Regional Planning Interests Act 2014

RE: Assessment Application for a Regional Interests Development Authority

RPI17-004-Bengal Coal - Dysart East Coal Mine

Submission pursuant to section 37 RPI Act 2014

Submitter:

This submission, as duly authorised, is made by George Houen of Landholder Services Pty Ltd on behalf of Cradcorp Pty Ltd (Cradcorp), the registered owner of Dysart Station. An area of 299 hectares within Dysart Station, being the part of Lot 2 on SP11062, is directly affected by mining lease application no. 70507 – please see map **Attachment "A".**

1. Expert Report – Pillar Design and Subsidence

The attached report: *Review of Pillar Design Methodology and Subsidence Assessment for the Proposed Dysart East Coal Mine Project* is by Dr Ismet Canbulat, Professor and Kenneth Finlay Chair of Rock Mechanics at the University of NSW (Canbulat 2017). As his CV shows, Dr Canbulat has extensive relevant experience in Australia and overseas, including the management of underground mining in the Bowen Basin.

The report Canbulat 2017 is at **Attachment "B"**

In summary, the report concludes:

- Geotechnical testing is required to study the roof, floor, overburden and parting characteristics in the target seam – testing to include rock mass characterisation, laboratory testing, and geophysical logging.
- So as to better inform owners of the surface of potential worst-case outcomes, a detailed surface subsidence study is required to determine associated subsidence parameters and extent of subsidence – the study to include both elastic subsidence due to settlement of coal pillars and potential surface and sub-surface subsidence in the event of pillar failure.

- Numerical modelling is required to determine the multiseam interactions, ie. the interaction between seams, thus the loading environment of pillars and in response, appropriate pillar design.

- Design of pillars at shallow depth has to be considered – taking account of cover depths using an appropriate minimum pillar width (as per the NSW legislation) rather than relying on a factor of safety or probability of failure.

- Time to failure of pillars has to be evaluated using the above methodologies.

- After all of the above studies, then design the pillars.

Dr Canbulat emphasises that knowledge gaps still exist regarding basic mechanisms of pillars, particularly as to long-term stability – eg at Canbulat 2017 section 4 paragraph 3, he says that the best predictions available will only provide guidance, stating: *strictly speaking the formulae do not consider the time-dependent failure based on pillar dimensions.*

Dr Canbulat confirms (Canbulat 2017 section 1 Background) that his review assumes extraction will be limited to first workings. That term describes a process where headings and cut-throughs are extracted on a grid pattern leaving pillars of coal that are meant to hold up the roof, leaving a substantial proportion of the coal unmined. Please see the plan **Attachment "C".**

Dr Canbulat emphasises (Canbulat 2017 section 5, first Dot Point) that the pillars are part of a system comprising the floor, roof, overburden and the pillar itself. Failure of any element or combination of elements can result in failure of the whole system, especially in a multi-seam project such as this.

2. Expert Report – Potential Impact on SCL

The attached report: *Potential Impact of Dysart East Coal Mine on SCL covering Lot 2 on SP 161102* is by Mr Peter Shields (Shields 2017). As an attachment it carries his 2013 report in response to the EIS regarding the effects of proposed longwall subsidence at Springsure Creek. His CV which is attached shows his expertise as a soil scientist with significant experience in the processes of predicting and modelling surface subsidence from underground mining and the impacts of subsidence on SCL.

The report Shields 2017 is at **Attachment "D"**

Mr Shields' conclusions are summarised as:

- The Applicant provides no quantitative evidence supporting its assertion of negligible subsidence

- Case studies highlight the potential for subsidence to severely impact SCL

- Subsidence-induced slopes that are tangential and often perpendicular to the contour significantly limit remediation including by amplifying the area of cropping land affected

- Only by substantial earthworks could the subsided land and adjoining land potentially be returned to its pre-mining condition.

- To satisfactorily assess the impact on SCL requires detailed investigation of predicted subsidence from which to produce subsidence modelling and "before and after" digital elevation models – then to determine degree and extent of slope changes, the need for and extent of earthworks and the feasibility of the earthworks that would be required for successful rehabilitation.

3. Background

The subject land is strategic cropping land (SCL) that is part of a valuable cropping land resource underpinning the productivity and viability of Dysart Station.

Totalling about 18,000 hectares, the property relies on a balance of land types and land capabilities for breeding, for growing and for fattening its cattle, as well as producing commercial grain crops and fodder crops. The subject land has to date not been developed, but kept as a cropping land reserve and used for grazing, pending clarification of any mining plans affecting it.

4. Subsidence, Bord and Pillar Style

The primary issue with the subject application is subsidence and the effects of subsidence on SCL.

The proposed mining method is bord and pillar, which is unusual in Queensland these days. And this is not a standard bord and pillar mine as it involves the mining of five seams, one below the other, at between about 50 metres and about 350 metres depth.

Another highly relevant factor is that the Applicant states first workings only will be extracted, ie leaving pillars in place. Whereas full scale bord and pillar mining removing some or all pillars would inevitably cause subsidence, first workings could, in a particular mine for example taking only a single seam, potentially cause only limited subsidence. But in this multi-seam project, numerous factors or combinations of factors will influence and cause ongoing uncertainty about the longevity and stability of the support system of pillar/roof/floor/partings, and their interactions. It stands to reason that accurate prediction of subsidence and its timing in this case is near-impossible.

Canbulat 2017 at 5, Dot Point 4, vindicates the Submitter's concern that Bengal Coal's promise of imperceptible (sometimes described as negligible) surface subsidence in the proposed multi-seam mine is not supported by appropriate investigation. At 5, Dot Point 4, the report states that the inevitable cumulative "elastic" subsidence over 5 seams due to settlement of pillars can alone exceed 200mm, sufficient to cause damage to structures and ponding on farm lands.

Thus even before any investigation of the specific issues, it is shown that pillar settlement is inevitable and will result in significant subsidence, which contradicts Bengal's claim that subsidence will be so limited as to be imperceptible .

Furthermore, the expert evidence shows that if the necessary investigations and design were done it is likely those studies would show that substantial subsidence is probable, however that it is simply not possible to predict its ultimate extent, nor to say when it will start or be complete. Obviously it would be futile to attempt rehabilitation by relevelling before subsidence is complete.

The only safe assumption for Cradcorp is that when it eventually regains the use of the subject land after mining, subsidence will still be underway and will potentially continue indefinitely, so that the capability of the land is irrevocably and permanently degraded from SCL to perhaps second-rate grazing land.

5. <u>Prediction</u>

As mentioned, the Applicant asserts it has properly established that any mining-related subsidence will be so small as to be "imperceptible" and therefore that the subsidence will not constitute permanent damage to the SCL, but Canbulat 2017 shows that assertion is unwarranted.

Shields 2017 at 2.4 states the Applicant has not provided any subsidence modelling to confirm the magnitude of predicted subsidence – nor has it done the necessary elevation modelling to compare after-mining slopes, nor has the other essential quantitative evidence been provided. Shields 2017 at 2.5 and its attachment Shields PG (2013) describe the studies conducted to assess subsidence impacts on SCL land in the Springsure Creek project and the actual experience spanning several decades with established longwall mining in that district.

Accordingly, Bengal Coal has not established that the Area of Surface Impact will be limited to 5.48 hectares as claimed.

6. <u>Timing</u>

As to timing of subsidence, especially with this plan for first workings only (where coal pillars are left with the intention of supporting the roof) the likelihood and timing of pillar failure or of roof and floor failure are problematic, consistent with the information in Canbulat 2017 at 4, third paragraph:

> *An important assumption made in Salamon et al.'s (1966) study, for practical reasons, was that the behaviour of pillars is not time dependent; therefore, the established formulae do not provide an associated probability of survival for the long-term stability of coal pillars.*

and

When the initial dimensions of pillars start altering over time, due to spalling of pillar ribs and/or increased mining height due to roof falls, assessing the pillar stability becomes more complicated as their initial design factors of safety become compromised.

Also relevant is Canbulat 2017 at 5, third dot point:

Based on the information provided in Table 1 (and in SCT's report) it is evident there will be multiseam interactions between the target seams, which exhibit a complex pillar loading environment. In underground mining, there are several factors that determine the degree of interaction ....

7. Depth and Distribution

As to the depth and spatial pattern of subsidence, it will be triggered by the pillars spalling, the roof collapsing or the floor being destabilised – or any combination of those. The risk is significantly greater here where interaction of forces generated by mining the multiple seams is likely to affect the loading of pillars. In contrast with longwall subsidence which directly overlies precisely-located extraction panels, in this bord and pillar project spatial distribution of subsidence will be random and unpredictable.

The subsidence in this project will in practice be incompatible with cropping – especially because, as applies throughout the Central Highlands and confirmed in Shields 2017 at 2.3, the economic, physical and climatic imperatives dictate the use of the largest and widest machines available for cultivation, planting, spraying and harvesting. The steep and irregular, uneven slopes with inevitable ponding of runoff cannot be efficiently farmed with such wide machines.

Shields 2017 at 2.3 states:

Guideline 08/14 for the Regional Planning Interests Act 2014 stipulates that land in the Western Cropping Zone must be on slopes of 3% or less.

and:

The soils deemed to be SCL inside Lot 2 on SP161102 currently have slopes <2%.

Subsidence-related slopes will exceed 3% which is the cut-off point for good cropping land, and will also exceed 4% which is the recommended limit for cultivation – Shields 2017 at 2.3. Random, irregular and uneven depth and distribution of subsidence will also make it effectively impossible to design workable contour banks and drains to control erosion – workover banks would be essential but they would fragment the cultivation area, resulting in a slopes network so impossibly complex as to rule out farming with the large, wide implements - or at all, for that matter – also Shields 2017 at 2.3.

Such an erosion-prone condition would be incompatible with Dysart Station's land management standards. Although the natural slopes are very modest, Cradcorp operates its existing cropping land with very strong erosion control in place. The design standard of erosion control banks and waterways on the property is above DPI's recommended levels.

The Submitter notes it is the general view of experienced mine operators that even if a bord and pillar system is initially stable, the longterm expectation is that subsidence will occur but be unpredictable.

8. Remediation

In practice, lack of certainty severely limits the scope for rehabilitating the subsidence. Even where subsidence has occurred, there will be little certainty as to if and when further subsidence will occur.

In theory, excessive surface slopes could be alleviated by levelling – ie. by grading soil from the high areas into the low areas.

The feasibility of re-levelling depends on:

a. firstly, whether subsidence is complete (re-levelling before subsidence was complete would be futile) ;

b. then whether there is sufficient depth of topsoil that the graded land will still comply with the SCL minimum topsoil depth limit;

c. then on whether moving the volumes of topsoil required would be cost-effective.

All told, it is unlikely that re-levelling of the post-subsidence land to comply with SCL criteria would be feasible.

9. First Workings

The all-important "first workings only" commitment is not binding on the Applicant. With a large proportion of the coal left behind, there would always be a temptation on any operator to extend to secondary extraction – that is, where pillars are removed and subsidence is inevitable. In that event the cumulative depth of extraction would be some proportion of the total thickness of the 5 seams – perhaps aggregate surface subsidence of 5 metres or so, where the time till cessation of subsidence would be unknown.

Bengal Coal's two other authorities – mining lease and environmental authority do not cover this issue either – thus if a RIDA is to be granted, it should carry the appropriate condition binding its holder to limit extraction to first workings only.

10. Subsidence Is Assumed

As to the reliability of Bengal Coals' assurance that subsidence will be so limited as to be imperceptible, it is submitted that the Assessor should inquire whether any agreements have been established with other entities having land or infrastructure interests potentially affected by subsidence which Bengal Coal's proposed mining may cause.

SUBMISSIONS

1. <u>Permanent Impact</u>

a. The Applicant has not done the studies necessary to identify or quantify the true nature, complexity and impacts on the subject land of the proposed mining of multiple seams.

b. Cradcorp and other affected landowners cannot know with any certainty what impacts the proposed mining will have, nor can they know what post-mining capability their land will have.

c. The extent and spatial distribution of subsidence from the bord and pillar underground mining will not be predictable especially over the long term.

d. There is no reasonable basis on which to conclude that the pre-mining cropping capability of the subsided land can be restored after the subsidence.

e. Accordingly, it must be assumed that adverse impacts of the proposed mining on the SCL will be permanent – consequently the Area of Surface Impact is not 5.48 hectares but, in Cradcorp's case, about 299 hectares.

2. <u>Scale of Impacts</u>

a. Virtually the whole of the SCL within the subject land will be affected by the impacts.

3. <u>First Workings</u>

   a. In the event that it is proposed to issue a RIDA to Bengal Coal for the subject mining proposal, the RIDA should carry conditions, especially one prohibiting any secondary extraction of the coal.

Submitter: George Houen, on behalf of and authorised by Cradcorp Pty Ltd ABN 18 788 708

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Phone: 07 4632 1024
Email: georgehouen@gmail.com

SIGNATURE OF SUBMITTER: ....

DATE: ...2nd June 2017

<u>Attachments:</u>

"A" Plan of land boundaries

"B" Report: *Review of Pillar Design Methodology and Surface Assessment for Proposed Dysart East Coal Mine Project* Dr Ismet Canbulat 12th April 2017 (Canbulat 2017) including:

- CV for Dr Canbulat

"C" Plan illustrating bord and pillar first workings method

"D" *Potential impact of Dysart East Coal Mine on SCL covering Lot 2 on SP 161102* Mr Peter Shields April 2017 (Shields 2017) including:

- Shields PG (2013) *The effect of longwall mining on cropping potential following subsidence at the proposed Springsure Creek Coal Mine*
- CV for Peter Shields

Regional Planning Interests Act 2014

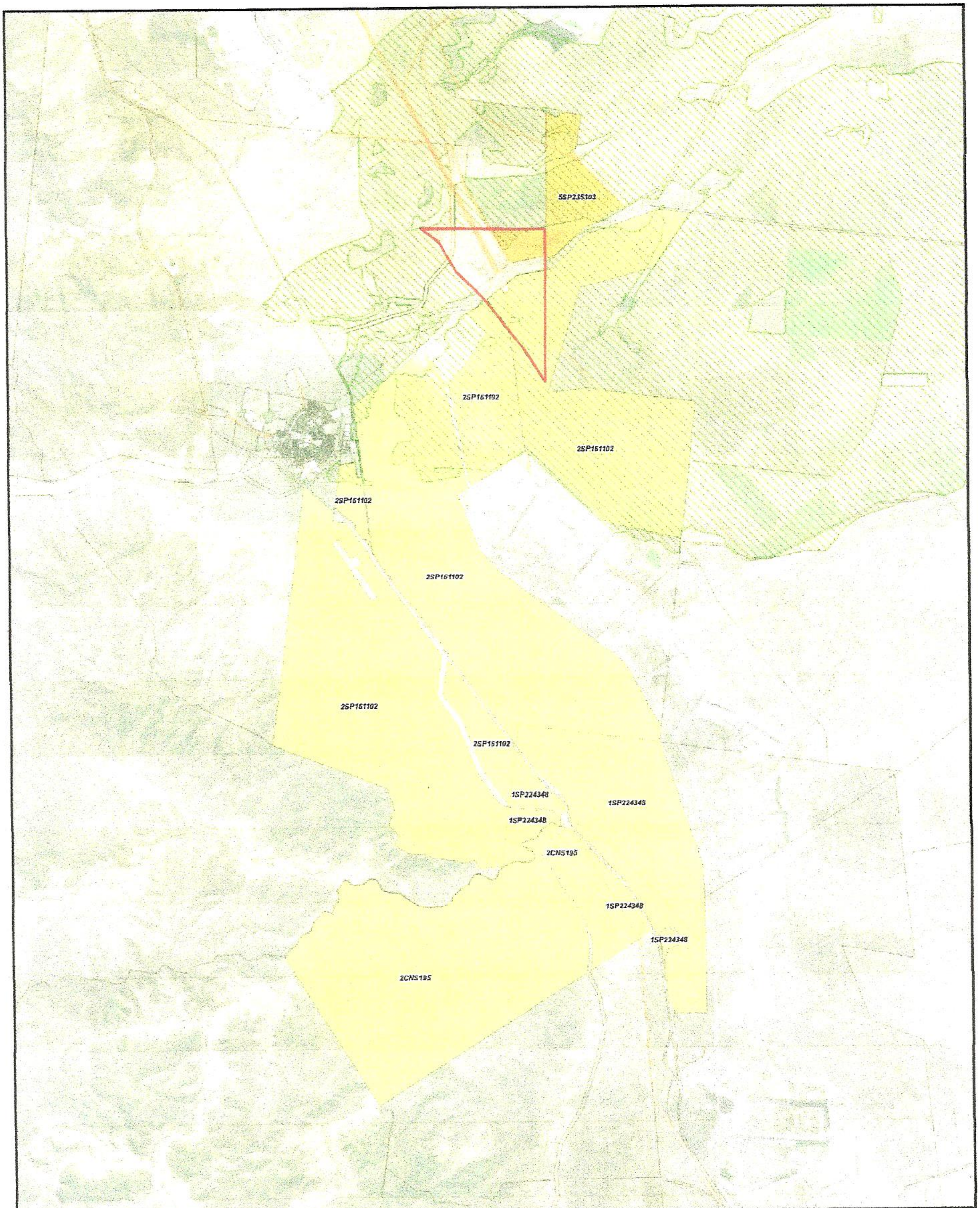
RPI17-004-Bengal Coal-Dysart East Coal Mine

Submission pursuant to section 37 RPI Act 2014

SUBMITTER: George Houen on behalf of Cradcorp Pty Ltd

ATTACHMENT "A"

Plan of land boundaries



www.aecom.com

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator

0 1,000 2,000 4,000
metres
1:100,000 (when printed at A3)

LEGEND

- Mining Lease Application (MLA70507)
- Easement
- Lot Type Parcel
- 5SP235303
- 1SP224348, 2SP161102, 2CNS195
- Strategic Cropping Land (Trigger)

Data source: Client Supplied Imagery

DYSART EAST COAL MINE

EXTENT OF PROPERTIES CONTAINING STRATEGIC CROPPING LAND

RIDA Application

PROJECT ID 42627233
CREATED BY RG
LAST MODIFIED RG - 22/03/2017
VERSION: 1

Map
F3

A3 size

Regional Planning Interests Act 2014

RPI17-004-Bengal Coal-Dysart East Coal Mine

Submission pursuant to section 37 RPI Act 2014

SUBMITTER: George Houen on behalf of Cradcorp Pty Ltd

ATTACHMENT "C"

Report: Canbulat 2017

CV for Dr Ismet Canbulat

Date: 12 April 2017

To: George Houen
Landholder Services Pty Ltd
P: 07 46321024
E: georgehouen@gmail.com

PO No: As per your instructions

From: Dr Ismet Canbulat

RE: **Review of Pillar Design Methodology and Surface Subsidence Assessment for the Proposed Dysart East Coal Mine Project**

1. BACKGROUND

At the request of Mr George Houen a review of the SCT's (2015) pillar design methodology and the surface subsidence assessment of the proposed Dysart East Coal Mine (DECM) project has been conducted. This report summarises the findings of that review.

Dysart East Coal Mine is seeking to undertake extraction of coking and thermal coal reserves located approximately 5 km northeast of the centre of the Dysart Township in Queensland using the first workings only (i.e., no secondary extraction) bord and pillar mining method. It is understood that DECM is now the subject of an application under the Regional Planning Interests Act (2014). Under this Act resource activity on Strategic Cropping Land requires approval in the form of a Regional Interest Development Approval.

Five seams are targeted by DECM, which are the P-Seam Split P08, P-Seam Split P07, P-Seam Split P14, Dysart Seam Split D53 and Dysart Seam Split D300. The minimum and maximum depths of the seams (SCT, 2015) are provided in Table 1.

Table 1: Target seams and their cover depths (after SCT, 2015)

Seam	Split	Minimum depth (m)	Maximum depth (m)
P-Seam (shallowest)	P08	50	220
P-Seam	P07	63	230
P-Seam	P14	85	250
Dysart Seam	D53	175	330
Dysart Seam (deepest)	D300	185	345

Evidently, the table above demonstrates that the proposed mining in the five seams involves multiseam extraction. The implications of this are elaborated below.

2. PURPOSE AND SCOPE

The purpose and scope of this review is outlined in an email by Mr George Houen, dated 30 March 2017, as follows:

a. describing what design and investigation would be required to allow a reliable prediction of the severity and shape of subsidence arising from this proposed multi-seam bord and pillar mining - including subsidence over the long-term and after mining; and

b. evaluating the reliance that can be placed on the applicant's assessment that subsidence from the proposed mine will be "imperceptible".

The aforementioned scope is not presented in any particular order in this report; yet all aspects are addressed in the subsequent sections.

3. INFORMATION PROVIDED

The following information has been provided:

- Review of the Potential for Subsidence for the Proposed Underground Bord and Pillar Operations, Dysart East Mine Project – Revision 3. By Yvette Heritage, SCT Operations. 29 April 2015.
- Dysart East Coal Mine Project Revised Environmental Assessment Report. Environmental Authority Supporting Information. Report No. 42627233/02/0. By Rob Storrs, URS. 5 May 2015.
- Email correspondence by George Houen. 30 March 2017.
- Various other email correspondences by George Houen between 17 February 2017 and 4 April 2017.

4. GENERAL COMMENTS

The bord and pillar mining method has been utilised since the start of coal mining around the world. It is applied in circumstances where open cut and/or longwall mining are not viable due to various reasons (e.g., economics, surface restrictions, unfavourable geology, etc.). In this mining method, a grid of headings and cut-throughs are developed and pillars are left between them to support the mine.

Despite coal pillars being one of the most researched aspects of underground coal mining, their behaviour, interaction between surrounding rock masses and strength still remain a critical subject due to the inherent complexity and variability of rock masses. Although the basic mechanisms of pillars are well understood, gaps exist in some areas, particularly in that of long-term stability.

Over the years numerous coal pillar strength formulae have been developed and many have been updated. Extensive discussion has taken place with regards to which formula is best used to estimate the strength of coal pillars and to describe their behaviour. In Australia, a risk based coal pillar design methodology developed by Salamon et al. (1999) (also known as the UNSW pillar strength formulae) is most commonly used in the design of coal pillars in bord and pillar workings. This methodology utilises the probability of failure of coal pillars, as the factor of safety alone does not provide an indication of the associated risks. This empirical approach has been considered to be the most effective, easy to use and reliable method for estimating coal pillar strength. The approach involved the development of pillar strength formulae using the maximum likelihood method, from a database of failed and unfailed case histories. An important assumption made in Salamon et al.'s (1996) study, for practical reasons, was that the behaviour of pillars is not time dependant; therefore, the established formulae do not provide an associated probability of survival for the long-term stability of coal pillars. Consequently, the pillar factor of safety (and the associated probability of stability) calculated using these formulae only refer to an intact coal pillar. When the initial dimensions of pillars start altering over time, due to spalling of pillar ribs and/or increased mining height due to roof falls, assessing the pillar stability becomes more complicated as their initial design factors of safety become compromised. Hence, any particular factor of safety value proposed for the long-term stability of pillars using these formulae can only provide guidance as, strictly speaking, the formulae do not consider the time-dependant failure based on changes to pillar dimensions.

SCT recommends the use of these formulae for the design of pillars at DECM, which is considered to be an acceptable recommendation. However, if the long-term stability of pillars is in question then further studies similar to those conducted by Salamon et al (1999) and Canbulat (2010) should be conducted.

5. SPECIFIC COMMENTS

- Coal pillars are part of a system that comprises the floor, roof, overburden and coal pillar itself. Failure of any one of these elements and/or a combination of them can result in the failure of the system. The most obvious advantage of the UNSW method is that the strength estimation is based on actual failed *in situ* cases; therefore the formulae is able to somewhat take into account the inherent variability of coal strength and potential loading conditions. However, a comprehensive pillar design study should consider all elements of this system through systematic geotechnical investigations. No geotechnical and/or geological data representing the floor, roof and overburden characteristics has been presented in any of the reports reviewed as a part of this study.

- SCT solely recommends the use of a factor of safety as the design criteria without considering the size and/or width to height (w/h) ratio of pillars, particularly at shallow depth. As presented in Table 1, some of the proposed workings will be located at depths as shallow as 50m. If a factor of safety of 1.63 is used for the design of pillars located at 50m (without considering the multiseam mining interactions), then the recommended pillar width would be approximately 5.0m, which is considered to be unreasonably narrow. It is well established that when coal pillars are slender, their stiffness becomes very low and even a minor geological structure can have a significant adverse impact on pillar strength that can result in premature failures. Work Health and Safety (Mines and Petroleum Sites) Regulation (2014) in NSW requires a minimum coal pillar width of:
  (a) one tenth of the thickness of the cover (to the surface), or
  (b) 10 metres, if the thickness of the cover is less than 100 metres.

- Based on the information provided in Table 1 (and in SCT's report) it is evident that there will be multiseam interactions between the target seams, which exhibit a complex pillar loading environment. In underground mining, there are several factors that determine the degree of interaction (and thus the loading of coal pillars) between workings located in different seams (in both below and above seams). These factors are:
  - Thickness of parting between the seams
  - Parting characteristics
  - Relative location of panel layouts
  - Percentage recovery of the coal seams
  - Seam thickness
  - Time interval between mining of seams
  - Depth of workings
  - Dimensions of workings, including the barrier pillar widths

  It is imperative that pillar design in a multiseam mining environment should be conducted with a consideration of future extraction in other seams. Therefore, the above factors should be assessed and the degree of interaction should be determined before designing the pillars in any of the target seams.

- Every underground opening will result in surface subsidence, which can either be significant or insignificant. The surface subsidence in a bord and pillar mining method can be divided into two main components, namely elastic subsidence due to settlement of pillars and subsidence should the pillars fail. Since five seams are targeted in DECM, the elastic subsidence due to settlement of pillars can be >200mm, depending on the dimensions and the depth of workings. This total amount of subsidence is not considered to be "imperceptible" as it can cause damage to both sub-surface and surface structures, and can also result in ponding in farm lands. Additionally, in the event of a failure of coal pillars, the maximum surface subsidence can be further exacerbated. Therefore, a detailed subsidence assessment specifying the following associated subsidence parameters should be conducted:
  - Expected maximum surface subsidence due to elastic pillar settlement and in the event of failure of pillars (in all seams)
  - Expected sub-surface and surface subsidence in the event of failure of coal pillars
  - Strains
  - Tilts
  - Curvature
  - Associated damage on surface

Note that it is understood that a detailed subsidence assessment was not the scope of the SCT study.

6. SUMMARY RECOMMENDATIONS FOR FURTHER STUDY

Based on the above review, it is evident that further studies are required to understand the surface subsidence in the proposed workings and its impact on the sub-surface and surface structures. The recommended studies are summarised below:

- A geotechnical testing programme should be established to study the roof, floor, overburden and parting characteristics in target seams. This testing programme should include rock mass characterisation, laboratory testing (i.e., uniaxial compressive strength, triaxial, slake durability, shear strength tests etc) and geophysical logging.

- A detailed surface subsidence study should be conducted to determine associated subsidence parameters and the extent of subsidence. This study should consider both elastic subsidence due to settlement of coal pillars and also potential surface and sub-surface subsidence in the event of failure of pillars in order to better inform the surface owners of potential worst-case consequences.

- One of the most appropriate tools used in determining the multiseam interactions is numerical modelling. A numerical modelling study should be conducted to determine the interaction between seams and thus the loading environment of pillars in order to design the pillars appropriately.

- Cover depths of workings should be considered and the design of pillars at shallow depth should be conducted using an appropriate minimum pillar width (i.e., similar to those under NSW legislation) rather than a factor of safety or probability of failure.

- Time to failure of coal pillars should also be evaluated using the above methodologies.

- Once the above studies have been conducted, pillar design study should be performed.

Yours Sincerely,

Dr Ismet Canbulat

References

Canbulat, I. 2010. Life of coal pillars and design considerations. *Proc. 2nd Ground Control Conference, Sydney.* pp 57-66.

Salamon, MDG, Galvin, J M, Hocking, G and Anderson, I. 1996. Coal pillar strength from back-calculation. *Research Report 1/96 (University of New South Wales, School of Mining Engineering).*

Salamon, MDG, Ozbay, MU and Madden, BJ. 1998. Life and design of bord and pillar workings affected by pillar spalling. *Journal of Southern African Institute of Mining and Metallurgy.* 98:135-145.

Heritage, Y. 2015. Review of the potential for subsidence for the proposed underground bord and pillar operations, Dysart East Mine Project – Revision 3. Strata Control Technology (SCT) Report No. DYS4309A_REV3.

Disclaimer

Ismet Canbulat is employed as Professor and Kenneth Finlay Chair of Rock Mechanics at The University of New South Wales (UNSW). In accordance with policy regulations of UNSW regarding external private consulting, it is recorded that this report has been prepared by the author in his private capacity as an independent consultant, and not as an employee of UNSW. The report does not necessarily reflect the views of UNSW, and has not relied upon any resources of UNSW.

Professor Ismet Canbulat
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Profile

Extensive international experience in mining and geotechnical engineering in research, consultancy, industry and academia. Committed to build excellence and achieving leadership in safety and sustainability. Implemented world-leading standards, systems and processes for underground and open-cut mines located at shallow to ultra-deep. Consulted/worked over 60 coal, gold and platinum mines as well as involved in numerous concept, pre-feasibility and feasibility studies, where he managed and worked with many highly skilled, multi-functional-and-national engineers, geologists, contractors and consultants to ensure safe and economic reserve recovery. Expert in effective and integrated mine design; mine layout selection and rock engineering impact assessment; ground control; design of pillar and roof support systems in shallow to highly stress environments; numerical modelling; quantitative, qualitative and semi-quantitative risk assessment and management as well as advanced risk based design for underground and open cut mines.

Academic and professional qualifications

- PhD Mining Engineering (Rock Mechanics), University of Pretoria, South Africa, April, 2008.
- MSc Mining Engineering (Rock Mechanics), University of the Witwatersrand, South Africa, 1997.
- BSc Mining Engineering, Istanbul Technical University, Turkey, 1991.
- Certificate in Rock Mechanics (No. 380) – Coal, Chamber of Mines of South Africa, 2003.

Current and Past Professional Associations

- Fellow of the Australasian Institute of Mining and Metallurgy
- Member of Engineers Australia
- Registered Professional Engineer – Queensland (Geotechnical)
- Member of Australian Geomechanics Society
- Member of International Society for Rock Mechanics
- Member of Society of Mining, Metallurgy and Exploration (SME, USA)
- Past Member and Chairman of Strata Control Technical Sub-committee of the Australian Coal Industry's Research Program (ACARP)
- Past Vice-Chairman and Chairman of the Bowen Basin Underground Geotechnical Engineering Society (2010 - 2012)
- Registered Professional Engineer, Engineering Council of South Africa, (2006 – 2009)
- Vice Chairman of the South African National Institute of Rock Engineering Coalfields Branch (2001 - 2003)
- Member of the South African National Institute of Rock Engineering Executive Council (2001 - 2003)
- Member of the South African National Institute of Rock Engineering (SANGORM Previously) (1996 - 2006)

Employment History

2014 – Present **UNSW Sydney, School of Mining Engineering, Engineering Faculty**
Professor and Kenneth Finlay Chair of Rock Mechanics
Responsible to:

- Provide academic and industry leadership across the mining rock mechanics discipline with particular attention to underground coal mining techniques, and more broadly, to become established and recognised as a world leader in the development of coal mine strata control understanding and related coal mining issues.
- Develop research initiatives, strategies and innovative solutions appropriate to the ongoing development of rock mechanics in the coal mining industry; in particular associated with strata control and related underground mining issues.
- Provide leadership and direction in the further development and operation of world-class coal mining rock mechanics research practice within the School of Mining Engineering, comprising a team of research-focussed academics and postgraduate students.
- Contribute to strategic planning and implementation, both within the School of Mining Engineering, and in multi-disciplinary opportunities across and beyond the Faculty of Engineering, within UNSW.
- Regularly review and identify priority education and research focus areas and issues affecting the coal mining sector.
- Engage in high quality research projects and attract competitive grants.

2008 – 2014 **Anglo American Coal, Brisbane, Australia**
Principal Geotechnical Engineer – Underground
Responsible to:

- Lead development of geotechnical engineering standards, procedures and the best practices to achieve zero-harm and zero geotechnical delays at operations.
- Support operations in mine design and geotechnical engineering.
- Support green field and growth projects at concept, pre-feasibility and feasibility levels.
- Provide technical support for business risk management.
- Provide technical support for design and selection of mining equipment.
- Conduct regular audits at operations on systems and standards
- Implement new technologies and research findings at operations.
- Lead development of geotechnical engineering capacity
- Coach and mentor junior and senior geotechnical engineers
- Management of staff and consultants in operational and mining projects.
- Review all related technical evaluation reports, and
- Provide training courses for all AAC Geotechnical Engineers.

2006 – 2008 **Strata Engineering (Australia) Pty Ltd**
Principal Engineer
Responsible for:

- Consultancy and applied research projects in coal Geotechnical Engineering to numerous local and international mining companies and mines.
- Provide technical support for Geotechnical Engineering and mine planning in pre-feasibility and feasibility projects.

2003 – 2006 **Groundwork Consulting Pty Ltd. Johannesburg, South Africa**
Principal Consultant
Responsible for:

- Management of a range of long and short-term research projects in mining and geotechnical engineering

- Consultancy and technical support to numerous 20 local and international mining companies and mines.
- Management of projects and staff.
- Review related technical reports.

1994 – 2003 **Council for Scientific and Industrial Research (CSIR) – Division of Mining Technology. Johannesburg, South Africa**

2001-2003 **Research Area Manager – Coal and Other Mines, Rock Engineering Programme**

Responsible for:

- Leading a wide range of long-term and short-term research projects in Mining and Geotechnical Engineering (in coal, gold and platinum mines) in one of the largest research organisations in the world.
- Securing these projects through research grants
- Planning and management of projects.
- Management of project staff.
- Shared-responsibility for long-term strategy and planning of Rock Engineering Programme of the CSIR.
- Consultancy for many mining companies in South Africa.

1994-2001 **Research Engineer, Rock Engineering Programme**

Technical responsibility for research and consultancy projects in coal and platinum mines.

1993-1994 **University of the Witwatersrand. South Africa**

Lecturer/Engineer: Mining Engineering and related rock mechanics and rock behaviour in the rock-testing laboratory.

1991 – 1993 **ASON Exploration (Pty) Ltd. Turkey**

Site Engineer responsible for daily drilling and exploration activities. Assistance in civil projects.

Publications

- **Technical Papers**
  Has published over 50 technical papers published in refereed journals and conference proceedings focusing on many aspects of Geotechnical Engineering and mine planning.

- **Peer-reviewed Research Reports**
  Has been the author and co-author of over 20 major technical reports (and two theses) submitted on long and short-term applied research projects.

- **Consultancy Reports**
  Has been author and co-author of over 100 consultancy and internal reports submitted to many mines in South Africa and Australia focusing on all major aspects of mining and Geotechnical Engineering.

A detailed list of the above publications is available upon request.

Awards and Honours

2013	Recipient of the 2013 the Syd S. Peng Ground Control in Mining Award presented by the Society for Mining, Metallurgy and Exploration (SME), USA. The purpose of the award is to provide recognition to individuals that have demonstrated technical and scientific excellence in advancing the understanding of ground control technologies or approaches.
2013	Recipient of the 2013 Geotechnical Practitioner of the Year Award presented by the Bowen Basin Geotechnical Underground Geotechnical Society (BBUGS). This award is given to a BBUGS participant who has contributed the field of underground coal geotechnical engineering in the Bowen Basin.
2011	Finalist, Applaud 2011, The Anglo American Excellence Award, Innovation Category. This award recognises individuals and teams for outstanding achievements that help Anglo American deliver the strategic priorities. Only eight finalists (out of more than 100,000 employees) are selected around the world in four categories: sustainable development, safety, working in partnership and innovation.
2009	Awarded the "Gold Medal" by the Southern African Institute of Mining and Metallurgy for the best paper published in the Journal in 2009. This award is given to authors of papers that are of a world-class standard and judged to be publications that will become key reference in the mining and metallurgy field in the future.
2009	Best paper presented in GeoMeet 2009. This paper is presented at Anglo American's annual Geo Meeting Symposium for the best paper presented.
2006	Awarded the Innovation and Patent Incentive Award – GoafWarn, Foundation for Research and Development (South African Government) for obtaining an international patent.
2006	Awarded the Innovation and Patent Incentive Award – In Situ Roof Bolt Integrity Tester (ISBIT), Foundation for Research and Development (South African Government) for obtaining an international patent.
2001	Director's Achievement Award CSIR Division of Mining Technology.

Regional Planning Interests Act 2014

RPI17-004-Bengal Coal-Dysart East Coal Mine

Submission pursuant to section 37 RPI Act 2014

SUBMITTER: George Houen on behalf of Cradcorp Pty Ltd

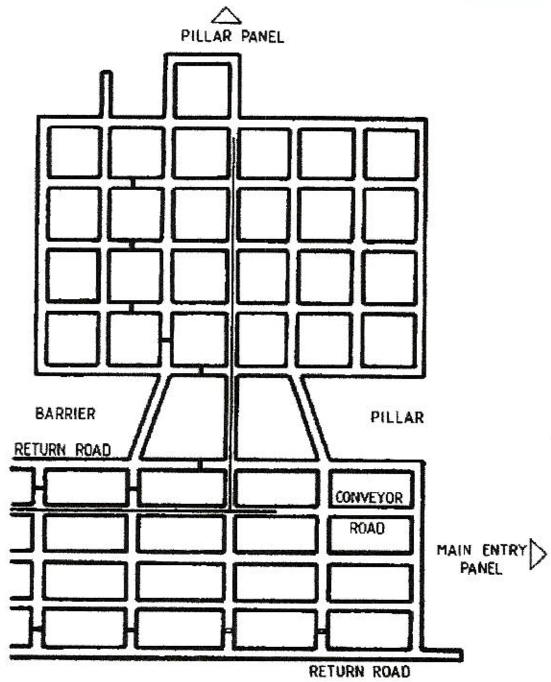
ATTACHMENT "C"

Illustration of bord and pillar mining method

BORD AND PILLAR Mining

METHOD OVERVIEW

The fundamental concept of bord and pillar methods of mining is that the coal seam is divided into a regular block like array by driving through it primary headings which are intersected at regular intervals by connecting cutthroughs. The headings and cutthroughs may be taken as "bords" although this is not strictly correct terminology. The blocks of coal bounded by them are the "pillars". The pillars support the overlying strata during the "first workings" as the bords are driven. They may or may not be extracted systematically on subsequent "second workings", depending on the scheme adopted. In its simplest and most traditional form bord and pillar workings are illustrated to the right.



Layouts such as the one displayed here originated from hand working practices in seams thicker than 1 m where insufficient waste material was obtainable during the working to allow construction of the packwalls and stowage necessary in hand worked longwall methods. Essentially it has always been the method of mining the medium-thick seams in Australia.

Exactly the same layout is suited to modern mechanised practices but it has taken some intervening stages of machine development to reach this situation.

Regional Planning Interests Act 2014

RPI17-004-Bengal Coal-Dysart East Coal Mine

Submission pursuant to section 37 RPI Act 2014

SUBMITTER: George Houen on behalf of Cradcorp Pty Ltd

ATTACHMENT "D"

Report: Shields 2017

Including Shields 2013

CV for Peter Shields

LR AM
Land Resource Assessment and Management Pty. Ltd.
ABN 65 446 117 882
ACN 059 780 602

Potential impact of Dysart East Coal Mine on SCL covering Lot 2 on SP 161102

Compiled by P.G. Shields

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Contents

1. Purpose of this report

This report addresses aspects of an assessment application (RPI17/004/Bengal-DEC) by Bengal Coal Pty Ltd for a Regional Interest Development Approval (RIDA) of the Dysart East Coal Project (the project).

The application covers approximately 765 ha located within Mineral Development Lease (MDL) 450.

MLA 70507 covers part of Lot 2 on SP161102, which is owned by Cradcorp Pty Ltd. The owners are concerned about impact of underground mining on the agricultural productivity of Lot 2.

The purpose of this report is to describe the potential impact of the proposed resource activity on the strategic cropping land (SCL) designated on Lot 2. The report has been prepared to provide supporting information for a submission by the owners regarding mining impacts.

2. Issues of concern with Application RPI17/004/Bengal-DEC

2.1 Background

The assessment application states that SCL on Lot 2 of SP161102 will be impacted by the proposed resource activity.

Before the assessment application was lodged, a detailed soil and land resource study of MLA 70507 was conducted as part of the revised environmental assessment report for the project (URS 2015). The study confirmed that all the area inside Lot 2 SP161102 that is mapped as Potential SCL on the Queensland Government trigger map meets the criteria for SCL. Supporting information in the application report (AECOM 2017) calculates this area to be 284 ha.

The assessment application states that 5 ha of this SCL will be impacted by above ground infrastructure associated with the underground mining operation. The accompanying application report describes this infrastructure as monitoring, tracks, seismic tracks, a ventilation shaft , boreholes and monitoring stations.

Appendix A of the application report describes the proposed mining system will exclude mining below the nominated infrastructure (a power substation not on Lot 2). However, a traditional bord and pillar technique for underground mining will be used elsewhere and surface subsidence may occur across the remainder of the mine lease.

2.2 Issues of concern

Land must be within threshold values for eight criteria to be deemed SCL. These criteria include three ground surface features and five features associated with properties of the soil profile.

Surface activities and infrastructure associated with underground mining can change both surface features and soil profile properties and thus alter the capacity of land to meet the thresholds for these criteria.

Underground mining activities can also affect SCL status if the ground surface features are changed as a result of mining through subsidence and if earthworks are required to rehabilitate the ground surface to its pre-mining condition.

Subsidence can change the slope over much shorter distances than naturally occurring; creating steeper and shorter slopes, producing greater slope complexity and altering the surface run-off conditions.

2.3 Case studies for the Central Highlands

Guideline 08/14 for the Regional Planning Interests Act 2014 stipulates that land in the Western Cropping zone must be on slopes of 3% or less.

The soils deemed to be SCL inside Lot 2 on SP161102 currently have slopes <2%. However, evidence from cropping land around Emerald that has already been mined and has suffered subsidence indicates that the shape of the post subsidence land surface is not as smooth and slopes are increased across substantial areas.

This evidence was collected in conjunction with a detailed analysis of slope changes and their effect on SCL status for the proposed underground Springsure Creek Coal Mine (Shields 2013). This analysis was prepared and submitted in response to an environmental impact study (EIS) lodged by the proponent.

The slope analysis was based on detailed digital elevation modelling of the existing surface and predicted post subsidence surface undertaken by the proponent. Results showed there would be a substantial increase in slopes on all affected rural properties following subsidence.

The new areas with these steeper slopes would not cover large contiguous areas but they were distributed throughout the mined area and would affect the shape and slope complexity of almost all cultivation paddocks.

Selected cross-sections for seventeen locations clearly showed that subsidence would cause steeper slopes and greater slope complexity in all but one cross-section.

Use of 20 m wide cultivation machinery is standard practice for broadacre cropping throughout the Central Highlands as it provides numerous benefits, including:

- less operator time spent cultivating the large paddocks;
- lower fuel expenses for cultivation; and
- shorter time required to plant a crop and higher germination rates, especially for summer crops which are planted at times when the soil is rapidly drying due to high evaporation rates.

Overlays representing 20 m wide cultivation machinery placed on each cross-section profile for the proposed Springsure Creek Coal Mine demonstrated that substantial earthworks would be necessary to smooth the land surface in seven cross-sections so that cultivation was possible.

Moreover, even after the necessary earthworks were undertaken slopes would remain at 4% or higher in parts of thirteen cross-sections. Soil conservation works are not effective and cropping is not recommended on slopes of more than 4%.

Where post subsidence slopes became steeper but less than 4%, soil conservation cropping practises would have to be intensified. In particular, the horizontal interval between contour banks would have to be reduced resulting in smaller cultivation runs between banks and increased costs of production.

Overall, it was shown that the distribution of new, steeper areas would fragment the existing SCL. This situation would create major difficulties in farm layout and the SCL would not be able to be farmed to its maximum potential.

Moreover, it was shown that subsidence would destroy the entire run-off and erosion control system currently used on the properties to safely collect and dispose of excess rainfall that can't infiltrate into the soil. The generally greater unevenness in the surface microrelief following subsidence would cause:

- a greater propensity for rainfall to pond in lower localised sites; and
- disruption to contour banks and to integration with designed waterways.

The only reasonable measure that can be applied to restore affected land to its SCL status prior to disturbance is to reduce slope to an acceptable value. This necessitates earthworks involving removal of soil from higher areas to adjacent lower areas to reduce and even out their relative relief and thus the overall slope.

Earthworks will also be essential to re-establish an adequate drainage system that controls surface run-off and erosion control.

2.4 Existing situation for Dysart East Coal Mine

The application report declares that "*The assessment report (Appendix A) demonstrates that the proposed mine would result in negligible subsidence to surface areas which would be subject to underground mining, meaning that any subsidence from mining operations would be less than typical seasonal soil movements and, as such, would be imperceptible.*"

Appendix A explains that "*To manage surface subsidence to negligible effects, it is proposed to extract coal using the traditional bord and pillar technique using first workings only. No secondary extraction of coal will occur which eliminates caving and goaf formation that is associated with the main mode of surface subsidence (resulting from full extraction).*"

Appendix A then concludes that negligible surface subsidence "*.... has been achieved through a staged approach of elimination of mining in Restricted Land areas and applying an appropriate level of risk for design of the mine, based on the probability of pillar stability.*"

Yet no acceptable modelling of subsidence has been undertaken to confirm the magnitude of the predicted subsidence. Furthermore, the results have not been incorporated into detailed digital elevation modelling to compare slope conditions before and after mining. No quantitative evidence has been provided to support these conclusions.

Cultivation machinery currently used by Cradcorp Pty Ltd on Lot 2 is 22 m wide and planting machinery is 19 m wide. Use of such machinery is standard practice in the Central Highlands and is very efficient provided the ground surface is relatively smooth and slopes have quite a low gradient.

For SCL status to be maintained on Lot 2 slopes must remain at 3% or less. To ensure the long-term cropping potential of this SCL is retained slope complexity cannot be exacerbated by any mining subsidence.

3. Conclusions

Application RPI17/004/Bengal-DEC provides no quantitative evidence to support its application that the proposed mining will produce negligible surface subsidence.

Case studies of past and proposed underground mining activities in the Central Highlands have highlighted the potential for subsidence to severely impact SCL. Underground mining can produce areas of increased slope that are tangential and often perpendicular to the contour. This arrangement interferes with the usability of the remaining suitable cropping land for broadacre cropping and amplifies the impact of the actual size of cropping land affected. Substantial earthworks are required to restore the ground surface to its pre-mining condition by reducing slopes to satisfy the SCL criterion and by re-establishing an adequate drainage system that controls surface run-off and erosion control.

Lot 2 on SP161102 contains 248 ha of SCL inside MLA 70507; the SCL covers almost all of the area to be disturbed.

In order to accurately assess the impact of underground mining on SCL inside Lot 2:

- Detailed investigation of predicted subsidence across the entire mined area needs to be conducted.
- Reliable subsidence modelling results need to be used to prepare before and after digital elevation models on the ground surface to determine
  - the degree and extent of any slope changes;
  - the need and extent of earthworks to reduce slope to meet the SCL requirement and to re-establish adequate surface drainage; and thus
  - the volume and feasibility of any earthworks program for successful rehabilitation.

4. References

AECOM (2017, Regional *Interest Development Approval - Application Report: Dysart East Coal Mine*, AECOM Services Pty Limited.

Shields PG (2013), *The effect of longwall mining on cropping potential following subsidence at the proposed Springsure Creek Coal Mine*, Land Resource Assessment and Management Pty Ltd.

URS (2015), *Dysart East Coal Mine Project Revised Environmental Assessment Report: Environmental Authority Supporting Information, May 2015, 42627233/02/0*, URS Australia Pty Ltd.

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The effect of longwall mining on cropping potential following subsidence at the proposed Springsure Creek Coal Mine

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Contents

Figures

1. Introduction

1.1 Background

Bandanna Energy Limited (Bandanna Energy) has submitted an environmental Impact Statement (EIS) to the Queensland Government for the proposed Springsure Creek Coal Mine Project.

The EIS addresses potential opportunities and impacts on environmental, economic and social values of the underground, longwall mine component of the greater project that are of interest to the State of Queensland.

1.2 Concerns with the effects of subsidence reported in the EIS

The original EIS released in February 2013 concluded in Chapter 5 (Springsure Creek 2013) that:

- modelling predictions indicate the maximum subsidence over the project area will range from 1.2 m to 2.3 m; and
- the greatest level of subsidence is likely to occur within the central section of the project area.

The impacts of this subsidence were also predicted to tilts for the land surface to range from approximately 1.8% to 2.5% across the project area. Figure 5-17 in the EIS conveys the impression that this tilt will be fairly uniform across the disturbed areas.

Figures 5-15 and 5-16 in the report compare the predicted surface level after subsidence with the existing surface level for two cross-sections, each of approximately 3 km length. Unfortunately, the vertical scale used in these figures does not enable close inspection of the difference in surface level within individual mined panels.

Moreover, anecdotal evidence from nearby cropping land within the Central Highlands that has already been mined and has suffered subsidence indicates that the shape of the post subsidence land surface is not as smooth as intimated from these figures in the EIS report.

In fact, Appendix A4-2 of the Supplementary EIS, which was prepared in August 2013 (Seedsman 2013), states:

> *It is also important to note that the predictions and subsequent visualisations assume smooth continuum behaviour. In fact, the subsidence databases are built on the maximum values recorded from survey lines. In reality, subsidence profiles (especially for wide/shallow panels) are characterised by small-scale irregularities.*

Landholders on three affected rural properties have requested an independent analysis of the predicted subsidence levels and their impacts on cropping potential due to the concerns mentioned above. The analysis has been undertaken for the following properties:

- Arcturus Downs (Lots 7 and 8 on RP620355);
- Cedar Park (Lot 11 on RP619636); and
- Springton (Lot5 on DSN856 and Lot 2 on Sp141314).

1.3 Purpose of this document

This document provides the results of the independent analysis of the post subsidence effects of longwall mining on cropping potential at the proposed Springsure Creek Coal Mine.

The independent analysis has been conducted to investigate in more detail (than supplied in the project EIS) the effects of subsidence on slopes and the resultant impacts on:

- potential for continued cultivation using the broadacre machinery;
- Strategic Cropping Land (SCL) status; and
- surface run-off and subsequent ponding within paddocks.

Cultivation machinery currently used by the affected landholders is 20 m wide. Use of such wide cultivation machinery is standard practice for broadacre cropping throughout the Central Highlands as it provides numerous benefits, including:

- less operator time spent cultivating the large paddocks;
- lower fuel expenses for cultivation; and
- shorter time required to plant a crop and higher germination rates, especially for summer crops which are planted at times when the soil is rapidly drying due to high evaporation rates.

2. Methodology

2.1 Data source

Bandanna Energy supplied approximately 1 GB of data, made up of ASCII files and Digital Elevation Models (DEMs). data supplied represented a digital elevation model for the:

- existing surface (SC_DEM_Existing_5m);
- predicted post subsidence surface using a tanB=2 model (EIS_tanB2_post_sub_5m); and
- predicted post subsidence surface using a tanB=4 model (EIS_tanB4_post_sub_5m).

It is understood that these models were generated from LiDAR data acquired by Bandanna Energy. This data was not supplied, although requested, and it has been assumed that Bandanna determined that the DEMs supplied were at the best resolution that could be extracted from the LiDAR data.

2.2 Data analysis

The GIS consulting firm Australian Geographical Information Solutions (AUSGIS) undertook data manipulation and analysis.

The Bandanna Energy DEMs were loaded into ESRI's ArcGIS 10.2 for Desktop software to be processed. A subset of the DEMs was generated for each of the three nominated properties of interest to reduce the size of the initial data sets and minimising the processing time.

3D Analyst was used to generate slope data from the supplied DEMs. The slope analysis was classified into three groups:

- 0% to 1%;
- greater than 1% to 3%; and
- greater than 3%.

Table 1 provides the rationale for these categories.

Slope maps were generated for each property using the existing slope and post subsidence slope following subsidence using results from the tanB=4 model. This post subsidence model was chosen rather than the tanB=2 model as a value of 4.0 is more representative of the Bowen Basin (Seedsman 2013).

3D Analyst was also used to generate seventeen (17) cross-section profiles in selected locations across the 3 properties from the TanB=4 digital elevation model along with cross-section profiles from the same locations for the existing surface digital elevation model. Each cross-section is approximately 300 m in length.

Most locations for the cross-section were selected to extend from the one chain pillar to an adjacent chain pillar. However, at least one cross-section was selected on each property to extend approximately 300 m from a barrier pillar and one was selected to extend down the centre of the mined panel from a main heading on Arcturus Downs.

Table 1. Slope categories used in the analysis

Category	Rationale
0-1%	Level land Depending on soil type, suitable for cropping provided simple conservation cropping practices are adopted (minimum tillage, trash retention etc.) Depending on soil type, represents the best broadacre cropping land and is **SCL**
1-3%	Very gently undulating land Depending on soil type, suitable for cropping provided simple conservation cropping practices plus standard physical works (widely spaced contour banks, waterways) are adopted Depending on soil type, represents the best broadacre cropping land and is **SCL**
>3%	Gently undulating land Depending on soil type, suitable for cropping on slopes of ≤4% provided special soil conservation practices and physical works (diversion banks, closely spaced contour banks, waterways) are adopted Not the best broadacre cropping land and **non SCL**

3. Slope analysis results

3.1 Subsidence near barrier pillars and main headings

The subsidence modelling predicts changes within the longwall panels and appears to concentrate on the effect between chain pillars (which separate each mined panel).

Chain pillars are assumed to be 40 m wide (Seedsman 2013). In addition to the chain pillars, there will be in place much wider barrier pillars separating a group of approximately eight longwall panels. There will also be pillars supporting the main headings, which are the underground infrastructure containing major roadways and communication systems and providing mine ventilation, access for people, machinery, electricity, water supplies.

Barrier pillars may be as wide as 160 m (Springsure Creek 2013) but the width of the pillars supporting the main headings is not described.

Most subsidence will occur within the mined panels but the chain pillars are also expected to subside between 0.2 and 1 m. Subsidence of the wider barrier pillars should be less, if at all, and in fact subsidence is predicted to be greatest adjacent to the barrier pillars (Springsure Creek 2013).

Presumably, the amount of pillar support for the important main headings infrastructure will be greater than provided by a single span of chain pillars. If so, the area above the main headings should also subside very little and subsidence adjacent to the main headings should be thus greater than around the chain pillars.

Yet Figures 2 and 6, which include barrier pillars and main headings, show that subsidence is predicted to be more extensive along the chain pillars than along these other types of pillar support.

The EIS does not compare or discuss the extent of subsidence around the three different types of pillar support. Therefore, it is questionable whether the modelling adequately incorporates the effects of nil or negligible subsidence on the barrier pillars and along the main headings.

3.2 Post subsidence vs. existing slopes across the properties

The existing slopes and predicted post subsidence slopes are mapped across the three affected rural properties in:

- Figures 1 and 2 for Arcturus Downs;
- Figures 3 and 4 for Cedar Park; and
- Figures 5 and 6 for Springton.

Comparing these figures reveals there is a substantial increase in steeper slopes (above 3%) on all three properties following subsidence.

Within the mined panels, the new areas with > 3% slopes are predominantly aligned with either:

- the proposed chain pillars; or
- existing drainage lines.

Even though the new areas with > 3% slopes do not cover large contiguous areas they are distributed throughout the mined areas, and will affect the shape and slope complexity of almost all cultivation paddocks.

3.3 Post subsidence vs. existing slopes within mined panels

The post subsidence land surface is not as uniform as Figure 5-17 in the EIS appears to suggest. There is substantial slope complexity within individual mined panels as shown in Figures 2, 4 and 6.

The increased slope complexity is even more clearly illustrated by comparing cross-section profiles for the existing surface (Figures 7, 9 and 11) with profiles for the same locations after subsidence (Figures 8, 10 and 12):

- Figures 7 and 8 compare six locations on Arcturus Downs;
- Figures 9 and 10 compare five locations on Cedar Park; and
- Figures 11 and 12 compare six locations on Springton.

The location of these cross-sections and their relative position to the proposed chain and barrier pillars are shown in Figures 2, 4 and 6.

The profiles show that subsidence will cause steeper slopes and greater slope complexity in parts of all seventeen profiles except for cross-section F to F' on Arcturus Downs.

3.4 Effect of subsidence on cultivation

The effect that the post subsidence land surface will have on cultivation machinery is illustrated in Figures 8, 10 and 12. Rectangular blocks representing 20 m wide cultivation machinery are overlain on each slope profile in these figures. The overlays clearly demonstrate that substantial earthworks will be necessary to smooth the land surface so that cultivation is possible in:

- all profiles of Arcturus Downs except C to C' and E to E';
- profile D to D' of Cedar Park; and
- profiles D to D' and F to F' of Springton.

Moreover, even after the necessary earthworks are undertaken slopes will remain at 4% or higher in parts of all profiles except for:

- cross-section E to E' for Arcturus Downs; and
- cross-section C to C' for Cedar Park; and
- cross-sections C to C' and D to D' for Springton.

Soil conservation works are not effective at slopes greater than 4% and cropping is not recommended on such land (Bourne and Tuck 1993).

Where slopes after subsidence are steeper but less than 4%, soil conservation cropping practises will have to be intensified. In particular, the horizontal interval between contour banks will have to be reduced resulting in smaller cultivation runs between banks and increased costs of production.

3.5 Effect of subsidence on SCL status

The Strategic Cropping Land Act 2011 stipulates that land in the Western Cropping zone must be on slopes of 3% or less (as well as satisfying seven other criteria) to be designated SCL.

An SCL assessment in the Appendix A4-1 of the final EIS (McCann 2103) shows that, apart from the flood plains flanking the drainage lines, the vast majority of land within the three affected rural properties would currently be classified as SCL. Moreover, this SCL occurs in large contiguous areas.

Figures 2, 4 and 6 of this report show that subsidence will create substantial new areas with > 3% slopes which are distributed throughout the mined areas (see section 3.2) and throughout the current SCL.

Subsidence due to longwall mining will cause a substantial reduction in SCL within the three affected rural properties. The distribution of new, steeper areas will fragment the existing SCL and much of the non SCL will be too steep for sustainable, long-term cropping. This situation will create major difficulties in farm layout and use of the remaining SCL which will not be able to be farmed to its maximum potential.

3.6 Effect of subsidence on surface run-off and ponding

The increased slope complexity within parts of the longwall panels (see section 3.2) will affect the current movement of surface water within and from farm paddocks.

The current farming system safely collects and disposes of excess rainfall that can't infiltrate into the soil through:

- contour banks integrated with waterways; and
- cultivation across the slopes and on fairly even microrelief between the banks.

This entire run-off and erosion control system will be destroyed by subsidence. Figures 8, 10 and 12 demonstrate a generally greater unevenness in the surface microrelief following subsidence and thus:

- a greater propensity for rainfall to pond in lower localised sites; and
- disruption to contour banks and to integration with designed waterways.

Moreover, as mentioned in section 3.1 above, the subsidence modelling does not appear to adequately incorporate the effects of greater subsidence around pillar support areas having negligible subsidence. Thus, the surface water studies in the EIS which use the model results for their assessments are more than likely flawed and will not represent an accurate prediction of overland flow above the drainage lines following subsidence.

4. Conclusions

Longwall mining involves three different pillar support systems:

- chain pillars between longwall panels;
- barrier pillars between groups of longwall panels; and
- pillar support systems for the main headings.

Yet, the EIS does not compare or discuss the extent of subsidence around these different types of pillar support and slope analysis for this report appears to contradict the EIS conclusions regarding subsidence around barrier pillars. Therefore, it is questionable whether the modelling adequately incorporates the effects of negligible subsidence on the barrier pillars and along the main headings.

The slope analysis shows there is a substantial increase in slopes of more than 3% on all three affected rural properties following subsidence.

The new areas with these steeper slopes do not cover large contiguous areas but they are distributed throughout the mined area and will affect the shape and slope complexity of almost all cultivation paddocks.

Selected cross-sections for seventeen locations clearly show that subsidence will cause steeper slopes and greater slope complexity in all but one cross-section.

Overlays representing 20 m wide cultivation machinery placed on each cross-section profile demonstrate that substantial earthworks will be necessary to smooth the land surface in seven cross-sections so that cultivation is possible.

Moreover, even after the necessary earthworks are undertaken slopes will remain at 4% or higher in parts of thirteen cross-sections. Soil conservation works are not effective and cropping is not recommended on slopes of more than 4%.

Where post subsidence slopes are steeper but less than 4%, soil conservation cropping practises will have to be intensified. In particular, the horizontal interval between contour banks will have to be reduced resulting in smaller cultivation runs between banks and increased costs of production.

Subsidence due to longwall mining will cause a substantial reduction in SCL within the three affected rural properties. The distribution of new, steeper areas will fragment the existing SCL and much of the non SCL will be too steep for sustainable, long-term cropping. This situation will create major difficulties in farm layout and use of the remaining SCL which will not be able to be farmed to its maximum potential.

Subsidence will destroy the entire run-off and erosion control system currently used on the properties to safely collect and dispose of excess rainfall that can't infiltrate into the soil.

Moreover, the subsidence modelling does not appear to adequately incorporate the effects of greater subsidence around barrier pillars and main headings. Thus, the surface water studies in the EIS which use the model results for their assessments are more than likely flawed and not accurately predict overland flow above the drainage lines following subsidence.

5. References

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McCann Reece (2013), *Springsure Creek Coal Mine Project: Soils and Land Suitability Assessment June 2013*, in *Springsure Creek Coal Mine Project: Final Environmental Impact Statement June2013, Appendix A4-1 – Soil results and SCL reports*, GT Environmental Services Pty Ltd.

Seedsman R (2013), *Springsure Creek Coal Mine Project: Environmental Impact Statement August 2013, Appendix A4-2 – Subsidence report*, Springsure Creek Coal Pty Ltd.

Springsure Creek (2013), *Springsure Creek Coal Mine Project: Environmental Impact Statement February 2013, Chapter 5 - Land*, Springsure Creek Coal Pty Ltd.

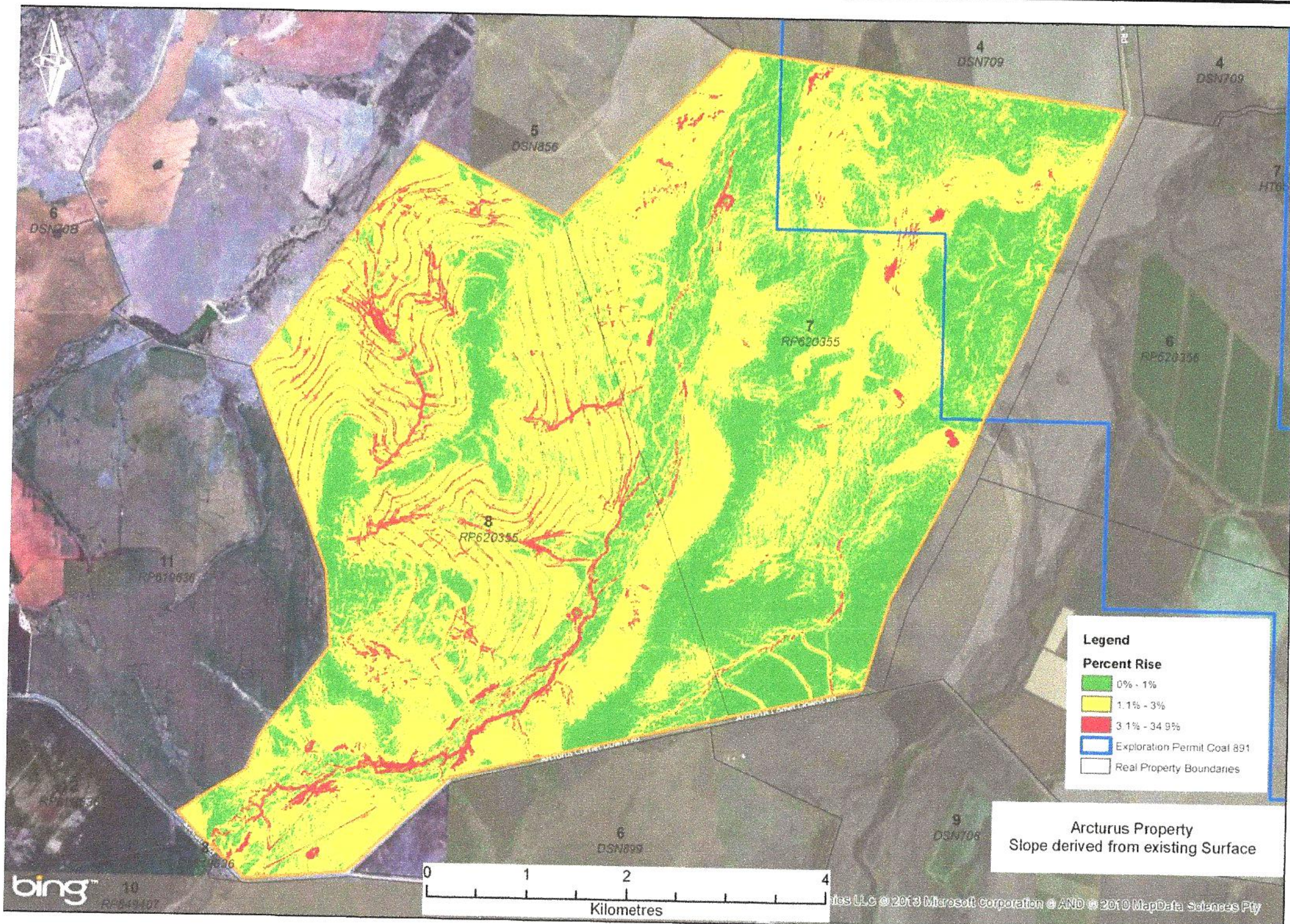


Figure 1. Existing slopes for Arcturus Downs

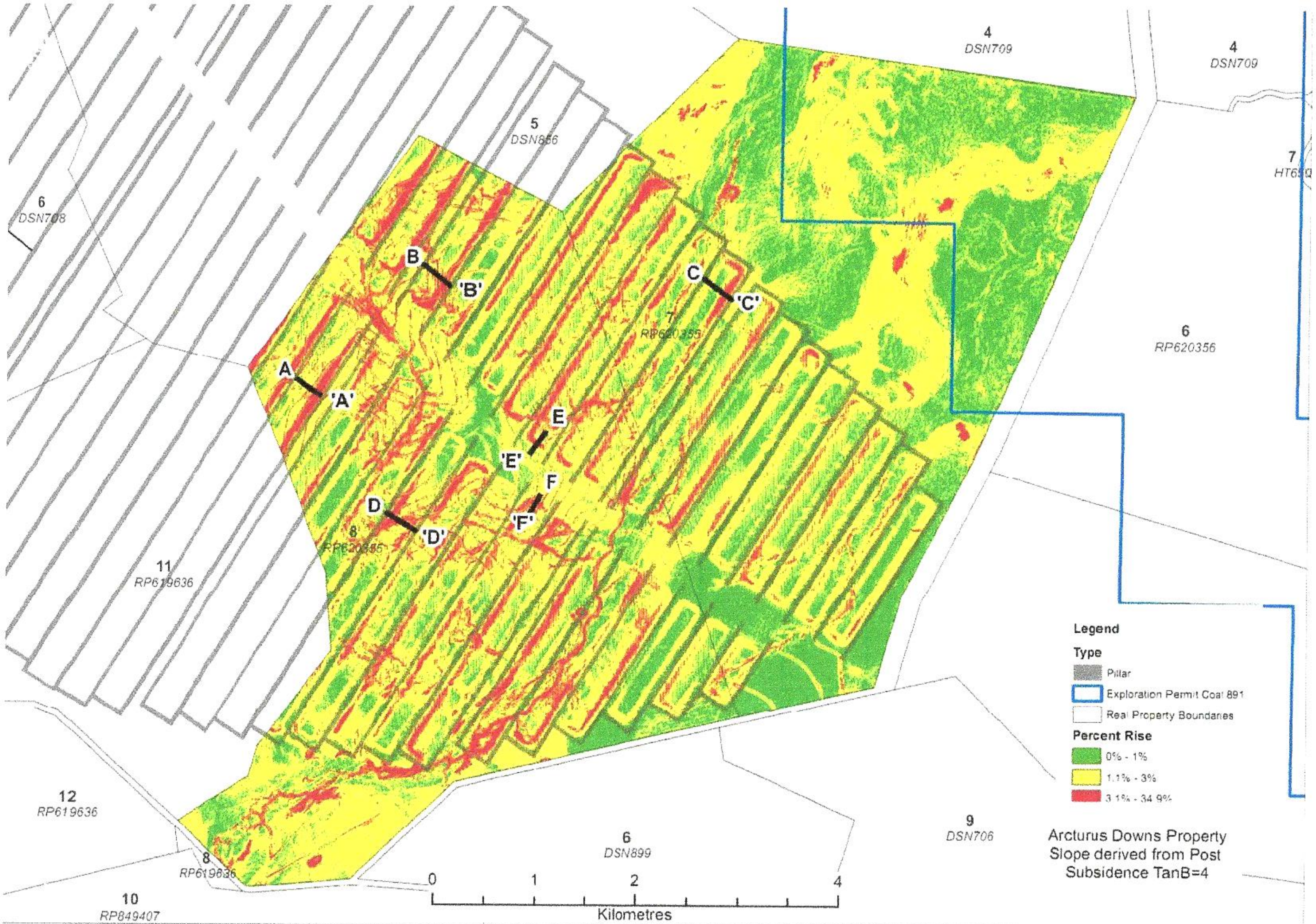


Figure 2. Predicted post subsidence slopes (tanB=4) for Arcturus Downs

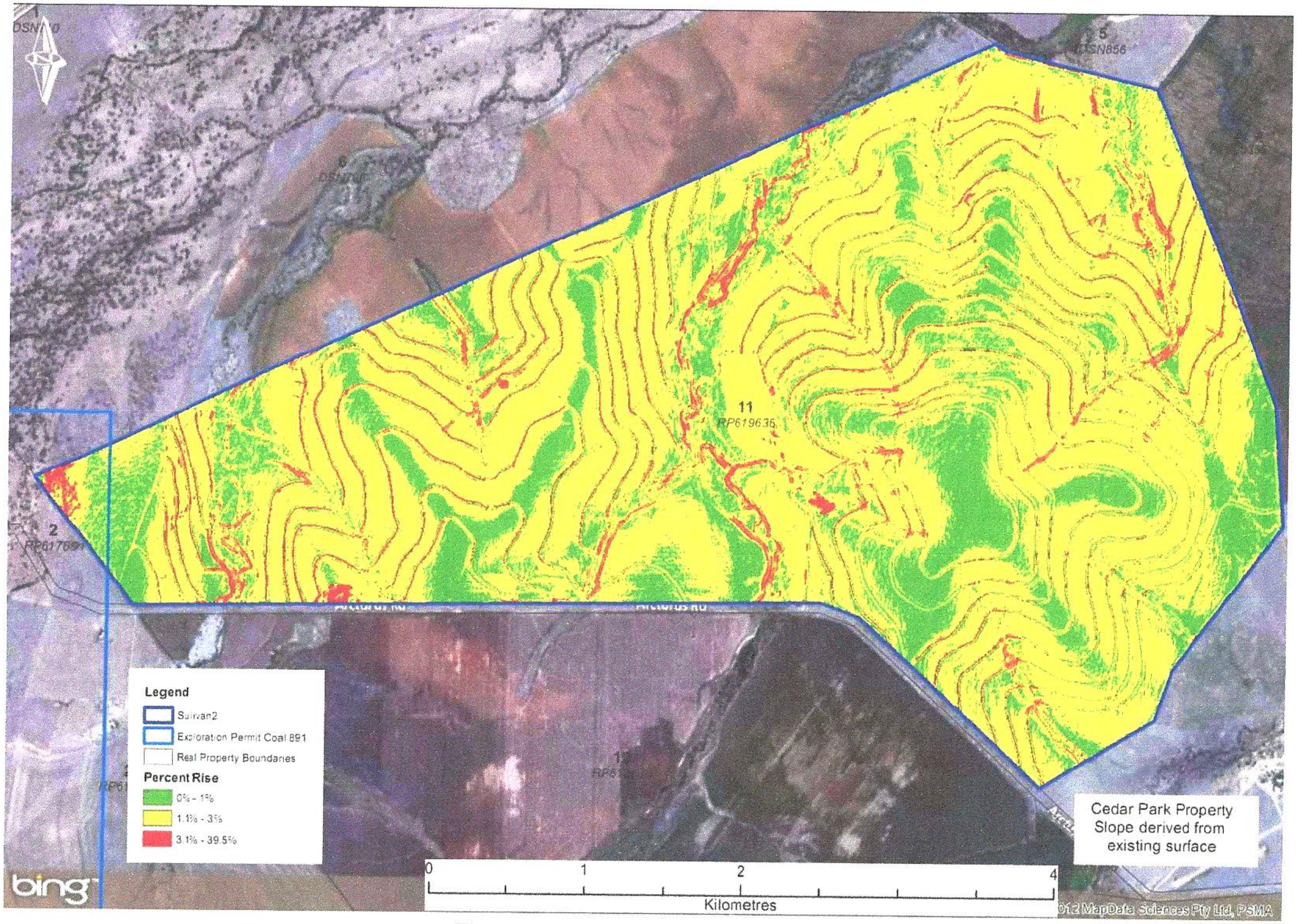


Figure 3. Existing slopes for Cedar Park

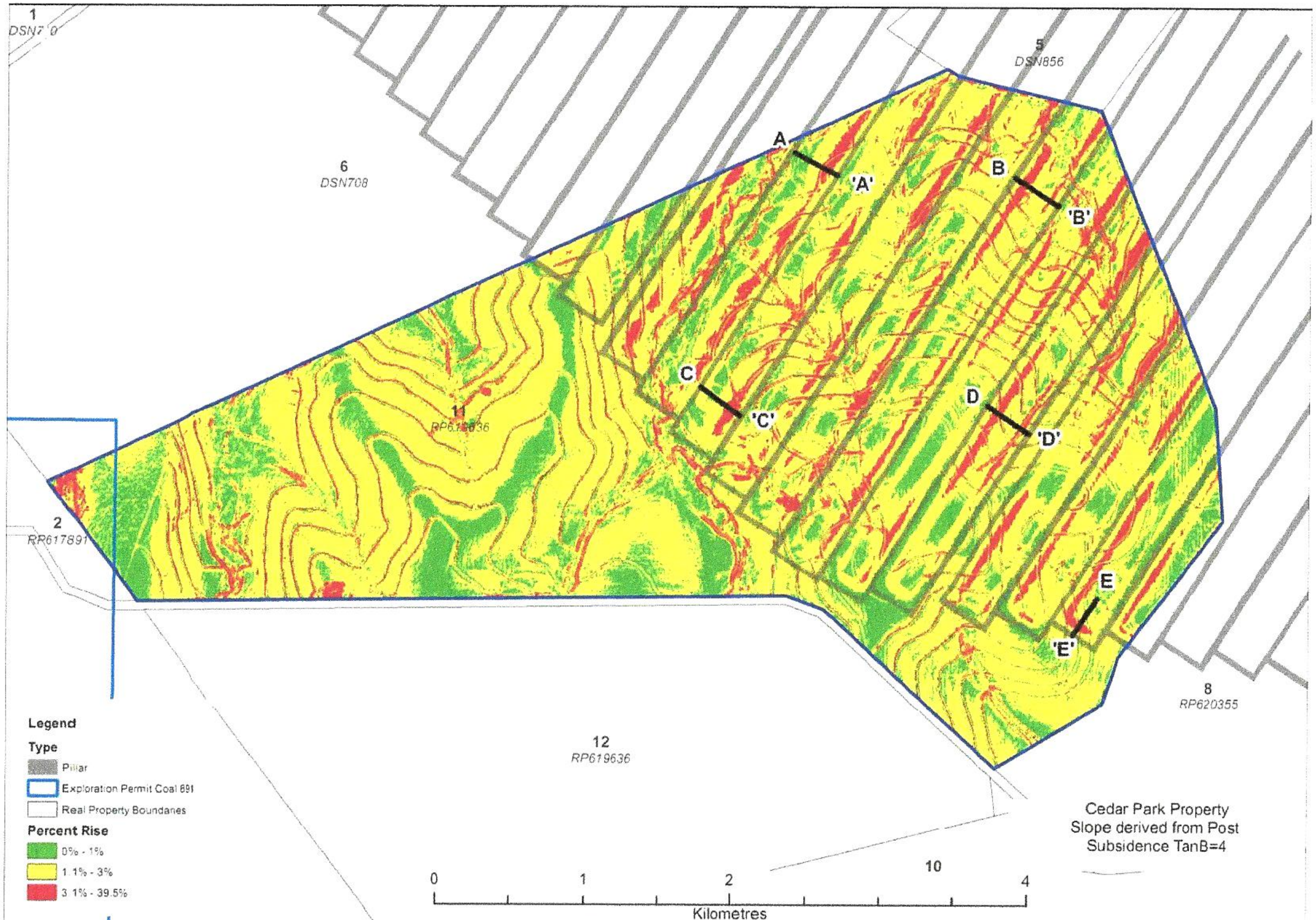


Figure 4. Predicted post subsidence slopes (tanB=4) for Cedar Park

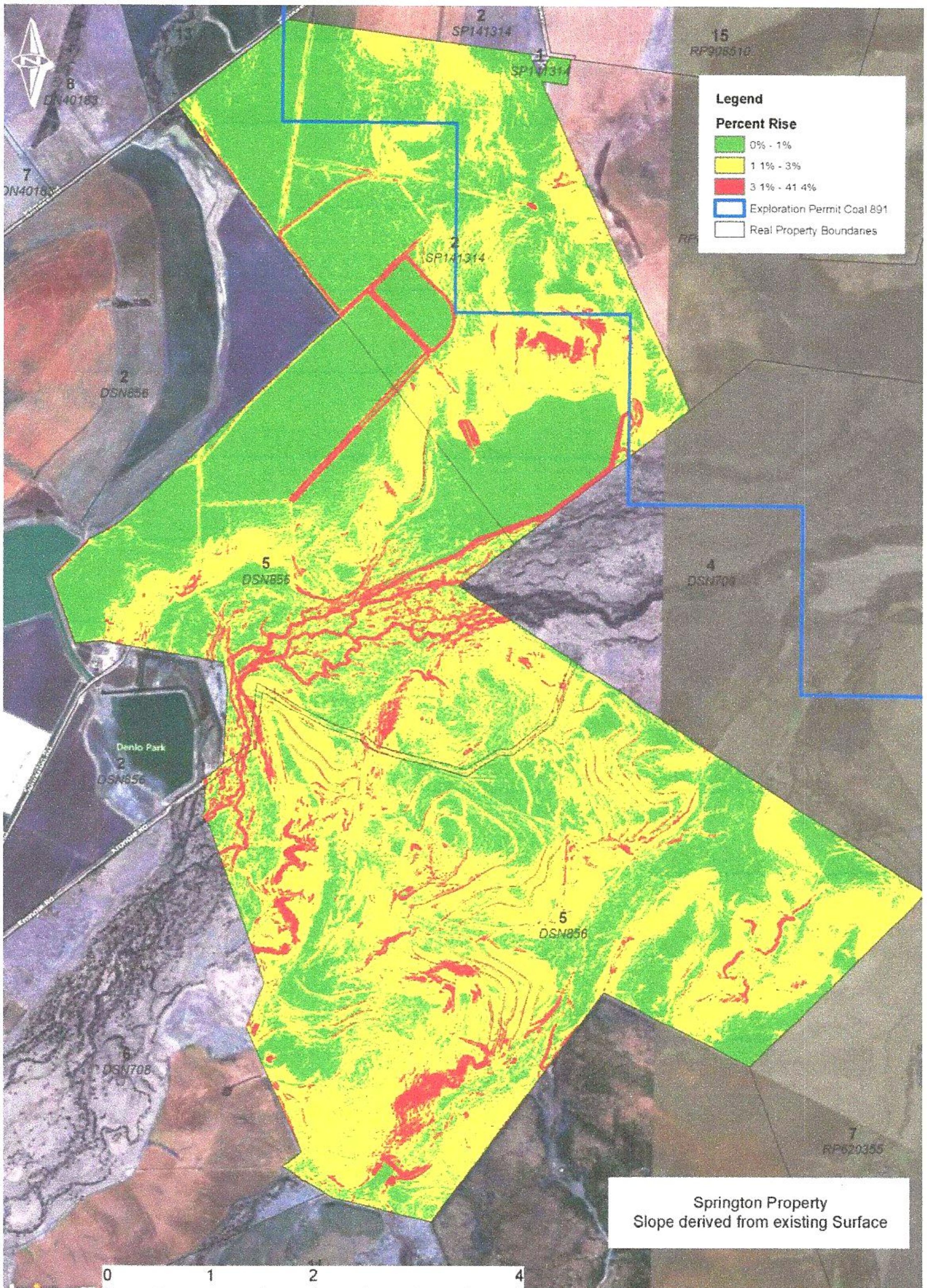


Figure 5. Existing slopes for Springton

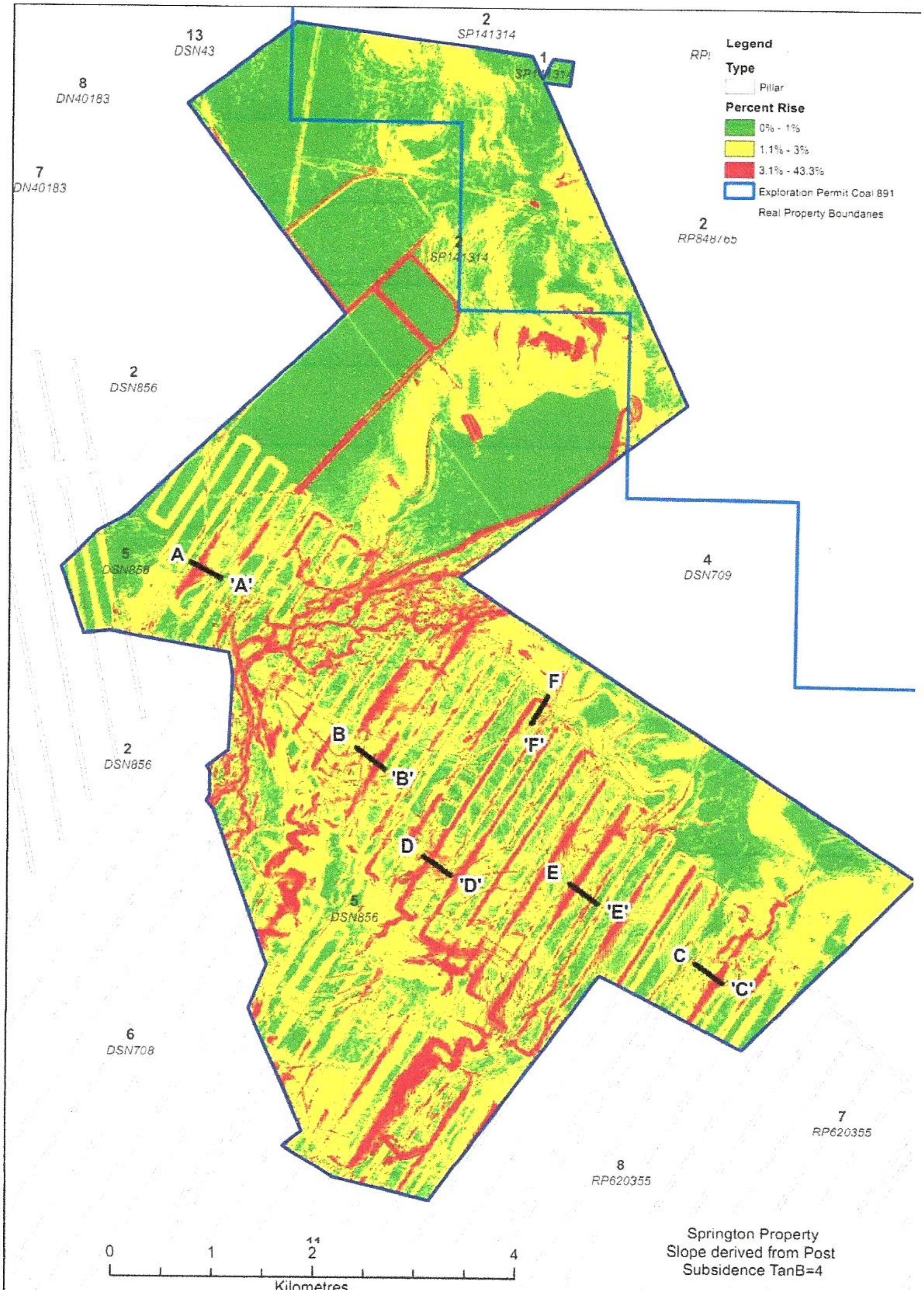


Figure 6. Predicted post subsidence slopes (tanB=4) for Springton

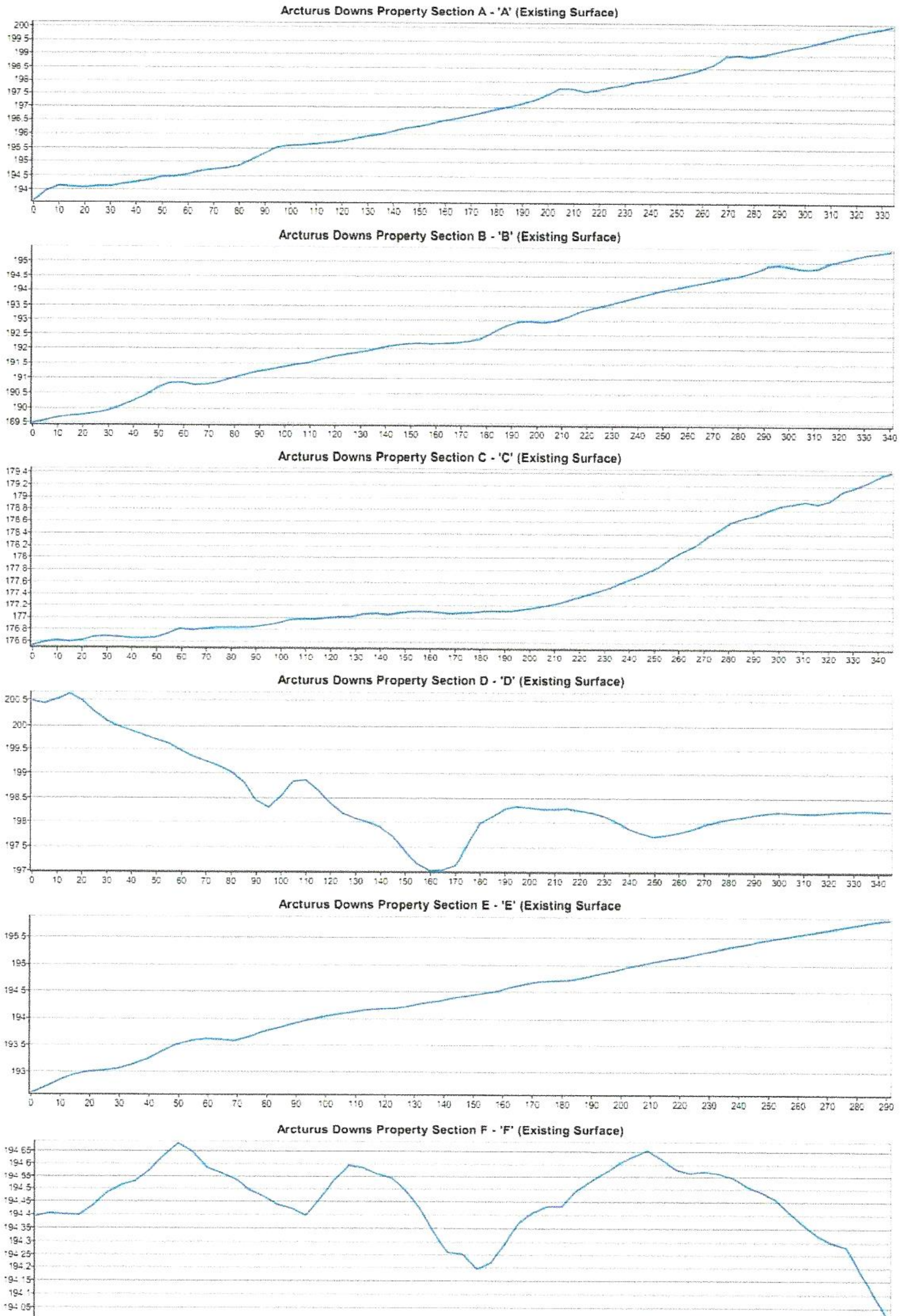


Figure 7. Cross-section profiles of existing surface for Arcturus Downs

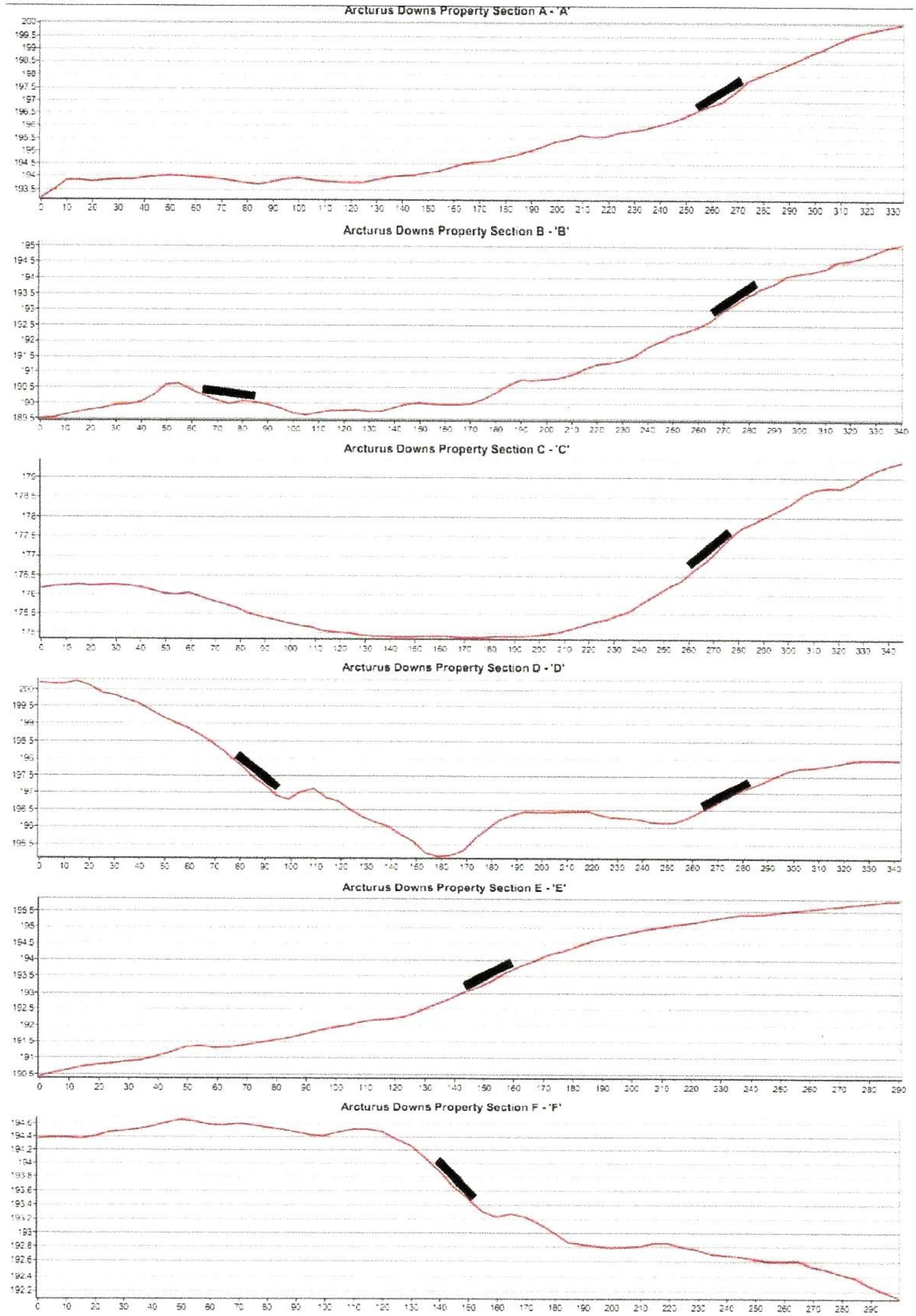
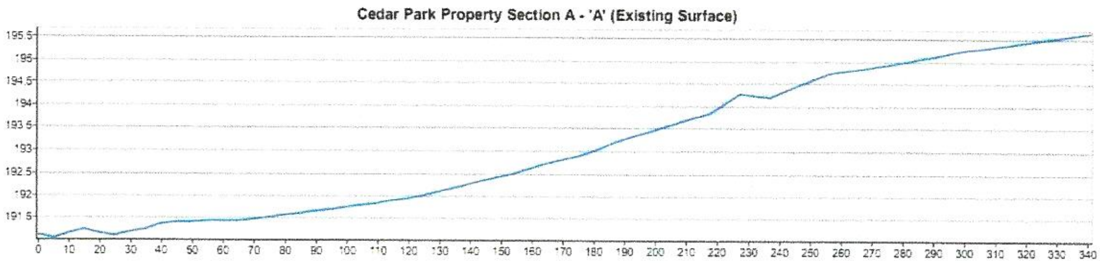
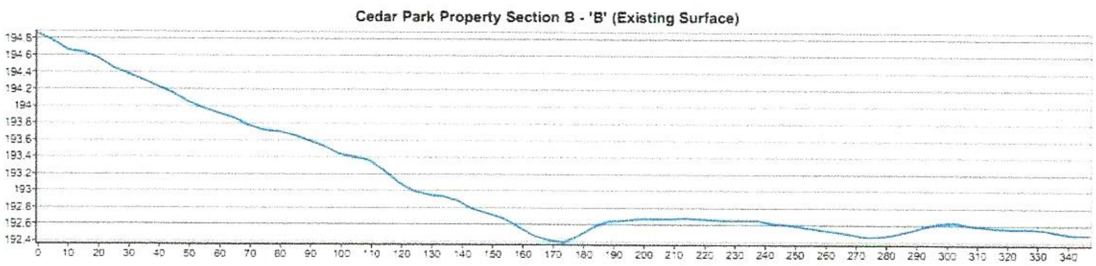
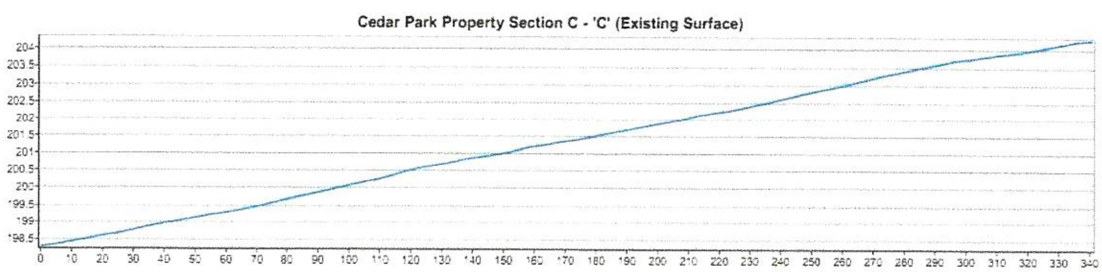
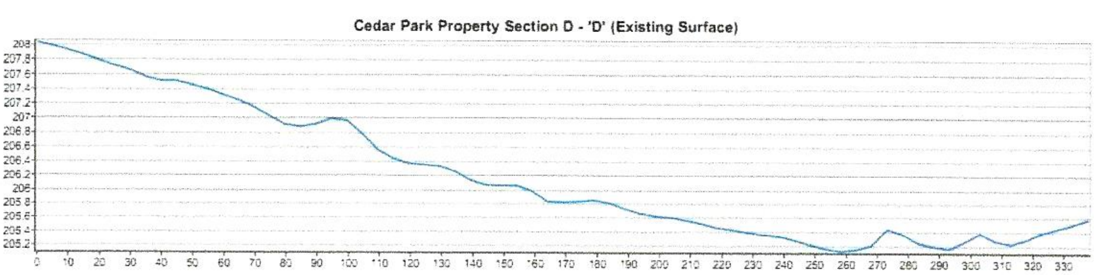


Figure 8. Cross-section profiles of post subsidence surface for Arcturus Downs (Black rectangular blocks represent 20 m wide cultivation machinery)









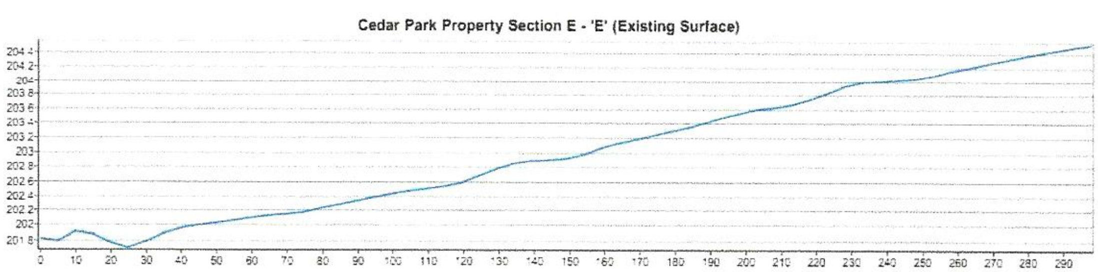


Figure 9. Cross-section profiles of existing surface for Cedar Park

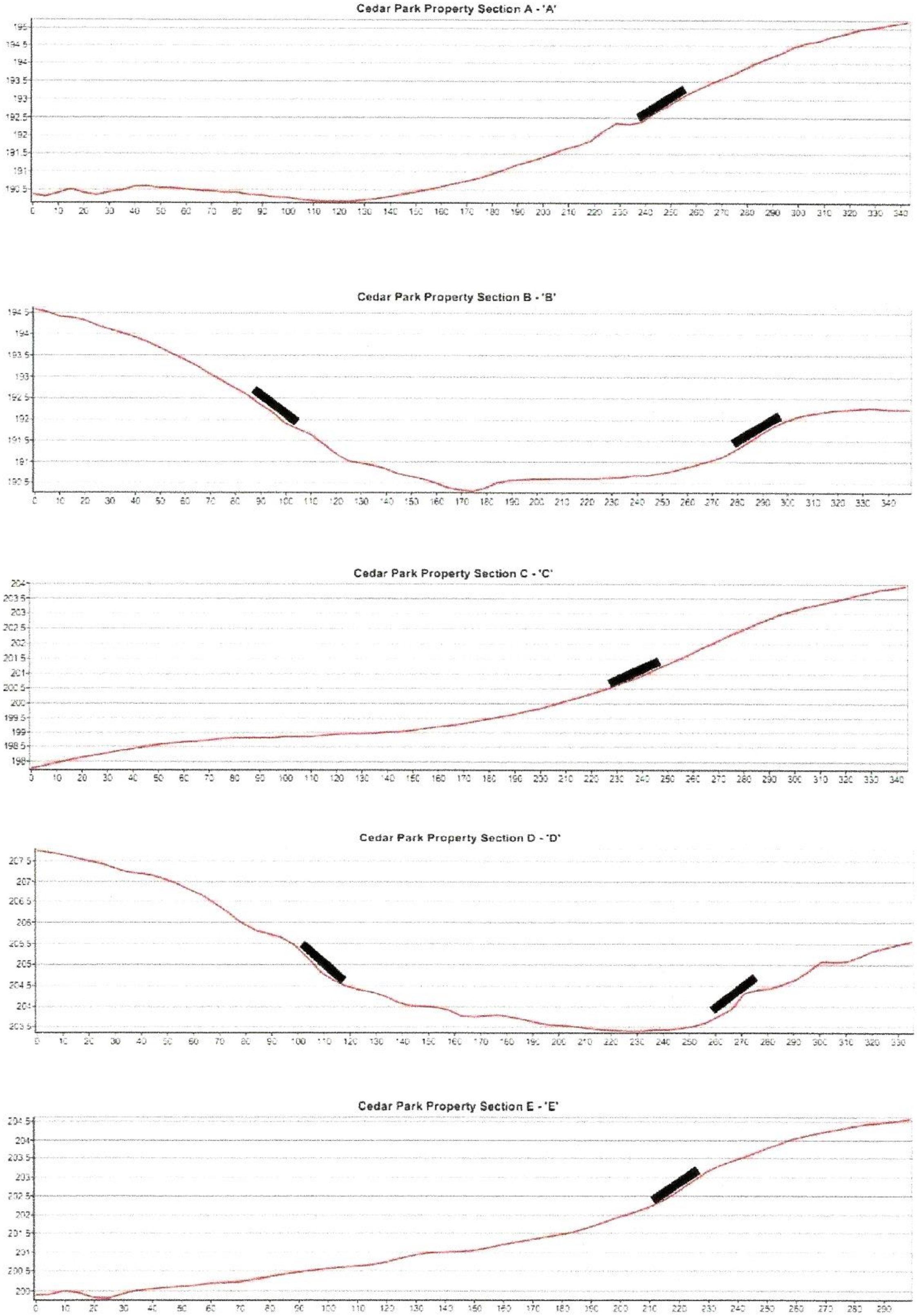


Figure 10. Cross-section profiles of post subsidence surface for Cedar Park
(Black rectangular blocks represent 20 m wide cultivation machinery)

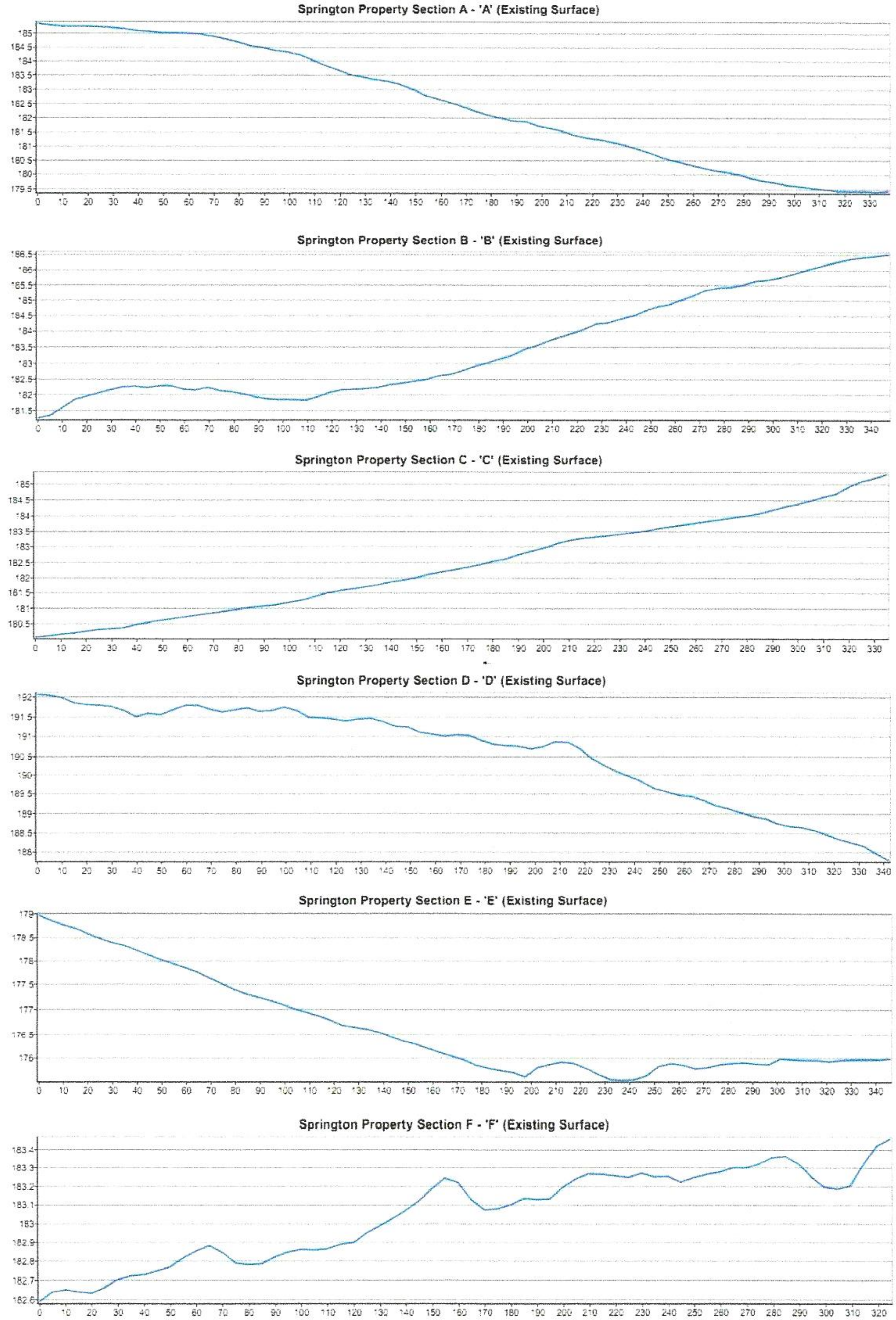


Figure 11. Cross-section profiles of the existing surface for Springton

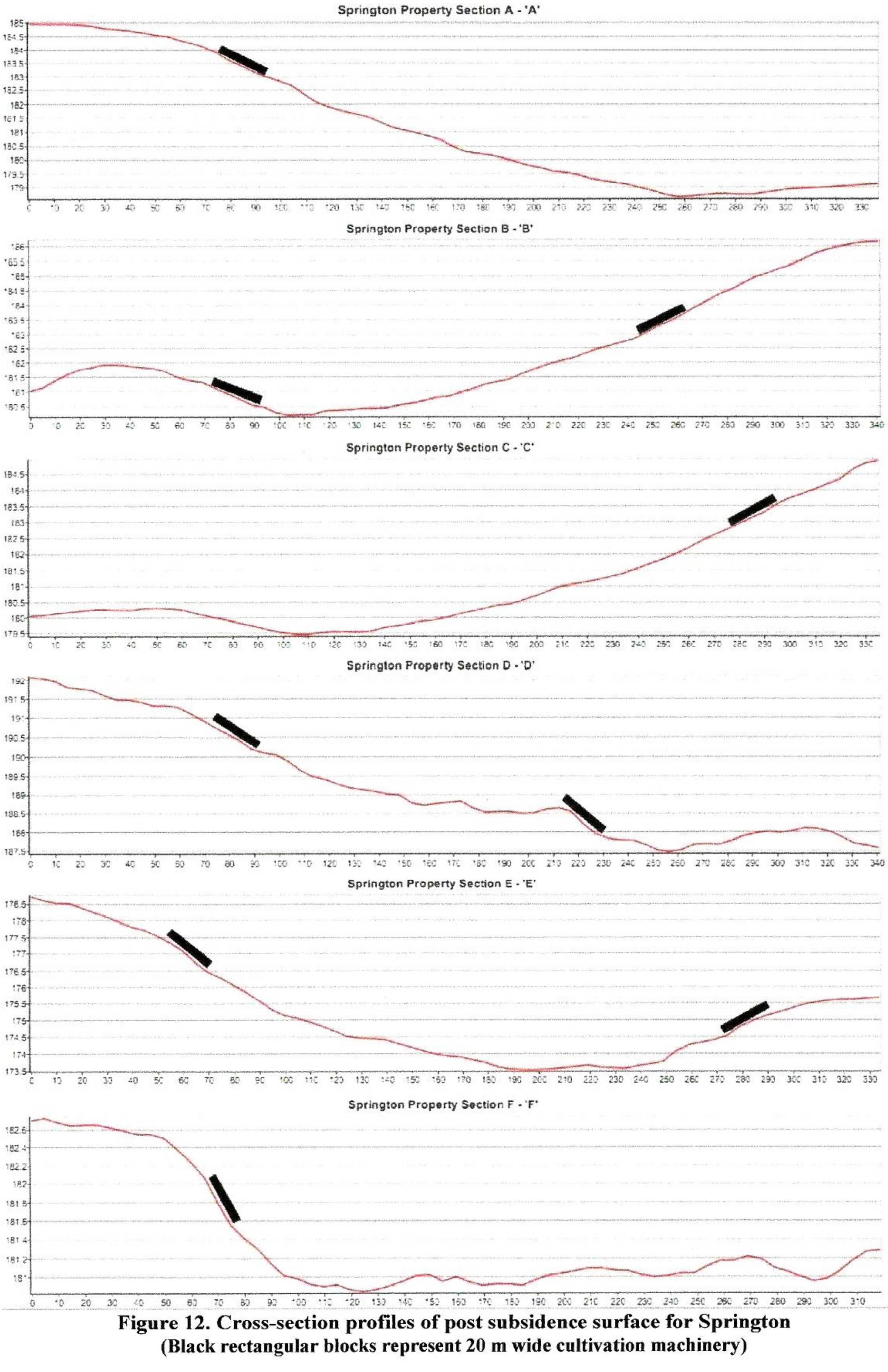


Figure 12. Cross-section profiles of post subsidence surface for Springton (Black rectangular blocks represent 20 m wide cultivation machinery)

ANNEX A - Curriculum Vitae for Peter Shields

NATIONALITY: Australian **PERMANENT RESIDENCE:** Australia

QUALIFICATIONS and ASSOCIATIONS

Bachelor of Agricultural Science, University of Queensland, 1974
Member - Australian Society of Soil Science Incorporated

PROFESSIONAL RECORD

1993 onwards	Working Director, Land Resource Assessment & Management (LRAM) Pty. Ltd.
1989-93	Senior Soil Scientist, QDPI, Brisbane
1984-89	Regional Soil Scientist, QDPI, Central Queensland
1978-84	Development Planning Officer, QDPI, Mackay
1974-78	Development Planning Officer, QDPI, Townsville

COUNTRIES OF EXPERIENCE: Australia, Nauru, Oman, Vanuatu

AUSTRALIAN EXPERIENCE

Commercial consultancy

2014 Soil and Land Management Specialist, Understanding soil features for soil management workshop, Soil Science Australia.

Soil and Land Management Specialist, Revising a Soil Management Plan to cover general soil, erosion and salinity issues within an expanded area of CSG tenements.

Land Evaluation Specialist, Review of agricultural status and protection at Greenridge, Pimpama.

Soil Specialist, Preparing an interpretation guide for CSG environmental officers to use a third-party technical soil document prepared for CSG tenements.

Soil and Land Management Specialist, Preparing a Soil Management Guideline to provide clear direction to CSG staff and contractors on soil management requirements.

Land Evaluation Specialist, Agricultural Land Classification and Strategic Cropping Land Studies – Scenic Rim.

2013 Land Resources Specialist, Soil survey of disturbed areas within CSG tenement.

Land Management Specialist, Soil Management Plan for the Nathan Dam pipeline.

Land Management Specialist, BUA/RMP for Origin Fairymeadow Road irrigation pipeline.

Land Management Specialist, Springsure Creek Coal Mine response to EIS.

Land Evaluation Specialist, Strategic Cropping Land Studies – Western Downs, Eastern Downs and Scenic Rim.

2011-2013 Soil and Land Management Specialist, Soil training for CSG environmental officers.

1997-2013 Land Management Specialist, Annual review of wastewater disposal from Stanbroke Beef abattoir, Grantham.

2012 Land Evaluation Specialist, Strategic Cropping Land Studies – Western Downs.

Land Resources Specialist, IAS for the Elimatta Rail & Services Corridor.

Land Management Specialist, Assessing BUA applications for irrigating treated CSG water.

Land Degradation Specialist, Erosion survey and management plan for Wyaralong Dam catchment.

Land Evaluation Specialist, Training of Local Authority officers on the implications of the Strategic Cropping Land Policy, Toowoomba Regional Council.

2011 Soil and Land Management Specialist, Preparing a Soil Management Plan in response to EA conditions to cover general soil, erosion and salinity issues within CSG tenements.

Soil Specialist, Soil quality and land suitability assessment of South Galilee Coal Project.

Soil Specialist, Soil study and impact assessment of Ironbark CSG Project.

2010-2011 Land Evaluation Specialist, Development of an assessment framework for the Strategic Cropping Land Policy, Queensland Government.

Agricultural Planning Specialist, Rural lands study, Rockhampton Regional Council.

Agricultural Planning Specialist, Rural resources study, Townsville City Council.

2010 Soil and Irrigation Specialist, Assessment of environmental impact from irrigating treated CSG water near Chinchilla.

Land Evaluation Specialist, Good Quality Agricultural Land Studies – Jones Hill Development Application.

Soil Specialist, Compiling combined soil map for Queensland, Queensland Department of Transport and Main Roads.

Soil and land Degradation Specialist, Statewide Soil Training Package, Queensland Department of Transport and Main Roads.

Land Management Specialist, On-site domestic wastewater disposal suitability study for Kilcoy and Jones Hill residential Development Applications.

2009 Land Evaluation Specialist, Good Quality Agricultural Land Studies – Frazerview Quarry Development Application.

Soil Surveyor and Soil Erosion Specialist, Bruce Highway Upgrade, Cooroy to Curra Section A.

Soil Specialist, Compiling combined soil map for 7 Main Roads Regions.

Soil and land Degradation Specialist, Soil Training Package for Main Roads North West Region.

Agricultural Land Use Specialist, Long-term viability of three orchards on the Maleny Plateau.

Soil Erosion Specialist, Road Drainage Manual, Department of Main Roads.

2008-2009 Soil Specialist, Soil study of Queensland Curtis Liquefied Natural Gas Project - Coal Seam Gas Field.

2008 Land Management Specialist, On-site wastewater disposal suitability study for upgraded Kolijo Caravan Park.

Soil Surveyor and Soil Erosion Specialist, Ipswich Motorway Upgrade, Goodna to Dinmore.

Land Resource Specialist, Environmental impact assessment of Lions Way (Casino to Ipswich) gas pipeline.

Soil and land Degradation Specialist, Request to negotiate NRW acceptable solutions for erosion control.

Land Management Specialist, On-site domestic wastewater disposal suitability study for Rocky Point Distillery Development Application.

Land Evaluation Specialist, Good Quality Agricultural Land Studies – Mt Larcom Development Application.

Land Degradation Specialist, SEQ Catchments.

Land Management Specialist, Impact analysis of irrigating recycled water at Noosa North Shore Ecotourism Portal.

Land Degradation Specialist, Residential development at Airlie Beach.

Land Management Specialist, Establishment of baseline monitoring for new wastewater disposal area at Stanbroke Beef abattoir, Grantham.

2008-2007 Soil and land Degradation Specialist, Soil Training Package for Main Roads Metropolitan District.

2007 Soil Surveyor, Industrial Parks at Brisbane Airport, Brisbane Airport Corporation.

Soils Specialist, Land resource assessment project for Burdekin Dry Tropics - Phase 2.

Soil Surveyor and Soil Erosion Specialist, Bruce Highway Upgrade, Uhlmann Rd to Caboolture Bypass.

Land Management Specialist, Water balance modelling for treated wastewater from Brisbane Airport.

Soil Surveyor and Land Management Specialist, Port of Brisbane Motorway Upgrade Stage 2. Soil Erosion Specialist, Gully erosion monitoring trial, South West Transport Corridor.

Soil Surveyor and Land Management Specialist, Ripley Steel Mill.

Soil Surveyor and Soil Erosion Specialist, Darra to Springfield Transport Corridor.

Land Evaluation Specialist, Agricultural Buffer Strip Studies – Response to Information Request for Hervey Bay Development Application.

Land Evaluation Specialist, Good Quality Agricultural Land Studies – Rosslyn Hills at Yeppoon, Grasstree Beach near Sarina, Cedar Grove, Fitzroy River at Belmont, Bundaberg and Bli Bli Development Applications.

Land Management Specialist, On-site domestic wastewater disposal suitability studies for Rosewood, Oakhurst Gardens Commercial and Eungella Tourism Development Applications.

Land Evaluation Specialist, Good Quality Agricultural Land Study – Pimpama Master Plan.

2007-2006 Soil and land Degradation Specialist, Soil Training Package for Main Roads Emerald District.

2006 Soils Specialist, Land resource assessment project for Burdekin Dry Tropics - Phase 1.

Land Evaluation Specialist, Agricultural Buffer Strip Studies – Response to Information Request for Pimpama, Boonah Development Applications.

Land Management Specialist, Bushfire Hazard Management Plan – Response to Information Request for Caboolture Development Applications.

Land Management Specialist, Review of environmental impacts from on-site wastewater irrigation onto pastures at a Mt Cotton processing factory.

Soil Surveyor and Soil Erosion Specialist, Bundaberg Ring Road.

Land Evaluation Specialist, Good Quality Agricultural Land Studies – Coominya, Yeppoon Development Applications.

Soil Surveyor and Land Management Specialist, Acid sulfate soil mapping and management plan for urban development at Hervey Bay.

Agricultural Specialist, Potential rural customers for Tyagarah Reuse Pipeline.

Land Evaluation and Land Management Specialist, Good Quality Agricultural Land and Acid Sulfate Soil Studies – Dundowran Quarry.

Land Management Specialist, On-site domestic wastewater disposal suitability studies for Fernvale, Beenleigh, Rosewood and Midge Point Development Applications.

2005 Soil Surveyor and Soil Erosion Specialist, South Western Transport Corridor.

Land Resource Specialist, Rural Futures Study, Beaudesert Shire.

Land Management Specialist, Mapping land cover and land degradation in the Burnett, Burrum, Baffle and Kolan catchments.

Land Management Specialist, On-site domestic wastewater disposal suitability study - Highvale Development Application.

Land Management Specialist, Ballina-Lennox Head Wastewater Reclamation & Augmentation Program.

Land Management Specialist, Reuse of effluent from Oakey STP.

Agricultural Specialist, Nitrogen budgeting for on-site disposal of effluent from Stanbroke Beef abattoir, Grantham.

Land Resource Specialist, Mapping Grazing Land Types in the Burnett Mary Catchments.

Land Evaluation Specialist, Good Quality Agricultural Land Studies - Coominya, Minden, Bundaberg, Kin Kin, Maryborough, Fernvale and Rathdowney Development Applications.

2004 Land Resource Specialist and Team leader, Grafton Sewerage reuse assessment.

Land Management Specialist, On-site domestic wastewater disposal suitability studies - Lowood, Beaudesert, Noosa North Shore, Toowoomba, Fernvale, Sarina and Mt Glorious Development Applications.

Land Management Specialist, Effluent disposal from Mt Morgan CBD Sewer.

Land Evaluation Specialist, Good Quality Agricultural Land Studies – Lowood, Jimboomba, Sippy Downs, Beaudesert, Toowoomba, Kalbar, Fernvale and Bargara Development Applications.

Project Manager, Priority Action Plan for Burnett Mary catchment association.

Land Resource Specialist, Submission to Land Resources Tribunal regarding agricultural potential within a mining lease on part of Mourallyn property.

Land Evaluation Specialist, Potential for irrigating effluent within Fitzroy Agricultural Corridor.

Land Resource Specialist, Land suitability for irrigating treated effluent from a Burnett Valley piggery.

Land Resource Specialist, Noosa North Shore ecotourism effluent disposal suitability study.

2003 Agricultural Specialist, Alternative crops for Maroochy effluent reuse.

Land Management Specialist, Woodlands Rise Estate and River Oak Estate effluent disposal suitability study.

Land Resource Specialist, Soil and land suitability study for part of Mourallyn property.

Land Resource Specialist, Richmond Irrigation Potential.

Land Resource Specialist, Overview study of acid sulfate soils on proposed development site.

Agricultural Specialist, Good Quality Agricultural Land study for Twin Waters residential development.

Land Resource Specialist, Brunswick Effluent Reuse Study.

2002 Agricultural Specialist, Nitrogen budgeting for on-site disposal of effluent from Valley Beef abattoir, Grantham.

Land Resource Surveyor, Nebo/Broadsound Land and Irrigation Assessment Study.

Soil Surveyor and Land Evaluation Specialist, Falkiner Memorial Field Station Soil Survey. Groundwater Resource Specialist, Northern Wastewater Strategy Baseline Environmental Monitoring.

2001 Land Resource Assessment Specialist, Review of Australian Collaborative Land Evaluation Program.

GIS and Land Resource Specialist, Redland Vegetation Mapping.

Soil Surveyor and Land Evaluation Specialist, Stanwell DCP.

Agricultural Land Use Planner, Thuringowa Rural Lands Study. Land Management Specialist, Agricultural Specialist, Sippy Creek Industrial Study.

Soil Surveyor and Land Management Specialist, Brunswick Sewage Scheme preliminary site assessment.

Soil Surveyor and Land Evaluation Specialist, Woodgate STP alternative land disposal site.

2000 Soil Surveyor and Land Evaluation Specialist, Caloundra City Good Quality Agricultural Land Mapping.

Agricultural Land Use Planner, South Burnett Joint Five Council Planning Scheme Reviews.

Land Management Specialist, Groundwater monitoring report for Valley Beef abattoir, Grantham. Land Management Specialist, Irrigation plan for wastewater disposal on new land at Valley Beef abattoir, Grantham.

Land Management Specialist, Wetalla Wastewater Study Phase 2.

Soil and Land Management Specialist, Southern Cairns Integrated and Land Use Transport Study – IAS.

Land Degradation Specialist, Estimates of land degradation and responses for NRM strategy.

Land Management Specialist, Irrigation of wastewater from Wujal Wujal STP, Wujal Wujal Community. Using daily water balance modelling, salinity mass balance and nutrient mass balance methods to assess the potential impact of land-based disposal of wastewater from a package STP.

Land Degradation Specialist and Team leader, Caloundra Downs agricultural and forestry impact analysis.

Soil Specialist and Land Management Specialist, REF of Barrolka petroleum complex.

1999 Land Use Specialist, Soil survey and farm management plan, Yarrabee Coal Company.Natural Resource Specialist, Rural Plan for Gunnedah Shire.

Soil Specialist, Road Drainage Design Manual, Department of Main Roads.

Land Management Specialist, Irrigation plan for wastewater disposal on new land at Valley Beef abattoir, Grantham.

Land Use Planner, AusAid training program "Participatory approach to research and technology development for sustainable land management".

Land Management Specialist, Optus fibre cable links.

Soils and Irrigation Specialist, Assessment of potential irrigation lands at Condamine, Darling Downs.

Land Management Specialist, Stanwell and Environs Industrial Development Study.

GIS Specialist, Caloundra Downs II Joint Venture.

Land Management Specialist, REF for mid-western SWER lines.

Soil Surveyor, Oakey STP Disposal Site.

Land Management Specialist, Wetalla STP Irrigation Scheme.

Agricultural Land Use Planner, Caloundra Downs II Joint Venture.

Agricultural Specialist, Townsville Planning Scheme review.

Land Management Specialist, Bucca Weir Groundwater Rescue Project, Bundaberg.

1998 Soils and Irrigation Specialist, Assessment of potential irrigation lands along Bungil Creek, Roma.

Wastewater Disposal Specialist, Irrigation plan for wastewater disposal from Mission Beach STP, North Queensland.

Wastewater Disposal Specialist, Irrigation plan for wastewater disposal from Barron Gorge Power Station, North Queensland.

Land Management Specialist, Survey of landholder attitudes and practices in the Mary River Catchment.

Soils and Irrigation Specialist, Assessment of potential irrigation lands within Taroom Shire.

Irrigation and Land Management Specialist, Impact assessment studies of proposed O'Connell River and Lethebrook irrigation schemes near Proserpine.

Land Management Specialist, Irrigation plan for wastewater disposal from Peanut Company of Australia processing plant, Kingaroy.

Land Evaluation Specialist, Burnett River Catchment Study (Central Burnett).

Land Management Specialist, IAS of proposed Gunpowder to Century transmission line, North West Queensland.

Soil surveyor and land management specialist, Collinsville irrigation soil survey.

Remote Sensing Specialist, Maroochy Rural Lands Study.

Land Management Specialist, IAS for Stanwell Power Station at Townsville.

Land Management Specialist, Irrigation plan for wastewater disposal from Marian sugar mill at Mackay.

Land Resources Specialist, Soil survey and assessment of acid sulphate soils, Molongle Creek Boat Ramp, Bowen.

GIS Specialist, Upgrade of a Land Administration System, South East Queensland Water Board.

Land Management Specialist, IAS of proposed Mica Creek to Hilton transmission line, North West Queensland.

1997 Land Management Specialist, IAS for land-based disposal of wastewater from Golden Cockerel factory at Mt. Cotton.

Land Management Specialist, IAS of proposed Hilton to Gunpowder transmission line.

Land Management Specialist, Preliminary IAS for Hail Creek rail spur, Nebo.

Land Management Specialist, IAS for land-based disposal of wastewater from Stockyard abattoir at Grantham.

Soil surveyor, Yarraman mine site, North Stradbroke Island.

GIS Specialist, Development of a Land Administration System, South East Queensland Water Board.

Salinity Specialist, Suitability of sewerage effluent for irrigating onto Sheraton Mirage golf course at Port Douglas.

GIS Specialist, Scoping study for the proposed Paranui Weir in Central Queensland.

Land Management Specialist, Resource Assessment Study and EMP for Cowley Beach and Tully Training Areas.

Soil surveyor, Dungeness Marina Development at Lucinda.

Land Management Specialist, IAS of proposed Mica Creek to Gunpowder transmission line, North West Queensland.

1996 Land Management Specialist, IAS for land-based disposal of wastewater from Thomas Borthwick's abattoir at Baker's Creek, Mackay.

Land Management Specialist, Dawson River Irrigation Project IAS and EMP.

Tour Leader, Integrated Catchment Management Study Tour, University of Queensland.

GIS Specialist, Preparation of Strategic Plan Maps, Mackay City.

Course Coordinator, Land Use Management in Tropical Agriculture, University of Queensland.Land Resources Specialist, Soil survey and assessment of acid sulphate soils, 10 Regiment Terminal, Townsville.

GIS Specialist, Preparation of Town Planning Scheme Maps, Banana Shire.

Land Resources Specialist, Resource assessment and land management plan, Oakey Army Aviation Centre.

Land Management Specialist, Impact assessment study of proposed transmission lines, North west Queensland.

Land Management Specialist, EIS for land based disposal of wastewater from KR Darling Downs Toowoomba factory.

Land Management and GIS Specialist, Regional Land Use Study, Eastern Downs Regional Organisation of Councils (EDROC).

1995 Land Management Specialist, EIS for piggery effluent disposal.

Land Resources Specialist, Research Impact Assessment Model, Meat Research Corporation.Land Resources Specialist, Potential salinity from irrigation of Kinchant soils.

Land Management Specialist, Preparation of Tree Management Plan for Moray Downs.Land Use Planning Specialist, Review of Mackay Strategic Plan.

Land Resources Specialist, Invicta Transmission Lines.

Land Resources Specialist, Nelly Bay Marine Harbour IAS.

Course Coordinator, Land Use Management in Tropical Agriculture, University of Queensland.Land Management Specialist, Mauri Yeast Factory IAS.

Land Management Specialist, Land Based disposal of effluent from Atherton Sewage Treatment Plant.

Agricultural Specialist, Market survey of fertiliser potential.

1994 Land Resources Specialist, Geology and Soils Study for Planning Scheme Review, Noosa Council.Soil Salinity Specialist, Catchment Based Guidelines for Water Supply, Esk Shire Council.

Resources Specialist, Cooloola Environmental Audit.

Land Management Specialist, Impact Assessment Study and Environmental Management Plan Teemburra Dam and Irrigation Project.

Land Evaluation Specialist, National Review of Land Evaluation, Australian Collaborative Land Evaluation Program.

Land Resources Specialist, Review of National Resource Assessment Program for the Cape York Peninsula Land Use Strategy.

Land Evaluation Specialist, Environmental Management Guidelines for mining in Queensland.

Land Resources Specialist, Environmental Impact Assessment of Proposed Camira Bypass routes.

1994, 1993 Specialist Soil Scientist, Soil fertility survey of north-east Queensland grazing lands.

1993 Land Resources Specialist, Feasibility study for land based disposal of wastewater from Dawson treatment plant.

Land Resources Specialist, Gatton Development Control Plan.

Senior Soil Scientist, Soil fertility survey of north-east Qld. grazing lands.

Land Resources Specialist, Daintree-Mossman-Mowbray ICM Scoping Study.

Land Management Specialist, Upper Lockyer ICM Study.

Land Resources Specialist, Elimbah Development Control Plan.

Land Resources Specialist, Fitzroy Shire Strategic Plan.

Land Resources Specialist, Teviot Brook Impact Assessment.

Land Resources Specialist, Alton Downs Study, Fitzroy Shire.

Land Resources Specialist, Banana Shire Strategic Plan.

Land Resources Specialist, Gordonvale and Whitsunday Land Disposal Studies for Sewage.

Major tasks within QDPI:

1989-1993

Team Leader, Potential for expansion of Queensland's cane lands, Report to the Queensland Sugar Industry Policy Council.

Land suitability for irrigated agriculture in Queensland, Water Resources Report.

Team Leader, Tree clearing in south-central Queensland.

Senior Soil Scientist, with responsibility for training.

1984-1989

Team Leader, Land Resource Survey and Evaluation of the Kilcummin area, Queensland.Team Leader, Land Management Manual Dawson/Callide Districts.

Soil mapping of Biloela Research Station.

Team Leader, Soil fertility of Capricornia grazing lands.

Regional soil scientist with responsibility for training.

1978-1984

Mackay sugar cane land suitability study.

Team Leader, The use of a computer in detailed land resource assessment.

Land suitability study of the Collinsville-Nebo-Moranbah region.

1974-1978

Land capability study of the northern Burdekin region.

A study of land resources, hazards and non urban land suitability for the catchment area of Ross River Dam.