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30 May 2013

Melissa Masters
Department of Sustainability, Environment, Water, Population and Communities
Via email

Re: Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development advice on Cobbora Coal Project (EPBC 2011/6158)

Dear Melissa

As you are aware, EMGA Mitchell McLennan (EMM) provided information regarding the Cobbora Coal Project to the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) on behalf of Cobbora Holding Company Pty Limited (CHC) in February 2013. The IESC's *Advice to decision maker on coal mining project* was received on 18 Aril 2013.

Responses to the IESC advice are attached (Appendix A). These have also been provided to the NSW Department of Planning and Infrastructure (DP&I).

On 6 May 2013, CHC's Chief Executive, Steve Ireland, and HSEC Manager, Trish McDonald, met with Tony Pooley, Deputy Chief of Staff to the Hon Tony Burke MP. Mahani Taylor from Department of Sustainability, Environment, Water, Communities and Population (SEWPaC) also attended the meeting. As discussed, the assessment of potential water impacts from the Cobbora Coal Project have been extensively reviewed as part of the NSW approval process, including independent experts commissioned by CHC, DP&I and the NSW Planning Assessment Commission (PAC). A summary of the assessment process to date (focused on the assessment of water issues) is provided below to put this into context for IESC.

1 Environmental assessment process

Approval for the Project is being sought under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The relevant controlling provisions of the EPBC Act are listed threatened species and communities (sections 18 & 18A) and listed migratory species (sections 20 & 20A).

The environmental assessment (EA) for the Project was prepared by EMM, with input from external specialists. A draft of the EA was provided to DP&I, a range of NSW agencies and SEWPaC on 6 July 2012 for 'adequacy review'. DP&I determined that once specific issues raised the review were addressed the EA could be placed on public exhibition.

The EA was placed on public exhibition for six weeks between 5 October 2012 and 16 November 2012. Submissions were received from government agencies, interest groups and the public.

A Preferred Project Report and Response to Submissions (PPR&RTS) was publically exhibited in March 2013. The PPR&RTS included revised groundwater and surface water assessments that addressed comments raised during exhibition of the EA. A number of agencies interest groups and community members provided further comments on the PPR&RTS.

The Minister for Planning and Infrastructure requested that the PAC review the merits of the Project and conduct hearings during the review. Public hearings were held in Dunedoo on 10 December 2012. The PAC Review report was provided to CHC on 19 April 2013. The PAC Review report considers the merits of the Project as a whole. The report concluded that "[t]he Commission has also made a number of recommendations to ensure the mine is appropriately designed and managed, and finds that the project could be approved, subject to conditions".

The PAC Review Report includes a *Review of Potential Water Impacts for the Cobbora Coal Project* prepared by independent expert, Dr Steve Perrens. Parson Brinkerhoff's responses to the issues raised by Dr Perrens are provided in Appendix B.

DP&I are currently reviewing CHC's response to the PAC Review report. DP&I will then prepare the Director-General's Environmental Assessment Report and draft project approval conditions. These will be provided to the PAC, which will determine whether to approve the Project, and if so, the conditions of the Project Approval. Following approval under state legislation, the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities will determine the Project under the EPBC Act.

2 Groundwater and surface water assessment

The groundwater and surface assessment program started in 2009 with the installation of piezometers, test production bores and surface water monitoring stations. This program was expanded to include more extensive fieldwork in 2011 and 2012.

Groundwater and surface water assessments have been produced and updated by Parsons Brinkerhoff as follows:

- preliminary groundwater and surface water assessments (August 2010): these assessments were based on a mine plan with a larger footprint and greater production rate than that now proposed;
- draft groundwater and surface water assessments for EA adequacy review (July 2012): these assessments were based on a mine plan similar to that currently proposed;
- groundwater and surface water assessments for EA public exhibition (July 2012): these assessments were updated in response to comments received during the EA adequacy review to consider a final landform with one final void lake as opposed to three as shown in the draft EA; and
- groundwater and surface water assessments for PPR&RTS (January 2013): these assessments were updated in response to comments received during the EA public exhibition.

These reports have undergone extensive reviews that have been commissioned by CHC or as part of the NSW approvals process as summarised in Table 1.

Table 1 Water assessment reviews

Period	Reviewer	Notes
Draft EA for adequacy review		
February 2012	Heritage Computing, Dr Noel Merrick	Independent review of the draft groundwater assessment. This was a comprehensive peer review based on the Murray Darling Basin Commission Groundwater Flow Model Guideline. The review is included in Appendix I of the groundwater assessment report (EA Appendix D). The groundwater assessment was updated to address the review comments
January–July 2012	EMM, Bob McCotter	Review of groundwater and surface water assessments
	CHC, Dr Andrew Krause	Review of groundwater and surface water assessments
July 2012	Heritage Computing, Dr Noel Merrick	Independent review of components of the updated groundwater assessment. This was an incremental review of the changes to the report following the February 2012 review and following changes to the mine plan. The review is included in Appendix I of the Groundwater Assessment report (EA Appendix D)
	Evans & Peck for DP&I, Dr Steve Perrens	Review of the adequacy of the surface water assessment
	Kalf and Associates for DP&I, Dr Frans Kalf	Review of the adequacy of the groundwater assessment
	NSW Office for Water	Review and adequacy submission on the EA
	NSW Environment Protection Authority	Review and adequacy submission on the EA
	Gilbert & Sutherland for Mid-Western Regional Council	Review and adequacy submission on the EA
EA for public exhibition		
August 2012	Dr Andrew Krause, CHC	Review groundwater and surface water assessments prior to EA public exhibition
September–October 2012	Evans & Peck for DP&I, Dr Steve Perrens	Review of the surface water assessment (ongoing from adequacy review)
	Kalf and Associates for DP&I, Dr Frans Kalf	Review of the groundwater assessment (ongoing from adequacy review)
	NSW Office for Water	Review and submission on the EA
	NSW Environment Protection Authority	Review and submission on the EA
PPR&RTS		
January 2013	EMM, Bob McCotter	Review of groundwater and surface water assessments
	CHC, Dr Andrew Krause	Review of groundwater and surface water assessments
February –April 2013	Evans & Peck for PAC, Dr Steve Perrens	Review of groundwater and surface water assessments for PAC Review
April–May 2013	IESC	Review of groundwater and surface water assessments

3 Closing

DP&I have engaged Dr Perrens to continue to provide specialist advice regarding the water assessments for the Project. Dr Perrens has been provided with the IESC advice.

We are liaising closely with DP&I to resolve the remaining issues. We look forward to working with SEWPaC to resolve any remaining issues related to the EPBC Act.

We trust this information is useful in placing the IESC advice into context.

Yours sincerely

Philip Towler
Associate Director
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Appendix A

Responses to comments from the Independent Expert Scientific Committee

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Memo

Date	27 May 2013
To	Andrew Krause, Trish McDonald, CHC Phil Towler, EMM
From	Rob Leslie
Ref	2162570C-DMS-WAT-008 RevC
Subject	Cobbora Coal Project - Surface Water Assessment - Responses to comments from the Independent Expert Scientific Committee

Dear Andrew and Trish

1. Introduction

This memo provides PB's responses to comments on the Cobbora Coal Project Surface Water and Groundwater Assessments provided in the Independent Expert Scientific Committee (IESC) advice dated 8th April 2013.

2. Responses to IESC advice comments

The IESC advice provides numbered comments which are repeated in this section with PB's responses below.

1. There is insufficient information to reasonably understand the potential impacts of the proposed project, without a regional water balance, without a comprehensive cumulative impact assessment and without potential downstream water quality impact assessments, particularly in relation to salinity.

PB response:

The groundwater modelling demonstrates that drawdown and depressurisation impacts are limited to an area of approximately 280km^2 centred on the mining area. The area of potential impact sits well within the boundaries of the model and the model is considered to provide reasonable estimates of groundwater components of the water balance. There are no impacts on the aquifers outside of this impacted area. Furthermore, the proposed Cobbora Project lies some 40 km to the west of the active Ulan Mine. Groundwater impacts from the Ulan mine are highly unlikely to extend to the Cobbora project and therefore a cumulative groundwater impact assessment in regard to that project is not required.

The surface water modelling demonstrates that the main impacts on downstream flows will be experienced in the following reaches:

- Lower 3km of Blackheath Creek adjacent to mining area C
- Lower 8km of Laheys Creek adjacent to mining area B
- Lower 11km of Sandy Creek adjacent to mining areas B and A

The flow impacts will also extend further downstream into the Talbragar River below its confluence with Sandy Creek; however, the impacts will be greatly diminished due to the influence of the larger Talbragar catchment. These impacts would also diminish further downstream as the contributing catchment of the Talbragar increases. The Sandy Creek sub-catchment is approximately 8% of the Talbragar River catchment to the Sandy Creek and Talbragar River confluence; and approximately 1% of the Macquarie River catchment to the Talbragar River and Macquarie River confluence. Therefore, the Sandy Creek sub-catchment is a very small portion of the broader Macquarie River catchment system. The Surface Water Assessment identified that the mean daily flow in Sandy Creek is approximately 11% of the mean daily flow in the Talbragar River at Elong Elong, 0.9% of the mean daily flow in the Macquarie River at Warren Weir and 2% of the mean daily flow in the Macquarie River at Oxley Station. Therefore, there are no significant regional impacts of the Project on downstream flow regimes beyond the confluence of Sandy Creek and the Talbragar.

2. The increased risk of salinity as a result of surface discharge and groundwater drawdown resulting from the proposed project may have significant ramifications for downstream users and ecosystems. In this regard the Committee notes the following:

    a. The proponent has not identified all the potential risks associated with salinity in the Sandy Creek sub-catchment (and the Talbragar River catchment) and should undertake a risk assessment to ensure that an appropriate mitigation plan is in place to manage the potential impacts from increased regional salinity;

PB response:

The water quality modelling indicates that the main impact on salinity is in the Sandy Creek system, with TDS concentrations increased by up to 52% during mining. The impact on the Talbragar system is much lower with TDS concentrations increased by up to 5%. The elevated TDS concentrations in the Talbragar remain well below the customised water quality objective. As for the flow impact assessment, there are no significant regional impacts of the Project on downstream water quality beyond the confluence of Sandy Creek and the Talbragar.

    b. The Jurassic Purlawaugh Beds are a major source of salt in the Sandy Creek sub-catchment and the Talbragar River catchment. The Jurassic Purlawaugh Beds and the Pilliga Sandstone, should be included in the geological conceptual model and then translated into the numerical groundwater model; and

PB response:

The Jurassic Purlawaugh Formation and Pilliga Sandstone were considered in the Groundwater Assessment, and were included as a distinct layer in the groundwater model. It was found that groundwater flow from the Jurassic beds was insignificant compared with the Triassic strata. Regional groundwater quality monitoring (Figure 5.12 of the Groundwater Assessment) does not support a high source of salinity from the Purlawaugh Formation. Sampling indicates that groundwater within and immediately down-gradient of the Purlawaugh Formation is of a similar or lower salinity (e.g. bore GW18; 2306 µS/cm) to samples collected from the Triassic rocks in recharge areas such as the ridges within the Project area (e.g. bore GW24; 2970 µS/cm). This implies that the risk of adverse salinity impact from enhanced recharge via the Purlawaugh Formation is negligible.

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c. The proposed transfer of 3,311 ML per year of water from the Cudgegong River catchment into the Sandy Creek sub-catchment has the potential to exacerbate the issues surrounding salinity in the already highly saline Sandy Creek sub-catchment.

PB response:

While the full entitlement from the Cudgegong is 3,311 ML per year, the actual transfer of water under most climate conditions will be far less. Cudgegong water that is used in the mine for activities such as dust suppression and then captured in sedimentation dams and released to the Sandy Creek system will form a relatively small portion of the flow in the downstream system, e.g. for the reference dry year the releases from the sedimentation dams forms a maximum of approximately 18% of the flow in Sandy Creek. This water will also be subject to performance criteria for a range of water quality parameters, including TDS, before release. The water quality assessment shows that salinity in the Sandy Creek system is increased; however, the TDS concentrations remain at or just over the customised water quality objective.

3. A risk assessment is needed to determine the potential impacts on recharge into the Great Artesian Basin and downstream irrigation areas. In relation to the Great Artesian Basin, the Sandy Creek sub-catchment geology includes Jurassic sediments which may connect to the southern recharge zone of the basin. Further work is required to ensure that the drawdown in the proposal will not affect recharge to the Great Artesian Basin as the Southern Groundwater Recharge Source extends to the northern edge of the Talbragar River in this area.

PB response:

The maximum predicted drawdown extends just to the margin of the Great Artesian Basin water source but does not propagate significantly into it, implying negligible impact to the GAB recharge areas. Drawdown may extend to three Jurassic outliers to the west of the project area, but these are disconnected outliers from the GAB and similarly imply no additional impact to the GAB recharge areas (See figures 6.7 and 8.1a of the Groundwater Assessment). Drawdown impacts to the GAB have therefore been considered in the current model, the results of which imply a negligible risk to that water source. We suggest that additional modelling would not change this assessment.

4. The proponent has not considered the potential impacts on the surrounding creeks and water quality as a result of uncontrolled discharge from the mine water dams. The sedimentation dams are currently designed to contain 95 per cent of a 5 day storm event (63.3 mm), which means that they have the potential to overflow approximately 1 to 2 times per year. Consideration should be given to sedimentation dams being redesigned to contain a larger storm event (1 in 1000 year average recurrence interval) to minimise the potential for downstream water quality and ecological impacts.

PB response:

Sedimentation dams have been designed in accordance with the “Blue Book” (Landcom 2004, *Managing urban stormwater: Soils and construction*), and increasing the storage capacity beyond guideline values to retain larger storm events without controlled release or spilling would have impacts on the flow regime downstream. The mine water system has been designed to harvest sedimentation dam water up to a point, but balanced so as to avoid significant impacts on the flow regime in the creeks downstream. A range of rules were tested during development of the water balance model for harvesting from sedimentation dams; (1) no sedimentation dam water harvesting; (2) pump from sedimentation dams to mine water dams when mine water dams fall below 25% full; and (3) pump from sedimentation dams to mine water dams when mine water dams fall below 50% full. The results of these early tests are summarised below for mining year 20 in Table 1:

Table 1 – Annual flow impacts at Sandy Creek outlet

Climate condition	Impact on creek flow – mining year 20		
	0% rule	25% rule	50% rule
10%ile (dry) year	+11%	-5%	-5%
50%ile (median) year	+12%	+5%	+3%
90%ile (wet) year	+2%	+2%	+1%

The 25% rule was chosen as the preferred operating procedure as it was found to provide a significant volume of water to reduce reliance on the Cudgegong entitlement while not significantly impacting the downstream flow regime.

5. The proposed project identifies mitigation measures, including creation of permanent water sources to offset the impact of dry years on the riparian vegetation due to the reduction of catchment runoff along creek channels. Insufficient information has been provided as to the adequacy of these water sources to recharge the shallow alluvial aquifers that support the existing riparian vegetation.

PB response:

Groundwater monitoring carried out in the Groundwater Assessment indicates that groundwater in the vicinity of the lower reaches of Laheys Creek and Sandy Creek is shallow and sits within the alluvium of those creeks. It is likely that vegetation and some refuge pools are partially reliant on groundwater within the alluvium. In addition, test pumping and isotopic analysis in the Groundwater Assessment showed that the alluvium is only weakly connected to the underlying Permian Coal Measures and recharges rapidly during high rainfall events (the alluvial groundwater is relatively "young" and rainfall derived). Therefore it is likely that the alluvium and the pools will recharge rapidly during recharge events and be sustained for several months after the rainfall event due to storage in the alluvium, even with mining impacts. This also implies that any releases to the creeks would be effective in recharging shallow groundwater, provided the releases were large.

6. The Committee made a number of observations about the proposal's potential impacts on surface water and groundwater resources and groundwater dependent ecosystems:

   a. The predicted drawdown levels of 90 m in mining area B and 60 m in area A have the potential to impact groundwater dependent ecosystems and surface water including refuge pools;

PB response:

It should be noted that the drawdown predicted by the groundwater model at the pool locations is in the range 1 to 18m.

   b. The regional 1 m drawdown is predicted to extend 5 km to the south, 4 km to the west and 3 km to the north and east of the mining area highlighting the need to determine the potential regional impacts on water; and

PB response:

The groundwater model adequately shows the potential water table drawdown extents in relation to groundwater users and surface water sources. The impacts on vegetation and irrigation areas located away

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from the major creek lines will be negligible because the depth to groundwater increases from <3 m near the creeks to >15 m beneath the interfluves and ridges.

The NSW Planning Assessment Commission (PAC) Review Report (April 2013) includes a Review of Potential Water Impacts for the Cobbora Coal Project prepared by Dr Steve Perrens. Parson Brinkerhoff's responses to the issues raised are provided in a memo titled Cobbora Coal Project – Responses to PAC Review of Water Modelling (14 May 2013). These responses include a discussion of the interaction of surface and groundwater systems as summarised below:

The Sandy Creek sub-catchment is approximately 8% of the Talbragar River catchment to the Sandy Creek and Talbragar River confluence; and approximately 1% of the Macquarie River catchment to the Talbragar River and Macquarie River confluence. Therefore, the Sandy Creek sub-catchment is a very small portion of the broader Macquarie River catchment system. In terms of magnitude of flows, the Surface Water Assessment found that the mean daily flow in Sandy Creek is approximately 11% of the mean daily flow in the Talbragar River at Elong Elong, 0.9% of the mean daily flow in the Macquarie River at Warren Weir and 0.2% of the mean daily flow in the Macquarie River at Oxley Station.

Surface water modelling indicates that impacts to surface water flow will extend downstream to the Talbragar River below its confluence with Sandy Creek; however, the impacts will be greatly diminished due to the influence of the larger Talbragar catchment. These impacts would also diminish further downstream as the contributing catchment of the Talbragar River increases.

In order to quantitatively assess the potential changes in annual flow in Sandy Creek and the resulting impact on flows in the Talbragar River, estimates of annual stream flow from surface water modelling were combined with estimates of potential seepage losses from the creeks from the groundwater model. When the groundwater model river losses are applied 60% of the time (to account for the ephemeral nature of Sandy Creek), the maximum reduction in flow is 11% in the Sandy Creek system in a median year and 1% (negligible) for the Talbragar River at Elong Elong. In a very dry year the losses may be up to 54% and 11% respectively. This is assessed as the most likely upper bound or most severe impact on the river system.

c. There is insufficient information on hydraulic connectivity across the proposed project area and regionally to understand the impacts of drawdown on surface water systems and groundwater dependent ecosystems.

PB response:

Connectivity has been defined in the Groundwater Assessment and incorporated into the model. The hydraulic conductivity for all relevant units has been determined using appropriate hydraulic tests (See Section 4 of the Groundwater Assessment). Further, the connectivity between the Permian Coal Measures and the alluvium which contains the potential groundwater dependent vegetation was determined by long duration test pumping. These attributes were used to parameterise the numerical model and therefore we consider that the hydraulic connectivity is well represented in the model. Potential drawdown beneath all surface water courses and refuge pools has been predicted with the model and presented in the Groundwater Assessment (Section 6). The absolute impact on individual pools and species is subject to several sources of uncertainty, including the detailed hydrology and soil characteristics of each pool and plant environment. However the relative drawdown predicted by the model provides an adequate basis for risk assessment.

8. The Committee, while noting that field investigations have been undertaken, recommends that further information be provided to improve the reliability of the groundwater model, particularly in regard to:

   a. Formation-scale hydraulic properties such as vertical permeability and hydraulic conductivity for relevant geologic units, which are required to assess aquifer connectivity;

.

PB response:

The groundwater model has been conceptualised appropriately and peer reviewed by two independent reviewers. While it is acknowledged that there is uncertainty with these parameters, that has been addressed through the uncertainty analysis (Section 5.3 of the Groundwater Modelling Technical Report) and the model is considered to be adequate in determining localised and regional impacts. The adopted regional vertical and horizontal permeability values are considered to be in line with field testing and consistent with ranges in published data from elsewhere (including many studies in the Hunter Valley).

   b. Geological conceptualisation model, including faulting and the Jurassic formations to reduce the uncertainty in regards to regional salinity impacts;

PB response:

Jurassic Formations were included in the numerical model, however they were not found to be sensitive parameters with respect to mine inflow or drawdown impacts. Faults are known to occur within the project area. However faults can influence groundwater in a variety of ways, in some cases acting as hydraulic conduits and in some cases as barriers to flow (or any gradation between). Given this high degree of variability in behaviour and the likely occurrence of unknown faults, the most appropriate and conservative approach is to exclude them from models unless there is strong evidence for their influence on groundwater flow. No such evidence was encountered during the field investigations.

   c. Evapotranspiration;

PB response:

Evapotranspiration has been allowed for in the groundwater model. It is represented using the EVT package in MODFLOW Surfact and shown to be a significant component of the regional groundwater budget (See Table 4.3 of the Groundwater Modelling Technical Report).

   d. Ongoing review and validation of the model during the life of the project, including data on the impacts of the proposed voids; and

PB response:

It is agreed that the model should be subject to ongoing review and validation.

   e. Uncertainty analysis of the outputs from the groundwater model, which is consider to be best practice.

PB response:

An uncertainty analysis has been done – See Section 5.3 of the Groundwater Modelling Technical Report. Additional sensitivity runs were carried out in response to comments from the PAC technical reviewer (Dr Frans Kalf) to assess the role of the ephemeral streams in recharging the aquifers and mitigating drawdown impacts. Water balance modelling of the final void was carried out in a stochastic manner using ranges for groundwater inflow to reflect the likely uncertainty in those estimates (derived from the groundwater uncertainty analysis).

Yours sincerely

Rob Leslie

Rob Leslie
Team Manager, Water Resources NSW
Parsons Brinckerhoff

Appendix B

Responses to PAC Review of Water Modelling

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Memo

Date	14 May 2013
To	Andrew Krause, Trish McDonald, CHC Phil Towler, EMM
From	Rob Leslie
Ref	2162570C-DMS-WAT-007 RevG
Subject	Cobbora Coal Project - Responses to PAC Review of Water Modelling

Dear Andrew and Trish

1. Introduction

This memo provides Parson Brinkerhoff's (PB's) responses to Dr Steve Perren's Review of Potential Water Impacts for the Cobbora Coal Project as provided in Appendix 7 of the Planning Assessment Commission (PAC) Review Report dated April 2013.

2. General

The majority of Dr Perrens' comments relate to the impact on flows in the creek systems downstream of the mining areas due to a combination of changes to the surface water catchments predicted by the site water balance model (which includes a hydrological model) and losses to the river systems due to water table drawdown predicted by the groundwater model.

Dr Perrens concluded his review by noting:

"This review has identified a range of uncertainties associated with the estimated water requirements for the operation of the Cobbora Mine and the relative contributions from different sources of supply. Notwithstanding these uncertainties, none of them individually or collectively would be 'show stoppers'. A range of options are available that would allow the mine to adapt its water use and manage the various sources to allow the mine to operate within the constraints of the available water resources."

The review pointed to a number of specific issues on water supply and consumption but ultimately, most of them can only be resolved once detailed design is completed. The present submission responds to each of the questions raised by the Department of Planning and Infrastructure following its receipt of the review report, while recognising the need for detailed design to answer them in more specific terms. Nevertheless, PB concurs with Dr Perrens' assessment that none of the issues raised could not be resolved during detailed design stage and that none would compromise the ability of the mine to appropriately manage surface and ground water resources.

This section combines information from the Surface Water and Groundwater Assessments to respond to the PAC Review Report.

2.1 Impacts on downstream flows

The main impacts on downstream flows will be experienced in the following reaches:

- Lower 3km of Blackheath Creek between mining areas A/C and mining area B
- Lower 8km of Laheys Creek adjacent to mining area B
- Lower 11km of Sandy Creek adjacent to mining areas B and A

The flow impacts will also extend downstream to the Talbragar River below its confluence with Sandy Creek; however, the impacts will be greatly diminished due to the influence of the larger Talbragar catchment. These impacts would also diminish further downstream as the contributing catchment of the Talbragar River increases. The Sandy Creek sub-catchment is approximately 8% of the Talbragar River catchment to the Sandy Creek and Talbragar River confluence; and approximately 1% of the Macquarie River catchment to the Talbragar River and Macquarie River confluence. Therefore, the Sandy Creek sub-catchment is a very small portion of the broader Macquarie River catchment system. In terms of magnitude of flows, the Surface Water Assessment found that the mean daily flow in Sandy Creek is approximately 11% of the mean daily flow in the Talbragar River at Elong Elong, 0.9% of the mean daily flow in the Macquarie River at Warren Weir and 0.2% of the mean daily flow in the Macquarie River at Oxley Station.

In order to quantitatively assess the potential changes in annual flow in Sandy Creek and the resulting impact on flows in the Talbragar River, estimates of annual stream flow from surface water modelling were combined with estimates of potential seepage losses from the creeks from the groundwater model. It should be noted that the two systems (surface and groundwater) were modelled using different approaches and software, and have different spatial and temporal resolutions. Groundwater impacts were modelled in 3D using MODFLOW with yearly time steps and a relatively coarse grid structure to assess regional impacts, whereas surface water models used a 1D model to assess changes in catchment runoff and stream flow for each tributary with daily time steps under a number of rainfall scenarios. The groundwater model in particular includes a number of conservative assumptions to allow for adequate licensing of surface water and groundwater take and to provide conservative predictions of groundwater drawdown impacts to the environment and bore users. As a result, a simple combination of model outputs has limitations because the conservative assumptions of the groundwater model, when combined with the surface water predictions can be overly conservative to the point of being unrealistic. Therefore, in the approach outlined below an effort has been made to compensate for this and align the model outputs.

The groundwater model tends to overestimate losses from the creeks for the following reasons: First, the groundwater model represented the creeks using the MODFLOW 'river cell' module which assumes that the creeks supply a continuous source of water that can be impacted by drawdown of the water table. This is an appropriate conservative assumption for the purpose of water licencing as it overestimates the river losses due to drawdown caused by mining. However, it assumes that the creeks are flowing continuously, whereas in reality the Sandy Creek system is ephemeral and flow only occurs 60% of the time (see Surface Water Report Appendix C Figures 5-1 to 5-3). Secondly, the elevation of the river cells in the model are defined using a regional DTM based on 10 m contour data. In many cases this may also result in a slight overestimate of the increase in seepage to the groundwater system as a result of drawdown. For these reasons, the base case total stream flow estimates have been presented, followed by potential reductions in flow expected in response to typical climate conditions. Potential reductions have been estimated by adjusting the stream losses down by a factor related to the amount of time the stream actually flows during average and dry years.

Tables 1 and 2 give a highly conservative (base case) assessment of impacts on annual flows at the downstream reach of Sandy Creek and at Elong Elong on the Talbragar River downstream of its confluence with Sandy Creek for the representative dry, median and wet years in the historical climate sequence. The tables combine the changes in surface water flow regime predicted by the water balance model with river losses predicted by the groundwater model.

Tables 3 and 4 present the same stream flow estimates but apply a seepage loss that is factored down by 40% to account for the observation that, in a median rainfall year, the creek flows only 60% of the time and can therefore only lose water during periods of flow. Tables 5 and 6 apply a seepage loss that is factored down by 80% to account for the amount of time (20%) that the creek is estimated to flow in dryer conditions.

Tables 1 to 6 demonstrate the following:

- For the conservative scenario (Tables 1 and 2) in which the full estimate of modelled river losses are applied, calculations suggest that there may be reductions in annual flow in Sandy Creek compared with baseline (pre-mining) conditions of approximately 21% in the median rainfall case. There would be an almost negligible reduction (2%) in annual flow in the Talbragar River at Elong Elong in a median year. In a dry year the calculated reduction in annual flow would be up to 86% in Sandy Creek and 9% in the Talbragar River under this scenario. However for reasons outlined above, while useful as a check on modelling consistency, this combination of scenarios is not considered to be a realistic estimate of total system impacts.
- When the groundwater model river losses are applied only 60% of the time (reduced by 40%; Tables 3 and 4), the maximum reduction in flow is 11% in the Sandy Creek system in a median year and 1% (negligible) for the Talbragar River at Elong Elong. In a very dry year the losses may be up to 54% and 11% respectively. This is assessed as the most likely upper bound or most severe impact on the river system.
- When the groundwater model river losses are applied only 20% of the time (reduced by 80%; Tables 5 and 6), the maximum reduction in flow in the Sandy Creek system and the Talbragar River at Elong Elong is negligible in a median year. In a dry year, the reductions in flow under this scenario may be up to 21% and 2% respectively. This is the most likely lower bound impact on the rivers.

In all cases, estimated flow reductions are much less for the reference median year and slight flow increases are predicted for the reference wet year due to increased runoff from the modified surface water catchments, which compensates for the river losses to groundwater.

As noted above, the Sandy Creek system is ephemeral, flowing 60% of the time, and therefore baseflow conditions in the system involve filling and drying of isolated pools and discharge from temporary storage in the alluvium, rather than perennial low flow fed by groundwater discharge (as assumed in the conservative groundwater model). Given that the majority of the groundwater model river loss occurs in the Sandy Creek system and this system provides minimal baseflow to the Talbragar River, it can be concluded that the predicted flow impacts to the Talbragar River are likely to be relatively minor.

2.2 Impacts on refuge pools

In the absence of detailed survey and water balance modelling for each individual refuge pool, the impacts on the pools were assessed based on the water table drawdown predicted by the groundwater model. The assessment aimed to determine potential impacts on refuge pools that persist during extended dry conditions by focussing on groundwater drawdown impacts rather than flow impacts on the refuge pools, given that pools that persist during extended dry periods are likely to be sustained by groundwater.

Table 7 repeats the results of the refuge pool assessment from the Surface Water Report. The results of a more recent sensitivity analysis on drawdown undertaken using the groundwater model (assuming no constant head in the creeks) are also presented in the table. The base case assessment predicted that pools 3, 6 and 10 would lose groundwater supply due to drawdown and pool 5 is also at risk. The conservative case modelled in the sensitivity analysis predicts that pool 5 would lose supply and pool 3 would be affected earlier by year 12 rather than by year 16 in the base case.

CHC is committed to providing contingency measures for pools that could be affected by drawdown. An aquatic monitoring strategy will be developed to detect changes to the quality and quantity of water in semi-permanent pools. A river monitoring committee will be formed to review the results from this strategy and to assist formulate adaptive management measures. These measures may include releasing water from the mine site to fill pools. It may be necessary to transport the water by pipe or water truck if gravity feed is not possible for upstream locations or where water transmissions losses are unacceptable for downstream locations.

3. Responses to PAC Review Report comments

The Department of Planning & Infrastructure summarised the key PAC Review Report comments on the water assessments into 19 key points. These are repeated in this section with PB's responses below:

1. p17 impacts of assumptions of dry creeks and rivers (additional groundwater sensitivity run assuming no constant head) on dewatering flows to the mine, baseflow losses to Talbgragar River and pools on Sandy and Laheys Creek have not been assessed.

PB response:

Additional model sensitivity runs were carried out to assess the potential groundwater drawdown impacts in the vicinity of nearby refuge pools on Sandy and Laheys Creeks, in line with the recommendations of Dr Kalf. The results of that sensitivity analysis in terms of impacts on refuge pools are described in Section 2.2. Under the highly conservative assumption that the creeks provide no recharge to the groundwater systems when they are flowing, the model predicts that between 5 m and 22 m of drawdown will occur within the coal measures underlying the refuge pools. This amounts to between 4 m and 14 m greater drawdown than the original EA modelling that assumed that creeks provide recharge to groundwater. Baseline monitoring since 2010 has shown that significant recharge to groundwater does occur during high rainfall and runoff events which will mitigate mine related drawdown to some extent.

It is expected that in a case where no recharge to the aquifers occurs via the streams during high flow events then the predicted inflow to the mine pits will be slightly less in the long term. However most inflow will be initially derived from aquifer storage and therefore mine inflows in the first several years should not differ under such a scenario. The numerical groundwater model estimates that a maximum of 480 ML/a may be lost from the surface water systems towards the end of mining, and in the years following the end of mining. This amounts to between 10% and 15% of maximum predicted groundwater inflows to the mine. Therefore the uncertainty in groundwater inflows to the mine as a result of uncertainty in the assumptions associated with recharge from the streams will be of the same order (10 to 15%).

As discussed in Section 2.1, there is no impact on baseflow in the Talbragar River as the water table drawdown impacts are concentrated in the Sandy Creek catchment which does not contribute baseflow to the Talbragar River.

2. p17 Baseflow % - larger impacts during lower flow periods in Talbragar River – further discussion needed

PB response:

Section 2.1 presents further results of downstream flow impacts and combines the predicted flow changes from the water balance model with the groundwater model predictions of river losses. This shows that for the highly conservative case adopted in the EA groundwater modelling, the maximum reduction in annual flow at Elong Elong on the Talbragar River is 9% for the reference dry year. However, taking into account the conservative nature of the groundwater model, this reduction is more likely to be in the range of 2 to 6%.

Also, Sandy Creek does not contribute baseflow to the Talbragar River system; therefore, there are no impacts on baseflow in the Talbragar River.

3. p18 - loss of base-flow in Sandy and Laheys Creek is not clear – figures are provided for entire Talbragar River water source within the g/w model domain – not clear what reduction in baseflow impacts will have on tributary creek flows

PB response:

The EA groundwater model reported the estimated total loss of surface water due to partial loss of baseflow and increased infiltration during high flow. This total loss will relate mainly to losses from the streams adjacent to the mining areas and within the cone of drawdown (Sandy Creek and Laheys Creek), with relatively little direct loss from the Talbragar River. Tables 3 and 5 provide upper and lower bound estimates of potential reductions in based flows to Sandy Creek.

The majority of the loss is attributed to the streams of the Sandy Creek system adjacent to the mining areas, i.e. the lower 3km of Blackheath Creek, the lower 8km of Laheys Creek and the lower 11km of Sandy Creek. The combined loss in these reaches is then transferred to the Talbragar River downstream of its confluence with Sandy Creek. The loss transferred to the Talbragar River is loss due to increased infiltration during high flow conditions. There is no loss of baseflow in the Talbragar River due to baseflow reductions in the Sandy Creek system.

4. p19 Clarify the status and capacity of Clean Water Dams 9 and 10 – discrepancy in volumes

PB response:

The revised mine plan has reduced the in-pit tailings emplacement areas, which is consistent with the reduction in fines being generated, refer Tailings Management Review M01-CHC-351-RP-ENV-001. The revised mine plan requires one out-of-pit tailings storage facility (Out-Of-Pit East) and three in-pit tailings emplacement areas. Clean water dam 10 will be located upslope of Out-Of-Pit East and have a volumetric capacity of 357 ML.

CHC intends to licence clean water dam 10 under its harvest right provision in accordance with part 1 of Chapter 3 of the *Water Management Act 2000*.

5. p21 - Clarification on potential contingency to maximise utilisation of captured water from sediment dams to reduce raw water demand from Cudgegong – however will also affect assumptions regarding provision of contingent flows to Laheys/ Sandy Creek system.

PB response:

The mine water system has been designed to harvest sedimentation dam water up to a point, but balanced so as to avoid significant impacts on the flow regime in the creeks downstream. A range of rules were tested during development of the water balance model for harvesting from sedimentation dams; (1) no sedimentation dam water harvesting; (2) pump from sedimentation dams to mine water dams when mine water dams fall below 25% full; and (3) pump from sedimentation dams to mine water dams when mine water dams fall below 50% full. The results of these early tests are summarised below for mining year 20 in Table 8:

Table 8 – Annual flow impacts at Sandy Creek outlet

Climate condition	**Impact on creek flow – mining year 20**		
	0% rule	**25% rule**	**50% rule**
10%ile (dry) year	+11%	-5%	-5%
50%ile (median) year	+12%	+5%	+3%
90%ile (wet) year	+2%	+2%	+1%

The 25% rule was chosen as the preferred operating procedure as it was found to provide a moderate volume of water to reduce reliance on the Cudgegong River entitlement while keeping the reductions in dry year flow within 5% assuming that the resulting impacts will be acceptable.

Harvested (from sedimentation dams) and imported (from the Cudgegong River) water volumes are presented in the Surface Water Report Appendix E Addendum Tables 2-3 to 2-5. For mining year 20 under the reference dry year conditions the harvested volume is 123 ML and the imported volume is 2,400 ML, approximately 900 ML below the full entitlement from the Cudgegong River. For mining year 20 under the reference wet year conditions the harvested volume is 104 ML and the imported volume is 400 ML, approximately 2,900 ML below the full entitlement from the Cudgegong. This demonstrates that there is a low probability that the full entitlement from the Cudgegong River will be required and that moderate volumes of water can be harvested from the sedimentation dams under the 25% pumping rule under a range of climate conditions.

6. p22 - additional freeboard capacity of 1m on mine water dams recommended

PB response:

The mine water dams were initially sized using the Blue Book procedure to retain the 100 year 72 hour rainfall volume. The dams were then tested in the water balance model under the historical climate and upsized as required to avoid spilling under prolonged wet sequences in the climate record. A standard 500mm freeboard was then adopted on top of the upsized dams. This is considered to be a sufficient basis of design to avoid spilling of the dams.

7. p22. Incidental take of base-flow (480ML peak) in Talbragar River – how administered within water sharing rules – prohibits pumping when there is no visible flow into and out of pools.

CHC has received advice from NSW Office of Water that surrendering of surface water access entitlement in the Lower Talbragar River Water Source is an acceptable offset of baseflow loss to the Talbragar River. CHC has not been advised of any temporal constraint associated with the offset. Licensed dams in the area of the mine have a reliability factor of 1.17, requiring at least 562,000 m^3 or 562 ML (480 ML x 1.17) of licensed dam capacity to be surrendered to offset baseflow loss.

8. p25 – Clarification of total combined induced loss of flows in Talbragar River Water Source of 799ML/year – inclusive of groundwater baseflow loss of 480ML/year – it is not clear what the additional flow loss is from?

PB response:

The EA groundwater model predicted that a maximum of 480 ML per year would be lost from all surface water drainages as a result of groundwater drawdown related to mining. That maximum would occur in the year following the end of mining and reduce thereafter. The additional loss component (319 ML) reflects the capture of the enhanced recharge in the spoils area by the remaining void. This was accounted for as a relative loss to the surface water system.

9. p31 – anomalous data for evaporation losses from water storages in the revised water balance tables

PB response:

The apparent anomaly is in the higher evaporation loss in the reference dry year than in the reference median year. This is explained by the preceding climate of the reference dry year, which was wetter than that of the reference median year. This results in considerably larger volumes of water in storage at the start of the dry year than for the median year, and therefore more volume is evaporated throughout the dry year than in the median year.

10. Provide further advice as to potential contingency and strategy to manage water in dry and wet years – linked to PAC recommendation that mechanical dewatering be implemented to reduce raw water demand.

Dr Perrens has indicated that 'based on the assumptions that underpin the water balance analysis, it appears water shortage is more likely than excess'. For responses regarding potential contingency and strategy to manage water in dry years, refer to Cobbora Holding Company report M01-CHC-350 -RP-ENV-0001 (see Section 3.2). *11. p36 – further clarification on discharging to creek systems using operational rules – eg. where pump to mine dams if capacity of MWD is less than 25% - to specifically meet flow objectives*

PB response:

Refer to response to comment 5 above.

12. p36 – Baseflow losses of up to 480ML/year need to be considered in assessment of impacts on Sandy Creek/ Laheys Creek and how this may affect flow regime and impacts on creek system.

PB response:

Refer to Section 2.1 and 2.2. The groundwater model is conservative in estimation of river losses for the purposes of licencing. When impacts on creeks predicted by the water balance model and groundwater model are combined, significant flow reductions are seen in dry and median years in the Sandy Creek system, in the range of 10 to 20% for median years. However as discussed above, due to the conservative nature of the stream loss estimates, it is appropriate to adjust the estimated stream losses down to account for the times when the stream is not flowing (40% in a median year and 80% in a dry year). With these adjustments, predicted reductions in total flow in Sandy Creek are moderate to minor (Tables 3 to 6).

13. p37 - Groundwater drawdown on semi-permanent pools – underestimation of groundwater drawdown due to running River Package assuming constant head in creek system – additional information of drawdown predictions on semi-permanent pools is needed.

PB response:

Refer to Section 2.2. The sensitivity test shows that an additional pool would be affected by drawdown under this scenario.

14. p38- Further analysis of how releases from sediment dams could positively affect semi-permanent pools is required.

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PB response:

Refer to the response to comment 5.

Table 8 demonstrates that if all of the water collected in sedimentation dams were to be released (see 0% rule column) to the creeks there will be increase in flows in Sandy Creek for all reported climate scenarios. This is expected to compensate for potential reduction in base flow contributions to the pools in Sandy Creek. It is expected that controlled releases would be made directly to the creek via an appropriate dedicated pipeline during very low flow conditions.

The water management system has been balanced to avoid significant impacts on the flow regime in downstream creeks. Harvesting of sedimentation dam water could be further reduced to provide more releases to the downstream systems without significantly increasing demand from the Cudgegong. The imported water requirement from the Cudgegong remains well below the full entitlement under the reference dry year climate condition.

15. p38 - Combined impact of reduced surface runoff and baseflow loss on semi-permanent pools not assessed (link to 3, 12 above)

PB response:

Refer to responses to comments 3 and 12 above.

16. p38 - Clarification regarding offsetting of cumulative baseflow losses in Talbragar River from Ulan Coal Mine by discharge from treated mine water from Ulan post mining. Further assessment is recommended.

PB response:

Refer to Section 2.1. Due to the ephemeral nature of Sandy Creek, it does not contribute significant baseflow to the Talbragar River, and therefore the Project impacts on the Sandy Creek system have minimal to negligible impact on flows downstream in the Talbragar River.

17. p41 - Flood impacts of increased channel and flood velocities in the vicinity of crossings 4, 5 and 7 and proposed mitigation measures to prevent scouring; protection of the toe of overburden dump within 1 in 100 year flood in Laheys Creek

The impacts of the crossing structures on local channel and floodplain velocities are available from the flood model. Model predictions of the changed velocity profiles will be used to inform design of: scour protection measures such as energy dissipation aprons and basins at the inlets and outlets of culverts; assessment of extreme flood event scour potential at abutments and piers of bridges and design of measures to protect the structures under these events; assessment of extreme flood event scour potential along the areas of the flood protection levees and overburden dumps and dams that are at risk of flooding and design of measures to protect these structures from erosion during extreme events.

Existing and future case flood velocities at Crossings 4, 5 and 7 are provided below in Table 9.

Table 9 – Existing and future case flood velocities at key crossing structures

Crossing no.	Flood velocities (m/s)			
	100 year ARI		2000 year ARI	
	Existing	Future	Existing	Future
4	1.1	1.4	0.9	1.0
5	0.5	0.5	0.9	0.6

7	1.0	1.2	1.3	3.8

Velocities at crossings 4 and 5 are relatively low for extreme events and standard scour protection measures will be adopted for these crossings. Crossing 7 has significantly higher velocities for the 2000 year ARI event and will require significant scour protection for this permanent structure.

2000 year ARI velocities will be used to design the scour protection around the toe of flood protection levees, overburden dumps and sedimentation dams that are located at the edge of the creek floodplains.

18. p42 - Consideration of 3m cover in backfilling of voids to minimise soil salinisation

The 3 m backfill cover is sufficient to avoid soil salinisation (refer to Attachment 1)

19. p55 – issues regarding base-flow and surface runoff losses require further clarification as to magnitude, location and progression over time – and proposed mechanism for offsetting the losses needs clarification. Refer also items 1-3, 12 above.

PB response:

Refer to responses to comments 5, 11, 15 and 16. In Tables 1 to 6, potential losses from the stream are applied to the total flow which includes the baseflow component and runoff. The estimates of total flow in Sandy Creek and the Talbragar River therefore include a conservative (high) estimate of potential losses to those systems. In the case of the Talbragar River it is noted that losses transferred downstream to the Talbragar River equate to between 1% and 6% decrease in total flow and would diminish downstream as the Talbragar catchment increases.

The mechanism for offsetting the losses to the system during and post mining is yet to be determined, but a management plan will be developed based on the ongoing surface water monitoring program that will continue through the operational life of the mine (see also the response to comment 7).

Yours sincerely

Rob Leslie
Team Manager, Water Resources NSW
Parsons Brinckerhoff

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Table 1 – Annual flow impacts at Sandy Creek outlet – no reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	575	1,852	26,088	-	-	-	-	-	-	-	-	-	-	-	-
1	618	1,960	27,241	43	108	1,154	-4	-4	-4	39	104	1,150	7%	6%	4%
4	559	2,014	27,355	-16	161	1,267	-125	-125	-125	-141	36	1,142	-25%	2%	4%
12	538	2,046	27,301	-37	193	1,214	-341	-341	-341	-378	-148	873	-66%	-8%	3%
16	540	2,043	27,462	-35	191	1,374	-416	-416	-416	-451	-225	958	-78%	-12%	4%
20	548	1,930	27,439	-27	78	1,351	-469	-469	-469	-496	-391	882	-86%	-21%	3%
2035 (Post mining)	642	1,933	28,830	67	81	2,742	-474	-474	-474	-407	-393	2,268	-71%	-21%	9%
Post recovery	642	1,933	28,830	67	81	2,742	0	0	0	67	81	2,742	12%	4%	11%

Table 2 – Annual flow impacts at Elong Elong on Talbragar River – no reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	5,227	16,836	237,164	-	-	-	-	-	-	-	-	-	-	-	-
1	5,618	17,818	247,645	43	108	1,154	-4	-4	-4	39	104	1,150	1%	1%	0%
4	5,082	18,309	248,682	-16	161	1,267	-125	-125	-125	-141	36	1,142	-3%	0%	0%
12	4,891	18,600	248,191	-37	193	1,214	-341	-341	-341	-378	-148	873	-7%	-1%	0%
16	4,909	18,573	249,655	-35	191	1,374	-416	-416	-416	-451	-225	958	-9%	-1%	0%
20	4,982	17,545	249,445	-27	78	1,351	-469	-469	-469	-496	-391	882	-9%	-2%	0%
2035 (Post mining)	5,836	17,573	262,091	67	81	2,742	-474	-474	-474	-407	-393	2,268	-8%	-2%	1%
Post recovery	5,836	17,573	262,091	67	81	2,742	0	0	0	67	81	2,742	1%	0%	1%

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Table 3 – Annual flow impacts at Sandy Creek outlet – 40% reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	575	1,852	26,088	-	-	-	-	-	-	-	-	-	-	-	-
1	618	1,960	27,241	43	108	1,154	-2	-2	-2	41	106	1,152	7%	6%	4%
4	559	2,014	27,355	-16	161	1,267	-75	-75	-75	-91	86	1,192	-16%	5%	5%
12	538	2,046	27,301	-37	193	1,214	-205	-205	-205	-242	-12	1,009	-42%	-1%	4%
16	540	2,043	27,462	-35	191	1,374	-250	-250	-250	-285	-59	1,124	-49%	-3%	4%
20	548	1,930	27,439	-27	78	1,351	-281	-281	-281	-308	-203	1,070	-54%	-11%	4%
2035 (Post mining)	642	1,933	28,830	67	81	2,742	-284	-284	-284	-217	-203	2,458	-38%	-11%	9%
Post recovery	642	1,933	28,830	67	81	2,742	0	0	0	67	81	2,742	12%	4%	11%

Table 4 – Annual flow impacts at Elong Elong on Talbragar River – 40% reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	5,227	16,836	237,164	-	-	-	-	-	-	-	-	-	-	-	-
1	5,618	17,818	247,645	43	108	1,154	-2	-2	-2	41	106	1,152	1%	1%	0%
4	5,082	18,309	248,682	-16	161	1,267	-75	-75	-75	-91	86	1,192	-2%	1%	1%
12	4,891	18,600	248,191	-37	193	1,214	-205	-205	-205	-242	-12	1,009	-5%	0%	0%
16	4,909	18,573	249,655	-35	191	1,374	-250	-250	-250	-285	-59	1,124	-5%	0%	0%
20	4,982	17,545	249,445	-27	78	1,351	-281	-281	-281	-308	-203	1,070	-6%	-1%	0%
2035 (Post mining)	5,836	17,573	262,091	67	81	2,742	-284	-284	-284	-217	-203	2,458	-4%	-1%	1%
Post recovery	5,836	17,573	262,091	67	81	2,742	0	0	0	67	81	2,742	1%	0%	1%

Table 5 – Annual flow impacts at Sandy Creek outlet – 80% reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	575	1,852	26,088	-	-	-	-	-	-	-	-	-	-	-	-
1	618	1,960	27,241	43	108	1,154	-1	-1	-1	42	107	1,153	7%	6%	4%
4	559	2,014	27,355	-16	161	1,267	-25	-25	-25	-41	136	1,242	-7%	7%	5%
12	538	2,046	27,301	-37	193	1,214	-68	-68	-68	-105	125	1,146	-18%	7%	4%
16	540	2,043	27,462	-35	191	1,374	-83	-83	-83	-118	108	1,291	-21%	6%	5%
20	548	1,930	27,439	-27	78	1,351	-94	-94	-94	-121	-16	1,257	-21%	-1%	5%
2035 (Post mining)	642	1,933	28,830	67	81	2,742	-95	-95	-95	-28	-14	2,647	-5%	-1%	10%
Post recovery	642	1,933	28,830	67	81	2,742	0	0	0	67	81	2,742	12%	4%	11%

Table 6 – Annual flow impacts at Elong Elong on Talbragar River – 80% reduction in groundwater model river losses

Year	Annual flow (ML/yr)			Change in annual flow from SW model (ML/yr)			River losses from GW Model (ML/yr)			Change in annual flow (ML/yr)			Change in annual flow (%)		
	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)	10th %ile dry year (1967)	50th %ile median year (1906)	90th %ile wet year (1990)
0 (baseline)	5,227	16,836	237,164	-	-	-	-	-	-	-	-	-	-	-	-
1	5,618	17,818	247,645	43	108	1,154	-1	-1	-1	42	107	1,153	1%	1%	0%
4	5,082	18,309	248,682	-16	161	1,267	-25	-25	-25	-41	136	1,242	-1%	1%	1%
12	4,891	18,600	248,191	-37	193	1,214	-68	-68	-68	-105	125	1,146	-2%	1%	0%
16	4,909	18,573	249,655	-35	191	1,374	-83	-83	-83	-118	108	1,291	-2%	1%	1%
20	4,982	17,545	249,445	-27	78	1,351	-94	-94	-94	-121	-16	1,257	-2%	0%	1%
2035 (Post mining)	5,836	17,573	262,091	67	81	2,742	-95	-95	-95	-28	-14	2,647	-1%	0%	1%
Post recovery	5,836	17,573	262,091	67	81	2,742	0	0	0	67	81	2,742	1%	0%	1%

Table 7 – Annual flow impacts at Sandy Creek outlet
*(adverse impacts highlighted in **bold text**, additional sensitivity run impacts highlighted in **red text**)*

Site	Location	Groundwater fed under baseline conditions?	Groundwater fed at Year 4?	Groundwater fed at Year 12?	Groundwater fed at Year 16?	Groundwater fed at Year 20?
1	Talbragar River upstream of Sandy Creek confluence	No	No	No	No	No
2	Sandy Creek downstream of Laheys Creek confluence	No	No	No	No	No
3	Sandy Creek downstream of Laheys Creek confluence	Potentially	Potentially	Potentially **No**	**No**	**No**
4	Sandy Creek downstream of Laheys Creek confluence	No	No	No	No	No
5	Sandy Creek downstream of Laheys Creek confluence	Yes	Yes	**Potentially** **No**	**Potentially** **No**	**Potentially** **No**
6	Sandy Creek upstream of Laheys Creek confluence	Potentially	**No**	**No**	**No**	**No**
7	Laheys Creek downstream of Blackheath Creek confluence	No	No	No	No	No
8	Laheys Creek at Blackheath Creek confluence	No	No	No	No	No
9	Laheys Creek at Blackheath Creek confluence	No	No	No	No	No
10	Laheys Creek upstream of Blackheath Creek confluence	Potentially	Potentially	**No**	**No**	**No**
11	Laheys Creek upstream of Blackheath Creek confluence	No	No	No	No	No
12	Laheys Creek upstream of Blackheath Creek confluence	No	No	No	No	No
13	Laheys Creek upstream of Blackheath Creek confluence	Potentially	Potentially	Potentially	Potentially	Potentially
14	Fords Creek	Yes	Yes	Yes	Yes	Yes

Attachment 1: Capillary rise in overburden

Memorandum

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13 May 2013

To Trish McDonald
Cobbora Holding Company Pty Limited
From Timothy Rohde

Subject Capillary rise in overburben

Dear Trish,

The purpose of this memorandum is to explain the concept of capillary rise, how it is calculated and whether the proposed rehabilitation strategy for final voids at the Cobbora mine is appropriate. The closure strategy is to backfill the voids to 3 m above the permanent water table post-mining. Capillary rise in the reinstated profile could interfere with the successful revegetation of the site if excess soluble salt from backfilled overburden or groundwater inhibits plant growth.

1 What is capillary rise?

Water in soil or rock (this includes overburden) is held to the surface of the particles by adhesive and cohesive forces. The downward movement of water occurs when gravitational forces exceed adhesive-cohesive forces. When atmospheric forces from evaporation and transpiration exceed both gravitation and adhesive-cohesive forces then it is possible for soil water to rise back towards the surface. This is capillary rise.

2 The calculation of capillary rise

Refer to Annexure A. The annexure also includes some basic details on how to interpret a soil water characteristic curve (SWCC).

The extent of capillary rise depends somewhat on soil texture. Capillary rise is usually greater with fine-textured (small pore size) soils then coarse-textures (large pore size) rock. This is illustrated in Figure 1 by the comparison of SWCCs for topsoil to overburden.

The success of the strategy is a question of whether there is a risk of capillary rise of groundwater, carrying salts that may inhibit vegetation growth.

Figure 1 presents two indicative SWCC for topsoil and overburden. The SWCC have been taken from a database of curves contained within the *Soilvision* program. Figure 1 illustrates that that the potential capillary rise potential of overburden is less than 0.1 m By comparison topsoil is much higher with a maximum potential capillary rise of 20 m.

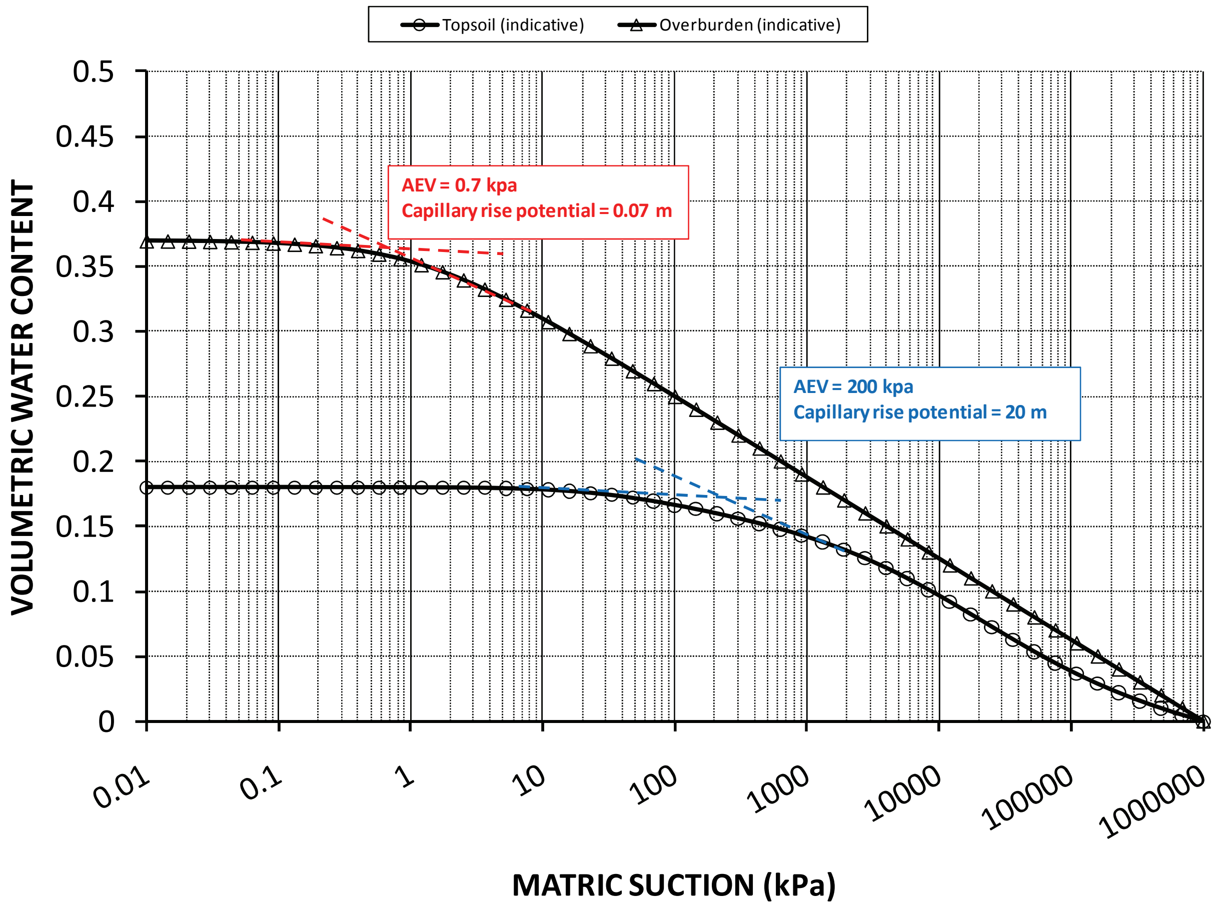


Figure 1 Indicative soil water characteristic curve for topsoil and overburden (Soilvision)

3 Cobbora mine rehabilitation strategy

Capillary rise in fresh and competent overburden is expected to be far less than 3 m. This allows for a layer of soil to support native vegetation.

Provided that the overburden does not contain considerable amounts of kalonite or illite, the weathering process will not result in a pore size distribution that is closer to soil over time. Weathering is not expected to greatly influence the capillary rise potential over time. However, if this does occur, capillary rise in weathered overburden is expected to be far less than 3 m.

The closure strategy for the placement of Cobbora mine overburden in voids is expected to be sufficient to prevent capillary rise.

4 Credentials

This appraisal of whether the conceptual design is suitable at Cobbora mine has been completed by Timothy Rohde. Timothy has a PhD (mining engineering), Graduate Diploma (mined land rehabilitation) and a Bachelor of environmental science (natural resource science). He has practice in the field of mine closure for the last 10 years, specialising in landform and cover design.

The appraisal was completed based on a review of *Mine Rehabilitation Strategy: Cobbora Coal Project* prepared by GSS Environmental. The potential for capillary rise has been determined from indicative air-entry values derived from the *Soilcover* program.

Inc. Annexure A

Appendix A

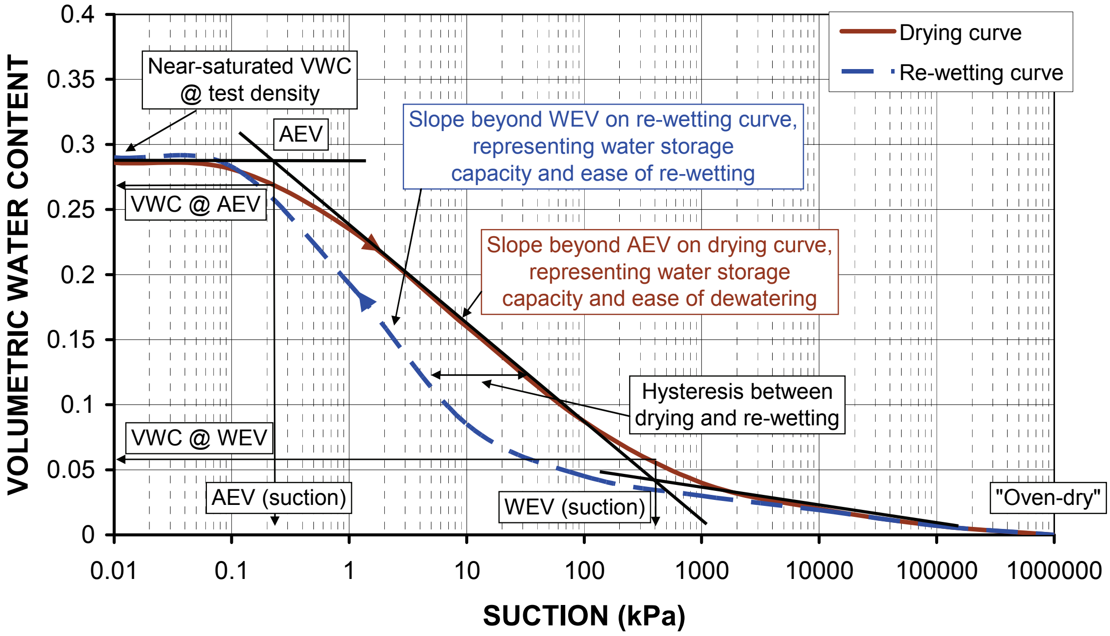
SWCC interpretation

SWCC INTERPRETATION

The Soil Water Characteristic Curve (SWCC) is fundamental to understanding unsaturated soil mechanics. It is a plot of soil water (conventionally in terms of volumetric water content = volume of water/total volume; but it could also be in terms of degree of saturation = volume of water/volume of voids; or gravimetric moisture content = mass of water/mass of solids, expressed as a %.

The key elements of the SWCC are the following (Figure 1).

- The intercept on the vertical axis represents ***near-saturated conditions*** at the test density (the higher the density the lower the intercept, and increasing the density will induce drainage).
- The break in the curve at a high degree of saturation or high water content, referred to as the ***Air-Entry Value*** (AEV) on drying, beyond which the material is unable to remain saturated, and air starts to replace any further moisture lost from the pores of the material. Up to the AEV, the material is essentially saturated (degree of saturation S > 85%) and suction effects can be ignored. The capillary rise in metres at the AEV = AEV/9.81.
- The slope of the curve at matric suctions higher than the AEV. The flatter the curve, the more water the material is able to ***"store"***, and the harder it is to ***dewater*** (that is, the higher the applied pressure required to effect dewatering). Over this portion of the curve, matric (or capillary) suction and liquid water flow dominate.
- The break in the curve at a low degree of saturation or low water content, referred to as the ***Water-Entry Value*** (WEV) on re-wetting, beyond which osmotic suction and water vapour flow dominate. ***The WEV is the suction at which the material starts to rapidly wet up on re-wetting***. As the material dries beyond the WEV, the salt concentration of the diminishing pore water increases and so too does the osmotic suction. Beyond the WEV, further dewatering is more difficult to achieve, as evidenced by the flatter curve. Evaporation continues unabated to about 3,000 kPa suction, thereafter decreasing at an increasing rate and ceasing at a suction of about 100,000 kPa.
- The ***"oven-dry"*** (zero moisture) state corresponds to a suction of 1,000,000 kPa, for all materials.
- There is a ***hysteresis*** between drying and re-wetting cycles. As a soil desaturates, moisture is first lost from the largest pores, with residual moisture retreating to ever-finer pores, requiring ever-higher matric suctions to remove it. As a soil re-wets, the largest pores saturate first, with the finer pores saturating last, but at much lower matric suctions than were required to drain them during the drying cycle.
- Over the suction range up to about 1,000 kPa, matric (or capillary) suctions dominate, while above about 1,000 kPa the increasing concentration of salts in the pore water mean that osmotic (or solute) suctions come to dominate. Most soil-like materials exist at a suction of < 10,000 kPa, and hence matric suction usually dominates. An exception is salt pan deposits and hypersaline tailings.



SWCC data are conventionally measured in the laboratory using a Tempe cell and the curves are then fitted to the measured data using the method of Fredlund and Xing (1994)[1]. Field SWCC data may also be collected, and the curve fitted using the same method. The laboratory and field data may produce quite different SWCCs, the differences being greatest where there is significant structure or cementation in situ, which is destroyed on sampling and laboratory testing. The SWCC for a material with significant structure or cementation is shifted to the right, having a much higher AEV and steeper post-AEV slope. An estimate of the laboratory SWCC may also be obtained from the particle size distribution, density and specific gravity of the material using the Fredlund *et al.* (1997)[2] and the library of data contained within the program *SoilVision*.
In addition, the saturated hydraulic conductivity of the material at a representative density may be obtained by constant or falling head testing or calculated from consolidation testing.

From the SWCC and measured saturated hydraulic conductivity, the unsaturated hydraulic conductivity function of the material may be calculated using the method of Fredlund *et al.* (1994)[3].

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[1] Fredlund, D.G. and Xing, A. (1994). Equations for the soil-water characteristic curve. *Canadian Geotechnical Journal*, **31**, 521-532.
[2] Fredlund, M.D., Fredlund, D.G. and Wilson, G.W. (1997). Prediction of the soil water characteristic curve from grain size distribution and volume mass properties. *Proceedings of 3rd Brazilian Symposium on Unsaturated Soils, Rio de Janeiro, Brazil, 22-25 April 1997*, 12 pp.
[3] Fredlund, D.G., Xing, A. and Huang, S. (1994). Predicting the permeability function for unsaturated soils using the soil water characteristic curve. *Canadian Geotechnical Journal*, **31**, 533-546.