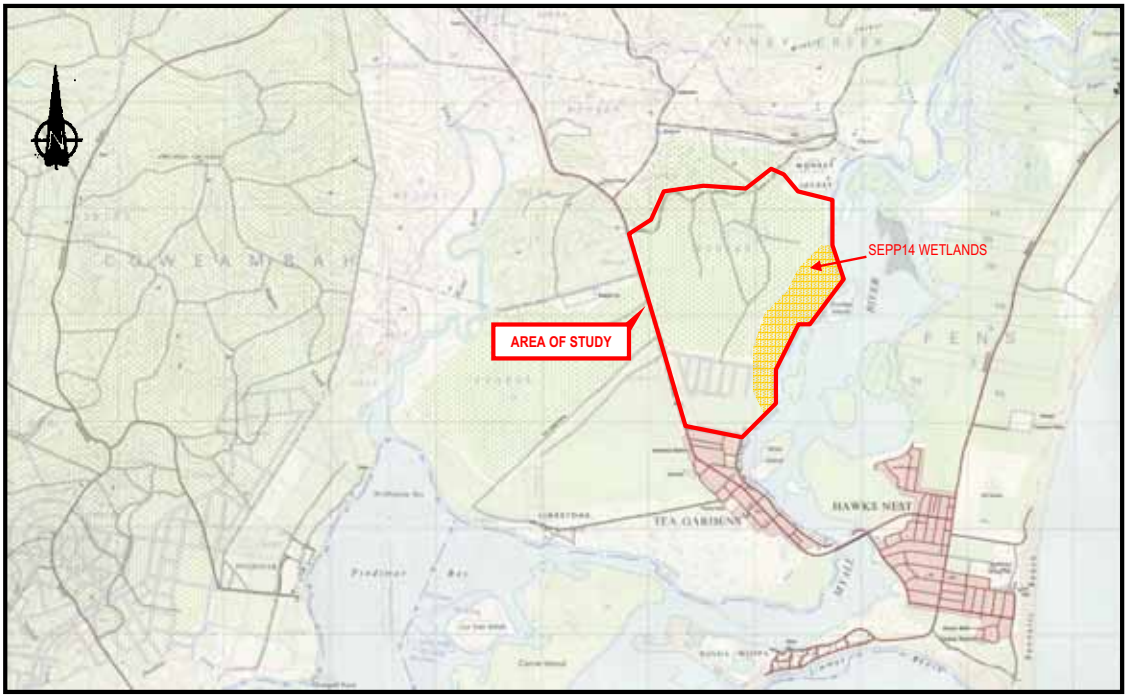
Figures

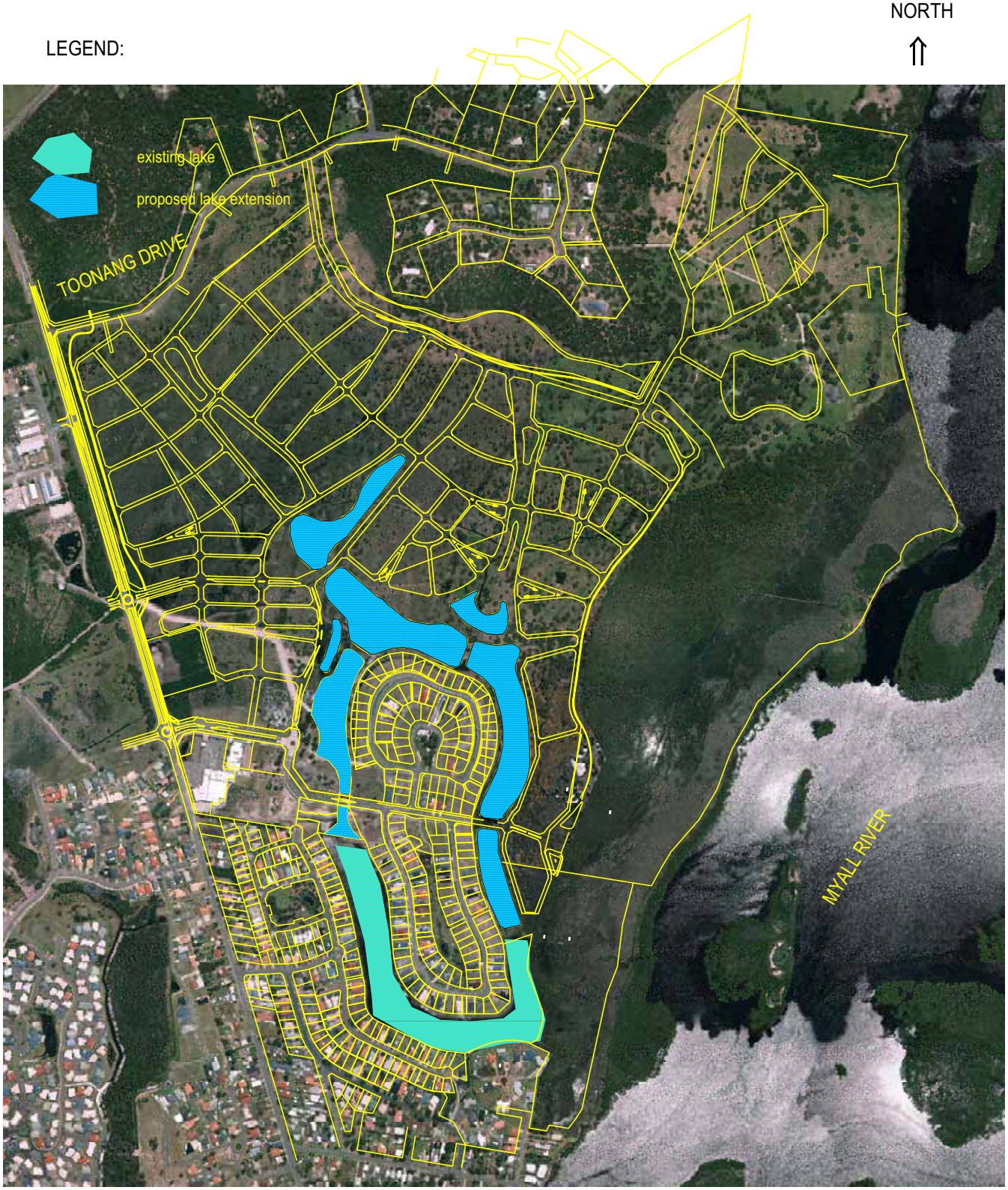


REFERENCE:
Central Mapping Authority of NSW (1976)
Port Stephens Topographic Map
9332-IV-S First Edition 1:25000 Series

Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES GROUNDWATER ASSESSMENT MYALL QUAYS DEVELOPMENT SITE LOCATION PLAN	**FIGURE 1**
Approved	RJB		
Date	23/04/07		
Scale	1:500,000		Job no: **GEOTLCOV23225**

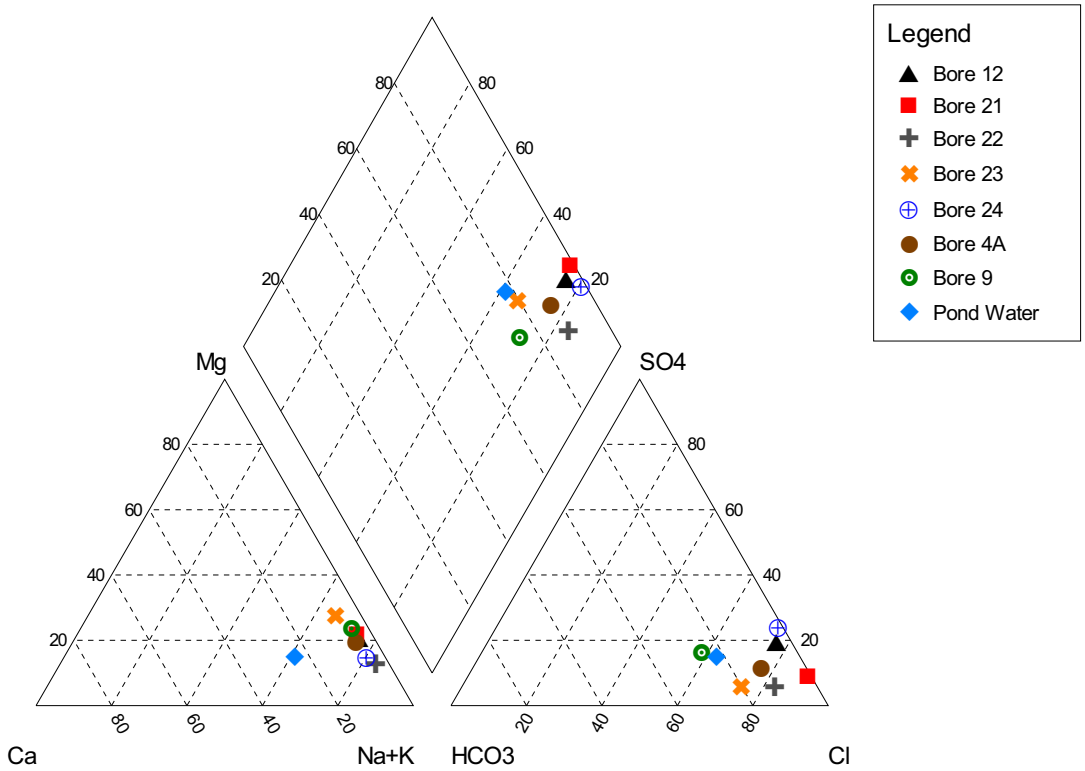
LEGEND:

NORTH



Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	AF	CRIGHTON PROPERTIES GROUNDWATER ASSESSMENT MYALL QUAYS DEVELOPMENTS PROPOSED DEVELOPMENT	**FIGURE 2**
Approved	RJB		
Date	23/04/2007		
Scale	NTS		Job No: GEOTLCOV23255

Piper Plot - Surface and Groundwater Samples

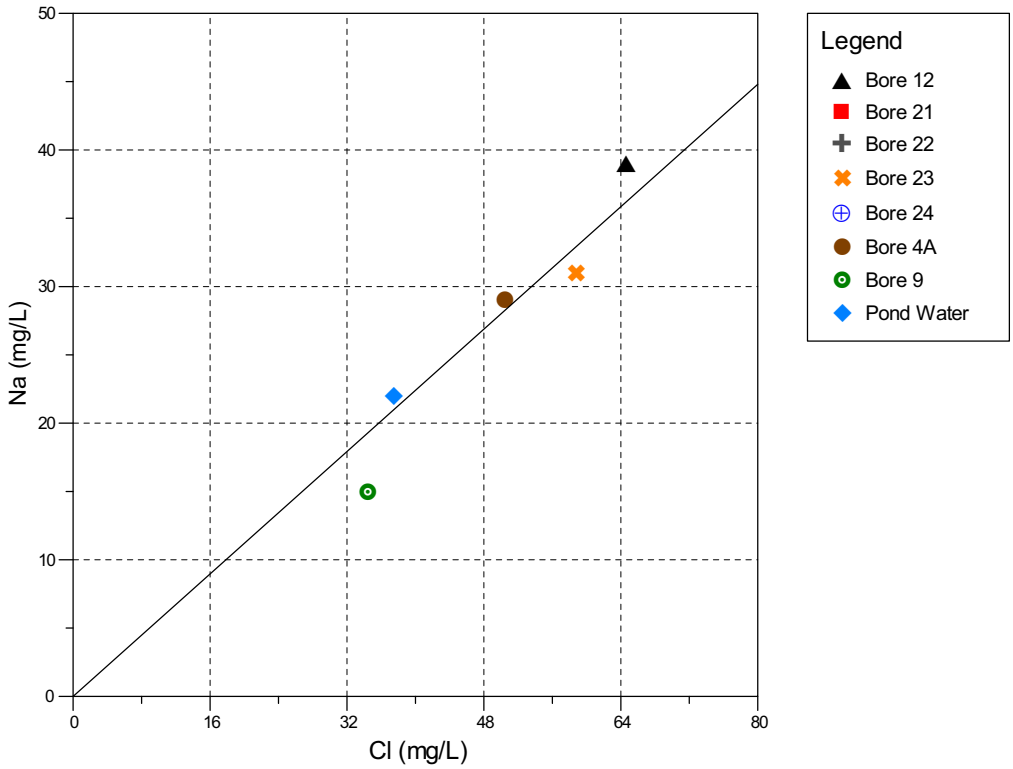


drawn	JN
approved	
date	20/04/07
scale	NTS
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

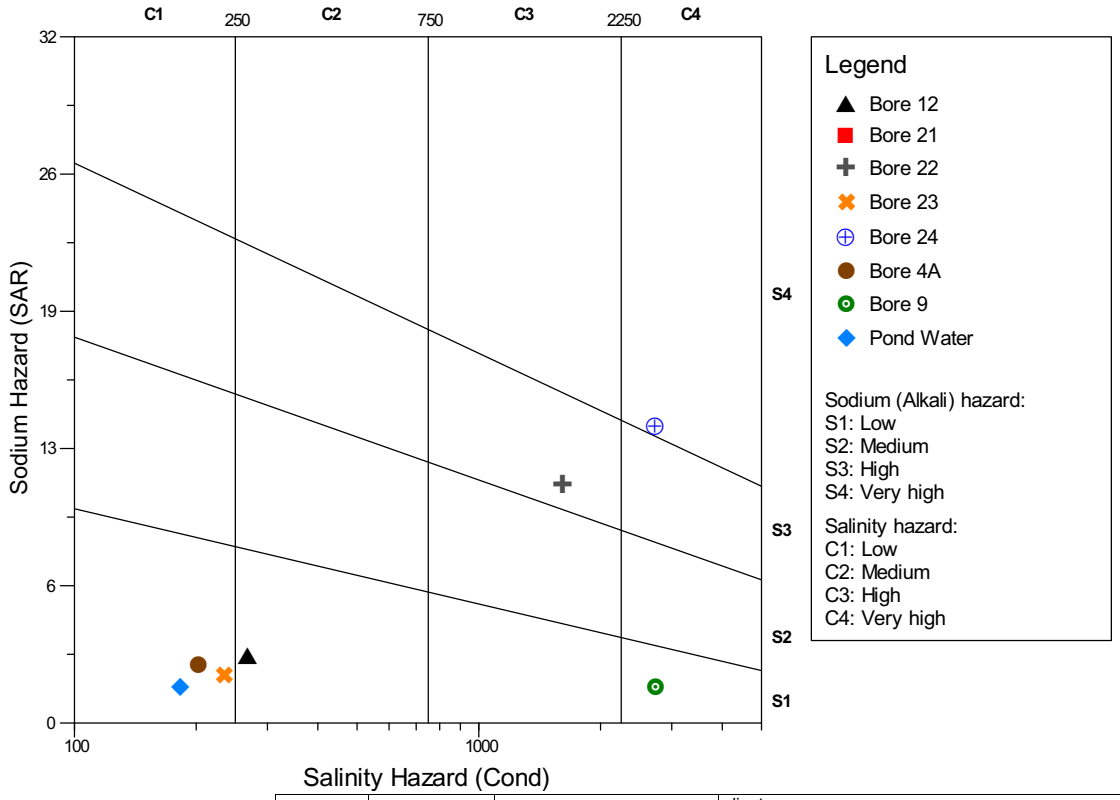
client:	CARDNO WILLING
project:	GROUNDWATER ASSESSMENT RIVERSIDE DEVELOPMENT TEA GARDENS
title:	Piper Diagram – Groundwater and Surface Water Samples
project no: GEOTLCOV23225AA	figure no: FIGURE 3

Seawater Dilution Ratio Na: Cl



drawn	JN	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	CARDNO WILLING
approved			project:	GROUNDWATER ASSESSMENT RIVERSIDE DEVELOPMENT TEA GARDENS
date	20/04/07		title:	Seawater Dilution Ratio Na:Cl for selected samples
scale	NTS		project no: GEOTLCOV23225AA	figure no: FIGURE 4
original size	A4			

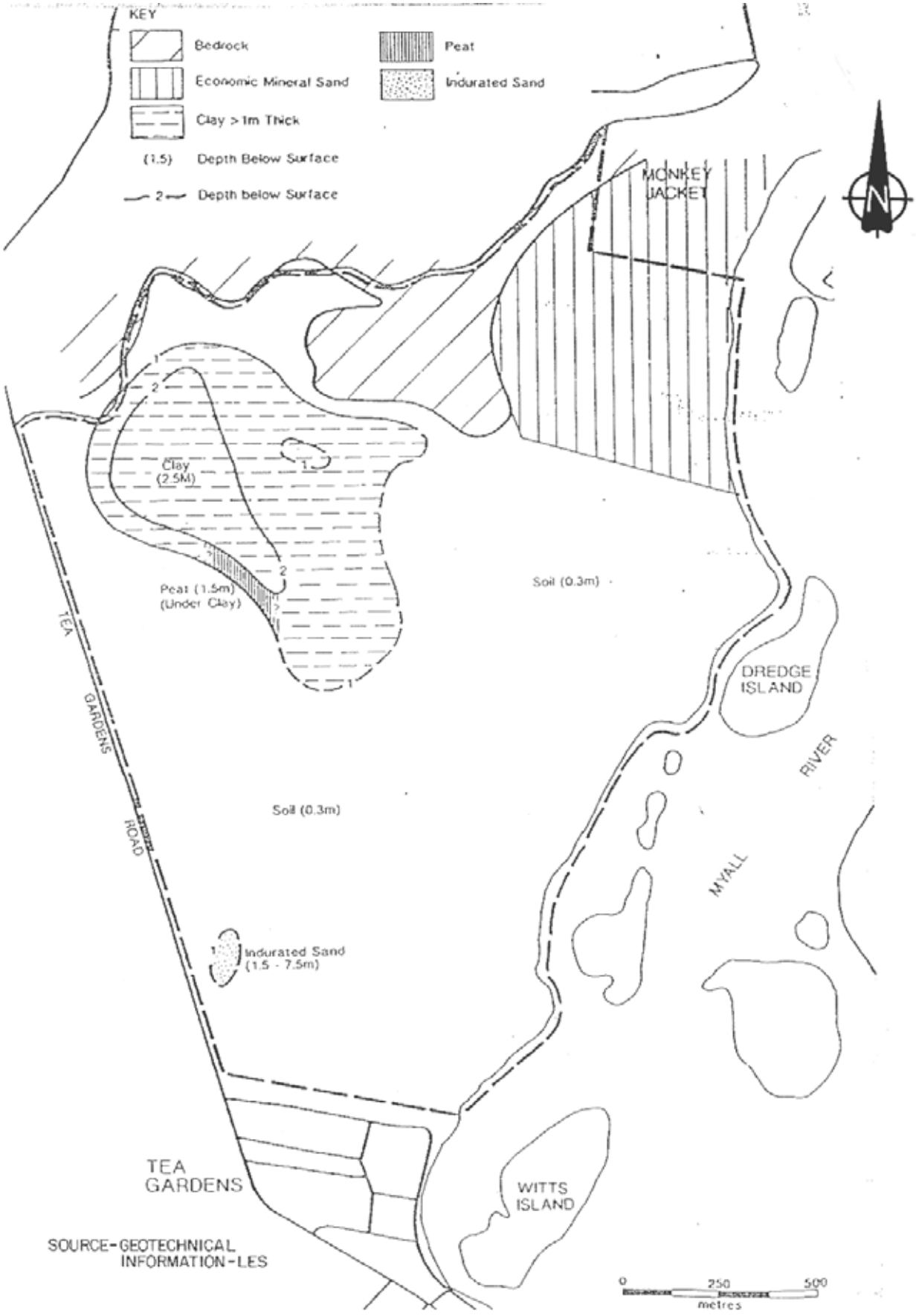
Wilcox Diagram - Groundwater and Surface Water Samples



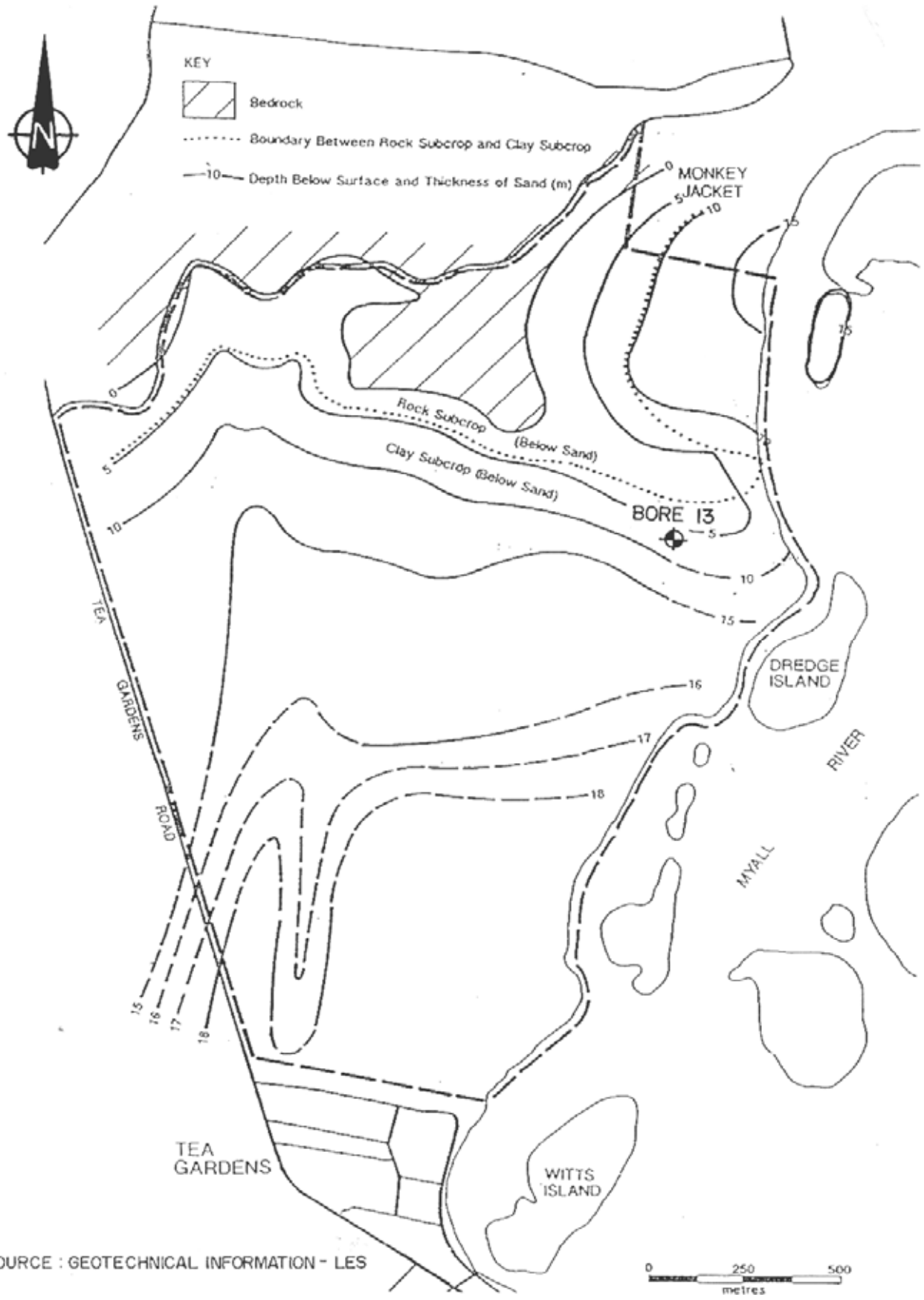
drawn	JN
approved	
date	20/04/07
scale	NTS
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

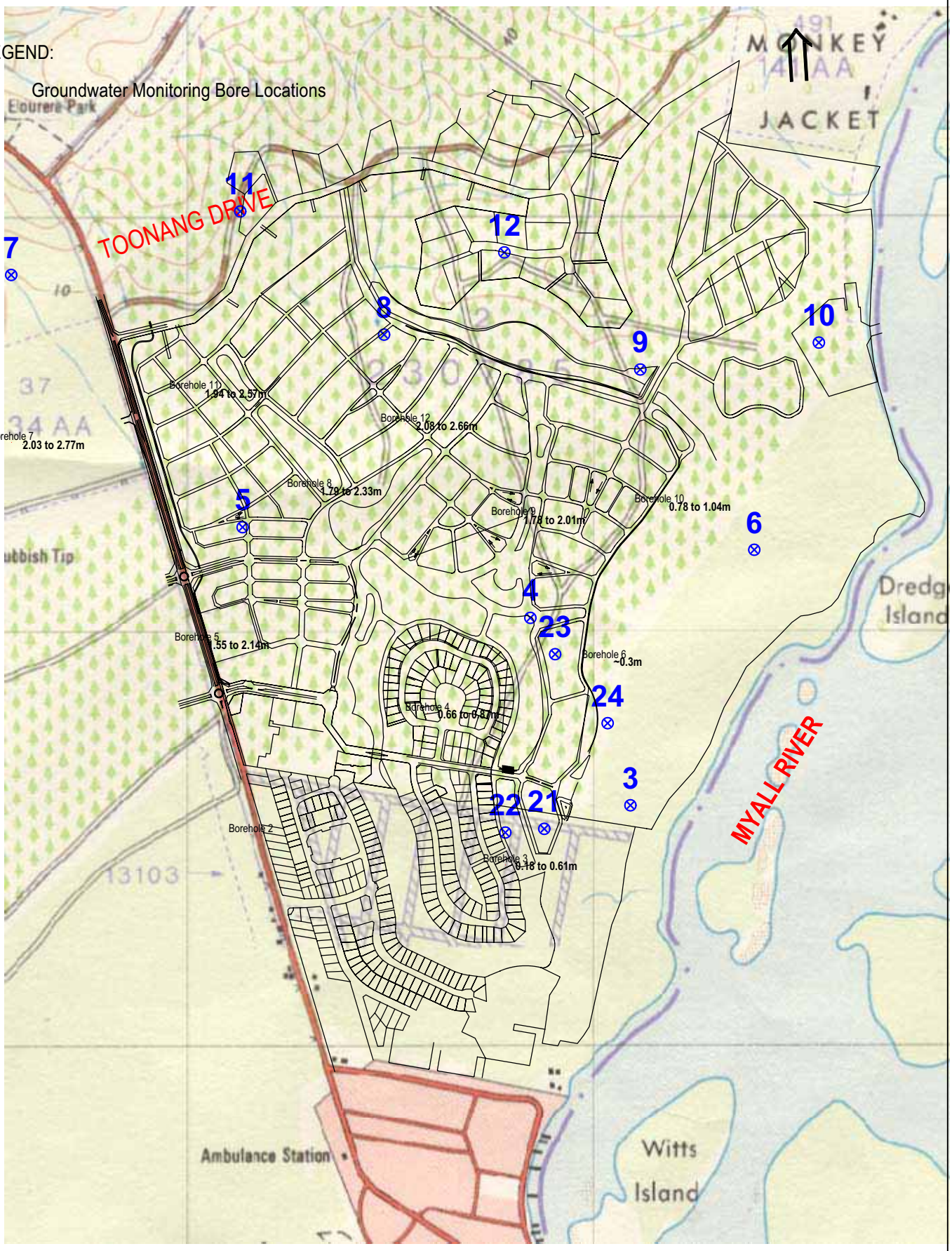
client:	CARDNO WILLING
project:	GROUNDWATER ASSESSMENT RIVERSIDE DEVELOPMENT TEA GARDENS
title:	Wilcox Diagram – Groundwater and Surface Water Samples
project no: GEOTLCOV23225AA	figure no: FIGURE 5



Coffey Geotechnics Pty Ltd		Geotechnical **I Resources I** Environmental **I Technical I** Project Management	
Drawn	**EW/RJB**	**CRIGHTON PROPERTIES GROUNDWATER ASSESSMENT MYALL QUAYS DEVELOPMENT EXTENT OF SURFACE CLAY**	Drawing no: **FIGURE 6**
Approved	**RJB**		
Date	**23/04/07**		
Scale	**As Shown**		Job no: **GEOTLCO23225**



Coffey Geotechnics Pty Ltd ACN 056 335 516		Geotechnical **I Resources I** Environmental **I Technical I** Project Management	
Drawn	**EW/RJB**	**CRIGHTON PROPERTIES** **GROUNDWATER ASSESSMENT** **MYALL QUAYS DEVELOPMENT** **SAND THICKNESS**	Drawing no: **FIGURE 7**
Approved	**RJB**		
Date	**23/04/07**		
Scale	**As Shown**		Job no: **GEOTLCOV23225**

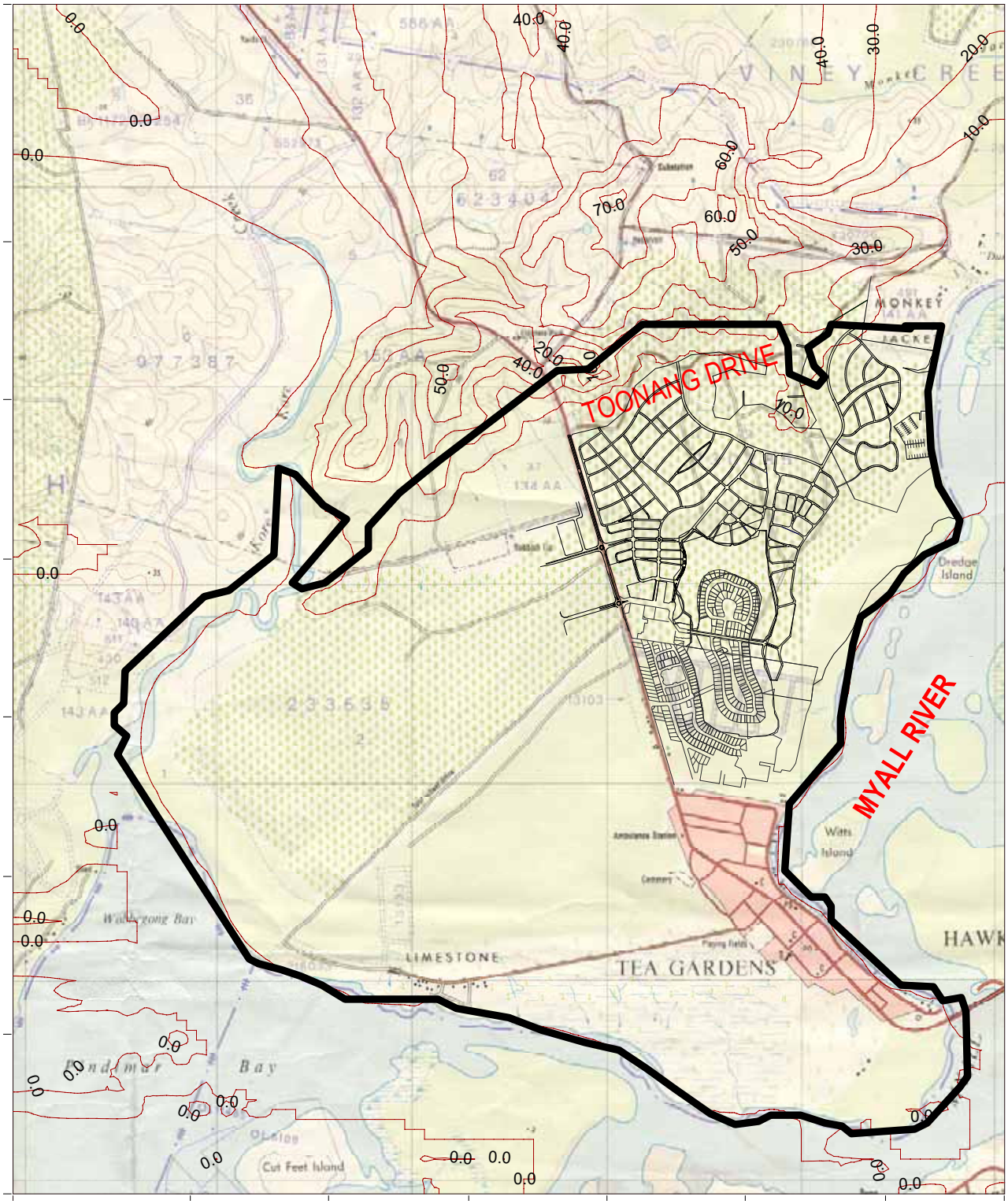


Coffey Geotechnics Pty Ltd	ABN 57 056 335 516 ACN 056 335 516	Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES	**FIGURE 8**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/04/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:12500	GROUNDWATER MONITORING BORE LOCATIONS	Job No: GEOTLCOV 23225

NORTH

LEGEND:

Extent of the Modflow Model

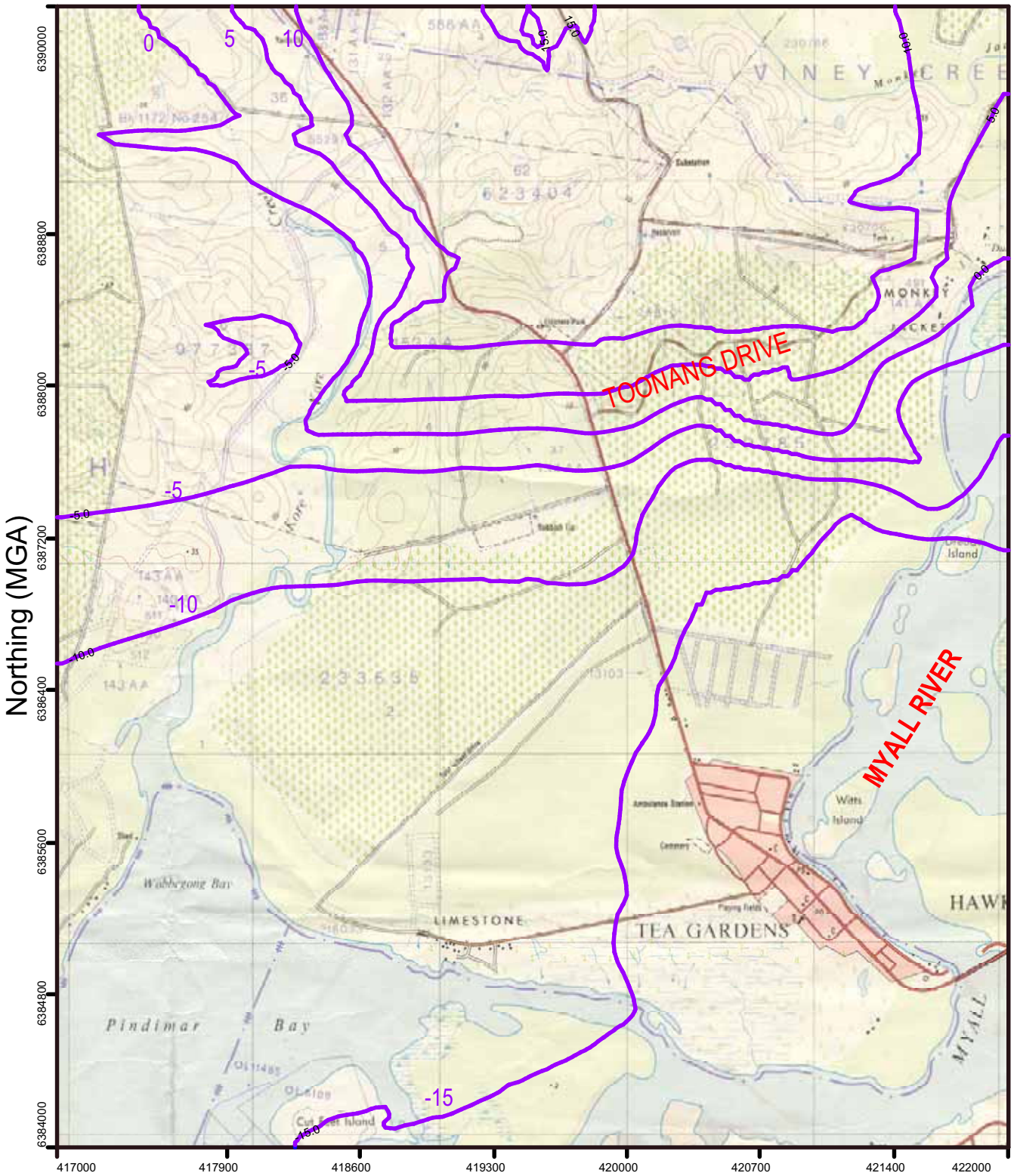


Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES	**FIGURE 9**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/04/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:30000	EXTENT OF MODFLOW MODEL	Job No: GEOTLCOV23225

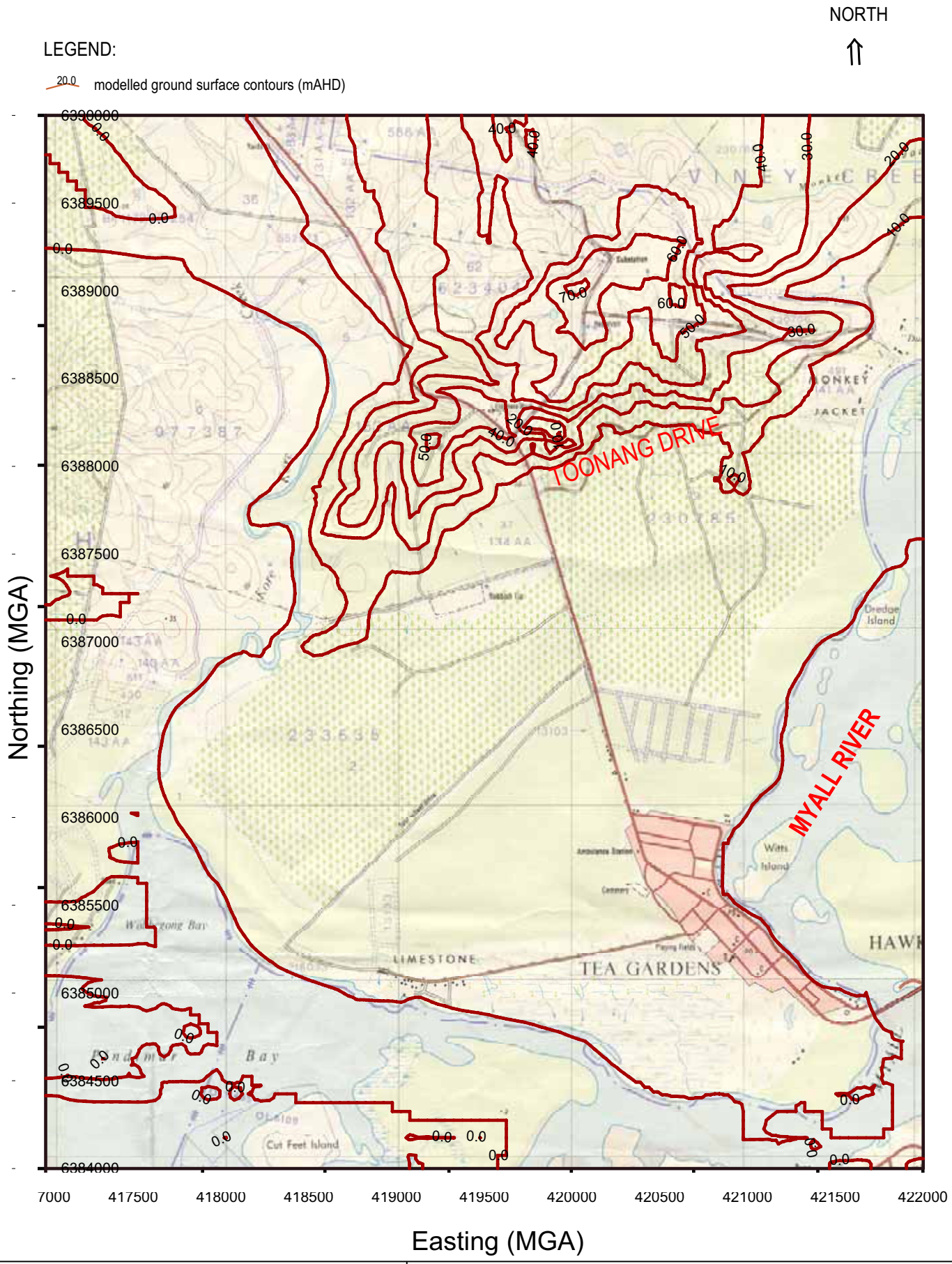
NORTH

LEGEND:

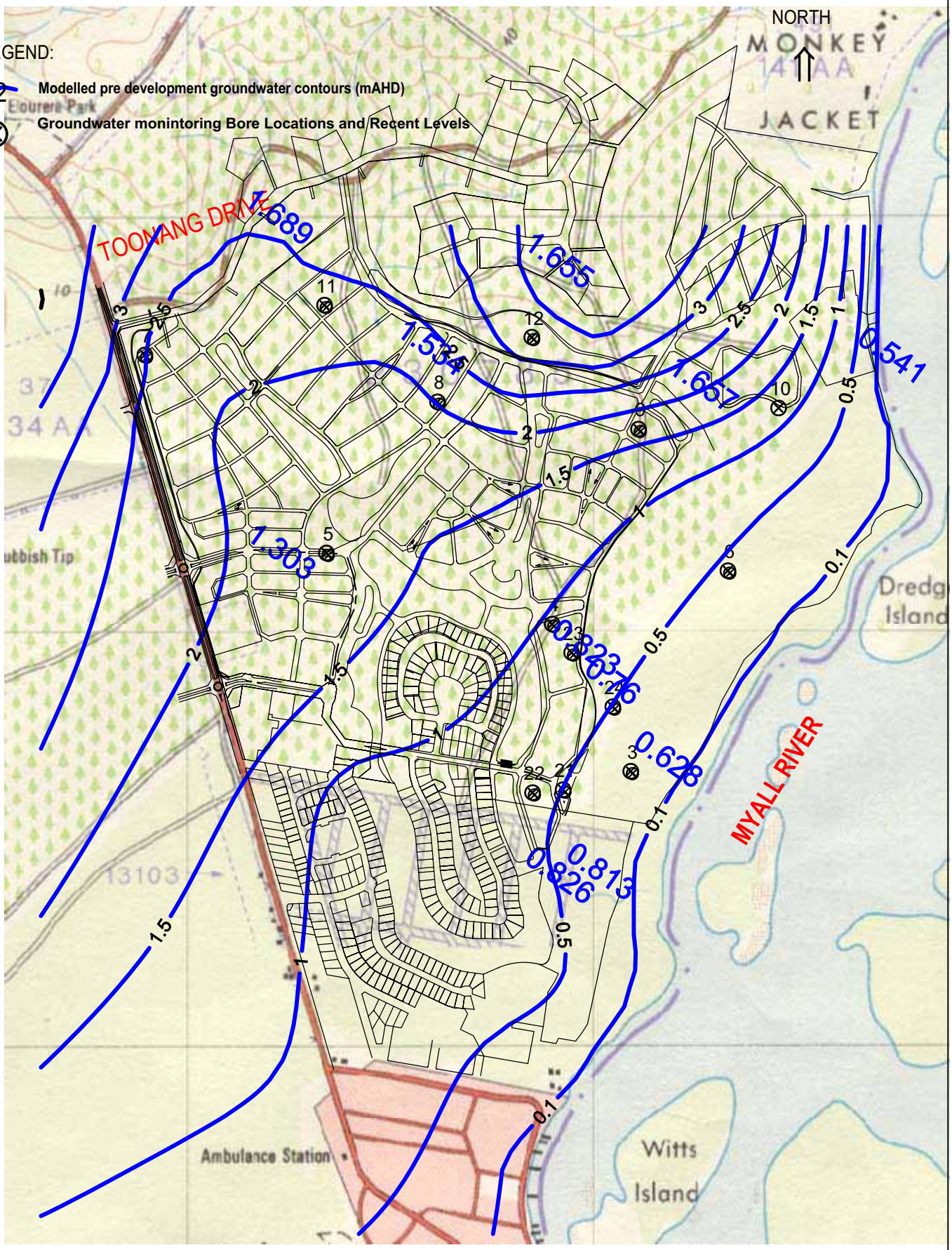
modelled top of rock level contours (mAHD)



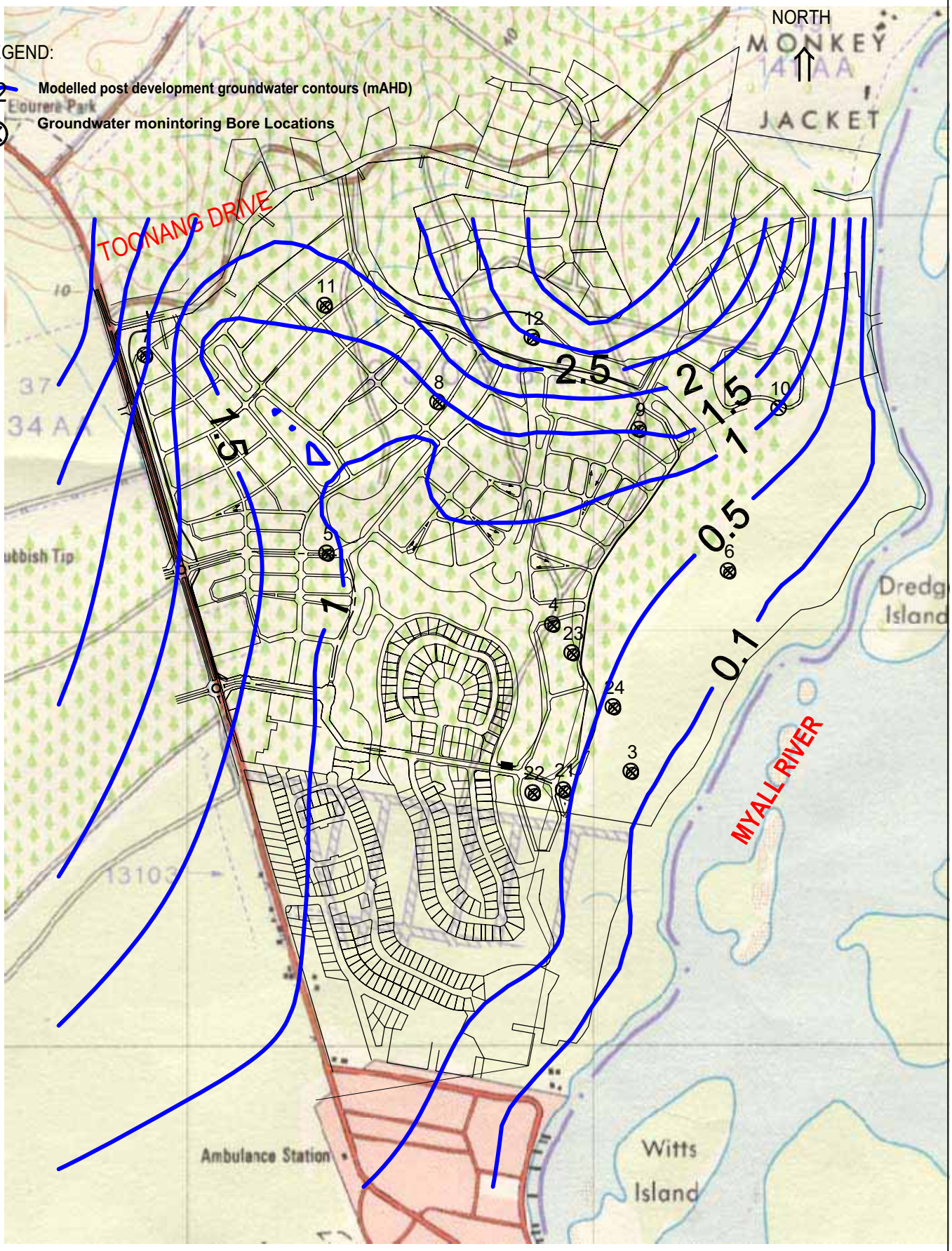
Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES	**FIGURE 10**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/04/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:30000	MODELLED ROCK LEVEL CONTOURS	Job No: GEOTLCOV23225



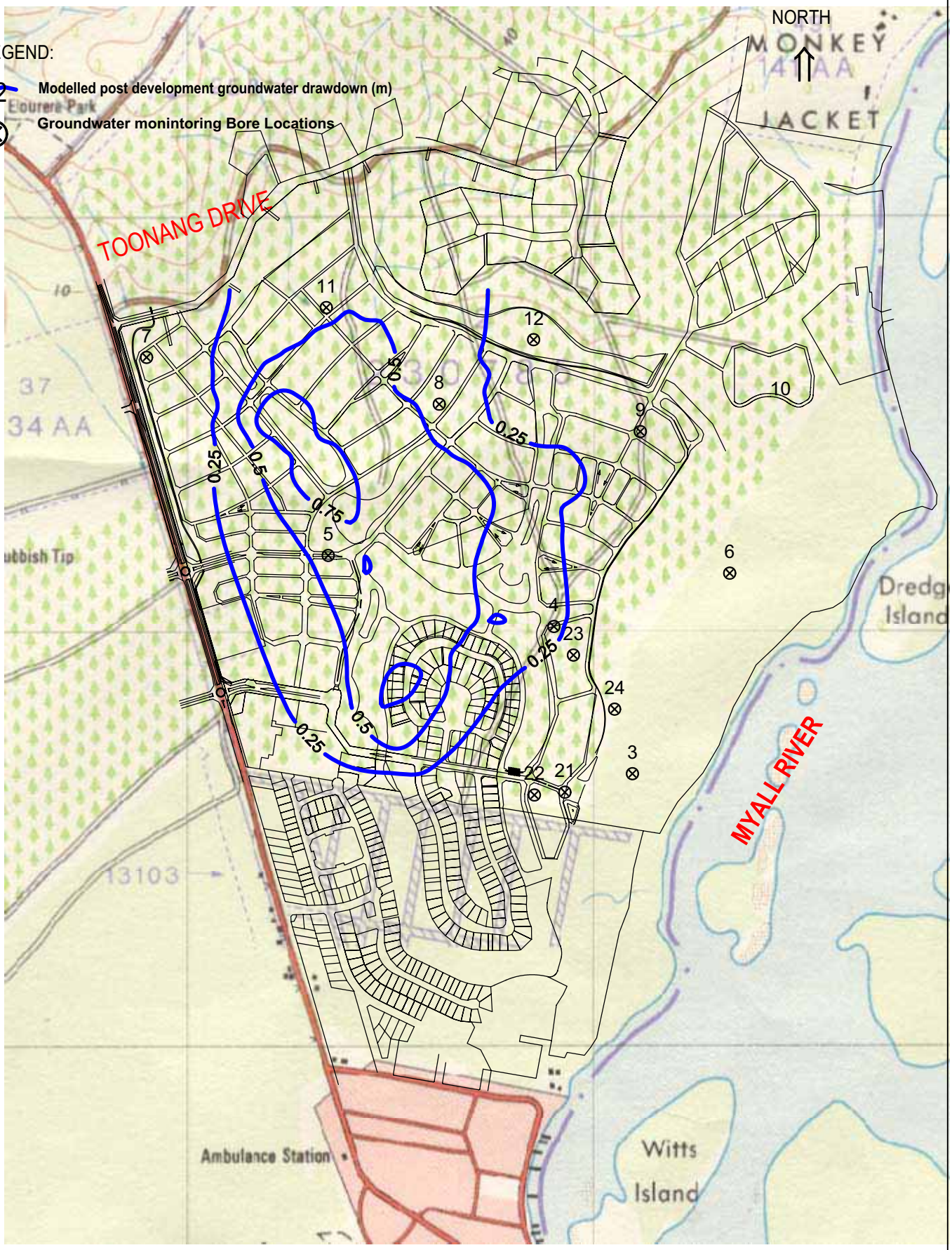
Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES	**FIGURE 11**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/04/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:30000	MODELLED GROUND SURFACE CONTOURS	Job No: GEOTLCOV23225



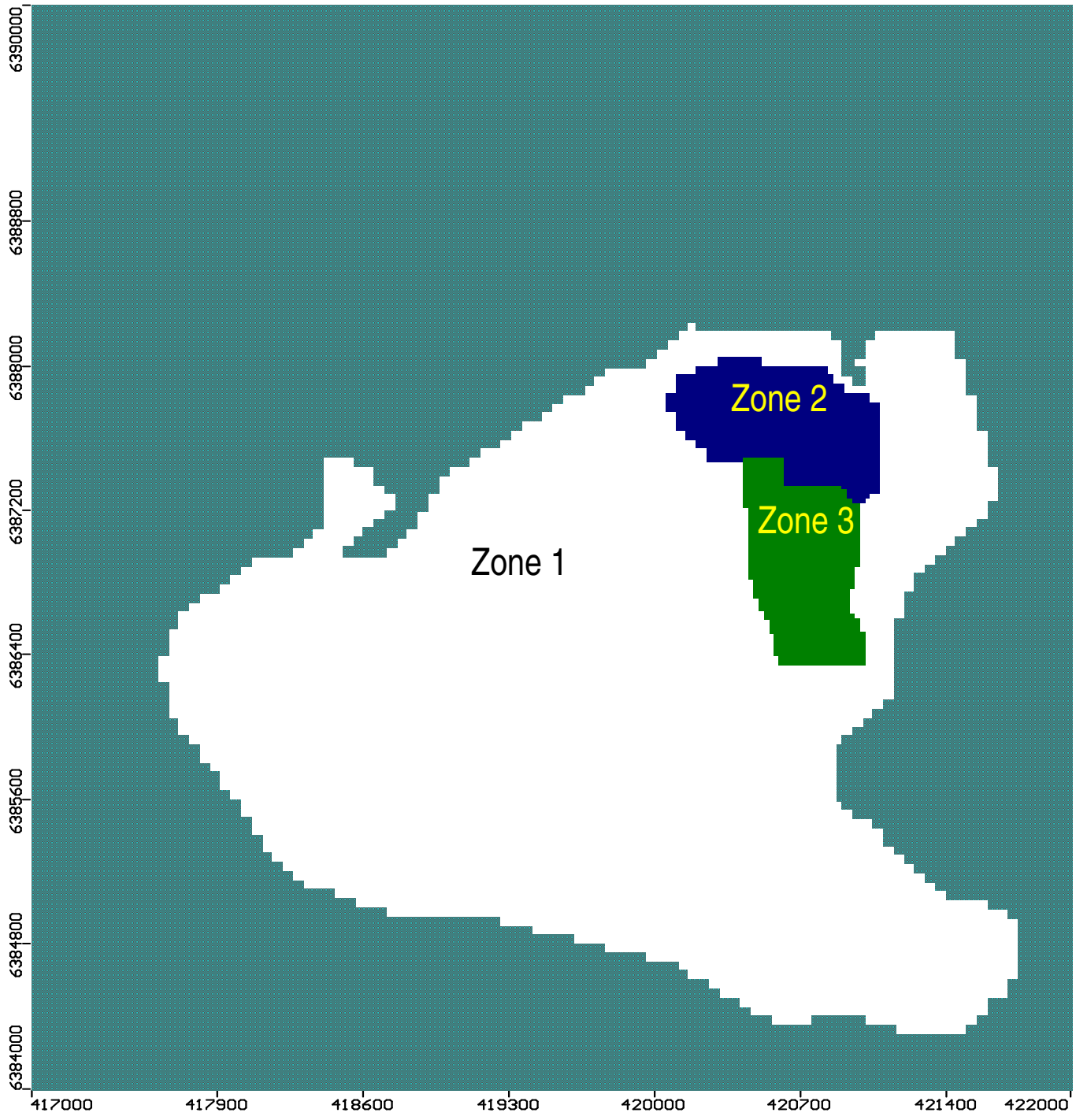
Coffey Geotechnics Pty Ltd		Geotechnical | **Resources** | Environmental | **Technical** |	
Drawn	AF	CRIGHTON PROPERTIES	**FIGURE 12**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/04/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:12500	MODELLED PRE DEVELOPMENT GROUNDWATER CONTOURS	Job No: GEOTLCOV23225



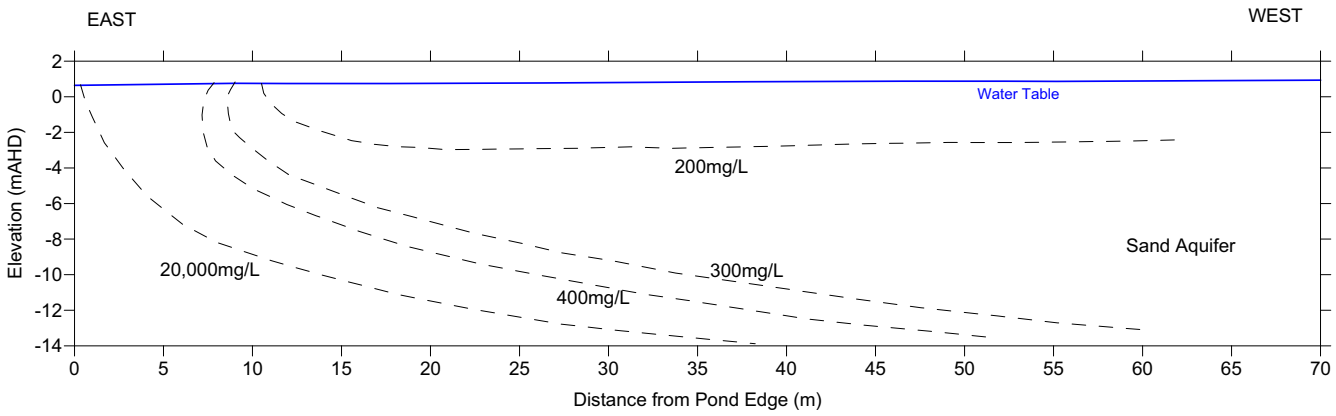
Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I	
Drawn	AF	CRIGHTON PROPERTIES	**FIGURE 13**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	26/10/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:12500	MODELLED POST DEVELOPMENT GROUNDWATER CONTOURS	Job No: GEOTLCOV23225



Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I	
Drawn	AF	CRIGHTON PROPERTIES	**FIGURE 14**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	26/10/2007	MYALL QUAYS DEVELOPMENTS	
Scale	1:12500	MODELLED POST DEVELOPMENT GROUNDWATER DRAWDOWN	Job No: GEOTLCOV23225



drawn	AF	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Crighton Properties
approved	RJB		project:	Myall Quays Development Myall Quays
date	4/04/2007		title:	Mass Balance Budget Zones
scale	AS SHOWN		project no: GEOTLCOV 23225	figure no: FIGURE 15
original size	A4			



— — Interpreted concetration contour for total dissolved solids

drawn	PT
approved	RJB
date	Apr 2007
scale	1:300
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: Cardno Willing

project: Groundwater Assessment
Riverside Development
Tea Gardens, NSW

title: **INTERPRETED TYPICAL SALINITY CONTOURS**

project no: GEOTLCOV23225AA

figure no: **FIGURE 16**

Appendix A

TABLE LR1

SUMMARY OF RESULTS

GROUNDWATER

All results in mg/L unless stated

SAMPLE ID	ANZECC Marine (slightly to moderately disturbed system)	NHMRC Human Health Guidelines	ANZECC Irrigation and General Use (moderately sensitive crops)	4A	9	12	21
MATRIX				WATER	WATER	WATER	WATER
SAMPLE DATE				29/03/2007	30/03/2007	29/03/2007	29/03/2007
GENERAL PARAMETERS							
pH (pH Unit)		6.5-8.5 [7]		5.32	3.99	5.02	5.62
Electrical Conductivity (µS/cm)				202	178	268	15500
Total Dissolved Solids		500 [7]		155	200	1210	11500
Total Hardness as $CaCO_3$		200 [7]		23	14	29	2040
SAR				19.3	15	19.5	19.4
MAJOR ANIONS							
Sulphate as SO_4^{2-}				10	13	22	702
Chloride		250 [7]	175-350 [3]	50.4	34.4	64.6	**5300**
Bicarbonate Alkalinity as $CaCO_3$				14	26	6	92
Total Alkalinity as $CaCO_3$				14	26	6	92
MAJOR CATIONS							
Calcium				2	<1	2	126
Magnesium				4	3	6	420
Sodium		180 [7]	115-230 [3]	29	15	39	**2650**
Potassium				<1	4	4	65
HEAVY METALS							
Arsenic	0.0023 [2]	0.007 [6]	0.1 [4]	<0.001	<0.001	<0.001	0.002
Cadmium	0.014 [1]	0.002 [6]	0.01 [4]	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.0486 [1]	0.05 [6]	0.1 [4]	<0.001	<0.001	<0.001	0.002
Copper	0.003 [1]	2.0 [6]	0.2 [4]	<0.001	<0.001	<0.001	0.001
Lead	0.0066 [1]	0.01 [6]	2.0 [4]	<0.001	<0.001	<0.001	<0.001
Nickel	0.2 [1]	0.02 [6]	0.2 [4]	<0.001	<0.001	<0.001	<0.001
Zinc	0.023 [1]	3.0 [7]	2.0 [4]	0.085	0.017	0.009	<0.005
Mercury	0.0007 [1]	0.001 [6]	0.002 [4]	<0.0001	<0.0001	<0.0001	<0.0001
NUTRIENTS							
Ammonia as N		0.5 [7]		0.212	0.545	0.303	0.934
Nitrite as N		3 [6]		<0.010	0.028	0.027	<0.010
Nitrate as N		50 [6]		0.034	<0.010	0.039	0.027
Nitrite + Nitrate as N				0.034	0.034	0.066	0.027
Total Kjeldahl Nitrogen as N			5.0 [4]	0.9	2.5	3	**12.1**
Total Phosphorus as P			0.05 [4, 5]	**0.14**	**1**	**0.76**	**1.38**
Reactive Phosphorus as P				0.017	0.799	0.036	0.035
TOC / BOD							
Total Organic Carbon				16	-	22	109
Biochemical Oxygen Demand				9	-	<2	<2

Concentration exceeds the respective ANZECC (2000) Marine Water Guideline for slightly to moderately disturbed systems

Concentration exceeds the respective human health guideline NHMRC (2004) for drinking water

5 Concentration exceeds the respective ANZECC (2000) Irrigation Water Guideline for moderately sensitive crops / long term use

[1] ANZECC (2000) Marine Water Guidelines for protection of 90% of species in slightly to moderately disturbed systems

[2] Low reliability trigger level

[3] ANZECC (2000) Guidelines for irrigation and general use - moderately sensitive crops

[4] ANZECC (2000) Guidelines for irrigation and general use - long-term trigger value

[5] To minimise bioclogging of irrigation equipment only

[6] Human Health Guidelines (NHMRC, 2004)

[7] Aesthetic Guidelines (NHMRC, 2004)

- Not Analysed

TABLE LR2

RESULTS 2004 and

SAMPLE RANGE OF RESULTS 2004-2007

All results in mg/L unless stated

SAMPLE ID	ANZECC Marine (slightly to moderately disturbed system)		NHMRC Human Health Guidelines		ANZECC Irrigation and General Use (moderately sensitive crops)		BORE 4A	BORE 9	BORE 12
							2007 results	2007 results	2007 results
SAMPLE DATE							(range 2004-1007)	(range 2004-1007)	(range 2004-1007)
GENERAL PARAMETERS									
pH (pH Unit)			6.5-8.5	[7]			5.32 (5.24-6.26)	3.99 (3.99-4.43)	5.02 (5.02-6.12)
Electrical Conductivity (µS/cm)							202 (159-239)	178 (141-178)	268 (254-290)
Total Dissolved Solids			500	[7]			155 (106-185)	200 (162-200)	1210 (197-1210)
Total Hardness as $CaCO_3$			200	[7]			23 (17-23)	14 (12-14)	29 (21-29)
MAJOR ANIONS									
Sulphate as SO_4^{2-}							10 (4-15)	13 (6-34)	22 (15-22)
Chloride			250	[7]	175-350	[3]	50.4 (40-51)	34.4 (25-37)	64.6 (57-65)
Total Alkalinity as $CaCO_3$							14 (7-14)	26 (<1-26)	6 (6-8)
MAJOR CATIONS									
Calcium							2 (<1-2)	<1 (<1)	2 (1)
Magnesium							4 (4)	3 (3-4)	6 (5)
Sodium			180	[7]	115-230	[3]	29 (19-36)	15 (14-19)	39 (38-43)
Potassium							<1 (<1)	4 (<1-4)	4 (2)
HEAVY METALS									
Arsenic	0.0023	[2]	0.007	[6]	0.1	[4]	<0.001 (<0.001-0.002)	<0.001	<0.001 (<0.001-0.002)
Cadmium	0.014	[1]	0.002	[6]	0.01	[4]	<0.0001 (<0.0001-<0.001)	<0.0001 (<0.0001-<0.001)	<0.0001 (<0.0001-<0.001)
Chromium	0.0486	[1]	0.05	[6]	0.1	[4]	<0.001 (<0.001-0.002)	<0.001 (<0.001-0.004)	<0.001 (<0.001-0.001)
Copper	0.003	[1]	2.0	[6]	0.2	[4]	<0.001 (<0.001-0.235)	<0.001 (<0.001-0.008)	<0.001
Lead	0.0066	[1]	0.01	[6]	2.0	[4]	<0.001 (<0.001-0.026)	<0.001 (<0.001-0.006)	<0.001 (<0.001-0.017)
Zinc	0.023	[1]	3.0	[7]	2.0	[4]	0.085 (0.047-0.140)	0.017 (0.006-0.017)	0.009 (0.009-0.026)
NUTRIENTS									
Ammonia as N			0.5	[7]			0.212 (0.07-0.21)	0.545 (0.37-0.55)	0.303 (0.17-0.3)
Nitrite + Nitrate as N							0.034 (0.02-0.034)	0.034 (0.02-0.07)	0.066 (0.01-0.07)
Total Kjeldahl Nitrogen as N					5.0	[4]	0.9 (0.5-1)	2.5 (1.6-3.6)	3 (1.2-3)
Total Phosphorus as P					0.05	[4, 5]	0.14 (<0.01-0.14)	1 (0.46-1.08)	0.76 (0.13-0.76)
TOC / BOD									
Total Organic Carbon							16 (6-10)	42-51	22 (20-47)
Biochemical Oxygen Demand							9 (<2-9)	<2-2	<2 (<2)

TABLE LR1

SUMMARY OF RESULTS

GROUNDWATER

All results in mg/L unless stated

SAMPLE ID	ANZECC Marine (slightly to moderately disturbed system)	NHMRC Human Health Guidelines	ANZECC Irrigation and General Use (moderately sensitive crops)	22	23	24	POND
MATRIX				WATER	WATER	WATER	WATER
SAMPLE DATE				29/03/2007	29/03/2007	29/03/2007	30/03/2007
GENERAL PARAMETERS							
pH (pH Unit)		6.5-8.5 [7]		6.05	5.6	5.46	5.83
Electrical Conductivity (µS/cm)				1610	234	2730	182
Total Dissolved Solids		500 [7]		1350	212	2250	129
Total Hardness as $CaCO_3$		200 [7]		123	39	300	33
SAR				33.3	12.4	25.9	8.0
MAJOR ANIONS							
Sulphate as SO_4^{2-}				39	6	344	12
Chloride		250 [7]	175-350 [3]	**430**	58.7	**800**	37.4
Bicarbonate Alkalinity as $CaCO_3$				102	28	26	23
Total Alkalinity as $CaCO_3$				102	28	26	23
MAJOR CATIONS							
Calcium				11	3	31	8
Magnesium				23	7	54	3
Sodium		180 [7]	115-230 [3]	**283**	31	**551**	22
Potassium				7	1	24	2
HEAVY METALS							
Arsenic	0.0023 [2]	0.007 [6]	0.1 [4]	0.001	<0.001	0.006	<0.001
Cadmium	0.014 [1]	0.002 [6]	0.01 [4]	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.0486 [1]	0.05 [6]	0.1 [4]	0.007	<0.001	0.005	<0.001
Copper	0.003 [1]	2.0 [6]	0.2 [4]	<0.001	<0.001	0.001	0.005
Lead	0.0066 [1]	0.01 [6]	2.0 [4]	<0.001	<0.001	<0.001	<0.001
Nickel	0.2 [1]	0.02 [6]	0.2 [4]	<0.001	<0.001	0.003	0.001
Zinc	0.023 [1]	3.0 [7]	2.0 [4]	<0.005	0.008	0.016	0.029
Mercury	0.0007 [1]	0.001 [6]	0.002 [4]	<0.0001	<0.0001	<0.0001	<0.0001
NUTRIENTS							
Ammonia as N		0.5 [7]		0.655	0.179	0.893	<0.010
Nitrite as N		3 [6]		0.087	<0.010	0.013	<0.010
Nitrate as N		50 [6]		<0.010	0.013	0.013	0.02
Nitrite + Nitrate as N				0.037	0.013	0.026	0.02
Total Kjeldahl Nitrogen as N			5.0 [4]	7.2	2.5	**9.3**	0.7
Total Phosphorus as P			0.05 [4, 5]	**0.79**	**0.32**	**1.12**	**0.08**
Reactive Phosphorus as P				0.095	-	0.062	<0.010
TOC / BOD							
Total Organic Carbon				189	56	94	-
Biochemical Oxygen Demand				<2	9	<2	5

Concentration exceeds the respective ANZECC (2000) Marine Water Guideline for slightly to moderately disturbed systems

Concentration exceeds the respective human health guideline NHMRC (2004) for drinking water

5 Concentration exceeds the respective ANZECC (2000) Irrigation Water Guideline for moderately sensitive crops / long term use

[1] ANZECC (2000) Marine Water Guidelines for protection of 90% of species in slightly to moderately disturbed systems

[2] Low reliability trigger level

[3] ANZECC (2000) Guidelines for irrigation and general use - moderately sensitive crops

[4] ANZECC (2000) Guidelines for irrigation and general use - long-term trigger value

[5] To minimise bioclogging of irrigation equipment only

[6] Human Health Guidelines (NHMRC, 2004)

[7] Aesthetic Guidelines (NHMRC, 2004)

- Not Analysed

TABLE LR2

RESULTS 2004 and

SAMPLE RANGE OF RESULTS 2004-2007

All results in mg/L unless stated

SAMPLE ID	ANZECC Marine (slightly to moderately disturbed system)		NHMRC Human Health Guidelines		ANZECC Irrigation and General Use (moderately sensitive crops)		BORE 22	BORE 23	BORE 24
							2007 results	2007 results	2007 results
SAMPLE DATE							(range 2004-1007)	(range 2004-1007)	(range 2004-1007)
GENERAL PARAMETERS									
pH (pH Unit)			6.5-8.5	[7]			6.05 (5.88)	5.6 (5.92)	5.46 (5.45)
Electrical Conductivity (µS/cm)							1610 (7410)	234 (317)	2730 (6060)
Total Dissolved Solids			500	[7]			1350 (4390)	212 (192)	2250 (4580)
Total Hardness as $CaCO_3$			200	[7]			123 (1310)	39 (26)	300 (791)
MAJOR ANIONS									
Sulphate as SO_4^{2-}							39 (299)	6 (7)	344 (300)
Chloride			250	[7]	175-350	[3]	430 (2240)	58.7 (39)	800 (2580)
Total Alkalinity as $CaCO_3$							102 (44)	28 (24)	26 (96)
MAJOR CATIONS									
Calcium							11	3	31
Magnesium							23	7	54
Sodium			180	[7]	115-230	[3]	283 (982)	31 (28)	551 (1390)
Potassium							7	1	24
HEAVY METALS									
Arsenic	0.0023	[2]	0.007	[6]	0.1	[4]	0.001 (<0.001)	<0.001 (0.002)	0.006 (3)
Cadmium	0.014	[1]	0.002	[6]	0.01	[4]	<0.0001	<0.0001	<0.0001 (0.1)
Chromium	0.0486	[1]	0.05	[6]	0.1	[4]	0.007 (0.004)	<0.001 (0.012)	0.005 (7)
Copper	0.003	[1]	2.0	[6]	0.2	[4]	<0.001 (0.003)	<0.001 (0.003)	0.001 (2)
Lead	0.0066	[1]	0.01	[6]	2.0	[4]	<0.001 (0.002)	<0.001 (0.004)	<0.001 (2)
Zinc	0.023	[1]	3.0	[7]	2.0	[4]	<0.005 (0.008)	0.008 (0.005)	0.016 (7)
NUTRIENTS									
Ammonia as N			0.5	[7]			0.655 (0.51)	0.179 (0.14)	0.893 (1.1)
Nitrite + Nitrate as N							0.037 (0.04)	0.013 (0.01)	0.026 (0.02)
Total Kjeldahl Nitrogen as N					5.0	[4]	7.2 (5.9)	2.5 (2.1)	9.3 (6.4)
Total Phosphorus as P					0.05	[4, 5]	0.79 (<0.01)	0.32 (0.15)	1.12 (0.08)
TOC / BOD									
Total Organic Carbon							189 (29)	56	94 (53)
Biochemical Oxygen Demand							<2 (6)	9 (<2)	<2 (11)

Appendix B

ALS 5 Rosegum Close, Warabrook, NSW 2304. Phone (02) 4968 9433. Facsimile (02 4968 0349. Email Samples.Newcastle@alsenviro.com

CHAIN OF CUSTODY DOCUMENTATION

Australian Laboratory Services Pty Ltd

CLIENT: Coffey Geosciences	SAMPLER: JJT
ADDRESS / OFFICE: Sandgate	MOBILE: 0421 763 913
PROJECT MANAGER (PM): Andrew Fulton	PHONE:
PROJECT ID: Myall Quays	EMAIL REPORT TO: andrew_fulton@coffey.com.au
SITE:	P.O. NO.: EMAIL INVOICE TO (if different to report):
RESULTS REQUIRED (Date): standard	QUOTE NO.: ANALYSIS REQUIRED including SUITES (note - suite codes must be listed to attract suite prices)

FOR LABORATORY USE ONLY — COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL

COOLER SEAL (circle appropriate): Intact: (Yes) No N/A

SAMPLE TEMPERATURE: 3.9°C

CHILLED: (Yes) No

Notes: e.g. Highly contaminated samples e.g. "High PAHs expected". Extra volume for QC or trace LORs etc.

****Please see note below****

ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Tota. bottles	B Metals	Ca,Mg, Na, K, Chloride, Sulphate	Total Alkalinity, Total Hardness	N'trite, Nitrate, Ammonia, TKN	Total Phosphorus	pH, Ec, TDS	TOC	BOD
(1)	22	H20	29/03/2007				x	x	x	x	x	x	x	x
(2)	21		29/03/2007				x	x	x	x	x	x	x	x
(3)	24		29/03/2007				x	x	x	x	x	x	x	x
(4)	23		29/03/2007				x	x	x	x	x	x	x	x
(5)	4A		29/03/2007				x	x	x	x	x	x	x	x
(6)	8		29/03/2007				x	x	x	x	x	x	x	x
(7)	DUP1		29/03/2007				x	x	x	x	x	x	x	x
	10						Sample not received							
	11						Sample not received							
	5						Sample not received							
(8)	21		30/03/2007				x	x	x	x	x	x		
	8#						Sample not received							
	D1						Sample not received							
(9)	D2		30/03/2007				x	x	x	x	x	x		x
(10)	POND		30/03/2007				x	x	x			x		x
	Split	↓	30/03/2007				x	x	x	x		x		x

Environmental Division Sydney
Work Order
ES0704246

Telephone : 61 2-8784 8555

Send to SGS Acknowledged FF

RELINQUISHED BY		RECEIVED BY		METHOD OF SHIPMENT
Name: Jon Tonks	Date: 30/3/07	Name: Ken Reid	Date: 30/3/07	Con' Note No:
Of: Coffeys	Time: 5:52pm	Of: ALS Newcastle	Time: 5:55 pm	
Name: Kate Kell	Date: 2/4/07	Name: Frank Ferraro	Date: 03/04/07	Transport Co.
Of: ALS Newcastle	Time: 4pm	Of: ALS Sydney	Time: 08:30	

Water Container Codes: P = Unpreserved Plastic, N = Nitric Preserved Plastic ORC = Nitric Preserved ORC, SH = Sodium Hydroxide/Cd Preserved, S = Sodium Hydroxide Preserved Plastic, AG = Amber Glass Unpreserved, V = VOA Vial HCl Preserved VS = VOA Vial Sulphuric Preserved SG = Sulfuric Preserved Amber Glass, H = HCl preserved Plastic, HS = HCl preserved Speciation bottle, SP = Sulfuric Preserved Plastic, F = Formaldehyde Preserved Glass. Z = Zinc Acetate Preserved Bottle, E = EDTA Preserved Bottles, ST = Sterile Bottle, ASS = Plastic Bag for Acid Sulphate Soils, B = Unpreserved Bag

AUSTRALIAN LABORATORY SERVICES P/L

COC Page _1__ of _1__

*** Please Note: Modifications made, as per Ross East (Coffey). 2/4/07, 11:15am. Both verbally and as per attached email. ***

ALS Environmental

CERTIFICATE OF ANALYSIS

Client	: COFFEY GEOTECHNICS	Laboratory	: Environmental Division Sydney	Page	: 1 of 7
Contact	: MR ANDREW FULTON	Contact	: Victor Kedicioglu	Work Order	: ES0704246
Address	: 13 MANGROVE ROAD SANDGATE NSW AUSTRALIA 2304	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164		
E-mail	: andrew_fulton@coffey.com.au	E-mail	: Victor.Kedicioglu@alsenviro.com		
Telephone	: 49676377	Telephone	: 61-2-8784 8555		
Facsimile	: 49675402	Facsimile	: 61-2-8784 8500		
Project	: MYALL QUAYS	Quote number	: EN/007/07	Date received	: 2 Apr 2007
Order number	: - Not provided -			Date issued	: 12 Apr 2007
C-O-C number	: - Not provided -			No. of samples	- Received : 10
Site	: - Not provided -				Analysed : 10

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NATA Accredited Laboratory 825

This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Position	Department
Ankit Joshi		Inorganics - NATA 825 (10911 - Sydney)
Phyu Phyu Lwin	Spectroscopist	Inorganics - NATA 825 (10911 - Sydney)

Comments

This report for the ALSE reference ES0704246 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- **Analytical Results for Samples Submitted**
- **Surrogate Recovery Data**

The analytical procedures used by ALS Environmental have been developed from established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.

Specific comments for Work Order **ES0704246**

It has been noted that RP is greater than TP (sample ID D2), however this difference is within the limits of experimental variation.
TDS by method EA-015 may bias high on various sample due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
EK059G: It has been noted that Nitrite is greater than NOx on sample ID (22), however this difference is within the limits of experimental variation.

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID: 22	21	24	23	4A
Sample Matrix Type / Description:				WATER	WATER	WATER	WATER	WATER
Sample Date / Time:				29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00
Laboratory Sample ID:				ES0704246-001	ES0704246-002	ES0704246-003	ES0704246-004	ES0704246-005
EA005: pH								
pH Value		0.01	pH Unit	6.05	5.62	5.46	5.60	5.32
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C		1	µS/cm	1610	15500	2730	234	202
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	1350	11500	2250	212	155
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3		1	mg/L	123	2040	300	39	23
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	102	92	26	28	14
Total Alkalinity as CaCO3		1	mg/L	102	92	26	28	14
ED040F: Dissolved Major Anions								
Sulphate as SO4 2-	14808-79-8	1	mg/L	39	702	344	6	10
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1.0	mg/L	430	5300	800	58.7	50.4
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	11	126	31	3	2
Magnesium	7439-95-4	1	mg/L	23	420	54	7	4
Sodium	7440-23-5	1	mg/L	283	2650	551	31	29
Potassium	7440-09-7	1	mg/L	7	65	24	1	<1
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.001	0.002	0.006	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	0.007	0.002	0.005	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.001	0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.003	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.016	0.008	0.085
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.010	mg/L	0.655	0.934	0.893	0.179	0.212
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N		0.010	mg/L	0.087	<0.010	0.013	<0.010	<0.010

ALS Environmental

Analytical Results

	Client Sample ID :	22	21	24	23	4A
	Sample Matrix Type / Description :	WATER	WATER	WATER	WATER	WATER
	Sample Date / Time :	29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00	29 Mar 2007 15:00
	Laboratory Sample ID :					
Analyte / CAS number / LOR / Units		ES0704246-001	ES0704246-002	ES0704246-003	ES0704246-004	ES0704246-005
EK058G: Nitrate as N by Discrete Analyser						
Nitrate as N / 14797-55-8 / 0.010 mg/L		<0.010	0.027	0.013	0.013	0.034
EK059G: NOX as N by Discrete Analyser						
Nitrite + Nitrate as N / 0.010 mg/L		0.037	0.027	0.026	0.013	0.034
EK061: Total Kjeldahl Nitrogen (TKN)						
Total Kjeldahl Nitrogen as N / 0.1 mg/L		7.2	12.1	9.3	2.5	0.9
EK067G: Total Phosphorous-As P by Discrete Analyser						
Total Phosphorus as P / 0.01 mg/L		0.79	1.38	1.12	0.32	0.14
EK071G: Reactive Phosphorous as P by discrete analyser						
Reactive Phosphorus as P / 0.010 mg/L		0.095	0.035	0.062	----	0.017
EP005: Total Organic Carbon (TOC)						
Total Organic Carbon / 1 mg/L		189	109	94	56	16
EP030: Biochemical Oxygen Demand (BOD)						
Biochemical Oxygen Demand / 2 mg/L		<2	<2	<2	9	9

ALS Environmental

Analytical Results

				Client Sample ID :	8	DUP1	?1	D2	POND
				Sample Matrix Type / Description :	WATER	WATER	WATER	WATER	WATER
				Sample Date / Time :	29 Mar 2007 15:00	29 Mar 2007 15:00	30 Mar 2007 15:00	30 Mar 2007 15:00	30 Mar 2007 15:00
				Laboratory Sample ID :					
Analyte	*CAS number*	*LOR*	*Units*		ES0704246-006	ES0704246-007	ES0704246-008	ES0704246-009	ES0704246-010
EA005: pH									
pH Value		0.01	pH Unit		5.02	5.53	3.99	3.86	5.83
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C		1	µS/cm		268	15500	2730	169	182
EA015: Total Dissolved Solids									
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L		1210	9700	200	195	129
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3		1	mg/L		29	2070	14	13	33
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		6	96	26	<1	23
Total Alkalinity as CaCO3		1	mg/L		6	96	26	<1	23
ED040F: Dissolved Major Anions									
Sulphate as SO4 2-	14808-79-8	1	mg/L		22	701	13	10	12
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1.0	mg/L		64.6	5180	34.4	33.7	37.4
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		2	127	<1	<1	8
Magnesium	7439-95-4	1	mg/L		6	427	3	3	3
Sodium	7440-23-5	1	mg/L		39	2670	15	14	22
Potassium	7440-09-7	1	mg/L		4	66	4	4	2
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	0.002	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	0.001	<0.001	0.001	0.005
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	0.001
Zinc	7440-66-6	0.005	mg/L		0.009	<0.005	0.017	0.032	0.029
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.010	mg/L		0.303	1.14	0.545	0.541	<0.010
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N		0.010	mg/L		0.027	<0.010	0.028	0.027	<0.010

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID: 8	DUP1	?1	D2	POND
Sample Matrix Type / Description:				WATER	WATER	WATER	WATER	WATER
Sample Date / Time:				29 Mar 2007 15:00	29 Mar 2007 15:00	30 Mar 2007 15:00	30 Mar 2007 15:00	30 Mar 2007 15:00
Laboratory Sample ID:				ES0704246-006	ES0704246-007	ES0704246-008	ES0704246-009	ES0704246-010
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.010	mg/L	0.039	0.011	<0.010	0.013	0.020
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N		0.010	mg/L	0.066	0.011	0.034	0.040	0.020
EK061: Total Kjeldahl Nitrogen (TKN)								
Total Kjeldahl Nitrogen as N		0.1	mg/L	3.0	11.2	2.5	3.8	0.7
EK067G: Total Phosphorous-As P by Discrete Analyser								
Total Phosphorus as P		0.01	mg/L	0.76	1.33	1.00	1.10	0.08
EK071G: Reactive Phosphorous as P by discrete analyser								
Reactive Phosphorus as P		0.010	mg/L	0.036	0.016	0.799	1.12	<0.010
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon		1	mg/L	22	110	----	----	----
EP030: Biochemical Oxygen Demand (BOD)								
Biochemical Oxygen Demand		2	mg/L	<2	<2	----	6	5

Surrogate Control Limits

- **No surrogates present on this report.**

ALS Environmental

QUALITY CONTROL REPORT

Client	:	**COFFEY GEOTECHNICS**	**Laboratory**	: Environmental Division Sydney	**Page**	:	**1 of 11**
Contact	:	MR ANDREW FULTON	**Contact**	: Victor Kedicioglu			
Address	:	13 MANGROVE ROAD SANDGATE NSW AUSTRALIA 2304	**Address**	: 277-289 Woodpark Road Smithfield NSW Australia 2164	**Work order**	:	**ES0704246**
					Amendment No.	:	
Project	:	MYALL QUAYS	**Quote number**	: EN/007/07	**Date received**	:	**2 Apr 2007**
Order number	:	- Not provided -			**Date issued**	:	**12 Apr 2007**
C-O-C number	:	- Not provided -					
Site	:	- Not provided -					
E-mail	:	andrew_fulton@coffey.com.au	**E-mail**	: Victor.Kedicioglu@alsenviro.com	**No. of samples**		
Telephone	:	49676377	**Telephone**	: 61-2-8784 8555	**Received**	:	10
Facsimile	:	49675402	**Facsimile**	: 61-2-8784 8500	**Analysed**	:	10

This final report for the ALSE work order reference ES0704246 supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

Work order specific comments

TDS by method EA-015 may bias high on various sample due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
EK059G: It has been noted that Nitrite is greater than NOx on sample ID (22), however this difference is within the limits of experimental variation.
It has been noted that RP is greater than TP (sample ID D2), however this difference is within the limits of experimental variation.

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NATA Accredited Laboratory - 825

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This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Ankit Joshi	Inorganics - NATA 825 (10911 - Sydney)
Phyu Phyu Lwin	Inorganics - NATA 825 (10911 - Sydney)

ALS Environmental

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
- Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations:* ***LOR*** = *Limit of Reporting,* ***RPD*** = *Relative Percent Difference.*
* Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER ***Laboratory Duplicates (DUP) Report***

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EA005: pH						
EA005: pH - (QC Lot: 385626)				**pH Unit**	**pH Unit**	**%**
ES0704246-001	22	pH Value	0.01 pH Unit	6.05	6.05	0.0
ES0704246-010	POND	pH Value	0.01 pH Unit	5.83	5.86	0.5
EA010P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 385345)				**µS/cm**	**µS/cm**	**%**
ES0704246-001	22	Electrical Conductivity @ 25°C	1 µS/cm	1610	1580	2.0
ES0704252-001	Anonymous	Electrical Conductivity @ 25°C	1 µS/cm	22400	22300	0.4
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 385565)				**mg/L**	**mg/L**	**%**
ES0704217-001	Anonymous	Total Dissolved Solids @180°C	1 mg/L	7890	7720	2.2
ES0704229-006	Anonymous	Total Dissolved Solids @180°C	1 mg/L	500	508	1.6
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 385344)				**mg/L**	**mg/L**	**%**
ES0704246-001	22	Hydroxide Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	102	102	0.0
		Total Alkalinity as CaCO3	1 mg/L	102	102	0.0
ES0704252-001	Anonymous	Hydroxide Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Total Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 386020)				**mg/L**	**mg/L**	**%**
ES0704246-001	22	Sulphate as SO4 2-	1 mg/L	39	40	0.0
ED045G: Chloride Discrete analyser						
ED045G: Chloride Discrete analyser - (QC Lot: 386094)				**mg/L**	**mg/L**	**%**

ALS Environmental

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED045G: Chloride Discrete analyser - continued						
ED045G: Chloride Discrete analyser - (QC Lot: 386094) - continued				mg/L	mg/L	%
ES0704246-001	22	Chloride	1.0 mg/L	430	436	1.4
ES0704246-008	?1	Chloride	1.0 mg/L	34.4	33.9	1.5
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 386021)				mg/L	mg/L	%
ES0704246-001	22	Calcium	1 mg/L	11	11	0.0
		Magnesium	1 mg/L	23	24	0.0
		Sodium	1 mg/L	283	285	0.6
		Potassium	1 mg/L	7	7	0.0
ES0704314-001	Anonymous	Calcium	1 mg/L	3	3	0.0
		Magnesium	1 mg/L	62	63	2.3
		Sodium	1 mg/L	779	746	4.3
		Potassium	1 mg/L	<1	<1	0.0
EG020F: Dissolved Metals by ICP-MS						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 385229)				mg/L	mg/L	%
ES0704242-001	Anonymous	Arsenic	0.001 mg/L	<0.001	<0.001	0.0
		Cadmium	0.0001 mg/L	<0.0001	<0.0001	0.0
		Chromium	0.001 mg/L	<0.001	<0.001	0.0
		Copper	0.001 mg/L	0.001	<0.001	0.0
		Lead	0.001 mg/L	<0.001	<0.001	0.0
		Nickel	0.001 mg/L	<0.001	<0.001	0.0
		Zinc	0.005 mg/L	0.014	0.014	0.0
ES0704246-002	21	Arsenic	0.001 mg/L	0.002	<0.001	0.0
		Cadmium	0.0001 mg/L	<0.0001	<0.0001	0.0
		Chromium	0.001 mg/L	0.002	0.002	0.0
		Copper	0.001 mg/L	0.001	0.001	0.0
		Lead	0.001 mg/L	<0.001	<0.001	0.0
		Nickel	0.001 mg/L	<0.001	<0.001	0.0
		Zinc	0.005 mg/L	<0.005	<0.005	0.0
EG035F: Dissolved Mercury by FIMS						

ALS Environmental

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
EG035F: Dissolved Mercury by FIMS - continued						
EG035F: Dissolved Mercury by FIMS - (QC Lot: 385598)				mg/L	mg/L	%
ES0704246-001	22	Mercury	0.0001 mg/L	<0.0001	<0.0001	0.0
ES0704289-004	Anonymous	Mercury	0.0001 mg/L	<0.0001	<0.0001	0.0
EK055G: Ammonia as N by Discrete Analyser						
EK055G: Ammonia as N by Discrete Analyser - (QC Lot: 386879)				mg/L	mg/L	%
ES0704246-001	22	Ammonia as N	0.010 mg/L	0.655	0.670	2.3
ES0704246-010	POND	Ammonia as N	0.010 mg/L	<0.010	<0.010	0.0
EK057G: Nitrite as N by Discrete Analyser						
EK057G: Nitrite as N by Discrete Analyser - (QC Lot: 385367)				mg/L	mg/L	%
ES0704246-002	21	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
ES0704246-010	POND	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EK059G: NOX as N by Discrete Analyser						
EK059G: NOX as N by Discrete Analyser - (QC Lot: 386091)				mg/L	mg/L	%
ES0704246-001	22	Nitrite + Nitrate as N	0.010 mg/L	0.037	0.036	2.7
ES0704246-010	POND	Nitrite + Nitrate as N	0.010 mg/L	0.020	0.019	5.1
EK061: Total Kjeldahl Nitrogen (TKN)						
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 387458)				mg/L	mg/L	%
ES0704246-001	22	Total Kjeldahl Nitrogen as N	0.1 mg/L	7.2	6.4	11.7
ES0704246-010	POND	Total Kjeldahl Nitrogen as N	0.1 mg/L	0.7	0.7	0.0
EK067G: Total Phosphorous-As P by Discrete Analyser						
EK067G: Total Phosphorous-As P by Discrete Analyser - (QC Lot: 387459)				mg/L	mg/L	%
ES0704246-001	22	Total Phosphorus as P	0.01 mg/L	0.79	0.76	3.9
ES0704246-010	POND	Total Phosphorus as P	0.01 mg/L	0.08	0.03	85.7
EK071G: Reactive Phosphorous as P by discrete analyser						
EK071G: Reactive Phosphorous as P by discrete analyser - (QC Lot: 385204)				mg/L	mg/L	%
ES0704246-001	22	Reactive Phosphorus as P	0.010 mg/L	0.095	0.111	15.5
EP005: Total Organic Carbon (TOC)						
EP005: Total Organic Carbon (TOC) - (QC Lot: 385545)				mg/L	mg/L	%
ES0704203-004	Anonymous	Total Organic Carbon	1 mg/L	20	20	0.0
ES0704252-001	Anonymous	Total Organic Carbon	1 mg/L	4	3	0.0

Matrix Type: WATER ***Laboratory Duplicates (DUP) Report***

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EP030: Biochemical Oxygen Demand (BOD)						
EP030: Biochemical Oxygen Demand (BOD) - (QC Lot: 385733)				**mg/L**	**mg/L**	**%**
EB0703652-001	Anonymous	Biochemical Oxygen Demand	2 mg/L	6	6	0.0
EB0703660-015	Anonymous	Biochemical Oxygen Demand	2 mg/L	23	19	19.0
EP030: Biochemical Oxygen Demand (BOD) - (QC Lot: 385734)				**mg/L**	**mg/L**	**%**
EB0703640-001	Anonymous	Biochemical Oxygen Demand	2 mg/L	3850	3640	5.5
ES0704278-001	Anonymous	Biochemical Oxygen Demand	2 mg/L	1740	1840	5.8

ALS Environmental

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Flagged outliers on control limits for inorganics tests may be within the NEPM specified data quality objective of recoveries in the range of 70 to 130%. Where this occurs, no corrective action is taken. Abbreviations: LOR = Limit of reporting.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
EA010P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 385345)		µS/cm	µS/cm	%	%	%
Electrical Conductivity @ 25°C	1 µS/cm	----	2000	101	86.3	112
	1 µS/cm	<1	----	----	----	----
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 385565)		mg/L	mg/L	%	%	%
Total Dissolved Solids @180°C	1 mg/L	----	293	107	77.9	122
	1 mg/L	<1	----	----	----	----
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 385344)		mg/L	mg/L	%	%	%
Total Alkalinity as CaCO3	1 mg/L	----	200	91.6	80.2	108
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 386020)		mg/L	mg/L	%	%	%
Sulphate as SO4 2-	1 mg/L	<1	1	----	----	----
	1 mg/L	----	150	93.4	82.9	114
ED045G: Chloride Discrete analyser						
ED045G: Chloride Discrete analyser - (QC Lot: 386094)		mg/L	mg/L	%	%	%
Chloride	1 mg/L	----	50	104	83.7	124
	1 mg/L	----	250	96.0	83.7	124
	1.0 mg/L	<1.0	----	----	----	----
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 386021)		mg/L	mg/L	%	%	%
Calcium	1 mg/L	<1	----	----	----	----
	1 mg/L	----	50	92.9	82.9	121

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name	*LOR*	*Method blank result*	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
				LCS	*Low*	*High*
ED093F: Dissolved Major Cations - continued						
ED093F: Dissolved Major Cations - (QC Lot: 386021) - continued		mg/L	mg/L	%	%	%
Magnesium	1 mg/L	----	50	96.1	82.7	114
	1 mg/L	<1	----	----	----	----
Potassium	1 mg/L	----	50	94.5	84.3	118
	1 mg/L	<1	----	----	----	----
Sodium	1 mg/L	<1	----	----	----	----
	1 mg/L	----	50	92.1	77.4	113
EG020F: Dissolved Metals by ICP-MS						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 385229)		mg/L	mg/L	%	%	%
Arsenic	0.001 mg/L	<0.001	----	----	----	----
	0.001 mg/L	----	0.1	94.6	70	130
Cadmium	0.0001 mg/L	----	0.1	92.3	70	130
	0.0001 mg/L	<0.0001	----	----	----	----
Chromium	0.001 mg/L	----	0.1	96.4	70	130
	0.001 mg/L	<0.001	----	----	----	----
Copper	0.001 mg/L	----	0.1	91.7	70	130
	0.001 mg/L	<0.001	----	----	----	----
Lead	0.001 mg/L	<0.001	----	----	----	----
	0.001 mg/L	----	0.1	94.3	70	130
Nickel	0.001 mg/L	----	0.1	91.9	70	130
	0.001 mg/L	<0.001	----	----	----	----
Zinc	0.005 mg/L	----	0.1	101	70	130
	0.005 mg/L	<0.005	----	----	----	----
EG035F: Dissolved Mercury by FIMS						
EG035F: Dissolved Mercury by FIMS - (QC Lot: 385598)		mg/L	mg/L	%	%	%
Mercury	0.0001 mg/L	<0.0001	----	----	----	----
	0.0001 mg/L	----	0.010	115	80.5	117
EK055G: Ammonia as N by Discrete Analyser						
EK055G: Ammonia as N by Discrete Analyser - (QC Lot: 386879)		mg/L	mg/L	%	%	%

ALS Environmental

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name	*LOR*	*Method blank result*	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
				LCS	*Low*	*High*
EK055G: Ammonia as N by Discrete Analyser - continued						
EK055G: Ammonia as N by Discrete Analyser - (QC Lot: 386879) - continued		mg/L	mg/L	%	%	%
Ammonia as N	0.01 mg/L	----	1.00	105	75.6	128
	0.010 mg/L	<0.010	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser						
EK057G: Nitrite as N by Discrete Analyser - (QC Lot: 385367)		mg/L	mg/L	%	%	%
Nitrite as N	0.010 mg/L	<0.010	----	----	----	----
	0.01 mg/L	----	0.96	102	66.6	131
EK059G: NOX as N by Discrete Analyser						
EK059G: NOX as N by Discrete Analyser - (QC Lot: 386091)		mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	0.010 mg/L	<0.010	----	----	----	----
	0.01 mg/L	----	0.96	94.3	76.9	122
EK061: Total Kjeldahl Nitrogen (TKN)						
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 387458)		mg/L	mg/L	%	%	%
Total Kjeldahl Nitrogen as N	0.1 mg/L	----	10	98.2	62.4	140
	0.1 mg/L	<0.1	----	----	----	----
EK067G: Total Phosphorous-As P by Discrete Analyser						
EK067G: Total Phosphorous-As P by Discrete Analyser - (QC Lot: 387459)		mg/L	mg/L	%	%	%
Total Phosphorus as P	0.01 mg/L	<0.01	----	----	----	----
	0.01 mg/L	----	4.42	90.3	64.3	120
EK071G: Reactive Phosphorous as P by discrete analyser						
EK071G: Reactive Phosphorous as P by discrete analyser - (QC Lot: 385204)		mg/L	mg/L	%	%	%
Reactive Phosphorus as P	0.010 mg/L	<0.010	----	----	----	----
	0.01 mg/L	----	0.50	102	83.8	122
EP005: Total Organic Carbon (TOC)						
EP005: Total Organic Carbon (TOC) - (QC Lot: 385545)		mg/L	mg/L	%	%	%
Total Organic Carbon	1 mg/L	----	10	92.2	86.9	125
	1 mg/L	<1	----	----	----	----
EP030: Biochemical Oxygen Demand (BOD)						

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name	*LOR*	*Method blank result*	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
				LCS	*Low*	*High*
EP030: Biochemical Oxygen Demand (BOD) - continued						
EP030: Biochemical Oxygen Demand (BOD) - (QC Lot: 385733)		mg/L	mg/L	%	%	%
Biochemical Oxygen Demand	2 mg/L	<2	----	----	----	----
	2 mg/L	----	200	99.5	66.8	112
EP030: Biochemical Oxygen Demand (BOD) - (QC Lot: 385734)		mg/L	mg/L	%	%	%
Biochemical Oxygen Demand	2 mg/L	<2	----	----	----	----
	2 mg/L	----	200	96.0	66.8	112

Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQO's). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations:* ***LOR*** *= Limit of Reporting,* ***RPD*** *= Relative Percent Difference.*

* Indicates failed QC

Matrix Type: WATER

Matrix Spike (MS) Report

					Actual Results		*Recovery Limits*	
					Sample Result	*Spike Recovery*	*Static Limits*	
Analyte name	*Laboratory Sample ID*	*Client Sample ID*	*LOR*	*Spike Concentration*		*MS*	*Low*	*High*
ED045G: Chloride Discrete analyser								
ED045G: Chloride Discrete analyser - (QC Lot: 386094)				mg/L	mg/L	%	%	%
Chloride	ES0704246-001	22	1 mg/L	250	430	125	70	130
EG020F: Dissolved Metals by ICP-MS								
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 385229)				mg/L	mg/L	%	%	%
Arsenic	ES0704242-001	Anonymous	0.001 mg/L	0.2	<0.001	98.1	70	130
Cadmium			0.0001 mg/L	0.05	<0.0001	98.4	70	130
Chromium			0.001 mg/L	0.2	<0.001	94.9	70	130
Copper			0.001 mg/L	0.2	0.001	95.4	70	130
Lead			0.001 mg/L	0.2	<0.001	100	70	130
Nickel			0.001 mg/L	0.2	<0.001	96.8	70	130
Zinc			0.005 mg/L	0.2	0.014	104	70	130
EG035F: Dissolved Mercury by FIMS								
EG035F: Dissolved Mercury by FIMS - (QC Lot: 385598)				mg/L	mg/L	%	%	%
Mercury	ES0704246-001	22	0.0001 mg/L	0.0100	<0.0001	116	70	130
EK055G: Ammonia as N by Discrete Analyser								
EK055G: Ammonia as N by Discrete Analyser - (QC Lot: 386879)				mg/L	mg/L	%	%	%
Ammonia as N	ES0704246-001	22	0.01 mg/L	1.00	0.655	93.3	70	130
EK057G: Nitrite as N by Discrete Analyser								
EK057G: Nitrite as N by Discrete Analyser - (QC Lot: 385367)				mg/L	mg/L	%	%	%
Nitrite as N	ES0704246-002	21	0.01 mg/L	0.60	<0.010	102	70	130
EK059G: NOX as N by Discrete Analyser								
EK059G: NOX as N by Discrete Analyser - (QC Lot: 386091)				mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	ES0704246-001	22	0.01 mg/L	0.60	0.037	92.3	70	130
EK061: Total Kjeldahl Nitrogen (TKN)								

Matrix Type: WATER

Matrix Spike (MS) Report

					Actual Results		Recovery Limits	
					Sample Result	Spike Recovery	Static Limits	
Analyte name	***Laboratory Sample ID***	***Client Sample ID***	***LOR***	***Spike Concentration***		***MS***	***Low***	***High***
EK061: Total Kjeldahl Nitrogen (TKN) - continued								
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 387458)				mg/L	mg/L	%	%	%
Total Kjeldahl Nitrogen as N	ES0704246-001	22	0.1 mg/L	25	7.2	100	70	130
EK067G: Total Phosphorous-As P by Discrete Analyser								
EK067G: Total Phosphorous-As P by Discrete Analyser - (QC Lot: 387459)				mg/L	mg/L	%	%	%
Total Phosphorus as P	ES0704246-001	22	0.01 mg/L	5	0.79	75.3	70	130
EK071G: Reactive Phosphorous as P by discrete analyser								
EK071G: Reactive Phosphorous as P by discrete analyser - (QC Lot: 385204)				mg/L	mg/L	%	%	%
Reactive Phosphorus as P	ES0704246-001	22	0.01 mg/L	0.50	0.095	101	70	130
EP005: Total Organic Carbon (TOC)								
EP005: Total Organic Carbon (TOC) - (QC Lot: 385545)				mg/L	mg/L	%	%	%
Total Organic Carbon	ES0704203-004	Anonymous	1 mg/L	100	20	94.9	70	130

17 May 2007 **TEST REPORT**

Coffey Environments Pty Ltd
8/12 Mars Road
LANE COVE WEST
NSW 2066

Your Reference: GEOTLCOV23225AA
Report Number: 52430

Attention: Jessica Northey

Dear Jessica
The following samples were received from you on the date indicated.

Samples: Qty.	6 Soils, 1 Water
Date of Receipt of Samples:	08/05/07
Date of Receipt of Instructions:	08/05/07
Date Preliminary Report Emailed:	Not Issued

These samples were analysed in accordance with your written instructions.
A copy of the instructions is attached with the analytical report.

The results and associated quality control are contained in the following pages of this report. Unless otherwise stated, solid samples are expressed on a dry weight basis (moisture has been supplied for your information only), air and liquid samples as received.

Should you have any queries regarding this report please contact the undersigned.

Yours faithfully
SGS ENVIRONMENTAL SERVICES

Ly Kim Ha
Senior Organic Chemist

Edward Ibrahim
Laboratory Services Manager

Alexandra Stenta
Key Account Representative

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Unit 16, 33 Maddox Street, Alexandria Australia
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www.au.sgs.com
Member of the SGS Group

Inorganics Our Reference: Your Reference Sample Type Depth Date Sampled	UNITS ---------- ----------	52430-7 NUTRIENT WATER Water -
pH	pH Units	6.6
Nitrate as N	mg/L	4.7
Total Phosphorus as P	mg/L	2.5

ASLP by client requested water						
Our Reference:	UNITS	52430-1	52430-2	52430-3	52430-4	52430-5
Your Reference	----------	HA1	HA1	HA2	HA2	HA3
Sample Type	----------	Soil	Soil	Soil	Soil	Soil
Depth		0.0-0.1	0.4-0.5	0.0-0.1	0.4-0.5	0.0-0.1
Date Sampled		30/03/2007	30/03/2007	30/03/2007	30/03/2007	30/03/2007
pH of final Leachate	pH units	5.40	5.30	4.90	5.60	5.30
Nitrate as N (in leachate)	mg/L	5.0	4.8	5.3	5.0	4.6
Total Phosphorus as P (in leachate)	mg/L	<0.10	0.80	<0.10	0.50	<0.10

ASLP by client requested water		
Our Reference:	UNITS	52430-6
Your Reference	----------	HA3
Sample Type	----------	Soil
Depth		0.4-0.5
Date Sampled		30/03/2007
pH of final Leachate	pH units	5.00
Nitrate as N (in leachate)	mg/L	4.6
Total Phosphorus as P (in leachate)	mg/L	<0.10

Method ID	Methodology Summary
AN101	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
SEI-038	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 20th ED, 4110-B.
SEI-067	Total Phosphorus - Jirka modification, followed by colorimetric determination using an Ascorbic Acid method, in accordance with APHA 20th ED, 4500-P-F. Analysis is carried out by SGS Environmental Services Welshpool.
SEP-003	Toxicity Characteristic Leaching Procedure (TCLP) and AS Bottle leach procedure.

QUALITY CONTROL Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
pH	pH Units		AN101	[NT]	[NT]	[NT]	[NR]	[NR]
Nitrate as N	mg/L	0.05	SEI-038	<0.05	[NT]	[NT]	LCS	101 || [N/T]
Total Phosphorus as P	mg/L	0.1	SEI-067	<0.10	[NT]	[NT]	LCS	94 || [N/T]
QUALITY CONTROL ASLP by client requested water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
pH of final Leachate	pH units		SEP-003	[NT]	52430-1	5.40 || 5.30 || RPD: 2	[NR]	[NR]
Nitrate as N (in leachate)	mg/L	0.05	SEI-038	<0.05	52430-1	5.0 || 5.0 || RPD: 0	LCS	101 || [N/T]
Total Phosphorus as P (in leachate)	mg/L	0.1	SEI-067	<0.10	52430-1	<0.10 || [N/T]	LCS	94 || [N/T]

QUALITY CONTROL ASLP by client requested water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
pH of final Leachate	pH units	[NT]	[NT]	[NR]	[NR]
Nitrate as N (in leachate)	mg/L	[NT]	[NT]	52430-2	99 || [N/T]
Total Phosphorus as P (in leachate)	mg/L	[NT]	[NT]	[NR]	[NR]

Result Codes

[INS]	:	Insufficient Sample for this test	[HBG]	:	Results not Reported due to High Background Interference
[NR]	:	Not Requested	*	:	Not part of NATA Accreditation
[NT]	:	Not tested	[N/A]	:	Not Applicable

Result Comments

Date Organics extraction commenced: N/A
NATA Corporate Accreditation No. 2562, Site No 4354
Note: Test results are not corrected for recovery (excluding Dioxins/Furans* and PAH in XAD and PUF).
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Quality Control Protocol

Reagent Blank: Sample free reagents carried through the preparation/extraction/digestion procedure and analysed at the beginning of every sample batch analysis. For larger projects, a reagent blank is prepared and analysed with every 20 samples.
Duplicate: A separate portion of a sample being analysed which is treated the same as the other samples in the batch. A duplicate is prepared at least every 10 samples.
Matrix Spike Duplicates: Sample replicates spiked with identical concentrations of target analyte(s). The spiking occurs during the sample preparation and prior to the extraction/digestion procedure. They are used to document the precision and bias of a method in a given sample matrix. Where there is not enough sample available to prepare a spiked sample, another known soil/sand or water (or Milli-Q water) may be used. A duplicate spiked sample is prepared at least every 20 samples.
Surrogate Spike: Added to all samples requiring analysis for organics (where relevant) prior to extraction. Used to determine the extraction efficiency. They are organic compounds which are similar to the target analyte(s) in chemical composition and behaviour in the analytical process, but which are not normally found in environmental samples.
Internal Standard: Added to all samples requiring analysis for organics (where relevant) after the extraction process; the compounds serve to give a standard of retention time and response, which is invariant from run-to-run with the instruments.
Control Standards: Prepared from a source independent of the calibration standards. At least one control standard is included in each run to confirm calibration validity.
Additional QC Samples: A calibration standard and blank are run after every 20 samples of an instrumental analysis run to assess analytical drift.

coffey

Chain of Custody

No: 0225

Laboratory Quotation / Order No: 0225

Job No: GEOTLCOV23225AA Sheet 1 of 1

Dispatch to: SGS ENVIRONMENTAL SERVICES (Address & Phone No.) 16/33 Maddox St Alexandria 2015 ph 8594 0400	Sampled by: Jonathan Tanks	Consigning Officer: LANE COVE WEST Date Dispatched: ph 9911 1099
Attention: Alex Steele	Project Manager: (report results to) JESSICA NORTHEY / ANDREW FULTON	Courier Service: Consignment Note No:

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
K Ramsay	8/5/07	8.45am	X Jan Robson #112	8/5/07	8.45am

Comments	Sample Matrix	Container Type and Preservative	Sample No.	Date Sampled	Analyses Required: PAHs	TPHs	MAHs = BTEX	Metals:	ASLP with nutrient water	+ NO_3, pH, total phosphorus	pH	NO_3	Total P	Sample Condition on Receipt
	SOIL	250ml glass jar 1	HA1 0.0-0.1	30/3/07					X					
	↓	↓ 2	HA1 0.4-0.5	↓					X					
		3	HA2 0.0-0.1						X					
		4	HA2 0.4-0.5						X					
		5	HA3 0.0-0.1						X					
		6	HA3 0.4-0.5						X					
SGS Received 8/5/07 By Cheryl Time 10:55 am/pm Sample Intact yes/no Ice/Cooler Pack yes/no Comments 52430	WATER	N/A 7	NUTRIENT WATER	N/A							X	X	X	

Special Laboratory Instructions: Please do ASLP with nutrient water (manufactured by SGS) & analyse nutrient water + leachate for pH, NO_3 & total P.

Detection Limits: P: 0.1 mg/L, others STANDARD

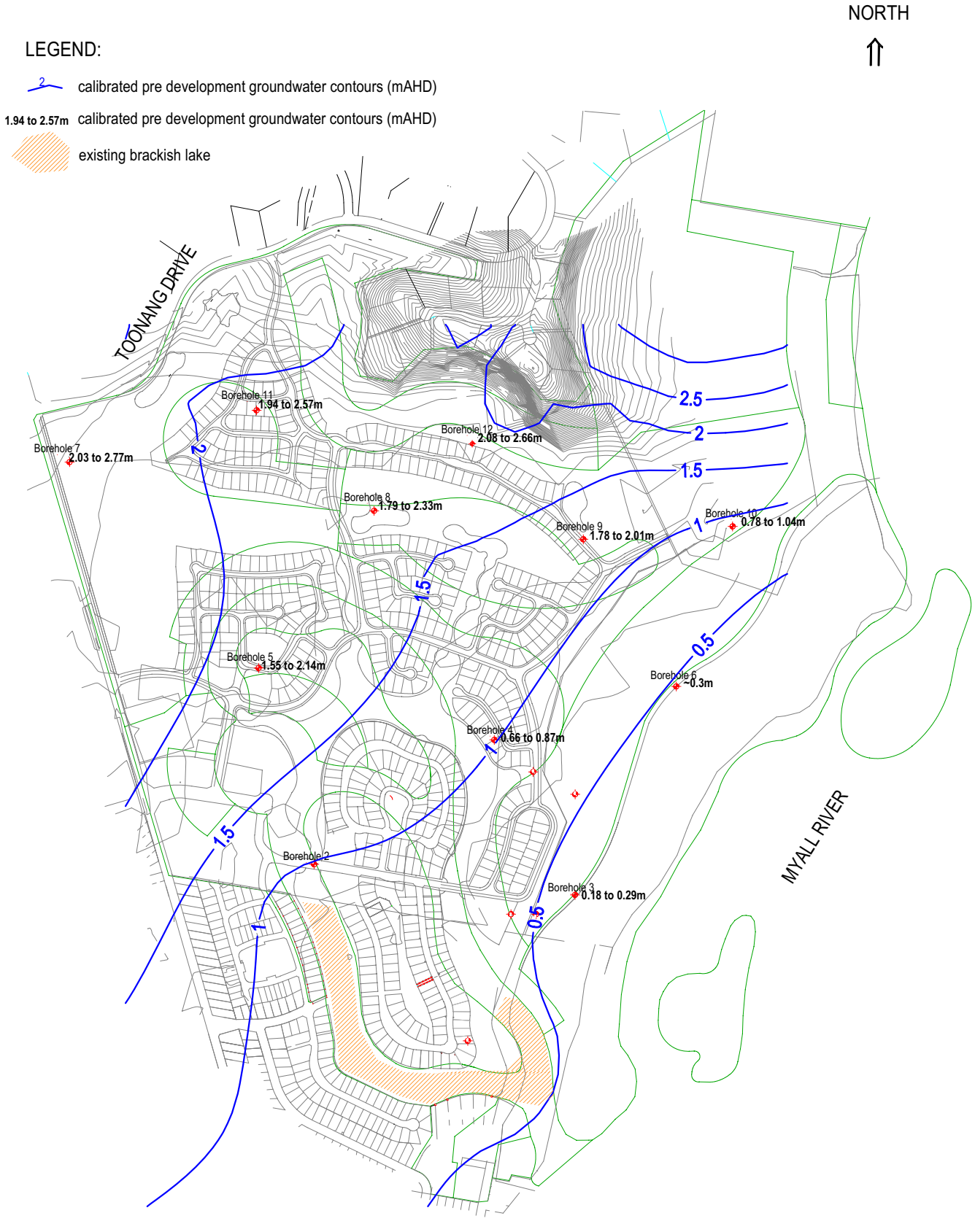
Turnaround Required: STANDARD - 7 days

JOB NUMBER **MUST** BE REFERENCED ON ALL SUBSEQUENT PAGES

64220/9-06

Copies: **WHITE:** Sign on release. **YELLOW:** If dispatched to interstate Lab, Lab to sign on receipt and fax back to Coffey. **BLUE:** To be returned with results.

Appendix C



Coffey Geotechnics Pty Ltd		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	EW	CRIGHTON PROPERTIES	**Appendix D**
Approved	RJB	GROUNDWATER ASSESSMENT	
Date	23/12/2004	MYALL QUAYS DEVELOPMENTS	
Scale	1:12500	CALIBRATED GROUNDWATER CONTOURS VS EXPECTED LEVELS	Job No: GEOTLCOV23225

APPENDIX H

FISH COMMUNITY SURVEY
APRIL 2007

Harris Research

Pty Ltd

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Fish Community Survey of the 'Riverside' Lake, April 2007

Summary Report & Overview for Crighton Properties Pty Ltd

Executive Summary

The fish community of the Riverside lake (previously Myall Quays) was surveyed in April 2007 as part of a series of biological studies to record the aquatic ecological development of the lake. Seine netting and gill netting captured numbers of both individual fish and fish species that were well in excess of previous surveys. Substantially larger-bodied fish and some fisheries species were caught including yellow-fin bream, striped mullet, sand mullet and silver biddies. The distribution patterns and occurrence of aquatic plants in the lake were similar to those recorded in 2002.

Increased biological diversity and abundance of the fish community show that the Riverside lake is continuing its development towards the ecological condition of the surrounding Myall River estuary and supports casual observations of recreational fishing in the lake. Habitat conditions, water quality and the food web are continuing to develop, supporting fish recruitment and productivity. Fish recruitment and growth in the lake are contributing to biological values in the estuary as a whole and this should increase as ecological processes mature further.

It is recommended that previous recommendations for enhancing the amount and quality of aquatic habitats remain relevant and should be pursued in the design of any extension of the existing lake system, particularly with respect to increasing the extent, complexity and quality of near-shore habitats for fish, invertebrates and birds. It is also important to continue development and maintenance of runoff management systems to sustain high and stable water-quality values. Completion of the planned circular enlargement of the lake would increase tidal ventilation and reduce water-quality variability as well as improving the availability of habitats and food for aquatic and water-associated plants and animals. Additionally, some consideration could be given to augmenting the existing lake (where possible) with additional submerged structure such as sunken logs, rock mounds and artificial reefs to enhance the amount and quality of aquatic habitat.

These development initiatives will ensure the Riverside lake system continues to contribute increasingly to environmental assets of the Tea Gardens area.

Introduction

The third survey in an ongoing series of biological studies in the Riverside lake was completed by The Ecology Lab in April 2007. Previous surveys by the Australian Museum, including water quality, plants, macroinvertebrates and fish, were completed in 1998 (Appendix 1) and 2002 (Appendix 2) (Australian Museum 2002). The broad objective of these surveys is to monitor aquatic ecological and fisheries conditions in the lake and to record its ecological development from a constructed drainage basin to a functional component of the Myall River ecosystem. The general conclusion from the earlier surveys was that ecological conditions in the lake were still maturing, with an aquatic diversity of plants and animals that had not yet approached that of the surrounding waters of the Myall River estuary and with a salinity regime that varied substantially following rainfall runoff.

Ecological principles and options for the Riverside development were considered in a background paper (Harris 2002) (Appendix 3), which noted that the lake's dynamic ecology is driven by tidal and saline regimes together with rainfall runoff events. The paper listed options for ecological management and described ways in which aquatic habitat values could be enhanced, as well as reviewing fish population-dynamics processes that control the fish community.

Fish community analysis was chosen to represent the ecological condition of the lake for the current study because of the role of fish as indicators of the condition of the food web, water quality and other habitat conditions in aquatic systems (MDBC 2004; Harris 1995).

Methods

Fish were surveyed by a fieldwork team from The Ecology Lab on 26 and 27 April 2007 (Appendix 4). Aquatic plant distribution at sampling sites was also noted. Sampling sites in the lake are shown in a map (Appendix 5).

Seine netting

Seine netting was conducted along the shoreline at 8 locations (Appendix 1). GPS coordinates for sampling locations at given in Table 1. The seine used measured 25 m long x 2 m deep, with a mesh size of 5mm. The net was run out from the shore in a U-shape using a boat and then hauled up on to the bank. Fish were collected in the cod end and placed in a tub with water, in order to minimise handling and stress. Identification, measurements and enumeration were done and all native fish were then released. Those species not readily recognisable were preserved in formalin and returned to the laboratory for identification checks.

Gill netting

This technique was used to capture fish in deeper areas of the water body. Nets were made of a rectangular panel measuring 30m (50mm mesh x 0.25mm diameter) x 1.8m deep. Four gill nets were deployed along the middle of the lake with GPS points taken at the start and end of each panel. GPS coordinates for gill-net sampling locations are given in Table 2 and shown in Appendix 5. Gill nets were placed either perpendicular or horizontal to the shore. Deployment times were 90 minutes, with times deployed listed in Table 2. Captured fish were identified to species, measured

and released. Those fish species not readily identifiable in the field were preserved in 10% formalin and checked in the laboratory.

Aquatic plants

Aquatic plants and algae were identified at fish sampling sites using a visual assessment of percentage cover.

Table 1 . Field sampling locations and time of each seine net shot. Datum: WGS84 - Zone 56H.

Sample	Easting	Northing	Date	Time
SEINE 1	420583	6155610	26/04/07	13:15
SEINE 2	420571	6386708	26/04/07	13:45
SEINE 3	420978	6386366	26/04/07	14:50
SEINE 4	421001	6386403	26/04/07	15:15
SEINE 5	420599	6386606	27/04/07	8:40
SEINE 6	420793	6386419	27/04/07	9:10
SEINE 7	420969	6386597	27/04/07	9:40
SEINE 8	420678	6386536	27/04/07	10:15

Table 2. Field sampling locations, depths and time for the start and end of each gill net set. Datum: WGS84 - Zone 56H.

	Start				
Sample	Date	Time	Easting	Northing	Depth (m)
GILL 1	26/04/07	12:55	420973	6386428	3.4
GILL 2	26/04/07	13:05	420829	6386389	3.5
GILL 3	27/04/07	8:15	420586	6386780	2.1
GILL 4	27/04/07	8:18	420642	6386597	3.1
	End				
Sample	Time		Easting	Northing	Depth (m)
GILL 1	14:25		420970	6386399	3.3
GILL 2	14:35		420814	6386373	3.4
GILL 3	9:45		420563	6386763	3
GILL 4	9:48		420629	6386572	3.5

Results

In fish samples there was a total of 11 or 12 species of finfish (the two flathead gudgeon species were not positively identified), listed in Table 3, and the palaemonid estuary shrimp. A total of 840 fish was caught. The catch was dominated by flathead gudgeons, striped ('sea') mullet, exquisite sand gobies, Pacific blue-eyes and silver biddies, with the other species in smaller numbers. Only one alien species (i.e. originating outside Australia) was recorded, the eastern gambusia, only four individuals were caught.

While small-bodied and juvenile fish dominated the catch, some larger fish were either caught or observed. They included striped mullet up to 420mm, sand mullet to 290mm and yellow-fin bream to 329mm.

Table 3. Fish species collected in combined netting samples from Riverside lake, 26-27 April 2007.

Species	**Common name**
Gambusia holbrooki	Eastern gambusia
Psuedomugil signifer	Pacific blue-eye
Mugil cephalus	Striped (or 'sea') mullet
Myxus elongatus	Sand mullet
Acanthopagrus australis	Yellow-finned Bream
Gerres subfasciatus	Silver Biddy
*Philypnodon grandiceps/*sp.	Flathead gudgeon/Dwarf flathead gudgeon
Psueudogobius sp.	Blue spot goby
Afurcagobius tamarensis	Tamar River goby
Amoya bifrenatus	Bridled goby
Favonigobius exquisitus	Exquisite sand goby

Aquatic plants that were identified included green algae *Cladophora* sp*., Spirogyra* sp. and *Rhizoclonium* sp.; unidentified filamentous Blue-Green/Red algae; the seagrasses *Zostera capricorni* and *Ruppia polycarpa;* the hornwort *Ceratophyllum demersu;* the emergent saltmarsh *Sarcocornia quinqueflora;* and emergent macrophytes including *Juncus* sp*., Triglochin striata and Phragmites australis.*

Conclusions

It is difficult to make direct comparisons of the fish communities represented in the three surveys, as the seasonality, amount of effort and sampling methods varied among the surveys. The current survey sampled less intensively than earlier ones. Nevertheless, previous samples of the Riverside lake's fish community in 1998 and 2002 recorded fewer species – nine in 1998 and seven in 2002 - compared to the 11 or 12 species captured in the current survey.

A much greater size range of fish is also present in 2007, up to 420mm, whereas all fish caught in the 2002 survey were less than 50mm long. And 304 individual fish were collected in the more-extensive sampling in 2002, compared with 840 caught in the current survey's sampling. Fishes that were collected in the current survey but not present in 2002 samples included sand mullet, yellowfin bream, the Tamar River goby, exquisite sand goby, bridled goby and silver biddy. The silver biddy and three gobies were recorded in the lake in 1998. A single common jollytail, *Galaxias maculatus,* was found in 2002 but none were detected in 2007 samples.

The distribution patterns and occurrence of aquatic plants in the lake were not examined in detail in the current survey, but the species listed were similar to those recorded in 2002.

The increased biological diversity and abundance of the fish community shows that the Riverside lake is continuing its development towards the ecological condition of the surrounding Myall River estuary. This result supports casual observations of increasing levels of recreational fishing activity in the lake. Habitat conditions, water quality and the food web are continuing to develop, supporting improved fish recruitment and productivity. Fish recruitment and growth in the lake are contributing to biological values in the estuary as a whole and this should increase as ecological processes mature further.

Recommendations

Previous recommendations (Harris 2002) (Appendix 3) for enhancing the amount and quality of aquatic habitats remain relevant and should be pursued, particularly with respect to increasing the extent, complexity and quality of near-shore habitats for fish, invertebrates and birds. These recommendations for optimising the quality of aquatic habitats, which are incorporated in current proposals to extend the lake area, include:

- Influencing the water-quality regime to increase habitat diversity and stability.
- Continuing effective management of the series of runoff-treatment ponds.
- Increasing variability of depth profiles by introducing physical structures such as submerged logs, rockwork or other artificial reefs
- Experimentally introducing indigenous submerged and emergent aquatic plants and planting littoral trees, shrubs and grasses and
- Introducing shoreline complexity in newly created waterway areas.

It is important to continue development and maintenance of runoff management systems to sustain high and stable water-quality values, especially through the system of treatment ponds.

Completion of the planned circular enlargement of the lake and incorporation of these recommendations would increase tidal ventilation and reduce water-quality variability as well as improving the availability of habitats and food for aquatic and water-associated plants and animals.

These development initiatives will ensure the Riverside lake system continues to contribute increasingly to environmental assets of the Tea Gardens area.

References

Australian Museum (2002). *Biological Study of Myall Quays Lake.* Report No. 2002009 for Crighton Properties Pty Ltd by Australian Museum Business Services, Sydney, September 2002.

Harris, J.H. (1995) . The use of fish in ecological assessments. *Australian Journal of Ecology,* **20** (1), 65-80.

Harris J.H. (2002). *Ecological Principles and Development Options for the Myall Quays Waterway.* Harris Research Pty Ltd Report to Crighton Developments Pty Ltd, August 2002.

MDBC (2004). *Sustainable Rivers Audit Program Report.* Murray-Darling Basin Commission, Canberra. November 2004.

Appendix 1.

AMBS CONSULTING

Biological Study of Myall Quays Lake

Crighton Properties/Myall Quay Estate

Australian Museum Business Services
No. 1 Stanley Lane East Sydney, NSW 2010
Ph (02) 9331-5566, Fax (02) 9380-6964
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June 1998

Printed - 1 July, 1998

Project Team

Dr Eleni Taylor-Wood ..... Project Manager/Phycologist

Dr John Paxton ..... Ichthyologist

Ms Dianne Bray ..... Ichthyologist

Dr Alan Jones ..... Marine Ecologist

Summary

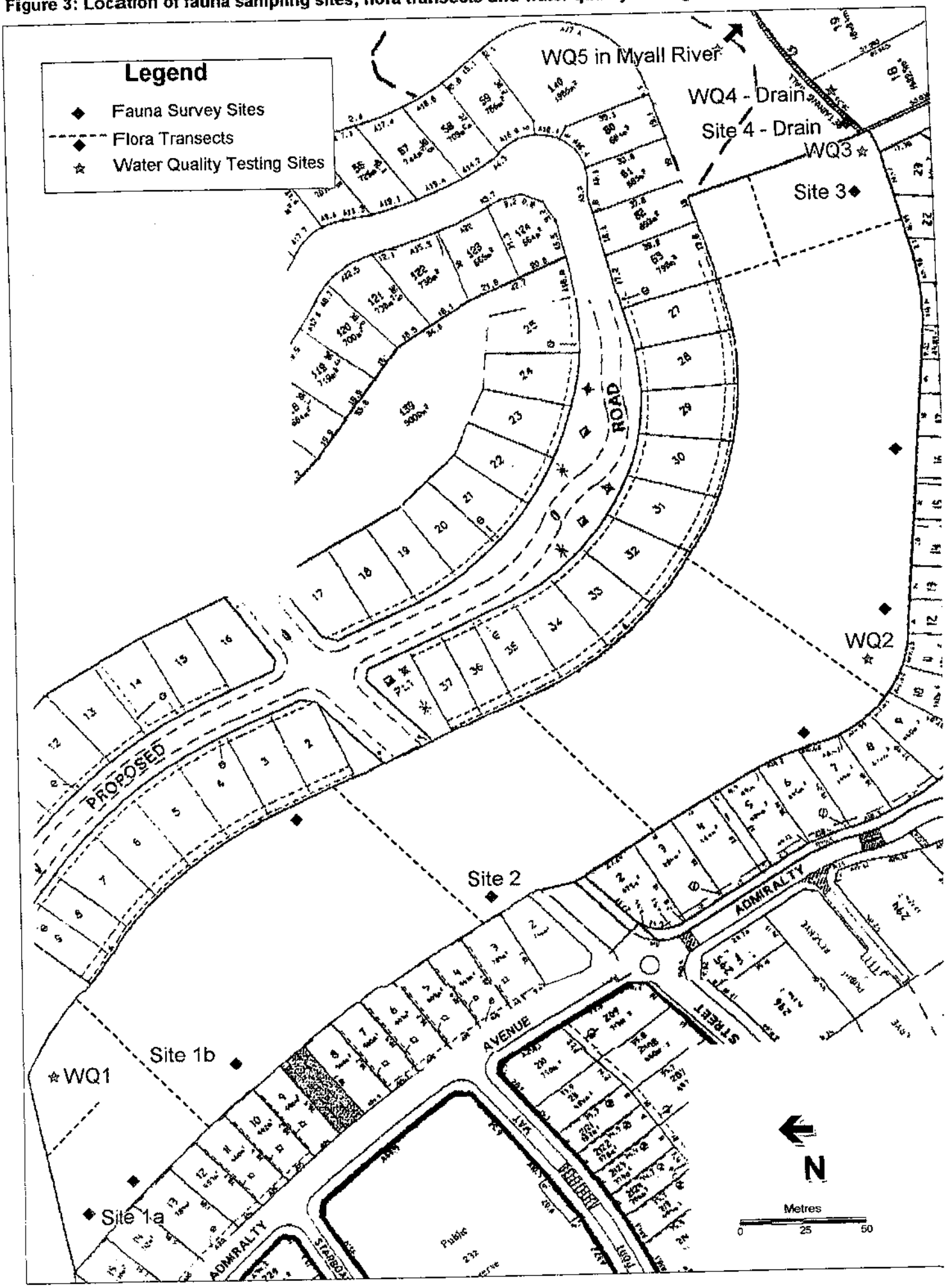
This study evaluated the health of the Myall Quays Lake by comparing the water quality with the ANZECC guidelines and by investigating the flora and fauna found in the lake. AMBS specifically looked at fishes, macro-invertebrate epifauna, seagrass and algal communities in the lake. Community structure was compared to water quality data, to evaluate whether salinity and nutrient levels influence the distribution of species in the lake.

Myall Quays Lake (32 30.40'S, 152 09.11'E) is contained within the Myall Quays development which is located near Tea Gardens, north of Newcastle. It was constructed as a detention basin to serve the needs of the adjoining residential development. The lake is approximately 4.8 hectares in surface area and varies in depth up to 4m. It has five freshwater inlets and is also tidal on certain spring tides (ie. ≥1.6m) through an established drain located in the easternmost corner of the lake.

The ecosystem within the lake is only two years old and communities within it may still be maturing. Currently, a total of eleven plants, nine fishes and one confirmed macro-invertebrate species are found in the lake, with a relatively uniform band of vegetation found in the shallow margin of the lake. The species are predominantly marine/estuarine species, although a few freshwater/brackish species are also found. As the lake was not horizontally stratified, the distribution of species and communities did not appear to be influenced by salinity and nutrient levels. Based on oxygen and the nutrient levels (total phosphorus and nitrogen) Myall Quays Lake has good surface water quality, with conditions within the guidelines recommended for lakes and reservoirs by ANZECC (1992).

Contents

Figure 3: Location of fauna sampling sites, flora transects and water quality testing sites



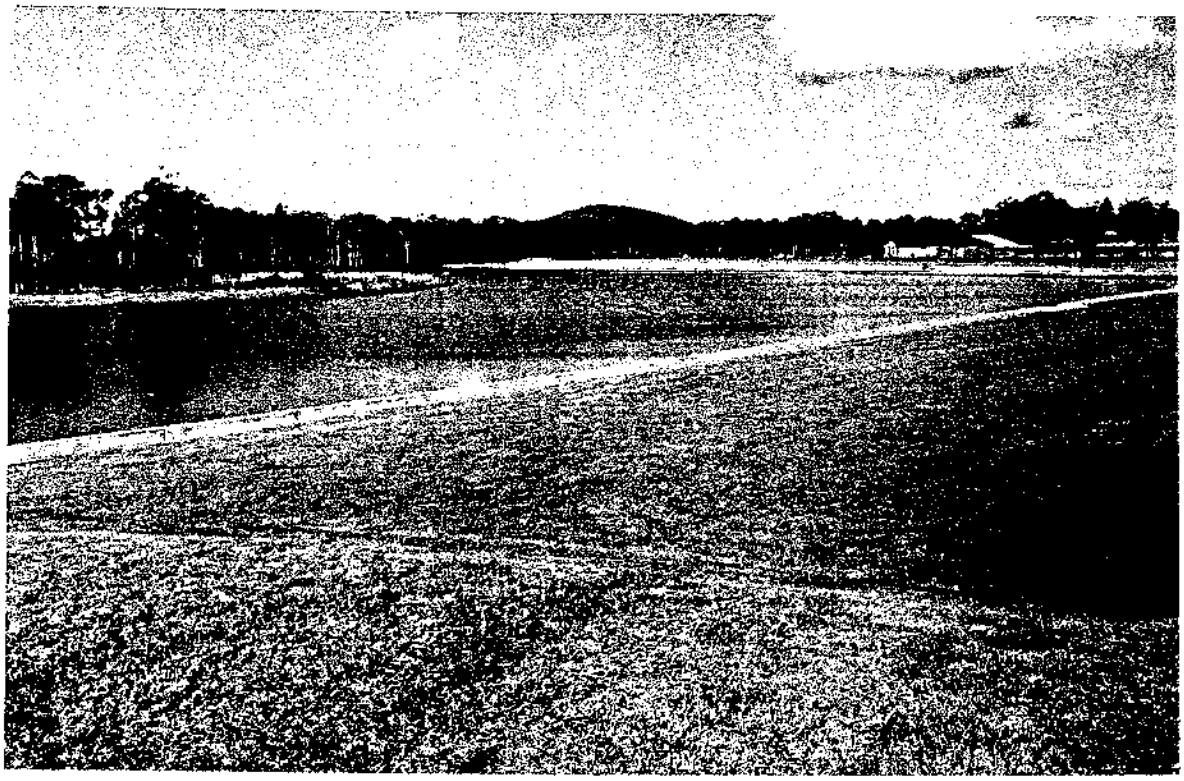
Biological Study of Myall Quays Lake

1. Introduction

Australian Museum Business Services (AMBS) was requested by Crighton Properties to undertake a biological survey of Myall Quays Lake (32 30.40'S, 152 09.11'E) The lake is contained within the Myall Quays development which is located near Tea Gardens, north of Newcastle. Myall Quays Lake was constructed as a detention basin to serve the needs of the adjoining residential development and has the capacity to detain 17,000 m^{-3} of stormwater (Figure 1). The lake is approximately 4.8 hectares in surface area and varies in depth up to 4m, with shallow edges (1:9 slope for 15-20m) sloping (1:4) into deeper water. It has five freshwater inlets and is also tidal on certain spring tides (ie. ≥1.6m) through an established drain located in the easternmost corner of the lake.

AMBS evaluated the health of the lake was evaluated by comparing the water quality with the ANZECC guidelines and by investigating the flora and fauna found in the lake. AMBS will specifically look at fishes, macro-invertebrate epifauna, seagrass and algal communities in the lake were specifically surveyed, their abundance estimated from various areas of the lake, including near the northwestern freshwater inlet and the eastern tidal mouth (drain) of the lake. Community structure is compared to water quality data, to evaluate whether salinity and nutrient levels influence the distribution of species in the lake.

Figure 1: Myall Quays Lake



2. Methods

2.1 Review of Available Water Quality Data

Hunter Water has been taking regular water samples from the lake at varying intervals from 3-10 months since February 1996. The Australian Museum assessed these data to determine the lake's nutrient status and its horizontal stratification. Horizontal stratification of the lake would influence the sampling design used during the fieldwork component of the project. As only single water samples were taken at each site, no data were available to determine the vertical stratification of the lake or the variation between replicate water samples.

Sampling times for water samples were compared to tide and rainfall data, as both factors should influence, at least, the salinity values. Tidal heights are taken from the tide tables for Australia, East Coast - Newcastle, for the years 1996 and 1997. At high tides of 1.6m and greater, there is an inflow of saline water from the lower Myall River into the lake (R. Wraight, pers. comm. 23/1/98). The rainfall figures are daily amounts in mm taken at the Myall Quays development site.

2.2 Field Work

Field work was conducted on 22 January 1998 by three members of the AMBS team, aided by personnel from Myall Quays Estate. Fish and macroinvertebrate epifauna were collected using seine nets (0.5cm mesh) at three sites within the lake and from the drain (Figure 2) leading into the lake from the wetlands adjoining the Myall River (Figure 3). Sites in the lake were located at either end of the lake and in the middle, so that variation in community structure could be determined.

Figure 2: Myall Quays Lake showing mouth of drain leading into the lake from the wetlands

The sampling site locations are:

Site 1a: Northwestern end of lake - bulrushes and algae growing near edge;

Site 1b: Northwest from office - 25m northwest from stormwater drainage inlet in front of freshwater lake;

Site 2: In front of Office;

Site 3: Eastern end of lake near drain entrance; and

Site 4: In drain.

In deeper areas of the lake a 25m long beach seine was used in conjunction with a rowboat; the seine was overweighted so it pulled along the bottom in deeper water. Both a 5m seine and small Japanese seine were used in shallower areas. The various fish collections retained were qualitative rather than quantitative. The majority of the mullet were returned to the lake and the largest specimens of mullet escaped by jumping over the seine. Larger numbers of the smaller species were retained because precise field identification is not possible for these. Fishes were identified primarily using Kuiter (1993) and McDowall (1996), and both sources were used for information on biology and distribution.

Observations on the extent, pattern of cover and species composition of aquatic angiosperms and macroalgae were made by the use of transects normal to the shoreline to determine the composition and distribution of plant communities (Figure 3). The transects extended until the limit of vegetation was reached. Observations were made by snorkelling and whilst wading. The abundance of the vegetation and their distribution patterns were recorded according to the abundance/sociability scale described in Table 1 (King and Barclay 1986). Sainty and Jacobs (1981), Moore (1986) and Womersley (1984, 1987) were the primary sources for identification of and information on the aquatic plants.

From these observations, a vegetation map was drawn up showing the distribution and abundance of the vegetation using the key outlined in Table 1. Specimens collected were identified by Australian Museum scientists.

Table 1: Abundance/sociability scale from King and Barclay (1986)

Abundance	Sociability		
	a Individual strands or clumps	b Patches	c Beds of relatively even distribution
1 Sparse growth (<15%)	5%	10%	15%
2 Moderate growth (15-50%)	15%	25%	35%
3 Abundant growth (>50%)	-	60%	65%

3. Results

3.1 Water Quality

The water quality data were limited to single samples taken at five sites over a period from January 1996 to November 1997. As no replicates were taken or samples from different depth (readings taken from within 1m of the surface), AMBS was unable to assess variability in readings at each site or whether the lake was vertically stratified. Vertical stratification, especially saline or dissolved oxygen levels, can significantly affect the composition and distribution of flora and fauna communities.

3.1.1 Salinity

After construction of the lake in January 1996, it was filled by stormwater following heavy rain during the first week. During the month of January 1996 the tide reached 1.8-2.0 m on 11 days. The salinity of Myall Quays Lake gradually increased from approximately 3.5ppt (February 1996) to 16.1-22.8ppt in January 1997. The salinity fluctuated from 7-12ppt between November 1997 and January 1998 (Figure 4). Water samples taken during the present survey indicated that the salinity of the lake was between 10-12ppt (Table 2), with the northwestern portion of the lake slightly lower than the middle and eastern portions of the lake. Water samples taken by Hunter Water show that there is little horizontal stratification within the lake, with minor variations in salinity between sites 1-3 at anyone point in time. However, in January 1997 the southern corner in the middle of the lake had a salinity of 22.8ppt, in contrast to 16.1-16.5ppt at either end of the lake, and only 11.9ppt in the drain.

Variations in salinity within the lake may occur as a result of:

- Freshwater influxes;
- Runoff;
- tidal influx;
- groundwater input; and,
- vertical stratification of salt and fresh water after heavy rainfall.

As the lake is fed by stormwater and saline river water during high tides (> 1.6m), it may be expected that the salinity of the lake would fluctuate during the month depending on the amount of rainfall and the number of tidal flows into the lake. However, care needs to be taken when comparing the water quality data with tide and rainfall data because of the time lag between rainfall and freshwater influx, and the timing of water testing compared to tidal influx.

Figure 4: Salinity of Myall Quays Lake 1996-1997

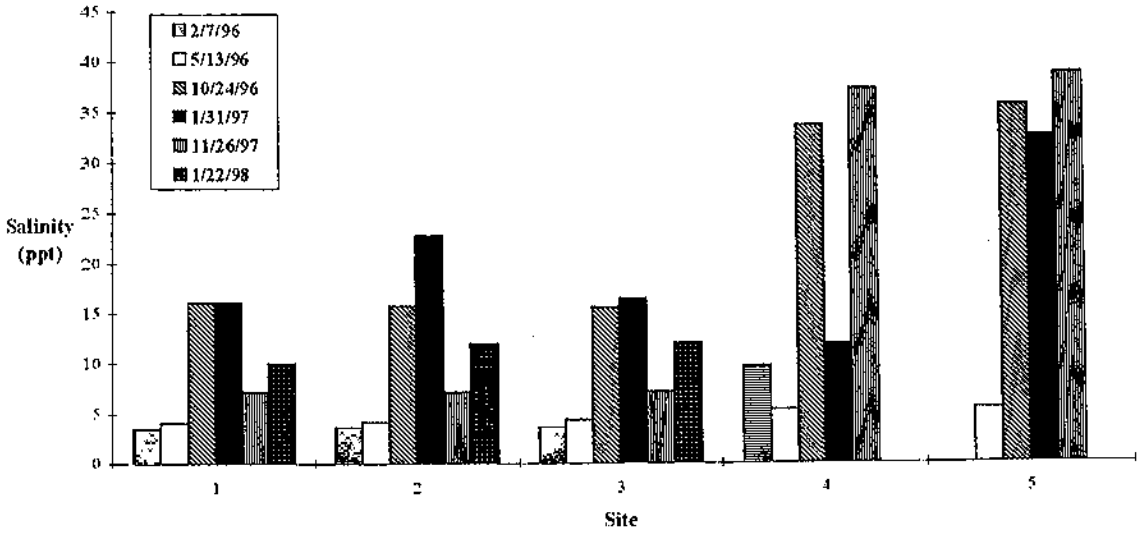
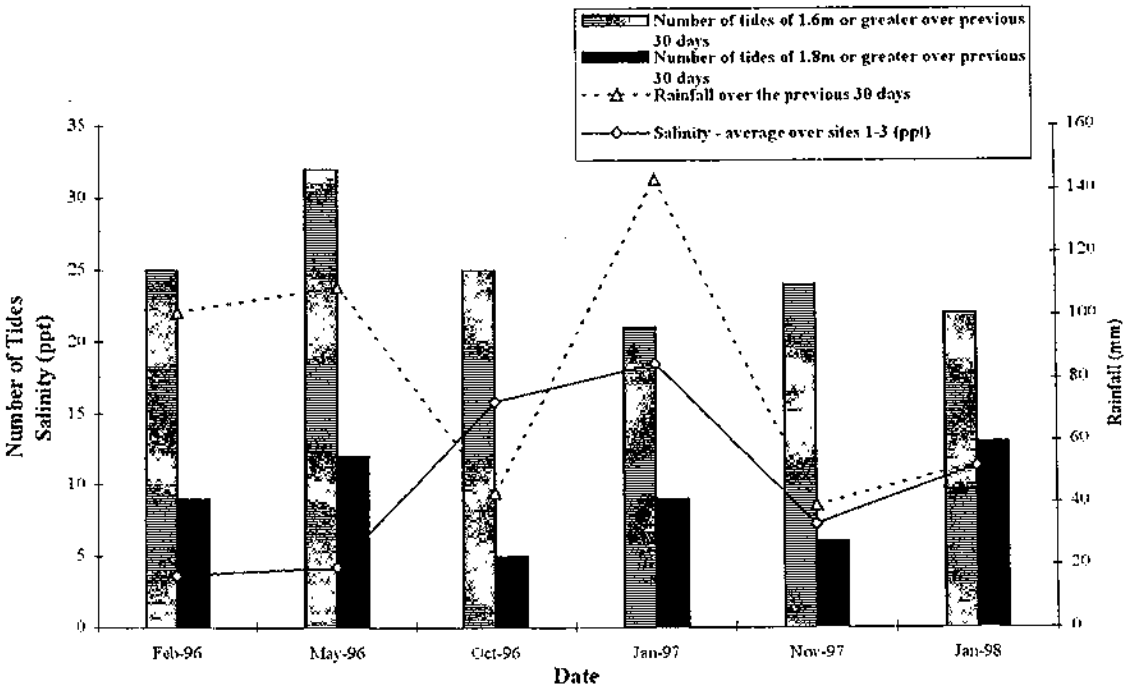


Table 2: Salinity reading recorded during January 1998

Site	Salinity (ppt)
1	10
2	12
3	12

When all three variables (salinity, tide and rainfall) are plotted (Figure 5), it can be seen that for the three samples of 1996, rainfall and salinity were highly correlated. When rainfall was high (100 or more mm in the preceding 30 days), salinity was low (less than 5ppt) and when rainfall was low (less than 50 mm in the preceding month) salinity was high (15+ppt). However, in January 1997, 143mm rain preceded a salinity of 15+ppt, and in November 1997, 39mm of rain preceded salinity of 7ppt. The addition of tidal information neither accounts for the breakdown of the rainfall/salinity relationship in 1997, nor improves the predictability of the model. Whether examining the number of tides 1.6m or greater in the preceding month, 1.8m or greater in the month, or the number of tides 1.6m or greater in the preceding week, the tides are not correlated with salinity variations.

Figure 5: Salinity, rainfall and high tide variations in Myall Quays Lake

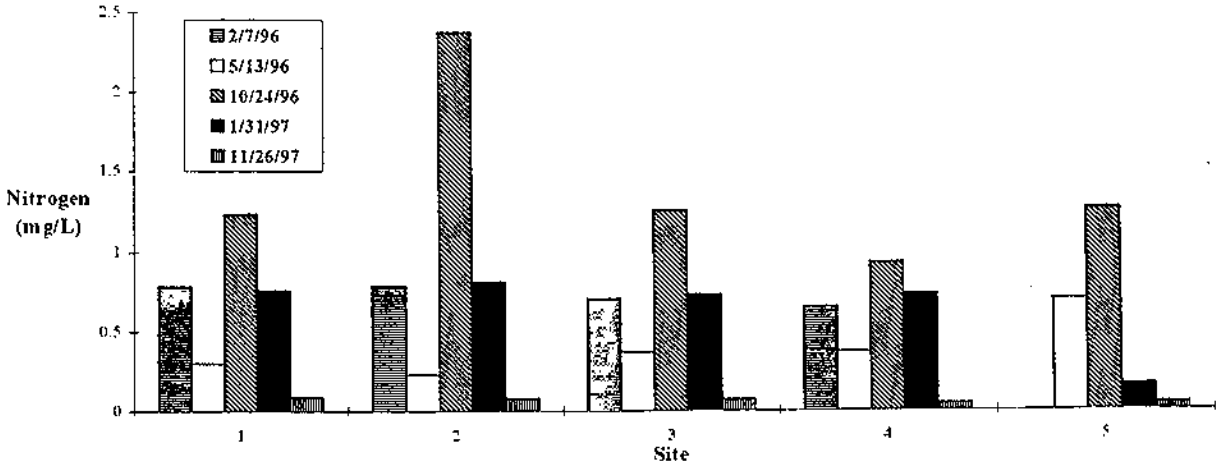


It is not clear from the tide and rainfall data what is causing the variation in salinity in the lake and drain in 1997. In January 1997 the salinity in the drain was 11.9ppt, about 25% lower than anywhere else in the lake and only about 1/3 of the salinity in the Myall River (Figure 4). Yet 21 tidal cycles in the previous 30 days had been 1.6 m or higher, and 9 of these had been 1.8 m or higher. In May 1996, the salinity in Myall River was only 5.5 ppt, compared with other river values in excess of 30 ppt. In January 1997 rainfall was more than 30% higher without significantly affecting river salinity. Thus, it is clear that salinity variations cannot be explained by simple variation in rainfall and tidal heights and that the lake and drain are part of a complex hydrological system that is influenced by other factors such as groundwater and vertical stratification.

3.1.2 Nutrients

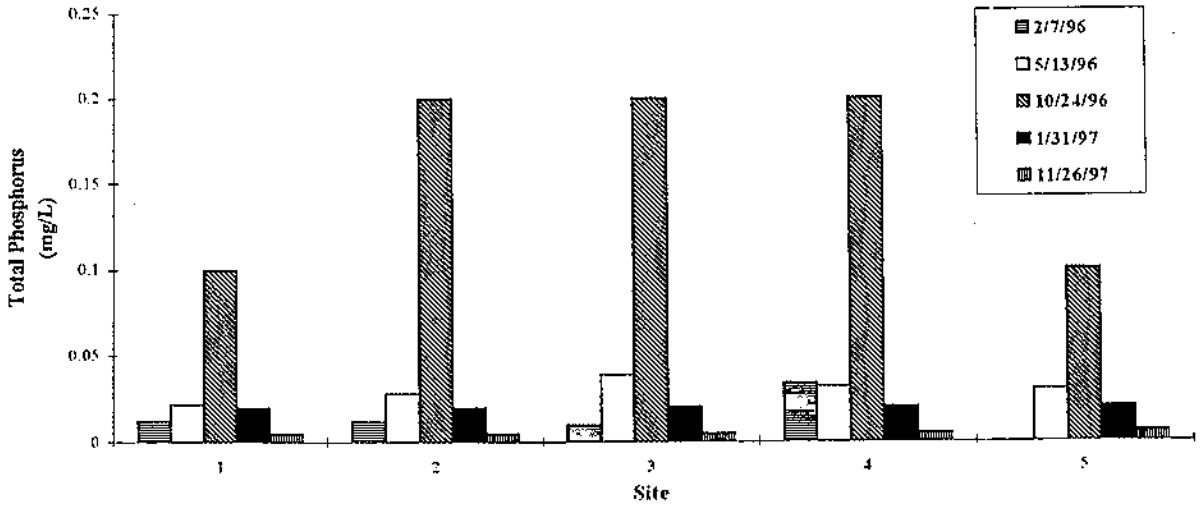
As for salinity, the nutrient levels (nitrogen and phosphorus) increased in the lake during 1996, with levels peaking in October 1996 (Figure 6 and Figure 7). During 1997, both total nitrogen and total phosphorus levels decreased in the lake. The variations in nitrogen and phosphorus levels are not correlated with rainfall, and may be a natural evolution of the lake as it matures. The low levels in 1997, particularly in November, match those in the Myall River. However, the phosphate values for November 1997 are for ortho-phosphate only and are not comparable to the total phosphate values given in all previous measurements. Total phosphate also includes the amount of condensed phosphates and organically bound phosphates as well as ortho-phosphate.

Figure 6: Total nitrogen in Myall Quays Lake 1996-1997



NB. February 1996 - January 1997 sum of Total Oxidised Nitrogen and Total Kjeldahl Nitrogen, November 1997 sum of Total Oxidised Nitrogen and Free Ammonia (no data available on Organic Nitrogen)

Figure 7: Total phosphorus in Myall Quays Lake 1996-1997



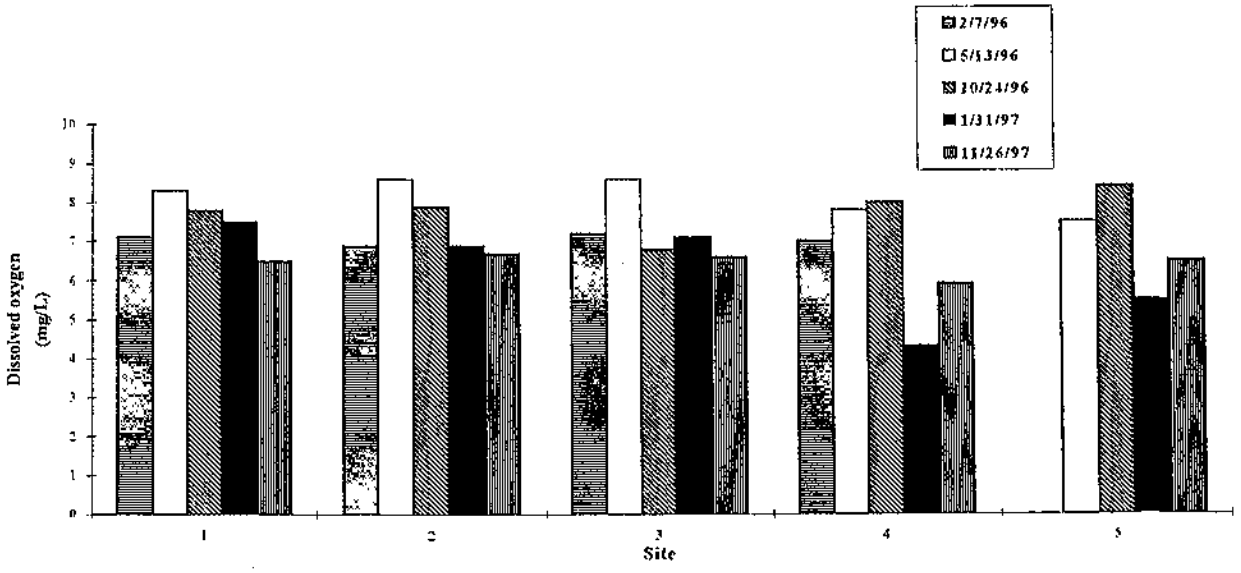
NB. February 1996 - January 1997 Total Phosphorus measured, November 1997 Ortho-Phosphate measured (no data available on condensed phosphates and organically bound phosphates)

3.1.3 Dissolved Oxygen

Dissolved oxygen levels, although increasing initially (from February 1996 to May 1996), have declined gradually but slightly over time (Figure 8). The variation in the drain has been greater, more closely approximating the variation in the Myall River. The amount of dissolved oxygen is inversely proportional to water temperature, with colder water able to hold more oxygen. Therefore, percent oxygen saturation is often calculated. Lake levels have varied between 80-96% saturation, while the Myall River has fluctuated between 76-100% saturation. Due

to the limitations of the available water quality data, it is unknown whether the lake is vertical stratificatied in terms of dissolved oxygen levels.

Figure 8: Dissolved oxygen levels in Myall Quays Lake 1996-1997



3.2 Flora

3.2.1 Flora Species Present in Myall Quays Lake

The aquatic angiosperms and macroalgae recorded in Myall Quays Lake are:

Seagrass

Ruppia polycarpa (Sea Tassel)

Grows in coastal lakes and lagoons at similar or lower salinities than seawater. *Ruppia polycarpa* is the second most dominant species in Myall Quays Lake.

Aquatic angiosperms

Triglochin striata (Streaked Arrow Grass)

Grows in tidal and freshwater swamps. Found growing in shallow areas around the lake.

Elatine gratioloides (Waterwort)

Usually found in or on the margins of stationary or slowly flowing freshwater to about 40 cm. Isolated patches were found growing in the northwestern portion of the lake.

Juncus spp. (Rushes)

Most species of *Juncus*. occur in periodically damp areas but vary greatly in their tolerance to the intervening dry periods. Some species (eg. *J. acutus* and *J. usitatus*) prefer areas with damp subsurface moisture, while other species are able to survive permanent or periodic inundation (eg. *J. aridicola*, *J. prismatocarpus*).

The species found around Myall Quays Lake is most likely *J. krausii* (grows in saline or brackish conditions) or the commonly occurring freshwater species *J. acutus* or *J. usitatus*. However, specimens were not collected for identification as the species was growing around the lake rather than in the lake.

Other

Isolate plants of two unidentified aquatic angiosperms were observed growing in the northwestern/middle section of the lake.

Macroalgae

Charophytes (Stoneworts)

Lamprothamnium papulosum

Dominant vegetation in Myall Quays Lake. Studies have shown that *L. papulosum* has an optimal salinity range between 24-28 ppt, with a minimum salinity tolerance around 8 ppt. However, *L. papulosum* is able to withstand salinities up to and including 104ppt, although it does not grow satisfactorily in salinities over 60ppt (Womersley 1984). *Lamprothamnium papulosum* is reported to be a food source for water fowl (Delroy 1974 cited in Womersley 1984).

Nitella subtilissima

Usually found in still or flowing freshwater. Occasionally found in brackish water. Only one other record of its occurrence in NSW.

Chlorophyta (Green Algae)

Cladophora sp.

Member of the Chlorophyta which grow in freshwater and saline conditions. Usually found attached to rocks, hard substrates, plants and algae in eutrophic and alkaline streams and lakes.

Rhizoclonium sp.

Member of the Chlorophyta which is often found entangled with other filamentous algae in slow flowing water. Generally found in alkaline and/or saline streams and common in estuarine areas.

Spirogyra sp.

Member of the Chlorophyta which is found floating or attached in flowing or still freshwater.

Phaeophyta (Brown Algae)

Family Chordariaceae

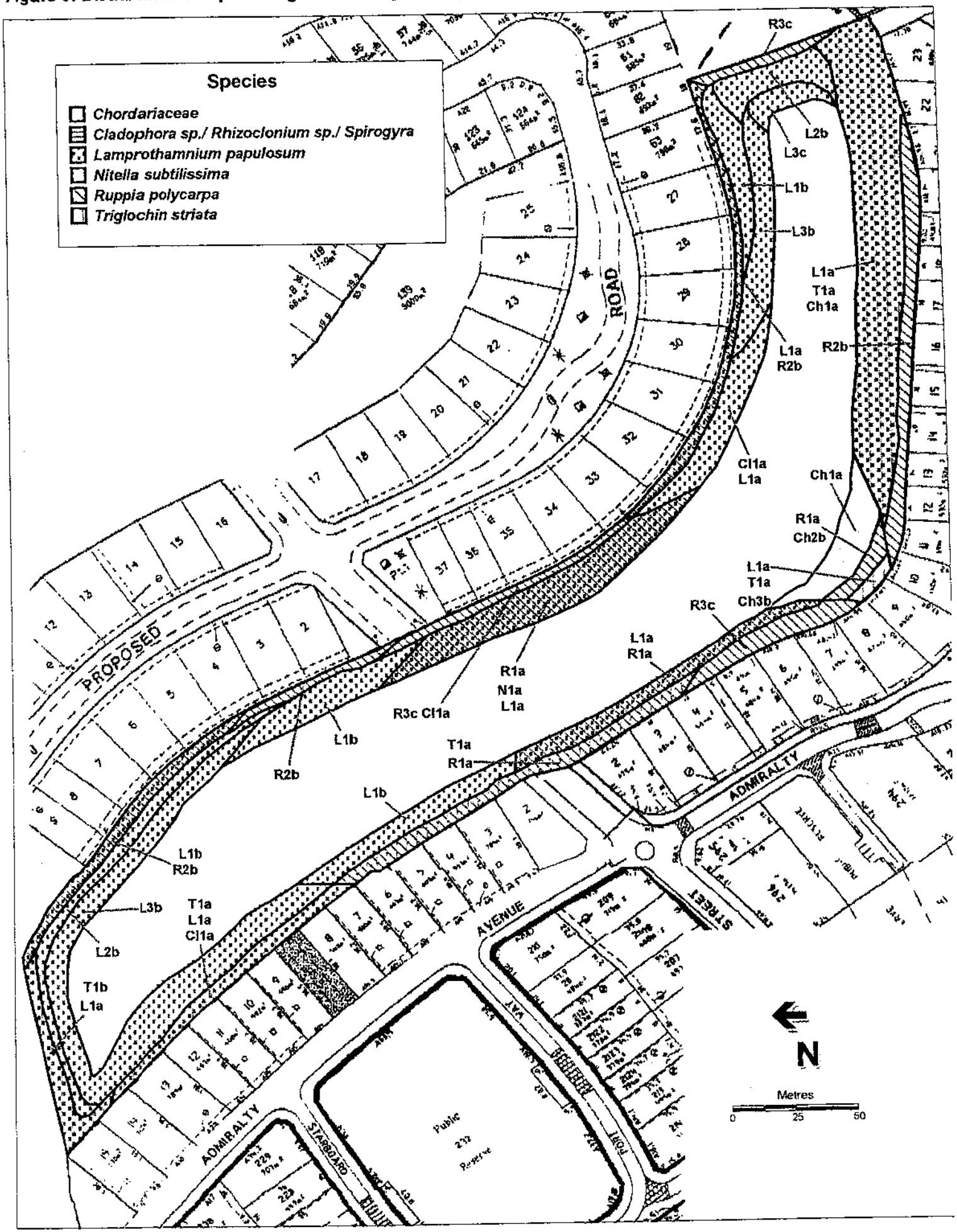
Members of this family are usually common in the lower intertidal and upper sublittoral and are also usually seasonal (in summer) in the occurrence of the macrosporophytes (macroscopic form of alga).

3.2.2 Distribution

The distribution of these aquatic angiosperms and macroalgae is presented in Figure 9, with a relatively uniform band of vegetation (approximately 20-25m in width) found around the margin of the lake. The vegetation of Myall Quays Lake was dominated by *Lamprothamnium papulosum* (a stonewort). In the deeper water (approximately 4m to 25m from the shore), *L. papulosum* was usually the only species present, with large clumps (up to approximately 50-75cm diameter and 50cm high) covering the bottom sediment. *Ruppia polycarpa* was dominant in shallow areas of the lake (less than 0.5m), where smaller clumps of *L. papulosum* were also found. These two species comprised approximately 80-90% of the total plant biomass of the lake. A brown alga of the family Chordariaceae was also abundant in the middle portion of the lake, where it formed a dense, free floating blanket over the bottom sediment. This patch was located near a stormwater outlet. Only isolated individuals of the other dominant species were found growing amongst the brown alga.

Several other species were also recorded, but they were usually found in isolated patches. In the northwestern portion of the lake, the number of species present appeared to be greater (including *Elatine gratioloides* and two unidentified aquatic angiosperms) than in the middle (southern) and eastern areas. However, further studies would be needed to verify this.

Figure 9: Distribution of aquatic vegetation in Myall Quays Lake



3.3 Fauna

3.3.1 Fauna Species Present in Myall Quays Lake

Fish and macroinvertebrates recorded in Myall Quays Lake are:

Fish

Family Poeciliidae

Gambusia holbrooki (Mosquito Fish)

Mosquito fish is an exotic species, introduced into Australia from the USA in the 1920s. It is widespread and abundant throughout NSW, SA and Victoria in both inland and coastal drainages, and coastal Queensland. Mosquito fish tolerates a wide range of salinities, from pure freshwater to full marine salinities. It is most abundant in warm and gently flowing or still waters, mostly around margins and along the edges of aquatic vegetation beds. This species feeds on a wide range of both terrestrial and aquatic organisms ie. it is an adaptable generalist predator, that may be a threat to other small fish species into whose habitat it has been introduced or spread. Recently it has been implicated in the reduction of green and golden bell frog distribution, presumably by feeding on the tadpoles.

Family Pseudomugilidae

Pseudomugil signifer (Southern Blue-eye)

Southern blue-eye is widespread throughout eastern drainages, from northern Queensland to Narooma, NSW (South-East Drainage). It is abundant in fresh or brackish coastal waters, but does not penetrate far inland.

Family Gerreidae

Gerres subfasciatus (Common Silver Belly)

Common silver belly is found in the northern half of Australia, south to Wollongong on the east coast. It occurs in estuaries and harbours out to fairly deep water along the shore.

Family Mugilidae

Mugil cephalus (Sea Mullet)

Sea mullet occurs along the entire Australian coast in estuaries; large schools migrate along ocean beaches. It spawns offshore and small schools of juveniles enter rivers, as do adults occasionally. The species can survive more than one year in freshwater. It is an important commercial species.

Family Gobiidae

Favonigobius exquisitus (Exquisite Sand Goby)

Exquisite sand goby occurs in NSW coastal bays and sandy estuaries, sometimes in seagrass.

Gobiopterus semivestitus (Glass Goby)

Glass goby occurs from southern Queensland to SA, in quiet coastal estuaries. It enters freshwater and is usually found in small to large schools.

Mugilogobius paludis (Mangrove Goby)

Mangrove goby is known from southern Queensland to SA. Its intertidal in mangroves and also enters lower reaches of freshwater streams.

Pseudogobius sp. (Blue-Spot Goby)

An undescribed species, but is not uncommon. It is found from southern Queensland to Victoria and occurs in coastal estuaries, usually in muddy upper reaches with rocks or seagrasses.

Philypnodon sp. (Dwarf Flathead Gudgeon)

Dwarf flathead gudgeon is another undescribed species, occurring in coastal streams of southern Queensland, NSW, Victoria and SA. It is found in brackish waters in estuaries, to altitudes of a few hundred metres and is common in coastal northern areas of range. This species prefers relatively calm waters and lives over mud or rocks, or in weedy areas.

Family Anguillidae

Anguilla reinhardtii (Long Finned Freshwater Eel)

Long finned freshwater eel occurs from Cape York to Tasmania, in all coastal rivers, streams and lakes, as well as in brackish waters. It migrates out to sea to breed after up to ten years in freshwater and is commercially important. Previously it was observed by Myall Quays staff, but it was not collected in January 1998.

Macroinvertebrates

Crustacea: Infraorder Caridea

Family Palaemonidae

These shrimps are commonly found in estuaries and feed on algae and detritus. The commonest species of estuary shrimps do not exceed 45 mm in length and

are of no commercial importance.

Crustacea: Infraorder Brachyura

Family Portunidae

Portunus pelagicus (Blue Swimmer Crab)

Blue swimmer crab is found Australia-wide, in bays and estuaries as well as offshore. A large crab of commercial importance. Previously it was observed by Myall Quays staff, but was not collected in January 1998.

3.3.2 Distribution

The number of fish/macroinvertebrates captured is presented in Table 3. The fauna of Myall Quays Lake was dominated in numbers by *Favonigobius exquisitus* (Exquisite sand goby) and *Pseudomugil signifer* (Southern blue-eye). *Mugil cephalus* (Sea mullet) was the largest fish recorded in Myall Quays Lake, and dominant in biomass. No accurate count of numbers of this species was obtained, as most of the mullet were released. Several other fish species were also recorded with *Gobiopterus semivestitus* (Glass goby) the next most common species (based on numbers caught). Only one species of macroinvertebrates, an estuary shrimp of the family Palaemonidae, was caught during the sampling period.

Table 3: Fish numbers from Myall Quays Estate, Tea Gardens

Species		Site					Total
		1a	1b	2	3	4	
FISHES							
Gambusia holbrooki	Mosquito fish	-	-	6	-	16	**22**
Pseudomugil signifer	Southern blue-eye	132	26	1	40	75	**274**
Gerres subfasciatus	Common silver belly	-	-	-	6	-	**6**
Mugil cephalus	Sea mullet	-	2	11	3	2	**18**
Favonigobius exquisitus	Exquisite sand goby	32	52	19	174	-	**277**
Gobiopterus semivestitus	Glass goby	79	12	-	60	2	**153**
Mugilogobius paludis	Mangrove goby	-	-	-	-	1	**1**
***Pseudogobius* sp.**	Blue spot goby	5	9	1	10	-	**25**
***Philypnodon* sp.**	Dwarf flathead gudgeon	18	32	-	13	-	**63**
MACROINVERTEBRATES							
Palaemonidae		4	-	-	-	14	**18**
	Total	**270**	**133**	**38**	**306**	**110**	**839**

Most of the fish species appear to occur in all parts of the lake. The exception seems to be the mosquito fish *Gambusia*, with largest numbers in the drain and few in the lake proper. The same is also true of the estuary shrimp, with most in

the drain and low numbers only in the northwest corner of the lake. The two rarest fishes, the Mangrove goby and Common silver belly, were both found only in the drain or eastern end of the lake near the drain entrance. All other fish species were taken in at least 3 of the 4 lake sites, but four fish species, including the commonest Exquisite sand goby, were absent from the drain.

4. Discussion

4.1 Water Quality

Indicative concentrations (preferred upper limits) of total nitrogen and phosphate for lakes and reservoirs (as recommended by ANZECC 1992) are shown in Table 4. They were not able to recommend a single set of nitrogen and phosphorus concentrations, as this would require a site-specific study. However, these ranges provide an indication of levels at or above which problems (such as phytoplankton blooms) have been known to occur (depending on a range of other factors eg. temperature, turbidity).

Table 4: Indicative concentration range of total nitrogen and phosphate for lakes and reservoirs (as recommended by ANZECC 1992)

Nutrient	Indicative Concentration Range
Total Phosphorus	5-50µg/L (0.005-.05mg/L)
Total Nitrogen	100-500µg/L (0.1-0.5mg/L)

With the exception of October 1996, total phosphorus in Myall Quays Lake has always been 0.04mg/L or less. All of the January 1997 values were less than 0.02mg/L (the November 1997 values were for ortho-phosphate and are not comparable).

With the exception of October 1996, where total nitrogen values of 1-2+mg/L were attained, all measurements of total nitrogen within the lake have been only slightly over or under the recommended value of 0.5mg/L. From the peak of October 1996 the nitrogen values have been steadily decreasing, with the values of November 1997 exceptionally low at >0.1mg/L. These values are indicative of very good water quality.

The figures given above are for freshwater; Australian estuarine studies are very limited and ANZECC (1992) recommended figures for estuarine waters, based on one study in Western Australia, are not presented in either total nitrogen or total phosphate and thus are not comparable to our data. Variation in nutrient levels within the lake may be a result of runoff from the catchment, either wastewater discharge or diffuse runoff. They may also be a result of metabolic decomposition,

which may be seasonal resulting in a timelag in nutrient levels within the lake. In terms of potential algal blooms, one of the important factors is the ratio of total nitrogen/total phosphorus. With both nutrients being below the maximum recommended values, algal blooms should not be a problem if the present range of values are maintained.

The ANZECC (1992) guidelines also recommended that dissolved oxygen levels normally should not be permitted to fall below 6mg/L or 80-90% saturation. None of Myall Quays Lake surface (top 1m) values ever fell below these recommended minima. However, it is not known whether dissolved oxygen levels at the bottom of the lake comply with ANZECC guidelines. Dissolved oxygen varies significantly during a 24 hour period, depending on temperature, salinity, and biological activity (ie. whether the aquatic plants are photosynthesising during the day and producing oxygen or respiring at night and using oxygen). Therefore, oxygen levels should be determined over at least one circadian cycle. Water samples should also be taken at more than one depth including from near the bottom to determine if the lake is vertically stratified. Dissolved oxygen levels in bottom waters may be significantly different (lower) that surface waters due bacterial decomposition of organic matter. This can result in the death of organisms which are unable to escape from the zone of oxygen depletion (Scanes and Scanes 1995). Reduction in dissolved oxygen concentrations in water can also reduce the physiological efficiency of fishes and non-airbreathing invertebrates, with levels below 5mg/L stressful to many species (Koehn and O'Connor 1990). During both sampling times in 1997, oxygen saturation in the drain was less than 80% and in January 1997 the oxygen was only 4.3 mg/L, thus placing the fishes in the drain under stress. One feature of fishes is their ability which to move to higher quality water in times of stress, and they may have moved into the lake during January 1997.

Overall, on the basis of both oxygen levels and the nutrient levels of total phosphorus and nitrogen as recommended in the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 1992), Myall Quays Lake has good surface water quality.

4.2 Flora

The vegetation of Myall Quays Lake was dominated by the Charophyte *L. papulosum*. The seagrass, *Ruppia polycarpa*, was also prominent in shallow areas of the lake. These two species made up 80-90% of the plant biomass of the lake. Charophyte beds are ecologically important as they have a high biomass, accumulate large concentrations of nutrients and have a large surface area which is readily colonised by micro-organisms which can support a large invertebrate population (Moore 1986). The large clumps of *L. papulosum* would most likely provide shelter and food for fishes.

Aquatic macrophytes usually grow best in lakes and rivers in areas of fine sediment and low current velocity (Wright and McDonnell 1986). These condition

are met in Myall Quays Lakes, where the sediment is composed of fine sand and there is frequently little or no water flow. Macrophyte and algal growth in Myall Quays Lake is thought to be primarily limited by turbidity, with only *Lamprothamnium papulosum* found growing in the deeper, turbid waters of the lake. In the deepest areas of the lake no vegetation was found growing.

Charophytes, such as *L. papulosum* and *Nitella subtilissima,* usually prefer calcium rich waters which are low in phosphate, with phosphate levels above 20µg/L often inhibiting their growth (Moore 1986). Water quality testing of Myall Quays Lake has shown that total phosphate levels vary. However, total phosphate levels in January 1997 were less than 20µg/L (total phosphate was not recorded in November 1997). Thus the current physical environment within the lake appears to be suitable for Charophyte growth. A permanent increase in nutrient levels could affect the growth of Charophytes and result in a change in the vegetation communities found in the lake.

Highly fluctuating salinity levels may limit the survival of some aquatic plants. Many species, although able to withstand saline conditions, are unable to cope with rapidly fluctuating salinities. If the level of salinity change seen in the lake between January and November 1997 (from 23 to 7 ppt at site 2) occurred over a short period, some species probably would not survive.

4.3 Fauna

A total of nine species of fishes and one shrimp species were collected. The two dominant fish species in the lake in terms of numbers are the exquisite sand goby, *Favonigobius exquisitus,* and the southern blue eye, *Pseudomugil signifer.* The sea mullet, *Mugil cephalus,* is by far the largest in terms of biomass, making up all the large fish in the lake. Based on our sampling, the school of fish that comes to feed on the bread every day consists entirely of sea mullet.

All of the nine fish species are tolerant to relatively wide salinity ranges. However, if the salinity continue to vary over a wide range, the number of additional species to colonise the lake may be limited. Many species cannot tolerate such a wide range of salinities, particularly if the changes occur over a short period of time. It may be that these fluctuating salinities are a natural feature of this lake, due to its function as a stormwater reservoir, and therefore there will never be a rich fauna of resident fishes and macroinvertebrates.

4.4 Ecology of Myall Quays Lake

As the lake is only two years old, the communities within the lake are probably still maturing and may change in composition, abundance and distribution over time. Although the lake is currently dominated by the plants *Lamprothamnium papulosum* and *Nitella subtilissima,* and the fishes *Mugil cephalus, Favonigobius exquisitus,* and *Pseudomugil signifer*, the dominant species present could

significantly change if nutrient concentrations or salinity were to change dramatically. Currently the species present in the lake are adapted to a changing physical environment, with fluctuations in salinity, nutrients and dissolved oxygen occurring as a complex result of freshwater influxes (stormwater), tidal flows, and other causes.

If nutrient levels within the lake increased significantly, this could also significantly affect the vegetation community currently found in the lake. Growth of the dominant species, *L. papulosum*, may be affected by high phosphate levels, which could result in decline of the species. Other species such as cyanobacteria and *Cladophora* sp. prefer high nutrient conditions, and if conditions changed in the lake such that nutrient levels increased, this may result in excessive growth of such species. Although not all species are toxic, excessive growth may affect other species by smothering or shading. The positioning of the brown alga currently found in the lake (family Chordariaceae), near a stormwater outlet suggests that biomass of this alga may increase in high nutrient conditions. An increase in cyanobacteria in the lake may result in blooms when suitable conditions (high temperature, stable water column, nutrients) occur. Cyanobacteria blooms are known to be toxic. Thus, although the species composition of the lake may not change due to increasing nutrient levels, the dominant species may. Changes in the vegetation community of the lake would affect faunal species that rely on the plants for food and shelter.

Presently the lower Myall River and wetlands serve as the main source for species found in the lake. The species composition of the lake may be expected to increase as the community becomes more complex with age. New plants may also be introduced into the lake by animals such as birds, while many freshwater invertebrates have aerial adult stages. There is a reasonable likelihood of achieving a healthy ecosystem with good water quality if a natural source of species is present. Many artificial lakes require considerable management, including the monitoring of water quality, to ensure that they do not become eutrophic (promoting the incidence of toxic cyanobacteria blooms) or deficient in dissolved oxygen.

The drain allows Myall River water to flow back into the lake during the highest tides of each month, benefiting water quality. During previous heavy rain in March 1997, the mullet population was washed out of the lake into the river. The present mullet, some of which exceed 20 cm length, are presumably juveniles that entered after that flood and have grown to their present size in the intervening year. Thus the lake can act as a supplementary growing area for populations of Myall River species.

4.5 Conclusion

The ecosystem within the lake is only two years old and communities within it are probably still maturing and may change in composition, abundance and distribution over time. Currently, a total of eleven plants (excluding *Juncus* sp.), nine fishes and one confirmed macroinvertebrate species are found in the lake, with a relatively uniform band of vegetation found in the shallow margin of the lake. The species are predominantly marine/estuarine species, although a few freshwater/brackish species (eg. *Nitella* sp., *Triglochin striata, Elatine gratioloides*) are also found. As the lake was not horizontally stratified, the distribution of species and communities did not appear to be influenced by salinity and nutrient levels. Based on oxygen and the nutrient levels (total phosphorus and nitrogen) Myall Quays Lake has good surface water quality, with conditions within the guidelines recommended for lakes and reservoirs by ANZECC (1992).

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