Centennial Coal

STATEMENT OF ENVIRONMENTAL EFFECTS

Western Coal Services Project
State Significant Development 5579
Modification 1

Volume 2: Appendices

November 2016

APPENDIX LIST

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Appendix B:	**Correspondence from the Department of Planning and Environment**
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Development Consent SSD 5579

APPENDIX – A

Development Consent

Section 89E of the *Environmental Planning & Assessment Act 1979*

As delegate of the Minister for Planning and Infrastructure under delegation from the Minister dated 14 September 2011, the Planning Assessment Commission of NSW approves the project application referred to in Schedule 1, subject to the conditions in Schedules 2 to 5.

These conditions are required to:
- prevent, minimise, and/or offset adverse environmental impacts;
- set standards and performance measures for acceptable environmental performance;
- require regular monitoring and reporting; and
- provide for the ongoing environmental management of the development.

Gabrielle Kibble AO
Member of the Commission

Alan Coutts
Member of the Commission

Sydney 4 April 2014

SCHEDULE 1

Application Number:	SSD-5579
Applicant:	Springvale Coal Pty Limited
Consent Authority:	Minister for Planning and Infrastructure
Land:	See Appendix 1
Development:	Western Coal Services Project

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DEFINITIONS

Annual review	The review required by condition 4 of Schedule 5
Applicant	Springvale Coal Pty Limited, or any other person or persons who rely on this consent to carry out the development that is subject to this consent
BCA	Building Code of Australia
CCC	Community Consultative Committee
CHPP	Coal Handling and Preparation Plant
Conditions of this consent	Conditions contained in Schedules 2 to 5 inclusive
Consent	This development consent
CPI	Australian Bureau of Statistics Consumer Price Index
Day	The period from 7am to 6pm on Monday to Saturday, and 8am to 6pm on Sundays and Public Holidays
Development	The development described in the EIS
Director-General	Director-General of P & I, or nominee
DRE	Division of Resources and Energy, within the Department of Trade & Investment, Regional Infrastructure & Services
EIS	Environmental Impact Statement titled *Western Coal Services Project Environmental Impact Statement,* dated July 2013, and associated response to submissions titled *Western Coal Services Project Response to Submissions,* dated October 2013
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPL	Environment Protection Licence issued under the POEO Act
Evening	The period from 6pm to 10pm
Feasible	Feasible relates to engineering considerations and what is practical to build or carry out
Heritage item	An item as defined under the *Heritage Act 1977* and/or an Aboriginal Object or Aboriginal Place as defined under the *National Parks and Wildlife Act 1974*
ICNG	The EPA's *Interim Construction Noise Guideline (2010),* or its latest version
Incident	A set of circumstances that: • causes or threatens to cause material harm to the environment; and/or • breaches or exceeds the limits or performance measures/criteria in this consent
Land	As defined in the EP&A Act, except for where the term is used in the noise and air quality conditions in Schedules 3 and 4 of this consent where it is defined to mean the whole of a lot, or contiguous lots owned by the same landowner, in a current plan registered at the Land Titles Office at the date of this consent
LCC	Lithgow City Council
Material harm to the environment	Actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial
Coal transportation and processing operations	Includes the following, where carried out on the site: • processing, handling and storage of coal; • transportation of coal by private haul road or conveyor; and • transportation and emplacement of coal rejects.
Minister	Minister for Planning and Infrastructure, or delegate
Minor	Not very large, important or serious
Mitigation	Activities associated with reducing the impacts of the development
Negligible	Small and unimportant, such as to be not worth considering
Night	The period from 10pm to 7am on Monday to Saturday, and 10pm to 8am on Sundays and Public Holidays
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
P&I	NSW Planning and Infrastructure
POEO Act	*Protection of the Environment Operations Act 1997*
Privately-owned land	Land that is not owned by a public agency or a mining or power generation company (or its subsidiary)
Product coal	Saleable coal transported from the site, whether processed or unprocessed.
Public infrastructure	Linear and related infrastructure and the like that provides services to the general public, such as roads, railways, water supply, drainage, sewerage, gas supply, electricity, telephone, telecommunications, etc

Reasonable	Reasonable relates to the application of judgement in arriving at a decision, taking into account: mitigation benefits, cost of mitigation versus benefits provided, community views and the nature and extent of potential improvements
Rehabilitation	The treatment or management of land disturbed by the development for the purpose of establishing a safe, stable and non-polluting environment
Remediation	Activities associated with partially or fully repairing or rehabilitating the impacts of the development or controlling the environmental consequences of this impact
RMS	Roads and Maritime Services
ROM coal	Run of Mine coal
SCA	Sydney Catchment Authority
SCSS	Springvale Coal Services Site
Site	All land within the development area as listed in Appendix 1 and shown in Appendix 2

SCHEDULE 2
ADMINISTRATIVE CONDITIONS

OBLIGATION TO MINIMISE HARM TO THE ENVIRONMENT

1. In addition to meeting the specific performance criteria established under this consent, the Applicant shall implement all reasonable and feasible measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.

TERMS OF CONSENT

2. The Applicant shall carry out the development generally in accordance with the:
   (a) EIS;
   (b) statement of commitments; and
   (c) conditions of this consent.

   Notes:
   - *The general layout of the development is shown in Appendix 3.*
   - *The Applicant's statement of commitments is shown in Appendix 8.*

3. If there is any inconsistency between the above documents, the most recent document shall prevail to the extent of the inconsistency. However, the conditions of this consent shall prevail to the extent of any inconsistency.

4. The Applicant shall comply with any reasonable requirement/s of the Director-General arising from the P&I's assessment of:
   (a) any strategies, plans, programs, reviews, audits, reports or correspondence that are submitted in accordance with this consent; and
   (b) the implementation of any actions or measures contained in these documents.

LIMITS ON CONSENT

5. The Applicant may carry out coal transportation and processing operations on the site until 30 June 2039.

   Note: Under this consent, the Applicant is required to rehabilitate the site and perform additional undertakings to the satisfaction of both the Director-General and the Director Environmental Sustainability. Consequently, this consent will continue to apply in all other respects other than the right to conduct coal transportation and processing operations until the rehabilitation of the site and these additional undertakings have been carried out satisfactorily.

Coal Processing

6. The Applicant shall not:
   (a) receive more than a total of 9.5 million tonnes of ROM coal at the SCSS in any calendar year, including not more than 1.0 million tonnes of ROM coal from sites other than Angus Place and Springvale Collieries; and
   (b) process more than 7 million tonnes of ROM coal at the SCSS in any calendar year.

Coal Transport

7. The Applicant shall ensure that all product coal is transported from the SCSS by conveyor.

8. The Applicant shall ensure that not more than 6.3 million tonnes of product coal is transported from the SCSS to the Lidsdale Siding Coal Loader in any calendar year.

SURRENDER OF EXISTING DEVELOPMENT CONSENTS

9. Prior to the end of December 2015, or as otherwise agreed by the Director-General, the Applicant shall surrender all existing development consents or approvals that it holds for the site in accordance with section 104A of the EP&A Act.

   Note: This requirement does not extend to the surrender of construction and occupation certificates for existing and proposed building works under Part 4A of the EP&A Act. Surrender of a consent should not be understood as implying that works legally constructed under a valid consent can no longer be legally maintained or used.

10. Prior to the surrender of any existing development consent, the conditions of this consent shall prevail to the extent of any inconsistency with the conditions of that consent.

STRUCTURAL ADEQUACY

11. The Applicant shall ensure that all new buildings and structures, and any alterations or additions to existing buildings and structures, are constructed in accordance with the relevant requirements of the BCA.

    Notes:
    - *Under Part 4A of the EP&A Act, the Applicant is required to obtain construction and occupation certificates for the proposed building works; and*
    - *Part 8 of the EP&A Regulation sets out the requirements for the certification of the development.*

DEMOLITION

12. The Applicant shall ensure that all demolition work is carried out in accordance with *Australian Standard AS 2601-2001: The Demolition of Structures,* or its latest version.

PROTECTION OF PUBLIC INFRASTRUCTURE

13. Unless the Applicant and the applicable authority agree otherwise, the Applicant shall:
    (a) repair, or pay the full costs associated with repairing, any public infrastructure that is damaged by the development; and
    (b) relocate, or pay the full costs associated with relocating, any public infrastructure that needs to be relocated as a result of the development.

    Note: This condition does not apply to damage to roads caused as a result of general road usage.

OPERATION OF PLANT AND EQUIPMENT

14. The Applicant shall ensure that all plant and equipment used at the site is:
    (a) maintained in a proper and efficient condition; and
    (b) operated in a proper and efficient manner.

STAGED SUBMISSION OF STRATEGIES, PLANS OR PROGRAMS

15. With the approval of the Director-General, the Applicant may submit any strategy, plan or program required by this consent on a progressive basis.

    Notes:
    - *While any strategy, plan or program may be submitted on a progressive basis, the Applicant will need to ensure that the existing operations on site are covered by suitable strategies, plans or programs at all times.*
    - *If the submission of any strategy, plan or program is to be staged, then the relevant strategy, plan or program must clearly describe the specific stage to which the strategy, plan or program applies, the relationship of this stage to any future stages, and the trigger for updating the strategy, plan or program.*

16. Until they are replaced by an equivalent strategy, plan or program approved under this consent, the Applicant shall implement the existing strategies, plans or programs for the site that have been approved under existing development consents or approvals.

OTHER DEVELOPMENTS ON THE SCSS

17. The Applicant shall consult and engage with the proponents/applicants of other approved developments/projects on the SCSS, with the aim of maximising the outcomes of all developments/projects with respect to:
    - operational efficiencies;
    - water, noise and air quality management;
    - biodiversity conservation;
    - rehabilitation; and
    - future land uses.

SCHEDULE 3
ENVIRONMENTAL PERFORMANCE CONDITIONS

ACQUISITION UPON REQUEST

1. Upon receiving a written request for acquisition from an owner of the land listed in Table 1, the Applicant shall acquire the land in accordance with the procedures in conditions 5-6 of Schedule 4.

Table 1: Land subject to acquisition upon request

Property ID	
B4 - Blackmans Flat	Mason (east) – Wolgan Road

Note: To interpret the locations referred to in Table 1 see the applicable figure in Appendix 4.

ADDITIONAL MITIGATION UPON REQUEST

2. Upon receiving a written request from the owner of any residence on the land listed in Table 1, the Applicant shall implement additional noise mitigation measures (such as double glazing, insulation, and/or air conditioning) at the residence in consultation with the owner. These measures must be reasonable and feasible and directed towards reducing the noise impacts of the development on the residence.

   If within 3 months of receiving this request from the owner, the Applicant and the owner cannot agree on the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Director-General for resolution.

NOISE

Construction Noise

3. The Applicant shall prepare and implement a Construction Noise Management Plan prepared in accordance with the EPA's *Interim Construction Noise Guideline 2009* (or any relevant updated version), to the satisfaction of the Director-General. This plan must be prepared in consultation with the EPA, and be approved by the Director-General prior to commencing construction.

Construction Hours

4. The Applicant may only undertake construction activities between the hours of 7am to 6pm Monday to Friday, and 8am to 1pm Saturday, with no construction activities on Sundays or public holidays, unless otherwise agreed to by the Director-General in accordance with condition 5 of Schedule 3.

Out of Hours Construction Works

5. If the Applicant proposes to undertake any construction works outside the hours specified in condition 4 of Schedule 3, then the Applicant must prepare and implement an Out of Hours Work Protocol for these works to the satisfaction of the Director-General. This protocol must be prepared in consultation with the EPA and the residents who would be affected by the noise generated by these works, and be consistent with the requirements of the ICNG. The Applicant shall not carry out any out of hours construction works before this protocol has been approved by the Director-General.

Hours of Operation

6. Except for the carrying out of construction, the Applicant shall comply with the operating hours in Table 2.

Table 2: Operating hours

Activity	***Operating Hours***
Coal transportation operations on the Angus Place to Wallerawang power station haul road	No truck movements to take place during the Night
Coal transportation operations on the Angus Place to Mount Piper power station haul road	No truck movement to occur during adverse meteorological conditions during the Night
Kerosene Vale Coal Stockpile operations	During the Day only
All other operational activities	24 hours a day, 7 days per week

Noise Criteria

7. Except for the carrying out of construction, and for the land in Table 1, the Applicant shall ensure that the noise generated by the development does not exceed the criteria in Table 3 at any residence on privately-owned land.

Table 3: Noise criteria dB(A)

Land	Day $L_{Aeq(15\ min)}$	Evening $L_{Aeq(15\ min)}$	Night $L_{Aeq(15\ min)}$	Night $L_{A1\ (1\ min)}$
B12	40	35	35	47
B13	41	36	36	50
B14	41	35	35	55
B15	36	35	35	45
B16	35	35	36	45
B17	42	44	45	45
W1	37	37	41	45
W2	35	35	36	45
L1	42	35	35	45
L2	40	39	35	45
WR1	41	38	36	57
WR2	38	37	35	48
S3	36	36	39	45
All other privately-owned residences	35	35	35	45

Note: To interpret the locations referred to in Table 3 see the applicable figure in Appendix 4.

Noise generated by the development is to be measured in accordance with the relevant requirements of the *NSW Industrial Noise Policy*. Appendix 5 sets out the meteorological conditions under which these criteria apply and the requirements for evaluating compliance with these criteria.

However, these criteria do not apply if the Applicant has an agreement with the owner/s of the relevant residence or land to generate higher noise levels, and the Applicant has advised P&I in writing of the terms of this agreement.

Operating Conditions

8. The Applicant shall:
   (a) implement best management practice to minimise the construction, operational and road noise of the development;
   (b) operate a comprehensive noise management system that uses a combination of predictive meteorological forecasting and real-time noise monitoring data to guide the day-to-day planning of coal transport and processing operations, and the implementation of both proactive and reactive noise mitigation measures to ensure compliance with the relevant conditions of this consent;
   (c) minimise the noise impacts of the development during meteorological conditions under which the noise limits in this consent do not apply (see Appendix 5);
   (d) co-ordinate noise management on site with the noise management of other approved developments and/or projects on or in the vicinity of the site to minimise cumulative noise impacts; and
   (e) carry out regular monitoring to determine whether the development is complying with the relevant conditions of this consent,

   to the satisfaction of the Director-General.

Noise Management Plan

9. The Applicant shall prepare and implement a Noise Management Plan for the development to the satisfaction of the Director-General. This plan must:

(a) be prepared in consultation with the EPA, and submitted to the Director-General for approval within 4 months of the date of this consent, unless otherwise agreed by the Director-General;
(b) describe the measures that would be implemented to ensure compliance with the noise criteria and operating conditions in this consent;
(c) describe the proposed noise management system in detail; and
(d) include a monitoring program that:
- evaluates and reports on:
  - the effectiveness of the on-site noise management system;
  - compliance against the noise criteria in this consent; and
  - compliance with the noise operating conditions;
- includes a program to calibrate and validate real-time noise monitoring results with attended monitoring results over time (so the real-time noise monitoring program can be used as a better indicator of compliance with the noise criteria and as a trigger for further attended monitoring); and
- defines what constitutes a noise incident, and includes a protocol for identifying and notifying P&I and relevant stakeholders of any noise incidents.

BLASTING

Restriction on Blasting

10. The Applicant shall only carry out blasting on site to construct the Link Haul Road and only between 9 am and 5 pm Monday to Saturday inclusive. No blasting is allowed on Sundays, public holidays, or at any other time without the written approval of the Director-General.

Operating Conditions

11. The Applicant shall:
(a) implement best blasting management practice to:
- protect the safety of people in the surrounding area;
- protect public infrastructure and private property in the surrounding area from any damage; and
- minimise the dust and fume emissions of any blasting;

(b) minimise the frequency and duration of any required road closures;
(c) consult with, and obtain the approval of, the RMS for any blasts within 500 metres of the Castlereagh Highway; and
(d) operate a suitable system to enable the public to get up-to-date information on the proposed blasting schedule on site,

to the satisfaction of the Director-General.

AIR QUALITY

Odour

12. The Applicant shall ensure that no offensive odours, as defined under the POEO Act, are emitted by the development.

Air Quality Criteria

13. The Applicant shall ensure that all reasonable and feasible avoidance and mitigation measures are employed so that particulate matter emissions generated by the development do not cause exceedances of the criteria in Tables 4, 5 and 6 at any residence on privately-owned land.

Table 4: Long-term criteria for particulate matter

Pollutant	***Averaging Period***	[d] ***Criterion***
Total suspended particulate (TSP) matter	Annual	[a] 90 µg/m^3
Particulate matter < 10 µm (PM_{10})	Annual	[a] 30 µg/m^3

Table 5: Short-term criteria for particulate matter

Pollutant	***Averaging Period***	[d] ***Criterion***
Particulate matter < 10 µm (PM_{10})	24 hour	[a] 50 µg/m^3

Table 6: Long-term criteria for deposited dust

Pollutant	*Averaging Period*	*Maximum increase in deposited dust level*	*Maximum total deposited dust level*
[c] Deposited dust	Annual	[b] 2 g/m^2/month	[a] 4 g/m^2/month

Notes to Tables 4 - 6:

[a] Total impact (ie incremental increase in concentrations due to the development plus background concentrations due to all other sources).

[b] Incremental impact (ie incremental increase in concentrations due to the development on its own).

[c] Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method.

[d] Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed by the Director-General.

[e] "Reasonable and feasible avoidance measures" includes, but is not limited to, the operational requirements in condition 17 to develop and implement a real-time air quality management system that ensures operational responses to the risks of exceedance of the criteria.

Mine-owned Land

14. The Applicant shall ensure that all reasonable and feasible avoidance and mitigation measures are employed so that particulate matter emissions generated by the development do not cause exceedances of the criteria in Tables 4, 5 and 6 at any occupied residence on mine-owned land unless:
    (a) the tenant and landowner (if the residence is owned by another mining or power generation company) have been notified of any health risks associated with such exceedances in accordance with the notification requirements under Schedule 4 of this consent;
    (b) the tenant of any land owned by the Applicant can terminate their tenancy agreement without penalty at any time, subject to giving reasonable notice;
    (c) air mitigation measures such as air filters, a first flush roof water drainage system and/or air conditioning) are installed at the residence, if requested by the tenant or landowner (if the residence is owned by another mining or power generation company);
    (d) air quality monitoring is regularly undertaken to inform the tenant or landowner (if the residence is owned by another mining or power generation company) of the actual particulate emissions at the residence; and
    (e) data from this monitoring is presented to the tenant or landowner in an appropriate format for a medical practitioner to assist the tenant and/or landowner (if the residence is owned by another mining or power generation company) in making informed decisions on health risks associated with occupying the property,

    to the satisfaction of the Director-General.

Air Quality Acquisition Criteria

15. If particulate matter emissions generated by the development exceed the criteria, or contribute to an exceedance of the relevant cumulative criteria, in Tables 7, 8 or 9, at any residence on privately-owned land, then upon receiving a written request for acquisition from the landowner the Applicant shall acquire the land in accordance with the procedures in conditions 5-6 of Schedule 4.

Table 7: Long term land acquisition criteria for particulate matter

Pollutant	*Averaging period*	*[d] Criterion*
Total suspended particulate (TSP) matter	Annual	[a] 90 $\mu g/m^3$
Particulate matter < 10 µm (PM_{10})	Annual	[a] 30 $\mu g/m^3$

Table 8: Short term land acquisition criteria for particulate matter

Pollutant	*Averaging period*	*[d] Criterion*
Particulate matter < 10 µm (PM_{10})	24 hour	[a] 150 $\mu g/m^3$
Particulate matter < 10 µm (PM_{10})	24 hour	[b] 50 $\mu g/m^3$

Table 9: Long term land acquisition criteria for deposited dust

Pollutant	***Averaging period***	***Maximum increase in deposited dust level***	***Maximum total deposited dust level***
[c] Deposited dust	Annual	[b] 2 g/m^2/month	[a] 4 g/m^2/month

Notes to Tables 7-9:
a Total impact (ie incremental increase in concentrations due to the development plus background concentrations due to all other sources);
b Incremental impact (ie incremental increase in concentrations due to the development on its own);
c Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method*;*
d Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents, or any other activity agreed by the Director-General.

Operating Conditions

16. The Applicant shall:
    (a) implement best practice management to minimise the off-site odour, fume and dust emissions of the development;
    (b) implement all reasonable and feasible measures to minimise the release of greenhouse gas emissions from the site;
    (c) minimise the surface disturbance of the site;
    (d) minimise any visible off-site air pollution generated by the development;
    (e) operate a comprehensive air quality management system that uses a combination of predictive meteorological forecasting, predictive air dispersion modelling and air quality monitoring data to guide the day-to-day planning of coal transportation and processing operations and implementation of both proactive and reactive air quality mitigation measures to ensure compliance with the relevant conditions of this consent; and
    (f) minimise the air quality impacts of the development during adverse meteorological conditions and extraordinary events (see note d to Tables 7-9 above),

    to the satisfaction of the Director-General.

Air Quality Management Plan

17. The Applicant shall prepare and implement an Air Quality Management Plan for the development to the satisfaction of the Director-General. This plan must:
    (a) be prepared in consultation with the EPA, and submitted to the Director-General for approval within 4 months of the date of this consent, unless otherwise agreed by the Director-General;
    (b) describe the measures that would be implemented to ensure compliance with the relevant air quality criteria and operating conditions of this consent;
    (c) describe the proposed air quality management system; and
    (d) include an air quality monitoring program that:
        - uses a combination of at least one tapered element oscillating microbalance air quality monitor, sited in the vicinity of Blackmans Flat, and supplementary monitors to evaluate the performance of the development against the air quality criteria in this consent;
        - adequately supports the proactive and reactive air quality management system;
        - evaluates and reports on:
            - the effectiveness of the air quality management system; and
            - compliance with the air quality operating conditions; and
        - defines what constitutes an air quality incident, and includes a protocol for identifying and notifying P&I and relevant stakeholders of any air quality incidents.

METEOROLOGICAL MONITORING

18. For the life of the development, the Applicant shall ensure that there is a meteorological station in the vicinity of the site that:
    (a) complies with the requirements in the *Approved Methods for Sampling of Air Pollutants in New South Wales* guideline; and
    (b) is capable of continuous real-time measurement of temperature lapse rate in accordance with the *NSW Industrial Noise Policy*, unless a suitable alternative is approved by the Director-General following consultation with the EPA.

SOIL AND WATER

Water Supply

19. The Applicant shall ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations on site to match its available water supply.

Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development.

Water Pollution

20. Unless an EPL authorises otherwise, the Applicant shall comply with Section 120 of the POEO Act.

Remediation of Soil Contamination

21. Within 4 months of the date of this consent, unless otherwise agreed by the Director-General, the Applicant shall commence a Phase 2 Contamination Assessment for the SCSS.

22. The Applicant shall manage the remediation of the SCSS and the Kerosene Vale Coal Stockpile Area to the satisfaction of the EPA.

23. The Applicant shall comply with the performance measures in Table 10 to the satisfaction of the Director-General.

Table 10: Water Management Performance Measures

Feature	***Performance Measure***
Potable Water	• Minimise the use of potable water for purposes where non-potable water is acceptable
Construction and operation	• Design, install and maintain erosion and sediment controls generally in accordance with the series *Managing Urban Stormwater: Soils and Construction* including *Volume 1, Volume 2A – Installation of Services* and *Volume 2C – Unsealed Roads*, or its latest version • Design, install and maintain all works within 40 m of watercourses generally in accordance with the *Guidelines for Controlled Activities on Waterfront Land (DPI 2012)*, or its latest version • Design, installation and maintenance of creek crossings generally in accordance with the *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, 2003) and *Why Do Fish Need To Cross The Road*? *Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003), or their latest versions
Sediment Dams	• Design, install and maintain dams generally in accordance with *Managing Urban Stormwater: Soils and Construction – Volume 1 and Volume 2E Mines and Quarries*, or its latest version
Clean water diversions & storage infrastructure	• Design, install and maintain the clean water system to capture and convey the 100 year ARI flood, as far as is reasonable and feasible • Maximise diversion of clean water around disturbed areas, as far as is reasonable and feasible
Mine-water storages	• Design, install and maintain the mine-water storage infrastructure to store all runoff from a 95 percentile 5 day rain event • Prevent seepage from the DML and Cooks Dams to the surface, as far as is reasonable and feasible
Chemical and hydrocarbon storage	• Chemical and hydrocarbon products to be stored in bunded areas in accordance with the relevant Australian Standards
Aquatic and riparian ecosystems, including affected sections of Wangcol and Lamberts Gully Creeks	• Maintain or improve baseline channel stability • Develop site-specific in-stream water quality objectives in accordance with ANZECC 2000 and *Using the ANZECC Guidelines and Water Quality Objectives in NSW* procedures (DECC 2006), or its latest version

Water Management Plan

24. The Applicant shall prepare and implement a Water Management Plan for the development to the satisfaction of the Director-General. This plan must:
    (a) be prepared in consultation with the EPA, SCA, NOW, LCC, Forestry Corporation of NSW and Energy Australia by suitably qualified and experienced person/s whose appointment has been approved by the Director-General;
    (b) be submitted to the Director-General for approval within 4 months of the date of this consent, unless otherwise agreed by the Director-General; and
    (c) include a:
        (i) Site Water Balance, that:
            - includes details of:
                - sources and security of water supply, including contingency supply for future reporting periods;
                - water use and management on site;
                - any off-site water discharges; and
                - reporting procedures, including the preparation of a site water balance for each calendar year; and
            - investigates and implements all reasonable and feasible measures to minimise potable water use and to re-use and recycle water;
        (ii) Surface Water Management Plan, that includes:
            - detailed baseline data on water flows and quality in the watercourses that could potentially be affected by the development;
            - a detailed description of the SCSS water management system, including the:
                - clean water diversion systems;
                - erosion and sediment controls; and
                - mine-water management systems;
            - detailed plans, including design objectives and performance criteria for:
                - design and management for the emplacement of coal reject materials and potential acid-forming or sulphate-generating materials;
                - management of sodic and dispersible soils;
                - reinstatement of appropriate drainage lines on the rehabilitated areas of the site; and
                - control of any potential water pollution from the rehabilitated areas of the site;
            - performance criteria for the following, including trigger levels for investigating any associated potentially adverse impacts:
                - SCSS water management system;
                - downstream surface water quality; and
                - stream and riparian vegetation health for the Wangcol and Lamberts Gully Creeks;
            - a program to monitor and report on:
                - effectiveness of the SCSS water management system; and
                - surface water flows and quality in the watercourses potentially affected by the development; and
            - reporting procedures for the results of the monitoring program; and
            - a plan to respond to any exceedences of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the development;
        (iii) Groundwater Management Plan that includes:
            - detailed baseline data of groundwater levels, yield and quality on the SCSS and surrounds that could be affected by the development, including any licensed privately-owned groundwater bores;
            - groundwater impact assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts;
            - a program to monitor and report on:
                - groundwater inflows to former open cut pits;
                - the seepage/leachate from water storages, emplacements of power station ash and/or coal rejects, and former open cut voids;
                - background changes in groundwater yield/quality against changes induced by the development; and
                - impacts of the development on:
                    - regional and local (including alluvial) aquifers;
                    - groundwater supply of any potentially affected private landowners; and
                    - any potentially affected groundwater dependent ecosystems and riparian vegetation;
            - a program to validate the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions; and
            - a plan to respond to any exceedences of the performance criteria; and

(iv) protocol that has been prepared in consultation with the owners of nearby power generation or mining developments to:
- minimise cumulative water quality impacts;
- review opportunities for water sharing/water transfers between these developments;
- co-ordinate water quality monitoring programs as far as practicable;
- undertake joint investigations/studies in relation to complaints/exceedences of trigger levels where cumulative impacts are considered likely; and
- co-ordinate modelling programs for validation, re-calibration and re-running of groundwater and surface water models.

Note: The protocol can be developed in stages and will need to be subject to ongoing review, dependent upon the determination of, and commencement of, other mining and/or power generation developments in the area.

BIODIVERSITY

Biodiversity Offset Strategy

25. By the end of December 2016, the Applicant shall, to the satisfaction of the Director-General:
    (a) provide an area that is suitable in its vegetation types and extent to satisfactorily offset the impacts of clearing 10.67 hectares of native vegetation (*Coxs Permian Red Stringybark – Brittle Gum Woodland*); and
    (b) make suitable arrangements to manage, protect and provide long-term security for this area, consistent with the relevant NSW Offsets policy.

Additional Rehabilitation Initiatives

26. The Applicant shall implement the Additional Rehabilitation Initiatives for the Lamberts Gully Creek catchment on the SCSS by the establishment and enhancement of locally endemic native vegetation species and improvement of fauna habitat values in the areas shown in Appendix 7, to the satisfaction of the Director-General.

Wangcol and Lamberts Gully Creeks

27. The Applicant shall improve the riparian habitat of Wangcol Creek for at least 100 metres downstream of the proposed Link haul road bridge crossing of the creek, to the satisfaction of the Director-General.

Habitat for Threatened Fauna Species

28. The Applicant shall ensure that the Biodiversity Offset Strategy and Additional Rehabilitation Initiatives areas, in combination, provide suitable habitat for threatened fauna species recorded on the SCSS, namely the:
    - Brown Treecreeper;
    - Gang-gang Cockatoo;
    - Little Eagle;
    - Scarlet Robin;
    - Large-eared Pied Bat;
    - Eastern Falsistrelle;
    - Eastern Bent Wing Bat; and
    - Yellow Bellied Sheathtail Bat.

Biodiversity Management Plan

29. The Applicant shall prepare and implement a Biodiversity Management Plan for the development to the satisfaction of the Director-General. This plan must:
    (a) be prepared in consultation with OEH and Forestry Corporation of NSW, and be submitted to the Director-General for approval by the end of December 2016;
    (b) describe the short, medium, and long-term measures that would be implemented to:
    - manage remnant vegetation and habitat on the site; and
    - implement the Biodiversity Offset Strategy;
    (c) include detailed performance and completion criteria for evaluating the performance of the Biodiversity Offset Strategy, and triggering any necessary remedial action;
    (d) include a detailed description of the measures that would be implemented over the next 3 years (to be updated for each 3-year period following initial preparation of the plan) for:
    - enhancing the quality of existing vegetation and fauna habitat;
    - establishing native vegetation and fauna habitat in the Additional Rehabilitation Initiatives area through focusing on assisted natural regeneration, targeted vegetation establishment and the introduction of naturally scarce fauna habitat features (where necessary);

- enhancing the landscaping of the site and along public roads to minimise visual and lighting impacts, particularly along the Castlereagh Highway;
- protecting vegetation and soil outside the approved disturbance area;
- maximising the salvage of resources within the approved disturbance area – including tree hollows and vegetative and soil resources – for beneficial reuse in the biodiversity offset strategy;
- collecting and propagating seed;
- minimising the impacts to fauna on site, including undertaking pre-clearance surveys;
- managing any potential conflicts between the proposed restoration works in the Additional Rehabilitation Initiatives area and any Aboriginal heritage values (both cultural and archaeological);
- managing salinity;
- controlling weeds and feral pests;
- controlling erosion;
- controlling access; and
- managing bushfire risk;

(e) include a program to monitor and report on the effectiveness of these measures, and progress against the detailed performance and completion criteria;

(f) identify the potential risks to the successful implementation of the Biodiversity Offset Strategy, and include a description of the contingency measures that would be implemented to mitigate against these risks; and

(g) include details of who would be responsible for monitoring, reviewing, and implementing the plan.

Note: The Biodiversity Management Plan and Rehabilitation Management Plan require substantial integration to achieve biodiversity objectives for the undisturbed and rehabilitated areas of the SCSS.

Conservation Bond

30. Within 6 months of the approval of the Biodiversity Management Plan, unless the Director-General agrees otherwise, the Applicant shall lodge a Conservation Bond with P&I to ensure that the Biodiversity Offset Strategy is implemented in accordance with the performance and completion criteria of the Biodiversity Management Plan.

The sum of the bond shall be determined by:

(a) calculating the full cost of implementing the Biodiversity Offset Strategy (other than land acquisition costs); and

(b) employing a suitably qualified quantity surveyor to verify the calculated costs.

If the offset strategy is completed generally in accordance with the completion criteria in the Biodiversity Management Plan to the satisfaction of the Director-General, the Director-General will release the bond.

If the offset strategy is not completed generally in accordance with the completion criteria in the Biodiversity Management Plan, the Director-General will call in all, or part of, the conservation bond, and arrange for the satisfactory completion of the relevant works.

Notes:

- *Alternative funding arrangements for long-term management of the Biodiversity Offset Strategy, such as provision of capital and management funding as agreed by OEH as part of a Biobanking Agreement or transfer to the conservation reserve estate can be used to reduce the liability of the conservation bond.*
- *The sum of the bond may be reviewed in conjunction with any revision to the Biodiversity Management Plan.*

HERITAGE

Protection of Aboriginal Sites

31. The Applicant shall ensure that the development does not cause any direct or indirect impact on identified Aboriginal sites located outside the approved disturbance area of the development on the site.

Heritage Management Plan

32. The Applicant shall prepare and implement a Heritage Management Plan for the development to the satisfaction of the Director-General. This plan must:

(a) be prepared by suitably qualified and experienced person/s whose appointment has been endorsed by the Director-General;

(b) be prepared in consultation with OEH and local Aboriginal stakeholders (in relation to the management of Aboriginal heritage values);

(c) be submitted to the Director-General for approval within 6 months of the date of this consent, unless the Director-General agrees otherwise;

(d) include a description of the measures that would be implemented for:

- addressing relevant statutory requirements under the *National Parks and Wildlife Act 1974;*
- protecting, monitoring and managing Aboriginal sites outside the approved disturbance area (including sites shown on the figure in Appendix 6, with particular attention to site 45-1-0218);
- maintaining and managing reasonable access for Aboriginal stakeholders to cultural heritage items on site;
- managing the discovery of any human remains or previously unidentified Aboriginal objects on site, including (in the case of human remains) stop work provisions and notification protocols;
- ongoing consultation with local Aboriginal stakeholders in the conservation and management of Aboriginal cultural heritage both on-site and in the Biodiversity Offset Strategy area; and
- ensuring any workers on site receive suitable heritage inductions prior to carrying out any activities which may disturb Aboriginal sites, and that suitable records are kept of these inductions.

TRANSPORT

Intersection Upgrade

33. Within 6 months of the date of this consent, unless the Director-General agrees otherwise, the Applicant shall re-paint line markings at the intersection of the Castlereagh Highway and the SCSS Access Road to the satisfaction of RMS.

Castlereagh Highway Overbridge

34. The Applicant shall design, construct and operate the Link Haul Road overbridge of the Castlereagh Highway at no cost to, and to the satisfaction of, RMS.

Construction Traffic Management Plan

35. The Applicant shall prepare and implement a Construction Traffic Management Plan for the development, to the satisfaction of the Director-General. This plan shall be prepared in consultation with LCC and RMS, and must be submitted to the Director-General for approval prior to the commencement of construction activities on the site. This plan must address:
    (a) management of wide loads;
    (b) minimising inconvenience to the public, particularly during the construction of the Link Haul Road overbridge of the Castlereagh Highway; and
    (c) maintaining public safety.

Road Maintenance – Private Haul Roads

36. Within 3 months of the date of consent, until coal transportation ceases on each respective haul road, unless otherwise agreed by the Director-General, the Applicant shall maintain the surface of the haul roads from Angus Place to Mount Piper and Wallerawang power stations with a smooth sealed surface, effectively free of potholes, indentations or other unevenness of the surface that would cause noise levels from traffic travelling on the road to exceed the sleep disturbance criteria in Table 3, to the satisfaction of the Director-General.

37. Within 3 months of the date of consent, and every 6 months thereafter until coal transportation ceases on each respective haul road, unless otherwise agreed by the Director-General, the Applicant shall arrange and pay the cost of independent inspections and condition reports of the surface of the haul roads from Angus Place to Mount Piper and Wallerawang power stations by an independent road maintenance expert, approved by the Director-General. Copies of the inspection and condition reports must be forwarded to the Director-General at the same time as they are provided to the Applicant.

38. If any haul road condition report, referred to in condition 37, recommends repair or remedial works in order to prevent exceedances of the sleep disturbance criteria in Table 3, then the Applicant must not undertake trucking operations on the affected haul road at Night until the recommended repair and/or remedial works are undertaken to the satisfaction of the independent road maintenance expert.

Transport Monitoring

39. The Applicant shall monitor and report on:
    (a) the amount of coal transported to and from the site; and
    (b) the date and time of each truck movement of coal or coal rejects to and from the site;
    to the satisfaction of the Director-General.

VISUAL

Operating Conditions

40. The Applicant shall:
    (a) implement all reasonable and feasible measures to minimise the visual and off-site lighting impacts of the development;
    (b) ensure no fixed outdoor lights or mobile lighting rigs shine above the horizontal;
    (c) ensure that all external lighting associated with the development complies with *Australian Standard AS4282 (INT) 1997 – Control of Obtrusive Effects of Outdoor Lighting* or its latest version;
    (d) ensure revegetation works associated with the batters of the Link Haul Road overbridge of the Castlereagh Highway are undertaken as soon as practicable and maintained to reduce visual impacts;
    (e) employ reasonable and feasible landscaping measures to minimise visual impacts of all private haul roads forming part of the development; and
    (f) ensure that the visual appearance of all buildings, structures, facilities or works (including paint colours and specifications) is aimed at blending as far as possible with the surrounding landscape,

    to the satisfaction of the Director-General**.**

BUSHFIRE MANAGEMENT

41. The Applicant shall:
    (a) ensure that the development is suitably equipped to respond to any fires on site; and
    (b) assist the Rural Fire Service, emergency services and Forestry Corporation of NSW as much as possible if there is a fire in the surrounding area.

WASTE

42. The Applicant shall:
    (a) implement all reasonable and feasible measures to minimise the waste (including coal reject) generated by the development;
    (b) ensure that the waste generated by the development is appropriately stored, handled and disposed of; and
    (c) monitor and report on the effectiveness of waste minimisation and management measures in the Annual Review.

REHABILITATION

Rehabilitation Objectives

43. The Applicant shall rehabilitate the site to the satisfaction of the Director Environmental Sustainability. This rehabilitation must be generally consistent with the proposed Rehabilitation Strategy described in the EIS (and shown conceptually in Appendix 7) and comply with the objectives in Table 11.

Table 11: Rehabilitation objectives

Feature	***Objective***
Site (as a whole)	Safe, stable and non-polluting Constructed landforms drain to the natural environment Minimise visual impact of final landforms as far as is reasonable and feasible
Lands on which other approved developments exist or are proposed, such as Energy Australia's ash emplacement or LCC's waste management facility	Final land use to be determined in consultation with, and the agreement of the landowner The default objective for all land where a final land use is not otherwise agreed is to rehabilitate to the standards required for "Remainder of the SCSS" in this table
Surface infrastructure	To be decommissioned and removed, unless the Director Environmental Sustainability agrees otherwise
Castlereagh Highway overbridge	To be decommissioned and removed, unless the Director Environmental Sustainability and RMS agrees otherwise
Portion of Ben Bullen State Forest within the SCSS	To be managed to the satisfaction of the Forestry Corporation of NSW with the implementation of biodiversity enhancement measures, including weed and feral animal control
Remainder of the SCSS	Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems comprising:

Feature	Objective
	• a wildlife corridor (shown as Additional Rehabilitation Initiatives in the figure in Appendix 7); • local native plant species; and • a landform consistent with the surrounding environment
Community	Ensure public safety Minimise the adverse socio-economic effects associated with closure of the development

Progressive Rehabilitation

44. The Applicant shall progressively rehabilitate the site, including the Kerosene Vale Stockpile Area, as soon as reasonably practicable following disturbance. All reasonable and feasible measures must be taken to minimise the total area exposed for dust generation at any time. Interim rehabilitation strategies must be employed where areas prone to dust generation are not subject to active operations but cannot yet be permanently rehabilitated.

Note: It is accepted that parts of the site that are progressively rehabilitated may be subject to further disturbance in future.

Rehabilitation Management Plan

45. The Applicant shall prepare and implement a Rehabilitation Management Plan to the satisfaction of the Director Environmental Sustainability. This plan must:
   (a) be prepared in consultation with P&I, EPA, NOW, OEH, SCA, Forestry Corporation of NSW, CCC and LCC;
   (b) be submitted to the Director Environmental Sustainability for approval within 4 months of the date of this consent; unless the Director Environmental Sustainability agrees otherwise;
   (c) be prepared in accordance with any relevant DRE guideline;
   (d) describe how the rehabilitation of the site would be integrated with the implementation of the Biodiversity Management Plan;
   (e) include detailed performance and completion criteria for evaluating the performance of the rehabilitation of the site, and triggering remedial action (if necessary);
   (f) describe the measures that would be implemented to ensure compliance with the relevant conditions of this consent, and address all aspects of rehabilitation including facility closure, final landform and final land use;
   (g) include interim rehabilitation where necessary to minimise the area exposed for dust generation;
   (h) include a program to monitor, independently audit and report on the effectiveness of the rehabilitation measures and progress against the detailed performance and completion criteria; and
   (i) build to the maximum extent practicable on the other management plans required under this consent.

Note: The Biodiversity Management Plan and Rehabilitation Management Plan require substantial integration to achieve biodiversity objectives for the undisturbed and rehabilitated areas of the SCSS.

SCHEDULE 4
ADDITIONAL PROCEDURES

NOTIFICATION OF LANDOWNERS/TENANTS

1. Within 1 month of the date of this consent, unless the Director-General agrees otherwise, the Applicant shall:
   (a) notify in writing the owners of:
   - the land listed in Table 1 of Schedule 3 that they have the right to require the Applicant to acquire their land at any stage during the development; and
   - any residence listed in condition 2 of Schedule 3, that they have the right to request the Applicant for additional noise mitigation measures to be installed at their residence at any stage during the development;

   (b) notify the tenants of any mine-owned land of their rights under this consent; and
   (c) send a copy of the NSW Health fact sheet entitled "Mine Dust and You" (as may be updated from time to time) to the owners and/or existing tenants of any land (including mine-owned land) where the predictions in the EIS identify that dust emissions generated by the development are likely to be greater than the relevant air quality criteria in Schedule 3 at any time during the life of the development.

2. Prior to entering into any tenancy agreement for any land owned by the Applicant that is predicted to experience exceedances of the recommended dust and/or noise criteria, or for any of the land listed in Table 1 that is subsequently purchased by the Applicant, the Applicant shall:
   (a) advise the prospective tenants of the potential health and amenity impacts associated with living on the land, and give them a copy of the NSW Health fact sheet entitled "Mine Dust and You" (as may be updated from time to time); and
   (b) advise the prospective tenants of the rights they would have under this consent,

   to the satisfaction of the Director-General.

3. As soon as practicable after obtaining monitoring results showing:
   (a) an exceedance of any relevant criteria in Schedule 3, the Applicant shall notify affected landowners in writing of the exceedance, and provide regular monitoring results to each affected landowner until the development is again complying with the relevant criteria; and
   (b) an exceedance of the relevant air quality criteria in Schedule 3, the Applicant shall send a copy of the NSW Health fact sheet entitled "Mine Dust and You" (as may be updated from time to time) to the affected landowners and/or existing tenants of the land (including the tenants of any mine-owned land).

INDEPENDENT REVIEW

4. If an owner of privately-owned land considers the development to be exceeding the criteria in Schedule 3, then he/she may ask the Director-General in writing for an independent review of the impacts of the development on his/her land.

   If the Director-General is satisfied that an independent review is warranted, then within 2 months of the Director-General's decision, the Applicant shall:
   (a) commission a suitably qualified, experienced and independent expert, whose appointment has been approved by the Director-General, to:
   - consult with the landowner to determine his/her concerns;
   - conduct monitoring to determine whether the development is complying with the relevant impact assessment criteria in Schedule 3; and
   - if the development is not complying with these criteria then:
     - determine if more than one mine or development is responsible for the exceedance, and if so the relative share of each mine or development regarding the impact on the land; and
     - identify the measures that could be implemented to ensure compliance with the relevant criteria; and

   (b) give the Director-General and landowner a copy of the independent review.

LAND ACQUISITION

5. Within 3 months of receiving a written request from a landowner with acquisition rights, the Applicant shall make a binding written offer to the landowner based on:
   (a) the current market value of the landowner's interest in the land at the date of this written request, as if the land was unaffected by the development, having regard to the:

- existing and permissible use of the land, in accordance with the applicable planning instruments at the date of the written request; and
- presence of improvements on the land and/or any approved building or structure which has been physically commenced at the date of the landowner's written request, and is due to be completed subsequent to that date, but excluding any improvements that have resulted from the implementation of the additional noise mitigation measures in condition 2 of Schedule 3;

(b) the reasonable costs associated with:
- relocating within the Lithgow local government area, or to any other local government area determined by the Director-General; and
- obtaining legal advice and expert advice for determining the acquisition price of the land, and the terms upon which it is to be acquired; and

(c) reasonable compensation for any disturbance caused by the land acquisition process.

However, if at the end of this period, the Applicant and landowner cannot agree on the acquisition price of the land and/or the terms upon which the land is to be acquired, then either party may refer the matter to the Director-General for resolution.

Upon receiving such a request, the Director-General will request the President of the NSW Division of the Australian Property Institute to appoint a qualified independent valuer to:
- consider submissions from both parties;
- determine a fair and reasonable acquisition price for the land and/or the terms upon which the land is to be acquired, having regard to the matters referred to in paragraphs (a)-(c) above;
- prepare a detailed report setting out the reasons for any determination; and
- provide a copy of the report to both parties.

Within 14 days of receiving the independent valuer's report, the Applicant shall make a binding written offer to the landowner to purchase the land at a price not less than the independent valuer's determination.

However, if either party disputes the independent valuer's determination, then within 14 days of receiving the independent valuer's report, they may refer the matter to the Director-General for review. Any request for a review must be accompanied by a detailed report setting out the reasons why the party disputes the independent valuer's determination. Following consultation with the independent valuer and both parties, the Director-General will determine a fair and reasonable acquisition price for the land, having regard to the matters referred to in paragraphs (a)-(c) above, the independent valuer's report, the detailed report of the party that disputes the independent valuer's determination and any other relevant submissions.

Within 14 days of this determination, the Applicant shall make a binding written offer to the landowner to purchase the land at a price not less than the Director-General's determination.

If the landowner refuses to accept the Applicant's binding written offer under this condition within 6 months of the offer being made, then the Applicant's obligations to acquire the land shall cease, unless the Director-General determines otherwise.

6. The Applicant shall pay all reasonable costs associated with the land acquisition process described in condition 5 above, including the costs associated with obtaining Council approval for any plan of subdivision (where permissible), and registration of this plan at the Office of the Registrar-General.

SCHEDULE 5
ENVIRONMENTAL MANAGEMENT, REPORTING AND AUDITING

ENVIRONMENTAL MANAGEMENT

Environmental Management Strategy

1. The Applicant shall prepare and implement an Environmental Management Strategy for the development to the satisfaction of the Director-General. This strategy must:
   - (a) be submitted to the Director-General for approval within 6 months of the date of this approval, unless the Director-General agrees otherwise;
   - (b) provide the strategic framework for environmental management of the development;
   - (c) identify the statutory approvals that apply to the development;
   - (d) describe the role, responsibility, authority and accountability of all key personnel involved in the environmental management of the development;
   - (e) describe the procedures that would be implemented to:
     - keep the local community and relevant agencies informed about the operation and environmental performance of the mining complex;
     - receive, handle, respond to, and record complaints;
     - resolve any disputes that may arise;
     - respond to any non-compliance;
     - respond to emergencies; and
   - (f) include:
     - copies of any strategies, plans and programs approved under the conditions of this consent; and
     - a clear plan depicting all the monitoring to be carried out in relation to the development.

Adaptive Management

2. The Applicant must assess and manage development-related risks to ensure that there are no exceedances of the criteria and/or performance measures in Schedule 3. Any exceedance of these criteria and/or performance measures constitutes a breach of this consent and may be subject to penalty or offence provisions under the EP&A Act or EP&A Regulation.

   Where any exceedance of these criteria and/or performance measures has occurred, the Applicant must, at the earliest opportunity:
   - (a) take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur;
   - (b) consider all reasonable and feasible options for remediation (where relevant) and submit a report to P&I describing those options and any preferred remediation measures or other course of action; and
   - (c) implement remediation measures as directed by the Director-General,

   to the satisfaction of the Director-General.

Management Plan Requirements

3. The Applicant shall ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include:
   - (a) detailed baseline data;
   - (b) a description of:
     - the relevant statutory requirements (including any relevant approval, licence or lease conditions);
     - any relevant limits or performance measures/criteria;
     - the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;
   - (c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;
   - (d) a program to monitor and report on the:
     - impacts and environmental performance of the development;
     - effectiveness of any management measures (see c above);
   - (e) a contingency plan to manage any unpredicted impacts and their consequences;
   - (f) a program to investigate and implement ways to improve the environmental performance of the development over time;
   - (g) a protocol for managing and reporting any:
     - incidents;
     - complaints;
     - non-compliances with statutory requirements; and
     - exceedances of the impact assessment criteria and/or performance criteria; and
   - (h) a protocol for periodic review of the plan.

Annual Review

4. By the end of March each year, or other timing as may be agreed by the Director-General, the Applicant shall review the environmental performance of the development to the satisfaction of the Director-General. This review must:
   (a) describe the development that was carried out in the previous calendar year, and the development that is proposed to be carried out over the current calendar year;
   (b) include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, which includes a comparison of these results against the:
      - the relevant statutory requirements, limits or performance measures/criteria;
      - the monitoring results of previous years; and
      - the relevant predictions in the EIS;
   (c) identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
   (d) identify any trends in the monitoring data over the life of the development;
   (e) identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and
   (f) describe what measures will be implemented over the next year to improve the environmental performance of the development.

Revision of Strategies, Plans and Programs

5. Within 3 months of:
   (a) the submission of an annual review under Condition 4 above;
   (b) the submission of an incident report under Condition 7 below;
   (c) the submission of an audit report under Condition 9 below; or
   (d) any modification to the conditions of this consent, (unless the conditions require otherwise),

   the Applicant shall review the strategies, plans, and programs required under this consent, to the satisfaction of the Director-General. Where this review leads to revisions in any such document, then within 4 weeks of the review the revised document must be submitted for the approval of the Director-General.

   Note: The purpose of this condition is to ensure that strategies, plans and programs are regularly updated to incorporate any measures recommended to improve environmental performance of the development.

Community Consultative Committee

6. Within 3 months of the date of this consent, the Applicant shall establish and operate a regional Community Consultative Committee (CCC) for the development in general accordance with the *Guidelines for Establishing and Operating Community Consultative Committees for Mining Projects* (Department of Planning, 2007, or its latest version), and to the satisfaction of the Director-General. This CCC is to service this development and any other approved project and/or development operated by the company in the Wallerawang district.

   Notes:
   - *The CCC is an advisory committee. P&I and other relevant agencies are responsible for ensuring that the Applicant complies with this consent; and*
   - *The CCC should be comprised of an independent chair and appropriate representation from the Applicant, LCC, recognised environmental groups and the local community to the satisfaction of the Director-General.*

REPORTING

Incident Reporting

7. The Applicant shall immediately notify the Director-General and any other relevant agencies of any incident that has caused, or threatens to cause, material harm to the environment. For any other incident associated with the development, the Applicant shall notify the Director-General and any other relevant agencies as soon as practicable after the Applicant becomes aware of the incident. Within 7 days of the date of the incident, the Applicant shall provide the Director-General and any relevant agencies with a detailed report on the incident, and such further reports as may be requested.

Regular Reporting

8. The Applicant shall provide regular reporting on the environmental performance of the development on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this consent.

INDEPENDENT ENVIRONMENTAL AUDIT

Independent Environmental Audit

9. By the end of December 2015, and every 3 years thereafter, unless the Director-General directs otherwise, the Applicant shall commission and pay the full cost of an Independent Environmental Audit of the development. This audit must:
   (a) be conducted by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Director-General;
   (b) include consultation with the relevant agencies;
   (c) assess the environmental performance of the development and assess whether it is complying with the requirements in this consent, and any other relevant approvals, relevant EPL/s and/or Mining Lease/s (including any assessment, plan or program required under these approvals);
   (d) review the adequacy of any approved strategy, plan or program required under the abovementioned approvals; and
   (e) recommend measures or actions to improve the environmental performance of the development, and/or any strategy, plan or program required under these approvals.

   Note: This audit team must be led by a suitably qualified auditor, and include experts in field specified by the Director-General.

10. Within 3 months of commissioning this audit, or as otherwise agreed by the Director-General, the Applicant shall submit a copy of the audit report to the Director-General, together with its response to any recommendations contained in the audit report.

ACCESS TO INFORMATION

11. The Applicant shall:
   (a) make the following information publicly available on its website:
   - the EIS;
   - all current statutory approvals for the development;
   - approved strategies, plans or programs required under the conditions of this consent;
   - a comprehensive summary of the monitoring results of the development, which have been reported in accordance with the various plans and programs approved under the conditions of this consent;
   - a complaints register, which is to be updated on a monthly basis;
   - minutes of CCC meetings;
   - the last five annual reviews;
   - any independent environmental audit, and the Applicant's response to the recommendations in any audit;
   - any other matter required by the Director-General; and

   (b) keep this information up to date,

   to the satisfaction of the Director-General.

APPENDIX 1
SCHEDULE OF LAND

Land within area subject of the EIS	**Centennial Fassifern Pty Ltd**
	Lots 2 and 4 DP 260621
	Lot 1 DP 386554
	Lot 3 DP 542432
	Lots 32, 41, 57 and 351 DP 751636
	Lots 43, 51 and 406 DP 751651
	Lots 120, 121 and 124 DP 1188105
	Lots 138, 139, 140, 141, 142, 143, 144 and 145 DP 1185660
	Lots 1, 3 and 4 DP 1139982
	Lot 1 DP 400022
	Lot 1 DP 920999
	Lots 2 and 3 DP 1151441
	Centennial Springvale Pty Ltd and Springvale Kores Pty Ltd
	Lot 1 DP 88503
	Lots 1 and 2 DP 126483
	Lot 13 and 357 DP 751651
	Lot 501 DP 825541
	Lot 2 DP 835651
	Coal Link>Pty Ltd
	Lot 1 DP 825887
	Council of the City of Lithgow
	Lot 42 DP 751636
	Lot 1 DP 1049889
	Lot 1 DP 1127043
	Lot 4 DP 1151441
	Delta Electricity
	Lot 191 DP 629212
	Lots 1 and 2 DP 702619
	Lot 67 DP 751636
	Lot 1 DP 803655
	Lots 9 and 15 DP 804929
	Lot 1 DP 825124
	Lots 140, 146, 147, 148, 149, 151 and 152 DP 1185660
	Lots 3 and 5 DP 829137
	Lot 101 DP 829410

	Lot 16 DP 855844
	Lot 2 DP 1018958
	Lots 1 and 5 DP 1087684
	Lot 228 DP 1131953
	Lots 10 and 11 DP 1139978
	Lots 2 and 3 DP 1139982
	Lot 103 DP 1164619
	Enhance Place Pty Ltd
	Lots 132, 135, 136, 137 138, 139, 140 and 141 DP 1188105
	Lot 10 DP 877753
	Lot 29 DP 1096381
	State of NSW / Ben Bullen State Forest
	Lot 70 DP 751636
	Lot 502 DP 825541
	Lot 7005 DP 1026541
	Lots 290 and 291 DP 751636
	Ivanhoe Coal Pty Ltd
	Lot 2 DP 567915
	Lots 16, 174, 375 and 385 DP 751651
	Lot 101 DP 1137972
	Private Owner (Janette Winifred Hunt)
	Lot 371 DP 751651
	Lidsdale Holdings Pty Ltd
	Lot 128 DP 1188105
	State Rail Authority
	Lots 1 and 8 DP 252472
	Crown Roads
	Lots 4, 5, 9 and 10 DP 1187371
	Lot 70 DP 751636
	Lot 7005 DP 1026541

APPENDIX 2
DEVELOPMENT AREA

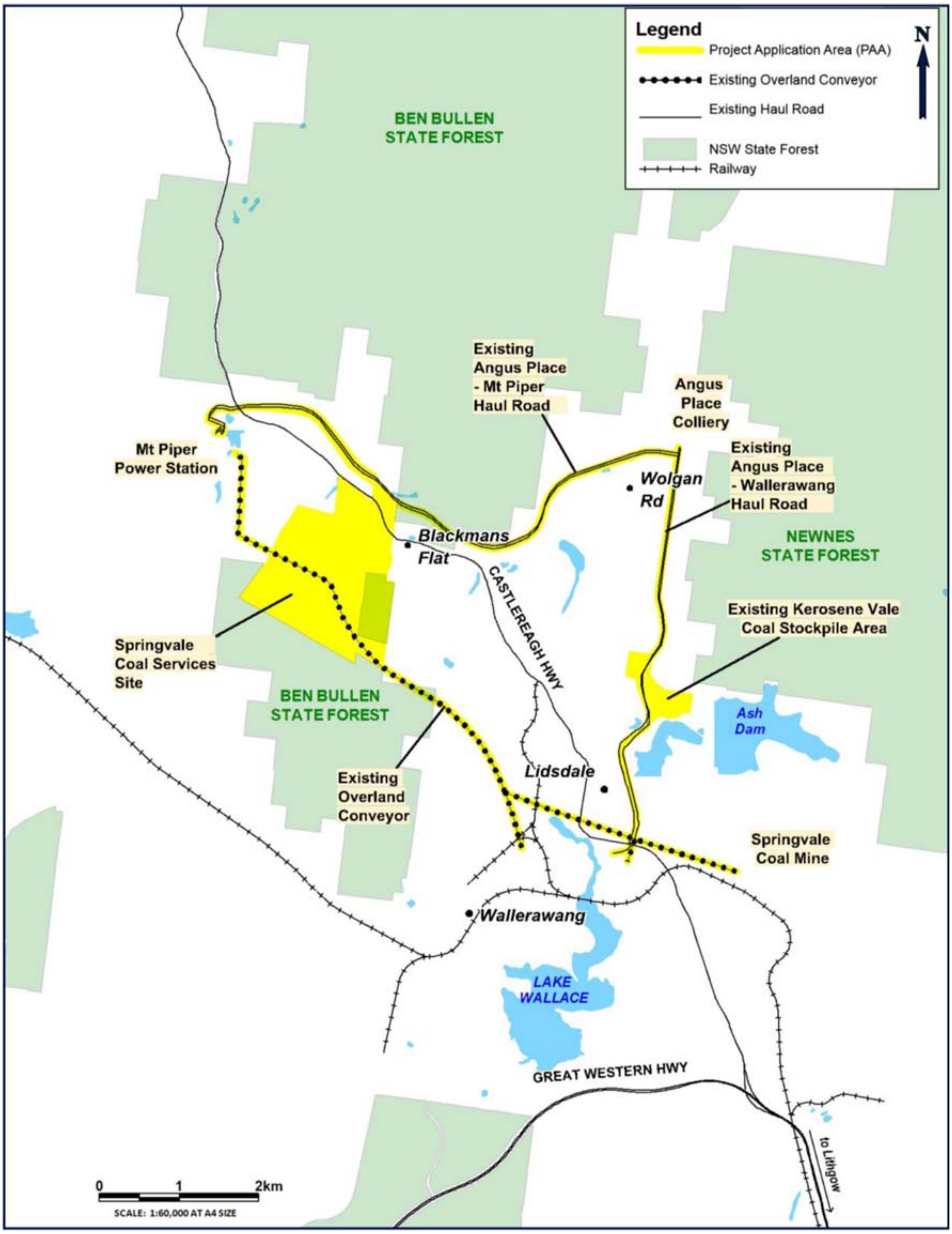

Figure 1: *Western Coal Services Project – Development Area*

APPENDIX 3
DEVELOPMENT LAYOUT

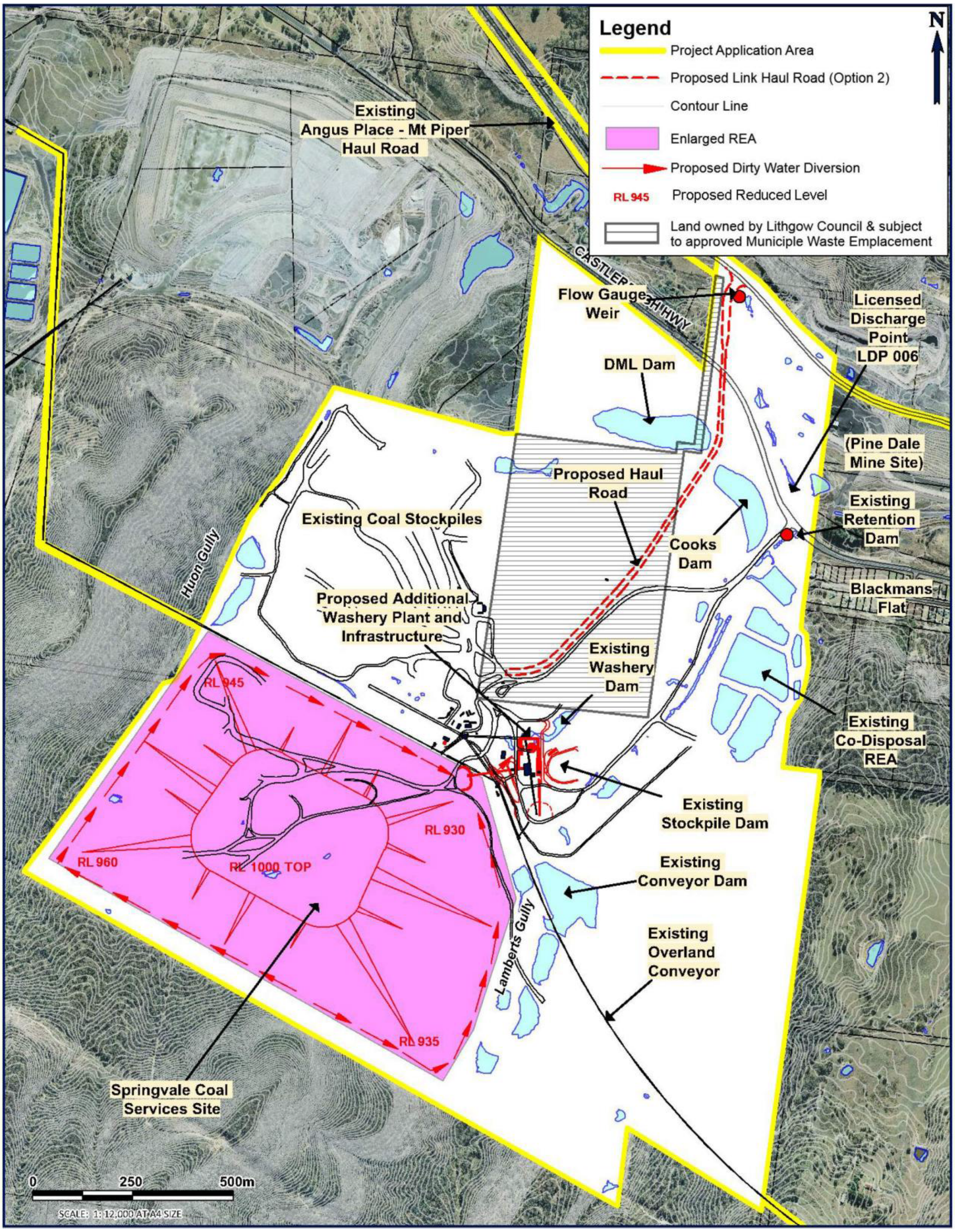

Figure 1: *General layout of proposed infrastructure on the SCSS*

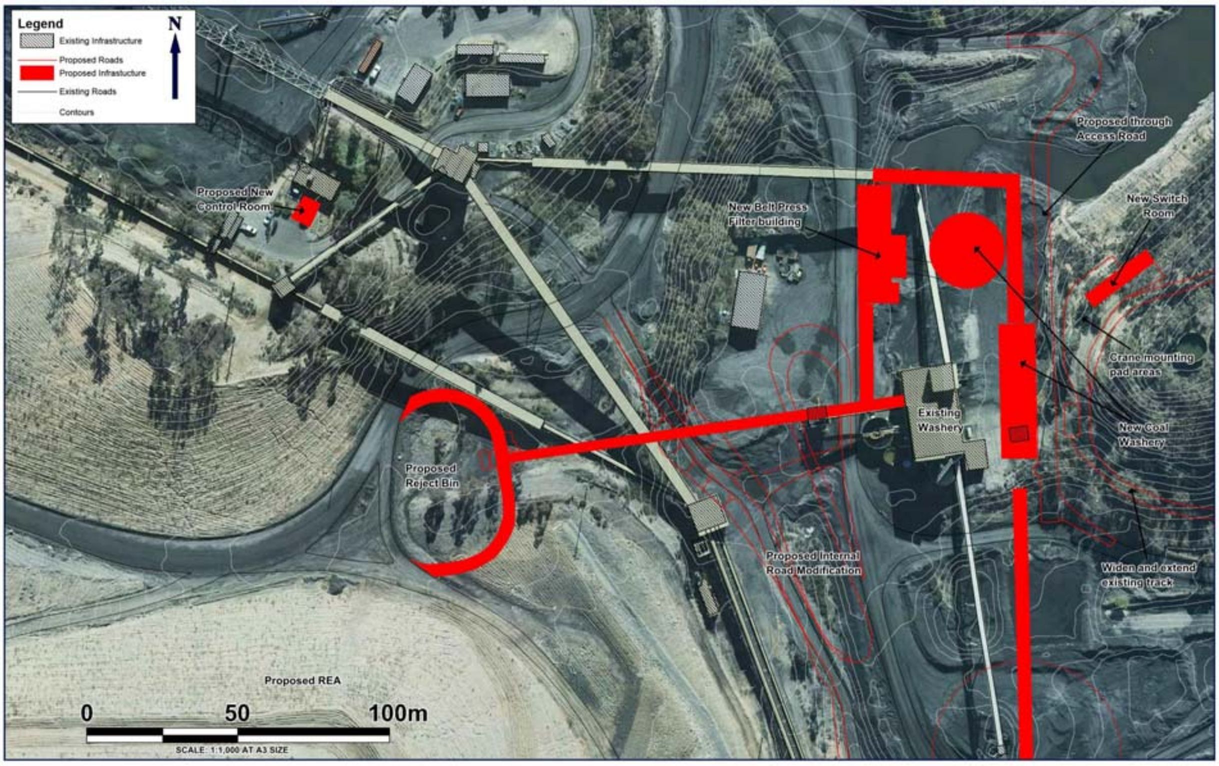

Figure 2: *General layout of proposed upgrade to the CHPP on the SCSS*

APPENDIX 4
RECEIVER LOCATIONS

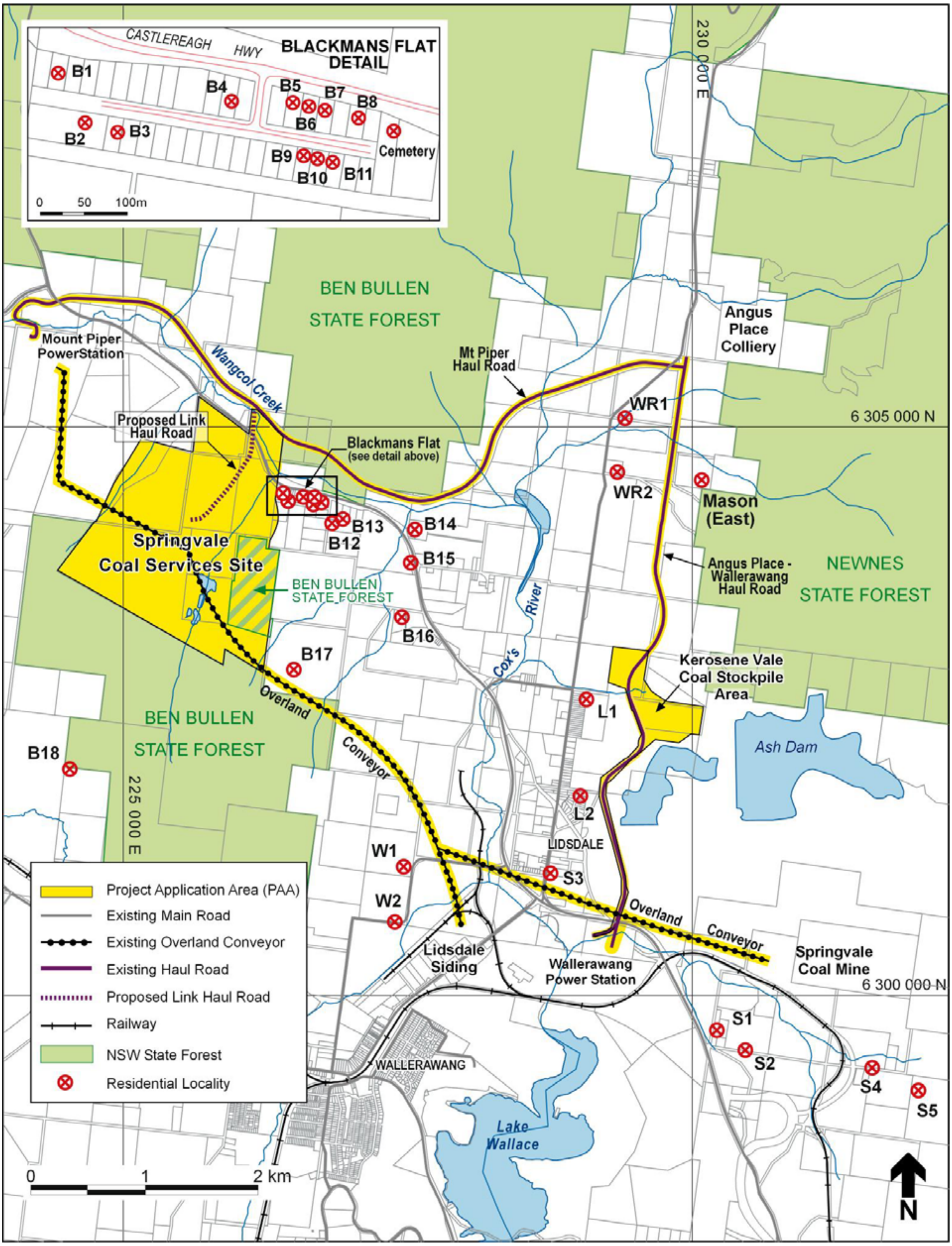

***Figure 1**: Residential locations used for noise and air quality predictions*

APPENDIX 5
NOISE COMPLIANCE ASSESSMENT

Applicable Meteorological Conditions

1. The noise criteria in Table 3 in Schedule 3 are to apply under all meteorological conditions except the following:
   (a) average wind speed at microphone height exceeds 5 m/s;
   (b) wind speeds greater than 3 m/s measured at 10 m above ground level; or
   (c) temperature inversion conditions greater than 3°C/100 m.

Determination of Meteorological Conditions

2. Except for wind speed at microphone height, the data to be used for determining meteorological conditions shall be that recorded by the meteorological station required under condition 18 of Schedule 3.

Compliance Monitoring

3. Attended monitoring is to be used to evaluate compliance with the relevant conditions of this consent.

4. This monitoring must be carried out at least 12 times in each calendar year (ie at least once in every calendar month), unless the Director-General directs otherwise.

5. Unless the Director-General agrees otherwise, this monitoring is to be carried out in accordance with the relevant requirements for reviewing performance set out in the *NSW Industrial Noise Policy* (as amended from time to time), in particular the requirements relating to:
   (a) monitoring locations for the collection of representative noise data;
   (b) meteorological conditions during which collection of noise data is not appropriate;
   (c) equipment used to collect noise data, and conformity with Australian Standards relevant to such equipment; and
   (d) modifications to noise data collected, including for the exclusion of extraneous noise and/or penalties for modifying factors apart from adjustments for duration.

APPENDIX 6
ABORIGINAL CULTURAL HERITAGE SITES

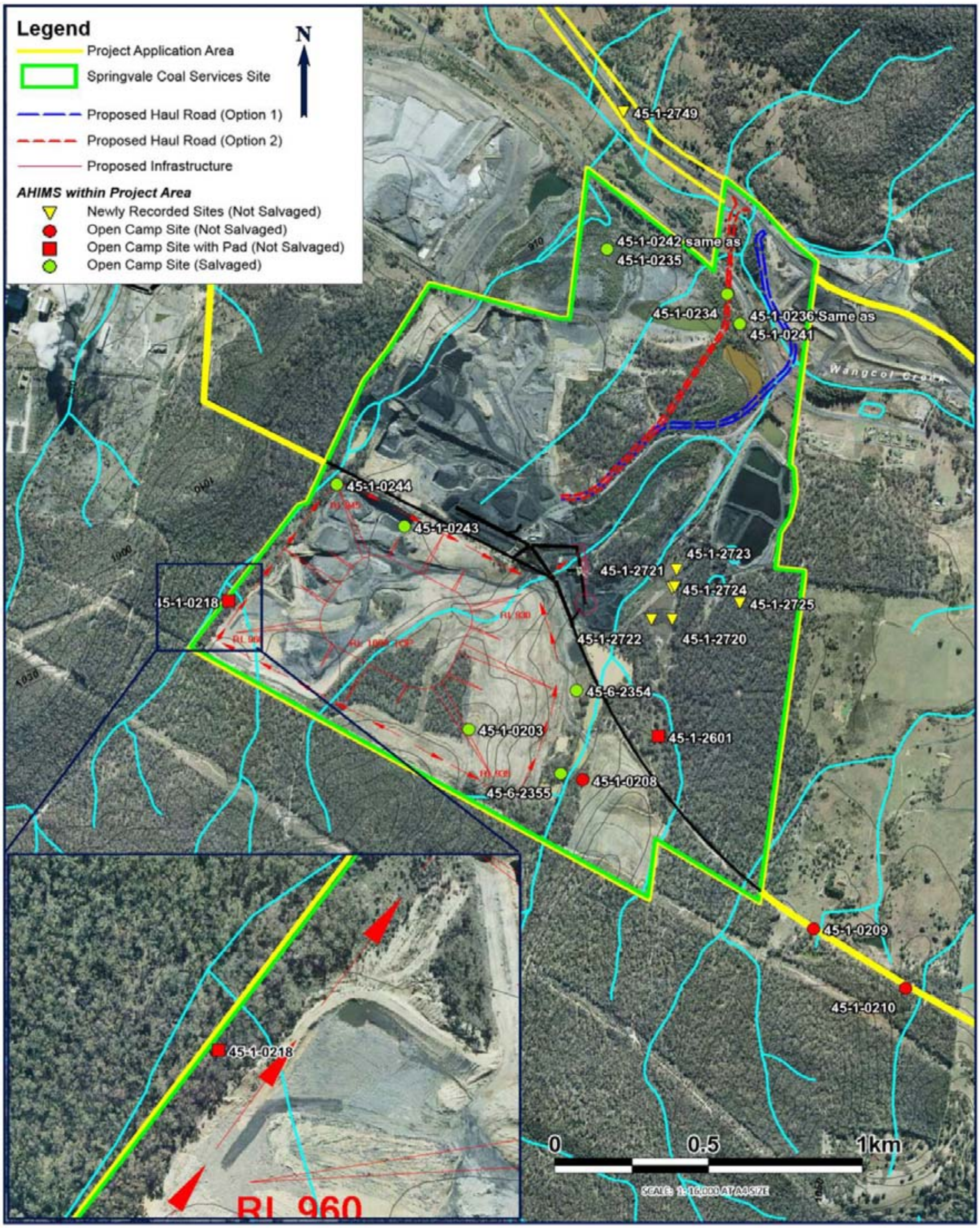

Figure 1: *Location of Aboriginal cultural heritage sites*

APPENDIX 7
ADDITIONAL REHABILITATION INITIATIVES

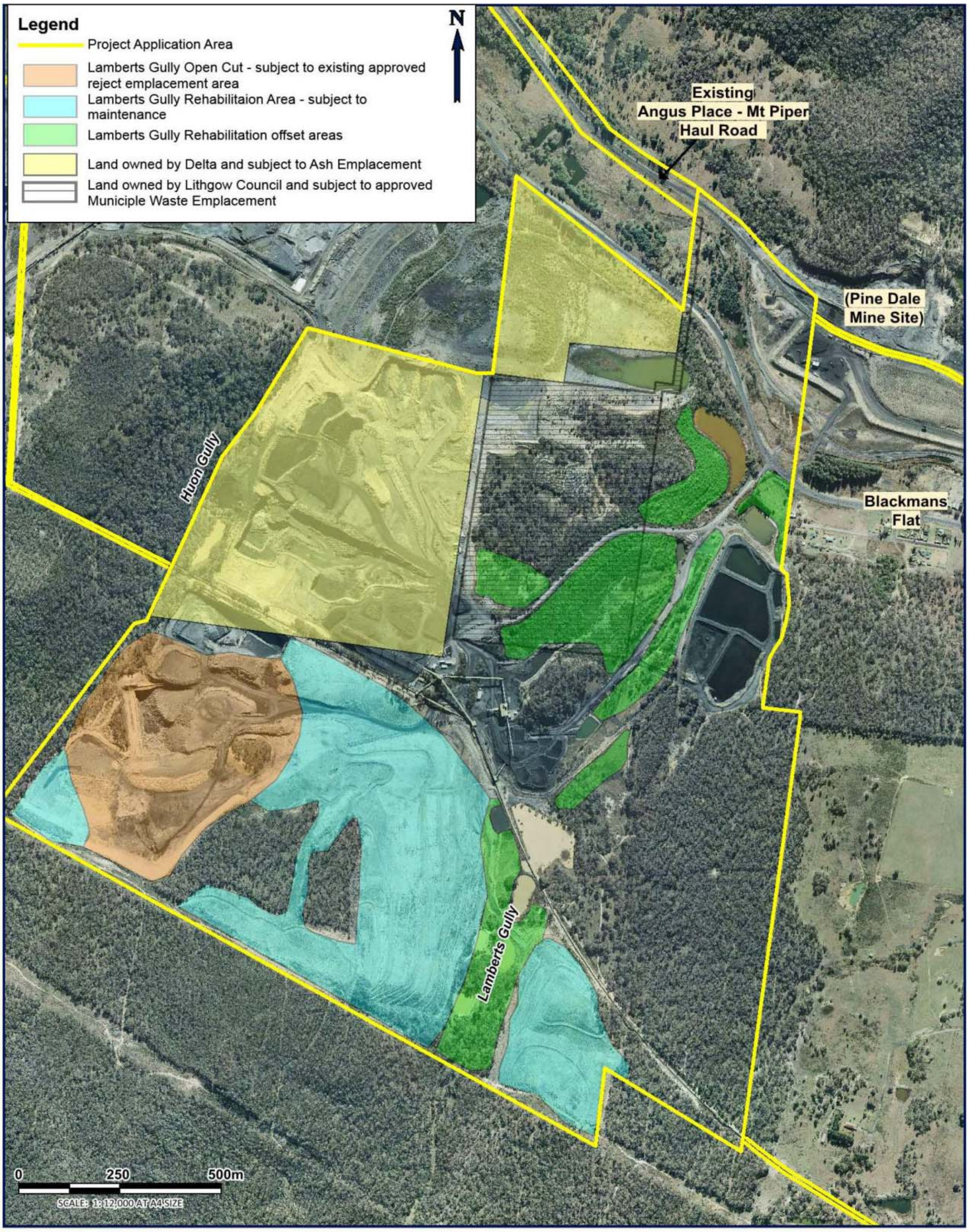

Figure 1: *Location of Additional Rehabilitation Initiatives at SCSS (in green)*

APPENDIX 8
STATEMENT OF COMMITMENTS

EIS Table 66 - Project Development Phase – Statement of Commitments

Desired Outcome	Action
Development Phase	
All construction operations are appropriately undertaken to minimise potential impacts to the environment.	1.1 Appropriate erosion and sediment control measures will be implemented for construction of the upgrading of the Washery and associated infrastructure (additional conveyors and transfer points on the Springvale Coal Services Site, refer to Figure 8 of the EIS), extension and enlargement of the existing REA, and construction of the Link Haul Road and overpass of the Castlereagh Highway and will be installed prior to commencement of disturbance activities, generally in accordance with the guidelines '*Managing Urban Stormwater – Soils and Construction, Volume 2E: Mines and Quarries' (DECC 2008).* **1.2** A Works Authorisation Deed with RMS will be obtained for the overpass of the Castlereagh Highway prior to construction works within the highway easement. **1.3** Prior to construction a CEMP will be prepared for the Springvale Coal Services Site that will be implemented during the construction phase and will include: ❒ Noise Management Plan; ❒ Air Quality Management Plan; ❒ Site Water Management Plan; ❒ Groundwater Management Plan; ❒ Cultural Heritage Management Plan; ❒ Weed Management Plan; and ❒ Construction Traffic Management Plan.

EIS Table 67 - Project Operation - Statement of Commitments

Desired Outcome	Action
1.General	
All operations are undertaken in a manner that will minimise the environmental impacts associated with the Project.	**1.1** Operations will be undertaken generally in accordance with the description provided in this EIS dated April 2013.
2. Hours of Operation	
All operations are undertaken within the approved operating hours.	**2.1** Operations may be undertaken 24 hours a day 7 days a week.
3. Noise and Vibration	
All noise impacts are minimised to the greatest extent possible.	**3.1** Removal of the northern two thirds of the existing Co-Disposal REA at the Springvale Coal Services Site within five years of Project Approval. **3.2** The construction of the Link Haul Road in the location as depicted in Figure 1 of the EIS. **3.3** Material haulage will be managed to maintain compliance with the approved noise criteria on the private Haul Roads. **3.4** Reduction of truck movements along Mt Piper Haul Road during prevailing noise enhancing weather conditions in order to meet the nominated Project Specific Noise Criteria. The default level will be zero trucking during these conditions until such time as noise monitoring confirms the truck movements required to meet the Project Specific Noise Criteria during these conditions. **3.5** Within 6 months of the date of the Project Approval, A Noise Management Plan will be prepared for the entire PAA. The plan will be prepared in consultation with the EPA. The Noise Management Plan will include the existing monitoring and mitigation strategies contained in the current approved Angus Place Noise Monitoring program, specifically,

Desired Outcome	Action
	quarterly inspections of road surfaces, quarterly attended and unattended monitoring to assess compliance and additional noise monitoring in response to noise complaints. The Noise Management Plan will include a protocol for determining the prevailing noise enhancing weather conditions which would trigger reduced transport on the Mt Piper Haul Road. **3.6** The following dust mitigation measures will be implemented and will be completed prior to operating the new infrastructure: ❒ Enclosure of the existing and proposed Washery; ❒ Enclosure of conveyor transfer points; ❒ Loading of coal rejects from an enclosed bin; ❒ Majority of coal reclaimed from stockpiles via underground reclaim tunnel; ❒ Three quarter enclosed conveyors; and ❒ New Link Haul Road will be fully sealed. **3.7** Location of infrastructure as per Figure 8 of the EIS.
4. Air Quality	
All air quality impacts are minimised to the greatest extent possible.	**4.1** The following dust mitigation measures will be implemented and will be completed prior to operating the new infrastructure: ❒ Enclosure of the existing and proposed Washery; ❒ Enclosure of conveyor transfer points; ❒ Loading of coal rejects from an enclosed bin; ❒ Majority of coal reclaimed from stockpiles via underground reclaim tunnel; ❒ Three quarter enclosed conveyors; ❒ Stockpile water sprays which are wind activated; ❒ New Link Haul Road will be fully sealed; ❒ Regular use of water carts on unsealed roads trafficked by heavy vehicles. This will include the surface of the proposed REA; and ❒ Installation of a TEOM continuous atmospheric dust monitoring unit within the Blackmans Flat residential area. **4.2** Within 6 months of the date of the Project Approval, an updated Air Quality Management Plan will be prepared for the entire PAA. The plan will be prepared in consultation with the EPA.
5. Surface Water, Groundwater, Geomorphology and Aquatic	
All surface water groundwater and aquatic impacts are minimised to the greatest extent possible.	**5.1** Within 6 months of Project Approval a single Water Management Plan will be prepared for the entire PAA and will include operation of the new infrastructure, water recycling system, surface and groundwater monitoring including Wangcol Creek mixing zone and a staged implementation of the separation of the Lamberts Gully drainage line as it passes through the Springvale Coal Services Site as well as the localised changes associated with approved Mt Piper Power Station Ash Emplacement Project. **5.2** Within 6 months of the date of the Project Approval apply for any necessary water licenses covering the Springvale Coal Services Site. **5.3** Within 5 years of the date of the Project Approval, complete the separation of clean and dirty water at the Springvale Coal Services Site. The design will include the diversion of upstream catchments of Huon Gully around the new REA. The sub-catchment containing the existing A Pit REA (previously the Lambert Gully upstream of the Springvale Coal Services Site Open Cut) as well as the new REA will be diverted into the New Sediment Dam. This sub-catchment currently discharges to Huon Gully without treatment and the staged bypass and therefore the proposed change will lead to improved water quality in Huon Gully. Following remediation of the new REA, this sub-catchment of Huon Gully

Desired Outcome	Action
	will be restored. **5.4** Construct a staged bypass of the Conveyor Dam and Retention Pond on the Springvale Coal Services Site within 3 years of the date of the consent. **5.5** Construct a pollution control pond control runoff from the new REA. This structure will have a capacity of approximately 15 ML and will be located on the north-eastern corner of the REA. The dam will have a pipe connection to the existing Washery Dam, which is connected to Cooks Dam via a pipeline. This will enable treated stormwater from the new REA to be recycled back to the Washery via Cooks Dam. This dam is to be constructed once the current A Pit REA is completed but prior to the base of the new REA being completed. **5.6** Provision of a belt press filter system (or equivalent) to recover water from the tailings produced from the new Washery. This water recovery system will cover tailings produced from the existing Washery but will be installed as part of the construction of the new Washery. **5.7** Apply for a separate EPL covering the entire PAA that includes LDP 003 (Kerosene Vale Stockpile Area) and LDP 006 and LDP 007 (conveyor at Duncan Street, Lidsdale). **5.8** Within 3 months of completion of the clean and dirty water separation system consent apply to relocate the current LDP006 to the spillway of Cooks Dam and replace the existing LDP006 with a license monitoring point. **5.9** Within 6 months of completion of the Link Haul Road, complete the additional riparian planting for a 100 m section of Wangcol Creek downstream of the Link Haul Road crossing. The species selection and density is to be determined in consultation with the SCA and NOW. **5.10** Within 12 months of Project Approval, site specific trigger values based on ANZECC 2000 Guidelines will be developed for Wangcol Creek. **5.11** To better understand the groundwater linkages, within 12 months of Project Approval, a baseline groundwater monitoring program will be established for the Springvale Coal Services Site. The baseline groundwater monitoring program will include: ❒ Quarterly monitoring of water levels from a network of monitoring bores following the completion of construction; ❒ Six monthly sampling of monitoring bores for field analysis of pH, EC and temperature and laboratory analysis on major ions, pH, EC, TDS, dissolved arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel and zinc; and ❒ An annual review so that its capacity as an accurate predictive tool can be assessed and maintained.
6. Visual	
All visual impacts are minimised to the greatest extent possible.	**6.1** Prior to its completion, the battered slopes of the Link Haul Road overpass bridge will be planted with low maintenance hardy groundcover flowering species. **6.2** Staged rehabilitation of the REA will be in accordance with the timeframes provided within the EIS.
7. Aboriginal Heritage Management	
Ensure that identified and unidentified Aboriginal Sites are appropriately managed.	**7.1** Within six months of Project Approval, a CHMP will be prepared as part of the ongoing management of the Springvale Coal Services Site. The CHMP which will be developed in consultation with the Aboriginal Stakeholders.
8. Traffic Management	

Desired Outcome	Action
Project-related impacts on the road network are limited.	**8.1** The Link Haul Road will be constructed in accordance with AUSROADS Guidelines in consultation with RMS. **8.2** All construction sites associated with the infrastructure upgrade prepare and implement a Construction Traffic Management Plan. **8.3** Upgrade Springvale Coal Services intersection line-marking to RMS standards.
9. Contamination	
Potential contamination impacts are minimised to the greatest extent possible.	**9.1** A Phase 2 Assessment of the entire Springvale Coal Services Site will be conducted before February 2015, in accordance with Springvale Coal's stated commitments to the NSW EPA (letter dated 2 February 2012).
10. Rehabilitation	
Rehabilitation of the Springvale Coal Services Site is conducted in accordance with Industry Standards.	**10.1** Within six months of Project Approval a single Rehabilitation Plan will be prepared for the entire PAA in consultation with DRE and DPI and will include the timeframes provided within this EIS, details of the rehabilitation methods, monitoring and reporting framework. Results arising from the implementation of the program will be reported each year in the Annual Review (currently referred to as the AEMR). **10.2** The rehabilitation program will include previous commitments from the Lamberts Gully Project Approval (06-0017) including *Eucalyptus cannonii*.

Correspondence from the Department of Planning and Environment

APPENDIX – B

Planning Services
Resource Assessments

Contact: Paul Freeman
Phone: (02) 9274 6587
Email: paul.freeman@planning.nsw.gov.au

Mr James Wearne
Group Approvals Manager
Centennial Coal Limited
PO Box 1000
Toronto NSW 2283

Ref: SSD-5579

Dear Mr Wearne

Springvale Coal Services Project – SSD-5579 Proposed Modifications

I refer to your letters, dated 21st September 2016, requesting the Department's advice on the approval pathway for proposed modifications to the Springvale Coal Services Project.

The Department has carefully reviewed the information you provided and can confirm that Section 96(2) of the *Environmental Planning and Assessment Act 1979* is the applicable approval pathway for both proposed modifications.

The Department considers that the proposed assessment approaches detailed in your letters are reasonable.

However, the Department considers that the Modification 1 application should assess any changes to the rehabilitation strategy for the project, in addition to assessing the water impacts of the modification. The Modification 2 application should also consider traffic impacts.

You should ensure the level of environmental assessment is commensurate with the scale of the proposed modifications and the likely environmental impacts.

I would appreciate it if you could contact the Department at least 2 weeks before you intend to lodge the modification applications, to:

- confirm the applicable fees (in accordance with clause 245K of the *Environmental Planning and Assessment Regulation 2000*); and
- determine the public consultation process.

If you wish to discuss the matter further, please contact Paul Freeman on (02) 9274 6587.

Yours sincerely

Cpreshaw

11/10/16

Clay Preshaw
A/Director
Resource Assessments
(as nominee of the Secretary)

APPENDIX – C

Schedule of Lands

Schedule of Lands – Western Coal Services Project (SSD 5579)

Centennial Fassifern Pty Ltd	
Lots 2 and 4 DP 260621	Lot 51 DP 751 651
Lot 1 DP 386554	Lots 20, 24 and 44 DP 827626
Lot 3 DP 542432	Lot 20 DP 877752
Lots 32, 41, 57 and 351 DP 751636	Lots 1 and 4 DP 1139982
Centennial Springvale Pty Ltd and Springvale Kores Pty Ltd	
Lot 1 DP 88503	Lot 501 DP 825541
Lots 1 and 2 DP 126483	Lot 2 DP 835651
Lot 13 and 357 DP 751651	
Coal Link>Pty Ltd	
Lot 1 DP 825887	
Council of the City of Lithgow	
Lot 42 DP 751636	Lot 1 DP 1127043
Lot 1 DP 1049809	
Delta Electricity	
Lot 191 DP 629212	Lot 101 DP 829410
Lots 1 and 2 DP 702619	Lot 16 DP 855844
Lot 67 DP 751636	Lot 2 DP 1018958
Lot 1 DP 803655	Lots 1 and 5 DP 1087684
Lots 9 and 15 DP 804929	Lot 228 DP 1131953
Lot 1 DP 825124	Lots 10 and 11 DP 1139978
Lots 40, 47, 49, 51 and 52 DP 827626	Lots 2 and 3 DP 1139982
Lots 3 and 5 DP 829137	Lot 103 DP 1164619
Enhance Place Pty Ltd	
Lots 32, 35, 36, 37, 38 and 39 DP 827626	Lot 29 DP 1096381
Lot 10 DP 877753	
State of NSW / Ben Bullen State Forest	
Lot 70 DP 751636	Lot 7005 DP 1026541
Lot 502 DP 822541	
Ivanhoe Coal Pty Ltd	
Lot 2 DP 567915	Lot 101 DP 1137972
Lots 16, 174, 375 and 385 DP 751651	
Private Owner (Janette Winifred Hunt)	
Lot 371 DP 751651	
Lidsdale Holdings Pty Ltd	
Lot 28 DP 827626	
State Rail Authority	
Lots 1 and 8 DP 252472	

APPENDIX – D

Water Resources Impact Assessment

Springvale Coal Pty Ltd

Western Coal Services Project Modification 1

Water Resources Impact Assessment

November 2016

Executive summary

Western Coal Services Project (WCS) is seeking consent for the modification of its existing development consent (SSD-5579) for changes in operation at the Springvale Coal Services Site (SCSS). As part of the proposed Springvale Water Treatment Plant Project, which will be developed in partnership between Springvale Coal Pty Ltd and EnergyAustralia NSW Pty Ltd, the residual stream from the water treatment plant (WTP) will be transferred to the Reject Emplacement Area (REA) at the SCSS.

A Water Resources Impact assessment has been developed to determine the potential impact of the transfer of residual to the REA on surface water and groundwater environments. The assessment investigated the environment specific to the Wangcol Creek catchment, for which baseline conditions were determined from the available monitoring data, and predictive models were developed in order to understand the consequences of the transfer of WTP residual to the REA.

Existing and future conditions

The characterisation of surface water upstream of the SCSS, on site and at the LDP006 discharge, and downstream of the SCSS was undertaken to determine baseline conditions. Baseline conditions were also determined for the groundwater at the SCSS. The study indicated that surface water upstream of the site shows impacts from historical landuse, including elevated nutrient and aluminium and zinc concentrations.

Baseline conditions for surface water and groundwater at the SCSS are indicative of the high level of interfacing with historical mine workings and the SCSS water management system, which uses water from the surface storages for coal washing and dust suppression. The effects of these management practices on water quality are evidenced by moderate to high salinities and elevated concentrations of the metals boron, iron, manganese, nickel and zinc. Similar existing conditions were also characterised for LDP006 and the downstream monitoring locations in Wangcol Creek.

Future conditions for surface water at the SCSS are likely to be improved through the implementation of clean water diversion works that will reduce catchment contributing to LDP006. These works will also include the diversion of catchment into the clean water system from Huon Gully via a pump system to be implemented within the Huon Gully Dam (storage referred to as SHG1). These works are likely to reduce some opportunities for surface water to recharge the groundwater environment.

Water and salt balance modelling indicated that, under the existing conditions, the average annual discharge from LDP006 was 848 ML. This discharge accounts for approximately 831 ML of surface water that has migrated into the groundwater system via historical workings. Discharges via LDP006 contribute approximately 1517 tonnes of salt to Wangcol Creek per year.

As part of future conditions the water and salt balance modelling indicated that the average annual discharge from LDP006 reduced from existing conditions to 441.2 ML (approximately 48% reduction in flow volume). Salt load also reduced due to the diversion of clean water away from LDP006 with a reduction from existing conditions down to 1107 tonnes per year (approximately 27% reduction in salt load via the LDP).

Proposed conditions

The predicted quality of the residual to be transferred to the REA was established through the study of results from jar testing performed by Hunter Water and a case study of the residual stream from the Newstan Colliery WTP. These studies predicted that the majority of the metals in the proposed residual are likely to co-precipitate with the ferric hydroxide that precipitates as a result of dosing with ferric chloride. Considering this, and the existing groundwater conditions at the SCSS, increased groundwater metals concentrations are not predicted as a result of the transfer of WTP residuals to the REA.

Preliminary mass balance modelling using the predicted residual water quality and the historical water quality of the LDP006 discharge indicated that metal concentrations in the discharge to Wangcol Creek are unlikely to increase as a result of the Project. Some water quality parameters however were identified to have a greater risk of increasing in concentration as a result of the Project, these included aluminium, boron, nickel and manganese. This outcome was based on the findings from the Newstan WTP case study. For aluminium it was concluded that any actual increase in discharged concentrations would not result in the introduction of a new toxicant to Wangcol Creek, as aluminium concentrations in the creek upstream of the SCSS have historically been higher than that of LDP006. The concentrations of boron, nickel and manganese indicated no change in concentration within the residuals monitored from the Newstan Colliery WTP case study. Given that these concentrations are elevated already within discharges from site, and it is likely that due to the fact that concentrations within the mine water feed into the WTP are lower, some dilution may occur from the resultant residual stream on the elevated concentrations present within the surface and groundwater environment at SCSS. The diversion of clean water volume from LDP006 is likely to result in some concentration of water quality being observed at LDP006 in the future, however it is likely to be more representative of Cooks Dam historical median.

Water and salt balance modelling of the proposed conditions predicted that the annual input of 157 ML of WTP residual to the system would result in an average annual discharge from LDP006 of 570 ML, which is an increase from the modelled future conditions . The proposed conditions also predicted an average annual salt output from the SCSS through LDP006 as 1444 tonnes per year which was also accompanied by an increase in average electrical conductivity being discharged to the receiving environment as a result of the Project. Increased electrical conductivity was primarily due to increased flow volume load on Cooks Dam with the dam at capacity most days. In addition to this, the electrical conductivity within the dam is elevated and is dominate over the lower residual stream electrical conductivity. The increased conductivity in proposed conditions does not provide any local benefit but rather maintains the current conditions of the receiving environment negating any benefit from the works undertaken in the future conditions. To further assess the effect of these increases the local assessment was extended to a regional scale to determine the extent of this change.

The regional water and salt balance prepared for the Springvale WTP was utilised to consider the influence of the Project on a regional scale where this considered the Coxs River catchment down to Lake Burragorang. Modelling predictions indicated that a flow and volume increases are likely to extend for the length of Wangcol Creek and further downstream to Lake Wallace. Changes in flow volume between future and proposed conditions downstream of SCSS are likely to be in the order a 5% increase whereas electrical conductivity is predicted to be an increase in order of 16%.

At Lake Wallace the effects of the Project are significantly reduced as a result of catchment influences and the cessation of LDP009 discharges to be implemented as part of the Springvale WTP. Regional model predictions between future and proposed conditions indicate a reduction in flow at Lake Wallace of 2% and a reduction in electrical conductivity of 20%.

It should be noted that these predictions are more contributable to the influence of ceasing LDP009 discharges than the influence of the Project's discharges. A reduction in flow (reduction of 1%) and electrical conductivity (reduction of 6%) was predicted at Lake Burragorang as a result of regional modelling.

The local and regional water and salt balances concluded that whilst there was a predicted increase in EC locally within Wangcol Creek as a result of the Project, the transfer of the residuals to the REA is required to facilitate the Springvale WTP. As observed in the results including and below Lake Wallace, the benefits of the Springvale WTP, for which this Project supports, provide a regional benefit to the water quality downstream to Lake Burragorang.

As the regional water balance modelling predicted only a minor increase in flows at the confluence of Wangcol Creek and the discharge from SCSS in the average future, there is no predicted change to the geomorphological stream health as a result of the Project, as the channel of Wangcol Creek has been shown to be relatively stable.

No impact on the existing instream habitat and macroinvertebrate diversity of Wangcol Creek has been predicted, as previous studies of the aquatic ecology of Wangcol Creek have identified that the site located within the mixing zone of the LDP006 discharge had the most degraded habitat and the lowest level of macroinvertebrate diversity of the four Wangcol Creek aquatic ecology monitoring sites. Any dilution of the elevated toxicant concentrations present within the surface and groundwater environment at SCSS may result in the reduced toxicity of the discharge.

Within the zone of predicted increase in electrical conductivity, it was determined that one surface water user exists. The surface water user utilises Coxs River water for the purposes of irrigation. Based on the predicted electrical conductivity between the confluence between Wangcol Creek and Coxs River and Lake Wallace, and the results between the various scenarios, the usage category of the water for this user is unlikely to be effected by the Project. This is further supported by the user's location on the Coxs River below the point at which LDP009 discharges (to be ceased as part of the Springvale WTP) contributes to the Coxs River (via Sawyers Swamp). This is likely to result in the user having an improved water quality within the Coxs River but some potential reduction in flow volume.

A new Environment Protection Licence (EPL) is to be developed to cover the Western Coal Services Operation and specifically Springvale Coal Services. Currently the operations are included within Springvale Mine's EPL 3607. The process of developing the new EPL will be undertaken in consultation with EPA. No surface water or groundwater access licences will be required for the Project.

As part of Springvale WTP, a commissioning phase will undertake specific monitoring of the plants performance which will be compared against predictions. The assessment of flow and quality of the residual stream is to be reviewed as part of this Project and the Springvale WTP following the commissioning of the plant.

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Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate ($CaCO_3$).
Alluvial	Deposition from running waters.
Ambient	Pertaining to the surrounding environment or prevailing conditions.
Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Australian Height Datum	A common national surface level datum approximately corresponding to sea level
Average recurrence interval	A statistical estimate of the average period in years between the occurrence of a flood of a given size or larger, e.g. floods with a discharge equivalent to the 1 in 100 year average recurrence interval flood event will occur on average once every 100 years.
Baseflow	The component of flow in a watercourse that is driven from the discharge of underground water.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or water quality) prior to the commencement of a specific activity.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular location.
Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings. Water removed from mine workings is regarded as dewatering unless the workings are flooded and at equilibrium with the surrounding strata (in which case the removal is considered groundwater extraction).
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

Floodplain	Area of land that is periodically inundated by floods up to the probable maximum flood event.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Goaf	The part of a mine from which the mineral has been partially or wholly removed, including the waste left in workings.
Groundwater	Water occurring naturally below ground level.
Groundwater extraction	For the purposes of this assessment, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline	A numerical concentration or narrative statement that provides appropriate guidance for a designated water use or impact.
Hardness	The concentration of multivalent cations present in water. Generally, hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate ($CaCO_3$) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Ion	Electrically charged atom.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site Environmental Protection License.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Newstan Colliery	Newstan Colliery is an existing underground coal mine owned and operated since 2002 by Centennial Newstan Pty Limited. Newstan Colliery operates a conventional water treatment plant which used clarification and filtration process technologies to treat mine dewatering volumes suitable for environmental discharge.
PHREEQC	PHREEQC is a modelling package developed by the USGS (United States Geological Survey) for simulating chemical reactions in industrial processes.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.

Potable water	Water of a quality suitable for drinking.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Toxicity	The inherent potential or capacity of a substance to cause adverse effects in a living organism.
Tributary	A stream or river that flows into a main river or lake.
Trigger value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a risk of impact if exceeded and should ‘trigger’ action to conduct further investigations or to implement management or remedial processes.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

ADWG	Australian drinking water guideline
AHD	Australian height datum
ARI	Annual recurrence interval
ARR	Australian Rainfall and Runoff
AWBM	Australian Water Balance Model
BOM	Bureau of Meteorology
Centennial Angus Place	Centennial Angus Place Pty Ltd
Centennial Coal	Centennial Coal Pty Limited
Centennial Springvale	Centennial Springvale Pty Limited
CRD	Cumulative rainfall departure
DGV	Default guideline value
DOC	Dissolved organic carbon
DPE	Department of Planning and Environment
DPI-Water	Department of Primary Industries – Office of Water
DTA	Direct toxicity assessment
EC	Electrical conductivity
EC_{XX}	Effective concentration for XX
EIS	Environmental impact statement
EnergyAustralia	EnergyAustralia NSW Pty Ltd
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment protection licence
ESA	Ecotox Services Australasia
GDE	Groundwater dependent ecosystem
GHD	GHD Pty Ltd
GMR WSP	Greater Metropolitan Region Groundwater Sources WSP
GMRU WSP	Greater Metropolitan Region Unregulated River Water Sources WSP
ha	Hectare
km	Kilometre
km^2	Square kilometre
L/s	Litre per second
LDP	Licensed discharge point

Lidsdale Siding	Lidsdale Siding Rail Loading Facility
m	Metre
m/s	Metre per second
m^3/s	Cubic metre per second
MHRDC	Maximum harvestable right dam capacity
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
mm/hr	Millimetre per hour
MNES	Matters of national environmental significance
MPPS	Mount Piper Power Station
Mtpa	Million tonnes per annum
NATA	National Association of Testing Authorities
NOEC	No observable effect concentration
NTU	Nephelometric turbidity units
NWQMS	National Water Quality Management Strategy
OEH	Office of Environment and Heritage
POEO Act	*Protection of the Environment Operations Act 1997*
RCBC	Reinforced concrete box culvert
REA	Reject emplacement area
RMS	Roads and Maritime Services
RO	Reverse osmosis
ROM	Run of mine
SCSS	Springvale Coal Services site
SDWTS	Springvale-Delta Water Trading Scheme
SEARS	*Secretary's Environmental Assessment Requirements Application Number SSD 16_7592*
SILO	Scientific Information for Land Owners
Springvale Coal	Springvale Coal Pty Limited
Springvale SK Kores	Springvale SK Kores Pty Ltd
SSD	State Significant Development
SSGV	Site-specific guideline values
t/year	Tonnes per year
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon

TSS	Total suspended solids
WAL	Water access licence
WM Act	*Water Management Act 2000*
WRIA	Water Resources Impact Assessment
WSP	Water sharing plan
WTP	Water treatment plant
µS/cm	Microsiemens per centimetre

1. Introduction

GHD Pty Ltd (GHD) was commissioned by Springvale Coal Pty Limited (Springvale Coal) to prepare a Water Resources Impact Assessment (WRIA) for the Western Coal Services Modification 1 Project (the Project). This assessment forms part of a Statement of Environmental Effects (SEE) to support a modification application under Part 4, Division 7, Section 96(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Background

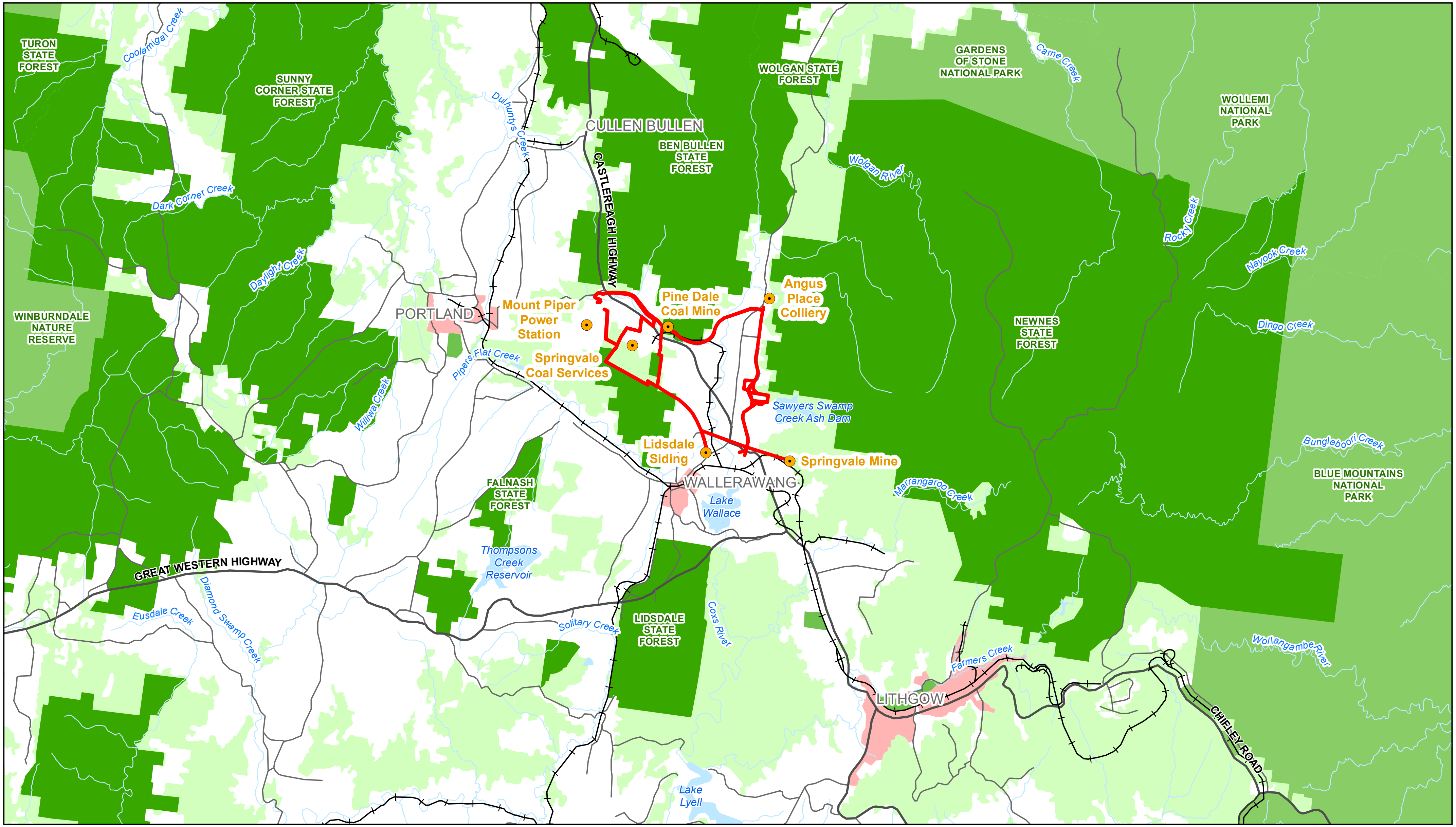
The Springvale Coal Services site (SCSS) is a coal processing facility in the Western Coalfield of NSW located approximately 18 km north of Lithgow, as shown in Figure 1-1, and is part of the Western Coal Services Project. The other components of the Western Coal Services Project include an overland conveyor system, the Kerosene Vale Stockpile Area and a system of private haul roads comprising Mount Piper Haul Road, Wallerawang Haul Road and a Link Haul Road between Mount Piper Haul Road and SCSS (Link Haul Road not yet constructed).

The SCSS currently operates under development consent SSD-5579 for the Western Coal Services Project. The site receives coal from Springvale Mine by overland conveyor and provides coal storage, handling, and processing functions. Run of mine (ROM) coal is also transported by overland conveyor under SSD-5579 directly from Springvale Mine to Mount Piper Power Station (MPPS). Beneficiated (washed) coal is transferred by overland conveyor to Lidsdale Siding for export.

1.2 Project description

Springvale Coal is currently seeking consent for the Springvale Water Treatment Project (SWTP; SSD 16_7592). The SWTP involves:

- A system to transfer up to 36 ML/day of dewatered mine water from the existing gravity tank forming part of the approved dewatering facilities on the Newnes Plateau to a new water treatment plant (WTP) to be located at the MPPS site.
- A WTP incorporating desalinisation processes to reduce the salinity in mine water to a standard suitable for either industrial reuse or environmental release.
- Transfer of treated water from the WTP to the MPPS cooling water system to contribute to the demand for make-up water.
- Discharge of any excess treated water not able to be reused within the MPPS cooling water system to Wangcol Creek via a new licensed discharge point (LDP) to be located within the SCSS.
- Transfer of residual material from the pre-treatment process to the existing REA at the SCSS.
- Transfer of the saline brine stream from the WTP to the MPPS cooling water system for integration with existing treatment and brine disposal practices.
- Installation of a crystalliser to provide further treatment of the additional salt load generated as a result of the WTP.



Paper Size A4

0 0.75 1.5 3 4.5 6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Principal Road
- Secondary Road
- Minor Road
- Existing Rail
- Waterway
- Waterbody
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub

Western Coal Services
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Water Resources Impact Assessment

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Locality Plan

Figure 1-1

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: Commonwealth of Australia (Geoscience Australia); 250K Topographic Data Series, 2006. Created by: tmorton

The Project is being undertaken to address operational interactions between the SWTP and the SCSS, in particular the need to dispose of residual material from the SWTP. Springvale Coal is seeking to modify development consent SSD-5579 for the Western Coal Services Project to allow for the transfer of residual material from the SWTP to the existing reject emplacement area (REA) at the SCSS.

An overview of the SWTP is provided in Figure 1-2 with a water management schematic provided in Figure 1-3.

1.3 Study area

The study area for the WRIA primarily encompasses the existing facilities at the SCSS and surrounding infrastructure, as shown in Figure 1-4. The WRIA also considers impacts on surface water and groundwater environments that extend beyond the study area.

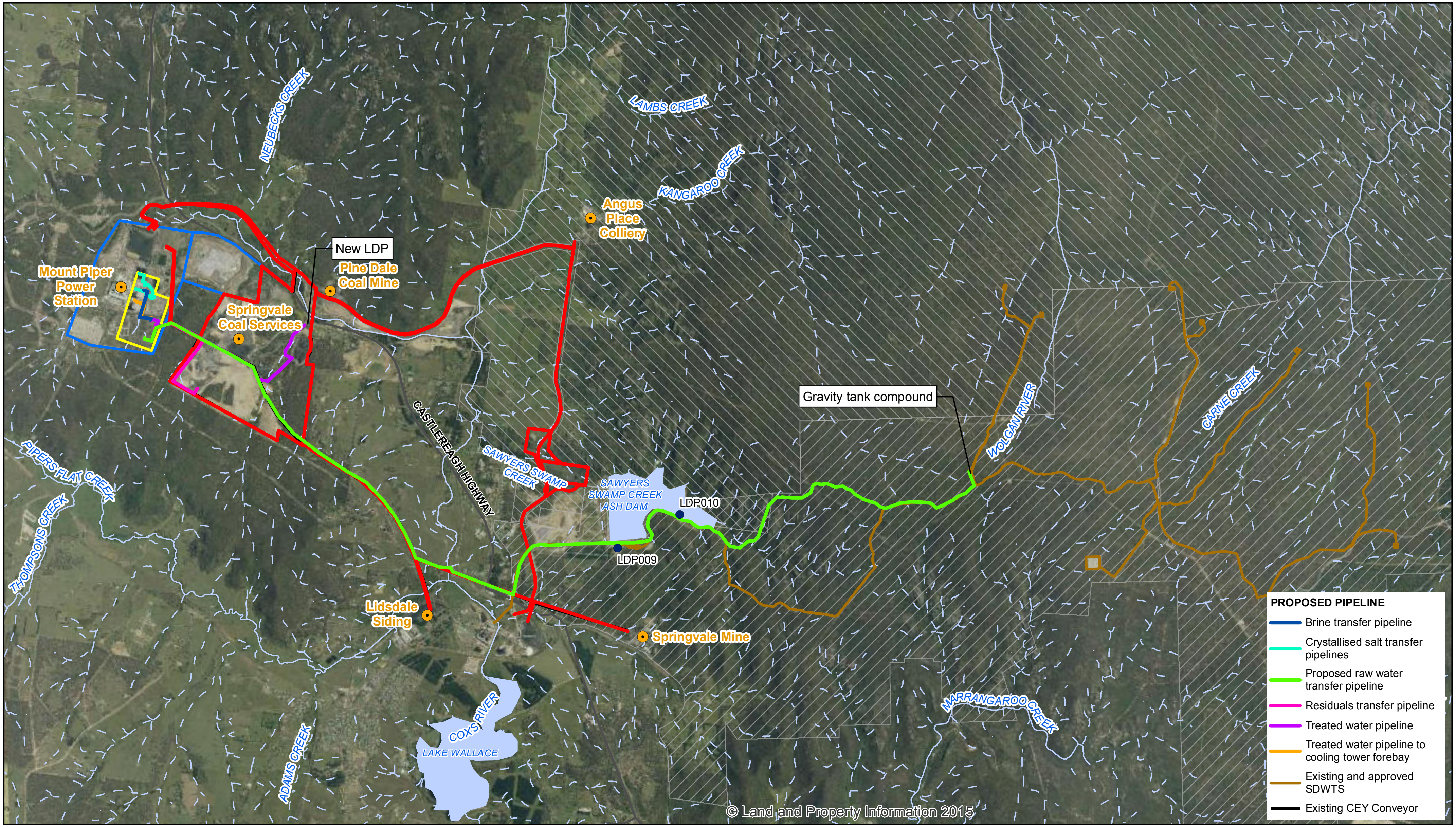
1.4 Objectives of the Water Resources Impact Assessment

The primary objective of the WRIA is to determine the potential impacts of the Project on the surface water and groundwater environments in the vicinity of the Project and the broader regional environment. This involves an assessment of surface water and groundwater in terms of hydrology, hydrogeology, geomorphology, water quality and impacts on water users.

1.5 Scope of work

The scope of work for the WRIA includes:

- Review existing assessments and data relevant to the Project.
- Review relevant statutory requirements.
- Establish the existing conditions for surface water and groundwater environments.
- Identify components of the Project with the potential to impact surface water and groundwater environments.
- Undertake an assessment of the potential impacts of the Project on:
  - Water and salt balance.
  - Surface water quality.
  - Groundwater levels and quality.
  - Waterway geomorphology.
  - Aquatic ecology.
  - Downstream water users, including licensed water users and basic landholder rights.
- Develop measures to avoid, minimise and mitigate the identified potential impacts and provide recommended management, monitoring and reporting requirements.



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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Principal Road
- Watercourse - NonPerennial
- Watercourse - Perennial
- Project application area

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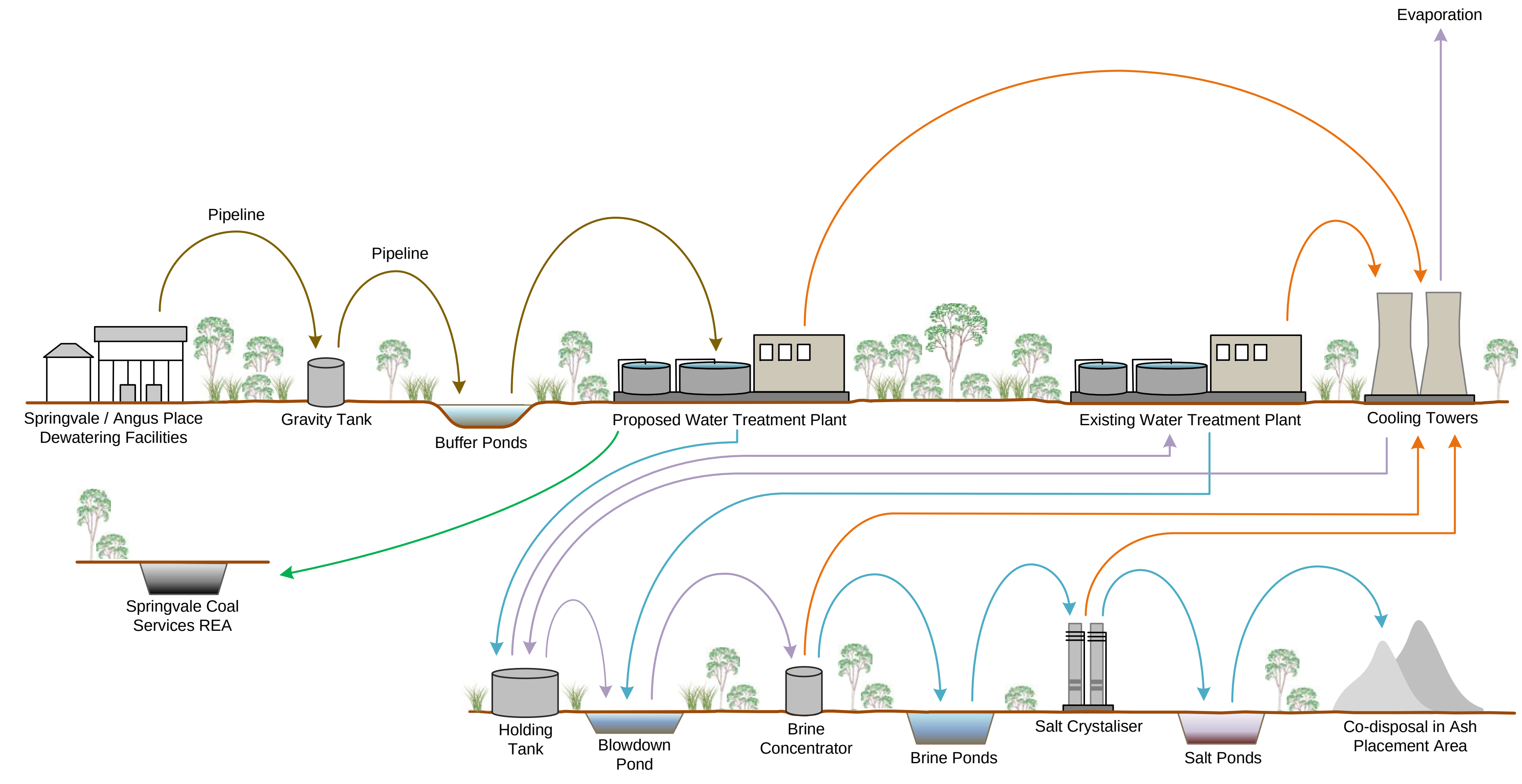
SVWTP Project

Figure 1-2

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA002_Projectoverview_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton



Mine water
Residual water
Treated water
Treatment by-product
Worked water

LOCATION	SCS
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services Project Modification 1
Water Resources Impact Assessment

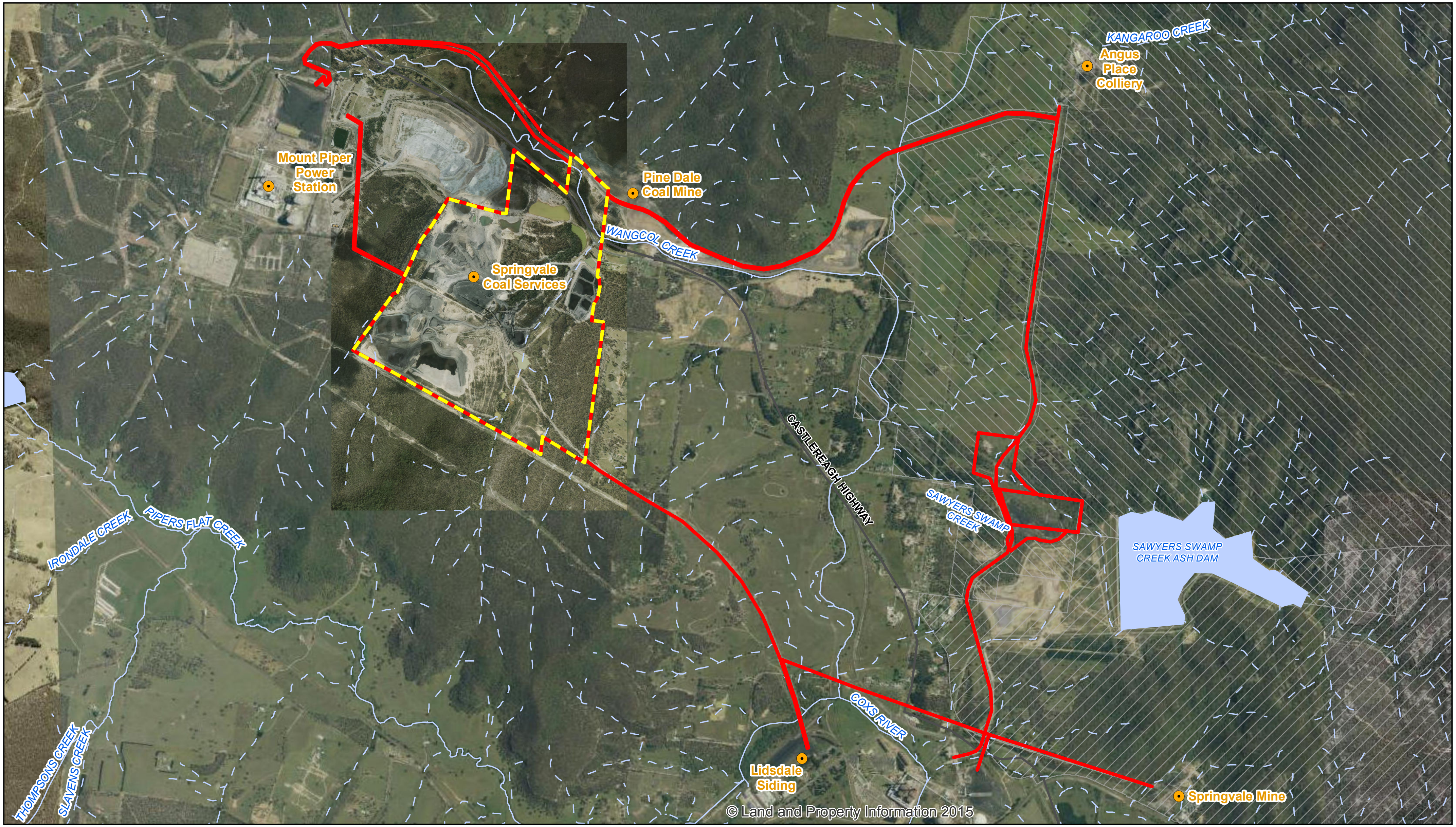
Springvale Water Treatment Project
Water management schematic

Centennial Coal

DATE Nov 2016

Figure 1-3

G:\22\18584\Tech\Visio\2218584_FIG1-2_Water Management Cross Section Schematic.vsdx



Paper Size A4

0 0.15 0.3 0.6 0.9 1.2

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Principal Road
- Waterbody
- Watercourse - NonPerennial
- Watercourse - Perennial

Western Coal Services
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Study area

Figure 1-4

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA003_Studyarea_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

2. Legislation, policies and guidelines

2.1 Legislation

2.1.1 Environmental Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of the Environment and provides a legal framework to protect and manage nationally and internationally significant flora, fauna, ecological communities and heritage places defined as 'matters of national environmental significance' (MNES). Any action that "has, will have or is likely to have a significant impact on a matter of national environmental significance" is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Environment Minister, as provided under Part 9 of the EPBC Act. Approval is also required where actions are proposed on, or will affect, Commonwealth land and its environment.

The EPBC Act identifies MNES as:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- Great Barrier Reef Marine Park.
- A water resource in relation to coal seam gas development and large coal mining development.

The EPBC Act is also relevant to the determination of the ecological value of a groundwater dependent ecosystem (GDE). If a GDE contains a threatened species as listed under the EPBC Act, the GDE is then taken to have a higher ecological value.

Potential impacts on any MNES are subject to assessments of significance pursuant to the EPBC Act *Significant Impact Guidelines 1.1* (Department of the Environment, 2013a). If a significant impact is considered likely, a referral under the EPBC Act must be submitted to the Commonwealth Environment Minister.

The *Significant Impact Guidelines 1.3* (Department of the Environment, 2013b) includes general criteria for whether an action is likely to have a significant impact on water resources, which are for the possibility for direct or indirect changes to:

- The hydrology of a water resource.
- The water quality of a water resource.

According to the *Significant Impact Guidelines 1.3* (Department of the Environment, 2013b), the value of the water resource needs to be confirmed such that impacts from actions can be evaluated on their significance. The guidelines indicate that key factors for evaluating a water resource's value include its utility for all third party users. Third party user categories specific to the Project include:

- Provisioning services (e.g. use by other industries and use as drinking water).

- Cultural services (e.g. recreation and tourism, science and education).
- Supporting services (e.g. maintenance of ecosystem function).

If evidence can be provided that proposed actions would not materially affect the availability and quality for third party users, then the likelihood of an action having a significant impact would be reduced (Department of the Environment, 2013b).

The modification of the SCSS development consent has the potential to impact on MNES with respect to water resources, through changes to hydrology and water quality of a water resource (Wangcol Creek).

As part of this report, an assessment was undertaken considering the typical Independent Expert Scientific Committee (IESC) requirements and guidelines for assessing potential impact to water resource in relation to coal seam gas development and large coal mining development.

The significant impact guideline and IESC checklist were completed and provided in Appendix C.

2.1.2 Environmental Planning and Assessment Act 1979

The EP&A Act, administered by the NSW Department of Planning and Environment, is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

The WRIA forms part of a SEE to support an application to modify SSD-5579 under Part 4, Division 7, Section 96(2) of the EP&A Act for the Project. The Minister for Planning (or delegate, such as the NSW Planning Assessment Commission) is the determining authority for the Project.

2.1.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the EPA, which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include programs to reduce pollution at the source and monitoring and reporting on environmental quality. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution.

Under the POEO Act, an environment protection licence (EPL) is required for premises at which a ‘scheduled activity’ is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purpose of the act. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity.

The Western Coal Services Project is a premises-based ‘scheduled activity’ and currently operates under the provisions of EPL 467 and EPL 3607. EPL 467 for Angus Place Colliery (held by Centennial Angus Place Pty Limited) covers the mining operation, surface facilities, road haulage of coal, Kerosene Stockpile Area and three LDPs. EPL 3607 for Springvale Mine (held by Springvale Coal) covers the mining operations, surface facilities, overland conveyors and the SCSS and eight LDPs for water discharge off site.

The following three LDPs are relevant to the Project:

- LDP003 (EPL 467) – Discharge from the Kerosene Vale Stockpile Area.

- LDP006 (EPL 3607) – Discharge from the SCSS to Lamberts Gully as a result of overflow of Cooks Dam and Retention Pond.
- LDP007 (EPL 3607) – Discharge from the overland conveyor system to the Coxs River.

No changes to EPL 467 or EPL 3607 are proposed as part of the Project.

2.1.4 Water Management Act 2000

The *Water Act 1912* has historically been the main legislation for managing water resources in NSW, however it is currently being progressively phased out and replaced by water sharing plans (WSPs) under the *Water Management Act 2000* (WM Act). Once a WSP commences, existing licences under the *Water Act 1912* are converted to water access licences (WALs) and to water supply works and use approvals under the WM Act.

The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Water sharing plans

Fresh water sources throughout NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of groundwater dependent ecosystems (GDEs) and waterways. WSPs also provide how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

The following two WSPs made under Section 50 of the WM Act are relevant to the Project:

- Greater Metropolitan Region Unregulated River Water Sources WSP (GMRU WSP).
- Greater Metropolitan Region Groundwater Sources WSP (GMR WSP).

Greater Metropolitan Region Unregulated River Water Sources Water Sharing Plan

For surface water, the Project is located within the GMRU WSP, which became operational in July 2011. This WSP covers six water sources which are made up of a total of 87 management zones. The Project is located within the Wywandy Management Zone of the Upper Nepean and Upstream Warragamba Water Source.

Greater Metropolitan Region Groundwater Sources Water Sharing Plan

For groundwater, the Project is located within the GMR WSP, which became operational in July 2011. This WSP covers 13 groundwater sources on the east coast of NSW. The Project is located within the Sydney Basin Coxs River Groundwater Source.

Basic landholder rights

Under the WM Act, extraction of water for basic landholder rights is protected by allocating and prioritising water for basic landholder rights. There are three types of basic landholder rights in NSW under the WM Act:

- Domestic and stock rights.
- Native title rights.
- Harvestable rights.

Domestic and stock rights

Landholders are entitled to take water from a river, estuary or lake which fronts their land or from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a licence. However, a water supply work approval is required to construct a dam or a groundwater bore.

Native title rights

Anyone who holds native title with respect to water, as determined by the *Native Title Act 1993*, can take and use water for a range of purposes, including personal, domestic and non-commercial communal purposes. There are no native title rights in the GMRU WSP or GMR WSP and therefore this type of basic landholder rights has not been considered in the WRIA.

Harvestable rights

Landholders are entitled to collect a portion of runoff from their property and store it in one or more dams up to a certain size, known as a 'harvestable right', which is determined from the total contiguous area of land ownership. In the Central and Eastern Divisions of NSW (where the Project is located), landholders may capture and use up to 10% of the average regional rainfall runoff for their property without requiring a licence under the WM Act. The maximum harvestable right is the total volume of rainfall runoff that a landholder is entitled to use without requiring a licence. If the maximum harvestable right for a site is exceeded, licensing for the volume of water extracted from the surface water source exceeding the harvestable right is required under the WM Act.

The guidelines for determining the maximum harvestable right dam capacity (MHRDC) indicate that the following dams are exempt from the calculation of the MHRDC and do not require a licence (NOW, 2010):

- Dams for the control or prevention of soil erosion.
- Dams for the capture, containment and recirculation of drainage.
- Dams without a catchment.

2.1.5 Water NSW Act 2014

The *Water NSW Act 2014* defines the functions and objectives of WaterNSW, which was formed in 2015 by the merger of the Sydney Catchment Authority and State Water Corporation. WaterNSW is Australia's largest water supplier and NSW's major supplier of raw water. The Act specifically sets the objectives:

- To capture, store and release water in an efficient, effective, safe and financially responsible manner.
- To supply water in compliance with appropriate standards of quality.
- To ensure that declared catchment areas and water management works in such areas are managed and protected so as to promote water quality, the protection of public health and public safety and the protection of the environment.
- To provide for the planning, design, modelling and construction of water storages and other water management works.
- To maintain and operate the works of WaterNSW efficiently and economically and in accordance with sound commercial principles.

The functions of WaterNSW under the Act that are specific to the Project are:

- Construct, maintain and operate water management works (including providing or constructing systems or services for supplying water).

- Protect and enhance the quality and quantity of water in declared catchment areas.
- Manage and protect declared catchment areas and water management works vested in or under the control of WaterNSW that are used within or for the purposes of such areas
- Undertake flood mitigation and management.
- Undertake research on catchments generally, and in particular on the health of declared catchment areas.
- To undertake an educative role within the community.

The Project involves discharge of water within the upper Coxs River catchment, which is part of the Sydney drinking water catchment. WaterNSW, under this Act, is required to manage this catchment with respect to protection of catchment areas and water management works.

2.2 Policies

2.2.1 State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

The *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011* replaced the Drinking Water Catchments Regional Environmental Plan No. 1 and specifically requires all proposed developments in the Sydney drinking water catchment to demonstrate a neutral or beneficial effect (NorBE).

The management of the drinking water catchment is undertaken through WaterNSW, which have identified the following series of principles for managing mining impacts:

- Mining activities must not result in a reduction in the quantity of surface and groundwater inflows to storages or loss of water from storages or their catchments.
- Mining activities must not result in a reduction in the quality of surface and groundwater inflows to storages.
- Mining activities must not pose increased risks to human health as a result of using water from the drinking water catchments.
- The integrity of the WaterNSW's water supply infrastructure must not be compromised.
- The ecological integrity of the Special Areas must be maintained and protected.
- Information provided by proponents, including environmental impact assessments for proposed mining, must be detailed, thorough, scientifically robust and holistic. The potential cumulative impacts must be comprehensively addressed.

In response to the WaterNSW principles, the WRIA will detail how the Project will address potential impacts to quantity and quality of surface water. As there are no components of WaterNSW water supply infrastructure or Special Areas present within or surrounding the Project, it is unlikely that the Project will impact upon these.

2.2.2 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

The Level 1 minimal impact considerations for less productive groundwater sources are relevant to the groundwater sources at the SCSS and are as follows:

- Water table: less than or equal to 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 m from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply.
- Water pressure: a cumulative pressure head decline of not more than 40% of the ‘post-water sharing plan’ pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work.
- Water quality: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. For alluvial water sources, there should be no increase of more than 1% per activity in the long-term average salinity in a highly connected surface water source at the nearest point to the activity.

2.3 Guidelines

2.3.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The National Water Quality Management Strategy (NWQMS) provides a national framework for improving water quality in Australia’s waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation’s water resources, protecting and enhancing their quality, while maintaining economic and social development.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) is a benchmark document of the NWQMS which provides a guide for assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. ANZECC (2000) provide a framework for determining appropriate guideline values or performance criteria to evaluate the results of water quality monitoring programs.

The ANZECC (2000) guidelines adopt a risk-based approach to assessing ambient water quality by providing the framework to tailor water quality guidelines to local environmental conditions. Guideline values provided by ANZECC (2000) can be modified into regional, local or site-specific guideline values (SSGVs) by taking into account factors such as the variability of the particular ecosystem, soil types, rainfall and level of exposure to contaminants. It should be noted that guideline values are applied to the receiving environment at the edge of the mixing zone and do not apply to mine water discharges.

2.3.2 Australian Guidelines for Water Quality Monitoring and Reporting

The Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000) is a benchmark document of the NWQMS that relates closely to the water quality guidelines (ANZECC 2000). These guidelines provide a nationally accepted framework for undertaking monitoring and reporting of water quality that applies to freshwater, marine waters and groundwater.

2.3.3 Approved Methods for the Sampling and Analysis of Water Pollutants in NSW

The document Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA 2004) lists the sampling and analysis methods to be used when acquiring water samples for compliance with environmental protection legislation, a relevant licence or relevant notice.

2.3.4 Waste classification guidelines

The NSW EPA Waste Classification Guidelines, Part 1: Classifying waste (EPA 2014) covers the classification of wastes into groups that pose similar risks to the environment and human health. The residual to be transferred to the SCSS REA has been classified as liquid waste in accordance with these guidelines.

3. Site description

3.1 Land use

The Project is located on the western slopes of the north-south oriented sandstone ridgeline of the Great Dividing Range, to the west of the Wollemi and Blue Mountains national parks. The nearest large regional urban centre is Lithgow, with other nearby residential areas including Wallerawang, Portland and Cullen Bullen. The region consists primarily of undulating hills and mountain tops, with some low lying areas. These low-lying areas have been cleared of natural vegetation for agricultural, commercial and industrial purposes, including coal and shale mining, forestry and power generation. There are a number of national parks and state forests in the region, including Ben Bullen State Forest and Wolgan State Forest to the north of the Project and the Newnes State Forest to the east.

Key operations in the vicinity of the Project include:

- Angus Place Colliery (care and maintenance).
- Lidsdale Siding Rail Loading Facility (Lidsdale Siding).
- MPPS.
- Pine Dale Coal Mine (care and maintenance).
- Springvale Mine.
- Wallerawang Power Station (decommissioned).

3.2 Topography

The site lies mid-slope between the rising hills to the south and the Wangcol Creek valley to the north. Terrain to the south rises to 1050 m Australian Height Datum (AHD), while the elevation of the site itself is between 960 m AHD to 920 m AHD, with the overall terrain sloping to the north-east.

3.3 Climate

3.3.1 Rainfall

Annual rainfall

Daily rainfall data was obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation. SILO patched point data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data ‘patched in’ with interpolations from nearby stations.

For this assessment, SILO data was obtained for Lithgow (Birdwood St) Station (station number 63224) which is located approximately 13 km south-east of SCSS. This station was chosen based on the length and quality of the data record and proximity to the Project.

The period of rainfall data extended from January 1889 to December 2015 and is summarised as annual totals in Figure 3-1. The statistics for this rainfall set are:

- Minimum annual rainfall – 447 mm in 1944.
- Average annual rainfall – 862 mm.
- Median annual rainfall – 853 mm.

- Maximum annual rainfall – 1,683 mm in 1950.

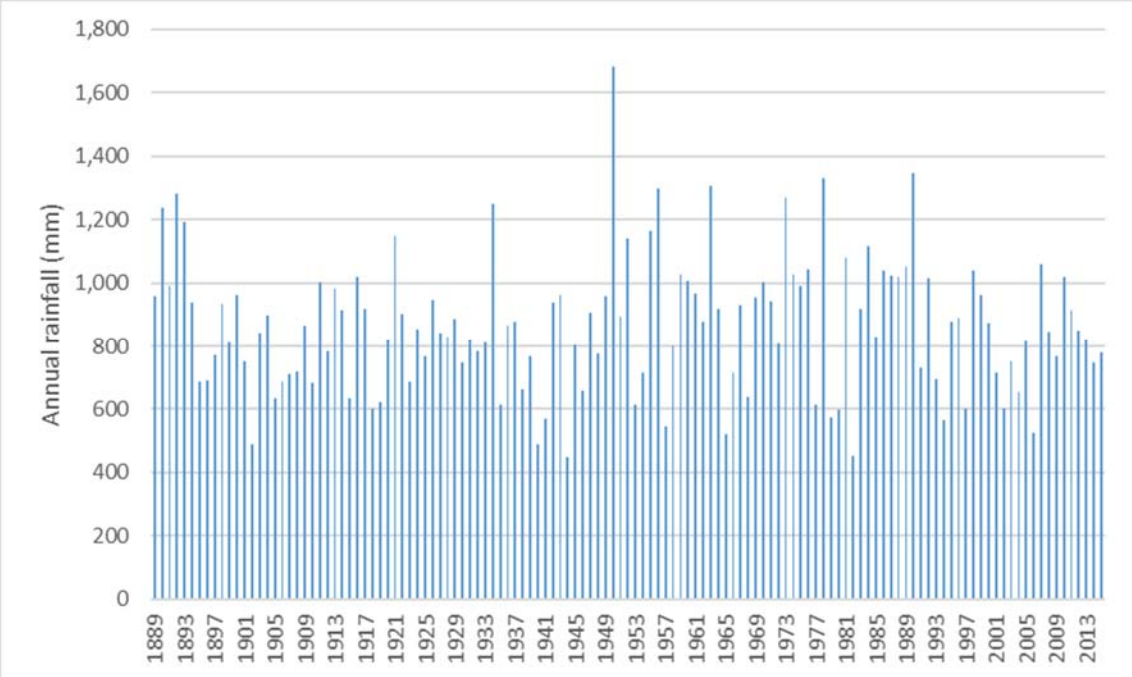

Figure 3-1 Annual rainfall recorded at Lithgow (Birdwood St) Station

Monthly rainfall

The monthly rainfall statistics were also determined for the period of record from the Lithgow (Birdwood St) station and are provided in Figure 3-2. The average monthly rainfall was observed to vary from a low of approximately 57 mm in September to a high of approximately 93 mm in January. Figure 3-2 shows a significant variation in the maximum recorded monthly rainfall with the maximum monthly value being approximately 374 mm in August and the lowest monthly value being approximately 196 mm in September. The minimum monthly rainfall is less than 10 mm for all months.

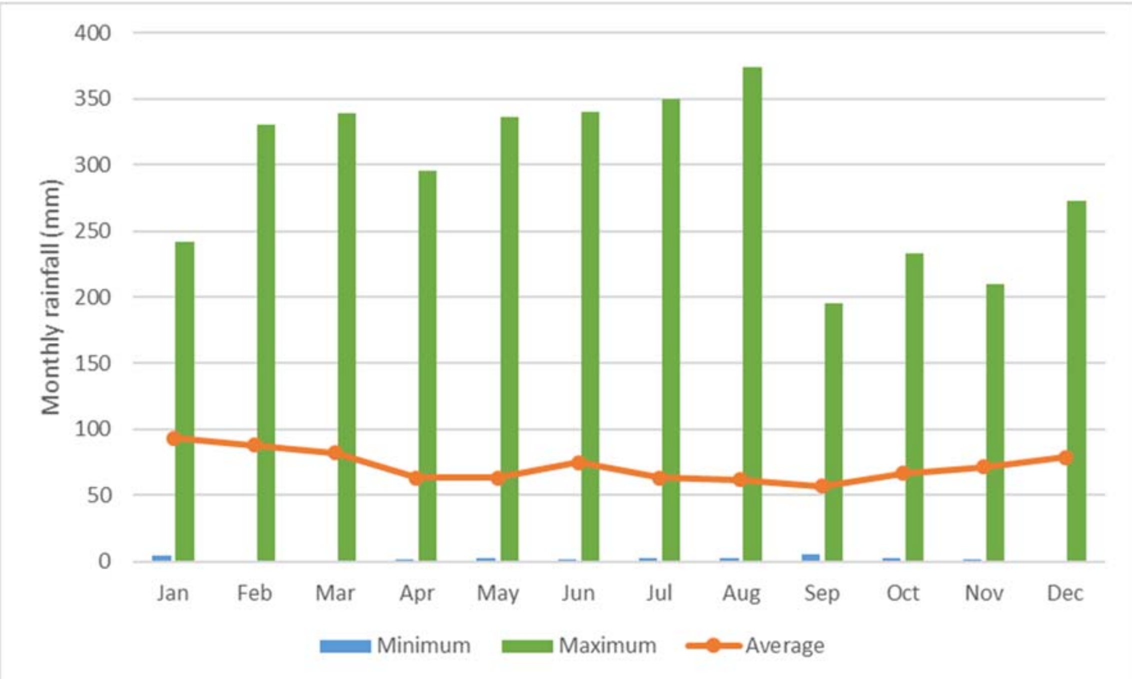

Figure 3-2 Monthly rainfall statistics for Lithgow (Birdwood St) Station

Cumulative rainfall departure

The SILO patched point data from the Lithgow (Birdwood St) Station was also used to generate a cumulative rainfall departure (CRD) curve over the period from 1889 to 2015, presented in Figure 3-3. A CRD curve is a monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall. Any increase in the CRD curve reflects above average rainfall while a decrease in CRD curve reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall.

Figure 3-3 Cumulative rainfall departure curve

As shown in Figure 3-3, the CRD curve indicates a period of approximately 15 years of above average rainfall between 1990 and 2005. From 2006 through to present, monthly rainfall has been less than average, with a relatively low rainfall period in 2007.

The relationship presented in the CRD curve is important to consider with respect to water quality and streamflow results. Water quality within Wangcol Creek has been known to vary in response to water level within the creek affecting the health of the aquatic ecology. Typically, Wangcol Creek operates such that as runoff derived flow reduces, groundwater contribution to the creek will increase. This subsequently introduces groundwater quality characteristics which include increased dissolved metals and EC.

3.3.2 Evaporation

Information provided at the closest BOM station which records evaporation, Bathurst Agricultural Station (station number 63005), was reviewed and average monthly evaporation rates were determined. The average daily evaporation is presented in Figure 3-4, based on 44 years of data from 1966 to 2016.

The total average annual evaporation is approximately 1350 mm, compared to the annual average rainfall total of approximately 862 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 488 mm.

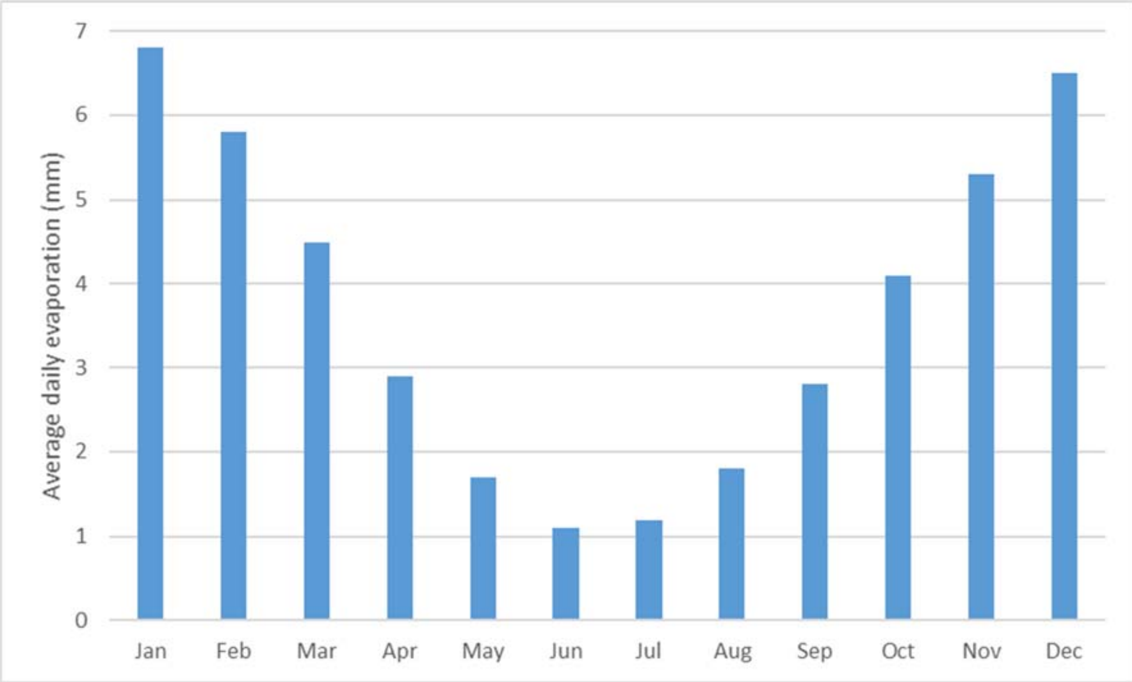

Figure 3-4 Average daily evaporation from Bathurst Agricultural Station

3.4 Geology

The Project is located in the southern part of the Western Coalfield and on the western edge of the Sydney Basin. The area is underlain by Permian Illawarra Coal Measures, which is underlain by Berry Siltstone of the Shoalhaven Group. The Triassic sandstone of the Narrabeen Group outcrops approximately 700 m to the north-east of the site.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. These form the gently dipping beds of the Illawarra Coal Measures, capped by shale and sandstone from the Wiannamatta and Narrabeen Group (Triassic Period) and Basalt from the Tertiary period.

Directly below the Illawarra Coal Measures lies the silty, coaly sedimentary rocks of the Nile Subgroup and sandy siltstone of the Berry Siltstone.

Basement rocks of Western Sydney are folded Palaeozoic metamorphosed rocks of the Lachlan Fold Belt, Late Carboniferous granites and Early Permian Rylstone Volcanics.

There are seven identified coal seams within this region, listed in descending stratigraphical order as follows:

- Katoomba Seam.
- Middle River Seam.
- Moolarben Seam.
- Upper Irondale Seam.
- Irondale Seam.
- Lidsdale Seam.
- Lithgow Seam.

Seismic activity has been noted along the Coxs River Lineament Fault Zone, a 250 m wide, north-south trending graben structure which follows the valley of Coxs River.

The regional stratigraphy of the Project is summarised in Table 3-1.

Table 3-1 Regional geology

Period	Stratigraphy			Unit/lithology	Approximate elevation	Approximate thickness
	Group	Subgroup	Formation			
Quaternary	–	–	–	Alluvium	At ground surface	–
Triassic	Narrabeen	Grose	Bankswall Sandstone	Sandstone, shale, tuff	>950 m AHD	–
Permian	Illawarra Coal Measures	Wallerawang	Gap Sandstone	Predominantly sandstone (fine to coarse grained) with interbedded mudstones, tuff and chert	>909 m AHD	0 m in areas of low relief but >25 m in northern elevated areas.
		Charbon	Denman Formation Glen Davis Formation Newnes Formation Ivanhoe Sandstone			
			Irondale Seam	Coal	909–929 m AHD	1.4–1.6 m
			Long Swamp Formation	Predominantly sandstone (fine to coarse grained) and mudstone with isolated tuff and chert beds	–	13–19 m
			Lidsdale Seam	Coal	889–912 m AHD	1.4–4 m

Period	Stratigraphy			Unit/lithology	Approximate elevation	Approximate thickness
	Group	Subgroup	Formation			
		Cullen Bullen	Blackmans Flat Formation	Sandstone, shale or absent	–	0–4 m
			Lithgow Seam	Coal	886–907 m AHD	1.1 m (southern areas) to 3.7 m (northern areas)
			Marrangaroo Formation	Sandstones and siltstones	–	10 m
	Shoalhaven	–	Berry Siltstone Formation	Shale, sandstone, conglomerate and chert with coal, torbanite seams	<880 m AHD	Unknown
Carboniferous	Bathurst Batholith		Tarana Granite	Adamellite, granite and granodiorite	Estimated to be <800 m AHD. Based on outcrop in Wolgan River Valley.	Unknown
			Turondale, Waterbeach and Merrions	Feldspathic Volcaniclastics, grewacke, slate	Estimated to be <800 m AHD. Based on outcrop in Wolgan River Valley.	Unknown
Devonian	Crudine			Feldspathic siltstone and sandstone, limestone, conglomerate	Unknown	Unknown

3.5 Surface water environment

Watercourses in the vicinity of the Project are presented in Figure 3-5. The Project is located within the upper Hawkesbury River catchment, which includes the greater Warragamba Dam catchment and the upper Coxs River sub-catchment. The Coxs River is a perennial river that drains a catchment area of approximately 1,700 km^2 and is part of the greater Hawkesbury/Nepean catchment. The river rises within the Ben Bullen State Forest east of Cullen Bullen and flows generally in a south-east direction into Lake Burragorang (impounded by Warragamba Dam), which is the primary reservoir for drinking water supply to Sydney. The flow in Coxs River is regulated by three reservoirs, Lake Wallace, Thompsons Creek Reservoir and Lake Lyell, which are used to supply water for power generation activities at MPPS.

The SCSS is located within the Wangcol Creek catchment. This creek is a highly modified stream that drains into the Coxs River approximately 3 km to the east of SCSS. Wangcol Creek has also been diverted to assist in mining land uses historically.

The runoff from the SCSS concentrates into two natural watercourses, Huon Gully to the west and Lamberts Gully to the east. The hydrology of the site has been significantly changed due to historical open cut and underground mining and related activities. The natural watercourse in Huon Gully now terminates in a surface water storage, Huon Gully sediment pond 1 (SHG1), as the gully has been disturbed by open cut mining and lower down filled by the MPPS Lamberts North ash emplacement area.

3.6 Groundwater environment

The geological conditions present within the vicinity of the Project create a range of aquifer systems associated with higher permeability sandstones and coal seams. These are likely separated by lower permeability aquitards associated with mudstones, claystones and shale layers.

Shallow sandstone aquifers are predominant across the SCSS and are expected to be associated with the Gap and Ivanhoe sandstone units. These aquifers are likely to be weathered in their near-surface profile resulting in relatively high permeability with potential for significant hydraulic connection with surface water features, including Wangcol Creek.

Surrounding the SCSS, groundwater is connected to remnant open cut areas, some of which have been backfilled while others remain open. SKM (2010) indicate that following mining (pillar extraction), the connectivity between surface water and groundwater can increase up to three times due to changes in permeability and storage capacities above the mine. This is supported by observations at the SCSS where a number of groundwater recharge areas exist, which maintain an influencing factor over discharge volume and quality currently. The site has a long history of mining using both underground and open cut methods. There are a number of historical open cut voids in the western part of the SCSS, including the H Pit West, H Pit East and Council Pit. Water stored in these voids is likely to be connected to the historical underground mine workings which contribute down gradient to Cooks Dam. Inflows to Cooks Dam have been observed to occur from various locations along the western edge of the dam, originating from historical underground workings. The storage was historically constructed using a small (less than 3 m in height) homogeneous earth fill (overburden) bund, around the crest of an existing open cut pit and is not lined. Cooks Dam is located at the lowest point within the Lithgow Seam and forms a sink for much of the local groundwater environment.

The mudstone and siltstone units that are present between the primary coals seams (the Lidsdale and Lithgow seams) and sandstones throughout the profile significantly retard vertical flow between aquifer units. Much of this material has been extracted through mining activities

Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Angus Place Colliery boundary
- Principal Road
- Watercourse - NonPerennial
- Watercourse - Perennial
- Waterbody

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Watercourses

Figure 3-5

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA004_Watercourses_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

The primary hydrogeological units identified as part of the MPPS Ash Placement Project (SKM, 2010) and the Western Coal Services Project (RPS 2013b) are summarised in Table 3-2.

In accordance with the NSW Aquifer Interference Policy and the GMR WSP, the existing aquifer systems within the vicinity of the Project are expected to form less productive porous rock aquifer systems associated with the Sydney Basin Coxs River groundwater source.

Table 3-2 Hydrogeological units surrounding the WTP

Unit	Comments
Quaternary alluvium	Isolated to Wangcol Creek, very little presence within the SCSS.
Triassic sandstone	Areas of fracturing due to historical underground mining.
Permian Illawarra Coal Measures	Areas of Lidsdale and Lithgow seam have been mined historically.
Marrangaroo conglomerate	Outcrops to the south.
Basal unit comprising the Shoalhaven Group	Outcrops to the south with a high porosity but low permeability.

3.7 Sensitive receptors

The following sensitive surface and groundwater receptors have been identified:

- GDEs located along Wangcol Creek downstream from the Project.
- Aquatic ecology maintained in local waterbodies, including macroinvertebrate fauna, frogs, macrophytes and algae, fish, semi-aquatic invertebrate species and semi-aquatic mammals.
- Waterways of Wangcol Creek and Coxs River.
- The drinking water catchment for Warragamba Dam, which receives inflows from a number of waterways including Coxs River.
- Users of surface water and groundwater downstream of the Project, including licensed water users and basic landholder rights.

4. Assessment methodology

4.1 Potential impacts

The objective of the WRIA is to determine the potential impact of the Project on surface water and groundwater environments. The identification of potential impacts enables the development of measures to avoid or mitigate impacts or to provide the framework of monitoring programs that may be required for the Project. The following potential impacts to surface water and groundwater systems were identified:

- Changes to the local water cycle.
- Changes to geomorphological condition of waterways.
- Altered surface water and groundwater quality downstream of the Project.
- Altered availability of surface and groundwater downstream of the Project.

4.2 Water and salt balance assessment

To assess changes in the local and regional water and salt cycle and to quantify potential impacts of the Project, utilisation of existing site based and regional water and salt balance models were evaluated. These models have been prepared through the completion of the following assessments:

- *Springvale Coal Services: Site Water and Salt Balance Assessment* (GHD 2016c), refer to Section 4.2.1 and Appendix A.
- *Springvale Coal Water Treatment Project, Water Resources Impact Assessment* (GHD 2016a), of which the methodology is discussed further in Section 4.2.2.

The two models above address the two scales of the Project, a site and regional scale. The Springvale Coal Services site water and salt balance has considered the assessment of the site water cycle and how the Project will influence transfers from various water management components. The regional water and salt balance has considered the regional influence of the Project on the water resources such as Coxs River and the reservoirs of Lake Wallace, Lake Lyell and Lake Burragorang.

4.2.1 Project water and salt balance

A water and salt balance assessment was undertaken to quantify the water and salt budgets, including inflows, outflows and net change in storage, in relation to the water management system at SCSS. A site water and salt balance was previously developed in GoldSim (Version 11.1) for SCSS (GHD 2016c), which is provided in Appendix A.

The water and salt balance model was updated to assess the impacts of the Project. The water management system for SCSS was modelled for the following scenarios:

- Existing conditions.
- Future conditions, following the construction of a clean water diversion (CWD) (see Section 5.1.1 for further discussion).
- Proposed conditions, where the inputs from the transfer of residuals to the REA are accounted for.

The model was created by representing the water and salt cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements within the water and salt cycle. The water management system was simulated over time in GoldSim and selected outputs from the model were statistically summarised.

To assess the impact of rainfall on the site, modelling was completed using a historical time series of daily rainfall data extending over 127 years, from January 1889 to December 2015 (refer Section 3.3.1). A total of 127 simulations were applied with each simulation modelling a different rainfall pattern.

The salt balance was developed as an extension of the water balance model, with expected concentrations of salt applied to water inflows to the system. Transfers of the resulting salt loads were modelled throughout the site. The mass and concentration of salt within particular storages was established such that a mass balance was achieved after allowing for salt discharged via extraction and overflows.

Further information on the water and salt balance assessment methodology is provided in Appendix A.

4.2.2 Coxs River catchment water and salt balance

An assessment of the regional water and salt balance of the wider Coxs River catchment was undertaken as part of the SWTP to predict the flows and salt loads in the Coxs River. The regional modelling includes relevant results for Angus Place Colliery, Lidsdale Siding, Springvale Mine and SCSS. Figure 4-1 indicates the location of the operations and licensed discharges within the Coxs River catchment included in the GoldSim model.

As part of this Project and assessment the regional water and salt balance was re-run to consider the Project's influence on the key points of interest which include, Wangcol Creek at confluence with discharges, Wangcol Creek at confluence with Coxs River, Coxs River flow to Lake Wallace, Coxs River flow to Lake Lyell and Coxs River flow to Lake Burragorang. Whilst this assessment was considered for the SWTP, it was re-evaluated given finalisation of the SCSS and inclusion of future works.

GHD has previously developed detailed site water and salt balances in GoldSim for all Centennial sites in the Coxs River catchment, as discussed in the following documents:

- *Angus Place Mine Extension Project: Water and Salt Balance Assessment* (GHD, 2013).
- *Springvale Mine Modification 1 Project: Water and Salt Balance Assessment* (GHD, 2016g).
- *Lidsdale Siding Rail Loading Facility: Water and Salt Balance Assessment* (GHD, 2016h).

The detailed water and salt balance models for each of these sites were directly incorporated into the regional GoldSim model.

It should be noted that the Neubeck Coal Project and Pine Dale Coal Mine within the Wangcol Creek catchment were not included in the water and salt balance model due to the undetermined status of their respective proposed operations. Only catchment runoff contributing to Neubecks Creek and Wangcol Creek from the proposed Neubeck Coal Project and Pine Dale Coal Mine respectively was modelled.

The SCSS (draft at the time of the EIS) has since been finalised following the completion of the SWTP EIS in 2016. Some changes in the models predictions have occurred as a result of the finalisation and hence the results between the SWTP and this report should not be attempted.

Outcomes from the regional modelling are covered as part of the assessment of neutral or beneficial effect in Section 6.7.

SWTP modelling

Due to the variability associated with power generation requirements and water demand at MPPS, a number of scenarios were modelled for the SWTP (0% to 100% power generation). Results for the 50% power generation requirement was used to present the results for the modelling as a result of this Project. The 50% power generation requirement was considered appropriate for regional assessment as it correlated to recent historical trends of between 40 to 50% power generation. For the purposes of this assessment no discharges of excess treated water were considered. This assists in providing clarity to the potential impacts created by the residual transfers.

Springvale Delta Water Transfer Scheme

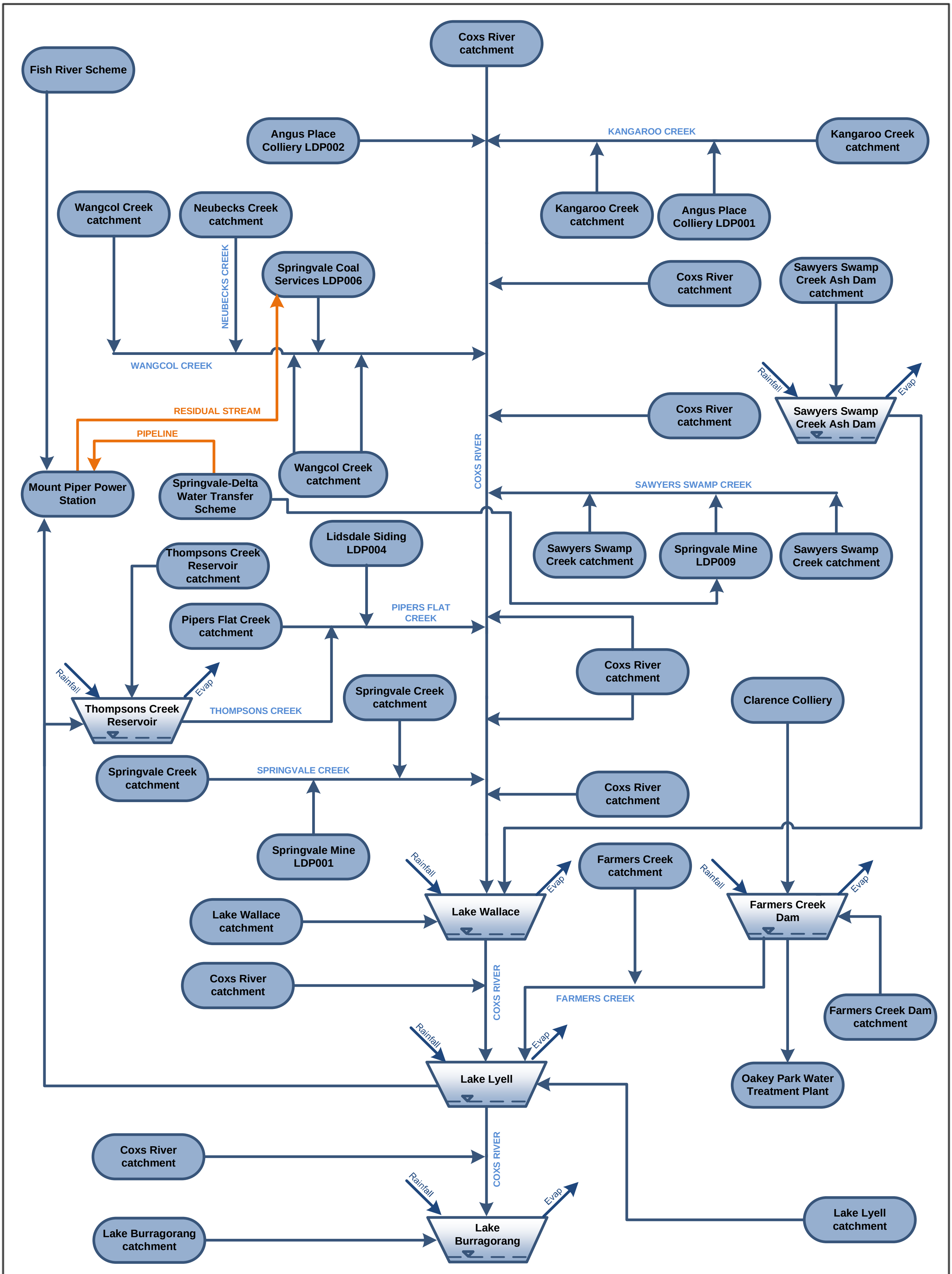
For the purposes of clarity for the Project, the volume of water being supplied via the Springvale Delta Water Transfer Scheme, that is the supply of water to the SWTP, was modelled at a constant rate. This consideration is important as it can influence the results of Lake Lyell and Lake Burragorang due to the supply of water to MPPS from the regional reservoirs. By keeping the supply rate constant, the results are able to be assessed for just the Projects influence on the region water resources. The supply rate was considered such that it was less than the demand of MPPS and hence no excess water was required to be managed. This was modelled as 22.4 ML/day based on 2015-2017 groundwater CSIRO (2015) predictions for the supply to the SWTP.

4.2.3 Modelling qualifications on predictions

GHD has developed the water and salt balance models for the Project based on information supplied by Centennial Springvale Pty Ltd, EnergyAustralia (2016a), Jacobs (2015) and external data sources. Where data was not available, GHD has made assumptions as appropriate.

Data used to develop the models are categorised as follows:

- Relatively reliable data:
  - SILO rainfall data.
  - BOM evaporation data.
  - Surface catchment areas based on topographic maps.
  - Water infrastructure data.
- Less reliable data:
  - Runoff rates from impervious and naturally vegetated catchments.
  - Operational precedences for transfers between storages.
  - Reactive chemistry of water.
  - Operational conditions (including day to day decisions).



LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

GHD

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Regional water cycle schematic

Centennial Coal

DATE Nov 2016

Figure 4-1

The consequence of the items listed within the 'less reliable data' category is there is likely to be a risk that the model predictions are somewhat inaccurate. Model predictions based on the above information should be considered to have an accuracy of ±30%. The accuracy is expected to improve once more site data is gathered during the life of the Project. This additional data will allow refinement of the model input and hence increase the reliability of the model predictions. A review of the model is likely to be undertaken as part of the commissioning phase of the Project.

In developing the regional water and salt balance, information and data relating to the water cycle at MPPS have resulted in the system being treated as a closed system with only the broad inflows and outflows considered. In relation to the operation of reservoirs, data has been interpreted from available WAL conditions. Centennial Coal operated sites are all modelled to a detailed site level.

Where publically available information has been used, GHD has endeavoured to interpret the information presented from these sources as accurately as possible in the modelling undertaken, however cannot be held responsible for inaccuracies due to misleading or absent information in the reports reviewed.

The commencement and cessation of operations have a significant impact on the assessment undertaken. If project timelines change from the timelines assumed for the water and salt balance assessment, model predictions may be impacted.

It should also be noted that the adoption of historical rainfall and evaporation data within the detailed models does not take into account the potential impacts of climate change.

4.3 Surface water quality

4.3.1 Water quality assessment

A surface water quality assessment was undertaken for the existing site conditions in order to establish baseline water quality for receiving watercourses. This water quality assessment has been undertaken in accordance with the assessment framework and methodologies outlined by ANZECC (2000).

The surface water quality assessment considered data from 14 monitoring locations. The monitoring locations were categorised into the following:

- Upstream locations – upstream of the SCSS within the Wangcol Creek catchment.
- SCSS locations – surface water storages at the SCSS and the LDP006 discharge.
- Downstream locations – downstream of the SCSS on Wangcol Creek.

Monitoring locations are shown in Figure 4-2 and described in Table 4-1.

Surface water quality data was compared to the default guideline values (DGVs) as recommended by ANZECC (2000) and the site-specific guideline values (SSGVs) derived for Wangcol Creek (GHD 2014). Water quality at LDP006 was also compared to the EPL discharge limits for the site.

Paper Size A4

0 0.125 0.25 0.5 0.75

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Discharge locations
- Downstream locations
- Upstream locations
- Surface storage sampling site
- Aquatic Ecology Monitoring Sites
- Watercourse - Non Perennial
- Watercourse - Perennial
- Waterbody

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Surface water monitoring locations

Figure 4-2

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline; imagery, 2016. Created by: tmorton

Table 4-1 Surface water quality monitoring locations

Location	Site description
Upstream locations	
SW1	Neubecks Creek at the Mount Piper Haul Road culvert, upstream of the Neubecks Creek and Wangcol Creek confluence.
SW2	Wangcol Creek downstream of the Neubecks Creek and Wangcol Creek confluence.
SW3	Wangcol Creek upstream of the Neubecks Creek and Wangcol Creek confluence.
Wangcol Creek gauge	Wangcol Creek downstream of SW2.
SCSS locations	
A-Pit	Serves as a sediment pond for the REA by receiving tailings return water, which is then pumped to Cooks Dam.
Cooks Dam	Dirty water collection and management dam
Main Sediment Pond	Receives overflow from five ‘fill and spill’ sediment ponds in the Lamberts Gully area. Reports to SLG6, which in turn reports to the Retention Pond.
Retention Pond	Collects catchment runoff from a large proportion of the SCSS. Supplies all dust suppression on site and also supplements supply to the washery. Contributes to LDP006.
SLG6	Receives water from the Main Sediment Pond and the Washery Sediment Pond. Overflows to the Retention Pond.
Stockpile Sediment Pond	Receives surface water runoff from the coal stockpile area and surrounding catchments. Some water is pumped from the washery makeup tank for re-use at the washery.
Washery Sediment Pond	Receives runoff water from the coal washery and surface water runoff from the surrounding catchments.
LDP006	LDP006 discharge from SCSS to Lamberts Gully.
Downstream locations	
Wangcol Creek D/S	Wangcol Creek downstream of the Lamberts Gully tributary.
Wangcol Creek far D/S	Wangcol Creek further downstream of the Lamberts Gully tributary.

The period of data reviewed for each location is provided in Table 4-2.

Table 4-2 Period of surface water quality data assessed

Location	Frequency	Number of samples	From	To
Upstream locations				
SW1	Bimonthly	60	15/03/2012	19/02/2015
SW2	Bimonthly	71	15/03/2012	11/01/2016
SW3	Bimonthly	67	15/03/2012	11/01/2016
Wangcol Creek gauge	Bimonthly	47	02/01/2014	17/12/2015
SCSS locations				
A-Pit	Monthly	4	22/05/2015	21/08/2015
Cooks Dam	Monthly	34	03/01/2013	03/12/2015
Main Sediment Pond	Bimonthly	61	03/01/2013	17/12/2015
Retention Pond	Bimonthly	62	03/01/2013	17/12/2015
SLG6	Bimonthly	61	03/01/2013	17/12/2015
Stockpile Sediment Pond	Bimonthly	61	03/01/2013	17/12/2015

Location	Frequency	Number of samples	From	To
Washery Sediment Pond	Bimonthly	61	03/01/2013	17/12/2015
LDP006	Monthly during discharge	46	03/01/2013	03/12/2015
Downstream locations				
Wangcol Creek D/S	Bimonthly	46	16/01/2014	17/12/2015
Wangcol Creek far D/S	Bimonthly	45	16/01/2014	17/12/2015

4.3.2 Ecotoxicology assessment

Sample collection

Three ecotoxicology assessments have been conducted on the LDP006 discharge, in May 2011 (GHD 2011), July 2012 (GHD 2012) and May 2016 (GHD 2016f). For all of these ecotoxicology assessments, samples were transported to the Ecotox Services Australasia (ESA) laboratory in Sydney for toxicity testing. Samples were also collected and transported to the ALS Environment Division Laboratory in Sydney for water quality analysis.

Direct toxicity assessment

Direct toxicity assessment (DTA) is a common method used to determine the toxicity of mixtures of compounds in ambient waters. The method provides an integrated measure of effects and accounts for interactions (synergistic, additive and ameliorative) within a mixture, therefore closely simulating the effects in the receiving waterway. To ensure a close simulation of the toxic effects of the discharge, site-specific testing was undertaken using species indigenous to, or representative of, the receiving ecosystem.

DTA was undertaken for the mine water discharge samples collected in May 2011 and May 2016. Toxicity testing in July 2012 was conducted using a screening test with freshwater cladoceran, which has been found to be the most sensitive test species in previous toxicity testing conducted by Centennial Coal in the region.

DTA involves exposing laboratory test species to a range of concentrations of sampled water for a specified exposure period. At the end of the exposure period, specific end points are assessed, such as species survival, reproduction or growth. Statistical analysis of the results provides the effect concentration of the discharge where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibited an inhibition effect and the no observable effect concentration (NOEC) of the discharge, which represents the highest tested concentration that has no effect on the test organisms (when compared to the results of the control sample).

Species tested

<u>May 2011</u>

The following freshwater species and test protocols were used to test the sample collected from LDP006 in May 2011:

- Eight-day partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*, based on the USEPA (2002) and Bailey *et al.* (2000) protocols.
- 72-hour microalgal growth inhibition test using the freshwater alga *Selenastrum capricornutum*, based on the USEPA (2002) protocol.

- 96-hour survival test using the freshwater shrimp *Paratya australiensis*, based on the USEPA (2002) protocol. It should be noted that this bioassay is not accredited with the National Association of Testing Authorities (NATA).
- Seven-day growth inhibition test using the freshwater aquatic duckweed *Lemna disperma*, based on the OECD (2006) protocol.
- 12-day embryonic development and post-hatch survival test using the freshwater eastern rainbowfish *Melanotaenia splendida splendida*, based on the USEPA (2002) protocol. It should be noted that this bioassay is not NATA accredited.

<u>July 2012</u>

The 48-hour immobilisation acute toxicity test using the freshwater cladoceran *Ceriodaphnia dubia* was conducted using the sampled LDP006 discharge in July 2012, based on the protocols specified by USEPA (2002) and Bailey *et al.* (2000).

<u>May 2016</u>

The following freshwater species and test protocols were used to test the sample collected from LDP006 in May 2016:

- Seven-day partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*, based on the USEPA (2002) and Bailey *et al.* (2000) protocols.
- 72-hour microalgal growth inhibition test using the freshwater alga *Selenastrum capricornutum*, based on the USEPA (2002) protocol.
- 96-hour growth inhibition test using the freshwater aquatic duckweed *Lemna disperma*, based on the OECD (2006) protocol.
- 10-day embryonic development and post-hatch survival test using the freshwater eastern rainbowfish *Melanotaenia splendida splendida*, based on the USEPA (2002) protocol.
- 10-day survival test using the freshwater shrimp *Paratya australiensis*, based on the USEPA (2002) protocol. It should be noted that this bioassay is not NATA accredited.

Concentrations tested

ESA recommends the use of laboratory dilution water to provide a more accurate indication of the toxicity of the samples rather than the toxicity of the background water. ESA used in-house diluents for all dilutions and controls to ensure the toxicity observed can be attributed directly to the sample tested. All samples were serially diluted with the appropriate diluent to achieve the test concentration.

For the samples collected in May 2011, the concentrations of mine discharge used varied depending on the bioassay (refer Table 1 in GHD 2011). For the sample collected in July 2012, the screening test with the cladoceran bioassay was conducted at 100% concentration (i.e. no dilution of samples). For the samples collected from LDP006 in May 2016, the concentrations used in the toxicity testing were 0%, 3.1%, 6.3%, 12.5%, 25%, 50% and 100%.

Dilution factor

The BurrliOZ 2.0 statistical analytical program (CSIRO 2014) used the EC_{10} results from the toxicity testing in May 2016 to calculate the concentration of mine water discharge to protect 99%, 95%, 90% and 80% of species in the receiving environment from a 10% reduction in growth or reproduction. Where EC_{10} values were unreliable or only otherwise available through extrapolation, values were calculated following the methods set out by Warne *et al*. (2014). Dilution factors were then calculated for each species protection level, which can be used to assist in deriving site-specific concentrations of contaminants that will not adversely impact organisms within the receiving ecosystem. Concentrations of individual contaminants cannot be extrapolated from toxicity testing results for use as guideline values. However, concentrations can be used for monitoring purposes to ensure that the dilution factors are met at the appropriate monitoring site.

It should be noted that the future version of the ANZECC (2000) guidelines will require the use of a log-logistic distribution for datasets of small sample sizes. The BurrliOZ program requires a minimum of eight datasets to obtain an accurate species sensitivity distribution and results using less datasets must be interpreted with caution.

4.4 Groundwater environment

The hydrogeology at the SCSS has been modelled by GHD to establish groundwater flow paths and predict seepage into and from surface water storages at the site (GHD 2016b). A review of the baseline groundwater level and quality data has been undertaken using data reported by SCSS for the boreholes detailed below in Table 4-3. The groundwater monitoring locations are shown in Figure 4-3.

Table 4-3 Groundwater monitoring locations

Bore	Top of casing (m AHD)	Strata	Ground level (m AHD)	Bore depth (m bgl*)	Screen (m bgl)
BH01	913	Lithgow Seam	912.37	18.3	15.3-18.3
BH02	918.5 (approx.)	Marrangaroo Formation/ Berry Siltstone	916.2	30	24-30
BH03	905.76	Saturated overburden	905.13	18.57	15.5-18.5
BH04	930.71	Lithgow Seam workings (void)	929.98	27.51	
BH05	929.59	Lithgow Seam (unmined pillar)	928.83	30.19	
BH06	905.9	Lithgow Seam	905.35	9.3	
BH07	925.16	Up-gradient saturated overburden	924.24	33	18-33
BH08	928.27	Lithgow Seam workings (void)	927.38	24.4	21.4-24.4
BH09	930.75	Lithgow Seam workings (void)	929.79	25.5	22.5-25
BH10	937.4	Lithgow Seam workings (void)	936.45	25.2	22-25
BH11	950 (approx.)	Marrangaroo		34.19	
BH12	917.81	Marrangaroo	917	18.68	
BH13	917.67	Back fill	917	12.37	
BH15	913	Up-gradient overburden	940	25.5	18.6-24.6

* bgl – below ground level.

Paper Size A4

0 110 220 440 660

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Centennial Coal borehole
- Watercourse - Non Perennial
- Watercourse - Perennial
- Waterbody

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Revision | 1
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Groundwater monitoring locations

Figure 4-3

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA006_GWMonitoringLocations_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, alignment, monitoring locations, imagery, 2016. Created by: tmorton

4.1 Stream health

Stream health of Wangcol Creek has previously been assessed as part of the SWTP (GHD 2016a), which included a desktop assessment for aquatic ecology and a field and desktop geomorphologic review. These studies have been considered with a specific focus on the potential impacts on the water quality and volume of the LDP006 discharge from the transfer of the residual stream to the REA.

4.2 Residual stream water quality

4.2.1 Jar testing and case studies

The predicted water quality of the residual stream was assessed based on results of jar testing performed by Hunter Water and the limiting maximum transfer of residual of 0.43 ML/day, as per GHD (2016e).

GHD have also undertaken water quality testing of mine water pre- and post-dosing with ferric chloride, in order to provide a better indication of the likely mobility of metals in the residual stream. These samples were collected from the Centennial Newstan Colliery WTP on 23 September 2016, and analysed by the NATA accredited Eurofins|MGT laboratory in Sydney. The results from this testing were used to predict the potential impact of the dissolved fraction of the proposed residual stream on the quality of water discharged at LDP006.

4.2.2 Preliminary PHREEQC Modelling

A mixture of the dissolved fraction of the case study residual stream (Section 4.2.1) and the historical median water quality at LDP006 was modelled using PHREEQC (Parkhurst and Appelo 1999). PHREEQC is a program developed by the USGS (United States Geological Survey) for simulating chemical reactions in industrial processes. The model assumed a mixing ratio of 0.3:1 (residual to discharge), which was based on predictions made by the water and salt balance assessment (GHD 2016c).

It is important to note that this modelling was preliminary only and was limited by various assumptions which affect the resultant predicted water quality. The following factors were not accounted for:

- The impact of the planned CWD on LDP006 water quality.
- The attenuation of metals concentrations in either the shallow groundwater flow path or dewatering volumes between the REA and Cooks Dam.
- Reductions in dissolved metal concentrations through the precipitation of insoluble species.
- The result of mixing of the residual stream and the fine coal rejects slurry.
- Any differences between the Newstan Colliery residual stream and the proposed residual stream from the WTP.

The modelling provided resultant concentrations for the mixed solution that allowed for an assessment to be undertaken.

4.3 Downstream water users

The potential impacts of the Project on licensed surface water users and basic landholder rights under the WM Act were assessed by identifying the downstream users within the potential area of impact. The potential area of impact was estimated conservatively based on the results of the assessments on water and salt balance, catchment hydrology and hydraulics, waterway geomorphology, surface water quality and groundwater environment.

Licensed surface water users and domestic and stock rights users with a water supply work approval were identified by searching for all lots within the potential area of impact in the *NSW Water Register* (DPI-Water, 2016a). Groundwater users were identified by searching the NSW groundwater bore database (DPI-Water, 2016b) for registered groundwater bores.

5. Existing conditions

5.1 Water management

Due to the extent of historical disturbance at the SCSS, the current water management system involves the mixing of clean and dirty water prior to discharge into Wangcol Creek. The objective of the water management system is to generally secure supply for coal washing and dust suppression and to control the quantity and quality of water discharged into Wangcol Creek via LDP006.

The water storages and other water management features of the site are shown in Figure 5-1 The catchment of each of the water storages was delineated based on topographic information and aerial imagery, accounting for constructed diversions. A plan of the surface water catchment and diversions is shown in Figure 5-2.

5.1.1 Clean water management

Clean water diversion drains concentrate the catchment upstream of the site into two drainage lines that are then intercepted by the site. Lamberts Gully, to the east, is intercepted by the Main Sediment Pond, which also collects runoff from established rehabilitation areas. Huon Gully, to the west, terminates at SHG1 where retained runoff is lost to seepage. It is likely that water seeping out of this storage is seeping into historical underground workings. Whilst, Main Sediment Dam provides the sites most reusable source of water, from time to time, suspended sediment can increase in concentration above environmental limits for discharge, which results in various management measures being adopted.

Future works

SCSS is currently undertaking design and construction works relating to the separation and optimisation of clean and dirty surface water flow paths within the Lamberts Gully catchment. These works are expected to reduce the clean water load from LDP006 and improve the quality of water discharged from the site in both daily and rainfall discharge events. Additionally, the volume of clean water that infiltrates into the groundwater and subsequently reports to LDP006 is expected to reduce, in part due to improved flow efficiency through the site and the planned pumping of water from SHG1 to the Main Sediment Pond. The primary objective of these works are to promote the capture and settlement of runoff from dirty catchments and to bypass cleaner water appropriately through site. As part of these works ongoing stabilisation of some catchments will be undertaken to reduce the risk of sediment laden water contributing to the clean water system. These works are expected to be minimal and will be undertaken within the operations existing commitments.

The CWD works are being undertaken as a result of a commitment made in the Western Coal Services EIS (RPS, 2013) to separate clean and dirty water at SCSS.

5.1.2 Dirty water management

The dirty water management system consists of a series of ponds, pumps and pipes that allow runoff and water seeping from the groundwater to be captured, treated (if required) and redistributed within the site for reuse or to improve the water quality of another pond through dilution. Water is used in the washery and for dust suppression.

Various measures are employed to manage the water quality onsite. Runoff from disturbed areas and areas not fully rehabilitated is captured in sediment ponds and treated if required prior to discharge. This allows for maximum reuse of influenced water. The Retention Pond is used as a final storage location prior to water being discharged offsite.

Paper Size A4

0 100 200 400 600

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Principal Road
- Storage
- Water flow path
- Springvale Coal Services LDP
- Watercourse - Non Perennial
- Watercourse - Perennial

GHD

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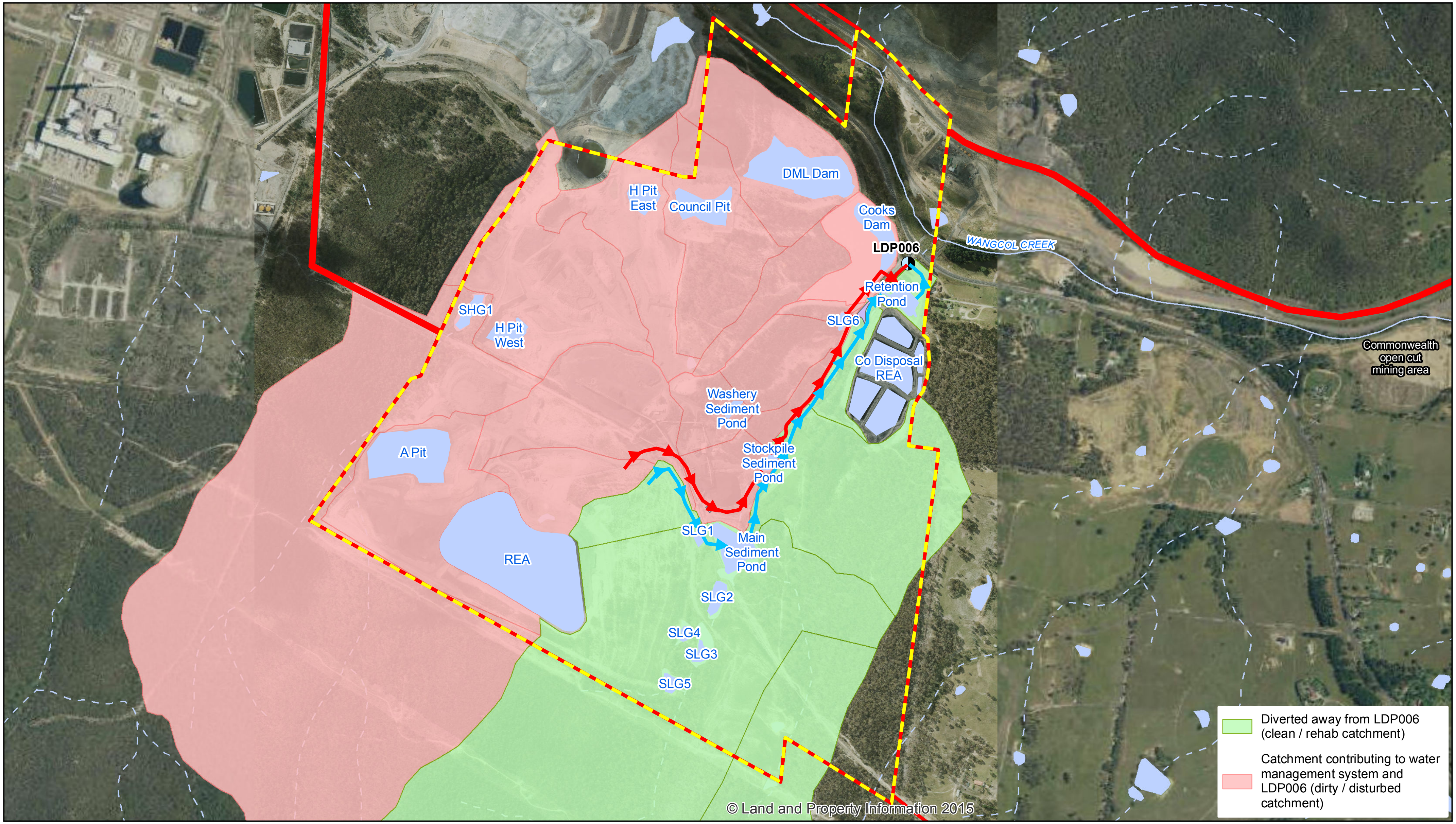
Existing water management features **Figure 5-1**

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA007_SCSS_Projectwatermanagement_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Imagery, 2016. Created by: tmorton



Paper Size A4

0 70 140 280 420 560

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial
- Clean water diversion
- Dirty water diversion

GHD

Western Coal Services
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Revision	1
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Surface water catchment and diversions

Figure 5-2

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA008_SWcatchementsanddiversions_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial Coal: Imagery, 2016. Created by: tmorton

The inputs into the surface water system consist of:

- Direct rainfall onto the surface of surface water storages.
- Surface water runoff from catchment areas.
- Moisture entrained in the ROM coal.
- Seepage from the historical mine workings.

The output from the surface water system consist of:

- Evaporation from the surface of the surface water storages.
- Evaporation from water applied for dust suppression.
- Moisture entrained in product coal.
- Moisture entrained in coarse coal rejects.
- Moisture entrained in fine coal rejects.
- Discharge from LDP006 to Wangcol Creek.
- Seepage into the historical mine workings.

5.1.3 REA storage augmentation

The REA was constructed in 2016. It is a progressive structure with works incorporating the former A-Pit REA. The first stage of the REA construction, referred to as the REA Storage Augmentation Project (REASA) has involved the extension to the south and east of the A-Pit REA using sub-aerial deposition techniques, in order to store up to 1.4 million m^3 of sub-aerially deposited fine coal reject material. The walls of the REA will be constructed from coarse reject materials. The development has been planned as part of three stages based on the down gradient crest level. The stages and crest levels are as follows:

- Stage 1 with crest level at 960 m AHD.
- Stage 2A facility extension westwards with crest level at 960 m AHD.
- Stage 2B with the final crest level at 970 m AHD.
- Stage 3 with the final crest level at 970 m AHD.

The enlarged REA will have an operating life of up to some 8 years at current reject production levels.

Water management of the REA allows for any water captured within the area to be dewatered to the SCSS water management system which reports to Cooks Dam and LDP006. Historical performance of the REA since construction has indicated that the infiltration capacity of the area has been significant enough that dewatering has not been required with the majority of the water infiltrating and reporting to the shallow groundwater system across the site, which is intercepted by Cooks Dam (GHD 2016c).

5.1.1 Discharge management

Discharges from Cooks Dam and the Retention Pond at SCSS occur to Wangcol Creek via LDP006, which is licensed under EPL 3607 held by Springvale Mine. Monitored daily discharges through LDP006 from March 2012 to March 2016 are presented in Figure 5-3. The figure indicates a historical range of discharge volumes between 0 ML/day and 14 ML/day. LDP006 monitors discharges from the SCSS as well as the contribution of catchment runoff to Lamberts Gully and hence discharge volumes become elevated following rainfall events.

Discharge volumes from the SCSS are on average 1.29 ML/day which is predominately from the contribution of groundwater to Cooks Dam.

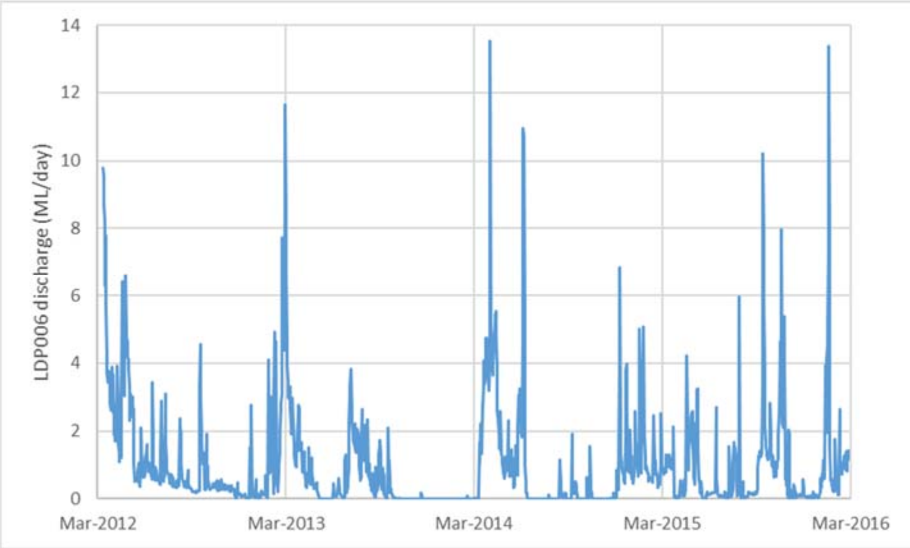


Figure 5-3 Daily discharge at LDP006

5.2 Water and salt balance assessment

The water and salt balance assessment for the site is provided in Appendix A. The following sections below provide a summary of the existing and future scenario predictions from the modelling undertaken.

5.2.1 Water balance results

Table 5-1 presents the key information from the water balance model in the form of average annual water transfers under existing and future conditions, prior to the transfer of the residual stream to the REA.

Table 5-1 Annual average water transfers

	Existing conditions (ML/year)	Future conditions (ML/year)
Inputs		
Direct rainfall	137	163
Catchment runoff	743	743
ROM coal moisture	108	108
Flocculant makeup	11	11
Seepage into Cooks Dam	1095	978
WTP residuals	0	0
Total Inputs	**2094**	**2003**
Outputs		
Evaporation	201	243
Dust suppression	32	35
Product coal moisture	100	100
Coarse coal rejects moisture	11	11
Discharge through LDP006	848	441
Discharge via clean water diversion	0	350

	Existing conditions (ML/year)	Future conditions (ML/year)
Seepage into historical mine workings	831	752
Retained in REA	71	71
Total Outputs	**2094**	**2003**
Change in storage		
Total change in storage	**0**	**0**
Balance	**0**	**0**

The annual water transfers for the existing and future conditions are presented in Figure 5-4 and Figure 5-5.

5.2.2 Salt balance results

Table 5-2 presents the key information from the salt balance model in the form of average annual salt transfers under existing and future conditions, prior to the transfer of the residual stream to the REA.

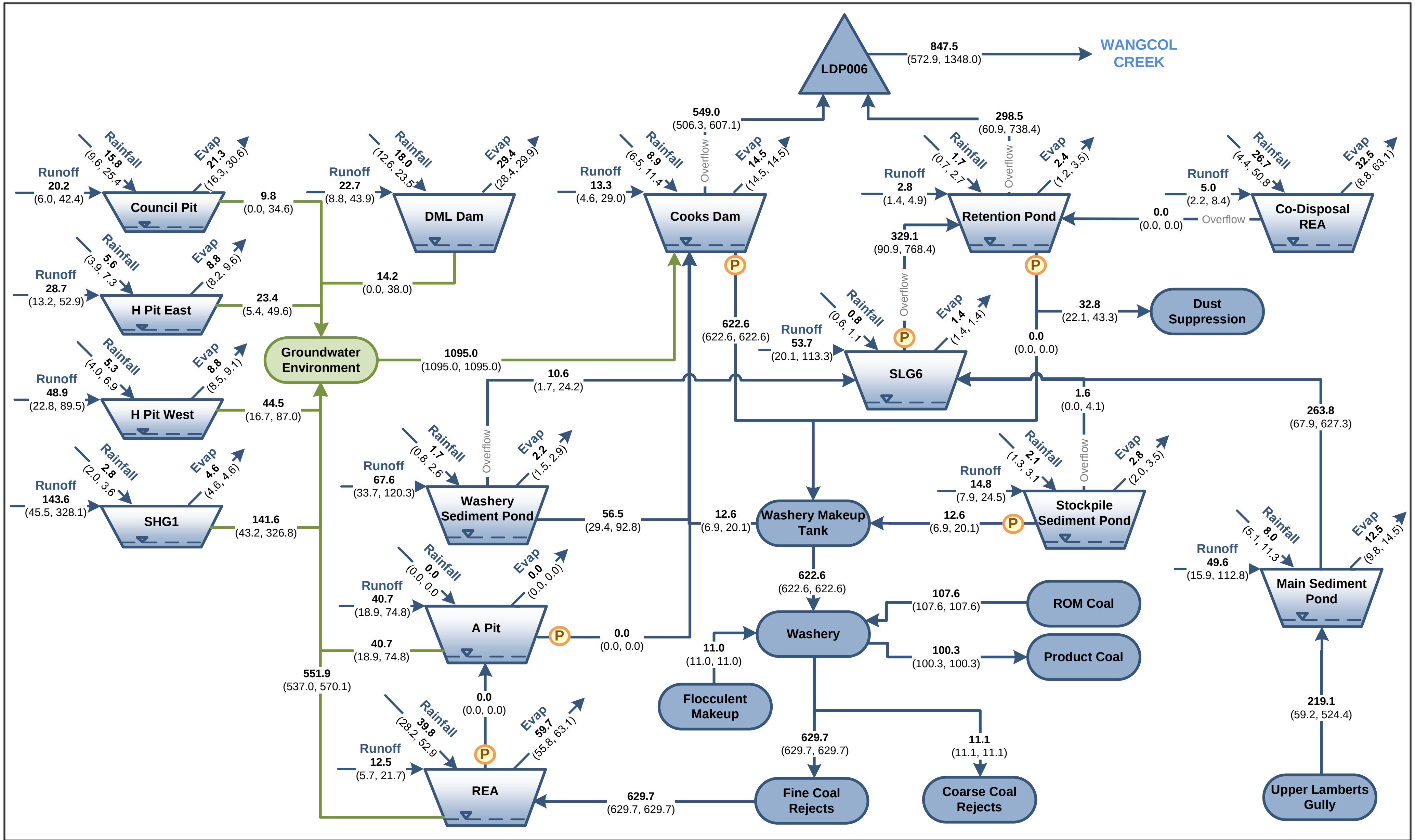
Table 5-2 Annual average salt transfers

	Existing conditions (tonne/year)	Future conditions (tonne/year)
Inputs		
Direct rainfall	3	3
Catchment runoff	433	445
ROM coal moisture	82	82
Flocculant makeup	1	1
Seepage into Cooks Dam	2935	2622
WTP residuals	0	0
Total Inputs	**3454**	**3153**
Outputs		
Evaporation	0	0
Dust suppression	15	15
Product coal moisture	226	226
Coarse coal rejects moisture	25	25
Discharge through LDP006	1517	1107
Discharge via clean water diversion	0	152
Seepage into historical mine workings	1498	1466
Retained in REA	172	162
Total Outputs	**3454**	**3153**
Change in storage		
Total change in storage	**0**	**0**
Balance	**0**	**0**

The annual salt transfers for the existing and future conditions are presented in Figure 5-6 and Figure 5-7.

5.2.3 Model validation

Outputs of the water and salt balance model were compared to the available discharge and EC data for LDP006 to provide an indication of the validity of the representation of existing conditions in the model. Refer to Section 5.1 of the water and salt balance assessment for a detailed discussion of the validation of the model (Appendix A).



LEGEND

Surface Water Transfer

Underground Water Transfer

Pump

Storage

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services
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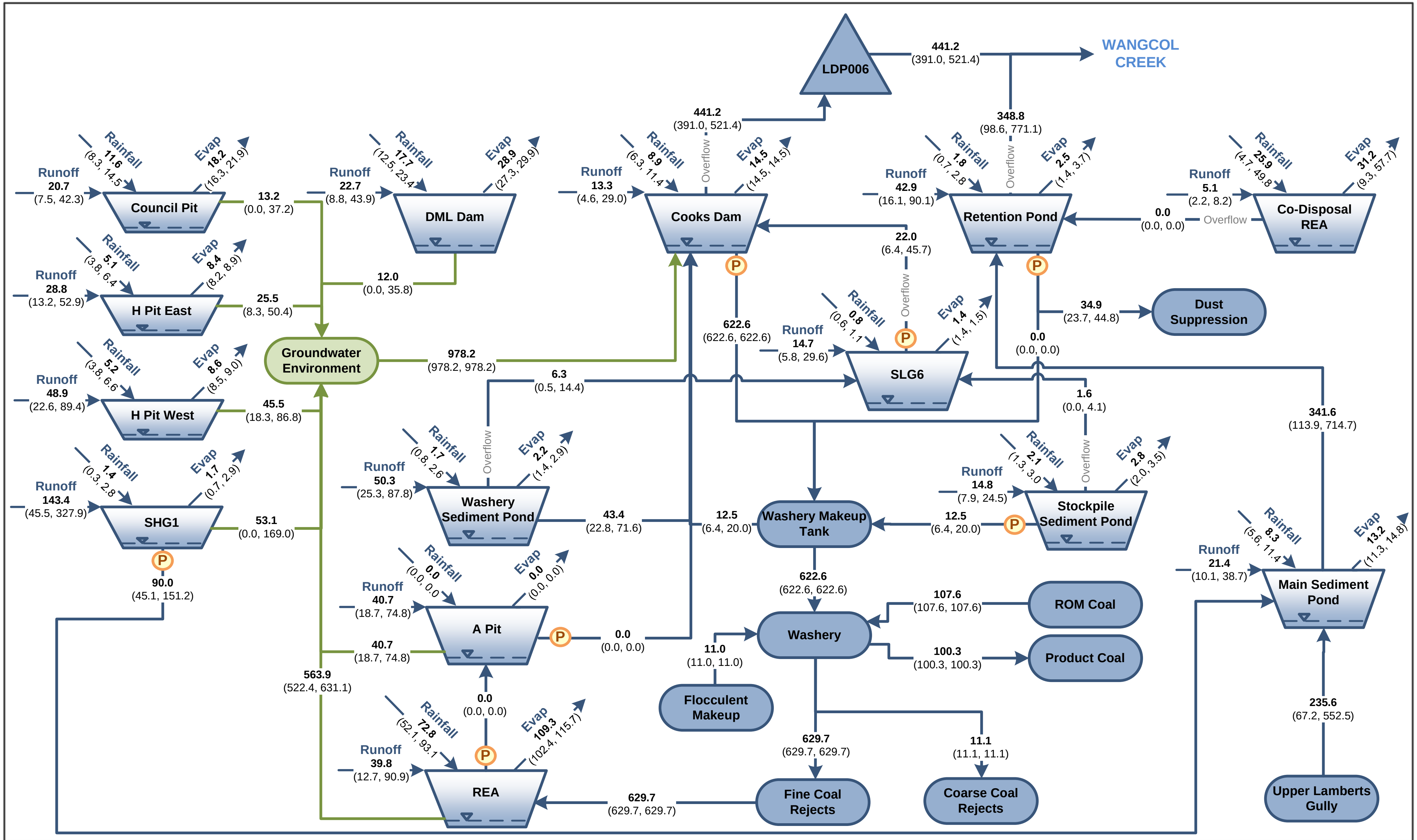
Annual water transfers
Existing conditions

Centennial Coal

DATE 9 Nov 2016

Figure 5-4

G:\22\18584\Tech\Visio\2218584-VIS-Annual_water_transfers-existing.vsdx



LEGEND

Surface Water Transfer

Underground Water Transfer

Pump

Storage

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services
Project Modification 1
Water Resources Impact Assessment

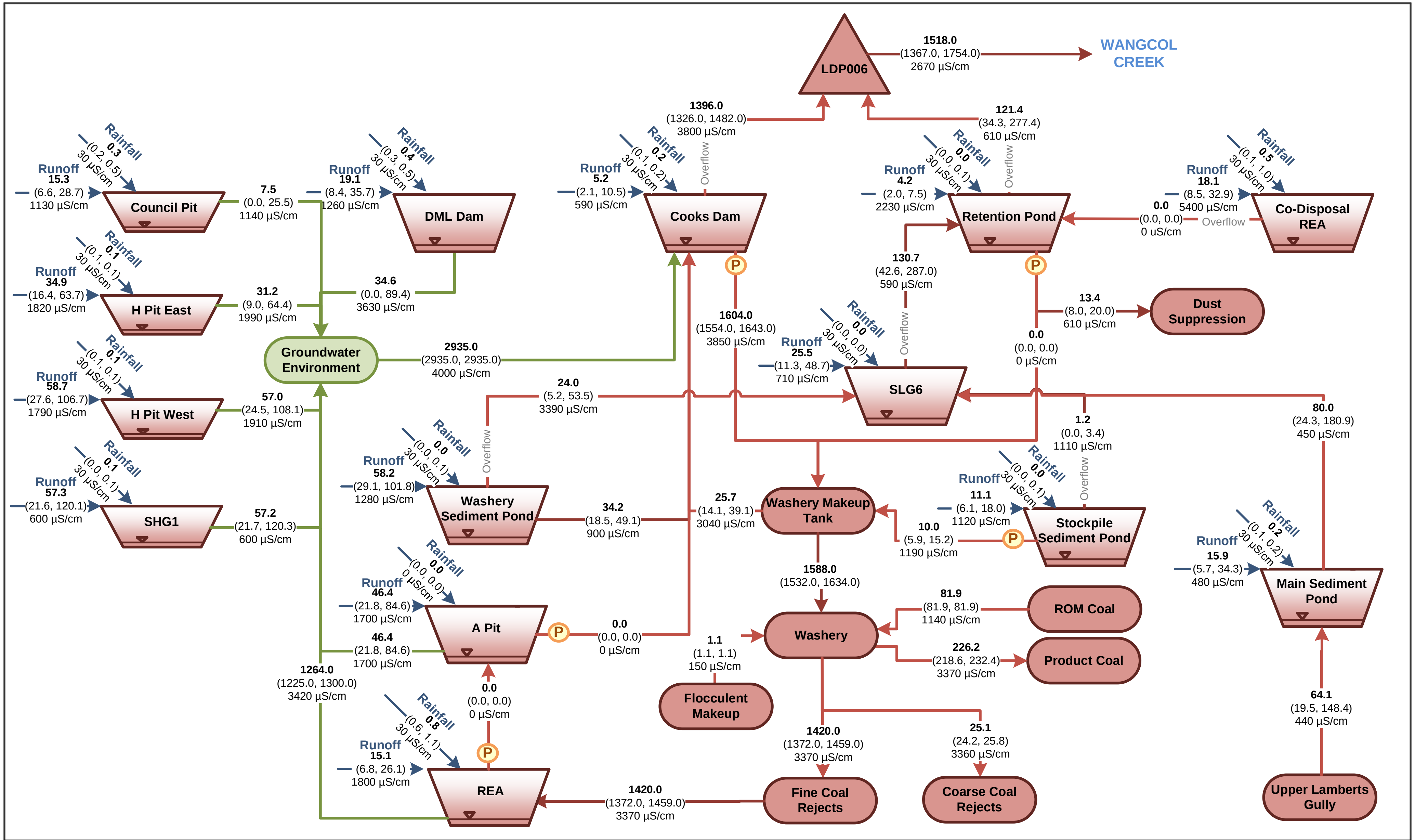
Annual water transfers
Future conditions

Centennial Coal

DATE 9 Nov 2016

Figure 5-5

G:\22\18584\Tech\Visio\2218584-VIS-Annual_water_transfers-future.vsdx



LEGEND

- Surface Water Transfer
- Underground Water Transfer
- Pump
- Storage

GHD

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services
Project Modification 1
Water Resources Impact Assessment

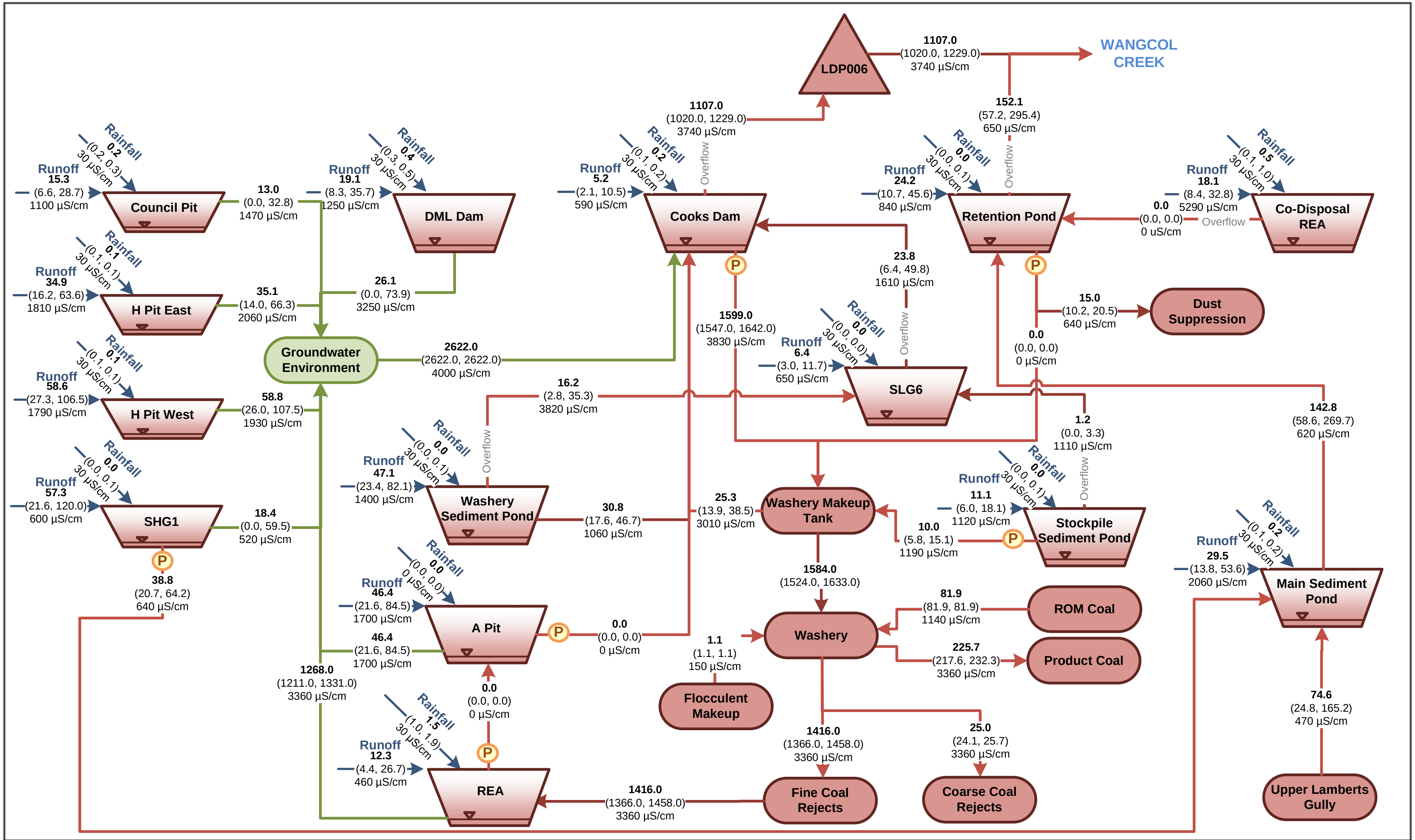
Annual salt transfers
Existing conditions

Centennial Coal

DATE 9 Nov 2016

Figure 5-6

G:\22\18584\Tech\Visio\2218584-VIS-Annual_salt_transfers-existing.vsdx



LEGEND

Surface Water Transfer

Underground Water Transfer

Pump

Storage

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services
Project Modification 1
Water Resources Impact Assessment

Annual salt transfers
Future conditions

Centennial Coal

DATE 9 Nov 2016

Figure 5-7

G:\22\18584\Tech\Visio\2218584-VIS-Annual_salt_transfers-future.vsdx

5.3 Surface water environment

5.3.1 Upstream water quality

Available surface water quality data at monitoring sites SW1, located on Neubecks Creek (a tributary of Wangcol Creek), and SW2, SW3, and the Wangcol Creek gauge, located on Wangcol Creek, have been assessed. All sites are upstream of the LDP006 discharge.

A statistical summary of the water quality at upstream monitoring sites SW1, SW2, SW3 and Wangcol Creek gauge is provided in Table 5-3. The median (50th percentile) results provided are representative of the ambient water conditions. DGVs recommended by ANZECC (2000) are provided in Table 5-3 for comparative purposes.

Physicochemical parameters

EC recorded at upstream sites SW1, SW2 and SW3 generally ranged between 50 µS/cm and 500 µS/cm. An increasing trend in EC is apparent with increasing distance downstream in the catchment, with the Wangcol Creek gauge recording EC results in the range of approximately 200 µS/cm to 2,000 µS/cm. ECs reported at SW2, SW3 and the Wangcol Creek gauge frequently exceeded the ANZECC (2000) DGV of 350 µS/cm.

The pH levels at the upstream sites indicated that the water is neutral to slightly acidic, with samples typically ranging between 6.0 and 7.6. The majority of pH levels were within the ANZECC (2000) DGVs of 6.5 and 9.0.

Results for TSS were generally below the ANZECC (2000) DGV of 25 mg/L for all upstream monitoring sites.

The majority of turbidity results have been below 60 NTU at SW1, SW2 and SW3. Maximum levels of turbidity of 281 NTU in February 2015, 174 NTU in May 2012 and 171 NTU in September 2013 have been recorded for SW1, SW2 and SW3 respectively. Approximately 30% to 40% of all turbidity results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000) DGV of 25 NTU. The majority of turbidity results for the Wangcol Creek gauge have been below the ANZECC (2000) DGV of 25 NTU, with the exception of two results in February 2014 and April 2015 of 26 NTU.

Nutrients

The majority of recorded ammonia concentrations at SW1, SW2 and SW3 have ranged between the Limit of Reporting (LOR) of 0.01 mg/L and 0.1 mg/L. All results have been below the ANZECC (2000) DGV of 0.9 mg/L. No monitoring of ammonia has been undertaken at the Wangcol Creek gauge.

Total nitrogen concentrations generally ranged between the LOR of 0.1 mg/L and 0.6 mg/L for SW1, SW2 and SW3, with a maximum level of 1.9 mg/L recorded at SW3 in September 2013. Approximately 60% to 70% of all total nitrogen results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000) DGV of 0.25 mg/L. No monitoring of total nitrogen has been undertaken at the Wangcol Creek gauge.

Concentrations of total phosphorus were typically below 0.1 mg/L at SW1, SW2 and SW3. Maximum results of 0.24 mg/L in February 2015, 0.3 mg/L in November 2013 and 0.12 mg/L in September 2013 have been recorded for SW1, SW2 and SW3 respectively. Approximately 30% to 50% of all total phosphorus results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000) DGV of 0.02 mg/L. The results for total phosphorus at the Wangcol Creek gauge were generally below the ANZECC (2000) DGV of 0.02 mg/L.

Metals

Dissolved aluminium results were found to be elevated at sites SW1 and SW2 compared to results for SW3 and the Wangcol Creek gauge. The majority of results at SW1 and SW2 were below 0.4 mg/L. The maximum concentration of dissolved aluminium of 1.18 mg/L was reported for SW2 in March 2013. Results for SW3 and the Wangcol Creek gauge displayed less variability, with results typically below the ANZECC (2000) DGV of 0.055 mg/L.

Dissolved arsenic results for upstream locations SW1, SW2 and SW3 have been below the LOR of 0.001 mg/L, with the exception of five samples collected at SW2 and one sample collected at SW3. The maximum concentration of dissolved arsenic reported was 0.003 mg/L at SW2 in March 2014. All results were below the ANZECC (2000) DGV of 0.024 mg/L. No monitoring of arsenic has been undertaken at the Wangcol Creek gauge.

Dissolved barium results generally ranged between 0.02 mg/L and 0.06 mg/L for SW1, SW2 and SW3, with the maximum result of 0.15 mg/L recorded at SW2 in February 2014. Concentrations of dissolved barium have been found to increase over time, with elevated results for 2014 compared to 2013. Limited results are available for 2015. No monitoring of barium has been undertaken at the Wangcol Creek gauge.

The majority of results for dissolved boron were below the LOR of 0.05 mg/L for all upstream monitoring locations. Concentrations reported at the Wangcol Creek gauge displayed more variability than SW1, SW2 and SW3 results, with the maximum dissolved boron result of 1.58 mg/L in August 2014 recorded for the Wangcol Creek gauge. All results were found to be below the ANZECC (2000) DGV of 0.37 mg/L, with the exception of two results recorded at the Wangcol Creek gauge.

Concentrations of dissolved cadmium were generally below the LOR of 0.0001 mg/L for all upstream sites. Dissolved cadmium was detected in several samples collected at SW1 and SW2, however all results were reported below the ANZECC (2000) DGV of 0.0026 mg/L.

Dissolved chromium concentrations were consistently reported below the LOR, equivalent to the ANZECC (2000) DGV of 0.001 mg/L, for SW2 and SW3, with one exception for SW1 in August 2014 recorded at 0.002 mg/L. No monitoring of chromium has been undertaken at the Wangcol Creek gauge.

Concentrations of dissolved copper varied throughout the monitoring period and were similar between sites SW1, SW2 and SW3, ranging between the LOR of 0.001 mg/L and 0.004 mg/L. Approximately 50% to 70% of all dissolved copper results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000) DGV of 0.0014 mg/L. No monitoring of copper has been undertaken at the Wangcol Creek gauge.

Reported dissolved iron concentrations at all sites were found to range between the LOR of 0.05 mg/L and 1 mg/L in general. A maximum of 9.84 mg/L of dissolved iron has been recorded at SW2 in February 2014.

The majority of dissolved lead results for SW1, SW2 and SW3 were recorded to be below the LOR of 0.001 mg/L. The maximum concentration recorded was 0.006 mg/L for SW3 in April 2015. All results for SW1, SW2 and SW3 were below the ANZECC (2000) DGV of 0.129 mg/L. No monitoring of lead has been undertaken at the Wangcol Creek gauge.

Dissolved manganese concentrations reported for upstream monitoring locations were found to be generally lower than the ANZECC (2000) DGV of 1.9 mg/L. Results ranged between the LOR of 0.001 mg/L and 1 mg/L, with SW1 concentrations typically lower than other sites. Less than 10% of all dissolved manganese results were found to exceed the DGV.

Dissolved mercury concentrations at SW1 were consistently reported below the LOR of 0.0001 mg/L, which is below the ANZECC (2000) DGV of 0.0006 mg/L. No monitoring of mercury has been undertaken at the Wangcol Creek gauge.

The majority of dissolved nickel concentrations varied between the LOR of 0.001 mg/L and 0.02 mg/L. Results reported for the Wangcol Creek gauge were elevated compared to results for SW1, SW2 and SW3. The ANZECC (2000) DGV of 0.011 mg/L was not exceeded at SW1, whereas less than 10% of the results for SW2 and SW3 exceeded this value. Approximately 60% of all dissolved nickel results exceeded the DGV at the Wangcol Creek gauge.

Concentrations of dissolved zinc generally varied between the LOR of 0.001 mg/L to 0.05 mg/L. The maximum result of 0.353 mg/L was reported for SW2 in February 2014. The majority of results exceeded the ANZECC (2000) DGV of 0.008 mg/L.

Other parameters

The majority of fluoride results for SW1, SW2 and SW3 were reported to be below the LOR of 0.1 mg/L. The maximum concentration of fluoride recorded was 0.5 mg/L at SW3 in March 2013. No monitoring of fluoride has been undertaken at the Wangcol Creek gauge.

The majority of oil and grease results for all upstream monitoring locations were found to be below the LOR of 5 mg/L. One sample of 6 mg/L was recorded at SW1 in June 2013. Three samples at the Wangcol Creek gauge were found to be above the detection limit, with a maximum concentration of 11 mg/L reported in April 2015.

Total cyanide results for SW1, SW2 and SW3 were generally found to be below the LOR of 0.004 mg/L. Two samples were found to be above the detection limit, with 0.006 mg/L reported for SW1 in November 2013 and for SW3 in May 2013. No monitoring of cyanide has been undertaken at the Wangcol Creek gauge.

Table 5-3 Statistical summary of surface water quality upstream of the SCSS

Parameter	Units	SW1		SW2		SW3		Wangcol Creek Gauge		DGVs (ANZECC 2000)
		Count	Median	Count	Median	Count	Median	Count	Median	
Physicochemical parameters										
EC	µS/cm	60	77	67	244	63	361	47	585	350
pH	pH units	60	6.8	73	7.0	69	7.0	47	7.1	6.5-9.0
TDS	mg/L	60	71	71	752	65	198	45	384	-
TSS	mg/L	60	5	73	5	69	7	47	5	25
Turbidity	NTU	60	12	69	9	65	17	47	3	25
Nutrients										
Ammonia	mg/L	59	0.01	70	0.02	66	0.01	-	-	0.9
TKN	mg/L	60	0.4	71	0.3	67	0.3	-	-	-
Total nitrogen	mg/L	60	0.4	71	0.3	67	0.3	-	-	0.25
Total phosphorus	mg/L	60	0.02	71	0.03	67	0.02	45	0.01	0.2
Anions										
Alkalinity (total)	mg/L	60	7	71	39	66	69.5	47	46	-
Chloride	mg/L	60	8	71	9	67	9	47	26	-
Sulfate	mg/L	60	10	71	23	67	71	47	193	-

Parameter	Units	SW1		SW2		SW3		Wangcol Creek Gauge		DGVs (ANZECC 2000)
		Count	Median	Count	Median	Count	Median	Count	Median	
Cations										
Calcium	mg/L	60	2.5	71	20	67	24	47	36	-
Magnesium	mg/L	60	2	71	10	67	14	47	23	-
Potassium	mg/L	60	2	71	4	67	5	47	5	-
Sodium	mg/L	60	7	71	15	67	23	47	38	-
Dissolved metals										
Aluminium	mg/L	60	0.145	73	0.11	68	0.02	47	0.01	0.055
Arsenic	mg/L	60	0.001	71	0.001	67	0.001	-	-	0.024
Barium	mg/L	60	0.026	68	0.026	64	0.029	-	-	-
Boron	mg/L	60	0.05	73	0.05	69	0.05	47	0.09	0.37
Cadmium	mg/L	60	0.0001	71	0.0001	67	0.001	47	0.0001	0.0002
Chromium	mg/L	15	0.001	22	0.001	20	0.001	-	-	-
Copper	mg/L	60	0.002	73	0.002	69	0.002	-	-	0.0014
Iron	mg/L	60	0.17	71	0.19	69	0.17	47	0.09	-
Lead	mg/L	60	0.001	71	0.001	67	0.001	-	-	0.0034
Manganese	mg/L	60	0.063	73	0.191	69	0.236	47	0.318	1.9

Parameter	Units	SW1		SW2		SW3		Wangcol Creek Gauge		DGVs (ANZECC 2000)
		Count	Median	Count	Median	Count	Median	Count	Median	
Mercury	mg/L	15	0.0001	22	0.0001	20	0.0001	-	-	0.0006
Nickel	mg/L	60	0.002	73	0.003	69	0.002	47	0.013	0.011
Selenium	mg/L	-	-	-	-	-	-	47	0.01	-
Zinc	mg/L	60	0.012	73	0.009	69	0.009	47	0.014	0.008
Other parameters										
Cyanide (total)	mg/L	60	0.004	68	0.004	64	0.004	-	-	-
Fluoride (total)	mg/L	60	0.1	70	0.1	66	0.2	-	-	-
Oil and grease	mg/L	60	5	70	5	66	5	47	5	-

5.3.2 SCSS surface storage water quality

A statistical summary of the water quality at the storage sites A-Pit, Cooks Dam, Main Sediment Pond, Retention Pond, SLG6, Stockpile Sediment Pond and Washery Sediment Pond is provided in Table 5-4. The median (50th percentile) results provided are representative of the ambient water conditions.

Physicochemical parameters

The EC recorded at the SCSS surface storages is shown to be variable, with median values ranging from 369 µS/cm at the Main Sediment Pond to 4125 µS/cm at A-Pit. Cooks Dam and A-Pit are shown to have the highest salinities due to their use as a dirty water storage and management dam and a sediment dam/tailings return water storage respectively.

pH at all surface water storages is circum-neutral, recorded medians range from 6.6 at Cooks Dam to 7.5 at the Main Sediment Pond and the Washery Sediment Pond.

TSS concentrations and turbidity were generally low at all sites, with the exception of A-Pit, where the median values were 1440 mg/L and 792 NTU respectively. These values are likely due to the high concentrations of coal fines in the water at A-Pit.

Nutrients

The only nutrient monitoring undertaken for the surface storages is for total phosphorous at Cooks Dam, where results have been below the laboratory LOR of 0.01 mg/L for the majority of all observations.

Metals

Sampling for dissolved metals analysis has only been performed at the surface water storage sites A-Pit and Cooks Dam. Metal concentrations appear to be higher in general at Cooks Dam, where median concentrations of boron, iron and manganese were all higher than those observed at A-Pit.

Nickel and zinc concentrations at Cooks Dam are generally elevated, and have been shown to be greater than 0.31 mg/L and 0.24 mg/L for 80% of all sampling events.

Other parameters

The majority of oil and grease results for all surface storage locations were found to be below the LOR of 5 mg/L. The highest recorded oil and grease concentration was 17 mg/L at the Retention Pond in August 2015.

Table 5-4 Statistical summary of surface water quality monitoring of SCSS storages

Parameter	Units	A-Pit		Cooks Dam		Main Sediment Pond		Retention Pond		SLG6		Stockpile Sediment Pond		Washery Sediment Pond	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical parameters															
EC	µS/cm	4	4125	34	3273	61	369	62	1146	61	1380	61	1650	61	2830
pH	pH units	3	7.0	34	6.6	61	7.5	62	7.3	61	7.0	61	7.1	61	7.5
TDS	mg/L	2	2847	32	3149	-	-	10	1106	-	-	-	-	-	-
TSS	mg/L	3	1440	34	5	61	5	61	5	61	8	61	5	61	5
Turbidity	NTU	2	792	34	10	61	16	62	14	60	23	61	15	61	10
Nutrients															
Total phosphorus	mg/L	-	-	34	0.01	-	-	-	-	-	-	-	-	-	-
Anions															
Alkalinity (total)	mg/L	-	-	16	48	-	-	2	33	-	-	-	-	-	-
Chloride	mg/L	-	-	34	248	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	34	1765	-	-	-	-	-	-	-	-	-	-
Cations															
Calcium	mg/L	-	-	34	236	-	-	-	-	-	-	-	-	-	-
Magnesium	mg/L	-	-	11	179	-	-	-	-	-	-	-	-	-	-

Parameter	Units	A-Pit		Cooks Dam		Main Sediment Pond		Retention Pond		SLG6		Stockpile Sediment Pond		Washery Sediment Pond	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Potassium	mg/L	-	-	34	37	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	-	-	34	412	-	-	-	-	-	-	-	-	-	-
Dissolved metals															
Aluminium	mg/L	2	0.015	34	0.01	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/L	3	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	3	0.47	34	1.34	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/L	-	-	34	0.0002	-	-	-	-	-	-	-	-	-	-
Copper	mg/L	3	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Iron	mg/L	3	0.05	34	0.655	-	-	-	-	-	-	-	-	-	-
Manganese	mg/L	3	0.986	34	4.025	-	-	-	-	-	-	-	-	-	-
Nickel	mg/L	-	-	34	0.324	-	-	-	-	-	-	-	-	-	-
Selenium	mg/L	-	-	34	0.01	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	-	-	34	0.28	-	-	-	-	-	-	-	-	-	-
Other parameters															
Cyanide (total)	mg/L	2	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Oil and grease	mg/L	3	5	34	5	61	5	32	5	60	5	61	5	49	5

5.3.3 LDP006 and downstream water quality

A statistical summary of the water quality of the discharge from the SCSS through LDP006 to Wangcol Creek and the downstream water quality monitoring sites Wangcol Creek DS and Wangcol Creek far DS is provided in Table 5-5. SSGVs derived for LDP006 (GHD 2014) are provided in Table 5-5 for comparative purposes, as well as the recommended ANZECC (2000) DGVs.

LDP006 water quality

Physicochemical parameters

The EC of LDP006 discharges generally ranged between 1,000 µS/cm and 4,500 µS/cm, with a median concentration of 3,040 µS/cm. An increasing trend in EC is apparent over the assessed time period. The EC recorded at LDP006 is sensitive to rainfall due to the clean catchment runoff contribution from Lamberts Gully that also flows through the discharge point. All recorded EC levels at LDP006 exceeded the SSGV (GHD, 2014) of 690 µS/cm.

The LDP006 discharge was found to be slightly acidic to slightly alkaline, with results ranging from 6.1 to 8.0. The majority of pH levels were within the ANZECC (2000) DGVs of 6.5 and 9.0.

Results for TSS were generally below the ANZECC (2000) DGV of 25 mg/L for LDP006 discharge, with the exception of one sample collected in April 2015 with a concentration of 63 mg/L.

The majority of turbidity results were below the ANZECC (2000) DGV of 25 NTU. Median turbidity was found to be 8 NTU for LDP006 discharge. With the exception of one sample collected in April 2015 of 148 NTU, all results for the LDP006 discharge from July 2013 to December 2015 have been below the ANZECC (2000) DGV.

Nutrients

Concentrations of ammonia at LDP006 were found to range between 0.01 mg/L and 0.15 mg/L, with a median concentration of 0.05 mg/L. All results have been below the ANZECC (2000) DGV of 0.9 mg/L.

The majority of total phosphorus results were below the LOR of 0.01 mg/L. A maximum result of 0.12 mg/L was reported for LDP006 discharge in June 2013. Less than 10% of all total phosphorus results exceeded the ANZECC (2000) DGV of 0.02 mg/L.

Metals

Dissolved aluminium results were found to be below the ANZECC (2000) DGV of 0.055 mg/L, with a median value of 0.02 mg/L. The maximum concentration of dissolved aluminium of 0.46 mg/L was reported in February 2013.

Dissolved arsenic results have been below the LOR of 0.001 mg/L, with the exception of one sample of 0.012 mg/L collected in December 2014. All results were below the ANZECC (2000) DGV of 0.024 mg/L.

Concentrations of dissolved boron for LDP006 discharge ranged between 0.15 mg/L and 1.83 mg/L, with a median value of 0.93 mg/L. Approximately 77% of all dissolved boron results exceeded the ANZECC (2000) DGV of 0.37 mg/L.

Dissolved cadmium concentrations ranged between the LOR of 0.0001 mg/L and 0.0004 mg/L. Approximately 12% of the dissolved cadmium results for LDP006 exceeded the ANZECC (2000) DGV of 0.0002 mg/L.

Dissolved chromium concentrations were consistently reported below the LOR, equivalent to the ANZECC (2000) DGV of 0.001 mg/L. All dissolved trivalent and hexavalent chromium results for LDP006 were found to be below the LOR of 0.01 mg/L. The only exception was one sample in April 2015, which reported a dissolved hexavalent concentration of 0.1 mg/L.

Concentrations of dissolved cobalt varied throughout the assessment period between 0.004 mg/L and 0.118 mg/L.

The majority of results for dissolved copper were below the LOR of 0.001 mg/L. However, seven samples collected at LDP006 were above the ANZECC (2000) DGV of 0.0014 mg/L, with the maximum dissolved copper result of 0.008 mg/L recorded in August 2013.

Reported dissolved iron concentrations were found to range between the LOR of 0.05 mg/L and 2.1 mg/L in general. A maximum of 6.1 mg/L was recorded at LDP006 in May 2013. Approximately 60% of all dissolved iron results were found to exceed the SSGV of 0.3 mg/L (GHD, 2014).

Dissolved lead concentrations were consistently reported below the LOR of 0.001 mg/L, with the exception of one sample in December 2014 recorded at 0.002 mg/L. All results were found to be below the ANZECC (2000) DGV of 0.0034 mg/L.

Results for dissolved manganese for LDP006 discharge varied from 0.48 mg/L to 5.22 mg/L in general, with a maximum result of 9.36 mg/L recorded in May 2013. Approximately 75% of all dissolved manganese results were found to be above the SSGV (GHD, 2014b) and ANZECC (2000) DGV of 1.9 mg/L.

Dissolved mercury concentrations at LDP006 were consistently below the LOR of 0.0001 mg/L, which is below the ANZECC (2000) DGV of 0.0006 mg/L.

Dissolved nickel concentrations varied between 0.015 mg/L and 0.48 mg/L. Approximately 75% of all results for LDP006 were found to exceed the SSGV of 0.114 mg/L.

All dissolved selenium results for LDP006 discharge were reported to be at or below the LOR of 0.01 mg/L.

Concentrations of dissolved zinc generally varied from 0.1 mg/L to 0.4 mg/L. The maximum result of 0.571 mg/L was reported for LDP006 in February 2013. Approximately 77% of dissolved zinc results were found to be above the SSGV of 0.135 mg/L. Elevated concentrations of zinc, along with dissolved nickel, are a typical indication of groundwater influenced by previous mining activities contributing to the discharge through LDP006.

Other parameters

The majority of fluoride results for LDP006 discharge were found to vary between 0.1 mg/L and 0.4 mg/L. The maximum concentration of fluoride recorded was 1.4 mg/L in March 2015.

All results for oil and grease were found to be below the LOR of 5 mg/L for LDP006.

All total cyanide results were found to be below the LOR of 0.004 mg/L for LDP006.

Downstream water quality

Physicochemical parameters

EC recorded at Wangcol Creek DS and Wangcol Creek Far DS (Figure 4-2) generally ranged between 500 µS/cm and 4,300 µS/cm. An increasing trend in EC is apparent over time, paralleling the increase in EC at LDP006. The majority of EC results for the downstream monitoring sites were found to be above the ANZECC (2000) DGV of 350 µS/cm.

The pH levels at the downstream sites indicated that the water is generally neutral in Wangcol Creek, with samples ranging between 6.3 and 7.7. The majority of pH levels were within the ANZECC (2000) DGVs of 6.5 and 9.0.

Results for TSS and turbidity were generally below the ANZECC (2000) DGVs for the downstream monitoring sites.

Nutrients

The majority of total phosphorus results for Wangcol Creek sites were found to be below the LOR of 0.01 mg/L. Maximum results of 0.1 mg/L in November 2015 and 0.06 mg/L in February 2014 have been recorded for Wangcol Creek DS and Wangcol Creek far DS respectively. Approximately 10% of all total phosphorus results for Wangcol Creek far DS exceeded the ANZECC (2000) DGV of 0.02 mg/L.

Metals

Dissolved aluminium results generally ranged between the LOR of 0.01 mg/L and 0.04 mg/L for the downstream monitoring sites. The majority of the results for the two Wangcol Creek sites were found to be below the ANZECC (2000) DGV of 0.055 mg/L.

Concentrations of dissolved boron reported for the Wangcol Creek sites displayed more variability, ranging between 0.09 mg/L and 1.5 mg/L. Approximately half of all dissolved boron results for Wangcol Creek DS and Wangcol Creek far DS were found to exceed the ANZECC (2000) DGV.

Concentrations of dissolved cadmium were generally below the LOR of 0.0001 mg/L for the downstream sites. There were no exceedances of the ANZECC (2000) DGV of 0.0002 mg/L.

In general, reported dissolved iron concentrations were found to range between the LOR of 0.05 mg/L and 1.00 mg/L.

Dissolved manganese concentrations were found to vary between 0.11 mg/L and 3.5 mg/L, with approximately 10% to 20% of all results exceeding the ANZECC (2000) DGV of 1.9 mg/L.

Dissolved nickel results varied between 0.008 mg/L and 0.203 mg/L for both Wangcol Creek downstream monitoring sites, which indicates dilution of the elevated concentrations in the LDP006 discharge. The majority of the reported results were found to be above the ANZECC (2000) DGV of 0.011 mg/L.

All dissolved selenium results for Wangcol Creek DS and Wangcol Creek far DS were found to be below the LOR of 0.01 mg/L.

Dissolved zinc results varied between 0.005 mg/L and 0.203 mg/L for the Wangcol creek downstream sites, which again indicates dilution of the elevated concentrations in the LDP006 discharge. The majority of the reported results were found to be above the ANZECC (2000) DGV of 0.008 mg/L.

Other parameters

The majority of oil and grease results for the downstream monitoring locations were found to be below the LOR of 5 mg/L. A maximum concentration of 15 mg/L was recorded at Wangcol Creek DS in August 2015.

Table 5-5 Statistical summary of surface water quality at LDP006 and downstream sites

Parameter	Units	LDP006		Wangcol Creek DS		Wangcol Creek Far DS		SSGVs (GHD 2014)	DGVs ANZECC (2000)
		Count	Median	Count	Median	Count	Median		
Physicochemical parameters									
EC	µS/cm	46	3040	46	1592	45	1650	690	350
pH	pH units	46	6.80	46	6.9	45	7.2	-	6.5-9.0
TDS	mg/L	41	2418	44	1183	43	1208	-	-
TSS	mg/L	44	5	46	5	45	5	-	25
Turbidity	NTU	43	8	46	2	45	3	-	25
Nutrients									
Ammonia	mg/L	25	0.05	-	-	-	-	-	0.9
Total phosphorus	mg/L	45	0.01	45	0.01	44	0.01	-	0.2
Anions									
Alkalinity (total)	mg/L	42	38	46	38	45	28	-	-
Chloride	mg/L	42	190	46	93	45	105	-	-
Sulfate	mg/L	42	1505	46	693	45	669	-	-
Cations									
Calcium	mg/L	42	187.5	46	94	45	104	-	-
Magnesium	mg/L	42	131	46	72	45	74	-	-

Parameter	Units	LDP006		Wangcol Creek DS		Wangcol Creek Far DS		SSGVs (GHD 2014)	DGVs ANZECC (2000)
		Count	Median	Count	Median	Count	Median		
Potassium	mg/L	42	29.5	46	13	45	13	-	-
Sodium	mg/L	42	333	46	140	45	134	-	-
Dissolved metals									
Aluminium	mg/L	42	0.02	46	0.01	45	0.03	-	0.055
Arsenic	mg/L	29	0.001	-	-	-	-	-	0.024
Boron	mg/L	34	0.945	46	0.39	45	0.38	-	0.37
Cadmium	mg/L	43	0.0001	46	0.0001	45	0.0001	-	0.0002
Chromium	mg/L	19	0.001	-	-	-	-	-	-
Cobalt	mg/L	27	0.054	-	-	-	-	-	-
Copper	mg/L	27	0.001	-	-	-	-	-	0.0014
Iron	mg/L	42	0.43	46	0.12	45	0.1	0.3	-
Lead	mg/L	24	0.001	-	-	-	-	-	0.0034
Manganese	mg/L	42	3.265	46	0.793	45	1.23	1.9	1.9
Mercury	mg/L	27	0.0001	-	-	-	-	-	0.0006
Nickel	mg/L	42	0.253	46	0.044	45	0.053	0.114	0.011
Selenium	mg/L	44	0.01	46	0.01	45	0.01	-	-

Parameter	Units	LDP006		Wangcol Creek DS		Wangcol Creek Far DS		SSGVs (GHD 2014)	DGVs ANZECC (2000)
		Count	Median	Count	Median	Count	Median		
Silver	mg/L	3	0.001	-	-	-	-	-	-
Zinc	mg/L	42	0.203	46	0.035	45	0.065	0.135	0.008
Other parameters									
Cyanide (total)	mg/L	25	0.004	-	-	-	-	-	-
Fluoride (total)	mg/L	26	0.2	-	-	-	-	-	-
Oil and grease	mg/L	42	5	46	5	45	5	-	-

5.3.4 Ecotoxicology assessment

The toxicity testing conducted by ESA on discharges from LDP006 at Springvale Coal Services site in May 2011, July 2012 and May 2016 fulfilled the criteria for NATA accredited tests (with the exception of the freshwater shrimp bioassays and the rainbowfish bioassay in May 2011 that were not NATA accredited at the time of testing) with all quality assurance/quality control parameters being met.

As discussed in Section 4.3.2, statistical analysis of the toxicity testing results provide the concentration of the sample where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibit the specific end point of the bioassay and the NOEC, which represents the highest concentration that has no effect upon the test species.

Screening bioassay results are considered to show toxicity if the results are less than 80% of the control. This is based on the quality control parameter for test acceptability used by the testing laboratory.

May 2011

A summary of the toxicity testing results from May 2011 is provided in Table 5-6 (GHD 2011).

Table 5-6 Summary of ecotoxicology assessment results (May 2011)

Bioassay	Endpoint	Concentration (95% confidence limits)		
		EC_{10}	EC_{50}	NOEC
Cladoceran	Survival	1.7% (0.4%-2.7%)	5.6% (3.6%-20%)	3.1%
	Reproduction	0.5% (0.4%-0.6%)	1.8% (1.2%-2.1%)	0.4%
Microalga	Growth	<1.6%	21% (18%-27%)	12.5%
Duckweed	Growth	4.5% (1.5%-12%)	33% (26%-36%)	24%
Fish	Survival	42%*	>100%	100%
Shrimp	Survival	>100%	>100%	100%

* 95% confidence limits not reliable.

Table 5-6 shows that the discharge sampled from LDP006 in May 2011 was toxic to the cladoceran, alga and duckweed bioassays. The cladoceran was shown to be the most sensitive to the discharge from LDP006. The rainbowfish and the shrimp tests showed no toxicity to the discharge.

July 2012

A summary of the toxicity testing results from July 2012 is provided in Table 5-7 (GHD, 2012).

Table 5-7 Summary of ecotoxicology assessment results (July 2012)

Sample	Survival (%) (mean ± SD)
Laboratory control	100 ± 0.0

Sample	Survival (%) (mean ± SD)
LDP006 discharge	50 ± 11.5

The results of the toxicity testing conducted in July 2012 and presented in Table 5-7 indicate that the LDP006 discharge was less toxic to the cladoceran than the sample collected in May 2011, as on average 50% of the cladocerans were shown to survive the 48-hour test period in undiluted discharge, whereas the EC_{50} for the eight-day survival test on the May 2011 sample was shown to be 5.6%. It should be noted that this is only an indication, as the two tests are not readily comparable due to the different exposure durations. These results show clearly that longer exposure times result in increased toxicity and that short-term exposure can underestimate the potential impacts of a long-term exposure.

May 2016

A summary of the toxicity testing results from May 2016 is provided in Table 5-8.

Table 5-8 Summary of ecotoxicology assessment results (May 2016)

Bioassay	Endpoint	Concentration (95% confidence limits)		
		EC_{10}	EC_{50}	NOEC
Cladoceran	Survival	5.7%*	8.6% (3.3%-12%)	6.3%
	Reproduction	<3.1%	<3.1%	<3.1%
Microalga	Growth	<3.1%	4.6% (3.7%-5.3%)	<3.1%
Duckweed	Growth	<3.0%	44.4% (26%-79%)	24%
Fish	Survival	Not reliable	>100%	100%
Shrimp	Survival	>100%	>100%	100%

* 95% confidence limits not reliable.

The results presented in Table 5-8 indicate that the LDP006 discharge sampled in May 2016 was toxic to the cladoceran, alga and duckweed species. The fish and the shrimp tests showed no toxicity to the discharge, similar to that observed in May 2011.

Water quality analysis

A summary of the results of the water quality analysis for the LDP006 discharge when sampled for toxicity testing is provided in Table 5-9. During these sampling events, there was only one exceedance of the EPL limits, for turbidity in July 2012.

SSGVs for LDP006 were exceeded on all three of the toxicity testing sample dates for electrical conductivity, and on the May 2011 and May 2016 sample dates for dissolved iron, manganese, nickel and zinc. GHD (2016f) concluded that, of these metals, the nickel and zinc are the most likely to be contributing to the toxicity of the LDP006 discharge.

Table 5-9 Summary of water quality results from sampling undertaken in parallel with toxicity testing

Parameter	Units	SSGVs (GHD, 2014)	EPL 3607 limits	May 2011 (GHD, 2011)	July 2012 (GHD, 2012)	May 2016		
						LDP006	Wangcol US	Wangcol DS
Physicochemical parameters								
EC	µS/cm	690	–	2,440	987	4,722	2,577	4,510
pH	pH units	–	6.5–9.0	6.78	6.94	6.70	7.07	7.40
TDS	mg/L	–	–	2,007	–	3,200	1,260	3,040
TSS	mg/L	–	30	2	15	6	<5	7
Turbidity	NTU	–	50	–	65	33	0.7	0.3
Nutrients								
Ammonia	mg/L	–	–	–	–	0.08	0.02	0.04
DOC	mg/L	–	–	–	–	9	4	8
Nitrate	mg/L	–	–	<0.01	–	0.16	0.04	0.18
Nitrite	mg/L	–	–	<0.01	–	<0.01	<0.01	<0.01
Nitrite + nitrate	mg/L	–	–	<0.01	0.13	0.16	0.04	0.18
TKN	mg/L	–	–	–	0.2	0.1	0.2	0.1
Total nitrogen	mg/L	–	–	–	0.3	0.3	0.2	0.3
Total phosphorus	mg/L	–	–	0.04	<0.01	0.05	<0.01	<0.01

Parameter	Units	SSGVs (GHD, 2014)	EPL 3607 limits	May 2011 (GHD, 2011)	July 2012 (GHD, 2012)	May 2016		
						LDP006	Wangcol US	Wangcol DS
Anions								
Alkalinity	mg/L	–	–	56	27	64	84	59
Chloride	mg/L	–	–	103	31	368	147	347
Sulfate	mg/L	–	–	1,110	403	1,900	743	1,810
Cations								
Calcium	mg/L	–	–	190	54	254	111	240
Magnesium	mg/L	–	–	136	42	208	99	196
Potassium	mg/L	–	–	26	12	47	13	42
Sodium	mg/L	–	–	191	81	637	189	592
Dissolved metals								
Aluminium	mg/L	–	–	<0.01	0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	–	–	–	0.013	0.011	0.021	0.011
Beryllium	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	–	–	1.48	–	1.58	0.37	1.41
Cadmium	mg/L	–	–	0.0008	<0.0001	0.0002	<0.0001	0.0001

Parameter	Units	SSGVs (GHD, 2014)	EPL 3607 limits	May 2011 (GHD, 2011)	July 2012 (GHD, 2012)	May 2016		
						LDP006	Wangcol US	Wangcol DS
Chromium	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	–	–	–	0.019	0.096	0.002	0.067
Copper	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.3	–	0.33	–	0.46	0.07	0.12
Lead	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.9	–	6.03	1.34	4.27	1.31	3.39
Mercury	mg/L	–	–	–	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	–	–	–	–	<0.001	<0.001	<0.001
Nickel	mg/L	0.114	–	0.392	0.082	0.477	0.053	0.398
Selenium	mg/L	–	–	<0.01	–	<0.01	<0.01	<0.01
Strontium	mg/L	–	–	–	–	1.78	0.536	1.66
Vanadium	mg/L	–	–	–	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.135	–	0.305	0.088	0.266	0.036	0.188
Total metals								
Aluminium	mg/L	–	–	–	0.25	0.01	0.02	0.01
Arsenic	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001

Parameter	Units	SSGVs (GHD, 2014)	EPL 3607 limits	May 2011 (GHD, 2011)	July 2012 (GHD, 2012)	May 2016		
						LDP006	Wangcol US	Wangcol DS
Barium	mg/L	–	–	–	0.011	0.010	0.022	0.012
Beryllium	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	–	–	–	–	1.59	0.40	1.48
Cadmium	mg/L	–	–	–	0.0002	0.0002	<0.0001	0.0002
Chromium	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	–	–	–	0.018	0.098	0.003	0.070
Copper	mg/L	–	–	–	<0.001	<0.001	<0.001	0.001
Iron	mg/L	–	–	–	–	0.77	0.30	0.27
Lead	mg/L	–	–	–	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	–	–	–	1.13	4.13	1.26	3.35
Mercury	mg/L	–	–	–	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	–	–	–	–	<0.001	<0.001	<0.001
Nickel	mg/L	–	–	0.428	0.08	0.481	0.055	0.404
Selenium	mg/L	–	–	–	–	<0.01	<0.01	<0.01
Strontium	mg/L	–	–	–	–	1.86	0.578	1.74
Vanadium	mg/L	–	–	–	<0.01	<0.01	<0.01	<0.01

Parameter	Units	SSGVs (GHD, 2014)	EPL 3607 limits	May 2011 (GHD, 2011)	July 2012 (GHD, 2012)	May 2016		
						LDP006	Wangcol US	Wangcol DS
Zinc	mg/L	–	–	–	0.094	0.268	0.011	0.201
Other parameters								
Bromide	mg/L	–	–	–	–	1.16	0.451	1.09
Fluoride	mg/L	–	–	–	–	0.2	0.2	0.2
Oil and grease	mg/L	–	10	<5	–	<5	<5	<5
Phenols	mg/L	–	–	–	–	<0.05	<0.05	<0.05
Free cyanide	mg/L	–	–	–	–	<0.004	<0.004	<0.004
Total cyanide	mg/L	–	–	–	–	<0.004	<0.004	<0.004

Dilution factor

The values as seen in Table 5-8 were modified prior to analysis in the BurrliOZ 2.0 software package (CSIRO, 2014) in order to prevent the use of extrapolated or unreliable EC_{10} values. The values used for the analysis are shown in Table 5-10, along with brief descriptions of the value derivation and justification (Warne *et al*., 2014).

Table 5-10 EC_{10} value derivations for the May 2016 BurrliOZ analysis

May 2016 Bioassay	EC_{10} value used in BurrliOZ (%)	Derivation and Justification
Cladoceran	2.2	The acute to chronic ratio (4 using the LOEC data from this study) was used due to the lack of a reliable EC_{10} endpoint.
Microalga	0.92	The EC_{50} was divided by 5 due to the lack of a reliable EC_{10} endpoint. (Warne *et al*., 2014)
Duckweed	24.2	The NOEC was used due to the lack of a reliable EC_{10} endpoint.
Fish	100	The NOEC was used due to the lack of a reliable EC_{10} endpoint
Shrimp	10	The LOEC was divided by 10 to convert from acute to chronic toxicity (Warne *et al*., 2014).

The values presented in Table 5-10 were analysed in the BurrliOZ software package (CSIRO, 2014) and the concentration of LDP006 discharge for varying species protection levels were calculated, as shown in Table 5-11. This was also performed for the LDP006 discharge tested in May 2011, as reported by GHD (2011), though it is important to note that a previous version of the BurrliOZ software was used.

Table 5-11 Dilution factors determined from ecotoxicology results

Species protection (%)	May 2011 (GHD, 2011)		May 2016	
	Concentration of LDP006 (%)	Dilution factor	Concentration of LDP006 (%)	Dilution factor
80	0.89	1:112	2.1	1:48
90	0.47	1:213	0.9	1:111
95	0.29	1:345	0.42	1:238
99	0.14	1:714	0.078	1:1,282

Discussion

The results from the May 2011 and May 2016 bioassays were similar, with the cladoceran, alga, and duckweed all showing significant toxicity. No toxicity was shown for the shrimp or fish bioassays on either of these dates.

While only screening tests were performed on the sample taken in July 2012, the results indicate a lower acute toxicity for the cladoceran when compared to the results from the other two testing rounds, though it is important to note that different test protocols were used. This assumption agrees with the water quality results for July 2012, which indicate that the discharge at the time of sampling was less saline than the other two occasions, with lower dissolved metal concentrations.

Analysis of the water quality results for LDP006 indicates that dissolved nickel and zinc concentrations in the discharge are probable contributors to the toxicity observed from the bioassays as the cladocerans and algal species are known to be sensitive to these metals (ANZECC, 2000).

Table 5-11 shows that the BurrliOZ 2.0 software package (CSIRO, 2014) predicts that significant dilution of the LDP006 discharge would be required in order to provide the listed species protection levels, with a minimum dilution factor of 1:48 for the 80 percent level in May 2016.

5.3.5 Summary of existing surface water conditions

Water quality in the Wangcol and Neubecks creek catchments upstream of the SCSS shows evidence of impacts from historical landuse, as salinities were shown to be slightly elevated for an upland creek and numerous exceedances of the ANZECC (2000) DGVs have been noted for total nitrogen and total phosphorous concentrations. Regular exceedances of the relevant DGVs were also observed for aluminium and zinc.

Surface storages at the SCSS generally exhibit elevated salinities and metal concentrations due to water reuse at the site. Of the metals, elevated concentrations of nickel and zinc in particular have been observed, which are common water quality indicators associated with historical coal mine workings.

The LDP006 discharge is moderately saline, and salinity has been shown to be increasing over time. In contrast to the surface water in Wangcol Creek upstream of the discharge, LDP006 exhibits low nutrient concentrations, however dissolved concentrations of the metals boron, iron, manganese, nickel and zinc are generally high. The impact of the discharge on Wangcol Creek is evident in the salinities and metal concentrations of the downstream sites, however significant dilution is observed at the Wangcol Creek far DS site.

The LDP006 discharge has been shown by ecotoxicology assessments to be toxic to the cladoceran, microalga and duckweed bioassays. Use of the BurrliOZ 2.0 software package (CSIRO, 2014) indicated that significant dilution of the discharge would be required to attain the species protection levels as prescribed in ANZECC (2000).

5.4 Groundwater environment

5.4.1 Local groundwater elevations

There are currently 15 monitoring bores located within the SCSS, the details and locations for which are presented in Table 4-3 and Figure 4-3 respectively. Groundwater elevation data has been collected from these bores on either a quarterly or monthly basis since 2013.

The hydrogeology model report for the SCSS (GHD 2016b) has been provided as Appendix B. This model indicated that seepage from the REA is possible due to the elevated position of the REA on the SCSS and the lack of any low permeability lining. Modelled groundwater contours indicate that groundwater generally flows to the north east, following the dip in the regional strata, whereas groundwater contours developed using the observed groundwater monitoring data indicate a general west to east hydraulic gradient.

5.4.2 Local groundwater quality

Historical mining within the SCSS and the surrounding areas has had a long-term influence on groundwater quality. The groundwater environment specific to the SCSS is dominated by geochemical influences of the seams that have been exposed. Much of the historical open cut workings have been backfilled with overburden material, with some existing remanent voids being utilised as REAs and potential landfill areas.

A statistical summary of the groundwater quality at boreholes BH1, BH2, BH3, BH4, BH5, BH6, BH7 and BH8 is provided in Table 5-12. The median (50th percentile) results provided are representative of the ambient water conditions.

The results presented in Table 5-12 indicate a variable groundwater quality with elevated concentrations of sulfate, iron, manganese, nickel and zinc, which are typical indicators for the water quality of the historical workings. Bores BH4 and BH5 are shown to be the least saline whereas BH8 is the most saline and is somewhat representative of water quality within DML and Cooks dams, as the bore represents the shallow groundwater prior to seepage into these dams.

It should be noted that groundwater is reused in washing of coal at the SCSS. It is likely that through the reuse of groundwater, concentrations of some parameters have increased in concentration as coal reject is emplaced and some water from the washing process re-enters the groundwater.

5.4.3 Groundwater users

Licensed groundwater users were identified by searching the NSW groundwater bore database (DPI-Water, 2016b) within a 7.5 km radius of the proposed WTP site in the SWTP. The search identified 121 bores, with the majority registered as monitoring bores (47 bores) and stock and/or domestic use (47 bores). The remaining bores were registered for mining or dewatering, irrigation and industrial use. There were nine bores with an unknown use. The locations of these bores are shown in Figure 5-8.

5.4.4 Groundwater Dependent Ecosystems

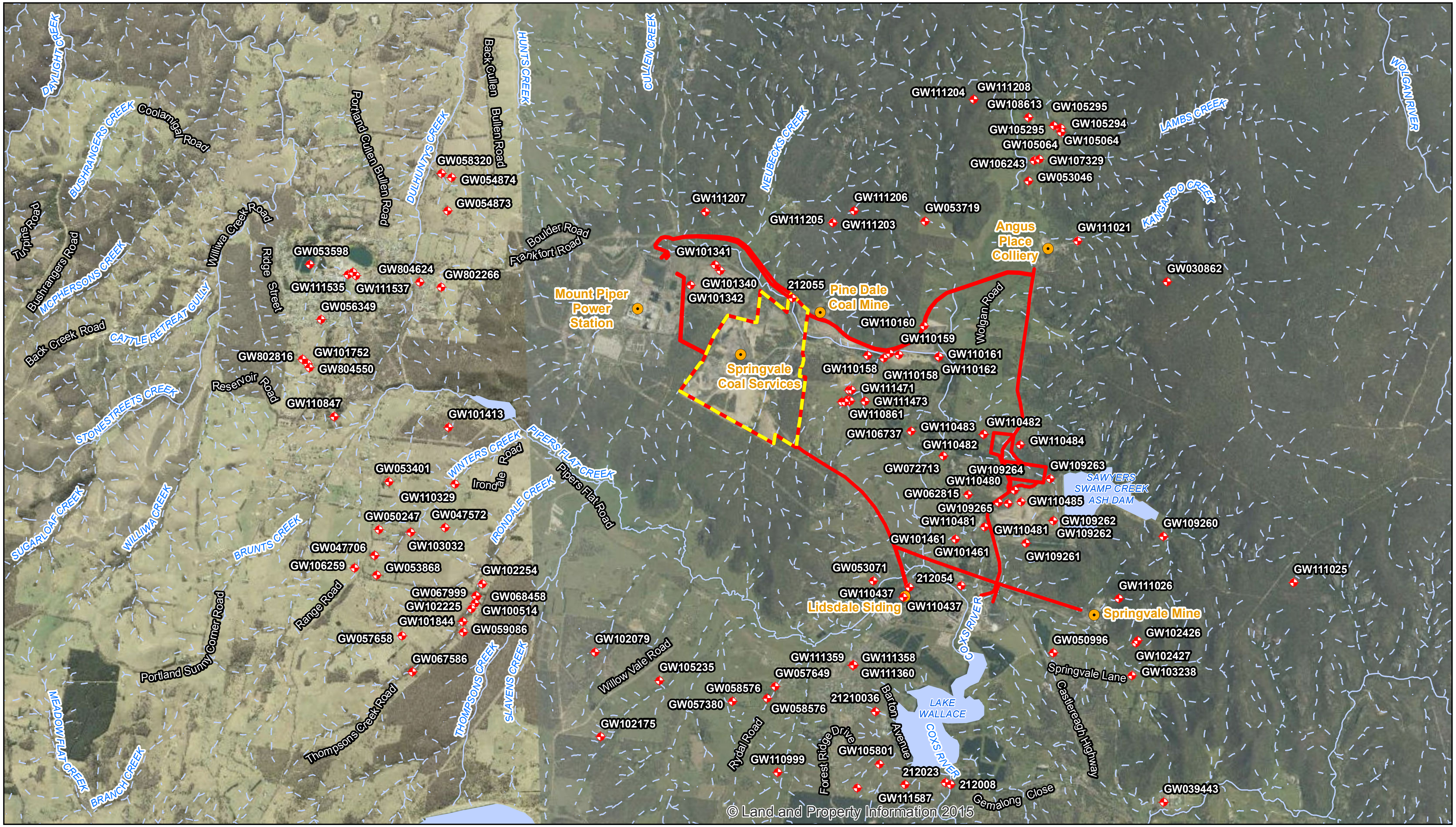
No GDEs have been identified as part of the Western Coal Services Project (RPS 2013b) for the SCSS.

Table 5-12 Statistical summary of groundwater quality at SCSS borehole sites

Parameter	Units	BH01		BH02		BH03		BH04		BH05		BH06		BH07		BH08	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical parameters																	
EC	µS/cm	7	3820	7	969	7	1092	1	395	1	489	7	2320	7	1092	7	4460
pH	pH unit	7	5.84	7	7.0	7	4.14	1	6.7	1	7.01	7	6.43	7	6.88	7	6.22
TDS	mg/L	6	3283	6	666	6	849	1	266	1	334	6	1958	6	787	6	3741
TSS	mg/L	5	46	5	654	5	41	1	364	1	95	5	31	5	95	5	26
Nutrients																	
Ammonia	mg/L	6	0.01	6	0.01	6	0.01	1	0.02	1	0.01	6	0.01	6	0.01	6	0.01
Total nitrogen	mg/L	6	0.02	6	0.16	6	0.03	1	0.31	1	0.06	6	0.065	6	0.12	6	0.04
Anions																	
Alkalinity (total)	mg/L	6	84	6	237	6	1	1	192	1	240	6	101.5	6	305.5	6	51.5
Chloride	mg/L	6	276.5	6	96	6	45	1	12	1	24	6	176	6	35	6	322
Sulfate (total)	mg/L	5	1810	5	72	5	465	1	26	1	42	5	1010	5	267	5	2120

Parameter	Units	BH01		BH02		BH03		BH04		BH05		BH06		BH07		BH08	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Cations																	
Calcium (dissolved)	mg/L	6	145	6	80	6	50.5	1	44	1	53	6	161	6	117.5	6	227
Magnesium (dissolved)	mg/L	6	243	6	37	6	48.5	1	18	1	25	6	95.5	6	52	6	172
Potassium (dissolved)	mg/L	6	11	6	10.6	6	5	1	9	1	9	6	16	6	15	6	39
Sodium (dissolved)	mg/L	6	351.5	6	32.5	6	37.5	1	16	1	18	6	210.5	6	20	6	501.5
Metals																	
Aluminium (total)	mg/L	7	0.27	7	4.57	7	8.02	1	2.65	1	1.12	7	0.17	7	1.02	7	0.47
Boron (total)	mg/L	6	0.575	6	0.05	6	0.05	1	0.05	1	0.05	6	0.63	6	0.05	6	1.535
Cadmium (total)	mg/L	6	0.0002	6	0.0001	6	0.0004	1	0.0001	1	0.0001	6	0.0001	6	0.0001	6	0.00015
Iron (total)	mg/L	6	7.965	6	11.765	6	60	1	12.2	1	3.42	6	11.2	6	4.45	6	4.885
Manganese (total)	mg/L	6	8.575	6	1.165	6	6.19	1	0.597	1	0.103	6	2.58	6	0.258	6	3.98

Parameter	Units	BH01		BH02		BH03		BH04		BH05		BH06		BH07		BH08	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Nickel (dissolved)	mg/L	6	0.6125	6	0.0065	6	0.2405	1	0.01	1	0.007	6	0.085	6	0.003	6	0.3375
Nickel (total)	mg/L	6	0.705	6	0.0165	6	0.3015	1	0.022	1	0.01	6	0.0955	6	0.007	6	0.3995
Selenium (dissolved)	mg/L	6	0.01	6	0.01	6	0.01	1	0.01	1	0.01	6	0.01	6	0.01	6	0.01
Zinc (dissolved)	mg/L	6	0.495	6	0.0155	6	0.752	1	0.062	1	0.07	6	0.0485	6	0.019	6	0.258
Zinc (total)	mg/L	6	0.618	6	0.226	6	1.003	1	0.022	1	0.087	6	0.0695	6	0.0855	6	0.3735



Paper Size A4

0 500 1,000 2,000 3,000

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Study area
- Licensed Groundwater Bore
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

GHD

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Licensed groundwater bores

Figure 5-8

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

5.5 Stream health

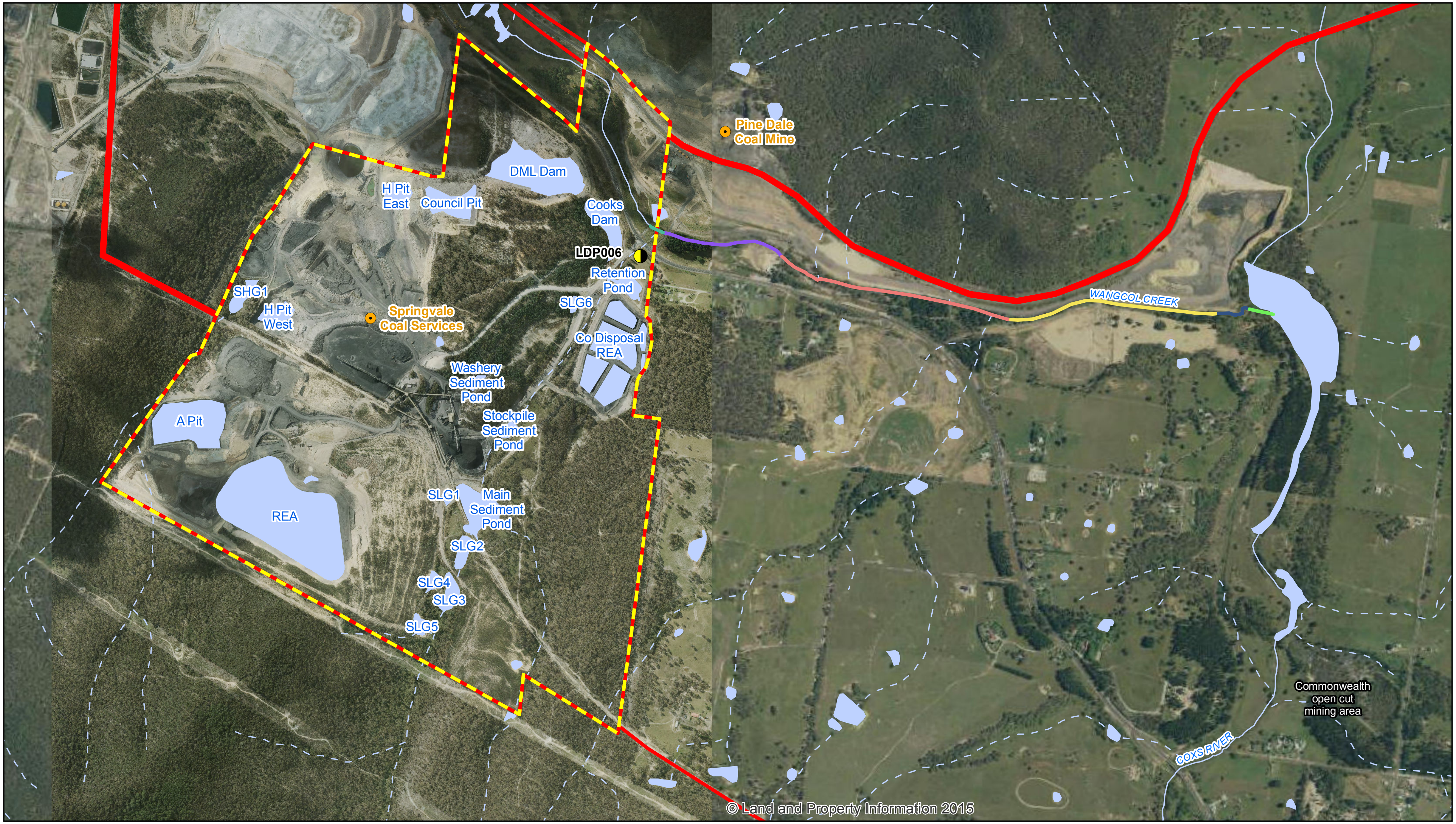
5.5.1 Geomorphology of Wangcol Creek

At LDP006, Wangcol Creek has a catchment area in the order of 20 km^2 and is a 4th order watercourse. Downstream of LDP006, Wangcol Creek flows an approximate further 2.2 km before discharging into the Coxs River. At this location, the Coxs River is characterised by a lake-like environment created by the past capture of the river into the open cut pit voids of the abandoned Commonwealth Mine. Downstream of LDP006, Wangcol Creek exhibits four different watercourse types (as per the River Styles framework, Brierley and Fryirs, 2005). The water course types identified were:

- Valley fill system–These are relatively flat, featureless valley floor surfaces, lacking a continuous, well-defined channel. Typically, the substrate comprises of fine alluvial silts and muds vertically deposited out of suspension.
- Low sinuosity, gravel bed system–Exhibits a low-sinuosity channel surrounded by continuous floodplains. The banks of this stream type are relatively cohesive and stable due to the presence of fine-grained materials (clay, mud and silt). Bed sediments typically consist of gravel and cobble materials.
- Partly confined, gravel bed system–Exhibits a low-sinuosity channel set within a partly confined valley, whereby floodplain continuity is disrupted by the channel having regular contact with the valley margins. Bed sediments typically consist of gravel and cobble materials.
- Gorge system–Exhibits a single, low-sinuosity channel confined within bedrock or terrace margins with no floodplains.

The headwaters of tributaries to Wangcol Creek largely drain forested catchments; however, the middle and lower reaches have been disturbed by mining and agricultural practices. In particular, the channel is highly modified downstream of LDP006, having been diverted through excavation into in situ soil or bedrock materials as well as being bounded by overburden and/or reject coal material in sections. Despite this, the channel is generally stable and the reach of Wangcol Creek downstream of LDP006 is considered to be in poor to moderate geomorphic condition.

Based on the watercourse types and condition, the assessed extent of Wangcol Creek downstream of LDP006 has been subdivided into eight reaches as mapped in Figure 5-9 and summarised in Table 5-13.



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Water Resources Impact Assessment

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Date 09 Nov 2016

Distribution of reaches along Wangcol Creek downstream of LDP006

Figure 5-9

G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218584\2218584_WRIA010_WangcolCreek_Reaches_1.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial Coal: Imagery, 2016. Created by: tmorton

Table 5-13 Wangcol Creek geomorphology summary

Reach	Length	Type	Condition	Comments	Photographs	
WC1	N/A, extends upstream from LDP006 discharge entry point.	Valley fill	Moderate	Swampy area with no defined channel. Active headcut zone at downstream extent. LDP006 discharges enter Wangcol Creek uncontrolled on the right bank upstream of culvert crossing causing bank erosion.	 Upstream view towards headcut zone.	 Discharges are eroding the right bank upstream of the culvert Pine Dale Access Road crossing.
WC2	440 m	Low-sinuosity, gravel bed	Poor	Low-sinuosity channel with limited in-channel diversity. Channel is considered to have been largely excavated into the surrounding in situ material including clay and bedrock.	 Clay and conglomerate exposed in right bank.	 . Uniform excavated channel

Reach	Length	Type	Condition	Comments	Photographs	
WC3	845 m	Low-sinuosity, gravel bed	Poor to moderate	In the upstream section, the channel is inset within natural materials and banks are prone to localised erosion. In the downstream section, the channel is deeper and bounded by overburden and coal reject material.	 Upstream section displays localised erosion of banks composed of in situ alluvial silt.	 View of right bank composed of coal reject materials.
WC4	740 m	Partly confined, gravel bed	Moderate	Typically, stable channel with well vegetated banks composed of overburden materials. Valley is confined by Pine Dale haul road to the north and a flood and/or visual bund to the south of the channel.	 Upstream view with southern bank adjacent to Pine Dale haul road.	 Downstream view displaying right bank composed of overburden.
WC5	130 m	Partly confined, gravel bed	Poor	Section impacted by disused railway bridge crossing. Shotcrete channel to protect crossing which discharges via an approximate 1 m drop into a large scour pool with eroding banks.	 Upstream view of rail crossing and shotcrete channel	 Large scour pool downstream of rail crossing with eroding banks.

Reach	Length	Type	Condition	Comments	Photographs	
WC6	85 m	Gorge	Poor	Excavated channel in bedrock before discharging into flooded open pit void of the Commonwealth Mine.	 Downstream view of gorge section.	 Wangcol Creek discharges to flooded void of Commonwealth Mine.

5.5.2 Aquatic ecology of Wangcol Creek

Instream aquatic ecology monitoring of Wangcol Creek is undertaken in conjunction with Angus Place Colliery, the SCSS and Springvale Mine, referred to as the Centennial West aquatic ecology monitoring program. The monitoring program considers other catchment and creek systems in the region which include Wolgan Creek and the shrub swamp systems within the Newnes Plateau.

The existing condition of the aquatic ecology of Wangcol Creek was assessed within the Aquatic Ecology Impact Assessment (GHD, 2016d) for the SWTP and is summarised below. The locations of the sample sites discussed within this section are provided in Figure 4-2.

GHD (2016d) described Wangcol Creek as an ephemeral stream which is highly degraded due to past land-use activities. Minimal instream habitat remains within the creek – with evidence suggesting that site WC2 is the most degraded.

Macroinvertebrate sampling of four sites distributed along Wangcol Creek over the past four years has indicated significant variation. Recent sampling found more taxa in the two upstream and the furthest downstream sites. Results indicate that site WC2, which is located within the mixing zone of the LDP006 discharge, has the lowest level of macroinvertebrate diversity. Signs of recovery in terms of habitat condition and macroinvertebrate diversity were noted at site WC3.

The vegetation health of Wangcol Creek was determined to be of a moderate level, with some degradation and incompleteness in riparian vegetation extent. Historical sampling of the site has found that the health of Wangcol Creek has improved with bank stabilisation works. Previous development and current mining land uses have degraded some reaches of Wangcol Creek.

6. Impact assessment

6.1 Proposed water management

The proposed change to the existing water management at the SCSS (as outlined in Section 5.1) is a residual transfer system relating to the SWTP. A detailed water cycle schematic of the SWTP is provided in Figure 6-1 where the residual stream is identified as the management of a wastewater volume from the pre-treatment process. The pre-treatment process involves solids removal via a lamella clarifier. Clarified effluent would then be directed to the water treatment process with residuals (thickened solids) transferred to the REA at SCSS. Further details on the infrastructure required for this process is discussed in Section 6.1.1.

The proposed modification to the WCS consent SSD-5579 relates to the receipt of the residuals from the WTP proposed in the SWTP. Hence only the impacts of the residuals transfer on the SCSS water management system are assessed in the WRIA.

6.1.1 Residuals transfer

As discussed in Section 6.1, the residual is the transfer of thickened solids from the pre-treatment process proposed as part of the SWTP, to the REA. The residuals transfer pipeline from the WTP to the REA will be terminated as an open end pipe arranged as a distribution header which will allow the water to discharge at multiple points with low velocity and low volumetric flow to avoid localised erosion within the REA.

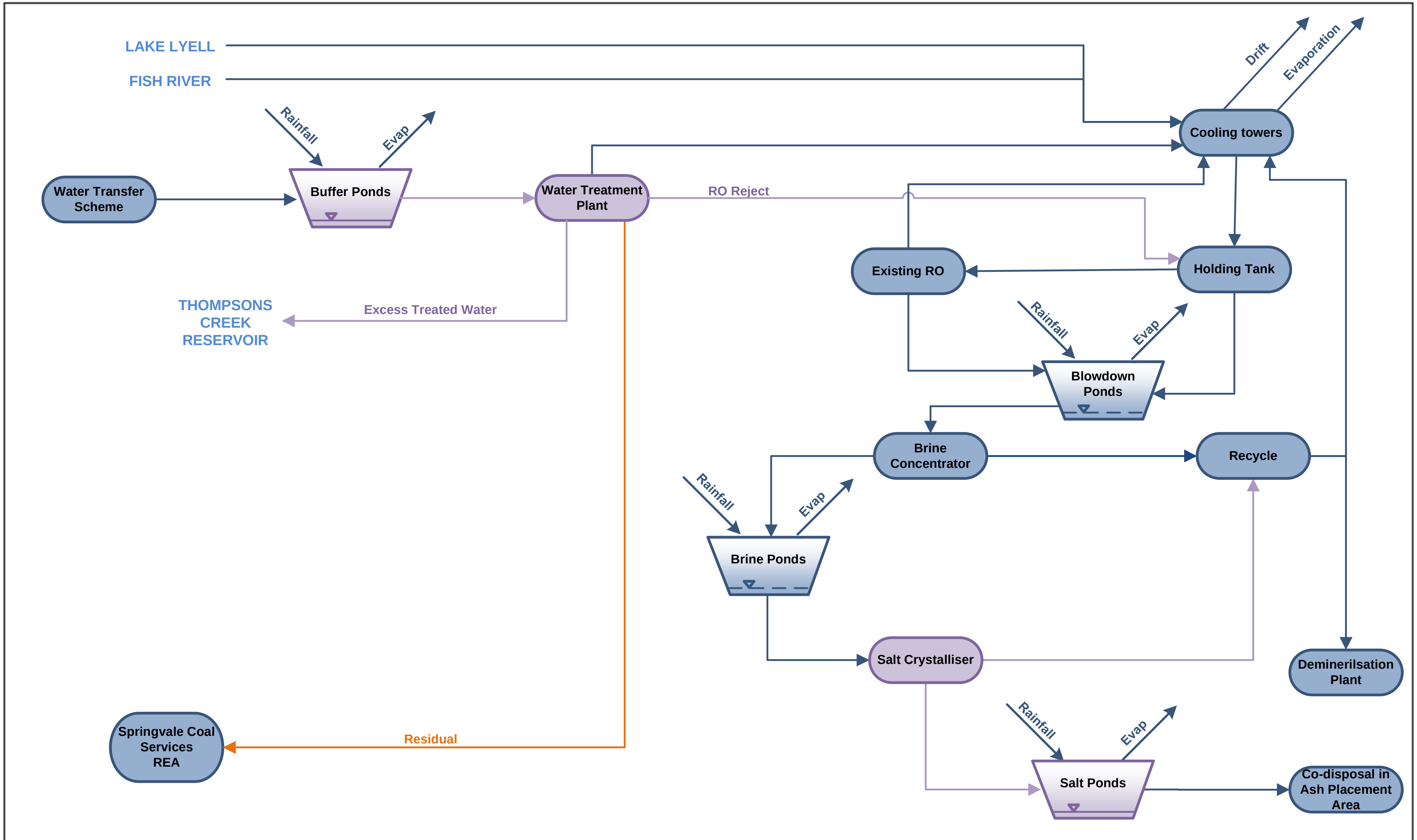
The pipeline will be capable of transferring residuals at a flow rate of 30 L/s in batch flow periods. The maximum transfer rate to the REA from the WTP will be 0.43 ML/day.

The clean-in-place (CIP) waste from membrane cleaning at the WTP will also be transferred to the REA once every three months. The volume of these residuals is predicted to be approximately 10 kL, which is minor in comparison to the standard residual.

The CIP solution will consist of treated water, acids and bases as the main cleaning agents. Typically, hydro-chloric acid is used as is the common industry practice. Prior to the CIP solution being discharged into the residual stream, the solution will be neutralised and stored. Appropriate blending of the CIP solution will occur into the residual stream to achieve a consistent overall quality target. Additional treatment chemicals may be introduced to the CIP solution, which may include surfactants and chelating agents depending upon the final water treatment plant design and operation, however all chemicals are proposed to be biodegradable and compatible with the receiving environment. Further clarification of the specific CIP solution compounds, including material safety data sheets, are to be provided as part of the WTP commissioning period and assessment.

6.2 Predicted residual water quality

The assumed chemical properties of the residual stream have been calculated based on jar testing performed by Hunter Water. The required dosing rate of ferric chloride was assumed to be 90 mg/L (as $FeCl_3$) for an average flow of 30 ML/day and 50 percentile TSS of 46 mg/L, and 180 mg/L for the maximum flow of 36 ML/day with a TSS of 721 mg/L. It is important to note that these dosing rates were based on jar tests undertaken on a sample of water taken from a single bore, and therefore may not accurately represent the water to be supplied to the WTP from Springvale Mine.



LEGEND

- Surface water transfer
- Proposed water transfer
- Covered as part of Springvale Water Treatment Plant Project
- Storage

LOCATION	SCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Western Coal Services Project Modification 1
Water Resources Impact Assessment

Water Cycle for Springvale Water Treatment Plant and Mt Piper Power Station

Centennial Coal

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Figure 6-1

G:\22\18584\Tech\Visio\2218584_FIG6-1_MPPS Water Cycle Schematic.vsdx

Table 6-1 shows the TSS and total metals concentrations of the raw water used for the jar tests, and those predicted for the thickened residual stream based on the aforementioned dosing rates. These results are considered conservative as the assessment assumes that the pre-treatment process captures all of the constituents listed, whereas in practice some of these constituents will pass through to the reverse osmosis process.

Table 6-1 Assumed residual stream properties based on jar tests

Analyte	Units	Raw Mine Water		Residual Stream	
		50%ile	Max	50%ile	Max
EC at 25°C	µS/cm	1167	1310	1170*	2500
pH (20%ile to 80%ile range)	pH units	7.81-7.97	8.28	7.81-7.97	6.5-8.5**
TSS	mg/L	46.21	721	3224.0	60362.7
Aluminium (total)	mg/L	0.4	1.57	27.9	131.4
Arsenic (total)	mg/L	0.04	0.07	2.79	5.86
Cadmium (total)	mg/L	0.0002	0.0002	0.014	0.017
Copper (total)	mg/L	0.002	0.006	0.14	0.50
Cobalt (total)	mg/L	0.002	0.002	0.14	0.17
Nickel (total)	mg/L	0.005	0.008	0.35	0.67
Zinc (total)	mg/L	0.02	0.07	1.4	5.9
Iron (total)	mg/L	1.26	2.22	2251.8	5379.1
Boron (total)	mg/L	0.08	0.12	5.6	10.0
Manganese (total)	mg/L	0.02	0.07	1.4	5.9
Lead (total)	mg/L	0.001	0.001	0.07	0.08
Mercury (total)	mg/L	0.0001	0.0001	0.007	0.008
Chromium (total)	mg/L	0.002	0.002	0.14	0.17
Selenium (total)	mg/L	0.01	0.01	0.7	0.8
Total Solids	kg/d	-	-	2316.8	28189.1

* based on the makeup of the water that would form the residuals, the EC is expected to be equal to or less than the median raw water EC. This outcome however is to be confirmed during the commissioning phase of the SWTP.
** maximum required to be within range provided.

Table 6-2 shows the results for the water quality samples taken at the Centennial Newstan Colliery WTP on 23 September 2016. The table shows that the Newstan Colliery residual stream can be considered comparable to the predicted residual in terms of pH and salinity.

Comparison of the 50th percentile raw water condition used for the jar tests (Table 6-1) and the raw water supply to the Newstan Colliery WTP (Table 6-2) indicates that, in terms of total metals concentrations, the former has:

- Comparable concentrations of cadmium, chromium, cobalt, copper, lead and nickel.
- Higher concentrations of aluminium, arsenic, iron, selenium and zinc.
- Lower concentrations of boron and manganese.

Comparison of the dissolved and total metals concentrations of the Newstan Colliery residual stream indicates that ferric chloride dosing is effectively removing arsenic, chromium, cobalt, copper, iron, lead and zinc from solution, as the total concentrations of these metals all exceeded the dissolved concentrations, which were below the laboratory LOR. This same comparison shows that a proportion of the total aluminium, barium, boron, manganese and nickel concentrations remains in solution following dosing, indicating the possibility of the residual transfer to the REA impacting upon concentrations of these metals in the groundwater at SCSS.

The risk of exceeding the DGV for aluminium (ANZECC 2000) at LDP006 is slightly increased by the transfer of residuals to the REA, as a significant proportion of the total concentration is shown to remain in solution, at a concentration which exceeds the DGV of 0.055 mg/L. It is also possible that the raw water that will be received by the proposed WTP will have higher concentrations of aluminium, as indicated by the jar testing results. This would also increase the risk of exceeding the DGV for aluminium at LDP006.

Of the other metals shown to have observable dissolved concentrations following ferric chloride dosing, there are only DGVs/SSGVs for manganese and nickel. The predicted concentrations of these metals in the residual are predicted to be lower than those of the present day LDP006 discharge. As such, the residual is predicted to dilute the concentrations of these metals as it reports to LDP006.

Table 6-2 Raw water and residual stream quality at Newstan Colliery WTP 23/09/16

Analyte	Units	Raw water supply to Newstan Colliery WTP	Newstan Colliery residual stream
Physicochemical parameters			
pH	pH unit	8.4	8.2
EC at 25°C	µS/cm	2400	2500
Anions			
Chloride	mg/L	380	400
Sulfate	mg/L	100	99
Total alkalinity as CaCO3	mg/L	740	780
Cations			
Calcium	mg/L	29	31
Magnesium	mg/L	11	11
Potassium	mg/L	5.5	5.1
Sodium	mg/L	450	470
Dissolved Metals			
Aluminium	mg/L	<0.05	0.46
Arsenic	mg/L	<0.001	<0.001
Barium	mg/L	0.23	0.19
Boron	mg/L	0.16	0.17
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001
Copper	mg/L	0.002	<0.001
Iron	mg/L	<0.05	<0.05
Lead	mg/L	0.001	<0.001
Manganese	mg/L	0.048	0.075
Nickel	mg/L	0.007	0.008
Selenium	mg/L	<0.001	<0.001
Zinc	mg/L	<0.005	<0.005
Total metals			
Aluminium	mg/L	0.12	0.75
Arsenic	mg/L	0.001	0.01
Barium	mg/L	0.24	0.74

Analyte	Units	Raw water supply to Newstan Colliery WTP	Newstan Colliery residual stream
Boron	mg/L	0.18	0.2
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.001	0.018
Cobalt	mg/L	<0.001	0.002
Copper	mg/L	0.003	0.008
Iron	mg/L	0.24	89
Lead	mg/L	0.003	0.016
Manganese	mg/L	0.078	0.34
Nickel	mg/L	0.007	0.012
Selenium	mg/L	<0.001	<0.001
Zinc	mg/L	0.006	0.037

From the review of the results obtained from the Newstan Colliery WTP case study it is clear that for parameters such as pH and EC that little variance is observed between the raw water feed and the residual stream. This should be noted when Newstan Colliery WTP results are compared with the results of the jar testing undertaken for the Project. This supports the conservatism stated on the results of the jar testing process.

6.3 Water and salt balance assessment

6.3.1 Water balance results

Table 6-3 presents the key information from the water balance model in the form of average annual water transfers for the proposed conditions i.e. the transfer of residuals to the REA. Existing and future conditions have also been provided for comparative purposes. As the table shows, discharges through LDP006 are predicted to decrease under the future conditions due to the construction of the CWD. Following the transfer of residuals to the REA this discharge rate is predicted to increase, though remain below the discharge rate of the existing current conditions.

Table 6-3 Predicted annual average water transfers

	Existing conditions (ML/year)	Future conditions (ML/year)	Proposed conditions (ML/year)
Inputs			
Direct rainfall	137	163	169
Catchment runoff	743	743	743
ROM coal moisture	108	108	108
Flocculant makeup	11	11	11
Seepage into Cooks Dam	1095	978	1109
WTP residuals	0	0	157
Total Inputs	**2094**	**2003**	**2298**
Outputs			
Evaporation	201	243	253
Dust suppression	32	35	35
Product coal moisture	100	100	100
Coarse coal rejects moisture	11	11	11
Discharge through LDP006	848	441	570

	Existing conditions (ML/year)	Future conditions (ML/year)	Proposed conditions (ML/year)
Discharge via clean water diversion	0	350	350
Seepage into historical mine workings	831	752	909
Retained in REA	71	71	71
Total Outputs	**2094**	**2003**	**2297**
Change in storage			
Total change in storage	**0**	**0**	**0**
Balance	**0**	**0**	**0**

A comparison of daily discharge probabilities via LDP006 for all conditions is provided in Figure 6-2.

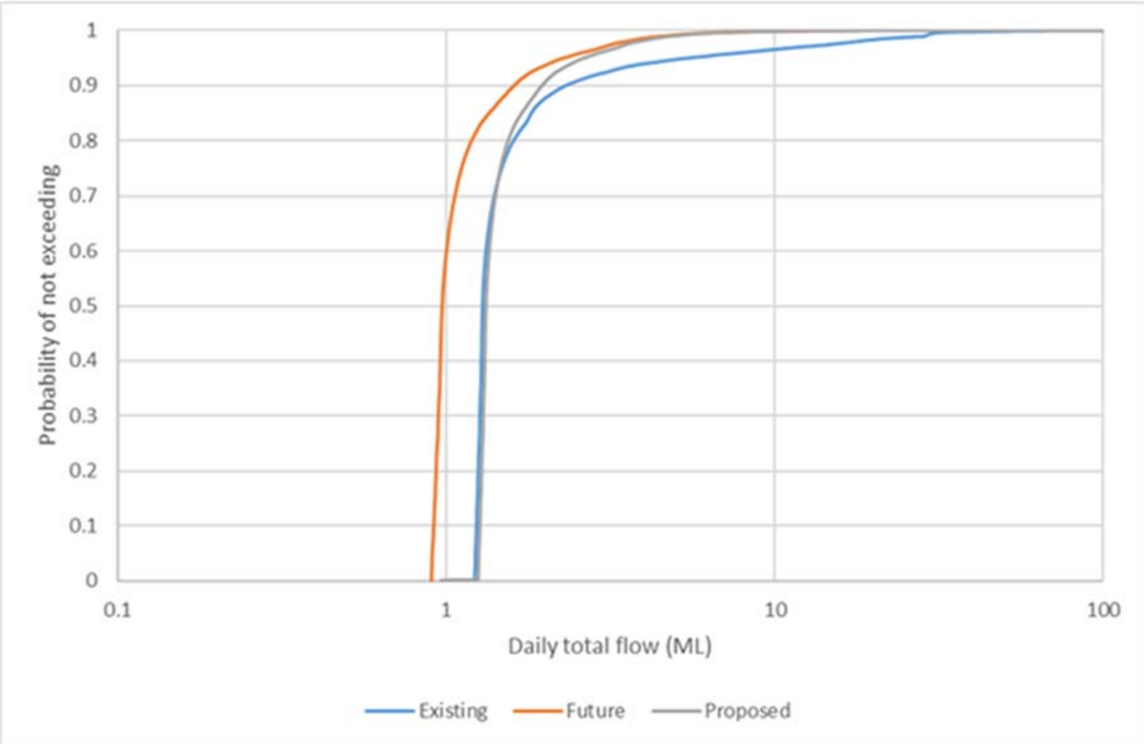
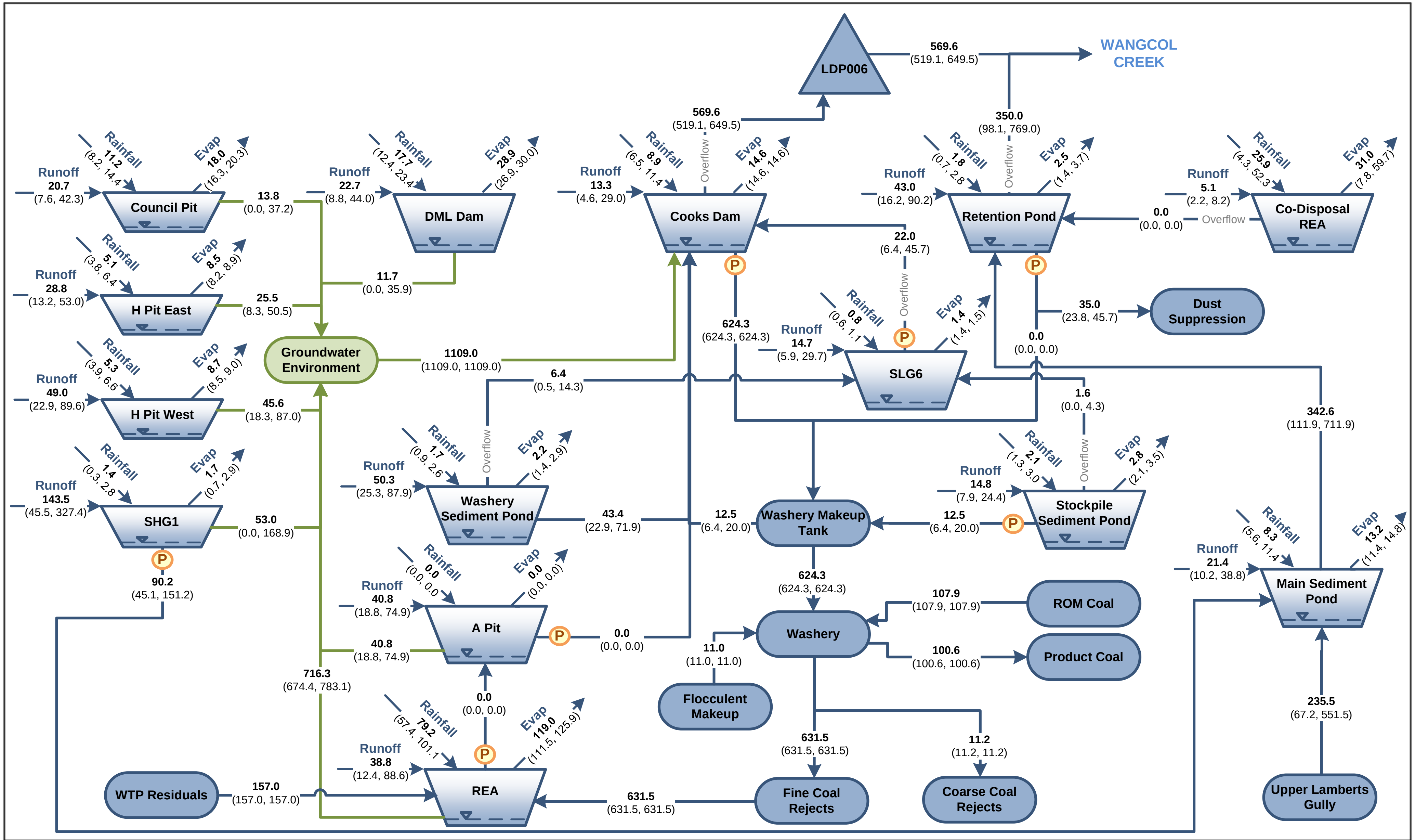


Figure 6-2 Cumulative probability distribution of daily discharge volume via LDP006 for all conditions

Figure 6-2 indicates that results for existing and proposed conditions are comparable in both frequency and volume. It is clear that the proposed scenario indicates a slightly reduced flow volume compared with the existing conditions. The comparison of the future and proposed conditions indicate that improvements made by implementation of the clean water diversion is matched by the increase by inflows due to the addition of the residuals.

Figure 6-3 presents the annual water transfers for the proposed conditions.



LEGEND

- Surface Water Transfer
- Underground Water Transfer
- Pump
- Storage

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

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Annual water transfers
Proposed conditions

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Figure 6-4

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6.3.2 Salt balance results

Table 6-4 presents the results from the salt balance model in the form of average annual salt transfers under the proposed conditions i.e. the transfer of residuals to the REA. Again, the inclusion of existing and future conditions was provided for comparative purposes.

The total input of salinity to the SCSS is predicted to increase due to the transfer of residuals to the REA. The most notable changes to salt outputs under the proposed conditions are in the discharge through LDP006, which is shown to increase from the future conditions, though remain below the existing conditions, and the seepage into the historical mine workings, for which a slight increase from the existing and future conditions is predicted.

It is important to note that the water and salt balance modelling was performed assuming the maximum predicted salinity of the residual (2500 µS/cm), and therefore the predicted impacts on the salt outputs from the SCSS can be seen as conservative, upper-limit estimates. It is more likely, based on the results from the Newstan Colliery WTP case study, that the EC is expected to be closer to the raw water feed, which in the case of LDP009 is approximately 1170 µS/cm. This assumption is further supported by the likely process ramifications of a pre-treatment system. The pre-treatment system (filtration process) is unlikely to influence the chemical parameters that comprise of EC or concentrate the feed water significantly resulting in EC increases.

Table 6-4 Predicted annual average salt transfers

	Existing conditions (tonne/year)	Future conditions (tonne/year)	Proposed conditions (tonne/year)
Inputs			
Direct rainfall	3	3	3
Catchment runoff	433	445	441
ROM coal moisture	82	82	82
Flocculant makeup	1	1	1
Seepage into Cooks Dam	2935	2622	2971
WTP residuals	0	0	264
Total Inputs	**3454**	**3153**	**3763**
Outputs			
Evaporation	0	0	0
Dust suppression	15	15	15
Product coal moisture	226	226	227
Coarse coal rejects moisture	25	25	25
Discharge through LDP006	1517	1107	1444
Discharge via clean water diversion	0	152	152
Seepage into historical mine workings	1498	1466	1769
Retained in REA	172	162	130
Total Outputs	**3454**	**3153**	**3762**
Change in storage			
Total change in storage	**0**	**0**	**0**
Balance	**0**	**0**	**0**

The cumulative probability distribution of predicted electrical conductivity for LDP006 is provided in Figure 6-4 for all conditions.

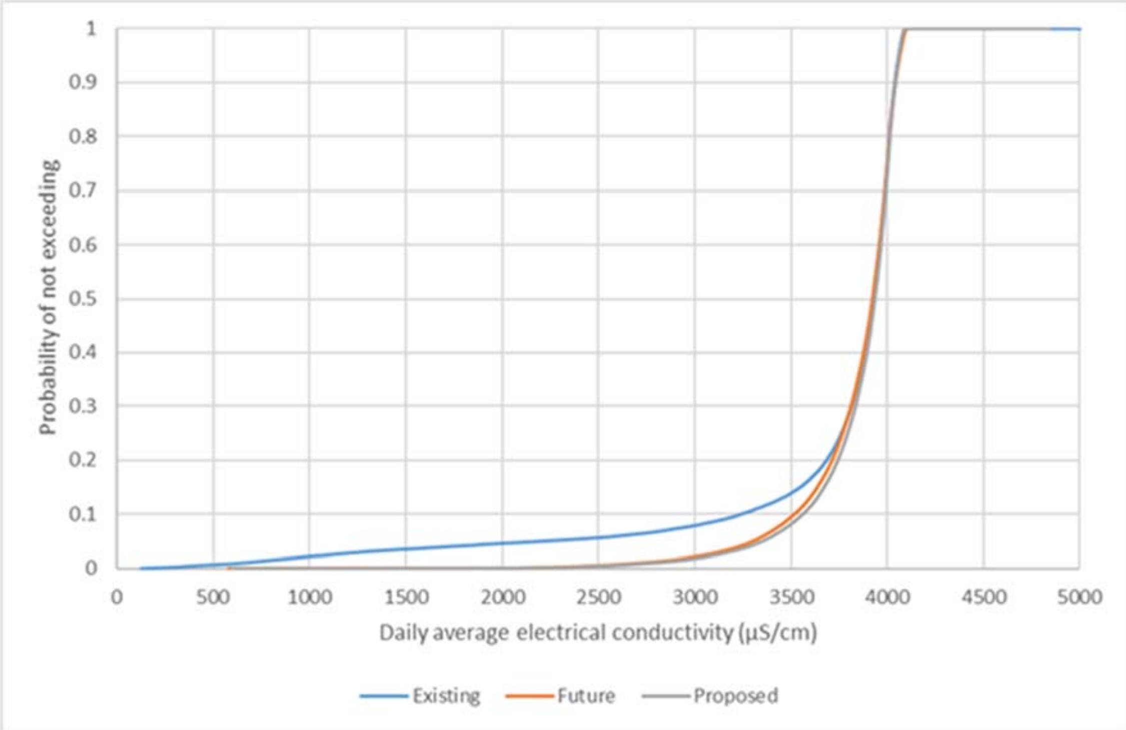
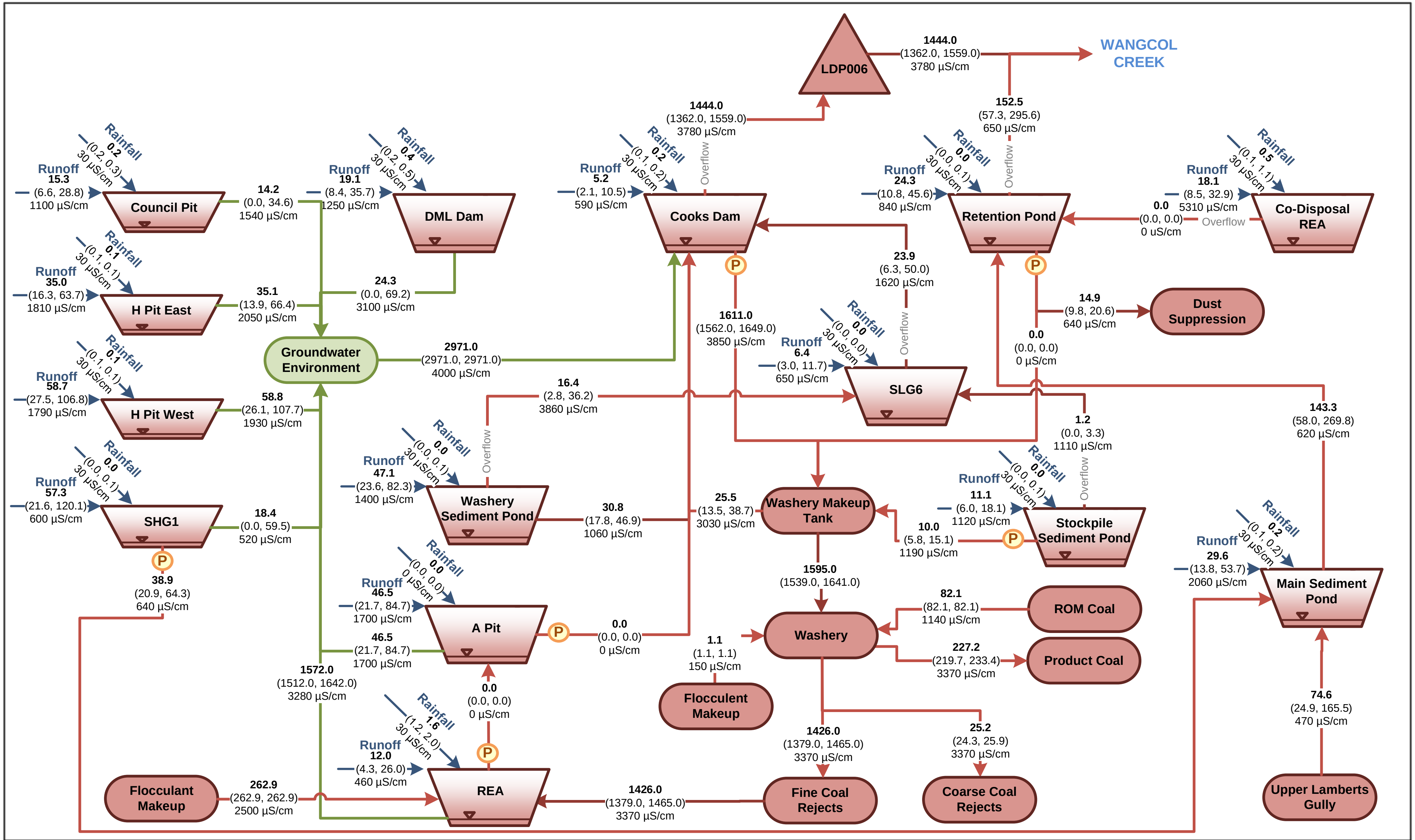


Figure 6-4 Cumulative probability distribution of daily electrical conductivity via LDP006 for all conditions

The results of Figure 6-4 indicate that the predicted EC for the future and proposed scenarios are comparable. The results indicate that the diversion of clean water away from contributing to LDP006 has resulted in a smaller but higher range of EC. This is expected given the historical dilution effect clean water was had on LDP006.

Annual salt transfers for the proposed conditions are presented in Figure 6-5.



LEGEND

Surface Water Transfer

Underground Water Transfer

Pump

Storage

LOCATION	WCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

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Annual salt transfers
Proposed conditions

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Figure 6-5

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6.4 Surface water environment

As predicted by the water balance modelling (Section 6.3.1) an increase in the volume discharged through LDP006 is likely as a result of the increased load on the SCSS water management system due to the residuals transfer. This outcome is based on the comparison of future and proposed conditions.

As per the assessment works undertaken for the SWTP, the consideration of EC is typically used as an indicator for impact from mining related systems and processes. For this situation where the Project is the management of a wastewater stream from a Water Treatment Plant, a more detailed approach in addition to simply the evaluation of EC was undertaken. The following sections detail speciation and mix modelling (using PHREEQC) in addition to the site and regional evaluation of water and salt balance results. .

6.4.1 Preliminary PHREEQC modelling

PHREEQC modelling (Parkhurst and Appelo 1999) was undertaken using the median LDP006 water quality data (Table 5-5) and the Newstan Colliery residual stream data (Table 6-2) in order to predict the effect of residual water from the REA on the LDP006 discharge. The modelling results presented in Table 6-5 indicate that the following changes from the historical LDP006 discharge water quality (Table 5-5) are predicted as a result of the transfer of the residual stream to the REA:

- pH is predicted to increase as a result of the increased alkalinity of the residual stream.
- Concentrations of the major ions sulfate, calcium, magnesium and potassium are predicted to decrease.
- Dissolved boron, iron, manganese, nickel and zinc concentrations are predicted to decrease.

These modelling results are particularly limited by the use of historical LDP006 data, which is not considered to be representative of discharge conditions following the construction of the CWD (future conditions). Without the significant dilution provided by catchment runoff, dissolved constituent concentrations in the site’s dirty water system are predicted to increase, which is likely to result in the salinity of the LDP006 discharge increasing compared to the current conditions however being limited to the quality currently within Cooks Dam (Table 5-5).

As the predicted maximum EC of the residual is 2500 µS/cm, this water would have the effect of dilution as it reports to Cooks Dam but more so when considering a more realistic EC of 1170 µS/cm (based on LDP009 feed water quality). This should be considered with caution however as a number of other influences are in place on the Cooks Dam such as localised increased groundwater EC and its minimal capacity to accept additional flows. These influences, for EC specifically, mean that dilution effects are likely to be minimal for EC. This effect is observed within the water and site balance results for the Project (refer to Section 6.3.2) and regional modelling (refer to Section 6.7.1)

From the PHREEQC mass balance modelling major ion and metals concentrations can be considered reliable predictions, though in a comparative sense only, as the future water quality at Cooks Dam following the construction of the CWD could not be accounted for in the modelling.

As part of plant commissioning phase of the SWTP the residual stream quality is to be assessed and these are to be compared to the predictions presented within Table 6-5.

Table 6-5 Predicted water quality resulting from the mixing of the residual stream and the historical LDP006 discharge

Analyte	Units	Modelled result of LDP006 and residual mix
Physicochemical parameters		
pH	pH unit	7.62
EC at 25°C	µS/cm	2713*
Anions		
Chloride	mg/L	240
Sulfate	mg/L	1175
Total alkalinity as CaCO3	mg/L	214
Cations		
Calcium	mg/L	151
Magnesium	mg/L	103
Potassium	mg/L	24
Sodium	mg/L	366
Dissolved Metals		
Aluminium	mg/L	0.124
Arsenic	mg/L	0.001
Boron	mg/L	0.763
Cadmium	mg/L	0.0001
Copper	mg/L	0.001
Iron	mg/L	0.334
Lead	mg/L	0.001
Manganese	mg/L	2.516
Nickel	mg/L	0.196
Zinc	mg/L	0.156

* EC input data was based upon maximum jar testing outcomes which correlated with the Newstan Colliery WTP residual quality results allowing for a comparison to occur. This was undertaken regardless of the conservative nature of the jar testing results when compared to the raw mine water feed.

6.4.2 Summary of the predicted changes to LDP006 water quality

A summary of the predicted changes to the water quality of the LDP006 discharge resulting from the residual is provided in Table 6-6 below. All predictions are qualitative only, as they are limited by the assumptions noted in Section 6.4.1.

Table 6-6 Qualitative predictions of the changes to the LDP006 discharge water quality as a result of the residual transfer

Analyte	Predicted change to LDP006 water quality	Reasoning
Physicochemical parameters		
pH	Increase	The residual is predicted to have bicarbonate alkalinity concentrations an order of magnitude higher than those historically observed at LDP006
EC at 25°C	Increase	Whilst the residual is predicted to be chemically dilute in comparison to the groundwater at the SCSS, the increased flows reporting to Cooks Dam and the Dam's dominate EC is likely to result in increases to

Analyte	Predicted change to LDP006 water quality	Reasoning
		LDP006. Based on results presented in Sections 6.3.2 and 6.7.1.
Anions		
Chloride	Cannot be confirmed	Differences between the raw mine waters studied make prediction unreliable
Sulfate	Decreased concentration	The sulfate concentration of the residual is predicted to be significantly lower than that historically observed at LDP006
Total alkalinity	Increased concentration	As above for pH
Cations		
Calcium, magnesium and potassium	Decreased concentrations	The residual is predicted to have low concentrations of these metals in comparison to the surface water at the SCSS
Sodium	Cannot be confirmed	Differences between the raw mine waters studied make prediction unreliable
Dissolved metals		
Aluminium	Cannot be confirmed	The case study residual (refer Section 6.2) indicates that a substantial portion of the total aluminium remains in solution in the residual. Concentrations will depend on the raw mine water and if any polymer is used by the WTP in pre-treatment.
Arsenic	Decreased concentration	Arsenic is shown to co-precipitate with ferric hydroxide, as such the residual stream is predicted to dilute any arsenic concentrations in the LDP006 discharge.
Boron	Decreased concentration	The residual is predicted to have a lower boron concentration than the surface water at the SCSS
Cadmium	No change predicted	LDP006 generally has a cadmium concentration below the laboratory LOR. This is also predicted for the residual.
Copper	Decreased concentration	Copper is shown to co-precipitate with ferric hydroxide, as such the residual stream is predicted to dilute any copper concentrations in the LDP006 discharge.
Iron	Decreased concentration	The majority of all iron in the residual stream is predicted to precipitate as ferric hydroxide, therefore the residual reporting to LDP006 via the groundwater is predicted to dilute dissolved iron concentrations.
Lead	Decreased concentration	Lead is shown to co-precipitate with ferric hydroxide, as such the residual stream is predicted to dilute any lead concentrations in the LDP006 discharge.
Manganese	Decreased concentration	The residual is predicted to have a lower dissolved manganese concentration than the surface water at the SCSS
Nickel	Decreased concentration	The residual is predicted to have a lower dissolved nickel concentration than the surface water at the SCSS
Zinc	Decreased concentration	Zinc is shown to co-precipitate with ferric hydroxide, as such the residual stream is predicted to dilute any zinc concentrations in the LDP006 discharge.

6.5 Groundwater environment

6.5.1 Groundwater quality

The results for the case study residual from Newstan Colliery (Section 6.2) indicate that the increased transport of metals from the REA to the groundwater environment as a result of the proposed residual transfer is unlikely. This case study, where dissolved metal concentrations of the supply water to the Newstan Colliery WTP were mostly similar to those predicted for the Springvale WTP, showed that the majority of metals were co-precipitated with ferric hydroxide as a result of the ferric chloride dosing. The case study indicated that aluminium may be concentrated in the residual when compared to the raw mine water supplied to the WTP, however the concentrations indicated by the Newstan Colliery case study and the Hunter Water jar testing (Section 6.2) are less than those of the majority of the groundwater monitoring bores at the SCSS, as indicated by the long term median concentrations of aluminium presented in Table 5-12.

6.5.2 Aquifer interference policy

No aquifer interference activities are predicted as a result of the modification, as the seepage of residual into the historical mine workings is not predicted to have an observable impact on the groundwater table outside of the SCSS. No pressure head decline would occur as a result of the Project, and no change in the groundwater quality which would lower the beneficial use of the groundwater (as agricultural or industrial water) is predicted.

6.6 Stream Health

6.6.1 Geomorphology of Wangcol Creek

As the water balance modelling predicted a decrease in the average future and proposed LDP006 discharge rate, there is no predicted change to the geomorphological stream health as a result of the Project, as the channel of Wangcol Creek has been shown to be relatively stable (Section 5.5.1).

6.6.2 Aquatic ecology of Wangcol Creek

The preliminary PHREEQC modelling presented in Section 6.4.1 showed that concentrations of the metal toxicants boron, manganese, nickel and zinc in the LDP006 discharge are all predicted to decrease as a result of the Project. Additionally, the increased alkalinity predicted has the effect of reducing the toxic/bioavailable concentrations of metals, particularly for nickel and zinc. A possible increase in dissolved aluminium concentrations has been predicted, however the concentration predicted in Section 6.4.1 can be considered a conservative upper limit due to the assumptions outlined, in addition to the fact that higher concentrations of aluminium have been regularly observed in the groundwater monitored at the SCSS which do not appear to report to Cooks Dam or LDP006.

When compared to the future conditions, the Project is unlikely to result in the discharge of poorer quality water, though the volume and frequency of discharges is predicted to increase. The increased frequency of discharges is not predicted to impact on geomorphological stream health, though has the effect of increasing the frequency of exposure of aquatic species to potential toxicants, albeit at decreased concentrations. This is not predicted to impact on the existing instream habitat and macroinvertebrate diversity of Wangcol Creek, as GHD (2016d) identified that site WC2, which is located within the mixing zone of the LDP006 discharge, had the most degraded habitat and the lowest level of macroinvertebrate diversity of the four Wangcol Creek aquatic ecology monitoring sites. The lower toxicant concentrations predicted in the LDP006 discharge may result in increased macroinvertebrate diversities downstream of the discharge.

6.6.3 Conservation of biological diversity and ecological integrity

The principle of conservation of biological diversity and ecological integrity holds that it should be a fundamental consideration for development proposals. The Centennial West aquatic ecology monitoring program includes the monitoring of four sites on Wangcol Creek, which is considered among other catchment and creek systems in the region. The WRIA has considered the potential impacts of the proposed modification on the macroinvertebrate diversity of Wangcol Creek, which is low due to the degraded instream habitat associated with past land use activities. As discussed in Section 6.6.2, the modification is unlikely to adversely impact on the existing aquatic ecology environment of Wangcol Creek. On this basis the modification is consistent with the principle of conservation of biological diversity and ecological integrity.

6.7 Neutral or beneficial effect

6.7.1 Regional water and salt balance modelling

Regional water and salt balance modelling was undertaken for the SWTP. This modelling was reviewed and updated for this report based on management changes at SCSS and further progression of the design process for the SWTP. As such, the results of the regional water and salt balance modelling in this report should not be compared to those of GHD (2016a).

Summaries of the average results for existing, future and proposed scenarios (refer Section 4.2) for the regional water and salt balance model are provided in Table 6-7 and Table 6-8 for water volume and electrical conductivity results respectively. All results are based on a 50% power generation requirement at MPPS (considered due to regional extraction influences from Thompsons Creek Reservoir and Lake Lyell, but as discussed in Section 4.2.2, do not consider discharges of excess treated water within the region).

Results were provided at reporting locations consistent with those used in regional modelling undertaken for the SWTP. Results were provided for:

1. Wangcol Creek at confluence with discharge from SCSS.
2. Wangcol Creek at confluence with Coxs River.
3. Coxs River flow to Lake Wallace.
4. Coxs River flow to Lake Lyell.
5. Coxs River flow to Lake Burragorang.

As shown in Table 6-7 the flow within Wangcol Creek was predicted to decrease by 2% on average under future conditions compared to existing conditions. This is due to the implementation of the clean water diversion works..

Flow is increased slightly under proposed conditions as a result of the Project. with an average of 4% to 5% increase compared to future conditions. This increase in flow continues down to Lake Wallace (Location 3) where catchment influences and the cessation of LDP009 discharges (to occur as part of the SWTP, commencing in 2017), result in a reduction in flow at this point by approximately 2%. Due to the large catchment influence, there are negligible changes as result of this Project and the implementation of the SWTP in Lake Lyell (Location 4) and Lake Burragorang (Location 5) with reduction in flow predicted of 1%.

The EC in Wangcol Creek was predicted by the regional water and salt balance model to decrease by 13% under future conditions compared to existing conditions, as shown in Table

6-8. This is due to a reduction in salt yield from disturbed areas as they are rehabilitated (where this is required with catchment contributing to the clean water diversion) however the majority of this change is as a result of the improved separation of clean and dirty water system. Where the two systems were mixed, reuse on-site was required in greater volumes with dirty water captured on-site and recirculated. With the clean water diversion in place, the runoff volume captured is reduced with volumes rather discharged to Wangcol. This change allows for a reduced on site recirculation component which can contribute to increased EC through concentration of water and can be influenced by the groundwater environment which can be as high as 4460 µS/cm.

For the future and proposed conditions, the regional modelling indicated an increase in EC as a result of the increase in LDP006 discharge associated with the transfer of residual material to the REA. The EC was predicted to increase by 16% on average as a result of the proposed conditions. From the predictions, this increase is expected to be more contributable to increased water volume load on the SCSS water management system rather than specific toxicants being added into the REA as a result of residuals. From a review of the chemical constituents of LDP006, the proposed residuals, and the Newstan Colliery WTP case study, a series of toxicants are likely to be of more risk to the receiving environment as a result of the Project. The parameters of aluminium, boron, manganese and nickel all indicated no change or an increase as a result of the Newstan Colliery WTP case study. Aluminium concentration was found to be elevated at reference sites upstream of Wangcol Creek with the residual load unlikely to exceed the concentrations already present within the receiving environment, on current predictions. Due to the concentrations of boron, manganese and nickel already present within the surface and groundwater environment, the addition of the residual load is likely to dilute these three concentrations present and contributing to LDP006 historically and therefore will unlikely result in a material effect within the receiving environments specifically as a result of the introduction of residuals. Loads for these chemical parameters however would most likely increase given the residual flow volume.

Considering future versus proposed scenario results beyond Wangcol Creek, predicted EC levels indicated that the increase at Location 1 (Wangcol Creek at the confluence of SCSS discharges) is likely to be ameliorated by the time it enters Lake Wallace. Modelled EC within Coxs River at the inflow to Lake Wallace was found to decrease by 20% on average under proposed conditions compared to both existing and future conditions. This is as a result of the cessation of discharges from Springvale Mine via LDP009 to Sawyers Swamp Creek due to the SWTP and significant catchment contribution at this location. For locations further downstream of the Coxs River, such as Lake Lyell and Lake Burragorang, the EC predictions indicated a decrease of 19% and 6% in EC as a result of comparisons between future and proposed conditions, respectively. Due to extractions from Lake Lyell for power generation the changes in EC are different between Location 4 and 5.

In summary, whilst there is an increase in EC locally within Wangcol Creek as a result of the Project, the transfer of the residuals to the REA is required to facilitate the SWTP. Equally, it is the SWTP that ameliorates this impact in Lake Wallace and further downstream through cessation of discharges at LDP009.

Table 6-7 Summary of change in water volume results from regional model

Location	Existing conditions (ML/year)	Future conditions (ML/year)	Proposed conditions (ML/year)	Difference between		
				Existing and future conditions	Existing and proposed conditions	Future and proposed conditions
1	2720	2661	2791	-2%	3%	5%
2	3028	2969	3099	-2%	2%	4%
3	46,960	46,754	45,994	negligible	-2%	-2%
4	57,399	57,185	56,362	negligible	-2%	-1%
5	124,097	123,874	123,062	negligible	-1%	-1%

Table 6-8 Summary of change in electrical conductivity* results from regional model

Location	Existing conditions (µS/cm)	Future conditions (µS/cm)	Proposed conditions (µS/cm)	Difference between		
				Existing and future conditions	Existing and proposed conditions	Future and proposed conditions
1	1000	870	1010	-13%	1%	16%
2	910	790	920	-13%	1%	16%
3	600	600	480	negligible	-20%	-20%
4	520	520	420	negligible	-19%	-19%
5	170	170	160	negligible	-6%	-6%

* Conductivity considered over salt load as this is more representative of the risk to the environment

6.7.2 Neutral or beneficial effect

The assessment of NorBE on water quality is undertaken through consultation between WaterNSW and the DPE. As the Minister for Planning is the consent authority for the Project, the assessment of NorBE is at the Minister's discretion. The NorBE guideline (WaterNSW, 2015) provides some guidance to how various projects can be assessed. As the Project is an SSD, it falls under Module 5 of the guideline. Module 5, defined as 'other development', allows for a customised assessment approach that still achieves the overall objectives of the effect-based assessment and provides the framework for the consultation process between WaterNSW and DPE during the evaluation of a project.

As the transfer of residuals to the REA is planned to occur following the construction of the CWD at the SCSS, the evaluation of NorBE has been performed through the comparison of the future and proposed conditions, as they have been referred to for the water and salt balance modelling. This evaluation used the results of the water and salt balance (Sections 6.3.1 and 6.3.2) and the results from Sections 6.4 and 6.5.

The transfer of residuals to the REA will result in the increased frequency of discharges from LDP006 and therefore an increase to the annual salt load discharged, as indicated by Table 6-4. The salinity of the discharge is predicted to decrease, due to the salinity of the residual stream being lower than that of the dirty water at SCSS (refer Table 6-5) however this is not replicated in water and salt balance modelling undertaken where the more dominant EC of Cooks Dam contributes a greater volume to LDP006 resulting in increases to EC at Wangcol Creek. The EC increase is likely to result in receiving environment EC levels of 1010 μS/cm reducing to 920 μS/cm by the location of Wangcol Creek at the confluence with Coxs River.

The concentrations of some metal toxicants in the discharge are predicted to decrease as a result of dilution effects with the Newstan Colliery WTP case study supporting either reductions or no change in a number of parameters.

The outcome of the Project can be considered to be of no benefit in terms of salt discharged, and minor benefit in terms of dissolved constituent concentrations contributing via LDP006. The increases in flow volume and EC level are observed for the length of Wangcol Creek.

From a regional perspective, the modelling outcomes indicate that residual influences from the proposed LDP006 discharges have an influence for flows and EC levels up to Lake Wallace. Downstream of Lake Wallace, reductions in flow volume and EC levels were predicted that occur as a result of the the cessation of discharges from Springvale Mines LDP009 allowed for by the operation of the SWTP.

In summary, whilst there was a predicted increase in EC locally within Wangcol Creek as a result of the Project, the transfer of the residuals to the REA is required to facilitate the SWTP. As observed in the results including and below Lake Wallace, the benefits of the SWTP, for which this Project supports, provide a regional benefit to the water quality downstream to Lake Burragorang. The likely influence of the residuals on the chemistry of water contributing to Wangcol Creek is unlikely to result in change (given the similarities to existing quality) of the current receiving environment health with these risk being minimal when compared to the overall benefit to the catchment provided by the SWTP.

6.8 Downstream water users

Based on the search of the NSW Water Register (DPI-Water 2016), three WALs were identified for surface water use downstream of the Project. These WALs are applicable to allotments that are within the upper Coxs River catchment (Lake Lyell). The WALs have been summarised in Table 6-9.

Table 6-9 Surface water users within Coxs River catchment (Jacobs 2016)

Surface water user	Allocation	Distance from LDP006	Impact to flow	Impact to quality
WAL 25607 – Unregulated River, Irrigation usage, Lot 2, DP574754 (located adjacent to Coxs River upstream of Lake Wallace)	10 ML	4.1 km downstream	Approximately 4% increase in flow	Approximately 16% increase in EC
WAL 27428 (Lake Wallace Storage) – Major Utility (Power Generation)	Total Lake Wallace and Lake Lyell - 25,000 ML	7.9 km downstream	Negligible	Negligible
WAL 27428 (Lake Lyell Storage) – Major Utility (Power Generation)		21.2 km downstream	Negligible	Negligible

From a review of the location of the allotments with WALs from Table 6-9, one user is likely to be at risk of increased conductivity as a result of the Project. The location of the applicable lot is adjacent to both the Coxs River and Sawyers Swamp Creek located on the downstream side of the Sawyers Swamp Creek. The application of results from Location 2 of the regional modelling undertaken are likely to be conservative based on the subject allotments location especially given its proximity downstream of the existing LDP009 discharges, which are to be ceased as a result of the SWTP, resulting in an improvement to EC. Regardless of improvements, the predicted increase is unlikely to degrade the usage category of the water given a predicted EC of between approximately 800 to 1000 µS/cm.

6.9 Licensing implications

As a result of the Project, the management of residuals will form part of a new EPL to be applied for following during the Project's approval phase. This is due to the fact that the current EPL is managed as part of the Springvale Mine operations and EPL 3607. It is unlikely that any additional LDPs will be required to be implemented as part of a new EPL.

The preparation of the new EPL will include other revisions likely to occur as the EPL requirements for Western Coal Services operation. This is to be undertaken in consultation with EPA.

The Project will not result in any additional take of surface or groundwater and hence does not require any water access licences.

7. Avoidance, mitigation and management measures

7.1 Monitoring and management requirements

The transfer of the residual stream to the REA at the SCSS will result in a revision to the existing Western Coal Services Water Management Plan. A Trigger Action Response Plan (TARP) will be developed which considers triggers and responses to the following potential risks:

- Groundwater contamination.
- Erosion or scour of material within REA.
- Water volume on REA.
- Surface water quality of decant water from REA.
- Water quality of the LDP006 discharge.

In addition to the current surface and groundwater monitoring at the SCSS, which is proposed to continue, the residual discharge to the REA is proposed to be monitored monthly during discharge for the following parameters:

- **Physicochemical parameters:** pH, EC, turbidity, TSS, O&G.
- **Metals (dissolved and total):** Al, B, Cd, Fe, Pb, Mn, Ni, Se and Zn.
- **Anions:** alkalinity, sulfate, chloride.
- **Cations:** sodium, calcium, potassium, magnesium, total hardness.

In addition to the water quality monitoring of the residual discharge, the residual pipeline will be added to the existing discharge flow monitoring program. Monitoring will comprise of an inline electronic metering device recording the total volume discharged through each point over a day.

The existing groundwater monitoring program at the SCSS is proposed to continue.

7.2 Implementation

As part of SWTP, a commissioning phase will undertake specific monitoring of the plants performance which will be compared against predictions. The assessment of flow and quality of the residual stream is to be reviewed as part of this Project and the SWTP.

7.3 Review

The review of the outcomes predicted within this WRIA will be required to validate the assumptions made concerning the impacts of the transfer of the residual stream to the REA on the surface water and groundwater environments.

At a minimum, a review of the impacts of the transfer of the residual stream is to be undertaken every year or specifically as a result of:

- Any statutory or regulatory requirements.

- Any significant change to water management practices.
- Continual exceedances of any relevant criteria at LDP006 and/or the Wangcol Creek sites downstream of the Lamberts Gully confluence.
- Any incident that requires reporting.

8. Conclusions

This WRIA has assessed the potential impacts of the transfer of the residual stream from the proposed Springvale WTP to the REA at the SCSS.

Design and construction works for a clean water diversion at the SCSS are currently being undertaken, the modelled result of which is a decrease in the water and salt outputs from LDP006. The proposed conditions of the Project (transfer of residuals) are predicted by the site water and salt balance model to increase water and salt outputs from LDP006 from the future conditions (noting that the construction of clean water diversions at SCSS is currently being undertaken at SCSS), however the water output from LDP006 is predicted to be less than that of the existing conditions (prior to construction of clean water diversions). Outputs of water and salt from the site in the form of seepage into the historical mine workings are predicted to increase under the proposed conditions.

The characterisation of surface water upstream of the SCSS, on site and of the LDP006 discharge, and downstream of the SCSS was undertaken to determine baseline conditions. Baseline conditions were also determined for the groundwater at the SCSS. This study indicated that surface water upstream of the site shows impacts from historical landuse, including elevated nutrient, aluminium and zinc concentrations.

Baseline conditions for surface water and groundwater at the SCSS are indicative of the high level of interfacing with historical mine workings and the water management system of the site, which uses water from the surface storages for coal washing and dust suppression. These effects on water quality are evidenced by moderate to high salinities and elevated concentrations of the metals boron, iron, manganese, nickel and zinc. Similar existing conditions were also characterised for LDP006 and the downstream monitoring locations in Wangcol Creek.

The predicted quality of the residual to be transferred to the REA was established through the study of results from jar testing performed by Hunter Water and a case study of the residual stream from the Newstan Colliery WTP. These studies predicted that the majority of the metals in the proposed residual are likely to co-precipitate with the ferric hydroxide which precipitates following dosing with ferric chloride. Considering this and the existing groundwater conditions at the SCSS, increased groundwater metals concentrations are not predicted as a result of the transfer of WTP residuals to the REA.

Preliminary mass balance modelling using the predicted residual water quality and the historical water quality of the LDP006 discharge indicated metal concentrations are unlikely to increase in discharges to Wangcol Creek as a result of the Project. Some water quality parameters however were identified to have a greater risk of increasing in concentration as a result of the Project, these included aluminium, boron, nickel and manganese. This outcome was based on the findings from the Newstan WTP case study. For aluminium it was concluded that any actual increase in discharged concentrations would not result in the introduction of a new toxicant to Wangcol Creek, as aluminium concentrations in the creek upstream of the SCSS have historically been higher than that of LDP006. The concentrations of boron, nickel and manganese indicated no change in concentration within the residuals monitored from the Newstan Colliery WTP case study. Given that these concentrations are elevated already within discharges from site, and it is likely that due to the fact that concentrations within the mine water feed into the WTP are lower, some dilution may occur from the resultant residual stream on the elevated concentrations present within the surface and groundwater environment at SCSS.

Water and salt balance modelling of the proposed conditions predicted that the annual input of 157 ML of WTP residual to the system would result in an average annual discharge from LDP006 of 570 ML, which is an increase from the modelled future conditions. The proposed conditions also predicted an average annual salt output from the SCSS through LDP006 as 1444 tonnes per year which was also accompanied by an increase in average electrical conductivity being discharged to the receiving environment as a result of the Project. Increased electrical conductivity was primarily due to increased flow volume load on Cooks Dam with the dam at capacity most days. In addition to this, the electrical conductivity within the dam is elevated and is dominate over the lower residual stream electrical conductivity. The increased conductivity in proposed conditions does not provide any local benefit but rather maintains the current conditions of the receiving environment negating any benefit from the works undertaken in the future conditions. To further assess the effect of these increases the local assessment was extended to a regional scale to determine the extent of this change.

The regional water and salt balance prepared for the Springvale WTP was utilised to consider the influence of the Project on a regional scale where this considered the Coxs River catchment down to Lake Burragorang. Modelling predictions indicated that flow and volume increases are likely to extend for the length of Wangcol Creek and further downstream to Lake Wallace. Changes in flow volume between future and proposed conditions downstream of SCSS are likely to be in the order a 5% increase whereas electrical conductivity is predicted to be an increase in order of 16%.

At Lake Wallace the effects of the Project are significantly reduced as a result of catchment influences and the cessation of LDP009 discharges to be implemented as part of the Springvale WTP. Regional model predictions between future and proposed conditions indicate a reduction in flow at Lake Wallace of 2% and a reduction in electrical conductivity of 20%. It should be noted that these predictions are more contributable to the influence of ceasing LDP009 discharges than the influence of the Project's discharges. A reduction in flow (reduction of 1%) and electrical conductivity (reduction of 6%) was predicted at Lake Burragorang as a result of the Project from the regional modelling predictions.

The local and regional water and salt balances concluded that whilst there was a predicted increase in EC locally within Wangcol Creek as a result of the Project, the transfer of the residuals to the REA is required to facilitate the Springvale WTP. As observed in the results including and below Lake Wallace, the benefits of the Springvale WTP, for which this Project supports, provide a regional benefit to the water quality downstream to Lake Burragorang.

As the regional water balance modelling predicted only a minor increase in flows at the confluence of Wangcol Creek and the discharge from SCSS in the average future, there is no predicted change to the geomorphological stream health as a result of the Project, as the channel of Wangcol Creek has been shown to be relatively stable.

No impact on the existing instream habitat and macroinvertebrate diversity of Wangcol Creek has been predicted, as previous studies of the aquatic ecology of Wangcol Creek have identified that the site located within the mixing zone of the LDP006 discharge had the most degraded habitat and the lowest level of macroinvertebrate diversity of the four Wangcol Creek aquatic ecology monitoring sites. Any dilution of the elevated toxicant concentrations present within the surface and groundwater environment at SCSS may result in the reduced toxicity of the discharge.

Within the zone of predicted increase in electrical conductivity, it was determined that one surface water user exists. The surface water user utilises Coxs River water for the purposes of irrigation. Based on the predicted electrical conductivity between the confluence between Wangcol Creek and Coxs River and Lake Wallace, and the results between the various scenarios, the usage category of the water for this user is unlikely to be effected by the Project.

This is further supported by the user’s location on the Coxs River below the point at which LDP009 discharges (to be ceased as part of the Springvale WTP) contributes to the Coxs River (via Sawyers Swamp). This is likely to result in the user having an improved water quality within the Coxs River but some potential reduction in flow volume.

A new Environment Protection Licence (EPL) is to be developed to cover the Western Coal Services Operation and specifically Springvale Coal Services. Currently the operations are included within Springvale Mine’s EPL 3607. The process of developing the new EPL will be undertaken in consultation with EPA. No surface water or groundwater access licences will be required for the Project.

As part of Springvale WTP, a commissioning phase will undertake specific monitoring of the plants performance which will be compared against predictions. The assessment of flow and quality of the residual stream is to be reviewed as part of this Project and the Springvale WTP following the commissioning of the plant.

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Appendices

Appendix A – Site Water and Salt Balance Report

Springvale Coal Pty Ltd

Springvale Coal Services

Site Water and Salt Balance Assessment

November 2016

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Table index

Figure index

1. Introduction

1.1 Overview

GHD Pty Ltd (GHD) was engaged by Springvale Coal Pty Ltd (Springvale) to undertake a site water and salt balance for the Springvale Coal Services site (the site). The locality of the site is shown in Figure 1-1. The Springvale Coal Services site forms part of the Western Coal Services project (the project). The site water and salt balance allows for the assessment of operational and environmental risks associated with the existing water management system.

The site has been historically mined, both by underground and open cut methods. The current operational activities at the site consist of the washing and stockpiling of coal from Springvale Mine bound for Mount Piper Power Station for power generation and to Lidsdale Siding for export.

There are two designated coal placement areas within the site; a product stockpile area, southeast of the washery, and ROM stockpile, northwest of the washery. An overland conveyor that transports the coal from Springvale Mine to the Mount Piper Power Station and Lidsdale Siding passes adjacent to the washery and stockpile areas

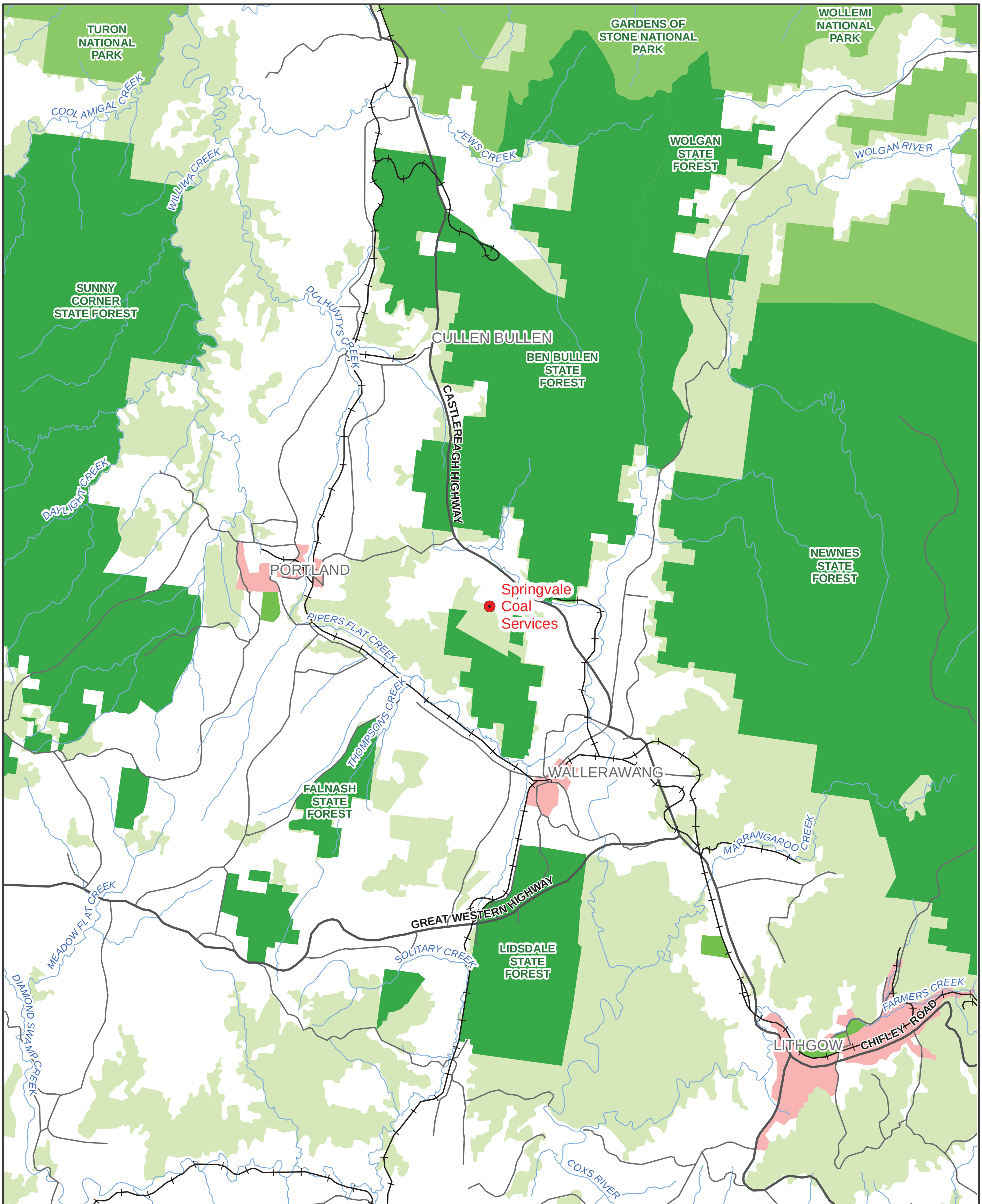
Previously open cut mined areas are also undergoing rehabilitation with the reshaping of land and revegetation.

1.2 Scope

The scope of the water and salt balance assessment includes the rainfall, runoff and evaporation of surface storages on site, gravity and pumped flows of water, coal moisture, water usage for the washery and dust suppression. Notably the assessment includes seepage out of the endoheric storages (closed drainage basin with no outflow) in the western portion of the site and the seepage into Cooks Dam. A hydrogeological model developed in 2016 by GHD considered modelling of the relationships between surface and groundwater environments. The outcomes from this assessment has been further discussed in Section 4.8.

1.3 Assumptions and limitations

This assessment considers the effect of rainfall variation on the results of the model, based on a historical rainfall record. This approach assumes that the rainfall record accurately characterises the future rainfall variability and does not consider inter-annual climate patterns such as El Niño or long term trends such as climate change.



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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site location
- Existing rail
- Dual carriageway
- Principal road
- Secondary road
- Minor road
- Waterway
- Built up area
- Nature conservation
- State forest
- Forest or shrub

LOCATION	NA
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	Refer to scalebar

Springvale Coal Services
Site Water and Salt Balance Assessment

Locality plan

Centennial Coal

DATE 02 Nov 2016

Figure 1-1

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22-18193

1.4 Site topography and hydrology

The terrain of the site generally drains northeast towards Wangcol Creek, which flows south-east to the Coxs River. The Coxs River flows to Lake Burragorang (Warragamba Dam) approximately 60 km to the southeast of the site. There are two lakes downstream of the site, Lake Wallace and Lake Lyall. These two lakes receive runoff from their own catchments in additional to stream flow from Coxs River. The lakes store water for industrial use on nearby power station sites. The Castlereagh Highway runs along the northern side of the site, parallel to Wangcol Creek.

The site lies mid slope between the rising hills to the south and the Wangcol Creek valley to the north. Terrain to the south rises to 1050 m AHD, while the elevation of the site itself is between 960 m AHD to 920 m AHD, with the overall terrain sloping to the northeast.

The runoff from the site concentrates into two natural watercourses, Huon Gully to the west and Lamberts Gully to the east. The hydrology of the site has been significantly changed due to open cut and underground mining and related activities. The natural watercourse in Huon Gully now terminates in a surface water storage, Huon Gully sediment pond 1 (SHG1), as the gully has been disturbed by open cut mining and lower down filled by the Mt Piper Power Station Ash Emplacement Area (Ash Emplacement Area). A site plan, including the catchments of Lamberts Gully and Huon Gully is shown in Figure 1-2.

1.5 Environmental Protection License

The Environment Protection Licence (EPL) relevant to this site is EPL 3607, held by Springvale Mine, which currently applies to both Western Coal Services project, and Springvale Mine. Licensed Discharge Point 6 (LDP006) is located at the entrance to the site, above the confluence of Lamberts Gully and Wangcol Creek and is the only point relevant from EPL 3607 for this assessment. The EPL prescribes pollutant concentration limits for discharged water but does not prescribe any volumetric limits. The concentration limits are deemed not to apply when the discharge from the stormwater control structures (sediment dams) occurs solely as a result of rainfall measured at the premises which exceeds:

- for the Washery and Stockpile Sediment dams, a total of 56 mm of rainfall over any consecutive 5 day period.
- for the Main Sediment dam, a total of 29 mm of rainfall over any consecutive 5 day period.

1:12,000 for A4

0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site boundary
- Road
- Local watercourse catchment
- Waterway
- Historical watercourse
- Existing watercourse

LOCATION	SCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Site Water and Salt Balance Assessment

Site area plan

Centennial Coal

DATE 02 Nov 2016

Figure 1-2

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22-18193

2. Water management

The water management system at Springvale Coal Services site is comprised of a clean and dirty water system, however due to the extent of the disturbance at the site, clean and dirty water are mixed before discharging into Wangcol Creek. The objective of the water management system is to generally secure supply for coal washing and dust suppression and to control the quantity and quality of water discharged into Wangcol Creek via LDP006.

The water storages and other water management features of the site are shown in Figure 2-1. The catchment of each of the water storages was delineated based on topographic information and aerial imagery, accounting for constructed diversions. A plan of the surface water catchment and diversions is shown in Figure 2-2. The water management system is shown conceptually as a water cycle in Figure 2-3 and a water transfer schematic in Figure 2-4.

2.1 Clean water management

Clean water diversion drains concentrate the catchment upstream of the site into two drainage lines that are then intercepted by the site. Lamberts Gully, to the east, is intercepted by Main Sediment Pond, which also collects runoff from established rehabilitation areas. Huon Gully, to the west, terminates at SHG1 where retained runoff is lost to seepage. It is likely that water seeping out of this storage is seeping into historical underground workings. There are no dedicated clean water storages at the site.

2.2 Dirty water management

The dirty water management system consists of a series of ponds, pumps and pipes that allow runoff and water seeping from the groundwater to be captured, treated (if required) and redistributed within the site for reuse or to improve the water quality of another pond through dilution. Water is used in the washery and for dust suppression.

Various measures are employed to manage the water quality onsite. Runoff from disturbed areas and areas not fully rehabilitated are captured in sediment ponds and treated if required prior to discharge. This allows for maximum reuse of influenced water. The Retention Pond is used as a final polishing pond prior to water being discharged offsite.

The inputs into the surface water system consist of:

- Direct rainfall onto the surface of surface water storages,
- Surface water runoff from catchment areas,
- Moisture entrained in the ROM coal
- Seepage from the historical mine workings

The output from the surface water system consist of:

- Evaporation from the surface of the surface water storages
- Evaporation from water applied for dust suppression
- Moisture entrained in product coal
- Moisture entrained in coarse coal rejects
- Moisture entrained in fine coal rejects
- Discharge from LDP006 to Wangcol Creek
- Seepage into the historical mine workings

1:12,000 for A4

0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site Boundary
- LDP
- Road
- Storage
- Waterway

LOCATION	SCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Site Water and Salt Balance Assessment

Surface water management features

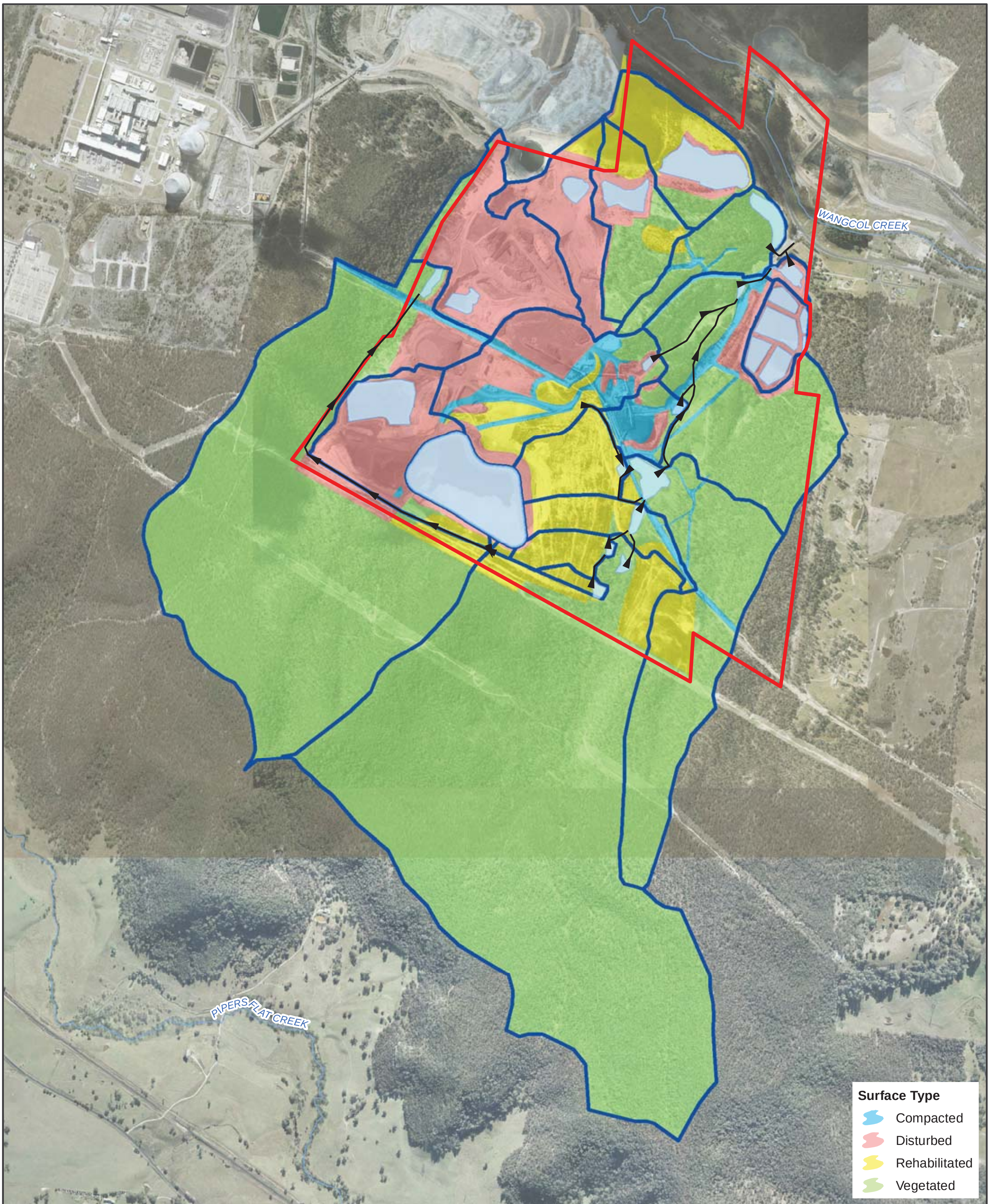
Centennial Coal

DATE 02 Nov 2016

Figure 2-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218193\2218193_003_SWManagementFeatures_0.mxd

22-18193



1:20,000 for A4

0 85 170 340 510 680

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site Boundary
- Waterway
- Water Diversion
- Storage
- Catchment

LOCATION	SCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Site Water and Salt Balance Assessment
Surface water catchments
and diversions

Centennial Coal

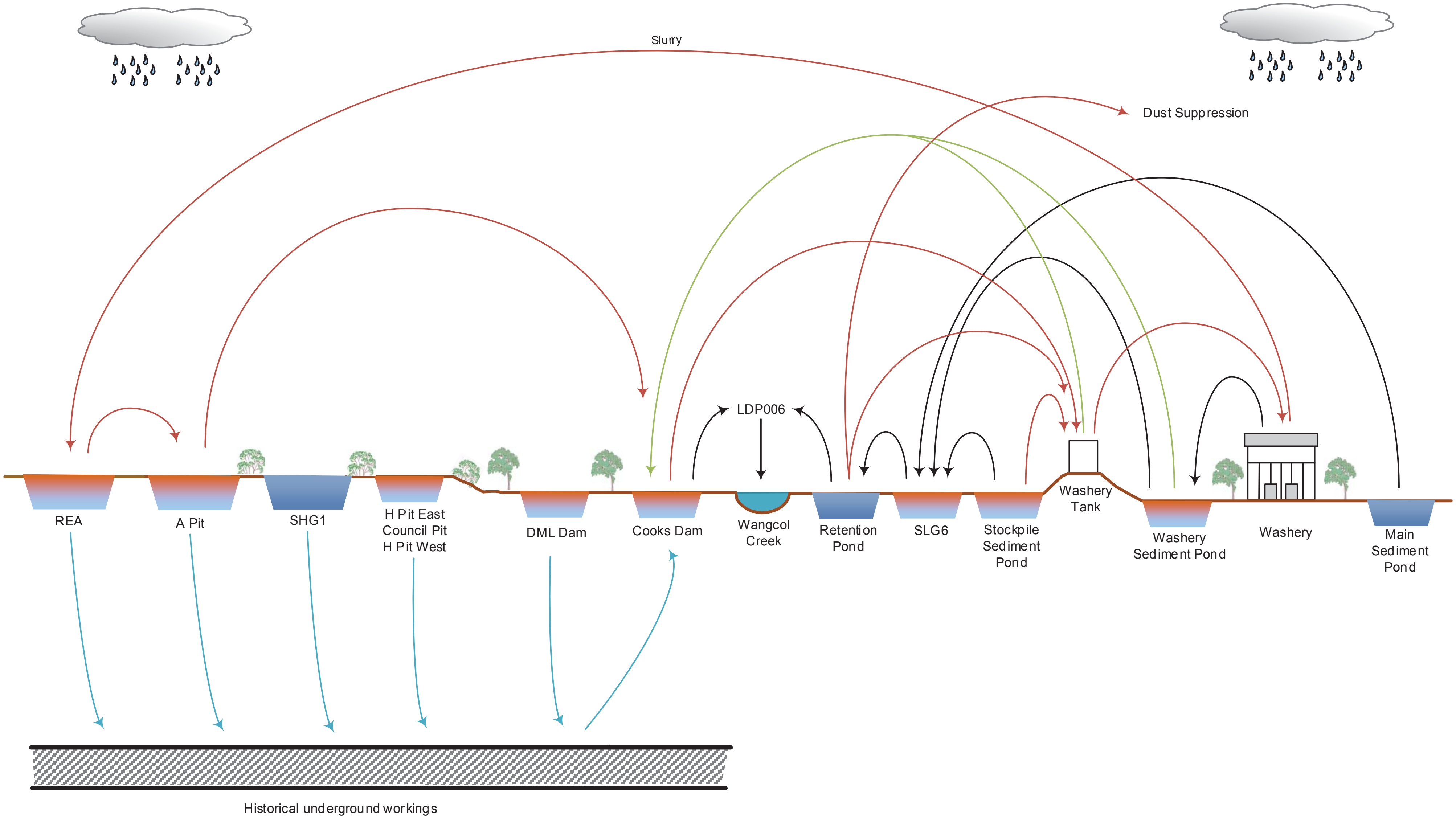
DATE 02 Nov 2016

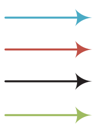
Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218193\2218193_004_SWCatchmentsandDiversions_0.mxd

22-18193

© LPI: DTDB, 2012. ESRI: Imagery, 2014, LIDAR: Imagery, 2015; Centennial: Boundary





LOCATION	SCS
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Springvale Coal Services
Site Water and Salt Balance Assessment

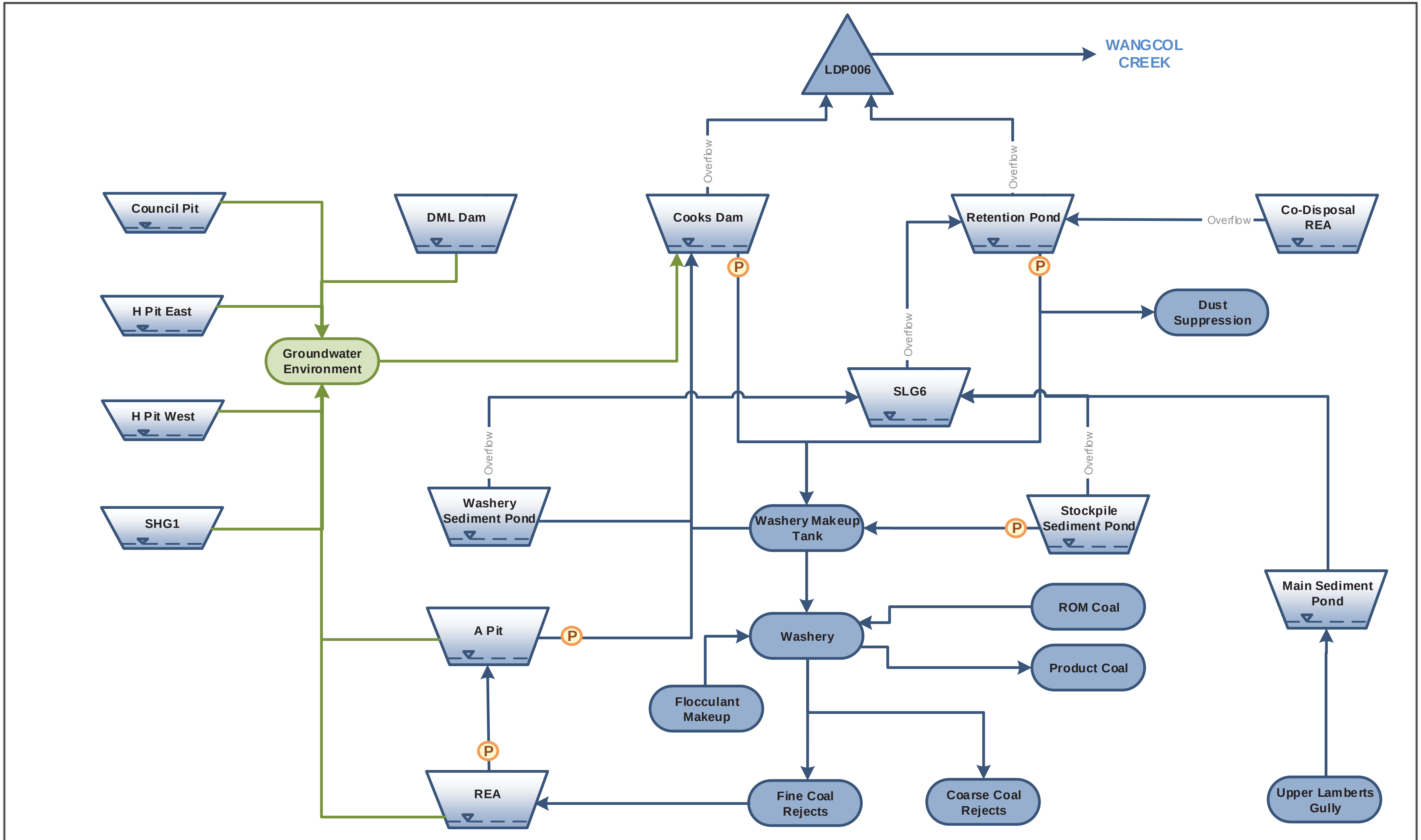
Water cycle diagram

Centennial Coal

DATE 2 Nov 2016

Figure 2-3

G:\22\18193\Visio\2218193-VIS-Water_cycle_diagram.vsd



LEGEND

Surface Water Transfer

Underground Water Transfer

Pump

Storage

LOCATION	SCS
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Springvale Coal Services
Site Water and Salt Balance Assessment

Water transfer schematic

Centennial Coal

DATE Nov 2016

Figure 2-4

G:\22\18193\Visio\2218193-VIS-Water_transfer_schematic.vsd

2.3 Potable and wastewater management

Potable and ablutions water is supplied by a Lithgow City Council water main. Drinking water is provided to site by contractor in the form of bottled water. Potable water (approximately 11 ML/year in April 2014 to August 2015), is used predominately for flocculent makeup in the washery process.

Wastewater is managed by a site sewage management system from all demountable building systems and is aerobically treated. Treated effluent is sprayed on surrounding lands.

2.4 Water management features

The following sections detail each of the key water management features present within the site. The details associated with each feature, in terms of volume and operation, is outlined in Section 4.

2.4.1 Cooks Dam

Cooks Dam is used for the collection and management of dirty water on site. Water is received from a pipeline from a low flow outlet from Washery Sediment Dam and Washery Makeup Tank. Decant water from A Pit also reports to Cooks Dam. Water from the dam can be:

- Pumped to the Washery (pump 506)
- Discharged off site (via LDP006)

Transfers occur through three submersible pumps. Two 27 kW pumps are used to pump water to the Washery Makeup Tank (one duty and one standby pump).

It has been observed that inflows to the dam occur from various locations along the western edge of the dam, originating from the underground workings. This has been supported by observed piping in this area (typical of an increased hydraulic conductivity) (Aurecon, 2013).

The storage was historically created by constructing a small (less than 3 m in height) homogeneous earth fill (overburden) bund, around the crest of an existing open cut pit and is not lined.

Up to early 2016 there was a transfer from Cooks Dam to DML Dam (via pump 508) in order to suppress overflows from the dam and through LDP006. This was ceased as it was determined that there was no benefit achieved through this process and the action was resulted in an elevated groundwater table surrounding around Cooks and DML Dam. Elevated groundwater tables were potentially leading to increased instances of piping around the dam.

2.4.2 DML Dam

DML Dam receives inflow from catchment runoff. Subsurface inflows possibly also enter the dam, similar to the relationships observed at Cooks Dam. The water level in the dam reportedly remains relatively constant apart from after significant rainfall events, which causes the water level to rise temporarily.

No spillway exists at the dam and there has been no known uncontrolled spilling from the dam as a result of its capacity being exceeded, however it is likely that water from the dam infiltrates into the historical mine workings. DML Dam is an unlined storage.

Since the cessation of transfers from Cooks Dam into DML Dam, the typical water level has been significantly lower (approximately 2.5 m) during 2016.

2.4.3 Retention Pond

Retention Pond indirectly collects catchment runoff from a large proportion of the site. Excess inflows bypass through the cement impregnated geotextile fabric lined spillway. Water discharges from the spillway into the same outflow channel that outflows from the Cooks Dam spillway flow and contributes to LDP006. Retention Pond is a partially lined dam. There is a pump located at the pond that supplies all dust suppression on site and also supplements supply to the washery.

2.4.4 Co-Disposal Storage Facility

The co-disposal storage facility has been divided into six separate cells, with four utilised for tailings and coarse reject co-disposal and the remaining two (located along the eastern side) used to hold decant water. Historically the cells were used to temporarily hold tailings and coarse rejects for a drying period, before they were mined out using a long-arm excavator and blended with coal product. This facility is rarely utilised with the washery currently sending fine rejects to the REA. Recently, the facility was temporarily used in interim between the closing of A Pit REA and the opening of the REA.

2.4.5 Washery Sediment Pond

Washery Sediment Pond receives runoff water from the coal washery and surface water runoff from the haul roads and admin building areas and surrounding catchments. During high rainfall events, depending on the preceding water levels in the pond, water will overflow from Washery Sediment Pond into SLG6 via overland flow across rehabilitated land. The pond has an overflow weir and low flow outlet pipe.

The low flow outlet pipe is a 225 mm diameter gravity pipeline connection between Washery Sediment Pond and Cooks Pond which was installed in 2012 to minimise and reduce overflow events from the Washery Sediment Pond in high rainfall events.

2.4.6 Stockpile Sediment Pond

Stockpile Sediment Pond receives surface water runoff from the coal stockpile area and surrounding contributing catchments. Water levels within the pond are controlled by a manually operated diesel pump, pumping water from the Stockpile Sediment Pond to the Washery Makeup Tank for re-use at the coal washery.

During high rainfall events, water may overflow from Stockpile Sediment Pond into SLG6 via a combination of open channels and pipe networks.

2.4.7 Main Sediment Pond

Main Sediment Pond (also known as Conveyor Dam) is located south of the main coal stockpile area. The dam is designed to be operated at a level greater than 1.0 m below the full supply level so that it has sufficient capacity to store the 80th percentile, 5 day runoff event. The retention time within the dam allows for settlement before the water is discharged into a channel that reports to SLG6. Controlled discharges occur via a 30 m long 425 mm diameter pipe with a valve on the downstream outlet, whilst the storage may overflow via a nearby concrete spillway. Main Sediment Pond receives overflow from five upstream ‘fill and spill’ sediment ponds in the Lamberts Gully area, SLG1, SLG2, SLG3, SLG4 and SLG5.

2.4.8 Washery makeup tank

The washery makeup tank is located on the top of the ridge north east of the washery. Water is pumped to this location from Cooks Dam, Retention Pond and Stockpile Sediment Pond to meet the demands of the washery. The tanks overflow into a pipe that joins the low flow outlet of the Washery Sediment Pond and returns to Cooks Dam.

2.4.9 Washery

The washery process separates ROM coal into product coal and coarse and fine rejects. Fine rejects are pumped away as a slurry to the REA.

2.4.10 A Pit

A Pit is a historical open cut used as a fine rejects emplacement area until late 2015. The design of the REA included modifications to A Pit to allow it to serve as the sediment pond for the REA by receiving tailings return water, which would then be pumped to Cooks Dam. However, it is understood that since the commissioning of the REA, neither the REA decant pump nor the A Pit decant pump have been required to be operated, as surface water has been seeping to the historical underground workings.

2.4.11 SHG1

Huon Gully Sediment Pond 1 (SHG1) is a clean water retention structure located in Huon Gully that terminates the natural water course. Previously this storage contributed to Wangcol Creek via Huon Gully, however it is now intercepted by historical open cut mine workings with the Gully truncated by part of Mt Piper Ash Emplacement, Lamberts North development.

Despite the storage having no defined outlet, the storage has not been observed to overtop. Given that evaporation is not significant enough for all captured water to be lost, it is high likely that there is significant seepage into the historical mine workings.

2.4.12 Historical open cut voids

There are a number of historic open cut voids (extraction down to the Lithgow Seam) in the western part of the site that normally hold a volume of water. The water in these voids is believed to be connected to the historical mine workings and then down gradient to Cooks Dam. These voids are:

- H Pit West.
- H Pit East.
- Council Pit.

2.4.13 REA

The REA is a Fine Coal Reject (FCR) and Coarse Coal Reject (CCR) storage facility with an ultimate storage capacity of approximately 1400 ML. The FCR is pumped from the washery and deposited.

The design of the REA included a decant pump drawing from a shallow decant pond, with a maximum pond radius under normal operating conditions of 50 m, to A Pit. However, it is understood that since the commissioning of the REA, neither the REA decant pump nor the A Pit decant pump have been required to be operated, as surface water has been seeping to the historical underground workings.

3. Methodology

The water and salt balance was modelled as a probabilistic mass balance, implemented using Goldsim 11.1.5. This software is a graphical object orientated system for simulating either static or dynamic systems. It is like a 'visual spreadsheet' that allows one to visually create and manipulate data and equations.

The model consisted of the water management features and the transfer into and from each feature. The transfers were driven either by environmental processes: rainfall, runoff, evaporation and seepage, or by operational process: pumped transfers, coal and slurry moisture and dust suppression. The water cycle was simulated over time and selected outputs from the modelled system were statistically summarised. The site was simulated over a period of 1 year with a basic timestep of 1 day.

3.1 Hydrologic model

The Australian Water Balance Model (AWBM) was used to estimate the runoff contributing to the surface water storages. The AWBM was adopted as it is widely used throughout Australia, has been verified through comparison with large amounts of recorded streamflow data, and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew, 2003). Another advantage of the AWBM is the consideration of soil moisture retention when determining runoff.

The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. Figure 3-1 is a schematic of the model, which shows that the model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing soil moisture.

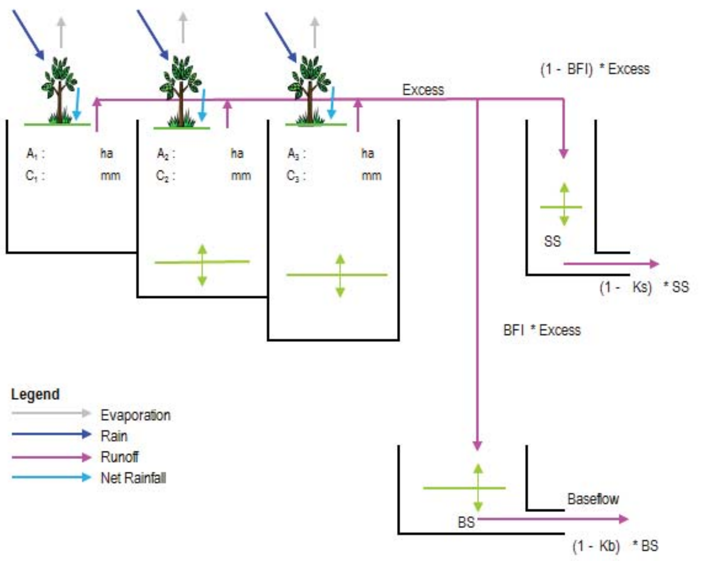


Figure 3-1 AWBM model schematic

Rainfall enters these storages and when a storage element is full, any additional rainfall is considered to be excess rainfall. Of this excess rainfall a proportion is routed to the baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the baseflow storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages. The definition of the parameters used in the AWBM is provided in Table 3-1.

Table 3-1 AWBM parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively.
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively.
BFI	The proportion of excess rainfall flowing to the baseflow.
K_b	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day.
K_s	The proportion of the surface storage remaining in the storage at the end of each day.

3.2 Climatic variability

In order to assess the impact of climatic variability on the site water balance, the rainfall was sampled from a continuous historical rainfall record. A series of simulations were performed, each beginning in a different year of the historical rainfall record and proceeding consecutively through the record (and looped where required).

3.3 Numerical implementation

The water cycle was simulated over time in GoldSim version 11.1.5 and selected outputs from the model were statistically summarised. Daily time steps were used for the modelling as daily rainfall data was the shortest period of data available and changes in operational conditions are typically made on a daily (or shorter) basis.

3.4 Simplifications and assumptions

This methodology assumes that the historical rainfall record and average monthly evaporation characterises rainfall variability and seasonality of potential evaporation in the future, over the time frame of the predictions made by the model. In general, the model considers daily averages for environmental and operational processes.

4. Data

The development of the water and salt balance for Springvale Coal Services site involved the collation and interpretation of data from various sources. The purpose of this section is to outline the data and assumptions used.

4.1 Data sources

The sources of data used in the water and salt balance model are shown in Table 4-1.

Table 4-1 Data sources

Source	Item
Provided by Springvale	Pump rates for 506 and 508 pumps (from daily total volume from 2015-01-01 to 2015-11-23)
Derived from information provided by Springvale	Catchment areas (from topographic information)
	Catchment surface types (from aerial imagery)
	Stage storage relationships for Cooks Dam, DML Dam, Main Sediment Pond, REA and Retention pond
	Surface storage water surface elevations, maximum surface areas, maximum depths and capacity (from topographic information) for all other storages
	Average ROM and product coal moisture contents
SILO (Queensland Climate Change Centre of Excellence)	Patched historical daily rainfall total record for Lidsdale (Maddox Lane) station
Bureau of Meteorology	Average monthly evaporation data for Bathurst Agricultural Station
Clarence Colliery Extension Project Water and Salt Balance Assessment (GHD, 2015)	Coarse coal reject moisture content
Lamberts Gully Reject Emplacement Area (GHD, 2015)	Fine and coarse coal rejects production rate, slurry solids content
Centennial Western Coal Services Project Water Management Plan (RPS, 2014)	Dust suppression demand and rainfall threshold
Salinity management handbook (DNRW, 2007)	Rainfall salinity
Springvale Water and Salt Balance Assessment (GHD, 2016a)	ROM coal moisture salinity

4.2 Environment

4.2.1 Rainfall

A historical record of daily rainfall depth was obtained from SILO patched point data from the Queensland Climate Change Centre of Excellence. SILO patched point data is based on observed historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations.

For this assessment, SILO data was obtained for the Lidsdale (Maddox Lane) station (station number 63132), which is located approximately 3.5 km south east of the site at an elevation of 890 m AHD. This station was chosen based on proximity to the site and similarity of elevation.

The period of rainfall data used for this assessment extended from 1 January 1889 to 1 January 2016 (a total of 127 years) and is summarised as annual totals in in Figure 4-1. The statistics for this rainfall data set are:

- Minimum annual rainfall – 330 mm in 2006.
- Average annual rainfall – 737 mm.
- Median annual rainfall – 730 mm.
- Maximum annual rainfall – 1 515 mm in 1950.

The monthly rainfall averages ranged from a low of approximately 52 mm in September to a high of approximately 79 mm in January, averaged over a period of 127 years.

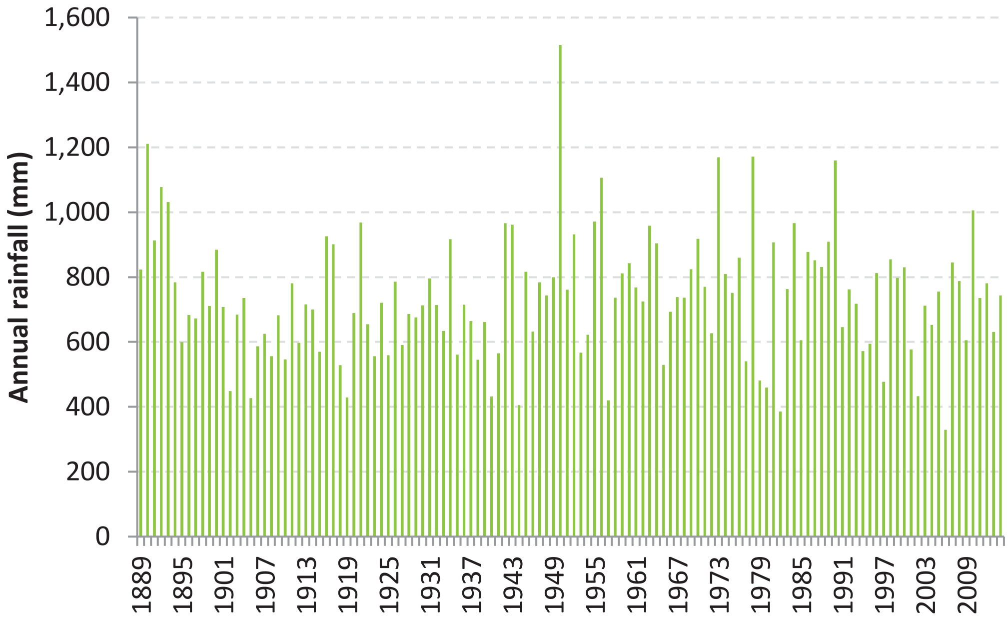


Figure 4-1 Annual total rainfall for SILO patched record for Lidsdale (Maddox Lane) Station

The monthly rainfall statistics were also determined for the historical rainfall record. The minimum, maximum and average monthly rainfall depth totals are shown in Figure 4-2. The average monthly rainfall varied from a low of approximately 50 mm in April to a high of approximately 79 mm in January. The rainfall is typically highest in the summer months and lowest in the autumn and spring months.

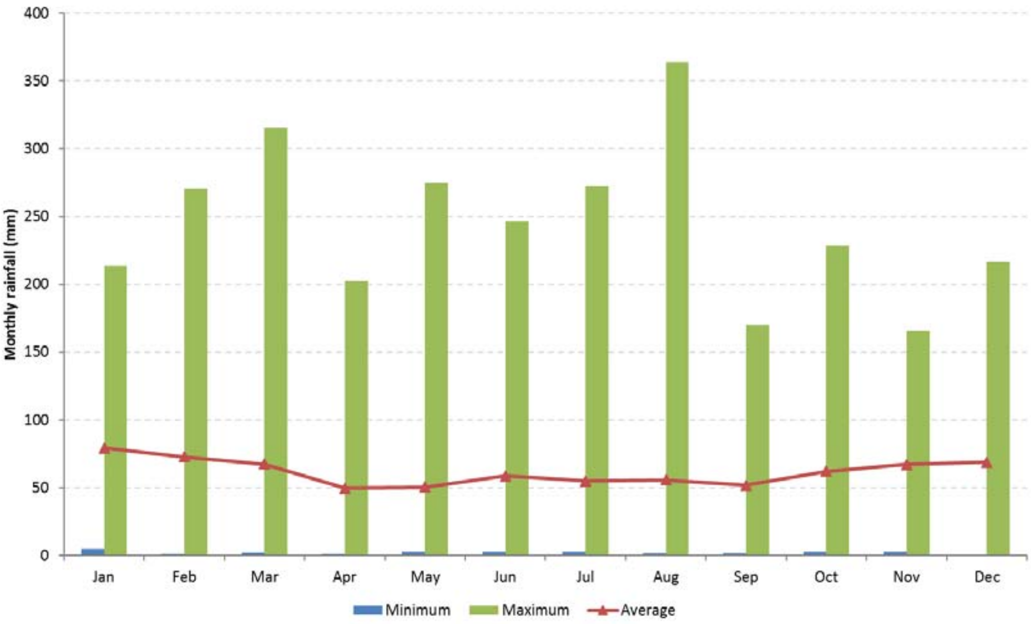


Figure 4-2 Monthly rainfall totals for historical record

An analysis of rainfall data was undertaken to enable an understanding of the likely rainfall patterns at the site. For various intervals of daily rainfall totals, the average number of days per year which have a rainfall depth within each interval are presented as a histogram and cumulative probability distribution in Figure 4-3, which non-rainfall days (with less than 0.1 mm) omitted. On average, 209 days of the year have daily totals less than 0.1 mm.

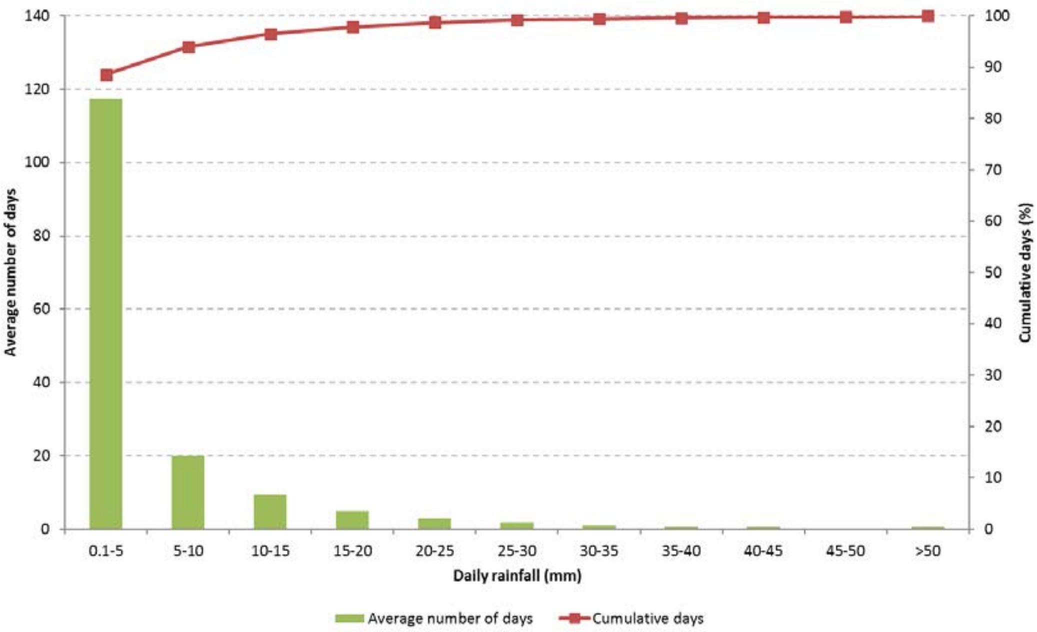


Figure 4-3 Number of rain days of various daily totals for historical record

The SILO patched historical rainfall record was compared to the raw Bureau of Meteorology record for Lidsdale (Maddox Lane) Station. A plot of mean monthly rainfall totals in shown in Figure 4-4. The indicates that SILO patched rainfall record is reasonable characteristic of the observed rainfall at the Lidsdale since August 1959, when the rainfall records began at the Lidsdale station.

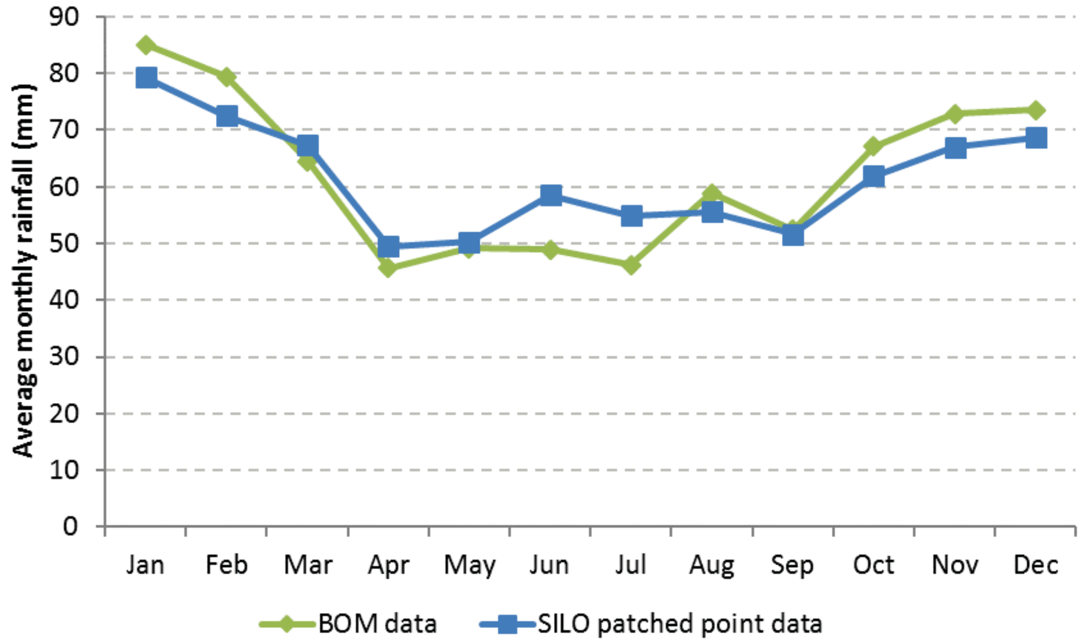


Figure 4-4 Comparison of average monthly rainfall totals for BOM and SILO rainfall

Rainfall has been observed at the site since February 2012. Daily and monthly rainfall totals for the site record and the SILO record for the period 10/2/2016 to 29/9/2016 were compared. A comparison of the distribution daily totals is shown in Figure 4-5 and comparison of monthly totals is shown in Figure 4-6.

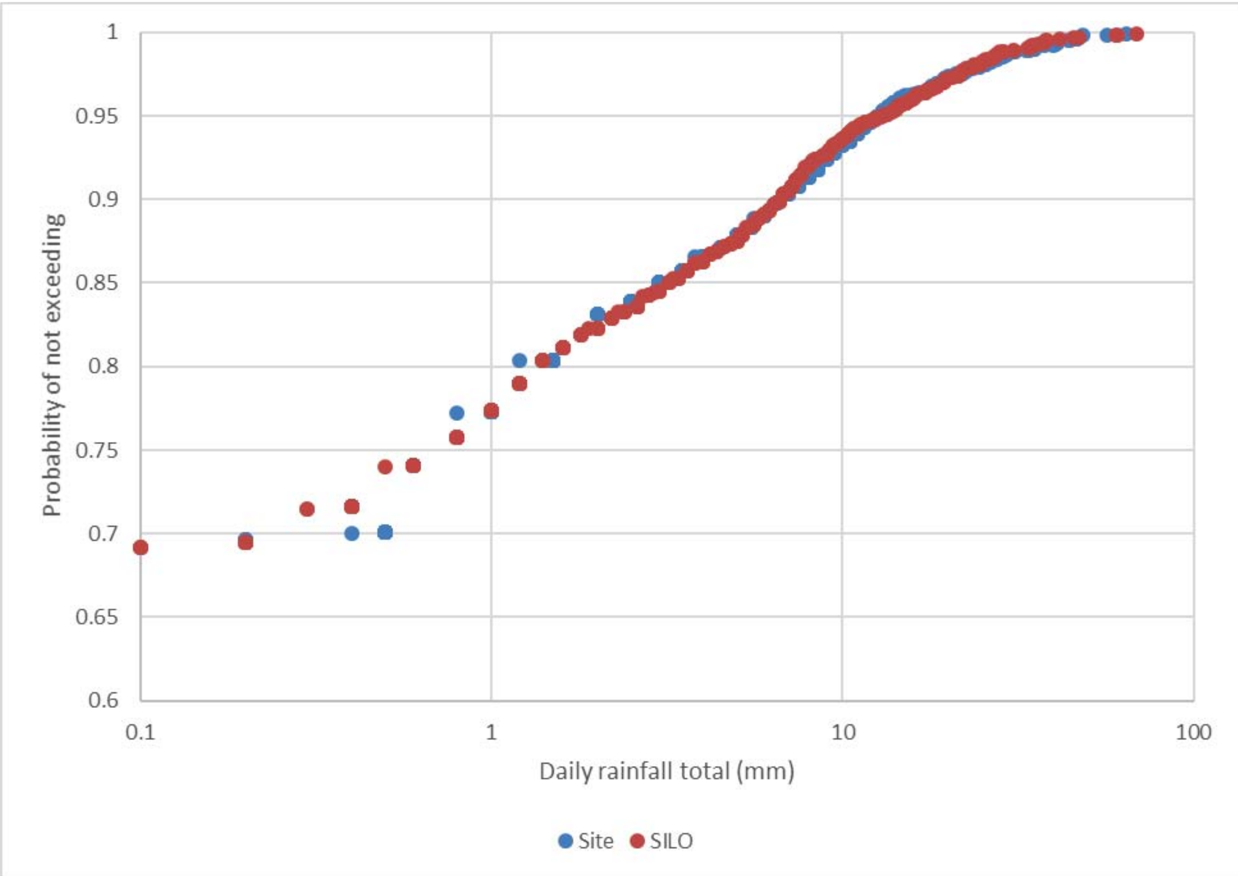


Figure 4-5 Comparison of distribution of site and SILO daily rainfall totals

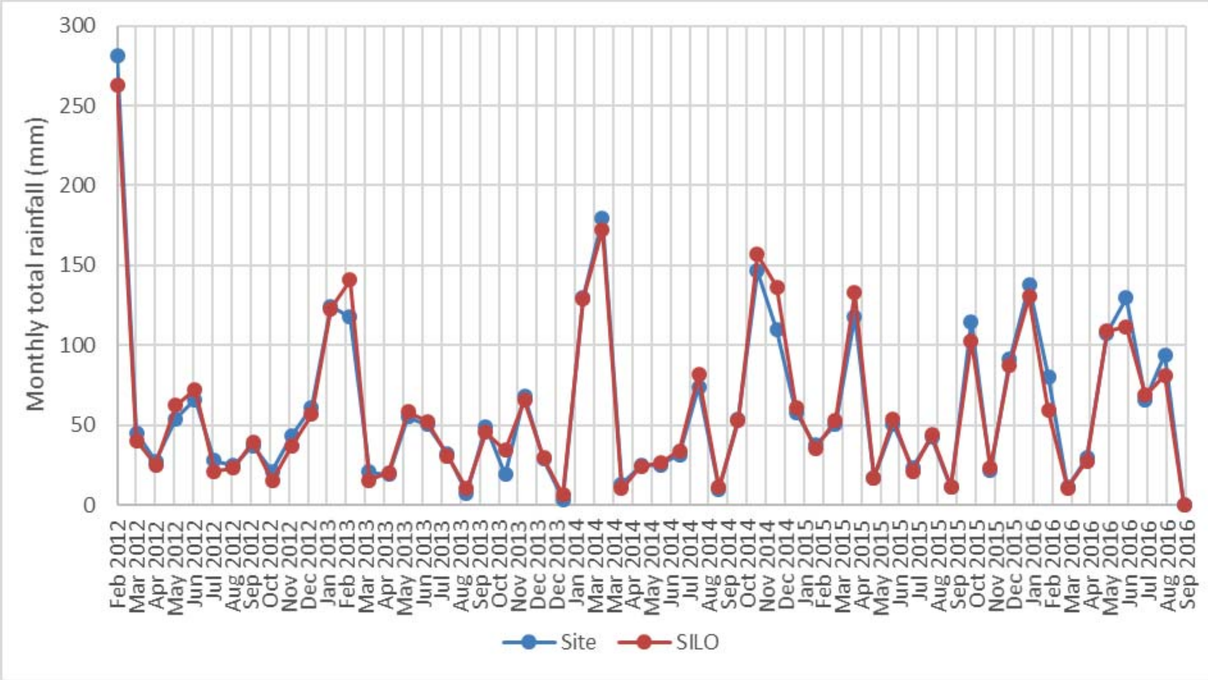


Figure 4-6 Comparison of site and SILO monthly rainfall totals

There is strong correlation between site and SILO rainfall record on both for both the distribution of daily totals and monthly totals with a regression slope of 0.98 and 0.99 and a coefficient of determination of 0.99 and 0.97 respectively. This indicates that SILO rainfall record is valid estimate of the observed rainfall at the site over the period considered.

4.2.2 Evaporation

Information provided at the closest BOM station which records evaporation, Bathurst Agricultural Station (station number 63005), was reviewed and average monthly evaporation rates were determined, as shown in Figure 4-7. This station is approximately 60 km west of the site. A pan factor of 0.9 was applied to the pan evaporation to estimate both potential evaporation and potential evapotranspiration. When average annual evaporation is compared to average annual rainfall, a rainfall deficit of approximately 732 mm/year occurs on average.

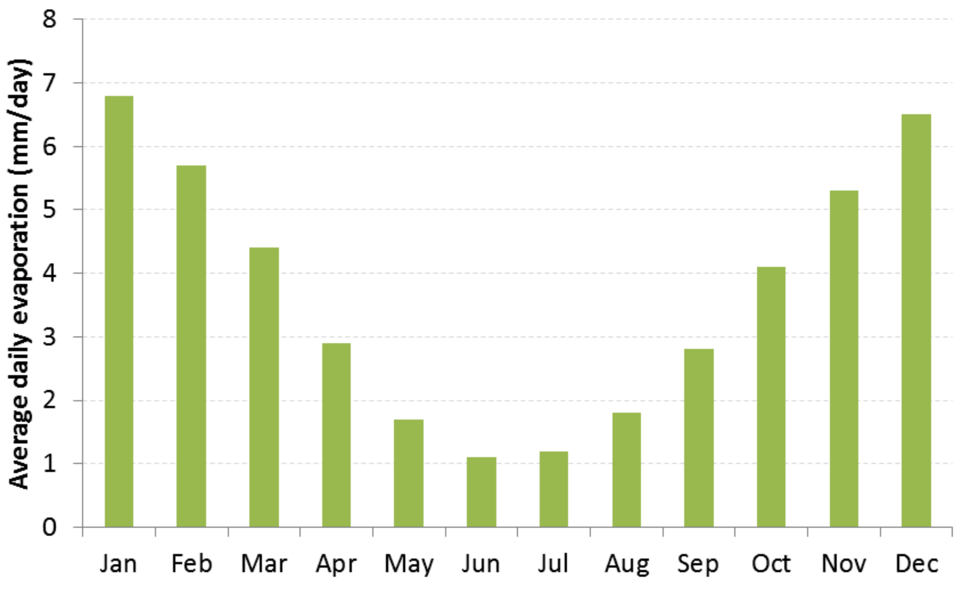


Figure 4-7 Average Daily Evaporation Each Month from BOM Bathurst Agricultural Station

4.3 Runoff

The surface of the site was characterised into four different surface types, based on inspection of aerial imagery:

- vegetated: all undisturbed bush land and grassed areas
- compacted: roads and working pad areas
- disturbed: stockpiles, bunds, coarse reject and waste rock emplacement areas
- rehabilitated: all rehabilitated areas, deemed to no longer qualify as disturbed

The four surfaces types were characterised with different sets of AWBM parameters. The AWBM parameters adopted for the water balance model are presented in Table 4-2.

Table 4-2 Australian Water Balance Model parameters

Parameter	Vegetated surface	Compacted surface	Disturbed surface	Rehabilitated surface
A_1, A_2, A_3	0.134, 0.433, 0.433	1.0, 0.0, 0.0	0.134, 0.433, 0.433	0.134, 0.433, 0.433
C_1, C_2, C_3 (mm)	6.0, 61.0, 121.9 (C_{ave} = 80 mm)	5.0, 0.0, 0.0	1.5, 15.2, 30.5 (C_{ave} = 20 mm)	3.7, 37.3, 74.2 (C_{ave} = 50 mm)
BFI	0.4	0.0	0.4	0.4
K_s	0.5	0.5	0.5	0.5
K_b	0.9	NA	0.9	0.9

The parameters for vegetated surface were determined based on available literature where historical streamflow data had been used to provide recommendations on parameter selection. The nearest location for which AWBM model parameters had been determined by Boughton and Chew (2003) was Coxs River, located 46 km south-west of the Project.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage was assigned a non-zero capacity. This storage represents depression storage of 5 mm for impervious areas. The baseflow parameters were adjusted to reflect no baseflow.

The parameters for rehabilitated areas and disturbed area are typical hydrologic parameters for such areas. The soil storage parameters were then calibrated for each surface type to the average annual runoff depth. The runoff parameters adopted were considered reasonable given the lack of site-specific flow gauging data and significant variability in catchment runoff characteristics that can occur.

4.4 Catchments

The catchment areas and surface types areas were estimated from aerial imagery and topography as shown in Figure 2-2. The catchment areas for each storage and the distribution amongst the surface types is shown in Table 4-3.

Table 4-3 Catchment areas and surface types

Storage	Vegetated area (ha)	Compacted area (ha)	Disturbed area (ha)	Rehabilitated area (ha)	Total catchment
A Pit	0.7	0.2	17.0	1.3	19.1
Co-Disposal REA	0.0	0.0	6.8	0.0	6.8
Cooks Dam	10.8	0.9	0.0	0.2	12.0
Council Pit	7.2	0.0	4.4	4.0	15.6
DML Dam	2.2	0.0	5.7	8.4	16.4
H Pit East	0.1	0.0	12.9	1.1	14.1
H Pit West	1.7	0.3	21.5	0.0	23.5
Main Sediment Pond	37.8	1.5	0.0	4.8	44.2
REA	0.0	0.0	11.1	0.0	11.1
Retention Pond	0.0	0.1	1.5	0.0	1.6
SHG1	112.8	1.9	7.7	2.4	124.8
SLG1	0.0	0.0	0.7	9.3	10.0
SLG2	1.6	0.8	0.5	5.9	8.8
SLG3	171.6	0.0	0.0	7.6	179.2
SLG4	0.1	0.0	0.1	4.5	4.7
SLG5	0.0	0.0	0.0	1.3	1.3
SLG6	33.9	3.5	3.0	0.0	40.4
Stockpile Sediment Pond	1.1	3.4	1.1	0.2	5.8
Washery Sediment Pond	1.7	7.2	14.4	6.8	30.1

4.5 Salinity

The electrical conductivity (EC) of the rainfall and coal moisture were assumed from regional and site data. The EC of runoff from the different surface types and seepage into Cooks Dam was calibrated to observed salinity in surface storages and LDP006 discharge in 2014 and 2015. EC was converted to a salinity concentration using a factor of 0.67 (mg/L)/(µS/cm) (DNRW, 2007).

The salinity parameters adopted from the calibration are shown in Table 4-4.

Table 4-4 Salinity parameters

Parameter	Electrical conductivity (µS/cm)
Rainfall	30
Vegetated runoff	400
Compacted runoff	1000
Disturbed runoff	1800
Rehabilitated runoff	400
Coal moisture	1135
Seepage into Cooks Dam	6000
Flocculent makeup	150

4.6 Storages

Stage storage relationships were provided for Cooks Dam, DML Dam, Main Sediment Pond, REA and Retention Pond. The geometry storages were approximated with the depth-area-volume relationships described in Brooks and Hayashi (2002) based on aerial and topographic information.

The key properties of all storages is listed in Table 4-5.

Table 4-5 Storage properties

Storage	Stage storage relationship	Spill level (m AHD)	Maximum depth (m)	Maximum surface area (ha)	Capacity (ML)
A Pit	Estimated	947.5	2.0	3.52	50.3
Co-Disposal REA	Estimated	912.0	4.0	4.27	121.9
Cooks Dam	Provided	905.5	8.1	1.20	44.6
Council Pit	Estimated	912.0	3.0	1.33	19.9
DML Dam	Provided	912.0	11.1	4.52	193.2
H Pit East	Estimated	912.0	3.0	0.68	10.2
H Pit West	Estimated	920.0	3.0	0.70	10.5
Main Sediment Pond	Provided	916.5	3.8	1.73	29.7
REA	Provided	970.0	20.2	13.55	1449.0
Retention Pond	Provided	903.0	1.9	0.42	3.9
SHG1	Estimated	934.0	5.0	0.38	9.5
SLG6	Estimated	905.8	2.0	0.11	1.1
Stockpile Sediment Pond	Estimated	910.0	1.0	0.17	0.8
Washery Sediment Pond	Estimated	922.0	1.0	0.17	0.8

4.7 Operations

The ROM coal production rate was distributed between both product coal and reject material according to fractions. The fine rejects slurry moisture was derived from fine rejects final dry density, fine rejects particle density and fine coal reject fraction. The total retained water volume was calculated as:

$$\frac{Total\ fine\ rejects\ [tonne]}{Fine\ rejects\ final\ dry\ density\ [\frac{tonne}{m^3}]} - \frac{Total\ fine\ rejects\ [tonne]}{Fine\ reject\ \ particle\ density\ \ [\frac{tonne}{m^3}]}$$

Dust suppression was assumed as constant flow if the total daily rainfall did not exceed the rainfall threshold. The parameters used are shown in Table 4-6. The operational pumping rules applied are summarised in Table 4-7.

Table 4-6 Operational data

Parameter	Value
ROM coal production rate (Mtpa)	1.5
Coarse coal reject fraction (%)	7.5
Fine coal reject fraction (%)	7.5
ROM coal moisture content (%)	6.7
Coarse coal reject moisture content (%)	9.0
Product coal moisture content (%)	7.3
Slurry solids content (% solids w/w)	16
Fine coal rejects particle density (kg/L)	2.0
Fine coal rejects final dry density (tonne/m^3)*	0.9
REA seepage rate (L/s)	1.4
Dust suppression rainfall threshold (mm/day)	1
Dust suppression on roads (ML/day)	0.136
Dust suppression on stockpiles (ML/day)	0.068

Table 4-7 Operating rules

Transfer	Operating rules
Cooks Dam to Washery (506 Pump)	First preference for supply to washery at maximum pump rate of 38 L/s.
Stockpile sediment pond to Washery (small diesel pump)	Pumping triggered when the sediment stockpile pond exceeds 50 % of capacity or as the second preference for supply to washery at maximum pump rate of 5 L/s.
Retention pond pump to dust suppression and washery	Supply dust suppression and supplement washery when storage greater than 90 % full at maximum pump rate of 25 L/s.
REA to A Pit (Diesel Pump 1)	Decant at a maximum rate of 40 L/s. Cease pumping if A Pit greater than 947 m AHD.
A Pit to Cooks Dam (Diesel Pump 2)	Pump at 20 L/s when above 946.5 m AHD, 90 L/s when above 947 m AHD.
Main sediment pond to SLG6 (outlet valve)	Outlet valve opens when no rain has occurred for 5 days. Flow through 425 mm pipe under gravity to discharge into the watercourse below the spillway at a maximum flow rate of 318 L/s. Discharge relationship is shown in Figure 4-8.
Washery sediment pond (low flow pipe)	Low flow outlet that discharge continuously with a maximum flow rate of 103 L/s. Discharge relationship is shown in Figure 4-9

The pumping capacity of the 506 and 508 pumps were estimated as maximum observed daily pumped transfer from the supplied pumping records. The pumping triggers and thresholds were developed through consultation with site personnel. Discharge relationships were derived from hydraulic properties for the outlets of Main Sediment Pond and Stockpile Sediment Ponds and are shown in Figure 4-8 and Figure 4-9.

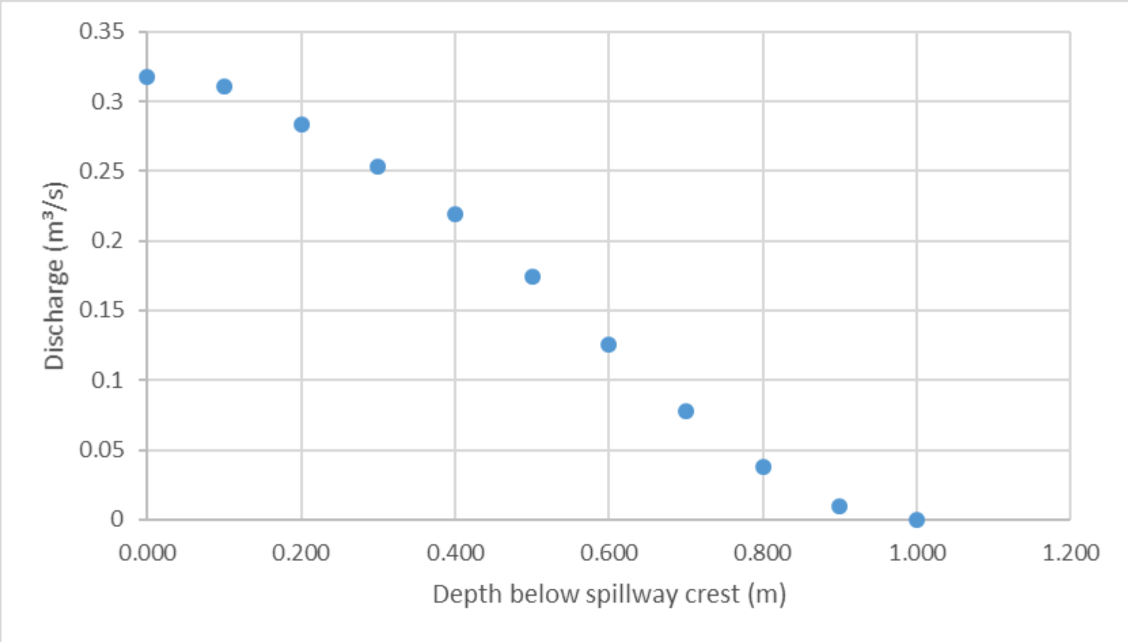


Figure 4-8 Main Sediment Pond low flow outlet discharge

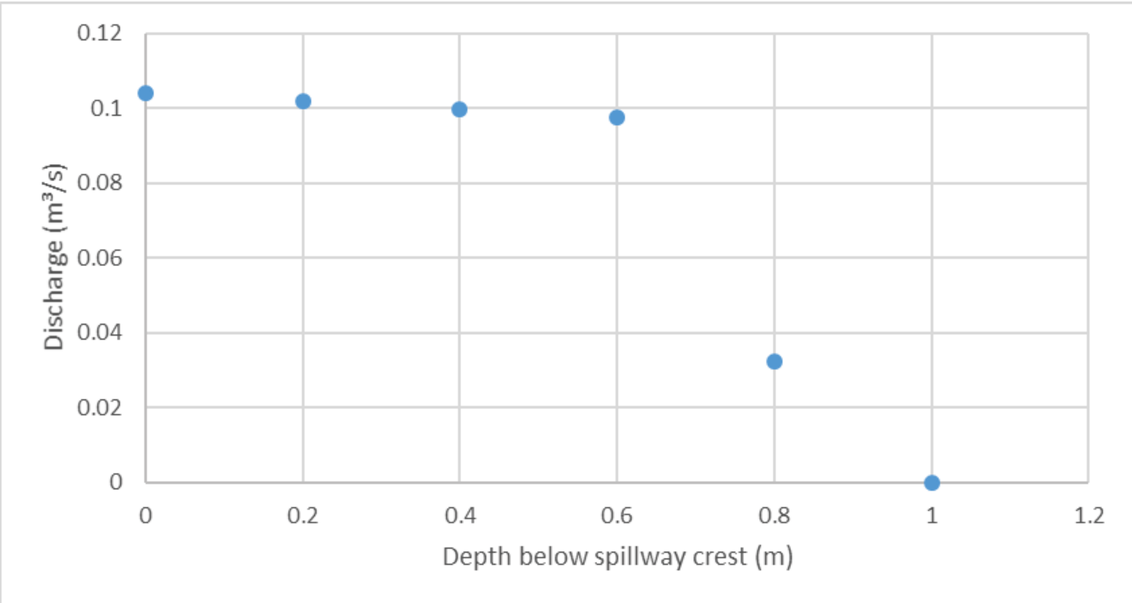


Figure 4-9 Stockpile Sediment Pond low flow outlet discharge

4.8 Groundwater environment

Hydrogeological modelling has been undertaken of the Springvale Coal Services site in 2013 (RPS) and was revised in 2016 (GHD). The 2016 hydrogeology modelling was tasked with some key objectives which included:

- Quantify the potential variability in groundwater conditions for the site with regards to flow volume and direction
- Validation of assumptions of the water and salt balance around surface and groundwater connectivity
- Estimate seepage rates

The modelling considered data provided by Centennial Coal for Springvale Coal Services and included groundwater level, geological data, and outcomes from previous assessments. The assessment did not consider groundwater information for the EnergyAustralia Mount Piper Power Station site which forms the western boundary of the site.

The predictions from the hydrogeology modelling undertaken in 2016 considered the following:

- Observed pumped transfer rate from Cooks Dam to DML Dam of 5.5 to 6.2 ML/day.
- Net seepage rate of 0.4 ML/day into Cooks Dam as a calibration target. This was derived from an analysis of DML Dam levels, Cooks Dam levels, pump records and LDP006 discharges from January 2015 to April 2015.
- Water levels within the Centennial monitoring bore network and surface water storages were used for transient simulations that considered groundwater flow directions with the objective of achieving the calibration target.

Following the development of the hydrogeology model it was determined that the results were not compatible with the observations made on site as the hydrogeology modelling cannot achieve the flow rates that are being observed through the high conductivity media at the timestep considered. It was determined that the water balance provided an improved tool of predicting groundwater contribution where surface storages connected to the groundwater environment can be represented by the historical underground working as a flow paths with short time frames.

The following assumptions were made for the representation of the groundwater environment in the model:

- Seepage rates are sufficient that water accumulation within the REA decant system and historical open cut voids does not occur. All surplus water captured is lost to the historical underground workings, that report to Cooks Dam.
- Cooks Dam seepage rate considered as a constant rate. However there is some evidence that the seepage rate may vary with rainfall driven infiltration into the disturbed areas.

4.9 Initial conditions

The model was initialised with all storage volumes at the corresponding operational volumes and all soil moisture storages in the hydrologic model empty. The initial conductivity was used to estimate the initial salt storage mass, based on the initial water storage volume.

The initial levels, estimated initial volumes and initial conductivities for each storage are shown in Table 4-8.

Table 4-8 Initial conditions

Storage	Initial level (m AHD)	Initial volume (ML)	Initial conductivity (µS/cm)
A Pit	946.0	7.2	3000
Co-Disposal REA	911.0	17.5	5000
Cooks Dam	905.5	44.8	4500
Council Pit	908.0	2.2	2000
DML Dam	908.5	92.2	4500
H Pit East	910.0	1.1	2000
H Pit West	918.0	1.2	2000
REA*	916.0	21.0	4000
Main Sediment Pond	955.0	22.5	5000
Retention Pond	903.0	3.9	1500
SHG1	930.0	0.4	500
SLG1	917.0	0.1	500
SLG2	915.0	0.9	500
SLG3	917.0	0.2	500
SLG4	919.0	0.1	500
SLG5	922.0	2.2	500
SLG6	904.0	0.1	1000
Stockpile Sediment Pond	909.0	0.1	2000
Washery Sediment Pond	921.0	0.1	3000

Note: REA initial conditions refer to volume of fine coal rejects and entrained moisture. The decant pond and beach were initialised empty.

5. Results

5.1 Validation

The validation process of the model is ongoing with the capture of monitoring data, and modifications to the water management system. The validation of the existing model was undertaken using a period of four months given recent changes to the water management system.

The model was validated against the observed LDP006 discharge and EC from 1/7/2016 to 1/11/2016. The validation period was selected as the time after water levels in DML Dam had returned to an equilibrium with the surrounding groundwater environment following cessation of pumping from Cooks Dam to DML Dam in April 2016. The validation considered seepage into Cooks Dam with:

- a flow rate of 3 ML/day (of which 53 % (1.6 ML/day) was from the REA)
- a conductivity of 4000 μS/cm attributed to groundwater seepage

A plot of observed and modelled cumulative LDP006 discharge is shown in Figure 5-1.

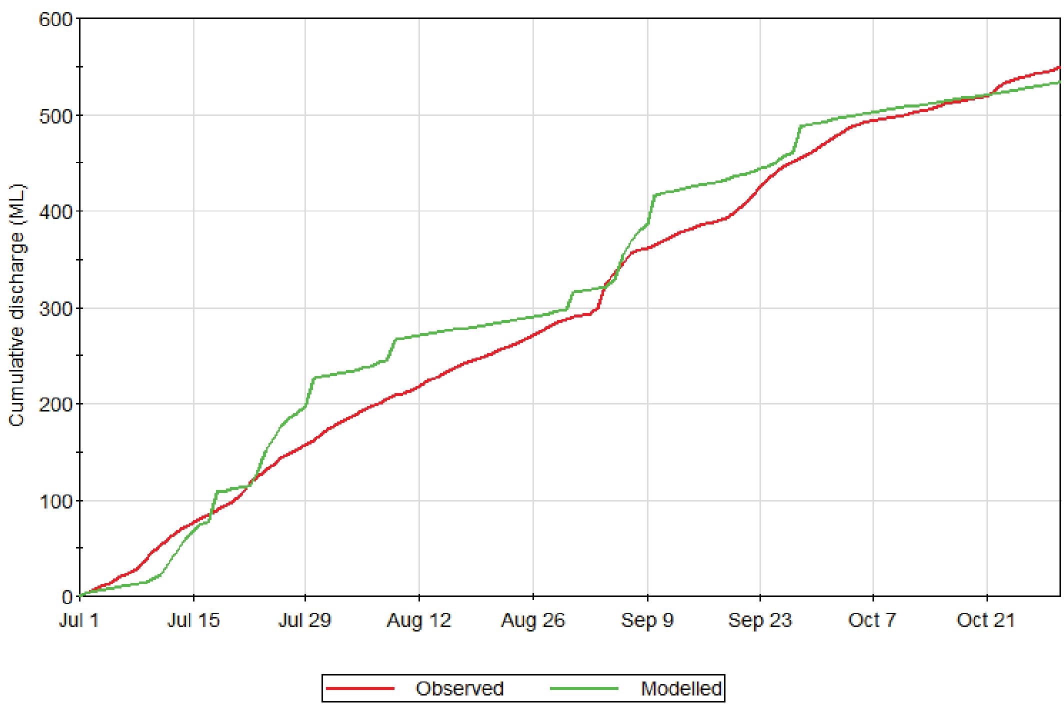


Figure 5-1 Comparison of observed and modelled cumulative LDP006 discharges

The model generally predicts a more flashy response to rainfall compared to observed discharges, but the total discharge volume over the validation period is within 10 % of the observed. Whilst the cumulative discharge volumes are similar, the daily result indicates a poor comparison between modelled predicted and observed results. This is due to poor physical representation of the recession of infiltration from the surface to the underground or from recharge locations to Cooks Dam, and lack of knowledge of actual operation of infrastructure such as Main Sediment Pond over the validation period.

The 7 day average of observed and modelled electrical conductivity (EC) is compared in Figure 5-2. A moving average was applied to filter fluctuations in the modelled EC due to the flashiness of the modelled flow rates. Overall the average matches well and captures most of the peaks and troughs over time.

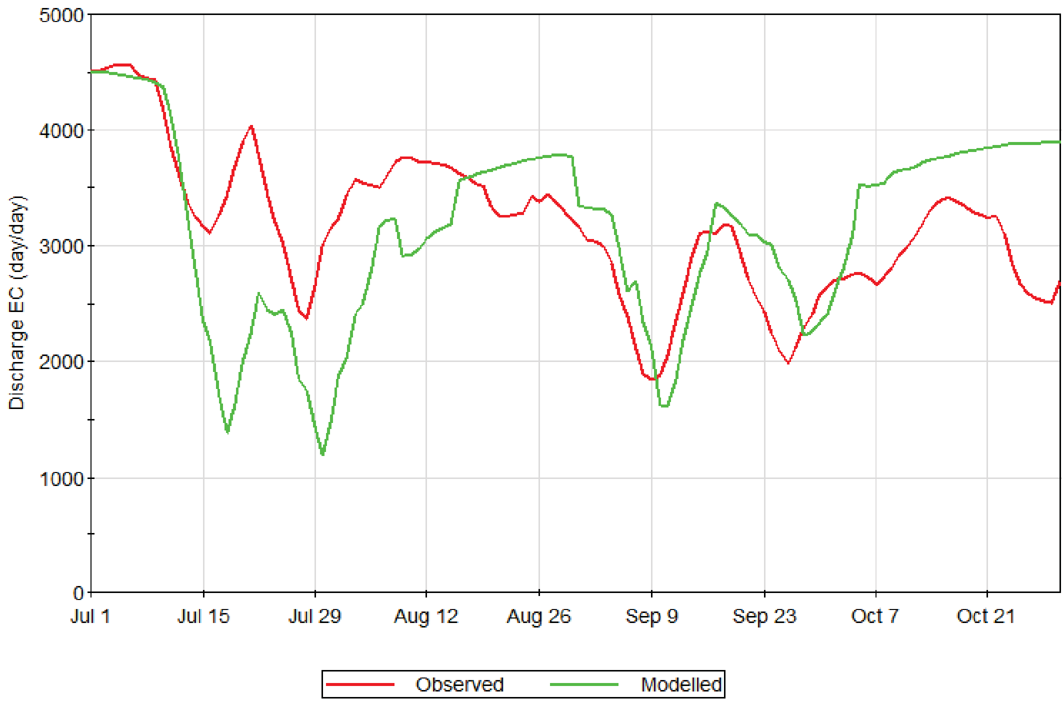


Figure 5-2 Comparison of observed and modelled 7 day average EC for LDP006 discharge

The validation of the model can be improved with a updated record of data for:

- Pump 506 transfers
- Coal washery rates and fine coal rejects pump rates to the REA
- Discharges from Main Sediment Pond, which can be estimated from a record of the periods when the discharge valve was open

5.2 Interpretation of results

The site water balance was modelled for one year under existing conditions. This timeline was simulated using a historical time series of daily rainfall data extending over 127 years.

A total of 127 different rainfall patterns were applied to this timeline (refer Section 3.2). As a result, 127 annual totals were available for each transfer element within the water management system, thereby representing a wide range of possible rainfall conditions.

The results presented show the average annual volumes (and 10th and 90th percentile values) for the water management elements under existing conditions. The purpose of displaying the three results for each water transfer is to show the average transfer volume and indicate the likely distribution of annual transfer volumes for each element.

The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value. The 10th and 90th percentile values have been used (rather than minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions. The set of 10th or 90th percentile values do not necessarily all correspond to the same rainfall series, that is, they do not correspond to a 10th percentile “dry” or 90th percentile “wet” year.

5.3 Water balance results

The predicted value for the existing conditions for each of the water transfers for the water balance model are shown in the water cycle schematic in Figure 5-3. The results show the mean and the 10th percentile and 90th percentile.

A summary of the mean overall input and output is shown in Table 5-1.

Table 5-1 Summary of average overall water balance

	Existing conditions (ML/year)
Inputs	
Direct rainfall	137
Catchment runoff	743
ROM coal moisture	108
Flocculent makeup	11
Seepage into Cooks Dam	1095
Total Inputs	**2094**
Outputs	
Evaporation	201
Dust suppression	32
Product coal moisture	100
Coarse coal rejects moisture	11
Discharge through LDP006	848
Seepage into historical mine workings	831
Retained in tailings	71
Total Outputs	**2094**
Change in Storage	0
Balance	**0**

The most significant transfers in the system are the recycle between the Cooks Dam and the REA. Water is withdrawn from Cooks Dam to supply the demand of the Washery. Most of this water is pumped as part of the slurry with the fine coal rejects which are emplaced in the REA. The return water from the fine rejects as they consolidate then flows back through historical mine workings to Cooks Dam.

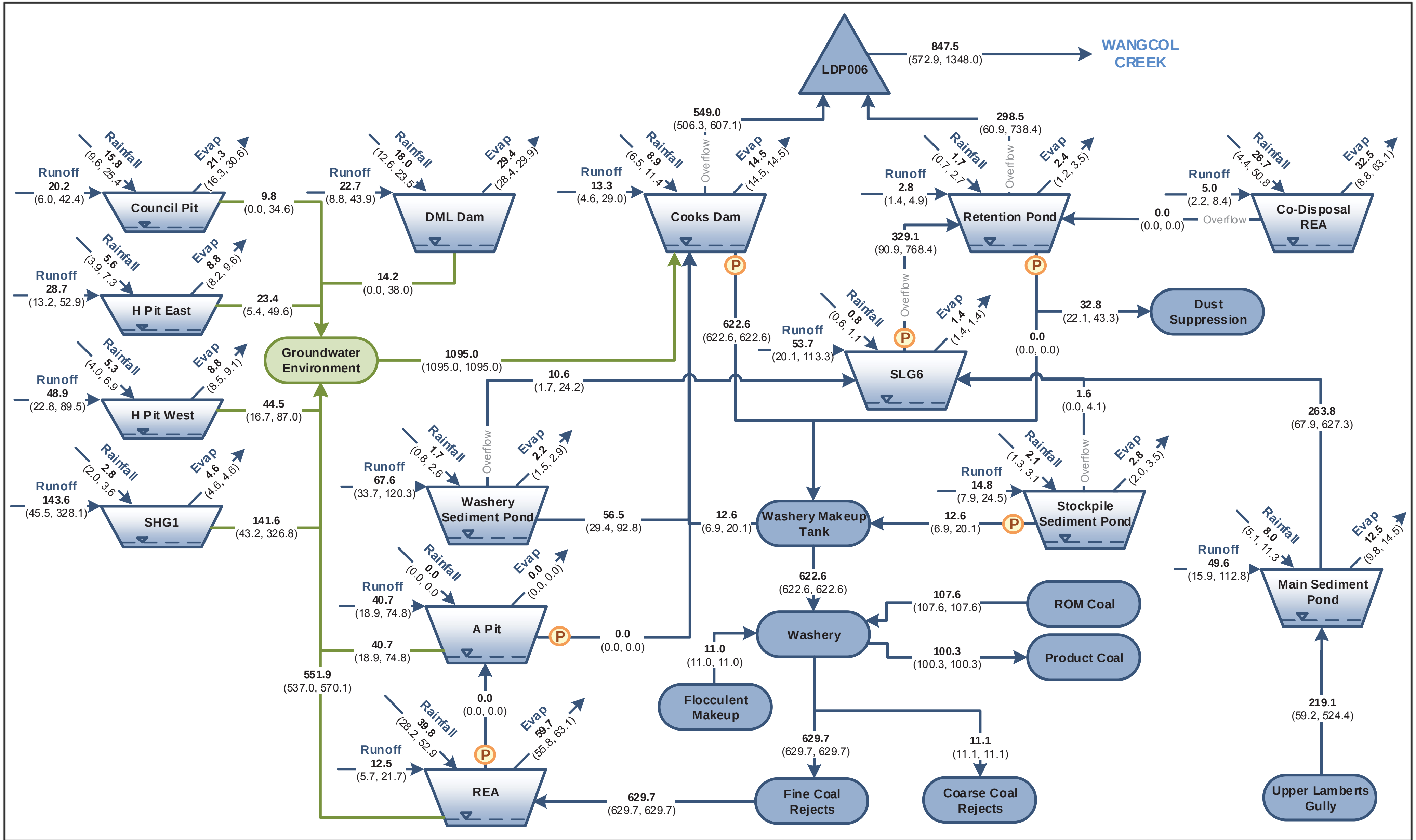
5.4 Salt balance results

The predicted value for the existing conditions for each of the water transfers for the water balance model are shown in the water cycle schematic in Figure 5-4. The results show the mean and the 10th percentile and 90th percentile.

A summary of the mean overall input and output is shown in Table 5-2.

Table 5-2 Summary of average overall salt balance

	Existing conditions (tonne/year)
Inputs	
Direct rainfall	3
Catchment runoff	433
ROM coal moisture	82
Flocculent makeup	1
Seepage into Cooks Dam	2935
Total Inputs	**3454**
Outputs	
Evaporation	0
Dust suppression	15
Product coal moisture	226
Coarse coal rejects moisture	25
Discharge through LDP006	1517
Seepage into historical mine workings	1498
Retained in tailings	172
Total Outputs	**3454**
Change in Storage	0
Balance	**0**



LEGEND

- Surface Water Transfer
- Underground Water Transfer
- Pump
- Storage

LOCATION	SCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Springvale Coal Services
Site Water and Salt Balance Assessment

Annual water transfers
Existing conditions

Centennial Coal

DATE 2 Nov 2016

Figure 5-3

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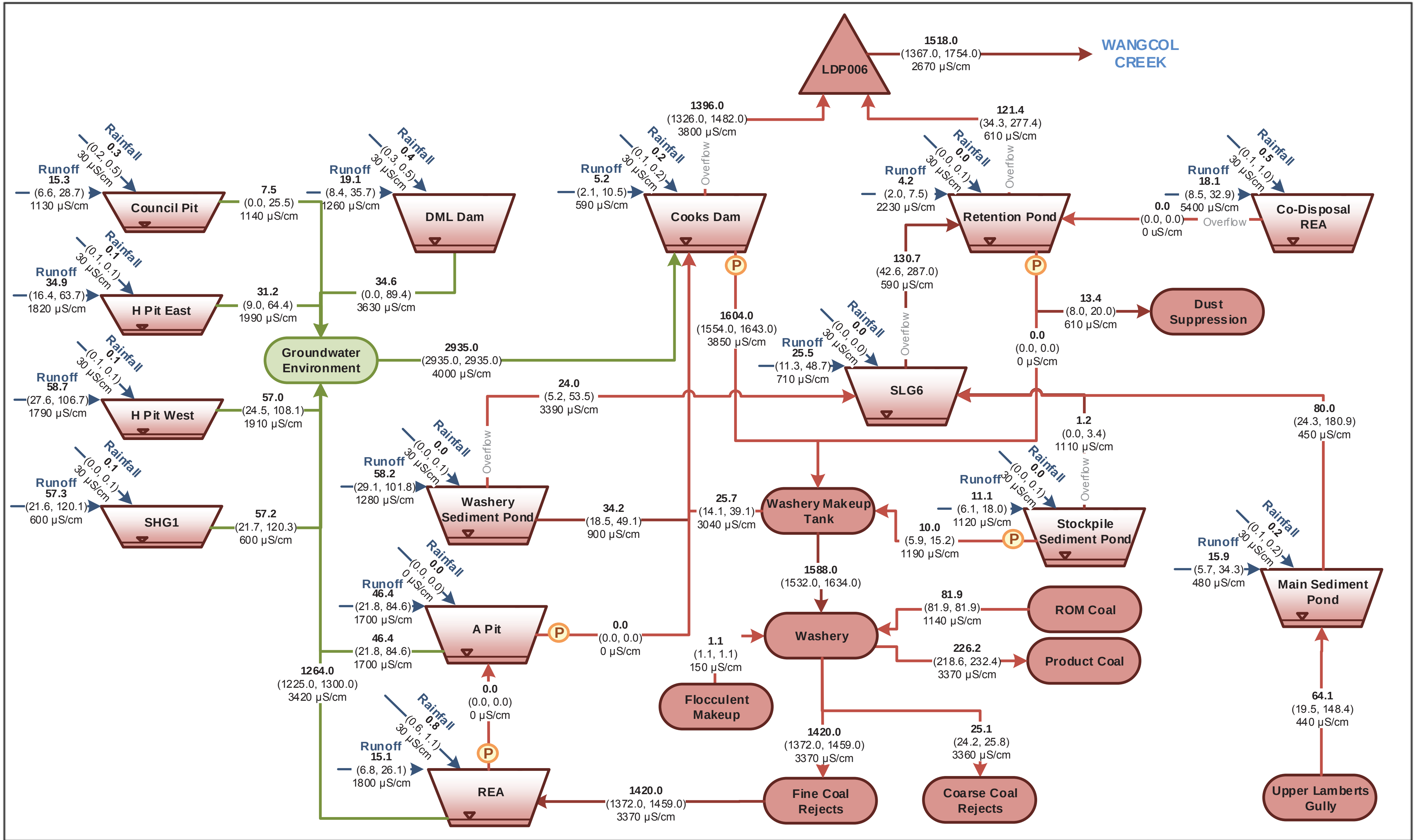

LEGEND

- Surface Water Transfer
- Underground Water Transfer
- P Pump
- Storage

LOCATION	SCS
SEAM	NA
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Springvale Coal Services
Site Water and Salt Balance Assessment

Annual salt transfers
Existing conditions

Centennial Coal

DATE 2 Nov 2016

Figure 5-4

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5.5 Qualification of predictions

GHD has developed the water and salt balance model for the Project based on information supplied by Springvale and external data sources. Where data was not available, GHD has made assumptions as appropriate.

Data used to develop the model are categorised as follows:

- Relatively reliable data:
  - SILO rainfall data.
  - BOM evaporation data.
  - Surface catchment areas based on topographic maps.
  - Coal moisture and salinity parameters
- Less reliable data:
  - Runoff volumes from impervious, disturbed and natural catchments.
  - Operational precedence for transfers between storages.
  - Seepage into and out of the historical mine workings, which is based on a mass balance approach only and has not yet been validated against actual hydrogeological parameters
  - Storage geometry for storages that have not been surveyed.
  - Final dry density of fine rejects

The consequence of the items listed within the 'less reliable data' category is there is likely to be a risk that the model predictions are somewhat inaccurate. The accuracy is expected to improve once more site data is gathered during the life of the Project. This additional data will allow refinement of the model input and hence increase the reliability of the model predictions. The adoption of historical rainfall and evaporation data within the detailed water balance model does not take into account the potential impacts of climate change.

It should be noted that the water and salt balance model is sensitive to the final dry density of the fine rejects emplaced in the REA. The values used in this assessment were the best available at the time this assessment was undertaken. The outcomes of this assessment, particularly the predicted discharge volumes are sensitive to these values. If predicted final dry density of fine rejects change substantially, GHD recommends the model and assessment be revised.

6. Summary

GHD Pty Ltd (GHD) was engaged by Springvale Coal Pty Ltd (Springvale) to undertake a site water and salt balance for the Springvale Coal Services site (the site). The water balance allows the assessment of operational and environmental risks associated with the quantity of water managed within the site. The water management system at the site is comprised of a clean and a dirty water system, however due to the extent of the disturbance at the site, clean and dirty water are mixed before discharging into Wangcol Creek. The objective of water management system is to ensure supply to the washery and for dust suppression and to control the quantity and quality of discharged water.

The water balance was modelled as a probabilistic mass balance, implemented using Goldsim 11.1.5. The model consisted of the water management features and the transfer into and from each feature. The transfers were driven either by environmental processes, rainfall, runoff, evaporation and seepage, or by operational process, pumped transfers, coal moisture and dust suppression. The water cycle was simulated over time in GoldSim and selected outputs from the modelled system were statistically summarised. Data to parameterise the water balance was collated and interpreted from data provided by Springvale and from previous reports. A historical rainfall record was used to assess the impact of climate variability of the model.

The model was validated against the observed LDP006 discharge from 1/7/2016 to 1/11/2016. The model generally predicts a more flashy response to rainfall compared to observed discharges, but the total discharge volume is within 3 % of the observed. Whilst the cumulative discharge volumes are similar, the daily result indicates a poor comparison between modelled predicted and observed results. The 7 day average of observed and modelled electrical conductivity overall the matches well and captures most of the peaks and troughs over time.

The most significant transfers in the system are the recycle between the Cooks Dam and the REA. Water is withdrawn from Cooks Dam to supply the demand of the Washery. Most of this water is pumped as part of the slurry with the fine coal rejects which are emplaced in the REA. The return water from the fine rejects as they consolidate then flows back through historical mine workings to Cooks Dam.

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https://projects.ghd.com/OC/Newcastle/wcsmodforsvwtpwaste/Delivery/Documents/2218193-REP-111922_Site_Water_and_Salt_Balance_Assessment_.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	T Tinkler	L Hammersley	L Hammersley	S Gray	[illegible]	2/11/2016

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Appendix B – Hydrogeology Model Report

Springvale Coal Pty Ltd

Springvale Coal Services

Hydrogeological Model Report – 2016 Update

November 2016

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Appendices

Glossary

Aquifer	A groundwater bearing formation sufficiently permeable to transmit and yield productive volumes of groundwater.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Bord and pillar	A mining system whereby coal is extracted leaving 'pillars' of untouched coal to support the strata above.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Clean Water	Waters within a site that have not come into physical contact with coal, disturbed areas or mined carbonaceous material.
Dirty Water	Waters within a site that have come into contact with coal, disturbed areas, mined carbonaceous material or otherwise contain an elevated sediment load.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Groundwater	Subsurface water that occurs in soils and geological formations.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Interburden	Strata between coal seams.
Outcrop	Where bedrock is exposed at the ground surface
Overburden	The strata between the topsoil and the upper coal seam
Permian age	The youngest geological period of the Palaeozoic era, covering a span between approximately 290 and 250 million years.
Quaternary	The most recent geological period spanning from approximately 2.5 million years ago to present.
Runoff	The amount of rainfall that ends up as streamflow, also known as rainfall excess.
Strata	Geological layers below the ground surface.

Abbreviations

AHD	Australian Height Datum
bgl	Below ground level
BOM	Bureau of Meteorology
m	Metres
ML	Megalitres
mm	Millimetres
REA	Rejects Emplacement Area

1. Introduction

GHD Pty Ltd was commissioned by Springvale Coal Pty Ltd to develop a numerical hydrogeological model for the Springvale Coal Services site (the site). The locality of the site is shown in Figure 1-1. The numerical hydrogeological model has been developed to investigate the hydrogeological environment at the site, predict regional groundwater flow and investigate potential interactions between the groundwater environment and surface water storages at the site. This report outlines the hydrogeological modelling methodology and results. The objectives and scope of this report are detailed further in Section 1.1 and 1.2.

1.1 Objectives of this hydrogeological model

A hydrogeological model has been developed to:

- Review regional groundwater flow direction and flow paths in the vicinity of the site.
- Predict the rate of regional groundwater flow across the site.
- Estimate seepage from and into surface water storages at the site to assist in quantifying transfers of water between storages in the site water balance (GHD, 2016).

1.2 Scope of work

The scope of works for the hydrogeological modelling is as follows:

- Collation of available hydrogeological and mining data.
- Development of a conceptual hydrogeological model of the coal seam, backfilled areas, ash emplacement and overlying/underlying strata.
- Construction of a MODFLOW numerical hydrogeological model, based on the conceptual model.
- Calibration of the model using available data under steady state conditions.
- Creation of groundwater contours to indicate groundwater flow direction across the site.
- Prediction of groundwater flow rates and seepage to and from surface water storages.

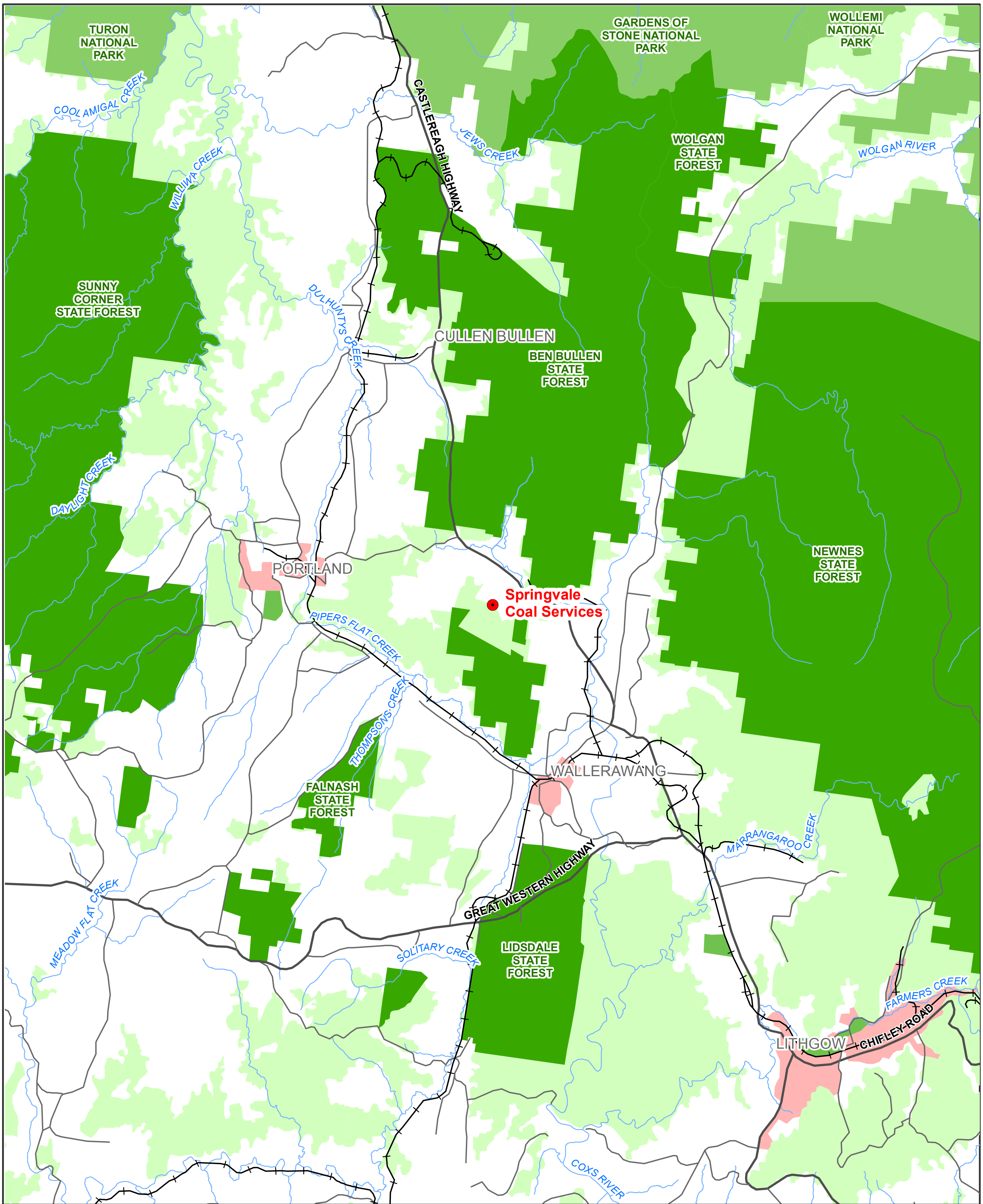
1.3 Existing water management

The existing water management system is comprised of clean and dirty water management systems, however due to the extent of disturbance at the site, clean and dirty water are mixed before discharging into Wangcol Creek. The discharge design is currently being modified to avoid mixing of clean and dirty water.

The water storages and other water management features of the site are shown in Figure 1-2.

1.3.1 Clean water management

Clean water diversion drains concentrate the catchment upstream of the site into two drainage lines that are then intercepted by the site. Lamberts Gully, to the east, is intercepted by Main Sediment Pond, which also collects runoff from rehabilitation areas. Huon Gully, to the west, terminates at SHG1 where retained runoff is lost to seepage. It is likely that water seeping out of this storage is seeping into historical underground workings. There are no dedicated clean water storages at the site.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site location
- Existing rail
- Dual carriageway
- Principal road
- Secondary road
- Minor road
- Waterway
- Built up area
- Nature conservation
- State forest
- Forest or shrub

LOCATION	NA
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	Refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Locality plan

Centennial Coal

DATE 02 Nov 2016

Figure 1-1

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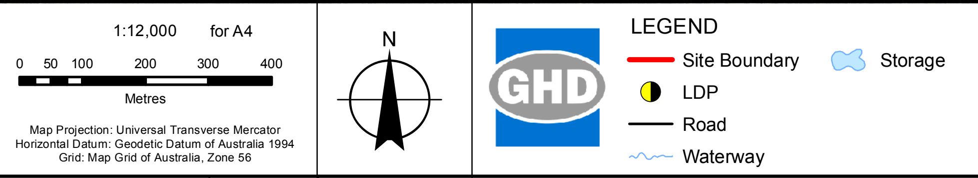

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Water management features

Centennial Coal

DATE 02 Nov 2016

Figure 1-2

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© LPI: DTDB, 2012. LIDAR: Imagery, 2015; Centennial: Boundary, site features

1.3.2 Dirty water management

The dirty water management system consists of a series of ponds, pumps and pipes that allow runoff and water seeping from the groundwater to be captured, treated (if required) and redistributed within the site for reuse or to improve the water quality of another pond through dilution. Water is used in the washery and for dust suppression.

Further detail regarding the transfer of water between surface water storages is detailed in the water balance (GHD, 2016).

A number of the surface water storages are unlined and are expected to seep into and/or receive seepage from groundwater including water in the historical mine workings. These unlined storages include DML Dam, Cooks Dam, SHG1, Council Pit, H Pit East, H Pit West, A Pit reject emplacement area (REA) and the REA.

2. Existing conditions

2.1 Site topography and hydrology

The site lies mid slope between the rising hills to the south and the Wangcol Creek valley to the north. Terrain to the south rises to 1050 m Australian height datum (AHD), while the elevation of the site itself is between 960 m AHD to 920 m AHD, with the overall terrain sloping to the northeast.

The runoff from the site concentrates into two natural watercourses, Huon Gully to the west and Lamberts Gully to the east. The hydrology of the site has been significantly changed due to open cut and underground mining and related activities. As discussed in Section 1.3.1, the natural watercourse in Huon Gully now terminates in a surface water storage (SHG1), as the gully has been disturbed by open cut mining and lower down filled by the Mt Piper Power Station Ash Emplacement Area (Ash Emplacement Area).

2.2 Geology

The site is located within the southern part of the Western Coalfield of NSW, on the western edge of the Sydney Basin. The area is underlain by Permian Illawarra Coal Measures, which is underlain by Berry Siltstone of the Shoalhaven Group. The Triassic sandstone of the Narrabeen Group outcrops approximately 700 m to the north east of the site.

The stratigraphy at the site is summarised in Table 2-1. This information has been sourced from the Western Coalfield (Southern Part) Regional Geology 1:100,000 map (NSW Department of Mineral Resources, 1992) and borehole logs at Springvale Coal Services. The outcrop geology in the vicinity of the site is shown in Figure 2-1.

Table 2-1 Stratigraphic sequence – Springvale Coal Services

<table>
<tr><th rowspan="2">Period</th><th colspan="3">Stratigraphy</th><th rowspan="2">Lithology</th></tr>
<tr><th>Group</th><th>Subgroup</th><th>Formation</th></tr>
<tr><td>Quaternary</td><td colspan="3">Alluvium</td><td>Silt, clay, sand, gravel</td></tr>
<tr><td rowspan="3">Permian</td><td rowspan="2">Illawarra Coal Measures</td><td>Charbon</td><td>Irondale Seam
Long Swamp Formation</td><td>Sandstone, claystone, coal, mudstone</td></tr>
<tr><td>Cullen Bullen</td><td>Lidsdale Seam
Blackmans Flat Conglomerate
Lithgow Seam
Marrangaroo Formation</td><td>Coal, claystone, siltstone, mudstone, conglomerate</td></tr>
<tr><td colspan="2">Shoalhaven Group</td><td>Berry Siltstone</td><td>Siltstone, lithic sandstone, conglomerate</td></tr>
<tr><td>Devonian</td><td colspan="3">Metamorphic rocks</td><td>Quartzite, shale, sandstone, limestone, tuff</td></tr>
</table>

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0 150 300 600 900 1,200

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site Boundary
- Illawarra Coal Measures (Pi)
- Shoalhaven Group (Ps)
- Quaternary (Qa)
- Triassic Formations (Tn)

LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Geological map

Centennial Coal

DATE 02 Nov 2016

Figure 2-1

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© LPI: DTDB, 2012. LIDAR: Imagery, 2015; Centennial: Boundary, site features; NSW DPI: Geology, 2010.

The Lithgow Seam was the historical target seam of the historical underground Western Main workings. The Lithgow Seam outcrops to the south of the site. The Lidsdale Seam overlies the Lithgow Seam and also outcrops to the south of the site. The Irondale Seam outcrops to the north of the site and along the northern and southern slopes of the Wangcol Creek valley, including throughout the site. The Lidsdale Seam outcrops along Wangcol Creek to the north-east of the site. The Katoomba Seam outcrops to the north of the site.

There are areas of unconsolidated Quaternary alluvium along creek lines in the vicinity of the site. Mapped areas of Quaternary alluvium occur along reaches of Wangcol Creek upstream of the site and there are deposits of alluvium along the Coxs River to the east and south east of the site.

2.3 Hydrogeology

The local hydrogeology at the site is highly modified due to activities associated with historical mining including underground and open cut workings and backfilling of open cut voids, as described in Section 2.3.2, and placement of ash associated with the Mount Piper Power Station.

Previous hydrogeological models of the site have been developed by CDM Smith (2012) and RPS (2013). These models are of a local scale and were developed to assess impacts of changes to site operations. These previous studies indicate that groundwater flow in the deeper strata, including the Marrangaroo Formation and underlying strata, is generally to the north east following the dip of the strata. RPS (2014) reports that within shallow strata groundwater levels generally correspond to topography with higher groundwater elevations in elevated areas and lower groundwater levels along valleys and drainage lines.

Geophysical groundwater investigations undertaken in August 2016 identified areas of elevated salinity between the Energy Australia Ash Stockpile and DML and Cooks Dam and in the vicinity of the REA Dam and the A-Pit (Groundwater Imaging, 2016). These areas of higher groundwater salinity are potentially seeping into DML Dam and Cooks Dam.

2.3.1 Hydraulic conductivity

Hydraulic conductivities for the strata at the site have been reported by RPS (2013) based on analysis of hydraulic test data and information from other studies and are shown in Table 2-2.

Table 2-2 Hydraulic conductivity (RPS, 2013)

Geological unit	Hydraulic conductivity range (m/d)
Quaternary alluvium/residual soil (regolith)	0.001 – 5
Triassic Narrabeen sediments	0.04 – 7
Permian coal measures and overburden	0.0003 – 14
Marrangaroo Formation/Berry Siltstone	0.006 – 0.2

2.3.2 Connectivity between surface water storages and groundwater

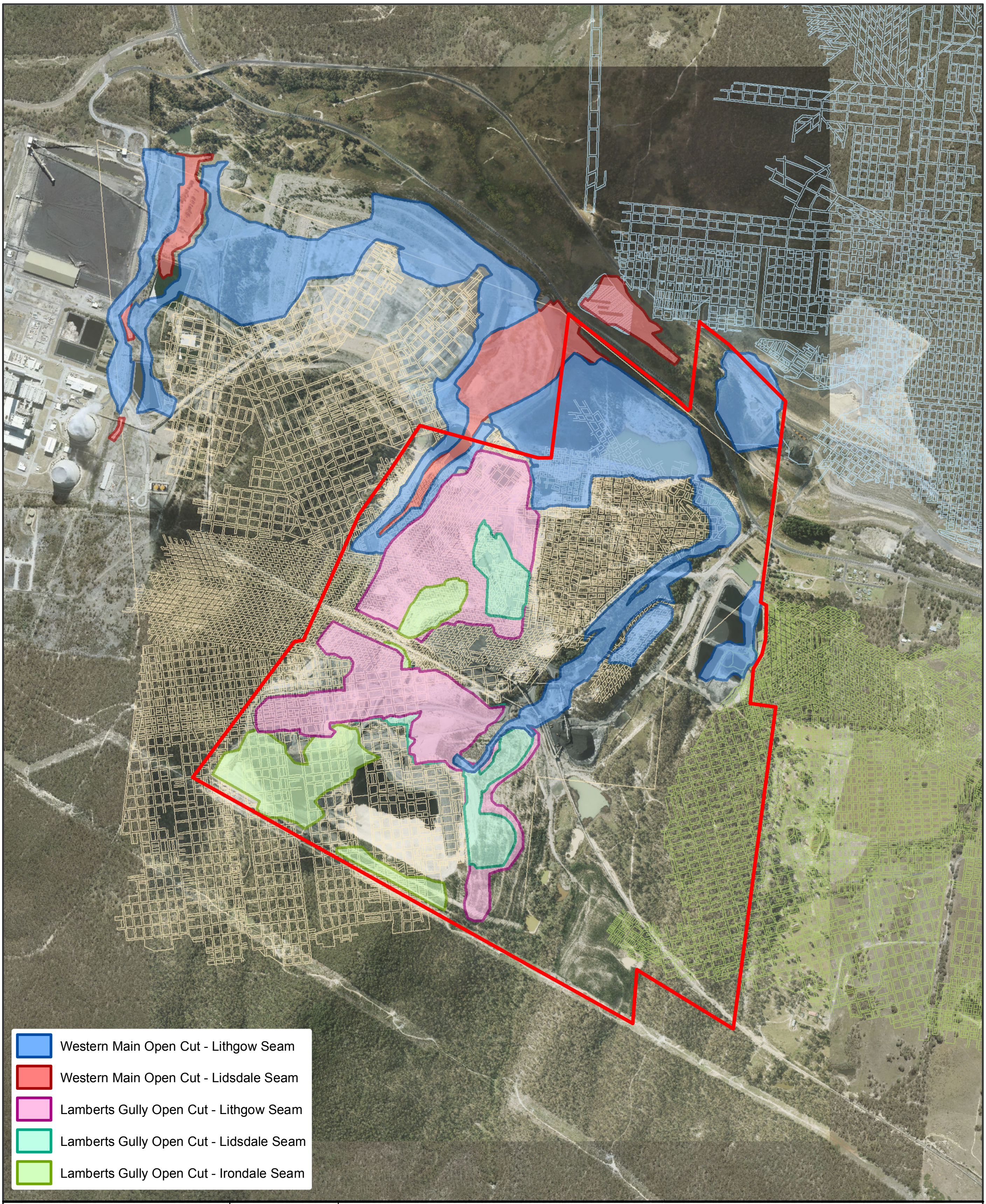
The site includes a number of surface water storages that are unlined and are likely seeping into groundwater or are receiving seepage from groundwater.

The results from the water balance (GHD, 2016) indicate that seepage was occurring from a number of storages into the groundwater, potentially into the historical mine workings. This is based on the observation that water levels within surface water storages generally do not change by much over time, indicating that runoff into these storages must be entering the groundwater system. The water balance also indicated that seepage was occurring from DML Dam into Cooks Dam.

As outlined in Section 1.1, the purpose of the hydrogeological model, developed as part of this report, was to estimate seepage from and into surface water storages at the site to assist in quantifying transfers of water between storages as part of an update of the site water balance.

2.4 Historical mining operations

The historical Western Main underground workings are located under the Springvale Coal Services site. The Western Main workings include bord and pillar workings that targeted the Lithgow Seam. Open cut workings (referred to as third workings) were undertaken as part of the Western Main and Lamberts Gully mining operations within and surrounding the Springvale Coal Services Site. The open cut workings involved extraction down to the floor of the Lithgow Coal Seam, including extraction of remaining pillars from the underground Western Main workings. Following open cut extraction the voids were generally backfilled. Open cut mining at Lamberts Gully finished in June 2010. The historical Western Main underground workings and areas of open cut workings are shown in Figure 2-2.



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0 65 130 260 390 520

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Site Boundary
- Wallerawang Underground Workings
- Eastern Main Underground Workings
- Western Main Underground Workings

LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Historical mining

Centennial Coal

DATE 02 Nov 2016

Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218391\2218391_004_HistoricalMining_0.mxd

22-18391

3. Data sources and analysis

The hydrogeological model has been developed with reference to the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). As outlined in Section 1.1, the purpose of the model is to review groundwater flow direction in the vicinity of the site and estimate seepage from and into surface water storages at the site for a range of surface water storage levels. It has been designed to inform operational management of the site and has not been developed for groundwater impact assessment in accordance with the NSW Aquifer Interference Policy.

Based on the model objectives, the availability of existing data and the value of the groundwater sources, the model is considered to have a Class 2 level of confidence, as defined under the Guidelines. A Class 2 model is considered suitable for:

- Prediction of impacts of proposed developments in medium value aquifers.
- Evaluation and management of medium risk impacts.
- Providing estimates of dewatering requirements for mines and excavations and the associated impacts.
- Designing groundwater management schemes such as managed aquifer recharge, salinity management schemes and infiltration basins.

This section outlines the initial process of data collation and analysis. Data requirements for the hydrogeological model can be divided into hydrogeological framework data, hydrological stress data and groundwater monitoring data. The hydrogeological framework data have generally been used to build and parameterise the model, whereas the hydrological stress data have been used in model calibration.

3.1 Hydrogeological framework data

Hydrogeological framework data includes extent, thicknesses and boundaries of geological (and aquifer) units and aquifer properties (hydraulic conductivity, porosity, storage and specific yield). In typical modelling scenarios these parameters do not change over time, however in a mining context there may be changes due to rock fracturing and subsidence. These data have been sourced from the following:

- 1:100,000 Western Coalfield (Southern Part) regional geological map (NSW Department of Mineral Resources, 1992).
- Depth of cover, seam thickness and seam outcrop drawings (supplied by Centennial Coal).
- 10 m topographical contours (obtained from Land and Property Information, NSW Government, 2012).
- Historical workings in the vicinity of the site (supplied by Centennial Coal).
- Previous assessments (RPS, 2013; RPS, 2014; CDM Smith 2012) for aquifer properties (further details in Section 4.3).

3.2 Hydrological stress data

Hydrological stress data includes the time varying hydrological data such as natural recharge, injection/extraction, drains, creeks and other sources and sinks. This data has been sourced from the following:

- Rainfall data (obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence).

- Groundwater level monitoring data and levels of surface water storages.
- Seepage rates into and out of some surface water storages that were estimated from a simulation of the site water balance for historical conditions.

3.2.1 Rainfall data

Daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data ‘patched in’ by interpolating with data from nearby stations.

For this assessment, SILO data was obtained for BOM Lidsdale (Maddox Lane) Station (station number 63132), which is located approximately 3.5 km south east of the site at an elevation of 890 m AHD. This station was chosen based on the length and quality of the data record and the proximity to the site.

The period of rainfall data was obtained for this assessment extended from 1 January 1889 to 1 January 2015. The statistics for this rainfall data set are:

- Minimum annual rainfall – 330 mm in 2006.
- Average annual rainfall – 737 mm.
- Median annual rainfall – 725 mm.
- Maximum annual rainfall – 1515 mm in 1950.

Annual rainfall totals have been plotted and are shown in Figure 3-1.

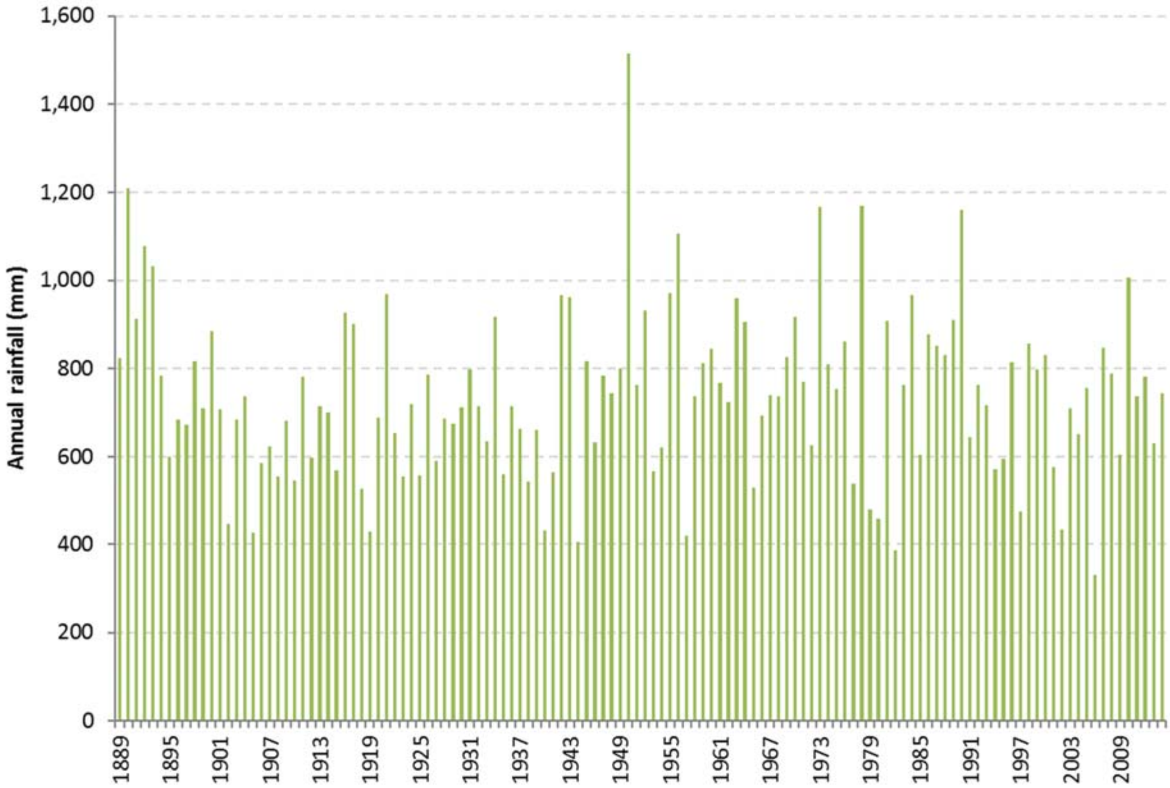


Figure 3-1 Annual rainfall totals – BOM Lidsdale (Maddox Lane) Station (station number 63132)

3.2.2 Groundwater monitoring data

Groundwater level data reported by Springvale Coal Services has been used where appropriate to calibrate the hydrogeological model. The existing groundwater monitoring network at the site includes a number of groundwater monitoring bores.

Existing monitoring location details at the site are outlined in Table 3-1 and locations are shown in Figure 3-2.

Groundwater hydrographs for monitoring bores are shown in Appendix A. The hydrographs show that there has been only a small degree of fluctuation in groundwater levels over time at most groundwater monitoring locations across the site. The exceptions to this are:

- BH02 which has shown a generally decreasing trend in groundwater levels throughout 2015.
- BH10 which has been consistently dry.
- BH12 which has been consistently dry in 2016.

The minor temporal changes in groundwater levels across the site indicate that groundwater levels in the vicinity of the site have stabilised following the completion of mining.

Table 3-1 Springvale Coal Services groundwater monitoring locations

Bore	Top of casing (m AHD)	Strata	Ground level (m AHD)	Bore depth (m bgl)	Screen (m bgl)
BH01	913	Lithgow Seam	912.37	18.3	15.3-18.3
BH02	918.5 (approx)	Marrangaroo Formation/ Berry Siltstone	916.2	30	24-30
BH03	905.76	Saturated overburden	905.13	18.57	15.5-18.5
BH04	930.71	Lithgow Seam workings (void)	929.98	27.51	
BH05	929.59	Lithgow Seam (unmined pillar)	928.83	30.19	
BH06	905.9	Lithgow Seam	905.35	9.3	
BH07	925.16	Up-gradient saturated overburden	924.24	33	18-33
BH08	928.27	Lithgow Seam workings (void)	927.38	24.4	21.4-24.4
BH09	930.75	Lithgow Seam workings (void)	929.79	25.5	22.5-25
BH10	937.4	Lithgow Seam workings (void)	936.45	25.2	22-25
BH11	950 (approx.)	Marrangaroo		34.19	

Bore	Top of casing (m AHD)	Strata	Ground level (m AHD)	Bore depth (m bgl)	Screen (m bgl)
BH12	917.81	Marrangaroo	917	18.68	
BH13	917.67	Back fill	917	12.37	
BH15	913	Up-gradient Overburden	940	25.5	18.6-24.6

Note: bore information sourced from RPS (2013) and RPS (2014)
bgl: below ground level

3.2.3 Surface water storages

As discussed in Section 1.3.2 and 2.3.2 there are a number of surface water storages that have been determined, based on the site water balance, to seep into groundwater or receive seepage from groundwater. These storages have been considered for inclusion in the hydrogeological model. Water levels for DML Dam, Cooks Dam, Council Pit, H Pit West, H Pit East, REA and A Pit REA have been monitored at the site. Average surface water levels for each of these storages for June 2016 (where data was available) are presented in Table 3-2. Water level at SHG1 has not been monitored. The water level at SHG1 was estimated from aerial photography

Historical surface water storage level data are available from 2013 onwards for the majority of surface water storages at the site. For pre 2013, storage volume data are available for DML Dam only. The volume data for DML was converted to a water level using the stage storage relationship developed for DML Dam as part of the site water balance (GHD, 2016). Water levels for all other surface water storages pre 2013 were assumed to be constant and equal to 2013 water levels.

Table 3-2 Average surface water storage levels – June 2016

Surface water storage	Water level (m AHD)
DML Dam	907.9
Cooks Dam	905.9
Council Pit	910.0
H Pit West[1]	919.0
H Pit East	910.7
REA[2]	956.1
A Pit REA	946.4
SHG1[3]	932.7

Notes:

1. Based on January 2016 water level.
2. The water level for REA is likely to refer to water on the surface of the REA. This water is decanted off the top of the REA.
3. Estimated from aerial photography.

3.2.4 Estimated seepage rates

The site water balance (GHD, 2016) was simulated over historical conditions and seepage rates into and out of a number of the surface water storages was estimated. Using observed surface water storage level data, seepage rates were estimated by a balance of inputs and outputs of water for each of the surface water storages. Inputs into each of the storages included rainfall, runoff, groundwater seepage and pumping of water into the storages, while outputs included evaporation, groundwater seepage and pumping of water out of the storages.

Further details regarding the surface water storage inflows and outflows calculated from the site water balance and utilised in the development of the hydrogeological model are outlined in Appendix C. The site water balance has since been updated with additional site data and this will be used in the next update and recalibration of the hydrogeological model.

1:12,000 for A4

0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Site Boundary

Monitoring bore

LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Groundwater monitoring network

Centennial Coal

DATE 02 Nov 2016

Figure 3-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218391\2218391_005_GWMonitoring_0.mxd

22-18391

4. Conceptual model and boundary conditions

A conceptual model of groundwater sources within the site has been developed to define the hydrogeological domain, define boundary conditions (including sources and sinks to the groundwater sources), describe groundwater flow, nominate aquifer properties and outline model assumptions and limitations.

4.1 Hydrogeological domain

The horizontal domain of the hydrogeological model includes the outcrop boundary of the Illawarra Coal Measures to the west and south of the site and extends into the Shoalhaven group outcrop area as shown by the boundary in Figure 4-1. The boundary also extends to the north and east to include the Wangcol Creek catchment. The vertical domain of the hydrogeological model extends from the ground surface to a level of 450 m AHD.

The model has been divided into 11 layers and 9 different hydrogeological units as follows:

- Layer 1: Alluvium and shallow zone including outcropping coal, backfill and ash emplacement
- Layer 2: Narrabeen Sandstone, backfill and ash emplacement
- Layer 3: Coal seam (Katoomba), backfill and ash emplacement
- Layer 4: Permian Interburden, backfill and ash emplacement
- Layer 5: Coal seam (Irondale), backfill and ash emplacement
- Layer 6: Permian Interburden, backfill and ash emplacement
- Layer 7: Coal seam (Lidsdale), backfill and ash emplacement
- Layer 8: Permian Interburden, backfill and ash emplacement
- Layer 9: Coal seam (Lithgow), backfill, ash emplacement and historical underground mine voids
- Layer 10: Marrangaroo Formation
- Layer 11: Basement rock (Shoalhaven Group)

The degree of vertical definition reflects the level of detail available in existing data from exploration logs and groundwater monitoring bores and is considered to provide sufficient detail to fulfil the model objectives.

4.2 Boundary conditions and groundwater flow

The boundaries to the flow of groundwater within each hydrogeological unit are summarised in Table 4-1. A conceptualisation of groundwater flow in the vicinity of the site is shown in Figure 4-2.

The shallow zone (Layer 1) extends over the entire model domain to represent soils and weathered rock down to 10 m bgl. Across the model domain it primarily includes alluvial soil, weathered Narrabeen Sandstone and outcropping Permian Illawarra Coal Measures. In the vicinity of the site, Layer 1 represents areas of backfill in areas of third workings, compacted ash in the existing ash emplacement area and coal within outcrop of the Lidsdale and Lithgow coal seams.

The alluvial groundwater sources are assumed to be unconfined aquifers that are associated with the main watercourses within the hydrogeological domain (Coxs River and Wangcol Creek). They are assumed to extend to a depth of approximately 10 m bgl and are generally underlain by Permian Illawarra Coal Measures. They occupy only small areas along the creek lines throughout the shallow zone of the hydrogeological model. Note that bedrock of the Permian Illawarra Coal Measures outcrops along reaches of Wangcol Creek in the vicinity of and downstream of the site and this has been reflected in the hydrogeological model.

The alluvial groundwater sources are recharged by net rainfall and catchment runoff and discharge into the connected creeks providing baseflow. Since the majority of watercourses are assumed to be generally ephemeral and intermittent, it is assumed they are 'water gaining' streams and function as drains. The alluvial groundwater discharges into these watercourses (drains) at elevations corresponding to the elevations of the stream beds. When a drain cell in Layer 1 is flooded (i.e. groundwater is at surface elevation), this does not prevent the input of rainfall recharge into the model at this location.

The Coxs River is assumed to be a perennial watercourse. Additionally, flows in Wangcol Creek are generally consistent due to discharge from Mount Piper Power Station upstream of the site and discharges from Springvale Coal Services. Coxs River and Wangcol Creek have therefore been represented in the hydrogeological model as rivers. Unlined surface water storages including DML Dam, Cooks Dam, Council Pit, H Pit West, H Pit East, REA, A Pit REA and SHG1 have also been represented as rivers to allow modelling of seepage into and out of these storages.

The coal seams and the Permian interburden outcrop in the vicinity of the site. The outcrop areas are recharged by net rainfall and catchment runoff.

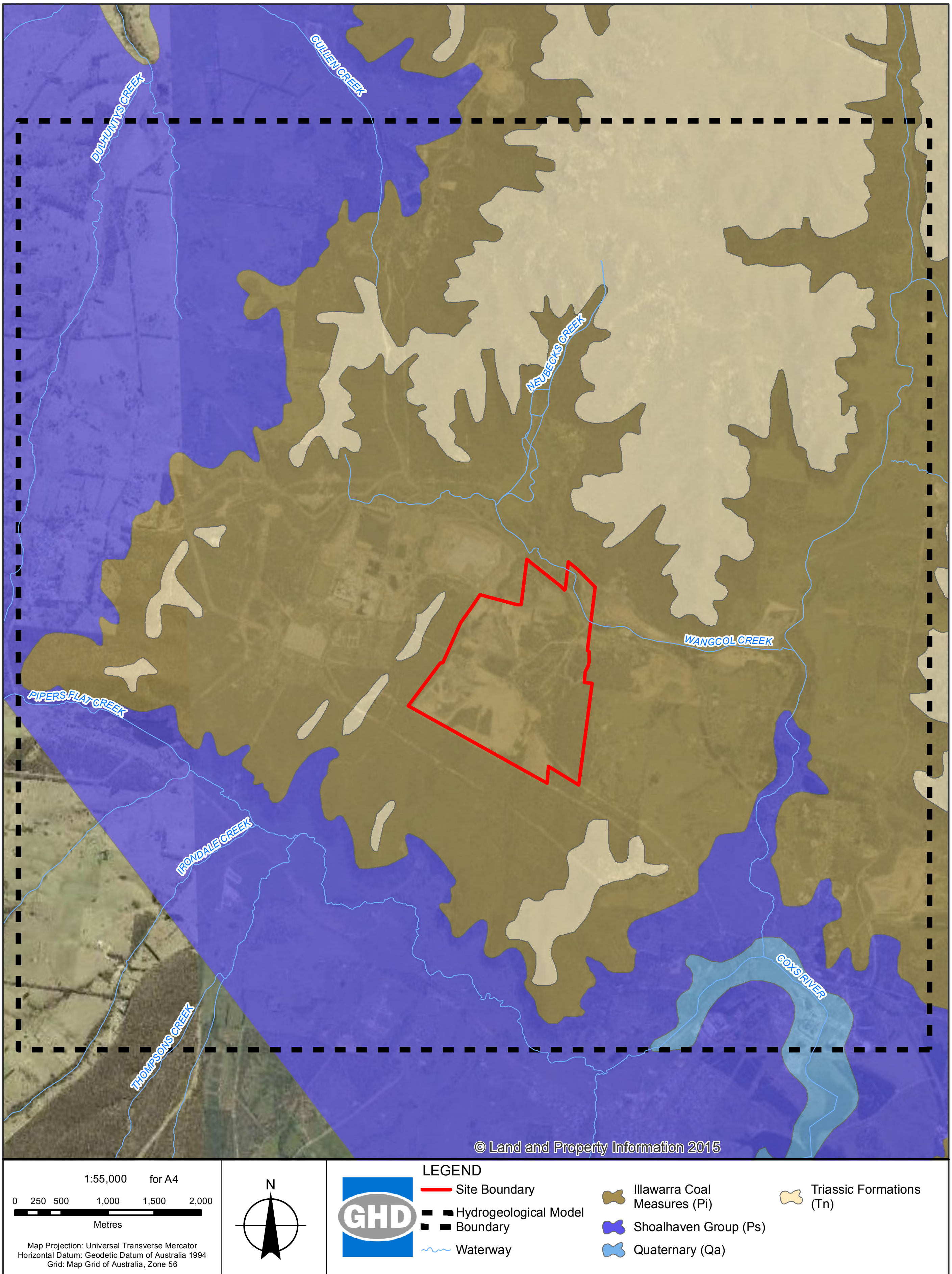
The Narrabeen Sandstone is an unconfined aquifer that outcrops to the north and north east of the site. The outcrop areas are recharged by net rainfall and catchment runoff. Groundwater discharges to the surface along the slopes, which are represented in the hydrogeological model as seepage/drain cells. Piezometric head therefore reduces towards the seepage areas, however the overall groundwater level within this hydrogeological unit is considered to reduce towards the northeast in the direction of the dip of the strata.

Table 4-1 Model boundary condition details

Hydrogeological unit	Boundary condition	Boundary details
Alluvium and Shallow zone (Layer 1)	Recharge	Net recharge (i.e. rainfall and catchment runoff after evaporation) was initially set to 2% of annual rainfall across Layer 1. Based on average annual rainfall between 1889 and 2015 this equates to a net recharge of approximately 0.014 m/year.
	Seepage	Shallow/alluvial groundwater discharges into the connected watercourses and drainage lines represented by drain or river cells. The drainage elevations have been determined from topographic elevation data.
	Rivers	Perennial watercourses (assumed to include Wangcol Creek and Coxs River) have been represented in the model by rivers.

Hydrogeological unit	Boundary condition	Boundary details
		Unlined surface water storages at the site have been represented by river cells. Surface water levels for these storages have been adopted from observation data.
Backfill and ash emplacement (Layer 1 to Layer 9)	Recharge	Net recharge (i.e. rainfall and catchment runoff after evaporation) for the ash emplacement was initially set to 2% of annual rainfall across Layer 1. Based on average annual rainfall between 1889 and 2015 this equates to a net recharge of approximately 0.014 m/year. Enhanced recharge was considered to occur in the backfill area at the site. Recharge in backfilled areas was initially set to 6% of annual rainfall. Based on average annual rainfall between 1889 and 2015 this equates to a net recharge of approximately 0.042 m/year.
	Seepage	Shallow/alluvial groundwater discharges into the connected watercourses and drainage lines represented by drain or river cells. The drainage elevations have been determined from topographic elevation data.
	Rivers	Unlined surface water storages at the site have been represented by river cells. Surface water levels for these storages have been adopted from observation data.
Narrabeen Sandstone (Layer 2)	Seepage	Drain cells have been set at ground level throughout the outcrop extent of this unit to simulate the seepage of groundwater at the ground surface. Conductance values have been set to represent the hydraulic conductivity of the surrounding geology.
	Internal flows	There is limited groundwater flow from the Narrabeen Sandstone to the underlying Permian Illawarra Coal Measures.
Permian interburden and Marrangaroo Formation (Layer 4, 6, 8 and 10)	Internal flows	Flows into and out of these units are limited due to low permeability strata
	Recharge and seepage	Recharge and seepage occur in areas of outcrop. These areas have been defined using the available geological and topographic data.
Coal Seams and underground mine voids (Layer 3, 5, 7 and 9)	Internal flows	Typically limited flow to and from adjacent strata. However there is potentially increased connectivity in areas adjacent to the underground workings and the backfilled areas in the vicinity of the site.
	Recharge and Seepage	Recharge and seepage occur in areas of outcrop.

Hydrogeological unit	Boundary condition	Boundary details
Shoalhaven Group (Layer 11)	No Flow	No flow boundaries have been defined along the southern and western extents since these are generally the up gradient extents of this unit (within the hydrogeological domain). The base of this unit has also been defined as a no flow boundary and represents the vertical extent of the model.
	Seepage	Drain cells have been set at ground level throughout the outcrop extent of this unit to simulate the seepage of groundwater at the ground surface. Conductance values have been set to represent the hydraulic conductivity of the surrounding geology.



LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Hydrogeological model domain

Centennial Coal

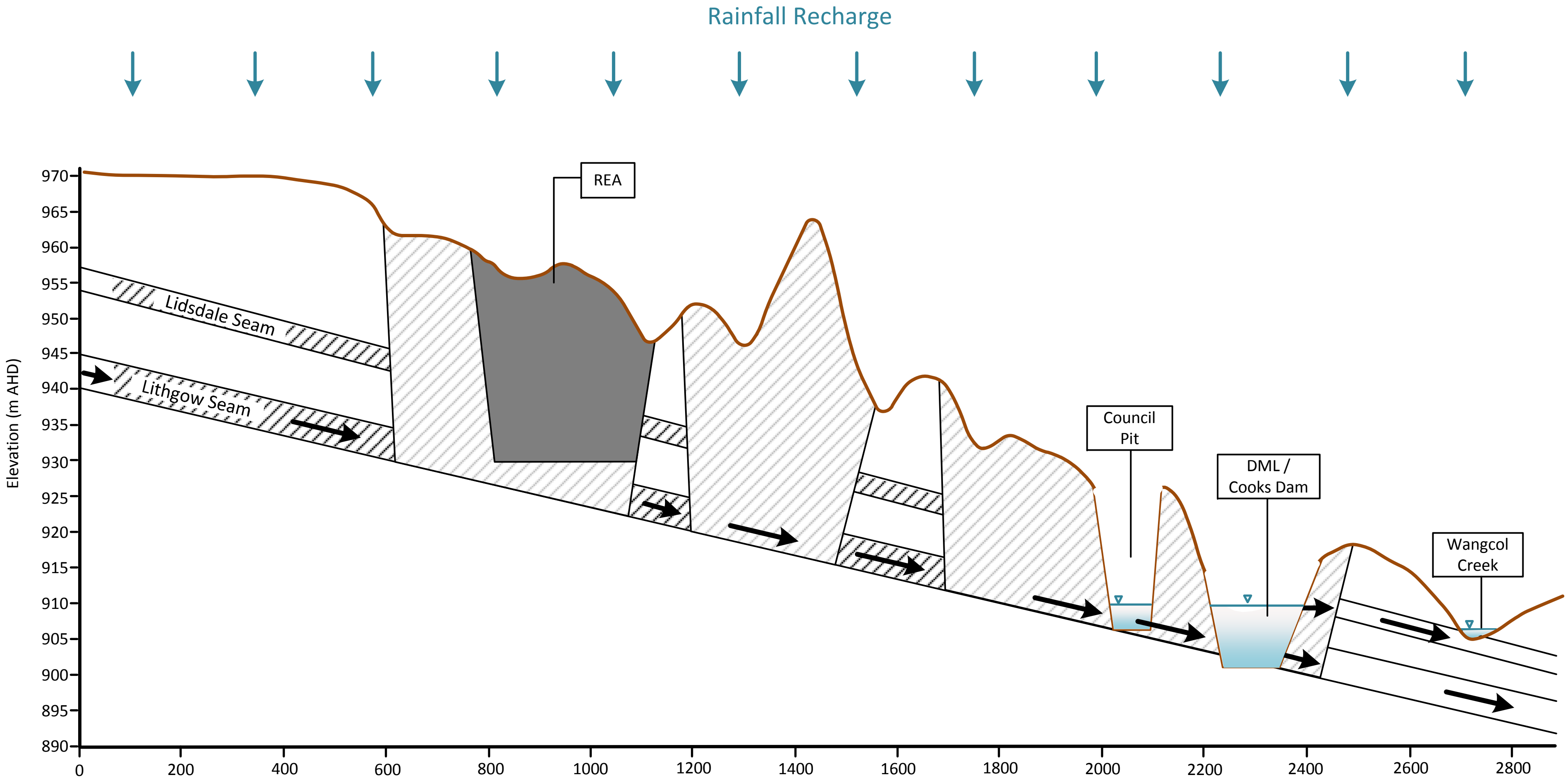
DATE 02 Nov 2016

Figure 4-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218391\2218391_006_GWModelBoundary_0.mxd

22-18391

© LPI: DTDB, 2012. LIDAR: Imagery, 2015; Centennial: Boundary, site features; NSW DPI: Geology, 2010.



Backfill

Historical underground workings

Groundwater flow direction

LOCATION	Springvale
SEAM	Lidsdale
DRAWN	SM
CHECKED	IG
APPROVED	SG
SCALE	NTS

Springvale Coal Services
Hydrogeological Model Report

Conceptual Groundwater Model

Centennial Coal

DATE Nov 2016

Figure 4-2

G:\22\18391\Visio\2218391_FIGX-X_Conceptual Groundwater Model.vsdx

4.3 Material properties

Initial material properties were selected based on material properties used in previous assessments including CDM Smith (2012), RPS (2013) and typical hydraulic conductivities presented by Kruseman and de Ridder (1994) and are shown in Table 4-2. Final material properties were selected through model calibration.

4.4 Model assumptions and limitations

Assumptions and limitations in the hydrogeological model are outlined as follows:

- Potential groundwater impacts from site operations will not extend beyond the active area of the model.
- River levels in perennial waterways are constant over time.
- Recharge and evapotranspiration have been represented by a net recharge value, proportional to annual rainfall. Net recharge remains constant throughout the transient model so that non-rainfall related effects on groundwater levels and flows can be assessed.
- Material properties are homogeneous throughout each hydrogeological unit. Material properties do not change with the degree of saturation. Any natural discontinuous faults and lineaments within the strata creates a uniform effect on aquifer properties throughout each hydrogeological unit.
- Groundwater extractions from registered bores within the hydrogeological domain have a negligible effect on model results.
- Horizontal hydraulic conductivity is ten times the vertical hydraulic conductivity for each hydrogeological unit. This is a typical relationship for essentially horizontal strata.
- The model is not sufficiently refined in time or space to simulate daily changes in on site water management. The model represents and predicts regional groundwater flow across the site.
- Historical open cut mining and resulting aquifer depressurisation has not been taken into consideration for historical simulations. Where material properties of strata have been modified due to mining operations (e.g. backfilling of open cut areas), these material properties are assumed to remain constant over the historical simulation period.

Table 4-2 Pre-calibration hydrogeological properties

Hydrogeological unit	Model layers	Horizontal hydraulic conductivity 'kh' (m/year)	Vertical hydraulic conductivity 'kv' (m/year)	Effective porosity (ne)	Specific yield / Specific storage	Previous assessments horizontal hydraulic conductivity (m/year)	
						CDM Smith (2012)	RPS (2013)
Shallow zone/ alluvium	Layer 1	365	36.5	0.2	0.2	NA	365
Backfill	Layer 1 to 9	400	40	0.1	0.1	1825	460
Ash emplacement	Layer 1 to 9	3	0.3	0.1	0.1	36.5	NA
Narrabeen sandstone	Layer 2	7.3	0.73	0.1	0.1 / 0.0001	NA	NA
Coal seams	Layer 1 (outcropping coal); Layer 3, 5, 7 and 9	73	7.3	0.1	0.1 / 0.0001	7 × 10-6 (virgin coal) 1825 (uncollapsed pillar coal)	168
Permian Interburden	Layer 4, 6 and 8	1	0.1	0.1	0.0001	0.11 to 1.46	NA
Marrangaroo Formation	Layer 10	0.36	0.036	0.1	0.0001	3.7 × 10-5	0.32

Hydrogeological unit	Model layers	Horizontal hydraulic conductivity 'kh' (m/year)	Vertical hydraulic conductivity 'kv' (m/year)	Effective porosity (ne)	Specific yield / Specific storage	Previous assessments horizontal hydraulic conductivity (m/year)	
						CDM Smith (2012)	RPS (2013)
Shoalhaven Group	Layer 11	0.3	0.03	0.1	0.0001	NA	0.0365
Mine void/goaf	Layer 9	73	7.3	0.1	0.1	18250	NA

NA denotes value not provided or hydrogeological unit not included in modelling

5. Numerical model construction and calibration

5.1 Model software

Numerical modelling was undertaken using the MODFLOW-NWT solver with the Upstream Weighting flow package. MODFLOW-NWT is a version of MODFLOW 2005 that provides a different formulation of the groundwater flow equation (Newton formulation) designed to solve models that are non-linear due to unconfined cells or non-linear boundary conditions. MODFLOW 2005 is a three-dimensional finite difference groundwater flow model from the United States Geological Survey and is one of the industry standard codes for numerical groundwater modelling. The model was built using the Groundwater Modelling System (GMS) graphical user interface (version 10.0). GMS is a three-dimensional user interface for the MODFLOW groundwater modelling code.

It was considered that MODFLOW-NWT and GMS incorporates the features required to adequately fulfil the model objectives.

5.2 Model construction

The hydrogeological model domain shown in Figure 4-1 covers 98 km^2, extending from N: 6300000 and E: 220200 in the southwest to N: 6310000 and E: 230000 in the northeast. Active and inactive cells were defined by the available geological data and geological boundaries.

The area has been divided into a grid consisting 196 columns and 200 rows, generating equally sized cells with dimensions 50 m × 50 m. The model was refined in the vicinity of the site to a cell size of 25 m. It was considered that this degree of discretisation would provide adequate refinement throughout the main areas of interest (historical mine workings, surface water storages and backfilled areas) without leading to excessive run times.

As outlined in the conceptualisation of the hydrogeological system, the model has been divided into 11 layers of varying thickness. The top and base elevations of each layer are defined in Table 5-1.

Table 5-1 Vertical extent of model layers

Layer	Description	Top	Base
1	Shallow Zone	Topographic contours	Topographic contours -10 m
2	Narrabeen Sandstone	Topographic contours -10 m	Katoomba seam data
3	Katoomba Seam	Seam elevation data	Seam elevation data
4	Permian Interburden	Katoomba seam floor elevation data	Irondale seam roof elevation data
5	Irondale Seam	Seam elevation data	Seam elevation data
6	Permian Interburden	Irondale seam floor elevation data	Lidsdale seam roof elevation data

Layer	Description	Top	Base
7	Lidsdale Seam	Seam elevation data	Seam elevation data
8	Permian Interburden	Lidsdale seam floor elevation data	Lithgow seam roof elevation data
9	Lithgow Seam	Seam elevation data	Seam elevation data
10	Marangaroo Formation	Lithgow seam floor elevation data	Lithgow seam floor elevation data – 10 m
11	Shoalhaven Group	Lithgow seam floor elevation data – 10 m	450 m AHD

5.3 Steady state calibration

Calibration of the hydrogeological model was initially undertaken under steady state conditions. Horizontal and vertical conductivities and the net recharge coefficient were adjusted in order to minimise the residual errors between modelled and observed groundwater levels.

5.3.1 Observation data

Observation datasets for standpipe monitoring locations (Table 3-1) were used to define observed steady state groundwater levels. Review of the groundwater monitoring data indicated that groundwater levels were generally consistent throughout 2015 at the majority of monitoring locations. Average groundwater elevations for 2015 reported at each of these monitoring locations were adopted as the steady state groundwater elevations. Surface water elevations for surface water storages were adopted from June 2016 water levels.

5.3.2 Steady state calibration results

Calibration was undertaken by trial and error for a number of runs to assess the sensitivity of changes to recharge and material properties. The following calibration targets were adopted:

- The model must converge.
- Water balance error must be less than 1%.
- The scaled root mean square error (SRMSE) of unweighted residuals must be less than 10%.

The lowest SRMSE obtained (using realistic material properties) for a converging steady state run was 12%. The water balance error for this run was 0.02%.

Modelled groundwater levels and residual errors were found to be most sensitive to the following parameters:

- Coal seam hydraulic conductivity.
- Backfill hydraulic conductivity.

For a number of the runs it was identified that despite changing material properties of various strata including wreath, Narrabeen Sandstone, Marrangaroo Formation and Shoalhaven Group by considerable amounts (e.g. by 50% of pre-calibration values) it was found that there was minimal change in modelled steady state levels. This is assumed to be due to the majority of monitoring locations utilised for steady state calibration being located in the Lithgow Coal Seam and the backfill and modelled and observed groundwater levels in this strata appear to both be corresponding to seam elevations.

Table 5-2 gives the hydrogeological properties for the best fit steady state run. Note that the best fit steady state run had hydrogeological properties for the underground void that were equal to the surrounding unmined coal seam. The net recharge coefficient for this run was 0.015 m/year (approximately 2% of average annual rainfall) across the model with an increased rainfall recharge for mapped areas of backfill of 0.044 m/year (approximately 6% of average annual rainfall).

Table 5-2 Hydrogeological properties – best fit steady state calibration

Hydrogeological unit	Model layers	Horizontal hydraulic conductivity ‘K_h’ (m/year)	Vertical hydraulic conductivity ‘K_v’ (m/year)	Range of horizontal hydraulic conductivity values simulated (m/year)
Shallow zone	Layer 1	730	73	36.5 to 7300
Backfill	Layer 1 to Layer 9	200	20	5 to 1825
Ash emplacement	Layer 1 to Layer 9	0.1	0.01	0.1 to 5
Narrabeen sandstone	Layer 2	73	7.3	2 to 360
Coal seam	Layer 3, 5, 7 and 9	73	7.3	1 to 180
Underground void	Layer 9	73	73	1 to 24090
Permian interburden	Layer 4, 6 and 8	10	1	0.5 to 20
Marrangaroo Formation	Layer 10	20	2	0.36 to 40
Shoalhaven Group	Layer 11	1	0.1	0.03 to 10

5.3.3 Flow budget

The steady state groundwater flow budget is shown in Table 5-3. The flow budget has been calculated for the entire model domain.

Table 5-3 Steady state flow budget

Model zone	Inputs (ML/year)			Outputs (ML/year)		
	Net recharge	Rivers	Total	Drains	Rivers	Total
All zones	1479.7	4730.3	6210	6101.8	108.2	6210

Rivers includes Wangcol Creek, Coxs River and site pit top storages

6. Transient simulations

6.1 Transient calibration

As discussed in Section 2.3.2, the water balance developed for the site (GHD, 2016) identified that seepage of groundwater was occurring into or out of a number of surface water storages at the site. The estimated rates of seepage from the site water balance were utilised as calibration targets for the transient model.

As detailed in Appendix C, an estimate of groundwater inflow into Cooks Dam, based on available data at the time, was 0.4 ML/day. This value was selected as a calibration target for transient calibration. It was also considered that the net seepage rate out of SHG1 should be a calibration target. As discussed in Appendix C, net seepage out of SHG1 was occurring at rate of approximately 0.2 ML/day. Estimated seepages from other pits (H Pit West, H Pit East and Council Pit) were considerably lower than SHG1 pit and not considered for transient calibration. The transient model was calibrated by adjusting vertical and horizontal conductivities of the strata at the site to match the transient calibration targets.

The steady state model was converted to a transient model and run from 2009 to 2016 using annual stress periods and monthly time steps. The modelled steady state heads were utilised as the starting heads for the transient model. The model was run using historical rainfall data and historical site surface water storage water levels. Note that the new REA at the site was constructed in 2016 and therefore the river boundary cells that simulate the new REA were activated on 1 January 2016.

The modelled net seepage into Cooks Dam between 2009 and 2016 is shown in Figure 6-1. Note that this modelled seepage does not include any historical direct connection between DML Dam and Cooks Dam. Transient runs 1, 8, 10, 12, 14, 15 and 16 are presented in Figure 6-1. Note a negative seepage rate in Figure 6-1 indicates modelled net seepage out of Cooks Dam. The modelled hydraulic conductivity values for each of these model runs are outlined in Table 6-2.

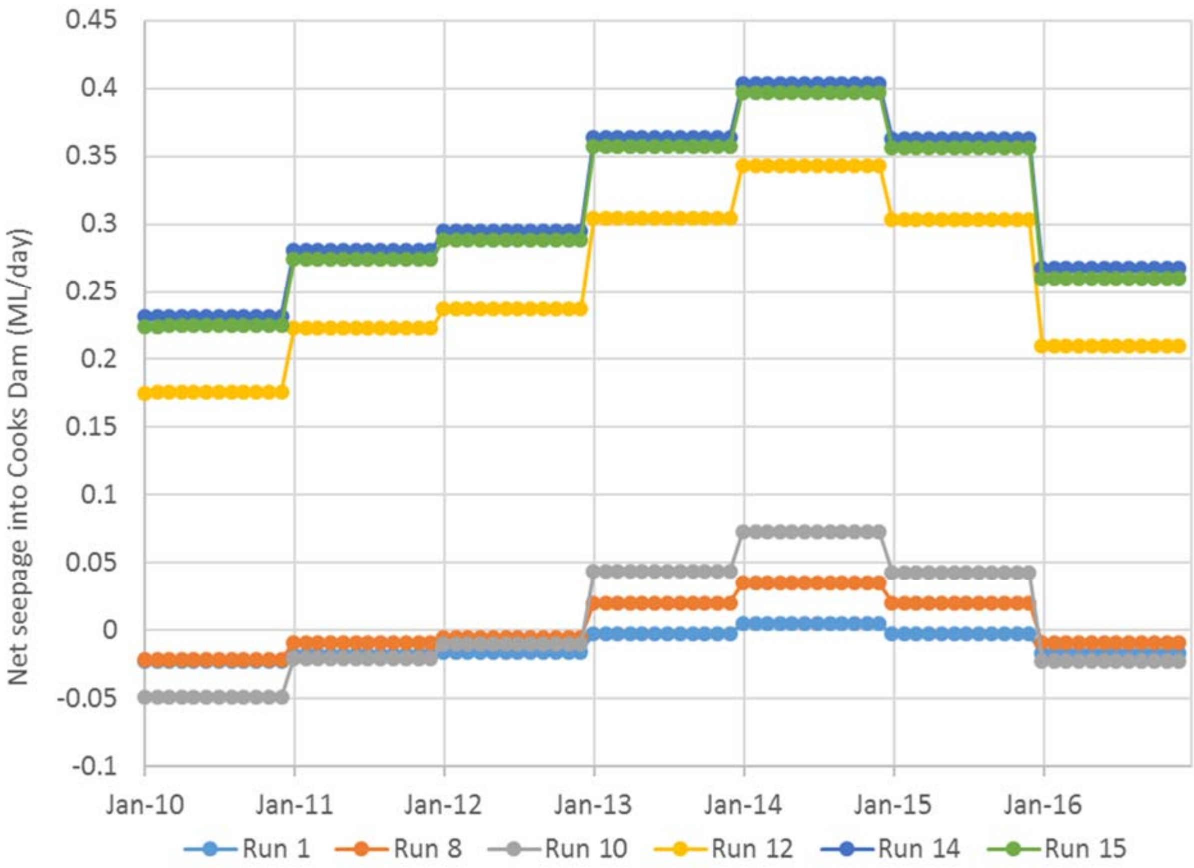


Figure 6-1 Modelled seepage into Cooks Dam

In transient run 1, the hydraulic conductivity values established from the best fit steady state model run were adopted. Modelled seepage into Cooks Dam between 2013 and 2015 for this transient model run indicated that net seepage into Cooks Dam was approximately zero (seepage in to this storage approximately equalled seepage out). It was considered that if the hydrogeological properties in the best fit steady state model run were used in transient modelling it would result in an underestimation of seepage into Cooks Dam (based on values estimated from the site water balance).

The hydraulic conductivity values of the wreath, Narrabeen Sandstone, backfill and the ash emplacement were increased in transient run 8. These hydraulic conductivity values were generally below the range of values used by CDM Smith (2012) and RPS (2013). As shown in Figure 6-1 modelled seepage into Cooks Dam between 2013 and 2015 for transient run 8 was less than 0.05 ML/day. It was considered that increasing the hydraulic conductivity values further would increase modelled seepage into Cooks Dam.

The hydraulic conductivity values of Narrabeen Sandstone, coal, Permian interburden, Marrangaroo Formation, Shoalhaven Group, backfill and ash emplacement were increased in transient run 10. The hydraulic conductivity values for these model runs were generally within the range of values used by CDM Smith (2012) and RPS (2013). As shown in Figure 6-1 modelled seepage into Cooks Dam between 2013 and 2015 for transient run 10 was less than 0.1 ML/day. It was considered that hydraulic conductivity values needed to be increased further to match the rate of seepage into Cooks Dam estimated from the water balance.

For transient run 12, hydraulic conductivities of the various strata were kept the same as transient run 10 except that the hydraulic conductivity of the mined Lithgow Seam was increased in the area of mining that has not been subject to third workings and backfilling. The extent of this area is shown in Figure 2-2. The hydraulic conductivity of Lithgow Seam in this area was increased to the hydraulic conductivity used by CDM Smith (2012) for goaf. As shown in Figure 6-1 modelled net seepage into Cooks Dam between 2013 and 2015 for transient run 12 was between 0.3 and 0.35 ML/day, slightly lower than the calculated seepage rate of 0.4 ML/day.

The hydraulic conductivity of the mined Lithgow Seam workings (not backfilled) was increased in transient run 14. The hydraulic conductivity of the Lithgow Seam in this area was increased to the hydraulic conductivity used by RPS (2013) for goaf. As shown in Figure 6-1 modelled net seepage into Cooks Dam between 2013 and 2015 for transient run 14 was between 0.35 and 0.4 ML/day. This was considered to be a good calibration to the calculated rate of seepage into Cooks Dam of 0.4 ML/day.

As shown in Figure 6-2, the modelled net rate of seepage out of SHG1 between 2013 and 2015 for transient run 14 was 0.45 ML/day. This modelled seepage rate out of SHG1 fulfils the transient calibration criteria in Section 6.1 (i.e. that there is net seepage out of SHG1), however the modelled net seepage rate out of SHG1 exceeds the estimated seepage rate of 0.2 ML/day based on the site water balance.

The hydraulic conductivity of the wreath was reduced in transient run 15. As shown in Figure 6-1 modelled net seepage into Cooks Dam between 2013 and 2015 for transient run 15 was between 0.35 and 0.4 ML/day. This was considered to be a good calibration to the calculated rate of seepage into Cooks Dam of 0.4 ML/day. As shown in Figure 6-2, the modelled net rate of seepage out of SHG1 between 2013 and 2015 for transient run 15 was 0.2 ML/day. This modelled net rate of seepage out of SHG1 provides a good fit to the calculated net rate of seepage out of SHG1 of 0.2 ML/day. Transient run 15 was considered to provide the best-fit transient calibration.

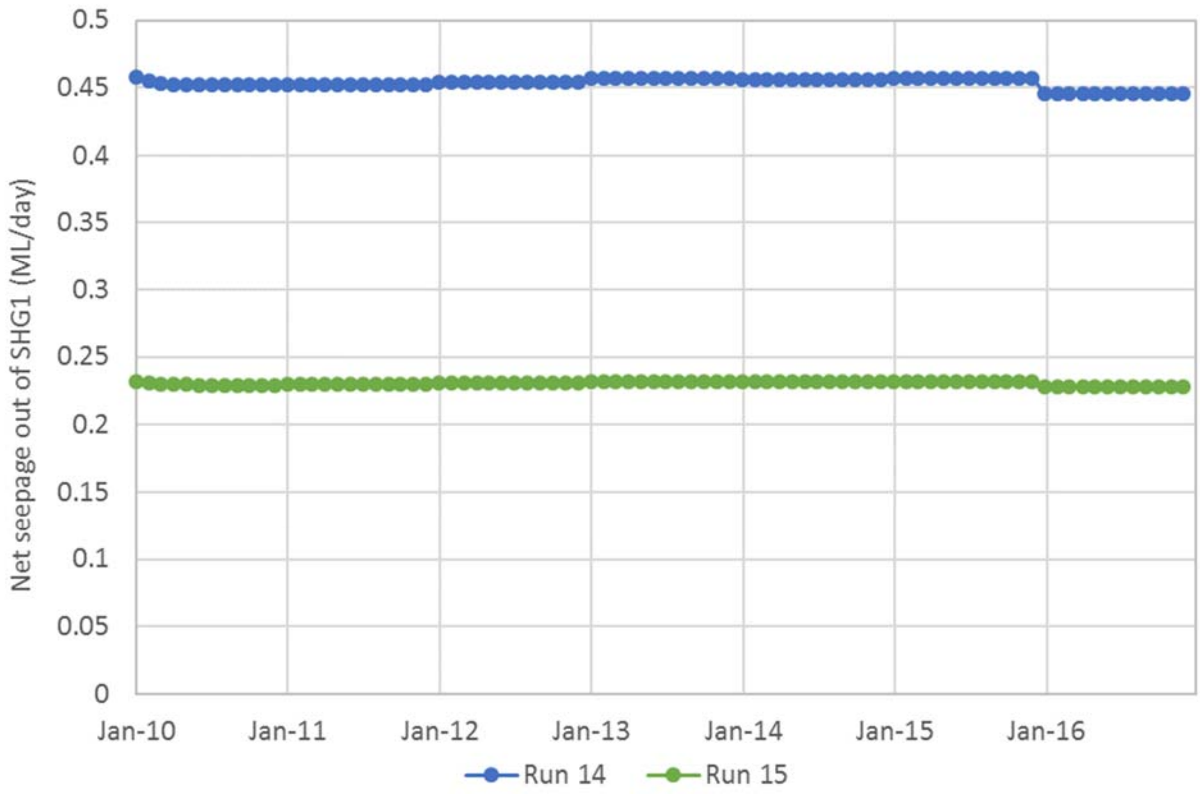


Figure 6-2 Modelled seepage out of SHG1 – Transient run 14 and 15

6.2 Transient model results

For the best fit transient model run (Run 15), net seepage is predicted to occur from storages where dam levels exceeded modelled groundwater levels. Where groundwater levels exceeded dam levels net seepage into the dam is predicted to occur. The results indicate that seepage out of DML Dam exceeded seepage into DML Dam. Seepage into Cooks Dam was modelled to peak in 2014, while seepage out of Cooks Dam was at a minimum in 2010. It is assumed that this was due to variation in historical dam levels with peak groundwater seepage into Cooks Dam matching the period when the water level at Cooks Dam was at its lowest.

For SHG1 net seepage was out of this storage. The model results indicated that seepage out of H Pit West, H Pit East and Council Pit was less than 0.05 ML/day over the modelled period. The model results also indicated that seepage is occurring from A Pit REA.

Modelled net seepage rates for DML Dam, SHG1 and Cooks Dam for the best fit transient model run are shown in Appendix B. Note a negative seepage rate indicates net seepage out of the storage.

Sensitivity analysis indicates that changing the aquifer storage parameter (including the storage of the underground void) has little effect on groundwater inflows into and out of storages. In addition, reducing the hydraulic conductivity of underlying strata such as the Marrangaroo Formation and Shoalhaven Group also has negligible effect on groundwater inflows into and out of storages.

6.2.1 Groundwater flow contours

Groundwater flow contours for the best fit transient model run are shown in Figure 6-3 for the Lithgow coal seam. Groundwater contours have been presented for the end of 2015. Modelled contours for the Lithgow Seam have been compared with groundwater contours developed using groundwater monitoring data within the deeper strata on site (including the Lithgow Seam, Marrangaroo Formation and up-gradient overburden) collected from 2015 to 2016 from a larger monitoring network than used to calibrate this model.

The modelled groundwater contours indicate that groundwater generally flows to the north east following the dip of the regional strata. Groundwater contours developed using observed groundwater monitoring data indicate a general west to east hydraulic gradient. The discrepancy in flow direction between modelled and observed contours can be attributable in part to the observed contours generated from monitoring bores in different strata and some intercepting perched groundwater.

Both the modelled and observed groundwater contours indicate a hydraulic gradient occurs between the Ash emplacement and the surface water storages DML Dam and Cooks Dam.

6.2.2 Flow budget

The groundwater flow budget for the best fit transient model run is shown in Table 6-1. The flow budget has been calculated for the entire model domain and provides an indication of groundwater flow through this region.

Table 6-1 Best fit transient model flow budget

Model zone	Inputs (ML/year)				Outputs (ML/year)			
	Net recharge	Storage	Rivers	Total	Storage	Drains	Rivers	Total
All zones, Year 2010	1,480	0	5,826	7,306	99	6,512	695	7,306
All zones, Year 2015	1,450	0	6,074	7,524	0	6,708	816	7,524

Note:

GHB: General head boundary

Drains represent seepage to surface

1:12,000 for A4

0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Site Boundary

Observed Groundwater Contours

Modelled Groundwater Contours - December 2015

LOCATION	WCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	LH
SCALE	refer to scalebar

Springvale Coal Services
Hydrogeological Model Report

Groundwater contours

Centennial Coal

DATE 02 Nov 2016

Figure 6-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\WesternCoal\2218391\2218391_007_GWContours_0.mxd

22-18391

Table 6-2 Transient modelling – Model runs and material properties

	Horizontal hydraulic conductivity [1] (m/year)									Specific storage [2]	Rainfall recharge (%)	
	Wreath	Backfill	Ash emplacement	Narrabeen sandstone	Coal	Underground mine workings – not backfilled	Permian interburden	Marrangaroo Formation	Shoalhaven Group		Backfill	Wreath and ash emplacement
Run 1	730	200	0.1	73	73	73	10	20	1	0.0001	6	2
Run 8	1825	600	3	180	73	73	10	20	1	0.0001	6	2
Run 10	1825	1825	5	360	180	180	20	40	10	0.0001	6	2
Run 12	1825	1825	5	360	180	18250	20	40	10	0.0001	6	2
Run 14	7300	1825	5	360	180	24090	20	40	10	0.0001	6	2
Run 15	365	1825	5	360	180	24090	20	40	10	0.0001	6	2

1. Vertical hydraulic conductivity equal to one tenth of horizontal hydraulic conductivity for all materials for all model runs
2. Specific yield and storage maintained the same for all materials

7. Conclusions and recommendations

A three dimensional eleven-layer numerical hydrogeological model has been constructed to investigate regional groundwater flow directions at the Springvale Coal Services Site and to estimate seepage from and into surface water storages at the site for a range of surface water storage levels and rainfall scenarios.

Hydrogeological modelling was undertaken using the MODFLOW-NWT solver of the MODFLOW 2005 groundwater modelling code. The model was constructed using the GMS graphical user interface with reference to the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). Model assumptions and limitations are detailed in Section 4.4. The hydrogeological model was calibrated under steady state conditions using available groundwater observation data.

Net seepage rates for Cooks Dam and DML Dam from 2013 to 2015 were calculated from the site water balance. The hydrogeological model was calibrated under transient conditions to the historical calculated net seepage rate into Cooks Dam with transient calibration also taking into consideration seepage rates out of SHG1.

The best fit transient model was used to report seepage rates for the various surface water storages at the site for historical conditions (2010 to 2016) and also predict regional groundwater flow rates in the vicinity of the site. The best fit transient model indicated that for the period from 2010 to 2016 for SHG1 there was generally net seepage out of this storage. The hydrogeological model indicated that seepage out of H Pit West, H Pit East and Council Pit was less than 0.05 ML/day. The model results also indicated that seepage is occurring from A Pit REA.

The hydrogeological model has validated the assumption within the site water balance that there is connectivity between surface water storages and the groundwater system, although the site water balance is the more appropriate tool for predicting water transfers across the site. The hydrogeological model provides an estimate of regional groundwater flow, including regional flow to the site from the south-west and regional flow from the site towards Wangcol Creek. Moving forward, it is recommended that this hydrogeological model be updated and recalibrated to reflect the more recent site observations detailed in the site water balance report. Specifically, this would involve:

- Recalibrating the model to updated groundwater inflows and outflows for surface water storages.
- Identifying preferential flow pathways across the site based on further geophysical surveys.
- Refining the model grid where appropriate to define these preferential flow pathways.

8. References

Barnett et al (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report, National Water Commission, Canberra.

CDM Smith (2012) *Lamberts North Ash Placement Project Groundwater Modelling Report,* prepared for Delta Electricity.

GHD (2016) *Western Coal Services – Site Water and Salt Balance Assessment.*

Groundwater Imaging (2016) *Geophysical Groundwater Investigation at Western Coal Services,* August 2016.

NSW Department of Mineral Resources (1992). 1:100,000 Western Coalfield (Southern Part) Regional Geology Map, Edition 1.

RPS (2013) *Centennial Western Coal Services Project Groundwater Assessment,* RPS Aquaterra.

RPS (2014) *Cooks Dam Inflow Investigation Report.*

Appendices

Appendix A – Groundwater Data

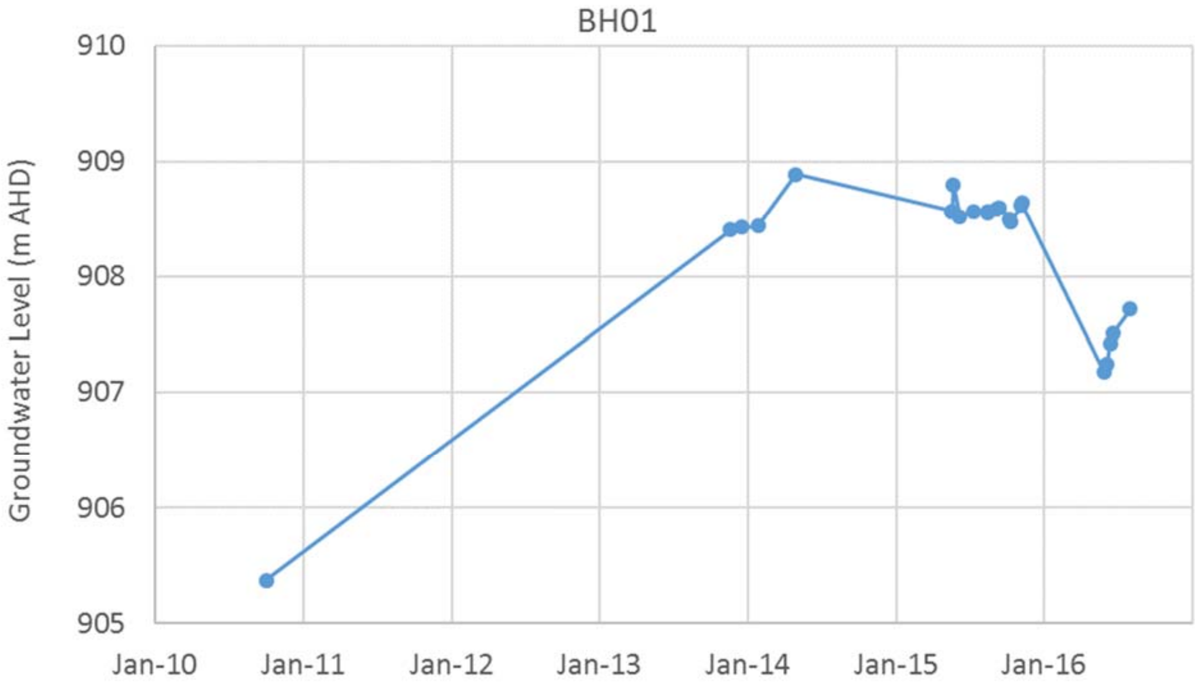


Figure A-1 BH01 hydrograph

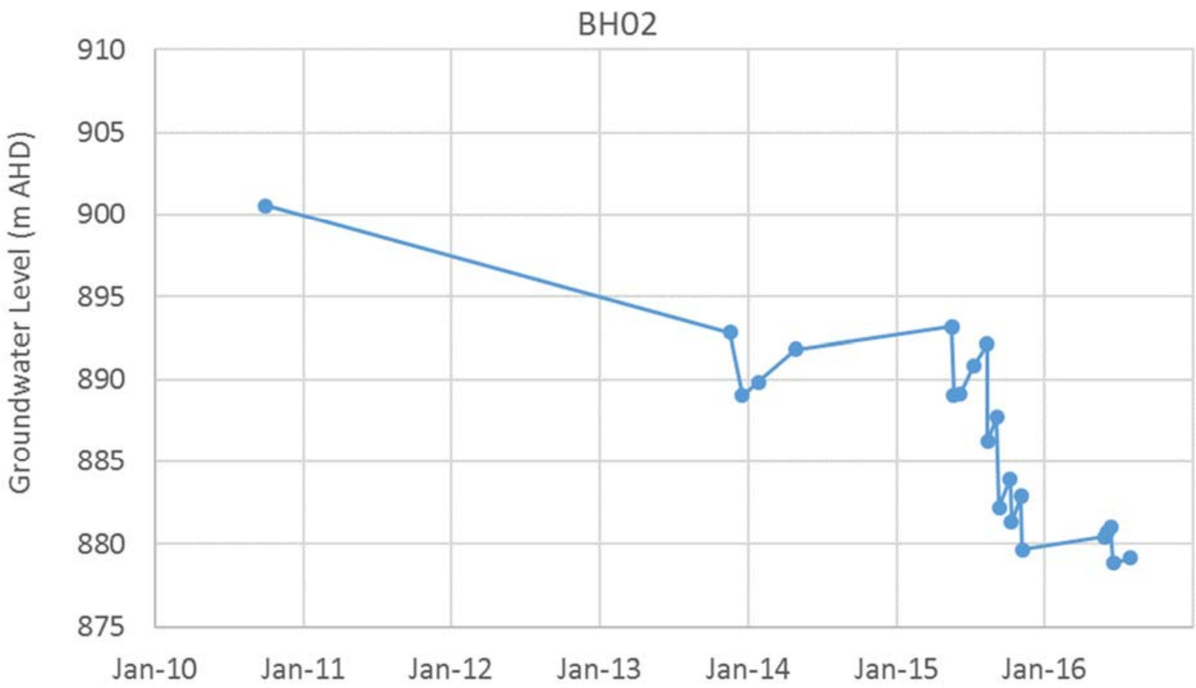


Figure A-2 BH02 hydrograph

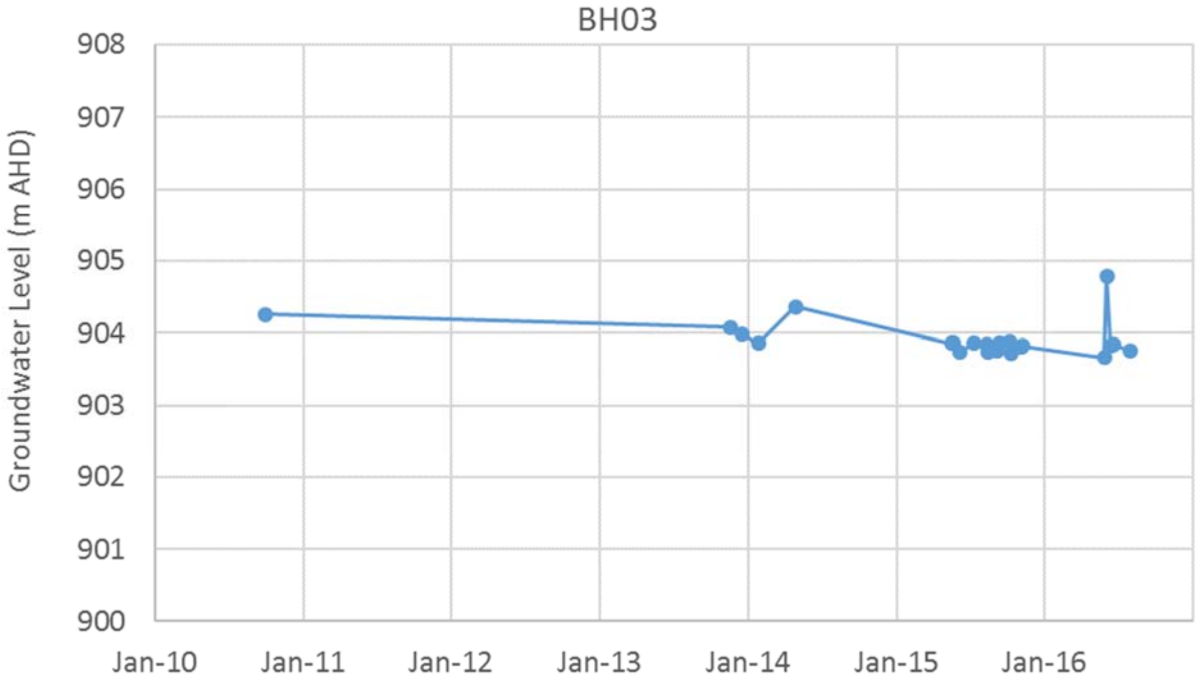


Figure A-3 BH03 hydrograph

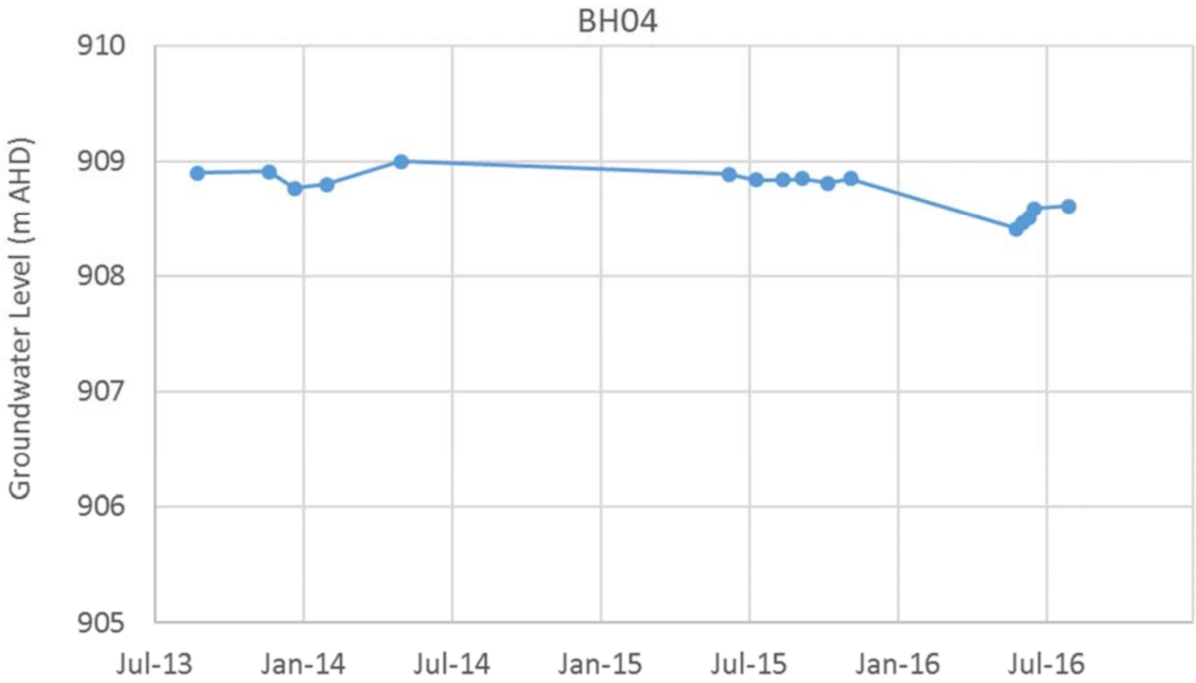


Figure A-4 BH04 hydrograph

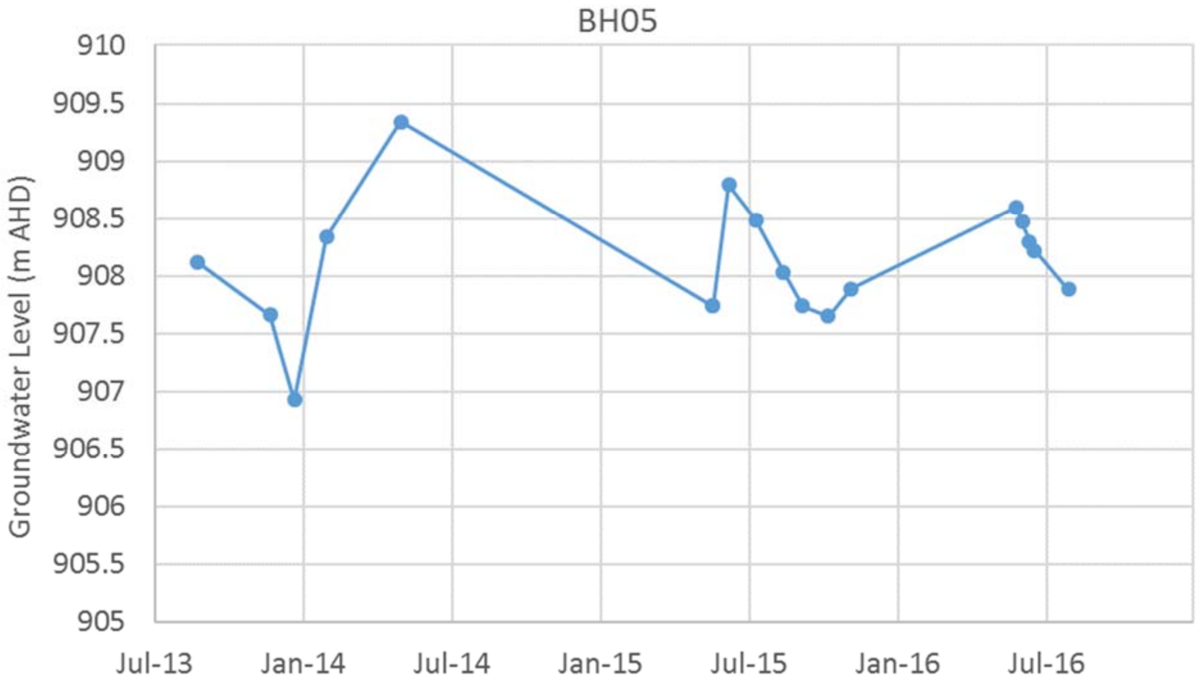


Figure A-5 BH05 hydrograph

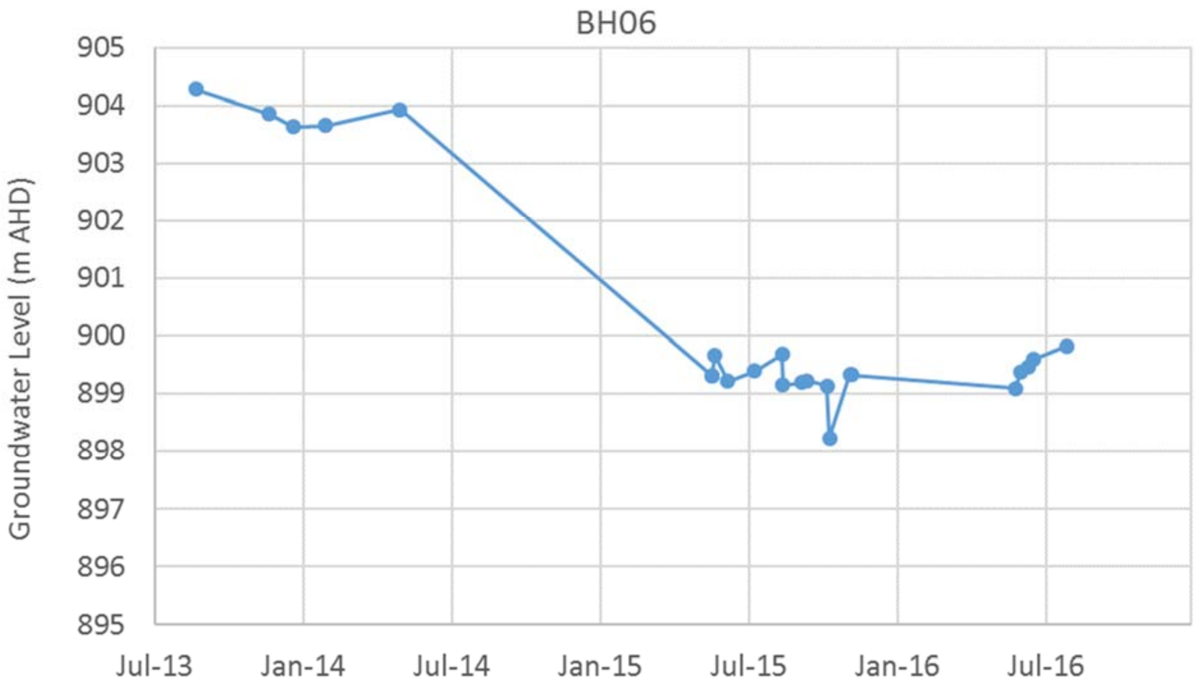


Figure A-6 BH06 hydrograph

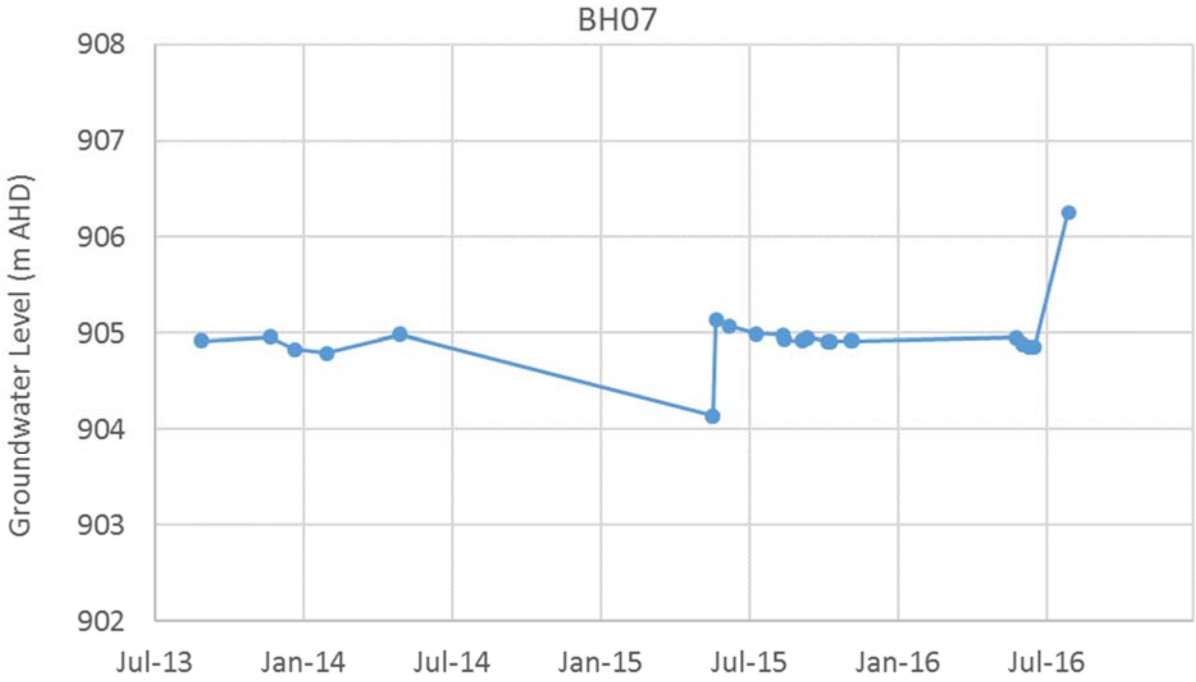


Figure A-7 BH07 hydrograph

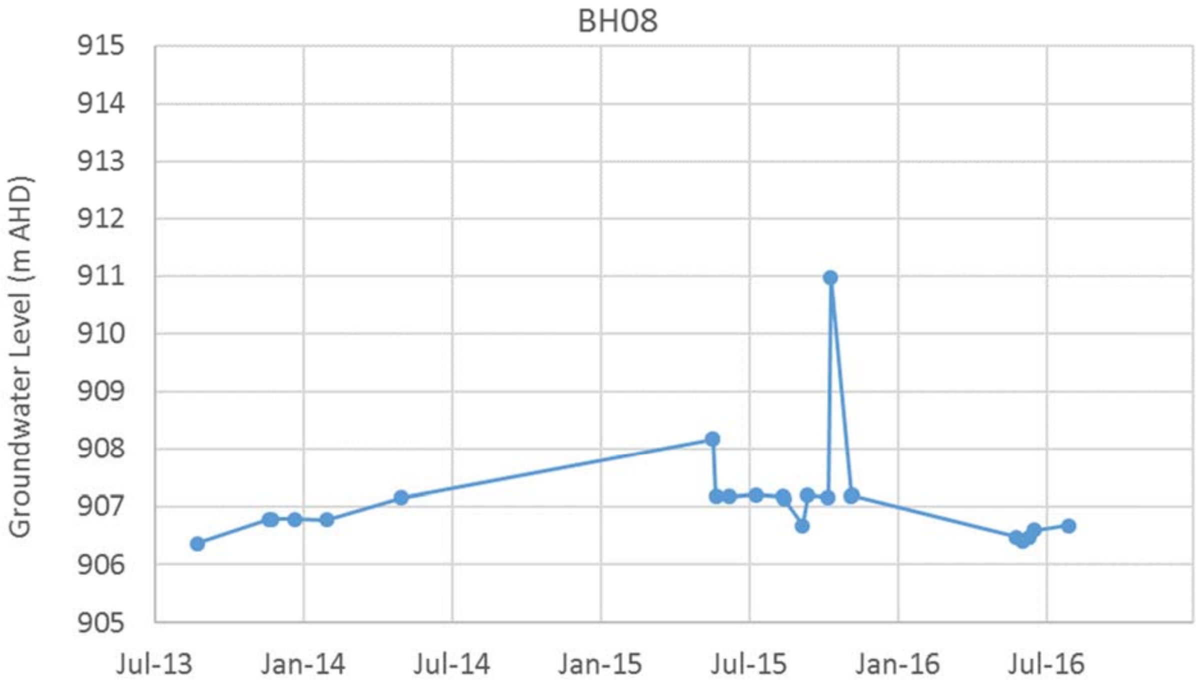


Figure A-8 BH08 hydrograph

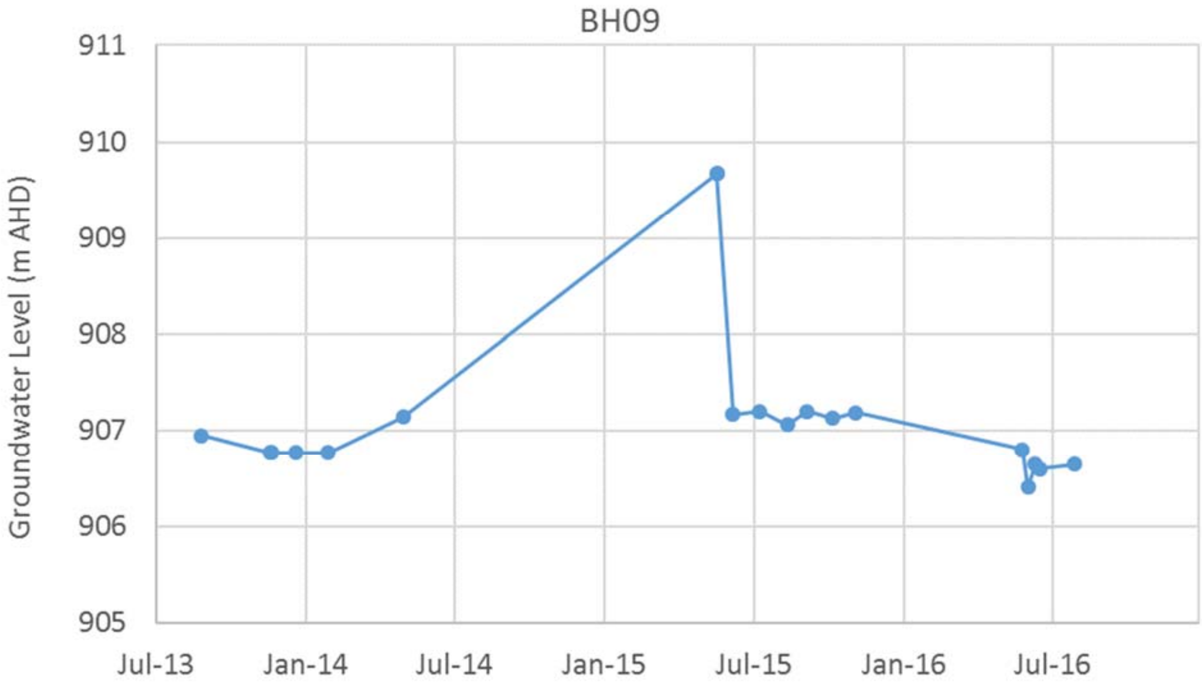


Figure A-9 BH09 hydrograph

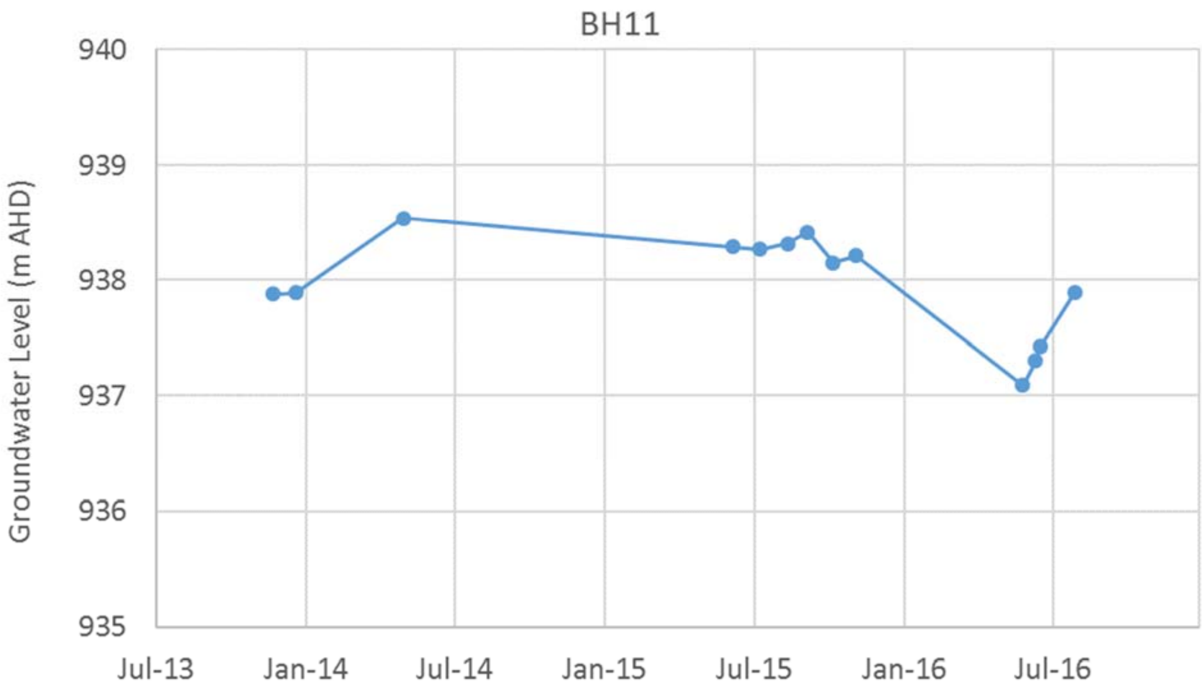


Figure A-10 BH11 hydrograph

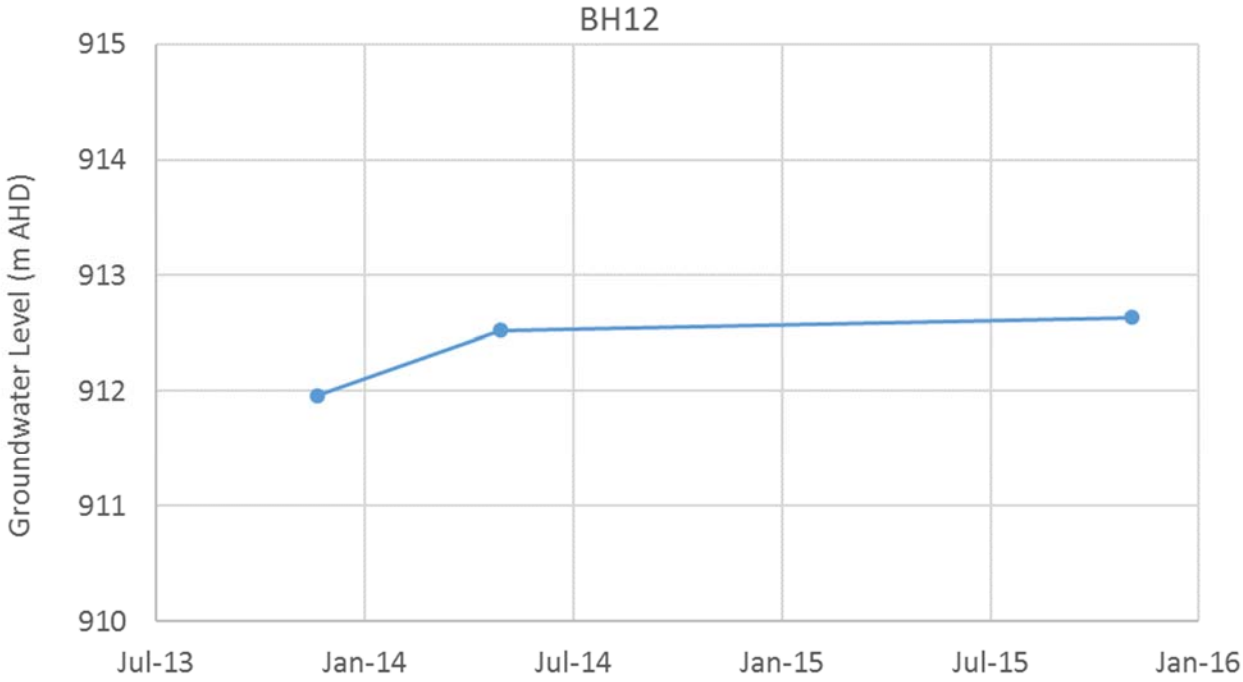


Figure A-11 BH12 hydrograph

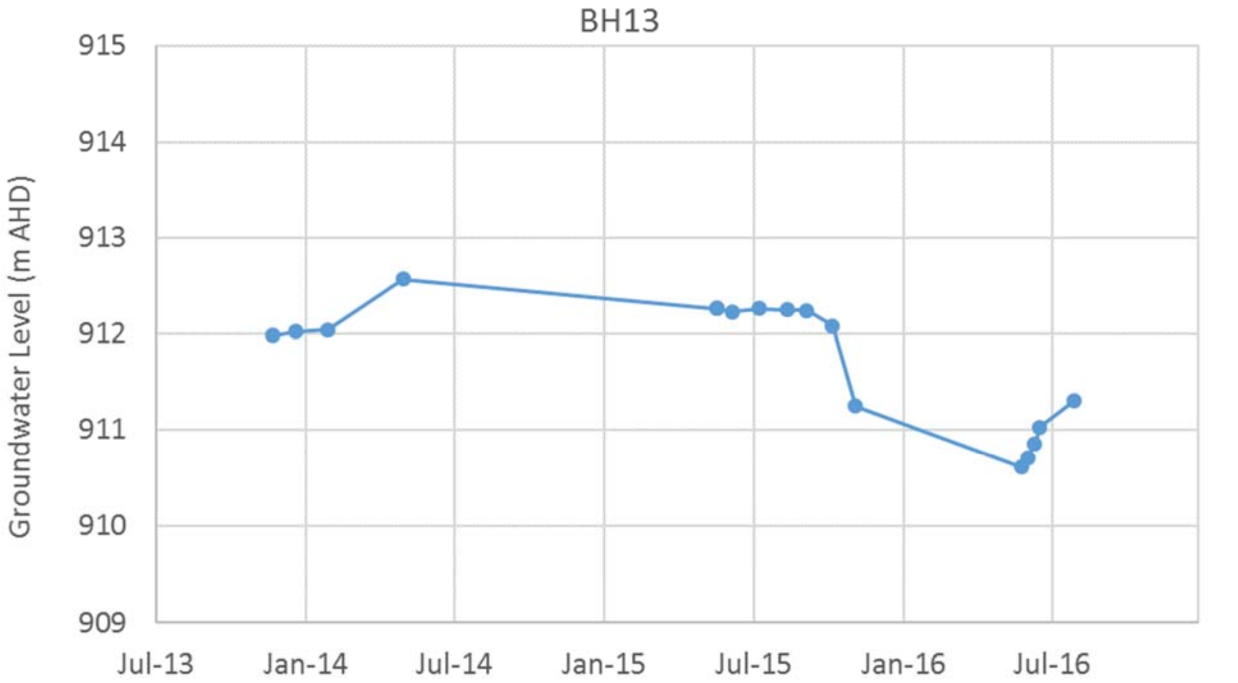


Figure A-12 BH13 hydrograph

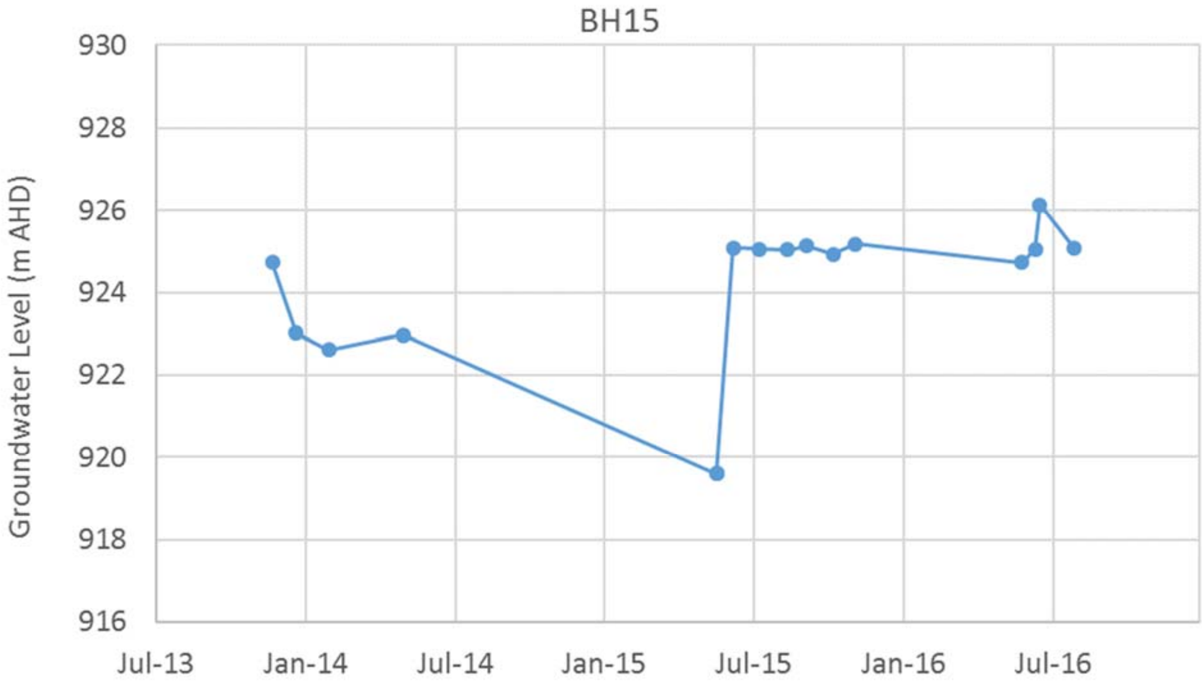


Figure A-13 BH15 hydrograph

Appendix B – Best fit transient run – modelled seepage for surface water storages

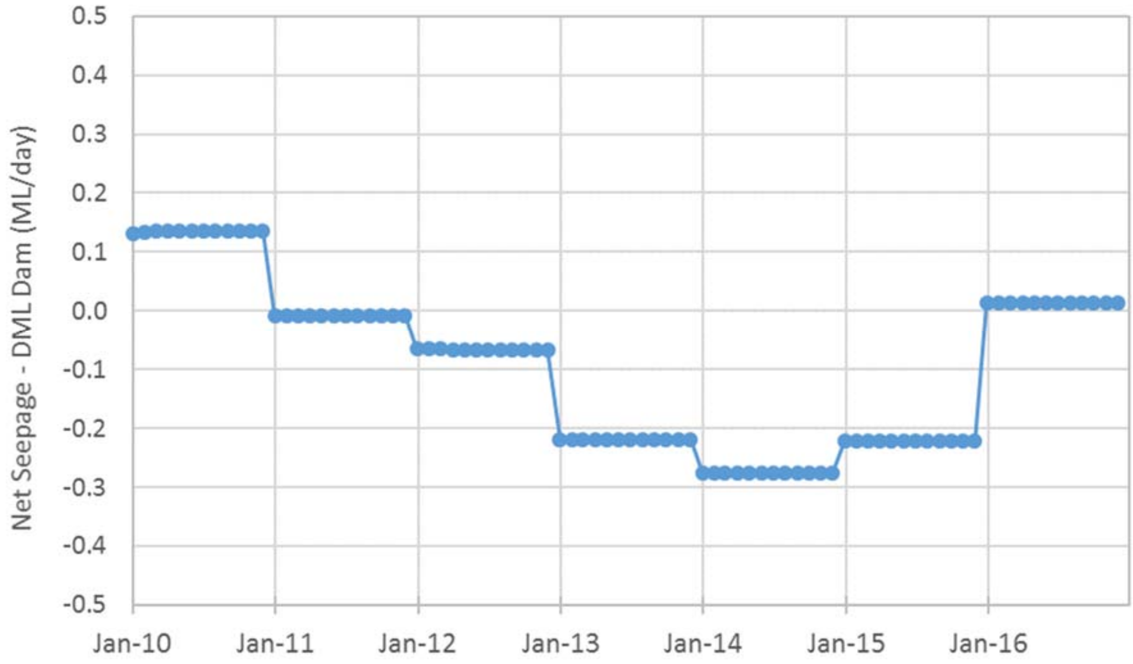


Figure B-1 Modelled seepage for DML Dam

Note negative net seepage indicates net seepage out of the storage.

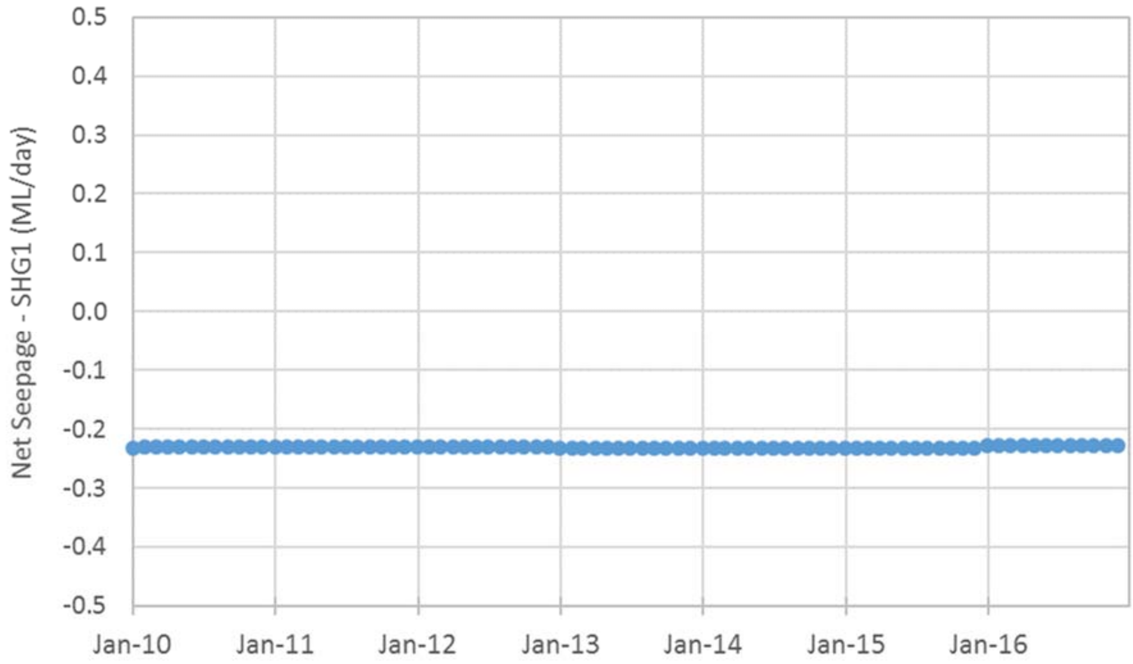


Figure B-2 Modelled seepage for SHG1

Note negative net seepage indicates net seepage out of the storage.

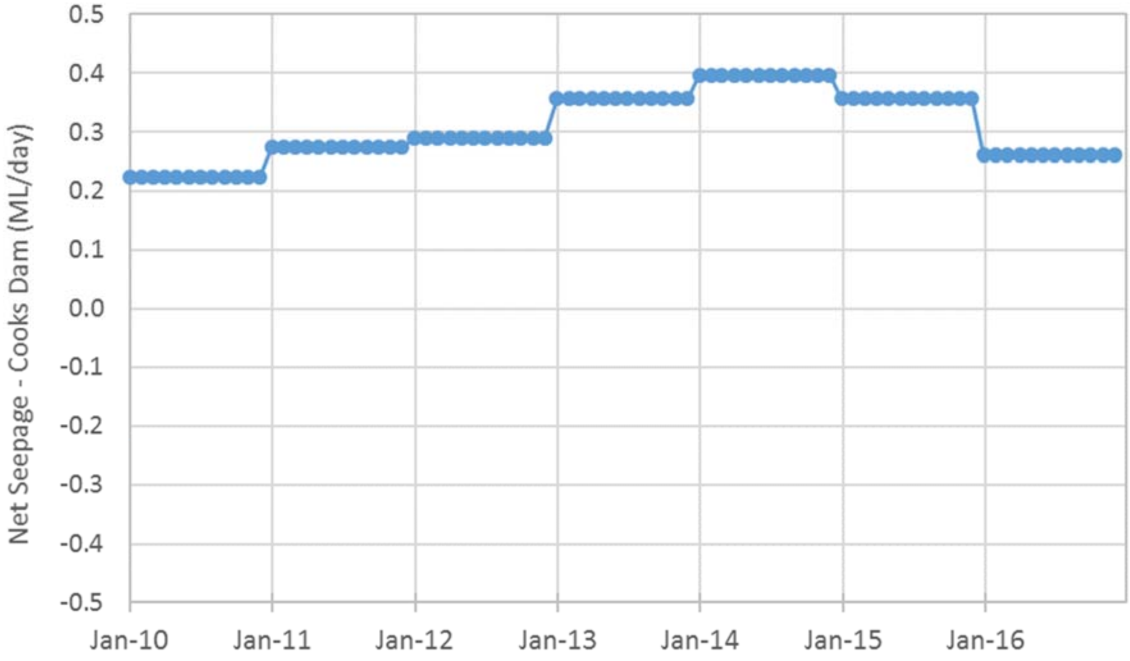


Figure B-3 Modelled seepage for Cooks Dam

Appendix C – Reconciliation of water balance and hydrogeological model

Memorandum

13 September 2016

To	Stuart Gray		
Copy to	Ian Gilmore		
From	Tyler Tinkler	Tel	0249799061
Subject	Analysis of groundwater flows at SCS	Job no.	22/18931/

1 Introduction

The purpose of this document is to inform the hydrogeological model, by performing a validation and sensitivity analysis of the assumptions and data considered in Draft B of the Site Water and Salt Balance Assessment.

Cooks Dam forms a key point of interest for both hydrogeological and water balance modelling as it is both representative of the bottom of the Lithgow seam and its outflows are connected to LDP006 discharges.

2 Data and assumptions

2.1 Net Cooks Dam inflows

A constant inflow of 0.8 ML/day has previously been considered. This constant value assumes that underground water levels remain constant over time and rainfall driven spikes in water volumes are sufficiently attenuated. This does not include seepage directly from DML Dam, which is discussed in Section 2.2.

2.2 Net seepage from DML Dam to Cooks Dam

The seepage between DML Dam and Cooks Dam is understood to be via a preferential flow path, or sinkhole, between the two storages. A lumped Darcys Law approach has been used to related head difference between DML Dam and Cooks Dam to seepage rate with a hydraulic conductivity $K = 39$ m/day, flow path length of $L = 30$ m, and flow area of $A= 1000$ m^2. A discharge rating curve is shown in Figure 2-1.

Since May 2016, DML levels have stabilised 908 m AHD to 908.5 m AHD after pumping from Cooks Dam ceased.

Due to the high connectivity and cessation of pumping and elevated water levels in DML Dam, it is not considered necessary for the hydrogeological model to consider this seepage.

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T 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com

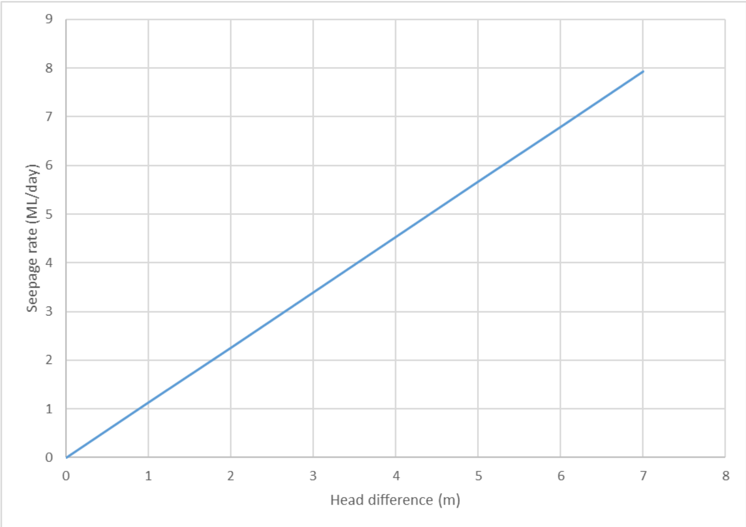

Figure 2-1 DML Dam to Cooks Dam seepage discharge rating

2.3 Net seepage from SHG1, H Pit West, H Pit East and Council Pit

Table 2-1 presents the estimate of groundwater contributions from respective surface storages within Springvale Coal Services based on water balance accounting of rainfall, evaporation and catchment runoff.

No record of water levels for the SHG1 were available for modelling predictions. However, there were levels available for H Pit West. The levels observed within H Pit West were transposed onto SHG1 considering an increase in water levels of 14 m to account for difference in the elevation based on observed water levels in the latest aerial and LIDAR data.

Table 2-1 Estimate of average net groundwater outflows

Result	SHG1 (ML/day)	H Pit West (ML/day)	H Pit East (ML/day)	Council Pit (ML/day)
2013	0.21	0.12	0.05	0.05
2014	0.20	0.10	0.05	0.00
2015	0.22	0.12	0.05	0.04

2.4 Seepage from A Pit

It is understood that pumping infrastructure at A Pit has been sufficient to decant all return water to Washery Sediment Pond or Cooks Dam. Therefore, no seepage from A Pit has been considered.

2.5 Seepage from REA

Seepage from the REA was estimated at up to 1.0 L/s as per GHD (2016) *Stage 2 Lamberts Gully REA Storage Augmentation (REASA) Design Report*.

3 Validation and sensitivity analysis

A validation and sensitivity analysis was performed based on observed water levels in Cooks Dam and DML Dam and observed LDP006 discharge. This validation and sensitivity analysis was undertaken based on data and assumptions considered in Draft B of the water and salt balance assessment, as discussed above.

The validation period was limited to 1/1/2015 to 1/4/2015 due to the reliability of the pumping data and the absence of rainfall driven LDP006 discharge from the Lamberts Gully catchment. This period of data was at a time where water from Cooks Dam was pumped into DML Dam.

It should be noted that it was assumed approximately 1.5 ML/day was being removed from Cooks Dam for use in the washery through the validation period. It was assumed that all of this water returned to Cooks Dam, less the evaporation from the active beach area and decant pond of A Pit. This assumption is likely to underestimate net additional groundwater inflows, as, in reality, some water is retained in tailings emplaced in A Pit.

The sensitivity analysis considered 5 sensitivity scenarios with parameter values shown in Table 2.

Table 2 Parameter values for sensitivity analysis scenarios

Scenario	Net inflow into Cooks Dam (ML/day)	DML Dam to Cooks Dam hydraulic conductivity (m/day)
Base case	0.8	39
GW 0.0 ML/day	0.0	39
GW 0.4 ML/day	0.4	39
K +20 %	0.8	47
K -20 %	0.8	31

Figure 3-1 and Figure 3-2 presents the comparisons between modelled and predicted water levels at the key validation locations of DML Dam and Cooks Dam.

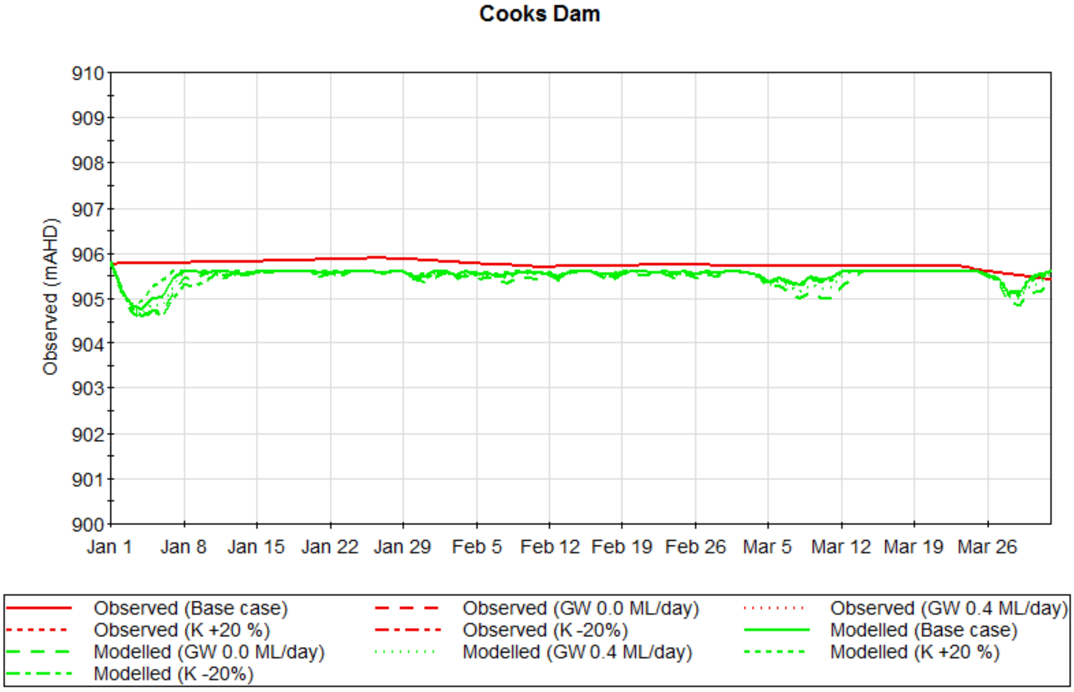

Figure 3-1 Comparison of model and observed predictions – Cooks Dam water levels

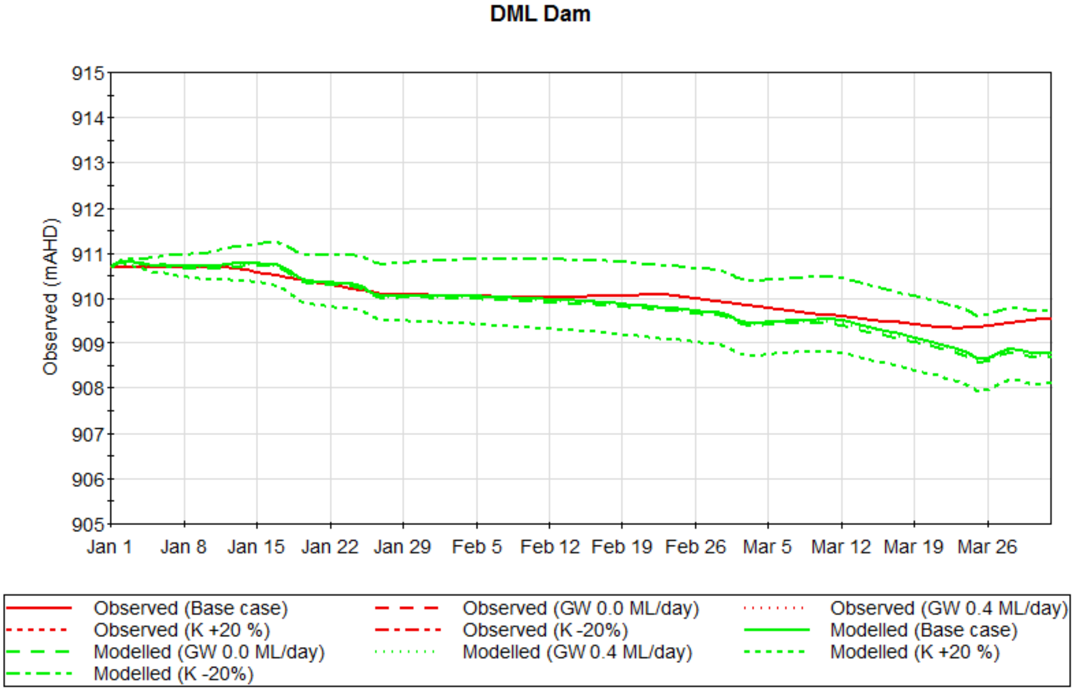

Figure 3-2 Comparison of model and observed predictions – DML Dam water levels

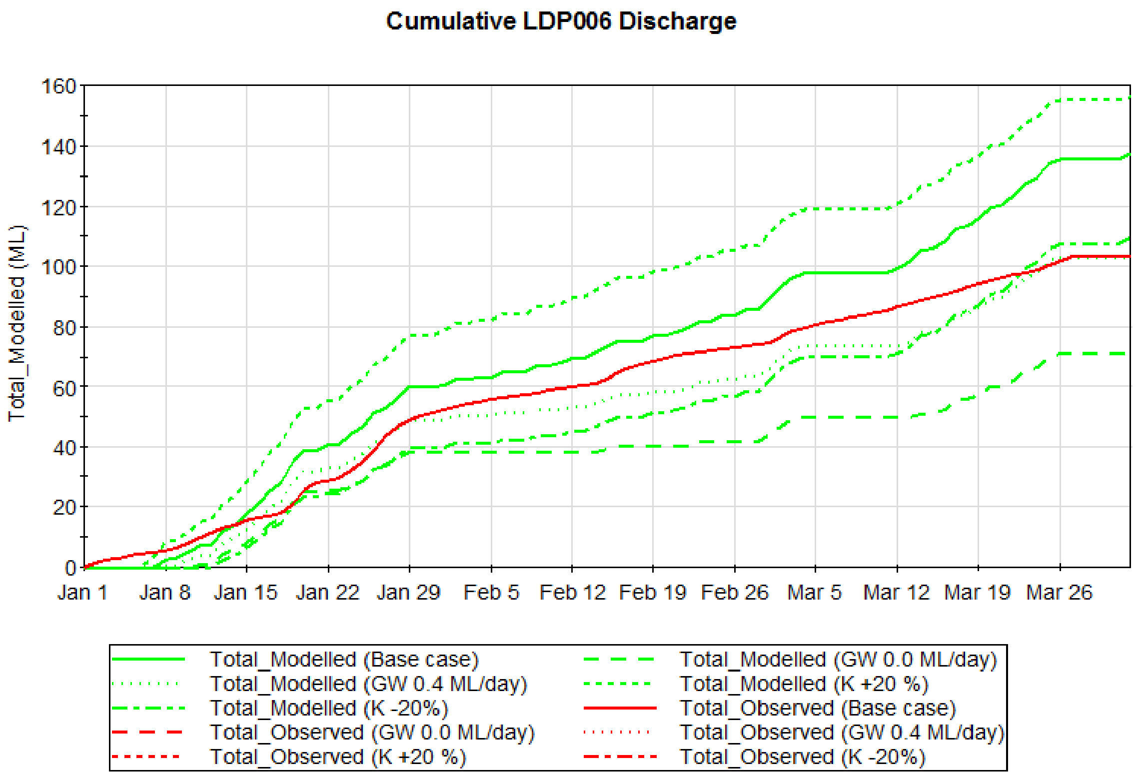

Figure 3-3 Cumulative comparison of modelled and predicted discharges at LDP006

As Cooks Dam was close to spill level throughout the validation period, therefore the fit was insensitive to all parameters considered.

Water surface levels in DML Dam was sensitive to the hydraulic conductivity back to Cooks Dam. The fit of data suggested that hydraulic conductivity is likely to be between 31 to 39 m/day.

Considering that LDP006 discharges during this period were not likely to include catchment runoff contributions, the results of the Cooks Dam balance suggest a net groundwater inflow of 0.4 ML/day rather than the previously assumed 0.8 ML/day.

The groundwater inflow value was sensitive to the assumption about the washery process and fine rejects bleed within the site water cycle. Water retained in the fine rejects in the REA would be lost from the water cycle. The water balance model is limited in its consideration of this as there are no observations of return water or wash rates monitored by site for period assessed.

4 Summary

A summary of the understanding groundwater flows at Springvale Coal Services is provided in Table 4-1, which includes the outcomes determined from the validation and sensitivity analysis described in Section 3. Notably:

- the estimate of net groundwater inflows into Cooks Dam has been reduced from 0.8 ML/day to 0.4 ML/day based on the sensitivity analysis described above
- due to the high connectivity between DML Dam and Cooks Dam, it is not considered necessary to consider this connection in hydrogeological model

Table 4-1 Summary of groundwater flows

Groundwater flow	Value	Source
Calibration period 2012 to 2016 - DML and Cooks Dam interactions		
Net Cooks Dam inflows	Constant 0.4 ML/day	Updated based on sensitivity analysis as described in Section 3
DML Dam to Cooks Dam seepage	Average of 5.6 ML/day depending on DML Dam levels..	Approximated as a lumped Darcys Law approach described in Section 2.2 and validated as described in Section 3
H Pit West	Approximately 0.1 ML/day	Draft B of Site Water and Salt Balance Assessment
H Pit East	Approximately 0.05 ML/day	Draft B of Site Water and Salt Balance Assessment
Council Pit	Approximately 0.05 ML/day	Draft B of Site Water and Salt Balance Assessment
SHG1 outflow	Approximately 0.2 ML/day	Draft B of Site Water and Salt Balance Assessment
A Pit outflow	Not considered	Draft B of Site Water and Salt Balance Assessment
REA outflow	Constant 1 L/s	Draft B of Site Water and Salt Balance Assessment

Regards

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Appendix C - Supporting assessment requirements

Table C-1 Significant Impact Test

Element	Triggers an impact	Reasoning
Changes to Hydrology		
Flow regimes (volume, timing, duration, frequency)	No	Changes to the discharge regime from the SCSS are negligible and of minimal consequence.
Recharge rates	No	No active groundwater interactions
Aquifer pressure or pressure relationships between aquifers	No	No active groundwater interactions
Groundwater table levels	No	No active groundwater interactions
Groundwater/surface water interactions	No	Connectivity exists between surface and groundwater environments however these are existing with no change proposed in relation to these interactions
River/floodplain connections	No	Changes to the discharge regime from the SCSS are negligible and of minimal consequence.
Inter-aquifer connectivity	No	No groundwater interactions
Changes to Water Quality		
Create risks to human or animal health or to the condition of the natural environment	No	No risk predicted associated with increased ECs predicted by the regional salt balance.
Substantially reduce the amount of water available for human consumptive uses or for other uses, including environmental, which are dependent on water of a particular quality	No	No reduction in the amount of water available is predicted
Cause persistent organic chemicals, heavy metals, salts or other potentially harmful substances to accumulate in the environment	No	No accumulation of potentially harmful substances predicted.
ANZECC Water Quality Assessment undertaken	Yes	Applied to LDP006 discharge and

Element	Triggers an impact	Reasoning
		downstream Wangcol sites.
Changes to Ecosystem Function and Integrity		
Areas of the water resource being destroyed or substantially modified in a way that has an adverse effect on a water-dependent ecosystem	No	
An adverse change to the benefits or services provided by a water resource	No	No change to beneficial use categories
A change in the biological diversity or species composition of a water resource or its ecological connectivity to other water resources	No	See Section 6.6.3
The habitat or lifecycle of native species which are ecologically associated with the water resource or which are important determinants of the water resource's character being seriously affected	No	
An invasive or pest species that is harmful to the ecosystem functioning or integrity of the water resource becoming established (or an existing invasive or pest species being spread) in the water resource.	No	
Cumulative Impacts		
An assessment of the cumulative impacts of all other known projects in the surface or groundwater source area	Yes	Standard cumulative assessment approach down to the boundary of Lake Burragorang
Timing, Scale and Value		
An assessment of the impacts in both the short and long term. The long term will at a minimum be 100 years, unless otherwise defined by a peer reviewed hydrogeological model	Yes	Assessment period determined from length of groundwater supply (2035). No hydrogeology component.
Timing of the activities that are likely to impact water resources	Yes	Up to 2035.
A robust water balance that identifies when in the project timing water impacts are likely to be *greater than* the existing situation	Yes	Regional water and salt balance that considers both local (operational level) and regional scales
A complete or revised existing local and regional water balance and hydrogeological model	Yes	Development of new modelling considering multiple scales (operations and regional) of modelling.

Element	Triggers an impact	Reasoning
A statement as to the value of the water resource must be included in the significant impact test. This statement must be in the context of the services provided by the resource as well as the connectivity of the resource to other water resources. Services include provisioning to other industries or potable water supplies, cultural services and supporting ecosystem services.	Yes	The value of Coxs River is high as it contributes to the drinking water supplies of Sydney. The value of Wangcol Creek is low as it only supports aquatic ecology that is somewhat degraded.

Table C-2 Consolidated IESC Checklist

Element	Assessed within WRIA
Background Data and Modelling Identification of the water related assets Identification of the geological formation/aquifer to which groundwater dependent ecosystems (GDEs) are connected Location of springs and other groundwater dependent ecosystems A site specific water balance complemented by a regional water balance A description of the water resources of the site A description of the geology and hydrogeology at a local and regional level, including definition of the geological sequence The depth to aquifers and standing water levels, hydro-chemical characteristics A description of the likely recharge sources for each aquifer, details of discharges from each aquifer, direction of groundwater flow and contours of groundwater elevations for all aquifers Surface water assessment and model, including hydrology and water quality parameters Relevant information to describe the existing state of water related ecosystems	Yes
Water and Salt Balance A site specific water balance and a site specific salt balance, complemented by a regional balance of both water and salt covering the larger area of potential impact. An assessment of the changes to any water storage or flow of water in the system as a result of the project, including changes to salt loads.	Yes
Assessment of the likely significant impacts on water resources and water related assets Consideration of the State based policies and guidelines Predicted change to both local and regional water balances Impacts associated with surface water diversions	Yes

Element	Assessed within WRIA
Estimates of the quantity and quality of operational discharges of water, including emergency discharges Indication of the vulnerability to contamination and the likely impacts on the identified water assets Consideration of the impacts of water management infrastructure on the biodiversity assets Assessment of the cumulative impact of the project with past, present and known future projects Proposed mitigation measures for each identified impact	
Assessment of cumulative impacts The cumulative impact assessment needs to consider all past, present and known future projects, undertaking with regard to the regional water balance. Catchment and regional scale information Total existing and planning licensed and extracted water for consumptive, industrial and agricultural purposes in the surface catchment and groundwater system Existing water quality guidelines, targets, environmental flow objectives and requirements for the ecosystems of the surface and groundwater systems The proportional increase in water resource use and impacts as a consequence of the proposal The overall level of risk to water related assets that combine probability of occurrence with severity of impact of all past, present and known future projects	Yes
Ongoing management and monitoring Plan of management is to be included that focuses on the avoid, mitigate, manage and offset principles Clearly defined monitoring objectives Maps/figures demonstrating location of bores, their purpose and distribution such that impacts to groundwater gradients, flow directions, recharge processes, quality and water levels in each aquifer Variables such as water levels, EC, pH and other quality parameters to be measured and the interval for measurement An ANZECC water quality assessment and the development of guideline trigger values	Yes

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