

Form

Mining

Application to amend an environmental authority (mining activities) for a level 1 mining project

OFFICIAL USE ONLY

DATE RECEIVED:

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FILE REF:

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PROJECT REF:

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COMPLETE FORM

☐

CORRECT AA

☐

COMPLETE FEE

☐

ADMINISTERING REGION:

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ENTERED BY (SIGNATURE):

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DATE:

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This form is to be used when applying for an amendment of an environmental authority for a level 1 mining project under s. 240 of the *Environmental Protection Act 1994*.

The holder of an environmental authority (mining activities) may use this form to:

- add a new mining tenement to an existing environmental authority;
- increase the surface area of a tenement;
- include additional activities or change the scale or type of activities;
- request an amendment to the conditions of an existing environmental authority;
- request an amendment to an environmental authority to reflect a change in the relevant standard environmental conditions;
- remove one or more existing holders of an environmental authority;
- as part of an application for the transfer of environmental authority, the proposed transferee is seeking an amendment to the authority;
- to nominate a principal holder.
(The principal holder under the *Environmental Protection Act 1984* should also be the principal holder under the *Mineral Resources Act 1989*.)

Do not use this form:

- to correct a clerical or formal error. The administering authority can make the correction as long as the proposed amendment does not adversely affect the interests of the environmental authority holder, or anyone else.

To amend a financial assurance, if there are no other amendments to your environmental authority, use the form Application for Amendment or Discharge of Financial Assurance for an Environmental Authority (Mining Activities) (EM2104¹).

If you are applying for a new mining tenement to be added to an existing environmental authority, or requesting additional surface area for an existing environmental authority, please submit this form, together with the required fee, to the Mining Registrar.

For all other applications, please submit the completed form, together with the required fee, to the administering authority.

¹ This is the publication number, which can be used as a search term to find the latest version of the publication at <www.ehp.qld.gov.au>.

Form

Application to amend an environmental authority (mining activities) for a level 1 mining project

Specific information requirements

Question 1 – Applicants

The applicants for, and/or holders of a relevant mining tenement for a mining project must also be the applicants for and/or holders of the associated environmental authority (EA).

Joint holders may appoint one of the applicants as the principal applicant (for submitting and receiving notices etc) by completing Attachment A.

1. Environmental authority (EA) holder name(s)

NAME & ABN/ACN: Barrick (Kalgoorlie) Limited A.B.N. 12 009 712 092
NAME & ABN/ACN:
NAME & ABN/ACN:

Question 2

Ensure that Attachment A is completed.

2. Principal holder name (where applicable)

NAME & ABN/ACN:

Question 3 – Contact person

Where the holder or principal holder is a company, identify a responsible person to act as signatory of this application.

3. Contact person for this application

NAME : CTPI 49-Sch4	
POSITION: Reclamation and Closure Manager	
REGISTERED BUSINESS ADDRESS: Level 9 Brookfield Place, 125 St Georges Terrace, PERTH WA 6000	
FULL POSTAL ADDRESS: Level 9 Brookfield Place, 125 St Georges Terrace, PERTH WA 6000	
PHONE: ()	FAX:
MOBILE PHONE: CTPI 49-Sch4	EMAIL: CTPI 49-Sch4@barrick.com

Form

Application to amend an environmental authority (mining activities) for a level 1 mining project

Environmental authority to be amended

Question 4

EA details may be found on the existing authority, relevant tenement approval or quoted in other correspondence received from the administering authority.

If you cannot locate the authority number, please contact the administering authority.

Where the Mining Registrar has previously issued a project number, provide that number.

4. EA details

PROJECT NUMBER (WHERE ISSUED):
PROJECT NAME: Croydon
ENVIRONMENTAL AUTHORITY NUMBER MIN100401906
TENEMENT TYPE AND NUMBER (E.G. ML1234): Mining Lease, ML5248

Question 5 – Removing holders

This application form cannot be used to include a person as a new holder of the authority. Use the form titled Application to Transfer an Environmental Authority (Mining Activities) (EM568).

If the person to be removed is the holder of a relevant mining tenement, it is likely that the administering authority may require that person to remain a holder of the authority.

The holders of the EA must be the same people as are holders of the associated tenements.

5. Do you wish to remove one or more existing holders from the EA?

- ☐ Yes → List the existing holders of the EA to be removed from the authority

HOLDER(S) NAME:

If this is the only purpose of the amendment application, no further information is required → go to Question 18

- ☒ No → Go to Question 6

Question 6

The maps for identifying strategic cropping land (SCL) and potential SCL can be found on the EHP website at www.ehp.qld.gov.au/licences-permits/maps_of_environmentally_sensitive_areas.php.

6. Are any of the current or proposed mining tenements over land that is designated as strategic cropping land (SCL) or potential SCL as shown on a SCL trigger map?

- ☐ Yes → Go to Question 7
☒ No → Go to Question 8

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Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 7

An application for an SCL compliance certificate provides a streamlined assessment pathway for resource activities that pose a low risk to adversely impacting on SCL or potential SCL. You must be able to comply with the SCL standard conditions code for resource activities to apply for an SCL compliance certificate.

If you cannot comply with SCL standard conditions code for resource activities, you must apply for an SCL protection decision.

The SCL application forms and SCL standard conditions code for resource activities are available on the EHP website.

An environmental authority can not be issued unless an SCL compliance certificate has been given or an SCL protection decision has been made.

Question 8

The amendment is not limited to the existing conditions of the EA. Holders may apply to have additional conditions included in the EA.

7. How will, or have, you considered *Strategic Cropping Land Act 2011* requirements?

- ☐ Considered under the SCL standard conditions code for resource activities.
- ☐ I/We have already applied for a compliance certificate:
Ref No.
- ☐ I/We will be applying for a compliance certificate.
- ☐ Considered under a SCL protection decision
- ☐ I/We have already applied for a protection decision:
Ref No.
- ☐ I/We will be applying for a protection decision.

8. What is the purpose for seeking an amendment to the environmental authority?

- To include additional activities or a change in the scale or type of activities → Go to Question 9
- To amend conditions of an existing authority → Go to Question 10
- As part of an application for the transfer of an EA where the proposed transferee is seeking an amendment of the EA → Go to Question 17
- To increase surface area of the tenement, or to add a new mining tenement to the existing EA (provide details in the below sections).

TENEMENT TYPE AND NUMBER (E.G. MLA1234):

- ☐ Other.

PLEASE SPECIFY:

Form

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 9 – Activities

Please include information on any additional tenements, an increase in surface area, an increase in rate of production or disturbance, or the building of additional infrastructure.

The application may be refused on the grounds that it would be more appropriate for the applicant to seek the amendment by replacement of the EA.

9. Do you intend to carry out additional activities and/or change the scale or type of activities that make up the project?

☐ Yes → Please provide details below

PLEASE SPECIFY:

LIST ADDITIONAL TENEMENT(S):

PLEASE ATTACH DETAILED INFORMATION OUTLINING THE CHANGES TO THE ACTIVITIES THAT MAKE UP THE PROJECT

Tick to indicate attachments: ☐

☐ No → Go to Question 10

Question 10 – Conditions

Holders may apply to have additional conditions included in the EA. However, the administering authority may grant the application only if it considers the amendment necessary or desirable.

10. Do you wish to amend one or more conditions of your EA?

☒ Yes → Go to Question 11

☐ No → Go to Question 14

Question 11

A condition of an EA requiring a financial assurance cannot be amended or discharged using this form, or under the amendment provisions of chapter 5, part 8 of the EP Act.

11. Identify the EA condition(s) to be amended

CONDITION NUMBER(S):

Clause F1-1

IF YOU REQUIRE ADDITIONAL SPACE, PLEASE ATTACH A SEPARATE SHEET

Tick to indicate attachments: ☐

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Form

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 12

If you require additional space, please attach a separate sheet

12. Explain why the conditions listed in Question 11 cannot be met

EXPLANATION:

Extreme rainfall can produce discharge from the Content Pit Lake which has been treated to be within stock watering guidelines. Consequent dilution in the receiving environment and high flow conditions in Belmore Creek result in no discernible environmental impact. However, clause F1-1 effectively prohibits any discharge under any circumstances.

Tick to indicate attachments:



Question 13

Please provide supporting information to ensure the activities do not cause material or serious environmental harm.

If you require additional space, please attach a separate sheet

13. Propose replacement condition(s)

NEW CONDITION(S):

Clause F1-1 to be amended to provide for discharge from the Content Pit and Lady Isabella Pit lakes under the appropriate flow conditions in the receiving Belmore Creek.

Tick to indicate attachments:



Question 14 – Financial assurance

As a result of the amendment process, the holder of the EA must provide financial assurance as required by the Codes of environmental compliance.

For further details, see the guideline Calculating Financial Assurance for Mining Projects (EM585) and the relevant code of environmental compliance. Electronic copies are available at <www.ehp.qld.gov.au>

Financial assurance is calculated as follows:

- (i) for mining leases, from a schedule of disturbance and rehabilitation in the plan of operations
- (ii) for exploration permits and mineral development licences, by reference to the schedule of rehabilitation costs in the Code of Environmental Compliance for Exploration and Mineral Development Projects
- (iii) total financial assurance for the mining project is obtained by adding the financial assurances in (i) and (ii) above.

14. Indicate the amount of financial assurance to be held for the amended EA for the mining project:

Total amount of financial assurance proposed to be held:

\$

Tick to indicate attachment:



The proposed amount of financial assurance will be reviewed by the administering authority and may be altered at the discretion of the administering authority if it is not consistent with the area of disturbance and rehabilitation requirements.

Released

Form

Application to amend an environmental authority (mining activities) for a level 1 mining project

Questions 15 - 17

Include the GST component when stating the amount proposed to be held/lodged, and the amounts currently held where relevant (adding the GST component if it has not been previously submitted).

15. In the table below, insert the appropriate amounts and form of financial assurance in relation to the EP Act.

	Amount of financial assurance	Form of financial assurance ³
Amount proposed to be held in Question 14	\$	
Amount currently held ¹	\$	
Difference between the amount proposed and the amount currently held ²	\$	

¹ Insert the amount and form of financial assurance that is currently held by the administering authority under the EP Act (i.e. not including tenement security required by the Mining Registrar under the *Mineral Resources Act 1989*).

² A negative amount is the amount of financial assurance to be returned by the administering authority (Question 17 applies). A positive amount is the additional financial assurance (including GST) to be submitted to the administering authority (Question 16 applies).

³ The administering authority will require financial assurance either as cash or as an unconditional guarantee from a suitable financial institution.

16. Where a financial assurance is to be amended and lodged with this application, please identify the person(s), company/companies or institution providing the financial assurance on behalf of the (proposed) authority holder(s), nominate the amount and the manner in which the financial assurance is being provided.

NAME(S) & ABN/ACN: N/A	AMOUNT \$:	MANNER HELD: ☐ cash ☐ financial institution unconditional guarantee
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Questions 17

Where a financial assurance is to be returned to a company or financial institution, provide the Australian Business Number (ABN) or the Australian Company Number (ACN) for that company/institution.

17. Where a financial assurance is to be discharged and returned to a person(s), company/companies or financial institution, please identify the person, company or institution, nominate the amount to be returned and the manner in which the financial assurance is currently held.

NAME(S) & ABN/ACN: N/A	AMOUNT \$:	MANNER HELD: ☐ cash ☐ financial institution unconditional guarantee
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Rele

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 18

Please read carefully through the certification opposite and tick all of the boxes if appropriate, before signing.

Privacy statement

The Department of Environment and Heritage Protection is committed to protecting the privacy, accuracy and security of your personal information in accordance with the *Information Privacy Act 2009*. The information will be accessed only by authorised employees within the department for the purposes of processing this application to amend an environmental authority, as authorised under s. 240 of the *Environmental Protection Act 1994*. To enable the processing of this application, information may be given to the Department of Natural Resources and Mines. Your personal information will not be disclosed to any other third parties without your consent or unless authorised or required by law. All information supplied on or with this form may be made available to others upon request, subject to provisions of the *Right to Information Act 2009* and *Evidence Act 1977*. For queries about privacy matters email: AdminReview@ehp.qld.gov.au or telephone: (07) 3896 3705.

18. Applicant certification

- ☒ I/we, being the person(s)/entity identified at Question 1, hereby apply to amend the EA stated at Question 4 as detailed in this application.
- ☒ I/we solemnly and sincerely declare that the information provided is true and correct to the best of my/our knowledge and I/we make this solemn declaration conscientiously believing the same to be true.
- ☒ I/we understand that all information supplied on or with this application form may be made available upon request, subject to the provisions of the *Right to Information Act 2009* and/or administrative access arrangements of the administering authority.
- ☒ I/we understand that suitability inquiries may be made of any applicant.
- ☒ I/we enclose the required amendment application fee² of \$ 276
- ☐ I/we am/are authorised to sign on behalf of the applicant(s), and commit this person/entity in all matters relevant to this application.
- ☒ I/we am/are aware that under s. 480 of the *Environmental Protection Act 1994*, it is an offence to give the administering authority information that I/we know is false, misleading or incomplete in any material particular.
- ☒ I/we understand that an incomplete application (including applications that do not include the fee) may be invalid. Invalid applications will be returned without processing and will only be processed if resubmitted with all invalidating issues addressed

SIGNATURE :		
NAME AND POSITION OF SIGNATORY:		
CTPI 49-Sch4	Reclamation Closure Manager	DATE: 10/12/12

² See the information sheet Fees for Permits for Environmentally Relevant Activities (ERAs) (EM33), available at www.ehp.qld.gov.au or through Permit and Licence Management, phone 13 QGOV (13 74 68).

Form

Application to amend an environmental authority (mining activities) for a level 1
mining project

Applicant checklist

- ☒ Application form completed and signed
- ☒ Fees paid or enclosed (if applicable)
- ☒ Supporting information or accreditation attached (if applicable)

Please return the completed application form with the required fee to either:

Permit and Licence Management
Department of Environment and Heritage Protection
GPO Box 2454
BRISBANE QLD 4001

The relevant district office of the:
Mining Registrar
Department of Natural Resources and Mines

Enquiries:

Permit and Licence Management
Phone: 13 QGOV (13 74 68)
Fax: (07) 3896 3342
Email: palm@ehp.qld.gov.au

Rele

Application to amend an environmental authority (mining activities) for a level 1 mining project

Attachment A

Appointment of principal holder

We, being joint holders/applicants for this amendment application, hereby appoint

PRINT NAME OF PRINCIPAL APPLICANT:

as the Principal Holder for this EA until otherwise revoked by us or the EA is surrendered.

List all joint applicants

APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:

The administering authority may accept an application for EA made for all the joint holders by a person who is a joint holder if satisfied the person is authorised to make the application for each of the joint holders.

In deciding an application for the EA, the administering authority must consider any suitability report obtained for the application.

Apostol Alex

From: Butler Hamish
Sent: Thursday, 3 November 2011 12:33 PM
To: Apostol Alex
Cc: Kidston Richard
Subject: RE: Carpentaria Shire letter concerns with water supply.pdf

Alex,

I discussed this with Richard this morning and he is happy for us to write a response letter to CSC.

The letter will need to have a couple parts; the first part should detail our response at the site. What inspections and sampling have occurred to demonstrate there is no major impacts to Bellmore Creek. Is there any on going/planned action for the mine site or RE.

The second part of the letter should indicate if they are concerned with the water quality in the Corydon water supply they should contact QH.

Give me a call if you want to discuss.

Cheers.

Hamish Butler
Team Leader- Mount Isa
North Region
Mining & Heavy Industry
Department of Environment and Resource Management
Phone: (07) 4222 5333
Fax : (07) 4222 5070
Email: hamish.butler@derm.qld.gov.au

-----Original Message-----

From: Kidston Richard
Sent: Thursday, 3 November 2011 8:45 AM
To: Butler Hamish
Subject: RE: Carpentaria Shire letter concerns with water supply.pdf

Yep no problem.

Richard Kidston

A/Manager
Mining & Industry, North Region
Department of Environment and Resource Management

PO Box 937
CAIRNS QLD 4870
Phone: (07) 42 22 5337 Fax: (07) 42 22 5070

Mobile CTPI 49-Sch4

E Mail richard.kidston@derm.qld.gov.au

□

www.derm.qld.gov.au

-----Original Message-----

From: Butler Hamish
Sent: Wednesday, 2 November 2011 4:18 PM
To: Apostol Alex; Kidston Richard
Cc: Sharpe Dean
Subject: FW: Carpentaria Shire letter concerns with water supply.pdf

Thanks Alex,

Richard, can Alex I discuss this with you tomorrow.

Proposed action is to respond to Carpentaria Shire council to update on status of Belmore creek and actions taken when triggers were exceeded. We will highlight that no contaminate limits were exceeded for both water and sediment.

In addition, refer the council to QH regarding the level of As that may or may not be in the water supply.

Cheers.

Hamish Butler
Team Leader- Mount Isa
North Region
Mining & Heavy Industry
Department of Environment and Resource Management
Phone: (07) 4222 5333
Fax : (07) 4222 5070
Email: hamish.butler@derm.qld.gov.au

-----Original Message-----

From: Apostol Alex
Sent: Wednesday, 2 November 2011 4:02 PM
To: Butler Hamish
Cc: Sharpe Dean; Kidston Richard
Subject: RE: Carpentaria Shire letter concerns with water supply.pdf

Hamish,

Below are some relevant information to the inquiry on As level at Belmore Creek/Croydon open pits:

1. Barrick Australia Pacific submitted analytical results for relevant receiving water monitoring sites @ Belmore Creek as a result of the Content Pit overtopping that happened on March 2011. The attached sheet summarises the As analysis of water samples taken at various sampling points along Belmore Creek. Some samples slightly exceeded the EA trigger level of 0.013 mg/L As but no samples have exceeded the contaminant limit of 0.5 mg/L As.

2. The most recent DERM site inspection was conducted on 22 August 2011. Water samples were taken from Golden Butterfly Pit, Golden Butterfly North Pit, Content Pit and Lady Isabella Pit. As per info from the site representative during the site inspection, water from the Golden Butterfly North Pit is pumped to the water treatment plant on the outskirts of Croydon Township for use as municipal drinking water. Results of As analysis follows:

Golden Butterfly Pit - 0.004 mg/L As
Golden Butterfly North Pit - 0.009 mg/L As Content Pit - 0.003 mg/L As Lady Isabella Pit - <0.001 mg/L

During the same site inspection, sediment samples were taken from Belmore Creek at the licensed monitoring locations and the analysis results were:

Belmore Creek & Stock Dam "Confluence" - <5 mg/kg As Reference site SW7 on Belmore Creek upstream - <5 mg/kg As

EA trigger level 80th %ile or 20 mg/kg (ISQG low trigger value) EA limit 70 (ISQG high) or 2x reference value

No samples exceeded the trigger and contaminant limits.

Rgrds,
Alex

Rel

Alex Apostol
Senior Environmental Officer
Environmental Services | North Region
Mining & Industry
Department of Environment & Resource Management

Suite 30 Level 1 Mt Isa House | PO Box 2316 Cnr Camooweal & Mary Streets Mt Isa QLD
4825 Australia
Phone: (07) 4744 7814 | Fax: (07) 4744 7800
Email: alex.apostol@derm.qld.gov.au
Website: www.derm.qld.gov.au

-----Original Message-----

From: Butler Hamish
Sent: Wednesday, 2 November 2011 3:00 PM
To: Apostol Alex
Cc: Sharpe Dean; Kidston Richard
Subject: FW: Carpentaria Shire letter concerns with water supply.pdf

Alex,

Can you have a look at the letter attached from Carpentaria Shire Council who are concerned with elevated levels of As in the water supply at Croydon.

Can you please check the recent inspection completed by Michael and Geraldine to see if any water samples were taken from the Croydon water supply or Belmore Creek. Was As an issue with any of the samples collected in the area, are the old pits located anywhere near Belmore Creek?

If you can let me know what you find out it would be appreciated.

Cheers.

Hamish Butler
Team Leader- Mount Isa
North Region
Mining & Heavy Industry
Department of Environment and Resource Management
Phone: (07) 4222 5333
Fax : (07) 4222 5070
Email: hamish.butler@derm.qld.gov.au

-----Original Message-----

From: Jensen Gary
Sent: Wednesday, 2 November 2011 2:25 PM
To: Butler Hamish
Cc: Cavicchiolo Mark
Subject: FW: Carpentaria Shire letter concerns with water supply.pdf

Hamish

This is a copy of the letter which was discussed with Mark Cavicchiolo. Am happy for you to respond.
From a water perspective, we have no records of any levels of arsenic. Our monitoring requirements have never included arsenic. We only provide authorisations for the take of water for XXXXXX purpose, or storage etc., but not the quality.

Cheers
GaryJ

Gary Jensen
Manager, Water Services, North Region
Telephone: 07 4799 7505 Facsimile: 07 4799 7971 Mobile: CTPI 49-Sch4
Email: gary.jensen@derm.qld.gov.au
www.derm.qld.gov.au

Department of Environment and Resource Management
187 - 209 Stanley Street, Townsville Q 4810 PO Box 5318, Townsville Q 4810

-----Original Message-----

From: Jensen Gary
Sent: Wednesday, 2 November 2011 2:18 PM
To: Sharpe Dean
Subject: FW: Carpentaria Shire letter concerns with water supply.pdf

Dean

Are you intersected in responding to this at all?

Cheers
Gary

Gary Jensen
Manager, Water Services, North Region
Telephone: 07 4799 7505 Facsimile: 07 4799 7971 Mobile: CTPI 49-Sch4
Email: gary.jensen@derm.qld.gov.au
www.derm.qld.gov.au

Department of Environment and Resource Management
187 - 209 Stanley Street, Townsville Q 4810 PO Box 5318, Townsville Q 4810



CARPENTARIA SHIRE

Outback by the Sea

PO Box 31 Normanton Qld 4890
P 07 4745 2200 • F 07 4745 1340
E council@carpentaria.qld.gov.au
W www.carpentaria.qld.gov.au

Enquiries: Mark Kelleher
AAP

14 October, 2011

Department of Environment and Resource Management
PO Box 5318
TOWNSVILLE QLD 4810

Dear Sir,

Re: Concerns with Water Supply

The Carpentaria Shire Council has for many years been concerned at the quality of its water supply for the communities of Normanton and Karumba given the source is the upper reaches of the Norman River which includes various creeks such as Belmore.

The concern stems from the fact during the mining days in the Croydon Shire a legacy remains from the toxic gold processing plants.

Of recent times the Council has been made aware there are reports of significantly high traces of arsenic in Belmore Creek.

Given this situation, the Council requests DERM or any other relevant body to confirm these reports and advise what action is being taken to mitigate against the contamination of the water supply.

I have also referred a copy of this letter to the Croydon Shire Council for their information and input where appropriate.

I look forward to receiving confirmation from the Department of this correspondence and particularly a contact for ongoing discussions and actions regarding this matter.

Please do not hesitate to contact me on (07) 4745 2200.

Yours faithfully,

CTPI 49-Sch4

Mark Kelleher
CHIEF EXECUTIVE OFFICER



Cc: Croydon Shire Council
PO Box 17
CROYDON QLD 4871

July 20th, 2011 marks the 120th Anniversary of the Gulflander!

Opened in 1891 to join Normanton to the teeming gold fields of Croydon, the line has never been linked to the main Queensland Rail network. But these minor oddities do not concern the hundreds of passionate advocates of the Gulflander, they only add to the appeal as the "Tin Hare" rattles its way across the Savannah country. Today the Gulflander is a tourism icon and working tribute to the early pioneers of the Gulf of Carpentaria.



BARRICK GOLD OF AUSTRALIA LIMITED Tel: (618) 9212 5777
A.B.N. 19 008 143 137 Fax: (618) 9322 5700
Level 10
2 Mill Street
Locked Bag 12
CLOISTERS SQUARE WA 6850
PERTH WA AUSTRALIA

4 November 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2066
CAIRNS QLD 4870

Attention: Neil Maver

Project: Croydon Gold Mine

Subject: Environmental Investigation

Dear Neil,

Please find enclosed for your records the Barrick Australia Pacific (Barrick) *Croydon Gold Mine Environmental Investigation*. This report has been prepared to investigate the potential risk to Belmore Creek and its relevant tributaries in the vicinity of the Croydon Gold Mine as a result of the Content Pit surface water outflow on 30 March to 2 May 2011.

As described in Barrick's follow-up written advice submitted to the DERM on 1 August 2011, the assessments within the report have been conducted in accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) risk-based decision framework.

The assessments within the *Croydon Gold Mine Environmental Investigation* indicate that the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM. Therefore, in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, no remediation measures are considered necessary.

Pit lake water level monitoring and observations during the 2011 dry season have indicated that the water level of the Content Pit has lowered, therefore increasing the storage capacity of the open pit. Notwithstanding, should above average rainfall conditions occur during the 2011/2012 wet season, a reduction in the storage capacity of the Content Pit is likely and surface water outflows may occur.

Based on the conclusion of the *Croydon Gold Mine Environmental Investigation* and recent Content Pit lake water quality results (which demonstrates no deterioration of pit lake water quality during the 2011 dry season), should a surface water outflow occur from the Content Pit during the 2011/2012 wet season, Barrick expects the water quality of the outflow would be similar to that reported within the *Croydon Gold Mine Environmental Investigation* (i.e. with no receiving water contaminant limit exceedances of relevant metals). Therefore, Barrick would expect the outflow would pose a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM.

Notwithstanding, Barrick will continue to implement an additional monitoring programme during the 2011/2012 wet season. The monitoring programme would include surface water quality and stream sediment quality monitoring and a continuation of aquatic habitat and macroinvertebrate monitoring at locations in Belmore Creek upstream and downstream of the CGM.

Please do not hesitate to call me on [CTPI 49-Sch4] if you should have any queries regarding the above.

Yours sincerely

BARRICK AUSTRALIA PACIFIC LIMITED

[CTPI 49-Sch4]

[CTPI 49-Sch4]

Reclamation and Closure Manager

CC. Dean Sharpe



CROYDON GOLD MINE

ANNUAL GROUNDWATER MONITORING REPORT 2011

NOVEMBER 2010 – NOVEMBER 2011

Released

TABLE OF CONTENTS

1	INTRODUCTION	3
2	HYDROGEOLOGICAL STATUS	5
2.1	RAINFALL	5
2.2	CONCEPTUAL HYDROGEOLOGICAL MODEL	11
2.3	EXISTING GROUNDWATER ENVIRONMENT	13
3	GROUNDWATER MONITORING PROGRAM	20
4	GROUNDWATER MONITORING RESULTS	20
4.1	GROUNDWATER CHEMISTRY	20
4.2	GROUNDWATER CONDITIONS	25
5	APPENDIX 1: MONITORING RESULTS	28
6	REFERENCES	43

LIST OF TABLES

Table 1: Croydon Township Weather Station Rainfall Data	6
Table 2: Croydon Pit Lake Levels	12
Table 3: Groundwater Monitoring Programme	20
Table 4: Summary of Trigger Level and Contaminant Limit Exceedance for Croydon Groundwater	21
Table 5: Groundwater monitoring bore details	25
Table 6: Groundwater Quality – Confined Fractured Rock Aquifer 1995 to 2009	29
Table 7: Groundwater Quality – Unconfined Alluvial Aquifer 2001 to 2009	30
Table 8: Groundwater monitoring results 2010 – 2011	31
Table 9: Groundwater levels in monitoring bores	33

LIST OF FIGURES

Figure 1: Croydon project site location	4
Figure 2: Yearly rainfall totals from Croydon Weather Station, 1889 to 2011	7
Figure 3: Wet and dry season rainfall totals from Croydon Weather Station, 1889 to 2011	7
Figure 4: Frequency histogram of calendar year rainfall totals for Croydon	8
Figure 5: Frequency histogram of annual “wet season” rainfall totals for Croydon	8
Figure 6: Mean 2011 monthly rainfall totals for Croydon	9
Figure 7: Daily and cumulative 2011 rainfall for Croydon	9
Figure 8: Croydon calendar year annual rainfall normal probability plot	10
Figure 9: Croydon “water year” annual rainfall normal probability plot	10
Figure 10: Croydon Pit Lake water level monitoring stations	12
Figure 11: Croydon conceptual hydrological model	14
Figure 12: Content Pit contour map	15
Figure 13: Croydon Surface Water Monitoring Sites	16
Figure 14: Croydon Surface Monitoring Sites – South-Eastern Close-up	17
Figure 15: Croydon Groundwater Monitoring Bores	18
Figure 16: Croydon Groundwater Monitoring Bores– South-Eastern Close-up	19
Figure 17: Golden Butterfly Pit Monitoring Bore Water Levels	26
Figure 18: Golden Butterfly Dump Monitoring Bore Water Levels	26
Figure 19: Content Pit Monitoring Bore Water Levels	27
Figure 20: Golden Butterfly North Pit Monitoring Bore Water Levels	27
Figure 21: Golden Butterfly Dump Monitoring Bores – Time Series	35
Figure 22: Golden Butterfly Pit Monitoring Bores – Time Series	37
Figure 23: Content Pit Monitoring Bores – Time Series	39
Figure 24: Golden Butterfly North Pit Monitoring Bores – Time Series	41

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority (EA) No. MIN100401906 for the Project.

This Groundwater Monitoring Report has been prepared in accordance with EA Condition F4-4:

F4-4 Annual groundwater monitoring reports analysing groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions are to be prepared by November each year as an element of the water management strategy review.

The remainder of this Groundwater Monitoring Report is structured as follows:

- Section 2: Provides a description of the hydrogeological status of the Project.
- Section 3: Outlines the groundwater monitoring program for the Project.
- Section 4: Analyses the groundwater monitoring results for the Project during the period November 2010 to November 2011.
- Section 5: Provides tabulated monitoring results and various time series graphs.

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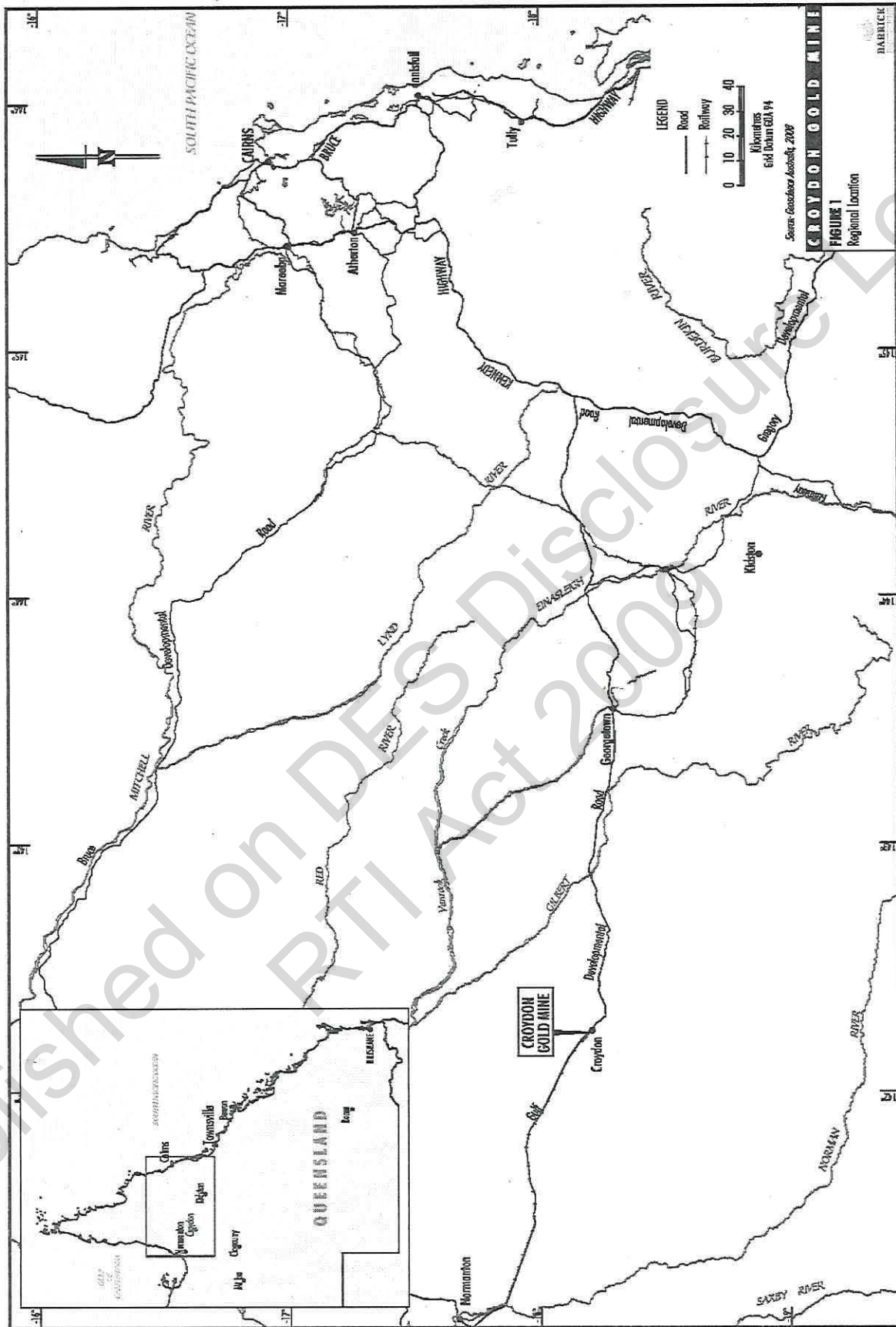


Figure 1: Croydon project site location

2 HYDROGEOLOGICAL STATUS

2.1 RAINFALL

Daily rainfall records are available from the Queensland Bureau of Meteorology (BoM) Croydon Township Weather Station (station number 29012) since 1889 with various statistics summarised in Table 1. The statistics presented in Table 1 show that the 2010/2011 wet season was again extraordinary. The 2011 calendar year recorded a total rainfall of 1104.1 mm which is the tenth highest annual total in the 123 year record. A further statistic that is perhaps of greater consequence to groundwater is that again during 2011 the number of rain days, and in particular the number of days with rainfall events greater than 10mm and 25mm, is significantly higher than the long term average. This all follows on from the 2009/2010 wet season which was itself the wettest on record.

Figure 2 presents calendar year rainfall totals since 1889 from the Croydon Township Weather Station and illustrates that the Croydon site, and hence the four pit lakes, has experienced an extremely wet period since approximately 2005. This is further highlighted by Figure 3 which categorises rainfall into "dry" and "wet" season totals (wet season being defined as the period from November through to April) rather than just annual totals. Again it is clearly evident that the last half the decade has had unprecedented extreme rainfall totals, with the three highest totals of the 123 year record occurring successively between 2009 and 2011.

Frequency histograms of calendar year and annual "wet season" rainfall totals are presented in Figure 4 and Figure 5 respectively. This representation of the Croydon rainfall record again graphically demonstrates the extreme nature of the 2009, 2010 and 2011 wet seasons. While the 1974 yearly total of 1932mm was significantly higher than either 2009 (1338mm), 2010 (1290mm) or 2011 (1104mm) the fact of having three of the four highest wet season totals from a 123 year period occurring in succession has considerable impact on groundwater and pit lake water levels.

Mean monthly rainfall from the Croydon Township record is presented in Figure 6. While the consistent exceedance of mean monthly totals for the 2009 to 2011 period is not surprising in view of the previous discussion of yearly totals, the rainfall for March 2011 (similar to that recorded in April 2010) is notable in itself. Large rainfall events such as observed in March 2011 (and previously in April 2010) occurring at the very end of the normal "wet season" period, potentially increases annual net infiltration to groundwater. If such rainfall occurred earlier in the "wet season" when surface storage is already saturated, it is highly likely the majority would result in surface runoff rather than recharge. This "late" rainfall, together with the increased frequency of greater than 10mm and 25mm rainfall events, is likely to increase groundwater levels and for a longer period of time.

The increased frequency of greater than 10mm rainfall events is also noteworthy in the 2011 annual record as they extend across a longer time period than normal (see Figure 7). This follows from a similar observation of the 2010 annual record. Such changes in frequency of the volume and intensity of rainfall and variation in antecedent conditions due to seasonal timing of rainfall, are important governing processes in how a catchment responds to rainfall and hence accuracy of modelling¹.

The Croydon rainfall data is notable *per se* in terms of the length of the historical record. This enables some degree of confidence in calculated statistical measures such as the recurrence interval. The data must be random, independent and stationary to be strictly used for such frequency analysis², and the Croydon data approximates such conditions sufficiently to enable management information to be produced (as opposed to mathematically rigorous statistical values).

Figure 8 plots the normal cumulative distribution function for the Croydon calendar year rainfall. This indicates that the year 2011 rainfall was in the order of a 20-year event. However, using "wet season" annual totals, which better approximate annual totals based upon actual climatic factors, the 2011 rainfall was in the order of a 100-year event and the preceding 2010 and 2009 both 50-year events (see Figure 9). This demonstrates that the perception that a 100-year event having occurred, will only occur for another 100 years is incorrect, and highlights the unusual nature of recent rainfall at Croydon.

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Table 1: Croydon Township Weather Station Rainfall Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	223	181	115.7	25.5	7.8	8.5	3.9	2.7	5.5	14	44.6	116.3	747.9	1889 - 2011
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2008	2011	2010	2011	2011	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.2	43.5	16.5	0	0	0	0	0	0	0	5.8	36.2	438.6	
Decile 5 (median) rainfall (mm)	200.8	170.6	93.7	9.9	0.4	0.4	0	0	0	4.6	27.6	103.6	715.7	
Decile 9 rainfall (mm)	397	304.2	239.3	63.6	22.9	21.1	11.1	8.9	20	37	95.5	232.5	1038	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	29 JAN 1908	05 FEB 1964	12 MAR 1936	06 APR 2010	07 MAY 1956	05 JUN 1990	15 JUL 2006	29 AUG 1924	04 SEP 1943	15 OCT 1964	27 NOV 1973	20 DEC 1976	29 JAN 1908	
Mean number of days of rain	12.8	12.3	8.3	2.1	1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.7	2011
Mean number of days of rain ≥ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.6	48	
Mean number of days of rain ≥ 10 mm	6	5.5	3.3	0.6	0.3	0.2	0.1	0.1	0.2	0.5	1.3	3.4	21.5	
Mean number of days of rain ≥ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	338.8	401.6	241.6	13.2	0	0.6	0	0	0	30	36.4	42.2	1104.4	
Highest daily rainfall (mm)	77	142.4	53.2	12.4	0	0.6	0	0	0	17.8	25.8	14.8	77	
Number of days of rain	16	18	21	3	0	1	0	0	0	4	5	9	77	
Number of days of rain ≥ 1 mm	16	15	20	1	0	0	0	0	0	2	4	6	64	
Number of days of rain ≥ 10 mm	11	8	6	1	0	0	0	0	0	2	1	1	30	
Number of days of rain ≥ 25 mm	5	5	2	0	0	0	0	0	0	0	1	0	13	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012)

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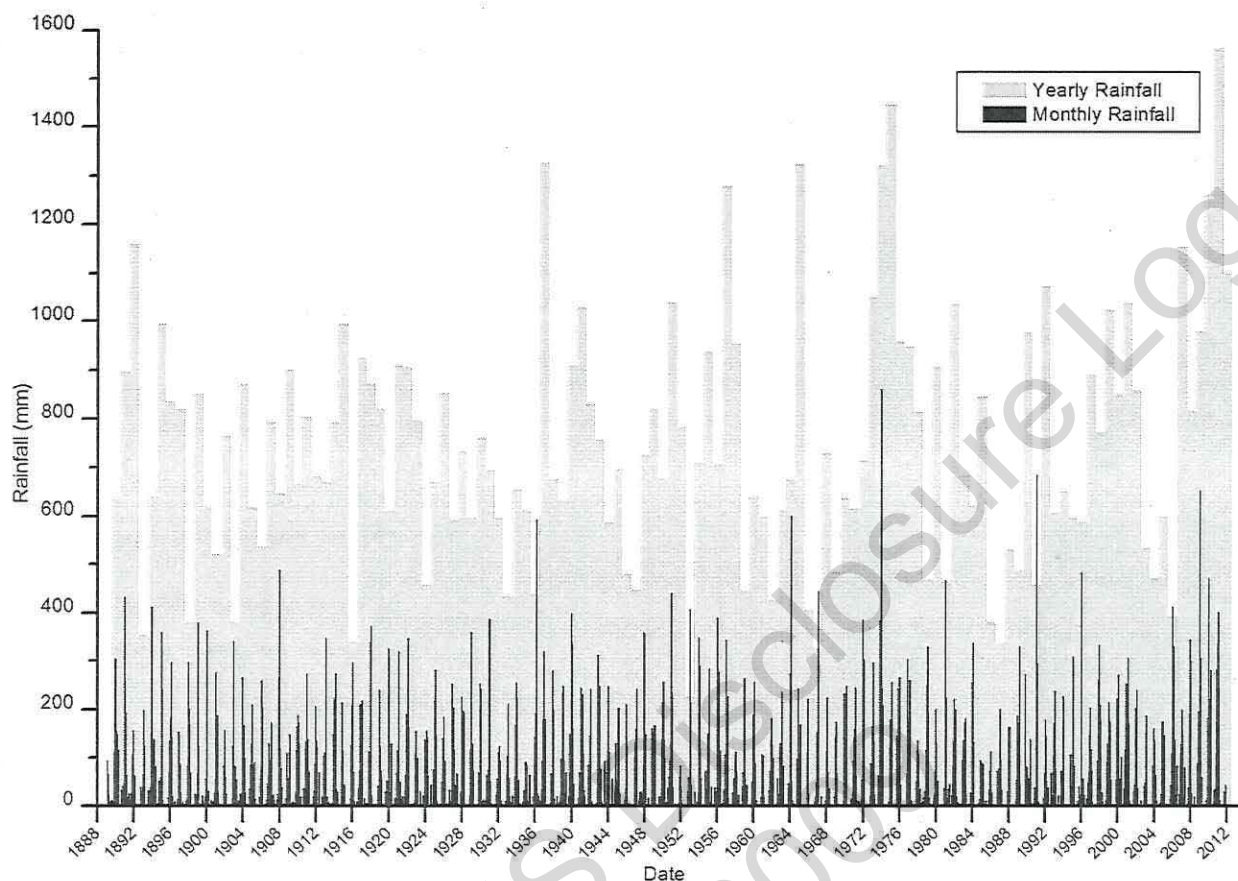


Figure 2: Yearly rainfall totals from Croydon Weather Station, 1889 to 2011

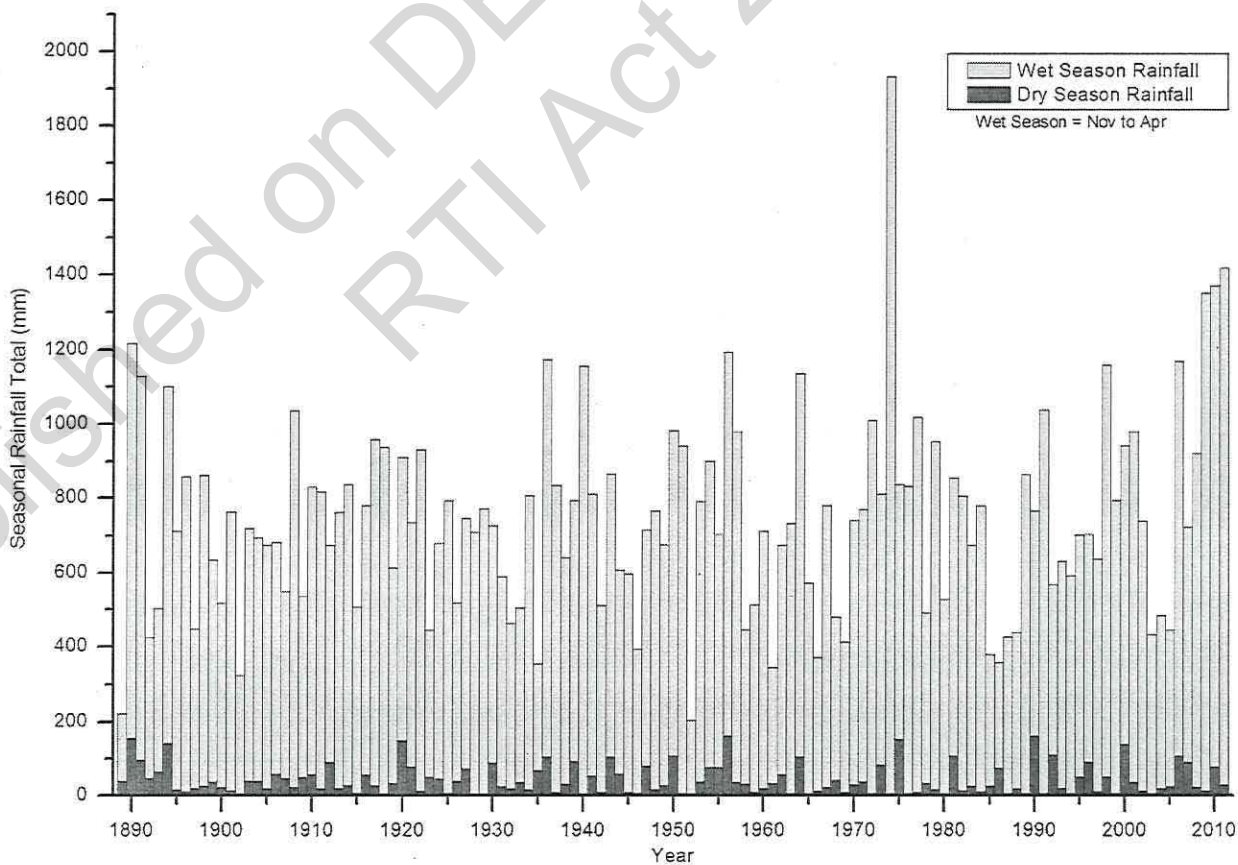


Figure 3: Wet and dry season rainfall totals from Croydon Weather Station, 1889 to 2011

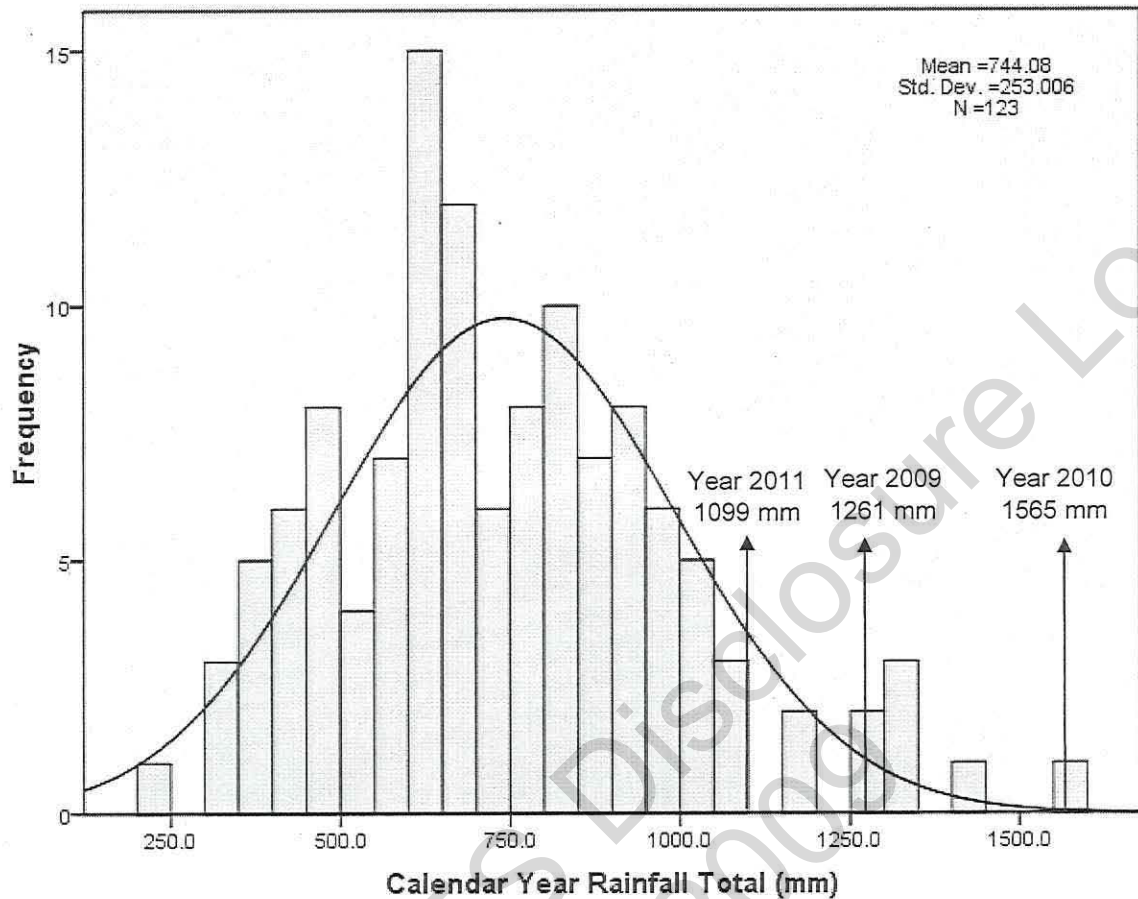


Figure 4: Frequency histogram of calendar year rainfall totals for Croydon

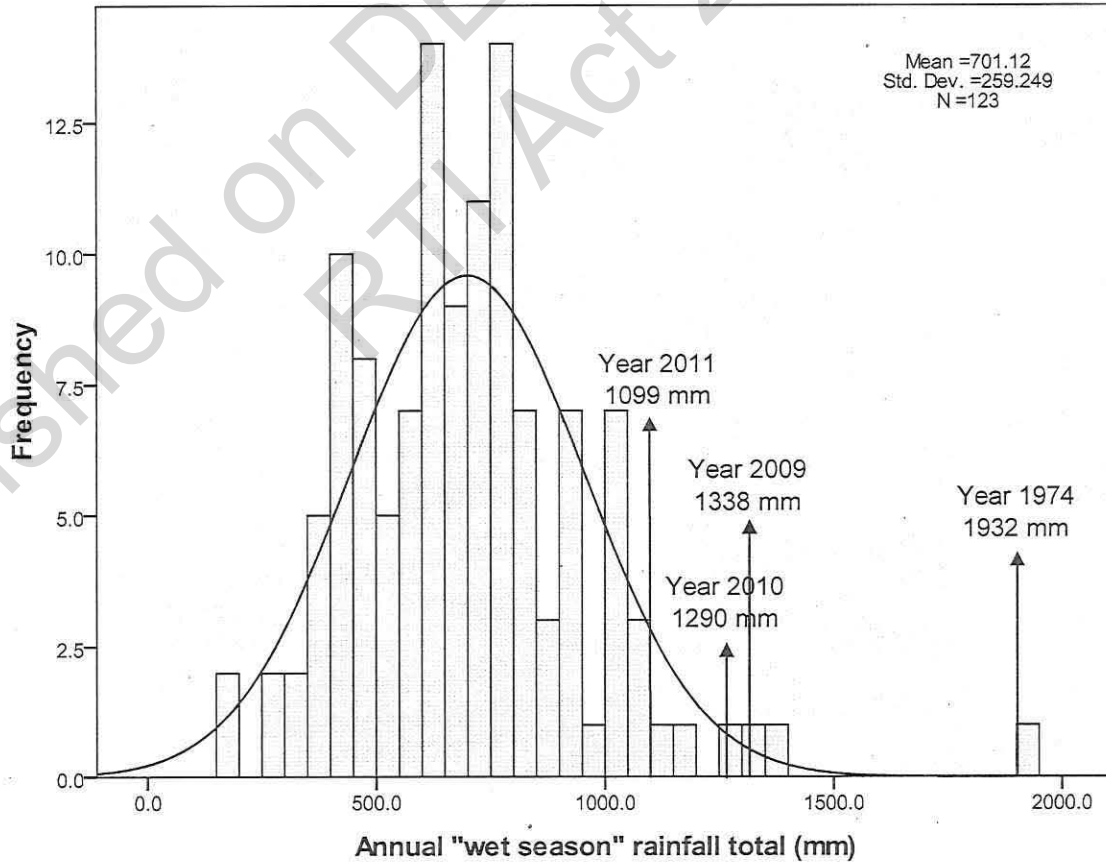


Figure 5: Frequency histogram of annual "wet season" rainfall totals for Croydon

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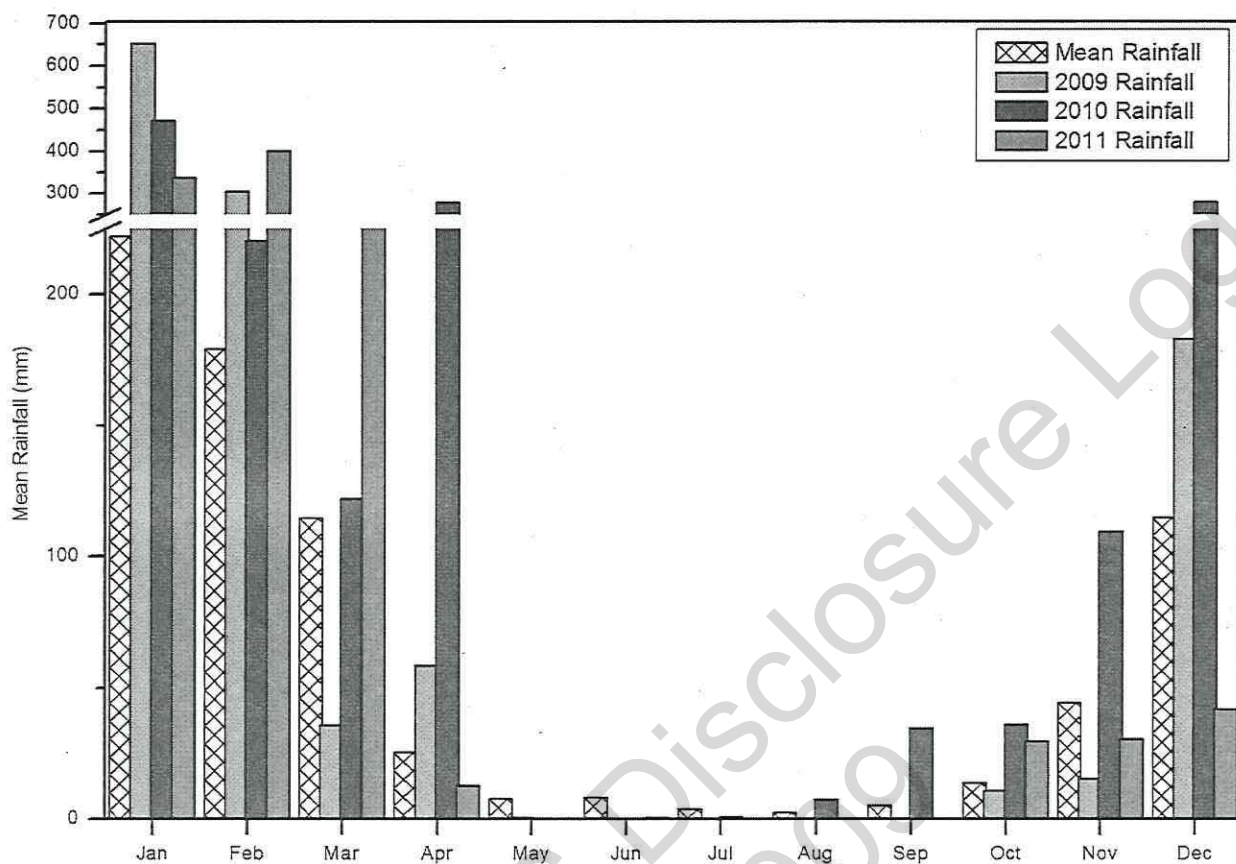


Figure 6: Mean 2011 monthly rainfall totals for Croydon

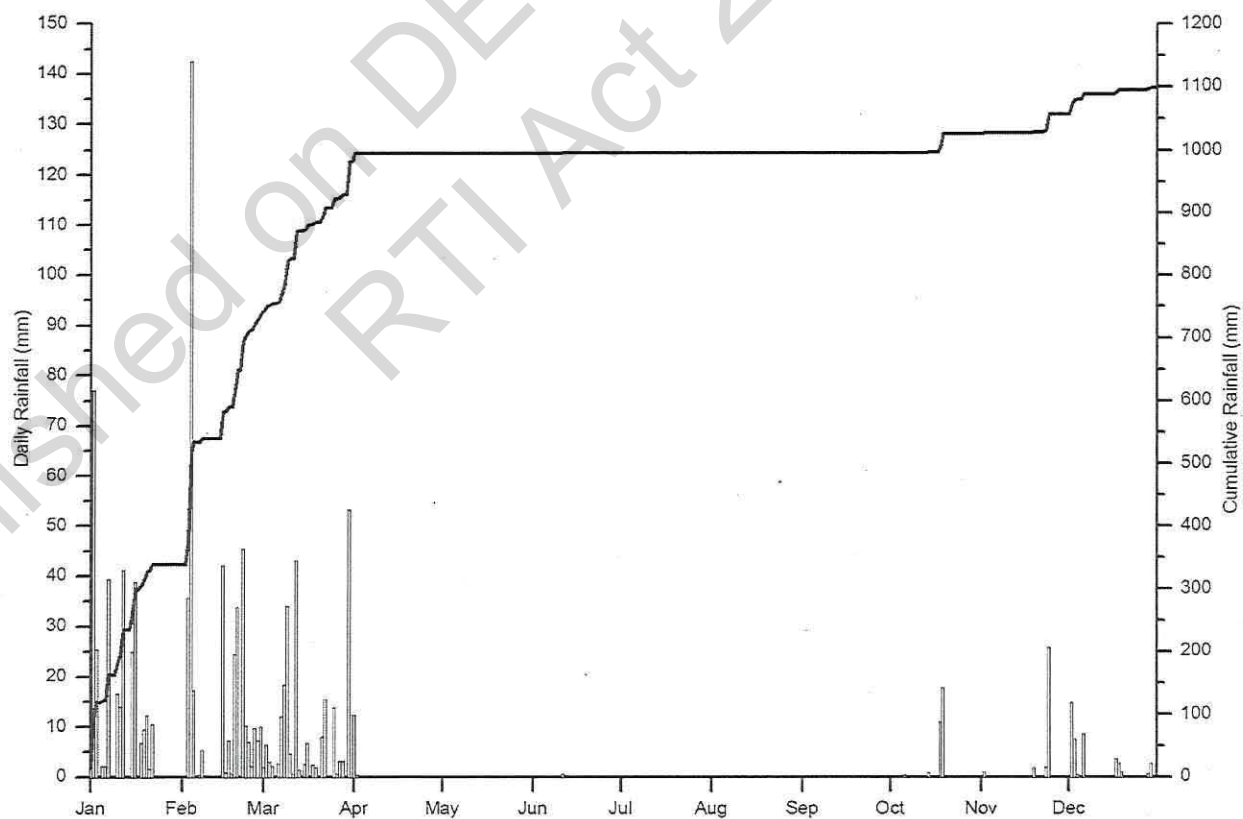


Figure 7: Daily and cumulative 2011 rainfall for Croydon

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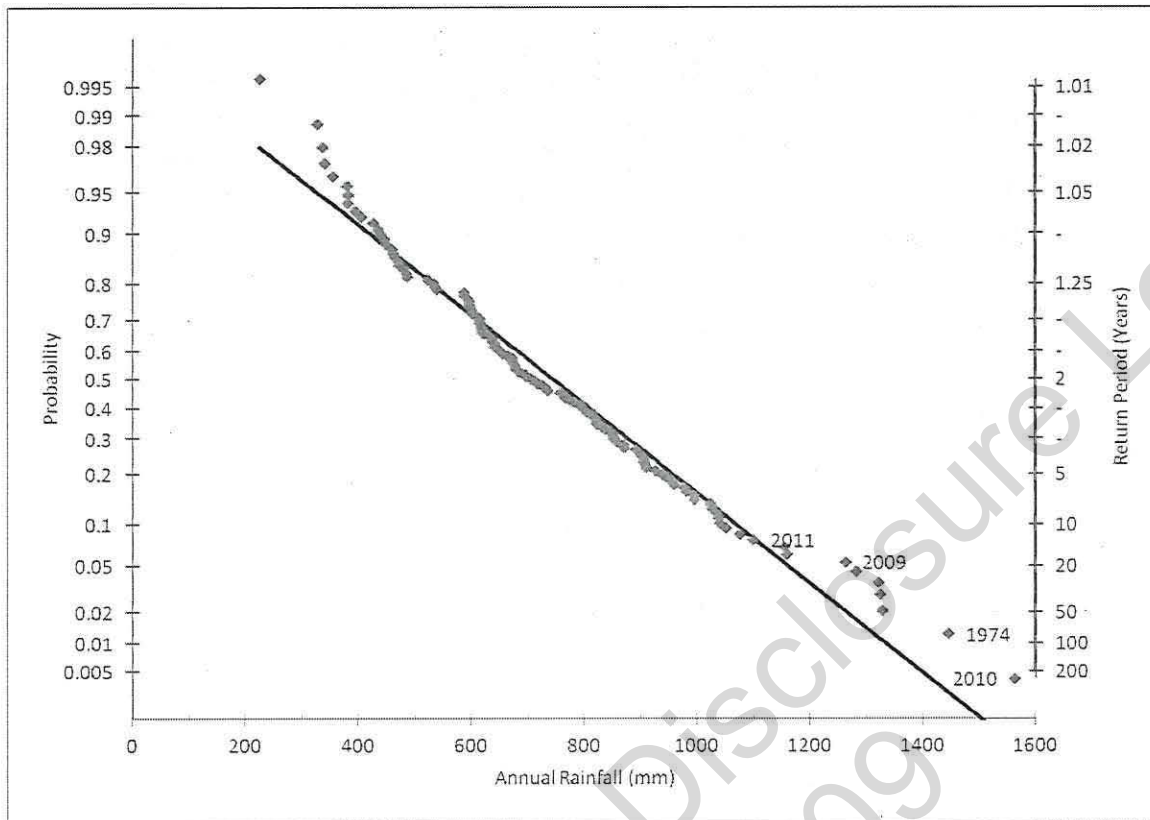


Figure 8: Croydon calendar year annual rainfall normal probability plot

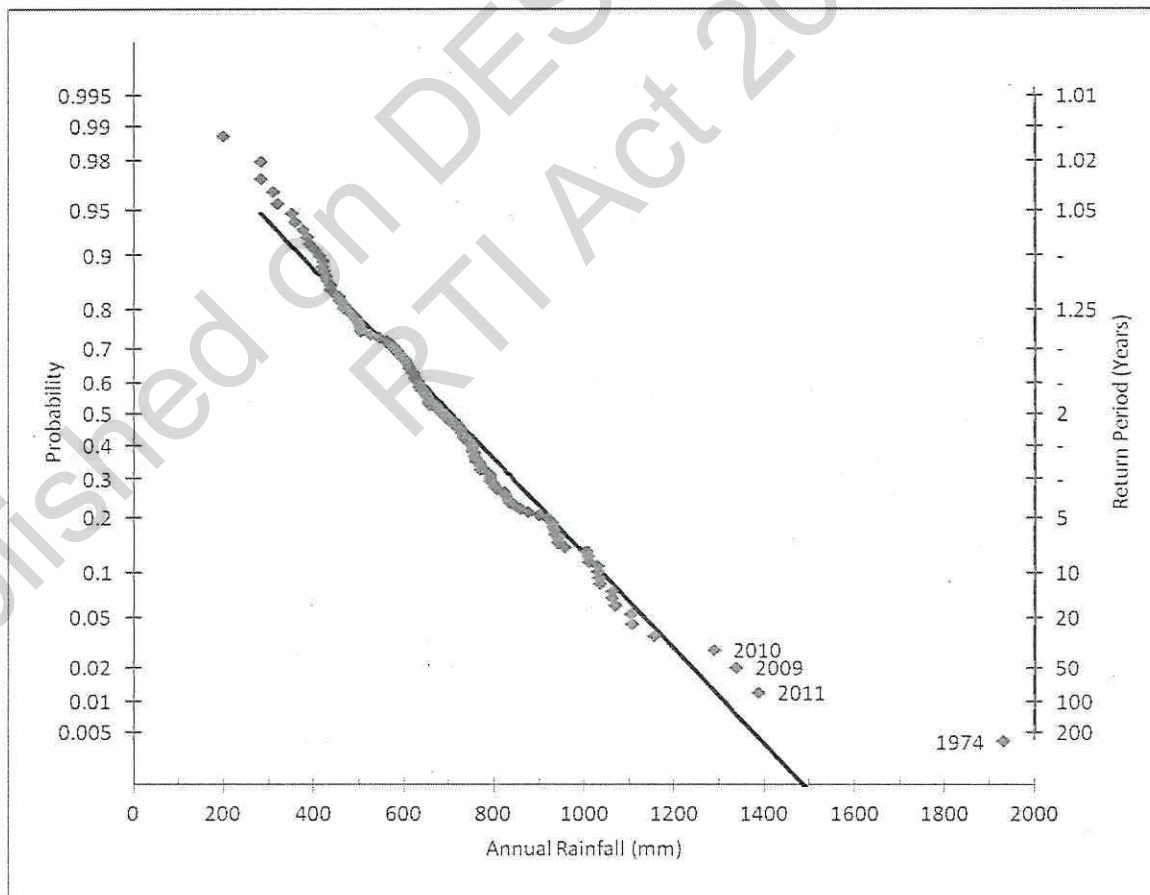


Figure 9: Croydon "water year" annual rainfall normal probability plot

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2.2 CONCEPTUAL HYDROGEOLOGICAL MODEL

A conceptual hydrogeological model (Figure 11) was developed for the Project and surrounds during preparation of the Environmental Management Plan (EM Plan)³. The conceptual hydrogeological model was based on the hydrogeological study conducted by HLA-Envirosciences⁴ and available groundwater quality information.

The hydrogeological study indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pits. In addition, the hydrogeological study showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping⁵. Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 (see Section 2.1) raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (see Figure 2). In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. Figure 12 presents an aerial photograph of the area around the Content Pit overlaid with a contour map. The Lady Isabella Pit when full is approximately five meters higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting fracture zones and or fault lines enabling water flow.

During the period 23rd February 2011 to 22nd December 2011 the Content Pit Lake decreased by approximately 1.13m while during the same period the Lady Isabella Pit decreased by approximately 1.94m (see Table 2). Daily evaporation and rainfall records from the Queensland Bureau of Meteorology (BoM) Croydon Township Weather Station (station number 29012) for the same period record a total evaporation of 1786mm with a rainfall of 407mm equating to an evaporation excess of 1379mm. Surface water inflows to all Croydon pits have been effectively eliminated by the installation of safety berms surrounding each pit and other measures such as interception drains. Therefore, to a first approximation the Lady Isabella Pit has had approximately 0.56m of groundwater outflow, while the Content Pit has had 0.25m of groundwater inflow during the period.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed in each of the pit lakes at Croydon (see Figure 10). Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit.

Table 2: Croydon Pit Lake Levels

	Content Pit		Golden Butterfly Pit		Lady Isabella Pit		Golden Butterfly North Pit	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10 th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13 th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27 th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18 th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19 th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7 th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29 th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23 rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23 rd Aug 2011	103.24	0.47	106.31 ^a	8.19	108.26 ^a	1.44	113.31	9.40
20 th Oct 2011	102.89	0.81	104.91 ^a	9.59	107.90 ^a 108.13 ^b	1.57	112.64	10.07
6 th Dec 2011	102.65 ^d	1.05	104.75 ^d	9.75	107.96 ^c 107.82 ^d	1.74	na	na
22 nd Dec 2011	102.57 ^d	1.13	104.74	9.76	107.76 ^d	1.94	113.78 ^d	8.92

a. Using Dumpy Level

b. Compared to last gauge board reading (8th Dec 2010)

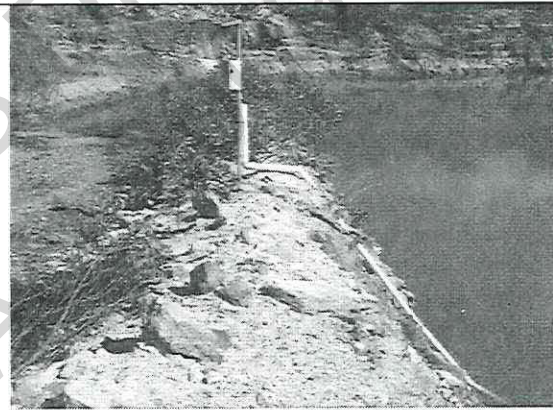
c. Using gauge board reading

d. Using survey equipment

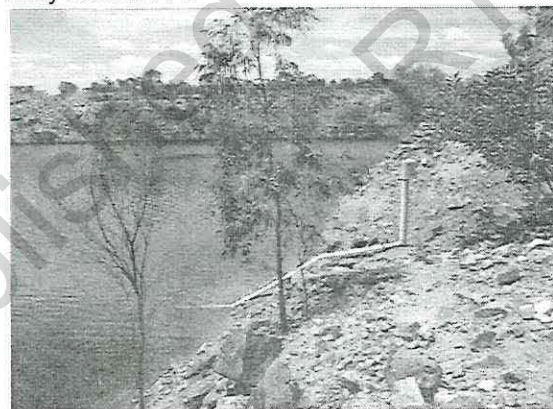
e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m



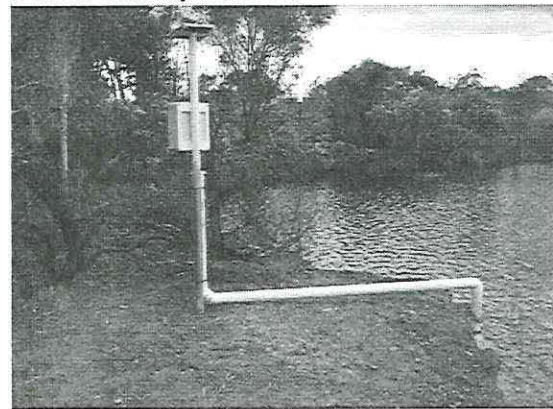
Lady Isabella Pit



Golden Butterfly North Pit



Golden Butterfly Pit



Content Pit

Figure 10: Croydon Pit Lake water level monitoring stations

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2.3 EXISTING GROUNDWATER ENVIRONMENT

ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 10 years ago, is located within Slaughteryard Creek approximately 1 km south-west of Golden Butterfly Pit (see Figure 15). It is considered that the borefield exploits both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. A series of monitoring bores (i.e. GBMB series Figure 16) located between the old town borefield and ML 5248 have been monitored for more than 12 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield.

In accordance with EA Condition F4-5 additional monitoring bores BH8, BH9, BH10, BH11, BH12 and SY1 were constructed in late October 2008 (Figure 3) and continue to be monitored. A detailed analysis of the groundwater monitoring bore results for the period November 2010 to November 2011 is provided in Section 4.

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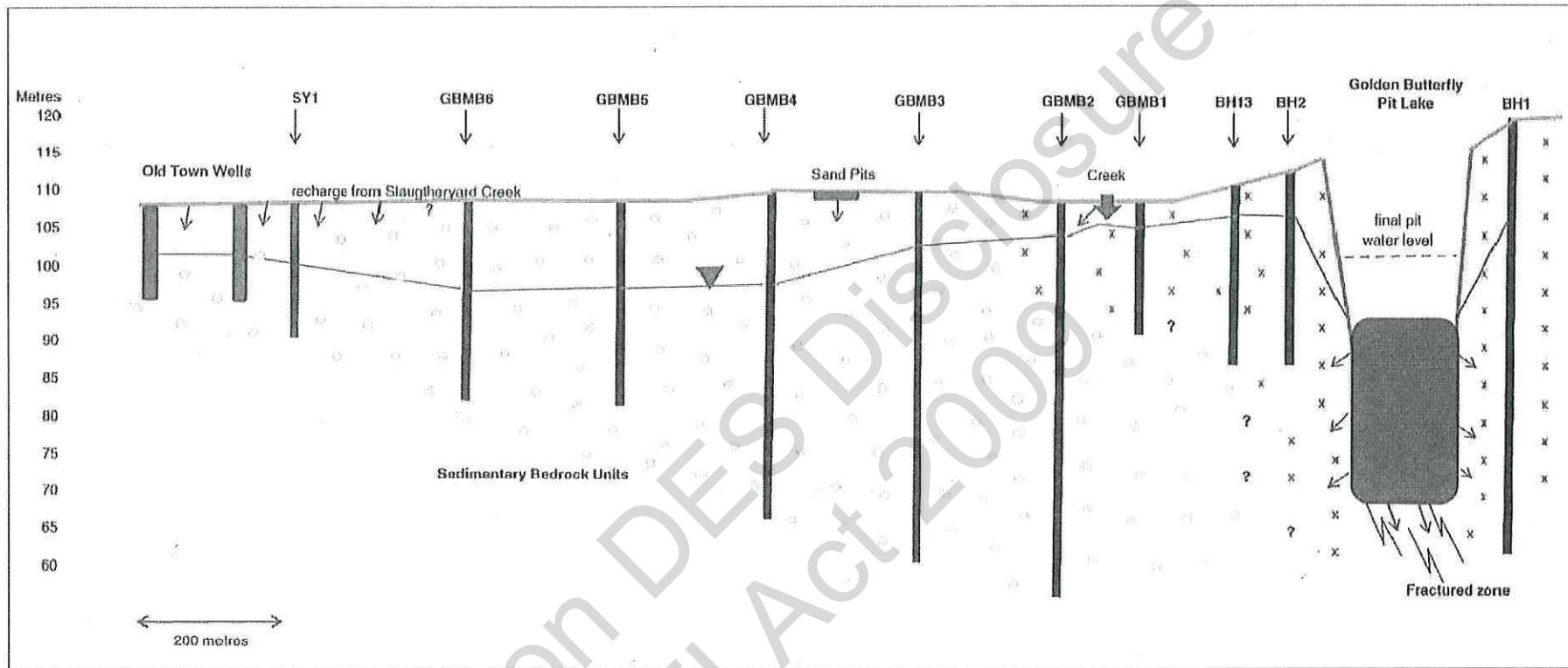
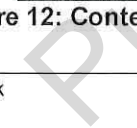


Figure 11: Croydon conceptual hydrological model



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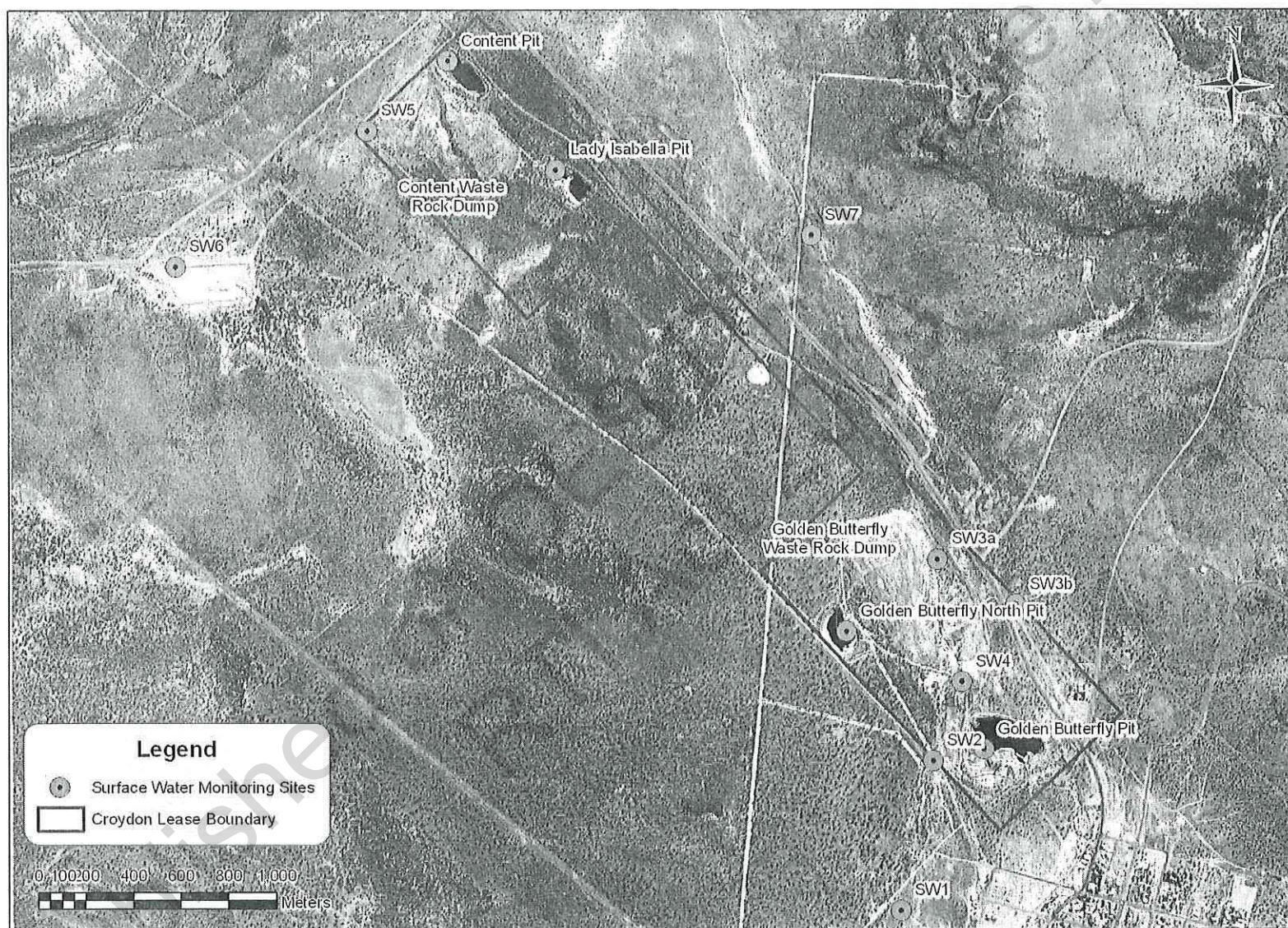


Figure 13: Croydon Surface Water Monitoring Sites



Figure 14: Croydon Surface Monitoring Sites – South-Eastern Close-up

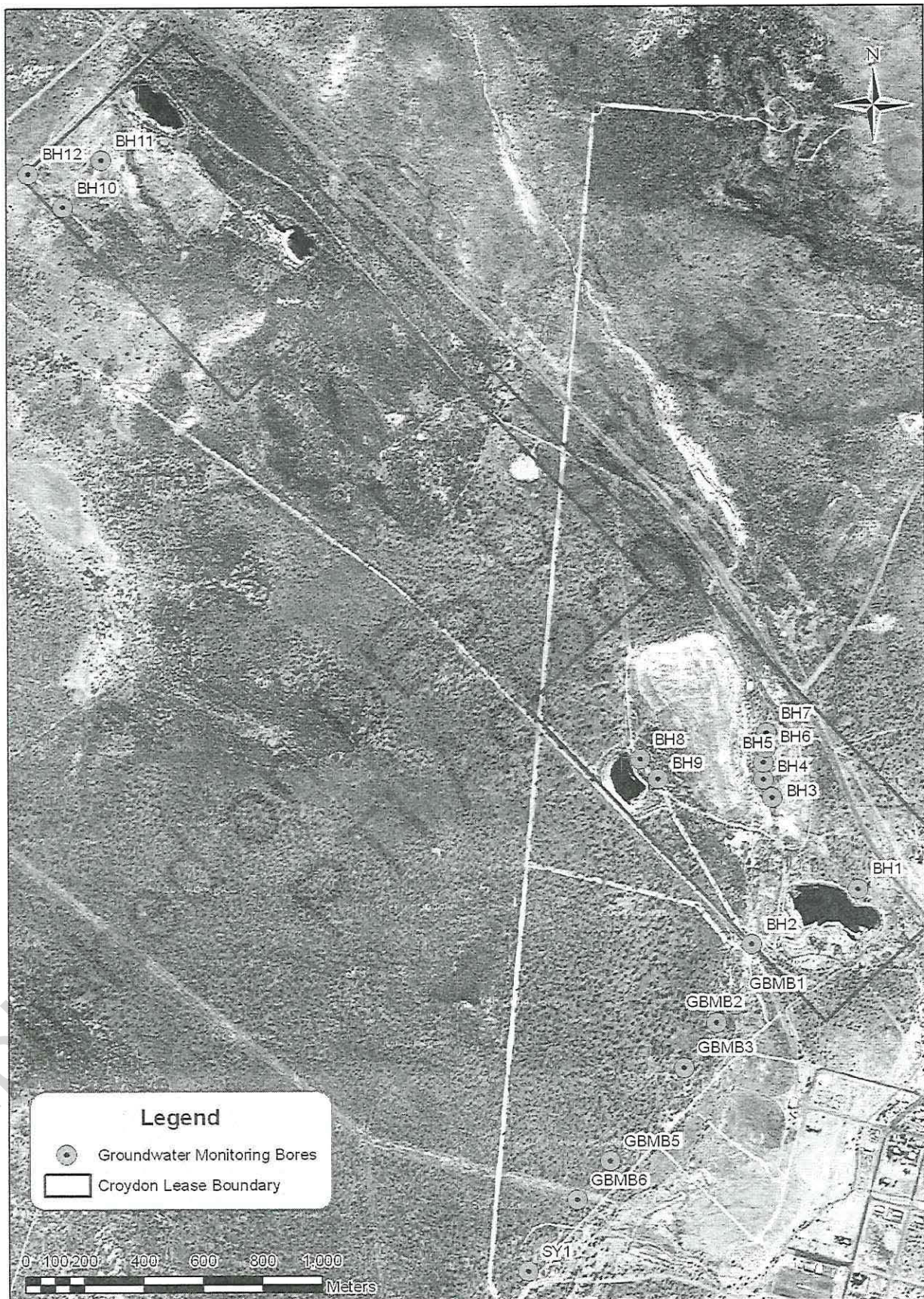




Figure 16: Croydon Groundwater Monitoring Boreholes– South-Eastern Close-up

3 GROUNDWATER MONITORING PROGRAM

In accordance with EA Condition F4-1 groundwater monitoring is conducted at the locations and frequencies defined in Schedule F - Table 9 of the EA for the parameters identified in Schedule F - Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 3.

In addition, groundwater levels are recorded in all monitoring bores defined Schedule F - Table 9 of the EA as soon as practical after the end of wet season (generally March/April after access roads have opened) and again during the dry season.

Table 3: Groundwater Monitoring Programme

Monitoring Location ¹	Frequency	Parameters
BH1 (North of Golden Butterfly Pit)	Annually during the dry season	pH
BH2 (South-west of Golden Butterfly Pit)		EC
BH3 (South-east of Golden Butterfly Waste Rock Dump)		Turbidity
BH5 (East of Golden Butterfly Pit Waste Rock Dump)		Sulphate
BH7 (East of Golden Butterfly Waste Rock Dump)		Fluoride
BH8 (West of Golden Butterfly Waste Rock Dump)		Aluminium
BH9 (West of Golden Butterfly Waste Rock Dump)		Arsenic
BH10 (West of Content Waste Rock Dump)		Boron
BH11 (West of Content Waste Rock Dump)		Cadmium
BH12 (West of Content Waste Rock Dump at lease boundary)		Chromium (CrVI)
GBMB1 (Slaughteryard Creek)		Cobalt
GBMB3 (Slaughteryard Creek)		Copper
GBMB6 (Slaughteryard Creek)		Mercury (inorganic)
SY1 (Slaughteryard Creek)		Nickel
		Selenium (total)
		Zinc

1. See Figure 15 and Figure 16 for locations

4 GROUNDWATER MONITORING RESULTS

Groundwater samples for the reporting period November 2010 to November 2011 were taken from the monitoring bores defined in Schedule F - Table 9 of the EA and sent to Australian Laboratory Services for analysis.

4.1 GROUNDWATER CHEMISTRY

The groundwater quality results for the EA monitoring bores are provided in Appendix 1 both in tabular format and as a sequence of time series graphs.

Trigger values were calculated as per the instructions in the footnotes to Schedule F – Table 10, of the EA for groundwater monitoring locations specified in Schedule F, Table 9 of the EA. Table 9 of Schedule F of the EA does not specify reference sites as required in the calculation of trigger values. Therefore, trigger values default to the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems. Table 4 provides a summary of trigger value exceedances for groundwater monitoring locations during the reporting period.

Groundwater from bores identified in Schedule F – Table 9, must not exceed any of the limits defined in Schedule C – Table 11 of the EA. Table 4 provides a summary of contaminant limit exceedances for groundwater monitoring locations during the reporting period.

The various groundwater monitoring bores (see Figure 15 and Figure 16) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps. Consequently, groundwater quality monitoring results in terms of the various trigger level exceedances are discussed in the following groupings in subsequent sections:

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

Table 4: Summary of Trigger Level and Contaminant Limit Exceedance for Croydon Groundwater

Parameter ¹	Groundwater Location Exceeding Trigger Level ^{1,2}	Groundwater Location Exceeding Contaminant Limit ^{2,3}
pH	BH1, BH2, BH5, BH8, BH9, BH10, BH11, BH12, GBMB1	
Electrical Conductivity	BH1, BH2, BH3, BH5, BH7, BH10, BH11, BH12, GBMB1	BH5
Aluminium	BH2, BH3, BH9, SY1, GBMB3	
Arsenic	BH11, BH12, GBMB1, GBMB3, GBMB6	
Cadmium	BH5, BH7	
Cobalt	BH2, BH3, BH7, BH10, SY1, GBMB3	
Copper	All Sites, except BH9, BH12	
Nickel	BH2, BH7	
Zinc	BH1, BH2, BH5, BH6, BH7, BH8, BH9, BH10, BH11, BH12, GBMB1, GBMB3, GBMB6, SY1	
Sulphate		BH5, BH7, BH10
Fluoride		BH1, BH3, BH5, BH7, BH10, BH11, BH12, GBMB1

¹ Parameters and trigger levels defined in Schedule F Table 10

² Groundwater monitoring locations defined in Schedule F Table 9

³ Parameters and contaminant limits defined in Schedule F Table 11

Golden Butterfly Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the following locations BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1 (see Figure 16). Monitoring bore BH1 is located within 50 meters of the north-eastern wall of the Golden Butterfly Pit and monitoring bore BH2 is located approximately 150 meters to the south-west. The remaining bores, GBMB1, GBMB3, GBMB6 and SY1 are located successively further away from the Golden Butterfly Pit towards the south-west, approximately following the course of a tributary to Slaughteryard Creek that drains from the mine lease area. Figure 22 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Electrical conductivity observed at the Golden Butterfly Pit Monitoring bores has approximately flat trends when viewed over the greater than fifteen year period for which data is available (Figure 22). Although the electrical conductivity trend for GBMB1 appears to indicate an improvement at this location over time. Consequently, the observed trigger level exceedance of electrical conductivity at monitoring bores BH1, BH2, and GBMB1 is as per previous reporting periods and not an emergent issue.

The major difficulty in assessing the relevance of the observed electrical conductivity trigger level exceedance is that no reference sites have been stipulated against which to judge the results. The default of using the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed, not surface water, and further, the bores are located within a metalliferous area that has hosted mining for over one hundred years. Notwithstanding these difficulties, the time series graphs of electrical conductivity for the Golden Butterfly Pit Monitoring bores (see Figure 22) clearly show that potentially down gradient groundwater sites from the Golden Butterfly Pit such as GBMB1, GBMB3, GBMB6 and SY1 are not being affected by recharge from pit water. Reference to Section 4.2 also shows that the local groundwater gradient as measured by bores along the Slaughterhouse Creek drainage is toward the Golden Butterfly Pit void, which will result in subsurface flow towards the pit and not away from the mine pit lake.

Bores BH1 and BH2 also exceeded the trigger levels for pH during the reporting period. Again with reference to the relevant time series for pH (Figure 22) such exceedances are not indicative of emergent issues but in line with the long term monitoring record and highlight the lack of suitable reference sites. The dramatic difference in observed pH for monitoring bore BH2 compared to the others in the category (BH2, GBMB1, GBMB3, GBMB6 and SY1) indicate a likely difference in geology in which the bore is located.

As previously mentioned, groundwater levels argue against the possibility of low pH water from the Golden Butterfly Pit Lake flowing subsurface to BH1. The gold mineralisation is contained within granites and intruded volcanics in close proximity to the contact of two rock units⁶, resulting in a highly heterogeneous zonation. This potential difference in localised geology within which BH2 is located means interpretation of bore monitoring results in terms of potential pit lake influence is likely limited. Therefore, trigger level exceedances for nickel, copper, cobalt, aluminium and zinc observed at BH2 are likely not of wider significance. Further, the relevant time series show no increasing trends, potentially down gradient groundwater sites from the Golden Butterfly Pit such as GBMB1, GBMB3, GBMB6 and SY1 are not similarly elevated, and finally, subsurface flows are towards the pit lake in any case.

Zinc and copper trigger levels were exceeded at all the Golden Butterfly Pit Monitoring bore site during the reporting period. Taking into account subsurface flows are towards the pit lake and there is no evidence of groundwater contaminated plumes from the observed time series for electrical conductivity and sulphate for example (Figure 22), the trigger level exceedances for zinc and copper are more indicative of inappropriate limits and the lack of suitable reference sites.

Fluoride contaminant limits were exceeded at bores BH1 and GBMB1 during the reporting period. The fluoride concentration recorded in the Golden Butterfly Pit Lake is 0.4-2.6 mg/L ($\bar{x}$ =1.04, median=0.65, n=12), whereas, the fluoride concentration recorded in bore BH1 is 3.3-4.0 mg/L ($\bar{x}$ =3.67, median=3.7, n=12). This coupled with groundwater levels (see Section 4.2), indicates that BH1 is a source of fluoride to the Golden Butterfly Pit rather than the pit lake affecting surrounding groundwater. Further, calcium concentration in the Golden Butterfly Pit is in the order of 300 mg/L which would form highly insoluble CaF_2 .

Figure 22 presents the time series for observed fluoride concentration in bores BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1. While there are no apparent trends over time, Figure 22 also demonstrates that the concentration of fluoride at bore GBMB1 is predominately higher than at bore BH2. However, Figure 16 shows that bore BH2 lies between GBMB1 and the Golden Butterfly Pit Lake. Therefore the fluoride contaminant exceedance at GBMB1 is not likely the result of groundwater inputs from the Golden Butterfly pit lake. This conclusion is supported by the local groundwater gradient as measured by bores along the Slaughterhouse Creek drainage (see Section 4.2), which is toward the Golden Butterfly Pit void, which will result in subsurface flow towards the pit and not away from the mine pit lake. Monitoring results for bores GBMB3, GBMB6 and SY1 show fluoride concentrations an order of magnitude lower than that observed in bores around the mineralised zone associated with the Golden Butterfly pit.

Golden Butterfly North Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the locations BH8 and BH9 (see Figure 16). Both these monitoring bores are located within 50 meters of the north-eastern wall of the Golden Butterfly North Pit approximately 100 meters apart. Figure 24 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Zinc, copper and pH trigger levels were exceeded at both the Golden Butterfly North Pit Monitoring bore sites during the reporting period. While monitoring data only exists back to April 2009 when the bores were installed, the available time series data presents no evidence of increasing trends and hence emerging issues. Similar to the discussion in the previous section, the trigger level exceedances for zinc, copper and pH are more indicative of inappropriate limits and the lack of suitable reference sites.

Content Pit Monitoring Bores

The Content Pit Monitoring Bores consist of the locations BH10, BH11 and BH12 (see Figure 15). Monitoring bore BH11 is located approximately 250 meters from the south-western wall of the Content Pit. Bores BH10 and BH12 are also located to the south-west of the Content Pit but at a distance of approximately 500 meters. Bores BH10 and BH12 are approximately 150 meters apart. Figure 23 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

The electrical conductivity trigger level of 250 $\mu\text{S}/\text{cm}$ was exceeded at each of the Content Pit Monitoring Bores during the reporting period. While monitoring data only exists back to April 2009 when the bores were installed, the available time series data presents no evidence of increasing trends and hence emerging issues. Further, monitoring bore BH11, which is the closest to both the Content Pit and Content Waste Rock Dump, recorded electrical conductivity values approximately four to five times lower than monitoring bores BH10 and BH12 which are approximately 250 meters further down gradient. Hence, it is unlikely that the observed exceedance of electrical conductivity is the result of input from either the Content Pit lake or the Content Waste Rock Dump. The observed exceedances are more likely a consequence of inappropriate limits and the lack of suitable reference sites as discussed in previous sections.

The upper pH trigger level of 7.5 was exceeded at each of the Content Pit Monitoring Bores during the reporting period. Similar to previous discussion, the available time series data for pH at these locations presents no evidence of increasing trends and hence emerging issues. The pH at monitoring bores BH10 (pH 7.16-7.92 $\bar{x}$ =7.48, n=3), BH11 (pH 7.13-8.10 $\bar{x}$ =7.57, n=3) and BH12 (pH 7.40-8.44 $\bar{x}$ =7.84, n=3) only marginally exceeded the trigger level. This is compared to the pH in the Content Pit lake during the same period of pH 3.91-4.31, $\bar{x}$ =4.09, n=14. Obviously the acidic character of the Content Pit Lake water cannot have an influence on the pH in the monitoring bores causing an increase in pH to exceed the upper pH trigger level. This indicates that the Content Pit Lake is not having an influence on groundwater beyond the immediate vicinity of the pit.

Trigger levels for cobalt, copper, zinc and arsenic were exceeded at one or more of the Content Pit Monitoring Bores during the reporting period. However, previous discussion of electrical conductivity and pH demonstrated that the Content Pit Lake and the Content Waste Rock Dump are not impacting on groundwater quality in the vicinity of the bores. Therefore, the observed trigger level exceedances for the various metals are more likely a consequence of inappropriate limits and the lack of suitable reference sites as discussed in previous sections.

The contaminant limit of 2mg/L for fluoride was exceeded at each of the Content Pit Monitoring bores during the reporting period. The previous discussion regarding electrical conductivity and pH shows that the Content Pit Lake does not impact down gradient groundwater. Therefore, the fluoride contaminant limit exceedance at the Content Pit Monitoring bores is the result of local geology. This is further supported by the observed fluoride concentration in the Content Pit Lake (1.1-1.7 mg/L, $\bar{x}$ =1.3, n=14) during the period being two to three times lower than that observed in BH10, BH11 and BH12.

Golden Butterfly Waste Rock Dump Monitoring Bores

The Golden Butterfly Waste Rock Dump Monitoring Bores consist of the locations BH3, BH4, BH5, BH6, and BH7 (see Figure 16). These bores are located approximately 100 meters from the toe of the north-eastern side of the Golden Butterfly Waste Rock Dump. Each bore is approximately 75 meters apart trending on a straight line running parallel with the toe of the waste rock dump. Figure 21 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

The electrical conductivity trigger level of 250 $\mu\text{S}/\text{cm}$ was exceeded at each of the Golden Butterfly Waste Rock Dump Monitoring Bores during the reporting period. The time series data indicates a possible decreasing trend for electrical conductivity at BH7 whereas, the other monitoring bores show flat trends over the approximately sixteen year record. The observed electrical conductivity data groups the Golden Butterfly Waste Rock Dump Monitoring Bores into two categories.

Firstly, bores BH7, BH5 and BH4 with approximately equivalent electrical conductivities in the range of 5500 $\mu\text{S}/\text{cm}$. Secondly, bores BH6 and BH3 which electrical conductivity in the order of 500 $\mu\text{S}/\text{cm}$. Bores BH4, BH5 and BH7 are approximately 16 meters deep, whereas, BH3 has a depth of 20 meters and BH6 a depth of only eleven (11) meters. Geographically, BH3 is approximately 200 meters away from BH6, with BH4 and BH5 located within the intervening distance.

A tentative interpretation is that BH4, BH5 and BH7 intercept an upper unconfined aquifer, whereas, BH3 represents a deeper aquifer. The elevated electrical conductivity in the tentatively identified upper aquifer, which is correlated with sulphate concentration (Figure 21), therefore represents either input from the Golden Butterfly Waste Rock Dump or the mineralised zone that extends NW-SE between the mine pits. The lower aquifer represented by BH3 indicates such influences do not extend with depth. However, the shallower BH6 complicates the interpretation, as it would be expected this site would also show elevated electrical conductivity but instead trends at the same value as bore BH3. An alternative interpretation is that BH6 represents the surface unconfined weathered rock aquifer which shows low levels of electrical conductivity (and hence sulphate concentration), whereas, BH4, BH5 and BH7 represent an intercepted mineralised zone with consequently elevated concentrations of sulphate, and finally, BH3 a deeper confined aquifer that is not impacted by surface features.

This alternative explanation allows interpretation of metal trigger level exceedances observed at the various Golden Butterfly Waste Rock Dump Monitoring Bores during the reporting period. BH3 records in general the lowest metal concentrations for the parameters measured, fitting well with the interpreted "lower un-impacted aquifer" scenario. Exceedances for aluminium and copper at BH3, for which concentrations are in the low parts-per-billion range, are more likely a consequence of inappropriate limits and the lack of suitable reference sites as discussed in previous sections. BH5 and BH7 being interpreted as intercepting a mineralised zone, consequently show the most trigger level exceedances including cadmium, cobalt, copper and zinc. However, BH6 which tentatively represents the surface aquifer, and which records relatively low levels of sulphate and hence the assumption low levels of input from oxidation of sulphides, also returned the highest concentrations of aluminium, arsenic and copper exceeding trigger levels in each case.

The groundwater quality on the western side of the Golden Butterfly Waste Rock Dump shows no influence from possible seepage below the dump (see previous section). Similarly, results from the unconfined alluvial aquifers (GBMB1, GBMB3, GBMB6 and SY1) show no influence from possible seepage from either the Golden Butterfly Waste Rock Dump or the pit lakes (which act as hydrologic sinks). Therefore, the trigger level exceedances observed at the various Golden Butterfly Waste Rock Dump Monitoring Bores likely represent localised geology and or reflect inappropriate limits and the lack of suitable reference sites as discussed in previous sections.

4.2 GROUNDWATER CONDITIONS

Details of the dimensions of the various groundwater monitoring bores is given in Table 5. The groundwater levels for the monitoring bores defined in Schedule F – Table 9 of the EA are provided in Table 9.

The various groundwater monitoring bores (see Figure 15 and Figure 16) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps. Consequently, groundwater level monitoring results are presented as time series graphs in the following groupings in

Figure 17 to

Figure 20:

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

Table 5: Groundwater monitoring bore details

Monitoring Bore	Bore Depth (m)	Elevation (AHD)	Monitoring Bore	Bore Depth (m)	Elevation (AHD)
BH 1	55	117*	BH 10	21	103.95
BH 2	26	112*	BH 11	36	104.13
BH 3	20	113*	BH 12	17	102.08
BH 5	16	114*	GBMB 1	17	109*
BH 7	16	116*	GBMB 3	49	113*
BH 8	29	123.92	GBMB 6	27	113*
BH 9	29	122.29	SY 1	17	107.48

Notes: AHD = Australian Height Datum, * Elevations derived from available topographic mapping and are therefore approximate

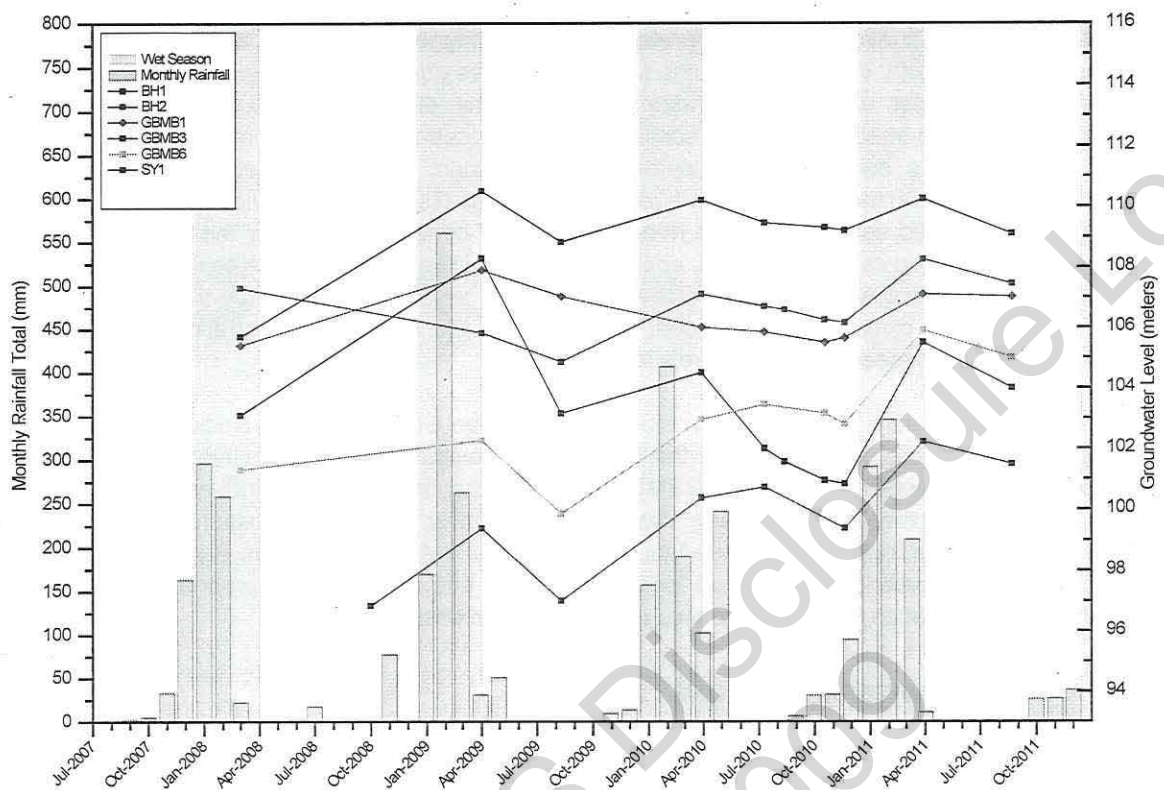


Figure 17: Golden Butterfly Pit Monitoring Bore Water Levels

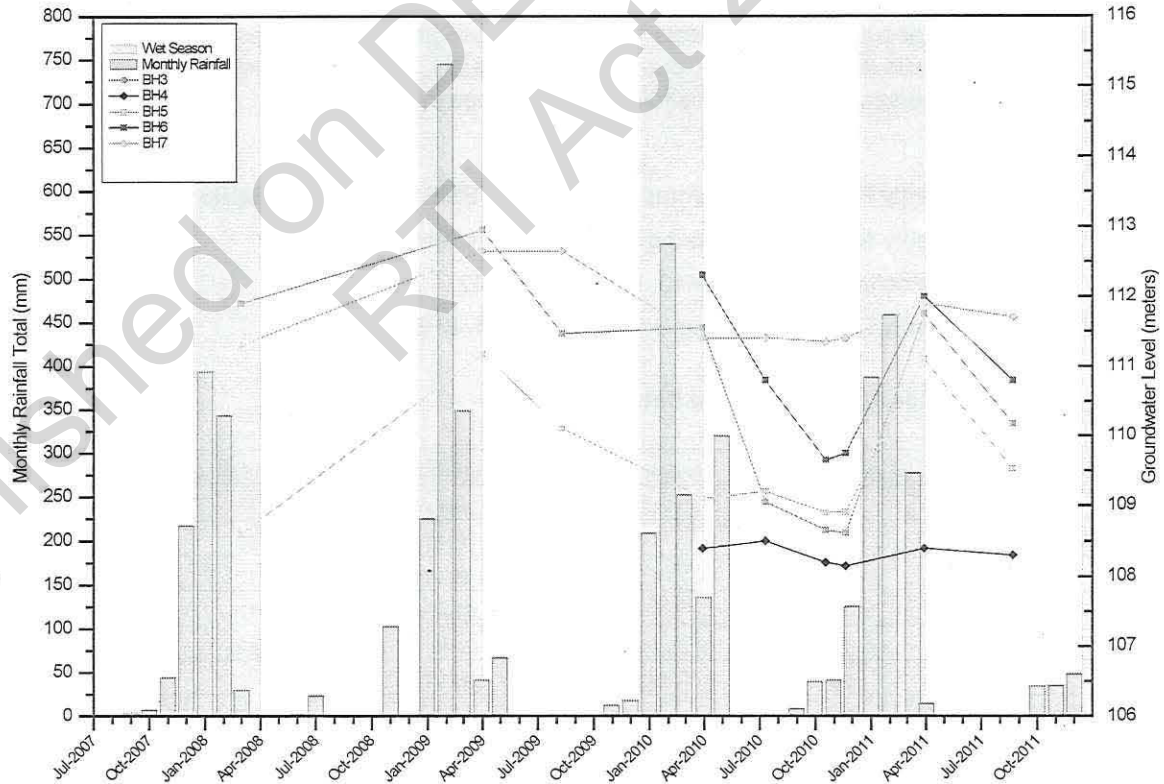


Figure 18: Golden Butterfly Dump Monitoring Bore Water Levels

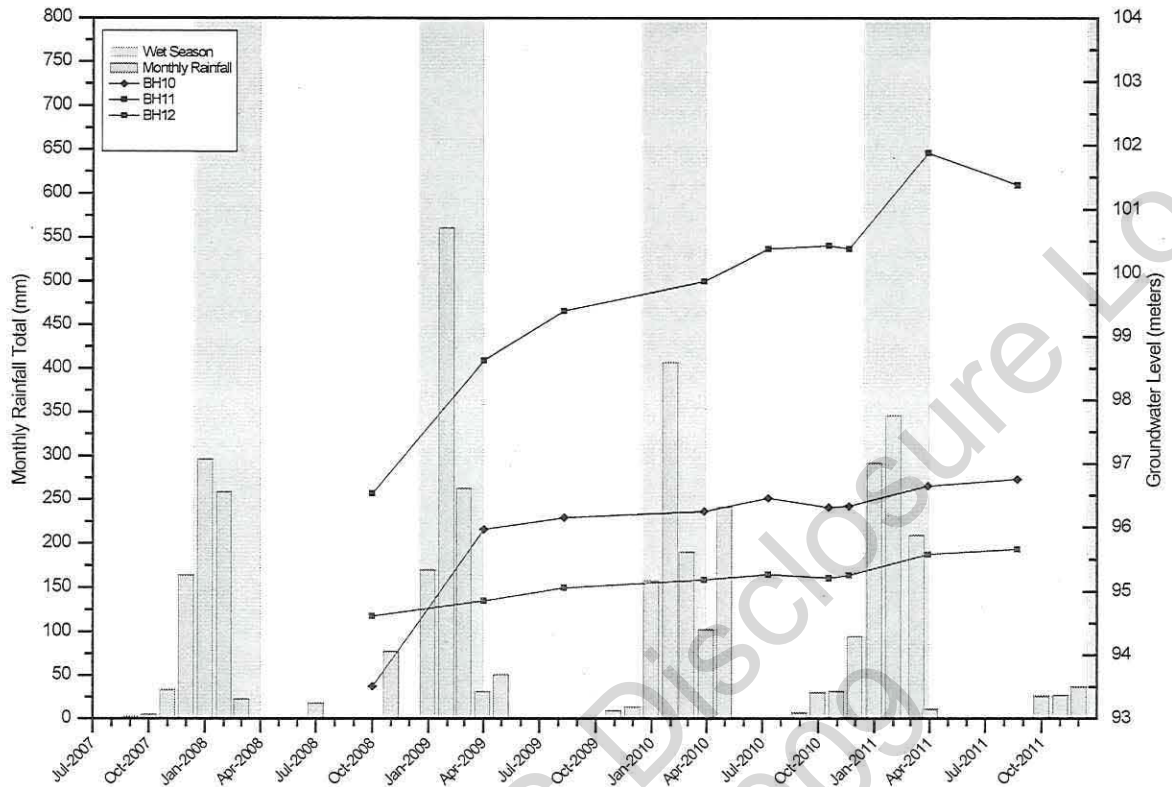


Figure 19: Content Pit Monitoring Bore Water Levels

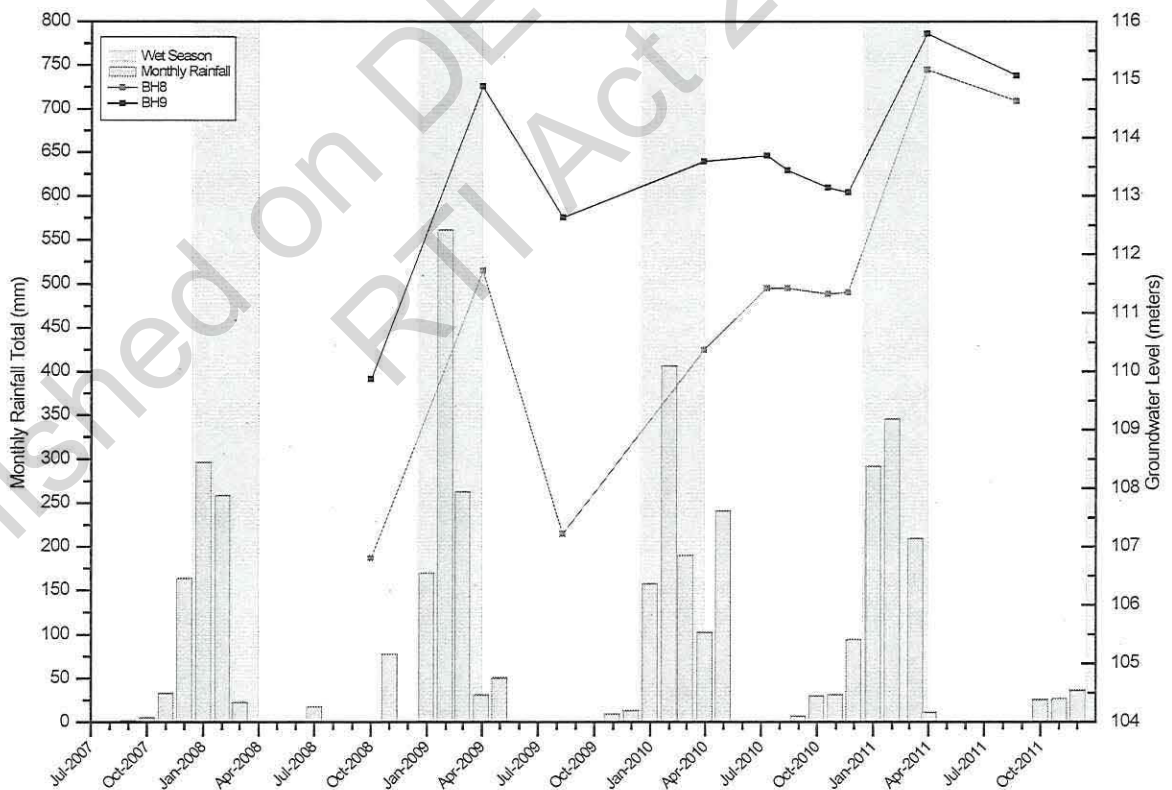


Figure 20: Golden Butterfly North Pit Monitoring Bore Water Levels

5 Appendix 1: Monitoring Results

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Table 6: Groundwater Quality – Confined Fractured Rock Aquifer 1995 to 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1-7.9 (42)	7.2 7.2	3.3-6.5 (41)	3.7 3.6	5.5-7.7 (35)	6.41 6.4	6.9-8.6	7.4	7.3-7.8 (13)	7.5 7.5	6.9-7.5	7.15	6.4-7.1	6.8	6.4-7	6.7	6.9-7.7	7.3
EC (µS/cm)	985-2260 (42)	1298 1300	740-1300 (41)	1016 980	110-3000 (35)	604 340	4800- 7200	5611	4900-6800 (13)	5550 5600	480-2200	933	6400- 8700	7472	160-760	591	2200- 2700	2491
SO ₄ (mg/L)	310-1160 (42)	471 460	260-850 (40)	442 435	20-990 (35)	172 100	1200- 1800	1522	1400-2000 (13)	1733 1800	59-530	172	1400- 2600	1950	36-190	120	630-790	703
Cu (mg/L)	<0.001-0.05 (16)	0.008 0.005	0.002-0.05 (15)	0.011 0.005	0.001-0.025 (13)	0.009 0.005	<0.001- <0.05	<0.01	<0.001-0.03 (13)	0.007 0.005	0.009- 0.02	0.01	<0.003- 0.03	<0.01	0.001- 0.01	<0.01	<0.001- <0.05	<0.01
Pb (mg/L)	<0.001-0.35 (13)	0.031 0.001	<0.001- 0.15 (13)	0.051 0.046	<0.001- 0.072 (11)	0.013 0.001	<0.001- 0.006	<0.002	<0.001-0.24 (11)	0.023 0.001	<0.002- 0.056	0.009	<0.001- 0.35	<0.002	<0.002- 0.003	<0.002	<0.002- 0.02	0.002
Ni (mg/L)	0.002-0.025 (16)	0.016 0.025	0.025-0.09 (15)	0.056 0.05	<0.001- 0.025 (10)	0.014 0.0145	<0.002- <0.05	<0.05	<0.001-0.025 (13)	0.016 0.025	0.002- <0.05	<0.05	0.004- <0.05	<0.05	0.02- <0.05	<0.05	<0.002- <0.05	<0.05
Al (mg/L)	0.02-0.25 (15)	0.045 0.025	0.16-2.7 (14)	1.54 1.65	0.07-2.1 (10)	0.49 0.33	<0.05- 0.37	<0.05	<0.01-0.29 (13)	0.049 0.025	0.14-6.8	2.35	<0.05- 0.16	<0.05	<0.05- 0.092	<0.05	<0.05- 0.21	<0.05
Zn (mg/L)	0.01-0.18 (16)	0.053 0.038	0.043-1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008- 0.04	0.017	0.0025-0.032 (13)	0.0127 0.012	0.005- 0.055	0.021	0.029- 0.15	0.072	0.012- 0.047	0.024	0.011- 0.056	0.028
Co (mg/L)	<0.001- 0.025 (11)	0.016 0.025	0.018- 0.045 (11)	0.018 0.025	<0.001- 0.025 (9)	0.015 0.025	<0.005- <0.05	<0.05	<0.001-0.05	<0.05	<0.005- <0.05	<0.05	<0.005- 0.07	<0.05	<0.05- <0.05	<0.05	<0.005- <0.05	<0.05
Cd (mg/L)	<0.0001- 0.0025 (16)	0.0003 0.0001	<0.0001- 0.0025 (15)	0.0007 0.0007	<0.0001- 0.0009 (13)	0.0002 0.0001	<0.0001- 0.0003	<0.0002	<0.0005- 0.0004 (13)	<0.0005 0.0001	<0.0001- <0.0002	<0.0002	0.0002- 0.002	0.00085	<0.0001- 0.0067	0.0005	<0.0001- 0.0003	<0.0002*
Fe (mg/L)	<0.05-3.2 (32)	0.436 0.1	0.025-27 (32)	4.54 1.3	0.025-1.75 (29)	0.33 0.25	<0.05- <0.05	<0.05	<0.05-0.09 (5)	<0.05	0.06-3.1	1.4	<0.05- 0.27	<0.05	<0.05- 0.08	<0.05	<0.05- <0.05	<0.05
Mn (mg/L)	<0.05-1.19 (8)	0.247 0.075	0.95-1.97 (8)	1.23 1.1	0.0025- 0.025 (4)	0.019 0.025	<0.05- <0.05	<0.05	<0.05-0.06 (7)	0.034 0.025	<0.05- 0.68	0.06	<0.05- 1.9	<0.05	0.26-1.4	0.83	0.67-1.2	0.90
As (mg/L)	0.01-0.022 (16)	0.014 0.014	<0.001- 0.09 (15)	0.008 0.025	<0.003-0.03 (13)	0.010 0.009	<0.005- 0.003	<0.005	<0.05-0.009 (13)	0.012 0.007	0.013- 0.048	0.026	<0.005- 0.007	<0.005	0.007- 0.034	0.02	<0.003- 0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 7: Groundwater Quality – Unconfined Alluvial Aquifer 2001 to 2009

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-6.8	6.2	5.9-6.5	6.1	5.6-7.1	6.0	5.7-7.1	6.2
EC ($\mu\text{S}/\text{cm}$)	52-110	79.4	260-350	308	68-490	114	66-580	152
SO_4 (mg/L)	3-13	6.3	17-38	28.8	2-13	4.4	3-19	7.1
Cu (mg/L)	0.001-0.01	<0.01*	<0.001-<0.05	<0.01*	<0.001-0.01	<0.01*	<0.001-<0.05	<0.01*
Pb (mg/L)	0.002-0.018	0.008	<0.001-0.008	<0.002*	<0.001-0.004	<0.002*	<0.001-0.31	<0.002*
Ni (mg/L)	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*
Al (mg/L)	0.07-4.8	0.99	<0.05-0.29	<0.05*	<0.05-0.05	<0.05*	<0.05-0.69	<0.05*
Zn (mg/L)	0.017-0.11	0.052	0.006-0.18	0.043	0.01-.015	0.08	<0.005-0.092	0.025*
Co (mg/L)	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*
Cd (mg/L)	<0.0002-<0.0002	<0.0002*	<0.0001-0.0018	<0.0002*	<0.0001-<0.0002	<0.0002*	<0.0001-<0.0002	<0.0002*
Fe (mg/L)	0.53-3	1.8	<0.05-6.6	0.18*	<0.05-<0.05	<0.05	<0.05-0.39	<0.05*
Mn (mg/L)	<0.05-0.15	0.05*	<0.05-.07	<0.05*	<0.05-0.26	<0.05*	<0.05-.037	<0.05*
As (mg/L)	0.003-0.012	<0.005*	<0.003-0.007	<0.005*	<0.003-0.091	<0.005*	<0.005-0.15	0.005

* indicates Median.

Table 8: Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH1	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH2	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH3	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH5	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH6	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH7	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031
	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH8	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH9	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 7 (Continued): Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

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Table 9: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH6	114	29/03/2010	1.70	112.30
BH1	117	2/04/2009	8.71	108.29	BH6	114	11/07/2010	3.20	110.80
BH1	117	10/08/2009	13.85	103.15	BH6	114	18/10/2010	4.35	109.65
BH1	117	29/03/2010	12.50	104.50	BH6	114	20/11/2010	4.25	109.75
BH1	117	11/07/2010	15.00	102.00	BH6	114	29/03/2011	2.00	112.00
BH1	117	13/08/2010	15.44	101.56	BH6	114	22/08/2011	3.20	110.80
BH1	117	18/10/2010	16.05	100.95					
BH1	117	20/11/2010	16.17	100.83	BH7	116	1/03/2008	4.70	111.30
BH1	117	29/03/2011	11.50	105.50	BH7	116	2/04/2009	3.35	112.65
BH1	117	22/08/2011	13.00	104.00	BH7	116	10/08/2009	3.35	112.65
					BH7	116	29/03/2010	4.60	111.40
BH2	112	1/03/2008	4.70	107.30	BH7	116	11/07/2010	4.60	111.40
BH2	112	2/04/2009	6.17	105.83	BH7	116	18/10/2010	4.65	111.35
BH2	112	10/08/2009	7.14	104.86	BH7	116	20/11/2010	4.60	111.40
BH2	112	29/03/2010	4.90	107.10	BH7	116	29/03/2011	4.10	111.90
BH2	112	11/07/2010	5.30	106.70	BH7	116	22/08/2011	4.30	111.70
BH2	112	13/08/2010	5.41	106.59					
BH2	112	18/10/2010	5.75	106.25	BH8	123.92	1/10/2008	17.12	106.80
BH2	112	20/11/2010	5.84	106.16	BH8	123.92	2/04/2009	12.20	111.72
BH2	112	29/03/2011	3.75	108.25	BH8	123.92	10/08/2009	16.70	107.22
BH2	112	22/08/2011	4.55	107.45	BH8	123.92	29/03/2010	13.55	110.37
					BH8	123.92	10/07/2010	12.50	111.42
BH3	113	1/03/2008	1.10	111.90	BH8	123.92	13/08/2010	12.50	111.42
BH3	113	2/04/2009	0.05	112.95	BH8	123.92	18/10/2010	12.60	111.32
BH3	113	10/08/2009	1.53	111.47	BH8	123.92	20/11/2010	12.57	111.35
BH3	113	29/03/2010	1.45	111.55	BH8	123.92	29/03/2011	8.75	115.17
BH3	113	11/07/2010	3.95	109.05	BH8	123.92	22/08/2011	9.28	114.64
BH3	113	18/10/2010	4.35	108.65					
BH3	113	20/11/2010	4.39	108.61	BH9	122.29	1/10/2008	12.42	109.87
BH3	113	29/03/2011	1.25	111.75	BH9	122.29	2/04/2009	7.40	114.89
BH3	113	22/08/2011	2.82	110.18	BH9	122.29	10/08/2009	9.66	112.63
					BH9	122.29	29/03/2010	8.70	113.59
BH4	113	29/03/2010	4.60	108.40	BH9	122.29	10/07/2010	8.60	113.69
BH4	113	11/07/2010	4.50	108.50	BH9	122.29	13/08/2010	8.85	113.44
BH4	113	18/10/2010	4.80	108.20	BH9	122.29	18/10/2010	9.15	113.14
BH4	113	20/11/2010	4.85	108.15	BH9	122.29	20/11/2010	9.23	113.06
BH4	113	29/03/2011	4.60	108.40	BH9	122.29	29/03/2011	6.50	115.79
BH4	113	22/08/2011	4.70	108.30	BH9	122.29	22/08/2011	7.22	115.07
BH5	114	1/03/2008	5.40	108.60	BH10	103.95	1/10/2008	10.44	93.51
BH5	114	2/04/2009	2.82	111.18	BH10	103.95	2/04/2009	7.98	95.97
BH5	114	10/08/2009	3.89	110.11	BH10	103.95	10/08/2009	7.80	96.15
BH5	114	29/03/2010	4.90	109.10	BH10	103.95	28/03/2010	7.70	96.25
BH5	114	11/07/2010	4.80	109.20	BH10	103.95	11/07/2010	7.50	96.45
BH5	114	18/10/2010	5.10	108.90	BH10	103.95	18/10/2010	7.64	96.31
BH5	114	20/11/2010	5.09	108.91	BH10	103.95	20/11/2010	7.62	96.33
BH5	114	29/03/2011	2.90	111.10	BH10	103.95	29/03/2011	7.30	96.65
BH5	114	22/08/2011	4.48	109.52	BH10	103.95	22/08/2011	7.19	96.76

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Table 9 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH11	104.13	1/10/2008	7.60	96.53	SY1	107.48	1/10/2008	10.62	96.86
BH11	104.13	2/04/2009	5.51	98.62	SY1	107.48	2/04/2009	8.09	99.39
BH11	104.13	10/08/2009	4.73	99.40	SY1	107.48	10/08/2009	10.47	97.01
BH11	104.13	28/03/2010	4.26	99.87	SY1	107.48	29/03/2010	7.10	100.38
BH11	104.13	11/07/2010	3.75	100.38	SY1	107.48	11/07/2010	6.75	100.73
BH11	104.13	18/10/2010	3.70	100.43	SY1	107.48	20/11/2010	8.10	99.38
BH11	104.13	20/11/2010	3.75	100.38	SY1	107.48	29/03/2011	5.25	102.23
BH11	104.13	29/03/2011	2.25	101.88	SY1	107.48	22/08/2011	6.00	101.48
BH11	104.13	22/08/2011	2.75	101.38					
BH12	102.08	1/10/2008	7.46	94.62					
BH12	102.08	2/04/2009	7.22	94.86					
BH12	102.08	10/08/2009	7.02	95.06					
BH12	102.08	28/03/2010	6.90	95.18					
BH12	102.08	11/07/2010	6.82	95.26					
BH12	102.08	18/10/2010	6.87	95.21					
BH12	102.08	20/11/2010	6.83	95.25					
BH12	102.08	29/03/2011	6.50	95.58					
BH12	102.08	22/08/2011	6.42	95.66					
GBMB1	109	1/03/2008	3.60	105.40					
GBMB1	109	2/04/2009	1.09	107.91					
GBMB1	109	10/08/2009	1.97	107.03					
GBMB1	109	29/03/2010	3.00	106.00					
GBMB1	109	11/07/2010	3.15	105.85					
GBMB1	109	18/10/2010	3.50	105.50					
GBMB1	109	20/11/2010	3.35	105.65					
GBMB1	109	29/03/2011	1.90	107.10					
GBMB1	109	22/08/2011	1.98	107.02					
GBMB3	113	1/03/2008	7.30	105.70					
GBMB3	113	2/04/2009	2.48	110.52					
GBMB3	113	10/08/2009	4.18	108.82					
GBMB3	113	29/03/2010	2.80	110.20					
GBMB3	113	11/07/2010	3.55	109.45					
GBMB3	113	18/10/2010	3.70	109.30					
GBMB3	113	20/11/2010	3.80	109.20					
GBMB3	113	29/03/2011	2.75	110.25					
GBMB3	113	22/08/2011	3.90	109.10					
GBMB6	113	1/03/2008	11.70	101.30					
GBMB6	113	2/04/2009	10.73	102.27					
GBMB6	113	10/08/2009	13.14	99.86					
GBMB6	113	29/03/2010	10.05	102.95					
GBMB6	113	11/07/2010	9.55	103.45					
GBMB6	113	18/10/2010	9.85	103.15					
GBMB6	113	20/11/2010	10.20	102.80					
GBMB6	113	29/03/2011	7.10	105.90					
GBMB6	113	22/08/2011	8.00	105.00					

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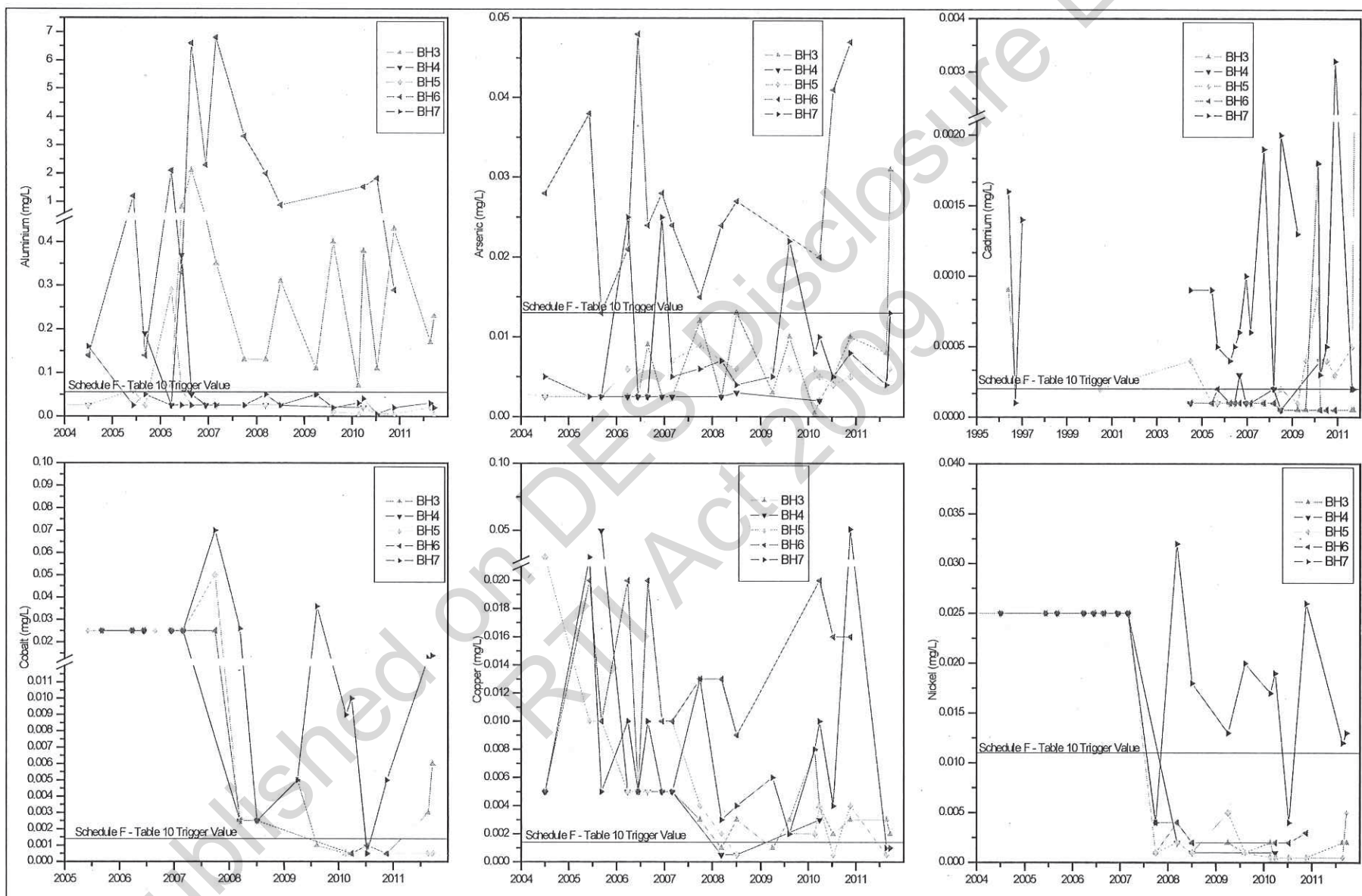


Figure 21: Golden Butterfly Dump Monitoring Bores – Time Series

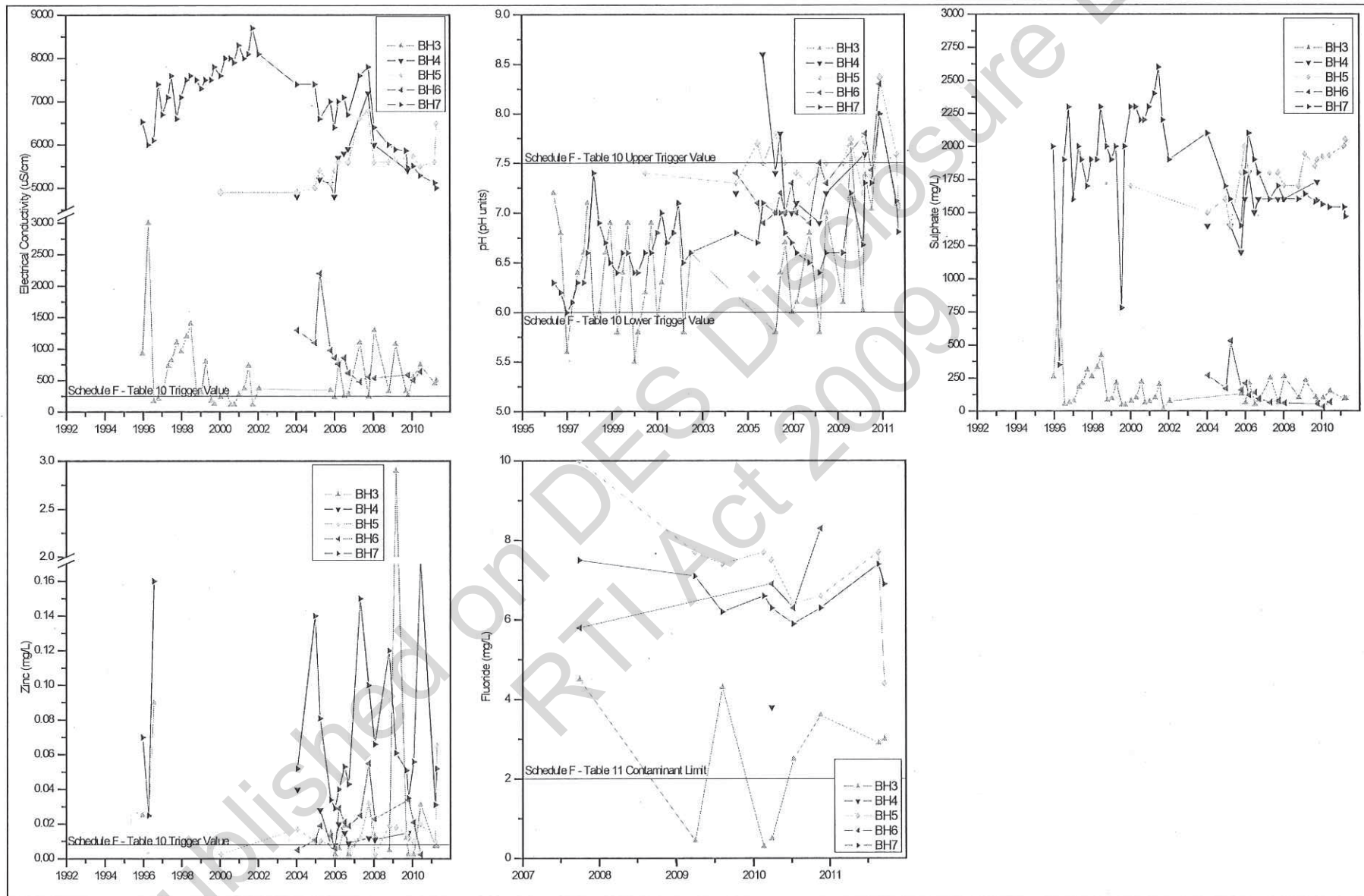


Figure 21 (Continued): Golden Butterfly Dump Monitoring Bores – Time Series

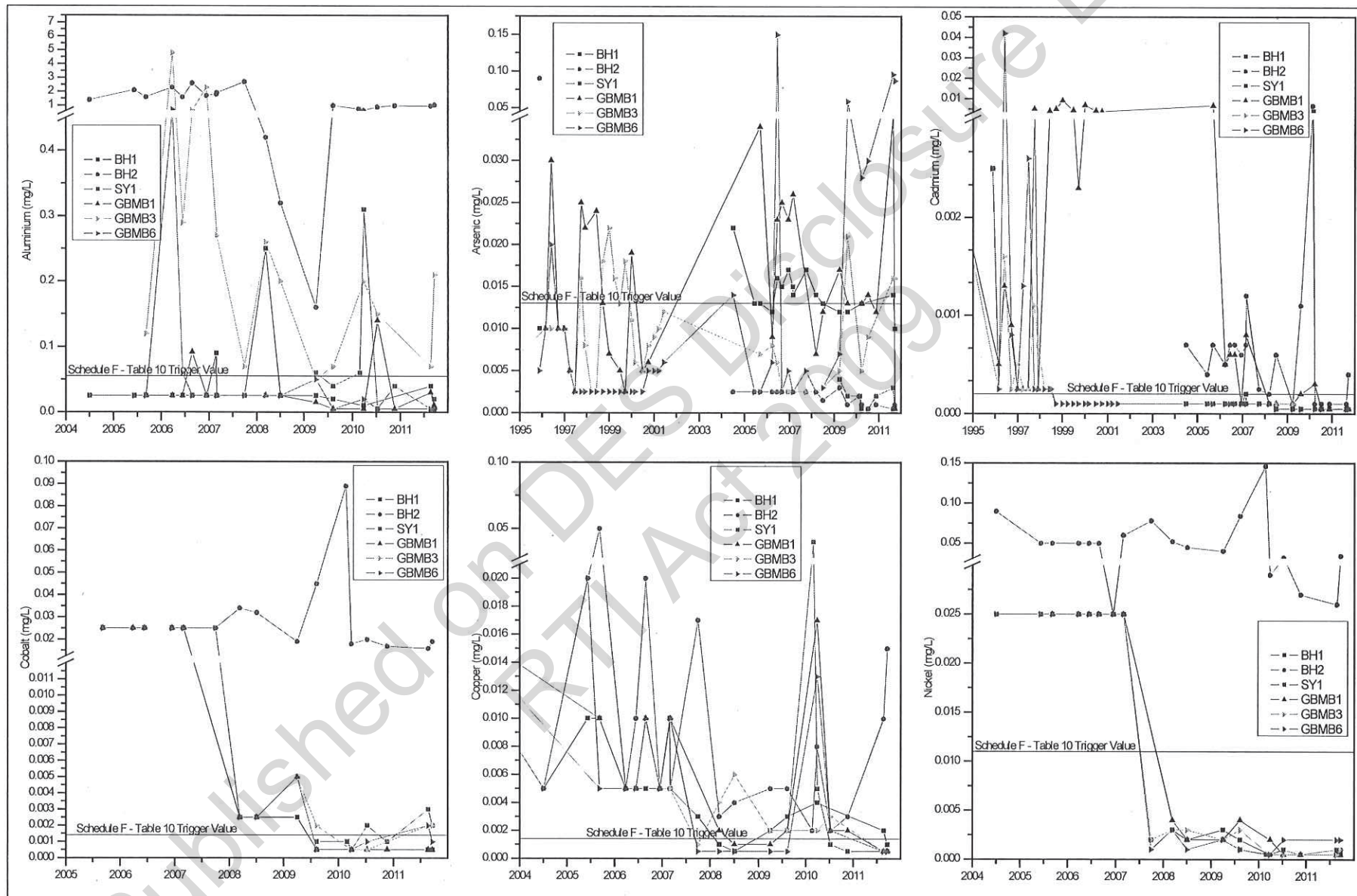


Figure 22: Golden Butterfly Pit Monitoring Bores – Time Series

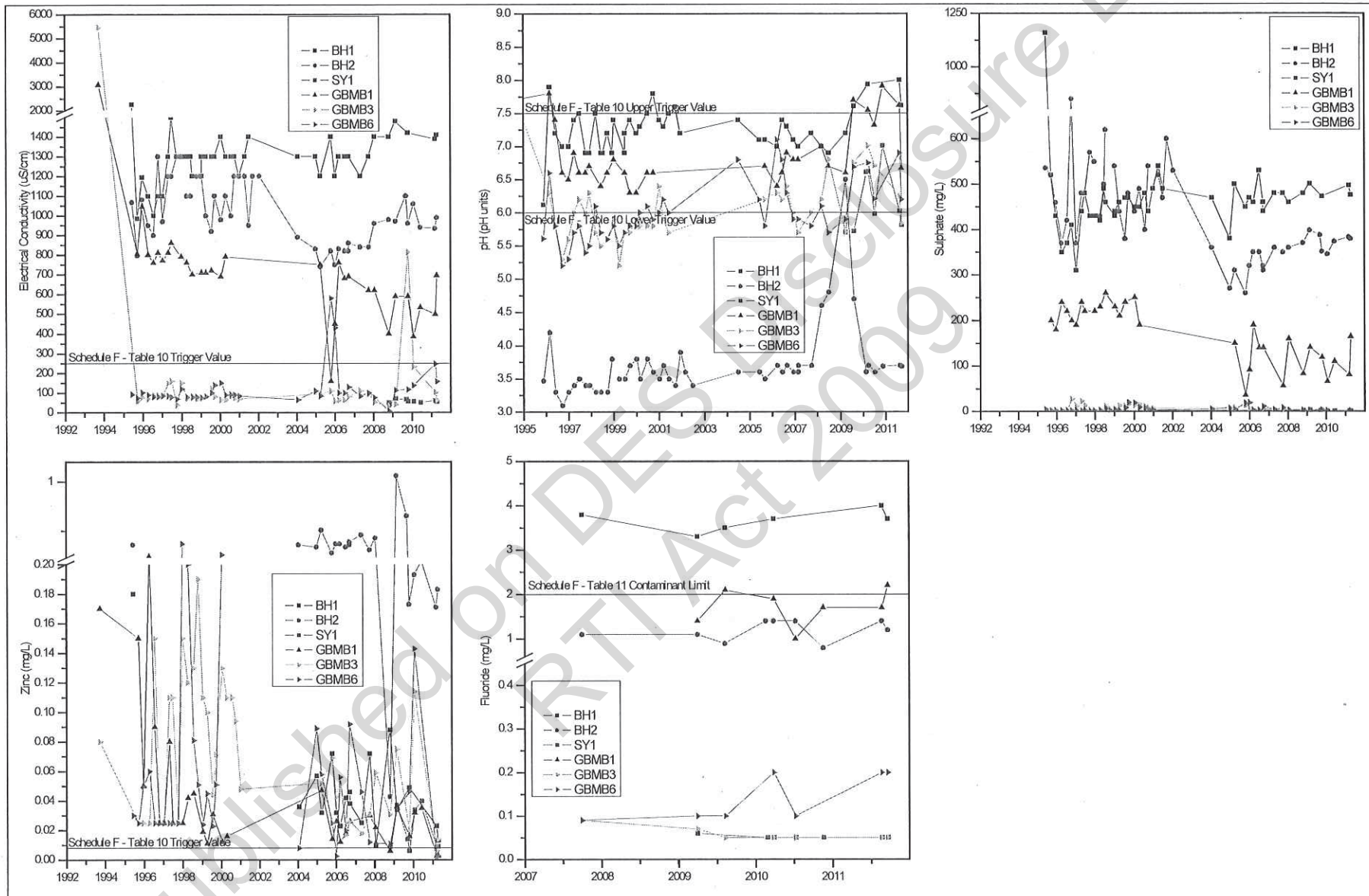


Figure 22 (Continued): Golden Butterfly Pit Monitoring Bores – Time Series

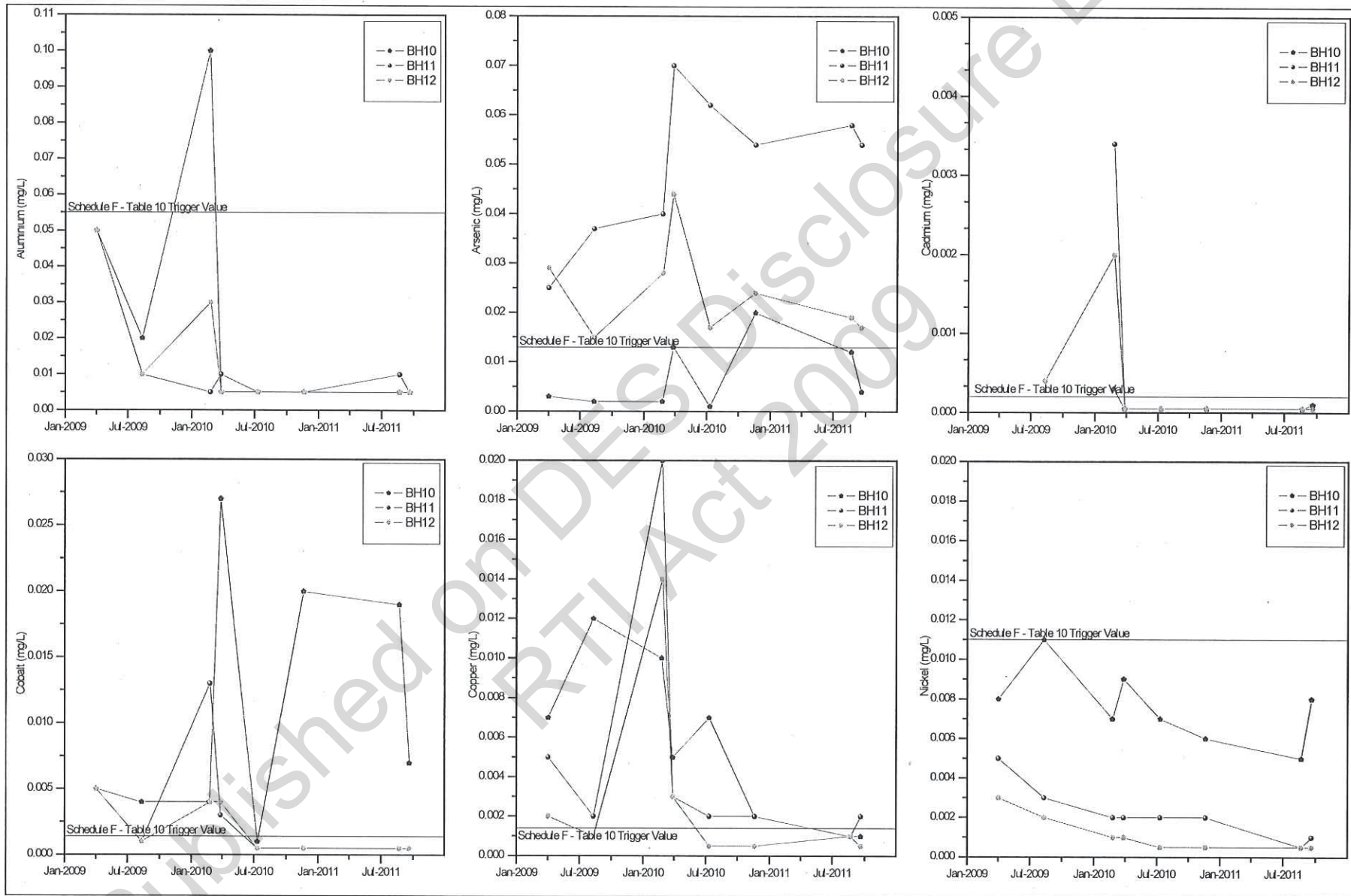


Figure 23: Content Pit Monitoring Bores – Time Series

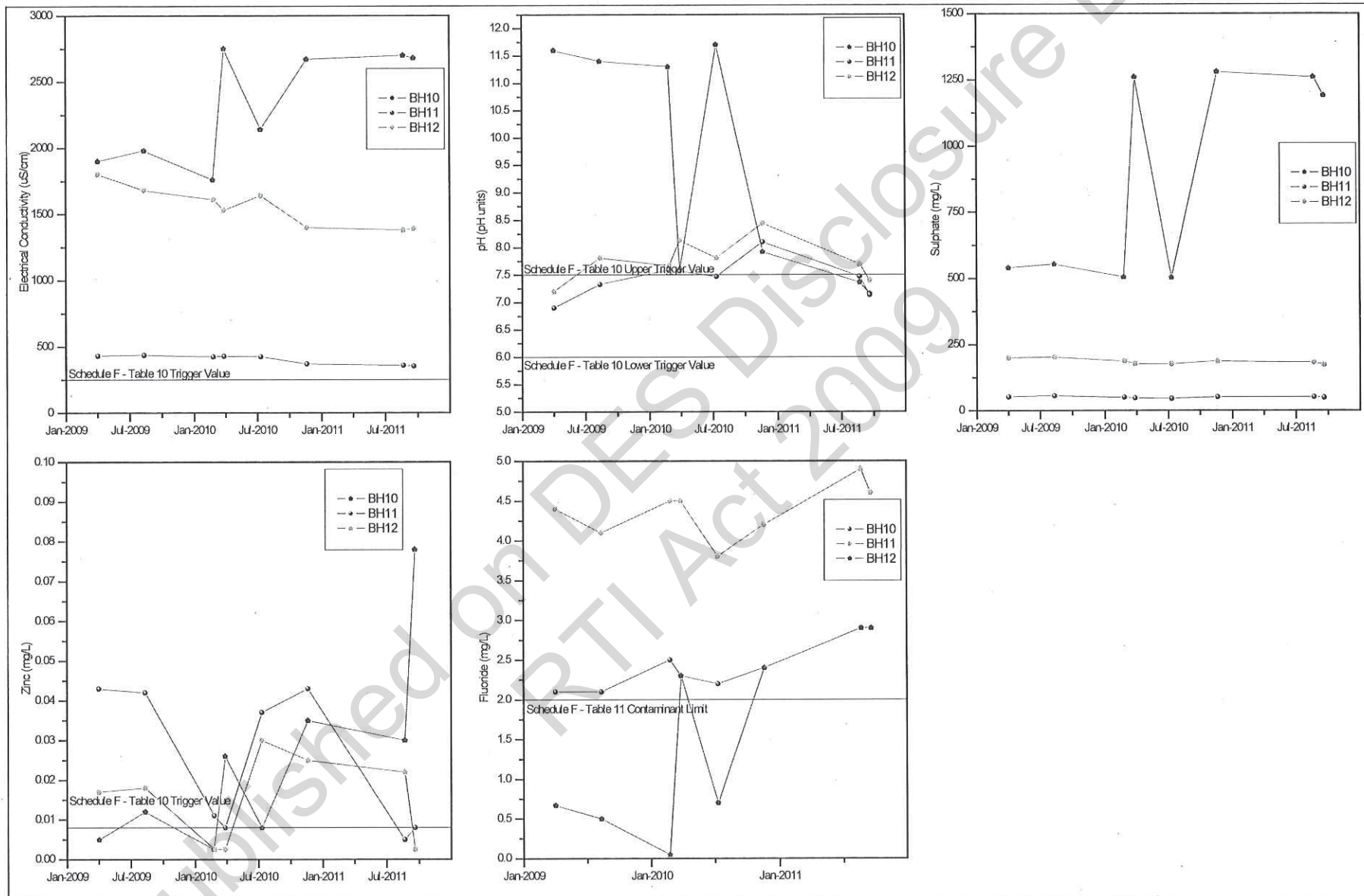


Figure 23 (Continued): Content Pit Monitoring Bores – Time Series

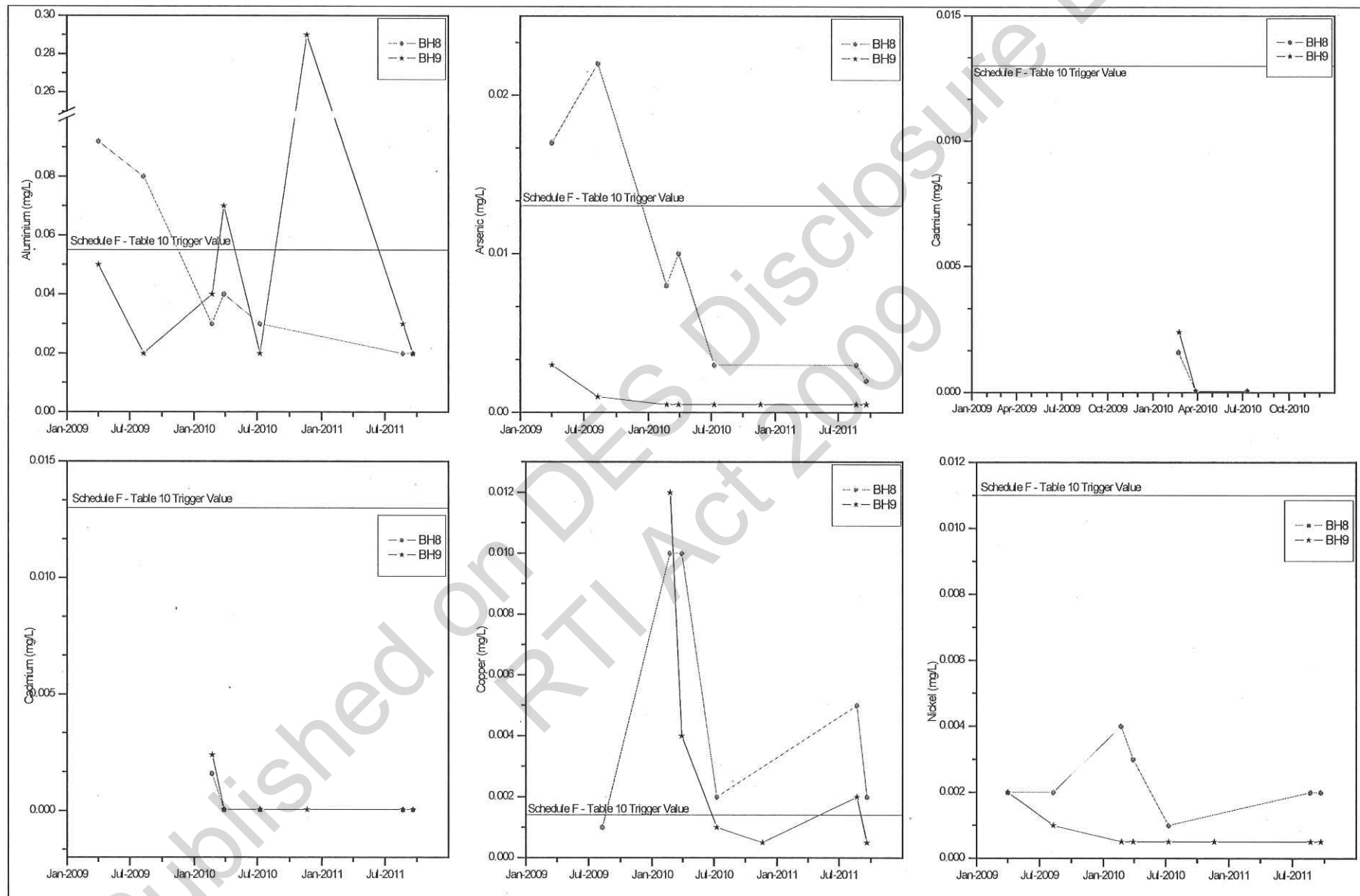


Figure 24: Golden Butterfly North Pit Monitoring Bores – Time Series

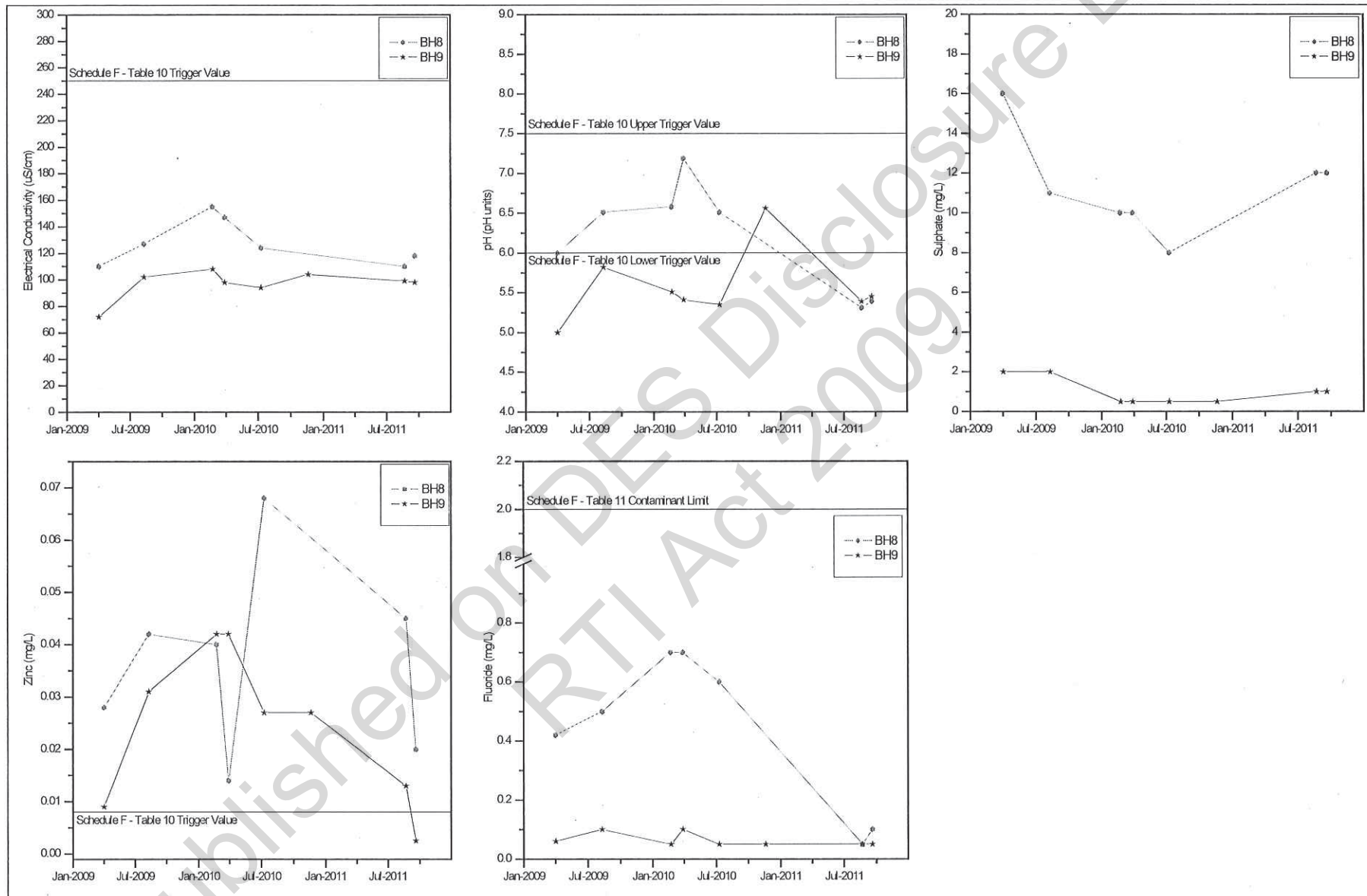


Figure 24 (Continued): Golden Butterfly North Pit Monitoring Bores – Time Series

6 References

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- ² Thompson, S.A., p. 64, Hydrology for Water Management, Balkema, 1999.
- ³ Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan*
- ⁴ HLA - Envirosciences (2001) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.
- ⁵ HLA – Envirosciences, Ibid.
- ⁶ DME Bulletin

Croydon Gold Mine

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Appendix A

POST MINE LANDUSE PLAN



CROYDON GOLD MINE
POST MINE LANDUSE PLAN

DECEMBER 2011

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1
2 REHABILITATION CONCEPTS	4
2.1 REVEGETATION	4
2.2 FINAL LANDFORMS	5
2.3 SLOPE AND COVER DESIGN	9
2.3.1 Effectiveness of Cover System	9
2.4 DRAINAGE DESIGN	14
2.5 EROSION AND SEDIMENT CONTROL	15
2.6 MATERIALS BALANCE	16
3 GEOTECHNICAL ASSESSMENT	17
3.1 MINING RELATED LANDFORMS	17
3.2 SUMMARY OF GEOTECHNICAL ASSESSMENT	17
3.3 GOLDEN BUTTERFLY NORTH PIT STABILITY ASSESSMENT	18
4 GEOCHEMICAL ASSESSMENT	19
5 HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENTS	20
5.1 HYDROLOGICAL ASSESSMENT	20
5.1.1 Existing Hydrological Environment	20
5.2 HYDROGEOLOGICAL ASSESSMENT	26
5.2.1 Existing Groundwater Environment	26
6 REHABILITATION MONITORING PROGRAM	38
7 GRAZING MANAGEMENT PLAN	38
8 COMPLETION CRITERIA	39
8.1 FINAL LANDFORMS	39
8.2 REVEGETATION	40
8.3 SURFACE WATER	40
8.4 GROUNDWATER	43
9 RESEARCH PROGRAM	46
10 REVIEW	46
11 REFERENCES	47

LIST OF TABLES

Table 1: Components of the Post Mine Landuse Plan	3
Table 2: Post-Mining Land Description and Rehabilitation Objectives	7
Table 3: Groundcover Monitoring Results for Croydon Waste Rock Dump Vegetation Monitoring Sites	11
Table 5: Materials Balance	16
Table 6: Materials Characteristics	19
Table 7: Croydon Township Weather Station Rainfall Data	21
Table 8: Pit Lake Water Quality 2000-2011	23
Table 9: Water Quality Summary of Surface Water Monitoring Sites 2000- 2011	24
Table 10: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009	30
Table 11: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2009	31
Table 12: Groundwater monitoring results 2010 – 2011	32
Table 13: Groundwater levels in monitoring bores	34
Table 14: Croydon Pit Lake Levels	37
Table 15: Final Landforms Completion Criteria	39
Table 16: Revegetation Completion Criteria	40
Table 17: Surface Water Completion Criteria	40
Table 18: Schedule F – Table 1 of EA MIN100401906 Receiving Water Monitoring Sites	41
Table 19: Schedule F – Table 2 of EA MIN100401906 Receiving Water Contaminant Limits	42
Table 20: Schedule F – Table 7 of EA MIN100401906 On-site Storage Monitoring Sites	42
Table 21: Schedule F – Table 8 of EA MIN100401906 On-site Storage Monitoring Sites	43
Table 22: Groundwater Completion Criteria	43
Table 23: Schedule F – Table 9 of EA MIN100410906 Groundwater Monitoring Sites	44
Table 24: Schedule F – Table 11 of EA MIN100410906 Groundwater Contaminant Limits	45

LIST OF FIGURES

Figure 1: Regional Location	2
Figure 2: Site Location and Location of Environmental Monitoring Stations	6
Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Cross Section Schematics	8
Figure 4: Average Monthly Rainfall Totals for Croydon Township	20
Figure 5: Conceptual Hydrogeological Model	29
Figure 6: Golden Butterfly Pit Monitoring Bore Water Levels	36
Figure 7: Content Pit local area contour map	36
Figure 8: Croydon Pit Lake water level monitoring stations	37

LIST OF ATTACHMENTS

Attachment A	Rehabilitation Monitoring Program
Attachment B	Grazing Management Plan

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Post Mine Landuse Plan (PMLP) has been prepared in accordance with EA Condition C2-1:

(C2-1) A Post Mine Land Use Plan for the licensed place must be developed and implemented for a nominal period of:

- (a) at least thirty (30) years following the cessation of mining activities on the licensed place; or*
- (b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.*

In addition, EA Condition C2-2 outlines the components of the PMLP (Table 1). A summary of where the components of the PMLP are addressed in this report is also provided in Table 1.

In accordance with EA Condition C2-2, this PMLP will be included in the Project Plan of Operations and will be updated with each subsequent Plan of Operations.

The remainder of this PMLP is structured as follows:

- Section 2: Describes the rehabilitation concepts for the Project.
- Section 3: Provides a description of the Geotechnical Assessment.
- Section 4: Provides a description of the Geochemical Assessment.
- Section 5: Describes the Hydrology and Hydrogeology of the Project.
- Section 6: Describes the Rehabilitation Monitoring Program.
- Section 7: Details the Grazing Management Plan.
- Section 8: Identifies the Completion Criteria for the Project.
- Section 9: Outlines the Research Programs for the Project.
- Section 10: Describes the review process for this PMLP.
- Section 11: Lists the references cited in this PMLP.

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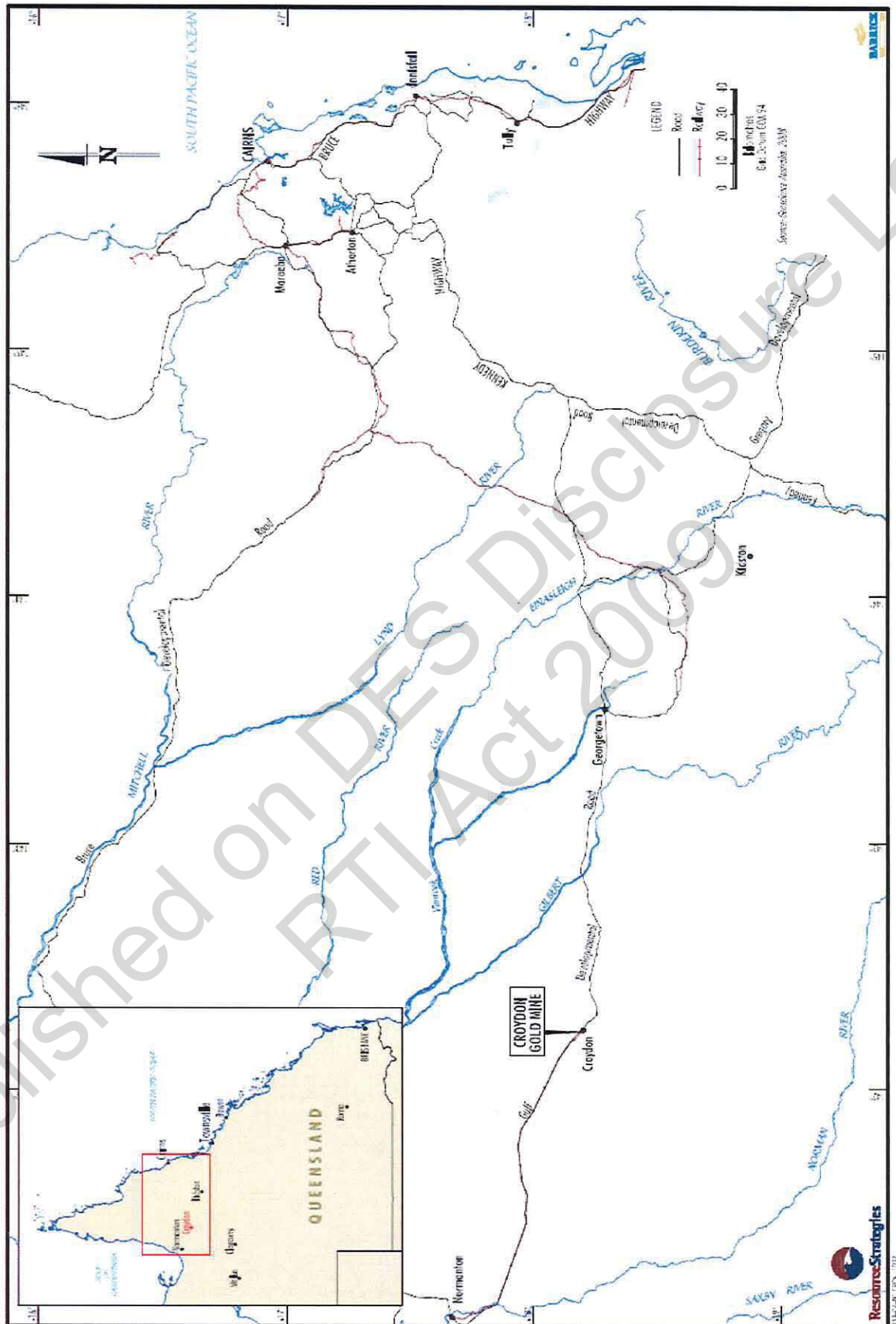


Figure 1: Regional Location

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Table 1: Components of the Post Mine Landuse Plan

Component of PMLP		Section of this Report
C2-2	<i>The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:</i>	
(a)	<i>schematic representation of final land form inclusive of drainage features;</i>	Section 2.2
(b)	<i>slope designs;</i>	Section 2.3
(c)	<i>cover design;</i> <i>including a report on the effectiveness of existing cover systems;</i>	Section 2.3 Section 2.3.1
(d)	<i>drainage design;</i>	Section 2.4
(e)	<i>erosion controls on reformed land;</i>	Section 2.5
(f)	<i>description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design;</i>	Section 6
(g)	<i>proposed revegetation criteria including:</i> <i>(i) species diversity, abundance and composition;</i> <i>(ii) projective cover;</i> <i>(iii) dry matter production; and</i> <i>(iv) stocking rates to ensure self sustaining vegetation is maintained;</i>	Section 8.2
(h)	<i>proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation;</i>	Section 2.1
(i)	<i>materials balance including available top soil; and</i> <i>low permeability encapsulation media for capping;</i>	Section 2.6 Section 2.3
(j)	<i>research program and associated milestones;</i>	Section 9
(k)	<i>geotechnical;</i> <i>geochemical; and</i> <i>hydrological studies;</i>	Section 3 Section 4 Section 5
(l)	<i>chemical, physical and biological properties of soil; and</i> <i>chemical, physical and biological properties of water;</i>	Sections 2.3.2 and 4 Section 5
(m)	<i>measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type;</i>	Section 8
(n)	<i>rehabilitation monitoring program, including the monitoring of:</i> <i>(i) surface water quality;</i> <i>(ii) groundwater quality;</i> <i>(iii) erosion rates;</i> <i>(iv) integrity and effectiveness of final cover of final cover systems; and</i> <i>(v) health and resilience of vegetative cover;</i>	Section 6 and Attachment A
(o)	<i>grazing management plan;</i>	Section 7 and Attachment B
(p)	<i>operation and maintenance of:</i> <i>(i) the surface water management system;</i> <i>(ii) groundwater monitoring network;</i> <i>(iii) final cover systems; and</i> <i>(iv) vegetative cover.</i>	Section 2.4 Section 5.2.1 Section 2.3.1 Section 2.3.1

2 REHABILITATION CONCEPTS

The rehabilitation concepts for the Project provide for the re-establishment of a stable and sustainable ecosystem which is consistent with the proposed post mine landuse of low intensity grazing/disturbed native habitat, with exception of the open pits (Section 2.2). This section provides a description of the revegetation, final landforms, slope and cover design, effectiveness of the cover system, soil properties, drainage design, erosion and sediment control and the materials balance at the Project. Any additional rehabilitation works required at the Project will be conducted utilising similar rehabilitation concepts described in this section.

2.1 REVEGETATION

The revegetation methods undertaken in the 1996 Rehabilitation Program are outlined below. The rehabilitation works conducted in 1996 are fully reported in Fawcett (2001) and HLA-Envirosciences (2001a). In the event additional rehabilitation works are required at the Project, similar revegetation methods to those described below will be implemented.

Selection of Plant Species

Sixteen tree and shrub species were included in the seed mix used during the 1996 revegetation program. Additional tree and shrub species have been recorded at the revegetation monitoring transects most likely self-seeding from the adjacent vegetation. HLA-Envirosciences (2001a) reported 19 species at the vegetation monitoring sites, including seven species of *Acacias*, seven species of *Eucalypts* and five species belonging to other genera including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

Any additional rehabilitation works required at the Project will utilise a similar selection of plant species in the seed mix as mentioned above.

Re-profiling, Soil Respreading and Surface Preparation

Minor re-profiling on both waste rock dumps was conducted to remove surface irregularities. Soil was respread with appropriate earth moving equipment (e.g. grader). Immediately prior to seeding all areas were ripped along contour to a depth of 250 millimetres (mm) to 300 mm. All ripped areas were aerial topdressed with an NPK fertiliser at a rate of 500 kilograms per hectare (Fawcett, 2001).

Any additional rehabilitation works required at the Project will conduct appropriate re-profiling and utilise similar soil respreading and surface preparation methods as mentioned above.

Method of Propagation and Soil Ameliorant

An aerial application of DAP fertiliser to the rehabilitation sites in 2004 has markedly improved the phosphorus status of the soil but has had no lasting impact on the nitrogen status. It is considered that the most practical method of improving soil nitrogen status in the long term is to sow groundcover legumes, such as *Seca stylo* (*Stylosanthes scabra*) and *Verano stylo* (*S. hamata*) which are well adapted to the Gulf country area (Landline Consulting, 2007).

Any additional rehabilitation works required at the Project will utilise similar propagation and soil ameliorant methods as mentioned above.

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Weed Management

A weed control program was initiated in 1996 to control isolated Calotrope (*Calotropis procera*) plants observed around the southern end of the Golden Butterfly waste rock dump (Fawcett, 2001). This weed species is ubiquitous in the Croydon area. Where necessary, a similar weed management program to that initiated in 1996 will be conducted at the Project.

2.2 FINAL LANDFORMS

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives. The post-mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

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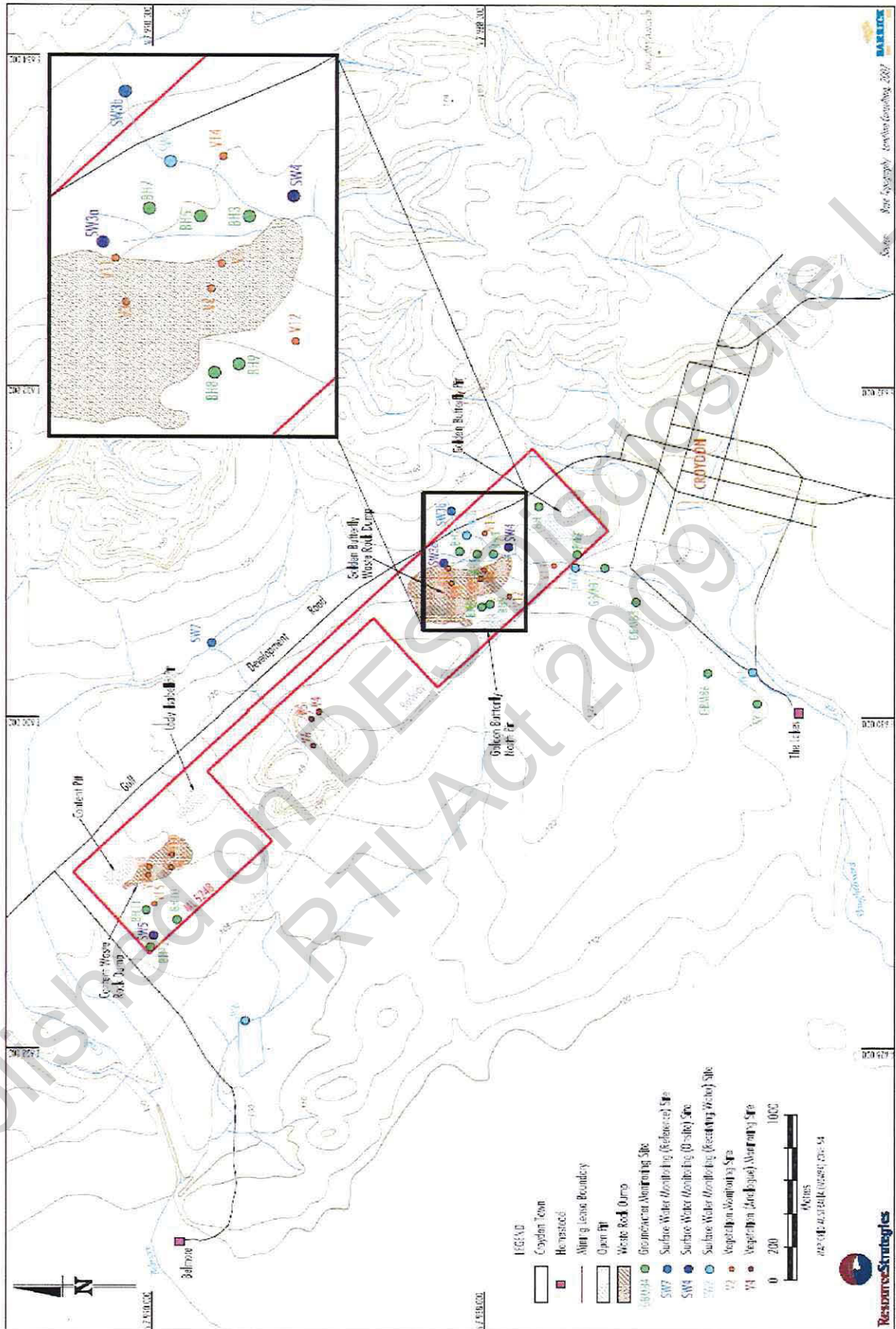


Figure 2: Site Location and Location of Environmental Monitoring Stations

Table 2: Post-Mining Land Description and Rehabilitation Objectives

Landform (refer Schedule H – Map 1)	Surface area (hectares)	Rehabilitation Objectives		
		Post-mine land description	Land classification ¹	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites.
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G. ² /disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G. ² /disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G. ² /disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G. ² /disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G. ² /disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G. ² /disturbed native habitat	Class VI or better	

¹ QLD department of Minerals and Energy (2008).

² L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria.

The final landforms were constructed when the Project was decommissioned/closed in 1993 and additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML 5248 are dominated by low hills (i.e. waste rock dumps) which are compatible with the surrounding topography in terms of elevation and slope and final voids.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3.

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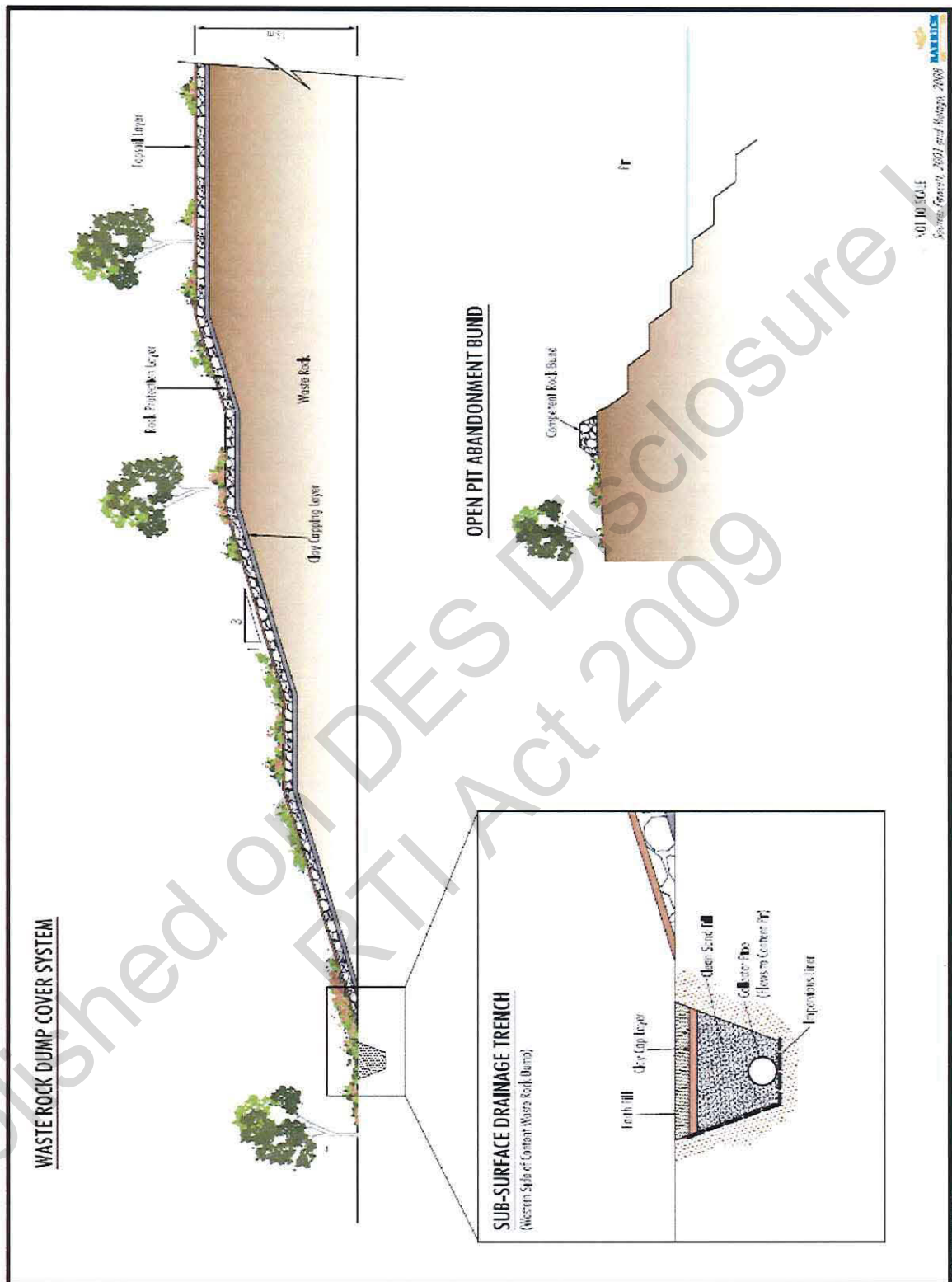


Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Cross Section Schematics

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2.3 SLOPE AND COVER DESIGN

Since the Project was decommissioned/closed, reclamation works were conducted on the final landforms identified in Section 2.2. Full details of the reclamation works are reported in Fawcett (2001) and HLA-Envirosciences (2001a).

The slope and cover design of the waste rock dumps have been developed to provide low permeability encapsulation. The reclamation work in 1996/1997 on both the Golden Butterfly and Content waste rock dumps involved (Figure 3):

- battering of slopes to 3H:1V minimum, with benches of 5 metres (m) width provided at a maximum of 5 m¹ vertical spacing; and
- construction of an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and a layer of topsoil.

Following preparation of the engineered cover system, all areas were sown with a seed mix of native tree and shrub species broadly representative of species found in the surrounding undisturbed woodlands.

2.3.1 Effectiveness of Cover System

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Details of the final cover system monitoring program are provided in the Rehabilitation Monitoring Program (Attachment A).

Golden Butterfly Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Golden Butterfly waste rock dump is effective. The following monitoring sites provide an indication of the effectiveness of the cover system of the Golden Butterfly waste rock dump (Figure 2):

- on-site surface water monitoring sites, SW3a and SW4;
- receiving water monitoring sites, SW1, SW2 and SW3, downstream of the Golden Butterfly waste rock dump; and
- vegetation monitoring sites, V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump.

On-site Surface Water Monitoring

On-site surface water monitoring site SW3a (i.e. Golden Butterfly waste rock dump toe drain) (Figure 2) is consistently of good quality and records no exceedances of the contaminant limits specified in Schedule F – Table 8 of the EA.

On-site monitoring site SW4 (i.e. stock water dam) (Figure 2) recorded one aluminium EA contaminant limit (5 mg/L) exceedance of 11mg/L in February 2005 and one pH range contaminant limit (greater than 4 pH units and less than 9 pH units) exceedance of 9.3 pH units in January 2007 during the period 2001 to 2011. No contaminant limit exceedances have been recorded since the pH range exceedance in 2007 at site SW4.

¹ HLA-Envirosciences (2001a) stated the vertical spacing of the Golden Butterfly and Content waste rock dumps as 50 m. However, it is considered the correct vertical spacing elevation of the waste rock dumps is 5 m.

Receiving Waters Monitoring

Each receiving water monitoring site surrounding the Golden Butterfly waste rock dump (i.e. SW1, SW2 and SW3) (Figure 2) displayed low pH levels and elevated levels of electrical conductivity (EC), sulphate, arsenic, cadmium, iron, manganese, lead and zinc during the period 1994 and 1995 (Landline Consulting, 2007). Following the reclamation works and clay capping of the Golden Butterfly waste rock dump in 1996, water quality at each receiving water monitoring site has improved. Since 1996, only short-term exceedances of the contaminant limits specified in Schedule F – Table 3 of the EA have been recorded at these receiving water monitoring sites. Schedule F – Table 3 is reproduced in Section 8.

During the period 2001 and 2011, receiving water monitoring site SW1 has recorded two pH range contaminant limit exceedances, recording 9.1 pH units in February 2006 and 9.2 pH units in April 2006. No contaminant limit exceedances have been recorded since these pH range exceedances in 2006 at monitoring site SW1.

At receiving water monitoring site SW2, pH and aluminium exceeded the contaminant limits specified in Schedule F – Table 3 of the EA during the period 2001 to 2011. The pH contaminant limit range was exceeded on one occasion reaching 9.1 pH units in April 2006. The aluminium contaminant limit (5 mg/L) was exceeded on one occasion to 18 mg/L in January 2007. No contaminant limit exceedances have been recorded since 2007 at site SW2.

No contaminant limit exceedances have been recorded at receiving water monitoring site SW3 during the period 2001 to 2011.

Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Golden Butterfly waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. Further complicating identification of grasses as well as the overall evaluation was over-utilization of forage by horses illegally pastured on the Golden Butterfly Waste Dump. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non-exotic species with greater than 2% relative cover, or 2) 50% of the number of non-exotic species with greater than 2% relative cover from the appropriate analogue area. The Golden Butterfly waste rock dump exceeded both of these optional success criteria based on the analogue areas.

The Golden Butterfly waste rock dump display good potential for adequate and diverse plant communities. However, illegal grazing is significantly impacting the landform in terms of vegetative cover and limiting the ability of the monitoring program to produce data to demonstrate achievement of success criteria. Despite this situation, the fact that the waste rock dump is a target for illegal grazing demonstrates vegetation performance and that the Golden Butterfly waste rock dump is effective.

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Table 3: Groundcover Monitoring Results for Croydon Waste Rock Dump Vegetation Monitoring Sites

Scientific Name	Area -> Common Name	Content Dump	Golden Butterfly	Boiler Analogue	V Analogues
Grasses					
P <i>Aristida</i> sp.	Wire Grass	0.42	0.04	2.03	4.19
A <i>Brachiaria</i> sp.	Armgrass	-	-	-	0.07
P <i>Cymbopogon bombycinus</i>	Silky Oilgrass	-	-	-	0.28
P <i>Cyperus</i> sp.	Sedge	0.57	-	-	-
A <i>Eriachne armitii</i>	Longawn Wanderie Grass	2.24	-	-	-
I <i>Pennisetum ciliare</i>	Buffelgrass	-	0.58	-	-
P <i>Sedge</i> sp.	Sedge	-	-	-	0.07
A <i>Setaria surgens</i>	Pigeon Grass	-	-	-	0.07
Unidentifiable	**Grazed beyond recognition**	11.70	4.90	11.68	-
Herbaceous					
P <i>Anisomeles malabarica</i>	Chodhava	-	-	-	0.03
P <i>Cheilanthes brownii</i>	Lip Fern	-	-	-	0.03
E <i>Hyptis suaveolens</i>	Horehound	0.76	0.31	1.55	0.69
E <i>Sida cordifolia</i>	Flannel Weed	0.04	-	-	-
A <i>Striga curviflora</i>	Witchweed	-	-	-	0.17
I <i>Stylosanthes scabra</i>	Shrubby Stylo	0.15	6.29	-	-
A <i>Triumfetta pinnosa</i>	Chinese Burr	-	-	-	0.45
Shrubs and Trees					
P <i>Acacia eleocharis</i>	White Thorn	0.08	-	-	0.14
P <i>Acacia holosericea</i>	Silver-leaved Wattle	0.38	0.49	-	-
P <i>Acacia julifera</i>	Wattle	-	-	0.12	-
P <i>Acacia leptostachya</i>	Slender Wattle	-	-	-	0.03
P <i>Corymbia confertiflora</i>	Broad leaved Carbeen	0.04	-	0.12	-
P <i>Corymbia gummiifera</i>	Red Bloodwood	0.08	-	-	-
P <i>Corymbia pocillum</i>	Bloodwood	-	0.13	-	-
P <i>Corymbia polycarpa</i>	Long-fruited Bloodwood	-	0.09	-	-
P <i>Corymbia setosa</i>	Rough-leaved Bloodwood	0.08	0.22	-	-
P <i>Erythrophileum chlorostachys</i>	Red Ironwood	-	-	-	0.07
P <i>Eucalyptus charitaboma</i>	Queensland Flaky-bark	-	-	-	0.10
P <i>Eucalyptus polycarpa</i>	Long-fruited Bloodwood	0.04	-	-	-
Overstory Hits					
P <i>Acacia eleocharis</i>	White Thorn	11.30	-	-	3.44
P <i>Acacia holosericea</i>	Silver-leaved Wattle	1.85	1.10	-	-
P <i>Acacia julifera</i>	Wattle	-	-	32.40	-
P <i>Acacia leptostachya</i>	Slender Wattle	-	-	-	4.78
P <i>Acacia shirleyi</i>	Lancewood	4.30	2.45	-	-
P <i>Adenanthera aobrasperma</i>	Red Sandalwood	-	-	-	2.22
P <i>Alphitonia excelsa</i>	Red Ash	-	-	-	3.89
P <i>Corymbia apurranima</i>	Ghost Gum	-	0.35	-	-
P <i>Corymbia confertiflora</i>	Broad leaved Carbeen	0.10	-	7.10	-
P <i>Corymbia gummiifera</i>	Red Bloodwood	0.05	-	-	-
P <i>Corymbia papuana</i>	Ghost Gum	0.60	0.20	-	-
P <i>Corymbia pocillum</i>	Desert Gum	-	1.80	-	-
P <i>Corymbia polycarpa</i>	Long-fruited Bloodwood	0.75	4.20	-	-
P <i>Corymbia setosa</i>	Rough-leaved Bloodwood	1.05	-	0.60	-
P <i>Erythrophileum chlorostachys</i>	Red Ironwood	-	-	-	1.89
P <i>Erythroxylum ellipticum</i>	Kerosene Tree	-	-	0.20	0.22
P <i>Eucalyptus charitaboma</i>	Queensland Flaky-bark	-	-	-	20.06
P <i>Eucalyptus polycarpa</i>	Long-fruited Bloodwood	4.05	-	-	-
P <i>Gardenia wilhelmii</i>	Gardenia	-	-	-	0.50
P <i>Petalostigma banksii</i>	Quinine Bush	-	-	0.10	-
P <i>Terminalia aridicola</i>	Brown Damson	-	-	-	0.61
Understory Plant Cover		16.56	13.08	15.50	6.41
Rock (> 5 mm)		19.33	23.78	12.04	17.05
Litter		32.92	41.94	29.74	37.26
Bare Ground		7.14	11.10	2.32	1.66
Overstory Plant Cover		24.05	10.10	40.40	37.61
Total Plant Cover		40.61	23.18	55.90	44.02
Annual and Perennial Cover (excluding exotics and unidentifiables)		28.11	17.97	42.66	43.33

Source: Barrick 2011.

To maintain the revegetation performance at this eastern section of ML 5248 (i.e. Golden Butterfly mining area) it is proposed that controlled low intensity grazing by domesticated stock on the area surrounding the Golden Butterfly waste rock dump occur only during the dry season. No grazing is to occur on the waste rock dump. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on-site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Golden Butterfly waste rock dump is effective and no works are proposed.

Content Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Content waste rock dump is effective, with the exception of the western side on the waste rock dump. During the reclamation works conducted in 1996, the rehabilitation performance on the western batter was considered adequate and the western batter was not capped with the engineered cover system identified in Section 2.3. Seepage has affected the hardstand area to the west of the Content waste rock dump and may be a source of elevated parameters at site SW 5 (i.e. Sediment Dam) at the north-western corner of ML 5248.

The following monitoring sites provide an indication of the effectiveness of the cover system of the Content waste rock dump (Figure 2):

- on-site surface water monitoring sites, SW5;
- receiving water monitoring sites, SW6; and
- vegetation monitoring sites, V7, V8, V9 and V10, on the surface of the Content waste rock dump.

On-site Surface Water Monitoring

During the period 2001 to 2011, water quality at monitoring site SW5 demonstrated consistently low pH levels and elevated levels of aluminium and arsenic exceeding the contaminant limits specified in Schedule F – Table 8 of the EA. Schedule F – Table 8 of the EA is reproduced in Section 8. In addition a single exceedance of the cadmium contaminant limit was recorded in April 2011, while the nickel contaminant limit (1 mg/L) was exceeded on four occasions since 2001, with the last exceedance occurring March 2010.

The proposed reclamation works to be conducted during the term of this Plan of Operations (Section 3.1 of the Plan of Operations [Barrick, 2011]) includes excavation of the Sediment Dam (i.e. SW5), sampling and characterisation of the excavated and residual material in the Sediment Dam and the installation of a subsurface drainage trench at the western foot of the Content waste rock dump. However, these proposed works are dependent upon the outcomes of the refinement of the Content Pit hydrological model. At the completion of the proposed reclamation works, monitoring at the Sediment Dam will continue to assess the effectiveness of the works.

Receiving Waters Monitoring

Monitoring commenced at receiving water monitoring site SW6 in 1999 in response to the deterioration of water quality at the on-site monitoring site SW5. During the period 2001 to 2011, aluminium exceeded the contaminant limit (5 mg/L) on seven occasions. No other contaminants exceeded the contaminant limits specified in Schedule F – Table 3 during the period 2001 to 2011 at monitoring site SW6. Schedule F – Table 3 of the EA is reproduced in Section 8.

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Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V7, V8, V9 and V10, on the surface of the Content waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Content waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non-exotic species with greater than 2% relative cover, or 2) 50% of the number of non-exotic species with greater than 2% relative cover from the appropriate analogue area. The Content waste rock dump exceeded both of these optional success criteria based on the analogue areas. Further, it was determined that soil stability results were closely tied to the vegetation cover results. All evaluated slopes of the Content Waste Dump passed the soil stability standard. It is considered from these results that the vegetation performance on the Content waste rock dump is effective.

It is proposed that domesticated stock be permanently excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas) to minimise the impact of grazing on the revegetation performance in this area. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on-site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Content waste rock dump is effective, except for the western batter. The proposed reclamation works for the Content waste rock dump are scheduled during the yearly dry season period when site access and working conditions are suitable. However, the exact timing of the proposed works is dependent upon the outcomes of the refinement of the Content Pit hydrological model. At completion of the proposed reclamation works (Section 3.1 of the Plan of Operations [Barrick, 2208a]), monitoring at the on-site water, receiving water and vegetation monitoring sites identified above, will continue to assess the effectiveness of the proposed works.

As required by Condition C2-2 (c) of the EA a report on the effectiveness of the above works on the Content waste rock dump cover system will be finalised when the proposed reclamation works are completed and will include monitoring results from site SW5, SW6, and V7 to V10.

Operation and Maintenance of the Vegetation Cover and Final Cover Systems

If vegetation, erosion and water monitoring indicates poor final cover system performance, reclamation works will be conducted to maintain the integrity and effectiveness of the final cover systems and vegetation performance at the Project. As stated above a report on the effectiveness of the final cover systems will be finalised upon completion of the proposed reclamation works described in Section 3.1 of the Plan of Operations (Barrick, 2011).

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2.4 DRAINAGE DESIGN

A Water Management Strategy (WMS) has been prepared in accordance with Condition F7-1 of the EA. The WMS includes details of the drainage management strategies for the Project and is included as Appendix D of the Plan of Operations (Barrick, 2011). A summary of the WMS is provided below.

Water Management Strategy Summary

The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology.

Drainage management strategies have been prepared for the final landforms on ML 5248 where required. The proposed strategies will include:

- excavating a subsurface trench at the western foot of the Content waste rock dump and installing a collector pipe to drain any contaminated seepage to the Content Pit (Figure 3);
- capping the trench with a clay layer to exclude any surface runoff;
- excavating the salted area to the west of the Content waste rock dump, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit, back filling the excavated area and re-contouring to shed all surface runoff to the west of ML 5248; and

A monitoring program of the surface water and groundwater monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will be included in the annual review of the WMS which will assist in assessing the effectiveness of the proposed drainage management strategies.

Operation and Maintenance of Surface Water Management System

Should surface water monitoring indicate poor performance of the surface water management system, further reclamation works will be conducted. A description of the proposed drainage management plan for the Project is provided in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]).

2.5 EROSION AND SEDIMENT CONTROL

An Erosion and Sediment Control Plan (ESCP) has been prepared in accordance with Condition F5-1 of the EA. The ESCP details the erosion protection and sediment control measures implemented at the Project and is included as Appendix E of the Plan of Operations (Barrick, 2008a). A summary of the ESCP is provided below.

Erosion and Sediment Control Plan Summary

The ESCP provides a review of the status and sources of erosion and sediment on the Project. The principles that underpin the control measures are provided to justify the proposed erosion protection and sediment control works.

The proposed erosion protection and sediment control measures for the final landforms on ML 5248, will include:

- excavating the Sediment Dam (i.e. SW5) in the north-west corner of ML 5248, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit and constructing a shallow sediment dam to capture any sediment transport off ML 5248; and
- maintenance works on existing drainage structures in the event of major damage due to extreme storm events (e.g. cyclones).

A monitoring program of the vegetation monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will assist in assessing the effectiveness of the proposed erosion and sediment control measures and if necessary, the ESCP will be updated where required.

2.6 MATERIALS BALANCE

A materials investigation was conducted by Woodward-Clyde (1996) at the Golden Butterfly and Content waste rock dumps and near surrounds during the reclamation works of 1996/1997. The materials characteristics from this investigation are identified in Section 4.

In addition to this investigation and in accordance with EA Condition C2-2 (i) a materials balance, including low permeability encapsulation media, has been prepared for the proposed reclamation works scheduled for the Content waste rock dump as described in Section 3.1 of the Plan of Operations (Barrick, 2011). The materials balance, including low permeability encapsulation media, for the proposed works is provided in Table 5.

Table 4: Materials Balance

Material Requirements/Sources	Volume (m ³)
Material Requirements	
<i>Content hardstand area</i>	
Rock mulch and soil	10,000
Sand	450
Clay	45
Material Sources	
<i>Golden Butterfly waste rock dump - east haul ramp</i>	
Rock mulch	6,000
<i>External sources</i>	
Rock mulch and soil	5,000
Sand	450
Clay	45

Note: m³ = cubed metres

3 GEOTECHNICAL ASSESSMENT

There is no documentation available to indicate that any historical geotechnical investigations have been completed. A geotechnical investigation of the various landforms at the Croydon site was conducted by Allan Watson Associates in November 2009 based on the following scope of work:

- Data review of available information relating to the Project site and associated landforms.
- Site visit and geotechnical assessment, comprising a confirmation of general geological setting and a detailed visual inspection of each landform to identify key geotechnical issues/constraints.
- Geotechnical interpretation and analysis to further characterise the mining landforms and to isolate any geotechnical issues of significance.

The focus of this scope of work has been to inform a Project risk assessment conducted by Barrick, in compliance with the requirements of the EA No. MIN100401906.

3.1 MINING RELATED LANDFORMS

The mining-related landforms on ML 5248 comprise waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps. These landforms are located on Figure 2 and include the following:

- Golden Butterfly pit.
- Golden Butterfly North pit.
- Golden Butterfly waste rock dump.
- Content pit.
- Content waste rock dump.
- Lady Isabella pit.
- Hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps.
- Stormwater diversion bunds and sediment/stormwater dams adjacent to the Content and Golden Butterfly waste rock dumps.
- Roads and tracks.

No processing infrastructure (e.g. plant areas or tailings storage facility) was located within ML 5248. Furthermore, historic mine workings (e.g. shafts and mullock heaps) are located near to the site but outside ML 5248.

3.2 SUMMARY OF GEOTECHNICAL ASSESSMENT

The geotechnical assessment identified areas of geotechnical significance. A summary of these areas is as follows:

- There is potential for a slip failure within the sandstone on the south-western face of the Golden Butterfly North pit that would also include the overlying fill. Given the sub-horizontal bedding of the sandstone, which precludes a block-type failure, such a failure would likely occur by a circular failure mechanism within the mass of the pit wall. The circular failure mechanism could be initiated through saturation of tension cracking observed within the surface of the fill profile which would act as a surcharge to the pit wall. The adjacent Croydon Railway and surcharge from the abandonment bund could also be potential mechanisms for failure.
- The southern pit wall of the Golden Butterfly pit is surcharged by an area of fill material, with evidence of tension cracking within the surface of the fill profile. Whilst it is considered that the cracking occurred as a result of settlement immediately following placement, and not an indication of imminent failure, instability could occur with excessive water ingress within the fill material with the fractured surface being confined to the fill profile.

- Undercutting of the less competent alluvium below a ferricrete profile is possible on the north-western face of the Content pit, being initiated by water level drawdown in the pit.
- Shear foliation noted in the granite in the south western face of the Lady Isabella pit may allow shallow translational or planar failures into the pit void. The scale of such a failure would be limited. No specific mechanism would exist to initiate such movement.
- With the exception of the potential slip failure of the south-western face of the Golden Butterfly North pit, it is considered that a higher level of investigation is not warranted for the areas of geotechnical significance.

Given the potential consequence of a failure of the south-western face of the Golden Butterfly North pit affecting the Croydon Railway, it is considered that additional investigations into this area of geotechnical significance are required. A slope stability has therefore been conducted and is and discussed in the following section.

3.3 GOLDEN BUTTERFLY NORTH PIT STABILITY ASSESSMENT

The stability analysis was completed using the Slope/W computer package, which uses limit equilibrium theory to solve for the factor of safety of earth and rock slopes. The model calculates a factor of safety for a modeled two-dimensional section, satisfying both moment and force equilibrium. This software is widely used in the assessment of stability of landforms such as the Golden Butterfly North pit wall.

In the absence of a detailed intrusive investigation program (eg drilling and sampling of subsurface materials), no opportunity for geotechnical testing of pit wall material to identify strength parameters was available. Notwithstanding, an inspection of rock mass and structure was made at the south western pit face as part of the geotechnical assessment. Given the sub-horizontal bedding of the Coffin Hill Member sandstone in the walls, with bedding struck into the face, any failure would occur through the rock mass rather than via structural lineation. Compressive strength of the sandstone rock, based on rock quality observed in the pit face has been estimated to be 10 to 50MPa. It has also been estimated that effective strength properties for intact rock, tested in direct shear, would be in the order of:

Fraction Angle (ϕ') 40 to 60 degrees
Effective Cohesion (c') up to 100 kPa

For the purpose of this assessment, the following unit weighting for fill and insitu sandstone were adopted:

Sandstone 21.0kN/m³
Fill 17.0kN/m³

No strength parameters for the fill profile were considered as it is considered that any localized failure within this material would be of low consequence (i.e. would not affect the Croydon Railway). All theoretical failure circles were therefore forced into the sandstone unit.

The stability model assumed that the sandstone profile was dry (i.e. assuming groundwater coincided with pit water level), although assumed that the tension crack was saturated as void recharge to the pit face. The overall assessment methodology adopted for the stability assessment overestimates the potential for pit wall failure and is therefore considered to be conservative.

The typical range of the calculated strength parameters for the sandstone mass based on the analysis was as follows:

Fraction Angle (ϕ') 45 degrees
Effective Cohesion (c') 60 kPa

This combination of strength parameters are within the estimated range of strength properties as outlined above and are at the lower bound for strength properties of intact rock. The sensitivity of the model to the applied line load representing the train (i.e. 10kN/m) was carried out. Line loads up to 30kN/m were applied with no change to the FoS for a failure encompassing the Croydon Railway. It is considered based on this analysis that the Golden Butterfly North pit wall (excluding minor failures which may occur within the granitic spoil) is stable and that failure of the pit face encompassing the railway line based on the assumed parameters has a FoS greater than 1.5.

Rel

4 GEOCHEMICAL ASSESSMENT

Woodward-Clyde (1996) investigated the acid producing potential of various rock types within the waste rock dumps and surrounding areas (i.e. former hardstand and ore stockpile areas and drainage channels) including key mine-related landforms and infrastructure areas (HLA-Envirosciences, 2001a). The Woodward-Clyde (1996) investigation included the excavation of 49 test pits from the locations identified in Table 6. Materials recovered from each pit were geologically logged, and tested for pH and EC in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity was carried out on these samples for estimation of the maximum potential acidity and net acid producing potential. The characteristics of the materials are provided in Table 6.

Table 5: Materials Characteristics

Location	Materials Characteristics	Potential for Acid Production
Golden Butterfly Waste Rock Dump	<ul style="list-style-type: none"> Surface soil layer of clay and red sand overlying grey granite waste. White granite materials were encountered beneath the surface soils in some areas. 	<ul style="list-style-type: none"> Indeterminate Indeterminate
Content Waste Rock Dump	<ul style="list-style-type: none"> Brown sandy topsoil layer overlying grey granite waste. Thin layers of red gravelly clay were encountered in some areas. Grey granite was found on the dump surface in a number of locations. 	<ul style="list-style-type: none"> Potentially Acid Producing - Grey Granite Indeterminate Potentially Acid Producing - Grey Granite
Haul Road	<ul style="list-style-type: none"> Mixture of granite, sand and red gravelly clay. The mixed waste material was considered to be potentially acid producing, however due to the high level of compaction of the haul road, the materials were effectively encapsulated. 	<ul style="list-style-type: none"> Potentially Acid Producing - Grey Granite Potentially Acid Producing - Grey Granite
Stockpile Area	<ul style="list-style-type: none"> Surficial red sand/sandstone overlying grey granite, similar to that found in Golden Butterfly waste rock dump. 	<ul style="list-style-type: none"> Potentially Acid Producing - Grey Granite
Western Side of Content Pit	<ul style="list-style-type: none"> Grey granite waste similar to Content waste rock dump. 	<ul style="list-style-type: none"> Potentially Acid Producing - Grey Granite
Drainage Channel	<ul style="list-style-type: none"> Red clay to brown sandy clay. 	<ul style="list-style-type: none"> Indeterminate
North of Golden Butterfly Pit	<ul style="list-style-type: none"> Non-acid producing natural soils. 	<ul style="list-style-type: none"> Non Acid Producing

Source: Woodward-Clyde (1996)

The investigation resulted in the re-profiling and capping of the Golden Butterfly and Content waste rock dumps and the removal of all potentially acid generating material from the Golden Butterfly and Content stockpile hardstand areas and the Slaughteryard Creek drainage channel. These works were conducted in 1996. No further geochemical work is considered necessary for the Project.

5 HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENTS

5.1 HYDROLOGICAL ASSESSMENT

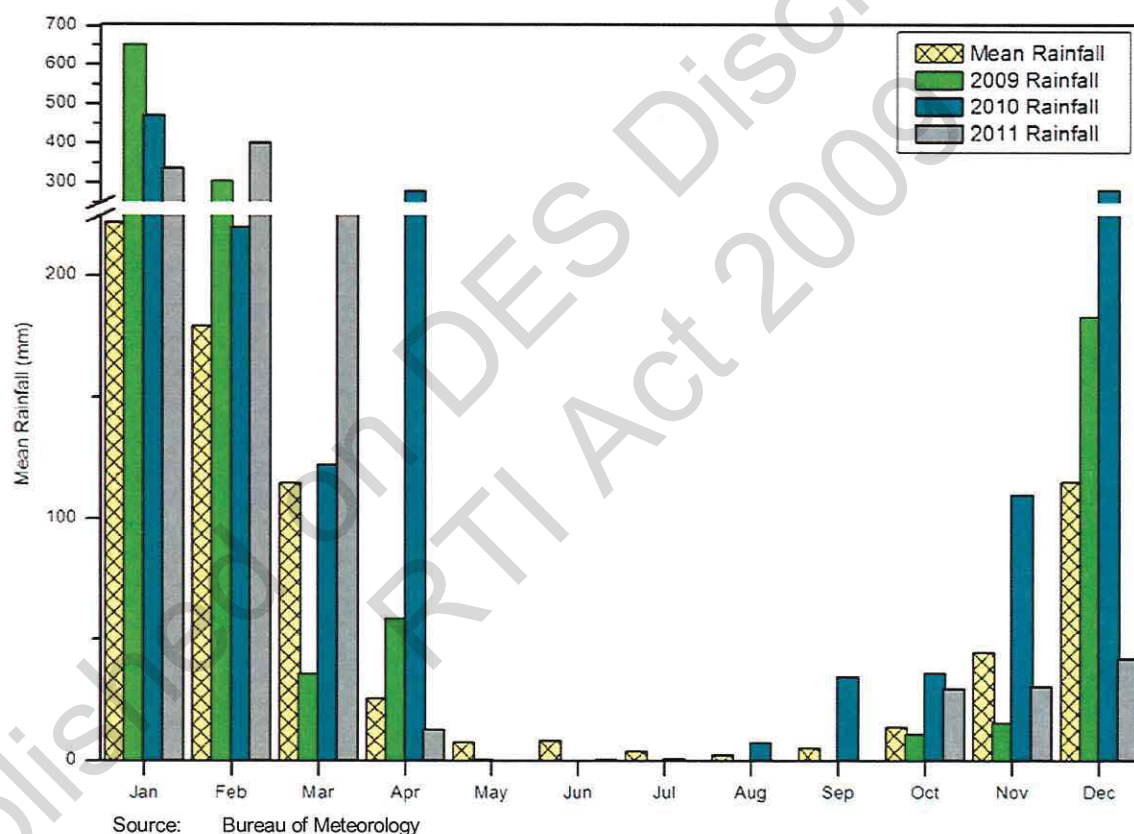
This section provides a description of the existing hydrological environment at the Project. The water management requirements and proposed drainage remediation works for the Project have been prepared and are included in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]). The water quality from the surface water monitoring sites is analysed to provide an indication of the rehabilitation performance at the Project.

5.1.1 Existing Hydrological Environment

Rainfall

The Project experiences highly seasonal rainfall with an average annual rainfall of 747.9 mm (Table 7). This rainfall pattern is illustrated in Figure 4.

Figure 4: Average Monthly Rainfall Totals for Croydon Township



Flow Regime

The highly seasonal nature of rainfall means that all local creeks are ephemeral. The south-eastern section ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and the north-western section of ML 5248 (i.e. the Content and Lady Isabella mining areas) lie within the Belmore Creek catchment.

There is no hydrological flow gauging records for ML 5248, however it is considered that surface water runoff in local creeks and drainage lines ceases relatively soon after storm events. Gradients are very low on much of ML 5248 which means that sheet flow is the dominant hydrological process during the short wet season.

Table 6: Croydon Township Weather Station Rainfall Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	223	181	115.7	25.5	7.8	8.5	3.9	2.7	5.5	14	44.6	116.3	747.9	1889 - 2011
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2008	2011	2010	2011	2011	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.2	43.5	16.5	0	0	0	0	0	0	0	5.8	36.2	438.6	
Decile 5 (median) rainfall (mm)	200.8	170.6	93.7	9.9	0.4	0.4	0	0	0	4.6	27.6	103.6	715.7	
Decile 9 rainfall (mm)	397	304.2	239.3	63.6	22.9	21.1	11.1	8.9	20	37	95.5	232.5	1038	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	29 JAN 1908	05 FEB 1964	12 MAR 1936	06 APR 2010	07 MAY 1956	05 JUN 1990	15 JUL 2006	29 AUG 1924	04 SEP 1943	15 OCT 1964	27 NOV 1973	20 DEC 1976	29 JAN 1908	
Mean number of days of rain	12.8	12.3	8.3	2.1	1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.7	
Mean number of days of rain $\geq$ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.6	48	
Mean number of days of rain $\geq$ 10 mm	6	5.5	3.3	0.6	0.3	0.2	0.1	0.1	0.2	0.5	1.3	3.4	21.5	
Mean number of days of rain $\geq$ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	338.8	401.6	241.6	13.2	0	0.6	0	0	0	30	36.4	42.2	1104.4	2011
Highest daily rainfall (mm)	77	142.4	53.2	12.4	0	0.6	0	0	0	17.8	25.8	14.8	77	
Number of days of rain	16	18	21	3	0	1	0	0	0	4	5	9	77	
Number of days of rain $\geq$ 1 mm	16	15	20	1	0	0	0	0	0	2	4	6	64	
Number of days of rain $\geq$ 10 mm	11	8	6	1	0	0	0	0	0	2	1	1	30	
Number of days of rain $\geq$ 25 mm	5	5	2	0	0	0	0	0	0	0	1	0	13	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012)

Release

On-site Water Storages

The on-site water storages on ML 5248 include the following (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Lady Isabella Pit;
- Content Pit;
- Golden Butterfly waste rock dump toe drain (i.e. SW3a);
- Stock water dam (i.e. SW4); and
- Sediment dam (i.e. SW5).

A summary of the most recent open pit water quality and surface water quality data (2000 to 2011) is provided in Table 8 and Table 9

Monitoring

In addition to the open pit and on-site surface water monitoring sites identified above, the surface water monitoring program is inclusive of the following receiving water monitoring sites (Figure 2):

- SW1 (lower Slaughteryard Creek);
- SW2 (Slaughteryard west tributary at the boundary of ML 5248);
- SW3 (Slaughteryard Creek upstream of the Golden Butterfly waste rock dump);
- SW6 (Belmore Creek borrow pit/stock dam);
- SW3b (Reference site for Slaughteryard Creek); and
- SW7 (Reference site for Belmore Creek).

A summary of the most recent receiving water quality data (2000 to 2011) is provided in Table 9. No biological monitoring has been conducted at the Project. Given that no waste water treatment system is operating at the Project, it is considered that the monitoring of biological parameters in surface water is not required.

The monitoring program for the open pit waters, on-site water storages and receiving waters is provided in the Rehabilitation Monitoring Program (Attachment A).

Open Pit Water Balance and Storage Capacity

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

Water Demand

As the Project is decommissioned/closed water would only be required for reclamation works. Water for these works would be sourced from the Golden Butterfly North Pit.

Table 7: Pit Lake Water Quality 2000-2011

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3-2.8	2.5	5.8-7.7	6.8	3.3-4.3	3.8	3.4-4.6	3.7
EC (µS/cm)	2910-12000	5971	60-370	270	737-1800	1135	491-1300	891
SO ₄ (mg/L)	1910-8000	5130	11-92	69	300-780	483	180-610	372
Cu (mg/L)	3.3-24	14.1	<0.005-<0.05	<0.05*	0.048-0.28	0.12	0.13-1.4	0.69
Pb (mg/L)	<0.002-<0.005	<0.005*	<0.001-<0.002	<0.002*	<0.001-<0.002	<0.002*	0.002-0.007	0.003
Ni (mg/L)	1.56-8.5	5.10	<0.004-<0.05	<0.05*	0.087-0.32	0.18	0.14-0.77	0.39
Al (mg/L)	122-700	436	0.025-0.73	0.20	1.31-7.0	3.1	2.98-20	9.8
Zn (mg/L)	2.4-36	19.2	<0.005-0.05	0.011	0.23-1.1	0.58	0.82-5.8	2.98
Co (mg/L)	1.24-7.3	3.5	<0.005-<0.05	<0.05*	0.09-0.29	0.14	0.109-0.53	0.25
Cd (mg/L)	0.055-0.34	0.19	<0.0001-0.0002	<0.0002*	0.0021-0.023	0.006	0.013-0.19	0.08
Fe (mg/L)	240-450	356	<0.05-0.18	0.06*	0.69-1.5	0.95	<0.05-0.66	0.23*
Mn (mg/L)	56-110	79	<0.05-0.17	<0.05*	3.7-5.2	4.4	3.3-6.3	4.7
As (mg/L)	0.34-1.3	0.71	<0.005-0.01	<0.005*	<0.005-0.058	0.015	<0.003-0.013	0.004

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 8: Water Quality Summary of Surface Water Monitoring Sites 2000- 2011

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2-9.2	7.20	5.7-9.1	6.78	6.2-8.00	6.96	5.3-6.76	6.16	6.4-9.3	7.45	3.5-6.75	4.3	5.3-9.0	7.4
EC (µS/cm)	77-610	245	64-301	144	38-450	116	17-97	54	38-770	159	32-1400	473	24-480	105
S04 (mg/L)	12-100	44	18-96	42	9-140	25.3	5-23	12.4	8-150	32	6-810	210	<1-43	12.6
Cu (mg/L)	0.004-0.063	0.019	<0.001 – 0.022	0.01	0.001-0.05	0.02	0.001-0.03	0.01	0.002-0.020	0.008	<0.001-2.5	0.38	0.001-0.158	0.018
Pb (mg/L)	<0.001-0.004	0.002*	0.001-0.01	<0.002*	<0.002-0.004	<0.002*	<0.002-0.004	<0.002*	0.001-0.012	0.004	<0.002-0.006	<0.002*	<0.002-0.047	0.006*
Ni (mg/L)	<0.002-0.003	0.002	<0.001 – 0.011	0.004	<0.001-0.03	0.02	<0.001-0.03	0.01	<0.001-0.025	0.010	<0.001-1.0	0.20	<0.001-0.025	0.017
Al (mg/L)	0.06-2.7	0.55	0.01-18	1.08	<0.05-3.5	0.41	<0.01-0.62	0.12	0.03-11.0	0.93	0.11-77	9.8	0.025-350	9.1
Zn (mg/L)	0.008-0.03	0.018	<0.005 – 0.07	0.04	0.003-0.17	0.02	0.01-0.03	0.01	<0.005-0.110	0.020	<0.005-6.0	0.95	<0.005-0.073	0.019
Co (mg/L)	<0.005-0.05	<0.05*	<0.001-0.003	0.002	<0.001-0.03	0.3	<0.001-0.03	0.01	<0.001-0.05	<0.05*	<0.001-1.0	0.21	<0.001-0.025	0.020
Cd (mg/L)	<0.0002-0.00025	<0.0002*	<0.0001-0.0002	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0002	0.0001	<0.0001-0.24	0.036	<0.0001-0.0004	0.0001
Fe (mg/L)	0.33-2.7	1.19	0.27-1.2	0.69	0.73-5.2	2.05	0.33-1.2	0.77	0.42-5.1	1.30	0.08-0.39	0.24	0.57-13	2.6
Mn (mg/L)	<0.05-0.24	<0.05*	<0.05-0.014	0.08*	<0.05-1.9	<0.05*	<0.05-0.07	<0.05*	<0.05-0.14	<0.05*	0.31-10	3.69	<0.05-0.14	<0.05*
As (mg/L)	<0.005-0.033	0.010	<0.001 – 0.055	0.02	0.002-0.07	0.01	<0.001-0.018	0.004	0.003-0.04	0.01	0.002-0.02	0.004	<0.001-0.011	0.003

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Water Management Requirements

In accordance with Condition F7-1 of the EA a WMS is required. The WMS is provided as Appendix D in the Plan of Operations (Barrick, 2011). The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology. Drainage management strategies have been prepared for the final landforms on ML 5248. A brief description of the proposed drainage management strategies is provided in Section 2.4.

5.2 HYDROGEOLOGICAL ASSESSMENT

This section provides a description of the existing groundwater environment at the Project and provides a brief description of the conceptual hydrogeological model that was developed for the Project during the preparation of the Environmental Management Plan (Barrick, 2008b). The conceptual hydrogeological model was based on available hydrogeological and groundwater quality information.

5.2.1 Existing Groundwater Environment

It is expected that the area covered by ML 5248 is a 'hardrock' geological terrain with groundwater hosted in the upper weathered rock horizon and deeper fractured rock aquifers associated with the mineral deposit. This is supported by the limited use of groundwater in the surrounding region for stock watering. The aquifers are therefore not considered a potential resource. Groundwater quality is expected to reflect the mineralised nature of the country rock and bore yields are likely to be highly erratic due to the expected lack of hydrogeological interconnectivity between fractures. Regional groundwater levels are believed to be some 15 m below ground surface and any groundwater exploration would have to target geological structures.

The only known use of groundwater in the surrounding area is the decommissioned town borefield located some 2 km to the south-west of ML 5248. The town borefield, which exploited an unconfined alluvial aquifer located along Slaughteryard Creek and deeper sedimentary bedrock aquifers, was decommissioned in 1995 when Lake Belmore was constructed as the permanent town water supply. Anecdotal evidence (Croydon Shire Council Engineer, pers. comm., 2008) indicates that many of the initial bores were dry and yields in the equipped bores rapidly decreased from an initial 1.3 litres per second (L/s) to 0.2 L/s at the time of decommissioning. Groundwater quality in this aquifer was fresh but several bores and the shallow wells had a high iron content. At the time unsuccessful attempts were made to implement a local artificial recharge scheme within the creek sands. Currently only two shallow wide diameter wells remain functional as a potential backup water supply for the town oval.

Fractured Rock Aquifers

Groundwater monitoring and pit lake recovery trends support the hypothesis that the deeper fractured rock aquifers are highly variable in water quality and have limited connectivity. Figure 5 shows the conceptualised hydrogeology in the Golden Butterfly Pit area. Groundwater levels on either side of the pit differ by up to 5 m and water qualities differ significantly (i.e. Bores BH1 and BH2) (Figure 6 and Table 9). It is suggested, based on the groundwater quality data (Table 9, Table 10, Table 11) that a major geological contact exists between bores GBMB2 and GBMB3 (Figure 5). This is borne out by the geology and the different water quality found in Golden Butterfly North Pit (Table 7). A summary of the groundwater quality from 2000 to 2011 is provided in Table 9, Table 10, and Table 11.

All four pits (i.e. Golden Butterfly, Golden Butterfly North, Content and Lady Isabella) now contain pit lakes largely as a result of groundwater inflow at depth from expected rock aquifers. The differing pit water qualities reflect country rock geology and varying mineralisation within the ore deposit through which the groundwater is moving prior to entering the pits. A summary of the water quality from 2000 to 2011 of the four open pits is provided in Table 7.

A hydrogeological study by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping. A simple water balance indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

Rel

This hypothesis is supported by water quality monitoring results with a change in water quality occurring with increased distance from the Golden Butterfly Pit (shown in Table 9, Table 10, and Table 11). Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (Figure 4). In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. Figure 7 presents an aerial photograph of the area around the Content Pit overlaid with a contour map. The Lady Isabella Pit when full is approximately five meters higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting fracture zones and or fault lines enabling water flow.

Unconfined Alluvial Aquifer – Slaughteryard Creek

The Slaughteryard Creek unconfined alluvial aquifer previously exploited by the original town water supply borefield is located off ML 5248 and some 2 km from the Golden Butterfly Pit (Figure 5). Although there are no bore logs for the town borefield, it is believed that it utilised the shallow unconfined alluvial aquifer associated with Slaughteryard Creek. It is expected that the unconfined alluvial aquifer is locally recharged by surface water flow within the creek. As previously stated the surface water recharge component that can be attributed to the Golden Butterfly Pit Lake is most unlikely. This has been confirmed by groundwater monitoring over the past ten years (Table 10, Table 11 and Table 12).

Groundwater Management Requirements

In addition to the groundwater monitoring network additional hydrogeological investigations are required by Condition F4-6 of the EA. A hydrogeological investigation/assessment was conducted in 2009 (Barrick, 2010) with the aim to confirm the conceptual hydrogeological model. In accordance with EA Condition F4-6 the hydrogeological investigation/assessment included:

- Obtaining additional geological information, regional groundwater use and bore water levels.
- Analysing groundwater quality data from the decommissioned town water supply bores.
- Surveying pit lake water levels and erection of water level gauges.
- Pit water level fluctuations and behaviour.

The 2009 hydrogeological investigation/assessment (Barrick, 2010) concluded the following:

- Groundwater is not considered a significant water resource within the mining lease and does not support or recharge any surface water drainage system. Some groundwater contamination has occurred below sections of the Content waste rock dump and around the mine pits. This contamination is highly localised and of no environmental concern, except along the western toe of Content Waste Rock Dump where remedial drainage measures are planned.

- There is no direct hydrogeological link between the Golden Butterfly Pit Lake and the Town Borefield or Lakes homestead bore and no possibility of this alluvial aquifer being contaminated by pit lake seepage water.
- The mine pits which have been considered hydrogeological sinks have until recently been slowly filling with rain and groundwater seepage. The two southern pits, namely, Golden Butterfly and Golden Butterfly North remain groundwater sinks and are likely to always be sinks if all stormwater runoff is diverted away from the surrounding area. Content and Lady Isabella Pits on the other hand have now filled with water to the extent that pit lake levels reflect local groundwater levels and hence currently represent hydrogeological flow through cells.
- The water quality in the pit lakes has improved over the past 20 years, and it is only Golden Butterfly Pit that currently has a true acid mine drainage problem. Access to this pit lake must be restricted at all times. The current water quality in the remaining pit lakes does not exclude their use for irrigation in the case of Golden Butterfly North and dust suppression (road construction) for Content and Lady Isabella. There is however an ongoing safety concern and issue that natural evapo-concentration will continue in all pit lakes, particularly during low rainfall cycles. As such these facilities should not be considered as potential stock water supplies and all access restricted to avoid any unnecessary safety liabilities.
- Current water balance modelling and field observations suggests that the proposed surface drainage plan for the Golden Butterfly Pit area needs to be fully implemented before the next wet season. The relatively simple earth works proposed could significantly reduce seepage and groundwater recharge to the mine pits. It is also suggested that drainage measures be put in place to provide for potential managed discharge (spillage) from Content Pit lake. This is a precautionary measure that needs to be taken as this pit lake will at some stage briefly overtop and the excess water needs to be directed in a control manner to discharge into the adjacent Belmore Creek. Water quality is not considered an issue, should such a spill occur, particularly as it would only occur during extreme flood conditions.

All recommendations for earthworks and other physical changes to improve drainage measures and restrict access to the various pit lakes were implemented during 2009/2010.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon (Figure 8). Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit.

Operation and Maintenance of Groundwater Monitoring Network

The groundwater monitoring network for the Project includes the groundwater monitoring sites identified in Section 8 and is described in the Rehabilitation Monitoring Program (Attachment A).

The groundwater monitoring bores will be inspected during each monitoring event and maintenance would be conducted as required.

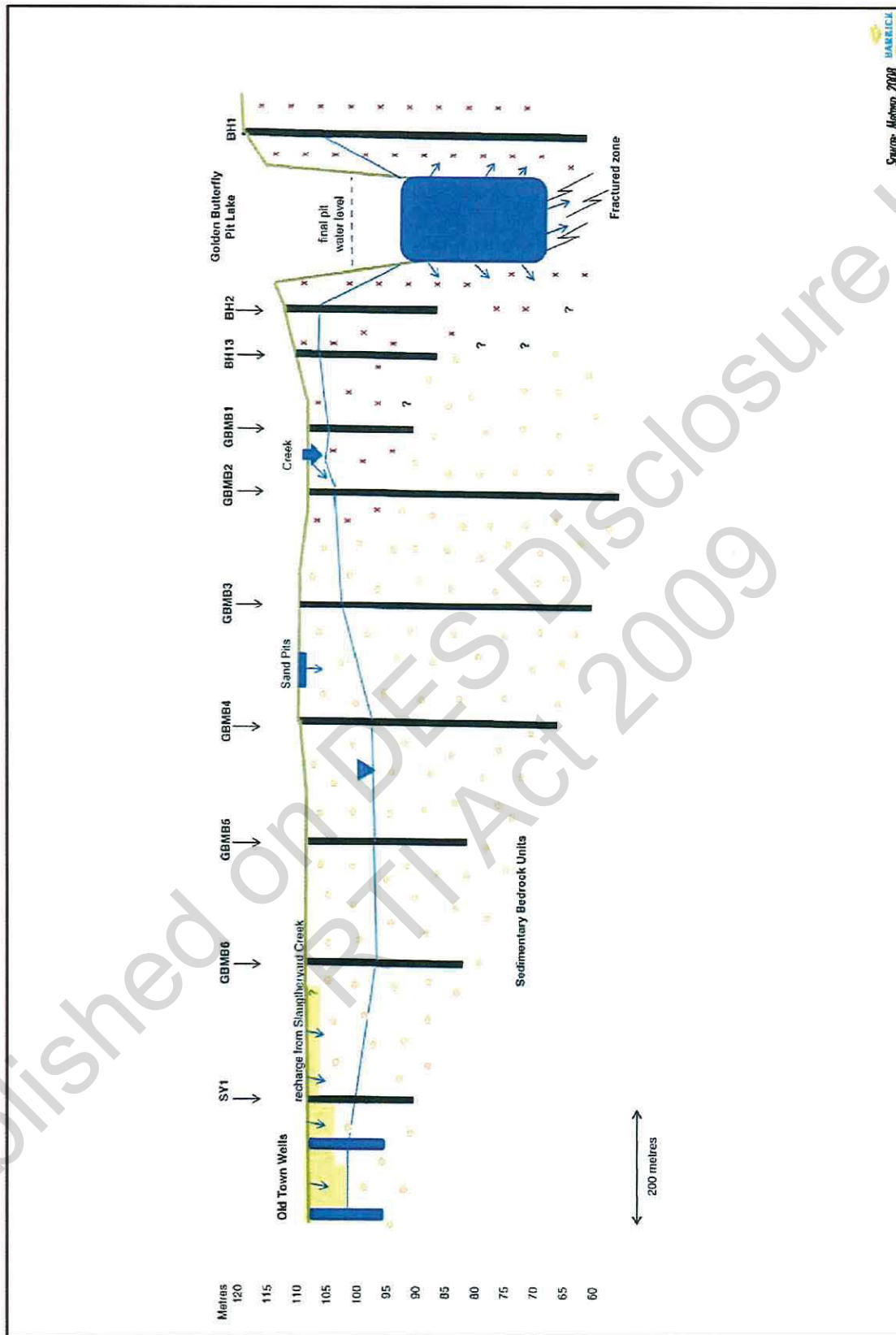


Figure 5: Conceptual Hydrogeological Model

Released

Table 9: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1-7.9 (42)	7.2 7.2	3.3-6.5 (41)	3.7 3.6	5.5-7.7 (35)	6.41 6.4	6.9-8.6	7.4	7.3-7.8 (13)	7.5 7.5	6.9-7.5	7.15	6.4-7.1	6.8	6.4-7	6.7	6.9-7.7	7.3
EC (µS/cm)	985-2260 (42)	1298 1300	740-1300 (41)	1016 980	110-3000 (35)	604 340	4800- 7200	5611	4900-6800 (13)	5550 5600	480-2200	933	6400- 8700	7472	160-760	591	2200- 2700	2491
SO ₄ (mg/L)	310-1160 (42)	471 460	260-850 (40)	442 435	20-990 (35)	172 100	1200- 1800	1522	1400-2000 (13)	1733 1800	59-530	172	1400- 2600	1950	36-190	120	630-790	703
Cu (mg/L)	<0.001-0.05 (16)	0.008 0.005	0.002-0.05 (15)	0.011 0.005	0.001-0.025 (13)	0.009 0.005	<0.001- <0.05	<0.01	<0.001-0.03 (13)	0.007 0.005	0.009- 0.02	0.01	<0.003- 0.03	<0.01	0.001- 0.01	<0.01	<0.001- <0.05	<0.01
Pb (mg/L)	<0.001-0.35 (13)	0.031 0.001	<0.001- 0.15 (13)	0.051 0.046	<0.001- 0.072 (11)	0.013 0.001	<0.001- 0.006	<0.002	<0.001-0.24 (11)	0.023 0.001	<0.002- 0.056	0.009	<0.001- 0.35	<0.002	<0.002- 0.003	<0.002	<0.002- 0.02	0.002
Ni (mg/L)	0.002-0.025 (16)	0.016 0.025	0.025-0.09 (15)	0.056 0.05	<0.001- 0.025 (10)	0.014 0.0145	<0.002- <0.05	<0.05	<0.001-0.025 (13)	0.016 0.025	0.002- <0.05	<0.05	0.004- <0.05	<0.05	0.02- <0.05	<0.05	<0.002- <0.05	<0.05
Al (mg/L)	0.02-0.25 (15)	0.045 0.025	0.16-2.7 (14)	1.54 1.65	0.07-2.1 (10)	0.49 0.33	<0.05- 0.37	<0.05	<0.01-0.29 (13)	0.049 0.025	0.14-6.8	2.35	<0.05- 0.16	<0.05	<0.05- 0.092	<0.05	<0.05- 0.21	<0.05
Zn (mg/L)	0.01-0.18 (16)	0.053 0.038	0.043-1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008- 0.04	0.017	0.0025-0.032 (13)	0.0127 0.012	0.005- 0.055	0.021	0.029- 0.15	0.072	0.012- 0.047	0.024	0.011- 0.056	0.028
Co (mg/L)	<0.001- 0.025 (11)	0.016 0.025	0.018- 0.045 (11)	0.018 0.025	<0.001- 0.025 (9)	0.015 0.025	<0.005- <0.05	<0.05	<0.001-0.05	<0.05	<0.005- <0.05	<0.05	<0.005- 0.07	<0.05	<0.05- <0.05	<0.05	<0.005- <0.05	<0.05
Cd (mg/L)	<0.0001- 0.0025 (16)	0.0003 0.0001	<0.0001- 0.0025 (15)	0.0007 0.0007	<0.0001- 0.0009 (13)	0.0002 0.0001	<0.0001- 0.0003	<0.0002	<0.0005- 0.0004 (13)	<0.0005 0.0001	<0.0001- <0.0002	<0.0002	0.0002- 0.002	0.00085	<0.0001- 0.0067	0.0005	<0.0001- 0.0003	<0.0002*
Fe (mg/L)	<0.05-3.2 (32)	0.436 0.1	0.025-27 (32)	4.54 1.3	0.025-1.75 (29)	0.33 0.25	<0.05- <0.05	<0.05	<0.05-0.09 (5)	<0.05	0.06-3.1	1.4	<0.05- 0.27	<0.05	<0.05- 0.08	<0.05	<0.05- <0.05	<0.05
Mn (mg/L)	<0.05-1.19 (8)	0.247 0.075	0.95-1.97 (8)	1.23 1.1	0.0025- 0.025 (4)	0.019 0.025	<0.05- <0.05	<0.05	<0.05-0.06 (7)	0.034 0.025	<0.05- 0.68	0.06	<0.05- 1.9	<0.05	0.26-1.4	0.83	0.67-1.2	0.90
As (mg/L)	0.01-0.022 (16)	0.014 0.014	<0.001- 0.09 (15)	0.008 0.025	<0.003-0.03 (13)	0.010 0.009	<0.005- 0.003	<0.005	<0.05-0.009 (13)	0.012 0.007	0.013- 0.048	0.026	<0.005- 0.007	<0.005	0.007- 0.034	0.02	<0.003- 0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 10: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2009

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-6.8	6.2	5.9-6.5	6.1	5.6-7.1	6.0	5.7-7.1	6.2
EC ($\mu\text{S}/\text{cm}$)	52-110	79.4	260-350	308	68-490	114	66-580	152
SO_4 (mg/L)	3-13	6.3	17-38	28.8	2-13	4.4	3-19	7.1
Cu (mg/L)	0.001-0.01	<0.01*	<0.001-<0.05	<0.01*	<0.001-0.01	<0.01*	<0.001-<0.05	<0.01*
Pb (mg/L)	0.002-0.018	0.008	<0.001-0.008	<0.002*	<0.001-0.004	<0.002*	<0.001-0.31	<0.002*
Ni (mg/L)	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*
Al (mg/L)	0.07-4.8	0.99	<0.05-0.29	<0.05*	<0.05-0.05	<0.05*	<0.05-0.69	<0.05*
Zn (mg/L)	0.017-0.11	0.052	0.006-0.18	0.043	0.01-.015	0.08	<0.005-0.092	0.025*
Co (mg/L)	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*
Cd (mg/L)	<0.0002-<0.0002	<0.0002*	<0.0001-0.0018	<0.0002*	<0.0001-<0.0002	<0.0002*	<0.0001-<0.0002	<0.0002*
Fe (mg/L)	0.53-3	1.8	<0.05-6.6	0.18*	<0.05-<0.05	<0.05	<0.05-0.39	<0.05*
Mn (mg/L)	<0.05-0.15	0.05*	<0.05-.07	<0.05*	<0.05-0.26	<0.05*	<0.05-.037	<0.05*
As (mg/L)	0.003-0.012	<0.005*	<0.003-0.007	<0.005*	<0.003-0.091	<0.005*	<0.005-0.15	0.005

* indicates Median.

Table 11: Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH1	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH2	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH3	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH5	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH6	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH7	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031
	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH8	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH9	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 11 (Continued): Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Released

Table 12: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH6	114	29/03/2010	1.70	112.30
BH1	117	2/04/2009	8.71	108.29	BH6	114	11/07/2010	3.20	110.80
BH1	117	10/08/2009	13.85	103.15	BH6	114	18/10/2010	4.35	109.65
BH1	117	29/03/2010	12.50	104.50	BH6	114	20/11/2010	4.25	109.75
BH1	117	11/07/2010	15.00	102.00	BH6	114	29/03/2011	2.00	112.00
BH1	117	13/08/2010	15.44	101.56	BH6	114	22/08/2011	3.20	110.80
BH1	117	18/10/2010	16.05	100.95					
BH1	117	20/11/2010	16.17	100.83	BH7	116	1/03/2008	4.70	111.30
BH1	117	29/03/2011	11.50	105.50	BH7	116	2/04/2009	3.35	112.65
BH1	117	22/08/2011	13.00	104.00	BH7	116	10/08/2009	3.35	112.65
					BH7	116	29/03/2010	4.60	111.40
BH2	112	1/03/2008	4.70	107.30	BH7	116	11/07/2010	4.60	111.40
BH2	112	2/04/2009	6.17	105.83	BH7	116	18/10/2010	4.65	111.35
BH2	112	10/08/2009	7.14	104.86	BH7	116	20/11/2010	4.60	111.40
BH2	112	29/03/2010	4.90	107.10	BH7	116	29/03/2011	4.10	111.90
BH2	112	11/07/2010	5.30	106.70	BH7	116	22/08/2011	4.30	111.70
BH2	112	13/08/2010	5.41	106.59					
BH2	112	18/10/2010	5.75	106.25	BH8	123.92	1/10/2008	17.12	106.80
BH2	112	20/11/2010	5.84	106.16	BH8	123.92	2/04/2009	12.20	111.72
BH2	112	29/03/2011	3.75	108.25	BH8	123.92	10/08/2009	16.70	107.22
BH2	112	22/08/2011	4.55	107.45	BH8	123.92	29/03/2010	13.55	110.37
					BH8	123.92	10/07/2010	12.50	111.42
BH3	113	1/03/2008	1.10	111.90	BH8	123.92	13/08/2010	12.50	111.42
BH3	113	2/04/2009	0.05	112.95	BH8	123.92	18/10/2010	12.60	111.32
BH3	113	10/08/2009	1.53	111.47	BH8	123.92	20/11/2010	12.57	111.35
BH3	113	29/03/2010	1.45	111.55	BH8	123.92	29/03/2011	8.75	115.17
BH3	113	11/07/2010	3.95	109.05	BH8	123.92	22/08/2011	9.28	114.64
BH3	113	18/10/2010	4.35	108.65					
BH3	113	20/11/2010	4.39	108.61	BH9	122.29	1/10/2008	12.42	109.87
BH3	113	29/03/2011	1.25	111.75	BH9	122.29	2/04/2009	7.40	114.89
BH3	113	22/08/2011	2.82	110.18	BH9	122.29	10/08/2009	9.66	112.63
					BH9	122.29	29/03/2010	8.70	113.59
BH4	113	29/03/2010	4.60	108.40	BH9	122.29	10/07/2010	8.60	113.69
BH4	113	11/07/2010	4.50	108.50	BH9	122.29	13/08/2010	8.85	113.44
BH4	113	18/10/2010	4.80	108.20	BH9	122.29	18/10/2010	9.15	113.14
BH4	113	20/11/2010	4.85	108.15	BH9	122.29	20/11/2010	9.23	113.06
BH4	113	29/03/2011	4.60	108.40	BH9	122.29	29/03/2011	6.50	115.79
BH4	113	22/08/2011	4.70	108.30	BH9	122.29	22/08/2011	7.22	115.07
BH5	114	1/03/2008	5.40	108.60	BH10	103.95	1/10/2008	10.44	93.51
BH5	114	2/04/2009	2.82	111.18	BH10	103.95	2/04/2009	7.98	95.97
BH5	114	10/08/2009	3.89	110.11	BH10	103.95	10/08/2009	7.80	96.15
BH5	114	29/03/2010	4.90	109.10	BH10	103.95	28/03/2010	7.70	96.25
BH5	114	11/07/2010	4.80	109.20	BH10	103.95	11/07/2010	7.50	96.45
BH5	114	18/10/2010	5.10	108.90	BH10	103.95	18/10/2010	7.64	96.31
BH5	114	20/11/2010	5.09	108.91	BH10	103.95	20/11/2010	7.62	96.33
BH5	114	29/03/2011	2.90	111.10	BH10	103.95	29/03/2011	7.30	96.65
BH5	114	22/08/2011	4.48	109.52	BH10	103.95	22/08/2011	7.19	96.76

Table 13 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH11	104.13	1/10/2008	7.60	96.53	SY1	107.48	1/10/2008	10.62	96.86
BH11	104.13	2/04/2009	5.51	98.62	SY1	107.48	2/04/2009	8.09	99.39
BH11	104.13	10/08/2009	4.73	99.40	SY1	107.48	10/08/2009	10.47	97.01
BH11	104.13	28/03/2010	4.26	99.87	SY1	107.48	29/03/2010	7.10	100.38
BH11	104.13	11/07/2010	3.75	100.38	SY1	107.48	11/07/2010	6.75	100.73
BH11	104.13	18/10/2010	3.70	100.43	SY1	107.48	20/11/2010	8.10	99.38
BH11	104.13	20/11/2010	3.75	100.38	SY1	107.48	29/03/2011	5.25	102.23
BH11	104.13	29/03/2011	2.25	101.88	SY1	107.48	22/08/2011	6.00	101.48
BH11	104.13	22/08/2011	2.75	101.38					
BH12	102.08	1/10/2008	7.46	94.62					
BH12	102.08	2/04/2009	7.22	94.86					
BH12	102.08	10/08/2009	7.02	95.06					
BH12	102.08	28/03/2010	6.90	95.18					
BH12	102.08	11/07/2010	6.82	95.26					
BH12	102.08	18/10/2010	6.87	95.21					
BH12	102.08	20/11/2010	6.83	95.25					
BH12	102.08	29/03/2011	6.50	95.58					
BH12	102.08	22/08/2011	6.42	95.66					
GBMB1	109	1/03/2008	3.60	105.40					
GBMB1	109	2/04/2009	1.09	107.91					
GBMB1	109	10/08/2009	1.97	107.03					
GBMB1	109	29/03/2010	3.00	106.00					
GBMB1	109	11/07/2010	3.15	105.85					
GBMB1	109	18/10/2010	3.50	105.50					
GBMB1	109	20/11/2010	3.35	105.65					
GBMB1	109	29/03/2011	1.90	107.10					
GBMB1	109	22/08/2011	1.98	107.02					
GBMB3	113	1/03/2008	7.30	105.70					
GBMB3	113	2/04/2009	2.48	110.52					
GBMB3	113	10/08/2009	4.18	108.82					
GBMB3	113	29/03/2010	2.80	110.20					
GBMB3	113	11/07/2010	3.55	109.45					
GBMB3	113	18/10/2010	3.70	109.30					
GBMB3	113	20/11/2010	3.80	109.20					
GBMB3	113	29/03/2011	2.75	110.25					
GBMB3	113	22/08/2011	3.90	109.10					
GBMB6	113	1/03/2008	11.70	101.30					
GBMB6	113	2/04/2009	10.73	102.27					
GBMB6	113	10/08/2009	13.14	99.86					
GBMB6	113	29/03/2010	10.05	102.95					
GBMB6	113	11/07/2010	9.55	103.45					
GBMB6	113	18/10/2010	9.85	103.15					
GBMB6	113	20/11/2010	10.20	102.80					
GBMB6	113	29/03/2011	7.10	105.90					
GBMB6	113	22/08/2011	8.00	105.00					

Figure 6: Golden Butterfly Pit Monitoring Bore Water Levels

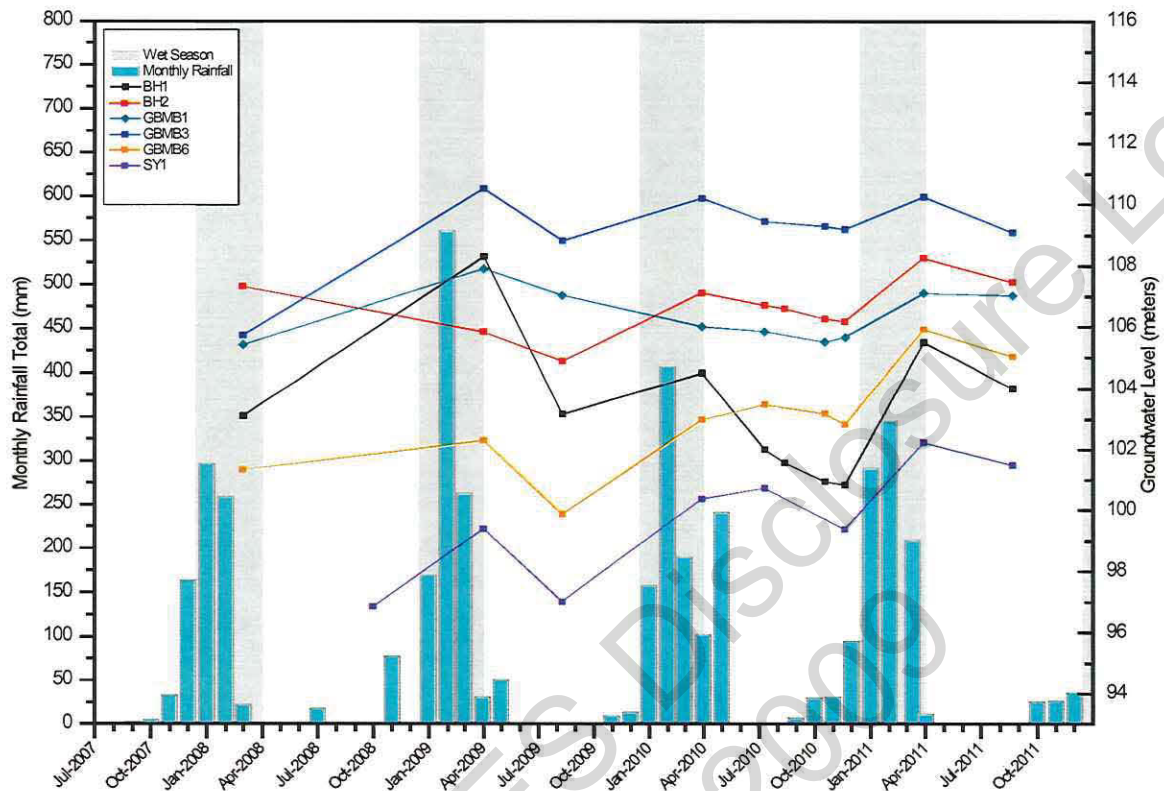


Figure 7: Content Pit local area contour map

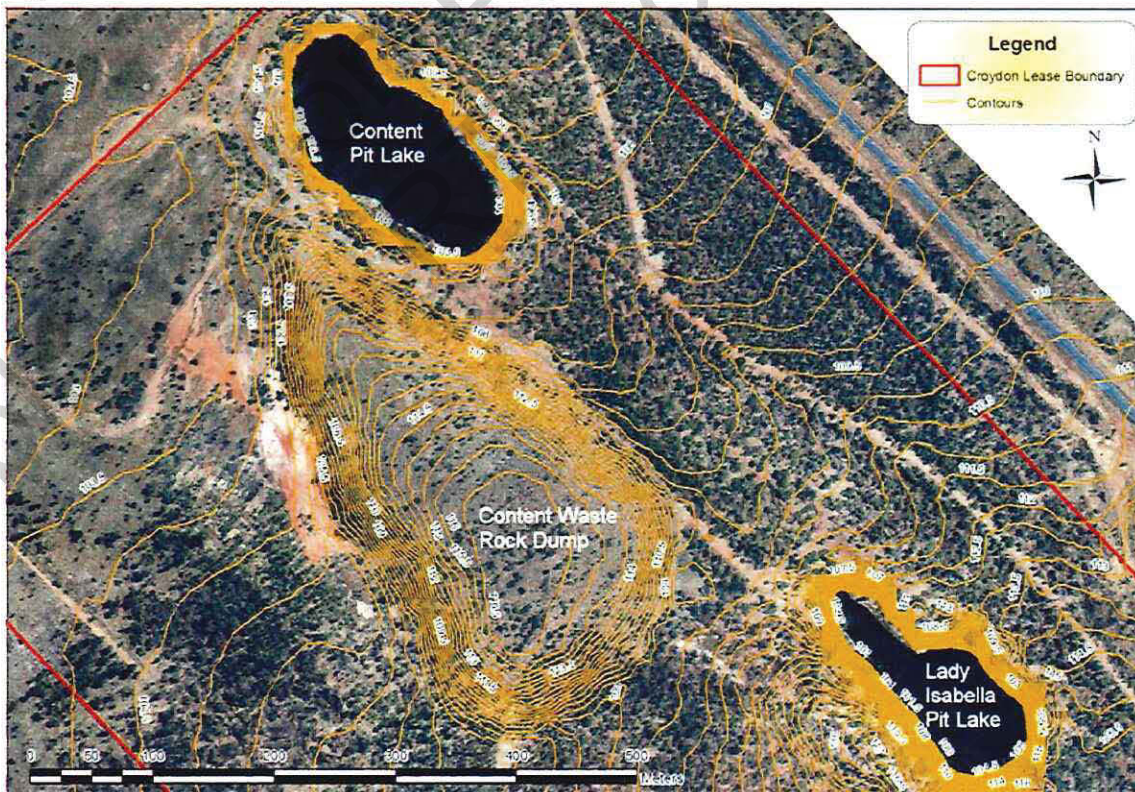


Table 13: Croydon Pit Lake Levels

	Content Pit		Golden Butterfly Pit		Lady Isabella Pit		Golden Butterfly North Pit	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10 th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13 th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27 th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18 th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19 th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7 th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29 th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23 rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23 rd Aug 2011	103.24	0.47	106.31 ^a	8.19	108.26 ^a	1.44	113.31	9.40
20 th Oct 2011	102.89	0.81	104.91 ^a	9.59	107.90 ^a 108.13 ^b	1.57	112.64	10.07
6 th Dec 2011	102.65 ^d	1.05	104.75 ^d	9.75	107.96 ^c 107.82 ^d	1.74	na	na
22 nd Dec 2011	102.57 ^d	1.13	104.74	9.76	107.76 ^d	1.94	113.78 ^d	8.92

a. Using Dumpy Level

b. Compared to last gauge board reading (8th Dec 2010)

c. Using gauge board reading

d. Using survey equipment

e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m

**Lady Isabella Pit****Golden Butterfly North Pit****Golden Butterfly Pit****Content Pit****Figure 8: Croydon Pit Lake water level monitoring stations**

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6 REHABILITATION MONITORING PROGRAM

A Rehabilitation Monitoring Program has been prepared in accordance with Condition C2-2 (n) of the EA and is included as Attachment A.

The Rehabilitation Monitoring Program includes the description of:

- surface water monitoring;
- groundwater monitoring;
- vegetation monitoring;
- erosion monitoring; and
- final cover system monitoring.

The current Rehabilitation Monitoring Program is focused on rehabilitation performance monitoring and is a refinement of the program that has been in place since 1996. The emphasis is on water and vegetation monitoring and will continue until sufficient data is available to confirm rehabilitation trends satisfy the completion criteria identified in Section 8. In the event rehabilitation monitoring indicates ineffective final cover systems and/or poor vegetation performance, additional reclamation works will be conducted.

Experimental and Statistical Design

A Rehabilitation Monitoring Program has been prepared for the Project and is provided as Attachment A. The Rehabilitation Monitoring Program includes three analogue monitoring sites and 12 rehabilitation monitoring sites (Figure 2). The parameters identified in the Rehabilitation Monitoring Program are collected at both the analogue monitoring sites and the rehabilitation monitoring sites. Comparisons between the data from the analogue monitoring sites and the rehabilitation monitoring sites will be made with the objective of:

- determining if there is significant statistical difference between the analogue monitoring sites and rehabilitation monitoring sites; and/or
- establishing relevant trends from the rehabilitation monitoring site data which establish that these sites demonstrate similar characteristics to the analogue monitoring sites.

In the event that the data indicates no significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or a trend toward the analogue monitoring site values, it will be considered that the rehabilitation monitoring sites are characteristic of analogue monitoring sites. If the data indicates that there is a significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or there is no evident trend of rehabilitation monitoring site data toward the analogue monitoring site values, an investigation will be conducted to determine the likely cause of the difference and/or trend (e.g. bushfire has occurred at one monitoring site and not the other). If the investigation indicates the likely cause of the difference and/or trend is likely to be due to rehabilitation site characteristics, additional rehabilitation works will be conducted, amelioration measures will be implemented and/or more time will be allowed for the revegetation performance to improve.

7 GRAZING MANAGEMENT PLAN

A Grazing Management Plan for the Project has been prepared in accordance with Condition C2-2(o) of the EA and is provided as Attachment B.

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8 COMPLETION CRITERIA

Measurable completion criteria will provide the ability to monitor the performance of the rehabilitation. The measurable completion criteria for the final landforms, revegetation, surface water and groundwater are outlined below.

8.1 FINAL LANDFORMS

The completion criteria for the final landforms at the Project are outlined in Table 11.

Table 14: Final Landforms Completion Criteria

Rehabilitation Type	Completion Criteria
Final Landforms	<ul style="list-style-type: none"> Post-mining landforms will be rehabilitated in accordance with rehabilitation objectives defined in Schedule C – Table 1 of the EA which is provided in Table 2. <p>The post-mining landforms will:</p> <ul style="list-style-type: none"> be stable now and in the foreseeable future; have a low probability of subsidence, rock falls and/or slope slippage; and have comparable management requirements similar to the non-mined land surrounding the Project by demonstrating that the site can sustain a low intensity grazing / disturbed native habitat landuse. <p>The parameters measured will include:</p> <ul style="list-style-type: none"> no observable subsidence, rock falls and/or slope slippage; incidence of erosion; and results from geotechnical investigation (Section 3).

8.2 REVEGETATION

The completion criteria for the revegetated areas at the Project are outlined in Table 12.

Table 15: Revegetation Completion Criteria

Rehabilitation Type	Completion Criteria
Revegetation	<ul style="list-style-type: none"> Establish a self sustaining natural vegetation cover on all post-mining landforms. Species diversity is comparable to the surrounding areas of the Project. Species abundance is comparable to the surrounding areas of the Project. The abundance of weeds is minimal. Species composition is comparable to the surrounding areas of the Project. Projective cover is comparable to the surrounding areas of the Project: <ul style="list-style-type: none"> Groundcover is adequate to support the intended post-mining landuse and is self sustaining. Tree cover is adequate to support the intended post-mining landuse and is self sustaining. Dry matter production is comparable to the surrounding areas of the Project. <ul style="list-style-type: none"> Nutrient cycling is occurring. Leaf litter is assisting in limiting erosion on the soil/spoil surface. Stocking rates maintain self sustaining vegetation cover at the Project.

In order to maintain the revegetation performance and satisfy the revegetation completion criteria described above, domesticated stock will be excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas). Controlled low intensity grazing of domesticated stock during the dry season will occur on the eastern section of ML 5248 (i.e. Golden Butterfly mining area) as described in the Grazing Management Plan (Attachment B).

8.3 SURFACE WATER

The completion criteria for surface water, including receiving waters and on-site storages, at the Project are outlined in Table 17 to Table 21.

Table 16: Surface Water Completion Criteria

Rehabilitation Type	Completion Criteria
Receiving Waters	<ul style="list-style-type: none"> The water quality at the receiving water monitoring locations defined in Schedule F – Table 1 of the EA (Table 14) will be in accordance with contaminant limits specified in Schedule F – Table 3 of the EA (Table 15).
On-site Storages	<ul style="list-style-type: none"> Any contaminated seepage water will be contained on-site within the open pits. Any on-site storages, defined in Schedule F – Table 7 of the EA (Table 16), containing water that exceeds the contaminant limits defined in Schedule F – Table 8 of the EA (Table 17), will be fenced to exclude access by livestock and minimise access by native fauna.

Table 17: Schedule F – Table 1 of EA MIN100401906 Receiving Water Monitoring Sites

Monitoring point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
SW1 Lower Slaughteryard Creek	630350	7986405
SW2 Slaughteryard West Tributary at the ML boundary	630197	7987640
SW3 Slaughteryard Creek upstream of the Golden Butterfly waste rock dump	TBA ²	TBA ²
SW6 Belmore Creek borrow pit / stock dam	627908	7989454
Reference Site¹		
SW3b Reference point for Slaughteryard creek	613208	7988220
SW7 Reference point for Belmore Creek	TBA ²	TBA ²

¹ Reference sites must:

- (a) be from the same bio-geographic and climatic region; and
- (b) have similar geology, soil types and topography; and
- (c) contain a range of habitats similar to those at the test sites; and
- (d) have a similar flow regime; and
- (e) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.

² TBA – Location co-ordinates to be provided to the Administering Authority by 30 September 2008.

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Table 18: Schedule F – Table 2 of EA MIN100401906 Receiving Water Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit ²
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 ¹
Sulphate	mg/L	Maximum	1000 ¹
Fluoride	mg/L	Maximum	2 ¹
Aluminium ²	mg/L	Maximum	5 ¹
Arsenic ²	mg/L	Maximum	0.5 ¹
Boron ²	mg/L	Maximum	5 ¹
Cadmium ²	mg/L	Maximum	0.01 ¹
Chromium ²	mg/L	Maximum	1 ¹
Cobalt ²	mg/L	Maximum	1 ¹
Copper ²	mg/L	Maximum	1 ¹
Mercury ²	mg/L	Maximum	0.002 ¹
Nickel ²	mg/L	Maximum	1 ¹
Selenium ²	mg/L	Maximum	0.02 ¹
Zinc ²	mg/L	Maximum	20 ¹

¹ Contaminant limit based on Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) stock water quality guidelines.

² Analysis for soluble metal concentrations only, not totals.

Table 19: Schedule F – Table 7 of EA MIN100401906 On-site Storage Monitoring Sites

Monitoring Point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
Golden Butterfly Pit (base of ramp)	631140	7987525
Golden Butterfly North Pit (base of ramp)	630545	7987921
Lady Isabella Pit (base of ramp)	629473	7990023
Content Pit (base of ramp)	629048	7990435
SW3a Golden Butterfly waste rock dump toe drain	630913	7988253
SW4 Stock water dam	631049	7987892
SW5 Sediment dam at lease boundary	628691	7990012

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Table 20: Schedule F – Table 8 of EA MIN100401906 On-site Storage Monitoring Sites

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 4, less than 9 ¹
EC	µS/cm	Maximum	5970 ²
Turbidity	TDS	Maximum	4000 ²
Sulphate	mg/L	Maximum	1000 ²
Fluoride	mg/L	Maximum	2 ²
Aluminium ³	mg/L	Maximum	5 ²
Arsenic ³	mg/L	Maximum	0.5 ²
Boron ³	mg/L	Maximum	5 ²
Cadmium ³	mg/L	Maximum	0.01 ²
Chromium ³	mg/L	Maximum	1 ²
Cobalt ³	mg/L	Maximum	1 ²
Copper ³	mg/L	Maximum	1 ²
Mercury ³	mg/L	Maximum	0.002 ²
Nickel ³	mg/L	Maximum	1 ²
Selenium ³	mg/L	Maximum	0.02 ²
Zinc ³	mg/L	Maximum	20 ²

¹ Page 4.2-15 of ANZECC (2000) "Soil and animal health will not generally be affected by water with pH in the range of 4–9".

² Contaminant limit based on ANZECC (2000) stock water quality guidelines.

³ Analysis for soluble metal concentrations only, not totals.
TDS = total dissolved solids

8.4 GROUNDWATER

The completion criteria for groundwater at the Project are outlined in Table 22 to Table 24.

Table 21: Groundwater Completion Criteria

Rehabilitation Type	Completion Criteria
Groundwater	<ul style="list-style-type: none"> The water quality at the groundwater monitoring locations identified in Schedule F – Table 9 of the EA (Table 19) will be in accordance with contaminant limits specified in Schedule F – Table 11 of the EA (Table 20). Confirmation of the conceptual hydrogeological model described in Section 5.2.

Table 22: Schedule F – Table 9 of EA MIN100410906 Groundwater Monitoring Sites

Monitoring Point	Easting MGA (GDA94)	Northing MGA (GDA94)	Surface RL ¹ (m)	Monitoring Frequency
BH1 west of Golden Butterfly Pit	631270	7987673	TBA ²	Annually during the dry season
BH2 east of Golden Butterfly Pit	630985	7987444	TBA ²	Annually during the dry season
BH3 east of Golden Butterfly Waste Rock Dump	TBA ²	TBA ²	TBA ²	Annually during the dry season
BH5 east of Golden Butterfly Waste Rock Dump	630987	7988051	TBA ²	Annually during the dry season
BH7 east of Golden Butterfly Waste Rock Dump	631000	7988150	TBA ²	Annually during the dry season
BH8 (east of Golden Butterfly Waste Rock Dump)	TBA ³	TBA ³	TBA ³	Annually during the dry season
BH9 east of Golden Butterfly Waste Rock Dump	TBA ³	TBA ³	TBA ³	Annually during the dry season
BH10 west of Content Waste Rock Dump	TBA ³	TBA ³	TBA ³	Annually during the dry season
BH11 west of Content Waste Rock Dump	TBA ³	TBA ³	TBA ³	Annually during the dry season
BH12 west of Content Waste Rock Dump at lease boundary	TBA ³	TBA ³	TBA ³	Annually during the dry season
GBMB1 Slaughteryard Creek	630894	7987274	TBA ²	Annually during the dry season
GBMB3 Slaughteryard Creek	630685	7987087	TBA ²	Annually during the dry season
GBMB6 Slaughteryard Creek	630257	7986656	TBA ²	Annually during the dry season
SY1 Slaughteryard Creek	TBA ³	TBA ³	TBA ³	Annually during the dry season

¹ Relative Level (RL) measurement to be taken from top of bore casing.

² TBA to be provided by 30 September 2008.

³ Co-ordinates and elevation to be determined once the proposed bores have been constructed.

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Table 23: Schedule F – Table 11 of EA MIN100410906 Groundwater Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 ¹
Turbidity	TDS	Maximum	4000 ¹
Sulphate	mg/L	Maximum	1000 ¹
Fluoride	mg/L	Maximum	2 ¹
Aluminium ²	mg/L	Maximum	5 ¹
Arsenic ²	mg/L	Maximum	0.5 ¹
Boron ²	mg/L	Maximum	5 ¹
Cadmium ²	mg/L	Maximum	0.01 ¹
Chromium ²	mg/L	Maximum	1 ¹
Cobalt ²	mg/L	Maximum	1 ¹
Copper ²	mg/L	Maximum	1 ¹
Mercury ²	mg/L	Maximum	0.002 ¹
Nickel ²	mg/L	Maximum	1 ¹
Selenium ²	mg/L	Maximum	0.02 ¹
Zinc ²	mg/L	Maximum	20 ¹

¹ Contaminant limit based on ANZECC (2000) stock water quality guidelines.

² Analysis for soluble metal concentrations only, not totals.

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9 RESEARCH PROGRAM

Research programs and/or trials will be commissioned in instances where baseline environmental surveys and/or on-going monitoring indicate the need for additional specific studies. No specific research programs have been proposed. Where additional research activities are considered appropriate, the timing and nature, including associated milestones, of the research programs will be provided to the EPA.

10 REVIEW

EA Condition A2-4 is of additional relevance to this PMLP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2-4 of the EA this PMLP will be reviewed for effectiveness at least every two years and amended promptly when required.

11 REFERENCES

- Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
- Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations*.
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- HLA-Envirosciences (2001a) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Ltd, November 2001.
- HLA-Envirosciences (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.
- Landline Consulting (2007) *Croydon ML 5248 Monitoring Report 2006*. Report prepared for Barrick Gold of Australia, April 2007.
- Woodward-Clyde (1996) *Croydon Gold Mine – (Amended) Decommissioning Plan for ML 5248*. Report prepared for Pancontinental Mining Limited.

ATTACHMENT A
REHABILITATION MONITORING PROGRAM



CROYDON GOLD MINE
REHABILITATION MONITORING PROGRAM

DECEMBER 2011

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1
2 BACKGROUND	3
3 OVERVIEW OF PROJECT REHABILITATION MONITORING	3
4 SURFACE WATER MONITORING	1
4.1 RECIEIVING WATERS	1
4.2 ON-SITE STORAGES	2
5 STREAM SEDIMENT MONITORING	3
6 GROUNDWATER MONITORING	4
7 REHABILITATION MONITORING	5
7.1 MONITORING PROGRAM	5
7.1.1 Location of Monitoring Transects	5
7.1.2 Monitoring Parameters	5
7.2 DATA ANALYSIS AND ASSESSMENT	6
7.3 REHABILITATION OBJECTIVES AND CRITERIA	6
7.3.1 Rehabilitation Objectives	6
7.3.2 Rehabilitation Criteria	7
8 EROSION AND FINAL COVER SYSTEM MONITORING	7
8.1 EROSION MONITORING	7
8.2 FINAL COVER SYSTEM MONITORING	7
9 REVIEW	8
10 REFERENCES	8

LIST OF TABLES

Table 1: Receiving Water Monitoring Programme.....	1
Table 2: On-site Storages Monitoring Programme.....	2
Table 3: Stream Sediment Monitoring Program.....	3
Table 4: Groundwater Monitoring Program.....	4
Table 5: Schedule C – Table 1 of the EA MIN10401906.....	6

LIST OF FIGURES

Figure 1: Regional Location	2
Figure 2: Site Location and Location of Environmental Monitoring Stations	4

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Rehabilitation Monitoring Program (RMP) has been prepared in accordance with EA Condition C2-2:

C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:

...
(n) **rehabilitation monitoring program**, including the monitoring of:

- (i) surface water quality;
- (ii) groundwater quality;
- (iii) erosion rates;
- (iv) integrity and effectiveness of final cover systems; and
- (v) health and resilience of vegetative cover.

Other EA conditions of relevance to this RMP are provided below:

C3-1 The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.

C3-2 The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.

C3-3 Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.

The above conditions are also addressed where relevant in this RMP.

In accordance with EA Condition C2-2 this RMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this RMP is structured as follows:

Section 2: Provides a description of the Project.

Section 3: Presents an overview of rehabilitation monitoring at the Project.

Section 4: Details the surface water monitoring program.

Section 5: Illustrates the stream sediment monitoring program.

Section 6: Presents the groundwater monitoring program.

Section 7: Describes the rehabilitation monitoring program.

Section 8: Details monitoring of erosion and the final cover systems at the Project.

Section 9: Describes the review process for this RMP.

Section 10: Lists the references cited in this RMP.

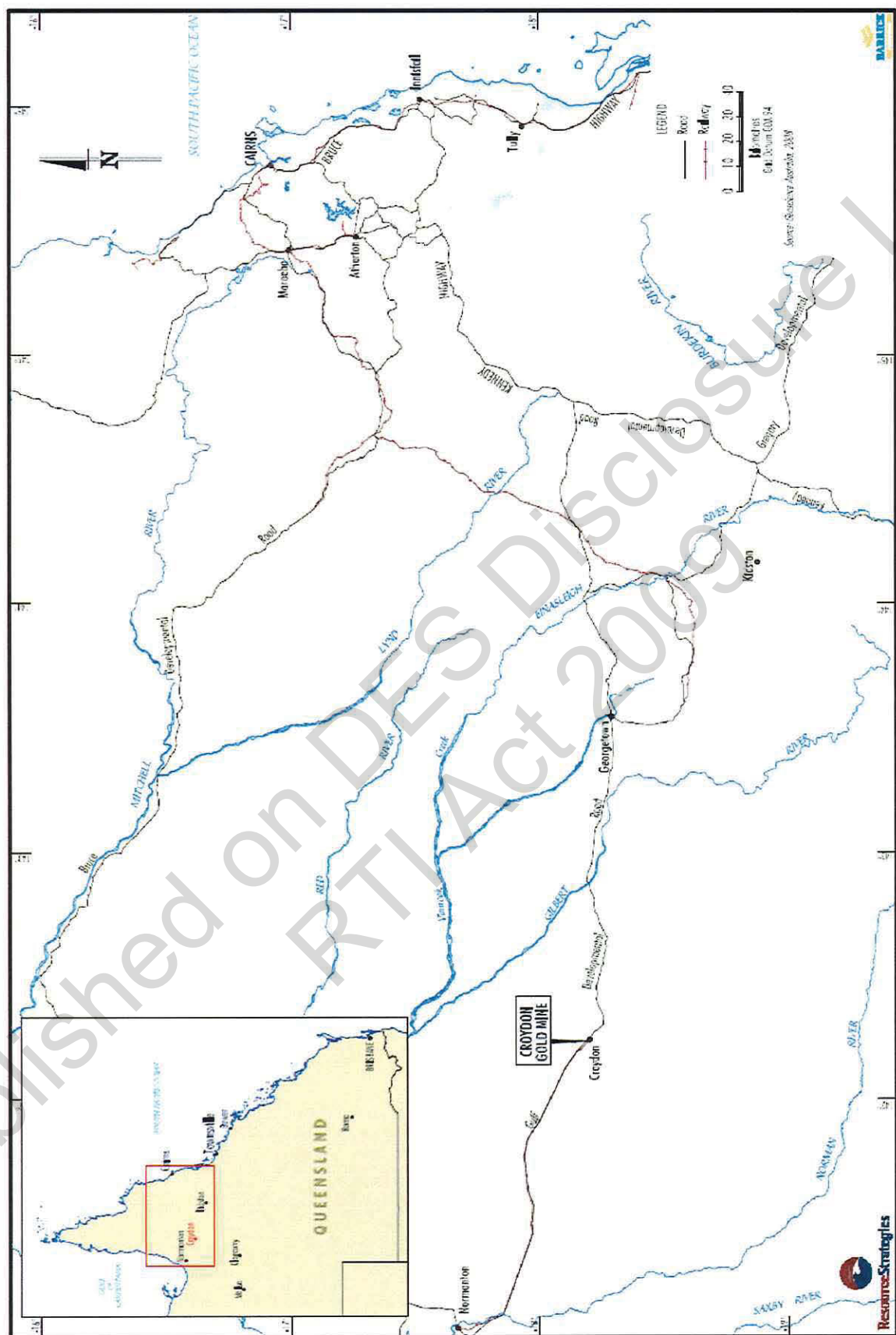


Figure 1: Regional Location

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2 BACKGROUND

Extensive gold mining at the Project commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/97 and significant additional reclamation works were undertaken in 1996 and 1997 (Barrick, 2008).

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste
- rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives. The post-mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

3 OVERVIEW OF PROJECT REHABILITATION MONITORING

Monitoring of surface water, groundwater, vegetation and soil fertility at the Project has been conducted since 1997. Annual rehabilitation monitoring results are available from 1997 to 2001 and from 2004 to present. Vegetation, soil fertility and erosion monitoring has occurred at vegetation monitoring transects on the Golden Butterfly and Content waste rock dumps and at analogue transects between these two waste rock dumps (Figure 2).

Surface water monitoring has occurred at monitoring sites in the receiving waters of Slaughteryard Creek and Belmore Creek, as well as at the base of the access ramp to the four open pit on-site storages of Golden Butterfly Pit, Golden Butterfly North Pit, Lady Isabella Pit and Content Pit (Figure 2).

Groundwater monitoring has occurred at BH1 and BH2 adjacent to the Golden Butterfly Pit, BH3, BH5 and BH7 on the eastern side of the Golden Butterfly waste rock dump and at bores GBMB1, GBMG3 and GBMB6 parallel to Slaughteryard Creek (Figure 2).



19-181

4 SURFACE WATER MONITORING

Surface water monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the surface water monitoring program is provided in Sections 4.1 and 4.2.

The surface water monitoring program described below is based on the existing monitoring program currently implemented at the Project.

4.1 RECEIVING WATERS

In accordance with EA Condition F1-3 receiving waters monitoring will be conducted at the locations defined in Schedule F – Table 1 of the EA for the parameters identified in Schedule F – Tables 2 and 3 of the EA. The frequency of monitoring will be conducted in accordance with EA Condition F1-3. A summary of the receiving waters monitoring for the Project is provided in Table 1.

Table 1: Receiving Water Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	For routine monitoring: <ul style="list-style-type: none"> Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event ¹ or flow events ² : <ul style="list-style-type: none"> One representative sample must be taken of a discharge event or flow event. Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken 	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW7 Reference point for Belmore Creek		

¹ Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.

² Flow event is a surface water flow in Slaughteryard Creek and/or Belmore Creek that occurs as a result of rainfall.

Note: Where discharge events or flow event occur simultaneously only one set of samples are required to be taken.

No sample is required where there is insufficient flow during the dry season (July – September).

The sampling method for the receiving waters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

Released

4.2 ON-SITE STORAGES

In accordance with EA Condition F3-1 monitoring of the on-site storages will be conducted at the locations defined in Schedule F – Table 7 for the parameters identified in Schedule F – Table 8. The frequency of monitoring will be conducted in accordance with EA Condition F3-1. A summary of the monitoring for the on-site storages for the Project is provided in Table 2.

Table 2: On-site Storages Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
Golden Butterfly Pit (base of ramp)	For routine monitoring: <ul style="list-style-type: none"> Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event ¹ or flow events ² : <ul style="list-style-type: none"> One representative sample must be taken of a discharge event or flow event. Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken 	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
Golden Butterfly North Pit (base of ramp)		
Lady Isabella Pit (base of ramp)		
Content Pit (base of ramp)		
SW3a Golden Butterfly WRD toe drain		
SW4 Stock water dam		
SW5 Sediment Dam at lease boundary		

¹ Discharge event is an unauthorised surface water discharge from an on-site water storage.

Note:

- Samples must be analysed for all parameters listed in Schedule F – Table 8.
- Monitoring of the storage is to be conducted at the spillway.
- No sample is required where there is insufficient water present in on-site locations during the dry season (July – September).

The sampling method for the on-site storages will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

5 STREAM SEDIMENT MONITORING

In accordance with EA Condition F2-1 stream sediment monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 4 of the EA for the parameters identified in Schedule F – Table 5 and Table 6 of the EA. A summary of the stream sediment monitoring for the Project is provided in Table 3.

Table 3: Stream Sediment Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	Twice yearly in wet season (January – March) & dry season (July – September).	Aluminium Arsenic Boron Cadmium Chromium Cobalt Copper Mercury Nickel Selenium Zinc
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW7 Reference point for Belmore Creek		

The sampling method for stream sediment will comply with the Australian Standard 5667.12 Guidance on Sampling of Bottom Sediments 1998 in accordance with EA Condition F2-4. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

Released

6 GROUNDWATER MONITORING

Groundwater monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the groundwater monitoring program is provided below. The groundwater monitoring program described below is based on the existing monitoring program currently being used at the Project.

In accordance with EA Condition F4-1 groundwater monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 9 of the EA for the parameters identified in Schedule F – Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 4.

Table 4: Groundwater Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
BH1 North of Golden Butterfly Pit	Annually during the dry season	pH
BH2 South-west of Golden Butterfly Pit		EC
BH3 South-east of Golden Butterfly Waste Rock Dump		Turbidity
BH5 East of Golden Butterfly Pit Waste Rock Dump		Sulphate
BH7 East of Golden Butterfly Waste Rock Dump		Fluoride
BH8 West of Golden Butterfly Waste Rock Dump		Aluminium
BH9 West of Golden Butterfly Waste Rock Dump		Arsenic
BH10 West of Content Waste Rock Dump		Boron
BH11 West of Content Waste Rock Dump		Cadmium
BH12 West of Content Waste Rock Dump at lease boundary		Chromium (CrVI)
GBMB1 Slaughteryard Creek		Cobalt
GBMB3 Slaughteryard Creek		Copper
GBMB6 Slaughteryard Creek		Mercury (inorganic)
SY1 Slaughteryard Creek		Nickel
		Selenium (total)
		Zinc

The sampling method for groundwaters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

In accordance with EA Condition F4-4 annual groundwater reports analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions will be prepared by November each year.

Released

7 REHABILITATION MONITORING

A monitoring program will be implemented to assess the performance of rehabilitation at the Project. In accordance with EA Conditions C3-1 and C3-2, rehabilitation monitoring will be conducted on at least a yearly basis by a person nominated by Barrick possessing appropriate qualifications and experience in the field of rehabilitation management.

The monitoring program described below is based on the existing monitoring program currently being used at the Project. Section 7.1 describes the monitoring program, Section 7.2 discusses data analysis and assessment, and Section 7.3 outlines rehabilitation objectives and criteria.

7.1 MONITORING PROGRAM

7.1.1 Location of Monitoring Transects

Rehabilitation monitoring will be conducted at 12 vegetation transect sites (Figure 2). Each of the transect sites is 50 metres long. Four transect sites have been established on the Golden Butterfly waste rock dump, four transect sites have been established on the Content waste rock dump, and four transect sites will be established on areas of general disturbance (Figure 2).

In addition, three transect sites have been established as analogue sites. These analogue transect sites are located to the south of ML 5248 between the Golden Butterfly and Content waste rock dumps (Figure 2).

7.1.2 Monitoring Parameters

Vegetation

The following vegetation parameters will be monitored at each of the transect sites:

- tree density;
- tree height;
- tree species composition;
- pasture biomass;
- pasture cover;
- pasture species composition;
- weed abundance; and
- dry matter production.

In addition to the above, a photographic record will be taken of each transect. The health and resilience of the vegetation cover at the Project will be determined by the performance of the vegetation parameters identified above.

Soils

Soil samples will be taken to a depth of ten centimetres at five metre intervals along the transect sites. Large debris and stone will be extracted from the soil samples before they are sent to a commercial laboratory for analysis for the following parameters:

- pH (1:5 soil:H₂O);
- EC (1:5 soil:H₂O);
- nitrate;
- extractable-phosphorus;
- organic carbon;
- total nitrogen and total carbon;
- cation exchange capacity (CEC);
- exchangeable cations (calcium, magnesium, potassium, sodium and aluminium); and
- DTPA-extractable copper, zinc, iron and manganese.

7.2 DATA ANALYSIS AND ASSESSMENT

The rehabilitation monitoring results obtained from annual monitoring will be reviewed by a person possessing appropriate qualifications and experience in the field of rehabilitation management to track rehabilitation progress against the analogue sites and the rehabilitation objectives and criteria discussed in Section 7.3.

The monitoring programs outlined in this RMP will allow sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be established.

7.3 REHABILITATION OBJECTIVES AND CRITERIA

7.3.1 Rehabilitation Objectives

The rehabilitation objectives for the Project are prescribed in Condition C1-1 of the EA in Schedule C – Table 1 which is reproduced in Table 5. This condition requires ML 5248 (except for the open pits) to be rehabilitated to a post-mine landuse of low intensity grazing/disturbed native habitat. Condition C1- 1 of the EA also requires ML 5248 (except for the open pits) to be rehabilitated to a land classification of Class VI or better (DME, 1995).

The open pits are required to be rehabilitated to a post-mine landuse of “non-beneficial land use” and to a land classification of Class VIII (DME, 1995) by Condition C1-1 of the EA.

Table 5: Schedule C – Table 1 of the EA MIN10401906

Landform (refer Schedule H – Map 1)	Surface Area (ha)	Rehabilitation Objectives		
		Post-mine Land Description	Land Classification ¹	Analogue Site Identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites.
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G ² / disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G ² / disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G ² / disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G ² / disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G ² / disturbed native habitat	Class VI or better	
Roads/ Tracks	3.5	L.I.G ² / disturbed native habitat	Class VI or better	

¹ Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME), 1995.

² L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria

Released

7.3.2 Rehabilitation Criteria

The Post Mine Landuse Plan (PMLP) (Appendix A of the Plan of Operations [Barrick, 2008a]) has been prepared in accordance with Condition C2-1 of the EA. As required by EA Condition C2-2, the PMLP includes the following:

(g) *proposed revegetation criteria including:*

- (i) *species diversity, abundance and composition;*
- (ii) *projective cover;*
- (iii) *dry matter production; and*
- (iv) *stocking rates to ensure self sustaining vegetation is maintained.*

...

(h) *measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type.*

In accordance with Condition C3-3 of the EA (Section 1) the verification of rehabilitation success will be determined by the comparison with the measurable completion criteria documented in Section 8 of the PMLP (Appendix A of the Plan of Operations [Barrick, 2008a]).

8 EROSION AND FINAL COVER SYSTEM MONITORING

8.1 EROSION MONITORING

Erosion monitoring at the Project will consist of conducting an annual qualitative assessment at each of the vegetation monitoring transects listed in Section 7.1.1. In general accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) this will include:

- field traverses to observe incidence of erosion;
- recording details of any incidence of erosion (e.g. rills and sheeting); and
- maintaining a photographic record for comparison.

In addition to the above, the following parameters will be monitored as part of the rehabilitation monitoring program at the vegetation monitoring transects to provide an indication of the potential for erosion at the Project:

- tree density;
- pasture biomass;
- pasture cover; and
- pasture species composition.

8.2 FINAL COVER SYSTEM MONITORING

The final cover system of the Content waste rock dump and the Golden Butterfly waste rock dump consists of a clay capping layer, a rock fill surface protection layer and topsoil layer, except for the western batter of the Content waste rock dump.

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Erosion and vegetation cover monitoring on the waste rock dumps will be monitored at the sites listed in Section 7.1.1 utilising the parameters identified in Section 8.1 for erosion monitoring and in Section 7.1.2 for vegetation cover monitoring.

Potential failure of the final cover system would possibly result in impacts on surface water and groundwater quality and vegetation cover performance. Accordingly, the integrity and effectiveness of the final cover systems at the Project are monitored indirectly via surface water, groundwater, vegetation and erosion monitoring (Sections 4, 6, 7 and 8).

Released

9 REVIEW

EA Condition A2-4 is of additional relevance to this RMP and is provided below:

(A2-4) *Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.*

In accordance with Condition A2-4 of the EA this RMP will be reviewed for effectiveness at least every two years and amended promptly when required.

10 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan*.

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations*.

Department of Minerals and Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*, Queensland Government.

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ATTACHMENT B
GRAZING MANAGEMENT PLAN

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CROYDON GOLD MINE
GRAZING MANAGEMENT PLAN

DECEMBER 2011

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1
2 BACKGROUND	3
3 OBJECTIVES	3
4 MANAGEMENT OF GRAZING	5
4.1 EASTERN SECTION OF ML 5248	5
4.2 WESTERN SECTION OF ML 5248	5
5 MONITORING	6
6 CONSULTATION	6
7 REVIEW	7
8 REFERENCES	7

LIST OF FIGURES

Figure 1: Regional Location	2
Figure 2: Site Location and Location of Environmental Monitoring Stations	4

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Grazing Management Plan (GMP) has been prepared in accordance with EA Condition C2-2:

C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:

...

(o) grazing management plan.

In accordance with EA Condition C2-2 this GMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this GMP is structured as follows:

- Section 2: Provides a background of the existing grazing practices and current vegetation cover at the Project.
- Section 3: Identifies the objectives of this GMP.
- Section 4: Provides details of how grazing will be managed at the Project.
- Section 5: Outlines how grazing will be monitored at the Project.
- Section 6: Describes the consultation process for this GMP.
- Section 7: Describes the review process for this GMP.
- Section 8: Lists the references cited in this GMP.

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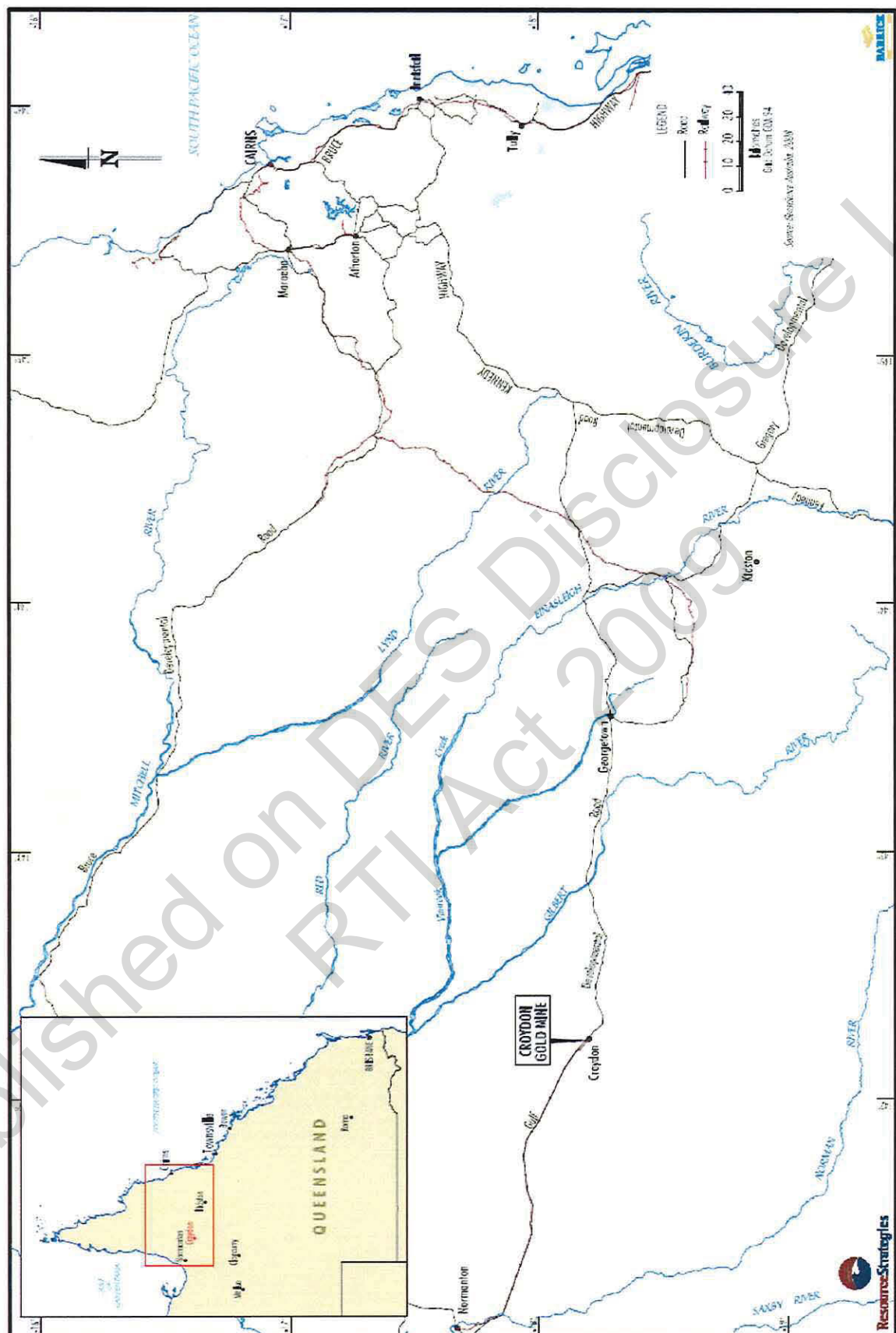


Figure 1: Regional Location

2 BACKGROUND

Existing Grazing Practices

Since the Project was decommissioned/closed and final rehabilitation works were completed in 1996/1997 the eastern section of ML 5248 (i.e. area between the Golden Butterfly waste rock dump, Golden Butterfly Pit and Golden Butterfly North Pit) has been used by the Croydon Shire Council as a paddock for holding and grazing domesticated stock during the dry season (Figure 2). This eastern section of ML 5248 was previously a section of the Croydon Town Common which has traditionally been used for grazing of domesticated stock.

The western section of ML 5248 (i.e. area surrounding the Content waste rock dump, Content Pit and Lady Isabella Pit) is not currently fenced and domesticated stock graze this western section and surrounding areas (Figure 2).

Current Vegetative Cover

During the rehabilitation works conducted in 1996/1997 the rehabilitated areas at the Project were seeded with pasture species and trees and fertilised to stimulate growth (Landline Consulting, 2007). Fertilisation of the rehabilitated areas was repeated in 2004. As the Project experiences summer dominant rainfall, the productivity of native and improved pastures, coincides with the wet season (DNRW, 2008a). As a result higher levels of vegetation cover occur during the wet season and to a lesser extent during the dry.

The Golden Butterfly waste rock dump displays good potential for adequate and diverse plant communities (Barrick, 2011). However, illegal grazing is significantly impacting the landform in terms of vegetative cover and limiting the ability of the monitoring program to produce data to demonstrate achievement of success criteria. Despite this situation, the fact that the waste rock dump is a target for illegal grazing demonstrates substantial vegetative cover.

3 OBJECTIVES

The grazing management objectives on ML 5248 are to control grazing by implementing appropriate management measures that will:

- result in minimal impact on revegetation;
- encourage the development of a vigorous pasture and litter layer;
- enable the development of a tree layer that will be self-sustaining and resistant to fire;
- reduce the potential for competitive advantage of weed growth; and
- assist with fire control.

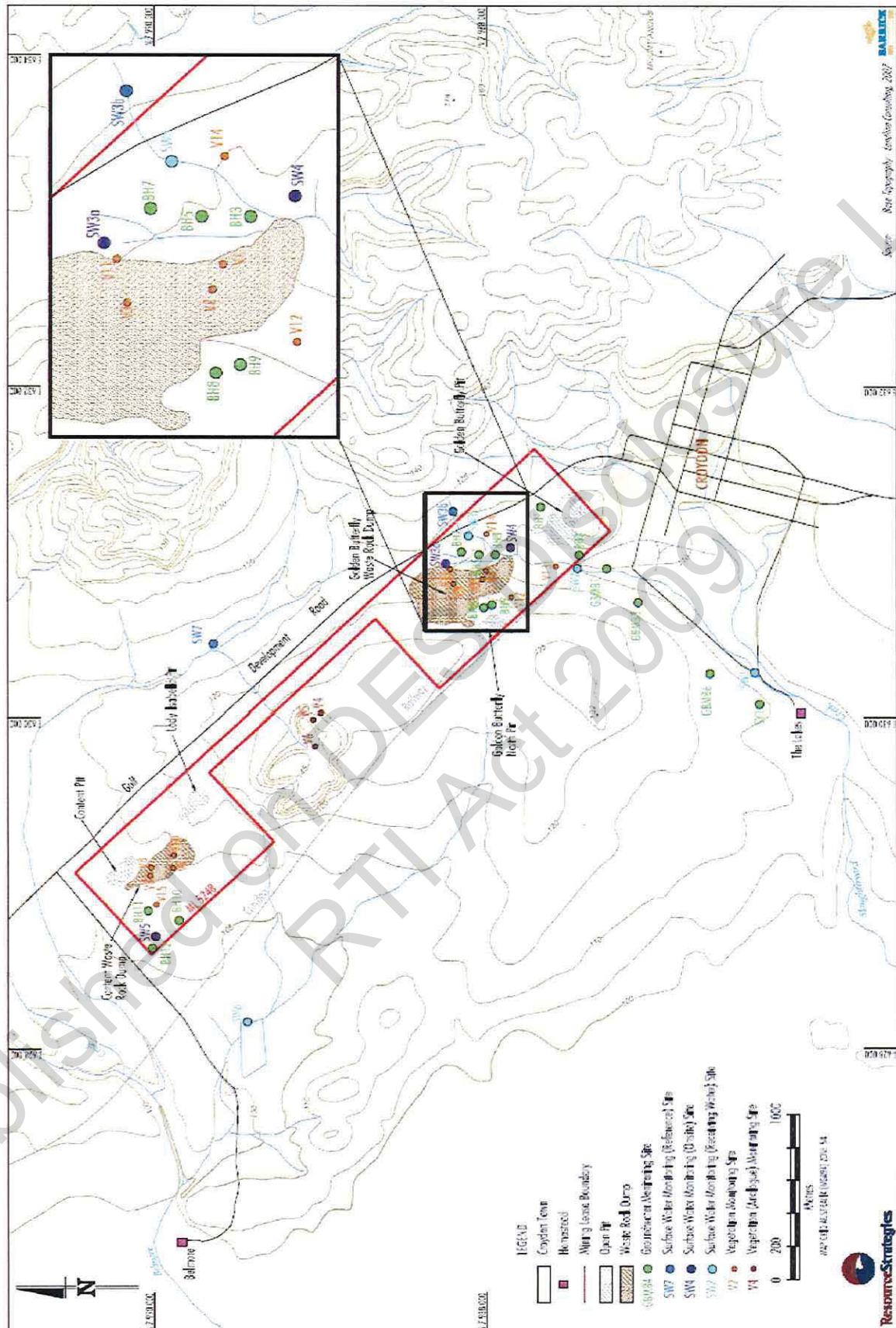


Figure 2: Site Location and Location of Environmental Monitoring Stations

4 MANAGEMENT OF GRAZING

Inappropriate stocking rates and overgrazing has the potential to inhibit rehabilitation performance at the Project. Pasture species seed during the late wet season therefore the impact of grazing is reduced if domesticated stock graze during the dry season only. However, excessive grazing in dry years can impact the survival of perennial pasture species, decreasing vegetative cover and exposing the surface soil to erosion and the introduction of weeds.

Stocking Rates

Ideal stocking rates match stock numbers to the available feed each year. It is considered that most native pastures will remain in good condition when no more than 30% of the summer growth is eaten (DNRW, 2008b). Groundcover yields during the mid dry season at the Project average approximately 30 to 50 kilograms per hectare (kg/ha) under current grazed conditions.

Low intensity grazing on the eastern section of ML 5248 (Figure 2) will assist with reducing fire hazards. Managing fuel loads through grazing assists with reducing the potential spread and intensity of any bushfires on ML 5248.

4.1 EASTERN SECTION OF ML 5248

The following grazing management measures will be implemented on the eastern section of ML 5248 (Figure 2):

- Low intensity grazing of domesticated stock will be conducted during the dry season.
- Supplementary feeding of domesticated stock will be provided by the owner of the domesticated stock during the dry season.
- Domesticated stock will be removed when vegetation monitoring indicates the vegetation cover cannot sustain further grazing without impacting on the revegetation performance (Section 5).
- Domesticated stock will be excluded during the wet season.
- Secure fencing will be maintained.

4.2 WESTERN SECTION OF ML 5248

Domesticated stock will be excluded from the western section of ML 5248 throughout the year (Figure 2). Secure fencing of the western section will be maintained.

Rele

5 MONITORING

As described in Section 4 domesticated stock will be removed from ML 5248 during excessively dry periods. The following vegetation parameters from the Rehabilitation Monitoring Program (RMP) (Section 7.1.2 of the RMP) will be monitored at the beginning of the dry season at the vegetation monitoring sites V1 to V3 and V11 to V14 (Figure 2) to assess the capacity of the vegetation cover to carry domesticated stock:

- pasture cover;
- pasture biomass; and
- pasture species composition.

To minimise the potential detrimental effects on the revegetation performance by overgrazing, domesticated stock will be excluded from the eastern section of ML 5248 if vegetation monitoring indicates:

- insufficient pasture cover and pasture biomass for the quantity of domesticated stock on the eastern section of ML 5248 as determined by visual observation of pasture cover and dry matter production monitoring (Section 7.1.2 of the RMP);
- incidence of erosion; and
- occurrence of weeds.

The Rehabilitation Monitoring Program is provided as Attachment A of Appendix A of the Plan of Operations (Barrick, 2008).

6 CONSULTATION

Contact with the Croydon Shire Council will be maintained throughout the year so:

- the eastern section of ML 5248 is not overgrazed (Sections 4 and 5); and
- that domesticated stock are excluded from the western section of ML 5248.

Released

7 REVIEW

EA Condition A2-4 is of additional relevance to this RMP and is provided below:

(A2-4) *Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.*

In accordance with Condition A2-4 of the EA this GMP will be reviewed for effectiveness at least every two years and amended promptly when required.

8 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine – Plan of Operations*.

Barrick Gold of Australia (2011) *Croydon Mine – 2010 Revegetation Efforts Monitoring, Evaluation and Recommendations*, November 2011.

Department of Natural Resources and Water (2008a) *Guide to the factors influencing carrying capacities of Queensland's rangelands*, Fact Sheet L 80, Queensland Government.

Department of Natural Resources and Water (2008b) *Managing for drought in grazing lands*, Fact Sheet L 90, Queensland Government.

Landline Consulting (2007) *Croydon ML 5248 Monitoring Report 2006*. Report prepared for Barrick Gold of Australia, April 2007.



CROYDON GOLD MINE
ENVIRONMENTAL AUTHORITY AMENDMENT

DECEMBER 2012

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TABLE OF CONTENTS

1	INTRODUCTION	2
1.1	BACKGROUND	2
1.2	LONG-TERM MITIGATION STRATEGY	7
1.3	PURPOSE OF THIS REPORT	7
2	WATER QUALITY DATA FROM 2011 DISCHARGE EVENT	8
3	TOXICITY TESTING OF CONTENT PIT LAKE WATER	10
4	FLOW REGIME OF BELMORE CREEK	10
5	CONCLUSION	11
6	REFERENCES	11

LIST OF TABLES

Table 1: Summary of Surface Water Quality Data from 30 th March to 2 nd May 2011	2
Table 2: Analytical Data for Water Sampling During Content Pit Discharge	7
Table 3: Content Pit Discharge Estimated Flow Rate	9

LIST OF FIGURES

Figure 1: Croydon Site Regional Location Map	3
Figure 2: Croydon Site Location Features	4
Figure 3: Sample Site Locations	10
Figure 4: Sample Site and Date versus pH, Electrical Conductivity and Sulfate	11
Figure 5: Sample Site and Date versus Metal Concentrations	12
Figure 6: Content Pit Discharge Estimated Flow Rate versus Date	13
Figure 7: Velocity-Area Method Used to Estimate Content Pit Discharge Flow Rate (5th April 2011)	14
Figure 8: Croydon Daily Rainfall for 2011	15
Figure 9: Belmore Creek at sample site "Belmore d/s" March 2011	16

LIST OF APPENDICES

Appendix 1: Surface Water Quality Monitoring Results and Figures

Rele

1 Introduction

The Croydon Gold Mine (the CGM) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (Figure 1). The CGM was formerly a low-grade gold mine and has since been closed and decommissioned. Activities at the CGM include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Australia Pacific Limited (Barrick) in 2005. Barrick holds Environmental Authority (EA) No. MIN100401906 for the CGM.

1.1 Background

General

Extensive gold mining at the CGM commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the CGM was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/1997 and significant additional reclamation works were subsequently undertaken (Barrick, 2008).

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps. Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Background to Content Pit Surface Water Outflow

The 2008 and 2009 annual rainfall totals (i.e. 978 millimetres [mm] and 1,262 mm, respectively) recorded at the nearest Commonwealth Bureau of Meteorology (BOM) station (Croydon Township - station 029012) were above the average annual rainfall recorded over the past 123 years (i.e. 748.4 mm) (BOM, 2012). The 2010/2011 wet season in the Croydon area was characterised by extraordinary rainfall totals. In recognition of the diminishing storage capacity within the Content Pit, Barrick was granted approval by the Department of Environment and Heritage Protection (DEHP) on 23 September 2010 to undertake short-term remediation works involving the transfer of water from the Content Pit to the Golden Butterfly Pit to increase the storage capacity of the Content Pit.

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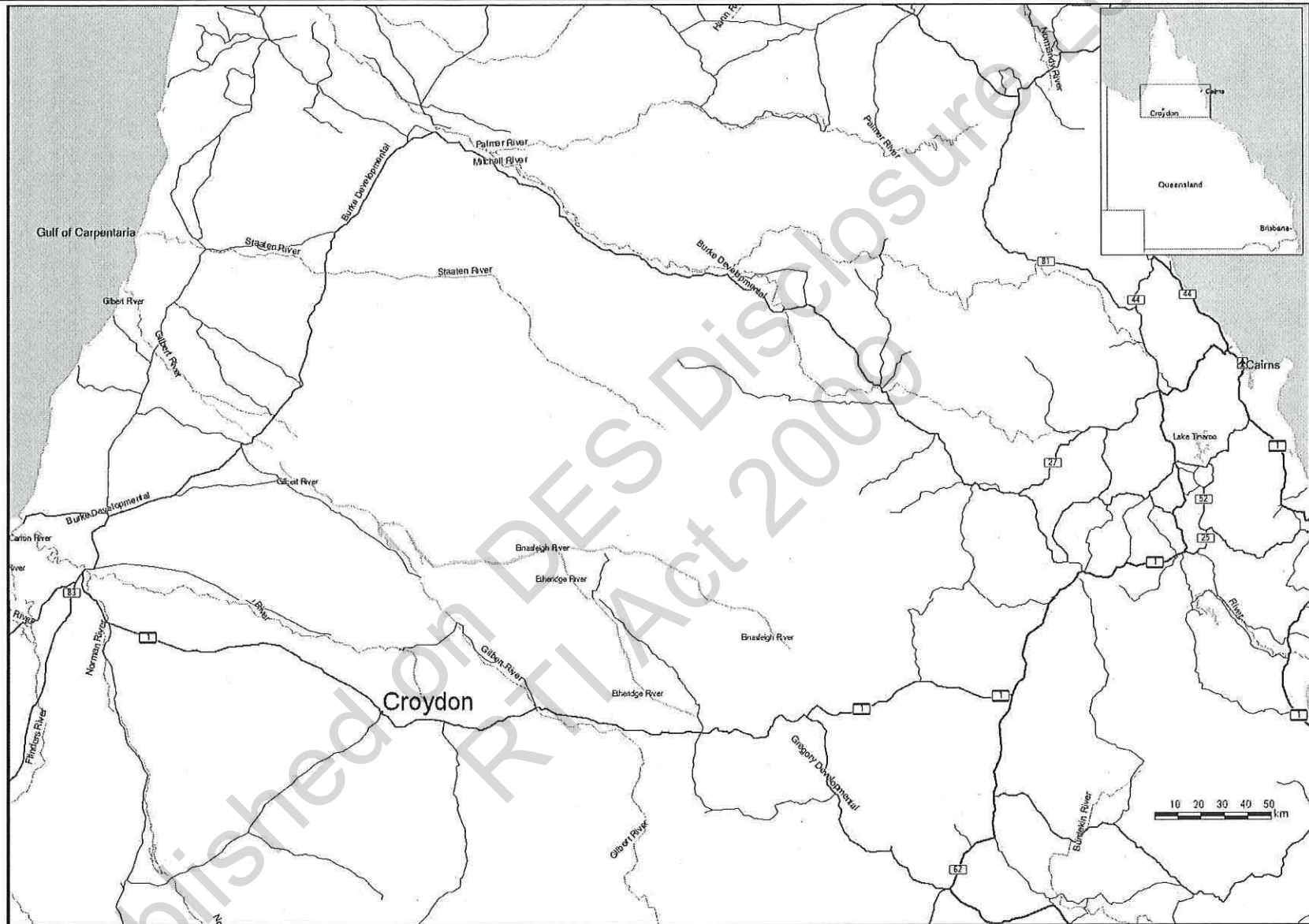


Figure 1: Croydon Site Regional Location Map

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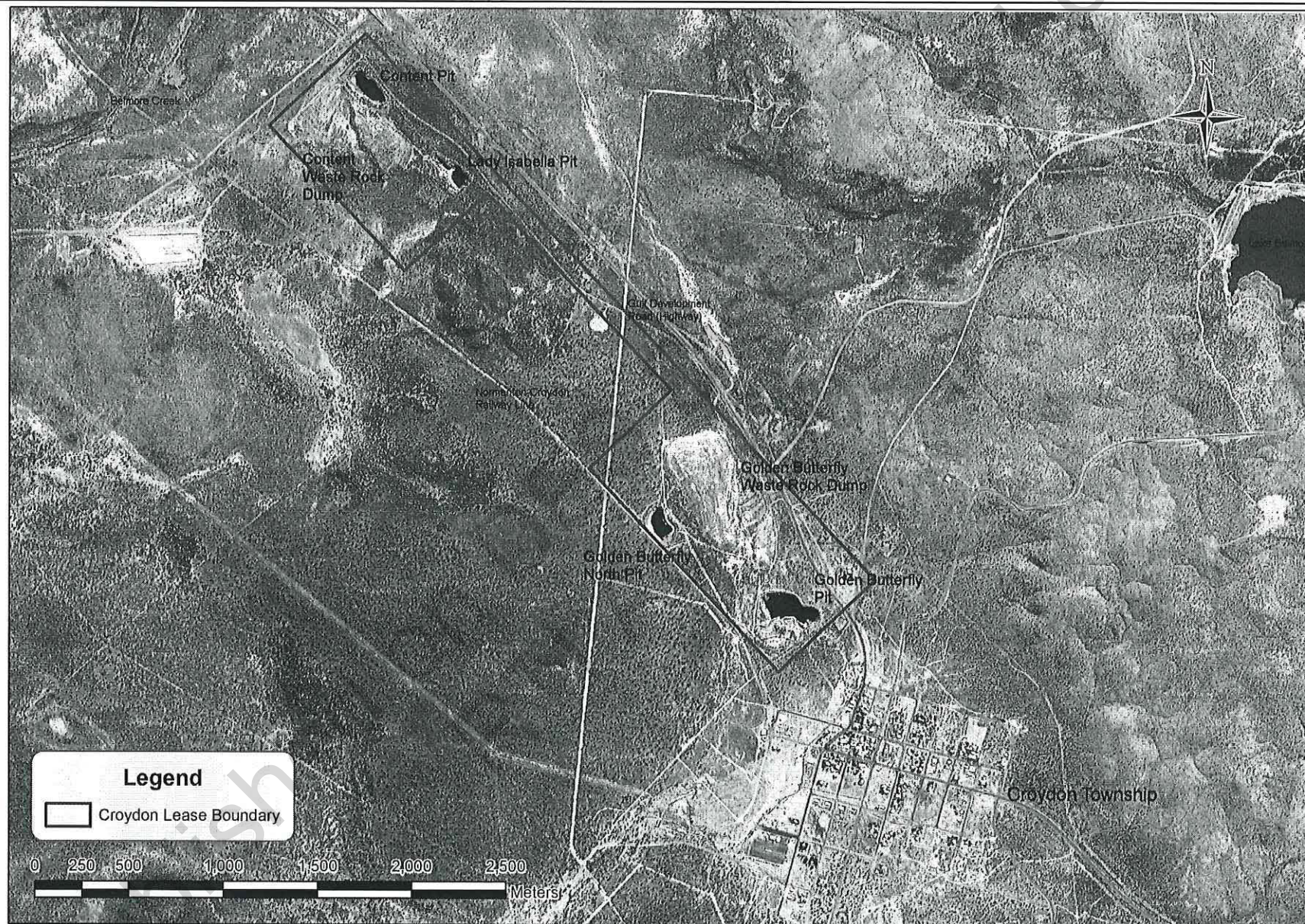


Figure 2: Croydon Site Location Features

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As a result of the works, the water level within the Content Pit was decreased by approximately four metres during November and December 2010 (with a subsequent increase of one meter in the Golden Butterfly Pit).

Since completion of the water transfer works in December 2010 and subsequent to the extraordinary wet season rainfall during the 2010/2011 wet season, monitoring of the pit lake water levels on 23 February 2011 indicated that the storage capacity within the Content Pit had again diminished. In recognition of the diminished storage capacity within the Content Pit since the water transfer works, DEHP was notified on 24 March 2011 of the following points:

- Barrick had completed the approved short-term remediation works to minimise the potential risk of the Content Pit over-topping during the 2010/2011 wet season. The works included transferring water from the Content Pit to the Golden Butterfly Pit.
- Since completion of the works, Barrick has continued undertaking regular monitoring of the pit lake water levels as a component of the additional hydrogeological investigations required in accordance with the EA.
- Observations of the pit lake water levels on 23 February 2011 following the heavy rainfall conditions in Northern Queensland indicated that the remaining freeboard of the Content and Lady Isabella Pits was approximately 1.5 m and 3 m respectively.
- Given the remaining freeboard of these pits, it was considered that should further heavy rainfall be experienced, there is potential for the Content Pit and Lady Isabella Pit to spill during this wet season.
- Water quality monitoring (conducted on 23 February 2011) of the Content and Lady Isabella Pits indicated pH results of 4.59 and 4.10 respectively and electrical conductivity (EC) results of 810 microSiemens per centimetre ($\mu\text{S}/\text{cm}$) and 530 $\mu\text{S}/\text{cm}$ respectively.
- Access to the site to recommence water transfer works was restricted due to the recent heavy rainfall conditions. As a result, Barrick was unable to access the site to undertake similar short-term works to minimise the potential spill risk from the Content Pit.
- Notwithstanding the above, Barrick:
 - continued to undertake regular monitoring of the pit lake water levels and water quality; and
 - continued hydrogeological investigations in accordance with the EA.

Due to inaccessibility of the site during the 2010/2011 wet season, Barrick retained the services of a local resident to visually monitor the site, in particular the pit lake levels. Barrick was informed by the local resident on the 29th March 2011 that the Content Pit was full and surface water outflows from the pit were observed due to the recent heavy rainfall conditions. A Barrick representative visited the site on the 30th March 2011 and confirmed the surface water outflows from the Content Pit and notified the DEHP by telephone as required by EA Conditions A4-1 and A4-2 and began monitoring and sampling as per EA Condition F1-3.

No surface water outflows were recorded from any of the other open pits at the CGM, viz Lady Isabella, Golden Butterfly and Golden Butterfly North open pits during the 2010/2011 wet season. Surface water outflows from the Content Pit ceased on 2 May 2011. Observations also showed that no flow was occurring at the Mine Drainage site or at site DSDi as of 13 April 2011.

Formal written advice regarding the Content Pit surface water outflow was submitted to the DEHP on 14 April 2011. Further follow-up written advice including surface water quality monitoring results undertaken as a result of the Content Pit surface water outflows and results from the April 2011 macroinvertebrate survey report was submitted to the DEHP on 1 August 2011.

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As described in Barrick's follow-up written advice submitted to the DEHP on 1 August 2011, based on the results of the surface water quality monitoring undertaken on-site and at receiving water sites located downstream of the surface water outflows from the Content Pit, Barrick immediately commenced an investigation into the potential for environmental harm as a result of the Content Pit outflow.

The investigation included analysing the results of water quality, stream sediment quality and aquatic habitat condition monitoring undertaken and assessing the potential impacts to surface waters, stream sediment and the aquatic habitat of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow. A summary of the conclusions of the surface water quality, stream sediment quality and aquatic habitat condition assessments is provided below (Barrick, 2011).

Surface Water

Based on the surface water quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no receiving water contaminant limits were exceeded at any of the downstream monitoring sites;
- three of the four toxicity test species showed nil to little effect from the Content Pit surface water;
- based on the toxicity test results and macroinvertebrate survey results, it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek.

Stream Sediment

Based on the stream sediment quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- a comparison of the stream sediment monitoring results from April 2011 and the sediment speciation test results from August 2011 indicate that the quality of the Belmore Creek downstream sediments, and the sediments at site DSDi, are comparable with the quality of Belmore Creek upstream sediments;
- that the upstream results were in fact higher than downstream results.

These results indicate that an alternative source of the parameters measured is present upstream in Belmore Creek.

Aquatic Habitat Condition

Based on the aquatic habitat assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no impact was observed to macroinvertebrate communities or aquatic habitat condition in Belmore Creek;
- although a minor localised impact was observed to macroinvertebrates within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited. Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

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1.2 Long-Term Mitigation Strategy

"The [Content Pit] outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low" (Barrick, 2011). Nevertheless, since the relevant Environmental Authority for Croydon does not permit release of "contaminants" appropriate actions should be instigated to either eliminate future discharges and or further ameliorate possible off-site environmental effects.

All possible surface water inflows have already been diverted from the Croydon pit lakes (other than direct rainfall interception) and groundwater inflows appear to be the major factor in pit lake recharge. In lieu of viable further earthworks responses, the relatively benign nature of water quality within the pit lakes provided the option for in-pit treatment of the pit lake waters, so that in the event of a possible discharge the effect on the receiving environment would be minimal. The proposed water treatment strategy involving dosing the Content Pit and Lady Isabella Pit Lakes with limestone was presented to the DEHP during a meeting held on the 8th November 2012. Upon gaining DEHP approval, the pit lakes were dosed with limestone during late November 2012 raising the pH to above 7 as of the 8th December 2012.

1.3 Purpose of this Report

Clause F1-1 of the Croydon Environmental Authority states "Contaminants must not be released directly or indirectly to any waters". Therefore, despite the fact that limestone dosing of the Content Pit Lake has brought this water to within stock watering guidelines, any future discharge of water from the pit lake would require a repeat of the above discussed investigation in accordance with the ANZEEC (2000) methodology and the various reporting requirements as per the Croydon Environmental Authority.

This report presents information to assist the determination of appropriate discharge criteria to amend the Croydon Environmental Authority to provide for discharges from the Content Pit and Lady Isabella Pit Lakes during flow conditions in the receiving water body Belmore Creek.

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2 Water quality data from 2011 discharge event

Water quality data collected from various sites within the Croydon lease and at possible downstream impact locations including Belmore Creek during the 2011 discharge from the Content Pit, provides useful information to determine appropriate criteria to amend the EA to enable discharges during high flow conditions in the receiving water body Belmore Creek.

As reported in the formal notification of the incident (Barrick, 2011a), an initial series of samples were taken between 30 March 2011 and 1 April 2011 subsequent to the recorded surface water outflows from the Content Pit from various sites (see Figure 3) for the full range of parameters specified in Schedule F Tables 2 and 3 of the EA. In accordance with EA Condition F1-3 weekly sampling was continued from the various sample sites selected to monitor the potential impact of the outflow from Content Pit until the discharge ceased. All analytical laboratory results from these various samples received from ALS Laboratory Services and are reproduced in Table 2.

Analytical Results and Interpretation

The indication from the initial field meter readings was that the recorded surface water outflows from the Content Pit are diluted from flows of rain/surface water. Further, there was no significant difference between the upstream and downstream Belmore Creek sample sites. These hypotheses are supported by the laboratory analytical results from the samples taken between 30 March 2011 and 2 May 2011 (see Table 2). The data for pH, electrical conductivity and sulphate concentration from Table 2 are plotted against sample site and date in Figure 4. Sample sites in Figure 4 are plotted approximately in order starting with the Content Pit discharge moving successively further downstream (see Figure 3 for sample site locations). Similarly, analytical data for the various metals stipulated in the EA Schedule F Table 2 are plotted in Figure 5.

It is clearly evident in Figure 4 that flows of rain/surface water successively dilute the discharge from Content Pit as the flow progressed to the SW5 and then the Mine Drainage sample location. The observed electrical conductivity and sulphate concentration being decreased by more than approximately 50%.

Sample site SW6 is located at a large stock water dam which was physically verified as being isolated from any possible inputs from the Content Pit discharge. Overflow from the stock water dam at SW6 mixes downstream with the drainage line which carries the discharge from the Content Pit, and the result of this mixing is monitored by the sample site "conf". This mixing at sample site "conf" results in pH, electrical conductivity and sulphate concentration at comparable levels to that observed at both the upstream sample locations on Belmore Creek. Further, the observed pH, electrical conductivity and sulphate concentration gives no evidence of a downstream influence in Belmore Creek due to the discharge from the Content Pit. Similar observations and conclusions can be drawn in terms of metal concentrations as depicted by Figure 5.

Figure 8 presents daily rainfall data from the Queensland Bureau of Meteorology Croydon Station for 2011. The last significant daily rainfall was 53.2mm on the 30th March 2011 and 12.4 mm recorded on the 1st April 2011 with no other rainfall being observed for April or May 2011. This rainfall data supports the inference that surface water outflows from the Content Pit are diluted from flows of rain/surface water. Figure 4 shows for both sulphate and electrical conductivity an increasing trend at sample site SW5 from the 30th March 2011 whereas Content Pit water recorded relatively constant values for these two parameters. The cessation of rainfall at the end of March 2011 would have resulted in decreasing surface flows of intercepted rain water reporting over time to the drainage lines that confluence with the discharge from the Content Pit. This combined flow being measured at sample site SW5. This decreasing flow of intercepted rain water over time results in less dilution of the pit discharge flow with the resultant observed increasing trend in sulphate and electrical conductivity at sample site SW5.

The analytical data for samples from the Content Pit collected during the 30th March 2011 to 2nd May 2011 show that the discharged water had a relatively constant concentration of constituents (see Figure 4 and Figure 5). For example, electrical conductivity recorded an average of 772 $\mu\text{S}/\text{cm}$ (range 737 – 789 $\mu\text{S}/\text{cm}$, $n=9$). Since the discharged water from Content Pit is the only input to the SW5 sample site other than surface flow from intercepted rain water as previously argued, it would be expected that concentrations of constituents at sample site SW5 would trend toward a maximum concentration as recorded at Content Pit. Since observed concentrations of metals, sulphate and electrical conductivity at SW5 exceeded the concentrations recorded at Content Pit after approximately the 7th April 2011, this shows that evapoconcentration is a significant contributor to resultant water quality at SW5 after this time.

Physical observation showed there was no flow from the Content Pit at the "Mine Drainage" sample site or flow from the "Conf" sample site to Belmore Creek as from the 13th April 2011. The discharge flow rate from the Content Pit was estimated using the "velocity area" method (see Table 3 and Figure 6) which by the 13th April 2011 had decreased to approximately 3 L/s. Therefore, the approximately 3 L/s discharge rate was being assimilated by infiltration and or evaporation prior to reaching the "Mine Drainage" sample site.

The elevated pH of 6.88 at the "Mine Drainage" site recorded on the 13th April 2011 compared to prior results for pH at this site (average 5.15, range 4.9 – 5.56, $n=6$) also indicates that un-contaminated flow from SW6 predominated input at the "Conf" sample site during this time (which back flowed along the channel connecting the "Conf" site to the "Mine Drainage" site). Coincident to the elevated pH on the 13th April 2011 at the "Mine Drainage" site, sulphate concentration and electrical conductivity decreased to values compared to that observed for SW6. Again, this confirms that un-contaminated flow from SW6 dominated input to the "Conf" site at the time. Flow from SW6 during the earlier period in the monitoring record (see Figure 4) diluted input from the "Mine Drainage" site by approximately 50% as by the observed decrease in electrical conductivity and sulphate concentration.

The resultant flow from the "Conf" site had concentrations of constituents with comparable levels to that observed upstream of the confluence with Belmore Creek. Analytical results obtained from the upstream and downstream sites of the confluence of the drainage from the "Conf" site on Belmore Creek show no significant difference.

The analytical results for the various metals conform to the prior interpretation of successively greater serial dilution as the flow from the Content Pit moved down stream and the effect of evapoconcentration at SW5. However, there appears another source of copper, zinc and aluminium at SW5 as these metals have higher concentrations than that observed from samples taken from the Content Pit. There were no other obvious input streams to SW5 however there are a number of historical gold mining workings in close vicinity. A tentative explanation is that the material from which the dam at SW5 is constructed contains elevated concentrations of metals.

The clayey material (potentially dispersive clayey material) from which both SW5 and SW6 dams are constructed also likely explains the elevated aluminium concentrations observed. Samples are field filtered using 0.45 μm disc filters to provide "filterable" metals which are operationally equated with the soluble fraction (as required by the EA). However, colloids containing aluminium also pass the 0.45 μm filter which after acid digestion in the laboratory report to the "soluble" metal analysis. Therefore, the reported aluminium concentrations are not likely solely the "soluble" concentration but have a contribution from the colloidal fraction.

Indicator for Receiving Stream Flow Criterion

During the period of the discharge of the Content Pit in 2011 environmental monitoring performed showed no discernible impact on Belmore Creek (see Section **Error! Reference source not found.**). Therefore, observed water quality results would provide an indication of the dilution levels required by using pit water quality compared to downstream sites. Suitable indicators would optimally be exclusively present in the pit lake water and behave conservatively upon mixing. The concentration of a conservative constituent is not significantly affected by chemical or biological reactions, responding as a simple ratio of concentrations upon mixing with another solution.

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Sulfate is present at elevated concentrations in Content Pit Lake water due to oxidation of sulfidic materials (mean 306 mg/l, range 300-316 mg/l, n=9; Table 2). Whereas, Belmore Creek upstream of the discharge input point (site "Belmore u/s" in Table 2) has a low sulfate concentration (mean 4.2 mg/l, range 2-8 mg/l, n=9; Table 2). Sulfate is a stable, oxidized form of sulfur (in oxygenated surface waters such as Belmore Creek) and is readily soluble in water with the exception of lead, barium and strontium which are not present in Belmore Creek and or Content Pit Lake water (Chapman, 1992, p86). Therefore, sulfate can be considered to be a conservative constituent within Belmore Creek surface waters and used to provide an indication of dilution factors that occurred during the 2011 Content Pit discharge.

Belmore Creek downstream of the discharge input point (site "Belmore d/s" in Table 2) had an observed sulfate concentration of mean 4.3 mg/l, range 2-8 mg/l, n=9; Table 2). This shows both that the Content Pit discharge did not appreciably affect the Belmore Creek sulfate concentration and that a minimum dilution in the order of 100 times was achieved.

3 Toxicity Testing of Content Pit Lake Water

In accordance with the ANZECC and ARMCANZ (2000) *Simplified decision tree for assessing toxicants in ambient waters*, Barrick initiated a biological effects assessment (i.e. toxicity testing) of water samples from the Content Pit to investigate the potential risk to receiving waters (Barrick, 2011).

The following five fresh water aquatic toxicity tests were conducted for samples of Content Pit water:

1. 48 hour acute (immobilisation) test using the freshwater cladoceran *Ceriodaphnia dubia*.
2. Partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*.
3. 48 hour acute toxicity test using the freshwater chironomid *Chironomus tepperi*.
4. 96 hour acute toxicity test with the freshwater shrimp *Marcobrachium australiense*.
5. 7 day growth inhibition test using a freshwater aquatic duckweed *Lemna diasperra*.

Interpretation of the Content Pit toxicity test results has been undertaken by Associate Professor Barry Noller of the University of Queensland (Barrick, 2011). In summary, three of the four species showed nil to little response to the pit water. The freshwater cladoceran *Ceriodaphnia dubia* was the most sensitive of the test species to the Content Pit water.

Professor Noller indicated that in accordance with ANZECC and ARMCANZ (2000) guidelines, the safe dilution of Content Pit water so that there would be no observed effect would be 100 times the NOEC (i.e. no observed effect concentration) value for the most sensitive test species (i.e. 3.1%). No acute or chronic effects would likely occur at this dilution.

4 Flow Regime of Belmore Creek

Figure 9 presents a photograph of Belmore Creek at the sample site "Belmore d/s" during March 2011. This shows that Belmore Creek during wet season peak flows is in the order of 100m wide with an average depth of greater than 2 meters.

Lake Belmore, the freshwater supply for Croydon, was constructed upstream of the lease area during the mid 1990's and perhaps construction literature for this project provides stream gauging data.

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5 Conclusion

"The [Content Pit] outflow event [which occurred in 2011] is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low" (Barrick, 2011). This is due in part to the relatively benign nature of the Content Pit water quality and the large dilutions achieved within the receiving water bodies.

Nevertheless, since the relevant Environmental Authority for Croydon does not permit release of "contaminants" appropriate actions should be instigated to either eliminate future discharges and or further ameliorate possible off-site environmental effects. All possible surface water inflows have already been diverted from the Croydon pit lakes (other than direct rainfall interception) and groundwater inflows appear to be the major factor in pit lake recharge. In lieu of viable further earthworks responses, the existing relatively benign nature of water quality within the pit lakes enabled the option for in-pit treatment of the pit lake waters with limestone to raise the pH to within stock watering guidelines. Therefore, in the event of a possible future discharge from the Content Pit the effect on the receiving environment would be minimal.

Clause F1-1 of the Croydon Environmental Authority states "Contaminants must not be released directly or indirectly to any waters". Therefore, despite the fact that limestone dosing of the Content Pit Lake has brought this water to within stock watering guidelines, any future discharge of water from the pit lake would still trigger environmental sampling and an investigation in accordance with the ANZECC (2000) methodology as per the existing Croydon Environmental Authority.

This report presents information to support the determination of appropriate discharge criteria to amend the Croydon Environmental Authority to provide for discharges from the Content Pit and Lady Isabella Pit Lakes during flow conditions in the receiving water body Belmore Creek.

6 REFERENCES

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APPENDIX 1

SURFACE WATER QUALITY MONITORING RESULTS AND FIGURES

Table 1: Summary of Surface Water Quality Data from 30th March to 2nd May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Belmore Creek EA Upstream Sites																	
SW7	Maximum	7.19	153	0.2	47	40	1.53	0.013	0.05	0.0001	0.002	0.001	0.002	0.0001	0.003	0.01	0.005
	Minimum	6.63	25	0.1	1	20	0.25	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.92	83.43	0.14	17.29	29.10	0.87	0.01	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.93	102	0.1	20	25.1	0.85	0.004	0.05	0.0001	0.001	0.001	0.002	0.0001	0.002	0.01	0.005
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
SW6	Maximum	6.99	40	0.1	1	120	4.82	0.002	0.05	0.0001	0.002	0.001	0.002	0.0001	0.002	0.01	0.005
	Minimum	6.8	32	0.1	1	83.2	2.13	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.90	36.00	0.10	1.00	101.6	3.48	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.895	36	0.1	1	101.6	3.46	0.002	0.05	0.0001	0.0015	0.001	0.0015	0.0001	0.0015	0.01	0.005
	No. of samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Additional Belmore Creek Upstream Site																	
Belmore Creek U/S	Maximum	7.21	65	0.2	8	29.7	1.28	0.016	0.05	0.0001	0.003	0.001	0.002	0.0001	0.002	0.01	0.007
	Minimum	6.73	33	0.1	2	9.7	0.04	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.97	41.44	0.11	4.22	22.39	0.62	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.95	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

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Table 1 (Continued): Summary of Surface Water Quality Data from 30th March to 2nd May 2011

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L) (total)	Zn (mg/L)
Additional Belmore Creek Upstream Sites																	
Belmore Creek Upstream	BCUS1 (Sample 1)	7.16	31	0.1	1	24	0.76	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 2)	7.02	39	0.1	4	26	0.64	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 3)	6.94	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.003	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 4)	6.94	39	0.1	3	25	0.52	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS2	7.05	34	0.2	1	23	0.54	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.007
	BCUS3	7.14	37	0.1	3	24	0.25	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

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Table 1 (Continued): Summary of Surface Water Quality Data from 30th March to 2nd May 2011

Site	Category	pH	EC (μ S/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
On-Site Waters																	
Content Pit	Maximum	4.2	789	1.5	316	90	1.62	0.009	0.05	0.0025	0.002	0.112	0.062	0.0001	0.103	0.01	0.279
	Minimum	3.91	737	1.1	300	0.8	1.31	0.004	0.05	0.0021	0.001	0.09	0.056	0.0001	0.087	0.01	0.229
	Average	4.08	772	1.3	307	12.5	1.45	0.006	0.05	0.0023	0.001	0.100	0.059	0.0001	0.096	0.01	0.254
	Median	4.11	781	1.3	304	3	1.38	0.006	0.05	0.0022	0.001	0.101	0.059	0.0001	0.097	0.01	0.259
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
SW5	Maximum	4.38	1,130	2.5	491	11	14.9	0.004	0.05	0.0244	0.002	0.234	0.593	0.0001	0.22	0.01	0.959
	Minimum	3.75	428	1	160	0.8	3.9	0.003	0.05	0.0091	0.001	0.089	0.195	0.0001	0.082	0.01	0.385
	Average	3.93	734	1.66	305	3.44	8.45	0.0037	0.05	0.0158	0.0012	0.153	0.387	0.0001	0.147	0.01	0.642
	Median	3.9	757	1.7	311	2	8.89	0.004	0.05	0.0156	0.001	0.16	0.396	0.0001	0.152	0.01	0.662
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
EA Contaminant Limit ³		4-9	5,970	2	1,000	4,000 (TDS)	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

³ On-site Water Contaminant Limit as defined in Schedule F-Table 8 of the EA.

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Table 1 (Continued): Summary of Surface Water Quality Data from 30th March to 2nd May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Surface Water Outflow Pathway Sites																	
Mine Drainage	Maximum	6.88	354	0.8	130	110	1.74	0.003	0.05	0.0032	0.001	0.071	0.035	0.0001	0.047	0.01	0.158
	Minimum	4.9	71	0.3	17	1	0.37	0.002	0.05	0.0001	0.001	0.001	0.008	0.0001	0.003	0.01	0.005
	Average	5.40	237	0.57	84	19.8	0.90	0.0024	0.05	0.0024	0.001	0.0444	0.0263	0.0001	0.033	0.01	0.118
	Median	5.17	236	0.6	80	6	0.71	0.002	0.05	0.0028	0.001	0.041	0.029	0.0001	0.036	0.01	0.142
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
DSDi	Maximum	6.83	185	0.4	64	110	2.42	0.004	0.05	0.0007	0.002	0.018	0.02	0.0001	0.013	0.01	0.037
	Minimum	6.2	60	0.1	13	44.2	0.28	0.001	0.05	0.0001	0.001	0.001	0.004	0.0001	0.002	0.01	0.005
	Average	6.58	103.6	0.26	30	74.21	1.54	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02
	Median	6.64	86	0.25	21.5	75	1.66	0.002	0.05	0.00055	0.001	0.008	0.008	0.0001	0.008	0.01	0.025
	No. of samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Belmore Creek D/S	Maximum	7.27	66	0.2	8	35	2.1	0.019	0.05	0.0003	0.002	0.002	0.004	0.0001	0.003	0.01	0.011
	Minimum	6.58	32	0.1	2	8.9	0.08	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.93	42.44	0.12	4.33	22.36	0.71	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.97	39	0.1	4	22.3	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ⁴		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁵		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁴ Receiving Water Trigger Levels – EA Schedule F Table 2.⁵ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Rele

Table 1 (Continued): Summary of Surface Water Quality Data from 30th March to 2nd May 2011

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Additional Belmore Creek Downstream Sites																	
Belmore Creek Downstream	BCDS1 (Sample 1)	6.97	38	0.1	3	28	0.14	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 2)	6.94	40	0.2	4	23	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 3)	6.98	39	0.1	3	23	0.19	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS2	7.02	38	0.1	3	25	0.44	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS3	7.05	39	0.1	3	23	0.41	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS4	7.05	39	0.1	3	23	0.19	0.009	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ⁶		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.001 4	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁷		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁶ Receiving Water Trigger Levels – EA Schedule F Table 2.⁷ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

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Table 2: Analytical Data for Water Sampling During Content Pit Discharge

Sample Site	Sample Date	pH	EC µS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Content Pit	30/03/2011	3.91	782	0.8	300	1.37	0.004	0.0024	0.095	0.059	0.091	0.242	<0.05	<0.01	<0.0001	0.002	1.2
Content Pit	31/03/2011	3.96	740	0.8	303	1.36	0.004	0.0022	0.093	0.057	0.089	0.235	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	1/04/2011	3.98	737	1.2	301	1.38	0.005	0.0021	0.090	0.056	0.087	0.229	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	5/04/2011	4.11	781	2.1	304	1.62	0.009	0.0023	0.103	0.062	0.099	0.266	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	6/04/2011	4.11	778	3.0	304	1.55	0.008	0.0023	0.104	0.061	0.1	0.27	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	7/04/2011	4.19	783	5.8	309	1.51	0.006	0.0022	0.104	0.062	0.101	0.261	<0.05	<0.01	<0.0001	<0.001	1.5
Content Pit	13/04/2011	4.13	770	90	316	1.34	0.006	0.0021	0.101	0.057	0.096	0.244	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	21/04/2011	4.2	784	4.3	310	1.31	0.007	0.0022	0.112	0.056	0.103	0.259	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	2/05/2011	4.13	789	4.4	312	1.62	0.009	0.0025	0.101	0.061	0.097	0.279	<0.05	<0.01	<0.0001	0.002	1.4
Mine Drainage	30/03/2011	5.11	236	1.1	75	0.71	0.002	0.0032	0.041	0.030	0.036	0.142	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	31/03/2011	5.19	192	1.0	80	0.69	0.002	0.0032	0.040	0.029	0.035	0.143	<0.05	<0.01	<0.0001	0.001	0.5
Mine Drainage	1/04/2011	5.56	168	5.3	56	0.37	0.002	0.0028	0.029	0.025	0.027	0.115	<0.05	<0.01	<0.0001	0.001	0.4
Mine Drainage	5/04/2011	5.17	334	7.4	122	1.01	0.003	0.0026	0.066	0.034	0.047	0.158	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	6/04/2011	4.9	354	7.7	130	1.14	0.003	0.0028	0.071	0.035	0.047	0.152	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	7/04/2011	4.97	301	6	108	0.63	0.002	0.0019	0.063	0.023	0.036	0.111	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	13/04/2011	6.88	71	110	17	1.74	0.003	0.0001	0.001	0.008	0.003	0.005	<0.05	<0.01	<0.0001	0.001	0.3
Conf	30/03/2011	6.82	88	44.2	20	2.02	0.002	0.0007	0.009	0.020	0.009	0.028	<0.05	<0.01	<0.0001	0.002	0.2
Conf	31/03/2011	6.74	68	44.9	20	2.42	0.002	0.0006	0.009	0.008	0.009	0.029	<0.05	<0.01	<0.0001	0.001	0.2
Conf	1/04/2011	6.83	60	54.6	13	2.24	0.002	0.0005	0.007	0.007	0.007	0.026	<0.05	<0.01	<0.0001	0.002	0.1
Conf	5/04/2011	6.2	185	65	64	0.28	0.001	0.0007	0.018	0.008	0.013	0.037	<0.05	<0.01	<0.0001	0.001	0.4
Conf	6/04/2011	6.34	156	90	48	0.99	0.002	0.0006	0.012	0.006	0.01	0.024	<0.05	<0.01	<0.0001	0.001	0.4
Conf	7/04/2011	6.54	116	85	32	1.45	0.001	0.0003	0.006	0.004	0.005	0.01	<0.05	<0.01	<0.0001	0.001	0.3
Conf	13/04/2011	6.78	84	100	23	1.87	0.002	0.0001	0.001	0.011	0.004	0.005	<0.05	<0.01	<0.0001	0.001	0.3

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Sample Site	Sample Date	pH	EC µS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Conf	21/04/2011	6.35	72	110	20	1.04	0.004	0.0001	0.001	0.01	0.002	0.005	<0.05	<0.01	<0.0001	0.001	0.2
SW5	30/03/2011	3.81	428	1.2	160	4.83	0.003	0.0137	0.089	0.278	0.093	0.492	<0.05	<0.01	<0.0001	0.001	1.0
SW5	31/03/2011	3.96	565	0.8	239	4.61	0.003	0.0113	0.106	0.232	0.103	0.478	<0.05	<0.01	<0.0001	0.002	1.2
SW5	1/04/2011	3.99	462	1.5	176	3.90	0.003	0.0091	0.089	0.195	0.082	0.385	<0.05	<0.01	<0.0001	0.002	1.0
SW5	5/04/2011	3.9	730	2	301	9.31	0.004	0.0167	0.156	0.425	0.152	0.692	<0.05	<0.01	<0.0001	0.001	1.7
SW5	6/04/2011	3.89	757	3.9	311	8.46	0.004	0.0156	0.16	0.396	0.148	0.654	<0.05	<0.01	<0.0001	0.001	1.7
SW5	7/04/2011	3.92	778	11	322	8.89	0.004	0.0154	0.164	0.395	0.157	0.662	<0.05	<0.01	<0.0001	0.001	1.7
SW5	13/04/2011	3.79	853	2	363	9.79	0.004	0.0164	0.179	0.433	0.177	0.688	<0.05	<0.01	<0.0001	0.001	2
SW5	21/04/2011	4.38	904	4.9	385	11.4	0.004	0.0192	0.202	0.534	0.19	0.771	<0.05	<0.01	<0.0001	0.001	2.1
SW5	2/05/2011	3.75	1130	3.7	491	14.9	0.004	0.0244	0.234	0.593	0.22	0.959	<0.05	<0.01	<0.0001	0.001	2.5
SW7	30/03/2011	6.93	102	37.3	24	1.23	0.004	<0.0001	0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	31/03/2011	6.63	102	35.3	23	1.53	0.004	<0.0001	<0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	1/04/2011	6.77	102	25.1	20	1.23	0.004	<0.0001	0.001	0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW7	6/04/2011	6.97	153	40	47	0.85	0.002	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.2
SW7	13/04/2011	7.19	32	20	1	0.7	0.01	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	21/04/2011	6.92	25	22	2	0.29	0.011	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	2/05/2011	7.06	68	24	4	0.25	0.013	<0.0001	<0.001	<0.001	<0.001	0.005	0.05	0.01	<0.0001	0.001	0.1
Belmore u/s	30/03/2011	6.83	37	22.6	2	1.28	0.005	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore u/s	31/03/2011	6.73	39	27.5	2	1.15	0.004	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	<0.1
Belmore u/s	1/04/2011	6.95	40	29.7	4	1.14	0.005	<0.0001	0.001	0.002	0.002	0.007	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore u/s	5/04/2011	7.02	39	26	4	0.64	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore u/s	6/04/2011	6.94	39	25	4	0.56	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.003	0.1
Belmore u/s	7/04/2011	6.94	39	25	3	0.52	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore u/s	13/04/2011	7.11	42	21	4	0.16	0.016	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore u/s	21/04/2011	7	33	15	7	0.04	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore u/s	2/05/2011	7.21	65	9.7	8	0.08	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.002	0.1

Release

Sample Site	Sample Date	pH	EC µS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Belmore d/s	30/03/2011	7.05	38	22.3	2	1.24	0.004	<0.0001	<0.001	0.004	0.001	0.005	<0.05	<0.01	<0.0001	0.001	<0.1
Belmore d/s	31/03/2011	6.58	38	22.0	2	1.51	0.005	<0.0001	0.001	0.002	0.001	0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore d/s	1/04/2011	6.77	50	35.0	7	2.10	0.004	0.0003	0.002	0.004	0.003	0.011	<0.05	<0.01	<0.0001	0.002	0.1
Belmore d/s	5/04/2011	6.97	38	28	3	0.14	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore d/s	6/04/2011	6.94	40	23	4	0.45	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore d/s	7/04/2011	6.98	39	23	3	0.19	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore d/s	13/04/2011	7.06	41	21	4	0.53	0.019	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore d/s	21/04/2011	6.75	32	18	6	0.11	0.012	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore d/s	2/05/2011	7.27	66	8.9	8	0.08	0.009	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
SW6	30/03/2011	6.99	40	83.2	<1	4.82	0.002	<0.0001	<0.001	0.002	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW6	5/04/2011	6.8	32	120	1	2.13	0.002	<0.0001	<0.001	<0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.001	0.1

Table 3: Content Pit Discharge Estimated Flow Rate

Date	time (secs) for 5m	width (m)	depth (m)	flow rate m3/s	flow rate L/s
5/04/2011 6:00	17.5	0.75	0.05	0.011	10.7
5/04/2011 18:00	16.5	0.7	0.05	0.011	10.6
6/04/2011 7:00	18	0.7	0.05	0.010	9.7
6/04/2011 18:00	19	0.7	0.05	0.009	9.2
13/04/2011 15:30	25	0.5	0.03	0.003	3.0
21/04/2011 16:00	50	0.4	0.02	0.001	0.8
2/05/2001	No discharge				

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Figure 3: Sample Site Locations

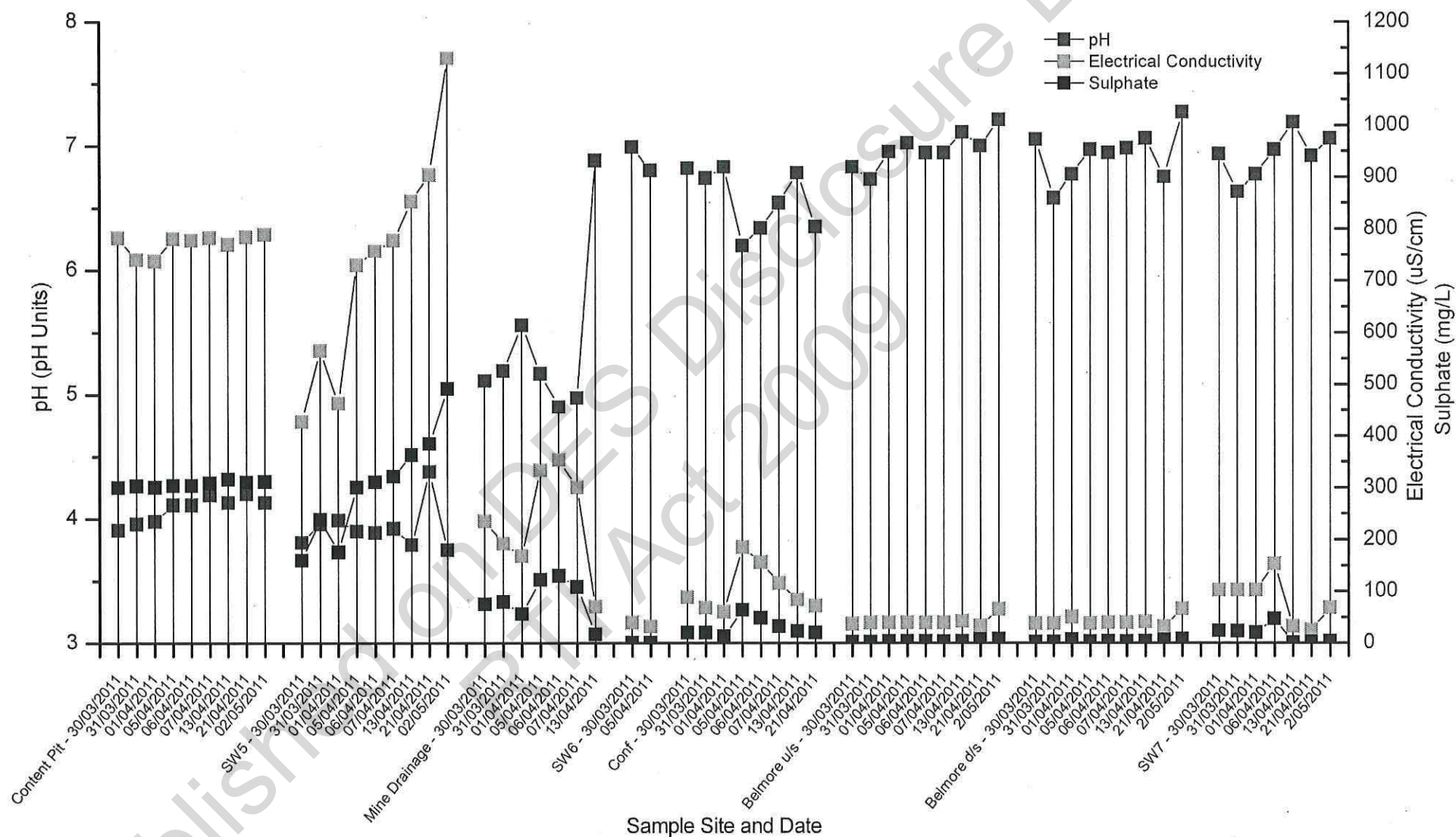


Figure 4: Sample Site and Date versus pH, Electrical Conductivity and Sulfate

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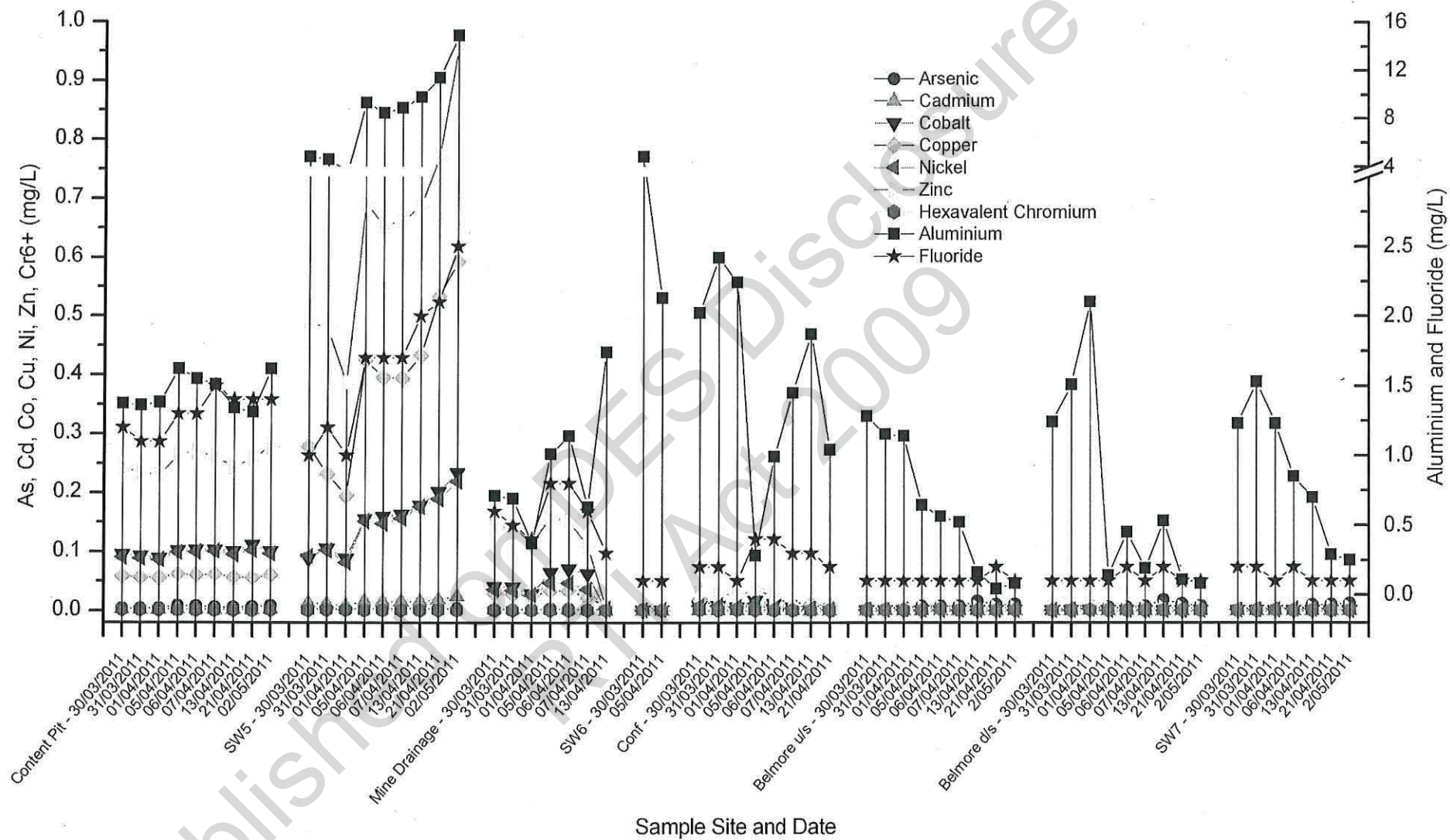


Figure 5: Sample Site and Date versus Metal Concentrations



CROYDON GOLD MINE
ENVIRONMENTAL INVESTIGATION

NOVEMBER 2011
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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1
1.1 BACKGROUND	1
1.2 PURPOSE AND SCOPE OF THIS REPORT	5
1.3 REPORT STRUCTURE	5
2 RELEVANT ENVIRONMENTAL VALUES	6
2.1 SURFACE WATER	6
2.2 STREAM SEDIMENT	10
2.3 AQUATIC HABITAT CONDITION	10
3 ADDITIONAL MONITORING PROGRAMME CONDUCTED IN RESPONSE TO CONTENT PIT SURFACE WATER OUTFLOW	12
4 RESULTS OF MONITORING PROGRAMME AND ASSESSMENT OF POTENTIAL IMPACTS	14
4.1 SURFACE WATER	14
4.1.1 Assessment of Potential Impact	16
4.2 STREAM SEDIMENT	19
4.2.1 Assessment of Potential Impact	21
4.3 AQUATIC HABITAT CONDITION	24
4.3.1 Assessment of Potential Impact	24
5 CONCLUSION	26
6 REFERENCES	28

LIST OF TABLES

Table 1	Summary of Surface Water Quality Results Recorded at Upstream Site SW7 Since January 2009
Table 2	Summary of Surface Water Quality Results Recorded at Upstream Site SW6 Since January 1999
Table 3	Summary of Content Pit Surface Water Quality Results (1994 – 2011)
Table 4	Summary of Additional Monitoring Programme
Table 5	Comparison of Surface Water Quality Results Against Relevant EA Trigger Levels and Contaminant Limits
Table 6	Comparison of Stream Sediment Results Against Relevant EA Trigger Levels and Contaminant Limits
Table 7	Summary of Sediment Speciation (1 M Hydrochloric Extract) Test Results

TABLE OF CONTENTS (continued)

LIST OF FIGURES

- Figure 1 Regional Location
- Figure 2 Location of Monitoring Sites and Content Pit Surface Water Outflow Pathway
- Figure 3 Simplified Decision Tree for Assessing Toxicants in Ambient Waters
- Figure 4 Decision Tree for the Assessment of Contaminated Sediments

LIST OF ATTACHMENTS

- Attachment 1 Surface Water Monitoring Results
- Attachment 2 Stream Sediment Monitoring Results

LIST OF APPENDICES

- Appendix A Croydon Gold Mine Macroinvertebrate Survey April 2011
- Appendix B Summary Interpretation of Content Pit Water Toxicity Results

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1 INTRODUCTION

The Croydon Gold Mine (the CGM) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The CGM was formerly a low-grade gold mine and has since been closed and decommissioned. Activities at the CGM include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Australia Pacific Limited (Barrick) in 2005. Barrick holds Environmental Authority (EA) No. MIN100401906 for the CGM.

1.1 BACKGROUND

General

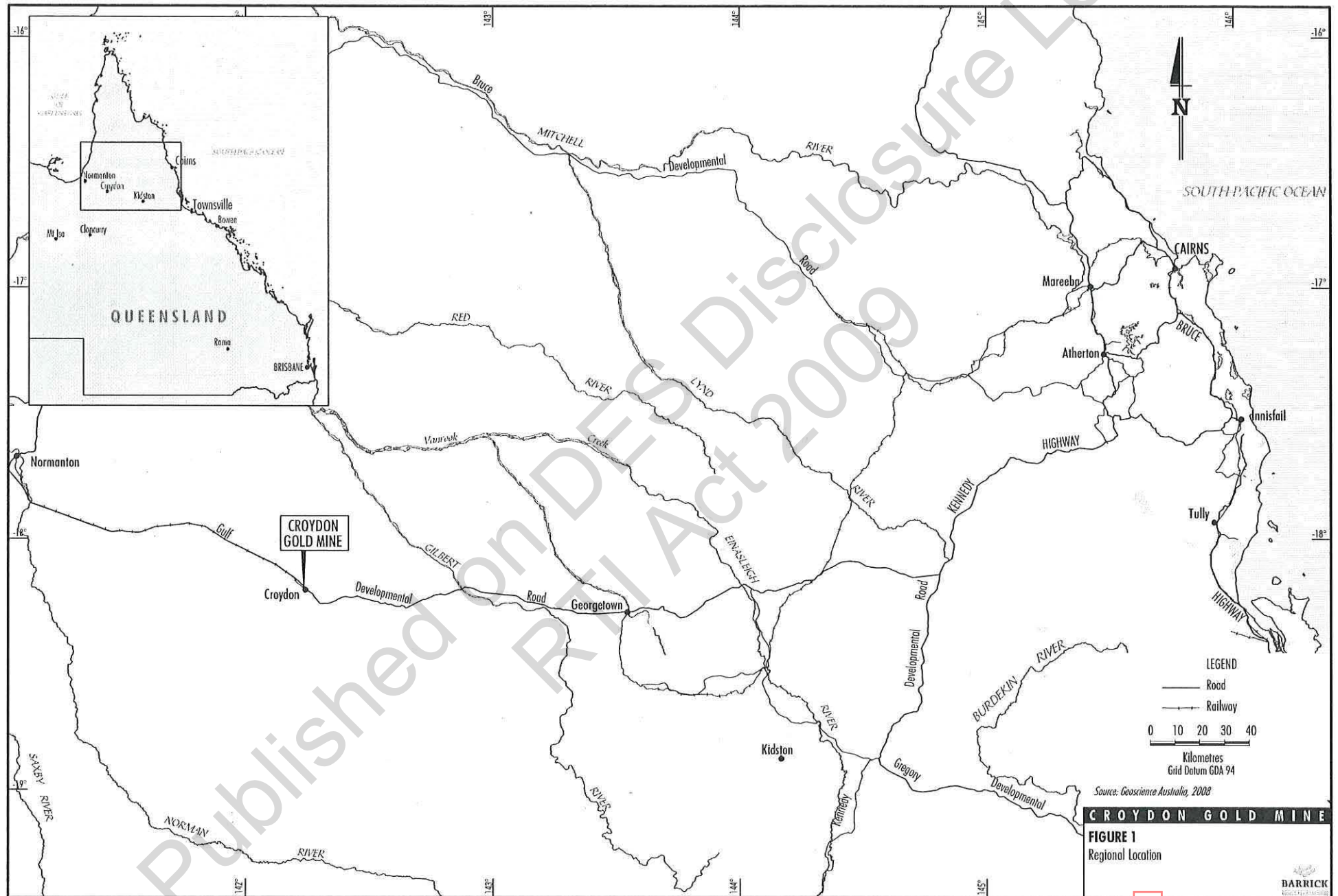
Extensive gold mining at the CGM commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the CGM was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/1997 and significant additional reclamation works were subsequently undertaken (Barrick, 2008).

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps. Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

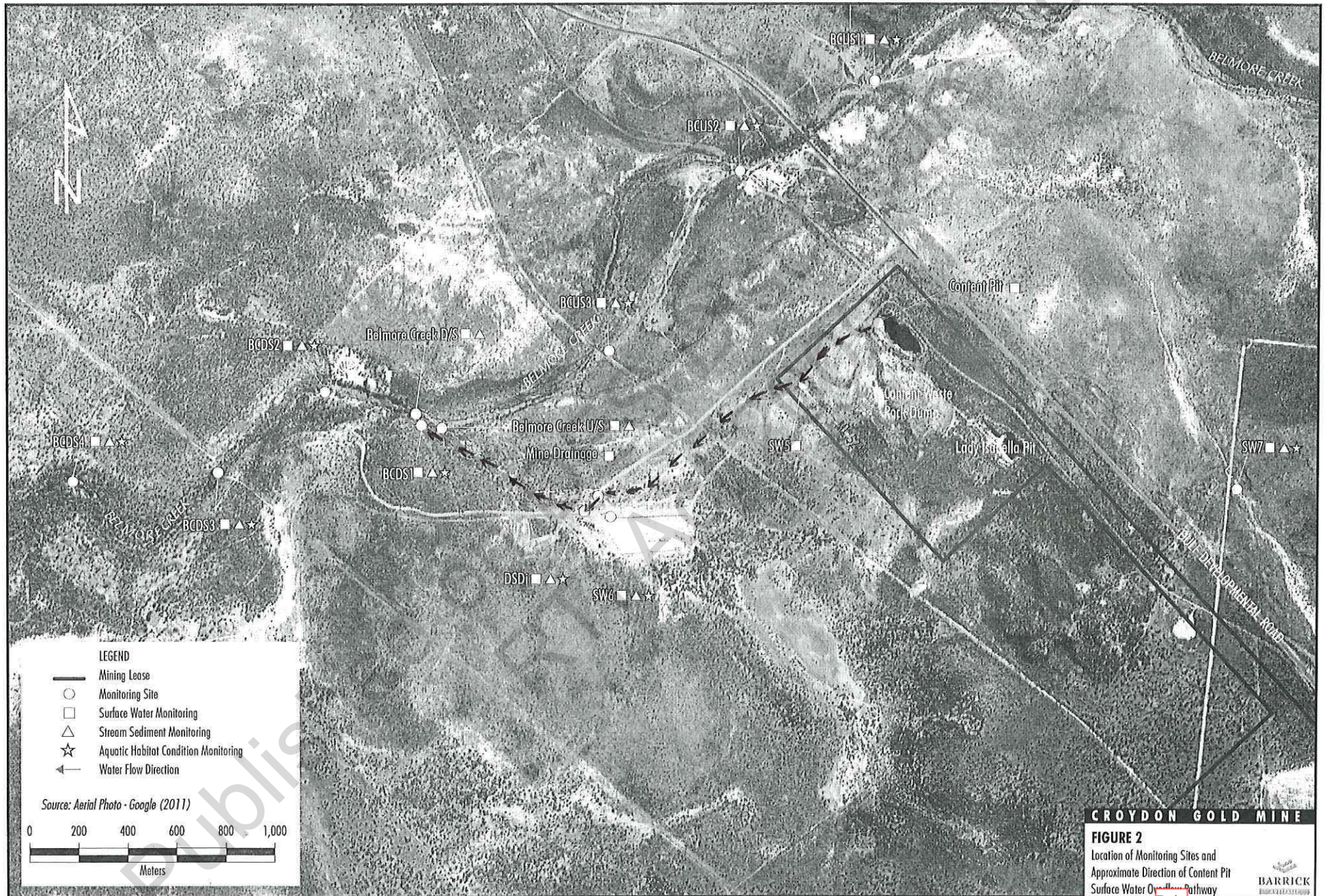
Background to Content Pit Surface Water Outflow

The 2008 and 2009 annual rainfall totals (i.e. 978 millimetres [mm] and 1,262 mm, respectively) recorded at the nearest Commonwealth Bureau of Meteorology (BOM) station (Croydon Township - station 029012) were above the average annual rainfall recorded over the past 123 years (i.e. 748.4 mm) (BOM, 2011). The 2010/2011 wet season in the Croydon area was characterised by extraordinary rainfall totals (Section 2.1). In recognition of the diminishing storage capacity within the Content Pit, Barrick was granted approval by the Department of Environment and Resource Management (DERM) on 23 September 2010 to undertake short-term remediation works involving the transfer of water from the Content Pit to the Golden Butterfly Pit to increase the storage capacity of the Content Pit.



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As a result of the works, the water level within the Content Pit was decreased by approximately four metres (m) during November and December 2010 (with a subsequent increase of one meter in the Golden Butterfly Pit).

Since completion of the water transfer works in December 2010 and subsequent to the extraordinary wet season rainfall during the 2010/2011 wet season, monitoring of the pit lake water levels on 23 February 2011 indicated that the storage capacity within the Content Pit had again diminished. In recognition of the diminished storage capacity within the Content Pit since the water transfer works, DERM was notified by phone on 24 March 2011 of the following points:

- Barrick had completed the approved short-term remediation works to minimise the potential risk of the Content Pit over-topping during the 2010/2011 wet season. The works included transferring water from the Content Pit to the Golden Butterfly Pit.
- Since completion of the works, Barrick has continued undertaking regular monitoring of the pit lake water levels as a component of the additional hydrogeological investigations required in accordance with the EA.
- Observations of the pit lake water levels on 23 February 2011 following the heavy rainfall conditions in Northern Queensland indicated that the remaining freeboard of the Content and Lady Isabella Pits was approximately 1.5 m and 3 m respectively.
- Given the remaining freeboard of these pits, it was considered that should further heavy rainfall be experienced, there is potential for the Content Pit and Lady Isabella Pit to spill during this wet season.
- Water quality monitoring (conducted on 23 February 2011) of the Content and Lady Isabella Pits indicated pH results of 4.59 and 4.10 respectively and electrical conductivity (EC) results of 810 microSiemens per centimetre ($\mu\text{S}/\text{cm}$) and 530 $\mu\text{S}/\text{cm}$ respectively.
- Access to the site to recommence water transfer works was restricted due to the recent heavy rainfall conditions. As a result, Barrick was unable to access the site to undertake similar short-term works to minimise the potential spill risk from the Content Pit.
- Notwithstanding the above, Barrick:
 - continued to undertake regular monitoring of the pit lake water levels and water quality; and
 - continued hydrogeological investigations in accordance with the EA.

Due to inaccessibility of the site during the 2010/2011 wet season, Barrick retained the services of a local resident to visually monitor the site, in particular the pit lake levels. Barrick was informed by the local resident on the 29th March 2011 that the Content Pit was full and surface water outflows from the pit were observed due to the recent heavy rainfall conditions. A Barrick representative visited the site on the 30th March 2011 and confirmed the surface water outflows from the Content Pit and notified the DERM by telephone as required by EA Conditions A4-1 and A4-2 and began monitoring and sampling as per EA Condition F1-3.

No surface water outflows were recorded from any of the other open pits at the CGM, viz Lady Isabella, Golden Butterfly and Golden Butterfly North open pits during the 2010/2011 wet season. Surface water outflows from the Content Pit ceased on 2 May 2011. Observations also showed that no flow was occurring at the Mine Drainage site or at site DSDi as of 13 April 2011 (Figure 2).

Formal written advice regarding the Content Pit surface water outflow was submitted to the DERM on 14 April 2011. Further follow-up written advice including surface water quality monitoring results undertaken as a result of the Content Pit surface water outflows and results from the April 2011 macroinvertebrate survey report was submitted to the DERM on 1 August 2011.

As described in Barrick's follow-up written advice submitted to the DERM on 1 August 2011, based on the results of the surface water quality monitoring undertaken on-site and at receiving water sites located downstream of the surface water outflows from the Content Pit, Barrick immediately commenced an investigation into the potential for environmental harm as a result of the Content Pit outflow.

This report presents the results of the investigation into the potential for environmental harm as a result of the Content Pit outflow.

1.2 PURPOSE AND SCOPE OF THIS REPORT

This report investigates the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit outflow. The investigation included analysing the results of water quality, stream sediment quality and aquatic habitat condition monitoring undertaken and assessing the potential impacts to surface waters, stream sediment and the aquatic habitat of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow.

1.3 REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2: Describes relevant environmental values.
- Section 3: Outlines the monitoring programme conducted in response to the surface water outflow.
- Section 4: Presents the results of monitoring undertaken in response to the surface water outflow and provides an assessment of the potential impacts from the surface water outflow in accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) risk-based decision framework.
- Section 5: Presents the conclusions of this report.
- Section 6: Lists the references cited in this report.

Appendices A and B contain supporting documentation for this report.

- Appendix A: Croydon Gold Mine Macroinvertebrate Survey April 2011
- Appendix B: Summary Interpretation of Content Pit Water Toxicity Results

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2 RELEVANT ENVIRONMENTAL VALUES

The environmental values relevant to this investigation include surface water, stream sediments and the aquatic habitat (including macroinvertebrates) of the Belmore Creek and its tributaries in the vicinity of the CGM.

This section provides a description of the background (i.e. upstream) environment relevant to the environmental values described above.

2.1 SURFACE WATER

Local Hydrology

The CGM experiences highly seasonal rainfall with an annual average of 748.4 mm of rainfall recorded at the nearest Commonwealth Bureau of Meteorology (BOM) station (Croydon Township - station 029012) over the past 123 years (BOM, 2011).

The highly seasonal nature of rainfall means that local creeks/systems in the vicinity of the CGM, including Belmore Creek and its tributaries, are ephemeral, similar to other systems in North Queensland. The north-western section of ML 5248, which includes the Content Pit mining area, lies within the Belmore Creek catchment (Figure 2).

Surface water runoff in local creeks and drainage lines in ML 5248 ceases soon after storm events (Barrick, 2008). Gradients are very low on much of ML 5248 which means that sheet flow is the dominant hydrological process during the wet season (Barrick, 2008).

The Content Pit surface water outflow pathway was confined within a defined channel (which is not a natural watercourse) up to site DSDi (Figure 2). At this point, the surface water outflow pathway enters a tributary of Belmore Creek, approximately 800 m upstream of where the tributary enters Belmore Creek (Figure 2).

2010/2011 Wet Season

The 2010/2011 wet season was characterised by extraordinary rainfall conditions. 2010 was the wettest year on record over the past 123 years with 1,565.8 mm of rainfall recorded at the Croydon Township BOM station (BOM, 2011). The 2010 annual rainfall (1,565.8 mm) was more than double the annual average rainfall over the past 123 years (748.4 mm).

Belmore Creek Upstream Surface Water Quality

Surface water quality monitoring has been conducted at the EA upstream reference monitoring site SW7 (Figure 2) located on a tributary of Belmore Creek north-east of ML 5248 since 2009. Surface water quality monitoring results from this site are considered to be representative of the water quality in Belmore Creek and its tributaries without influence from the CGM.

Surface water quality monitoring has also been undertaken since January 1999 at site SW6 which is located on another tributary of Belmore Creek at a stock water dam south-west of ML 5248 (Figure 2). Considering site SW6 is located upstream of the Content Pit surface water outflow pathway (Figure 2), the water quality at this site was not influenced by the Content Pit surface water outflow and therefore this site is a relevant upstream monitoring site for the purposes of this report.

The remainder of this section provides an overview of the surface water quality monitoring results recorded at Belmore Creek upstream reference monitoring site SW7 since January 2009 and at upstream site SW6 since January 1999.

EA Upstream Reference Monitoring Site SW7 – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at the Belmore Creek EA upstream reference monitoring site SW7 (Figure 2) since January 2009. Site SW7 is located on a tributary of Belmore Creek north-east of ML 5248 (Figure 2).

The pH for the Belmore Creek upstream reference site SW7 has been generally neutral to slightly acidic (i.e. values ranging from 6.7 to 7.2) since January 2009. EC results have exceeded the EA receiving water trigger level of 250 $\mu\text{S}/\text{cm}$ on two occasions and results have ranged between 25 and 290 $\mu\text{S}/\text{cm}$ since January 2009.

The sulphate trigger level of 56 milligrams per litre (mg/L) was exceeded on one occasion at site SW7. Sulphate results have ranged from 1 mg/L to 57 mg/L since January 2009. Turbidity results exceeded the EA trigger level of 26 NTU on four occasions and results have ranged from 1.5 to 70 NTU since January 2009. Fluoride exceeded the EA trigger level on one occasion and aluminium, cobalt, copper and zinc have each recorded several trigger level exceedances since January 2009.

No parameters have exceeded the receiving water contaminant limits defined in Schedule F – Table 3 of the EA since January 2009.

Table 1 presents a summary the surface water quality results recorded at the Belmore Creek upstream reference site SW7 since January 2009.

Table 1
Summary of Surface Water Quality Results Recorded at Belmore Creek Upstream Site SW7 Since January 2009

Parameter	Trigger Level ¹	Trigger Level Exceedance/ Number of Samples	Range
pH	6-7.5	0/28	6.58 to 7.2
EC	250 $\mu\text{S}/\text{cm}$	2/28	25 to 290 $\mu\text{S}/\text{cm}$
Turbidity	26 NTU	4/24	1.5 to 70 NTU
Sulphate	56 mg/L	1/29	1 to 57 mg/L
Aluminium	1.42 mg/L	4/29	0.01 to 1.53 mg/L
Arsenic	0.013 mg/L	0/29	0.001 to 0.013 mg/L
Cadmium	0.0002 mg/L	0/29	0.0001 to 0.0002 mg/L
Cobalt	0.0014 mg/L	8/29	0.001 to 0.005 mg/L
Copper	0.003 mg/L	8/29	0.001 to 0.012 mg/L
Nickel	0.011 mg/L	0/29	0.001 to 0.004 mg/L
Zinc	0.008 mg/L	5/29	0.005 to 0.025 mg/L
Boron	0.370 mg/L	0/29	0.003 to 0.05 mg/L
Selenium	0.011 mg/L	0/29	0.003 to 0.1 mg/L
Mercury	0.0006 mg/L	0/29	0.0001 to 0.0003 mg/L
Chromium	0.01 mg/L	0/29	0.001 to 0.01 mg/L
Fluoride	0.3 mg/L	1/29	0.1 to 0.34 mg/L

¹ Trigger levels calculated in accordance with Schedule F- Table 2 of the EA.

Belmore Creek Upstream Monitoring Site SW6 – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at monitoring site SW6 (Figure 2) since January 1999. Site SW6 is located on a stock dam on a separate tributary of Belmore Creek (south-west of ML 5248) compared with EA upstream reference site SW7 (Figure 2).

The pH results at site SW6 have varied between slightly acidic to slightly alkaline (i.e. with values ranging from 5.3 to 9) since January 1999. EC results have exceeded the EA receiving water trigger level of 250 $\mu\text{S}/\text{cm}$ on four occasions. Generally, however, EC has been low relative to the EA receiving water trigger level.

No sulphate concentrations have exceeded the relevant Belmore Creek sulphate trigger level of 56 mg/L since January 2009 with results ranging between 1 mg/L and 43 mg/L. Turbidity results have exceeded the EA trigger level of 26 NTU on each sampling occasion since January 1999. Cadmium, cobalt, copper, nickel, zinc and fluoride results have recorded several exceedances of the relevant EA trigger levels defined in Schedule F – Table 2 of the EA.

Aluminium results have consistently exceeded the EA trigger level of 1.42 mg/L since January 1999 and aluminium was the only parameter to exceed the EA contaminant limit of 5 mg/L on 27 March 2006.

Table 2 provides a summary of the surface water quality results recorded at site SW6 since January 1999. As described earlier in this section, for the purposes of this report, site SW6 is an upstream monitoring site, given it is located upstream of the Content Pit surface water outflow pathway (Figure 2).

Table 2
Summary of Surface Water Quality Results Recorded at Belmore Creek Upstream Site SW6 Since January 1999

Parameter	Trigger Level ¹	Trigger Level Exceedance/ Number of Samples	Range
pH	6-7.5	30/78	5.3 to 9
EC	250 $\mu\text{S}/\text{cm}$	4/78	24 to 480 $\mu\text{S}/\text{cm}$
Turbidity	26 NTU	20/20	72.4 to 310 NTU
Sulphate	56 mg/L	0/78	1 to 43 mg/L
Aluminium	1.42 mg/L	36/55	0.025 to 27 mg/L
Arsenic	0.013 mg/L	0/78	0.001 to 0.011 mg/L
Cadmium	0.0002 mg/L	6/78	0.00001 to 0.0014 mg/L
Cobalt	0.0014 mg/L	32/49	0.001 to 0.025 mg/L
Copper	0.003 mg/L	69/78	0.001 to 0.158 mg/L
Nickel	0.011 mg/L	40/78	0.001 to 0.025 mg/L
Zinc	0.008 mg/L	64/78	0.0025 to 0.073 mg/L
Boron	0.370 mg/L	0/26	0.002 to 55 mg/L
Selenium	0.011 mg/L	0/26	0.003 to 0.1 mg/L
Mercury	0.0006 mg/L	0/26	0.0001 to 0.0002 mg/L
Chromium	0.01 mg/L	0/26	0.001 to 0.01 mg/L
Fluoride	0.3 mg/L	5/28	0.1 to 0.59 mg/L

¹ Trigger levels calculated in accordance with Schedule F- Table 2 of the EA.

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Content Pit – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at the Content Pit (Figure 2) since February 1994.

The pH results recorded at the Content Pit have been acidic with values ranging between 2.81 and 4.3 with pH results gradually improving over time. EC results have been well below the EA contaminant limit of 5,970 $\mu\text{S}/\text{cm}$ defined in Schedule F – Table 8 of the EA. Sulphate levels have not exceeded the EA contaminant limit of 1,000 mg/L since February 1994 and sulphate levels have consistently improved over time. Metal concentrations have been low in comparison with the contaminant limits defined in Schedule F – Table 8 of the EA with the exception of aluminium, cadmium and copper. However, aluminium has not exceeded the contaminant limit of 5 mg/L since October 2008, cadmium has not exceeded the contaminant limit of 0.01 mg/L since January 2001 and copper has not exceeded the contaminant limit of 1 mg/L since January 1995. Fluoride results have only exceeded the contaminant limit of 2 mg/L on two occasions.

Results for all other parameters have remained relatively stable and have not deteriorated since monitoring commenced.

Table 3 provides a summary of the surface water quality results recorded at the Content Pit since February 1994.

Table 3
Summary of Content Pit Surface Water Quality Results (1994 – 2011)

Parameter	EA Contaminant Limit ¹	Number of Contaminant Limit Exceedances/Number of Samples	Range
pH	4-9	48/57	2.81 to 4.3
EC	5,970 $\mu\text{S}/\text{cm}$	0/47	737 to 1,900 $\mu\text{S}/\text{cm}$
Turbidity	4,000 TDS	0/16	0.2 to 97 TDS
Sulphate	1,000 mg/L	0/56	300 to 1,000 mg/L
Aluminium	5 mg/L	6/26	1.31 to 7 mg/L
Arsenic	0.5 mg/L	0/56	0.0025 to 0.23 mg/L
Cadmium	0.01 mg/L	23/57	0.0021 to 0.045 mg/L
Cobalt	1 mg/L	0/24	0.09 to 0.29 mg/L
Copper	1 mg/L	4/57	0.056 to 1.85 mg/L
Nickel	1 mg/L	0/54	0.087 to 0.59 mg/L
Zinc	20 mg/L	0/57	0.229 to 2.52 mg/L
Boron	5 mg/L	0/16	0.044 to 0.06 mg/L
Selenium	0.02 mg/L	0/16	0.003 to 0.01 mg/L
Mercury	0.002 mg/L	0/16	0.0001 to 0.0002 mg/L
Chromium	1 mg/L	0/16	0.001 to 0.01 mg/L
Fluoride	2 mg/L	2/17	1.1 to 2.6 mg/L

¹ Contaminant limits as defined in Schedule F- Table 8 of the EA.

Although the above provides context to the historical water quality results recorded at the Content Pit, this water quality summary is not representative of the Content Pit water quality recorded during the surface water outflow between 30 March and 2 May 2011. The water quality results recorded at the Content Pit during the surface water outflow event are provided in Section 4.

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2.2 STREAM SEDIMENT

Belmore Creek Upstream Stream Sediment Quality

Stream sediment monitoring was conducted at the EA upstream reference monitoring site SW7 (Figure 2) located on a tributary of Belmore Creek north-east of ML 5248 during April 2011. Stream sediment monitoring results from this site are considered to be representative of the sediment quality in Belmore Creek and its tributaries without influence from the CGM.

Stream sediment monitoring was also undertaken at site SW6 which is located on a stock water dam on another tributary of Belmore Creek south-west of ML 5248 during April 2011 (Figure 2). Considering site SW6 is located upstream of the Content Pit surface water outflow pathway (Figure 2), the sediment quality at this site was not influenced by the Content Pit surface water outflow and therefore this site is a relevant upstream monitoring site for the purposes of this report.

As described in Section 2.1, the presence of an historic tailings deposit located on the banks of Belmore Creek north-west of the CGM near where the Gulf Development Road crosses Belmore Creek (Figure 2) could potentially have influenced the stream sediments of Belmore Creek over time in the vicinity of the CGM.

The remainder of this section provides an overview of the stream sediment monitoring results recorded at Belmore Creek upstream reference monitoring sites SW7 and SW6 during April 2011.

Belmore Creek EA Upstream Monitoring Sites SW7 and SW6 – Summary of Stream Sediment Monitoring Results

Results from stream sediment monitoring at the Belmore Creek EA upstream reference monitoring sites SW7 and SW6 during April 2011 indicated no exceedances of the ANZECC & ARM CANZ (2000) Interim Sediment Quality Guidelines (ISQG) low values (i.e. the EA stream sediment trigger level values defined in Schedule C – Table 7 of the EA). Elevated aluminium concentrations were recorded at both upstream sites. These naturally elevated aluminium concentrations are considered due to the natural colloidal fraction (i.e. aluminium in an unavailable form).

2.3 AQUATIC HABITAT CONDITION

No baseline macroinvertebrate surveys or aquatic habitat studies have been conducted in Belmore Creek in the vicinity of the CGM prior to 2011. FRC Environmental conducted an investigation into the potential impact of the outflow in April 2011. A detailed description of the results of the macroinvertebrate survey is provided Section 4.3.

Considering the lack of baseline macroinvertebrate or aquatic habitat information for Belmore Creek in the vicinity of the CGM, relevant information of the macroinvertebrates and aquatic habitat recorded at upstream sites in Belmore Creek has been used from FRC Environmental's (2011) *Croydon Gold Mine Macroinvertebrate Survey April 2011* as control sites against which the downstream sites were compared. FRC Environmental's (2011) report included a description of the aquatic habitat and macroinvertebrates at sites located in Belmore Creek upstream of the CGM (i.e. sites BCUS1, BCUS2 and BCUS3) and at the Belmore Creek EA upstream monitoring sites SW7 and SW6. A summary of the aquatic habitat and macroinvertebrates recorded at these upstream sites from FRC Environmental's (2011) report is provided below.

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Belmore Creek Upstream Aquatic Habitat

FRC Environmental (2011) identified that the aquatic habitat at the Belmore Creek upstream sites BCUS1, BCUS2 and BCUS3 was in good condition with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation comprising much of the riparian zone. However, sites SW7 and SW6 (located in tributaries of Belmore Creek) recorded the least suitable macroinvertebrate habitat, as the substrates were dominated by fine sand and silt (*ibid.*). Both sites had poor riparian vegetation and had low in-stream habitat diversity (*ibid.*).

FRC Environmental (2011) also observed evidence of cattle access at upstream sites BCUS1, BCUS2, BCUS3 and SW6, which was reported to likely affect macroinvertebrate communities.

Belmore Creek Upstream Aquatic Macroinvertebrates

Total taxonomic richness and PET richness was reported to be generally low at all upstream sites, and was typically higher in the edge and riffle habitats than in bed habitats (FRC Environmental, 2011). No riffle habitat was present at upstream sites SW7, BCUS1 or at site SW6 (FRC Environmental, 2011).

SIGNAL 2 scores are based on the sensitivity of each macroinvertebrate community to pollution or habitat degradation (FRC Environmental, 2011). A low number means the macroinvertebrate is tolerant of a range of environmental conditions including common forms of water pollution (e.g. suspended sediments and nutrient enrichment) (FRC Environmental, 2011). The lowest SIGNAL 2 scores for the edge habitat were recorded at the upstream sites SW7 and BCUS3 (FRC Environmental, 2011). The lowest SIGNAL 2 score for the bed habitat was recorded at the upstream site SW7 (FRC Environmental, 2011). The highest SIGNAL 2 score for each habitat was recorded at upstream site BCUS2 (FRC Environmental, 2011).

A comparison of the macroinvertebrate survey results between the Belmore Creek upstream sites and sites located downstream of the Content Pit surface water outflow pathway is provided in Section 4.3 and Appendix A.

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3 ADDITIONAL MONITORING PROGRAMME CONDUCTED IN RESPONSE TO CONTENT PIT SURFACE WATER OUTFLOW

Barrick initiated an additional monitoring programme on 30 March 2011 in response to the surface water outflow from the Content Pit. The approximate direction of the surface water outflow is presented in Figure 2. The additional monitoring programme included surface water and stream sediment monitoring at additional monitoring sites within Belmore Creek upstream and downstream of the CGM (including sites along the surface water outflow pathway). As described in the follow-up written advice provided to the DERM on 1 August 2011, a macroinvertebrate survey was also undertaken by FRC Environmental at relevant sites upstream and downstream of the CGM. A summary of the additional monitoring programme undertaken is provided in Table 4 below.

Table 4
Summary of Additional Monitoring Programme

Monitoring Component	Location	Site ¹	Site Description
Surface Water	On-site Waters	Content Pit	Sample taken from point where surface water flowed from the Content Pit.
		SW5	Sediment dam near the south-west corner of ML 5248 boundary. Sample taken from point where surface water flowed from the dam.
	Surface Water Outflow Pathway	Mine Drainage	The defined channel draining the surface water outflow from the Content Pit. Other surrounding surface water also flowed to this drainage channel.
Surface Water and Stream Sediment	Upstream within a tributary of Belmore Creek	DSDi	Downstream of where the channel draining the Content Pit surface water outflow enters a tributary of Belmore Creek (approximately 800 m upstream of where the tributary enters Belmore Creek).
		SW7	Upstream EA reference monitoring site located on a tributary of Belmore Creek north-east of ML 5248.
		SW6	EA monitoring site located at a stock water dam on a tributary of Belmore Creek south-west of ML 5248. Site located upstream of surface water outflow pathway.
	Belmore Creek Upstream	BCUS1	Located in Belmore Creek approximately 2.4 km upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCUS2	Located in Belmore Creek approximately 1.85 km upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCUS3	Located in Belmore Creek approximately 800 m upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		Belmore Creek U/S	Located in Belmore Creek immediately upstream of where the Content Pit surface water outflow pathway enters Belmore Creek.
	Belmore Creek Downstream	BCDS1	Located in Belmore Creek immediately downstream of where the Content Pit surface water outflow pathway enters Belmore Creek.
		Belmore Creek D/S	Located in Belmore Creek approximately 50 m downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCDS2	Located in Belmore Creek approximately 450 m downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCDS3	Located in Belmore Creek approximately 1 km downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCDS4	Located in Belmore Creek approximately 1.9 km downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).

¹ Refer to Figure 2.

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Table 4 (Continued)
Summary of Additional Monitoring Programme

Monitoring Component	Location	Site ¹	Site Description
Macroinvertebrate Survey	Upstream	SW7, SW6, BCUS1, BCUS2 and BCUS3	As above.
	Downstream	DSDi, BCDS1, BCDS2, BCDS3 and BCDS4	As above.

Refer to Figure 2.

The results from the additional monitoring programme undertaken in response to the Content Pit surface water outflow are provided in Section 4. An analysis of the results and an assessment of the potential impact to the relevant environmental values (Section 2) from the Content Pit surface water outflow is provided in Section 4.

Macroinvertebrate Survey

In response to the Content Pit surface water outflow, Barrick immediately commissioned FRC Environmental to conduct a macroinvertebrate survey in Belmore Creek and its relevant tributaries to characterise the macroinvertebrate communities and aquatic habitat at sites located upstream and downstream of the CGM. A total of ten sites were surveyed in Belmore Creek and its tributaries between 4 and 6 April 2011. Comparative sites (or upstream sites) were chosen to represent the range of aquatic habitats in the area and to match potentially impacted sites, in terms of water body type, stream order and environmental conditions.

The results of the macroinvertebrate survey, including a comparison of the upstream and downstream macroinvertebrate communities and aquatic habitat conditions and an assessment of the impact to macroinvertebrate communities as a result of the Content Pit surface water outflow, are summarised in Section 4.3.

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4 RESULTS OF MONITORING PROGRAMME AND ASSESSMENT OF POTENTIAL IMPACTS

This section provides an analysis of the results of the monitoring programme (Section 3) and an assessment of the potential impacts to the relevant environmental values (Section 2) of Belmore Creek and its tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow. The assessments in this section have been conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to investigate the potential risk to the ecosystem of Belmore Creek and its tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow.

4.1 SURFACE WATER

Surface Water Quality Results

The surface water quality results from the monitoring programme undertaken between 30 March and 2 May 2011 in response to the Content Pit surface water outflows have been compared against the receiving water trigger levels and receiving water or on-site water contaminant limits defined in Schedule F of the EA. A summary of the trigger level and contaminant limit exceedances recorded at the surface water monitoring sites described in Section 3 is provided in Table 5.

Table 5
Comparison of Surface Water Quality Results Against Relevant EA Trigger Levels and Contaminant Limits

Location	Site ¹	EA Trigger Level Exceedance ²	EA Contaminant Limit Exceedance ³
Belmore Creek Upstream	SW7	Aluminium, Turbidity	No Exceedance
	SW6	Aluminium, Turbidity	No Exceedance
	BCUS1	No Exceedance	No Exceedance
	BCUS2	No Exceedance	No Exceedance
	BCUS3	No Exceedance	No Exceedance
	Belmore Creek U/S	Arsenic, Turbidity	No Exceedance
On-site Waters	Content Pit	Not Applicable	pH
	SW5	Not Applicable	pH, Aluminium, Cadmium and Fluoride
Surface Water Outflow Pathway	Mine Drainage	Aluminium, Cadmium, Cobalt, Copper, EC, Fluoride, Nickel, pH, Sulphate, Turbidity and Zinc	No Exceedance
	DSDi	Aluminium, Cadmium, Cobalt, Copper, Fluoride, Nickel, Sulphate, Turbidity and Zinc	No Exceedance
Belmore Creek Downstream	Belmore Creek D/S	Aluminium, Arsenic, Cadmium, Cobalt, Copper, Turbidity and Zinc	No Exceedance
	BCDS1	Turbidity ⁴	No exceedance
	BCDS2	No exceedance	No exceedance
	BCDS3	No exceedance	No exceedance
	BCDS4	No exceedance	No exceedance

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 2 of the EA.

³ Contaminant limits as defined Schedule F- Table 3 of the EA for receiving waters and Schedule F – Table 8 of the EA for on-site waters.

⁴ Turbidity trigger level exceedance only recorded in one of three samples taken at site BCDS1.

A summary of the surface water quality data from the monitoring programme undertaken between 30 March and 2 May 2011 is provided in Attachment 1.

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Surface Water Quality Results Analysis

Laboratory analysis of the water quality samples was undertaken for each sample collected at the surface water monitoring sites described in Section 3. The surface water results (Attachment 1) represent the filtered results, except where indicated (i.e. for Selenium). A comparison of the surface water monitoring results against the relevant EA on-site water contaminant limits and EA receiving water trigger level and contaminant limits is provided in Table 5.

The remainder of this section provides an analysis of the surface water quality results downstream of the Content Pit surface water outflow point and in accordance with ANZECC and ARMCANZ (2000) risk-based decision framework, where a trigger level is exceeded, investigates the potential risk to the ecosystem as a result of that exceedance.

On-site Waters

No on-site water EA contaminant limit exceedances were recorded at the Content Pit during the reporting period of 30 March to 2 May 2011 except for pH. One Content Pit water sample recorded a pH result marginally below the contaminant limit range of 4 to 9 (i.e. 3.91 on 30 March 2011) (Attachment 1).

Surface water concentrations at on-site water monitoring site SW5 recorded contaminant limit exceedances of pH, aluminium, cadmium and fluoride during the reporting period (Attachment 1). Historical mine workings are present in the vicinity of site SW5 and it is considered that the material from which the dam at SW5 is constructed could possibly influence the water quality at this site considering the water quality from the Content Pit did not contain elevated metal concentrations.

The exceedances of the parameters above were recorded at either then end of the sampling period or successively increased over time, indicating that evapoconcentration of the water contained in the SW5 sediment dam occurs and increases the concentration of these parameters. In accordance with Condition F3-2 of the EA, both the Content Pit and site SW5 are fenced to minimise access by livestock or native fauna.

Surface Water Outflow Pathway and Downstream Belmore Creek

No receiving water contaminant limits were exceeded at sites downstream of ML 5248 (Table 5).

The monitoring sites Mine Drainage and DSDi each recorded receiving water trigger level exceedances for aluminium, cadmium, cobalt, copper, fluoride, nickel, pH, sulphate, turbidity and zinc, with the Mine Drainage site also recording three exceedances of the receiving water EC trigger level (Table 5).

At the Belmore Creek D/S site, trigger level exceedances were recorded for aluminium, arsenic, cadmium, cobalt, copper, turbidity and zinc (Table 5). All metals concentrations reduce to below receiving water trigger levels by site BCDS1 with this site only recording a trigger level exceedance for turbidity on one occasion (Attachment 1).

Observations during the monitoring programme showed that no flow was occurring at the Mine Drainage site or at site DSDi as of 13 April 2011 (Figure 2). Outflows from the stock dam located upstream of site DSDi were observed to dominate the input to site DSDi at this time. Water was also observed to backflow from site DSDi to the Mine Drainage site once flows from the Content Pit had ceased reporting to the Mine Drainage site. These observations confirm the increase in pH results and decrease in sulphate and EC results at the Mine Drainage and DSDi sites.

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4.1.1 Assessment of Potential Impact

The following assessment of the potential impact to surface waters in Belmore Creek and its relevant tributaries in the vicinity of the CGM has been based on the ANZECC and ARMCANZ (2000) *Simplified decision tree for assessing toxicants in ambient waters* (Figure 3). The assessment aims to investigate the potential risk to the ecosystem where a trigger level has been exceeded.

Level of Protection - Target Ecosystem Condition

In accordance with Schedule F – Table 2 of the EA, the ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems*. In accordance with ANZECC and ARMCANZ (2000), an increased level of change of biological indicators might be acceptable for this ecosystem condition compared with an ecosystem of high conservation/ecological value. The key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition (ANZECC and ARMCANZ, 2000).

Comparison of Downstream Surface Water Quality Results with Background Concentrations

Surface water monitoring results from upstream sites SW7 and SW6 each recorded trigger level exceedances for aluminium and turbidity during the reporting period (Table 5). Results from the Belmore Creek U/S site recorded exceedances of the arsenic and turbidity trigger levels defined in the EA (Table 5).

Aluminium concentrations at the upstream sites SW7 and SW6 are also elevated and comparable with aluminium concentrations recorded at sites Mine Drainage, DSDi and Belmore Creek D/S (Attachment 1). Upstream site SW6 recorded a maximum aluminium concentration of 4.82 mg/L (Attachment 1). These naturally elevated aluminium concentrations present upstream and downstream in Belmore Creek are considered a measure of total aluminium and due to the natural colloidal fraction (i.e. aluminium in an unavailable form).

Turbidity results at upstream sites SW7 and SW6 were also elevated, with upstream site SW6 recording a maximum turbidity result of 120 NTU which is comparable to the maximum turbidity results of 110 NTU recorded at sites Mine Drainage and DSDi.

The arsenic trigger level exceedance recorded at the Belmore Creek D/S site (i.e. 0.019 mg/L) is comparable with the arsenic concentration recorded at the Belmore Creek U/S site (0.016 mg/L).

Although the pH results recorded at the Mine Drainage site averaged 5.4 during the reporting period, pH results at site DSDi and sites further downstream increased and remained neutral therefore reducing the potential availability of the parameters that exceeded trigger levels at those sites.

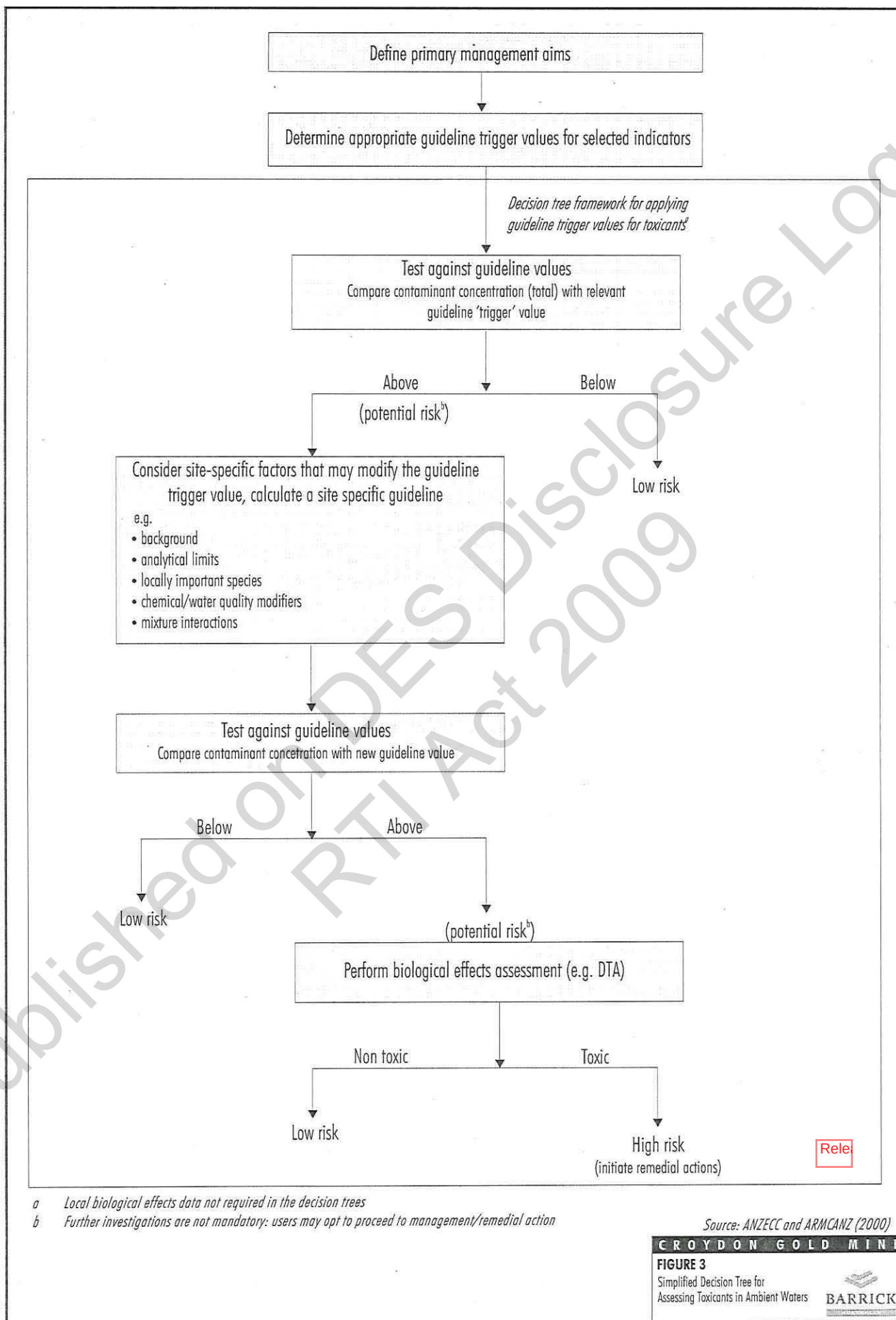
Toxicity Testing of Content Pit Surface Waters

In accordance with the ANZECC and ARMCANZ (2000) *Simplified decision tree for assessing toxicants in ambient waters* (Figure 3), Barrick initiated a biological effects assessment (i.e. toxicity testing) of water samples from the Content Pit to investigate the potential risk to the ecosystem from the pH contaminant limit range exceedance recorded at the Content Pit and the potential risk from the receiving water trigger level exceedances recorded at sites Mine Drainage, DSDi and Belmore Creek D/S

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The following five fresh water aquatic toxicity tests were conducted for samples of Content Pit water:

1. 48 hour acute (immobilisation) test using the freshwater cladoceran *Ceriodaphnia dubia*.
2. Partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*.
3. 48 hour acute toxicity test using the freshwater chironomid *Chironomus tepperi*.
4. 96 hour acute toxicity test with the freshwater shrimp *Marcobrachium australiense*.
5. 7 day growth inhibition test using a freshwater aquatic duckweed *Lemna diasperma*.

A summary interpretation of the Content Pit toxicity test results has been undertaken by Associate Professor Barry Noller of the University of Queensland. Professor Noller's interpretation is provided in full in Appendix B.

The complete test results including a detailed description of the test methods used is presented in Ecotox Services Australasia Pty Ltd's *Toxicity Assessment of Two Pit Water Samples Test Report August 2011* (Attachment 1 of Appendix B).

A summary of Professor Noller's interpretation of the toxicity test results is provided below.

Results of the toxicity testing indicated the sensitivity of the test species ranged from nil or little response to a significant level of effect (Appendix B). Three of the four species showed nil to little response to the pit water (Appendix B). The freshwater cladoceran *Ceriodaphnia dubia* was the most sensitive of the test species to the Content Pit water (Appendix B).

Professor Noller indicated that in accordance with ANZECC and ARMCANZ (2000) guidelines, the safe dilution of Content Pit water so that there would be no observed effect would be 100 times the NOEC (i.e. no observed effect concentration) value for the most sensitive test species (i.e. 3.1%) (Appendix B). No acute or chronic effects would likely occur at this dilution (Appendix B).

Assessment of Dilution Effect During Content Pit Surface Water Outflow

Significant dilution of the Content Pit water is expected with distance from the Content Pit outflow point. By conducting toxicity testing on direct Content Pit water and not water from site DSDi (the point at which outflows entered the tributary of Belmore Creek), Barrick has undertaken a conservative approach to the toxicity testwork.

Based on the results from the macroinvertebrate survey (Section 4.3), it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek. Only a minor localised impact was observed to macroinvertebrates in the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where the tributary enters Belmore Creek (Section 4.3). Therefore, it is considered the dilution of the Content Pit water required to achieve no observed effects to the most sensitive test species had not yet occurred at this site, although had by the time flows reached site BCDS1. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the above, it is considered that no acute or chronic effects to the most sensitive test species (i.e. *Ceriodaphnia dubia*) would occur from the Content Pit surface water outflows in Belmore Creek.

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Assessment of Potential Impact Relevant to Target Ecosystem Condition

As shown by the surface water quality results, some impact to surface waters occurred within the tributary of Belmore Creek (downstream of site DSDi) and immediately where tributary flows enter Belmore Creek (i.e. at site BCDS1). However, based on the application of ANZECC and ARMCANZ (2000) risk-based decision framework and the results of the Content Pit water toxicity tests and macroinvertebrate survey, it is considered the Content Pit surface water outflow posed a low risk to Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no receiving water contaminant limits were exceeded at any of the monitoring sites downstream of ML 5248;
- three of the four toxicity test species showed nil to little effect from the Content Pit surface water;
- based on the toxicity test results and macroinvertebrate survey results, it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek; and
- only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the above, the outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low.

4.2 STREAM SEDIMENT

Stream Sediment Results

The results from the stream sediment monitoring programme undertaken between 5 to 6 April 2011 in response to the Content Pit surface water outflows have been compared against the stream sediment trigger levels and contaminant limits defined in Schedule F - Tables 5 and 6 of the EA respectively. A summary of the trigger level and contaminant limit exceedances recorded at the stream sediment monitoring sites described in Section 3 is provided in Table 6.

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Table 6
Comparison of Stream Sediment Results against EA Trigger Levels and Contaminant Limits

Location	Site ¹	EA Trigger Level Exceedance ²	EA Contaminant Limit Exceedance ³
Belmore Creek Upstream	SW7	No Exceedance	No Exceedance
	SW6	Not Applicable ⁴	Aluminium
	BCUS1	Arsenic, Mercury ⁴	Aluminium
	BCUS2	Arsenic, Mercury	Aluminium, Arsenic
	BCUS3	Arsenic, Mercury	Aluminium, Arsenic
Belmore Creek Downstream	DSDi	Arsenic, Mercury	Aluminium, Arsenic
	BCDS1	Arsenic, Mercury ⁴	Aluminium, Arsenic, Cobalt
	BCDS2	Arsenic, Mercury	Aluminium
	BCDS3	Arsenic, Mercury	Arsenic
	BCDS4	Arsenic, Mercury	Aluminium, Arsenic

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 5 of the EA.

³ Contaminant limits as defined Schedule F- Table 6 of the EA.

⁴ No trigger levels for aluminium and cobalt are defined in Schedule F- Table 5 of the EA and insufficient data is available to calculate a relevant trigger level in accordance with Schedule F- Table 5 of the EA.

Attachment 2 provides a summary of the stream sediment monitoring data from the monitoring programme undertaken between 5 to 6 April 2011.

Stream Sediment Results Analysis

Laboratory analysis of the stream sediment samples taken on 5 and 6 April 2011 was conducted for each sample collected at the stream sediment monitoring sites described in Section 3. The sediment samples were analysed for the relevant total metals and total mercury at the ALS laboratory. The results provided in Attachment 2 represent the total results. A comparison of the stream sediment monitoring results against the relevant EA stream sediment EA trigger levels and contaminant limits is provided in Table 6.

As identified in Table 6, sites DSDi and sites BCDS1 to BCDS4, downstream of the Content Pit surface water outflow point exceeded the EA stream sediment trigger levels for arsenic and mercury. Exceedances of the arsenic EA contaminant limit (i.e. ISQG high value) were recorded at the downstream sites DSDi, BCDS1, BCDS3 and BCDS4. Exceedances of the aluminium EA contaminant limit were recorded at downstream sites DSDi, BCDS1, BCDS2 and BCDS4. A single cobalt contaminant limit exceedance was also recorded at site BCDS1.

However, in comparison with background/upstream concentrations, EA stream sediment trigger levels (i.e. ISQG low values) for arsenic and mercury were also recorded at upstream sites BCUS1 to BCUS3. Exceedances of the arsenic EA contaminant limit (i.e. ISQG high value) were recorded at upstream sites BCUS2 and BCUS3. Exceedances of the EA aluminium contaminant limit were recorded at upstream sites SW6, BCUS1 to BCUS3. Concentrations of aluminium were typically higher upstream than downstream. These naturally elevated aluminium concentrations present upstream and downstream in Belmore Creek are considered a measure of total aluminium and due to the natural colloidal fraction (i.e. the aluminium in an unavailable form).

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In addition to these stream sediment results, it should also be noted that no surface water quality results from the Content Pit or site SW5 or sites within the tributary of the surface water outflow pathway (i.e. Mine Drainage and DSDi) recorded arsenic or mercury trigger level exceedances (Section 4.1). Arsenic surface water trigger level exceedances were only recorded at sites Belmore Creek U/S and Belmore Creek D/S (Section 4.1).

These results suggest that an alternative source of arsenic and mercury is present upstream in Belmore Creek and that the Content Pit surface water outflow has not impacted stream sediments in the tributary of the surface water outflow pathway or in Belmore Creek beyond the existing disturbed condition of stream sediments within these systems.

The remainder of this section provides an assessment of potential impact based on the stream sediment results within the tributary downstream of the Content Pit surface water outflow point (i.e. commencing at site DSDi) and downstream in Belmore Creek (up to the final monitoring site BCDS4) and investigates the potential risk to the ecosystem where a trigger level is exceeded in accordance with ANZECC and ARMCANZ (2000) risk-based decision framework.

4.2.1 Assessment of Potential Impact

The following assessment of the potential impact to stream sediments in Belmore Creek and its relevant tributaries in the vicinity of the CGM has been based on the ANZECC and ARMCANZ (2000) *Decision tree for the assessment of contaminated sediments* (Figure 4). The assessment aims to investigate the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM where a trigger level has been exceeded.

Level of Protection - Target Ecosystem Condition

The ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems* (Section 4.1.1). The key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition (ANZECC and ARMCANZ, 2000) (Section 4.1.1.).

In accordance with ANZECC and ARMCANZ (2000) methodology, if an ISQG low value (i.e. trigger value) is exceeded, the *Decision tree for the assessment of contaminated sediments* (Figure 4) prompts for further action to be taken to investigate the potential risk to the ecosystem. Although an analysis of the stream sediments indicated comparable upstream and downstream results, based on the trigger level exceedances recorded, in accordance with ANZECC and ARMCANZ (2000) methodology, Barrick conducted sediment speciation tests (i.e. 1M hydrochloric extract tests) on the stream sediment samples from sites Belmore Creek U/S and Belmore Creek D/S (Figure 2) to better estimate the bioavailable fraction of the concentrations.

The results of the sediment speciation tests for the Belmore Creek U/S and Belmore Creek D/S site samples were then compared against ANZECC and ARMCANZ (2000) ISQG low and high values. A summary of the sediment speciation test results for both the <2 mm fraction and <63 µm fraction of the sediments is provided in Table 7 below.

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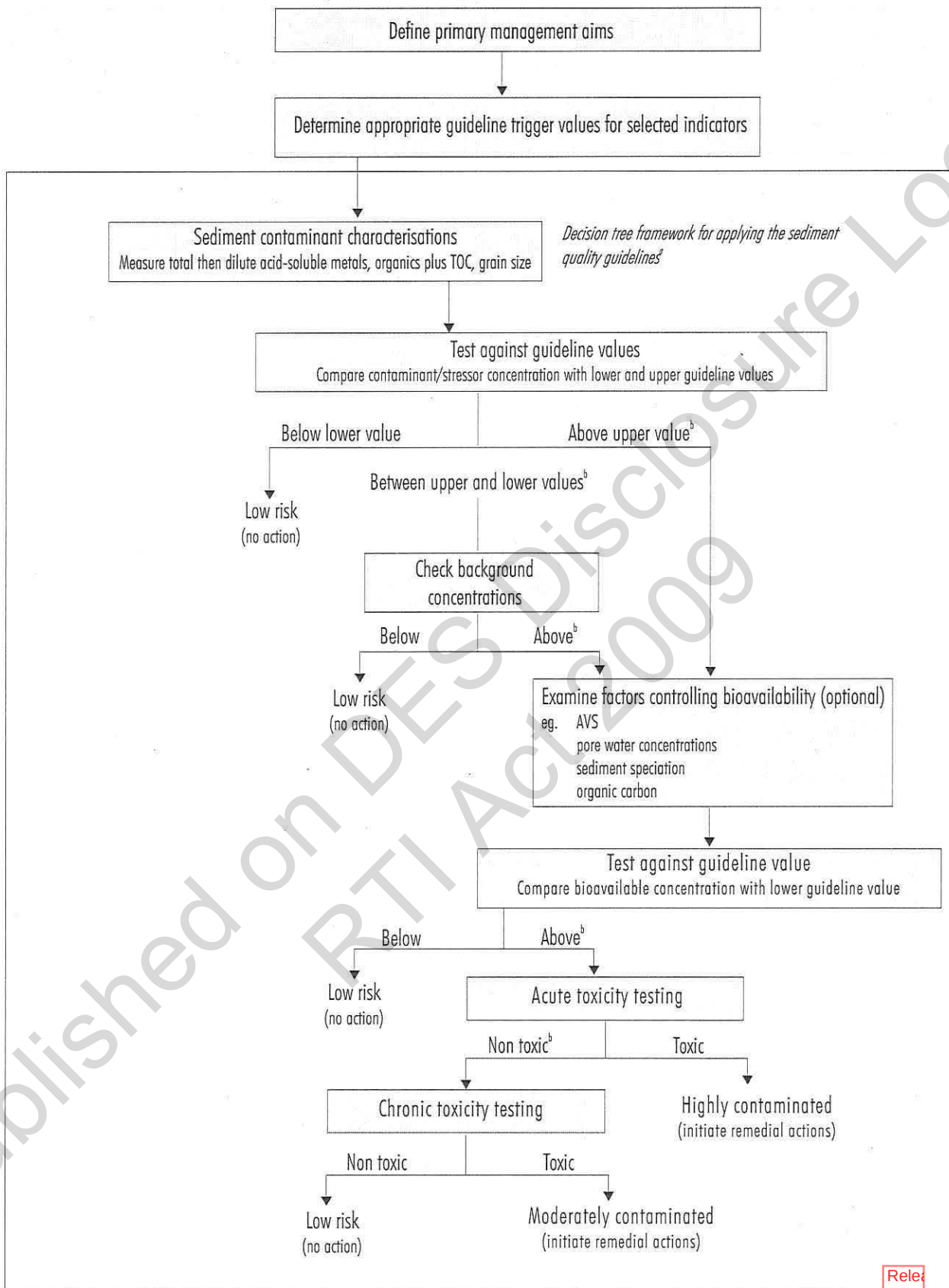


Table 7
Summary of Sediment Speciation (1M Hydrochloric Extract) Test Results

Monitoring Site	Fraction	Parameter	Concentration after 1M HCL Test	ISQG Low Value ¹	ISQG High Value ¹
Belmore Creek U/S	<63 µm	Arsenic	23	20	70
		Arsenic	312	20	70
		Zinc	290	200	410
		Mercury	1.3	0.15	1
Belmore Creek D/S	<63 µm	Arsenic	25	20	70
		Arsenic	290	20	70
		Zinc	303	200	410
		Mercury	1.14	0.15	1

¹ Table 3.5.1 of ANZECC and ARMCANZ (2000).

Although the sediment speciation test results for the more bioavailable fraction of the sediment samples (i.e. the <63 µm fraction) indicate exceedances of the ISQG low value for arsenic, zinc and mercury and exceedances of the ISQG high value for arsenic and mercury, these exceedances were recorded at both the upstream and downstream sites, with arsenic and mercury concentrations higher at the Belmore Creek U/S site compared with the Belmore Creek D/S site.

Assessment of Potential Impact Relevant to Target Ecosystem Condition

Based on the comparison of downstream stream sediment results with the background concentrations recorded, it is therefore considered:

- that an alternative source of arsenic, mercury and zinc is present upstream in Belmore Creek;
- that the Content Pit surface water outflow posed a low risk to Belmore Creek and its relevant tributaries in the vicinity of the CGM and did not impact stream sediments in Belmore Creek beyond the existing disturbed condition of the stream sediments in this system.

This conclusion is also supported by the results from the macroinvertebrate survey conducted at sites upstream and downstream in Belmore Creek and its relevant tributaries. As discussed in Section 4.3, only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the conclusions above, no further acute toxicity testing is considered necessary as the outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low.

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4.3 AQUATIC HABITAT CONDITION

Macroinvertebrate Survey Results

As described in Section 3, in response to the surface water outflow from the Content Pit, Barrick immediately conducted a macroinvertebrate survey of Belmore Creek and its relevant tributaries in the vicinity of the CGM. The survey was undertaken by FRC Environmental between 4 and 6 April 2011. FRC Environmental prepared the report *Croydon Gold Mine Macroinvertebrate Survey April 2011* which presents a detailed description of the results of the survey and characterises the impact observed to macroinvertebrates as a result of the outflow.

The macroinvertebrate survey consisted of measuring aquatic habitat, in-situ water quality and macroinvertebrate assemblages at ten sites on Belmore Creek and its relevant tributaries. The monitoring sites included upstream sites SW7, SW6, BCUS1, BCUS2 and BCUS3 and downstream sites DSDi, BCDS1, BCDS2, BCDS3 and BCDS4 (Section 3 and Figure 2). FRC Environmental's full report is provided as Appendix A.

A summary of FRC Environmental's assessment of potential impact to the aquatic habitat and macroinvertebrates is provided in Section 4.3.1 below.

4.3.1 Assessment of Potential Impact

FRC Environmental characterised the potential impact to macroinvertebrates by assessing the in-stream aquatic habitat condition and measuring macroinvertebrate survey data at sites downstream of the Content Pit surface water outflow point compared with relevant upstream sites. Macroinvertebrate survey data collected included macroinvertebrate taxonomic richness, abundance, PET richness, dominant taxa, community composition and SIGNAL 2 scores. The condition of the aquatic habitat was assessed based on the *Queensland AUSRIVAS Sampling and Processing Manual* (Department of Natural Resources and Mines, 2011). Statistical analysis of the survey data was undertaken to determine if changes to components or the entire macroinvertebrate community were present.

A summary of the aquatic habitat and aquatic macroinvertebrate assessments conducted by FRC Environmental is provided below. A description of the aquatic habitat condition and macroinvertebrates at the Belmore Creek upstream monitoring sites is provided in Section 2.3. A detailed description of the results of the survey is provided in FRC Environmental's full report (Appendix A).

Summary of Aquatic Habitat Assessment

Aquatic habitat (including in-stream and surrounding habitat) was assessed based on the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM, 2001) which includes the assessment of various environmental factors. The assessment of the condition of habitat uses the River Bioassessment Program scoring system. This score places the sites into one of four categories (excellent, good, moderate and poor) based on the quality of the macroinvertebrate habitat.

Habitat scores across all the survey sites ranged from moderate to good (FRC Environmental, 2011). Upstream reference sites SW7 and SW6 had the lowest bioassessment scores (*ibid.*). These scores were due to high embeddedness of the substrate (as it was dominated by fine sediments) and low diversity of in-stream habitat (i.e. there was only shallow pools and runs with no deep pools or riffles present) and poor streamside cover (*ibid.*).

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FRC Environmental (2011) reported that these scores indicated that these sites (i.e. SW7 and SW6) are likely to be less suitable for macroinvertebrates. Sites DSDi and BCDS1 also had low bioassessment scores due to high embeddedness and poor in-stream habitat diversity (*ibid.*). Downstream sites BCDS2 and BCDS3 had the highest bioassessment scores which were noted to be greater than upstream sites BCUS2 and BCUS3.

Summary of Aquatic Macroinvertebrate Assessment

Macroinvertebrate survey data collected by FRC Environmental included total taxonomic richness, PET richness, SIGNAL 2 scores and mean taxonomic richness, abundance and community composition across the edge, bed and riffle habitats. A detailed description of these results is provided in Appendix A. The summary or assessment of impact to macroinvertebrates as a result of the Content Pit surface water outflow reported by FRC Environmental (2011) is provided below.

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities (i.e. on taxonomic richness, abundance and community composition) at site DSDi, which is approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land) (Figure 2.1). However, the impact appeared to be confined to a small spatial area, and did not extend to the first downstream site on Belmore Creek (i.e. BCDS1), which is approximately 700 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (Figure 2.1). As such, the macroinvertebrate taxonomic richness, abundance and community composition at sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

The in situ water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Increased electrical conductivity was observed at site DSDi immediately downstream of the confluence of the overflow pathway with the tributary of Belmore Creek. Though electrical conductivity levels in the study area did not correlate highly to macroinvertebrate community structure, suggesting that electrical conductivity levels here may not have had a substantial influence on macroinvertebrate community structure.

A number of other factors (e.g. habitat condition, land use [i.e. cattle access] and water quality) also appear to have had an effect on macroinvertebrate communities. As a result, the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

Assessment of Potential Impact Relevant to Target Ecosystem Condition

Based on the above, the Content Pit surface water outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the outflow is considered low.

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5 CONCLUSION

This report has presented assessments of surface water quality, stream sediment quality and aquatic habitat condition which have been undertaken in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to investigate the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow between 30 March and 2 May 2011.

As identified in the CGM EA, the ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems*. ANZECC and ARMCANZ (2000) identifies that the key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition. ANZECC and ARMCANZ (2000) also indicate that an increased level of change of biological indicators might be acceptable for this ecosystem condition compared with an ecosystem of high conservation/ecological value.

A summary of the conclusions of the surface water quality, stream sediment quality and aquatic habitat condition assessments is provided below.

Surface Water

Based on the surface water quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.1), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no receiving water contaminant limits were exceeded at any of the monitoring sites downstream of ML 5248;
- three of the four toxicity test species showed nil to little effect from the Content Pit surface water;
- based on the toxicity test results and macroinvertebrate survey results, it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek; and
- only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited. Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Stream Sediment

Based on the stream sediment quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.2), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- a comparison of the stream sediment monitoring results from April 2011 and the sediment speciation test results from August 2011 indicate that the quality of the Belmore Creek downstream sediments, and the sediments at site DSDi, are comparable with the quality of Belmore Creek upstream sediments; and
- that the upstream results were in fact higher than downstream results.

These results indicate that an alternative source of the parameters measured is present upstream in Belmore Creek.

Aquatic Habitat Condition

Based on the aquatic habitat assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.3), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no impact was observed to macroinvertebrate communities or aquatic habitat condition in Belmore Creek; and
- although a minor localised impact was observed to macroinvertebrates within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited. Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

As a result of the above conclusions and in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, no remediation measures are considered necessary.

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6 REFERENCES

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ATTACHMENT 1

SURFACE WATER QUALITY MONITORING RESULTS

Attachment 1
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (μ S/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Belmore Creek EA Upstream Sites																	
SW7	Maximum	7.19	153	0.2	47	40	1.53	0.013	0.05	0.0001	0.002	0.001	0.002	0.0001	0.003	0.01	0.005
	Minimum	6.63	25	0.1	1	20	0.25	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.92	83.43	0.14	17.29	29.10	0.87	0.01	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.93	102	0.1	20	25.1	0.85	0.004	0.05	0.0001	0.001	0.001	0.002	0.0001	0.002	0.01	0.005
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
SW6	Maximum	6.99	40	0.1	1	120	4.82	0.002	0.05	0.0001	0.002	0.001	0.002	0.0001	0.002	0.01	0.005
	Minimum	6.8	32	0.1	1	83.2	2.13	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.90	36.00	0.10	1.00	101.6	3.48	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.895	36	0.1	1	101.6	3.46	0.002	0.05	0.0001	0.0015	0.001	0.0015	0.0001	0.0015	0.01	0.005
	No. of samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Additional Belmore Creek Upstream Site																	
Belmore Creek U/S	Maximum	7.21	65	0.2	8	29.7	1.28	0.016	0.05	0.0001	0.003	0.001	0.002	0.0001	0.002	0.01	0.007
	Minimum	6.73	33	0.1	2	9.7	0.04	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.97	41.44	0.11	4.22	22.39	0.62	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.95	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L) (total)	Zn (mg/L)
Additional Belmore Creek Upstream Sites																	
Belmore Creek Upstream	BCUS1 (Sample 1)	7.16	31	0.1	1	24	0.76	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 2)	7.02	39	0.1	4	26	0.64	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 3)	6.94	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.003	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 4)	6.94	39	0.1	3	25	0.52	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS2	7.05	34	0.2	1	23	0.54	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.007
	BCUS3	7.14	37	0.1	3	24	0.25	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.

² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (μ S/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
On-Site Waters																	
Content Pit	Maximum	4.2	789	1.5	316	90	1.62	0.009	0.05	0.0025	0.002	0.112	0.062	0.0001	0.103	0.01	0.279
	Minimum	3.91	737	1.1	300	0.8	1.31	0.004	0.05	0.0021	0.001	0.09	0.056	0.0001	0.087	0.01	0.229
	Average	4.08	772	1.3	307	12.5	1.45	0.006	0.05	0.0023	0.001	0.100	0.059	0.0001	0.096	0.01	0.254
	Median	4.11	781	1.3	304	3	1.38	0.006	0.05	0.0022	0.001	0.101	0.059	0.0001	0.097	0.01	0.259
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
SW5	Maximum	4.38	1,130	2.5	491	11	14.9	0.004	0.05	0.0244	0.002	0.234	0.593	0.0001	0.22	0.01	0.959
	Minimum	3.75	428	1	160	0.8	3.9	0.003	0.05	0.0091	0.001	0.089	0.195	0.0001	0.082	0.01	0.385
	Average	3.93	734	1.66	305	3.44	8.45	0.0037	0.05	0.0158	0.0012	0.153	0.387	0.0001	0.147	0.01	0.642
	Median	3.9	757	1.7	311	2	8.89	0.004	0.05	0.0156	0.001	0.16	0.396	0.0001	0.152	0.01	0.662
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
EA Contaminant Limit ³		4-9	5,970	2	1,000	4,000 (TDS)	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

³ On-site Water Contaminant Limit as defined in Schedule F-Table 8 of the EA.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (μ S/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Surface Water Outflow Pathway Sites																	
Mine Drainage	Maximum	6.88	354	0.8	130	110	1.74	0.003	0.05	0.0032	0.001	0.071	0.035	0.0001	0.047	0.01	0.158
	Minimum	4.9	71	0.3	17	1	0.37	0.002	0.05	0.0001	0.001	0.001	0.008	0.0001	0.003	0.01	0.005
	Average	5.40	237	0.57	84	19.8	0.90	0.0024	0.05	0.0024	0.001	0.0444	0.0263	0.0001	0.033	0.01	0.118
	Median	5.17	236	0.6	80	6	0.71	0.002	0.05	0.0028	0.001	0.041	0.029	0.0001	0.036	0.01	0.142
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
DSDi	Maximum	6.83	185	0.4	64	110	2.42	0.004	0.05	0.0007	0.002	0.018	0.02	0.0001	0.013	0.01	0.037
	Minimum	6.2	60	0.1	13	44.2	0.28	0.001	0.05	0.0001	0.001	0.001	0.004	0.0001	0.002	0.01	0.005
	Average	6.58	103.6	0.26	30	74.21	1.54	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02
	Median	6.64	86	0.25	21.5	75	1.66	0.002	0.05	0.00055	0.001	0.008	0.008	0.0001	0.008	0.01	0.025
	No. of samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Trigger Level ⁴		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁵		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁴ Receiving Water Trigger Levels – EA Schedule F Table 2.

⁵ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data 30 March to 2 May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Belmore Creek D/S	Maximum	7.27	66	0.2	8	35	2.1	0.019	0.05	0.0003	0.002	0.002	0.004	0.0001	0.003	0.01	0.011
	Minimum	6.58	32	0.1	2	8.9	0.08	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.93	42.44	0.12	4.33	22.36	0.71	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.97	39	0.1	4	22.3	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ⁶		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁷		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Additional Belmore Creek Downstream Sites																	
Belmore Creek Downstream	BCDS1 (Sample 1)	6.97	38	0.1	3	28	0.14	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 2)	6.94	40	0.2	4	23	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 3)	6.98	39	0.1	3	23	0.19	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS2	7.02	38	0.1	3	25	0.44	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS3	7.05	39	0.1	3	23	0.41	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS4	7.05	39	0.1	3	23	0.19	0.009	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ⁶		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁷		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁶ Receiving Water Trigger Levels – EA Schedule F Table 2.

⁷ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

ATTACHMENT 2

STREAM SEDIMENT MONITORING RESULTS

Released

Attachment 2
Summary of Stream Sediment Results from April 2011

Location	Site ¹	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Hg (mg/kg)	Zn (mg/kg)
Belmore Creek Up-stream	SW7	620	5	50	1	3	2	5	2	5	0.1	5
	SW6	3,300	6	50	1	6	4	5	3	5	0.1	13
	BCUS1	3,480	27	50	1	4	2	9	2	5	0.3	56
	BCUS2	2,110	160	50	1	7	2	6	2	5	0.6	30
	BCUS3	1,900	98	50	1	5	2	5	2	5	0.4	22
Belmore Creek Downstream	DSDi	2,580	76	50	1	6	2	8	2	5	0.3	14
	BCDS1	3,190	74	50	1	10	8	24	3	5	0.7	30
	BCDS2	1,860	50	50	1	5	2	5	2	5	0.5	21
	BCDS3	1,240	73	50	1	3	2	5	2	5	0.3	18
	BCDS4	1,630	97	50	1	3	2	5	2	5	0.6	22
Trigger Level ²		NA	20	NA	1.5	80	NA	65	21	NA	0.15	200
Contaminant Limit ³		1,240	70	100	10	370	4	270	52	10	1	410

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 5 of the EA.

³ Contaminant limits as defined Schedule F- Table 6 of the EA.

NA – Not Available (insufficient data to calculate relevant trigger level in accordance with Schedule F- Table 5).

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28 April 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2316
MT ISA QLD 4825

Attention: Alex Apostol

Project: Croydon Gold Mine

Subject: Follow-up Advice of Incident – Croydon Gold Mine - Environmental Authority
MIN100401906 (ML 5248)

Dear Alex,

In accordance with Condition A4-4 of the Croydon Gold Mine Environmental Authority (EA) No. MIN100401906, this advice has been prepared in response to the recorded surface water outflows from the Content Pit at the Croydon Gold Mine in follow-up to the initial notification provided to you on 30 March 2011 and the formal notification submitted on the 14 April 2011. Condition A4-4 of the EA provides:

A4-4 As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.

Condition F1-3 of the EA is also relevant to this advice and has been reproduced below.

F1-3 Receiving waters must be monitored at the locations defined in Schedule F – Table 1 & Schedule H – Map 2 for parameters identified in Schedule F – Table 2 & Table 3 and at a frequency of:

For the routine monitoring of receiving waters:

- *Twice yearly once during wet season (January - March) & once during dry season (July - September)*
- *Event based sampling of discharge¹ or flow events²:*
 - *One representative sample must be taken of a discharge event¹ or flow event².*
 - *Where a discharge¹ or flow event² has a duration of 24 hours or greater, samples must be taken daily for one week, and once a week thereafter.*

¹ *Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.*

² *Flow event is a surface water flow in Slaughteryard Creek and / or Belmore Creek that occurs as a result of rainfall.*

Note: Where discharge events¹ or flow events² occur simultaneously only one set of samples are required to be taken. No sample is required where there is insufficient flow during the dry season (July - September).

Released

As reported in the formal notification of the incident, an initial series of samples were taken between 30 March 2011 and 1 April 2011 subsequent to the recorded surface water outflows from the Content Pit from various sites (see Figure 1) for the full range of parameters specified in Schedule F Tables 2 and 3 of the EA. The analytical results for these samples have been received from ALS Laboratory Services and are reproduced in Table 3. In accordance with EA Condition F1-3 weekly sampling has been continued from the various sample sites selected to monitor the potential impact of the outflow from Content Pit, with field data provided in Table 2. Analytical laboratory results from these samples and for those samples previously submitted for the period 5 April 2011 to 7 April 2011 will also be reported when available.

Initial Analytical Results and Interpretation

The indication from the initial field meter readings previously reported was that the recorded surface water outflows from the Content Pit are diluted from flows of rain/surface water. Further, there was no significant difference between the upstream and downstream Belmore Creek sample sites. These hypotheses are supported by the analytical results from the samples taken between 30 March 2011 and 1 April 2011 (see Table 3). The data for pH, electrical conductivity and sulphate concentration from Table 3 are plotted against sample site and date in Figure 2. Sample sites in Figure 2 are plotted approximately in order starting with the Content Pit discharge moving successively further downstream (see Figure 1 for sample site locations).

It is clearly evident in Figure 2 that flows of rain/surface water successively dilute the discharge from Content Pit as the flow progressed to the SW5 and then the Mine Drainage sample locations. The observed electrical conductivity and sulphate concentration being decreased by more than approximately 50%. Sample site SW6 is located at a large stock water dam which was physically verified as being isolated from any possible inputs from the Content Pit discharge. Overflow from the stock water dam at SW6 mixes downstream with the drainage line which carries the discharge from the Content Pit, and the result of this mixing is monitored by the sample site "conf". This mixing at sample site "conf" results in pH, electrical conductivity and sulphate concentration at comparable levels to that observed at both the upstream sample locations on Belmore Creek. Further, the observed pH, electrical conductivity and sulphate concentration gives no evidence of a downstream influence in Belmore Creek due to the discharge from the Content Pit. Similar observations and conclusions can be drawn in terms of metal concentrations as depicted by Figure 3.

Results from Continued Field Observations

In accordance with EA Condition F1-3 weekly sampling has been continued from the various sample sites selected to monitor the potential impact of the outflow from Content Pit, with field data provided in Table 2. This continued monitoring continues to show that the discharge from Content Pit is not producing a significant difference in the pH/EC results of the upstream and downstream Belmore Creek sample sites.

It was observed during the site visit of the 13 April 2011 that discharge from the Content Pit had decreased sufficiently that there was no longer a surface flow at the "mine drainage" sample location. Following the drainage line upstream it was observed that the discharge from Content Pit still exited the lease boundary at the SW5 sample location, but the resultant surface sheet flow infiltrated/evaporated within approximately 100 meters of this location. This off-lease flow at the SW5 location had ceased by 21 April 2011 with field observation showing that discharge from Content Pit, while stilling occurring, was ponding immediately downstream of the v-drain exiting the pit and infiltrating/evaporating at this point.

Estimation of the flow rate of the discharge from the Content Pit was commenced on the 5 April 2011 using the "velocity area" method. The cross-sectional area of flow in the v-drain was measured together with an estimate of the velocity by timing the distance travelled by a floating object over a set distance of five (5) meters. The results of these flow rate estimates are provided in Table 4 and plotted in Figure 4. While these estimates clearly lack precision and accuracy, they are relative over time and provide an indication that the discharge from Content Pit is likely to cease by the end of April or during early May.

Should you require any further information regarding this advice, please do not hesitate to contact me on CTPI

CTPI 49-S

Yours sincerely

BARRICK (AUSTRALIA PACIFIC) LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

Table 1: Sample sites selected to monitor the potential impact of the outflow from Content Pit

Sample Site ¹	Sample Site Description
Content Pit	The point where water was flowing from the Content Pit.
SW5	The on-site surface water monitoring site located on the ML5248 boundary.
Mine Drainage	The defined channel draining the surface water outflows from the Content Pit. Other surrounding surface water flows also drain to this defined channel.
Conf	The confluence of flow from the Mine Drainage channel with the separate channel draining the outflows from SW6. ²
Belmore Creek Upstream	Upstream of where the drainage channel enters Belmore Creek.
Belmore Creek Downstream	Downstream of where the drainage channel enters Belmore Creek.

¹ See Figure 1 for sample site location.² After the Confluence of these two drainage channels, the combined streams flow within a drainage channel to enter Belmore Creek after approximately one kilometre.

Table 2: March - April 2011 Water Quality – Field Data

Sample Site ¹	Sample Date	pH	EC (µS/cm)
Upstream Monitoring Sites			
SW7	30 th March 2011	7.12	230
	5 th April 2011	7.17	151
	13 th April 2011	6.48	47
	21 st April 2011	6.69	58
SW6 ²	30 th March 2011	6.39	199
	5 th April 2011	6.92	97
Belmore Creek Upstream	30 th March 2011	6.41	193
	31 st March 2011	6.35	195
	1 st April 2011	6.24	196
	5 th April 2011	6.67	48
	6 th April 2011	6.37	51
	7 th April 2011	6.57	50
	13 th April 2011	6.51	47
	21 st April 2011	6.97	60
On-site Monitoring Sites			
Content Pit	30 th March 2011	4.14	892
	31 st March 2011	4.12	886
	1 st April 2011	4.14	878
	5 th April 2011	4.44	702
	6 th April 2011	4.13	827
	7 th April 2011	4.14	835
	13 th April 2011	4.32	846
	21 st April 2011	4.24	870

¹ See Figure 1 for sample site location.² No further field sampling was conducted at site SW6 on 31 March 2011 and 1 April 2011 as the recorded surface water outflows from the Content Pit do not enter SW6. Site SW6 is located east of the defined Mine Drainage channel and outflows from SW6 are drained via a separate drainage channel (see Figure 1).

Table 2 Continued: March - April 2011 Water Quality – Field Data

Released

Sample Site ¹	Sample Date	pH	EC (µS/cm)
On-site Monitoring Sites			
SW5	30 th March 2011	3.91	557
	31 st March 2011	4.01	706
	1 st April 2011	4.03	603
	5 th April 2011	3.96	800
	6 th April 2011	3.91	705
	7 th April 2011	3.90	808
	13 th April 2011	3.83	746
	21 st April 2011	3.80	700
Downstream Monitoring Sites			
Mine Drainage	30 th March 2011	5.13	355
	31 st March 2011	5.31	326
	1 st April 2011	5.43	298
	5 th April 2011	5.11	316
	6 th April 2011	4.95	347
	7 th April 2011	5.18	326
	13 th April 2011	6.01	101
	21 st April 2011	dry	dry
Confluence	30 th March 2011	6.36	242
	31 st March 2011	6.29	232
	1 st April 2011	6.41	218
	5 th April 2011	5.67	267
	6 th April 2011	5.95	173
	7 th April 2011	6.17	130
	13 th April 2011	6.68	102
	21 st April 2011	7.24	82
Belmore Creek Downstream	30 th March 2011	6.47	207
	31 st March 2011	6.44	193
	1 st April 2011	6.49	194
	5 th April 2011	6.65	50
	6 th April 2011	6.39	54
	7 th April 2011	6.52	48
	13 th April 2011	6.50	49
	21 st April 2011	7.00	63

¹ See Figure 1 for sample site location.

Release

Table 3: Analytical Data for initial samples taken 30 March 2011 to 1 April 2011

Sample Site	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Content Pit	30/03/2011	3.91	782	0.8	300	1.37	0.004	0.0024	0.095	0.059	0.091	0.242	<0.05	<0.01	<0.0001	0.002	1.2
Content Pit	31/03/2011	3.96	740	0.8	303	1.36	0.004	0.0022	0.093	0.057	0.089	0.235	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	1/04/2011	3.98	737	1.2	301	1.38	0.005	0.0021	0.090	0.056	0.087	0.229	<0.05	<0.01	<0.0001	0.002	1.1
Mine Drainage	30/03/2011	5.11	236	1.1	75	0.71	0.002	0.0032	0.041	0.030	0.036	0.142	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	31/03/2011	5.19	192	1.0	80	0.69	0.002	0.0032	0.040	0.029	0.035	0.143	<0.05	<0.01	<0.0001	0.001	0.5
Mine Drainage	1/04/2011	5.56	168	5.3	56	0.37	0.002	0.0028	0.029	0.025	0.027	0.115	<0.05	<0.01	<0.0001	0.001	0.4
Conf	30/03/2011	6.82	88	44.2	20	2.02	0.002	0.0007	0.009	0.020	0.009	0.028	<0.05	<0.01	<0.0001	0.002	0.2
Conf	31/03/2011	6.74	68	44.9	20	2.42	0.002	0.0006	0.009	0.008	0.009	0.029	<0.05	<0.01	<0.0001	0.001	0.2
Conf	1/04/2011	6.83	60	54.6	13	2.24	0.002	0.0005	0.007	0.007	0.007	0.026	<0.05	<0.01	<0.0001	0.002	0.1
SW5	30/03/2011	3.81	428	1.2	160	4.83	0.003	0.0137	0.089	0.278	0.093	0.492	<0.05	<0.01	<0.0001	0.001	1.0
SW5	31/03/2011	3.96	565	0.8	239	4.61	0.003	0.0113	0.106	0.232	0.103	0.478	<0.05	<0.01	<0.0001	0.002	1.2
SW5	1/04/2011	3.99	462	1.5	176	3.90	0.003	0.0091	0.089	0.195	0.082	0.385	<0.05	<0.01	<0.0001	0.002	1.0
SW7	30/03/2011	6.93	102	37.3	24	1.23	0.004	<0.0001	0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	31/03/2011	6.63	102	35.3	23	1.53	0.004	<0.0001	<0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	1/04/2011	6.77	102	25.1	20	1.23	0.004	<0.0001	0.001	0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
Belmore u/s	30/03/2011	6.83	37	22.6	2	1.28	0.005	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore u/s	31/03/2011	6.73	39	27.5	2	1.15	0.004	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	<0.1
Belmore u/s	1/04/2011	6.95	40	29.7	4	1.14	0.005	<0.0001	0.001	0.002	0.002	<0.007	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore d/s	30/03/2011	7.05	38	22.3	2	1.24	0.004	<0.0001	<0.001	0.004	0.001	<0.005	<0.05	<0.01	<0.0001	0.001	<0.1
Belmore d/s	31/03/2011	6.58	38	22.0	2	1.51	0.005	<0.0001	0.001	0.002	0.001	<0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore d/s	1/04/2011	6.77	50	35.0	7	2.10	0.004	0.0003	0.002	0.004	0.003	0.011	<0.05	<0.01	<0.0001	0.002	0.1
SW6	30/03/2011	6.99	40	83.2	<1	4.82	0.002	<0.0001	<0.001	0.002	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	0.1

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Table 4: Content Pit Discharge Estimated Flow Rate

Date	time (secs) for 5m	width (m)	depth (m)	flow rate m3/s	flow rate L/s
5/04/2011 6:00	17.5	0.75	0.05	0.011	10.7
5/04/2011 18:00	16.5	0.7	0.05	0.011	10.6
6/04/2011 7:00	18	0.7	0.05	0.010	9.7
6/04/2011 18:00	19	0.7	0.05	0.009	9.2
13/04/2011 15:30	25	0.5	0.03	0.003	3.0
21/04/2011 16:00	50	0.4	0.02	0.001	0.8

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Figure 1: Sample Site Location

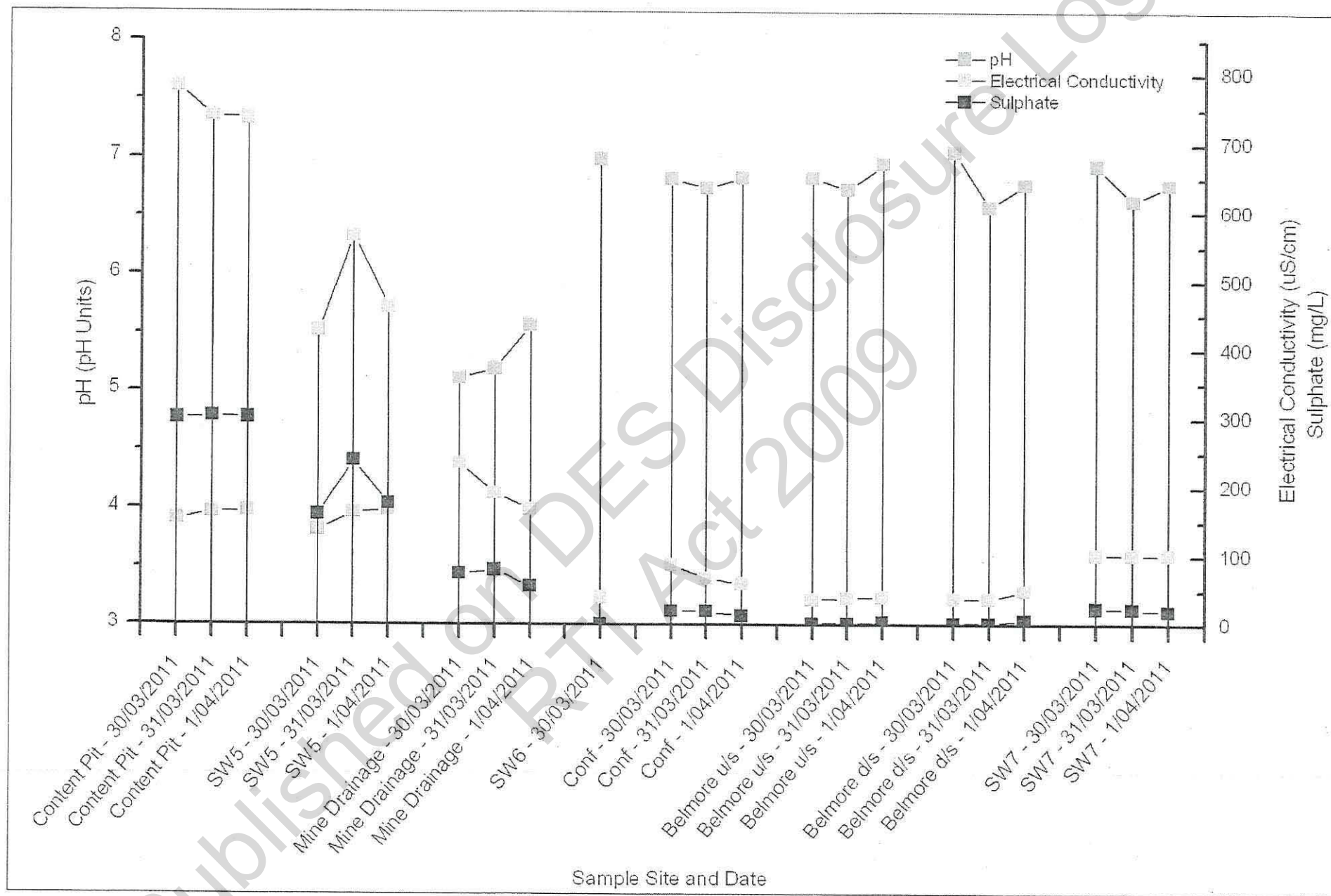


Figure 2: Sample site and date versus pH, electrical conductivity and sulphate

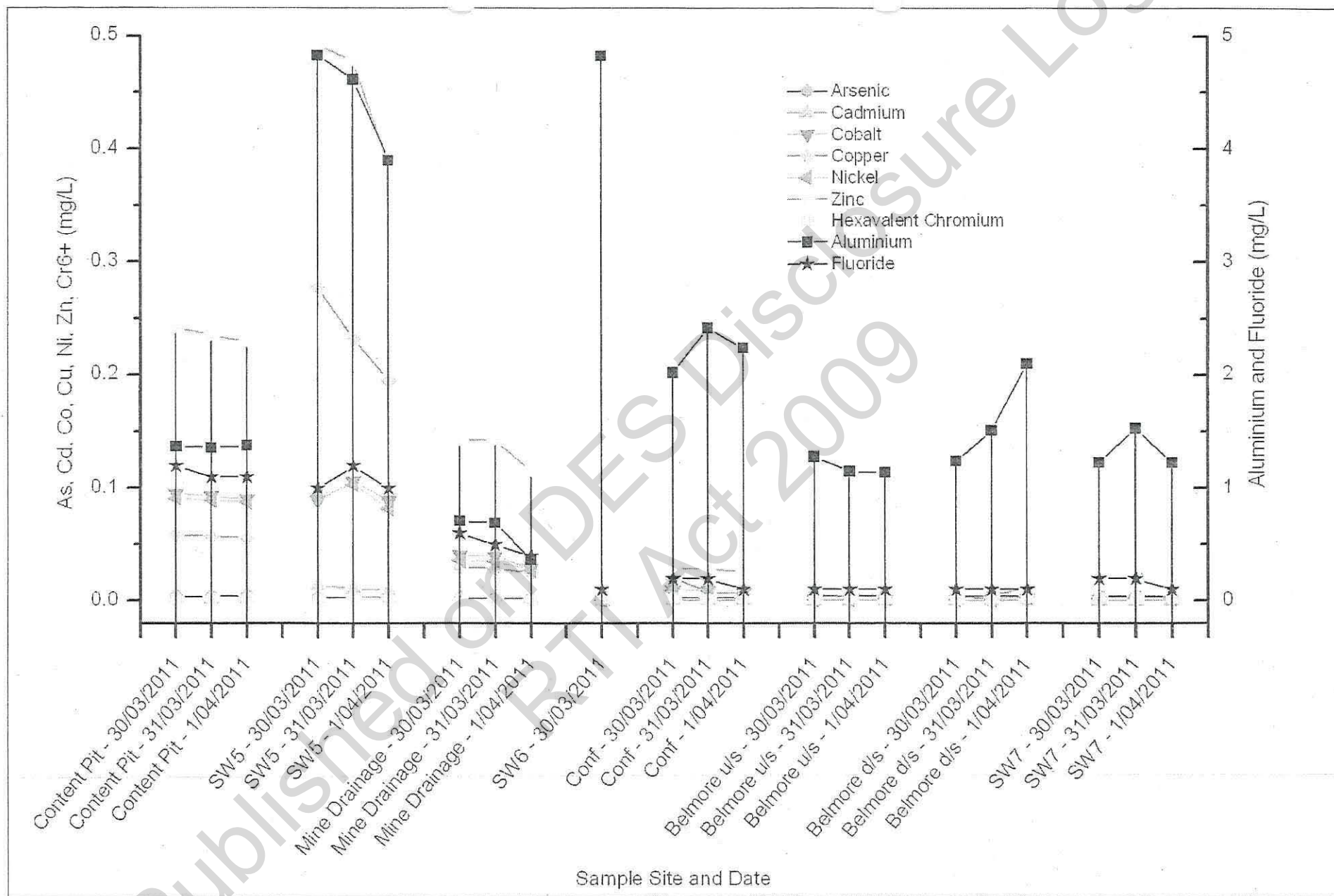


Figure 3: Sample site and date versus metal concentrations

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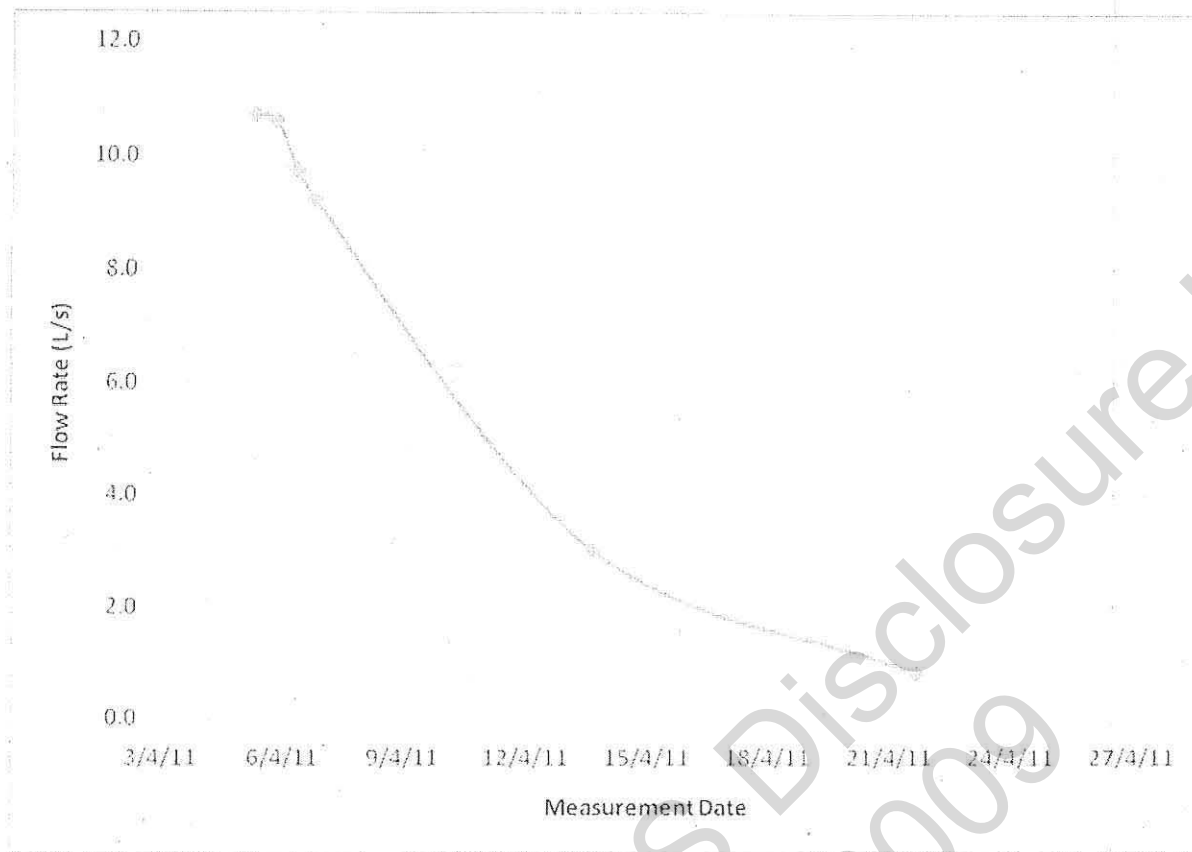


Figure 4: Content Pit Discharge Estimated Flow Rate versus Date

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BARRICK

CNS 1741 14/1/37
BARRICK (AUSTRALIA PACIFIC)
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14 April 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2066
CAIRNS QLD 4870

Attention: Neil Maver

Project: Croydon Gold Mine

Subject: Advice of Incident – Croydon Gold Mine - Environmental Authority
MIN100401906 (ML 5248)

Dear Neil,

In accordance with Condition A4-3 of the Croydon Gold Mine Environmental Authority (EA) No. MIN100401906, this advice has been prepared by Barrick (Australia Pacific) Limited (Barrick), operator of the Croydon Gold Mine, in response to the recorded surface water outflows from the Content Pit at the Croydon Gold Mine in follow-up to the initial notification provided to you on 30 March 2011. Condition A4-3 of the EA provides:

Within fourteen (14) days following the initial notification of an emergency or incident, further written advice must be provided to the administering authority, including the following:

- (a) *results and interpretation of all samples taken and analysed (if available, if not yet available nominate a timeframe);*
- (b) *outcomes of actions taken at the time to prevent or minimise environmental harm; and*
- (c) *proposed actions to prevent a recurrence of the emergency or incidence.*

Conditions A4-4 and F1-3 of the EA are also relevant to this advice and have been reproduced below.

A4-4 As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.

F1-3 Receiving waters must be monitored at the locations defined in Schedule F – Table 1 & Schedule H – Map 2 for parameters identified in Schedule F – Table 2 & Table 3 and at a frequency of:

For the routine monitoring of receiving waters:

- *Twice yearly once during wet season (January - March) & once during dry season (July - September)*

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Event based sampling of discharge¹ or flow events²:

- One representative sample must be taken of a discharge event¹ or flow event².
- Where a discharge¹ or flow event² has a duration of 24 hours or greater, samples must be taken daily for one week, and once a week thereafter.

¹ Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.

² Flow event is a surface water flow in Slaughteryard Creek and / or Belmore Creek that occurs as a result of rainfall.

Note: Where discharge events¹ or flow events² occur simultaneously only one set of samples are required to be taken. No sample is required where there is insufficient flow during the dry season (July – September).

Background

Barrick (Kalgoorlie) Ltd holds EA No. MIN100401906 for the former Croydon Gold Mine located on Mining Lease (ML) 5248 to the immediate west of the Croydon Township, 560 kilometres west of Cairns, Queensland. The Project was formerly a low grade gold mine and has since been closed and decommissioned. Activities at the former Croydon Gold Mine now only involve maintenance, monitoring, investigations and reclamation works (as required).

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (see Figure 1). In recognition of the diminishing storage capacity within the Content Pit, Barrick was granted approval by the DERM on 23 September 2010 to undertake short-term remediation works involving the transfer of water from the Content Pit to the Golden Butterfly Pit to increase the storage capacity of the Content Pit.

As a result of the works, the water level within the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit).

However, since completion of the works the 2010/2011 wet season has again resulted in yet another extraordinary wet season rainfall total. Subsequent to the further heavy rainfall, observations of the pit lake water levels on 23 February 2011 indicated that the storage capacity within the Content Pit had again diminished. In recognition of the diminished storage capacity within the Content Pit since the works conducted during November and December 2010 DERM was notified by phone on 24 March 2011 of the following points:

- Barrick had completed the approved short-term remediation works to minimise the potential risk of the Content Pit over-topping during the 2010/2011 wet season. The works included transferring water from the Content Pit to the Golden Butterfly Pit.
- Since completion of the works, Barrick has continued undertaking regular monitoring of the pit lake water levels as a component of the additional hydrogeological investigations required in accordance with the EA.
- Observations of the pit lake water levels on 23 February 2011 following the heavy rainfall conditions in Northern Queensland indicated that the remaining freeboard of the Content and Lady Isabella Pits was approximately 1.5 m and 3 m respectively.
- Given the remaining freeboard of these pits, it was considered that should further heavy rainfall be experienced, there is potential for the Content Pit and Lady Isabella Pit to spill during this wet season.
- Water quality monitoring (conducted on 23 February 2011) of the Content and Lady Isabella Pits indicated pH results of 4.59 and 4.10 respectively and EC results of 810 μ S/cm and 530 μ S/cm respectively.
- Access to the site to recommence water transfer works was restricted due to the recent heavy rainfall conditions. As a result, Barrick was unable to access the site to undertake similar short-term works to minimise the potential spill risk.

- Notwithstanding the above, Barrick will:

- continue to undertake regular monitoring of the pit lake water levels and water quality; and
- continue hydrogeological investigations during this wet season in accordance with the EA, including detailed water balances for each pit lake to confirm the preliminary pit water balance modelling results and to guide the long-term management requirements for the site.

Due to inaccessibility of the site during the 2010/2011 wet season, Barrick retains the services of a local resident to visually monitor the site, in particular the pit lake levels. Barrick was informed by the local resident on the 29th March 2011 that the Content Pit was full and surface water outflows from the pit were observed due to the recent heavy rainfall conditions. A Barrick representative visited the site on the 30th March 2011 and confirmed the surface water outflows from the Content Pit and notified the Department of Environment and Resource Management (DERM) by telephone as required by EA Conditions A4-1 and A4-2 and began monitoring and sampling as per EA Condition F1-3.

No surface water outflows have been recorded from any of the other open pits, viz Lady Isabella, Golden Butterfly and Golden Butterfly North open pits.

The results of field water quality monitoring conducted during February 2011 prior to the recorded surface water outflows from the Content Pit are provided in Table I.

Table I: February 2011 Water Quality

Location	Sample Site ¹	Sample Date	pH	Electrical Conductivity (µS/cm)
Belmore Creek Upstream EA Monitoring Site	SW7	23 February 2011	7.10	239
On-site EA Monitoring Sites	Content Pit	23 February 2011	4.02	948
	SW5	23 February 2011	5.69	441
Belmore Creek Downstream EA Monitoring Site	SW6	23 February 2011	6.97	169

¹ See Figure 2 for sample site location.

Initial Field Results and Interpretation

Sample site selection to monitor the potential impact of the recorded surface water outflows from the Content Pit is based upon the following:

Sample Site ¹	Sample Site Description
Content Pit	The point where water was flowing from the Content Pit.
SW5	The on-site surface water monitoring site located on the ML5248 boundary.
Mine Drainage	The defined channel draining the surface water outflows from the Content Pit. Other surrounding surface water flows also drain to this defined channel.
Conf	The confluence of flow from the Mine Drainage channel with the separate channel draining the outflows from SW6. ²
Belmore Creek Upstream	Upstream of where the drainage channel enters Belmore Creek.
Belmore Creek Downstream	Downstream of where the drainage channel enters Belmore Creek.

¹ See Figure 2 for sample site location.

² After the Confluence of these two drainage channels, the combined streams flow within a drainage channel to enter Belmore Creek after approximately one kilometre.

Initial field data for pH and Electrical Conductivity (EC) from sampling undertaken between 30 March 2011 and 1 April 2011 subsequent to the recorded surface water outflows from the Content Pit are given in Table 2. Water samples were collected from various sites (see Figure 2) for the full range of parameters specified in Schedule F Tables 2 and 3 of the EA. The samples collected during the period 30th March 2011 to 1st April 2011 inclusive have been submitted to ALS Laboratory Services in Brisbane with analytical results expected within two weeks (i.e. by mid April 2011). Additional samples were collected daily during the period 5th April 2011 to 7th April 2011. Analytical results from subsequent samples as required by EA Condition F1-3 will also be available within the same time frame after submission to ALS.

Table 2: March - April 2011 Water Quality

Sample Site ¹	Sample Date	pH	EC (µS/cm)
Upstream Monitoring Sites			
SW7	30 th March 2011	7.12	230
SW6 ²	30 th March 2011	6.39	199
Belmore Creek Upstream	30 th March 2011	6.41	193
	31 st March 2011	6.35	195
	1 st April 2011	6.24	196
On-site Monitoring Sites			
Content Pit	30 th March 2011	4.14	892
	31 st March 2011	4.12	886
	1 st April 2011	4.14	878
SW5	30 th March 2011	3.91	557
	31 st March 2011	4.01	706
	1 st April 2011	4.03	603
Downstream Monitoring Sites			
Mine Drainage	30 th March 2011	5.15	355
	31 st March 2011	5.31	326
	1 st April 2011	5.43	298
Confluence	30 th March 2011	6.36	242
	31 st March 2011	6.29	232
	1 st April 2011	6.41	218
Belmore Creek Downstream	30 th March 2011	6.47	207
	31 st March 2011	6.44	193
	1 st April 2011	6.49	194

¹ See Figure 2 for sample site location.

² No further field sampling was conducted at site SW6 on 31 March 2011 and 1 April 2011 as the recorded surface water outflows from the Content Pit do not enter SW6. Site SW6 is located east of the defined Mine Drainage channel and outflows from SW6 are drained via a separate drainage channel (see Figure 2).

The initial field EC/pH results from the recorded surface water outflows from the Content Pit compared to the initial field results from surrounding standing surface waters allowed relatively confident delineation of the physical extent of possible impact. The indication from the initial field meter readings is that the recorded surface water outflows from the Content Pit are diluted from flows of rain/surface water and in terms of pH/EC are approximately comparable with the background surface water levels at the sample site Conf. There is no significant difference in the pH/EC results of the upstream and downstream Belmore Creek sample sites.

Actions Taken

A baseline macroinvertebrate survey in Belmore Creek was scheduled to be performed by FRC Environmental prior to end of the current wet season. In light of the surface water outflows from the Content Pit, this survey has been brought forward with FRC Environmental commencing the survey on the 4th April 2011. This survey is being conducted in accordance with the Australian River Assessment System (AUSRIVAS) methodology.

Barrick has also notified the relevant landholder downstream of the Croydon Gold Mine of the incident.

In accordance with EA Condition A4-4, the analytical results of the surface water sampling submitted to the ALS Laboratory since 30 March 2011 and the macroinvertebrate survey results (if available) will be provided to the DERM no more than six weeks following the conduct of the monitoring.

Once the results of the surface water quality monitoring have been received and the outcomes of the macroinvertebrate survey in Belmore Creek have been determined, Barrick will assess the options available for preventing a recurrence of the incident and the requirement for management measures. Should management measures be required, consultation with the DERM will be undertaken prior to commencing any works.

As discussed with the DERM by telephone on 23 March 2011, Barrick is continuing to undertake monitoring in accordance with Condition F1-3 of the EA and is continuing to undertake hydrogeological investigations during this wet season in accordance with Condition F4-6 of the EA.

Should you require any further information regarding this advice, please do not hesitate to contact me on

CTPI 49-Sch4

Yours sincerely,

BARRICK (AUSTRALIA PACIFIC) LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

Published on DES Disclosure Log
RTI Act 2009

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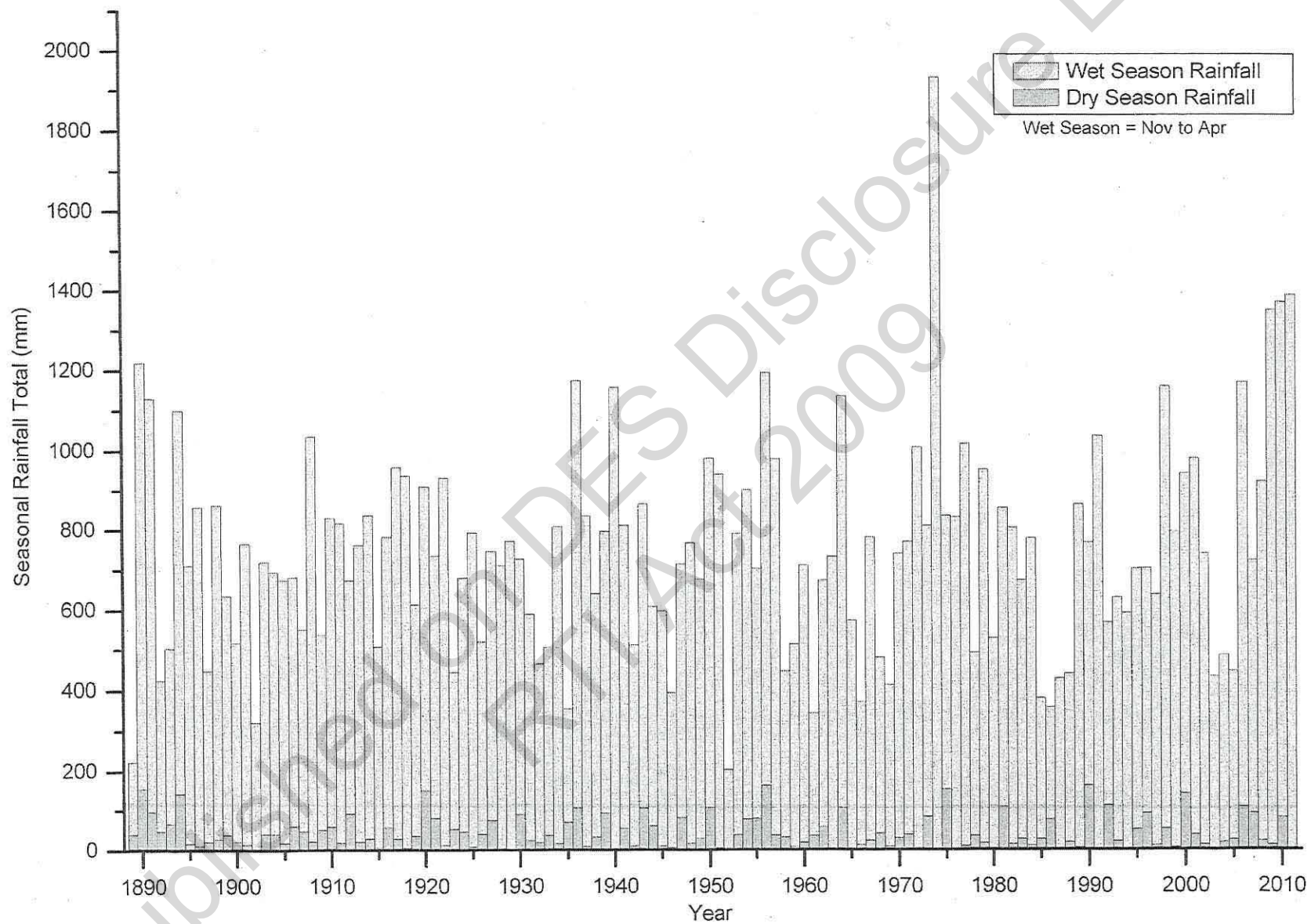


Figure 1: Seasonal Rainfall versus Time



Figure 2: Sample Site Location

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Memorandum

EA MIN100401906 (CN55741)

(EFF 23 MAR 2009)

FA- \$1,484,328

Enquiries
Telephone
Your reference
Our reference

Neil Maver
(07) 4222 5331
ML5248

22 February 2011

To: Alex Apostle
Cc Hamish Butler

From: Neil Maver

Subject: Croydon Gold Mine PMLUP

The sections below outline the requirements in the EA relating to post mine landuse and rehab followed by an assessment of how the PMLUP and Rehabilitation Monitoring Program satisfies each requirement.

Post Mine Land Use Plan

(C2-1) A Post Mine land Use Plan for the licensed place must be developed and implemented for a nominal period of:

- (a) at least thirty (30) years following the cessation of mining activities on the licensed place; or
- (b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.

The Post Mine Land Use Plan was submitted with the Plan of Operations (dated November 2008) approved on 18 December 2008 for a term of 3 years. *Expiring on Oct. 2011*

(C2-2) The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:

- (a) schematic representation of final land form inclusive of drainage features; and

A schematic representation has been included showing all mine related landforms, drainage, topography etc.

- (b) slope designs; and

Slope design was finalised during reclamation work in 1996/97 and reported in 2001. It involved battering of slopes to 3H:1V with benches of 5m and width at 5m spacing.

- (c) cover design including a report on the effectiveness of existing cover systems; and

Cover design was finalised during reclamation work in 1996/97 and reported in 2001. Further detail on its current effectiveness has been included. The cover system for WRDs consists of a clay capping layer, rock fill surface layer and topsoil. Final cover system monitoring is provided in the Rehabilitation Monitoring Program.

Grazing pressure and the results of on-site waters and receiving waters monitoring which indicate exceedences (though only short term) suggests the effectiveness of the cover system is limited in some areas.

- (d) drainage design; and

A Water Management Strategy (WMS) has been prepared that includes detail of drainage management. There is a commitment for an annual review of the WMS which should assist in assessing the effectiveness of the proposed drainage management strategies. Should surface water monitoring indicate poor performance of the surface water management system, Barrick have committed to completing further reclamation works.

- (e) erosion controls on reformed land; and

An Erosion and Sediment Control Plan (ESCP) has been prepared in accordance with Condition F5-1 of the EA. The results of the monitoring program should assist in assessing the effectiveness of the proposed erosion and sediment control measures and if necessary, the ESCP will be updated where required.

(f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design; and

A Rehabilitation Monitoring Program has been prepared and is provided as an Attachment. The Rehabilitation Monitoring Program includes three analogue monitoring sites and 12 rehabilitation monitoring sites.

(g) proposed revegetation criteria including:

- i. species diversity,
- ii. abundance and composition,
- iii. projective cover,
- iv. dry matter production and
- v. stocking rates to ensure self sustaining vegetation is maintained; and

All the above criteria have been identified as revegetation criteria and a grazing management plan has been developed.

For landforms other than the pits the rehab objective is to return the land to disturbed native habitat. Sixteen tree and shrub species were included in the seed mix used during the 1996 revegetation program. Nothing specific has been presented on the monitoring of fauna populations. Barrick argues there is a relatively low species diversity indicative of the savannah bio-region of Croydon.

(h) proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation; and

The Plan does include detail of the revegetation methods used to date including all those above. HLA-Envirosciences (2001a) reported 19 species at the vegetation monitoring sites, including seven species of *Acacias*, seven species of *Eucalypts* and five species belonging to other genera including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*. The commitment is made that where additional rehab works are required similar reveg methods to these will be implemented.

(i) materials balance including available top soil and low permeability encapsulation media for capping; and

A materials balance was identified for works complete during the 2009 dry season including volumes of available soil and encapsulation media.

(j) research program and associated milestones.

There is a commitment to undertake research programs in consultation with DERM where monitoring shows a need.

(k) geotechnical, geochemical and hydrological studies;

The Plan states that no historical geotechnical investigations have been completed. A geotechnical investigation for the Project has been conducted by a suitably qualified person and is currently under review. A risk-based approach will be used to identify areas of the site where geotechnical risk is relevant. This investigation will include the highwall of the Golden Butterfly North open pit and the railway line.

A geochemical investigation undertaken in 1996 resulted in the identification of areas with acid producing potential. The re-profiling and capping of the Golden Butterfly and Content waste rock dumps and the removal of all potentially acid generating material from the Golden Butterfly and Content stockpile hardstand areas and the Slaughteryard Creek drainage channel were conducted in 1996.

A hydrological assessment has been completed and is detailed in the PMLUP. The water management requirements and proposed drainage remediation works for the Project have been prepared and are included in the WMS. In addition to the groundwater monitoring network additional hydro-geological investigations are required by Condition F4-6 of the EA. Further hydro-geological investigation/assessment will be conducted during the 2010/11 wet season and will aim to confirm the conceptual hydro-geological model.

(l) chemical, physical and biological properties of soil and water;

It is stated that monitoring suggests soil properties of the rehab sites will support the desired landuse. Two areas of concern are high acidity on the Content dump and low nitrogen on the site in general. It is proposed to improve soil nitrogen through sowing groundcover legumes.

Hydrological assessments and monitoring have been completed in accordance with the EA. The water quality from the surface water monitoring sites is analysed to provide an indication of the rehabilitation performance at the Project.

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(m) measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type; and

Measurable completion criteria for final landforms (stable, free of erosion etc), revegetation (species diversity, abundance etc), surface water and groundwater (compliance with limits set out in the EA) have been identified.

(n) rehabilitation monitoring program, including the monitoring of:

- i. surface water quality;
- ii. groundwater quality;
- iii. erosion rates;
- iv. integrity and effectiveness of final cover of final cover systems; and
- v. health and resilience of vegetative cover

A rehabilitation program with descriptions of the above has been identified.

(o) grazing management plan, and;

A Grazing Management Plan has been included as Attachment B.

(p) Operation and maintenance of:

- i. the surface water management system;

There is a commitment for further maintenance of the system should monitoring indicate poor performance.

- ii. groundwater monitoring network;

Groundwater monitoring is being performed in accordance with the EA.

- iii. final cover systems; and

Final covers will be monitored in accordance with rehab monitoring program.

- iv. vegetative cover

Vegetation cover will be monitored in accordance with rehab monitoring program.

Rehabilitation Monitoring Program

(C3-1) The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.

Monitoring is completed annually with rehab monitoring results available from 1997 to 2001 and from 2004 to present.

The statistical validity of the vegetation monitoring requires further analysis. Barrick suggest a total of 12 transects for disturbed areas and three for analogue sites will be adequate to enable scientifically justifiable conclusions.

The incidence of erosion is monitored along similar field traverses.

(C3-2) The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.

The monitoring of receiving, onsite and groundwaters and sediment is being performed in accordance with the requirements of the EA.

(C3-3) Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.

Rehabilitation success to be verified through annual monitoring reports.

Conclusions / Recommendations:

The PMLUP and Rehab Monitoring Plan have been developed and implemented in accordance with the relevant conditions of the EA and broadly in terms of the requirements under Guideline 18. It is recommended a letter be issued requiring further review and on-site assessment including:

1. A review of the effectiveness of the experimental design used for vegetation monitoring. Further investigation on the statistical validity of the vegetation monitoring program is recommended in terms of the appropriateness of having only three analogue monitoring sites and 12 rehabilitation monitoring sites.
2. An increased emphasis on the monitoring of fauna populations as a component of rehabilitation success.

Following a response from Barrick:

- Complete a review of monitoring data supplied with the 2010 Annual Return with reference to the data provided in 2009 to determine the effectiveness of the water management strategy.
- As part of the next scheduled site inspection assess the following:
 - a) Effectiveness of the grazing management plan with reference to actual grazing regimes.
 - b) Rates of erosion on site to determine the effectiveness of the ESCP.
 - c) The performance of the WRD capping design.
 - d) The performance of vegetation growth and the need for any improvement to soil properties

Rele

1 August 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2316
MT ISA QLD 4825

Attention: Alex Apostol

Dear Alex,

Subject: Croydon Gold Mine - Results of Water Quality Monitoring and Macroinvertebrate Survey Report

As you are aware, surface water outflows were recorded from the Content Pit at the Croydon Gold Mine at the end of March and early April 2011. Initial notification of the surface water outflows was provided by Barrick Australia Pacific Limited (Barrick) to the Department of Environment and Resource Management (DERM) on 30 March 2011. A detailed description of the background to the Content Pit outflow was provided in the follow-up written advice submitted by Barrick to the DERM on 14 April 2011.

In accordance with Condition A4-4 of the Croydon Gold Mine Environmental Authority (EA) No. MIN100401906, please find attached the following results of the monitoring performed in response to the Content Pit surface water outflow:

- analytical results from surface water quality monitoring undertaken at the relevant on-site and receiving water monitoring locations defined in Schedule F – Tables 7 and 1 respectively of the EA and at other relevant sites between 30 March to 2 May 2011 (Attachment A); and
- the *Croydon Gold Mine Macroinvertebrate Survey* (report prepared by frc environmental) undertaken in Belmore Creek (and relevant tributary downstream of ML 5248) on 4 to 6 April 2011 (Attachment B).

A description of the on-site and receiving water monitoring sites is provided in Table 1 and the locations are shown on Figure 1.

Table 1
Description of On-site and Receiving Water Monitoring Sites

Sample Site ¹	Sample Site Description
Content Pit	The point where water was flowing from the Content Pit.
SW5	The on-site surface water monitoring site located on the ML5248 boundary.
Mine Drainage	The defined channel draining the surface water outflows from the Content Pit. Other surrounding surface water flows also drain to this defined channel.
Confluence	The confluence of flow from the Mine Drainage channel with the separate channel draining the outflows from SW6. ²
Belmore Creek Upstream	Upstream of where the mine drainage channel enters Belmore Creek.
Belmore Creek Downstream	Downstream of where the mine drainage channel enters Belmore Creek.

¹ See Figure 1 for sample site locations.

² After the confluence of these two drainage channels, the combined streams flow within a drainage channel to enter Belmore Creek after approximately one kilometre.



A summary of the on-site water quality monitoring results from 30 March 2011 to 2 May 2011 compared with the on-site water contaminant limits defined in Schedule F – Table 8 of the EA is provided in Table 2 below.

Table 2
Summary of Analytical Results for Relevant On-site Water Monitoring Sites

Sample Site ¹	Analyte	Contaminant Limit	Number of Exceedances	Number of Samples	Minimum	Maximum	Mean
Content Pit	pH	4 - 9 pH units	3	9	3.91	4.20	4.08
SW5	pH	4 - 9 pH units	8	9	3.75	4.38	3.93
	Fluoride	2 mg/L	2	9	1.00	2.50	1.66
	Aluminium	5 mg/L	6	9	3.90	14.90	8.45
	Cadmium	0.01 mg/L	8	9	0.0091	0.0244	0.018

¹ Refer to Figure 1.

A summary of the receiving water quality monitoring results from 30 March 2011 to 2 May 2011 compared with the receiving water trigger levels and contaminant limits defined in Schedule F – Tables 2 and 3 respectively of the EA is provided in Table 3 below.

Table 3
Summary of Analytical Results for Relevant Receiving Water Monitoring Sites

Sample Site	Parameter	pH	EC (µS/cm)	F (mg/L)	Sulphate (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
SW7 (Belmore Creek EA upstream reference site)	Maximum	7.19	153	0.2	47	40	1.53	0.013	0.05	0.0001	0.002	0.001	0.002	0.0001	0.003	0.01	0.005
	Minimum	6.63	25	0.1	1	20	0.25	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.92	83.43	0.14	17.29	29.10	0.87	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.93	102	0.1	20	25.1	0.85	0.004	0.05	0.0001	0.001	0.001	0.002	0.0001	0.002	0.01	0.005
	No. of samples.	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	-	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
SW6 – Stock Water Dam (upstream of surface water outflow pathway)	Maximum	6.99	40	0.1	1	120	4.82	0.002	0.05	0.0001	0.002	0.001	0.002	0.0001	0.002	0.01	0.005
	Minimum	6.8	32	0.1	1	83.2	2.13	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.90	36.00	0.10	1.00	101.60	3.48	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.895	36	0.1	1	101.6	3.475	0.002	0.05	0.0001	0.0015	0.001	0.0015	0.0001	0.0015	0.01	0.005
	No. of samples.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	-	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Belmore Creek u/s (upstream of surface water outflow pathway confluence with Belmore Creek)	Maximum	7.21	65	0.2	8	29.7	1.28	0.016	0.05	0.0001	0.003	0.001	0.002	0.0001	0.002	0.01	0.007
	Minimum	6.73	33	0.1	2	9.7	0.04	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.97	41.44	0.11	4.22	22.39	0.62	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.95	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Trigger Level Exceedance	-	-	-	-	Yes	-	Yes	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Trigger Level ¹		6 - 7.5	250	0.3	51.2	25.8	1.348	0.013	0.37	0.0002	0.005	0.0025	0.0046	0.0006	0.011	0.011	0.0092
Contaminant Limit ²		5 - 9	5970	2	1000	-	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2

² Receiving Water Contaminant Limits – EA Schedule F Table 3

Note: As per note 6 of Schedule F -Table 2 of the EA, comparison against trigger and contaminant limits is made to the maximum test values collected since a discharge event occurred.

Table 3 (Continued)
Summary of Analytical Results for Relevant Receiving Water Monitoring Sites

Sample Site	Parameter	pH	EC (µS/cm)	F (mg/L)	Sulphate (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Mine Drainage	Maximum	6.88	354	0.8	130	110	1.74	0.003	0.05	0.0032	0.001	0.071	0.035	0.0001	0.047	0.01	0.158
	Minimum	4.9	71	0.3	17	1	0.37	0.002	0.05	0.0001	0.001	0.001	0.008	0.0001	0.003	0.01	0.005
	Average	5.40	237	0.57	84	19.8	0.90	0.0024	0.05	0.0024	0.001	0.0444	0.0263	0.0001	0.033	0.01	0.118
	Median	5.17	236	0.6	80	6	0.71	0.002	0.05	0.0028	0.001	0.041	0.029	0.0001	0.036	0.01	0.142
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Trigger Level Exceedance	Yes	Yes	Yes	Yes	Yes	Yes	-	-	Yes	-	Yes	Yes	-	Yes	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Confluence of surface water outflow pathway with tributary of Belmore Creek	Maximum	6.83	185	0.4	64	110	2.42	0.004	0.05	0.0007	0.002	0.018	0.02	0.0001	0.013	0.01	0.037
	Minimum	6.2	60	0.1	13	44.2	0.28	0.001	0.05	0.0001	0.001	0.001	0.004	0.0001	0.002	0.01	0.005
	Average	6.58	103.63	0.26	30.00	74.21	1.54	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02
	Median	6.64	86	0.25	21.5	75	1.66	0.002	0.05	0.00055	0.001	0.008	0.008	0.0001	0.008	0.01	0.025
	No. of samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Trigger Level Exceedance	-	-	Yes	Yes	Yes	Yes	-	-	Yes	-	Yes	Yes	-	Yes	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Belmore Creek d/s (downstream of confluence of surface water outflow pathway with Belmore Creek)	Maximum	7.27	66	0.2	8	35	2.1	0.019	0.05	0.0003	0.002	0.002	0.004	0.0001	0.003	0.01	0.011
	Minimum	6.58	32	0.1	2	8.9	0.08	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.93	42.44	0.12	4.33	22.36	0.71	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.97	39	0.1	4	22.3	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	Yes	-	Yes	-	-	-	-	-	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Trigger Level ¹		6 - 7.5	250	0.3	51.2	25.8	1.348	0.013	0.37	0.0002	0.005	0.0025	0.0046	0.0006	0.011	0.011	0.0092
Contaminant Limit ²		5 - 9	5970	2	1000	-	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2

² Receiving Water Contaminant Limits – EA Schedule F Table 3

Note: As per note 6 of Schedule F -Table 2 of the EA, comparison against trigger and contaminant limits is made to the maximum test values collected since a discharge event occurred.

Actions Taken

Based on the results of the surface water quality monitoring undertaken on-site and at receiving water sites located downstream of the recorded surface water outflows from the Content Pit (Attachment A), Barrick immediately commenced an investigation into the potential for environmental harm as a result of the Content Pit outflows.

The investigation is currently being completed and includes:

- a detailed description of the monitoring programme conducted in response to the outflows;
- results of all monitoring undertaken in response to the outflows; and
- an assessment of the monitoring results in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to assess whether a stressor represents a low, possible or high risk to the aquatic ecosystem (this assessment includes a comparison of the monitoring data against ANZECC and ARMCANZ (2000) guideline trigger values and would identify the investigations conducted to determine whether or not a real risk to the ecosystem exists).

Barrick will submit the investigation including the components described above to the DERM by 31 October 2011.

Should you require any further information, please do not hesitate to contact me on CTPI 49-Sch4

Yours sincerely

BARRICK (AUSTRALIA PACIFIC) LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

ATTACHMENT A
ANALYTICAL RESULTS OF SURFACE WATER QUALITY MONITORING

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011

Sample Site ¹	Sample Date	pH	EC µS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant EA On-site Water Monitoring Sites																	
Content Pit	30/03/2011	3.91	782	0.8	300	1.37	0.004	0.0024	0.095	0.059	0.091	0.242	<0.05	<0.01	<0.0001	0.002	1.2
Content Pit	31/03/2011	3.96	740	0.8	303	1.36	0.004	0.0022	0.093	0.057	0.089	0.235	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	1/04/2011	3.98	737	1.2	301	1.38	0.005	0.0021	0.090	0.056	0.087	0.229	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	5/04/2011	4.11	781	2.1	304	1.62	0.009	0.0023	0.103	0.062	0.099	0.266	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	6/04/2011	4.11	778	3.0	304	1.55	0.008	0.0023	0.104	0.061	0.1	0.27	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	7/04/2011	4.19	783	5.8	309	1.51	0.006	0.0022	0.104	0.062	0.101	0.261	<0.05	<0.01	<0.0001	<0.001	1.5
Content Pit	13/04/2011	4.13	770	90	316	1.34	0.006	0.0021	0.101	0.057	0.096	0.244	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	21/04/2011	4.2	784	4.3	310	1.31	0.007	0.0022	0.112	0.056	0.103	0.259	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	2/05/2011	4.13	789	4.4	312	1.62	0.009	0.0025	0.101	0.061	0.097	0.279	<0.05	<0.01	<0.0001	0.002	1.4
SW5	30/03/2011	3.81	428	1.2	160	4.83	0.003	0.0137	0.089	0.278	0.093	0.492	<0.05	<0.01	<0.0001	0.001	1.0
SW5	31/03/2011	3.96	565	0.8	239	4.61	0.003	0.0113	0.106	0.232	0.103	0.478	<0.05	<0.01	<0.0001	0.002	1.2
SW5	1/04/2011	3.99	462	1.5	176	3.90	0.003	0.0091	0.089	0.195	0.082	0.385	<0.05	<0.01	<0.0001	0.002	1.0
SW5	5/04/2011	3.9	730	2	301	9.31	0.004	0.0167	0.156	0.425	0.152	0.692	<0.05	<0.01	<0.0001	0.001	1.7
SW5	6/04/2011	3.89	757	3.9	311	8.46	0.004	0.0156	0.16	0.396	0.148	0.654	<0.05	<0.01	<0.0001	0.001	1.7
SW5	7/04/2011	3.92	778	11	322	8.89	0.004	0.0154	0.164	0.395	0.157	0.662	<0.05	<0.01	<0.0001	0.001	1.7
SW5	13/04/2011	3.79	853	2	363	9.79	0.004	0.0164	0.179	0.433	0.177	0.688	<0.05	<0.01	<0.0001	0.001	2
SW5	21/04/2011	4.38	904	4.9	385	11.4	0.004	0.0192	0.202	0.534	0.19	0.771	<0.05	<0.01	<0.0001	0.001	2.1
SW5	2/05/2011	3.75	1130	3.7	491	14.9	0.004	0.0244	0.234	0.593	0.22	0.959	<0.05	<0.01	<0.0001	0.001	2.5
SW7	30/03/2011	6.93	102	37.3	24	1.23	0.004	<0.0001	0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	31/03/2011	6.63	102	35.3	23	1.53	0.004	<0.0001	<0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	1/04/2011	6.77	102	25.1	20	1.23	0.004	<0.0001	0.001	0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW7	6/04/2011	6.97	153	40	47	0.85	0.002	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.2
SW7	13/04/2011	7.19	32	20	1	0.7	0.01	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	21/04/2011	6.92	25	22	2	0.29	0.011	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	2/05/2011	7.06	68	24	4	0.25	0.013	<0.0001	<0.001	<0.001	<0.001	0.005	0.05	0.01	<0.0001	0.001	0.1
SW6*	30/03/2011	6.99	40	83.2	<1	4.82	0.002	<0.0001	<0.001	0.002	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW6*	5/04/2011	6.8	32	120	1	2.13	0.002	<0.0001	<0.001	<0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.001	0.1

¹ Refer to Figure 1.

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011 (Continued)

Sample Site ¹	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant Belmore Creek Upstream Reference Monitoring Sites																	
Belmore Creek u/s	30/03/2011	6.83	37	22.6	2	1.28	0.005	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek u/s	31/03/2011	6.73	39	27.5	2	1.15	0.004	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	<0.1
Belmore Creek u/s	1/04/2011	6.95	40	29.7	4	1.14	0.005	<0.0001	0.001	0.002	0.002	0.007	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek u/s	5/04/2011	7.02	39	26	4	0.64	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	6/04/2011	6.94	39	25	4	0.56	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.003	0.1
Belmore Creek u/s	7/04/2011	6.94	39	25	3	0.52	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	13/04/2011	7.11	42	21	4	0.16	0.016	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	21/04/2011	7	33	15	7	0.04	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek u/s	2/05/2011	7.21	65	9.7	8	0.08	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.002	0.1
Mine Drainage	30/03/2011	5.11	236	1.1	75	0.71	0.002	0.0032	0.041	0.030	0.036	0.142	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	31/03/2011	5.19	192	1.0	80	0.69	0.002	0.0032	0.040	0.029	0.035	0.143	<0.05	<0.01	<0.0001	0.001	0.5
Mine Drainage	1/04/2011	5.56	168	5.3	56	0.37	0.002	0.0028	0.029	0.025	0.027	0.115	<0.05	<0.01	<0.0001	0.001	0.4
Mine Drainage	5/04/2011	5.17	334	7.4	122	1.01	0.003	0.0026	0.066	0.034	0.047	0.158	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	6/04/2011	4.9	354	7.7	130	1.14	0.003	0.0028	0.071	0.035	0.047	0.152	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	7/04/2011	4.97	301	6	108	0.63	0.002	0.0019	0.063	0.023	0.036	0.111	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	13/04/2011	6.88	71	110	17	1.74	0.003	0.0001	0.001	0.008	0.003	0.005	<0.05	<0.01	<0.0001	0.001	0.3

¹ Refer to Figure 1.

* No further field sampling was conducted at site SW6 on 31 March 2011 and 1 April 2011 as the recorded surface water outflows from the Content Pit do not enter SW6. Site SW6 is located east of the defined Mine Drainage channel and outflows from SW6 are drained via a separate drainage channel (see Figure 1).

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011 (Continued)

Sample Site ¹	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant Receiving Water Monitoring Sites																	
Confluence	30/03/2011	6.82	88	44.2	20	2.02	0.002	0.0007	0.009	0.020	0.009	0.028	<0.05	<0.01	<0.0001	0.002	0.2
Confluence	31/03/2011	6.74	68	44.9	20	2.42	0.002	0.0006	0.009	0.008	0.009	0.029	<0.05	<0.01	<0.0001	0.001	0.2
Confluence	1/04/2011	6.83	60	54.6	13	2.24	0.002	0.0005	0.007	0.007	0.007	0.026	<0.05	<0.01	<0.0001	0.002	0.1
Confluence	5/04/2011	6.2	185	65	64	0.28	0.001	0.0007	0.018	0.008	0.013	0.037	<0.05	<0.01	<0.0001	0.001	0.4
Confluence	6/04/2011	6.34	156	90	48	0.99	0.002	0.0006	0.012	0.006	0.01	0.024	<0.05	<0.01	<0.0001	0.001	0.4
Confluence	7/04/2011	6.54	116	85	32	1.45	0.001	0.0003	0.006	0.004	0.005	0.01	<0.05	<0.01	<0.0001	0.001	0.3
Confluence	13/04/2011	6.78	84	100	23	1.87	0.002	0.0001	0.001	0.011	0.004	0.005	<0.05	<0.01	<0.0001	0.001	0.3
Confluence	21/04/2011	6.35	72	110	20	1.04	0.004	0.0001	0.001	0.01	0.002	0.005	<0.05	<0.01	<0.0001	0.001	0.2
Belmore Creek d/s	30/03/2011	7.05	38	22.3	2	1.24	0.004	<0.0001	<0.001	0.004	0.001	0.005	<0.05	<0.01	<0.0001	0.001	<0.1
Belmore Creek d/s	31/03/2011	6.58	38	22.0	2	1.51	0.005	<0.0001	0.001	0.002	0.001	0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek d/s	1/04/2011	6.77	50	35.0	7	2.10	0.004	0.0003	0.002	0.004	0.003	0.011	<0.05	<0.01	<0.0001	0.002	0.1
Belmore Creek d/s	5/04/2011	6.97	38	28	3	0.14	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	6/04/2011	6.94	40	23	4	0.45	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek d/s	7/04/2011	6.98	39	23	3	0.19	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	13/04/2011	7.06	41	21	4	0.53	0.019	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek d/s	21/04/2011	6.75	32	18	6	0.11	0.012	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	2/05/2011	7.27	66	8.9	8	0.08	0.009	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1

Refer to Figure 1.

ATTACHMENT B
CROYDON GOLD MINE
MACROINVERTEBRATE SURVEY

Croydon Gold Mine

Macroinvertebrate Survey

April 2011

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Croydon Gold Mine Macroinvertebrate Survey

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Contents

Summary	i
1 Introduction	1
1.1 Background	1
1.2 Study Area	2
2 Methods	4
2.1 Survey Design	4
2.2 Aquatic Habitat	6
2.3 Aquatic Macroinvertebrates	9
3 Results and Discussion	14
3.1 Aquatic Habitat	14
3.2 Aquatic Macroinvertebrates	23
4 Summary and Recommendations	39
4.1 Summary	39
4.2 Recommendations	39
4.3 Limitations	40
5 References	41

Tables

Table 2.1	Habitat bioassessment scores used to derive overall condition of habitats.	7
Table 2.2	ANZECC & ARMCANZ (2000) trigger values for physico-chemical water quality parameters in lowland freshwater systems in the survey area.	9

Figures

Figure 1.1	Croydon Gold Mine Location and Site Drainage.	3
Figure 2.1	Survey sites.	5
Figure 2.2	Quadrant diagram for SIGNAL 2 / Family Bi-plot.	12
Figure 3.1	View downstream at site SW7 (comparative site).	14
Figure 3.2	View upstream at site BCUS1 (comparative site).	14
Figure 3.3	View downstream at site BCUS2 (comparative site).	15
Figure 3.4	View upstream of right channel at site BCUS3 (comparative site).	15
Figure 3.5	View of tributary outflow at site SW6 (comparative site).	16
Figure 3.6	View upstream at site DSDi (potentially impacted site).	16
Figure 3.7	View across stream at site BCDS1 (potentially impacted site).	16
Figure 3.8	View upstream at site BCDS2 (potentially impacted site).	17
Figure 3.9	View upstream at site BCDS3 (potentially impacted site).	17
Figure 3.10	View upstream at site BCDS4 (potentially impacted site).	17
Figure 3.11	Habitat bioassessment scores at each site.	18
Figure 3.12	Turbidity at each site.	19
Figure 3.13	The pH at each site.	20
Figure 3.14	Electrical conductivity at each site.	21

Figure 3.15	Dissolved oxygen at each site, and the ANZECC & ARMCANZ (2000) trigger level range.	22
Figure 3.16	Total taxonomic richness for bed, edge and riffle habitats.	23
Figure 3.17	PET richness for edge, bed and riffle habitats.	24
Figure 3.18	SIGNAL 2 scores for the edge, bed and riffle habitats.	25
Figure 3.19	SIGNAL 2 / Family Bi-plot for edge, bed and riffle habitats.	26
Figure 3.20	Mean taxonomic richness in edge habitat.	27
Figure 3.21	Mean taxonomic richness in bed habitat.	28
Figure 3.22	Mean taxonomic richness in riffle habitat.	29
Figure 3.23	Mean abundance in the edge habitat.	30
Figure 3.24	Mean abundance in the bed habitat.	31
Figure 3.25	Mean abundance in the riffle habitat.	32
Figure 3.26	MDS ordination showing the differences between sites in macroinvertebrate community composition in edge habitat, and 50% similarity groupings based on CLUSTER analysis.	34
Figure 3.27	MDS ordination showing the differences between sites in macroinvertebrate community composition (averaged across replicates) in edge habitat.	35
Figure 3.28	MDS ordination showing the differences between sites in water quality (turbidity, magnesium, arsenic, copper and total phosphorus).	35
Figure 3.29	MDS ordination showing the differences between sites in macroinvertebrate community composition in bed habitat.	37
Figure 3.30	MDS ordination showing the differences between sites in macroinvertebrate community composition in riffle habitat.	38

Summary

Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the decommissioned Croydon Gold Mine. Due to extensive rainfall in the region in late 2010 and early 2011, an increase in the water level in the Content Pit occurred. Water level monitoring of the Content Pit indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. As a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

Study Area

Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment) the survey focused on Belmore Creek. A total of ten sites were surveyed in Belmore Creek and its tributaries including five comparative (upstream) sites and five potentially impacted (downstream) sites.

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Aquatic Habitat

In general, aquatic habitat condition was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation was dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, poor riparian zones and low in-stream habitat diversity.

In Situ Water Quality

In situ water quality was within the ANZECC & ARMCANZ (2000) default trigger values for lowland streams¹ in tropical Australia (and the QWQG trigger value for electrical conductivity) except for turbidity. Turbidity exceeded the upper ANZECC & ARMCANZ (2000) trigger value at all sites except one, but this was likely caused by recent rainfall (and subsequent sediment-laden runoff) in the area.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Electrical conductivity was similar at all sites, except comparative site SW7 and potentially impacted site DSDi, immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, where levels were higher. However, electrical conductivity levels were below the QWQG trigger value at all sites, including DSDi. The pH at all sites was within recommended guidelines and dissolved oxygen concentrations were only slightly below the trigger value range at two sites.

Macroinvertebrates

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities at site DSDi, which is located approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land). The overflow from Content Pit appears to have affected the macroinvertebrate taxonomic richness, abundance and community composition at this site. However, the impact appears to be confined to a small spatial area, not extending to the first downstream site on Belmore Creek (BCDS1). As such sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

¹ Streams that are at <150 m elevation.

A number of other factors such as habitat condition, land use and water quality also appear to be having an effect on macroinvertebrate communities. As a result the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

Results and Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are insufficient to fully characterise the impact of the overtopping event from the Content Pit, when compared with the influence of other factors.

Additional survey events or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area
- determine if the overtopping event from the Content Pit had a short or long term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

1 Introduction

1.1 Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine. The Croydon Gold Mine was a low-grade gold mine located west of Croydon, 560 kilometres west of Cairns. Operational mining ceased at the Croydon Gold Mine in 1990 and the mine was decommissioned in 1993. Since 1993, activities on the site have included maintenance, monitoring, investigations and reclamation works.

Mining related landforms on the site include waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures, and roads and tracks). The open pits and waste rock dumps include:

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Golden Butterfly waste rock dump
- Content Pit
- Content waste rock dump, and
- Lady Isabella Pit.

Extensive rainfall in the region in late 2010 and early 2011 led to an increase in the water level in the Content Pit at the Croydon Gold Mine. Water level monitoring indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. In late March 2011 a baseline macroinvertebrate survey was commissioned to characterise the existing environment in order to assess the risk to macroinvertebrate communities in the receiving environment if the Content Pit overtopped. However, as a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

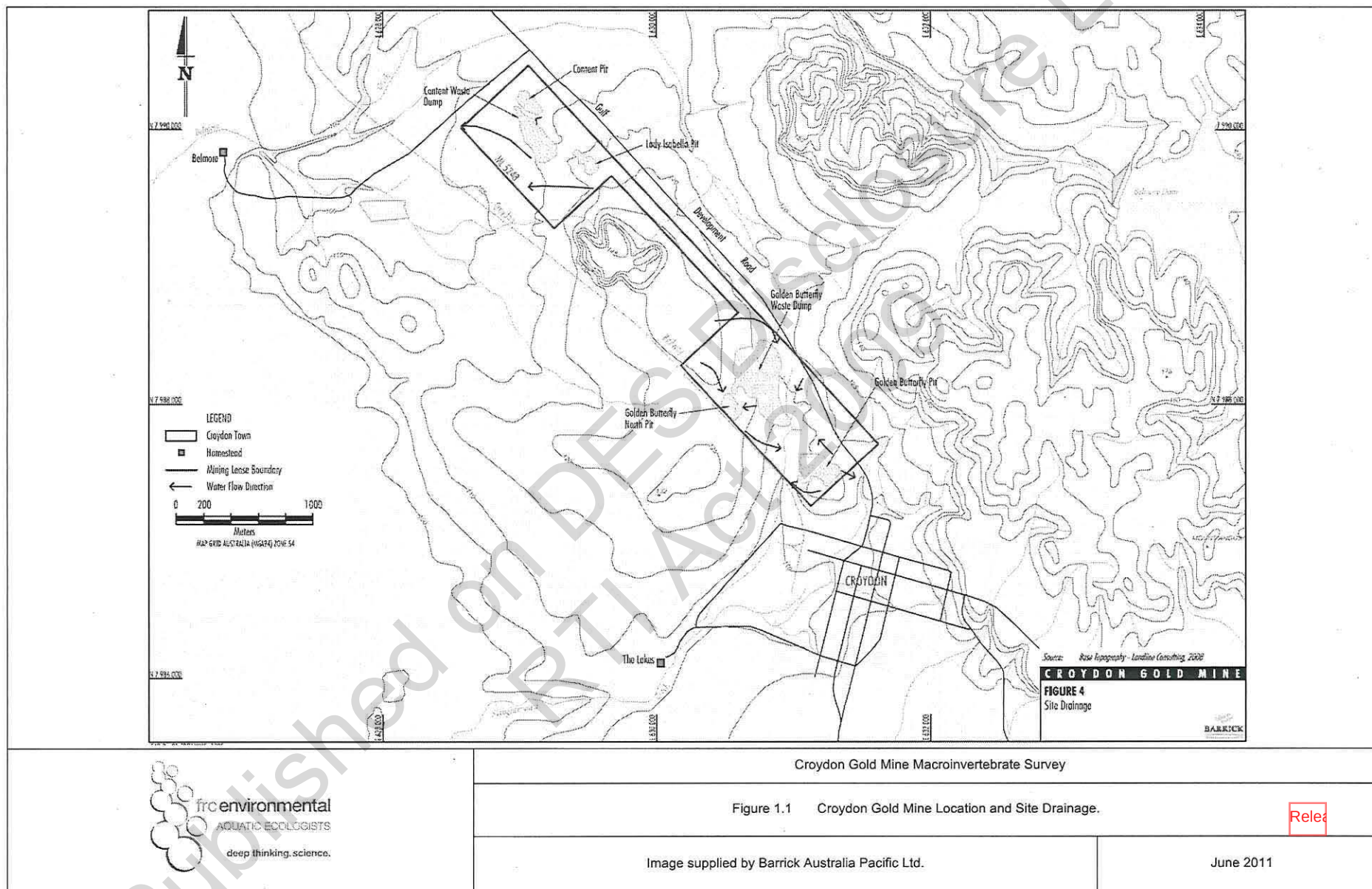
This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

1.2 Study Area

The Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall in the area is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment. There are no hydrological flow records for the mining lease, but it is believed that surface water runoff in local creeks ceases shortly after rainfall events and that sheet flow is dominant in the wet season.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment), the survey focused on Belmore Creek and its tributaries. A total of ten sites were surveyed on Belmore Creek and its tributaries, including five comparative (upstream) sites and five potentially impacted (downstream) sites (Figure 1.1).

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2 Methods

2.1 Survey Design

Survey Timing

Aquatic habitat, water quality and macroinvertebrates were surveyed between 4 and 6 April 2011.

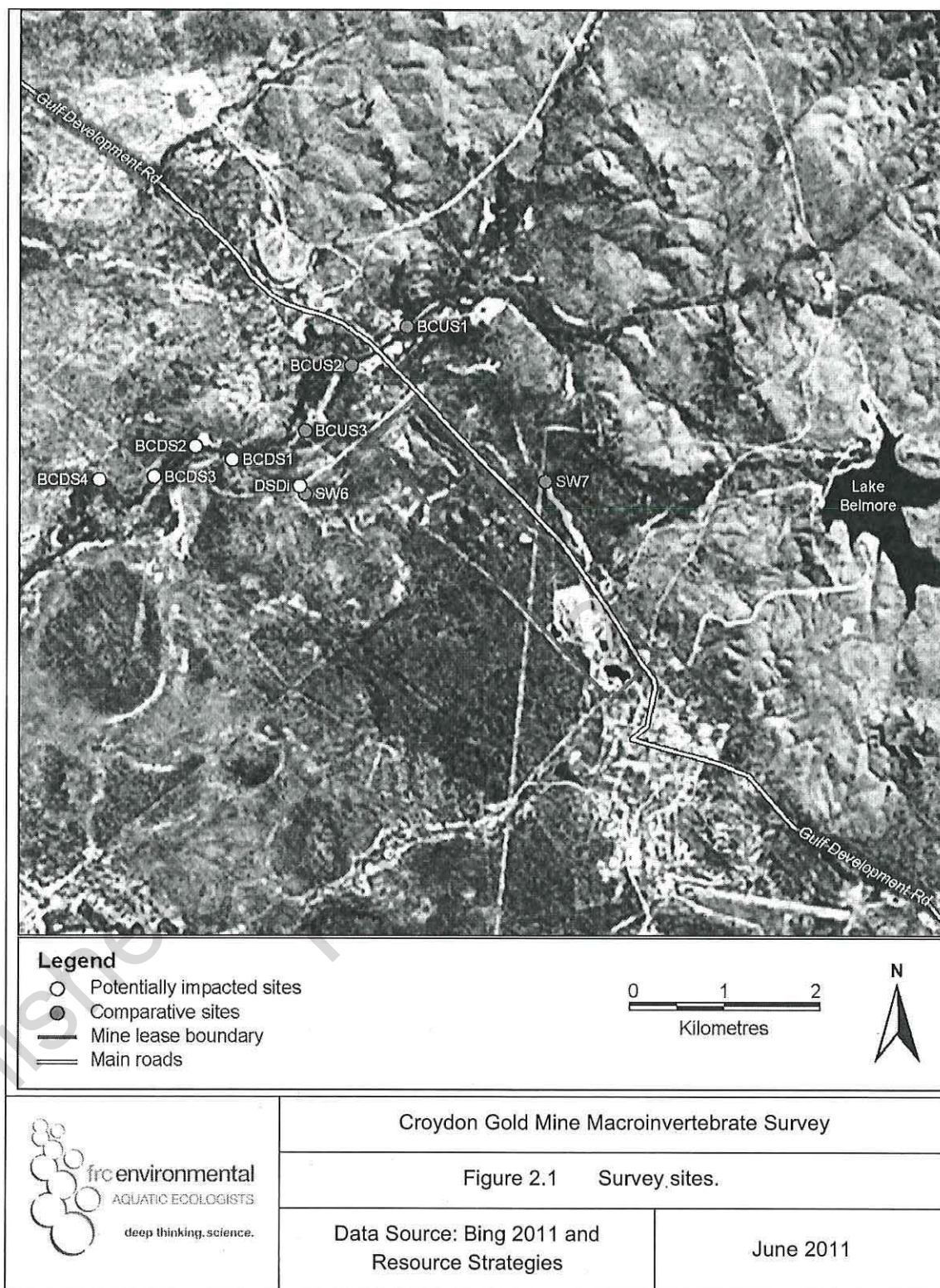
Weather was fine for the duration of the survey; there was dry track access and flowing water present in all creeks. The survey area experienced substantial rainfall in the months before the survey.

Site Details

A total of ten sites were surveyed in Belmore Creek and its tributaries by frc environmental (Figure 2.1):

- site SW7 – a comparative site, upstream of the mine, on a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- sites BCUS1, BCUS2 and BCUS3 – three comparative sites on Belmore Creek, upstream of the mining lease
- site SW6 – a comparative site, upstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- site DSDi – a potentially impacted site immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, and
- sites BCDS1, BCDS2, BCDS3 and BCDS4 – four potentially impacted sites on Belmore Creek, downstream of the confluence of the Content Pit overflow and a tributary of Belmore Creek.

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With the exception of sites SW7 and SW6, comparative sites were chosen to represent the range of aquatic habitats in the area and to match potentially impacted sites, in terms of water body type (e.g. natural channel), stream order, and environmental conditions (e.g. erosion, vegetation and available habitat). Comparative site SW7 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the mine. Site SW6 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the Content Pit overflow. Site SW6 was located on the edge of a stock dam situated on a tributary of Belmore Creek. Sampling was conducted where the Belmore Creek tributary flowed out of the stock dam. The stock dam also receives flow from natural runoff.

Limitations

The waterways in the survey area are ephemeral, and of the sites surveyed, many are likely to be dry for part of the year. Aquatic faunal communities within ephemeral waterways are highly variable over time, with community structure strongly linked to flow conditions (Smith et al. 2004). The results of this study are based on a single field survey, completed during a very wet summer period. Additional surveys would be required to assess the natural variation of the macroinvertebrate communities.

2.2 Aquatic Habitat

Aquatic Habitat for Fauna

At each site, the condition of the surrounding and in-stream habitat was described based on the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001), including an assessment of:

- reach environs (i.e. land directly adjacent to the riparian zone)
- type and condition of riparian vegetation
- availability of habitats (e.g. pools, riffles and runs)
- water depth, mean and maximum
- water velocity, mean and maximum
- bank erosion
- substrate composition
- channel diversity
- the presence of in-stream habitat (e.g. large woody debris), overhangs, undercuts, bars, and other forms of shelter, and
- physical barriers to water flow and fish passage.

Habitat Bioassessment Scores

The aquatic habitat descriptions were used to provide an assessment of the condition of habitat following the River Bioassessment Program scoring system. Based on these descriptions, each site was given a habitat assessment score following the River Bioassessment Program scoring system (DNRM 2001).

The habitat bioassessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat assessment score (Table 2.1):

- Excellent >110
- Good 75 – 110,
- Moderate 39 – 74, and
- Poor ≤38.

Table 2.1 Habitat bioassessment scores used to derive overall condition of habitats.

Habitat Category	Category Score Range			
	Excellent	Good	Moderate	Poor
Bottom substrate / available cover	16 – 20	11 – 15	6 – 10	0 – 5
Embeddedness	16 – 20	11 – 15	6 – 10	0 – 5
Velocity / depth category	16 – 20	11 – 15	6 – 10	0 – 5
Channel alteration	12 – 15	8 – 11	4 – 7	0 – 3
Bottom scouring & deposition	12 – 15	8 – 11	4 – 7	0 – 3
Pool / riffle, run / bend ratio	12 – 15	8 – 11	4 – 7	0 – 3
Bank stability	9 – 10	6 – 8	3 – 5	0 – 2
Bank vegetative stability	9 – 10	6 – 8	3 – 5	0 – 2
Streamside cover	9 – 10	6 – 8	3 – 5	0 – 2
Total (Habitat Bioassessment Score for the Site)	111 – 135	75 – 110	39 – 74	0 – 38

Water Quality

Physical water quality measurements were collected *in situ* using a Hydrolab QUANTA water quality meter. The following variables were recorded:

- water temperature (°C)
- turbidity (NTU)
- dissolved oxygen (DO, % saturation)
- pH, and
- electrical conductivity (EC, $\mu\text{S}/\text{cm}$).

The water quality meter electrical conductivity probe failed to take readings during the survey; however, water quality samples collected by Barrick Australia Pacific Ltd at the same time as the survey were analysed for electrical conductivity and those results are presented in this report.

Data Analysis

There are no relevant guidelines for intermittent and ephemeral streams of this region in the Queensland Water Quality Guidelines (QWQG) (with the exception of a preliminary guideline value for conductivity), and the QWQG advises that the default ANZECC & ARMCANZ (2000) guidelines may not be appropriate (DERM 2009). Nevertheless, in the absence of any other guidelines, the results were compared with the ANZECC & ARMCANZ (2000) default trigger values for lowland streams² in tropical Australia and the preliminary QWQG trigger value for electrical conductivity (Table 2.2), to provide an overall indication of water quality. Results at the potentially impacted sites were also compared with the results at the comparative sites during the survey.

² Streams that are at <150 m elevation.

Table 2.2 ANZECC & ARMCANZ (2000) trigger values for physico-chemical water quality parameters in lowland freshwater systems in the survey area.

Parameter	Units	ANZECC & ARMCANZ (2000)
		Trigger Values
Dissolved oxygen ³	% saturation	90 – 120
pH	pH units	6.0 – 8.0
Electrical conductivity	µS/cm	500 ⁴
Turbidity ⁵	NTU	2 – 15.0

2.3 Aquatic Macroinvertebrates

Sample Collection

AUSRIVAS Samples

At each site, single samples from each of the edge, bed and riffle habitats (where present) were also collected. This sampling followed the methods in the Queensland AUSRIVAS sampling manual, and is designed to provide a broad description of macroinvertebrate communities, rather than a quantitative assessment (DNRM 2001). A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples. A 10 m section of stream bed or edge habitat was disturbed, and a sample collected by passing the net through the disturbed area.

Quantitative Samples

At each site, five macroinvertebrate samples were collected from edge habitat and five samples were collected from the bed habitat. At sites where a riffle habitat was present, five macroinvertebrate samples were also collected from the riffle habitat. The substrate and edge habitat for edge samples was disturbed within a 30 x 30 cm area for five seconds, and each sample was then collected by sweeping a standard triangular-framed, macroinvertebrate sampling net, with 250 µm mesh, through the disturbed area five times.

³ Dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth.

⁴ Preliminary QWQG value for freshwaters in the Gulf region (75th percentile).

⁵ Low values for base flow conditions in Northern Territory rivers; Queensland turbidity values highly variable and dependent on catchment modification and seasonal rainfall runoff.

This quantitative sampling enabled a more rigorous analysis of the variability within and between sites to determine whether the overtopping from Content Pit impacted macroinvertebrate communities downstream.

Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003).

Data Analysis

Data from the potentially impacted sites was compared to background data from the comparative sites for:

- taxonomic richness
- abundance
- PET richness
- dominant taxa
- community composition, and
- SIGNAL 2 / family bi-plots.

Calculation of Indices

Taxonomic richness, PET richness and SIGNAL 2 scores were calculated for each sample. These indices were used to indicate the current ecological health of surveyed waterways.

Taxonomic Richness

Taxonomic richness is the number of taxa (in this assessment, families) present in a sample. Taxonomic richness is a basic, unambiguous and effective diversity measure. It is however, affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare and common taxa are considered equally.

Abundance

Abundance is the total number of macroinvertebrates present in a sample.

PET Richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat and water quality than in degraded sites. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score the greater the inferred degradation.

SIGNAL 2 Scores

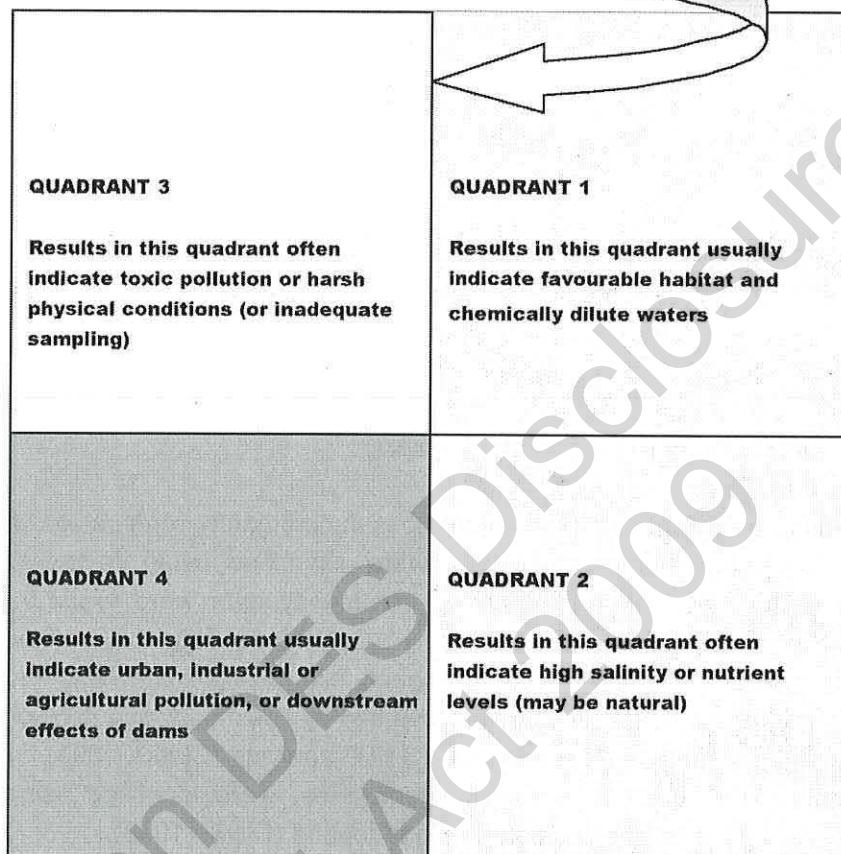
SIGNAL (Stream Invertebrate Grade Number — Average Level) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxa, and
- divided by the total of the weight factors for each taxa.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 2.2). The quadrants used in this report are based on the default quadrant boundaries provided in Chessman (2001).

Borders between quadrants vary with geographic area,
sampling method and habitat type



Number of macro-invertebrate families

Figure 2.2 Quadrant diagram for SIGNAL 2 / Family Bi-plot.

Analyses of Quantitative Samples

Univariate

ANOVA (analysis of variance) is a statistical hypothesis testing procedure that compares the mean and variance around the mean within each test group (e.g. among replicates within a site) with that among each test group (e.g. sites). The null hypothesis is that this mean is the same for all groups. Generally, if the significance level of the F-test (p value) is below 0.05, the null hypothesis can be rejected.

A one-way ANOVA (analysis of variance) test was used for differences among sites. A significant difference ($p < 0.05$) at a potentially impacted site, relative to comparative sites,

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may indicate an impact associated with the Content Pit overtopping. As macroinvertebrate richness is strongly linked to habitat type, differences in richness were therefore analysed separately for each habitat. Where an ANOVA test indicated significant differences among sites, a Student Newman-Keuls (SNK) test was used to determine which pairs of sites differed.

Multivariate

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or single indices derived to represent the community (i.e. univariate analyses such as richness). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

To determine the extent of impact, differences in community composition within potentially impacted sites and comparative sites were examined using a one-way analysis of similarity (ANOSIM). Prior to analysis, community data were $\log_{x+1}$ transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, for each habitat at each site, using non-metric multi-dimensional scaling (MDS) ordinations. These were overlaid by lines indicating 40% or 50% similarity between sites, as determined using CLUSTER analysis (Clarke 1993). Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

To examine the relationships between macroinvertebrate communities and environmental variables (e.g. substrate composition, metal concentrations in sediments and water, pH levels and electrical conductivity), these were compared at the same sites using BIOENV.

The combination of environmental variable/s that best described the biological community pattern were ranked and analysed using a rank correlation coefficient test (Spearman's coefficient – Rho (ρ)). The combinations of environmental variables that best describe the macroinvertebrate communities typically have values of ρ closer to 1 than 0. Environmental variables were normalised and converted to a Euclidean Distance matrix for the analyses, and the most strongly correlated groups were visualised using MDS ordinations.

3 Results and Discussion

3.1 Aquatic Habitat

Aquatic Habitat for Fauna

Site Descriptions

In general, aquatic habitat was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, and poor riparian zones.

Figure 3.1

View downstream at site SW7 (comparative site).

The substrate was dominated by sand, with some gravel and silt. The riparian zone comprised mainly native vegetation, dominated by grass, with some small trees. Sand deposits were evident along the creek. There were no aquatic macrophytes. There was no evidence of cattle access.

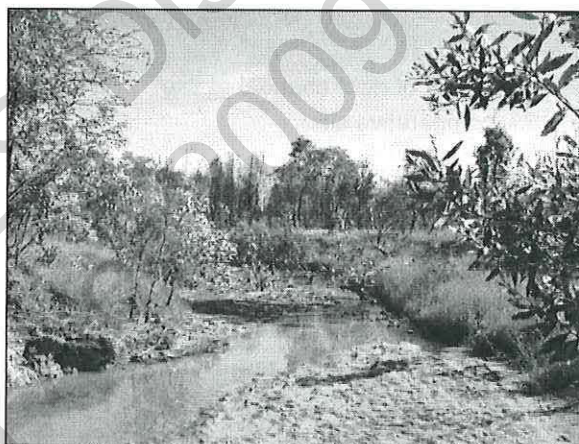
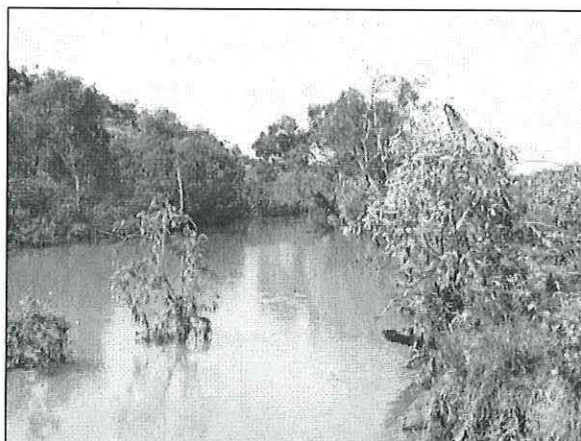


Figure 3.2

View upstream at site BCUS1 (comparative site).

The substrate was dominated by cobbles, with some pebbles, gravel and sand. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs, with some grass. There were no sand deposits or aquatic macrophytes at this site. There was evidence of cattle access.



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Figure 3.3

View downstream at site BCUS2 (comparative site).

The substrate was dominated by sand, with some pebbles, gravel and silt. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs. Sand deposits were evident on the creek bed. There were no aquatic macrophytes, but there was some filamentous algae. There was evidence of cattle access.



Figure 3.4

View upstream of right channel at site BCUS3 (comparative site).

The substrate was dominated by sand, gravel and pebbles, with some cobbles and silt. The riparian zone comprised mainly native vegetation, dominated by shrubs, with some grass and small trees. Sand deposits were evident on the creek bed. The submerged aquatic macrophyte water milfoil (*Myriophyllum* sp.) formed large beds. There was evidence of cattle access.



Figure 3.5

View of tributary outflow at site SW6 (comparative site).

This site was on the edge of a stock dam. The substrate was dominated by silt, with some sand and gravel. The riparian zone comprised sparse, mainly native vegetation and was dominated by grasses. There were no sand deposits or aquatic macrophytes. There were some filamentous algae along the edge. There was evidence of cattle access.



Figure 3.6

View upstream at site DSDi (potentially impacted site).

The substrate was dominated by sand, with some cobble, pebble, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass. There were no aquatic macrophytes. There was evidence of cattle access.

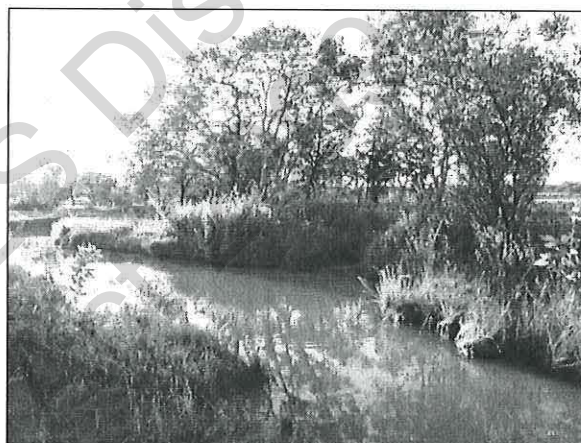
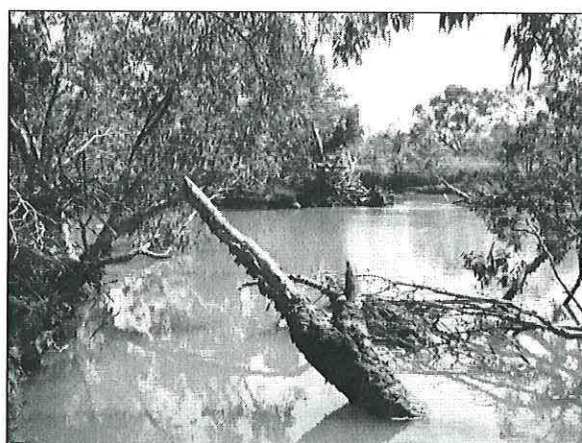


Figure 3.7

View across stream at site BCDS1 (potentially impacted site).

The substrate was dominated by sand, with some bedrock, boulders, cobbles, pebbles, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised dominated by small trees and shrubs. There was low coverage of the substrate by the aquatic macrophyte water milfoil (*Myriophyllum* sp.). There was evidence of cattle access.



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Figure 3.8

View upstream at site BCDS2 (potentially impacted site).

The substrate was dominated by sand, with cobbles, pebbles, gravel and silt also present. There were no sand deposits. The riparian zone comprised mainly native vegetation dominated by small trees and shrubs. There were no aquatic macrophytes. There was evidence of cattle access.

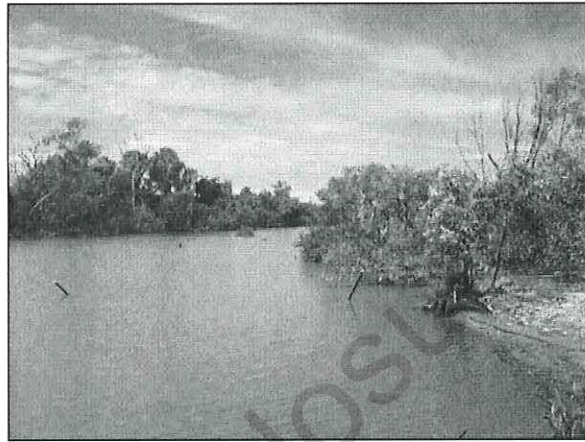


Figure 3.9

View upstream at site BCDS3 (potentially impacted site).

The substrate was dominated by sand and gravel, with some cobbles, pebbles and silt. Some sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass, shrubs and small trees. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.10

View upstream at site BCDS4 (potentially impacted site).

The substrate was dominated by sand, with some cobbles, pebbles, gravel and silt. The riparian zone comprised mainly native vegetation dominated by shrubs, with some grass and trees. There were no sand deposits or aquatic macrophytes. There was evidence of cattle access.



Release

Bioassessment Scores

Habitat bioassessment scores ranged from moderate to good at all sites (Figure 3.11).

Comparative sites SW7 and SW6 had the lowest bioassessment scores. These scores were due to high embeddedness of the substrate (as it was dominated by fine sediments), as well as low diversity of in-stream habitat (i.e. there was only shallow pools and runs, with no deep pools or riffles present), and poor streamside cover. This indicates that these sites are likely to be less suitable for macroinvertebrates. Potentially impacted sites DSDi and BCDS1 also had relatively low bioassessment scores due to high embeddedness and poor in-stream habitat diversity.

There was a noticeable improvement in habitat condition between potentially impacted sites BCDS1 and BCDS2 (Figure 3.11). Along with comparative sites BCUS2 and BCUS3, potentially impacted sites BCDS2 and BCDS3 had the highest bioassessment scores, with each site classified as good. These sites had good in-stream habitat diversity, low embeddedness and high streamside cover.

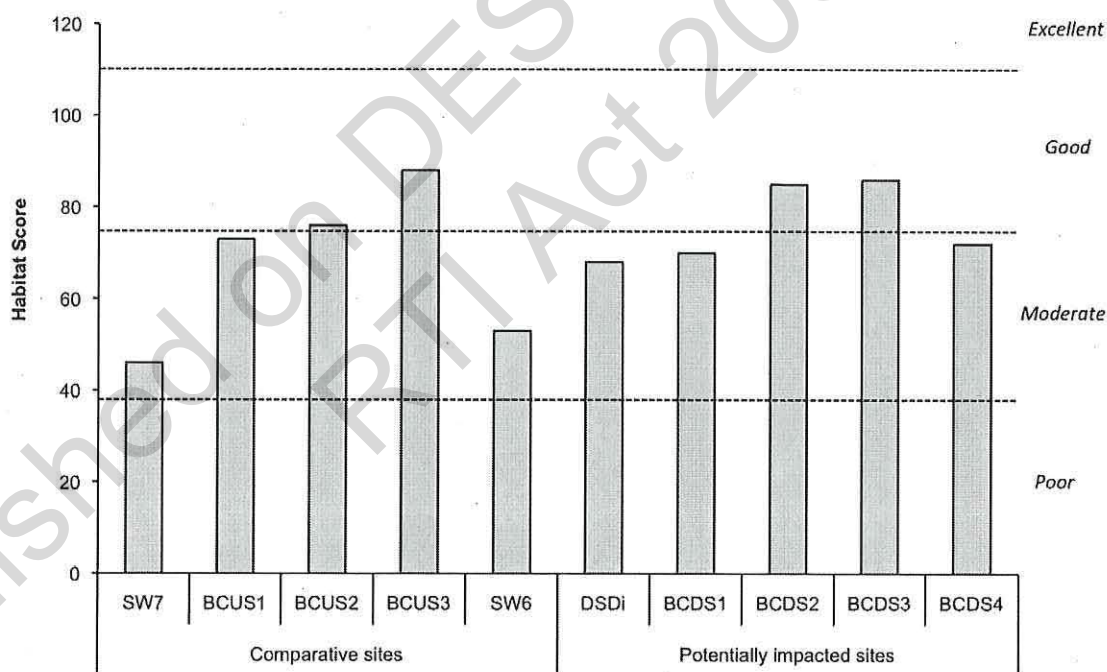


Figure 3.11 Habitat bioassessment scores at each site.

Water Quality

Water Temperature

Water temperature ranged from 24.1 °C – 31.4 °C. There are no ANZECC & ARMCANZ (2000) trigger values for water temperature. Temperature was similar across all sites however it was slightly lower at site DSDi, downstream of confluence of the Content Pit overflow and the Belmore Creek tributary. This is likely due to diurnal variation in temperature and the time of day it was measured.

Turbidity

Turbidity exceeded the upper and lower ANZECC & ARMCANZ (2000) trigger values at all sites, except site SW6 where it only exceeded the lower trigger value (Figure 3.12). Turbidity ranged from 14.2 – 52.6 NTU.

In general, turbidity was similar at all sites except comparative sites SW7 and BCUS3 (Figure 3.12). Turbidity at these sites was approximately double the turbidity at all other sites. The high turbidity recorded at all sites was likely due to the recent rainfall in the region and runoff carrying suspended sediments entering the creeks. Turbidity can have a negative impact on aquatic flora and fauna through a reduction in light penetration of the water and the siltation of interstitial spaces between cobbles and pebbles that provide habitat.

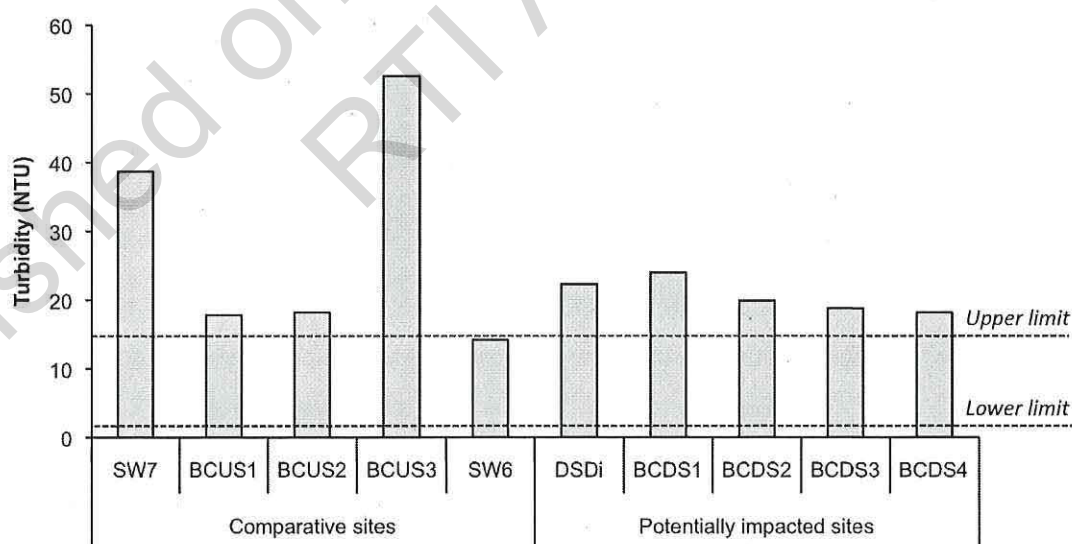


Figure 3.12 Turbidity at each site.

Rel

pH

The pH was within the ANZECC & ARMCANZ (2000) trigger value range at all sites, ranging from 6.6 to 7.59 (Figure 3.13). The pH was more alkaline downstream of the Content Pit overflow at DSDi, but the pH here was not substantially higher than at the other sites.

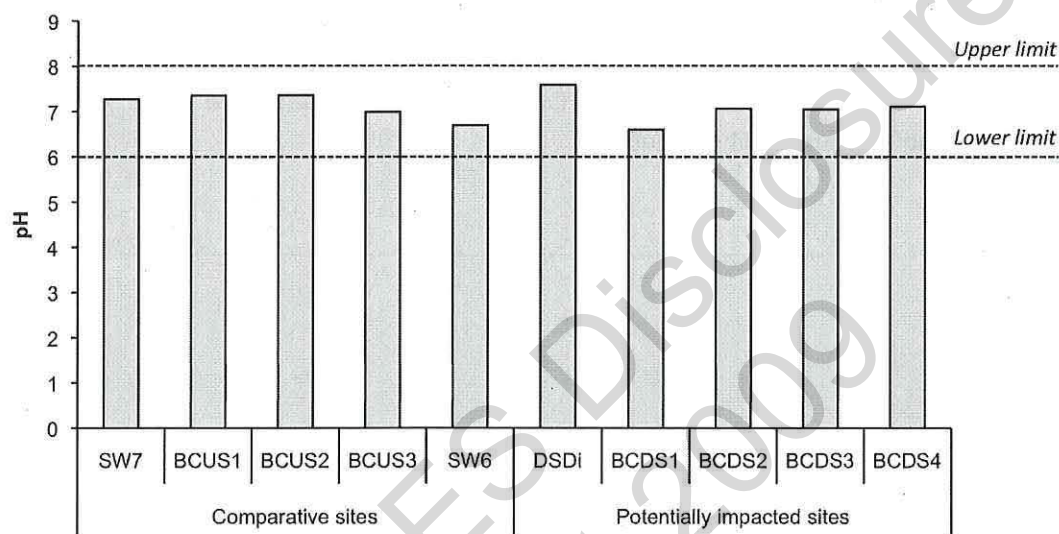


Figure 3.13 The pH at each site.

Electrical Conductivity

Electrical conductivity was below the QWQG trigger value at all sites (Figure 3.14). Conductivity was similar at all sites except comparative site SW7 and potentially impacted site DSDi. It is possible that the Content Pit overflow had an impact on conductivity at site DSDi, but the substantial decrease in conductivity between sites DSDi and BCDS1 (which are approximately 700 m apart) and the high value at comparative site SW7 suggest local variation may also be a factor. High conductivity can be directly toxic to macroinvertebrates and lead to reduced abundance and taxonomic richness; however the conductivity recorded at sites SW7 and DSDi is not considered to be 'high' in the context of the available water quality guidelines.

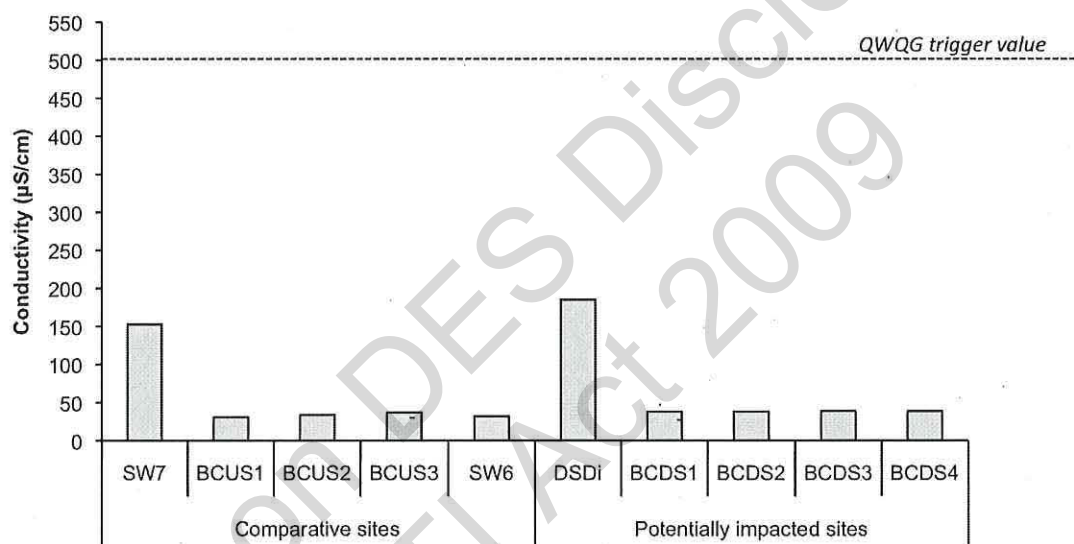


Figure 3.14 Electrical conductivity at each site.

Released

Dissolved Oxygen

The percent saturation of dissolved oxygen (DO) was within the ANZECC & ARMCANZ (2000) trigger value range at all sites except comparative sites SW7 and SW6 (Figure 3.15). These sites had less flow than other survey sites, which may be a contributing factor to the lower dissolved oxygen. Dissolved oxygen was also slightly lower in potentially impacted sites than at comparative sites on Belmore Creek (although DO was within the trigger value range at all potentially impacted sites). This may indicate an impact from the Content Pit overflow; however, dissolved oxygen is highly variable throughout the day and should be measured over 24 hours to determine if any differences are real. Dissolved oxygen is essential to aquatic fauna survival and low dissolved oxygen can lead to a reduction in abundance and taxonomic richness.

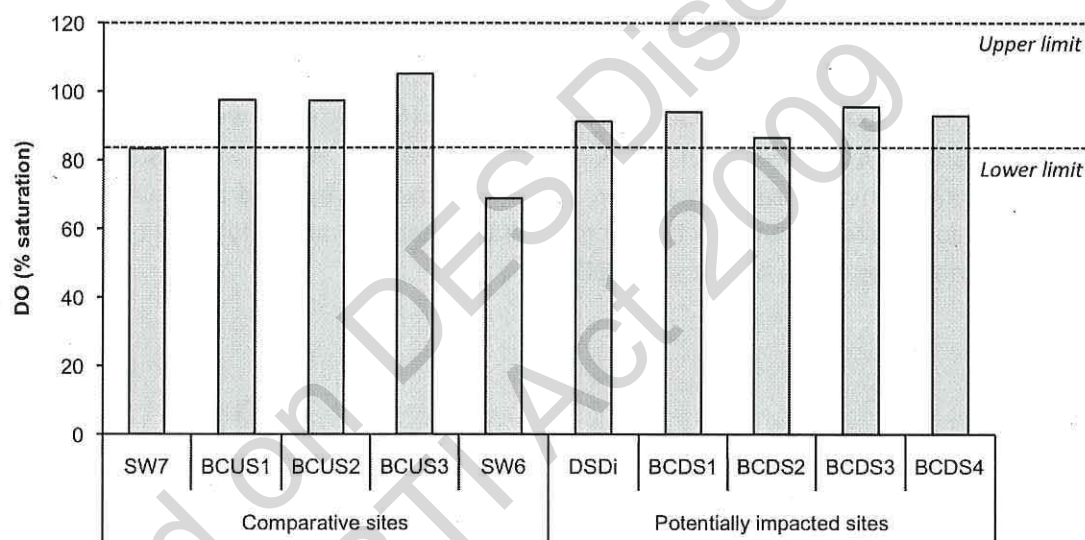


Figure 3.15 Dissolved oxygen at each site, and the ANZECC & ARMCANZ (2000) trigger level range.

3.2 Aquatic Macroinvertebrates

AUSRIVAS Assessment

Total Taxonomic Richness

Total taxonomic richness was generally low and variable across sites. It was typically higher in the edge and riffle habitats than in the bed habitat (Figure 3.16).

Macroinvertebrate taxonomic richness in the edge habitat was lowest at potentially impacted site BCDS1 and highest at potentially impacted site BCDS3 (Figure 3.16). Taxonomic richness was higher at site DSDi, downstream of the Content Pit overflow, than at comparative sites BCUS2 and SW6. This suggests that the overflow has not had a substantial impact on macroinvertebrates in edge habitat.

Total taxonomic richness in the bed habitat was variable, with similar results in the comparative and potentially impacted sites (Figure 3.16). No taxa were recorded for the site immediately downstream of the Content Pit overflow which suggests a potential impact on macroinvertebrates; however, only three taxa were found at sites BCUS2 and BCDS1 which indicates other factors (e.g. habitat or natural variability) may be influencing macroinvertebrates in the bed at site DSDi.

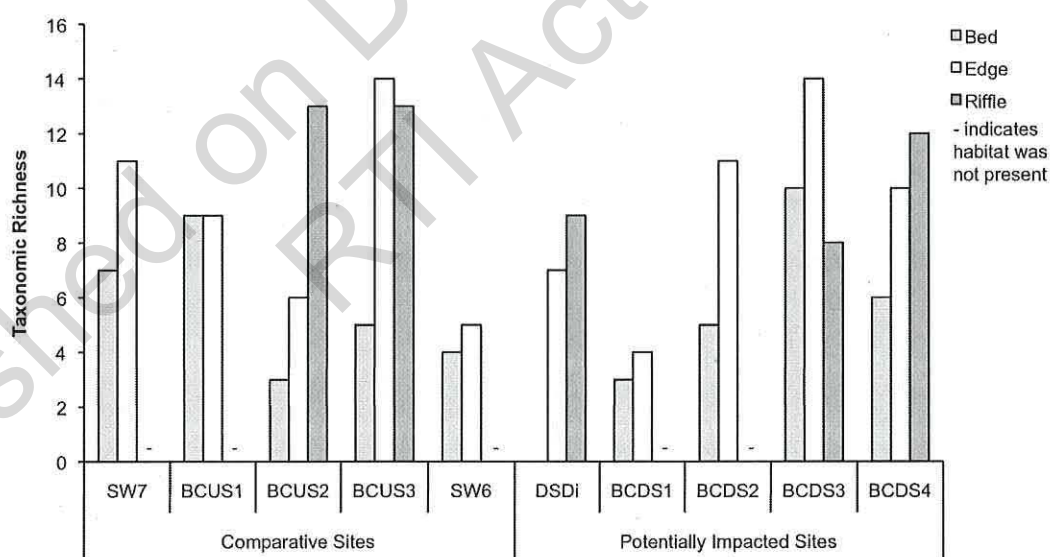


Figure 3.16 Total taxonomic richness for bed, edge and riffle habitats.

Total taxonomic richness in the riffle was generally lower at potentially impacted sites than at comparative sites. This is similar to the results for the quantitative samples and is likely to be the result of better riffle habitat (i.e. a greater percentage of cobble and pebble in the substrate; and shallow, fast flow) at these sites.

Variation in the results for the edge, bed and riffle habitats suggest that the Content Pit overflow did not have a substantial, or possibly any, effect on macroinvertebrate taxonomic richness.

PET Richness

PET richness was typically low across all habitats, but was higher in the edge and riffle habitats than in the bed habitat (Figure 3.17).

Potentially impacted site DSDi, immediately downstream of the Content Pit overflow, had the lowest PET richness for all habitats (with no taxa at all recorded in the bed) (Figure 3.17). This may indicate a potential impact from the Content Pit overflow; however, PET richness was low for the bed habitat at all comparative sites except site BCUS1, which suggests other factors (e.g. habitat) may also have been affecting PET taxa.

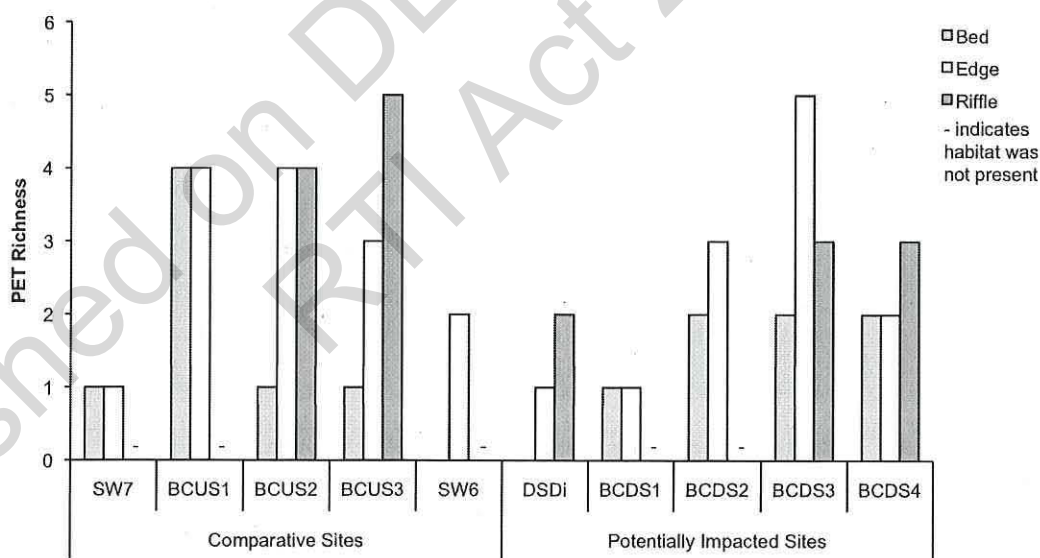


Figure 3.17 PET richness for edge, bed and riffle habitats.

SIGNAL 2

The lowest SIGNAL 2 scores for the edge habitat were recorded at comparative sites SW7 and BCUS3 (Figure 3.18). The lowest SIGNAL 2 score for the bed habitat was recorded at site SW7. The highest SIGNAL 2 scores for each habitat were recorded at comparative site BCUS2. SIGNAL 2 scores for all other sites were similar.

These results suggest there was no clear impact on pollution sensitive taxa from the Content Pit overflow. This is supported by the SIGNAL 2 / Family Bi-plot, which shows no distinction between comparative and potentially impacted sites, with all sites located in quadrants three and four (Figure 3.18). Quadrant three indicates toxic pollution or harsh physical conditions, while quadrant four indicates urban, agricultural or industrial pollution, or the downstream effects of dams. As the creeks in this region are ephemeral they are subject to naturally harsh conditions; and all sites are in an agricultural area, with most sites showing signs of cattle access. These conditions were likely to be affecting the macroinvertebrate communities.

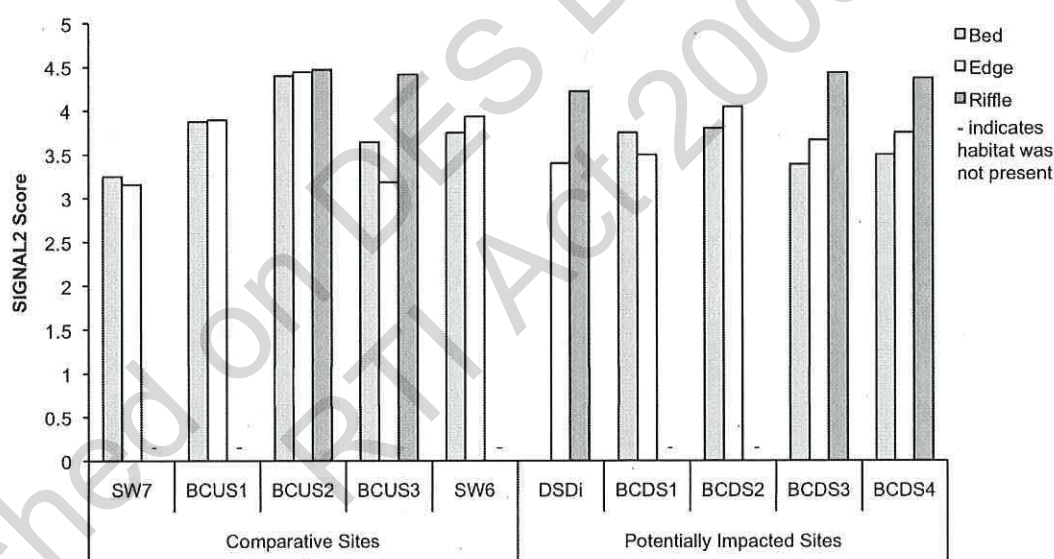


Figure 3.18 SIGNAL 2 scores for the edge, bed and riffle habitats.

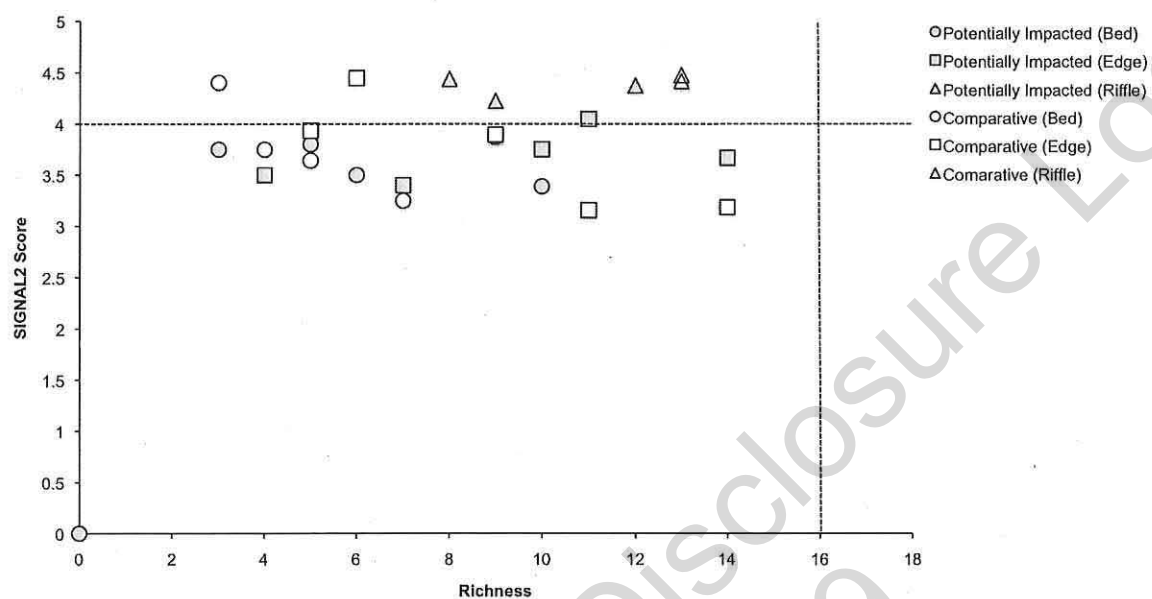


Figure 3.19 SIGNAL 2 / Family Bi-plot for edge, bed and riffle habitats.

Quantitative Impact Assessment

Mean Taxonomic Richness

Edge Habitat

Mean taxonomic richness in the edge habitat was highest at comparative site SW7 and lowest at comparative site SW6, where richness was significantly lower than all other sites (ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This is likely due to the good and poor quality of the edge habitat present at these sites, respectively. Although the habitat bioassessment score at site SW7 was low, the presence of overhanging grasses at this site provided good edge habitat that was not affected by the embeddedness and low in-stream diversity.

In general, macroinvertebrate taxonomic richness was higher at the potentially impacted sites than at the comparative sites, except site DSDi (although richness here was only significantly lower than at site SW7; ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This suggests that the Content Pit overflow did have an impact at site DSDi, but did not have an impact on the macroinvertebrate communities of the edge habitat further downstream in Belmore Creek.

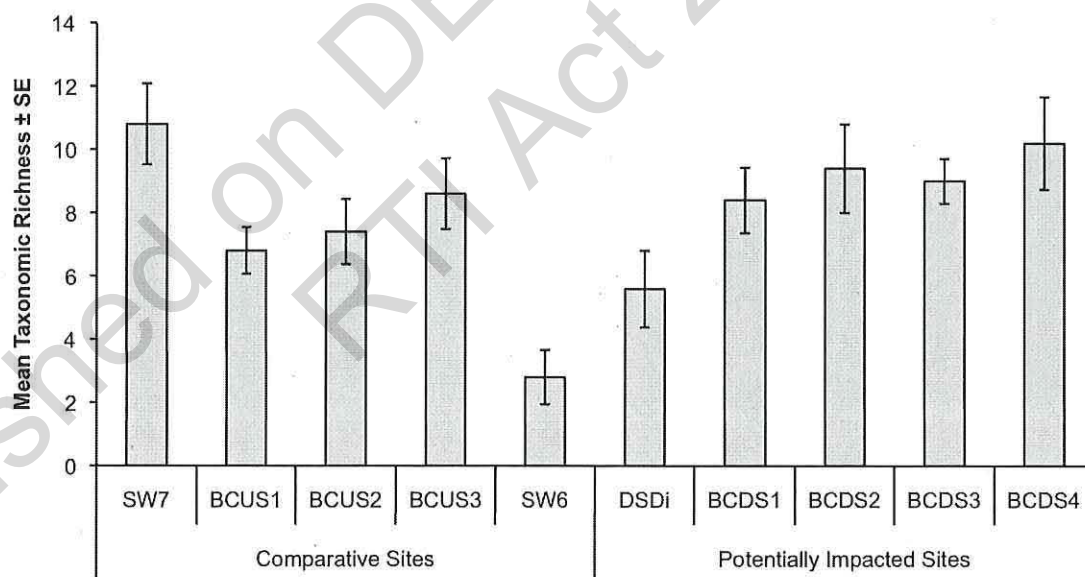


Figure 3.20 Mean taxonomic richness in edge habitat.

Bed Habitat

Mean taxonomic richness in the bed habitat was lowest at comparative site BCUS2 and potentially impacted sites DSDi and BCDS4 (Figure 3.21). It was highest at potentially impacted sites BCDS2 and BCDS3.

A decrease in taxonomic richness on the tributary of Belmore Creek from comparative site SW6 to potentially impacted site DSDi indicates a likely impact from the Content Pit overflow (Figure 3.21). However taxonomic richness increased from site DSDi to site BCDS1 and sites further downstream (with the difference in richness between site DSDi and BCDS2 being statistically significant; ANOVA SNK tests, $p < 0.05$), suggesting that any potential impact was limited in spatial extent. In addition, taxonomic richness in the bed was variable across sites, which may indicate that natural variability was also a factor in the low richness at site DSDi.

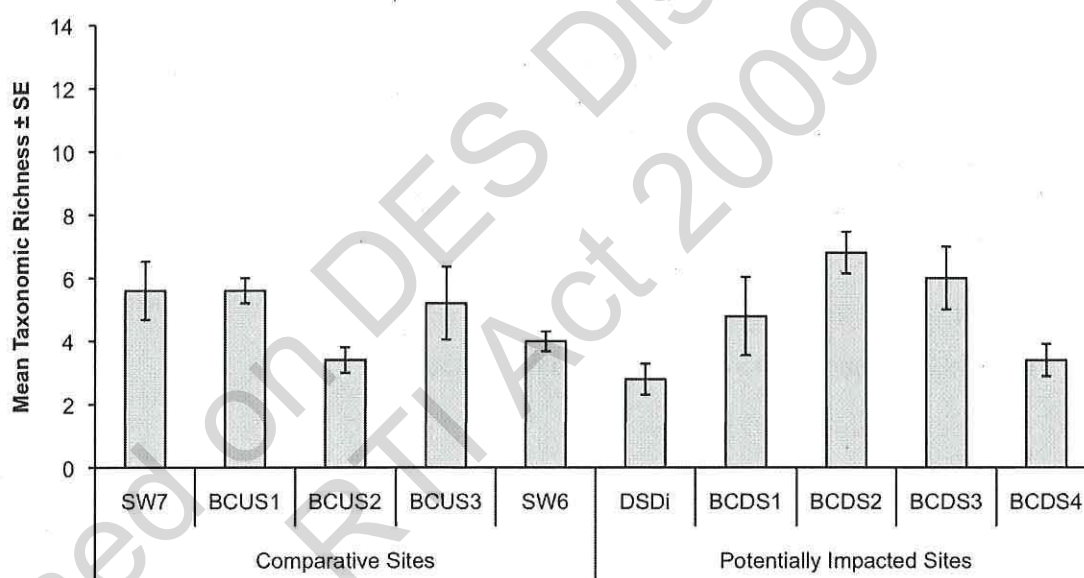


Figure 3.21 Mean taxonomic richness in bed habitat.

Riffle Habitat

Mean taxonomic richness in the riffle habitat was lower at the potentially impacted sites than at the comparative sites (Figure 3.22), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$). The taxonomic richness in the edge and bed habitats was relatively high at potentially impacted site BCDS3 and relatively high for the edge habitat at BCDS4; this difference may have been due to the Content Pit overflow, but is more likely to be related to habitat conditions or other factors.

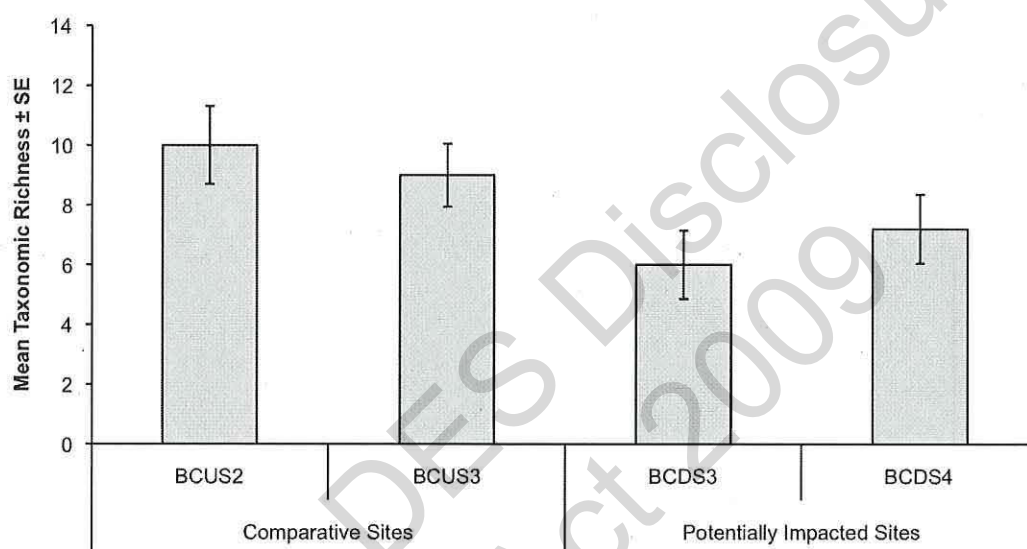


Figure 3.22 Mean taxonomic richness in riffle habitat.

Mean Abundance

Edge Habitat

Mean abundance in the edge habitat was lowest at potentially impacted site DSDi but was also low at comparative sites SW7 and SW6 (Figure 3.23); abundance at sites DSDi and SW6 was significantly lower than at most other sites (ANOVA SNK tests, $p < 0.05$). In general, mean abundance was higher at potentially impacted sites on Belmore Creek than at comparative sites, except for BCUS3.

Limited habitat availability at sites SW7 and SW6 is likely to have contributed to the low abundance at these sites, despite the presence of some good habitat at site SW7. It is possible that the Content Pit overflow had an impact in the tributary to Belmore Creek at site DSDi. Site DSDi had good edge habitat, therefore it is possible that the Content Pit overflow impacted macroinvertebrates communities at this site. Mean abundance increased between sites DSDi and BCDS1, suggesting that any potential impact was spatially limited.

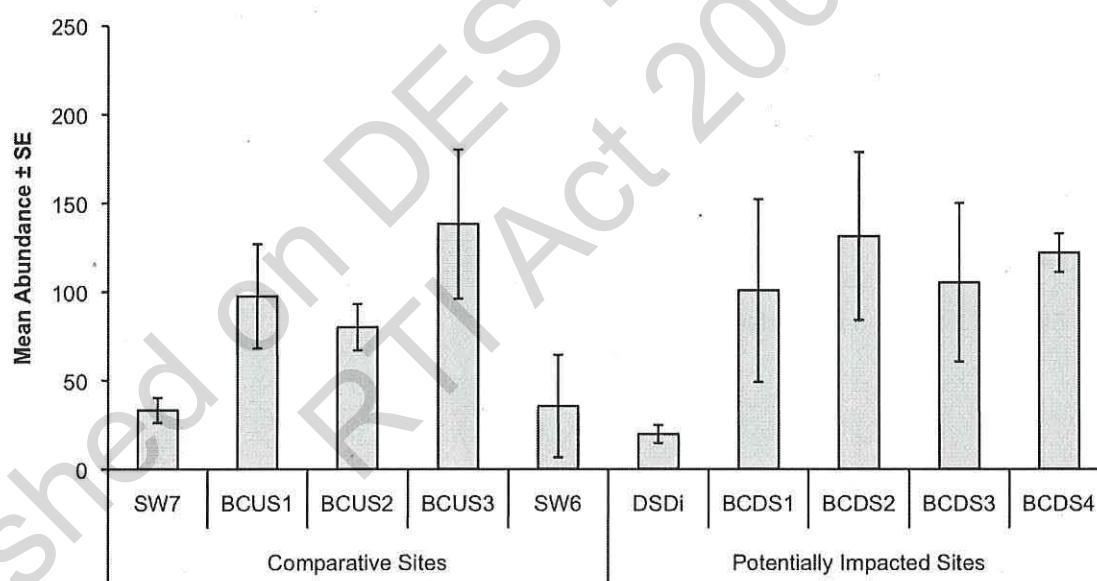


Figure 3.23 Mean abundance in the edge habitat.

Bed Habitat

Mean abundance in the bed habitat was low at all sites except sites BCUS3 and BCDS2, where abundance was significantly higher than at all other sites (ANOVA SNK tests, $p < 0.05$; Figure 3.24). The lowest abundances were at potentially impacted sites DSDi and BCDS4. A decrease in abundance between sites SW6 and DSDi indicates a possible impact on macroinvertebrates from the Content Pit overflow. However, the increase in abundance between sites DSDi and BCDS1, and the variability in abundance across sites, suggests any impact is limited or may be the result of natural variation.

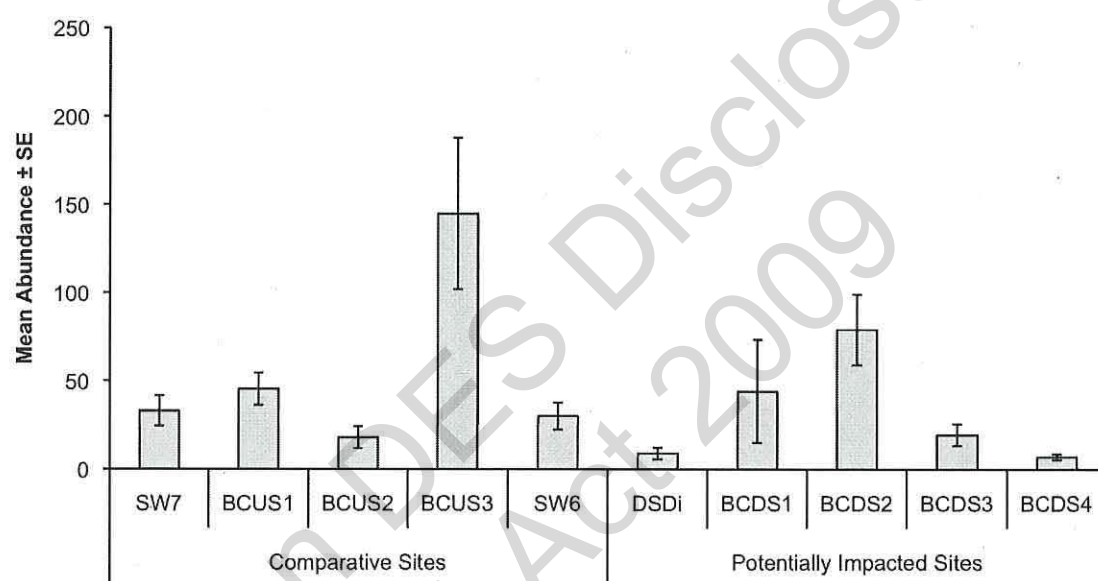


Figure 3.24 Mean abundance in the bed habitat.

Riffle Habitat

Mean abundance in the riffle habitat was higher at comparative sites than at potentially impacted sites (Figure 3.25), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$).

The abundance in the edge habitat at these potentially impacted sites was relatively high compared to the comparative sites, but was low for the bed habitat. This suggests that the difference in abundance between comparative and potentially impacted sites for the riffle habitat may not have been due to the Content Pit overflow, but was likely due to habitat conditions.

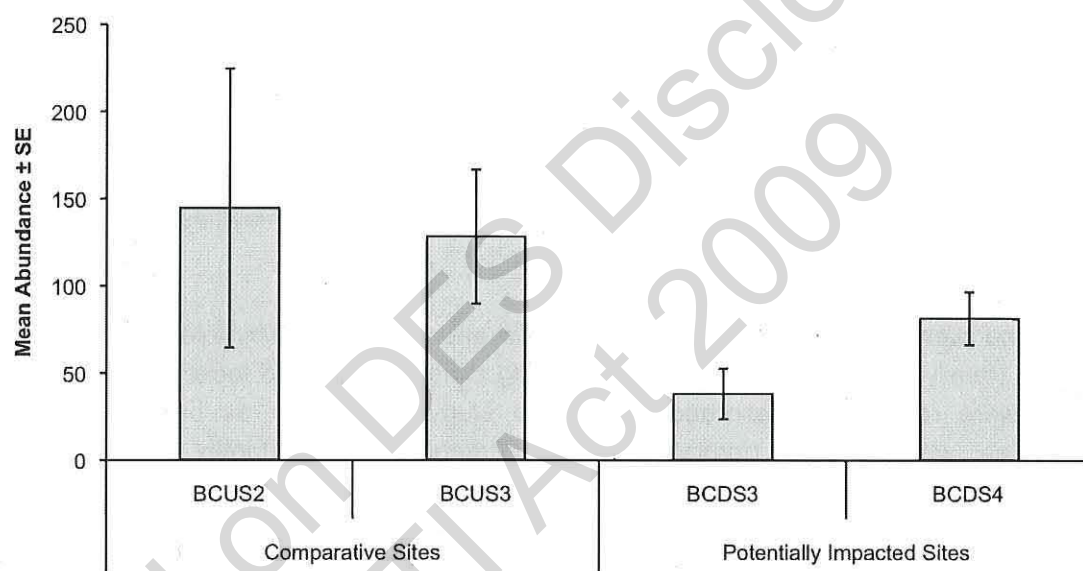


Figure 3.25 Mean abundance in the riffle habitat.

Community Composition

Edge Habitat

Macroinvertebrate community composition in the edge habitat was significantly different between sites; however, the differences were small (ANOSIM Global $R = 0.37$, $p = 0.001$). While communities between some sites were different from each other, there were no distinct groupings between communities at comparative and potentially impacted sites (Figure 3.26).

Communities at comparative site SW6 and potentially impacted site DSDi were the most distinct from communities at other sites (Figure 3.26). At potentially impacted site DSDi, this was mostly due to a decreased abundance or an absence of some taxa at this site compared with other sites, including both tolerant taxa such as non-biting midge larvae (sub-families Chironominae and Tanypodinae), and sensitive taxa such as caenid mayflies and leptocerid and ecnomid caddisflies (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit, though it is important to note that abundances of other relatively sensitive taxa such as baetid mayflies and mites were similar to or higher than at other sites.

Communities at comparative site SW6 had low abundances of fairly tolerant taxa such as biting (family Ceratopogonidae) and non-biting midge larvae, and lacked a range of taxa that were relatively widespread across the study area, such as baetid and caenid mayflies, waterboatmen (family Corixidae), dragonfly larvae (family Libellulidae) and caddisflies (families Leptoceridae and Ecnomidae).

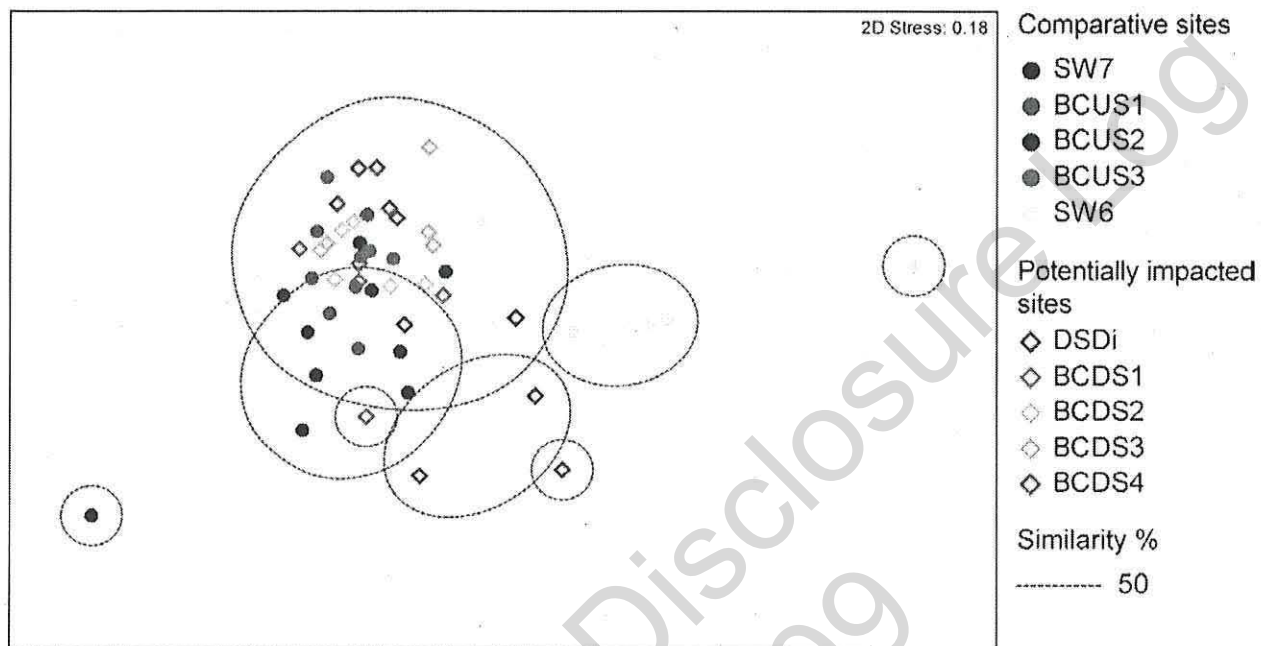


Figure 3.26 MDS ordination showing the differences between sites in macroinvertebrate community composition in edge habitat, and 50% similarity groupings based on CLUSTER analysis.

A comparison of environmental variables and macroinvertebrate community composition in the edge showed a significant correlation between community composition and a combination of turbidity, magnesium, arsenic, copper and total phosphorus concentrations (BIOENV Rho = 0.895, p=0.04). Comparative sites SW7 and SW6 and potentially impacted site DSDi were distinctly different from all other sites (Figure 3.27 and Figure 3.28), which suggest these water quality variables influenced macroinvertebrate communities at these sites.

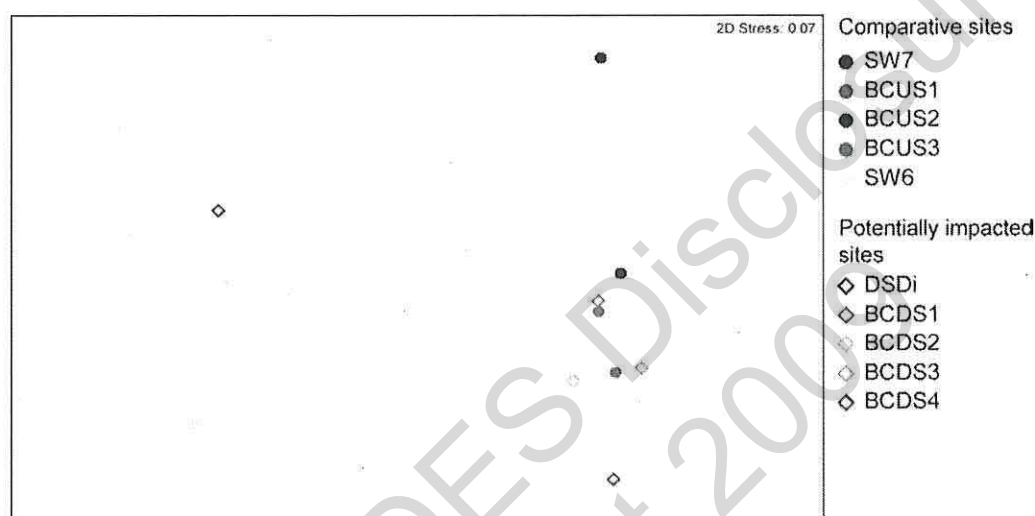


Figure 3.27 MDS ordination showing the differences between sites in macroinvertebrate community composition (averaged across replicates) in edge habitat.

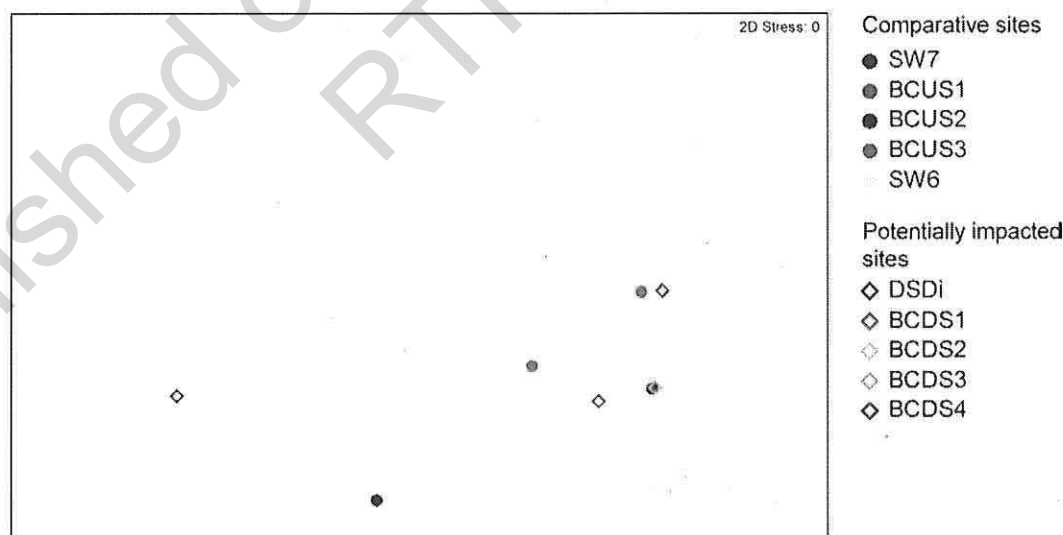


Figure 3.28 MDS ordination showing the differences between sites in water quality (turbidity, magnesium, arsenic, copper and total phosphorus).

Of these water quality variables, turbidity was higher at sites SW7, SW6 and DSDi than at the other sites surveyed; it is possible that elevated turbidity at site DSDi was related to overland flow from the overtopping Content Pit carrying suspended sediments to the tributary of Belmore Creek (though note that turbidity at site DSDi was similar to that at other sites during *in situ* sampling of turbidity). Magnesium concentrations were elevated at sites DSDi and SW7, and total phosphorus concentrations were elevated at sites DSDi and SW6; it is unclear whether this is related to the overtopping of Content Pit.

Arsenic concentrations were lower at sites SW7, SW6 and DSDi than at the other sites surveyed, which indicates that the overtopping of Content Pit did not have an adverse effect on macroinvertebrate communities due to toxicity of arsenic. Conversely, copper concentrations were elevated at these sites compared with the others surveyed: particularly at site DSDi, which may be a result of the overtopping of the Content Pit.

Bed Habitat

Macroinvertebrate community composition in the bed habitat was significantly different between sites, however the magnitude of this difference was small, and mostly indistinct at a 40% similarity level (ANOSIM global $R = 0.452$, $p = 0.01$; Figure 3.29).

Nevertheless, communities at site DSDi were different from those at other sites (Figure 3.29). This was mostly attributable to a low abundance of most taxa, including some sensitive taxa such as caddisflies (Ecnomidae and Leptoceridae), and an absence of taxa commonly found in the study area (caenid mayflies, mites and waterboatmen) (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit.

A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the bed showed no significant correlations.

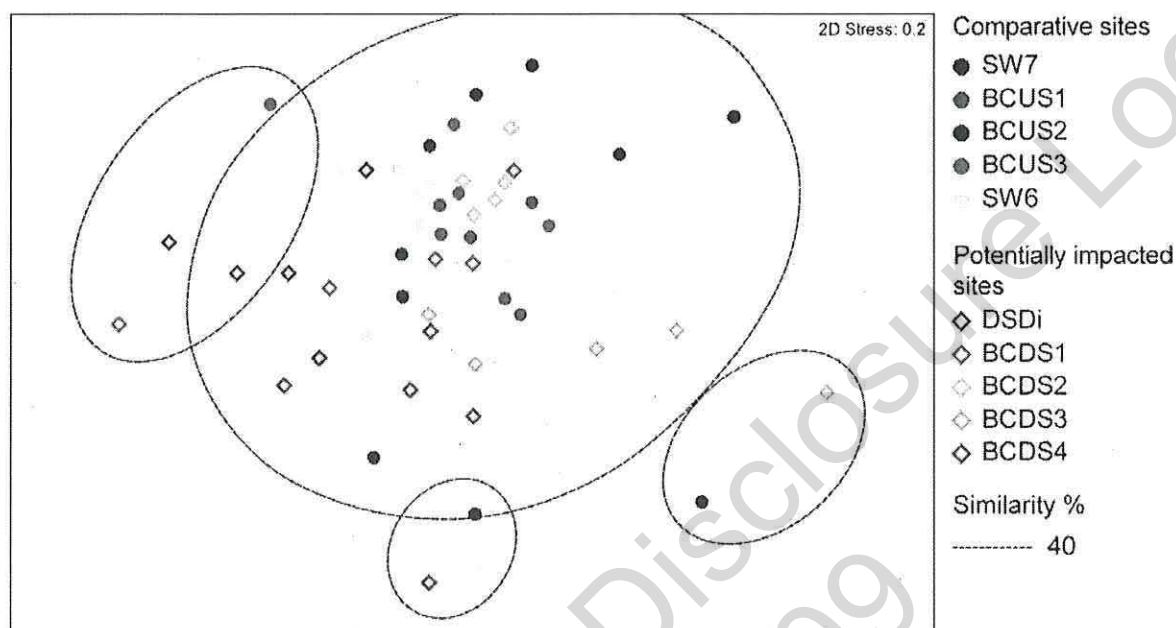


Figure 3.29 MDS ordination showing the differences between sites in macroinvertebrate community composition in bed habitat.

Riffle Habitat

There were distinct differences in macroinvertebrate community composition in the riffle habitat at comparative sites and the riffle habitat at potentially impacted sites (ANOSIM Global $R = 0.336$, $p = 0.01$); however communities at both the two comparative sites and the two potentially impacted sites were not significantly different from each other (ANOSIM pairwise tests $p > 0.05$, Figure 3.30). As discussed above, based on the results for other habitats, it is likely that these differences are related to riffle habitat quality upstream and downstream of the Content Pit, rather than the overtopping of the pit. A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the riffle showed no significant correlations.

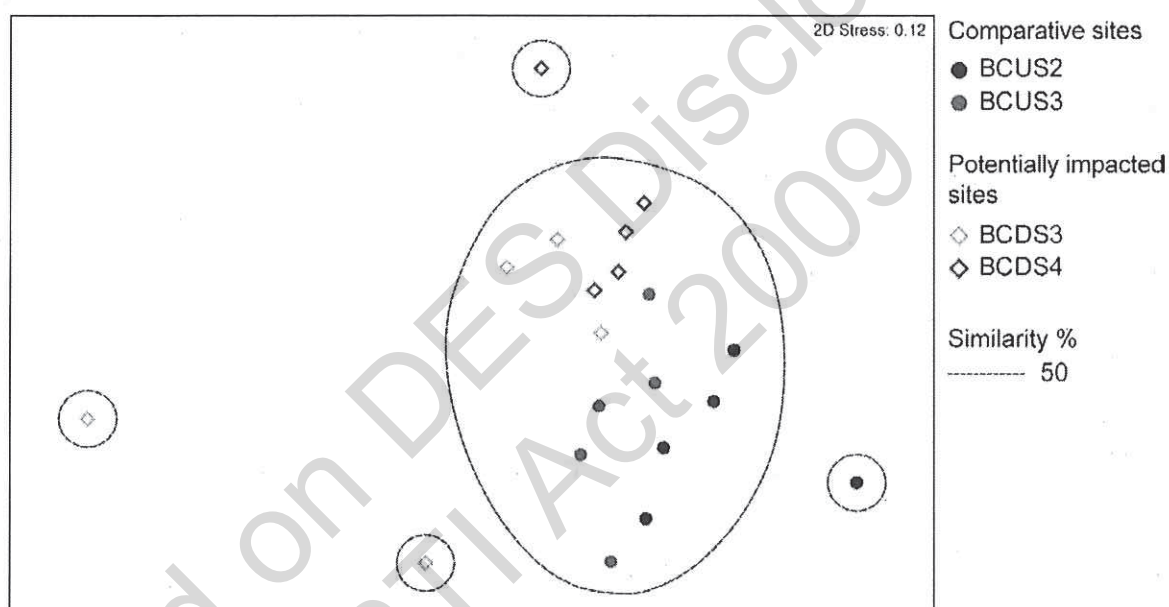


Figure 3.30 MDS ordination showing the differences between sites in macroinvertebrate community composition in riffle habitat.

4 Summary and Recommendations

4.1 Summary

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities (i.e. on taxonomic richness, abundance and community composition) at site DSDi, which is approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land) (Figure 2.1). However, the impact appeared to be confined to a small spatial area, and did not extend to the first downstream site on Belmore Creek (i.e. BCDS1), which is approximately 700 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (Figure 2.1). As such, the macroinvertebrate taxonomic richness, abundance and community composition at sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Increased electrical conductivity was observed at site DSDi immediately downstream of the confluence of the overflow pathway with the tributary of Belmore Creek. Though electrical conductivity levels in the study area did not correlate highly to macroinvertebrate community structure, suggesting that electrical conductivity levels here may not have had a substantial influence on macroinvertebrate community structure.

A number of other factors (e.g. habitat condition, land use [i.e. cattle access] and water quality) also appear to have had an effect on macroinvertebrate communities. As a result, the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

4.2 Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are in-sufficient to fully characterise the impact from overtopping of the Content Pit, when compared with the influence of other factors. Additional surveys or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area

- determine if the overtopping event from the Content Pit had a short or long-term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

4.3 Limitations

This macroinvertebrate survey was initially intended to provide baseline data for a survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine, however due to heavy rainfall before sampling began, the Content Pit overtopped. Consequently, there is no baseline data from the area to which the survey results can be compared. The lack of baseline data limits the interpretation of the survey data, as it is not possible to assess whether the patterns in macroinvertebrate community structure existed before the overtopping occurred.

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DRAFT REPORT

**Final Rehabilitation Report
Croydon Gold Mine
ML 5248**

Prepared for

Goldfields Limited
1 Castlereagh Street
Sydney NSW 2000

HLA-Envirosciences Project No F1715/2

by

CTPI 49-Sch4 MSc FAusIMM CPEnv
Senior Principal (Mining)

6 November 2001

23 NOV 2001



23 Nov

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Principal Environmental Scientist (Mining)
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PO Box 73 HRMC NSW 2310

Dear CTPI 4

At the Council meeting on 15th November 2001 the following was resolved:*That Council accept the advice of the Environmental Protection Agency in the following manner:-*

- *Council not provide a landholder statement until such time that Council is happy with the state of the mine;*
- *Undertake the surrender process with the Environmental Protection Agency giving advice in relation to Council concerns;*
- *That Council request to be advised when technical aspects of the rehabilitation success is reviewed by Environmental Protection Agency Technical and Contaminated Land Staff prior to surrender in order that this advice be considered by Council; and*
- *That when a site based management plan is in place for the longer term monitoring and management requirements that Council ensures that it has had adequate input into the Plan to satisfy any concerns that may exist.*

I have perused previous correspondence regarding the Landowner/Landholder statement and I look forward to working with you in order to finalise this matter.

Yours sincerely

CTPI 49-Sch4

Lisa Wain
A/Chief Executive Officer

19 November 2001

ESTABLISHED
IN 1900
BY THE CONSOLIDATION
OF THE
CROYDON DIVISIONAL BOARD
(EST. 1888)
AND
THE CROYDON
MUNICIPAL COUNCIL
(EST. 1882)

FACSIMILE TRANSMISSION**To:** Queensland Environmental Protection Agency**Attention:** Dean Ellwood**Fax Number:** +61 (7) 4744 7800**From:** CTPI 49-Sch4**Date:** 26 November 2001**Subject:** Croydon Shire Council**Project Number:** F1715/2/F1715 Ellwood Fax 26-Nov-01**Number of pages (including this cover sheet):** 2**Documents faxed in this transmission to follow by mail:** No**Message:**

Dear Dean,

Please find attached the letter received this morning from Croydon Shire Council. I will contact Lisa Wain in an attempt to find out where we should proceed from here.

Regards,

CTPI 49-Sch4

Transmitted by: CTPI 49-Sch4**If you do not receive all pages, please call** CTPI 49-Sch4 **on** 02 49680044

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This document was prepared for the sole use of Goldfields Limited and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Goldfields Limited.

CONTENTS

EXECUTIVE SUMMARY.....	ES-1
1.0 INTRODUCTION.....	1
2.0 PROJECT DETAILS	3
3.0 PROJECT DESCRIPTION	4
3.1 Mining History	4
3.2 Landforms	4
3.3 Drainage	5
3.4 Land Use and Capability	5
3.5 Land Tenure	5
4.0 STATUS REPORT	7
4.1 Rehabilitation	7
4.1.1 Pre-1996 Rehabilitation History	7
4.1.2 1995 Rehabilitation Objectives	7
4.1.3 1996 Rehabilitation Program	8
4.2 Commitments and Conditions	9
4.2.1 Plan of Operations and Commitments	9
4.2.2 Environmental Authority Conditions	10
4.3 Results of the Monitoring Program	11
4.3.1 Monitoring Reports	11
4.3.2 Relinquishment Criteria	12
4.3.3 Surface Water Quality	12
4.3.3.1 Relinquishment Criteria	12
4.3.3.2 Results and Discussion	14
4.3.4 Groundwater Quality	17
4.3.4.1 Relinquishment Criteria	17
4.3.4.2 Results and Discussion	18
4.3.5 Vegetation	20
4.3.5.1 Relinquishment Criteria	20
4.3.5.2 Results and Discussion	23
4.3.6 Erosion	26
4.3.6.1 Relinquishment Criteria	26
4.3.6.2 Results and Discussion	27
4.4 Continuing Requirements	28
5.0 CONTAMINATED LAND ASSESSMENT	30
5.1 1996 Site Assessment	30
5.1.1 Assessment Methodology	31
5.1.2 Results of the Waste Rock Dump Assessment	31
5.2 Site Rehabilitation Work	33
5.2.1 Rehabilitation Specifications	34
5.2.2 Upgraded Rehabilitation Works Program	35
5.3 Current Status of the Site	35

5.3.1	Open Pits	36
5.3.2	Waste Rock Dumps	36
5.3.3	Other Areas.....	38
5.4	Conclusion.....	38
6.0	LANDHOLDER/LANDOWNER ISSUES	40
6.1	Landholder Requirements	40
6.2	On-going Commitments	41
6.3	Financial Assurance	41
7.0	AUDIT STATEMENT.....	42
7.1	Introduction	42
7.2	Audit Report.....	42
7.3	Conclusion.....	42
7.4	Certification.....	43
8.0	REFERENCES.....	44

Released

TABLES

Table 1: Project Details.....	3
Table 2: Underlying Land Tenure for Mining Related Landforms.....	6
Table 3: 1995 Rehabilitation Scenario.....	8
Table 4: Mining Lease Conditions and Status	10
Table 5: Lease Relinquishment Criteria - Surface Water	12
Table 6: Lease Relinquishment Criteria - Groundwater	17
Table 7: Lease Relinquishment Criteria - Vegetation.....	20
Table 8: Species Seeded and Recorded at Monitoring Sites.....	24
Table 9: Tree Species Richness at Monitoring Sites.....	24
Table 10: Lease Relinquishment Criteria - Erosion.....	26
Table 11: Classification of Waste Rock for Acid Drainage Potential.....	31
Table 12: Relationship between Golden Butterfly Dump Rock Type and Acid Drainage Potential.....	32
Table 13: Relationship between Content Dump Rock Type and Acid Drainage Potential	32
Table 14: Rehabilitation Options Considered by RGC.....	33
Table 15: Selected Rehabilitation Options.....	33
Table 16: Waste Rock Dump Cover Configuration.....	34

FIGURES

Figure 1: Site Location.....	2
Figure 2: Surface Water Monitoring Locations	13
Figure 3: pH at SW5 over Time.....	15
Figure 4: Total Dissolved Solids at SW5 over Time	15
Figure 5: Sulphate Concentration at SW5 over Time.....	16
Figure 6: Cadmium Concentration at SW5 over Time	16
Figure 7: Arsenic Concentration at SW6 over Time.....	17
Figure 8: Groundwater Monitoring Locations.....	19
Figure 9: Location of Revegetation and Erosion Monitoring Sites	22
Figure 10: Tree Species Density at Monitoring Sites	25
Figure 11: Herb Species Density at Monitoring Sites.....	25
Figure 12: Mean Height of Eucalypts at Monitoring Sites	26
Figure 13: Mean Height of Acacias at Monitoring Sites	26
Figure 14: Stability Index at Monitoring Sites	27
Figure 15: Infiltration Index at Monitoring Sites.....	28
Figure 16: Nutrient Cycling Index at Monitoring Sites	28

PLATES

Plate 1: Vegetation Cover on Golden Butterfly Waste Rock Dump (February 2001).....	29
Plate 2: Vegetation Cover on Batter of Content Waste Rock Dump (February 2001)	29
Plate 3: Isolated Calotrope Plant on Golden Butterfly Waste Rock Dump	30
Plate 4: Lower Batter of Content Waste Rock Dump showing Effect of Acid Drainage	37
Plate 5: Former Hardstand Area adjacent to Content Waste Rock Dump	38
Plate 6: Former Hardstand West of Golden Butterfly Open Pit.....	38

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APPENDICES

Appendix 1	Report on Rehabilitation Works undertaken at Croydon in 1996 and 1997
Appendix 2	Table of Commitments for ML 5248 in the Plan of Operations
Appendix 3	Lease Relinquishment Criteria
Appendix 4	Water Quality Data
Appendix 5	Water Level Analysis of Golden Butterfly Pit Croydon Gold Mine

EXECUTIVE SUMMARY

This Final Rehabilitation Report has been prepared by HLA-Envirosciences Pty Limited on behalf of Goldfields Limited to support an application for relinquishment of ML 5248.

The Croydon Gold Mine, located close to the town of Croydon in north-west Queensland, was operated between 1987 and 1990. During this time ore was obtained from four open pits commonly known as Golden Butterfly, Golden Butterfly North, Content and Lady Isabella. ML 5248 is linear in nature, resembling a dumbbell and runs approximately south-east north-west from Croydon. The two Golden Butterfly open pits are located in the south-east portion of the lease and this is joined to the north-western portion which contains the other two pits by a narrow strip that served as a haul road. A waste rock dump accompanies each pair of open pits. Processing of the ore was undertaken on an adjacent lease that is not the subject of this Report.

Initial rehabilitation of the mine site was undertaken in 1993 and comprised bunding and fencing of the open pits and partial rehabilitation of the waste rock dumps. Goldfields acquired ML 5248 in 1995 after a takeover of the previous holder and, after an assessment of progress, undertook additional rehabilitation during 1996.

An Amended Decommissioning Plan for the site was submitted in 1996 and this has been accepted as the Plan of Operations for the lease. Monitoring of the effectiveness of the rehabilitation commenced in 1996 in accordance with this Plan.

Water quality monitoring has shown that the relinquishment criteria proposed in the Decommissioning Plan have been met at the nominated compliance point. However, the occurrence of localised acid drainage from the Content waste rock dump has meant that desired compliance at another monitoring point has not been met. This acid drainage remains localised and further monitoring has shown that its impact is not detectable at the boundary of the lease.

Vegetation and erosion monitoring confirms that the waste rock dumps are relatively stable and that native vegetation communities are progressing towards a self-sustaining system.

A contamination assessment was undertaken in 1996. This identified that potential acid drainage from the waste rock dumps was the only concern and the rehabilitation program was undertaken with control of this issue in mind. With the exception of the localised acid drainage from the Content waste rock dump, this has proved to be very effective.

Earthen bunds and stock fences surround the only other remaining features on the site, the open pits. While three of these contain acid water with elevated concentrations of some metals, modelling has shown that filling and overflow of these pits is highly unlikely. They are therefore nominated for inclusion on the Environmental Management Register.

ML 5248 overlies land that is either Crown Land or Croydon town common. The two landholders, the Department of Natural Resources and Mines and the Croydon Shire Council have been requested to supply Landowner/Landholder Statements but these have not been supplied despite follow-up requests.

This Report shows that the long-term environmental risks at the mine site are minimal and, therefore, relinquishment of the lease is supported.

1.0 INTRODUCTION

Goldfields Kalgoorlie Limited (formerly Pancontinental Mining Limited) is the holder of ML 5248 situated immediately to the west of Croydon township, North Queensland (refer to Figure 1). ML 5248 formed part of the Croydon Gold Project and was mined from 1987 until 1990. In 1993, a Decommissioning Plan was prepared, submitted to, and accepted by the Department of Minerals and Energy (DME). Rehabilitation works then commenced according to the Decommissioning Plan.

In 1995 Goldfields Limited (Goldfields) acquired a controlling interest in Pancontinental Mining Limited and immediately commenced reviewing the environmental performance of all sites in conjunction with its then parent, RGC Limited. Goldfields and RGC decided it was necessary to undertake further rehabilitation work at Croydon. An Amended Decommissioning Plan was prepared, incorporating relinquishment criteria, a monitoring program and a commitment to prepare an annual report on the performance of the rehabilitation against the criteria. This additional rehabilitation work was undertaken in late 1996.

Control of the site now rests with Goldfields, following the divestment of the Company by RGC in late 1998.

This Final Rehabilitation Report has been prepared by HLA-Envirosciences Pty Limited (HLA), on behalf of Goldfields, to support an application for relinquishment of the Mining Lease.

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Figure 1: Site Location

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2.0 PROJECT DETAILS

The following table presents the project details as required by the EPA Guideline on preparation of Final Rehabilitation Reports.

Table 1: Project Details

	Details
EA Number	T 2465
Holder's Name and Contact Details	Goldfields Kalgoorlie Limited PO Box R986 Royal Exchange Post Office NSW 1225
Tenure Number and Termination Date	ML 5248 31 August 2009
Project Name	Croydon Gold Mine
Contact Person	Goldfields' Representative: CTPI 49-Sch4 Tel: (02) 8223 2408 Project Controller: CTPI 49-Sch4 HLA-Envirosciences Pty Limited Tel: (02) 4968 0044
Author of FRR	CTPI 49-Sch4 HLA-Envirosciences Pty Limited
Location Information	Part Lot 952, C3591 Part Lot 46, USL48265 Part Lot 78, USL48265 Approximately 0.5 km north-west of Croydon

3.0 PROJECT DESCRIPTION

ML 5248 is located to the north-west of the township of Croydon in North Queensland (refer Figure 1). The lease is approximately 1.7 km² in area and extends along a corridor adjacent to the south side of the Normanton Developmental Road.

3.1 Mining History

The Croydon Gold Project was operated between 1987 and 1990 by an unincorporated joint venture between Central Coast Exploration NL (CCE) and Pancontinental Mining Limited (Pancon). Mining took place on several leases, including ML 5248, to the west and north-west of Croydon. Ore processing was carried out at facilities located on CCE leases that are not the subject of this Final Rehabilitation Report. Mining and ore processing on both Pancon and CCE leases was carried out by Barrick Mine Management (BMM).

The Pancon operation commenced in December 1988 with mining from the Golden Butterfly Pit, located within the eastern portion of ML 5248, as shown on Figure 1. The mining operation was subsequently expanded with the development of the Golden Butterfly North Pit (adjacent to Golden Butterfly) and the Content and Lady Isabella pits located within the western portion of the lease area. Pancon's mining operation at Croydon ceased in April 1990, with processing of ore from these leases completed in August 1990. In total, approximately 445,000 tonnes of ore were treated to produce around 63,000 ounces of gold.

Following the cessation of mining in 1990, a portion of the original lease area was relinquished by Pancon. Only those areas covering the open pits and waste dumps, plus a connecting corridor, were retained. The current lease boundary is indicated on Figure 1.

3.2 Landforms

On completion of mining, ML 5248 included the following mining-related landforms:

- Golden Butterfly Pit and surrounds;
- Golden Butterfly North Pit;
- Golden Butterfly Waste Rock Dump;
- Content Waste Rock Dump;
- Content Pit and surrounds; and
- Lady Isabella Pit.

In addition, mining hardstand areas (including old ore stockpile and crusher pad areas), a haul road and numerous open exploration drill holes related to the Pancon operations, remained within the lease area. Open shafts and adits from historical (ie. pre-1900) mining activities were also present within the area.

Generally, these landforms (with the exception of the pits) have revegetated with grasses and shrubs, either from past sowing activities or by natural colonisation. These landforms, however, have been subject to some disturbance through erosion and livestock or vehicle trafficking. All open pits hold water,

recharged either through direct rainfall, runoff or from groundwater entry. Each pit is surrounded by an earthen safety bund at least 1 metre high and a three-strand barbed wire fence and is clearly signposted.

Undisturbed areas surrounding the mining landforms, but within ML 5248, are generally grassed and/or partially covered with trees and are typical of the Gulf savanna land system.

3.3 Drainage

ML 5248 is located within the catchment of Slaughteryard Creek. The lease area is drained by a number of smaller tributaries, including Town Creek (from the Croydon township) and Belmore Creek (located within Belmore Station to the west) as well as Slaughteryard Creek itself. The site drainage is as follows:

- Eastern portion - southward, directly via Slaughteryard Creek and Town Creek; and
- Western portion - generally westward via minor drainages to Belmore Creek thence into Slaughteryard Creek to the south west of Croydon.

An area of higher relief between the eastern and western portions of the lease acts as a drainage divide between these areas.

3.4 Land Use and Capability

The pre-mining land use within ML 5248 comprised cattle grazing on the western portion of the lease, with low levels of grazing on the eastern portion. Some cattle grazing continues in the western portion of the lease.

An assessment of pre-mining land capability was undertaken by Woodward-Clyde and reported in Woodward-Clyde (1993), in accordance with Rosser et al (1974). The assessment comprised inspection and sampling of soils not disturbed through mining within and adjacent to ML 5248. Based on this assessment, the pre-mining land capability of ML 5248 was determined as Class VII. Rosser et al (1974) defines Class VII as land that is not suitable for cultivation but on which pastoral use is possible only with careful management and on which pasture improvement involving the use of machinery is considered impracticable.

From 1990 to 1995 the Croydon Shire Council (CSC) used water from the Golden Butterfly North Pit (refer Figure 1) to supplement the existing town water supply, which was based on a borefield located on Slaughteryard Creek downstream from the lease area. Water was pumped from the pit to a tank (Town Tank) located on a hill at the south-eastern boundary of the lease area, for reticulation to the township. During 1995, a new water supply dam was constructed to the north of Croydon and is now used as the town water supply. The Golden Butterfly North Pit and the borefield are no longer used to supply water to the township. However, the water supply reticulation system from the borefield, including water pipes, tank and pumps, has been retained.

3.5 Land Tenure

The locations of the mining related landforms, as described above, with respect to land tenure are described in Table 2 below.

Table 2: Underlying Land Tenure for Mining Related Landforms

LOCATION	MINING LANDFORM	BACKGROUND LAND TENURE
Eastern Portion of Lease Area	Golden Butterfly Pit	Town Common, Croydon Shire Council
	Golden Butterfly North Pit	
	Golden Butterfly Waste Rock Dump	
Western Portion of Lease Area	Content Pit	Crown Land, Department of Natural Resources and Mines
	Lady Isabella Pit	
	Content Waste Rock Dump	

Hardstand areas, the haul road, drill holes and shafts occurred within both land tenure areas.

Information regarding landholder requirements for the area is provided in Section 6.1.

4.0 STATUS REPORT

The following section provides a summary of the rehabilitation of the site, commitments and their status, results of the monitoring program and an assessment of continuing requirements for the area.

4.1 Rehabilitation

With the exception of the open pits, the components of ML 5248 that were disturbed by mining have been rehabilitated. Details of this rehabilitation follow.

4.1.1 Pre-1996 Rehabilitation History

Planning for rehabilitation of ML 5248 commenced in November 1992 at a site meeting involving representatives from Pancon, the Department of Minerals and Energy and Woodward-Clyde. During this meeting, the principal environmental concerns relating to the lease area were identified as:

- Development of acidic water in the open pits;
- Discharge of acidic water into Slaughteryard Creek from the Golden Butterfly waste rock dump and adjacent areas;
- Off-lease movement of groundwater from the Golden Butterfly pits; and
- Erosion and potential instability of mining-related landforms.

Pancon committed, at that time, to address each of these concerns. In 1993, Pancon initiated a rehabilitation program that involved the following works:

- **Golden Butterfly Waste Dump:** re-profiling of the waste rock dump surface, including flattening of batters to a nominal slope of 3(H) to 1(V); construction of cover layers over plateau areas of the waste dump; construction of drainage runoff control areas and construction of stormwater diversion bunds.
- **Content Waste Dump:** re-profiling of the western batter to a nominal 3H:1V slope; construction of cover layers over this batter and clean-up of waste rock piles adjacent to the dump.
- **Open pits** (Golden Butterfly, Golden Butterfly North, Lady Isabella and Content) - construction of perimeter safety bunds, fencing around each pit and erection of warning signs.

Revegetation of the waste dump surfaces was carried out by hand broadcasting of seed following completion of the earthworks portion of the program. Species used included improved pasture grasses, legumes and native shrubs.

4.1.2 1995 Rehabilitation Objectives

In 1995, Goldfields acquired a controlling interest in Pancon and immediately commenced reviewing the environmental performance of all Pancon sites. This review and subsequent work was conducted by Goldfields in collaboration with its then major shareholder RGC Limited and made use of the expertise and resources available within the RGC Group.

In reviewing the rehabilitation status of ML 5248, Goldfields considered that the rehabilitation works conducted to date were not adequate in meeting its corporate environmental standards. In addition, it was found, based on these corporate standards, that the 1993 Decommissioning Plan (Woodward-Clyde, 1993)

did not comprehensively address the environmental issues or meet the overall rehabilitation objectives for the site. This review provided the catalyst for updating the 1993 Decommissioning Plan.

The rehabilitation objectives adopted for ML 5248 were to:

- Secure the site for the long term by inhibiting the formation of Acid Drainage (AD) and subsequent release of AD products into the surrounding environment; and
- Enhance the overall stability and sustainability of the developed landforms.

These objectives were to be achieved by isolating AD-producing material, either through disposal in open pits or capping with low permeability constructed covers and, in conjunction with these works, to re-profile the existing landforms, as appropriate, and to revegetate final surfaces (either covered or uncovered). Additionally, all practical measures were to be taken to ensure the safety of the public and livestock using the site. A rehabilitation works program was carried out within ML 5248 in 1996 based on these general rehabilitation requirements.

4.1.3 1996 Rehabilitation Program

Goldfields undertook an analysis of rehabilitation options that included assessment of engineering feasibility, success in achieving the objectives and cost. From that assessment, the rehabilitation scenario outlined in Table 3 was selected by Goldfields for ML 5248:

Table 3: 1995 Rehabilitation Scenario

Landform	Favoured Rehabilitation Option
Waste Dumps	Re-profiling and Capping
Pits	Do Nothing
Other Areas:	
- Stockpile Area	Remove AD potential rock
- Haul Road	Do nothing
- Western side of Content Pit	Remove AD potential rock
- Drainage Channel	Remove AD potential material
- North of Golden Butterfly Pit	Do nothing

An upgraded rehabilitation works program for ML 5248 was commenced in August 1996 and completed in December 1996. This program comprised the following works:

- Golden Butterfly Waste Rock Dump

Clay fill capping and rock fill surface protection of the entire waste dump surface, including construction of a key trench around the dump perimeter;

- Content Waste Dump

Re-profiling of batter slopes (other than the western batter), with clay fill capping and rock fill surface protection of the entire dump surface;

- Other lease area activities, including:
 - (i) Removal of potentially acid producing waste rock within hardstand areas adjacent to the Golden Butterfly and Content Waste Rock Dumps, with disposal of the excavated waste to adjacent open pits; and
 - (ii) Removal of channel bed sediments within the reach of the Slaughteryard Creek tributary that drains the Golden Butterfly waste dump.
- Miscellaneous rehabilitation works that were considered necessary to complement the above major activities or to comply with specific background landholder requirements, as follows:
 - (i) Backfilling of open drill holes and removal of associated rubbish;
 - (ii) Construction of surface drains and a pond to collect surface water drainage from the Content Waste Rock Dump (for the purpose of surface water sampling);
 - (iii) General site clean-up;
 - (iv) Backfilling of open mine shafts;
 - (v) Removal of AD producing material from an area adjacent to the lease which had the potential to affect that part of the Belmore Creek catchment on ML5248; (This material was discovered during the course of the rehabilitation works program, was a significant AD source, and had the potential to mask any benefit from the works around the waste dump site) and
 - (vi) Revegetation of disturbed areas including rehabilitated waste dumps.

The objective of the revegetation program was to establish a sustainable vegetative cover and provide long-term stabilisation and protection of waste dump surfaces and other disturbed areas on ML 5248. The revegetation work carried out comprised sowing with a seed mix of native tree and shrub species similar to those found in the surrounding native woodland communities.

A monitoring program was then established to measure success in achieving the rehabilitation objectives.

A report on this rehabilitation program is attached as Appendix 1.

4.2 Commitments and Conditions

Because of the age of the site, there are no specific rehabilitation or closure requirements placed on formal authorities such as the Mining Lease. Some commitments have been included in the 1996 Decommissioning Plan.

4.2.1 Plan of Operations and Commitments

The 1996 Amended Decommissioning Plan prepared by Woodward-Clyde was submitted to the DME and accepted as the Plan of Operations for ML 5248. Approval of this Plan is current until the end of 2001.

The Plan also included a summary of commitments by Goldfields. These actions and goals were established in order to achieve the rehabilitation objectives and completion criteria for lease relinquishment. The list of commitments, together with an assessment of compliance, is included as Appendix 2.

4.2.2 Environmental Authority Conditions

The Environmental Authority, which is actually the Mining Lease, has a number of Special Conditions relevant to lease relinquishment. These Conditions, and an assessment of compliance, are shown in Table 4.

Table 4: Mining Lease Conditions and Status

	Status
2. The Lessee shall at all times cause all steps and things to be taken and done to prevent mineralised or impure water or sludge or mining debris resulting from mining operations within the boundaries of the Lease from unlawfully polluting, obstructing, damaging or interfering with the sea, any watercourse, lake or reservoir or any land.	Remediation works undertaken in 1996 were aimed at preventing acid drainage leaving the lease. The effectiveness of this work has been demonstrated through the monitoring program.
9. The Lessee shall grade and contour the mined area, overburden and waste rock dumps progressively, so that: <ul style="list-style-type: none"> a) final voids are landscaped and connected to the drainage pattern in the area for best practical advantage for use as water storage areas; b) rock and overburden dumps are contoured to conform as nearly as is practicable to the adjoining landforms in terms of slopes and slope lengths; and c) all disturbed areas are stabilized against the natural forces of erosion. 	<p>As three of the voids contain acid water, Goldfields considers that this condition should not be complied with. Golden Butterfly North pit has water directed into it to maximise storage. Waste rock dumps have been regraded to a maximum slope of 3H:1V, similar to natural slopes in the area.</p> <p>Waste rock dumps have been stabilised by a rock mulch and vegetation cover.</p>
10. After an area has been contoured in accordance with condition 9 the Lessee shall: <ul style="list-style-type: none"> a) cover the surface of the contoured area with the soil removed in compliance with condition 8; and b) take such measures as the Minister may direct to promote the stabilization of the area and the regrowth of vegetation during the term of the lease. 	<p>Where available, topsoil has been used on the surfaces of the waste rock dumps to enhance vegetation establishment. Stabilization has been achieved by a combination of rock mulch and vegetation cover.</p>
13. When the Minister so requires, the Lessee shall ensure that overburden or waste rock dumps that react with water to produce substances toxic to animal and plant life are covered by an approved layer of inert material.	Potentially acid forming waste rock dumps have been capped with a compacted clay layer to reduce the potential for production of acid drainage.

Condition	Status
14. All fences on the Lease shall be kept intact at all times, except that, where the Lessee requires to remove a fence an alternative fence of a standard equal to or better than the displaced fence shall be provided by the Lessee.	Open pits have been fenced and are currently maintained by Goldfields. Other fences on the lease are also maintained in this manner.
17. The Lessee shall maintain the Lease area in a tidy state and, prior to the termination of the Lease, remove all machinery and plant unless otherwise approved.	All machinery and plant associated with the modern mining operation have been removed. Some historic machinery remains <i>in situ</i> .

4.3 Results of the Monitoring Program

Regular monitoring of surface and groundwater quality, vegetation establishment and erosion potential has been undertaken since late 1996. The results of these programs are reviewed in this section.

4.3.1 Monitoring Reports

Regular monitoring has been conducted at Croydon since 1996 for:

- Surface water quality;
- Groundwater quality;
- Vegetation establishment on waste rock dumps; and
- Erosion on waste rock dumps.

Annual monitoring reports, presenting the results from the previous year's monitoring and providing an evaluation of the progress towards the aims and objectives of the Amended Decommissioning Plan, have been produced since 1996.

Reports on ML 5248 addressing various aspects of the mining rehabilitation program are:

- Woodward-Clyde (1993). *Pancontinental Mining Limited - ML 5248 Mine Decommissioning Plan*. Report No. 4371 December 1993;
- Woodward-Clyde (1994). *ML 5248 Mine Decommissioning - Croydon 1994 Annual Inspection Report*. May 1994;
- Woodward-Clyde (1996). *Croydon Gold Mine 1996 Monitoring Report ML 5248*. Report No. 280/0005 October 1996;
- Woodward-Clyde (1997). *Croydon Gold Mine (Amended) Decommissioning Plan for ML 5248*. Prepared for Pancontinental Mining Limited, May 1997;
- ERA Environmental Services (1997). *Croydon Mine Revegetation Monitoring, May 1997*. Prepared for RGC Limited;
- Woodward-Clyde (1998a). *Croydon Gold Mine 1997 Annual Monitoring Report*. February 1998;
- ERA Environmental Services (1998). *Croydon Mine Revegetation Monitoring, November 1997*. Prepared for RGC Limited, February 1998;
- Fawcett Mine Rehabilitation Services Pty Limited (1998). *Croydon Site Inspection Report*. May 1998;

- Woodward-Clyde (1998b). *Croydon Gold Mine 1997-98 Annual Monitoring Report*. August 1998.
- ERA Environmental Services (1999). *Croydon Mine Revegetation Monitoring, November 1998*. Prepared for RGC Limited, March 1999;
- Fawcett Mine Rehabilitation Services Pty Limited (1999). *Croydon Site Inspection Report, April 1999*;
- Woodward-Clyde (1999). *Croydon Gold Mine 1998-99 Monitoring Report*. Prepared for Goldfields Limited. Report A8601308\R369-D;
- EWL Sciences (1999). *Croydon Mine Revegetation Monitoring, November 1999*. Prepared by EWL Sciences Pty Limited for Goldfields Kalgoorlie Limited, December 1999;
- HLA-Envirosciences (2000). *Croydon Gold Mine 1999-2000 Monitoring Report*. Project No. F1715, November 2000; and
- Lane, A. (2001). *Final Report Croydon Mine Revegetation Monitoring, November 2000*. Prepared for Goldfields Kalgoorlie Limited by Annie Lane, March 2001.

4.3.2 Relinquishment Criteria

Relinquishment criteria were proposed in the 1996 Amended Decommissioning Plan and accepted by the DME. Relevant criteria for each monitoring program are summarised at the beginning of each section in this report. A complete set of the relinquishment criteria is attached as Appendix 3.

4.3.3 Surface Water Quality

This section provides information on the surface water quality monitoring program and the analytical results obtained during the monitoring period. The locations of monitoring points are shown on Figure 2.

4.3.3.1 Relinquishment Criteria

A summary of the approved relinquishment criteria for surface water is provided in Table 5.

Table 5: Lease Relinquishment Criteria - Surface Water

Category	Parameters	Relinquishment Criteria
SW Series	pH, TDS, EC, Ca, Mg, Na, SO ₄ , As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	Livestock watering guidelines (ANZECC, 1992) or 115% of background surface water quality*
Open Pits	pH, TDS, EC, Ca, Mg, Na, SO ₄ , As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	No relinquishment criteria

* = whichever is greater

The SW Series comprises monitoring sites for surface drainage within ML 5248. Results for this monitoring are compared against the ANZECC (1992) livestock watering guidelines. If the results exceed these guidelines, they are then compared against 115% of the background water quality (defined as analytical results for locations SW3 and SW4). If no guideline is suggested for a parameter in the ANZECC criteria, it is assumed that this is not a key water quality parameter and no comparison to background data is conducted. The acceptable criteria for each analyte, based on ANZECC (1992) livestock watering guidelines, are provided in Appendix 3.

Figure 2: Surface Water Monitoring Locations

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Goldfields nominated SW1 as the compliance point for ML 5248 and aimed for compliance with the surface water quality criteria at both SW2 and SW5 (refer to Figure 2). This nomination has been adopted by Goldfields.

Background surface water quality for the site is measured at SW3 and SW4.

The 1996 Amended Decommissioning Plan stated that relinquishment criteria for the quality of contained water are not set, as no beneficial use has been established for the open pits. Nevertheless, monitoring of water quality in the open pits has continued throughout the year.

4.3.3.2 Results and Discussion

A complete set of surface water monitoring results is included in Appendix 4.

As can be seen in Table A4-1, water quality at SW1, the nominated compliance point, has been consistently below the relinquishment criteria since monitoring started in January 1996. All parameters have been at least one order of magnitude below the livestock watering guideline limit. While the concentration of arsenic appears to have risen since January 2001, the concentration is still 25 times lower than the guideline.

Water quality at SW2 (Table A4-2), one of the two points at which compliance was also sought, is also good, with all parameters at least one order of magnitude below the corresponding guideline value and many of them over two orders of magnitude lower.

SW5 is located at a small dam in the drainage line from the Content waste rock dump. The water quality at this site was good between December 1996 and December 1997, but started deteriorating in January 1998 (Table A4-6). The drop in pH (Figure 3) and increase in TDS (Figure 4), sulphate (Figure 5) and some of the metals suggested the presence of acid drainage. While the concentration of sulphate did not remain elevated above the livestock watering guideline after April 1998, that of cadmium has been consistently above the relevant guideline concentration since December 1997 and appears to have stabilised at around twenty times the guideline concentration (Figure 6). This is most likely because the pH of the drainage is at the optimum level for mobilisation of cadmium while other metals have become relatively insoluble. Mobilisation of cadmium will likely continue until the supply of the metal is exhausted or the characteristics of the drainage change.

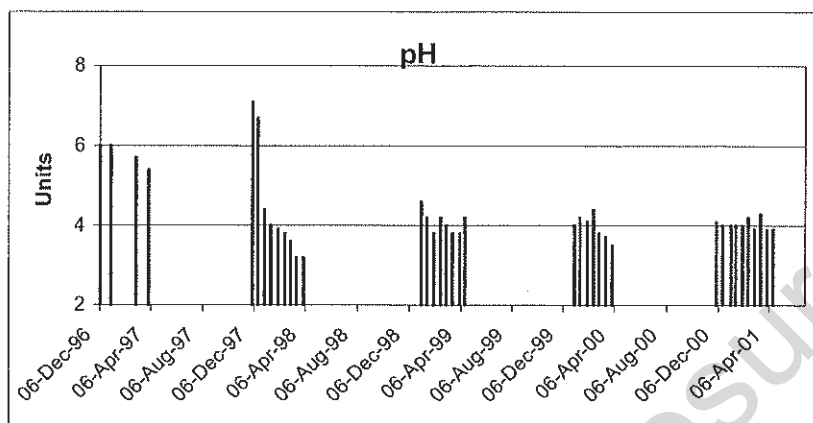


Figure 3: pH at SW5 over Time

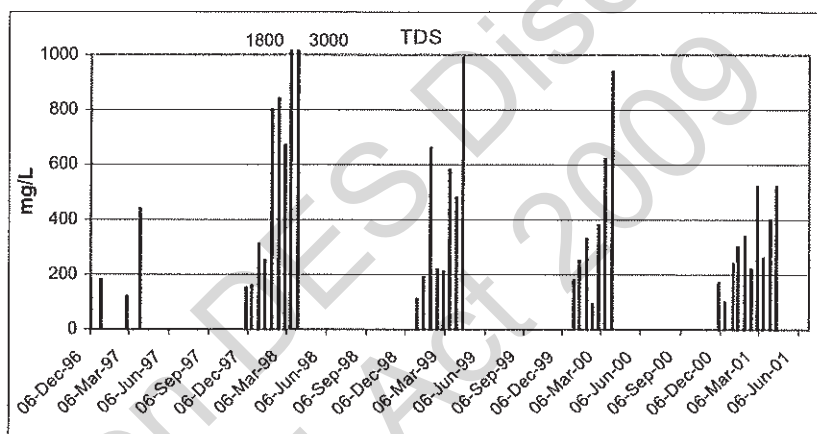


Figure 4: Total Dissolved Solids at SW5 over Time

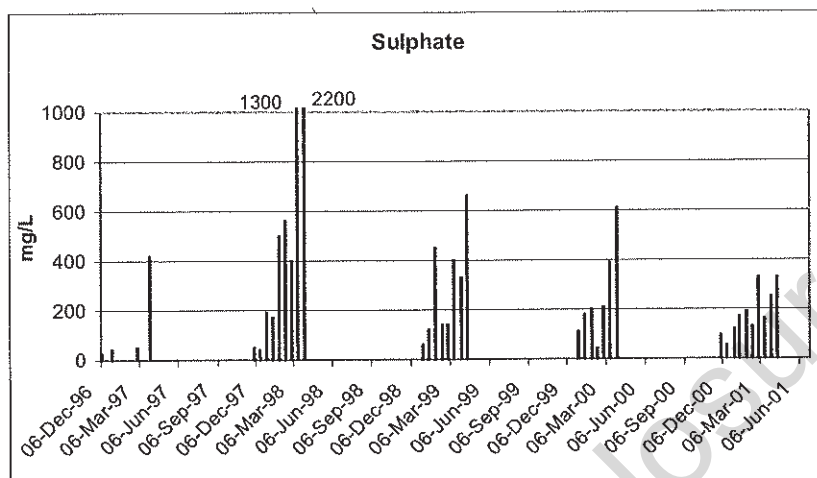


Figure 5: Sulphate Concentration at SW5 over Time

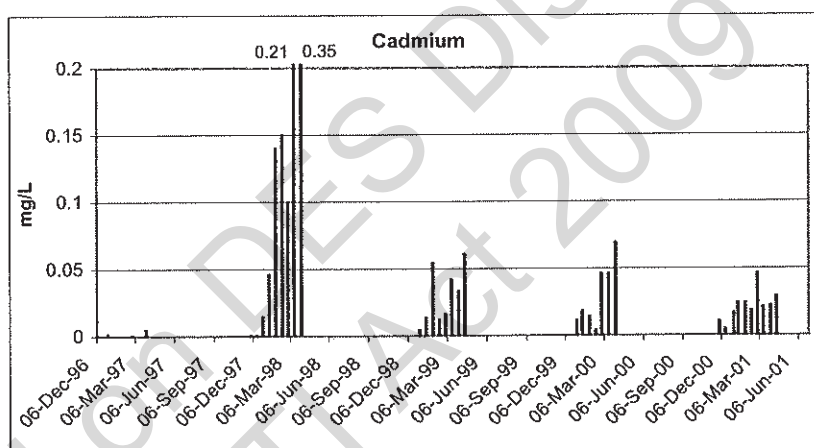


Figure 6: Cadmium Concentration at SW5 over Time

Following the detection of this acid drainage, presumed to originate at a localised point on the western batter of the Content waste rock dump, an additional water monitoring point was established further downstream of SW5 at the boundary of the adjacent pastoral property. This point was designated SW6 and the results of monitoring since June 1998 are shown in Table A4-7. Despite the occurrence of the acid drainage upstream, the monitoring at this point shows that the water quality has been consistently well below the livestock watering guideline concentrations. For most parameters, concentrations have been at least two orders of magnitude lower than the guideline. The concentration of arsenic has been below the limit of detection until early 2001 but is still 50 times lower than the guideline value of 0.5 mg/L (Figure 7).

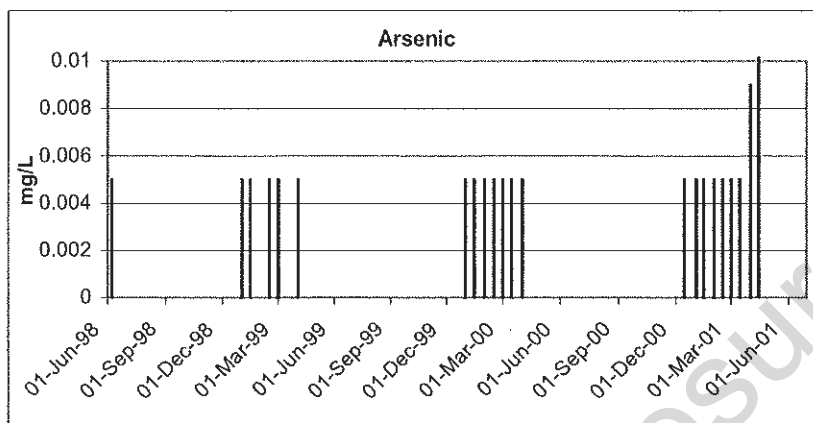


Figure 7: Arsenic Concentration at SW6 over Time

Although no relinquishment criteria were established for the open pits, water samples continue to be collected and analysed on a quarterly basis. The results of this monitoring are tabulated in Appendix 4.

Three of the four open pits, Golden Butterfly, Content and Isabella, contain water that has a low pH, generally around 3.0, and only lightly elevated concentrations of dissolved solids and major ions (Tables A4-8 to A4-11). The water in the Golden Butterfly pit has the lowest pH (around 2.5) and highest TDS (around 8,500 mg/L) and sulphate (around 6,000 mg/L) concentrations. Concentrations of arsenic, cadmium, copper, nickel and zinc are also elevated and, in most cases, are at least twice the corresponding livestock watering guideline. In contrast, water in the Content and Isabella pits is slightly less acid (pH around 3.5 in each case) with much lower concentrations of TDS, sulphate and metals. In both of these pits only the cadmium concentration is above the livestock watering guideline.

The water in the Golden Butterfly North pit is totally different in composition, being neutral to slightly alkaline with low concentrations of major ions and metals. Although there are no completion criterion for the open pits, none of the livestock watering guidelines are exceeded in this water.

4.3.4 Groundwater Quality

This section provides information on the groundwater monitoring program.

4.3.4.1 Relinquishment Criteria

A summary of the lease relinquishment criteria for groundwater is provided in Table 6.

Table 6: Lease Relinquishment Criteria - Groundwater

Category	Parameters	Relinquishment Criteria
GBMB Series Bores	pH, TDS, EC, Ca [#] , Mg [#] , K, Na, SO ₄ , Cl, As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	Maintain existing water quality measured during the 1990-1993* period
BH Series Bores	pH, TDS, EC, SO ₄ , Fe.	No relinquishment criteria

= no criteria available as parameter added in 1996 Decommissioning Plan

* = see ranges in Appendix 3

The list of analytes for the GBMB Series is a modified suite based on a review of the 1993 Decommissioning Plan parameter list and the results of past monitoring.

Monitoring locations for these bores are shown on Figure 8.

4.3.4.2 Results and Discussion

The results of water quality analyses in the GBMB series bores are included in Appendix 4 as Tables A4-12 to A4-17.

None of the GBMB series bores has water that, in a strict sense, meets the relinquishment criteria established in the 1996 (Amended) Decommissioning Report. However, in most cases, this is because the criteria are very strict rather than because the quality of the water is poor. For example, for GBMB1 to meet the criterion for TDS the concentration in the water should be between 390 and 520 $\mu\text{S}/\text{cm}$, a very narrow range. Similarly, because the range of pH in this bore between 1990 and 1993 was 3.6 to 6.15, water with a pH value of 7.0 would not meet the relinquishment criterion even though it is neutral and “better” quality water. Therefore, non-conformance with the relinquishment criteria is an artefact of the baseline quality varying very little rather than a test of suitability for use.

In all cases there are no substantial departures in water quality from the relinquishment criteria and the quality of the water in the boreholes is generally good, being neutral or slightly acid with relatively low concentrations of TDS, major ions and metals. None of the measurable parameters appears to have changed with time since the current monitoring program commenced in early 1996.

The water in GBMB2 is noticeably different to that in the other boreholes, having higher concentrations of TDS, major ions and some metals eg. manganese. While GBMB1 water also has TDS, sodium and sulphate concentrations higher than the remaining boreholes, they are lower than those in GBMB2.

As no construction details for these boreholes can be located, it cannot be determined whether these differences are due to the influence of the mine or because the boreholes are located in different aquifers.

Given the absence of any trends with time, it is unlikely that the quality of the water in these boreholes will ever meet the relinquishment criteria proposed in the 1996 (Amended) Decommissioning Plan. As there is no longer any beneficial use of this water, we consider that maintaining the requirement to meet the nominated relinquishment criteria for the GBMB series boreholes is unnecessary. The monitoring shows that the quality of the water in these boreholes has not changed as a result of the rehabilitation and we consider that it is adequate for lease relinquishment.

Figure 8: Groundwater Monitoring Locations

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Results of water quality monitoring in the BH series bores are attached in Appendix 4 as Tables A4-18 to A4-21.

The BH series monitoring bores were established for two purposes. BH1 and BH2 were installed in November 1995 on the northern and southern sides of the Golden Butterfly pit respectively. Their purpose was to monitor the groundwater depth and quality close to the pit and to assess any relationship between pit water quality and the quality of the surrounding groundwater. Five additional shallow bores (BH3 to BH7) were established as monitoring points in May 1996 adjacent to the Golden Butterfly waste rock dump to monitor possible shallow groundwater influences within the Slaughteryard Creek area resulting from drainage from the dump. Two of these bores, BH3 and BH7, were sampled as part of the environmental monitoring program. Completion criteria were not nominated for any of the BH series bores.

The quality of the water in BH1 and BH2 differs markedly, suggesting that the bores intersect two different and possibly unconnected aquifers. This is further substantiated by the water levels, which are also markedly different. The water in BH1 can be characterised as neutral or slightly alkaline, with a TDS around 1,000 mg/L and low sulphate (around 450 mg/L) and iron (variable between <0.05 and 2 mg/L) concentrations. Although the water in BH2 is acid (pH around 3.5), the TDS, sulphate and iron concentrations are comparable with those in BH1. With the exception of pH in BH2, the water quality in these bores is more similar to that in the GBMB series than the Golden Butterfly pit itself.

Therefore, these bores are showing no indication that water is permeating out from the Golden Butterfly pit into the surrounding aquifers.

The water in BH3 is slightly acidic with relatively low concentrations of TDS, sulphate and iron. In contrast, water in BH7 has a similar pH but higher concentrations of the other parameters. There are no obvious trends in water quality since monitoring commenced and these holes are not showing any apparent influence of the nearby waste rock dump.

4.3.5 Vegetation

This section summarises the results of the vegetation monitoring since May 1997.

4.3.5.1 Relinquishment Criteria

The lease relinquishment criteria for the establishment of vegetation are summarised in Table 7.

Table 7: Lease Relinquishment Criteria - Vegetation

Category	Parameters	Relinquishment Criteria
Vegetation	Landscape Function Analysis (LFA)	Capture and decomposition of leaf litter within troughs is occurring Vegetational structural complexity trending towards control sites Vegetation compositional complexity trending towards control sites Habitat complexity trending towards control sites

Category	Parameters	Relinquishment Criteria
	Vegetation Measures: Species richness Species frequency Plant density Growth rate	No criteria for vegetation measures

These terms were defined in the 1996 (Amended) Decommissioning Plan as follows:

- Vegetational structural complexity - a measure of how well the tree layer is developing, determined by measuring tree diameter at breast height (DBH);
- Vegetation compositional complexity - the measure of how well the site is developing the mix of plant species found on the control sites;
- Habitat complexity - a measure to demonstrate how well vegetation structures and other landscape features, and their suitability as sites for wildlife, are developing;
- Species richness - the number of species per unit area; and
- Species frequency - percentage of quadrats in which that species is recorded.

Vegetation monitoring is based on Landscape Function Analysis (LFA), a method developed by the CSIRO (CSIRO, 1997). The basis of LFA is to measure how well a rehabilitated landscape is using water and nutrients, its ability to resist erosion and the landscape's progress towards becoming a stable self-sustaining unit in comparison with selected control sites with similar topography.

Species richness, species frequency, plant density and growth rate are parameters additional to LFA. These parameters and LFA are measured at permanent locations on the rehabilitated and control sites. The first monitoring of vegetation was conducted in May 1997 and subsequent monitoring has occurred every November. This timing, at the end of the dry season, is considered most appropriate for the monsoonal tropics.

Six monitoring sites have been located on revegetation areas and the control (Site 7) is located in natural bushland roughly midway between the two former operating areas. Sites 1 to 4 are situated on slopes of the Golden Butterfly waste rock dump while Site 5 is located on a slope of the Content waste rock dump. Only one site was located on the Content dump because the revegetation was much more uniform on that dump and one site was considered appropriate. The remaining monitoring site, Site 6, is located on the flat former hardstand area adjacent to the Content dump.

The locations of the vegetation monitoring sites are shown on Figure 9.

Figure 9: Location of Revegetation and Erosion Monitoring Sites

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4.3.5.2 Results and Discussion

The most recent report on the vegetation monitoring provides an assessment in November 2000. This report concluded that *"the rehabilitation of the Croydon site is progressing towards self-sustaining ecosystems [ie. meeting the vegetation criteria described in Table 7] in terms of:*

- *Vegetation density and composition of the rehabilitation sites are trending towards those of the natural site; and*
- *Landscape processes such as soil stability, infiltration capacity and nutrient cycling capacity are gradually trending toward those of the natural sites".*

Although Landscape Function Analysis (LFA) parameters were proposed as vegetation relinquishment criteria for the Croydon site, appropriate methods for calculation of these have not been developed. The CSIRO has developed a procedure for the calculation of Habitat Complexity but, as this was developed some time after vegetation monitoring commenced at Croydon, it has not been used in the program. Accordingly, these indicators cannot be used to demonstrate the progress of vegetation re-establishment.

Data are available on the four vegetation measures described in the completion criteria table (Table 7).

Sixteen tree and shrub species were included in the seed mix used during the 1996-97 revegetation program. Most of these were recorded in at least one quadrat during the November 2000 monitoring (Table 8). In addition, other species were recorded at some sites; these reflect either difficulty in identification or self-seeding from surrounding vegetation. In all, nineteen tree and shrub species were recorded at the revegetation sites. Of these, seven were acacias, seven were eucalypts and five belonged to other genera, including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

Table 8: Species Seeded and Recorded at Monitoring Sites

	Rate (kg/ha)	1	2	3	4	5	6	Control
<i>Acacia decora</i>	0.1		✓					
<i>Acacia julifera</i>	0.1			✓	✓	✓		
<i>Acacia platycarpa</i>	0.2				✓			
<i>Acacia shirleyi</i>	0.25	✓	✓	✓		✓		✓
<i>Acacia torulosa</i>	0.2			✓	✓	✓		
<i>Acacia tropica</i>	0.005							
<i>Erythrophleum chlorostachys</i>	0.1							✓
<i>Eucalyptus confertiflora</i>	0.08		✓	✓				
<i>Eucalyptus leptophleba</i>	0.14	✓	✓	✓	✓	✓		
<i>Eucalyptus melanophloia</i>	0.3	✓	✓	✓	✓	✓		
<i>Eucalyptus miniata</i>	0.34	✓		✓		✓	✓	✓
<i>Eucalyptus polycarpa</i>	0.18	✓	✓	✓		✓	✓	
<i>Eucalyptus setosa</i>	0.14	✓			✓			
<i>Hakea arborescens</i>	0.02							
<i>Melaleuca nervosa</i>	0.05							
<i>Melaleuca viridiflora</i>	0.25	✓		✓				
Species not Seeded								
<i>Melaleuca leucadendron</i>		✓						
<i>Acacia holosericea</i>			✓		✓	✓		
<i>Hakea</i> sp.			✓					
<i>Acacia difficilis</i>				✓				
<i>Atalaya</i> sp.					✓			
<i>Acacia</i> sp.		✓						
<i>Eucalyptus</i> sp.		✓			✓			
<i>Alphitonia</i> sp.								✓

All of the sites except Site 6 have equal, or greater, tree species richness than the control (site 7), as shown in Table 9. Site 2 appears to have recovered from the effects of the fire in 1998, while Site 6 still shows the effects of vegetation dieback as a result of acid drainage from the Content waste rock dump. There is a general decrease in species richness, bringing the monitoring sites closer to the control.

Table 9: Tree Species Richness at Monitoring Sites

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Control
Nov 1997	10	13	10	10	8	11	4
Nov 1998	10	6	10	8	8	8	5
Nov 1999	8	11	13	9	12	5	5
Nov 2000	10	8	10	9	8	2	4

The dominant genus at a site in terms of density and frequency is either *Acacia* or *Eucalyptus*. In most cases the differences in number of plants belonging to each genus is not substantial and their relative proportions are reasonably constant. The exception is Site 6, where there are no acacias and only resprouting eucalypts, mainly *E. confertiflora* and *E. polycarpa*.

Tree species density at all sites has been decreasing and approaching that of the control (Figure 10: Tree Species Density at Monitoring Sites)

). In contrast, the density of herbs at all sites has increased recently, parallelling the situation at the control site (Figure 11). With the exception of Site 6, where approximately one hectare of revegetation has been affected by acid drainage, Lane concluded that plant health and vigour is “on a par with other sites”.

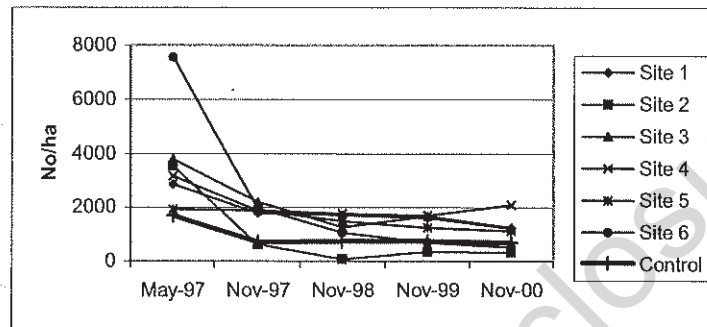


Figure 10: Tree Species Density at Monitoring Sites

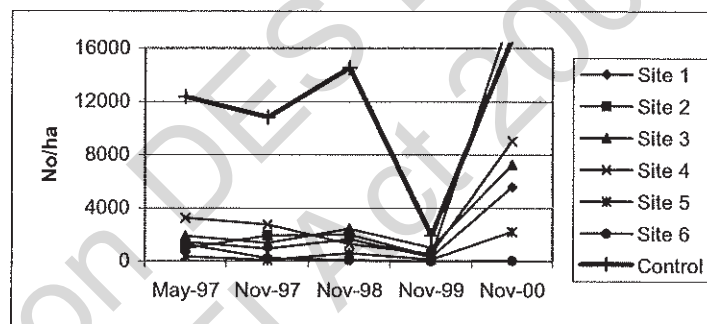


Figure 11: Herb Species Density at Monitoring Sites

Trees and shrubs have continued to increase steadily in height during the period of the monitoring program (Figure 12 for trees [note logarithmic scale on vertical axis], Figure 13 for shrubs), and both are trending towards the heights at the control site.

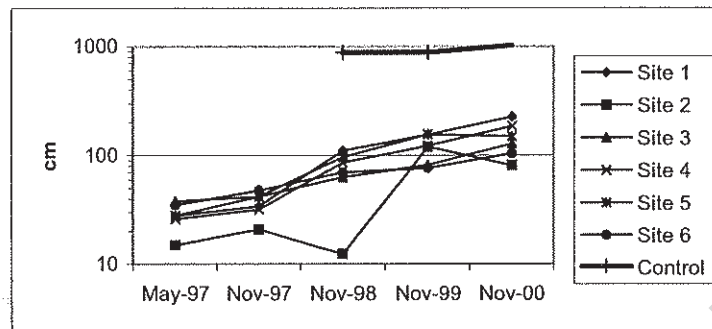


Figure 12: Mean Height of Eucalypts at Monitoring Sites

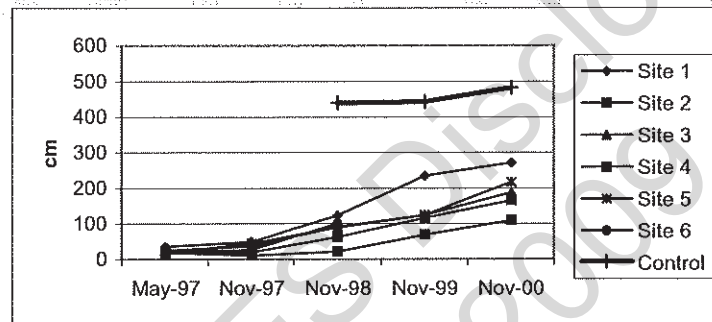


Figure 13: Mean Height of Acacias at Monitoring Sites

4.3.6 Erosion

This section summarises the results of the erosion monitoring since May 1997.

4.3.6.1 Relinquishment Criteria

The relinquishment criteria for erosion have been defined and are presented in Table 10.

Table 10: Lease Relinquishment Criteria - Erosion

Category	Parameters	Relinquishment Criteria
Erosion	(LFA) Soil Surface Condition Class	Trending towards control site
	<ul style="list-style-type: none"> Surface stability Infiltration Nutrient recycling 	
	Integrity of bank and trough systems on waste dump slopes	Maintained
	Erosion gully stability and depth	Erosion depth not greater than 300 mm

The monitoring of erosion is very similar to that of the vegetation. The LFA procedure of Tongway and Ludwig is used to examine the way resources such as water, soil and litter are regulated down a transect through a system of banks, troughs, slopes and flats (Tongway and Ludwig, 1997).

Ten soil surface features are assessed and ranked into classes. These soil surface condition classes (SSCC) are then grouped and summarised to indicate the:

- Stability of the soil surface;
- Water infiltration storage capacity of the soil; and
- Degree of nutrient cycling processes.

The sites used are those sampled for vegetation monitoring (Figure 9).

4.3.6.2 Results and Discussion

The following summary has been adopted from the conclusions that were reached by Annie Lane in the report on the November 2000 monitoring.

The Landscape Function Analysis survey showed that there were no substantial changes to landscape surface condition. Soil surfaces were stable, and minor rilling that was recorded at some sites in previous surveys had not deteriorated. Rip lines remained essentially intact but were shallower due to infilling. The soil surface stability index either remained unchanged or increased slightly at all sites (Figure 14). Similarly, there was little movement in the indicators of infiltration (Figure 15) and nutrient cycling capacity (Figure 16). These indicators are slow to increase due to the absence of topsoil and decomposing litter. Litter accumulation is the major component of these two indices and their values will inevitably increase as the volume and rate of decomposition of litter increases.

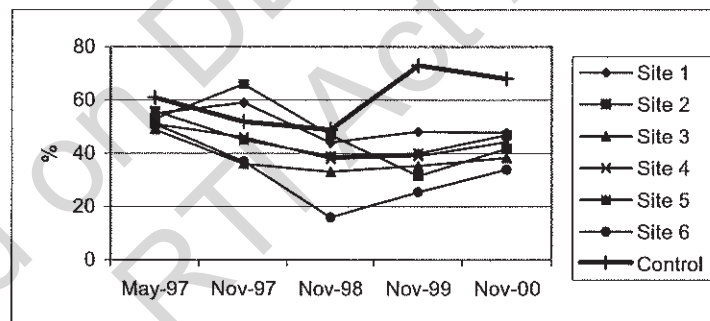


Figure 14: Stability Index at Monitoring Sites

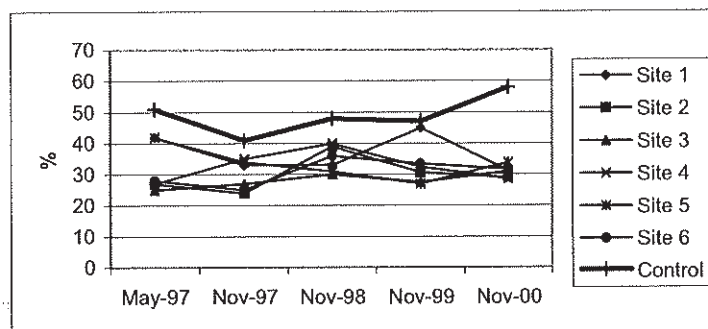


Figure 15: Infiltration Index at Monitoring Sites

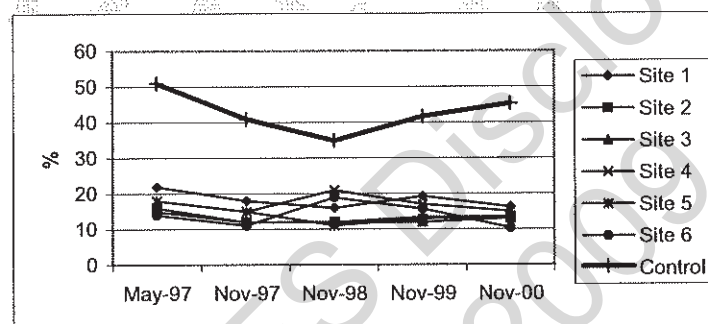


Figure 16: Nutrient Cycling Index at Monitoring Sites

4.4 Continuing Requirements

The monitoring of vegetation and landscape function shows that the ecosystems on the rehabilitated waste rock dumps and hardstand areas are continuing to develop and trend towards the control site. Vegetation cover on the waste rock dumps is increasing and the vegetation is generally progressing towards a stable ecosystem (see Plate 1 and Plate 2).

Goldfields committed to establishing a vegetation cover that would develop and provide protection for the soil surface such that erosion would not exceed that of the natural ground surface. These data show that this commitment has been met at all sites except for the area adjacent to the Content waste rock dump that has been affected by acidic leachate from the adjacent dump. However, the affected area is relatively small and does not appear to be increasing in area. Lane (2001) estimated that the area of vegetation affected was no more than one hectare.



Plate 1: Vegetation Cover on Golden Butterfly Waste Rock Dump (February 2001)

The occurrence of a fire at Site 2 in 1998 provided an opportunity to examine the resilience of the newly established vegetation cover. Despite the trees and shrubs being severely impacted upon by the fire, these rapidly recovered and have continued to develop. This provides some assurance that the vegetation cover is self-sustaining and that it can recover after natural perturbations.

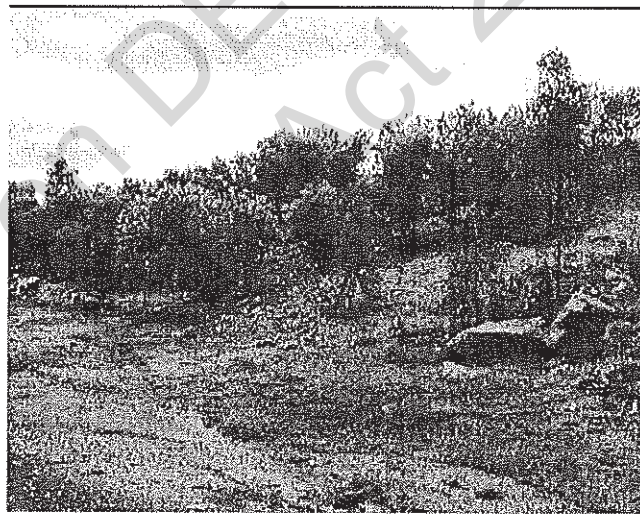


Plate 2: Vegetation Cover on Batter of Content Waste Rock Dump (February 2001)

The vegetation cover established by the revegetation program consists of local species and there are few weed species present. The only maintenance that has been required since 1996 is a program of weed control within the lease area that has concentrated on removal of isolated plants of Calotrope (*Calotropis procera*) (Plate 3). This weed species is ubiquitous in the Croydon area and it is likely that localised infestations will continue.

Control of Calotrope on the lease area could be incorporated into any control programs initiated by the landholders. No other maintenance of the site is considered necessary.



Plate 3: Isolated Calotrope Plant on Golden Butterfly Waste Rock Dump

5.0 CONTAMINATED LAND ASSESSMENT

During the rehabilitation of the site in 1996, any areas with visible contamination such as acid drainage and hydrocarbons were excavated and the soil was buried in one of the open pits. This section provides details of the investigations undertaken at that time and the current status of the lease.

5.1 1996 Site Assessment

Environmental monitoring carried out within the site following Pancon's initial (1993) rehabilitation program (monitoring data reported in Woodward-Clyde, 1994 and 1996) indicated that these works were inadequate to achieve the rehabilitation objective as outlined in Section 1.0, with evidence of continuing acid drainage and erosion from the waste dumps. Upon acquisition of the controlling interest in Pancon, Goldfields commissioned a detailed site assessment to identify the nature and extent of the problem areas. This site assessment formed the basis for design and implementation of a revised and upgraded rehabilitation works program.

The scope of the site assessment was as follows:

- (i) identification of acid producing materials within the existing waste dumps and identification of other visible areas of potentially acid producing material, including former ore stockpile and associated hardstand areas;
- (ii) characterisation of surface and groundwater within the site, with particular emphasis on discharge from the southern portion of the lease; and
- (iii) review of the existing environmental monitoring program currently in place for the tenement (contained within the 1993 Decommissioning Plan).

The site assessment was carried out in December 1995 and April 1996 by Woodward-Clyde, on behalf of Goldfields.

A description of the methodology and results of these works is provided below.

5.1.1 Assessment Methodology

The purpose of this program was to identify the various rock types within the waste rock dumps and surrounding areas and, based on field and laboratory testing, to assess the acid producing potential of these materials.

The investigation was concentrated within areas that were known or suspected to contain acid producing materials. These areas were:

- Golden Butterfly waste rock dump and near surrounds; and
- Content waste rock dump and near surrounds.

The waste dump surrounds incorporate former hardstand and ore stockpile areas and drainage alignments which were potentially impacted by waste dump areas.

The program comprised excavation of 49 test pits within these areas. Materials recovered from each pit were geologically logged, and tested for pH and electrical conductivity (EC) in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity (ANC) was carried out on these samples for estimation of the maximum potential acidity (MPA) and net acid producing potential (NAPP).

Classification of the waste rock materials into three broad categories was undertaken using the three categories shown in Table 11.

Table 11: Classification of Waste Rock for Acid Drainage Potential

MPA : ANC Ratio	Net Acid Producing Potential
> 1:1 and total sulphur > 0.25%	Potentially Acid Producing
Between 1:3 and 1:1	Indeterminate
< 1:3 and total sulphur < 0.25%	Non Acid Producing

Note: Where waste rock has been exposed to oxidation, as in the case of the Croydon site, the testwork is unable to accurately gauge the degree to which the waste has already oxidised. As a result, sulphate oxidation products which are no longer acid producing are included in the maximum potential acidity. Therefore the net acid producing potential (NAPP) may be over estimated.

These categories, in conjunction with the field testing (pH and EC) results, were used to characterise the waste rock materials sampled during the investigation program.

5.1.2 Results of the Waste Rock Dump Assessment

Golden Butterfly Waste Dump

The relationship between material type in the Golden Butterfly dump and acid producing potential is shown in Table 12.

Table 12: Relationship between Golden Butterfly Dump Rock Type and Acid Drainage Potential

Material	Potential for Acid Production
Red Sand/Sandstone	Indeterminate
White Granite	Indeterminate
Clay	Non Acid Producing*
Grey Granite	Potential Acid Producing

* Inferred classification - no confirmation testwork carried out.

The assessment indicates the profile within the waste dump comprises a surface soil layer (clay and red sand) overlying grey granite waste. At a number of sites, sandstone or white granite materials were encountered beneath the surface soils. These granites most likely originated from the Golden Butterfly North Pit and are scattered throughout the dump.

Content Waste Dump

The relationship between material type in the Content dump and acid producing potential is shown in Table 12.

Table 13: Relationship between Content Dump Rock Type and Acid Drainage Potential

Material	Potential for Acid Production
Brown Sandy Topsoil	Indeterminate
Red Gravelly Clay	Indeterminate
Grey Granite	Generally non acid producing but with some localised acid producing areas

The site investigation indicates the profile comprises a brown sandy topsoil layer overlying grey granite waste. Thin layers of red gravelly clay were encountered in some areas. Grey granite was found on the dump surface in a number of locations.

Other Areas

Waste rock characteristics within other parts of the lease were as follows:

- Haul Road:** Waste rock materials within the haul road comprised a mixture of granite, sand and red gravelly clay. The mixed waste material was considered to be potentially acid producing; however, due to the level of compaction within the haul road formation, these materials were effectively encapsulated.
- Stockpile Area:** The stockpile area comprised surficial red sand/sandstone overlying grey granite, similar to those encountered within the Golden Butterfly waste dump. The sand/sandstone were of indeterminate acid producing potential and the granites potentially acid producing.
- Western Side of** This area was underlain generally by grey granite waste, similar to that

Content Pit:	encountered within the Content dump. Therefore it was potentially acid producing
Drainage Channel:	This tributary of Slaughteryard Creek within the channel area, downstream from the Golden Butterfly waste dump, comprised red clay to brown sandy clay. This channel was considered to be an area of contamination due to acidic drainage from the waste dump. The soils themselves were, however, considered to be non acid producing.
North of Golden Butterfly Pit:	The natural soils encountered within this area were considered to be non-acid producing.

5.2 Site Rehabilitation Work

Following the site assessment, Goldfields and its consultants prepared rehabilitation options for each of the mining related landforms on the site. These options are shown in Table 14.

A further review of the options for each of the areas resulted in the development of the preferred rehabilitation plan that would achieve the objectives set by Goldfields. The selected actions are shown in Table 15.

Table 14: Rehabilitation Options Considered by Goldfields

Landform	Rehabilitation Option
Waste Rock Dumps	(i) Do nothing
	(ii) Drainage redirection
	(iii) Re-profiling and capping
	(iv) Removal
Open Pits	(i) Do nothing
	(ii) Backfilling
Other Areas*	(i) Do nothing
	(ii) Removal

* Includes stockpile areas, haul road, western side of the Content dump, drainage channel and sandy area to the north of the Golden Butterfly pit

Table 15: Selected Rehabilitation Options

Landform	Selected Option
Waste Rock Dumps	Re-profiling and capping
Open Pits	Do nothing
Other Areas:	Removal of suspect material as follows:
Stockpile area	Remove
Haul road	Do nothing
Western side of Content pit	Remove
Drainage channel	Remove
North of Golden Butterfly pit	Do nothing

5.2.1 Rehabilitation Specifications

The reasons for selecting these options and the specifications developed for each landform were as follows.

Waste Rock Dumps

The do nothing and drainage redirection options would not assist in compliance with the adopted rehabilitation objectives as acid drainage would continue to occur. Backfilling of the open pits with the waste rock dump material was the most expensive option and would not result in total removal of the dumps. Therefore the re-profiling and capping option was selected. Design features of this option were:

(i) Re-profiling works

Batter slopes to 3H:1V minimum, with benches of 5 metres width provided at a maximum of 50 metres vertical spacing.

(ii) Waste Dump Cover Configuration

As the site investigation and previous water quality monitoring showed there was potential for acid drainage to occur from the Golden Butterfly waste rock dump, Goldfields decided to rehabilitate the entire dump. The acid drainage potential from the Content waste rock dump was assessed by Woodward-Clyde to be lower and some of the dump surface had rehabilitation that was considered acceptable. Therefore, all but the western batter of the Content dump was proposed for rehabilitation. A two layer cap, with the specification shown in Table 16, was proposed for the waste rock dump rehabilitation work.

Table 16: Waste Rock Dump Cover Configuration

Layer	Surface	Batters
Capping layer	Clay fill	Clay fill
	- 600 mm thickness	- 450 mm thickness
	- permeability < 10^{-8} m/s*	- permeability < 10^{-8} m/s*
Surface protection layer	Rock fill	Rock fill
	- 400 mm thickness	- 400 mm thickness

* Re-compacted to 98% of standard maximum dry density at -2% to +3% of optimum

Open Pits

Woodward-Clyde concluded that there was limited potential for net outward movement of Golden Butterfly pit water into the surrounding shallow groundwater system, although the impact on deeper aquifers was not assessed. Based on preliminary calculations they considered there was no risk of overtopping of the pits and therefore the “Do nothing” option was considered appropriate.

Other Areas

The site assessment identified areas that were potentially acid forming or that were contaminated by acid drainage. Woodward-Clyde considered it prudent that material from these areas that was considered suspect should be removed, leaving any other material in situ. Removal of material was to be on a visual basis, supported by occasional field pH measurements when considered appropriate.

5.2.2 Upgraded Rehabilitation Works Program

The program of works developed by GOLDFIELDS and Woodward-Clyde comprised the following tasks:

- Golden Butterfly waste rock dump
Clay fill capping and rock full surface protection of the entire waste rock dump surface, including construction of a key trench around the dump perimeter;
- Content waste rock dump
Re-profiling of batter slopes (other than the western batter) with clay fill capping and rock fill surface protection of the entire dump surface; and
- Other lease area activities, including:
 - Removal of potentially acid producing waste rock within hardstand areas adjacent to the Golden Butterfly and Content waste rock dumps, with disposal of the excavated material to the adjacent open pits;
 - Removal of channel bed sediments within the reach of the Slaughteryard Creek tributary which drained the Golden Butterfly waste rock dump.

Miscellaneous rehabilitation works considered necessary to complement the major activities or to comply with specific background landholder requirements were:

- Backfill of open drill holes and removal of associated rubbish;
- Construction of surface drains and a pond to collect surface water drainage from the Content waste rock dump (for the purpose of surface water sampling);
- General site clean-up;
- Backfilling of open mine shafts; and
- Reclamation of between 10,000 and 15,000 m³ of arsenopyrite-rich material from an area adjacent to the lease and controlled by Union Mining and placing in the Golden Butterfly open pit. This material was reclaimed because it appeared to be highly reactive and was producing acidic leachate that reported to locations that would be used for compliance monitoring of the rehabilitation works.

This rehabilitation program was undertaken between August 1996 and January 1997. A report on the works undertaken, prepared by CTPI 49-Sch4 the project superintendent, is attached as Appendix 1.

Following the earthworks, all areas were sown in February 1997 with a seed mix of native tree and shrub species (see Table 8) similar to those found in the surrounding native woodland communities.

5.3 Current Status of the Site

An evaluation of the monitoring program that was established to demonstrate the effectiveness of the rehabilitation work has been included in Section 4.3. The current status of the site with regard to contamination is summarised in this section.

5.3.1 Open Pits

As outlined in previous sections, the primary contamination issue with the open pits is the presence of acidic water in the Golden Butterfly, Content and Lady Isabella pits. Each pit is surrounded by an earthen bund approximately 2 metres high and also a barbed wire fence to limit access by humans and grazing animals.

In order to assess the potential for the open pits to overflow, Goldfields commissioned HLA-Envirosciences Pty Limited (HLA) to undertake an evaluation of the likelihood of the pits overflowing in extreme weather conditions. A copy of the HLA report on this desktop study is attached as Appendix 5 and a summary of the conclusions is provided here.

HLA studied the Golden Butterfly pit as the monitoring data set was most complete for this site. HLA reached the following conclusions in this study:

Based on the above assumptions and calculations, it is unlikely that the pit would be overtopped in even the wettest year on record. The available data show that without groundwater inflow, the pit would lose water even in a wet year. The only conditions that may cause the pit to overtop would be a rise in the groundwater levels, equivalent to the top of the pit. In that case there would be water on the ground at other locations before it got to the top of the pit. Taking the worst case scenario that the pit water level will recover to the highest level recorded in the two boreholes, there would still be 3.7 metres of freeboard in the pit at the end of a 90 percentile wet season. All of these assumptions are based on the continued maintenance and integrity of the bunds around the pit ensuring that no surface runoff from the surrounding catchments can enter the pit.

5.3.2 Waste Rock Dumps

The rehabilitation work on the Golden Butterfly waste rock dump has proven effective in eliminating the acid drainage that apparently occurred from this site, as demonstrated by the surface water monitoring program (Section 4.3.3). In addition, the good establishment of vegetation on the dump (see Plate 1) is demonstration of the continued integrity of the rehabilitation cover.

Although the rehabilitation work on most of the Content waste rock dump is also successful (see Plate 2), there has been surface and shallow groundwater expression of acid drainage that has resulted in some dieback of vegetation on the toe of the western batter of the dump (Plate 4) and the adjacent former hardstand area (Plate 5). The results of the vegetation monitoring at this site show that the revegetation was initially successful and that the plants died back at the same time that acid drainage was detected in late 1997 (see Figure 10: Tree Species Density at Monitoring Sites).

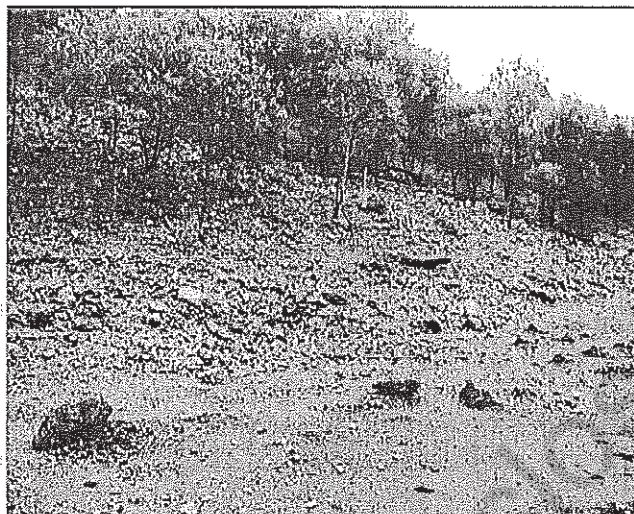


Plate 4: Lower Batter of Content Waste Rock Dump showing Effect of Acid Drainage

Since that time, the bare area on the waste rock dump has remained the same size, at less than 100 m² and the area of the adjacent scalded land has also remained relatively stable at less than 1 hectare. While the quality of water leaving this site is poor, it has not deteriorated over time and the downstream water quality has remained quite good (see Section 4.3.3).

It would appear that this small area of acid producing rock was identified during the 1996 site assessment but not considered for remediation because of the apparently successful rehabilitation of the western batter of the dump. Remediation of this site now would require extensive disturbance of the dump cover by stripping it back to the dump surface and installing an engineered cover at considerable cost and effort. Appropriate cover materials would have to be located and transported to the site, requiring further rehabilitation of the borrow area. Excavation of the dump surface could also result in further acid drainage being triggered in areas currently not affected. Given the relatively small area affected by the acid drainage, and the apparent chemical stability of the drainage, Goldfields considers that further remediation work on the Content waste rock dump is not warranted.

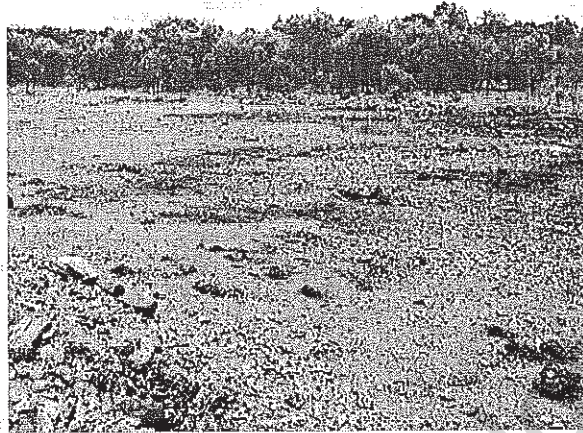


Plate 5: Former Hardstand Area adjacent to Content Waste Rock Dump

5.3.3 Other Areas

The rehabilitation work undertaken on other areas appears to have been successful and the monitoring shows no acid drainage occurring elsewhere on the site. Vegetation establishment has also been good and consistent with the surrounding vegetation (Plate 6).



Plate 6: Former Hardstand West of Golden Butterfly Open Pit

5.4 CONCLUSION

While contamination of the site resulting from acid drainage has not been totally removed, the remaining areas affected by acid drainage are either isolated from the public and livestock (the open pits) or relatively small and not expanding (part of the Content waste rock dump and hardstand area). These are considered not to provide a threat to future use of the site.

The open pits are adequately fenced and banded and will not be a threat to humans or animals so long as these protections remain intact. While three of the pits contain acid water, preliminary modelling has shown that the likelihood of overflow is extremely low.

HLA and Goldfields propose that the entire site be recorded on the Environmental Management Register as a former mining site.

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6.0 LANDHOLDER/LANDOWNER ISSUES

This section summarises the views of the landholders to the rehabilitation program and outlines Goldfields' position with regard to transfer of any residual liability for the mining lease area.

6.1 Landholder Requirements

Woodward-Clyde summarised the outcomes of discussions with the underlying landholders of the lease area, the Queensland Department of Lands (now the Department of Natural Resources and Mines) and Croydon Shire Council. These were as follows.

Queensland Department of Lands (DoL)

Landholder requirements were received in 1993 from the DoL Regional Operations Manager of Land Services, Cairns and were confirmed verbally in 1996. The desired post-mining land use as indicated by DoL is grazing. Specific rehabilitation requirements include the following:

- *That road areas be rehabilitated with natural vegetation cover using endemic species, apart from minimal access roads suitable for local usage. (The location of the access tracks should be ascertained by reference to CSC);*
- *DoL has no specific requirements with regard to fencing around reserves but advises that the replacement or maintenance of any fencing damaged/removed/erected in the mining process be reviewed in consultation with the landowners in the locality, with their legal boundaries taken into consideration;*
- *Areas used for grazing be revegetated with improved pasture;*
- *All foreign equipment and rubbish removed; and*
- *Suitable vegetation be established to control soil erosion where necessary.*

Croydon Shire Council (CSC)

Landholder preferences were received in October 1993 from CSC and revised following discussions in 1996. The desired post-mining land use as indicated by the CSC is Town Common with a portion of the site being allocated as town water supply catchment (with grazing being discouraged within these areas). In addition, the following specific requirements were indicated:

- *Maximisation of watershed catchment into Golden Butterfly North Pit (although CSC is not likely to require this resource again since the construction of a new water supply dam);*
- *Retention of access to Golden Butterfly North, Lady Isabella and Content pits; and*
- *Use of native tree species in the revegetation program.*

Further to these requirements, CSC has confirmed that restrictions to livestock access within the Town Common area would be continued. CSC would take responsibility for control of access through fencing, and maintenance as required.

HLA has attempted to confirm these requirements by writing to the Department of Natural Resources and Mines (NR&M) and the Croydon Shire Council in March 2001 requesting completion of the Landowner/Landholder Statement required by the EPA. At the time of writing this report these statements had not been returned despite follow-up letters and telephone calls. The only response has been a letter from NR&M stating:

The area known as ML5248 appears to have been well revegetated, and all old mining equipment has been removed. However, there is an outstanding requirement to conduct a contaminated land assessment on the site to determine if contamination poses a threat to the future use of the site. On this basis, this Department cannot agree that the site has been adequately rehabilitated.

[Letter from CTPI 49-Sch4 District Manager, to HLA dated 14 May 2001]

This is a comment on the perceived adequacy of the rehabilitation rather than the landholder statement required by the EPA. HLA contacted NR&M in early June 2001 requesting completion of the Statement but this has not been received by either HLA or Goldfields.

6.2 On-going Commitments

Goldfields considers that the rehabilitation of ML5248 is complete and that the monitoring undertaken between 1996 and 2001 demonstrates that the rehabilitation objectives have been met. Therefore there are no management, maintenance or monitoring requirements beyond normal maintenance of fences and management of weeds that would normally be undertaken by a responsible landholder in the area.

6.3 Financial Assurance

Goldfields considers there is no requirement for continuation of the financial surety for ML5248 and applies for cancellation of this requirement.

7.0 AUDIT STATEMENT

7.1 Introduction

Name of Auditor: CTPI 49-Sch4
Qualifications/Experience: MSc, FAusIMM (CPEnv)
Senior Auditor in the Environmental Program, Quality Society of Australasia, CTPI 49-Sch4
Relationship to the EA Holder: Consultant engaged by Goldfields as nominated Project Controller and to prepare the annual monitoring reports and Final Rehabilitation Report for ML5248
Date of Audit: 6 November 2001
Method of Audit: Review of previous documentation relating the environmental management of ML5248;
Review of monitoring data;
Site Inspections;
Discussions with representatives of Goldfields Limited;
Preparation and review of the Final Rehabilitation Report.
Project Name: ML 5248, Croydon Gold Mine

7.2 Audit Report

I have conducted an audit of documentation and evidence against commitments in the approved Plan of Operations and conditions of the EA for the Croydon Gold Mine and consider that these commitments have been met for this project.

The Final Rehabilitation Report that has been prepared for this project is accurate and reflects the current status of the site. Rehabilitation is complete and the completion criteria nominated in the 1996 (Amended) Decommissioning Plan for the site (the Plan of Operations) have either been met or are considered inappropriate for the site. I consider that there are no on-going monitoring requirements and that any maintenance required is no different to that normally undertaken on similar land in the region.

I consider that the financial surety held over ML5248 is no longer required and can be cancelled.

7.3 Conclusion

This Final Rehabilitation Report adequately summarises the rehabilitation that has been undertaken by the leaseholder and the current condition of the ML. All conditions of the Environmental Authority have been met.

7.4 Certification

I, CTPI 49-Sch4 being aware that it is an offence under Section 171 of the Environmental Protection Act 1994 to provide false or misleading information, state that:

- (i) I am authorised to sign on behalf of the person (meaning a corporation or individual) holding the Environmental Authority;
- (ii) All information provided is true and complete; and
- (iii) I understand that information given with this Final Rehabilitation Report and Audit Statement could become available to the public in accordance with the Freedom of Information Act 1992.

Signed Date

CTPI 49-Sch4

8.0 REFERENCES

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APPENDIX 1

Release

FAWCETT MINE REHABILITATION SERVICES PTY LTD

P.O.BOX 781, HOWARD SPRINGS, NT • 0835 • PH (08) 8988 1348 • FAX (08) 8988 1218
ABN 92 073 811 855

4 May, 2001

CTPI 49-Sch4

Goldfields Limited
Box R986
Royal Exchange Post Office
NSW 1225

cc: CTPI 49-Sch4 - HLA Envirosiences

Dear CTPI 4

Please find following a report on rehabilitation works undertaken at Croydon in 1996 and 1997. Fawcett Mine Rehabilitation Services Pty Limited (FMRS) acted as Project Superintendent on behalf of the lease owners Pancontinental. In addition CTPI 49-Sch4 acted as the Registered Mine Manager as required by Queensland mining legislation during the rehabilitation programme.

FMRS's range of responsibilities during this project were:

1. Supervise the contractor (Cardross P/L) on a daily basis to ensure that they conformed with the tender specifications.
2. Supervision and direction of the geotechnical contractors (Earthtech P/L).
 - a. Earthtech were to have originally been employed by Cardross, however due to concerns over Cardross's proposed testing frequency and backcharge costs, they were employed directly by Pancontinental and directed by FMRS.
3. Approve variations from the contract as and when required.
4. Design, implement and supervise the revegetation programme.
5. Liaison with the Qld DME and local government officials during the execution of the project.

I was on site from the 27th of August 1996 until the 23rd of November 1996 (with the exception of the dates listed below) acting as Contract Superintendent and again between the 16th and 24th of January 1997 to undertake the revegetation programme.

During the period 27th of August 1996 until the 23rd of November 1996, I was off site at the following times:

20th to the 24th of September - during this period no earthworks were undertaken due to the original equipment fleet being demobilised and delays in sourcing replacements.

12th to the 16th of October. - during this period CTPI 49-Sch4 delegated for me and I remained in daily phone contact.

6th to the 13th of November.. - during this period CTPI 49-Sch4 delegated for me and I remained in daily phone contact.

The earthworks programme consisted of the following major components:

Page -1-

1. Selection and development of a borrow pit as a source of capping material.
2. Stripping existing vegetation from the surfaces of Golden Butterfly and Content Waste Rock Dumps in preparation for capping. Minor reprofiling of the dumps surfaces.
3. Plugging open drillholes.
4. Backfilling historic shafts and associated minor workings within the lease area.
5. Stripping material affected by acidic leachate in the headwaters of Slaughteryard Creek adjacent to eastern toe of the Golden Butterfly WRD.
6. Construction of a haul road from the borrow pit on Belmore Station to the waste rock dumps.
7. Formation of drainage structures on both waste rock dumps - intermediate contour drains and drop structures.
8. Reclaiming of material from the Golden Butterfly hardstand area.
9. Reclaiming of material from the Content hardstand area.
10. Placement of a compacted clay cover over the entire surface of Golden Butterfly WRD.
11. Placement of a rock armour layer over the compacted clay layer placed on Golden Butterfly WRD.
12. Reshaping of the eastern batter of Content WRD to a 1V : 3H slope.
13. Placement of a compacted clay cover over all but the western batter of Content WRD.
14. Placement of a rock armour layer over the compacted clay layer placed on Content WRD.
15. Construction of a surface water control structure (SW 5) at the north-western corner of the lease.
16. Reduction in width of the original mine haul road between Content and Golden Butterfly from approximately 10 metres to 3 metres wide.
17. Removal of infrastructure used during the rehabilitation programme, ie:
 - a. Haulroads.
 - b. Rail crossing
 - c. Heavy equipment servicing and laydown area.
 - d. Used earthmoving tyres etc.
18. Additional out of scope earthworks undertaken included:
 - a. Reclaiming some 10 to 15,000 m³ of arsenopyrite rich material from an area adjacent to the lease and controlled by Union Mining. Reclaimed material was placed in the Golden Butterfly open pit. It felt it necessary to reclaim this material as it appeared to be highly reactive and was producing acidic leachate that reported to locations that would be used for compliance monitoring of the rehabilitation works.
19. All water used for construction purposes was sourced initially from Content open pit and

subsequently from Lady Isabella open pit.

BORROW PIT

Previous site investigation work undertaken by Woodward-Clyde had located three potential clay borrow sources on Belmore Station. Approval was sought and received from the station owners CTPI 49-Sch4 to develop a borrow pit on their property.

An area of approximately 10 hectares was stripped of vegetation and sandy topsoil, this was located approximately 1.5 km west of Content WRD. The final surface area of the borrow pit was about 7 hectares and its depth varied from 2 metres in the southeast corner to about 5 metres in the northwest corner. As much as possible attempts were made to limit the surface area and maximise the depth of the pit in order to create a viable farm dam.

STRIPPING WASTE ROCK DUMP SURFACES

All vegetation was stripped from the surfaces of the waste rock dumps, stockpiled and burnt prior to earthworks commencing on either of them. In addition minor reprofiling to remove surface irregularities was then performed over both waste rock dumps. This work was done in accordance with the specifications set out in the tender.

DRILLHOLE PLUGGING

A number of open diamond drillholes were known to exist on the lease. These were rehabilitated in the following manner:

- PVC collar excavated to approximately 0.5 to 1.0 metres below surface.
- Hole plugged with a cast conical concrete plug.
- Excavation backfilled to surface and compacted using an excavator bucket.

From my recollection approximately 30 drillholes were located and plugged in the above manner.

BACKFILLING HISTORIC WORKINGS

All historic mine workings that were judged to be potential safety hazards to humans or fauna within the lease boundaries were located and backfilled. Backfilling was undertaken using a Caterpillar 950 loader. Typically spoil piles adjacent to the workings were used for the backfilling. Backfill was mounded up over the shaft to allow for potential slumping caused by consolidation of the backfill over time. Where there was a deficit of material, additional clean fill was sourced from the closest available source. Approximately 15 shafts were backfilled, they varied in depth from 2 metres to 10 metres.

STRIPPING AFFECTED MATERIAL IN SLAUGHTERYARD CREEK

Soils surrounding and the sediments in the upper section of Slaughteryard Creek adjacent to the southeastern end of Golden Butterfly WRD had become saturated with acidic seepage sourced from the WRD. This material was excavated and placed into Golden Butterfly open pit. Material to be removed was selected on the following basis:

1. Lateral extent of excavation was determined by vegetation impacts, ie; all material

within the area not supporting a grass cover was assumed to be affected.

2. The vertical limit of excavation was determined by:
 - a. In the creek line and immediate surrounds material was excavated to bedrock - this generally extended 1 to 2 metres either side of the original drainage line.
 - b. Beyond the zone described in a. the excavation was tapered to daylight at the perimeter defined in 1.
3. Any areas where salts formed after 1. and 2. had additional material removed.
4. A number of checks of soil pH were done on 1 in 5 slurries using test strips as a field check. Records of these tests were not kept.

A total of 16,093 m³ of material was removed from this area. This work was performed using a 950 loader and 10 m³ body trucks.

CONSTRUCTION OF HAULROAD

A haulroad was constructed from the borrow pit on Belmore Station to connect up with the existing haulroad between Content and Golden Butterfly. In addition a new sect of road was constructed to run along the western side of Golden Butterfly WRD. It was also necessary to construct a crossing over the Normanton to Croydon railway line capable of supporting heavy (100 tonne +) earthmoving machinery.

FORMATION OF DRAINAGE STRUCTURES

Tender specifications called for the construction of drainage berms and rock-lined drop structures on Golden Butterfly WRD and for a drainage channel on Content WRD. These were all constructed as per the specifications in the following manner:

1. Shape to the structure formed in the WRD either by excavation or fill as required.
2. Compacted clay layer placed with appropriate compaction and moisture content testing.
3. For the drop-structures a layer of woven geofabric was then placed over the compacted clay.
4. A layer of selected coarse armour rock was then placed over the geofabric.

RECLAIMING GOLDEN BUTTERFLY HARDSTAND

The former Golden Butterfly hardstand area was located immediately to the west of Golden Butterfly pit and extended west to Slaughteryard Creek. It consisted of an area that had been filled with waste rock to form a level surface on which a crushing plant had been located and ore stockpiled. Material was excavated from this area until the Superintendent was satisfied that the original ground surface had been exposed. The area was then graded to remove any remaining loose material.

During excavation three distinct layers of material were observed in the hardstand:

1. Coarse waste rock layer with a well compacted surface.
2. Red sand layer up to 0.5 metres thick.

3. Coarse waste rock.

The thickness of material removed from the hardstand varied from a few centimetres along its eastern edge to approximately 2.5 metres at its western extremity. At the northern end of this area historic tailings were encountered so the area of excavation was expanded to remove this material as well. Material was excavated using a Komatsu PC650 (65 tonne) excavator, and hauled in two Komatsu HD 465 (50 tonne) off-highway dump trucks.

A total of 51,200 m³ of material was removed from this area, compared with the provisional estimate provided in the tender documentation of 27,000 m³.

RECLAIMING CONTENT HARDSTAND

The former Content hardstand area was located immediately to the west of Content Waste Rock Dump and extended approximately 100 m to the west. Similar to the Golden Butterfly hardstand, it consisted of an area that had been filled with waste rock to form a level surface on which a crushing plant had been located and ore stockpiled.

The tender specifications called for this material to be hauled to and dumped into the Golden Butterfly open pit. However, the followings changes were made at the Superintendent's direction (note material was identified as potentially acid forming - PAF - if it showed a paste pH <4/4.5 in a field test using indicator strips) :

1. The eastern face of Content WRD was at angle of repose, it was filled out to a batter slope of 1V : 3H prior to capping using PAF material from the hardstand. It was excavated and placed using Caterpillar 633 Scrapers. This required approximately 8,000 m³ of material.
2. 23,500 m³ of non-PAF material was identified and used to provide the rock armour used to cover Content WRD. Material was pushed up into large windrows (2 to 3 m high) using a D9 dozer, then loaded into 50 tonne off-highway dump trucks using a PC 650 excavator.
3. The remaining material (regardless of its properties) approximately 10,000 m³ was hauled to and dumped into the Golden Butterfly open pit.

Material was excavated from the Content hardstand area until the Superintendent was satisfied that the original ground surface had been exposed.

A total of 44,950 m³ of material was removed from this area, compared with the provisional estimate provided in the tender documentation of 25,000 m³.

CLAY CAPPING GOLDEN BUTTERFLY WRD

The entire surface of Golden Butterfly WRD was covered with a compacted clay cover. The thickness of the cover varied depending on its location on the dump as per the tender specifications.

The contractor initially had significant difficulties meeting the tender specifications both for compaction as well as moisture content. Approximately the first 4000 m³ of material laid failed to meet one or both of the specifications and had to be pulled up and relaid. Once the contractor had developed a technique for conditioning the clay in the borrow pit, no further problems complying with the moisture content requirements were encountered. Likewise once sufficient suitable compaction equipment arrived on site no further significant problems were met in achieving the required compaction.

Material was placed in layers with a nominal thickness of 300 mm prior to compaction. The

surface of the dump or preceding layer was wet down prior to placing the next layer. Layer thickness was constantly inspected by the Superintendent and where excessive thickness (>400mm) was observed the contractor was instructed to cut it back before commencing compaction.

The compacted clay layer was tied into a cutoff keyway around the entire perimeter of the WRD. This keyway was excavated until solid bedrock was encountered or to a depth of two metres, whichever occurred first. The keyway was excavated to a minimum of 2.5 metres wide to allow a 633 Scraper to fit in it. Moisture conditioned clay was then placed in the keyway in layers and compacted to specification using an Ingersol Rand SP 100 compactor.

There was a rigorous programme of quality control maintained throughout the placement of the compacted clay layer with typically 10 to 15 measurements being taken per day which from my recollection equated to approximately one test per 200 m³ of material placed. This compares with the testing density required by the tender specifications of one test per 2000 m³.

ROCK ARMOURING GOLDEN BUTTERFLY WRD

The entire surface of the WRD was covered with a layer of benign rock armour placed on top of the compacted clay layer. This material consisted of bleached, lightly weather granite. This material had previously been identified as non acid forming and a number of field paste pH tests were undertaken during its excavation to confirm this. No records of the field pH tests were retained. The material was sourced from the northwestern corner of the WRD and appears to have originated from the excavation of Golden Butterfly North open pit.

Approximately 70,000 m³ of rock armour was placed over the dump surface in layer thicknesses varying between 0.3 m and 0.45 m, depending on the contract specification. Rock armour was excavated by a PC 650 excavator, hauled by two 50 tonne off-highway dump trucks and spread using a Caterpillar D6H dozer.

RESHAPING EASTERN BATTER OF CONTENT WRD

The eastern face of Content WRD was at angle of repose, it was filled out to a batter slope of 1V : 3H prior to capping using PAF material from the hardstand. It was excavated and placed using Caterpillar 633 Scrapers and required approximately 8,000 m³ of material to complete. Material was placed in layers of between 0.3 and 0.5 metres thick and spread and compacted using a Caterpillar 825.

CLAY CAPPING CONTENT WRD

All of the surface of Content WRD with the exception of the western batter, was capped with a compacted clay cover in the same manner as that used for Golden Butterfly WRD. Quality control testing to ensure that compaction and moisture content were within contract specifications was carried out at the same frequency as Golden Butterfly WRD.

ROCK ARMOURING CONTENT WRD

As stated in a preceding section, rock armour was sourced from identified non acid forming material excavated from the Content hardstand area. It was placed over the entire surface of the WRD, with the exception of the western batter, which was considered to have been rehabilitated during the 1993 programme. Rock armour was placed to a minimum thickness of 0.45 m.

CONSTRUCTION OF SW 5

A drainage control structure was constructed in the northwest corner of the lease. It consisted of two compacted bunds each about 300 metres long at right angles to each other meeting at the extreme northwest corner of the lease. At this point a pond approximately 25 metres by 25 metres square by 1.5 metres deep was excavated on the upstream side of the bunds. A spillway over the bunds was also constructed at this point. This structure has become SW 5 sampling point.

ADDITIONAL WORKS

A single stock-proof fence was erected around the Golden Butterfly Pit, Golden Butterfly North Pit, Golden Butterfly hardstand and Golden Butterfly WRD. This supplemented and encapsulated the existing fences around the two pits. A single stock-proof fence was also erected around the Content Pit, Lady Isabella Pit, Content hardstand and Content WRD. This supplemented and encapsulated the existing fences around the two pits.

A weed control programme was initiated to control infestations of Calotrope (*Calotropis procera*) observed around the southern end of Golden Butterfly WRD.

COSTS & VOLUMES

	Surface area - m ²	Volume of material moved - m ³	Cost
Golden Butterfly WRD			
Clearing dump surfaces	159,500		\$5,775
Clearing borrow area	98,000		\$2,754
Topsoil	90,000		\$22,500
Cutoff key excavation		9,500	\$17,100
Clay fill - Cutoff key		9,500	\$38,950
- waste dump batters 0.45 m thick layer		94,000	\$197,400
- waste dump batters 0.9 m thick layer		11,500	\$34,500
- waste dump surfaces 0.3 m thick layer	24,000	7,200	\$48,000
- waste dump surfaces 0.6 m thick layer	30,000	18,000	\$75,000
Rock fill - waste dump batters 0.45 m thick layer	30,000	13,500	\$63,000
- waste dump surfaces 0.3 m thick layer	24,000	7,200	\$36,000
- waste dump surfaces 0.45 m thick layer	103,540	46,593	\$207,080
Spill channels - excavate		1,960	\$11,760
- rock fill		1,960	\$5,880
Hardstand - excavate		51,200	\$204,800
Content WRD			
Clearing dump surfaces	53,100		\$1,858
Clay fill - waste dump surfaces 0.6 m thick layer	38,000	21,600	\$76,000
- waste dump surfaces 0.45 m thick layer	15,100	6,795	\$37,750

	Surface area - m ²	Volume of material moved - m ³	Cost
Rock fill - waste dump batters 0.45 m thick layer	14,150	6,368	\$28,300
- waste dump surfaces 0.45 m thick layer	38,000	17,100	\$57,000
Spill channels - excavate		955	\$5,730
- rock fill		955	\$2,865
Hardstand - excavate		44,950	\$179,800
Slaughteryard Creek - excavate		16,093	\$48,279
Surface diversion & pond (SW 5)			\$8,710
Backfill drillholes			\$1,400
Backfill shafts			\$3,050
Extra drainage works - east of Golden Butterfly WRD			\$2,365
True Blue - reclaim rock containing arsenopyrite			\$11,025
Additional clean up - Content			\$446
Construct haulroads			\$16,000
Mobilisation/demobilisation			\$125,000
TOTAL		386,932	\$1,576,077

REVEGETATION

The revegetation programme was carried out between the 16th and 24th of January 1997. Direct seeding was used, sowing a selection of native tree species broadly representative of those found in the surrounding undisturbed woodlands. Seed was sourced from two commercial suppliers; Top End Seeds and Queensland Tree Seeds. Wherever possible seeds of local provenance were used. The Australian Trust for Conservation Volunteers provided volunteers to undertake the hand seeding programme.

The revegetation programme was designed by FMRS and based on proven techniques developed by them on other minesites.

Immediately prior to seeding all areas were ripped along contour by a Caterpillar D6H dozer using triple shank rippers to a depth of 250 to 300 mm. Some of the flat areas adjacent to the Content Waste Rock Dump were ripped using a Caterpillar 12H equivalent grader. The actual seeding took place over four days between the 20th and the 23rd of January. All ripped and seeded areas were aerial topdressed with an NPK fertiliser on the at a rate of 500 kg/ha on the 23rd of January.

SAFETY

Set out following are the safety statistics for the earthworks and revegetation programmes:

Earthworks

Estimated hours worked: 17,200

Lost time injuries: Nil
First aid treatments: Nil
Notifiable incidents: Nil

One written direction regarding safety was made by the DME Mines Inspector during the project, this related to the inadequacy of the safety bund height on the tip-head into Golden Butterfly open pit. This occurred at the start of the project and was immediately rectified.

Revegetation

Estimated hours worked: 500
Lost time injuries: Nil
First aid treatments: Nil
Notifiable incidents: Nil

I have included as an appendix to this report a copy of the results of the test-work undertaken by Earthtech Laboratories (NQ) on this project. I have previously provided to CTPI 49-Sch4 a copy of the map showing the sample locations and test results for Golden Butterfly WRD, unfortunately the map showing test locations for Content WRD has been lost in the intervening years.

I confirm that all works during the rehabilitation programme were undertaken and completed in a professional and competent manner and that they complied with the specifications set out in the contract.

Yours sincerely,

CTPI 49-Sch4

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APPENDIX 2

Release

The following table is a summary of the status of Commitment Compliance at ML 5248.

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Identify background landholder requirements regarding rehabilitation of ML 5248.	In compliance	Completed - detailed in the Decommissioning Plan.
Prepare and implement an upgraded and enhanced site environmental monitoring program.	In compliance	The environmental monitoring program is implemented.
Review environmental monitoring program annually in consultation with the DME to ensure the continued effectiveness of the program.	In compliance	Completed.
Golden Butterfly Waste Dump - Clay fill covering and rock fill surface protection of the entire waste dump surface and construction of a cut-off key around the dump perimeter.	In compliance	Completed November 1996.
Content Waste Dump - Reprofile batter slopes (other than western batter). Clay fill covering and rock fill surface protection of the entire waste dump surface.	In compliance	Completed November 1996.
Identify, remove and dispose of potentially acid producing material from the Golden Butterfly hardstand area.	In compliance	Completed November 1996.
Identify, remove and dispose of contaminated sediments in Slaughteryard Creek adjacent to the Golden Butterfly waste dump.	In compliance	Completed November 1996.
Revegetate waste dump surfaces, former hardstand areas and other disturbed areas with native woodland tree species.	In compliance	Seed planting completed January 1997.

Released

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Revegetation performance will be monitored on an annual basis.	In compliance	First monitoring completed May 1997 and will continue to be monitored late in the dry season (November) of each year.
Generation of sediment will be limited by: (i) diversion of upstream runoff and, (ii) sediment traps will be constructed where necessary.	In compliance	Some works completed in 1993, remainder completed November 1996.
The effectiveness of sediment control measures will be monitored on a regular basis.	In compliance	Being inspected regularly by local representative.
Erosion monitoring on the waste dump surfaces will be undertaken on a regular basis.	In compliance	First monitoring completed May 1997 and monitoring continues late in the dry season (November) of each year.
Water monitoring of creek sites will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	In compliance	Monitoring has been undertaken close to the correct date since the sampling schedule was introduced.
Water quality at monitoring sites SW1, (Golden Butterfly catchment) & SW5 (Content/Lady Isabella catchment) will comply with ANZECC (1992) Water Quality Guidelines for livestock watering (cattle), or not exceed 115% of background whichever is greater. Background will be measured at sites SW3 & SW4.	Substantially in compliance <i>[Note that this statement as included in the 1996 (Amended) Decommissioning Plan table is not consistent with statements in the text of the document]</i>	Water quality at SW1 was in compliance, however, many cadmium concentrations at SW5 were above the relinquishment criteria during the monitoring period. Note that the text of the 1996 Decommissioning Report specifies that SW1 is the nominated compliance point but that compliance is aimed at for SW2 and SW5.
Water quality monitoring within open pits will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Substantially in compliance	Quarterly samples were not always collected at the beginning of the specified months, however, this has improved since the sampling schedule was introduced.

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Pit water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.	In compliance	Review undertaken in the Annual Monitoring Report.
Groundwater quality monitoring will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Substantially in compliance	Samples were not always collected at the beginning of the specified months.
GBMB series groundwater monitoring bores - maintain water quality within the range of water quality data collected for these bores over the period 1990 to 1993.	Not in compliance	Some GBMB bores have continual exceedances of the relinquishment criteria. However, the stated criteria are very strict and the water has no beneficial use.
BH series groundwater monitoring bores - water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.	In compliance	Review undertaken in the Annual Monitoring Report.
Monitoring data will be collated, interpreted and reported to the DME on an annual basis together with an audit of compliance status against commitments.	In compliance	Annual Monitoring Report
An annual lease inspection will be carried out by Goldfields	In compliance	The last lease inspection was undertaken in December 2000 by Goldfields staff.
Where practicable runoff water will be diverted away from voids via diversion bunds.	In compliance	Completed.
Safety bunding and fencing will be erected around open pits.	In compliance	Completed.

Released

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Warning signs will be placed in strategic sites around the lease.	In compliance	Completed.
Abandoned shafts will be identified and backfilled.	In compliance	Completed November 1996.
Exploration drill holes will be located, plugged and covered over.	In compliance	Completed November 1996.
The lease will be monitored for the outbreak of noxious weeds, any outbreaks will be controlled by DPI recommended methods.	In compliance	Regular inspections are being carried out by Fawcett Mine Rehabilitation Services and Jim Willis.
Submit to the DME a Final Rehabilitation Report.	In compliance	This document is the Final Rehabilitation Report.

Release

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APPENDIX 3

Released

The complete set of relinquishment criteria for ML 5248 is provided in the table below.

Category	Location	Parameters	Relinquishment Criteria
Surface Water	SW Series	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	Livestock watering guidelines - beef cattle (ANZECC, 1992) or 115% of background surface water quality.
	Open pits	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	No criteria
Groundwater	GBMB Series Bores	pH, TDS, EC, Calcium, Magnesium, Potassium, Sodium, Sulphate, Chloride, Arsenic, Cadmium, Copper, Iron, Lead, Manganese, Nickel, Zinc	Maintain existing water quality measured during the period 1990 to 1993.
	BH Series Bores	pH, TDS, EC, Sulphate, Iron	No criteria
Vegetation	Golden Butterfly and Content Waste Dumps and adjacent revegetated areas	<ul style="list-style-type: none"> • Landscape Function Analysis (LFA) • Vegetation Measures <ul style="list-style-type: none"> – Species richness – Species frequency – Species density – Growth rate 	<ul style="list-style-type: none"> • Capture and decomposition of leaf litter is occurring • Vegetation structural complexity trending towards control sites • Vegetation compositional complexity trending towards control sites • Habitat complexity trending towards control sites • No criteria
Erosion	Golden Butterfly and Content Waste Dumps	<ul style="list-style-type: none"> • LFA SSCC <ul style="list-style-type: none"> – surface stability – infiltration – nutrient cycling • Integrity of bank and trough systems on waste dump sloping • Erosion stability and depth 	<ul style="list-style-type: none"> • trending towards control site • Maintained • Erosion depth not > 300 mm

Release

The following table is part of the relinquishment criteria for the SW Series.

Summary of ANZECC (1992) Livestock Watering Guidelines

PARAMETER	SYMBOL	UNIT	CRITERION
pH	pH	-	NGR
Electrical Conductivity	EC	µS/cm	NGR
Total Dissolved Solids	TDS	mg/L	4000
Sodium	Na	mg/L	NGR
Calcium	Ca	mg/L	1000
Magnesium	Mg	mg/L	600
Sulphate	SO ₄	mg/L	1000
Arsenic	As	mg/L	0.5
Cadmium	Cd	mg/L	0.01
Copper	Cu	mg/L	5
Iron	Fe	mg/L	NGR
Lead	Pb	mg/L	0.1
Manganese	Mn	mg/L	NGR
Nickel	Ni	mg/L	1.0
Zinc	Zn	mg/L	20

Notes:

NGR = No guideline recommended

Released

The following table is the lease relinquishment criteria for groundwater (GBMB Series bores only).

GBMB Series Bore Monitoring 1990 to 1993

PARAMETER	UNITS	GBMB1	GBMB2	GBMB3	GBMB4	GBMB5	GBMB6
pH	-	3.6-6.15	7.3 - 8.15	6.65-7.25	5.95-6.5	5.6-6.95	5.85-6.85
Total Dissolved Solids (TDS)	mg/L	390-520	1290-2040	280-500	150-240	40-100	110-150
Electrical Conductivity (EC)	µS/cm	590-610	1970-2040	410-445	190-225	68-73	98-305
Sodium	mg/L	17-91	350-400	72-76	27-31	9.3-11	7-14
Sulphate	mg/L	170-240	500-580	11-110	11-65	0.8-7.9	2.8-22
Chloride	mg/L	7-55	190-370	107-130	13-42	11-30	16-26
Arsenic	mg/L	0.01-0.06	0.03-0.07	0.01-0.04	0.02	0.01-0.02	0.01-0.06
Cadmium	mg/L	<0.01-0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	mg/L	0.01-0.05	<0.01	0.01	<0.01	<0.01	<0.01
Iron	mg/L	2.1-6.2	1-1.8	1.8-3.7	2.2-2.6	1.3-3.6	1.7-2.9
Lead	mg/L	0.08-0.23	0.12-0.70	0.02-0.54	0.07-0.16	0.12-0.24	0.05-0.18
Manganese	mg/L	0.45-0.55	0.44-0.68	0.05-1.3	<0.01 -0.04	<0.01 -0.04	<0.01 -0.03
Zinc	mg/L	0.04-0.34	0.02-0.15	<0.01 -0.24	<0.01 -0.45	0.05-0.19	0.03-0.18

Release

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APPENDIX 4

Release

Croydon Water Quality Results

Table A4-1: Site SW1

Analyte	Units	28-Jan-1996	6-Dec-1996	31-Dec-1996	28-Feb-1997	1-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998
GENERAL												
Electrical Conductivity	uS/cm				370	110	260	140	250	160	160	180
pH	units	3.9	5.1	6.3	5	7.9	6.1	6.8	7	6.7	6.6	6.9
TDS	mg/L	300	110	100	200	150	180	100	150	140	110	130
MAJOR-IONS												
Calcium	mg/L	6.8	3.7	3.4	12	4.3	9.3	4.3	4.4	4.7	3.4	3
Magnesium	mg/L	7.4	2	1.8	7	1.9	4.1	2.8	2.7	2.8	2.1	2.4
Nitrate as N	mg/L	0.58	1.8	0.39								
Nitrite as N	mg/L	<0.002	0.017	0.28								
Oxidised Nitrogen	mg/L		1.8	0.67								
Sodium	mg/L				40	8.6	29	14	32	18	18	22
Sulphate	mg/L	200	33	17	190	27	76	32	62	43	36	44
METALS												
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0051	<0.0005	0.0024	0.0019	<0.0005	0.0009	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	0.38	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.9	5	3.5	0.08	2.5	0.13	1.5	0.68	2.2	0.64	0.97
Lead	mg/L	<0.005	0.022	0.013	<0.002	0.015	<0.002	0.005	<0.002	0.007	0.003	0.003
Manganese	mg/L		0.37	0.14	0.92	0.09	0.58	<0.05	<0.05	0.09	0.09	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005								
Molybdenum	mg/L	<0.1	<0.05	<0.05								
Nickel	mg/L	0.13	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.45	0.08	<0.05	0.28	<0.05	0.15	0.05	<0.05	0.06	<0.05	<0.05

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Jan-2000	15-Feb-2000	29-Feb-2000	15-Dec-2000	4-Jan-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001
GENERAL														
Electrical Conductivity	uS/cm	110	100	320	150	190	170	200	140	180	190	200	140	160
pH	units	6.8	6.8	7.2	6.8	6.5	6.7	6.8	6.2	7.5	7.3	7.5	7.2	7.5
TDS	mg/L	98	100	220	120	160	140	170	170	220	140	170	100	140
MAJOR-IONS														
Calcium	mg/L	3.3	1.9	7.4	2.6	3.5	1.9	4.6	2.9	4.1	3.8	3.8	2.7	2.2
Magnesium	mg/L	1.7	1.4	4.2	1.8	2.3	1.4	2.7	1.7	2.7	2.6	3	2	1.8
Nitrate as N	mg/L													
Nitrite as N	mg/L													
Oxidised Nitrogen	mg/L													
Sodium	mg/L	12	12	39	18	21	17	29	17	30	27	30	21	21
Sulphate	mg/L	22	25	79	33	50	32	48	32	44	46	44	28	27
METALS														
Arsenic	mg/L	0.008	<0.005	0.008	0.007	0.005	0.008	0.012	0.007	0.026	0.029	0.033	0.021	0.019
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	2.3	0.4	1.2	0.72	1.4	1.6	1.2	0.77	1.3	2.7	1.9	1.7	1.8
Lead	mg/L	0.004	0.004	<0.001	0.004	0.003	0.003	0.002	0.005	0.002	0.003	0.002	0.003	0.002
Manganese	mg/L	0.11	<0.05	0.31	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.06	<0.05	0.07	<0.05
Mercury	mg/L													
Molybdenum	mg/L													
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.034	0.02	0.065	0.016	0.029	0.01	<0.005	0.034	0.009	0.024	0.013	0.013	0.009

Values shaded are above the completion criterion but less than twice the value

Values shaded are more than twice the completion criterion

Released

**Croydon Monitoring
Water Quality Results**

Table A4-2: Site SW2

Analyte	Units	28-Jan-1996	5-Mar-1996	6-Nov-1996	8-Dec-1996	31-Dec-1996	28-Feb-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998
GENERAL													
Electrical Conductivity	uS/cm						1000	520	240	420	190	250	190
pH	units	2.8	3.8	6.2	3.9	4	4	4.2	4.2	4.3	5.2	4.6	4.8
TDS	mg/L	1040	9300	900	490	350	690	340	100	260	150	160	130
MAJOR-IONS													
Calcium	mg/L	13.1	78	34	23	21	33	21	10	15	6.9	8.7	8.6
Magnesium	mg/L	27	224	14	19	11	29	12	5.8	8.6	3.7	4.7	3
Nitrate as N	mg/L	0.94	0.06	1.2	1.6	1.3							
Nitrite as N	mg/L	<0.002	0.021	0.024	<0.002	0.014							
Oxidised Nitrogen	mg/L		0.08	1.2	1.6	1.3							
Sodium	mg/L						78	46	15	37	16	21	15
Sulphate	mg/L	950	9600	620	340	220	570	220	76	170	57	75	66
METALS													
Arsenic	mg/L	0.05	0.5	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.024	0.18	0.0045	0.0051	0.0076	0.01	0.0042	0.0028	0.0023	0.0014	0.0016	0.0009
Copper	mg/L	2.06	22	<0.05	0.31	0.13	0.45	0.09	0.1	0.09	<0.05	0.05	<0.05
Iron	mg/L	23	197	<0.05	0.6	<0.05	0.12	<0.05	0.12	0.12	0.19	0.12	0.08
Lead	mg/L	<0.005	<0.1	<0.005	<0.005	<0.005	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L			1.7	3.1	2	4.8	2	0.72	0.88	0.61	0.78	0.33
Mercury	mg/L	<0.0005	0.001	<0.0005	<0.0005	<0.0005							
Molybdenum	mg/L	<0.1	<0.1	<0.05	<0.05	<0.05							
Nickel	mg/L	0.66	7.2	0.07	0.27	0.14	0.29	0.1	0.06	<0.05	<0.05	0.05	<0.05
Zinc	mg/L	2.2	19	<0.05	0.7	0.44	1.3	0.69	0.62	0.56	0.25	0.45	0.4

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	15-Feb-2000	29-Feb-2000	15-Dec-2000	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001
GENERAL													
Electrical Conductivity	uS/cm	400	180	570	360	310	170	190	200	110	110	100	140
pH	units	4.7	6.8	4.4	4.6	6.5	6.8	6.6	6.4	6.7	7.2	7.3	6.9
TDS	mg/L	260	130	400	240	220	260	170	300	200	150	120	130
MAJOR-IONS													
Calcium	mg/L	17	3.9	22	11	12	3.2	4.9	4.3	2.3	5.2	2.6	2.6
Magnesium	mg/L	7.4	2.8	12	7	6.4	2.5	3.3	2.9	1.4	3.3	1.8	1.8
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	45	22	51	32	33	21	25	30	15	20	16	17
Sulphate	mg/L	140	49	260	140	120	51	68	63	42	58	32	42
METALS													
Arsenic	mg/L	<0.005	<0.005	0.008	<0.005	0.005	0.01	0.006	0.009	0.015	0.014	0.016	0.015
Cadmium	mg/L	0.0018	0.0003	0.0045	0.0044	0.0005	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	0.2	0.13	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.13	0.14	0.63	0.23	0.19	0.76	0.51	1.8	0.55	0.71	1	1.2
Lead	mg/L	<0.001	<0.001	<0.001	<0.002	<0.002	0.003	<0.002	0.005	0.004	<0.002	0.003	<0.002
Manganese	mg/L	1.3	0.36	3.1	1.7	0.82	0.19	0.23	0.06	0.06	<0.05	<0.05	<0.05
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	0.08	<0.05	0.16	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.31	0.024	0.98	0.67	0.12	0.031	0.031	0.046	0.033	0.027	0.027	0.016

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

**Croydon Monitoring
Water Quality Results**

Table A4-3: Site SW3

Analyte	Units	28-Jan-1996	5-Mar-1996	6-Dec-1996	31-Dec-1996	28-Feb-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL													
Electrical Conductivity	uS/cm					120	150	78	92	100	90	69	100
pH	units	6.6	6.5	6	6.5	6.4	6.6	6.3	8.7	7.1	6.6	7.8	6.9
TDS	mg/L	130	140	130	150	80	200	83	64	120	81	72	90
MAJOR-IONS													
Calcium	mg/L	2.5	4.3	2.4	3.7	2.4	4.6	2.7	2.5	2.4	1.8	<0.5	2.7
Magnesium	mg/L	1.9	1.9	1.5	1.7	1.9	2.4	2.2	1.1	1.4	1.2	<0.5	1
Nitrate as N	mg/L	1.4	0.98	0.82	0.34								
Nitrite as N	mg/L	0.009	0.016	0.017	0.037								
Oxidised Nitrogen	mg/L		1	0.84	0.38								
Sodium	mg/L					16	18	8.1	11	13	11	10	12
Sulphate	mg/L	35	53	20	36	39	40	15	16	22	26	13	21
METALS													
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0006	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.84	1.53	6.5	1.5	0.2	0.92	0.94	2.2	2.6	1.3	0.88	0.31
Lead	mg/L	<0.005	<0.1	0.006	0.006	<0.002	0.004	<0.002	<0.002	0.002	<0.002	<0.002	<0.002
Manganese	mg/L		<0.05	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005								
Molybdenum	mg/L	<0.1	<0.1	<0.05	<0.05								
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Feb-2000	29-Feb-2000	15-Dec-2000	1-Mar-2001	15-Mar-2001
GENERAL										
Electrical Conductivity	uS/cm	61	57	170	100	240	120	66	100	84
pH	units	6.5	6.7	7.2	6.9	6.7	6.9	6.4	7.6	7.5
TDS	mg/L	89	110	210	140	240	130	130	130	110
MAJOR-IONS										
Calcium	mg/L	0.97	0.91	2.1	1.2	5.5	2.3	1	2.4	2.1
Magnesium	mg/L	0.92	0.72	1.5	0.98	4.9	2	0.7	1.5	1.5
Nitrate as N	mg/L									
Nitrite as N	mg/L									
Oxidised Nitrogen	mg/L									
Sodium	mg/L	7.8	7	25	14	26	15	8.7	16	17
Sulphate	mg/L	14	15	36	27	76	36	22	21	21
METALS										
Arsenic	mg/L	<0.005	<0.005	0.023	<0.005	<0.005	<0.005	<0.005	0.009	0.012
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.69	0.49	4.6	1.6	0.26	0.95	0.63	1.9	3.2
Lead	mg/L	0.003	0.003	0.001	0.002	<0.002	<0.002	0.008	0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	0.28	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L									
Molybdenum	mg/L									
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.014	0.017	0.017	<0.005	0.007	<0.005	0.02	0.008	0.008

**Croydon Monitoring
Water Quality Results**

Table A4-4: Site SW3A

Analyte	Units	28-Jan-1996	5-Mar-1996	30-Mar-1996	3-May-1996	6-Dec-1996	28-Feb-1997	15-Jan-1998	1-Mar-1998	15-Jan-1999	15-Feb-1999	15-Feb-2000
GENERAL												
Electrical Conductivity	uS/cm						1400	830	710	460	2300	86
pH	units	2.5	2.8	2	1.7	4	4.2	4.3	4.5	5.4	4.3	6.9
TDS	mg/L	1570	11300	26000	120000	560	1100	560	510	320	2100	100
MAJOR-IONS												
Calcium	mg/L	11	41	45	4250	29	45	29	21	16	100	0.5
Magnesium	mg/L	25	184	350	3400	27	60	27	25	15	93	0.8
Nitrate as N	mg/L	0.19	0.52	0.43	0.22	1.5						
Nitrite as N	mg/L	0.002	0.015	0.02	0.044	0.014						
Oxidised Nitrogen	mg/L		0.54	0.45	0.26	1.5						
Sodium	mg/L						120	79	69	50	280	12
Sulphate	mg/L	1450	10600	18200	240	420	880	370	280	190	1300	22
METALS												
Arsenic	mg/L	0.4	5.4	12.5	80	<0.02	<0.01	<0.005	<0.005	<0.005	0.005	0.005
Cadmium	mg/L	0.037	0.18	0.295	4.4	0.0063	0.017	0.0079	0.005	0.0034	0.035	<0.0002
Copper	mg/L	3.66	26	56	340	0.23	0.49	0.11	0.17	<0.05	0.34	<0.05
Iron	mg/L	90	630	1100	4850	0.52	<0.05	0.09	0.12	<0.05	0.14	0.56
Lead	mg/L	<0.005	<0.1	<0.05	<0.05	0.005	0.004	<0.002	<0.002	<0.001	0.004	<0.002
Manganese	mg/L				380	3.6	8.1	2.7	2.6	1.3	10	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.05						
Nickel	mg/L	0.91	6.3	13	80	0.29	0.4	0.19	0.19	<0.05	0.49	<0.05
Zinc	mg/L	2.7	18	42	235	0.58	0.96	0.36	0.44	0.06	0.89	0.007

**Croydon Monitoring
Water Quality Results**

Table A4-5: Site SW4

Analyte	Units	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	28-Feb-1997	31-Mar-1997	4-Oct-1997	1-Dec-1997	15-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL																				
Electrical Conductivity	uS/cm								150	160	820	330	300	120	56	99	79	82	84	100
pH	units	7.3	7.8	7.6	8.3	7.5	7	6.8	6.6	6.8	7.9	7.5	7.5	6.7	6.2	7.3	7	6.6	7.1	7.1
TDS	mg/L	190	210	270	410	530	300	290	170	190	600	430	440	250	83	70	120	89	78	91
MAJOR-IONS																				
Calcium	mg/L	6.7	9.5	10	15	22	12	7.9	4.3	4.3	18	6.6	6.5	4.2	2.6	2.8	2.8	2	1.7	3.5
Magnesium	mg/L	3.5	4.3	5	6.8	8.6	8	3.4	3.1	2.2	8.9	3.3	3.2	1.7	2	1.7	1.5	1.4	1	1.7
Nitrate as N	mg/L	0.23	0.05	<0.05	<0.05	0.05	0.76	0.57												
Nitrite as N	mg/L	0.037	0.016	0.002	<0.005	0.013	0.04	0.12												
Oxidised Nitrogen	mg/L	0.27	0.07	<0.05	<0.05	0.06	0.8	0.59												
Sodium	mg/L								19	23	130	45	38	16	5.4	11	9	10	10	12
Sulphate	mg/L	58	76	72	78	170	140	68	56	73	260	88	72	36	14	20	20	22	19	21
METALS																				
Arsenic	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.01	<0.01	0.01	<0.005	0.007	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.8	0.87	0.15	0.5	1.3	0.76	2.7	0.38	0.5	1.5	1.1	0.98	0.41	0.47	1.5	1.9	0.92	0.34	0.34
Lead	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.006	0.002	0.003	0.003	0.008	0.008	0.004	0.005	0.002	0.007	0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	0.05	<0.05	0.13	0.18	0.12	<0.05	<0.05	0.58	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.14	<0.05	0.08	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Jan-1999	15-Jan-1999	31-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	1-Apr-1999	15-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000
GENERAL																	
Electrical Conductivity	uS/cm	420	410	180	93	110	130	120	140	140	150	130	100	120	130	120	130
pH	units	8.4	8.5	7.3	7.1	7.2	7.3	6.9	8.2	8.3	7.9	6.7	7	9.3	7	7	7.9
TDS	mg/L	270	400	220	150	180	180	140	140	140	130	220	190	180	170	130	130
MAJOR-IONS																	
Calcium	mg/L	12	10	3	1.7	1.7	2.8	2	2.2	2.5	3.1	2.7	1.2	1.8	2.3	2.8	2.4
Magnesium	mg/L	5	5.2	2	1.3	1.5	1.3	1.4	1.4	1.8	2	1.7	1.3	1	1.5	1.5	1.8
Nitrate as N	mg/L																
Nitrite as N	mg/L																
Oxidised Nitrogen	mg/L																
Sodium	mg/L	50	71	24	14	14	17	16	18	20	22	20	13	17	18	16	19
Sulphate	mg/L	73	96	31	22	24	30	27	36	36	39	30	28	33	33	35	27
METALS																	
Arsenic	mg/L	0.011	0.016	0.005	<0.005	0.01	0.012	<0.005	0.012	0.017	0.014	0.006	0.007	0.014	0.015	<0.005	0.011
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.52	1.3	1.3	0.69	3.8	2.2	0.8	0.69	0.76	1.1	1	1.2	0.72	0.69	0.66	0.81
Lead	mg/L	<0.001	0.003	0.005	0.003	0.003	0.001	<0.002	0.006	0.004	0.004	0.003	0.003	0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05
Mercury	mg/L																
Molybdenum	mg/L																
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.007	0.013	0.03	0.015	0.2	0.013	0.005	0.009	0.006	0.012	0.022	0.037	0.016	0.01	<0.005	0.028

Analyte	Units	1-Apr-2000	1-Dec-2000	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL												
Electrical Conductivity	uS/cm	150	390	160	120	170	170	73	86	88	100	110
pH	units	8.6	7.2	6.5	6.8	8.6	8.3	7.1	7.3	7.5	7.4	7.4
TDS	mg/L	140	660	320	270	280	230	140	130	110	130	140
MAJOR-IONS												
Calcium	mg/L	2.7	7.9	3.2	2.8	3.1	3.3	1.5	2.5	2	1.4	1.5
Magnesium	mg/L	1.9	5.2	2.2	1.8	2	2.1	0.9	1.8	1.5	1	1.3
Nitrate as N	mg/L											
Nitrite as N	mg/L											
Oxidised Nitrogen	mg/L											
Sodium	mg/L	21	85	25	21	28	28	10	14	15	14	14
Sulphate	mg/L	32	110	45	43	43	43	23	25	22	20	23
METALS												
Arsenic	mg/L	0.017	0.018	0.008	0.01	0.013	0.013	0.01	0.01	0.011	0.009	0.01
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.63	6.4	2.4	1.6	1.6	1.6	0.55	1.1	0.96	1.2	1.7
Lead	mg/L	<0.002	0.008	0.006	0.003	0.002	<0.002	0.002	0.003	0.003	0.003	0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05
Mercury	mg/L											
Molybdenum	mg/L											
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.024	0.02	0.01	0.01	0.031	0.006	0.014	0.014	0.032	0.026	<0.005

**Croydon Monitoring
Water Quality Results**

Table A4-6: Site SW5

Analyte	Units	6-Dec-1996	31-Dec-1996	28-Feb-1997	31-Mar-1997	1-Dec-1997	15-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL														
Electrical Conductivity	uS/cm			130	650	140	150	440	400	990	890	790	1700	2800
pH	units	6	6	5.7	5.4	7.1	6.7	4.4	4	3.9	3.8	3.6	3.2	3.2
TDS	mg/L	180	180	120	440	150	160	310	250	800	840	670	1800	3000
MAJOR-IONS														
Calcium	mg/L	4	6.3	3.3	24	5.3	4.4	13	9.5	31	26	15	23	45
Magnesium	mg/L	2.8	2.5	2	20	2.2	2.8	17	16	45	32	29	66	120
Nitrate as N	mg/L	0.3	0.4											
Nitrite as N	mg/L	0.034	0.043											
Oxidised Nitrogen	mg/L	0.33	0.44											
Sodium	mg/L			16	57	13	12	30	16	44	24	23	39	71
Sulphate	mg/L	24	42	50	420	47	39	190	170	500	560	400	1300	2200
METALS														
Arsenic	mg/L	<0.02	<0.02	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.056	<0.005	<0.005	<0.01
Cadmium	mg/L	<0.0005	0.0012	<0.0005	0.0046	<0.0005	<0.0005	0.014	0.046	0.14	0.15	0.1	0.21	0.35
Copper	mg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.37	0.86	1.9	1.3	4.3	6.3
Iron	mg/L	6.2	4	0.3	<0.05	0.28	2.7	0.07	0.19	0.12	0.62	0.67	2.4	0.87
Lead	mg/L	0.024	0.023	0.003	<0.001	0.005	0.007	<0.002	0.003	0.005	0.007	0.005	0.016	0.05
Manganese	mg/L	0.22	0.51	0.12	1.9	0.51	0.15	2.1	1.6	7.6	6.1	3.8	8.1	22
Mercury	mg/L	<0.0005	<0.0005											
Molybdenum	mg/L	<0.05	<0.05											
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.16	0.47	0.63	0.45	1.1	2
Zinc	mg/L	<0.05	0.05	<0.05	0.2	<0.05	<0.05	0.6	0.92	2.5	2.6	2.1	4	8.5

Analyte	Units	1-Jan-1999	15-Jan-1999	31-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	1-Apr-1999	15-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000	1-Apr-2000
GENERAL																
Electrical Conductivity	uS/cm	170	260	860	320	340	740	640	1000	280	400	430	130	480	780	1200
pH	units	4.6	4.2	3.8	4.2	4	3.8	3.8	4.2	4	4.2	4.1	4.4	3.8	3.7	3.5
TDS	mg/L	110	190	660	220	210	560	480	990	180	250	330	92	380	620	940
MAJOR-IONS																
Calcium	mg/L	6.6	8.3	25	14	8.3	20	23	48	8.4	13	16	4.3	11	20	36
Magnesium	mg/L	3.2	6.9	32	8.9	11	34	25	54	8.6	11	14	2.8	19	35	58
Nitrate as N	mg/L															
Nitrite as N	mg/L															
Oxidised Nitrogen	mg/L															
Sodium	mg/L	13	9	40	14	15	30	26	54	17	18	27	5.8	22	38	61
Sulphate	mg/L	61	120	450	140	140	400	330	660	110	180	200	43	210	390	610
METALS																
Arsenic	mg/L	<0.005	<0.005	0.014	<0.005	<0.005	<0.005	<0.005	0.026	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	0.01
Cadmium	mg/L	0.0043	0.013	0.054	0.012	0.016	0.042	0.033	0.061	0.011	0.018	0.014	0.0038	0.046	0.046	0.069
Copper	mg/L	0.05	0.24	0.57	0.21	0.22	0.73	0.49	0.82	0.15	0.21	0.18	0.05	0.43	0.53	0.69
Iron	mg/L	<0.05	<0.05	0.36	0.29	0.16	0.28	0.13	0.15	0.08	0.07	<0.05	<0.05	0.27	0.1	0.1
Lead	mg/L	<0.001	<0.001	0.004	<0.001	<0.002	0.009	0.004	0.007	<0.002	<0.002	<0.002	<0.002	0.004	0.005	0.005
Manganese	mg/L	0.84	2.1	6.9	2.3	2.7	5.5	5.3	12	2.1	2.4	3.2	0.84	3.2	5.6	9.8
Mercury	mg/L															
Molybdenum	mg/L															
Nickel	mg/L	0.06	0.09	0.36	0.08	0.15	0.35	0.3	0.58	0.11	0.14	0.18	<0.05	0.22	0.37	0.57
Zinc	mg/L	0.17	0.41	1.3	0.46	0.54	1.3	0.92	1.9	0.37	0.49	0.58	0.12	0.83	1.2	1.9

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

**Croydon Monitoring
Water Quality Results**

Table A4-6: Site SW5

Analyte	Units	1-Dec-2000	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL											
Electrical Conductivity	uS/cm	260	170	300	440	480	310	640	350	530	670
pH	units	4.1	4	4	4	4	4.2	3.9	4.3	3.9	3.9
TDS	mg/L	170	100	240	300	340	220	520	260	400	520
MAJOR-IONS											
Calcium	mg/L	8	3.9	7.2	12	13	12	17	9.6	13	19
Magnesium	mg/L	6.4	3.4	11	15	17	12	25	13	19	26
Nitrate as N	mg/L										
Nitrite as N	mg/L										
Oxidised Nitrogen	mg/L										
Sodium	mg/L	12	8.4	15	26	30	15	25	15	20	27
Sulphate	mg/L	96	56	120	170	190	130	330	160	250	330
METALS											
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0099	0.0044	0.017	0.024	0.024	0.018	0.046	0.021	0.022	0.029
Copper	mg/L	0.12	0.1	0.11	0.19	0.19	0.23	0.62	0.25	0.38	0.44
Iron	mg/L	<0.05	<0.05	<0.05	0.07	0.05	0.08	0.22	0.18	0.24	0.19
Lead	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	0.003	0.003	0.003
Manganese	mg/L	2.2	1	1.8	2.9	3.6	1.8	4.4	2.6	4.4	6.8
Mercury	mg/L										
Molybdenum	mg/L										
Nickel	mg/L	0.08	0.06	0.12	0.18	0.19	0.13	0.35	0.19	0.32	0.44
Zinc	mg/L	0.37	0.2	0.55	0.69	0.68	0.65	1.4	0.66	0.94	1.2

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

**Croydon Monitoring
Water Quality Results**

Table A4-7: Site SW6

Analyte	Units	7-Jun-1998	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	1-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000	1-Apr-2000
GENERAL														
Electrical Conductivity	uS/cm	76	120	85	46	98	89	110	110	110	93	84	80	88
pH	units	7.5	7.7	6.5	6.1	6.9	6.8	7.2	7.2	9	6.6	6.6	7.8	7.2
TDS	mg/L	400	580	130	76	390	370	700	880	780	300	280	470	370
MAJOR-IONS														
Calcium	mg/L	1.2	3	3	1.4	2.6	2.1	3.7	3.5	3.7	2.1	3	2	1.9
Magnesium	mg/L	1.3	1.6	2	0.59	1.9	1.5	1.9	5.1	1.5	3.4	1.6	1.2	1.2
Nitrate as N	mg/L													
Nitrite as N	mg/L													
Oxidised Nitrogen	mg/L													
Sodium	mg/L	15	26	8.3	5.2	14	13	24	21	24	14	14	16	18
Sulphate	mg/L	8	2	26	13	23	18	16	4	25	24	25	5	6
METALS														
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	<0.0002	0.0014	<0.0002	0.0007	0.0005	<0.0002	<0.0002	<0.0002	0.0004	0.0003	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.1	2	0.59	0.63	1.9	1	2.9	3.5	1.4	2	0.74	0.96	0.65
Lead	mg/L	0.009	0.019	<0.001	<0.001	0.005	0.004	0.004	0.007	0.006	0.004	0.003	0.013	0.006
Manganese	mg/L	<0.05	0.06	0.34	0.14	0.21	<0.05	<0.05	0.08	0.13	0.19	0.05	<0.05	<0.05
Mercury	mg/L													
Molybdenum	mg/L													
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	0.058	0.054	0.019	0.03	0.039	0.049	0.047	0.042	0.042	0.026	0.027	0.024

Analyte	Units	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL										
Electrical Conductivity	uS/cm	56	100	100	110	63	66	50	68	88
pH	units	5.3	7.1	7.4	7.8	7.2	7	7.4	7.2	7.5
TDS	mg/L	81	690	750	750	360	430	400	410	580
MAJOR-IONS										
Calcium	mg/L	1.7	2.7	2.9	2.8	1.7	1.9	1.8	1.2	2
Magnesium	mg/L	1.1	1.9	2	2	1	1.2	1.1	1.7	1.7
Nitrate as N	mg/L									
Nitrite as N	mg/L									
Oxidised Nitrogen	mg/L									
Sodium	mg/L	50	21	25	25	12	13	13	11	15
Sulphate	mg/L	19	25	26	27	20	19	16	15	12
METALS										
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.011
Cadmium	mg/L	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.29	4	3.8	3.7	0.66	0.95	0.76	2.9	3.8
Lead	mg/L	<0.002	0.007	0.007	0.007	0.003	0.003	0.004	0.004	0.008
Manganese	mg/L	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	0.07	0.07	0.1
Mercury	mg/L									
Molybdenum	mg/L									
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.024	0.014	0.009	0.006	0.012	0.016	0.021	0.006	0.012

**Croydon Monitoring
Water Quality Results**

Table A4-8: Golden Butterfly Pit

Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997	15-Mar-1998	7-Jun-1998
GENERAL																
Electrical Conductivity	uS/cm										6700	7100	7400	7500	4500	6000
pH	units	3.4	2.1	2.2	2.3	2.2	2.1	2.1	2.2	2.3	2.3	2.5	2.2	2.5	2.3	2.3
TDS	mg/L	8200	8500	9700	9900	9700	8700	11000	11000	10000	9400	12000	11000	11000	5200	7500
MAJOR-IONS																
Calcium	mg/L	241	205	260	250	250	300	250	250	280	180	360	370	340	99	140
Magnesium	mg/L	136	140	165	175	165	180	190	200	190	180	200	210	220	100	140
Nitrate as N	mg/L	0.08	0.03	<0.5	<0.05	<0.05	<0.05	0.02	<0.5	0.01						
Nitrite as N	mg/L	0.046	0.033	0.03	0.014	0.43	0.067	0.069	0.2	0.068						
Oxidised Nitrogen	mg/L	0.11	0.06	<0.5	<0.05	0.43	0.08	0.09	<0.5	0.08						
Sodium	mg/L										160	160	160	150	87	110
Sulphate	mg/L	8000	6840	6600	5500	7600	7400	7900	8400	7900	7400	670	7400	8300	3500	5100
METALS																
Arsenic	mg/L	1.75	2.1	2.9	4.5	48	3.5	4.4	3.4	3.1	3.2	2.6	3	1.6	1.4	2.9
Cadmium	mg/L	0.19	0.21	0.275	0.6	0.3	0.32	0.32	0.33	0.16	0.27	0.31	0.32	0.32	0.41	0.21
Copper	mg/L	24.4	26	32	33.8	34	34	34	35	31	26	30	30	33	14	22
Iron	mg/L	640	660	640	1100	1000	860	940	890	760	67	820	840	780	320	500
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.025	<0.05	<0.005	<0.01	0.003	<0.01	<0.005	<0.002	<0.005
Manganese	mg/L			140	82	7.8	69	88	89	79	67	79	93	81	34	54
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05						
Nickel	mg/L	5.6	5.8	6.8	7.7	7.8	7.2	8.7	8.5	8.1	4.4	7.5	8.4	8.3	3.4	5.2
Zinc	mg/L	21	22.4	27.8	27	28	30	30	29	26	22	28	30	32	12	20

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	6900	6900	5500	6300	6800	5600	5400	6300	6700	6100	5500	6400
pH	units	2.3	2.4	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.3	2.6	2.4
TDS	mg/L	9700	11000	6800	11000	10000	7600	7400	9900	10000	8700	8300	9000
MAJOR-IONS													
Calcium	mg/L	280	150	240	290	340	260	240	330	290	280	220	320
Magnesium	mg/L	190	190	130	200	200	150	150	190	190	160	150	180
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	140	160	100	140	150	110	120	150	150	140	130	150
Sulphate	mg/L	6200	7400	5000	7200	6600	5300	4800	6700	7000	5600	5200	6400
METALS													
Arsenic	mg/L	2.4	2.6	1	1.8	1.8	1.5	1.1	1.7	1.6	1.3	1	1.3
Cadmium	mg/L	0.25	0.27	0.18	0.27	0.29	0.21	0.21	0.26	0.27	0.23	0.21	0.24
Copper	mg/L	28	30	18	27	28	19	18	24	24	20	18	21
Iron	mg/L	630	630	400	700	710	450	400	520	500	440	370	450
Lead	mg/L	<0.005	<0.005	<0.004	<0.002	<0.002	<0.005	<0.002	<0.01	<0.004	<0.004	<0.005	<0.002
Manganese	mg/L	73	85	54	78	84	65	56	74	76	74	56	72
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	7.1	7.9	5.2	7.6	7.6	5.2	5	7.1	7.2	6.3	6.5	6.9
Zinc	mg/L	27	29	19	29	31	17	18	26	27	23	19	23

**Croydon Monitoring
Water Quality Data**

Table A4-9: Golden Butterfly North Pit

Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997
GENERAL													
Electrical Conductivity	uS/cm										270	290	350
Oxidised Nitrogen	mg/L	<0.05	0.02	0.17	0.08	<0.05	<0.05	<0.05	<0.05	0.3			
pH	units	8.2	7.7	7.2	7.6	8	7.9	7.6	7.7	7.2	7.3	8.2	8.3
TDS	mg/L	190	185	200	210	220	280	250	240	250	170	190	230
MAJOR-IONS													
Calcium	mg/L	21.3	21	21.8	22.5	22	20	25	23	20	12	14	15
Magnesium	mg/L	3.4	3.6	3.1	4.5	3.9	4.4	4.6	4.2	4.4	3.7	4.1	4.5
Nitrate as N	mg/L	<0.05	0.02	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	0.3			
Nitrite as N	mg/L	<0.002	<0.002	<0.002	0.05	<0.002	<0.005	<0.005	<0.02	0.004			
Sodium	mg/L										34	37	38
Sulphate	mg/L	72	69	57	64	60	67	72	72	59	68	56	59
METALS													
Arsenic	mg/L	0.04	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0087	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05
Iron	mg/L	0.13	0.12	0.14	0.13	0.05	<0.05	<0.05	<0.05	0.1	0.52	<0.05	<0.05
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.001	<0.002	<0.002
Manganese	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005			
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05			
Nickel	mg/L	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	0.1	<0.05	0.07	<0.05	0.07	0.22	<0.05	<0.05	<0.05	<0.05

Analyte	Units	1-Dec-1997	15-Mar-1998	7-Jun-1998	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL																
Electrical Conductivity	uS/cm	360	220	250	250	230	230	230	250	250	230	260	260	260	230	250
Oxidised Nitrogen	mg/L															
pH	units	7.2	8	7.6	7.9	8.1	7.6	7.7	6.3	6.9	5.8	5.9	7.2	7.2	7.7	7
TDS	mg/L	200	130	130	140	160	130	140	150	170	150	150	170	220	150	160
MAJOR-IONS																
Calcium	mg/L	16	7.9	8.2	10	8.9	7.4	8.9	9.7	8.8	7.2	8.3	8.9	8.2	8.2	8.1
Magnesium	mg/L	4.9	2.9	3.4	3.3	3.5	3.7	4.3	4.6	4.3	3.7	4.6	4.7	4.7	4.3	4.5
Nitrate as N	mg/L															
Nitrite as N	mg/L															
Sodium	mg/L	42	26	28	29	30	25	30	32	32	29	30	32	31	30	29
Sulphate	mg/L	64	39	39	40	55	47	45	59	56	61	60	64	62	59	66
METALS																
Arsenic	mg/L	<0.005	0.01	0.017	0.009	0.006	0.006	0.014	0.006	0.008	<0.005	0.007	0.006	<0.005	<0.005	0.01
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.2	<0.05	<0.05	<0.05	0.1	0.16	<0.05	<0.05	0.24	<0.05	0.11	<0.05	0.07	0.18	<0.05
Lead	mg/L	<0.005	<0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.25	0.11	<0.05	<0.05	0.14
Mercury	mg/L															
Molybdenum	mg/L															
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	<0.05	0.007	0.008	<0.005	0.006	0.01	0.012	<0.005	0.01	0.006	<0.005	0.007	<0.005

**Croydon Monitoring
Water Quality Results**

Table A4-10: Content Pit

Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997
GENERAL														
Electrical Conductivity	uS/cm										1700	1700	1800	1900
Oxidised Nitrogen	mg/L	1.2	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				
pH	none	4.2	3	3.1	3.2	3.1	3.1	2.9	3	3.1	3.3	3.3	3.1	3.3
TDS	mg/L	1200	1200	1320	1200	1300	1300	1400	1400	1300	1300	1300	1400	1400
MAJOR-IONS														
Calcium	mg/L	73	69	78	70	72	77	81	73	80	64	75	72	83
Magnesium	mg/L	38.7	41	42.5	42	42	44	46	41	42	40	42	42	46
Nitrate as N	mg/L	1.2	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				
Nitrite as N	mg/L	<0.002	<0.002	<0.002	<0.002	0.003	<0.005	<0.005	0.02	<0.002				
Sodium	mg/L										140	150	160	170
Sulphate	mg/L	870	850	1000	850	770	840	960	960	1000	1000	810	890	890
METALS														
Arsenic	mg/L	0.03	<0.02	0.05	0.11	0.08	0.05	<0.02	0.03	0.02	<0.01	0.12	0.09	0.23
Cadmium	mg/L	0.019	0.044	0.045	0.0275	0.025	0.025	0.025	0.03	0.024	0.018	0.017	0.026	0.022
Copper	mg/L	0.86	0.83	0.78	0.75	0.8	0.76	0.93	0.9	0.82	0.6	0.55	0.52	0.59
Iron	mg/L	2.04	1.83	4.82	6.6	4.1	4.4	4.3	4.2	3.8	4.3	6.3	5.9	3.8
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	0.003	0.002	<0.002	<0.005
Manganese	mg/L			5	5.2	5.3	5.1	6.2	6.2	5.8	6	5.2	5.1	5.5
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005				
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05				
Nickel	mg/L	0.48	0.48	0.46	0.46	0.5	0.45	0.54	0.59	0.55	0.38	0.46	0.48	0.47
Zinc	mg/L	1.66	1.61	1.65	1.6	1.7	1.9	1.9	1.9	1.8	1.5	1.5	1.6	1.8

Analyte	Units	15-Mar-1998	7-Jun-1998	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL															
Electrical Conductivity	uS/cm	1300	1400	1400	1400	1700	1300	1400	1400	1300	1300	1300	1300	1200	1200
Oxidised Nitrogen	mg/L														
pH	none	3.3	3.2	3.3	3.4	3.3	3.4	3.4	3.3	3.3	3.5	3.5	3.4	3.7	3.6
TDS	mg/L	930	980	1000	1100	1000	1000	1000	1100	1000	1000	1000	1100	960	970
MAJOR-IONS															
Calcium	mg/L	47	53	55	58	57	52	60	59	50	51	53	50	46	48
Magnesium	mg/L	32	32	35	36	34	36	37	36	34	34	35	34	31	32
Nitrate as N	mg/L														
Nitrite as N	mg/L														
Sodium	mg/L	110	110	120	130	110	120	130	130	130	130	130	130	130	130
Sulphate	mg/L	540	570	570	660	640	610	570	600	560	590	600	550	540	560
METALS															
Arsenic	mg/L	0.015	0.013	0.039	0.017	0.019	0.086	0.024	0.029	0.011	0.058	0.031	0.012	0.022	0.038
Cadmium	mg/L	0.0085	0.011	0.011	0.013	0.013	0.0097	0.011	0.013	0.023	0.0086	0.0072	0.011	0.009	0.0089
Copper	mg/L	0.31	0.33	0.42	0.45	0.33	0.29	0.29	0.28	0.26	0.23	0.22	0.21	0.2	0.17
Iron	mg/L	1.8	1.9	1.4	1.2	0.8	1.5	1.6	1.3	1.1	1.2	1.2	0.78	1.2	0.79
Lead	mg/L	<0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	3.3	3.3	4.2	4.2	3.8	3.8	3.9	3.8	3.6	3.6	3.9	3.8	3.6	3.6
Mercury	mg/L														
Molybdenum	mg/L														
Nickel	mg/L	0.27	0.31	0.34	0.33	0.35	0.34	0.29	0.29	0.26	0.27	0.26	0.27	0.27	0.25
Zinc	mg/L	0.92	0.99	1.1	1.2	1.1	0.99	0.99	0.89	0.9	0.93	0.89	0.86	0.85	0.78

**Croydon Monitoring
Water Quality Results**

Table A4-11: Lady Isabella Pit

Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997	15-Mar-1998	7-Jun-1998
GENERAL																
Electrical Conductivity	uS/cm										990	1000	1100	1100	730	750
pH	units	4.3	3.4	3.4	3.5	3.3	3.4	3.2	3.3	3.4	3.5	3.6	3.4	3.5	3.5	3.5
TDS	mg/L	930	930	940	930	960	940	1000	970	910	850	820	900	860	540	560
MAJOR-IONS																
Calcium	mg/L	59	55	57	61	62	69	70	57	60	43	52	50	55	29	33
Magnesium	mg/L	28.2	40.5	28	33	33	36	36	32	31	26	27	26	29	18	18
Nitrate as N	mg/L	0.57	0.66	0.59	0.51	0.41	0.29	0.39	0.35	0.34						
Nitrite as N	mg/L	<0.002	<0.002	0.002	0.008	0.002	<0.005	<0.005	<0.02	<0.002						
Oxidised Nitrogen	mg/L	0.57	0.66	0.59	0.51	0.41	0.29	0.39	0.35	0.34						
Sodium	mg/L										60	58	62	62	38	41
Sulphate	mg/L	680	660	670	550	490	480	660	600	520	580	450	490	530	280	270
METALS																
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.155	0.185	0.365	0.19	0.15	0.09	0.22	0.21	0.02	0.16	0.16	0.15	0.17	0.091	0.11
Copper	mg/L	1.36	1.38	1.45	1.53	1.58	1.6	1.7	1.5	1.4	1	1.1	1	1.2	0.7	0.77
Iron	mg/L	0.76	0.62	0.32	0.31	0.3	0.23	0.92	0.91	1.3	0.46	0.32	0.48	0.3	0.29	0.17
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	0.005	0.005	0.004	0.004	0.002	0.002
Manganese	mg/L			5.5	6.4	5.6	7.1	6.7	6.1	5.5	4.2	4.5	4.5	4.8	2.4	2.5
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05						
Nickel	mg/L	0.6	0.59	0.57	0.64	0.6	0.64	0.74	0.73	0.67	0.43	0.53	0.53	0.57	0.29	0.34
Zinc	mg/L	4.5	4.6	4.99	4.7	4.85	5.9	6.9	6.6	4.8	3.5	3.9	3.8	4.4	2.3	2.6

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	810	790	790	800	850	890	830	830	890	890	650	840
pH	units	3.5	3.7	3.5	3.5	3.5	3.5	3.4	3.6	3.6	3.5	3.8	3.6
TDS	mg/L	570	660	610	660	690	710	690	680	740	740	660	680
MAJOR-IONS													
Calcium	mg/L	36	36	36	41	44	45	40	40	43	42	38	41
Magnesium	mg/L	20	21	18	22	23	24	22	21	24	23	20	22
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	42	47	44	48	52	52	49	48	52	56	49	50
Sulphate	mg/L	310	360	330	330	340	370	330	360	380	350	330	360
METALS													
Arsenic	mg/L	0.005	0.008	<0.005	<0.005	<0.005	0.013	<0.005	0.008	0.005	<0.005	<0.005	0.006
Cadmium	mg/L	0.094	0.11	0.1	0.011	0.11	0.11	0.12	0.1	0.12	0.11	0.1	0.1
Copper	mg/L	0.91	0.97	0.85	0.95	1	0.98	0.9	0.92	0.96	0.95	0.88	0.89
Iron	mg/L	0.11	0.18	0.11	0.12	0.12	0.11	0.06	0.24	0.1	0.1	0.23	0.15
Lead	mg/L	0.003	0.002	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
Manganese	mg/L	3.2	3.2	2.9	3.3	3.5	3.5	3.2	3.3	3.7	3.6	3.3	3.4
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	0.37	0.41	0.41	0.45	0.44	0.44	0.4	0.42	0.43	0.44	0.44	0.45
Zinc	mg/L	3.1	3.4	3.1	3.2	3.6	3.1	3.2	3.3	3.3	3.3	3.4	3.1

Release

**Croydon Monitoring
Water Quality Results**

Table A4-12: Bore GBMB1

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	7-Jun-1998
GENERAL										
Electrical Conductivity	uS/cm	805	1045	800	760	810	770	810	860	790
pH	units	7.8	7.4	6.6	6.5	6.9	6.6	6.6	6.7	6.4
TDS	mg/L	570	560	560	580	540	570	630	580	580
MAJOR-IONS										
Calcium	mg/L					11	14	14	14	13
Chloride	mg/L	35	48	53	46	37	37	36	35	37
Magnesium	mg/L	8.5	8.5	8.4	8.5	8.8	9.8	9.7	9.5	9.6
Nitrite as N	mg/L	0.012	0.061	0.006	0.59					
Sodium	mg/L	130	119	220	120	120	120	120	120	410
Sulphate	mg/L	200	180	240	220	200	190	240	220	220
METALS										
Arsenic	mg/L	<0.02	0.03	<0.02	<0.02	<0.01	<0.005	0.025	0.022	0.024
Cadmium	mg/L	0.0005	0.0013	0.0009	<0.0005	<0.0005	<0.0005	0.0051	<0.0005	0.0041
Copper	mg/L	<0.05	0.08	<0.05	0.15	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.96	0.88	11	3.9	1.6	2.5	3.4	2.8	3.6
Lead	mg/L	0.9	<0.05	1.4	0.13	0.018	0.051	0.21	0.008	0.13
Manganese	mg/L					1	1.6	1.8	1.6	1.6
Mercury	mg/L	0.0006	<0.0005	<0.0005	<0.0005					
Zinc	mg/L	0.15	0.05	0.24	0.09	<0.05	<0.05	0.08	<0.05	<0.05

Analyte	Units	21-Sep-1998	6-Dec-1998	28-Jun-1999	20-Sep-1999	1-Jan-2000	28-Jun-2000	29-Sep-2000
GENERAL								
Electrical Conductivity	uS/cm	760	700	710	710	720	690	700
pH	units	6.6	6.8	6.6	6.3	6.3	6.6	6.6
TDS	mg/L	580	590	580	590	590	590	580
MAJOR-IONS								
Calcium	mg/L	13	12	11	11	10	9.6	10
Chloride	mg/L	37	35	34	34	35	35	39
Magnesium	mg/L	7.8	8	8.4	7.7	7.2	7.2	6.6
Nitrite as N	mg/L							
Sodium	mg/L	110	120	110	120	110	110	120
Sulphate	mg/L	230	260	230	210	240	250	190
METALS								
Arsenic	mg/L	0.013	0.007	0.005	<0.005	0.019	<0.01	0.006
Cadmium	mg/L	0.005	0.0091	0.0045	0.0023	0.0069	0.0042	0.0038
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.16	0.14	0.2	0.63	3.8	3.5	1.2
Lead	mg/L	0.008	0.006	0.013	0.006	0.035	0.05	0.12
Manganese	mg/L	1.6	1.6	1.6	1.1	1.8	1.7	1.4
Mercury	mg/L							
Zinc	mg/L	0.042	0.045	0.019	0.011	0.031	0.012	0.016

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-13: Bore GBMB2

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	7-Jun-1998
GENERAL										
Electrical Conductivity	uS/cm	1620	2220	2000	1900	2100	2100	2400	2700	2400
pH	units	8.3	7.5	7.3	7.2	7.2	7.8	6.9	6.9	7
TDS	mg/L	1400	1400	1400	1500	1400	1600	1700	1800	1700
MAJOR-IONS										
Calcium	mg/L					63	64	71	73	72
Chloride	mg/L	200	200	220	210	200	210	240	250	240
Magnesium	mg/L	15.2	13.6	17	18	19	18	19	20	20
Nitrite as N	mg/L	0.003	<0.002	<0.002	0.27					
Sodium	mg/L	370	370	370	350	370	380	440	470	420
Sulphate	mg/L	730	680	640	660	800	600	680	670	680
METALS										
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0082	0.0012	0.0005	<0.0005	0.0013	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.53	0.06	0.19	0.53	0.2	0.16	2.8	0.82	0.16
Lead	mg/L	0.3	<0.05	<0.05	0.022	0.014	0.01	0.022	0.003	<0.001
Manganese	mg/L					0.07	<0.05	1.3	1	0.69
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005					
Zinc	mg/L	0.11	<0.05	0.07	<0.05	<0.05	<0.05	0.07	0.07	0.17

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	11-Jun-2001
GENERAL												
Electrical Conductivity	uS/cm	4000	2300	2400	2300	2400	2400	2300	2200	2300	2400	2400
pH	units	7.2	7.2	6.8	7	6.8	7	6.8	7.2	7.2	7.5	7.4
TDS	mg/L	1700	1700	1700	1700	1700	1700	1700	1700	1700	1900	1700
MAJOR-IONS												
Calcium	mg/L	73	69	74	71	74	72	72	72	68	68	69
Chloride	mg/L	250	250	240	250	250	250	250	250	240	250	250
Magnesium	mg/L	21	19	20	21	21	21	20	20	20	19	20
Nitrite as N	mg/L											
Sodium	mg/L	410	430	410	430	460	450	450	450	440	440	450
Sulphate	mg/L	670	780	680	720	690	690	580	820	720	730	740
METALS												
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.09	<0.05	0.1	<0.05	0.13	<0.05	<0.05	0.1	<0.05	<0.05	<0.05
Lead	mg/L	0.002	<0.001	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	0.58	0.38	0.37	0.43	1.5	1.4	1.3	1.2	1.1	1.2	1
Mercury	mg/L											
Zinc	mg/L	0.28	0.085	0.078	0.12	0.019	0.018	0.007	0.047	0.01	0.025	0.011

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-14: Bore GBMB3

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	58	78	70	88	89	89	150	160	38	150
pH	units	6.3	5.8	5.3	5.6	6	6.2	6	6.3	5.7	5.5
TDS	mg/L	77	74	76	250	250	180	680	1600	69	79
MAJOR-IONS											
Calcium	mg/L					2.6	1.2	6.4	3.1	<0.5	1.1
Chloride	mg/L	11	11	16	14	12	12	17	13	6	10
Magnesium	mg/L	<0.5	<0.5	<0.5	1.4	1.5	0.6	2.5	2.7	<0.5	1.2
Nitrite as N	mg/L	0.003	0.003	0.002	0.033						
Sodium	mg/L	12.8	11.3	10	15	14	14	22	20	5.5	8.3
Sulphate	mg/L	<5	<5	<5	<5	27	12	23	13	3	2
METALS											
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	0.016	0.008	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0016	<0.0005	0.0005	<0.0005	<0.0005	0.0011	0.0007	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	8	0.13	2.4	5.8	3.3	2.4	3.8	1.5	1.7	1.2
Lead	mg/L	0.1	<0.05	<0.05	0.07	0.041	0.029	0.043	0.018	0.014	0.018
Manganese	mg/L					<0.05	<0.05	0.28	0.15	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	0.11	0.11	<0.05	0.15

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	71	83	68	71	82	120	82	66	65	83	72	69
pH	units	5.6	5.9	5.2	5.7	5.7	5.9	5.8	5.8	5.8	6.4	5.9	5.7
TDS	mg/L	110	220	150	160	180	250	180	150	170	220	140	160
MAJOR-IONS													
Calcium	mg/L	0.21	0.45	<0.05	0.9	1.4	2	0.8	0.6	<0.5	1	0.7	<0.5
Chloride	mg/L	12	16	12	14	15	19	16	13	12	15	14	13
Magnesium	mg/L	0.25	0.63	<0.05	0.9	0.8	1.2	<0.5	0.6	<0.5	0.6	0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	12	15	11	12	14	19	13	10	11	13	14	11
Sulphate	mg/L	4	11	4	6	13	13	16	13	16	11	8	7
METALS													
Arsenic	mg/L	0.018	0.022	0.016	0.013	0.018	0.011	0.006	<0.01	0.008	0.009	0.01	0.012
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.4	1.9	1.5	2.2	3.1	3	2	2.3	2.1	2.2	3	1.6
Lead	mg/L	0.017	0.012	0.037	0.012	0.008	0.013	0.013	0.014	0.006	0.014	0.008	0.006
Manganese	mg/L	<0.05	0.08	<0.05	<0.05	<0.05	0.16	0.05	0.05	0.05	0.14	0.09	<0.05
Mercury	mg/L												
Zinc	mg/L	0.12	0.13	0.19	0.11	0.1	0.044	0.071	0.13	0.11	0.11	0.094	0.048

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-15: Bore GBMB4

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	6-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	185	251	230	220	240	240	270	280	260	520
pH	units	7.1	5.9	5.4	5.5	5.8	6	5.7	5.9	6	5.6
TDS	mg/L	210	200	220	250	240	210	260	310	230	230
MAJOR-IONS											
Calcium	mg/L					2.3	2	3.2	1.8	2.2	2
Chloride	mg/L	39	37	41	50	43	46	39	40	43	44
Magnesium	mg/L	1	1	1.3	1.9	1.5	1.1	1.8	1.8	1.6	2.2
Nitrite as N	mg/L	0.002	<0.002	<0.002	0.011						
Sodium	mg/L	33.3	23	35	35	34	33	38	35	38	38
Sulphate	mg/L	32	23	27	29	34	26	35	33	29	31
METALS											
Arsenic	mg/L	0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0005	0.0042	0.0007	<0.0005	0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	2.15	<0.05	0.52	1.1	0.22	0.31	0.72	0.1	<0.05	<0.05
Lead	mg/L	0.3	<0.05	0.05	0.045	0.028	0.029	0.031	0.005	0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	0.06	0.06	0.09	0.06	<0.05	<0.05	0.09	0.32	0.05	0.11

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	290	270	280	280	290	290	280	280	280	290	270	290
pH	units	5.8	5.9	5.6	6	5.9	5.9	6.2	5.9	5.9	6	6.4	6.1
TDS	mg/L	120	250	240	240	250	250	240	250	250	340	230	240
MAJOR-IONS													
Calcium	mg/L	1.8	1.7	2.1	2.3	2.9	2.5	1.5	2.1	1.9	2.3	2.1	1.4
Chloride	mg/L	45	44	44	46	47	47	46	47	47	45	45	47
Magnesium	mg/L	1.7	1.8	1.9	2.4	2.3	2	1.7	2.2	1.9	2	2	1.7
Nitrite as N	mg/L												
Sodium	mg/L	38	40	39	40	42	42	42	39	41	41	42	41
Sulphate	mg/L	33	42	34	37	37	35	43	39	43	38	35	38
METALS													
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	6.6	<0.05
Lead	mg/L	<0.001	<0.001	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.008	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.63	0.15	0.48	0.12	0.1	0.1	0.076	0.25	0.12	0.18	0.079	0.05

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-16: Bore GBMB5

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	78	88	75	68	71	73	88	84	77	130
pH	units	7.8	5.8	5.2	5.3	5.9	5.8	5.7	5.9	6.4	5.5
TDS	mg/L	120	90	80	82	74	88	110	96	93	94
MAJOR-IONS											
Calcium	mg/L					1	0.7	1.8	<0.5	0.6	<0.5
Chloride	mg/L	11	19	23	21	14	18	14	15	16	16
Magnesium	mg/L	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1
Nitrite as N	mg/L	0.002	0.002	<0.002	0.005						
Sodium	mg/L	14	11.4	12	10	11	11	11	9.6	12	11
Sulphate	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<2	2
METALS											
Arsenic	mg/L	0.03	0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0029	0.0008	<0.0005	0.0006	<0.0005	0.0009	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.65	<0.05	0.19	0.32	<0.05	0.1	0.44	0.18	<0.05	<0.05
Lead	mg/L	0.1	<0.05	<0.05	0.009	0.011	0.006	0.1	0.005	0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	0.29	0.13	0.1	0.1

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	80	74	77	77	78	78	78	80	79	80	80	78
pH	units	5.6	5.7	5.4	5.7	5.6	5.6	6.1	5.8	5.7	5.9	6	6
TDS	mg/L	80	100	88	110	97	96	96	96	95	140	120	94
MAJOR-IONS													
Calcium	mg/L	0.2	0.08	<0.05	<0.5	1	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloride	mg/L	15	15	15	16	16	16	16	16	15	16	15	16
Magnesium	mg/L	0.2	0.29	<0.05	0.7	0.7	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	9.8	11	11	11	12	12	12	11	11	11	13	10
Sulphate	mg/L	<2	4	2	4	<2	3	3	<2	8	4	3	2
METALS													
Arsenic	mg/L	<0.005	<0.005	0.006	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	<0.001	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.41	0.11	0.067	0.046	0.061	0.019	0.047	0.11	0.07	0.087	0.075	0.07

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-17: Bore GBMB6

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	17-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	75	102	90	80	80	85	84	79	69	120
pH	units	6.6	5.8	5.2	5.3	5.7	5.8	5.4	5.5	6.1	5.7
TDS	mg/L	110	120	110	120	100	110	120	87	91	100
MAJOR-IONS											
Calcium	mg/L					1.1	1.1	1.4	<0.5	<0.5	<0.5
Chloride	mg/L	12	12	19	18	14	14	13	13	13	14
Magnesium	mg/L	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8
Nitrite as N	mg/L	0.002	<0.002	<0.002	0.006						
Sodium	mg/L	13.5	12.5	14	12	12	12	11	10	11	12
Sulphate	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<2	2
METALS											
Arsenic	mg/L	<0.02	0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.042	0.0008	<0.0005	0.0013	0.0026	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.1	<0.05	0.2	0.42	<0.05	0.18	0.16	0.16	<0.05	<0.05
Lead	mg/L	<0.1	<0.05	<0.05	0.011	0.016	0.034	0.049	0.003	<0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	80	78	79	76	82	100	140	150	90	92	90	85
pH	units	5.6	5.8	5.5	5.7	5.8	5.8	6	6.1	5.9	6	6.2	6
TDS	mg/L	80	110	100	110	110	120	140	150	110	170	110	110
MAJOR-IONS													
Calcium	mg/L	0.26	0.11	<0.05	<0.5	1	1.2	0.9	2.7	<0.5	<0.5	<0.5	0.9
Chloride	mg/L	14	12	12	13	11	14	21	22	12	12	11	11
Magnesium	mg/L	0.21	0.31	<0.05	0.7	0.7	0.7	0.6	1.3	<0.5	<0.5	<0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	11	12	12	12	14	16	22	22	14	13	16	13
Sulphate	mg/L	3	6	3	4	2	8	20	19	9	7	5	3
METALS													
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	0.005	0.006
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	<0.001	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.2	0.081	0.051	0.024	0.045	0.023	0.051	0.26	0.06	0.055	0.091	0.029

Values shaded are above but less than twice the completion criterion

Values shaded are more than twice the completion criterion

Release

**Croydon Monitoring
Water Quality Results**

Table A4-18: Bore BH1

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL															
Electrical Conductivity	uS/cm	985	1195	1100	1000	1100	1100	1300	1500	1300	1300	1300	1200	1300	1200
pH	none	7.9	7.2	7	7	7.4	7.5	6.9	6.9	7.5	6.9	7.2	7.2	6.9	7.4
TDS	mg/L	910	840	850	840	870	630	1000	1100	1000	970	960	1000	1000	980
MAJOR-IONS															
Chloride	mg/L	18	12	31	21										
Magnesium	mg/L	20	17.7	20	22										
Nitrite as N	mg/L	0.004	0.002	<0.002	0.52										
Sodium	mg/L	140	88	130	120										
Sulphate	mg/L	520	430	350	370	410	310	440	480	430	430	420	470	490	460
METALS															
Arsenic	mg/L	0.08	0.04	<0.02	<0.02										
Cadmium	mg/L	<0.0005	0.0008	<0.0005	<0.0005										
Copper	mg/L	<0.05	<0.05	<0.05	<0.05										
Iron	mg/L	1.08	<0.05	0.6	0.32	0.16	<0.05	2	3.2	0.4	<0.05	0.14	0.12	0.13	0.19
Lead	mg/L	<0.1	<0.05	0.08	0.065										
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	0.1	<0.05	0.05	0.07										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	1200	1300	1300	1300	1300	1400	1300	1300
pH	none	6.9	7.2	7.4	7.2	7.3	7.5	7.8	7.4
TDS	mg/L	970	1000	1100	1100	1100	1100	1100	1000
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	430	440	460	470	470	450	450	480
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.11	0.07	<0.05	0.13	<0.05	<0.05	2	0.08
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

Release

**Croydon Monitoring
Water Quality Data**

Table A4-19: Bore BH2

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	797	1082	950	900	1300	970	1200	1200	1300	1300
pH	none	4.2	3.3	3.1	3.3	3.4	3.5	3.4	3.4	3.3	3.3
TDS	mg/L	720	680	700	660	1000	720	880	880	1000	990
MAJOR-IONS											
Chloride	mg/L	19	18	35	21						
Magnesium	mg/L	12.3	13.8	13	13						
Nitrite as N	mg/L	0.003	<0.002	0.002	1.1						
Sodium	mg/L	110	98	120	98						
Sulphate	mg/L	520	460	370	420	850	370	480	480	570	550
METALS											
Arsenic	mg/L	0.07	<0.02	0.03	0.12						
Cadmium	mg/L	<0.0005	0.0028	<0.0005	<0.0005						
Copper	mg/L	<0.05	<0.05	<0.05	<0.05						
Iron	mg/L	12	0.95	17	27	2.8	1	11	0.54	1.3	1.3
Lead	mg/L	0.4	0.06	<0.05	0.022						
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	0.34	0.37	0.23	0.27						

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	1100	1100	1200	1200	1000	920	1100	980	1100	1000	1200	1200
pH	none	3.3	3.8	3.5	3.5	3.7	3.8	3.5	3.8	3.6	3.5	3.7	3.5
TDS	mg/L	810	880	910	1000	830	730	890	800	870	820	1000	930
MAJOR-IONS													
Chloride	mg/L												
Magnesium	mg/L												
Nitrite as N	mg/L												
Sodium	mg/L												
Sulphate	mg/L	430	500	620	540	440	380	480	440	490	400	540	520
METALS													
Arsenic	mg/L												
Cadmium	mg/L												
Copper	mg/L												
Iron	mg/L	0.5	6.9	6.5	0.19	12	11	0.73	8.9	3.3	6.9	0.47	0.3
Lead	mg/L												
Mercury	mg/L												
Zinc	mg/L												

Release

**Croydon Monitoring
Water Quality Results**

Table A4-20: Bore BH3

Analyte	Units	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL														
Electrical Conductivity	uS/cm	928	3000	170	210	300	730	820	1100	960	1200	1400	270	310
pH	none	7.2	6.8	5.6	6.1	6.4	6.6	7.1	5.9	6	6.6	6.9	5.8	6.4
TDS	mg/L	570	2100	240	160	220	470	510	880	680	830	1000	230	260
MAJOR-IONS														
Chloride	mg/L	62	310	18										
Magnesium	mg/L	2.6	18	1.4										
Nitrite as N	mg/L	0.006	<0.005	0.024										
Sodium	mg/L	169	620	31										
Sulphate	mg/L	260	990	54	66	79	180	210	310	260	330	420	84	95
METALS														
Arsenic	mg/L	0.03	0.03	<0.02										
Cadmium	mg/L	0.0009	<0.0005	<0.0005										
Copper	mg/L	<0.05	<0.05	<0.05										
Iron	mg/L	1.75	0.3	0.82	0.36	0.38	0.54	0.5	<0.05	<0.05	<0.05	<0.05	0.16	0.44
Lead	mg/L	<0.05	<0.05	0.072										
Mercury	mg/L	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	<0.05	<0.05	0.09										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	800	180	130	230	360	110	120	270
pH	none	6.9	5.5	5.8	6.2	6.9	5.9	6.3	6.7
TDS	mg/L	500	150	130	250	270	160	160	320
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	210	47	47	76	100	220	63	73
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.13	0.16	<0.05	0.47	0.18	0.54	0.22	0.86
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

Release

**Croydon Monitoring
Water Quality Data**

Table A4-21: Bore BH7

Analyte	Units	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL														
Electrical Conductivity	uS/cm	6530	6000	6100	7400	6700	7100	7600	6600	7100	7500	7600	7500	7300
pH	units	6.3	6.2	6	6.1	6.3	6.3	6.6	7.4	6.9	6.7	6.5	6.4	6.6
TDS	mg/L	4500	4600	5000	5400	4900	5600	5200	5000	5100	11000	12000	5700	5600
MAJOR-IONS														
Chloride	mg/L	1200	1300	1400										
Magnesium	mg/L	132	120	160										
Nitrite as N	mg/L	<0.002	<0.002	0.096										
Sodium	mg/L	200	880	1100										
Sulphate	mg/L	2000	350	1900	2300	1600	2000	1900	1700	1900	1900	2300	2000	1900
METALS														
Arsenic	mg/L	0.1	<0.1	<0.02										
Cadmium	mg/L	0.0016	<0.003	0.0014										
Copper	mg/L	<0.05	<0.05	<0.05										
Iron	mg/L	<0.05	0.52	0.82	<0.05	<0.05	0.24	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.05	<0.05	0.056										
Mercury	mg/L	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	0.07	<0.05	0.16										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	7500	7500	7800	7600	8000	8000	7900	8300
pH	units	6.6	6.4	6.4	6.6	6.6	6.8	7	6.7
TDS	mg/L	5700	5800	6000	6100	6400	6600	6200	6400
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	2000	780	2000	2300	2300	2200	2200	2300
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.14	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

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DRAFT

APPENDIX 5

Release

**Water Level Analysis
of Golden Butterfly Pit
Croydon Gold Mine**

Prepared for

Goldfields Limited

PO Box R986

Royal Exchange Post Office

NSW 1225

HLA-Envirosciences Project No 1715-3

by

CTPI 49-Sch4 BSc(CivEng) MSc(EnvEng) CPEng
Principal Civil/Environmental Engineer

CTPI 49-Sch4 BSc
Principal Hydrogeologist

15 May 2001

This document was prepared for the sole use of Goldfields Limited and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Goldfields Limited.

Release

CONTENTS

1.0	INTRODUCTION.....	1
2.0	PRECIPITATION AND EVAPORATION.....	1
2.1	Average Monthly Precipitation and Evaporation.....	1
2.2	Wet Season Rainfall	2
3.0	GROUNDWATER.....	2
4.0	CONCLUSIONS	4

Release

1.0 INTRODUCTION

Goldfields Limited requested HLA-Envirosciences review the available meteorology and groundwater data for the area around the Golden Butterfly Pit and Waste Dump at the Croydon Mine in Northwest Queensland. The purpose of the review was to determine the likelihood of the pit overflowing in extreme weather conditions.

Goldfields Kalgoorlie Limited (formerly Pancontinental Mining Limited) is holder of ML 5248, just west of Croydon township in Northwest Queensland. ML 5248 was mined between 1987 to 1990. In 1993 a Decommissioning Plan was accepted by the Department of Minerals and Energy and decommissioning commenced.

The data reviewed for this study included the following:

- Rainfall and Evaporation data from Bureau of Meteorology Station 029012 – Croydon Township. Rainfall data commenced in 1889 and evaporation data commenced in 1972.
- Groundwater levels from two monitoring wells for 19 monitoring events from March 1996 through January 2001.

2.0 PRECIPITATION AND EVAPORATION

2.1 Average Monthly Precipitation and Evaporation

The Croydon Mine is located in Northwest Queensland, which is subject to very distinct monsoonal wet and dry seasons. **Table 1** shows that on average, 85% of the rainfall falls from December to March, but the evaporation is spread relatively evenly throughout the year.

Month	Rainfall (mm/month)	Evap (mm/month)
Jan	218.8	202
Feb	177.0	158
Mar	115.0	189
Apr	23.1	195
May	8.2	177
Jun	8.5	147
Jul	3.4	161
Aug	2.8	198
Sep	5.7	243
Oct	14.0	279
Nov	44.5	267
Dec	111.4	248
12 Month Total	732.4	2464
Dec to Mar Total	622.2	797
Dec to Mar %	85%	31%
Apr to Nov Total	110.2	1667

Table 1 also shows that between December and March average rainfall exceeds average evaporation by only 175 mm. In a wet year, rainfall will exceed evaporation as described in the next section. During the dry months, April to November evaporation exceeds precipitation by about 1.5 metres. This means that there is no real significance to a sequence of wet or dry years. Each year will have a wet season and a dry season. In a sequence of wet years, the dry season would still cause evaporation to exceed rainfall. For this reason there is no reason to analyse a series of wet years.

2.2 Wet Season Rainfall

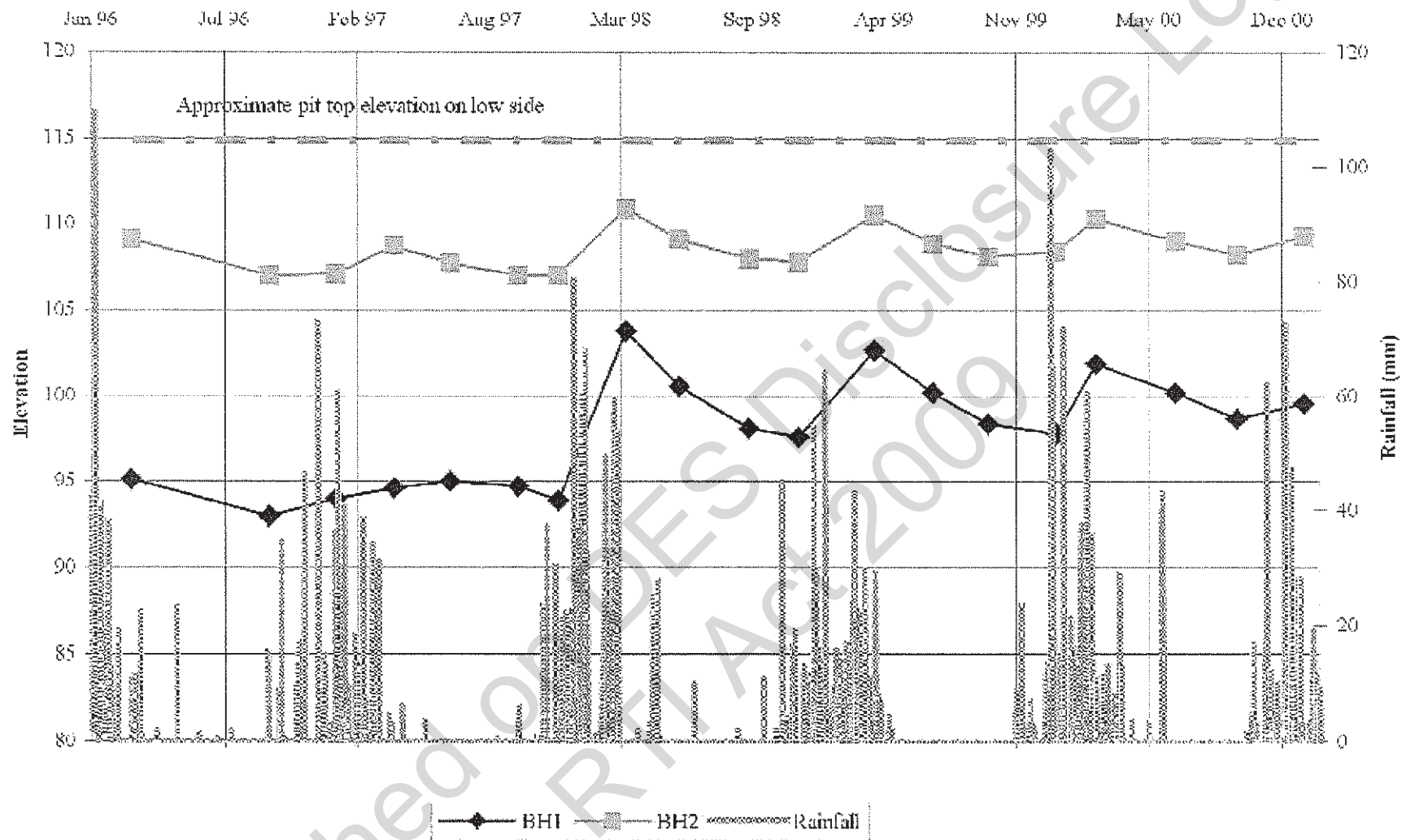
Table 2 – Ranked Rainfall from December to March, Croydon			
Wet Year	rank / 112	Year	Rainfall Dec-Mar (mm)
Wettest	1/112	1974	1611
90%	11/112	1922	942.2
80%	22/112	2001	823.8
50%	56/112	1927	647.7
20%	90/112	1926	431.3
10%	101/112	1978	378.8
Driest	112/112	1952	192.6
Average Wet Season Evaporation			797

The rainfall records at Croydon Met Station have been recorded for 112 years. **Table 2** shows that during the 80 percentile or wetter year there will be more rainfall than the average evaporation in the wet season from December to March (as shown in **Table 1**). The net additional rainfall is very small (between 0 and 0.8 m) compared to the evaporation during the dry months, when a net loss of water on the order of 1.5 metres of water is likely.

3.0 GROUNDWATER

Groundwater levels for two monitoring wells located adjacent to the Golden Butterfly Pit were evaluated for change over time and magnitude of change with rainfall. Monitoring Well BH1 is located approximately 60 metres northeast of the pit and BH2 is located approximately 50 metres southwest of the pit. The water level dataset includes 19 monitoring events from March 1996 through January 2001.

Figure 1 presents a plot of water levels in BH1 and BH2 over time, as well as daily rainfall for the period (March 1996 through January 2001). The data show a good correlation with rainfall. Water levels show a marked increase in 1998, which was the 8th wettest year on record over a 112 year period. The overall trend in groundwater levels appears to be increasing very slightly over this 5 year period. It is possible that the increase is cyclical and related to series of wet years. The rainfall in the years following 1998 were also above the mean (1999 – 0.2%; 2000 – 7.4%). The plot also shows that the equivalent water elevation in BH1 ranges from 7 to 14 metres deeper than in BH2, even though BH1 is considered to be the up gradient well.



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GROUNDWATER ELEVATION PLOT
GOLDEN BUTTERFLY PIT
Goldfields Limited
Croydon Gold Mine, QLD

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Figure 2 presents a southwest to northeast cross section through the pit and the monitoring wells. It shows the relative difference between the water levels in BH1 and BH2. Because the depth of the pit and the water level in the pit are not known, it is not possible to quantify the effect of the change in the pit water level has on the monitoring well levels, hence the groundwater levels surrounding the pit.

As discussed above, the historic rainfall and evaporation data indicate a relatively large deficit because of the high evaporation during 7 to 8 months of the year. Assuming that the bund surrounding the pit does not allow surface run off to enter the pit and that groundwater flows into and out of the pit at the same rate, direct rainfall would be the only source of water into the pit. There is also the possibility that the pit could be acting as a groundwater sink due to the surrounding geology and the significant amounts of water removed by evaporation. Table 3 shows the impact of rainfall and evaporation in the wet and dry seasons and how the pit level and freeboard in the pit is affected.

Table 3 – Summary of Estimated Pit levels and Freeboard under wet and dry conditions								
Wet Year	mm added by Rainfall	mm removed by Evap	Change in Pit Level	Approx Free-board [#]	mm added by Rainfall	mm removed by Evap	Change in Pit Level	Approx Free-board [#]
	December to March			1 st Apr	April to November			1 st Dec
90%	942mm	563mm	+0.4m	3.7m	84mm	1424mm	-1.3m	5.0m
50%	648mm	662mm	0.0m	4.1m	57mm	1381mm	-1.3m	5.4m
10%	379mm	1011mm	-0.6m	4.7m	56mm	1841mm	-1.8m	6.5m

[#] - assumes starting pit water level of RL110.9 (worst case of all readings, BH2 18 march 1998) and lowest pit top level of RL115.0 (based on Woodward-Clyde Plan dated July 1996)

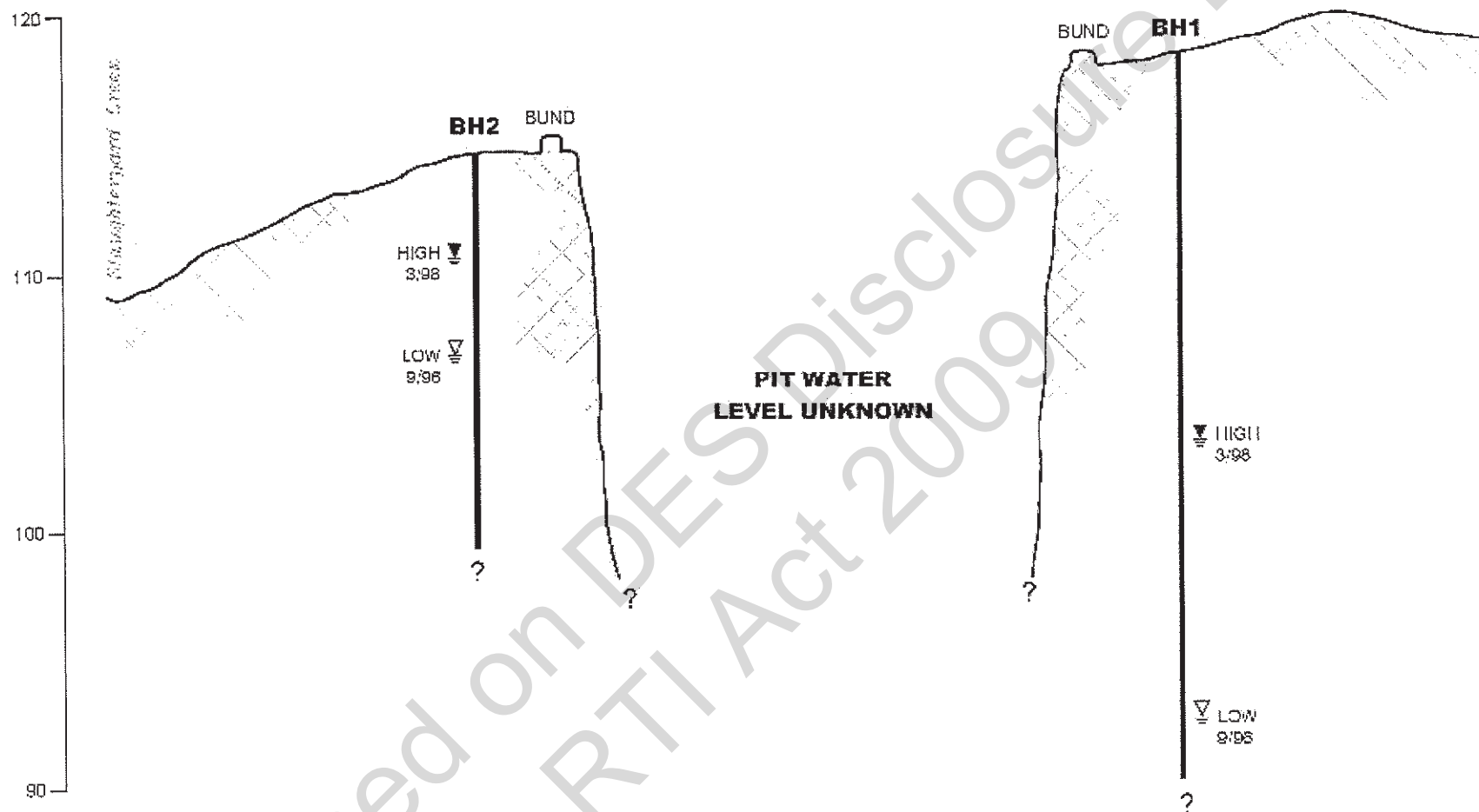
Table 3 shows that even in a very wet year the pit water level will drop by 0.9m without any inflow of groundwater, assuming that runoff from surrounding catchments is kept out of the pit.

Although it would be useful if the data used to make the conclusions were more complete, the existing data points very strongly toward the conclusion that the net evaporation can only decrease the pit level, as long as surface runoff is kept out of the pit. If pit levels increase, then there would have to be inflow from groundwater. No water levels for the pit have been recorded, so it will be difficult to test this theory with data over a long period. No construction details are available for the wells, so there may be some inconsistencies in the way that the wells can accept groundwater from all the strata over the full depth of the well. Wellhead elevations were estimated based on a drawing entitled "Golden Butterfly Pit and Waste Dump Plan of Existing Layout" by Woodward-Clyde, dated July 1996.

Additional monitoring wells are located adjacent to Slaughteryard Creek to the southwest of the pit. Water levels in these wells were not evaluated due to their proximity to the creek. It is considered that the

South West

South East



LEGEND

- HIGHEST WATER LEVEL DURING MONITORING PERIOD
- LOWEST WATER LEVEL DURING MONITORING PERIOD



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CROSS SECTION THROUGH GOLDEN BUTTERFLY PIT
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FIGURE

2

DRAWN	PROJECT FILE NAME	APPROVED	DATE	REVISED DATE
LJE	F1715-001		May 2001	

File D

Page 385 of 390

levels in these wells would be affected to a larger degree by the creek and not by a change in the pit water level.

4.0 CONCLUSIONS

Based on the above assumptions and calculations, it is unlikely that the pit would be overtopped in even the wettest year on record. The available data shows that without groundwater inflow, the pit would lose water even in a wet year. The only conditions that may cause the pit to overtop would be a rise in the groundwater levels, equivalent to the top of the pit. In that case there would be water on the ground at other locations before it got to the top of the pit. Taking the worst case scenario that the pit water level will recover to the highest level recorded in the two boreholes, there would still be 3.7 metres of freeboard in the pit at the end of a 90 percentile wet season. All of these assumptions are based on the continued maintenance and integrity of the bunds around the pit ensuring that no surface runoff from the surrounding catchments can enter the pit.

DISTRIBUTION

Water Level Analysis
of Golden Butterfly Pit
Croydon Gold Mine

15 May 2001

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PO Box R986
Royal Exchange Post Office
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Project File

Quality Control Reviewer

CTPI 49-Sch4

Managing Director

Quality Control Reviewer

CTPI 49-Sch4

Principal Environmental Scientist (Mining)

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Final Rehabilitation Report Croydon Gold Mine ML 5248

6 November 2001

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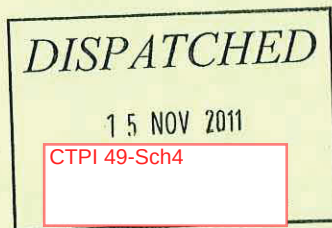
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Queensland
Government

Department of
Environment and Resource
Management

11 November 2011

Rp 483832546012

Mark Kelleher
Chief Executive Officer
Carpentaria Shire Council
P.O. Box 31
Normanton QLD 4890

Dear Sir,

Water Quality Update - Belmore Creek

I refer to your letter received by the Department of Environment & Resource Management (the department) on 24 October 2011 highlighting concerns over elevated levels of heavy metals, most notably arsenic (As) in Belmore Creek.

DERM recently conducted an inspection of the Barrick Croydon Gold Mine located to the immediate west of the Croydon Township. The inspection involved monitoring of the onsite water storages/pits and the receiving environment of Belmore Creek. Results of monitoring indicated that both water and sediment samples did not exceed the licence limits for As, as shown in the table below.

Water & Sediment Sampling Results for Arsenic

Croydon Gold Mine & Belmore Creek, 22 August 2011

Monitoring Point	Matrix	Result	Trigger Level	As Contaminant Limit
Onsite Water Storages				
Golden Butterfly Pit	Water	0.004 mg/L	N/A	0.5 mg/L ¹
Golden Butterfly North Pit	Water	0.009 mg/L		
Content Pit	Water	0.003 mg/L		
Lady Isabella Pit	Water	<0.001 mg/L		
Receiving Environment (Belmore Creek)				
Belmore Creek & Stock Dam “Confluence”	Sediment	<5 mg/kg	20 mg/kg ² or 80 th percentile of reference, whichever is higher	70 mg/kg ³ or twice the reference value, whichever is higher
Reference Site SW7 on Belmore Creek Upstream	Sediment	<5 mg/kg		

¹ Contaminant limit based on ANZECC (2000) stock water quality guidelines;

² ANZECC (2000) Interim Sediment Quality Guidelines – low value based on total sediments;

³ ANZECC (2000) Interim Sediment Quality Guidelines – high value based on total sediments.

Should the receiving waters and/or sediments exceed the contaminant trigger levels, the department will require Barrick Australia Pacific Ltd, owner of the Barrick Croydon Gold

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ABN 46 640 294 485

Mine, to complete an investigation in accordance with the *Australia & New Zealand Environment and Conservation Council (ANZECC) 2000* methodology into the potential for environmental harm and where required, implement measures to prevent environmental harm from occurring.

The department is committed to continually monitoring the Barrick Corydon Gold mine through the wet season. If a release of contaminated water from the open pits to Belmore Creek should occur, this release will be investigated by the department.

Croydon Water Supply

During the inspection on 22 August 2011 the Croydon water supply was not sampled for metal concentrations. With regards to concerns the Croydon water supply may not be suitable for human consumption due to elevated levels of metals, the department suggests that you contact either the Croydon Shire Council or Queensland Health for further information on this issue.

If you have any queries in relation to this matter please contact Alex Apostol on (07) 4744 7814.

Yours sincerely,

CTPI 49-Sch4

Richard Kidston
A/Manager
Mining and Heavy industry
North Region
Department of Environment and Resource Management

Cc: Croydon Shire Council
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