REPORT TO: NSW Department of Planning & Environment

ATTN: Mr Brendan Liew

SUBSIDENCE REVIEW
– Russell Vale Colliery Residual Matters Report
Independent Peer Review

REPORT NO: 1407/02.1

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1. SCOPE OF WORK

An independent peer review report has been requested by the NSW Department of Planning and Environment, with respect to the Residual Matters Report relating to Russell Vale Colliery, owned by Wollongong Coal Ltd. The purpose of this review is to inform the Department's final assessment report, and any recommendations for approval conditions.

1.1 Background

The following background information is a direct extract from the Preferred Project Residual Matters Report prepared by Hansen Bailey, on behalf of Wollongong Coal Ltd, dated 20th June, 2014:

> *"Wollongong Coal Limited (WCL) owns and operates the Russell Vale Colliery (formerly known as NRE No. 1 Colliery). In October 2013, WCL submitted a Preferred Project Report (PPR) to modify the application for the Underground Expansion Project (UEP). Submissions on the PPR were made by a number of regulatory authorities.*
>
> *This Residual Matters Report has been prepared by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of WCL to provide a response to the submissions from regulatory authorities. ....*
>
> *A Project Application (PA 09_0013) for the UEP was made on 12 August 2009 which sought approval for longwall mining operations in the Wongawilli Seam. The Project Application proposed the extraction of 11 longwalls in the Wonga East area and 7 longwalls in the Wonga West area. The Project Application was supported by the "NRE No.1 Colliery Project Application (09_0013) Environmental Assessment" (ERM, 2009) (UEP EA). The UEP EA was placed on public exhibition from 18 February 2013 to 5 April 2013. A total of 840 submissions were received including 12 regulators, two special interest groups and 826 individuals (446 of which were in support of the Project and 380 were objections).*
>
> *The proponent's Response to Submissions report (RTS) was included in the PPR submitted to the Department of Planning & Infrastructure (P&I) in October 2013. The PPR proposed significant changes to the mine plan to reduce environmental impacts in response to stakeholder comments.*
>
> *The PPR proposed the following changes to the mine plan for the UEP:*
> - *Removal of the Wonga West area from the proposed mine plan;*
> - *Removal of LW8 in the Wonga East area; and*
> - *Amendments to the alignments and dimensions of the other longwalls in the Wonga East area.*
>
> *The mine plan that is currently proposed comprises eight longwall panels (LW1-3, LW6-7 and LW9-11).*

The UEP PPR was provided by P&I to various regulators for comment. Submissions were received from 10 regulators and three independent peer reviewers engaged by P&I. This Residual Matters Report responds to these submissions. ....

Since the submission of the PPR and RTS, Gujarat NRE Coking Coal Limited has changed its name to Wollongong Coal Limited and the name of the mine has been changed from NRE No.1 Colliery to Russell Vale Colliery. P&I has also changed its name to the Department of Planning & Environment (DP&E)".

The mine plan that is currently proposed comprises eight longwall panels (LW1-LW3, LW6-LW7 and LW9 - LW11). Note that LW4 and LW5 have now been extracted as part of a previous approval, and so do not appear in this current project, and LW8 no longer forms part of the plan.

This current review has been tasked with a specific review of subsidence issues and impact assessment, as discussed in a report prepared by Strata Control Technology (SCT) for Wollongong Coal Ltd, titled *"Update of Subsidence Assessment for Wollongong Coal Preferred Project Report: Russell Vale No 1 Colliery".* The report (No. WCRV4263) was authored by Dr Ken Mills, and is dated 18 June, 2014. This SCT report forms Appendix B of the current Residual Matters Report, and supersedes the previous report that was contained in the original 2013 Preferred Project Report.

1.2 Previous Subsidence Peer Review

B K Hebblewhite had previously been engaged by the then NSW Department of Planning and Infrastructure (DPI) to review the various earlier stages of the Preferred Project Reports submitted by Gujarat NRE in 2013. The Hebblewhite Review consisted of three sequential stages, and the following is an extract from the Introduction to the 3rd Stage Report (No. 1303/02.3) to DPI in October 2013, which also references the previous two stage reports:

"This third stage Report should be read in conjunction with, and as a sequel to my original Peer Review Report on this project, Report No. 1303/02.1, dated 20th June, 2013. This report is specifically focussed on the Preferred Project Report submitted by Gujarat NRE (undated).

For clarity, the scope of work section of my original report is repeated below:

Report 1303/02.1 Scope of Work

"This report has been commissioned by the NSW Department of Planning & Infrastructure as an independent peer review of the Subsidence Impact Assessment provided by Gujarat NRE No. 1 Mine associated with their Expansion Project.

The scope of this peer review has been defined as follows:

"Part 1: Independent Peer Review of Subsidence Impact Assessment
- *Review of the overall contents of the EA documentation in order to provide background and mining-related context.*
- *Preparation of an independent peer review report specifically focussed on the Subsidence Impact Assessment contained within the project Environmental Assessment documentation. This would require development of a clear understanding of:*

- *the proposed mining systems and overall mining schedules and plans;*
- *the prevailing geological and geotechnical environment;*
- *the existence and nature of any particular natural or man-made surface or sub-surface features considered to require any degree of protection from adverse subsidence impacts (excluding aquifer and groundwater considerations which are understood to be being considered separately);*

- *The peer review report would include a detailed analysis and assessment of the methodology of subsidence predictions provided, and their applicability to the environments and requirements listed above, together with assessment of the actual predictions made and the confidence levels quoted regarding such predictions.*
- *This peer review will be provided on the basis of the knowledge and skills of the author, and experience gained in review of similar materials and project matters over recent years.*

Part 2: Review of the Gujarat Response to Submissions (RtS) and possible Preferred Project Report (PPR)

- *It is difficult to provide any further specific scope at this stage, other than to say that this Part 2 review would build on, and likely take a similar form to the Part 1 EA Review – and again it would be focused on matters pertaining to subsidence impact."”*

This third report (1303/02.3) is therefore addressing Part 2 of the above scoped process. Gujarat NRE has submitted a Preferred Project Report (PPR) to the Department, with a modified, greatly reduced "Preferred Project", compared to that envisaged in the original NRE No. 1 Mine Expansion Project that was reviewed under Part 1. A summary of the new project features is provided below (as an extract from the PPR).

1. *The estimated project life has been reduced to a maximum of 5 years.*
2. *The Wonga East Longwall (LW) layout has been extensively modified to minimise impacts to identified significant features while attempting to maximise the recovery of coal reserves.*
3. *The Wonga Mains drivage will not be extended northwards under the south arm of the Cataract Reservoir through the known geological feature (in the Bulli Seam).*
4. *The Wonga West longwalls will be removed from this application. The Wonga West longwall layout will be revised and resubmitted as a separate application at a later date.*
5. *The Western Balgownie and Western Bulli Seam first workings will be removed from this application.*
6. *There is no change proposed to the Pit Top upgrade, 3 Mtpa extraction rate or peak coal transport rates as presented in the original Environmental Assessment (EA)."*

The SCT Report that was reviewed in the above Part 3 Report was Report No. NRE14123, also authored by Dr Ken Mills, and dated 24th September, 2013. A copy of the review section of my Part 3 Report, with respect to the Sept 2013 SCT Report, is contained in Appendix A of this report.

2. REVIEW OF SCT REPORT No. WCRV4263 (18 June, 2014)

The following represents a point-form summary of key issues or comments in relation to the prediction and assessment of subsidence, and subsidence impact, referencing the relevant section and/or page numbers from the original SCT document. The points are listed in the order that they appear in the SCT report, for easy cross-referencing. As such, the order of points does not imply any relative importance or priority of issues. It is also important to note that in reviewing the report in this manner, some issues raised in report sequence order are subsequently answered or further expanded later in the report. Therefore the report should be read in its entirety, prior to reacting to individual issues raised. (Any reference to the "previous SCT report" refers to SCT Report No. NRE14123, 14 September, 2013).

It should also be noted that general comments of factual and historical data for the site, and confirmation of predictive approaches adopted in the previous review will not be repeated here, unless they relate or are impacted by new information.

A. **Summary Section**

1) Summary, p(i) – It is noted that since the previous SCT report, mining of LW5 has been completed; additional subsidence monitoring data is available and has been reviewed, in particular valley closure data; additional field studies have been conducted; and responses to the earlier Hebblewhite peer review have been developed. This is summarised in the following quote from the current report:

   "This current report is an update of the earlier report with the main changes being inclusion of subsidence monitoring results to the end of Longwall 5, revision of the valley closure estimates, and identification of a sandstone formation downstream of CCUS4. Changes and clarifications recommended in the peer review have also been included".

2) Summary, p(i) – SCT concludes that subsidence impacts can be adequately managed *"to a level consistent with impacts from previous mining in the area".* It is noted that ongoing subsidence monitoring will play an important role, together with adaptive management strategies, and some requirements for mitigation efforts with respect to the high voltage power transmission lines.

3) Summary, p(ii) – Additional monitoring data from LW 4 and LW5 has confirmed SCT's view that their prediction approach for subsidence associated with the *"relatively complex mining environment"* of multi-seam mining is appropriate. The report states:

   "The experience available from mining Longwalls 4 and 5 indicates that the subsidence behaviour is predictable albeit with somewhat different characteristics to subsidence over single seam mining operations. The main difference is that the overburden strata are more flexible as a result of the disturbance caused by previous mining. The bridging capacity across individual panels is reduced and sag subsidence in the middle of individual panels is thus greater than it would be above single seam operations".

This conclusion is considered reasonable; however the state of knowledge with regard to multi-seam subsidence prediction must still be regarded as formative, in early days, based on a growing, but still quite limited database. The previously expressed concern about time-dependant re-mobilisation of overlying areas of workings remains as expressed in the previous report, i.e. there is *"no reference to the important issue of time-dependency, when previous goaf areas (particularly old partial or first workings panels) are remobilised".* **The imperative for ongoing data collection, rigorous analysis and regular critical review of the overall understanding of mechanisms at play, and prediction techniques and outcomes, must be recognised and implemented as an ongoing part of this project.**

4) Summary, p(iii) – There remains some concern expressed by SCT about overlying pillar stability in just one area of the lease, in the vicinity of LW1. This is expressed as:

   "There is considered to be some potential for pillar instability in the Bulli Seam to cause additional surface subsidence of up to about 0.5m in localised areas of marginally stable pillars when the proposed longwall panels are mined in the Wongawilli Seam. The area likely to be most affected by pillar instability is located at the northern end of Longwall 1 and although the area is relatively small compared to overburden depth, special consideration is required in this area to limit impacts on power transmission pylons located nearby".

   This concern should be reflected in adoption of an effective monitoring and adaptive management campaign in this location.

5) Summary, p(iii) and p(v) – A range of predicted subsidence values, tilts and strains are provided in the Summary. There are also updated predictions of valley closure in the vicinity of Cataract Creek, as follows:

   "The predicted closures across Cataract Creek have been revised slightly from the earlier report. Total closures are predicted to range up to 300mm adjacent to the end of Longwall 5 and up to 290mm adjacent to the end of Longwalls 6 and 7. Closure across the second order southern branch of Cataract Creek upstream of the Mount Ousley Road crossing is predicted to reach 700mm".

   The impacts of valley closure on Cataract Creek should be closely monitored throughout all longwall panel extraction, with a readiness to implement effective adaptive management strategies, should there be any evidence of unacceptable, adverse impacts on the creek bed or valley sides.

6) Summary, p(iv) – The question of subsidence above previous goaf edges that will be undermined is again identified as a factor that can change the otherwise conventional expected behaviour. The previous report made the statement that in the multi-seam environment *"the goaf edge subsidence profile is expected to be softer than elsewhere".* In this summary, this factor is again recognised, with greater levels of subsidence predicted, as follows:

   "In areas where there has been previous mining in both the overlying seams, vertical subsidence at the goaf edge is expected to increase up to 300-500mm and the goaf edge subsidence profile is expected to be more gradual outside the goaf edge and steeper directly over the panel".

This is a significant difference in behaviour, relative to single seam mining, which should be validated through the ongoing monitoring program.

7) Summary, p(v) – The impact of surface subsidence on overlying upland swamps remains an issue where the level of quantitative data is very limited. The previous Hebblewhite peer review report on SCT's work made the following comments regarding the question of subsidence impact on swamps:

"SCT makes a significant comment and recommendations, with respect to the potential impact of mining is not expected to cause significantly different impacts to those already experienced due to earlier mining – however, such previous experience has not been well documented, to date (this is partly due to the simple lack of previous data available). It is therefore difficult to agree with, or endorse this statement, in the absence of any supporting data. Consistent with a lack of real quality data on swamp impacts, SCT then rightly argues for "more work is required to determine the relationship between mining subsidence and the long term health of swamps". It is stated that there is a rare opportunity within this lease area where base data, or at least experience exists over many decades, to undertake a more thorough review. SCT further recommends the formation of an ongoing monitoring and review strategy with respect to subsidence impacts on swamps and their subsequent recovery over time.

Such a view is strongly supported, and is in line with some of the recommendations from the Southern Coalfield Review Panel Report (2008). The issue then becomes, how is such a review and further investigation possible without mining progressing in the vicinity of such swamps in order to generate further data? It is proposed that an incremental approach be adopted, with the first stage being a summary of historical impacts and evidence of recovery; followed by more precise monitoring of subsequent impacts as mining proceeds – preferably in relation to less significant swamps in the first instance".

The comments and recommendations in these earlier statements remain valid and support the need for a much more comprehensive and ongoing measurement of subsidence effects and resultant impacts in and around swamps.

In this current report, SCT identifies swamp CCUS4 as one which will undergo a significant level of further subsidence effects.

"CCUS4 has been identified as a significant swamp within the PPR mining area that drains via a first order watercourse. CCUS4 has previously been subsided 0.6-0.8m by mining in the Balgownie Seam without apparent impact. Proposed mining in the Wongawilli Seam is expected to cause up to 2.1m of additional subsidence. Impacts such as cracking of the sandstone base and surface water diversion are expected as a result of proposed mining".

Provided that the Department is prepared to allow such subsidence effects and potential impacts on this swamp, then this presents an ideal opportunity to gather valuable data on subsidence-swamp interaction. **It should be a requirement for both the subsidence effects, and all resultant impacts to be thoroughly monitored in and around (downstream of) this swamp - before, during and after undermining – for some extended period of time.**

8) Summary, p(vii) – Comments are made with respect to the prescribed barrier between the closest goaf edge and the edge of the Cataract Reservoir (using a design width of 0.7 x depth). In particular, there are some locations where previous Bulli Seam pillar extraction mining was allowed to occur within this barrier zone. This issue is considered to be more of a concern in relation to LWs 7 and 9. SCT acknowledges that if seepage flow from the reservoir to the mine were to occur, it is most likely to occur along horizontal bedding plane shears, most likely at or near the level of the valley floors. SCT then concludes:

   "This pathway is not expected to interact with the pre-existing Bulli Seam mining areas. As a result, there is not considered to be any potential for these existing Bulli Seam mining areas to significantly reduce the effectiveness of the 0.7 time depth barrier".

   There is some ongoing concern about the justification of the size of the barrier, and this apparent compromising of the barrier width due to previous mining. Inclinometer or similar monitoring in vertical boreholes well ahead of the proposed mining can provide valuable evidence about this type of subsidence mechanism involving horizontal shearing. **It is recommended that a program of such monitoring be included at a range of distances ahead of/adjacent to mining to enable this mechanism to be further investigated; and to provide a source of data for an effective adaptive management strategy to be implemented, if necessary, in regard to this issue**.

9) Summary, p(vii) and (viii) – **All comments with regard to the ongoing subsidence monitoring, analysis and review strategies and the improved techniques for measurement of subsidence effects are endorsed; as are the comments (referred to above also) with regard to the need for a broad-based technical committee to be established to further investigate the impacts of mining subsidence effects on swamps.**

10) Summary, p(x) – Reference is made to current adaptive management practices used by Wollongong Coal:

   "Adaptive management strategies are being practiced by Wollongong Coal. Examples include the significant revision to the mine layout represented by the PPR and the use of closure monitoring across Cataract Creek to control the length of Longwalls 5, 6 and 7".

   The comment on this topic in my previous report is still considered valid, i.e.

   "It is noted that the PPR includes an adaptive management strategy "based on closure monitoring and cessation of mining if there is a likelihood of significant perceptible impacts becoming apparent". This is discussed in relation to Cataract Creek in particular, and the possible impacts of valley closure effects. Whilst this principle of adaptive management is considered reasonable, it is reliant on several factors which have not as yet been clearly defined, but which are essential to the success of such a strategy. These were identified in my initial report and include:

   a. *What amount of lead time will be available in the relevant monitoring data locations, to provide meaningful data on which decisions can be made prior to the impacts occurring at Cataract Creek?*
   b. *What certainty will there be, that the observed surface subsidence effects and related impacts will cease immediately if mining is ceased in the area?*

c. *What is the proposed management structure whereby such decisions will be made – both with regard to the interpretation of the monitoring data; and also with respect to deciding to stop the longwall, and how quickly can such a process take place?".*

It is recommended that Wollongong Coal should be required to produce a comprehensive statement on the proposed adaptive management strategies, relative to key specific subsidence impacts, as part of their Subsidence Management Plan. This should discuss adaptive management strategies with respect to all relevant aspects of this mining proposal (such as valley closure impacts on Cataract Creek and valley; effective barriers to Cataract Reservoir; remobilisation of overlying old pillar workings etc) and specifically address the above questions.

B. Section 1. Introduction

No further review comments.

C. Section 2. Site Description

No further review comments.

Section 2 of the SCT report provides a very good overall site plan showing the proposed mining panels; surface topography contours; and all surface infrastructure and other features. This plan is reproduced below as Figure 1.

For completeness, Table 1 from the SCT is also reproduced below, which summarises the various panel widths, depths and width:depth ratios. The mining height in the proposed longwalls is understood to range between 2.5m and 3.0m in the lower section of the Wongawilli Seam, for quality reasons.

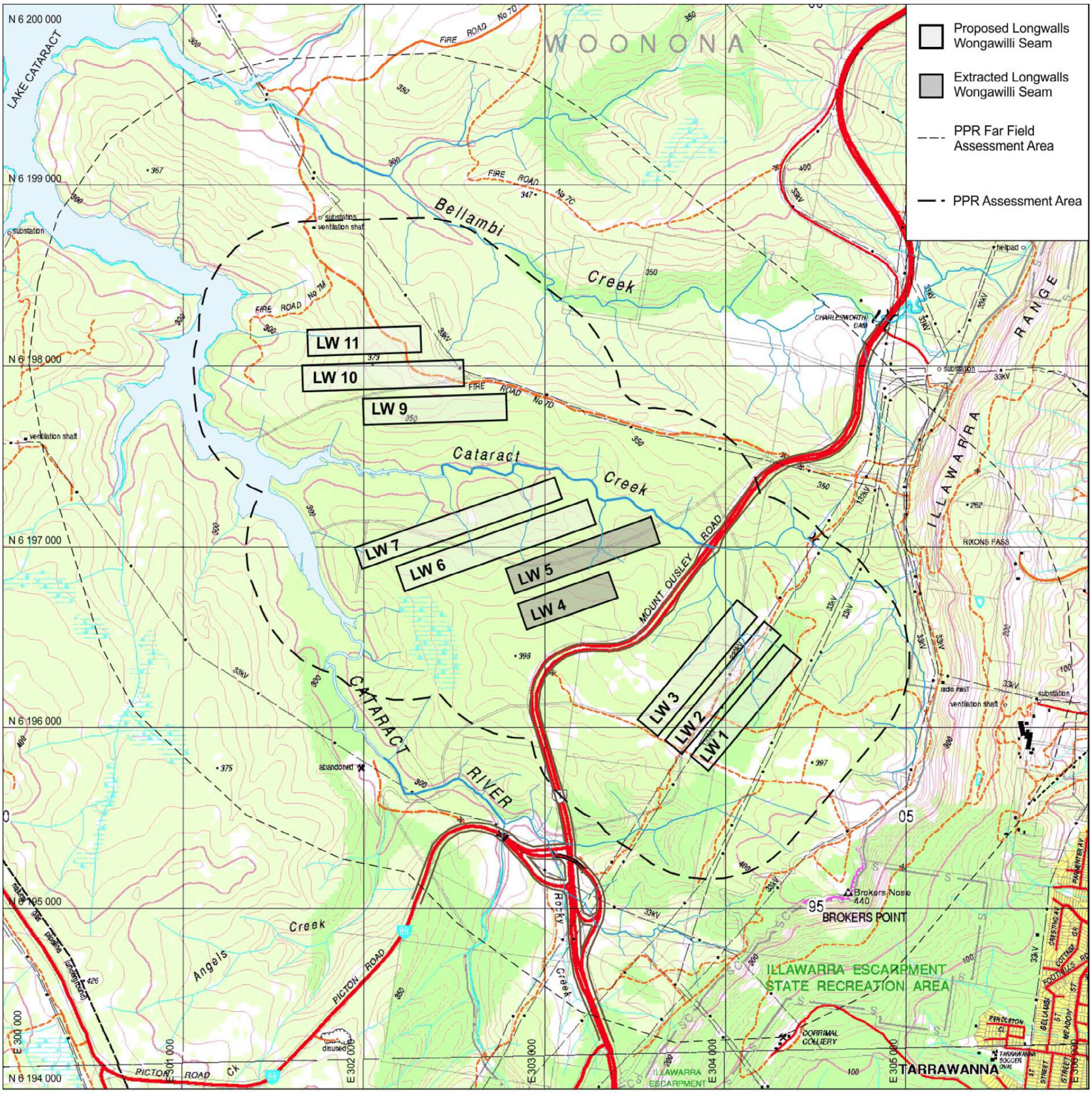

Figure 1: Plan showing location of PPR Assessment Area and proposed longwall panels superimposed onto a 1:25,000 topographic series map with creek alignments update based on LiDAR imaging of the ground surface.

Figure 1. Russell Vale Colliery Mine Plan

(source: Figure 1 in SCT Report WCRV4263 (18 June, 2014*)*

Table 1: Overburden Depth Range *(source: SCT Report)*

Longwall Panel	Panel Width (m)	Overburden Depth Range (m)	Width on Depth Ratio
1	131	255-320	0.41-0.51
2	125	255-330	0.37-0.49
3	150	250-340	0.44-0.60
4	150	300-360	0.42-0.50
5	150	265-345	0.43-0.57
6	150	270-345	0.43-0.55
7	131	270-340	0.39-0.49
9	150	330-380	0.39-0.45
10	150	335-390	0.38-0.45
11	150	350-385	0.39-0.43

D. Section 3. Previous Mining Activity

1) Section 3, P19 – The data now available from monitoring subsidence over both LWs 4 and 5 provide a significant degree of comfort with respect to understanding the effects of multi-seam mining on subsidence in this area. However, as stated above in response to the Summary discussion on this topic, the overall database and hence knowledge base is still small and needs to be continually developed and the level of behavioural understanding should be critically reviewed on a regular basis to audit the prediction capabilities. The SCT commentary on this point, is as follows:

   "*Subsidence monitoring data available from mining in the Balgownie Seam and more recently from two longwall panels in the Wongawilli Seam is available and this provides a basis for predicting future subsidence behaviour. This data indicates that while there are some significant differences in behaviour compared to single seam mining, the multi-seam behaviour is predictable and occurs predominantly within the bounds of the panel being mined and the chain pillar to the previous panel. This data and observations of previous impacts indicate that the impacts of future mining are likely to be similar in nature to the impacts that have already occurred".*

   These are considered to be valid and appropriate learnings – but ongoing caution should be used until further evidence is gathered, analysed and interpreted. It is reasonable to claim predictability in behaviour, but the level of confidence is undoubtedly still lower than in comparison to single seam behaviour.

2) Section 3, P24 – **The concern over possible localised failure of a region of Bulli Seam pillars is raised again here. Proactive, adaptive management of this issue should be incorporated into the Subsidence Management Plan**. SCT states:

   "The site visit to this area indicated that additional subsidence due to pillar instability would be possible in the area shown if Longwall 1 was extended to its full length although surface subsidence may be relatively small given the narrowness of the panel at an overburden depth of 270m. Any additional subsidence would have potential to impact on pylons on the

two 33kV power transmission lines and this potential is addressed in the impact assessment for these structures".

3) Section 3, P24 – SCT clarifies the issue discussed in the previous report regarding the meaning of "pillar run", which had previously been applied quite broadly, and somewhat loosely. The current report discusses the issue of regional abutment load impacts on regions of pillars which may cause excessive loading, and possible "pillar creep", without necessarily pillar failure occurring.

4) Section 3, PP21-35 – The discussion regarding subsidence resulting from Balgownie and Bulli Seam extraction is largely the same as has previously been reviewed – no further comment required here, other than repeating the concern about lack of available data or interpretation regarding subsidence impacts on swamps that were previously undermined. The comment from the October 2013 Hebblewhite report is repeated here:

   "It is unfortunate that having discussed the Balgownie Seam subsidence data with respect to subsidence effects and impacts, strains, tilts, valley closure, surface cracking, rock falls, Cataract Creek etc, there is no discussion about the subsidence effects in the vicinity of upland swamps that were impacted by the Balgownie longwalls (such as are indicated to exist in Figure 2 in the middle of proposed Wongawilli LW6, which in reference to Figure 3, lies directly above some of the Balgownie longwall panels). It would be extremely valuable to know how much subsidence and strains, tilts etc occurred in the vicinity of those (and any other) swamps, and then to assess what was the immediate impact on the swamps, if that was recorded at the time, and what is the current state of recovery in such swamps to any adverse impacts that occurred. Such a correlation between quantitative subsidence data and resultant impacts is the major missing element in this project assessment. If, as SCT states, such data was collected, it is essential that it be reported in the above manner to provide a valuable benchmark dataset and case study (c/f paragraph A(7) above). (Note: There is some discussion on this point later in the SCT report, and some data is included in Appendix 1 of the report, but there is no discussion of it here in the context raised above)".

   Whilst this deficiency should not be regarded as a critical issue impacting on approval, a specific study should be required, containing a comprehensive analysis and report on the historical data that is said to be available. This report should be required to be made publicly available.

E. <u>Section 4. Subsidence Prediction Methodology</u>

1) Section 4, PP35-46 – Apart from some generic discussion of subsidence principles which have been previously reviewed, this section provides very useful analysis of the vertical subsidence above Wongawilli LW4 and LW5. The following is a brief extract from this extensive discussion in the SCT Report:

   "At the completion of Longwall 4, the maximum subsidence in the centre of the panel was 1.3m and this represents the sag subsidence for a single panel 150m wide and about 340m deep. When Longwall 5 had finished, centreline subsidence ranged from 1.1-1.8m and the centreline subsidence on Longwall 4 had increased to 1.6-1.8m consistent with strata

compression at the intermediate chain pillar. Subsidence monitoring on M Line indicated that the total elastic chain pillar compression was approximately 0.7m based on superposition of the subsidence measured on M Line during Longwall 5 and goaf edge monitoring observed during mining of Longwall 4. The increase in Longwall 4 centreline subsidence from 1.3m at the completion of Longwall 4 to 1.7m when Longwall 5 had been substantially mined is consistent with strata compression above the chain pillar between the panels of about 0.8m causing the surface above one side of the panel to be lowered 0.8m and the surface above the centre of Longwall 4 to be lowered a further 0.4m. There has been no significant increase in sag subsidence over Longwall 4 as a result of mining Longwall 5. The additional subsidence is due to strata compression above the chain pillar between Longwalls 4 and 5".

The evidence reported regarding angle of draw and subsidence outside panel boundaries in the multi-seam mining environment is summarised as:

"These measurements indicate the angle of draw to 20mm of subsidence is greater than 26.5° consistent with experience elsewhere in the Southern Coalfield at this overburden depth. At the projection of the north-eastern corner of Longwall 4 where both the Bulli Seam and the Balgownie Seam have been mined, subsidence at 230m from the goaf corner is 20mm at 320m deep indicates the angle of draw to 20mm off the corner of the panel is equal to 35°. At the south-eastern corner of Longwall 4, where the Balgownie Seam has not been mined but there are areas of mining in the Bulli Seam, the 14mm of subsidence at 225m at 360m overburden depth indicates an angle of draw off the corner of the panel of less than 32°".

The data and comprehensive analysis presented here appears to be good quality data and sound analysis of the subsidence behaviour involved. As a result, the predictions calibrated by such data have clearly increased in confidence levels and are considered to be based on "best available" knowledge and technique, subject to the qualifiers already mentioned in earlier discussion.

2) Section 4, P46 – The conclusions regarding far-field horizontal movements are as follows: "*The GPS controlled surveying does not show any convincing evidence of far-field horizontal movements. The survey tolerance of the systems being used is ±20mm".*

F. <u>Section 5. Predicted Subsidence</u>

1) There are relatively few new issues in this section of the report, relative to the previous report.

2) This section contains an updated presentation and discussion of predicted subsidence effects, taking into account the learnings from the LW4 and LW5 data. Overall, the results and predictions appear sound, having used industry "best practice" prediction methodologies. **As previously stated, all predictions should be regularly reviewed in the light of additional data analysis, once mining commences.**

3) Section 5, P57 – Valley closure predictions have been modified in the light of more recent data. SCT states:

> *"The predicted closures across Cataract Creek have been revised slightly from the earlier report. Total closures are predicted to range up to 300mm adjacent to the end of Longwall 5 and up to 290mm adjacent to the end of Longwalls 6 and 7. Closure across the second order southern branch of Cataract Creek upstream of the Mount Ousley Road crossing is predicted to reach 700mm. These closure estimates are recognised as being upper limit values because they are based on experience in deep gorges at high stress levels. Monitoring to date indicates closure movements of up to 49mm. These movements are less than 40% of the 135mm predicted for Longwall 5 only".*

As indicated in the prior discussion of the report Summary, an effective adaptive management plan needs to incorporate active monitoring of valley closure effects and impacts, with an ability to make changes to the mine plan in the event that these impacts approach a point where they become excessive and unacceptable.

G. <u>Section 6. Subsidence Impacts</u>

1) There are relatively few new issues in this section of the report, relative to the previous report.

2) Section 6, P59 – SCT repeats the plan to use an adaptive management approach with respect to subsidence impacts as a result of valley closure. SCT states:

   > *"A management approach based on monitoring closure and stopping the longwall panels if the closure reaches unacceptably high values is considered an appropriate method of managing the closures across Cataract Creek. Barbato et al (2014) report experience in Hawkesbury Sandstone river channels indicating that flow diversion and perceptible cracking in major river channels such as Cataract Creek has not been observed where valley closure is predicted to be less than 100mm with the proportion of pools impacted increasing linearly with closure to be 100% by 700mm of predicted closure. By adopting a TARP based system and adaptive management strategy for limiting closure, it is anticipated that the potential for flow diversion and perceptible impacts on Cataract Creek can be maintained at low levels. SCT understand that acceptable trigger levels will be set in management plans developed in consultation with regulatory authorities".*

   As has already been discussed, this approach is considered appropriate, but the management plan must clearly demonstrate the timeliness and effectiveness of any decisions, and the ability to deal with any residual, ongoing closure after the decision has been implemented; together with explanation of the decision-making process itself, to ensure the appropriate decisions can be made before adverse impacts are experienced.

3) Section 6, P63 – SCT addresses the issue of impact on swamps, with full recognition that subsidence effects will occur, with potential short-term adverse impacts. It is a matter for the Department to determine what is acceptable in regard to swamps. This is difficult in the absence of hard, quantitative data. SCT acknowledges the need to gain more data with respect to swamps – a position I strongly endorse.

   > *"When strains are greater than about 1-2mm/m in tension and 2-3mm/m in compression, perceptible fracturing of the sandstone strata below swamps are expected.*

It is unclear how sensitive swamps are to mining subsidence. There is a clear association between mining and short term loss of piezometric pressure after rain within the surface layers of some swamps. However, the swamps located within the PPR Assessment Area appear to be thriving despite having been previously subsided to levels that are of the same order as the subsidence expected above future longwall panels. This observation suggests that the drop in piezometric pressure observed when some swamps are mined under may not have had a significant impact on their long term condition.

More work is required to determine the relationship between mining subsidence and the long term health of swamps. The extended baseline of subsidence impacts over 60-100 years in the Bulli Seam and 30-40 years in the Balgownie Seam provides a rare opportunity to study these effects at this site. Proposed mining is expected to cause impacts to the rock strata and to surface and near surface water flows in the areas directly mined under, so it would be helpful to study how and if the wide range of swamps present above the site are significantly impacted by further mining".

4) Section 6, P82 – The question of potential seepage from the reservoir through horizontal bedding/shear planes back to the mine workings is discussed here. Comments have been made in the earlier discussion of the Summary, with regard to this issue. SCT argues that since the height of depressurisation is not likely to extend to the level of valley floor level shear planes, then seepage flow is unlikely to occur. This is a valid conclusion, although some form of advance monitoring of bedding plane shear ahead and adjacent to mining would be worth inclusion in the forward monitoring plan.

H. <u>Section 7. Management Strategies</u>

1) Section 7, P86 – Relative to the same issue as Section 6, point (4) above, the specific consideration of effective barrier width, where overlying workings are within the nominated 0.7 x depth barrier is discussed:

   "The 0.7 times depth (nominally 203m) stand-off from the FSL is considered to be the primary control for protecting the stored waters of Cataract Reservoir and this barrier is expected to provide a high level of protection to these stored water. The presence of existing pillar extraction areas within the barrier reduces the protection afforded by the barrier to 80m from the FSL in some areas".

   In these particular areas, monitoring of bedding plane shear should definitely be incorporated into the monitoring and management regime.

2) Section 7, P87 - As has previously been discussed, **the use of technical advisory committees to inform and participate in the adaptive management program, as well as further investigating complex issues such as swamp impacts, is considered a valuable, worthwhile approach and should be adopted.** SCT make the following comments on this issue:

   "However, it is recommended that one or more technical committees are formed to design monitoring programs that not only review the changes that may be associated with proposed mining but also take the opportunity to review the longer term impacts from

previous mining in the same area. These technical committees should include external expertise from the community where appropriate so that monitoring programs are targeted, appropriate, can be ongoing, and are transparent to all stakeholders".

I. Section 8. Response to Submissions

1) Section 8, P88 – SCT has adopted an informed view and demonstrated recognition of the complexities of multi-seam subsidence behaviour, which is commended and agreed with:

   "Although there is somewhat greater uncertainty for subsidence predictions in a multi-seam environment, the available data and further monitoring data is expected to continue to provide a strong base for further understanding. The behaviour observed is repeatable and consistent with the mechanics of the processes involved".

Bruce Hebblewhite
25th September, 2014

APPENDIX A

The following is an extract from Hebblewhite Report 1303/02.3 (dated 17 October, 2013). This extract covers the review comments related to the following SCT report which was the basis of subsidence assessment in the Gujarat Preferred Project Report submitted in October, 2013. The SCT Report is Report No. NRE14123, also authored by Dr Ken Mills, and dated 24th September, 2013. Although the current SCT report under review supersedes this previous report, it does respond to the issues raised here and makes references to it – hence the inclusion of this extract here, to assist with clarity.

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2. REVIEW OF SCT REPORT NRE14123

The following represents a point-form summary of key issues or comments in relation to the prediction and assessment of subsidence, referencing the relevant section and/or page numbers from the original SCT document. The points are listed in the order that they appear in the SCT report, for easy cross-referencing. As such, the order of points does not imply any relative importance or priority of issues. It is also important to note that in reviewing the report in this manner, some issues raised in report sequence order are subsequently answered or further expanded later in the report. Therefore the report should be read in its entirety, prior to reacting to individual issues raised.

A. <u>Summary Section</u>

2) Summary, p(i) – SCT notes correctly that the presence of the old workings in the other mined overlying (Balgownie and Bulli) Seams, whilst providing some challenges, does present an advantage in the ability to project the location of known geological structures between the seams into the proposed Wongawilli workings.

3) Summary, p(ii) – SCT notes that previous Bulli Seam longwall experience will assist in understanding the subsidence mechanisms involved (for this geology), and the prediction of actual subsidence values. It is also noted that incremental subsidence and the approach of Holla and Barclay will be used for predicting tilts and strains; and that the ACARP Method (Waddington Kay & Associates (now MSEC)) will be used for predicting maximum closure. These approaches are considered valid and appropriate; furthermore, they now address the shortcomings in the previous Seedsman work which was lacking with respect to predictions in non-conventional subsidence effects such as valley closure due to surface topographic variations.

4) Summary, p(ii) – It is noted that *"subsidence behaviour is essentially predictable albeit with somewhat different characteristics to subsidence over single seam mining operations".* The term "essentially predictable" is rather vague or imprecise in meaning, presumably due to the complexity of the issue under discussion. As previously noted, it is due to the effect of multi-seam mining on subsidence behaviour. It is simply not possible to provide accurate, absolute subsidence predictions, based on such a limited database of current multi-seam experience. SCT identifies the reason for subsidence differences in a multi-seam environment as being due to *"overburden stiffness characteristics and therefore the bridging capacity across individual panels, but is otherwise essentially similar to the subsidence behaviour above single seam*

operations". Whilst I agree with this statement to a point, it perhaps over-simplifies the issue of exactly how the assessment of the changed overburden stiffness characteristics can be carried out in order to predict multi-seam subsidence with any degree of certainty. It also makes no reference to the important issue of time-dependency, when previous goaf areas (particularly old partial or first workings panels) are remobilised.

5) Summary, p(ii) – SCT notes that there is potential for some localised pillar instability in the overlying Bulli Seam workings in the vicinity of Longwall 1 when mining in the Wongawilli Seam takes place.

6) Summary, pp(iii-iv) – SCT has undertaken an assessment of previous subsidence effects due to the mining of both the Bulli and Balgownie Seams. The Bulli Seam subsidence is estimated (see later in body of report for explanation of basis for estimation technique); this has then been combined with measured data from longwall mining in the Balgownie Seam. An interesting (and considered reasonable) statement is that in the multi-seam environment *"the goaf edge subsidence profile is expected to be softer than elsewhere".*

7) Summary, p(iv) – It is noted that the PPR includes an adaptive management strategy *"based on closure monitoring and cessation of mining if there is a likelihood of significant perceptible impacts becoming apparent".* This is discussed in relation to Cataract Creek in particular, and the possible impacts of valley closure effects. Whilst this principle of adaptive management is considered reasonable, it is reliant on several factors which have not as yet been clearly defined, but which are essential to the success of such a strategy. These were identified in my initial report and include:
   a. What amount of lead time will be available in the relevant monitoring data locations, to provide meaningful data on which decisions can be made prior to the impacts occurring at Cataract Creek?
   b. What certainty will there be, that the observed surface subsidence effects and related impacts will cease immediately if mining is ceased in the area?
   c. What is the proposed management structure whereby such decisions will be made – both with regard to the interpretation of the monitoring data; and also with respect to deciding to stop the longwall, and how quickly can such a process take place?

8) Summary, p(iv) – SCT makes a significant comment and recommendations, with respect to the potential impact of mining on the identified 33 upland swamps identified by Biosis. Firstly, it is stated that mining is not expected to cause significantly different impacts to those already experienced due to earlier mining – however, such previous experience has not been well documented, to date (this is partly due to the simple lack of previous data available). It is therefore difficult to agree with, or endorse this statement, in the absence of any supporting data. Consistent with a lack of real quality data on swamp impacts, SCT then rightly argues for *"more work is required to determine the relationship between mining subsidence and the long term health of swamps".* It is stated that there is a rare opportunity within this lease area where base data, or at least experience exists over many decades, to undertake a more thorough review. SCT further recommends the formation of an ongoing monitoring and review strategy with respect to subsidence impacts on swamps and their subsequent recovery over time.

9) Such a view is strongly supported, and is in line with some of the recommendations from the Southern Coalfield Review Panel Report (2008). The issue then becomes, how is such a review and further investigation possible without mining progressing in the vicinity of such swamps in order to generate further data? It is proposed that an incremental approach be

adopted, with the first stage being a summary of historical impacts and evidence of recovery; followed by more precise monitoring of subsequent impacts as mining proceeds – preferably in relation to less significant swamps in the first instance.

10) Summary, pp(iv-vi) – Further summary impacts are discussed, with conclusions that impacts on sandstone cliff formations, aboriginal sites, Mount Ousley Road, Cataract Reservoir, and the Illawarra Escarpment are likely to be minimal to negligible. This view is supported. In relation to electricity transmission towers, it is noted that some protection and remedial actions will be required. In regard to the use of a barrier between mining and the Full Supply Level (FSL) of Cataract Reservoir, a horizontal protection barrier of at least 0.7 times depth has been applied around the FSL which seems reasonable. However SCT then notes on p(vi) that *"the presence of these goafs reduces the effectiveness of the 0.7 times depth barrier".* This is referring to goafs from old workings. If this reduction in effectiveness is real, as stated here by SCT, then surely this requires further justification of the adequacy of the 0.7 barrier, or else a modification to the barrier width or control measure for the FSL? Such an explanation is lacking, but should be provided.

11) Summary, p(vii) – Discussion of the other submissions includes comments in relation to the subsidence prediction technique(s). It is noted and agreed that prediction techniques are being continually improved, based on available data, to enable better understanding of the subsidence processes involved. The following sentence is then included in this discussion: *"Although there is somewhat greater uncertainty for subsidence predictions in a multi-seam environment, the available data indicates that the behaviour observed is repeatable and consistent with the mechanics of the processes involved".* This statement does not yet appear to be supported by a substantial body of factual data. On the evidence presented to date, there is still a reliance on hypotheses and estimates, to provide a complete understanding of the multi-seam behaviour. It is, to put it simply, early days in relation to this topic, with very little comprehensive quality data available, and I therefore find it difficult to support such a bold statement at this time.

12) Summary, p(vii) – It is noted that the presence of the old workings in other seams provides valuable data with respect to geological structures, and there are only two major structures in the area, which have been accounted for in the PPR mine design.

13) Summary, p(vii) – SCT concedes correctly that the prediction of valley closure, upsidence and far-field movements are only approximate, since these techniques are still under development. However, to their credit, SCT has made such predictions (which were absent in the earlier prediction reports), using the best available techniques and sources of data. Reference is again made, with respect to valley closure in the vicinity of Cataract Creek, to *"NRE's commitment to stop the longwalls short if closure movements become likely to cause unacceptable impacts".* As discussed above, the ability, practicality and processes for achieving such a management control require further explanation and justification.

B. <u>Section 1. Introduction</u>
No comments.

C. <u>Section 2. Site Description</u>

1) Section 2, p4 – This includes a useful summary of the subsidence constraints used in the redesign of the mine plan for the PPR. This is reproduced below:

- *The constraints of the mine lease.*
- *Geological constraints including the Corrimal Fault in the south, silling (an igneous intrusion within the seam) in the north, and coal quality considerations and its impact on mining height.*
- *Mining constraints associated with the need for main headings in the north and the legacy of previous mining extent and geometry.*
- *Surface subsidence constraints including:*
  - *Avoiding longwall extraction within 0.7 times depth (equivalent of 35° angle of draw) of the full supply level (FSL) of Cataract Reservoir including the section of the reservoir that extends up Cataract Creek.*
  - *Avoiding mining directly under the third and fourth order sections of Cataract Creek.*
  - *Minimising impacts on Mount Ousley Road to tolerable levels by remaining beyond approximately half depth (equivalent to 26.5° angle of draw) from the road easement.*
  - *Significant upland swamps.*

These constraints all seem reasonable and appropriate, however the constraint with respect to the significant upland swamps lacks any quantitative or measurable definition, in terms of how does this translate to a design constraint. Figure 2 is a copy of Figure 2 from the SCT report, showing both original and the revised PPR mine layouts, together with the various constraints identified above.

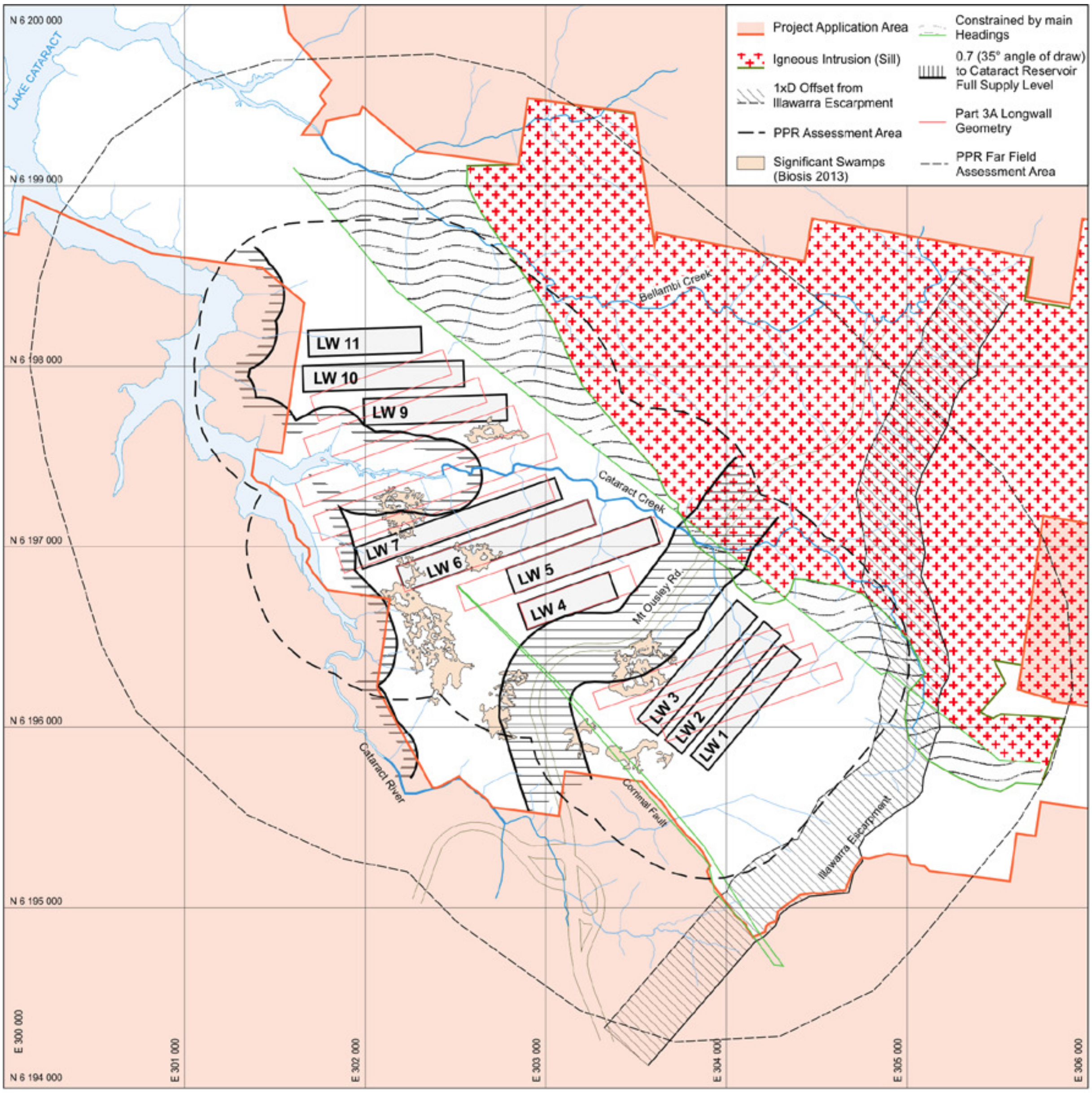

Figure 2: Plan showing the design constraints (lease, geological, mining, and surface protection) as the basis for the PPR mine layout design.

Figure 2. *(source: SCT Report NRE14123)*

2) Section 2, p6 – This provides an appropriate definition of the assessment area as extending 600m horizontally from any proposed longwall panels, and up to 1.5km to allow for far-field horizontal effects on any significant features, such as the Illawarra Escarpment.

3) Section 2, p6 – It is acknowledged that the single seam subsidence seam prediction methodology used in the original assessment was not appropriate, given the measured subsidence values over the current longwalls (LW4) being well above the predictions.

4) Section 2, Figures 6, 7 and 8 – These figures provide a useful record of the previous workings in each of the Bulli and Balgownie Seams, together with the proposed Wongawilli Seam longwall panels. The location of the major geological structures is also discussed (pp10-16), and it is noted that the major fault structure, known as the Corrimal Fault, while significant in throw towards the southern end of the lease (away from the proposed longwalls), diminishes to the northwest, to the extent that it is believed to be insignificant at the point where it will be intersected by LW6.

D. <u>Section 3. Previous Mining Activity</u>

1) Section 3, p18 – It is noted that subsidence from previous mining in the Bulli Seam has been estimated, but for the Balgownie Seam, measurements were taken at the time of mining. The recent mining of LWs 4 and 5 in the Wongawilli Seam has confirmed that observed subsidence does not match single-seam prediction behaviour, although it is claimed that the multi-seam effects are largely restricted to within the chain pillar boundaries of the currently mined panels. SCT again uses the expression "essentially predictable" when referring to multi-seam behaviour, although the basis for such a claim is yet to be substantiated.

2) Figure 3 provides a good overlay of the proposed Wongawilli longwall panels, together with the location of the previous Balgownie Seam longwalls and the areas of old Bulli Seam bord and pillar workings. This is reproduced from Figure 11 of the SCT report.

3) Section 3, p20 – SCT explains that their estimates of Bulli Seam subsidence have been obtained on the basis of previous experience *"from mining in the Bulli Seam further to the west above the T and W (200 and 300 series) longwall panels at South Bulli and subsequent pillar extraction operations".* Whilst it seems reasonable to develop an understanding of subsidence over Bulli Seam bord and pillar workings, the detail is not provided to allow any assessment of the validity or accuracy of this approach, and regardless, it would be very difficult to gain any high levels of confidence in what are no doubt a range of different mining panel geometries and extraction scenarios. This approach is therefore a reasonable one, but there must be a significant note of caution with respect to the confidence in the magnitude or variability of the predicted values, relative to the current areas of interest.

4) Section 3, p20 notes that an extensive underground inspection was undertaken on 21 June 2013 which has identified an area of pillar workings in the Bulli Seam above/adjacent to the proposed Wongawilli panels which are likely to be destabilised as a result of Wongawilli undermining. (This is backed up by evidence of pillar destabilisation caused by the previous Balgownie longwalls, in a similar area of Bulli Seam pillar workings). It is noted that such effects are likely to be localised, and confined close to the new goaf edge, but need to be taken into consideration. This has already been discussed under section A(4), and relates to an area near Longwall 1 (further discussed on SCT Report p23).

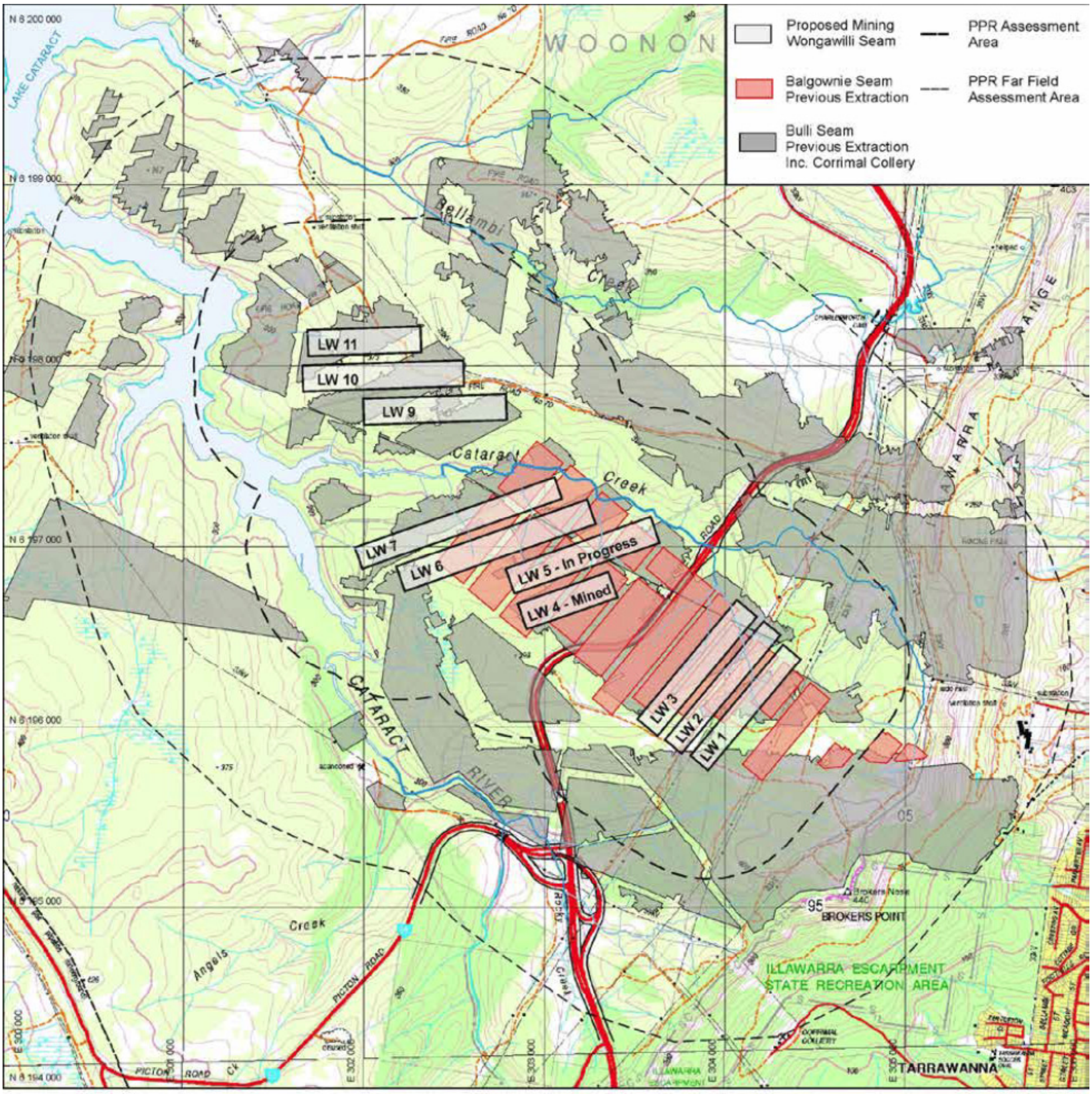

Figure 11: Plan showing extent of previous extraction in Bulli Seam (black) and Balgownie Seam (red) in the PPR Application Area.

Figure 3. Superimposed mine workings (all three seams)
(source: SCT Report NRE14123)

5) Section 3, p23 – Discussion of measured Balgownie Seam longwall-related subsidence confirms that there is evidence from the data that there was additional subsidence at the time due to associated, remobilised pillar instability.

6) Section 3, p23 – Further discussion addresses the question of pillar run potential. SCT states that such a scenario is certainly possible, in the context of localised pillar regions, as discussed above, but is unlikely to extend over any large distances, based on a combination of assessment of the old mine plans, and underground inspection. This opinion and conclusion is considered reasonable. SCT then extends the definition of "pillar run" to include the impact of additional abutment stresses on pillar regions causing, not instability, but simply an additional increment of elastic compression of the pillars, hence an additional increment (albeit small) of surface subsidence, without pillar failure. This is certainly not only feasible, but a certain outcome, where regional load transfers and abutment stresses change the loading regime on standing pillars. However, it is not considered appropriate to include this under the heading of a "pillar run" which historically has been a term used to describe large scale, dynamic pillar instability and failure. The issue of incremental elastic compression does not fall under this description and it is strongly recommended that such terminology should not be used for such behaviour.

7) Section 3, p24 and following – Section 3.2 discusses the Balgownie Seam subsidence effects. Firstly, it is noted that in areas where there was overlying Bulli Seam goaf, the measured goaf edge region subsidence extends further, but only to the extent of being a secondary effect. It is also noted (pp26-27) that where the Bulli Seam goaf areas were narrow and possibly bridging, the effect of underlying Balgownie workings is to cause a greater increment of additional subsidence, such that the resultant surface subsidence extends up to 100% (1.4m) of the Balgownie Seam mining height, i.e. the Balgownie goaf formation has reactivated the goaf above the Bulli Seam and caused this additional subsidence, over and above what would have been expected from single-seam Balgownie subsidence prediction.

8) Section 3.2 also discusses both horizontal strains and tilts, and then valley closure effects associated with Balgownie subsidence (p29). The ACARP method of predicting valley closure and upsidence is applied to these sites and compared to measured data in regions around Cataract Creek where previous Bulli Seam mining had taken place. It is found that this method provided good correlation between measured and predicted data and so is considered applicable for assessing upper bound valley closure and upsidence effects in multi-seam applications. This is a reasonable conclusion going forward, in the face of no other current methodology being available. However it is a conclusion based on a very small dataset, and should be applied with great caution, and a lower level of confidence than when working in single-seam situations.

9) Section 3, p32-35 – It is unfortunate that having discussed the Balgownie Seam subsidence data with respect to subsidence effects and impacts, strains, tilts, valley closure, surface cracking, rock falls, Cataract Creek etc, there is no discussion about the subsidence effects in the vicinity of upland swamps that were impacted by the Balgownie longwalls (such as are indicated to exist in Figure 2 in the middle of proposed Wongawilli LW6, which in reference to Figure 3, lies directly above some of the Balgownie longwall panels). It would be extremely valuable to know how much subsidence and strains, tilts etc occurred in the vicinity of those (and any other) swamps, and then to assess what was the immediate impact on the swamps, if that was recorded at the time, and what is the current state of recovery in such swamps to any adverse impacts that occurred. Such a correlation between quantitative subsidence data and resultant impacts is the major missing element in this project assessment. If, as SCT states, such data was collected, it is essential that it be reported in the above manner to provide a valuable benchmark dataset and case study (c/f paragraph A(7) above). (Note: There is some

discussion on this point later in the SCT report, and some data is included in Appendix 1 of the report, but there is no discussion of it here in the context raised above).

E. Section 4. Subsidence Prediction Methodology

1) Section 4 provides a comprehensive discussion of the methodology adopted for subsidence prediction, based on the available empirical data and understanding of subsidence mechanics behaviour. It is largely based on the experience, to date, from monitoring subsidence above Wongawilli LWs 4 and 5, where previous overlying workings exist in both the Bulli and Balgownie Seams. It is a valuable contribution to understanding the multi-seam subsidence behaviour, and is a sound, and best available source of information on which to base the future prediction methodologies for this project. However, it is important to recognise that it is still a relatively small database, and so predictions must be made with caution, whilst the database is continually expanded, and regularly re-evaluated. A critical part of the management strategy for this project moving forward must be to conduct continual high level comprehensive monitoring; regular data analysis; and regular re-evaluation of the subsidence behavioural models and hence predictions based on such models.

2) Section 4, p37 – SCT draws the appropriate conclusion that in the multi-seam environment, the effect of the overlying goaf areas is to reduce the shear stiffness and rigidity of the overburden strata. Some subsidence data is provided to support this hypothesis. On p43, the logical conclusion from this effect is stated to be *"the reduced shear stiffness leads to reduced bridging capacity of the overburden strata and significantly increased maximum subsidence for the same overburden depth and longwall panel geometry".* This is a particularly important and valid conclusion, and is significant in terms of providing forward predictions of subsidence behaviour. The challenge remains as to how to quantify the magnitude of such increases, and define the conditions under which they occur. SCT does proceed to do this in the best manner available, but the caution remains that (a) it is based on a very limited dataset, and (b) the full knowledge of the nature of the overlying workings and subsequent subsidence is based on estimates only (at least in the case of the Bulli Seam). Therefore the subsequent predictions made (see Section 5) are appropriate, but must be applied with caution.

3) Section 4, p44 – The point that has already been made about the additional subsidence due to these effects being largely confined to within the current panel geometries is an important and positive one. However, the only scenario where this may not be the case is where overlying standing pillars are destabilised, in which case the additional subsidence effects due to such pillar failures may extend to the extent of the overlying pillar regions. This point is made on p45 with respect to the region of Bulli Seam pillars in proximity to Wongawilli LW1. SCT makes some specific recommendations with respect to the length of LW1 and the need to carefully manage this situation. This opinion is strongly endorsed.

4) Section 4, p46 and following – The remainder of this section discusses specific subsidence parameters, effects and impacts – all of which are accepted as stated, based on the previous qualifications discussed above with regard to the prediction methodologies.

5) Section 4, p48 and following – SCT confirms the adoption of a purely empirically-based subsidence prediction methodology, for all of the reasons already discussed. The more traditional analytical methods using Influence or Profile Function methods, or the single seam empirical Incremental Profile methods are not considered appropriate to this type of multi-seam subsidence behaviour. This conclusion is accepted as reasonable under the circumstances of

this project, albeit that the methodology adopted is in a very preliminary or prototype stage, as discussed previously.

6) Section 4, p50 – In discussing strains and tilts, it is worth emphasising the point made by SCT that it is simply not possible to predict exact locations of maximum or peak strains, and hence potential crack locations, for example. Regions where such strains might occur can be identified, but it is never going to be possible to predict in advance the actual location of actual cracks in the rock mass.

7) Section 4, pp50-52 – SCT discusses accuracy and sensitivity assessment for their prediction methodologies. This leads to the statement discussed earlier, that *"subsidence associated with multi-seam subsidence in this area is essentially similar to the subsidence behaviour in a single seam".* Once again, although it is only semantics, it is hard to see what is essentially similar about the behaviour predicted. SCT has just discussed significant changes in behaviour due to changes in the overburden characteristics, rendering traditional prediction relationships invalid. This statement is therefore not considered an appropriate description of a quite different world of multi-seam subsidence behaviour, the understanding of which is still relatively embryonic. SCT's own excellent approach to understanding this is still only based on data from two current longwalls (LWs 4 and 5).

8) Section 4, p52 – SCT makes a very important and valid conclusion, having discussed the impact of softened overburden leading to a change in bridging characteristics and potential increased subsidence. It is noted that in spite of this changed behaviour, all of the proposed panels within the PPR are of a reduced panel width such that there remains a significant subsidence-limiting control factor present due to the panel widths, such that full subsidence will not develop above these panels, compared to if they were wider, under the multi-seam environment.

F. Section 5. Predicted Subsidence

1) This section simply presents the factual predictions for the full range of scenarios and features present – based on all of the assumptions already discussed. These predictions are all accepted at face value, together with the various caveats already mentioned, especially with regard to confidence levels.

G. Section 6. Subsidence Impacts

1) Section 5, p61-62 – This section returns to the issue of upland swamps and refers to the data contained within the Appendix regarding past estimates, and future predicted subsidence effects. However it still does not address any detail with respect to either previous impacts or future likely impacts (accepting that some of these issues fall outside of the brief of SCT). The most relevant and pertinent statements made on these issues are:

   - *"It is unclear how sensitive swamps are to mining subsidence"*
   - *"the swamps located within the PPR Assessment Area appear to be thriving despite having been previously subsided to levels that are of the same order as the subsidence expected above future longwall panels"*
   - *"the drop in piezometric pressure observed when some swamps are mined under may not have a significant impact on their long term condition"*

- *"It is considered that more work is required to determine the relationship between mining subsidence and the long term health of swamps".*

Clearly there is a need for a more quantitative and comprehensive assessment of these relationships between the swamps and the impact factors – both immediately, based on the known and estimated subsidence data reported here; and also through further work in the future.

H. Section 7. Management Strategies

1) The recommended strategies discussed here are all considered of value and worth pursuing. These include the adoption of a higher standard of survey monitoring, including use of three dimensional GPS arrays, in support of conventional survey data, and also high precision point to point measurement of valley closure.

2) The concept of an adaptive management strategy discussed earlier is not specifically referenced in this section, but is an essential process that brings together the data from various sources of monitoring data and analysis, in order to inform operational mine management and planning decisions. It is critical that an appropriate management system is established to handle this in an effective manner, as previously discussed under paragraph A(6) and elsewhere. This system needs to be developed well in advanced, and clearly enunciated, including answers to the questions posed in A(6).