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DgS
Ditton Geotechnical Services

27 February, 2018

Steve Barr Pty Ltd
Director
1/25 Beresford St
Newcastle West, NSW 2302

Report No. BAR-001/1 **DRAFT**

Dear Stephen,

Subject: Residual Mine Subsidence Assessment for the Proposed Re-development of Areas 1 and 2 at the Abel Mine, John Renshaw Drive, Blackhill

1.0 Introduction

This report provides and assessment of future mine subsidence potential due to underground coal mine workings known as Areas 1 and 2 at the Abel Mine, Blackhill.

It is understood it is proposed to re-develop the site into an industrial subdivision, with each lot being about 5 hectares each. Large warehouses with footprints of 25,000 m^2 are to be constructed after extensive re-levelling earthworks (cut/fill). The buildings will have a network of fixed conveyor belts for moving commercial goods that will be sensitive to differential ground movements > 20 mm.

The Abel Mine worked the Upper Donaldson Coal Seam between January 2010 to August 2013. The mine workings consisted of twelve pillar extraction panels with main or access headings running between them. Coal pillars were extracted on retreat in the production panels, causing the ground to subside up to 1.2 m between unmined, inter-panel pillars. The main headings or first workings pillars were also extracted on retreat out of the mined area. Four partial extractions panels with large, stable remnant pillars were also mined in the western area of the site; see **Figure 1a**.

The mining methods employed were designed to minimise the risk of future subsidence occurring below surface re-development upon closure of the mine.

The site is located within the Blackhill Mine Subsidence District and will therefore require Development Application Approval from Subsidence Advisory NSW. SA NSW guidelines for subdivisions over abandoned and/or active underground coal mines require new

developments to consider the potential risks associated with future subsidence and design structures to either tolerate residual movements or eliminate risk through grout stabilisation.

2.0 Scope

The purpose of the review was to ascertain the following information regarding the proposed development:

- a description of the previous mine workings beneath the site
- the likelihood of any future mine workings (if any) being developed beneath the site
- post-mining (residual) subsidence effects and rates of subsidence development that could affect each lot; and
- design constraints on development to allow for future subsidence and to minimise impacts to Safe, Serviceable & Repairable (see SA NSW Guidelines).

The assessment of residual subsidence has been derived empirically from post-mining survey data provided by Donaldson Coal (part of the Yancoal Australia Group). The locations of the survey lines is shown in **Figure 1b**.

3.0 Previous Mine Workings and Maximum Subsidence

The location, geometry, completion dates and post-mining survey results for the second workings panels (total and partial pillar extraction) is summarised in **Table 1**.

Table 1 - Mine Workings Geometry and Maximum Subsidence Survey Summary

Panel No	Panel Width W (m)	Cover Depth H (m)	Mining Height T (m)	Panel Type	Extraction Ratio (%)	Finish Date	Survey Dates	Maximum Subsidence (mm)
1	125	75 - 100	2.4	TE	85	22/12/10	11/2/11, 24/6/11, 1/8/12	1193, 1228, 1250
2	160	60 - 85	2.4	TE	85	12/11/10	22/12/10, 21/6/11, 20/6/12, 10/9/13	1017, 1041, 1052, 1050
3	160	50 - 90	2.4	TE	85	19/04/11	19/5/11, 10/6/11, 25/10/11, 9/5/12	977, 982, 997, 1003
4	160	50 - 90	2.4	TE	85	20/07/11	24/8/11, 9/5/12 3/9/12	1065, 1064, 1064
5	160	50 - 90	2.4	TE	85	24/09/11	4/11/11, 2/5/12, 18/2/13, 14/9/13	1145, 1154, 1171, 1181
6	160	50 - 90	2.4	TE	85	02/02/12	1/5/12, 4/9/13	1215, 1212
7	160	50 - 85	2.4	TE	85	31/05/12	2/8/12, 28/5/13, 13/9/13	812, 852, 865
8	160	60 - 85	2.4	TE	85	17/07/12	31/10/12, 17/5/13, 6/9/13	835, 845, 846
15	139	100 - 110	2.4	TE	85	26/3/12	27/4/12, 14/1/13, 17/5/13	1125, 1157, 1164
19	155	105 - 125	2.4	TE	85	7/08/13	14/9/13, 9/7/14	1160, 1291
19A	227	105 - 120	2.4	TE	85	25/05/13	4/6/13, 14/9/13	1160, 1179
East Mains 1.1	155	85 - 100	2.4	TE	85	30/09/12	30/5/13, 14/1/13	1408, 1410
East Mains 1.2	155	85 - 100	2.4	TE	85	*30/04/13*	30/5/13, 14/1/15	1310, 1311
East Mains 1.3	125	90 - 100	2.4	TE	85	*30/05/13*	30/5/13, 14/1/15	831, 961
Tailgate Headings	74	95 - 115	2.4	TE	85	*10/11/12*	8/11/12, 19/12/12, 13/06/13, 10/01/14	227, 233, 241, 250

Italics - estimated panel completion date (approximately 1 month before first end-of-panel survey)

Table 1 (cont...) - Mine Workings Geometry and Maximum Subsidence Survey Summary

Panel No	Panel Width W (m)	Cover Depth H (m)	Mining Height T (m)	Panel Type	Extraction Ratio (%)	Finish Date	Survey Dates	Maximum Subsidence (mm)
Panel 20	125	100 - 110	2.4	PE	70	*8/01/13*	10/1/13 8/1/14, 9/7/14	42 62, 61
East Install	105	60 - 105	2.4	TE	85	*15/01/13*	23/1/13, 8/1/14	1192, 1277
Panel 21	205	105 - 120	2.4	PE	70	*1/05/13*	16/5/13 24/1/14, 1/9/14	38, 96, 77
Panel 22	125	115 - 130	2.4	PE	70	*24/12/13*	24/1/14, 1/9/14	52, 39
Panel 23	110	65 - 80	2.4	PE	70	*3/9/14*	3/10/14	37
East Mains 2	144	70 - 100	2.4	TE	85	1/10/14	3/10/14	980

Italics - estimated panel completion date (approximately 1 month before first end-of-panel survey)
Shaded - large remnant pillars left to control subsidence in the long-term.

For the total extraction panels, the average mining height was 2.4 m with a range from 2.2 m and 2.55 m. The extraction ratio was assumed to be a constant 85% due to remnant coal stooks that were left in-situ to provide local roof support at intersections during extraction.

The cover depth to the Upper Donaldson Seam ranged from 50 m to 120 m across the mining area. Several north-north west striking faults in the mining area limited the extent of mining at several locations and resulted in the mine abandoning its plans to extract coal to the east of Panels 8 and 15 (see **Figure 1a**).

The majority of the total pillar extraction panels had W/H ratios ranging from 1.27 to 2.37, which indicates the panels are *supercritical* and developed maximum subsidence between 0.81 m to 1.41 m (45% and 65% or 55% +/- 10%) of the effective mining height.

One *subcritical* panel (Tailgate Headings) had a W/H of 0.7 and developed reduced subsidence of 0.25 m (12% of the effective mining height).

The measured subsidence/effective mining height (S_{max}/Te) has been plotted against the panel width/cover depth ratio (W/H) in **Figure 1c**. The results indicate that the measured subsidence values are within the expected range for *supercritical* and *subcritical* panels.

For the Partial Pillar Extraction (PE) Panels No. 20 to 23, the panels were developed on an oversized grid of 45 m wide centre-to-centre spacing and had *critical* to *supercritical* W/H ratios ranging from 1.02 to 1.82. During second workings, the pillars were reduced in size to side-dimensions of 24 m x 24 m. The extraction ratio of the PE panels was ~ 70% with final bord widths of 21 m left between the pillars. The immediate siltstone/carbonaceous shale roof was estimated to cave to approximately 10 m to 12 m height above the bords (4 to 5 times the mining height), with the rubble re-supporting the sagging roof due to bulking effects.

Measured subsidence above these panels was < 100 mm (37 mm to 96 mm), due to the overburden being supported by the remnant pillars. The pillars were designed to control surface settlements and remain stable after mining for the long-term (>10 years) above these panels.

Revised final subsidence contours across the site has been prepared using SDPS software and presented in **Figure 2**.

4.0 Residual Subsidence Assessment

The Abel subsidence and strain data for Areas 1 & 2 and the rates of tilt, curvature and strain decay since mining over several panels have been assessed with 1 to 3 years of post-mining data.

The development of subsidence, tilt, curvature and strain after mining is summarised in **Table 2** since mining and termed *residual subsidence affects*. The data indicates that the re-compaction of the collapsed roof or goaf rubble in the extracted coal voids, including the crushing of remnant stooks, has resulted in residual subsidence ranging between 130 mm and -2 mm (upwards movement) has developed to date. The average residual subsidence is estimated to be 30 mm, with a 95th percentile value of 85 mm.

Annual subsidence effect charts (subsidence, tilt and curvature) for Panels 1 to 3 are presented in **Figures 3a-c, 4a-c** and **5a-c**. The residual subsidence for all the total extraction panels is also plotted with the subsidence development charts prepared for each panel.

The charts indicate a general deceleration of subsidence deformation may last for up to 5 to 10 years after mining has ceased. There may be further settlement again once mine workings flood, however, it is unlikely to cause movements that exceed the movements to-date.

Second workings or pillar extraction ceased between 22/12/2010 (panel 1) and 3/10/14 (East Mains 2), so cumulative subsidence development has been estimated using the mean and U95% Confidence Limit Curves for the annual data after year 4 (~2019).

Table 2 - Residual Differential Subsidence Data Summary

Time since Mining (years)	Annual Subsidence (mm)	Annual Tilt* (mm/m/a)	Annual Curvature* (1/km/a)	Annual Horizontal Strain* (mm/m/a)
0.6	23 - 173	0.1 - 10	0.1 - 1.5	0.2 - 15
1.6	12 - 40	0.1 - 5.3	0.0 - 1.01	0 - 10
2.8	-2 - 23	0.5 - 2.8	0.0 - 0.45	0.0 - 4.5
5	*<2*	*<0.5*	*<0.02*	*<0.20*
Cumulative Effect after 2019	***8 - 16***	***1.0 - 2.0***	***0.07 - 0.13***	***0.7 - 1.3***

* - results relevant to a peg spacing of 10 m; *italics* - estimated from trend lines.

5.0 Conclusions and Recommendations

The measured subsidence effects above the total extraction panels indicate that subsidence is practically complete and only likely to be affected by diminishing residual subsidence associated with goaf consolidation, seasonal clayey soil moisture variation and controlled fill settlement under load. The risk of 'pot-hole' subsidence affecting a subsidence in the future is very unlikely due to cover depths well in excess of 25 m over each panel.

It has been assumed that hazardous biological waste and uncontrolled fill will be removed from below proposed structures and replaced with controlled fill as defined in AS3798 - 2007 Earthworks Guideline.

A review of the subsidence data indicates that the majority of residual movements are likely to be insignificant 4 to 5 years after mining has ceased (circa 2014). Cumulative differential movements after 2019 have been estimated in Table 2 and indicate the proposed structures are unlikely to be affected by differential subsidence > 20 mm with tilt < 2 mm/m, hogging / sagging curvature < 0.1 km^{-1} and tensile / compressive strain < 1 mm/m over a 10 m bay-length.

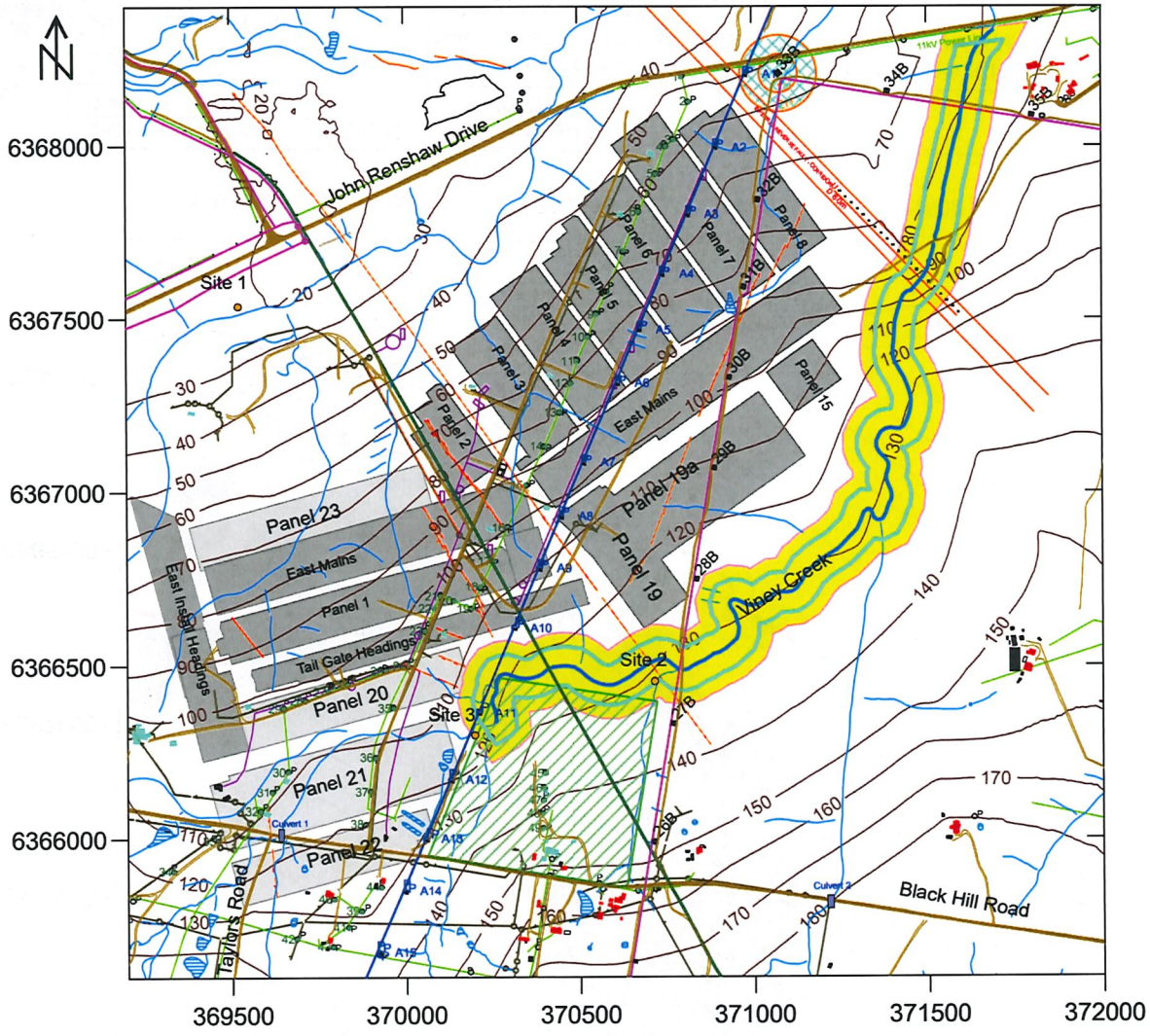
The flooding of the mining workings may see an increase in subsidence, however the differential movements indicated above are unlikely to be exceeded.

As the survey pegs were required by the landowner to be removed 2 years after mining, it is recommended that the new structures are monitored at 6-monthly intervals during the first two years after construction to ascertain the performance of the footings and determine if residual movements have in fact ceased.

It is also assessed that residual subsidence over partial pillar extraction panels will not affect the structures, as the pillars were designed to remain stable in the long-term under dry and flooded conditions (refer to Abel Mine for the documentation on this issue).

Key

- Schedule 2 Creek and Buffer Zone (DECCW)
- 26B — Transmission Towers (Transgrid, 330 kV)
- Optic Fibre Cable (Optus) has been re-located
- Sealed Road (Cessnock/ Newcastle City Councils)
- Water Supply Pipeline (Hunter Water)
- Principle Residences
- Non-Principle Residences and out buildings
- Disused Buildings
- A12 P — 132 kV Power Line and Poles (Ausgrid)
- 11 kV Domestic Powerline and Poles (Ausgrid)
- Proposed Blackhill Land Pty Ltd Lot Layout (Preliminary)
- Second Workings - Total Extraction
- Second Workings - Partial Extraction
- Telstra Copper Cabling (buried)
- Schedule 1 creeks/ gullies
- Stock Watering System
- Catholic Land - Proposed Development Area
- Geological Structure
- Site 1 — Aboriginal Artefact Site
- Culvert 1 — Culvert



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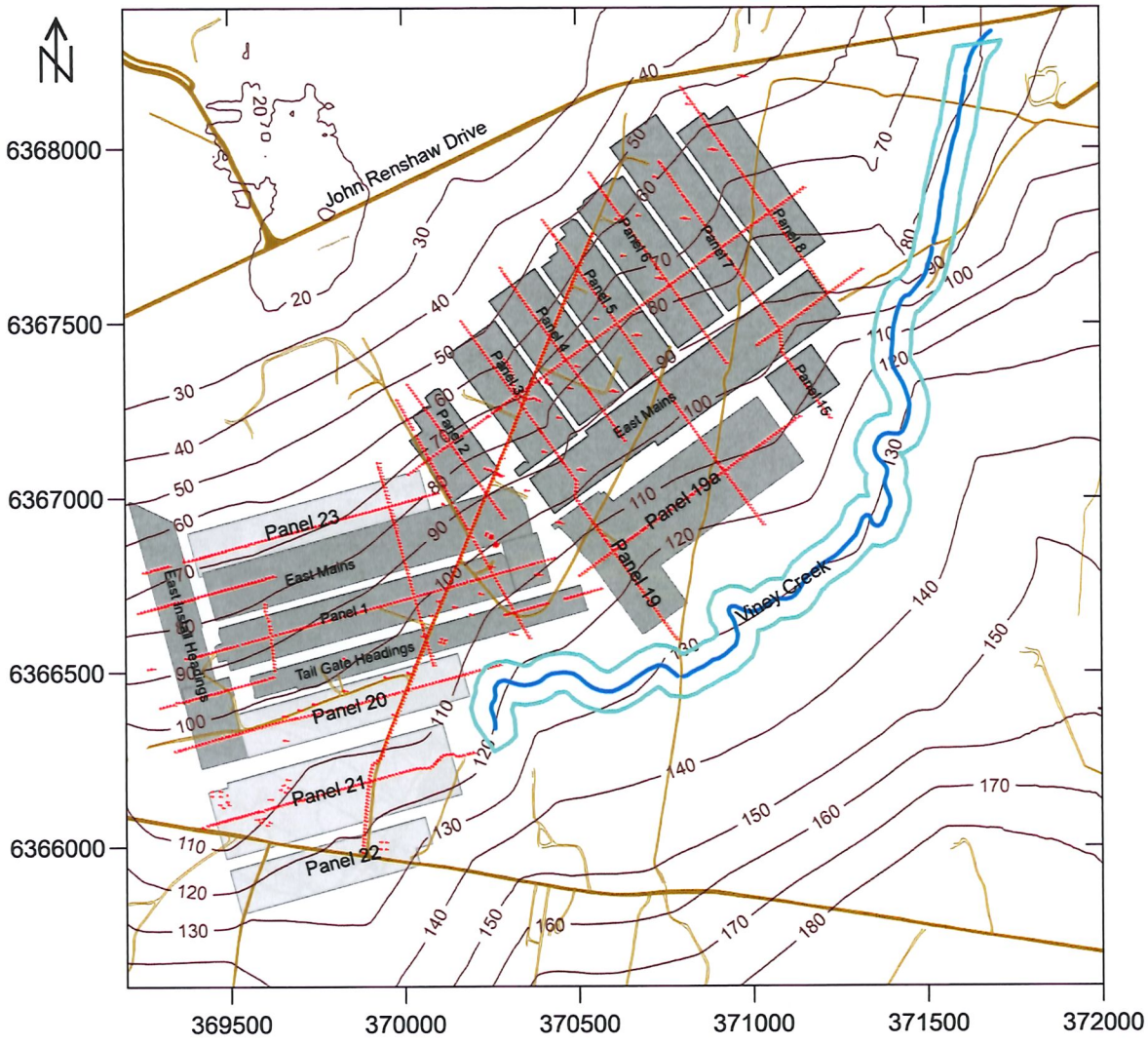
	Drawn: S.Ditton		
	Date: 29.11.17	Title:	Completed Total & Partial Pillar Extraction Panels 1 to 23 with Surface Features & Cover Depth Contours
		Scale:	1:25,000 (A4) — Figure No: 1a



Key

- Schedule 2 Creek and Buffer Zone (DECCW)
- Sealed Road (Cessnock/ Newcastle City Councils/Local Access)
- Subsidence Monitoring Lines (Pheno markers now removed)
- Cover Depth Contours (m)
- Second Workings - Total Extraction
- Second Workings - Partial Extraction

Remaining First workings not shown (for clarity)

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Drawn:	S.Ditton		
Date:	29.11.17	Title:	Completed Total & Partial Pillar Extraction Panels 1 to 23 with Surface Features, Cover Depth Contours and Survey Lines (now removed)
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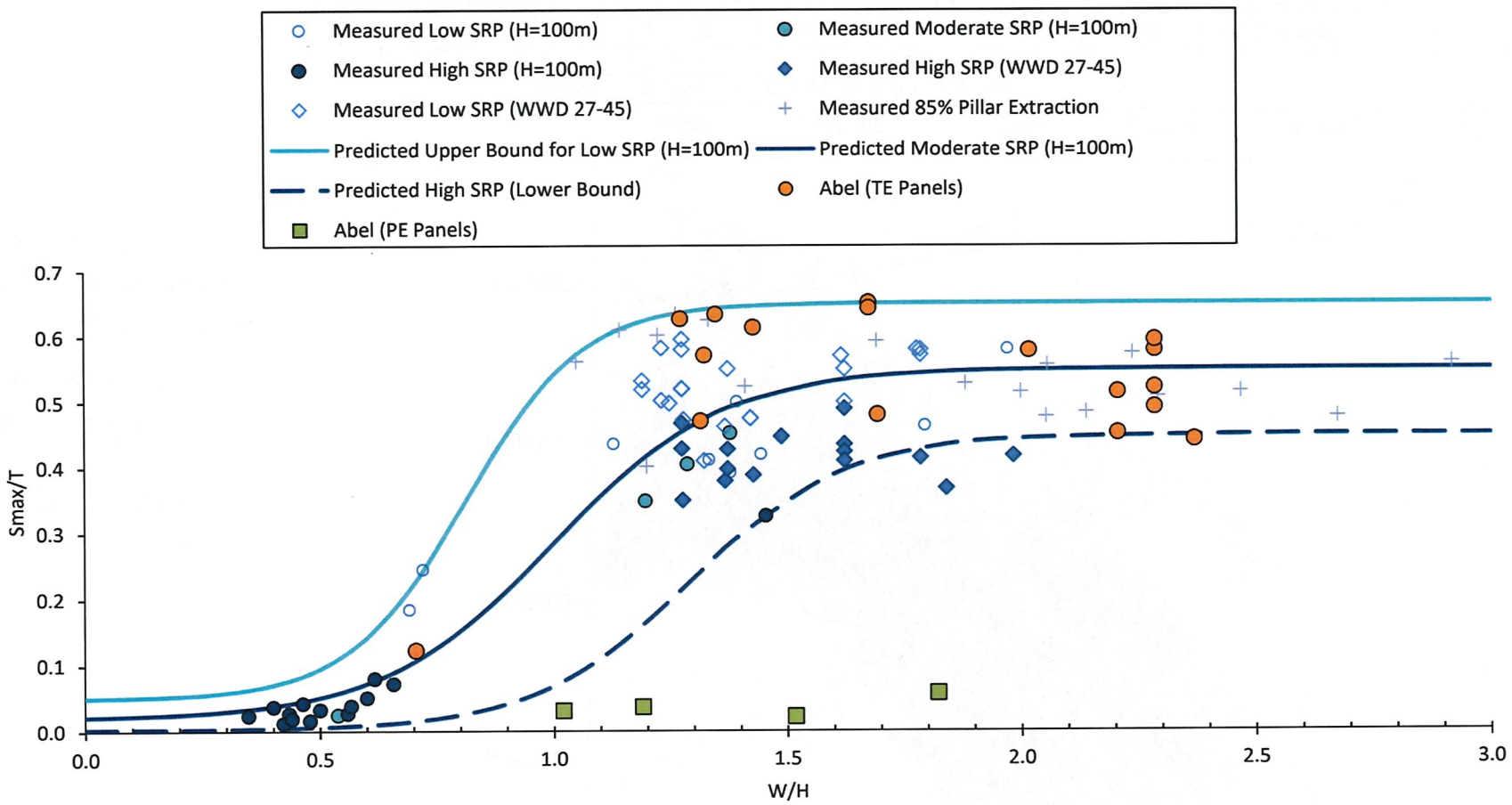

DgS	Engineer:	S.Ditton	Client:	F&F Properties	
	Drawn:	S.Ditton		BAR-001/1	
	Date:	25.11.17	Title:	Measured Pillar Extraction Panel Data for Abel Mine v. Newcastle Coalfield	
	Ditton Geotechnical Services Pty Ltd			Longwall Database	
			Scale:	NTS	Figure No: 1c

Subsidence (m):

-0.02
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6

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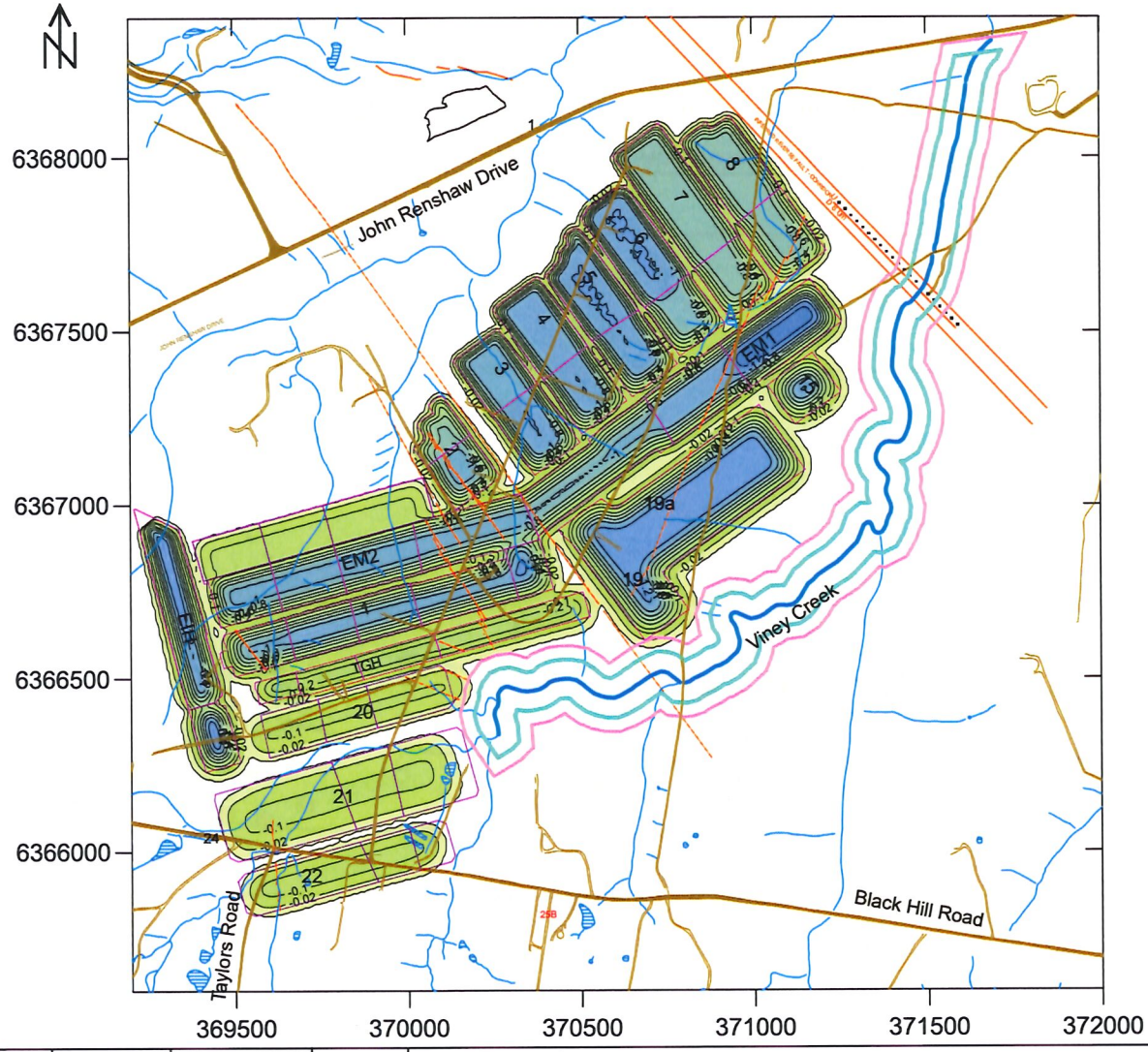
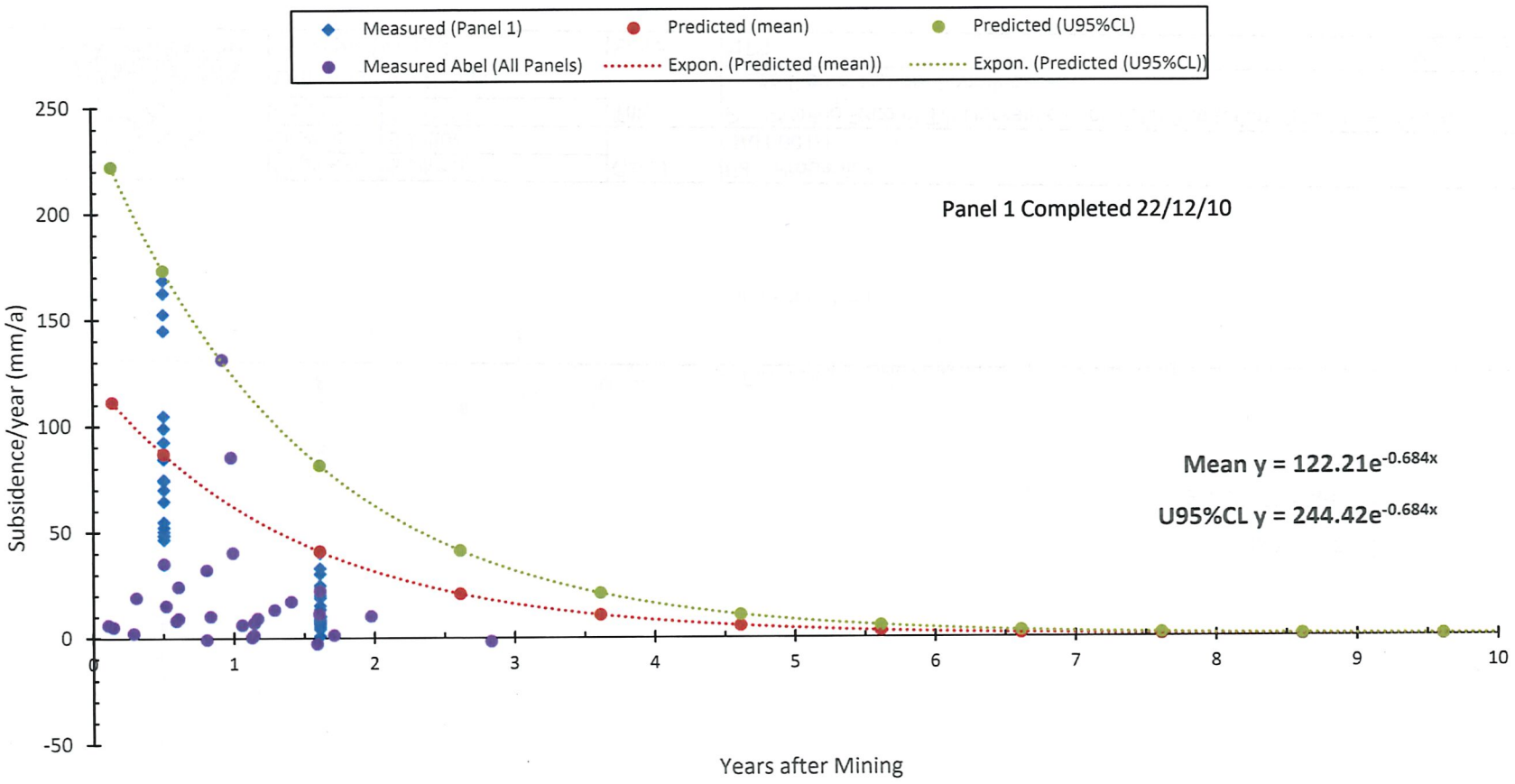
Key

- Schedule 2 Creek and Buffer Zone (DECCW)
- Sealed Road (Cessnock/ Newcastle City Councils)
- Schedule 1 Creeks/gullies
- Second Workings - Total Extraction
- Second Workings - Partial Extraction
- Geological Structure



DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton	Client:	F & F Properties BAR-001/1
	Drawn: S.Ditton		
	Date: 06.11.12	Title:	Predicted Final Worst-Case Subsidence Contours above the Completed Partial and Total Extraction Panels at the Abel Mine (SMP Areas 1 and 2)
		Scale:	1:20,000 — Figure No: 2



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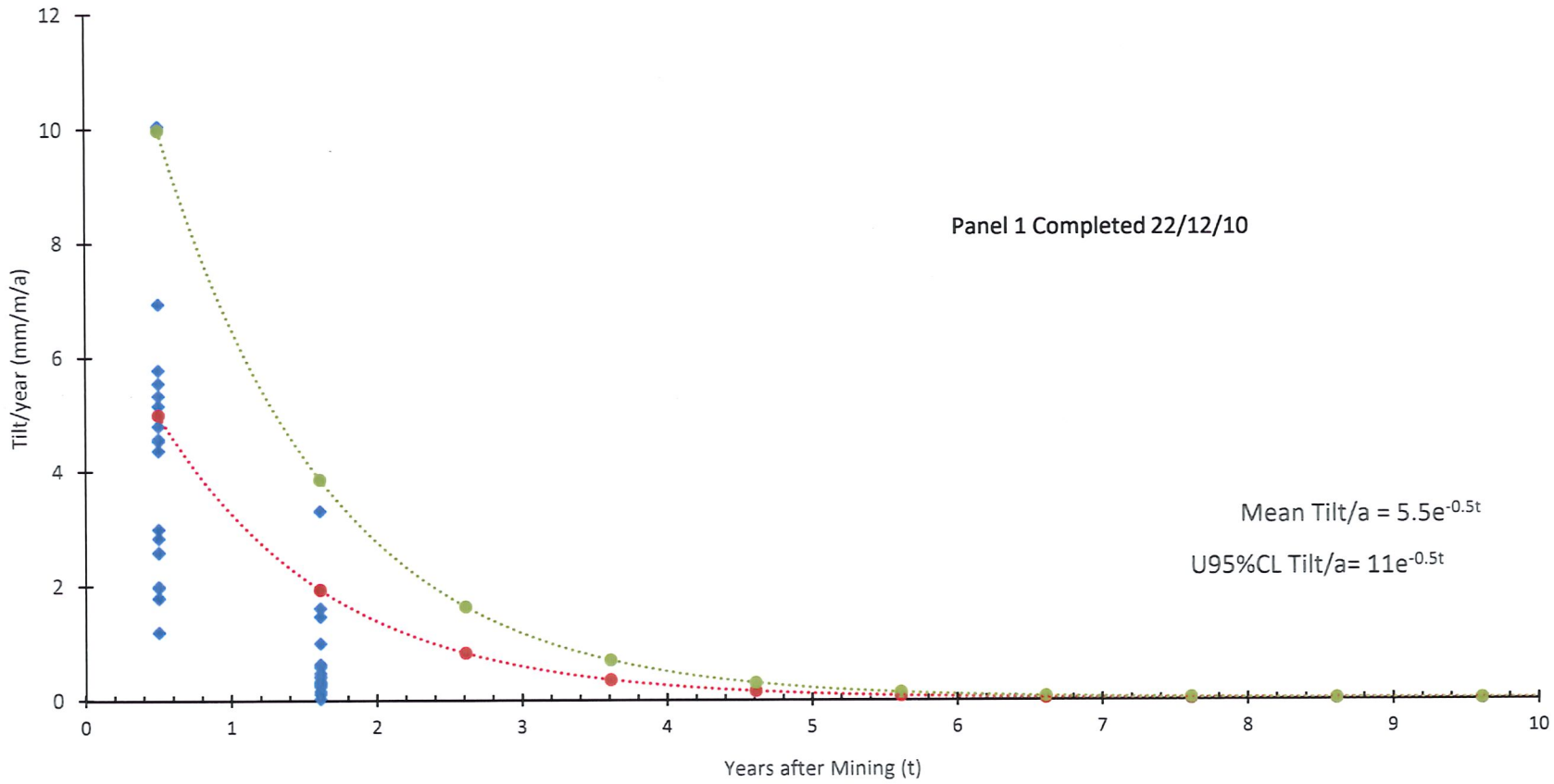
	Drawn:	S.Ditton			
	Date:	25.11.17	Title:	Post-Mining Rate of Subsidence Decrease over Panel 1 (All Pegs) & Maximum for All Total Extraction Panels - see Figure 1a/b for Peg Locations	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 3a



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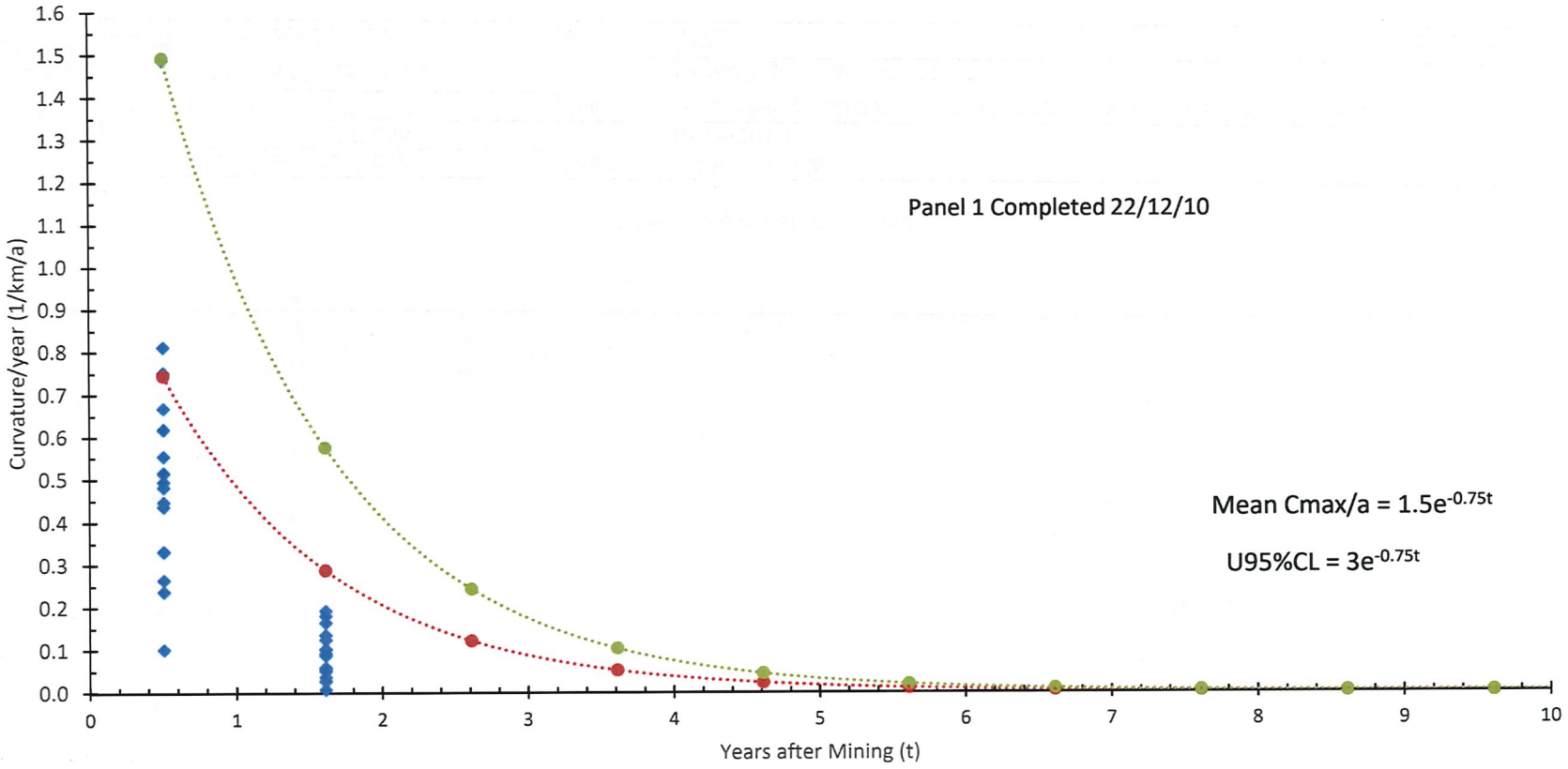
Ditton Geotechnical Services Pty Ltd				- see Figure 1a/b for Location	
			Scale:	NTS	Figure No: 3b



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	Date:	25.11.17	Title:	Post-Mining Rate of Curvature Decrease over Panel 1 (Total Extraction) - see Figure 1a/b for Location	
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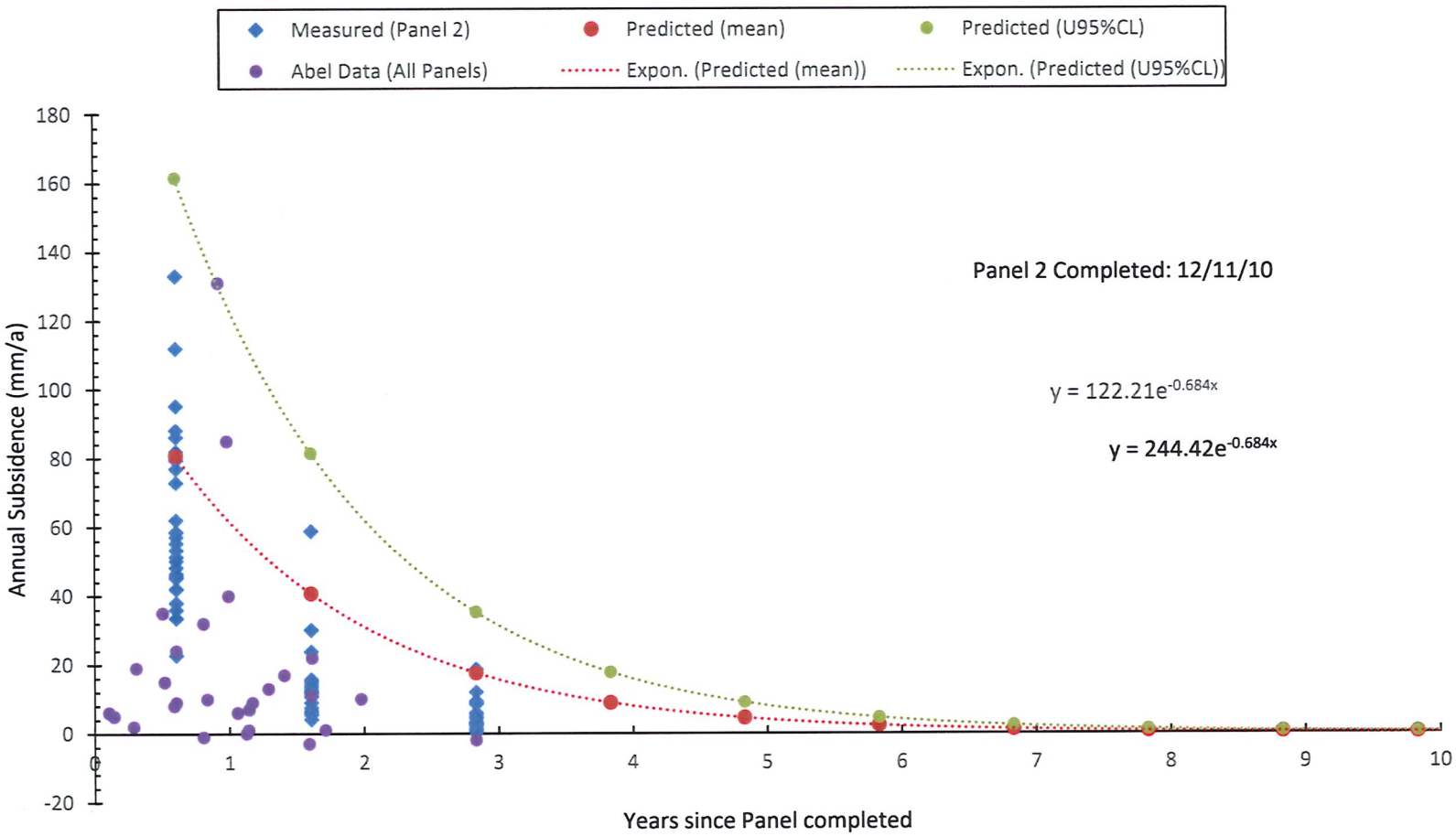

DgS	Engineer: S.Ditton	Client:	F&F Properties BAR-001/1
	Drawn: S.Ditton		
	Date: 25.11.17	Title:	Post-Mining Subsidence Development over Panel 2 (Total Extraction) - see Figure 1a/b for Location
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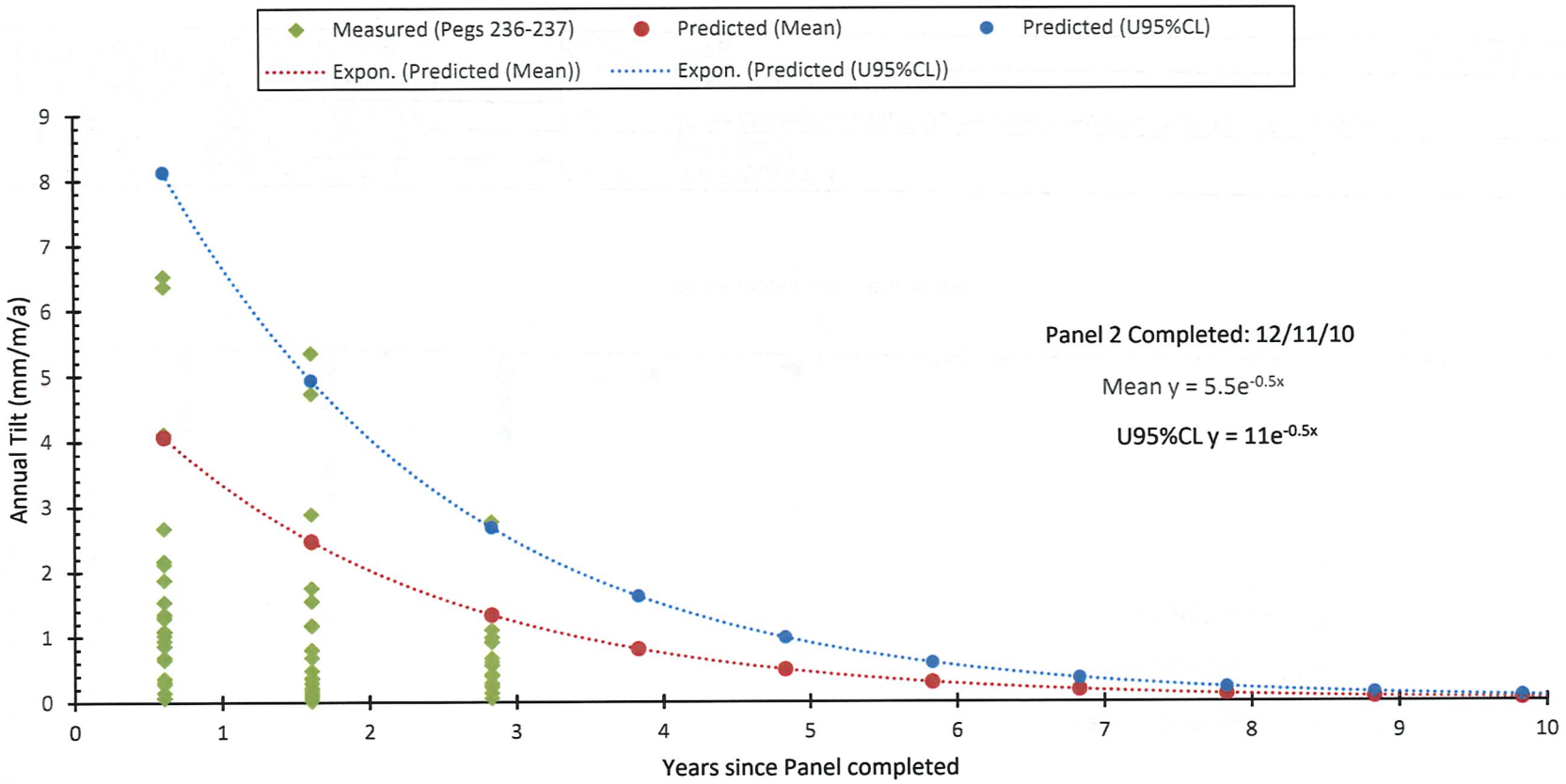

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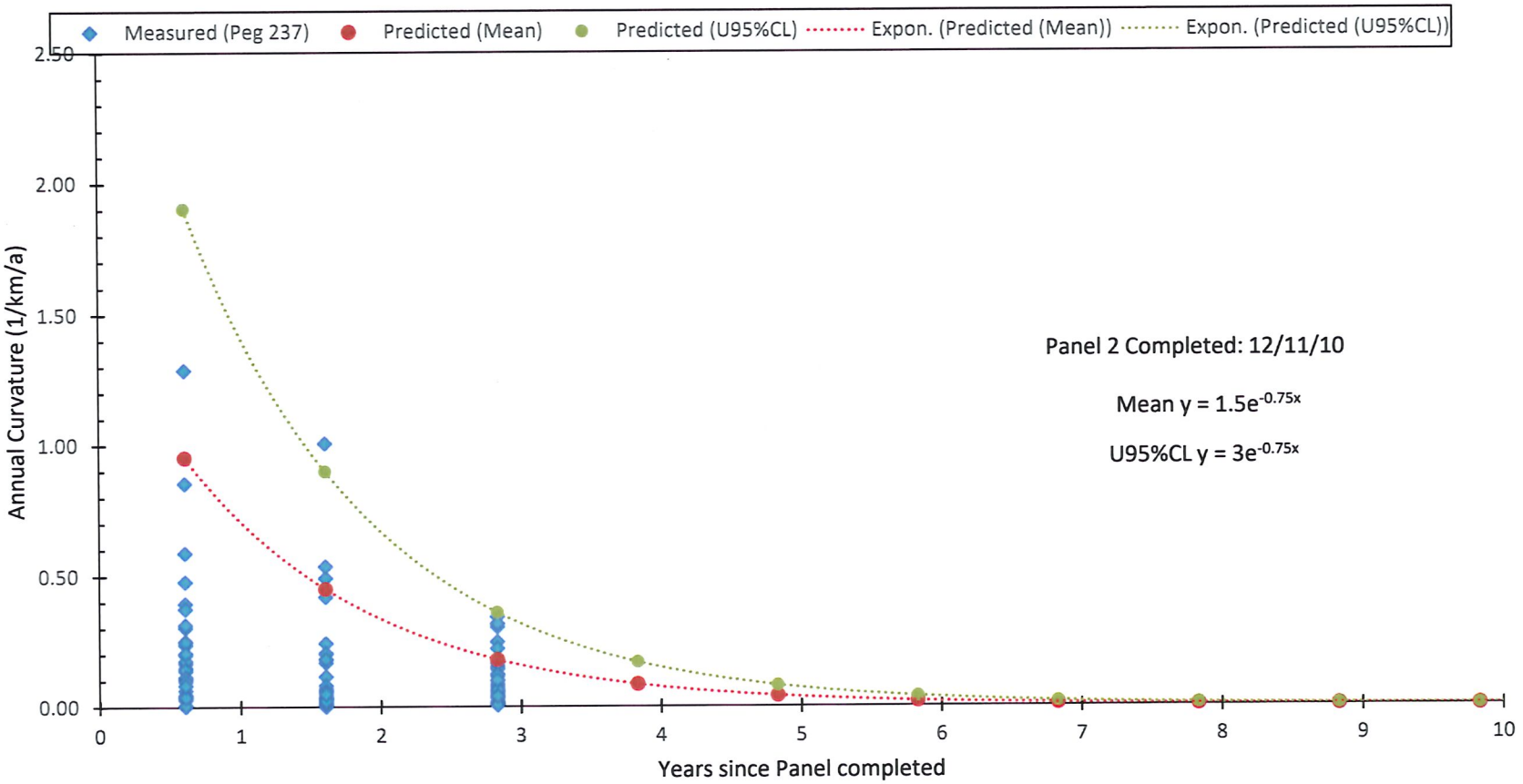

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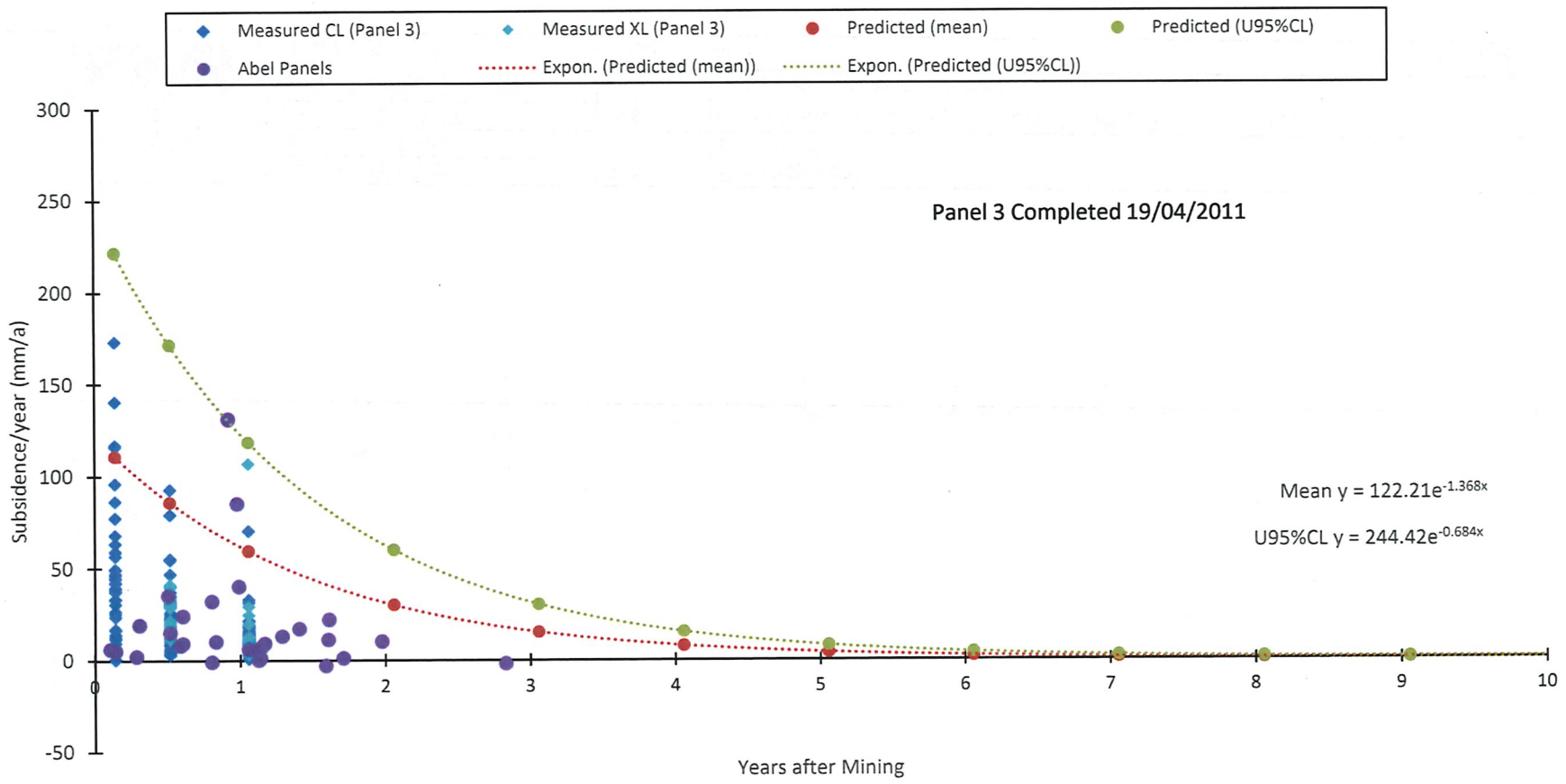

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	Drawn:	S.Ditton			
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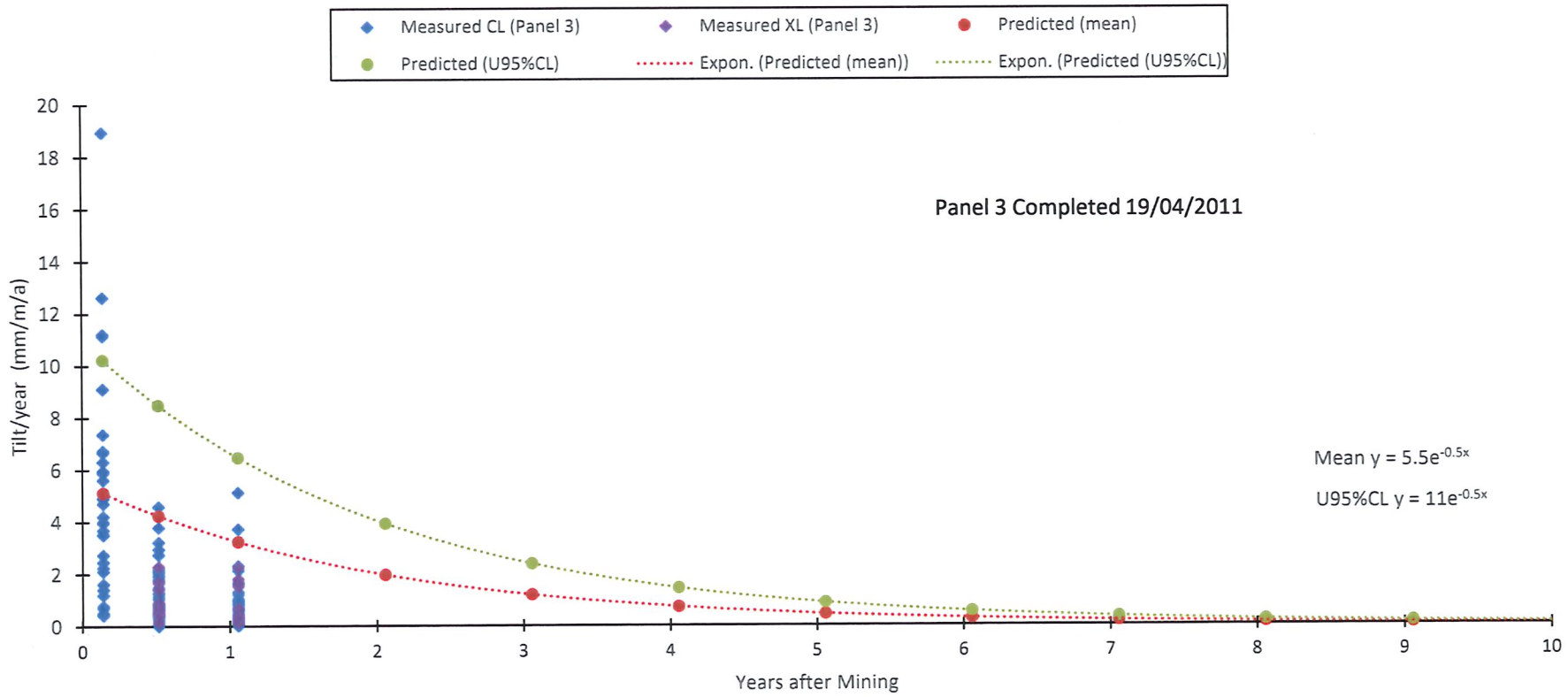

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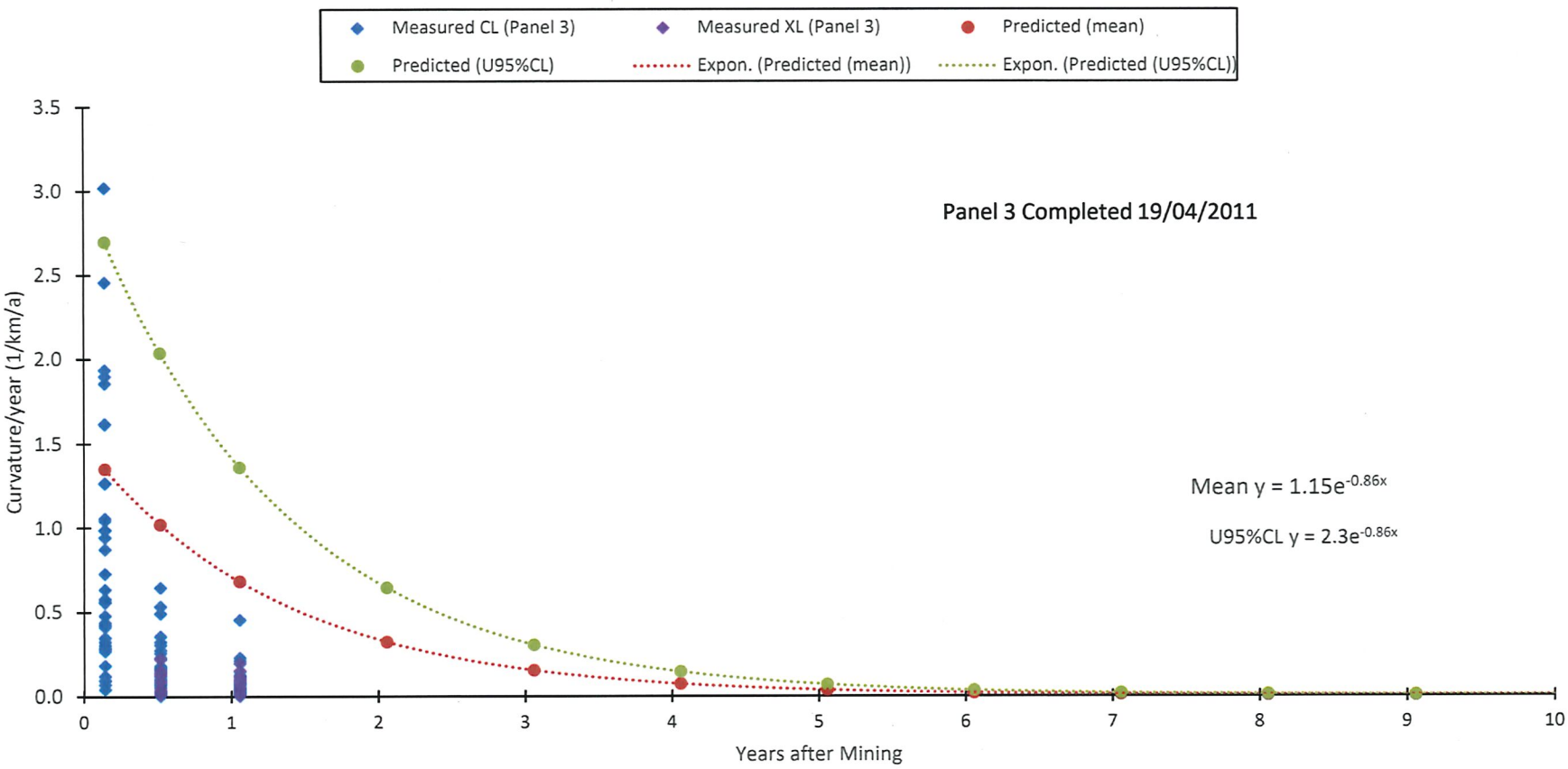

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