industry Competition Act (2006 (NSW).

The Narara Eco Village requires a source of raw water that is capable of being treated to reliably achieve potable standard for use in the development. The reason for this need is that it is not economically feasible for the Gosford Council Water Supply system to deliver a full water supply to the development.

An examination of the property revealed that it has a dam of approximately 45 ML capacity on site. The dam catchment is largely native forest. Initial water quality information indicated that the water quality would be suitable for feedstock into a modern water treatment plant. Hydrological investigation and modelling suggested that the dam could reliably supply the potable water demand even during the ‘millennium’ drought. It was therefore decided to propose utilisation of the dam as the primary source water for the potable water treatment facility.

The purpose of this Reservoir Water Management Plan is to

- Characterise the catchment, the dam, the catchment hydrology, the likely water demand, the likely water quality, the impacts of water abstraction on downstream environment
- Identify the proposed water abstraction and treatment train resulting in a reliable supply of potable water
- Identify and analyse the risks associated with the proposed management of the dam
- Identify and analyse the options to address the identified risks
- Identify potential emergencies and incidents
- Identify appropriate responses to these emergencies and incidents
- Identify OH &R requirements
- Identify an inspection, monitoring and maintenance regimes
- Identify the auditing needs

The key outcome of the Reservoir Water Management Plan is to demonstrate understanding and competence in the management of this key resource for the Narara Eco Village.

1.2 STATUTORY REQUIREMENTS

This Reservoir Water Management Plan has been prepared for the purpose of meeting the requirements of IPART as part of its duties under the Water Industry Competition Act (2006 (NSW).

The current license to abstract up to 30 ML/year from the dam is under the Water Management Act (2000). The Water Management Act also governs any impact of dam operations on the downstream environment.

Pollution incidents need to be referred to the EPA under the provisions of the Protection of Environment Operations Act (1997).

The Work Health and Safety Act 2011 No 10 identifies the management of risks, the duty of care and responsibilities relating to employees, contractors and employers.

The Amendment of Dams Safety Act 1978 No 96 removes the Narara Reservoir from the schedule of prescribed dams. This means that the Committee has no role in the oversight of the dam. The reason for this is that the dam is considered low risk to the downstream population.

Gosford City Council's 2014 Local Environment Plan (LEP) is a key determinant of landuse in the catchment.

The Public Health Act 2010 (NSW) requires drinking water suppliers such as NEV to establish, and comply with, a 'quality assurance program' that complies with the Public Health Regulation 2012 (NSW). This regulation requires water suppliers to implement a Quality Assurance Plan consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines (ADWG) 2011 (NHMRC / NRMMC 2011).

In 2015, NSW health released its guidelines for management of Private Water Supply Schemes. The document provides an important resource for the current Plan.

1.3 KEY REFERENCES FOR MANAGEMENT OF DRINKING WATER QUALITY

The Australian Drinking Water Guidelines (ADWG) (NHMRC/NRMMC, 2011) set out a holistic approach to drinking water management including understanding where sources of contamination may arise and how contamination may find its way to the consumer. The approach is termed the Framework for Management of Drinking Water Quality (the Framework, Table 1.1). As part of the WICA/WICR licensing requirements, the applicant must develop a management plan for the water supply scheme, which meets the 12 Elements of the Framework.

Other references include:

ANZECC (2000a). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra, ACT

ANZECC (2000b). Australian Guidelines for Water Quality Monitoring and Reporting Canberra, ACT

Water Services Association of Australia (2015). Drinking Water Source Assessment and Treatment Requirements : Manual for the Application of Health Based Treatment Targets (WSAA).

1.4 KEY GUIDING PRINCIPLES

WSAA (2015), refer to a series of guiding principles as set out in ADWG (2011).

Two of these are :

1. ***The drinking water systems must have and continuously maintain robust multiple barriers appropriate to the level of contamination facing the raw water supply***

2. ***Ensuring drinking water safety and quality requires the application of a considered risk management approach***

Applying these principles to the subject reservoir requires an assessment of the potential yield of contaminants from the catchment and an assessment of the dam as a mechanism that can reduce/ dilute the contaminant loads.

Risk management is concerned with taking a carefully considered course of action based on the precautionary principle.

1.5 APPLICATION OF DISABILITY ADJUSTED LIFE YEARS TO NARARA ECOVILLAGE

The WSAA 2015 sets an ‘aspirational target of <1 μDALY[1]. That is, on average one DALY is ‘lost’ per million persons per year. The maximum likely population of Narara ecovillage is under 500 persons. Assuming 500 persons, an infection rate of <1 μDALY is the equivalent of 1 DALY spread over 2000 years. This would be statistically extremely difficult to verify.

In these circumstances the log reduction of contamination should receive more emphasis.

1.6 COMMITMENT TO THE FRAMEWORK FOR MANAGEMENT OF DRINKING WATER QUALITY

The Revised 2011 edition of Australian Drinking Water Guidelines (NHMRC, NRMMC, 2011), contains the following framework for managing of drinking water quality

The framework is shown below.

[1] DALY stands for Disability Adjusted Lift Years.
It takes into account both the frequency of infection and its severity.
EXAMPLE: Infection with rotavirus causes:

• mild diarrhoea (severity rating of 0.1) lasting 3 days in 97.5% of cases

• severe diarrhoea (severity rating of 0.23) lasting 7 days in 2.5% of cases

• rare deaths of very young children in 0.015% of cases

The DALY per case = (0.1 x 3/365 x 0.975) + (0.23 x 7/365 x 0.025) + (1 x 80 x 0.00015)

= 0.0008 + 0.0001 + 0.012

= 0.013

If 1 person in 2000 get the infection, the DALY rate is $6.5*10^{-6}$ or 6.5 μDALY. This is 6.5 times the target of 1μDALY

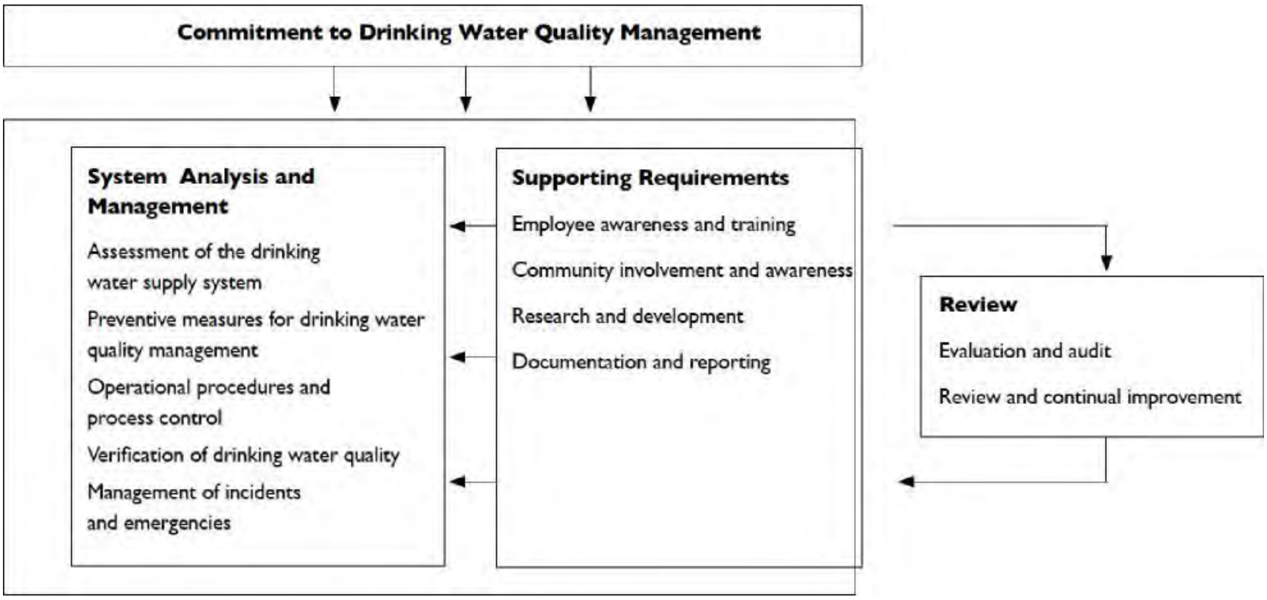


Figure 1.1: The Framework for Management of Drinking Water Quality (NHMRC / NRMMC, 2011).

Details of the components are shown in table 1.1 below.

Table 1.1. Details of components of the 12 elements in the Framework for Management of Drinking Water Quality (NHMRC / NRMMC, 2011).

1 . Commitment to Drinking Water Quality Management Drinking water quality policy Regulatory and formal requirements Engaging stakeholders 2. Assessment of the Drinking Water Supply System Water supply system analysis Assessment of water quality data Hazard identification and risk assessment 3. Preventive Measures for Drinking Water Quality Management Preventive measures and multiple barriers Critical control points 4. Operational Procedures and Process Control Operational procedures Operational monitoring Corrective action Equipment capability and maintenance Materials and chemicals 5. Verification of Drinking Water Quality Drinking water quality monitoring Consumer satisfaction Short-term evaluation of results Corrective action Management of Incidents and Emergencies Communication Incident and emergency response protocols	6. Employee Awareness and Training Employee awareness and involvement Employee training 7. Community Involvement and Awareness Community consultation Communication 8. Research and Development Investigative studies and research monitoring Validation of processes Design of equipment 9. Documentation and Reporting Management of documentation and records Reporting 10. Evaluation and Audit Long-term evaluation of results Audit of drinking water quality management 11. Review and Continual Improvement Review by senior executive Drinking water quality management Improvement plan

The application of this framework varies with individual situation. However the framework has been applied to the Narara Dam as it is the chief water source for the Narara Ecovillage.

A series of reports have already been prepared as part of the management of drinking water quality. These include:

- *Narara Ecovillage Potable Water Scheme: Drinking Water System Management System Development Plan* (*Aquacell, 2014a)*;
- *Risk Assessment Summary Paper (Aquacell and City Water Technology, 2014).*
- *Drinking Water Quality Improvement Plan (Aquacell, 2014b).*
- *Dam Safety Management System, 2015* (in accord with requirements of Guidance Note DSC 2A) *(Pells Consulting, 2015)*
- *Report on the Safety Inspection of Narara Dam, 2015 - detailed surveillance report (Pells Consulting, 2015).*

.

These documents are referred to and utilised in the current text.

2. ELEMENT 1: COMMITMENT TO DRINKING WATER POLICY

2.1. DEVELOP A DRINKING WATER QUALITY POLICY

The technical committee of the Narara Eco Village Limited (NEV Ltd.) has commissioned Aquacell in conjunction with City Water Technology to develop a Drinking Water Quality Policy. This policy will be adopted in full by NEV Ltd.

Additionally NEV Ltd. has commissioned separate but related plans and policies to establish consistency and to reinforce the Drinking Water Quality Policy.

These documents include:

- A water recreation policy for the dam
- The current Reservoir Water Management Plan, and
- A surveillance report in accordance with ANCOLD guidelines (Prepared by Pells consulting and is concerned with dam structural conditions).

Once approved by consenting authorities, the documents will become core resources for safe and long term sustainable management of the water supply system at NEV.

The NEV Drinking Water Quality Policy is presented on the next page.

Narara Eco Village Co-operative Ltd
Drinking Water Quality Policy

Narara Eco Village Co-operative Ltd (NEV) is committed to providing safe, high-quality drinking water that consistently meets the requirements of NSW Health, NSW Office of Water, the Australian Drinking Water Guidelines and consumer expectations.

NEV will work on an ongoing basis with our stakeholders to manage the multiple barriers that protect and maintain water quality water from catchment to consumer.

Priorities will be set using an objective, risk-based approach to water quality management, to improve the quality of water supplied and the reliability with which that quality is achieved.

A 'quality assurance program' that complies with the Public Health Regulation 2012 (NSW) will be documented within and maintained from our Drinking Water Management System. In turn, this system has adopted the Framework for Management of Drinking Water Quality given in the Australian Drinking Water Guidelines 9 (NHMRC, NRMMC, 2011).

All NEV members are stakeholders in the water supply and treatment system. As such all members must ensure that their activities do not compromise drinking water quality. All NEV members are required to be alert to external risks to the drinking water, e.g., algal blooms, wildfire, dead animals in the dam and unauthorised access to the dam water. NEV members will facilitate community involvement in water quality management via appropriate activities such as participation in Streamwatch.

The NEV maintenance staff and the NEV management team are responsible for understanding and working in accordance with relevant aspects of the Drinking Water Management System.

Drinking water quality monitoring will be conducted independently by NSW Health and NEV management team will report the results of that monitoring to the NEV community.

The Drinking Water Management System is an operational management system that will be adequately resourced, maintained and improved indefinitely as a core and ongoing function of Narara Ecovillage Co-operative Limited

Dated:

Signed: Convener, Technical Advisory Group/ (for the) Board of Directors

2.2. REGULATORY AND FORMAL REQUIREMENTS

Some of the regulatory requirements are identified in section 1.2. Additionally the Narara Ecovillage Potable Water Scheme: Drinking Water System Management System Development Plan (Aquacell, 2014). provides details of the requirements.

The requirements specific to the management of the water supply dam are listed below;

The Public Health Act 2010 (NSW) requires drinking water suppliers such as NEV to establish, and comply with, a 'quality assurance program' that, in turn, complies with the Public Health Regulation 2012 (NSW). This regulation requires water suppliers to implement a Quality Assurance Plan consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines (ADWG) 2011 (NHMRC, NRMMC 2011).

Table 2.1. Regulatory and Formal Requirements summary

Regulatory or formal requirement	*Relevance to drinking water quality*	*How NEV Ltd. meets this*
Public Health Act 2010 and Regulation (2012) (NSW)	The Public Health Act 2010 (NSW) requires drinking water suppliers such as NEV Ltd. to establish, and comply with, a 'quality assurance program' that complies with the Public Health Regulation 2012 (NSW).	Through this Reservoir Water Management Plan and the overarching DWMS
Australian Drinking Water Guidelines (NHMRC, NRMMC 2011, and as revised from time to time)	Sets out appropriate practice for drinking water quality management within Australia	Through this Reservoir Water Management Plan and the overarching DWMS
NSW Health Drinking Water Monitoring Program	Provides for independent testing by NSW Health of treated water as supplied to consumers	Described in more detail under the current plan.
Protection of the Environment Operations Act 1997 (NSW)	Sets out the requirements for the control of water pollution from certain activities which may be in the drinking water catchment and which are registered with the Office of Environment and Heritage	Through notification to OEH if concerns are raised
Local Environment Plan	Limits what can be developed and/or undertaken in a particular location. This is especially important for any proposed development in the catchment. The implications of land swaps with Council need to take the proposed role of the catchment into account. Additionally the zoning of some lands in the western portion of the catchment have been deferred within the 2014 LEP. NEV Ltd. must take a watchful, cautious role in ensuring its water supply is not put at risk from future zoning changes.	NEV Ltd. must ensure it is considered as a key stakeholder in any development or potential development within the Narara Reservoir Catchment. Ensure GCC considers NEV drinking water quality when assessing development applications within the Reservoir Catchment.

2.3. STAKEHOLDER ENGAGEMENT

All NEV members are stakeholders in the NEV water supply system. As such they must ensure that their activities do not compromise drinking water quality. All NEV members are required to be alert to external risks to the drinking water, e.g algal blooms, wildfire, dead and unauthorized access to the dam water.

The NEV maintenance staff and the NEV management team are responsible for understanding and working in accordance with relevant aspects of the Drinking Water Management System.

The key policies including the Drinking Water Policy must be given to all members before joining the NEV Ltd. Additionally they should be on display in community facilities and where members and visitors could potentially impact on drinking water quality.

Examples of site where the Policy should be on display include:

- Near the dam itself
- Near the water quality treatment system
- Near storage tanks

As stakeholders in having a continuing supply of drinking water the NEV Ltd., residents and employees must be encouraged to look for signs of change in water quality in the dam.

These signs can include

- increased turbidity,
- numerous dead animal evident in the water
- algal blooms (See Office of Water web site for information)

Additionally the NEV Ltd. residents and employees must be aware of the threat posed to the drinking water from the results of bushfire in the drinking water catchment.

NEV Ltd. is expected to encourage members to participate in general community activities such as Streamwatch and the Rural Fire Service.

3. ELEMENT 2: ASSESSMENT OF THE DRINKING WATER SUPPLY SYSTEM

3.1. ASSEMBLE A TEAM WITH APPROPRIATE EXPERTISE

The ADWG refers to the need to assemble a team with appropriate knowledge and expertise to undertake the assessment.

The proposed team is:

Aquacell (specifically Mr Warren Johnson) -contracted to supply technical expertise
Dr Peter Bacon-Contracted to supply water and wastewater management expertise
Mr John Talbott-NEV director
Mr David Roberts-NEV member with expertise in water management
Mr Geoff Cameron-NEV member with expertise in quality control
Mr Mark Fisher- NEV member with expertise in risk management

The current Reservoir Water Management Plan is focussed on the reliable supply of feed water that is 'Fit for Purpose' in the proposed Potable Water Treatment Train. The Reservoir Water Management Plan is therefore concentrated on catchment conditions, catchment hydrology, and the ability of the system to reliably supply 'Fit for Purpose' water to the proposed Potable Water Treatment Train.

The terminology used in the ADWG Framework for Management of Drinking Water quality- The twelve elements (NHMRC / NRMMC 2011) has been slightly adjusted to reflect the specific conditions relating to the raw water supply.

The catchment study, the hydrology assessment and the reliability of supply were assessed by Dr Peter Bacon, a Natural Resource Scientist, with over 35 years' experience in water and soil management. The monthly and weekly dam water sampling regime was established and managed by Aquacell.

Both Aquacell and Dr Bacon use laboratories that are NATA registered for the assessed anolytes.

3.2. TIER ONE SURFACE WATER ASSESSMENT

WSAA (2015) provide a detailed methodology for assessing catchments. This approach is considered in conjunction with the approach in ADWG Framework for Management of Drinking Water because it focusses more on the risks to raw water quality.

The WSAA(2015) process requires a Tier 1 assessment on all catchments. The first step in the assessment is a sanitary survey of the water supply catchment. The key outputs required are:

- Pathogen sources arising from the presence of people and cattle
- Intensity of these developments/activities
- Proximity to feeder streams and water storage
- Presence of is situ barriers such as riparian vegetation, fencing and detention in storage.

The outputs from the survey are aggregated to produce a vulnerability assessment for the source.

Figure 3.1 shows the process. This process has been integrated into the ADWG (2011) format.

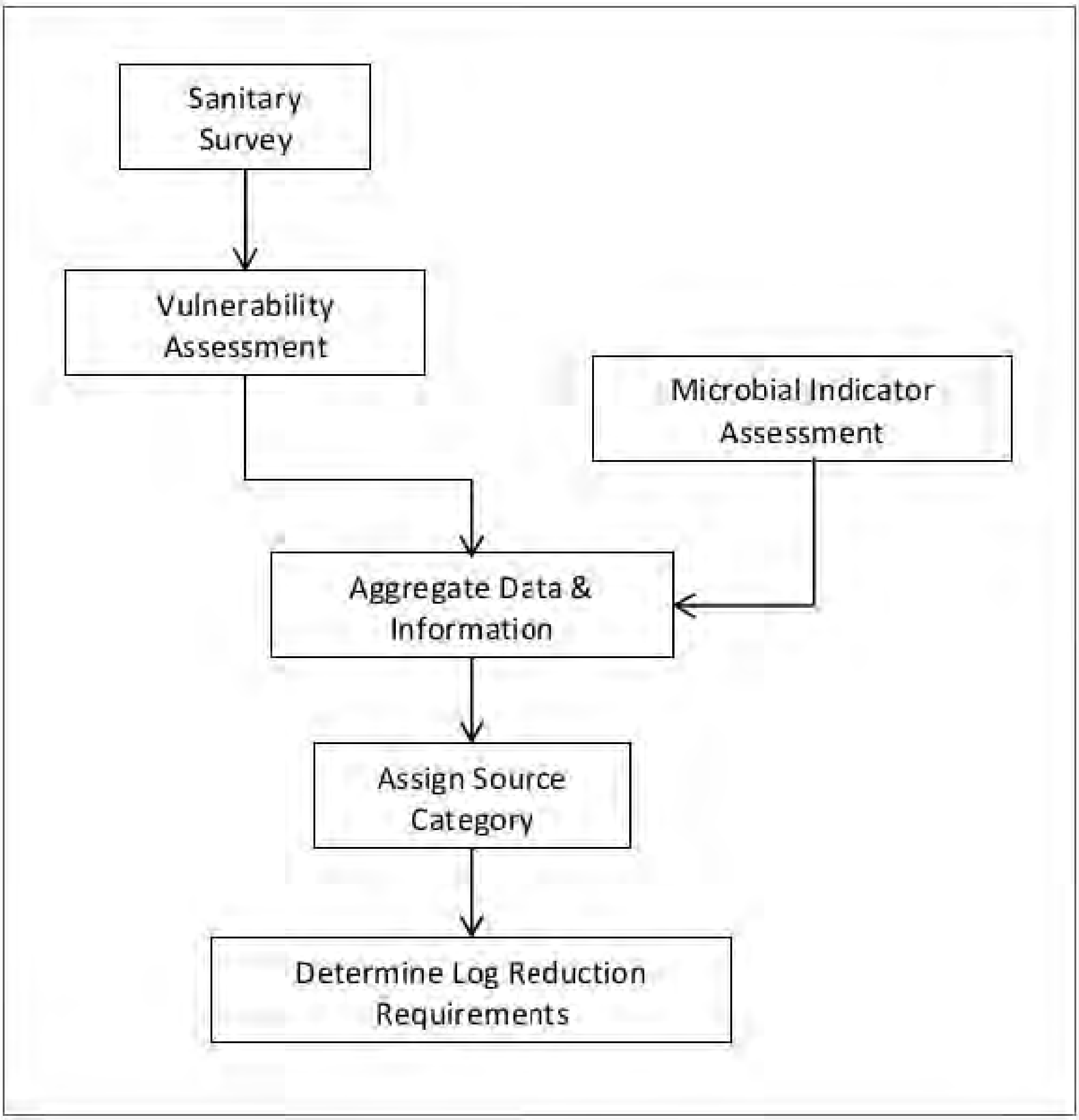


Figure 3.1. Process summary of a Tier 1 Source assessment (Copied from WSSA, 2015).

This Tier 1 assessment is a six step process for determining water treatment requirements:

1. *Sanitary Survey Assessment:* To identify specific pathogen pollution sources within the catchment as well as preventive measures and barriers within the catchment.
2. *Vulnerability Assessment*: To aggregate what is known about the pathogen pollution sources to assess the source vulnerability.
3. *Microbial Indicator Assessment:* To provide an independent evaluation of water quality.
4. *Aggregate Data and Information*: Assemble the above information, review and explain any anomalies
5. *Source Category:* Assign the Source Category based on the preceding analysis.
6. *Log Reduction Requirements*.

(Copied from WSSA, 2015).

3.3. CATCHMENT DESCRIPTION

LOCATION AND SETTING

The regional context of the dam and its catchment is shown in figure 3.2.

The NEV Ltd. water supply system is based on a 130 ha catchment that drains to an un-named creek. This creek is dammed, and the detained waters of this dam will supply the key water source for the Narara Eco Village.

As indicated in figure 3.2, the dam is located approximately 5 km NW of Gosford, NSW. The catchment of the dam is largely natural bushland as figure 3.3 suggests.

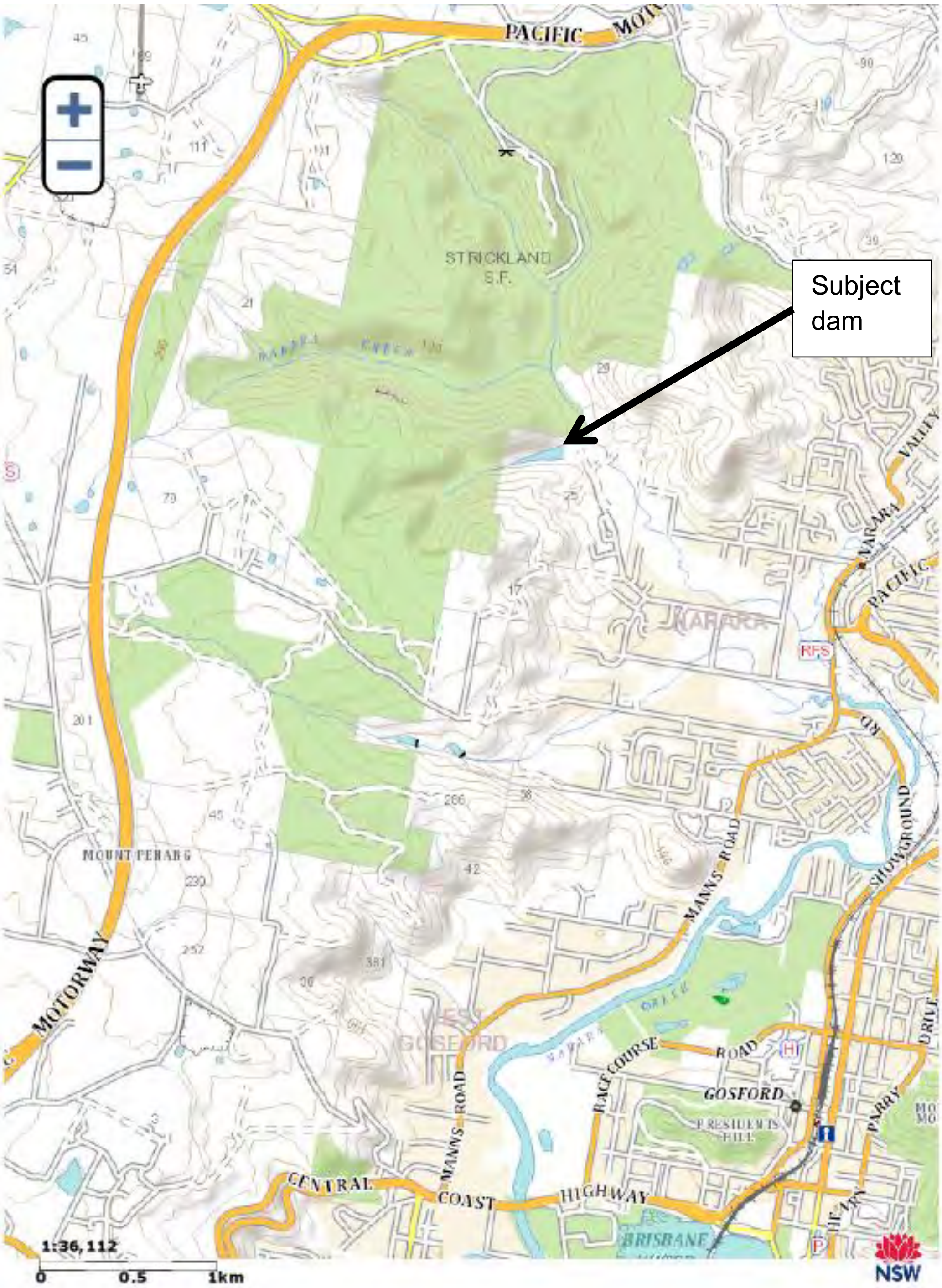


Figure 3.2. Regional context of the subject dam (Image source: NSW Dept Lands, 2014).

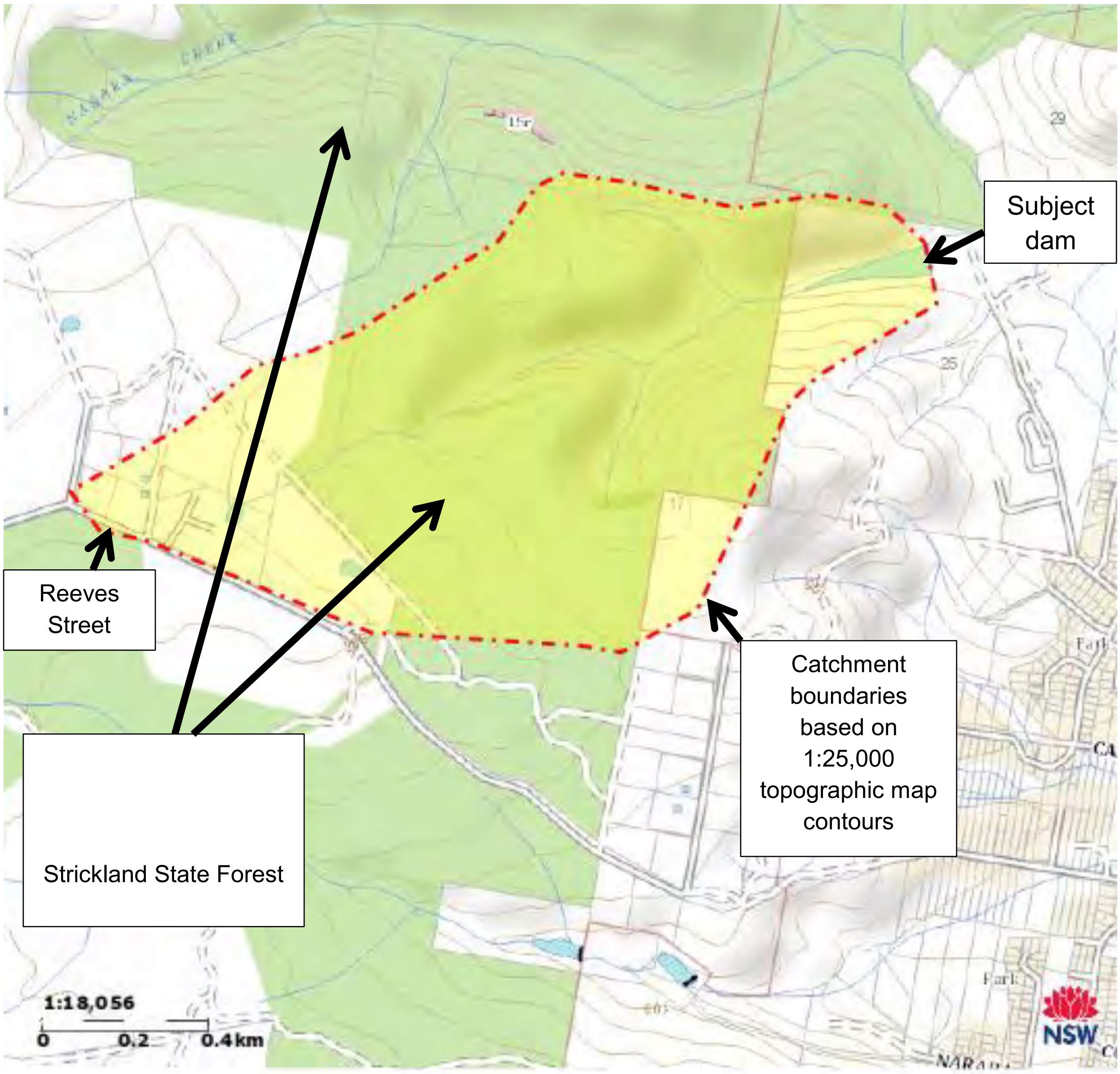


Figure 3.3. The maximum catchment based on contours off the 1:25,000 topographic map (Gosford, 9131-2S. LPI, 2001).

The western portion of the catchment is a relatively flat plateau, so the catchment boundaries are indistinct, and are determined by local drains. It is likely that the catchment is slightly smaller than as shown above. A conservative area of 130 ha was assumed for modelling water supply volume estimates. This is substantially less than the 159 ha assumed for the dam break studies. However the dam break studies were designed for the worst case flood scenario and so were conservatively large (NSW Public Works, 2011).

A site inspection suggested that the M1 motorway drainage system flows to areas outside the subject catchment. It also revealed than Reeves Street formed much of the western boundary of the Narara Reservoir Catchment.

Figure 3.4, below , shows that all but the western extremity of the catchment consists of naturel forest/woodland. There is a minimum of one kilometre between developed areas and the edge of the water surface in the reservoir.

This is important as it suggests relatively low risk of reservoir contamination (WSAA, 2015)..

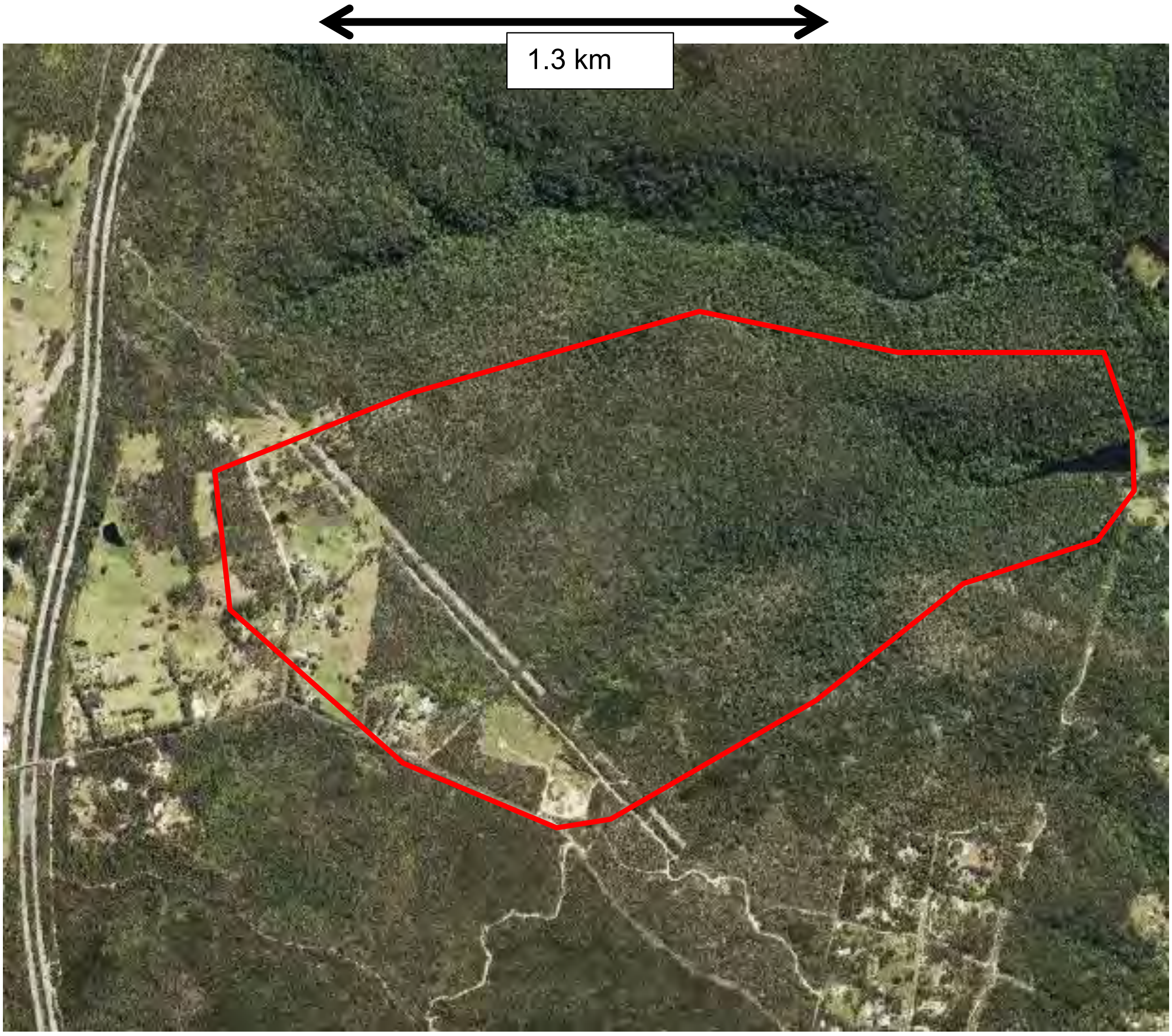


Figure 3.4. Indicative catchment boundaries superimposed onto a satellite view. The only developed area in the catchment is in the extreme west portion. (Image source NSW Dept Lands, 2015).

3.4 LANDUSE ZONING

Figure 3.5 shows the landuse zoning from the 2014 LEP.

The majority of the catchment is RU3: Forestry. Much of the remainder is E2: environmental conservation. There are also small areas of RU1: Primary Production, RU2: Rural Landscape and SP2 Special infrastructure (the M1 motorway). Some areas have had deferred matters. These are referred to as ‘unzoned’ land.

The main water supply issues for each landuse are listed in table 3.1

Table 3.1. Landuse zoning within the dam catchment and the potential issues associated with the zoning.

Landuse zoning	**Issues and concerns for water quality and quantity.**	**Comments**
RU3: Forestry	<u>Bushfire</u> -damage to infrastructure, e.g pumps, pipes, treatment plant -Loss of vegetative cover leading to soil erosion (and loss of dam capacity due to sedimentation) -Deposition of ash into the dam leading to increased turbidity and therefore increased difficulty in disinfection of the water -Increased nutrient supply leading to algal blooms	Logging is not an issue as there are no plans to log this area. Bushfire, is however, a long-term hazard that must be addressed.
E2: Environmental conservation	As for RU3 Minimal access for the public is preferred as a way of managing water contamination risk	Have minimal publicity about the area.
RU1: Rural production	Typically larger commercial rural enterprises	There are no commercial chicken production sheds in the area.
RU2: Rural landscape	Typically rural residential areas On-site sewage systems Erosion due to trail bikes and excessive stocking	Council is responsible for regular inspection of sewerage systems. NEV should liaise with Council about this issue.
Deferred Matter	These lands are currently unzoned.	This could become an issue if intensive subdivision occurred. NEV will have to be prepared to object to intensive development in the dam catchment.

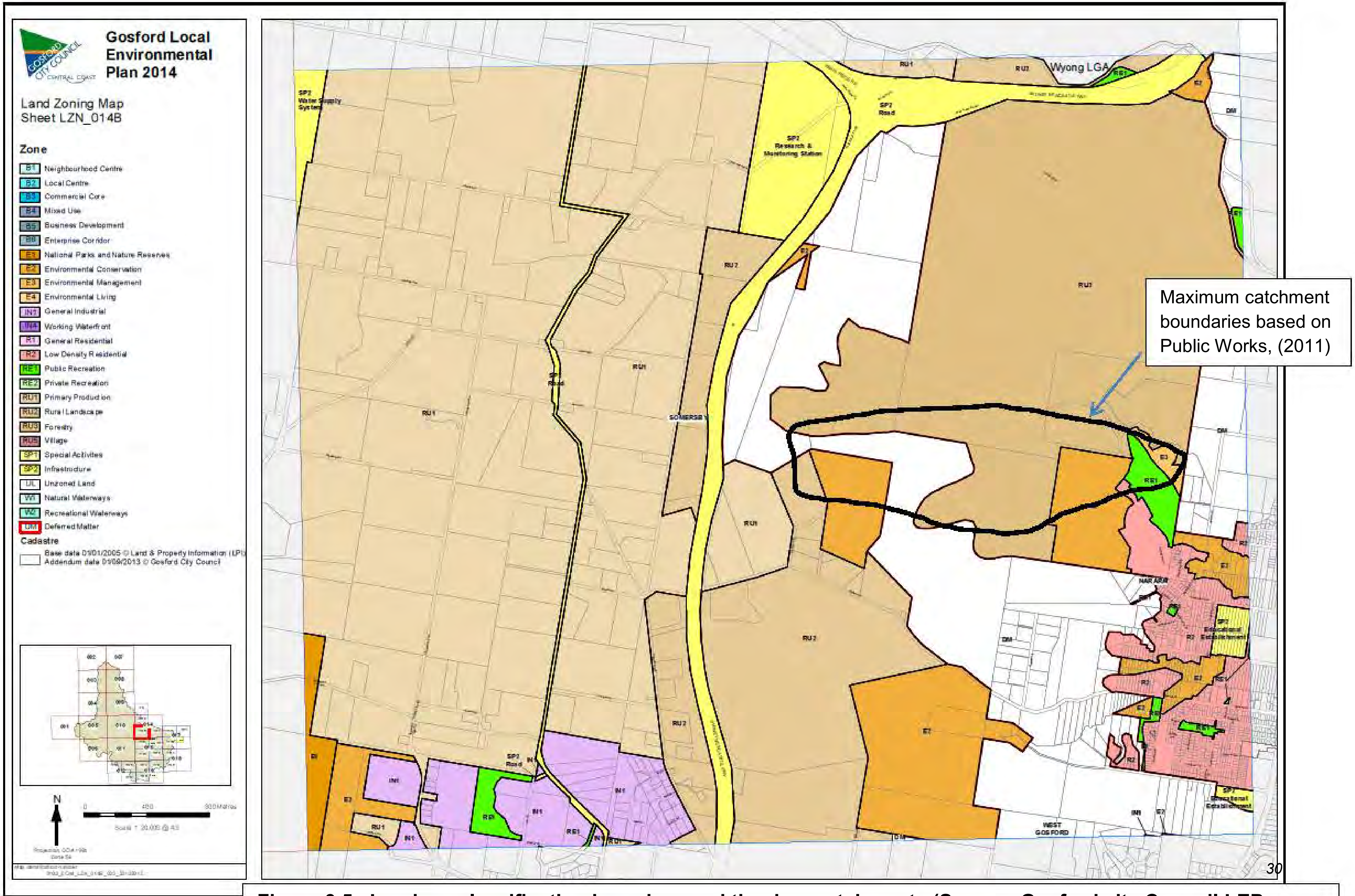


Figure 3.5. Landuse classification in and around the dam catchment. (Source: Gosford city Council LEP, 2014).

3.5 SANITARY SURVEY ASSESSMENT

The animal shelter on Reeves Street is an issue. Apparently the animal waste is treated on-site via a Council registered AWTS. The system is inspected and maintained on a quarterly cycle. The disinfection would reduce risk of pathogens escaping into the catchment. After treatment, the effluent is irrigated onto surrounding lands. This would again reduce risk of contamination. There is a significant effluent treatment dam on the site. The discharge from this may be contaminated, and this hazard requires assessment. The blue line of figure 3.3 extends from the RSPCA shelter dam to the subject reservoir. A blue line on a topographic map is prima face of the existence of a water course. However an inspection of lands downslope of the RSPCA dam showed no evidence of this water course for at least 400 m. This suggests that if there was ever any overtopping of the RSPCA dam the water would move downslope via non-concentrated flow and would be likely to percolated into the sandy topsoil.

An area to the east of Reeves Street has been used as a landfill site (L 422, DP 40341). The Google Earth photo of 2003 shows that the site has been closed for more than 11 years.

Reeves Street is the only significant road in the catchment. This bitumen road is a secondary route between Somersby and West Gosford. The impact of roads on stream water quality in the catchment is likely to be minimal.
Figure 3.6 summarises the main contamination issues in the upper catchment.

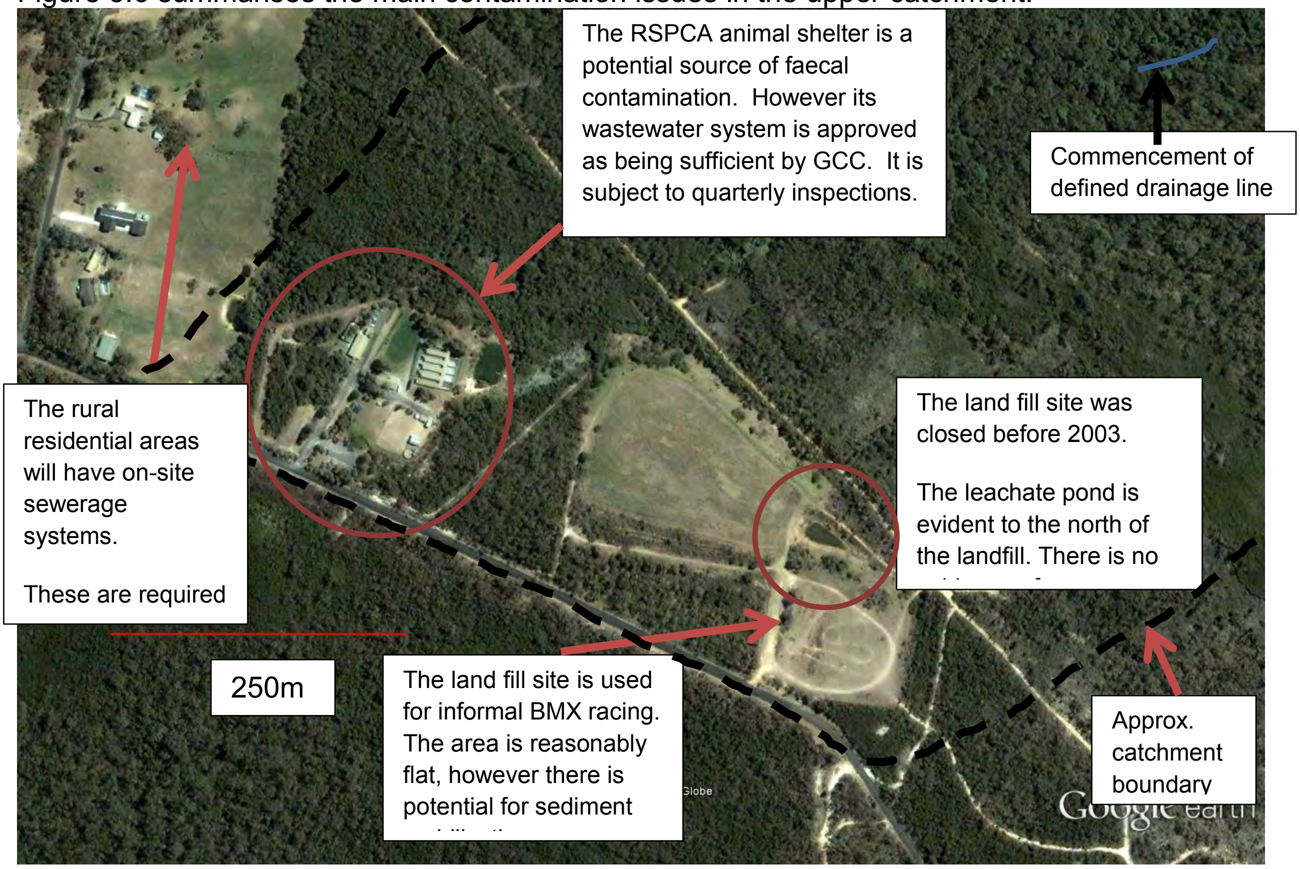


Figure 3.6. Water course contamination issues in the upper part of the dam catchment. (Image source: Google Earth, 2014).

3.6 VULNERABILITY ASSESSMENT

Table 3.2 identifies the vulnerability category of the Narara Reservoir.

Table 3.2. Vulnerability assessment categories for drinking water sources (Adapted from WSSA, 2015).

Category	Land use challenge	Intensity	Proximity	Protection	Relationship to Narara reservoir catchment
1. Protected catchment	Permanent human	• Negligible • No STPs • Minimal, well-managed on-site sewage management systems	Human settlements and recreation excluded from the whole area of influence, typically the whole hydrological catchment and reservoir	• Natural bushland • Protection enforced by policed regulation • Low intensity/low risk activities may be allowed in the outer catchment but active source protection (e.g. ranger patrols) is practiced to ensure negligible contamination risk • Supply is from a large reservoir	Not pristine
	Itinerant human	• Negligible • Minimal essential entry for rangers, pest controllers, fire			
	Stock animals	• Negligible • No farms • Limited (controlled) populations of feral animals			
2. Moderately protected catchment	Permanent human	• Minimal • No STPs • Low density rural developments with well-managed on-site	Human settlements excluded from inner catchment	• Bushland inner catchment, low density rural outer catchment • Stock fully fenced out of main feeder streams behind vegetated buffer zones. • Protection enforced by policed regulation • Low level and low intensity activities may be allowed within the outer catchment but active source protection (e.g. ranger patrols) is practiced to minimise	• Some rural lands on western end of catchment • No STPs, BUT RSPCA pound • Old landfill site
	Itinerant human	Low level, low intensity recreation	• Recreation excluded from inner catchment • No		Minor itinerant use, some informal BMX tracks in western end
	Stock animals	• Low density • No dairies, feedlots, etc.	Farming excluded from inner catchment		Low density & exclusion from inner catchment
3. Poorly protected catchment	Permanent human	• Moderate • May include limited sewered urban areas and STPs within outer catchment	Human settlements excluded from inner	• Medium density rural outer catchment possibly including some limited areas of urban development.	Not applicable

The characteristics of the catchment itemised in table 3.2 suggest that it is a Category 2, moderately protected catchment.

3.7 MICROBIAL INDICATOR ASSESSMENT

The AWSS 2015 guideline checks the vulnerability category against the E coli population density immediately prior to treatment. Table 3.3 is taken from AWSS 2015.

Table 3.3: Comparison of E. coli concentration with sanitary inspection category (Copied from WSAA,20150.

Source category Vulnerability Assessment Category	Microbial indicator concentration category Maximum *E. coli*‡ per 100 ml			
	< 20 Category 1	> 20 < 2,000 Category 2 & 3	> 2,000 < 20,000 Category 4	> 20,000 Not suitable for drinking
1	Source = Cat 1	Source = Cat 2	Anomalous	Not suitable
2	Source = Cat 2	Source = Cat 2	Anomalous	Not suitable
3	Anomalous	Source = Cat 3	Source = Cat 4	Not suitable
4	Anomalous	Source = Cat 4	Source = Cat 4	Not suitable

The cells with the 'green' colour indicate reasonable consistency between the catchment category and the population E coli density. The Narara Reservoir is category 2. Based on table 3.3 an E coli population density between 20 and 2000 CFU/100 mL is expected.

Section 6, below , discusses water quality including E coli population density. Table 3.4 shows the distribution of E coli based on 29 samples taken from August 2014 to April 2015. The average was 79 while the geomean was 28 CFU/100 mL.

Table 3.4 E coli population density distribution for 29 reservoir water samples taken from August 2014 and the end of April 2015.

Distribution	Minimur	5%ile	10%ile	25%ile	50%ile	75%ile	90%ile	95%ile	Maximum
E coli (CFU/100 mL)	0	0	8	13	32	110	200	310	330

The maximum population was 330 CFU/100 mL. This is well within the 20 to 2000 CFU/100 mL range and is consistent with the reservoir catchment being in Category 2 as per table 3.2.

RESPONSE TO SOURCE CATEGORISATION

The analysis above indicates that the catchment is category 2. Table B1 of WSAA recommends the following LRVs.

- Bacteria 5
- Viruses 3
- Cryptosporidium 2.5

These are challenging, especially as the 90%ile is only 200 SFU/100 mL.

3.8. ATTRIBUTES OF THE NARARA RESERVOIR

Attributes of the dam were copied from NSW Public Works (2011) and from observation made during the current investigation and assessment. The results of the assessment are summarised in table 3.5.

Table 3.5. Physical and performance attributes of the Narara Reservoir (Sources: various including NSW Public Works 2011).

Reservoir attribute	Unit	Result
Reservoir type		Earth fill embankment
Catchment area	Ha	130
Water surface area at FSL[1]	Ha	1.2
Reservoir water elevation at FSL	RL[2] (m)	15.9
Reservoir crest level	RL (m)	17.45
Available free board	m	1.55
Stream bed elevation	RL (m)	7.9
Reservoir height	m	9.55
Reservoir crest length	m	100
Reservoir capacity	ML	43.3
Spillway crest level		At FSL
Spillway length	m	18.2
Return period Reservoir Crest Flood		1 in 1,000 AEP

[1] FSL Full Surface Level

[2] RL Relative Level. These are reasonable estimates of actual elevation in lowland areas,

3.6 CATCHMENT HYDROLOGY AND CONTAMINANT YIELD

The stormwater model, MUSIC (Version 5), was used to estimate runoff volumes and contaminant influxes to the dam.

CATCHMENT AREA

Inspection of the topographic maps for the area indicated that the catchment draining to the dam was at least 130 ha. In practice the area could be up to 160 ha, depending on local drainage works. However, it is considered prudent to use the more conservative figure when estimating availability of water for potable use.

CATCHMENT SOILS

The main soil in the catchment is labelled Sydney Town Soil Landscape (Murphy, 1993). The soil is typically 15 – 30 cm of sandy loam overlying up to 50 – 150 cm of clay loam.

There is also some Hawkesbury Soil Landscape in the catchment. This soil is extremely sandy and shallow. It is likely to have a higher runoff coefficient than the Sydney Town Soil Landscape. However, the more conservative runoff coefficients for the Sydney Town Soil Landscape were used.

There may be a small portion of the Somersby Soil Landscape in the extreme west of the catchment. However the scale of the soil map makes it difficult precisely define the catchment boundaries.

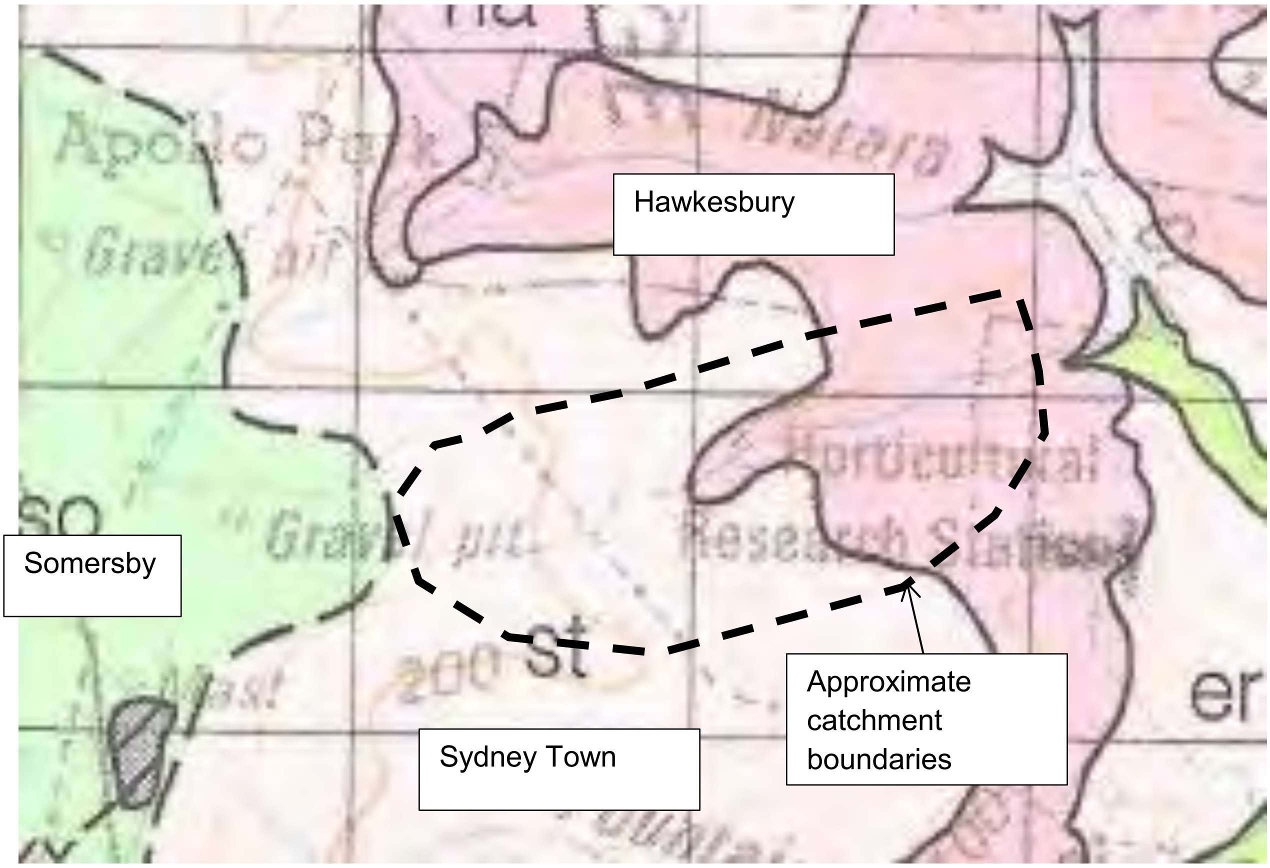


Figure 3.5. The major soil landscapes in the catchment are Sydney Town and Hawkesbury. There is a small area of Somersby Soil Landscape near the western edge of the catchment. The approximate maximum boundaries of the catchment are also shown (Murphy, 1993).

MODEL INPUTS

The model inputs were derived from the MUSIC (Version 5) Guidelines, and from Fletcher et al (2004). Tables 3.3 to 3.5 show the parameters used in the modelling.

Table 3.3. Inputs used for the MUSIC Model (Source: MUSIC (Version 5) Guidelines and Fletcher et al 2004).

Component	Units	Result
Catchment area	Ha	130 (the Public Works, 2012, estimate is 159 ha)
Reservoir surface area	Ha	1.1
Reservoir volume	ML	45 (the Public Works, 2012, estimate is 43.3 ML)
Evaporation rate from the catchment during wet weather	as a % of potential evapotranspiration	100
Catchment landuse	%	10% rural residential, 10% of which is impervious surfaces 90% forest, 98% of which is pervious

Table 3.4. Soil hydrological characteristics used in the MUSIC model (Source: MUSIC (Version 5) Guidelines and Fletcher et al 2004).

Component	Units	Result
Catchment soil		20 cm of sandy loam then 30 cm clay loam
Soil water storage capacity (top 50 cm)	mm	107
Soil field capacity moisture storage (top 50 cm)	mm	82
Soil infiltration coefficient (a)	mm/day	250
Infiltration capacity (b)		1.3
Daily recharge rate	%	60
Daily base flow	%	45
Daily seepage rate	%	0

Table 3.5. Pollutant concentration parameters used for base flow in the MUSIC model (Source: MUSIC Version 5 Guidelines and Fletcher et al 2004).

Component	Flow type	Total suspended solids (TSS - mg/L -Log_{10})		Total Phosphorus (TP mg/L -Log_{10})		Total Nitrogen (TN mg/L -Log_{10})	
		mean	**Std dev**	**mean**	**Std dev**	**mean**	**Std dev**
Rural residential	Base	1.15	0.17	-1.22	0.19	-0.05	0.12
	Storm	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	Base	0.78	0.13	-1.52	0.13	-0.52	0.13
	Storm	1.60	0.20	-1.10	0.22	0.05	0.24

Six minute rainfall data from Jan 1970 to August 2010 was used to generate runoff behaviour.

MODEL OUTPUTS

Table 3.6 shows the water inflow and exits to the dam.

Table 3.6. Inflows and outflows to the 45 ML dam based on 6 minute data since 1970.

Attribute	Flow (ML/y)
Flow In	450
ET Loss	13
Infiltration Loss	0
Low Flow Bypass Out	0
High Flow Bypass Out	0
Pipe Out	304
Weir Out	120
Transfer Function Out	0
Reuse Supplied	14
Reuse Requested	14
% Reuse Demand Met	100
% Load Reduction	6

Table 3.6 shows that the modelled flow into the dam is 450 ML/year. This is a runoff rate of 346 mm/year assuming a 130 ha catchment. Some of the rain water infiltrating into catchment soils is also likely to eventually reach the dam, so the total inflow/ year may be higher than 450 ML.

3.7 CATCHMENT HYDROLOGY-A CONSERVATIVE APPROACH

The daily runoff was estimated using the runoff curve number (RCN) technique (USDA, 1986). The RCN selected was 79. This number is relatively high (USDA, 1986) and reflects the undisturbed shallow soil overlying sandstone in much of the catchment (Murphy, 1993).

Runoff commenced when the rainfall exceeded 18 mm in any one day. This is also relatively conservative, and the assumption under-predicts catchment yield. The reason for using a conservative figure is to demonstrate that even with the assumption of relatively low water yields, and a conservative estimate of catchment area, the dam can reliably supply all the water needs of the development.

Another conservative component of the USDA RCN system is that it does not allow for water that infiltrates the soil, percolates to low permeability surfaces such as sandstone, moves down slope along the pervious/impervious interface (referred to as interflow in hydrology texts), and then reappears as surface water lower in the landscape. This process is likely to be a significant source of water in hilly, sandstone derived, landscapes such as the eastern portion of the Narara Reservoir Catchment.

The average predicted annual runoff since January 1889 is 148 mm or 12%[2] of rainfall. Over the 130 ha catchment this is 192 ML/year. The dam capacity was initially estimated at approximately 45 ML. Therefore, in the average year the catchment outflow is equivalent to some 4.3 times the dam volume.

Figure 3.6 uses daily rainfall since 1970 to assess runoff events into the reservoir. The period 1889 to 2015 included several major droughts.

[2] A 12% runoff coefficient for 1335 mm of rainfall /year is extremely conservative (Fletcher, et al, 2004). However it does provide a large margin of safety. The MUSIC model estimates runoff at 450 ML/year. The more conservative figure of 191 ML/year was used to assess reservoir water supply security.

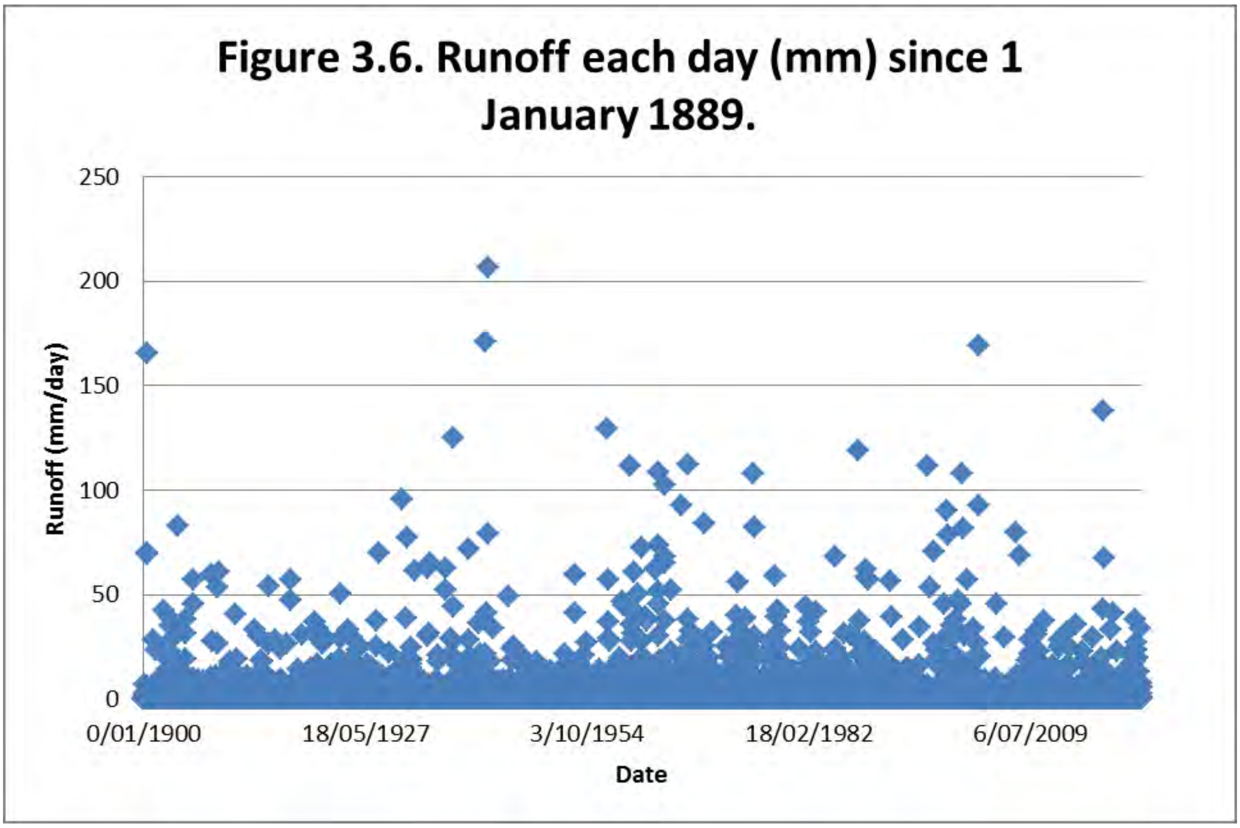
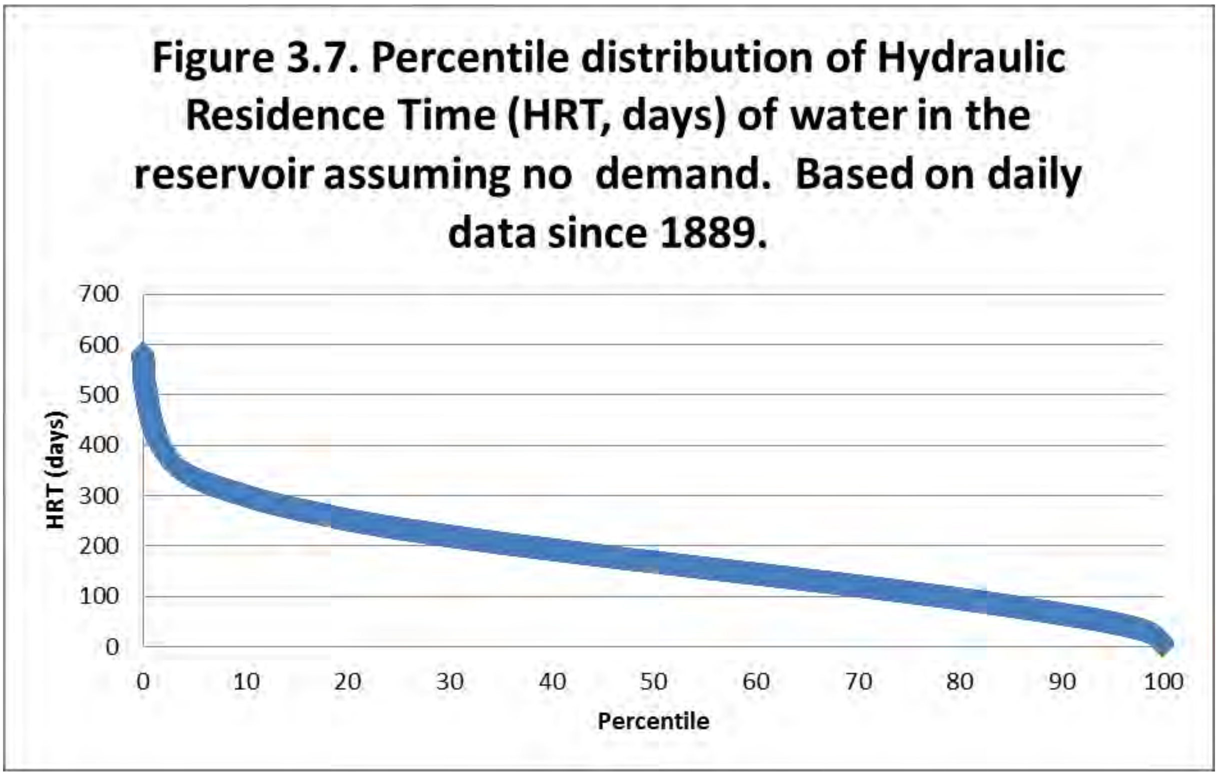


Figure 3.6 shows that there are numerous runoff events each year. A single 90 mm rain event would create a runoff volume that exceeds the dam volume. Figure 3.6 indicates that this occurred 20 times in the past 43 years. This result again emphasises the security of water supply to the proposed development.

Figure 3.7 shows the hydraulic residence time (HRT) as a percentile since 1889. This assumes no abstraction. Note the log scale.



The median residence time is 166 days. There is more than 25 days (the indicative residence time in lagoons to result in settling out of protozoa) in more than 98.9% of the time. The result suggests a high probability of parasite removal from incoming water prior to its abstraction. Additionally there are several other features which will increase the effect of the dam in reducing microbial load:

- The source areas for microbial contamination are at the far western end of the catchment, so there will be a relatively long travel time from the faecal deposition point to the water offtake line near the dam wall.

- The turbidity of the dam water is relatively low. See section 6, below. Therefore the UV disinfection from the sunlight should be relatively effective in inactivating microbiota.

- Much of the flow into the dam will come from native forest where human or domestic animal access is extremely limited

These features will combine to minimise contaminant load.

However, algal bloom management cannot rely on short residence times. This is especially true as the model did not allow for any reduction in water removal rate due to recycling or use of alternative sources. Recycling would reduce the net demand for water thereby increasing residence time. So the distribution in figure 3.7 is a worst case. The other issue is short circuiting of the water so that there is less ‘plug’ flow. The long narrow nature of the waterbody will assist in reducing short circuiting, but it could still occur when the inflowing water is much warmer than water at the top of the water column. It is prudent to assume that the break-through detention time is around 50% of that shown in figure 3.7.

4. RELIABILITY OF THE DAM AS THE SOLE SOURCE OF POTABLE WATER

The dam is expected to be the sole source of feed water into Potable Water Treatment Train.

Therefore the long term reliability of the dam to supply adequate quantities of raw water was assessed for the extreme example where there was no capture and use of roof water in the eco-village.

However it has been determined that the effluent from the wastewater treatment system will be treated so that the log reduction in pathogens meets the DPI guideline LRV to enable using effluent in toilet flushing (DPI, 2015). That is, the dam was the sole source of water for potable internal uses. The model's assumptions are shown in table 4.1.

4.1. POTABLE WATER DEMAND AND SUPPLY RELIABILITY AT STAGE 1 DEVELOPMENT

The estimated total internal water demand based on 5 persons/dwelling and effluent being used to flush toilets is 0.337 cubic m/day[3]. If there are 60[4] dwellings at the 50% development stage then the total internal demand is 20.22 cubic m/day or 7.4 ML/year.

Table 4.1. Water demand components for various number of residents per dwelling. Based on Sydney Water Corporation survey of 5400 dwellings in 2011.

Water demand Component	**Number of residents in dwelling**							
	1	2	3	4	5	6*	7*	8*
Toilet (L/day)	**31**	**53**	**74**	**95**	**115**	**130**	**145**	**160**
% of internal demand	25	25	25	25	25	26	27	28
Laundry (L/day) cold water	**29**	**53**	**76**	**95**	**113**	**123**	**131**	**136**
% of internal demand	24	25	25	25	25	25	25	24
Hot Water (L/day)	**49**	**87**	**119**	**151**	**182**	**197**	**210**	**218**
% of internal demand	40	41	40	40	40	40	39	39
Other internal uses (L/day)	**13**	**20**	**31**	**37**	**42**	**45**	**48**	**50**
% of internal demand	11	9	10	10	9	9	9	9
Total internal use (L/day)	**122**	**213**	**300**	**378**	**452**	**495**	**534**	**564**

The proposed water treatment plant requires up to 50% excess process water.

[3] The average number of people per residence in the Gosford region is 2.3 (ABS, 2011 census), so the actual internal demand per residence is likely to be less than 452 litres/day. Without toilet flushing the internal demand becomes 337 litres/day.

[4] The final development may have 120 dwellings. Actual consumption data from stage 1 of the development will be used to estimate the demand for the full development.

Table 4.2. Assumptions and inputs into the dam reliability simulation

Component	Input/ assumption
Climate data	Daily rainfall and evaporation since Jan 1889
Evaporation from the dam surface	80% of pan evaporation
Seepage from the dam	Zero
Catchment area	130 ha
Reservoir surface area at TWL (top water level)	1.1 ha
Reservoir capacity at TWL	45,000 cubic m (45 ML) (Note Public Works (2012) assumed 43.3 ML capacity in its dam break study)
Reservoir storage at commencement of simulation	30 ML (i.e. 2/3 full)
Demand for Internal use excluding toilet flushing. Assumes 5 people/dwelling, from table 4.1.	337 L/dwelling/day
Number of dwellings	60 at stage 1 development
Total demand for internal[5] water	20.2 cubic m/day or 7.4 ML/year.
Total demand at stage 1 including 50% process water	40.4 cubic m/day or 14.8 ML/year.

Figure 4.1 shows the daily water in storage based on the inputs from table 4.2. The dam is nearly full most of the time. The minimum volume in storage is 27 ML. This is 18 ML less than full supply. The result indicates that the dam can reliably supply all the internal water excluding toilet flushing needs of the stage 1 development.

4.1 POTABLE WATER DEMAND AND SUPPLY RELIABILITY AT STAGE 2 DEVELOPMENT

The estimated total internal water demand based on 5 persons/dwelling and effluent being used to flush toilets is 0.337 cubic m/day. If there are 120 dwellings at the 100% development stage then the total internal demand is 40.44 cubic m/day or 14.8 ML/year.

Assuming a 50% process water requirement, the total water demand is 80.88 cubic m/day or 29.5 ML/year[6]. Figure 4.2 shows that the minimum volume in the dam since 1889 is 18 ML or 40% of maximum volume. It is concluded that the dam supply is secure at full capacity PROVIDED toilet flushing water is sourced from elsewhere.

[5] Internal water is water used within dwellings. External water is water used for activities such as irrigation and wash-down.

[6] Note that the license is only 30 ML, so this is the absolute maximum that can be extracted from the dam.

Figure 4.1. Volume in the dam each day since Jan 1889. Assumes 60 dwellings with a total demand including process water of 40.4 cubic m/day.

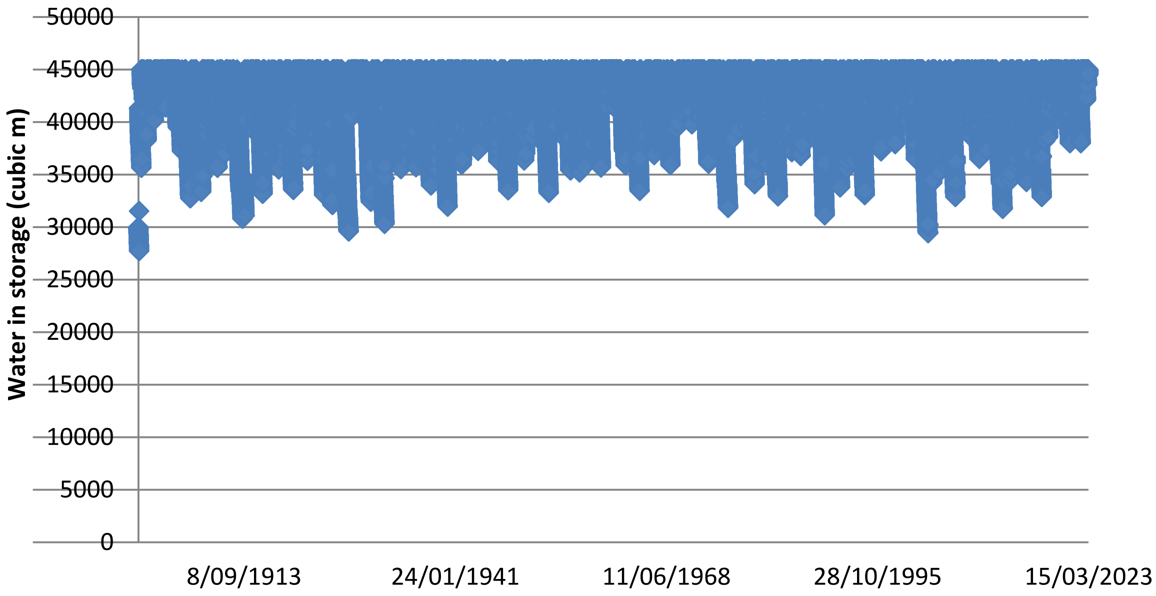
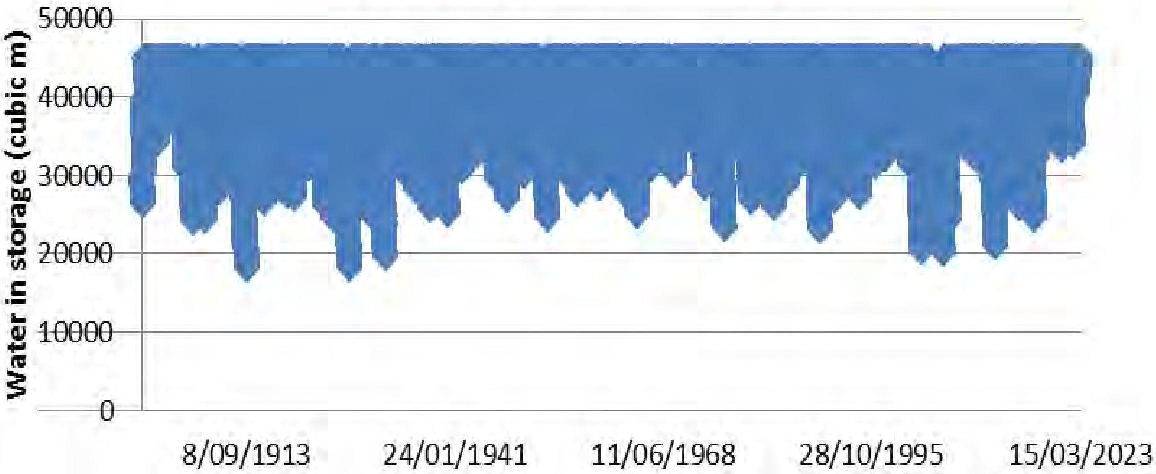
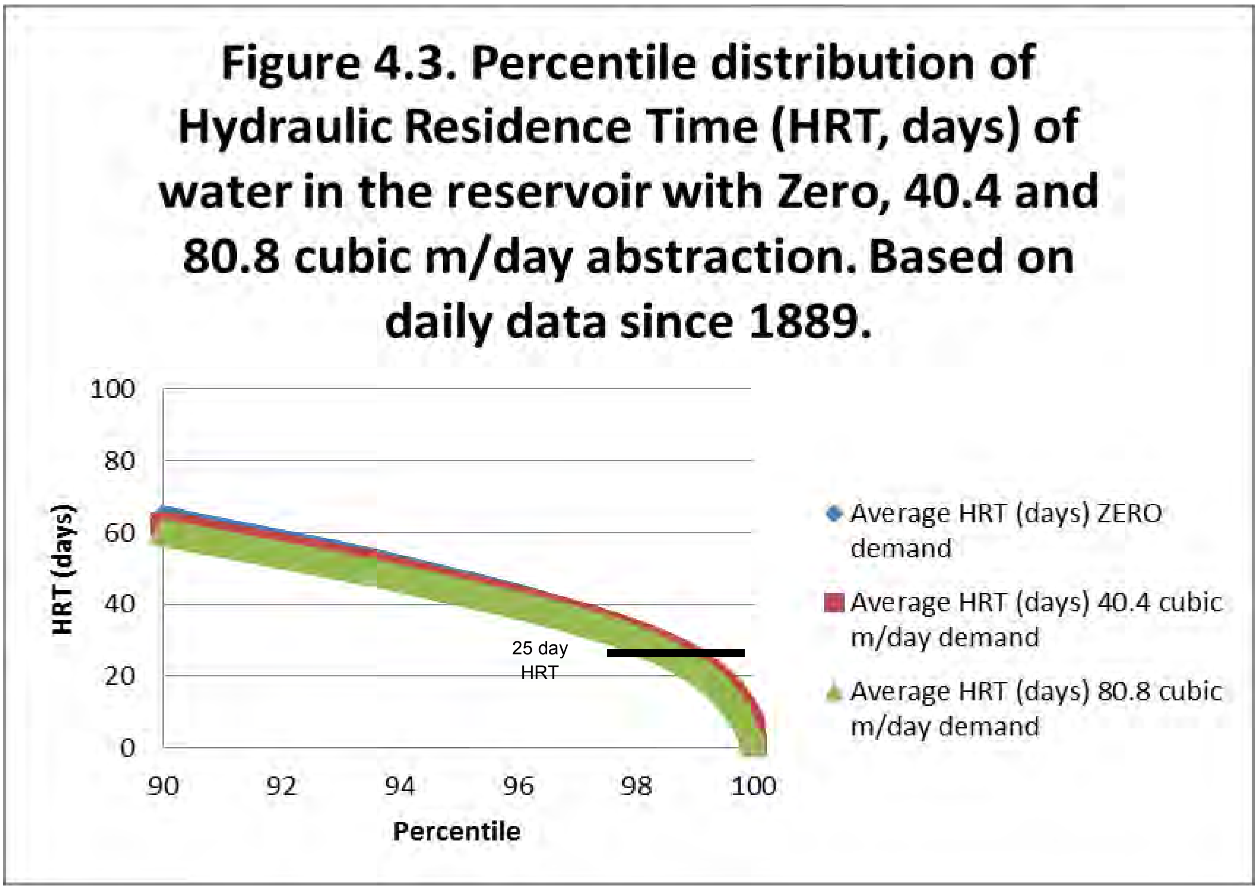


Figure 4.2. Volume in the dam each day since Jan 1889. Assumes 120 dwellings with a total demand including process water of 80.9 cubic m/day.



4.2 EFFECT OF ABSTRACTION ON THE HRT (HYDRAULIC RESIDENCE TIME

Figure 4.3 shows that the abstraction of 40.4 or 80.8 cubic m/day has minimal effect on the hydraulic residence time. This is important because a minimum of 25 days is required to allow settling out of protozoa from the water column.



Based on the 25 day requirement the water is 'safe' from protozoa for at least 98% of days.

4.3 CONCLUSIONS

- It is concluded that the dam can meet all anticipated demand for internal water excluding toilet flushing, for at least 120 dwellings.
- The impact will be less if the proportion of process water is reduced.
- Alternatively the process water could be returned to near the dam inflow point. The impacts of this require investigation.

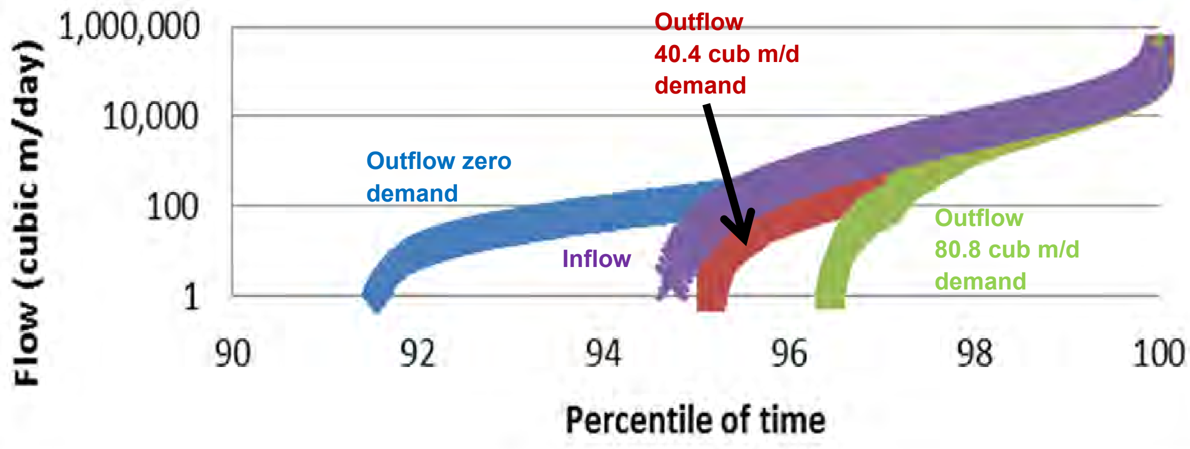
5. EFFECT OF ABSTRACTION ON DOWNSTREAM CONDITIONS

As part of the overall assessment of the proposed water supply system it is necessary to consider the downstream impacts of abstracting water from the existing dam.

Since 1889, the conservative runoff model indicates that the average annual inflow to the dam is 192 ML. Figure 5.1 shows the percentile frequency for flows more than 1 cubic m/day. Significant inflow occurred on 5.5% of days. If there was no extraction of water the dam would overtop in approximately 8.5% of time. The reason there are more overflow days than inflow days is that small rain events when the dam is full trigger an overflow event but not a runoff event.

An extraction rate of 40.4 cubic m/day reduces this to 4.7%, while an extraction rate of 80.8 cubic m/day results in overtopping 3.6% of days. That is, the proposed extraction rates have minimal impact on the percentage of time water overtops the dam.

Figure 5.1. Flow rates entering and exiting the dam for different demand scenarios. Based on daily data since 1889.



5.1. IMPACT OF ABSTRACTION ON DOWNSTREAM BIOTA

The overflow frequency may impact on downstream aquatic biota. However, there are two reasons for considering this impact to be minimal:

- Firstly, the dam overflow under low to moderate rainfall conditions is conveyed via a pipe from a glory hole (figure 5.2), and it emerges well downstream, and close to the confluence with Narara Creek (figure 5.3). So the current system largely bypasses the creek bed between the dam and the confluence.

- Secondly, the total distance from the dam wall to Narara Creek is approximately 165 m. Consequently, any impact is confined to an extremely short stretch of the stream immediately before its confluence with a much larger, permanently flowing creek (figure 5.4).

The photos below illustrate the conditions in the drainage line between the dam and Narara creek confluence some 165 m downstream.

Figure 5.2. Low to medium flows exit the dam via this glory hole. There is a need for safety fencing to prevent people being caught on the grill. The safety fencing would also reduce the quantity of floating debris being caught on the grill. Additionally the hole needs anti-vortex vanes to maximise out-flow capacity.

Figure 5.3. The glory hole pipe discharges into a drainage line located in this bush near the toe of the embankment, some 30 m downslope of the top of the embankment.

Figure 5.4. The water that exits the dam reaches Narara Creek some 165m downslope of the glory hole.

During high inflow periods the glory hole cannot accommodate the full flow of the water and some water begins to enter a spillway adjacent to the glory hole. There has been an attempt to cement the spillway, but this area has been outflanked so that the flow is conveyed on bedrock. Figure 5.5 shows a satellite image of the area while figure 5.6 and 5.7 show conditions along the spillway.

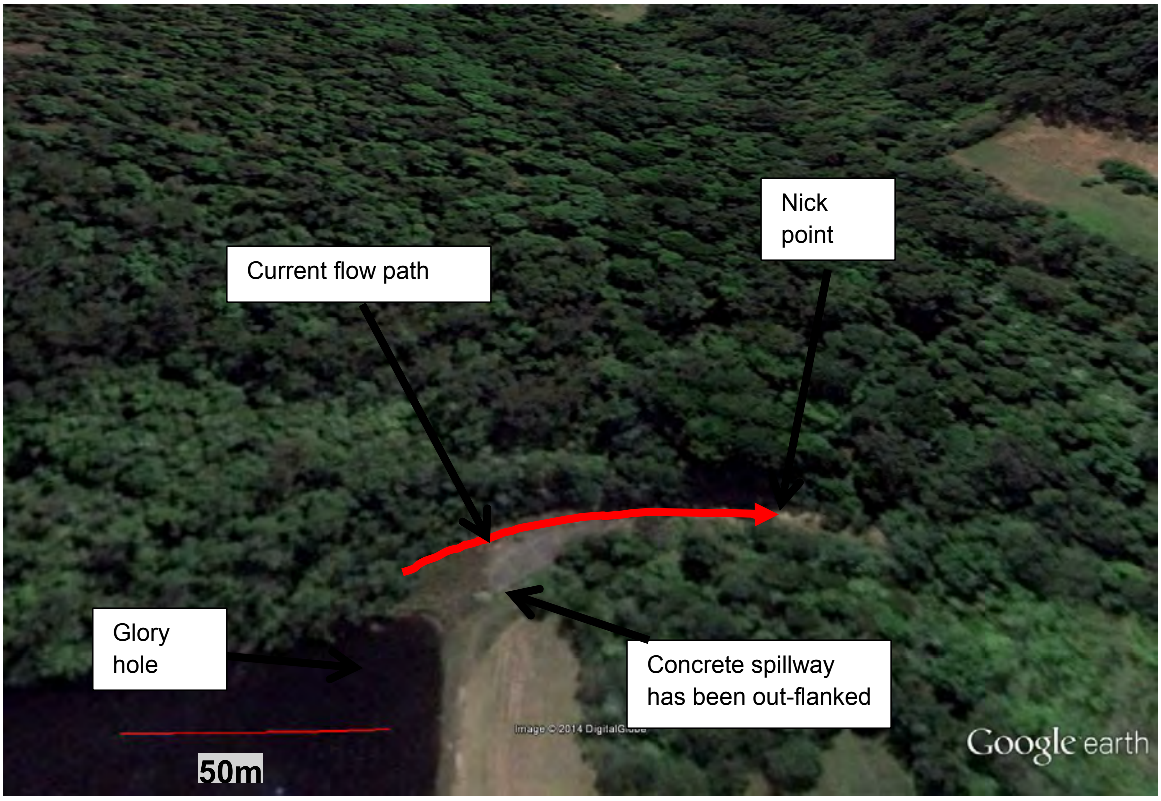


Figure 5.5. The discharge arrangements at the right hand abutment of the dam. (Image source: Google Earth).

Figure 5.6. There is a high flow spillway adjacent to the right hand abutment. The condition of the vegetation on the spillway indicates scouring flows rarely occur.

Figure 5.7. The sandstone bedding of the overflow route provides a resistant surface to high flow discharges.

Figure 5.8. The nick point in figure 5.5. Rocks over 2 cubic m in width have been displaced.

There is evidence that the nick point is continuing to move 'upstream'. The need for stabilisation has been assessed by Pell Consulting (2015).

Figure 5.9. The water downslope of the nick point is very turbid. This indicates dispersing conditions and low ecological value. This drainage line only flows during major overtopping events. Most of the time the entire overflow is conveyed down the glory hole and then by pipe.

CONCLUSIONS

- The current glory hole arrangement needs improvement to increase safety
- A chute structure is needed to stabilise the nick point (this issue is discussed in the Reservoir management plan prepared by Pell Consulting)
- The chute should be designed to accommodate the 1 in 100 ARI peak flow
- There is minimal evidence of significant ecological values in the short, degraded channel between the dam spillway and Narara Creek, however stabilisation of the nick point will reduce erosion of the downstream channel floor, and this will reduce sediment yield to Narara Creek.

6. ASSESSMENT OF WATER QUALITY DATA

Assessment of water quality data is a key component of Element 2 of the ADWG Framework for Managing Drinking Water Quality.

6.1. APRIL 2013 SAMPLING

Discussions with Council and the previous dam manager indicated that there was no information available on catchment water quality.
The Australian Drinking Water Guidelines (hereafter ADWG), (NHMRC / NRMMC, 2011) provide detailed assessment of the physical, chemical and biological characteristics of potable water. The criteria from the ADWG were used to assess water quality in the catchment. Where applicable the water sample attributes were also assessed against ANZECC (2000a) guidelines for ecological stressors.

Two water samples were collected in April 2013:

- Sample 1 was taken downslope of the animal shelter and the decommissioned landfill site (figure 6.1). The water course was approximately 0.4m wide and the water was less than 0.1m deep. The sample point was the first volume of surface water that was large and deep enough to sample.
- Sample 2 was from a stream of water flowing into the glory hole near the left hand abutment of the dam (figure 5.2). Sampling techniques were based on ANZECC (2000b).

The results of the analyses are shown in table 6.1.

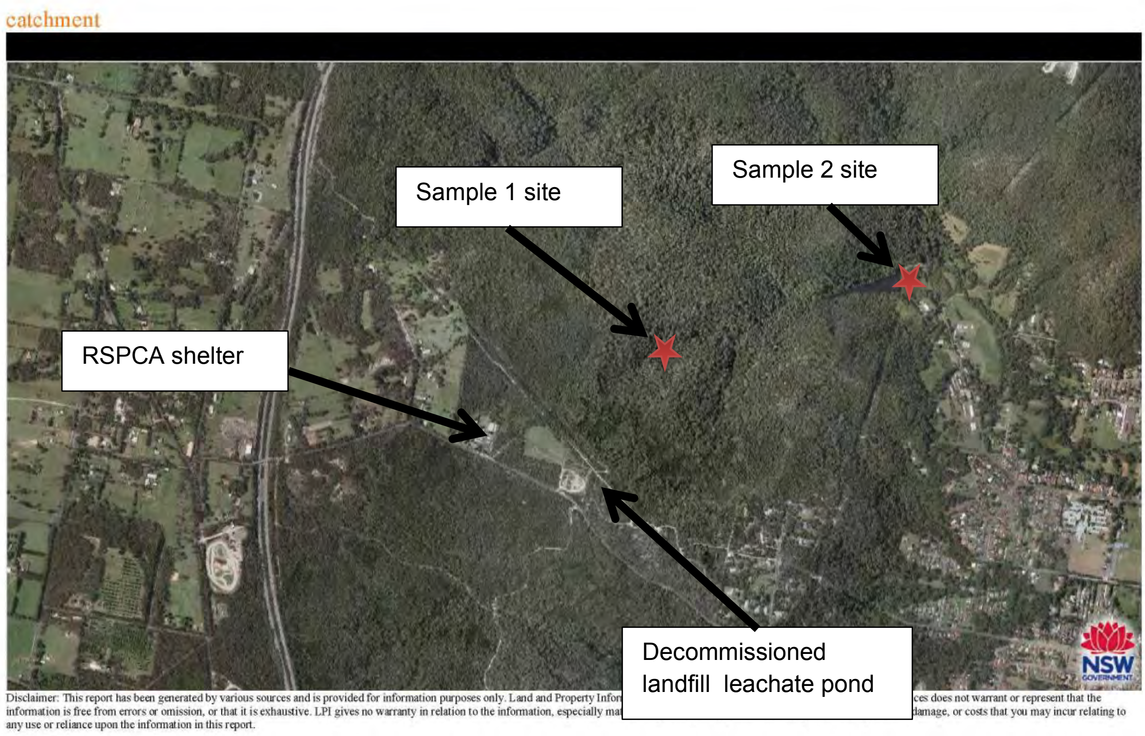


Figure 6.1. The two sites were sampled in April 2013. One is at the headwaters of the creek, from a point some 400 m into the bushland downslope of the RSPCA shelter. (Image source: Dept Lands, 2014).

Table 6.1. Quality attributes of water upstream of and within the dam. Sampled 19.3.2013.

Attribute	Sample 1	Sample 2	ADWG	Comment
pH	4.78	5.63	6.5-8.5	A bit low, but reflects sandstone geology
CONDUCTIVITY (EC) (dS/m)	0.15	0.12		Good
TOTAL DISSOLVED SALTS (mg/L)	105	84	<600 is 'good'	Good
TURBIDITY (ntu)	3	2	<5 for aesthetics <1 is target for effective disinfection	Very good, as low turbidity facilitates UV disinfection Filtration needed prior to disinfection
ALKALINITY (mg/L CaCO3 equivalent)	1	3	Not given	Would prefer higher
WATER HARDNESS (mg/L CaCO3 equivalent)	13	12	<60 could be corrosive	Would prefer higher
NITRATE (mg/L N)	<0.005	<0.005	<50 mg/L as NO_3	Low and therefore good
NITRITE (mg/L N)	0.002	0.003	<3 mg/L as NO_2	Low and therefore good
TOTAL COLIFORMS (cfu/100 ml)	1,710	460	Not given	High. Has to be zero therefore disinfect
E.coli (FAECAL BACTERIA) (cfu/100 ml)	110	130	Not detectable	High. Has to be zero therefore disinfect NOTE They both meet ANZECC (2000) guidelines for swimming.
ALUMINIUM (mg/L)	0.426	0.191	<0.2 (but no health guideline value).	Reservoir water OK
ARSENIC (mg/L)	0.001	<0.001	<0.01	OK
CADMIUM (mg/L)	<0.001	<0.001	<0.002	OK
CHROMIUM (mg/L)	0.001	0.001	<0.05 as Cr^{6+}	Ok
COPPER (mg/L)	0.001	0.001	<1	Ok
IRON (mg/L)	0.689	0.391	<0.3	Taste and minor staining could be an issue
MANGANESE (mg/L)	0.012	0.034	<0.1 is taste threshold	OK
NICKEL (mg/L)	0.001	0.001	<0.02	OK
LEAD (mg/L)	<0.001	<0.001	<0.01	OK
ZINC (mg/L)	0.008	0.004	<3	OK

The key result is that, based on the anolytes tested, the water is near 'potable' quality except for microbial contamination.

Disinfection will be essential. Filtration is needed to reduce the turbidity. Iron concentration slightly exceeds the ADWG threshold. Aluminium concentration is also elevated in the upper catchment.

Alkalinity and hardness are both very low. Soft water may lead to greater corrosion of pipes, although this will depend on other factors such as pH, alkalinity and dissolved oxygen concentration (NHMRC / NRMMC, 2011). Storage of the dam water in concrete tanks will assist in correcting for low pH and alkalinity.

The water being used for non-potable demand will be a mixture of roof runoff and dam water so the low alkalinity of the dam water may not be an issue.

6.2. RESULTS OF THE 2014 SAMPLINGS

There has been regular samplings of the dam since mid-2014. The results are tabulated below.

Table 6.2. Results of the monthly sample of the Narara Reservoir between August and October 2014.

Attribute	PQL	Units	Month 1 14/08/14 114642	Month 2 16/09/ 14 116250	Month 3 28/10/14 118373	ADWG See PQL Units	Health (H) Aesthetic (A)
Rain Fall, Day of Sample		mm	0.0	0.4	0		
Rain Fall, Day Before Sample		mm	17.0	0	0		
Bicarbonate Alkalinity	5	mg/L	12	6	6		
Carbonate Alkalinity	5	mg/L	<5	<5	<5		
Colour (True)	5	Pt/Co	55	50	50	15	A
Electrical Conductivity	1	µS/cm	170	160	190		
Hardness	3	mg $CaCO_{3/L}$	19	16	16	200	A
Hydroxide Alkalinity	5	mg/L	<5	<5	<5		
Ionic Balance		%	-3.1	3.1	-2.8		
pH		pH Units	7.3	6	6.4	6.5-8.5	A
Total Alkalinity	5	mg/L	12	6	6		
Total Dissolved Solids	5	mg/L	110	87	110	600	A
Total Organic Carbon	1	mg/L	5	7	7		
Total Suspended Solids	5	mg/L	<5	<5	<5		
Turbidity	0.1	NTU	3.4	2.4	2.5	5	A
Microbial Contents							
E.coli	1	CFU/100 mL	11	17	13	<1	H
Total coliforms	1	CFU/100 mL	150	40	17	<1	H
Chemical Contents							
Aluminium	10	µg/L	40	220	110	200	A
Antimony	1	µg/L	<1	<1	<1	3	H
Arsenic-Total	1	µg/L	<1	<1	<1	10	H
Barium	1	µg/L	15	13	12	2000	H
Boron Total	5	µg/L	21	15	18	4000	H
Cadmium	0.1	µg/L	<0.1	<0.1	<0.1	2	H
Calcium	0.5	mg/L	1.8	1.4	1.4		
Chloride	1	mg/L	39	36	35	250	A

Attribute	PQL	Units	Month 1	Month 2	Month 3	ADWG	Health (H)
Chromium	1	µg/L	<1	<1	<1	50	H
Cobalt	1	µg/L	<1	<1	<1		
Silicon- Total	0.2	mg/L	1.8	1.7	1.2		
Total Cyanide	0.004	mg/L	<0.004	<0.004	<0.004	0.08	H
Vanadium-Total	1	µg/L	<1	<1	<1		
Copper	1	µg/L	<1	<1	<1	2000, 1000	H, A
Fluoride, F	0.1	mg/L	<0.1	<0.1	<0.1	1.5	H
Iron Dissolved	10	µg/L	1200	350	430	300	A
Iron Total	10	µg/L	1200	570	660		
Lead	1	µg/L	<1	<1	<1	10	H
Magnesium Dissolved	0.5	mg/L	3.5	3.1	3		
Manganese	5	µg/L	32	26	22	500, 100	H, A
Mercury-Total	0.05	µg/L	<0.05	<0.05	<0.05	1	H
Molybdenum	1	µg/L	<1	<1	1	50	H
Nickel	1	µg/L	<1	<1	<1	20	H
Nitrate as N in water	0.005	mg/L	0.03	0.021	0.012	50	H
Nitrite as N in water	0.005	mg/L	<0.005	<0.005	<0.005	3	H
Phosphorus - Total	0.05	mg/L	<0.05	<0.05	<0.05		
Potassium - Dissolved	0.5	mg/L	1.9	1.3	1.5		
Selenium-Total	1	µg/L	<1	<1	<1	10	H
Silver-Total	1	µg/L	<1	<1	<1	100	H
Sodium - Dissolved	0.5	mg/L	21	23	19	180	A
Sulphate, SO4	1	mg/L	5	8	6	500, 250	H, A
Tin	1	µg/L	<1	<1	<1		
Zinc	1	µg/L	19	3	<1	300	A
Organics							
Organochlorine Pesticides (OCP)							
Aldrin + Dieldrin	0.2	µg/L	<0.2	<0.2	<0.2	0.3	H
alpha-BHC	0.2	µg/L	<0.2	<0.2	<0.2		
alpha-Chlordane + gamma-Chlordane	0.2	µg/L	<0.2	<0.2	<0.2	2	
beta-BHC (b-BHC)	0.2	µg/L	<0.2	<0.2	<0.2		
delta-BHC (d-BHC)	0.2	µg/L	<0.2	<0.2	<0.2		
Dieldrin (See Aldrin)	0.2	µg/L	<0.2	<0.2	<0.2	-	
Endosulfan I (a) and II (b)	0.2	µg/L	<0.2	<0.2	<0.2	20	H
Endosulfan II (See Endosulfan I)	0.2	µg/L	<0.2	<0.2	<0.2	-	H
Endosulfan Sulphate (See Endosulfan I)	0.2	µg/L	<0.2	<0.2	<0.2	-	H
Endrin	0.2	µg/L	<0.2	<0.2	<0.2		
Endrin aldehyde	0.2	µg/L	<0.2	<0.2	<0.2		
gamma-BHC (lindane)	0.2	µg/L	<0.2	<0.2	<0.2		
gamma-Chlordane (See alpha-Chlordane)	0.2	µg/L	<0.2	<0.2	<0.2	-	
HCB	0.2	µg/L	<0.2	<0.2	<0.2		
Heptachlor	0.2	µg/L	<0.2	<0.2	<0.2	0.3	H
Heptachlor Epoxide	0.2	µg/L	<0.2	<0.2	<0.2		H
Methoxychlor	0.2	µg/L	<0.2	<0.2	<0.2	300	H
pp-DDD	0.2	µg/L	<0.2	<0.2	<0.2		
pp-DDE	0.2	µg/L	<0.2	<0.2	<0.2		

Attribute	PQL	Units	Month 1	Month 2	Month 3	ADWG	Health (H)
pp-DDT	0.2	µg/L	<0.2	<0.2	<0.2	9	H
Organophosphate Pesticides (OP's) – Standard 12 list							
Bromophos Ethyl	0.2	µg/L	<0.2	<0.2	<0.2	10	H
Chlorpyriphos	0.2	µg/L	<0.2	<0.2	<0.2		
Chlorpyriphos-methyl	0.2	µg/L	<0.2	<0.2	<0.2		
Coumaphos	0.2	µg/L	<0.2	<0.2	<0.2		
Diazinon	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Dichlorovos	0.2	µg/L	<0.2	<0.2	<0.2		
Dimethoate	0.2	µg/L	<0.2	<0.2	<0.2	7	H
Disulfoton	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Ethion	0.2	µg/L	<0.2	<0.2	<0.2	4	H
Fenitrothion	0.2	µg/L	<0.2	<0.2	<0.2	7	H
Malathion (Maldison)	0.2	µg/L	<0.2	<0.2	<0.2	70	H
Methidathion	0.2	µg/L	<0.2	<0.2	<0.2	6	H
Methyl Parathion	0.2	µg/L	<0.2	<1	<0.2	20	H
Mevinphos	0.2	µg/L	<0.2	<0.2	<0.2	5	H
Naled	0.2	µg/L	<0.2	<0.2	<0.2		
Phenamiphos	0.2	µg/L	<0.2	<0.2	<0.2		
Phorate	0.2	µg/L	<0.2	<0.2	<0.2		
Phosalone	0.2	µg/L	<0.2	<0.2	<0.2		
Ronnel (fenchlorphos)	0.2	µg/L	<0.2	<0.2	<0.2		
Polychlorinated Biphenyls (PCB's)							
Aroclor 1016	2	µg/L	<2	<2	<2		
Aroclor 1021	2	µg/L	<2	<2	<2		
Aroclor 1032	2	µg/L	<2	<2	<2		
Aroclor 1042	2	µg/L	<2	<2	<2		
Aroclor 1048	2	µg/L	<2	<2	<2		
Aroclor 1054	2	µg/L	<2	<2	<2		
Aroclor 1060	2	µg/L	<2	<2	<2		
Radiation - Radium-226, Radium-228							
Alpha	5	mBq/L	<5			500	
Beta	10	mBq/L	<10			500	

The Narara Ecovillage Water Reservoir Initial Sampling Report (Aquacell, 2014c) contains details on the sampling and analyses procedures as well as conclusions. All samples were collected by an experienced technician using a long pole bottle holder. The water was collected from near the dam suction line.

There were three monthly samples and eight weekly samples. Where sampling for both weekly and monthly schedules occurred on the same day, the samples were collected and analysed separately. This resulted in some minor discrepancies in analytical results.

The results are shown in tables 6.2 and 6.3.

An important conclusion is that the analyses revealed similar results to the single 2013 sampling. That is the water in 2014 is low in alkalinity, pH and hardness. It is high in colour, iron, manganese and aluminium.

E coli populations were low, but disinfection will be essential as the ADWG requirement is for E coli to be ‘not detectable’ in 100 mL.

The report concludes that the ADWG water quality objectives could be achieved by addition of chemical dosing ahead of the filtration to remove colour, iron and manganese. Post filtration treatment is needed to increase hardness and alkalinity. The water could then comply to ADWG and at the same time, be less corrosive to pipework and fittings.

Where applicable the water sample attributes were also assessed against ANZECC (2000a) guidelines for ecological stressors.

Table 6.3. Results of weekly sampling during August September and October 2014.

	PQL	Units	Week 1 26/08 115159	Week 2 3/09 115601	Week 3 9/09 115897	Week 4 16/09 116249	Week 5 23/09 116618	Week 6 30/09 116981	Week 7 7/10 117255	Week 8 14/10 117682	Week 9 21/10 117968	Month 1 14/08 114642	Month 2 16/09 116250	Month 3 28/10 118373	ADWG See PQL Units	Health (H) Aesthetic (A)
Rain Fall, Day of Sample		Mm	2.4	4.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0		
Rain Fall, Day Before Sample		Mm	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	0	0.0		
Characteristics															
Bicarbonate Alkalinity	5	mg/L	7	<5	6	6	6	6.3	6.9	6	49	12	6	6		
Carbonate Alkalinity	5	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	5	Pt/Co	85	100	85	50	<5	40	45	40	55	55	50	50	15	A
Electrical Conductivity	1	µS/cm	140	135	140	140	140	155	156.05	140	130	170	160	190		
Hardness	3	mg $CaCO_{3/L}$	17	15	17	16	18	18	18	16	17	19	16	16	200	A
Hydroxide Alkalinity	5	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
pH		pH Units	6.1	4.9	5.9	6.1	6.2	6.1	6.3	6.4	6.2	7.3	6	6.4	6.5-8.5	A
Total Alkalinity	5	mg/L	7	<5	6	6	6	6.3	6.9	6	49	12	6	6		
Total Dissolved Solids	5	mg/L	98	11	78	82	81	91	119	100	90	110	87	110	600	A
Total Organic Carbon	1	mg/L	7	8	7	7	7	6.4	6.503	6	8	5	7	7		
Turbidity	0.1	NTU	3.6	4.85	3.4	2.5	3.5	1.6	1.2	1.4	2.6	3.4	2.4	2.5	5	A
Microbial Contents															
E.coli	1	CFU/100 mL	32	38	19	8	22	<1	40	200	53	11	17	13	<1	H
Chemical Contents															
Aluminium	10	µg/L	240	230	320	220	210	687	106.3	90	150	40	220	110	200	A
Calcium	0.5	mg/L	1.5	1.2	1.5	1.4	1.45	1.56	1.5	1.4	1.5	1.8	1.4	1.4		
Iron Total	10	µg/L	1000	700	730	550	640	1006	629.5	670	780	1200	570	660		

Magnesium Dissolved	0.5	mg/L	3.1	2.8	3.3	3.1	3.4	3.5	3.4	3.1	3.2	3.5	3.1	3		
Manganese	5	µg/L	26	1700	30	26	28	1860	20.7	28	31	32	26	22	500, 100	H, A

Additional sampling occurred between November 2015 and April 2015. The results are shown in tables 6.5 and 6.5.

Table 6.4. Results of weekly sampling during August September and October 2014.

	Sample	1	2	3	4	5	6	7	8	ADWG	Health (H)
	Units	18/11	2/12	9/12	16/12	20/1/`5	27/01	3/02	10/02	See PQL	Aesthetic (A)
Rain Fall, Day of Sample	mm	0.0	0	0.0	0.0	0	0	0.0	0.0		
Rain Fall, Week of Sample	mm	5.2	17.6	42.9	24.6	107.9	29	122.2	17.4		
Characteristics											
Bicarbonate Alkalinity	mg/L	7	8	8	8	11	8	8	8		
Carbonate Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	Pt/Co	40	40	50	50	30	25	60	60	15	A
Electrical Conductivity	µS/cm	140	140	150	140	160	150	130	120		
Hardness	$mgCaCO_{3/L}$	17	18	17	16	16	16	15	14	200	A
Hydroxide Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
pH	pH Units	6.1	6.5	6.5	6.5	6.4	6.3	6.3	6.1	6.5-8.5	A
Total Alkalinity	mg/L	7	8	8	8	11	8	8	8		
Total Dissolved Solids	mg/L	75	98	93	90	89	82	78	100	600	A
Total Organic Carbon	mg/L	8	7	6	7	6	7	10	11		
Turbidity	NTU	1.6	2.5	2	1.4	2	3.2	2.9	18	5	A
Microbial Contents											
E.coli	CFU/100mL	70	110	10	40	308	330	180	310	<1	H
Chemical Contents											
Aluminium	µg/L	70	60	50	90	50	120	420	350	200	A
Calcium	mg/L	1.5	1.6	1.5	1.4	1.4	1.4	1.3	1.3		
Iron Total	µg/L	660	780	510	550	530	1200	920	1200	300	
Magnesium Dissolved	mg/L	3.2	3.3	3.2	3	3.1	3	2.8	2.7		
Manganese	µg/L	12	19	10	13	22	49	57	98	500, 100	H, A
Phosphorous	mg/L		0.02	0.014	0.01	0.02	0.02	0.02	0.1		

Table 6.5. Reservoir water samples taken between February and April 2015.

	Sample	9	10	11	12	13	14	15	16	ADWG See PQL	Health (H) Aesthetic (A)
	Units	17/02	24/02	3/03	10/03	17/03	24/03	31/03	22/04		
Rain Fall, Day of Sample	mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	140.0		
Rain Fall, Week of Sample	mm	9.2	27.4	16.4	1.0	20.4	20.0	31.4	302.0		
Characteristics											
Bicarbonate Alkalinity	mg/L	8	6	10	7	6	10	6	6		
Carbonate Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
Colour (True)	Pt/Co	60	60	45	50	70	68	210	92	15	A
Electrical Conductivity	µS/cm	130	130	140	140	210	260	130	110		
Hardness	$mgCaCO_{3/L}$	16	13	15	15	12	13	14	11	200	A
Hydroxide Alkalinity	mg/L	<5	<5	<5	<5	<5	<5	<5	<5		
pH	pH Units	6.2	5.9	6.9						6.5-8.5	A
Total Alkalinity	mg/L	8	6	10	7	6	10	6	6		
Total Dissolved Solids	mg/L	83	91	92	77	120	110	75	68	600	A
Total Organic Carbon	mg/L	15	12	13	10	8	9	9	15		
Turbidity	NTU	6.4	11	4	37	2	1.4	3.3	6.7	5	A
Microbial Contents											
E.coli	CFU/100mL	62	180	24		82	16	130	70	<1	H
Chemical Contents											
Aluminium	µg/L	530.0	160	140	190	110	90	110	690	200	A
Calcium	mg/L	1.3	1.1	1.3	1.2	0.8	0.9	1	1		
Iron Total	µg/L	2100.0	610	600	1200	580	410	390	1000	300	
Magnesium Dissolved	mg/L	3.0	2.5	2.9	2.8	2.5	2.5	2.8	2		
Manganese	µg/L	200.0	15	31	63	35	19	29	56	500, 100	H, A
Phosphorous	mg/L	0.02	0.1	0.04		0.04	0.021	0.024			

The results of the late 2014 to mid-2015 sampling were broadly similar to the sampling in 2014. That is:

- Slightly low pH
- Very low alkalinity
- Low hardness
- Significant water 'colour'
- Low salinity
- High concentrations of iron, aluminium and Manganese.

These results are similar to those obtained in 2014. They suggest that significant pre-treatment will be needed to produce water with attributes conforming with ADWG (2011).

Maximum concentrations of phosphorus occurred in February and may be associated with severe storms mobilising and transporting sediment as associated phosphorus into the dam. Based on table 6 in WQRA, (2010) the reservoir water is classified as moderate to high risk for cyanobacterial growth. As such strategies are required to monitor and if required, address algal blooms.

ADDITIONAL SAMPLING ON 18TH NOVEMBER 2014

Water samples were collected from the leachate pond downslope of the decommissioned landfill on Lot 422 DP 40341, Reeves St, Somersby (figure 6.1) and from the Narara

Reservoir at the same sampling point as in 2013. That is, on the left side of the dam near the glory hole (figure 5.2).

Table 6.6. Results of sampling the leachate pond and Narara Reservoir on Nov 19th 2014.

Attribute	Analytical reference	Unit	Landfill pond	Narara Reservoir	ADWG guideline value for health	Comment
Turbidity	WC05: ALPHA 2130M (Modified)	NTU	48	1.6	5	Reservoir water compliant
Conductivity	WC12MET: ALPHA 2510B	mS/m	25	17	Not given	Not applicable
Total dissolved salts	WC62NS ALPHA 2540 C	mg/L	147	168	<600	Compliant
pH	WSMET: ALPHA 4500-H+		7.4	6.5	6.5-8.5	Compliant
Metals						
Hexavalent Cr	TM26TM USEPS 7196A	mg/L	<0.0004	<0.0004	0.05	Compliant
Total Al	TM50TML: USEAP 6010	mg/L	6.06	_		Reservoir water compliant
Total Br	TM56TML: USEPA 6020	mg/L	0.16	0.22	<4	Compliant
Total Al	TM56TML: USEPA 6020	mg/L	0.01	0.12	<0.1 (A)	Needs addressing
Total Mn	TM56TML: USEPA 6020	mg/L	0.018	0.012	<0.1 (A)	Compliant
Total Ni	TM56TML: USEPA 6020	mg/L	0.001	<0.001	<0.02	Compliant
Total Cu	TM56TML: USEPA 6020	mg/L	0.005	<0.001	<1(A)	Compliant
Total Zn	TM56TML: USEPA 6020	mg/L	0.008	<0.005	<3 (A)	Compliant
Total As	TM56TML: USEPA 6020	mg/L	0.001	<0.001	<0.01	Compliant
Total Se	TM56TML: USEPA 6020	mg/L	<0.003	<0.003	<0.01	Compliant
Total Cd	TM56TML: USEPA 6020	mg/L	<0.001	<0.001	<0.002	Compliant
Total Pb	TM56TML: USEPA 6020	mg/L	0.003	<0.001	<0.01	Compliant
Total Hg	TM56TML: USEPA 6020	mg/L	<0.0003	<0.0003	<0.001	Compliant
E coli	M128: ALPHA 9223 B	Orgs/100 mL	180	61	Not detected	Disinfection needed
Total coliforms	M128: ALPHA 9223 B	Orgs/100 mL	2400	1300	Not given	Not applicable
Total N	NU 102: ALPHA 4500-PH & NO3 1	mg/L	1.04	0.41	Not given	ANZECC suggest <0.35 mg/L for ecological stressor
Total P	NU 102: ALPHA 4500-PH & NO3 1	mg/L	0.101	0.015	Not given	ANZECC suggest <0.01 mg/L for ecological stressor

The samples were immediately transferred to a refrigerator in a car, kept refrigerated overnight and delivered to the laboratory on the morning of 20th November.

An attempt was also made to obtain a water samples from 2013 sampling site 1 in figure 6.1. However there was no surface water at this point, or for at least 100m down slope.

Aluminium was the only chemical exceeding the ADWG (2011) values in the dam water.

The leachate pond had higher turbidity, pH and concentrations of some trace elements than did the dam water, however the difference was not sufficient to require the leachate pond to be considered a dam water quality hazard.

E coli occurred in both samples and disinfection would be required.

Phosphorus concentration in the leachate pond is 10 times the ecological stressor threshold that given in ANZECC (2000a). The dam water is 1.5 time higher than the threshold value. Nitrogen is approximately 3 times higher than the ecological threshold in the leachate pond but only just over the threshold in the dam.

A broad series of thresholds for increased risk of algal blooms include P>0.015 mg/l OR N>0.15 mg/l PLUS turbidity<30 NTU (example in ANZECC 2000a). The nitrogen, phosphorus and turbidity values of the Narara Reservoir are all non-compliant with these thresholds. This suggests heightened risk of algal blooms.

CONCLUSIONS REGARDING WATER QUALITY

The key findings of the 2014-15 sampling program include:

- The water is 'fit-for-purpose'. That is it is suitable for a raw water supply into the proposed treatment system (See Aquacell's report for details of the water treatment sequence and the potable water quality management program).
- True colour is high and it will need to be reduced.
- Salinity is very low
- Alkalinity and hardness are very low. May be corrosive
- pH is slightly too low. This reflects sandstone catchment. Could add alkali if required.
- Turbidity is typically aesthetically acceptable, but filtration needed to maximise disinfection efficiency
- E coli is sufficiently low to meet the ANZECC (2000a) Guideline for swimming, but the water will need disinfection to achieve no detectable i.e.,<1 E coli/100 mL population density for potable water.
- Aluminium concentration is sometimes in excess of guideline values. Increasing the pH should reduce its concentration.
- Dissolved iron and manganese concentrations are frequently above guideline values. Increasing the pH and the increased aeration as part of the water treatment process will cause precipitation of iron and manganese, thereby reducing the dissolved concentration.
- A routine monitoring program is essential, especially when the dam water becomes the potable water supply source for the Narara Ecovillage.
- Algal blooms are a risk and monitoring for this hazard is specifically required.

The practical limit of quantification (PQL) used for phosphorus in the monthly testing in the spring samplings of 2014 is 0.05 mg/L. Phosphorus concentration is a critical factor in determining risk of algal blooms (Newcombe et al, 2010). According to these authors, < 0.01 mg/L is the threshold concentration for phosphorus to minimise the potential for cyanobacterial growth. Unfortunately the analytical methods used were not sensitive enough to detect the proposed threshold for algae risk. This deficiency is being addressed.

Newcombe et al, (2010) also discuss the importance of stratification. De-stratification may be an option if algal blooms eventuate.

7. HAZARD IDENTIFICATION AND RISK ASSESSMENT

Hazard identification and risk assessment is the third component of Element 2 of Framework for Management of Drinking Water Quality.

7.1. BACKGROUND

Narara Eco Village (NEV) has already produced a *Risk Assessment Summary Paper (Aquacell and City Water Technology, 2014).* This paper provides a detailed assessment of the risks associated with the water cycle system proposed for the Eco Village.

Some of the risks were related to the raw water supply. The hazards, the potential frequency of occurrence and their consequences were examined in detail in this report and subsequent documents. The text below focusses on the dam management risks, but utilises some of the information from the Aquacell /CWT 2014 report.

A significant component of the Framework Management of Drinking Water Quality is understanding and managing the risks to drinking water. In the current report this focusses on the dam as the key source of water.

The Water Quality Improvement Plan, which includes the water supply system risk assessment component of the WICA Audit Guideline for Greenfield Schemes (IPART 2013), is similarly based on the Framework.

The current Reservoir Water Management Plan focusses on hazards to the reliable supply of 'fit for purpose' water into the NEV drinking water treatment train.

7.2. RISK ASSESSMENT PROCESS

RISK ASSESSMENT METHODOLOGY

Events and hazards were identified for each process step. Risks posed by each of the events were then assessed. The key components of the process are:

Hazardous event

A hazardous event is one that introduces contaminants (hazards) to the water.

For this risk assessment the hazardous event will be for the level of contamination to be unacceptable for treatment through the downstream processes. Examples of a hazardous events include:

- Contamination resulting from catchment activities and processes resulting in unacceptable water quality in the dam (e.g very high turbidity)
- Algal blooms in the dam (toxic and non-toxic strains) resulting in poor water quality

Hazard

A hazard is a physical, chemical or biological agent in the dam water with the potential to cause an adverse effect.

Examples of hazards include:

- Human-infectious pathogens such as *Salmonella* and *Cryptosporidium*

Controls are practices and equipment that reduce the hazard or the hazardous event.

Controls in place

- **Examples of controls include:**
  - **Reservoir management program to reduce the potential for algal blooms**
  - **Liaison with catchment landholders, e.g. RSPCA, to ensure adequate management of animal waste**
  - **Hazard Reduction Burns designed to reduce the risk and potential severity of bushfires.**

Controlled Risk (After Mitigation)

Controlled or 'residual' risk was assessed by identifying the likelihood and consequence of the hazardous event occurring with the control in place. The risks were assessed as Likelihood (Table 7.1 + Consequence (Table 7.2).

Maximum Risk (Before Mitigation)

Likelihood and consequence of the hazardous event occurring if the controls were to fail or are inadequate.

A risk assessment matrix was used to assess risks to the identified end uses (Table 7.3).

Table 7.1. Likelihood table (Aquacell and City Water Technology, 2014).

RATING		LIKELIHOOD OF OCCURRENCE	
		Aquacell 2011 Descriptor	ADWG 2011 Descriptor
Almost Certain	5	The event ***will occur*** within the planning period (Chance of ***daily*** occurrence)	Is expected to occur in most circumstances
Likely	4	The event is ***likely to occur*** once a week within the planning period (Chance of ***weekly*** occurrence)	Will probably occur in most circumstances
Possible	3	The event ***may occur*** within the planning period (Chance of ***monthly*** occurrence)	Might occur or should occur at some time
Unlikely	2	The event ***not likely to occur*** in the planning period (Chance of ***annual*** occurrence)	Could occur at some time
Rare	1	The event will ***only occur in exceptional circumstances***	May occur only in exceptional circumstances

Table 7.2. Consequence table (Aquacell and City Water Technology, 2014).

RATING[23]		AREA OF IMPACT		
		Customer Service (Aquacell 2011)	Regulatory/ Legal (Aquacell 2011)	Water Quality (ADWG 2011)
Extreme	5	Virtually all customers are effected	Significant legal, regulatory or internal policy failure Loss of licence(s)	Major impact for large population, complete failure of systems
Major	4	Significant portion of customers effected	Major legal, regulatory or internal policy failure Imposition of licence conditions	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required
Moderate	3	Customer or community segment effected	Major legal, regulatory or internal policy failure Imposition of licence conditions	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
Minor	2	Separate group(s) of customers effected	Minor legal, regulatory or internal policy failure	Minor impact for small population, some manageable operation disruption, some increase in operating costs
Insignificant	1	Individual customer effected	Insignificant legal, regulatory or internal policy failure	Insignificant impact, little disruption to normal operation, low increase in normal operation cost

Figure 7.1 shows the risk rating matrix while table 7.3 shows the risk register matrix.

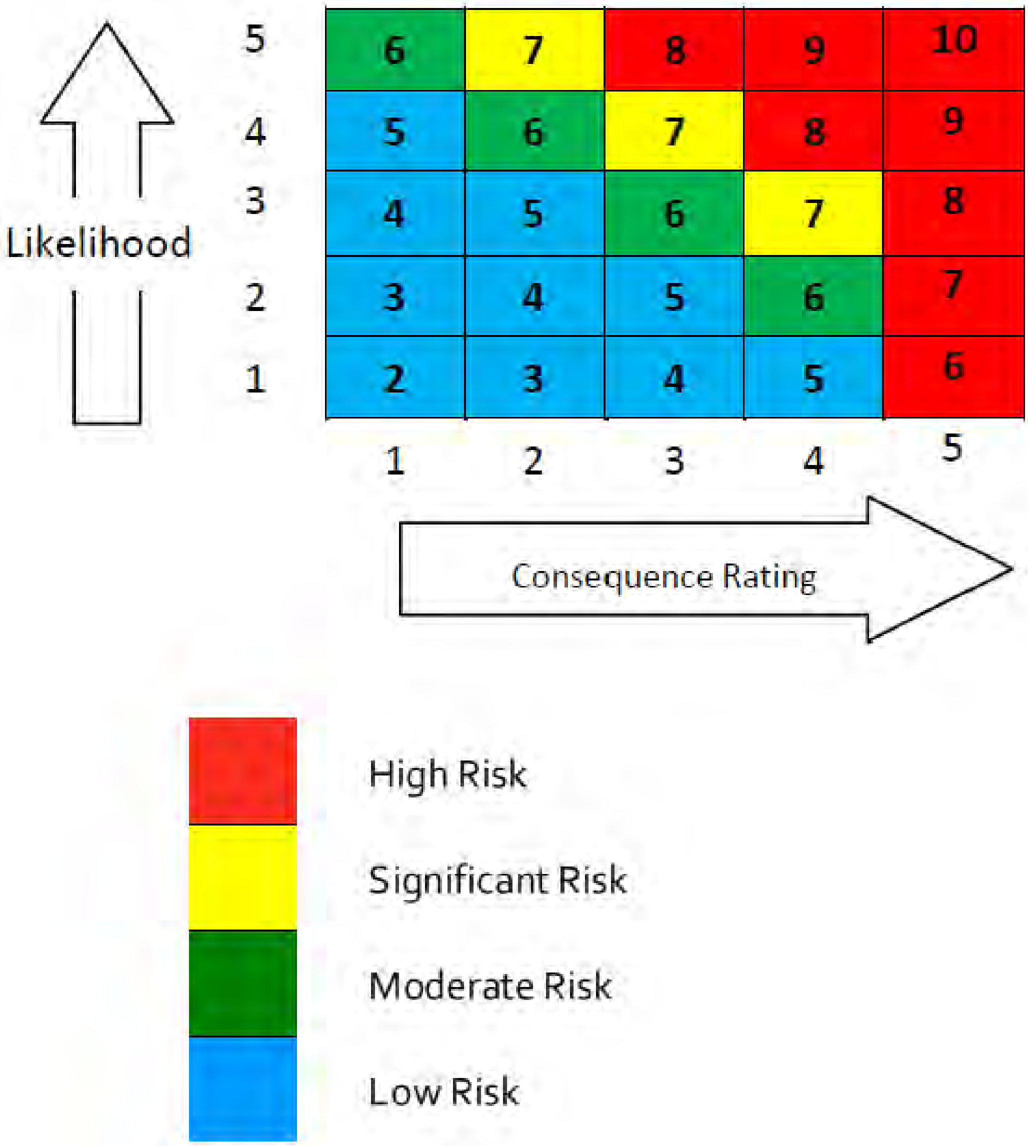


Figure 7.1. Risk rating matrix (Aquacell and City Water Technology, 2014).

Table 7.3. Risk register matrix for the catchment and the reservoir (adapted from Aquacell, 2011).

DESIGN / CONCEPT STAGE HACCP				Before Mitigation				After Mitigation						
***Risk* No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt1	**Catchment**	*Biological and physical hazards* Recreation and camping (residents and public) leading to raw water quality that is difficult to treat	Water treatment plant (proposed) Gated community residents aware that dam is water source Community rules especially in relation to swimming	4	5	**9**	High	1	4	**5**	Low		ALARP	NEV to develop recreational management policy (especially swimming). NEV to negotiate access policy for any land exchanged with Gosford City Council NEV to liaise with Strickland State Forest managers regarding location of walking tracks etc.

DESIGN / CONCEPT STAGE HACCP						Before Mitigation				After Mitigation				
***Risk* No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt2	**Catchment**	*Biological, physical and chemical hazards* Faecal matter (including from feral animals) and erosion products from agriculture (horticulture and animal husbandry) and forestry reaching waterways and causing a water quality problem in dam	Water treatment plant (proposed)	4	5	**9**	High	1	4	**5**	Low	The volume of the dam will dilute contaminants. Additionally the dam as significant hydraulic residence time, exceeding 26 days in 99% of time. The residence time enable UV radiation in sunlight to kill off susceptible microflora. However short circuiting will reduce the effective residence time.	Catchment mapping has been undertaken by Woodlots and Wetlands in Nov 2014. It indicates that the highway (M1) does NOT drain to the catchment. The main issues are : • RSPCA shelter • The decommissioned landfill and associated leachate pond • Soil erosion from BMX activities • On-site sewage on	NEV contacted Strickland State Forest regarding feral animal populations and associated baiting programs etc. State Forests state no baiting programs are planned. Sampling of the leachate pond component of the closed landfill at the top of the catchment has been undertaken. Results show the water is not a significant hazard to dam water quality

DESIGN / CONCEPT STAGE HACCP				Before Mitigation				After Mitigation						
Risk No.	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt3	**Catchment**	*Biological and physical hazards* Periodic changes in raw water quality leading to difficulty in treating raw water and increased chlorine demand	Water treatment plant (proposed)	2	4	6	Moderate	1	4	5	Low	12 samplings since Aug 2014 show E coli, colour, Al, Fe and Mn are a significant issues Concentrations of other attributes including TOC, TSS and turbidity are consistently low	These reservoir water quality issues can be addressed by appropriate water treatment.	Aquacell to develop full water treatment train.
Cmt4	**Catchment**	*Biological, physical and chemical hazards* Eutrophication resulting in low DO, high nutrients, increased possibility of algal blooms causing taste and odour, toxin production, mineral mobilisation resulting in poor water quality	Water treatment plant (proposed)	2	4	**6**	Moderate	1	4	**5**	Low	As per Cmt3, above	Not considered to be a problem for this system.	Include Chlorophyll ‘a’ in monitoring program. Also ensure analysis for total P and filterable reactive P can detect to <10 ug/L. Total N to be detectable to <300 ug/L.

DESIGN / CONCEPT STAGE HACCP						Before Mitigation				After Mitigation				
Risk **No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to 5*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to 5*	**C** *1 to 5*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt5	**Catchment**	*Physical and chemical hazards* Bushfire followed by heavy storm resulting in ash, nutrients and trace metals washing into the dam (Smith et al, 2011).	Water treatment plant (proposed). In particular the removal mechanisms for colour, Fe, Mn and Al.	3	5	8	High	2	4	6	Moderate	Some uncertainty as to whether WTP would be a control - depends on extent of bushfire and subsequent rainfall. Obviously if the WTP was destroyed then an immediate replacement OR an external supply would be essential. It is essential that the Ecovillage have access to sufficient funds to rapid replacement of destroyed/ damaged equipment.	Mobilization of soil exposed by the fires is an issue. The nutrients and trace attached to the soil could be deposited in the dam. Ash tends to be relatively high in potassium, but the main concern is a release of phosphorus, leading to an algal bloom . Installation of aeration in the dam will reduce risk of algal blooms.	NEV to consider water quality issues in bushfire management plan including alternate sources such as leaving town water connected to one of the public buildings or carting water. Liaise with Strickland State Forest, RFS and GCC to request development of a hazard reduction burn schedule REQUIRED actions NEV confirm funds availability NEV confirm intention to install

DESIGN / CONCEPT STAGE HACCP						Before Mitigation				After Mitigation				
Risk **No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt6	**Catchment**	*Physical and chemical hazards* Road crossings, accidents and spills, unsealed roads leading to water quality issues	Water treatment plant (proposed)	1	Up to 5	Up to 7	Significant	2	3	5	Low	The risk is dependent on the incident	BMX trails several km away from the dam are not likely to be an issue. Reeves Street is essentially the western boundary of the catchment and this road has minimal traffic. A major incident could be a sullage truck overturning and losing its load into the catchment. It is assumed this would invoke a major emergency response and clean-up operation	NEV to identify relevant stakeholders in incident management plan (HAZMAT, SES, Council, EPA, Police, Fire, NSW Health).

DESIGN / CONCEPT STAGE HACCP							Before Mitigation			After Mitigation				
***Risk* No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Cmt7	**Catchment**	*Biological hazards* Failing onsite sewage management systems in catchment leading to high levels of pathogens in source water	Water treatment plant (proposed)	1	6	6	Moderate	1	2	2	Low	There is over 350 m distance between the nearest private dwelling and the commencement of a catchment streamline (SIX maps)	There are no onsite sewage management systems close to waterway. Note that there is an animal shelter on Reeves St which has its own on-site sewage treatment plant.	NEV to identify onsite sewage management systems by liaising with GCC. There is minimal risk assuming system owners are required to comply with GCC on-site sewage management strategy (2006). Note that the main risk, the RSPCA shelter, does have an registered on-site sewage treatment system and it is maintained on a quarterly basis via a service contractor.

DESIGN / CONCEPT STAGE HACCP						Before Mitigation				After Mitigation				
Risk **No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Reservoir 1	**2. Source water (dam)**	*Biological hazards* Dead animals decaying and leaching nutrients resulting in poor water quality entering dam	Water treatment plant (proposed)	2	4	**6**	Moderate	1	4	**5**	Low	Animal death will be a continuing issue.		Reservoir Water Management Plan to be developed by NEV/Aquacell including how this fits with WICA licence. The WTP will have a multiple barrier approach to maintaining potable water quality.

DESIGN / CONCEPT STAGE HACCP						Before Mitigation				After Mitigation				
Risk No.	Step	Potential Hazard	Preventative Measure	L	C	Maximum Risk		L	C	Residual Risk		Uncertainty	Basis/ Notes	Further Actions
	Process unit	*Physical, chemical, biological, other*		*1 to*	*1 to 5*	*Score (D +*	*Risk Level*	*1 to*	*1 to*	*Score (D +*	*Risk Level*			
Reservoir 2	**2. Source water (dam)**	*Chemical and physical hazards* Reservoir stratification / inversion leading to release of P, Fe and Mn and increased turbidity	Shallow Reservoir De-stratification as required Water treatment plant (proposed)	3	3	6	Moderate	2	2	4	Low	ADWG guidelines for Fe, P and Al exceeded .in some but not all samples. Issue is likely to be periodic rather than continual.	Iron and aluminium were elevated in some of the monthly samples (table 6.2). The proposed water treatment train will minimise this risk.	NEV to liaise with previous site manager regarding dam stratification/ inversion (including instances of Taste &Odour in the water). Water analysis for P and N to have detection limits relevant to ANZECC (2000) guideline concentrations.
Reservoir 3	**2. Source water (dam)**	*Biological, physical and chemical hazards* Potential stormwater entry into dam	Stormwater from NEV site will not flow to dam (to Narara Creek) Dilution Water treatment plant (proposed)	1	3	**4**	Low	1	2	**3**	Low			Not an issue

DESIGN / CONCEPT STAGE HACCP				Before Mitigation				After Mitigation						
Risk **No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Reservoir 4	**2. Source water (dam)**	*Biological, physical and chemical hazards* Short-circuiting and rapid mixing and/or reduced detention time in the dam leading to poor quality water	Water treatment plant (proposed) has not been designed with dam as a barrier	2	3	**5**	Low	1	3	4	Low	Risk ratings to be determined once further information has been obtained.	The dam is elongated relative to its depth (15m depth, with more than 370 m fetch). High inflow during extreme rain events could result in stratification and temporary short-circuiting. However The catchment has minimal development and the main contaminant is likely to be mobilized sediment. The nutrient content of this sediment is likely to be extremely low due to its derivation from Hawkesbury Sandstone. Figure 3.6 shows that the 1%ile hydraulic residence time is 26 days.	Drawing the raw water from say 2m below the surface will reduce possibility of short circuiting.

DESIGN / CONCEPT STAGE HACCP				Before Mitigation				After Mitigation						
Risk **No.**	**Step** *Process unit*	**Potential Hazard** *Physical, chemical, biological, other*	**Preventative Measure**	**L** *1 to*	**C** *1 to 5*	**Maximum Risk** *Score (D +*	*Risk Level*	**L** *1 to*	**C** *1 to*	**Residual Risk** *Score (D +*	*Risk Level*	**Uncertainty**	**Basis/ Notes**	**Further Actions**
Reservoir 5	**2. Source water (dam)**	*Biological, physical and chemical hazards* Algal blooms (toxic and non-toxic strains) resulting in poor water quality	Water treatment plant (with proposed filtration system). De-stratification as needed	2	4	6	Moderate	1	3	4	Low	Risk ratings to be determined once further information has been obtained.	A key issue is the phosphorus concentration in the dam water. The P analysis so far has had too high a practical quantification limit of; 0.05 mg/L. It should be <0.01 mg/L. (this requirement is now included in the analytical specifications. Note that chlorination reduces the toxic effects of algae(Office of Water, 2014)	Sampling by Woodlots and Wetlands occurred on 20.11.2014 and demonstrated that both N and P concentrations exceeded guideline values. Prepare an Algal Bloom Emergency Plan Consider a de-stratification system. The proposed filtration system should remove algae and their toxins.
Reservoir 6	**2. Source water (dam)**	*Biological, physical and chemical hazards* Use of the dam for firefighting resulting in water quality contamination	Don't use fire suppressant chemicals within 100 of any water body	1	5	6	Moderate	1	2	2	Low		NEV firefighting system likely to use potable water from NEV reticulation for firefighting.	Rural Fire Service confirm that only approved chemicals are used . Chemicals are not included in water that is applied within 100 m of any water body

The analysis above suggests that risk can be significantly reduced via strategic management actions such as liaison with RFS and Council.

The risks remaining 'moderate' after controls were assessed were:

Catastrophic bushfires destroying key infrastructure such as the pump station and pipe lines

Catastrophic bushfires resulting in large scale mobilization of sediment to the dam during major post fire rain events (Smith, et al, 2011). Depends on local conditions, especially vegetation type, soils, the extent of catchment development and the interval between the fire and intense rain events. Iron and manganese concentrations are likely to increase (White et al., 2006), especially if additional nutrients released by the fire lead to anoxic conditions in the dam water column. The need to remove iron and manganese has already been included in the water supply management plan.

A key unknown is the risk of algal blooms. Two approaches are recommended:

- Increase knowledge of the dam water quality to determine the 'risk' level (Newcombe et al, 2010).
- Liaise with previous site managers to ascertain the incidence of algal blooms in the past 50 years.

If there is evidence of previous algal blooms, examine options to draw water from at least 2-3m below the surface. Also, draw water during the day rather than at night.

De-stratification could also be considered (The Water Directorate, 2014).

The potential for sabotage is an issue.

Whilst the proposed filtration system in the drinking water treatment train will remove the algae, the presence of algae will increase the treatment costs and add to the management complexity.

The WQRA (2010) document provides guidance om response to algal blooms in the water supply system.

8. ELEMENT 3. PREVENTATIVE MEASURES FOR DRINKING WATER QUALITY MANAGEMENT[7]

ADWG refers to:

- Preventative measures
- Multiple barriers, and
- Critical control points

ADWG emphasises the essential role of preventing hazards from occurring, or at least reduce them to acceptable levels. Additionally the level of protection should be proportionate to the associated risk.

The assessment in Section 7 above identifies the likely risks, quantifies them, then provides options to reduce the risks to an acceptable level.

Because most the catchment is not under NEV control, emphasis for raw water quality has been on preventative measures rather than multiple barriers or critical control points. It is emphasised again that the aim of the Reservoir Water Management Plan is to reliably deliver water that is 'fit for purpose' into the Potable Water Treatment Train.

Strategic risk minimisation actions include:

- Ensure NEV members and visitors know of and comply with the prohibition on swimming in the dam
- Liaison with Council to ensure any changes in land use zoning do not increase risk to the fit for purpose raw water supply (some of the lands in the upper catchment are listed as 'deferred matters' in the 2014 LEP (figure 3.3);
- Liaison with Council to ensure that the decommissioned landfill in the western portion of the catchment is kept closed and not developed in any way;
- Liaison with Council to ensure that BMX activities on Council owned land along Reeves Street do not result in excessive erosion and sediment transport to the dam;
- Liaison with Council to minimise the 'attractiveness' of the catchment for hiking and other recreational activities. Examples include
    - NOT advertising the area: Strickland State Forest has very good visitor facilities and can provide an extensive 'bush' experience. The facilities are in an adjacent catchment (See appendix 5).
    - NOT providing access points or tracks in the Narara Reservoir Catchment is another way of minimising risk to dam water quality.
- Liaison with State Forests to ensure that the Stoney Creek Catchment remains the focus of bush-based recreational activities in the area (see appendix 5). This catchment is several km to the north of the Narara Reservoir Catchment, and activities in the Stoney Creek Catchment will have no impact on the Narara Reservoir waters;
- Liaison with RSPCA to ensure that all wastes, wastewaters and wash-down water produced at the shelter receive adequate disinfection and are then irrigated onto surrounding lands at rates which do not result in runoff events.
- Liaison with the owners of the electricity transmission lines regarding
    - a). Minimising public access and
    - b). Reducing bushfire risk

[7] The specific actions needed to maintain dam structural integrity are included elsewhere.

- Liaison with Rural Fire Service and State Forests Corporation to develop a Hazard Reduction Burn Schedule for the Narara Reservoir Catchment bushland.

8.1. CRITICAL CONTROL POINTS

The raw water suction line location and the offtake depth provide opportunities to minimise water quality issues such as turbidity and algae population density. These are therefore critical control points on the raw water supply.

Table 8.1 shows the monitoring and target requirements.

Table 8.1. Critical control points relating to the raw water supply.

Critical Control Point	***Hazard(s) of concern***	***Operational monitoring***	***Location of Measurement***	***Target***	***Operational limit***	***Critical limit***
Raw water abstraction	Turbidity Pathogens	Raw water turbidity (via on line analyser and daily manual testing)	Sample line drawing from the raw water inlet pipe to the filtration plant	< 5 NTU	5 NTU	100 NTU
	Cyanotoxins	Monitoring cyanobacteria (weekly visual inspection.)	Raw water dam	< 2,000 cells/mL *M. aeruginosa* or < 0.2 mm^3/L all cyanobacteria	5,000 cells/mL *M. aeruginosa* or 0.4 mm^3/L all cyanobacteria	50,000 cells/mL *M. aeruginosa* or 4 mm^3/L toxigenic cyanobacteria or 10 mm^3/L all
	Geosmin MIB	Taste and odour of water (checked weekly pre-treatment (boiled) and post treatment)	Taps drawing from the raw water inlet pipe and clear water reservoir outlet	No taste & odour	Noticeable taste & odour	Not applicable

9. ELEMENT 4. OPERATIONAL PROCEDURES AND PROCESS CONTROL

Figure 9.1, on the following page, shows the proposed treatment train. It is expected that the train details will be adjusted slightly as more operational experience in obtained under local conditions.

9.1. OPERATIONAL PROCEDURES

REQUIRED ACTIONS FOR PROCESSES AND ACTIVITIES FROM CATCHMENT TO THE TREATMENT TRAIN INFLOW POINT.

Since the 1980s raw water has been withdrawn from the dam using a suction line attached to a pontoon. The final configuration has not yet been set, however it is expected to continue with a suction line 'hanging' below a pontoon. The proposed actions to improve water quality security include:

1. Inspection of the suction line to ensure integrity
2. Modification of the suction line to:
    a. Install an adequate cage around it to prevent entry of fish and other items being sucked in
    b. Install a height adjustment to allow taking the water from desired depths, especially when algae or high turbidity are issues.

DOCUMENT ALL PROCEDURES AND COMPILE INTO AN OPERATIONS MANUAL

An operations manual will be completed for the entire treatment train once the final design of the train is agreed upon. The raw water supply management and procedures will form the first component of the manual.

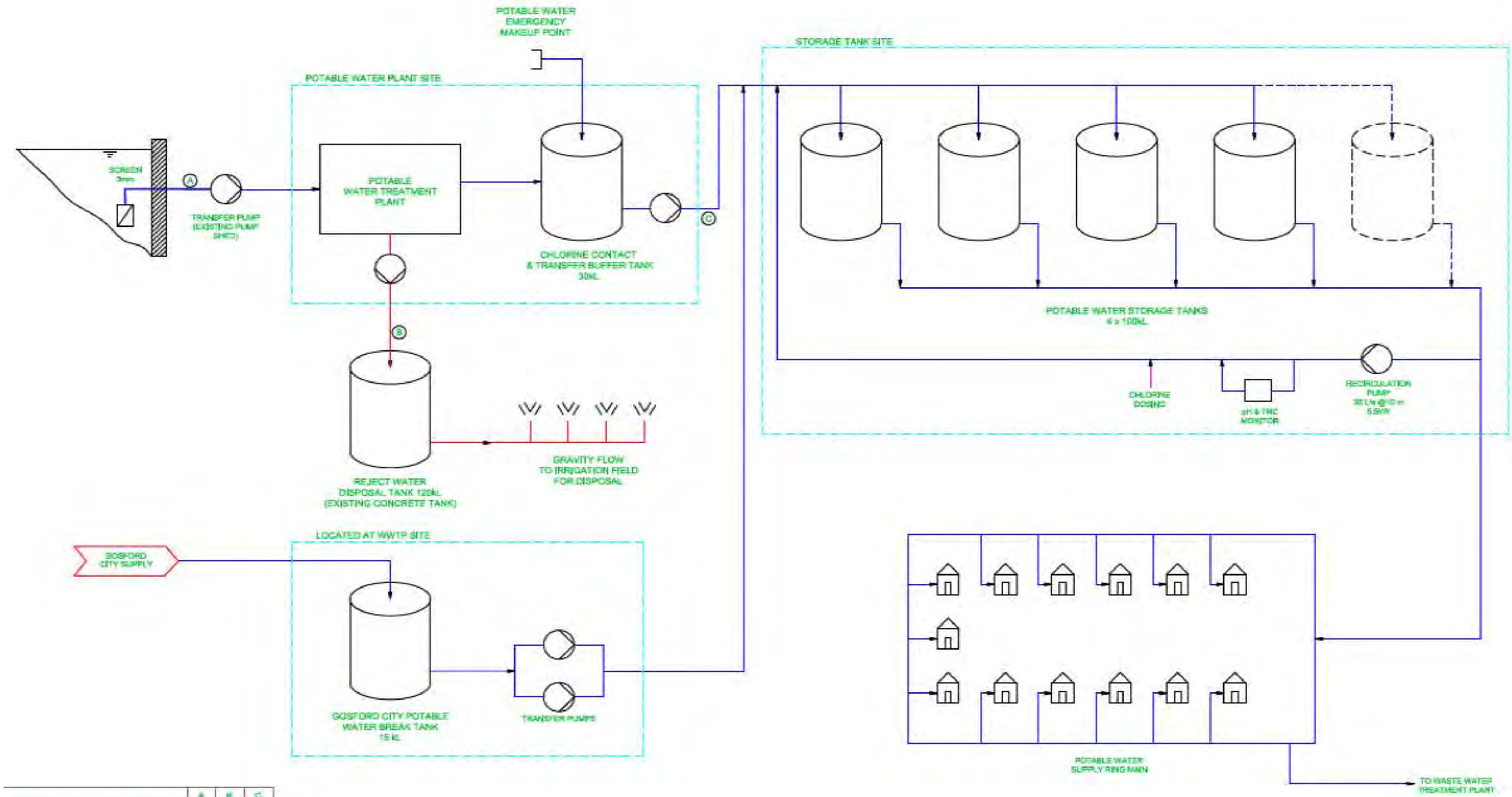
9.2. OPERATIONAL MONITORING

REQUIRED ACTIONS

Develop monitoring protocols for operational performance of the water supply system, including the selection of operational parameters and criteria and the routine analysis of results.

The key monitoring components are:

- Catchment risks
- Raw water quality
- Adequacy of the raw water abstraction system



	A	B	C
STAGE 1- AVERAGE DEMAND (kL/day)	36	17	16
STAGE 1- PEAK DEMAND (kL/day)	58	26	32
STAGE 1- DESIGN OUTPUT (kL/day)			70

Figure 9.1. Proposed potable water treatment train (Supplied by Aquacell, 1.12.2015).

9.3 CATCHMENT RISKS

Catchment risks were listed in section 7. These risks can be managed by a combination of liaison and continued alertness to ensure there is timely warning of any change in the catchment risk profile. Advocacy is required to promote risk reduction, e.g. hazard reduction burning.

Table 9.1. Catchment based risks to the Narara Reservoir, proposed responses and recommended monitoring actions.

Risk	Response	Monitoring/ actions
Contamination of the reservoir from people swimming in it	Ensure NEV members and visitors know of and comply with the prohibition on swimming in the dam. Provide an attractive alternative, e.g Narara Creek. Do not include photos of dam in NEV literature	Install warning signage adjacent to likely entry points. NEV should have a General Terms of Agreement for members. All members should sign and be given a copy. The GTA should include prohibition on swimming in the dam.
Changing landuse results in higher contaminant load reaching the dam	Liaise with Council to ensure any changes in land use zoning do not increase risk to the fit for purpose raw water supply (some of the lands in the upper catchment are listed as 'deferred matters' in the 2014 LEP (figure 3.3).	Make Council's planning section aware of concerns Have one member of NEV responsible for monitoring Council's planning position.
Disturbance of landfill site results in accelerated discharge of leachate	Liaison with Council to ensure that the decommissioned landfill in the western portion of the catchment is kept closed and not developed in any way.	Make Council's planning section aware of concerns.
BMX and similar activities results in accelerated erosion of bush tracks	Liaison with Council to ensure that BMX activities on Council owned land along Reeves Street do not result in excessive erosion and sediment transport to the dam.	Have one member of NEV responsible for visiting the area each month and assessing any evident increase in erosion.
Visitors to bush within the catchment could leave toilet waste and general rubbish. They can also increase track width and cause erosion rills leading to sediment entering the dam.	Liaison with Council to minimise the 'attractiveness' of the catchment for hiking and other recreational activities. Examples include <u>Not</u> advertising the area: Strickland State Forest has very good visitor facilities and can provide an extensive 'bush' experience. Not providing access points or tracks is another way of minimising risk to dam water quality.	Make Council's planning section aware of concerns. Ensure there are no tracks leading onto NEV property
Visitors assume they can hike through NEV lands and utilise the dam	Liaison with State Forests to ensure that the Stoney Creek Catchment remains the focus of bush-based recreational activities in the area (see appendix 5). This catchment is several km to the north of the Narara Reservoir Catchment and activities in the Stoney Creek Catchment will have no impact on the Narara Reservoir waters	Note the location in NEV literature

Risk	Response	Monitoring/ actions
	.	
Waste from the RSPCA shelter could contaminate the drainage lines delivering water to the Narara Reservoir	Liaison with RSPCA to ensure that all wastes, wastewaters and wash-down water produced at the shelter receive adequate disinfection and are then irrigated onto surrounding lands at rates which do not result in runoff events.	Arrange to meet with RSPCA. Convey NEV concerns and the reasons behind them. Annually sample the stream downslope of the RSPCA for potential pathogens , N and P. Sampling to occur following rain events. Geo-position sampling point.
Public enter catchment off power line easements. Lack of hazard reduction activities increases fire risk	Liaison with the owners of the electricity transmission lines regarding a). Minimising public access and b). reducing bushfire risk	Arrange to meet with owners of transmission lines. Convey NEV concerns and the reasons behind them.
Lack of hazard reduction activities increases fire risk	Liaison with Rural Fire Service and State Forests Corporation to develop a Hazard Reduction Burn Schedule for catchment bushland.	Arrange to meet with RFS and develop a Hazard Reduction Burn Schedule for catchment bushland. NEV keeps records of fire activity in the catchment Offer access to the dam for firefighting operations.

9.4 RAW WATER QUALITY

Section 6 contains the results of recent dam water quality monitoring. The sampling analytes and schedule will be developed in consultation with NSW Health.

In order to ensure consistence with NSW requirements it is recommended that routine raw water quality be tested within NSW Health laboratories.

REQUIRED ACTIONS

Liaise with the Public Health Unit of Health NSW to develop sampling (e.g. ANZECC, 2000b) and testing protocols.

Include protocols in potable water treatment train manual.

9.5 RAW WATER SUCTION LINE

General condition monitoring uses the observations of “look”, “listen”, and “feel” to identify potential equipment faults. Examples include:

- Unusual sounds or vibrations, which can be indicative of a mechanical fault such as a worn bearing
- Sucking noises along the pipe line indicating a pin hole leak
- Wet patches under or around equipment, which can be indicative of a slow leak

- Visible leaks from pipework, which can be indicative of a an impending rupture
- Equipment error messages, codes, or lights
- Pressure, temperature, or level readings outside of their normal operating ranges

REQUIRED ACTIONS

As an initial action the line needs to be carefully inspected during operation and replaced if deficient. The line needs to be included in the daily inspection regime.

- Record the cumulative flow volume each day.
- Mark the distance from the suction opening to the pontoon in 0.1m increments. Record suction opening depth.

9.6 CATCHMENT RISKS

Catchment risks and proposed corrective actions are shown in table 9.2.

Table 9.2. Recommended corrective actions for each potential risk to the NEV raw water source.

Risk	Corrective action
Contamination of the reservoir from people swimming in it	NEV members and visitors found swimming in the dam to be counselled strongly on the reasons why swimming is prohibited. Obtain their agreement to not do it again. Provide an attractive alternative, e.g Narara Creek.
Changing landuse results in higher contaminant load reaching the dam	Actively lobby Council to ensure there are no potentially adverse changes in landuse zoning in the catchment. The lobbying should include any evidence of the increased risk of contamination.
Disturbance of landfill site results in accelerated discharge of leachate	Liaison with Council to ensure that NEV is aware of any action by Council to change current conditions of the site. Actively lobby Council to ensure there are no potentially adverse changes
BMX and similar activities results in accelerated erosion of bush tracks	Actively lobby Council to ensure there are no significant increases in sediment yield from Council owned land on Reeves Street. If there is evidence of increased sediment mobilisation, request that Council stabilise its lands and remove the cause.
Visitors to bush within the catchment could leave toilet waste and general rubbish. They can also increase track width and cause erosion rills leading to sediment entering the dam	Ensure there are no access tracks through the 'bush' to NEV property. Close and re-seed any tracks that become evident.
Visitors assume they can hike through NEV lands and utilise the dam	As per action above, PLUS: Ensure that the Stoney Creek Catchment remains the focus of bush-based recreational activities in the area (see appendix 5).

Risk	Corrective action
Waste from the RSPCA shelter could contaminate the drainage lines delivering water to the Narara Reservoir	Arrange to meet with RSPCA. Convey NEV concerns and the reasons behind them. If sampling reveals an issue then contact the RSPCA and discuss corrective options.
Public enter catchment off power line easements. Lack of hazard reduction activities increases fire risk	Arrange to meet with owners of transmission lines. Convey NEV concerns and the reasons behind them. Ask that public assess for trailbikes, etc be discouraged as far as practical. Aim to ensure that the transmission line owners keep to their agreed hazard reduction protocols.
Lack of hazard reduction activities increases fire risk	Liaison with Rural Fire Service and State Forests Corporation to ensure the Hazard Reduction Burn Schedule is adhered to.

REQUIRED ACTIONS

Include all the actions listed in table 9.2 as a specific set of tasks for the NEV management committee to undertake/ delegate on a continuing basis.

9.7 RAW WATER QUALITY

Changing water quality in the dam is difficult, so prevention is critical.

Potentially useful corrective actions depend on the issue. The table below shows some issues and potentially corrective actions.

Table 9.3. Recommended corrective actions for deficiencies in raw water quality.

Issue	Corrective action
Elevated *E coli* population density	Check for catchment actions that could be responsible, e.g. the RSPCA, NEV members swimming in the dam, extended wet weather period. Raise the suction inlet to a shallow depth consistent with not causing vortexing, move it a close to the dam wall as practical consistent with not increasing risk of turbid water inflow.
Elevated turbidity	Check for catchment actions that could be responsible, e.g. intense rainfall events, dirt road construction, land clearance, bush fire. Raise the suction outlet to a shallow depth consistent with not causing vortexing, move it a close to the dam wall as practical consistent with not increasing risk of turbid water inflow
Increased N and P concentrations	• Check for catchment actions that could be responsible, e.g. intense rainfall events, dirt road construction, land clearance, bush fire. • Be aware that elevated P concentration could be related to release of dissolved P from sediments at the base of the water column. • Consider de-stratification • Be alert for algal bloom development
Elevated Fe concentration	Check for stratification ,especially for an anoxic zone near the base of the water column. Consider de-stratification
Increased algal population	• Check for catchment actions that could be responsible, e.g. intense rainfall events, dirt road construction, land clearance, bush fire. • Lower the suction line inlet. Operate suction pump during late morning to mid-afternoon when algae tend to congregate near the top of the water column. • Consider de-stratification

Note that the proposed drinking water treatment train is designed to address issues such as elevated E coli and algal population density, increased turbidity and increases in iron. The concern is that the raw water not become so contaminated that it is not ‘fit-for-purpose’ as influent to the potable water treatment train.

The proposed catchment based measures are preventative and should be seen as a strategic approach with the corrective actions in table 9.3 seen as short-term tactical responses.

Table 9.4 shows the indicative limits for raw water quality. These will be adjusted as operational experience is gained.

Table 9.4. Raw water indicative warning limit, critical quality limits and the required actions. (Aquacell pers comm).

Parameter	Limit	Action
Turbidity	> 10 NTU	Warning –adjust operational parameters if required to ensure membrane productivity is maintained.
	> 200 NTU	Critical – Operational limit of the membrane. Operation above this can be continued but will impact on throughout. May need supplementary water supply until water quality improves.
Colour	> 150 HCU	Monitor NF – may need more frequent cleaning.
pH	< 5	Warning - Check Fe and Mn levels as these may also be elevated leading to NF fouling. Consider adjusting offtake depth.
E. coli	> 1000 cfu	Indicator of higher than normal microbial contamination. Confirm UF membrane integrity and monitor closely. Investigate possible causes.
Algae	Visual presence on dam surface	If visual signs of algae present, arrange for samples to the taken to confirm if it is blue-green algae. Initiate testing for algal toxin in the raw and treated water.
Iron	> 2 mg/L	Monitor NF – may need more frequent cleaning. Check treated water is < 0.3 mg/L. Consider adjusting offtake depth.
Manganese	> 2 mg/L	Monitor NF – may need more frequent cleaning. Check treated water is < 0.02 mg/L. Consider adjusting offtake depth.
Phosphorus	> 0.005 mg/L	High levels of phosphorus could represent a risk of algae bloom. If above this level check for visual presence of algae and action as for “Algae”.

The NSW Water Directorate Operations and Maintenance Manual will be used to guide appropriate actions.

REQUIRED ACTIONS

A raw water tap is required upstream of the pump in order to establish raw water quality at the delivery point to the potable water treatment train.

Aquacell is contracted to deliver an operations manual for potable plant. This manual will contain

1. Procedures for corrective actions to control and correct non-complying performance within the treatment train.
2. A rapid communication system to deal with unexpected results.

9.8 Equipment Capability And Maintenance

Aquacell is contracted to deliver an operations manual for the potable water treatment train. The suction line, the pontoon and the pump management and their maintenance regimes will be included within the overall potable water treatment train.

During the risk assessment, the adequacy of existing equipment was considered in the context of its ability to manage water quality risks. Examples of items specifically considered as part of the assessment include:

- Reliability of equipment in the event of power failures (e.g. having sufficient diesel generator capacity available on-site)
- The ability of the system to respond to water quality changes due to, e.g., bushfire, floods or cyanobacteria (e.g adjusting depth of suction inlet, adjusting pump time)
- Reliability of equipment to prevent bypass of the treatment plant.
- Reliability of telemetry and on line monitoring systems (e.g. having the suction pump connected to the telemetry system)
- Overall capability of preventive measures, working in combination, to mitigate significant maximum risks

REQUIRED ACTIONS

- Ensure the raw water collection and transfer system is included in the operations manual for the potable water treatment train.
- Ensure adequate power generator capacity on standby for power failure.
- Ensure the raw water pump is included in the telemetry system. This is to include a loss of pressure/section alarm.

10. ELEMENT 5. VERIFICATION OF DRINKING WATER QUALITY

10.1 DRINKING WATER QUALITY MONITORING

Aquacell is providing the treatment train verification protocols. However there is a need to ensure that the raw water is 'fit-for–purpose' as the influent to the treatment train.

The drinking water quality will be monitored both via continuous, inline systems at critical points in the treatment train as well as at the final product output. The monitoring schedule and the anolytes tested will be as required by the PHU, consistent with the volume being treated and the population being served.

Verification monitoring will be undertaken by the accredited laboratories of the NSW Division of Analytical Laboratories through the NSW Health Drinking Water Monitoring Program with results being recorded on the NSW Drinking Water Database[8]. The program is specified by NSW Health. The samples are to be collected by adequately trained NEV staff, with the sampling program being designed to cover the full range of water qualities present in NEV's water supply system. Samples are submitted in accordance with the "Guide for Submitting Water Samples to DAL for Analysis".

The results of the program are maintained by NSW Health and NEV can access this program via the recently updated database. The program is described in more detail in NSW Health at
http://www.health.nsw.gov.au/publichealth/environment/water/drinkwater_nsw.asp.
Aquacell will specify the monitoring points in its monitoring schedule. The schedule will include the points listed in table 10.1.

Table 10.1. Water quality sampling points (to be adjusted to reflect the PHU and Aquacell's inputs and requirements).

Component	Rationale	Response to non-conformance
Raw water quality	Ensure raw water is 'fit for purpose' Provide early warning of potential stressors occurring within the treatment train (e.g elevated turbidity, high algal population)	• Adjust the treatment train settings to 'cope' with changes in raw water quality. • Adjust suction inlet depth. • Adjust pump time of day.
In-line monitoring of turbidity, chlorine and other dosing rates and their impacts. (As per Aquacell manual) The system's electrical performance	Ensure system is operating competently. The inline monitoring is important as it provides opportunity for real time correction of water quality issues.	• Visual inspection • Adjustment of dose rates, black-wash, etc as per operations manual.
Treated water quality on	Ensure adequacy of treatment.	• Visual inspection

[8] *Some of the guidance in the following sections is adapted from the example 'Risk-based Drinking Water Management System for Central River and Little Bore water supply systems'*. This use is acknowledged.

Component	Rationale	Response to non-conformance
discharge to header tanks	Sampling as per PHU requirements	• Adjustment of dose rates, black-wash, etc as per operations manual.
Treated water at consumers' taps	Ensure adequacy of residual disinfection.	Adjustment of chlorination dose rates as per operations manual.

10.2 CUSTOMER SATISFACTION

Consumer satisfaction is generally verified by an absence of complaints. Consumer satisfaction nonconformities include consumer enquiries relating to taste, odour, colour, air, particles, pressure, flow and suspected illness. Consumer complaints relating directly to water quality (taste, odour, dirty water, air in water), suspected water safety concerns and potential indirect water quality issues (low pressure) are received by the NEV management committee and recorded. If the NEV management committee are able to resolve consumer enquiries, no further action may be required. Consumer complaint calls may be directed to operational staff.

Anticipated issues can include water pressure, taste of chlorine, and water colour.

REQUIRED ACTIONS

NEV through Aquacell is to establish a consumer complaint and response program including appropriate training of employees.

10.3 SHORT TERM EVALUATION OF RESULTS

The inline, real time results are recorded and sent via telemetry. Any non-conformity sets off alarms and requires immediate corrective action.

Water quality test results from the Health NSW's Division of Analytical Laboratories are reported to NEV's Manager the day that the results become available within the laboratory. The target for assessing the acceptability of the raw water quality results is the ability of the potable water treatment train to produce water to the relevant ADWG guideline value. The Manager compares the results received with the guideline values and records and actions any exceedances.

REQUIRED ACTIONS

- Establish raw water quality guidelines based on the demonstrable ability of the proposed treatment train processes to produce potable water from the available raw water supply.
- Establish a raw water quality monitoring and alert protocol. (Base on Aquacell's raw water quality requirements).
- Establish procedures for daily review of drinking water quality monitoring data and consumer satisfaction.
- It is recommended that the recording and reporting system be incorporated into to a iPad system based on Excel®, Access® or similar data base.

- Any raw water quality or flow data is to be captured within the treatment train monitoring protocols.
- Develop internal and external reporting mechanisms as required by consenting authorities.

10.4 CORRECTIVE ACTIONS

Drinking water quality monitoring exceedances
Raw water quality monitoring nonconformities trigger a notification by the laboratory to the NEV Manager.

The first response will be to check the management manual to guide the actions.

Depending on the nature of the exceedance, the response may include re-testing, via the "Form for urgent sample submission to DAL"), investigation and, in some cases, notification to NSW Health which may result in boil water or water avoidance notices to consumers.

Algal bloom management shall be in accordance with the Water Directorate's 2014. In Nov 2014, the Hunter Regional Algal Co-ordination Committee Technical Co-ordinator was Alison Lewis Phone: 49042517. Mobile 0417140410.

In relation to health-related parameters, NEV will respond in line with the requirements of NSW Health with respect to the protocols listed under Section 11, below.

11. ELEMENT 6. MANAGEMENT OF INCIDENTS AND EMERGENCIES

11.1 COMMUNICATION

NEV will follow the guidance of NSW Health in response to specific water quality issues. Section 10.4 shows the initial responses to water quality exceedances. The corrective actions will follow pre-defined protocols, as shown under Section 11.2 below.

If the Corrective Actions fail to contain the situation and broader notification is required, NEV will continue to follow the guidance of NSW Health with respect to its recommended response protocols (see section 11.2 below). Key contacts for NEV, Aquacell and the PHU are kept within the NEV's general Disaster Plan.

In general, any water quality incident would be handled initially by the NEV Manager and Aquacell, and the PHU would be brought in to provide guidance as required.

REQUIRED ACTIONS

- Define communication protocols with the involvement of relevant agencies and prepare a contact list of key people, agencies and businesses.
- Develop a public and media communication strategy.

11.2 INCIDENT AND EMERGENCY RESPONSE PROTOCOLS

As of December 2014, NEV has no specific water quality incident response plan other than the response protocols noted below, that have been prepared as guidance by other parties, NEV does not have its own specific incident response protocols for foreseeable water quality incidents.

However it undertakes to develop emergency protocols for algae, flood surges adding turbidity, bushfire, spills, dam wall overtopping, etc, as well as liaison with GCC, SES, RFS and the PHU.

A Draft Water Quality Improvement Action Plan has been developed for NEV by Aquacell to develop contingency plans for incidents and emergencies related to drinking water quality (Aquacell/ CWT, 2014). In the interim, the following protocols are accessible to NEV to guide the response of NEV and the Public Health Unit in the event of water quality incidents:

- NSW Health Response Protocol: for the management of physical and chemical quality.
- NSW Health Response Protocol: for the management of microbiological quality of drinking water:
    - Action on the detection of E. coli or coliform bacteria.
    - Action in response to a failure in treatment or disinfection, or rapidly changing source water quality.
    - Corrective actions following the detection of contamination or treatment/disinfection failure.
    - Contamination investigation and sanitary survey - assessing the need for a boil water alert.
    - Factors to consider before issuing a boil water alert.

- NSW Health Response Protocol: following failure in water treatment or detection of Giardia or Cryptosporidium in drinking water.
- •NSW Health Drinking Water Monitoring Program (use the current version).
- NSW Health Response Protocols (except where superseded by the above, more recent, protocols):

Action on the exceedance of guideline values.

Risk assessment and considerations for public notification.

Public notification considerations.

Copies of these protocols are to be maintained in the NEV Ltd. offices as part of the monitoring and maintenance schedule.

It is emphasised that the Aquacell monitoring and response protocols are concerned with the potable water treatment train. The Reservoir Water Management Plan is concerned with the production of 'fit-for-purpose' feed water to this treatment train. Thus the raw water quality criteria is not the ADWG, but rather the specifications that ensure the dam is a suitable source of feed water.

One of most common responses to foreseeable drinking water quality problems is to issue a boil water notice or provide other notification. Notices would only be issued in liaison with the NSW Health Public Health Unit, and with consideration being given to the relevant guidance from NSW Health Water Unit, noted above. In practice, NEV would most likely have to physically issue a boil water notice to residents. NEV would make use of the NSW Health templates as starting points in preparing such notices:

- Example Boil water alert for Cryptosporidium and or Giardia contamination
- Example Boil Water Alert E. coli Contamination

In relation to cyanobacteria (blue---green algae), NEV has adopted the Blue---green Algae Management Protocols, NSW Water Directorate, 2014. Incidents will be managed with reference to this protocol and in liaison with the NSW Office of Water.

NEV has not undertaken formal training in relation to water quality incident response but intends to undertake exercises with NSW Health in future (see draft Improvement Plan).

REQUIRED ACTIONS

- Obtain copies of the protocols listed above. Have them readily accessible in NEV offices as part of the Monitoring and Maintenance schedule for the water treatment train.
- Liaise with the PHU to ensure NEV can participate in relevant training exercises.

12 ELEMENT 7. EMPLOYEE AWARENESS AND TRAINING

NEV has a policy of ensuring staff, NEV members and the NEV management committee are appropriately skilled and trained in water quality management to the level needed to have an assured fit-for-purpose raw water supply.

NEV is assessing the skills and competencies required to operate plant, and will ensure plant operator staff training and certification are in accord with all stakeholder expectations.

A key action proposed as part of the system commissioning is to provide drinking water quality awareness training to key staff, and to inform them of the DWMS and its management implications.

REQUIRED ACTIONS

Develop mechanisms and communication procedures to increase employees' awareness of and participation in drinking water quality management.

Facilitate staff taking part in the NSW Office of Water training programs

As part of increasing water awareness NEV will:

- Ensure that employees, including contractors, maintain the appropriate experience and qualification.
- Identify training needs and ensure resources are available to support training programs.
- Document training and maintain records of all employees' training.
- Ensure that all NEV members are fully aware of the need to maintain the dam water in a 'fit-for-purpose' condition.
- The 'fit-for-purpose condition is to be clearly identified in the water treatment train maintenance and monitoring manual.

13 ELEMENT 8. COMMUNITY INVOLVEMENT AND AWARENESS

The reliable supply of adequate quantities of 'fit-for-purpose' raw water is absolutely essential for the long term sustainability of the NEV. NEV member involvement in water management and their water quality awareness are therefore essential.

NEV will develop standards for liaison with co-operative members, site visitors and neighbours. Examples include

- the development of a recreation policy for the dam and
- the policy for use of herbicides near the dam water
- inviting neighbours to attend NEV functions.

ACTIONS REQUIRED

- Include a section on the water supply system and its sensitivity to various impacts in the NEV literature given to prospective and new members.
- Include comment on water matters in the regular NEV newsletter.
- Use current technology, e.g twitter, email, SMS, Facebook, etc, to keep NEV members up to date on any water quality issues.
- Encourage NEV members to actively participate in water supply management
- In consultation with NEV members, identify suitable alternatives for recreational activities that do not include use of the Narara Reservoir .

14 ELEMENT 9. RESEARCH AND DEVELOPMENT

14.1 INVESTIGATIVE STUDIES

NEV needs to be become involved with the NSW Water Directorate. Staff must remain up to date through their involvement in industry bodies including the Australian Water Association and their attendance at industry seminars and conferences. NEV will actively pursue a positive relationship with the NSW Central Coast PHU via inviting PHU to the site and keeping PHU staff informed of health related activities on site.

NEV collects and retains information on changes in raw water quality over time, creating a data bank /historical record on the reservoir conditions.

ACTIONS REQUIRED

NEV ensures it has sufficient information to understand the raw water supply system and the potential for water quality impacts.

14.2 VALIDATION OF PROCESSES

Validation involves gathering objective evidence that the treatment should be effective in providing safe, quality water. General validation of the raw water supply system is listed in Table 14.1.

Table 14.1. Validation of the catchment management and raw water quality measures

<table>
<tr><th>Item validated</th><th>Validation</th><th>Reference</th></tr>
<tr><td>Effectiveness of catchment management measures</td><td>No development occurs in the catchment that is likely to negatively impact on raw water quality or yield
The dam is remains structurally sound
Outflow to at least the 1 in 1,000 ARI flood is safely conveyed downstream via a combination of the current glory hole plus an enhanced, stabilised spillway.</td><td rowspan="3">Risk assessment spreadsheet showing the cross---check of identified significant risks against existing and proposed control measure combinations</td></tr>
<tr><td>Effectiveness of managing out of specification water, e.g. algal blooms and increased turbidity</td><td>Staff are aware of increased algal activity/ increased turbidity based on their previous experience.
Staff have heightened alertness to the potential need to adjust the raw water intake configuration and to increase back-flushing of the filtration system.</td></tr>
<tr><td>Effectiveness of raw water supply system</td><td>The raw water supply system reliably transfers sufficient quantities of ‘fit for purpose’ water to the inflow point of the potable water treatment train.</td></tr>
</table>

NEV maintains liaison with catchment stakeholders.

NEV encourages staff to operate proactively when water quality could become an issue.

15 ELEMENT 10. DOCUMENTATION AND REPORTING

15.1 DOCUMENTATION

Aquacell will provide detailed operations, maintenance and monitoring manuals for the water treatment train. These manual will include the raw water supply system. It is expected that there will be minor changes in protocols as staff gain experience In such circumstances, NEV relies on staff experience, understanding and judgment as to how objectives are achieved rather than on adherence to documented procedures. However it is essential that any significant changes be documented.

The complexity, variability, remote and outdoor nature of many tasks makes the use of fully documented procedures impractical in many circumstances. Operator induction, initial and refresher training, mentoring and supervision and the maintenance of experienced staff are used to retain control of processes.

A key component of documentation is the use of modern technology such as iPads to capture data on site. The use of telemetry is also critical in enabling rapid response to out-of-specification conditions.

It is also important to record the results of interactions with other stakeholders in the catchment. The results of meetings, inspections, advocacy, etc should be recorded in the NEV logbook.

The documentation and reporting standards are to be consistent with current Water Quality Management Guidelines for isolated villages and small towns. Aquacell will document the reporting standards required.

ACTIONS REQUIRED

- NEV to facilitate rapid response to risky issues through use of iPad data capture and telemetry
- NEV to document any significant changes in the operations, maintenance and monitoring manuals AND check with Aquacell regarding the advisability of these changes.
- NEV to maintain a permanent record of liaison actions with stakeholders in the catchment.

15.2 REPORTING

INTERNAL REPORTING

Internal reporting in undertaken through a number of reports e.g. the NEV news. The reporting can also be distributed by SMS, Twitter, closed circuit TV, etc.

NEV monthly, quarterly and annual reports should include comment and performance information on the water supply system

EXTERNAL REPORTING

NEV reports externally as required. The report receivers may include:

- NSW Health --- compliance reports relating to drinking water quality monitoring results.

- NSW Office of Water --- Report relating to drinking water quality monitoring results and consumer complaints.
- Regional State of the Environment Report relating to catchment management.
- NEV will assist Aquacell in meeting its license requirements.

The extent of reporting required needs to be verified once the raw water supply becomes operational.

ACTIONS REQUIRED

- NEV to establish and maintain a strong, fact based information service for residents. It is important that the system be designed to highlight critical information rather than just be a Facebook-like ‘mass’.
- NEV to establish what its external reporting obligations are.

16 ELEMENT 11. EVALUATION AND AUDIT

16.1 EVALUATION

NEV will need to undertake reviews of the monitoring results to assess the performance of the system against numerical guideline values as part of Office of Water and NSW Health reporting requirements.

This includes:

- NEV Annual Report
- NSW Health -compliance reports relating to drinking water quality monitoring results.

There may also be a need to report to the NSW Office of Water on satisfactory performance of the raw water supply system

ACTIONS REQUIRED

- Collect and evaluate long term data to assess performance and identify problems.
- Document and report results.

16.1 AUDIT

The drinking water management system will be internally and externally audited once the requirements of NSW Health for auditing of these DWMS documents have been clarified. The Audit will be specified by Aquacell, based on the license conditions.

In the meantime, it is noted that NSW Health can audit the document at any time so that NEV needs to maintain this DWMS in an audit---ready state.

ACTIONS REQUIRED

- Establish processes for internal and external audits
- Document and communicate audit results as specified under Aquacell's license conditions.

17 ELEMENT 12. REVIEW AND CONTINUAL IMPROVEMENT

17.1 REVIEW BY SENIOR NEV COMMITTEE

A senior member of NEV undertakes a review of the effectiveness of the management system and the underlying policies as part of the development of the Annual Report and the Strategic Business Plan.

The periodic operational reviews and compliance audits of treatment train performance will identify: number of non- scheduled call outs, number of water quality criteria exceedances, responses to these exceedances, water quality data, catchment conditions, dam water levels and downstream impacts of dam operations.

ACTIONS REQUIRED

•Senior NEV executive to review of the effectiveness of the raw water management system.

•Senior NEV executive to evaluate the need for change.

17.2 DRINKING WATER QUALITY MANAGEMENT IMPROVEMENT PLAN

A detailed list of Improvement Actions for the water treatment system has been identified following the risk assessment workshop (Aquacell/ CWT, 2014)).

The allocation of actions and associated timeframes given in this version of the document are indicative, and have yet to be agreed with the responsible parties. Where relevant, directly related risks have been identified using their reference numbers as given in the Risk Assessment Summary document, provided separately.

ACTIONS REQUIRED

NEV to ensure that the plan is communicated and implemented and that improvements are monitored for effectiveness.

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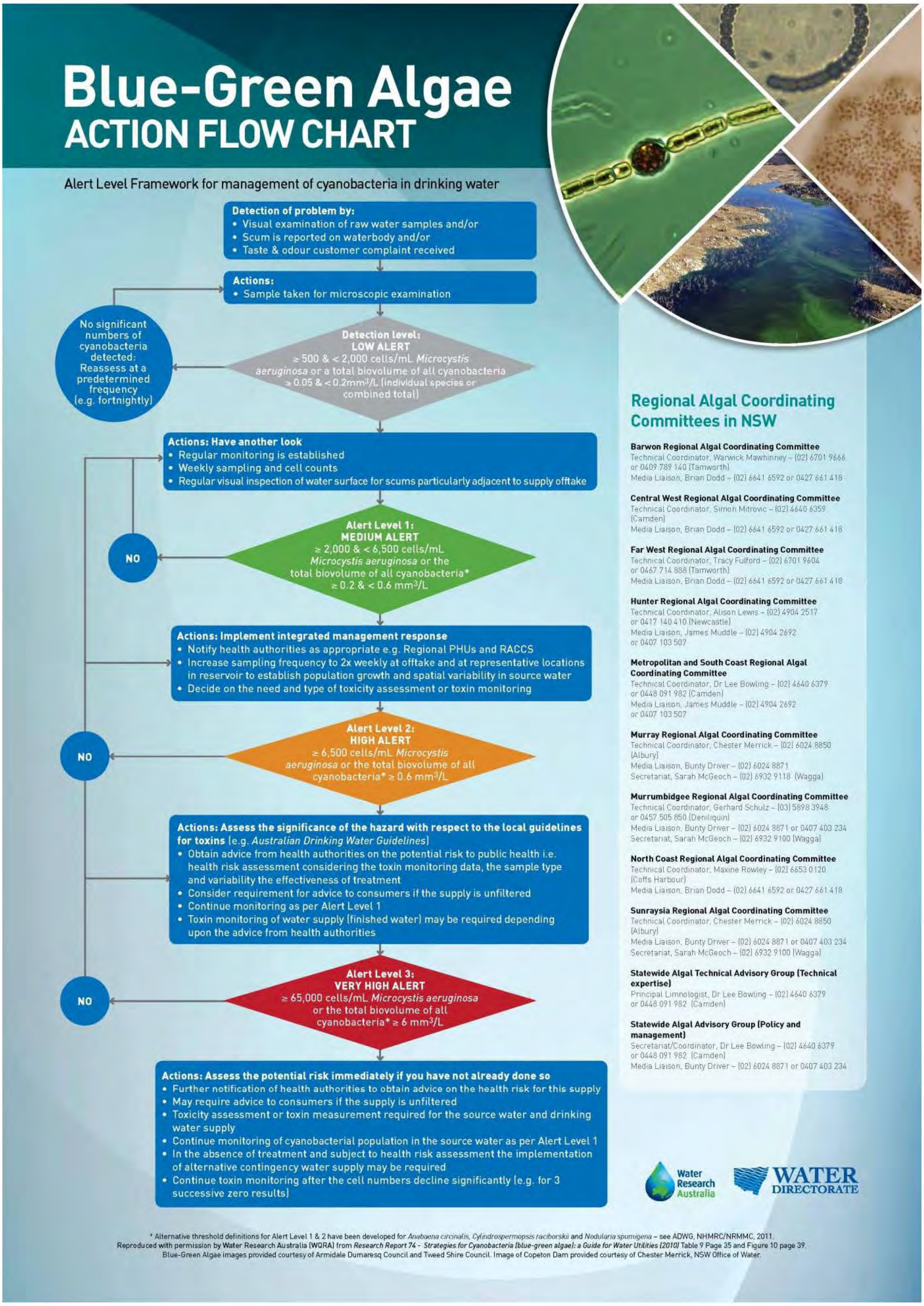
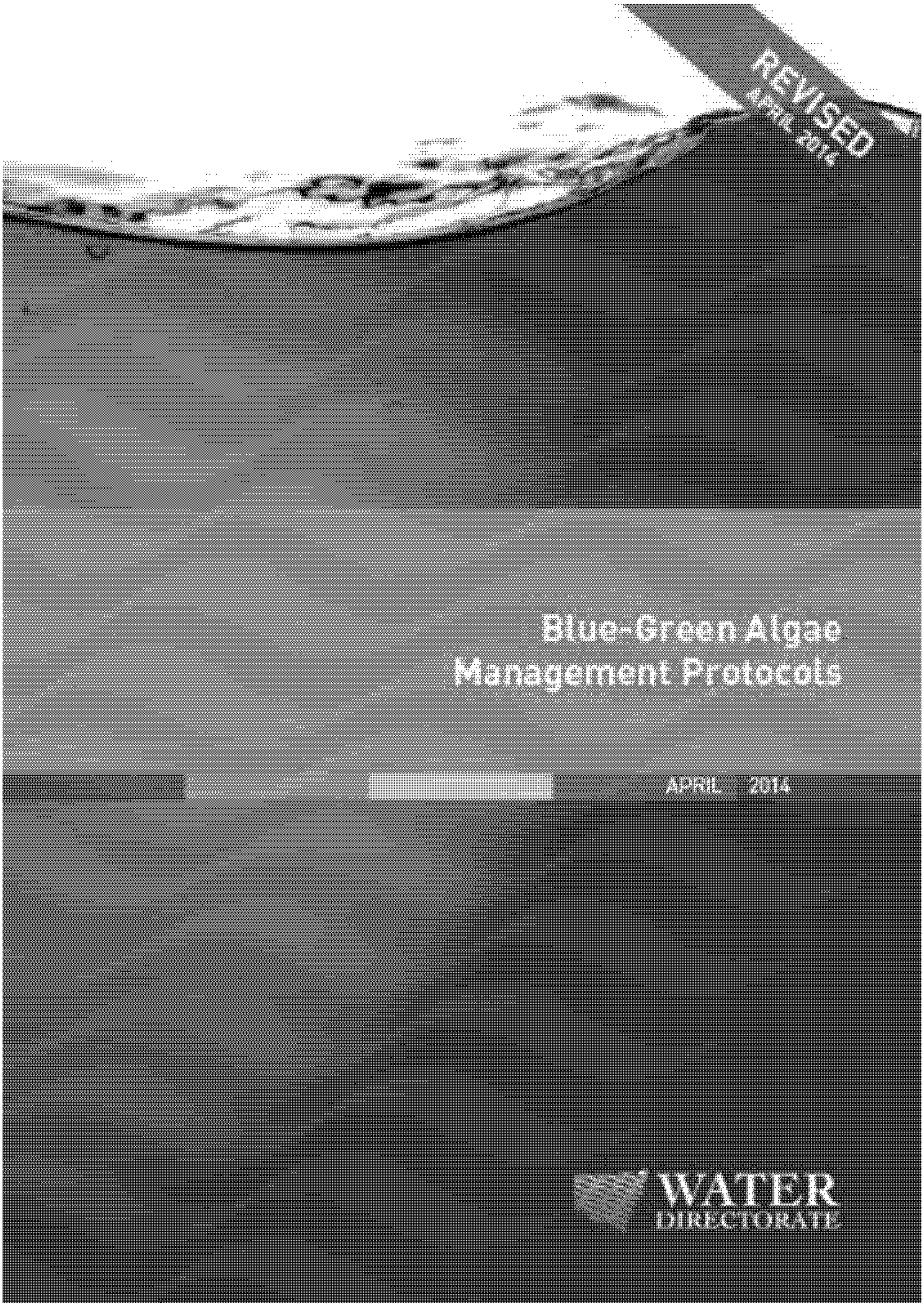
Appendix 1. Access points and permitted activities in Strickland State Forest. These are in Stoney Creek Catchment approximately 2 km north of the Narara Reservoir Catchment.

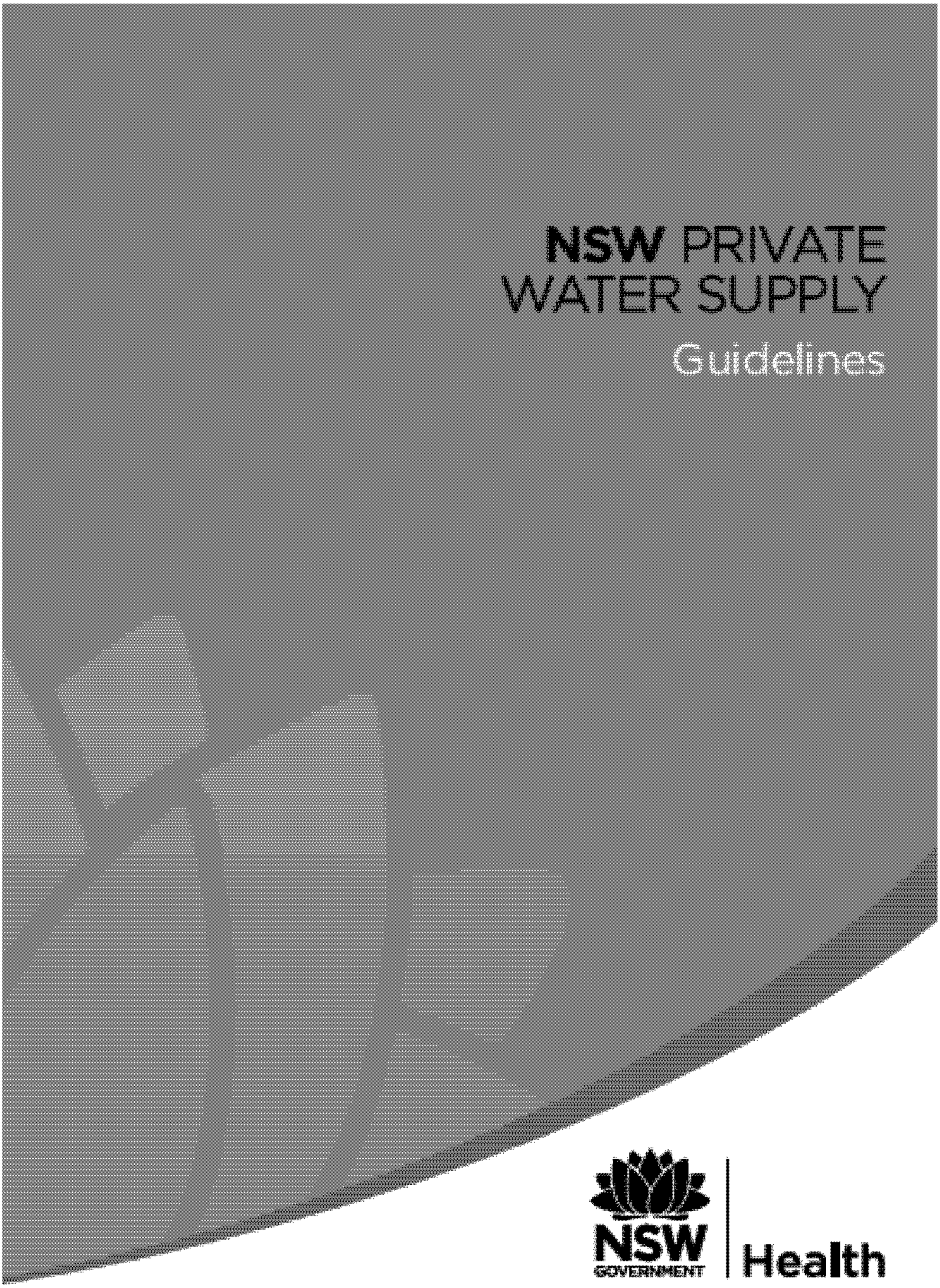
Appendix 2. Blue-Green algae Action Flow Chart (Source: Water Research Australia).



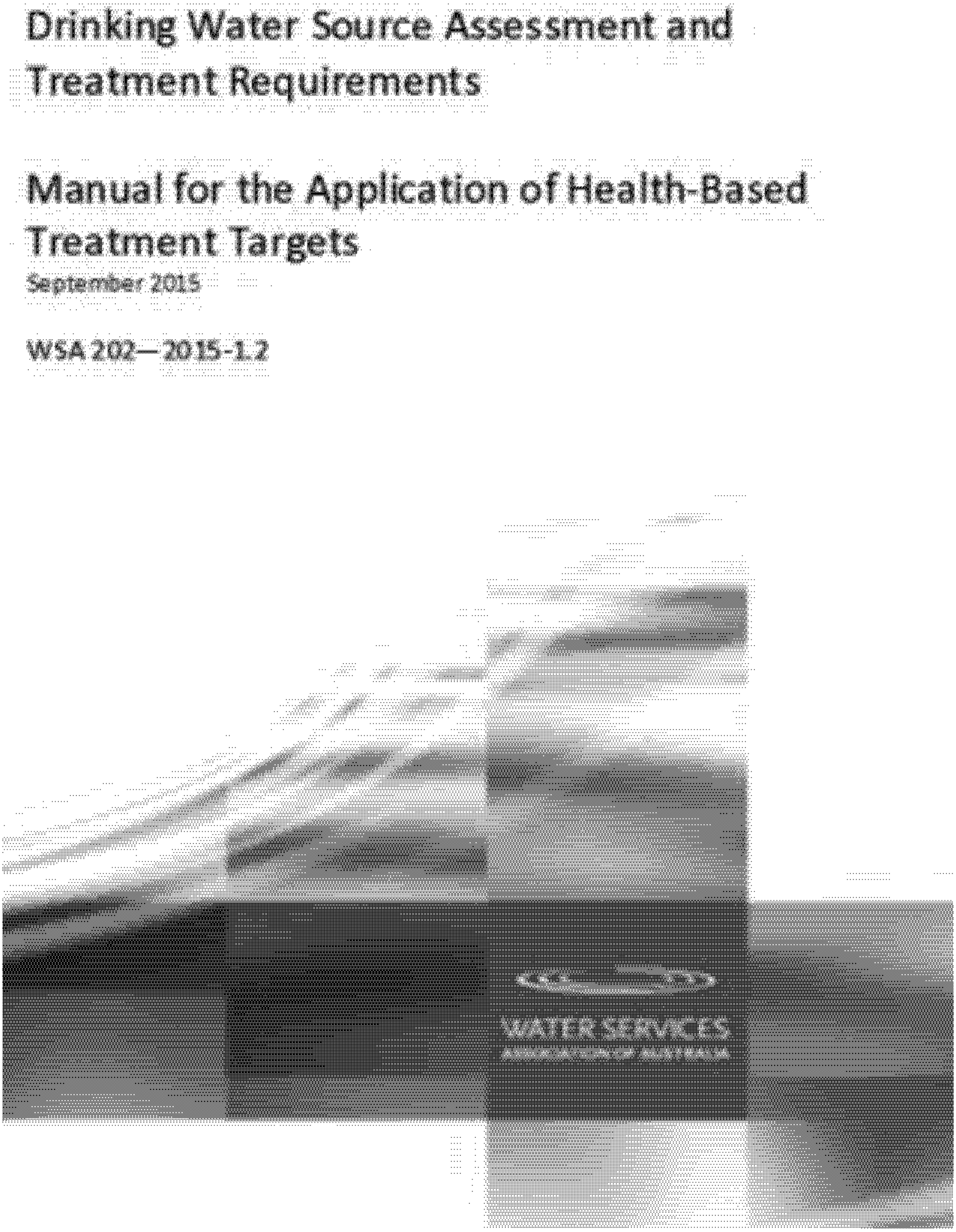
Appendix 3. Cover of the Blue Green algae Management Protocols (NSW Water Directorate, 2014).



Appendix 4. Cover of NSW Health (2015) NSW Guidance Private Water Supply Guidance



Appendix 5. Cover of Water Services Association of Australia (2015). Drinking Water Source Assessment and Treatment Requirements. Manual for the Application of Health – Based Treatment Targets. WSA202-2015-1.2.



Drinking Water Source Assessment and Treatment Requirements

Manual for the Application of Health-Based Treatment Targets

September 2015

WSA 202—2015-1.2

Sara Roach
Planning Services & Michael Woodland
Consulting Pty Ltd

DEVELOPMENT APPLICATION
Statement of Environmental Effects

Narara Ecovillage: 25 Research Road, Narara:

Development Application: Stage 1- Subdivision, infrastructure and associated works.

Submitted to Gosford City Council
On behalf of *Narara Ecovillage Co-operative Ltd*
December 2013

Sara Roach Planning Services
Sara_roach@bigpond.com
.

Michael Woodland Consulting Pty Ltd
michael@michaelwoodlandconsulting.com.au

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1.0 Introduction and Background

1.1 Introduction

This Statement of Environmental Effects (SEE) is submitted to Gosford City Council (Council) as part of a Development Application (the application) which seeks approval under Part 4 of the *Environmental Planning and Assessment Act 1979* (the Act) for Stage 1 works associated with the establishment of an ecovillage at 25 Research Road, Narara. The application proposes a 40 lot community title subdivision and ancillary works required to support the future development of the Narara Ecovillage site (NEV site).

The NEV site comprises approximately 62.97 hectares of land which was acquired by Narara Ecovillage Co-operative Ltd (the Co-operative) from the Department of Primary Industries in September 2012 (settlement in May 2013). Prior to the sale of the land, the site was zoned 5(a) Special Uses (Experimental Station) pursuant to Gosford Interim Development Order No. 122 and it was occupied and operated as the Gosford Horticultural Research and Advisory Station (Horticultural Institute).

On 1 February 2008, Gosford Local Environment Plan No. 464 was gazetted, amending the Gosford Planning Scheme Ordinance (GPSO) and rezoned the NEV site to facilitate the future development and use of the land primarily for residential purposes. Approximately 11.5 hectares of the land is now zoned 2(a) Residential and is able to support as range of housing types including conventional dwellings and cluster housing, subject to approval. Importantly, the significant rural, ecological and heritage features on the site are preserved in GPSO by zoning a portion of the site 7(a) Conservation, 7(c2) Rural Small Holdings and 6(a) Open Space.

The SEE has been prepared in accordance with the requirements of Part 4 of the Act and Part 6 of the Environmental Planning and Assessment Regulations 2000 (the Regulations). The application is integrated development pursuant to section 91 of the Act. In order for the development to be carried out, Terms of Approval will be required to be issued by the NSW Office of Water and the RFS under the *Water Act 2000* and the *Rural Fire Services Act 1997*. The application is not designated development pursuant to Clause 4 of the Regulations.

The Co-operative proposes to lodge a concurrent application with the Independent Pricing and Regulatory Authority Tribunal (IPART) for a retail operator's licence and network operator's licence under the Water Industry Competition Act 2006 (WICA) for the integrated water management system (water and sewer) which forms part of this application.

The Co-operative has also lodged 3 other applications for the use of the site and 2 cluster housing developments on lots 15 and 36. These applications are currently being assessed by Council.

The application is supported by a range of technical reports which demonstrate that the proposal will result in minimal environmental impact. Therefore, favourable consideration of the application is requested.

1.2 Overview of the Project

The Concept Plan and Project Objective

The key overall objective for the NEV site is to recast the Horticultural Institute into an ecovillage with a key emphasis on environmental, social and economic sustainability. The Concept for the ecovillage is to establish a community of people living in a sustainable way, focusing on the principles of environmental sensitive property design and living practices, active community relationships and events, and developing sustainable economic activities.

Specifically, the vision for the site is as follows:

> *"to create, live in and continue to learn and improve in, a model ecovillage with a joyful, unified, effective and sustainable community intelligent and sustainable uses of the earths resources throughout the life of the ecovillage."*

In line with this vision, the Stage 1 application seeks to establish the foundations for the future development of the site. The design focuses on retaining as mainly of the existing site features including the road network and the landform and minimising site intervention in recognition of the important ecological and heritage values of the site.

A non-statutory Concept Plan has also been prepared for the NEV site and is submitted with this Stage 1 DA. The Concept Plan prepared by Hill Thalis Architecture + Urban Projects (Hill Thalis) illustrates the proposed redevelopment of the site in 3 Stages (refer to Plan 2.21 in Design Report at **Appendix B**), the integration of services including water and sewer management system, road and pedestrian circulation, the network of community association land and open space through the site.

The Concept Plan proposes the community title subdivision of the site for residential purposes with supporting land uses including community uses and neighbourhood shops. Fundamental to the Concept Plan is the integration of the ecovillage with the existing heritage and ecological values of the site.

The Concept Plan is included in the Design Report prepared by Hill Thalis included at **Appendix B**. The Design Report contains detailed strategies for the arrangement of the subdivision, the street pattern and the provision of site facilities and the design principles for elements including dwelling siting and design, landscaping and water management which underpin the Stage 1 development of the NEV site.

The Concept Plan for the redevelopment of the NEV site envisages the progressive staged development of the site as an ecovillage.

The illustrative Concept Plan is provided in **Figure 1** below.

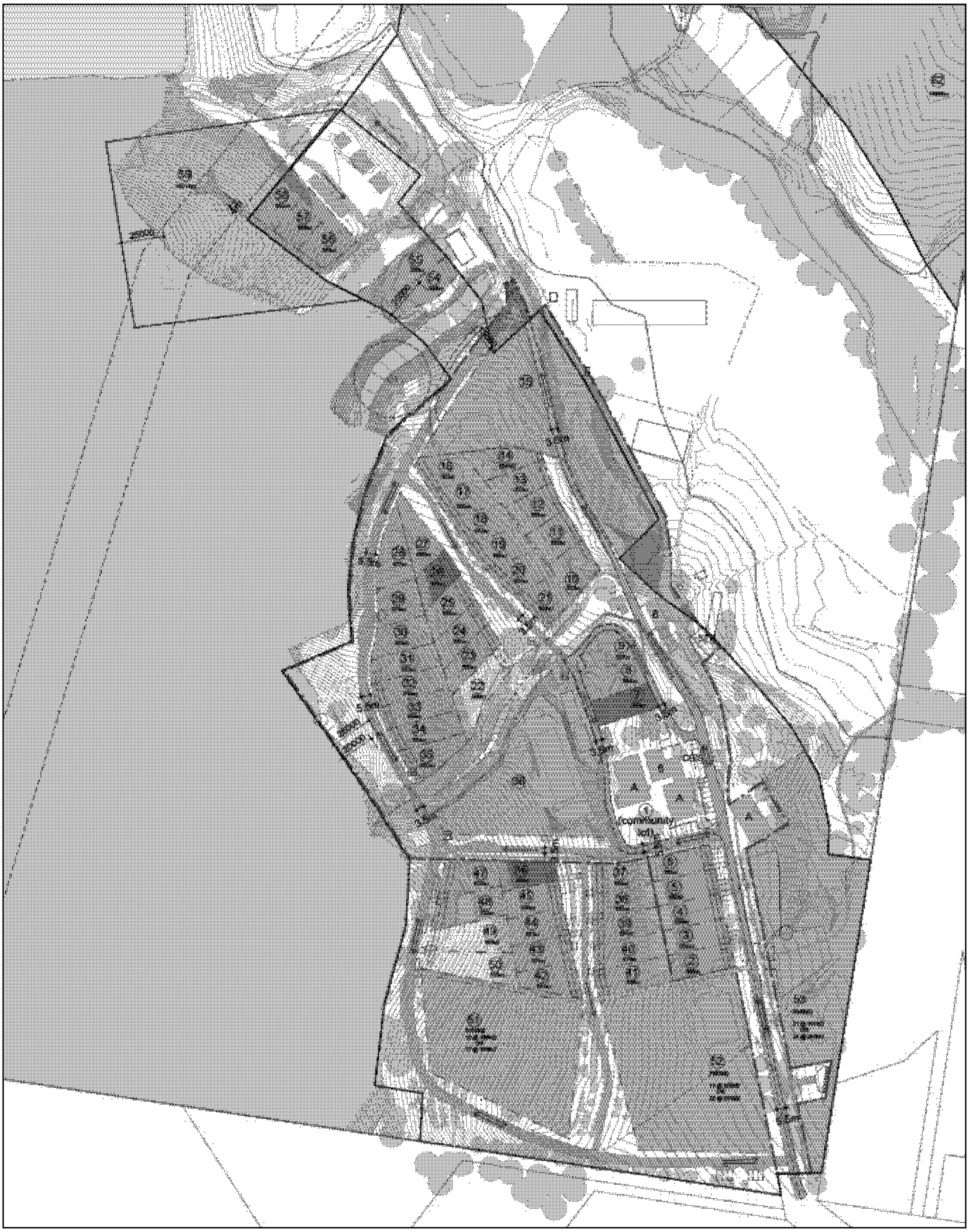

Figure 1: Illustrative Concept Plan for NEV Site (Source: Hill Thalis)

The Development Proposal

The Stage 1 DA for the redevelopment of the NEV site seeks approval to subdivide the site under the provisions of the *Community Land Development Act 1989* to create a Community Title Scheme. The Conceptual Draft Community Subdivision Plan proposes a 40 lot subdivision. To support the subdivision of the site and to meet the servicing requirements for Stage 1, the following ancillary works are also proposed:

- remediation of the site;
- the demolition of 15 redundant site structures and removal of 45 trees;
- the construction of the road network including new internal circulation roads and two (2) bridges over the middle western gully;
- provision of essential utility services and infrastructure to service the site including the construction of an integrated water management system (water recycling facility and sewer reticulation system);
- the implementation of the first stage in a comprehensives landscape strategy for the site;
- works to make the site bushfire safe including the establishment of asset protection zones; and
- the first stage in the ecological restoration of the site.

The application is predominantly limited to the land on the site which is current zoned 2(a) residential under the GSPO. However, due to the irrational alignment of the eastern boundary of the 2(a) land with the contiguous 6(a) open space land, some civil works are proposed on the 6(a) zoned land, to ensure that road access is suitably upgraded to service the NEV site. The concept for the Stage 1 development of the NEV site is illustrated in **Figure 2**.

Other applications

The Concept Plan proposes 3 stages in the development of the NEV site, which will be subject to separate development applications. The development of these stages will broadly accord with the concept proposal and design principles prepared for the NEV site by Hill Thalis.

The Co-operative has lodged several recent development applications with Council for the development of the site. These are as follows:

- **Application No.0011.2013.0044899.001:** DA for demolition of existing structures and construction of 17 cluster housing units and associated works on proposed Lot 36;
- **Application No. 0011.2013.0044898.001:** DA for demolition of existing structures and construction of 10 cluster housing units on proposed Lot 18; and
- **Application No. 0011.2013.0044650.001:** DA to formalise the community use of the existing Visitors Centre and the Administration Block. The residential occupation of both the Managers Cottage and Foremans Cottage is also proposed and is necessary to establish a permanent presence on the site, and to facilitate the care, maintenance and security of the site head of obtaining any future approval for the redevelopment of the site.

The determination of the two cluster housing applications is contingent on the registration of the Plan of Subdivision proposed in this application with the Land and Property Information (LPI).

Figure 2: Stage 1 Concept Plan (Source: Hill Thalis)

1.3 Consultation

Gosford City Council

The Co-operative and the specialist consultant team have held a series of meetings with Gosford City Council throughout the design development of the Concept Plan for the NEV site. The most recent meeting was convened with senior staff of Council on 13 November 2013. The Minutes of the meeting provided by Council are included at **Appendix C**.

This application has been prepared in accordance with the direction discussed at the pre-lodgement meeting with Council. In accordance with Council's requirements, this application specifically includes details regarding the following:

- Compliance with the key provision of the Gosford Planning Scheme Ordinance, Interim Development Order No.122 and Draft Gosford Local Environmental Plan 2013- refer **Section 4.0** and **Appendix Z** of the SEE;
- Compliance with key State environmental planning policies- refer **Section 4.0** of the SEE;
- Compliance with relevant Council Development Control Plans including Development Control Plan No. 175: Gosford Horticultural Institute Rezoning and Development Control Plan No.112: Residential Subdivision- refer **Section 4.0** of the SEE and **Appendix Z**.
- The integrated development provisions and the designated development provisions of the Act- refer to **Section 4.0** of the SEE.
- The development staging- refer to Plan 2.21 in Design Report at **Appendix B**.
- The engineering requirements of Council including:
    - Traffic Impact Assessment- refer to Transport Impact Assessment has been prepared by Chris Hallam & Associates **Appendix W**.
    - Road Design- refer to Concept Road Grading Plans and the Concept Engineering & Public Utility Services Report prepared by Chase Burke Harvey at **Appendix N** and **Appendix P**, respectively.
    - Stormwater Management- refer to Concept Stormwater Plans have been prepared by Chase Burke Harvey and the Integrated Water Cycle Management Plan prepared by Woodlots & Wetlands at **Appendix Q** and **Appendix S**, respectively.
    - Water Cycle Management- Refer to the Integrated Water Cycle Management Plan prepared by Woodlots & Wetlands and the Water Systems Management Overview prepared by Aquacell at **Appendix S** and **Appendix T**, respectively.
    - Waste Services- refer to the Preliminary Waste Management Plan has been prepared in accordance with the requirements of DCP 106 at **Appendix V**.
- The environmental requirements of Council including the following:
    - Tree Schedule/Arboricultural Report- refer to Arboricultural Impact Assessment prepared by Michael Shaw at **Appendix I**.
    - Flora and Fauna Assessment- refer to the Flora and Fauna Gap Analysis Survey Report and an Ecological Restoration Plan prepared by Robert Payne at **Appendix J** and **Appendix K**, respectively.
    - Soil and Water Management- refer to the Concept Erosion and Sediment Control Plan prepared by Chase Burke Harvey at **Appendix R**.
    - Landscape Plan- refer to Landscape Plans prepared by McGregor Coxall at **Appendix B**.

- Aboriginal Cultural Heritage Assessment- The findings of the Aboriginal Archaeological & Cultural Heritage Assessment Report prepared by Danny O'Brien for the rezoning, remains valid and relevant to the current DA. A new Report has not been commissioned.
- Site Contamination Assessment- refer to the Phase 1 Contamination Assessment has prepared by Douglas Partners at **Appendix F**.

Further to the above, the application has addressed the requirements of the Voluntary Planning Agreement in relation to the dedication the land that is zoned 6(a) Open Space, together with land identified as containing the stand of *Araucaria cunninghamii* (Hoop Pines). VPA requires that the land be dedicated free of cost to Council on registration of a plan of subdivision of the land. This land is proposed as Lot 38 in the Draft Plan of Subdivision prepared by Chase Burke Harvey and provided at **Appendix E**.

As detailed by Council in the pre-lodgement meeting, part of the 7(a) land has been identified within the Coastal Open Space System (COSS) as being desirable for future voluntary acquisition in full or in part by Council's Minute 2008/457. The Co-operative notes the comments of Council and would welcome the opportunity to discuss a land contribution toward the COSS to offset the 6(a) land dedication. This matter is discussed in further detail in **Section 4.1.2** of this SEE.

NSW Rural Fire Service (RFS)

A number of meetings (including a site visit) have been convened with the RFS to discuss appropriate fire protection measures for the NEV site. Fundamental to the design resolution of the concept proposal has been the resolution of the following elements of the Stage 1 proposal:

- the perimeter access road network including the design road width, requirement for passing bays and off-pavement parking bays, and circulation within the NEV site;
- the application of appropriate APZ's and their management to meet the requirements of Planning for Bushfire Protection 2006; and
- the treatment of the middle western gully, which is now proposed to be managed to an Asset Protection Zone standard, therefore removing the Category 1 Bushfire Prone Vegetation classification.

It is understood that the current Concept Proposal and the scope of the Stage 1 works, including the implementation of necessary bushfire protection measures, are consistent with RFS requirements. Referral to the RFS is required under the integrated provisions of the Act.

NSW Office of Water (NOW)

The Stage 1 area of the NEV site is punctuated by two (2) gullies which run west to east/north-east. The Stage 1 DA proposes works to these gullies which are hereafter referred to as the middle western gully and northern gully which dissect the 2(a) zoned land on the site. The location of the gullies is shown in **Figure 3** below:

Consultation has been undertaken with NOW regarding works proposed to the gullies. NOW has indicated that the drainage depression to the south of proposed Lots 10, 21, 22 and 35 (the middle western gully) may constitute a river under the *Water Management Act 2000* and therefore, may be a first order watercourse. This would require a Core Riparian Zone ("CRZ") of 10 metres in width from the top of the bank on either side of the watercourse.

The consequence of this classification is significant for the Co-operative, as it prohibits the building of infrastructure within the CRZ and the Co-operative would be required to ensure that the CRZ remains, or becomes vegetated with fully structured vegetation.

An examination of relevant case law has been undertaken by Mattila Lawyers and supports the position that the middle western gully is in fact a drainage depression (refer **Appendix T1**). Mattila Lawyers conclude that NOW's classification of the drainage depression is inconsistent with the definition of a "River" under the *Water Management Act 2000* and the interpretation of the definition of "watercourse" taken by the Courts. The Co-operative and the consultant team, therefore maintain that the gully is a drainage depression and is not a river and therefore, that a CRZ should not be established. Based on this position, the current DA does not accommodate a CRZ and the gully is now proposed to be managed to an Asset Protection Zone standard.

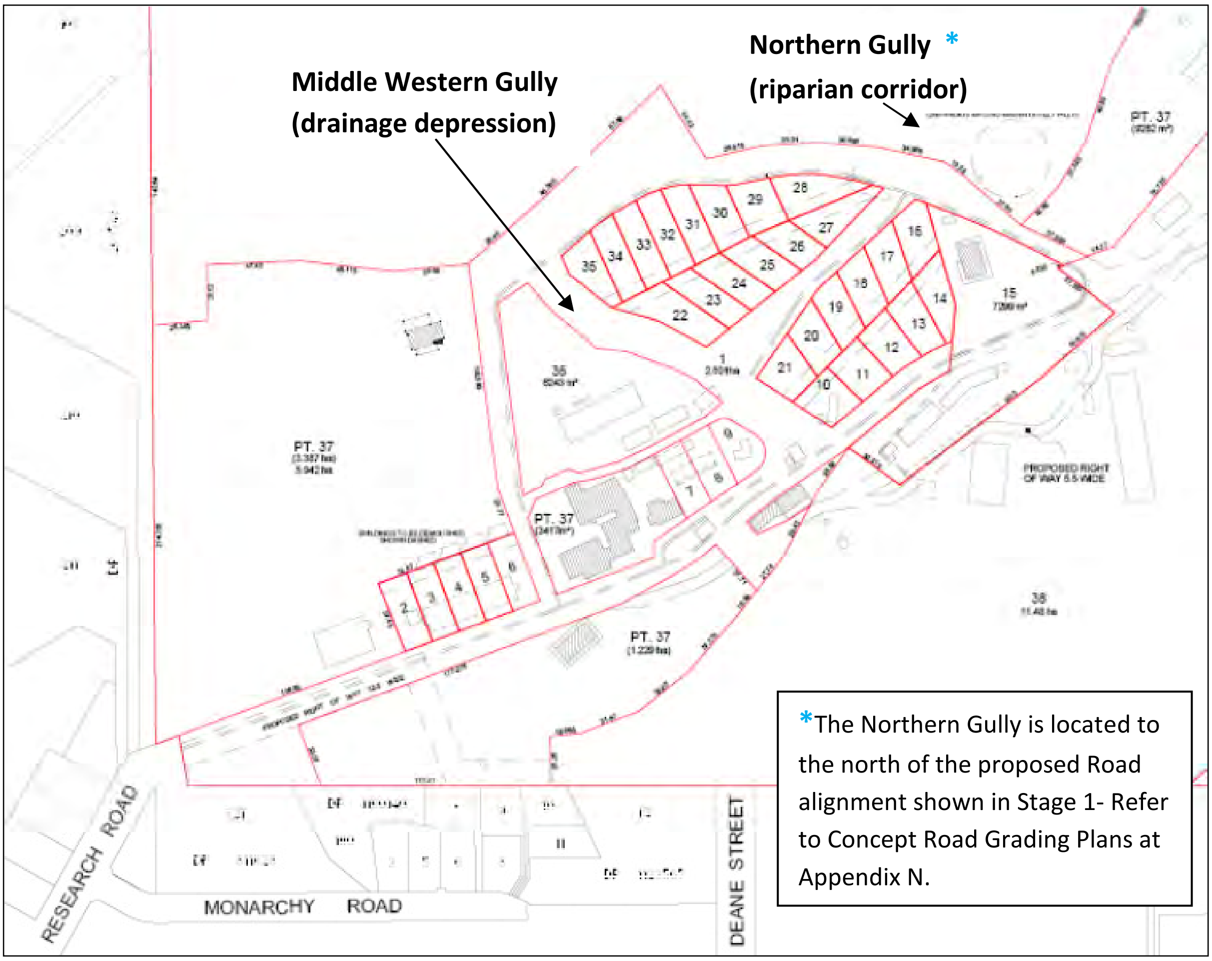

Figure 3: Location of gullies within Stage 1 area

This matter will be the subject of further discussion with NOW during the assessment phase of this Stage 1 DA. Notwithstanding this, works are proposed within 40 metres of the northern gully and referral to NOW under the integrated provisions of the Act is required. Refer to further discussion in **section 4.1** of this report.

Community Engagement

The Co-operative has undertaken ongoing consultation with the local community of Narara since their acquisition of the land. The communication strategy has typically includes regular letter box drops, information meetings and open-days on site. Details regarding the proposed redevelopment of the NEV site are also posted on the Narara Ecovillage website www.nararaecovillage.com.

On 14 December 2013, another community information session was held to inform the community of the impending lodgement of the Stage 1 DA. Approximately 500 letters were distributed by letterbox drop to local residents of Narara. The meeting had limited attendance. Notwithstanding this, all attendees were in support of the proposal. Only one resident raised a concern in relation to potential traffic impacts on the local road network as a result of the redevelopment of the site.

The Co-operative intend to keep the community well informed in relation to future stages in the development of the site and will continue with its communication policy and website.

1.4 The Applicant and the Project Team

1.4.1 The Applicant

Narara Ecovillage Co-operative Ltd (the Co-operative) is incorporated as a trading co-operative under the *Co-operative Act 1992* (NSW). The Co-operative is controlled by a Board of 5 directors. The role of the Co-operative is to raise members share capital and bank financing for the purchase and development of NEV.

Specifically, the Co-operatives role in the development of NEV, as a community title development, includes:

- the engagement of the property development core team;
- to facilitate negotiations and respond to necessary requirements of Gosford City Council as part of the development approvals process;
- the sale of lots to members as part of the staged development of the site; and
- the retention of part of the property for commercial use to contribute to the Community Association sinking fund.

Once development consent is secured for the community title subdivision of the site, the Board will establish the Narara Ecovillage Community Association (NECA). Subject to the registration of the NEV community title plan with the LPI, The NECA will be constituted under the *Community Land Development Act 1989* (NSW).

The responsibilities of the NECA will include the following:

- administration and enforcement of the by-laws of the community scheme;
- raising funds by levying its members in the scheme to carry out its duties; and
- managing the administrative find and sinking fund to cover the costs of maintaining the association property and any other relevant expenses.

The Co-operative will maintain an ongoing role in the development and management of the site.

1.4.2 The Project Team

This SEE has been prepared on behalf of the Co-operative, the proponent for the project. The specialist consultant team are detailed in **Table 1** below:

Table 1: Consultant team for the NEV site

CONSULTANT	*FIELD*
• **Hill Thalis**	Concept Planning and Architecture
• **Sara Roach Planning Services/ Michael Woodland Consulting Pty Ltd**	Urban Planning Consultants
• **McGregor Coxall**	Landscape Architecture
• **Chase Burke Harvey**	Civil Engineering
• **Chase Burke Harvey**	Surveying
• **Robert Payne**	Ecology
• **Michael Shaw**	Arboriculture
• **APBB**	Bushfire
• **Douglas Partners**	Geotechnical and Contamination
• **Woodlots & Wetlands**	Integrated Water Management System
• **Harris Page/ Aquacell**	Hydraulic Engineering (water & sewer)
• **Chase Burke Harvey**	Waste Management
• **Musecape**	Heritage
• **Lighting Art Science**	Lighting
• **City Plan Services**	Project Management

1.5 Report Structure

This SEE provides an assessment of the proposal against the relevant matters for consideration under Part 79C of the *Act*. The proceeding sections of the SEE are structured as follows:

Table 2: Report Structure

Section	**Title**
• **Section 2.0**	• The Site and its Context
• **Section 3.0**	• The Stage 1 Development Proposal
• **Section 4.0**	• The Statutory and Strategic Planning Framework and Assessment
• **Section 5.0**	• Environmental Assessment
• **Section 6.0**	• Conclusion

2.0 The Site and its context

2.1 The Site

The NEV site is located at 25 Research Road, Narara and is legally referred to as Lot 13 in DP 1126998. The NEV site has a total area of approximately 62.97 hectares of which the portion of the site zoned 2(a) Residential pursuant to Gosford Planning Scheme Ordinance (GPSO) is approximately 11.5 hectares (refer **Figure 4** below). The remainder of the site is zoned 7(c2) Scenic Protection Rural Small Holdings, 7(a) Conservation and 6(a) Open Space.

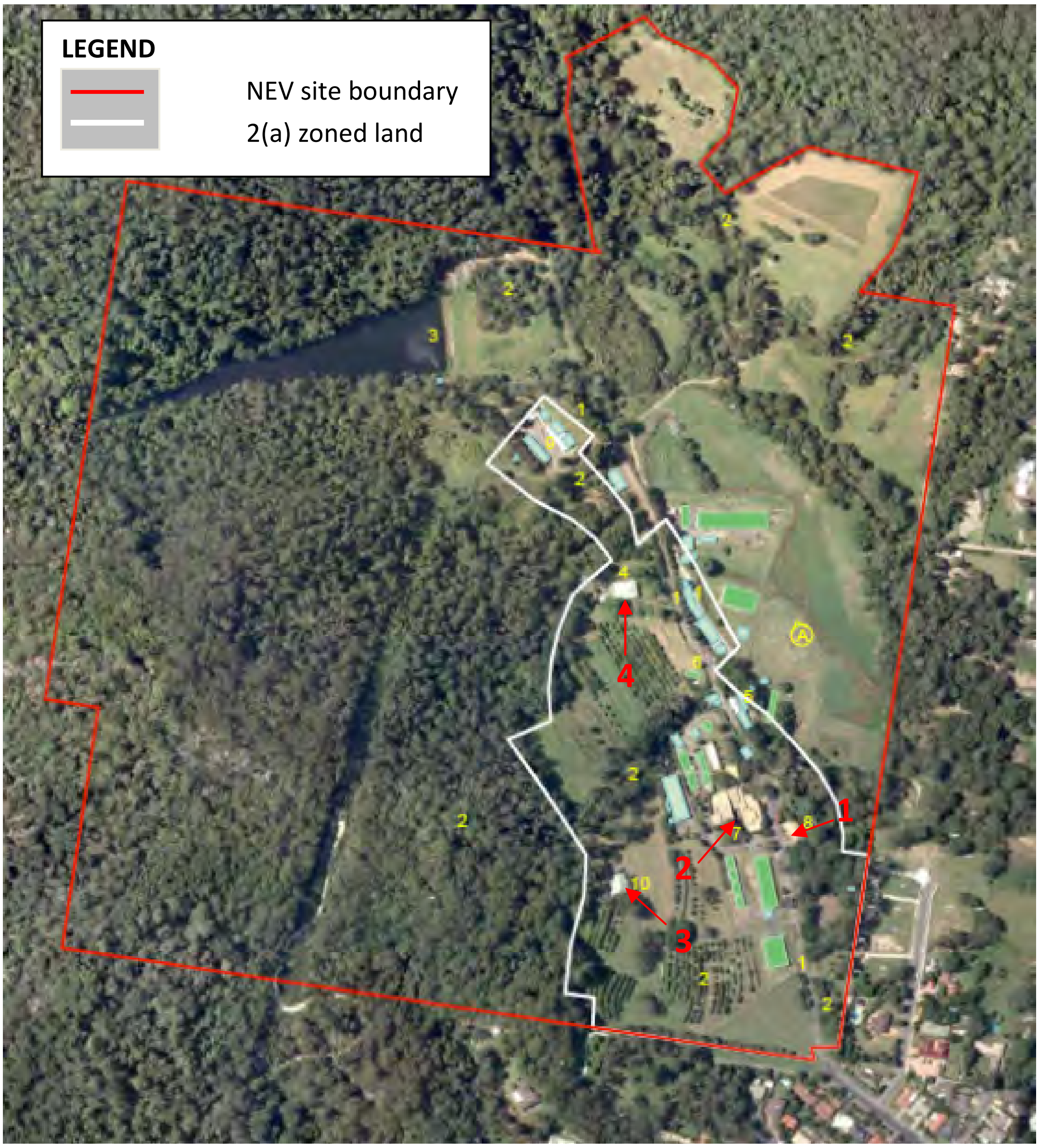

Figure 4: Site Aerial *(Source:* Hill Thalis*)*

The Narara Ecovillage site contains in excess of 56 buildings and structures which were used during the sites' former occupation as the Gosford Horticultural Research and Advisory Station. The Plan at **Appendix D** illustrates the location of a number of existing buildings on the site.

The existing structures include a number of glasshouses, sheds, workshops and offices associated with horticultural research and production. Two dwellings are located on the site, being the Foremans Cottage (identified as '3' in **Figure 4**) and the Managers Cottage (identified as '4' in **Figure 4**), the latter of which is identified as a heritage item in Schedule 8 of the GPSO. A number of large multi-purpose buildings including a Visitors Centre (identified as '1' in **Figure 4**) and Administration Block (identified as '2' in **Figure 4**) are located at the southern end of the site and are directly accessed from Research Road. A number of marked and informal parking spaces are currently available in close proximity to these administrative buildings and are also accessed from Research Road.

The location of the NEV site is illustrated in **Figure 5**. It is accessed off Fountain Road to the south east. The site includes a series of internal road (private roads) with the main spine road through the site named Research Road- refer **Figures 6** and **7** below.

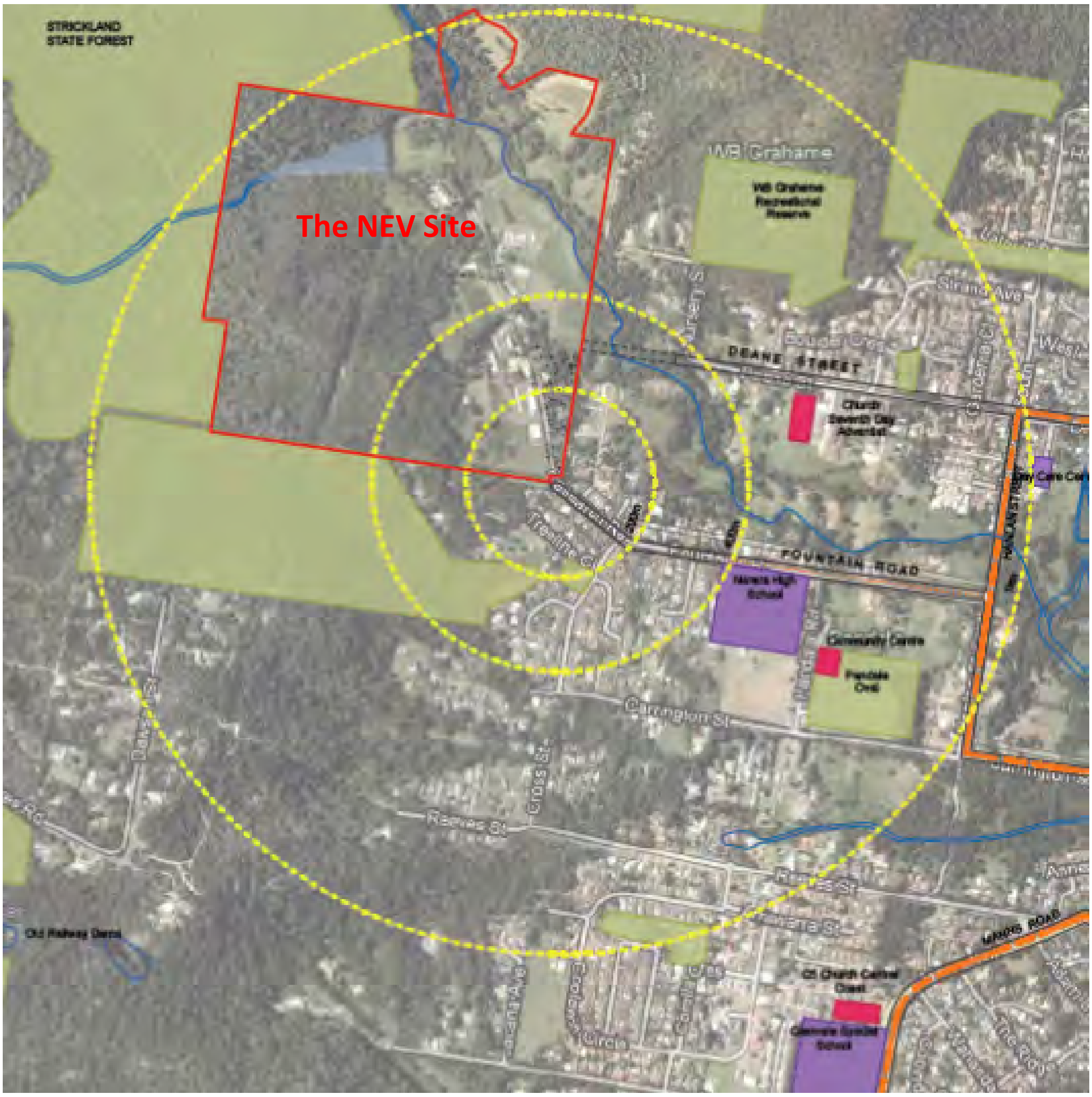

Figure 5: Location Plan- Narara Eco Village (Source: Hill Thalis)

Figure 6: Access to the site from Fountain Road. Dwellings on Fountain Road to the south-east of the site.

Figure 7: Research Road looking north from the entry off Fountain Road.

The NEV site contains varied topography. Narara Creek runs across part of the site, flowing from the State Forest to the 2(a) residential zoned land to the south. The areas surrounding Narara Creek are flood liable.

The land is steeper along the western parts of the site. There are a number of gullies running from the west to the east through the site towards Narara Creek. Generally, the western slopes of the valley fall to the northeast at approximately 10-15^{o}, with surface levels ranging from RL 55 AHD along the western end of Stage 1 to approximately RL 10m AHD along the eastern side of the site.

The section of the site which is the subject of this application mainly consists of citrus orchards and managed vegetation including the gardens surrounding the buildings and mown grass within the open areas of the site. The vegetation on the remainder of the site includes Dry Sclerophyll Low Open Forest on the ridgelines to the northwest, Closed Forest growing on the alluvial flats of Narara Creek to the northeast, and Closed Remnant Freshwater Grassland with sedgeland/rushland along the alluvial flats of Narara Creek.

A 30 metre wide electricity easement crosses the site in a south westerly to a north easterly direction, as illustrated in the site survey at **Appendix A**.

An existing dam is located in the north-western corner of the site and was previously used for onsite irrigation for the Gosford Horticultural Research and Advisory Station. The dam has a capacity of approximately 43.3 mega litres.

Figures 8 to **13** illustrate the general site features.

Figure 8: Existing orchards in south-eastern corner of the site

Figure 9: View over 6(a) zoned land (flood liable) looking north-east.

Figure 10: View of Fisheries Building looking south along Research Road.

Figure 11: View looking north west towards Managers Cottage from Research Road

Figure 12: View looking west towards the Foreman's Cottage. Strickland State Forest is in the background.

Figure 13: The dam- view from eastern edge looking north-west. Strickland State Forest is in the background.

2.2 Local Context

The NEV site is bounded by rural residential development to the south and the east, residential lots to the east and the south- east, and dense bushland to the west, north, north-east and south-west (**Figure 5**). The surrounding residential development predominantly comprises standard residential lots with a mix of single and two storey dwellings.

Strickland State Forest adjoins the site to the north and the west and it covers an area of approximately 468 hectares. Strickland State Forest includes areas of dense open forest and closed forest (rainforest) vegetation and exposed low open woodland vegetation. There is no formal public access from the NEV site to Strickland State Forest.

Narara train station is located approximately 1.3 kilometres to the east of the site. A small local shopping centre is located at the eastern end of Dean Street. The Narara Valley High School is located on Fountain Road amongst predominantly residential development. The Narara Valley Community Centre is located on the corner of Pandala Road and Carrington Street (**Figure 5**).

Niagara Park Shopping Centre, High School and recreation facilities are located to the north east of the site.

Employment areas of West Gosford, Niagara Park and Wyoming are all located within close proximity to the site. Gosford Town Centre is located approximately 4 km to the south of the site.

Figure 14 below illustrates the proximity of the subject buildings to neighbouring land.

Figure 14: Proximity of NEV site to neighbouring residential development.

Figures 15 and **20** illustrate the surrounding site context and the condition along the south-eastern boundary of the NEV site relative to the dwellings on the western side of Monarchy Way.

Figure 15: View looking north along Fountain Road toward the NEV site.

Figure 16: Fountain Road looking east towards Narara High School.

Figure 17: View of Monarchy Way looking north.

Figure 18: Dwellings on western side of Monarchy Way.

Figure 19: View from Research Road (southern end of site) looking to rear of dwellings on Monarchy Way.

Figure 20: View looking south east across the orchards to Fountain Road and dwellings beyond.

3.0 The Stage 1 Development Application

The information included in this section of the SEE is based on information provided by the Co-operative and should be read in conjunction with the appended supporting technical reports.

3.1 Stage 1 Overview

This Stage 1 application for the NEV site seeks approval to subdivide the site under the provisions of the *Community Land Development Act 1989* to create a Community Title Scheme. The scope of the Stage 1 works is illustrated in the Stage 1 Concept Plan prepared by Hill Thalis (refer **Appendix B1**). This plan illustrates the general arrangement for the subdivision, site access, existing structures to be retained and demolished; and existing and proposed landscape features and supporting infrastructure.

Specifically, the Stage 1 application seeks approval for the following works:

- The creation of a community title scheme comprising a 40 lot subdivision.
- To support the subdivision of the site and to meet the servicing requirements for Stage 1, the following ancillary works are also proposed:
    - Remediation of the site;
    - The demolition of 15 redundant site structures and the removal 45 trees including 1 hollow bearing tree;
    - Limited bulk earthworks to enable the construction of the Stage 1 works (roadways and infrastructure);
    - The construction of the site's road network including new internal circulation roads accessing the community title lots and to facilitate servicing of the site by emergency services. The Stage 1 works also include two (2) bridges over the middle western gully and the construction of visitor car parking and the concept design for access to the private residential lots;
    - Provision of essential utility services and infrastructure to service Stage 1 of the development including the construction of an integrated water management system (water recycling facility and sewer reticulation system), the extension and augmentation of electricity and telecommunications through the site; a waste storage area and mail room;
    - The implementation of the first stage in a comprehensives landscape strategy for the site including the greening of common areas, key access ways through the site, the creation of contour gardens and feature entry detail. The works include specific landscape treatment adjacent to the internal roads;
    - All works relevant to Stage 1 to make site bushfire safe including the establishment of asset protection zones; and
    - The first stage in the ecological restoration of the site including enhancement works to the green corridors and implementation of significant landscape works to offset tree loss on the site.

The section below provides a detailed description of the proposed development works which comprise this Stage 1 application. This section should be read in conjunction with the documents and plans appended to the report. In particular, the Stage 1 DA should be read in conjunction with the Draft Community Title Subdivision Plan (**Appendix E**) and the Civil Works Package prepared by Chase Burke Harvey (**Appendix L-N**) and the Design Report prepared by Hill Thalis (**Appendix B**).

3.2 Subdivision

The Concept Plan for the site envisages the subdivision of the development under the *Community Land Development Act 1989* (NSW) to create a Community Title Scheme. The concept for the Draft Community Title Subdivision Plan (Draft Plan of Subdivision) has been prepared by Chase Burke Harvey and is provided at **Appendix E**.

The indicative layout for the 40 lot community title subdivision, which also proposes the creation of the 35 private residential lots for Stage 1, is illustrated in **Figure 21.**

The subdivision and lot layout provides for creation of the following:

- **Lot 1: A Community Association Lot-** Lot 1 is vested in the community association that is entrusted with the ownership and management of the community property for the benefit of its members. This includes the site infrastructure, access ways, roadways, gullies and associated landscaped/open space areas.
- **Lots 2-36: 35 Private Residential Lots-** these lots are proposed to be individually sold for future dwelling house development. The lot sizes for future residential development in Stage 1 range from 474 to 800sqm for conventional residential development. Two large lots for cluster housing comprising 7299sqm (Lot 15) and 6243sqm (Lot 36) are also proposed.
- **Lot 37- A Private Lot:** Lot 37 will be initially owned by the Co-operative (as the developer). The lot configuration has been created to reflect future stages in the development of the NEV site. This lot may be subject to further subdivision associated with the staged development of the site and will require community association approval. There are no development contracts proposed in this community title subdivision.
  Lot 37 contains a number of existing buildings including the Administration Building and the Visitors Centre and these will be retained by the Co-operative. It is noted that these buildings are the subject of separate license agreements constituted under common law between the Co-operative and the Sydney Coastal Ecovillage Incorporated (SCEV). These licenses allow SCEV to enter, occupy, and use these buildings and the surrounding land for community purposes. The community use of the site is subject of a current DA being considered by Council, as detailed in **Section 1.2** of this SEE.
- **Lot 38**: **Lot comprising 6(a) zoned Land**- this lot contains all land currently zoned 6(a) pursuant to GPSO. This land is proposed to be dedicated to Council under the terms on an existing Voluntary Planning Agreement (VPA) which has been prepared for the NEV site in accordance with the requirements of the rezoning process undertaken by DPI and as stipulated in Section 8.1 of DCP No.175. The VPA makes specific provision for the dedication to Council of the 6(a) Open Space zoned portion of the site, together with a small area of land upon which a stand of Araucaria cunninghamii (Hoop Pines) are located.
- **Lot 39: Lot comprising 7(c2) zoned land:** Lot 39 will be initially owned by the Co-operative (as the developer). The lot configuration has been created to reflect the current zoning boundary.

This lot may be subject to further subdivision associated with the staged development of the site.

- **Lot 40: Lot comprising 7(a) zoned land:** Lot 40 incorporates the 7(a) bushland, the residual 7(a) land (which has one dwelling entitlement) and the dam. This land has been incorporated into one lot so as not to create a "split zone lot".

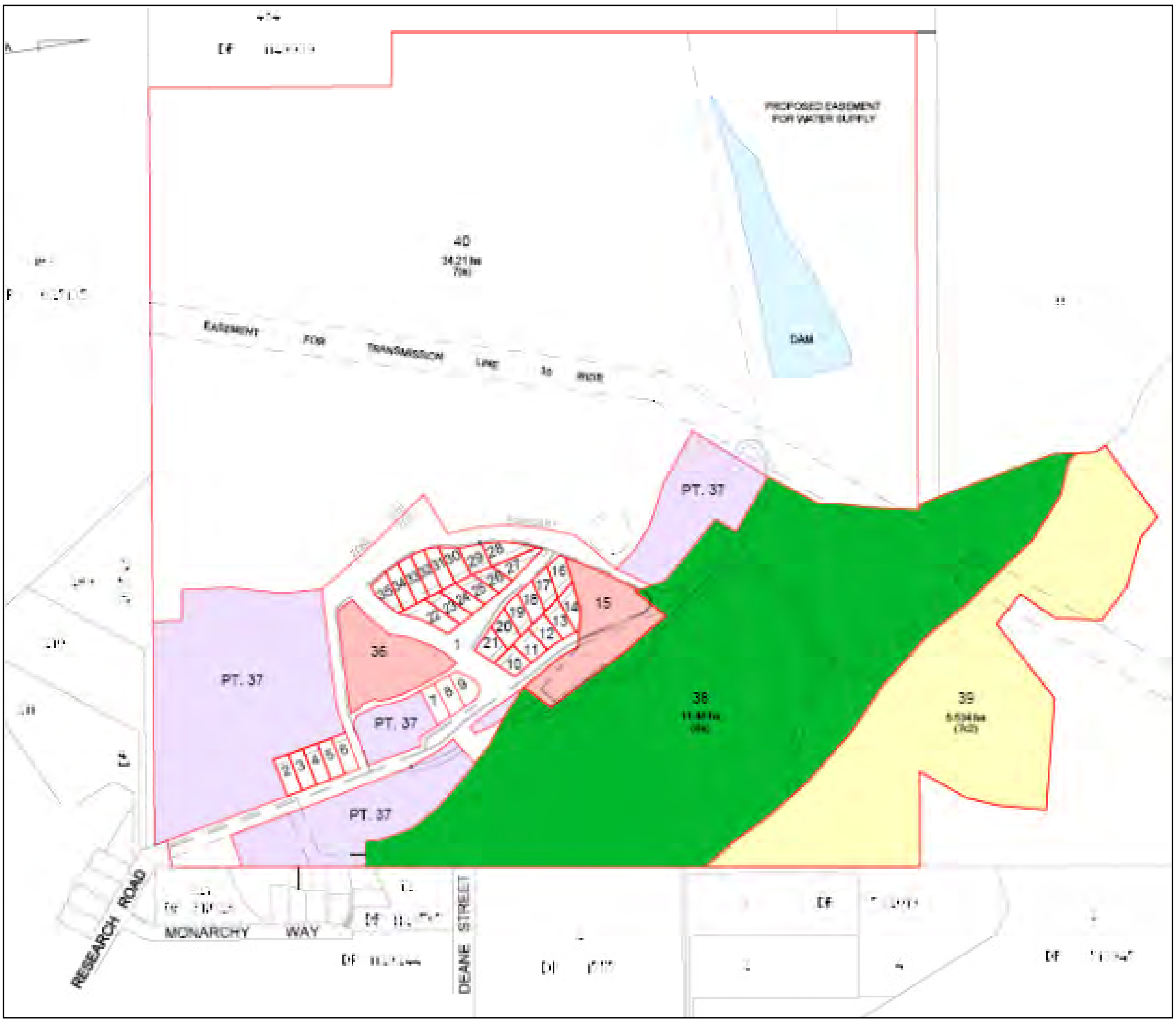

Figure 21: Proposed 40 lot Community Title Subdivision. (Source: CBH)

The Draft Plan of Subdivision also includes various easements associated with services and drainage, and proposed rights of way. A proposed restriction on the use of the land (6m wide) is also proposed at the rear of a number of private dwelling lots where this land forms part of the communal garden strategy.

The structure for the community title subdivision also details how Lots 15 and 36 will be subject to future subdivision (cluster housing lots) and Lot 37 will be potentially structured to accommodated Stage 2 and 3 in the development of the NEV site (**Figure 22**).

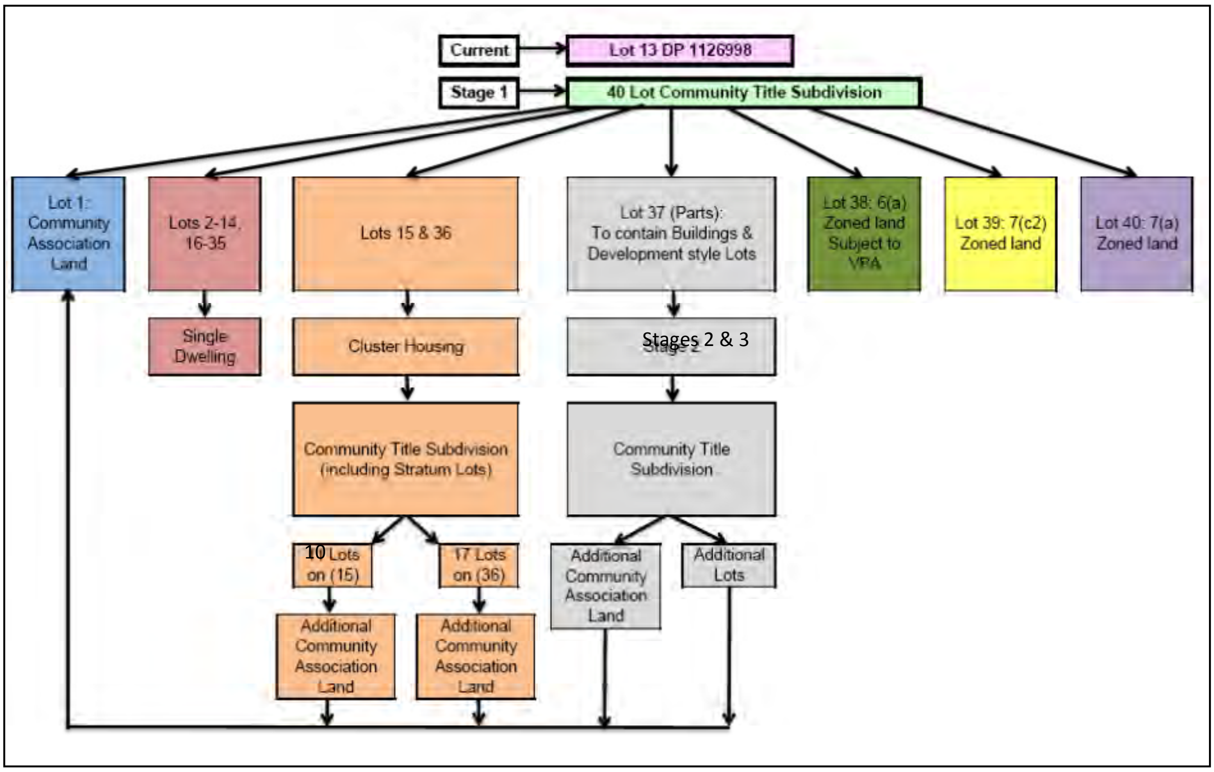

Figure 22: Community Title Structure (Source: CBH)

The application is supported by a draft Community Management Statement prepared by Andrews & Holms Lawyers, which will be provided to Council under separate cover. Pursuant to Schedule 3 of the *Community Land Development Act 1989;* management statement includes the following mandatory matters:

- The location, control, management, use and maintenance of all parts of the community property that is an open accessway.
- The control, management, use and maintenance of any other parts of the community property.
- Storage and collection of garbage and the related obligations of the community association.
- Maintenance of water, sewer, drainage, gas, electricity, telephone and other services.
- Insurance of community property.
- Executive committee of the community association, office-bearers of the committee and their functions.
- Meetings of the executive committee otherwise than at a meeting of the committee; and
- The keeping of records of proceedings of the executive committee.

The control, maintenance and management of the subdivision are proposed to be regulated through the by-laws contained in the management statement. These by-laws address the following matters:

- Ongoing service and maintenance contracts.
- Bushfire controls and requirements for maintenance.
- The implementation of the Property Vegetation Management Plan and Vegetation Management Plan (Ecological Restoration Plan).
- The heritage conservation of the site.

- The role and function of the network and retail operators licences under the Water Industry Competition Act 2006 (NSW).
- The allocation of unit entitlements for each lot.

3.3 Remediation

The area which comprises the Stage 1 site is proposed to be remediated prior to the issue of a construction certificate for the Stage 1 works. A Phase 1 Preliminary Site Assessment report (PSA Report) has been prepared by Douglas Partners in accordance with SEPP 55 and is included at **Appendix F.**

Douglas Partners has recommended that a Sampling and Analysis Quality Plan be prepared followed by a Phase 2 Environmental Site Assessment and a Remediation Action Plan. In accordance with the requirements of DCP No. 175, a Site Audit Statement will be issued for the site prior to the issue of a construction certificate for the Stage 1 works.

3.4 Stage 1 Construction Enabling Works

The site preparation and construction enabling works for Stage 1 include demolition of existing structures, the clearing of existing vegetation required for the construction of the roadways and infrastructure and bulk earthworks. These matters are addressed separately below.

3.4.1 Demolition

A number of buildings and structures on the site have been identified for demolition. The structures are typically located across lot boundaries proposed in the Draft Plan of Subdivision or are impacted by the infrastructure layout and therefore, retention is not feasible.

Fifteen (15) buildings have been identified for demolition. These buildings are identified as Buildings 3, 8, 11, 13, 30, 39, 45, 47 to 52, the fence around Building 17 and an unnumbered structure at the rear of Building 17, and are located on **Figure 23** below. Where possible, building materials will be stockpiled on site for recycling and adaptive re-use.

A number of the buildings proposed for demolition (Buildings 3, 8, 11, 13 and 30) have been identified as containing hazardous materials. Where buildings to be demolished have been identified as containing asbestos products, they will be removed by an AS-1 licensed asbestos removalist contractor in accordance with the NOHSC Code of Practice for the Management and Control of Asbestos in Workplaces and disposed of as asbestos waste to an appropriately licensed facility.

No heritage items listed in Schedule 8 (Environmental Heritage) of the Gosford Planning Scheme Ordinance are proposed to be removed to accommodate the proposal. All buildings and structures have been assessed as having low significance and not requiring retention. The exception is Building 39, an old A-Framed Glasshouse, which has been identified as being of ‘moderate significance. MUSEcape has recommended that this structure be archivally recorded or alternatively, relocated on the site.

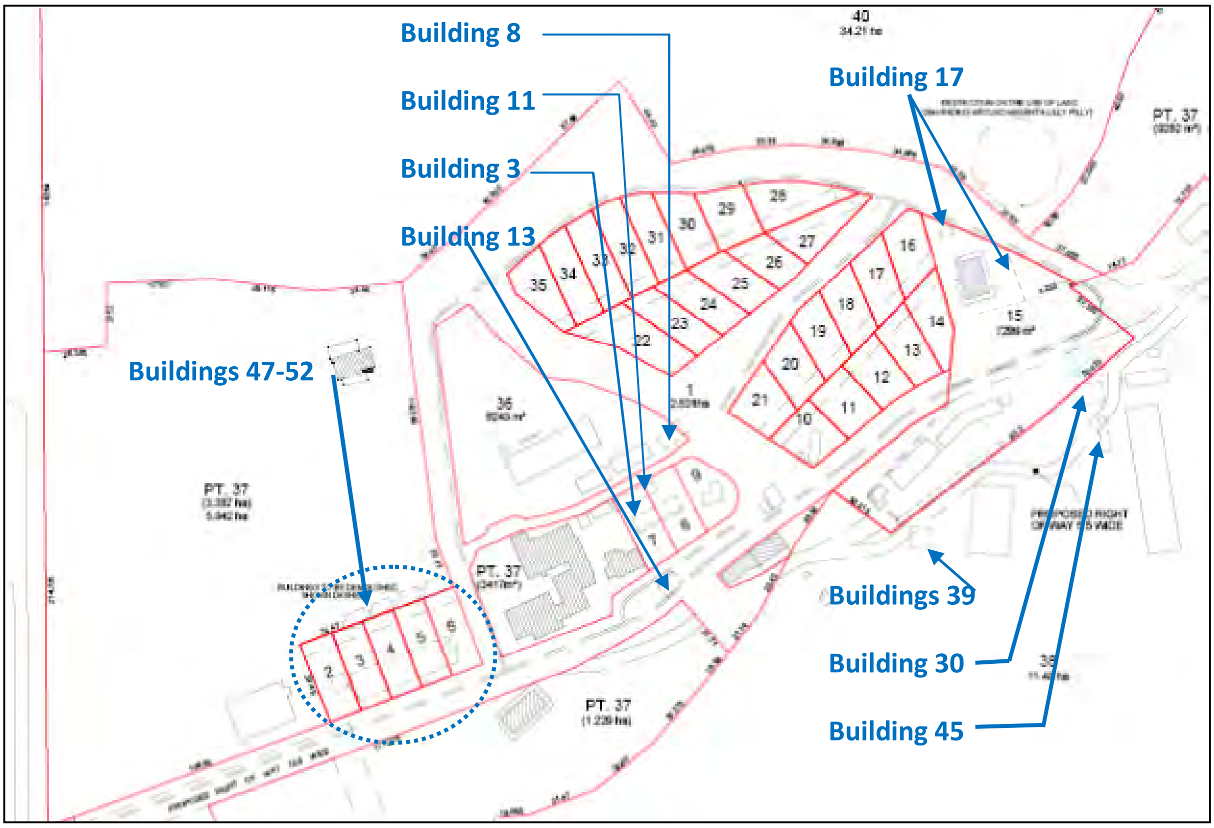

Figure 23: Buildings proposed to be demolished.

3.4.2 Tree Removal

Approximately 65 trees have been identified as being impacted by the Stage 1 works. A total of 45 of these trees will require removal to accommodate the scope of works proposed in this application. All trees identified for removal, with exception of a *Syncarpia glomulifera* (Turpentine, Tree 244, located in south-western bend in Road 2- refer **Figure 24** below), have been assessed as having low to moderate arboricultural significance. The Tree 244 has been allocated a high arboricultural significance rating and a moderate retention rating.

The tree removal includes 7 non-heritage listed specimens of *Pyrus calleryana* (Callery Pear) in a row along the entrance drive, 5 specimens of *Carya illinoinensis* (Pecan) north of the former Grafting Shed / Administration Office (Building 24) and one specimen of *Carya illinoinensis* in the row north of the former Manager's residence are also proposed to be removed.

In addition to the above, a small area of native vegetation will be required to be removed from the southern bank of the middle western gully to accommodate the proposed asset protection zone. Therefore, approval will be required under the *Native Vegetation Act 2003*.

One hollow bearing tree (Tree 191) is required to be removed as it is located within the road reserve- refer **Figure 25**. The Tree is a multi-stemmed *Callistemon viminalis* with a hollow at the base. The project ecologist has recommended that the loss of this Tree 191 be offset and substituted with a bat roosting box.

No heritage listed trees in Schedule 8 (Environmental Heritage) of the Gosford Planning Scheme Ordinance are proposed to be removed to accommodate the proposal.

An arboricultural audit of the trees on the NEV site has been undertaken by the project appointed arborist, Michael Shaw and is provided at **Appendix I.** All trees proposed for removal will be replaced by sympathetic new landscaping of an equivalent landscape contribution and size at maturity.

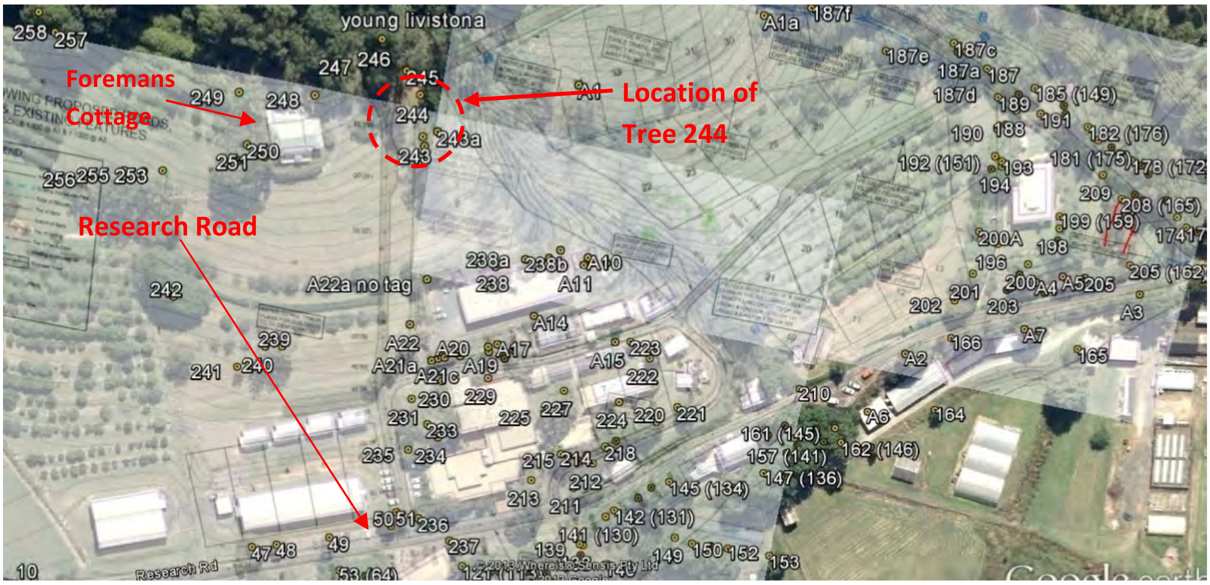

Figure 24: Location of Tree 244 (Source: Michael Shaw)

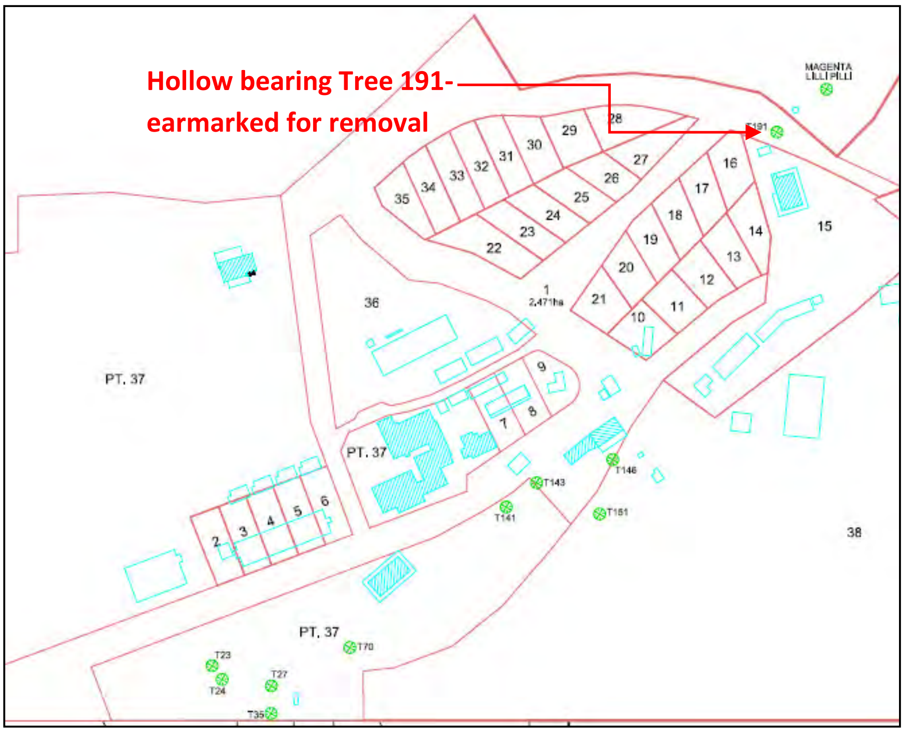

Figure 25: Location of Hollow Bearing Tree No.191- note, Plan shows location of 10 hollow bearing trees within the Stage 1 area (Source: Robert Payne)

3.4.3 Bulk Earthworks

The bulk earthworks for Stage 1 are principally associated with the road construction. To allow for the provision of underground services/utilities an additional unpaved width of 1.2m adjacent to the road pavement and at the same cross fall as the road pavement has been adopted, this will double as an informal pedestrian footway. There will also be some temporary regrading of sites relative to the new road formation to reconcile level changes and to reduce the steepness of a number of batters alongside the roads. Batters of 2.0H:1V have been generally adopted for the project in accordance with the Slope Stability Report prepared by Douglas Partners, which is provided at **Appendix M**.

Concept site regrading plans and sections have been prepared for the site by Chase Burke Harvey and are provided at **Appendix N** and **Appendix N1**. One of the overarching design principles for the NEV site has been to minimise the extent of cut and fill to accommodate future development. In most instances, the regrading associated with the roads is generally less than 1.0m. However, there are a number of areas particularly, adjacent to the western extent of Stage 1 where regrading will result in up to 2.0m variation in the current site levels.

It is estimated that the extent of cut and fill associated with Stage 1 works comprise approximately 3700m³ of cut and 2700m³ of fill. The net balance of the fill is proposed to be stockpiled on site for future use.

Erosion/sedimentation controls are proposed to be installed prior to commencement of any construction works and will be maintained until the finished works have been stabilised. Concept details of the erosion/sedimentation control requirements for this development have been prepared by Chase Burke & Harvey and are detailed on Plan ES12242 at **Appendix R**.

3.5 Road network

The road network proposed for the NEV site is based on the concept which utilises and builds on the existing pattern of streets to make a connective and walkable network through the site. All roads will be maintained as private road and will be encumbered by various rights-of-way and easements, as appropriate.

The components of the road network are illustrated in the NEV Design Report provided at **Appendix B** and include:

- establishing contour streets as the primary way of ordering redevelopment of the site;
- widening the space at the ends of contour streets to spatially modulate the street;
- consolidating plantings and accommodate small groupings of shared car parking; and
- introducing cross streets (perpendicular to the slope) with more regular reservation widths for increased connections.

The road network design is illustrated in **Figure 26** below and consists of a series of one-way and two-way roads. The road network includes the construction of two (2) bridges over the middle western gully to facilitate efficient site access and in order to minimise the extent of site invention and excavation.

The carriageway width for a one-way road is proposed to be 3.5m and the carriageway width for a two-way road is proposed to be 5.5m. The road circulation and the location roads have been prepared to promote practical access to the all lots and to comply with the requirements of *Planning for Bushfire Protection*. The grade requirements of AS2890.1 have been adopted for the proposed road network.

The road network is illustrated in the Stage 1 Road Circulation Plan prepared by Chase Burke & Harvey's Plan RC12242 at **Appendix O**. This plan should be read in conjunction with the Road Grading Plans provided at **Appendix N** and **Appendix N1**.

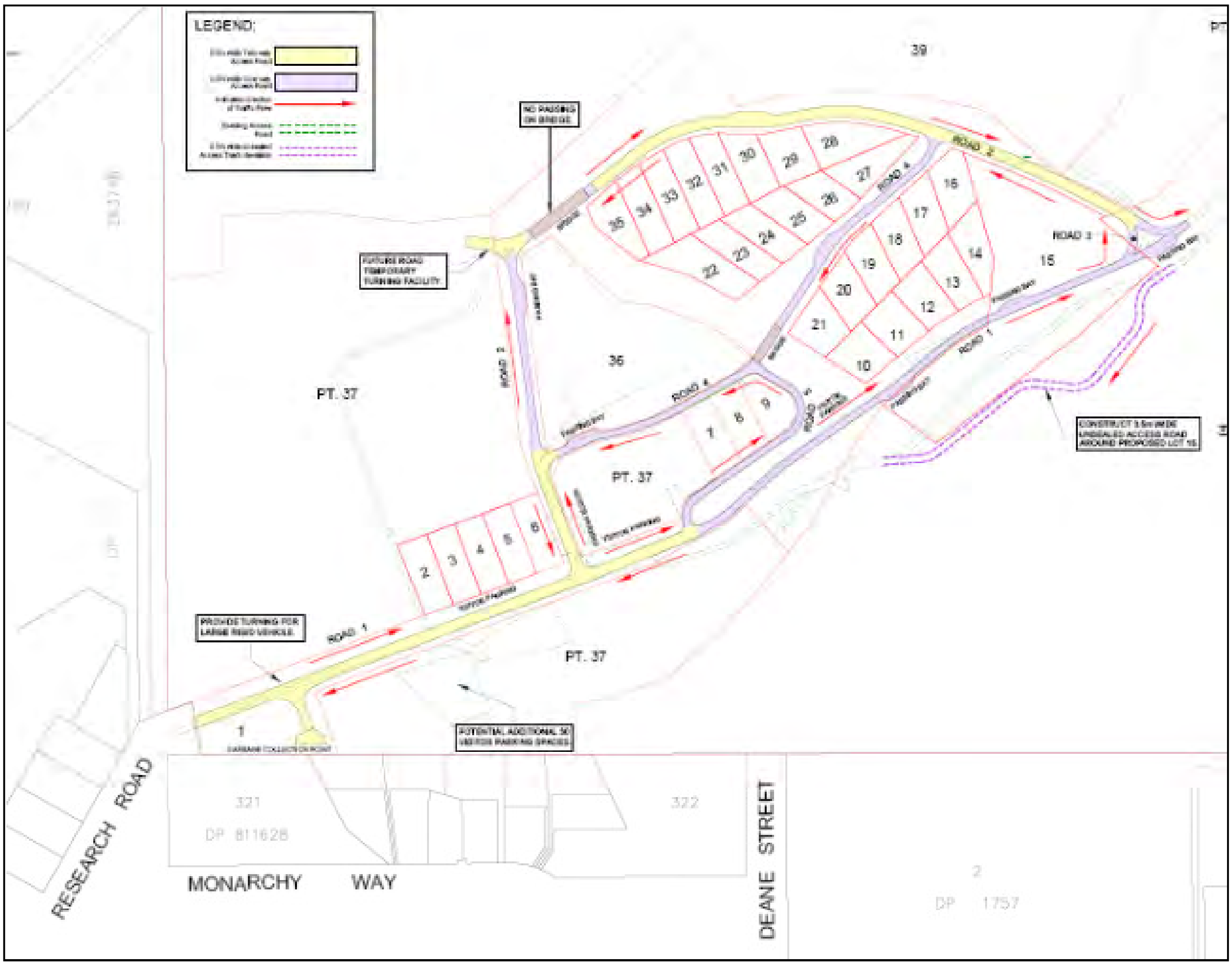

Figure 26: Stage 1 Circulation Road Plan (Source: CBH)

3.6 Infrastructure and Services

3.6.1 Water and Sewer

A key component of the water and sewer infrastructure proposal for the site is an Integrated Water Management System (IWMS). The IWMS is a water recycling facility and sewer reticulation system with a maximum capacity of 50 kilolitres per day and is a closed system. The IWMS will capture waste water from the development and distribute it for beneficial use within the development site.

A report on the IWMS has been prepared by Woodlots & Wetlands and is provided at **Appendix S**. The Concept Design and an overview of the IWMS is provided at **Appendix T1** and **Appendix T**. The design refinement of the IWMS will be subject to detailed consultation with the IPART as part of the application which will be lodged concurrently for a Retail Operator's Licence and a Network Operator's Licence.

This infrastructure will be privately owned and operated and maintained in accordance with WICA licensing requirements. No connection to Council water or sewer services will be required. Once Stage 1 of the IWMS is fully operation, the existing connections to Council's sewer and water system will be discontinued.

The key infrastructure to be installed on the site is as follows:

1. **Potable and Recycled Water Systems**- this will comprise a combination of rainwater (collected from roofs of dwellings), potable water (water supply originates from the on-site dam) and recycled water. In the future water tanks with a 10 cubic metre capacity will be installed on all residential lots as part of each residential development.
2. **Wastewater treatment and recycled water system (waste water treatment plant)**- this will comprise the installation of a Membrane Bioreactor (MBR) as the primary treatment technology- although, the final treatment process selected will be determined in consultation with NSW Health and its operation will be subject to a WICA license. This infrastructure will combine biological treatment with ultra filtration to produce high quality treated water.
   The MBR is proposed to be located on the eastern boundary of the site adjacent to the 6(a) zoned land and directly to the south-east of the Fisheries Building. The treated water will be sent to two (2) treated water storage tanks (each 100 kilolitres in volume) for reuse within the NEV community and for irrigation. An example of the scale and visual appearance of an MBR is provided in **Figures 27** and **28** below.
3. **Potable water supply-** this will be supplied from an existing dam on the site. A treatment plant, to improve the water quality and ensure it meets the requirements of the Australian Drinking Water Guidelines and WICA requirements, is proposed to be installed near the existing dam in the vicinity of the existing pump station. The treated water will be stored in header tanks near the dam and is proposed to be supplied by gravity to all future dwellings.

The IWMS is fully detailed in the Integrated Water Cycle Management Plan prepared by Woodlots and Wetlands Pty Ltd provided at **Appendix S**. This Plan includes an assessment of demand and supply for the water cycle components based on a maximum density of 130 residential lots, the demand for irrigation water and wet weather storage, waste water modelling output and the use of dam water to supply potable water to the NEV site. In addition, the Plan includes a land capability assessment for a proposal for reclaimed water irrigation and an associated soil assessment.

It is proposed to construct the IWMS in two stages. Details regarding the staging are provided in **Section 3.6.2** below. The Stage 1 construction will ensure the capacity of the network can accommodate the demand and supply requirements of 60 dwelling and other on-site uses.

Figure 27: Example of the MBR which has been installed at the Blacktown Workers Club (Source: Aquacell)

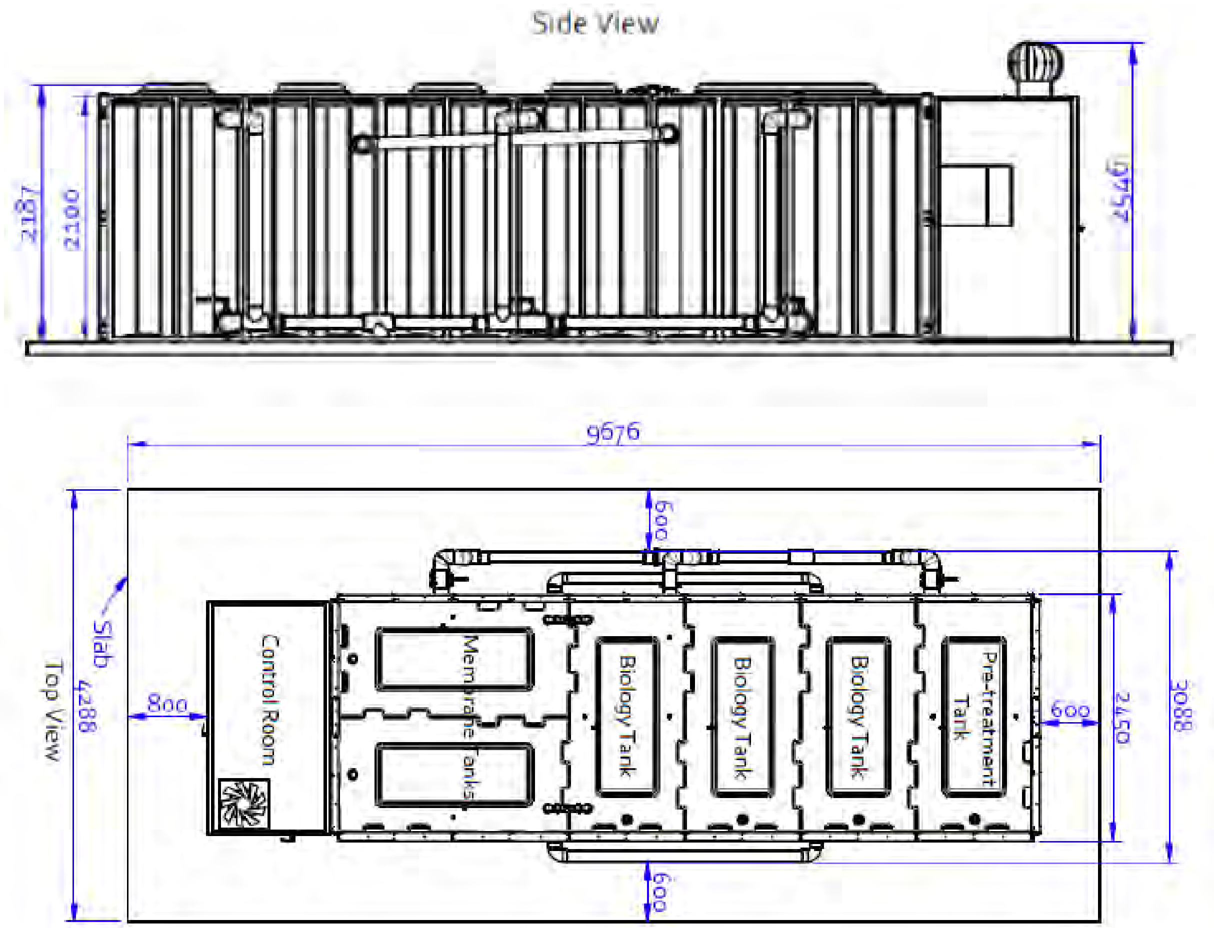

Figure 28: Typical details for MBR dimensions and details. (Source: Aquacell)

3.6.2 Staged Implementation of IWMS

It is proposed to construct the IWMS in 2 stages to largely respond to anticipated population and the capacity of the system. The stages are anticipated as follows and are detailed in the Water and Waste Water System Overview and Integrated Water Cycle Management Plan at **Appendices T** and **S**, respectively.

- **Wastewater treatment and recycled water system-**
  - waste water treatment plant: the plant will be constructed in 2 stages to correlate with the future increase in population on the site. The first stage will be capable of handling at least 30 kL/day, whereas the demand for Stage 1 is estimated at 24.3 kL/day).
  - Screening, buffer and treatment water storage: The first stage will include infrastructure for the full plant capacity for screening, buffer and treated water storage.
  - Biological Treatment: this infrastructure will be split into 2 equal stages. This allows the necessary control over the biological system during the early stages of development when the population and wastewater supply volume is low.
  - Effluent Irrigation: Woodlots & Wetlands has estimated that in the development of Stage 1, there is likely to be extended periods when reclaimed water supply exceeds demand and accordingly, it is proposed to use this water to irrigate the citrus orchard to the south of Stage 1 (part of proposed Lot 37). At Stage 2, when there is sufficient water flows, an irrigation dam with a storage capacity of 3ML will be required. The location of the dam to be constructed in Stage 2 will be resolved in consultation with IPART as part of the WICA licence.
- **The potable water supply system:-** all infrastructure associated with the potable water supply will be constructed upfront in 1 stage.

3.6.3 Public Utilities

All public utilities services including Telstra, Gas & Power are available at the Research Road Frontage of the site and are available to the site. Preliminary contact has been made with the relevant service authorities, which has confirmed that these services will be available to the site.

Some public utilities have previously been extended onto the site to service the existing buildings. However, it is likely that these will be adjusted or removed, as required to suit the development.

The proposal for Stage 1 envisages that the public utilities will generally be located parallel to the proposed road network within a 1.2m allocated corridor. When the public utility services are extended through the site to existing buildings, these will be adjusted or retrofitted to the requirements of the relevant authority and to suit the overall development of Stage 1.

Details of the preliminary consultation with public utility companies is provided at **Appendix P**.

3.7 Stormwater Management

The stormwater management system proposed for the NEV site is based on Water Sensitive Urban Design principles and is detailed in the Integrated Water Management Plan prepared by Woodlots & Wetlands at **Appendix S**. The concept for the stormwater management for Stage 1 is illustrated on the Concept Stormwater Plans prepared by Chase Burke and Harvey at **Appendix Q**.

The stormwater management system will typically incorporate the use of bio-retention swale drains. Where it is not practical to utilised swale drains, a kerb, pit and pipe system will be constructed. Where the slope of the site prevents the use of swale drains, smaller rock lined/pitched open drains, stabilised with geo fabric, will be constructed to direct stormwater flows to a piped system. Based on this approach, the key components of the stormwater system include:

- contour banks upslope of the development, designed to convey bushland runoff to local gullies;
- protection of gully discharge points via use of turf reinforced mesh and rock rip rap;
- soak-a-ways (shallow infiltration basins) to retain runoff from individual lots where it is difficult to connect to a common swale;
- pits and pipes/ rock lined drains to convey road runoff where the grades average over 7 to 10%;
- bio-retention swales to convey local runoff parallel to roads where grades are moderate;
- bio-retention basins in less steep areas to treat runoff converging from roads and lots;
- semi-permanent infiltration basins in lower parts of the landscape; and
- inclusion of environmental features such as frog ponds and permaculture beds within the stormwater swales and bio-retention ponds.

A typical detail for the stormwater design is illustrated in **Figure 29** below. It is noted that the swale drain illustrated at the rear of Lots 10 to 15 and 16-21 is part of the contiguous common gardens at the rear of the residential lots which will form part of the network of landscaped gardens and pathways through the site. Refer to further discussion in **Section 3.9** below.

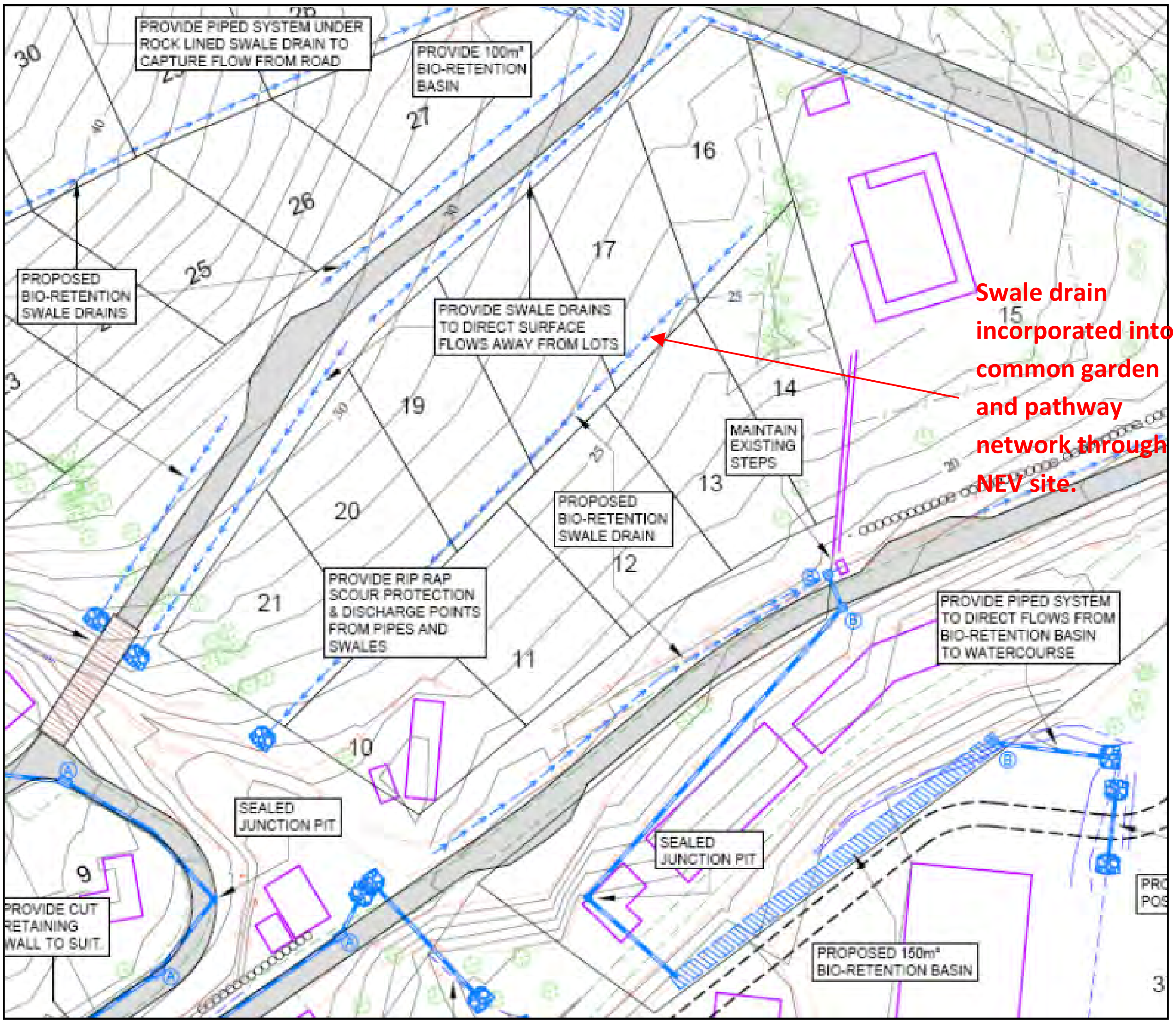

Figure 29: Extract from Stormwater Management System (Source: CBH)

3.8 Landscape Strategy

The landscape strategy for the NEV site has been prepared by McGregor Coxall and is detailed in the Design Report at **Appendix B**. The key principles underpinning the strategy are:

- to work with the site's existing history in terms of its native forest and introduced exotic plantings that were part of its historic past;
- to recognise and respond to the site's unique topography and water movement; and
- to minimise environmental impact of the construction of the landscape, in terms of materials by employing environmentally sustainable strategies including recycled materials.

The first stage of this strategy is proposed to be implemented in Stage 1 and includes the following elements as illustrated in **Figure 30**:

- Potential entry planting external to the site;
- Landscaping of the main entry road (Research Road) and other new roads within Stage 1 including new street planting and landscaping to carriageways including landscaping to drainage swales. It is proposed to work with the existing landscape to reinforce the character of the site. Exotic tree species are proposed to be planted along Research Road and endemic species to all other roads- refer Landscape Planting Palette in the Design Report.
- Streetscape treatments between a number of road edges and the boundaries of proposed Lots;
- Restoration of gullies through the site in accordance with the Ecological Restoration Management Plan- refer further discussion in **Section 3.10** below.
- The landscape treatment of the swales which form the common gardens are the rear of the proposed residential lots. This strategy builds on the concept devised for the site by Hill Thalis of creating a linear accessways through the site which connect into the network of roads and open space throughout.

As detailed in section 3.4.3 above, some regrading works will be required adjacent to new roads to stabilise the land. Where batters are required, some temporary measures (including grass seeding) will be employed to stabilise the batters and prevent soil erosion prior to the development of the individual lots.

Figures 31 and **32** illustrate the typical landscape detail for the Research Road, including the proposed palette of materials and finishes and the general arrangement for the landscaping treatment to the carriageway edge comprising street tree planting, the swale, access to residential lots and potential car parking provision. Driveway access will not be provided to the individual lots as part of this application however, concept details have been prepared to show how access will be typically achieved.

Figure 30: Landscape Plan for Stage 1 of the NEV site (Source: McGregor Coxall)

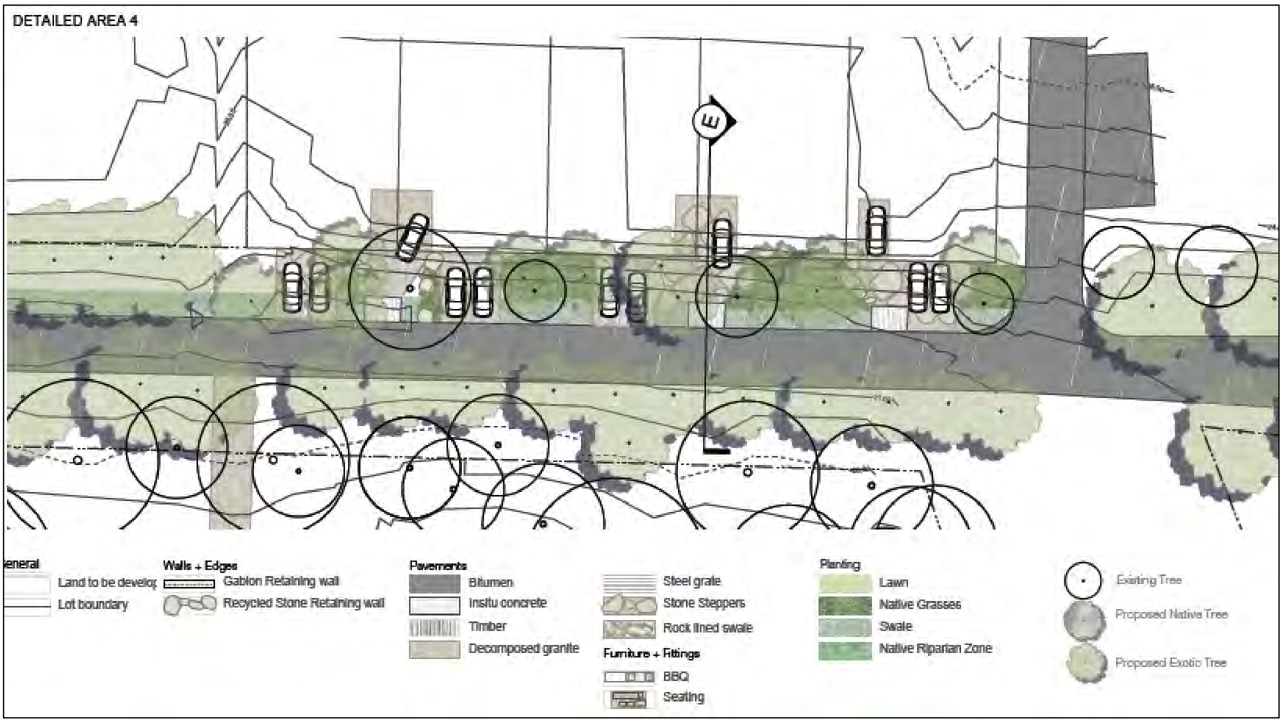

Figure 31: Typical landscape detail for Research Road. (Source: McGregor Coxall)

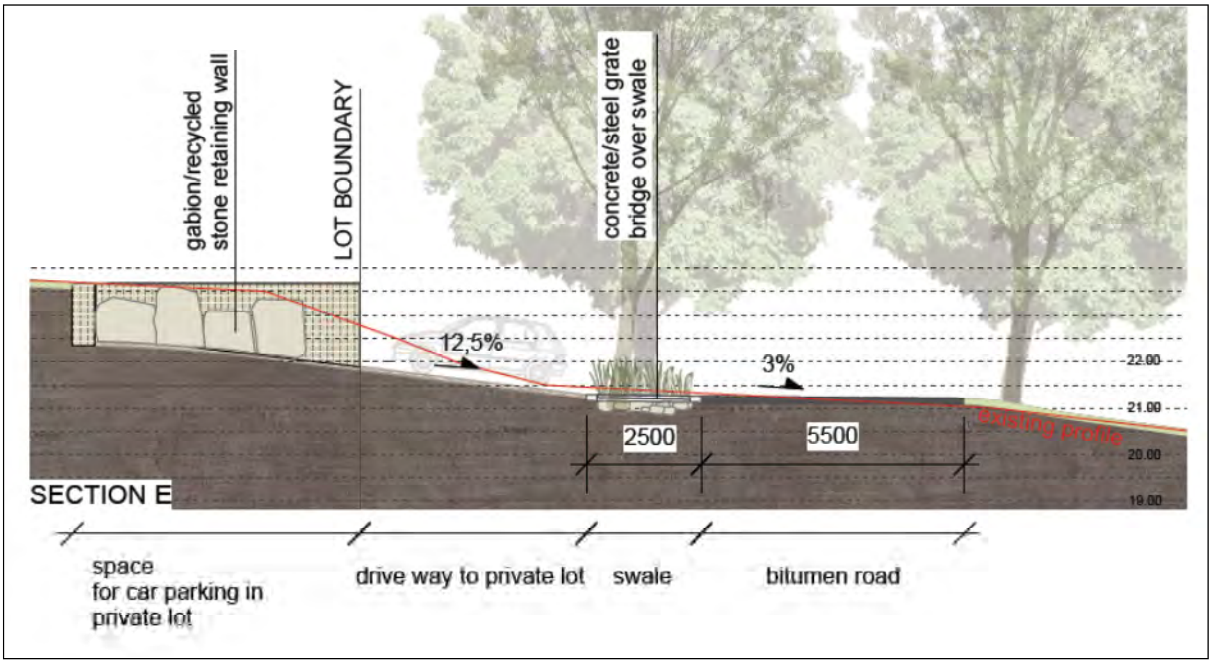

Figure 32: Selected section through Research Road (Source: McGregor Coxall)

3.9 Bushfire

The NEV site is identified as containing bushfire prone vegetation (Category 1 and 2 Bushfire Prone Vegetation). Subdivision of bushfire prone land is Integrated Development as defined by Section 91(1) of the Act and requires the consent of the Commissioner of the NSW Rural Fire Service, under Section 100B of the *Rural Fires Act 1997*. Council Bushfire Prone Land Map has mapped the unmanaged vegetation within the development site as Category 1 Bushfire Prone Vegetation, except for a small area of Category 2 vegetation located to the south of the large dam.

The requirement for 100 metre wide buffer zone to the Category 1 vegetation impacts the existing cleared areas of the development site, therefore triggering the requirements of Sections 79BA and the integrated provisions of the Act.

A Bushfire Protection Assessment Report has been prepared by ABPP (**Appendix V**). The Report undertakes an assessment of the bushfire protection measures required to address the bushfire risk to the future development of the site, in accordance with Planning for Bushfire Protection and the requirements of the Rural Fires Regulation 2008.

In order to mitigate the risk of bushfire hazard, ABPP has advised that the bushfire loads on the site and within the designated APZ's will need to be managed including to minimise fuel loading at ground floor level to ensure that fuels are discontinuous and to avoid transfer of fire to the development from fires burning in the adjoining bushfire prone vegetation. These works will be undertaken as part of this application and in order to ensure that the site is bushfire safe and maintained to current recognised standards.

The required APZ's have been graphically presented by ABPP on plan for the concept proposal and Stage 1, as illustrated in **Figures 33** and **34** below:

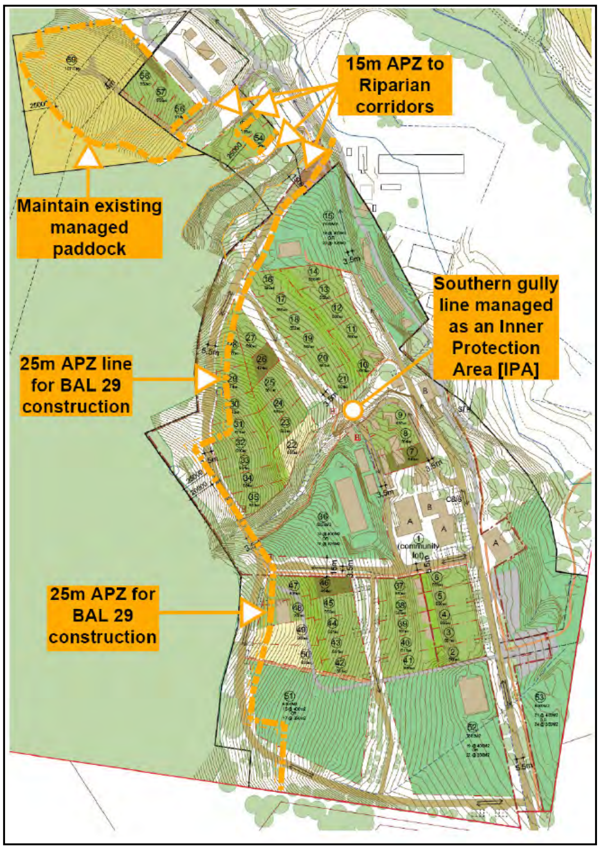

Figure 33: APZ's- Concept Plan

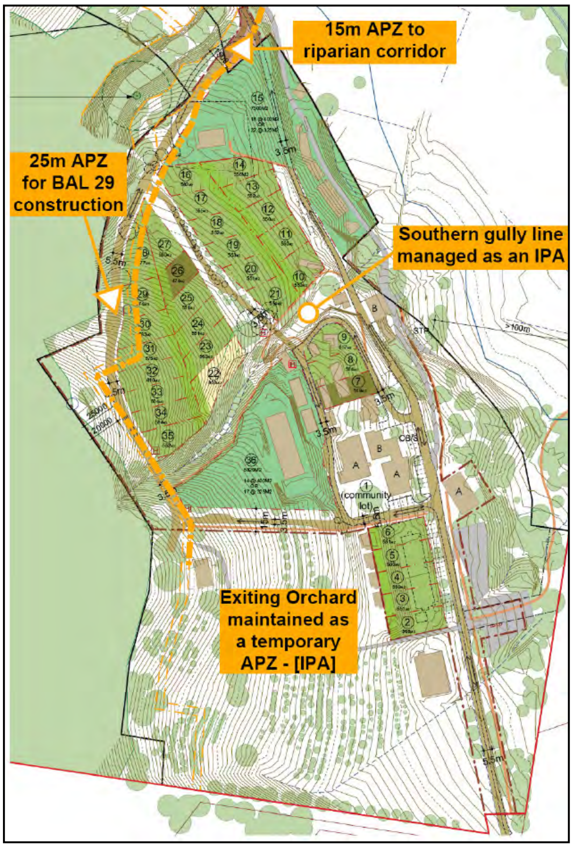

Figure 34: APZ's Stage 1

In addition to the APZ requirements, a number of additional bushfire protection strategies for the proposed subdivision are recommended and will be completed as part of the Stage 1 works. These works include the following:

- the provision of fire fighting water supplies;
- the construction of access requirements for emergency service vehicles; and
- the preparation of an evacuation management plan.

3.10 Ecology

The Ecological Restoration Plan prepared by Robert Payne (**Appendix K**) includes recommendations for the appropriate ecological management of the NEV site and is required to be prepared in accordance with section 8.3 of DCP 175. The Ecological Management Plan provides a prescriptive framework for the management of known threatened species habitat; weed management, potential impacts associated with the sub-division and ongoing management. Management matters include replacement tree planting for Camphor Laurel, threatened plant species management, feral animal control, removal of weeds, and ecological restoration of floodplain wetlands and riparian grasslands.

Ecological Restoration Plan mainly addresses both embellishment of the DCP 175 area and the eradication of weeds, particularly any noxious weeds or weeds of national significance including Lantana, Small-leaved Privet and Fireweed and are in need of more urgent eradication.

The works indentified in the Ecological Restoration Plan proposed to be implemented as part of the Stage 1 include the following:

- To provide for a 20m buffer zone around the known location of Syzygium paniculatum.
- To regenerate the native riparian grassland alongside drainage lines within the 10m riparian buffer zone, where required by the NSW Department of Water.
- To take steps, through discussions with Government Authorities, to eradicate the European Fox, the European Rabbit and Feral Cats.
- To undertake weed management including:
    - To eradicate the Small-leaved Privet from all relevant drainage lines and paddock areas;
    - To remove all noxious weeds that apply to the stage 1 area; and
    - To remove all weeds of national significance that apply to the stage 1 area.

The Co-operative has prepared a Property Vegetation Plan in conjunction with the Hunter Central River Catchment Management Authority (Catchment Management Authority) as required by Section 8.9 of the DCP 175. This Plan is currently under final review by the Catchment Management Authority. Any works required to be undertaken to the 7(a) zoned land will be negotiated with Council and the Catchment Authority as part of the development assessment process and implemented by the Co-operative as required to ensure the protection of the high environmental and scenic qualities of this western section of the site.

3.11 Construction Staging- Integrated Water Management System

An application will also be lodged concurrently with IPART for a Network Operators Licence and Retail Suppliers Licence under the WICA. This will specifically relate to the operation and supply of water and sewer services within the NEV site.

The application will seek approval for the entire IWMS and will acknowledge that the system will be implemented in 2 stages. Relevant to the obtaining the WICA Licence, is the need to obtain development consent in the first instance for the infrastructure pursuant to section 105 of State Environmental Planning Policy (Infrastructure) 2007 (refer further discussion in section 4.2.1 of this report).

In order to the WICA Licence to be issued for the entire IWMS (as opposed to only Stage 1), it is imperative that the determination of this application acknowledge the entire IWMS and that it will be constructed in two stages. Furthermore, that any conditions imposed on any development consent permit the following:

- Separate construction certificates and occupation certificates to be issued for the two stages of construction of the IWMS.
- That any restriction on the registration of the community title subdivision with the LPI be linked only to the completion of Stage 1 of the IWMS works (and not the entire IWMS), as these works are relevant to the supply of water and the sewage services associated with Stage 1 of the development of the NEV site.

3.12 Future Stages:

The development of Stage 1 will require future approval to be obtained for each dwelling house proposed to be constructed on each the private residential lots. It is anticipated that development will commence as soon as practicable and following the registration of the community title scheme with NSW Land & Property Information (LPI).

Fundamental to the design of all future housing will be the consideration of and general adherence to the design principles and consistency with the concept for the NEV site detailed in the Hill Thalis Design Report.

4.0 The Statutory and Strategic Planning Framework and Assessment

4.1 Statutory Planning Framework- Key Legislation

4.1.1 Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Commonwealth government's central piece of environmental legislation. It provides the legal framework to protect and management eight nationally and internationally important items including flora, fauna, ecological communities and heritage places. These items are referred to in the EPBC Act as matters of National Environmental Significance (NES).

Under the EPBC Act, any action (including a development, project or activity) that is considered likely to have a significant impact on matters of NES must be referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC). The purpose of the referral is to allow a decision to be made about whether an action requires approval at a Commonwealth level. If the action is declared a 'controlled action' then the approval of the Commonwealth is required.

The Flora and Fauna Assessment Gap Analysis Report (**Appendix J)** includes an assessment of the potential impact of this application on the significance of the identified flora and fauna species. The report should be read in conjunction with the Flora and Fauna Assessment prepared by Andrews Neil Pty Ltd (February 2006) for the site rezoning. In combination, the site surveys undertaken have indentified that the NEV site contains the following vulnerable species listed under the EPBC Act:

- the Magneta Lilly Pilly, *Syzygium paniculatum:* a single tree was located- refer to Addendum to Flora and Fauna Gap Analysis Survey Report at **Appendix J**; and
- Grey-headed Flying Fox.

In addition, the NEV site has been identified as containing 2 Endangered Ecological Communities (EEC's) comprising the Lowlands Rainforest and Freshwater Wetlands. The Flora and Fauna Assessment Gap Analysis concludes that potential impacts to the Lowland Rainforest will be minimised by the ensuring that new infrastructure is located away from the gullies. It is noted that the middle western gully has not been classified as being part of the Rainforest EEC. As the Freshwater Wetlands EEC is confined to the alluvial flats and therefore, is outside the Stage 1 development area, there is limited potential for impact on the EEC. Notwithstanding this, it is recommended that the wetland be appropriately managed and protected including to prevent the habitat becoming dominated by Cumbungi and to allow waterbirds to continue to utilise the habitat for feeding. Measures have been included in the Ecological Restoration Plan to address this matter and the management of the gullies.

Having regard to the findings of the commonwealth assessment undertaken by Robert Payne, it has been concluded that the Stage 1 works will have little impact on the Commonwealth listed species and that the proposed development is not expected to have any significant impacts on matters of NES listed under the EPBC Act. It is noted that a restriction on the land use for a 20 metres radius around the Magneta Lilly Pilly is included in the Draft Plan of Subdivision.

On this basis, it is advised that no approval is required through the Commonwealth under the EPBC Act.

4.1.2 Environmental Planning and Assessment Act 1979 (the Act) & The Environmental Planning and Assessment Regulation 2000 (the Regulation)

The Act and the Regulation provide the overarching planning legislation in NSW. The Act provides for the creation of the planning instruments that guide land use planning and development in the State. The key provisions of the Act and the Regulations as relevant to the proposal are addressed below.

Section 5 A

Section 5A of the Act provides for the consideration of environmental and biodiversity values and specifically the effects of development on species, populations and ecological communities and their habitats. Specifically, Section 5A(2) requires that the consent authority must take into account the following when determining an application:

(2)The following factors must be taken into account in making a determination under this section:

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Matters relating to the assessment of the impact of the application on the species, populations and ecological communities and their habitats on the NEV site have been relevantly addressed in the Flora and Fauna Gap Survey at **Appendix J**. This report concludes that the project is unlikely to have a significant impact on threatened species and their habitat identified on the site. A number of mitigation works and strategies are recommended in the Flora and Fauna Gap Survey to ensure that the environment of the NEV site is improved above its current condition and to minimise impacts to threatened species and their habitats. Specifically, these measures include:

1. to undertake weed removal around the tree of *Syzygium paniculatum* for a distance of 20 metres (as set out in DCP 175) and not to introduce any impure forms of *Acmena spp*. or *Syzygium spp*. into the site through the horticultural trade for landscaping purposes elsewhere throughout the property. The removal of the unwanted intrusive *Acmena sp*. from the middle-western gully and any other gully in which it occurs.
2. To install only low level lighting against the forest edge and the dam because of the presence of foraging threatened fauna species.
3. To inspect buildings prior to demolition to ensure that no bat roosts are apparent behind battons and struts.
4. To install a number of microbat roost boxes, suitable for colonization by the Greater Broad-nosed, Southern Myotis and the other forest bats along the forest edge, equivalent to the number of hollow trees which will be removed.
5. To place restrictions for domestic dogs and cat management due to the fact that there is the potential for the Long-nosed Potoroo to become established on the site.
6. To implement best practice soil erosion and sediment control structures to protect the Freshwater Wetland EEC and Narara Creek.
7. To ensure that procedures for tree pruning minimize environmental impacts to threatened fauna.

Based on the above mitigation measures and the ecological restoration works for the NEV site, the application is unlikely to have a significant impact on threatened species or their habitat.

Section 79C

The proposed development has been assessed and evaluated against the relevant heads of consideration pursuant to Section 79C of the Act. Section 79C of the Act requires the following matters be considered in the assessment of the proposed development.

> *79C Evaluation*
>
> *(1)* ***Matters for consideration—general***
>
> *In determining a development application, a consent authority is to take into consideration such of the following matters as are of relevance to the development the subject of the development application:*
>
> *(a) the provisions of:*
>
> *(i) any environmental planning instrument, and*
>
> *(ii) any draft environmental planning instrument that is or has been placed on public exhibition and details of which have been notified to the consent authority (unless the Director-General has notified the consent authority that the making of the draft instrument has been deferred indefinitely or has not been approved), and*
>
> *(iii) any development control plan, and*
>
> *(iiia) any planning agreement that has been entered into under section 93F, or any draft planning agreement that a developer has offered to enter into under section 93F, and*
>
> *(iv) the regulations (to the extent that they prescribe matters for the purposes of this paragraph), that apply to the land to which the development application relates,*
>
> *(b) the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality,*
>
> *(c) the suitability of the site for the development,*
>
> *(d) any submissions made in accordance with this Act or the regulations,*
>
> *(e) the public interest.*

The key statutory and non-statutory framework reference in 79C(1) (a) is addressed in this section of the report. The assessment of the likely environmental impacts of the proposal and matters for consideration with reference to section 79C(1) (c) to (e) are addressed in **Section 5.0** of this report.

The provisions of Act and the Regulations that are relevant to the proposal are considered below.

Objects of the Act

The proposal is considered to be consistent with the objects of the Act for the following reasons:

- it promotes the orderly and economic use of the land;
- it will provide social and economic benefits to the broader community through opportunities to support additional housing and housing choices in the Gosford LGA;
- it has been designed to the heritage and significant environmental qualities of the site and will not result in unacceptable environmental impacts; and
- it is will provide an outcome that is consistent with the principles of ecologically sustainable development.

Integrated Development

As required by Section 91 of the Act, additional approvals will be required in order for the development to be carried out. The development is integrated development with respect to the *Rural Fires Act 1997* and the *Water Management Act 1997*, as set out in **Table 3** below:

Table 3: Integrated Development

Relevant Act (NSW)	Comment	Referral
Rural Fires Act 1997	As the land which is subject to the community title subdivision is identified as bushfire prone land on Council's Bushfire Prone Land Map, the application is integrated development as defined by section 91(1) of the EP&A Act and requires the consent of the Commissioner of the NSW RFS under Section 100B of the *Rural Fires Act 1997*.	The application is integrated development and referral to the NSW RFS is required pursuant to section 91A of the EP& A Act
Water Management Act 2000	Works are proposed within 40 metres of waterfront land including to regenerate the native riparian grassland alongside drainage lines within the 10m riparian buffer zone (applies to the northern gully only as first order streams, noting that the middle western gully is not a first order stream), road and infrastructure works- Refer to works illustrated in **Figure 35** below. Therefore, an approval under section 90 of the *Water Management Act 2000* will be required and the application is therefore, integrated development as defined by section 91(1) of the EP&A Act.	The application should be referred to the NSW Office of Water for consideration.

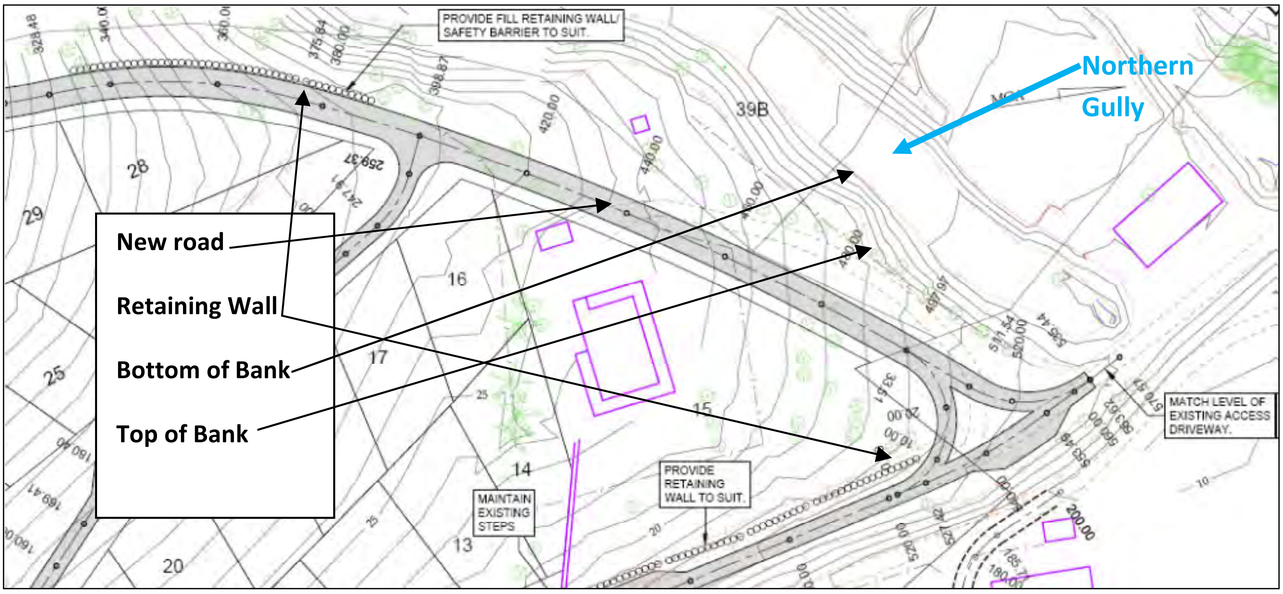

Figure 35: Works proposed adjacent to the northern gully (Source: CBH-Extract from Concept Road Grading Plan)

Designated Development

In accordance with Section 77A of the Act, designated development is development that is declared designated development by either an environmental planning instrument or the Regulations. This application includes the construction of an IWMS comprising a water recycling facility and a sewerage reticulation system. As relevant to this application, Schedule 3 of the Regulation establishes the triggers for when development of this type is 'designated development'.

Pursuant to Clause 29, Part 1 of Schedule 3 of the Regulation, the IWMS proposed for the NEV site is defined as a 'sewerage system' and therefore, is designated development. However, Clause 37A of Schedule 3 states the following:

> *"(1) Development of a kind prescribed in Part 1 is not designated development if:*
>
> *(a) It is ancillary to other development, and*
>
> *(b) It is not proposed to be carried out independently of that other development*
>
> *(2) Subclause (1) does not apply to development of a kind specified in clause 29(1)(a)."*

The IWMS is considered to be ancillary development as the dominant purpose of the development application is the subdivision of the land. The IWMS is ancillary as its entire purpose is to service the subdivided allotments and it is not proposed to be carried out independently of the subdivision of the land. We note that clause 37A(2) does not apply to the application as the sewerage system does not have an intended processing capacity of more than 2,500 persons equivalent capacity or 750 kilolitres per day. Therefore, by virtue of clause 37A of the Regulation, the IWMS is not designated development.

Voluntary Planning Agreement

Section 79C(1)(a)(iia) of the Act requires that a consent authority take into consideration any planning agreement that has been prepared pursuant to section 93 of the Act. A Draft Voluntary Planning Agreement (Draft VPA) has been prepared for the NEV site in accordance with the requirements of the rezoning process undertaken by DPI and as stipulated in Section 8.1 of DCP No.175. The Draft VPA makes specific provision for the dedication to Council of the 6(a) Open Space zoned portion of the site (being that land immediately to the east and contiguous with the 2(a) residential land), together with a small area of land upon which a stand of *Araucaria cunninghamii* (Hoop Pines) are located.

In accordance with the terms of the VPA, the Draft Plan of Subdivision prepared for this application (refer **Appendix E**) includes the creation of a single allotment (Lot 38) which incorporates the entire 6(a) Open Space zoned land and the Hoop Pines. The Draft Plan of Subdivision includes a number of encumbrances on this land to provide for easement for services and proposed access to Lot 39. A proposed right-of-way is proposed over Lot 1 to provide access to the Lot 38 as required by the terms of the VPA.

The 6(a) Open Space land is an important parcel of land for the Co-operative both in terms of its location, as it provides a contiguous link to western and eastern portion of the site and its potential to provide opportunities for community gardens and further embrace sustainable living pursuits on the site.

The Co-operative is willing to pursue further discussions with Council with respects to the potential for a land swap between the 6(a) open space zoned land and a component of the 7(a) Conservation land to the west and south-west of the transmission easement. It is understood that this 7(a) Conservation land is strategically important to the integration of the Coastal Open Space System (COSS) and provides an integral link between land currently managed by Council to the south of the site and Strickland State forest.

Alternatively, an agreement for management of the 6(a) land under license could be designed to allow the Co-operative use of the land whilst reducing maintenance and management costs to Council.

4.1.3 Water Industry Competition Act (WICA)

WICA provides the key enabling legislation which permits private sector innovation and investment in water and waste water infrastructure. WICA is supported by the Water Industry Competition (General) Regulation 2008 which sets out the matters a licence application must address, standard licence conditions and the retailer of last resort provisions.

As detailed in **Section 3.12** of this report, the Co-operative propose to lodge an application under the WICA for a retail operator's licence and network operator's licence with IPART.

It is understood that Council will be consulted as part of IPART's consideration of the application for a WICA licence. Furthermore, it is noted that the design of the IWMS may be amended and refined to respond the IPARTS's requirements.

4.1.4 Other relevant NSW Acts

A number of other NSW Acts are relevant to the application and additional approvals may be required to permit the proposed development to occur. An overview of this legislation and its relevance to the application is addressed in **Table 4** below.

Table 4: Overview of other relevant Acts

Name of Act	Comment	*Relevance of Act*
Native Vegetation Act 2003	The only vegetation clearing which will trigger the *Native Vegetation Act 2003*, is the middle western gully, where depending on discussion between Gosford City Council, the NSW Department of Water and the Hunter Central Rivers Catchment Management Authority, a small area will be required to accommodate a fire asset protection zone. At this location there is a short gully present which is not shown on the state mapping system and some native riparian vegetation will need to be removed from the southern side slope on the bank and overbank. The Co-operative notes that development consent under the *Native Vegetation Act 2003* may be required. The Minister for the Environment is the consent authority.	*The Council may refer the application to the Department of Environment, Climate Change and Water for consideration.*
Protection of the Environment Operations Act 1997	The development is too small to be a scheduled activity under the POEO Act (see Clause 36 of Schedule 1) and therefore, an Environment Protection Licence is not required.	*Not relevant to this application*
Threatened Species Conservation Act 1995	The TSC Act is the key piece of legislation in NSW relating to the protection and management of biodiversity and threatened species. The Fauna and Fauna Gap Analysis Survey Report (**Appendix J**) has identified a number of threatened species, populations, communities and their habitats which are potentially impacted by the development. The NEV site contains lowland rainforest endangered ecological community and the freshwater wetland endangered ecological community. The potential impacts of the development have been assessed through seven-part tests and have concluded that the development will not result in unacceptable environmental impacts	*The Council may consider that consultation and concurrence of the Director-General of the Department of Environment, Climate Change and Water pursuant to section 79B(3) of the Act is required.*
Roads Act 1993	Approval from the RMS under Section 138 of the *Roads Act 1993* will not be required for this development. No road works are proposed outside the boundary of the site.	*Not relevant to this application*
Pipelines Act 1967	All pipelines proposed to be constructed and associated with the integrated water management system are proposed to be contained wholly within the site. Therefore, the *Pipelines Act 1967* does not apply to require a licence, in accordance with section 5(1)(c).	*Not relevant to this application*

4.2 State Environmental Planning Policies

4.2.1 State Environmental Planning Policy (Infrastructure) 2007 (ISEPP)

Clause 104

Clause 104 of ISEPP relates specifically to the referral of certain development applications to the RTA (now RMS) prior to their determination based on these developments being defined as ‘traffic generating development’ in Schedule 3 of the SEPP. With respect to subdivision of land, Schedule 3 of the SEPP specifies that referral to the RMS is required for ‘200 or more allotments where the subdivision includes the opening of a public road’. As the proposal is limited to a 40 lot subdivision, referral to the RTA is not considered to be warranted in the circumstances, as the proposal is not considered to meet the other relevant size or capacity requirement.

Clause 105

Pursuant to Clause 105 of ISEPP, the integrated water management system proposed to be constructed on the NEV site is considered a 'water recycling facility' and a 'sewer reticulation system'. As the IWMS is not being carried out in a prescribed zone defined in Clause 105 of the SEPP, pursuant to Clause 106 of the SEPP development consent is required. It is noted that such works are only permitted to be carried out in a prescribed zone where the proponent is a public authority or a person is licensed under the WICA.

4.2.2 State Environmental Planning Policy No.55- Remediation of Land (SEPP 55)

SEPP 55 aims to provide a state wide approach to the remediation of contaminated land. In particular, SEPP 55 aims to promote the remediation of contaminated land to reduce the risk of harm to human health and the environment by specifying under what circumstances consent is required, specifying certain considerations for consent to carry out remediation work and requiring that remediation work undertaken meets certain standards.

As outlined in Section 3.3, a PSA Report has been prepared by Douglas Partners and is included at **Appendix F**. The Stage 1 PSA Report has identified and assessed key areas of environmental concern and provided advice on the need for further site investigations and management, in order to ensure that the requirements of SEPP 55 have been satisfied.

The Stage 1 PSA Report has identified that there is a low to moderate risk of contamination across the site. Given the sites former use as a horticultural institute, the site has been subject to potentially contaminating activities and land uses. Subsequently, a number of areas of higher contamination potential and areas of environmental concern have been identified by Douglas Partners and will require further site investigations.

In order to inform the remediation process, Douglas Partners has recommended that a Sampling and Analysis Quality Plan be prepared followed by a Phase 2 Environmental Site Assessment and a Remediation Action Plan. In accordance with the requirements of DCP No. 175, a Site Audit Statement will be issued for the site prior to the issue of a construction certificate for the Stage 1 works including road and servicing infrastructure.

4.2.3 State Environmental Planning Policy No. 19- Bushland in Urban Areas (SEPP 19)

The general aim of SEPP 19 is to protect and preserve bushland within areas referred to in the SEPP, this includes the Gosford LGA. Relevant consideration of the SEPP 19 has been provided in the Compliance Table for DCP 112- Residential Subdivision. Reference should also be made to the Flora and Fauna Gap Analysis Survey Report at **Appendix J**.

4.3 Key State Policies, Plans and Guidelines

4.3.1 Central Coast Regional Strategy

The Central Coast Regional Strategy sets out the NSW Government position to guide sustainable growth and economic development within the Central Coast for the period 2006 - 2031. The Strategy incorporates the Gosford LGA.

The implementation of the Strategy is through the Action Plans outlined in the NSW State Plan. The key aims of the Strategy, as relevant to the NEV site are to:

- provide 56,000 new dwellings by 2031 in order to accommodate an additional 100,000 people expected in the Region by 2031;
- ensure that there is an adequate supply of land strategically located to support economic growth and the capacity for an additional 45,000 new jobs by 2031;
- increase densities and revitalise areas around major centres and towns to provide housing choice and to support economic growth in accessible locations;
- provide housing choice including more units and townhouses in key centres to provide a better housing mix; and
- promote a Regional City at Gosford focusing on business activity, housing opportunities and employment generation.

The Strategy also provides detailed objectives for Gosford as a Regional City. This includes a target of 6,000 additional dwellings and 10,000 additional jobs. The Strategy estimates that existing and planned urban areas within the entire Central Coast Region can supply approximately 56,000 dwellings to 2031.

The NEV site is strategically located to contribute both to the housing and job targets included in the Strategy. The Concept Plan for the NEV site incorporates opportunities for a range of housing types and short term and long term employment opportunities link both to the construction and occupation phase. It is expected that the NEV site can provide for a total of approximately 400 future residents, with ability for 50 future jobs.

The NEV site is identified as the only 'urban release area' in the Draft Gosford Local Environmental Plan 2013 and therefore, this development plays an important role in contributing to the key the aims and objectives underpinning the Central Coast Regional Strategy.

4.4 Local Environmental Planning Instruments

4.4.1 Gosford Planning Scheme Ordinance

The key provisions included in the GPSO of relevance to the NEV site are considered in the Compliance Table provided at **Appendix Z**. In summary, the proposal is consistent with the key provisions in GPSO as detailed below:

- The development proposed in this application is permitted with consent pursuant to the provisions of Part III of GPSO.
- The allotment sizes proposed for the 2(a) land comply with the provisions of Clause 30AAA.
- The application seeks consent for demolition, as required by Clause 26C of GPSO.
- The application is supported by a Heritage Impact Statement and therefore, satisfies the requirements of Clause 49T of GPSO.

With respect to Clause 49U of GPSO, which sets out the requirements for subdivision and regional transport infrastructure, the application will result in the urban intensification of the 2(a) zoned land.

Accordingly, the provisions of Clause 49U(3) require that the subdivision of the land must not be granted by Council for the additional allotments proposed unless 'satisfactory arrangements' have been made to contribute to the provision of regional transport infrastructure and services.

The Co-operative advises that a Memorandum of Understanding (MOU) was executed between the then Minister for Primary Industry and the then Minister for Planning on 18th August 2008 setting out the requirement for the rezoning of the site (which will enable it to be subdivided into 121 residential allotments and 5 rural residential allotments) to be subject to the payment of a regional infrastructure contribution. The MOU establishes that an amount of $567,000 will be paid by the Minister for Primary Industry to the Minister for Planning 7 days before the settlement of the sale of the Property.

The Co-operative has made enquiries to the DPI regarding this matter. The DPI is yet to confirm whether or not the contribution has been paid and therefore, whether 'satisfactory arrangements' have been made to contribute to regional transport infrastructure.

4.4.2 Gosford City Council Interim Development Order No.122

The key provisions included in Gosford City Council Interim Development Order No.122 (IDO 122) of relevance to the NEV site are considered in the Compliance Table provided at **Appendix Z**.

In summary, the proposal is consistent with the key provisions in GPSO as detailed below:

- The application proposes the subdivision of the 7(c2) land to created an allotment with an area of 5.534 hectares. The allotment size therefore complies with Clause 18(3)(e).
- The application proposed the subdivision of the 7(a) land to create an allotment with an area of 34.21 hectares. The allotment size is less than the minimum allotment size stipulated in Clause 18(3)(a) of 40 hectares. However, the allotment is proposed as a single allotment reflecting the extent of the 7(a) zoning and is consistent with Clause 19, as the proposed allotment does not constitute a split zoning allotment.

4.5 Development Controls Plans

4.5.1 Development Control Plan No.175- Gosford Horticultural Institute Rezoning

DCP 175 is the key DCP which applies to the NEV site. The stated purpose of this DCP is *"to provide more detailed guidelines for the development and use of the land for a residential subdivision into approximately 120 lots, approximately four rural residential lots to be zoned Scenic Protection Rural Small Holdings 7(c2), and one residue rural residential lot to be zoned Conservation 7(a) or other permissible development".*

Section 6 of the DCP requires that where a development application is lodged which relates to land to which this Plan applies, Council shall take the provisions of this Plan into consideration in determining that application.

The key provisions included in DCP 175 of relevance to the application are considered in the Compliance Table provided at **Appendix Z**.

4.5.2 Development Control Plan No. 112 – Residential Subdivision

The key provisions included in Development Control Plan No.112- Residential Subdivision (DCP 112) of relevance to the NEV site are considered in the Compliance Table provided at **Appendix Z**.

4.5.3 Development Control Plan No.5 – Narara

The objectives of this Development Control Plan are as follows:

a*) Encourage orderly development of urban land in the most economic and unconstrained manner*

b) Enhance the residential amenity as a living environment, having regard to the local environment and life styles of people.

c) Provide for the accommodation of adequate community and recreation facilities and services.

d) Encourage maximum desirable utilisation of the land for residential purposes in close proximity to community, recreation and transport facilities.

e) Encourage multi-unit type development to take advantage of developable land, the natural setting and reducing the land cost component of housing.

f) Integrate areas with the existing suburban and rural settlement patterns.

g) Facilitate the flow of through traffic along arterial and sub-arterial routes with minimum disruption to residential areas.

h) Protect and preserve any attractive or significant features of the environment, eg retain prominently located trees.

i) Facilitate the flow of stormwater along drainage lines and retarding basin areas.

j) Minimise any likely adverse effects of development.

k) Provide a system of pedestrian footpaths integrated with areas of open space, playgrounds and passive recreational uses.

l) To ensure that development takes account of the existing physical constraints of the land.

m) To promote development in harmony, rather than in conflict, with the environment.

This proposal is consistent with the aims of DCP 5 by providing for development which complements existing development and will not place additional demands on infrastructure or natural resources. The technical reports which support that application demonstrate that the proposal will result in a suitable use of the land, will provide opportunities for a range of housing types and will minimise likely environmental impacts.

4.5.4 Development Control Plan No. 89- Scenic Quality

The objectives of the Development Control Plan in relation to the Narara Creek Geographic Unit are as follows:

a) Restrict zoning density of development to current levels on higher slopes, particularly Steep Land zoned areas.

b) Opportunities for increases in densities and scale are available in areas not subject to visibility constraints or other physical constraints. Visually constrained land includes lands on higher slopes.

c) Maintain broad patterns of land use within area to ensure protection of landscape diversity and in particular Scenic Protection and Conservation areas.

d) Recognise importance of Brisbane Water Escarpment with its visual integrity and naturalness being valuable assets which need to be protected from development involving rezonings which increase development densities and/or increase the range of uses permissible.

e) Continue to attempt to secure lands identified for inclusion in the Coastal Open Space System as part of the visual landscape.

f) Retain current subdivision standards in scenic protection zoned areas to ensure continuing dominance of landscape features over built environment.

g) Recognise importance of privately owned Conservation zoned land in providing a complimentary land system to and a buffer area for COSS lands.

This proposal is consistent with the objectives of the DCP. The Draft Plan of Subdivision proposes that the residential subdivision be limited to the already cleared sections on the lower slopes of the site, thereby maintaining the landscape diversity and scenic qualities of the 7(a) and 7(c2) zoned land (albeit that these zones also have limited dwelling entitlements). Opportunities for the NEV site to contribute to the COSS have been outlines in Section 4.1.2 above.

4.5.5 Development Control Plan No. 115- Building on Flood Liable Land

The objectives of this Development Control Plan are as follows:

a) To bring to the attention of the community, Council's policy in relation to building on flood liable land in the area.
b) To insist that buildings and other structures built in flood liable areas are designed and constructed to withstand the likely stresses of the highest probable flood.
c) To limit building that may reduce the ability of the flood plain, and in particular the floodway, to carry water and subsequently add to the height of floods.
d) To minimise the financial burden to owners of flood liable land and to the general public.
e) To reduce flood losses by restricting and controlling building so that it is less susceptible to flood damage and minimises risks to residents and those involved in rescue operations during floods.

The subdivision layout has been designed in consideration of potential flooding impacts. As illustrated in **Figure 36** below, the residential lots and the community association land are located well to the west of the 1 in 100 year flood level. The flood affectation is principally restricted to the 6(a) land.

The 1 in 100 year flood level does impact the western edge of the Lot 39 comprising the land zoned 7(c2). Notwithstanding this, the topography of the land in conjunction with the size of the lot can ensure that dwellings are sited 0.5 metre above the 1% AEP flood level to achieve 0.5 metre freeboard in accordance with the requirements of DCP 175.

Having regard to the above, it can be concluded that the subdivision of the land and its future development will be largely unaffected by flooding and complies with the provisions of DCP 115. No flood mitigation measures are proposed as part of this application.

Dambreak

The existing dam on the NEV site was built in 1985 and was historically used for irrigation of the Narara Horticultural Research Station. The dam is built on a creek tributary that drains into Narara Creek. The local catchment area for this tributary covers an area of 159.20ha.

A number of studies were commissioned by the NSW Primary industries to support the rezoning and sale of the NEV site. The studies were undertaken by NSW Department of Commerce, Dams & Civil Section and were prepared to simulate and assess the failure of the dam and the possible downstream flooding impacts.

A more recent study undertaken in November 2011 by NSW Public Works re-examined the flood consequences utilising updated modelling results. The Study concluded that under various cases or scenarios (ie. sunny day dambreak, 1 in 100 AEP Flood both with and without dambreak, and dam crest flood both with and without dam break) the risk of dam failure and downstream flooding was found to create minimal additional flood affects. Furthermore, a sunny day dambreak event was found to have no flood effects on the Population at Risk largely as the floodwater remain in channel and within its local floodplain.

As a consequence of these recent findings, it can be concluded that the 2(a) zoned land on the NEV site will be unaffected by a dam break. No further dam break analysis has been prepared to support this application. As the 1:100 year floor level is located to the east of the residential lots well within the 6(a) land, flood inundation to the residential lots and STP as a result of dam failure or flooding is unlikely.

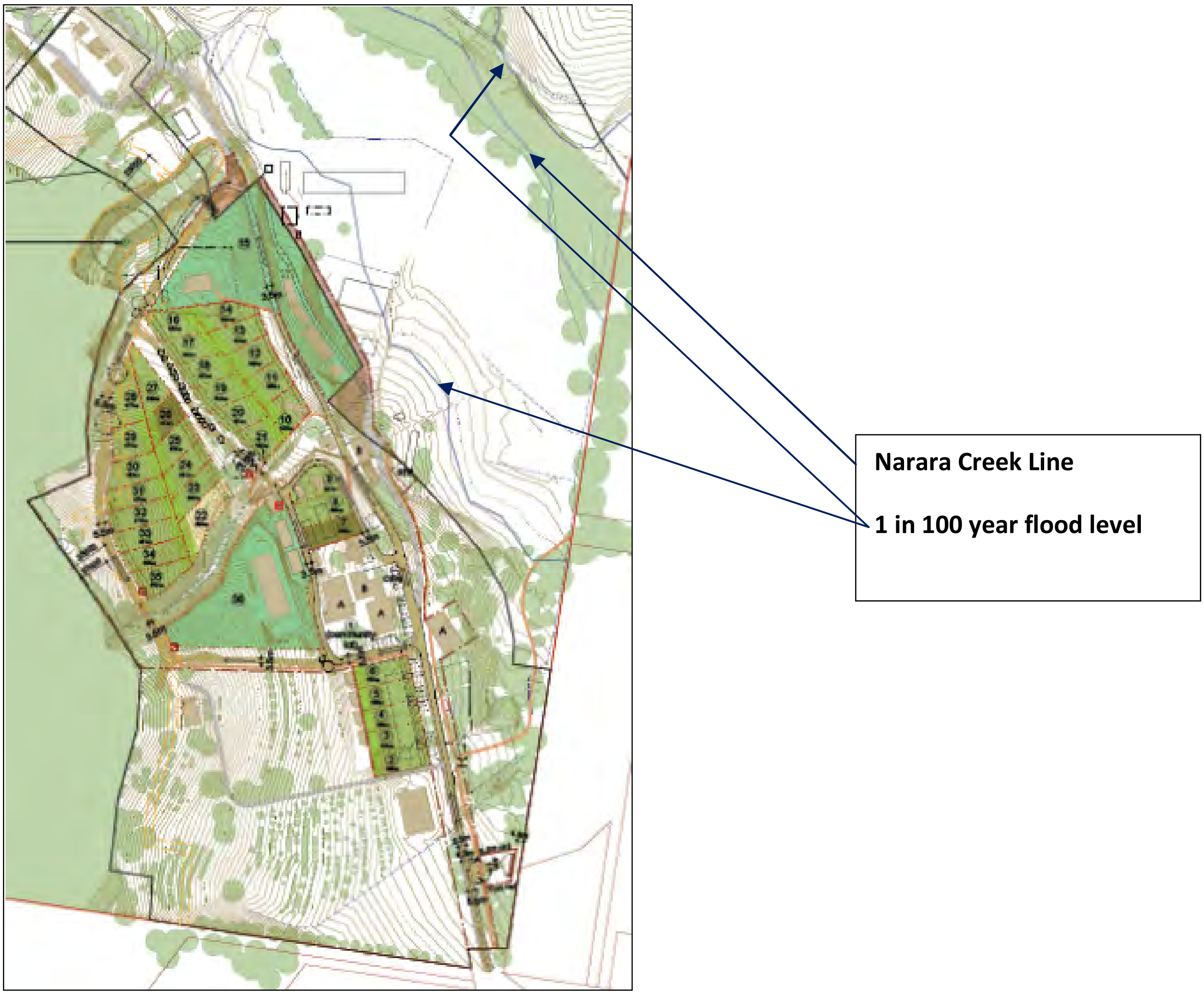

Figure 36: Location of 1 in 100 year flood level on NEV site.

4.5.6 Development Control Plan No. 159 – Character (Narara)

Development Control Plan No.159- Character (DCP 159) establishes the future desired character for the broader Narara Area. The NEV site is identified as Narara 14 (scenic buffers) and Narara 15 (scenic conservation). DCP 159 stipulates that the future desired character for the NEV site should preserve its rural-residential character and its ecological and scenic qualities.

The proposed subdivision of the site meets the aims of this DCP in that the vegetated slopes will be maintained and there will be minimal impact on scenic quality. The subdivision will not facilitate the future development of the western slopes or northern part of the site and therefore, there will be no loss of the scenic or the ecological qualities of these areas. In this regard, development is proposed on the lower slopes that are not vegetated and whilst the proposed development will increase the number of buildings on the site, the impact on scenic quality will be minimal given that the majority of vegetation will be retained and will be embellished as part of the site redevelopment. As such, it is considered that the proposed development can be accommodated without unacceptable changes to the perception of the site as viewed from major viewing points.

Consistent with the desired future character for Narara 14 and 15, the proposal will achieve the following:

- It will maintain the ecological values of the site including the habitat values and informal scenic quality, by limiting residential subdivision principally to the cleared areas of the site.
- Whilst providing for a variety of housing types, the predominant development will be low density- residential development. The rural character of the 7(c2) zone will be preserved. Therefore, the scale of development will be consistent with the prevailing scale of development in neighbouring areas.
- It will allow for the development of the NEV site with minimal site intervention including hazard reduction clearing to achieve APZ's, minimising the extent of cut/fill and landform modification.
- It will provide for the implementation of an Ecological Restoration Plan which aims to eliminate noxious weeds and to plant trees which are predominantly indigenous to complement the established tree canopy.
- It will enable the future development of the site in accordance with the Hill Thalis Design Report which establishes the design principles which are in keeping with the future desired character for Narara. These principles include:
  - Providing generous rear setbacks to create consolidated bands along the contour gardens across each block thereby contributing to the landscape quality of the site and complementing the established tree canopy.
  - Limiting the footprint and size of all houses to minimise energy consumption and resource, so that the landscape becomes pre-eminent.
  - Source low embodied energy, recycled or recyclable plantation or certified materials as the predominant construction materials for dwellings.

For the above reasons, the application is considered to be consistent with the provision of DCP 159.

4.5.7 Other Development Control Plans

A number of other development controls plans are relevant to the application and have been considered in the various technical reports and documents which support this application, as detailed in **Table 5** below. Consideration should be given to these technical reports and documents with respect to compliance with the relevant DCP provisions.

Table 5: Other Development Control Plans

Relevant Development Control Plan (DCP)	Relevant reference within SEE
• **DCP No. 111** - Car Parking (Amendment No 1)	Refer to Transport Impact Assessment at **Appendix W**.
• **DCP No. 106** - Controls for Site Waste Management	Refer to Waste Management Plan at **Appendix V**.
• **DCP No. 165** - Water Cycle Management (Amendment 1) and related WCM Guidelines	Refer to Integrated Water Management Plan at **Appendix S**.
• **DCP No. 163** - Geotechnical Requirements for DAs	Refer to Stage 1 Preliminary Geotechnical Report at **Appendix L**.
• **DCP No. 122** - Cut and Fill Restrictions	Refer to Concept Road Grading Plans at **Appendix N** and the Concept Engineering & Public Utilities Report at **Appendix P**.

4.6 Draft Gosford Local Environmental Plan 2013

The key provisions included in Draft Gosford Local Environmental Plan 2013 (Draft GLEP 2013) of relevance to the NEV site are considered in the Compliance Table provided at **Appendix Z**. In summary, the proposal is consistent with the key provisions in Draft GLEP 2013 as detailed below:

- The development proposed in this application is permitted with consent pursuant to the Land Use Tables.
- The allotment sizes proposed comply with the provision of Draft GLEP 2013 and are not subject to the minimum lots sizes stipulated in Clause 4.1 (ie. the minimum lots size provisions do not apply to community title subdivision).
- The application seeks to preserve trees and development consent is sought for tree removal in accordance with Clause 5.9.
- The application is supported by a Heritage Impact Statement and therefore, satisfies the requirements of Clause 5.10.

With respect to Part 6- Urban Release Areas of Draft GLEP 2013, the NEV site is identified as the only urban release area. The following comments are relevant with respect to the consideration of these provisions:

- **Clause 6.1-** the discussion in section 5.3.1 above, remains relevant with respect to the making of 'satisfactory arrangements' to contribute to the provision of regional transport infrastructure and services.
- **Clause 6.2**- the development seeks approval for infrastructure provision to service the urban release area. The application demonstrates that adequate arrangements can be made to service the NEV site.
- **Clause 6**.3- the application proposes that the development of site occur in a logical and cost-effective manner, in accordance with a staging plan and principles included in the Hill Thalis Design Report. Whilst a DCP has not been prepared, the Hill Thalis Design Report is considered to adequately address the staged development of the NEV site and those specific matters listed in subclause 3.

4.7 Draft Gosford Development Control Plan 2013

The development controls included in Draft Gosford Development Control Plan 2013 (Draft GDCP 2013) are consistent with those contained in the current range of DCP's which apply to the NEV site and which have been addressed in section 4.3 above. For this reason, further consideration of Draft GDCP 2013 is not warranted.

5.0 Environmental Assessment

This section of the report includes discussion and assessment of the key issues and matters for consideration pursuant to Section 79C(1)(b) to (e) of the Act. These matters for consideration include the likely environmental, social and economic impacts of the development, the suitability of the site for the development, and the public interest.

These matters for consideration are addressed separately below, as relevant to the proposal.

5.1 Subdivision Layout and Urban Design

5.1.1 Subdivision Layout

The subdivision layout illustrated in the Hill Thalis Design Report at **Appendix B** has been informed by a detailed site analysis. The lot layout has been devised to create a variety of housing lots whilst responding to the aspect and the topography of the site. This has resulted in a range of residential lots sizes, a network of open space through the site and the road network which build on the existing road pattern and responds to the requisite lot access and the servicing requirements of the site. This analysis has underpinned the final subdivision proposal detailed in the Draft Plan of Subdivision (**Appendix E**) and the key elements of the subdivision, as follows.

- To minimise the modification to the landscape including the extent of cut and fill by arranging the allotments to conform as closely as possible with the existing landform features, including the terrace nature of the site and the established road network;
- To maximise the northerly aspect and to configure lots to maximise the potential for solar access to future dwellings;
- To maximise the opportunity for a variety of housing forms by proposing a range of allotment sizes;
- To maximise site amenity and appreciation of the environmental qualities of the site including the gully, surrounding bushland and views across the valley;
- To establish APZ with minimal impact to bushland and to ensure the preservation of the landscaped character of the site;
- To incorporate common gardens as a key element of the open space and access network through the site and secure their provision through easements on title; and
- To establish an identifiable landscape concept for the accessways through the site including to retain significant existing vegetation and to provide for the dual use of the landscape street verges as part of the integrated water management on-site by utilising water sensitive urban design principles.

The lot layout has been designed having regard to the objectives DCP 112- Residential Subdivision, which are:

(a) to ensure that residential land developed for subdivision is done so in an efficient and orderly manner;
(b) to ensure that all lots created are satisfactorily serviced by infrastructure;
(c) to maximise development potential of residential land whilst retaining any significant environmental characteristic that may occur on the land;
(d) to encourage a variety of allotments to cater for different housing needs.

The Stage 1 DA is considered to meet the intent of the above objectives for the following reasons:

- The subdivision of the site in accordance with the proposed development stages (Sheet 2.21 **Appendix A**), ensure the site is developed in a planned and orderly manner. The application proposes that all allotments have frontage to a street and are integrated with the planned network of open space and accessways through the site. All allotments are readily accessible to common car parking areas and other group facilities including mail and garbage.
- The upfront provision of utility services and essential infrastructure will ensure that the development of the allotments can occur in an efficient and co-ordinated manner. The infrastructure provision proposed in the application is essential to service Stage 1 of the development and to provide the foundation for the future amplification of the systems and networks to services future Stages 2 and 3 in the development of the NEV site.

  The provision of the IWMS is a fundamental component of the site infrastructure. Its staged implementation, will provide for an environmentally sustainable system of the water management. The IWMS is proposed to be implemented in stages to respond to the anticipated site demands for water and sewer services and to ensure it is economically feasible.
- The subdivision layout has had regard to the key environmental and heritage qualities of the site. Importantly, all significant vegetation identified on the site has been retained and the residential subdivision has largely been restricted to the cleared sections of the site. Appropriate management and mitigation measures have been recommended by the project appointed arborist to minimise impacts as a result of construction on existing vegetation. Significant landscaping works and ecological restoration works are proposed as outlined in sections 3.8 and 3.10 of the SEE to improve the ecological quality of the site.
- The impact of the subdivision on the heritage values have been minimised through the lot layout and importantly, opportunities for the future siting of development. The allotment sizes and configuration have taken into account curtilages to all heritage items and groups of significant trees.
- The subdivision layout has been designed to conform with the existing features including the road layout and the site topography. This has ensured that the impact of the subdivision on the environmental characteristics of the site have been minimised. This approach has result in the extent of cut and fill on the site being minimised to accommodate the subdivision layout. Consequentially, the visual impact of the subdivision has been minimised, with significant bushland to the north and west of the site being retained.
- The subdivision design includes a range of allotment sizes and configurations to provide opportunities for a range of housing options as currently permitted under GPSO. Typically, the residential allotments will accommodate single dwelling houses with opportunities for dual occupancy development. The Hill Thalis Design Report establishes the design principles for the placement of houses on allotments and to establish that all houses design must be based on the principle of environmental sustainability, incorporating passive solar design and the sustainable use of energy and resources.

  The Stage 1 application includes provision for two cluster housing developments, which are currently being considered by Council.

  Therefore, it is considered that the application provides sufficient opportunities for a variety of housing types and complies with the key objectives of the DCP.

Further matters in relation to lot layout have been detailed in the Compliance Table at **Appendix Z** and the Hill Thalis Design Report at **Appendix B**.

5.1.2 Crime Prevention Through Environmental Design

The subdivision layout has been informed by the CPTED principles of natural surveillance, access control, territorial reinforcement and space management. The design and layout of the lots appropriately respond to the CPTED principles of reducing the potential for crime and increasing perception that the development provides a safe environment. From a design perspective, crime deterrence on the site has been achieved by the following initiatives:

- providing opportunities for clear sightlines and for passive surveillance between the community association land (proposed Lot 1) and private realm (each dwelling lot);
- providing opportunities for effective lighting of the common areas during evening hours;
- incorporating landscaping that will make the place attractive and will complement existing site landscaping, but does not provide offenders with a place to hide or entrap victims; and
- providing clearly defined paths of travel between dwelling lots, car parking and the common areas.

In addition to the above, the planned road and pedestrian network through the NEV site, is anticipated to be well utilised by residents and visitors of the ecovillage, thereby reducing opportunities for crime including to deter opportunities for vandalism and graffiti.

Having regard to the above, it is considered that the development adequately addresses the CPTED principles.

5.1.3 Objectives of the Local Controls

As demonstrated in the Compliance Tables at **Appendix Z**, the application complies with the key objectives and policy controls of Council's development controls plans which are applicable to the NEV site and the nature of the development. The application is considered to provide an appropriate and well considered response to the site conditions and the surrounding context.

5.2 Geotechnical and Slope Stability

5.2.1 Geotechnical

Douglas Partners has undertaken a preliminary assessment of the geotechnical condition of the site (refer **Appendix L**). The Report outlines the findings of field work investigations which included 7 borehole tests in the area of the Stage 1 subdivision, laboratory testing and engineering analysis. The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide indicative site classifications and pavement thickness designs for the new roads.

The report advises that the site is located in an area mapped as Terrigal Formation which typically comprises sandstone with minor siltstone and claystone and is also located in an area mapped as having no known occurrence of acid sulfate soils. Within the Stage 1 area, the surface conditions generally encountered in the bores consisted of filling and/or topsoils to 0.2-0.6 metres underlain by firm or stiff sandy clay and silt or medium dense clayey sand/silty sand to depths of up to 1.8 metres. This was further underlain by stiff through to hard clay over the remaining depth of the investigation.

The result of clay testing on the site indicates that the natural clay soils on the site are slightly to moderately susceptible to shrinkage and swelling movements associated with variations in soil moisture content but that they do not undergo significant loss in strength following saturation. The tests undertaken were carried out in accordance with AS1289.6.3.2 to provide information on the relative strength and densities of the soils and to test the reactivity of the soil, standard compaction and field moisture content to provide indicative site classifications in accordance with AS2870-2011: *Residential Slabs and Footings*.

The results of the testing have informed the recommendation for the engineered design of road network and infrastructure. These have included specific recommendation in relation the following:

- site preparation;
- anticipated subgrade conditions;
- the design of subgrade CBR Values;
- design traffic loading;
- subsurface preparation;
- flexible pavement thickness design;
- material quality and compaction requirements; and
- drainage requirements.

The investigations indicate that the geotechnical conditions of the Stage 1 site can accommodate the development. Further site investigations are recommended at the construction certificate stage when the detailed engineered design for the project will be finalised.

5.2.2 Groundwater

The geotechnical investigations undertaken by Douglas Partners, as outlined in section 5.2.1 above, did not encounter any ground water within the borehole testing undertaken on the site. Given the limited extent of the excavation proposed, particularly adjacent to the floodplain (ie. 6(a) zoned land), it is unlikely that any works will result in the groundwater being intercepted.

5.2.3 Slope Stability

Douglas Partners has also prepared a Slope Stability Assessment Report to provide a broad overview of slope instability issues associated with the Stage 1 site. As detailed in Section 2.0, the topography of the site is varied and ranges in slope from 10-18^{O} in the higher western area falling to 5-10^{O} in north-eastern area of Stage 1. For the purposes of this report, Douglas Partners has based the slope classifications for the subdivision on Tables M1 and R1 within DCP 163 (Geotechnical Requirements for DA's), which applies to sites underlain by sandstone sequences of the Terrigal Formation.

Based on the site conditions observed, Douglas Partners has advised of the following:

- the northern group of residential lots and part of Lot 15 have slopes ranging from 5^{O}-10^{O}. The slope is therefore classified as Category 1- Low Hazard Area.
- The residential lots that are located away from the existing gully and do not include existing building terraces, fall to the north-east at about 12^{O} – 15^{O}, and are classified as Category 2- Medium Hazard Area.
- A number of areas across the site which include retaining walls and batters and lots that are located close to the inner western gully are classified as Category 3- High Hazard Areas.

The slope classifications across the site are illustrated in **Figure 37** below. In accordance with DCP 163, those sites which have been assigned a classification of either Category 2 or 3 will be subject to further slope stability assessment and risk assessment at the individual DA stage.

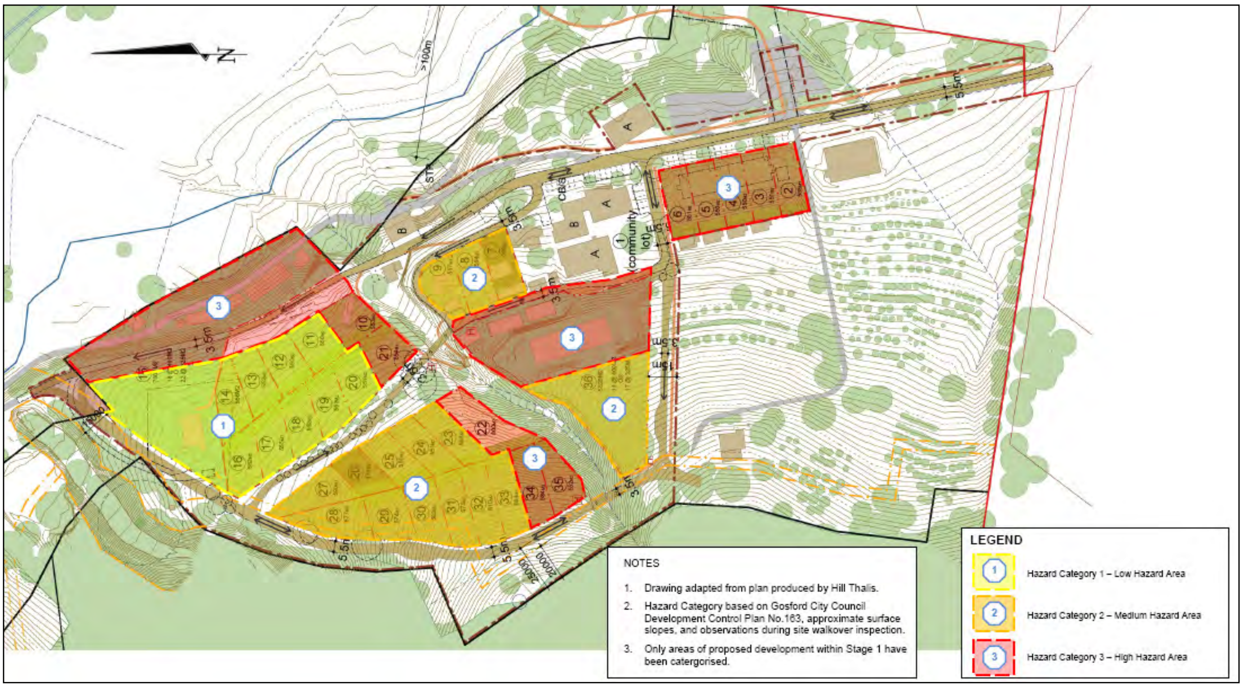

Figure 37: Slope Classifications across the Stage 1 site.

In order to counteract slope instability issues, including those associated with soil creep and slumping/wash away/local slip of cuttings and embankments, Douglas Partners has recommended that the batter slopes at the site should be as follows:

- 2.5H:1V within controlled fill;
- 2.5H:1V within existing filling and alluvial/colluvial soils; and
- 2H:1V within stiff residual clay.

The above recommendations have been incorporated into the project design for the Stage 1 infrastructure works as illustrated in the Concept Road Grading Plans prepared by Chase Burke Harvey (**Appendix N**).

5.3 Contamination

Matters in relation to site contamination and compliance with SEPP 55 have been addressed in Section 4.2.2 of this report. Reference should also be made to the Phase 1 Preliminary Site Assessment prepared by Douglas Partners at **Appendix F**.

5.4 Stormwater Management

The stormwater management strategy (stormwater strategy) for the site has been prepared by Woodlots & Wetland and is included in the Integrated Water Cycle Management Plan at **Appendix S**. Concept Stormwater Plans and Erosion and Sediment Control Plans have been prepared by Chase Burke Harvey to reflect the stormwater management strategy and are included at **Appendix Q** and **Appendix R,** respectively.

The stormwater strategy is based a Water Sensitive Urban Design (WSUD) approach to manage stormwater quality and quantity. The key components of this approach include:

- Roof water capture, disinfection and re-use within individual dwellings;
- Bio-retention systems to provide significant water quality treatment to runoff from impervious areas while at the same time providing additional stormwater detention; and
- WSUD features, including swales, to convey stormwater and to ensure peak flows and contaminant loads are reduced to achieve compliance with Council's stormwater treatment requirements.

Stormwater modelling using MUSIC Version 5 has been undertaken. The stormwater modelling demonstrates that the proposed stormwater system will meet the performance criteria of DCP 165 with the stormwater outflow volume being reduced by 81% and the peak flow rates reduced by 51% when compared with current conditions. Additionally, contaminant loads were shown to meet the performance targets presented in DCP 165.

Stormwater management also includes measure to avoid damage to gullies and streamlines. It is proposed that discharge points be protected with a combination of turf reinforced meshing and rock riprap, as illustrated in the Concept Stormwater Plans at **Appendix Q**.

The Concept Stormwater Plans illustrate the proposed layout for the stormwater system and its components. These plans illustrate that the majority of the system (pipes and swales) is designed to run parallel with the road network (i.e. within the 1.2 metre servicing corridor) in order to minimise site disturbances and requisite excavation.

Through the implementation of the measures proposed in the stormwater strategy, the proposal can ensure a safe and ecological sustainable environment and will comply with DCP 165 and Council's Water Cycle Management Guidelines.

5.5 Integrated Water Management System

5.5.1 Design

The key components of the IWMS have been detailed in **Section 3.6** of this SEE and are located in **Figure 38** below. The key consideration in the siting of the infrastructure has been to maximise the efficiency of the system in addition to ensuring that the IWMS can be installed in an orderly and economic manner. This will require the staged implementation of the IWMS.

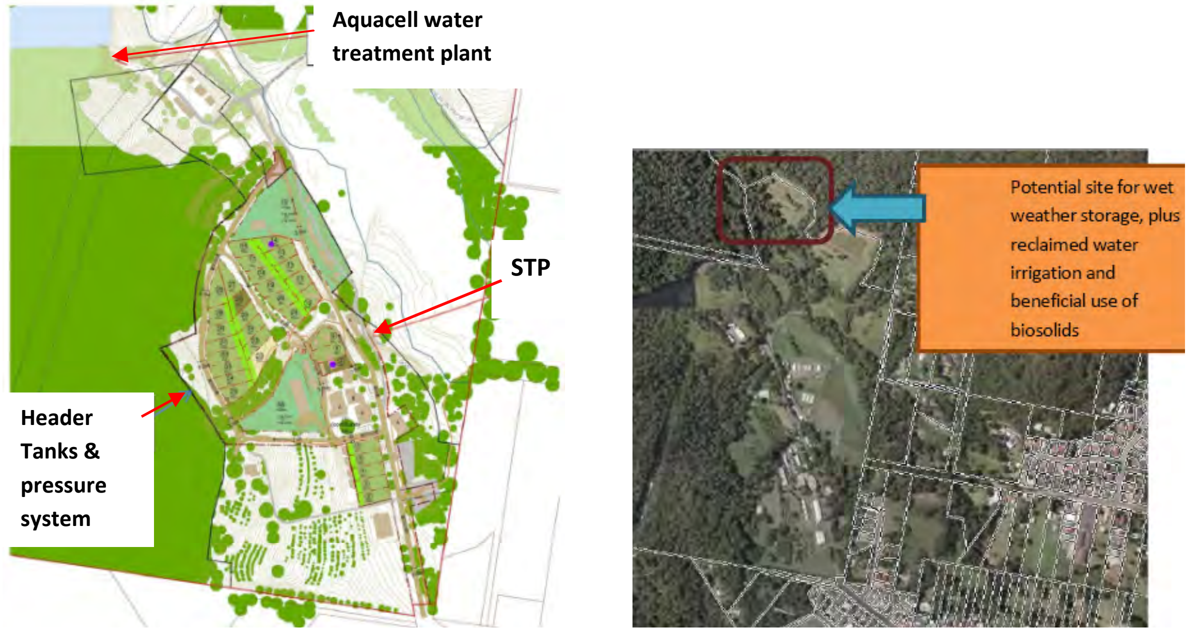

Figure 38: Location of key components of the IWMS (source: Aquacell)

Importantly, the IWMS will ensure that water and sewer management on the site is undertaken in an environmentally sensitive manner and with considerable environmental benefits to NEV site and the broader community. The modelling of the IWMS presented in the Integrated Water Cycle Management Plan at **Appendix S**, demonstrates that the staged implementation of the system is appropriate and can more than satisfy the servicing requirements of the ecovillage. The installation of the IWMS will ensure that the development will not place unreasonable demands on local services and furthermore, that appropriate human and environmental standards and safeguards can be put in place in accordance with regulatory requirements.

The final design of the IWMS will be resolved in consultation with the IPART. However, as currently proposed, the technical assessment of the IWMS indicates that it will have minimal adverse environmental impacts for the following reasons:

- The locations selected for the infrastructure are well within the NEV site and therefore, the IWMS will have minimal visual impact. Landscaping is proposed to the perimeter of the STP to ensure that it is suitably integrated within the Stage 1 site and its impact when viewed from the 6(a) land minimised. Notwithstanding this, by design, the STP is low in scale (refer **Figure 27**) and will not dominate the landscape. The location for the water treatment plant (WTP) is proposed adjacent to existing pumping station and will be suitably integrated into the setting of the dam.
- The construction footprints will not adversely affect the EEC's or threatened species identified in the Flora and Fauna Gap Analysis Report.
- No direct clearing or tree removal is required for the STP or the WTP.
- Construction can be managed to ensure impacts are controlled and appropriate tree protection zones and sediment and erosion controls measures are in place.
- Most of the pipes associated with IWMS will be integrated with the other servicing and can be sited within the 1.2m services corridor which runs parallel with the road network. This will

ensure the efficient provision of services to the individual lots and will minimise site disturbances and requisite excavation.

- The Air Quality Assessment and the Noise Impact Assessments prepared for the STP have concluded that odour and noise generated will be within acceptable limits and that there are unlikely to be adverse amenity impacts to surrounding development including within the NEV site and neighbouring dwellings- refer discussion in Sections 5.12 below.
- The capability of the landform and soil character is suitable for the IWMS- refer to further discussion in Section 5.5.2 below.

5.5.2 Water Supply

The Integrated Water Cycle Management Plan includes modelling of water demand for the site based on the estimated number of dwellings at Stage 1 and at full development and estimated water demand. The daily potable water source for the development will be derived from tank water and the dam. The modelling has considered various scenarios to ensure that water supply can be available to the development including where the dam is the sole source of water ie. there is no capture and use of roof water in the ecovillage.

The modelling shows that flows into the dam are approximately 450ML per year and it is estimated that maximum demand for potable water (i.e. without use of water tanks) will be 14.2 ML/year. The demand for water therefore, represents approximately 3% of the average annual runoff/ anticipated catchment yield. It is estimated that the dam will typically supply less than 25% of the long term demand for water within the ecovillage, equivalent to 4ML in the average year.

Having regard to the storage capacity of the dam and climatic factors, under these scenarios it has been determined that the dam in conjunction with tank water can meet the potable water needs of the development and that it is a reliable water source, subject to the water being disinfected and treated prior to use to meet Australian Drinking Water Guidelines.

5.5.3 Land Capability

The Integrated Water Cycle Management Plan includes a land capability assessment of the land proposed to be used for reclaimed water irrigation. It is estimated that during Stage 1 excess reclaimed water will need to be disposed of through irrigation. The modelling provided in the Integrated Water Cycle Management Plan indicates that the orchard area to the south of Stage 1 provides sufficient area and has suitable site attributes to accommodate the irrigation. This area is illustrated in **Figure 39** below. **Figure 39** also show the potential location of the proposed wet weather storage and irrigation proposed for Stage 2.

The land capability analysis has assessed the capability of the landform and soil character to support the proposed irrigation. Woodlots & Wetlands concludes from the analysis that the site is suitable for irrigation. It is recommended that a low pressure, low application rate, spray/drip irrigation be installed to minimise of runoff and other environmental risks. In order to minimise the environmental impacts from the irrigation, Woodlots & Wetland has also recommended that the following measures be employed:

- a contour bank be constructed to the west of the site to divert run-off from the forested areas;
- a long term strategy be developed to increase the organic matter in the soil and to increase soil structure and stability; and

- a good cover of vegetation either crops or long term pasture is critical to the irrigation areas.

Subject to the above recommendations, it is concludes that the site is suitable for irrigation and that effluent irrigation can form an appropriate strategy to eliminate excess reclaimed water. The measures recommended will ensure that the potential for environmental impacts are minimised. It is not anticipated that there will be any visual or adverse amenity impact arising from the irrigation.

Figure 10.1. Landform and soil sampling / assessment sites within the Narara Ecovillage development. (Image source: hill thalis).

Figure 39: Landform and soil sampling assessment sites (Source: Woodlots & Wetlands)

Reference should be made to the detailed discussion in the Integrated Water Cycle Management Plan prepared by Woodlots & Wetlands with respect to the design and further measures to minimise the environmental impacts of the proposal.

5.6 Flora and Fauna

An assessment of flora and fauna on the site has been undertaken by Robert Payne. This assessment has relied on previous site survey work undertaken by Andrews Neil and has supplemented the results with additional targeted survey work and site investigations. The Flora and Fauna Gap Analysis Survey Report (Flora and Fauna Report) is provided at **Appendix J.**

Based on the surveys of the NEV site, the Flora and Fauna Report has identified that the following threatened species are present or have been identified from anecdotal evidence:

- The Eastern Bent-wing Bat
- The Powerful Owl
- The Sooty Owl
- The Grey-headed Flying Fox
- Evidence of the Yellow-bellied Glider
- The Magenta Lilly Pilly
- The Red-crowned Toadlet
- The Glossy Black-cockatoo
- Black Bittern

The vegetation community present on the site includes 2 endangered ecological communities that are protected under the Threatened Species Conservation Act 1995 and the EPBC Act, as detailed Section 4.1.1 of this SEE.

Table 6 below provides a summary of the threatened species impacts from the proposal:

Table 6: Summary of Threatened Species Impacts from the proposed development
(Source: Flora and Fauna Gaps Analysis Survey Report)

Species	Identified impact on individual species
Magenta Lilly Pilly	One tree located in the 7(a) zoned land. Twenty metre exculsion zone set (see Figure 13). Second tree unable to be located. Will not be impacted.
Yellow-bellied Glider	Sap site tree found during previous AN survey and area added to Strickland State Forest. Now protected in Strickland SF.
Grey-headed Flying Fox.	Possibly feeding in orchards. Therefore maybe some loss of these feed trees. Expected minimal impact from development except for any lighting at forest edges, where some feed trees exist.
Eastern Bent-wing Bat	Would feed between and beside forest remnants. Lighting could impact feeding regime.
Little Bent-wing Bat	Would feed between and beside forest remnants. Lighting could impact feeding regime.
Eastern Free-tail Bat	Forest edges and clearing for foraging. Roosts in tree hollows. Lighting could impact feeding regime.
Southern Myotis	Feeds over dam. Requires roosts in tree hollows nearby but mayuse some of the old buildings, even culverts and bridges. Lighting could impact feeding regime.
Greater Broad-nosed Bat	Feeds over freshwater wetland. Requires roosts in tree hollows,
Sooty Owl	Requires forest areas for breeding, roosting and feeding. Minimal impact from development except for any lighting at forest edges.
Powerful Owl	Requires forest areas for breeding, roosting and feeding. Minimal impact from development except for any lighting at forest edges.
Glossy Black Cockatoo	Confined to DCP land. Large hollows found on ridge & food trees are found on dry slopes. Will not be impacted.
Red-crowned Toadlet	Confined to DCP land in ephemeral re-entrants on the ridge. Will not be affected.
Giant Burrowing Frog	Confined to DCP land in ephemeral re-entrants and wet areas on the ridge. Will not be affected.
Stuttering Frog	Prefers rainforest riparian habitats. Will not be affected.
Black Bittern	Confined to alluvial flats in wetland. Outside zone for this development application.

Endangered ecological community	Identified impact on EEC
Lowland Rainforest	Unlikely to be impacted provided infrastructure is kept well away from relevant gullies.
Freshwater Wetland	Confined to alluvial flats in wetland. Outside zone for this development application.

Further to the above, it has been identified that 10 hollow bearing trees are located on the site. It has been determined that 1 hollow bearing tree (Tree 191- refer Figure 25) will need to be removed to accomodate the development. It is recommended that the removal of this tree, whilst contrary to the provision in Section 8.3 of the DCP 175, can be suitably offset by the provision of a bat roosting box.

Based on the above assessment, the Flora and Fauna Report concludes as follows with the respect to potential impact on the Flora and Fauna on the site:

Given the fact that all of the vegetated slope and ridge area is unlikely to be compromised by the development proposed by the proponent it would be difficult to conclude a significant impact would result on threatened species and endangered ecological communities. When all matters are considered together the resources required by the known threatened species to survive are mostly captured by the slope and ridge vegetation although it is somewhat disturbed. This current disturbance is not a function of the proposed development. Following on, the likely impacts of the development on the DCP land are expected to be minimal because the impact zone is all downslope of the vegetated area and would impact through the site by way of Narara Creek only.

Based on the above conclusion, a number of actions are recommended in respect of the maintenance and development planning for the site. The actions have been included in the Ecological Restoration Plan and the Property Vegetation Plan, and as relevant to the Stage 1 works including the following:

1. Undertake weed removal around the tree of *Syzygium paniculatum* for a distance of 20 metres as set out in DCP175. Do not introduce any impure forms of *Acmena spp.* or *Syzygium spp.* into the site through the horticultural trade for landscaping purposes elsewhere throughout the property. Remove the unwanted intrusive *Acmena sp.* from the middle-western gully and any other gully in which it occurs.
2. Install only low level lighting against the forest edge and the dam because of the presence of foraging threatened fauna species.
3. During the demolition of any old buildings care must be taken that no bat roosts are apparent behind batons and struts. Care should be taken during the demolition process and if any species are found the Ecologist should be contacted for further advice.
4. At least three months prior to construction install along the forest edge a number of microbat roost boxes, suitable for colonization by the Greater Broad-nosed, Southern Myotis and the other forest bats, equivalent to the number of hollow trees which will be removed. At this stage consider establishing four bat roosting boxes one of which is to replace the tree hollow in tree 191.
5. Removal of tree No. 191 is recommended because of its location with a proposed feeder road. A tree protection zone of an estimated radius of 4.8m under AS 4970-2009 is not possible. Recommendation 9 also applies to this tree.
6. Due to the fact that there is the potential for the Long-nosed Potoroo being present establish community title for the project. Further establish a condition through a section 88b instrument that all dogs shall be on a leash at all times and cats will only be allowed within a cat run. The latter must be in place prior to accommodation.
7. During construction implement best practice soil erosion and sediment control structures to protect the Freshwater Wetland EEC and Narara Creek.

8. If in the event an Aboriginal relic is found during work procedures the location and detail is to be reported immediately to NSW OEH.
9. The following tree pruning procedure will be applicable to any tree with a hollow to minimize environmental impacts to threatened fauna. With the aid of a "Cherry Picker" inspect any vertical and horizontal hollow for the presence of nocturnal animals with the aid of a spotlight or similar.

   If no animals are found to be present then proceed to take off sections of the tree. This will be done according to best practice guidelines and with safety.

   If an animal is found to be present in the vertical or horizontal hollow then at nightfall wait for the animal to exit the hollow. Then bag the entrance to the hollows ensuring that each bag is tied securely. This will prevent the animal re-entering any of the hollows just prior to dawn.

   Next day proceed to take off sections of the tree up to a limit of three metres depth. This will be done with the supervision of an Arborist who will organize the removal of the hollow bearing stem with safety.

5.6.1 Tree Removal and Ecological Restoration

The subdivision and associated infrastructure has been designed to maximise the number of trees retained with the Stage 1 site.

Michael Shaw (**Appendix I**) has undertaken an audit of significant trees on the site. 300 trees were individually assessed and it has been determined that 65 tree will be potentially affected by the Stage 1 works, including a requirement to remove 45 of the trees. Mitigation measures have been recommended to ensure the protection and retention of all other trees.

All trees proposed to be removed have been assessed as having low to moderate arboricultural rating and have been allocated a low to moderate level of heritage significance by MUSEcape in the Heritage Impact Statement (**Appendix G**) and the Conservation Management Plan Review 2013 (**Appendix H**). The exception is Tree 244 identified in **Figure 24**, which has been allocated a high arboricultural rating. Subject to suitable replacement planting of locally endemic species to compensate for the loss of the tree, its removal is supported.

As detailed in section 3.8 and the 3.10 of the SEE, the Concept Plan for the site includes a comprehensive landscape strategy and ecological restoration works, some of which will be implemented as part of the Stage 1 works. These works are considered to result in positive ecological outcomes for the site and will more than compensate for the tree removal. In addition, these works are consistent with the anticipated environmental and ecological site improvements intended by Section 8.3 of the DCP 175 and required as result of the sites redevelopment. In accordance with DCP 175, no yellow bellied sap trees are proposed to be removed.

5.6.2 Riparian Corridor

The Ecological Restoration Plan includes works to regenerate the riparian corridor of the northern gully alongside the drainage lines within the 10m riparian buffer zone. It is also proposed to cultivate and propagate the riparian floodplain grasses, particularly *Ottochloa gracillimus* and take steps to re-introduce these grasses as a community within and beside the gully drainage lines or as part of the buffer/asset protection zone. In addition, weed removal will be undertaken to allow for the natural understorey to re-generate.

These works will have a positive impact on the environmental quality of the riparian corridor. The scope of works proposed to be undertaken in Stage 1 are outlined in the Ecological Restoration Plan (**Appendix K**) and are part of the Co-operative's strategy to improve the quality of the riparian corridor and manage the impacts associated with the subdivision of the site.

5.7 Environmental Sustainable Development

The Design Report includes opportunities for sustainable design features to be incorporated into Stage 1. These are predominantly relevant to the future development of the residential lots. Notwithstanding this, the proposal is considered to provide genuine sustainable environmental outcomes and with positive environmental benefits due to the following:

- Installation of the IWMS;
- the beneficial re-use of materials within in the site; and
- the use of materials with low-embodied energy in construction.

The sustainable environmental design features to be incorporated into the future development of Stage 1 of the ecovillage are included in sheet 4.06 of the Design Report (**Appendix B**) and include the following design principles:

- provide all houses with water tanks to locally capture rain water for productive reuse;
- provide all houses with the potential for renewable energy generation to meet energy requirements;
- select all appliances and systems based on their environmental performance;
- use materials in construction with potential of end of life recycling or which are manufactured with high levels of recycled or waste materials;
- employ both passive design and active systems which achieve best possible environmental performance, adopting the principles of long life, loose fit and low energy;
- site and design all houses to optimise the sun and minimise overshadowing or neighbours, relative to each season; and
- design all houses to maximise natural ventilation.

5.8 Heritage

5.8.1 Cultural Heritage

The Heritage Impact Statement prepared by MUSEcape to accompany this Stage 1 application and is provided at **Appendix G**. The HIS has been prepared to satisfy the requirements of Clause 49T of the GPSO. The HIS identifies the site as a place of heritage significance with historical, associational, aesthetic, social and potential archaeological, educational and technical research significance as it features some rare built and landscape elements and is representative of horticultural research facilities in coastal NSW retaining evidence of research activities spanning more than a century.

The HIS also identifies that documentary and physical evidence of the site suggests that it contains potential archaeological evidence relating to its early development including with links to the original Gosford Forestry Nursery site, the short-lived Narara Forestry School and the use of the site as an adjunct to the Gosford Farm Home. The cultural landscape is also identified as including a number of rare elements, particularly the former Manager's Residence, the former Grafting Shed /

Office building and an early glasshouse. Rare plantings include the *Pyrus calleryana* D6 type specimen and a number of mature ornamental plantings which are locally uncommon are also present on the site.

Based on their assessment of the Stage 1 proposal, MUSEcape advise that:

- The subdivision layout has retained listed heritage items and a number of existing buildings with potential for adaptive reuse, to provide environmentally sustainable orientation of new buildings and sympathetic site landscaping which enhances retained significant native vegetation and historic trees within new plantings of suitable species.
- The proposed subdivision layout is sympathetic to the cultural landscape of the site, interpreting the plantations that previously characterised the site.
- The conceptual built forms, siting, proportions and landscaping have all been designed to be sympathetic to the heritage items and at the same time environmentally sustainable in terms of their orientation, solar access and contribution to local amenity.
- The visual absorption capacity of the area is such that the proposed development can be accommodated without unacceptable changes to the perception of the site as viewed from major viewing points within the heritage items' curtilages and the former Primary Industries Institute site generally.
- The proposed landscaping will respect the cultural landscape qualities of the site and minimise impacts of new dwellings by recognising and responding to the site's topography, water movements, natural vegetation and horticultural heritage.

  The proposed landscaping will enhance the settings of new dwellings and make a positive contribution to the landscape which has become downgraded to a degree by weed invasion and relative lack of maintenance in recent years.
- Only one building, the old A-frame Glasshouse (Building 39) has been assessed as being of moderate significance in the CMP Review 103. If it cannot be relocated on site it should be archivally recorded prior to demolition. All other buildings proposed for demolition have been assessed as being of low significance.

A number of mitigation measures have been recommended by MUSEcape to reduce any adverse impacts likely to arise from implementation of the Stage 1 works. These are outlined below:

1. Designs, materials and exterior finishes of new dwelling units should be chosen to minimise visual impacts when viewed from the listed heritage items and major viewing points within the former Horticultural Institute.
2. Site to be landscaped with plant species appropriate to the locality, to meet one or more of the following requirements:
   (a) Known to be part of the original plant community;
   (b) Environmentally sustainable;
   (c) Non-invasive;
   (d) Any exotic ornamentals should be historically appropriate for the cultural landscape of the area.
3. Measures should be taken to ensure that during construction there is no runoff or spillage of concrete, adhesives or other waste from the site that might have a negative impact on heritage values or the environment generally.

4. Any existing significant trees or other vegetation to be retained should be protected during implementation of the Proposal in accordance with current best practice in arboriculture, as recommended by the consulting arborist.
5. Any major trees required to be removed for infrastructure construction to comply with relevant controls / standards should be replaced where feasible with specimens of the same species, ideally propagated from the removed trees, and planted close-by if conforming with landscape design intent or, if not, in another more appropriate location on site.
6. If the Old A-frame Glasshouse (Building 39), which has been assessed as of moderate significance, cannot be relocated on site for adaptive re-use, then it should be archivally recorded prior to its demolition.
7. An interpretive strategy should be prepared to comply with the requirements of clause 8.6(e) of Gosford DCP No.175 – Gosford Horticultural Institute Rezoning. Any interpretive devices at the entry to the site should be designed to be culturally appropriate, visually unobtrusive and located to minimise visual impacts on the heritage listed historic gate posts and name panels.
8. New way-finding, informational, safety and interpretive signage at the entrance to the site and within the site should be designed and located to minimise visual impacts on listed heritage items and the cultural landscape values generally.

Finally, MUSEscape recommends that an Archaeological Management Plan (AMP) be prepared to cover both indigenous and non-indigenous cultural heritage. Given the age and significance of the Narara site, MuSEcape has advised that is likely that any early archaeological artefacts, objects or other sub-surface material evidence that may be unearthed on the site will be of at least local significance.

It is concluded that the proposal is within the limits of acceptable change for the listed heritage items and the site generally, and any impacts are manageable.

5.8.2 Aboriginal Cultural Heritage

An Aboriginal Archaeological & Cultural Heritage Assessment Report (AA&CHA Report) was prepared for the Gosford Horticultural Research Statement rezoning in May 2006. The AA&HCA Report was commission by NSW Department of Commerce and was prepared by Danny O' Brien.

The AA&HCA Report included background data on pre-recorded Aboriginal sites for the township of Narara and its environs. Fifty-two (52) registered Aboriginal archaeological sites were found to occur, of which none were registered AHIMS Aboriginal sites located within or adjacent to the subject site.

The AA&HCA Report also included the results of field assessment and whilst fifteen (15) additional 'new' or previously unrecorded sites were identified, none of these were recorded within or immediately adjacent to the proposed development precinct (ie. the including Stage 1 are which is the subject of this application).

Based on the above findings it was concluded that the identified Aboriginal archaeological sites will not be directly affected by any future development, as these sites are not located within the proposed developable precincts of the subject site. It was also advised that the Darkinjung Local Aboriginal Land Council had no objection to the future development of the developable precincts identified at the rezoning stage. The development area identified in the Concept Plan and the Stage

1 DA remains consistent with the development precincts identified in the rezoning, with the works being largely contained within that portion of the site zoned 2(a) residential.

In light of the conclusions of the AA&HCA Report, no further archaeological investigations of the site have been undertaken. However, further consultation will be undertaken with the Darkinjung Local Aboriginal Land Council during the DA assessment phase as required by Clause 49T(7) of the GPSO and prior to the commencement of development on the site.

A number of recommendations contained in the AA&HCA Report remain valid and relevant to the current application, as outlined below:

- That no plans should be made to include walking trails within the subject site that lead to sensitive Aboriginal sites.
- That should fire trails or APZ be required to be established to protect future dwellings, then a detailed Aboriginal archaeological site survey be undertaken to ensure that any cryptic or sub-surface sites are considered.
- Should any Aboriginal sites be located during the construction phases for any future development including for road, infrastructure or dwellings, then all works at this location should cease, and the Department of Environment & Conservation's National Park & Wildlife Services should be contacted for further advice.

Should any artefacts be unearthed, the Co-operative is aware of its legal responsibility in respect to any requirement to obtain a permit under the Heritage Act and that Aboriginal sites and artefacts are protected under *the National Parks and Wildlife Act 1974*.

5.9 Transport and Accessibility

A Transport Impact Assessment has been prepared by Chris Hallam & Associates (**Appendix W**). This assessment has identified the existing transport context, including the current traffic generation and capacity of the surrounding road network. This assessment has also assessed the expected traffic generation, access and parking arrangements for the proposed development including the concurrent community use of the site.

The TIA includes consideration of the Traffic Assessment Reports undertaken for the site rezoning by BJ Bradley and based on a 150 lot residential subdivision of the NEV site. Significantly, these TIA's conclude that the traffic generated by the development will not have an adverse impact on the level of service, level of safety or capacity of the local road network and that the traffic impacts associated with the development of the site would be negligible. These conclusions were based on an estimated weekday peak hour traffic generation of about 130 vehicles/hour, and an estimated daily traffic generation of 1,350 vehicles/day, based on standard RMS traffic generation rates. Since the completion of these TIA's, there has been only a minor change in traffic generation as a result of new development in the local area and therefore, the conclusion of these studies remain valid and relevant to the current application.

5.9.1 Traffic Generation

The site is currently serviced by an efficient functioning local road network. The TIA includes the results of recent traffic counts of the local road network to determine the current traffic flows and predicted traffic impacts resulting from the application.

The key conclusions from the TIA with respect to the current traffic situation are summarised below:

- Current traffic flows in Fountain Road are well within the environmental goal for local streets established by the RMS environmental capacity guidelines.
- A Sidra Analysis of the Manns Road/Carrington Street junction operates at a 'good' to 'satisfactory' level of operation during the current AM and PM peak hours depending on the chosen movement and therefore, achieves a Level of Service between 'A' and 'C'. The right turn movement into Carrington Street during the AM peak achieves a Level of Service 'D' and during the PM peak of 'C' which indicates that it operating at a level between 'satisfactory' and 'near capacity'.

The predicted traffic generation associated with the development has been based on the recommended RMS *Guidelines for Traffic Generating Development*. The intersection modelling has been based on the full development of the ecovillage as reflected in the current Concept Plan ie. 120 dwellings. This would result in a weekday peak hour flow of 78 vehicles/hour being added to the road network. Having regard to this traffic increase, the TIA concludes that:

- Peak traffic flows at the junction of Fountain Road and Hanlan Street South will continue to have satisfactory capacity and the Level of Service of the intersection will remain 'satisfactory'.
- At Manns Road and Carrington Street junction, the through traffic on Manns Road would remain undelayed. The right turn out of Carrington Street is currently delayed and this would increase as a result of the proposal. The signalisation of this intersection would result in further delays to traffic including to the through traffic along Manns Road and therefore, it is recommended that the intersection be retained as existing. It is however, noted that drivers would have the option of using Deane Street to make a right turn onto Narara Valley Road- Manns Road.

Given Stage 1 of the development only proposes a maximum of 60 dwellings, Chris Hallam & Associates has concluded that the traffic generation resulting from the development will be satisfactory. On this basis, no mitigation measures or local traffic improvement measures are recommended.

5.9.2 Road Network

The proposed access to the site is maintained via the existing entry to the site off Fountain Road in accordance with the requirements of DCP 175. The access will be upgraded and the carriageway width increased to 5.5 metres.

TIA has assessed the proposed road network and design illustrated in the Road Circulation Plan prepared by Chase Burke Harvey (**Appendix O**). The TIA concludes that the road network design is satisfactory for the following reasons:

- The ecovillage roads would be private roads rather than public roads. Accordingly, the road layout has not been designed to conform with DCP 122- Residential Subdivision.

- The roads have been designed on AMCORD principles. The AMCORD principles are considered to set an appropriate standard for road design for the ecovillage based on the low level of traffic generation.
- The road network complies with the RFS Guidelines contained in Planning for Bushfire Protection.
- The AMCORD guidelines provide for shared car and pedestrian travel. The 1.2 metre services corridor adjacent to the carriageway, will also double as an informal pedestrian footway and is an appropriate design response for pedestrian movement and low traffic volumes. The footpaths will be provided through some of the common gardens and within common areas.

5.9.3 Green Travel Plan and Parking

The Co-operative intends to develop a Green Travel Plan to limit traffic congestion and car dependency and to encourage the use of public transport and non-motorised modes such as walking and cycling within the ecovillage itself and neighbouring sites. This approach is in recognition of the increasingly detrimental impact car travel is having on the environment, road safety and personal health. Additionally, this approach is intended to reduce the dominance of cars within the ecovillage, including its design layout and general functioning of as 'pedestrian priority' concept.

The Green Travel Plan will include measures tailored to suit the ecovillage, including the investigation of opportunities for a community bus service to provide regular visits to the train station and local shopping centres, the use of a electric buggies and car sharing schemes.

It is considered that this approach will provide real environmental benefits to the ecovillage and raise general awareness in the community about the benefits of choosing alternative transport means, including to reduce emissions of greenhouse gases, improving local air quality, minimising health risks and reducing congestion, noise, dirt and fumes. Overall, it is anticipated that this approach will have a real impact on reducing car dependence and therefore, will reduce the overall number of vehicle trips generated by the ecovillage and the demand for car parking.

The Concept Plan for the NEV site proposes that most car parking being provided in common street reserves. Opportunities for on-site parking on individual residential lots can be accommodated subject to design impacts being minimised and sensitively integrated with the streetscape qualities of the ecovillage. Free standing enclosed garages will not be permitted and the use of cluster parking areas on common property is encouraged.

To meet the requirements of DCP 111- Car Parking, the Concept Plan proposes that car parking be limited to 1 space per dwelling. This may be provided in common areas (i.e. as part of the group facilities approach included in the Concept Plan) and therefore, may not meet a number of the requirements in the DCP in terms of siting and design for car parking.

The Stage 1 application proposed the construction of a number of common car parking areas along the Research Road as illustrated in the Road Circulation Plan at **Appendix O**. These spaces are centrally located meet the anticipated demand for parking generated by the existing community uses on the site and will be located within proposed Lot 1. The parking for individual dwelling lots proposed in the subdivision will be considered with each future development application.

5.10 Bushfire

A Bushfire Protection Assessment Report (BPA Report) has been prepared by ABPP for the proposal and is included at **Appendix V**. The BPA Report provides a detailed analysis of the proposal with regard to bushfire risk and management in response to the aims and objectives for *Planning for Bushfire Protection 2006*.

Gosford's Bushfire Prone Land Map shows that the development site contains areas of Category 1 & 2 Bushfire Prone Vegetation.

The BPA Report includes an assessment of the assets protection zones (APZ's) for the development required in accordance with the Appendix 2 of *Planning for Bushfire Protection 2006*. The assessment concludes that the proposed subdivision complies with the APZ requirements. An extract from the assessment tabulating these findings is provided in **Table 7** below. It is noted that the middle western gully (referred to as the southern gully) is proposed to be managed to an APZ standard, therefore removing the Category 1 Bushfire Prone Vegetation classification from this gully.

Table 7: Determination of Asset Protection Zones

Aspect	Vegetation within 140m of development	Predominant Vegetation Class (Table A2.1 of PfBFP 2006)	Average Slope of Land	Recommended Width of Asset Protection Zone (Table A2.4 of PfBFP 2006))	Width of Asset Protection Zone Provided	Compliance with Table A2.5 of PfBFP 2006.
West of Lot 16; 27 – 36; 47 – 51;	Dry Sclerophyll Low Open Forest	Forest	> 15 degrees upslope	Minimum 20.0 metres required by Table A2.4.	25 metres provided by setback to dwellings.	YES – complies with PfBFP 2006
South of Lots 51 & 52	Managed land on adjoining property	Not Classified	> 15 degrees upslope	Nil required by Table A2.4.	N.A.	N.A.
South west of Lots 54 – 58	Dry Sclerophyll Low Open Forest	Forest	Level & < 15 degrees upslope	20 metres required by Table A2.4.	25 metres provided by setback to dwellings	YES – exceeds width required by PfBFP 2006
North west of Lot 59	Dry Sclerophyll Low Open Forest	Forest	Level - follows contours	Minimum 20.0 metres required by Table A2.4.	> 25 metres provided by setback to dwelling.	YES – complies with PfBFP 2006
South west of Lot 59	Dry Sclerophyll Low Open Forest	Forest	< 15 degrees upslope	Minimum 20.0 metres required by Table A2.4.	> 25 metres provided by setback to dwelling.	YES – complies with PfBFP 2006
Riparian/ Habitat Corridors [except for southern gully]	Wet/Dry Sclerophyll Low Open Forest – except for southern gully which is to be managed	Forest reclassified as 'rainforest' due to low hazard [width being less than 50m]	< 10 degrees down slope	15 metres recommended by Table A2.4.	Minimum 15 metres	YES – complies with PfBFP 2006

In order to mitigate the risk of bushfire hazard, ABPP has advised that the bushfire loads on the site and within the designated APZ's will need to be managed including to minimise fuel loading at ground floor level and to ensure that trees and shrubs are located away from buildings to minimise radiant heat and direct flame attack.

ABPP has assessed the road design, as detailed in the Road Circulation Plan provided at **Attachment O**, and has advised that:

- the perimeter road network, which has been designed with a trafficable width of 5.5 metres with designated passing bays and off-pavement parking bays, satisfies the perimeter road design requirements of *Planning for Bushfire Protection 2006*.
- the internal one-way roads, which have been designed to provide a trafficable width of 3.5 metres with designated off pavement parking bays and passing bays strategically located satisfy the performance criteria of one-way roads within section 4.2.3(1) of *Planning for Bushfire Protection 2006.*

A number of management and mitigation measures are recommended to address the requirements of Section 44(g) of the *Rural Fires Regulation 2008* and the deemed-to-satisfy provisions of *Planning for Bushfire Protection 2006* as a prerequisite for the issue of a Bushfire Safety Authority under Section 100B (4) of the *Rural Fires Act* for the subdivision, as follows:

- **Asset Protection Zones**: The APZ's to future dwellings shall be determined to maintain a maximum 29kW/m2 radiant heat flux on the exterior of the buildings.
- **Management of vegetation:** The APZ's and vegetation within the future residential lots shall be maintained as an Inner Protection Area and a Section 88B instrument be applied to the title of all future residential lots, the residual lots and the community association lot (Lot 1) to ensure the long term management of the vegetation in order to maintain minimum fuel loads.
- **Construction Standards:** the future dwellings on the lots created by the subdivision of the land shall be located with a separation distance from unmanaged bushfire prone vegetation (including the vegetation within the habitat/riparian corridors) which maintains the bushfire construction standard requirement to maximum BAL 29. All dwellings within 100 metres of bushfire prone vegetation shall be constructed to a minimum standard of BAL 12.5 and fitted with non-combustible gutter ember protection devices.
- **Fire-fighting access:** Access road within the development shall be constructed with a minimum pavement width of 5.5 metres for the main entrance road and the perimeter road and a minimum pavement width of 3.5 metres for the one-way internal roads. The property access roads to the individual lots shall be designed and constructed to a minimum width of 4.0 metres located in a 6.0 metre wide managed corridor. Temporary 'T' turning heads shall be provided at the terminus of 'dead-end' roads created in the construction of the individual development stages.
- **Water Supply for fire-fighting operations**: the water supply shall be provided with hydrant spacing, sizing and pressure complying with the specifications of AS 2419.1-2005 and have a flow rate of 10 litres/second.
- **Bushfire Survival:** The owners of lots directly exposed to the bushfire hazard prepare a 'Bushfire Survival Plan'.

Subject to compliance with these recommendations, ABPP has advised that the proposal complies with the 'deemed-to-satisfy' provisions set out in Chapter 4 (performance based controls) and the aims and objectives of *Planning for Bushfire Protection 2006,* and therefore, the proposal complies with Section 8.4 of DCP 175.

5.11 Waste Management

5.11.1 Construction Waste

A Preliminary Waste Management Plan (PWM Plan) has been prepared for Stage 1 construction and is included at **Appendix U**.

The PWM Plan is based on minimising off-site removal of waste and maximising the beneficial re-use of the waste. The key sources of waste from the Stage 1 works will be associated with the removal of trees, the demolition of existing structures and the regrading works as following:

- A number of trees will be felled to accommodate the regrading works and infrastructure installation. These trees will be chipped and stockpiled on site for future re-use.
- Approximately 1000m^3 of net cut will be available as a result of the bulk earthworks for the construction of the road and associated regrading. This material will be stockpiled on site for future re-use.
- Bricks, concrete and other construction material associated with the building demolition will be stockpiled on site for future re-uses. Where buildings to be demolished have been identified as containing asbestos products, they will be removed by an AS-1 licensed asbestos removalist contractor in accordance with the NOHSC *Code of Practice for the Management and Control of Asbestos in Workplaces* and disposed of as asbestos waste to an appropriately licensed facility.

The design philosophy for the NEV site is underpinned by environmental responsible design principles. A design using sustainability and recycled materials will provide both short and long term cost benefits in terms of the health of the environment. These design principles are incorporated into the Design Report and encourage the use of the following:

- recycled materials wherever possible, this includes recycled compacted site fill behind the rubble walls;
- recycled rubble as a facing material in gabion walls;
- recycled aggregates for drainage and edging;
- recycled soils and mulch; and
- recycled timber from removed trees for seats, decking , walls and informal play equipment.

A final Waste Management Plan quantifying the volumes of waste and the relevant waste facilities to be utilised will be prepared once a construction manager and building contractors have been engaged.

5.11.2 Operational Waste

There will be minimal operational waste associated with the Stage 1 works. However, the proposal includes the construction of the communal garbage store for the site required to service the future residential needs of Stage 1. The waste management area has been designed in consultation with Council's Waste Officer and to meet the requirements of DCP 106.

The bins store has been designed to accommodate a dual axle 9.8 metre truck with a HRV turning radius of 12.5 metres, in accordance with Council waste services requirements.

As illustrated in **Figure 40** below, the garbage store is setback 4.5 metres from the eastern boundary of the site. This setback will be landscaped in order to suitably screen the garbage store from neighbouring residential properties to the east. It is likely that the area will also be partially enclosed at the eastern end to minimise any adverse amenity impacts to neighbouring residential premises.

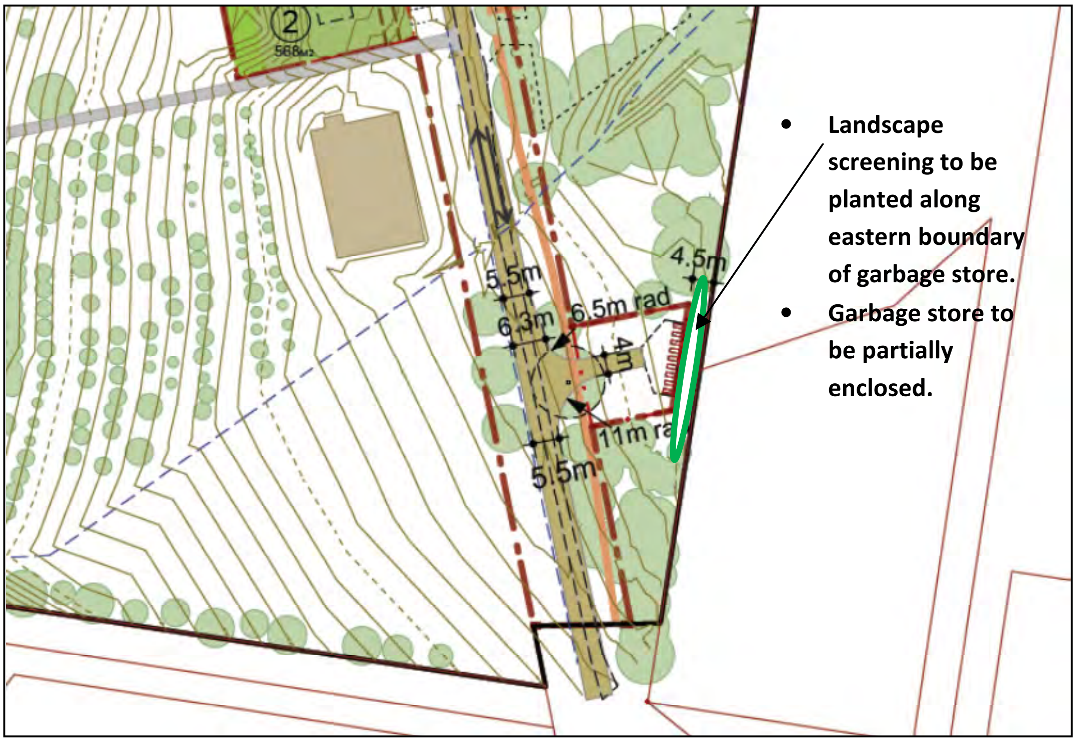

Figure 40: Location and design of communal garbage store (Source Hill Thalis Design Report)

The garbage store will be maintained and managed by the site manager.

It has been estimated the 60 residences proposed in Stage 1 will generate 7.2m^3 off mixed waste per week and therefore, require 10 bulk bins. An equivalent number of bins will technically be required to store recyclable waste. The amount of waste will be minimised on site and were possible will be composted and beneficially used in gardens. This will substantially reduce off-site disposal of waste. All residents will be responsible for transferring their waste as required to the communal garbage store.

Having regard to the above, the proposal is considered to be consistent with key provisions of DCP 106.

5.12 Amenity Impacts

5.12.1 Air Quality

The installation of the sewerage treatment plant (STP) has the potential to generate odours as a result of the treatment process. Accordingly, an Air Quality Assessment Report (AQA Report) has been prepared by Aubin Environmental to assess the likely emissions from the STP and to determine whether these emissions are likely to have a detrimental impact on air quality both within and surrounding the NEV site. The AQA Report is included at **Appendix Y**.

As detailed in Section 3.6 of the SEE, the STP is referred to as a Membrane Bio-Reactor (MBR). MBR provides for a biological process that is highly controlled and this reduces the risk of generating odorous compounds produced under anaerobic conditions.

The AQA Report includes an assessment of impact of potential emissions from the STP to the surrounding area using AUSPLUME v6 dispersion model in accordance with the methodology in the *NSW EPA's Technical Framework: Assessment and Management of odour from stationary sources in NSW" (November 2006).* The Ausplume model was configured to measure the maximum ground level concentrations at each junction of a grid that spans 1km x 1km around the STP and to determine the worst impact to the nearest sensitive receptors. This is based on ground level concentrations at each grid intersection within the assessment area for every hour in one calender year. The area covered by the dispersion assessment is shown in **Figure 41** below and includes residential development to the east of the NEV site (SR1 & SR2), and residential development within the NEV site itself (SR3- SR5).

Figure 41: Area included in the dispersion assessment (Source: Aubin Environmental)

The modelling showed that in all instances, the results of the testing were significantly lower than the assessment criteria. Based on the odour assessment criteria adopted for the site of '4', it was determined that the ground level concentrations at sensitive receptors SR1 and SR2 were 0.6 and 0.8, respectively. Within the NEV site itself, the levels are slightly higher but still remain well below the assessment criteria. In this regard, the concentrations at ground level for SR5 and SR3 ranged from 0.5 to 1.5, respectively. SR4 had an estimated concentration of 1.1, as illustrated in **Figure 42** below. It is noted that the ground level concentrations at the STP are estimated to be above '4' and that this level was detected at 5 out of the 448 locations assessed in the modelling. However, the frequency at which the ground level concentrations at these locations were above 4 were predicted to range from 1-10 hours in any calender year, and for this reason were determined to be acceptable. Aubin Environmental have also advised that in reality the ground level concentrations of odours are likely to be lower in reality due to the conservative basis upon which the modelling was undertaken.

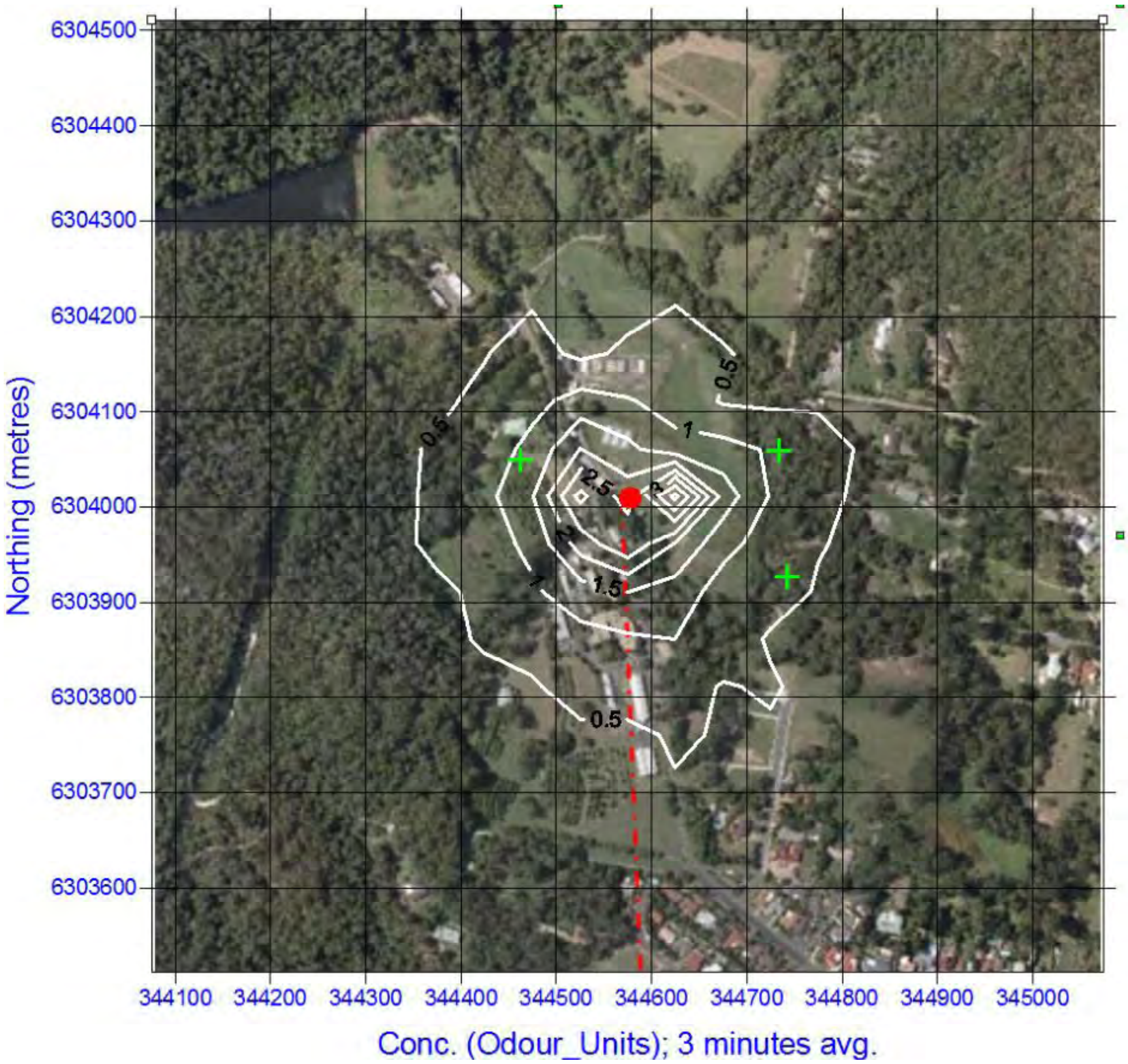

Figure 42: Contour plot showing predicted ground level odour impact

Based on the assessment Aubin Environmental concluded that there are unlikely to be any negative air quality impacts resulting from the operation of the STP.

5.12.2 Noise

A Noise Impact Assessment (NIA) of the proposed STP has been undertaken by VIPAC and is provided at **Appendix Y**. The assessment has been undertaken to determine potential noise impacts from the operation of the STP on the nearest sensitive receptors in the surrounding areas, including on the NEV site and existing neighbouring residential areas.

The NIA uses the standards and guidelines in the EPA's Industrial Noise Policy and Australian Standard AS 1055-1997- "Acoustics Description and Measurement of Environmental Noise, Part 1- General Procedures". The existing baseline environmental noise levels were determined from the results of noise logging undertaken at two locations.

The main noise contributors associated with the STP are anticipated to be Bio Blowers and MBR Blower. This equipment would be contained within a STP building and therefore, the acoustic performance of the building's facade is likely to reduce noise impacts.

VIPAC's assessment included modelling 4 scenarios for the STP using the SoundPlan Program under both neutral and worst weather conditions for the day, evening and night periods, given the STP will operate 24 hours a day. The predicted noise impact from the STP on noise sensitive receivers ranged from between 4 to 42dB(A) and therefore, is well within the applicable criteria during the day, evening and night time period.

VIPAC therefore conclude that the STP will not result in adverse noise impacts to neighbouring residential development both within the NEV site and in neighbouring residential areas.

VIPAC has also prepared a Noise and Vibration Management Plan (N&VM Plan) to address impacts associated with the construction of the STP (**Appendix Y**). The N&VM Plan predicts construction associated with the STP will result in the following:

- the predicted construction noise levels at all noise sensitive receivers will be within the Noise Management Levels and the Noise-Affected Levels of the NSW Interim Construction Guidelines for construction work undertaken during standard construction hours; and
- the predicted vibration impacts produced will be of a low to mid frequency. Consequently, excavation equipment is unlikely to have an impact on the nearest sensitive receiver.

The N&VM Plan includes a recommendation for community enquiries management, including notification before and during construction and complaints handling. The Co-operative will comply with these recommendations.

5.12.3 Lighting

A Lighting Report has been prepared by Light, Art + Science and is provided at **Appendix X**. This report specifically responds to the requirements of Section 8.3(f) of DCP 175 which requires that any external night lighting associated with the future development of the site be designed to reduce light spillage into the adjacent forested areas.

The Flora and Fauna Gap Assessment prepared by Robert Payne (refer **Appendix J**) has identified that a number of threatened species may be impacted by lighting of the forest edges by the development and that this could impact on feeding regime of a number of species including: Grey-headed Flying Fox, Eastern Bent-wing Bat, Little Bent-wing Bat, Eastern Free-tail Bat, Southern Myotis, Sooty Owl, Powerful Owl. Accordingly, the installation of low level lighting against the forest edge and the dam because of the presence of foraging threatened fauna species has been recommended.

Having regard to the lighting requirement of the NEV and the potential for impacts to foraging species, the Lighting Report makes specific recommendations to ensure compliance with the AS/NZS

1158.3.1 Lighting of roads and public spaces Part 1.1 Vehicular traffic (Category V) lighting- Performance and Design Requirements and AS/NZs 1158.3.1 Lighting of road and public spaces Part 3.1 Pedestrian Area (Category P) Lighting – Performance and Design Requirements. Specifically, the Lighting Report concludes that the selection of luminaires should comply with the following requirements:

- Light source for external lighting should be of colour temperature 3000K;
- Street lighting should be pole mounted at no higher than 7.5m and have a full cut of lense based LED luminaire;
- Pathways lighting should be poled mounted at a height of 5m to 5.5m and have a full cut off lense based LED luminaire;
- Landscaping accent lighting should be directed to the item intended to be lit, have suitable light distribution that avoids light spillage and be fitted with a glare shield. The light source should be LED or low wattage ceramic metal halide.
- Building lighting should be ensure the majority of the lighting is below the horizontal if wall mounted or fully recessed if in an awning. Uplighting should only be used if it is under an awning or soffit. The light source should be LED, low wattage ceramic metal halide or compact fluorescent.

The Lighting Report includes the results of a sample section of street lighting that was modlled to calculate the spill light into the surrounding areas using horizontal illuminance calculation points in the forest areas of the NEV site. The test results showed that the horizontal calculation points fall to zero at around 30 metres beyond the street lighting if full cut off LED luminaires are used (as opposed to convention style metal halide street lighting).

The road design for the NEV site (refer plan RC12242 at **Appendix O**) proposes that the new perimeter road (Road 2) be setback from the boundary of Lot 40 which defines the extent of the 7(a) conservation land (bushland). Therefore any potential lighting spill to the west towards the bushland would be reduced. It is noted that the area between the 7(a) conservation land and the Stage 1 development will be maintained as an APZ.

The Co-operative proposes to finalise the design of the street lighting including the location and pole spacing at the construction certificate stage. Subject to compliance with the recommendations of the Lighting Report, it is considered that the proposal will comply with Section 8.3f of the DCP 175.

5.13 Visual Impacts

Matters in relation to the visual impact of the land subdivision have been addressed with reference to the relevant development controls in the Compliance Tables provided at **Appendix Z**.

The residential subdivision has been limited to the predominantly cleared sections of the site. The significant bushland and established landscaping throughout the site will be maintained. The topography of the site will ensure that many views of the development are screened by existing vegetation and the natural lay of the land. The Design Report demonstrates how future development of the residential lots can be designed to accommodate existing site features and furthermore, through the selection of materials and finishes, can appropriately integrate with the character of the site.

The landscape strategy prepared for the site (**Appendix B**) includes significant new planting thoughout the Stage 1 site including planting along the reformed Research Road to provide an avenue of trees. The Ecological Restoration Plan (**Appendix K**) also makes recommendation for the embellishment of the site including the eradication of weeds. In combination, these works will significantly improve the visual quality of the site.

Having regard to the above, it is considered that the proposed subdivision will not result in unacceptable visual amenity impacts to neighbouring lands.

5.14 Social and Economic Impacts

The project will deliver social and economic benefits to the local economy through direct job creation associated with the design development and construction phases. There will be resultant multiplier effects generated throughout the local economy including related to trade employment and supply of construction materials.

Given the overall development of the NEV site is to be staged, job creation linked to the construction phase of the development will be ongoing for considerable period of time.

Post completion of the project, it is estimated that the project will create a number of ongoing jobs associated with the maintenance and management of the ecovillage. Employment may also be linked to some of the proposed complementary uses on the site.

The proposal will provide opportunities for housing choices in the Gosford LGA and will assist in meeting the dwelling targets in the Central Coast Regional Strategy. The location of the site, including its convenient access to transport and services in the area and its environmental and scenic qualities will result in positive social impacts. The design principles for the development of the ecovillage have embraced these qualities and this will deliver social benefits to residents of the ecovillage.

The development of the site will also provide positive social impacts principally relating to the increased opportunities for the public to engage with and better understand the environmental and historic significance of the site, and through the provision of the 6(a) land to Council's open space network.

Overall, the development will deliver positive social and economic benefits to the local area and the broader Gosford LGA.

5.15 Construction Impacts

Construction activities associated with the development are largely contained well within the site boundaries. In order to minimise the potential for noise and vibration impacts to nearby sensitive receivers, construction work is proposed to be undertaken during Council's standard daytime construction periods (ie. 7.00am to 6.00pm Monday to Friday and 8,00am to 1pm on Saturday).

Prior to the commencement of construction, when the construction methodology and program has been finalised, a Construction Environmental Management Plan will be prepared. This will address each stage of construction and identify the appropriate mitigation and management measures to be employed to minimise construction impacts including traffic, noise, vibration and dust.

The Soil and Sediment Control Plan included at **Appendix R** proposed water quality management appropriate to mitigate on-site and off-site soil and sediment impacts to watercourses. The proposed soil and sediment control measures will be in place and maintained during construction.

5.16 Suitability of the Site for the Development

Having regard to the characteristics of the site and its location, the site is considered suitable for the proposed use in that:

- It is appropriately zoned to accommodate the proposed development and the development is consistent with the provisions in GPSO and the Draft Gosford LEP 2013, which promote land uses that are compatible with the low density residential character of the area;
- The existing buildings and the environmental qualities of the site lend themselves to the establishment of an ecovillage;
- The reports which support this application demonstrate that the subdivision of the site and associated development will result in minimal environmental impact including to the existing environment, heritage, road network and scenic quality of the site;
- The site is conveniently located to a number of schools, shopping centres and local business including Gosford City centre;
- The site has good access to a range of public transport option including local bus services and Narara Railway Station; and
- It will not result in any material environmental impacts to the adjoining properties.

5.17 Any submissions made in accordance with the Act or Regulation

The proposed development will be notified in accordance with Council's notification policy. Any submissions received will be duly considered by Council prior to the determination of the application.

Prior to the determination of the application, Council is also required to obtain general terms of any approval proposed to be granted in relation to the development from the NSW Rural Fire Service and the NSW Office of Water in accordance with Section 91A of the Act.

5.18 The Public Interest

The proposal is considered to be in the public interest as it will achieve the following:

- facilitate the use of the site and in doing so, will aid in the conservation, protection, security and enhancement of the environmental and heritage of the site;
- contribute to Council's open space network through the dedication of the 6(a) land;

- provide opportunities for greater housing choice in the Gosford LGA and will assist in meeting the dwelling targets in the Central Coast Regional Strategy; and
- development that is compatible with the surrounding residential areas and is a permissible use with consent pursuant to the provisions of GPSO and therefore, will promote the orderly and economic use of the land.

The proposal is considered to uphold the public interest as no adverse environmental, social or economic impact is to result from the development.

5.19 Summary

The environmental assessment on the proposal has demonstrates that the Concept Plan and the implementation of the Stage 1 works will result in the following key outcomes:

- The orderly and economic development of the site;
- A subdivision layout which delivers a variety of housing lots capable of supporting a variety of housing choices;
- A road network and parking provision which meets the needs of the ecovillage and the access arrangements of the RMS and minimises impacts to the local road network;
- The provision for on-site contamination to be addressed;
- The incorporation of appropriate and sound provisions for environmental protection and ecological restoration;
- Relevant and appropriate provisions to ensure the bushfire protection of the site;
- Restricts development in flood liable areas;
- Provides genuine sustainable environmental outcomes and with positive environmental benefits;
- Demonstrates that public utility services are available to the site;
- Protects items of environmental heritage on the site and establishes a range of relevant conservation policies;
- Contributes to the public open space network through the dedication of the 6(a) zoned land to Council; and
- No adverse environmental impacts to neighbouring land.

On this basis, it is considered that the proposal is worthy of Council's support.

6.0 Conclusion

This application seeks approval for Stage 1 works associated with the establishment of an ecovillage on the NEV site. The application proposes a 40 lot community title subdivision and ancillary works required to support the future development of the NEV site.

This Statement of Environmental Effects has assessed the proposal having regard to the section 79C of the Act. The assessment has demonstrated that the proposal complies with the relevant environmental planning instruments and complies with the key objectives and controls of the relevant development controls plans which apply to the site, as demonstrated in the SEE and the accompanying compliance tables. The assessment has also concluded that the proposal positively responds to site conditions and will result in positive economic, environment and social benefits to the community. Importantly, the proposal will increase the provision of future housing stock in the Gosford LGA in line with local and regional planning strategies.

The relevant technical reports which support the application demonstrate that the site is capable of supporting the proposal and that it can be fully serviced (including via an integrated water management system) and that the development of the site will not pose any significant risks to the environment or hazards to future residents. The detailed analysis provided in this SEE and the supporting technical reports demonstrate that the proposal does not give rise to any unreasonable adverse amenity impacts to adjoining properties.

The application establishes the foundations for the future development of the ecovillage. The ecovillage has been designed to embrace the site conditions. Considerable community benefits will result from the proposal including through its sustainable design approach which will foster economic, environmental and social well-being, housing choice and the enhancement of the environmental and cultural heritage of the site. In addition, the proposal will make a positive contribution to Council's open space network and provides for the ecological restoration of the site. The Design Report provided with the application demonstrates that the development of the site will occur in an orderly and planned manner and that a high quality urban design outcome will be achieved.

For the above reasons, the proposal represents an appropriate development outcome for the site. It is recommended that the application be approved by Council.

NARARA ECOVILLAGE

AIR QUALITY (ODOUR) IMPACT ASSESSMENT

www.aubin.com.au
ABN: 68 282 361 454

EXECUTIVE SUMMARY

AUBIN Environmental (AUBIN) has conducted an air quality impact assessment of a proposed residential development in Narara, NSW.

This development includes a self-contained sewage treatment plant (STP) that will be sized to process all sewage generated within the development. Treated water will be stored on site for reuse.

Emissions from the STP have been estimated based on odour concentrations that are typical of aerobic bio-treatment systems.

Dispersion modelling was conducted using AUSPLUME in accordance with NSW regulatory requirements. The principle of conservatism was applied at all times during this assessment, meaning that ground level impact is expected to be lower than suggested by the model.

The results of the dispersion modelling were assessed using assessment criteria established by the NSW EPA in their document 'Technical Framework: The measurement and assessment of odour sources in NSW".

On this basis, all results of the assessment were acceptable and it is concluded that there will be no negative impact on air quality.

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APPENDICIES

APPENDIX A: AUSPLUME TEXT FILE

APPENDIX B: CV - STEPHEN PEREIRA

APPENDIX C: CV - TONY TRUMAN

QUALITY CONTROL

REPORT PREPARED FOR:	Narara Ecovillage Narara, NSW
REPORTING PREPARED BY:	AUBIN Environmental info@aubin.com.au 0421 241 425
REPORTDATE	2/12/2013
REPORT STATUS	Finalised
QA/QC CHECKS	Complete – TT
REPORT VERSION	Rev2

1. INTRODUCTION

AUBIN Environmental (AUBIN) has been engaged by Narara Ecovillage to prepare an air quality impact assessment for a proposed development in Narara, NSW.

AUBIN has specialist expertise in the scientific assessment of odour generation, dispersion, environmental impact and mitigation measures.

Please see attached for AUBIN personnel's CV's, or contact AUBIN to obtain further details.

2. OVERVIEW OF DEVELOPMENT

Background information about the proposed development and environmental context has been provided to AUBIN by Narara Ecovillage and the equipment supplier, Aquacell Pty Ltd.

Narara Ecovillage is a proposed residential development that is comprised of 120 dwellings and includes a dedicated sewage treatment plant (STP).

The proposed development aims to be independent of town mains for water supply and discharge. The STP would process all domestic waste water from the 120 dwellings. Treated water would be stored on site for reuse within the residential development.

It is proposed that the STP be installed in two phases to match the phased construction of dwellings. The initial phase will be approximately 54 dwellings and the total number of dwellings will be approximately 120 once the development is complete.

This assessment has been based on the full scale development – which is considered to represent a worst case scenario.

1.1 The Location and Sensitive Receptors

Narara Ecovillage is to be located on a parcel of land on the fringe of the township of Narara, near Gosford in NSW.

The locality is considered semi-rural and is adjacent to extensive areas of National Park. An overview of the general area is shown in Figure 1.

Methodology and criteria for assessment of nuisance odours has been established by the NSW EPA in a November 2006 document entitled "Technical Framework: Assessment and management of odour from stationary sources in NSW" (Technical Framework).

In this document it is stipulated that impact must be assessed at the location of 'sensitive receptors'.

The Technical Framework defines a sensitive receptor as "*a location where people are likely to work or reside; this may include a residential dwelling, school, hospital, office or public recreational area. An odour assessment should also consider the location of known or likely future receptors*" (Technical Framework, page 55).

Nearby sensitive receptors (dwellings) are identified in Figure 2. Figure 2 depicts the entire area covered by the Ausplume dispersion assessment, which is a 1km by 1km grid overlaid on this area with the STP at the centre.

The closest *existing* sensitive receptors (shown as white human figures marked SR1 & SR2) are located directly east and south-east of the proposed STP site, at a distance of approximately 150 meters. These are residential dwellings.

The proposed Narara Ecovillage dwellings (shown in Figure 2 as a blue human figure marked as SR3, SR4 & SR5) would be to the north-west, west and south of the proposed STP site, the closest being at a distance of approximately 100m.

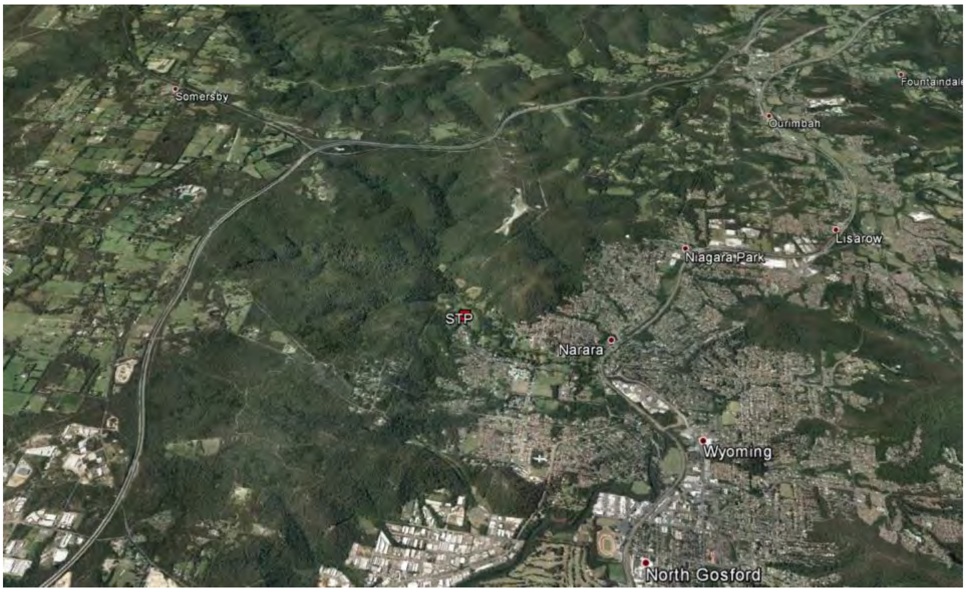

Figure 1: Overview of the locality of Narara Source: Google Earth

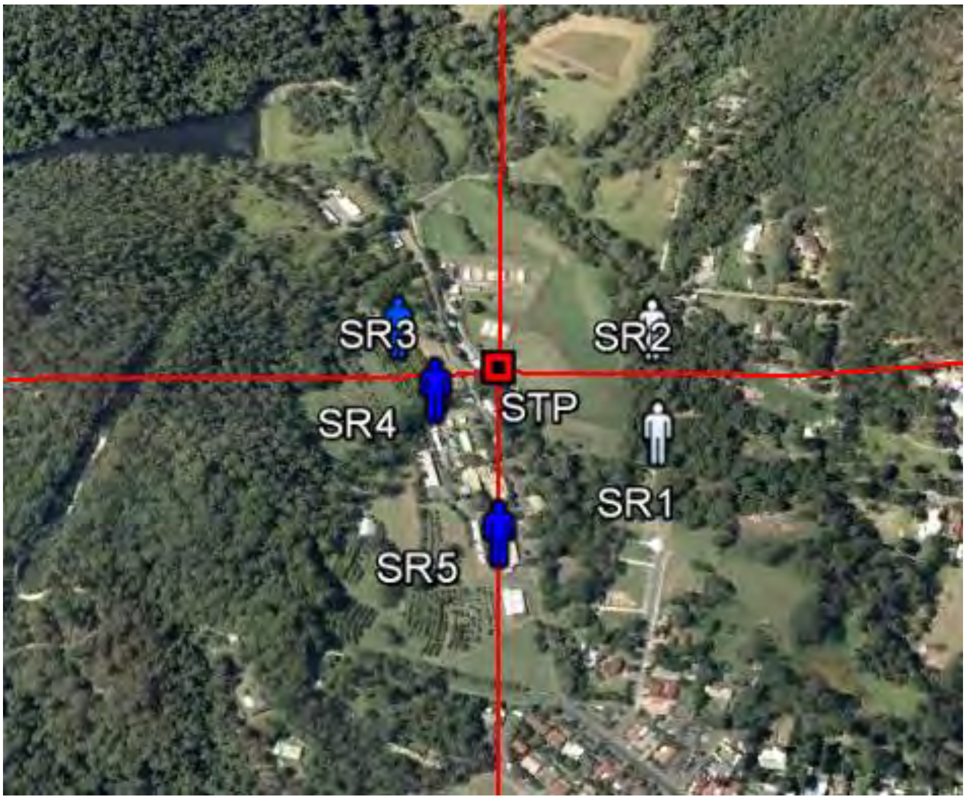

Figure 2: The area included in the dispersion assessment (1km x 1km) Source: Google Earth

1.2 Background Air Quality

There are no significant sources of extraneous odours within this area. Background odours can be expected to be dominated by odours that are typical of residential, light commercial and rural areas.

No adjustment has been made for the accumulation of background odours in this assessment.

1.3 The Sewage Treatment Plant (STP)

The STP is based on aerobic biological removal of organic contamination and utilises membrane technology to facilitate efficient removal of the treated water. Systems of this type are known as Membrane Bio-Reactors (MBR).

This particular STP is designed in modular tanks that can be combined to meet the requirements of any given application.

The full scale plant would consist of two independent trains like the one depicted in Figure 3, Figure 4 and Figure 5. Each train would include up to five (5) aeration tanks and two membrane tanks. Tanks are vented to atmosphere through a 50 mm hole on the roof of each tank.

All tanks are vigorously aerated to maintain high concentrations of dissolved oxygen. This highly controlled environment guarantees that all biological activity is aerobic, the products of which are carbon dioxide and water.

Aerobic conditions eliminate the chance of anaerobic bacterial activity, and so maintaining high concentrations of dissolved oxygen eliminates the potential for generating odorous reduced compounds such as hydrogen sulphide.

Aeration rate for each tank is expected to be 19 Nm^3/hr.

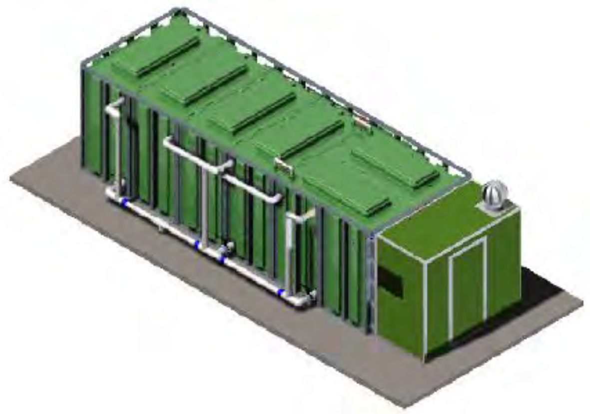

Figure 3: Sewage Treatment Plant – Isometric view Source: Aquacell Pty Ltd

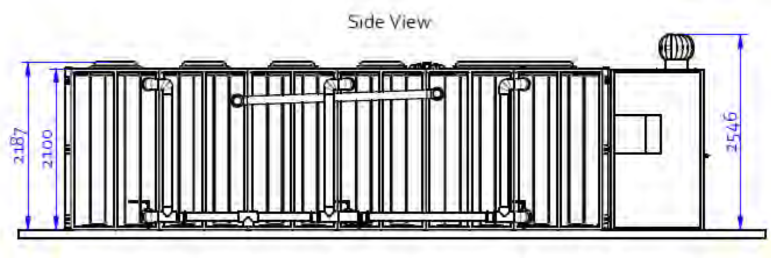

Figure 4: Sewage Treatment Plant – Side view Source: Aquacell Pty Ltd

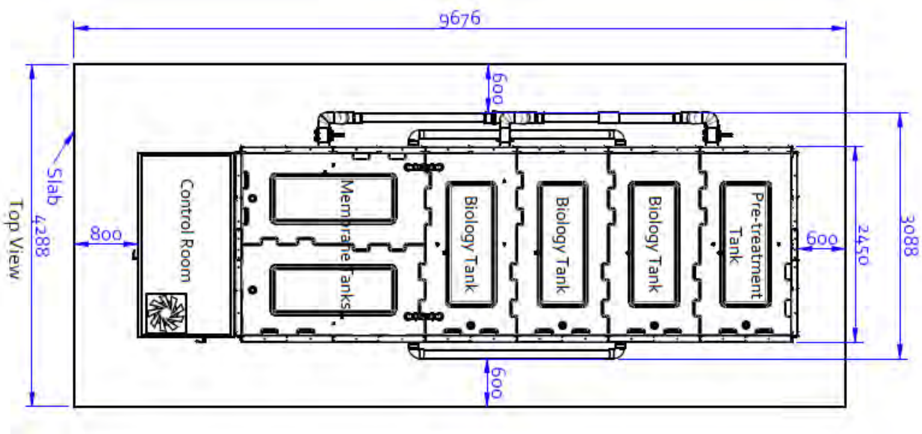

Figure 5: Sewage Treatment Plant – Plan view Source: Aquacell Pty Ltd

3. POTENTIAL AIR EMISSIONS (ODOUR)

Membrane Bio-Reactors are based on the well proven technology of aerobic biological digestion. Figure 5 (above) shows the individual modules that will make up the system. Raw water is introduced into the pre-treatment tank (to the right of the drawing). This, along with the 'biology' tanks are aerated to ensure that high levels of dissolved oxygen are maintained. Water passes from one stage to the next, becoming cleaner as it progresses.

Tanks are vented to atmosphere through a 50mm hole in the top of each tank.

The membrane tanks are also aerated but the water is clean by this stage and so there would be no significant odour associated with this emission.

Odours associated with aerobic biological digestion are known to be mild in strength and neutral to mildly unpleasant in character. Such odours are often described with words such as musty, earthy or damp.

Odour of this character is congruent with odours typical of rural background odours. This emission is expected to be quickly diluted to a concentration at which it is indistinguishable from the existing odour profile of the general area.

MBR provides a highly controlled and reliable format for the biological process. This provides reassurance that dissolved oxygen levels can be consistently maintained, which eliminates the potential for generating odorous compounds (predominantly reduced sulphur compounds such as hydrogen sulphide) produced under anaerobic conditions.

The treatment tanks are identical in process to aerated zones of typical activated sludge treatment plants. Odour concentration has been estimated based on AUBIN Environmental personnel's experience in sampling and assessment of such plants.

Odour concentrations for such sources are typically between 270 and 440 OU. In the interests of maintaining a conservative approach a concentration of 500 OU has been used in the model.

Sewage from the underground tank will be introduced into the system in the first tank. This tank is expected to be predominantly aerobic but it is foreseeable that remnants of anaerobic derived compounds could be present in the vented emission. A conservative estimate of 10,000 OU would be considered typical. A concentration of 20,000 OU has been applied to the emission from the first tanks to ensure that the highest of peaks is considered in a conservative manner.

Upstream of the STP, raw water is stored in an underground storage tank. This is sealed to atmosphere and so there will be no direct emission at this location. Any atmosphere displaced from this tank will be vented back through the sewer and discharged to atmosphere via commonplace sewer vents.

4. METEOROLOGY

A site specific meteorological file was generated from synoptic analyses for 2008 using The Air Pollution Model ('TAPM'), CSIRO Version 4.0.

TAPM is a three-dimensional prognostic meteorological and dispersion modelling system which uses databases of terrain, vegetation, soil type, sea surface temperature and synoptic scale meteorological analyses for Australia.

CSIRO have undertaken verification studies to compare TAPM derived meteorology and dispersion with observation-based information for various regions throughout Australia. These studies included consideration of the Melbourne region air monitoring network operated by EPA Victoria. The results of the studies show that TAPM performs well for meteorological results in a variety of regions throughout Australia (e.g., coastal, inland and generally complex terrain for sub-tropical to mid-latitude conditions).

The settings for the TAPM meteorological modelling are summarised below:

- High resolution terrain height database (9 second GEODATA);
- TAPM meteorological grid centre at latitude 33° 25.1' S and longitude 151° 20.6' E (North Gosford, NSW);
- 2008 synoptic data (75 kilometre resolution);
- 5 nested grid domains were defined, each domain comprising 25 x 25 horizontal and 25 vertical grid points and grid centres. The inner most grid was set to 300m resolution in order to capture topographic influences on the local scale;
- TAPM default settings for advanced meteorological parameters;
- AUSPLUME meteorological file generated for latitude 33° 23.7' S and longitude 151° 20.2' E (Narara, NSW) at 10m.

1.4 Katabatic Drainage

Katabatic drainage is the process whereby cold air 'sinks' down the gradient of sloping terrain. This will generally follow the lowest contour and flow down to valleys.

Katabatic air movement is typically associated with stable conditions and slower velocities, which are conditions that are conducive to preventing mixing and dilution of any entrained emission.

Assessment of the surrounding terrain indicates that it is likely that the katabatic drainage would occur as shown by the arrows overlayed on the aerial image in Figure 6. Cold air will flow down the valleys to the low lands spreading out as the valleys broaden into lowlands.

This suggests that it is possible that STP emission would, at times, be entrained in the drainage channel. It is expected that this will have minimal impact given:

- The low levels of odour that will be present at the STP, and
- That the drainage channel is expected to have already started spreading out horizontally at this point, limiting the distance at which this could cause detectable impact to the immediate vicinity surrounding the STP.

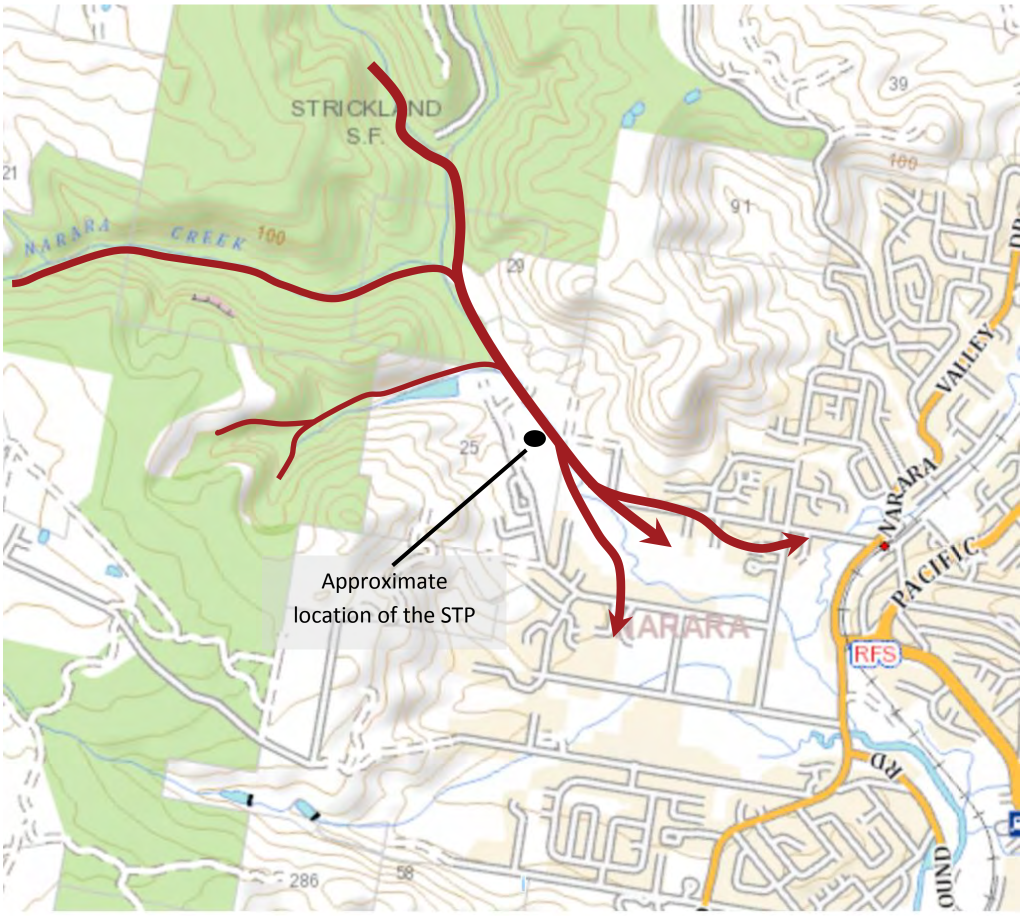

Figure 6: Likely katabatic drainage lines

Source: Six Maps, NSW

5. DISPERSION MODELLING

Assessment of impact of emissions on the surrounding vicinity has been conducted using AUSPLUME v6 dispersion model according to the methodology stipulated in NSW EPA's Technical Framework.

In principle, air is discharged into the atmosphere vertically and forms a plume within the atmosphere. Initially the plume moves up and starts growing wider as it mixes with the atmosphere. The upwards momentum of the plume is eventually overcome by wind and is turned around to move in a horizontal direction. The plume continues to mix with the atmosphere (dilution), growing in width and height as it does so.

Eventually, the plume grows so large that it reaches ground level. By this time the mixing has diluted the concentration of extraneous compounds in the plume. AUSPLUME applies 'Gaussian Plume Dispersion' theory to predict the concentration that any such compound would be at any given distance from a source.

The Ausplume model has been configured to measure the maximum ground level concentration (GLC) at each junction on a grid that spans 1km x 1km, with the STP located in the centre. Additionally, the location of the nearest sensitive receptors has been input into the program to ascertain the worst impact specifically at these locations.

The area covered by the dispersion assessment matches the area shown in Figure 2.

4.5 Ausplume Parameters

A summary of the main Ausplume configuration parameters is provided in Table 3. Full details can be found in the AUSPLUME text file output that is included as Appendix A.

Table 1: A summary of Ausplume Configuration

Parameter	Current
Technical framework classification	Level 3 assessment (the highest level of detail and accuracy)
Assessment area	Minimum of 500 m in all directions from the STP, calculations have been conducted on the basis of a grid with 50 meter intervals.
Stack diameter	50mm vent in the roof of each tank
Stack height	2.1m
Odour concentration	Tank 1: 20,000 OU Tanks 2 to 4: 500 OU
Discharge velocity	2.7 m/s, Vertical
Flow rate per discharge point	19 Nm^3/hour per vent, one per biological tank
Meteorological File	Site specific, as per description in section 4
Building wake effects	Yes – the tanks
Sensitive receptors	Yes
Background and other sources	None
Terrain effects	None – the sensitive receptors are within close proximity
Averaging time	3 minutes
Variable emission rate	None – emission is continuous
Reported results	100^{th} percentile

4.6 Assessment criteria

Assessment criteria are established by the NSW EPA in the Technical Framework. These are reproduced here in Table 2.

This schedule of criteria is based on the premise that a smaller population presents lower risk of raising complaints about an odour than a larger population. The total population size within the entire area is likely to be between 300 and 500 people, based on an average household size of 2.5 people. However, as the only potential for detection of STP odours is within the immediate vicinity surrounding the STP, it is reasonable to consider the 'potentially effected' population size to by significantly lower.

If the entire population within the area is considered then the assessment criteria would be 3 OU. A more appropriate assessment criteria is considered to be 4 OU.

If it is predicted that impact will be above these levels then a risk assessment based approach should be taken, and should include consideration of:

- Odour quality
- Odour intensity
- Odour frequency, timing and duration
- Population sensitivity
- Background level
- Public expectation
- Source characteristics
- Health effects

Table 2: NSW EPA odour assessment criteria

Population of affected community	Odour assessment criteria (OU)
Rural single residence (<2)	7
~ 10	6
~ 30	5
~ 125	**4**
~ 500	3
Urban area (> 2000) and / or schools and hospitals	2

4.7 Results & Discussion

The results of the dispersion assessment are shown in Table 3.

According to the Technical Framework the assessment criteria is to be applied at the location of sensitive receptors, and the criteria should be adjusted to reflect the population size. On this basis, the results and assessment criteria are shown in Table 3.

Note that the definition of 1 OU is the concentration of an odour at which, statistically, 50% of the population can detect it and 50% can't.

The contour plot shown in Figure 7 shows the predicted odour impact in the area assessed. It can be seen that the 4 OU level is only expected to be experienced in the immediate vicinity of the treatment tanks.

Results in real life will be lower than suggested by this model given its conservative basis.

It is important to understand the frequency with at which these GLC's are predicted to occur.

Ausplume calculates ground level concentration at each grid intersection within the assessment area for every hour of one calendar year. Figure 7 shows the 99.9th percentile (the 9th highest result in this case)

Ausplume has predicted concentrations above 4 OU at 5 of the 448 locations assessed, at the frequency shown in Table 4. There are 8760 hours in one year, and so the frequencies shown in Table 4 suggest that this occurrence is unlikely to occur in reality.

Table 3: Ground level concentrations

Location	Assessment criteria (OU)	Odour assessment criteria (OU)
SR1	4	0.6
SR2	4	0.8
SR3	4	1.1
SR4	4	1.5
SR5	4	0.5

Table 4: Frequency at which GLC above 4OU is predicted

Coordinate (mE)	Coordinate (mS)	Number of 1 hour periods per year
344575	6303961	2 of 8760
344625	6303961	1 of 8760
344525	6304011	5 of 8760
344625	6304011	10 of 8760
344625	6304061	1 of 8760

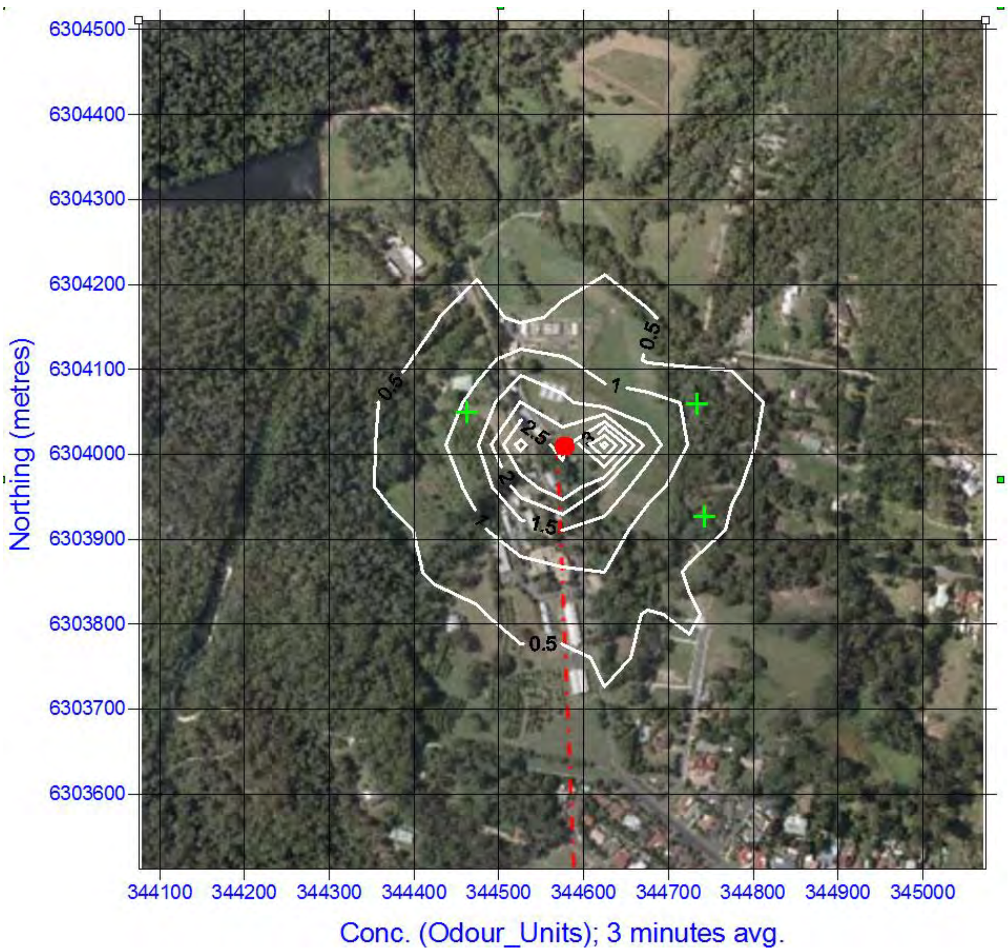

Figure 7: Contour plot that shows predicted ground level odour impact (OU)

6. SUMMARY OF RISK ASSESSMENT & CONCLUSION

An assessment of odour emissions from the proposed STP in the Narara Ecovillage has been conducted in accordance with NSW regulatory requirements.

The results have been compared with assessment criteria provided for this purpose by the NSW EPA in the Technical Framework.

In all cases the result is significantly lower than the assessment criteria. Results are expected to lower than predicted by this assessment in reality.

It is concluded that there will be no unacceptable impact on air quality caused by the proposed development.

VIPAC 40 1973 - 2013 CELEBRATING ENGINEERING EXCELLENCE

Vipac Engineers & Scientists Ltd.
4/5 Leo Lewis Close, Toronto, NSW 2283, Australia
PO Box 306, Toronto, NSW 2283, Australia
t. +61 2 4950 5833 | **f.** +61 2 4950 4276 | **e.** huntervalley@vipac.com.au
w. www.vipac.com.au | A.B.N. 33 005 453 627 | A.C.N. 005 453 627

Vipac Engineers & Scientists

Narara Ecovillage Co-operative Ltd

Sewage Treatment Plant

Noise Impact Assessment

29N-13-0156-TRP-472220-1

16 Dec 2013

Report Title: Noise Impact Assessment Job Title: Sewage Treatment Plant		
DOCUMENT NO: 29N-13-0156-TRP-472220-1 **PREPARED FOR:** **Narara Ecovillage Co-operative Ltd** 2/83 Ramsgate Avenue Bondi NSW 2026 **CONTACT:** John Talbott **Tel:** +61 2 9130 4241 **Fax:** +61 2 9130 3837		**REPORT CODE:** TRP **PREPARED BY:** Vipac Engineers & Scientists Ltd. 4/5 Leo Lewis Close, Toronto, NSW 2283, Australia **Tel:** +61 2 4950 5833 **Fax**: +61 2 4950 4276
PREPARED BY: Author:	Lynne Tan Lynne Tan **Project Engineer**	Date: 16 Dec 2013
REVIEWED BY: Reviewer:	Darragh Kingston Darragh Kingston **Team Leader, Acoustics**	Date: 16 Dec 2013
AUTHORISED BY:	Darragh Kingston Darragh Kingston **Team Leader, Acoustics**	Date: 16 Dec 2013
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EXECUTIVE SUMMARY

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Narara Ecovillage Co-operative Ltd to carry out the acoustic assessment of a Proposed Sewage Treatment Plant (STP) at lot 13 Research Road, Narara NSW.

The following standards and guidelines were used for this assessment:

- Environment Protection Authority (EPA) (Office of Environmental and Heritage (OEH)) NSW *Industrial Noise Policy* (INP),
- Australian Standard AS 1055-1997- "*Acoustics Description and Measurement of Environmental Noise, Part 1- General Procedure*".

A noise impact assessment has been undertaken to determine the potential noise impact of the proposed sewage treatment plant operations on noise sensitive receptors in the surrounding area.

The acoustic impact of the proposed sewage treatment plant is predicted to be well within the applicable noise criteria during day, evening and night-time periods.

Therefore, it is Vipac's professional opinion that the proposed sewage treatment plant is acceptable from an acoustic point of view.

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1 INTRODUCTION

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Narara Ecovillage Co-Operative Ltd to carry out the acoustic assessment of a Proposed Sewage Treatment Plant (STP) at 25 Research Road, Narara, NSW.

The following standards and guidelines were used for this assessment:

- Office of Environmental and Heritage (OEH) NSW *Industrial Noise Policy* (INP),
- Australian Standard AS 1055-1997- "*Acoustics Description and Measurement of Environmental Noise, Part 1- General Procedure*".

2 GLOSARY OF TERMS

A list of commonly used acoustical terms (and their definition) used in this report is provided below in ***Table 1***, as an aid to readers of the report.

Table 1: Definition of Acoustical Terms

Term	Definition
$L_{eq,1hr}$	Equivalent Continuous Noise Level - which, lasting for as long as a given noise event has the same amount of acoustic energy as the given event for the period of an hour.
$L_{A10,1\,hr}$	The noise level, which is equalled or exceeded for 10% of the measurement period of one hour.
$L_{A90,T}$	The noise level, which is equalled or exceeded for 90% of a given measurement period, T. $L_{A90,T}$ is used in Australia as the descriptor for background noise.
$L_{Aeq,T}$	The equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time, for a given time period. It can be considered as the average sound pressure level over the measurement period and is commonly used as the descriptor for ambient noise.
L_n	The Sound Pressure levels that is equalled or exceeded for n% of the interval time period. Commonly used noise intervals are L_1, L_{10}, L_{90} and L_{99}%
$L_{A10,18hrs}$	The L_{10} noise level for the time period extending from 6am to midnight.

3 PROJECT DESCRIPTION

3.1 Site Location

The proposed sewage treatment plant is located at Lot 13 DP 1126998 Research Road, Narara, NSW, approximately 6-kilometers northwest of Gosford, NSW. The site location of the proposed sewage treatment and surrounding noise sensitive receptors is illustrated in ***Figure 1***.

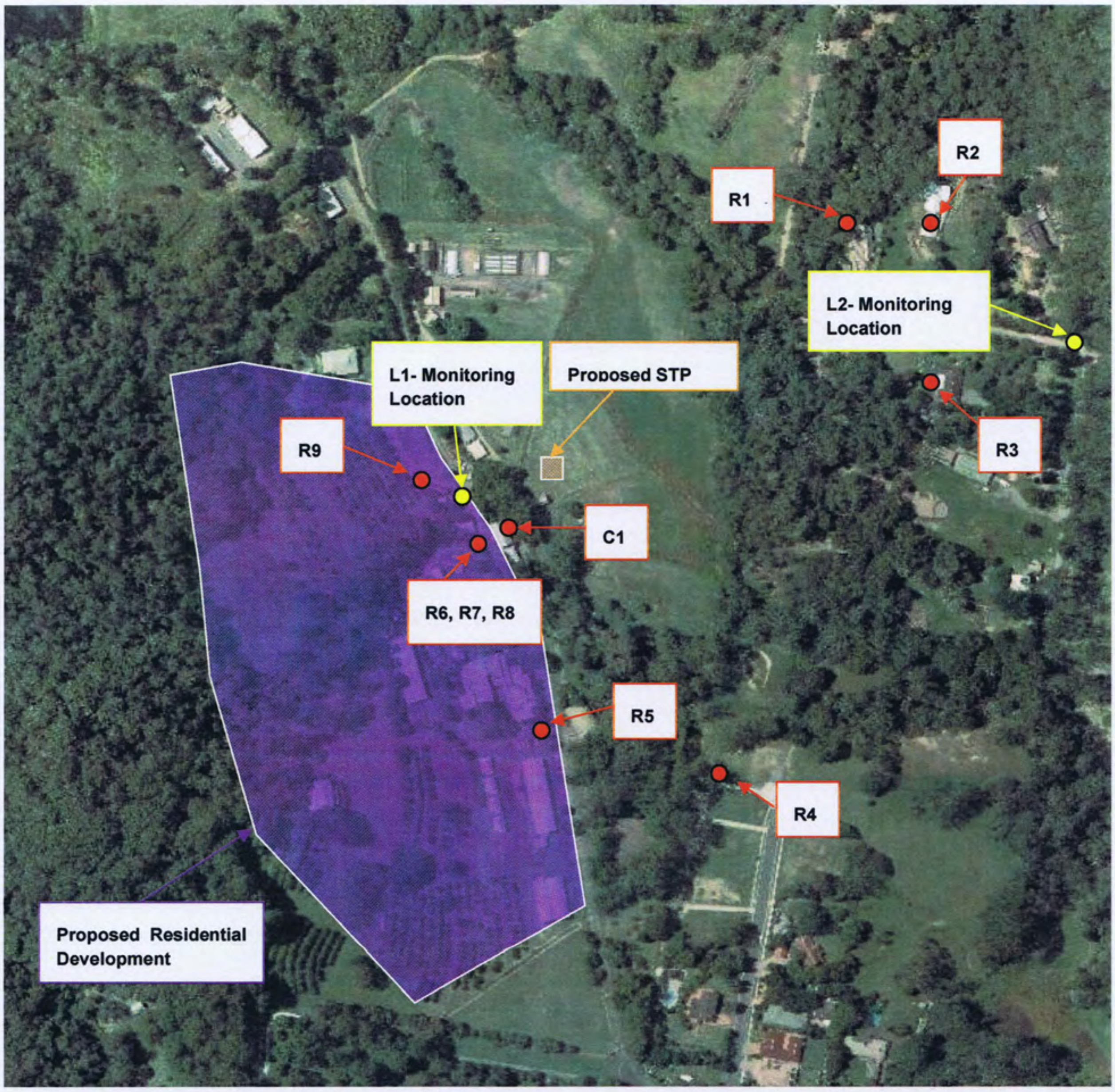

Figure 1: Locality Plan of Proposed STP, Noise Sensitive Receptors and Baseline Noise Monitoring Positions

3.2 Noise Sensitive Receivers

A list of the nearest potentially affected noise sensitive receivers to the proposed sewage treatment plant (STP) is provided below in ***Table 2***. The distance is calculated from the boundary of proposed STP to the property boundary of noise sensitive receivers.

Table 2: Noise Sensitive Receivers

ID	Property	Location
R1	3 Nursery Street, Narara	Approximately 220m to the North East of the STP
R2	2 Nursery Street, Narara	Approximately 260m to the North East of the STP
R3	16 Nursery Street, Narara	Approximately 260m to the North East of the STP
R4	7,9,10 Monarchy Way, Narara	Approximately 150m to the South East of the STP
R5	Lot 6 of proposed development	Approximately 120m to the South of the STP
R6	Lot 7 of proposed development	Approximately 40m to the West of the STP
R7	Lot 8 of proposed development	Approximately 40m to the West of the STP
R8	Lot 9 of proposed development	Approximately 40m to the West of the STP
R9	Lot 10 of proposed development	Approximately 75m to the North West of the STP
C1	Proposed development (office)	Approximately 15m to the West of the STP

3.3 Proposed Sewage Treatment Plant

The proposed Sewage Treatment Plant will provide sewerage and recycled water services to the Narara Ecovillage development at Narara. The size of the proposed STP is approximately 120m^2 in area and will be located approximately 60 metres to the North-North-East of the communities' lot.

4 EXISTING NOISE ENVIRONMENT

Vipac installed noise logging equipment at two locations to measure baseline environmental noise levels at representative locations in the vicinity of the proposed sewage treatment plant. The location of the monitoring points are listed in ***Table 3*** and shown in ***Figure 1***.

The primary aim of the noise logging surveys was to determine the existing environmental noise levels of the potentially affected area and to enable an assessment of the potential noise impacts on the receiving environment.

Table 3: Monitoring Locations

Loc.	Date	Location / Address	Instrument	Serial No.
L1	04/11/13 - 12/11/13	25 Research Road, Narara	LD 870	1466
L2	04/11/13 – 12/11/13	Near 16 Nursery Street, Narara	LD 870	1459

The instruments were programmed to accumulate noise data continuously over sampling periods of 15-minutes for the entire monitoring period. Internal software then calculates and stores the Ln percentile noise levels for each sampling period, which can later be retrieved for detailed analysis.

The instruments were calibrated using a Rion NC-73 calibrator immediately before and after monitoring and showed a maximum error of 0.5 dB.

Table 4 presents a summary of current baseline noise levels at the site.

Table 4: Summary of current baseline noise levels (dB(A))

Location	Period	L_{A10}	L_{Aeq}	L_{A90}
L1	Day	50	46	38
	Evening	54	51	38
	Night	46	41	32
L2	Day	50	47	37
	Evening	58	53	36
	Night	47	41	35

5 CRITERIA

THE EPA (OEH) INP sets limits on the noise that may be produced by the STP when operational. These limits are dependent upon the existing noise levels at the site and are designed to ensure changes to the existing noise environment are minimised and deal with the intrusiveness of the noise and the amenity of the environment. The most stringent of the limits is taken as the limiting criterion for the noise source.

The intrusiveness noise criterion requires that the $L_{Aeq,15minutes}$ for the noise source, measured at the most sensitive receiver under worst-case conditions, should not exceed the Rated Background Level (RBL) by more than 5dB, represented as follows:

- $L_{Aeq,15minutes} < RBL + 5dB$

The noise emissions associated with the proposed STP should not exceed the Project Specific Noise Levels detailed in ***Table 5.***

Table 5: Project Specific Noise Levels at Noise Sensitive Receptors dB(A)

Location	Period	L_{Aeq}	RBL	Recommended Acceptable L_{Aeq} [1]	Intrusiveness Criteria Level	Project Specific Noise Level
R4 – R9 (L1)	Day	46	37	50	42	42
	Evening	51	34	45	39	39
	Night	41	27[2]	40	35	35
R1-R3 (L2)	Day	47	34	50	39	39
	Evening	53	31	45	36	36
	Night	41	30	40	35	35
Commercial premises (C1)	When in use	-	-	65	-	-

6 NOISE MODELLING

Noise modelling has been performed using the SoundPLAN® computational noise modelling software package. The use of the SoundPLAN® software and referenced modelling methodology is accepted for use in the state of NSW by the Office of Environment and Heritage (OEH) for environmental noise modelling purposes. Vipac have undertaken numerous noise modelling and impact assessments previously for a range of projects, including mining and industrial projects using SoundPLAN®.

[1] Recommended Acceptable L_{Aeq} noise level for residence in rural area from Table 2.1 in EPA (OEH) Industrial Noise Policy.

[2] Where the rating background level (RBL) is found to be less than 30dB(A), then it is set to 30dB(A).

6.1 Geographical Data

The Narara Ecovillage Co-operative (Client) supplied Vipac with topographical details of the area in 3-dimensional DXF format (Drawing No. D12242-4A.DXF). The proposed residential development and STP layout plan is shown in ***Appendix A:***.

6.2 Noise Sources

Vipac has been advised by Aquacell Pty Ltd (the supplier of the sewage treatment system to Narara Ecovillage) that the main noise contributors associated with the proposed sewage treatment plant will be Bio Blowers and the Membrane Bioreactor (MBR) blower.

Details of the proposed STP equipment and associated sound power levels (i.e. noise emission levels associated with the equipment) are listed below in ***Table 6***.

Table 6: Sound Power levels of equipment to be utilized in the proposed STP

Description	Model	No of Units	Sound Pressure (L_p) levels/unit (dB(A))	Sound Power (L_w) Levels (dB(A))
Bio Blower	Becker - KDT 3.100	2	75 at 1-metre	83
MBR membrane blower	Becker - KDT 4.40k	1	67 at 1-metre	75

It is anticipated that the major noise sources listed above would be contained within the STP building. In the absence of the STP building layout plan, Vipac has assumed that the STP building's façade will provide a reduction of at least 10dB. It should be noted that vent on the façade will reduce the acoustic performance of a wall. Hence it is recommended that the vent should be located away from the nearest noise sensitive receptors (e.g. install vents on southern and eastern façade of the STP building).

6.3 Noise Modelling Scenario

Four acoustic modelling scenarios were run for the STP within the SoundPLAN program using CONCOWE algorithms under both neutral and worst case weather conditions for the day and evening/night periods. It should be noted that sound waves (i.e. noise) will propagate further through the atmosphere under certain weather conditions. The 'worst-case' weather conditions chosen were those highly conducive to the propagation of sound. As operations occur during 24 hours 7days a week, this situation has been considered in the noise predictions.

Table 7 presents the weather parameters used in the CONCOWE calculations based on the annual data the Bureau of Meteorology (BoM) Weather Station at Mangrove Mountain.

Table 7: Sound Plan Weather Parameters

Parameter	Day		Evening/Night	
	Neutral	Worst-Case	Neutral	Worst-Case
Pasquill Stability Category	B	D	D	F
Wind Speed (m/s)	0	3	0	3
Humidity (%)	64	64	85	85
Temperature (deg Celsius)	17	17	6	6
Met Category	3	5	4	6

7 MODELLED STP NOISE - OPERATIONAL PHASE

Noise prediction modelling has been carried out to identify the potential impact associated with the proposed Sewage Treatment Plant on the existing noise environment at the nearest noise sensitive receptors located in proximity to the site. The predicted noise levels representative of the operational phase for each period (day, evening and night-time) for both neutral conditions and worst-case conditions are presented in ***Table 8***.

Table 8: Proposed STP, Operational - Predicted Noise Impact (L_{Aeq}) dB(A)

Receiver ID	Day			Evening			Night		
	Neutral	Worst-Case	Criteria	Neutral	Worst-Case	Criteria	Neutral	Worst-Case	Criteria
R1	6	13	39	9	13	36	9	13	35
R2	4	12	39	8	12	36	8	12	35
R3	4	12	39	8	12	36	8	12	35
R4	5	10	42	8	10	39	8	10	35
R5	5	8	42	7	8	39	7	8	35
R6	25	26	42	26	26	39	26	26	35
R7	25	27	42	26	27	39	26	27	35
R8	24	25	42	25	25	39	25	25	35
R9	19	20	42	20	20	39	20	20	35
C1	42	42	65	42	42	65	42	42	65

Noise modelling has been undertaken for four scenarios considering both the neutral and worst-case conditions during day time and evening/night-time. The predicted noise impact from the proposed sewage treatment plant on the noise sensitive receivers ranged between 4 to 42dB(A), which is well within the applicable criteria during day, evening and night time periods.

Noise contour maps illustrating the results of the noise propagation models for the various scenarios represented in ***Table 8*** are presented in ***Appendix B:***.

8 CONCLUSION

A noise impact assessment has been undertaken to determine the potential noise impact of the proposed sewage treatment plant operations on noise sensitive receptors in the surrounding area.

The acoustic impact of the proposed sewage treatment plant is predicted to be well within the applicable noise criteria during day, evening and night-time periods.

Therefore, it is Vipac's professional opinion that the proposed sewage treatment plant is acceptable from an acoustic point of view.

Appendix A: PROPOSED RESIDENTIAL LOT AND STP LAYOUT PLAN

11 Dec 2013

Appendix B: NOISE CONTOUR MAPS

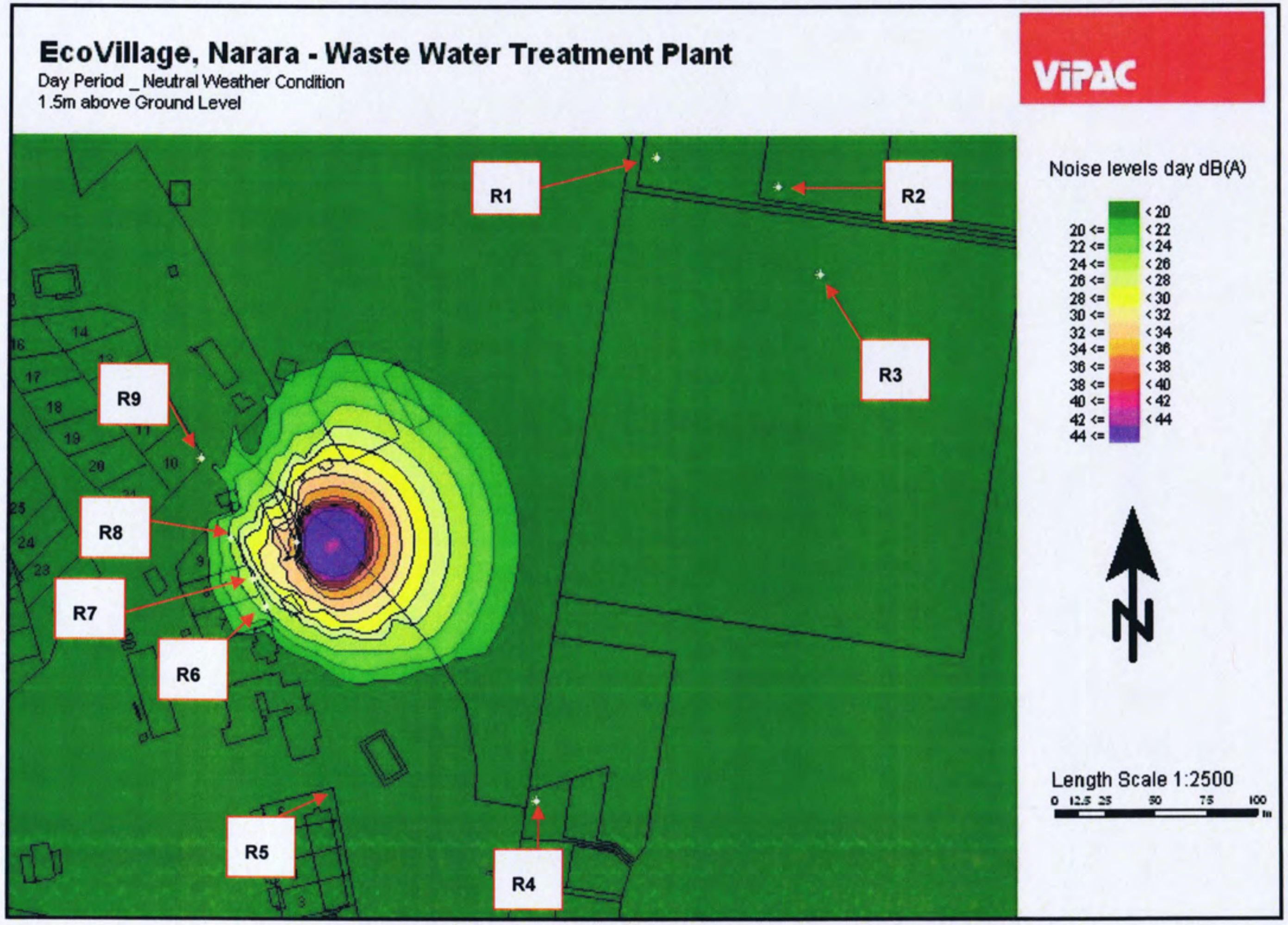

Figure 2: Proposed STP – Day Period, Neutral Weather Condition

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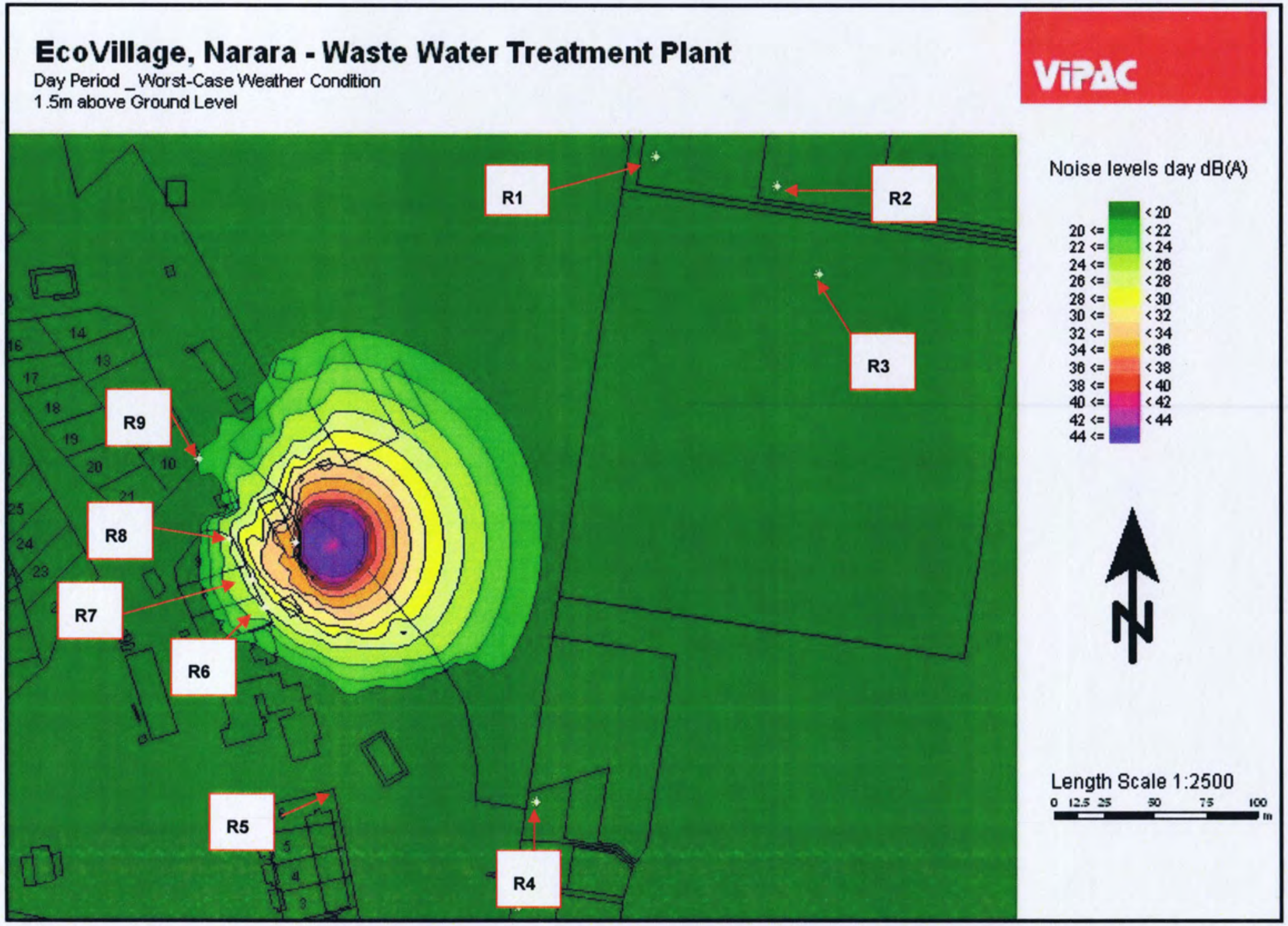

Figure 3: Proposed STP – Day Period, Worst-Case Weather Condition

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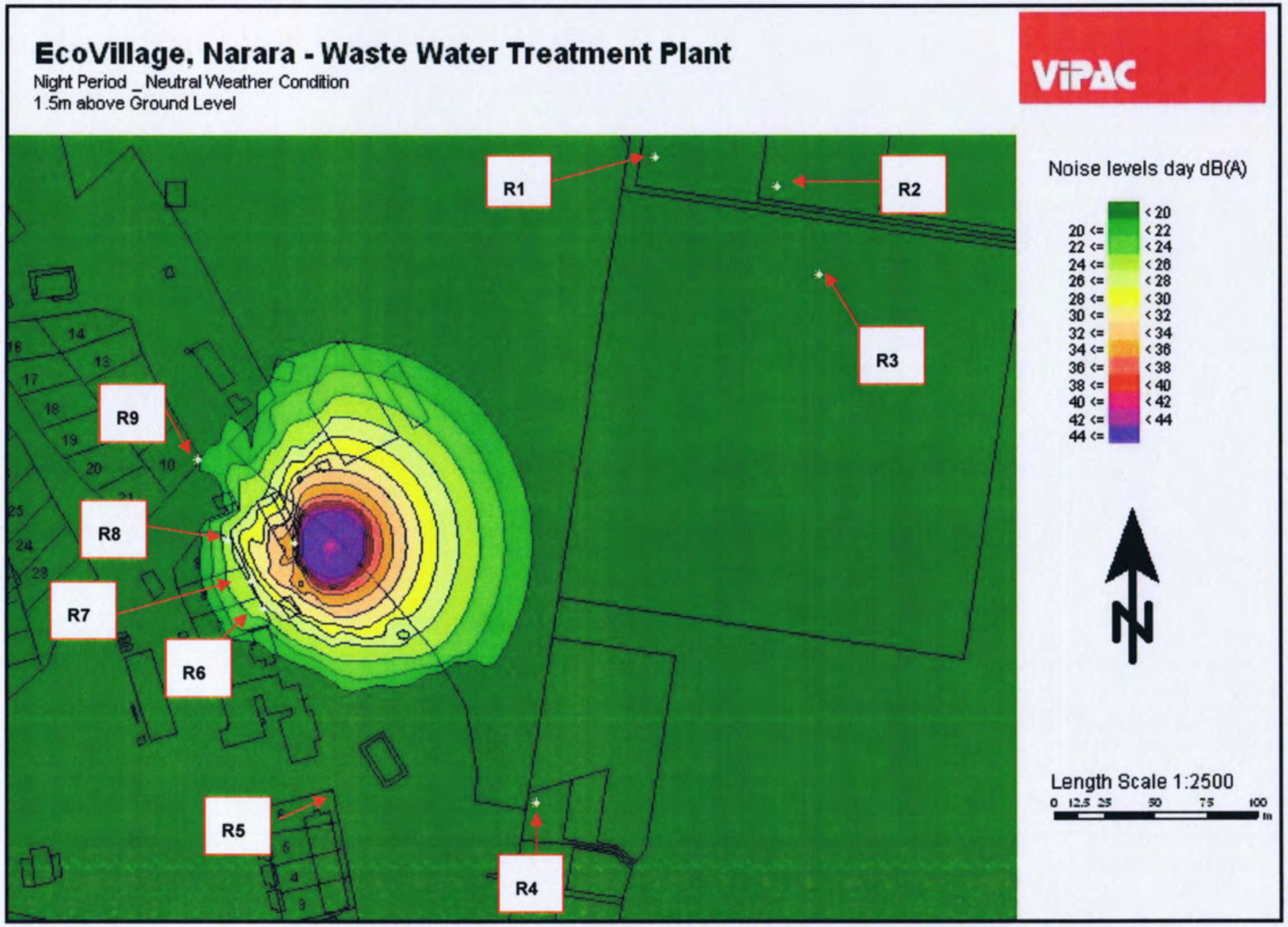

Figure 4: Proposed STP – Night Period, Neutral Weather Condition

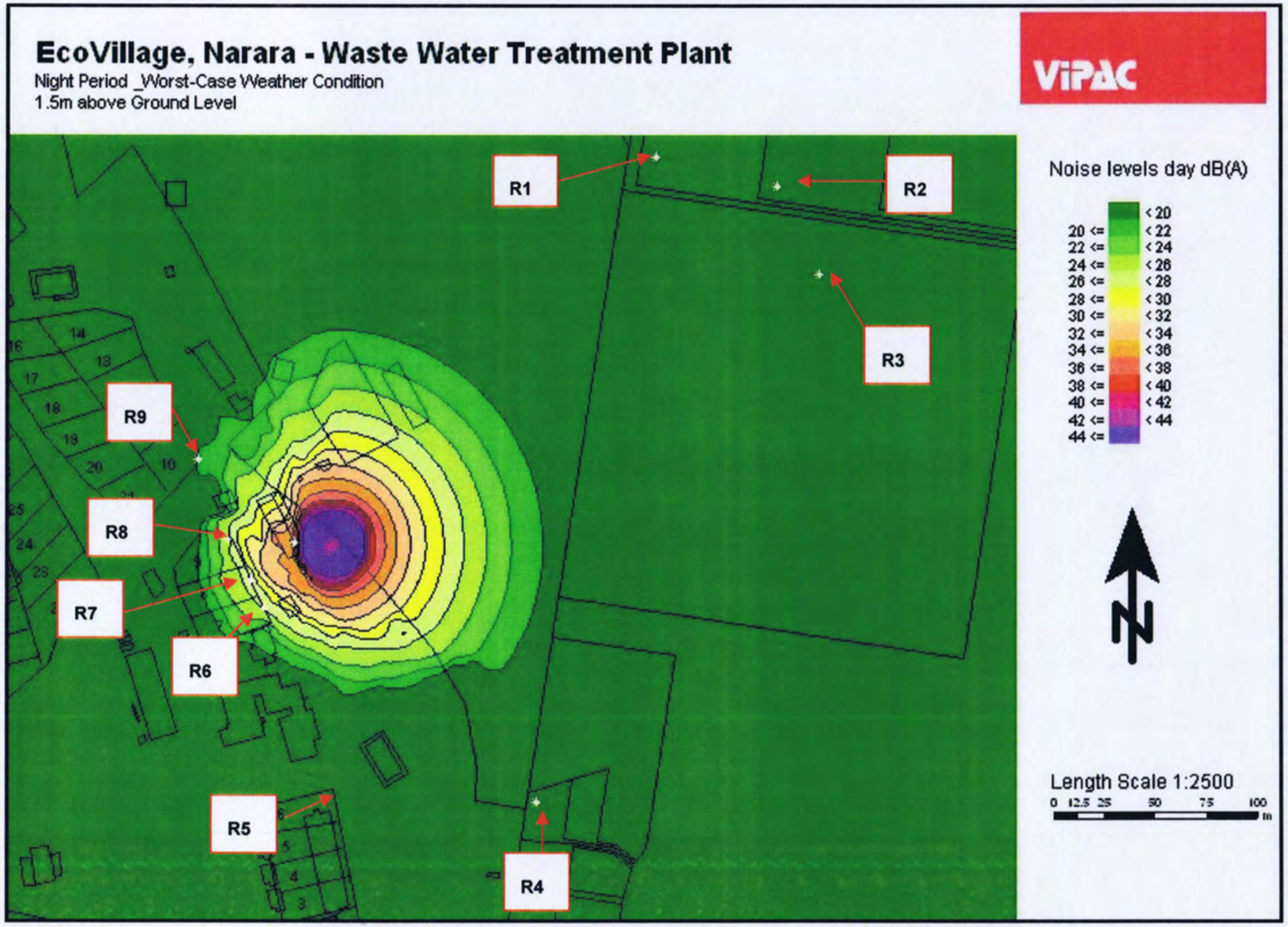

Figure 5: Proposed STP – Night Period, Worst-Case Weather Condition

Vipac Engineers & Scientists Ltd.
4/5 Leo Lewis Close, Toronto, NSW 2283, Australia
PO Box 306, Toronto, NSW 2283, Australia
t. +61 2 4950 5833 | **f.** +61 2 4950 4276 | **e.** huntervalley@vipac.com.au
w. www.vipac.com.au | A.B.N. 33 005 453 627 | A.C.N. 005 453 627

Vipac Engineers & Scientists

Narara Ecovillage Co-operative Ltd

Sewage Treatment Plant

Noise and Vibration Management Plan

29N-13-0156-TRP-472221-0

16 Dec 2013

Report Title: Noise and Vibration Management Plan **Job Title: Sewage Treatment Plant**		
DOCUMENT NO: 29N-13-0156-TRP-472221-0 **PREPARED FOR:** **Narara Ecovillage Co-operative Ltd** 2/83 Ramsgate Avenue Bondi NSW 2026 **CONTACT:** John Talbott **Tel:** +61 2 9130 4241 **Fax:** +61 2 9130 3837		**REPORT CODE:** TRP **PREPARED BY:** Vipac Engineers & Scientists Ltd. 4/5 Leo Lewis Close, Toronto, NSW 2283, Australia **Tel:** +61 2 4950 5833 **Fax**: +61 2 4950 4276
PREPARED BY: Author:	Lynne Tan Lynne Tan Project Engineer	Date: 16 Dec 2013
REVIEWED BY: Reviewer:	Darragh Kingston Darragh Kingston Team Leader, Acoustics	Date: 16 Dec 2013
AUTHORISED BY:	Darragh Kingston Darragh Kingston Team Leader, Acoustics	Date: 16 Dec 2013
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1 INTRODUCTION

Vipac Engineers and Scientists Ltd (Vipac) was commissioned by Narara Ecovillage Co-operative Ltd to undertake a Construction Noise and Vibration Impact Assessment associated with the Proposed Sewage Treatment Plant (STP) at 25 Research Road, Narara, NSW.

This Noise Management Plan has been prepared in accordance with the following guidance documents:

- Environmental Protection Authority (EPA) Office of Environment and Heritage (OEH) NSW "*Interim Construction Noise Guideline";*
- EPA (OEH) NSW "*Industrial Noise Policy";*
- AS 2436-2010 "*Guide to Noise Construction, Maintenance and Demolition Sites";*

The steps for managing noise impacts from construction are as follows:

- Identify the location of the proposed works.
- Identify the sensitive receiver locations with respect to proposed works.
- Define noise management levels for the sensitive locations.
- Describe the nature of the works to be undertaken and their expected duration.
- Predict levels of noise and vibration from construction work at the identified sensitive receivers.
- Provide reasonable and feasible mitigation and management strategies where the noise management levels are exceeded.

2 GLOSSARY OF TERMS

A list of commonly used acoustical terms (and their definition) used in this report is provided below in ***Table 1***, as an aid to readers of the report.

Table 1: Definition of Acoustical Terms

Term	Definition
$L_{eq,1hr}$	Equivalent Continuous Noise Level - which, lasting for as long as a given noise event has the same amount of acoustic energy as the given event for the period of an hour.
$L_{A10,1\ hr}$	The noise level, which is equalled or exceeded for 10% of the measurement period of one hour.
$L_{A90,T}$	The noise level, which is equalled or exceeded for 90% of a given measurement period, T. $L_{A90,T}$ is used in Australia as the descriptor for background noise.
$L_{Aeq,T}$	The equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time, for a given time period. It can be considered as the average sound pressure level over the measurement period and is commonly used as a descriptor for ambient noise.
L_n	The Sound Pressure levels that is equalled or exceeded for n% of the interval time period. Commonly used noise intervals are L_1, L_{10}, L_{90} and L_{99}%
$L_{A10,18hrs}$	The L_{10} noise level for the time period extending from 6am to midnight.

3 PROJECT DESCRIPTION

3.1 Site Location

The proposed sewage treatment plant (STP) is located at Lot 13 DP 1126998 Research Road, Narara, NSW, approximately 6-kilometers northwest of Gosford, NSW. The site location of the proposed sewage treatment plant and surrounding noise sensitive receptors is illustrated in ***Figure 1***.

There are a number of noise sensitive receptors located to the North-East and South-East of the proposed STP, situated within a 300-metre radius of the proposed STP that may potentially be impacted by the construction activities of proposed STP.

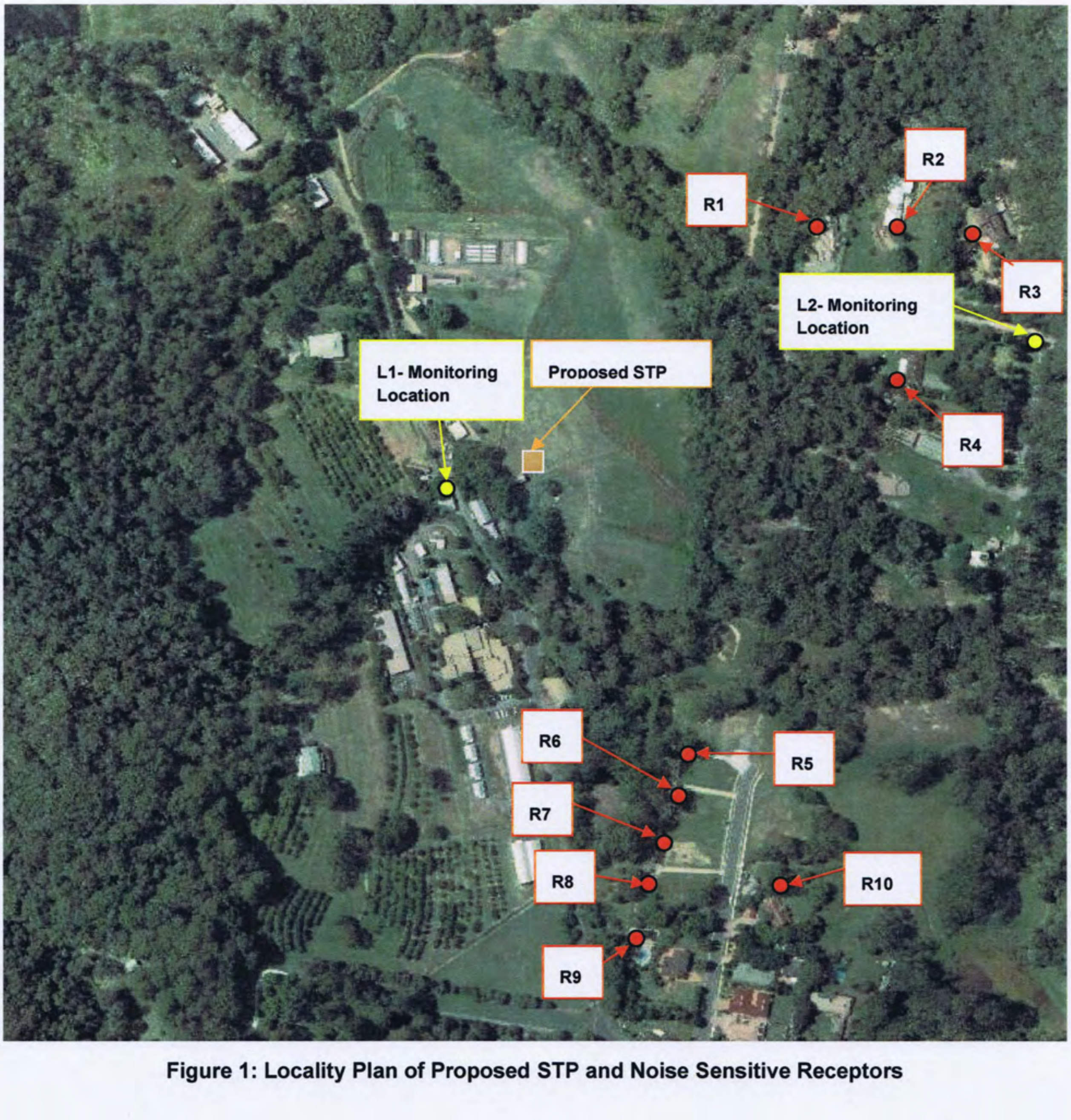

Figure 1: Locality Plan of Proposed STP and Noise Sensitive Receptors

3.2 Noise Sensitive Receivers

A list of the nearest potentially affected noise sensitive receivers located in the vicinity of the site of the proposed sewage treatment plant (STP) is provided below in ***Table 2***. The distance for each of the sensitive receptors is calculated from the boundary of proposed STP to the property boundary of noise sensitive receivers.

Table 2: Noise Sensitive Receivers

ID	Property	Location
R1	3 Nursery Street, Narara	Approximately 220m to the North East of the STP
R2	2 Nursery Street, Narara	Approximately 260m to the North East of the STP
R3	1 Nursery Street, Narara	Approximately 320m to the North East of the STP
R4	16 Nursery Street, Narara	Approximately 260m to the South East of the STP
R5	Lot 10 Monarchy Way, Narara	Approximately 150m to the South East of the STP
R6	Lot 8 & 9 Monarchy Way, Narara	Approximately 170m to the South East of the STP
R7	Lot 6 & 7 Monarchy Way, Narara	Approximately 200m to the South East of the STP
R8	Lot 3 & 4 Monarchy Way, Narara	Approximately 210m to the South East of the STP
R9	Lot 1 & 2 Monarchy Way, Narara	Approximately 250m to the South of the STP
R10	Lot 21 Monarchy Way, Narara	Approximately 200m to the South East of the STP

3.3 Construction Methodology

Typical construction activities consist of the following stages:

- Excavation
- Construction

The following is the typical construction equipment that will be used during the construction activities of each stage:

- Excavation - Excavator and trucks for removals]
- Construction - Mobile crane, material hoist, concrete mixer and concrete pump, delivery trucks and general construction tools such as drill, nail gun, electric saw, etc.

4 CONSTRUCTION NOISE GUIDELINES

4.1 NSW EPA (OEH) "Interim Construction Noise Guideline"

The NSW Interim Construction Noise Guideline was developed by the NSW - OEH and contains detailed procedures for the assessment and management of construction noise impacts.

The Guideline presents two ways of assessing construction noise impacts – the quantitative method, which is generally suited to longer-term construction, and the qualitative method, which is generally suited to short-term works (usually not more than 3 weeks) such as infrastructure maintenance.

It is expected that the length of the construction works will be more than 3 weeks and therefore, a quantitative method has been used for this assessment.

4.1.1 Residences and Other Sensitive Land Uses

Table 3 sets out the management levels for noise at residences and sensitive land uses, respectively. Restrictions to the hours of construction may apply to activities that generate noise at residences above the 'highly noise affected' noise management level.

Table 3: Noise at residence using Quantitative Assessment

Recommended Hours	Time of Day	Management level[1] $L_{Aeq(15min)}$
Recommended standard hours	Monday to Friday - 7 am to 6pm Saturday - 8am to 1 pm No Work on Sundays or Public holidays	Noise affected RBL[2] + 10dB
		Highly noise affected[3] 75dB
Outside recommended standard hours		Noise affected RBL[2] + 5dB

When assessing construction noise it should be noted that several types of plant and equipment can be particularly annoying to nearby residents. In those instances a +5dB penalty is applied to the predicted noise level. A list of typical plant and equipment commonly used on construction projects is provided below:

- Use of 'beeper' style reversing or movement alarms, particularly at night time
- Use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work
- Grinding metal, concrete or masonry
- Rock drilling
- Line drilling
- Vibratory rolling
- Rail tamping and regulating
- Bitumen milling or profiling
- Jack hammering, rock hammering it rock breaking'
- Impact piling

1 Noise levels apply at the boundary that is most exposed to construction noise and at a height of 1.5 m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise-affected residence.

2 RBL is the Rating Background Level as defined in the OEH Industrial Noise Policy.

3 $L_{Aeq\ 15\text{-}minute} \geq 75$ dB is highly likely to generate strong community reactions and should be avoided.

4.1.2 Assessing Impacts

The process of predicting noise is summarised in ***Figure 2.***

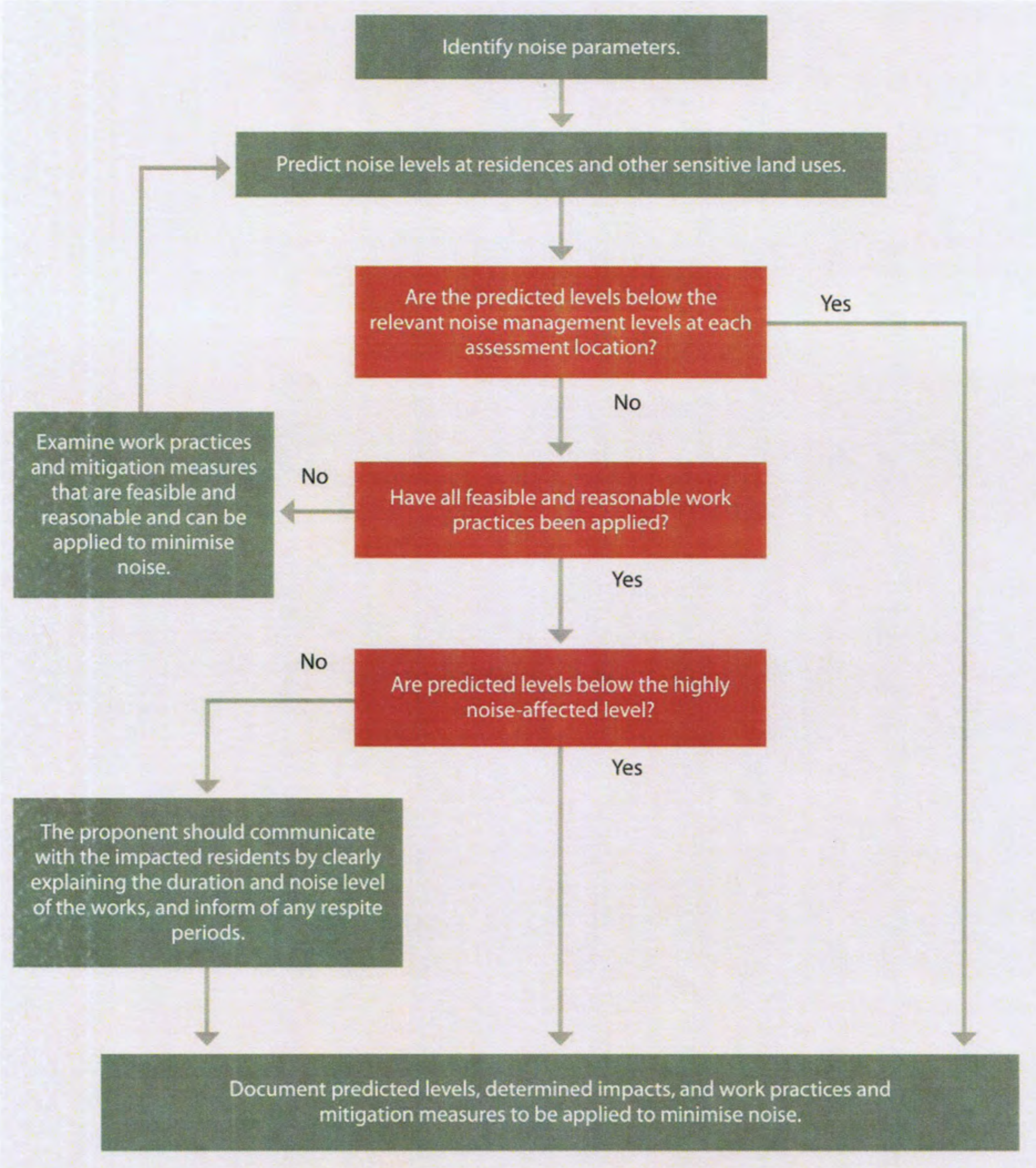

Figure 2: Prediction and Assessment of impacts- Quantitative method

4.2 Sleep Disturbance Assessment Approach

The NSW Construction Noise Guideline also recommends that when construction works extend for more than two consecutive nights, the analysis should cover maximum noise levels, and the extent that they exceed the Rating Background Level (RBL). Guidance indicating the potential for sleep disturbance is set out in the NSW Environmental Criteria for Road and Traffic Noise (EPA 1999), and is summarised as follows:

"OEH reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research, OEH recognised that current sleep disturbance criterion of an LA1, (1 minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, OEH will continue to use it as a guide to identify the likelihood of sleep disturbance.

This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:

- *How often high noise events will occur*
- *Time of day (normally between 10pm and 7am)*
- *Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. DECCW will accept analysis based on either LA1, (1 minute) or LA(Max).

It should be noted that the OEH refers to the Office of Environment and Heritage, and DECCW refers to the Department of Environment, Climate Change and Water.

5 CONSTRUCTION VIBRATION CRITERIA

The effects of construction vibration upon buildings can be separated into three main categories:

- Perceptibility of the occupants to the vibration, and the possibility of them being disturbed or annoyed;
- Vulnerability of the building structures to vibration induced damaged;
- Vulnerability of the contents of the building that includes types of equipment, activities and processes.

5.1 Human Response to Vibration

Humans are very sensitive to vibration, and they can be disturbed, annoyed, and have their work activities interfered with if the levels are too high. The OEH "Assessing Vibration – Technical Guidelines" and British Standard 6472 provide guidance on human response to vibration in buildings. These guidelines set down base vibration levels at which there would be minimal interference to occupants.

BS 6841 also sets out guidance on the effects to physical health from sustained exposure to vibration. However it is unlikely that such levels would be encountered from construction or demolition activities. The frequency weighting to be applied to the vibration levels are obtained from BS 6841.

The vibration criteria and guidelines relating to human response are summarised below.

5.1.1 OEH ASSESSING VIBRATION: A Technical Guideline

The OEH technical guideline for assessing vibration provides evaluation methods to assess the human response from continuous, impulsive and intermittent vibration in buildings from 1Hz to 80Hz which is based on British Standard 6472:1992 "Evaluation of the Human Exposure to Vibration in Building (1Hz to 80Hz)".

For continuous and impulsive vibration, assessment of impact should be considered on the basis of weighted RMS acceleration values. For intermittent vibration, assessment of impact should be considered on the basis of vibration dose values (VDV).

The OEH guidelines also include a section on mitigation when the predicted vibration value exceeds the criteria. Vibration mitigation may be achieved by way of:

- Controlling the vibration at the source, using the application of Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA).
- Controlling the transmission of vibration.
- Controlling the vibration at the receiver

5.1.2 British Standard 6472:2008- Evaluation of Human Exposure to Vibration in Buildings

BS6472:1992 was updated in 2008 by BS6472:2008 Parts 1 and 2. BS6472:2008 Part 1 sets out vibration levels at which minimal comment is likely to be provoked from the occupants of a building subject to vibration (BS6472:2008 Part 2 relates to Blast-induced vibration). BS 6472 takes into account the fact that humans perceive vertical vibrations to a greater extent than horizontal vibrations, although the effect is reversed at very low frequencies, below 4 Hz.

The evaluation of building vibration with respect to annoyance and comfort for occupants, over all weighted values of vibration is the preferred method of evaluation.

Continuous vibration would be generated for typical construction work. The curves in ***Figure 3*** represent the magnitudes of continuous vibration in buildings for Z-axis acceleration, below which adverse comments or complaints are rare. Multiplication factors are applied to the base level curve to define criteria for residential or office spaces. There are similar curves for x and y-axis.

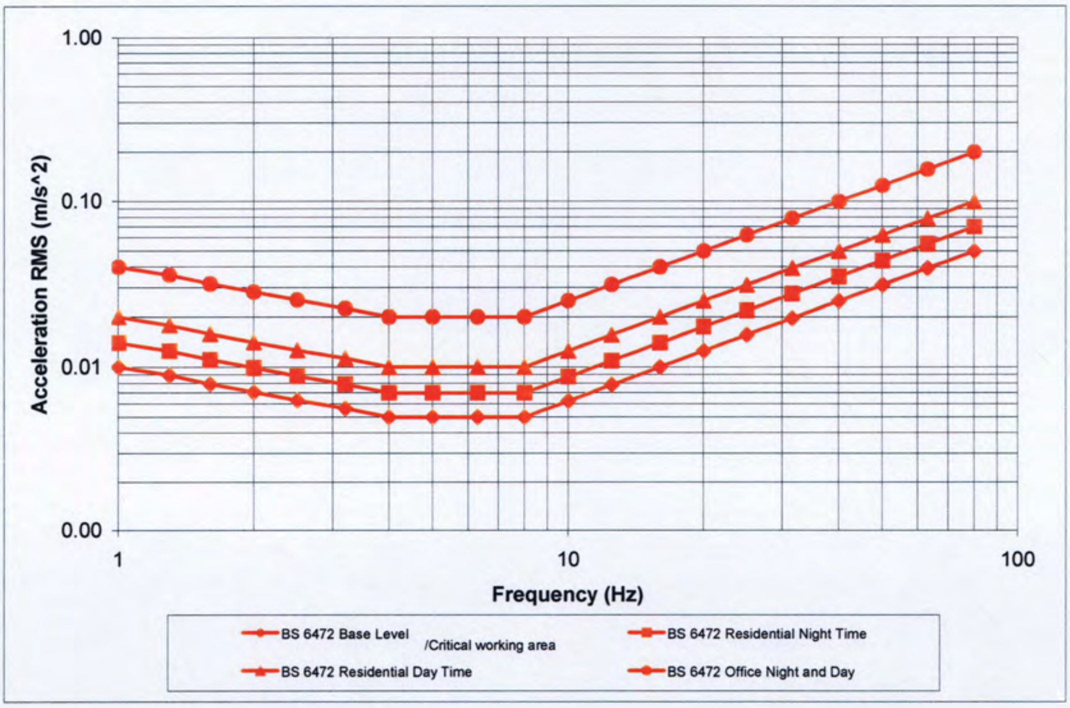

Figure 3: BS 6472 building vibration levels. Z-axis.

The Vibration Dose Value in BS 6472 is a concept used to evaluate the cumulative effects of bursts of both intermittent vibration and impulsive vibrations. Vibration Dose Value or the VDV represents a single value amount used to quantify the level of vibration.

The recommended VDV levels outlined in the OEH Vibration Guidelines (based on the BS6472:1992 Standard) which specifies levels of VDV expressed in daytime, night-time and typical human response are presented in ***Table 4*** . ***Table 5*** presents levels of VDV expressed in daytime, night-time and typical human response, based on the updated BS6472:2008 Part 1.

Table 4: Acceptable vibration dose values for intermittent vibration in various buildings ($m/s^{1.75}$)

Location	Daytime[1]		Night-time	
	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$
Critical areas[2]	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

Note 1: Daytime is 07:00 am to 10:00 pm and night-time is 10:00 pm to 07:00 am.

Note 2: Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical cases.

Table 5: Vibration dose value ranges which might result in various probabilities of adverse comment within various buildings ($m/s^{1.75}$)

Place and time	Low probability of adverse comment $m/s^{1.75}$ Note 1	Adverse comment possible $m/s^{1.75}$	Adverse comment probable $m/s^{1.75}$ Note 2
Residential buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Office buildings 16h day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshop buildings 16h day	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

Note 1: Below these ranges, adverse comment is not expected.

Note 2: Above these ranges, adverse comment is very likely.

Vibration frequency was assessed in the range from 8Hz - 80 Hz, as predominant frequencies are known to be above 8Hz. Vibration levels below the low probability of adverse comment range presented in ***Table 5*** correspond to a low probability of disturbance to building occupants. Adverse comment or complaints may be expected when the VDV approaches the higher range levels in the possible and probable categories. Values up to the maximum level in ***Table 4*** can only be used where all reasonable and feasible measures have been implemented and they can be justified.

Criteria for exposure to continuous and impulsive vibration with regard to PPV levels expressed in daytime and night-time (outlined in the OEH Vibration Guidelines) are provided in ***Table 6.***

Table 6: Peak Particle velocity for z-axis

Place	Time	Peak Particle velocity (mm/s) for z-axis vibration Frequency range 8Hz-80Hz	
		Exposure to continuous vibration (16h day, 8h night)	Impulsive vibration excitation with up to three occurrences
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day Night	0.14 to 0.28 0.14 to 0.28	0.14 to 0.28 0.14 to 0.28
Residential	Day Night	0.28 to 0.56 0.2 to 0.4	8.6 to 17.0 2.8 to 5.6
Office	Day Night	0.56 to 1.1 0.56 to 1.1	18.0 to 36.0 18.0 to 36.0
Workshops	Day Night	1.1 to 2.2 1.1 to 2.2	18.0 to 36.0 18.0 to 36.0

5.2 Structural Response to Vibration

The response of a building to vibration is affected by several factors that include its type of foundation; the underlying ground conditions, its construction and the condition of the building.

BS 7385: Part 2-1993 provides guide values for building damage, as well as guidance on vibration measurement and data analysis. The German Standard DIN 4150: Part 3-1999 also provides guidelines for evaluating the effects of vibration on structures.

5.2.1 German Standard DIN 4150-3:1999 – Structural Vibration – Effects of Vibration on Structures

The German standard DIN 4150-3 Structural Vibration Part 3: Effects on buildings and structures is commonly used in Australia to evaluate the effects of vibration on structures primarily used for static loading.

Short-term vibration is defined as vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated.

Table 7 below provides guideline limits for short-term vibration to ensure that damage reducing the serviceability of a building will not occur provided vibration levels do not exceed these limits. This is also shown graphically in ***Figure 4***. Vibration at the foundation is taken as the maximum absolute value in the x, y, and z directions, and vibration at the highest floor is the maximum of the in plane components.

Table 7: DIN4150-3 Vibration Limits

Type of structure	Guideline values for velocity in mm/s			
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies
	1Hz to 10Hz	10 to 50Hz	50 to 100Hz (and above)	
Buildings for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
Structures that because of their particular sensitivity to vibration, cannot be classified as above and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

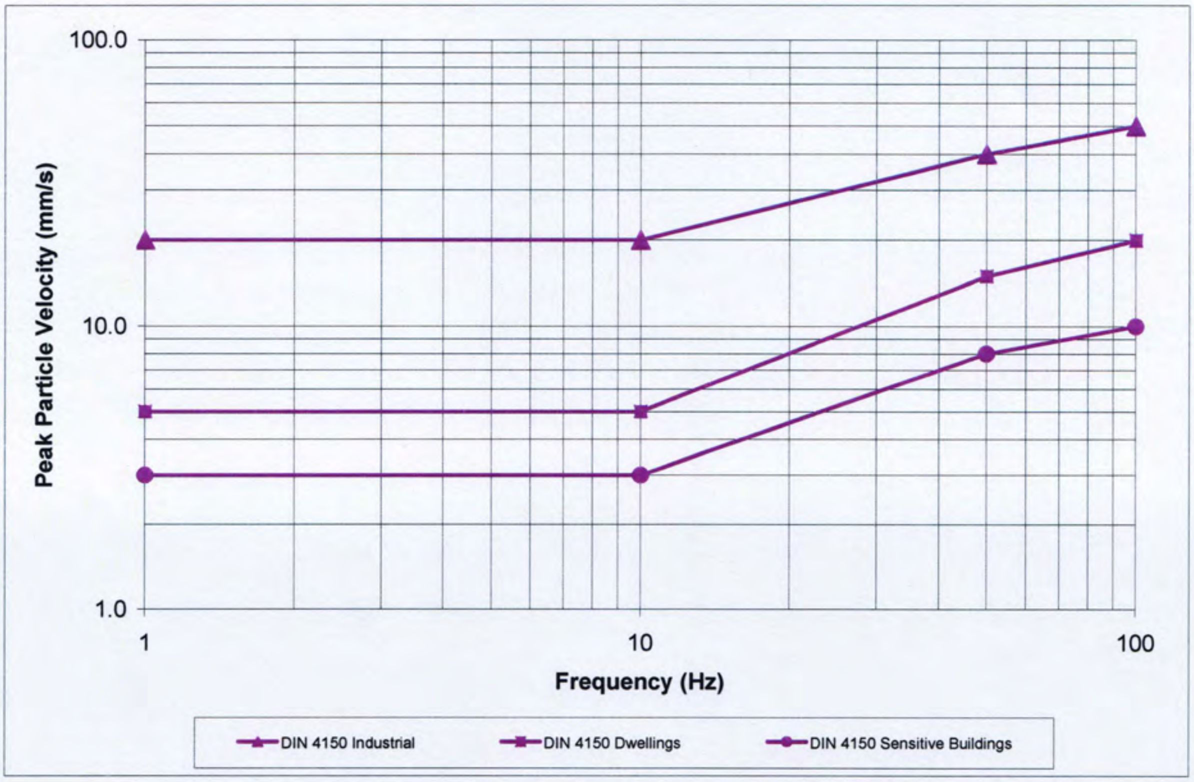

Figure 4: DIN 4150-3 Vibration Limits

5.2.2 British Standard 7385 Part 2 – 1993 Guidelines

The limits for transient vibration, above which cosmetic damage could occur to buildings, are given in ***Table 8*** and shown graphically in ***Figure 5.***

These guide values however relate predominantly to transient vibration that does not give rise to resonant responses in structures. The guide values in ***Table 8*** should be reduced by up to 50%, in the case of dynamic loading caused by continuous vibration. The values presented in BS 7385-2 are frequency dependant levels that are judged to give a minimal risk of vibration-induced damage.

Table 8: Transient vibration guide values for cosmetic damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced framed structures, Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Un-reinforced or light framed structures, Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Note 1: Values referred to are at the base of the building Note 2: For the residential buildings group, at frequencies below 4 Hz, a maximum displacement of 0.6mm (zero to peak) should not be exceeded		

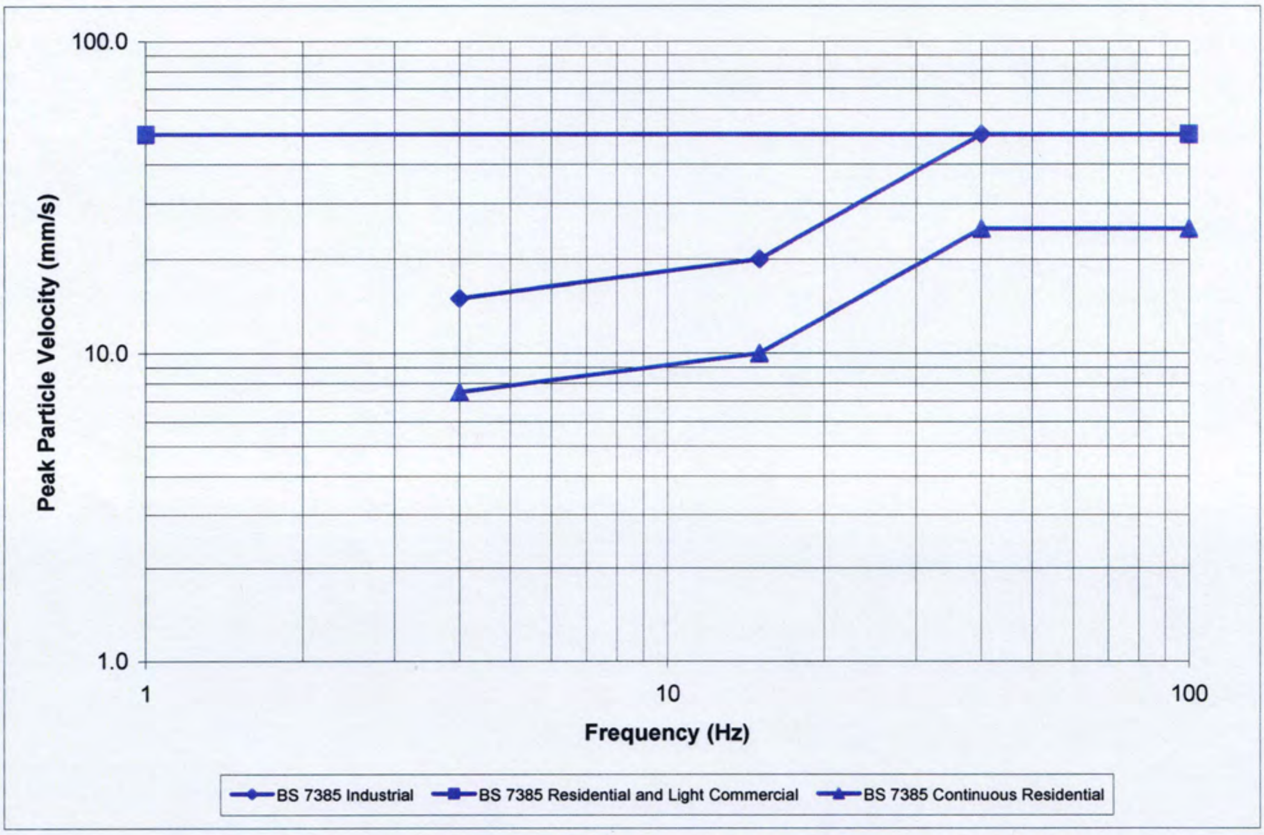

Figure 5: Transient Vibration Guide for Cosmetic Damage

5.2.3 Construction Vibration Assessment Criteria Summary

A comparison of the above criteria is shown in ***Figure 6***. PPV values have been used for the human disturbance values, in order to compare against building damage guide values.

The human disturbance criterion from BS6472 for continuous vibration is significantly lower than the various threshold damage levels from DIN4150 and BS7385. This is due to humans being able to perceive vibration levels that are well below those that could cause any risk to damage to a building or its contents.

The values in DIN4150 are levels that if complied with, damage will not occur. If levels are exceeded damage will not necessarily occur, however if they are significantly exceeded, then further investigations will be required.

The values specified in BS7385 are the lowest vibration levels above which damage has been credibly demonstrated. This is the basis on which the values are much higher than those of DIN4150.

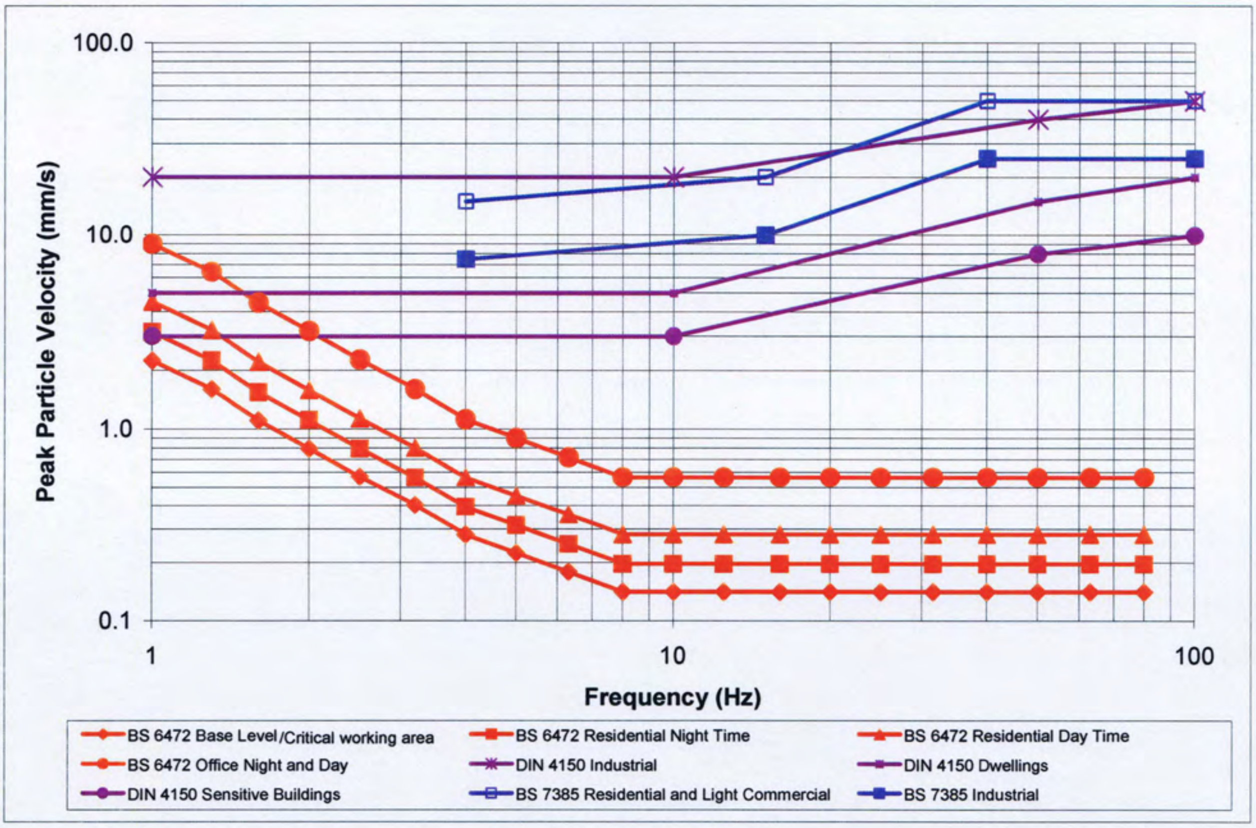

Figure 6: Human Disturbance and Building Damage Guide Values

Based on the above, the following criterion is deemed most appropriate and is recommended for use in this assessment:

- When the adjacent building subject to vibration is occupied, continuous vibration levels from BS 6472 will be used to assess human perception. Human perception occurs at lower thresholds than that for building damage and during occupied periods will be the limiting criteria.
- When it is un-occupied, vibration levels from DIN4150 will be used to protect the building from cosmetic damage.

6 CONSTRUCTION NOISE & VIBRATION GOALS

A noise survey was carried out to measure the current ambient noise levels in the vicinity of the proposed STP. The results of unattended measurements are shown in ***Table 9.*** The noise limits for construction on the site have been determined in accordance with the interim construction noise guideline.

Table 9: Existing Noise levels, dB(A)

Period	Descriptor	L1	L2
Day (7am- 6pm)	L_{Aeq}	46	47
	L_{A90}	38	37
	RBL[1]	37	34
Evening (6pm-10pm)	L_{Aeq}	51	53
	L_{A90}	38	36
	RBL[1]	34	31
Night (10pm-7am)	L_{Aeq}	41	41
	L_{A90}	32	35
	RBL[1]	27	30

Table 10 and ***Table 11*** provide a summary of noise and vibration management levels criterion at the sensitive receivers.

Table 10: Construction Noise Management Levels

Receiver type	Period	NML		Highly affected Noise Level
		L1	L2	
Residential	Day - (RBL+10)	47	44	75
	Day - (RBL+5) (or outside standard hours)	42	39	
	Evening - (RBL+5) (or outside standard hours)	39	36	
	Night (RBL+5) (or outside standard hours)	32	35	
Commercial	When in use	70		

In absence of the proposed construction hours for the proposed STP, Vipac has assessed the construction noise impact during day, evening and night periods, in the event that partial operations need to be conducted outside of standard construction hours.

[1] RBL is the median of the overall assessment background noise level calculated using OEH Industrial Noise Policy methodology as defined in the glossary of acoustic terms.

Table 11: Human perception and cosmetic damage criteria (minimum value)

Receiver	Type	Human Perception and cosmetic damage criteria	
		Human Perception (mm/s)	Cosmetic Damage (mm/s)
R1-R4	Residential	0.28 - 0.56	5
C1	Commercial	0.56 – 1.1	5

7 CONSTRUCTION NOISE ASSESSMENT

7.1 Plant and Equipment

Table 12 details the proposed construction plant and equipment and the corresponding acoustic power produced by each item. The total predicted sound power levels for each of the construction phases is also presented. The typical sound levels of the plant and equipment were extracted from *"Australian Standard AS 2436-2010, Appendix A"*, "*British Standard BS 5228-1:2009 - Code of practice for noise and vibration control on construction and open sites- Part 1: Noise*" and "*Vipac database*".

Table 12: Construction activities and Sound Powel Levels

Plant & Equipment	Quantity	Sound Power Level (LWA) dB	Predicted Sound Pressure Levels (dB(A)) at various distances per equipment (metres)						
			10	20	60	150	200	250	300
Tracked excavator (103kW)	1	103	75	69	59	51	49	47	45
Mobile Crane (70 tonne)	1	98	70	64	54	46	44	42	40
Trucks	1	102	74	68	58	50	48	46	44
Mobile Concrete Line Pump	1	103	75	69	59	51	49	47	45
Hand-held Electric Drill	1	94	66	60	50	42	40	38	36
Hand-held Electric Grinder	1	103	75	69	59	51	49	47	45
Hoist	1	93	65	59	49	41	39	37	35
Circular Saw	1	113	85	79	69	61	59	57	55

7.2 Predicted Construction Noise Levels

The predicted noise levels have been calculated using the SoundPLAN computational noise modelling software package. The use of the SoundPLAN software and referenced modelling methodology is accepted for use in the state of NSW by the Office of Environment and Heritage (OEH) for environmental noise modelling purposes. Vipac have undertaken numerous noise modelling and impact assessments previously for a range of projects, including mining and industrial projects using SoundPLAN.

Noise levels are expressed as external $L_{Aeq,15\ minutes}$ at the nearest boundary of the receiver properties. The predicted levels are presented in ***Table 13*** for each of the construction stages. The results presented in bold red font represent exceedances of the applicable noise assessment goal.

Table 13: Predicted Noise Levels

Receptor ID Reference	Period	Criteria	Noise Management level	Predicted Noise Level (L_{Aeq}) dB	
				Excavation	Construction
R1	Standard Hours	Highly Noise Affected	75	36	46
		Noise Affected (RBL+10dB)	47	36	46
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	42	36	46
		Noise Affected Evening (RBL + 5dB)	39	36	46
		Noise Affected Night (RBL + 5dB)	32	36	46
R2	Standard Hours	Highly Noise Affected	75	35	45
		Noise Affected (RBL+10dB)	47	35	45
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	42	35	45
		Noise Affected Evening (RBL + 5dB)	39	35	45
		Noise Affected Night (RBL + 5dB)	32	35	45
R3	Standard Hours	Highly Noise Affected	75	33	44
		Noise Affected (RBL+10dB)	47	33	44
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	42	33	44
		Noise Affected Evening (RBL + 5dB)	39	33	44
		Noise Affected Night (RBL + 5dB)	32	33	44
R4	Standard Hours	Highly Noise Affected	75	35	45
		Noise Affected (RBL+10dB)	47	35	45
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	42	35	45
		Noise Affected Evening (RBL + 5dB)	39	35	45
		Noise Affected Night (RBL + 5dB)	32	35	45
R5	Standard Hours	Highly Noise Affected	75	37	45
		Noise Affected (RBL+10dB)	44	37	45
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	37	45
		Noise Affected Evening (RBL + 5dB)	36	37	45
		Noise Affected Night (RBL + 5dB)	35	37	45

Receptor ID Reference	Period	Criteria	Noise Management level	Predicted Noise Level (L_{Aeq}) dB	
				Excavation	Construction
R6	Standard Hours	Highly Noise Affected	75	35	43
		Noise Affected (RBL+10dB)	44	35	43
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	35	43
		Noise Affected Evening (RBL + 5dB)	36	35	43
		Noise Affected Night (RBL + 5dB)	35	35	43
R7	Standard Hours	Highly Noise Affected	75	34	42
		Noise Affected (RBL+10dB)	44	34	42
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	34	42
		Noise Affected Evening (RBL + 5dB)	36	34	42
		Noise Affected Night (RBL + 5dB)	35	34	42
R8	Standard Hours	Highly Noise Affected	75	32	39
		Noise Affected (RBL+10dB)	44	32	39
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	32	39
		Noise Affected Evening (RBL + 5dB)	36	32	39
		Noise Affected Night (RBL + 5dB)	35	32	39
R9	Standard Hours	Highly Noise Affected	75	32	38
		Noise Affected (RBL+10dB)	44	32	38
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	32	38
		Noise Affected Evening (RBL + 5dB)	36	32	38
		Noise Affected Night (RBL + 5dB)	35	32	38
R10	Standard Hours	Highly Noise Affected	75	36	43
		Noise Affected (RBL+10dB)	44	36	43
	Outside Standard Hours	Noise Affected Day (RBL + 5dB)	39	36	43
		Noise Affected Evening (RBL + 5dB)	36	36	43
		Noise Affected Night (RBL + 5dB)	35	36	43

7.3 Sleep Disturbance

For construction activities, the L_1 sound pressure level of a known L_{eq} (ambient noise level) is typically 10dB higher than the L_{eq} level, (L_1 refers to the 1 percentile noise level, i.e. the noise level that is exceeded for 1% over a given measurement period and L_{eq} refers to the equivalent (or average) noise level over a given measurement period). It is on this basis (i.e. the relationship of an L_1 noise level being approximately 10dB greater than the L_{eq} noise level for a given noise source) that the L_1 noise emission level of the proposed construction equipment has been estimated. Vipac have assessed sleep disturbance by using the criteria of RBL+15dB. It should also be noted that the assessment has been completed for all activities. The results presented in bold red font represent exceedances of the sleep disturbance criteria.

Table 14: Stage 1- Sleep disturbance assessment

Location ID	Predicted Noise Level (L_{A1}) dB		
	Excavation	Construction	Sleep Disturbance RBL+15dB
R1	**46**	**56**	42
R2	**45**	**55**	
R3	**43**	**54**	
R4	**45**	**55**	
R5	**47**	**55**	45
R6	**45**	**53**	
R7	44	**52**	
R8	42	**49**	
R9	42	**48**	
R10	**46**	**53**	

7.3.1 Discussion

The noise levels during the initial site excavation/earthworks stage are predicted to be within noise management levels (for standard construction hours and outside standard construction hours) and also within the highly noise affected levels at all noise sensitive receivers. However, the predicted initial site excavation/earthworks noise levels would be elevated above the sleep disturbance criteria at most of the noise sensitive receivers, in the unlikely event that such works were undertaken during night-time hours.

Predicted noise levels during the construction stage are within the noise management levels (standard construction hours) and highly noise affected levels at all noise sensitive receivers with the exception of residential area R5. The excursion at R5 is primarily attributable to the circular saw activity. In order to reduce the noise impact at R5, any circular saw activity that may be required at the construction site should be carried out away from the noise sensitive receptors. The majority of the noise sensitive receivers are predicted to exceed the noise management level outside construction hours and would potentially cause sleep disturbance at all of the receivers, in the unlikely event that construction work was to be undertaken during night-time hours or outside of standard construction hours.

Overall, the noise impact assessment indicates that the predicted construction noise levels at all noise sensitive receivers will be within the Noise Management Levels and the Noise-Affected Levels of the NSW Interim Construction Guideline for construction work undertaken during standard construction hours. However, the predicted noise levels are predicted to exceed the Noise Management Levels for construction work undertaken outside of standard construction hours, in the unlikely event that work is undertaken outside of standard construction hours.

In the event that any construction work is required to be undertaken outside of standard construction hours, there is a potential that such activity would cause sleep disturbance at all noise sensitive receivers during the site preparation/excavation and construction stages. As such, a site specific noise management plan adopting reasonable and feasible mitigation and management measures should be adopted as detailed in ***Section 8***.

7.4 Construction Vibration Assessment

Vibration may also be generated as a result of construction work and has been considered both in respect of potential damage of buildings and potential annoyance to the occupants.

In many cases, it is the occupants/residents fear of building damage that enhances the potential annoyance. The most common form of vibration measurement is peak particle velocity (PPV) in mm/s. In respect to building damage, a vibration level limit and frequency is normally specified. However, in respect of potential annoyance to receivers, a combination of vibration level frequency and duration is more appropriate. This is normally termed as a dose value.

Most excavation activities will produce low and mid frequency vibrations. The nearest receiver (R10) to the excavation area/proposed development is approximately 150-metres. At this distance the excavation equipment would be unlikely to have an impact on the building at R10.

Hence, it is Vipac's opinion that the potential vibration impact that is likely to be generated by the construction activities associated with the proposed STP will not cause damage to the properties at the sensitive receptors located in the surrounding area.

8 CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN (CNVMP)

Construction Noise and Vibration Management Plan		
Component		**Details**
General / Site. Management Issues		All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: requirements of Transport for NSW's Construction Noise Strategy, and should instruct all persons at the site with regard to all relevant project specific and standard noise and vibration mitigation measures detailed herein including permissible hours of work; any limitations on high noise generating activities; location of nearest sensitive receivers; construction employee parking areas; designated loading/unloading areas and procedures; site opening/closing times (including deliveries); and environmental incident procedures.
		A dedicated person will form a point of contact for the dissemination of general information regarding site operations. Contact persons will also be defined to receive comment or complaints from the community – refer to community liaison / complaints handling plan below.
Hours of Work / Respite Periods		Standard Hours for Construction: 07:00 – 18:00 Monday – Friday 07:00 -13:00 Saturday
		No more than four consecutive nights of high noise and/or vibration generating work may be undertaken over any seven-day period, unless otherwise approved by Transport for NSW.
Source Controls	**General / Work Practices**	Avoid unnecessary revving of engines and turn off plant that is not being used / required.
		Use only non-tonal reverse alarms (broadband alternatives are needed). Where possible organise the site so that delivery trucks and haulage trucks only drive forward to avoid the use of reversing alarms.
		Organise and schedule the equipment operations to limit the noisiest machines operating simultaneously.
		Turn off or throttle back plant that is not being used
		Site set up / movement of plant / delivery of materials / waste removal to site should be restricted to daytime.
		Truck drivers are to be informed of site access routes, acceptable delivery hours and must minimise extended periods of engine idling.

Construction Noise and Vibration Management Plan		
Component		**Details**
		Ensure there is no unnecessary shouting or loud stereos/radios on-site. There must be no dropping of materials from heights, throwing of metal items, or slamming of doors.
		Equipment must be inspected on a regular basis and maintained as necessary, to ensure it is in good working order. This must include inspections of the condition and performance of mufflers.
	Substitution	Use less noise-intensive equipment where reasonable and feasible.
		Construction equipment with the most effective mufflers, enclosures and low-noise tool bits and blades must be procured and utilised for the project.
		Where possible mains power should be utilised for temporary traffic signals / work area lighting. Where this is not feasible silenced generator sets are to be used instead.
		Vipac recommends that all plant and equipment be certified prior to use.
	Enclosures	Utilise partial enclosure for cutting of kerbs and pavers.
	Use and Siting of Equipment / activities	Where practical fixed plant should be positioned as far away as possible from sensitive receivers.
		During resurfacing / paving works consideration should be given to taking pavers off site for cutting where practical.
Consultation	**General**	A Community Involvement Plan should be implemented to engage with government agencies, relevant councils, landowners, community members and other stakeholders to provide a single consultation framework.
	Notification	A letter should be distributed to local residents in advance of the works to notify them of the nature and estimated timescales for completion of the proposed works. Thereafter a newsletter should be distributed to the local community by letter on a 2 weekly basis.
	Project info-line and Construction response line	A 24-hour construction response line should be provided as a contact point for any complaints regarding the construction work. A project info line should also be provided as a dedicated contact point for any project enquires. A Transport Project representative should respond to complaints within 2 hours.

Construction Noise and Vibration Management Plan		
Component		**Details**
Complaints management		Upon receiving any complaint regarding construction activities, the nominated member of staff must investigate the source of the complaint. The aim will be to initiate an immediate investigation no later than two hours after the complaint is made. Where practicable a visit should be made to the complainant to verify the nature of the complaint and if justified appropriate action should be taken to cease or amend the activity causing the complaint. Where three or more substantiated complaints of a similar nature are received (from at least two complainants), the work element must be reviewed in order to consider whether the work methods can be changed or if additional mitigation methods can be employed in order to prevent or reduce the likelihood of further complaints being made.
Monitoring Requirements	**Noise**	Attended monitoring should also be undertaken in response to complaints made by the community in order to validate and assess the source(s) giving rise to complaint(s).

9 COMMUNITY ENQUIRIES MAANAGEMENT

As part of the management plan, the community should be informed and consulted regarding the work activities, duration and details. An effective system should also be put in place to handle the complaints. The following details outlined herein are an example of what should be incorporated into a Community Relations Plan and include recommendations for complaints handling:

Notification before and during construction:

- Provide, reasonably ahead of time, information to the community regarding the construction work, duration, what is being done to minimise noise etc. For work to be undertaken outside of standard construction hours, inform affected residents between 5 and 14 days before commencement.
- To provide information to the neighbours, methods such as letterbox drops, meetings, individual contacts or setting up a website can be used.
- Maintain good communication between the community and project staff.
- Appoint a community liaison officer where required.
- Consider having a regular newsletter with site news, significant project events and timing of different activities.
- Facilitate contact with people to ensure that everyone can see that the site manager understands potential issues, that a planned approach is in place and that there is an ongoing commitment to minimise noise.

Complaints handling:

- Provide a readily accessible contact point for example a 24-hour toll-free information and complaints line.
- Give complaints a fair hearing.
- Have a documented complaints process including an escalation procedure so that if a complaint is not satisfied there is a clear path to follow.
- Call back as soon as possible to inform people of the actions to be taken.
- Provide a quick response to complaints with complaint handling staff having both a good knowledge of the project and ready access to information.
- Implement all feasible and reasonable measures to address the source of complaint.
- Keep a register of complaints including details such as date time description of the complaint, time of verbal response and timeframe for written response where appropriate.
- If the complaint is justified, remedial actions to be taken to remove the cause. In some cases noise measurements and noise monitoring may be required.

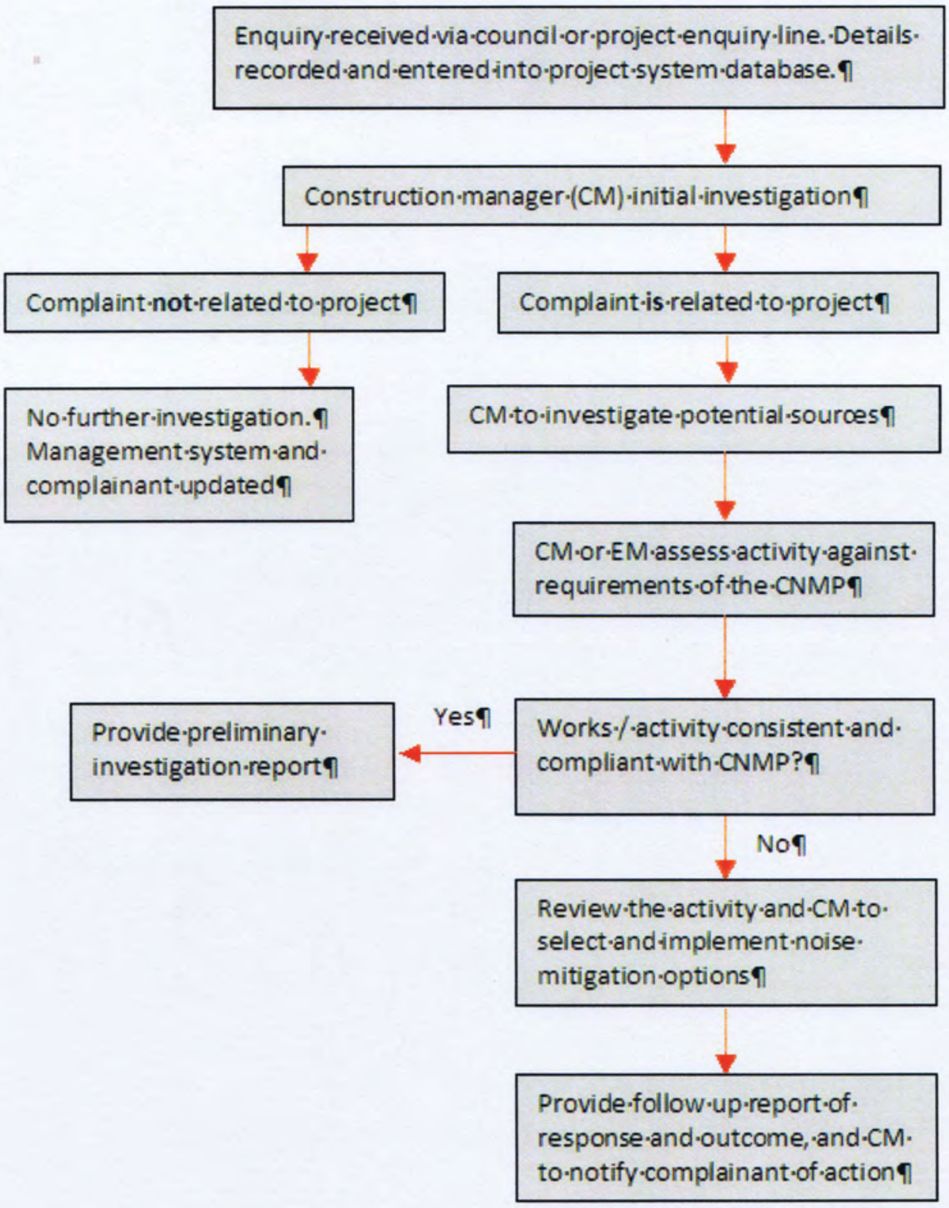

Figure 7: Complaint Handling Procedure

10 OUT OF HOURS WORK PROCEDURE (OOHW)

10.1 OOHW Justification & approval

All proposed OOHW requires a full justification as to why the works are required to be undertaken outside of standard construction hours. There are however a number of reasons why works can only be undertaken out of hours and these include, but are not limited to:

- Ensuring the safety of construction personnel;
- Ensuring road user and public safety;
- Minimising disruption to road network users/ pedestrians;
- Minimising disruption to essential utility services.

Where it is considered possible (safe and reasonable) for works to be undertaken during standard hours, OOHW proposals should not be further actioned.

Approval for OOHW shall be given by the Construction Manager (CM).

10.2 OOHW Noise Assessment

A noise assessment for OOHW and a CNVMP should be prepared to assess the extent of noise impact that the proposed OOH construction activities may have upon the community/residential receivers.

The assessment should be undertaken by an appropriately qualified person experienced in assessing the impacts of noise from construction works.

As part of the assessment process:

- The level of noise impact will be evaluated and classified;
- Any exceedance of the construction noise management levels will be identified;
- Appropriate noise management and mitigation measures will be determined where applicable;

10.3 OOHW Community Notifications

Notification to specific impacted noise-sensitive receivers should be provided prior to the OOHW.

Any additional management measures identified for the works that require community notification are to be undertaken.

10.4 Approval of OOHW and Implementation of OOHW Conditions

On receipt of the approval, any specific conditions that relate to the OOHW are to be:

- Actioned for implementation (such as any additional notification to the community);
- Tool-boxed to relevant workforce and site personnel before each shift to introduce/reinforce works restrictions, management measures and expected workforce behaviour.
- Implemented during works and to be monitored.

10.5 OOHW Enquiries/Complaints Management

All complaints are to be managed by the project team as outlined in ***Section 9*** of this report.

An integrated water cycle management plan

for

the proposed Eco-village at

LOT 1 DP 1087535

Research Road, Narara

Prepared at the request of

Mr B. Nettleton and Mr J. Talbott

For

Narara Ecovillage Co-operative Ltd

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

Document Registration

Client	Narara Ecovillage Co-operative Ltd
Prepared By	Woodlots & Wetlands Pty Ltd 220 Purchase Road Cherrybrook NSW 2126 Telephone (02) 94842700 Mobile 0427905440 E mail woodlots3@bigpond.com
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Glossary of technical terms and anagrams

Abbreviation or acronym	Explanation
Al	Aluminium
Available capacity	The active capacity is the volume of the rainwater tanks that is accessible without stirring up sediment on the tank floor. For a 10 cubic m tank this is assumed to be 8.5 cubic m.
BOD	Biological Oxygen Demand
C	Carbon
Ca	Calcium
Cl	Chloride
cm	centimetres
Contour bank	A bank installed upslope of the effluent irrigation area to divert upslope runoff towards local drainage systems.
dS/m	decisiemens/metre A measure of electrical conductivity (1 dS/m=1000 microsiemens/cm)
DEC	Department of Environment and Conservation
DCP	Development Control Plan produced by Gosford City Council. DCP 175 refers specifically to the Narara Site. DCP 165 is concerned with Water Cycle Management.
DIPNR	Department of Planning Infrastructure and Natural Resources in May 2012, the environmental components had been transferred to the Office of Water (NOW) and OEH)
Effective risk management	The identification of all potential hazards, their sources and hazardous events, and an assessment of the level of risk presented by each.
Effluent	Treated wastewater sometimes referred to as reclaimed water.
EMP	Environmental Management Plan
ESCP	Erosion and Sediment Control Plan
Field capacity (water holding capacity)	The amount of water held in soil once gravitational water has drained from the profile. Typically it is reached approximately 48 hr after saturation. It can be expressed as a variety of units. In the current report it is in mm of water stored in the plant root zone.
Faecal coliforms	Bacteria that are indicative of faecal contamination.
g	grams

GCC	Gosford City Council
K	Potassium
ha	hectare (1 ha=100m*100m)
HACCP	HACCP is the Hazard Analysis and Critical Control Point system. (That is: What can we do to reduce hazards)
Hazard	HAZARD=probability*consequences A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard. (what can happen and how).
HRT	Hydraulic Retention Time – the average travel time for water to pass through a system such as a wetland or reaction chamber.
kg	Kilograms
kL	Kilolitres (1000 L)
km	kilometres
L	litres
m	metres
mg	milligrams (10^{-3}g)
Mg	Magnesium
mL	millilitres (10^{-3}L)
ML	megalitres (10^{6}L)
MSDS	Material Safety Data Sheets
Na	Sodium
N	Nitrogen
NEV	Narara Eco Village Co-operative Limited
P	Phosphorus
PET	Potential Evapotranspiration: Rate of loss of water from plants and soil when there is an unlimited supply.
pH	A measure of acidity
Risk	The likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences. (How likely is

	it to happen? How serious are the consequences?) Risk is maximum risk in the absence of preventive measures Residual risk is the risk after consideration of existing preventive measures.
SAR	Sodium Adsorption Ratio. A measure of the ratio of sodium to calcium plus magnesium. It is used in conjunction with salinity data to determine the stability of irrigation water.
STS	Sewage Treatment System
TSS	Total Suspended Solids
RVZ	Riparian Zone Width as defined in the Water Management Act regulations.
WICA	Water Industry Competition Act (2006).
WSUD	Water Sensitive Urban Design

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Appendix 1. Report on the unnamed gully to the immediate south of lots 35, 22, 21 and 10 Narara Ecovillage, Narara.

Appendix 2. Letter of advice regarding drainage depression

1 BACKGROUND

Narara Ecovillage Co-Operative Ltd wishes to establish an eco-village on lands previously owned by NSW Agriculture at Research Road Narara.

The site is being developed by Narara Ecovillage Co-operative Ltd. The development format will provide a range of dwelling types from cluster housing to individual dwellings.

The development will occur in a number of stages. The first stage will involve some 60 units, and much of the report is concerned with this initial development phase. However, where appropriate, and deemed necessary to demonstrate long term sustainability, the full development of some 110 to 130 dwellings is considered.

Purpose

The purpose of this report is to demonstrate the environmental sustainability and feasibility of establishing an integrated water cycle for the eco-village.

Key aims are:

- To manage the eco-village sustainably, with minimal risk to human or environmental health.
- To treat and reuse sewage and stormwater on site.
- To manage stormwater to meet the performance criteria in Gosford City Council's Development Control Plan 165 (2007) Water Cycle Management.
- To ensure that the water management within the development is consistent with national, state and local government regulations and guidelines.

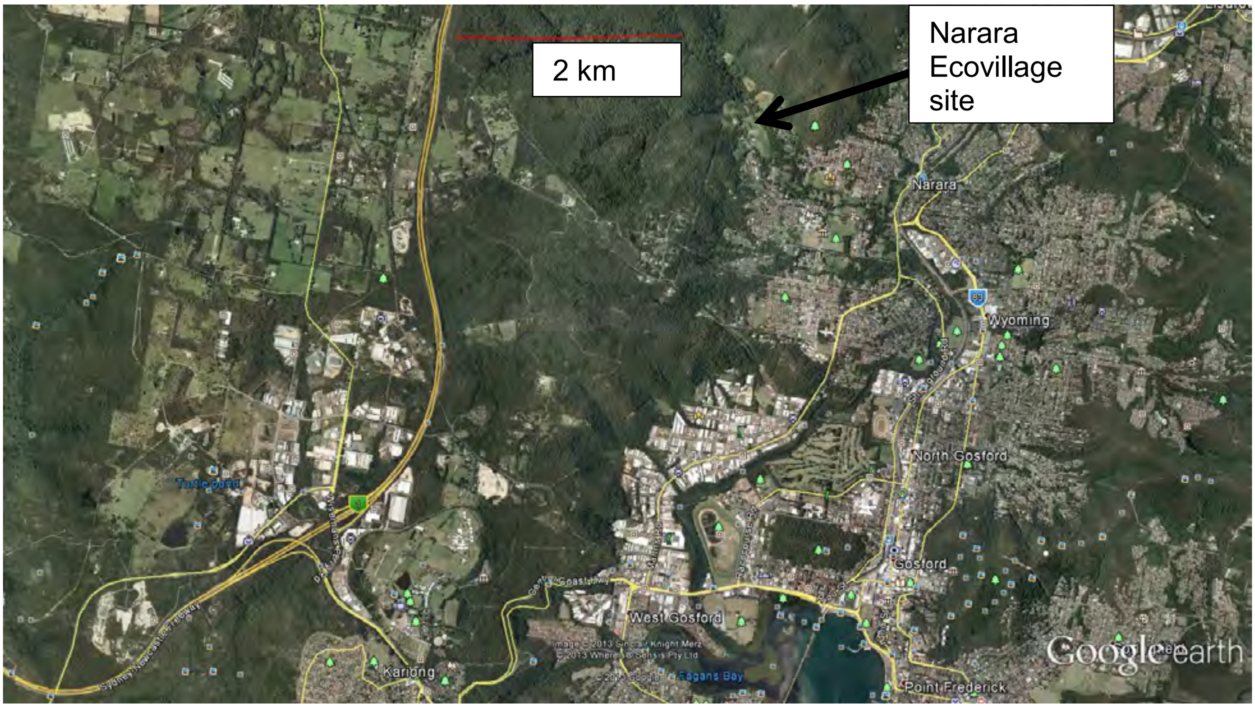

Figure 1.1 Regional context of subject site. The site is in Narara, some 5 km NW of Gosford.

Figure 1.2. Site details showing original boundaries. The site is on Research Road, Narara. It includes buildings and orchards associated with a disused Horticultural Research Station. There are rural residential lots in the north east of the site. The dam to the north of the development area is critical to the site's water management. (Image source: SIX MAPS).

Figure 1.3. Stage 1 of the development. Eventually areas to the south and north of the first stage will be developed. (Image source: hill thalis). Full development will comprise approximately 110 to 130 dwellings.

2 OVERALL CONCEPT

Figure 2.1 shows the overall concept.

Integrated water cycle management concepts shown in figure 2.1 include:

1. Capture of roof water (after UV disinfection) for all potable and non-potable internal uses except toilet flushing.
2. Runoff water from roads and other surfaces to be treated in a stormwater management system designed to achieve Gosford City Council's Water Cycle Management Guideline performance criteria (GCC, 2007).
3. Stormwater conveyance via existing drainage lines following their stabilisation
4. Combined wastewater from the homes, visitor centre, etc., to be conveyed to Sewage Treatment Plant (STP). The wastewater to be treated to National Recycled Water Standard for internal use in dwellings (NRMMC/EPHC/AHMC, 2006).
5. Recycled water used for toilet flushing, gardens and general irrigation.
6. Any wet weather excess volume to be conveyed to wet weather storage.
7. Outflow from the wet weather storage is not to occur in more than the 50%ile wet year (DEC, 2004).
8. The large dam at the northern portion of the site to provide potable water during low rainfall periods (water will need disinfection to meet Australian Drinking Water Guidelines (NHMRC, NRMMC, 2011)).
9. Fire-fighting requirements will be provided to meet NSW Fire and Rescue Service requirements.

The key features include:

- Consistency with National, State and Local Government regulations and guidelines
- Independence from centralised water and sewerage services.
- Productive recycling of stormwater
- Productive recycling of wastewater
- Minimised impact and call on external water bodies, and
- Protection of receiving water from contaminated stormwater outflows.

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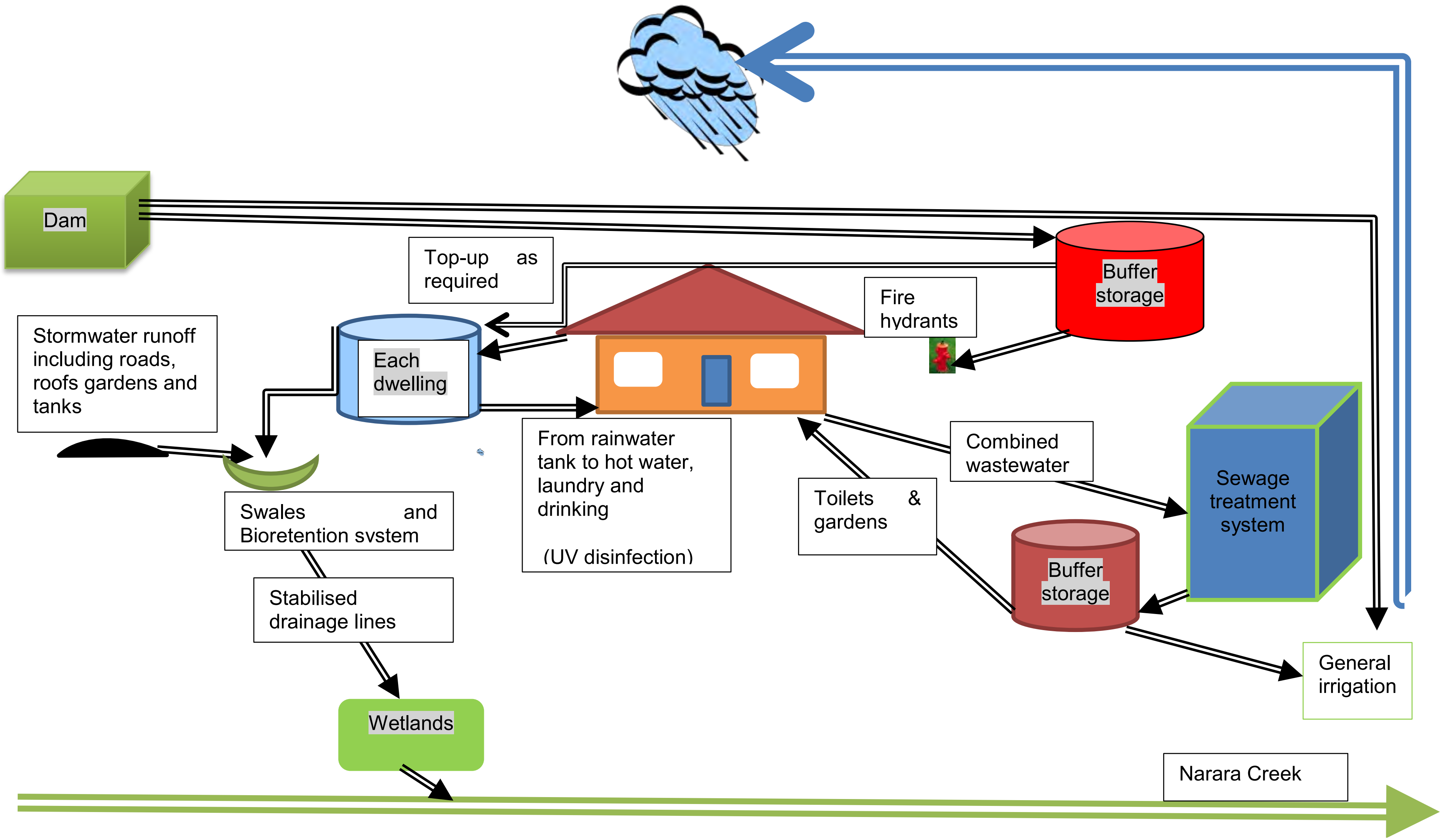


Figure 2.1 Schematic of an integrated water cycle for the site. Note zero demand on centralised water or sewerage services.

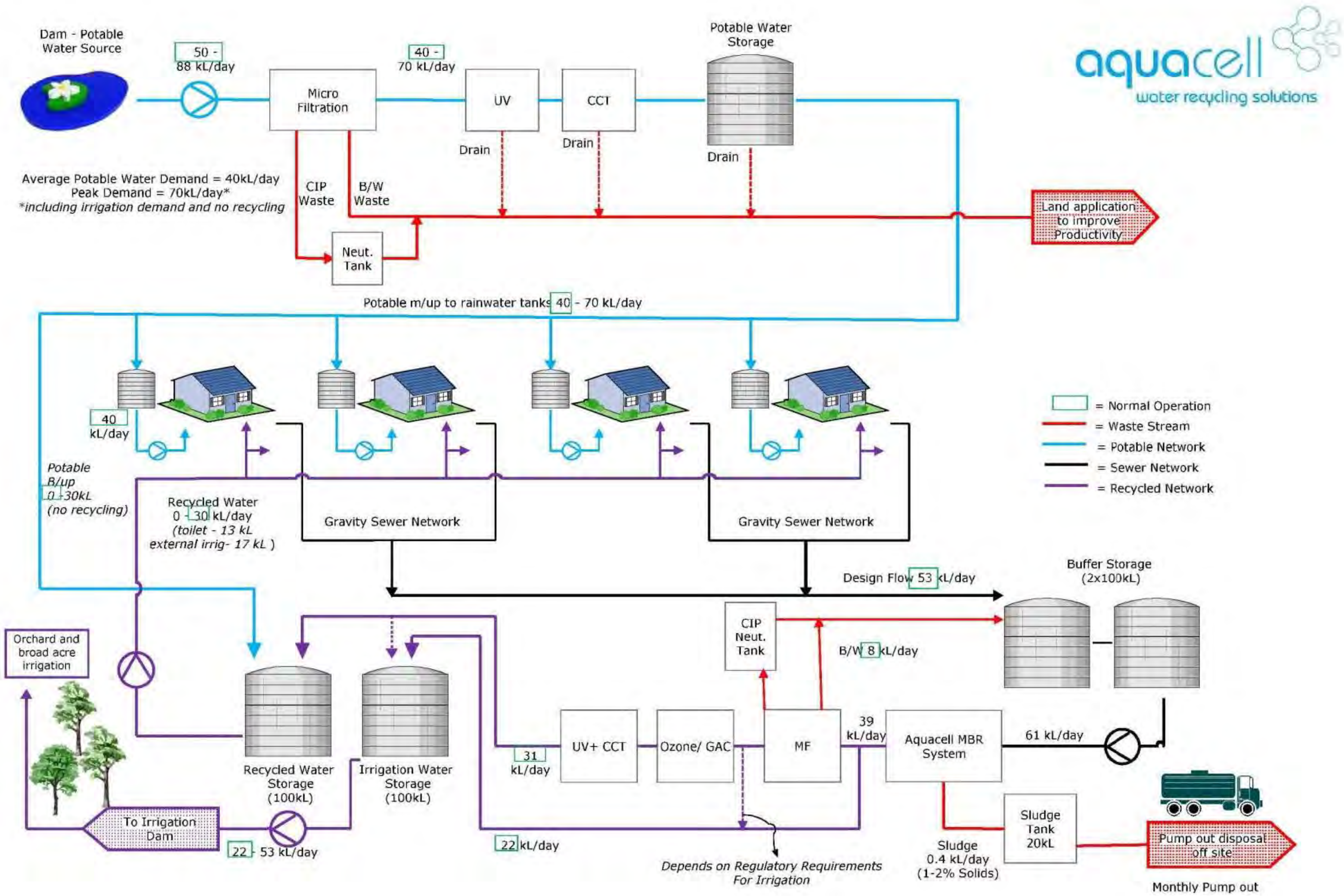


Figure 2.2. Water and wastewater systems overview and flow balance (Source: Aquacell Pty Ltd)

3 LEGAL AND REGULATORY REQUIREMENTS

This section of the plan identifies the key components of the water cycle, the proposed water sources, the issues associated with using the proposed water sources and the legislation and guidelines determining the quality controls and system safeguards.

It is absolutely critical that each component of the proposed system meets human and environmental health criteria.

Table 3.1. Relationship between water cycle components and reference documents and guidelines.

Water cycle component	Proposed sources	Issues	Reference documents/ guidelines
Laundry and hot water	Roof runoff plus dam	Roof water quality Hot water thermostat setting/UV disinfection Need for 1st flush diversion of 20 L Security of supply & back up (dam).	Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 1), (NRMMC, 2006). EnHealth. Guidance on use of rainwater tanks. (May 2007) Australian Drinking Water Guidelines (NHMRC, NRMMC, 2011) GCC's policy Central Coast unregulated and alluvial water sources Water Sharing Plan Water License WAL16886 Climate data Demand data
Drinking water	Roof runoff Plus dam	Water quality No overhanging branches, Litter guards on gutters. Frequent cleaning of gutters 1st flush diversion of 20 L Microbial contamination (inline UV) Security of supply & back up dam. License to abstract water for urban use.	• EnHealth. Guidance on use of rainwater tanks. May 2007 Australian Drinking Water Guidelines (NHMRC, 2011) Central Coast Water Sharing Plan Water License WAL16886 Climate data Demand data

Water cycle component	Proposed sources	Issues	Reference documents/ guidelines
Fire water	Dam then concrete buffer storages upslope of the development	Storage capacity Hydrants	Fire and Rescue Service requirements
Recycled wastewater • Toilets, • Gardens • General wash down	Reclaimed effluent	Meets WICA requirements (license, monitoring, maintenance) Must consistently meet water quality guidelines. Sufficient usage so that there is no discharge up to the 50%ile wet year. Monitoring and management expertise	• WICA requirements • Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 1), (NRMMC, 2006). • GCC's On-site Sewage Management strategy • Central Coast Water Corporation Act 2006 • GCC's sewerage projects • DEC (2004) • Climate data • Demand data
Stormwater	Surrounding catchment Dam Rainwater Rainwater Tank overflow Road runoff Pervious and impervious surface runoff	Relatively steep slopes and drainage lines Floodplain and wetland Must meet GCC requirements under DCP 165: 80% removal of TSS 45% removal of N & P No gross pollutants or visible O&G if flow is <25% of 1 Y ARI	• GCC DCP 165 • GCC Water Cycle Management Plan • Water Management Act • Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 2), Stormwater (NRMMC, 2007). • MUSIC V5 guidelines • Fletcher et al (2004)

Table 3.1 emphasises the linkage between the quality control systems for each component of the water cycle and the regulations.

Water Supply and Sewerage services within the City of Gosford are provided by Gosford City Council in its capacity as a Water Supply Authority subject to the provisions of the Water Supply Authorities Act, 1987 (From DCP 112, Residential subdivision). However the Narara site is outside the current sewerage reticulation system.

Several pieces of legislation are critical the water cycle management on the site. These include:

- The Water Management Act (2000)
- The Water industry Competition Act (2006)
- Central Coast Water Corporation Act 2006 No 105
- The Protection of the Environment Operations Act (1997)

The Water Management Act (2000)

The Water Management Act (2000) (WMA) provides for the protection, conservation and ecologically sustainable development of the water sources of the State, and for other purposes.

The objects of the Act are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular:
(a) to apply the principles of ecologically sustainable development, and
(b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and
(c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:
(i) benefits to the environment, and
(ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and
(iii) benefits to culture and heritage, and
(iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,
(d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,
(e) to provide for the orderly, efficient and equitable sharing of water from water sources,
(f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,
(g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,
(h) to encourage best practice in the management and use of water.

The likely interactions between the proposed development and this act include:

- Accession of water from the dam.
- Construction of water management facilities such as wetlands on the Narara Creek floodplain.
- Crossings, pipe installation and drainage outlets associated with drainage lines within the development area.

Access to water in the dam

Water access from streams and dams is addressed in the WATER SHARING PLAN: Central Coast unregulated and alluvial water sources (NSW Dept Water and energy, 2009). Under this plan, extraction of 29 ML/year is permissible from the BRISBANE WATER WATER SOURCE. This extraction is subject to the conditions of the Water Access Licence. The water is currently designated for irrigation.

A Water Supply Works and Use Approval has be received allowing the irrigation water to be used for urban purposes.

Construction on the floodplain

In relation to floodplain management the WMA states:

(a) floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and

(b) the impacts of flood works on other water users should be avoided or minimised, and

(c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised.

The simplest approach is to ensure that construction does not affect floodplain flows. As an example, structures such a bund wall should be minimised, and ideally water storages and wetlands should be ‘inserted’ into the floodplain rather than being constructed using bund walls that could interfere with flood distribution.

The dam is on a second order tributary of Narara Creek. Narara Creek is a 4th order stream. The straight drainage lines through the development are 1st order watercourses. These ‘orders’ determine the width of the riparian zones. SEE: NSW Office of Water Guidelines for Riparian Corridors on Waterfront Land July 2012.

Riparian corridor widths

Changes to the NSW Office of Water Guidelines for Riparian Corridors on Waterfront Land commenced in July 2012. In the section **Riparian corridor widths** The first sentence states:

The Officer (sic) of Water recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps.

The guideline changes clarify the activities permitted within 40m of the top of watercourse banks. The Vegetated Riparian Zone (VRZ) width for different stream orders is shown below.

Table 3.2. Vegetated Riparian Zone widths for various stream orders (Source: the July 2012 changes to NSW Office of Water Guidelines for Riparian Corridors on Waterfront Land).

Watercourse type	Vegetated Riparian Zone (VRZ) width	Vegetated buffer	Total Riparian corridor width (m)
1st order	10m	None	20m + channel width
2nd order	20m	None	40m + channel width
3rd order	30m	None	60m + channel width
4th order or greater (includes wetlands)	40m	None	80m + channel width

Where suitable there can be activities in the outer 50% of the VRZ provided it is offset by an equivalent area connecting to an equivalent area on waterfront land within the development site. For example there can be a stream line shown as a blue line on a 1 in 25,000 topographic map with a portion of its length having only a 5m with of riparian corridor. This is permissible provided there is an equivalent area of riparian corridor added to another portion of this or another riparian corridor in the development.

Note that this provision for equivalent off set does not apply to bridges, cycleways, paths, detention basins stormwater outlets or other essential services. See table 3.3, below.

Table 3.3. Riparian corridor (RC) matrix showing permissible activities for the vegetated riparian zones of different stream orders (Office of Water, 2012).

Stream order	VRZ width	RC off-setting for non-RC uses	Cycleway	Detention basins		Stormwater outlet structures and essential services	Stream re-alignment	Road crossing		
				Within outer 50%	On-line			Any	Culvert	Bridge
1st	10m	✓	✓	✓	✓	✓	✓	✓		
2nd	20m	✓	✓	✓	✓	✓		✓		
3rd	30m	✓	✓	✓		✓			✓	✓
4th	40m	✓	✓	✓		✓			✓	✓

Non-RC (Riparian Corridor) uses such as Asset Protection Zones can occur within the outer 50% provided offsets are included as discussed above.

The information in table 3.3 suggests that Narara Creek has a 40m VRZ between its bank and many likely activities. However, a detention basin could be constructed provided it is not closer than 20m to the top of the bank and appropriate offsets are provided.

The drainage lines (shown as blue lines on the 1:25000 Gosford topographic map) coming down slope and through the development area are 1st order streams, and items such as stormwater outlets and crossings can be constructed through the VRZ.

The Water industry Competition Act (2006)

The Water Industry Competition Act (2006) (WICA) is designed to encourage competition in relation to the supply of water and the provision of sewerage services and to facilitate the development of infrastructure for the production and reticulation of recycled water; and for other purposes.

In the current situation, WICA enables proponents to engage appropriate organisations to provide water supplies and sewerage services for the development. The provider can be an organisation such as Central Coast Water Corporation or a private organisation. The providing organisation will need a license for the project.

The application will be scrutinised to ensure that human and environmental standards and safeguards are in place.

Central Coast Water Corporation Act (2006)

Central Coast Water Corporation Act 2006 No 105 is an Act to provide for the constitution and functions of the Central Coast Water Corporation and for its establishment as a water supply authority under the *Water Management Act 2000*; and for other purposes.

:

(1) The principal objectives of the Corporation are as follows:

(a) to promote the efficient delivery of water supply, sewerage and drainage services for the long-term interests of consumers with respect to price, quality, safety, reliability and security of supply,

(b) to maximise water conservation, demand management and the use of recycled water,

(c) to be a successful business and, to this end:

(i) to operate at least as efficiently as any comparable business, and

(ii) to maximise the net worth of the constituent councils' investment in the Corporation,

(d) to exhibit a sense of social responsibility by having regard to the interests of the community in which it operates,

(e) where its activities affect the environment, to conduct its operations in compliance with the principles of ecologically sustainable development contained in section 6 (2) of the *Protection of the Environment Administration Act 1991*.

(2) Each of the principal objectives of the Corporation is of equal importance.

It is understood that this Act had not been proclaimed as at 29 October 2013.

The Protection of the Environment Operations Act (1997)

This Act (POEO) is designed to protect the environment.

The objects of the POEO are as follows:

(a) to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development,

(b) to provide increased opportunities for public involvement and participation in environment protection,

(c) to ensure that the community has access to relevant and meaningful information about pollution,

(d) to reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following:

(i) pollution prevention and cleaner production,

(ii) the reduction to harmless levels of the discharge of substances likely to cause harm to the environment,

(iia) the elimination of harmful wastes,

(iii) the reduction in the use of materials and the re-use, recovery or recycling of materials,

(iv) the making of progressive environmental improvements, including the reduction of pollution at source,

(v) the monitoring and reporting of environmental quality on a regular basis,

(e) to rationalise, simplify and strengthen the regulatory framework for environment protection,

(f) to improve the efficiency of administration of the environment protection legislation,

(g) to assist in the achievement of the objectives of the Waste Avoidance and Resource Recovery Act 2001.

The proposed development is consistent with many objectives of the POEO. Whilst the development is too small to be a scheduled activity under the Act, it is essential that the development not create a pollution incident.

It is therefore essential that the development has an adequate Operational Environmental Management Plan (OEMP) to address risks associated with the operation of the water and wastewater systems.

4 CLIMATE

The subject site is located within the boundaries of the disused Narara Horticultural Research Station. This research station has been supplying meteorological data since 1916. The station number is 061087. It is at 33.39 Degrees South and 151.33 Degrees East. The elevation is 20m. A selection of the data is shown in table 4.1

Table 4.1. Meteorological data for Narara horticultural Station (Number 061087). (Source: BoM).

Statistic Element	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ann**
Mean maximum temperature (Degrees C)	28	27	26	24	20	18	18	19	21	24	25	27	23
Mean minimum temp (Degrees C)	17	17	15	12	8	7	5	5	8	11	13	15	11
Mean daily temp (degrees C)	22	22	21	18	14	12	11	12	15	17	19	21	17
Mean number of days <= 0 Degrees C	0	0	0	0	0	0.4	1.6	0.6	0	0	0	0	2.6
Mean rainfall (mm)	135	153	149	139	118	131	80	72	69	85	92	104	1325
Decile 1 monthly rainfall (mm)	36	29	27	33	16	19	10	7	14	16	17	20	909
Decile 5 (median) monthly rainfall (mm)	111	117	132	96	80	87	55	49	54	62	82	83	1259
Decile 9 monthly rainfall (mm)	281	313	312	307	276	306	191	190	166	197	193	231	1893

Highest daily rainfall (mm)	211	192	206	218	177	229	195	144	110	129	155	155	229
Mean number of days of rain >= 10 mm	3.4	3.8	3.8	3.3	2.8	3.3	2.1	1.8	1.8	2.2	2.7	2.7	33.7
Mean daily wind run (km)	124	113	103	86	81	83	91	101	113	120	127	128	106
Mean daily solar exposure (MJ/(m*m))	22.4	19.8	17.1	13.8	10.2	8.8	9.8	13.3	17	19.8	21.6	23.1	16.4

The Narara Meteorological Station is within 10 km of the ocean and at 20m elevation. It has a warm, humid climate. Its location at the base of some relatively steep hills means that is protected to some extent from high winds.

The daily rainfall range of 12 degrees is moderate and reflects the separation from the coast. The annual average temperature of 17 degrees indicates a warm climate. Frosts typically occur in June, July and August; however most of the year is sufficiently warm to allow vegetation growth. The site has been successfully used for temperate and subtropical perennial species such as oranges and avocadoes for almost 100 years. This suggests that site conditions do not limit plant growth.

The long-term average rainfall is 1325 mm/year. This is more than double the Australian average and indicates a moist climate. The 10%ile year has 909 mm rainfall while the 90%ile year has 1893 mm. This two-fold difference is smaller than that of most of Australia, and suggests that the rainfall is relatively reliable.

Highest total monthly rainfall occurs in late summer / autumn, whilst late winter-spring is the driest period. Every average month has significant rainfall (>10 mm) in 2 to 4 days. The relatively large number of rainfall days indicates a relatively humid climate with only short periods of moisture stress.

Daily wind-run is highest in summer, but even then it averages less than 150 km/day. This reflects the relatively sheltered nature of the site.

Average daily solar radiation varies almost three fold between June and December. All months have at least moderate sunshine.

It is concluded that the climate is adequate for plant growth for all months. Growth will be limited by low temperatures in winter. Moisture availability will have relatively limited impacts on plant growth.

Rainfall intensity

Rainfall intensity was determined from IEA (1987). The site has an estimated rainfall Erosivity Factor –R of 3940. Table 4.2 shows the intensity/ duration estimates.

Table 4.2. Rainfall intensity (mm/hr) for events up to 1 in 100 year Average Recurrence Interval (ARI). (Derived from IEA, 1987).

Dur/ARI	5 min	6 min	10 min	20 min	30 min	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	91	86	70	51	41	28	19	16	10	7	5	3	2
2	118	111	91	66	54	37	25	20	14	9	6	4	3
5	154	144	119	88	72	50	33	26	17	11	8	5	4
10	174	164	136	101	83	58	38	30	19	13	8	6	4
20	201	190	158	118	97	68	45	34	22	14	10	7	5
50	267	224	187	140	116	82	53	40	26	17	11	8	6
100	264	250	209	157	131	93	59	45	29	18	13	9	7

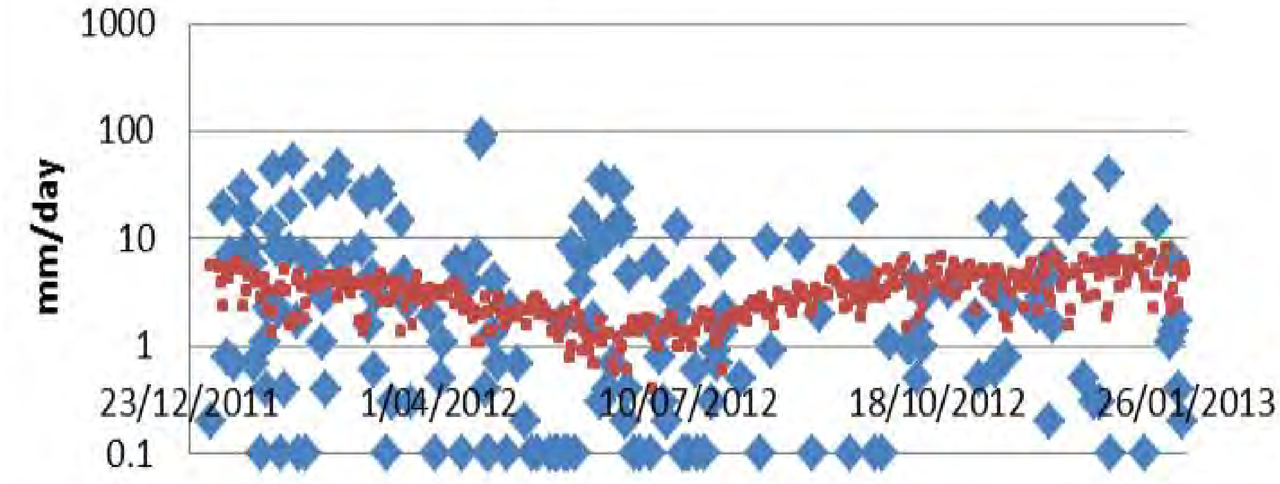
This data was used to calculate peak flows and then to determine design adequacy (Landcom, 2004).

Potential need for irrigation

Figure 4.1 shows the daily rainfall and potential evapotranspiration (FAO 56) from January 2012 to end of February 2013. During this period, there was some 1403 mm of rain and the potential evapotranspiration was 1138 mm. While total rainfall exceeded potential evapotranspiration, there were significant periods when there was no rainfall, but significant potential evapotranspiration.

Irrigation would be needed to maximise plant growth during these times. The relatively frequent rain events mean that irrigation water demand/ha/year will be limited.

Figure 4.1. Rainfall and potential evaporanspiration (mm) each day Jan 2012 to Feb 2013 (Data source BoM).



5 WATER CYCLE COMPONENTS-A. TOTAL DEMAND PER DWELLING

The BASIX policy is one of the NSW Government's key initiatives in promoting a water and energy efficient future for NSW. A Basix Monitoring Program has measured household water demand since 2007 (Sydney Water, 2012). Table 5.1 shows that potable water consumption in BASIX assessed dwellings ranged from 192 cubic m/y[1] in 2007-08 to 209 cubic m/y in 2008-2009.

Outdoor uses, showers; washing machine; toilets and indoor hand taps typically comprise 93-98% of household water use (Thyer et al, 2008).

Table 5.1. Characteristics of water consumption in BASIX assessed dwellings since 2005 (Sydney Water, 2012).

Component	2007-2008	2008-2009	2009-2010	2010-2011
Number of dwelling sampled	837	1392	2479	5294
Water consumption (L/dwelling/day)	886	890	899	903
Occupancy/dwelling	3.6	3.6	3.7	3.7
Percentage with dual water supply	13%	11%	12%	9%
Average actual potable water consumption (cubic m/year)	192	201	209	208
Potable consumption/occupant (L/day)	246	274	234	244

SWC (2011) examined demand for water from the rainwater tank and total household demand in 50 intensively monitored dwellings. The results are summarised in table 5.2. (SWC, 2011).

Table 5.2. Annual demand for various water sources based on intensive sampling of 50 dwellings (SWC, 2011).

	Median	Mean	Minimum	Maximum
Demand for water from the tank (cubic m/y)	57	59	5	161
Household demand for all uses (cubic m/y)	180	197	84	556

The average total demand of 197 cubic m/y is similar to the total demand for potable water in table 5.1. The total potable volume used is typically 250 L/occupant/day as table 5.1 shows.
Table 5.3 shows the change in daily demand with change in number of residents/dwelling.

[1] 1 kL=1,000 L=1 cubic m=1/1000 ML.

Table 5.3. Water use components for individual dwellings with 1 to 7 occupants (derived from SWC reports). The water use by 6 and 7 occupants was derived via extrapolation. Data based on 5294 dwellings.

Number of occupants	**1**	**2**	**3**	**4**	**5**	**6***	**7***
Average total water use for dwellings with various numbers of residents (L/day) (Sydney Water, 2011).	233	352	447	529	604	658	700
Toilet (L/day)	**31**	**53**	**74**	**95**	**115**	**130**	**145**
% of total water use	13	15	17	18	19	20	21
% of internal demand	25	25	25	25	25	26	27
Laundry (L/day)	**29**	**53**	**76**	**95**	**113**	**123**	**131**
% of total demand	12	15	17	18	19	19	19
% of internal demand	24	25	25	25	25	25	25
Hot Water (L/day)	**49**	**87**	**119**	**151**	**182**	**197**	**210**
% of total demand	21	25	27	29	30	30	30
% of internal demand	40	41	40	40	40	40	39
Other internal uses (L/day)	**13**	**20**	**31**	**37**	**42**	**45**	**48**
% of total demand	6	6	7	7	7	7	7
% of internal demand	11	9	10	10	9	9	9
Total internal use (L/day)	**122**	**213**	**300**	**378**	**452**	**495**	**534**
Internal use excluding toilets (L/day)	91	160	226	283	337	365	389
Daily External use (L/day)	**111**	**139**	**147**	**151**	**152**	**163**	**166**
External use as% of total demand	48	39	33	29	25	25	24
Internal use as % of total demand	52	61	67	71	75	75	76
Likely reclaimed sewage use L/day (toilet + external)	142	192	221	246	267	293	311
% of total demand	61	54	49	47	44	49	49
Roof runoff demand for laundry and hot water L/day	78	140	195	246	295	205	256
% of total demand	33	40	44	47	49	31	37
% of internal demand	64	66	65	65	65	41	48
Potable + non potable roof runoff demand	91	160	226	283	337	365	389
Roof runoff demand as a % of total demand	*39*	*46*	*51*	*54*	*56*	*56*	*56*
Return to sewer (internal uses) (L/day)	122	213	300	378	452	495	534
Sewer reuse (toilets, gardens) (L/day)	142	192	221	246	267	293	311
Total demand (cubic m/y)	*85*	*128*	*163*	*193*	*220*	*240*	*255*

Table 5.3 shows that water demand varies with number of residents/dwelling. The 2011 Census data for the Gosford Statistical Area (ABS web site, 2013), shows that the average number of persons per dwelling was 2.5. The individual lot dwellings were assumed to have 5 residents. This is effectively double that of the local number of residents/dwelling on census night is 2011.

For the cluster lots it was assumed that there would be 2 persons/bedroom. So a one bedroom dwelling would always have 2 people in residence, while a two bedroom residence would have 4 persons in permanent residence.

Table 5.4. Attributes of the dwellings in cluster lot 15 and lot 36.

Lot number	Dwelling classification	Number of dwellings in this classification	Number of bedrooms per dwelling in this classification	Assumed permanent number of occupants	Assumed potable water demand (from table 5.3)
15	A	1	2	4	283
15	B	2	2	4	283
15	C	1	2	4	283
15	D	2	2	4	283
15	E	2	3	6	365
15	F	2	3	6	365
15	Total	10			
36	1	4	1	2	160
36	2	4	1	2	160
36	3	9	2	4	283

First stage of development

Total potable water consumption in the 27 units within the two cluster lots is predicted to be 6.985 cubic m/day. The 33 individual dwellings on individual lots in the first Stage are assumed to have 5 persons/ dwelling. From table 5.3 the indicative potable demand will be 337 L/dwelling/ day or 11.121 cubic m/day. Therefore the total daily demand for potable water will be 18.106 cubic m.

Full development

At full development there is likely to be 115 to 130 dwellings. Assuming that there are 5 persons/dwelling, the average daily potable demand for stage 2 of the development based on an additional 55 to 70 dwellings at 337 L/dwelling would be 18.5 to 23.6 cubic m/day.

The potable demand at full development with up to 130 dwellings would therefore be approximately 37 to 42 cubic m/day. The mid-range figure of 39 cubic m/day was therefore used in estimates of potable water demand at full development.

6 WATER CYCLE COMPONENTS-B. INTERNAL DEMAND AND SUPPLY EXCEPT TOILETS

The internal demand was assumed to include all hot and cold water apart from toilet flushing. (The need for disinfection is noted).

According to table 5.3, the estimated total demand, except for toilets, ranges from 91 L/day for a single person to 389 L/day for a dwelling with 7 occupants.

Table 6.1. Attributes of the demand for potable water and their respective roof areas for dwellings on individual lots and for cluster lot 15 and lot 36.

Lot number	Dwelling classification	Number of dwellings in this classification	Number of bedrooms per dwelling in this classification	Assumed permanent number of occupants	Assumed potable water demand (from table 5.3) L/d.	Design roof area
Single dwellings		33	?	5	337	120
	Total				11,121	
15	A	1	2	4	283	75
15	B	2	2	4	566	76
15	C	1	2	4	283	73
15	D	2	2	4	566	64
15	E	2	3	6	730	135
15	F	2	3	6	730	135
15	Total	10			3158	
36	1	4	1	2	640	73
36	2	4	1	2	640	Zero
36	3	9	2	4	2547	89
Total		17			3827	
Total Stage 1 based on 33 individual lots and 2 cluster lots containing 27 dwellings					18,106 L/d.	
Final stage assuming 110 to 130 dwellings, 27 of which are in clusters					34,957 to 41,696 L/d.	

Note that the flows will be recorded for stage 1 dwellings and used as a more accurate estimate for the later stages.

Daily rainfall from 1 January 1970 to 26 February 2013 was used to estimate the volume of water that could be captured from the roof. The assumptions were:

- o Daily rainfall for Narara from January 1907 to February 2013 was used for the simulation
- o The demand/day was as per table 6.1.
- o The roof area was as per table 6.1.
- o There was a 2 mm/day initial loss of water due to evaporation
- o A first flush loss of 20 L/wet day
- o The tank size was 10.5 cubic m, of which 8.5 cubic m was active storage[2].

These assumptions tend to underestimate supply and overestimate demand. For example,

- o the permanent average population is typically 2.5 persons/dwelling of 1.2/bedroom, not 5 or 2 as used in this simulation.
- o the demand is for an average family. The emphasis on sustainable living means water use/person is likely to be less than the average.
- o the roof area of 120 msq is lower than the typical new home average of over 200 msq for single storey dwellings.

The conservative parameters were used to examine the worst-case scenario.

Rainwater tank management

According to ADWG (2011), *rainwater systems, particularly those involving storage in above-ground tanks, generally provide a safe supply of water. The principal sources of contamination are birds, small animals and debris collected on roofs. The impact of these sources can be minimised by a few simple measures: guttering should be cleared regularly; overhanging branches should be kept to a minimum, because they can be a source of debris and can increase access to roof catchment areas by birds and small animals; and inlet pipes to tanks should include leaf litter strainers.*

First-flush diverters, which prevent the initial roof-cleaning wash of water (20–25 L) from entering tanks, are recommended. If first flush diverters are not available, a detachable downpipe can be used to provide the same result.

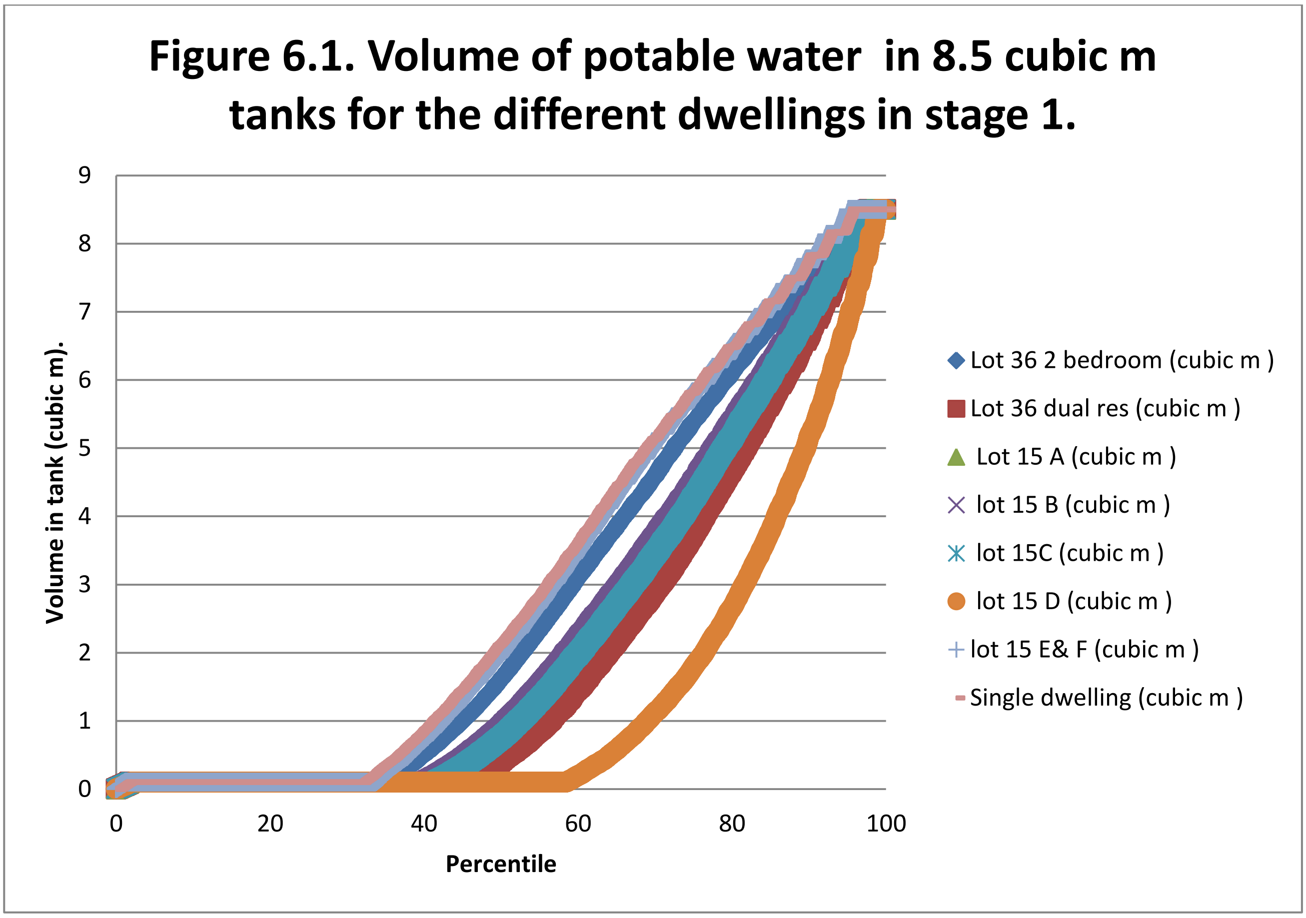
Effectiveness of a 8.5 cubic m rainwater tank

The consumption parameters above were combined with a rainwater tank with 8.5 cubic m effective storage and daily rainfall data from 1/1/1970 to 26/2/2013.

[2] Initial simulations indicated that a 10 cubic m tank was a reasonable compromise between providing water for a reasonable proportion of time and the loss of garden space due to the tank size.

The results are shown in figure 6.1.

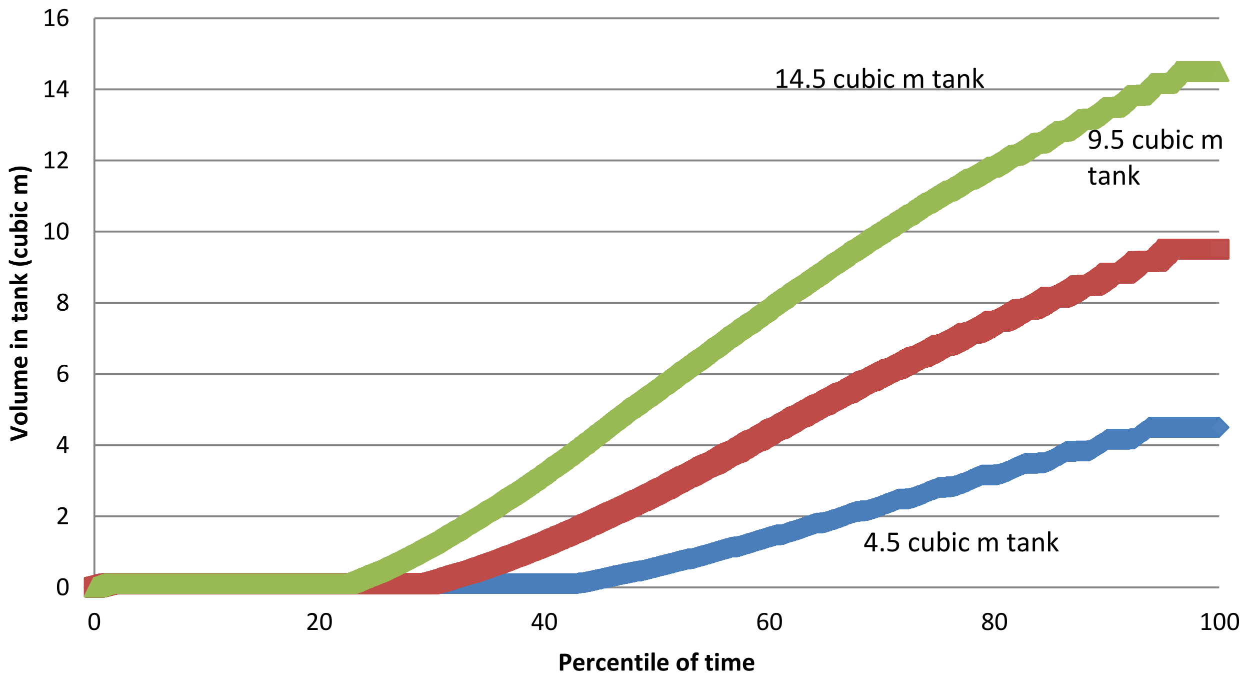
Figure 6.1 shows that the tanks will be able to supply water for between 33 and 60% of time depending on the combination of roof catchment and demand for potable water.



Effect of increasing tank storage capacity

The effectiveness of 4.5, 9.5 and 14.5 cubic m tanks were compared for the single dwellings assuming the same roof area, runoff characteristics and demand as in table 6.1.

Figure 6.3. Effect of changing tank volume on water stored as a percentile of time. Assumes daily potable demand 0.337 cubic m, 120 msq roof catchment.



Increasing the tank capacity from 4.5 to 9.5 or 10 cubic m increased the percentage of time the tanks had a minimum of 1 day supply from 47 could supply the demand to 68 and 76% respectively. The 14.5 cubic m tank would have represents 91 cubic m of water being utilised with 40 cubic m going to stormwater drainage in the average year.

There appears to be little advantage in using a 14.5 cubic m tank, conversely a 4.5 cubic m tank is dry for the majority of time. It is suggested at the 10 cubic m tank with 8.5 cubic m of active storage is a reasonable compromise.

7 WATER CYCLE COMPONENTS-C. DEMAND FOR TOILET FLUSHING AND EXCESS WATER PRODUCTION

Table 7.1 summarises the anticipated demand for toilets and external use for dwellings with 1 to 7 persons in full time residence.

Table 7.1. Effect of number of residents on sewage production and recycled water demand (Derived for SWC reports).

Number of occupants	1	2	3	4	5	6*	7*
Average total water use for dwelling with various numbers of residents (Sydney Water, 2011).	233	352	447	529	604	658	700
Toilet (L/day)	**31**	**53**	**74**	**95**	**115**	**130**	**145**
% of total water use	13	15	17	18	19	20	21
% of internal demand	25	25	25	25	25	26	27
Return to sewer (internal uses) (L/day)	122	213	300	378	452	495	534
Net difference between wastewater production and demand for toilet flushing (L/day)	91	160	226	283	337	365	389
Sewer reuse (toilets, gardens) (L/day)	142	192	221	246	267	293	311
Net difference between flow to sewer and demand for toilet and outside use water (L/day)	-20	21	79	132	185	202	223

Depending on the average number of residents per dwelling, between 31 and 145 L/dwelling/day will be required for toilet flushing. The net difference between toilet flushing demand and the potential supply ranges from 91 to 389 L/day depending on residents/dwelling. Therefore, assuming up to 130 dwellings at full development, between 10.5 and 44.8 cubic m/day will need to be irrigated. This volume is numerically equivalent to the volume to potable water needed.

The potable demand at full development was estimated in section 5 of the current report as being approximately 37 to 42 cubic m/day. The indicative volume of 39 cubic m/day (14.24 ML/y) was therefore used in estimates of excess reclaimed water that will need to be irrigated at full development.

Sewage production due to visitors

As an initial input, it was assumed that there were 70 visitors/day (490/week, concentrated into the weekends). It was also assumed that each visitor used the toilets once (7 L dual flush), washed their hands (1.2 L for spring-loaded taps) and ‘consumed’ 5.5 L via washing up of plates, etc. This gives a total of 13.7 L/visitor (Sturman, et al, 2004). Of this, 7 L was returned to flush the toilets.

Total sewage flow due to visitors is therefore: 70 visitors*13.7 L=0.959 cubic m/day. Return of treated water for toilet flushing is 70 visitors*7 L=0.490 cubic m/day, while net production is 0.469

cubic m/day. Staff for visitor facilities is likely to be largely drawn from residents, so there is no additional flow allocation.

Sewage flows at stage 1

Stage 1 of the development will consist of 33 individual lot dwellings plus 17 units on lot 36 and 10 units on lot 15. Based on total internal use data in table 5.3, stage will produce 24.3 cubic m/day of sewage of which 6.2 cubic m/day will be returned for toilet flushing and 18.1 cubic m/day will need to be irrigated.

Sewage flows at full development

Combined sewer flow of residents (5 persons /dwelling*115[3] dwellings) plus visitors (70/day) is 51.98+0.96= 53 cubic m/day or 19.3 ML/year.

The net sewerage flows, allowing for recycling for toilet flushing is numerically equivalent to the potable demand. According to section 5, potable demand at full development would be approximately 37 to 42 cubic m/day. The indicative figure of 39 cubic m/day was therefore used in estimates of both potable water demand AND effluent irrigation volume at full development.

Allowing for return of tertiary treated water for toilet flushing, the combined irrigation volume at full development is estimated at 39 + 0.5 or 39.5 cubic m/day. This is equivalent to 14.4 ML/year.

This will obviously vary slightly depending on the final number of dwellings and the average number of residents/dwelling.

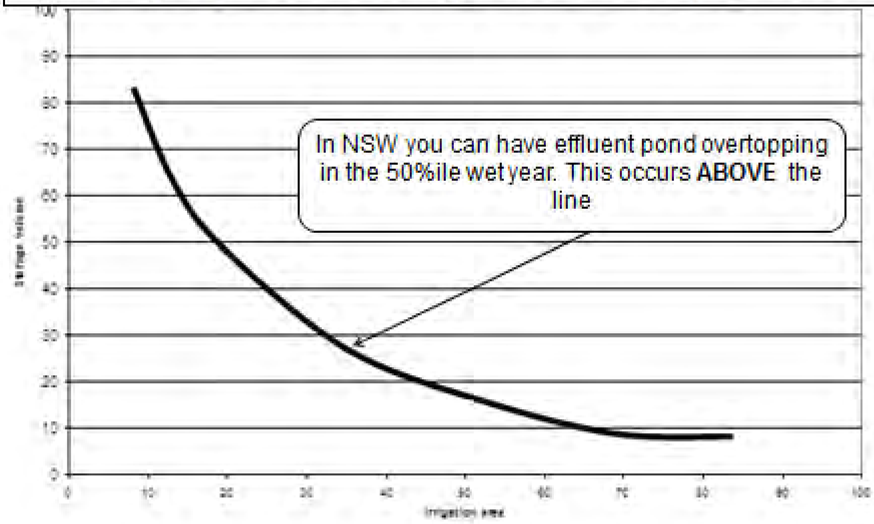
[3] The final number of dwellings may be up to 130. However the potable demand and sewage flows will depend on number of residents. The water use and irrigation pump volumes from first stage of the development will be used to estimate actual flows that could occur from up to 130 dwellings at full development.

8 WATER CYCLE COMPONENTS-D. DEMAND FOR IRRIGATION WATER AND WET WEATHER STORAGE.

The demand for irrigation water is a function of the evapotranspiration demand and the volume of water being supplied. In a humid climate such as at Narara there are likely to be extended periods when water supply exceeds the demand. Water needs to be stored during these periods[4].

Figure 8.1 shows the generalised relationship between irrigation area and storage volume. The optimal solution depends on local conditions, but it is commonly near the centre of the range in irrigation area.

Figure 8.1. Generalised relationship between effluent storage volume and irrigation area requirement.



Soil water balance and irrigation demand

Soil water balance and irrigation demand were determined using a combination of rainfall and potential evapotranspiration data. The soil assessment demonstrated that the soil was sand dominant, with loamy sands up to 2m deep overlying clay subsoil.

Model inputs

Table 8.1 itemises the inputs used to model the site water balance. The balance assumes 5 persons/dwelling and 70 visitors in the average day. This provides a large ‘safety’ margin.

[4] Note that in stage 1, the approach proposed is to utilise the relatively large area of citrus orchard to productively utilise effluent. The proposed application rate of 1 mm /day is 3.5 to 4 times less than the Design Irrigation Rate (DIR) recommended in AS/NZS 1547. The extremely low rate would ensure minimal risk of effluent runoff.

Table 8.1. Components used to model irrigation demand at full development. Daily data over the 42 years between Jan 1970 and Feb 2013 was used. (Climate data from BoM).

Component	units	Average/y
Raw sewage inflow (51.980 cubic m/day) + 70 visitors*13.7 L=0.959 cubic m/day Total 52.939 cubic m/day	cubic m	19,323
Return for toilet flushing (5 residents (115 L)*115[5] dwellings = 13.225 cubic m/day + 70 visitors*7 L/visitor= 0.490 cubic m/day. Total of 13.715 cubic m/day[6]	cubic m	5,006
Net effluent production (5 residents (337 L)*115 dwellings (38.755 cubic m/day)+ 70 visitors*6.7= 0.469 cubic m/day) total of 39.224 cubic m/day	cubic m	14,317
Rainfall	mm	1335
Potential evapotranspiration (PET)	mm	1159
Runoff	mm	157
Assumed pond evaporation coefficient: 80% of pan evaporation * the area of water surface within the wet weather storage pond		0.8
Percolation through the base of the pond	0.01 mm/ day	4 mm/y
Rainfall runoff from surrounding lands to the pond	Zero	
Effective root zone	500 mm	
Plant available water in root zone at field capacity	70 mm	
Plant evapotranspiration At PET until 35 mm deficit then a linear fall to zero at permanent wilting point.	mm	774 mm/y without irrigation
Irrigation trigger. Based on daily soil water content. Assumes 70 mm of available water in the root zone. Apply 12.5 mm if water was available and when the available soil water content fell below 50 mm (20 mm deficit). Assumed 95% efficiency in infiltration to soil, so apply 13 mm/irrigation.	mm	A 20 mm deficit

[5] This calculation assumes 115 single dwellings. In practice a combination of cluster lots with 27 dwellings with 1, 2 or 3 bedrooms are likely to have lower potable water demand and sewerage system flows than individual dwellings on single lots. It is expected that the flows and demands at full development from a combination of cluster houses and single dwellings on individual lots are likely to be similar to those in table 8.1 for up to 130 dwellings. This will be examined in more detail once actual flows and demands are determined from stage 1 dwellings.

[6] Note that there is no allowance for return of effluent for domestic irrigation. This reuse is considered separately below.

Sizing of irrigation dam and irrigation area at full development

Net effluent production

The design sewage flow at full development is 52.9 cubic m/day[7]. Some 13.7 cubic m/day is required for toilet flushing, so the volume available for irrigation is 39.2 cubic m/day.

This figure assumes 5 persons/ dwelling, plus 490 visitors/week. Based on the 2011 census data, it is highly likely that the net volume for irrigation is only 50 to 70% of this value.

Wet weather storage pond

The wet weather storage pond is designed to provide buffer storage and additional capacity storage during wet weather.

A range of irrigation capacities were examined. These were 2, 3 or 4 ML.

Irrigation area

The irrigation demand depends on the antecedent weather, irrigation area, the type of irrigation, the vegetation type, the extent of any fallow periods and the soil type. It is assumed that the irrigation will be onto domestic gardens, public open space and possibly commercial horticultural enterprises on the rural residential blocks.

The irrigation areas examined were 2 ha, 3 ha and 4 ha.

Adequate design criteria

According to the most recent EPA Guideline (DEC, 2004), overflow in a 50%ile wet year is acceptable for low strength effluent. In practice, it would be preferable to irrigate out the effluent onto wet soil prior to overtopping rather than allow a concentrated stream of water to be discharged. The site has sandy soil, so runoff would not normally be a significant issue. Additionally, it is noted that much of the discharge from the storage would be highly diluted due to the prolonged heavy rainfall needed to trigger the overtopping event.

The 50%ile wet year criterion was used as the benchmark for design adequacy.

[7] This could vary up up to 10% depending on final population residing within the site.

9 WASTEWATER MODEL OUTPUT

In the period Jan 1970 to Feb 2013, the average annual rainfall was 1335 mm. Of this 1178 mm infiltrated the soil while 23 mm ran off the site[8]. Some 293 mm of the infiltrated rainfall moved below the 500 mm deep root zone.

Pan evaporation averaged 1468 mm/year while potential evapotranspiration (PET) averages 1158 mm. The predicted evapotranspiration without irrigation averaged 811 mm/year. The PET has a strong annual cycle varying from over 6 mm/day in summer to 1 mm/day in winter. Figure 4.1 shows that a typical annual rainfall pattern is more varied than the potential evapotranspiration, and rain can occur throughout the year. The wet weather storage must be sufficient to retain this water in at least the 50%ile wet year. Table 9.1 shows the percentage of years when overflow occurs for a range of irrigation areas and wet weather storage pond capacities.

Table 9.1. Effect of varying irrigation storage capacity and irrigation area on the percentile of years when wet weather overflows are predicted to occur.

Wet weather storage pond (ML)	2 ha irrigation	3 ha irrigation	4 ha irrigation
2	Overflow in 86% of years	Overflow in 75% of years	Overflow in 74% of years
3	Overflow in 85% of years	Overflow in 45% of years	Overflow in 42% of years
4	Overflow in 42% of years	Overflow in 33% of years	Overflow in 23% of years

The combinations of irrigation dam capacity and irrigation area that met the design criterion are highlighted in yellow. The selection of the most suitable combination will depend on local conditions. However it is generally preferable to minimise the effluent application rate, so a 3 ML storage and 4 ha of irrigation is a preferred option.

Table 9.2 shows the area of gardens for a range of lot sizes that are likely to occur at full development.

[8] The runoff rate is extremely low and reflects the sandy soil.

Table 9.2. Estimation of irrigation areas associated with various lot areas. Note that Gosford City Council (2007) requires a minimum previous area/ dwelling of 50 sqm or 30%# of the site - whichever is greater

Indicative lot area (msq)	Estimated number of lots	Estimated hardstand including roofs, paths and rainwater tanks/ lot (msq)	Estimated area available for irrigated gardens (msq)	Estimated area among the homes that is available for irrigation (msq)
350	29	300	50	1450
400	12	300	120	1440
550	62	350	200	12400
800	12	350	450	5400

The total individual lot garden area is 2.04 ha. It is assumed that all owners would water their area as needed.

It would be prudent to have at least 2 ha of additional lands (a 141 m *142 m square or a 71 m *282 m would be sufficient) that could be intensively irrigated. An irrigation dam with at least 3 ML storage capacity is needed.

Alternative strategies during stage one of the development

Stage one of the development will commence with a few individual dwellings, and gradually increase to 60 units. There will be 33 individual dwellings on single lots and 10 dwellings on lot 15 and 17 dwellings, including four, 2 storey buildings with two units in each of them. It is not practical to set up a 3 to 4 ML dam at this stage as the dam would be empty almost all the time and this creates issues with dam wall cracking and potential leakage. Similarly there is little point in establishing 2 to 4 ha of irrigation when there is insufficient flow to operate the system. It is therefore proposed to take an alternative approach until there is sufficient flow to construct the dam. However it will be necessary to have an irrigation area dedicated to effluent disposal during periods when effluent production exceeds the evaporative demand.

According to AS/NZS 1547 (2012), the soil type at Narara Eco Village could sustainably accept an irrigation rate of 3.5 to 4 mm/day. This is equivalent to 3 to 4 L/msq/day.

Assuming a design net flow of 337 L/dwelling/day then some 112 msq is needed for each dwelling. As discussed above the volume of excess reclaimed water is numerically equivalent to the potable water demand. The data in table 6.4 indicates that the potable demand is likely to be approximately 18 cubic m/day for stage 1 of the development.

Reducing the rate to 1mm/day would result in an irrigation area requirement of 18,000 msq. The 33 single dwelling lots cover some 18,700 msq. Assuming 30% of the lots must be garden as per table 9.2, some 6200 msq of irrigation area would occur around the dwellings. Additionally cluster lots 15 and 36 have a combined total irrigation area of approximately 3000 msq. Therefore another 9,000 msq must be sourced. There is sufficient orchard and open space to the south of stage 1 of the development to accommodate an irrigation area of this magnitude. The irrigation area could be located within the existing orchard, south the proposed development area as figure 10.1 shows.

10 Land Capability Assessment for Reclaimed Water Irrigation

The site was inspected by Dr Peter Bacon of Woodlots and Wetlands in August 2013. The inspection activities included the soil and landscape assessment reported below.

Landform assessment

Figure 10.1 shows the site and the assessment points and sampling pits. The development area is on an eastern facing slope. Reclaimed water in excess of demand will be irrigated within the disused orchard, the surrounds and within the development footprint. Figure 8.1 also shows that the development site has bush to its west and north and a floodplain to the east. The nearest downslope waterbody is Narara Creek which is over 180 m east of the irrigation area.

Soil landscapes

The soil landscape map (Murphy, 1993) shows that the site is split between the Hawkesbury Soil Landscape in the more elevated areas and Erina Soil Landscape over much of the site. Typical attributes are summarised in table 10.1.

Table 10.1 typical attributes of the Hawkesbury and Erina Soil Landscapes (Source: Murphy, 1993).

Attribute	Hawkesbury Soil Landscape	Erina Soil Landscape
Geology	Hawkesbury Sandstone	Narrabeen Group, including lithic and quartz sandstone, siltstone, claystone and conglomerate
Topography	Rolling very steep hills	Undulating to rolling rises and low hills
Slopes	25 to 100%	>25%
Erosion hazard	Extreme	Low to moderate
Soils classification	Yellow earths and siliceous sands	Yellow earths and yellow podsolics
Fertility	Very low fertility	Low to very low fertility

The typical profile has loamy sand overlying light to medium clay at 2m depth.

Figure 10.1. Landform and soil sampling / assessment sites within the Narara Ecovillage development. (Image source: hill thalis).

Landform assessment procedures

Figure 10.1 shows the 15 localities within the proposed development area which were assessed for landform and soil characteristics. The sampling areas were either under orchard or volunteer grass. It is proposed that the majority of the site will be developed for housing; however the orchard to the south of the stage 1 development will be used for effluent irrigation of excess effluent from the first stage.

Table 10.2 summarises the results of the landform assessment.

Table 10.2. Site attributes and their likely impact on site suitability of effluent irrigation at the site.

Attribute	Rationale	Comment
Grid ref	Permanent record of assessment position	
Aspect	Influences solar radiation intensity on lands with more than 10% slope	Slopes towards the east. It will get full morning sun, but little late afternoon sun. There will be reduced exposure to dry westerly winds.
Exposure	Exposed areas have higher evapotranspiration demand	The orchard trees shown in figure 10.1 that are in the development envelope will be removed. Trees near sampling pits 4, 5 and 8 will be retained until stage 2. The irrigation will be established in this area.
Slope %,	Impacts on the erosion and runoff potential	Ranges from 5 to 24% within the main irrigation area (south of the development). Average slope on individual dwelling lots range from 10 to 25%
Slope length	Impacts on the erosion and runoff potential	Up to 350 m
Landscape position	Impacts on the extent on run-on from upper slopes. Impacts on local drainage.	Lower slope. This is not a major issue as the soils are deep and well drained. Run-on from above will be relatively limited. The site drains to the east. There is one gully to the north and east of the development site. Lots 5 and 6 are close to a designated drainage line, but all other sites are at least 50m away.
Local Relief	Indicates the extent of steep slopes	Rolling hills. .
Landform element	Identifies drainage issues, e.g. floodplains	Convex, divergent slope, so ideal (DEC, 2004).
Drainage line distance (m)	Indicates risk of stream contamination via runoff. Used in DEC (2004) as a buffer distance guide. A 50m distance is required between waterbodies and high pressure spray systems.	The proposed irrigation system will have low pressure and produce large droplets. The <1 E coli/100 mL contamination means there is extremely low health risk.
Flow patterns	Indicates stream networks and the risk of contamination	There are several ‘dry’ gullies through the site. These would convey water during severe storms. There is an

Attribute	Rationale	Comment
		opportunity to capture and convey stormwater runoff around the topside of the irrigation area. This will minimise run-on
Run-on/ runoff potential	Identify management needed to minimise excess inflow or losses from the site.	A contour bank/ berm will intercept flow above the development area and convey it to the gullies.
Surface water bodies-dams, ponds, springs DS or US of site	These features are used in DEC (2004) table 4.9 as a buffer distance guide.	No springs or other surface water bodies were evident within the irrigation area. Use of tertiary treatment of the effluent and irrigation at less than the AS/NZS 1547 design irrigation rate(DIR) will minimise risk
Storm water	Risk of external flooding, especially with contaminated water.	A contour bank will intercept flow above the irrigation area.
Salt	Salinisation can limit plants' ability to utilise the effluent. It can indicate poor drainage and the need salt tolerant plants. Salinisation can destroy soil structure leading to increased risk of effluent runoff.	The profiles are well drained. There is no evidence of salinisation.
Erosion potential+/- cult	Erosion potential is used to adjust the cropping/ pasture regime to minimise risk	Low erosion potential once permanent grass cover is established and maintained. There are some minor erosion nick points where overland flow paths discharge to gullies. These need erosion protection.
Rock out crops %	Rocky soil can reduce plant growth, make cultivation difficult and increase runoff.	None.
Depth to hard rock	Soil less than 1m deep can have poor root development and inadequate ability to retain nutrients. They can also become waterlogged.	All sites exceeded 1m to rock. All but 3 sites had at least 2m of soil overlying rotted rock.
Water table depth	Depth to water table is critical in determining the most suitable vegetation. A shallow water table will preclude irrigation in parts of the year.	Sites 3 and 9 had free water at <1m deep. The other sites had at least 2m depth above any water table.
Groundwater	Distance between the irrigation area and groundwater bores used for domestic purposes is a critical issue in risk assessment	The property has a bore on it. Gosford CC installed it to test the potential for supplying town water in 2007, during the Millennium Drought (see figure 10.2). The water pumped from the bore was too saline for use.
Flood risk	Frequent flooding can destroy infrastructure, prevent irrigation and damage crops.	Not an issue
Land use history	Past land use activities such as sheep dips and landfills can result in contaminated lands. These lands are normally unsuited for effluent irrigation because the irrigation will increase the risk of off-site contamination.	Long term orchard and therefore OK .

Attribute	Rationale	Comment
Proposed land use	The most suitable land uses should be the ones that result in acceptable minimum risks to human and environmental health. At the same time the landuse must be suitable for the site and not be too expensive to establish or operate.	A combination of disused orchard and pasture. The dwellings will have a mix of lawn and gardens. Therefore OK (assuming <1 E coli/100 mL in the effluent).
Distance to public roads houses, etc.	Buffer distances will be a function of the likely contaminant load and the likely level of exposure to the effluent.	A minimum of 60m to the nearest public road. This is well beyond the 25 to 30m recommended in the National Guidelines.
Fire hazard	Fire hazard can be significant for landuses such as woodlots. Fire can destroy both vegetation and equipment.	Not considered an issue as the site will have an asset protection zone and it is at the base of an eastern facing hill (hot, dry winds typically come from the west).

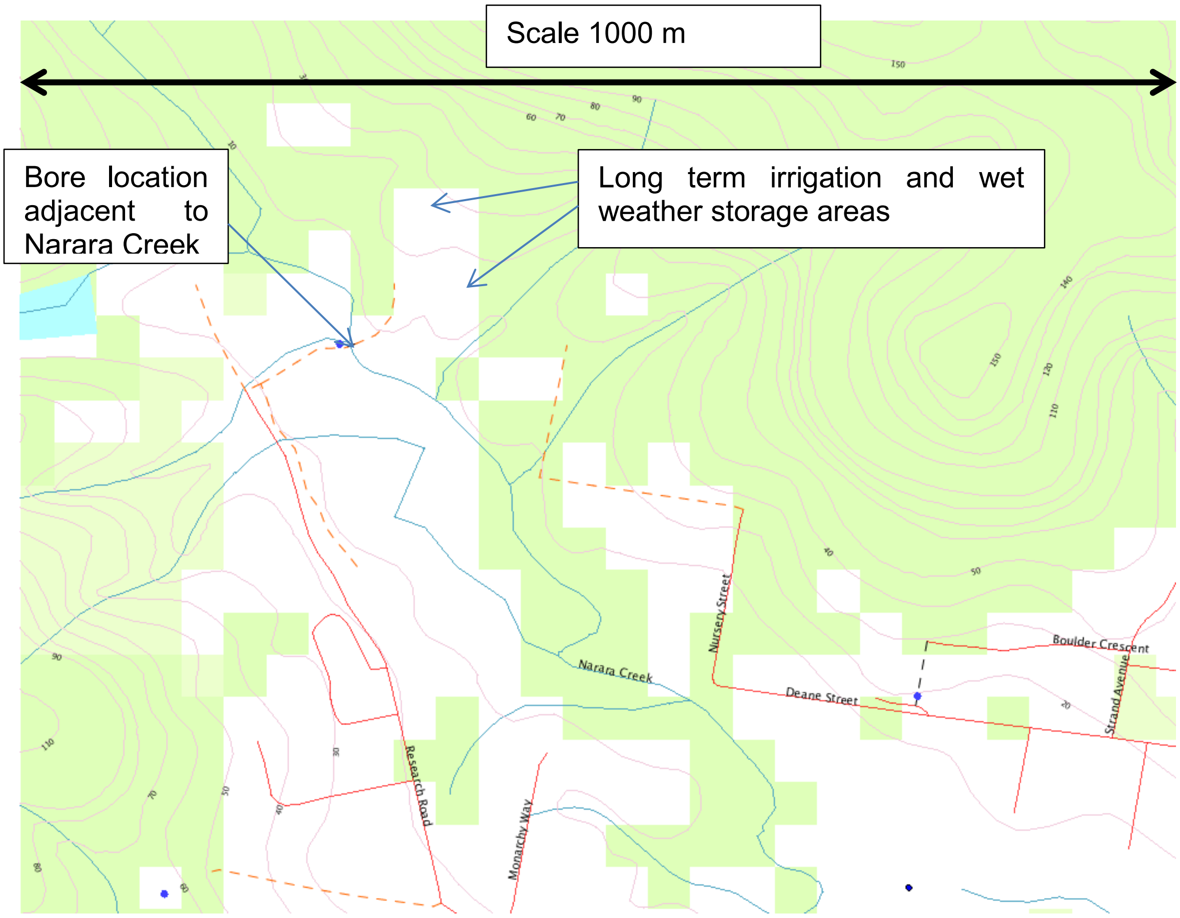


Figure 10.2. Location of the monitoring bore (GW 201197) established by Gosford City Council. The bore is some 190 m from the nearest proposed allotment. The water is too saline for potable use (Site map courtesy of NSW Government).

Conclusions from the landform assessment

The land slopes relatively steeply to the east. The slope means that run-on and run-off are likely to be moderate. Conversely, the free draining, sandy nature of the surface metre of soil means high hydraulic conductivity will exceed rainfall intensity in all but a few storms. Consequently runoff will be minimal in all but severe storms. Additionally a proposed contour bank immediately upslope of the irrigation area will assist in diverting run-on from the forest uphill of the subject site.

Low pressure, low application rate, spray/drip irrigation is proposed. This will minimise risk of runoff and aerosol formation. A permanent pasture cover within the orchard is ideal.

Other site attributes create minimal risk. On this basis, the site appears suitable for application of effluent, especially in view of the relatively low level of contamination in the effluent as discussed in section 11.

11 SOIL ASSESSMENT

Insitu soil assessment

A back hoe was used to excavate 15 pits within the development area. The locations were geo-positioned and are shown in figure 10.1. DEC (2004) suggests 4 sampling depths. Our soil sampling was based on sampling horizons to at least the surface 2 metres unless rock was encountered. The sample depths varied slightly to reflect the differences in horizon thickness at individual sites. Up to 5 horizons were noted. The results of the field assessment are shown in table 11.1.

Field texture

Table 11.1 shows that the field texture typically changed gradually from loamy sands/sandy loams in the surface 60 to 100 cm to clay loams to medium clay at between 1 and 2m depth.

The sand dominant surface horizons mean that the risk of runoff from irrigation is minimal. For example, the saturated hydraulic conductivity of loamy sands to sandy loams ranges from 60 to 700 mm/hr depending on soil conditions (Geeves et al, 2007). A 50 year 2 hr storm has an intensity of 53 mm/hr. So, in theory, even this storm would not create runoff.

The depth to the clayey subsoil varies from 45 cm at site N10 to 2m at site N2. The relatively deep sandy layer is important because hydraulic conductivity of the clay subsoil is likely to be at least 10 times lower than the surface layers. This would result in the rapidly infiltrating water being temporary perched on the clay during prolonged wet weather. However the slope of the site means that the excess water that reached the clay layer would move downslope along the top of the clay subsoil, eventually reaching the lower slopes.

Consistency

Consistency varied from loose, single grains in the topsoils at many sites to firm in the clay dominant subsoils

The loose, non-cohesive sand is at risk of erosion from concentrated flows. Therefore permanent grass cover and minimal tillage is recommended. Retention of organic matter on the soil surface and in the topsoil will reduce erosion risk.

Pedality

The pedality is not relevant for sand or loamy sands. The clayey dominant subsoils are either massive, apedal, or weak to moderately pedal.

Moderate pedality is preferred in the subsoil, as weak pedality can indicate structural degradation.

Fabric

Earthy or rough pedal fabric is preferred as sandy soils can be erosive. The sandy topsoils need a vegetative cover to reduce erosion risk.

Table 11.1. Insitu soil conditions. (No soil fauna evident, no water repellency, hard setting of the surface, obvious hard pan or bleaching).

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
N1	0 to 33	Loamy sand. Organic matter obvious	Loose	Sandy	Moist	Not applicable	V. dark grayish brown	Gradual	None	None	Common	None	Gradual	None
	33 to 80	Loamy sand	Loose	Sandy	Moist	Not applicable	Pale yellow	Diffuse	None	None	Few	None		None
	80 to 120	Sandy clay loam	Weak	Sandy	Wet	Not applicable	Brown	Diffuse	None	None	Common	None		None
	>120 cm has rotted rock													
N2	0-15	Sandy loam	Weak	Sandy	Moist	Not applicable	V dark brown	Gradual	None	None	Common	None	Gradual	None
	15-75	Clayey sand	Loose	Sandy	Moist	Not applicable	Brown	Gradual	None	None	Few	None		None
	75-160	Sandy clay loam	Weak	Sandy	Wet	Not applicable	Dark yellowish brown	Diffuse	None	None	None	None		None
	160-210	Light clay	Firm	Earthy	Wet	Massive	Brown		10% orange	None	None	None		100 % @ 2.2 m

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
N3	0-20	Loamy sand	Loose	Sandy	Moist	Not applicable	Dark brown	Gradual	None	None	Common	None	Gradual	None
	20-55	Loamy sand	Loose	Sandy	Moist	Not applicable	Grayish brown	Gradual	None	None	Few	None		None
	55-100	Loamy sand	Loose	Sandy	Wet	Not applicable	Light yellowish brown	Diffuse	None	None	Few	None		None
	100-170	Sandy loam	Weak	Sandy	Wet	Weak	Pale brown		None	Orange & black nodules <1% of volume	None	None		None
N4	0-20	Loamy sand	Loose	Sandy	Dry	Not applicable	V dark brown	Clear	None	None	Common	None	Gradual	None
	20-60	Clayey sand	Loose	Sandy	Moist	Not applicable	V. dark grayish brown	Gradual	None	None	Few	None		None
	60-100	Clayey sand	Loose	Sandy	Moist	Not applicable	Strong brown	Diffuse	None	None	None	None		None
	200-220	Sandy loam	Weak	Earthy	Moist	Not applicable	Brown		None	None	None	None		None
N5	0-20	Loamy sand	Loose	Sandy	Dry	Not applicable	V dark gray	Clear	None	None	Common	None	Gradual	None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
	20-60	Clayey sand	Loose	Sandy	Moist	Not applicable	V. dark grayish brown	Gradual	None	None	Few	None		None
	60-110	Clayey sand	Weak	Sandy	Moist	Weak pedality	Strong brown	Diffuse	None	None	None	None		None
	180-210	Light medium clay	Weak	Earthy	Moist	Not applicable	Strong brown		5% red	1% black	None	None		None
N6	0-22	Clayey sand	Loose	Sandy	Dry	Not applicable	V dark grayish brown	Clear	None	None	Common	None	Gradual	None
	22-43	Sandy loam	Weak	Sandy	Moist	Not applicable	V. dark grayish brown	Gradual	None	None	Few	None		None
	Isolated rock floaters @ 50 cm. Indicative diameter 10 cm													
	43-100	Light clay	Firm	Earthy	Moist	Weak pedality	Light yellowish brown	Diffuse	20% orange	None	None	None		None
	100-126	Light medium clay	Firm	Earthy	Moist	Weak	Light yellowish brown		30% orange	None	None	None		None
N7	0-21	Loamy sand	Loose	Sandy	Dry	Not applicable	V. dark grayish	Gradual	None	None	Common	None	Gradual	None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
							brown							
	21-75	Clayey sand	Loose	Sandy	Moist	Not applicable	Yellowish brown	Gradual	None	None	Few	None		None
	75-100	Clay loam	Firm	Earthy	Moist	Weak	Yellowish brown	Diffuse	None	None	Few	None		None
	150-220	Light clay	Firm	Earthy	Moist	Weak	Dark reddish brown		30% red	None	None	None		None
N8	0-25	Loamy sand	Loose	Sandy	Dry	Not applicable	V dark grayish brown	Gradual	None	None	Common	None	Gradual	None
	25-63	Loamy sand	Loose	Sandy	Moist	Not applicable	V. dark grayish brown	Gradual	None	None	Few	None		None
	63-100	Clayey sand	Loose	Sandy	Moist	Not applicable	Strong brown	Diffuse	5% orange	None	Few	None		None
	150-210	Light clay	Firm	Earthy	Moist	Not applicable	Brown		5% red	None	None	None		None
N9	0-21	Loamy sand	Loose	Sandy	Dry	Not applicable	V. dark grayish brown	Clear	None	None	Common	None	Gradual	None
	21-70	Loamy	Loose	Sandy	Moist	Not	Gray	Gradual	None	None	Few	None		None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
		sand				applicable								
	70-110	Sand	Loose	Sandy	Moist	Not applicable	Gray	Diffuse	None	None	Few	None		None
	150-200	Medium clay	Firm	Earthy	Moist	Not applicable	Gray		30% red	None	None	None		None
N10	0-25	Sandy loam	Weak	Sandy	Dry	Not applicable	V. dark grayish brown	Gradual	None	None	Common	None	Gradual	None
	25-45	Sandy loam	Weak	Sandy	Moist	Not applicable	V. dark gray	Gradual	None	None	Few	None		None
	45-100	Medium clay	Firm	Earthy	Moist	Moderate	Light gray	Clear	30% orange	None	Few	None		None
	175-210	Light clay	Firm	Earthy	Moist	Massive	Yellowish brown		20% red	None	None	None		None
N11	0-8	Clayey sand	Loose	Sandy	Dry	Loose	Dark brown	Gradual	None	None	Common	None	Gradual	None
	8-44	Clayey sand	Loose	Sandy	Moist	Loose	Yellowish brown	Gradual	None	None	Few	None		None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
	44-100	Loamy sand	Loose	Sandy	Moist	Loose	Brown	Gradual	None	None	Few	None		None
	100-220	Sandy loam	Weak	Sandy	Moist	Weak	Yellowish brown		None	None	None	None		None
N12	0-15	Sandy loam	Weak	Sandy	Dry	Not applicable	V dark gray	Gradual	None	None	Common	None	Gradual	None
	15-60	Clay loam	Firm	Sandy	Moist	Moderate	Dark grayish brown	Gradual	None	None	Few	None		None
	60-100	Clay loam	Firm	Sandy	Moist	Moderate	Yellowish brown	Clear	30% red	None	None	None		None
	100-125	Sandy clay	Weak	Earthy	Moist	Weak	Gray		30% orange	None	None	None		15% rock
	Rotted rock below 1.25 m													
N13	0-25	Loam	Weak	Sandy	Dry	Not applicable	V dark gray	Gradual	None	None	Common	None	Gradual	None
	25-75	Clay loam	Firm	Earthy	Moist	Weak	Brown	Gradual	None	None	Common	None		None
	75-100	Medium clay	Firm	Earthy	Moist	Moderate	Brownish yellow	Gradual	20% red	None	None	None		None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
	150-175	Medium clay	Very firm	Earthy	Moist	Moderate	V. pale brown		30% orange	None	None	None		None
N14	0-30	Clayey sand	Weak	Sandy	Dry	Not applicable	Yellowish brown	Gradual	None	None	Common	None	Gradual	None
	30-100	Sandy loam	Firm	Earthy	Moist	Moderate	Light yellowish brown	Gradual	None	None	Few	None		None
	150-200	Clay loam	Firm	Earthy	Moist	Moderate	Grayish brown		30% red	None	None	None		None
N16	0-25	Sandy loam	Weak	Sandy	Dry	Single grain	Very dark greyish brown	Gradual	None	None	Common	None		None
	25-65	Clayey sand	Weak	Sandy	Dry	Single grain	Light yellowish brown	Gradual	None	None	Few	None		None
	65-120	Sandy loam	Weak	Sandy	Dry	Single grain	Brownish yellow	Gradual	None	None	None	None	Duplex	None
	120-220	Sandy clay loam	Weak	Sandy	Dry	Weak pedality	Pale yellow		20% red	None	None	None		None

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
N18	0-25	Organic loam	Weak	Organic	Dry	Weak	Very dark greyish brown	Gradual	None	None	Common	None	Gradual	No
	25-60	Loam	Firm	Earthy	Dry	Weak	Yellowish brown	Gradual	None	None	Few	None	Gradual	No
	60-100	Clay loam	Weak	Earthy	Dry	Friable, moderate	Red	Gradual	None	None	None	None	Gradual	Non
	100-200	Clay loam	Firm	Earthy		Friable, moderate	Red		None	None	None	None	Gradual	5%

Notes:

1. A 15th pit was excavated downslope of the community facility to assess soil conditions in this area. The results are not required for stage 1.

2. There were three additional pits excavated on the northern most rural block on the right hand side of Narara Creek. The results of two of these pit inspections are shown as N16 and N18. This area is expected to be used for irrigation and wet weather storage at full development. Pit 17 was undertaken to assess suitability of the soil for dam construction.

Figure 11.1. Pit 7. The profile changes from loamy sand near the surface (right hand side) to light clay below 2m.

Figure 11.2. Pit 13. The profile has a similar change in colour and texture as the other profiles.

Figure 11.3. Pit 18. The soil has a higher clay content than the soil in the development area. It will be suitable for dam construction.

Colour

Soil colour is derived from organic matter, clay mineralogy, and drainage conditions. Pale greys, yellow and whites indicate poor drainage. Dark browns are indicative of organic matter accumulation, while bright reds and oranges are indicative of good drainage.

The topsoils are typically brown to dark gray, indicating organic matter accumulation and moderate drainage. The increasing grey colour with increasing depth indicated imperfect drainage.

Boundaries

The sharpness of the boundaries between the soil layers generally indicates the extent of soil development (Isbell, 1996). There is a gradual increase in clay content with depth. This suggests the soils have developed in situ over a very long time scale. This conclusion suggests that the soil profiles are stable. That is the rate of soil formation approximates the rate of soil erosion.

Mottle %

Mottles can indicate imperfect drainage, especially if they are yellow. Mottles become evident from 70 to 100 cm. The mottles are typically red or orange, suggesting reasonable drainage.

Nodule %

There were few if any nodules evident. Site 3 had a few black nodules. This site was relatively wet and the nodules were probably a combination of iron and manganese rich precipitates.

Root number

Root number is typically ‘common’ in the surface 40 cm and ‘common’ to ‘few’ in the 40-70 cm layers. Roots were ‘few’ to ‘absent’ below 70 cm layer.

There was no evidence of impedance. It is expected that the root frequency will be maintained under permanent vegetative cover. The widespread presence of roots at depth suggests adequate physical conditions throughout the normal rooting depth.

Biological activity

Biological activity indicators include the presence of ants, earthworms, millipedes and insect holes in the ground. The activity was absent. The acidic conditions can reduce soil biota numbers.

Liming and planting of long term grass will increase soil biodiversity, thereby ensuring longevity of the effluent irrigation system.

Rock %

More than 10% rock in the surface horizon can increase risk of machinery damage. None of the soils has rock in the surface 40 cm.

Profile N 6 has some small rocks at 50 cm. Continuous rotted rock was evident below 2m at all sites. Site 18 has 5% rock below 1m

Conclusions and management recommendations based on insitu assessment

The ideal soil for effluent irrigation has sand dominant topsoil overlying moderately structured clay subsoil. The subject site has this desirable attribute. Therefore, the risk of runoff during irrigation is low.

Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Consequently, the establishment of long term is strongly recommended for the area.

Soil colour indicates that the subsoils have imperfect internal drainage through the clay subsoil. It is likely that a perched water table develops at depth following intense, prolonged rainfall. This excess water would slowly move downslope and dissipate on the floodplain.

The soils have good root penetration into the surface 50 to 70 cm. This also suggests that the soils are suitable for effluent irrigation.

Rocks are not an issue.

It is concluded that the soils appear suited to effluent irrigation. A good cover of vegetation, either as crops or long term pasture, is critical.

Soil chemistry

The soil analysis aims to quantify the soil attributes that influence the ability of the site to sustainably utilise the effluent. Soil samples from 5 out of the 15 profiles were analysed in detail. The soil sample depth varied to reflect field conditions. The average depth of the surface horizon was 20 cm, while the second horizon was typically 20 to 71 cm below the soil surface. Table 11.2 sets out the major soil attributes.

Additional samples were taken from the 0.7 to 1m and from the lowest soil layer. All soil samples were then analysed for P sorption capacity. The data was combined with bulk density to estimate P sorption capacity of the soil profiles.

pH (5_{water}:1_{soil})

The pH tends to fall with depth as table 11.2 shows. This may be due to surface application of agricultural lime. The surface 20 cm is ideally between 5.8 and 7 (Slattery, et al, 1999). Soils 7 and 9 are below this range and would benefit from liming. These sites are away from current orchard plantings and may not ever have received lime.

Liming will assist microbial activity in removing contaminants from the effluent.

Application of 200 kg/ha is recommended for areas such as site 16 and 18 which are away from the orchards. Retest after 3 years.

pH (0.01 M $CaCl_2$)

This second method of pH measurement is mostly used where the soils are very dispersive. Acid sensitive plants such as medic, peas, onions and celery will have depressed growth when the pH ($CaCl_2$) is below 4 to 4.3. Liming is recommended for soil 9 and possibly soils 5 and 7.

Salinity

Salinity is expressed as electrical conductivity (EC) in saturated paste equivalent. The units are dS/m. Soils with $EC_{sat\ paste}$ less than 4 are non-saline (Richards, 1954). Table 11.2 shows that none of the soils are saline. This is an important result as it means that salinity will not limit the site's usefulness for effluent irrigation.

Cation exchange capacity

Cation exchange capacity (CEC) is a measure of the soil's ability to retain nutrients. The CEC is related to the concentration of clay and or soil organic carbon. The Narara soils are sand dominant, with relatively little clay. Consequently the quantity of soil organic carbon is a critical determinant of soil CEC.

Ideally the CEC should be at least 5, and preferably greater than 12 cmol (+)/kg (Metson, 1961). Table 11.2 shows that sites 2 and 5 have more than 5 cmol (+)/kg CEC. Both these samples have higher concentrations of soil organic carbon than the other samples.

Increasing soil organic carbon, for example via mulching and composting, will assist in retaining and processing nutrients in the irrigated effluent.

Exchangeable calcium (Ca)

Ideally soils should contain over 10 cmol (+) /kg of exchangeable Ca (Metson, 1961). However soils with 5 to 10 cmol (+) /kg of exchangeable Ca are considered to have moderate concentrations. Table 11.2 shows that only sites 2 and 13 have ‘moderate’ quantities of exchangeable Ca. The other sites have ‘low’ concentrations.

Adding good quality agricultural lime will remove Ca deficiency, and increase production of acid sensitive plants such as legumes and celery.

According to Abbott (1989) Ca should make up 65 to 80 % of the sum of cations. Both profiles 7 and 9 are deficient in Exch Ca expressed as a % of the CEC. This can result in Ca deficiency. Addition of 200 kg/ha of lime prior to commencement of irrigation is essential to correct this. The calcium concentration ids low on the rural blocks where effluent irrigation is likely to occur in the long term. Liming will assist in improving productivity on these areas.

The soil should be retested after 3 years.

Exchangeable magnesium (Mg)

Soils should contain at least 1, and up to 3 cmol (+) of exchangeable Mg (Metson, 1961). The data in table 9.2 show that profiles 2, 5 and 13 have ‘sufficient Mg. Profiles 7 and 9 are deficient.

According to Abbott (1989) Mg should make up 10 to 15 % of the sum of cations. All profiles have depths where this range is achieved or exceeded.

The ratio of Exch Ca : Exch Mg should be at least 2:1. This occurs in portions of every profile. Excessive Mg is not an issue.

Application of dolomite is an option, if retesting soil after 3 years’ irrigation shows there is still an Mg deficiency in some soils.

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Table 11.2. Attributes of the soil surface horizons.

Attribute	*Units*	***N2 0-15***	***N2 15-75***	***N5 0-20***	**N5 20-60**	**N7 0-21**	**N7 21-75**	**N9 0-21**	**N9 21-70**	**N13 0-25**	**N13 25-75**	**N16 0-25**	**N16 25-65**	**N18 0-25**	**N18 25-60**
P (Bray 1)	mg/kg	27.8	23.1	14.1	3.1	10.5	2.0	109.3	3.1	126.9	13.5	3.5	3.4	1.2	1.0
pH	units	6.07	6.22	5.72	5.32	5.37	4.94	4.94	5.54	5.92	5.14	5.28	5.05	5.44	4.93
Conductivity	dS/m	0.057	0.080	0.048	0.017	0.018	0.014	0.016	0.007	0.032	0.025	0.023	0.010	0.019	0.016
		1.32	1.85	1.10	0.39	0.42	0.32	0.36	0.15	0.30	0.22				
OM	%	8.5	3.0	7.9	2.2	2.5	0.9	2.4	0.1	4.0	1.5	2.5	0.5	3.1	0.9
Calcium	cmol+/Kg	8.33	5.26	4.41	0.86	1.35	0.23	0.34	0.17	5.20	2.43	1.09	0.13	2.50	0.57
Magnesium	cmol+/Kg	2.91	0.79	2.59	0.28	0.58	0.13	0.16	0.08	0.93	0.43	0.63	0.05	1.39	0.42
Potassium	cmol+/Kg	0.45	0.14	0.56	0.20	0.18	0.07	0.07	0.02	0.42	0.13	0.12	0.04	0.13	0.09
Sodium	cmol+/Kg	0.10	0.19	0.10	0.05	0.05	0.04	0.03	0.03	0.08	0.07	0.05	0.02	0.12	0.09
Aluminium	cmol+/Kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Hydrogen	cmol+/Kg	0.27	0.17	0.63	2.32	1.72	2.93	2.55	0.31	0.27	3.58	1.71	1.64	2.18	6.89
Effective Cation Exchange Capacity (ECEC)	cmol+/Kg	12.08	6.55	8.31	3.72	3.88	3.41	3.16	0.62	6.91	6.65	3.61	1.89	6.34	8.06
Ca	%	69.0	80.2	53.1	23.1	34.8	6.9	10.8	27.9	75.2	36.6	30.3	6.8	39.5	7.1

Mg	%	24.1	12.0	31.2	7.5	14.9	3.7	4.9	13.6	13.5	6.4	17.4	2.8	22.0	5.2
K	%	3.7	2.2	6.8	5.3	4.5	2.1	2.2	2.5	6.1	2.0	3.3	2.0	2.1	1.1
Na	%	0.9	2.9	1.2	1.4	1.2	1.1	1.0	4.3	1.2	1.1	1.3	1.2	1.9	1.1
Al	%	0.1	0.1	0.1	0.2	0.2	0.3	0.3	1.4	0.1	0.1	0.2	0.5	0.1	0.1
H+	%	2.2	2.6	7.6	62.4	44.3	85.9	80.7	50.4	3.9	53.8	47.4	86.8	34.4	85.5
Ca:Mg	ratio	2.9	6.7	1.7	3.1	2.3	1.8	2.2	2.1	5.6	5.7	1.7	2.4	1.8	1.4
C	%	4.87	1.74	4.53	1.25	1.40	0.49	1.38	0.08	2.29	0.84	1.46	0.27	1.78	0.53
N	%	0.269	0.073	0.308	0.060	0.074	0.010	0.069	0.001	0.139	0.041	0.097	0.006	0.104	0.025
C:N	ratio	18.1	23.8	14.7	20.7	18.9	47.0	19.9	83.2	16.5	20.6	15.0	45.9	17.2	21.5
Cl	equiv. ppm	37	51	31	11	12	9	10	4	21	16	14	6	12	10

Exchangeable potassium (K)

Potassium is an essential nutrient, and topsoils should have at least 0.3 cmol (+)/kg. Table 11.2 shows that profiles 7 and 9 are deficient. The effluent will contain potassium, and so the potassium concentrations should increase over time. Soils in the proposed effluent irrigation areas have sufficient potassium.

Retest the soils after 3 years.

Exchangeable sodium (Na)

Exchangeable Na in soil is important because excessive Na can cause structural instability via deflocculation of clays. This is especially critical in the topsoil, where cultivation or heavy rainfall can make the soil susceptible to structural degradation. The Narara soils have minimal clay, and rely on organic matter to maintain structure.

Generally the potential impact of sodium on soil structure is expressed as Exch Na as a percentage of the sum of cations:

$$\frac{\text{Exch Na*100}}{\text{Exchangeable (Na+K+Ca+Mg+Al)}}$$

Less than 5% exchangeable Na is preferred.

Table 11.2 shows that all surface soils have less than 5% Exchangeable Na. The surface soils are therefore non-sodic. Sodicity is also low at depth. Thus sodicity is not an issue in these soils.

Exchangeable aluminium (Al)

Exchangeable Al is a potentially toxic ion. Ideally its concentration is below detection. It can stunt growth of susceptible plants such as legumes when more than 5% of the total exchangeable cations are Al. None of the sites has excessive Al.

Soil organic carbon

Soils with less than 1% organic carbon (OC) are likely to have poor structure and low structural stability (Charman and Roper, 2000). Sandy soils similar to the Narara topsoils typically should have at least 1.4% OC. Table 11.2 shows that soils 7 and 9 have around 1.4% organic carbon in the surface 20 cm. These sites have had intensive agricultural use. Sites 16 and 18 in the rural blocks, where effluent irrigation is likely to occur in the long term, have relatively high organic matter reflecting the permanent pasture on these areas.

Ideally the effluent irrigation will be used to produce permanent vegetative cover band this will result in a gradual increase in soil organic carbon concentration. Actions such as compost addition and mulching are recommended as ways of increasing soil organic carbon content.

Total Nitrogen

Soil total nitrogen concentrations less than 0.15% are considered ‘low’ in nitrogen (Bruce and Rayment (1982). The nitrogen concentrations of soils 7, 9 and 13 are close to or below this value. Some initial fertilisation will stimulate plant growth on these areas.

Nitrogen addition via effluent irrigation should gradually increase site nutritional status.

C : N ratio

The C : N ratio in typical soils is 10 to 12. The higher values in the current soils suggest that there is accumulation of carbon-rich residues. This may be due to the acidic conditions inhibiting bacterial activity. Liming will assist in normalising carbon transformations.

Bray No.1 Available phosphorus

Available phosphorus concentration is a measure of the current adequacy of supply of this nutrient. According to Moody and Bolland (1999), a concentration of 10 to 12 mg/kg in the surface 7.5 cm is sufficient for 90% potential yield of pastures. Table 11.2 shows that the surface horizons of sites 9 and 13 have extremely high available phosphorus. This may be because of banding fertiliser or accidental dumping near the orchard. The other profiles have low to medium concentrations of available P.

Soils in the proposed long term effluent irrigation areas have extremely low concentrations of available phosphorus and will benefit from the nutrients in the effluent.

The soils on much of the development area would benefit from the phosphorus in the effluent. So effluent irrigation will increase pasture yield, partly at least by increasing phosphorus supply.

P sorption capacity

Table 11.3 shows the P sorption capacity expressed in mg/kg and kg/ha for each horizon. The P sorption capacity is a measure of the soils' ability to retain phosphorus. It is a function of the P sorption capacity expressed as either mg/kg of soil or kg / metre depth of soil.

The storage capacity ranges from 7.8 t/ha in profile 9 to 17.5 t/ha in profile 7. The average is 13.5 T/ha (Std. Deviation of 3.7 t/ha). These are 'high' storage capacities, as many soils have less than 6 t/ha (DEC, 2004).

Table 11.3 also shows the time till the profiles become saturated with phosphorus. Applying a relatively heavy irrigation rate of 6.8 ML/ha/y will result in saturation after 88 to 197 years. Applying effluent at the recommended rate, equivalent to 1 mm/day, will result in saturation in between 167 and 373 years (average of 287 years).

The extremely low concentrations of available phosphorus in the land proposed for long term irrigation of effluent suggests that there are several centuries of sorption capacity available within these sites.

It is likely that technology changes over the next 3 centuries will ensure the long-term sustainability of the proposed system.

Table 11.3. Phosphorus sorption concentrations and P storage capacity/ha.

Profile	P sorption (mg/kg)	P sorption (kg/ha)	*Profile*	P sorption (mg/kg)	P sorption (kg/ha)	*Profile*	P sorption (mg/kg)	P sorption (kg/ha)	*Profile*	P sorption (mg/kg)	P sorption (kg/ha)	Profile	P sorption (mg/kg)	P sorption (kg/ha)
N2 0-15	337	657	*N5 0-20*	353	918	*N7 0-21*	320	872	*N9 0-21*	233	636	N13 0-25	250	813
N2 15-75	303	2549	*N5 20-60*	402	2250	*N7 21-75*	420	3174	*N9 21-70*	39	267	N13 25-75	523	3658
N2 75-160	438	5586	*N5 60-110*	383	5746	*N7 75-100*	574	6460	*N9 70-110*	47	423	N13 75-100	729	5468
N2 2m	559	3469	*N5 180-210*	704	5459	*N7 150-220*	646	7013	*N9 150-200*	600	6506	N13 150-175	700	5422
Profile P storage (kg/ha)		12260			14373			17520			7832			15361
Number of years till saturation (89 kg/ha/y application rate, 6.8 ML/ha/y)		138			161			197			88			173
Number of years till saturation (47 kg/ha/y application rate, 3.7 Ml/ha/y)		261			306			373			167			327

Conclusions and soil management recommendations

The soils varied across the site and within individual profiles. However some generalisations can be made:

- The soils are non-saline and non-sodic.
- The soils within the current orchards are more 'fertile' than several soils in the surrounding pastures. This is likely to have resulted from more intensive land management under the orchard.
- The non-orchard soils, especially sites 7, 9, 16 and 18, are acidic, have low soil organic carbon and nitrogen concentrations, are low in CEC, as well as low in exchangeable Ca and K.
- Liming at an initial rate of 200 kg/ha is recommended for areas not currently under orchard.
- Retest all soil in 3 years.
- The soil organic carbon content is critically important, and practices such as composting and mulching will assist long term sustainability of the development.
- The P sorption capacity of the soil is sufficient for an average of almost 300 years at the indicative effluent irrigation rate of 365 mm/year.

These features mean that all the soils tested are suitable for long term irrigation of effluent provided the nutrient deficiencies are addressed and the soil organic carbon content is maintained.

The key recommendations:

- Install runoff diversion banks upslope of the development area and divert runoff towards existing drainage lines.
- Apply and incorporate 0.2 t/ha of agricultural lime
- Install surface irrigation
- Retain orchard where practical and trees are healthy. Use for effluent irrigation from stage 1 of the development
- After full development transfer all unrequired effluent to the rural blocks for long term irrigation.
- A wet weather storage will need to be constructed in this area.
- Plant pasture in other areas as soon as possible after the irrigation system is installed and operational.
- The pasture should include a mix of perennial temperate grasses such as perennial ryegrass.
- Facilitate accumulation of soil organic carbon by combinations of long term pasture, mulching and compost addition.
- Retest the soil for nutrients, pH and organic carbon after 3 years of effluent irrigation.

12 POTENTIAL FOR USING THE DAM TO SUPPLY POTABLE WATER

Catchment hydrology and contaminant yield

The stormwater model, MUSIC (Version 5), was used as an initial guide to runoff volumes and contaminant influxes to the dam.

Catchment area

Inspection of the topographic maps for the area indicated that the catchment draining to the dam was at least 130 ha. In practice the area could be up to 160 ha, but without a more detailed survey, it is considered prudent to use the more conservative figure.

Catchment soils

The main soil in the catchment is labelled Sydney Town Soil Landscape (Murphy, 1993). The soil is typically 15 – 30 cm of sandy loam overlying up to 50 – 150 cm of clay loam.

There is also some Hawkesbury Soil Landscape in the catchment. This soil is extremely sandy and shallow. It is likely to have a higher runoff coefficient than the Sydney Town Soil Landscape. However the more conservative runoff coefficients for the Sydney Town Soil Landscape were used.

Model inputs

The model inputs were derived from the MUSIC (Version 5) Guidelines, and from Fletcher et al (2004). Tables 12.1 to 12.3 show the parameters used in the modelling.

Potable water demand at full development

Section 6 shows that the estimated potable water demand based on 5 persons/dwelling is 0.337 cubic m/day. If there are 115[9] dwellings then the potable demand is 39 cubic m/day or 14.2 ML/year.

Table 12.1. Inputs used for the MUSIC Model (Source: MUSIC (Version 5) Guidelines and Fletcher et al 2004).

Component	Units	Result
Catchment area	ha	130
Dam surface area	ha	1.1
Dam volume	ML	45
Evaporation rate	As % of potential evapotranspiration	100
Catchment landuse	%	10% rural residential, 10% of which is impervious surfaces

[9] The final development may have up to 130 dwellings. Actual consumption data from stage 1 of the development will be used to estimate the effect on demand of various numbers of dwellings at final development.

Component	Units	Result
		90% forest 98% of which is previous

Table 12.2. Soil hydrological characteristics used in the MUSIC model (Source: MUSIC (Version 5) Guidelines and Fletcher et al 2004).

Component	Units	Result
Catchment soil		20 cm of sandy loam then 30 cm clay loam
Soil water storage capacity (top 50 cm)	mm	107
Soil field capacity moisture storage (top 50 cm)	mm	82
Soil infiltration coefficient (a)	mm/day	250
Infiltration capacity (b)		1.3
Daily recharge rate	%	60
Daily baseflow	%	45
Daily seepage rate	%	0

Table 12.3. Pollutant concentration parameters used for base flow in the MUSIC model (Source: MUSIC (Version 5) Guidelines and Fletcher et al 2004).

Component	Flow type	Total suspended solids (TSS - mg/L -Log_{10})		Total Phosphorus (TP mg/L - Log_{10})		Total Nitrogen (TN mg/L -Log_{10})	
		mean	**Std dev**	**mean**	**Std dev**	**mean**	**Std dev**
Rural residential	Base	1.15	0.17	-1.22	0.19	-0.05	0.12
	Storm	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	Base	0.78	0.13	-1.52	0.13	-0.52	0.13
	Storm	1.60	0.20	-1.10	0.22	0.05	0.24

Six minute rainfall data from Jan 1970 to August 2010 was used to generate runoff behaviour.

Model outputs

Table 12.4 shows the water and pollutant inflow and exits to the dam.

Table 12.4. Inflows and outflows to the 45 ML dam based on 6 minute data since 1970.

Attribute	Flow (ML/y)
Flow In	450.1
ET Loss	13
Infiltration Loss	0
Low Flow Bypass Out	0
High Flow Bypass Out	0
Pipe Out	304
Weir Out	120
Transfer Function Out	0
Reuse Supplied	14
Reuse Requested	14
% Reuse Demand Met	100
% Load Reduction	6

The modelled flow into the dam is 450 ML/year. The anticipated demand when there is zero water left in the rainwater tanks is 39 cubic m/day or 14.2 ML/year. The demand is therefore a maximum of approximately 3% of the anticipated catchment yield.

The results suggest that even if the eco-village were totally dependent on dam water supplies it would only use some 3% of the average annual runoff.

Catchment hydrology-A conservative approach

The daily runoff was estimated using the runoff curve number technique. The RCN selected was 79. This number is relatively high (USDA, 1986) and reflects the shallow soil overlying sandstone in much of the catchment (Murphy, 1993).

Runoff commenced when the rainfall exceeded 18 mm in any one day. This is also relatively conservative, and the assumption under-predicts catchment yield. The reason for using a conservative figure is to demonstrate that even with relatively low water yields, the dam can reliably supply all the water needs of the development.

The average predicted annual runoff since January 1970 is 157 mm or 12%[10]. Over the 130 ha catchment this is 204 ML/year. The dam capacity is estimated at approximately 45 ML, so in the average year the catchment outflow is equivalent to some 4.5 times the dam volume.

[10] A 12% runoff coefficient for 1335 mm of rainfall /year is extremely conservative . However it does provide a large margin of safety.

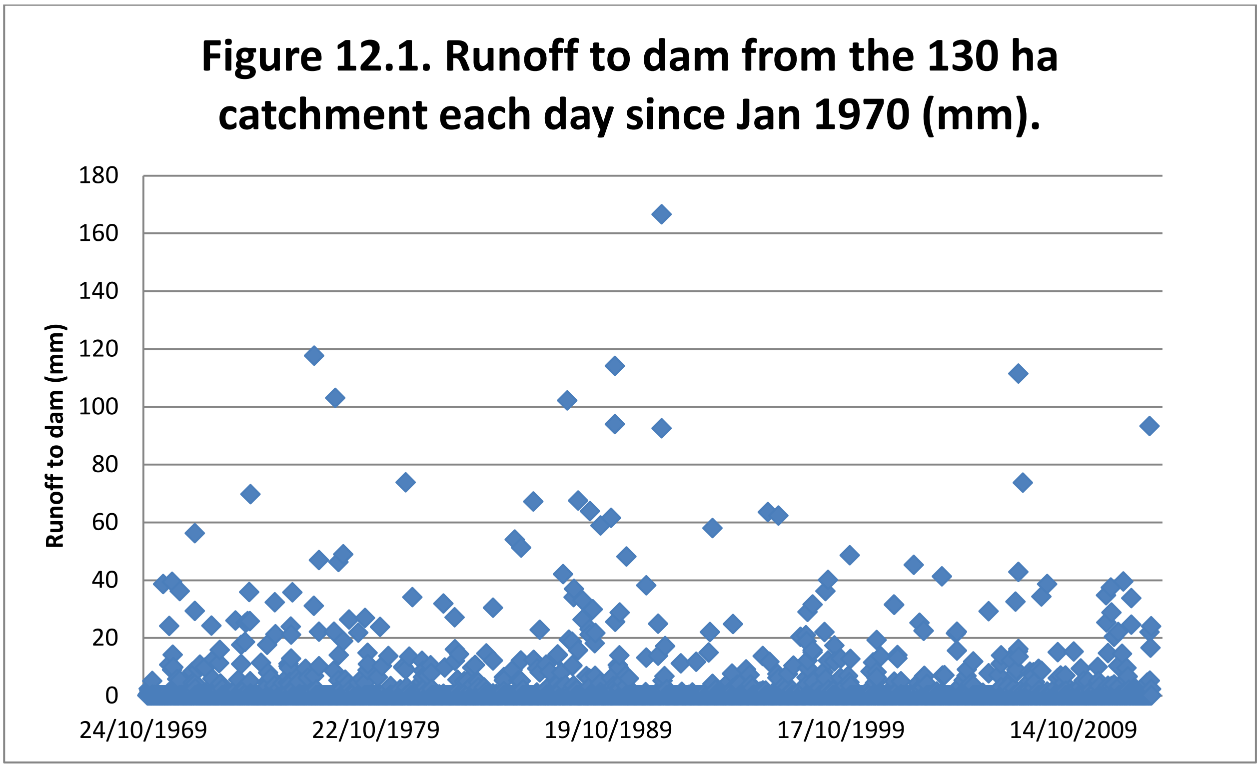


Figure 12.1 shows that there are numerous runoff events. A 90 mm rain event would create a runoff volume that exceeds the dam volume. Figure 10.1 shows that this occurred 9 times in the past 43 years.

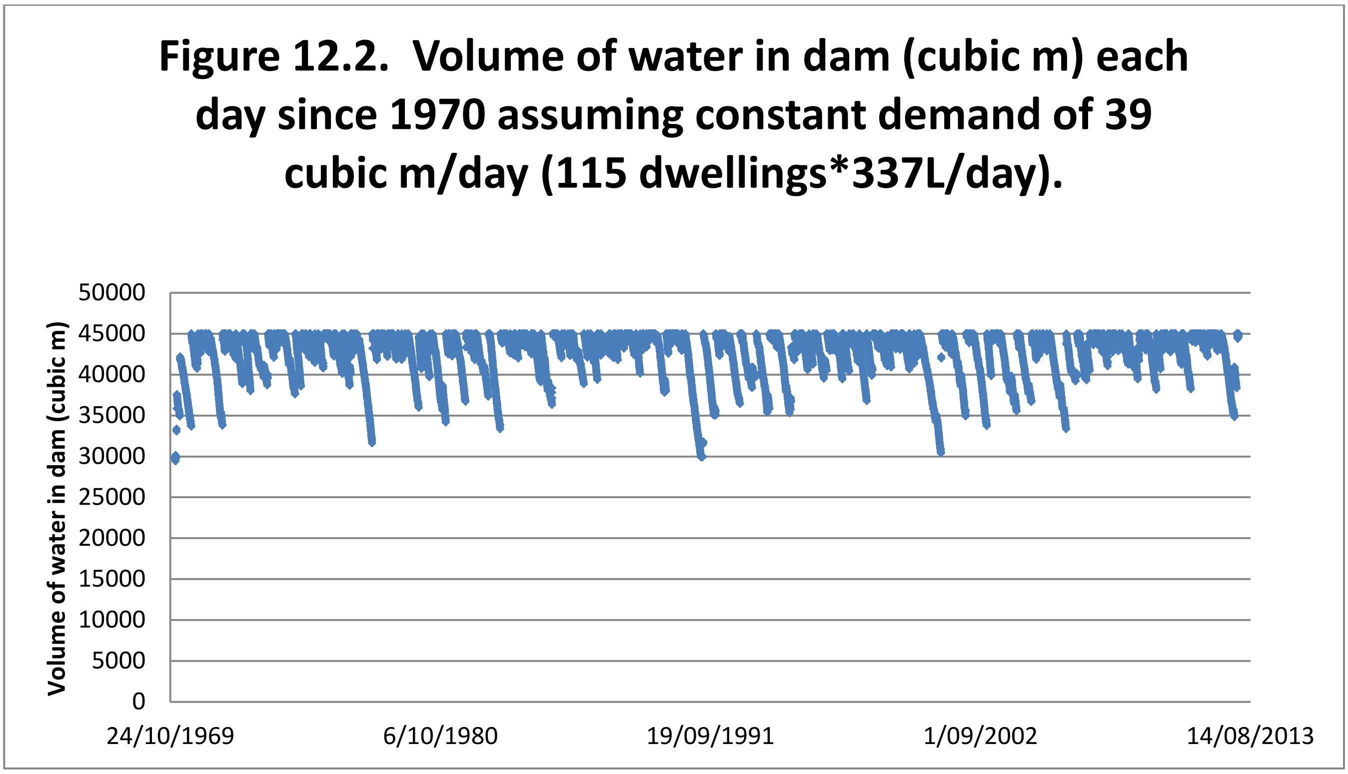
Reliability of the dam as the sole source of potable water

The reliability of the dam was assessed for the extreme example where there was no capture and use of roof water in the eco-village. That is, the dam was the sole source of potable water. The model's assumptions are shown in table 12.5.

Table 12.5 Assumptions and inputs into the dam reliability simulation

Component	Input/ assumption
Climate data	Daily rainfall and evaporation since Jan 1970
Evaporation from the dam surface	80% of pan evaporation
Seepage from the dam	Zero
Catchment area	130 ha
Dam surface area at TWL (top water level)	1.1 ha
Dam capacity at TWL	45,000 cubic m (45 ML)
Dam storage at commencement of simulation	30 ML (i.e. 2/3 full)
Demand for potable water Internal use only for washing, cooking and drinking. Assumes 5 people/dwelling	377 L/dwelling/day
Number of dwellings	115 at full development
Total demand for potable water	39 cubic m/day or 14.2 ML/year.

Figure 12.2 shows the daily water in storage based on the inputs in table 10.1. The dam is nearly full most of the time. The minimum storage is 29 ML. This is 16 ML less than full supply. The result indicates that the dam can supply all the potable needs of the development.



Reliability of the dam to supplement roof runoff

In this simulation it was assumed that each dwelling had a 10.5 cubic m rainwater tank and that 8.4 cubic m of this volume could be utilised.

Dam water was supplied to the individual tanks on a daily basis once the water in the tank fell below 2.1 cubic m.

The results of this simulation are shown in figure 12.3.

Figure 12.3. Volume in the dam each day since Jan 1970. Assumes a daily demand of 337L/dwelling, 8.4 cubic m active storage capacity for rainwater , 120 msq roofs and 115 dwellings.

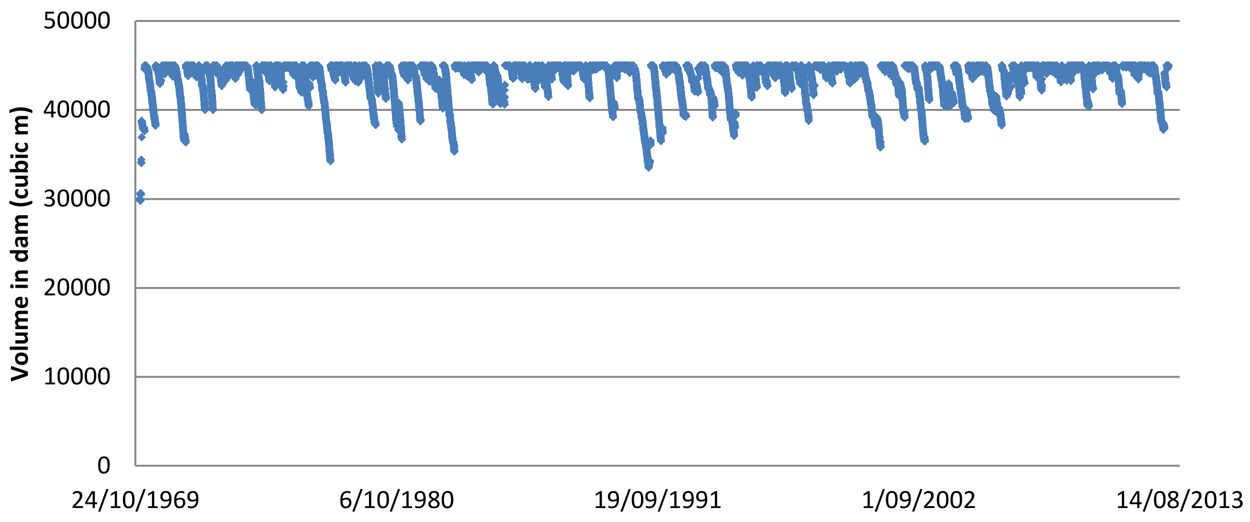


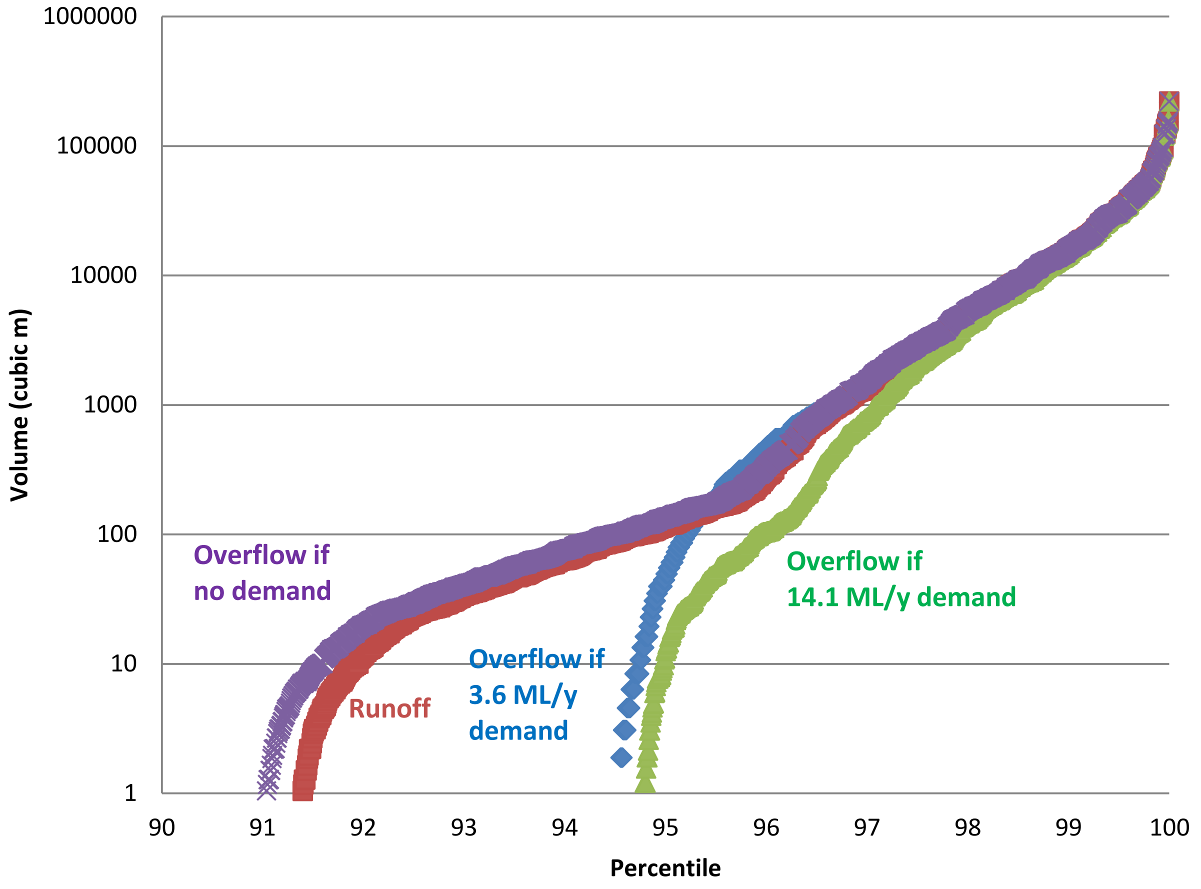
Figure 12.3 shows that whilst there is demand for water in each year, the drawdown is less than in figure 12.2, even in extreme drought years. For example, the minimum water in the dam is 33.5 ML in early 1991. The average demand from the dam is 3.6 ML/year. This is less than 10 % of the dam's 45 ML nominal capacity.

Effect of abstraction on downstream flows

The conservative runoff model indicates that the average annual inflow to the dam is 203 ML. If all the estimated potable demand 39 cubic m/day were met from the dam then the overflow volume would be 192 ML (i.e. a 6% fall in overtopping volume). However if each dwelling had a rainwater tank with an active storage volume of 8.5 cubic m to supply potable water, then the demand for water from the dam would be less, and the overtopping volume would be 202 ML/year. Under these conditions, the effect of the abstraction to supplement the rainwater tanks would be to reduce overtopping by 0.7%.

Figure 12.4 shows the percentile frequency for flows more than 1 cubic m/day.

Figure 12.4. Percentile exceedance of catchment runoff, overflow without any demand, and overflows with demands of 3.6 and 14.1 ML/year.



The modelling suggests that without any demand on water from the dam, overflow exceeds runoff volume at least to the 96%ile event. The reason for this is that all water falling onto the 1.1 ha dam surface contributes to overtopping once the dam is full. Conversely, runoff from the catchment does not commence until rainfall exceeds the initial loss figure of some 17 mm.

Without abstraction for irrigation or domestic use significant overflow commenced at the 91%ile frequency (i.e. no overflow in 90% of days). Abstracting an average of 3.6 ML/year from the dam results in significant overflows commencing in around the 95%ile frequency. However once the outflows approach 100 cubic m/day there is virtually no difference between the no demand and the 3.6 ML/year demand simulations. This occurs for the flows above the 95%ile frequency.

The overflow from the 14.1 ML/y demand is less than the overflow without demand until at least the 99%ile day. Above this, the volumes entering and overtopping the dam are orders of magnitude greater than the daily demand. Consequently, the effect of the demand on the overtopping becomes trivial.

Impact of abstraction on downstream biota

The overflow frequency may impact on downstream aquatic biota. However, there are two reasons for considering this impact to be minimal:

- Firstly, the dam overflow under low to moderate rainfall conditions is conveyed via a pipe from a glory hole, and it emerges well downstream close to the confluence with Narara Creek. So the current system largely bypasses to creek bed between the dam and the confluence.
- Secondly, the total distance from the dam wall to Narara Creek is approximately 165 m. Consequently, any impact is confined to an extremely short stretch of the stream immediately before its confluence with a much larger, permanently flowing creek.

The photos below illustrate the conditions in the drainage line between the dam and Narara creek confluence some 165 m downstream.

Figure 12.5. Low to medium flows exit the dam via this partly blocked glory hole. The debris needs to be removed.

Figure 12.6. The glory hole pipe discharges into a drainage line located in this bush near the toe of the embankment, some 30 m downslope of the top of the embankment.

Figure 12.7. The water that exits the dam reaches a stream some 165m downslope of the glory hole.

Figure 12.8. There is a high flow spillway adjacent to the right hand abutment. The condition of the vegetation indicates scouring lfows rarely occur.

Figure 12.9. There is a nick point at the base of the high flow spillway. The spillway is largely protected by an armoured layer of sandstone. The location of the nick point needs to be marked and any future advance monitored.

Figure 12.10. The water downslope of the nick point is very turbid. This indicates dispersing conditions and low ecological value. This drainage line only flows during major overtopping events. Most of the time the entire overflow is conveyed by pipe.

It is concluded that the proposed relatively small change in overflow characteristics is unlikely to have significant impact on downstream aquatic biota.

Quality of water in the catchment

The Australian Drinking Water Guidelines (2011) provide detailed assessment of the physical, chemical and biological characteristics of potable water. The criteria was used to assess water quality in the catchment.

Water samples were taken from near the glory hole outflow from the dam and a second sample from the upstream end of the catchment. Figure 10.11 shows the sampling locations.

The results of the analyses are shown in table 10.6.

catchment

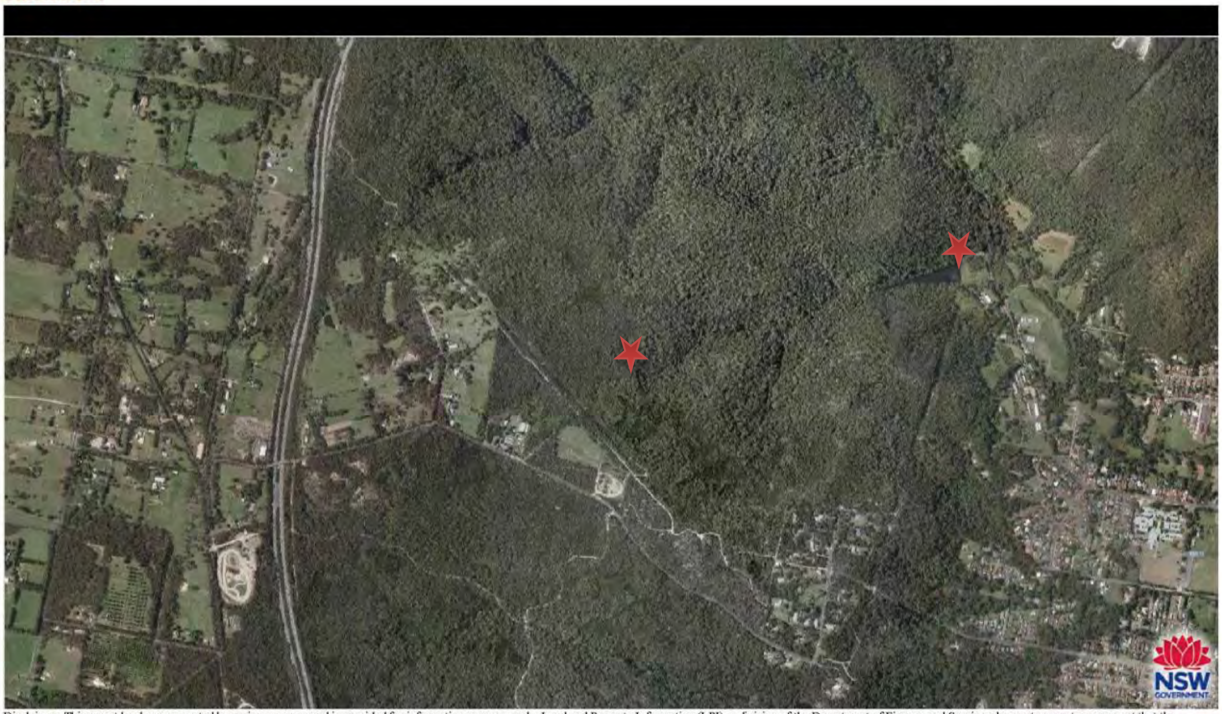


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Figure 12.11. Water sampling sites. One is at the headwaters of the creek, from a point some 400 m into the bushland downslope of the dog pound. (This site was chosen because it was below a minor confluence and had running water). The other sample was taken adjacent to the glory hole that provides the dam overflow point.

Table 12.6. Quality attributes of water upstream of and within the dam. Sampled 19.3.2013.

pH	**APHA 4500-H+-B**	**4.78**	**5.63**	**A bit low, but reflects sandstone** geology
CONDUCTIVITY (EC) (dS/m)	APHA 2510-B	0.15	0.12	Good
TOTAL DISSOLVED SALTS (mg/L)	calculation using EC x 680	105	84	Good
TURBIDITY (ntu)	APHA 2130	3	2	Very good, as low turbidity facilitates UV disinfection
ALKALINITY (mg/L CaCO3 equivalent)	** Total Alkalinity - APHA 2320	1	3	Would prefer higher
WATER HARDNESS (mg/L CaCO3 equivalent)	** APHA 2340-C	13	12	Would prefer higher
NITRATE (mg/L N)	APHA 4500 NO3--F	<0.005	<0.005	Good
NITRITE (mg/L N)	APHA 4500 NO3--I	0.002	0.003	Good
TOTAL COLIFORMS (cfu/100 ml)	** APHA 9222-B	1,710	460	High. Has to be zero therefore disinfect
Ecoli FAECAL BACTERIA (cfu/100 ml)	** APHA 9222-D	110	130	High. Has to be zero therefore disinfect
ALUMINIUM (mg/L)	APHA 3125 ICPMS*note 1&2	0.426	0.191	OK
ARSENIC (mg/L)	APHA 3125 ICPMS*note 1&2	0.001	<0.001	OK
CADMIUM (mg/L)	APHA 3125 ICPMS*note 1&2	<0.001	<0.001	OK
CHROMIUM (mg/L)	APHA 3125 ICPMS*note 1&2	0.001	0.001	Ok
COPPER (mg/L)	APHA 3125 ICPMS*note 1&2	0.001	0.001	Ok
IRON (mg/L)	APHA 3125 ICPMS*note 1&2	0.689	0.391	Minor staining could be an issue
MANGANESE (mg/L)	APHA 3125 ICPMS*note 1&2	0.012	0.034	OK
NICKEL (mg/L)	APHA 3125 ICPMS*note 1&2	0.001	0.001	OK

LEAD (mg/L)	APHA 3125 ICPMS*note 1&2	<0.001	<0.001	OK
ZINC (mg/L)	APHA 3125 ICPMS*note 1&2	0.008	0.004	OK

The key result is that the water is of 'potable' quality except for microbial contamination. Disinfection will be essential.

Alkalinity and hardness are both very low. Soft water may lead to greater corrosion of pipes, although this will depend on other factors such as pH, alkalinity and dissolved oxygen concentration (NHMRC, NRMMC (2011). Storage of the dam water in concrete tanks will assist in correcting for low pH and alkalinity.

The water being used will be a mixture of roof runoff and dam water so the low alkalinity of the dam water may not be an issue.

Supply of water for fire fighting

Fire-fighting infrastructure will be provided to meet NSW Fire and Rescue Service requirements. It is assumed that these will be based on AS 2412 (2005).

Water Licensing

Dams on streams and rivers are contentious issues throughout Australia. However, the Narara site already has a dam on site. This dam was used to provide irrigation water for the horticultural institute. The water was abstracted under license WAL16886. The license was for 29 units/year, with a unit being a ML of water.

The 2009 Water Sharing Plan for Central Coast unregulated and alluvial water sources sets out the water management arrangements.

The license conditions have been rearranged to allow use of the dam water within the development for urban purposes. There are two areas of water demand:

> Water supply of up to 15 ML/year for residential use (note that onsite tank water is expected to supply approximately 70 to 80% (10 to 12 ML/year) of the demand. The 15 ML/year is for extreme drought. The anticipated average annual demand for potable water is 4 ML/year.
>
> Additionally the site is relying on recycled water for most of its irrigation and toilet flushing needs. However, it is expected that residents may wish to grow a relatively high proportion of their food needs. This may require irrigation water in excess of the STP outflows at least during extended dry periods.

Conclusions

A very conservative runoff model demonstrated that the dam could supply all the potable water demand for the site. The maximum volume depression was 16 ML below full supply.

If each dwelling had 8.4 cubic m active storage for potable water, then the demand on the dam would be 4 ML in the average year. According to the modelling, the maximum drawdown for the dam since 1970 would be 11.5 ML below full supply.

In both scenarios, there would be water available for other uses including emergency augmentation of water supplies to Gosford City if requested by Council.

The dam is expected to supply less than 25% of the long-term demand for potable water.

The faecal coliform population density is the main concern with use of dam water. Disinfection is essential.

The alkalinity of water will adjust gradually as the water is stored in concrete buffer tanks. This plus the reliance on rainwater for the majority of time means that alkalinity should not be a major issue.

Recommendations

- Operate the dam as a backup system for when there is inadequate water in the roof runoff tanks.
- Disinfect any water taken from the dam. The low turbidity means that either chlorination of UV can be used. UV followed by chlorination is recommended because of its residual effect.
- Alkalinity may be an issue; however, the contribution from the dam is expected to be approximately 30 to 55%, so alkalinity is largely determined by rainwater rather than dam water.
- Aquacell Pty Ltd, holder of the WICA license, will be responsible for the water treatment plant.
- Ensure there is sufficient capacity to meet fire fighting requirements. This should be supplied from the dam.

13 STORMWATER MANAGEMENT

Urban stormwater is recognised as a significant source of contaminants to urban streams (Duncan, 1999, Fletcher et al, 2004). The contamination arises from a combination of soil disturbance, motor vehicle emissions and mobilisation of pollutants from industrial activities. In some catchments, leaking sewers can make a major contribution to faecal contamination of stormwater as well as elevated concentrations of nutrients and trade waste pollutants.

Stormwater management objectives

The objectives of Gosford City Council's Development Control Plan 165 are as follows:

- maintain and restore natural water balance whilst reducing the cost of providing and maintaining water infrastructure in a sustainable and efficient manner
- reduce nuisance and high level flooding in urban areas and the cost of providing and maintaining flood mitigation infrastructure whilst improving water quality in streams and groundwater and that on-site retention systems be supported as the main principle
- make more efficient use of water resources, awareness and education of water conservation
- reduce the erosion of waterways, slopes and embankments and protect the scenic, landscape and recreational values of streams
- protect and restore aquatic and riparian ecosystems and habitats

Gosford City Council's Water Cycle Management Guidelines (GCC, 2007) list a range of stormwater management components. These include:

- **Reduced Stormwater Discharge**
- **Quality of Stormwater Discharge**
- **Natural Water Courses & Drainage Channels**
- **Additional Requirements include**
- **Flood management**
- **Reduced impervious areas**
- **Alternative water sources such as recycled water**
- **Maintenance of stormwater infrastructure**
- **Management of points of discharge**

The Narara Ecovillage intends to address each of these elements.

Council's requirements

Council's Water Cycle Management Guidelines (GCC, 2007) contains a range of specific requirements. These include:

a) Use of water saving devices:

• water saving shower heads - WELS 3 star rating or higher
• dual flush toilets 6/3 or 4/3 and waterless/water efficient urinals or urinal equipment - WELS 3 star rating or higher
• tap aerators or tap equipment of WELS 3 star rating or higher
• clothes washing machines and dishwashers where provided shall achieve a WELS 3 star rating or higher
• Any proposed WELS device shall be rated 3 Star or better

b) Potable Water Substitution where feasible

c) Onsite Stormwater Detention as per GCC (2007)

d) Management of stormwater discharge quality

e) Natural Water Courses & Drainage Channels retention

f) No impact on flooding

g) Impervious Areas to be kept to a practical minimum

h) Alternative water sources to be utilised where practical.

Council requires the expected average annual post-development pollutant loads in stormwater discharges from the site to achieve the values shown in table 11.1.

Table 13.1. Stormwater treatment requirements (GCC, 2007).

Pollutant	Stormwater Treatment Requirements
Suspended Solids (TSS)	80% retention of the annual average load in the Narara Creek, Erina Creek and Coastal catchments
Total phosphorus (TP)	45% retention of the average annual load in the Narara Creek, Erina Creek and Coastal catchments
Total nitrogen (TN)	45% retention of the average annual load in the Narara Creek, Erina Creek and Coastal catchments
Litter	Retention of litter greater than 40 mm in size for flows up to 25% of the 1 year ARI peak flow in all catchments
Oil and grease	No oil or grease to be visible downstream of urban and industrial areas for flows up to 25% of the 1 year ARI peak flow in all catchments

Narara Ecovillage stormwater management strategy

The Narara Ecovillage development is based on the concepts of Water Sensitive Urban Design (WSUD). Components include:

- Roof water capture, disinfection and reuse within individual dwellings
- Minimised impervious surfaces
- Significant open space within the development

- Use of swales, bioretention systems and other WSUD features to ensure that peak flows and contaminant loads are reduced to achieve the criteria in table 11.1

Stormwater modelling

MUSIC, a stormwater modelling program, was used to assess the likely impacts of various stormwater management treatments.

Detailed modelling has only been undertaken for the first stage as there is insufficient information on subsequent stages to determine likely impervious surface areas, open space, etc.

Approach and MUSIC inputs

MUSIC Version 5 software was used to model stormwater and the effect of a range of stormwater infrastructure options. The design objective was to ensure that the performance criteria in Gosford City Council's DCP 165 were met.

The inputs to the MUSIC model are discussed below.

Rainfall

6 minute pluviograph were used in the MUSIC model.

Existing landuse

MUSIC model includes options to assess the impact of changing landuses. It was assumed that the current land use was 'agricultural'.

Existing buildings

The existing buildings consist of a mixture of brick administration buildings, glasshouses, cottages and workshops. Some of this infrastructure will be removed, however much will be retained. It was therefore decided to take a conservative approach and assume they were all retained except where the land has been designated for individual lots. The roof areas of buildings to be removed were used to estimate current imperviousness.

Existing and new roads

There is already a limited number of narrow roads through the stage 1 development area. The proposed development includes a new set of roads and bridges to meet access requirements for both residents and for emergency services, especially fire fighting.

Additional roads were modelled as 'new' infrastructure.

Road surface area was simply length* width. Roads were modelled as 100% impervious with a runoff threshold of 1 mm/day.

Dwelling configurations

A maximum of 60 dwellings was assumed for stage 1. The roof area was based on those in table 6.1. Additional impervious surfaces were included to take into account patios and paths. The MUSIC model examined clusters of dwellings draining to a single point. Figure 13.1 shows the model layout.

Rainwater tank configuration and rainwater demand

This is discussed in detail in sections 5 and 6. The main points are:

Roof catchment area	as per table 6.1.
Rainfall runoff threshold	0.3 mm/day
Roof runoff tank storage active capacity	8.5 cubic m
Demand from roof runoff tank	as per table 6.1.

Excess water from the tank joins other runoff from the lots and enters to stormwater management infrastructure.

Soil inputs

Soil parameters are critical because they determine the proportion of water that runs off the site or percolates towards the watertable. The surface horizon is sand dominant, so the hydraulic conductivity will be at least 100 mm/hr. consequently there will be little runoff during low to medium rainfall intensities.

The assumed parameters were:

Runoff threshold from impervious surfaces: 1.5 mm/day

Soil properties

Soil storage capacity	139 mm
Initial storage (% of capacity)	25%
Field capacity (surface 0.5m)	69 mm
Infiltration Capacity coefficient –a	360
Infiltration capacity exponent-b	0.50

Groundwater properties:

Initial depth	10 mm
Daily recharge rate	100%
Daily Base flow rate	50%
Daily deep seepage rate	10%

The rates and coefficient above reflect the very sandy nature of the surface 1 to 2m of soil (See MUSIC guidelines for details-available online from Ewater).

Stormwater management infrastructure

The stormwater infrastructure varies with location and opportunities within the development areas. For example steep grades along some of the roads precluded use of bioretention swales in these areas. Stormwater would therefore be conveyed via combinations of pipes or rock lined drains to flatter areas where bioretention basins could be installed.

Stormwater components included:

- Contour banks upslope of the development, designed to convey bushland runoff to local gullies.
- Protection of gully discharge points via use of TRMs (turf reinforced mesh) and rock riprap (Landcom, 2004).
- Soak-a-ways (shallow infiltration basins) to retain runoff from individual lots where it was difficult to connect to a common swale.
- Pits and pipes/ rock lined drains to convey road runoff where the grades averaged over 7 to 10%.
- Bioretention swales to convey local runoff parallel to roads where grades were moderate
- Bioretention basins in less steep areas to treat runoff converging from roads and lots
- Semi-permanent infiltration basins in lower parts of the landscape
- Inclusion of environmental features such as frog ponds and permaculture beds within the stormwater swales and bioretention ponds.

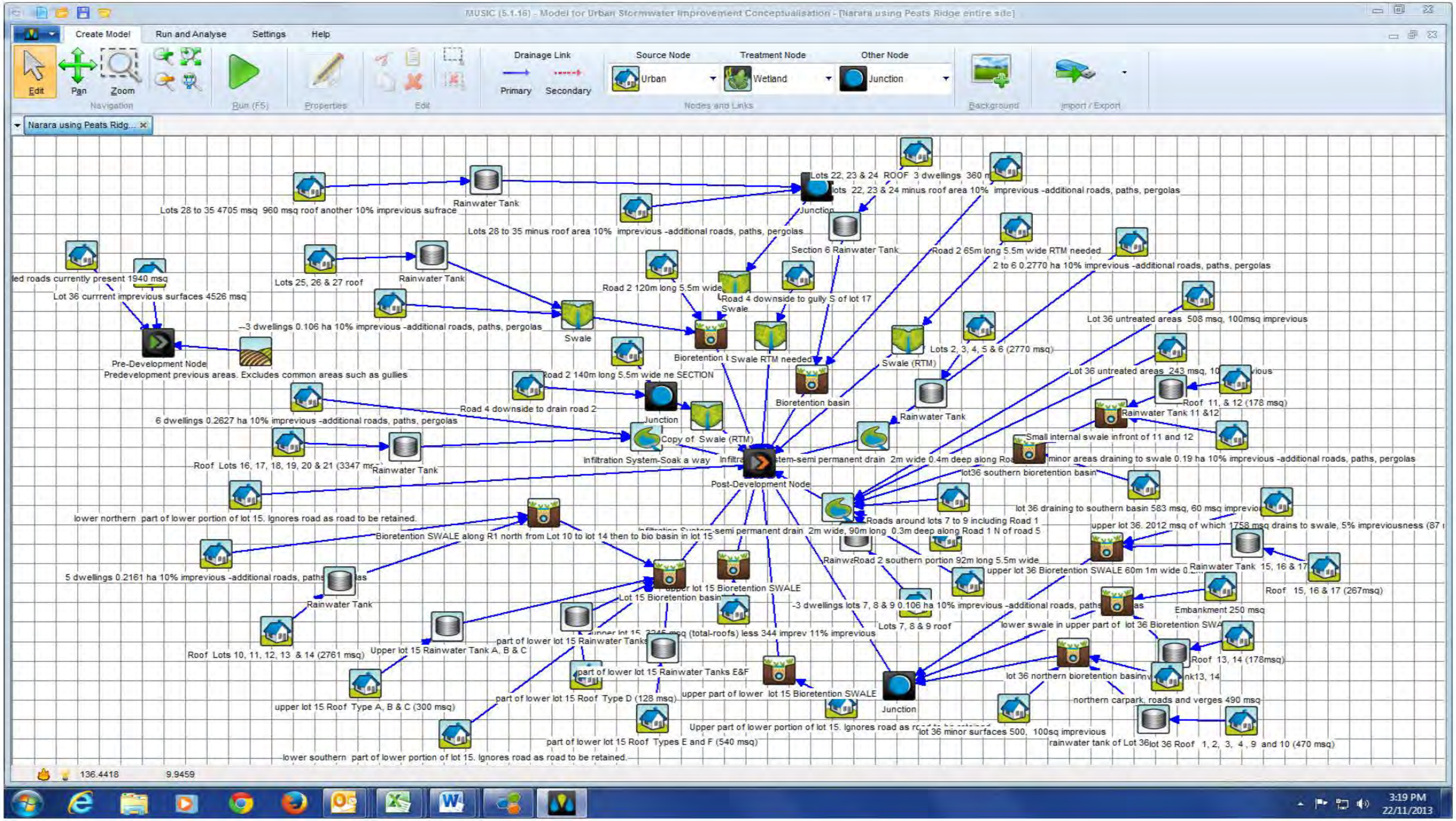

Figure 13.1. Layout of the MUSIC model for stage 1.

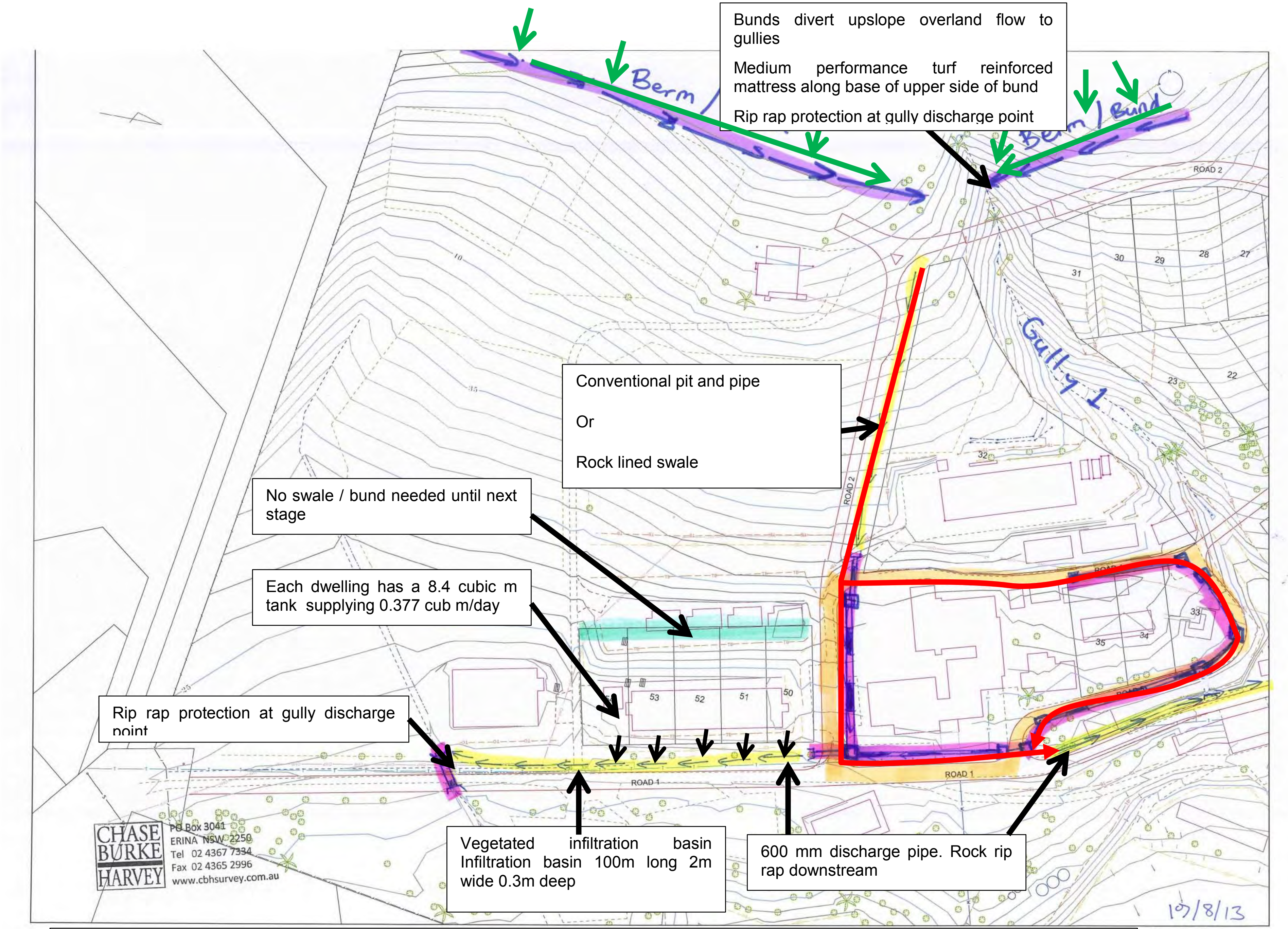

Figure 13.2. Stormwater treatment features in the southern portion of Narara Ecovillage stage 1.

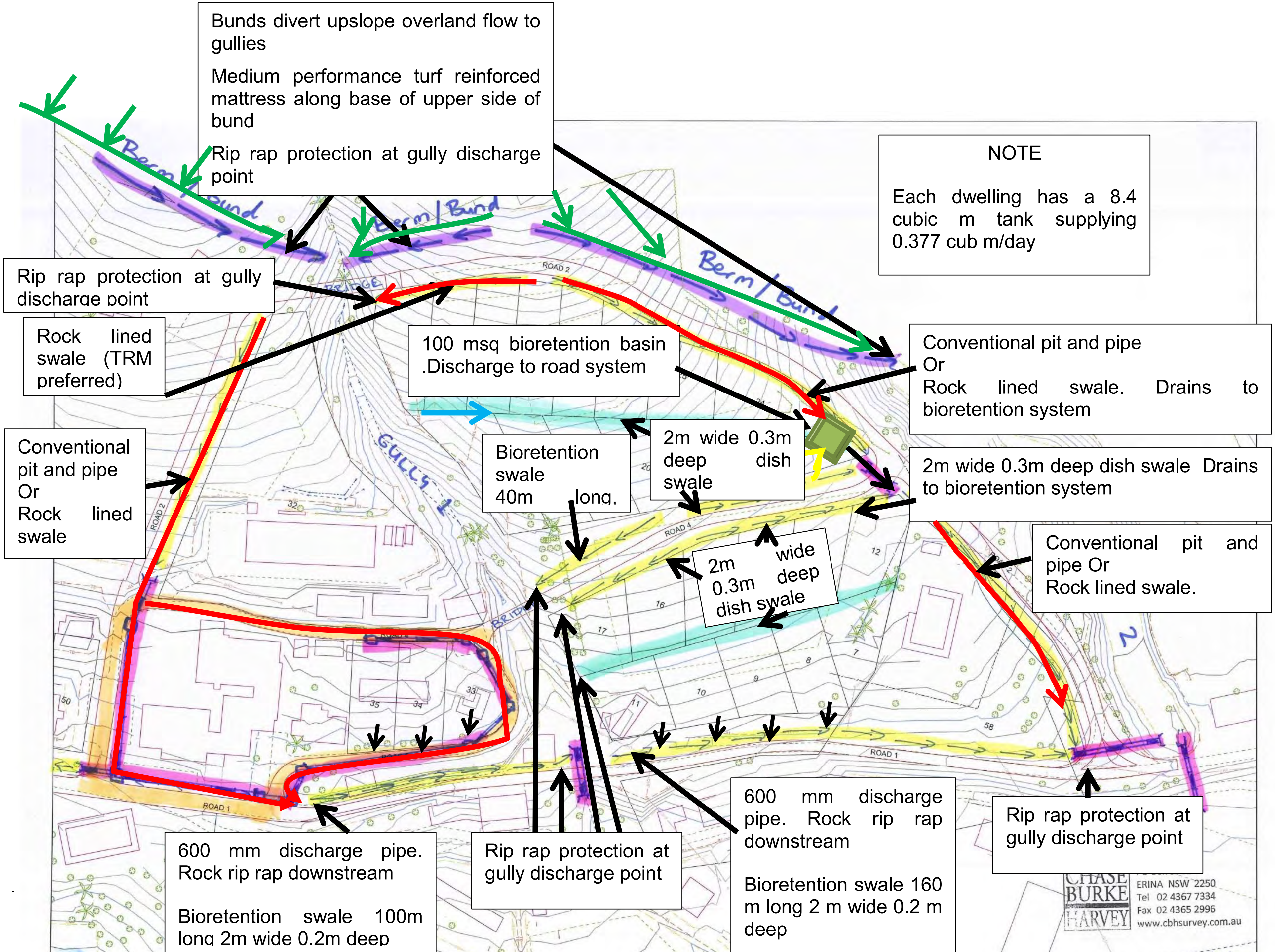

Figure 13.3 Stormwater treatment features in the northern portion of Narara Ecovillage stage 1.

Results of MUSIC modelling

Data management

Data from the simulations were analysed to assess compliance with DCP 165. The overall analysis compared the current landuse with the whole of the stage 1 of the development. Individual components of the development were then analysed separately.

Performance targets

The performance targets shown in table 13.2 are taken from DCP 165. MUSIC models Total Suspended Solids (TSS), Nitrogen (N), Phosphorus (P) and gross pollutants. Oil and grease is not modelled, however its removal should approximate TSS removal (See Horner et al, 1994 and other texts).

Table 13.2. Performance targets presented in DCP 165 (Source: Gosford City Council, 2007).

Pollutant	Stormwater Treatment Requirements
Suspended Solids (TSS)	80% retention of the annual average load in the Narara Creek, Erina Creek and Coastal catchments
Total phosphorus (TP)	45% retention of the average annual load in the Narara Creek, Erina Creek and Coastal catchments
Total nitrogen (TN)	45% retention of the average annual load in the Narara Creek, Erina Creek and Coastal catchments
Litter	Retention of litter greater than 40 mm in size for flows up to 25% of the 1 year ARI peak flow in all catchments
Oil and grease	No oil or grease to be visible downstream of urban and industrial areas for flows up to 25% of the 1 year ARI peak flow in all catchments

Results of modelling

Pre vs. post development

Table 11.3 compares the ‘current’ conditions with those anticipated following development which includes WSUD[11] features. Total outflow is reduced by 86% while peak flow is reduced by 38%.

There is almost complete removal of TSS, N and gross pollutants, while P removal averages an 88% reduction compared with pre development conditions.

[11] WSUD—Water Sensitive Urban Design. In the current situation with sandy soils this includes a range of swales, infiltration basins and bioretention systems.

These results demonstrate compliance with DCP 165.

Table 13.3. Effect of the development on the flow and contaminant loads exiting the combined lots 10-14 and cluster lot 15.

Component	Pre development	Post development with WSUD	% reduction	Gosford CC DCP 165 criteria	Compliance
Flow (ML/yr)	4.8	2.34	51	Not given	Not applic.
Peak Flow (m3/s)	0.266	0.178	33	Not given	Not applic.
Total Suspended Solids (kg/yr)	326	41.3	87	80	Yes
Total Phosphorus (kg/yr)	1.41	0.335	76	45	Yes
Total Nitrogen (kg/yr)	8.93	2.34	74	45	Yes
Gross Pollutants (kg/yr)	37.6	3.68	90	Not given	Not applic.

The results in table 13.3 show that stormwater outflow volume is reduced by 81% while the peak flow rate is reduced by 51% compared with current conditions. The proposed system is fully compliant with Council's requirements for 80%, 45% and 45% reduction in export of TSS, P and N respectively. Some 98% of the gross pollutants will be retained.

Conclusions based on MUSIC modelling

The combination of rainwater tanks, bioretention and bioretention basins has resulted in the stormwater management trains meeting the DCP 165 performance requirements.

This is due to a combination of very porous soils, use of rainwater tanks to supply all potable water needs wherever available, and between 1 and 2% of the development area being allocated to stormwater management devices.

14 MANAGEMENT OF DRAINAGE LINES CURRENTLY WITHIN THE DEVELOPMENT.

The topographic map Gosford (9131-2S) 2001 edition shows two, first order streamlines arising in bushland and traversing the property to the north of the heritage house. Both stream lines travel east to Narara Creek.

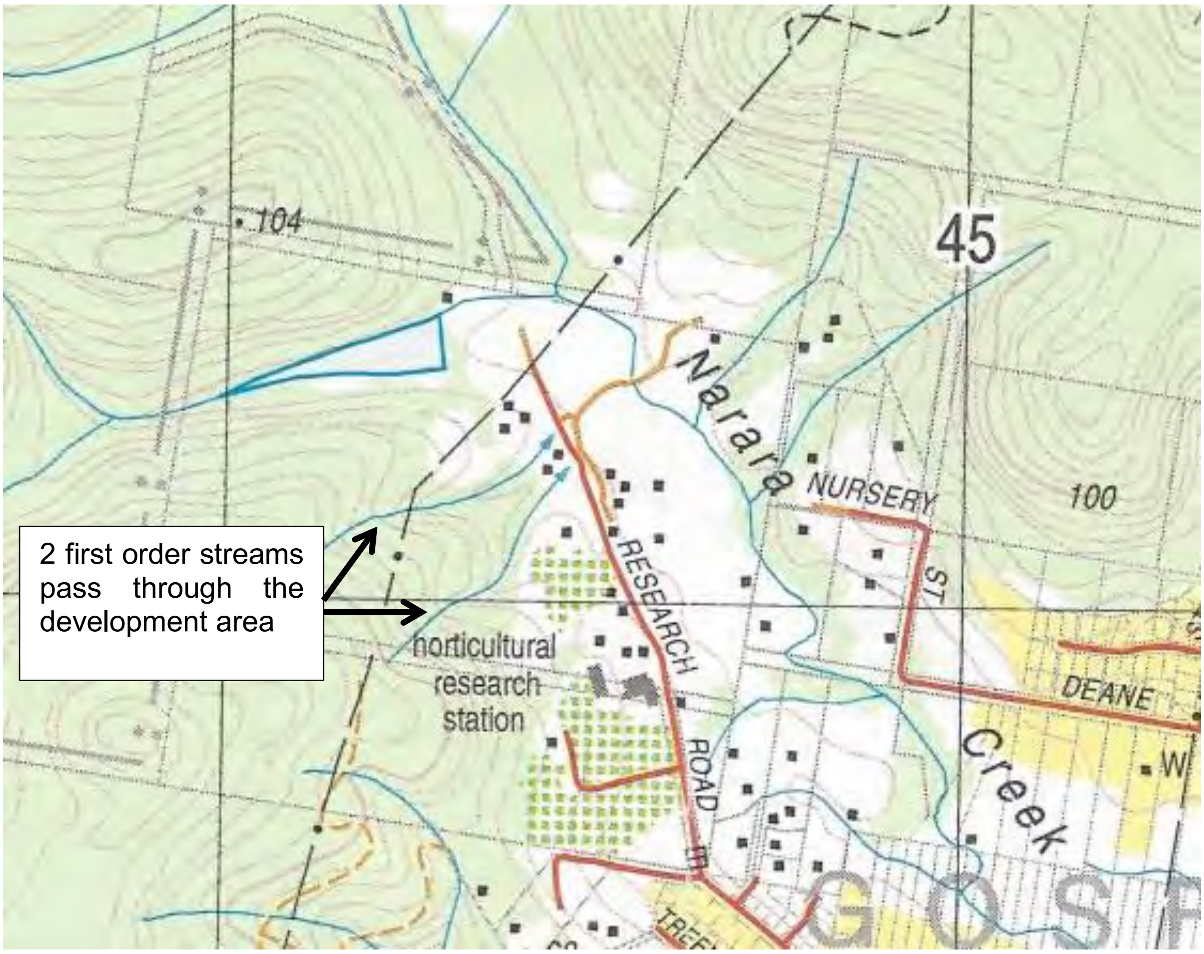

Figure 13.4. Location of streamlines within the subject site (1:25,000 Topographic map. Gosford 9131-2S 3rd Edition, LPI).

According to the Water Management Act (2000) Regulations most recent guidelines:

Waterfront land-Controlled activities-guidelines for riparian corridors on waterfront land, page 2 Riparian corridor widths.

These are first order streams which require a 10 m vegetated riparian zone extending on each side of the drainage line from the top of teach bank.

Additionally another two first order streams commence downslope of Research Road and travel east to Narara Creek. These will also require a 10m wide vegetated riparian zone for both banks.

There are a number of ‘drains’ within the site. These are not shown on any topographic map, but they need to be managed to avoid increase erosion risk resulting from the proposed development.

The key way to avoid damage to the streamlines is to maintain the vegetation (replacing it as necessary with appropriate native species) and to ensure that stormwater outlets are protected from erosion by appropriate means. See Office of Water (2012).

Discharge points to gullies will be protected with combinations of turf reinforced mesh (TRM) and rock riprap.

Guidelines for outlet structures on waterfront land

It is preferable to have several discharge points rather than one large one.

Conclusions

- The proposed combination of rainwater tanks, swales and bioretention systems will ensure that the development's stormwater management will comply with Council's stormwater system performance criteria.
- The outflow volume and peak rates will be less than those that currently occur.
- The contaminant export rates will be less than those that currently occur.
- The stream lines present on the site will need protection from erosion, especially where stormwater outflows are being constructed. The approach should be based on the Office of Water 2012 guidelines.

15 EROSION AND SEDIMENT CONTROL

The MUSIC modelling was used to generate peak 6 minute outflows into and out of each component of the stormwater train that were conveyed to a drainage system.

Pipe sizes and erosion and sediment control structures were sized to accommodate these flows. This approach is conceptual at this stage of development.

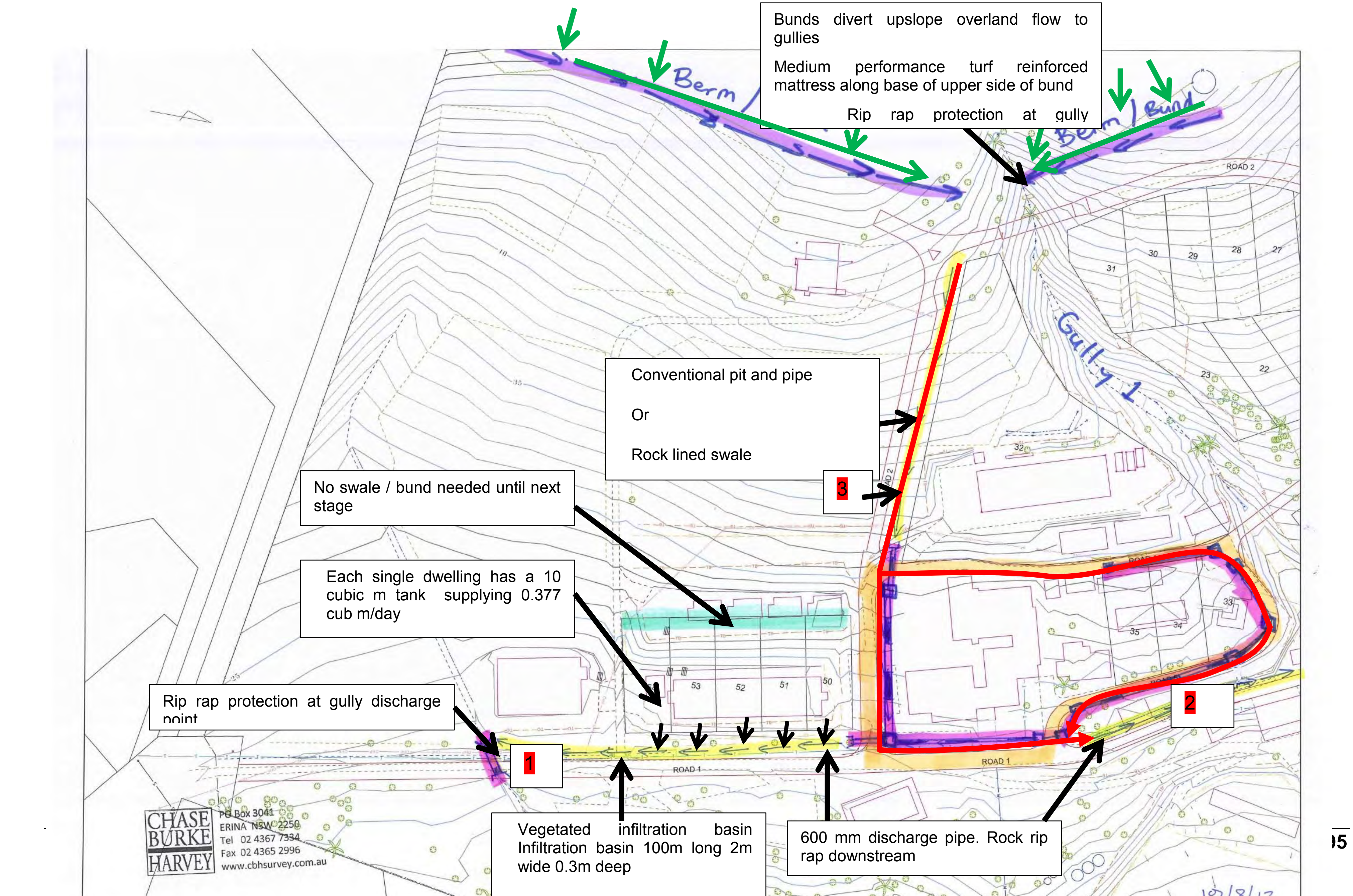

Figure 14.1. Stormwater treatment features in the southern portion of Narara Ecovillage stage 1. The numbers in red refer to discharge points in table 14.1, 14.2 and 14.3

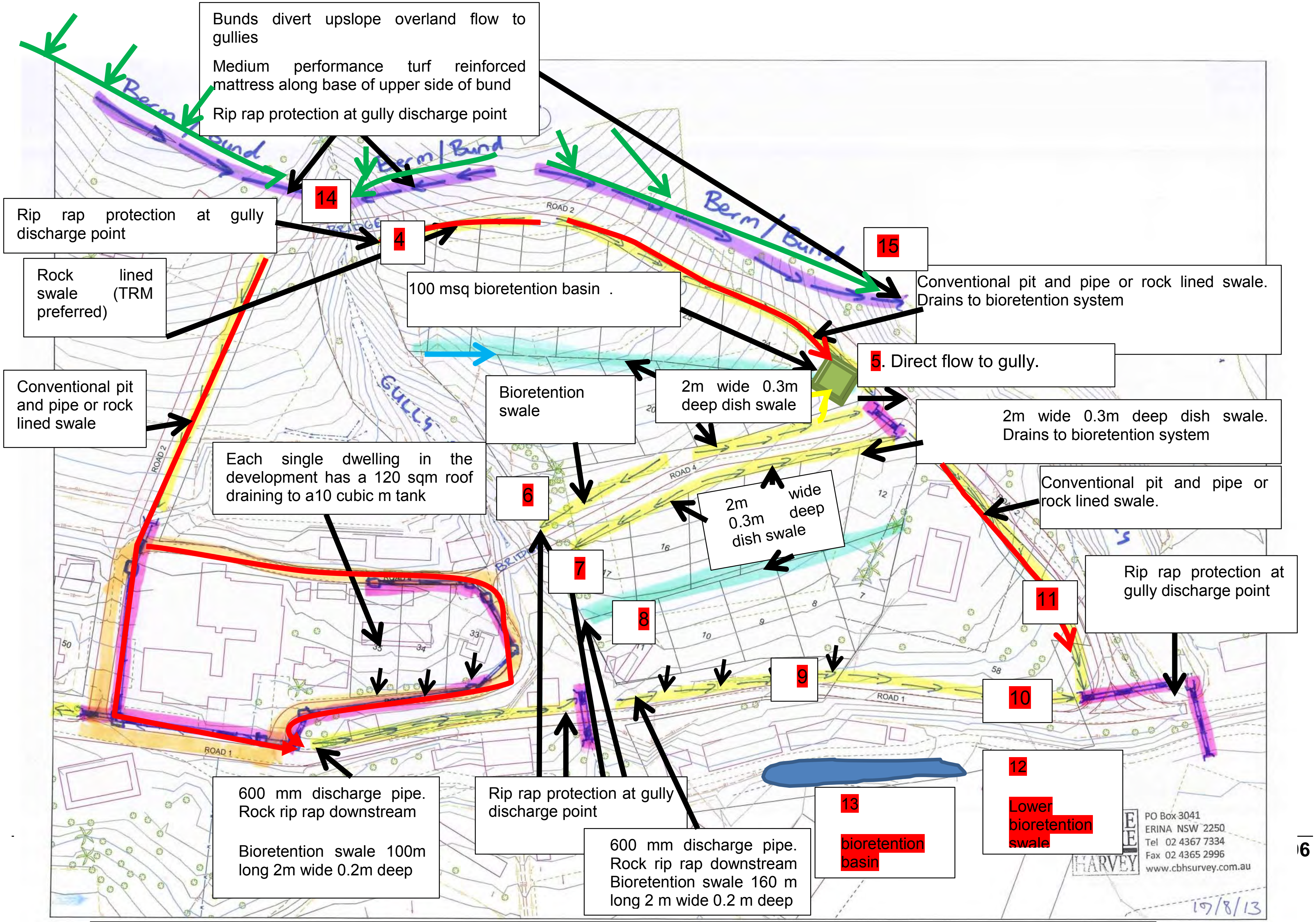

Figure 14.2. Stormwater treatment features in the northern portion of Narara Ecovillage stage 1.

Table 14.1. Estimated peak flow from the 13 outlets in figures 14.1 and 14.2 based on maximum 6 minute storm between 1980 and 2010.

Site	Inflow (cubic m/sec)	Outflow (cubic m/sec)
1	0.047	<0.047
2	0.141	0.094
3		0.075
4	0.0196	0.0111
5	0.117	0.114
6	0.119	0.087
7	0.0125	0.0067
8	0.0844	0.0323
9	0.0695	0.0564
10	0.82	0.069
11	0.052	0.034
12	0.038	0.026
13	0.111	0.091
14 (southern gully)	0.63	Not applicable
15 (northern gully)	0.31	Not applicable

Table 14.2. Suitable pipe diameters for the 13 outlets within the development based on the maximum 6 minute flow rate in 29 years. Maximum permissible pipe velocity was set at 2m/sec to minimise risk of scour / erosion in the gullies.

Outlet number	Outflow (cubic m/sec)	Pipe size (CSA msq)
1	<0.047	0.175
2	0.094	0.25
3	0.075	0.225
4	0.0111	0.1
5	0.114	0.275
6	0.087	0.25
7	0.0067	0.1
8	0.0323	0.15
9	0.0564	0.2
10	0.069	0.225
11	0.034	0.15
12	0.026	0.15
13	0.091	0.25

Based on a maximum outlet velocity of 2m/sec and a maximum pipe diameter of 275 mm, the following criteria will suit all the outlets listed above:

- 2 layers of 200 mm D_{50}, underlain by filter cloth.
- Maximum rock size should not exceed 300 mm.
- The length of the pad should extend for at least 1metre.
- The pipe should face downstream at an angle of 45 to 60^{O}. Ideally the exit should be recessed into the bank
- The rock is to be installed into the floor of the drainage line so that they do not protrude above the natural base.

The exception to this are sites 4 and 7. Their flow is so low that a 0.5m long riprap will be sufficient.

Sites 14 and 15 consist of diversion banks designed to safely discharge clean water into the gullies between the dwellings. The rational method (ARR) was used to calculate peak flow. This information was combined with grade to determine the most suitable dimensions and armouring for the bank. The results are shown in table 14.3.

Table 14.3. Components used to determine suitable sizes and armouring for the diversion bunds upslope of the development area.

Component	Southern most area (against S boundary fence)	Middle area above lots 31 to 35	Northern area abov lots 27 to 28
Area (ha)	2.5	1	0.5
Time of Conc (hr)	0.077988541		
Time of Conc (min)	4.679312459	5	4.679312
Assume 20 Y ARI stability criterion			0
ff 20	1.12	1.12	1.12
Design storm 5 min 20 Y ARI	201	201	201
C10 (F3)	0.75	0.75	0.75
Flow (cubic m/sec)	1.564584	0.6258336	0.312917
Length (m)	65	65	120
Max grade (%)	20	30	25
Duration (m)	5	5	5
Intensity (mm/hr)	201	201	201
Contour bank details			
Width of base (m)	2	2	2
Side slope	1 to 3	1 to 3	1 to 3
Flow depth (m)	0.17	0.17	0.17
Channel slope(max) %	20	30	25
Discharge rate for 20Y ARI ToC storm (cubic m/sec)	1.56	0.6258336	0.312917
Manning's N	0.0321	0.026	0.327
Flow duration <6 ha			
Vegetation height (mm)	<50 mm	<50 mm	<50 mm
Erodibility	high	high	high

Anticipated maximum velocity (m/sec)	4.3	3.6	2.3
Proposed lining	Medium preformance re-enforced mesh	Medium preformance re-enforced mesh	Mesh reinforced turf
Maximum acceptable velocity (m/sec)	5	5	2.4
Acceptable	Yes	Yes	Yes

The need for HEC-RAS modelling

Note that HEC-RAS analyses was not undertaken for the gullies because the flows in the gullies were rare; likely to be a few times per year, and then only trickle flow.

For example in November 2013, a total of 101 mm of rainfall fell in the 4 days prior to the photo shown below as figure 14.3 was taken. The rainfall quantities were: 16th Nov 19 mm, 17th Nov 9 mm, 18th Nov 45 mm, 19th Nov 28 mm (Station 61319, Glennie St., Gosford). That is, there was no free water in the base of the gully on the afternoon of the 19th Nov despite the 101 mm of rainfall in the previous 4 days.

Figure 14.3. There was zero free water in this gully despite over 100 mm of rainfall in the previous 4 days. The evidence suggests that occur following rare, very intense rain events. A HEC-RAS analysis will have little relevance in this situation as the 'capacity' of the gully will far exceed the likely flows.

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APPENDIX 1

Report on the unnamed gully to the immediate south of lots 35, 22, 21 and 10 Narara Ecovillage, Narara.

Prepared by Dr Peter Bacon

Woodlots and Wetlands Pty Ltd

220 Purchase Road Cherrybrook 2126

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1. Background

The Narara Ecovillage Co-operative Ltd has purchased the disused Gosford Horticultural Institute, and intends to develop portion of the site for residential use. The site is Lot 1 DP 1087535, Research Road, Narara. Gosford City Council rezoned the site to allow for this landuse change (DCP 175, 2007).

Development Control Plan's objectives are to:
- encourage the orderly development of the residential and rural residential use;
- facilitate traffic management
- make provision for environmental protection
- make provision for bushfire protection;
- restrict development in flood liable areas and consider flooding and drainage issues and to ensure there is no increase in downstream flooding
- protect items of environmental heritage
- ensure the development is carried out in accordance with best practice management for site development
- ensure on-site contamination is addressed
- provide for additional matters in relation to the residue Conservation 7(a) allotment
- ensure the land is adequately serviced.

The DCP 175 calls up the requirement for the preparation of a Plan of Management to provide a prescriptive framework for the future management of the threatened species habitats, weed management etc., including strategies for the ongoing management of the site. This will obviously extend to the gullies and will form part of the future subdivision DA. The Management Statement, which will sit with the community title subdivision of the site, will also include the commitment to implement the recommendations in the Plan of Management.

According to the DCP, the urban development will consist of approximately 120 lots and approximately 5 rural lots.

Figure 1 shows the proposed stage 1 of the urban development. There is a discontinuous line of vegetation shown to the immediate south of lots 35, 22, 21 and 11. This 'line' approximates a gully.

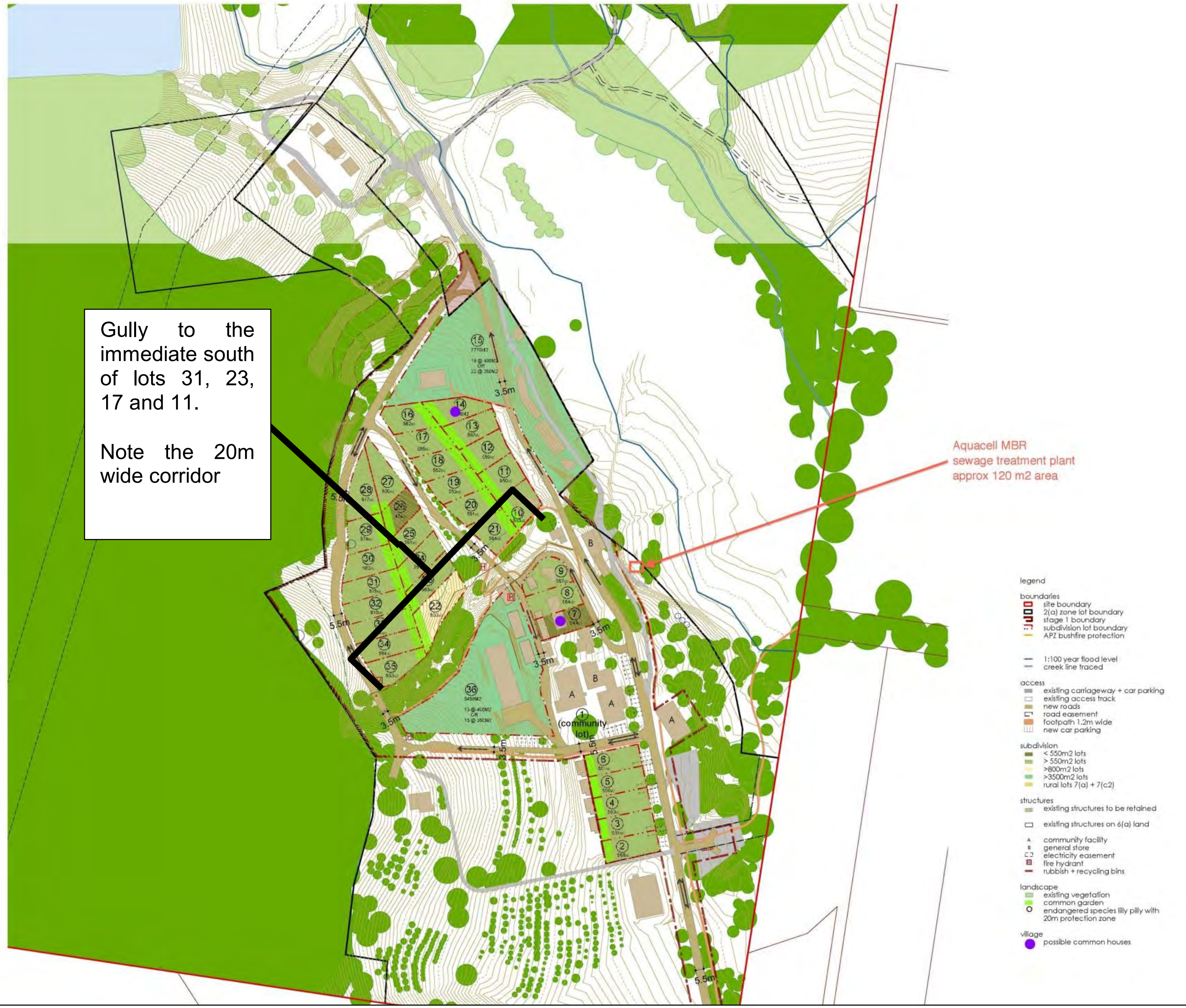


Figure 1. Development details showing the individual lots in Stage 1 and the gully to the south of lots 35, 22, 21 and 10. The location of a vegetated gully is also shown.

2. Statement of commitment to environmental action

The Narara Ecovillage Co-operative Ltd is strongly committed to environmental sustainability. As part of its commitment the Co-operative has developed an integrated water cycle management strategy. This strategy includes capture and use of roof runoff. This will reduce the stormwater volumes and contaminant loads exiting the urban development areas.

The Co-operative is also taking a proactive approach to managing its natural environment.

The Co-operative is strongly committed to managing BOTH gullies AND the designated streamlines within the development area. The management commitments include:

1. Protection of downstream gullies from scouring stormwater flows
2. Replacement of weeds along gullies with a variety of appropriate native vegetation
3. Preservation and enhancement of key native vegetation species including the various eucalypts and palms currently growing in and around the gullies.
4. Development of a full suite of native vegetation including ground cover, shrubs and trees as appropriate.

It is noted that DCP 175 calls up the requirement for the preparation of a Plan of Management to provide a prescriptive framework for the future management of the threatened species habitats, weed management etc. including strategies for the ongoing management of the site. This will obviously extend to the gullies and will form part of the future subdivision/DA.

The Management Statement, which will sit with the community title subdivision of the site, will also include the commitment to implement the recommendations in the Plan of Management.

3. Regulatory Arrangements

In July 2012, the Department of Primary Industries, Office of Water published a document:

Changes to NSW Office of Water Guidelines for riparian corridors on waterfront land (commencing 1 July 2012).

As part of the industry launch of this document, the Office of Water included Planning circular PS 12-003. (issued 6 June 2012). The circular was produced by NSW Department of Planning and Infrastructure . Its title is

'Initiatives to improve housing supply'.

The document refers to the impact of size of corridors and types of uses allowed in them affect housing supply. It then discusses the reforms introduced in July 2012.

The *Water Guidelines for riparian corridors on waterfront land* (commencing 1 July 2012) contains the section:

Riparian corridor widths

The first sentence states:

The Officer (sic) of Water recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps.

4. Current situation regarding the gully.

Figure 1 shows the location of the gully to the south of lots 35, 22, 21 and 10. Figure 2 shows the area on a 1:25,000 topographic map, while figure 3 shows a close up map of the development area. .

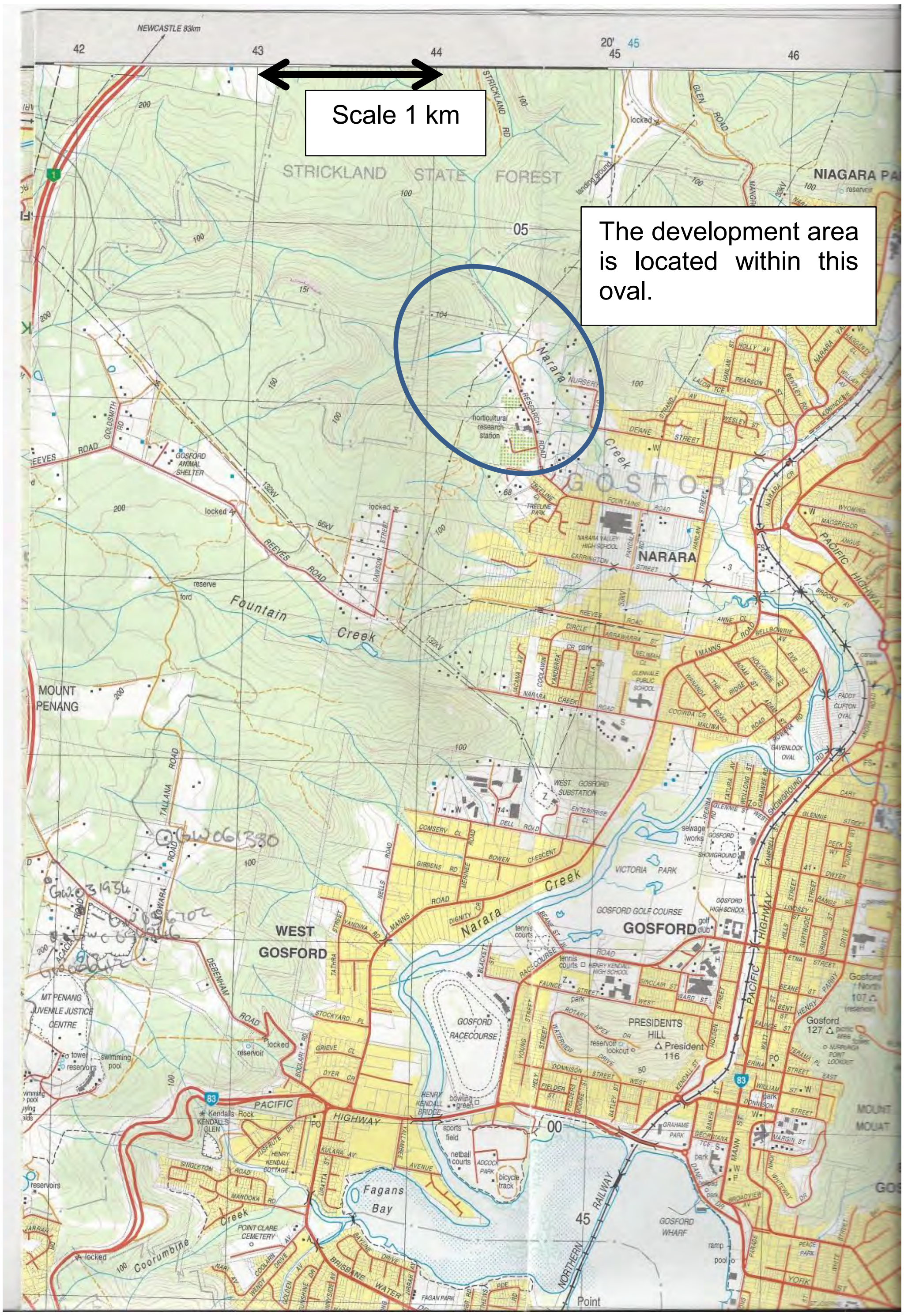


Figure 2. The regional drainage lines in the Narara area (1:25000 topographic map for Gosford-9131-2S). (Source: LPI).

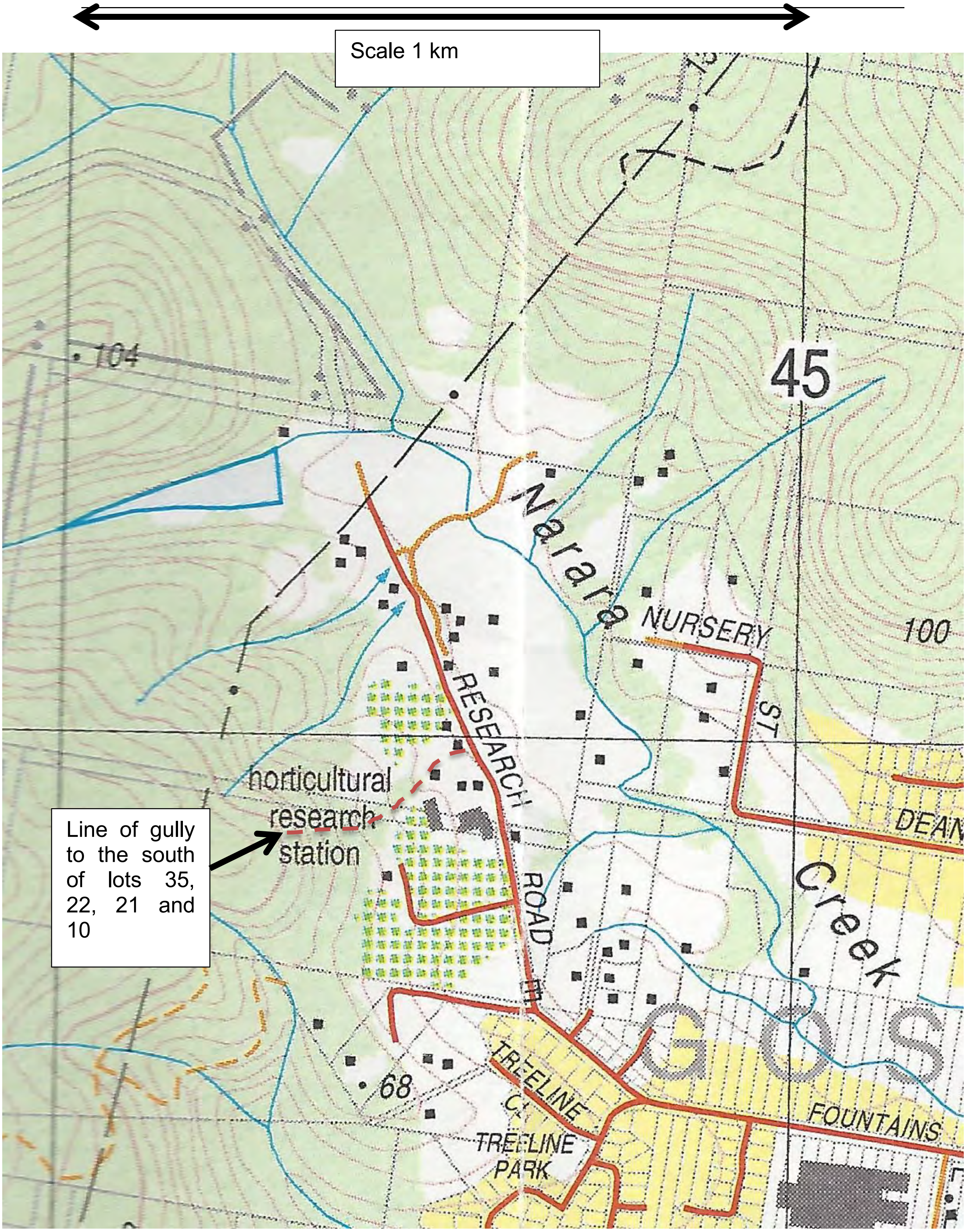


Figure 3. Close up view of the 1:25,000 map (Gosford 9131-S2). (Source: LPI). The subject gully is shown as red dashes.

The fact that the gully is not shown on the current 1:25,000 topographic map suggests that it is not a stream line based on current Departmental recommendations.

5. Legal discussion of what constitutes a 'stream'.

A review article in the Environmental and Planning Law Journal by Stokes and Taylor (2005), discussed legal definitions of 'rivers' and 'streams'

Some relevant comment includes:

Cooper V The Corporation of Sydney (1853) 1 Legge 765 in which the NSW Supreme Court found that the occasional outflow from a swamp did not constitute a watercourse in the legal sense. This was defined as a regular stream between banks.

Similarly

in Knezovic v Shire of Swan-Guilford (1968) 118 CRL 468: According to Barwick, CJ (at 475-476).

A water course consists of a stream with a bed, banks and water. …. It must, in my opinion, exhibit features of continuity, permanence and unity, best seen, of course, in the existence of a defined bed and banks with flowing water. It must, in my opinion be a stream and be sharply distinguished from a mere drain, or a drainage depression in the contours of the land which serves to relieve upper land of excess water in times of major precipitation. It is not enough that the water, when it does flow, does so in what may be seen as a defined course or channel.

This conclusion was developed for NSW conditions in the NSW Land and Environment Court. (Narrambulla Action Group Inc. v Mulwaree Council No. 40168 of 1995 (1996)(30 July, 1996)). In this case, Bannon, J determined that the watercourse under consideration could, at best,

'*be classified as a drainage line with gullies to the east and west, together with intermittent ponds and flood plane (sic), where water flows at rare intervals, under the influence of rain.*'

Bannon J concluded that this was insufficient to meet the test of 'continuity, permanence and unity developed in Knezovic v Shire of Swan-Guilford

In Mitchell v Vella (1998) 101 LGERA 333, Sheahan, J, determined that a series of channels which only flowed during times of heavy rain were not a 'waterbody'.

Outhet and Taylor (unpubl) developed a set of criteria against which the presence/ absence of fluvial features could be assessed. These were listed in Stokes and Taylor (2005) and are shown below:

Table 1. Criteria used to assess fluvial features consistent with a stream (from Outhet and Taylor (unpubl)), cited in Stokes and Taylor (2005).

Are there definable channel banks and a channel bed?
Are there fluvial bedforms, e.g. pools, riffles , sediment point bars, etc. and if so what are they?
Is there any evidence for substantial erosion from water flow within the drainage feature?
Are there any spring lines that may indicate intermittent or perennial or intermittent flow?
Is the catchment large enough to sustain perennial or intermittent groundwater flow?
Are there any indicators of prolonged wetness within the drainage feature?
If surface flow is present, is it continuous and how extensive across the base of the drainage feature is it?
Are there any visible habitats that might sustain aquatic fauna?
Are there any aquatic fauna present that would require periods of uninterrupted moisture?

These criteria were applied during an inspection of the gully on September 21, 2013.

Figure 4 shows the catchment of the gully as well as the assessment points. The catchment area upslope of the road is approximately 4.6 ha. Note that this is less than 25% of the often used 20 ha catchment area from which a ‘stream’ is likely to flow according to the informal guidelines of the previous DIPNR.

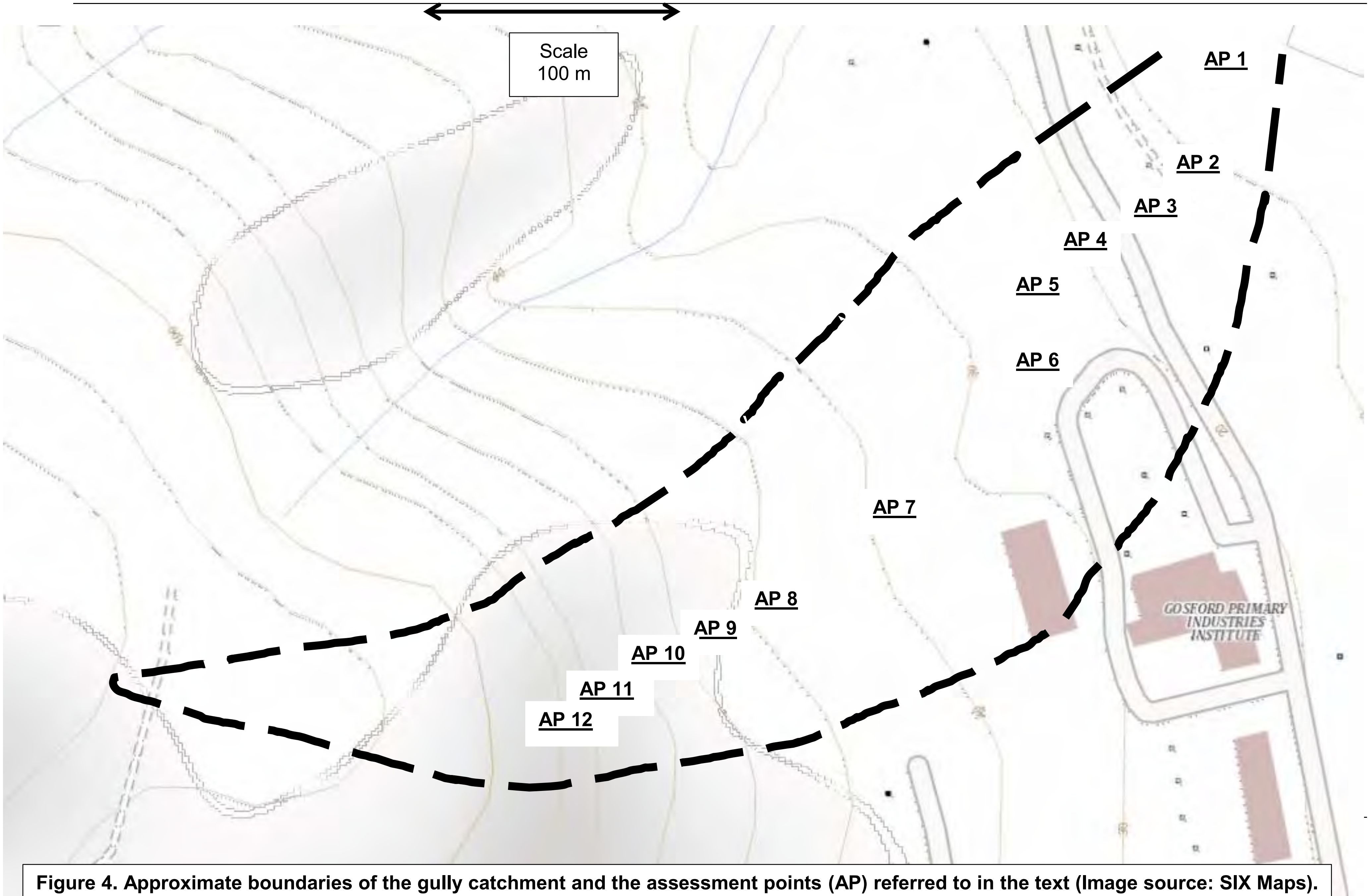


Figure 4. Approximate boundaries of the gully catchment and the assessment points (AP) referred to in the text (Image source: SIX Maps). Catchment area upslope of the road is 4.6 ha.

6. Assessment procedures

An assessment of site conditions was made at each of 12 points along a 360 m length of drainage line. The criteria listed in table 1 were used. Photos were taken at each site to provide evidence to support the individual assessments.

Assessment site 1.

GPS 56 344588 6304078

The photo below is taken looking up the drainage line from a point some 30m above the catchment's discharge into a typha dominated wetland. The drain is thickly vegetated with terrestrial grasses such as (Lambs tongue) *Plantago lanceolata* and ryegrass. Dock, an indicator of wet conditions, is also present.

Figure 5. AP 1.

The channel is ill-defined and appears to have been straightened. There was no evidence of scouring, sediment or debris deposition or lodging of vegetation. There was no evidence of water upslope of this point. This is despite recent heavy rainfall (22 mm), 5 days before this assessment. Table 2 shows the assessment in terms of the fluvial criteria. The assessment results show that the drainage line is NOT a stream.

Assessment site 2.

GPS 56 344583 6304055

344557	6304013

The photo below is the discharge point of the gully onto the floodplain (see figure 4). .

Figure 6. AP 2.

The channel is virtually indistinguishable from the surrounding lands at this point. There is no evidence of significant discharges from this 600 mm pipe (no sediment, no lodging of vegetation, no debris. It therefore cannot be considered a 'stream' at this location. The assessment against fluvial criteria in table 2 supports this conclusion.

Assessment site 3.

GPS 56 344557 6304013

The photo below is immediately downslope of the lower road (see figure 4).

Figure 7. AP 3.

This photo looks downslope from the lower road. The drainage line has a concrete bed.

Table 2 shows that this portion of the drainage line has few of the fluvial criteria characteristic of a stream.

Assessment site 4.

GPS 56 344538 6303998

The photo below is taken of the drainage line looking upstream above the upper road. There is a small walking track bridge immediately upslope.

Figure 8. AP 4.

The base of the drainage line is covered with *Tradescantia fluminensis* (Wandering Jew). This is a creeping plant common in low light, moist conditions. Note that there is no evidence of disturbance or litter deposition in this relatively large, flat area, despite the antecedent rainfall. This again suggests that the drainage system seldom has free water in it.

The pipe is half full of sediment. However this is not recently deposited material as it is colonised with undisturbed Wandering Jew.

There were no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

These observations and the lack of fluvial criteria as per table 2 leads to the conclusion that the drainage line is not a stream at this point.

Table 2. Comparison of site conditions with fluvial criteria consistent with a drainage line being a stream (from Outhet and Taylor (unpubl)), cited in Stokes and Taylor (2005).

Criterion	AP 1	AP 2	AP 3	AP 4	AP 5	AP 6	AP 7	AP 8	AP 9	AP 10	AP 11	AP 12
Are there definable channel banks and a channel bed?	In some sections	No	Yes (concrete)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Are there fluvial bedforms, e.g pools, riffle , sediment point bars, etc. and if so what are they?	No	No	No	Sediment collection area	No	No	No	No	No	No	No	No
Is there any evidence for substantial erosion from water flow within the drainage feature?	No	No	No	No	No	Yes, a nick point	No	No	No	No	No	No
Are there any spring lines that may indicate intermittent or perennial or intermittent flow?	No	No	No	No	No	No	No	No	No	No	No	No
Is the catchment large enough to sustain perennial or intermittent groundwater flow?	No	No	No	No	No	No	No	No	No	No	No	No
Are there any indicators of prolonged wetness within the drainage feature?	Dock	Dock	No	Wandering Jew	No	No	No	No	No	No	No	No
If surface flow is present, is it continuous and how extensive across the base of the drainage feature is it?	No flow	No flow	No	No	No	No	No	No	No	No	No	No
Are there any visible habitats that might sustain aquatic fauna?	No	No	No	No	No	No	No	No	No	No	No	No
Are there any aquatic fauna present that would require periods of uninterrupted moisture?	No	No	No	No	No	No	No	No	No	No	No	No

Assessment site 5.

GPS 56 344527 6303989

The photo below is taken of the drainage line upstream of the small walking track. It looks like a grassed swale rather than a drainage line. It has a 'floor' with minimal curvature or cross slope. There are no defined banks, there are simply sides of the gully. The vegetation on the 'floor' is basically terrestrial grasses and forbs. There are no aquatic plants evident. The vegetation on the sides of the gully consists of terrestrials such as lantana and camphor laurel. There is no evidence of sediment or vegetative debris being mobilised. There is no evidence of water in recent times. There were no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

Figure 9. AP 5.

The vegetation mix and the lack of any evidence of flowing water despite, antecedent heavy rainfall suggests that the drainage line is not a stream.

Note that even roof runoff from the nearby buildings have not resulted in 'substantial flows' in this drainage line.

These observations and the lack of fluvial criteria as per table 2 leads to the conclusion that the drainage line is not a stream at this point.

Assessment site 6.

GPS 56 344506 6303964

The photo below is taken of the drainage line approximately 20 m upslope of AP 5. There is a minor nick point. The gully sides are steep, with some exposed rock.

The ground cover is sparse and largely consists of ferns. There are no sedges or other aquatic flora present.

Immediately upslope of the nick point, there is some plant litter entangled in lantana branches. This suggests there has been some recent flow on the base of the gully. However the area was completely dry 5 days after heavy rainfall. Aquatic fauna would be unlikely to survive.

Figure 10. AP 6.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point.

Assessment site 7.

GPS 56 344479 6303931

The photo below is taken of the drainage line approximately 26 m upslope of AP 6. The gully floor is bare except for plant litter and the occasional fern. The litter has not been mobilised by antecedent rainfall. This suggests that significant flows are extremely rare. Lantana branches droop onto the bed of the gully, but there is no evidence of litter pack mobilisation.

There are no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

Figure 11. AP 7.

The vegetation mix, the lack of litter disturbance and the dry conditions, despite heavy antecedent rainfall, suggests that the drainage line is not a stream at this point.

Assessment site 8.

GPS 56 344456 6303894

The photo below is taken of the drainage line approximately 23 m upslope of AP 7. Palms are the major vegetation along the gully floor. There is considerable litter fall. However this has not been mobilised by antecedent rainfall. This suggests that significant flows are extremely rare.

There are no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

Figure 12. AP 8.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point.

Assessment site 9.

GPS 56 344418 6303863

The photo below is taken of the drainage line approximately 40 m upslope of AP 8. There is almost no vegetation of the floor of the gully. There is a thick litter layer. There is also a considerable mass of loose soil. However neither the soil nor the litter show signs of mobilisation despite recent heavy rainfall. This suggests that significant flows are extremely rare.

There are no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

Figure 13. AP 9.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point.

Assessment site 10.

GPS 56 344412 6303852

The photo below is taken of the drainage line upslope of AP 9. There is a thick litter layer adjacent to a Sydney Blue Gum tree. However, there is no defined bed and banks, possibly because of the slope is very steep. There are no sedges or other aquatic flora present. Aquatic fauna would be unlikely to survive.

Figure 14. AP 10.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point.

Assessment site 11.

GPS 56 344390 6303858

The photo below is of the drainage line some 23 m upslope of AP 10. There is a considerable area of bare earth, however there is no litter against the chicken wire fence (see below). This suggests there has been little or no flow in recent times.

There are a few ferns and palms on the floor of the gully, however there are no aquatic sedges. Aquatic fauna are unlikely to survive in this portion of the gully.

Figure 15. AP 11.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point.

The lack of litter against the fence indicates that there has not been sufficient flow to mobilise significant qualities of litter. If there is no significant flow despite the significant antecedent rainfall then the gully should not be considered a ‘stream’ at this point.

Assessment site 12.

GPS 56 344383 6303850

The photo below is of the drainage line in the 'forest' upslope of AP 11. The drainage line 'bed' consists of smooth boulders. There is litter on the ground among the boulders. This litter has not been mobilised by recent rainfall runoff. This suggests there has been little or no flow in recent times.

The vegetation is largely palms. There are no aquatic sedges. Aquatic fauna are unlikely to survive in this portion of the gully.

Figure 167. AP 12.

The vegetation mix and dry conditions despite heavy antecedent rainfall suggests that the drainage line is not a stream at this point. Any flow would need to be conveyed around the boulders. However there is no evidence of scouring or litter pack development and mobilisation.

If there is no significant flow despite the significant antecedent rainfall then the gully should not be considered a 'stream' at this point.

7. Conclusions

The Narara Ecovillage Co-Operative Limited is committed to ecologically sustainable development principles. As part of these principles, the Co-Operative has already commenced weed management within the subject gully. The ultimate aim will be to protect endangered species and to also safely convey any runoff along the drainage line to the floodplain wetlands.

The proposed management of the drainage line will include scour protection around and downstream of stormwater outlets.

A review of law precedents indicate a set of criteria from which to determine if a drainage line is a ‘stream’. According to these decisions a stream should have bed, banks and flow. The flow should not simply be in response to immediately preceding rainfall.

An assessment at 12 points along the drainage system produced little evidence that any significant length of the drainage line meets the precedents cited above.

The catchment area is less than 5 ha. There was little evidence of sustained flow despite heavy antecedent rainfall. There were few if any wetland plants, and none of the assessment points would be suitable for aquatic fauna such as fish. It is therefore concluded that the drainage line is <u>not</u> a stream, rather it is a gully which occasionally conveys runoff following significant rainfall.

Nevertheless the Co-Operative will actively manage the vegetation and the environment within the gully consistent with environmental and bush fire protection needs.

8. References

Stokes, R., and Taylor, M. (2005). Up the creek: What is wrong with the definition of a river in New South Wales?. Environmental and Planning Law Journal Vol 22 (3), 193-209

Appendix 2. Letter of Advice regarding drainage depression

MATTILA | LAWYERS

(formerly known as Jenni Mattila & Co Lawyers)
ABN 58 993 801 382

GPO BOX 4727
SYDNEY NSW 2000
ph: + 61 2 9252 7177
fax: +61 2 9241 4674

24 October 2013

Peter Bacon
Director of Woodlots and Wetlands Pty Ltd
Woodlots and Wetlands Pty Ltd
220 Purchase Road
CHERYBROOK, NSW 2126

SENT BY EMAIL

Dear Dr Bacon

Advice regarding whether Drainage Depression, south of lots 35,22 21 and 10 constitutes a "River" for the purposes of the *Water Management Act 2000* (NSW) (the "Act").

1. Your instructions You have requested

advice with respect to the following:

a Whether the drainage depression found immediately south of lots 11, 17, 23 and 31 (the "Drainage Depression") constitutes a River as defined in the Dictionary of the Act.

2. Background

We understand that:

a. Mr Algis Sutas NSW Office of Water ("NOW") has indicated that the Drainage Depression maybe a River for the purposes of the Act and may be a first order watercourse requiring a Core Riparian Zone ("CRZ") of 10 metres width from the top of the bank on either side of the watercourse.

b. Such a classification prohibits the building of infrastructure within the CRZ and that Narara Ecovillage Co-operative Ltd (the "Co-operative") will be required to ensure that the CRZ remains, or becomes vegetated with fully structured vegetation. This is in addition to any Vegetation Buffer or Asset Protections Zones required by Council and/or NOW.

3. Advice summary

3.1 Summary

We understand that NOW has indicated that it might classify the Drainage Depression as a River under the Act. Under the Act a River includes:

a. any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved; and

b. any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows; and

c. anything declared by the regulations to be a river.

The Act does not define "watercourse" and therefore an examination of the relevant case-law is necessary. After examination of the relevant case-law we are of the opinion that NOW's classification of the Drainage Depression is inconsistent with the definition of a River under the Act and the interpretation of the definition of "watercourse" taken by the Courts.

3.2 The test under the case-law

Case law in New South Wales has defined the characteristics of a river or watercourse. These characteristics are continuity, permanence, and unity, set out by Barwick CJ in the High Court of Australia decision of *Knezovic v Shire of Swan-Guildford* [1968] HCA 38 ("*Knezovic*").

It was posited by Taylor and Stokes (Taylor, M., and Stokes R., "Up the Creek: What is wrong with the definition of a river in New South Wales" Environment and Planning Law Journal 22 193 2005) following the introduction of the Act and taking into account the Act objectives, previous case-law could not be relied on when interpreting the definitions of a River or "watercourse". However in *Silva v Ku-ring-gai Council [2009]*

24 October 2013

NSWLEC 1060 ("*Silva*") Taylor C of the NSW Land and Environment Court, at [17], [23-25] and [48], confirms that whilst the Act contains a more expansive definition of

Rivers and watercourses, than in earlier Acts such as the *Rivers and Foreshores Improvement Act 1948* (NSW) and the *Environment Planning and Assessment Regulation 2000* (NSW), *Knezovic* remains the authoritative case for determining whether a river or watercourse exists.

Despite the greater inclusiveness of the definitions of "rivers" and "watercourses" under the Act, the decision in *Silva* confirms that the definition does not extend beyond watercourses or tributaries, which are watercourses in their own right and therefore does not capture every instance in which water "occasionally" flows. In determining what constitutes a watercourse under the Act Taylor C followed Barwick CJ's decision in *Knezovic* and held at [53] that what was crucial was whether or not there was a "flow" of water.

Therefore, the test as laid down in *Knezovic* remains the relevant test when determining the existence of a watercourse. However, the Courts did take into account other physical factors when determining the existence of a watercourse. These factors are set out in **section 3.3** below.

3.3 Relevant Factors for Determining the Existence of a Watercourse:

In *Knezovic* the High Court took into account the following factors to determine the existence of a watercourse (at [18]):

a. a watercourse must exhibit features of continuity, permanence and unity;
b. a watercourse is a stream with a defined bed, with banks and flowing water;
c. a watercourse must be a stream and be sharply distinguished from a mere drain, or drainage depression in the contours of the land which serve to relieve the upper land of excess water in times of major precipitation; and
d. it is not enough that the water, when it does flow, does so in what may be seen as a defined course or channel. When water flows "occasionally" it is not considered a regular flowing stream of water.

In *Silva* the NSW Land and Environment Court took the following factors into account:

a. observable areas of organic matter and inorganic sediment that have been moved following preceding rains indicate a watercourse (at [40]);
b. the presence of aquatic fauna indicates a watercourse (at [40]);
c. erosion marks in the channel bed such as striations, flutes, grooves, scallops and potholes indicate water flow of a reasonably regular and substantive nature over an extended timeframe (at [44]);

d. a blue cartographer's line on a map, while not a prescriptive or statutory consideration may be considered (at [44]);

e. aerial photography of the area showing a watercourse may indicate a watercourse (at [51]);

f. the Taylor and Stokes nine part test as laid down in Taylor and Stokes (2005) in the Environmental Planning Law Journal, 22, pages 193-211 was also taken into account (at [56]):

i. Are there definable channel banks and a channel bed?
ii. Are there fluvial bedforms e.g. pools, riffles, sediment point bars etc. and if so what are they?
iii. Is there any evidence for substantial erosion from water flow within the drainage feature?
iv. Are there any spring lines that may indicate seasonally intermittent or perennial flow?
v. Is the catchment large enough to sustain perennial or intermittent groundwater flow?
vi. Are there any indicators of prolonged wetness within the drainage feature?
vii. If the surface flow is present, is it continuous and how extensive across the base of the drainage feature is it?
viii. Are there any visible aquatic habitats that might sustain aquatic fauna?
ix. Is there any aquatic flora present that would require periods of uninterrupted moisture?

g. Consistency with any Development Control Plans (at [65]).

3.4 Applying these factors to the Drainage Depression

This section is to be read in conjunction with Dr Bacon's report on the gully titled: "Report on the unnamed gully to the immediate south of lots 31, 23, 17 and 11 Narara Ecovillage, Narara"

Your report made the following assessments and observations:

<u>At Assessment Site 1:</u>

The channel was described as ill defined and showed no evidence of water upslope of the point despite heavy rainfall (22mm 5 days before assessment) (p. 10). There was no evidence of scouring sedimentation or lodging of debris. It cannot be considered a 'stream' at this location.

At Assessment Site 2:

The channel is virtually indistinguishable from the surrounding lands at this point. There is no lodging of vegetation or debris. It cannot be considered a 'stream' at this location.

At Assessment Site 3:

The drainage line has a concrete bed.

At Assessment Site 4:

There is no evidence of disturbance or litter deposition in this relatively large, flat area, despite the antecedent rainfall. This suggests that the drainage system seldom has free water in it. The pipe is half full of sediment, but this is not recently deposited material as it is colonized with undisturbed wandering Jew. There were no sedges or other aquatic flora present. Aquatic Fauna would be unlikely to survive. The conclusion is that the drainage line is not a stream at this point.

At Assessment Point 5:

The photo below is taken of the drainage line upstream of the small walking track. It looks like a grassed swale rather than a drainage line. The vegetation on the floor is terrestrial grasses and forms. There are no aquatic plants evident. There is no evidence of sediment or vegetative debris being mobilized. There is no evidence of flowing water.

At Assessment Point 6:

There is a nick point. There is some plant litter entangled in Lantana branches. This suggests there has been recent flow in the gully, however five days after heavy rainfall the area was completely dry. There is no aquatic flora or fauna present.

At Assessment Point 7:

The gully floor is bare except for plant litter and fern. The litter has not been mobilized by antecedent rainfall. The photo shows a slope, but no defined banks.

At Assessment Point 8:

Palms are the major vegetation along the gully floor. There is considerable litter fall. However this has not been mobilized by antecedent rainfall, suggesting that significant flows are extremely rare. There are no sedges or aquatic flora present. Conditions are dry.

<u>At Assessment Point 9:</u>

There is a thick litter layer, however neither the soil nor the litter show signs of mobilization despite heavy rainfall. This suggests that significant flows are extremely rare. There are no sedges or aquatic flora present. Aquatic fauna would be unlikely to survive.

<u>At Assessment Point 10:</u>

There is no defined bed and banks possibly because the slope is very steep. There are no sedges or aquatic flora present.

<u>At Assessment point 11:</u>

There is a considerable area of bare earth; however there is no litter against the chicken wire fence. This suggests there has been little or no flow in recent times. There are few ferns and palms on the floor of the gully however, there are no aquatic sedges.

<u>At Assessment Site 12:</u>

The drainage line 'bed' consists of smooth boulders. There is litter on the ground among the boulders. This litter has not been mobilized by recent rainfall runoff. This suggests there has been little or no flow in recent times.

3.5 Conclusion

On your observations and applying the test as laid down by the High Court in *Knezovic*, it is clear that this is not a watercourse which exhibits features of "continuity, permanence and unity". This landform feature is evidently a drainage depression which is not a continuous defined channel with an identifiable bed, banks and margins. Your observations suggest that, at numerous points, the Drainage Depression cannot be distinguished from the surrounding land. Additionally, the Drainage Depression has no requisite flow characteristics as required by *Knezovic* and at most has "occasional" flow. At the time of your report was conducted there was no sustained flow, despite heavy antecedent rain. Evidence from your report suggests that significant flows were extremely rare and the Drainage Depression is not a regular stream, which is dry in certain seasons.

In addition your observations satisfy the majority of factors taken into account in *Silva*, which indicates a drainage depression and not a watercourse. For example, no aquatic fauna was present and there was very little movement of organic matter and inorganic sediment that have been moved as a consequence of preceding rains. Furthermore, aerial photography of the Narara site does not show a watercourse nor is there a blue cartographer's line indicating an identifiable watercourse.

As such, NOW cannot impose CRZ on the Drainage Depression.

4 Recommendations and next steps

We recommend that you provide our advice to Algis Sutas of NOW.

However, we advise that no CRZ can be imposed on the Co-operative with regards to this Drainage Depression.

Should you have any further questions or if you require any further assistance, please contact Jenni Mattila (details below).

Yours faithfully

Mattila Lawyers

Contact person:	Jenni Mattila
Direct email:	jennimattila@mattilalawyers.com.au
Our Ref:	NEV001
Doc. Id	3000013835

24 October 2013

Addendum to Integrated Water Management Cycle Version 6.

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

1. Background

The need to accommodate NSW Health Department concerns regarding the flushing of toilets with reclaimed water as per the National Guidelines for effluent reuse has required a revisiting of the site water supply and demand at the Narara Ecovillage. An additional issue is that residents may have to drink rainwater rather than treated dam water.

As an initial step, it was suggested that the reclaimed water could be used for large scale irrigation of public space and rural irrigation. Removal of this source of toilet flush water means that there is increased demand for potable water to flush the toilets. This increase in demand could be met by a combination of rainwater captured in tanks and treated water from the 45 ML dam. Using as high a proportion of the rainwater as possible maximises the 'air-space' in the rainwater tanks and this maximises the ability of the system to reduce stormwater volume and even peak flows. Additionally using water from the tanks will reduce demand on the dam water supply.

2. Methodology

The demands for the different types of water were based on the same data set as was used in the Integrated Water Cycle Study. In turn, the original data set was derived from Sydney Water Corporation surveys of several thousand dwellings. Table 2.1 contains the anticipated demands for dwellings with 1 to 7 residents.

First scenario-tank water used for toilets and laundry

Table 2.1. Water use components for individual dwellings with 1 to 7 occupants (derived from SWC reports). The water use by 6 and 7 occupants was derived via extrapolation. Data based on 5294 dwellings.

Number of occupants	**1**	**2**	**3**	**4**	**5**	**6***	**7***
Average total water use for dwellings with various numbers of residents (L/day) (Sydney Water, 2011).	233	352	447	529	604	658	700
Toilet (L/day)	**31**	**53**	**74**	**95**	**115**	**130**	**145**
% of total water use	13	15	17	18	19	20	21
% of internal demand	25	25	25	25	25	26	27
Laundry (L/day)	**29**	**53**	**76**	**95**	**113**	**123**	**131**
% of total demand	12	15	17	18	19	19	19
% of internal demand	24	25	25	25	25	25	25
Hot Water (L/day)	**49**	**87**	**119**	**151**	**182**	**197**	**210**
% of total demand	21	25	27	29	30	30	30
% of internal demand	40	41	40	40	40	40	39
Other internal uses (L/day)	**13**	**20**	**31**	**37**	**42**	**45**	**48**
% of total demand	6	6	7	7	7	7	7
% of internal demand	11	9	10	10	9	9	9
Total internal use (L/day)	**122**	**213**	**300**	**378**	**452**	**495**	**534**
Internal use excluding toilets (L/day)	91	160	226	283	337	365	389
Daily External use (L/day)	**111**	**139**	**147**	**151**	**152**	**163**	**166**
External use as% of total demand	48	39	33	29	25	25	24
Internal use as % of total demand	52	61	67	71	75	75	76
Likely reclaimed sewage use L/day (toilet + external)	142	192	221	246	267	293	311
% of total demand	61	54	49	47	44	49	49
Roof runoff demand for laundry and hot water L/day	78	140	195	246	295	205	256
% of total demand	33	40	44	47	49	31	37
% of internal demand	64	66	65	65	65	41	48
Potable + non-potable roof runoff demand	91	160	226	283	337	365	389
Roof runoff demand as a % of total demand	*39*	*46*	*51*	*54*	*56*	*56*	*56*
Return to sewer (internal uses) (L/day)	122	213	300	378	452	495	534
Sewer reuse (toilets, gardens) (L/day)	142	192	221	246	267	293	311
Total demand (cubic m/y)	*85*	*128*	*163*	*193*	*220*	*240*	*255*

Table 2.1 shows that water demand varies with number of residents/dwelling. The 2011 Census data for the Gosford Statistical Area (ABS web site, 2013), shows that the average number of persons per dwelling was 2.5. The individual lot dwellings were assumed to have 5 residents. This is effectively double that of the local number of residents/dwelling on census night in 2011 and is therefore a very conservative approach..

For the purpose of being consistent with the previous modelling, it was assumed that every dwelling had 5 persons. The anticipated daily demand for toilets and cold water in the laundry was 228 L/dwelling/day as table 2.1 shows.

Each residence had 120 msq of roof catchment draining to a tank with an active storage of 9.5 cubic m. Runoff occurred when the total rainfall in a day exceeded 2 mm. Additionally the first 20 L was 'lost' via a first flush diversion system.

The daily time-step model 'ran' from January 1970 to Feb 2013.

Second scenario-tank water used for toilets, laundry and irrigation of 100 msq of land

In this scenario, the demand for toilets and cold water into laundry was the same as the first scenario. That is 228 L/dwelling/day is required.

Irrigation demand was based on the Penman equation, and each irrigation applied 12.5 mm of water when the available soil water content fell below 70 mm of available water. This is designed to maximise water use via irrigation. Conversely, it is likely that more than 100 msq of land /dwelling will be irrigated however this is highly dependent on individual owners. In practice property owners are likely to have a higher than anticipated demand in dry weather and a less than expected demand in cooler weather.

Roof runoff behaviour was as per the first scenario.

The daily time-step model 'ran' from January 1970 to Feb 2013.

Third scenario-tank water used for toilets, laundry and the hot water system

The demand for toilets and cold water into laundry was the same as the first scenario. That is 228 L/dwelling/day is required. According to table 2.1, the hot water system will require an average of 182 L/dwelling/day for dwellings with 5 persons in residence. Therefore, the total daily demand is 410 L/dwelling.

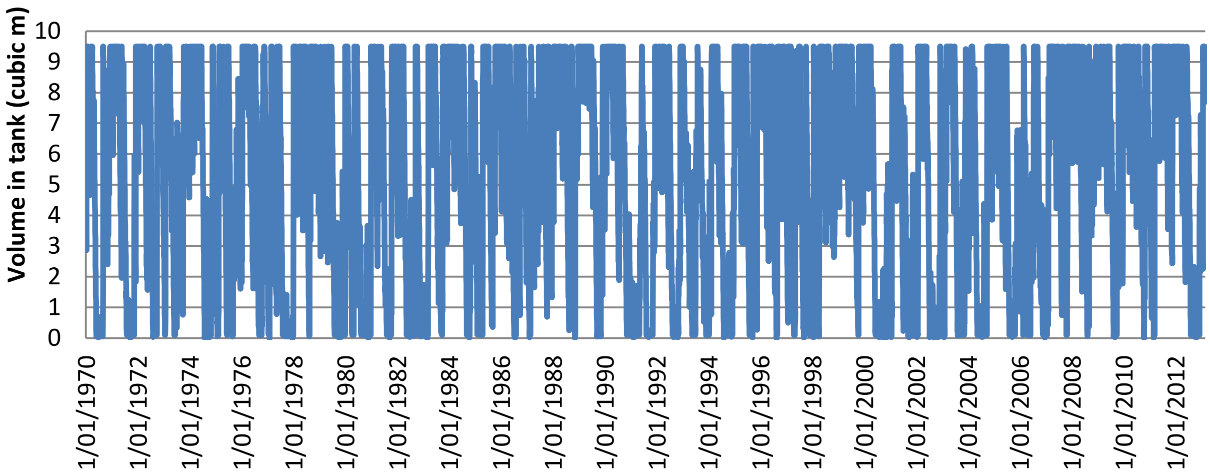
The daily time-step model 'ran' from January 1970 to Feb 2013.

3. Results

First scenario-tank water used for toilets and laundry

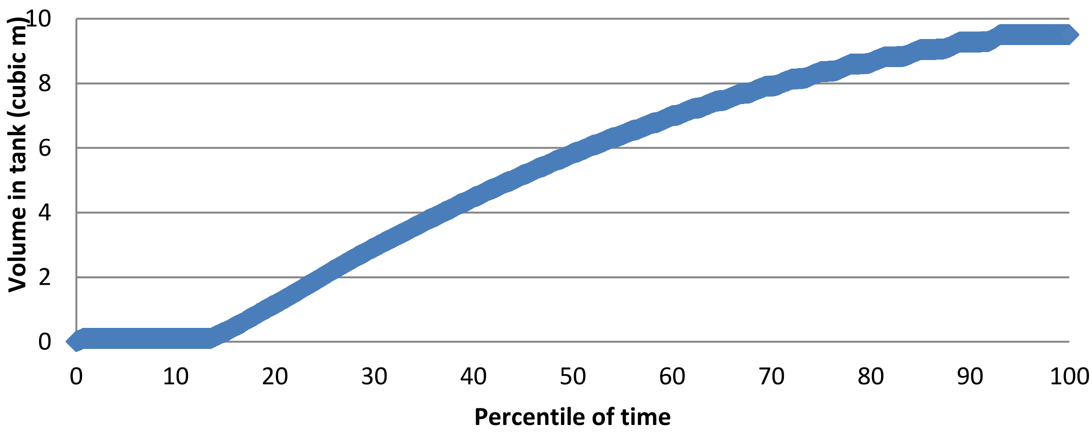
Figure 3.1 shows the volume in storage each day since 1970.

Figure 3.1. Volume in a 9.5 cubic m tank assuming 120 msq roof, 2mm evaporation, 20L first flush loss. (0.228 cubic m demand/day (5 persons in residence)).



It is obvious that the volume is highly dynamic. However, there is water in the tank for the majority of time. This is illustrated in figure 3.2.

Figure 3.2. Volume in a 9.5 cubic m tank as a precentile of time. Assumes 0.228 cubic m of daily demand. Supply to toilets and laundry (5 people in residence).



The tank has a least one day's supply in it in 86% of time. That is, a tank with 9.5 cubic m of active storage could meet anticipated demand for toilet flushing and laundry in a 5 EP dwelling in 86% of time. The median volume in the tank was 5.7 cubic m. Therefore, the median air space was 3.9 cubic m (9.5 cubic m total active volume).

The 228 L/dwelling per day is equivalent to 83.22 cubic m/dwelling/year. Assuming 115 dwellings used this volume/year, the total volume/year used for toilet flushing and laundries would be 9570 cubic m.

If the systems provided water on average for 86% of time then the rainwater consumption within the 115 dwellings would be 8,230 cubic m/ year.

Obviously the average number of residents/dwelling is likely to be closer to the 2.5 persons/ dwelling recorded for the Gosford area in 2011. This would result in lower demand and therefore increase the proportion of time that the tanks could supply water for toilets and laundry.

Based on the 5 EP / dwelling scenario, the tank would overflow some 65 cubic m/dwelling /year. Total runoff from a 120 msq roof is 133 cubic m/year, so the proposed system captures and utilises some 51% of the runoff with the other 49% exiting the tanks via overtopping.

Effect of proposed system on the dam

Figure 3.3 shows the impact of the proposed system on the 45 ML dam.

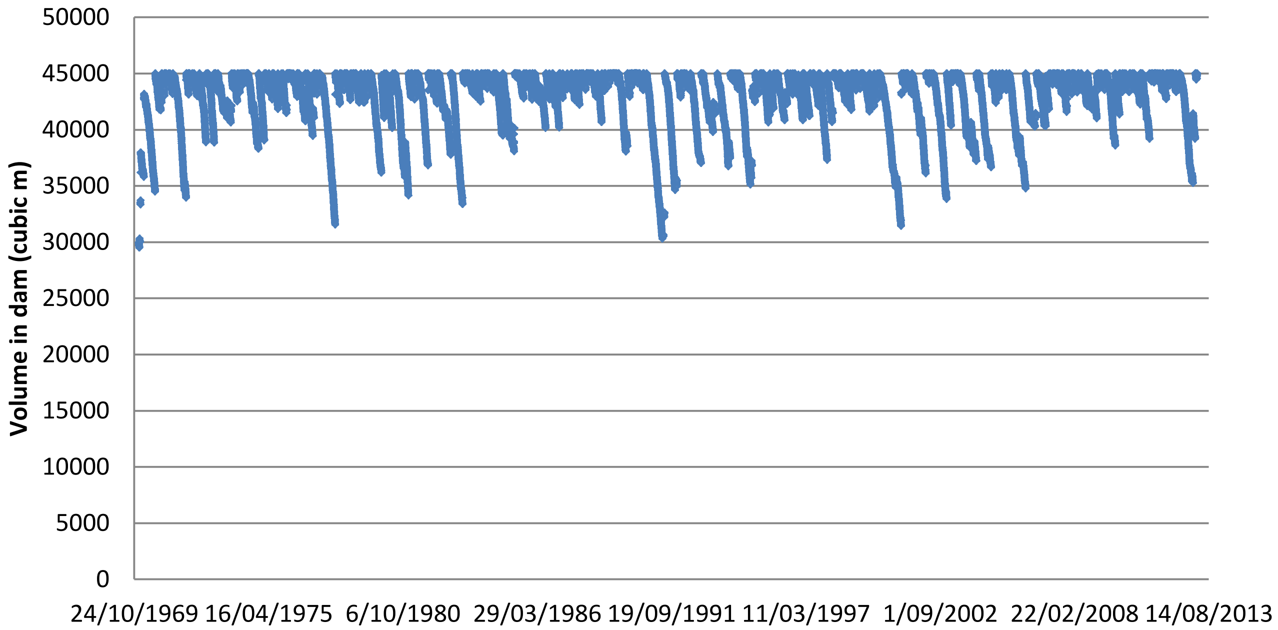


Figure 3.3. Volume in the dam each day since Jan 1970. Assumes a daily potable demand of 224L/dwelling, 9.5 cubic m active storage in rainwater tanks, 120 msq roofs and 115 dwellings. Demand increases by 228L/dwelling if rainwater tanks are empty.

The maximum volume depression in the dam was 15 ML in April 1991. This is approximately 1/3 of the total dam capacity. The result suggests that the system is sustainable.

Second scenario-tank water used for toilets, laundry and 100 msq of irrigation

Irrigation from the 9.5 cubic m tank occurred 17 times in the average year and some 212 mm were applied (21.2 cubic m/100 msq irrigation/year). This is approximately half the irrigation demand for fully irrigated grass in the Gosford area. Additional water would be required to maximise vegetative growth.

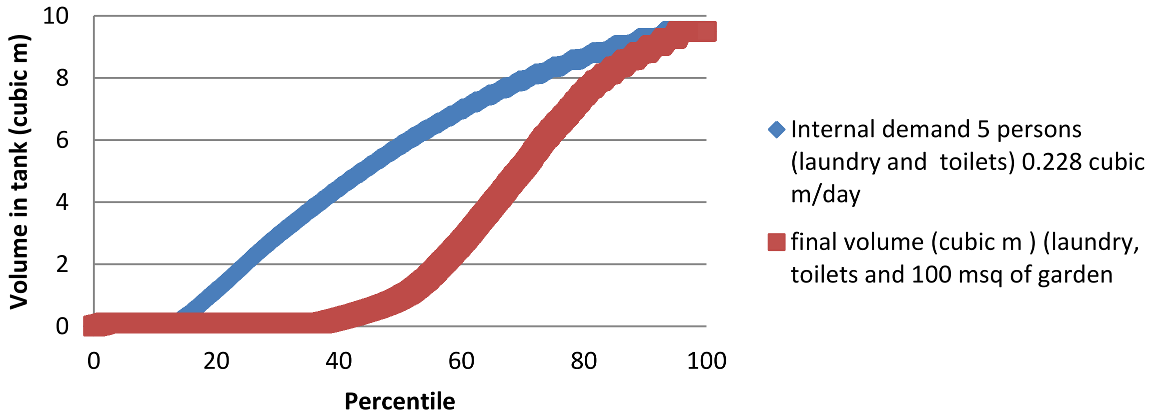
Overflow averaged 45 cubic m/year or approximately 1/3 of the roof runoff volume. Average volume in the tank was 3 cubic m, so the head space averages 6.5 cubic m.

Figure 3.4 illustrates the effect of irrigating the 100 msq of lawn/dwelling. Without irrigation, the tank can supply water in 86% of time, however including irrigation reduced the tank reliability of supply to 60% of time.

If the tanks were automatically given say 1.5 cubic m once the level of water in the tank fell below say 1 cubic m, then there would be significant ‘call’ on the dam. It would be preferable if this demand was met using reclaimed water.

This suggests that it would be preferable to use reclaimed water for irrigation. The option to use other water sources could be available for periods of high demand.

Figure 3.4. Volume in a 9.5 cubic m tank as a precentile of time. Assumes 0.228 cubic m of daily demand for toilets and cold water tap in laundry with or without 100 msq of irrigated lawns.
(5 people in residence).

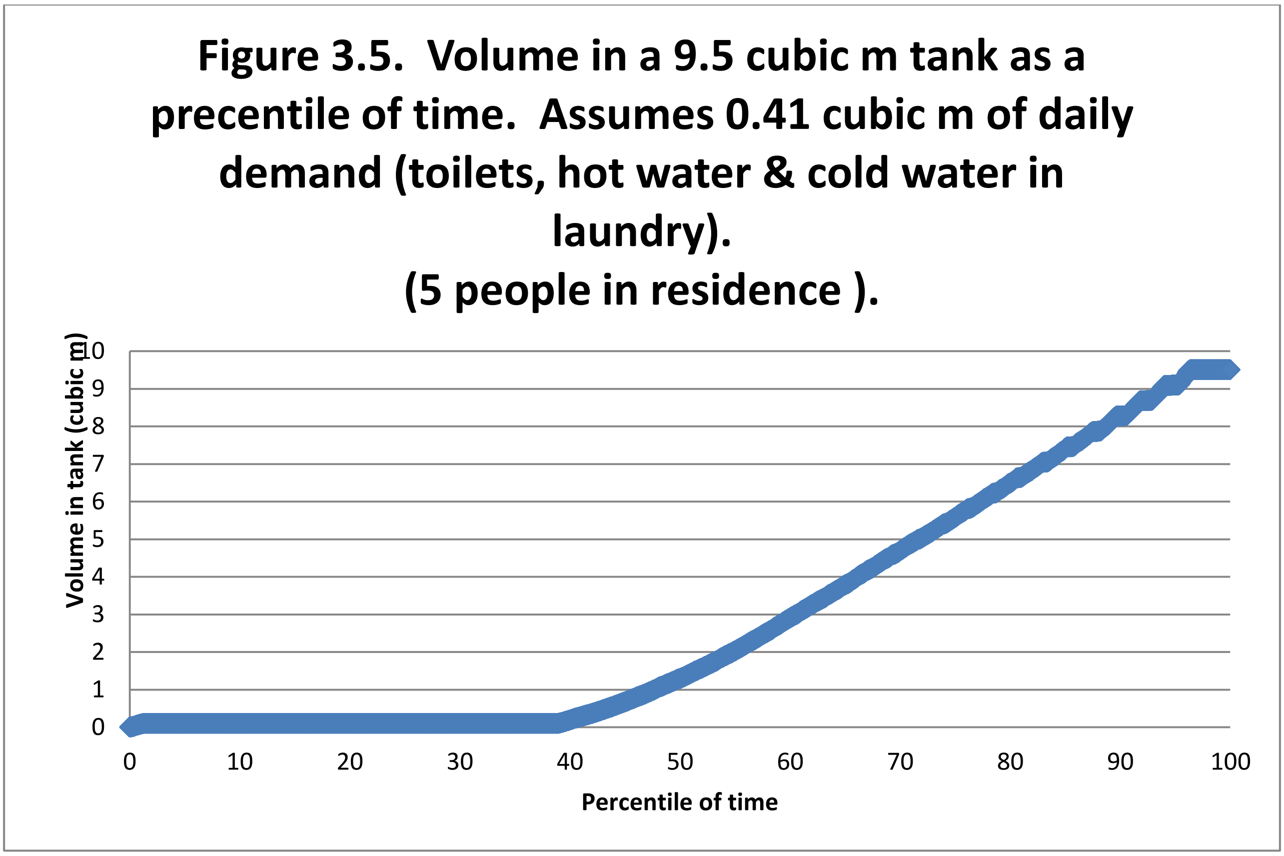


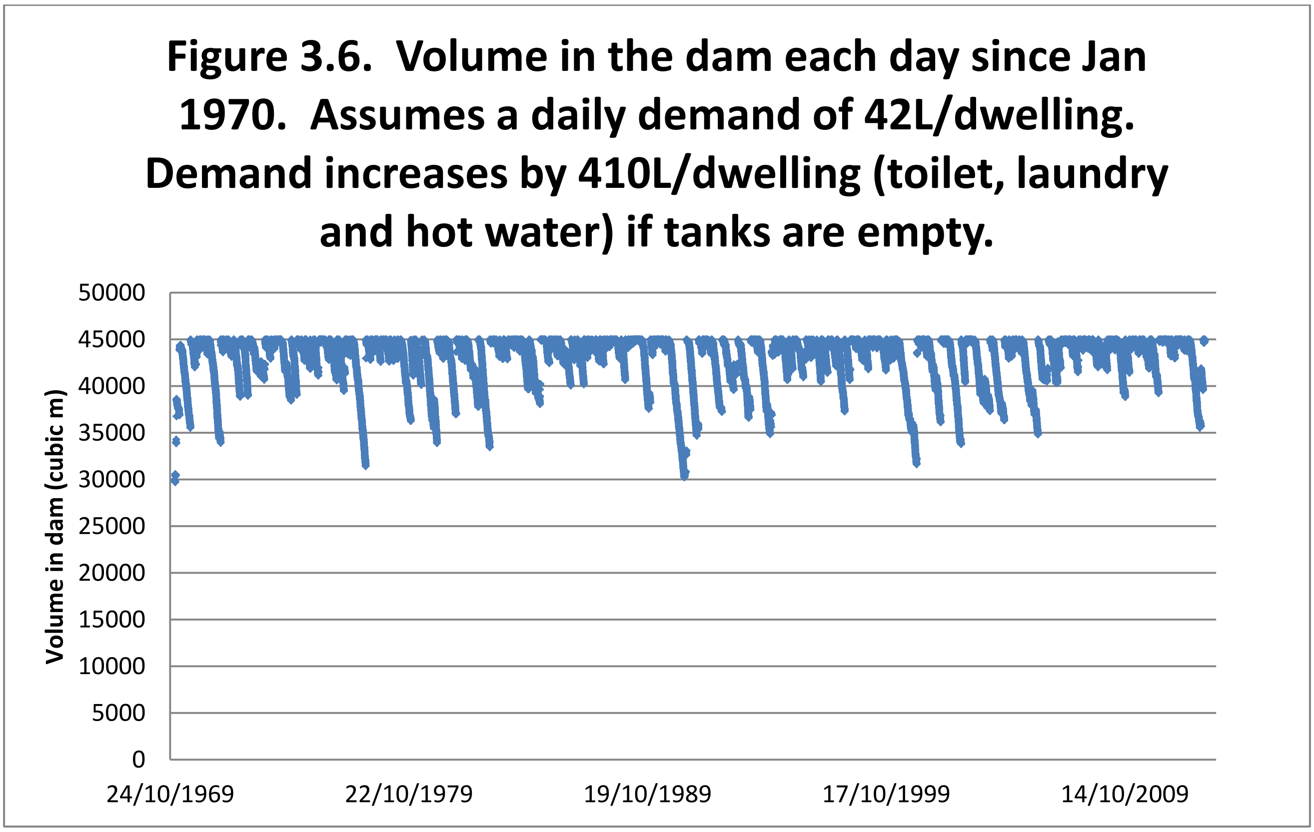
Third scenario-tank water used for toilets, laundry and hot water

Table 2.1 shows that the demand /day for toilets (115 L) , cold water tap in laundry (113L) and hot water (182L) for a dwelling with 5 persons in residence totals 410 L/day.

Modelling revealed that this system resulted in an average volume in the tank of 2.9 cubic m, giving an 'air' space of 6.6 cubic m. Tank overflow averaged 32% of the inflow or 42 cubic m in the average year.

Figure 3.5 shows that the 9.5 cubic m tank will have less than 1 day's water supply in 43% of time. This is obviously a high proportion of time and there will be significant 'call' on the dam water.





Minimum volume in the dam over the past 40 years is 30,200 cubic m. That is, the maximum dam head space is approximately 15 ML or 1/3 of the estimated dam storage capacity. This volume is similar to the other simulations and is indicative of the fact that demand for internal uses within dwellings in the Narara Development is small (a maximum of 18 ML/year) compared with the catchment inflows (204 ML/y) to the dam.

4. Impact of the rainwater tanks on stormwater management efficiency.

The impact of the rainwater tanks on stormwater management was examined The results of vhte modelling are shown in table 4.1 below.

Table 4.1. Effect of WSUD with and without rainwater tanks of stormwater volumes, peak flows and contaminant loads exiting the development.

	Pre dev	**Pos** dev no WSUD		**with WSUD**		**% reduction POST Development**
Flow (ML/yr)	19.4	22.3	19.4	3.74	0	83.2
Peak Flow (m3/s)	0.817	0.1	0.978	0.498	-19.7	-398
Total Suspended Solids (kg/yr)	670	2.45E+03	670	66.6	0	97.3
Total Phosphorus (kg/yr)	3.91	5.82	3.91	0.489	0	91.6
Total Nitrogen (kg/yr)	32.6	47.2	32.6	3.98	0	91.6
Gross Pollutants (kg/yr)	160	367	160	3.68	0	99

It is obvious that the WSUD components of the stormwater management system have a major impact on stormwater flows, peak discharge rates and contaminant loads. However the benefit to stormwater contamination of the tanks is minimal. This suggests that the main effect of the tanks would be to reduce reliance on the dam water by 60 to 85% depending on the demand for water.   Assuming a maximum saving of 84 cubic m/dwelling/year, this would reduce treatment costs by $167/dwelling /year (assuming $2/cubic m). However there will be additional pumping and maintenance costs.

5. Conclusions

The results above show that the proposed 9.5 cubic m rain water tanks will provide 'non-potable' water for a significant proportion of the year. If the reclaimed water is not used for toilet flushing then roof runoff can be used for this demand as well as for cold water to the washing machine in the laundry and even to the hot water system. Note that using roof runoff in the hot water system is consistent with NSW Health guidelines.

The rain water can also be used for irrigation instead of reclaimed water, but this will mean that additional irrigation area elsewhere will be required to productively utilise the reclaimed water.

Importantly utilising the roof runoff reduces the runoff volume by up to 2/3. This has the additional benefit in that the volume of stormwater to be treated is less.

The size of the dam is sufficient to hold almost 3 times the annual water demand. The average annual inflow from the catchment is over 10 times the total demand. Thus, the dam volume is well buffered, and variation in the demand for use within dwellings will have minimal effect.

The modelling assumes 5 persons in each dwelling. This is double the density reported for the 2011 census. Fewer people mean less water being used, so the demand on the dam will be less.

The dam can also support small scale irrigation, and the irrigation requirements of a few ha of intensive horticulture will have only moderate impact on dam volumes.

Narara Ecovillage Co-operative Ltd
25 Research Road Narara NSW 2250
ABN 86 789 868 574

Appendix - 4.1.13.6

Sewage Production, Treatment and Reuse Report

Sewage Production, Treatment and Reuse Report:

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To Accompany Planning Proposal for

Narara Ecovillage (NEV).

Prepared at the request of NEV

PREPARED BY

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

Document Registration

Document Registration

Client	Prepared under instructions of NEV Inc.
Prepared By	Woodlots & Wetlands Pty Ltd 220 Purchase Road Cherrybrook NSW 2126 Telephone (02) 94842700 Mobile 0427905440 E mail woodlots3@bigpond.com
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1. BACKGROUND

The Narara Ecovillage Incorporated (NEV) has been established within a disused horticultural research station at Narara, NSW.

In 2006, Johnson Partners on behalf of the NSW Department of Commerce, undertook an assessment of the ability of Council's infrastructure to convey likely sewage flows from the Narara Ecovillage (Johnson and Partners, 2006). The proposal was to rezone the site into a residential precinct of approximately 150 freestanding dwellings. The study found that Council's infrastructure was inadequate.

In 2013 Council staff examined the likely sewerage infrastructure requirements of the NEV. According to the findings, the costs to augment Council's infrastructure to allow connection of the Narara Ecovillage to Council's centralised sewerage system would be prohibitive. The estimated cost of $30m equates to $200,000/ dwelling for sewerage alone.

It was therefore decided to develop independent, site-specific sewerage management systems for NEV.

The initial sewage system investigation, prepared by Woodlots and Wetlands in 2013, assumed there would be the equivalent of 120 single lot dwellings, each with 5 residents/dwelling. That is, a population of 600 persons.

Subsequent assessment of potential markets indicated the potential for a mix of conventional and lower cost, multi-occupancy housing.

Two development phases are considered:

- First phase: a maximum of 46 free standing dwellings and a maximum of 18 multi-occupancy housing units.
- Full development with an indicative mix of 75 free standing dwellings and 75 multi-occupancy housing units.

Additional sewage flows are likely to be generated by non-residential activities within the ecovillage. These activities could include a café, open days, and eco-activities including short courses on sustainable production and well-being. These are detailed below.

In the flow calculations below it is assumed that these events commence in the first phase of the development.

2. BASIC ASSUMPTIONS

The original assessment assumed a 150 'conventional' lot development (Johnson Partners, 2006).

In the analysis below it is assumed that there were:

- First phase: a maximum of 46 free standing dwellings and a maximum of 18 multi-occupancy housing units.
- Full development with an indicative mix of 75 free standing dwellings and 75 multi-occupancy housing units.

Sewage production due to visitors

It was assumed that there were 70 visitors/day (490/week, concentrated in the weekends).

It was also assumed that each visitor used the toilets once (7 L dual flush), washed their hands (1.2 L for spring-loaded taps) and 'consumed' 5.5 L via washing up of plates, etc. This gives a total of 13.7 L/visitor (Sturman, et al, 2004). Of this, 7 L was returned to flush the toilets.

Additionally assume a maximum 'average' of 10 overnight guests per night. The guests are likely to be concentrated in the Friday to Monday period. Average waste water production is assumed to be 100 L/overnight guest.

Total sewage flow due to visitors is therefore:

(70 visitors*13.7 L/visitor)=0.959 cubic m/day, PLUS 10 overnight guests at 100 L/guest (1000 L/day)=1.959 cubic m/day

Return of treated water for toilet flushing is 70 visitors*7 L=0.490 cubic m/day, PLUS 20 L/overnight guest= 0.690 cubic m/day

Net effluent production is therefore 1.269 cubic m/day.

Staff for visitor facilities is likely to be effectively drawn from residents, so there is no additional flow allocation for staff.

Note that the sewage treatment plant has a 200 cubic m raw sewage buffer storage. This is designed to attenuate peak flows from weekend functions, etc.

Sewage production due to residents

The 2011 Census data for the Gosford Statistical Area (ABS web site, 2013), with 163,111 persons in it, shows that the average number of persons per dwelling was 2.5.

In the 2013 investigations by Woodlots and Wetlands it was assumed that there were 120 dwellings each with 5 persons in permanent residence. That is, the assumed number of persons per dwelling was double that reported in the 2011 census. This approach is extremely conservative and was designed to test the ability of the proposed sewerage system to reliably treat and reuse the likely sewage volumes.

In the current report it is assumed that there is an average of 5 persons per conventional dwelling and 3 persons per multi-occupancy housing unit. That is, the assumed number of people in residence in both types of proposed dwellings exceed the average persons per dwelling in the 2011 census. This number is likely to be an overestimate, and consequently the sewage flows and net effluent production are therefore considered safely conservative.

Note that the ecovillage members are expected to be 'conservative' in their water demands. For example the residents are expected to use high 'star' WELS products in their new dwellings[1]. This will reduce the volume of water being used and therefore the volume sewage being produced to below those estimates shown in table 2.1.

Table 2.1 shows the water demands in the Sydney area for dwellings with one to seven occupants/ dwelling. The water uses are:

- Toilets
- Laundry
- Hot water
- Other minor internal uses (e.g. cold drinking water, food preparation, floor washing and cleaning).
- External water uses (e.g garden watering)

It is assumed that all internal water will be conveyed to the sewerage system for treatment.[2]

At NEV it is intended to recycle water so that the toilets and the external water demands are met via reclaimed water that has been disinfected to the current guideline values (NSW Dept Primary Industries, Office of Water, 2015).

Table 2.1 shows the internal demands that the internal water demand for 3 persons/dwelling averages 300 L/dwelling/day, while the internal demand in a 5 person dwelling averages 452 L/day. It is assumed that all internal demand flows to sewer.

[1] WELS is Australia's water efficiency labelling scheme. It allows consumers to compare the water efficiency of different products by requiring that certain products have water rating labels at the point of sale or display/advertising. All WELS products must be registered with the regulator, rated and labelled according the requirements of the WELS Standard AS/NZS6400:2005 Water-efficient products-Rating and labelling.

[2] A few litres of water may be 'lost', e.g. via consumption, removal in drink containers, floor washing, etc. Conversely some liquids will be added to the flow to the sewer, e.g. water in urine and faeces, liquids in foods and drinks that are drained into the sinks. The net volumes are typically a few litres/dwelling/day.

Table 2.1. Water use components for individual dwellings with 1 to 7 occupants (derived from SWC reports). The water use by 6 and 7 occupants was derived via extrapolation. Data based on 5294 Sydney metropolitan area dwellings.

Number of occupants	**1**	**2**	**3**	**4**	**5**	**6**[3]	**7**
Average total water use for dwellings with various numbers of residents (L/day) (Sydney Water, 2011).	233	352	447	529	604	658	700
Toilet (L/day)	**31**	**53**	**74**	**95**	**115**	**130**	**145**
% of internal demand	25	25	25	25	25	26	27
Laundry (L/day)	**29**	**53**	**76**	**95**	**113**	**123**	**131**
% of internal demand	24	25	25	25	25	25	25
Hot Water (L/day)	**49**	**87**	**119**	**151**	**182**	**197**	**210**
% of internal demand	40	41	40	40	40	40	39
Other internal uses (L/day)	**13**	**20**	**31**	**37**	**42**	**45**	**48**
% of internal demand	11	9	10	10	9	9	9
Total internal use (L/day)	**122**	**213**	**300**	**378**	**452**	**495**	**534**
Internal use excluding toilets (L/day)	91	160	226	283	337	365	389
Daily External use (L/day)	**111**	**139**	**147**	**151**	**152**	**163**	**166**
External use as% of total demand	48	39	33	29	25	25	24
Internal use as % of total demand	52	61	67	71	75	75	76
Roof runoff demand for laundry and hot water L/day	78	140	195	246	295	205	256
% of total demand	33	40	44	47	49	31	37
% of internal demand	64	66	65	65	65	41	48
Potable + non potable roof runoff demand	91	160	226	283	337	365	389
Roof runoff demand as a % of total demand	*39*	*46*	*51*	*54*	*56*	*56*	*56*
Return to sewer (internal uses) (L/day)	122	213	300	378	452	495	534
Sewer reuse (toilets, gardens) (L/day)	142	192	221	246	267	293	311
Total demand (cubic m/y)	*85*	*128*	*163*	*193*	*220*	*240*	*255*

Sewage flows

First phase sewage volumes

- Assuming 46 free standing dwellings with 5 persons each
- plus a maximum of 18 multi-occupancy housing units with 3 persons each
- plus 1950 L/day for visitors:

Sewage flow = (46*452)+(18*300)+(1950)= 28,142 L/average day. That is 28.14 cubic m/day.

[3] The water demands for dwellings with 6 or 7 occupants is extrapolated for the SWC figures for 1 to 5 persons/dwelling

Full development sewage volumes

The sewage flow for 75 dwellings with 5 persons/dwelling is 75*452 = 33,900 L/day. Assuming 75 multi-occupancy dwellings with an average of 3 persons/dwelling the sewage flow is 75*300 = 22,500 L/day. The visitors will generate 1950 L/day of flow to the sewer.

The total sewage flow is therefore 33,900+22,500+1950=58,350 L or 58.354 cubic m/day. This flow will need to be treated as per NSW Dept Primary Industries, Office of Water, (2015) to allow reuse for toilet flushing.

The results are summarised in table 2.2.

Table 2.2 Estimated sewage flow components at the first phase and at full development.

Component	Flow source	Number of units	Rate (L/unit)	Total volume (L/day)
First phase				
Free standing dwellings	Internal use	46	452	20792
Multi-occupancy housing units.	Internal use	18	300	5400
Visitors	Internal use	1	1950	1950
Total				**28,142**
Full development				
Free standing dwellings	Internal use	75	452	33900
Multi-occupancy housing units.	Internal use	75	300	22500
Visitors	Internal use	1	1950	1950
Total				**58,350**

Effluent reuse components

Table 2.1 shows that dwellings with 5 occupants are expected to use an average of 115 L/dwelling/day for toilet flushing. Dwellings with 5 persons are expected to use an average of 74 L/dwelling/day for toilet flushing.

Visitors are assumed to require 690 L/day of recycled water for toilet flushing.

First phase reuse components - toilets

Assuming 46 dwellings with 5 occupants plus 18 dwellings with 3 occupants, the volume for toilet flushing is 46*115 L PLUS 18*74 L PLUS 690 L =7312 L/day.

This leaves 20,830 L/day to be reused elsewhere (28,142 L-7312 L =20,830 L/day).

Full development reuse components-toilets

Assuming 75 dwellings with 5 occupants plus 75 dwellings with 3 occupants, the volume for toilet flushing is 75*115 L PLUS 75*74 L PLUS 690 L =14,865 L/day.

This leaves 43,485 L/day to be reused elsewhere (58,350 L-14,865 L =43,485 L/day).

Reuse components – domestic garden watering

Table 2.1 shows the estimated volume of reclaimed water used for gardens, etc. Reclaimed water for irrigating gardens in free standing dwellings containing an average of 5 persons is 152 L/day. Garden watering in multi-occupancy housing areas is likely to be less because of relatively small garden areas per dwelling. An average external use of 111 L/day was assumed for the multi-occupancy dwellings.

The use of water in domestic gardens is very dependent on the attitude and interests of the residents (Micevski et al, 2011). The residents of NEV are being encouraged to actively garden within their own lots as well as on community lands. It is likely that the water consumption rate will be considerably higher than that used to estimate demand. This will reduce reclaimed water availability for irrigating the rural lot discussed below.

First phase reuse components –garden watering

Assuming 46 dwellings with 5 occupants plus 18 dwellings with 3 occupants, the volume for garden watering is 46*152 L PLUS 18*111 L =8,990 L/day.

Full development –garden watering

Assuming 75 dwellings with 5 occupants plus 75 dwellings with 3 occupants, the volume for garden watering is 75*152 L PLUS 75*111 L =19,725 L/day.

Reuse components – effluent availability for extensive irrigation

First phase-water for extensive irrigation

The anticipated volume available is : total-(toilet flushing plus garden watering) =28,142-(7312+8,990) =11,840 L/day (11.84 cubic m).

Full development-water for extensive irrigation

The anticipated volume available is : total-(toilet flushing plus garden watering) =58,350-(14,865+19,725) =23,760 L/day (23,76 cubic m).

Table 2.3 summarises the flow components in the first phase and in the full development phase.

Table 2.3. Volume of effluent produced in the average day and the estimated volumes used for toilet flushing, domestic irrigation and extensive irrigation in cubic m/day.

Development phase	Volume of effluent (cubic m/day)	Volume of effluent used for toilet flushing (cubic m/day)	Volume of effluent used for domestic irrigation (cubic m/day)	Volume of effluent used for extensive irrigation (cubic m/day
First phase	28.14	7.31	8.99	11.84
Full development	58.35	14.87	19.73	23.76

These volumes were used to set flow design specifications for the STP and the irrigation area.

3. THE SEWAGE TREATMENT REQUIRED TO PRODUCE EFFLUENT SUITABLE FOR DUAL RETICULATION SYSTEMS

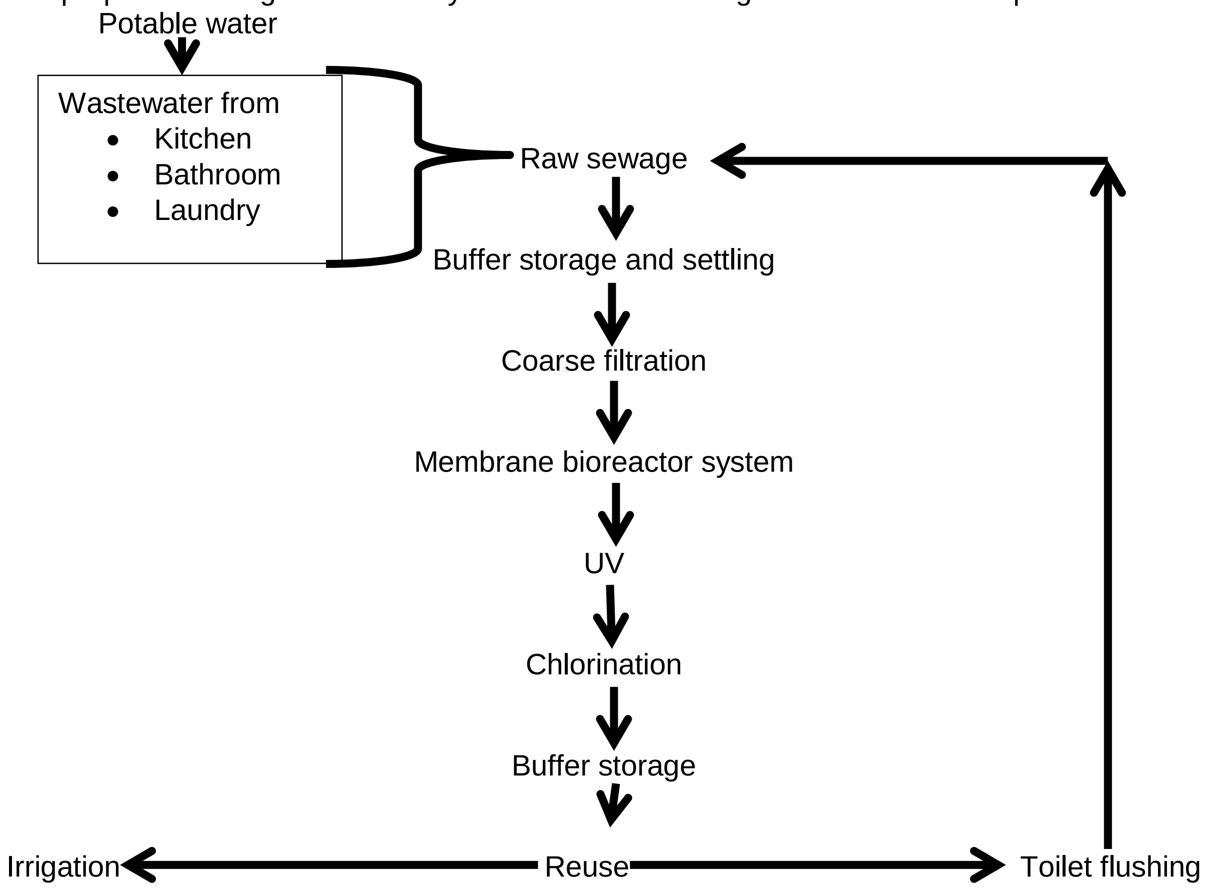
According to NSW Guidelines for Recycled Water Management Systems (DPI, 2015 a), the proposed dual reticulation system[4] requires specific minimum log reduction values. These values are itemised for some treatment systems in the publication *Recycled Water Information Sheet Number 3. Calculating Log Reduction Values*(DPI, 2015 b). The National Water Recycling guidelines provide more detailed information on use of log reduction values (NRMMC (2006).

According to the most recent DPI guideline (DPI, 2015 b), a dual reticulation system requires the log reductions shown in table 3.1.

Table 3.1. The required log reductions for protozoa, viruses and bacteria (derived from DPI, 2015, NRMMC, 2006).

End use of effluent	Log reduction requirement		
	Protozoa	Viruses	Bacteria
Dual reticulation including toilet use, home gardens. Extensive irrigation is also permissible.	4.9	6.3	5.1

The proposed sewage treatment system has the following treatment train components:



[4] Dual reticulation system allows effluent irrigation near domestic premises and the use of effluent to flush toilets. Extensive irrigation would also be permissible.

The log reduction values for the of the sewage treatment train components are shown below in table 3.2.

Table 3.2. The indicative and claimed log reduction for each component of the proposed effluent treatment train (Derived from DPI, (2015 b) and NRMMC (2006)).

Treatment barrier	Protozoa		Viruses		Bacteria	
	Indicative reduction	Claimed reduction	Indicative reduction	Claimed reduction	Indicative reduction	Claimed reduction
Primary treatment	0 to 0.5	0.25	0 to 0.1	0.05	0 to 0.5	0.25
Membrane filtration	>6.0	4	2.5 to 4.0	3.25	3.5 to 4.0	3.75
UV	3.0 to 4.0	3.5	1.0 to 3.0	2	2.0 to 4.0	3.0
Chlorination	0 to 0.5	0.25	1.0 to 4.0	2.5	2.0 to 4.0	3.0
Total log reduction based on average with a maximum of 4 per treatment barrier		8.0		7.8		10.0

Conclusions

A comparison of the log reduction requirements in table 3.1 with the anticipated log reductions in table 3.2 shows that the proposed system is compliant with the water quality requirements for a dual reticulation system.

Importantly it has a number of critical control points/ barriers, so that even if one of the barriers failed the others would ensure adequate log reduction.

The data also indicate that the membrane filtration is the most effective barrier. Maintaining its efficacy is critical.

4. Soils in the proposed extensive irrigation system

The Ecovillage is located on loam soils, with moderate slopes and a relatively high rainfall compared with much of NSW (see the Integrated Water Cycle Management Plan, Woodlots and Wetlands, 2013). The proposed irrigation system takes these features into account.

Soil type

These are discussed in detailed in the Integrated Water Cycle Management Plan (Woodlots and Wetlands, 2103).

Two pits were assessed for detailed insitu conditions. The results are tabulated in table 4.1. The soil sampling was based on sampling horizons down to at least 2 metres. The sample depths varied slightly to reflect the differences in horizon thickness at individual sites. Four horizons were noted. The results of the field assessment are shown below.

Field texture

Table 4.1 shows that the field texture typically changed gradually from sandy loam to loam in the surface 25 cm. Loam to clayey sand extends from 25 to 60-65 cm below the surface. Sandy clay loams to clay loams extend below 100 cm.

The sand-dominant surface horizons mean that the risk of runoff from irrigation is minimal. For example, the saturated hydraulic conductivity of loamy sands to sandy loams ranges from 60 to 700 mm/hr depending on soil conditions (Geeves et al, 2007). A 50 year, 2 hr storm at Narara has an intensity of 53 mm/hr. So, in theory, even this storm would not create runoff.

According to AS/NZS 1547 (2012) sandy loams to clay loams can be irrigated with a low pressure subsurface effluent distribution system (LPED) at a rate of up to 3 mm/day (Table M1 in AS/NZS 1547 (2012). See appendix 1, below.

Consistency

Consistency varied from loose, single grains in the topsoils to firm in the clay dominant subsoils

The loose, non-cohesive sand is at risk of erosion from concentrated flows. Therefore permanent grass cover and minimal tillage is recommended. Retention of organic matter on the soil surface and in the topsoil will reduce also erosion risk.

Pedality

The pedality is not relevant for sand or loamy sands. The clayey dominant subsoils are weakly to moderately pedal.

Moderate pedality is preferred in the subsoil, as weak pedality can indicate structural degradation. The clay loam subsoil has moderate pedality.

Fabric

Earthy or rough pedal fabric is preferred as sandy soils can be erosive. The sandy topsoils need a vegetative cover to reduce erosion risk.

Table 4.1. Insitu soil conditions at two inspection pits within the rural lots on the left hand side of Narara Creek.

Site No.	Depth (cm)	Field texture	Consistency	Fabric	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	% rock
RB 1	0-25	Sandy loam	Weak	Sandy	Single grain	Very dark greyish brown	Gradual	None	None	Common	None		None
	25-65	Clayey sand	Weak	Sandy	Single grain	Light yellowish brown	Gradual	None	None	Few	None		None
	65-120	Sandy loam	Weak	Sandy	Single grain	Brownish yellow	Gradual	None	None	None	None	Duplex	None
	120-220	Sandy clay loam	Weak	Sandy	Weak pedality	Pale yellow		20% red	None	None	None		None
RB 2	0-25	Organic loam	Weak	Organic	Weak	Very dark greyish brown	Gradual	None	None	Common	None	Gradual	No
	25-60	Loam	Firm	Earthy	Weak	Yellowish brown	Gradual	None	None	Few	None	Gradual	No
	60-100	Clay loam	Weak	Earthy	Friable, moderate	Red	Gradual	None	None	None	None	Gradual	Non
	100-200	Clay loam	Firm	Earthy	Friable, moderate	Red		None	None	None	None	Gradual	5%

Colour

Soil colour is derived from organic matter, clay mineralogy, and drainage conditions. Pale greys, yellow and whites indicate poor drainage. Dark browns are indicative of organic matter accumulation, while bright reds and oranges are indicative of good drainage.

The topsoils are typically brown to dark greyish brown, indicating organic matter accumulation and moderate drainage. The increasing red coloured clay loam at depth is indicative of good deep drainage conditions. The yellowish subsoil in profile RB1 suggests imperfect drainage.

Boundaries

The sharpness of the boundaries between the soil layers generally indicates the extent of soil development (Isbell, 2016). There is a gradual increase in clay content with depth. This suggests the soils have developed in situ over a very long time scale. This conclusion suggests that the soil profiles are stable. That is, the rate of soil formation approximates the rate of soil erosion.

Mottle %

Mottles can indicate imperfect drainage, especially if they are yellow. Mottles become evident from 70 to 100 cm. The mottles are typically red or orange, suggesting reasonable drainage.

Nodule %

There were no nodules evident. This again suggests reasonable drainage.

Root number

Root number is typically 'common' in the surface 25 cm and 'few' in the 25-60 cm layers. Roots were 'absent' below 60 cm layer.

There was no evidence of impedance. It is expected that the root frequency will be maintained under permanent vegetative cover. The widespread presence of roots at depth suggests adequate physical conditions throughout the normal rooting depth.

Biological activity

Biological activity indicators include the presence of ants, earthworms, millipedes and insect holes in the ground. The activity was absent. The acidic conditions can reduce soil biota numbers.

Liming and planting of long term grass will increase soil biodiversity, thereby ensuring longevity of the effluent irrigation system.

Additionally the effluent will contain much needed nutrients, and this will stimulate plant growth.

Rock %

More than 10% rock in the surface horizon can increase risk of machinery damage. None of the soils has rock in the surface 40 cm.

Site RB2 has 5% rock below 1m. This is not an issue.

Conclusions and management recommendations based on insitu assessment

The ideal soil for effluent irrigation has sand-dominant topsoil overlying moderately structured clay-dominant subsoil. The subject site has these desirable attributes. Therefore, the risk of runoff during irrigation is low.

Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Consequently, the establishment of long term pasture is strongly recommended for the area.

Soil colour indicates that the subsoils have imperfect internal drainage through the clay subsoil. It is likely that a perched water table develops at depth following intense, prolonged rainfall. This excess water would slowly move downslope and dissipate on the floodplain.

The soils have good root penetration into the surface 60 cm. This also suggests that the soils are suitable for effluent irrigation.

Rocks are not an issue.

It is concluded that the soils appear suited to effluent irrigation. A good cover of vegetation, either as crops or long-term, deep-rooted pasture, is critical.

Soil chemistry

The soil analysis aims to quantify the soil attributes that influence the ability of the site to sustainably utilise the effluent. Soil samples from the 0-25 and the 25-60 cm layers from pit RB2 were analysed in detail. Table 11.2 sets out the major soil chemistry attributes.

pH (5:1 water : soil)

The pH tends to fall with depth as table 4.2 shows. The surface 20 cm is ideally between 5.8 and 7 (Slattery, et al, 1999). The surface 20 cm is below this range, and liming is recommended. Retest after 3 years.

Salinity

Salinity is expressed as electrical conductivity (EC) in saturated paste equivalent. The units are dS/m. Soils with $EC_{sat\ paste}$ less than 4 are non-saline (Richards, 1954). Table 4.2 shows that neither of the soil samples are saline. This is an important result as it means that salinity will not limit the site's usefulness for effluent irrigation.

Bray No.1 Available phosphorus

Available phosphorus concentration is a measure of the current adequacy of supply of this nutrient. According to Moody and Bolland (1999), a concentration of 10 to 12 mg/kg in the surface 7.5 cm is sufficient for 90% potential yield of pastures. Table 4.2 shows that the soils have around 1 mg/kg available phosphorus. That is, they are extremely deficient.

The effluent will provide phosphorus, and this will stimulate plant growth.

Soil organic matter

Soil organic matter concentration fall from 3.1% in the surface 25 cm to 0.9% in the 25 to 60 cm layer. These concentrations are low, especially considering the long term pasture of the site. It is likely that phosphorus deficiency is inhibiting pasture growth and organic matter accumulation.

Ideally the effluent irrigation will be used to produce permanent vegetative cover band this will result in a gradual increase in soil organic carbon concentration. Actions such as compost addition and mulching are recommended as ways of increasing soil organic carbon content.

Table 4.2. Attributes of the soil surface horizon from pit RB2.

Attribute	Units	RB2 0-25 cm	RB2 25-60 cm
pH (5:1 water : soil)		5.44	4.93
Electrical conductivity (5:1 water : soil)	dS/m	0.019	0.016
Electrical conductivity as saturated paste equivalent	dS/m	0.18	0.15
P (Bray 1)	mg/kg	1.2	1.0
OM	%	3.1	0.9
Effective Cation Exchange Capacity (ECEC)	cmol+/Kg	6.34	8.06
Calcium	cmol+/Kg	2.50	0.57
Magnesium	cmol+/Kg	1.39	0.42
Potassium	cmol+/Kg	0.13	0.09
Sodium	cmol+/Kg	0.12	0.09
Aluminium	cmol+/Kg	0.01	0.01
Hydrogen	cmol+/Kg	2.18	6.89
Ca	%	39.5	7.1
Mg	%	22.0	5.2
K	%	2.1	1.1
Na	%	1.9	1.1
Al	%	0.1	0.1
H+	%	34.4	85.5
Ca:Mg	ratio	1.8	1.4
C	%	1.78	0.53
N	%	0.104	0.025
C:N	ratio	17.2	21.5
Cl	equiv. ppm	12	10

Cation exchange capacity

Cation exchange capacity (CEC) is a measure of the soil's ability to retain nutrients. The CEC is related to the concentration of clay and or soil organic carbon. The Narara soils are sand dominant, with relatively little clay. Consequently the quantity of soil organic carbon is a critical determinant of soil CEC.

Ideally the CEC in the topsoil should be at least 5, and preferably greater than 12 cmol (+)/kg (Metson, 1961). Table 4.2 shows that both horizons have more than 5 cmol (+)/kg CEC.

Increasing soil organic carbon, for example via mulching and composting, will assist in retaining and processing nutrients in the irrigated effluent.

Exchangeable calcium (Ca)

Ideally soils should contain over 10 cmol (+) /kg of exchangeable Ca (Metson, 1961). Soils with 5 to 10 cmol (+) /kg of exchangeable Ca are considered to have moderate concentrations. Table 11.2 shows that both soils have low concentrations of exchangeable Ca.

Adding good quality agricultural lime will remove Ca deficiency, and increase production of acid sensitive plants such as legumes.

According to Abbott (1989) Ca should make up 65 to 80 % of the sum of cations. Both soil horizons are very low in Exchangeable Ca expressed as a % of the CEC. This can result in Ca deficiency. Addition of 200 kg/ha of lime prior to commencement of irrigation is essential to correct this.

The soil should be retested after 3 years.

Exchangeable magnesium (Mg)

Soils should contain at least 1, and up to 3 cmol (+) of exchangeable Mg (Metson, 1961). The data in table 4.2 show that the topsoil chemistry is in the range.

According to Abbott (1989) Mg should make up 10 to 15 % of the sum of cations. The surface soil has 22% of its CEC as exchangeable Mg.

The ratio of Exchangeable Ca : Exchangeable Mg should be at least 2:1. Excessive Mg is an issue.

Liming should address this issue.

Exchangeable potassium (K)

Potassium is an essential nutrient, and topsoils should have at least 0.3 cmol (+)/kg. Table 4.2 shows that the soil is deficient in potassium. The effluent will contain potassium, and so the potassium concentrations should increase over time.

Retest the soils after 3 years.

Exchangeable sodium (Na)

Exchangeable Na in soil is important because excessive Na can cause structural instability via deflocculation of clays. This is especially critical in the topsoil, where cultivation or heavy rainfall can make the soil susceptible to structural degradation. The Narara soils have minimal clay, and rely on organic matter to maintain structure.

Generally the potential impact of sodium on soil structure is expressed as Exchangeable Na as a percentage of the sum of cations:

$$\frac{\text{Exchangeable Na*100}}{\text{Exchangeable (Na+K+Ca+Mg+Al)}}$$

Less than 5% exchangeable Na is preferred.

Table 4.2 shows that all surface soils have less than 5% Exchangeable Na. The surface soils are therefore non-sodic. Sodicity is also low at depth. Thus sodicity is not an issue in these soils.

Exchangeable aluminium (Al)

Exchangeable Al is a potentially toxic ion. Ideally its concentration is below detection. It can stunt growth of susceptible plants such as legumes when more than 5% of the total exchangeable cations are Al. None of the soils has excessive Al.

Total Nitrogen

Soil total nitrogen concentrations less than 0.15% are considered ‘low’ in nitrogen (Bruce and Rayment (1982). The nitrogen concentration of the surface 25 cm averages 0.1% and is therefore considered ‘low’.

Nitrogen addition via effluent irrigation should gradually increase site nutritional status.

C : N ratio

The C : N ratio in typical soils is 10 to 12. The higher values in the current soils suggest that there is accumulation of carbon-rich residues. This may be due to the acidic conditions inhibiting bacterial activity. Liming will assist in normalising carbon transformations.

Conclusions and soil management recommendations

- The soils are non-saline and non-sodic.
- The soils, are acidic, have low soil organic carbon and nitrogen concentrations, are low in CEC, as well as low in exchangeable Ca and K.
- Liming at an initial rate of 200 kg/ha is recommended.
- Retest all soil in 3 years.
- The soil organic carbon content is critically important, and practices such as composting and mulching will assist long term sustainability of the development.

The features above mean that all the soils are suitable for long term irrigation of effluent provided the nutrient deficiencies are addressed and the soil organic carbon content is maintained.

The key actions required:

- Install runoff diversion banks upslope of the development area and divert runoff towards existing drainage lines.
- Apply and incorporate 0.2 t/ha of agricultural lime

- Install sub-surface irrigation

- Plant pasture as soon as possible after the irrigation system is installed and operational.

- The pasture should include a mix of perennial temperate grasses such as perennial ryegrass and deep rooted species such as lucerne.

- Facilitate accumulation of soil organic carbon by combinations of long term pasture, mulching and compost addition.

- Retest the soil for nutrients, pH and organic carbon after 3 years of effluent irrigation.

5. Soil water balance and irrigation demand

Soil water balance and irrigation demand were determined using a combination of rainfall and potential evapotranspiration data (BoM). The analysis used a daily time-step schedule involving rainfall, potential and estimated actual evapotranspiration since 1970.

The irrigation soil was modelled as a sandy loam to loam for the surface 500 mm.

The sand-dominant nature of the soil means that there will be limited runoff. However the soil water storage capacity will be lower than soils with more clay in them. Consequently irrigation will be more frequent at Narara than at other sites with more clay dominant soils.

Model inputs

Table 5.1 itemises the inputs used to model the site water balance.

Table 5.1. Components used to model irrigation demand at full development. Daily data over the period between Jan 1970 and Feb 2013 was used. (Climate data from BoM).

Component	units	Average/y
Rainfall	mm	1335
Potential evapotranspiration (PET)	mm	1159
Runoff	mm	157
Effective root zone	mm	500
Plant available water in the 500 mm root zone at field capacity	mm	70
Plant evapotranspiration At PET until 35 mm deficit then a linear fall to zero at permanent wilting point.	mm	811 mm/y without irrigation

Table 5.2 shows the annualised water balance.

Table 5.2. Water balance components for subsurface irrigation at Narara ecovillage receiving 0, 1, 1.5 or 2 mm/day of effluent. Average rainfall (1335 mm), potential evapotranspiration (1159 mm) and surface runoff (157 mm) are as per table 5.1.

Water balance component	Zero irrigation	1 mm/day	1.5 mm/day	2 mm/day
Average available soil water (mm/500 mm of surface soil)	48	63	70	75
Actual evapotranspiration (mm/year)	811	992	1054	1098
Percolation (mm/year)	294	444	537	629

Design irrigation rate based on AS/NZS1547 (2012)

Table M1 (see appendix 1 in current document) indicates that soil profiles with loam topsoils have a LPED design application rate of 3.5 mm/day. However this ignores the effect of local climate. The relatively high rainfall (1337 mm/year) at Narara means that there are times when the soil will have a moisture content above field capacity, and irrigation will result in percolation.

By definition, irrigation increases the water content in soil, and therefore increases the risk that subsequent rainfall will result in percolation. Conversely the irrigation increases the potential evapotranspiration, so that much of the applied water is utilised by the plants. In practice the use of effluent will stimulate plant growth so that water use will approach potential evapotranspiration.

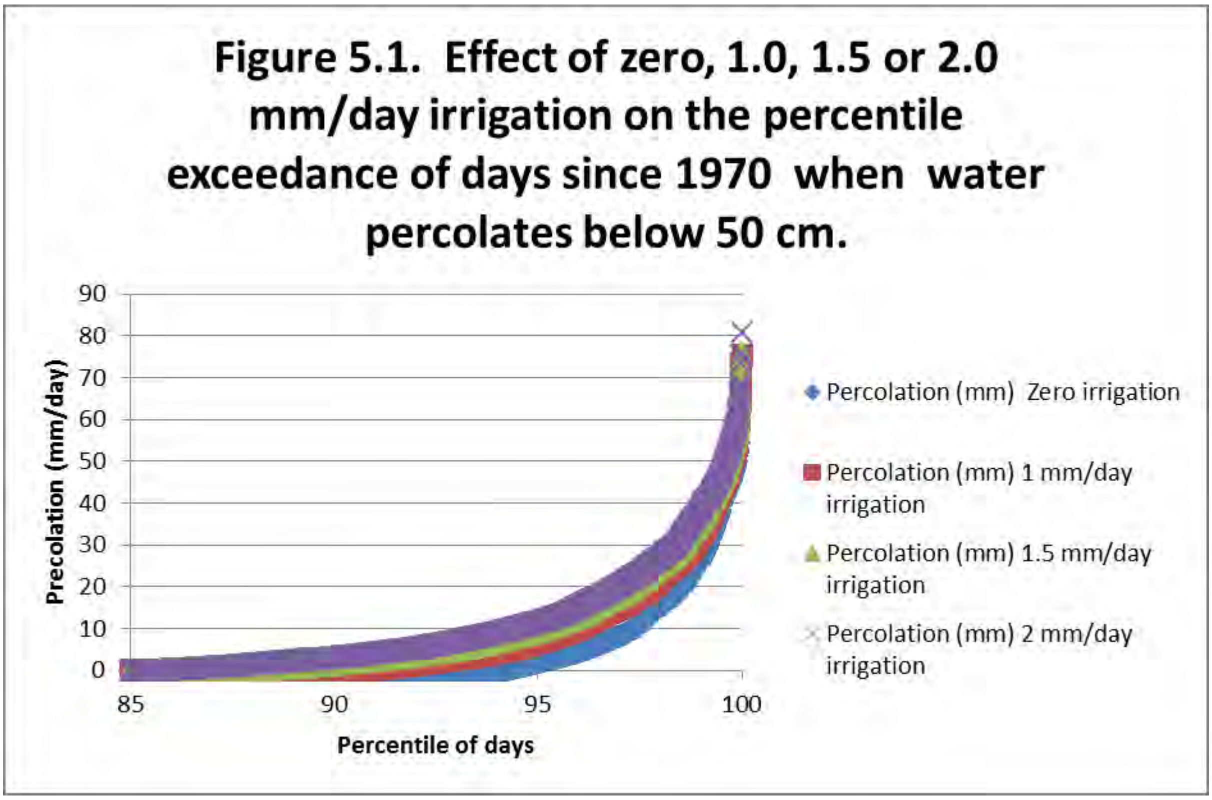


Figure 5.1 shows the effect of increasing irrigation rate on percolation. There is no percolation in over 85% of days. The differences between zero and 1.5 mm/day are trivial to approximately 95%ile of time. There is little difference above the 98%ile of time..

These results suggest minimal difference at least between zero and 1 to 1.5 mm/day.

The application rate of 1.5 mm/day is less than half the recommended design rate of 3.5 mm/day in AS/NZS 1547 (2012), see appendix a, below. That is the proposed application rate is very conservative.

Management to maximise evapotranspiration and to minimise increased percolation.

Deep rooted plants that use a lot of water are an obvious management input. Lucerne is a deep rooted perennial plant. The roots extend 2m into soils types present at Narara. The deep root system enables abstraction of water from deep in the profile during non-rainy periods, thereby providing a storage buffer for subsequent rainfall.

Area requirement for beneficial reuse of effluent.

Assuming that 1.5 mm/day is a reasonable compromise between un-necessarily excessive irrigation area and excessive percolation, the first phase irrigation area requirement is:

11.84 cubic m/day/0.0015 m /day irrigation rate = 7,893 msq of irrigation.

The full development area will produce an estimated 23.75 cubic m of irrigation water per day. Therefore the irrigation requirement is:

23.75 cubic m/day/0.0015 m /day irrigation rate = 15,833 msq of irrigation.

The figure below indicates that this area can be accommodated within the middle rural lot on the left hand side of Narara Creek.

Figure 5.2. The maximum area available for effluent irrigation in the middle lot is 1.62 ha. (Image source: NSW Government).

6. CONCLUSIONS

Effluent produced at both the first phase and at full development can be accommodated within the proposed treatment train.

The design flow assumes the number of persons per dwelling is up to double the average number per dwelling in the Gosford ABS statistical area. Therefore the design flows have a very large 'margin of safety'. Additionally the dwelling owners are expected to be conservative with water use, consistent with the eco-sensitive nature of the development. This conservative approach includes requirements to install high WELS , water conserving taps and low water use washing machines.

The sewage treatment train is designed to exceed the log reduction values required for dual reticulation systems (NRMMC, 2006 and DPI, 2015 a). This feature enables the treated effluent to be used for toilet flushing and domestic gardens. Reclaimed water in excess of domestic needs will be applied by subsurface irrigation to the central rural block to the east of the Narara Creek. The loam soils in this area are especially suitable for effluent irrigation. Additionally the effluent application will address nutrient deficiency in the area.

The design application rate at full development will be less than half the recommended design irrigation rate for subsurface irrigation in AS/NZS 1547 (2012). This adds a further margin of safety to the system.

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Appendix 1. Table M1 from AS/NZS 1547 (2012)

TABLE M1
RECOMMENDED DESIGN IRRIGATION RATE (DIR) FOR IRRIGATION SYSTEMS

Soil Category (see Note 1)	Soil texture	Structure	Indicative permeability (K_{sat}) (m/d)	Design irrigation rate (DIR) (mm/day)		
				Drip irrigation	Spray irrigation	LPED irrigation
1	Gravels and sands	Structureless (massive)	> 3.0	5 (see Note 2)	5	(see Note 3)
2	Sandy loams	Weakly structured massive	> 3.0			4
			1.4 – 3.0			
3	Loams	High/ moderate structured	1.5 – 3.0	4 (see Note 1)	4	3.5
		Weakly structured or massive	0.5 – 1.5			
4	Clay loams	High/ moderate structured	0.5 – 1.5	3.5 (see Note 1)	3.5	3
		Weakly structured	0.12 – 0.5			
		Massive	0.06 – 0.12			
5	Light clays	Strongly structured	0.12 – 0.5	3 (see Note 1)	3	2.5 (see Note 4)
		Moderately structured	0.06 – 0.12			
		Weakly structured or massive	< 0.06			
6	Medium to heavy clays	Strongly structured	0.06 – 0.5	2 (see Note 2)	2	(see Note 3)
		Moderately structured	< 0.06			
		Weakly structured or massive	< 0.06			

Appropriate design rate

NOTES:

1 For Category 3 to 5 soils (loams to light clays), the drip irrigation system needs to be installed in an adequate depth of topsoil (in the order of 150 – 250 mm of *in situ* or imported good quality topsoil) to slow the soakage and assist with nutrient reduction.

2 For Category 1, 2, and 6 soils, the drip irrigation system has a depth of 100 – 150 mm in good quality topsoil (see CM1 and M3.1).

3 LPED irrigation is not advised for Category 1 or Category 6 soils – drip irrigation of secondary effluent is the preferred irrigation method.

4 LPED irrigation for Category 5 soils needs a minimum depth of 250 mm of good quality topsoil (see M5 and CM7.1).