ENVIRONMENTAL ASSESSMENT

Mayfield Site Port-Related Activities Concept Plan
Volume 3 - Appendix H - I

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Prepared for Newcastle Ports Corporation
Corner Scott and Newcomen Streets | Newcastle | New South Wales | 2300
www.newportcorp.com

Prepared by AECOM
Level 8, 17 York Street| Sydney | New South Wales | 2000 | T +61 2 8023 9333 | F +61 2 8023 9399
www.aecom.com

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Appendix H

Water Monitoring Results and Preliminary Stormwater Strategy

1.0 Water Quality Monitoring Results

1.1 Existing EPL Water Quality Criteria

There are two EPLs that currently apply to portions of the site. EPL1708 (BHP Billiton HRRP) permits the treatment of contaminated soil and requires water quality monitoring be undertaken. The licence specifies ten locations for monitoring and one for discharge (effluent quality).

EPL13181 (NPC Mayfield Berth 4) specifies four surface water monitoring locations, including the biorentention swale and stormwater pits. The water quality criteria for these licences are outlined in **Table 1**.

Table 1 Water Quality Criteria for Existing EPLs that Apply to Parts of the Site

Pollutant	**Unit of Measure**	**Concentration Limit**	
		50%ile	100%ile
Licence 1708			
Ammonia	mg/L	35	50
Anthracene	mg/L	15	-
Benzo(a)pyrene	mg/L	4	-
Fluoranthene	mg/L	17	-
Napthalene	mg/L	90	-
pH	pH	-	6.5-8.5
Phenanthrene	mg/L	40	-
Total suspended solids	mg/L	50	50
Cyanide (weak acid dissociable)	mg/L	0.2	-
Licence 13181			
Copper	mg/L		1.3
Oil and grease	mg/L		10
pH	pH		6.5-8.5
Nitrogen (total)	mg/L		300
Total suspended solids	mg/L		30
Lead (total)	mg/L		4.4

1.2 Water Quality Standards and Monitoring Results

Water quality standards and monitoring results relied upon during preparation of this EA are provided in the following tables and the main body of the technical report prepared by Coffey Environments on 30 June 2008.

BHP Closure Area										
Surface water sampling results (November 2007)										
(ug/L unless otherwise stated)										
	SAMPLE ID	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9
	ANZECC (2000) Ecosystems Marine Water (95%)									
PYHSICAL PARAMETERS										
pH	6.5-8.0	-	7.12	**8.02**	7.44		7.92	**8.23**	7.99	**8.56**
TDS mg/L		-	1380	3430	2460	3260	20900	17800	37900	840
Turbidity NTU	0.5-10	-	3.2	0.6	3.1	4.1	**37.7**	**19.1**	6.8	**2620**
HEAVY METALS										
Arsenic	2.3	**3**	1	**12**	**7**	**3**	**8**	**6**	**11**	**13**
Cadmium	5.5	1	0.1	0.2	<0.1	<0.1	0.8	<0.1	<0.1	0.8
Chromium	4.4	**15**	1	<1	<1	<1	1	4	<1	**31**
Copper	1.3	**18**	**2**	**2**	**2**	<1	**9**	**5**	<2	**71**
Nickel	70	9	1	2	1	<1	4	2	<1	22
Lead	4.4	**53**	<1	**12**	2	<1	4	**9**	<1	**287**
Zinc	15	**210**	15	**46**	<5	5	**19**	**22**	<5	**470**
Mercury	0.4	0.3	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Cyanide	4	**16.7**	<4	**8.2**	**5.4**	<4	<4	<4	<4	**5.7**
NUTRIENTS										
Ammonia	910	**1700**	**2950**	<10	<10	**2430**	**7670**	**2380**	**6190**	44
TOTAL PETROLEUM HYDROCARBONS										
C6		<50	<50	<20	<20	90	<20	80	<20	<20
C10		500	<100	<50	<50	<50	<50	<50	<50	50
C15		160	<50	<100	<100	<100	200	<100	<100	400
C29		540	30	<50	<50	<50	<50	<50	<50	120
Total	325	ND	ND	90			200	80	ND	**570**
BTEX										
Benzene	700	221	22	<1	<1	<1	<1	<1	<1	<1
Toluene	180	<5	<2	<2	<2	3	<2	2	<2	<2
Ethylbenzene	5	<5	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylene		<5	<2	<2	<2	<2	<2	<2	<2	<2
POLYCYCLIC AROMATIC HYDROCARBONS										
Naphthalene	70	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	<1.0	<1.0
Acenaphthylene		1.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene		1.6	<1.0	<1.0	<1.0	<1.0	1.7	<1.0	<1.0	<1.0
Fluorene		3.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene		3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.9
Anthracene		3.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene		2.7	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	2
Pyrene		2.8	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	<1.0	1.6
Benz(a)anthracene		3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene		8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	0.2	**2.4**	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene		2.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene		4.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene		7.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total PAH		46.1	ND	ND	ND	ND	ND	2.7	ND	3.9
POLYCHLORINATED BIPHENYLS										
PCB		<1	<1	-	-	-	-	-	-	-

BHP Closure Area
Surface water sampling results (February 2008)
(ug/L unless otherwise stated)

	SAMPLE ID	SW3	SW4	SW5	SW7	SW9
	ANZECC 2000 95% protection of marine species	28/02/2008	28/02/2008	28/02/2008	28/02/2008	28/02/2008
PYHSICAL PARAMETERS						
pH	6.5-8.0	7.5	7.86	7.05	8.81	8.35
TDS		982	960	16800	68	950
Turbidity	0.5-10	99.3	1250	20.9	159	1820
HEAVY METALS						
Arsenic	2.3	2	7	2	0.4	0.6
Cadmium	5.5	0.8	0.2	68.5	7	12
Chromium	27.4	12	10	<1	27	59
Copper	1.3	14	70	4	75	104
Lead	4.4	50	77	<1	5	11
Nickel	70	19	10	4	275	217
Zinc	15	86	143	21	0.2	0.3
Mercury	0.4	<0.1	0.2	<0.1	<4	<4
NON-METALLIC INORGANICS						
Free Cyanide	4	<4	<4	<4	<4	<4
NUTRIENTS						
Ammonia	910	28	27	571	44	17
TOTAL PETROLEUM HYDROCARBONS						
C6-C9	C9	<20	<20	<20	<20	<20
C10-C14	C14	<50	<50	<50	<50	<50
C15-C28	C28	<100	100	<100	200	100
C29-C36	C36	60	80	<50	80	<50
Total C6-C36	325	60	180	ND	280	100
BTEX						
Benzene	700	<1	<1	<1	<1	<1
Toluene	180	<2	<2	<2	<2	<2
Ethylbenzene	5	<2	<2	<2	<2	<2
Total Xylene	75	<2	<2	<2	<2	<2
POLYCYCLIC AROMATIC HYDROCARBONS						
Naphthalene	70	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene		1.2	<1.0	<1.0	3.1	<1.0
Anthracene		<1.0	<1.0	<1.0	1	<1.0
Fluoranthene		3.5	1.8	<1.0	6.5	1.4
Pyrene		3.4	1.7	<1.0	5.9	1.2
Benz(a)anthracene		1.4	<1.0	<1.0	2.3	<1.0
Chrysene		1.6	<1.0	<1.0	2.2	<1.0
Benzo(b)fluoranthene		2.7	1	<1.0	3	<1.0
Benzo(k)fluoranthene		<1.0	<1.0	<1.0	1	<1.0
Benzo(a)pyrene	0.2	1.6	0.8	<0.5	2.3	<0.5
Indeno(1.2.3.cd)pyrene		1.3	<1.0	<1.0	1.6	<1.0
Dibenz(a.h)anthracene		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene		1.6	<1.0	<1.0	2	<1.0
Total PAH		18.3	5.3	ND	30.9	2.6

BHP Closure area
Surface Water Sampling Results (November 2008)
(ug/L unless otherwise stated)

	LOR	Field ID / Sample Date	SW9	SW8	SW4	SW5	A-DRAIN	RPD %
		Sample Date	6/11/2008	6/11/2008	6/11/2008	6/11/2008	6/11/2008	
		ANZECC (2000) Ecosystems Marine Water (95%)					Sample A-DRAIN is a duplicate of SW5	
Field/Physical Parameters								
Temperature (°C)	-	-	21.1	22.9	27.5	24.0	-	-
Conductivity (uS/cm)	-	-	528	19000	764	3900	-	-
pH	-	6.5-8.0	7.6	8.1	8.2	8.2	-	-
Dissolved Oxygen (ppm)	-	-	3.5	4.1	0.0	7.8	-	-
Redox Potential (mV)	-	-	160	-26	139	125	-	-
Total Dissolved Solids (mg/L)	-	-	368	16200	620	3490	3470	1
Turbidity (NTU)	-	0.5-10	16.1	3.9	81.6	3.2	3.3	3
Total Metals (mg/L)								
Arsenic	0.001	0.0023	0.002	0.002	0.005	<0.001	<0.001	-
Cadmium	0.0001	0.0055	0.0004	0.0004	0.0009	0.0004	0.0002	67
Chromium (III+VI)	0.001	0.0044	<0.001	0.004	0.001	<0.001	<0.001	-
Copper	0.001	0.0013	0.002	0.009	0.004	0.003	0.003	0
Lead	0.001	0.0044	0.001	0.019	0.005	0.004	0.004	0
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	0.07	0.001	0.003	0.002	0.003	0.003	0
Zinc	0.005	0.015	0.007	0.046	0.015	0.038	0.037	3
Inorganics (mg/L)								
Ammonia	0.01	0.91	0.16	0.1	<0.01	<0.01	<0.01	-
Cyanide Total	0.004	0.004	0.019	<0.004	<0.004	<0.004	<0.004	-
TPH								
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	-
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	-
TPH C15 - C28 Fraction	<100	-	<100	100	<100	<100	<100	-
TPH C29 - C36 Fraction	<50	-	<50	230	<50	<50	<50	-
TPH C10 - C36 (Sum of total)	<200	325	<200	330	<200	<200	<200	-
BTEX								
Benzene	1	700	<1	<1	<1	2	2	0
Ethylbenzene	2	5	<2	<2	<2	<2	<2	-
Toluene	2	180	<5	<5	<5	<5	<5	-
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	-
Xylene (o)	2	-	<2	<2	<2	<2	<2	-
Xylene Total		75	<4	<4	<4	<4	<4	-
PAH								
Acenaphthene	1	-	<1	<1	<1	<1	<1	-
Acenaphthylene	1	-	<1	<1	<1	<1	<1	-
Anthracene	1	-	<1	<1	<1	<1	<1	-
Benz(a)anthracene	1	-	<1	<1	<1	<1	<1	-
Benzo(a) pyrene	0.5	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	-
Benzo(b)fluoranthene	1	-	<1	<1	<1	<1	<1	-
Benzo(g,h,i)perylene	1	-	<1	<1	<1	<1	<1	-
Benzo(k)fluoranthene	1	-	<1	<1	<1	<1	<1	-
Chrysene	1	-	<1	<1	<1	<1	<1	-
Dibenz(a,h)anthracene	1	-	<1	<1	<1	<1	<1	-
Fluoranthene	1	-	<1	<1	<1	<1	<1	-
Fluorene	1	-	<1	<1	<1	<1	<1	-
Indeno(1,2,3-c,d)pyrene	1	-	<1	<1	<1	<1	<1	-
Naphthalene	1	70	1.2	<1	<1	<1	<1	-
Phenanthrene	1	-	<1	<1	<1	<1	<1	-
Pyrene	1	-	<1	<1	<1	<1	<1	-

BHP Closure area
Surface Water Sampling Results (January 2009)
(ug/L unless otherwise stated)

	LOR	ANZECC (2000) Ecosystems Marine Water (95%)	C/R
		Field ID	C/R
		Sample Date	30/01/2009
Field/Physical Parameters			
Temperature (°C)	-	-	18.8
Conductivity (uS/cm)	-	-	44900
pH	-	7.0-8.5[d]	7.92
Dissolved Oxygen (ppm)	-	-	5.65
Redox Potential (mV)	-	-	118
Total Metals (mg/L)			
Arsenic	0.001	0.0023[a]	<0.01
Cadmium	0.0001	0.0055	<0.001
Chromium (III+VI)	0.001	0.0044[b]	<0.01
Copper	0.001	0.0013	<0.02
Lead	0.001	0.0044	<0.01
Mercury	0.0001	0.0004	<0.0001
Nickel	0.001	0.07	<0.01
Zinc	0.005	0.015	<0.05
Inorganics (mg/L)			
Ammonia	0.01	0.91	1.1
TPH			
TPH C 6 - C 9 Fraction	<20	-	<20
TPH C10 - C14 Fraction	<50	-	<50
TPH C15 - C28 Fraction	<100	-	<100
TPH C29 - C36 Fraction	<50	-	<50
TPH C10 - C36 (Sum of total)	<200	600[c]	<200
BTEX			
Benzene	1	700	<1
Ethylbenzene	2	5[a]	<2
Toluene	2	180[a]	<5
Xylene (m & p)	2	-	<2
Xylene (o)	2	-	<2
Xylene Total		75[a]	<4
PAH			
Acenaphthene	1	-	<1
Acenaphthylene	1	-	<1
Anthracene	1	-	<1
Benz(a)anthracene	1	-	<1
Benzo(a) pyrene	0.5	0.2[a]	<0.5
Benzo(b)fluoranthene	1	-	<1
Benzo(g,h,i)perylene	1	-	<1
Benzo(k)fluoranthene	1	-	<1
Chrysene	1	-	<1
Dibenz(a,h)anthracene	1	-	<1
Fluoranthene	1	-	<1
Fluorene	1	-	<1
Indeno(1,2,3-c,d)pyrene	1	-	<1
Naphthalene	1	70	<1
Phenanthrene	1	-	<1
Pyrene	1	-	<1

(a) Low reliability trigger value
(b) Cr (VI) trigger value
(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)
(d) NSW estuaries

BHP Closure area
Surface Water Sampling Results (February 2009)
(ug/L unless otherwise stated)

	LOR	Field ID / Sample Date / ANZECC (2000) Ecosystems Marine Water (95%)	C/R 19/02/2009 Western Drain Culvert Outlet	SW3 19/02/2009 Eastern Drain Upstream	SW4 19/02/2009 Gatehouse Drain	SW5 19/02/2009 Western Drain	SW8 19/02/2009 Eastern Drain Downstream	SW9 19/02/2009 Daracon Drain	Q01 19/02/2009 Q01 is a duplicate of SW9	RPD %
Field/Physical Parameters										
Temperature (°C)	-	-	20.4	25.4	28.4	26.7	25.2	26.6	-	-
Conductivity (uS/cm)	-	-	4200	4630	1081	3700	3550	573	-	-
pH	-	7.0-8.5[d]	8.58	7.59	7.81	7.61	7.59	8.3	-	-
Total Dissolved Solids (mg/L)	-	-	3630	2660	670	2240	2040	376	330	13
Turbidity (NTU)	-	6[d]	6.8	28.5	1.1	4.3	26.1	50.1	49.7	1
Total Metals (mg/L)										
Arsenic	0.001	0.0023[a]	0.001	0.004	0.002	<0.001	0.004	0.002	0.001	67
Cadmium	0.0001	0.0055	0.0002	0.0024	0.0025	0.0194	0.0001	0.0056	0.0059	5
Chromium (III+VI)	0.001	0.0044[b]	0.001	0.005	0.002	0.001	0.004	0.002	0.002	0
Copper	0.001	0.0013	0.002	0.008	0.002	0.005	0.006	0.004	0.004	0
Lead	0.001	0.0044	0.008	0.017	<0.001	0.034	0.024	0.002	0.001	67
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	0.07	0.002	0.002	<0.001	0.007	0.002	0.002	0.002	0
Zinc	0.005	0.015	0.066	0.042	<0.005	0.303	0.053	0.039	0.039	0
Inorganics (mg/L)										
Ammonia	0.01	0.91	0.32	0.57	0.21	0.68	0.24	0.03	0.05	50
Cyanide Total	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.018	-
TPH										
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	<20	<20	-
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	-
TPH C15 - C28 Fraction	<100	-	<100	<100	<100	<100	<100	<100	<100	-
TPH C29 - C36 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	-
TPH C10 - C36 (Sum of total)	<200	600[c]	<200	<200	<200	<200	<200	<200	<200	-
BTEX										
Benzene	1	700	12	<1	<1	3	<1	<1	<1	-
Ethylbenzene	2	5[a]	<2	<2	<2	<2	<2	<2	<2	-
Toluene	2	180[a]	<5	<5	<5	<5	<5	<5	<5	-
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene (o)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene Total		75[a]	<4	<4	<4	<4	<4	<4	<4	-
PAH										
Acenaphthene	1	-	2.4	<1	<1	<1	<1	<1	<1	-
Acenaphthylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benz(a)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(a) pyrene	0.5	0.2[a]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
Benzo(b)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(g,h,i)perylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(k)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Chrysene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Dibenz(a,h)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Fluorene	1	-	1.5	<1	<1	<1	<1	<1	<1	-
Indeno(1,2,3-c,d)pyrene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Naphthalene	1	70	9.8	<1	<1	<1	<1	<1	<1	-
Phenanthrene	1	-	2.4	<1	<1	<1	<1	<1	<1	-
Pyrene	1	-	<1	<1	<1	<1	<1	<1	<1	-

(a) Low reliability trigger value
(b) Cr (VI) trigger value
(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)
(d) NSW estuaries

BHP Closure area

Surface Water Sampling Results (March 2009)

(ug/L unless otherwise stated)

	LOR	Field ID	C/R	SW3	SW4	SW5	SW8	SW9	QAWD	RPD %
		Sample Date	31/03/2009	31/03/2009	31/03/2009	31/03/2009	31/03/2009	31/03/2009	31/03/2009	
		ANZECC (2000) Ecosystems Marine Water (95%)	Western Drain Culvert Outlet	Eastern Drain Upstream	Gatehouse Drain	Western Drain	Eastern Drain Downstream	Daracon Drain	QAWD is a duplicate of SW5	
Field/Physical Parameters										
Temperature (°C)	-	-	21.5	21.5	21.1	21.6	21.5	21.0	-	-
Conductivity (uS/cm)	-	-	37400	11380	936	42200	12160	309	-	-
pH	-	7.0-8.5[d]	7.82	7.85	8.11	7.73	7.88	7.4	-	-
Total Dissolved Solids (mg/L)	-	-	21200	6550	566	27600	8330	350	27600	0
Turbidity (NTU)	-	6[d]	4.9	22.1	120	20.6	28	472	18.1	13
Total Metals (mg/L)										
Arsenic	0.001	0.0023[a]	0.003	0.002	0.006	0.006	0.004	0.006	0.003	67
Cadmium	0.0001	0.0055	0.0013	0.0002	0.0001	0.0053	<0.0001	0.0018	0.0054	2
Chromium (III+VI)	0.001	0.0044[b]	<0.001	<0.001	0.004	<0.001	<0.001	0.006	<0.001	-
Copper	0.001	0.0013	0.004	0.004	0.007	0.006	0.005	0.011	0.006	0
Lead	0.001	0.0044	0.002	0.005	0.008	0.008	0.007	0.017	0.008	0
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	0.07	0.002	0.001	0.002	0.004	0.002	0.005	0.004	0
Zinc	0.005	0.015	0.01	0.05	0.017	0.038	0.041	0.049	0.036	5
Inorganics (mg/L)										
Ammonia	0.01	0.91	0.17	0.12	<0.01	0.33	0.14	0.02	0.35	6
Cyanide Total	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-
TPH										
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	<20	<20	-
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	-
TPH C15 - C28 Fraction	<100	-	<100	<100	<100	<100	<100	<100	<100	-
TPH C29 - C36 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	-
TPH C10 - C36 (Sum of total)	<200	600[c]	<200	<200	<200	<200	<200	<200	<200	-
BTEX										
Benzene	1	700	<1	<1	<1	1	<1	<1	2	-
Ethylbenzene	2	5[a]	<2	<2	<2	<2	<2	<2	<2	-
Toluene	2	180[a]	<5	<5	<5	<5	<5	<5	<5	-
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene (o)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene Total		75[a]	<4	<4	<4	<4	<4	<4	<4	-
PAH										
Acenaphthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Acenaphthylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benz(a)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(a) pyrene	0.5	0.2[a]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
Benzo(b)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(g,h,i)perylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(k)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Chrysene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Dibenz(a,h)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Fluorene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Indeno(1,2,3-c,d)pyrene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Naphthalene	1	70	<1	<1	<1	<1	<1	<1	<1	-
Phenanthrene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Pyrene	1	-	<1	<1	<1	<1	<1	<1	<1	-

(a) Low reliability trigger value

(b) Cr (VI) trigger value

(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)

(d) NSW estuaries

BHP Closure area
Surface Water Sampling Results (May 2009)
(ug/L unless otherwise stated)

		Field ID	C/R	SW3	SW4	SW5	SW8	SW9	QA1	RPD %
		Sample Date	7/05/2009	7/05/2009	7/05/2009	7/05/2009	7/05/2009	7/05/2009	7/05/2009	
	LOR	ANZECC (2000) Ecosystems Marine Water (95%)	Western Drain Culvert Outlet	Eastern Drain Upstream	Gatehouse Drain	Western Drain	Eastern Drain Downstream	Daracon Drain	QA1 is a duplicate of SW5	
Field/Physical Parameters										
Temperature (°C)	-	-	19.2	20.8	23.1	21.8	21.4	21.5	-	-
Conductivity (uS/cm)	-	-	27300	29600	1357	27500	19780	440	-	-
pH	-	7.0-8.5[d]	8.09	7.96	8.18	8.32	7.91	8.6	-	-
Total Dissolved Solids (mg/L)	-	-	22200	19000	590	18800	14300	302	19600	4
Turbidity (NTU)	-	6[d]	1.8	3.3	18.8	3.7	2.8	118	4.2	13
Total Metals (mg/L)										
Arsenic	0.001	0.0023[a]	0.002	0.002	0.001	0.003	0.002	0.002	0.002	40
Cadmium	0.0001	0.0055	0.0009	0.0022	<0.0001	0.0006	<0.0001	0.707	0.0026	125
Chromium (III+VI)	0.001	0.0044[b]	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.001	-
Copper	0.001	0.0013	0.006	0.003	<0.001	0.002	0.002	0.05	0.003	40
Lead	0.001	0.0044	0.002	0.003	0.001	0.002	0.002	0.062	0.002	0
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	0.07	0.001	0.002	<0.001	0.002	0.001	0.006	0.002	0
Zinc	0.005	0.015	0.022	0.016	<0.005	0.025	0.015	0.326	0.022	13
Inorganics (mg/L)										
Ammonia	0.01	0.91	<0.10	<0.10	0.01	<0.10	<0.10	0.08	<0.10	-
Cyanide Total	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-
TPH										
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	<20	<20	-
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	-
TPH C15 - C28 Fraction	<100	-	<100	<100	<100	<100	<100	200	<100	-
TPH C29 - C36 Fraction	<50	-	<50	<50	<50	<50	<50	140	<50	-
TPH C10 - C36 (Sum of total)	<200	600[c]	<200	<200	<200	<200	<200	340	<200	-
BTEX										
Benzene	1	700	2	<1	<1	<1	<1	<1	<1	-
Ethylbenzene	2	5[a]	<5	<5	<5	<5	<5	<5	<5	-
Toluene	2	180[a]	<2	<2	<2	<2	<2	<2	<2	-
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene (o)	2	-	<2	<2	<2	<2	<2	<2	<2	-
Xylene Total		75[a]	<4	<4	<4	<4	<4	<4	<4	-
PAH										
Acenaphthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Acenaphthylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benz(a)anthracene	1	-	<1	<1	<1	<1	<1	1.1	<1	-
Benzo(a) pyrene	0.5	0.2[a]	<0.5	<0.5	<0.5	<0.5	<0.5	1	<0.5	-
Benzo(b)fluoranthene	1	-	<1	<1	<1	<1	<1	1.6	<1	-
Benzo(g,h,i)perylene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Benzo(k)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Chrysene	1	-	<1	<1	<1	<1	<1	1.1	<1	-
Dibenz(a,h)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Fluoranthene	1	-	<1	<1	<1	<1	<1	2.3	<1	-
Fluorene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Indeno(1,2,3-c,d)pyrene	1	-	<1	<1	<1	<1	<1	<1	<1	-
Naphthalene	1	70	<1	<1	<1	<1	<1	<1	<1	-
Phenanthrene	1	-	<1	<1	<1	<1	<1	1	<1	-
Pyrene	1	-	<1	<1	<1	<1	<1	2.1	<1	-

(a) Low reliability trigger value
(b) Cr (VI) trigger value
(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)
(d) NSW estuaries

BHP Closure area
Surface Water Sampling Results (June 2009)
(ug/L unless otherwise stated)

	LOR	Field ID	C/R	SW3	SW4	SW5	SW8	SW9	AD	RPD %
		Sample Date	19/06/2009	19/06/2009	19/06/2009	19/06/2009	19/06/2009	19/06/2009	19/06/2009	
		ANZECC (2000) Ecosystems Marine Water (95%)	Western Drain Culvert Outlet	Eastern Drain Upstream	Gatehouse Drain	Western Drain	Eastern Drain Downstream	Daracon Drain	AD is a duplicate of SW5	
Field/Physical Parameters										
Temperature (°C)	-	-	15.5	15.5	16.9	16.8	15.9	15.2	-	-
Conductivity (uS/cm)	-	-	17100	2010	832	21800	1701	482	-	-
pH	-	7.0-8.5(d)	6.81	7.59	8.37	8.45	7.79	8.06	-	-
Total Dissolved Solids (mg/L)	-	-	15600	2030	424	3230	896	310	3230	0
Turbidity (NTU)	-	6(d)	3.1	8.5	60.8	26.5	109	60	23.2	13
Total Metals (mg/L)										
Arsenic	0.001	0.0023(a)	0.002	0.003	0.002	0.002	0.002	0.001	0.002	0
Cadmium	0.0001	0.0055	0.0003	0.0002	0.0019	0.0004	0.0002	0.0002	0.0008	67
Chromium (III+VI)	0.001	0.0044(b)	0.002	0.002	0.004	0.002	0.008	0.002	0.002	0
Copper	0.001	0.0013	0.003	0.002	0.006	0.003	0.018	0.004	0.003	0
Lead	0.001	0.0044	0.002	0.005	0.028	0.006	0.031	0.005	0.005	18
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0
Nickel	0.001	0.07	0.002	<0.001	0.001	0.005	0.002	0.001	0.005	0
Zinc	0.005	0.015	0.04	0.021	0.03	0.3	0.15	0.021	0.294	2
Dissolved Metals (mg/L)										
Arsenic	0.001	0.0023(a)	<0.001	0.002	0.001	0.001	0.001	<0.001	0.001	0
Cadmium	0.0001	0.0055	0.0001	<0.0001	0.0004	0.0001	0.0002	<0.0001	0.0001	0
Chromium (III+VI)	0.001	0.0044(b)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0
Chromium (VI)	0.01	0.0044	-	-	-	-	-	<0.01	-	-
Copper	0.001	0.0013	0.003	0.001	<0.001	0.001	0.002	<0.001	0.001	0
Lead	0.001	0.0044	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0
Nickel	0.001	0.07	0.002	<0.001	<0.001	0.002	<0.001	<0.001	0.002	0
Zinc	0.005	0.015	0.008	0.009	<0.005	0.109	0.089	<0.005	0.109	0
Inorganics (mg/L)										
Ammonia	0.01	0.91	0.08	0.17	0.23	0.28	0.09	0.02	0.27	4
Cyanide Total	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.02	<0.004	0
TPH										
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	<20	<20	0
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	0
TPH C15 - C28 Fraction	<100	-	<100	<100	<100	<100	<100	<100	<100	0
TPH C29 - C36 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	0
TPH C10 - C36 (Sum of total)	<200	600(c)	<200	<200	<200	<200	<200	<200	<200	0
BTEX										
Benzene	1	700	2	<1	<1	<1	<1	<1	<1	0
Ethylbenzene	2	5(a)	<2	<2	<2	<2	<2	<2	<2	0
Toluene	2	180(a)	<5	<5	<5	<5	<5	<5	<5	0
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	<2	<2	0
Xylene (o)	2	-	<2	<2	<2	<2	<2	<2	<2	0
Xylene Total		75(a)	<4	<4	<4	<4	<4	<4	<4	0
PAH										
Acenaphthene	1	-	1.1	<1	<1	<1	<1	<1	<1	0
Acenaphthylene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Benz(a)anthracene	1	-	<1	<1	1.1	<1	<1	<1	<1	0
Benzo(a) pyrene	0.5	0.2(a)	<0.5	<0.5	1.2	<0.5	0.6	<0.5	<0.5	0
Benzo(b)fluoranthene	1	-	<1	<1	2	<1	<1	<1	<1	0
Benzo(g,h,i)perylene	1	-	<1	<1	1.5	<1	<1	<1	<1	0
Benzo(k)fluoranthene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Chrysene	1	-	<1	<1	1.1	<1	<1	<1	<1	0
Dibenz(a,h)anthracene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Fluoranthene	1	-	<1	<1	1.4	<1	1.4	<1	<1	0
Fluorene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Indeno(1,2,3-c,d)pyrene	1	-	<1	<1	1.1	<1	<1	<1	<1	0
Naphthalene	1	70	<1	<1	<1	<1	<1	<1	<1	0
Phenanthrene	1	-	<1	<1	<1	<1	<1	<1	<1	0
Pyrene	1	-	<1	<1	1.3	<1	1.3	<1	<1	0

(a) Low reliability trigger value
(b) Cr (VI) trigger value
(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)
(d) NSW estuaries

BHP Closure area
Surface Water Sampling Results (September 2009)
(ug/L unless otherwise stated)

	LOR	Field ID	C/R	SW3	SW4	SW5	SW8	SW9	AD	RPD %
		Sample Date	4/09/2009	4/09/2009	4/09/2009	4/09/2009	4/09/2009	4/09/2009	4/09/2009	
		ANZECC (2000) Ecosystems Marine Water (95%)	Western Drain Culvert Outlet	Eastern Drain Upstream	Gatehouse Drain	Western Drain	Eastern Drain Downstream	Daracon Drain	AD is a duplicate of SW5	
Field/Physical Parameters										
Temperature (°C)	-	-	18.3	21.9	22.4	20.4	20.6	21.9	-	-
Conductivity (uS/cm)	-	-	35300	46000	1931	40800	25290	518	-	-
pH	-	7.0-8.5[d]	8.12	8.54	8.96	8.81	8.19	8.50	-	-
Dissolved Oxygen (ppm)	-	-	3.51	8.46	6.48	11.08	8.77	5.63	-	-
Redox Potential (mV)	-	-	6	7	5	6	7	10	-	-
Total Dissolved Solids (mg/L)	-	-	28200	32400	814	30200	17100	620	29400	3
Turbidity (NTU)	-	6[d]	41.7	2.3	136	8.1	14.9	3550	7.6	6
Total Metals (mg/L)										
Arsenic	0.001	0.0023[a]	<0.010	<0.010	0.004	<0.010	0.001	0.079	<0.010	
Cadmium	0.0001	0.0055	<0.0010	0.0066	0.0039	0.0378	0.0014	0.0236	0.039	3
Chromium (III+VI)	0.001	0.0044[b]	<0.010	<0.010	0.003	<0.010	0.003	0.669	<0.010	
Copper	0.001	0.0013	<0.020	<0.020	0.006	<0.020	0.011	1.35	<0.020	
Lead	0.001	0.0044	<0.010	<0.010	0.009	0.019	0.017	3.54	0.017	11
Mercury	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0018	<0.0001	
Nickel	0.001	0.07	<0.010	<0.010	0.002	<0.010	0.003	0.458	<0.010	
Zinc	0.005	0.015	<0.050	<0.050	0.022	<0.050	0.173	12.7	<0.050	
Dissolved Metals (mg/L)										
Arsenic	0.001	0.0023[a]	-	-	-	-	-	-	-	
Cadmium	0.0001	0.0055	-	-	-	-	-	-	-	
Chromium (III+VI)	0.001	0.0044[b]	-	-	-	-	-	-	-	
Chromium (VI)	0.01	0.0044	-	-	-	-	-	-	-	
Copper	0.001	0.0013	-	-	-	-	-	-	-	
Lead	0.001	0.0044	-	-	-	-	-	-	-	
Mercury	0.0001	0.0004	-	-	-	-	-	-	-	
Nickel	0.001	0.07	-	-	-	-	-	-	-	
Zinc	0.005	0.015	-	-	-	-	-	-	-	
Inorganics (mg/L)										
Ammonia	0.01	0.91	<0.10	<0.10	0.01	<0.10	<0.10	0.39	<0.10	
Cyanide Total	0.004	0.004	0.006	<0.004	<0.004	<0.004	<0.004	0.067	<0.004	
TPH										
TPH C 6 - C 9 Fraction	<20	-	<20	<20	<20	<20	<20	<20	<20	
TPH C10 - C14 Fraction	<50	-	<50	<50	<50	<50	<50	<50	<50	
TPH C15 - C28 Fraction	<100	-	<100	<100	<100	<100	<100	600	<100	
TPH C29 - C36 Fraction	<50	-	<50	<50	<50	<50	<50	510	<50	
TPH C10 - C36 (Sum of total)	<200	600[c]	<200	<200	<200	<200	<200	1110	<200	
BTEX										
Benzene	1	700	<1	<1	<1	<1	<1	<1	<1	
Ethylbenzene	2	5[a]	<5	<5	<5	<5	<5	<5	<5	
Toluene	2	180[a]	<2	<2	<2	<2	<2	<2	<2	
Xylene (m & p)	2	-	<2	<2	<2	<2	<2	<2	<2	
Xylene (o)	2	-	<2	<2	<2	<2	<2	<2	<2	
Xylene Total		75[a]	<4	<4	<4	<4	<4	<4	<4	
PAH										
Acenaphthene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	
Acenaphthylene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	
Anthracene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	3.4	<1.0	
Benz(a)anthracene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	7	<1.0	
Benzo(a) pyrene	0.5	0.2[a]	<0.5	<0.5	<0.5	<0.5	<0.5	5.8	<0.5	
Benzo(b)fluoranthene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	10.8	<1.0	
Benzo(g,h,i)perylene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	4.9	<1.0	
Benzo(k)fluoranthene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	4.1	<1.0	
Chrysene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	7.2	<1.0	
Dibenz(a,h)anthracene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Fluoranthene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	17.9	<1.0	
Fluorene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	1.7	<1.0	
Indeno(1,2,3-c,d)pyrene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	4	<1.0	
Naphthalene	1	70	<1.0	<1.0	<1.0	<1.0	<1.0	9.8	<1.0	
Phenanthrene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	10.9	<1.0	
Pyrene	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	16.4	<1.0	

(a) Low reliability trigger value
(b) Cr (VI) trigger value
(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)
(d) NSW estuaries

BHP Closure area

Surface Water Sampling Results (October 2009)

(ug/L unless otherwise stated)

	LOR	Field ID / Sample Date	C/R	SW3	SW4	SW5	SW8	SW9	AD	RPD %
		Sample Date	13/10/2009	13/10/2009	13/10/2009	13/10/2009	13/10/2009	13/10/2009	13/10/2009	
		ANZECC (2000) Ecosystems Marine Water (95%)	Western Drain Culvert Outlet	Eastern Drain Upstream	Gatehouse Drain	Western Drain	Eastern Drain Downstream	Daracon Drain	AD is a duplicate of SW5	
Field/Physical Parameters										
Temperature (°C)	-	-	-	22.7	17.5	19.6	18.5	18.7	-	-
Conductivity (uS/cm)	-	-	-	30800	533	17900	22700	336	-	-
pH	-	7.0-8.5[d]	-	8.26	7.10	8.9	7.98	8.05	-	-
Dissolved Oxygen (ppm)	-	-	-	9.76	6.45	12.61	7.72	0.24	-	-
Redox Potential (mV)	-	-	-	-16	-3	1	1	-5	-	-
Total Dissolved Solids (mg/L)	-	-	-	28400	328	15700	15200	360	16000	2
Turbidity (NTU)	-	6[d]	-	4.1	94.9	9.7	6.2	321	7.6	24
Total Metals (mg/L)										
Arsenic	0.001	0.0023[a]	-	<0.010	0.003	<0.001	0.003	0.04	<0.001	-
Cadmium	0.0001	0.0055	-	0.0035	0.0001	0.0056	0.0006	0.0074	0.0062	10
Chromium (III+VI)	0.001	0.0044[b]	-	<0.010	0.004	0.003	0.004	0.273	0.002	40
Copper	0.001	0.0013	-	<0.020	0.009	0.004	0.008	0.55	0.005	22
Lead	0.001	0.0044	-	<0.010	0.012	0.015	0.021	1.49	0.014	7
Mercury	0.0001	0.0004	-	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	-
Nickel	0.001	0.07	-	<0.010	0.002	0.002	0.002	0.161	0.002	0
Zinc	0.005	0.015	-	0.02	0.021	0.035	0.084	6.34	0.034	3
Dissolved Metals (mg/L)										
Arsenic	0.001	0.0023[a]	-	<0.010	0.002	<0.001	<0.001	0.004	<0.001	-
Cadmium	0.0001	0.0055	-	0.002	0.0005	0.0062	0.0004	0.0019	0.0062	0
Chromium (III+VI)	0.001	0.0044[b]	-	<0.010	0.001	0.001	0.001	<0.001	0.001	0
Chromium (VI)	0.01	0.0044	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-
Copper	0.001	0.0013	-	<0.020	0.002	0.004	0.003	0.005	0.005	22
Lead	0.001	0.0044	-	<0.010	<0.001	<0.001	<0.001	0.002	0.001	-
Mercury	0.0001	0.0004	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	0.07	-	<0.010	<0.001	0.002	0.002	<0.001	0.002	0
Zinc	0.005	0.015	-	<0.050	<0.005	0.01	0.032	0.012	0.01	0
Inorganics (mg/L)										
Ammonia	0.01	0.91	-	<0.10	<0.01	<0.10	<0.10	0.4	<0.10	-
Cyanide Total	0.004	0.004	-	<0.004	<0.004	<0.004	<0.004	0.085	<0.004	-
TPH										
TPH C 6 - C 9 Fraction	<20	-	-	<20	<20	<20	<20	<20	<20	-
TPH C10 - C14 Fraction	<50	-	-	<50	<50	<50	<50	<50	<50	-
TPH C15 - C28 Fraction	<100	-	-	<100	<100	<100	<100	260	<100	-
TPH C29 - C36 Fraction	<50	-	-	<50	<50	<50	<50	170	<50	-
TPH C10 - C36 (Sum of total)	<200	600[c]	-	<50	<50	<50	<50	430	<50	-
BTEX										
Benzene	1	700	-	<1	<1	<1	<1	<1	<1	-
Ethylbenzene	2	5[a]	-	<2	<2	<2	<2	<2	<2	-
Toluene	2	180[a]	-	<5	<5	<5	<5	<5	<5	-
Xylene (m & p)	2	-	-	<2	<2	<2	<2	<2	<2	-
Xylene (o)	2	-	-	<2	<2	<2	<2	<2	<2	-
Xylene Total		75[a]	-	<4	<4	<4	<4	<4	<4	-
PAH										
Acenaphthene	1	-	-	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	-
Acenaphthylene	1	-	-	<1.0	<1.0	<1.0	<1.0	1.8	<1.0	-
Anthracene	1	-	-	<1.0	<1.0	<1.0	<1.0	4.2	<1.0	-
Benz(a)anthracene	1	-	-	<1.0	<1.0	<1.0	<1.0	11.4	<1.0	-
Benzo(a) pyrene	0.5	0.2[a]	-	<0.5	<0.5	<0.5	<0.5	13.1	<0.5	-
Benzo(b)fluoranthene	1	-	-	<1.0	<1.0	<1.0	<1.0	20.1	<1.0	-
Benzo(g,h,i)perylene	1	-	-	<1.0	<1.0	<1.0	<1.0	9.4	<1.0	-
Benzo(k)fluoranthene	1	-	-	<1.0	<1.0	<1.0	<1.0	5.1	<1.0	-
Chrysene	1	-	-	<1.0	<1.0	<1.0	<1.0	10.6	<1.0	-
Dibenz(a,h)anthracene	1	-	-	<1.0	<1.0	<1.0	<1.0	2.2	<1.0	-
Fluoranthene	1	-	-	<1.0	<1.0	<1.0	<1.0	26.3	<1.0	-
Fluorene	1	-	-	<1.0	<1.0	<1.0	<1.0	1.7	<1.0	-
Indeno(1,2,3-c,d)pyrene	1	-	-	<1.0	<1.0	<1.0	<1.0	8.6	<1.0	-
Naphthalene	1	70	-	<1.0	<1.0	<1.0	<1.0	10	<1.0	-
Phenanthrene	1	-	-	<1.0	<1.0	<1.0	<1.0	10.8	<1.0	-
Pyrene	1	-	-	<1.0	<1.0	<1.0	<1.0	25.4	<1.0	-

(a) Low reliability trigger value

(b) Cr (VI) trigger value

(c) Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)

(d) NSW estuaries

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SPECIALISTS IN LIVING AND WORKING PLACES

CLOSURE AREA, FORMER BHP STEELWORKS, MAYFIELD REMEDIATION AND VALIDATION REPORT

Prepared for:

Daracon Pty Ltd
17 James Street
WALLSEND NSW 2287

Report Date: 30 June 2008
Project Ref: ENVIWARA20150AD

Written/Submitted by:

Kirsty Greenfield
Environmental Scientist

Reviewed/Approved by:

Michael Dunbavan
Principal

Coffey Environments Pty Ltd ABN 45 090 522 759
Lot 101, 19 Warabrook Boulevard Warabrook NSW 2304 Australia
T (+61) (2) 4016 2300 F (+61) (2) 4016 2380 www.coffey.com/environments

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

30 June 2008

Daracon Pty Ltd
17 James Street
WALLSEND NSW 2287

Attention: Michael Rummery

Dear Michael

RE: Closure Area, Former BHP Steelworks Site, Mayfield
Remediation and Validation Report

We are pleased to present the draft Remediation and Validation Report for the remediation and validation of the Closure Area at the former BHP Steelworks Site off Selwyn Street, Mayfield, NSW. This report describes remediation activities undertaken, and validation of those activities, according to the Regional Land Management Corporation Mayfield Closure Area Stage 1 Civil Works Contract C-Specification between May 2007 and June 2008.

If you have any further questions regarding the Remediation and Validation Report, please do not hesitate to contact Kirsty Greenfield or the undersigned in our Lane Cove Office on 9911 1019.

For and on behalf of Coffey Environments Pty Ltd

M. Dunbavan.

Michael Dunbavan
Principal

Coffey Environments Pty Ltd ABN 45 090 522 759
Lot 101, 19 Warabrook Boulevard Warabrook NSW 2304 Australia
T (+61) (2) 4016 2300 F (+61) (2) 4016 2380 www.coffey.com/environments

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1	ENVIWARA20150AD-R01	Final	30 June, 2008	Coffey Environments Pty Ltd	KG

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ABBREVIATIONS

AHD	**Australian Height Datum**
ALS	**Australian Laboratory Services**
ANZECC	**Australian and New Zealand Environment and Conservation Council**
C6-C36	**Hydrocarbon chainlength fraction**
BTEX	**Benzene, Toluene, Ethylbenzene and Xylenes**
COC	**Chain of Custody**
DO	**Dissolved Oxygen**
EC	**Electrical Conductivity**
Eh	**Oxidation/Reduction Potential**
EPS	**Enviropacific Services Pty Ltd**
GPS	**Global Pacific Services Pty Ltd**
LOQ	**Limit of Quantification**
LOR	**Limit of Reporting**
MDL	**Method Detection Limit**
µg/L	**micrograms per litre**
mg/kg	**milligrams per kilogram**
mg/L	**milligrams per litre**
NATA	**National Association of Testing Authorities**
NEHF	**National Environmental Health Forum**
NEPM	**National Environment Protection Measure**
DECC	**New South Wales Department of Environment and Climate Change**
PAH	**Polycyclic Aromatic Hydrocarbon**
PCB	**Polychlorinated Biphenyl**

ABBREVIATIONS

PID	**Photoionisation Detector**
QA	**Quality Assurance**
QC	**Quality Control**
RL	**Reduced Level**
RLMC	**Regional Land Management Corporation**
RPD	**Relative Percent Difference**
TDS	**Total Dissolved Solid**
TPH	**Total Petroleum Hydrocarbon**
VOC	**Volatile Organic Compound**
VRA	**Voluntary Remediation Agreement**

1 INTRODUCTION

This Remediation and Validation Report has been prepared by Coffey Environments Pty Ltd (Coffey Environments) for Daracon Pty Ltd (Daracon) and provides a summary of remediation earthworks activities completed between May 2007 and June 2008 for the Area 1 Civil Earthworks at the Closure Area of the former BHP Steelworks site, off Selwyn Street, Mayfield.

This remediation was undertaken in compliance with a Voluntary Remediation Agreement (VRA) between the Department of Environment and Climate Change (DECC) and the Regional Land Management Corporation (RLMC).

Daracon have completed the Area 1 Civil Earthworks at the Closure Area in accordance with the C-Specification developed by RLMC and under project management by Global Pacific Services Pty Ltd (GPS) on behalf of RLMC.

In accordance with the C-Specification Clause C1.7, an Environmental Consultant is required '*to undertake contamination testing and verification of contractor requirements for the handling, tracking and fate of contaminated materials*.'

Enviropacific Services Pty Ltd (EPS) was engaged by Daracon to provide environmental contracting services relating to the handling, tracking and fate of contaminated materials. Coffey Environments was engaged by Daracon as the Environmental Consultant to undertaken contamination testing and verification of the services provided by EPS.

Mr Graeme Nyland of Environ Australia Pty Ltd (Environ) was engaged by RLMC as the Site Auditor to provide a Site Audit Statement at the completion of the Area 1 Civil Earthworks contract.

2 BACKGROUND

2.1 Site Location

The former BHP Steelworks site is located on Newcastle Harbour, an estuary of the Hunter River. The river is split into a northern and southern channel and the former BHP Steelworks site is located on the southern shore of the South Channel.

For the purposes of this report, the 'site' comprises the Closure Area, a 155 hectare area within the former BHP Steelworks, as shown on Figure 1.

2.2 Surrounding Environment

The site and surrounding areas are low lying and flat although the site has been raised with fill in various stages of its development. The present day landform has a surface elevation of between 1.5 m to 5.5 m AHD (Australian Height Datum) and slopes gently down to the north east.

The surrounding environment includes:

- Hunter River and bulk coal loading facilities to the north,
- Industrial land use, including the OneSteel wiremill to the west and Port Waratah Coal Services to the east;
- Residential land use, including a primary school to the south.

2.3 Site History

Prior to development of the BHP Steelworks in 1913, the site was generally characterised by low lying mangrove swamp intersected by several tidal channels.

Construction of the BHP Steelworks began following the purchase of a disused copper smelter site and other land along the Hunter River by BHP between 1896 and 1906. Construction of the BHP Steelworks included reclamation of the former tidal flats by progressive filling using waste materials from the iron and steel making processes, amongst other materials.

Characterisation of the fill material used in the land reclamation is outlined in URS (2000) *Development of a Multi Purpose Terminal and Remediation of the Closure Area, BHP Newcastle Steelworks EIS*. Reclamation included the random distribution of wastes from the BHP plant operations, including the use of blast furnace slag and brecketts, open hearth furnace slag and Basic Oxygen Steelmaking (BOS) slag, coal washery slurry, flue dusts, sinter plant dusts, fly ash, shale, ash from locomotives, waste from the coke ovens by-products (including sludge from rectification stills, tar from the decanters, oil and tar from spills occurring from the tar tanks at the tar plants) and wastes from the finishing and rolling mill operations (including spilt oil and lubricants from the mill floors and spent acid from the pickling plants).

The Closure Area is within the oldest part of the former Steelworks and contained the following major structures:

- Raw Materials Storage and Handling Area (Ore Wharf);
- Coke Ovens Batteries No.s 1 to 5 and the by-products plant;

- Coke Ovens Gasholder and Blast Furnace Gasholder;
- Sinter Plant;
- Coal Washery;
- Blast furnace No. 1 (1915 - 1981);
- Bloom Mill, Structural Steel and Rail Mill (1915 – 1962);
- Blast furnace No. 2 (1919 - 1985);
- Blast furnace No. 3 (commissioned 1921);
- Basic Oxygen Steelmaking plant (commissioned 1962);
- Continuous Bloom Caster (commissioned 1987).

The BHP Steelworks ceased operations in 1999.

URS (2000) indicates the site soils are contaminated with Polycyclic Aromatic Hydrocarbons (PAH), Volatile Organic Compounds (VOC), heavy metals, ammonia, cyanide, asbestos, Polychlorinated Biphenyls (PCB) and Total Petroleum Hydrocarbons (TPH).

2.4 Overview of Civil Earthworks

The Closure Area comprises a number of sub-areas, including Area 1A, Area 1B, Area 2A, Area 2B, Area 2C, Area 2D and Area 2E as shown on Figure 2.

The priority for remediation is to entirely cap Area 1, including Area 1A and Area 1B, to prevent normal human physical contact with the most highly contaminated material on the site and also consequently reduce the risk to the environment associated with this area.

The Area 1 Civil Earthworks included seven major components:

- Containment of contaminated soil via cut and fill in Area 1A, Area 1B and Area 2D and the construction of emplacement areas for highly contaminated soil in Area 1A;
- Construction of a Virgin Excavated Natural Material (VENM) cap over part of Area 1A, including a trial cap;
- Construction of a pavement cap over part of Area 1A and Area 1B, including a trial cap;
- Construction of a railway line through Area 1A and Area 2D;
- Construction of a landscape mound to accommodate geotechnically unsuitable material;
- Construction of the Western Drain;
- Construction of the Eastern Drain.

The locations of Area 1A, Area 1B, Area 2D, the railway line, the landscape mound and the Eastern and Western Drains are shown on Figure 2.

An outline of the remediation/ environmental works in each component is outlined below.

2.4.1 Containment of Contaminated Soil

The site contains soil contaminated with PAHs, VOCs, heavy metals, ammonia, cyanide, asbestos, PCB and TPH. Materials management is outlined in Section C3 of the C-Specification.

Soil materials encountered during the remediation earthworks activities were to be categorised under three broad levels using material assessment procedures:

- Level 1 – Unrestricted on-site reuse, PAH concentration <2,000mg/kg;
- Level 2 – Restricted on-site reuse, PAH concentration >2,000mg/kg;
- Level 3 – EPA notification obligation, Separate Phase Hydrocarbons (SPH).

Notification of Level 3 material to the DECC was a requirement of the VRA. EPS provided the notification information to GPS and RLMC. RLMC then provided this information to the DECC.

The classification of soil materials during the remediation earthworks activities was completed by EPS in accordance with their Handling, Transport and Materials Tracking System (See Section 5.4.4).

Remediation earthworks activities including the consolidation of Level 2 and Level 3 material during the cut and fill of Area 1A and Area 2D.

Level 2 materials were consolidated into a Level 2 Emplacement Area in Area 1A. Some Level 2 materials were left in-situ in Area 1A following amendment to the EPS Handling, Transport and Materials Tracking System in June 2007 and again in August 2007 (see Section 5.4.4).

Level 3 materials were consolidated into a Level 3 Emplacement Area in Area 1A. Some Level 3 materials were left in-situ within Area 1A and Area 2D.

Level 1 materials were used for general land forming in Area 1A, Area 1B and Area 2D. Level 1 materials were also used to provide buffer material over the Level 2 and Level 3 Emplacement Areas.

To gauge the effectiveness of the soil classification system, quality control soil samples were collected at a sampling frequency of 1 sample per 1,600m^2 across Area 1.

2.4.2 Trial VENM Cap and VENM Cap

The 500mm capping layer of VENM was constructed to limit infiltration of precipitation into the subsoils within Area 1A to the south of the railway line.

The capping material was from a natural source consisting of a well graded mixture of clay, silt, sand and gravel particles that was capable of being compacted to form a layer with a characteristic permeability of less than or equal to 10^{-9}m/s.

The capping material was VENM in accordance with the NSW DEC (2006) *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes*.

The requirements of the VENM cap are outlined in Section C10 of the C-Specification.

2.4.3 Trail Pavement Cap and Pavement Cap

The pavement cap consists of:

- 300mm thick subgrade replacement layer;
- 100mm thick crushed concrete layer;
- High-performance two coat bitumen seal.

The 300mm thick subgrade replacement layer consisted of slag won from on site. To enable reuse on site, the slag materials were assessed by field sensory screening using a Photo-Ionisation Detector (PID) and sampled at a frequency of 1 sample per 1,000m^2 following emplacement. Sampling was undertaken to assess that PAH concentrations were below 2,000mg/kg.

The 100mm thick crushed concrete layer consists of both concrete won from on site and 20mm dense grade sub base (DGS20) imported to site to make up a shortfall in concrete.

The pavement cap is generally within Area 1A to the north of the railway line.

The requirements of the pavement cap are outlined in Section C9 of the C-Specification.

2.4.4 Railway Line Embankment

A railway line embankment was constructed through Area 1A and Area 2D. The construction of the railway line embankment included cut and fill.

2.4.5 Landscape Mound

Material deemed to be unsuitable for use as clean compacted fill was transferred to the Landscape Mound Stockpile Area.

Material in the landscape mound was sampled at a rate of 1 sample per 1,000m^3. Soil samples were analysed for PAH to assess that the geotechnically unsuitable material complied with the requirements of Level 1 material.

Treated Acid Sulfate Soil (ASS) material was also relocated to the landscape mound. This material did not require testing for PAH. Treated ASS material required a 500mm cover of topsoil to reduce exposure of treated ASS to air.

The Landscape Mound stockpile was re-shaped as a windrow along the northern boundary of the Closure Area adjacent to Industrial Drive.

Information pertaining to the relocation of unsuitable material is outlined in Section C7.5 of the C-Specification.

2.4.6 Western Drain

The Western Drain was constructed along the western site boundary and extended from the southern end of the Closure Area north to the Hunter River, approximately 695m in length.

The first 475m of the Western Drain from chainage CH0 to CH475 was constructed as an open drain, including a High Density Polyethylene (HDPE) geomembrane, crushed concrete, soil and mangrove vegetation.

The remaining 220m of the Western Drain from chainage CH0 to CH220 was constructed using precast concrete box culverts.

Information on the drain construction is outlined in Sections C8, C11, C12, C14 and C17 of the C-Specification.

2.4.7 Eastern Drain

The Eastern Drain was constructed along the eastern site boundary and extended from the northern side of the current railway line to the Hunter River, approximately 920m in length.

665m of the Eastern Drain from chainage CH115 to CH780 was constructed as an open drain, including a High Density Polyethylene (HDPE) geomembrane, crushed concrete, soil and mangrove vegetation.

The remaining 248m of the Eastern Drain to the north of chainage CH780 from chainage CH0 to CH248 was constructed using precast concrete box culverts. A box culvert drain was also constructed at the Selwyn Street Inlet Structure, which extended approximately 50m south-west of chainage CH115.

The first 115m of the Eastern Drain from chainage CH0 to CH115 was to be redesigned and was not constructed during this contract.

Information on the drain construction is outlined in Sections C8, C11, C12, C14 and C17 of the C-Specification.

2.5 Proposed Future Use

The proposed future use of the site is at the conceptual stage of planning and is likely to be used for a multi-purpose shipping terminal, or similar commercial facility.

3 ENVIRONMENTAL SCOPE OF WORK

3.1 C-Specification Scope of Works

The environmental requirements of the C-Specification include the following:

- Development of procedures by EPS covering:
    - Acid sulfate soils (ASS) management and treatment;
    - Classification, handling and transport of materials;
    - Contaminated materials handling; and
    - Dust, odour and noise management.
- Development of a Sampling, Analysis and Quality Plan by Coffey Environments for assessment of contaminated soil;
- In-situ classification of soils during earthworks by EPS;
- Classification of emplaced and/or stockpiled materials by EPS;
- Monthly reporting by Coffey Environments; and
- Completion reporting by Coffey Environments.

3.2 Site Auditor Requirements

In accordance with Section C1.23 of the C-Specification, the Site Auditor has the following requirements:

- Ensure Area 1 is regarded to be draining and free of ponded areas;
- Ensure Area 1 has a cap that has a permeability of less than or equal to $K<10^{-9}$m/s;
- Ensure the specified cap is of correct thickness;
- Ensure that the stormwater drains are isolated from groundwater by suitable barriers;
- Ensure that all materials placed within Area 1 comply with the Materials Management Plan;
- Ensure that the VENM cap is inert materials in accordance with waste classification guidelines.

4 REPORT OUTLINE

This Remediation and Validation Report presents information pertaining to the environmental requirements of the C-Specification and the Site Auditor requirements, as outlined in Sections 3.1 and 3.2.

This report is set out as follows:

- Methodology and Environmental Procedures – Section 5;
- Overview of earthworks, including Area 1A, Area 1B, Area 2D and railway line embankment – Section 6;
- General Materials Tracking – Section 7;
- Level 1Materials Tracking – Section 8;
- Level 2 Materials Tracking, including Level 2 Emplacement Area – Section 9;
- Level 3 Materials Tracking, including Level 3 Emplacement Area – Section 10;
- Asbestos Waste Tracking – Section 11;
- Landscape Mound – Section 12;
- Environmental Sampling in Area 1, Landscape Mound and Railway Line – Section 13;
- Environmental Sampling of Level 2 material and Level 3 material – Section 14;
- Hot Spot Remediation – Section 15;
- Pavement Cap – Section 16;
- VENM Cap – Section 17;
- Imported material – Section 18;
- Western Drain, including construction and dewatering – Section 19;
- Eastern Drain, including construction and dewatering – Section 20;
- Treatment of ASS material excavated from drains – Section 21;
- Surface Water Sampling – Section 22;
- Conclusions – Section 23.

Supporting information for the text is included in Appendices A to Y (CD attached) and the topic addressed in each appendix is listed in the Table of Contents for this report as well as a reference file on the CD.

5 METHODOLOGY AND ENVIRONMENTAL PROCEDURES

5.1 Assessment of Materials on Site

As required by Section C3.4.3 of the C-Specification, soil materials encountered during the remediation earthworks activities were categorised under three broad levels using material assessment procedures:

- Level 1 – Unrestricted on-site reuse, PAH concentrations <2,000mg/kg;
- Level 2 – Restricted on-site reuse, PAH concentrations >2,000mg/kg;
- Level 3 – EPA notification obligation, SPH.

The C-Specification requires reuse of material on site to consolidate contaminated material and reduce land use restrictions as far as practicable. In Section C3.4.6, the C-Specification provided the following guidelines for the reuse locations of contaminated materials:

Level 1

- General land forming in areas that will ultimately be capped;
- Potential buffer material to be placed above Level 2 and Level 3 material and below final cap.

Level 2

- Leaving contaminated material in-situ providing there is no immediate danger to the environment or community, it will be covered with at least 1000mm of fill material, including the final capping layer;
- Relocate soil to an on-site location where it can be isolated by covering with at least 500mm of Level 1 material together with the final capping layer;
- Appropriate short term stockpiling for further quantification, characterisation and categorisation.

Level 3

- RLMC notification. The contractor is to notify RLMC or its representative within 12 hours of encountering Level 3 material. RLMC will then notify the DEC;
- Leaving contaminated material in-situ providing there is no immediate danger to the environment or community, it will be covered with at least 1000mm of fill material(including the final cap) and the area has appropriate controls in place;
- Isolation of soil by covering with at least 500mm of Level 1 material together with the final capping layer;
- Appropriate short-term stockpiling for further characterisation and categorisation;
- Ex-situ volatiles treatment using passive biological controls;
- Treatment to remove, stabilise or permanently emplace the material so as to address risks to the environment or human health.

The C-Specification indicated that soil criteria (i.e. soil criteria in NSW DECC (2006) Site Auditor Guidelines) are not relevant for areas to be capped. Proposed threshold concentrations for total PAH for classification of materials are:

- Level 1 PAH – less than 2000mg/kg (average after placement) and no individual results greater than 2500mg/kg;
- Level 2 PAH - greater than 2000mg/kg (average after emplacement) and no visible free phase compounds; and
- Level 3 materials are those soils with free diesel, oil, tar or other hydrocarbon product flowing in pore spaces.

EPS developed a Handling, Transport and Materials Tracking System to assess on site materials encountered during the remediation earthworks activities, which is discussed further in Section 5.4.4.

5.2 Assessment of Imported Material

Material was imported to site for the VENM cap and for filling of disused service trenches and stormwater drains.

Material imported to site for the VENM cap must classify as Virgin Excavation Natural Material (VENM) in accordance with NSW DEC (2006) *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes*.

Material imported to site for filling of disused service trenches and stormwater drains required a waste classification document from the site of origin in accordance with NSW DEC (2004) *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes*. Material imported to site for filling of disused service trenches and stormwater drains must classify as either Virgin Excavation Natural Material (VENM) or inert waste that is suitable for re-use on a commercial/ industrial property.

5.3 Assessment of PASS Treatment

Potential Acid Sulfate Soils (PASS) were encountered within the Western Drain excavation and the Eastern Drain excavation. An ASS treatment procedure was developed by EPS, which is outlined in Section 5.4.1.

Following treatment, one validation sample per 1,000m^3 was collected by a Coffey Environments Scientist and analysed at Environmental Analysis Laboratory (EAL) for Total Potential Acidity (TPA). A TPA result of 0 indicated that the treatment had been successful.

Following validation, an EPS Hold Point Release form was signed by a representative from Coffey Environments, EPS and Daracon and the treated PASS material was relocated within the New Landscape Mound.

5.4 EPS Management Plans and Procedures

EPS developed five procedures for on-site civil works, including

- Acid Sulfate Management Plan E0730_MP04;
- Acid Sulfate Management Procedure WP01, including Addendum No. 03;

- Asbestos Management Plan E0730_MP02;
- Contaminated Site Management Plan E0730_MP01;
- Handling, Transport and Materials Tracking System WP02, including Addendum No. 01, Addendum No. 02 and Addendum No. 04.

The EPS management plans and procedures were reviewed by Coffey Environments in May 2007. A copy of the EPS procedural documents is presented in Appendix A.

A summary of each procedure and addenda to the procedures is presented below.

5.4.1 Acid Sulfate Management Plan and Procedure

The Acid Sulfate Management Plan (Ref: E0730_MP04) provides a framework for the management and treatment of Acid Sulfate Soils (ASS) encountered during the remediation earthworks activities, including the identification of PASS material, the construction of a treatment area and lime neutralisation of ASS.

Following the completion of in-situ testing and a treatment trial, the Acid Sulfate Management Procedure (Ref: WP01) was updated with Addendum No. 03, which provided more detailed information regarding the treatment and of PASS material.

5.4.2 Asbestos Management Plan

The Asbestos Management Plan (Ref: E0730_MP02) indicates that small quantities of asbestos cement sheeting, gasket material or insulation containing asbestos may be encountered anywhere across the site and provides a framework for categorisation of asbestos bearing fill, control actions and dust management for asbestos works.

5.4.3 Contaminated Site Management Plan

The Contaminated Site Management Plan (Ref: E0730_MP01) includes procedures to ensure the following:

- The works progress without undue pollution of the environment;
- Management of contaminated soils is undertaken in accordance with the C-Specification, Contractors Environmental Management Plan (CEMP) and with best practice OHS;
- Any potential for exposure to contaminants during the remediation works is minimised and managed;
- The capping system on the Closure Area is installed to the requirements of the Consent Conditions and that the integrity of the system is maintained;
- The principal's desire to maintain the potential and value of the site for redevelopment by reducing the likelihood of encountering highly contaminated soils during subsequent development activities is achieved.

5.4.4 Handling, Transport and Materials Tracking System

A Plan for Handling, Transport, Tracking and Management of Materials (Ref: E0730_WP02_A3) was prepared in accordance with the requirements of the C-Specification. The plan included:

- Classification of Level 1, Level 2 and Level 3 materials and other fill types, including Potential Acid Sulfate Soils (PASS) and asbestos, excavated during the cut and fill process;
- A reuse decision matrix for Level 1, Level 2 and Level 3 materials to govern the management of materials excavated during remedial activities, as a flow chart; and
- Transport and tracking procedures for Level 1, Level 2 and Level 3 materials.

The re-use decision matrix flow chart was updated twice during the remediation earthworks activities, following two non-conformances with regard to use of the flow chart in the field.

Initially, the flow chart indicated that Level 2 material was to be transported to an appropriate area for emplacement, while Level 3 materials was to be transported to the Level 3 stockpile area.

Following a meeting between Coffey Environments, Daracon, EPS, GPS and Environ on 26 June 2007, the flow chart was updated to indicate that Level 2 and Level 3 material could remain in situ, with an adequate depth of cover of 1000mm for Level 2 material and 1500mm for Level 3 material. Addendum No. 2 outlined the updated flow chart.

The flow chart was updated again following instruction from GPS in August 2007 in relation to the excavation of Level 2 material and Level 3 material from areas of cut in Area 1, particularly in relation to excavation works around the new stormwater pipes in the Low Area. Addendum No. 4 outlined the updated flow chart, which stated ‘within Area 1A, material remaining within walls and base of excavation, including Level 2 and Level 3 fill above minimum depths is to be classified in situ, surveyed and documented for future land users.’

5.5 Coffey Environments Procedures

Coffey Environments developed a Sampling, Analysis and Quality Plan (Ref: GEOTSGTE20150AD-AD, dated 13 June 2007) for the sampling of soil during the remediation earthworks activities.

The Sampling, Analysis and Quality Plan included information on the following:

- Investigation criteria for soil, slag, crushed concrete and surface water;
- Sampling methodology for sampling of soil, groundwater and surface water;
- Laboratory analysis programme;
- Quality Assurance/ Quality Control (QA/QC) plan;
- Geotechnical testing requirements for the pavement cap and VENM cap;
- A contingency plan; and
- Reporting requirements, including monthly reporting.

A copy of this Sampling, Analysis and Quality Plan is included in Appendix A.

5.6 Data Management and Tracking

5.6.1 On-Site Materials Tracking

EPS Inspection and Test Reports (ITR) 01_A3 for on site materials tracking were completed on a daily basis during the remediation earthworks activities. The ITR 01_A3 was used to record the start time, finish time, truck identification, material type, origin and destination and truck docket number for Level 2 material and Level 3 material.

Truck dockets were completed for each truck load of Level 2 material and Level 3 material transported within the Closure Area. The truck dockets were used to record the date, time, the origin of the material (including the area, the chainage and off set), the truck ID, the material type, the classification and comments/ observations.

Hold points to verify the tracking of materials on site during the remediation earthworks activities were signed on a weekly basis. The hold points were signed by representatives of Coffey Environments, EPS and Daracon.

5.6.2 Dewatering of Drain Excavations

Drain excavations required dewatering to provide an accessible working area for construction of both the Eastern and Western Drains. During the time of dewatering of the Western Drain excavation and the Eastern Drain excavation, EPS Inspection and Test Reports ITR 08 were generally completed on a daily basis until March 2008. ITR 08 was completed twice a week from March 2008 to May 2008, when shorter sections of the drain were being dewatered.

The ITR 08 was used to record the chainage dewatered, the time, the location of dewatering, the visual appearance and the odour of the water extracted.

5.6.3 Treatment of PASS Material

During the treatment of PASS material, an EPS Inspection Checklist Report ICR 01_A3 was completed for each batch of treated PASS material. The ICR 01_A3 included inspection of the following activities/ items:

- Footprint of the storage area established by Daracon and GPS;
- Installation of appropriate environmental controls in accordance with WP01;
- PASS and ASS identified via field screening;
- Liming rate established by laboratory testing;
- Origin of PASS material using chainages;
- PASS/ ASS allowed to dry for more effective handling;
- Lime treatment carried out, including documentation of volume of PASS to be treated with volume of lime;
- Survey information attached to ICR 01_A3 for volume calculation;
- Consistency of mixing of lime for effective neutralisation of the PASS batch;

- Treatment material transported to appropriate fill type emplacement area of landscape mound.

At the completion of the PASS treatment for each batch, a Hold Point was signed by a representative from Coffey Environments, EPS and Daracon to verify the lime stabilisation of PASS material by EPS.

5.6.4 Sample Registers

Separate sample registers were established for fill sampling, slag sampling, sampling of the railway line embankment and sampling of the Landscape Mound. These sample registers were maintained by Coffey Environments during the period of the remediation earthworks activities.

Generally, the sample registers included the sample identification, the easting and northing, the depth, the PAH result, the intra-laboratory and inter-laboratory duplicate samples, duplicate sample results and the relative percent difference (RPD) between primary and duplicate sample results.

5.6.5 Coffey Environments Site Visits

Site visits were completed on a weekly basis by a representative from Coffey Environments to observe the remediation earthworks activities and review the following:

- Identification of Level 1, Level 2 and Level 3 material on site, including review of ITR 01_A3;
- Dewatering records, including review of ITR 08;
- PASS treatment, including review of ICR 01_A3.

The EPS Inspection and Test Reports were reviewed by a representative from Coffey Environments at the end of each month and relevant information from those reports was included in the monthly report.

5.7 Coffey Environments Reporting

Coffey Environments completed Monthly Reports summarising the remediation and civil earthworks activities completed during each month from May 2007 to May 2008 inclusive.

The Monthly Reports generally included the following information:

- Rainfall dates;
- Hold points signed for materials tracking and PASS treatment;
- Non- conformances (if any) identified during the month;
- Materials tracking of Level 1, Level 2 and Level 3 materials, geotechnically unsuitable material and slag used in the pavement cap;
- Tracking of VENM material imported to site;
- Dewatering of the Western Drain excavation and Eastern Drain excavation;
- PASS treatment;
- Fill sampling, slag sampling and sampling of the landscape mound and railway line;
- Surface water sampling; and
- Waste classification for other material imported to site.

The Monthly Reports were submitted to Daracon and EPS. Daracon forwarded the Monthly Reports to GPS, who then forwarded the Monthly Reports to the Site Auditor.

The Monthly Reports submitted to Daracon were:

- May 2007 Monthly Report, Ref: GEOTSGTE20150AD-AE;
- June 2007 Monthly Report, Ref: GEOTSGTE20150AD-AF;
- July 2007 Monthly Report, Ref: GEOTSGTE20150AD-AG;
- August 2007 Monthly Report, Ref: ENVIWARA20150AD-AJ;
- September 2007 Monthly Report, Ref: ENVIWARA20150AD-AK;
- October 2007 Monthly Report, Ref: ENVIWARA20150AD-AL;
- November 2007 Monthly Report, Ref: ENVIWARA20150AD-AN;
- December 2007 Monthly Report, Ref: ENVIWARA20150AD-AP;
- January 2008 Monthly Report, Ref: ENVIWARA20150AD-AS;
- February 2008 Monthly Report, Ref: ENVIWARA20150AD-AT;
- March 2008 Monthly Report, Ref: ENVIWARA20150AD-AU;
- April 2008 Monthly Report, Ref: ENVIWARA20150AD-AV;
- May 2008 Monthly Report, Ref: ENVIWARA20150AD-AW.

A copy of each Monthly Report is included in Appendix B.

6 OVERVIEW OF REMEDIATION EARTHWORKS ACTIVITIES IN AREA 1A, AREA 1B AND AREA 2D

6.1 Area 1A

Remediation earthworks activities in Area 1A included:

- Localised cut and fill;
- Relocation of excess Level 1 material;
- Filling of disused electrical conduits and stormwater drains;
- Relocation of classified Level 2 and Level 3 materials to Emplacement Areas;
- Construction of Level 2 Emplacement Area;
- Construction of Level 3 Emplacement Area;
- Drainage works;
- Construction of pavement cap;
- Construction of VENM cap.

6.2 Area 1B

Remediation earthworks activities in Area 1A included:

- Localised cut and fill;
- Relocation of excess Level 1 material; and
- Construction of pavement cap.

6.3 Area 2D

Remediation earthworks activities in Area 2D included:

- Localised cut and fill;
- Relocation of excess Level 1 material;
- Construction of the Western Drain;
- Relocation of classified Level 2 and Level 3 materials to Emplacement Areas in Area 1A.

7 MATERIALS TRACKING

7.1 General

EPS tracked materials used as cut and fill in the remediation earthworks activities. Materials tracking was documented on EPS Inspection and Test Reports (ITR) No. 01_A3.

Materials were classified as Level 1, Level 2 or Level 3 in accordance with the C-Specification and the Handling, Transport and Materials Tracking System WP02. The majority of the materials on site classified as Level 1.

Due to the high volume of Level 1 material, the tracking of Level 1 materials for cut and fill was completed using daily survey information for volumes. Level 1 material was tracked using the origin location, the destination and periods of time on a daily basis. Individual truck movements were not recorded on ITR No. 01_A3.

Geotechnically unsuitable materials, which were transported to the Landscape Mound, were tracked using the origin location, the destination and periods of time on a daily basis. Individual truck movements were not recorded on ITR No. 01_A3.

PASS material excavated from the Western Drain excavation and the Eastern Drain excavation were tracked using the origin location, the destination and periods of time on a daily basis. Individual truck movements were not recorded on ITR No. 01_A3.

Level 2 and Level 3 materials that were uncovered or moved during the remediation earthworks activities were tracked by logging individual truck movements on ITR No. 01_A3. Each truck transporting Level 2 or Level 3 material was provided with a truck docket, noting the origin and type of material and the destination. Truck dockets were also provided for Level 2 and Level 3 material classified in-situ but not moved.

Truck dockets for the remediation earthworks activities extended from 0001 to 0378, excluding dockets 0032, 0072 to 0095, 0230 and 0325.

ITRs for Level 3 material formed part of the documentation for notification of Level 3 material to GPS and RLMC.

Daily ITRs and truck dockets for on-site materials tracking were received from EPS for review by Coffey Environments on a weekly basis. Hold Points for the verification of the tracking of materials on site during the remediation earthworks activities were signed on a weekly basis. The hold points were signed by representatives of Coffey Environments, EPS and Daracon.

A copy of the daily ITRs No. 01_A3 for On Site Materials Tracking and truck dockets are presented in monthly batches in Appendix C. Copies of the Hold Points for materials tracking are also presented in Appendix C.

A Materials Tracking spreadsheet was maintained by EPS for the duration of the remediation earthworks activities, which tracked:

- Volumes of Level 2 and Level 3 materials moved on a daily basis, using a combination of truck volumes and survey volumes;
- Volumes of Level 1 materials moved on a monthly basis, using the end of month survey pick-up;

- Volumes of geotechnically unsuitable material moved on a monthly basis, using the end of month survey pick-up; and
- Volumes of treated ASS materials on the completion date of each batch, using the survey volume of each batch.

A copy of the Materials Tracking Spreadsheet is presented in Appendix D.

7.2 Area 1A

Cut and fill of Area 1A began in May 2007 and was completed in November 2007. Materials tracking in Area 1A, including the tracking of Level 1, Level 2 and Level 3 material, was documented on EPS ITR No. 01_A3 using the chainages from the railway line embankment to detail the origin of cut material and the destination of fill material.

The location of Level 2 and Level 3 material that was identified in-situ, but not moved, was surveyed in plan and elevation. The majority of the material classified as Level 2 or Level 3 material in Area 1A was discovered near the former Benzol Plant and the former Tar Plant.

7.3 Area 1B

Cut and fill of Area 1B began in December 2007 and was completed in late February 2008. Due to the relatively small size of Area 1B (45,460m^2), materials tracking in Area 1B was documented on EPS ITR No. 01_A3 without reference to chainages.

No Level 2 or Level 3 material was discovered in Area 1B.

7.4 Area 2D

Cut and fill of Area 2D began in May 2007 and was completed in May 2008. Materials tracking in Area 2D, including the tracking of Level 1, Level 2 and Level 3 material, was documented on EPS ITR No. 01_A3 using the chainages from the Western Drain to detail the origin of cut material and the destination of fill material.

The location of Level 2 and Level 3 material that was identified in-situ, but not moved, was surveyed in plan and elevation. The majority of the Level 2 and Level 3 material in Area 2D was discovered within and immediately east of the Western Drain excavation.

7.5 Drain Excavations

The Western Drain excavation commenced in July 2007 and was completed in December 2007. Material from the Western Drain excavation was tracked using the Western Drain chainages, as outlined in Section 7.4 above. Materials from the Western Drain excavation included Level 2 and Level 3 material and PASS material.

The Eastern Drain excavation commenced in August 2007 and was completed in January 2008. Material from the Eastern Drain excavation, including PASS material and Level 1 material, was tracked on EPS ITR No. 01_A3 using the Eastern Drain chainages.

7.6 Railway Line Embankment

The railway line embankment to the east of Area 1A from chainage CH410 to CH1010 was constructed between September 2007 and November 2007. The railway line embankment to the east of Area 1A from chainage CH60 to CH410 was completed in May 2008.

The railway line embankment in Area 2D from chainage CH1510 to CH1899 was completed between January 2008 and February 2008.

The majority of the railway line embankment to the east of Area 1A and in Area 2D required filling, with Level 1 material tracked from the origin location to the railway line embankment. In areas of cut, the cut material was tracked from the railway line embankment to its destination location, generally the Area 2A Disposal Stockpile.

7.7 Area 2A Disposal Stockpile

Excess Level 1 material excavated during the remediation earthworks activities from various locations, including Area 1A, railway line embankment cuts, Eastern Drain excavation, Area 2A pond and base of the new Landscape Mound was relocated to a stockpile in Area 2A, known as the Area 2A Disposal Stockpile.

Some Level 1 material from the Area 2A Disposal Stockpile was re-used in Area 1A, Area 1B and Area 2D (see Section 8.2).

8 LEVEL 1 MATERIALS TRACKING

8.1 Characterisation of Level 1 Material

Level 1 material classified during the remediation earthworks activities generally consisted of fill material, including:

- Dredged sand;
- Slag;
- Iron ore;
- Gravelly sand fill material.

8.2 Tracking of Level 1 Material

In accordance with Section C3.4.3, Level 1 material had unrestricted use on site. Level 1 material classified during the remediation earthworks activities was used as follows:

Area 1A

- Level 1 material used in localised cut to fill;
- Backfilling of ‘slag mine’ with slag from Area 2A; and
- Excess Level 1 material from the Level 3 Emplacement Area transported to Area 2A Disposal Stockpile.

Area 1B

- Level 1 material used in localised cut to fill; and
- Excess Level 1 material transported to Area 2A Disposal Stockpile.

Area 2D including Western Drain Excavation

- Level 1 material used in localised cut to fill;
- Level 1 material transported to Area 1B as fill; and
- Excess Level 1 material from Western Drain box culvert chainages transported to Area 2A Disposal Stockpile.

Railway Line Embankment

- Level 1 material from railway line embankment batters transported to Area 2A Disposal Stockpile;
- Level 1 material from the Western Drain excavation used to construct railway line embankment east of Area 1A;
- Level 1 material from the Area 2A Disposal Stockpile was used to construct railway line embankment in Area 2D; and
- Level 1 material from the Area 2A Slag Retrieval Pit was used to constructed railway line embankment in Area 2D.

Eastern Drain Excavation

- Level 1 material from the Eastern Drain excavation transported to Area 2A Disposal Stockpile.

Area 2A Disposal Stockpile

- Area 2A Disposal Stockpile consisted of excess Level 1 material from railway line embankment cuts, Eastern Drain excavation, Area 2A pond and base of the new Landscape Mound;
- Level 1 material from Area 2A Disposal Stockpile re-used for:
  - Filling of the railway line embankment in Area 2D,
  - Filling of former electrical conduits and disused trenches in Area 1B,
  - Filling of stormwater drains in Area 1A,
  - Filling around the former Innova Plant in Area 2D,
  - Filling around box culverts in Western Drain,
  - Filling of in Area 1B.

The cumulative volume of Level 1 material tracked between May 2007 and July 2007 within Area 1A and Area 2D was approximately 98,560m^3, as shown on the EPS Materials Tracking Spreadsheet in Appendix C. The volumes of Level 1 material entered into the Materials Tracking Register between May 2007 and July 2007 are from a daily earthworks volume summary using survey information. It is noted that Daracon created lots within Area 1A to assist with the cut to fill operation. Daracon maintained a Lot Status Register, including survey volumes of Level 1 material in the individual lots. The Lot Status Register was not used to collate this report.

The volume of Level 1 material tracked within Area 1A and Area 2D between July 2007 and May 2008 was not surveyed as the bulk of the cut to fill earthworks in Area 1A and Area 2D were completed by July 2007.

The volume of Level 1 material used in the cut to fill of Area 1B was not surveyed as Area 1B was considered by Daracon to be too small to create individual lots. Also, the cut to fill earthworks across Area 1B balanced, within practical limits, and did not require the importation of material volumes of Level 1 material into Area 1B, in the context of this project, to complete the earthworks.

The Area 2A Disposal Stockpile was created in August 2007 to store excess Level 1 material that could be subsequently re-used as required. The volume of Level 1 material added to the Area 2A Disposal Stockpile between August 2007 and January 2008 was 33,148m^3, as shown on the EPS Materials Tracking Spreadsheet in Appendix D.

Photographs of the remediation earthworks activities in Area 1A, Area 1B, Area 2D, the Western Drain, the Eastern Drain and the railway line embankment are included in Appendix E.

9 LEVEL 2 MATERIALS TRACKING

9.1 Characterisation of Level 2 Material

Level 2 material classified during the remediation earthworks activities included four distinct materials:

- Coal tar coated slag, generally located along the northern boundary of Area 1A near the former Benzol Plant and former Tar Plant;
- Oil soaked fill, identified in the Western Drain excavation near the former raw materials handling, storage and blending plant;
- Hydrocarbon impacted greasy material, near the former coal washery plant;
- Coal washery rejects with ammonia odour, identified within a buried steel structure located near the former coal washery.

Part of the two coat seal from the trial pavement cap was excavated, classified as Level 2 material and disposed of to the Level 2 Emplacement Area following the completion of the trial pavement cap.

Photographs of Level 2 material are included in Appendix E.

9.2 Tracking of Level 2 Material

Level 2 material transported to the Level 2 Emplacement Area during the remediation earthworks activities is summarised in Table 1.

The origin of the classified Level 2 material is presented in Figure 3. The Level 2 material was tracked using the truck dockets. A copy of the truck dockets is presented in monthly batches in Appendix C.

TABLE 1 – TRACKING OF LEVEL 2 MATERIAL IN AREA 1A AND AREA 2D

Dates	From Location	Material Type	Truck Dockets	Volume m^3
15 May 2007	Area 1A CH1200 off set south 20m	Black hydrocarbon impacted greasy material	0001to 0024	234.9
16 May 2007	Area 1A CH1200 off set north 50m to 100m	Black hydrocarbon impacted greasy material	0025 to 0031, 0033 to 0058	294.5
5 June 2007	Area 2C Hot spot	Tar coated gravels	0098	4.0
23 June 2007	Area 1A CH1250 off set south 20m	Coal wash material with ammonia odour	0100	3.5
13, 17, 20 July, 3,15 August, 14 September, 4 October 2007	Lot 7, 3 (Area 1A), Lot 29 (Area 1A), Area 1A, 16 (144), Area 1A, 9 (143)	Coal tar coated slag	0169, 0216 to 0229, 0248 to 0252, 0254 to 0256, 0330, 0335	268.3
7 September 2007	Slag Trial Lot in Area 1A	Trial two coat seal	0326	10.0
18 October 2007	Western Drain CH370	Oil soaked fill	0357	30.0
			TOTAL	**845.2**

9.3 Level 2 Emplacement Area

The Level 2 Emplacement Area is located beneath the pavement cap to the north of the railway line embankment in Area 1A. The location of the Level 2 Emplacement Area is shown in Figure 4.

The Level 2 Emplacement Area comprised a single cell that was constructed in a low area in between the former coal handling conveyor support units.

The Level 2 Emplacement Area was filled with Level 2 material as outlined in Table 1 between 15 May 2007 and 18 October 2007, aside from 198.5m3 of Level 2 material which was initially classified as Level 3 material and was then reclassified as Level 2 material as a result of a meeting between EPS and GPS on 21 May 2007. This volume of Level 2 material had been transported to the Level 3 Emplacement Area prior to the meeting and was not relocated to the Level 2 Emplacement Area following the change in classification.

The tracked volume of Level 2 material transported to the Level 2 Emplacement Area compared to the survey volume of the Level 2 Emplacement Area is shown in Table 2. The tracked volume of Level 2 transported to the Level 2 Emplacement Area does not include the 189.5m^3 of Level 2 that was transported as Level 3 to the Level 3 Emplacement Area and then reclassified as Level 2 material.

TABLE 2 – COPARISON OF TRACKED LEVEL 2 VOLUME TO SURVEY VOLUME

Area	Tracked Volume	Survey Volume	Difference
Level 2 Emplacement Area	655.7m^3	511m^3	-135.7m^3

The survey of the Level 2 Emplacement Area was completed in on 3 August 2007. The discrepancy between the survey volume and the tracked volume is due to the addition of approximately 119.7m^3 of Level 2 material to the Level 2 Emplacement Area following the survey pick up in early August and due to the over-estimation of some truck volumes when trucks were not fully loaded due to the wet nature of the material.

In accordance with Section C3.4.6 of the C-Specification, the Level 2 Emplacement Area was covered with at least 500mm of Level 1 material to isolate the Level 2 material from the future ground surface. Figure 5 shows that the depth of Level 1 material and pavement cap above the Level 2 Emplacement Area varies between 1.143m and 2.075m of Level 1 material and pavement cap. The pavement cap has a nominal thickness of 400mm, indicating the depth of Level 1 material above the Level 2 Emplacement Area varies between 0.743m and 1.675m.

9.4 Level 2 Material Remaining In-situ

Level 2 material classified during the remediation earthworks activities and which remained in situ at one location in Area 1A is shown on Figure 6.

Level 2 material was discovered and classified in Lot 7 at grid square 94 on 4 June 2007, at the time of fill sampling. The Level 2 material was observed to comprise bituminous material and the status as Level 2 was confirmed with the laboratory result of 7,540mg/kg for total PAH. The Level 2 material was discovered at a depth of approximately 300mm below the earthworks design level.

Minor excavation works were completed by EPS and observed by Coffey Environments on 28 June 2007 to assess the lateral and vertical extent of the Level 2 material around grid square 94. A shallow excavation, approximately 5m by 4m by 0.3m deep was completed and 6m^3 of Level 2 material was relocated to the Level 2 Emplacement Area. The Level 2 material was observed to comprise tar coated gravels similar to bituminous material identified at chainage CH1200 offset north 90m on 16 May 2007. The Level 2 material was observed to extend to the north and west of the excavation. Additional excavation was not undertaken at this time due to constraints on machinery availability.

Additional excavation works around grid square 94 were completed by EPS on 13 July 2007. The initial excavation was extended to approximately 6m by 6m by 0.5m. The base of the excavation was observed to comprise clayey gravelly sand fill. One truckload of Level 2 material was relocated to the Level 2 Emplacement Area and remaining excavation spoil was stockpiled near the excavation. The stockpiled bituminous material was observed to contain small quantities of coal tar pitch, which had been heated by the sun and become viscous over the intervening days. At the time of the excavation works, the coal tar pitch was in a solid state.

Excavation works were continued on 17 July 2007 by EPS and observed by Coffey Environments. Level 2 bituminous material and coal tar pitch was observed in the northern and western walls of the 6m by 6m by 0.5m excavation and consequently, the excavation was extended to the north and the west. A high area to the west of the excavation that required cut back to the earthworks design level was identified by Daracon and consequently, the excavation was extended approximately 30m to the west to cut Level 2 material back to the earthworks design level. The extended excavation was approximately 5m wide by 0.3m deep. The majority of the material cut from this extended excavation was observed to comprise Level 2 bituminous material. At the completion of the cut, Level 2 material was not observed in the southern and western walls of the excavation. A total of $117m^3$ of Level 2 material was relocated to the Level 2 Emplacement Area on 17 July 2007.

Level 2 material remains in situ to the north and west of the extended excavation around grid square 94, as shown in Figure 6. Photographs of this material are included in Appendix E.

10 LEVEL 3 MATERIALS TRACKING

10.1 Characterisation of Level 3 Material

Level 3 material identified during the remediation earthworks activities included four distinct materials:

- Fill impacted with free phase hydrocarbons, generally located near the former coal washery;
- Free phase tar and tar soaked fill/ tar impacted fill, generally located along the northern boundary of Area 1A near the former Benzol Plant and former Tar Plant; and within the Western Drain excavation near the former raw materials handling, storage and blending plant;
- Fill associated with an apparent waste oil pit, identified during the Eastern Drain excavation at chainage CH450;
- Naphthalene soaked coal wash material, identified within the Western Drain excavation to the north of the Koppers Gantry.

Photographs of Level 3 material are included in Appendix E.

10.2 Tracking Location of Level 3 Material

Level 3 material transported to the Level 3 Emplacement Area during the remediation earthworks activities is outlined in Table 3. The origin of the identified Level 3 material is presented in Figure 7. The Level 3 material was tracked using the truck dockets. A copy of the truck dockets is presented in monthly batches in Appendix C.

TABLE 3 – TRACKING OF LEVEL 3 MATERIAL IN AREA 1A AND AREA 2D

Dates	From Location	Material Type	Truck Dockets	Volume m^3
24 May 2007	Area 1A CH1380 off set south 120m	Free Phase hydrocarbon impacted fill	0063	24.5
25, 26 May 2007	Tar pit at Area 1A CH1300 off set north 150m	Tar (mixed with fill for transport)	0064 to 0071	60
30 May 2007	Western Drain CH 0 to CH20	Free phase tar mixed with slag	0096	4.8
4 June 2007	Area 1A CH1200 off set north 450m	Tar impacted fill	0097	6
10, 11, 12, 13, 30 July, 5, 6, 12 September, 3 October 2007	Western Drain CH160 to CH220	Hydrocarbon contaminated material and tar soaked fill	0101 to 0215, 237 to 239, 0295 to 0324, 0328 to 0329, 0331 to 0334	2,284

Dates	From Location	Material Type	Truck Dockets	Volume m^3
30 July 2007	Western Drain CH25-CH50	Tar soaked fill	0231 to 0236	70
31 July, 3, 17, 28 August 2007	Lot 29	Tar soaked fill	0240 to 0245, 0247, 0253, 0260 to 0292	618
16 August 2007	Western Drain CH290 off set east 60m	Tar soaked fill	0257 to 0258	30
16 August 2007	Area 1A, Lot 3 Slag	Tar soaked fill	0259	10
30 August 2007	Eastern Drain CH450	Waste oil pit and associated fill	0293 to 0294	40
4, 5, 7, 24 September 2007	Stormwater pipes near Hunter River	Fill from stormwater pipes	0327	32
12, 13 15, 16 October 2007	Western Drain CH280 to CH345	Tar soaked fill	0336 to 0355	569.3
17 October 2007	Western Drain CH170 to CH185	Tar soaked sand	0356	30
23 October 2007	Eastern Drain coffer dam	Hydrocarbon odour, sheen on fill	0358	36
1 November 2007	Western Drain CH475-500	Naphthalene soaked coal wash material	0359 to 0361	235
6, 7, 14, 15 November 2007	Western Drain box culvert CH140-CH200	Naphthalene soaked coal wash material	0362 to 0378	1,596.02
			TOTAL	**5,645.73**

10.3 Level 3 Emplacement Area

The Level 3 Emplacement Area is located beneath the VENM cap to the south of the railway line embankment in Area 1A. The Level 3 Emplacement Area comprised four cells, known as Cell 1, Cell 2, Cell 3 and Cell 4. The location of the Level 3 Emplacement Area is shown in Figure 4.

Cell 1 was constructed for the placement of Level 3 material during the construction of the groundwater barrier wall in 2006. This cell remained open at the start of the remediation earthworks activities and was the first cell filled with Level 3 material. Cell 1 contains Level 3 material transported between 5 May and 18 July 2007.

Cell 2 was opened in mid-July 2007 and contains Level 3 material transported between 18 July 2007 and 30 July 2007. Level 1 material excavated to accommodate Cell 2 was used as cut to fill in Area 1A.

Cell 3 was opened in early August 2007 and contains Level 3 material transported between 30 July 2007 and 30 October 2007. Level 1 material excavated to accommodate Cell 3 was used as cut to fill in Area 1A.

Cell 4 was opened in early November 2007 and contains Level 3 material transported between 30 October 2007 and 20 November 2007. Level 1 material excavated to accommodate Cell 4 was transported to the Area 2A Disposal Stockpile.

The tracked volume of Level 3 material transported to each cell compared to the survey volume of each cell is shown in Table 4. The tracked volume and the survey volume of Level 3 material does not include the 189.5m^3 of Level 2 material that was initially classified as Level 3 material.

TABLE 4 – COMPARISON OF TRACKED LEVEL 3 VOLUME TO SURVEY VOLUME

Cell	Tracked Volume m^3	Survey Volume m^3	Difference m^3
Cell 1	1714.3	1619.07	-95.23
Cell 2	160	99.99	-60.01
Cell 3	1940.3	1997.77	+57.47
Cell 4	1831.12	1831.12	0
TOTAL	5,645.72	5,547.95	-97.77

There is generally a small difference between the tracked volume when using truck counts and the survey volume due to assumptions made when using truck counts. These assumptions include that each truck will carry a set volume, in this case assumed to be 30m^3 and that each truck is fully loaded. Volume discrepancies of less than 100m^3 are not considered significant.

The discrepancy between the tracked volumes and the survey volumes for Cell 1 and Cell 2, where the survey volume was lower than the tracked volume, is due to the type of material moved and that some loads were not fully loaded. The Level 3 material moved into Cell 1 and Cell 2 included liquid tar and tar soaked fill, which meant that the trucks were not fully loaded and the full loads were less than the assumed volume of 30m^3.

The discrepancy between the tracked volumes and the survey volumes for Cell 3, where the survey volume was more than the tracked volume, is due to assuming the truck volume was less than $30m^3$ to be conservative.

In accordance with Section C3.4.6 of the C-Specification, the Level 3 Emplacement Area was covered with at least 500mm of Level 1 material to isolate the Level 3 material. Figure 8 shows that the depth of Level 1 material and VENM cap above the Level 3 Emplacement Area varies between 1.498m and 2.134m of Level 1 material and VENM cap. The VENM cap has a nominal thickness of 500mm, indicating that the depth of Level 1 material covering the Level 3 Emplacement Area varies between 0.998m and 1.634m.

10.4 Level 3 Material Remaining In-situ

Level 3 material discovered and classified during the remediation earthworks activities at one location in Area 1A and at one location in the Western Drain excavation in Area 2D remains in situ. The location of the Level 3 material remaining in-situ is presented in Figure 6.

10.4.1 Area 1A

Level 3 material remaining in-situ in Area 1A is located in the walls and base of an excavation completed to upgrade the stormwater system near former Benzol Plant.

During the excavation works, a steel framed ship was uncovered. The ship was surrounded by Level 3 material, including tar soaked fill and fill containing free phase tar.

The Level 3 material was over-excavated from the stormwater drain excavation to allow backfilling of the excavation with imported sand fill because contractors were required to work within the excavation. Approximately $618m^3$ of Level 3 material was excavated from the stormwater drain excavation on 31 July and 3, 17 and 28 August 2007.

Level 3 material remaining in-situ is located at a depth of approximately 1.5m below the earthworks design level. Photographs of this material are included in Appendix E.

10.4.2 Western Drain excavation in Area 2D

Level 3 material remaining in situ in the Western Drain excavation in Area 2D is located in the western wall of the drain excavation surrounding a stormwater pipe extending onto site from the adjacent OneSteel property at chainage CH220.

The Level 3 material could not be removed from the western wall of the Western Drain due to proximity to the site boundary. During the construction of the Western Drain in late September and October 2007, Level 3 material in the western wall of the Western Drain excavation was over-excavated by approximately 50mm to 100mm and replaced with sand to prevent contractors from having contact with Level 3 material during the placement of the HDPE liner.

A ring of approximately 200mm of Level 3 material remains surrounding the stormwater pipe that extends into the OneSteel property in the western wall of the Western Drain excavation. The stormwater pipe is located at a depth of approximately 1m below the earthworks design level. Photographs of this material are included in Appendix E.

11 ASBESTOS WASTE

Asbestos waste was discovered on three occasions during the remediation earthworks activities, as summarised in Table 5 below. Asbestos waste was disposed of to either the Level 2 or the Level 3 Emplacement Area.

Asbestos waste, including broken fibrous sheeting, discovered on 18 May 2007 was placed into the Level 2 Emplacement Area. In accordance with the Asbestos Management Plan E0370_MP02, asbestos air monitoring was completed during the excavation of the asbestos waste on 18 May 2007. Results of the asbestos air monitoring are included in Appendix F.

The asbestos pipes discovered during June and July 2007 were placed into the Level 3 Emplacement Area.

TABLE 5 – TRACKING OF ASBESTOS WASTE

DATES	FROM LOCATION	MATERIAL TYPE	TRUCK DOCKETS	VOLUME m^3
18 May 2007	Area 1A CH1225 off set north 150m	Asbestos waste	0059 to 0062	20
6 June 2007	Western Drain CH275 off set 35m	Asbestos pipe	0099	0.2
31 July 2007	Western Drain CH250 off set east 60m	Asbestos pipe	0246	0.5
			TOTAL	**20.7**

12 LANDSCAPE MOUND

12.1 Definition of Geotechnically Unsuitable Material

In accordance with Section C7.5, geotechnically unsuitable material was defined as:

- Organic soils such as topsoil, severely root-affected subsoils and peat;
- Silts, or material that have the deleterious engineering properties of silt;
- Other material with properties that were unsuitable for the forming of structural fill.

Geotechnically unsuitable material identified during the remediation earthworks activities included concrete, steel reinforcing, vegetation and attached soil. Photographs of the Landscape Mound are included in Appendix E.

12.2 Materials Tracking

Geotechnically unsuitable material discovered in Area 1A, Area 1B and Area 2D, including concrete, steel reinforcing, vegetation and attached soil, was transported to the landscape mound.

Treated PASS material from the Western Drain excavation and Eastern Drain excavation was also transported to the Landscape Mound, aside from Batch ED475-600 which was reused as backfill around the box culverts in the Eastern Drain. The treated PASS material was placed within the Landscape Mound such that it was covered with approximately 500mm of Level 1 material.

Large excavations were made in the base of the Landscape Mound to accommodate mass concrete that could not be recycled.

The Landscape Mound was covered with approximately 100mm of top soil won from on site in March 2008.

The volume of geotechnically unsuitable material added to the Landscape Mound was generally surveyed generally on a monthly basis. Tracking of Level 1 material and treated PASS material added to the Landscape Mound is summarised in Table 6. It is noted that the volume of treated PASS material added to the Landscape Mound is not the same as the volume of treated PASS material outlined in Section 21, due to volume loss following compaction of the treated PASS material in the Landscape Mound.

TABLE 6 – TRACKING OF UNSUITABLE MATERIAL ADDED TO LANDSCAPE MOUND

Month	**Level 1 Volume m^3**
May 2007	7014
June 2007	1550
July 2007	300
August 2007	7893
September 2007	325
October 2007	528
November 2007	5036
December 2007 to May 2008	2312
TOTAL	**24,958**

13 ENVIRONMENTAL SAMPLING IN AREA 1A, AREA 1B, AREA 2D, LANDSCAPE MOUND AND RAILWAY LINE EMBANKMENT

13.1 Sampling Procedures

The procedures for sampling fill material below the cap on the 40m by 40m grid are outlined in the Sampling, Analysis and Quality Plan (SAQP).

Soil samples were collected using the procedures outlined in the SAQP and summarised in Table 7. Table 7 indicates that general field and laboratory quality assurance/ quality control (QA/QC) was undertaken in accordance with the SAQP and is acceptable.

TABLE 7 – SAMPLING PROCEDURES FOLLOWED DURING SAMPLING

Procedure	Followed/ Comment
Sampling was completed with the aid of a backhoe.	Followed
Soil samples were collected directly from the base of the test pit or from the centre of the backhoe bucket using dedicated disposable gloves.	Followed
Soil samples were sub-divided into two sub-samples. One sub-sample was collected into laboratory-supplied acid-rinsed glass jars. The other sub-sample was collected in a plastic bag for headspace screening.	Followed
PID head space screening was completed on sub-samples.	Followed
Intra-laboratory and inter-laboratory duplicate samples were collected at a rate of 1 per 10 samples and 1 per 20 samples respectively or 1 per batch.	Followed
Soil samples were stored in a cooler box filled with ice during sampling and transportation to the laboratory.	Followed
Soil samples were transported under Chain of Custody conditions.	Followed
Soil samples with PID readings greater than 100ppm were analysed for TPH/ BTEX.	Followed
Wash blanks, trip blanks and trip spikes were not required.	Confirmed
Primary samples analysed by Labmark and inter-laboratory duplicate samples were analysed by ALS, both NATA accredited for PAH analysis. Surface water samples were analysed by ALS, who are NATA accredited for the analysis undertaken.	Followed

Procedure	Followed/ Comment
Soil samples were received within holding times and were chilled on arrival at the laboratory.	Followed
Samples were extracted and analysed within the holding times for PAH.	Followed
Fill sample register, Landscape Mound sample register and Railway Line Embankment sample register were maintained and up-dated by Coffey Environments.	Followed

13.2 Fill Sampling

13.2.1 Area 1A, Area 1B and Area 2D

Fill sampling of Area 1A, Area 1B and Area 2D was completed on a 40m by 40m grid, as specified in Section C3.4.9 of the C-Specification. In areas of fill, samples were collected at a rate of one sample per 500mm of fill material thickness at each grid square. In areas of cut, one sample was collected at a depth of 200mm below design level.

Daracon established the 40m by 40m grid, with samples collected by Coffey Environments from the centre of each grid square. The 40m by 40m gird, including grid square numbers and corresponding sample names in Area 1A and Area 2D is presented in Figure 9. The 40m by 40m gird, including grid square numbers and corresponding sample names in Area 1B is presented in Figure 10.

Daracon provided survey information, including the natural surface level, the design level and the easting and northing of the centre of each grid square to identify areas of cut, areas of fill and the depth of fill.

In areas of cut, fill samples were collected at a depth of 200mm below the design level. In areas of fill, fill samples were generally collected at a rate of one sample per 500mm, as outlined in Table 8.

TABLE 8 – DEPTHS AT WHICH SAMPLES WERE COLLECTED IN FILL MATERIAL

Depth of Fill	Sample Depths
Up to 250mm	Half the depth of fill
Between 250mm and 500mm	At 250mm
Between 500mm and 750mm	At 250mm
Between 750mm and 1250mm	At 250mm and 750mm
Between 1250 and 1750mm	At 250mm, 750mm and 1250mm
Between 1750mm and 2000mm	At 250mm, 750mm, 1250mm and 1750mm

Fill samples were labelled using the following information:

- Lot 1 to Lot 9 in Area 1A – Lot number, grid square number and depth in millimetres eg. Lot 7, 3 – 200;
- Western part of Area 1A – Area 1A, grid square number and depth in millimetres eg. Area 1A, 46 – 750;
- Area 1B – Area 1B, grid square number and depth in millimetres eg. Area 1B, 13 – 200;
- Area 2D – Area 2D, grid square number and depth in millimetres eg. Area 2D, 18 -200.

It is noted that sampling was generally completed on a lot by lot basis once each lot was near to the design level. In some locations where sampling was completed when the earthworks was not at the design level, the depth of some sample locations was outside the requirements of the C-Specification. In particular, deleterious clay material from Lot 9 was over-excavated prior to filling and this was not accounted for prior to the first round of sampling completed in August 2007. Following acknowledgement of this error, previous sampling locations were checked to identify errors in sample depths. Errors in sample depths were identified due to the following reasons:

- Where sampling was completed at a lower level than design level;
- Where areas of cut were over-excavated and then filled due to deleterious material;
- Where areas of fill were over-excavated and then filled due to deleterious material.

A second and on occasion, third round of sampling was completed at the following sampling locations:

- Locations that could be accessed (i.e. locations under the pavement cap could not be accessed);
- Locations where areas of cut had become areas of fill and the fill depth was greater than 250mm;
- Locations where the first round sampled below the natural surface and the fill depth was greater than 250mm.

Sampling locations were not re-sampled where areas of cut became areas of fill and the fill depth was less than 250mm or where sampling was completed below the natural surface and the fill depth was less than 250mm. Samples completed at these locations were considered to be in compliance with the requirements of the C-Specification.

The grid square locations (138, 139 and 140) within the ‘slag mine’ in Area 1A were re-sampled following filling of the ‘slag mine’ with slag from Area 2A. Extra samples were collected within the former ‘slag mine’ due to assumption that the former ‘slag mine’ was 2m deep, when it actually sloped from 2m deep at grid square 138 to 0.4m deep at grid square 140.

Cross sections of the fill sampling completed in Area 1A and Area 2D are included in Appendix K. The cross sections are numbered from Row 1 to Row 14. The row numbers correspond to those labelled on Figure 9. The cross sections show the natural surface level, the base level to which the natural surface level was cut back to, the design level and the sample locations, including extra samples and samples not completed in compliance with the C-Specification.

Information provided by Daracon, including grid square numbers and associated northings, eastings, natural surface level, base level (the level to which parts of the Area 1A were excavated to below the natural surface level) and design level, formed the basis of a sample register that was maintained by Coffey Environments for the duration of the remediation earthworks activities.

The Fill Sample Register is presented in Appendix G and includes the following information:

- Grid square number (established by Daracon);
- Lot number;
- Sample number;
- Sample depth;
- Depth below design level;
- Natural surface level;
- Base level;
- Design level;
- Depth of fill (difference between base level and design level);
- Compliance with C-Specification sampling requirements;
- Easting and northing;
- Cut or fill;
- Duplicate sample(s);
- Date sampled;
- Material type;
- Highest PID result;
- Laboratory testing (generally PAH only);
- Laboratory result for PAH testing;
- Duplicate result(s);
- Relative percent difference for primary and duplicate result(s).

A summary of the fill sampling of Area 1A, Area 1B and Area 2D is presented in Table 9, including the number of samples per batch and the number of intra-laboratory duplicate samples and inter-laboratory duplicate samples collected per batch. Fill sampling locations in Area 1A and Area 2D are presented in Figure 9. Fill sampling locations in Area 1B are presented in Figure 10.

TABLE 9 – SUMMARY OF FILL SAMPLING COMPLETED SINCE MAY 2007

Date	Lots Sampled	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
24 May 2007	Lot 1, Lot 2	29	3	1	E032147/ ES0707036
28 May 2007	Lot 4, Lot 5	13	2	1	E032190/ ES0707067
30 May 2007	Lot 3, Lot 6	15	2	1	E032234/ ES0707208
4 June 2007	Lot 7, Lot 8	28	3	1	E032336/ ES0707479
22 June 2007	Lot 9, 2nd round sampling Lots 1, 2, 3, 5 and 6	47	5	2	E032636/ ES0708563
28 June 2007	Area 1A, Area 2D, 2nd round sampling Lots 1, 3, 5, 8	44	4	2	E032725/ ES0708838
12 July 2007	Lot 5, Lot 6, Area 1A	39	4	2	E032950/ ES0709537
1 Aug 2007	Area 1A, Lot 7	18	2	1	E033314/ ES0710565
22 Aug 2007	Area 1A, 2nd round sampling Lots 8, 9	20	2	1	E033676/ ES0711732
31 Aug 2007	Area 1A	10	1	0	E033833
11 Oct 2007	Former Slag Mine in Area 1A	11	2	1	E034469/ ES0714208
21 Nov 2007	Area 2D	20	2	1	E035149/ ES0716247
29 Nov 2007	Area 2D	23	3	1	E035257/ ES0716708

Date	Lots Sampled	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
13 Feb 2008	Area 1B	17	2	1	E036262/ ES0801882
3 April 2008	Area 1B	7	1	0	E037036
29 May 2008	Area 1B, Area 2D	36	4	3	E037898/ ES0807574
TOTALS		**377**	**42**	**19**	

13.2.2 Landscape Mound

Geotechnically unsuitable material relocated to the Landscape Mound had to classify as Level 1 material. Sampling of the Landscape Mound was undertaken to confirm the Level 1 classification. Sampling of the Landscape Mound was completed at a rate of 1 sample per 1,000m^3.

Sampling of the Landscape Mound was completed on 24 September 2007. The Landscape Mound volume following the August 2007 survey was 16,757m^3. At the time of sampling, the Landscape Mound comprised three separate stockpiles, one of which was in the process of being relocated into the New Landscape Mound along the embankment of Industrial Drive.

Seventeen soil samples (LM1 to LM17) were collected either from test pits or sampling of stockpiles. Nine samples were collected from the eastern stockpile, four samples were collected from the southern stockpile, two samples were collected from the northern stockpile and two samples were collected from the emplaced material in the new landscape mound.

Between 24 September 2007 and mid-November 2007, an additional 984m^3 of Level 1 material was added to the Landscape Mound. One additional sample (LM18) was collected from the additional Level 1 material on 15 November 2007.

A summary of the sampling of the Landscape Mound is presented in Table 10, including the number of samples per batch and the number of intra-laboratory duplicate samples and inter-laboratory duplicate samples collected per batch.

TABLE 10 – SUMMARY OF LANDSCAPE MOUND SAMPLING

Date	Volume of Landscape Mound	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
24 Sept 2007	16,757m^3	17	2	1	E034177/ ES0713247
11 Nov 2007	Additional 984m^3	1	0	0	E035000
TOTALS		**18**	**2**	**1**	

Sampling locations completed on 24 September 2007 are presented on Figure 11.

A Landscape Mound sample register was maintained by Coffey Environments for the duration of the remediation earthworks activities. The Landscape Mound sample register is presented in Appendix H and provides the following information:

- Sample name;
- Sample location;
- Easting and northing;
- Depth of sample;
- Duplicate sample(s);
- Date sampled;
- Material type;
- Highest PID result;
- Laboratory result for PAH testing;
- Duplicate result(s);
- Relative percent difference for primary and duplicate result(s).

13.2.3 Railway Line Embankment

A railway line embankment was constructed during the remediation earthworks activities, extending from the southern end of the Eastern Drain through Area 1A and Area 2D. The railway line embankment was constructed of Level 1 material and generally comprised a raised embankment, although the eastern end of the railway line embankment was in cut.

Sampling was completed with one sampling location each 90 lineal metres on the section of the railway line embankment to the east of Area 1A and on the raised section of the railway line embankment in Area 2D, as shown in Figure 12.

Details of sample locations, including the easting, northing, chainage and depth of fill, were provided by Daracon. Samples were labelled from RL1 and included the depth of the sample in millimetres eg. RL1 – 200.

Sampling of the railway line embankment to the east of Area 1A was undertaken on 15 November 2007. Sampling of the railway line embankment to the east of Area 1A and in Area 2D was completed on 29 May 2008.

A summary of the completed sampling is presented in Table 11, including the number of samples per batch and the number of intra-laboratory duplicate samples and inter-laboratory duplicate samples collected per batch.

TABLE 11 – SUMMARY OF FILL SAMPLING OF RAIL LOOP

Date	Locations Sampled	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
15 Nov 2007	Railway line to the east of Area 1A	15	2	1	E035000/ ES0715959
29 May 2008	Railway line east of Area 1A and in Area 2D	7	1	1	E037898/ ES0807574
TOTALS		**22**	**3**	**2**	

Sampling locations completed on the railway line embankment are presented on Figure 12.

A Railway Line Embankment sample register was maintained by Coffey Environments for the duration of the remediation earthworks activities. The Railway Line sample register is presented in Appendix I and provides the following information:

- Sample name;
- Sample depth;
- Easting and northing;
- Chainage;
- Date sampled;
- Duplicate sample(s);
- Material type;
- Highest PID result;
- Laboratory result for PAH testing;

- Duplicate result(s);
- Relative percent difference for primary and duplicate result(s).

13.3 Field QA/QC

The sampling procedures followed during fill sampling are summarised in Table 7 in Section 13.1.

For sampling of the Landscape Mound and sampling of the railway line, sampling met the requirements of the C-Specification. This sampling was completed by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years experience.

For fill sampling of Area 1A, Area 1B and Area 2D, sampling generally met the requirements of the C-Specification. As indicated in 13.2.1 above, initial sampling completed when the earthworks were not at design level led to the collection of some samples at incorrect depths. Following identification of this error, a second and on occasion, third round of sampling was completed to collect fill samples within the requirements of the C-Specification. In some cases, the second and third rounds of sampling led to the collection of extra samples. Of the 377 samples collected, an extra 53 samples were collected that were either initially sampled at the wrong depth and then re-tested, or were not required. Of the 377 samples collected, 9 sampling locations (grid squares 20, 21, 40, 56, 70, 77, 121, 122, 131) were not collected within the requirements of the C-Specification. Cross sections of the fill sampling in Area 1A and Area 2D are included in Appendix K, showing the extra samples and sampling locations that were not completed in compliance with the C-Specification. With 97% of the sampling was completed within the requirements of the C-Specification, the fill sampling of Area 1A, Area 1B and Area 2D is considered to have been completed successfully.

This sampling was completed by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years experience, with the exception of one batch of fill sampling which was completed by Andrew Hills from Coffey Environments, an Environmental Scientist with 3 years experience.

A copy of the signed the applicable Chain of Custody form was included with each of the 20 primary batches and 18 inter-laboratory duplicate batches. The fill samples were analysed for PAH, in accordance with the SAQP (Ref: GEOTSGTE20150AD, dated 13 June 2007).

Intra-laboratory duplicate samples were collected at a rate of one duplicate sample per ten primary samples or one per batch. Inter-laboratory duplicate samples were collected at a rate of one duplicate sample per twenty primary samples.

Duplicate samples collected during fill sampling are summarised in Table 9. A total of 42 intra-laboratory duplicate samples and 19 inter-laboratory duplicate samples were collected for a total of 385 primary samples.

Duplicate samples collected during sampling of the Landscape Mound are summarised in Table 10, with two intra-laboratory duplicate samples and one inter-laboratory duplicate samples collected for 18 primary samples.

Duplicate samples collected during sampling of the railway line are summarised in Table 11, with 3 intra-laboratory duplicate samples and 2 inter-laboratory duplicate samples collected for 22 primary samples.

The duplicate samples were collected to assess whether the field sampling and laboratory procedures adequately reproduced results. Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pairs were less than 50%, with the exception of Lot 6, 5-100/ Dup 7/ Dup 7A and Lot 7, 13-200/ Dup 9.

RPDs for Lot 6, 5-100/ Dup 7/ Dup 7A and Lot 7, 13-200/ Dup 9 were greater than 50%. The high RPD results were considered to be due to the heterogeneity of the fill material and were not considered to affect the usability of the data.

The field Quality Assurance and Quality Control (QA/QC) results are generally acceptable.

13.4 Results

13.4.1 Laboratory QA/QC

Primary laboratory analysis was undertaken by Labmark, which is a NATA registered laboratory for the analysis undertaken. Secondary laboratory analysis was undertaken by ALS, which is a NATA registered laboratory for the analysis undertaken. Samples were received by Labmark and ALS within the recommended holding times and they were chilled when received.

Samples were collected in laboratory supplied glass jars and kept chilled in the field and during transit to the laboratory. The soil samples were dispatched to Labmark and ALS under chain of custody conditions on the dates listed in Tables 8, 9 and 10. Samples were received by the laboratory in good condition. Samples were extracted and analysed within the holding time for PAH of 14 days.

A NATA endorsed in-house laboratory method (E007.2) was used to analyse the soil samples for PAH and the NATA Seal was present on the laboratory reports.

A review of the laboratory internal quality assurance/quality control reports indicate that the appropriate laboratory quality assurance/quality control procedures were undertaken at an appropriate rate for contamination studies and that:

- Contaminant concentrations in the laboratory method blanks were below the laboratory detection limits. Method blanks were completed at a rate of 1 blank per 10 samples;
- Matrix spike recoveries were generally within control limits for organics (70% to 130%), aside from Laboratory Identification 97532s from Batch E032725. some matrix spike recoveries were below 50% due to matrix interference. Matrix spike samples were completed at a rate of 1 matrix spike sample per 10 samples;
- Spike recoveries for laboratory control samples were within control limits for organics (70% to 130%);
- RPDs for the laboratory duplicates were generally within control limits (0-50% for >10xEQL, 0-75% for 5-10xEQL and 0-100% for <5xEQL). RPDs of laboratory duplicates for Laboratory Identification 90540d and 90560d exceeded 50% in Batch E032147. Laboratory duplicate samples were completed at a rate of 1 duplicate sample per 10 samples;
- Surrogate recoveries were within the control limits for organics (70% to 130%). Two surrogate spike samples were analysed for PAHs.

The laboratory QA/QC results are generally acceptable.

13.4.2 Area 1A, Area 1B and Area 2D

Laboratory batch reports are presented in Appendix J. A summary of the laboratory results for Area 1A, Area 1B and Area 2D are presented in the Fill Sample Register in Appendix G.

The Fill Sample Register indicates that the majority of the laboratory results for total PAH were below the laboratory detection limit of 800mg/kg. Forty samples had a laboratory result greater than the laboratory detection limit for the individual PAH compounds of 50mg/kg. Of these 40 samples, five samples had a laboratory result for total PAH of greater than 2,000mg/kg, the threshold concentration for Level 1 material.

These five samples (Lot 1, 6-250; Lot 7, 3-200; Lot 7, 15-200; Area 1A, 1-100; Area 1A, 16-200) were considered to be non-conformances and are discussed further in Section 13.5. The location of these five samples are shown in Figure 13 and in the cross sections in Appendix K.

Based on the laboratory results and the materials tracking, the majority of fill material used in cut and fill in Area 1A, Area 1B and Area 2D was considered to comprise Level 1 material, aside from fill material at the five non-conformance locations.

The cross sections presented in Appendix K show that fill sampling in Area 1A, Area 1B and Area 2D was generally completed at the required rate, including one sample per 500mm of fill material and one sample at a depth of 200mm below design level in areas of cut.

13.4.3 Landscape Mound

Laboratory batch reports are presented in Appendix J. A summary of the laboratory results for the Landscape Mound are presented in the Landscape Mound Sample Register in Appendix H.

The Landscape Mound Sample Register indicates that one of the 18 samples had a laboratory result greater than the laboratory detection limit for individual PAH compounds of 50mg/kg. The laboratory result for LM14 was 190mg/kg.

Based on the laboratory results and the materials tracking, the Landscape Mound was considered to comprise Level 1 material.

13.4.4 Railway Line Embankment

Laboratory batch reports are presented in Appendix J on the attached CD. A summary of the laboratory results for the railway line are presented in the Railway Line Embankment Sample Register in Appendix I.

The Railway Line Embankment Sample Register indicates that none of the 22 samples had a laboratory result greater than the laboratory detection limit for individual PAH compounds of <50mg/kg.

Based on the laboratory results and the materials tracking, the railway line was considered to comprise Level 1 material.

13.5 Non-conformances in Area 1A

Fill sampling of Area 1A was completed between May 2007 and October 2007. Fill sampling of Area 1A was undertaken on a 40m by 40m grid, with fill samples generally collected as follows:

- One sample collected at a depth of 200mm below design level in areas of cut;
- One sample collected at 250mm below design level (or half the depth of fill if total fill depth is less than 250mm) and one additional sample each subsequent 500mm depth of fill in areas of fill.

Fill samples from Area 1A were analysed for PAH. Total PAH results below 2,000mg/kg indicated that the fill material classified as Level 1. Total PAH results exceeding 2,000mg/kg indicated that the fill material classified as Level 2 or Level 3, depending on the nature of the material.

Over 250 fill samples were collected from Area 1A and Area 2B between May 2007 and October 2007. Of the 256 fill samples, 251 fill samples had PAH concentrations of less than 2,000mg/kg. Based on the laboratory testing and fill classification, the majority of the fill material in Area 1A classified as Level 1.

Five fill samples had PAH concentrations exceeding 2,000mg/kg. These five sampling locations were considered to be non-conformances. The non-conformances were generally located in the “Low Area” near the former gas holders, the former Benzol Plant, the former Tar Plant and the former Sublimer House. A summary of the five non-conformances is presented in Table 12. The location of the five non-conformances is presented in Figure 13.

TABLE 12 – SUMMARY OF FIVE NON-CONFORMANCES IDENTIFIED FROM FILL SAMPLING IN AREA 1A

Grid Location	Sample ID	Total PAH (mg/kg)	Material Type	Classification	Remediation Completed
1	Lot 1 (2), 6-250	3,110	Fill material	Level 2	No
94	Lot 7, 3-200	7,540	Tar coated slag	Level 2	Yes
7	Lot 7, 15-200	4,350	Tar soaked fill	Level 2	Yes
11	Area 1A, 1-100	5,850	Tar soaked fill	Level 2	Yes
144	Area 1A, 16-200	3,360	Tar coated slag	Level 2	Yes

13.5.1 Remediation of Grid Square 1

Remediation was not completed on the non-conformance at grid square 1 at a depth of 250mm below the design level because analysis of an additional sample collected at a depth of 380mm below the design level reported a concentration of total PAH of 1,083mg/kg. The non-conformance was considered to be located within the top 300mm of fill material and the non-conformance was not visually distinguishable from surrounding fill material.

13.5.2 Remediation of Grid Square 94

Remediation completed around the non-conformance at grid square 94 included the excavation of tar coated slag over four days in July and August 2007, as outlined in Section 14.1. The tar coated slag was excavated during the installation of a stormwater drain to the east of Lot 7, 3 and during cutting of a high area to the west and north of Lot 7, 3 back to the design RL. It is noted that Level 2 material remained in the walls of the excavations completed around grid square 94, as discussed in Section 9.4 and Section 14.1. Photographs of this non-conformance are included in Appendix E.

13.5.3 Remediation of Grid Square 7

Remediation of the non-conformance at grid square 7 was undertaken on 15 August 2007. The hot spot was located at a depth of 200mm below the design level. The remedial excavation was intended to be 5m by 5m to a depth of 500mm. At the time of remedial works, the 300mm slag cap had been constructed in this area and the excavation was completed to a depth of 200mm below the design level. Additional excavation works were unable to be completed as the hot spot was located beneath the Koppers gantry. The non-conformance was not visually distinguishable from surrounding fill material and Level 2 material is likely to remain in-situ at this location. Photographs of the remediation works are included in Appendix E.

13.5.4 Remediation of Grid Square 11

Remediation of the non-conformance at grid square 11 was undertaken on 15 August 2007. The non-conformance was located at a depth of 100mm below the design level. The remedial excavation was intended to be 5m by 5m by 300mm. During the excavation works, Level 2 material was observed to comprise tar soaked fill that was visually distinguishable from surrounding fill material. The remedial excavation was extended to a depth of 1,000mm to remove the tar soaked fill material. One validation sample, Area 1A (2) 1-1000, was collected from the base of the excavation. The PAH concentration in the validation sample was 130mg/kg. Photographs of the remediation works are included in Appendix E.

13.5.5 Remediation of Grid Square 144

Remediation of the non-conformance at grid square 144 was completed on 14 September 2007 and included the excavation of an 8m by 8m area marked out around this location. The excavation was extended to a depth of 250mm, where a hard stand comprising coal tar coated slag was identified. The hard stand was removed and the excavation was extended to a depth of 500mm, where a dark layer with the appearance of coal fines was observed. The coal fines were considered to classify as Level 1 material and the excavation works ceased. Validation of the removal of the coal tar coated slag hard stand was completed visually. Photographs of the remediation works are included in Appendix E.

14 ENVIRONMENTAL SAMPLING OF LEVEL 2 MATERIAL AND LEVEL 3 MATERIAL

At a meeting with the Site Auditor on 26 June 2007, the Site Auditor indicated a concern with leaving Level 2 and Level 3 material in situ due to the potential for a build up of volatile compounds beneath the cap. To assess the potential for this to occur, sampling of Level 2 and Level 3 material remaining in situ was undertaken.

Level 2 material remained in situ at one location in Lot 7 in Area 1A, as shown in Figure 6. This material was sampled, as described in Section 14.1.

Level 3 material remained in situ at two locations, as shown in Figure 6. Level 3 material remaining in situ in the Western Drain excavation was sampled, as described in Section 14.2. Level 3 material remaining in situ in the low area was not sampled, as described in Section 14.3. The location of Level 3 material thought to be left in situ near the former Benzol Plant was excavated but no Level 3 material was identified, as discussed in Section 14.4.

Level 2 material and Level 3 material sampled was analysed for TPH, BTEX, PAH, Volatile Organic Compounds (VOC) and Semi-Volatile Organic Compounds (SVOC).

14.1 Level 2 Material in Lot 7

Level 2 material was identified in Lot 7 at grid square 94 on 4 June 2007 at the time of fill sampling. The Level 2 material was observed to comprise bituminous material and this classification was confirmed with the laboratory result of 7,540mg/kg for total PAH. The Level 2 material was identified at a depth of approximately 300mm below the earthworks design level. Photographs of this Level 2 material are presented in Appendix E.

Minor excavation works were completed by EPS and observed by Coffey Environments on 28 June 2007 to assess the extent of the Level 2 material around grid square 94. A shallow excavation, approximately 4m by 3m by 0.2m was completed and $8m^3$ of Level 2 material was relocated to the Level 2 Emplacement Area. The Level 2 material was observed to comprise tar coated gravels similar to bituminous material identified at chainage CH1200 offset north 90m on 16 May 2007. The Level 2 material was observed to extend to the north and west of the excavation. Additional excavation works was not completed at this time due to machinery availability.

Additional excavation works were completed by EPS on 13 July 2007. The initial excavation was extended to approximately 6m by 6m by 0.5m deep. The base of the excavation was observed to comprise clayey gravelly sand fill. One truckload of Level 2 material was relocated to the Level 2 Emplacement Area and remaining excavation spoil was stockpiled near the excavation. Photographs of this excavation works are presented in Appendix E.

Excavation works were continued on 17 July 2007 by EPS and observed by Coffey Environments. The stockpiled bituminous material was observed to contain small quantities of coal tar pitch, which had been heated by the sun and become viscous over the intervening days. At the time of the excavation works, the coal tar pitch was in a solid state. Level 2 bituminous material and coal tar pitch was observed in the northern and western walls of the excavation and the excavation was extended to the north and the west. Photographs of this excavation works are presented in Appendix E.

A high area that required cutting back to design level to the west of the excavation was identified by Daracon resulting in excavation of additional Level 2 material from this area. The excavation was extended approximately 30m to the west to cut Level 2 material back to the earthworks design level on 19 July 2007. The extended excavation was approximately 5m wide by 0.3m deep. The majority of the material cut from this extended excavation was observed to comprise Level 2 bituminous material. At the completion of the cut, Level 2 material was not observed in the southern and western walls of the excavation. A total of 117m^3 of Level 2 material was relocated to the Level 2 Emplacement Area on 20 July 2007. The location of the Level 2 material excavated from Lot 7 is shown in Figure 6. Photographs of this excavation works are presented in Appendix E.

The extent of the Level 2 material to the north of grid square 94 and the extended excavation has not been assessed. Level 2 bituminous material and coal tar pitch was observed at a depth of approximately 300mm within the open drain excavation to the north of the former Benzol Plant (refer to Section 5.2).

One sample of the coal tar pitch (Level 2, Lot 7) was collected by Coffey Environments on 17 June 2007. The coal tar pitch was analysed by Labmark for TPH, BTEX, PAH, VOC and SVOC. The laboratory results indicate the coal tar pitch contains high concentrations of TPH (100,300mg/kg), total PAH (41,920mg/kg) including naphthalene (41,00mg/kg - volatile) and semi-volatile organic compounds, including dibenzofuran (2,310mg/kg), carbazole (1,190mg/kg), 2-methylnaphthalene (1,120mg/kg), phenol (24.3mg/kg), 2-methylphenol (18.4mg/kg), 3-, 4- methylphenol (36mg/kg) and 2,4 dimethylphenol (26.5mg/kg).

14.2 Level 3 Material in the Western Drain

A large volume of Level 3 material was identified during the excavation of the Western Drain between the 10 and 13 July 2007. The Level 3 material was observed to comprise tar impacted dark grey gravelly sand fill with a hydrocarbon sheen. The fill material was classified as Level 3 due to a strong naphthalene and petroleum hydrocarbon odour (Truck Dockets 0101 to 0215).

The Level 3 material was observed to be contained within an area surrounded by sand fill, possibly in a purpose built burial compartment. The sand fill was not observed at the base of the Level 3 material, which was underlain by estuarine clays. A concrete stormwater pipe was located at the base of the Level 3 material and there was evidence of tar in stormwater pipe. Photographs of the Level 3 material are presented in Appendix E.

Within the Western Drain excavation, the Level 3 material extended to a depth of approximately 1.2m. Level 3 material and underlying estuarine clays were excavated to a depth of 1.5m. The northern and southern boundaries of the Level 3 material were observed to be confined by the location of sand, which appears to have been placed as a containment layer around the Level 3 material.

The Level 3 material was observed to extend from the eastern edge of the Western Drain excavation east approximately 35m. Level 3 material to the east of the Western Drain excavation was excavated to a depth of 1.5m below the earthworks design level, as directed by GPS. Level 3 material at a depth of greater than 1.5m below the earthworks design level was left in-situ and surveyed. Three test pits, one to the east, one to north and one to the south of the main excavation, were excavated to assess that Level 3 material had been excavated to the required depth.

A total of 1,619m^3 of Level 3 material was excavated between 10 July and 13 July 2007 and relocated to the Level 3 Emplacement Area. The location of the Level 3 material excavated from the Western Drain is shown in Figure 6.

Level 3 material remains in situ at a depth of at least 1.5m below the earthworks design level at the location shown in Figure 6. One sample of the Level 3 material from the western drain (Level 3 CH190) was collected by EPS on the 10 July 2007. This sample was analysed by Labmark for TPH, BTEX, PAH, VOC and SVOC. The laboratory results indicate the Level 3 material contains high concentrations of total PAH (4,440mg/kg) including naphthalene (1,180mg/kg, volatile), volatile organic compounds including benzene (50mg/kg), toluene (9mg/kg) and xylene (28mg/kg) and semi-volatile organic compounds including dibenzofuran (323mg/kg) and carbazole (120mg/kg).

14.3 Level 3 Material in the Low Area

EPS indicated that Level 3 material (tar) may have been left in-situ at a depth of about 2m below the earthworks design level within a drain excavation to the north of the former Benzol Plant in an identified Low Area (Truck Docket 0097). The location of the drain excavation was surveyed on 4 June 2007, at the time of excavation of Level 3 material from this location.

The drain excavation was located on 17 July 2007 and the excavation was observed to remain open. Level 3 material was not observed at the base of the excavation and consequently no soil samples were collected.

A new stormwater drain was constructed at the base of this excavation in late July and August 2007. An additional 618m^3 of Level 3 material (tar soaked fill) was transported to the Level 3 Emplacement Area during the drain construction (Truck Dockets 0240-0245, 0247, 0253, 0260-0292). The Level 3 material was over-excavated from the stormwater drain excavation to allow backfilling of the excavation with imported sand fill to provide a buffer between the Level 3 material and contractors working within the excavation. Photographs of this excavation works are presented in Appendix E.

Level 3 material remaining in the walls and base of the stormwater drain excavation was not sampled as the material was observed to be the same type of contamination (tar soaked fill) as the Level 3 material from the Western Drain excavation that was sampled. Level 3 material remaining in the walls and base of the stormwater drain excavation was surveyed and documented for future site users in accordance with Addendum No 04.

14.4 Level 3 Material near the Former Benzol Plant

Section 3.9 of the June 2007 Monthly Report stated that an unknown volume of tar was left in situ at a depth of 1.5m below the design level in a concrete lined tar pit located near the former Benzol Plant. The location of the concrete lined pit was surveyed by Daracon.

The location of the concrete lined tar pit was marked out on 17 July 2007 and a test pit was completed at this location to sample the remaining Level 3 material. The test pit was excavated to a depth of about 1.5m. The concrete lined tar pit was observed to have been backfilled generally with oversize material, including concrete blocks, bricks and metal reinforcing. The eastern wall of the concrete lined pit was observed in the eastern wall of the test pit at a depth of approximately 0.5m. Groundwater was observed in the test pit at a depth of approximately 0.8m. There was no sheen on the surface of the groundwater and there was no odour from the groundwater or the material excavated below the groundwater. At a depth of approximately 1.5m, the test pit was terminated on the suspected concrete base of the concrete lined pit. No Level 3 material was observed within the test pit and soil samples were not collected. Photographs of this excavation works are presented in Appendix E.

Approximately $70m^3$ of Level 3 material was excavated from the concrete lined tar pit on 25 and 26 May 2007. EPS indicated that the base of the concrete lined tar pit was not identified during the excavation works. Based on the observations made during the test pitting completed on 17 July 2007, it was considered that the base of the concrete lined pit is located at a depth of approximately 1.5m below the earthworks design level and that Level 3 material is unlikely to remain in-situ at this location.

15 HOT SPOT REMEDIATION

Excavation works were completed by EPS at the request of GPS at five hot spots identified across the Closure Area during previous investigations. The hot spots were locations where previous sampling had reported PAH results in excess of 5,000mg/kg.

The purpose of the hot spot remediation was to excavate Level 2 material (if visually classified) and relocate that material to the Level 2 Emplacement Area. The remediation of hot spots was completed for the purpose of providing information to future site users. Three reports outlining the hot spot remediation works were completed by EPS and a copy of the reports is provided in Appendix L.

Hot spot remediation was undertaken over three days: 5 and 14 June 2007 and 24 July 2007. The hot spot locations were marked out using survey information from the previous investigation. Excavation of the hot spot locations was completed with a 30 tonne excavator and excavation works were generally terminated at groundwater.

The locations of Hot Spot 1, Hot Spot 2 and Hot Spot 3 were excavated on 5 June 2007 and the location of Hot Spot 4 was excavated on 14 June 2007. Refusal at 0.5m occurred at Hot Spot 1and at 0.25m at Hot Spot 3 on self-cementing slag. Excavation works were completed to the north of the surveyed locations for Hot Spot 1 and Hot Spot 3. Level 2 material was identified between 0.7m and 0.9m at Hot Spot 3 and $4m^3$ of Level 2 material was relocated to the Level 2 Emplacement Area. Level 2 material was not identified in Hot Spots 1, 2 or 4.

Hot Spot 5 was located in the car park of the former BHP Steelworks near the security gate house. The location of Hot Spot 5 was excavated on 24 July 2007 and included the excavation of five test pits within the car park. The test pits were excavated to depths ranging between 1.7m and 2.4m. The subsurface conditions were similar across the car park and included bitumen underlain by slag fill (sub grade) to a maximum depth of 0.6m. The sub grade layer was underlain by tar coated slag (Level 2 material) in Test Pit 5 and black greasy fill (Level 2 material) in Test Pit 2. The sub grade layer was underlain by Level 1 fill material (sand and clay) in Test Pit 2 and Test Pit 4. Gravelly clay fill material with tar and a strong hydrocarbon odour (Level 3 material) was found in Test Pit 2 from 0.6m to 2.1m (limit of excavation). Level 1 fill material in Test Pit 3, Test Pit 4, Test Pit 5 and the bitumen in Test Pit 1 was underlain by estuarine sands and clays. No Level 2 or 3 was removed from Hot Spot 5 as it was beyond the scope of the contract.

The location of the five hot spots is outlined in Figure 14. Hot spot remediation works are summarised in Table 13.

TABLE 13 – SUMMARY OF HOT SPOT REMEDIATION WORKS

Hot Spot Number	Previous Identification	Depth	Material Identified	Truck Docket/ Volume
Hot Spot 1	Test No. 2D-3	0.75m	Level 1 only	-
Hot Spot 2	Test Pit SAA5-39	1.2m	Level 1 only	-
Hot Spot 3	Test Pit 2B-6	0.9m	Level 2 (tar coated gravel) at 0.7m	0098, 4m^3
Hot Spot 4	Test No. SAA4-61	0.6m	Level 1 only	-
Hot Spot 5	Car Park	2.4m	Level 2 material, Level 3 material	-

16 PAVEMENT CAP

16.1 Design of Pavement Cap

The pavement cap on the northern side of the railway line embankment in Area 1A consists of:

- 300mm thick subgrade replacement layer;
- 100mm thick crushed concrete layer;
- High-performance two coat bitumen seal.

The 300mm thick subgrade replacement layer will comprise slag won from the site, generally from slag stockpiles in Area 2D. The slag was placed in two 150mm thick layers.

16.2 Slag won from the Site

The 300mm thick subgrade replacement layer generally comprised slag won from the site.

Slag for the pavement cap in Area 1A was won from the following locations:

- Windrows in Area 2D; and
- A ‘slag mine’ covering grid squares 145 to 147 (fill grid) in Area 1A.

Slag for the pavement cap in Area 1B was won from the following locations:

- Within Area 1B;
- A ‘slag retrieval area’ near the Area 2D Stockpile; and
- A slag mine near the Innova Plant in Area 2D.

The slag was placed in two 150mm thick layers.

16.3 Environmental Sampling of Slag

16.3.1 Environmental Sampling

As outlined in Section C3.4.8 of the C-Specification, sampling of the slag used in the pavement cap was undertaken at a frequency of 1 sample per 1,000m^2. Based on the volume of slag to be used as a capping material, EPS indicated that sampling of the slag would be completed on a 33m by 33m grid, which would provide a sampling rate of 1 sample per 1,000m^2.

Daracon established the 33m by 33m grid including the easting and northing of the centre of each grid square, with samples collected from the centre of each grid square.

The slag capping material was placed in two 150mm thick layers across the northern area of Area 1A and across Area 1B.

Sampling of the slag in Area 1A was generally completed from the top of the first layer. In Area 1B, sampling of the slag was generally completed from the top of the second layer.

Slag samples were labelled using the grid square number established by Daracon eg. S146.

A slag sample register was maintained by Coffey Environments for the duration of the remediation earthworks activities. The slag sample register is presented in Appendix M and provides the following information:

- Sample name;
- Sample depth;
- Easting and northing;
- Date sampled;
- Duplicate sample(s);
- Material type;
- Highest PID result;
- Laboratory result for PAH testing;
- Duplicate result(s);
- Relative percent difference for primary and duplicate result(s).

The slag sampling completed in Area 1A and Area 1B between June 2007 and March 2008 are summarised in Table 14.

Slag sampling locations are presented in Figure 15.

TABLE 14 – SUMMARY OF SLAG SAMPLING COMPLETED SINCE JUNE 2007

Date	Lots Sampled	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
28 June 2007	Trial Lot	1	0	0	E032725
25 July 2007	Lot 2 Slag	16	1	0	E033199
8 August 2007	Lot 4 Slag	9	1	1	E033451/ ES0710862
13 August 2007	Lot 5 Slag, Lot 6 Slag	20	2	1	E033524/ ES0711126
15 August 2007	Lot 3 Slag, Lot 6 Slag	11	1	0	E033571
24 August 2007	Lot 7 Slag, Lot 10 Slag	16	2	1	E033710/ ES0711841

Date	Lots Sampled	No. of Samples per Batch	No. of Intra-lab Duplicates	No. of Inter-lab Duplicates	Labmark Batch No./ ALS Batch No.
29 August 2007	Lot 9 Slag	16	2	1	E033779/ ES0711996
13 Sept 2007	Lot 11 Slag	31	3	2	E034003/ ES0712804
20 Sept 2007	Lot 10 Slag	2	0	0	E034143
27 Sept 2007	Remaining slag lot Area 1A	33	3	2	E034229/ ES0713446
11 Oct 2007	Remaining slag lot Area 1A	4	1	1	E034469/ ES0714208
19 March 2008	Area 1B	27	3	2	E036837/ ES0803872
TOTALS		**186**	**19**	**11**	

16.3.2 Sampling Procedures

The procedures for sampling the slag cap are outlined in the Sampling, Analysis and Quality Plan (SAQP).

Slag samples were collected using the procedures outlined in the SAQP. Table 15 outlines the sampling procedures that were followed during the slag sampling. Table 15 indicates that general field quality assurance/ quality control (QA/QC) was undertaken in accordance with the SAQP and is acceptable.

TABLE 15 – SAMPLING PROCEDURES FOLLOWED DURING SLAG SAMPLING

Procedure	Followed/ Comment
Sampling was completed with the aid of a backhoe.	Followed
Soil samples were collected directly from the base of the test pit or from the centre of the backhoe bucket using dedicated disposable gloves.	Followed
Soil samples were sub-divided into two sub-samples. One sub-sample was collected into laboratory-supplied acid-rinsed glass jars. The other sub-sample was collected in a plastic bag for headspace screening.	Followed
PID head space screening was completed on sub-samples.	Followed
Intra-laboratory and inter-laboratory duplicate samples were collected at a rate of 1 per 10 samples and 1 per 20 samples respectively or 1 per batch.	Followed
Soil samples were stored in a cooler box filled with ice during sampling and transportation to the laboratory.	Followed
Soil samples were transported under Chain of Custody conditions.	Followed
Soil samples with PID readings greater than 100ppm were analysed for TPH/ BTEX.	Followed
Wash blanks, trip blanks and trip spikes were not required.	Confirmed
Primary samples analysed by Labmark and inter-laboratory duplicate samples were analysed by ALS, both NATA accredited for PAH analysis. Surface water samples were analysed by ALS, who are NATA accredited for the analysis undertaken.	Followed
Soil samples were received within holding times and were chilled on arrival at the laboratory.	Followed
Samples were extracted and analysed within the holding times for PAH.	Followed
Slag sample register were maintained and up-dated by Coffey Environments.	Followed

16.3.3 Field QA/QC

The sampling procedures followed during slag sampling are summarised in Table 15 in Section 16.3.2.

For slag sampling, critical locations were sampled according to the requirements of the C-Specification including sampling of slag material on a 33m by 33m grid at a rate of 1 sample per 1,000m^2.

Slag sampling was completed by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years experience, except for one batch of slag sampling was completed by Andrew Hills from Coffey Environments, an Environmental Scientist with 3 years experience.

A copy of the signed Chain of Custody form was included with each of the 12 primary batches and 8 inter-laboratory duplicate batches. The fill samples were analysed for PAH, in accordance with the SAQP (Ref: GEOTSGTE20150AD, dated 13 June 2007).

Intra-laboratory duplicate samples were collected at a rate of one duplicate sample per ten primary samples or one per batch. Inter-laboratory duplicate samples were collected at a rate of one duplicate sample per twenty primary samples.

Duplicate samples collected during slag sampling are summarised in Table 13. A total of 19 intra-laboratory duplicate samples and 11 inter-laboratory duplicate samples were collected for a total of 186 primary samples.

The duplicate samples were collected to assess whether the field sampling and laboratory procedures adequately reproduced results. Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pairs were less than 50%, with the exception of S81/ Dup H/ Dup H1 and S143/ Dup O/ Dup O1.

RPDs for S81/ Dup H/ Dup H1 and S143/ Dup O/ Dup O1 were greater than 50%. The high RPD results were considered to be due to the heterogeneity of the slag material and were not considered to affect the usability of the data.

The field Quality Assurance and Quality Control (QA/QC) results are generally acceptable.

16.3.4 Laboratory QA/QC

Primary laboratory analysis was undertaken by Labmark, which is a NATA registered laboratory for the analysis undertaken. Secondary laboratory analysis was undertaken by ALS, which is a NATA registered laboratory for the analysis undertaken. Samples were received by Labmark and ALS within the recommended holding times and they were chilled when received.

Samples were collected in laboratory supplied glass jars and kept chilled in the field and during transit to the laboratory. The soil samples were dispatched to Labmark and ALS under chain of custody conditions on the dates outlined in Tables 8, 9 and 10. Samples were received by the laboratory in good condition. Samples were extracted and analysed within the holding time for PAH of 14 days.

A NATA endorsed in-house laboratory method (E007.2) was used to analyse the soil samples for PAH and the NATA Seal was present on the laboratory reports.

A review of the laboratory internal quality assurance/quality control reports indicate that the appropriate laboratory quality assurance/quality control procedures were undertaken at an appropriate rate for contamination studies and that:

- Contaminant concentrations in the laboratory method blanks were below the laboratory detection limits. Method blanks were completed at a rate of 1 blank per 10 samples;
- Matrix spike recoveries were generally within control limits for organics (70% to 130%), aside from Laboratory Identification 97532s from Batch E032725. some matrix spike recoveries were below 50% due to matrix interference. Matrix spike samples were completed at a rate of 1 matrix spike sample per 10 samples;

- Spike recoveries for laboratory control samples were within control limits for organics (70% to 130%);
- RPDs for the laboratory duplicates were generally within control limits (0-50% for >10xEQL, 0-75% for 5-10xEQL and 0-100% for <5xEQL). Laboratory duplicate samples were completed at a rate of 1 duplicate sample per 10 samples;
- Surrogate recoveries were within the control limits for organics (70% to 130%). Two surrogate spike samples were analysed for PAHs.

The laboratory QA/QC results are generally acceptable.

16.3.5 Results

Laboratory reports for sampling of the slag are presented in Appendix J. A summary of the laboratory results is presented in the slag sample register in Appendix M.

Laboratory testing for PAHs was completed for 186 samples of slag used in the pavement cap. Of the 186 samples, 14 results were greater than the laboratory detection limit for individual PAH compounds of 50mg/kg. Of these 14 results, 13 results were below the guideline of 2,000mg/kg for Level 1 PAH.

The laboratory result for location S143 was greater than 2,000mg/kg and this result was considered to be a non-conformance. The non-conformance is discussed in Section 16.3.6.

Based on the laboratory results and the materials tracking, the slag used in the pavement cap is considered to have PAH concentrations below 2,000mg/kg.

16.3.6 Non-conformances

One non-conformance was identified during environmental sampling of the slag material used in the pavement cap, as shown in Figure 14.

The laboratory result from the slag sampling for S143 was 3,140mg/kg, which exceeded the guideline of 2,000mg/kg for Level 1 PAH. This sample was collected from the second (top) 150mm layer of slag.

Remediation work was completed on 4 October 2007. An 8m by 8m area was marked out around this location and 300mm of slag was excavated and transported to the Level 3 Emplacement Area.

16.4 Crushed Concrete

16.4.1 Area 1A

The pavement cap in Area 1A included the placement of 100mm of crushed concrete over the 300mm subgrade replacement layer. Stockpiles of concrete that were crushed prior to the start of the remediation earthworks activities were used for the crushed concrete layer in Area 1A.

A shortfall in crushed concrete was made up through the importation of 20mm dense grade sub base (DGS20) from Hunter Quarries Pty Ltd’s Karuah Quarry, as described in Section 16.5.

16.4.2 Area 1B

The pavement cap in Area 1B included the placement of 100mm of crushed concrete over the 300mm subgrade replacement layer. The crushed concrete for the pavement cap in Area 1B was sourced from concrete on site. The concrete was crushed in early April 2008 and was placed over the slag cap in Area 1B on in late April and early May 2008.

The volume of crushed concrete stockpiled for placement in Area 1B on 29 April 2008 was 8,876m^3. The volume of crushed concrete used to construct the 100mm concrete layer was 5,270m^3. The remaining 3,606m^3 of crushed concrete was stockpiled in Area 2A for future use.

The crushed concrete used in the pavement cap in Area 1B was sampled on a rate of 1 sample per 1,000m^3 for quality assurance as the crushed concrete was dark brown in colour. Six samples of the crushed concrete were collected on 29 May 2008 and analysed for PAH at Labmark. Sampling locations for the six samples are presented on Figure 16. The laboratory report is presented in Appendix J. The laboratory results for the six samples were below the laboratory detection limit of 50mg/kg.

16.5 Importation of DGS20

Daracon imported about 11,000 tonnes of 20mm dense grade sub base (DGS20) from Hunter Quarries Pty Ltd’s Karuah Quarry due to a shortfall in crushed concrete available on site for remediation earthworks activities during December 2007. The DGS20 was used as a replacement for the crushed concrete in the construction of the pavement cap in Area 1A.

A letter from Coffey Environments regarding the suitability of the DGS20 with respect to contamination and a letter from Coffey Geotechnics regarding the geotechnical suitability of the DGS20, are attached in Appendix N.

The DGS20 product imported in December 2007 was not sampled before, or at the time of importing the material, as the material is a blasted (hard rock) quarry product. A Coffey Geotechnics technician was on site during the importation of this material and visually inspected each load during placement. Observations made during the placement of each load indicated that no anthropogenic material was included in the DGS20.

An additional 160 tonnes of DGS20 was imported to site in February 2008 as a replacement for slag beneath the Koppers Gantry in Area 1B. One grab sample of the DGS20 (sample name DGS20) was collected from the placed material beneath the Koppers Gantry on 13 February 2008. To assess the suitability of the DGS20 for use on the site, the sample was analysed for heavy metals, TPH, BTEX and PAH. Photographs of the DGS20 are included in Appendix E.

The laboratory results for the DGS20 sample indicate:

- Concentrations of TPH, BTEX and PAH were below the laboratory detection limits;
- Concentrations of heavy metals were considered representative of natural background concentrations.

A copy of the laboratory report is presented in Appendix N.

The results of chemical analysis confirmed no contamination of the DGS20 material and classification of the material as Virgin Excavated Natural Material (VENM) is considered appropriate.

16.6 Two-Coat Bitumen Seal

A high performance two-coat bitumen seal was applied to the pavement cap in Area 1A.

In Area 1B, the high performance two-coat bitumen seal was applied to a 5m wide section immediately north of the Koppers Gantry to provide an access route over Area 1B. The two-coat bitumen seal covers an area of 10,500m^2 out of a total 45,460m^2 in Area 1B. The two-coat seal was not applied to the remainder of the pavement cap in Area 1B as this area is to be used by BHP for future site works.

The extent of the two-coat bitumen seal in Area 1B is shown in Figure 17. Photographs of the completed pavement cap are presented in Appendix E.

16.7 Thickness of the Cap

The pavement cap comprised a 300mm thick subgrade replacement layer and a 100mm thick crushed concrete layer. The survey plan and accompanying spreadsheet in Appendix O show the thickness of the subgrade replacement layer varies between 255mm and 354mm.

The survey plan and accompanying spreadsheet in Appendix O show the thickness of the crushed concrete layer varies between 74mm and 135mm.

Based on the survey plans and the observations made during the placement of the pavement cap, it is considered that the pavement cap meets the requirements for thickness under the C-Specification.

16.8 Ponding of Water over Crushed Concrete Layer

Section C9.5 of the C-specification requires that the crushed concrete layer in the pavement cap in Area 1A is to be trimmed and graded so that ponding on the surface does not exceed 5mm in any location and ponding shall not exceed a surface area of greater than 25m^2.

As indicated in Section 16.7, the thickness of the crushed concrete layer varies between 74mm and 135mm. The crushed concrete layer was constructed within a tolerance of ±26 to 35mm. As the crushed concrete layer was constructed within this tolerance, there should be no areas of ponded water greater than 25m^2 and no exceedence of 5mm depth of any ponded water based on the design. A plan showing the surface contours of Area 1A and Area 1B following the construction of the pavement cap is presented in Figure 18.

Observations of ponded water on the pavement cap made following a rainfall event of 72mm on 3 and 4 June 2008 indicated that the pavement cap was draining as per the design, with no areas of ponded water greater than 25m^2 and no exceedence of 5mm depth of any ponded water observed on 5 June 2008. Photographs of ponding on the pavement cap in Area 1A are included in Appendix E.

16.9 Pavement Cap Reports

The following reports on the pavement cap were completed by Coffey Geotechnics Pty Ltd:

- Report on Trial Section of Pavement Cap (Ref: GEOTSGTE20150AE-AD, dated 1 August 2007);
- Validation Report on Pavement Cap (Ref: GEOTSGTE20150AE-AH, dated 10 March 2008);
- Validation Report on Pavement Cap – Area 1B (GEOTSGTE20150AE-AI, dated 10 April 2008).

A copy of these reports is included in Appendix P. The Validation Report on Pavement Cap includes permeameter testing of the bituminous seal of the pavement cap, which was completed by Coffey Geotechncis using the Northern Territory Government Test Method NTTM 702.1. The Validation Report on Pavement Cap indicates that the pavement cap has a permeability less than 10^{-9}m/s.

17 VENM CAP

17.1 Importation of VENM

The material for the VENM cap was sourced from Daracon Quarries Pty Ltd at Buttai and comprised overburden material consisting of weathered siltstone/ claystone or shale.

VENM was imported to site in late July and early August 2007 for the VENM trial cap. Following the successful completion of the VENM trial cap, VENM was imported to site in September, October and early November 2007 for the construction of the VENM cap.

Daracon maintained an Imported VENM Material spreadsheet, which included the following information on a daily basis:

- The fleet number of the trucks;
- The docket numbers;
- Tonnage;
- Number of cycles;
- Total loads;
- Daily total tonnage.

A copy of the Imported VENM Material spreadsheet is included in Appendix Q.

Each load of VENM imported to site was visually assessed by a Coffey Geotechnics technician using the following criteria:

- Is the material consistent with that approved? (sandy gravel, clay);
- No concrete, wood or metal in soil?
- No material from a source other than Buttai Quarry?
- Inspection of the material in the truck ok?

Truck dockets were checked by the Coffey Geotechnics technician and truck registration numbers were also recorded. Copies of the Imported Materials Daily Quality Reports are included in Appendix P.

Geotechnical testing of the VENM from Buttai Quarry was undertaken by Coffey Geotechnics Pty Ltd at their Warabrook laboratory. Geotechnical testing included grading, plasticity index, permeability testing and SPOCAS. Following placement of the VENM, in situ geotechnical testing was undertaken, including compaction, field densities and permeability testing. Information regarding the testing of the VENM cap is included in the Report on VENM Cap in Appendix Q.

A summary of the VENM imported from Buttai Quarry is outlined in Table 16, including tonnes imported and visual assessment.

TABLE 16 – SUMMARY OF IMPORTED VENM FROM BUTTAI QUARRY

Area	Dates	Tonnes	Visual Check	Comments
Trial Cap	27 July 2007	1000	Passed	Tonnage not included in total
VENM Cap	30 August to 28 September 2007	35,473.25	Passed	6 loads were rejected from use in the VENM cap but not rejected from site
VENM Cap	3 to 30 October 2007	44,074.12	Passed	
VENM Cap	1 to 13 November 2007	9,922.59	Passed	
	TOTAL	**89,469.96**		Excludes 1000 tonnes Trial Cap

17.2 Thickness of the VENM Cap

The VENM cap had a design thickness of 500mm. The survey plan and accompanying spreadsheet in Appendix R shows that the placed thickness of the VENM cap varies between 478mm and 553mm.

Based on the survey plan and the observations made during the placement of the VENM cap, it is considered that the VENM cap meets the requirements for thickness under the C-Specification.

17.3 VENM Cap Reports

The following reports on the VENM cap were completed by Coffey Geotechnics Pty Ltd:

- Report on VENM Trial Cap (Ref: GEOTSGTE20150AE-AE, dated 20 August 2007);
- Report on VENM Cap (Ref: GEOTSGTE20150AE-AG, dated 21 February 2008).

A copy of these reports is included in Appendix S. The Report on VENM Cap includes permeability testing of the VENM cap, which was completed by Australian Geomechanical Laboratories on behalf of Coffey Geotechnics. Permeability testing was completed as falling head tests (Test Method AS1289 6.7.2 KH2) and the reports were NATA certified. The Report on the VENM Cap indicates that the VENM cap has a permeability less than or equal to 10^{-9}m/s.

18 IMPORTED MATERIAL

18.1 Honeysuckle Drive

Fill material was imported to site from the Lee Wharf Stage 3 site on Honeysuckle Drive, Newcastle. Approximately 2000 tonnes of sand fill material was imported to site on 3 and 4 July 2007.

Coffey Environments has completed two waste classification assessments of the fill material from Lee Wharf Stage 3 (Ref: N08459/12-AC, dated 31 October 2005 and N08459/12-AG, dated 15 March 2007). Three of the four units of fill material within the basement excavation at Lee Wharf Stage 3 classify as inert waste. Coffey Environments provided Robson Civil, the Lee Wharf contractor, with a letter indicating that the inert waste fill material from the basement excavation at Lee Wharf Stage 3 is suitable for re-use on a commercial/ industrial site such as the former BHP Steelworks site (Ref: GEOTSGTE20314AA-AB, dated 20 June 2007).

A Coffey Environments Scientist was present at the time of the excavation of the inert waste from Lee Wharf Stage 3 and tracked the inert waste on the EPS ITR_04, Off Site Materials Tracking. A copy of the ITRs is presented in Appendix S. Photographs of this material are included in Appendix E.

The imported sand fill was used as bedding sand in disused services trenches on site.

18.2 Belmont Bowling Club

Fill material was imported to site from the Belmont Bowling Club re-development, off Singleton Street, Belmont. Approximately 500m^3 of silty sand topsoil was imported to site on 25 July 2007.

A waste classification letter was provided by Coffey Environments to Woodbury's Haulage and Earthmoving (Ref: ENVIWARA00108AA F01, dated 24 July 2007) indicating that surficial fill and demolition waste was to be removed to an appropriately licensed landfill and that based on Coffey Environments' experience, it was considered that the excavated natural material beneath the surficial fill material would classify as Virgin Excavated Natural Material (VENM) in accordance with NSW DEC (2004) *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes*.

Observation of the topsoil material imported to site indicates it would not classify as VENM due to minor inclusions of bricks and concrete. A waste classification was completed by Coffey Environments for the 500m^3 of material imported from Belmont Bowling Club (Ref: ENVIWARA20150AD-AM, dated 2 November 2007). The assessment indicated that the material imported from Belmont Bowling Club classified as inert waste. Photographs of this material are included in Appendix E.

A copy of the Waste Classification assessment is presented in Appendix U.

The imported fill was used as bedding sand in disused services trenches on site.

19 WESTERN DRAIN

19.1 Excavation and Construction

The Western Drain excavation began in July 2007 and was completed in December 2007. Photographs of the Western Drain excavation and construction are included in Appendix E.

Material excavated from the Western Drain excavation included Level 1, Level 2 and Level 3 material and PASS material. Materials tracking of Level 1, Level 2 and Level 3 material is described in Sections 7, 8 and 9. Treatment of PASS material is described in Section 21.

Following the excavation of material from the Western Drain, a lined open channel drain was constructed from chainage CH0 to CH475. A box culvert drain was constructed from precast concrete elements from chainage CH0 to CH220 near the Hunter River. For the latter box culvert construction, chainage CH0 commenced at chainage CH475 for the open channel drain and generally continued northwards.

The section of the Western Drain completed as a lined open channel drain was lined with a 2mm thick HDPE liner provided by Curtis Barrier. To prevent puncturing of the liner during placement, the base and sides of the excavation to RL1 were lined with a product called Curtis RN380. Curtis RN380 was also used on the side walls to prevent rocks from puncturing through the liner from above. At the major headwalls at the ends of the open drain and at small headwalls along the drain, terminations in the concrete were sealed with a product called Elock, which is a HPDE material cast within the concrete. The 2mm thick HDPE liner was then welded to the Elock to provide a barrier between the open channel and the surrounding soil and groundwater.

The joints between the pre-cast concrete box culverts were sealed by external tape wrapping of the joint to prevent ingress of dirt using either Conwrap or Skiaproof 150 as available. A 30mm backing rod was then installed from inside the box culvert and pushed into the joint followed by a round, swellable joint product called Hydrotyte, a hydraulic water stop. Where the backing rod touches the concrete, it was sealed with a product called Leakmaster. Following this, another 30mm backing rod was squeezed into the joint. At the joints on the base of the box culverts, a sealant product called Sikaprimer 3 was used followed by another product called Sikaflex Tank. A product called Sikaflex Pro was used as a sealant on the top of the joints. The bottom of the concrete box culverts had an 80mm diameter hole where they sat on top of the timber piles. A pin was driven into the top of the timber pile to locate the box culvert and then the 80mm hole was filled with a water displacing grout called Sikadur.

A copy of the Curtis Barrier report on the drain construction is included in Appendix V.

19.2 Dewatering

Dewatering of the Western Drain excavation began on 3 August 2007 and was concluded on 15 April 2008 following the completion of the box culvert drain. The dewatering outlet comprised three ponds constructed from coal washery reject material located near the Landscape Mound. Water discharged to the ponds either returned to the local shallow groundwater, or was lost as evaporation, or a combination of both.

19.2.1 Daily Monitoring

EPS maintained dewatering records for the Western Drain, including daily monitoring of pH, visual appearance and odour.

Daily monitoring records for 3 August 2007 to 31 August 2007 is included in the Materials Tracking information for August 2007 in Appendix C. Daily monitoring records for September 2007 to 15 May 2008 are presented in Appendix W. It is noted that daily monitoring was not completed between 6 March 2008 and 31 March 2008. A summary of the daily monitoring records is included in Appendix W. Twice weekly monitoring was completed from 31 March 2008 to 15 May 2008.

The daily monitoring records indicate that the pH of the dewatering dropped over the 9 month period from pH 8.1 to pH 6.6.

19.2.2 Water Sampling

Dewatering samples were collected from the outlet pipe of the Western Drain dewatering system following commencement of dewatering and any major extension to the dewatering system. The dewater samples were analysed for heavy metals, TPH, BTEX, PAH, ammonia, cyanide, turbidity, total dissolved solids and pH.

The details of samples from the dewatering system for the Western Drain excavation are summarised in Table 17.

TABLE 17 – SAMPLING DETAILS FOR DEWATERING OF THE WESTERN DRAIN EXCAVATION

Date	Drain Excavation	Sample Name/ Duplicate	ALS Batch Number
3 August 2007	Western Drain	Dewater WD1	ES0710692
10 August 2007	Western Drain	Dewater WD2	ES0711076
29 August 2007	Western Drain	Dewater WD3	ES0711997
25 September 2007	Western Drain	Dewater WD4	ES0713301
22 October 2007	Western Drain	Dewater WD5	ES0714608
4 December 2007	Western Drain	Dewater WD6/ Dup 1	ES0716956

19.2.3 Field QA/QC

Environmental sampling activities were generally compliant with Coffey Environments Standard Operating Procedures, which are based on industry accepted standard practice.

Dewatering samples were collected by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years' experience.

A copy of the signed Chain of Custody form was included with each batch of laboratory results. The water samples were generally analysed as per the SAQP (Ref: GEOTSGTE20150AD, dated 13 June 2007).

One intra-laboratory duplicate sample (Dup 1) was collected for six primary water samples for the Western Drain dewatering. This represents the collection of duplicate samples at a rate of greater than one duplicate per ten samples and is considered to be adequate for the purposes of this investigation.

The duplicate samples were collected to assess whether the field sampling and laboratory procedures adequately reproduced results. Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pairs Dewater WD6/ Dup 1 were less than 50%.

One trip blank sample and one trip spike sample were included in the sample batches for Dewater WD3 and the surface water sampling event completed on 12 November 2007. The trip spike and trip blank samples were included to assess the effect of sample handling on volatile concentrations in the samples collected.

The field Quality Assurance and Quality Control (QA/QC) results are generally acceptable.

19.2.4 Laboratory QA/QC

Primary laboratory analysis was undertaken by ALS, which is a NATA registered laboratory for the analysis undertaken. Samples were received by ALS within the recommended holding times and they were chilled when received.

Samples were collected in appropriately preserved sampling containers and kept chilled in the field and during transit to the laboratory. The heavy metals sample was not filtered in the field. The water samples were dispatched to ALS under chain of custody conditions on the dates outlined in Table 15. Samples were received by the laboratory in good condition. Samples were extracted and analysed within the respective holding times for each analyte, as outlined in Table 18. Holding times for pH were generally exceeded due to travel times to the laboratory.

TABLE 18 – HOLDING TIMES FOR WATER SAMPLES – WESTERN DRAIN

Analysis	Holding Times	Maximum time between sampling and analysis	Holding Times met
PAH	14 days	5 days	Yes
Metals	6 months	8 days	Yes
TPH C6-C9/BTEX	14 days	5 days	Yes
TPH C10-C36	14 days	5 days	Yes
Ammonia	28 days	6 days	Yes
Cyanide	14 days	5 days	Yes
Turbidity	2 days	2 days	Yes

Analysis	Holding Times	Maximum time between sampling and analysis	Holding Times met
Total Dissolved Solids	7 days	5 days	Yes
pH	6 hours	1 day	No

NATA endorsed laboratory methods were used to analyse the samples, as listed in Table 19. The NATA Seal was present on the laboratory reports.

TABLE 19 – LABORATORY METHODOLOGIES FOR WATER ANALYSIS

Analyte	Analytical Method/ Referance	Limit of Reporting
Heavy metals	ICP-AES, USEPA 200.7	0.02- 0.05mg/L
PAH	GC/MS, USEPA 8270	1µg/L
TPH C6-C9	P&T GC/MS, USEPA 8260	10µg/L
TPH C10-C36	GC/FID, USEPA 8000	50-100µg/L
BTEX	Purge and Trap/GC-MS, USEPA 8020A	1-2µg/L
Ammonia	APHA 4500-NH_3^-	10µg/L
Cyanide	APHA 4500-CN^- C&N	4µg/L
Turbidity	APHA 2130 B	1mg/L
Total dissolved solids	APHA 2540 C	1mg/L
PCB	GC/ECD, USEPA 8080	1µg/L
pH	APHA 4500-H^+ B	0.1pH Units

A review of the laboratory internal quality assurance/quality control reports indicate that the appropriate laboratory quality assurance/quality control procedures were undertaken at an appropriate rate for contamination studies and that:

- Contaminant concentrations in the laboratory method blanks were below the laboratory detection limits. Method blanks were completed at a rate of 1 blank per 10 samples;

- Matrix spike recoveries were within static control limits for organics (70% to 130%), except for Laboratory Sample ID ES0711023-001 in Batch ES0711076 for ammonia, copper and zinc and Laboratory Sample ID ES0710692 in Batch ES0710692 for TPH C29-C36. The matrix spike for ammonia could not be determined due to the high concentration of the analytes in the spiked samples. The Laboratory Control Sample completed for this batch was within the acceptance criteria of the laboratory method and therefore, the non-reported matrix spike recovery is not considered to affect the usability of this data. The matrix spike for zinc was 50%. It is considered that the zinc concentration in the primary sample is significantly greater than the spiking level, therefore the spike recovery cannot be accurately determined for this analysis. The matrix spikes for copper and TPH C29-C36 were less than 1% below the lower data quality objective. Matrix spike samples were completed at a rate of 1 matrix spike sample per 10 samples;
- Spike recoveries for laboratory control samples were within the ALS dynamic control limits for organics and inorganics, except for the spike recovery for lead in Batch ES0714608 and the spike recovery for PCBs in Batch ES0710692. The spike recoveries were less than 1% below the low dynamic recovery limit;
- RPDs for the laboratory duplicates were within control limits (60% to 120%). Laboratory duplicate samples were completed at a rate of 1 duplicate sample per 10 samples;
- Surrogate recoveries were within the control limits for organics (70% to 130%) except for Laboratory Sample ID ES0710692-001 in Batch ES0710692 and Laboratory Sample ID ES0711997-002 in Batch ES0711997 for toluene. These surrogate recoveries were minor exceedences and were within industry standard practise. An adequate number of surrogate spike samples were analysed for organics

The laboratory QA/QC results are generally acceptable.

19.2.5 Results

A summary of the laboratory results is presented in Appendix W. The laboratory reports are included in Appendix J.

A comparison of the laboratory results for the dewatering sampling from the Western Drain with the ANZECC 2000 Guidelines for the protection of 95% of marine species (the Guideline values) indicates:

- Concentrations of heavy metals, including arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury, peaked in the second sampling event on 10 August 2007. During this sampling event, the concentrations of arsenic, copper, lead and zinc exceeded the Guideline values. In subsequent sampling events in late August, September, October and December 2007, heavy metals concentrations were relatively consistent, with the copper concentration (generally 2µg/L) marginally exceeding the Guideline values of 1.3µg/L;
- Total cyanide concentrations increased from less than the laboratory detection limit of 4µg/L to a peak of 78µg/L in Dewater WD3 on 29 August 2007. Total cyanide concentrations in September and October 2007 were less than the laboratory detection limit. Total cyanide concentrations in December 2007 increased to 13.2µg/L. Total cyanide concentrations on 10 and 29 August 2007 and 1 December 2007 exceeded the Guideline value of 4µg/L. The total cyanide concentration in the dewatering from the Western Drain is likely to be dominated by complex cyanide, rather than free cyanide due to the high iron content in fill material and interaction with ambient oxygen;

- Ammonia concentrations increased from the initial sampling event on 3 August 2007 until the final sampling event on 1 December 2007. Ammonia concentrations in late August, September, October and December 2007 the Guideline value of 910µg/L, with the highest concentration of 3,860µg/L identified on 1 December 2007. Ammonia concentrations from the dewatering of the Western Drain excavation increased as the dewatering progressed northwards towards the Hunter River. It is noted that historical steelworks infrastructure included above ground coke oven gas mains running parallel to the Hunter River on or near the Koppers Gantry. It is understood that gas mains condensate known to be high in ammonia was discharged to groundwater through several seal pots located along the mains. It is considered that the trend to increasing ammonia concentrations are likely to be attributable to residual ammonia contamination in the vicinity of the former gas mains seal pots along the Koppers Gantry;
- Total TPH C6-C36 concentrations did not exceed the laboratory detection limit of 220µg/L in the dewatering sampling events;
- Concentrations of toluene, ethyl benzene and xylene did not exceed the laboratory detection limits of 2µg/L in the dewatering sampling events. Concentrations of benzene peaked in Dewater WD3 on 29 August 2007 at 44µg/L then declined to 6µg/L over the subsequent three sampling events. The benzene concentration did not exceed the Guideline value of 700µg/L;
- Total PAH concentrations exceeded the laboratory detection limits on one sampling event, Dewater WD2 on 10 August 2007. At this time, the benzo(a)pyrene concentration (2.9µg/L) exceeded the Guideline value of 0.2µg/L. The total PAH concentrations in the subsequent four sampling events were below the laboratory detection limit of individual PAH compounds. The elevated PAH concentration on 10 August 2007 is likely to be due to the extraction of the dewatering through Level 3 material from the Western Drain excavation around chainage CH160 to CH220.

20 EASTERN DRAIN

20.1 Excavation and Construction

The Eastern Drain excavation began in August 2007 and was completed in December 2007. Photographs of the Eastern Drain excavation and construction are included in Appendix E.

Material excavated from the Eastern Drain excavation included Level 1 and Level 3 material and PASS material. Materials tracking of Level 1 and Level 3 material are outlined in Section 7 and 9. Treatment of PASS material is described in Section 21.

Following the excavation of material from the Eastern Drain, a lined open channel drain was constructed from chainage CH115 to CH780. A box culvert drain was constructed from box culvert chainage CH0 to CH248. For the latter box culvert construction, chainage CH0 commenced at chainage CH780 for the open channel drain and generally continued northwards. A box culvert drain was also constructed at the Selwyn Street Inlet Structure, which extends approximately 50m south-west from chainage CH115.

The construction of the open channel drain included a High Density Polyethylene (HDPE) liner and a concrete slab base.

The section of the Eastern Drain completed as an open channel drain was lined with a 2mm thick HDPE liner provided by Curtis Barrier. To prevent puncturing of the liner during placement, the base and sides of the excavation to RL1 were lined with a product called Curtis RN380. Curtis RN380 was also used on the side walls to prevent rocks from puncturing through the liner from above. At the major headwalls at the ends of the open drain and at small headwalls along the drain, terminations in the concrete were sealed with a product called Elock, which is a HPDE material cast within the concrete. The 2mm thick HDPE liner was then welded to the Elock to provide a barrier.

The joints between the precast concrete box culvert elements were sealed with a combined joint sealant consisting of external tape wrapping of the joint to prevent ingress of dirt using either Conwrap or Skiaproof 150 as available. A 30mm backing rod was then installed from inside the box culvert and pushed into the joint followed by a round, swellable joint product called Hydrotyte, a hydraulic water stop. Where the backing rod touches the concrete, it was sealed with a product called Leakmaster. Following this, another 30mm backing rod was squeezed into the joint. At the joints on the base of the box culverts, a sealant product called Sikaprimer 3 was used followed by another product called Sikaflex Tank. A product called Sikaflex Pro was used as a sealant on the top of the joints. The bottom of the concrete box culverts had an 80mm diameter hole where they sat on top of the timber piles. A pin was driven into the top of the timber pile to locate the box culvert and then the 80mm hole was filled with a water displacing grout called Sikadur.

A copy of the Curtis Barrier report on the drain construction is included in Appendix V.

20.2 Dewatering

Dewatering of the Eastern Drain excavation began 29 September 2007 and was concluded in June 2008 following the completion of the box culvert drain. The dewatering outlet comprised a deep pond in the centre of a large bunded area to the south of Area 2A Disposal Stockpile, called the Area 2A pond. Water discharged to the pond either returned to the local shallow groundwater, or was lost as evaporation, or a combination of both.

20.2.1 Daily Monitoring

EPS maintained dewatering records for the Eastern Drain, including daily monitoring of pH, visual appearance and odour.

Daily monitoring data for 29 September 2007 to 31 May 2008 are presented in Appendix W. A summary of the daily monitoring data is also included in Appendix W. It is noted that daily monitoring was not completed between 6 March 2008 and 31 March 2008. Twice weekly monitoring was completed from 31 March 2008 to 31 May 2008.

The daily monitoring records indicate that the pH of the dewatering dropped over the 7 month period from pH 7.9 to pH 7.3.

20.2.2 Water Sampling

Dewatering samples were collected from the outlet pipe of the Eastern Drain dewatering system following commencement of dewatering and any major extension to the dewatering system. The samples were analysed for heavy metals, TPH, BTEX, PAH, ammonia, cyanide, turbidity, total dissolved solids and pH.

The sampling events for dewatering of the Eastern Drain excavation are listed in Table 20.

TABLE 20 – SAMPLING EVENTS FOR DEWATERING OF THE EASTERN DRAIN EXCAVATION

Date	Drain Excavation	Sample Nae/ Duplicate	ALS Batch Number
3 October 2007	Eastern Drain	Dewater ED1	ES0713700
22 October 2007	Eastern Drain	Dewater ED2	ES0714608
22 January 2008	Eastern Drain	Dewater ED3/ Dup 2	ES0800837

20.2.3 Field QA/QC

Environmental sampling activities were generally consistent with Coffey Environments Standard Operating Procedures, which are based on industry accepted standard practice.

Dewatering samples were collected following any major extension to the dewatering system along the Eastern Drain excavation. Dewatering samples were collected directly from the discharge pipe, aside from Dewater ED2, which was collected from the Area 2A pond to assess ammonia concentrations in the pond for potential re-use of the water for dust suppression.

Dewatering samples were collected by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years' experience.

A copy of the signed Chain of Custody form was included with each batch of laboratory results. The water samples were generally analysed in accordance with the SAQP (Ref: GEOTSGTE20150AD, dated 13 June 2007).

One intra-laboratory duplicate sample (Dup 2) was collected for three primary water samples from the Eastern Drain dewatering, which is a rate of greater than one duplicate per ten samples required and is considered to be adequate for the purposes of this investigation.

The duplicate samples were collected to assess whether the field sampling and laboratory procedures adequately reproduced results. Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pair Dewater ED3/ Dup 2 were less than 50%.

The field Quality Assurance and Quality Control (QA/QC) results are generally acceptable.

20.2.4 Laboratory QA/QC

Primary laboratory analysis was undertaken by ALS, which is a NATA registered laboratory for the analysis undertaken. Samples were received by ALS within the recommended holding times and they were chilled when received.

Samples were collected in appropriately preserved sampling containers and kept chilled in the field and during transit to the laboratory. The water samples were dispatched to ALS under chain of custody conditions on the dates listed in Table 18. Samples were received by the laboratory in good condition. Samples were extracted and analysed within the respective holding times for each analyte, as listed in Table 21. Holding times for pH were generally exceeded due to travel times to the laboratory.

TABLE 21 – HOLDING TIMES FOR WATER SAMPLES – EASTERN DRAIN

Analysis	Holding Times	Maximum time between sampling and analysis	Holding Times met
PAH	14 days	5 days	Yes
Metals	6 months	8 days	Yes
TPH C6-C9/BTEX	14 days	5 days	Yes
TPH C10-C36	14 days	5 days	Yes
Ammonia	28 days	6 days	Yes
Cyanide	14 days	5 days	Yes
Turbidity	2 days	2 days	Yes
Total Dissolved Solids	7 days	5 days	Yes
pH	6 hours	1 day	No

NATA endorsed laboratory methods were used to analyse the samples and these are listed in Table 22. The NATA Seal was present on the laboratory reports.

TABLE 22 – LABORATORY METHODOLOGIES FOR WATER ANALYSIS

Analyte	Analytical Method/ Reference	Limit of Reporting
Heavy metals	ICP-AES, USEPA 200.7	0.02- 0.05mg/L
PAH	GC/MS, USEPA 8270	1µg/L
TPH C6-C9	P&T GC/MS, USEPA 8260	10µg/L
TPH C10-C36	GC/FID, USEPA 8000	50-100µg/L
BTEX	Purge and Trap/GC-MS, USEPA 8020A	1-2µg/L
Ammonia	APHA 4500-NH_3^-	10µg/L
Cyanide	APHA 4500-CN^- C&N	4µg/L
Turbidity	APHA 2130 B	1mg/L
Total dissolved solids	APHA 2540 C	1mg/L
PCB	GC/ECD, USEPA 8080	1µg/L
pH	APHA 4500-H^+ B	0.1pH Units

A review of the laboratory internal quality assurance/quality control reports indicate that the appropriate laboratory quality assurance/quality control procedures were undertaken at an appropriate rate for contamination studies and that:

- Contaminant concentrations in the laboratory method blanks were below the laboratory detection limits. Method blanks were completed at a rate of 1 blank per 10 samples;
- Matrix spike recoveries were within ALS dynamic control limits for organics except for Laboratory Sample ID ES0800837-002 in Batch ES0800837 for TPH C6-C9 and toluene. The matrix spike could not be determined due to the high concentration of the analytes in the spiked samples. The Laboratory Control Sample completed for this batch was within the acceptance criteria of the laboratory method and therefore, the non-reported matrix spike recovery is not considered to affect the usability of this data. Matrix spike samples were completed at a rate of 1 matrix spike sample per 10 samples;
- Spike recoveries for laboratory control samples were within the ALS dynamic control limits for organics and inorganics, except for the spike recovery for lead in Batch ES0714608. The spike recovery was less than 1% below the low dynamic recovery limit;

- RPDs for the laboratory duplicates were within control limits (60% to 120%). Laboratory duplicate samples were completed at a rate of 1 duplicate sample per 10 samples;
- Surrogate recoveries were within the ALS dynamic control limits for organics except for Laboratory Sample ID ES0800837-001 and Laboratory Sample ID ES0800837-002 in Batch ES0800837 for TPH C6-C9 and toluene. These surrogate recoveries were minor exceedences and were within industry standard practise. An adequate number of surrogate spike samples were analysed for organics.

The laboratory QA/QC results are generally acceptable.

20.2.5 Results

A summary of the laboratory results is presented in Appendix W. The laboratory reports are included in Appendix J.

A comparison of the laboratory results for the dewatering sampling from the Eastern Drain to the ANZECC 2000 Guidelines for the protection of 95% of marine species (the Guideline values) indicates:

- Heavy metals concentrations, including arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury, peaked during the second sampling event on 22 October 2007. During this sampling event, the concentrations of copper (5µg/L) and zinc (20µg/L) exceeded the Guideline values of 2µg/L and 15µg/L respectively. The sample from this sampling event was collected from the Area 2A pond, whereas the samples in the other 2 sampling events were collected from the discharge pipe to the Area 2A pond. In the other two sampling events on 3 October 2007 and 22 January 2008, heavy metals concentrations were below the Guideline values, aside from the copper concentration (2µg/L and 5µg/L respectively). It is likely that the elevated heavy metals concentrations during the second sampling event were due to an increase in sediment in the sample, which was collected from the Area 2A pond rather than the discharge pipe;
- Total cyanide concentrations in the first and second sampling events were below the laboratory detection limit of 4µg/L. The total cyanide concentration in the last sampling event on 22 January 2008 was 24.2µg/L, which exceeded the Guideline value of 4µg/L. The total cyanide concentration in the dewatering from the Eastern Drain is likely to be dominated by complex cyanide, rather than free cyanide as the high iron content in fill material and interaction with ambient oxygen is likely to have oxidised free cyanide present in the water;
- The ammonia concentration in the first sampling event on 3 October 2008 was 1,110µg/L, which exceeded the Guideline value of 900µg/L. Samples for the first sampling event were collected from the outlet pipe of the dewatering. Between the first and second sampling events, Daracon indicated they wanted to reuse the water from the 2A Disposal Pond for dust suppression. To assess the suitability of reusing this water for dust suppression, the sample for the second sampling event was collected from the Area 2A pond rather than the discharge pipe. The ammonia concentration in the pond in the second sampling event was 302µg/L and the water in the Area 2A pond was considered suitable for reuse for dust suppression;
- Total TPH C6-C36, BTEX and PAH concentrations did not exceed the laboratory detection limits in the dewatering sampling events for dewatering of the Eastern Drain.

21 PASS TREATMENT

21.1 Procedures

The Western Drain excavation and the Eastern (formerly Selwyn Street) Drain excavation involve the disturbance of potential acid sulfate soils (PASS) material. EPS completed an Acid Sulfate Management Plan EOT30_MP04 and an Acid Sulfate Management Procedure WP01 in May 2007. Based on the results of field screening, laboratory testing, ASS treatment trial and a letter of advice from Coffey Environments (Ref: GEOTSGTE20150AD-AH, dated 17 August 2007), Addendum No. 03 was completed by EPS for the Acid Sulfate Management Procedures WP01.

21.2 Western Drain

Estuarine clays and sands from the Western Drain excavation were considered to be PASS material and were excavated and transported to a treatment area set up near the Landscape Mound.

The estuarine clays and sands are overlain by fill material (including Level 3 material) close to the Hunter River. The fill material is not PASS material and does not require treatment. The fill material is visually distinct from the estuarine clays and sands, with the estuarine clays and sands petering out of the Western Drain excavation around chainage CH475.

PASS material was treated in batches as the Western Drain excavation was completed in approximate 100m sections generally toward the north. The batches were labelled by chainage in accordance with the section of the Western Drain excavation from which the batch originated. The Western Drain excavation for construction of an open channel drain extended from chainage CH0 to CH475, then continued as a box culvert drain near the Hunter River for a further 220m (new chainage CH0 to CH220).

Field screening and laboratory testing for Chromium Reduced Sulphur (CRS) was completed at approximate 100m intervals prior to excavation works to assess the acid generating potential of PASS material from the Western Drain alignment. Liming rates derived from the CRS results were averaged for PASS material from the Western Drain alignment, with a result of 3% lime by dry weight. This liming rate included a safety factor of 1.5.

An EPS Hold Point was generated for each batch of PASS material once the start and end chainages for each batch was identified. Each batch of PASS material was generally spread out in a 300mm thick layer over the treatment area and then the volume of the PASS material was surveyed. The survey volume was used to calculate the volume, or tonnes, of lime required to lime the PASS material at 3% by dry weight.

Treatment was completed with a 20 tonne excavator for mixing of lime. Following treatment, one validation sample per 1,000m^3 was collected by a Coffey Environments Scientist and analysed at EAL for Total Potential Acidity (TPA). A TPA result of 0 indicates that the treatment has been successful.

Following validation, an EPS Hold Point Release form was signed by representatives from Coffey Environments, EPS and Daracon and the treated PASS material was relocated within the New Landscape Mound.

21.2.1 PASS Treatment

Six batches of PASS material from the Western Drain excavation, including a trial batch, were treated between August 2007 and November 2007. A summary of the treatment of each batch of PASS material, including the chainage of the batch, the PASS volume, lime volume and TPA results is presented in Table 23.

PASS treatment information is presented in Appendix X.

TABLE 23 – TREATMENT OF PASS MATERIAL FROM THE WESTERN DRAIN

BATCH	CHAINAGE	PASS VOLUME	LIME VOLUME	TREATMENT RATE	TPA RESULTS	COMMENT
Trial	-	$90m^3$	-	1%	-	
WD0-100	CH0 to CH100	$621m^3$	$12.4m^3$	3% by volume	0	Passed
WD100-160	CH100 to CH170	$445.5m^3$	$13.3m^3$	3% by dry weight	0	Passed
WD170-285	CH170 to CH300	$1608m^3$	$48m^3$	3% by dry weight	0,0	Passed
WD300-400	CH300 to CH390	$659m^3$	$19.6m^3$	3% by dry weight	0	Passed
WD400-500	CH390 to CH475	$406.2m^3$	$14.14m^3$	3% by dry weight	0	Passed
	TOTAL	$3,829.7m^3$				

21.3 Eastern Drain

Estuarine clays and sands from the Eastern Drain excavation were considered to be PASS material and were excavated and transported to a treatment area set up near the Area 2A disposal stockpile.

The estuarine clays and sands are overlain by dredged sands close to the Hunter River. The dredged sands are not PASS material and do not require treatment. The dredged sands are visually distinct from the estuarine clays and sands, with the estuarine clays and sands petering out of the Eastern Drain excavation around box culvert chainage CH15.

PASS material was treated in batches as the Eastern Drain excavation was extended in approximately 100m sections from chainage CH115. The batches were labelled by chainage in accordance with the section of the Eastern Drain excavation from which the batch originated. The Eastern Drain excavation extends from chainage CH0 to CH780 for the construction of an open channel drain, then continued as a box culvert drain near the Hunter River for a further 248m (new chainage CH0 to CH248).

It is understood that the Eastern Drain from chainage CH0 to CH115 was being re-designed at the time this report was issued and no excavation works were completed in this area.

Field screening and laboratory testing for chromium reducible sulphur (CRS) was completed at approximate 100m intervals prior to excavation works to assess the acid generating potential of PASS material from the Eastern Drain alignment. Liming rates derived from the CRS results were averaged for PASS material from the Eastern Drain alignment, with a result of 1% lime by dry weight for clay material from chainages CH100 to CH440 and CH475 to CH780. Peaty clay material from chainage CH440 to CH475 was treated at a rate of 2.1% by dry weight. This liming rate included a safety factor of 1.5.

An EPS Hold Point was generated for each batch of PASS material once the start and end chainages for each batch was identified. Each batch of PASS material was generally spread out in a 300mm thick layer over the treatment area and then the volume of the PASS material was surveyed. The survey volume was used to calculate the volume or tonnes of lime required to lime the PASS material at 1% by dry weight or 2.1% by dry weight for peaty clay material from CH440 to CH475.

Treatment was completed with a 20 tonne excavator for mixing of lime. Following treatment, one validation sample per 1,000m^3 is collected by a Coffey Environments' Scientist and analysed at EAL for Total Potential Acidity (TPA). A TPA result of 0 indicates that the treatment has been successful.

Following validation, an EPS Hold Point Release form is signed by representatives from Coffey Environments, EPS and Daracon and the treated PASS material is relocated within the New Landscape Mound.

21.3.1 PASS Treatment

Five batches of PASS material from the Eastern Drain excavation were treated between October 2007 and April 2008. A summary of the treatment of each batch of PASS material, including the chainage of the batch, the PASS volume, lime volume and TPA results is presented in Table 24.

The post-treatment sample collected from batch ED315-425 failed, with a TPA result of 9 moles H^+/ tonne. The Acid Neutralising Capacity result indicates ample lime has been added to this batch to neutralise the acidity. The failure is likely to be due to inadequate mixing of the lime during treatment. This batch was re-mixed and three additional post treatment samples collected. One of these samples was analysed for TPA to assess the mixing of lime through this batch and the TPA result was 0, indicating adequate mixing of lime through this batch.

PASS treatment information is presented in Appendix X.

TABLE 24 – TREATMENT OF PASS MATERIAL FROM THE EASTERN DRAIN

BATCH	CHAINAGE	PASS VOLUME	LIME VOLUME	TREATMENT RATE	TPA RESULTS	COMMENT
ED115-315	CH115 to CH315	$3642m^3$	$21m^3$	1% by dry weight	0, 0, 0	Passed
ED315-425	CH315 to CH440	$617.4m^3$	$9.7m^3$	1% by dry weight	9 mole H+/ tonne 0	Failed Passed
ED440-475	CH440 to CH475	$311.5m^3$	$12.6m^3$	2.1% by dry weight	0	Passed
ED475-600	CH475 to CH600	$683m^3$	$4.3m^3$	1% by dry weight	0	Passed
	TOTAL	$5,253.9m^3$				

21.3.2 Areas of Eastern Drain Excavation not Treated

The Eastern Drain excavation from open channel drain chainage CH600 to box culvert chainage CH248 (Batch ED600-800), with a volume of approximately $640m^3$, comprised 95% dredged sand and 5% PASS material. To assess whether or not this batch required treatment, three samples were collected for TPA analysis during January 2008. The TPA results for the three samples were 0 and treatment of this batch was not required.

An extension to the Eastern Drain, called the Selwyn Street Inlet Structure, was constructed between March and May 2008. Material excavated from this section (approximately 40m by 15m by 2m deep) was observed to comprise 95% dredged sand and Level 1 fill material and 5% PASS material (Batch ED0-100). To assess whether or not this batch required treatment, three samples were collected for TPA analysis during April 2008. The TPA results for the three samples were 0 and treatment of this batch was not required.

Laboratory results for these two batches are presented in Appendix X.

Dredged sand fill material and PASS material from these two batches was reused as backfill around the box culverts in the Eastern Drain and in the Selwyn Street Inlet Structure.

22 SURFACE WATER SAMPLING

22.1 Major Rain Events

Rainfall events for each month are outlined in the Monthly Reports completed by Coffey Environments.

Rainfall events of greater than 10mm in a 24 hour period that occurred between May 2007 and June 2008 are presented in Table 25.

TABLE 25 – RAINFALL EVENTS EXCEEDING 10MM BETWEEN MAY 2007 AND JUNE 2008

Date	Rainfall in Millimetres*
Thursday 10 May 2007	45.6mm
Thursday 7 June 2007	82.0mm
Friday 8 June 2007	21.6mm
Saturday 9 June 2007	209.8mm
Sunday 10 June 2007	18.8mm
Saturday 16 June 2007	43.2mm
Sunday 17 June 2007	26.6mm
Tuesday 19 June 2007	58.4mm
Monday 20 August 2007	69.9mm
Tuesday 21 August 2007	14.8mm
Saturday 13 October 2007	30mm
Saturday 27 October 2007	23.6mm
Thursday 8 November 2007	10.6mm
Friday 9 November 2007	18.4mm
Saturday 10 November 2007	21.0mm
Tuesday 4 December 2007	14.8mm
Monday 10 December 2007	29.6mm

Date	Rainfall in Millimetres*
Monday 17 December 2007	11.0mm
Thursday 17 January 2008	13.2mm
Friday 18 January 2008	45.2mm
Sunday 20 January 2008	10.6mm
Monday 21 January 2008	10.4mm
Saturday 26 January 2008	10.8mm
Saturday 2 February 2008	11.8mm
Monday 4 February 2008	24.0mm
Tuesday 5 February 2008	26.4mm
Wednesday 6 February 2008	12.2mm
Friday 8 February 2008	17.4mm
Saturday 9 February 2008	21.8mm
Friday 29 February 2008	59.4mm
Saturday 14 March 2008	14.4mm
Monday 7 April 2008	18.8mm
Wednesday 9 April 2008	10.1mm
Saturday 19 April 2008	13.6mm
Monday 21 April 2008	20.4mm
Wednesday 23 April 2008	35.6mm
Thursday 24 April 2008	10.2mm
Friday 25 April 2008	70.4mm
Thursday 22 May 2008	27.2mm

Date	Rainfall in Millimetres*
Wednesday 4 June 2008	33.0mm
Thursday 5 June 2008	39.2mm

* Data from Bureau of Meteorology Website

22.2 Sampling Locations and Events

Surface water sampling locations were nominated by RLMC via GPS. Surface water sampling events were generally completed following rainfall events of greater than 10mm in a 24 hour period. Surface water sampling locations are presented in Figure 19.

Following a major rainfall event between 7 and 10 June 2007 and a rainfall event of less than 10mm in July 2007, surface water samples were collected from the barrage on the Hunter River (locations SW1 and SW2).

In November 2007, 7 surface water sampling locations were nominated by RLMC for testing, including the barrage on the Hunter River (location SW7), the coffer dams on the Western Drain (location SW6) and Eastern Drain (location SW8) and 4 stormwater drains around the former BHP Steelworks site (locations SW3, SW4, SW5 and SW9). These 7 locations were sampled 12 November 2007, 5 February 2008, 28 February 2008 and 7 April 2008. From February 2008, these 7 locations were sampled once per month following the first rainfall event of greater than 10mm.

Following the first round of sampling on 12 November 2007, surface water samples (locations SW10 to SW13) were collected on 4 December 2007 for heavy metals testing from four drainage ponds around the drain outside the Daracon Office (location SW9) at the request of RLMC.

Following heavy rainfall and the ponding of surface water over Area 1B on 17 January 2008 and 4 February 2008, surface water samples (locations SW14 and SW15 respectively) were collected from ponded water between Area 1A and Area 1B.

On 11 March 2008, one water sample was collected from the Eastern Drain coffer dam (location SW8) and one water sample was collected from the Hunter River adjacent to the Eastern Drain coffer dam (location SW1) to assist Daracon with dewatering options for the Eastern Drain coffer dam.

Following recept of the laboratory results from the sampling event on 7 April 2008, the drain near the Gatehouse on the road to the Landscape Mound (location SW4) was re-tested for PAH and TPH on 16 April 2008 due to an anomalous result.

A summary of the surface water sampling events completed at the former BHP Steelworks site is listed in Table 26, including sample locations, sample identity and duplicate samples. The unique sample identity is the sample name and the date.

TABLE 26 – SURFACE WATER SAMPLING EVENTS

SAMPLING LOCATION	SAMPLE LOCATION/ DUPLICATE	DATES	ALS BATCH NUMBER
Drain outside driveway to RLMC Administration Building	SW3	12 November 2007	ES0715687
	SW3	5 February 2008	ES0801513
	SW3	28 February 2008	ES0802674
	SW3	7 April 2008	ES0804707
	SW3	22 May 2008	ES0807574
Drain near Gatehouse on road to Landscape Mound	SW4	12 November 2007	ES0715687
	SW4	5 February 2008	ES0801513
	SW4	28 February 2008	ES0802674
	SW4	7 April 2008	ES0804707
	SW4	16 April 2008	ES0805276
	SW4	22 May 2008	ES0807574
Drain near OneSteel boundary	SW5	12 November 2007	ES0715687
	SW5	5 February 2008	ES0801513
	SW5	28 February 2008	ES0802674
	SW5/ Dup E	7 April 2008	ES0804707
	SW5	22 May 2008	ES0807574
Western Drain Coffer Dam	SW6	12 November 2007	ES0715687
Barrage on Hunter River	SW1	7 June 2006	ES0707677
	SW2	2 July 2007	ES0708885
	SW7	12 November 2007	ES0715687
	SW7	5 February 2008	ES0801513
	SW7	28 February 2008	ES0802674
	SW7	7 April 2008	ES0804707

SAMPLING LOCATION	SAMPLE LOCATION/ DUPLICATE	DATES	ALS BATCH NUMBER
Eastern Drain Coffer Dam	SW8/ Dup A SW8 SW8 SW8 SW8	12 November 2007 5 February 2008 11 March 2008 7 April 2008 22 May 2008	ES0715687 ES0801513 ES0803359 ES0804707 ES0807574
Drain in front of Daracon office	SW9 SW9A SW9/ Dup C SW9/ Dup D SW9 SW9/ Dup F	12 November 2007 4 December 2007 5 February 2008 28 February 2008 7 April 2008 22 May 2008	ES0715687 ES0716956 ES0801513 ES0802674 ES0804707 ES0807574
Ponded water adjacent to eastern boundary of Area 1A	SW10	4 December 2007	ES0716956
Ponded water on south side of rail loop	SW11	4 December 2007	ES0716956
Detention pond west of Daracon office	SW12/ Dup B	4 December 2007	ES0716956
Detention pond near south-east corner of Area 1A	SW13	4 December 2007	ES0716956
Ponded water in drain in Area 1A near grid square 12	SW14	17 January 2008	ES0800656
Ponded water between Koppers Gantry and Area 1A between grid square 1 and 8	SW15	4 February 2008	ES0801379
Hunter River next to Eastern Drain coffer dam	NH1	11 March 2008	ES0803359

22.2.1 Field QA/QC

Environmental sampling activities were consistent with Coffey Environments Standard Operating Procedures, which are based on industry accepted standard practice.

For the surface water sampling following rainfall events, nominated locations were sampled and included stormwater drains and areas of ponded water as requested by GPS, the project manager for RLMC.

The majority of the surface water samples were collected by Kirsty Greenfield from Coffey Environments, an Environmental Scientist with 5 years' experience. The remaining surface water samples were collected by Nat Stevens from EPS, a Project Engineer with over 2 years' experience.

A copy of the signed Chain of Custody form was included with each of the 13 batches of laboratory results. The water samples were generally analysed as per the SAQP (Ref: GEOTSGTE20150AD, dated 13 June 2007). Following the results of the first two rounds of surface water sampling in June 2007 and July 2007, PCBs were removed from the analytical schedule as PCBs were considered to be a low risk for surface water contamination. Analysis for total cyanide was completed on surface water samples collected between June 2007 and 4 February 2008. Analysis for free cyanide was completed on surface water samples collected from 28 February 2008 onwards as a consequence of a review of the surface water guidelines in February 2008.

Six intra-laboratory duplicate samples (Dup A, Dup B, Dup C, Dup D, Dup E and Dup F) were collected for 41 primary surface water samples. This represents the collection of duplicate samples at a rate of greater than one duplicate per ten samples and is considered to be adequate for the purposes of this investigation.

The duplicate samples were collected to assess whether the field sampling and laboratory procedures adequately reproduced results. Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pairs SW8 12/11/07 /Dup A, SW12 4/12/07 /Dup B, SW9 28/02/08 / Dup D, SW5 7/04/08 / Dup E and SW9 22/05/08 / Dup F were less than 50%. The RPDs for cyanide and cadmium between the primary/ intra-laboratory duplicate pair SW9 04/02/08 / Dup C were 104% and 200% respectively.

The cadmium concentration in the primary sample SW9 and the duplicate sample Dup C were confirmed by re-analysis. The cadmium concentration in Dup C (5,990µg/L) is similar to the concentration of cadmium in the preservative tablets used to preserve cyanide samples. Given that the RPD for cyanide also exceeded 50% and the cyanide concentration in Dup C was less then that in SW9 04/02/08, it appears that the preservative tablets for the cyanide sample were placed in the heavy metals sample by mistake.

The concentration of cyanide in the duplicate sample, Dup C, is considered to be low as the sample was not preserved correctly. The cadmium concentration in Dup C is considered to be artificially high due to contamination of the sample with the preservative tablet for the cyanide sample.

Relative Percent Differences (RPDs) between the primary/intra-laboratory duplicate pairs SW9 28/02/08 / Dup D were generally less than 50%, aside from the results for TPH C6-C36 at 57% (see Table LR2 in Appendix Y). The RPD exceedence was due to the results for TPH fraction C29-C36, where the primary result was less than 50µg/L and the duplicate result was 80µg/L. The RPD exceedence is not considered to affect the usability of the data as the duplicate result is less than 5 times the detection limit of 50µg/L.

One trip blank sample and one trip spike sample were included in the sample batches for the surface water sampling event completed on 12 November 2007. The trip spike and trip blank samples were included to assess the effect of sample handling on volatile concentrations in the samples collected.

The field Quality Assurance and Quality Control (QA/QC) results are generally acceptable.

22.2.2 Laboratory QA/QC

Primary laboratory analysis was undertaken by ALS, which is a NATA registered laboratory for the analysis undertaken. Samples were received by ALS within the recommended holding times and they were chilled when received.

Samples were collected in appropriately preserved sampling containers and kept chilled in the field and during transit to the laboratory. The water samples were dispatched to ALS under chain of custody conditions on the dates outlined in Table 26. Samples were received by the laboratory in good condition. Samples were extracted and analysed within the respective holding times for each analyte, as outlined in Table 27. Holding times for pH were generally exceeded due to travel times to the laboratory.

TABLE 27 – HOLDING TIMES FOR WATER SAMPLES

ANALYSIS	HOLDING TIMES	MAXIMUM TIME BETWEEN SAMPLING AND ANALYSIS	HOLIDNG TIMES MET
PAH	14 days	5 days	Yes
Metals	6 months	8 days	Yes
TPH C6-C9/BTEX	14 days	5 days	Yes
TPH C10-C36	14 days	5 days	Yes
Ammonia	28 days	6 days	Yes
Cyanide	14 days	5 days	Yes
Turbidity	2 days	2 days	Yes
Total Dissolved Solids	7 days	5 days	Yes
pH	6 hours	1 day	No

NATA endorsed laboratory methods were used to analyse the samples, as outlined in Table 28 and the NATA Seal was present on the laboratory reports.

TABLE 28 – LABORATORY METHODOLOGIES FOR WATER ANALYSIS

ANALYTE	ANALYTICAL METHOD/ REFERENCE	LIMIT OF REPORTING
Heavy metals	ICP-AES, USEPA 200.7	0.02- 0.05mg/L
PAH	GC/MS, USEPA 8270	1µg/L
TPH C6-C9	P&T GC/MS, USEPA 8260	10µg/L
TPH C10-C36	GC/FID, USEPA 8000	50-100µg/L
BTEX	Purge and Trap/GC-MS, USEPA 8020A	1-2µg/L
Ammonia	APHA 4500-NH_3^-	10µg/L
Cyanide	APHA 4500-CN^- C&N	4µg/L
Free Cyanide	APHA 4500-CN-C&N	4µg/L
Turbidity	APHA 2130 B	1mg/L
Total dissolved solids	APHA 2540 C	1mg/L
PCB	GC/ECD, USEPA 8080	1µg/L
pH	APHA 4500-H^+ B	0.1pH Units

A review of the laboratory internal quality assurance/quality control reports indicate that the appropriate laboratory quality assurance/quality control procedures were undertaken at an appropriate rate for contamination studies and that:

- Contaminant concentrations in the laboratory method blanks were below the laboratory detection limits. Method blanks were completed at a rate of 1 blank per 10 samples;
- Matrix spike recoveries were within ALS dynamic control limits for organics except for Laboratory Sample ID ES0708351-002 in Batch ES0708351 for TPH C6-C9 and toluene and Laboratory Sample ID ES0711023-001 in Batch ES0711023 for ammonia. The matrix spike could not be determined due to the high concentration of the analytes in the spiked samples. The Laboratory Control Sample completed for this batch was within the acceptance criteria of the laboratory method and therefore, the non-reported matrix spike recovery is not considered to affect the usability of this data. Matrix spike samples were completed at a rate of 1 matrix spike sample per 10 samples;

- Spike recoveries for laboratory control samples were within the ALS dynamic control limits for organics and inorganics;
- RPDs for the laboratory duplicates were within control limits (60% to 120%). Laboratory duplicate samples were completed at a rate of 1 duplicate sample per 10 samples;
- Surrogate recoveries were within the control limits for organics (70% to 130%). An adequate number of surrogate spike samples were analysed for organics.

The laboratory QA/QC results are generally acceptable.

22.3 Discussion of Surface Water Sampling Results

A summary of the surface water results is presented in Appendix Y. Laboratory reports are presented in Appendix J.

A comparison of the laboratory results for the June, July and November 2007 surface water sampling events to the ANZECC 2000 Guidelines for the protection of 95% of marine species (the Guideline values) indicates:

- Turbidity results exceeded the maximum value for estuarine and marine environments in south-east Australia of 10NTU at three locations, SW6, SW7 and SW9;
- Chromium concentrations exceeded the Guideline value of 27.4µg/L at one location, SW9;
- Copper concentrations exceeded the Guideline value of 1.3µg/L at seven locations, SW1, SW2, SW3, SW4, SW6, SW7 and SW9;
- Lead concentrations exceeded the Guideline value of 4.4µg/L at four locations, SW1, SW3, SW7 and SW9;
- Zinc concentrations exceeded the Guideline value of 15µg/L at five locations, SW1, SW3, SW6, SW7 and SW9;
- Ammonia concentrations exceeded the Guideline value of 910µg/L at the barrage on the Hunter River in SW1 and SW2;
- TPH C6-C36 concentrations exceeded the average of the target and intervention values for the Dutch (2006) guidelines for mineral oil of 325µg/L at one location, SW1.

It is noted that storm water runoff generally leaves the site through the designed storm water system, which includes a series of detention ponds within and outside the Closure Area.

Sample locations within the Closure Area include the Western Drain coffer dam and the barrage on the Hunter River. Samples SW1, SW2 and SW7 were collected from the same location, the barrage on the Hunter River, on 7 June 2007, 2 July 2007 and 12 November 2007 respectively. It is noted that following the large storm event in early June 2007, EPS placed two hydrocarbon absorbent booms across the outflow locations into the barrage, where a hydrocarbon sheen was observed on the surface of the water. It is also noted that in early June 2007, several subsurface drains within Area 1A were backfilled with sand to prevent inflow of stormwater.

In the barrage, the concentration of ammonia increased between the first and second sampling events, then decreased between the second and third sampling events. Concentrations of heavy metals, including cadmium, chromium, copper, nickel, lead and mercury, TPH C6-C36, total PAHs, benzene and cyanide generally decreased between the first and third sampling event. The observed reduction in the concentrations of the chemicals of concern in the barrage following the first sampling event is likely to be due to the use of hydrocarbon absorbent booms within the barrage and the backfilling of the subsurface drains within Area 1A.

Turbidity increased within the barrage between the second and third sampling events. It is noted that earthworks within Area 1A, including the construction of the VENM cap was completed in November 2007. The increase in turbidity and total dissolved solids within the barrage is likely to be due to erosion of material from Area 2D (not capped) and the VENM cap.

Five of the sample locations were located outside the Closure Area, including SW3, SW4, SW5, SW8 and SW9. Concentrations of heavy metals, TPH C6-C36, total PAH and turbidity were highest within the drain outside the Daracon office. Elevated concentrations of TPH may be due to the high use of this area by cars, trucks and plant such as excavators and backhoes. The combination of elevated pH, high turbidity and elevated metals concentrations indicates that the likely source of those metals is suspended particles in the water. This sample was not filtered prior to laboratory testing.

A comparison of the laboratory results for the surface water sampling events on 17 January 2008 (SW14) and 4 (SW15) and 5 February 2008 to the Guidelines values indicates:

- Chromium concentrations exceeded the Guideline value of 27.4µg/L at one location, SW15;
- Copper concentrations exceeded the Guideline value of 1.3µg/L at eight locations, SW3, SW4, SW5, SW7, SW8, SW9, SW14 and SW15;
- Lead concentrations exceeded Guideline value of 4.4µg/L at three locations, SW9, SW14 and SW15;
- Zinc concentrations exceeded the Guideline value of 15µg/L at five locations, SW3, SW5, SW9, SW14 and SW15;
- Cyanide concentrations exceeded the Guideline value of 4µg/L at three locations, SW5, SW9 and SW14;
- Total petroleum hydrocarbons (TPH C6-C36) concentrations exceeded the investigation level of 325µg/L at two locations, SW7 and SW9;
- Benzo[a]pyrene concentrations exceeded the Guideline value of 0.2µg/L at three location, SW7, SW14 and SW15;
- Turbidity exceeded Guideline value of 0.5 to 10NTUs at five locations, SW4, SW7, SW9, SW14 and SW15.

Compared to the previous round of surface water sampling, completed following heavy rain in November 2007, the following observations are noted:

- PAH concentrations have increased since November 2007 in the barrage on the Hunter River (SW7). Elevated PAH concentrations were also detected in two surface water samples (SW14 and SW15) collected from areas draining surface water off the slag cap in Area 1A. The increase in PAH concentrations in the barrage is considered likely to the due to run-off of PAHs from the 2-coat bitumen seal used to coat the slag cap in Area 1A;

- Ammonia concentrations decreased since November 2007 at SW5, SW7, SW8 and SW9. Ammonia concentrations increased marginally since November 2007 at SW3 and SW4. In the sampling event completed in February 2008, ammonia concentrations were below the Guideline value at the sampling locations analysed;
- TPH C6-C36 concentrations have increased since November 2007 at SW3, SW4, SW5, SW7, SW8 and SW9. TPH C6-C36 concentrations now exceed the investigation level in SW7 and SW9;
- Total cyanide concentrations have increased since November 2007 in the drain on the western boundary (SW5) and the drain outside the Daracon office (SW9). The cyanide concentrations at these two locations now exceed the Guideline value for free cyanide, however, the samples were analysed for total cyanide. The total cyanide concentrations at these two locations are likely to be dominated by complex cyanide, rather than free cyanide because the high iron content in fill material and interaction with ambient oxygen is likely to have oxidised free cyanide present in the water. It is recommended that free cyanide is analysed in the next surface water sampling event to resolve this uncertainty;
- The concentrations of heavy metals are similar in both sampling events. The heavy metals concentrations in the drain outside the Daracon office (SW9) remain elevated compared to other locations.

A comparison of the laboratory results for the surface water sampling events on 28 February and 11 March 2008 to the Guideline values indicates:

- Cadmium concentrations exceeded the Guideline value of 5.5µg/L at one location, SW5;
- Copper concentrations exceeded the Guideline value of 1.3µg/L at five locations, SW3, SW4, SW5, SW7 and SW9;
- Lead concentrations exceeded the Guideline value of 4.4µg/L at four locations, SW3, SW4, SW7 and SW9;
- Zinc concentrations exceeded Guideline value of 15µg/L at five locations, SW3, SW4, SW7 and SW9;
- Benzo[a]pyrene concentrations exceeded the Guideline value of 0.2µg/L at three location, SW3, SW4 and SW7;
- Turbidity exceeded the Guideline value of 0.5 to 10NTUs at five locations, SW3, SW4, SW5, SW7 and SW9;
- Total Petroleum Hydrocarbons (TPH) were detected at four locations, SW3, SW4, SW7 and SW9, but at concentrations below the investigation level of 325µg/L;
- BTEX and free cyanide were reported at concentrations below the relevant laboratory detection limits.

Compared to the previous round of surface water sampling, completed following heavy rain in early February 2008, the following observations are noted:

- PAH concentrations have increased since 5 February 2008 at four locations, the drain outside the administration building (SW3), the drain near the Gatehouse (SW4), the barrage on the Hunter River (SW7) and the drain outside the Daracon office (SW9). The benzo[a]pyrene concentrations at three of these locations, SW3, SW4 and SW7, exceed the Guideline value. The increase in PAH concentrations in the barrage is considered likely to the due to release of PAHs from the 2-coat bitumen seal used to coat the slag cap in Area 1A;

- TPH C6-C36 concentrations from the previous sampling event exceeded the Guideline value in the barrage on the Hunter River (SW7) and in the drain outside the Daracon office (SW9). TPH C6-C36 concentrations were lower at each location in the recent sampling event and the concentrations in SW7 and SW9 do not exceed the investigation level;
- Total cyanide results from the previous sampling event exceeded the Guideline value for free cyanide at two locations, in the drain on the western boundary (SW5) and the drain outside the Daracon office (SW9). Samples were analysed for free cyanide during the recent sampling event. Free cyanide concentrations were below the laboratory detection limit at the five locations sampled;
- The concentrations of heavy metals have generally increased in the drain outside the administration building (SW3), in the drain near the gatehouse (SW4) and in the barrage on the Hunter River (SW7) since the previous sampling event. The cadmium concentration in the drain on the western boundary (SW5) is much higher than in the previous sampling event and is elevated compared to other locations.

A comparison of the laboratory results for the surface water sampling on 22 May 2008 to the ANZECC 2000 Guidelines for the protection of 95% of marine species (Guideline values) indicates:

- Zinc concentrations exceeded the Guideline value of 15µg/L at four locations, SW3, SW5, SW8 and SW9, with a range of 25 to 508µg/L;
- Arsenic concentrations exceeded the Guideline value of 2.3µg/L at SW3 with a concentration of 4µg/L;
- Copper concentrations exceeded the Guideline value of 1.3µg/L at SW9 with a concentration of 13µg/L;
- Lead concentrations exceeded the Guideline value of 4.4µg/L at SW9 with a concentration of 32µg/L;
- Turbidity exceeded the Guideline value of 0.5 to 10NTUs at four locations, SW3, SW4, SW5 and SW9, with a range of 10.9 to 133NTUs;
- Total Petroleum Hydrocarbons (TPH) were detected at one location, SW9, at a concentration of 240µg/L, which is below the investigation level of 325µg/L;
- Benzo[a]pyrene concentration exceeded the Guideline value of 0.2µg/L at one location, SW9, with a concentration of 1.1µg/L;
- BTEX and free cyanide were reported at concentrations below the laboratory detection limits.

Compared to the previous round of surface water sampling, completed following heavy rain in April 2008, the following observations are noted:

- PAH concentrations in the recent sampling event are similar with results below the laboratory detection limits in SW3, SW4, SW5 and SW8. PAH concentrations in the drain outside the Daracon office (SW9) have increased, with the benzo[a]pyrene concentration now exceeding the Guideline value.

- TPH C6-C36 concentrations in the drain outside the Daracon office (SW9) have decreased slightly since the previous sampling event.
- The ammonia concentration in SW5 in the current sampling event is below the laboratory detection limit of 10µg/L, which has decreased from 1,100µg/L on 7 April 2008. Ammonia concentrations at SW3, SW4 and SW8 have also decreased since the previous sampling event.
- The concentrations of cadmium, copper, lead and zinc in SW3, SW4, SW5, SW8 and SW9 have generally decreased since the previous sampling event. The concentration of zinc in SW8 has increased since the previous sampling event from 130µg/L to 508µg/L. The concentration of arsenic in SW3 has increased to 4µg/L since the previous sampling event and now exceeds the Guideline value.

23 SUMMARY AND CONCLUSIONS

The civil works completed for the remediation earthworks activities at the Closure Area of the former BHP Steelworks have been summarised in the Sections above.

The conclusions of this report are based on the Site Auditor requirements described in Section C1.23 of the C-Specification and in Section 3.2 above. A summary and conclusion for each Site Auditor requirement is outlined below.

Ensure that all materials placed within Area 1 comply with the Materials Management Plan

Materials placed within Area 1 were classified in accordance with the Materials Management Plan and the requirements of Section C3.4.3 of the C-Specification, with a classification of Level 1, Level 2 or Level 3.

Level 2 material identified within Area 1 was generally placed in the Level 2 Emplacement Area, aside from Level 2 material identified around Lot 7 near the former Benzol Plant. The survey volume of Level 2 material within the Level 2 Emplacement Area is comparable to the volume of Level 2 material recorded as being transported to Level 2 Emplacement Area in the Materials Tracking Spreadsheet. The location of the Level 2 material left in situ was surveyed for future record and is shown in Figure 6.

Level 3 material identified within Area 1 was generally placed in the Level 3 Emplacement Area, aside from Level 3 material identified around the stormwater drain excavation near the formal Benzol Plant. The survey volume of Level 3 material within each of the four cells within the Level 3 Emplacement Area is comparable to the volume of Level 3 material recorded as being transported to each of the four cells within the Level 3 Emplacement Area. The location of the Level 3 material left in situ was surveyed for future record and is shown in Figure 6.

Level 1 material identified within Area 1 was used in general cut to fill and to fill over the Level 2 and Level 3 Emplacement Areas. Quality assurance testing was completed on the Level 1 material on a 40m by 40m grid, with samples collected at a rate of one sample per 500mm depth of fill material and one sample collected at a depth of 200mm below the design level in areas of cut. The cross sections in Appendix K show that 97.7% of the quality assurance sampling was completed at the specified rate. Five non-conformances were identified through the quality assurance sampling. The five non-conformances were managed in accordance with the Materials Management Plan, as outlined in Section 13.5.1.

Based on the completed materials tracking and the results of the quality assurance testing, it is considered that materials placed within Area 1 comply with the Materials Management Plan.

Ensure the VENM Cap is inert materials in accordance with waste classification guidelines

The VENM cap was constructed with overburden material consisting of weathered siltstone/ claystone or shale from the Buttai Quarry. VENM material imported to site was tracked by Daracon using truck dockets and truck registration numbers. VENM material imported to site was visually checked for conformance by a Coffey Geotechnics technician. No anthropogenic material was observed in the VENM material imported to site. Testing of the VENM material to ensure compliance of the material with the requirements of the C-Specification was undertaken in Coffey Geotechnics Warabrook laboratory and in situ following placement.

Based on visual observations, the VENM cap was constructed of materials that classify as VENM in accordance with the waste classification guidelines.

Ensure Area 1 has a cap that has a permeability of less than or equal to 10^{-9}m/s

Permeameter testing of the bituminous seal of the pavement cap was completed by Coffey Geotechncis using the Northern Territory Government Test Method NTTM 702.1.

Permeability testing of the VENM cap was completed by Australian Geomechanical Laboratories on behalf of Coffey Geotechnics. Permeability testing was completed as falling head tests (Test Method AS1289 6.7.2 KH2) and the reports were NATA certified.

Reports on the pavement cap and VENM cap in Appendix P and Appendix S respectively indicate that both the pavement cap and the VENM cap have a permeability of less than or equal to 10^{-9}m/s.

Ensure the specified cap is of correct thickness

The VENM cap included the construction of a 500mm thick VENM capping layer. The survey plan and accompanying spreadsheet in Appendix R shows that the thickness of the VENM cap varies between 478mm and 553mm. Based on the survey plan and the observations made during the placement of the VENM cap, it is considered that the VENM cap meets the requirements for thickness under the C-Specification.

Section C9 of the C-Specification indicated the pavement cap was to consist of:

- 300mm thick subgrade replacement layer;
- 100mm thick crushed concrete layer;
- High-performance two coat bitumen seal.

The survey data indicates that the subgrade replacement layer is between 255mm and 354mm thick. The survey data indicates that the crushed concrete layer is between 74mm and 135mm thick. Based on the survey plans and the observations made during the placement of the pavement cap, it is considered that the pavement cap meets the requirements for thickness under the C-Specification.

Ensure Area 1 is regarded to be draining and free of ponded areas

Section C9.5 of the C-specification indicates that the crushed concrete layer in the pavement cap in Area 1A is to be trimmed and graded such that ponding on the surface does not exceed 5mm in any location and ponding shall not exceed a surface area of greater than 25m^2.

As indicated in Section 16.7, the thickness of the crushed concrete layer varies between 74mm and 135mm. The crushed concrete layer was constructed within a tolerance of ±26 to 35mm. As the crushed concrete layer was constructed within this tolerance, there should be no areas of ponded water greater than 25m^2 and no exceedence of 5mm based on the design.

Observations of ponded water on the pavement cap made following a rainfall event of 72mm on 3 and 4 June 2008 indicated that the pavement cap was draining as per the design, with no areas of ponded water greater than 25m^2 and no exceedence of 5mm depth of any ponded water observed on 5 June 2008.

Ensure the stormwater drains are isolated from groundwater by suitable barriers

Section C8.2.4 of the C-specification indicates that stormwater controls, including open drains, pits, pipes, culverts and headwalls shall be constructed so that drainage flows are isolated from groundwater. Therefore, conduits are required to be sealed and open drains lined.

As discussed in Section 19.1 and 20.1, the section of the Western Drain and Eastern Drain completed as an open channel drain was lined with a 2mm thick HDPE liner supplied by Curtis Barrier. To prevent puncturing of the liner during placement, the base and sides of the excavation to RL1 were lined with a product called Curtis RN380. Curtis RN380 was also used on the side walls to prevent rocks from puncturing through the liner from above. At the major headwalls at the ends of the open drain and at small headwalls along the drain, terminations in the concrete were sealed with a product called Elock, which is a HPDE material cast within the concrete. The 2mm thick HDPE liner was then welded to the Elock to provide a continuous barrier.

The joints between the pre-cast concrete box culverts within the box culvert section of the Western Drain and Eastern Drain were sealed with a combined joint sealant consisting of external tape wrapping of the joint to prevent ingress of dirt using either Conwrap or Skiaproof 150 as available. A 30mm backing rod was then installed from inside the box culvert and pushed into the joint followed by a round, swellable joint product called Hydrotyte, a hydraulic water stop. Where the backing rod touches the concrete, it was sealed with a product called Leakmaster. Following this, another 30mm backing rod was squeezed into the joint. At the joints on the base of the box culverts, a sealant product called Sikaprimer 3 was used followed by another product called Sikaflex Tank. A product called Sikaflex Pro was used as a sealant on the top of the joints. The bottom of the concrete box culverts had an 80mm diameter hole where they sat on top of the timber piles. A pin was driven into the top of the timber pile to locate the box culvert and then the 80mm hole was filled with a water displacing grout called Sikadur.

Disused stormwater drains in Area 1A and Area 2D were backfilled with sand imported to site from Honeysuckle Drive. The sand was assessed and classified as inert waste.

Four new concrete stormwater pits were poured as complete units and installed in the low area of Area 1A without joints.

Based on the methods used to construct the Western Drain, Eastern Drain and the new stormwater pits and the backfilling of the disused stormwater drains, it is considered that the stormwater drains are isolated from the groundwater by suitable barriers.

24 REFERENCES

NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme. ISBNo0-7313 0177 3

ANZECC (1992) Australian Water Quality Guidelines for Fresh and Marine Waters. Australian and New Zealand Environment & Conservation Council. ISBN 0-642-18297-3.

Netherlands (1994) Environmental Quality Objectives in the Netherlands. Ministry of Housing, Spatial Planning and the Environment, Netherlands Government. ISBN 90-6092-783-4.

URS (2000) Development of a Multi Purpose Terminal and Remediation of the Closure Area, BHP Newcastle Steelworks EIS

Important information about your **Coffey** Environmental Report

Uncertainties as to what lies below the ground on potentially contaminated sites can lead to remediation costs blow outs, reduction in the value of the land and to delays in the redevelopment of land. These uncertainties are an inherent part of dealing with land contamination. The following notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report has been written for a specific purpose

Your report has been developed on the basis of a specific purpose as understood by Coffey and applies only to the site or area investigated. For example, the purpose of your report may be:

- To assess the environmental effects of an on-going operation.
- To provide due diligence on behalf of a property vendor.
- To provide due diligence on behalf of a property purchaser.
- To provide information related to redevelopment of the site due to a proposed change in use, for example, industrial use to a residential use.
- To assess the existing baseline environmental, and sometimes geological and hydrological conditions or constraints of a site prior to an activity which may alter the sites environmental, geological or hydrological condition.

For each purpose, a specific approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible, quantify risks that both recognised and unrecognised contamination pose to the proposed activity. Such risks may be both financial (for example, clean up costs or limitations to the site use) and physical (for example, potential health risks to users of the site or the general public).

Scope of Investigations

The work was conducted, and the report has been prepared, in response to specific instructions from the client to whom this report is addressed, within practical time and budgetary constraints, and in reliance on certain data and information made available to Coffey. The analyses, evaluations, opinions and conclusions presented in this report are based on those instructions, requirements, data or information, and they could change if such instructions etc. are in fact inaccurate or incomplete.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man and may change with time. For example, groundwater levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project and/or on the property.

Interpretation of factual data

Environmental site assessments identify actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from indirect field measurements and sometimes other reports on the site are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of Coffey through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other problems encountered on site.

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Important information about your **Coffey** Environmental Report

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered with redevelopment or on-going use of the site. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. In particular, a due diligence report for a property vendor may not be suitable for satisfying the needs of a purchaser. Your report should not be applied for any purpose other than that originally specified at the time the report was issued.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other professionals who are affected by the report. Have Coffey explain the report implications to professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), field testing and laboratory evaluation of field samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Contact Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to land development and land use. It is common that not all approaches will be necessarily dealt with in your environmental site assessment report due to concepts proposed at that time. As a project progresses through planning and design toward construction and/or maintenance, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Environmental reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

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REGIONAL LAND MANAGEMENT CORPORATION

PRELIMINARY DESIGN STORMWATER STRATEGY

Issue No. 2
AUGUST 2006

Patterson Britton
& Partners Pty Ltd
consulting engineers

REGIONAL LAND MANAGEMENT CORPORATION

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Document Amendment and Approval Record

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level 4
104 Mount Street
North Sydney 2060

PO Box 515
North Sydney 2059
Australia

telephone: (02) 9957 1619
facsimile: (02) 9957 1291
reception@patbrit.com.au
ABN 89 003 220 228

Newcastle Office
8 Telford Street
Newcastle East 2300

PO Box 668
Newcastle 2300
Australia

telephone: (02) 4928 7777
facsimile: (02) 4926 2111
mail@newcastle.patbrit.com.au

Patterson Britton & Partners Pty Ltd

consulting engineers

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1 INTRODUCTION

1.1 BACKGROUND

Patterson Britton and Partners (PBP) was engaged by Regional Land Management Corporation (RLMC) to undertake a preliminary design of the site earthworks and site drainage that forms the remediation works for the entire 120 ha closure area at the former BHP site in Mayfield. **Figure 1** shows the site locality, including the extent of the closure area.

A requirement of RLMC was that the preliminary design be consistent with the general stormwater strategy as previously agreed to by Newcastle City Council (NCC) as well as other regulatory authorities.

Stage 1 of the remediation works includes construction of the major trunk drainage infrastructure. Detailed design of this drainage infrastructure is being undertaken by PBP. Stage 2 of the remediation works, including internal roads and drainage, is expected to occur synergistically with development, and as such only a preliminary design of these stormwater components was required by PBP. However, it was critical to ensure that the earthworks design grades are compatible with future road grades and stormwater drainage, which are in turn compatible with the trunk drainage infrastructure which will be constructed 'up-front'. This stormwater strategy therefore accompanies the preliminary design and documents preliminary designs for both roads and stormwater networks to prove that the proposed earthworks design is compatible with technically viable solutions for the future roads and associated drains.

1.2 ASSOCIATED DOCUMENTATION

A number of previous flood studies and stormwater strategies have been undertaken for the site. The most recent was prepared to accompany the concept design prepared by Parsons Brinckerhoff. It is not the intention of this report to replicate in detailed the information previously provided, as such, it is recommended that this report be read in conjunction with the following:

- *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*
- *Addendum to Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2005*
- *Preliminary Design – Design Report (Patterson Britton and Partners), July 2006*

The following information contained in the previous stormwater strategy documentation remains unchanged, and has in general not been discussed further in this strategy:

- RLMC stormwater objectives
- Existing site conditions
- Existing drainage conditions
- Receiving water levels
- Previous Stormwater strategies (prepared by GHD, Hatch)
- NCC design criteria current at the time of previous reports

- Other design issues and constraints current at the time of the previous reports, including:
  - topographic characteristics
  - tidal inundation
  - site contamination
  - site capping
  - existing flooding

These 'other' design issues are best understood by reviewing the *Preliminary Design – Design Report (PBP), July 2006*, which covers the design constraints in detail.

The following items, which were contained in earlier stormwater strategies, have either been varied or significantly changed, and as such, this report supersedes all previous discussion of these issues:

- Site masterplanning (including potential changes to the Multi Purpose Terminal, MPT)
- NCC road and stormwater design criteria
- Preferred Stormwater Strategy, including key stormwater components and concept design

All stormwater modelling and system performance have been updated for this strategy. It is noted that it is not the intention of this report to assess or compare various options, merely to present the preferred strategy as determined as part of the design process.

1.3 AVAILABLE DATA

The following data was used for this stormwater strategy

- Previous reports as outlined in Section 1.2
- Aerial photos supplied by RLMC
- Services and structures locations plan prepared by PBP (May 2006)
- Correspondence and meetings with NCC
- Aerial survey undertaken by Hatch and supplied by RLMC
- Detailed survey along preferred drain alignments undertaken by Monteath and Powy's
- Revised site masterplan supplied by RLMC
- Preliminary design drawings for the entire closure area, as prepared by PBP as part of this engagement

1.4 SITE MASTERPLANNING

Details of site masterplanning are contained in the report: *Preliminary Design – Design Report (PBP), July 2006*. Key points include the following:

- The proposed MPT is currently not proceeding.
- The rail alignment through the site has been revised from earlier reports. This rail is to be constructed towards the end of Stage 2 works, and the existing rail line through the site into the One-Steel property will be removed at such time.
- RLMC has revised the internal masterplan (in particular, road layouts) throughout the preliminary design process. The overall earthworks design accommodates the current internal

masterplan. This impacts on stormwater drainage within the site, in particular, those sections to be constructed in the 'future'

1.5 NCC DESIGN CRITERIA

Site specific design criteria advised by NCC were adopted for the preliminary stormwater system design. Details of Councils design criteria, including the preferred approach for roads, are contained in the report: *Preliminary Design – Design Report (PBP), July 2006*. Key points include the following:

- Open channels are to be adopted as a 'green solution'. NCC advised that a preference for the use of mangroves, and cited a drain near Elizabeth Street, Carrington as an example.
- Manning's 'n' of 0.1 for mangroves is conservative.
- A tailwater of 0.8m AHD (spring high tide) for the 1 in 100 year Average Recurrence Interval (ARI) flood event (across the site) is appropriate. This should be compared to a 1 in 100 year ARI flood event based on a storm surge tailwater (1.34m AHD) with a 1 in 10 year ARI rainfall event across the site. Further discussion of this is provided in Section 3.3.
- Flap valves to prevent tidal inundation of the stormwater system should be located at the upstream end of open channels to provide ease of access and maintenance.
- Intentions of DCP 50 are to be followed for roofs only (using above ground tanks) due to capping of the site and possible issues resulting from breaching the cap. For each lot:
  - Assumed 60% roofs (of which 60% captured and released slowly as per DCP 50), therefore equivalent percentage impervious = 24%.
  - Remaining 40% (not roofs) would be 75% impervious, therefore equivalent percentage impervious = 30%. Adopting an additional 20% (to be conservative) gives an equivalent percentage impervious = 36%.
  - Total equivalent percentage impervious = 24% (roofs) + 36% (rest) = 60% (total).
- Minimum pipe slopes of 0.3% are to be adopted, whilst 0% longitudinal grade is permitted n the major trunk stormwater drainage.
- Grassed batters for swales would be maintained by boom-style mowers, and as such no minimum slope is required. NCC do not have minimum slopes from a safety perspective, and recommended LMCC guidelines be considered.
- Swales for treating stormwater are acceptable. Swales may undulate if required.
- If slag is used in the construction of major stormwater channels, testing is to be undertaken to demonstrate no leachate into the water.
- Velocity depth relationship of 1.0 is acceptable during the 1 in 100 year ARI flood event.
- Acceptable to run water along swales as well as roads and footways during major events.

Additional design criteria reported in previous strategies (*Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*) include:

- Trunk drainage designed for the 1 in 100 year ARI flood event
- Wet detention basins to have side slopes no steeper than 1V: 3H.
- Consideration is to be given to pipe blockage including risk of blockage, design features to minimise the risk of blockage, and storage effects.
- No exacerbation of existing flooding along Selwyn Street.
- Peak flow mitigation not required due to proximity to harbour.

2 STORMWATER STRATEGY

2.1 GENERAL

As outlined in Section 1.1, the stormwater system has been considered in two major components:

- Trunk drainage infrastructure, to be constructed as part of Stage 1 remediation works. Detailed design of this drainage infrastructure is being undertaken by PBP.
- Road and lot drainage to be constructed as Stage 2 of the remediation works, and will occur synergistically with development in the future. Since the future layout of development is not certain, only a preliminary design of road and lot drainage is required.

Whilst it is critical that these components be considered simultaneously to ensure a technically viable solution, it is equally important that the strategy does not lose sight of the fact that future development will dictate Stage 2 drainage design, and it is not possible to pre-empt the preferred stormwater solution.

As such, it is emphasised that the preliminary design within stage 2 areas demonstrates one possible solution that meets the design criteria. Refinement of that preliminary design will occur as part of the detailed design process for Stage 2 works.

An overall staging plan of the proposed stormwater components is presented in **Figure 2**, and details of the Stage 2 stormwater components are shown in **Figure 3**.

2.2 STAGE 1 STORMWATER COMPONENTS

The Stage 1 trunk drainage infrastructure includes the following:

- **Eastern (Selwyn Street) channel** – this includes an open channel located between Selwyn Street and the adjoining rail land. The channel will start east of the administration area where the current open channel is located. A culvert will convey stormwater beneath Selwyn Street to Newcastle harbour.
- **Eastern channel wet basin** – located in RLMC land just upstream of the eastern channel. The basin will be connected to the eastern channel via a series of culverts beneath Selwyn Street.
- **Western channel** – this includes an open channel located on RLMC's land parallel to the boundary with the One-Steel site. Stage 1 of the channel will start north of the 'future' Road 2 at the point where the rail line passes into One-Steel land. A culvert will convey stormwater beneath the Koppers pipeline and proposed rail to Newcastle harbour.

A low-point within the Area 1 design landform requires a culvert to drain this area direct to the waterfront. Drainage of this area will be done using a 'temporary' pipe, with future developers of the wharf area to construct an appropriately sized culvert as required.

2.3 OPEN CHANNELS

The flat nature of the site allows open channel drainage to be an economic and appealing solution to alleviate flooding and convey stormwater from the site. The use of open channels is possible since the trunk drainage has been located at the edges of the site, and therefore will not impact on future land uses (such as port-related operations). The key design objectives of the channels are as follows:

- Convey stormwater generated on site to Newcastle Harbour (receiving water)
- Isolate the stormwater from the local groundwater table
- Improve water quality and provide aquatic habitats where possible
- Provide maintenance access where necessary
- Provide an aesthetically appealing drainage solution
- Minimise construction costs and spatial requirements

The open channels have been designed to provide adequate hydraulic conductivity while meeting the other design objectives. Plans showing the general arrangement and typical sections of the Eastern (Selwyn Street) Channel are detailed in **Figures 5 & 6**, and the Western Channel in **Figures 7 & 8**.

Both the Eastern and Western channels share common design philosophies. The design for these channels will be linear estuarine (tidal) wetland systems incorporating the translocation of mangrove plants to colonise the intertidal shallows of the wetland. The channels will incorporate a shallow estuarine zone, consisting of an open water channel (constantly inundated through placement of a weir at the channel's downstream end to maintain permanent water at low tide) fringed by a shallower, sloping, intertidal mangrove beds for water quality and visual amenity. Deep water sedimentation zones throughout the estuarine channel will assist with maintenance and maximise water quality outcomes.

In order to prevent contamination from groundwater into the drainage system it is proposed to line the channel with a welded HDPE liner. The liner will be armoured to prevent accidental rupture. The centre channel has been designed to ensure it is wide enough to drive a 'bob-cat' excavator down as part of maintenance requirements.

Localised studies and expert opinion are necessary to determine the tidal levels best suited to mangrove growth in the channel. Levels of the shallow mangrove beds have been discussed in consultation with local mangrove experts from the Kooragang Wetland Rehabilitation Project (Hunter-Central Rivers Catchment Management Authority) as the exact levels of the intertidal zone conducive to mangrove growth is extremely variable from site to site.

The preliminary design for the linear estuarine wetland contains limited hydraulic control structures in an attempt to minimise the attenuation of the flood tide up the channel, which will be vital to the health of the estuarine wetland system. Detailed design will determine whether the placing of intermediate hydraulic controls *(eg. rock riffle weir structures)* is necessary in balancing flooding, water quality and estuarine wetland health objectives.

2.3.1 Eastern Channel

Conceptual details of the Eastern (Selwyn Street) Channel are provided in **Figures 5 & 6.** The Eastern channel comprises 770m of open channel with a variable width of approximately 13 metres. Along most of the alignment the channel is located within the existing Selwyn Street road reserve. At present, there is an existing drain along a partial length of the proposed channel alignment which drains Selwyn Street, parts of the former Steelworks site, the Morandoo sidings, Industrial Drive, and some of the urban area next to industrial Drive. The proposed works will improve the conveyance of the existing drainage system along Selwyn Street and alleviate flooding issues with Selwyn Street, the former Steelworks site and the Morandoo sidings.

and as such, the proposed channel would augment existing NCC infrastructure. This is advantageous as the trunk drainage is to ultimately become a NCC asset.

The open channel has been designed with 1V: 2H lightly vegetated batter slope from Selwyn Street enabling a more naturalistic channel edge treatment (grassed slope) before the commencement of the mangrove beds. Some sections of steeper slopes (1:1 maximum) will be necessary with gradual transition zones in between. This batter slope will meet a 2.5m wide bench at RL 0.3m AHD, located in the intertidal zone which will be planted with mangroves. A small rock retaining wall (1V: 1H) will provide the transition between the mangrove bench and the open channel, which is to have an invert level of -0.2 m AHD. The base width will vary around 3.0m, with a stacked rock wall (or similar) battering up at 1V: 1H (or at some locations steeper) to the ARTC boundary fence. Preliminary construction details are provided in **Figure 8**.

The channel, as viewed from Selwyn St, will have a landscaped appearance with the open water zone, eastern bank and adjoining ARTC land being obscured by the controlled proliferation of mangrove growth with a grassed slope in front.

A select number of deep water zones (with and invert at -0.5m AHD) are to be located within the channel to promote settlement of sediments and specific points for maintenance. There is an access road over the existing channel to ARTC land approximately 300m from the start of the channel. This access point would be augmented for the new channel. Deep water maintenance zones are located upstream and downstream of the ARTC culverts to prevent mangrove and weed growth around the culvert structure inlet and outlet and to assist in water quality objectives. ARTC has advised other access points may need to be included. Deep water maintenance zones are located at either end of the channel to accommodate the movement of sediment during incoming and outgoing tides.

Importantly, the Eastern channel has been designed to accommodate a future widening of Selwyn Street. The location of the channel allows a set widening of the existing road reserve into RLMC's site to provide a standard 13m pavement width plus 4.5m shoulder.

2.3.2 Western Channel

Conceptual details of the Eastern (Selwyn Street) Channel are provided in **Figures 7 & 8.** The design of the Western Channel was adopted from that of the Eastern Channel, without the width restriction that constrains the Eastern Channel design. The Western Channel comprises 470 metres of open channel (in Stage 1) with a variable width of approximately 18 meters. The channel will be located adjacent to One-Steel land to the west. It is expected that a future road would be constructed along the eastern length of the channel to provide access points for maintenance.

Like the Eastern Channel, the Western Channel has been designed with 1V: 2H lightly vegetated batter slopes on both sides, however a slightly wider 3.0m mangrove bench will be provided, gently sloping from RL 0.3m AHD to RL 0.6m AHD on the eastern side of the channel. A small rock retaining wall (1V: 1H) will provide the transition between the mangrove bench and the open channel, which will also have an invert level of -0.2 m AHD. The base width of the channel is 4m. The Western Channel will also include a select number of deep water zones to promote settlement of sediments and specific points for maintenance. Preliminary construction details are provided in **Figure 8**.

2.3.3 Water Quality Benefits

A downstream weir in both channels will keep a permanent water level in the channel at RL 0.1m AHD during low tide periods. During high tides, the proposed open channels will be subject to frequent tidal inundation. As the tide cycles, stormwater within the open channels will mix with tidal water and inundate the mangrove bench, where some nutrient uptake will occur. The water quality benefits of mangroves are not well documented, therefore the mangrove systems are expected to provide a final polishing of stormwater only. Further details on water quality are provided in Section 5.5.

The permanent pool (0.3m deep) created by the weir at the downstream end of the channel will also provide significant stormwater attenuation during water quality events (such as the 3 month ARI storm event). The low flow velocities in the channel will allow sufficient time for large to medium particles to settle out of the stormwater. These particles will collect in the deep water sections.

2.3.4 Common Design Considerations

To minimise potential ingress of saltwater into the upstream wet basins and stormwater network, tide flaps will be installed at the upstream end of the open channels, where culverts from the site discharge into the open channels. These locations will assist with maintenance of the tide valves, whilst allowing the open channels to remain tidal. It is noted that only the tide valve at the start of the Eastern Channel would be constructed in Stage 1.

Channel maintenance is critical to ensure their continued functionality. Vehicle access will be provided to each deep water section to allow for a small excavator to easily remove retained sediments. Stop boards above the downstream weir would be used to prevent tidal inflows during maintenance, and permanent water would be removed by pumping.

Complicating the design is the high groundwater table beneath the liner. This causes buoyancy issues should the channel be emptied (such as during maintenance). As such a large dense base (likely mass concrete) is required to prevent uplift of the channel. A mass concrete base has numerous advantages, including a robust system for protecting the underlying liner, reduced potential for reed growth, a hydraulically smoother surface for conveying flood flows, and a significant reduction in the potential for mangrove invasion of the channel.

2.4 CULVERTS TO HARBOUR

Culverts have been adopted for the conveyance of stormwater through port related land, and hydraulically connect the upstream channels to Newcastle Harbour. The culverts are to be tidal, and follow on at zero grade from the upstream channels. The design philosophy of these culverts was as per the pervious stormwater strategy *Addendum to Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2005*.

2.4.1 Eastern Channel Culverts

The Eastern Channel culverts consist of approximately 150m of twin 2.8m wide x 2.1m deep rectangular culverts. The culverts will pass beneath Selwyn Street and discharge into Newcastle Harbour.

2.4.2 Western Channel Culverts

The Western Channel culverts consist of approximately 250m of twin 2.4m wide x 2.1m deep rectangular culverts. The culvert will require two bends along its length. The culvert will pass beneath the Koppers overhead pipeline and discharge into Newcastle Harbour. The culverts may be extended in the future to accommodate new wharfs. Interaction of the western culvert and with the proposed railway and Koppers overhead pipeline warranted the extension of the culvert upstream to allow vehicular access between the open channel and railway.

The western culvert will discharge into the area referred to as BHP's contaminated sediments. As such, the concept design shows the culvert outlet directed away from the sediments to reduce the risk of disturbance. It is noted, however, that BHP may remove these sediments, and as such the final alignment of the culvert may vary.

It is noted that the final design may extend the open channel through to the waterfront with no culverts. This would allow future users of the port related land to replace the open channel with culverts, designed in combination with pavements to suit the soft underlying sediments in that area, particularly in the location of the former "Platts Channel".

2.4.3 Common Design Considerations

A headwall will direct flows into each culvert, however no outlet headwall into the harbour is expected to be required. The culvert outlets are required not to restrict future wharf construction.

It is expected that settlement within the filling and underlying soft estuarine clays could lead to distress of the culverts, and as such, piling of the culverts is preferred to minimise the likelihood of damage.

The culverts may be subject to port related loads. These could be as high as 95 tonne axle loads. It is expected that the detailed design of these culverts will assess more accurately the likely loads to ensure their structural stability during large future loads.

The culverts will not be easily accessible in the port related land. As per the previous concept design, it is not expected that these culverts would be maintained, and have been designed accordingly. Additionally, the durability of reinforced concrete drainage infrastructure in the inter-tidal zone needs to be considered as part of detailed design.

2.5 EASTERN BASIN

Stage 1 of the remediation works will involve the construction of the eastern wet basin for water quality purposes. This basin will primarily act as a sediment basin until development of the site, when it will ultimately serve a water quality function. The basin is shown in **Figure 3**. Further details of water quality are provided in Section 5.4.

The east basin is to have an invert at RL -0.5m AHD, with 1V: 3H batter slopes. The permanent water level in this basin would be RL 0.1m AHD, equal to the permanent 'low-tide' water level in the Eastern (Selwyn Street) Channel.

Like the open channels, the basin would be lined, and the high groundwater table would cause buoyancy should the basin be emptied (such as during maintenance). The basins would therefore also require a large dense base (likely mass concrete) to prevent uplift. The mass concrete base could still have an earth layer with macrophytes to improve water quality, whilst ensuring a reliable design that protects the underlying liner.

2.6 STAGE 2 STORMWATER COMPONENTS

The Stage 2 drainage infrastructure may include the following components. These may be undertaken in line with development of the site, and as such their final form may vary from that recommended in this strategy:

- **Extension to Western Channel** – this includes extending the western channel upstream to the 'future' Road 2, once the existing Morandoo sidings to One-Steel railway line is removed.
- **One-Steel Wet Basin** – located on the southern side of the 'future' Road 2, the existing basin (which will provide sediment control during Stage 1 works) would be upgraded and formalised into a wet basin with detention storage. High flow culverts beneath this 'future' Road 2 would connect the basin to the extended Western Channel.
- **Selwyn Street Dry Basin** – located near the intersection of Selwyn Street and Industrial Drive, existing landscaped mounds would be shaped to provide detention storage and reduce the flows that contribute to flooding along Selwyn Street.
- **Internal Roads and Drainage** – this would include the stormwater system as shown in the preliminary design for the current masterplan. The stormwater system includes conventional stormwater drainage, open channels / swales for conveying high flows, and large culverts beneath future roads.
- **Future Port Related Development Drainage** – this would include all stormwater drainage for port related land, being the area in front of the proposed railway line. This area would drain separately and peak flows have not been catered for in Stage 1 or Stage 2 infrastructure.

Stage 2 stormwater components are shown in **Figures 2 and 3**.

2.6.1 Extension to Western Channel

The extension to the Western Channel would be from the limit of Stage 1 works, upstream to the 'future' Road 2, once the rail line into One-Steel is removed. The extension to the channel would be similar to the Stage 1 Western Channel, however it would be primarily a deep water zone in this region. As such, there would be no mangrove bench for this section of channel.

The extension to the Western Channel would include the installation of tide valves adjacent to the future' Road 2. It is possible that the future extension to the western channel be done using culverts, and such options should be left open.

2.6.2 One-Steel Wet Basin

At present, there is an existing basin, referred to as the 'One-Steel Basin' located on the southern side of the 'future' Road 2. In Stage 2, this basin is to be upgraded and formalised into a wet basin with detention storage. High flow culverts beneath this 'future' Road 2 would connect the basin to the extended Western Channel (with tide valves at the outlet as mentioned in the previous Section).

The basin design would be similar to the Stage 1 Eastern Basin. It is proposed that the basin have an invert at RL -0.5m AHD with 1V: 3H batter slopes. The permanent water level in this basin would be RL 0.1m AHD, equal to the permanent 'low-tide' water level in the Western channel. The same issues of buoyancy, macrophytes and water quality apply as per Section 2.5.

As this basin is to be constructed as part of Stage 2 works, the location of this basin may be adjusted to suit future development in the area.

2.6.3 Selwyn Street Dry Basin

Existing landscaped mounds near the intersection of Selwyn Street and Industrial Drive provide an opportunity to provide dry detention storage at this location. Minimal earthworks would be required to construct the basin, which would be used to provide detention storage, thereby reducing the flows that contribute to flooding along Selwyn Street. Flows from Industrial Drive would be required to be directed into this basin. At this stage, an indicative design of this basin only has been undertaken.

2.6.4 Road and Lot Drainage

A preliminary concept design was undertaken for the internal roads and drainage, based on the current site masterplan provided by RLMC. As the roads and lots are going to be constructed concurrently with future development (Stage 2) the intent of this design is to demonstrate that there is a feasible stormwater solution. It is expected that a detailed design of the road and lot drainage will be completed in the future.

The conceptual road and lot drainage design utilises a combination of open swales as well as pit and pipe networks. Key components of the system are outlined below:

- Where possible, conventional piped stormwater drainage has been adopted in combination with a conventional, crowned industrial road cross section. To assist with cover over the flat site, minimum pipe slopes of 0.3% were adopted as per NCC advice (Section 1.5).
- Compliance with DCP 50 was limited to land west of the proposed rail line (and between the rail and Selwyn Street), with all 'port land' assumed to be un-detained and 90% impervious.
- Grassed open swales were used along future Road 2 and Road 5, and behind the heritage buildings. These roads are characterised by one-way cross-falls and low (at times zero) longitudinal grades. **Figure 9** provides a preliminary design of this.
- Roads 2 and 5 utilise existing pavements where possible, however pavement overlays will be required in many instances. Stormwater modelling indicated that Administration Drive (Road 5) is required to be raised to provide flood free access.
- Flat existing roads combined with minimum pipe slopes reduce cover over pipes to less than the generally accepted minimum. As such, culverts may need to replace stormwater pipes in some locations.
- Compliance with DCP 50 would be in the form of above ground systems (such as rainwater tanks) and would attenuate runoff from roofed areas within lots. Grassed swales, the East Basin and One-Steel basin, plus the tidal mangrove lined channels would provide the remaining water quality controls. Due to the likely nature of future development, it is expected that many lots would have licensed discharges and require their own on-site stormwater treatment systems.
- Tide valves would keep salt water from intruding into the stormwater system, and pipes would remain permanently wet around the small water quality control ponds.
- A splitter pit near the One-Steel basin would ensure low flows are piped into the basin, with high flows by-passing into the Western Channel.
- The open swale behind the heritage buildings is located within a low point on the regraded bulk earthworks topography, however this swale location may be varied depending on the ultimate earthworks design in this area.

Open swales are proposed along the flat sections of Roads 2 and 5 as well as behind the heritage area. The swales were designed to the following design criteria:

- Peak Velocity Depth product during a 1 in 100 year ARI flood event is to be less than 1.
- It is expected the swales will be lined to prevent stormwater infiltration into the local groundwater.
- Swales with inverts below the estimated ground water table will be sufficiently weighted to counter buoyancy forces.
- Low flow drainage will be provided to drain flat sections of swales.
- A small (approximately 150mm) freeboard was provided for the swale adjacent to Road 5. This allows depressions in the footway to be designed for controlled overflows into the administration precinct during rare flood events.

The swales are to be grassed and have been designed with batter slopes of 1V: 2H (adjacent to roads) and 1V: 3H behind the heritage buildings. The swales were permitted to undulate to assist drainage and prevent the formation of deep swales. The swales were designed to convey major flows, and would connect to a low-flow underdrain system to ensure the swales are adequately drained and do not become boggy. The swales were sized for conveyance but may also provide some treatment of stormwater. The swales would convey stormwater once the underdrain system reaches capacity and surcharges into the swale.

2.6.5 Future Port-Related Drainage

Detailed design of port-related drainage will not be undertaken until port uses are established. A conceptual drainage design was prepared to ensure the overall site preliminary design met drainage requirements.

An unavoidable low-point within Area 1 requires a culvert to drain this area direct to the waterfront. During Stage 1 remediation works, drainage of this area will be via a 'temporary' pipe. Ultimately, a larger culvert will be required, and the preliminary design suggests future developers of the wharf area will require a 2.4m wide x 1.9m high culvert to drain peak flows (without any ponding).

Southeast of Area 1, the proposed railway line will act as a catchment boundary, with stormwater from the port areas conveyed o a low point near the eastern end of Selwyn Street. A culvert parallel to the Stage 1 Eastern Drain culvert would need to be constructed (in Area 2E) by future developers of the waterfront, and would be maintainable by others. The preliminary design suggests this culvert would be 2.7m wide x 1.9m high culvert to drain peak flows (without any ponding).

3 HYDRODYNAMIC MODELLING PARAMETERS

3.1 CATCHMENT PLAN

A catchment plan was prepared for the preliminary site grading design and is shown in **Figure 4**. Offsite contributing areas identified in previous investigations (*Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*) were adopted, and where necessary, were modified to accommodate changes to the stormwater strategy.

A large portion of the site contributes to the Eastern and Western Channels, these areas are referred to as the Eastern and Western catchments respectively. Areas adjacent to Newcastle harbour in the northeast portion of the site will drain directly into the harbour and are identified as Port Areas 1, 2 and 3. Catchment boundaries are located in **Figure 4**. The total contributing area of each catchment is summarised in **Table 3.1.**

Table 3.1 – Contributing Catchment Areas

Catchment	Total Contributing Area (ha)
Eastern Catchment	96
Western Catchment	56
Port Area 1	20
Port Area 2	9
Port Area 3	25
Total	**206**

The combined area of all catchments is 206 ha, which conservatively exceeds the 195 ha area identified in previous reports.

3.2 HYDROLOGY PARAMETERS

The RUNOFF mode of XP-STORM was used to estimate the hydrographs for each subcatchment. The Laurenson routing method was adopted for the routing of excess rainfall to each subcatchment outlet.

3.2.1 Subcatchment Properties

Figure 4 presents the adopted subcatchment plan. A summary of subcatchment properties applied to the RUNOFF model are detailed in **Appendix A.** This data includes subcatchment areas, average slopes and impervious area fractions.

Subcatchment impervious fractions reflect the proposed land use. In general, all areas to the east of the proposed rail embankment are assumed to be port facilities. Areas to the west of the rail embankment are assumed to be used for other industrial and commercial purposes. All off-site subcatchments adopted the impervious fractions recommended in previous reports. **Table 3.2** summarises the assumed impervious area fractions for each land type.

Table 3.2 – Impervious Fractions for Land Types

Land Type	Percentage Impervious
Port Facilities	90 %
Future Industrial Development	60 %
Existing Administration Area *	90 %
Emplacement Area *	10 %
Rail Siding *	10 %
Existing Development *	25 – 50 %

* Data extracted form *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*

The following runoff loss models were adopted from the previous report, *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*:

- Pervious off site model;
- Pervious on-site model; and
- Impervious model.

Each runoff loss model defines the initial and continuing loss rates as well as the overland flow roughness. The adopted values for each loss model are summarised in **Table 3.3.**

Table 3.3 – Runoff Loss Models

Loss Model	Initial Loss (mm)	Continuing Loss Rate (mm/hr)	Manning's 'n'
Pervious Off Site	15	4	0.080
Pervious On Site	4	1	0.080
Impervious	1.5	0	0.015

It is noted that the on-site pervious loss model has significantly reduced initial and continuing loss rates due to the proposed clay capping layer which is required as part of the site remediation strategy.

3.2.2 Design Rainfall

Design rainfall pluviographs for a range of storm durations and recurrence intervals were generated by the XP-STORM software. Average rainfall intensities and temporal patterns recommended for Newcastle in the Australian Rainfall & Runoff (AR&R, 1987) were adopted.

3.3 FLOODING SCENARIOS

The flat nature of the site, with its proximity to Newcastle Harbour, means there are numerous flooding scenarios that could affect the site. Flooding within the site could occur from:

- Runoff resulting from local rainfall
- High water levels in Newcastle Harbour; or
- A combination of the above.

Council requires the 1 in 100 year ARI flood event to be considered as the design flood event. The following flooding scenarios were conjointly developed with Council to represent conservative flooding scenarios:

- **Scenario 1 - A rainfall dominated event** – A 1 in 100 year ARI rainfall event coinciding with a constant (non-varying) 0.8m AHD elevation in Newcastle Harbour, representing a typical high tide. In all simulations the critical duration storm event was assessed and adopted as the design storm. Adopting a constant high tide tailwater is considered to be conservative, and would arguably have an ARI exceeding the 1 in100 year ARI flood event.

- **Scenario 2 - A tidal dominated event** – A rainfall event coinciding with a variable tidal tailwater in Newcastle Harbour which peaks at 1.34m AHD (1 in100 year ARI water elevation in Newcastle Harbour). This peak tailwater level is associated with a storm surge. Significant storm surges are induced by the passage of large low pressure systems, in which a combination of high winds, large waves and low atmospheric pressure temporarily forces an elevated ocean water level along the coastline above that of the day to day astronomical tide. While low pressure systems often bring heavy rains they are generally similar to the longer duration storms. Additionally, storm surges usually occur prior to the heaviest rainfall associated with low pressure systems. As such, a six hour 1 in 10 year ARI rainfall event was chosen (rather than a critical storm event) to represent the rainfall during a storm surge tide. These two events were conservatively timed so that the peak runoff occurred simultaneously with the peak tailwater level. This is considered to be conservative, with a probability exceeding the 1 in 100 year ARI flood event.

Both of the above conservative flooding scenarios were simulated when assessing the hydraulic performance of the stormwater system. In all cases the highest water level (representing the worst case scenario) was adopted as the design flood level.

It is noted that NCC advised that an assessment of floods rarer than the 1 in 100 year ARI flood event was not required (such as the probably maximum flood, PMF), as the site will be industrial in nature. Additionally, flooding from the Hunter River is considered separate to the above scenarios. It is noted that a flood model developed by Paterson Britton and Partners of the Lower Hunter River estimates a peak 100 year flood level at 1.35m AHD in the harbour adjacent to the site. This included a conservative constant high tide tailwater, which would in fact vary as per Scenario 2. Therefore, it can be assumed that a Scenario 2 simulation would be indicative of a 1 in 100 year Hunter River flood dominated event.

3.4 HYDRAULIC PARAMETERS

Stormwater conveyance was modelled using the hydraulics layer in XP-STORM. The Dynamic Wave Equation was used to estimate stormwater conveyance and storage in all conduits and nodes (storage nodes only). This section summarises hydraulic parameters and outlines the modelling methodologies used in the XP-STORM stormwater model.

3.4.1 Initial Conditions

Dynamic tidal tailwaters and the use of tidal flap valves make the initial conditions complex. The tidal flap valves prevent tidal inundation upstream of the valve. As most of the stormwater modelling was conducted with high tidal tailwaters it was important to ensure that all basins and swales upstream of tidal flap valves are 'empty' (at permanent water level) at the start of the model. This was achieved by creating 'hot start' files. The 'hot start' files were created using the following methodology:

1. Simulate a minor storm (1 year event) with a tailwater at RL 0 to ensure all basins are filled to the permanent water level.
2. The model is then run until it reaches steady state (ie basins drain to permanent water level).
3. The tailwater level is then raised to simulate a high tide as per Scenarios 1 and 2. The tidal flap values prevent any tidal ingression into the basins.
4. The model is run for the new conditions until the system reaches steady state.

The steady state conditions created by the 'hot start' file are used as the initial conditions for the model simulations.

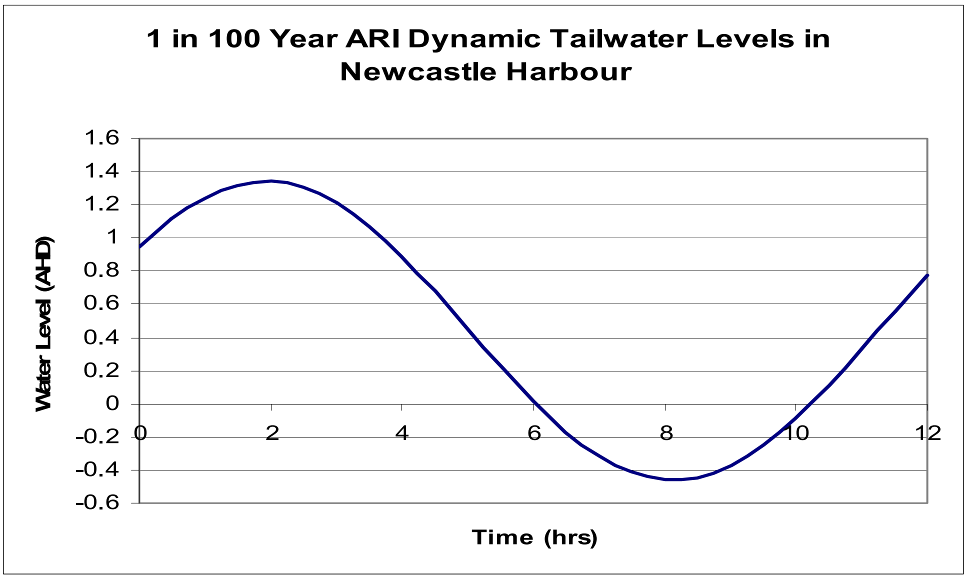
3.4.2 Tailwater Boundary Conditions

Newcastle Harbour represents the downstream boundary of the study area. The hydraulic conveyance of the stormwater system is influenced by the tidal levels in the harbour.

As described in Section 3.3, a constant tidal tailwater was adopted for ***Scenario 1*** simulations, however, a dynamic tidal tailwater was used for longer duration storms in ***Scenario 2*** simulations involving storm surge dominated flooding events. For the tidal simulation, A 12 hour time variable tidal level was developed using the following equation:

$$Water\ Elevation\,(m\ AHD) = A + a\cos(\omega t) + S$$

where A is the mean water level height (assumed to be 0.05m AHD), a is the tide amplitude (0.9m), ω is equal to 2π / T where T is the tide period (12.42 hours) and t is the time variable. S represents the storm surge which is independent from the tidal cycle. S is conservatively assumed to be a constant 0.39 meters. The following illustration shows the dynamic tidal water levels adopted for ***Scenario 2*** two flooding simulations.



3.4.3 Open Channels

The preliminary stormwater design features large open channels. Channel geometry and Manning's roughness parameters were imported in to the XP-STORM model from 12D (CAD software) at 20 metre intervals. This incorporated minor longitudinal variations in cross section along the eastern channel due constraints (refer Section 2.3.1). Proposed channel geometries for both the Eastern (Selwyn Street) and Western Channels are detailed in **Figures 5 & 6** (Eastern Channel) and **Figures 7 & 8** (Western Channel).

The proposed channel design comprises a variety of surfaces including mangroves, grassed / landscaped and rock lined channel banks, and a concrete lined channel bed, as shown in **Figure 8**. As there is significant variability in the roughness of these surfaces it is necessary to assign the appropriate Manning's roughness parameter to each surface type. The following Manning's 'n' roughness parameters were adopted in the channels:

- 0.02 – For the concrete lined permanent water section of the channel. This value is recommended in the HEC-RAS Flood Manual for 'concrete lined channels';
- 0.035 – For both rock-lined and grassed channel banks. This value is recommended in the HEC-RAS Flood Manual for these types of surfaces;
- 0.08 – For the Mangrove bench and the landscaped and vegetated channel banks. This value was based on a field and numerical modelling study undertaken on a highly vegetated mangrove swamp in Cairns *(Furukawa, Wolanski and Mueller (1995), "Currents and Sediment Transport in Mangrove Forests". Estuarine, Coastal and Shelf Science Journal).*

The sensitivity of the channels hydraulic performance to the Manning's roughness parameters was examined by increasing the Manning's roughness parameter. This analysis is discussed in Section 4.7.

3.4.4 Swales

The major swales along Roads 2 and 5 and behind the heritage area are expected to be grassed. Accordingly, a Manning's roughness parameter of 0.03 has been adopted for all swales. Details of swale geometry are provided in **Figure 9.**

3.4.5 Detention Basins and Other Storages

Preliminary design for the Eastern and One-Steel wet basins was undertaken using 12D software. Details of the basin surface area and volume at various elevations was used to define the storage properties at the basin storage nodes in XP-STORM.

Storage volume estimates along Selwyn Street and to the north of the administration building were adopted from the previous report, *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*.

Details of modelled storage nodes are provided in **Appendix B**.

3.4.6 Closed Conduit Roughness

Certain drainage components of the proposed stormwater system will be hydraulically connected to Newcastle Harbour. This will result in frequent tidal inundation of drainage infrastructure located below the mean high tide level, and potential for marine growth in areas exposed to temporary tidal inundation. The previous investigation *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*, recommends a reduction of hydraulic conductivity of closed conduits imposed by marine growth.

Accordingly, all closed culverts exposed to tidal inundation have been assigned a Manning's roughness of 0.03 to account for marine growth. Additionally, the effective (modelled) culvert width was reduced by 0.2 meters and the depth by 0.1 meters to account for constriction imposed by marine growth. These allowances were recommended in the previous stormwater strategy.

Culverts upstream of the tide flaps were modelled with a Manning's roughness of 0.014. Additionally, all culverts were assigned exit and entrance losses equal 0.5 to ensure pit losses were accounted for.

4 MODEL OUTPUT

4.1 STORMWATER SYSTEM PERFORMANCE

This section summaries the stormwater system performance for Scenarios 1 and 2. For presentational purposes, output from the XP-STORM hydrodynamic model has been presented at key locations only, as described by **Figure 4**. Further output from model simulations is provided in **Appendix C.**

4.2 EASTERN CATCHMENT

4.2.1 Model Results

Modelled flood levels for Scenarios 1 and 2 for key nodes in the eastern catchment are presented in **Table 4.1.** The scenario with the highest maximum flood level, being the worse case scenario, is shown in bold. Additionally, **Table 4.1** provides the critical storm durations and peak flows immediately downstream of the node.

Table 4.1 – Estimated Flood Levels – Eastern Catchment

Location	Description	Key Node	Scenario 1			Scenario 2		
			Peak Flood Level (m AHD)*	Peak Flow (m^3/s)	Critical Storm Duration (min)*	Peak Flood Level (m AHD)	Peak Flow (m^3/s)	Critical Storm Duration (min)
Eastern Channel	D/S End	E-14	1.12	8.40	60	**1.39**	4.60	360
	Middle Culvert	Sel – 3	1.39	7.8	90	**1.44**	4	360
	U/S End	Sel – 1	1.46	7.6	90	**1.47**	3.5	360
Selwyn St Basin		M 20	**1.60**	7.60	120 / 90	1.50	3.40	360
Road 5 Swale	D/S End	S-34	**1.73**	3.70	120	1.55	1.80	360
	Middle	S-22	**1.77**	3.00	120 / 90	1.58	1.20	360
	U/S End	Surcharge	**2.05**	2.50	90	1.71	0.75	360
Heritage Area Swale	D/S End	HP OLF	**1.85**	3.60	90	1.60	1.25	360
	U/S End	M11	**2.00**	2.10	90	1.68	0.70	360
Road 1 Culvert	Culvert Entrance	M10/M8	**2.10**	1.90	90	1.70	0.65	360
Admin Area	Eastern Segment	Stor – 2	**1.60** ***1.68***	1.40 *0.60*	120 *540*	1.52	0.40	360
	Western Segment	Stor -1	**1.67** ***1.71***	0.09 *0.14*	120 *540*	1.56	NF	360

Location	Description	Key Node	Scenario 1			Scenario 2		
			Peak Flood Level (m AHD)*	Peak Flow (m^3/s)	Critical Storm Duration (min)*	Peak Flood Level (m AHD)	Peak Flow (m^3/s)	Critical Storm Duration (min)
	U/S of East Channel	AD - 14	**1.58** **1.65**	2.1 2.3	120 540	1.50	1.85	360
Industrial Drive Basin		Ind_Basn	**2.92**	0.48	120	2.51	0.42	360

* Where two peak water levels are shown, the first is for the catchment critical storm, and the second is for localised flooding. This is discussed further below.

Modelling of Scenarios 1 and 2 indicates that the estimated flood levels from Scenario 1 (rainfall dominated) are higher in all locations except the Eastern Channel, where Scenario 2 (tailwater dominated) peak levels were marginally higher.

4.2.2 Discussion

Modelling indicates that the peak flood level at the head of the Eastern Channel (node Sel-1) is RL 1.47m AHD (Scenario 2). This would result in minor inundation of the southern side of Selwyn Street adjacent to the channel with detailed survey at this location showing pavement levels typically around RL 1.0m AHD. However flood waters would not overtop the centre of the road, with detailed survey along the centreline of Selwyn Street showing pavement levels typically around RL 1.60m AHD. Therefore, in its current condition, Selwyn Street would remain trafficable during a 1 in 100 year ARI flood event.

The limited storage volumes and a maximum operating water level elevation of 1.6m AHD inhibit the Selwyn Street basin from providing any significant detention during a 1 in 100 year ARI flood event. Increasing the operating water level would induce a higher tailwater on both the Road 5 (Administration Drive) and heritage area swales, and could increase the flooding potential in these areas. It should be noted that the primary purpose of this basin is to provide water quality benefits during low flow events.

Peak flood levels during a catchment critical 1 in 100 year ARI flood event would be between 1.58m AHD and 1.67m AHD in the administration and upper Selwyn Street areas (nodes Stor–2, Stor-1, AD–14). Survey data suggests that a significant portion of this area is under the estimated flood levels. Therefore, it is expected that large portions of the administration and upper Selwyn Street areas would be temporally inundated during a 1 in 100 year ARI flood event.

The preliminary design has involved raising Road 5 (Administration Drive) to 1.65m AHD to ensure it remains trafficable during a 1 in 100 year ARI flood event. The proposed one-way cross-fall of this road as shown in the preliminary design will result in partial inundation of Road 5, with at least 2 trafficable lanes (6.5 meters wide) remaining flood free. Peak flood levels in the Road 5 Swale are generally 150 mm below the gutter crest and would not 'spill over' into the administration area during a 1 in 100 year ARI flood event. Opportunities may exist during detailed design to create depressions in the footway to allow controlled overflows into the administration precinct during rarer flood events.

Modelling indicates that the longer duration storms would generate slightly higher peak flood levels, of between 1.65m AHD and 1.71m AHD in the administration and upper Selwyn Street areas, as shown in **Table 4.1** (nodes Stor–2, Stor-1, AD–14). This is because the large modelled storages are unable to discharge quickly during longer duration storms (the 540 minute, 100 year ARI storm was estimated to be worst case scenario). It is likely that this is a function of the modelled connections between nodes, and alternative overland flow relief may actually occur (such as along the southern side of Road 5). Nonetheless, Road 5 would still remain trafficable with between 1 and 2 lanes remaining flood free.

It is further noted that the only modelled hydraulic connection between nodes 'AD- 14' (down stream of the administration area) and 'Sel–1' (head of the Eastern Channel) are twin 25 m long 750mm circular culverts. These culverts, which convey stormwater under the existing rail crossing of Selwyn Street, restrict the discharge of stormwater from the Selwyn Street and administration areas. Increasing the conveyance capacity of these culverts, as well as providing additional overland flow relief, may assist in lowering the peak flood levels in the administration area by around 100 – 200 mm, however would require further detailed hydraulic modelling.

4.3 WESTERN CATCHMENT

4.3.1 Model Results

Modelled flood levels for Scenarios 1 and 2 for key nodes in the western catchment are presented in **Table 4.2.** The scenario with the highest maximum flood level, being the worse case scenario, is shown in bold. Additionally, **Table 4.2** provides the critical storm durations and peak flows immediately down stream of the node.

Table 4.2 – Estimated Flood Levels – Western Catchment

Location	Description	Key Node	Scenario 1			Scenario 2		
			Peak Flood Level (m AHD)	Peak Flow (m^3/s)*	Critical Storm Duration (min)	Peak Flood Level (m AHD)	Peak Flow (m^3/s)	Critical Storm Duration (min)
Western Channel	D/S End	1-5.00	1.48	8.50	120	**1.51**	4.60	360
	Middle	1-250.05	1.52	7.20	120	**1.55**	3.80	360
	U/S End	1-515.05	1.55	5.60	120	**1.56**	2.80	360
One-Steel Basin		W21 Basin	**1.95**	4.50 1.70	120	1.70	1.03	360
Road 2 Swale	D/S End	Rd2 Culvt -1	**1.68**	5.60	120	1.59	2.80	360

Location	Description	Key Node	Scenario 1			Scenario 2		
			Peak Flood Level (m AHD)	Peak Flow (m^3/s)*	Critical Storm Duration (min)	Peak Flood Level (m AHD)	Peak Flow (m^3/s)	Critical Storm Duration (min)
	Rd 2 CH 110	HP 19	**1.97**	4.40	90	1.71	1.83	360
	D/S End of R 3 culvert	Rd3-1	**2.11**	3.80	90	1.78	1.55	360
	U/S end of Rd 3 culvert	Rd3-2	**2.25**	3.46	90	1.81	1.35	360
	Rd 2 CH 385	HP 10	**2.32**	3.51	90	1.87	1.09	360
	U/S End	W 5	**2.33**	1.37	90	1.88	0.44	360

* Where two peak flows are shown the first is the inflow into a storage node and the second is the outflow

Similarly to the eastern catchment, the modelling of Scenarios 1 and 2 indicated that the estimated flood levels from Scenario 1 (rainfall dominated) are higher in all locations except the Western Channel, where Scenario 2 (tailwater dominated) peak levels were marginally higher.

4.3.2 Discussion

Modelling indicates that peak flood waters in the Western Channel would not breach the channel banks. The predicted peak water level elevation is generally 500mm or more below the channel banks (for the final remediated surface). The water level elevation at the head of the channel acts as a tailwater control for the Road 2 culvert, which hydraulically connects the Road 2 swale and One-Steel Basin to the Western Channel.

Table 4.2 demonstrates that the One-Steel Basin is effective at reducing peak flows from its upstream catchment from 4.5 m^3/s to 1.7 m^3/s. The peak operating level of the basin is 1.95m AHD. It is estimated that this basin reduces the peak water level at the head of the Western Channel by approximately 150mm.

It is noted that during a 1 in 100 year ARI flood event, the Road 2 swale would breach its banks and partially inundate Road 2, which has a one-way cross fall. Modelling indicates that peak water levels will not rise above the elevation of the centreline of Road 2, thereby ensuring that at least 6.5 meters of road (2 lanes) would remain flood free and trafficable under such an event.

4.4 OPEN CHANNEL VELOCITY AND STABILITY

Flow within the long, flat open channels only occurs when the upstream water level rises above the tailwater level, allowing the difference in hydrostatic pressure to ‘push’ stormwater along the channel towards the harbour. The flat friction slope of the water generally results in low flow velocities in the channels of the Eastern (Selwyn Street) and Western channels under the modelled tailwater conditions. These velocities are shown in **Table 4.3**.

The dynamic tidal tailwater levels will influence velocities within the channels. Velocities need to be considered when tailwater conditions do not influence upstream flood levels. This is required to ensure stability of the channel components (such as mangrove benches) under all conditions. **Table 4.3** provides velocities for a Scenario 1 simulation with no influence from downstream tailwater.

Table 4.3 – Velocities within Major Channels

Channel	Conduit Location	Conduit	Peak Velocity with design tailwater (m/s)	Peak Velocity with no tailwater (m/s)
Eastern	U/S End	L1 - 780	0.64	0.80
	D/S of ARTC access culvert	L1 - 480	0.71	0.84
	D/S End	L1 - 60	0.91	1.25
Western	U/S End	1 – 450.05	0.37	0.52
	Channel Chainage 250	1 – 250.05	0.46	0.64
	D/S End	1-75.05	0.51	0.66

4.5 SAFETY CONSIDERATIONS

For swales within the site, NCC requires the velocity depth (VD) product to be below $1m^2/s$ at all times. **Table 4.4** presents the estimated peak flow velocities, maximum depths and peak VD at key locations in the Road 2, Road 5 and heritage area swales. Since **Tables 4.1** and **4.2** indicated that Scenario 1 (flooding induced by a 100 year rainfall event over the site) is the critical flooding scenario within theses swales, therefore VD relationships have been reported for Scenario 1 only.

Table 4.4 – Velocities x Depth Relationships for Swales

Swale	Nodal Location	Node	Peak Velocity (m/s)*	Max Depth (m)*	Peak V.D (m^2/s)*
Road 5 Swale	D/S End	S-34	0.83	0.40	0.33
	Middle	S-22	0.60	0.96	0.58
	U/S End	Surcharge	0.65	1.11	0.72
Heritage Area Swale	D/S End	HP OLF	1.10	0.75	0.83
	U/S End	M11	0.40	1.00	0.40
Road 2 Swale	D/SEnd	HP 21	1.11	0.25	0.28
	CH 110	HP 19	1.10	0.65	0.71
	D/S of Road 3 culvert	Rd3-1	1.07	0.70	0.75
	U/S of Road 3 culvert	HP 18	1.09	0.80	0.87
	CH 385	HP 10	1.00	0.78	0.78
	U/S End	W 5	0.93	0.85	0.79

* These results are indicative of the critical storm duration in a Scenario 1 flooding simulation

The results in **Table 4.4** demonstrate that the peak VD product in all the swales does not exceed the maximum allowable value of 1 m^2/s.

Basins will result in deeper depths that could be hazardous if entered. The basins have been designed with 1V:3H side slopes, and could be planted to discourage entry, or fenced if required by Council.

Safety within the channels has been considered differently to safety within the open swales. Both the Eastern (Selwyn Street) and Western Channels will be fenced on one side, and will have a traffic barrier, landscaping, and mangroves to discourage entry to the channel on the road side. Fencing is not recommended as entry by persons into the channel is unlikely. Excluding deep water zones, the depth at the upstream end of the eastern channel, as shown in **Table 4.1** during a Scenario 1 event, is 1.46 + 0.2 = 1.66m. The velocity during this event, as shown in **Table 4.3**, is 0.64 m/s. The VD is therefore 1.06, marginally over the NCC requirement. At the downstream end of the channel, the VD during a Scenario 1 event is 1.2. When there is no tailwater control, the VD at the upstream end (depth = 1.85 m) and downstream (depth =1.15m) ends of the Eastern (Selwyn Street) channel was determined to be 1.48 m^2/s and 1.43 m^2/s respectively.

4.6 COMPARISON OF SYSTEM PERFORMANCE

4.6.1 Comparison to Previously Modelled Flood Levels

Previous studies have been undertaken of both the existing stormwater behaviour and the performance of concept stormwater systems. The preliminary design resulted in a proposed site grading and stormwater drainage configuration that is significantly different to concept designs modelled in previous investigations. In particular, the western catchment drainage has been significantly altered with the primary drainage route being realigned from the centre of the site to the One-Steel boundary. Additionally, the hydrology is different, with the application of DCP 50 and revised catchments, and the scenarios modelled (including tailwater levels) have changed

As such, a direct comparison of the current system performance to previously reported flood levels for the developed site is not possible. It is, however, noted that the most recent previous investigation *Stormwater Strategy – Former Steelworks Site (Parsons Brinckerhoff), May 2004*, tables concept design estimate peak flood levels of 1.71m AHD in the administration area and 1.60m AHD near the start of the Selwyn Street channel.

4.6.2 Comparison to Existing Flood Levels

RLMC provided a letter correspondence, *"Estimated Flood Levels, Existing Administration Area, Selwyn Street, Mayfield" (Parsons Brinkerhoff , 10/11/2004)*, detailing existing flooding behaviour in the eastern catchment area. Peak flood levels in the administration and Selwyn Street area were estimated to be 2.00m AHD during a storm event *similar* to Scenario 1.

RLMC provided PBP with an XP-Storm model for the existing site. When run, this model predicted peak flood levels of 1.86m AHD in the administration area and 1.76m AHD in the Selwyn Street Area during a storm event *similar* to Scenario 1.

Whilst it is not clear which results are most representative of the existing flood conditions, the stormwater system proposed in this report will significantly reduce the severity of flooding in both the administration and Selwyn Street areas.

No analysis of the existing flooding behaviour in the western catchment area was available.

4.7 MODEL SENSITIVITY

The sensitivity of the hydraulic efficiency of both the Eastern and Western Channels to increased channel roughness (which is defined by the Manning's 'n' roughness parameters) was examined. Higher Manning's 'n' parameters are indicative of an overgrown, poorly maintained channel.

The Manning's 'n' values for the concrete lined channel were increased to 0.035, and mangrove and landscaped benches to 0.10. These values were selected based on upper limits for silted concrete lined channels and straight mangrove lined channels *(refer: Natural Channel Guidelines, Brisbane City Council, 2000)*. It is emphasised that the depth of flow is typically around 1.5m, and as such in the upper part of the floodway there will be little resistance from silting or weed growth in the concrete lined channel. The result during a Scenario 1 event was an increase in flood levels within the Eastern Channel of 0.16m (at the upstream end of the channel, node sel–1). Upstream of the Eastern Basin, the impact was less pronounced, with a typical increase in flood levels of around 0.07m (At downstream end of road 5 swale, node S34). The Western Channel was found to have similar results.

5 WATER QUALITY CONTROL

5.1 TREATMENT TRAIN OF CONTROLS

For the ultimate development of the site, water quality treatment will be achieved through the following

- Compliance with DCP 50 would be in the form of above ground systems (such as rainwater tanks) and would treat runoff from roofed areas within lots. Water quality controls are required for the remainder of the lot.
- Grassed swales
- East Basin and One-Steel basin. These would include Gross Pollutant Traps (GPT's) at outlets from the drainage system into the wet basins or the linear wetlands.
- tidal mangrove-lined wetlands (open channels).

These water quality controls are discussed in greater detail in the following sections.

5.2 COMPLIANCE WITH DCP 50 AND ON-SITE CONTROLS

As outlined in Section 1.5, NCC has advised that the intentions of DCP 50 be followed for roofs only, due to capping the site. This assists in reducing the peak flow from each lot, and allows the trunk drainage infrastructure to be reduced in size.

Runoff from the remainder of each lot would still require individual water quality controls as part of their lot drainage system that connects to the road drainage system. These systems would be required to provide water quality treatment for water quality events (such as up to the 3 month ARI event) but would not have to retain stormwater with slow release as per roofs which are to comply with DCP 50. The water quality controls could be in the form of grassed swales, landscaping around car-parks, sand-filters, or other water quality controls as appropriate for the development.

In addition, it is expected that many lots would require their own on-site stormwater treatment systems. This could be in the form of first flush systems of other licensed requirements.

5.3 SWALES

Three major grassed swales are proposed for the development. These swales will provide some filtering of stormwater, and some nutrient uptake by the grasses for stormwater runoff from those lots that discharge directly into the swales. The swales will be required to be lined to isolate the stormwater from the groundwater, therefore no infiltration will be possible. However, as part of a future design of the swales, it may be possible to allow infiltration to an underdrain system, thereby acting as a biofiltration swale.

5.4 WET BASINS

Two wet basins are proposed for the site:

- The eastern basin has a wet surface area of 470 m^2, which represents approximately 1.3% of the contributing roadway area (the total area of new / upgraded road reserves as shown on the current masterplan).
- The One-Steel basin has a wet surface area of 410 m^2, which represents approximately 2.1% of the contributing roadway area (the total area of new / upgraded road reserves as shown on the current masterplan).

Whilst the Eastern Basin does not meet minimum recommended water quality pond size (of 2% as recommended by the Constructed Wetlands Manual), additional water quality is provided in the linear wetland downstream, as discussed in the following section.

The basins are required to have a large dense base (likely mass concrete) to prevent uplift by buoyancy, and a mass concrete base is proposed. The basin would still have earthen embankments along wet side slopes, and these would be planted with macrophytes that will assist in dissolved nutrient uptake and filtration of stormwater. The species would be required to be salt tolerant should the downstream tide valves leak.

Gross pollutant traps (GPT’s) upstream would remove gross pollutants, coarse sediment, and oils and greases.

5.5 TIDAL LINEAR WETLANDS

As a final water quality control, the open channels have been designed to operate as linear estuarine (tidal) wetland systems, and will incorporate mangroves planted on benches within the intertidal shallows of the linear wetland. Deep water sedimentation zones throughout the estuarine channel will assist with settling of particulates and provides locations for targeted maintenance. These deep water maintenance zones are located at either end of the channel to accommodate the movement of sediment during incoming and outgoing tides.

A weir at the downstream end of the linear wetlands will maintain the minimum water level at RL 0.1 m AHD during low tide periods, providing 300mmm of permanently pooled water in the majority of the channel, and 600mm of water in deep water zones. This volume of permanently pooled water will ensure low velocities and settling of particles during water quality events (such as the 3 month ARI storm event). Tidal mixing will ensure stormwater mixes with tidal water, and whilst this will reduce the residence time within the wetland, it will ensure some nutrient uptake will occur with daily inundation of the long mangrove benches.

The two linear wetlands are as follows:

- Eastern wetland, has a wet surface area of approximately 2,500 m^2 (excluding the area of the mangroves), which represents around 6.3% of the contributing roadway area (the total area of new / upgraded road reserves as shown on the current masterplan).

- Western wetland, with a wet surface area of 1,900 m^2, (excluding the area of the mangroves), which represents around 9.8% of the contributing roadway area (the total area of new / upgraded road reserves as shown on the current masterplan).

The two linear wetlands will therefore provide significant water quality benefits for the roads, as well as provide treatment of runoff from other areas, such as Industrial Drive and the administration area.

CONCLUSIONS

It is recommended that the stormwater system presented in the strategy, developed as part of the preliminary design for the remediation of the former BHP site, be adopted. The proposed stormwater system provides the following:

- An effective system for the conveyance of floodwater from the site;
- Creates an aesthetically pleasing stormwater system that is at the same time robust and meets the objectives for remediation of the site;
- Enhances water quality by providing linear estuarine wetlands along open channels;
- Reduces existing flooding problems around Selwyn Street;
- Meets Council's design criteria and is easily maintainable;

Detailed design and construction of Stage 1 components is required to satisfy remediation objectives for the site. The proposed trunk drainage system has been shown to be compatible with the preliminary design for the remainder of the site, however revised strategies within the site may be adopted as Stage 2 development occurs.

It is recommended that development occurring on the site adhere to the stormwater considerations outlined in this report, particularly on-site detention requirements in accordance with DCP 50 to ensure the system performs as designed. It is noted that additional water quality controls may be imposed on specific development types that occupy the site in the future.

FIGURES

FIGURE 1

SITE LOCALITY

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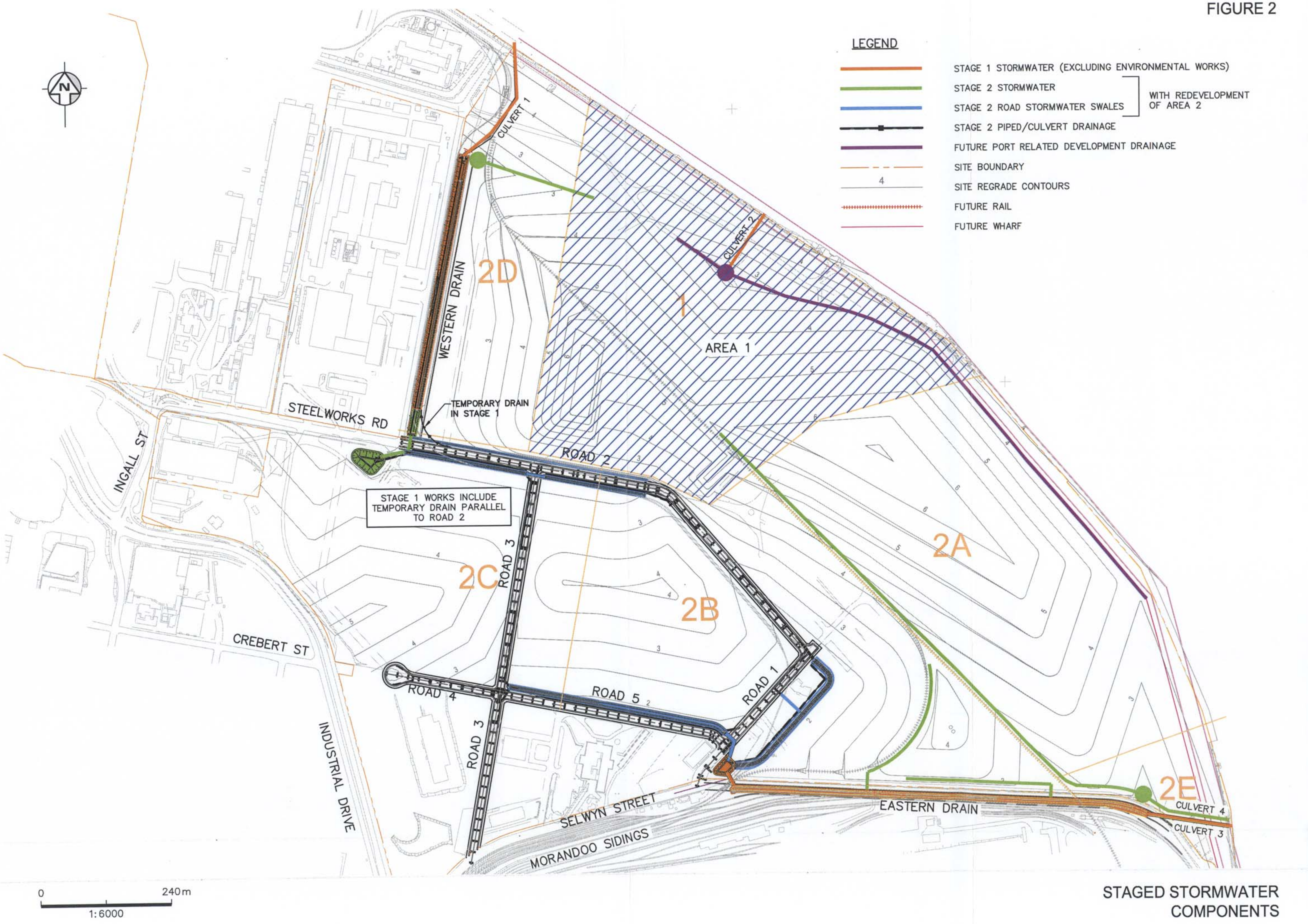
FIGURE 2



STAGED STORMWATER COMPONENTS

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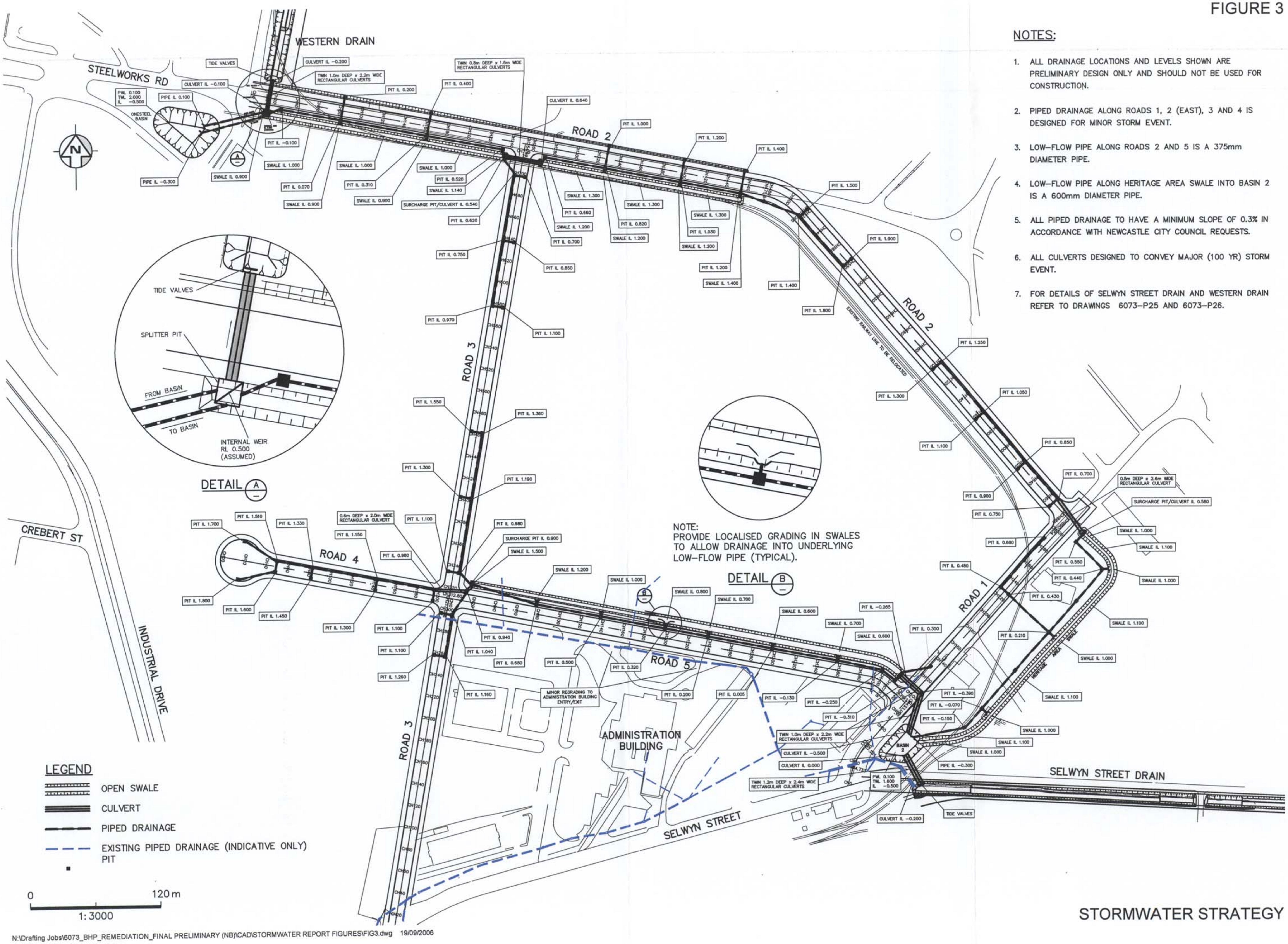
FIGURE 3



NOTES:

1. ALL DRAINAGE LOCATIONS AND LEVELS SHOWN ARE PRELIMINARY DESIGN ONLY AND SHOULD NOT BE USED FOR CONSTRUCTION.
2. PIPED DRAINAGE ALONG ROADS 1, 2 (EAST), 3 AND 4 IS DESIGNED FOR MINOR STORM EVENT.
3. LOW-FLOW PIPE ALONG ROADS 2 AND 5 IS A 375mm DIAMETER PIPE.
4. LOW-FLOW PIPE ALONG HERITAGE AREA SWALE INTO BASIN 2 IS A 600mm DIAMETER PIPE.
5. ALL PIPED DRAINAGE TO HAVE A MINIMUM SLOPE OF 0.3% IN ACCORDANCE WITH NEWCASTLE CITY COUNCIL REQUESTS.
6. ALL CULVERTS DESIGNED TO CONVEY MAJOR (100 YR) STORM EVENT.
7. FOR DETAILS OF SELWYN STREET DRAIN AND WESTERN DRAIN REFER TO DRAWINGS 6073-P25 AND 6073-P26.

STORMWATER STRATEGY

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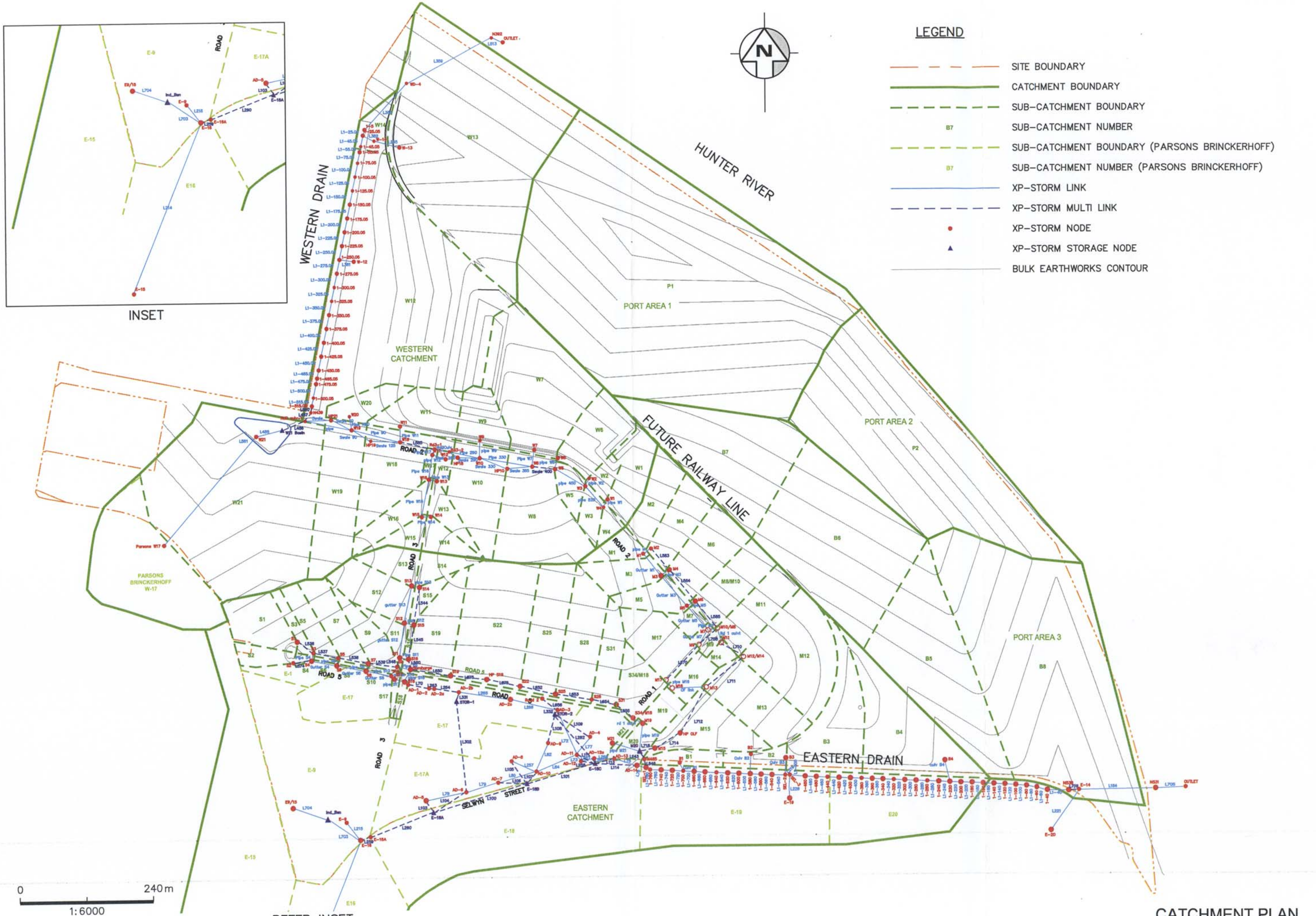
FIGURE 4



CATCHMENT PLAN

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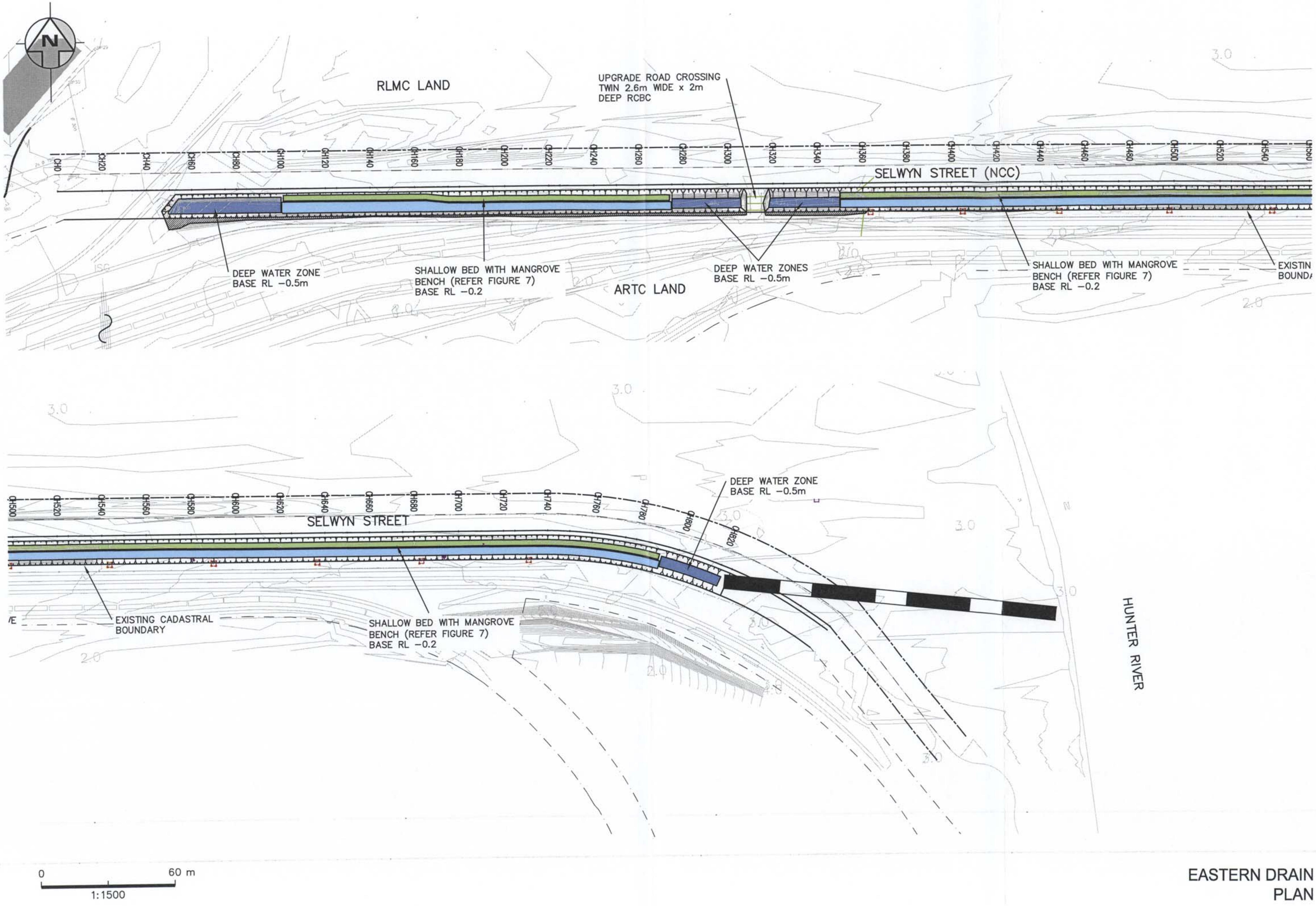
FIGURE 5



EASTERN DRAIN
PLAN

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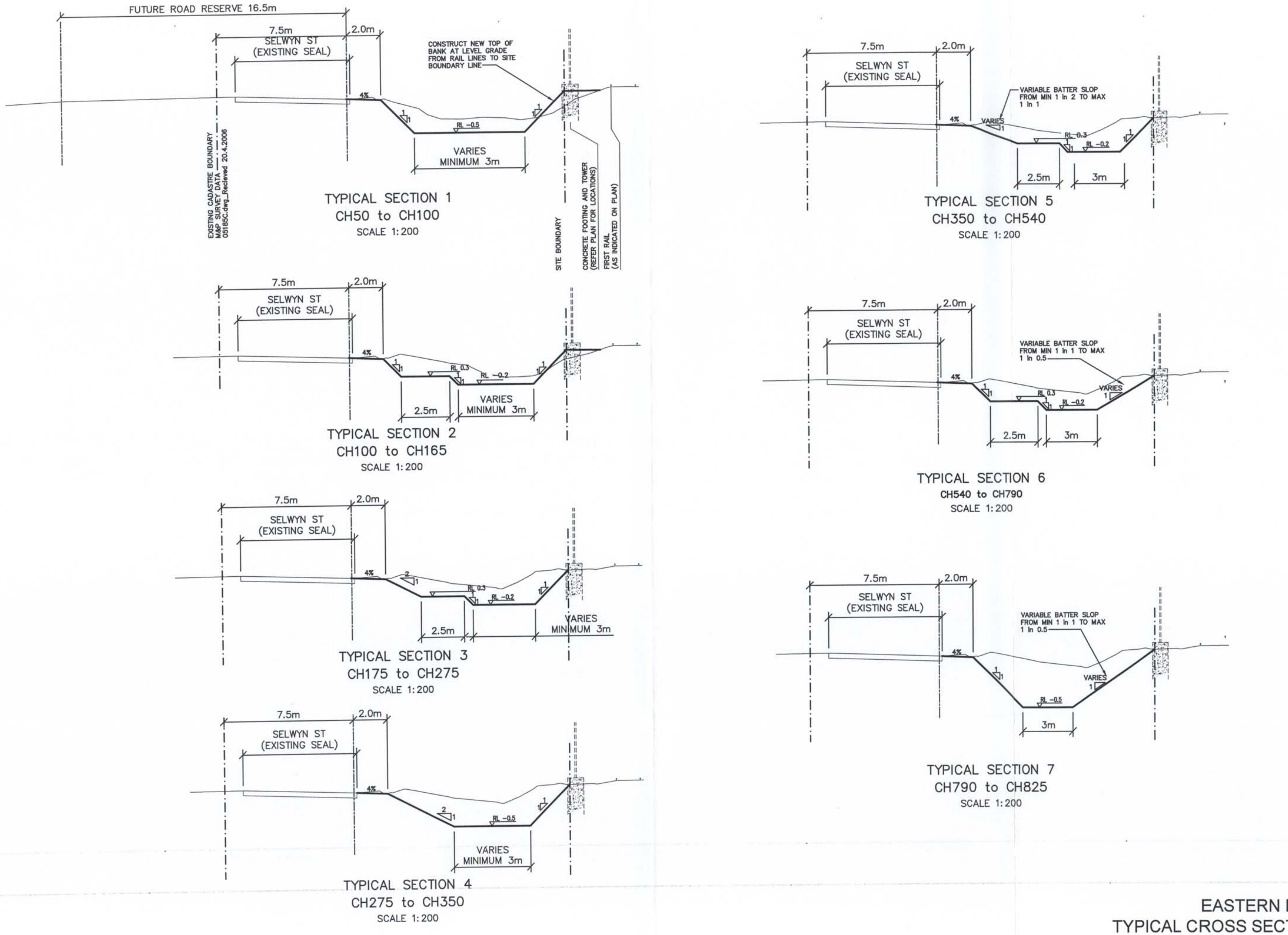
FIGURE 6



EASTERN DRAIN
TYPICAL CROSS SECTIONS

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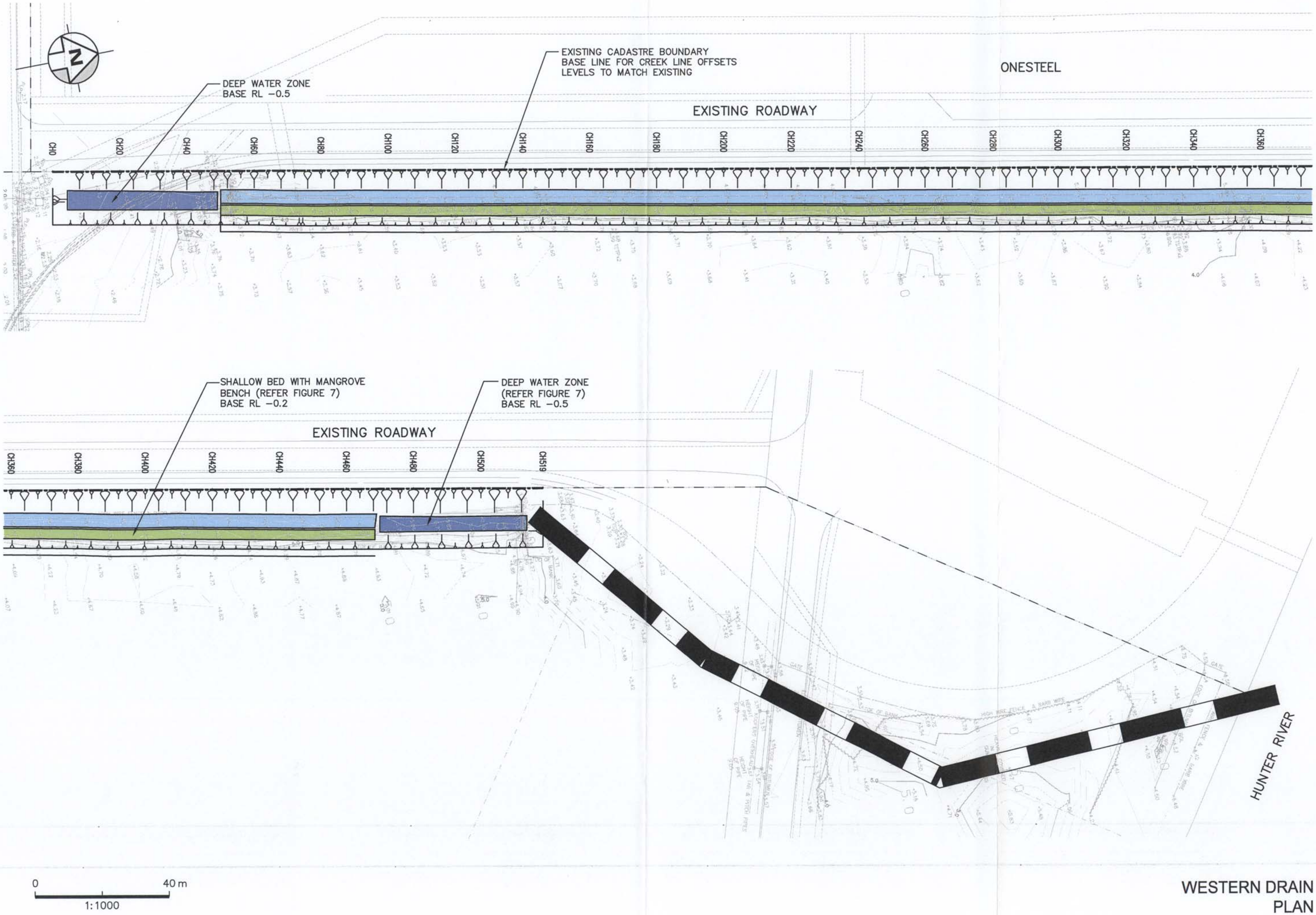

WESTERN DRAIN
PLAN

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FIGURE 8

WESTERN DRAIN
TYPICAL CROSS SECTIONS &
PRELIMINARY CONSTRUCTION DETAILS

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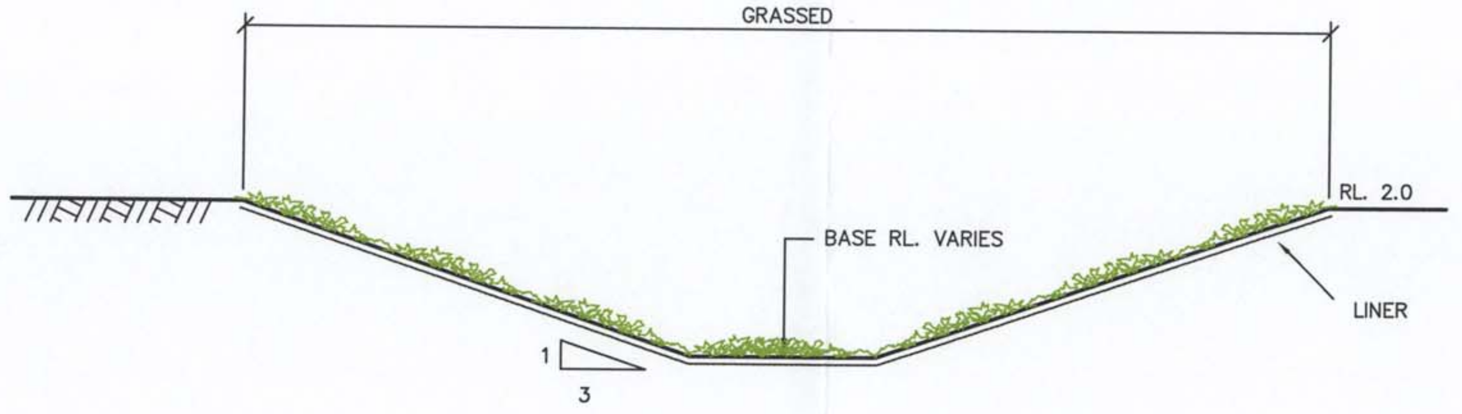
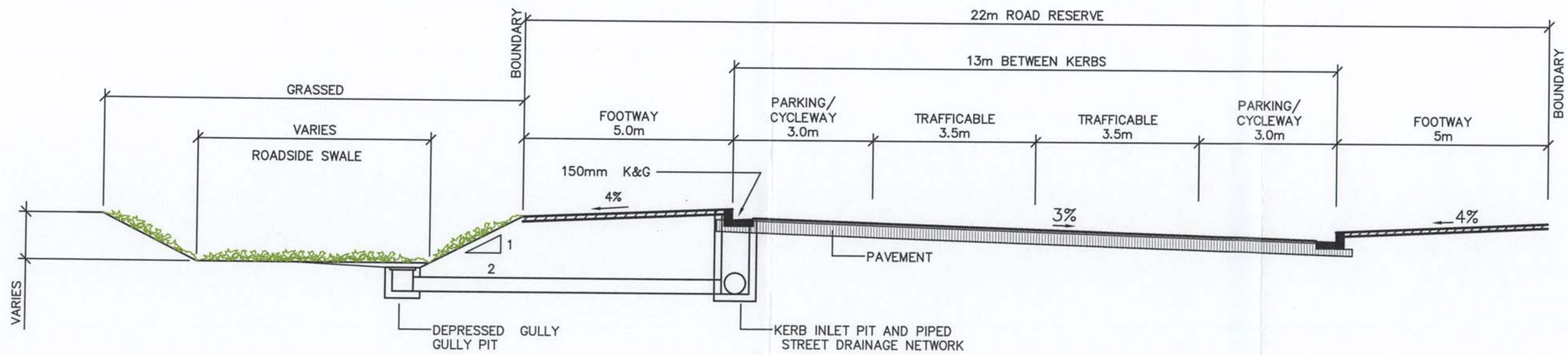


HERITAGE AREA SWALE
SCALE 1:100



ROAD 5
SCALE 1:100

SWALE
TYPICAL CROSS SECTIONS

APPENDIX A
SUBCATCHMENT PARAMETERS

Appendix A - Subcatchment Data

Western Catchment

Catchment Name	Subcatchment 1 ^ Area (ha)	Slope (m/m)	Impervious % *	Width (m) *	Infiltration Reference **	Subcatchment 2 ^ Area (ha)	Slope (m/m)	Impervious % *	Width (m) *	Infiltration Reference **
W-13	0.95	0.010	0	0	pervious on-site	8.54	0.010	0	100	impervious
W-14	0.44	0.010	0	0	pervious on-site	0.66	0.010	0	100	impervious
W-12	3.62	0.010	0	0	pervious on-site	5.43	0.010	0	100	impervious
W 11	0.62	0.029	0	100	impervious	0.42	0.029	0	0	pervious on-site
W 9	0.46	0.040	0	100	impervious	0.31	0.040	0	0	pervious on-site
W 7	2.29	0.013	0	100	impervious	1.52	0.013	0	0	pervious on-site
W 1	0.76	0.012	0	100	impervious	0.51	0.012	0	0	pervious on-site
W 4	0.12	0.012	0	100	impervious	0.08	0.012	0	0	pervious on-site
W 2	0.16	0.036	0	100	impervious	0.10	0.036	0	0	pervious on-site
W 3	0.19	0.014	0	100	impervious	0.13	0.014	0	0	pervious on-site
W 6	0.82	0.021	0	100	impervious	0.55	0.021	0	0	pervious on-site
W 5	0.22	0.010	0	100	impervious	0.14	0.010	0	0	pervious on-site
W 8	1.46	0.009	0	100	impervious	0.98	0.009	0	0	pervious on-site
W 10	0.93	0.008	0	100	impervious	0.62	0.008	0	0	pervious on-site
W 14	0.24	0.008	0	100	impervious	0.16	0.008	0	0	pervious on-site
W 15	0.19	0.009	0	100	impervious	0.13	0.009	0	0	pervious on-site
W 13	0.24	0.008	0	100	impervious	0.16	0.008	0	0	pervious on-site
W 16	0.40	0.007	0	100	impervious	0.26	0.007	0	0	pervious on-site
W 12	0.10	0.012	0	100	impervious	0.07	0.012	0	0	pervious on-site
W 17	0.07	0.012	0	100	impervious	0.04	0.012	0	0	pervious on-site
W18	1.01	0.009	0	100	impervious	0.68	0.009	0	0	pervious on-site
W 20	0.35	0.011	0	100	impervious	0.23	0.011	0	0	pervious on-site
W19	1.22	0.009	0	100	impervious	0.82	0.009	0	0	pervious on-site
Parson W17	1.00	0.060	0	100	impervious	3.00	0.060	0	0	pervious on-site
W 21	5.07	0.009	0	100	impervious	3.38	0.009	0	0	pervious on-site
WD-4	0.47	0.010	0	0	pervious on-site	4.23	0.010	0	100	impervious

Eastern Catchment

Catchment Name	Subcatchment 1 Area (ha)	Slope (m/m)	Impervious % *	Width (m) *	Infiltration Reference **	Subcatchment 2 Area (ha)	Slope (m/m)	Impervious % *	Width (m) *	Infiltration Reference **
E-20	8.28	0.005	0	0	pervious off-site	0.92	0.005	0	100	impervious
B 4	1.61	0.005	0	100	impervious	1.07	0.005	0	0	pervious on-site
B 3	1.10	0.006	0	100	impervious	0.74	0.006	0	0	pervious on-site
B 2	0.23	0.017	0	100	impervious	0.15	0.017	0	0	pervious on-site
B1	0.23	0.017	0	100	impervious	0.15	0.017	0	0	pervious on-site
AD-1	0.16	0.005	0	0	pervious off-site	1.44	0.005	0	100	impervious
AD-2b	0.14	0.005	0	0	pervious off-site	1.22	0.005	0	100	impervious
STOR-1	0.14	0.005	0	0	pervious off-site	1.22	0.005	0	100	impervious
AD-5	0.01	0.005	0	0	pervious off-site	0.13	0.005	0	100	impervious
E-15	4.40	0.020	0	0	pervious off-site	2.00	0.020	0	100	impervious
E-9	1.00	0.006	0	0	pervious on-site	0.50	0.006	0	100	impervious
E9/15	4.40	0.010	0	0	pervious on-site	3.20	0.010	0	100	impervious
E-16	4.32	0.010	0	0	pervious off-site	1.08	0.010	0	100	impervious
E-18A	3.15	0.005	0	0	pervious off-site	1.35	0.005	0	100	impervious
AD-8	0.04	0.005	0	0	pervious off-site	0.34	0.005	0	100	impervious
AD-9	0.04	0.005	0	0	pervious off-site	0.40	0.005	0	100	impervious
AD-4	0.02	0.005	0	0	pervious off-site	0.15	0.005	0	100	impervious
E-18C	3.15	0.005	0	0	pervious off-site	1.35	0.005	0	100	impervious
STOR-2	0.17	0.005	0	0	pervious off-site	1.54	0.005	0	100	impervious
AD-10	0.02	0.005	0	0	pervious off-site	0.21	0.005	0	100	impervious
E-18B	3.15	0.005	0	0	pervious off-site	1.35	0.005	0	100	impervious
AD-6	0.04	0.005	0	0	pervious off-site	0.33	0.005	0	100	impervious
Road 2	0.64	0.030	0	100	impervious	0.16	0.030	0	0	pervious on-site
AD-3	0.17	0.005	0	0	pervious off-site	1.54	0.005	0	100	impervious
AD-11	0.05	0.005	0	0	pervious off-site	0.47	0.005	0	100	impervious
AD-12	0.03	0.005	0	0	pervious off-site	0.25	0.005	0	100	impervious
M21	0.04	0.030	0	100	impervious	0.02	0.030	0	0	pervious on-site
S2	0.11	0.013	0	100	impervious	0.08	0.013	0	0	pervious on-site
S4	0.04	0.030	0	100	impervious	0.02	0.030	0	0	pervious on-site
S1	0.30	0.010	0	100	impervious	0.20	0.010	0	0	pervious on-site
S3	0.31	0.012	0	100	impervious	0.20	0.012	0	0	pervious on-site
S5	0.43	0.011	0	100	impervious	0.28	0.011	0	0	pervious on-site
S7	0.47	0.012	0	100	impervious	0.31	0.012	0	0	pervious on-site
S13	0.31	0.011	0	100	impervious	0.20	0.011	0	0	pervious on-site
S14	0.24	0.007	0	100	impervious	0.16	0.007	0	0	pervious on-site

S15	0.16	0.008	0	100	impervious	0.10	0.008	0	0	pervious on-site
S16	0.04	0.030	0	100	impervious	0.02	0.030	0	0	pervious on-site
S12	0.61	0.010	0	100	impervious	0.41	0.010	0	0	pervious on-site
S11	0.19	0.012	0	100	impervious	0.13	0.012	0	0	pervious on-site
S9	0.36	0.012	0	100	impervious	0.24	0.012	0	0	pervious on-site
S6	0.04	0.030	0	100	impervious	0.03	0.030	0	0	pervious on-site
S8	0.04	0.030	0	100	impervious	0.02	0.030	0	0	pervious on-site
S10	0.04	0.030	0	100	impervious	0.02	0.030	0	0	pervious on-site
S17	0.01	0.030	0	100	impervious	0.01	0.030	0	0	pervious on-site
S18	0.05	0.030	0	100	impervious	0.04	0.030	0	0	pervious on-site
S19	0.74	0.010	0	100	impervious	0.49	0.010	0	0	pervious on-site
S22	1.67	0.010	0	100	impervious	1.11	0.010	0	0	pervious on-site
S25	0.92	0.010	0	100	impervious	0.61	0.010	0	0	pervious on-site
S28	0.92	0.010	0	100	impervious	0.61	0.010	0	0	pervious on-site
S31	0.47	0.010	0	100	impervious	0.31	0.010	0	0	pervious on-site
S34/M18	0.79	0.009	0	100	impervious	0.52	0.009	0	0	pervious on-site
M19	0.21	0.004	0	100	impervious	0.14	0.004	0	0	pervious on-site
M 1	0.37	0.009	0	100	impervious	0.25	0.009	0	0	pervious on-site
M 2	0.40	0.008	0	100	impervious	0.26	0.008	0	0	pervious on-site
M4	0.46	0.011	0	100	impervious	0.31	0.011	0	0	pervious on-site
M6	0.50	0.011	0	100	impervious	0.34	0.011	0	0	pervious on-site
M 10 / M 8	0.92	0.008	0	100	impervious	0.62	0.008	0	0	pervious on-site
M 11	0.45	0.010	0	100	impervious	0.30	0.010	0	0	pervious on-site
M12 / M14	2.56	0.010	0	100	impervious	1.76	0.010	0	0	pervious on-site
M3	0.16	0.010	0	100	impervious	0.10	0.010	0	0	pervious on-site
M5	0.13	0.018	0	100	impervious	0.08	0.018	0	0	pervious on-site
M7	0.13	0.008	0	100	impervious	0.08	0.008	0	0	pervious on-site
M9	0.10	0.002	0	100	impervious	0.07	0.002	0	0	pervious on-site
M17	0.55	0.009	0	100	impervious	0.36	0.009	0	0	pervious on-site
M16	0.25	0.004	0	100	impervious	0.16	0.004	0	0	pervious on-site
M 13	0.08	0.005	0	100	impervious	0.06	0.005	0	0	pervious on-site
M 15	0.79	0.008	0	100	impervious	0.53	0.008	0	0	pervious on-site
M20	0.19	0.004	0	100	impervious	0.13	0.004	0	0	pervious on-site
E-19	8.64	0.005	0	0	pervious off-site	0.96	0.005	0	100	impervious

^ Each subcatchment was divided into two catchment areas. Each off these catchments represent the total pervious or impervious area of the total subcatchment.

* The impervious surfaces fractions were simulated by controlling the catchment width, in which a 100 meter catchment width is equivalent to 100% impervious surface, conversely a 0.001m catchment width is equivalent to a 100% pervious site. Further details for this methodology are provided in the XP-STORM user manual.

** Parameters values assigned for each infiltration reference are detailed Table 3.3 in Section 3.2.1 of the main report.

APPENDIX B
STORAGE DETAILS

Appendix B - Storage Node Properties

Eastern Basin

Stage (m AHD)	Basin Surface Area (ha)
-0.5	0.034
0	0.0438
0.5	0.0572
1	0.0722
1.5	0.0882
1.6	0.0902

One Steel Basin

Stage (m AHD)	Basin Surface Area (ha)
-2.2	0.025
-2	0.0273
-1.5	0.04
-1	0.0543
-0.5	0.0698
0	0.0868
0.5	0.105
1	0.125
1.5	0.146
2	0.169

Industrial Drive Basin

Stage (m AHD)	Basin Surface Area (ha)
2.1	0.3
2.5	0.35
3.1	0.4
3.6	0.449

APPENDIX C
MODEL OUTPUT

Scenario 2 Model output

Eastern Catchment

Conduit Name	Peak Flows (m^3/s) ^	Peak Velocity (m/s)
L214	0.5	0.8
L215	0.1	1.0
L219	2.0	0.5
L221	0.3	0.8
L226	0.4	0.8
L184	4.7	0.9
L72	0.2	1.1
L73	0.2	0.5
L75	0.4	1.1
L76	1.0	2.1
L77	0.1	0.8
L78	0.1	0.6
L79	0.1	0.4
L80	0.1	0.4
L82	0.1	0.4
L84	0.2	0.4
L257	0.0	0.3
L265	0.1	0.8
L266	0.1	0.8
L267	0.4	0.8
L268	0.4	1.0
L269	0.3	2.5
Pipe S9	0.5	0.4
Pipe S4	0.0	0.4
pipe S6	0.0	0.9
pipe S8	0.0	0.3
pipe S10	0.0	0.3
pipe S13	0.1	0.8
pipe S12	0.1	0.9
pipe S17	0.2	0.1
pipe S18	0.0	0.5
pipe M21	0.2	1.8
Gutter S4	0.0	0.0
Gutter S6	0.0	0.5
Gutter S8	0.0	0.0
gutter S13	0.0	0.3
gutter S12	0.1	0.5
gutter S10	0.1	0.3
rd 1 culv1	3.3	1.5
pipe M19	4.6	2.1
pipe M16	0.1	0.5
Gutter M1	0.0	0.0
Gutter M3	0.0	0.0
Gutter M5	0.0	0.0
Gutter M7	0.0	0.0
pipe M1	0.1	0.7
pipe M3	0.0	0.3
pipe M5	0.0	0.3

Node Name	Maximum Depth (m)	Peak WL (m AHD)
E-14	2.19	1.39
OUTLET	3.34	1.34
E-15	0.28	3.28
Ind_Bsn	0.43	2.53
E-9	0.11	2.57
E-20	0.39	1.39
E-19	0.46	1.46
SEL-1	2.28	1.48
SEL-2	2.26	1.46
SEL-3	2.26	1.46
AD-1	0.91	2.38
AD-2	0.91	1.96
AD-3	1.37	1.53
AD-11	1.37	1.53
AD-12	1.36	1.52
AD-13	1.44	1.51
AD-14	1.47	1.50
AD-4	0.92	1.52
AD-5	1.11	1.54
AD-6	1.18	1.54
AD-7	1.24	1.53
AD-10	1.28	1.53
AD-9	1.23	1.53
AD-8	1.23	1.53
E-18A	1.14	1.54
E-18B	1.33	1.53
E-18C	1.41	1.52
E-16A	1.03	1.54
AD-2a	0.56	1.76
AD-2b	1.40	1.56
AD-2c	1.38	1.54
AD-12a	1.41	1.52
STOR-1	0.36	1.56
STOR-2	0.42	1.52
S1	1.48	2.48
S2	1.41	2.41
S3	1.40	2.40
S4	1.40	2.40
S5	1.16	2.16
S6	2.00	3.00
S7	2.65	2.15
S8	2.65	2.15
S9	0.84	1.82
S10	2.31	1.81
S11	2.71	2.21
S12	3.02	2.52
S13	3.30	2.80
S14	3.27	2.77

Pipe M7	0.0	0.4	S15	2.98	2.48
Culv B1	0.1	1.3	S16	2.66	2.16
Culv B 2	0.1	1.1	Surcharge	2.30	1.80
Culv B 3	0.2	0.4	S17	2.31	1.81
culv B4	0.3	0.5	S18	2.37	1.87
L703	0.7	3.2	S19	2.14	1.64
L704	0.4	2.9	S22	2.07	1.57
L705	4.5	0.1	S25	2.07	1.57
Rd 1 culvt	0.3	0.3	S28	2.07	1.57
OF link	0.2	0.7	S31	2.06	1.56
L1-780.00	4.4	0.5	S34/M18	2.08	1.58
L1-760.00	4.3	0.3	M 2	2.58	2.58
L1-740.00	4.2	-0.3	M 1	2.64	2.64
L1-720.00	4.1	0.5	M4	2.34	2.34
L1-700.00	4.1	0.5	M3	2.35	2.35
L1-680.00	4.1	0.5	M6	1.99	1.99
L1-660.00	4.1	0.5	M5	2.00	2.00
L1-640.00	4.0	0.5	M7	1.70	1.70
L1-620.00	4.0	0.5	M 10 / M 8	2.69	1.69
L1-600.00	4.1	0.5	M 11	2.69	1.69
L1-580.00	4.2	0.5	M17	2.22	1.72
L1-560.00	4.0	0.5	M16	1.71	1.71
L1-540.00	4.2	0.4	M19	3.48	2.98
L1-500.00	4.3	0.4	M21	2.11	1.61
L1-480.00	4.3	0.6	M20	2.02	1.52
L1-460.00	4.3	0.6	M9	1.73	1.73
L1-440.00	4.3	0.6	M 13	2.65	1.65
L1-420.00	4.3	0.6	M 15	2.54	1.54
L1-400.00	4.3	0.6	B1	2.49	1.49
L1-380.00	4.3	0.6	B 2	2.48	1.48
L1-360.00	4.3	0.6	B 3	0.76	1.76
L1-340.00	4.3	0.6	B 4	0.79	1.79
L1-320.00	4.3	0.6	N485	1.99	1.49
L1-300.00	4.2	0.6	Road 2	0.53	1.53
L1-280.00	4.2	0.6	HP S19	2.09	1.59
L1-260.00	4.3	0.7	E-16	0.75	1.55
L1-240.00	4.4	0.7	E9/15	0.36	2.86
L1-220.00	4.4	0.7	N531	3.34	1.34
L1-200.00	4.4	0.7	M12 / M14	1.68	1.68
L1-180.00	4.5	0.7	HP OLF	2.10	1.60
L1-160.00	4.5	0.7	N536	2.21	1.41
L1-140.00	4.5	0.8	1-760.00	1.98	1.48
L1-120.00	4.5	0.8	1-740.00	1.97	1.47
L1-100.00	4.5	0.8	1-720.00	1.67	1.47
L1-80.00	4.5	0.9	1-700.00	1.67	1.47
L1-60.00	4.5	0.9	1-680.00	1.67	1.47
L1-40.00	4.4	0.6	1-660.00	1.67	1.47
Pipe s11	0.1	0.7	1-640.00	1.67	1.47
327.1	0.2	1.2	1-620.00	1.67	1.47
390.1	0.0	0.5	1-600.00	1.67	1.47
392.1	0.1	0.8	1-580.00	1.67	1.47
300.1	0.1	1.1	1-560.00	1.66	1.46
388.1	0.0	0.5	1-540.00	1.97	1.47
388.2	1.3	0.4	1-480.00	1.66	1.46
263.1	0.1	1.4	1-460.00	1.65	1.45
264.1	0.2	1.5	1-440.00	1.65	1.45

1192.1	0.0	0.0
1192.2	0.1	0.7
gutter3	0.0	0.0
pipe3	0.2	1.0
gutter	0.0	0.0
pipe	0.3	0.4
1195.1	0.0	0.0
1195.2	0.4	1.5
gut S14	0.0	0.1
pipe S14	0.1	1.0
gutter S15	0.0	0.4
pipe S15	0.2	1.3
gutter S11	0.0	1.1
gutter S16	0.0	0.5
pipe S16a	0.3	1.8
gutter M9	0.0	0.0
pipe M9	0.0	0.3
Gitter M2	0.0	0.0
pipe M2	0.2	1.1
Gutter M4	0.0	0.0
pipe M4	0.3	1.4
Gutter M6	0.0	0.0
Pipe M6	0.4	1.6
culvert 1	1.9	0.7
swale s19	0.7	0.6
LF S19	0.1	0.9
swale S25	1.3	0.3
LF S25	0.1	0.7
swale S28	1.6	0.4
LF S28	0.1	0.6
swale S31	2.3	-0.5
LF S31	0.1	0.6
Swale S34	3.2	0.8
LF S34	0.1	0.9
1469.1	-0.7	-0.2
pipe M11	0.1	0.7
1470.1	1.1	0.5
pipe M12	0.2	0.9
1471.1	-1.3	-0.5
pipe M13	0.2	0.9
1475.1	1.2	0.6
pipe M15	0.3	1.1
1475.1.1	1.5	0.7
pipe M15.1	0.3	1.2
gutter s2a	0.0	0.0
pipe s2a	0.0	0.6
1796.1.1	0.9	0.5
1796.2.1	0.1	0.8
1796.1	0.9	0.5
1796.2	0.1	0.7
AD-1 SUR	0.0	NA
E-18A SUF	1.4	NA
E-18C SUF	1.6	NA
AD-5 SUR	0.1	NA
AD-6 SUR	-0.1	NA
AD-8 SUR	0.0	NA

1-420.00	1.65	1.45
1-400.00	1.65	1.45
1-380.00	1.65	1.45
1-360.00	1.64	1.44
1-340.00	1.64	1.44
1-320.00	1.64	1.44
1-300.00	1.64	1.44
1-280.00	1.64	1.44
1-260.00	1.64	1.44
1-240.00	1.63	1.43
1-220.00	1.63	1.43
1-200.00	1.63	1.43
1-180.00	1.63	1.43
1-160.00	1.62	1.42
1-140.00	1.62	1.42
1-120.00	1.62	1.42
1-100.00	1.62	1.42
1-80.00	1.61	1.41
1-60.00	1.61	1.41
1-40.00	1.91	1.41

AD-7 SUR	0.0	NA
AD-10 SUI	0.0	NA
AD-9 SUR	0.1	NA
AD-4 SUR	-0.1	NA
AD-11 SUI	0.0	NA
AD-13 SUI	0.0	NA
AD-14 SUI	-1.5	NA
AD-12 SUI	-0.4	NA
E-16 weir	1.3	NA
E-18B SUI	0.7	NA
bypass 1	0.0	NA
bypass 2	0.0	NA
ad-2b oflov	0.0	NA
stor-1 weir	-0.1	NA
stor-2 weir	-0.2	NA
tide flap	4.5	NA
road 2	-1.0	NA
rd 2 overflc	0.0	NA
wier 44	4.5	NA

^ The peak flow rates through culverts are per barrel. If a conduit has twin culverts the peak flow through the conduit (ie the combined flow through both culverts) can be obtained by doubling the flow rate provided in this Appendix.

Scenario 2 - Model output

Western Catchment

Conduit Name	Peak Flows (m^3/s) ^	Peak Velocity (m/s)
L295	1.2	0.9
L359	2.5	0.6
L381	0.9	1.1
L382	1.4	1.3
L385	2.3	0.5
Rd3Culv	0.7	0.5
Swale 125	1.8	0.5
Swale 90	1.8	0.6
Pipe 90	0.1	1.0
Pipe W20	0.1	0.2
Pipe W11	0.1	0.3
Swale 40	2.1	0.6
Swale 265	1.3	0.7
pipe W9	0.1	0.2
Pipe 260	0.1	1.2
Swale 290	1.3	0.5
Swale 365	1.1	0.4
Swale 330	1.1	0.4
Pipe 330	0.1	0.9
Pipe W7	0.4	0.5
pipe W1	0.2	0.8
pipe 520	0.2	0.7
pipe 450	0.2	0.3

Node Name	Maximum Depth (m)	Peak WL (m AHD)
OUTLET	1.34	1.34
W-14	0.27	1.87
WD-4	1.97	1.47
W-13	0.32	2.22
W-12	0.22	1.82
Rd3-1	1.27	1.77
Rd3-2	1.20	1.80
W18	1.72	1.72
HP 19	1.70	1.70
W19	1.68	1.68
W 20	1.68	1.68
W 11	1.72	1.72
HP 21	1.63	1.63
HP 18	1.82	1.82
W 10	1.85	1.85
W 9	1.85	1.85
HP 10	1.86	1.86
W 8	0.87	1.87
W 5	1.08	1.88
W 7	1.89	1.89
W 6	0.88	1.88
W 2	1.89	1.89
W 3	1.08	1.89

pipe W6	0.2	0.4
pipe W2	0.0	0.3
Pipe W14	0.0	0.4
Pipe W15	0.1	0.3
Pipe W16	0.2	0.3
Pipe W17	0.3	0.3
Pipe W13	0.0	0.3
pipe W12	0.0	0.3
Swale 00	2.1	1.1
pipe 00	0.2	1.5
L485	1.4	1.7
L513	5.0	0.3
L561	0.4	0.5
L1-515.05	2.8	0.1
L1-500.05	2.8	0.2
L1-475.05	2.8	0.2
L1-465.05	2.9	0.3
L1-450.05	2.9	0.3
L1-425.05	2.9	0.3
L1-400.05	3.0	0.3
L1-375.05	3.0	0.3
L1-350.05	3.1	0.3
L1-325.05	3.1	0.3
L1-300.05	3.1	0.4
L1-275.05	3.2	0.4
L1-250.05	3.7	0.4
L1-225.05	3.8	0.4
L1-200.05	3.8	0.5
L1-175.05	3.8	0.5
L1-150.05	3.9	0.5
L1-125.05	3.9	0.5
L1-100.05	4.0	0.5
L1-75.05	4.0	0.5
L1-55.05	4.0	0.5
L1-45.05	4.0	0.3
L1-25.05	4.5	0.3
Swale	0.4	0.2
LF pipe	0.0	0.4
LF1 pipe	0.5	1.4
culvert487	1.4	0.6
pipe487	0.1	0.5
Swale 160	1.6	0.6
LF pipe16C	0.1	0.8
spill way	0.0	NA
tide flap	2.8	NA

W 1	1.00	2.00
W 4	0.91	1.91
W 17	1.18	1.78
W 12	1.78	1.78
W 16	1.28	1.78
W 13	1.78	1.78
W 15	0.88	1.78
W 14	0.68	1.78
W 21	1.86	1.86
W21 Basin	4.06	1.86
Rd2 culv-1	2.09	1.59
1-5.00	2.33	1.53
N392	1.84	1.34
1-515.05	2.05	1.55
N439	2.36	1.56
Parson W1	2.07	2.07
1-500.05	2.05	1.55
1-475.05	2.05	1.55
1-465.05	1.75	1.55
1-450.05	1.75	1.55
1-425.05	1.75	1.55
1-400.05	1.75	1.55
1-375.05	1.74	1.54
1-350.05	1.74	1.54
1-325.05	1.74	1.54
1-300.05	1.74	1.54
1-275.05	1.74	1.54
1-250.05	1.74	1.54
1-225.05	1.74	1.54
1-200.05	1.74	1.54
1-175.05	1.74	1.54
1-150.05	1.74	1.54
1-125.05	1.73	1.53
1-100.05	1.73	1.53
1-75.05	1.73	1.53
1-55.05	1.73	1.53
1-45.05	2.03	1.53
1-25.05	2.03	1.53

^ The peak flow rates through culverts are per barrel. If a conduit has twin culverts the peak flow through the conduit (ie the combined flow through both culverts) can be obtained by doubling the flow rate provided in this Appendix.