REPORT TO:	**NSW Department of Planning & Infrastructure**
ATTN:	**Mr Howard Reed** **Manager Mining Projects** **Major Project Assessments**
cc:	**Mr Clay Preshaw** **Team Leader**
	SUBSIDENCE IMPACT ASSESSMENT – GUJARAT NRE NO. 1 MAJOR EXPANSION PROJECT **Independent Peer Review**
REPORT NO:	**1303/02.1**
PREPARED BY:	**BRUCE K. HEBBLEWHITE**
DATE:	**20th June, 2013**

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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."*

2. BACKGROUND

2.1 Information Provided

The following documentation has been provided in order to assist with preparation of this peer review report:

- NRE No. 1 Colliery Project Application 09_0013, Environmental Assessment, Gujarat NRE Coking Coal Pty Ltd, Feb 2013 (EA)
- Subsidence data files (non-graphic) from Wonga East Area 1, LWs 4 and 5 (to 23 April, 2013)
- Agency Submissions in response to above Environmental Assessment from:
  - NSW Department of Primary Industries (Agriculture NSW);
  - NSW Department of Resources & Energy;

- NSW Dams Safety Committee;
- NSW Office of Environment & Heritage;
- Heritage Council of NSW;
- NSW Department of Transport – Roads & Maritime Services.

(Note: Discussion of these Agency responses will be included in a separate, subsequent report).

2.2 Proposed Mining Layouts

Full details of the proposed underground mining are contained in the EA documentation (Part C in particular) listed above. It is not proposed to repeat the detail of all past, present and proposed mining; however the summary points below are provided for clarity in reading this report. Figures 1, 2, 3 and 4 below have been extracted from the EA documentation to provide copies of the proposed longwall mining layouts relative to previous mine workings, the mine lease boundaries, and the prevailing surface topography.

A summary of the key features of the proposed underground mining is as follows:

- Mining is located in two distinct areas – Wonga East and Wonga West.
- Mining is primarily in the Wongawilli Seam, with additional first workings in the higher Balgownie and Bulli Seams in the Wonga West area (there is no expected subsidence of any significance associated with these proposed first workings in isolation).
- Access will be obtained by an extension of the existing "Wonga Mains" drivage from Russell Vale to both areas.
- Wongawilli Seam development will be nominally 5.5m wide, 3.2m high headings.
- Longwall extraction thicknesses will be 3.2m.

<u>Wonga East</u>

- The Wonga East area is located 500m to the west of the Illawarra escarpment.
- There are two longwall domains in Wonga East – Area 1 to the east of the Mount Ousley Rd, and Area 2 to the west.
- Area 1 comprises three, 105m wide longwall panels (A1 LW1 to A1 LW3) with 40m wide chain pillars. These panels lie beneath old pillar extraction and first workings in both of the overlying Balgownie and Bulli Seams. Depth of cover ranges between 237m to 255m.
- Area 2 comprises eight, 145m to 150m wide longwall panels (A2 LW4 to A2 LW11) with 60m wide chain pillars. Depth of cover ranges from 267m to 320m.
- Prior approval has already been granted for the mining of A2 LW4 and LW5, plus development of the LW6 maingate panel.
- Area 2 longwall panels have been configured such that maximum vertical surface subsidence under third order or above streams will not exceed 250mm.
- *"Narrow extraction panels and wide chain pillars are proposed at Wonga East to provide a management tool for subsidence risks on all surface features, including Cataract Creek and the upland swamps" (Gujarat EA, 2013).*

<u>Wonga West</u>

- The Wonga West mining area is located to the west of Cataract Reservoir.
- No longwall mining is proposed under: the main channel of Lizard Creek or Wallandoola Creek; under the Cataract Reservoir; or within one kilometre of the Cataract Reservoir dam wall or spillway.

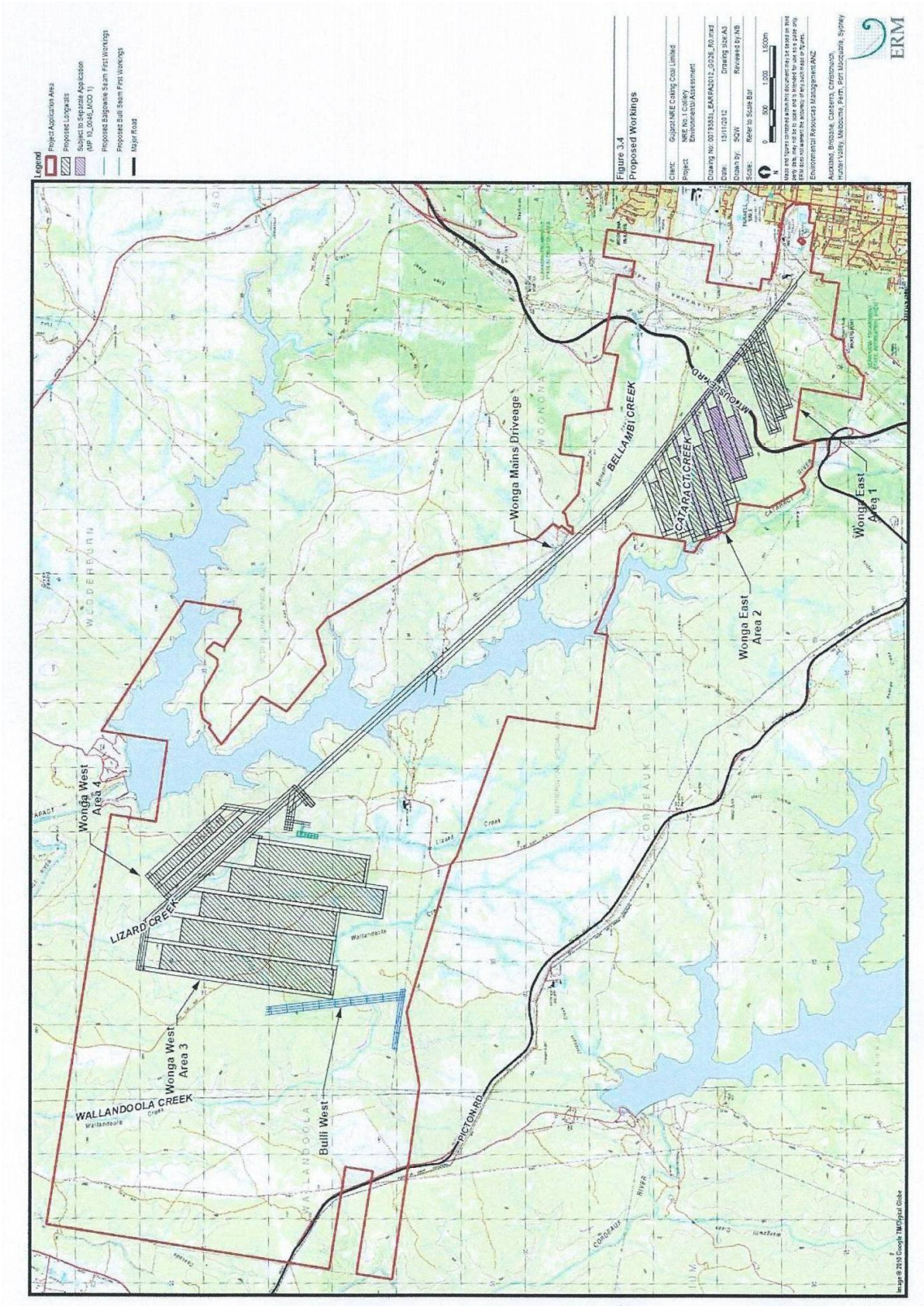

Figure 1. Overall mine lease showing proposed Wonga East and Wonga West longwall panels
(source: Gujarat NRE Environmental Assessment, 2013)

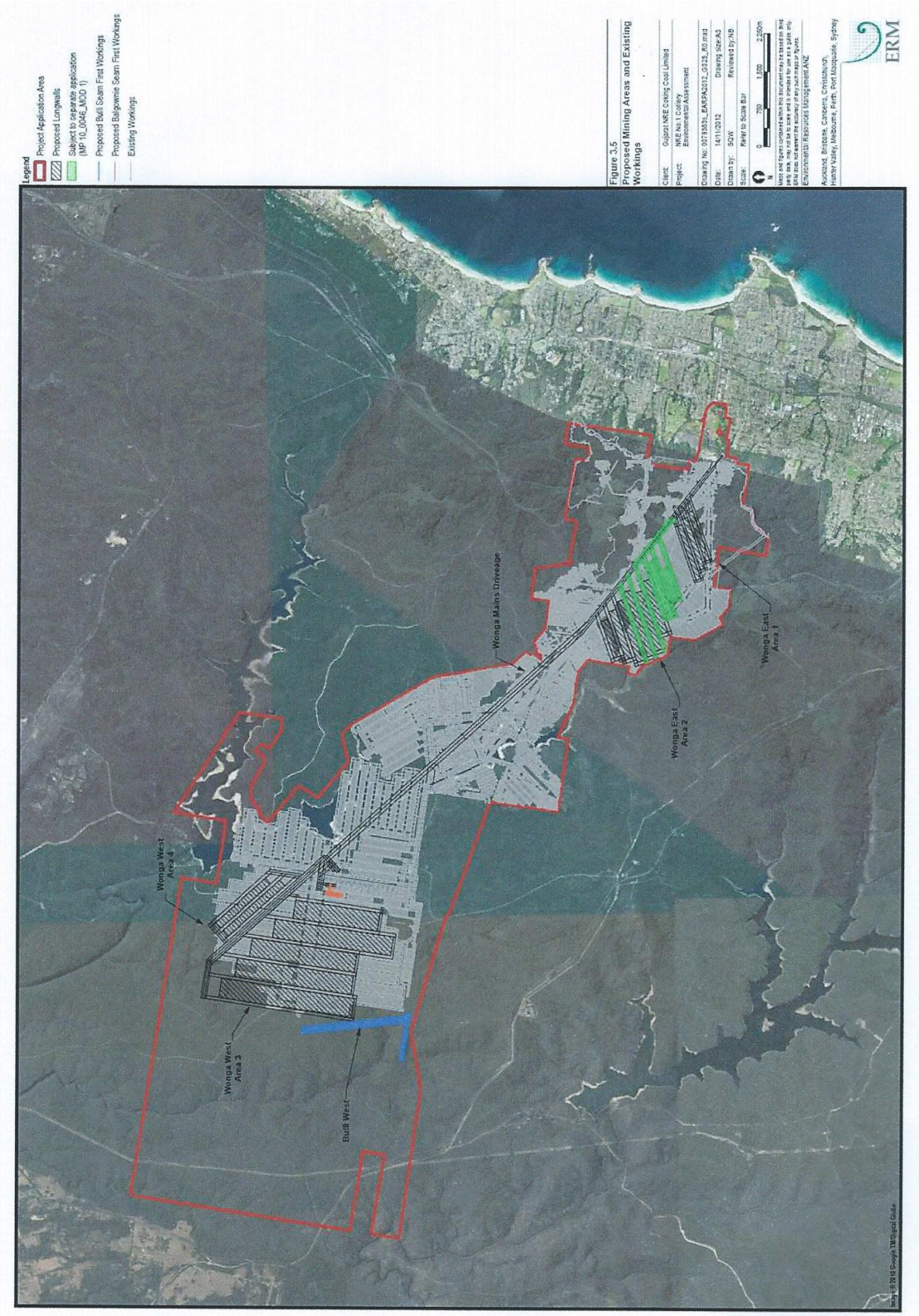

Figure 2. Overall mine lease showing previous workings and surface topography
(source: Gujarat NRE Environmental Assessment, 2013)

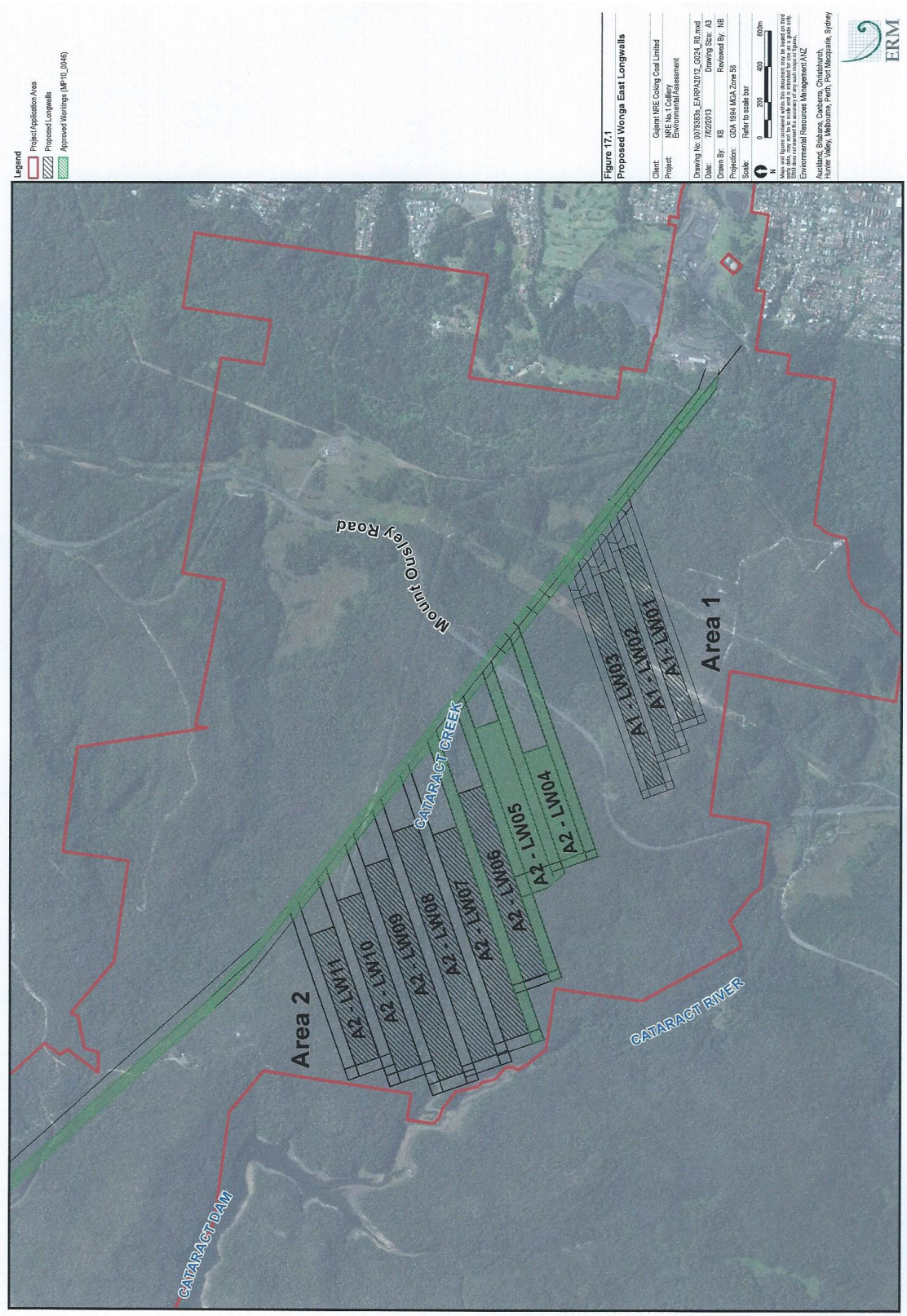

Figure 3. Proposed Wonga East Areas 1 and 2 longwall layouts
(source: Gujarat NRE Environmental Assessment, 2013)

Figure 4. Proposed Wonga West Areas 3 and 4 longwall layouts
(source: Gujarat NRE Environmental Assessment, 2013)

- There are two longwall domains in Wonga West – Area 3 to the south-west of Lizard Creek; and Area 4 to the north-east of Lizard Creek.
- Area 3 comprises five longwall panels (A3 LW1 to A3 LW5).
- Area 3 longwalls are located approximately 40m below the Bulli Seam, and are oriented according to the alignment of the previously mined Bulli Seam longwalls.
- Area 3 depth of cover ranges from 455m to 510m.
- Panels are planned to be 390m wide with 65m wide chain pillars.
- The chain pillars are located directly beneath the goaf of the overlying Bulli longwalls.
- Area 4 comprises two longwall panels (A4 LW6 to A4 LW7).
- Area 4 longwall panels are 155m wide with 65m chain pillars.
- Area 4 depth of cover ranges from 460m to 495m.
- Area 4 longwalls are positioned to maintain a separation of at least one kilometre from the Cataract Reservoir dam.

2.3 Report Structure

This peer review report is structured in the following manner. The specific subsidence prediction and impact assessment documentation is reviewed first. This is then followed by a review of the summary subsidence impact assessment, as discussed in the body of the EA report, which has drawn on the detailed prediction documentation. On this basis, the following section of the peer review report will address:

1) EA Annex M: Subsidence Assessment
    a. Management of subsidence risks associated with Wongawilli Seam extraction. Report No. GNE – 136.docx, July 2012, Seedsman Geotechnics Pty Ltd.
    b. Letter to Gujarat NRE from Seedsman Geotechnics Pty Ltd, dated 4 February 2013.

2) EA Annex N: Peer Review – Subsidence
    a. Review of subsidence and related facets of the NRE No. 1 Colliery. Report No. P043.R2, 19th October, 2011, Pells Consulting.

3) EA Annex G: Pillar Run
    a. The potential for a pillar run in the Balgownie and Bulli Seams following extraction of the Wongawilli East longwall panels. Report No. 06-001-NRE-2, 29 October, 2012, Strata Engineering (Australia) Pty Ltd.

4) Chapter 18 of the EA Report: Subsidence

3. PEER REVIEW DISCUSSION

Under each section of documentation reviewed, a summary of comments are provided in point form, referencing the relevant section and/or page numbers from the original documents.

3.1 Seedsman Report (July 2012)

- Executive Summary
  - p(i) – Design philosophy is stated as: "Elimination" - no longwall extraction is to be conducted under or in close proximity to the identified features of special significance. "Substitution" - Narrow longwall blocks are proposed with wide chain pillars in Wonga East, to reduce prediction uncertainty where the overlying seams have been extracted. It is then stated that the use of narrow blocks in Wonga West is not economical, hence use of 380m wide panels. It is noted that progressive validation of the model assumptions and predictions will occur, and so engineering and administrative controls are proposed to manage panel start and finish lines – developed progressively as monitoring occurs.

  - The above approach is sound, however lacks a degree of certainty with respect to subsidence impact management. For example, the initial statement about not mining in close proximity to special significance features does not provide any certainty about either intention or outcome of protecting such features. The design approach must be premised on no mining impacts on such features – regardless of the proximity. Secondly, the use of 380m wide panels due to economic reasons should not be a criterion for subsidence management, even if it is a reality in terms of mine planning. Either there is an issue with wide panels with respect to subsidence, or there is not.

  - It is noted that the proposed first workings in the Bulli and Wongawilli Seams will not result in any subsidence in excess of 20mm. This is accepted as both reasonable and achievable, provided these development roads have adequately sized pillars between them such that they do not result in a regional pillar failure, and that there is no possibility of them being impacted adversely from any future longwall extraction.

- Page 2 – It is noted that the overlying old workings include Bulli Seam workings from early last century, plus longwalls in the Balgownie Seam from the late 1970s. It is not stated, but above the Wonga West Area 3 longwalls were Bulli Seam longwalls from late last century also.

- Page 4 – Seedsman notes areas of special significance as being: Mount Ousley Rd, Cataract Dam wall and spillway, Stored water and Notification area of Cataract reservoir, Illawarra Escarpment, and fourth order streams. Significant natural features are listed as: third order streams, upland swamps and transitional shale forests.

- Page 5 – It is agreed that an elimination strategy be applied with respect to Mount Ousley Rd, Cataract Dam wall and spillway, fourth order streams and the Illawarra Escarpment – stating no mining "under or near these features". However, this offers little comfort. Ass indicated above, the design strategy must be no impact – regardless of proximity. It is critical that the design and predictions address this requirement and provide more precise definition of mining proximity relative to impact.

- Pages 5, 6 – Discussion is provided around substitution strategies using narrow longwalls, but this is compromised with the issue of economic panel widths for Wonga West. These two issues should not be inter-mixed.

- Page 6 – The risk management approach is stated as being delivering either *"no identified (subsidence) hazard, or a hazard that applies to only a small proportion of the total population".* It is up to the Department to decide if this latter strategy is acceptable – i.e. adverse impacts on a small proportion of the population (of creeks etc).

- Page 6 – Seedsman notes that a risk assessment workshop was convened (no date provided), involving Mr Arthur Waddington of MSEC and Dr Ken Mills of SCT – both eminent subsidence and geotechnical engineers. It is noted that *"the nature of the task meant that the quantification of the predicted risk was not possible. In all cases, the likelihood of an under-prediction was recorded as high, so the highest rankings, which were low to medium, related to the severity of any outcomes".* The meaning of this statement is not particularly clear; however it would appear to suggest that the level of confidence or certainty in predictions of subsidence effect magnitudes is somewhat reduced, compared to more simple single seam mining geometries. It is agreed that this is likely to be the case – such predictions would be extremely difficult. As a result, all design parameters and approaches must adopt extremely conservative values to take account of this clear reduced level of confidence. (For example, it is noted that predictions of closure and upsidence for fourth order streams should be doubled).

- Page 6 – It is noted that *"Stable Strata independently concluded that the likelihood of a pillar run at any location was unlikely to be negligible".* This statement is concerning, unless it is a typographical error. If something is unlikely to be negligible, it is likely to be significant, which would be a serious concern.

- Section 4 (pages 15 and following) – This discusses subsidence history in the Balgownie Seam across the lease (although under this heading the report proceeds to discuss Bulli Seam extraction also). Key data includes: maximum subsidence from Balgownie Seam longwalls was 1.4m, with variable strain levels influenced by adjacent Bulli Seam pillars; angles of draw between 5 and 34 degrees.

- Page 20 – Seedsman discusses a mechanism whereby depending on the impact of the previous Bulli Seam mining on the overlying massive Bulgo Sandstone, the resultant subsidence due to the underlying Balgownie Seam can vary considerably. This is a quite plausible scenario, but without extensive previous subsidence data, would be very difficult to build into any future prediction models with any degree of confidence.

- Page 23 – In discussion of recent 2012 subsidence from longwall mining of the Wongawilli Seam in Wonga East LW4, it is stated that *"the measured vertical subsidence is greater than anticipated: it appears that the Bulli and Balgownie extraction has had a greater impact on the spanning of the overburden than anticipated. However, the subsidence associated with the Wongawilli extraction is only 39% of the extracted thickness and cannot be considered to represent "supercritical" conditions".* Whilst this is a very open and honest statement, it does again fuel a significant degree of uncertainty with respect to confidence in predictions in this multi-seam environment, especially where old workings are also involved.

- Page 24 and following – Discussion takes place regarding the Wonga West former Bulli Seam longwall mining. It is noted and accepted here that the level of subsidence information is far

greater and of better quality than the other areas. Vertical subsidence values of up to 300mm in the 500 series panels under Cataract Dam are quoted, and it is stated that, of this value, 240mm is estimated to be pillar compression and 60mm of sag. This is a very significant proportion due to this mechanism. The other potential mechanism that is not discussed is any component due to pillar punching into the soft floor that existed – at least in the further western parts of the lease. This should be considered and clarified.

- Page 27 – It is noted that in accordance with the Southern Coalfield Inquiry (SCI) terminology, the subsidence above the proposed Wongawilli longwalls will be non-conventional, based on a number of factors listed.

- Page 27 – Seedsman notes that the Bulgo Sandstone is a critical geological unit within the overburden and that *"it is known to span over Bulli Seam longwall panels with widths of at least 200m to 250m".* This statement appears to be at odds with the discussion and mechanisms described on pages 19 and 20 where scenarios of fractured Bulgo Sandstone, plus failed and collapsed Bulgo Sandstone are described.

- Page 27 – The statement is made that almost all Southern Coalfield longwall layouts are designed with yielding or failed chain pillars, resulting in the majority of subsidence actually occurring above chain pillars. This statement is questioned, as is the next statement that claims that the mechanism of valley closure is only associated with down-hill movement and shear on bedding planes. This mechanism is certainly a component of valley closure, but it ignores the potential mechanism of valley closure due to stress and the component of valley floor buckling leading to upsidence.

- Section 5.2 (pages 27 and following) – The prediction of the subsidence profile for a single seam is discussed here. The primary mechanism used by Seedsman is to use a continuum based analytical model within the SDPS software package. Seedsman notes (p28) that *"The recent Bulli Seam PAC discussed the theoretical problems in the way subsidence strain is calculated, and there is reference to the well-acknowledged problem of assuming continuum behaviour for jointed rock mass".* This is a legitimate concern and the continuum-based predictions made here must be taken within the context of the broader engineering concepts and assumptions also discussed, which do correctly attempt to take account of these limitations. The lack of applicability or validity of the SDPS program in non-conventional subsidence regimes is worth noting. Issues such as valley closure, upsidence and far-field horizontal movements are not likely to be predictable by such a technique which is built around algorithms derived from conventional subsidence, and do not take account of surface topographic changes and their impact on stress fields.

- Section 5.3 contains a section on accuracy, uncertainty and prediction. Dr Seedsman is correct in claiming that we cannot produce an absolutely "accurate" prediction in the field of subsidence prediction. We must acknowledge the limitations and assumptions, and aim for an acceptable solution, preferably with values that represent or err on the side of upper-bounds, or worst-case scenarios. This is a sound engineering design approach. However, in the complexities of the multi-seam situation at Gujarat NRE No. 1, this is extremely difficult to do, without any significant amount of back-analysis or calibration data.

- Pages 30 and 31 – Discussion takes place here regarding the nature of bulking in a longwall goaf, however, Seedsman concludes that there is insufficient evidence to apply the work of Li et al (2010) for prediction of goaf mobilisation by under-mining. Seedsman then states that he

will use the principle of single seam subsidence prediction for the Wongawilli Seam workings, plus a component of residual seam subsidence from the upper seams. The former component can be achieved with some confidence, but the ability to confidently predict the upper seam residual subsidence is challenging, albeit that the approach is a reasonable one to attempt.

- For the Wonga East longwalls, he assumes a nominal 300mm maximum subsidence above the narrow panels for the Wongawilli component, plus two residual component factors – impact of collapse of Bulli Seam pillars due to Balgownie Seam mining; plus the nature of the extraction goafs in both the Bulli and Balgownie Seam workings.

- For Wonga West longwalls (Area 3), Seedsman predicts a maximum of 65% of Wongawilli extraction height, plus the residual subsidence for the Bulli Seam longwalls up to a maximum of 65% of Bulli Seam extraction height. This process is considered a reasonable and upper bound approach. He then states that such a figure will be a base case, with additional percentage values added to it, to allow for prediction uncertainty.

- Page 32 – The calculation of the 300mm component of the Wonga East subsidence is discussed. Based on the available databases, this is not an unreasonable estimate, although as Seedsman notes, the database is quite limited for Wongawilli Seam subsidence.

- Page 33 is a discussion of predicting the overlying Bulli and Balgownie subsidence values. Whilst the approach taken is plausible, there is absolutely no way of confidently calibrating or validating the prediction, prior to actually proceeding with mining. Even then, it will be difficult to know if what is observed is representative of the whole region of mining and goaf areas, or is being influenced by local anomalous behaviour. Therefore from an initial prediction perspective, the only reasonable way to proceed would appear to be to assume absolute, but plausible "worst case" scenarios.

- Section 5.7 (pages 35 and following) – This section considers the likelihood and potential mechanisms of a pillar run, or dynamic regional pillar failure in the Bulli Seam triggered by the impact of underlying mining. There is considerable discussion on lack of international precedent (at least in terms of published evidence). This is followed by discussion of pillar failure mechanisms and the potential for failure of various sized pillar systems. Whilst there are minor disagreements with some of the detailed statements made by Dr Seedsman regarding pillar failures, the overall conclusions are not disputed. That is, that the risk of a large scale regional pillar run is low, albeit not impossible. Similarly, a slower speed pillar creep event may occur (such as has been seen in the Bulli Seam before (Coal Cliff Colliery), but not due to an underlying goaf). The most likely consequence of an underlying goaf causing vertical subsidence beneath pillar regions, is a settlement of the overall pillar region rather than any form of catastrophic, wide-scale failure.

- Page 40 – The topic of valley closure and upsidence prediction is discussed in this section. Dr Seedsman makes the comment that *"The mechanisms for valley closure and upsidence are not fully understood and hence not amenable to an analytical engineering prediction. The raw data is not available in the public domain and only modified incremental data is presented".* On the basis of this statement, it appears that no predictions are to be offered by Seedsman. This is certainly a deficiency of the prediction model, given the widespread recognition and acceptance of this phenomenon.

- Section 5.9 (pages 40 and following) – This section discusses the prediction of subsurface effects and impacts. It is noted that a critical factor in this issue is the behaviour of the Bulgo Sandstone as a massive bridging unit. Whilst over the narrower panels in Wonga East and Wonga West Area 4, the wider panels over Area 3 certainly have the potential for major dislocation of the bridging Bulgo Sandstone unit. Seedsman discusses a conceptual model whereby bulking of the underlying goaf material will prevent large-scale dislocation of a 300m spanning sandstone beam. However, the fact remains that some significant dislocation of this strata unit could realistically occur and must be factored into any impact on overlying strata and potential aquifer horizons. Nevertheless, the conclusion on page 43 is still considered valid – that theory and available evidence suggests that connective cracking from the goaf through to the surface will not develop.

- Page 44 – An exclusion zone is recommended for 100m either side of the Mount Ousley Road, wherever Bulli Seam extraction has occurred. This is likely to be an appropriate strategy and adequate stand-off distance – however it is not and cannot be based on any definitive calculation or prediction, due to the complexity of issues and uncertainties involved. So until there is some precedent through mining practice, it is difficult to provide any further clarity to the design principle. At the earliest opportunity, this aspect of the design must be backed up by comprehensive monitoring data in the area where Bulli Seam extraction is also involved.

- Page 46 – It is noted that no Wongawilli Seam extraction will take place under the Cataract Reservoir. This design decision is appropriate. The issue of distance from the dam wall is then discussed. It is noted that a DSC limit of 1km separation of mining from the wall has recently been increased to 1.5km. There is no prediction work on the issue of far-field horizontal impacts, so no counter-position is offered in terms of separation distance proposed. Seedsman notes that *"it is possible that the mine plan will need to be altered in this area".* Clearly, some early and high quality monitoring data on far field deformations and strains is important to provide certainty for both the mine and the DSC before mining comes close to the 1.5km limit.

- Page 47 – Protection of Fourth Order Lizard Creek is discussed. A proposed 200m offset from the centreline of each longwall to the centreline of Lizard Creek is proposed, without any further substantiation. This proposal is rejected as inappropriate. Firstly because the offset distance is not justified by any calculation, but secondly because an offset from a longwall centreline is an inappropriate measure. It should be an offset from the edge of the longwall panel, i.e. the mining extremity, not a centreline.

3.2 Seedsman Letter (February 2013)

This letter discusses subsidence data gathered from the mining of Wonga East A1 LW4 during 2012, in an area where mining took place beneath both Bulli and Balgownie Seam old workings. Some of the notable conclusions were:

- the maximum measured subsidence was 1.4m (compared to a prediction of 1.2m)
- measured strains were less than predicted; measured tilts were close to predictions
- there was no evidence of a pillar run
- there is no evidence of the Balgownie Seam chain pillar in the subsidence profile (although this is not unexpected)

- the ongoing significant level of uncertainty associated with multi-seam subsidence prediction is reinforced by the author.

It is important to ensure that some longer term measurements are taken wherever old workings are involved. It is feasible that there may be some time-dependant further movements that should be assessed through long-term monitoring.

3.3 Pells Report (October 2011)

It is not proposed to go through this report in any level of detail. It was written in 2011, prior to the above Seedsman report, and is more focussed on subsidence impacts and consequences of subsidence on environmental factors, rather than on primary subsidence predictions of behaviour and effects.

The statement made by Pells on page 3 is worth repeating, and is considered entirely valid and appropriate in this case - "*However, it is a fact that the prediction of subsidence, and in particular tilts and ground surface strains, is fraught with uncertainty. The main reason for this is the impact of geological structures, often unknown, and, in the case of multi-seam mining is exacerbated by limited precedent".*

Pells also states on page 3 *"it is concluded that it is inappropriate to make a single prediction of subsidence contours, tilts etc, above the Wonga West and Wonga East longwalls. A predicted range is more appropriate".*

Pells then proceeds to provide comment on the validity of records of the old South Bulli Colliery mine records, and concludes that the available records used in the planning process are as accurate as can be reasonably achieved, based on the information available.

Pells then considers the issue of a pillar run. He discusses each area of pillar workings separately. Without quoting each conclusion in turn, a representative conclusion from his investigations is *"there is an insignificant probability of a pillar run ...".* This conclusion is endorsed.

3.4 Strata Engineering Report (October 2012)

The Strata Engineering Report is a specific set of calculations and analysis with respect to the pillar workings in both the Bulli and Balgownie Seams in Wonga East, and the likelihood of a pillar run triggered by underlying Wongawilli longwall extraction.

Without reporting on each individual calculation, the overall conclusion is endorsed – *"it is therefore assessed that the proposed longwall extraction in the Wongawilli Seam is unlikely to induce a pillar run in the overlying Balgownie and Bulli Seams which would otherwise adversely affect surface subsidence around Mount Ousley Road."*

3.5 EA Chapter 18 - Subsidence

This Chapter is included in the main body of the EA report, and draws together much of the detail contained in the various Annex Reports discussed above. The following is a short summary of these key points:

- Page 245 – Both Pells and Seedsman accept that the uncertainties are greater for multiple seam layouts *(Agreed).* This is even more so, given that some of the seam workings are old workings, and also that pillar workings are included as well as longwalls.

- Page 245/246 – Pells is quoted as calling for a range of subsidence values rather than single predictions. It is noted that Seedsman subsequently responded to this requirement with base case and upper bound predictions (*Although, as discussed above, the Seedsman predictions are not entirely justified in all instances, due to the complexity of some of the mining conditions eg old goaf behaviour etc. As such, even these upper bound values for residual upper seam subsidence, must be regarded with a reduced level of confidence, or higher uncertainty).*

- Page 246 discusses the more recent A1 LW4 monitoring data which reported higher than predicted vertical subsidence (1.4m as opposed to 1.2m). This is further evidence to support both a prediction range of values, and a greater allowance for uncertainty.

- Page 246 also refers to the use of *"an adaptive management approach",* using progressive monitoring data to fine tune predictions and hence future designs. Whilst this concept is strongly supported, it is important to realise that it is still quite a coarse level of control, and one which can be slow to respond to the ongoing time-dependent subsidence behaviour. It needs to be recognised that responding to "on-line" subsidence data and making management decisions about stopping a face early, for example, may not provide sufficient and timely control of the subsidence response. NRE No. 1 should be required to provide a more definitive explanation of exactly how their adaptive management approach would work – what data will be monitored; what mining decisions will be made with regard to any changes to the mine plan; when will such decisions be made; who will make such decisions; and when will they be implemented relative to the progress of mining; and what will be the overall decision-making process?

- Section 18.3.1 (p247) discusses far-field horizontal movements, but there does not appear to be any detailed prediction of the magnitude or extent of such movement, and any impacts it might cause. This is clearly of relevance to the dam wall, but may also be relevant to some of the natural features (creeks etc).

- Page 252 discusses the parameters considered by Seedsman for predicting Wonga East subsidence. These included potential pillar failure in overlying seams. It is important to note that any failure or even simple settlement of these pillar workings may involve some time-dependent longer term behaviour. In other words, subsidence over these areas may take some time before it is complete, even after current mining has passed.

Bruce Hebblewhite
20th June, 2013

APPENDIX A

Attached is a summary Curriculum Vitae for the author of this report, Bruce Hebblewhite. Bruce Hebblewhite has worked within the Australian mining industry from 1977 to the present time, through several different employment positions. Throughout this period, he has been actively involved in all facets of mining industry operations. In addition, he has visited and undertaken consulting and contract research commissions internationally in such countries as the UK, South Africa, China, New Zealand and Canada. For the majority of his 17 year employment period with ACIRL Ltd he had management responsibility for ACIRL's Mining Division which included specialist groups working within both the underground and surface coal mining sectors, and the coal preparation industry– actively involved in both consulting and research in each of these areas.

In his current employment position with The University of New South Wales, Bruce Hebblewhite is involved in academic management, undergraduate and postgraduate teaching and research, and contract industry consulting and provision of industry training and ongoing professional development programs – for all sectors of the mining industry – coal and metalliferous.

Both past and present employment positions require regular visits, inspections and site investigations throughout the Australian mining industry, together with almost daily contact with mining industry management, operations and production personnel.

Disclaimer

Bruce Hebblewhite is employed as a Professor within the School of Mining Engineering, at The University of New South Wales (UNSW). In accordance with policy regulations of UNSW regarding external private consulting, it is recorded that this report has been prepared by the author in his private capacity as an independent consultant, and not as an employee of UNSW. The report does not necessarily reflect the views of UNSW, and has not relied upon any resources of UNSW.

SUMMARY CURRICULUM VITAE

Bruce Kenneth Hebblewhite

(Professor, Chair of Mining Engineering)

Head of School and Research Director,
School of Mining Engineering, The University of New South Wales

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DATE OF BIRTH 1951

NATIONALITY Australian

QUALIFICATIONS

1973: Bachelor of Engineering (Mining) (Hons 1) School of Mining Engineering,
University of New South Wales
1977: Doctor of Philosophy, Department of Mining Engineering, University of Newcastle upon Tyne, UK
1991: Diploma AICD, University of New England

PROFESSIONAL MEMBERSHIPS; APPOINTMENTS; AWARDS & SPECIAL RESPONSIBILITIES

Member - Australasian Institute of Mining and Metallurgy
Member - Australian Geomechanics Society
Member – Society of Mining and Exploration (SME), USA
Member - International Society of Rock Mechanics (President – Mining Interest Group (2004 – 2011))
Secretary General (and Council Member) – International Society of Mining Professors (President for 2008/09)
former Executive Director – Mining Education Australia (July 2006 – December 2009)

Expert Witness assisting Coroner: Coronial Inquest (2002-2003): 1999 Northparkes Mine Accident
Member (2005 – 2008): Independent Expert Review Panel (Dendrobium Mine), NSW Dept of Planning
Expert Witness assisting Coroner – Coronial Inquest (2007): 2004 Sydney Cross City Tunnel Fatality
Chair: 2007-2008 Independent Expert Panel of Review into Impact of Mining in the Southern Coalfield of NSW (Dept of Planning & Dept of Primary Industries)
Member, Scientific Advisory Board, Advanced Mining Technology Centre, University of Chile.

2012 Syd S Peng Ground Control in Mining Award – by SME (USA) – awarded Feb 2013.

PROFESSIONAL EXPERIENCE

2003-present University of New South Wales, School of Mining Engineering
Head of School and Research Director,

(Professor, Kenneth Finlay Chair of Rock Mechanics (to 2006);
Professor of Mining Engineering (from 2006))

2006 – 2009 — Mining Education Australia
(a national joint venture between UNSW, Curtin University of Technology, The University of Queensland & The University of Adelaide)
Executive Director (a concurrent appointment with UNSW above).

1995-2002 — University of New South Wales, School of Mining Engineering
Professor, Kenneth Finlay Chair of Rock Mechanics and Research Director, UNSW Mining Research Centre (UMRC)

1983-1995 — ACIRL Ltd, Divisional Manager, Mining - Overall management of ACIRL's mining activities. Responsible for technical and administrative management of ACIRL's Mining Division covering both research and consulting activities in all aspects of mining and coal preparation.

1981-1983 — ACIRL Ltd, Manager, Mining - Responsibility for ACIRL mining research and commissioned contract programs.

1979-1981 — ACIRL Ltd, Senior Mining Engineer - Assistant to Manager, Mining Research for administrative and technical responsibilities. Particularly, development of geotechnical activities in relation to mine design by underground, laboratory and numerical methods.

1977-1979 — ACIRL Ltd, Mining Engineer Project Engineer for research into mining methods for Greta Seam, Ellalong Colliery, NSW. Also Project Engineer for roof control and numerical modelling stability investigations.

1974-1977 — Cleveland Potash Ltd, Mining Engineer and Department of Mining Engineering, University of Newcastle-upon-Tyne, UK - Research Associate. Employed by Cleveland Potash Limited to conduct rock mechanics investigations into mine design for deep (1100m) potash mining, Boulby Mine, N Yorkshire (subject of Ph.D. thesis).

SPECIALIST SKILLS & INTERESTS

- Mining geomechanics
- Mine design and planning
- Mining methods
- Mine safety and training
- Mine system audits and risk assessments
- Education and training

REPORT TO:	**NSW Department of Planning & Infrastructure**
ATTN:	**Mr Howard Reed** **Manager Mining Projects** **Major Project Assessments**
cc:	**Mr Clay Preshaw** **Team Leader**

SUBSIDENCE IMPACT ASSESSMENT – GUJARAT NRE NO. 1 MAJOR EXPANSION PROJECT
Independent Peer Review

PART 2: Review of Agency Submissions

REPORT NO:	**1303/02.2**
PREPARED BY:	**BRUCE K. HEBBLEWHITE**
DATE:	**20th June, 2013**

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1. SCOPE OF WORK

This Part 2 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, also dated 20th June, 2013. This report is specifically focussed on the responses provided by the various government Agencies, with regard to the Gujarat NRE No. 1 Expansion Project documentation.

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.""*

The following Agency submissions have been provided for review:

- NSW Department of Primary Industries (Agriculture NSW);
- NSW Department of Resources & Energy;
- NSW Dams Safety Committee;
- NSW Office of Environment & Heritage;
- Heritage Council of NSW;
- NSW Department of Transport – Roads & Maritime Services.

It is noted from the above Scope of Works documentation provided, that a further report is expected to be provided, reviewing the Gujarat response to these various submissions, once such a response is received.

2. AGENCY SUBMISSION REVIEW

A summary of comments on each of the Agency submissions is provided below. It should be noted that comments in this report only relate to matters of subsidence prediction, effect and impact. Other issues beyond this scope that are raised by Agencies are not considered here.

2.1 NSW Department of Primary Industries (Agriculture NSW)

No comments were offered other than stating a nil response on the basis that the NRE proposal does not impact on agricultural land.

2.2 NSW Department of Resources & Energy (DRE)

The DRE raises concerns regarding general rehabilitation methods and procedures, and notes that no criteria are provided in the EA. It is assumed that this refers more to mine site and infrastructure rehabilitation, rather than any natural ground surfaces impacted by subsidence. As such, no further comments are offered. There is also a comment about final landform design, but this also appears to be more related to mine site and infrastructure.

In response to a meeting between DRE representatives and Gujarat NRE (13 February, 2013), some further issues were raised:

- The DRE notes the need for further information on *"a detailed summary of subsidence rehabilitation plans".* This is considered to be a valid request.

- DRE expresses concerns over the accuracy of impact assessments, based on uncertainty over accuracy of subsidence modelling. They note *"there is a need to further validate subsidence modelling to improve certainty around the accompanying impact assessments".* This concern over accuracy and uncertainty in the subsidence modelling has been raised in my earlier report reviewing the subsidence prediction contained in the EA. It is a valid concern. However, as noted previously, the presence of the old workings together with multi-seam interactions makes this an extremely complex subsidence modelling task. It is unlikely that any further improvements in modelling predictions can be made, prior to mining commencing and calibration/validation being collected progressively. The DRE request for further validation is therefore considered reasonable, only in the context of validation data being gathered once mining commences and proceeds in initial areas. Further validation prior to any approval is not considered to be a viable option based on the complexity of the problem.

- DRE expresses further concerns regarding subsidence impacts due to undermining of Cataract Creek, swamps CCUS1 and CCUS5; and potential impact on WCUS4 and WCUS7, Lizard Creek waterfall and main channel. These concerns are more related to assessment of

the significance of these features, rather than subsidence prediction, and so fall outside of this brief.

DRE then note that further overall comments on subsidence issues will be provided to the Department following a site inspection. No further comments have been provided, to date, for review.

2.3 NSW Dams Safety Committee (DSC)

The DSC notes that there is no previous experience involving mining in three seams, in close proximity to a large dam reservoir (Cataract dam). They also note that the proposed mining includes mining close to the Full Supply Level (FSL) of the reservoir, and in places below the FSL. A particular concern is expressed regarding the possibility of geological structures connecting workings to the reservoir, and the possibility of a connection forming that could carry water from the reservoir. The risk of loss of water is their major concern, and they note that there is an *"absence of a geological assessment".* They therefore express a concern about the quality and detail of available data and related modelling and therefore do not support the current proposal.

The concern regarding lack of a geological report – at least with respect to detailed structural geology – appears to be a valid concern. The inclusion of such a report would assist greatly in understanding the presence of major geological structures. However, a caution should be raised on at least two counts. Firstly, it is not always possible to locate all significant geological structures in advance of mining – even with the highest level exploration technologies. Secondly, it must be understood that the presence of a geological structure does not, in itself, represent a potential flow path connecting to the surface. It is a more complex situation related to other geological units, stresses, mining geometries and hydrogeological factors which lie outside the scope of this report. As mentioned in the detailed comments by DSC, a detailed geological risk assessment – once major structures are identified – would be a very useful management tool to address many of the concerns raised.

Concerns are expressed regarding other hydrological matters as well as mining contingency matters, which are outside the scope of this report.

The DSC then also address detailed concerns regarding subsidence prediction, including time dependant effects of reactivation of old goaf areas; and far-field horizontal movements. Similar concerns were expressed in my original review report and warrant further investigation and explanation. The issue of the adequacy of a 1km buffer from the dam wall is also raised in this context and should be further investigated, based on the specific issues raised by the DSC. It is hoped that the Gujarat NRE response to Agency submissions will address all of these concerns through not only discussion, but further analysis of data and modelling parameters.

2.4 NSW Office of Environment & Heritage (OEH)

The OEH submission makes reference to a number of issues, many of which are of a hydrological and surface water management nature. However they also stem from an expressed concern about the adequacy of the subsidence predictions, or at least their view that questions the

adequacy of the subsidence impact assessments, which are claimed to have been under-estimated.

The OEH states that the proposed mine plan will *"have a significant impact on what is clearly acknowledged as an environmentally sensitive and culturally rich area".* This is a matter for the Department to assess the relative values of significant areas – based on all parameters of interest. However, the OEH proceeds to state that *"the longwall layout has not been modified to protect significant natural features...".* This statement may be slightly misleading. I would certainly state that the longwall layout has been modified to address a number of significant natural features. Whether all appropriate features have been considered is a separate matter on which I cannot comment. I have also previously raised the need for greater clarity, and possible modifications in terms of the extent of protection for such features (in matters such as stand-off distances for example).

In the supporting detail the OEH makes a statement that because multiple seams have been mined, the impact on surface features *"are likely to be at least equal to (and potentially worse than) previous mining impacts identified...".* This is a very broad statement which does not take any account of detailed mine dimensions, geology and depth. Whilst such a statement represents one possibility, it is certainly not valid to claim that this is a logical conclusion – without taking account of other factors which may well mitigate against worse or even equal impacts.

OEH makes further comments about previous subsidence impacts of longwall mining as being worse than predicted – again, this is a very broad and unsubstantiated statement. Caution should be exercised in accepting this opinion without supporting evidence from all other sources of previous mining.

A discussion on the risks posed by underestimating the subsidence predictions follows. As previously reported, I share some concerns over the confidence levels in the prediction values, although I note that some contingency has been incorporated into the prediction figures to account for uncertainty in these rather unique mining conditions. In this discussion, OEH notes and agrees with previous advice from the DRE's Chief Subsidence Engineer regarding serious reservations about the subsidence modelling. I have not received a copy of such advice, but would welcome the opportunity to review it before commenting further.

OEH proceeds to identify the lack of prediction data for valley closure and upsidence impacts. This concern was raised in my previous report. They also raise concern about the possible presence of geological structures (as mentioned by DSC).

There is considerable discussion regarding the means of producing subsidence predictions from multiple seam workings. A number of these points may be valid, but some points made are challenged, such as a statement that the total subsidence will be the sum of subsidence from each individual seam. The complexity of seam interactions; old workings and the timing of the different extractions makes the situation far more complex than this statement suggests.

OEH rejects what they refer to as a "trial and error" mining approach. In my earlier comments, I mentioned that the complexity of the subsidence modelling task in this case makes it difficult to make dramatic improvements in quality and accuracy of predictions. Some initial mining under the old workings, with comprehensive and time-dependant surface monitoring (in areas that do not impact significant features) would be a prudent approach to gain further understanding and

validation of the modelling predictions. I would not classify this approach as "trial and error" mining. Such language is rather emotive and misleading.

2.5 Heritage Council of NSW

The Heritage Council notes that previous comments have been made and that these have been adequately incorporated within the Gujarat NRE EA documentation.

2.6 NSW Department of Transport – Roads & Maritime Services (RMS)

RMS notes the existence of a number of requirements already in place for protection of RMS infrastructure. Whilst requesting some further information, at this stage they are not in a position to comment in any detail regarding the EA.

Bruce Hebblewhite
20th June, 2013