THE LAND COURT OF QUEENSLAND
File Numbers: MRA082-13 & EPA083-13

BETWEEN

Applicant:	**HANCOCK COAL PTY LTD (ACN 130 249 973)**

AND

Objectors:	**KATHRYN KELLY,** **PAUL AND JANEICE ANDERSON,** **COAST AND COUNTRY ASSOCIATION OF QUEENSLAND INC,** **PATRICIA JULIEN OF MACKAY CONSERVATION GROUP,** **FIORELLA PAOLA CASSONI, AND** **BRUCE AND ANNETTE CURRIE**

AND

Statutory Party:	**CHIEF EXECUTIVE, DEPARTMENT OF ENVIRONMENT AND HERITAGE PROTECTION**

JOINT EXPERTS REPORT ON GROUNDWATER

1. This joint report has been prepared in accordance with the directions of the Land Court on 22 April 2013, namely:

    8. By 18 July 2013, there shall be a meeting or meetings of experts where:

    (a) the experts in each area of expertise meet and attempt to reach agreement on the issues addressed in their reports;

    (b) the parties and their legal representatives do not participate in the meeting;

    (c) the parties, or their legal representatives, give the experts instructions to meet as directed by the Court, and assist the experts, prior to the meeting, for example, by identifying the issues in dispute and providing relevant documents and information, but no person gives and no expert accepts instructions to adopt, or reject, any particular opinion in relation to the issues addressed in their reports;

(d) *the experts produce a joint report or statement, identifying where they are in agreement, and where they disagree in relation to the issues addressed in their reports. The reasons for any disagreement are to be stated. The joint report or statement is to be prepared by the experts at the meeting, or as soon as practicable thereafter, without instruction from the parties or their legal representatives;*

(e) *save for the joint report or statement, evidence of anything done or said, or an admission made, at the meeting, is not admissible at the hearing of the proceeding except with the agreement of all relevant parties.*

2. The following groundwater experts participated in the meeting of experts:

   (a) Mr Iain Hair – Principal Hydrogeologist at Douglas Partners Pty Ltd, commissioned by Allens, solicitors for GVK Hancock Coal;

   (b) Mr Mark Stewart – Principal Hydrogeologist at URS Australia Pty Ltd, commissioned by Allens, solicitors for GVK Hancock Coal;

   (c) Dr Gavin Mudd (engaged on behalf of an objector, Ms Fiorella Paola Cassoni); and

   (d) Dr John Webb (engaged on behalf of an objector, Coast & Country Association of Queensland Inc).

3. The groundwater experts met in person on 17 July 2013 at the Brisbane offices of URS Australia Pty Ltd.

4. Pursuant to Rule 23 (Expert Evidence) of the *Land Court Rules 2000*, the address and qualifications of each of the experts who participated in the meeting of the experts is set out in their individual reports filed in the proceedings. These matters have not been repeated here.

5. Each of the experts who prepared this joint report acknowledge they having been instructed on an expert's duty in accordance with rule 426 of the *Uniform Civil Procedure Rules 1999* and having understood and discharged that duty, namely that:

(a) A witness giving evidence in a proceeding as an expert has a duty to assist the court.

(b) The duty overrides any obligation the witness may have to any party to the proceeding or to any person who is liable for the expert's fee or expenses.

6. Each of the experts who prepared this joint report verify that they understand their duty to the Land Court of Queensland, and that no instructions have been given or accepted by them to adopt or reject a particular opinion in preparing this report.

Background

7. In December 2009 the Applicant submitted an application for an environmental authority (mining lease) for a level 1 mining project. After submission of required environmental impact and management reports a draft environmental authority (MIN101017310) was issued on 17 December 2012.

8. Objections to the draft environmental authority were received. The Objectors cited their concerns regarding the potential impacts that the proposed mining operations may have on groundwater resources.

9. Expert witnesses in Hydrogeology (Groundwater), Mr Mark Stewart, Mr Iain Hair, Dr John Webb, and Dr Gavin Mudd met at the office of URS Pty Ltd at 240 Queen Street, Brisbane on 17 July 2013 to discuss groundwater concerns outlined in the objections to the granting of draft environmental authority. This Joint Experts Report is based on discussions between the experts, and considers their individual reports and the reports cited in their individual reports, which include:

- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Section 12 Groundwater, Volume 2;
- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Appendix 5G Groundwater, Volume 5;
- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Appendix 5P Environmental Management Plan, Volume 5;

- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Appendix N Groundwater and Final Void Report, Volume 2;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Appendix O Groundwater Bore Survey Report, Volume 2;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Addendum Tailings Storage Facility: Hydrogeological Assessment;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Addendum Tailings Storage Facility: Geotechnical Assessment;
- Hancock Coal Pty Ltd (2012), Alpha Coal Mine Environmental Management Plan, November 2012;
- URS (2012), Report for Hancock Coal Pty Ltd Groundwater Modelling Report – Alpha Coal Project, report ref 42626880, dated 28 March 2012;
- URS (2012b), Report for Hancock Galilee Pty Ltd Kevin's Corner SEIS Groundwater Report, report ref 42626920, dated 18 May 2012;
- JBT Consulting (2010), Great Artesian Basin – Groundwater Implications for Alpha and Kevin's Corner Projects, Letter report ref JBT01-005-015-GAB Summary, dated 3 June 2010;
- Queensland Government (2009), Terms of Reference for an Environmental Impact Statement, Alpha Coal Project, The Coordinator-General June 2009;
- Queensland Government (2012), Alpha Coal Project, The Coordinator-General Report Summary, May 2012;
- Queensland Government (2012), Alpha Coal Project, Coordinator-General's Evaluation Report on the Environmental Impact Statement, May 2012;

- Queensland Government (2012), Draft Environmental Authority (Mining Lease) Non Code Compliant Level 1 Mining Project Permit Number: MIN101017310 – Alpha Coal Mine, 17 December 2012;
- Van Heeswijck, A (2006), The Structure, Sedimentology, Sequence Stratigraphy and Tectonics of the Northern Drummond and Galilee Basins, Central Queensland, Australia;
- Heritage Computing Report (2013), Galilee Coal Project Groundwater Assessment for Waratah Coal Pty Limited, March 2013;
- E3 Consulting Australia Pty Ltd (2010), Waratah Coal China First: Groundwater Assessment, September 2010;
- RPS Aquaterra (2012), South Galilee Coal Project (SGCP) Groundwater Assessment and Modelling, October 2012;
- Salva Resources (2009), Summary of Galilee Regional Model (GAB), Internal Project Memorandum from Salva Resources to Hancock Coal Pty Ltd;
- Smerdon, BD and Ransley, TR (Editors) (2012), Water resource assessment for the Central Eromanga region. A report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment, CSIRO Water for a Healthy Country Flagship, Australia.

Additional reports and datasets were considered when providing the reasoning for the points of disagreement and these are referenced within the Joint Experts Report.

Abbreviations

CHM	Conceptual Hydrogeological Model
EIS	Environmental Impact Statement
GAB	Great Artesian Basin
GDR	Great Dividing Range
MDBC	Murray Darling Basin Commission
NRM	Department of Natural Resources and Mines
SEIS	Supplementary Environmental Impact Statement
TSF	Tailings Storage Facility
URS	URS Australia Pty Ltd

It is noted that there is a Glossary of groundwater terms included in Mark Stewart's Expert Witness Report and has not been repeated in the Joint Experts Report.

Points of Clarification

10. During the Joint Experts Meeting several points of clarification were made and included below. These points facilitated in the groundwater experts' considerations of points of agreement and disagreement.

Point 1

11. The modelling of the final void shows that it will be a permanent groundwater sink, so no pit water can migrate off site within the groundwater. The modelled potentiometric 270 m contour for the water table is concentric around the edge of the final void. This was not clear on the figure in the URS modelling report, and so Dr Webb misinterpreted the diagram as showing that groundwater would leak northwards from the void. Mr Stewart clarified this by presenting a better diagram of the modelled potentiometric contours around the void (Appendix A Figure 5b). Therefore paragraph 70 in Dr Webb's report needs to be modified by deleting sentences 2 and 3 (Northwards groundwater seepage ……. groundwater use.)

Point 2

12. The latest groundwater modelling report (URS, 2012) addressed the Terms of Reference based on the requirements dated June 2009. This report supersedes all previous reports, because as new groundwater information has become available, the groundwater concepts have been refined.

Point 3

13. The impact of the coal mine dewatering has been modeled for the Alpha mine alone and as cumulative impacts for both the Alpha and Kevin's Corner mines. The distinction between the two models needs to be kept in mind. Groundwater Model Report (URS, 2012) provides an impact assessment for Alpha Coal Mine alone, and for the cumulative impacts of mining at both Alpha and Kevin's Corner. Where necessary the impact being assessed needs to be considered.

Point 4

14. Groundwater information presented in the Alpha Coal Project Environmental Impact Statement (EIS), Supplementary EIS (SEIS), and additional hydrogeological reports for the proposed coal mine has been refined over time as new groundwater information became available. The EIS groundwater concepts are superseded in the

latest groundwater modelling report (URS, 2012). The latest Groundwater Conceptual Model is included in Appendix A Figure 1 attached.

Point 5

15. The potential impact of seepage from the Tailings Storage Facility (TSF) was assessed by numerical modelling. The simulation, which adopted conservative input parameters, was considered to be a "worst case scenario". Results showed that seepage would not reach Lagoon Creek until after 300 years (10 times the life of mine). This scenario modelled included a constant water level within TSF simulating constant 12 to 15 m head over 300 years, inclusion of the sub-E model layer (which is not located below the TSF based on drilling results), and no inclusion of an under drain.

16. Mr Stewart states that the simulation of seepage from TSF was an indicative simulation rather than a quantitative one. The display scale used in the model simulation, ranging from 1 to 10, allowed for the tracking of possible plume migration for 300 years under worst case conditions. The scale allows for an indication of plume endpoint after 300 years, where 10 indicates the most probable plume endpoint and 1 being the least likely endpoint (similar approach as particle tracking).

Point 6

17. The conceptual geological / hydrogeological model considered in the Waratah Coal China First EIS has been superseded in the Waratah Coal SEIS.

Point 7

18. It was discussed that the bulk sample pit wall failure, as noted by Dr Mudd in the note for his report cover page photograph, is related to the variable bench / pit wall angles included during construction. This was done to allow for the assessment of pit wall stability, as part of the pit geotechnical evaluation.

Points of Agreement

19. The groundwater experts are in general agreement on the following matters:

<u>Geology</u>

Point 8

20. Tertiary extrusive basalt is not mapped, on the 1:250 000 scale geological map Jericho, to extend onto the eastern mine lease boundary. It is recognised to do so.

Point 9

21. Local geology, within the Alpha Mine Lease, has adequately been represented in the EIS reports in terms of units, strata thickness, dip, and strike. The local geology within the mine area, as defined by extensive drilling, consists of Colinlea Sandstone and Bandanna Formation dipping shallowly (1 to 2°) to the west.

Point 10

22. The Tertiary cover comprises laterite and saprolite, where the saprolite comprises clay-rich residual material considered to be Permian sediments altered during the Tertiary period and iron-cemented Tertiary sediments.

Point 11

23. The Permian age geological units inclusive of the Bandanna Formation and the Colinlea Sandstone are confined, where present, above by Tertiary age saprolite and below by the Joe Joe Formation.

<u>Groundwater Resources</u>

Point 12

24. No groundwater discharge, from the Permian (Bandanna Formation and Colinlea Sandstone) aquifers, to the ephemeral creeks and rivers within the Alpha and Kevin's Corner coal mine leases has been reported.

Point 13

25. The confined aquifer hydrographs (time series graphs of groundwater levels and rainfall, Figures 4-15 to 4-20, Groundwater Model Report URS, 2012) indicate little or no response to seasonal rainfall variation due to slow recharge rates.

26. It is considered by Mr Stewart that the conditions included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part

B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the refinement of recharge rates.

Point 14

27. There is little or no risk to groundwater quality within the Great Artesian Basin (GAB) aquifers as a result of the proposed Alpha mining project. The Coordinator-General's Condition 17(a)(i) includes for monitoring of GAB units including the Clematis Sandstone and Rewan Formation.

Point 15

28. In response to Dr Mudd's enquiry regarding recharge assessment at the Colinlea Sandstone it was noted that groundwater recharge within the Colinlea Sandstone (east of Lagoon Creek) was assessed based on the hydrograph (groundwater level versus rainfall over time) compiled for the existing monitoring bore, ASTF-06B. ASTF-06B intersects the D-E sandstone subcrop at 38 to 44 m below surface. Appendix A Figure 2a depicts the monitoring bore network layout across both the Alpha and Kevin's Corner coal mine areas, and includes the nested bores along Sandy Creek; Appendix A Figure 2b presents the hydrograph for monitoring bore ASTF-06B (adjacent to Lagoon Creek).

<u>Groundwater Conceptualisation</u>

Point 16

29. It was agreed that topography influences groundwater flow and that groundwater within the model domain flows to the north east. Groundwater recharge occurs along the entire Great Dividing Range to the west and south of the Alpha Coal Mine (refer to Appendix A Figure 3, showing surface water drainage direction in the upper reaches of the Burdekin River Catchment, containing the Alpha Coal Mine).

30. Dr Webb and Dr Mudd agree that recharge occurs along the Great Dividing Range to the west of the Alpha Coal Mine and considers groundwater flow within the Alpha lease is to the east and north (average northeast).

Point 17

31. Groundwater quality (chloride method for estimating groundwater recharge) indicates low recharge rates to the confined aquifers (< 1% of Mean Annual Precipitation, or ≤ 5 mm per year as estimated in Smerdon and Ransley, 2012).

Groundwater Model

Point 18

32. It was agreed that the groundwater model construction and calibration, specifically with regard to model layers and hydrogeological parameters (hydraulic conductivity and storage parameters) are appropriate. Mr Hair commented that the numerical modelling undertaken by URS (2012) is of a high standard.

Point 19

33. As the Great Dividing Range represents a no-flow boundary, there will be no impact of dewatering within the Alpha Coal Mine on the Great Artesian Basin (in terms of groundwater quality or quantity). Dr Webb, Mr Hair, and Mr Stewart agree that this is the case, but Dr Webb's conceptual hydrogeological model that determines the no flow boundary is very different from that of Mr Hair and Mr Stewart (see point 29 of disagreement).

34. Dr Mudd does not agree as while he acknowledges the risk is low, if the drawdowns are greater than currently expected and the Rewan Formation has a higher conductivity (or preferential flow path), then the Great Dividing Range may not act as a no-flow boundary. As more projects are developed in the eastern central limb of the Galilee Basin, and if they expand westward, this risk will increase (especially if longwall mining leads to cracking of the Rewan Formation, for example).

Final Void

Point 20

35. Final void integrated modelling included for variations in rainfall and evaporation rates, to assess uncertainty regarding pit water quality and pseudo steady-state pit water level projections (Section 12.6 of the model report (URS, 2012)). Dr Mudd acknowledges this but considers that predicted trends in climate change were not included in the long term model simulations.

Point 21

36. The local groundwater flow patterns and resources will be impacted in perpetuity due to the final void acting as a "sink". It was agreed that the potential impacts of the final void on groundwater resources can be addressed through the provision of alternative water supply, as per the Applicant's make-good commitment and enforcement through the provisions of the *Water Act 2000*.

37. Dr Mudd acknowledges that this is technically true; he has reservations regarding the Applicant's ability to ensure the provision of alternative water in perpetuity.

38. Mr Stewart suggests that the final void, acting as a "sink", would prevent poor quality water migrating off site in the groundwater. This is in line with the Coordinator-General's conditions:

    Condition 10. Water—General

    (a) Contaminants that will or have the potential to cause serious or material environmental harm must not be released directly or indirectly to any waters except as permitted under the conditions of this environmental authority.

    Condition 14. Saline Drainage

    (a) The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of saline drainage.

Point 22

39. As modelled by URS, the salinity of the water within the final void will increase over time (an accumulation of salts due to evaporation). The predictive modelling considering 300 years into the future is sufficient to assess suitability of the water in the void for use.

<u>Environmental Authority Conditions</u>

Point 23

40. Management and conditions will limit the potential impacts of Acid Mine Drainage. The Coordinator-General's condition includes for the management of acid rock drainage, namely:

Condition 13. Water Management Plan

(b) The Water Management Plan must:

(i) provide for effective management of actual and potential environmental impacts resulting from water management associated with the mining activity carried out under this environmental authority; and

(ii) be developed in accordance with the administering authority's guideline *Preparation of water management plans for mining activities* and include:

(A) a study of the source of contaminants;

(B) a water balance model for the site;

(C) a water management system for the site;

(D) measures to manage and prevent saline drainage;

(E) measures to manage and prevent acid rock drainage;

(F) contingency procedures for emergencies; and

(G) a program for monitoring and review of the effectiveness of the water management plan.

Condition 15. Acid Rock Drainage

(a) The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage.

Point 24

41. Make-good commitments include for unduly affected groundwater supplies. It was agreed that the conditions for Alpha Coal Mine regarding make-good ensures water security. Dr Mudd acknowledges that whilst this is technically true; he has reservations regarding the Applicant's ability to ensure the provision of alternative water in perpetuity.

42. Appendix 3, Part B, Recommendation 4 of the Coordinator-General's report includes a copy of the standard Water Licence conditions;

- Condition SPEC6 – Urgent Restoration provides that the Chief Executive may issue notice requiring the licensee to commence an appropriate program for implementation of restoration measures within 48 hours of receipt of notice.

- If, in the Chief Executive's opinion, the Licensee fails to adequately comply with the notice, the Chief Executive will carry out the necessary restoration measures and the Licensee must pay the Chief Executive the costs of carrying out the restoration measures.

43. Dr Webb commented that make-good agreements with local land-holders should be consistent with the *Water Act 2000*, which includes specific conditions in this regard. Water security can be addressed through the provision of an alternative water supply to make good the impacts of dewatering and the final void. Whether these agreements also include the impact of depleted groundwater supplies on the environment is uncertain. Mr Hair commented that the conditions are legally binding, such that if the mining company did not comply then their Water Licence would be revoked.

Matters of Disagreement

44. Based on the discussions held during the Joint Experts Meeting and the subsequent drafting of the Joint Experts Report, the following matters of disagreement and the reasoning were identified:

Conceptual Hydrogeological Model

Point 25

45. Geological conceptualisation (structures) below the Great Dividing Range and influence on potentiometric surfaces of the confined Permian units and groundwater flow mechanisms. Uniformly westwards dipping beds (Mr Stewart, Mr Hair, and Waratah Coal China First SEIS (Heritage Computing Report, 2013)) compared to broad open folding (Dr Webb, Dr Mudd, and Waratah Coal China First EIS (E3 Consulting, 2010)).

Mr Stewart's Response to Point 25

46. Mr. Stewart acknowledged that the potentiometric surface associated with the confined Permian units, specifically the C-D and D-E sandstone presented in the various Alpha EIS, SEIS, and hydrogeological reports is contrary to the dip of the strata (to the west) and that the resultant groundwater flow is to the northeast. It was agreed that the groundwater flow mimics topography (as seen in Appendix A Figure 3). Dr Webb and Dr Mudd argue that the reason for this flow is related to geological structures, more specifically folding, within the units making up the Great Dividing Range where the folding allows for a higher potentiometric pressure (elevated units to the west compared to those mapped within Alpha Coal Mine footprint) within the units which facilitate groundwater movement.

47. Mr Stewart has considered the available geological data and has found no clear evidence of folding within the Great Dividing Range in the portion of Galilee Basin containing the Alpha Coal Mine. Data sets considered, as discussed during the Joint Experts Meeting, included:

- The Salva Resources GAB Model cross-section, derived from 1,201 bore logs, which provided a regional scale (> 200 km) geological trend;

- The Salva Resources cross-sections, constructed west to east, across Alpha and Kevin's Corner mine lease areas;
- The Galilee Basin Operators Forum cross-sections, which do not extend over the Great Dividing Range (RPS, 2012);
- The CSIRO Water resource assessment for the Central Eromanga region, which provides the tectonic and depositional history of the Eromanga Basin, including the GAB units along the Great Dividing Range (CSIRO, 2012);
- The Structure, Sedimentology, Sequence Stratigraphy and Tectonics of the Northern Drummond and Galilee Basins, Central Queensland, Australia, (Van Heeswijck, 2006);
- Queensland Carbon Dioxide Geological Storage Atlas (Queensland Government, 2009);
- Geology of Queensland (NRM, 2013); and
- Galilee Basin Exploratory Coal Drilling – Wendouree Area drilling report, bore logs, and fence diagram (Carr, 1973).

48. It is, however, acknowledged by all that, as the coal measures are located at depth below the topographic high Great Dividing Range and this area is off lease, there is limited local scale bore log data within the vicinity of the Alpha Coal Mine.

49. A site inspection, conducted by Mr Hair and Mr Stewart, across the Rewan Formation and Clematis Sandstone units within the Great Dividing Range (within the Cudmore National Park and Cudmore Resources Reserve) did not indicate any distinct evidence of folding or dipping beds.

50. Based on the available geological information, the Alpha Coal Mine geological model layers and dips, and local site geological outcrop it is considered that the conceptual geological units (dipping to the west with no pronounced folding) adopted in the groundwater model is valid and reflects the site geology. The groundwater model layer elevations in the computer model were created based on

the Alpha Coal Mine geological model[1] (using detailed exploration data), and the computed groundwater levels were calibrated to observed groundwater levels at monitoring bores with regional trends following topographic surface (from southwest to northeast).

51. Dr Mudd considered that there were only three possible mechanisms which can explain the control of groundwater heads to the west of Alpha Coal Mine, which include:

- Major recharge pathway in the Great Dividing Range, resulting in elevated groundwater pressures;
- A surface water feature which maintains a constant water level within the Great Dividing Range; and
- A geological control (an anticline fold which forms an effective divide)

52. It is acknowledged by all that major recharge does not occur due to the nature of the underlying units, the arid nature of the climate, and there are no major perennial surface water features within the Great Dividing Range. Thus, Dr Mudd surmises that the only plausible explanation is a geological control.

53. As stated above in this response to Point 25, there is no clear evidence of folding in the Great Dividing Range within the vicinity of the Alpha Coal Mine.

54. The groundwater conceptual model (as detailed in Point 28) envisaged by URS for inclusion in the predictive groundwater model considered the hydraulic connection of the confined (on three sides[2]) Permian coal bearing units resulting in the potentiometric pressures recorded in monitoring bores across the Alpha Coal Mine. These potentiometric pressures have equalised across the basin. Minor groundwater recharge in the topographic high areas and discharge in the topographic lows results in localised groundwater flow to the north east through the more permeable near

[1] The geological cross-sections generated from the Salva Resources Alpha Coal Mine geological model were reviewed and considered during the Joint Experts Meeting. It was agreed that the geology was representative and comprehensive, not simplified as originally considered in the objections.
[2] Above by the Rewan Formation and Tertiary saprolite, below by the Joe Joe Formation and to the west where the units pinch-out against the basement (Appendix A Figure 1).

horizontal beds within the portion of the Galilee Basin containing the Alpha Coal Mine.

55. Thus it can be argued that the resultant potentiometric surface results from the hydraulically connected and confined strata across the Galilee Basin. Localised groundwater flow occurs due to topography.

56. It is noted that the groundwater flow and units represented within the model are in general agreement with Dr Webb's and Dr Mudd's conceptual models.

57. Even though there is no clear supporting evidence of folding, the conceptualisation of geological structures (folding) controlling groundwater heads to the west of Alpha Coal Mine is plausible. Should folds occur then it is considered that this folding would limit any potential drawdown extension to the west.

58. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease. It is considered that these bores will provide additional geological data, which will be used in the regular model audits (Coordinator-General's Evaluation Report Appendix 3, Part B).

Mr Hair's Response to Point 25(The Conceptual Hydrogeological Model)

59. The Conceptual Hydrogeological Model (CHM) for the Alpha Coal Project has been derived from a number of data sources, namely:

- A geological model derived by Salva Resources;
- 1:250K scale regional mapping produced by the Bureau of Mineral Resources and the Queensland Geological Survey;
- Coal exploration programs which included the drilling of more than 1000 boreholes;
- Groundwater investigations undertaken for the Alpha Coal Project EIS; and
- A number of regional geological studies in portions of the Eromanga, Galilee and Drummond Basins.

The Alpha Coal Project CHM is the basis for the numerical model of URS (2012) constructed to assess the impact of the proposed Alpha Coal Mine on groundwater resources.

60. The current version of the CHM for the Alpha Coal Project is detailed in URS (2012), and is essentially comprised of a series of Mesozoic and Permian stratigraphic units with a near north-south strike, dipping shallowly to the west. The CHM is illustrated in a schematic provided by Mr Stewart (Appendix A, Figure 1 of this report). Some of the units are or contain aquifers with significant groundwater potential; including the Clematis Sandstone, the Bandanna Formation and the Colinlea Sandstone. Other units in the sequence are essentially aquitards (Moolayember Formation, Rewan Formation and Joe Joe Formation).

61. In their expert reports, Dr Webb and Dr Mudd dismiss the CHM of URS (2012) and proffer alternatives, the salient feature of which is significant regional folding of the Mesozoic / Permian sequence, particularly in the vicinity of the Great Dividing Range (GDR) to the west of the Alpha Coal Project.

62. Mudd (2013) suggested that the CHM outlined in the Waratah Coal China First EIS was more appropriate in explaining the hydrogeology of the Alpha Coal Project than the CHM of URS (2012). Since the Joint Experts Meeting, it is understood that Dr Mudd now prefers the CHM of the Waratah Coal China First SEIS, which is not too dissimilar from the CHM of URS (2012).

63. The CHM of Webb (2013) is characterised by a series of near north-south trending synclinal / anticlinal fold structures. Dr Webb bases his alternate CHM on:

- 1:250K Geological Mapping (Jericho Sheet SF55-14);
- Remote sensing imagery including airborne radiometric and magnetic data, Landsat 5 imagery and Google Earth imagery;
- Observations made and photographs taken during an overflight in a light plane; and
- Discussions with local landholders.

64. Figure 8 of Webb (2012) shows cross sections which illustrate Dr Webb's CHM. It should be noted that these cross sections are not supported by any "hard" data, such as bore logs from drilling programs. These cross sections are schematic, the subsurface (boundaries between geological units) are hand drawn to fit with locations of outcrop interpreted from geological mapping and Dr Webb's remote sensing imagery. Different boundaries such as those illustrated in the URS (2012) CHM (characterised by no folding), could just as easily be drawn to agree with known outcrop.

65. Examination of coal exploration drilling data and sections derived from the data by Salva Resources show no folding (synclinal structure) within the Alpha Coal Project ML. "Hard" data from drilling programs show that the easternmost synclinal and anticlinal folds of Dr Webb's CHM do not exist.

66. Dr Webb based his CHM (in part) on observations made and photographs taken of outcrop of the Clematis Sandstone, during a light plane overflight of Cudmore National Park and Cudmore Resources Reserve. Dr Webb claims that dips in bedding consistent with regional folding of the stratigraphic sequence were found. A field inspection comprising a low level helicopter flight, supplemented with an on-ground examination of Clematis Sandstone and Rewan Formation outcrop was undertaken by Mr Hair and Mr Stewart on 6 and 7 July 2013. The flight covered much of the Cudmore National Park and Cudmore Resources Reserve. The on-ground examination incorporated an inspection of an outcrop transect along a track / fire trail into Cudmore National Park. Figure 1 of Appendix D of this Joint Report shows the extent of the helicopter flight and field inspection. No evidence of significant folding of the Clematis Sandstone and Rewan Formation was found. Figure 2 of Appendix D of this Joint Report shows a photograph of typical Clematis Sandstone outcrop in Cudmore National Park. Generally north-south trending cliff-lines and a low angle westerly dip are evident in the photograph.

67. The CHM of URS (2012) is preferred by Mr Hair to that of Webb (2013) and Mudd (2013).

Dr Webb's Comments on Point 25

68. Dr Webb believes that the conceptual geological model of anticlinal folding beneath the Great Dividing Range is a viable hypothesis, that fits available evidence from outcrop patterns (as shown by a detailed remote sensing analysis of the area) and shallow dips evident from a flight over the area. The Waratah Coal China First EIS (E3 Consulting, 2010) used a similar geological model. It should be noted that all cross-sections of the Great Artesian Basin to the west show broad open folding similar to that envisaged as occurring beneath the Great Dividing Range to the west of the Alpha mine (e.g. CSIRO 2009; cross-section on Jericho 1:250,000 geological sheet). The dips of the beds are so shallow (<2°) that they are not evident in close inspection of outcrops or even from a relatively close helicopter fly-over, and for this reason Mr Stewart and Mr Hair did not locate any evidence of dipping beds during their site visit to Cudmore National Park and Cudmore Resources Reserve.

69. Dr Webb agrees that there is topography-driven groundwater flow through the more permeable near horizontal beds beneath the mine area, but this groundwater flow is, overall, not towards the northeast. If the groundwater flow was towards the northeast it would terminate where the Bandanna/Colinlea lenses out against the Joe Joe Formation on the western side of the low range along the eastern side of the Alpha lease. In this case there would be a groundwater discharge zone along the western side of this low range, and there is no evidence of this. In addition, detailed drilling for the TSF shows no evidence for groundwater discharge in this area.

70. The groundwater flow is also not localised. It continues towards the north, and forms part of the headwater system within the Burdekin River basin.

71. Dr Webb agrees that the cross sections showing his conceptual geological model are not supported by bore logs; none are available from close to the Great Dividing Range. These cross sections are schematic, in that the boundaries were hand drawn to fit with interpreted geological mapping and remote sensing imagery. However, the boundaries as interpreted from the remote sensing imagery are difficult to draw to agree with uniformly westwards dipping beds.

72. Dr Webb does not agree that drilling data shows that the easternmost synclinal and anticlinal folds of Dr Webb's conceptual model do not exist. All the detailed drilling occurred within the coal mine leases, where Dr Webb's conceptual model indicates that the beds should dip shallowly towards the west, and the drilling confirms this.

Dr Mudd's Comments on Point 25

73. As I outline in my report, there is clearly a higher groundwater pressure along the western side of the Alpha coal lease area, which coincides with the Great Dividing Range (GDR). Unfortunately the level of geological investigation in this region, some 30 km west of the proposed Alpha coal mine, is insufficient to definitively prove the geological structure and how this relates to the observed groundwater pressures. I maintain the view that the GDR is effectively a constant head boundary, as presented in the Waratah Galilee SEIS and shown in Appendix B Figure 1. It is my view that further field work is required to validate the geological controls on groundwater along the GDR and the interactions between the GDR, Galilee Basin and the Great Artesian Basin groundwater system to the west of the Alpha project area.

Point 26

74. A point of disagreement was the regional geology based on differences in the Salva Resources regional geology and Dr Webb's data sets. Some of the geological boundaries in the Salva Resources GAB Model, particularly the upper and lower boundaries of the Clematis Formation, differ from those mapped by Dr Webb using remote sensing and also from those depicted on the Jericho 1:250,000 geological map.

Mr Stewart's response to Point 26

75. The Salva Resources GAB Report (memorandum dated 18 February 2009) provided a plan view of formation subcrops (Appendix A Figure 6a) and a west-east cross-section across the GAB and Galilee Basin (Appendix A Figure 6b). According to the Salva Resources memorandum the regional geological model had been compiled based on:

- A total of 1,201 bore logs across a > 200 km cross-section to provide a broad trend of dip and strike;

- Detailed topographic data across Alpha MLA70426 and public domain topographic data across the geological model; and

- Stratigraphy to Formation level was included covering the Galilee and Eromanga basins.

76. During the Joint Experts Meeting it was discussed that the subcrops matched the outcrops mapped on the Jericho 1: 250 000 geological map as well as the coal seam subcrops. Dr Webb provided data for comparison which showed the Rewan Formation subcrop contours did not match; however, he was not able to provide the source of the data. It was discussed that the Rewan subcrop mapped by Salva Resources was the upper (western) edge of the formation, which may explain the difference if Dr Webb's data considered the eastern edge.

77. It is noted that the groundwater model layer elevations, units, and thickness were created from the Salva Resources geological model of the Alpha and Kevin's Corner mineral leases (MLA70426 and MLA70425, respectively). It was agreed at the Joint Experts Meeting that the local geology, within the mine footprint, has adequately been represented in the Environmental Impact Statement reports in terms of units, strata thickness, dip, and strike (Point 9 above).

78. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease. It is considered that these bores will provide additional geological data, which will be used in the regular model audits (Coordinator-General's Evaluation Report Appendix 3, Part B).

Mr Hair's Response to Point 26

79. Mr Hair notes that geological boundaries in the Salva Resources GAB Model agree reasonably well with 1:250K geological mapping. He further notes that there are some differences between geological boundaries in the 1:250K geological mapping and geological boundaries outlined in the CHM of Webb (2013). These are the Moolayember Formation to the west and southwest of the Alpha Coal Project ML, which the Webb (2013) CHM includes in the Clematis Sandstone, and the boundary between the Rewan Formation and the Clematis Sandstone in Cudmore National Park northwest of the Kevin's Corner Project ML. However, Mr Hair considers the differences in geological boundaries to be relatively minor, and not of a scale which would diminish the reliability of the groundwater assessment for the Alpha Coal Project.

Dr Webb's Comments on Point 26

80. The basal boundary of the Rewan Formation within the Alpha mine lease, as used by Dr Webb in his conceptual geological model, was derived from Figure 4-6 in the Alpha Coal Project EIS volume 2, section 04 Geology, page 4-9. During the Joint Experts Meeting Dr Webb was unable to locate this figure. This boundary of the Rewan Formation does not match that given on the Salva map, which is much closer to the upper boundary of the Rewan Formation, as Mr Stewart points out.

81. Mr Hair correctly points out that the geological map created by Dr Webb (Fig 4c in his report) differs from the Jericho 1:250,000 geological map in that the latter shows the Moolayember Formation along the western side of the Great Dividing Range, but Dr Webb's map does not show any Moolayember Formation outcrop in this area. A detailed examination of all the remotely sensed images available did not show any differences in the rock outcrops along the western side of the range, where the Moolayember Formation was mapped, in that they appear identical to outcrops that could be definitely identified as Clematis Formation. Therefore these areas were all mapped as Clematis Formation, and this fitted well with the cross-sections when they were constructed (Fig. 8 in Dr Webb's report). The Jericho sheet covers a very large area, and it is possible that the western boundary of the Great Dividing Range was incorrectly mapped (the remote sensing data was not

available to the geologists who mapped this sheet). Only a field visit will resolve this issue.

82. Mr Hair also states that the boundary between the Rewan Formation and the Clematis Sandstone in Cudmore National Park, as observed by Mr Hair during his visit to the national park, does not match that on Dr Webb's geological map. Dr Webb mapped the lower boundary of the Clematis Sandstone at the base of the prominent sandstone cliffs, and this is the same boundary that was used on the Jericho 1:250,000 geological map. The correspondence between the basal Clematis Formation boundary on Dr Webb's map and that on the Jericho 1:250,000 geological map is excellent. Some sandstone beds occur within the unit underlying the Clematis Sandstone (mapped as Dunda Beds by Dr Webb), and this may have led to some confusion as to the location of the basal boundary of the Clematis Sandstone when Dr Hair visited Cudmore National Park.

Dr Mudd's Comments on Point 26

83. No specific comments, except to re-inforce my view that such critical questions of regional geological structure, especially as they relate to groundwater pressure and flow controls, should have been addressed in the EIS and SEIS process – and as I note above, further field work is clearly required to significantly improve knowledge of this issue.

Point 27

84. A water table, unconfined and semi-confined, occurs within the Tertiary saprolite, as recognised within the bore logs below the TSF.

Dr Webb's Comments on Point 27

85. Dr Webb comments that drilling beneath the proposed TSF (Fig 5-2, p. 24 in Out-of-Pit Tailings Storage Facility: Hydrogeological Assessment; Alpha Coal Project Supplementary EIS, ADDENDUM C) shows that the water table within the Tertiary saprolite has essentially the same elevation as the potentiometric surface of the Colinlea Sandstone, implying that in this area the Colinlea Sandstone may be unconfined. The exact relationship between the water table and the potentiometric surface to the west, within the main part of the Alpha lease, is uncertain, but the

storativity values for the lower sandstone beds in the Colinlea Sandstone indicate that these beds are confined.

Mr Stewart's Response to Point 27

86. Mr Stewart considered the groundwater monitoring data compiled in Appendix A of the Groundwater Model Report (URS, 2012), which provides groundwater elevation data for standpipe monitoring bores in the Tertiary (ASTF-01B, ASTF-02, ASTF-03, ASTF-04B, and ASTF-07B). The groundwater level data from these bores indicate an average groundwater elevation of ~ 300 mAHD. The monitoring bore ASTF-06B, screened within the D-E sandstone has an average groundwater elevation of ~ 304.5 mAHD. This indicates a difference of ~ 4 m thus, is not the same elevation as stated by Dr Webb. These data confirm the confined nature of the Permian units as conceptualised and simulated in the groundwater model.

Mr Hair's Response to Point 27

87. Mr Hair has no comment to make in regard to Point 27.

Dr Mudd's Comments on Point 27

88. Dr Mudd considers that this suggests evidence of a possible locally perched aquifer (noting Figures 5-2 and 5-3 of URS, 2011, Out-of-Pit Tailings Storage Facility: Hydrogeological Assessment), demonstrating the local complexity of the geology and hydrogeology.

Groundwater Model

Point 28

89. It was agreed by Dr Webb, Mr Hair, and Mr Stewart that it was appropriate to simulate a no-flow boundary along the western boundary of the groundwater model to simulate a groundwater divide. During the conclave, Dr Mudd indicated the need to consider the model boundary in more detail, in particular the field work required to assess and demonstrate the behavior of the Great Dividing Range acting as either a 'no-flow' or 'constant head' boundary condition for regional groundwater flow.

Dr Webb's Comments on Point 28

90. It is recognised that Dr Webb's conceptual hydrogeological model that determines the no-flow boundary is very different from that of Mr Hair and Mr Stewart (see point 29 of disagreement).

91. Dr Webb agrees that there is a no flow boundary along the Great Dividing Range, and that the head and flux on this no-flow boundary can change over time.

92. However, Dr Webb does not agree that there may be additional flux into the system along this boundary, unless the boundary changes position (see discussion below). A no-flow boundary is exactly that, a boundary across which there is no flow; there cannot be additional flux into the system along this boundary. If Mr Stewart wishes to redefine the boundary as another type of boundary, e.g. constant head, specified head, specified flux, he needs to rerun the model for dewatering the mine site with the newly defined boundary.

93. Dr Webb does not agree that there is a no-flow boundary 10's of kilometers to the west where the Permian units pinch out against the Drummond basement. Firstly, none of the available cross-sections (apart from Appendix A, figure 1) show the Permian units pinching out against the Drummond basement. On the Salva cross-section, which Mr Stewart refers to several times, the Permian units pinch out against the overlying Triassic units, and this is also evident in other cross-sections, including the schematic cross-section in URS (2012).

94. Secondly, if there is a groundwater divide beneath the Great Dividing Range, then to the west of this divide, groundwater within the Bandanna/Colinlea aquifer must be flowing west, down the hydraulic gradient. There is, therefore, no possibility that groundwater from an area 10's of kilometers to the west of the Great Dividing Range can be flowing eastwards beneath the Great Dividing Range and into the mine lease.

95. Dr Webb disagrees with the statement that the Permian units at the Alpha Coal Mine are hydraulically connected to the Betts Creek Beds to the west. There is no doubt that the Permian units at the Alpha Coal Mine are laterally continuous to the west (as shown on the Salva cross-section and the schematic cross-section in URS,

2012), and they are hydraulically connected in the sense that a groundwater divide separates them. However, these strata are not called the Betts Creek beds; this unit occurs in the northern Galilee Basin (Van Heeswijck, A., 2006; RPS 2012). What Mr Stewart calls the Betts Creek beds are better called the Bandanna Formation and Colinlea Sandstone (as shown on the Salva cross-section and the schematic cross-section in URS (2012). The Betts Creek beds may be “Bandanna Formation equivalents, different facies resulting from different depositional systems” but this does not apply to the beds to the west of the mine site, which are shown on the Salva cross-section and the schematic cross-section in URS (2012) as having the same lithology as within the Alpha mine site.

96. Dr Webb agrees that if drawdown from the mine extended to the groundwater divide, then this could cause additional inflow from the west. The amount of additional inflow depends on the conceptual hydrogeological model used. Under Dr Webb’s preferred model of anticline axes along the Great Dividing Range, the groundwater divide would migrate up to 4 kilometers westwards, until the westwards dip on the western side of the anticline prevented further migration (see Fig 8 in Dr Webb’s report). In Mr Stewart’s preferred model of uniformly dipping beds to the west, the groundwater divide could potentially migrate westwards 10’s of kilometers until the Permian strata pinched out, well within the Great Artesian Basin. Under the latter scenario, dewatering within the Alpha Coal Mine is likely to impact on the Great Artesian Basin (in terms of groundwater quantity), because groundwater most likely flows from the Permian strata into the basal aquifer of the Great Artesian Basin where they come into contact as the Permian beds lens out (as shown on the Salva cross-section and the conceptual cross-section in URS (2012). This scenario therefore contradicts Point 19, i.e. Mr Stewart’s preferred model of uniformly dipping beds to the west means that dewatering for the Alpha Coal Mine will have an impact on the Great Artesian Basin by reducing groundwater flow into it.

Dr Mudd’s Comments on Point 28

97. Dr Mudd considers that based on the conceptual model he has been working with (based on the numerous EIS and SEIS studies for various proposed coal projects in

the region), his model simulates a constant head boundary to the west, which is different to Mr Hair and Mr Stewart.

Mr Stewart's Response to Point 28

98. Mr Stewart considered the use of a no-flow boundary within the Great Dividing Range (as shown in Appendix A Figure 4) which allowed for a conservative approach in order to assess potential impacts to the west of Alpha Coal Mine. It was recognised that a groundwater divide is likely to exist within the Great Dividing Range based on available groundwater level data from the Department of Natural Resources and Mines (NRM) groundwater database. The database includes one observed groundwater level to the west of the Great Dividing Range being lower than an observed groundwater level east of the range (Section 7.4.1 Groundwater Model Report, URS 2012). As groundwater flow is recognised to flow northeast on the eastern side of the divide it was interpreted that a likely groundwater divide exists. Thus a no-flow boundary was assumed in the model to represent the groundwater divide.

99. The use of a no-flow boundary is considered conservative as it assumes no groundwater flow from the western side of the Great Dividing Range, even though the strata are hydraulically connected. The head and flux on the no-flow boundary, at the groundwater divide, are not constant and thus can change based on head (gradient) and hydraulic conductivity (k) changes dependent on the adjacent model cell. In reality there may be additional flux into the system based on the hydraulic connection. The no-flow boundary in reality is some 10s of kilometres to the west of the model boundary where the Permian units pinch-out against the Drummond basement (Appendix A Figure 1).

100. The Permian units underlying Alpha Coal Mine are hydraulic connected to the Permian (Betts Creek beds) units to the west.

101. The Betts Creek beds are the Bandanna Formation equivalents, different facies resulting from different depositional systems. This hydraulic connection would result, if drawdown extended across the assumed groundwater divide, to provide inflow (additional flux) from the west. This doesn't happen in the model simulations

of Alpha Coal Mine based on aquifer hydraulic parameters (hydraulic conductivity and storage) and the predicted drawdown (0.5 m drawdown in the D coal seam) only extends to the western mine lease boundary at the end of mine life (Appendix A Figure 5a). The predictive modelling indicates that groundwater drawdown at the end of mining and post-closure (300 years) does not result in drawdown at the groundwater divide. The predicted drawdown contours in the D seam after 300 years, associated with the final void, is presented in Appendix A Figure 5b.

Mr Hair's Response to Point 28

102. Mr Hair is of the view that simulating the western margin of the model as a no flow boundary is the most appropriate boundary condition for what is in essence a groundwater divide.

Point 29

103. Western boundary of the groundwater model a no flow boundary to simulate a groundwater divide. Dr Mudd questioned the western boundary, arguing it was most likely a constant head, as shown by the Waratah SEIS conceptual groundwater model used for the numerical modelling study in that study (Appendix B Figure 1).

Mr Stewart's Response to Point 29

104. Mr Stewart comments that the eastern and western boundaries in the groundwater model were set as no-flow boundaries because of subcrops (Joe Joe Formation to the east) and the water divide assumed corresponding with the surface water divide along the Great Dividing Range. Dr Mudd incorrectly states in his Exert Report that the western boundary was set as constant-head boundary.

105. Appendix A Figure 7 shows a sketch of the no-flow boundary, which is used in groundwater models to simulate surface or groundwater divides.

106. Point 28 above includes comments on the conservative nature of the use of the no-flow boundary closer to the Alpha Coal Mine than the actual no-flow boundary where the Permian units pinch-out against the Drummond basement. It is also considered that when a no flow boundary is used to represent a ground water divide, drawdown may be overestimated, as the groundwater model does not facilitate ingress from the hydraulic connected units to the west of the no-flow

boundary. It is, however, noted that the drawdown does not extend sufficiently westwards from the Alpha Coal Mine to result in drawdown at the model no-flow boundary (Appendix A Figure 5a).

107. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease. These bores will allow for the compilation of additional groundwater level data to further assess the groundwater levels and flow patterns to the west of the Alpha Coal Mine. Make-good agreements to be agreed with neighbouring landholders, where at-risk bores have been identified (Groundwater Model Report URS, 2012), will include the compilation of additional groundwater level data across the area to the west of Alpha Coal Mine. These data will also be included in future model refinements.

Mr Hair's Response to Point 29

108. Mr Hair is of the view that simulating the western margin of the model as a no flow boundary is the most appropriate boundary condition for what is in essence a groundwater divide.

Dr Webb's Comments on Point 29

109. As in Dr Webb's response to Point 28, Dr Webb does not agree that the Permian units pinch out against the Drummond basement.

110. Dr Webb does not agree that drawdown may be overestimated because of the presence of a no flow boundary. If the no-flow boundary is correct, i.e. there is no flow across the boundary, then drawdown should be correctly estimated, because the groundwater model, correctly, does not allow influx from the laterally continuous units to the west.

Dr Mudd's Comments on Point 29

111. As I outline in my report (and agreed by all experts), there is clearly a higher groundwater pressure along the western side of the Alpha coal lease area, which coincides with the Great Dividing Range (GDR). Unfortunately the level of geological investigation in this region is insufficient to prove definitively the

geological structure and how this relates to the observed groundwater pressures. I maintain the view that the GDR is effectively a constant head boundary, as presented in the Waratah Galilee SEIS and shown in Appendix B Figure 1. It is my view that further field work is required to validate the geological controls on groundwater along the GDR and the interactions between the GDR, Galilee Basin and the Great Artesian Basin groundwater system to the west.

Point 30

112. Zone of influence (drawdown impacts) and propagation of drawdown cone to the north over time due to removal of recharge.

113. Dr Webb considers that the drawdown cone will propagate to the north over time due to interception of recharge and northwards groundwater flow.

Mr Stewart's Response to Point 30

114. The concept of effective radius and consideration of drawdown cone propagation is included in his responses to Points of Disagreement 31 and 32.

Mr Hair's Response to Point 30

115. Mr Hair is of the view that numerical modelling undertaken to assess the impact of the Alpha Coal Project on the groundwater system is comprehensive and robust. The extent of the cone of depression which will develop around the open cut to the north and to the south of the mine had been derived from the numerical modelling. Mr Hair is of the view that it can be relied upon.

Dr Webb's Response to Point 30

116. Dr Webb's responses to this point are covered in his response to Points 31 and 32.

Dr Mudd's Response to Point 30

117. It would have been preferred if the model was run for longer, say up to 500 years post-mining to ensure steady state conditions were achieved across the whole Alpha model region to address this issue.

Point 31

118. Constant head boundaries – southern model boundary

119. Dr Webb comments that because the drawdown cone will propagate to the north over time, due to interception of recharge and northwards groundwater flow, the assumption in the model of a constant head southern boundary needs revision.

Mr Stewart's Response to Point 31

120. The constant head boundary to the south was set sufficiently far away from the simulated mining (dewatering and depressurisation) so as not to affect model predictions of groundwater drawdown and groundwater ingress volumes.

121. The southern model boundary is located ~ 40 km from the south MLA40726 Alpha boundary (Appendix A Figure 8). Drawdown predictions at the end of mining at Alpha indicate the 0.5 m drawdown contour (0.5 m difference in pre-mining levels) extends ~ 8 km south of the south MLA40726 Alpha boundary (Appendix A Figure 5a), a marked distance from the southern constant head boundary. A further evaluation of whether the model boundary is sufficiently far from the area of stress within the model (open pit mining according to the mine plan and schedule) was conducted by assessing in-flow rates at steady-state (pre-mining) and post-mining.

122. This distance plus the negligible difference in in-flow rates at the southern boundary during steady-state and post-mining model simulations indicates that the southern boundary does not influence mine predictions and is used correctly in the predictive groundwater modelling.

123. The statement included by Dr Webb in his Expert Report; "Constant head assumes that horizontal inflow and outflow across the boundary are equal" is both vague and misleading. Horizontal inflow or outflow across a constant head model boundary is determined based on hydraulic conductivity and head difference between the specified head in the constant-head cell and the head in a cell adjacent to the constant-head cell, i.e. the flux is calculated based on Darcy's law for each cell; whilst the flow direction is determined based on a higher head to a lower head. Thus the total horizontal inflow across the boundary is not necessarily equal to the

total outflow as the constant head in each constant head cell can be different (based on topography and/or model layer) as well as the hydraulic conductivity in the adjacent cell (based on model layer).

124. Based on Dr Webb's statement that the drawdown cone will propagate to the south over time thus necessitating a revised model boundary condition; it is reiterated that the southern constant-head boundary was selected sufficiently far from the mining site to allow for projections of drawdown overtime (30 year mine life and 300 years post-closure). It is considered that using the low calibrated recharge, marked less than the dewatering rate; allowed for an assessment of a "worst-case" simulation of head decrease and propagation. Modelling indicates that drawdown propagates slowly due to low hydraulic conductivity in the system. Head decrease does not propagate to the constant-head boundary during the evaluation period of 330 years.

125. Decrease in potentiometric surface only occurred within impacted area (effective radius or radius of influence) and cannot be projected infinitely. The effective radius is essentially constrained by hydraulic conductivity, as recognised in the Thiem-Dupuit Steady-State Equation (Kruseman & de Ridder 1991[3]).

Equation 1

$$Q = \frac{\pi k(h_o^2 - h_w^2)}{1\,\mathrm{n}R(/\,r_e)}$$

where

Q = inflow (m^3/day),

k = hydraulic conductivity (m/day)

h_o = head at distance R from centre of pit (m),

h_w = head at distance r_e (m) at pit face (seepage face)

R = radius of "influence" or distance to negligible drawdown (m)

r_e = radius of "well" in this case the pit radius (m)

[3] Kruseman G.P. and N.A. de Ridder. 1991. Analysis and Evaluation of Pumping Test Data. 2nd Edition. International Institute For Land Reclamation and Improvement. Wageningen. The Netherlands.

126. The radius of "influence" (R) can also be estimated using the Sichardt's equation (Powers, 1992[4]).

Equation 2 $R = 3000(H\text{-}h)\ \sqrt{k} + r_e$ *(k for this calculation is measured in m/s)*

127. Based on the Thiem-Dupuit Steady-State Equation, it is considered that once the water level in the final void achieves a pseudo steady-state then the radius of influence reaches pseudo steady-state, as Q and the head difference remain relatively constant (allowing for seasonal changes in rainfall and evaporation). The remaining equation parameters are constant.

128. Thus the zone of impact at the end of mining is determined by the aquifer hydraulic properties; hydraulic conductivity (k). The k values for inclusion in the model were determined through model calibration corresponding to field test values in this case, including the transient groundwater (level and volume) data obtained from the Alpha Test Pit dewatering. It is noted that all the experts agree that the aquifer hydraulic parameters included in the model are representative, including the hydraulic conductivity of the units.

129. It is noted that the independent due diligence assessment of the groundwater model, conducted by Parsons Brinckerhoff (Appendix D Groundwater Model Report, URS 2012) consider that the applied boundary conditions (north and south) are plausible and unrestrictive based on conceptualisation and likely to have minimal impact on model output.

130. It is considered by Mr Stewart that the conditions (Appendix C) included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the validation and assessment of model boundaries.

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[4] Powers, J.P. 1992. Construction Dewatering: New Methods and Applications. Wiley, New York, Second Edition

Mr Hair's Response to Point 31

131. It is considered by Mr Hair that the southern boundary of the numerical model is appropriately simulated as a constant head boundary and that it is set a sufficient distance from the mine.

Dr Webb's Comments on Point 31

132. Dr Webb's responses to this point are covered in his response to Points 31 and 32 together; both points concern constant head boundaries.

Dr Mudd's Comments on Point 31

133. Similarly to the western boundary, the southern boundary has received virtually no detailed geological investigations and the most recent groundwater work for Alpha (URS, 2012), still fails to account for cumulative impacts of the proposed Galilee and South Galilee coal projects to the south of Alpha (it should be noted that the Galilee EIS was released by Waratah in September 2011, while the URS 2012 report was completed in March 2012). Thus, if these projects proceed, the southern boundary condition will not be a constant head but instead be significantly reduced from the assumed values in URS (2012). The cumulative drawdown impacts for groundwater from multiple proposed coal mine projects in the region remain poorly assessed and it is my view that further field investigations and numerical modelling work are required to synthesize a cohesive regional assessment of potential cumulative impacts to groundwater if all projects were to proceed.

134. In his response to Point 31, Mr Stewart proposes the use of the Thiem-Dupuit equation as a basis to consider the radius of drawdown from the Alpha project – however he has chosen the form relevant for an unconfined aquifer, and not the form for a confined aquifer. It is agreed by all experts that the sandstones are confined aquifers. The correct form of the Thiem-Dupuit equation for a confined aquifer is (where parameters are as defined by Mr Stewart, plus b is aquifer thickness in m):

$$Q = \frac{\pi\, k\, b\, (h_0 - h_w)}{\ln (R / r_e)}$$

Equation 3

135. For a confined aquifer, the aquifer thickness is therefore also a controlling factor in flow (Q). Mr Stewart does not clearly articulate a basis for Q as being the effective discharge from the final void due to evaporative losses, and that at steady state the groundwater inflow will be effectively equal to this loss.

Point 32

136. Constant head boundaries – northern model boundary

137. Dr Webb comments that because the drawdown cone will propagate to the north over time, due to interception of recharge and northwards groundwater flow, the assumption in the model of a constant head northern boundary needs revision.

Mr Stewart's Response to Point 32

138. Dr Webb argues that decrease in the level of the potentiometric surface north of the mine would be more extensive than modelled because of invalid constant head boundary in the north (the reviewer argued that the northern head boundary should be decreasing with time). However, the argument is not valid because the northern head boundary was chosen sufficiently far from the mining areas so the head boundary can remain the same even after the 30-year mining operation period (as discussed in Point 31 above for the southern model boundary). The decrease in potentiometric surface only occurs within impacted area (effective radius) and cannot be projected infinitely. The effective radius is essentially constrained by hydraulic conductivity, which was determined through model calibration corresponding to field test values in this case (refer to the Thiem-Dupuit Equation in Point 31).

139. A lower hydraulic conductivity will lead to a smaller effective radius. Thus, a constant head boundary can be specified if it is far beyond the effective radius (or cone of depression). This can also be verified by checking if there is any variation of inflow/outflow across constant-head boundaries during evaluation period. As verified in the modelled water budget, the inflow/outflow rates before mining stay essentially the same as the ones during evaluation period.

140. Groundwater level drawdown and propagation in each of the layers was also considered during the predictive modelling, through the inclusion of observation points within the model domain. For the drawdown impact evaluation and to evaluation potential impacts of induced flow (from over and under lying units to the depressurised D coal seam outside of the Alpha Coal Mine) eight (8) observation points were included north of the Alpha Mine Lease boundary (Appendix A Figure 9), labeled OP-N1 to OP-N8.

141. The long term projected hydrographs for the observation points north of Alpha (Groundwater Model Report Appendix E (URS, 2012)) indicate that groundwater heads do not stabilise once the pseudo steady-state final void water level is reached (after ~ 50 years). This is due to the model layer parameters (low vertical hydraulic conductivity determined from transient calibrations) and the ongoing final void evaporation (which represents a loss from the system). Model projections indicate pseudo steady-state groundwater levels and flow patterns (Appendix A Figure 5b (final void driven levels)) after ~ 300 years. The drawdown in each of the model layers indicates that even with the low calibrated recharge rate (< 0.1 % of Mean Annual recharge) the levels do not continually decrease and propagate northwards during this simulation period. Appendix A Figure 10 presents the projected drawdown levels and trends in OP-N7 and OP-N8 furthest from Alpha (Note these observations include Kevin's Corner as a cumulative impact assessment).

142. The predictive groundwater modelling allowed for the assessment of groundwater impacts to the north of Alpha Coal Mine during mining and 300 years post-closure, which is considered a reasonable time frame to assess drawdown propagation using a worst-case scenario (calibrated recharge < 0.1 % of rainfall) resulting in a larger drawdown cone intersecting through flow. The predicted radius of influence under these conditions does not extend sufficiently far north (or south) to be influenced by constant head boundaries.

143. The long term impacts indicate that groundwater levels do not recover to pre-mining levels and as such the groundwater resources will be "mined" from the Galilee Basin sediments and will be permanently lost.

144. It is considered by Mr Stewart that the conditions (Appendix C) included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the validation and assessment of model boundaries.

Mr Hair's Response to Point 32

145. It is considered by Mr Hair that the northern boundary of the numerical model is appropriately simulated as a constant head boundary and that it is set a sufficient distance from the mine.

146. In regard to both the northern and southern boundaries of the model (this Point and Point 31), the numerical model is to be revised every 3 years as one of the conditions of project approval. In addition, with the development of other coal projects in the Galilee Basin, an industry based basin wide model will be required to include all coal mining projects. The opportunity will arise to reassess the model boundaries on those occasions. However, at present, the existing numerical model is an appropriate tool for assessing the likely impact of the Alpha Coal Project on the surrounding groundwater system.

Dr Webb's Comments on Point 32 (including comments on Point 31)

147. According to Anderson & Woessner (Applied Groundwater Modelling, 2002, Academic Press), boundaries are "the most likely source of error in the modelling process", because they "are largely responsible for how flow occurs in the system". A constant head boundary is one for which there is no drawdown; the hydraulic head value is fixed "regardless of the system conditions in the surrounding grid cells, thus acting as an infinite source of water entering the system, or as an infinite sink for water leaving the system. Therefore, Constant Head boundary conditions can have a significant influence on the results of a simulation" (Visual MODFLOW Professional User's Manual, version 4.2, 2006, p. 226). Surface water bodies are often used as constant head boundaries, because they can supply an effectively infinite supply of water to the hydrogeological system. A constant head boundary must be an equipotential line, so there can be no flow along the boundary, and "the

flow must be directed at right angles either away from or toward that boundary" (Domenico, P.A. & Schwartz, F.W., 1990, Physical and Chemical Hydrogeology, pp.119-120, Wiley).

148. For a groundwater level to remain constant in a dynamic groundwater system with measurable rates of groundwater flow, the amount of groundwater coming into the system must be equal to the amount leaving. This is the basis of all hydrogeological modelling, and follows the law of conservation of mass in a hydrogeological setting; water can be neither created nor destroyed. Therefore across a constant head boundary, the amount of groundwater entering must be equal to the amount leaving, and flow is perpendicular to the boundary.

149. Mr Stewart states that "the constant head in each constant head cell can be different"; this is correct, because it will depend on the characteristics of the adjacent upflow and downflow cells. However, this does not contradict the fact that the inflow and outflow across each cell of the constant head boundary must be equal.

150. From the characteristics of a constant head boundary, it is evident that if the source of water entering or leaving the system across this boundary is not "infinite", then the boundary cannot have a constant head. If the source of water to the boundary is intercepted, as occurs to the north of the mine, then the condition of a constant head boundary can no longer be met. During its 30-year life, the Alpha mine will intercept almost all the groundwater flow to the north, and the final void will permanently intercept the bulk of groundwater flow northwards. Once dewatering has commenced, to the north of the mine groundwater within the aquifer will continue to flow northwards, down the hydraulic gradient, but there will not be an equivalent flow of groundwater from the south, due to interception by the mine, so inevitably the groundwater levels to the north of the mine will decrease and the drawdown cone will advance northwards.

151. Mr Stewart has located the northern boundary of the model ~ 40 km from the northern Kevins Corner boundary. This is an attempt to place the model boundary sufficiently far north that it will be a constant head boundary. The inflow of groundwater from the area unaffected by the drawdown is assumed to be enough to

maintain the head, despite the loss of all or most of the groundwater flow from the area to the south of the mine. However, this will not be the case. Assuming that the topographic catchment matches the groundwater catchment, the total catchment area for the northern boundary of the model is ~14,800 km^2 (most of this is the Belyando River catchment). The catchment area to the south of and within the mine area is ~2800 km^2, i.e. ~20% of the total catchment; groundwater flow from this area will be intercepted by dewatering for the mine. Therefore ~20% of the groundwater flow at the northern boundary of the model will be lost due to dewatering for the mine. It is evident that this decrease in groundwater flow at the designated northern boundary will be sufficient to invalidate the requirements for a constant head boundary.

152. The Thiem-Dupuit Steady-State Equation is a general equation that can be used to calculate the amount of drawdown around a well or pit, due to groundwater pumping from the well or groundwater flow into the pit. The equation assumes that pumping/groundwater flow has been occurring for a sufficiently long time that groundwater flow towards the pit or bore has achieved steady state. However, the equation also assumes that the only influence on the groundwater is the bore or pit that is being considered; the equation does not take into account any other influences on groundwater flow or levels. For the Alpha mine site, as Mr Stewart states, "once the water level in the final void achieves a pseudo steady-state then the radius of influence reaches pseudo steady-state, as Q and the head difference remain relatively constant". However, if the head to the north of the mine declines for the reasons given above, this external influence represents a factor that the Thiem-Dupuit Steady-State Equation cannot take into account. Using a steady state equation does not necessarily indicate a steady-state situation. It should also be noted that the zone of impact at the end of mining is not determined just by the aquifer hydraulic properties; the depth and width of the pit and the rate of groundwater seepage also have an influence.

153. As Mr Stewart states, a constant head boundary can be specified if it is far beyond the effective radius of drawdown. However, in the present case continuing drawdown to the north resulting from the permanent interception of groundwater flow means that the boundary must be drawn even further north, as discussed

above. In addition, there is always the danger of circular reasoning, because using a constant head boundary automatically helps to determine the radius of drawdown determined by the modeling (note the quote from Anderson & Woessner 2002 above).

154. The constant head southern boundary of the model was set ~ 40 km from the southern boundary of the Alpha lease boundary. The rate of pumping from the mine will be far greater than the likely inflow from the area to the south, so the drawdown around the mine will extend to the south, as presently modeled, but not to the southern boundary of the model. However, the constant head southern boundary has been set so far south that it is within 5 km of the drainage divide at the head of Lagoon (Tallarenha) Creek, meaning that it is close to being a no-flow boundary. For the modeling, it would probably have been better to extend the boundary to the drainage divide and define it as a no-flow boundary. Modifying the modeling in this way could well extend the drawdown further to the south; as Mr Stewart states, the use of a no-flow boundary is considered conservative.

Dr Mudd's Comments on Point 32

155. No specific comments on Point 32.

<u>Recharge</u>

Point 33

156. Recharge mechanisms, rates and influence on model.

157. Mr Stewart comments that the negligible recharge (<0.1% of Mean Annual Precipitation), determined during model calibration, simulated in model, allowed for a "worst case" scenario resulting in the assessment of possible groundwater drawdown impacts, i.e. the largest potential zone of influence at the end of mining, as increased recharge to the model would result in less drawdown.

158. Dr Webb states that the amount of recharge is significant. In any case, assuming negligible recharge (<0.1 % of MAP) is not a worst case scenario, because although additional recharge results in less drawdown, it also reduces groundwater flow through the site.

Mr Stewart's Response to Point 33

Recharge Rates

159. The magnitude of recharge applied in the model was obtained through model calibration, taking into account:

- The pre-mining groundwater levels measured across the site (i.e. steady-state calibration targets);
- The range of aquifer hydraulic parameters (based on site specific data); and
- The limited mechanisms and volumes of groundwater discharge (no baseflow to rivers and streams and evapotranspiration due to groundwater depth[5]).

160. The addition of increased recharge would require altering groundwater levels (model would not be calibrated), changing the model aquifer parameters (resulting in these parameters to be outside the range recognised for the units) and/or increase discharge from the model (no readily explainable mechanism). Thus the volume of recharge cannot simply be increased based on assumed recharge mechanisms but rather needs to be considered holistically across the model domain.

161. It is noted that recharge and hydraulic conductivity are closely correlated; a higher recharge would require a higher hydraulic conductivity to be balanced. If hydraulic conductivity is already in a reasonable range of field test values, a higher recharge can only result in higher discharge by feeding into streams or springs, which means more "supply" to streams or springs. In contrast, a lower recharge will mean less "supply" to streams or springs. Thus, in this case a negligible recharge will form a worst case scenario.

162. The recharge simulated is considered to be an order of magnitude smaller than the recharge considered by Dr Webb and Dr Mudd. The use of reduced recharge allowed for the assessment of groundwater impacts of a worst-case scenario. Such

[5] The model includes evapotranspiration as a discharge from the model using a root depth of 3 m. This occurs in the topographic low lying areas within the model domain, along the creeks. This approach uses an average annual volume ignoring seasonal vegetation changes thus the discharge could be overestimated.

that the resultant cone of depression would be larger than the one with a higher recharge. Given a larger cone of depression, the impact assessment is considered to be more rigorous than simulating higher recharge as proposed by Dr Webb and Dr Mudd.

<u>Recharge Mechanisms</u>

163. Based on site geology (bore logs) and groundwater and rainfall hydrographs (specifically AVP-13) it was considered that any potential recharge to the confined Permian aquifers within the proposed Alpha Coal Mine occurs as a result of diffuse recharge along the Great Dividing Range, where the Tertiary cover is thinnest. This mechanism allows rainfall recharge to enter the Bandanna Formation (as recognised in AVP-13 groundwater level over time). The relatively low vertical hydraulic conductivity, relative to horizontal hydraulic conductivity further limits vertical migration from the Bandanna Formation to the Colinlea Sandstone.

164. It is noted that this recharge mechanism is similar to the recharge mechanism considered by Dr Webb in his Expert Report (Figure 8 Middle E-W cross-section).

165. Dr Mudd considers recharge to potentially be ~ 1% of Mean Annual Precipitation but does not provide discussion on the recharge mechanisms.

<u>Influence on Model</u>

166. The impact assessment for the EIS adopted a worst-case scenario approach to allow for a rigorous evaluation of possible impacts on the groundwater resources. Simulating the low calibrated recharge to the confined Permian aquifers, to be impacted during mining, was considered a worst-case scenario as the cone of depression simulated at the end of 30 year life of mine would extend over the larger area based on the model removing the majority of groundwater from storage (i.e. minor recharge input over the 30 years of mine dewatering).

167. The model simulation (mine dewatering for 30 years) includes removal of through flow from south to north and induced flow (over- and under-lying units) within the cone of depression.

168. It is noted that even simulating a larger cone of depression, the impact areas did not extend to springs (for any of the model layer groundwater levels) in the north during the mining period.

Recharge review

169. An independent due diligence assessment (Appendix D of the Groundwater Model Report (URS, 2012)) was conducted by Parsons Brinckerhoff in accordance with the Murray Darling Basin Commission Groundwater Modelling Guidelines (MDBC, 2001). Consideration of recharge in the independent due diligence assessment included:

- The assessment of data analysis recognised that the recharge mechanisms and details provided in the Groundwater Model Report were adequately addressed;
- The recharge and discharge datasets had been adequately addressed;
- Acknowledged that recharge was considered minimal (0.1% rainfall) and discharge was limited to evapotranspiration areas where groundwater is at shallow depths; and
- The review of model parameterisation, permeability and recharge, recognised that recharge was relatively insensitive (i.e. variation in recharge has limited impact on model output).

170. It is considered by Mr Stewart that the conditions included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the refinement of recharge rates over time and validation of model predictions.

Mr Hair's Response to Point 33

171. Mr Hair has reviewed URS (2012) and considers the numerical modelling undertaken to be of a high standard. The numerical model has evolved throughout the EIS process and has been 3rd Party Audit Reviewed in its current form. The

structure, input, and calibration are sound, and results of the numerical model can be relied upon.

Dr Webb's Comments on Point 33

172. With respect to recharge, it is important to specify where the recharge is occurring. Dr Webb agrees that recharge across the area of the mine lease is probably very small, but believes that recharge along the Great Dividing Range is small but significant.

173. Dr Webb considers that most recharge occurs along the Great Dividing Range where the Tertiary cover is absent (rather than thinnest).

174. The chloride mass balance method is a reliable and widely used method to estimate recharge. In the present case Dr Webb used salinity rather than chloride concentrations to calculate recharge, because reliable data on the latter are lacking, and derived a recharge figure of ≤1% of rainfall. Mr Stewart's preferred recharge estimate of 0.1% of rainfall means that the average groundwater salinity in the Alpha Coal Mine area should be 10,000-20,000 µS/cm (using a likely salinity of rainfall of 10-20 µS/cm). This is 5-10 times higher than the actual average groundwater salinity across the area of 2000-3000 µS/cm. There is no possibility, based on the groundwater composition, that recharge can be only 0.1% of rainfall.

175. Dr Webb agrees that negligible recharge could in one sense be regarded as a worst-case scenario, because the resultant reduced groundwater inflow would cause a larger modelled drawdown cone compared to a model with higher recharge. However, the reduced groundwater flow means that the impact of mining through intercepting this groundwater flow will be underestimated.

Dr Mudd's Comments on Point 33

176. In my view, it is reasonable to expect that overall average groundwater recharge rates are low, based on the various EIS and SEIS studies, the arid climate (i.e. high annual pan evaporation rates of ~2.3 m versus modest rainfalls of ~0.54 m; URS, 2012) and other studies (e.g. Smerdon and Ransley, 2012). Furthermore, given the region's surface geology of Tertiary laterite and saprolite, this means that the

surficial soils are of a very low permeability and would effectively act as aquitards except where there was localized coarser or sandy sediments which could lead to a locally perched aquifer (as acknowledged in the Alpha EIS and SEIS and by URS, 2012). Given the intense summer storms which can pass through the region, it is also likely that there can be episodic events of groundwater recharge. The groundwater monitoring presented in URS (2012) is for the sandstones beneath the Tertiary laterite and saprolite surficial cover, and so it can be expected that they show little response to rainfall in the ~2 years of data. The episodic recharge is therefore more likely to occur in areas where there is either direct sandstone outcrop (such as the Great Dividing Range, or the small range east of the Alpha project and Lagoon Creek), or shallow sandstone subcrop. To date the groundwater monitoring bores for the Alpha and Kevin's Corner projects have focused on the immediate environs of the proposed mine areas and there are none in sandstone outcrop or subcrop areas. This failure limits any understanding of the potential for higher recharge rates in localised areas, which is also crucial to understanding hydrogeological boundary conditions and groundwater behaviour for the region.

Point 34

177. The Rewan Formation, although recognised to have zones of increased hydraulic conductivity, is regarded as an effective regional aquitard by Mr Stewart. Dr Webb's conceptualisation is that the Rewan Formation is largely an aquitard but contains zones of high hydraulic conductivity that allow significant recharge in places.

Mr Stewart's Response to Point 34

178. The Rewan Formation comprises labile sandstone and multicoloured (typically red in the Cudmore Reserve outcrops) argillaceous sediments (siltstone). The uppermost Rewan Group is a facies variant known as the Dunda beds, which has greater quartzose content and lutites (a fine grained sedimentary rock consisting of clay- or silt-particles) (Van Heeswijck, 2006). The Rewan Group units (comprising the Rewan Formation and the Dunda beds) in their pristine state have limited groundwater potential. It is recognised that, due to the low hydraulic conductivity of this unit, the confined aquifers of the Great Artesian Basin are bounded by the

Rewan Group (Habermehl, 1997). Secondary processes (such as faulting, fracturing, or weathering) are required to enhance groundwater potential.

179. Dr Webb and Dr Mudd consider that geological structures, broad folds, occur within the Great Dividing Range, which facilitate potentiometric heads recorded on the Alpha Coal Mine site. Dr Webb considers that extensional fractures on the folds could facilitate significant recharge.

180. It is considered that the weathering and laterisation within the Rewan Group would limit the transmissivity of any extensional fractures and that the extent (depth) of the fractures would be limited based on the limited deformation considered (broad folds). Thus it is not likely that any possible fold related faults would extend through the Rewan Group (average vertical thickness of 175 m) to the Bandanna Formation and remain open (filled with fines washed in from surface). This would reduce recharge potential.

181. An estimate of travel time (vertical deep drainage) was conducted to assess the aquitard nature of the Rewan Group, based on the available hydrogeological data compiled during the EIS.

182. Travel time was estimated using the formula:

Equation 3

$$Tt = di / [k/(\eta/100)]$$

Where:

Tt = Travel time (in days);

d = Depth (m), calculated for a vertical thickness 100 m[6];

i = Hydraulic gradient (dimensionless), where i = 1 (vertical movement);

k = Hydraulic conductivity (in m/day), using the calibrated model value 10^{-5} m/day (Table 11-4, Groundwater Model Report URS, 2012); and

[6] The average vertical thickness of the Rewan Group is 175 m, based on information from the Salva Resources GAB model, a conservative 100 m allowing for possible alteration was considered.

η = Porosity (%), using median value based on data in Table 10 (M Stewart's Expert Report).

Tt = 100 m / [0.00001 m/day/(23.3/100)]

Tt = 2,330,025 days (> 6,000 years)

183. It is considered that, ignoring the zones of very low permeability (where drill stem tests did not yield any losses such that a 0 value was recorded) it would take an estimated 6,000 years for groundwater to migrate vertically through 100 m of Rewan Group, indicating the aquitard nature of the Rewan Group.

184. It is noted that the horizontal hydraulic conductivity (k_x) is an order of magnitude greater than the vertical hydraulic conductivity (k_z) calibrated in the groundwater model (Table 11-4 of the Groundwater Model Report, URS 2012). This anisotropy indicates groundwater movement is more likely to occur horizontally than vertically.

185. As per point of agreement 18 above, groundwater quality indicates low recharge rates to the confined aquifers (< 1% of Mean Annual Precipitation). It is considered that the Rewan Formation aquitard reduces recharge to the underlying and adjacent Permian confined aquifers.

186. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease. These bores will allow for the compilation of additional groundwater level data to further assess the groundwater levels and flow patterns to the west of the Alpha Coal Mine. Make-good agreements to be agreed with neighbouring landholders, where at-risk bores have been identified (Groundwater Model Report URS, 2012), will include the compilation of additional groundwater data from the Rewan Formation. These data will allow for additional assessment of the Rewan Formation and aid in assessing potential impacts of mining on the permeability of the unit, for inclusion in future model refinements.

Mr Hair's Response to Point 34

187. The Rewan Formation is an aquitard which is comprised predominantly of siltstones, claystones and shales. The Rewan Formation is highly unlikely to transmit water. Even if it was fractured in part as a result of structural deformation, fractures would tend to heal up with clays derived from weathering of the rockmass.

Dr Webb's Comments on Point 34

188. The table of hydraulic conductivity values provided for the Rewan Formation by Mr Stewart in his Expert Report (Table 10) shows substantial variability, and includes a number of quite high values (up to 1.18 m/day), showing that parts of the Rewan Formation are transmissive. Any calculations of travel time through the Rewan Formation depend entirely on the value of k used; a low value will, of course, give a long travel time. If there are joints, fractures or faults that have, locally, higher k values, then groundwater travel times along these features will be shorter.

189. Dr Webb believes that it is likely that recharge is occurring through the Rewan Formation, particularly where it has been partly removed by erosion. In fact, both conceptual hydrogeological models require recharge through the Rewan Formation. For the folding model, the recharge pathways are shown on Fig 8 of Dr Webb's report. For the model preferred by Mr Stewart and Mr Hair, of uniformly westwards dipping beds, recharge must be occurring into the Bandanna/Colinlea aquifer beneath the high in the potentiometric surface along the Great Dividing Range. This can only be occurring through the Rewan Formation overlying the Bandanna/Colinlea aquifer beneath the Great Dividing Range.

Dr Mudd's Comments on Point 34

190. I agree with and support Dr Webb's view of the Rewan Formation.

Impact Assessment

Point 35

191. Impacts on and source of springs, including Degulla Lagoon

Point 35(a) Registered springs, source, and impact assessment

192. Three registered springs, 405, 70 and 71, are located to the north of Alpha Coal Mine (Appendix A Figure 8). These include the Albro Springs (70 and 71) and are, according to Dr Webb, permanent and artesian.

193. In the Groundwater Model Report (URS, 2012) Mr Stewart considers the springs to be seasonal and not artesian. Dr Webb states that if the springs are fed by groundwater flow from the confined aquifers, they could be impacted by mine dewatering if the drawdown cone propagates to the north (see point 32).

Mr Stewart's Response to Point 35(a)

194. During the EIS groundwater study consideration of the springs was given. Points of consideration included:

- The location of the springs, along a north-south direction, adjacent to a change in slope (Appendix A Figure 11a and Figure 11b);
- The springs appear to emanate at the topographic break of slope, where shallow groundwater is moving west to east from recharge areas on the Great Dividing Range, and discharging at the break of slope at points that also correspond with surface drainage lines;
- A review of hydrology and satellite imagery indicates that these springs are ephemeral (i.e. no perennial surface water flows from these registered springs).

195. It is therefore considered that these springs could be seasonal and flow due to limited effective storage within the colluvium cover at the slope break.

196. However, it was also considered that these springs coincides with the area to the north of Alpha Coal Mine where groundwater levels are at or approaching surface,

so there is an upward discharge potential from the deeper confined (semi-confined) groundwater units, as envisaged by Dr Webb.

197. The potential impact on these springs, if groundwater levels in deeper aquifers were impacted by mining, would mean that the discharge potential for deep (Permian) aquifers is removed at these spring locations, which could in turn impact on the discharge potential of the springs. As no detailed spring assessment (site reconnaissance) had been undertaken, an assessment of the potential for the proposed mining activities to impact on groundwater resources at and below these registered springs to the north was undertaken (URS, 2012).

198. In order to assess the potential impacts of mining on groundwater levels at the springs observation points, to consider both during mining activities and long-term (post closure), were included in the model and located adjacent to the springs (observation points OP-SP70, OP-SP71, and OP-SP405 Appendix A Figure 9). The observation points allowed for the estimation of changes in groundwater level in different model layers / hydrogeological units over time. As the source of the groundwater to the springs was not known, the observation points allowed for an assessment of the confined D seam potentiometric surface and the unconfined Tertiary model layers.

199. Groundwater level data for the Tertiary overburden (Layer 1), Tertiary sediments (Layer 2), and the target D seam was projected over time (30 years life of mine and 300 years post mining). The Tertiary layers were assumed to be saturated and have the same initial heads as the steady-state calibration. No change in groundwater levels (Appendix A Figure 12a and Figure 12b), in any of the model layers, was predicted.

200. As per Mr Stewart's response to Points 31 and 32 above, the radius of influence around the final void, once it reaches a pseudo steady-state (minor seasonal fluctuations), does not continue to propagate infinitely and is projected to not extend within the unconfined or confined aquifers to reach any of the observation points OP-SP70, OP-SP71, and OP-SP405 or OP-N7 and OP-N8 (as discussed in Point 32).

201. It is recognised, as discussed in the response to Point 33, that the model includes evapotranspiration as a discharge mechanism in the model. Evapotranspiration, using a root depth of 3 m, allows for groundwater removal in the topographic low lying areas within the model domain, along the creeks. This approach accommodates perennial groundwater discharge, as envisaged by Dr Webb, as groundwater levels at or approaching surface are discharged using an average annual volume thus ignoring seasonal vegetation changes in evapotranspiration.

202. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the north of Alpha mine lease, which will provide groundwater level data for regular model prediction validation. These bores will provide an "early warning" system should groundwater levels decrease quicker and deeper than predicted. Mitigation measures, such as artificial recharge, could then be considered to address possible impacts on springs.

Mr Hair's Response to Point 35a

203. Mr Hair has confidence in the results of the numerical modelling which indicate that the impact of the Alpha Coal Project will not extend to Albro Springs. The status of the springs (artesian / non-artesian; seasonal / perennial) is immaterial to the question of whether they will be impacted or not.

Dr Webb's Comments on Point 35a

204. Albro Springs are, as Mr Stewart states, located at a break in slope. However, this topographic feature is very subdued; the summit of the Great Dividing Range ~12 km to the west is only ~100m above the surface of the plain around the springs. The appearance of the springs, with extensive surrounding cemented sediments and apparently permanent swamp vegetation around the edges of the adjacent pool, strongly suggests that they are permanent.

205. The groundwater modelling shows that the radius of drawdown around the final void does not extend within the unconfined or confined aquifers to reach the springs. However, this assumes that a pseudo steady-state will be reached, such that

the drawdown does not continue to propagate. As previously discussed, Dr Webb notes that interception of all or most of the northwards groundwater flow from the mine lease means that the drawdown cone will propagate northwards, and could potentially reach the springs.

Dr Mudd's Comments on Point 35a

206. I agree with and support Dr Webb's view of the Albro Springs (70 and 71) being artesian.

Point 35 (b) <u>Degulla Lagoon, source, and impact assessment</u>

207. Dr Webb states that Degulla Lagoon is the only large, permanent surface water body in the region surrounding the Alpha lease; it may be groundwater fed, so could be impacted by mine dewatering if the drawdown cone propagates to the north (see Point 32).

Mr Stewart's Response to Point 35(b)

208. Consideration of Degulla Lagoon was conducted during the Kevin's Corner EIS study, in response to comments received from the owner of Degulla Lake who stated that the Degulla Lake is filled by the overflow water from the Belyando River during flood events. Note Degulla Lagoon is presented on Figure 9 Appendix A.

209. Hydrology (surface water) studies considered the potential impact of mining on the flow of water down Native Companion Creek and Sandy Creek, as these tributaries were considered by the owner of Degulla Lake to contribute large volumes of water to the Belyando River which cause the inflow into Degulla Lake during flood events.

210. It is considered that the Degulla Lagoon (or Lake) is a surface water feature based on:

- Its location within a ~ 24 km length ox-bow, cut-off from the Belyando River;

- Wet season images indicate large flood plain, which is readily recharged through surface water overflow;
- Large (spatial) alluvium is considered to provide storage for the lagoon; and
- Degulla Lagoon is located on or near the geological contact between the Colinlea Sandstone and the Joe Joe Formation; these units were intersected during drilling on the Alpha mine lease and indicated limited groundwater resources.

211. It is noted, however, that as the Degulla Lagoon is located within the area north of Alpha Coal Mine, where groundwater levels are at or approaching surface, and adjacent to the observation points included in the groundwater model. The impacts on groundwater levels in this area, as evaluated for the springs (Point 35 (a)), were simulated and are not projected to be altered during the life of the mine or post-mining (300 years). The observation points (Appendix A, Figure 9) OP-N7 and OP-N8 (as discussed in Point 32) located between Alpha and the Degulla Lagoon do no indicate any marked decrease in groundwater levels (even when considering the cumulative impacts of Alpha and Kevin's Corner coal mines), including the unconfined Tertiary unit, as shown in Appendix A Figure 10.

212. The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the north of Alpha mine lease, which will provide groundwater level data for regular model prediction validation. These bores will provide an "early warning" system should groundwater levels decrease quicker and deeper than predicted. Make-good provisions would then be planned to address possible impacts on the water supply from Degulla Lagoon, should it be found that groundwater contribution to the lagoon has been reduced due to mining.

Mr Hair's Response to Point 35b

213. It is understood that Degulla Lagoon is sustained by periodic surface water overbank flood flows from the Belyando River. The lagoon maybe in part sustained by groundwater seepage. Regardless of the source of water, Degulla Lagoon is located north of the extent of the cone of depression indicated by

numerical modelling. The potential for Degulla lagoon to be adversely affected by the Alpha Coal Project is very low.

Dr Webb's Comments on Point 35b

214. Degulla Lagoon is definitely filled by the Belyando River during flood events, but it is also permanent, even during extended periods of drought, and therefore may be groundwater fed. As for Point 35(a), Dr Webb acknowledges that the groundwater modelling shows that the drawdown around the mine does not extend to reach the lagoon, but interception of all or most of the northwards groundwater flow from the mine lease means that the drawdown cone will propagate northwards, and could potentially reach the lagoon, which is only 12.5 km from the 0.5 m drawdown contour as presently modelled.

Dr Mudd's Comments on Point 35b

215. No comments on Point 35b.

Point 36

216. Regional impact on the Burdekin River Catchment, significance of impact on a regional scale.

217. Dr Webb states that because the interception of recharge and groundwater flow is permanent, this will have a regional impact on the Burdekin River Catchment.

Mr Stewart's Response to Point 36

218. The groundwater model simulations allowed for an estimate of groundwater extraction during the life of mine, 30 years. It is estimated that a total of 60 GL (Alpha mine only) will be removed, an average extraction of 2 GL per year. The resultant impact on the groundwater resources, in terms of drawdown, has been assessed (Appendix A Figure 5a). Mine dewatering, at the rate of 2 GL per year, will reduce groundwater resources within the drawdown cone. It is considered that as the reduced groundwater resources do not have an impact on baseflow (ephemeral creeks and rivers) and do not impact the possible groundwater discharge features (Albro Springs and Degulla Lagoon) as considered by Dr Webb; it is considered that the proposed groundwater extraction of 2 GL per year will have

limited impact on surface water resources, which provide the main contribution to water resources in the Burdekin River Catchment.

219. URS conducted an assessment of the integrated surface water-groundwater model water budget. This model was constructed and calibrated to assess long term groundwater impacts associated with the final void. Modelled simulations of groundwater ingress after mining ceases resulted in continued groundwater extraction of ~ 600 m^3/day which reduces to ~ 450 m^3/day (7 to 5 L/s) after 300 years. This equates to a groundwater extraction volume of 0.22 to 0.16 GL/year. When a recharge rate of 0.1% of Annual Rainfall (500 mm/year) is considered, the resultant area of recharge required to yield 0.16 GL/year is ~ 320 km^2.

220. The annual groundwater extraction from the Burdekin River Catchment is estimated at 913 GL/year (SKM, 2012[7]), thus the long term impact of extraction would increase the current annual groundwater extraction volume by ~ 0.018%. Such groundwater extraction (through evaporation from the final void) from the final void area of ~ 24 km long by 270 m wide (~ 6.5 km^2) is considered to have a limited impact on the regional groundwater resources within the Burdekin River Catchment, an area comprised of 132,000 km^2 (almost 8% of Queensland). The physical size of the final void equates to 0.005% of the catchment area.

221. It is noted that groundwater contribution in the upper reaches of the Burdekin River Catchment, containing the Alpha Coal Mine, is limited as no groundwater from the confined aquifers (to be dewatered during mining) contributes to baseflow (Point 13) and as such the water contribution to the catchment is considered to comprise mainly of surface runoff. Groundwater resources utilised in the Burdekin River Catchment are predominantly associated with the Lower Burdekin floodplain where unconfined alluvium provides irrigation for ~ 80,000 ha. It is considered as these unconfined groundwater resources are recharged through rainfall, irrigation return flow, and managed aquifer recharge, the relatively minor reduction in groundwater volumes upstream of the Burdekin Dam are not considered to impact on these groundwater resources.

[7] Sinclair Knight Merz, 2012. Impacts of groundwater extraction on streamflow in selected catchments throughout Australia, Waterlines Report Series No 84, June 2012

222. The Alpha Coal Mine conditions (Appendix C) include the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the north, south, and west of Alpha mine lease. Regular groundwater monitoring data collection and analyses coupled with regular model audits will allow for the verification of groundwater impacts on local and regional groundwater resources.

Mr Hair's Response to Point 36

223. Mr Stewart has given a detailed credible response to this question (above). It is clearly evident that on the basis of comparing the volume of groundwater which will be intercepted by the Alpha Project with the quantum of groundwater resources of the Burdekin Basin, that a minimal (if at all discernible) impact will occur.

Dr Webb's Comments on Point 36

224. Mr Stewart acknowledges that 60 GL (2 GL/year) will be permanently withdrawn from the groundwater system during mining; 2 GL/year represents ~0.2% of the current annual groundwater extraction in the Burdekin River Catchment. The final void will largely intercept groundwater flow from the headwaters region of the Lagoon Creek catchment, an area of ~2800 km^2 (~2% of the area of the Burdekin River Catchment). Permanent removal of groundwater as a result of mining may not directly impact groundwater extraction on the Lower Burdekin floodplain, but it is likely to reduce baseflow in the Belyando River.

Dr Mudd's Comments on Point 36

225. No comment on Point 36 as it is outside the scope of my report.

Point 37

226. Groundwater experts could not agree that the groundwater approval conditions included in the following documents:

(a) Coordinator-General's Evaluation Report on the environmental impact statement, dated May 2012;

(b) Approval Decision under the *Environment Protection and Biodiversity Conservation Act 1999*, dated 23 August 2012; and

(c) Environmental Authority (Mining Lease) Non Code Compliant Level 1 Mining Project Permit Number: MIN101017310 – Alpha Coal Mine, dated 17 December 2012,

are appropriate and sufficient.

Mr Stewart and Mr Hair's Response to Point 37

227. Mr Stewart and Mr Hair agree that the conditions are appropriate and sufficient to:

- Assess and address identified potential impacts;
- Allow for the validation of predictions;
- Assess cumulative impacts of multiple coal mines;
- Ensure water security; and
- Provide a suitable framework to address potential impacts and make-good on water resources.

Dr Webb's Comments on Point 37

228. Dr Webb, in his Expert Report states that he is in agreement with all the conditions, however, there are a list of several modifications that he thinks are necessary (paragraphs 26 to 31 in his report). He therefore considers that the conditions are not appropriate and sufficient.

Dr Mudd's Comments on Point 37

229. Dr Mudd, in his Expert Report states that he is in general agreement with all of the conditions (paragraphs 5.1.1 to 5.1.6 in his report), however, some need more precise definition to ensure they achieve the objective of groundwater protection. There are a list of several modifications that he thinks are necessary. He therefore

considers that the conditions can be further improved, as discussed in paragraphs 5.1.1 to 5.1.6 of his report.

Agreed Recommendations

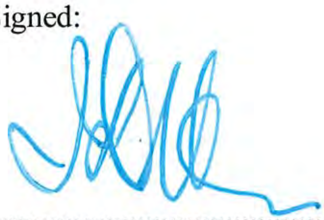
1. During the Joint Experts Meeting it was discussed that the conditions required additional consideration and the agreed recommendations included:

    - It was agreed that clarity is required with regards to the conditioned Galilee Basin regional groundwater model in regard to extent. That is, the regional model should focus only on the eastern central limb of the Galilee Basin where coal mining is proposed to occur.

    - The Groundwater Monitoring Program must include a groundwater monitoring network that allows for the monitoring of potential drawdown to the north, south, and west of the Alpha Coal Mine. Groundwater monitoring network is to include locations to the east, adjacent to mine water and waste infrastructure.

    - It is recommended that the audits of the groundwater model should occur at intervals of no longer than 3 years during the life of mine and post-closure.

Signed:



.... 02 August 2013

Mr Iain Hair

Signed

.... 02 August 2013

Mr Mark Stewart

Signed

.... 02 August 2013

Dr Gavin Mudd

Signed

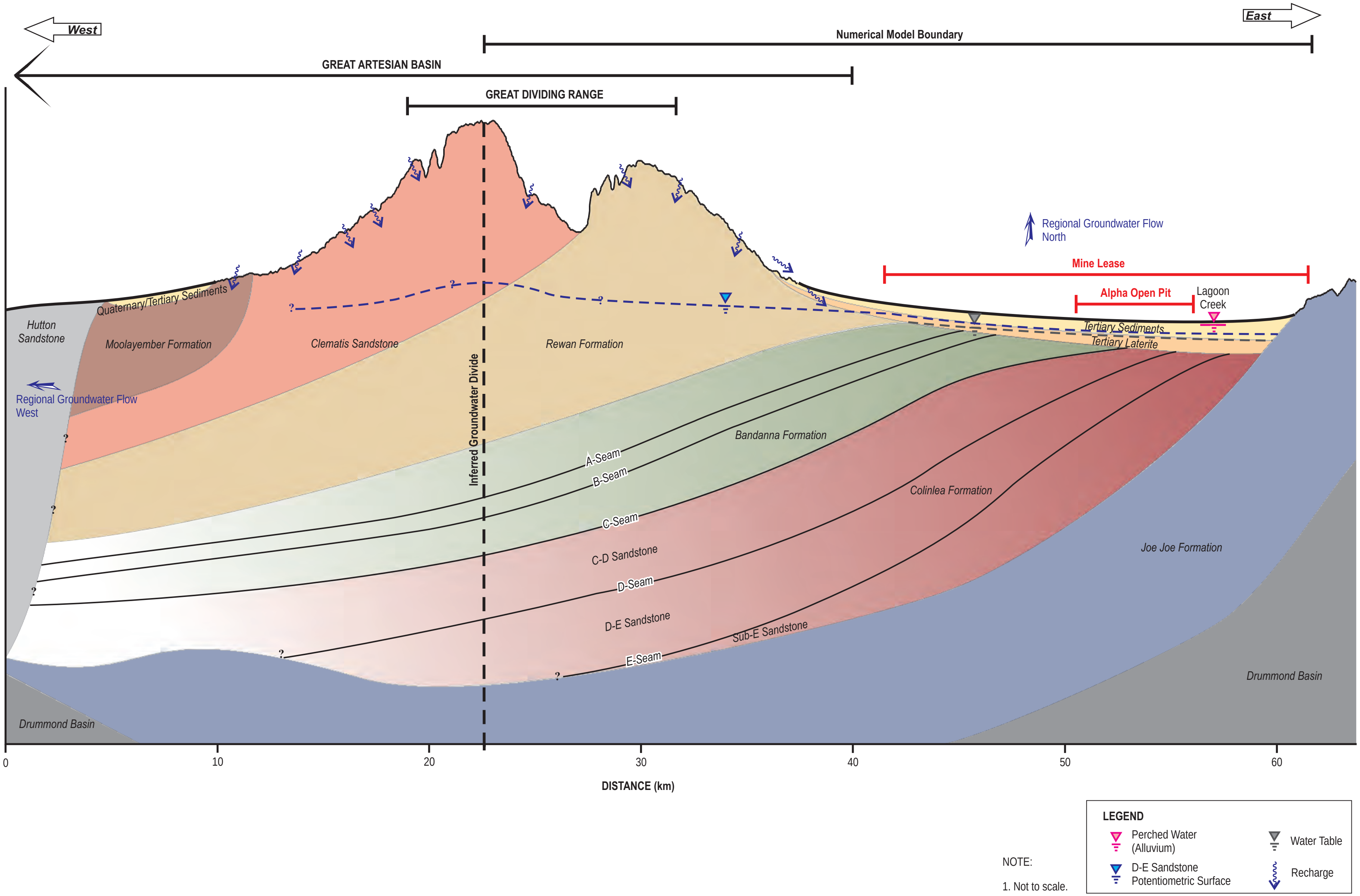
....

Dr John Webb

02 August 2013

Appendix A Mark Stewart Figures

Source:



NOTE:

1. Not to scale.

URS

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ALPHA COAL MINE PROJECT

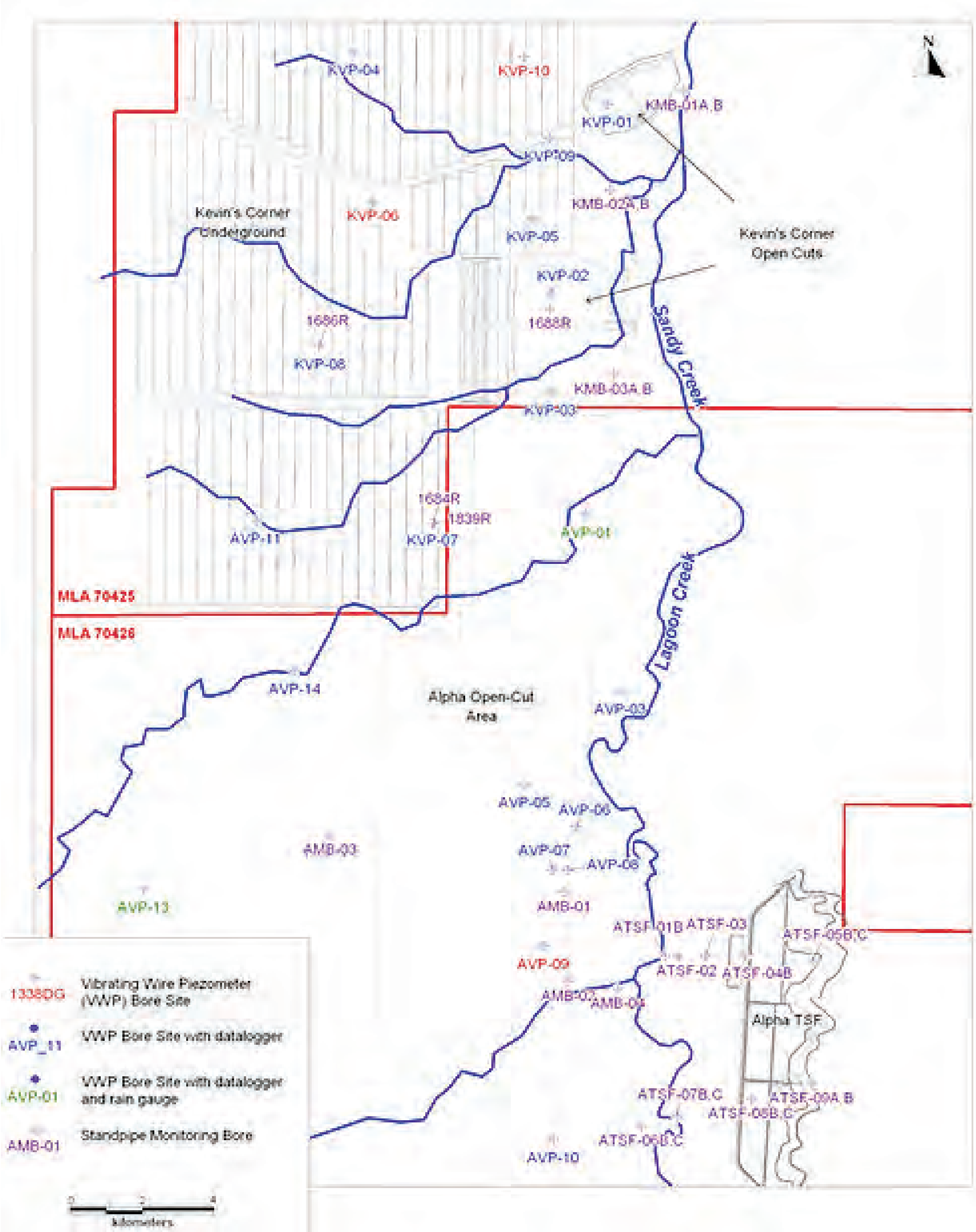
Draft

CONCEPTUAL GROUNDWATER MODEL

JOINT EXPERTS REPORT ON GROUNDWATER

Figure: 1

File No: 42627132-g-101.cdr Drawn: XL Approved: MS Date: 31-07-2013 Rev.A A4



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MONITORING BORE LAYOUT

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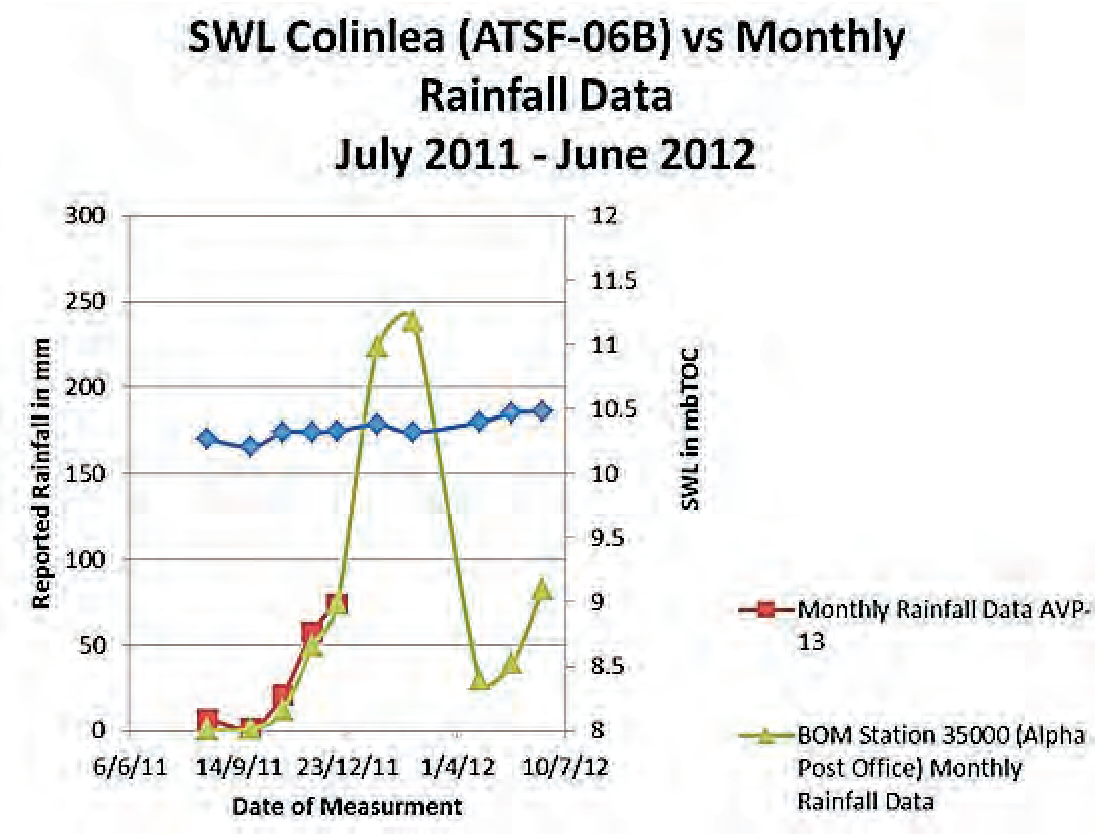
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **2a**

File No: **42627132-g-102.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev.**A** A4



Source:

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ASTF-06B HYDROGRAPH

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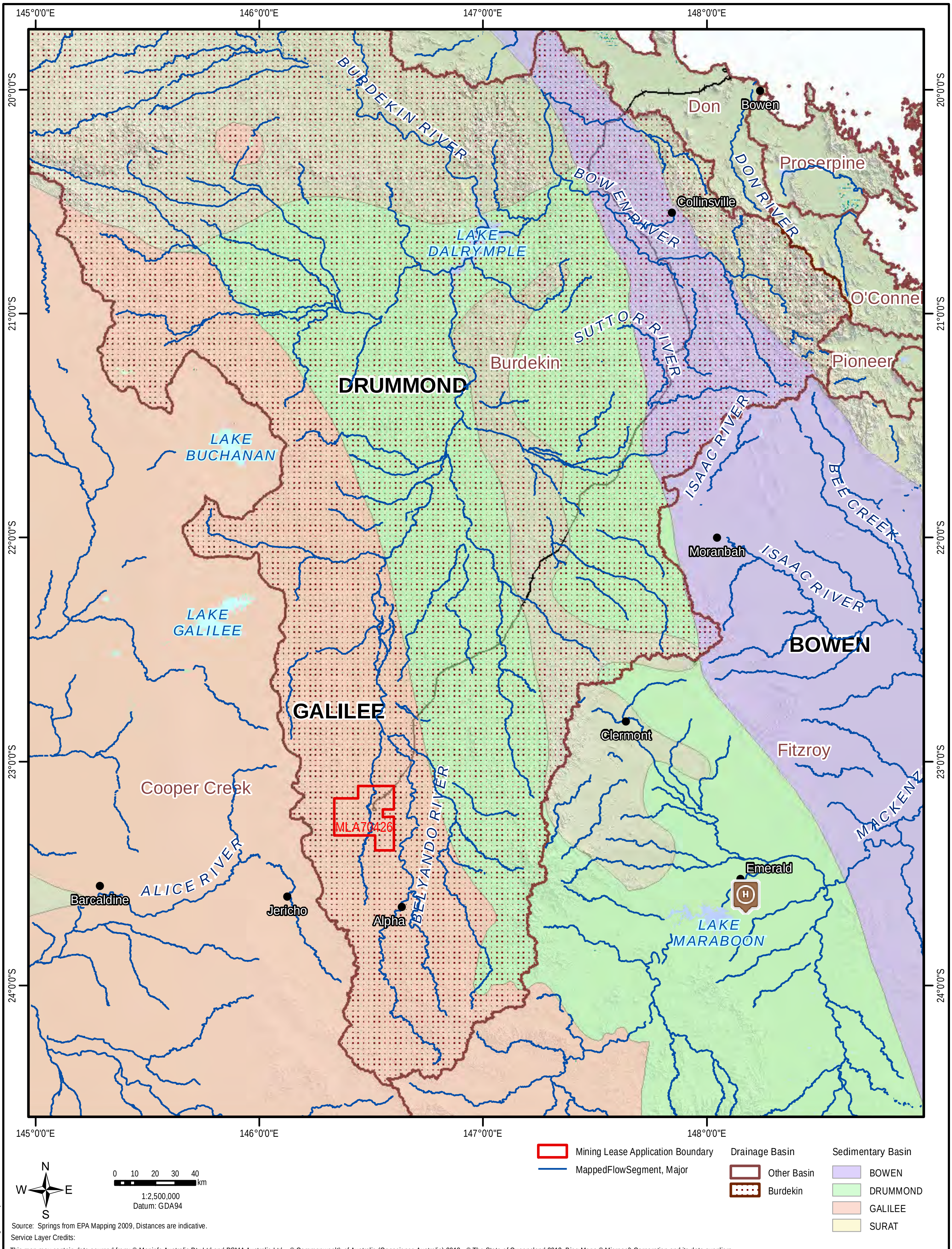
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: 2b

File No: 42627132-g-103.cdr Drawn: XL Approved: MS Date: 31-07-2013 Rev.A A4



Source: Springs from EPA Mapping 2009, Distances are indicative.

Service Layer Credits:

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BURDEKIN RIVER CATCHMENT

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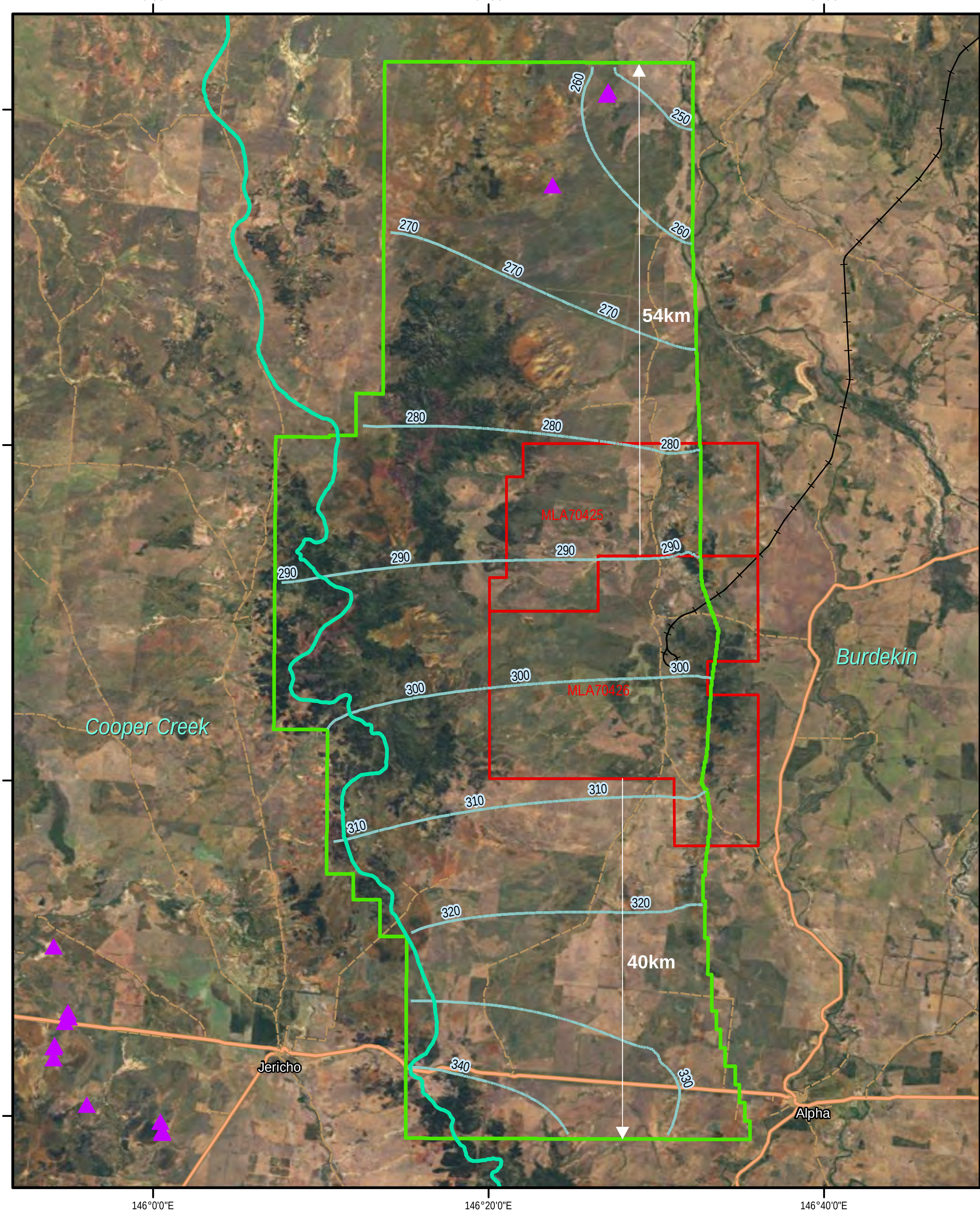
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **3**

File No: **42627132-g-104.mxd** Drawn: **MH** Approved: **MS** Date: **31-07-2013** Rev. **A** A4



Source: Springs from EPA Mapping 2009, Distances are indicative.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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MODEL DOMAIN AND BOUNDARIES

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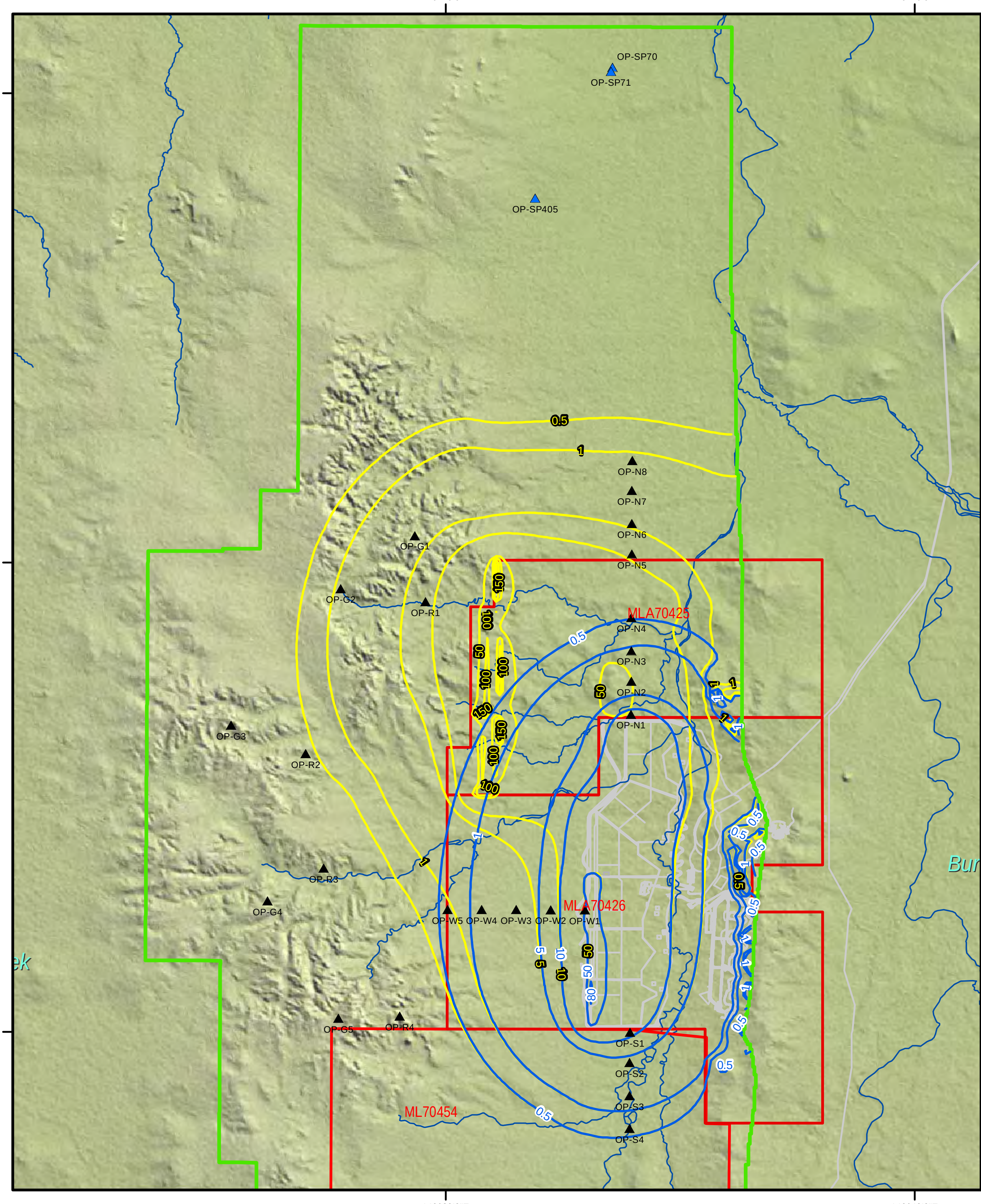
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **4**

File No: **42627132-g-105.mxd** Drawn: **MH** Approved: **MS** Date: **31-07-2013** Rev. **A** A4



N E S W

0 2.5 5 7.5 10 km

1:430,000
Datum: GDA94

Observation Point
Spring Observation Point
Alpha Only D-Seam Drawdown
Combined Alpha and Kevins Corner D-Seam Drawdown
Model Boundary
Mining Lease/Mining Lease Application Boundary
Drainage

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DRAWDOWN CONTOURS IN THE D SEAM AT LIFE OF MINE

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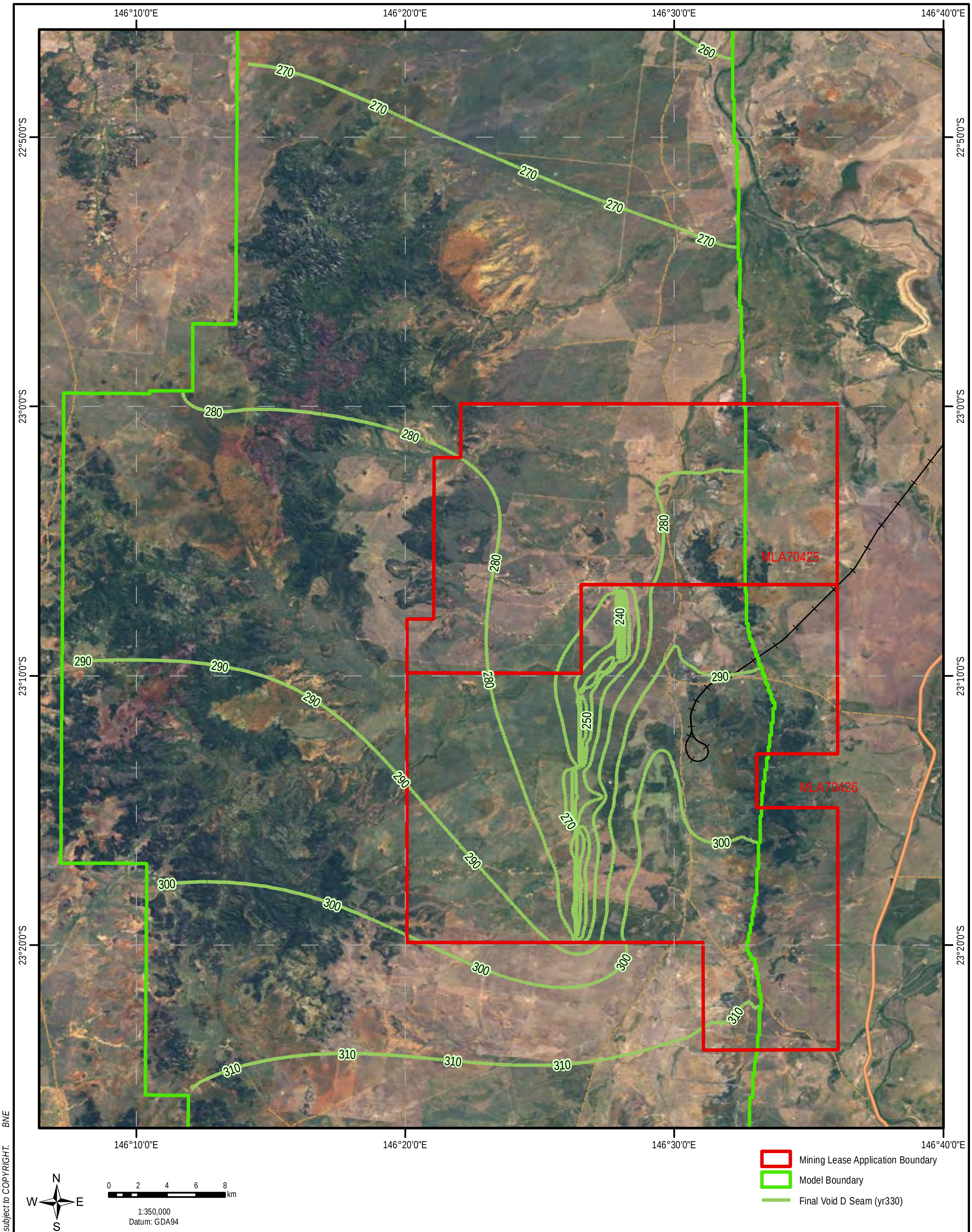
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **5a**

File No: **42627132-g-106.mxd** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev. **A** A4



Source: Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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ALPHA COAL MINE PROJECT

FINAL VOID DRAWDOWN CONTOURS IN THE D SEAM AFTER 300 YEARS

Draft

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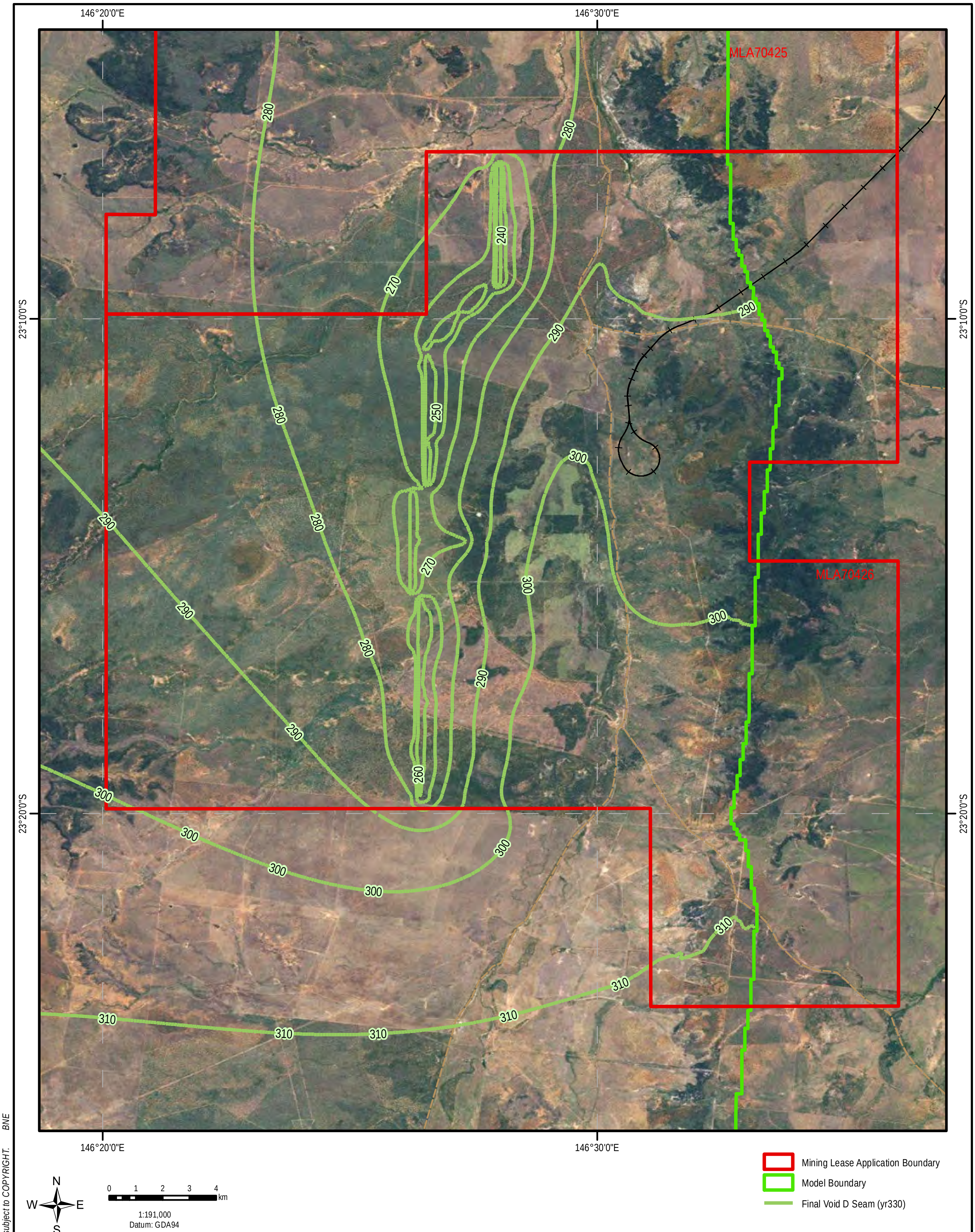
JOINT EXPERTS REPORTS ON GROUNDWATER

Figure: **5a**

File No: **42627132-g-107.mxd** Drawn: **MH** Approved: **MS** Date: **31-07-2013** Rev. **A** A4



Source: Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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FINAL VOID DRAWDOWN CONTOURS IN THE D SEAM AFTER 300 YEARS

Draft

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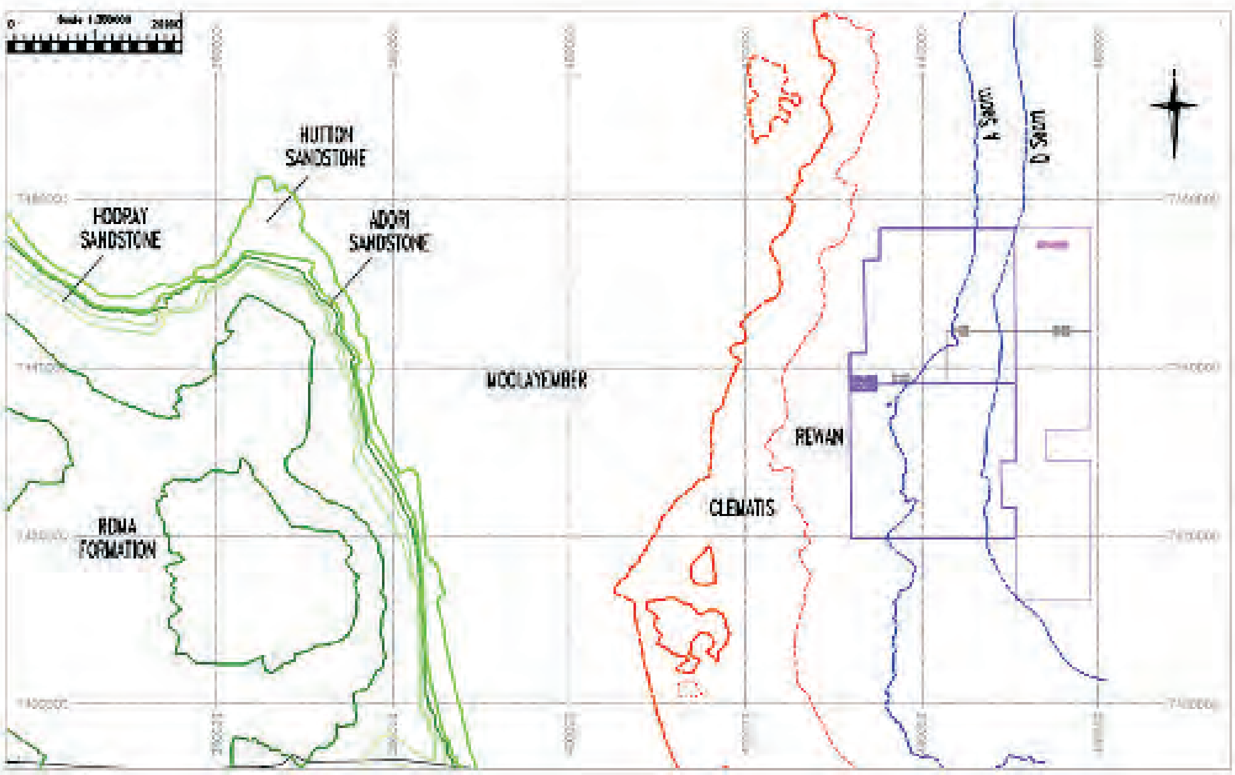
JOINT EXPERTS REPORTS ON GROUNDWATER

Figure: 5b

File No: 42627132-g-107.mxd Drawn: MH Approved: MS Date: 31-07-2013 Rev. A A4



Source:

GVK RESOURCES

ALPHA COAL MINE PROJECT

SALVA RESOURCES GAB GEOLOGY MODEL PLAN VIEW

Draft

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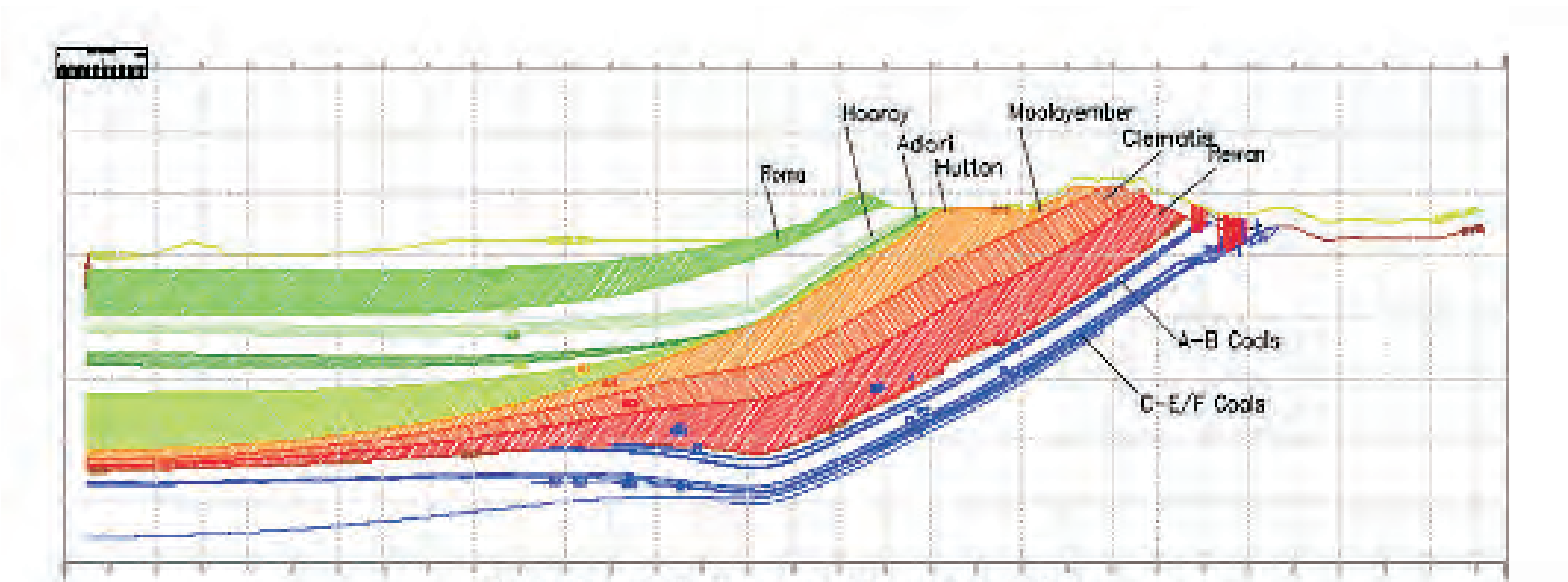
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **6a**

File No: **42627132-g-108.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev. **A** A4

Source:



Pictorial, vertical exaggeration V/H=>30:1

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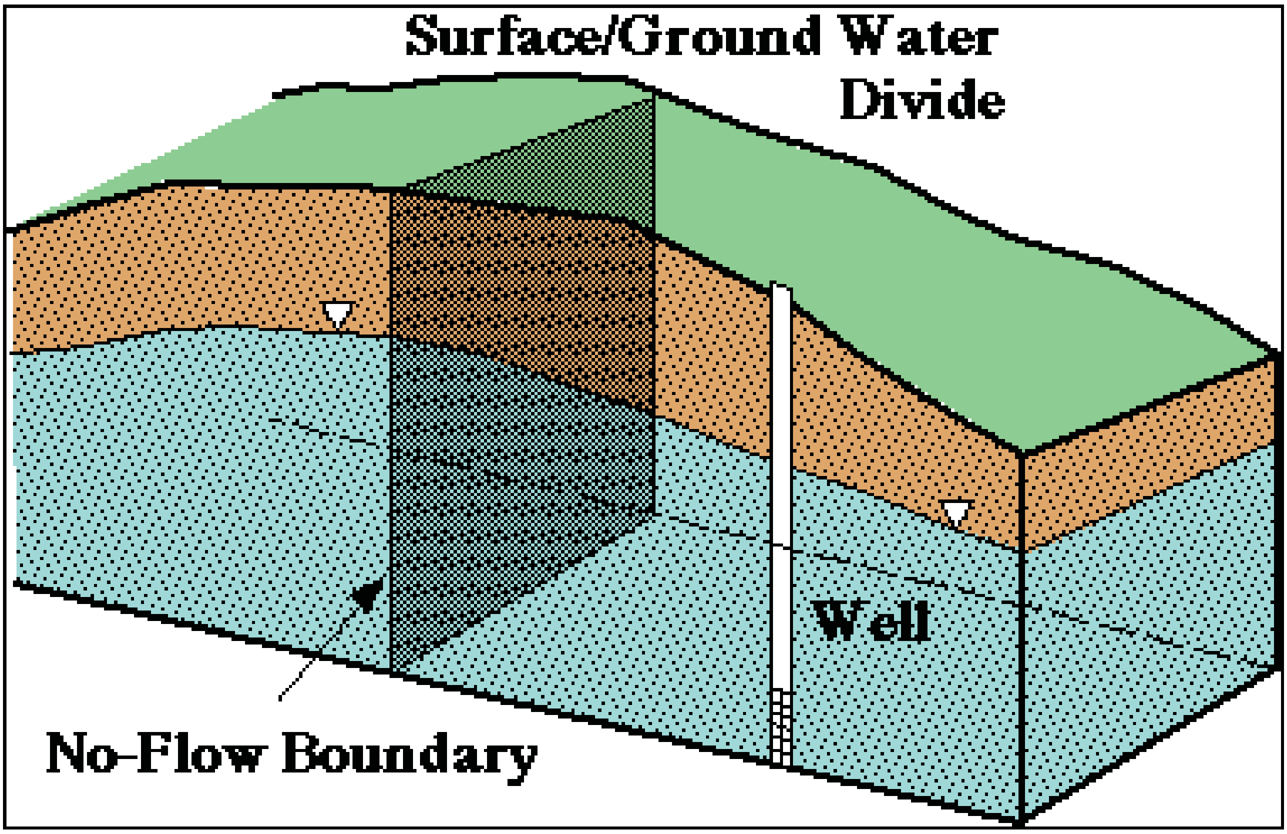
ALPHA COAL MINE PROJECT

JOINT EXPERTS REPORT ON GROUNDWATER

SALVA RESOURCES GAB GEOLOGY MODEL CROSS-SECTION

Figure: 6b

File No: 42627132-g-109.cdr Drawn: XL Approved: MS Date: 31-07-2013 Rev.A A4



Source: www.inside.mines.edu/

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NO FLOW BOUNDARY SKETCH

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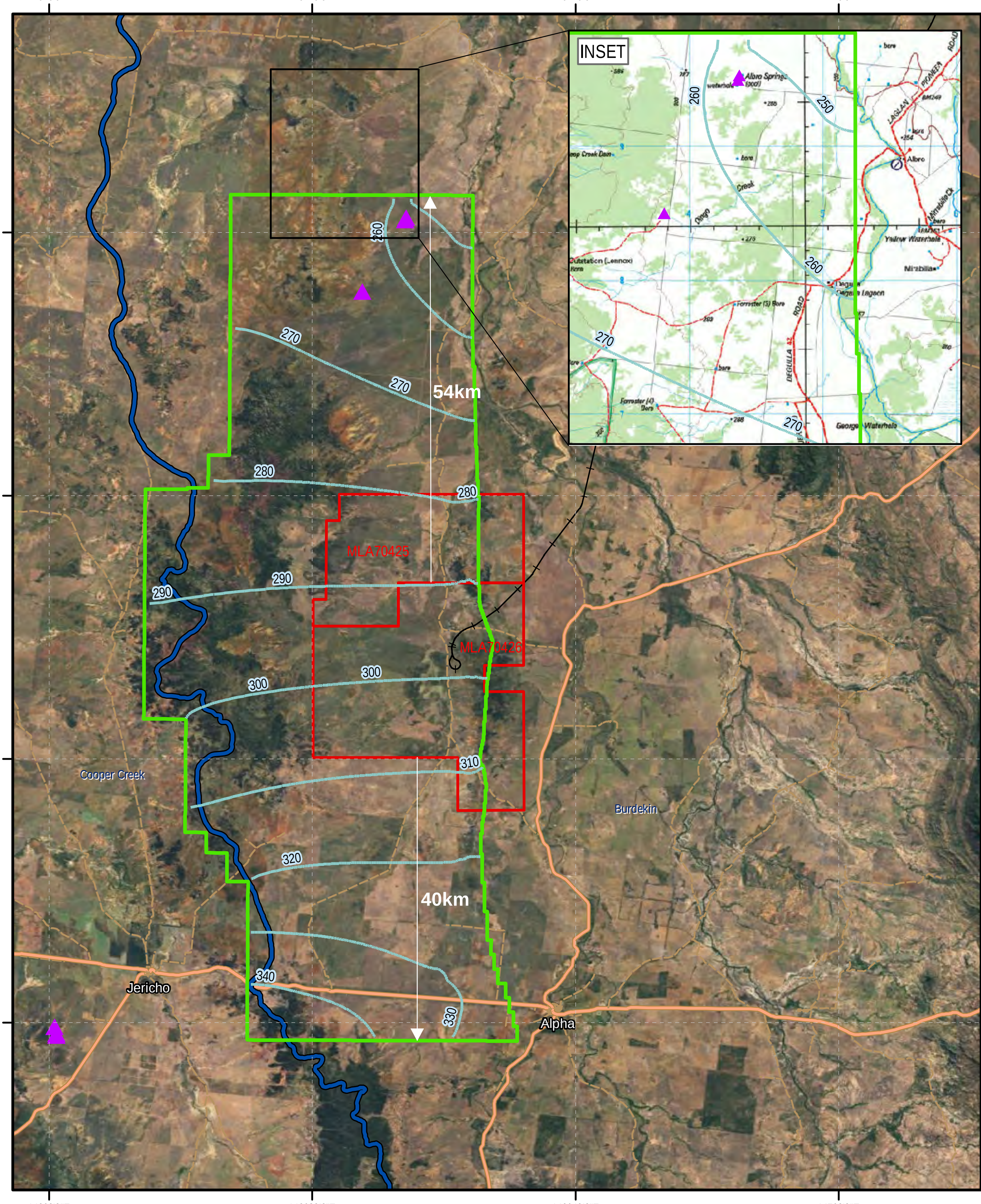
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **7**

File No: **42627132-g-110.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev.**A** A4



N W E S

0 4.5 9 13.5 18 km

1:766,267
Datum: GDA94

Spring
Steady State Contours
Model Boundary
Mining Lease Application Boundary
Catchment

Source: Springs from EPA Mapping 2009, Distances are indicative.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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MINE AND MODEL BOUNDARIES (INCLUDES SPRINGS)

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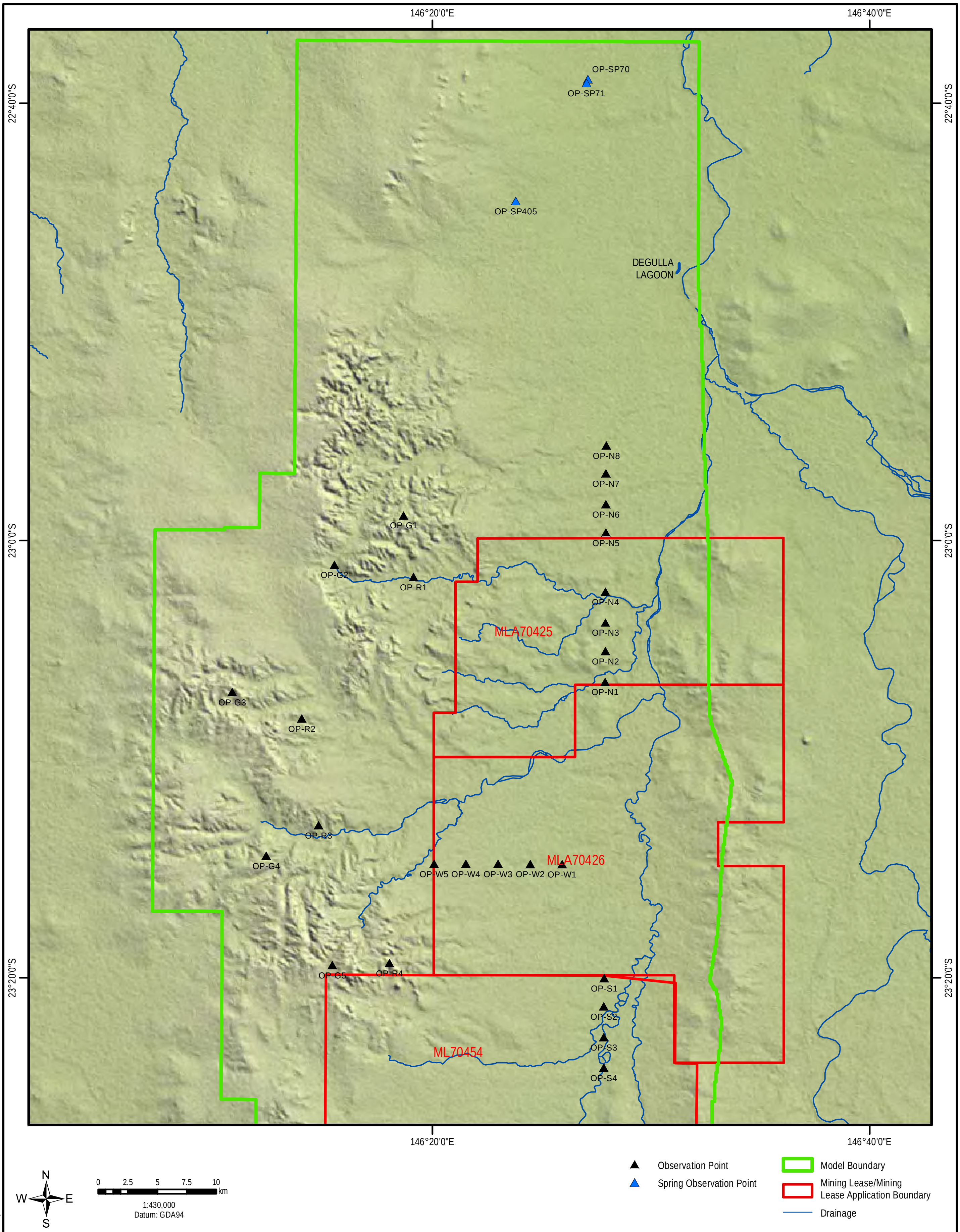
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **8**

File No: **42627132-g-111.mxd** Drawn: **MH** Approved: **MS** Date: **31-07-2013** Rev. **A** A4



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OBSERVATION POINTS WITHIN THE GROUNDWATER MODEL

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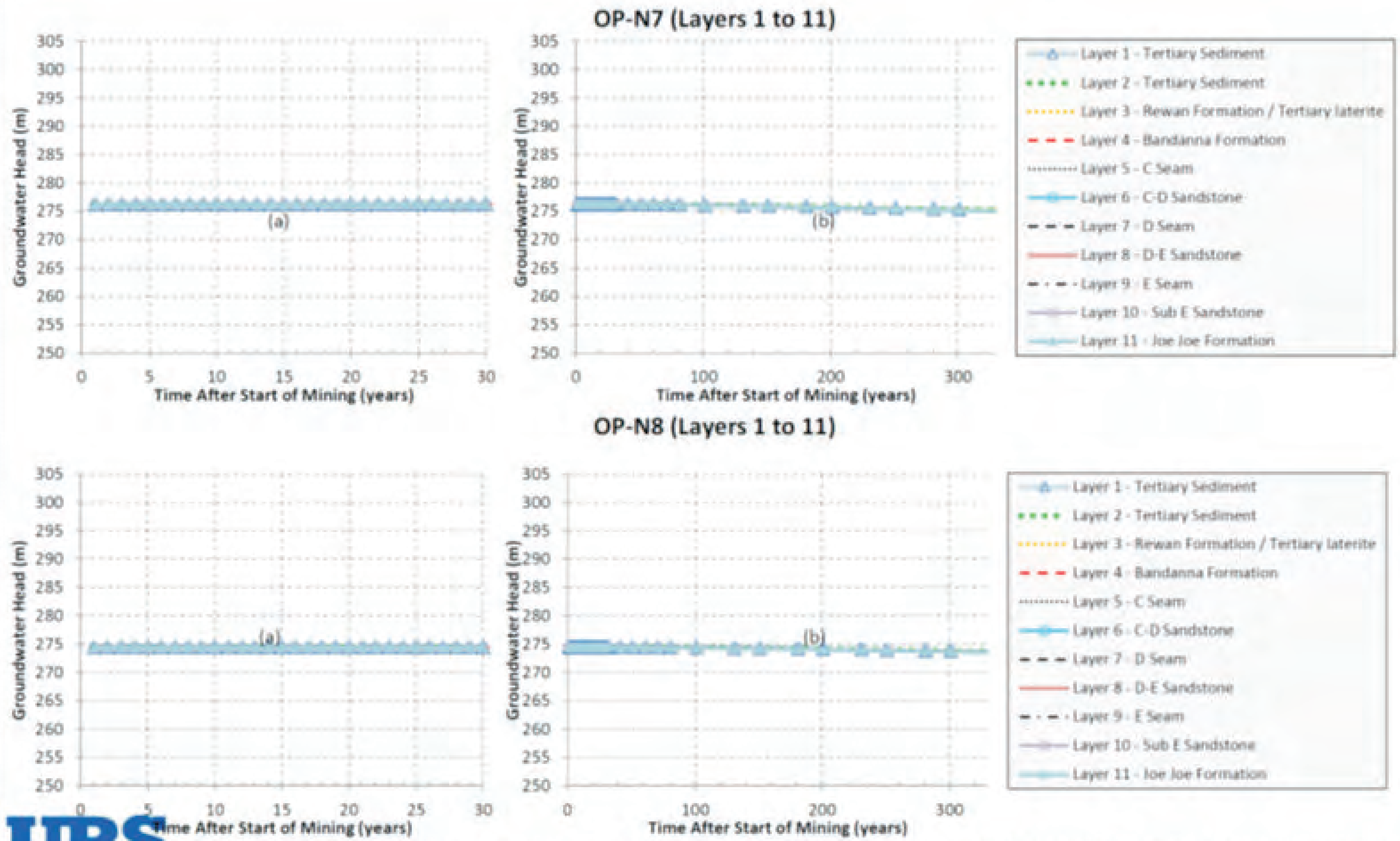
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **9**

File No: **42627132-g-112.mxd** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev. **A** A4

Source:



Model Projected Groundwater Heads for (a) 30-Year Life-of-Mine and (b) Long-Term Recovery - North Transect Near Kevin's Corner

Figure E14

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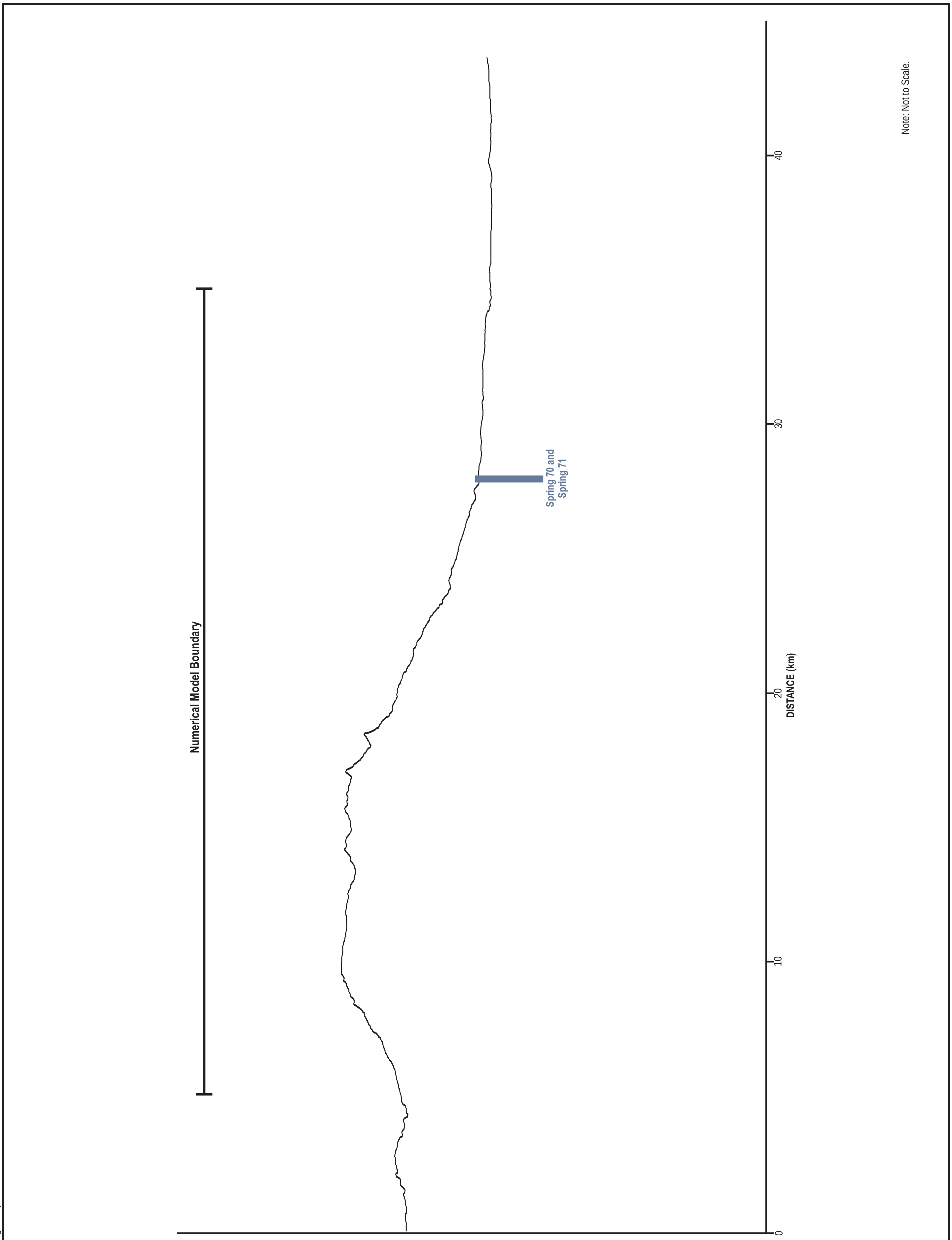
ALPHA COAL MINE PROJECT

JOINT EXPERTS REPORT ON GROUNDWATER

OP-N7 AND OP-N8 PROJECT GROUNDWATER LEVELS

File No: **42627132-g-113.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev.A A4

Figure: **10**



Source:

GVK RESOURCES

ALPHA COAL MINE PROJECT

TOPOGRAPHIC CROSS-SECTION WEST TO EAST ACROSS SPRING 70 AND 71

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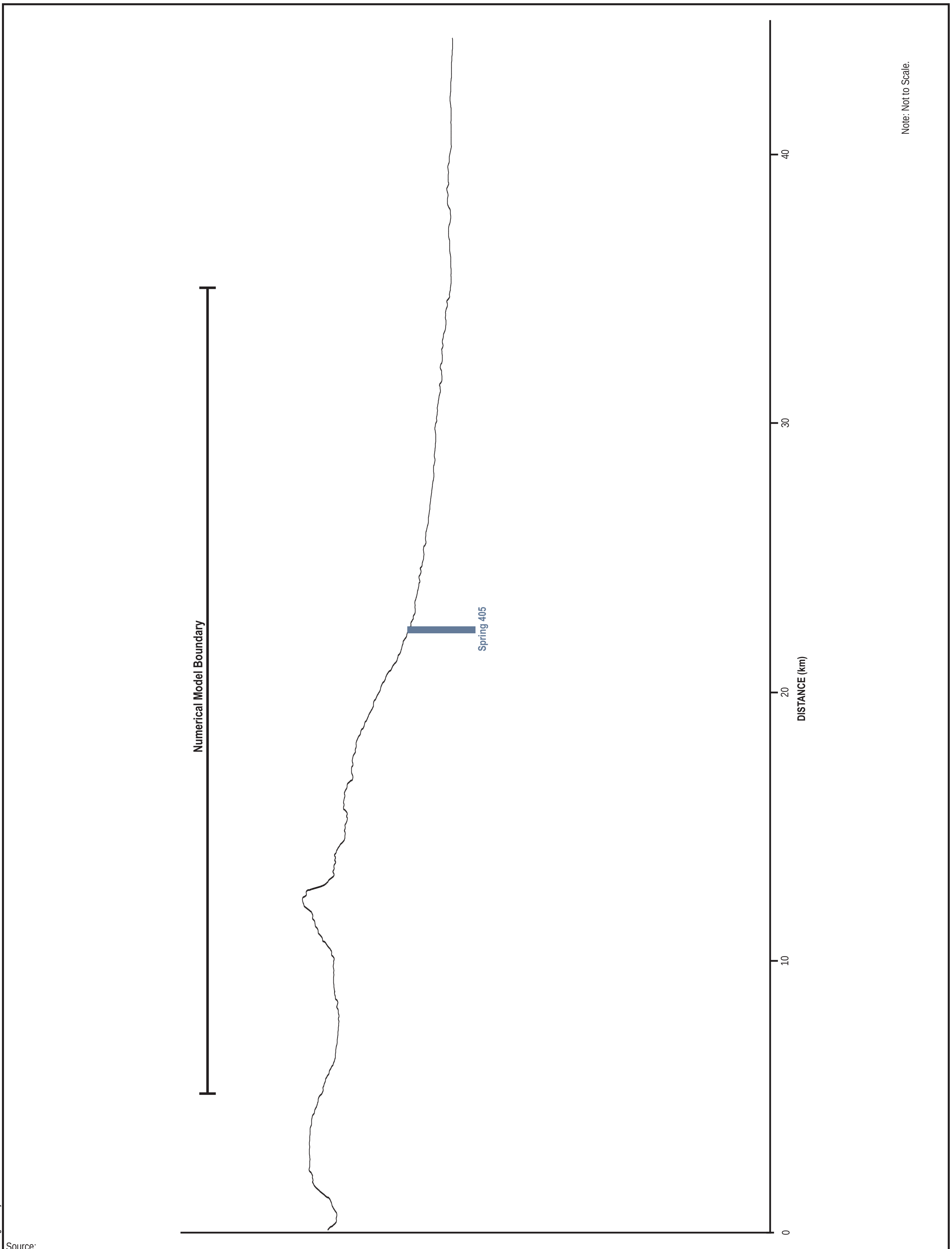
JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **11a**

File No: **42627132-g-114.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev.**A** A4



Source:

GVK RESOURCES

ALPHA COAL MINE PROJECT

TOPOGRAPHIC CROSS-SECTION WEST TO EAST ACROSS SPRING 405

Draft

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JOINT EXPERTS REPORT ON GROUNDWATER

Figure: 11b

File No: 42627132-g-115.cdr | Drawn: XL | Approved: MS | Date: 31-07-2013 | Rev.A | A4

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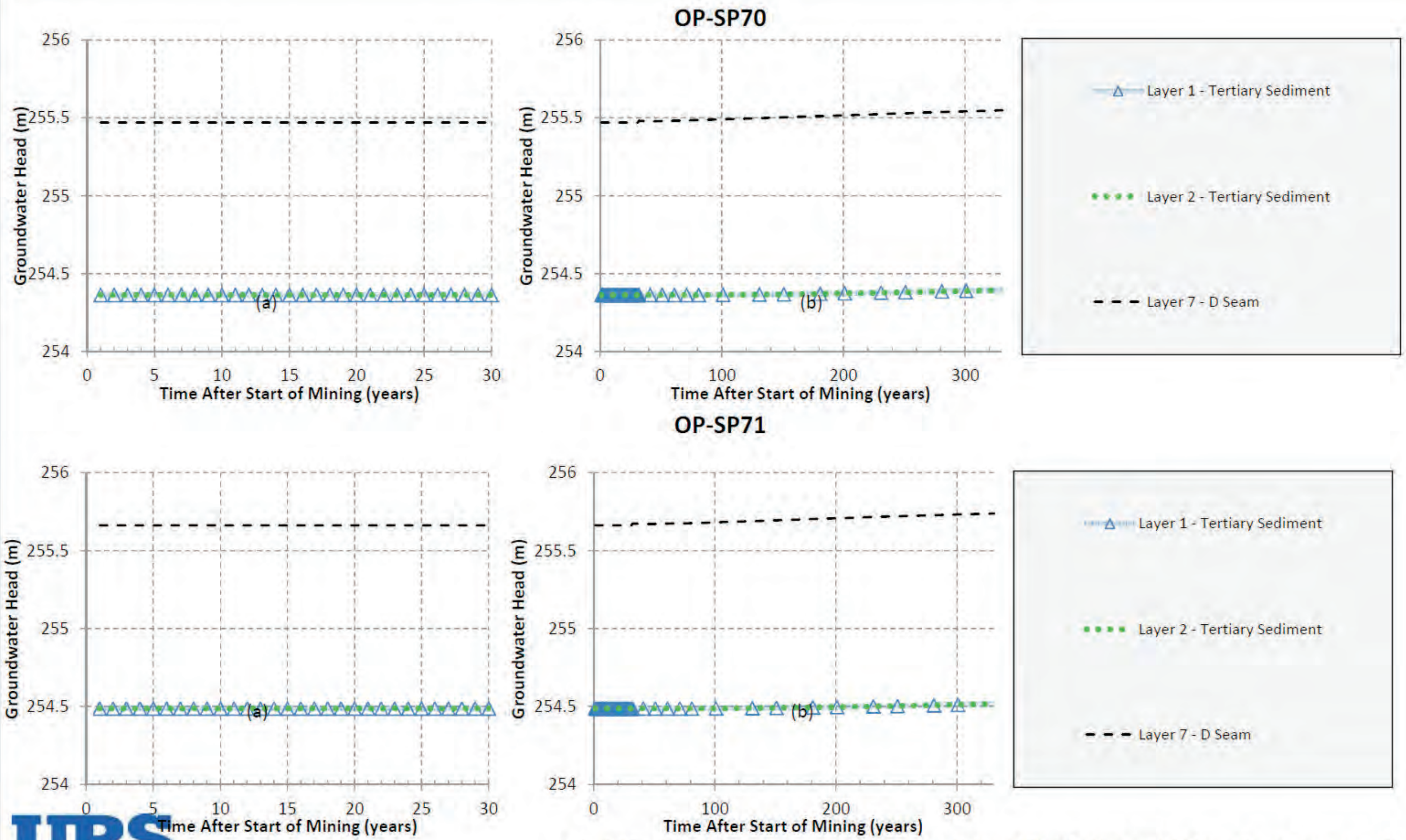
Source:



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Model Projected Groundwater Heads for (a) 30-Year Life-of-Mine and (b) Long-Term Recovery - Northerly Springs

Figure E15

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ALPHA COAL MINE PROJECT

JOINT EXPERTS REPORT ON GROUNDWATER

HYDROGRAPHS AT OP-70 AND OP-71

Draft

File No: **42627132-g-116.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013**

Figure: **12a**

Rev.A A4

Source:

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ALPHA COAL MINE PROJECT

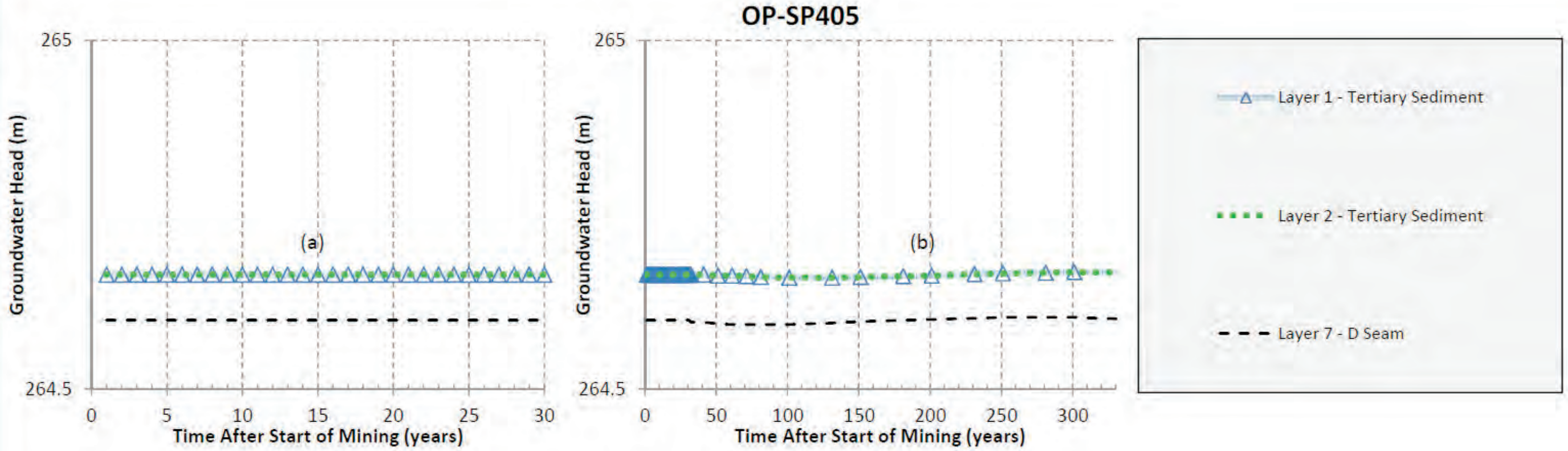
JOINT EXPERTS REPORT ON GROUNDWATER

HYDROGRAPHS AT OP-SP405

Draft

File No: 42627132-g-117.cdr Drawn: XL Approved: MS Date: 31-07-2013 Rev.A A4

Figure: 12b



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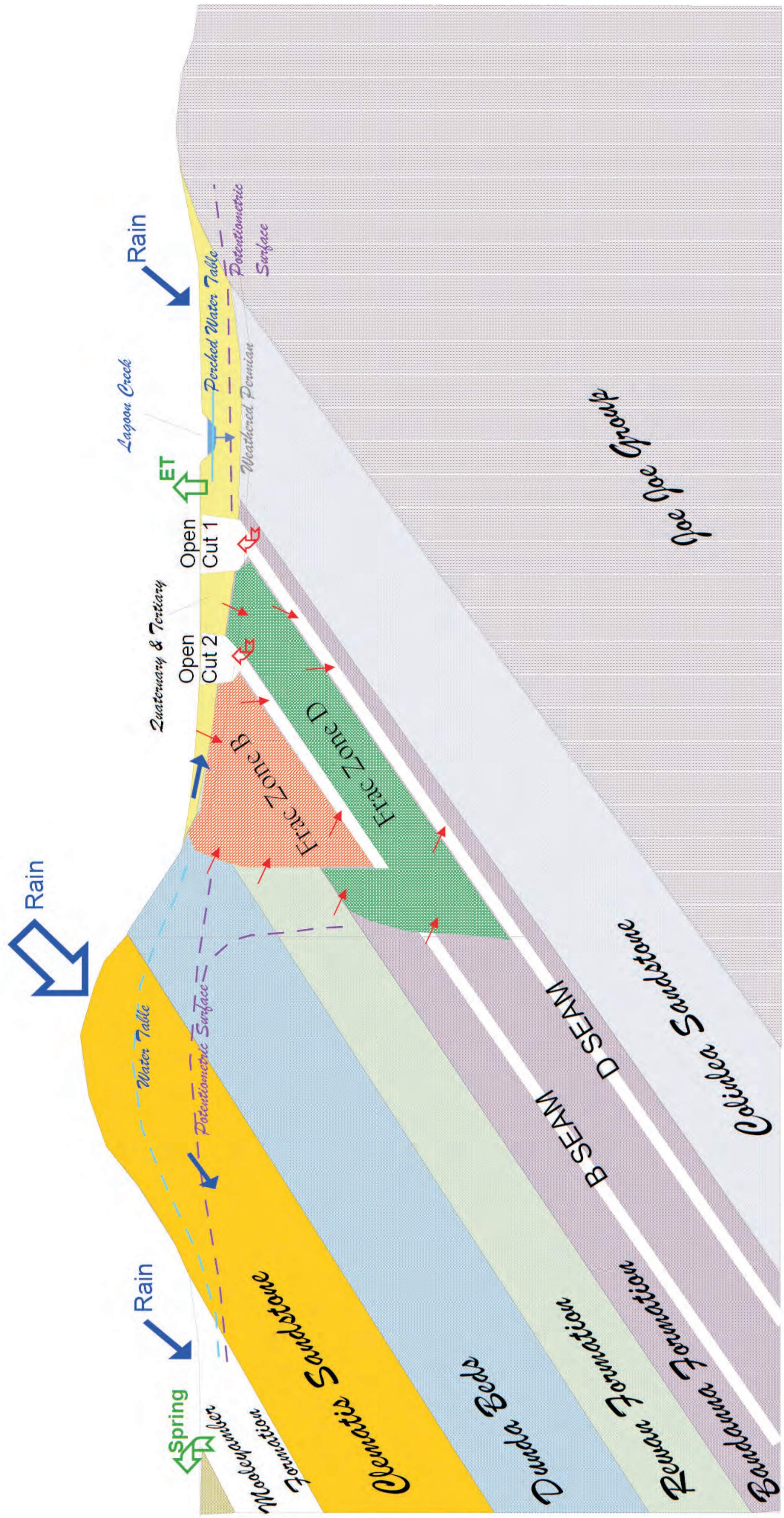
Model Projected Groundwater Heads for (a) 30-Year Life-of-Mine and (b) Long-Term Recovery - Northerly Springs

Figure E16

Appendix B Dr Gavin Mudd Figures



Source: Galilee Coal Project Groundwater Assessment Report, p.76, Heritage Computing Pty Ltd (2013)

GVK RESOURCES

ALPHA COAL MINE PROJECT

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WARATAH SEIS CONCEPTUAL GROUNDWATER MODEL

URS

JOINT EXPERTS REPORT ON GROUNDWATER

Figure: **1**

File No: **42627132-g-118.cdr** Drawn: **XL** Approved: **MS** Date: **31-07-2013** Rev.**A** A4

Appendix C Conditions

1. Coordinator – General Conditions

A. <u>Current Obligations (Section 5.7 of main text):</u>

- project design to ensure the minimum possible impacts on the groundwater resource;
- mitigate any adverse effects that may occur such as changes to water quality in groundwater resources;
- compliance with the terms of any water licence conditions issued by DEHP;
- establish an integrated groundwater and surface water monitoring program;
- the determination and approval by DEHP of water quality and trigger levels before the commencement of mine operations;
- The proponent has made a commitment to 'make-good' affected groundwater supplies and I have recommended conditions for the enforcement of this through the provisions of the *Water Act 2000*;
- The proponent will be required to undertake periodic audits of its groundwater model, and re-calibrate and re-predict future impacts during the mining phase of the project.

These obligations are further detailed below:

B. <u>Appendix 1: Stated Conditions – Mine EA (mining lease):</u>

Condition 17: Groundwater

(a) A groundwater monitoring program must be developed and submitted to the administering authority for approval before the commencement of mining activities. The monitoring program must:

(i) allow for the compilation of representative groundwater samples from the aquifers identified as potentially affected by mining activities. The geological units monitored include alluvium, Bandanna Formation, Colinlea Sandstone, Clematis Sandstone, Rewan Formation, and Joe Joe Formation;

(ii) include at least twelve sampling events, no more than two months apart over a two year period, to determine background groundwater quality;

(iii) obtain background groundwater quality in hydraulically isolated background bore(s), and

(iv) allow for the identification of natural groundwater level trends, hydrochemical trigger levels, and contaminant limits.

(b) In addition to Condition 17(a) groundwater quality and levels must be monitored at the locations and frequencies specified in Table A2: Groundwater monitoring network locations and frequency. Tables are listed below and attached:

Table A2: Groundwater monitoring network locations and frequency

Monitoring Sites*	Parameter	Frequency
AMB-01, AMB-02, AMB-03, AMB-04	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
TSF standpipe bores ATSF-01B ATSF-02, ATSF-03, ATSF-04B, ATSF-07B, ATSF-07C, ATSF-08B, ATSF-08C, ATSF-06B, ATSF-06C, ATSF-05B, ATSF-05C, ATSF-09A, ATSF-09B	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
Proposed monitoring bores adjacent infrastructure AlphaWest1, AlphaWest2, AlphaWest3, Landfill1, Landfill2, Landfill3, MIA, CHPP1, CHPP2, EWT, TLO1, RWD1, ROMSouth, ROMNorth	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients, TPH (selected bores only)	Every 2 months (for at least two years)
VWP bores AVP_11, AVP_01, AVP_14, AVP_03, AVP_05, AVP_04, AVP_06, AVP_07, AVP_08, AVP_13, AVP_09, AVP_10	Water level only	At least one reading every 12 hours – electronic data readers
New TSF VWP bores ATSF-01A, ATSF-04A, ATSF-05A, ATSF-06A, ATSF-07A, ATSF-08A	Water level only	At least one reading every 12 hours – electronic data readers
New GAB bores AlphaWest4, AlphaWest5, and AlphaWest6	Water level only	At least one reading every 12 hours – electronic data readers
All monitoring bores	Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn.	Annually

(c) If groundwater monitoring results greater than the trigger levels (or outside the trigger levels range for pH) specified for the relevant aquifer in Table A3 to Table A7 (inclusive) are recorded, then the following must be conducted:

(i) the relevant monitoring point(s) will be re-sampled and the samples analysed for major cations and anions, and selected dissolved metals, including Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn;
(ii) if elevated concentrations (above trigger) are recorded on two consecutive sampling events then an investigation into cause, optimum response, and the potential for environmental harm must be conducted; and
(iii) if elevated concentrations are recorded on two consecutive sampling events then the administering authority will be notified within 1 month of receiving the analysis results.

(d) If groundwater monitoring results greater than the contaminant limits (or outside the contaminant limits range for pH) specified for the relevant aquifer in Table A3 to Table A7 (inclusive) are recorded, then an investigation into cause, optimum response, and the potential for environmental harm must be conducted.

Table A3: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A4: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (dry season)

Parameter	Units	Trigger Levels	Contaminant limits
<u>Dissolved metals</u> Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Parameter	Units		
Electrical Conductivity	□S/cm		
Major anions and cations	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit		
Groundwater level	For interpretational purpose only		

Table A 5: Groundwater contaminant limits and trigger levels – Colinlea Sandstone Aquifers

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A6: Groundwater contaminant limits and trigger levels – Bandanna Formation Aquifers

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A7: Groundwater contaminant limits and trigger levels – Joe Joe Formation

Parameter	Units	Trigger Levels	Contaminant limits
JOE JOE FORMATION			
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Notes for all tables Table A3 to Table A7 inclusive
Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum/minimum pH values determined for the site.
Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

(e) Groundwater contaminant trigger levels for Table A3 to Table A7 (inclusive) must be finalised based on the Groundwater Monitoring Program approved under Condition 17(a) and submitted to the administering authority 28 days prior to commencing coal extraction.

(f) Groundwater monitoring bores must be constructed in accordance with methods prescribed in the Minimum Construction Requirements for Water Bores in Australia – 3rd Edition (LWBC), or equivalent.

(g) The monitored data must be reported to the administering authority, and must satisfy the following criteria:

(i) Data collected under the monitoring program will be forwarded to the administering authority on a quarterly basis within 30 business days of the end of each quarter and compiled in an annual monitoring report in a format approved by the administering authority;

(ii) The proponent shall undertake an assessment of the impacts of mining on groundwater after the first 12 months of dewatering commencing and thereafter every subsequent calendar year;

(iii) The annual monitoring report will be forwarded to the relevant authority by the first of March each calendar year; and

(iv) The annual monitoring report will include an assessment of impacts, any mitigation strategies as wells as any recommendations for changes to the approved monitoring program.

(v) If there is a requirement to submit a similar groundwater report as part of any condition issued under a water licence under the *Water Act 2000* then the proponent and the relevant administering authorities may agree for the reports to be combined.

C. <u>Appendix 2: Part B: Imposed Conditions - mine</u>

Imposed Conditions to Address Cumulative Impacts:

Regional groundwater monitoring and reporting program (Condition 2):
To address the potential cumulative impacts on groundwater quality and availability in the Galilee basin, the Coordinator-General has imposed the following condition for the Alpha project that will be similarly imposed for other projects in the basin. DEHP is designated as the agency responsible for this condition.

(a) The proponent must:

(i) before commencing mining activities prepare to the satisfaction of the administering authority and implement a groundwater monitoring and reporting program for aquifers impacted by the project off the mining lease

(ii) design the program to complement the environmental authority requirements and other groundwater management programs in the Galilee basin. The program should aim to enable a basin groundwater model to be developed to predict, verify and monitor groundwater impacts.

(iii) make monitoring results from the program publicly available on the proponent's web site updated at least annually

(iv) contribute to any basin wide collaborative project established by the administering authority to develop a basin groundwater model, including pro-rata funding

(v) contribute to development of a basin wide groundwater model for determining the capacity of aquifers and acceptable extraction rates, including pro-rata funding

Imposed condition 2, Part B, Appendix 2 would be complemented by DEHP/DNRM as the lead agencies for developing a coordinated basin wide monitoring and assessment program, to organise and collate basin wide monitoring programs, data and reports, and to ensure such outcomes influence the ongoing management of groundwater resources.

D. <u>Appendix 3 Part B: Coordinator- General's recommendations relating to approvals for the extraction and use of groundwater under the *Water Act 2000:*</u>

Recommendation 1. Water Security

(a) Before the commencement of mining activities, the proponent must develop to the satisfaction of the administering authority for the Water Act 2000, a plan to address the short and long term implications for groundwater users of dewatering the following:

(i) Alluvium aquifers

(ii) Colinlea sandstone

(iii) Bandanna Formation

(iv) Joe Joe Formation; and

(b) the plan in (a) must provide for actions to assure the long term security of water for all current groundwater users affected by the project.

Recommendation 2. Groundwater Modelling
(a) The proponent must recalibrate the groundwater model referred to in the Groundwater Modelling Report – Alpha Coal Project (Hancock Coal Pty Ltd, 28 March 2012) initially at a minimum of 3-yearly intervals, and subsequently with the approval of the administering authority for the *Water Act 2000*, at 5-yearly intervals throughout the mining phase of the project; and
(b) The proponent must provide a report on each recalibration to the administering authority for the *Water Act 2000* within 6 weeks of completion of the recalibration.

Recommendation 3. Monitoring
(a) The proponent must:
- (i) Monitor and record groundwater levels at representative monitoring bores agreed to by the administering authority for the *Water Act 2000*, at frequencies determined on the basis of the results of baseline monitoring and trigger values (monthly/quarterly/continuous);
- (ii) Monitor and record groundwater inflows and dewatering volumes pumped (monthly/continuous);
- (iii) Compare water level changes with model-predicted water level changes, to verify the reliability of model predictions, for input to Condition 25;
- (iv) Report annually to the administering authority for the *Water Act 2000*, the results of monitoring and comparison of observed impacts with predicted impacts.

Recommendation 4. Water License Terms (attached)

E. <u>Appendix 5 Proponent Commitments – Mine</u>

GROUNDWATER
HCPL will:

☐ Develop and implement a Groundwater Monitoring Program detailing the location and frequency of groundwater monitoring activities, as well as trigger levels and response actions,

☐ Expand the existing groundwater monitoring network over time to enable ongoing groundwater impact evaluations,

☐ Install groundwater monitoring bores a minimum six months prior to mining in an area,

☐ Undertake groundwater monitoring and sampling via a suitably qualified and experienced professional in accordance with recognised procedures and guidelines,

☐ Conduct an annual review of the monitoring data, using suitably qualified expert,

☐ Include in the review an assessment of groundwater level and water quality data, and the suitability of the monitoring network,

☐ Undertake groundwater modelling audits on a regular basis (intervals not exceeding three years) and provide the modelling results to the administering authority for review,

☐ Investigate all groundwater-based complaints, including the maintenance of a complaints register. The register will be made available to the regulating authority upon request, and

☐ Implement make-good agreements with land holders affected by groundwater drawdown.

2. Draft Environmental Authority Conditions

Schedule A - General

Third Party Audit:

A16: The holder of the environmental authority must nominate an appropriate third party auditor to audit compliance with the conditions of this environmental authority within one year of the commencement of this environmental authority, and then at regular intervals not to ex exceed 3 years.

A17: the holder must, at its cost, arrange for independent certification by a third party auditor of findings of the audit report required under condition A16.

A18: Within ninety days of completing the audit, provide a written report to the administering authority detailing any non-compliance issues that were found (if no non-compliance issues were found this should be stated in the report). If non-compliance issues were found the report must also address:

a) Actions taken by the holder of this environmental authority to ensure compliance with this environmental authority, and
b) Actions taken to prevent a recurrence of non-compliance.

A19: Where a condition of this environmental authority requires compliance with a standard published externally to this environmental authority and the standard is amended or changed subsequent to the issues of this environmental authority the holder of this environmental authority must:

a) Comply with the amended or changed standard within 2 years of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation; and
b) Until compliance with the amended or changed standard is achieved, continue to remain in compliance with the standard that was current immediately prior to the relevant amendment or change.

Schedule C – Water

C3: The release of mine affected water to internal water management infrastructure that is installed and operated in accordance with the water management plan that complies with conditions C33- C38 inclusive is permitted.

C50: Groundwater: A groundwater monitoring program must be developed and submitted to the administering authority for approval before the commencement of mining activities. The monitoring program must:

a) Allow for the compilation of representative groundwater samples from the aquifers identified as potentially affected by mining activities. The geological units monitoring include alluvium, Bandanna Formation, Colinlea Sandstone, Clematis Sandstone, Rewan Formation and Joe Joe Formation;

b) Include at least 12 sampling events, no more than 2 months apart over a 2 year period, to determine background groundwater quality;
c) Obtain background groundwater quality in hydraulically isolated background bore(s), and
d) Allow for the identification of natural groundwater level trends, hydrochemcial trigger levels, and contaminant limits.

C51: In addition to condition C50 groundwater quality and levels must be monitored at the locations and frequencies specified in *Table 15: Groundwater monitoring network locations and frequency* and *Figure 4: Groundwater Monitoring Locations*

Table 15: Groundwater monitoring network locations and frequency

Monitoring Sites*	Parameter	Frequency
AMB-01, AMB-02, AMB-03, AMB-04	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
TSF standpipe bores ATSF-01B ATSF-02, ATSF-03, ATSF-04B, ATSF-07B, ATSF-07C, ATSF-08B, ATSF-08C, ATSF-06B, ATSF-06C, ATSF-05B, ATSF-05C, ATSF-09A, ATSF-09B	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
Proposed monitoring bores adjacent infrastructure AlphaWest1, AlphaWest2, AlphaWest3, Landfill1, Landfill2, Landfill3, MIA, CHPP1, CHPP2, EWT, TLO1, RWD1, ROMSouth, ROMNorth	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients, TPH (selected bores only)	Every 2 months (for at least two years)
VWP bores AVP_11, AVP_01, AVP_14, AVP_03, AVP_05, AVP_04, AVP_06, AVP_07, AVP_08, AVP_13, AVP_09, AVP_10	Water level only	At least one reading every 12 hours – electronic data readers
New TSF VWP bores ATSF-01A, ATSF-04A, ATSF-05A, ATSF-06A, ATSF-07A, ATSF-08A	Water level only	At least one reading every 12 hours – electronic data readers

New GAB bores AlphaWest4, AlphaWest5, and AlphaWest6	Water level only	At least one reading every 12 hours – electronic data readers
All monitoring bores	Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn.	Annually

C52: If groundwater monitoring results in greater than the trigger levels (or outside the trigger levels range for pH) specified for the relevant aquifer in *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) are recorded, then the following must be conducted:

a) The relevant monitoring point(s) will be resampled and the samples analysed for major cations and anions, and selected dissolved metals including Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn;
b) If elevated concentrations (above trigger) are recorded on two consecutive sampling events then an investigation into cause, optimum response, and the potential for environmental harm must be conducted; and
c) If elevated concentrations are recorded on two consecutive sampling events then the administering authority will be notified within 1 month of receiving the analysis results.

C53: If groundwater monitoring results greater than the contaminant limits (or outside the contaminant limits range for pH) specified for the relevant aquifer in *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) are recorded, then an investigation into cause, optimum response, and the potential for environmental harm must be conducted.

Table 16: Groundwater contaminant limits and trigger levels- Alluvium Aquifers (wet season)

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.

[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.

[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 17 Groundwater contaminant limits and trigger levels – Alluvium Aquifers (dry season)

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.

[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.

[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 18: Groundwater contaminant limits and trigger levels – Colinlea Sandstone Aquifers

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 19 Groundwater contaminant limits and trigger levels – Bandanna Formation Aquifers

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.

[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.

[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 20 Groundwater contaminant limits and trigger levels – Joe Joe Formation

Parameter[2]	**Units**	**Trigger Levels**[3]	**Contaminant limits**
JOE JOE FORMATION			
<u>Dissolved metals</u> Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
<u>Major anions and cations</u> Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

C54: Groundwater contaminant trigger levels for *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) must be finalise based on the Groundwater Monitoring Program approved under condition C50 and submitted to the administering authority 28 days prior to commencing coal extraction.

C55: Groundwater monitoring bores must be constructed in accordance with methods prescribed in the Minimum Construction Requirements for Water Bores in Australia -3rd Edition (LWBC), or equivalent.

C56: The monitored data must be reported to the administering authority, and must satisfy the following criteria:

a) Data collected under the monitoring program will be forwarded to the administering authority on a quarterly basis within 30 business days of the end of each quarter and compiled in an annual motioning report in a format approved by the administering authority;
b) The proponent shall undertake an assessment of the impacts of mining on groundwater after the first 12 months of dewatering commencing and thereafter every subsequent calendar year;
c) The annual monitoring report will be forwarded to the relevant authority by the fist of March each calendar year; and
d) The annual monitoring report will include an assessment of impacts, any mitigation strategies as well as any recommendations for changes to the approved monitoring program.
e) If there is a requirement to submit a similar groundwater report as part of any condition issued under a water license under the *Water Act 2000* then the proponent and the relevant administering authorities may agree for the reports to be combined.

Schedule F – Land

F51: Residual Void: The holder of this environmental authority must complete an investigation into residual voids and submit a report to the administering authority by (Date 5 years from grant of EA). The investigation must include:

a) A study of options available for minimising final void area and volume;
b) A void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term;
c) A study of the measured to protect the residual voids, uncompacted overburden and workings from the probable maximum flood (PMF) level;
d) A pit wall stability study, considering the effects for long-term soil erosion and weathering of the pit wall and the effects of significant hydrological events; and
e) A study of void capability to support native flora and fauna.

F52: Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition of this environmental authority.

F55: The Post Closure Management Plan must include the following elements:

a) Operation and maintenance of:
    i. wastewater collection and reticulation systems;
    ii. wastewater treatment systems;
    iii. the groundwater monitoring network;
    iv. final cover systems of spoil dumps and
    v. vegetative cover; and
b) monitoring of:
    i. Surface water quality;
    ii. Groundwater quality;
    iii. Seepage rates;
    iv. Erosion rates;

v. Integrity and stability of all slopes, ramps, and voids; and
vi. The health and resilience of native vegetation cover.

3. *Environmental Protection and Biodiversity Conservation Act 1999* Conditions (T Burke, 23 August 2012)

Water Quality

Condition 11 - Regional Water Plan:

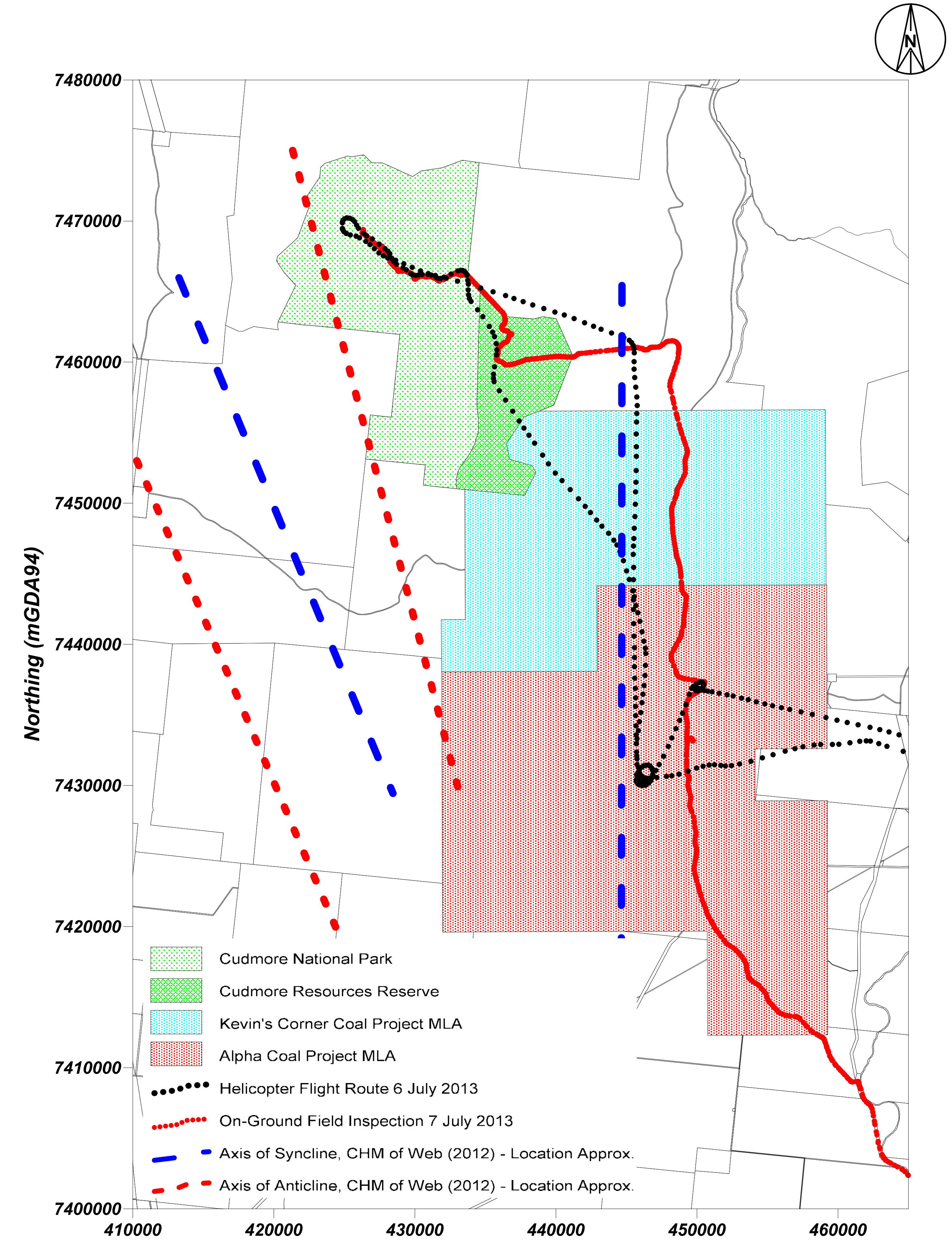
The person taking the action must submit a Regional Water Plan to the Minister for approval. The plan must address the following requirements:

a) a regional surface water and a regional groundwater water monitoring program with reference to groundwater dependent habitat for listed threatened species and ecological communities, and listed migratory species:
b) the monitoring identified in condition 11 (a) must include identification of linkages between the formations, and likely movement of water into and out of the aquifers;
c) address the potential for impacts to groundwater dependent habitat for listed species and ecological communities, and listed migratory species:
d) Include an ongoing monitoring program to be undertaken to:
   (i) ensure no drawdown impacts result from mining operations on groundwater dependent communities in the Great Artesian Basin;
   (ii) measure the success of management measures to inform an adaptive management approach that must be implemented;
   (iii) report on milestones and compliance with this plan;
   (iv) identify measures of success; and
   (v) identify thresholds for intervention, where rehabilitation and vegetation management measures are exceeded.

The person taking the action cannot commence construction activities until the Minister approves the Regional Water Plan in writing.

The approved Regional Water Plan must be implemented.

Appendix D Iain Hairs Appendix



Projection - GDA94 (Zone 55)
Level Datum - Australian Height Datum (AHD)

Scale 1:350,000

Douglas Partners Geotechnics | Environment | Groundwater	**Trace of Helicopter Flight & On-Ground Field Inspection** Joint Experts' Report on Groundwater Matters for the Alpha Coal Project Land Court of Queensland - File Numbers: MRA082-13 & EPA083-13		DATE: Jul 2013 OFFICE: Brisbane DRAWN BY: IDH
CLIENT: Allens > < Linklaters (Lawyers)	PROJECT No: 80204.00	FIGURE No: 1	REVISION: A
			APPROVED BY: CMD

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Allens > < Linklaters (Lawyers)		**CLEMATIS SANDSTONE OUTCROP IN CUDMORE NATIONAL PARK**	PROJECT No: 80204.00
DRAWN BY: IDH	DATE: Jul 2013	Joint Experts' Report on Groundwater Matters for the Alpha Coal Project Land Court of Queensland - File Numbers: MRA082-13 & EPA083-13	FIGURE No: 2
APPROVED BY: CMD	OFFICE: Brisbane		REVISION: A