APPENDIX A: MASTER TRIGGER ACTION RESPONSE PLANS

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
SURFACE WATER									
Surface Water Management Plan	Cataract Creek and Tributaries	CC3 CC4 CC5 CC6 CC7 CC8 CC9 CC10 CT3 3A 4 4A SPC1	pH EC TSS Stability	Monthly	To determine if mining operations are impacting surface water quality.	Level 1: Normal Operations pH 6.0 to 6.8; and EC < 200 µS/cm; and TSS < 6 mg/L; and Stability: No visible erosion	Continue monitoring.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader to monitor for trends in data.
						Level 2: pH: 3 consecutive samples outside of 6.0 – 6.8 range (20th/80th percentiles); or EC: 3 consecutive samples greater than 200 µS/cm (80th percentile); or TSS: 3 consecutive samples > 6 mg/L; (80th percentile); or Stability: Evidence of bed and band erosion and scouring	1. Investigate potential cause of exceedances (e.g., climatic; systemic; failure) 2. Identify mitigation options 3. Review monitoring frequency and parameters 4. Report potential impact, and response, within six monthly reporting	1. One Month 2. One Month, commence works within two months. 3. One Month 4. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader
						Level 3: pH: 1 sample outside of 4.9 – 7.5 range (5th/95th percentile); or EC: 1 sample outside of 30- to 350 µS/cm range (ANZG 2018 95th percentile – upland rivers); or TSS: 1 sample above 64.6 mg/L (95th percentile); or Stability: Visible migration (rerouting) of watercourse	1. Inform DPIE and WaterNSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3. Inform DPIE and WaterNSW of preliminary investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One Week 2. Commence within1 Week 3. One Month 4. Commence works within 2 months 5. One Month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Surface Water Management Plan	Cataract River	CR3 CR4	pH EC TSS Stability	Monthly	To determine if mining operations are impacting surface water quality.	Level 1: Normal Operations pH 6.1 to 6.8; and EC < 200 µS/cm; and TSS < 6 mg/L; and Stability: No Visible erosion	Continue monitoring.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader to monitor for trends in data.
						Level 2: pH 3 consecutive samples outside of 6.1 – 6.8 range (20th/80th percentiles); or EC 3 consecutive samples greater than 188 µS/cm (80th percentile); or TSS: 3 consecutive samples < 6 mg/L; (80th percentile for Cataract Creek and Tributaries); or Stability: Evidence of bed and band erosion and scouring	1. Investigate potential cause of exceedances (e.g., climatic; systemic; failure) 2. Identify mitigation options 3. Review monitoring frequency and parameters 4. 4. Report potential impact, and response, within six monthly reporting	1. One Month 2. One Month, commence works within two months. 3. One Month 4. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: pH: 1 sample outside of 5.8 – 7.3 range (5th/95th percentile); or EC 1 sample outside of 30- to 350 µS/cm range (ANZG 2018 95th percentile – upland rivers); or TSS: 1 sample above 64.6 mg/L (95th percentile for Cataract Creek and Tributaries); or Stability: Visible migration (rerouting) of watercourse	1. Inform DPIE and WaterNSW 2. Commence investigation on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3. Inform DPIE and WaterNSW of preliminary investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One Week 2. Commence within one Week 3. 1 Month 4. Commence works within two months 5. One Month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Surface Water Management Plan	Swamps	CCus3 CCus4c CRus1c (plus proposed new locations)	pH EC	Monthly	To determine if mining operations are impacting surface water quality of swamp outflows	Level 1 Normal Operations pH 6.0 to 6.8; and EC < 200 µS/cm	Continue monitoring.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader to monitor for trends in data.
						Level 2 pH 1 samples outside of 3.8 – 6.3 range (Swamp Piezo trigger from the GWMP); or EC 3 consecutive samples greater than 188 µS/cm (80th percentile)	1. Investigate potential cause of exceedances (e.g., climatic; systemic; failure) 2. Identify mitigation options 3. Review monitoring frequency and parameters 4. Report potential impact, and response, within six monthly reporting	1. One Month 2. One Month, commence works within 2 months. 3. One Month 4. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager) Environmental Monitoring Team Leader
						Level 3: pH: 2 consecutive samples outside of 3.8 – 6.3 range (Swamp Piezo trigger from the GWMP); or EC 1 sample outside of 30-to 350 µS/cm range (ANZG 2018 95th percentile – upland Rivers)	1. Inform DPIE and WaterNSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One Week 2. Commence within one week 3. One Month 4. Commence works within two months 5. One Month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
GROUNDWATER									
Groundwater Management Plan	Swamp water quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp piezometers, refer to USMP	EC	Field analysis when piezometers are manually dipped: Every 2 months prior to and after swamp is mined under; Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: No exceedance of Level 2 or Level 3	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 193 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger of 193 µS/cm	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
Groundwater Management Plan	Swamp water quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp piezometers refer to USMP	pH	Field analysis when piezometers are manually dipped: Every 2 months prior to and after swamp is mined under; Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: No exceedance of Level 2 or Level 3	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading outside of the trigger range of 3.8 to 6.3	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings outside of the trigger range of 3.8 to 6.3	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Swamp water levels	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp piezometers refer to USMP,	Water level	Daily – water level monitoring with logger set 6 hourly interval. Data downloaded and manually dipped: - Every 2 months prior to and after swamp is mined under; - Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: Water level readings consistently above the water level trigger* or levels below trigger during periods of low rainfall (<20 mm/month)	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One monthly water level reading above the water level trigger of: PCc10A: 0.56 mbgl; or PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded during a period with rainfall above 20 mm/month	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive monthly water level readings above the water level trigger of: PCc10A: 0.56 mbgl; or PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded during a period with rainfall above 20 mm/month	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameter 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Hawkesbury Sandstone water quality	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A	EC	2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 376 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: Two consecutive readings above the trigger level of 376 µS/cm	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Hawkesbury Sandstone water quality	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A	pH	2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading outside of the trigger range of 3.7 to 6.5	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings outside of the trigger range of 3.7 to 6.5	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Hawkesbury Sandstone water levels	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A	Water level	Monthly manual dipped water level in areas being actively undermined	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One monthly water level reading below the water level trigger	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive monthly water level readings below the water level trigger	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
Groundwater Management Plan	Bulgo Sandstone water quality	Newly installed open standpipes, which may include: RV43A and RV44	EC	2 monthly – field analysis for open standpipes	Verification of characterisation of Bulgo Sandstone water quality and detection of changes in quality post mining and closure, outside of predicted impacts	Level 1: No exceedance of Level 2 or Level 3 triggers	Report negligible impact in routine reporting.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 376 µS/cm within the first 12 months of installation	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger level of 376 µS/cm within the first 12 months of installation	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Bulgo Sandstone water quality	Newly installed open standpipes, which may include: RV43A and RV44	pH	2 monthly – field analysis for open standpipes	Verification of characterisation of Bulgo Sandstone water quality and detection of changes in quality post mining and closure, outside of predicted impacts	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading outside of the trigger range of 3.7 to 6.5 within the first 12 months of installation	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings outside of the trigger range of 3.7 to 6.5 within the first 12 months of installation	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Bulgo Sandstone water levels	Newly installed open standpipes, which may include: RV43A and RV44	Water level	Monthly manual dipped water levels	Detection of changes in Bulgo Sandstone groundwater level post mining and closure, outside of predicted impacts	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One monthly water level reading below the water level trigger	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: Two consecutive monthly water level readings below the water level trigger	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Groundwater levels and vertical head profile	Existing VWPs: NRE1B, NRE1D, GW1, RV16, RV17, RV20, RV22, RV23, RV24, RV25, RV27, RV29, RV35 and RV36	Water level	Daily – water level monitoring with logger set at 6 hourly interval and downloaded monthly in areas being actively undermined	Impact on groundwater levels and vertical head profile due to mining impacts/subsidence impacts beyond those already predicted.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: Detection of a significant change in vertical head gradient at one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile and baseline observation data (refer Appendix H)	1. Review condition of the VWP equipment. 2. If the data is representative, review climate trends, groundwater trends within other sensors and nearby monitoring locations and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Detection of a significant change in vertical head gradient at more than one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile and baseline observation data across multiple sensor levels (refer Appendix H)	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Groundwater levels and vertical head profile	Newly installed VWPs, which may include: RV43 and RV48	Water level	Daily – water level monitoring with logger set at 6 hourly interval and downloaded monthly	Impact on groundwater levels and vertical head profile due to mining impacts/subsidence impacts and recovery post mining, beyond those already predicted.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: Detection of a significant change in vertical head gradient at one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile.	1. Review condition of the VWP equipment. 2. If the data is representative, review climate trends, groundwater trends within other sensors and nearby monitoring locations and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Detection of a significant change in vertical head gradient at more than one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile.	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
Groundwater Management Plan	Underground workings	Mine inflows	Inflow	Daily volumetric flow monitoring of mine inflow and discharge	Inflows volumes to underground workings is in line with predictions and captured by appropriate water licences.	Level 1: Mine pump volumes are within predicted mine inflow range (< 1ML/day) – excluding changes in dewatering volumes to manage inrush risk or due to equipment maintenance.	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: Increase in flow rate of >1ML/day (above predictions) for 4 successive days from active mining areas - excluding changes in dewatering volumes to manage inrush risk or due to equipment maintenance.	1. Review equipment to verify if the reading is representative. If not, remeasure. 2. If the data is representative, review mine water quality and inflow data, ground water data and geotechnical/subsidence records to identify any adverse trends that may indicate any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Increase in flow rate of >1ML/day (above predictions) for 7 successive days from active mining areas - excluding changes in dewatering volumes to manage inrush risk or due to equipment maintenance.	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	pH	Monthly – field analysis Quarterly – discrete analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading outside of the trigger range of 7.7 to 9.4	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings outside of the trigger range of 7.7 to 9.4	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	EC	Monthly – field analysis Quarterly – discrete analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 5,226 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: Two consecutive readings above the trigger level of 5,226 µS/cm	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	Sulfate	Quarterly – discrete analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 167 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger level of 167 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	Dissolved Al	Quarterly full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 0.11 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger level of 0.11 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
Groundwater Management Plan	Underground workings	Mine inflows	Dissolved As	Quarterly – Full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 0.03 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger level of 0.03 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	Dissolved Mo	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 0.09 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)
						Level 3: Two consecutive readings above the trigger level of 0.09 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
Groundwater Management Plan	Underground workings	Mine inflows	Dissolved Sb	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Environmental Manager)
						Level 2: One reading above the trigger level of 0.03 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). One to two months to complete depending on timing of review of second data period.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: Two consecutive readings above the trigger level of 0.03 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPIE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Environmental Manager)
BIODIVERSITY									
Biodiversity Management Plan	Aquatic biodiversity	Monitoring of water quality and aquatic macroinvertebrate at five impact sites in Cataract Creek and Cataract River. Monitoring of water quality and aquatic Macroinvertebrates at four control sites.	A comprehensive visual inspection and photographic record of each monitoring site will be collected each time a site is visited. Physico-chemical water quality parameters, including temperature, conductivity, pH, Oxidation, dissolved oxygen and turbidity. Physicochemical properties of waterways are compared to ANZECC AMRANZ (2000) guidelines. Condition of aquatic habitats based on AUSRIVAS method. Upper and lower limits of aquatic habitat will be established using OE50TaxaScores and SIGNAL2 scores.	Minimum 12 months of baseline monitoring prior to mining. Monitoring during mining. A minimum of one years of monitoring post-mining. Macroinvertebrate monitoring is undertaken in spring and autumn.	To determine if subsidence effects resulting from mining result in impacts to aquatic habitats or threatened species. Inform stakeholders of baseline assessment and monitoring. Identify, investigate and report on impacts to aquatic ecology.	Within prediction (Level 1): Negligible environmental consequences for creeks, as illustrated by no significant changes in water quality or data collected during macroinvertebrate sampling.	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Within prediction (Level 2): Negligible environmental consequences for creeks, as illustrated by a short term (1 year) reduction in aquatic habitat, as shown by: • Water quality data exceeding upper or lower limits of baseline monitoring; or • Change in OE50Taxa Score; or • Change in AUSRIVAS Band.	1. Continue monitoring. 2. Review frequency and location of monitoring and determine if additional monitoring is required. 3. Inform BCD, and DAWE of potential impact. 4. Report potential impact in six monthly reports.	1. Six monthly reporting in accordance with Extraction Plan approval 2. Monitoring plan reviewed within one month of potential impact being identified. 3. BCD, and DAWE notified of potential impact within one week of potential impact being identified.	Russell Vale Colliery (Environmental Manager)
						Exceeding prediction (Level 3): Reduction in aquatic habitat at impact sites only for an extended timeframe (>2 years), as shown by: • Water quality data exceeding upper or lower limits of baseline monitoring; or • Change in OE50Taxa Score; or • Change in AUSRIVAS Band	1. Engage ecologist to investigate and report on the cause of trigger exceedances and advise of potential impacts. 2. Inform BCD and DAWE of investigation outcomes. 3. Review monitoring program, including frequency and location, and modify if necessary. 4. Develop and implement impact mitigation and remediation measures in consultation with BCD and DAWE. 5. Develop a monitoring plan to determine the success of mitigation / remediation measures. 6. If mitigation/Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DAWE. 7. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within one week of impact being identified. 2. Investigation initiated within one week of impact being identified. 3. Investigation results reported to BCD and DAWE within one week of completion. 4. Monitoring plan reviewed within one week of impact being identified. 5. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified, if required. 6. Monthly updates of investigation progress to BCD and DAWE, if required. 7. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
UPLAND SWAMP									
Upland Swamp Monitoring Plan	Vegetation monitoring and observational monitoring	Category 1: BCUS4 CCUS1 CCUS3 CCUS4 CCUS5 CCUS10 CCUS12 CRUS1 CRUS2 CRUS3 Category 2 (if triggered): CCUS2	TSR and species composition	Category 1 & 2: Collection of data on all species observed in 30 0.5m x 0.5m quadrats along 15 m transects. Statistical analysis of TSR and species composition.	To determine if the project results in changes to vegetation composition within coastal upland swamps exceeding negligible levels	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Level 2: Negligible change to the composition or distribution of species, as illustrated by a short term (less than one-year duration – first year after mining commences) significant statistical difference between control and impact sites or between before and after mining at the impact sites or minimal dieback recorded during observational monitoring.	1. Continue monitoring. 2. Review frequency and location of monitoring and determine if additional monitoring is required. Report potential impact in six monthly reports.	1. Six monthly reporting in accordance with Extraction Plan approval 2. Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
		CCUS6 CCUS14 CCUS20 CCUS21		Category 1, 2 & 3: Observational monitoring will be undertaken across the study area opportunistically during surveys including photo-point monitoring.		Level 3: Change to the composition or distribution of species as illustrated by a long term (greater than one year) significant statistical difference between control and impact sites or between before and after mining at the impact sites or significant dieback in more than one area recorded during observational monitoring.	1. Engage ecologist to investigate and report on the cause of trigger exceedances and advise of potential impacts. 2. Inform BCD and DAWE of investigation outcomes. 3. Review monitoring program, including frequency and location, and modify if necessary. 4. Develop and implement impact mitigation and remediation measures in consultation with BCD and DAWE. 5. Develop a monitoring plan to determine the success of mitigation / remediation measures. 6. If mitigation / Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DAWE. 7. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within one week of impact being identified. 2. Investigation initiated within one week of impact being identified. 3. Investigation results reported to BCD and DAWE within one week of completion. 4. Monitoring plan reviewed within one week of impact being identified. 5. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified, if required. 6. Monthly updates of investigation progress to BCD and DAWE, if required. 7. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
Upland Swamp Monitoring Plan	Giant Dragonfly monitoring	CCUS1 CCUS4 CCUS5 CCUS10 CRUS1 BCUS4	Number of exuviae recorded within a 1.5 m wide belt transect of variable length through suitable habitat. Sex, height above ground level, perch plant species, and distance to burrow (if identified) and seepage water will be recorded for all exuviae sighted. Exuviae will then be removed	A minimum of one year baseline data collection before any mining under the swamp. Monitoring annually during mining. A minimum of one year post mining monitoring at coastal upland swamps showing negligible impacts (level 1). Surveys are undertaken in summer with two replicates per year.	To determine if the project results in changes to Giant Dragonfly breeding within coastal upland swamps exceeding negligible levels.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Level 2: Decline in exuviae numbers observed when compared to control sites. Decline is one year duration, and in the absence of changes in other parameters	1. Continue monitoring. 2. Review frequency and location of monitoring and determine if additional monitoring is required.	1. Six monthly reporting in accordance with Extraction Plan approval. 2. Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Environmental Manager)
						Level 3: Decline in exuviae numbers observed when compared to control sites. Decline is for greater than one year duration, in conjunction with declines in soil moisture or piezometer data as available.	1. Engage ecologist to investigate and report on the cause of trigger exceedances and advise of potential impacts. Inform BCD and DAWE of investigation outcomes. Review monitoring program, including frequency and location, and modify if necessary. Develop and implement impact mitigation and remediation measures in consultation with BCD and DAWE. 2. Develop a monitoring plan to determine the success of mitigation/ remediation measures. If mitigation/ Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DAWE. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within one week of impact being identified. Investigation initiated within one week of impact being identified. Investigation results reported to BCD and DAWE within one week of completion. Monitoring plan reviewed within one week of impact being identified. 2. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified, if required. 3. Monthly updates of investigation progress to BCD and DAWE, if required. 4. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
Upland Swamp Monitoring Plan	Swamps within EP Area	Coastal upland swamp extent size and sub-community composition is mapped using LiDAR and field inspection.	TSR and species composition	One baseline survey prior to mining. Not required during mining. If greater than negligible impacts are identified through other monitoring methods, e.g. subsidence, peizometer or vegetation transect monitoring, additional LiDAR surveys will be undertaken at 2 to 5 year intervals.	To determine if the project results in changes to upland swamp extent or sub-community composition within coastal upland swamps exceeding negligible levels.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Within prediction: (Level 2) Minor change in swamp extent or sub-community composition within a coastal upland swamp. One year of decline in swamp extent or change in community composition greater than the mean (±SE) decline of the control group, taking into account any differences in variation between control and impact groups	1. Continue monitoring. 2. Review frequency and location of monitoring and determine if additional monitoring is required. Report potential impact in six monthly reports.	1. Six monthly reporting in accordance with Extraction Plan approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Environmental Manager)
						Level 3: Trending reduction in swamp extent or sub-community composition within an upland swamp. A multi-year of decline in swamp extent or change in community composition greater than the mean (±SE) decline of the control group, taking into account any differences in variation between control and impact sites.	1. Engage ecologist to investigate and report on the cause of trigger exceedances and advise of potential impacts. 2. Inform BCD and DAWE of investigation outcomes. 3. Review monitoring program, including frequency and location, and modify if necessary. 4. Develop and implement impact mitigation and remediation measures in consultation with BCD and DAWE. 5. Develop a monitoring plan to determine the success of mitigation / remediation measures. 6. If mitigation / Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DAWE. 7. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within one week of impact being identified. 2. Investigation initiated within one week of impact being identified. 3. Investigation results reported to BCD and DAWE within one week of completion. 4. Monitoring plan reviewed within one week of impact being identified. 5. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified, if required. 6. Monthly updates of investigation progress to BCD and DAWE, if required. 7. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
HERITAGE									
Heritage Management Plan	Aboriginal Heritage	Bulli Mine Shaft 20 (AHIMS 52-3-0311) Bulli Mine Shaft 29 (AHIMS 52-3-0313) Bulli Mine Shaft 26 (AHIMS 52-3-0323) Bulli Mine Shaft 27 (AHIMS 52-3-0325) Wonga East 4 (AHIMS 52-2-4170) Wonga East 5 (AHIMS 52-2-4171)	Baseline recording and comparative photograph monitoring regime.	Baseline archival recording 3 months prior to second workings within 350m of site. Continuous subsidence monitoring using GNSS units within the extraction area. Six monthly monitoring from the commencement of mining within 350m of the site. Final assessment recording within 12-24 months of second workings mining being completed within 350m of site.	To determine if subsidence effects resulting from bord and pillar mining system result in impacts to Aboriginal heritage sites and the heritage values of those sites.	Level 1: No change in site condition observed; and Less than 100mm recorded subsidence	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting	Russell Vale Colliery (Environmental Manager)
						Level 2: **Change in site condition is observed but the heritage values of the site are not impacted. or** • Greater than 100mm and less than 300mm recorded subsidence; or • Cracking in sandstone platforms or shelter walls/ceilings; or • Movement along existing joints and/or bedding planes; or • Changes to the water seepage patterns or water flow regime through the sandstone.	1. Continue monitoring 2. Increase the review of subsidence monitoring data to weekly 3. Undertake a review of the panel design parameters in consultation with geotechnical advice. 4. Inform DPIE, Resources Regulator, Heritage NSW and RAPs of potential impact, and consult on proposed adaptive management and, if required, remediation. 5. Undertake site inspection with RAPs to document and photograph any observed changes / impacts. 6. Investigate potential cause of observed changes in site condition. 7. Where the investigation identifies mining as a likely cause of the changes, consultation and meetings with RAPs to determine the most appropriate mitigation measures and management of the site. 8. Cease operations and implement adaptive management if assessed as a requirement 9. Review the mine plan for future mining areas to avoid impacts to sites potentially impacted by future second workings 10. Report potential impacts in six monthly reports.	1. DPIE, Heritage NSW and RAPs informed within one week. 2. Investigations into potential cause of observed changes to be commenced within 2 days of being detected. 3. Six monthly reporting.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: • **Change in site condition is observed, and the heritage values of the site are impacted; or** • Greater than 300mm recorded subsidence.	1. Continue monitoring and increase the review of subsidence monitoring data for that area to daily. 2. Inform DPIE, Resources Regulator, Heritage NSW, and RAP of potential impact. 3. Undertake a review of the panel design parameters in consultation with geotechnical advice 4. Undertake site inspection of surface areas to document and photograph any observed changes / impacts. 5. Investigate potential cause of observed changes in site condition. 6. Where the investigation identifies mining as a likely cause of the changes, consultation on potential remediation / mitigation action will be undertaken with Heritage NSW and RAP. 7. Cease mining operations in the impacted area and implement adaptive management and contingency plan. 8. Review the mine plan for future mining areas to avoid impacts to sites potentially impacted by future second workings. 9. Where required, use appropriate specialists to undertake physical remediation activities 10. Report potential impacts in six monthly reports.	1. DPIE, Heritage NSW and RAP informed within one week. 2. Investigations into potential cause of observed changes to be commenced within 2 days of being detected. 3. Commence preparation of mitigation/action and monitoring plan within one week (if required). 4. Within 14 days of the exceedance occurring, submit a report to the DPIE and Heritage NSW describing the remediation options and any preferred remediation measures of other course of action 5. Six monthly reporting.	Russell Vale Colliery (Environmental Manager)
Heritage Management Plan	Historical Heritage – Subsidence	Cataract Dam	Subsidence Monitoring LiDAR Visual Inspection GNSS	Impact assessment recording, within six months after each predicted subsidence movement at the site (that is when the bord and pillar mining system is closest traverse to the FSL of Cataract Reservoir). Final assessment recording within 6 months of completion of all subsidence movements at the site.	To determine if subsidence effects resulting from bord and pillar mining system result in impacts to the heritage values of Cataract Dam.	Within prediction (Level 1): No change in site condition observed; and Less than 100mm recorded subsidence.	Continue monitoring. Report negligible impact in six monthly reports	End of panel reporting.	Russell Vale Colliery (Environmental Manager)
						Within in prediction (Level 2): • Change in site condition is observed, but the heritage values of the site are not impacted; or • Greater than 100mm and less than 300mm recorded subsidence.	**Monitoring and remediation action** 1. Continue monitoring. 2. Increase the review of subsidence monitoring data to weekly. 3. Undertake a review of the panel design parameters in consultation with geotechnical advice 4. Inform DPIE and Heritage NSW of potential impact. 5. Undertake site inspection of surface area to document and photograph any observed changes / impacts. 6. Investigate potential cause of observed changes in site condition and, if identified as potential caused by mining, review management procedures. 7. Report potential impacts in six monthly reports.	1. DPIE and Heritage NSW and informed within one week. 2. Investigations into potential cause of observed changes to be commenced within 2 days of being detected. 3. Six monthly reporting.	Russell Vale Colliery (Environmental Manager)
						Exceeding prediction (Level 3): • Change in site condition is observed, and the heritage values of the site are impacted; or • Greater than 300mm recorded subsidence.	Monitoring and remediation action 1. Continue monitoring and increase the review of subsidence monitoring data for that area to daily 2. Stop mining in the impacted area and investigate causes of the increased subsidence 3. Undertake a review of the panel design parameters in consultation with geotechnical advice 4. Inform DPIE and Heritage NSW of potential impact.	1. DPIE and Heritage NSW and informed within one week. 2. Investigations into potential cause of observed changes to be commenced within 2 days of being detected. 3. Commence preparation of mitigation/action and monitoring plan within one week (if required). 4. Within 14 days of the exceedance occurring, submit a	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
							5. Implement adaptive management and contingency plan 6. Undertake site inspection of surface area to document and photograph any observed changes / impacts. 7. Investigate potential cause of observed changes in site condition. 8. Where the investigation identifies mining as a likely cause of the changes, consultation on potential remediation/mitigation works will be conducted with Heritage NSW. 9. Review mine planning for future mining areas to avoid further impacts 10. Where required, use appropriate specialists to undertake physical remediation activities. 11. Report potential impacts in six monthly reports.	report to the DPIE and Heritage NSW describing the remediation options and any preferred remediation measures of other course of action 5. Six monthly reporting.	
LAND									
Land Management Plan	Cliffs, Steep Slopes, Rocky Outcrops	All land features present within EP Area as outlined within the LMP.	Visual Monitoring of EP Area	Monitoring of key landscape features prior to, during and post mining for any potential impacts will be undertaken to confirm that the mine design measures to prevent such impact are adequate and in accordance with the Development Consent.	To determine if subsidence effects resulting from bord and pillar mining system result in impacts to land features.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Level 2: Change in land features condition is observed	1. Continue monitoring. 2. Inform DPIE and WaterNSW of potential impact. 3. Undertake site inspection to document and photograph any observed changes/impacts. 4. Report potential impacts in six monthly reports.	1. DPIE and WaterNSW informed within one week. 2. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Level 3: Change in land features condition is observed, and impact greater than predicted occurs.	1. Continue monitoring. 2. Submit an incident report to DAWE, DPIE and WaterNSW of potential impact. 3. Undertake site inspection to document and photograph any observed changes/impacts. 4. Discussion of potential remediation/ mitigation. Consultation with relevant stakeholders will be required if remediation or mitigation measures are required. 5. Use appropriate specialists to undertake physical remediation activities. 6. Report potential impacts in six monthly reports.	1. DPIE and WaterNSW are informed immediately. 2. DAWE to be notified within 48 hours. 3. Commence preparation of mitigation/action and monitoring plan within one week (if required). 4. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
SUBSIDENCE									
Subsidence	Vertical Subsidence	Surface terrain (non-swamp monitoring points	Millimetres	GNSS units and LiDAR	To determine the level of subsidence effects resulting from bord and pillar mining system.	<100 mm	Continue to monitor trends	Six monthly reporting in accordance with Extraction Plan approval.	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
						>100 mm, <300 mm	1. Environmental Manager to inform subsidence specialist within 24hrs 2. Continue to monitor trends	1. DPIE and WaterNSW informed within one week. 2. Six monthly reporting in accordance with Extraction Plan approval.	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
						>300 mm,	1. Environmental Manager to inform Subsidence specialist within 24hrs – Subsidence specialist to assess and provide advice on potential impacts and actions required including any adaptive management measures, recognising the performance measure of 300 mm and greater than 500 mm is considered possible in small, isolated areas	1. DPIE and WaterNSW and informed immediately and DAWE within 48 hours. 2. Commence preparation of mitigation/action and monitoring plan within one week (if required). 3. Six monthly reporting in accordance with Extraction Plan approval.	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
Subsidence	Closure	Valley Closure – Cataract Creek GNSS#1 - #8 CC1-CC4	Millimetres	**GNSS** Point to Point Hi Res Survey measurement across Cataract Creek	To determine the level of subsidence effects resulting from bord and pillar mining system.	<100 mm	Continue to monitor trends	Six monthly reporting in accordance with Extraction Plan approval.	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
						>100 mm, <150 mm	1. Environmental Manager to inform subsidence specialist within 24hrs 2. Continue to monitor trends	1. DPIE and WaterNSW informed within one week. 2. Six monthly reporting in accordance with Extraction Plan approval.	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
						>150 mm,	1. Halt underground mining operations within 80mm of observed subsidence impacts pending confirmation of vertical subsidence and preliminary investigation as to likely cause. 2. Recommencement of operations subject to approval from DAWE 3. Environmental Manager to inform Subsidence specialist within 24hrs - Subsidence specialist to assess and provide advice on potential impacts and actions required including any adaptive management measures. 4. Undertake surface observations of area where elevated subsidence impacts detected within 24 hours.	1. Immediately notify DPIE and DAWE	Environmental Manager Environmental Monitoring Team Nominated Mining Surveyor
Subsidence	Vertical Subsidence (Upland Swamps (Direct GNSS monitoring) CCUS1	GNSS#1 GNSS#2 GNSS#3	mm (vertical subsidence)	Daily (weekly Average)	Monitor levels of vertical subsidence	**Level 1** No exceedance of Level 2 or Level 3 triggers. (< 50mm or 100mm at GNSS#1)	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
	CCUS4 CCUS5	GNSS#13 GNSS#11				**Level 2:** >50 mm observed subsidence at all GNSS other than GNSS#1 >100 mm at GNSS#1	1. Review potential cause 2. Determine need for any changes to mine plan or mining method. 3. Review subsidence predictions. 4. Continue monitoring. 5. Review frequency and location of monitoring and determine if additional monitoring is required. 6. Report potential impact in six monthly reports.	1. Six monthly reporting in accordance with Extraction Plan approval 2. USMP Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
	CRUS1 CCUS15 CCUS17 CCUS18 CCUS19	GNSS#12 GNSS#14				Level 3: >100 mm observed subsidence at GNSS (other than GNSS#1 – no Level 3 swamp trigger for GNSS#1)	1. Immediately cease operations in any near active mining areas. 2. Inform DPIE and DAWE of performance criteria exceedance1 3. Investigate cause of potential exceedance. 4. Revise underground mine plan/mining methods (if necessary). 5. Inspect areas of swamp to identify any material surface impacts including slumping or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with BCD, WaterNSW and DAWE. 6. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp. 7. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within 24 hours of impact being identified. 2. Investigation of cause initiated within 24 hours week of impact being identified. 3. Investigation results reported to BCD and DAWE within one week of completion. 4. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified. 5. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required). 6. Monthly updates of investigation progress to BCD and DAWE, if required. 7. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
Subsidence	Vertical Subsidence - Upland Swamps (Indirect GNSS Monitoring) CCUS2	GNSS#3 GNSS#15 Underground observations in PC07 and PC08	mm (vertical subsidence)	Daily (weekly Average)	Monitor levels of vertical subsidence	**Level 1** No exceedance of Level 2 or Level 3 triggers. (< 50mm)	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
	CCUS20	GNSS#1 GNSS#2 Underground Observations in PC08 LiDAR				Level 2: >50mm observed subsidence at GNSS#14 and GNSS#15; or >80mm observed at GNSS#2 and GNSS#3; or >100mm at GNSS#1	1. Review potential cause and need for any changes to mine plan or mining method. 2. Review subsidence predictions. 3. Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required. 4. Report potential impact in six monthly reports.	1. Six monthly reporting in accordance with Extraction Plan approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Environmental Manager)
	CRUS3	GNSS#14 GNSS#15 Underground observations in PC07 and PC08				**Level 3:** Strata failure in Stage 1 second workings within 250m of swamp. > 100mm subsidence observed in LiDAR relative to Stage 1 baseline.	1. Immediately cease operations in any near active mining areas. 2. Inform DPIE and DAWE of performance criteria exceedance 3. Investigate cause of strata failure. 4. Revise underground mine plan/mining methods (if necessary). 5. Inspect areas of swamp to identify any material surface impacts including slumping or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with BCD, WaterNSW and DAWE. 6. Undertake LiDAR Survey to investigate where subsidence performance criteria exceeded. 7. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp. 8. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	1. BCD, and DAWE notified of potential impact within 24 hours of impact being identified. 2. Investigation of cause initiated within 24 hours week of impact being identified. 3. Investigation results reported to BCD and DAWE within one week of completion. 4. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified. 5. Undertake LiDAR survey of potentially affected area at soonest reasonable opportunity. 6. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required). 7. Monthly updates of investigation progress to BCD and DAWE, if required. 8. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
BUILT FEATURES									
Bult Features	Transmission Line 11 Dapto to Sydney South and Towers	330KV Single Circuit – Suspension Towers: 54, 55, 56, & 57	Observable surface deformations – **LIDAR** Separation between tower legs – **prism/ point Survey** Vertical subsidence – **GNSS** Tilt - – **prism/ point Survey**	**Prior to second workings** conduct baseline survey Prism/ point - Survey and GNSS continuous reading prior to second workings **During second workings within 350m of sites** Prism/ point - Survey After each panel or annual or by TARP trigger and LIDAR – Quarterly and GNSS - continuous During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post mining** 12 months after completion of each panel.	To determine if subsidence effects resulting from pilar and bord mining system result in impacts to built features	Observations within prediction and Approved Impact.			
						• No observable surface deformations; and • <5 mm leg vertical differential; and • <20 mm vertical subsidence; and • Tilt <1mm/m.	Data and report to: • TransGrid • Principal Subsidence Engineer RR;-	Within 1 week following collection & processing of data, document report quarterly during secondary extraction.	Russell Vale Colliery (Environmental Manager) Survey Manager
						Observations within approved impact but exceed or potential exceed predictions.			
						• Observable surface deformations and/or • Separation between tower legs (10 to 20 mm); or • vertical subsidence >20 mm; or • Tilt >1mm/m	1. Notify the following key stakeholders within 24hours of becoming aware of the trigger: • TransGrid • Principal Subsidence Engineer–DRE. 2. Continue consultation with TransGrid	1. Notify the Key Stakeholders, as appropriate, within 24hrs of becoming aware of the trigger:	Russell Vale Colliery (Environmental Manager) Survey Manager
						Observations exceed approved impact.			
						• Observable surface deformations or • Separation between tower legs (>20mm); or • Subsidence greater than predicted maximum (Upper 95% CL – identified as 100mm)	1. Notify the following Key Stakeholders, as appropriate: - TransGrid - Principal Subsidence Engineer–DRE. 2. Cease underground mining immediately and review mining options. 3. Undertake additional 3D survey and check against pre-mining data and review against predictions; 4. TransGrid and RVC to undertake visual inspections accordingly; 5. RVC to review mining options and Extraction Plan 6. Liaise with asset owner TransGrid regarding any action/s required. 7. Review mining options.	1. Notify the following Key Stakeholders, as appropriate, immediately following awareness of trigger being met:	Russell Vale Colliery (Environmental Manager) Survey Manager
Built Features	Transmission Line 132 kV Singlle Circuit – Tower No. E66 to E69 33KV transmission line and pylons	•33 kV pylons	Observable surface deformations – **LIDAR** Vertical subsidence - **GNSS** Tilt - **– prism/ point Survey**	**Prior to second workings** conduct baseline survey Prism/ point – Survey and GNSS continuous reading prior to second workings **During second workings** within 350m of sites Prism/ point - Survey After each panel or annual or by TARP trigger and LIDAR – Quarterly and GNSS - continuous During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP	To determine if subsidence effects resulting from pilar and bord mining system result in impacts to built features	Observations within prediction and Approved Impact			
						• No observable surface deformations; and • <5 mm leg vertical differential and • <50 mm vertical subsidence; and • Tilt <1mm/m.	Data and report to: • Endeavour Energy • Principal Subsidence Engineer RR;	Within 1 week following collection and processing of data, document and report quarterly during secondary extraction.	Russell Vale Colliery (Environmental Manager) Survey Manager
						Observations within approved impact but exceed or potentially exceed predictions			
						1. Observable surface deformations; or 2. vertical subsidence > 20 mm; or 3. Tilt >1mm/m or 4. Separation between tower legs (10 to 20 mm)	1. Notify the following key stakeholders within 24hours of becoming aware of the trigger: - Endeavour Energy - Principal Subsidence Engineer–DRE. 2. Continue consultation with Endeavour Energy	1. Notify the Key Stakeholders, as appropriate, within 24hrs of becoming aware of the trigger:	Russell Vale Colliery (Environmental Manager) Survey Manager
						Observations exceed approved impact.			
						1. Observable surface deformations or 2. Subsidence greater than 100mm (> 100 mm) or 3. Separation between tower legs (>20mm) or 4. Subsidence greater than predicted maximum (Upper 95% CL – identified as 100 mm)	1. Notify the following Key Stakeholders, as appropriate: • Endeavour Energy • Principal Subsidence Engineer–DRE. 2. Cease underground mining immediately and review mining options. 3. Undertake additional 3D survey and check against pre-mining data and review against predictions; 4. Endeavour Energy and RVC to undertake visual inspections accordingly;	1. Notify the following Key Stakeholders, as appropriate, **immediately following awareness** of trigger being met:	Russell Vale Colliery (Environmental Manager) Survey Manager

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
				trigger. **Post mining** - 12 months after completion of each panel.			5. RVC to review mining options and Extraction Plan 6. Liaise with Endeavour Energy regarding any action/s required. 7. Review mining options.		
Built Features	**Mt Ousley Rd** Carriageway General Carriageway– Cataract Creek (100m) Carriageway- Mt Ousley Road – tension zone at ridge (P46) **Bridges** Picton Rd interchange - B7926 Steel Arch over Rocky Creek Culvert – B7932 Culvert over Cataract River – B814 **Culverts** Cataract Creek Culverts Multiple Culverts **Slopes** ARL2 – 955771/ 95770/ 13482 ARL3 – 10839/ 13483/ 13484/ 13485	GNSS 1, 8, 16 LIDAR Cataract Creek Closure CT1-CT4 P-Line survey RMS twice weekly drive-through inspections Expansion tension monitoring (SXC1 – SXC2, SXC3 – SXC4 and QCN – QCS, Compression Slot monitoring (above Cataract Creek)	Subsidence monitoring by real time GNSS units as per specific GNNS detail (GNSS, 1, 8, 16) Yearly survey of CT1- CT4 creek closure Q-Line survey on southbound carriageway - reinstate Expansion crack monitoring Compression Slot monitoring (Continuous) RMS undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	**GNSS** GNSS readings prior to second workings, and During mining over active mining area GNSS data reviewed weekly and Monthly in all other areas, or as required by TARP trigger and GNSS meters 1 and 8 to be used to identify movement above predictions requiring attended survey **Survey** Yearly CT1-CT4 survey and Q-line Baseline Survey Within three months of completion of second workings panel. Post Mining - Quarterly for 12 months after cessation of mining		Observations within prediction and approved impact			
						• GNSS Subsidence <100mm; and • Valley Closure not greater than 100mm; and • Attended survey Pot bearings - longitudinal +- 10 mm from baseline,	Continue to monitor as per monitoring plan	Ongoing	WCL
						Observations within approved impact but exceed or potentially exceed predictions			
						• GNSS Subsidence 100mm – 280mm; or • Valley Closure 100-150mm; or • Attended survey Pot bearings - longitudinal +- 20 mm from baseline,	1. Continue to monitor as per monitoring plan 2. Review underground mining 3. Commence investigation into potential exceedance 4. Attended survey to be undertaken 5. RMS-TC to meet to review monitoring data to decide on and to direct proactive action 6. WCL and RMS to undertake visual inspections;	1. Inform the Technical Committee within 7 days 2. Investigation commences immediately 3. Notify DPIE of potential exceedance	WCL RMS Technical Committee
						Observations exceed approved impact			
						• GNSS Subsidence >280mm; or • Valley Closure greater than 150mm: or • Attended survey - Pot bearings - longitudinal >+- 25 mm	1. Stop mining and review mining options. 2. Commence investigation into potential exceedance 3. Attended survey to be undertaken 4. RMS-TC to meet to review monitoring data to decide on and to direct proactive action 5. WCL and RMS to undertake visual inspections;	1. Inform the Technical Committee within 24 hours 2. Investigation commence immediately 3. Notify DPIE within 48 hours 4. Immediately Notify RR with written confirmation within 48hours	WCL RMS Technical Committee
PUBLIC SAFETY									
Public Safety Features	All public safety features present in the EP Area as outlined in the PSMP	All public safety features present in the EP Area as outlined in the PSMP	Visual monitoring of the EP Area	Monitoring of key landscape features prior to, during and post mining for any potential impacts will be undertaken to confirm that the mine design measures to prevent such impact are adequate and in accordance with the Development Consent.	To determine if subsidence effects resulting from pilar and bord mining system result in impacts to public safety	Level 1: No change in condition of features observed.	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)
						Level 2: Change in features condition is predicted to occur. No change to the condition of features is observed.	1. Continue monitoring. 2. Inform DPIE and WaterNSW of potential impact. 3. Undertake site inspection to document and photograph any observed changes / impacts. 4. Report potential impacts in six monthly reports.	1. DPIE and WaterNSW informed within one week. 2. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)

Key Component Management Plan	Aspect	Location	Parameters	Frequency/ timing	Purpose	Level	Action/Reporting	Report timing	Responsibility
						Level 3: Change in features condition is observed, and impact greater than predicted occurs.	1. Make area safe as soon as practicable. 2. Continue monitoring. 3. Inform DPIE and WaterNSW of potential impact. 4. Undertake site inspection to document and photograph any observed changes / impacts. 5. Discussion of potential remediation/ mitigation. Consultation with relevant stakeholders will be required if remediation or mitigation measures are required. 6. Use appropriate specialists to undertake physical remediation activities. 7. Report potential impacts in six monthly reports.	1. DPIE and WaterNSW and informed within one week. 2. Commence preparation of mitigation/action and monitoring plan within one week (if required). 3. Six monthly reporting in accordance with Extraction Plan approval.	Russell Vale Colliery (Environmental Manager)

APPENDIX B: CONSULTATION

Richard Sheehan
Environmental Manager
NRE NO. 1 Colliery 7
Princes Highway
Corrimal, NSW, 2518

09/02/2021

Dear Mr Sheehan

Russell Vale Underground Expansion (MP09_0013)
Extraction Plan

I refer to your request (MP09_0013-PA-3) for the Planning Secretary's approval of suitably qualified persons to prepare the Extraction Plan for the Russell Vale Underground Expansion (MP09_0013).

The Department has reviewed the nominations and information you have provided and is satisfied that these experts are suitably qualified and experienced. Consequently, I can advise that the Planning Secretary approves the appointment of the experts to prepare the Extraction Plan.

Accordingly, the following experts are approved as authors for the Extraction Plan.

Consent Condition	Extraction Plan Requirement	Expert/Author
Schedule C Condition 10	Extraction Plan	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(i)	Subsidence Monitoring Plan	Dr Ken Mills – SCT Stephen Wilson - SCT
Schedule C Condition 10 (g)(ii)	Built Features Management Plan	Dr Ken Mills – SCT Stephen Wilson - SCT
Schedule C Condition 10 (g)(iii)	Water Management Plan	Susan Shield – Engeny Clare Stephenson - Umwelt
Schedule C Condition 10 (g)(iv)	Biodiversity Management Plan	Paul Price - Biosis
Schedule C Condition 10 (g)(v)	Swamp Monitoring Plan	Luke Stone - Biosis
Schedule C Condition 10 (g)(vi)	Land Management Plan	Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(vi)	Heritage Management Plan	Dr Amanda Markham - Biosis
Schedule C Condition 10 (g)(vii)	Public Safety Management Plan	Warwick Lidbury – RVC Mine Manager
Schedule C Condition 10 (g)(viii)	Trigger Action Response Plan/s	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(ix)	Contingency Plan	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt

If you wish to discuss the matter further, please contact Daniel Martin at daniel.martin@dpie.nsw.gov.au

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments
As nominee of the Planning Secretary

DOC21/911837-2

Ms Gabrielle Allan
Department of Planning, Industry and Environment
GPO Box 39
SYDNEY NSW 2001

Email: gabrielle.allan@dpie.nsw.gov.au

Dear Ms Allan

EPA Comments - Russell Vale Underground Expansion Project - Stage 1 Extraction Plan

I am writing in reply to the Department's request for comments on the Russell Vale Extraction Plan dated 8 October 2021.

The plan was submitted by Wollongong Coal Ltd for approval to extract coal from Stage 1 areas of the Russell Vale coal mine.

The EPA has reviewed the plan and provides the following comments on surface facilities that fall within the premises of the mine's Environment Protection Licence number 12040.

The plan has divided the installation of surface infrastructure into two stages. Stage 1 includes construction of new noise walls, noise bunds and a new primary sizer. Board and pillar mining will be undertaken and the coal will be loaded onto trucks from the ROM stockpile using front-end loaders. The coal will be transported to PKCT for export.

The plan states that Stage 1 includes an "evaluation of the feasibility of a coal processing plant (CPP) to be installed as part of the new Stage 2 surface infrastructure".

The EPA understands that the Revised Preferred Project Report and evaluation of environmental impacts during the planning approval included a new coal processing plant. If the plant is built as part of the project, the EPA recommends that expert confirmation be provided by Wollongong Coal that noise and dust impacts will be no more than those predicted in the environmental assessment and approved in the Consent.

If you have questions regarding the above, please phone Andrew Couldridge on (02) 4224 4100.

Yours sincerely

William Dove

22.10.2021

WILLIAM DOVE
Unit Head Regulation

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Phone 02 4224 4100
(from outside NSW)

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Our ref: DOC21/910629

Gabrielle Allan
Team Leader
Energy Resource Assessment
DPIE

By email: gabrielle.allan@dpie.nsw.gov.au

Dear Ms Allan

HERITAGE COUNCIL COMMENTS ON DRAFT STAGE 1 EXTRACTION PLAN FOR RUSSELL VALE COLLIERY (MP09_0013-PA-12)

Thank you for your referral dated 18 October 2021 inviting comments from the Heritage Council of NSW on the Draft Stage 1 Extraction Plan (for bord and pillar mining of sub-panels PC07, PC08 and PC21 to PC25) for Russell Vale Colliery.

It is understood that the subject modification was approved on 8 December 2020. The following condition is relevant: Schedule 2, Part C Condition C10 (Extraction Plan). Heritage NSW previously provided comments to the Historic Heritage Management Plan (HHMP), dated 5/3/2021 as per letter of 14 April 2021 (DOC21/211102).

The following report was considered:
Russell Vale Colliery Revised Underground Expansion Project – Extraction Plan Stage One – PC07, PC08 & PC21 to PC25, prepared by Wollongong Coal, dated 8 October 2021.
This Extraction Plan includes the updated Heritage Management Plan:

Russell Vale Colliery, Russell Vale East – Revised Underground Expansion Project, Cultural and Historical Heritage Management Plan, prepared by Wollongong Coal, dated 30/9/2021.

The following comments are provided to address the applicant's response to the heritage issues raised:

- Section 8.2 of the HHMP states that vertical subsidence impacts are predicted to be less than 100mm and the Performance Measure for vertical subsidence has been set at 300mm under the development consent; and that this level of subsidence impact would be restricted to the edge of the FSL area immediately adjacent to the Extraction Plan area and will have no observable impacts on the Reservoir and would not have any effect on the heritage values of the Cataract Dam.

  It is noted that the previously recommended actions in case of vibration and subsidence within Cataract Dam SHR curtilage included stopping activity in surrounding area, followed by urgent rehabilitation of the area and submission of a report to HNSW outlining the actions taken. Table 23 of the TARP (Trigger Action Response Plan) within Appendix A of the HHMP includes actions for three subsidence prediction levels. The previously recommended actions have not been included into the TARP. It is requested that the monitoring and remediation actions be incorporated into the HHMP, particularly at Level 2 (100-300mm recorded subsidence) and 3 (greater than 300mm recorded subsidence), where changes in site conditions are observable.

- It is noted that section 10.4.3 of the HHMP includes actions to be taken in instances of discovery of ‘relics’, as per the provisions of s.146 of the *Heritage Act 1977*. This is supported.

If you have any questions regarding the above advice, please contact Veerle Norbury, Senior Heritage Assessment Officer at Heritage NSW, on 9873 8616 or veerle.norbury@environment.nsw.gov.au.

Yours sincerely

Steven Meredith
Director, Heritage Programs
Heritage NSW
Department of Premier and Cabinet
As Delegate of the Heritage Council of NSW
4 November 2021

Response History

Public Authority Response

Monday, 25 October 2021 12:30:01 AM AEDT

Notes:

To whom it may concern,

Heritage NSW has reviewed the Wollongong Coal has submitted an Extraction Plan (EP) for Stage 1 bord and pillar mining (sub-panels PC07, PC08 and PC21 to PC25), in accordance with condition C10 of the project approval for the Revised Underground Expansion Project (MP09_0013).

Heritage NSW has no additional recommendations or comments on the submitted extraction plan.

Regards Nicole Davis

Nicole Davis | A/Senior Team Leader,
Aboriginal Cultural Heritage Regulation - North
Heritage NSW, Community Engagement,
Department of Premier and Cabinet
Level 6, 10 Valentine Ave, Parramatta |
Locked Bag 5020 Parramatta 2124
T: 02 4927 3156 M: 0409 394 343 | nicole.davis@environment.nsw.gov.au

MINING, EXPLORATION & GEOSCIENCE ADVICE RESPONSE

DOC21/932107

Gabby Allan
Planning & Assessment Group
Department of Planning, Industry and Environment
Locked Bag 5022
PARRAMATTA NSW 2150

Gabby.Allan@planning.nsw.gov.au

Dear Gabby

Project: Russell Vale U/G Expansion – Stage 1 – Revised Extraction Plan variation
Stage: Post Approval Assessment
Development Application: MP09_0013-PA-31

I refer to your correspondence dated 18 October 2021 inviting the Department of Regional NSW – Mining, Exploration & Geoscience (MEG) to provide comments on the Russell Vale U/G Expansion – Stage 1 – Revised Extraction Plan variation (the Project), submitted by Wollongong Coal Limited (the Proponent).

MEG has reviewed the information supplied and raises no issues regarding the Russell Vale U/G Expansion – Stage 1 – Revised Extraction Plan variation.

MEG considers the extraction plan to adequately recover coal resources and provide an appropriate return to the NSW Government.

For further advice concerning this matter, please contact Industry Advisory & Mining Concierge on 02 4063 6534 or mining.concierge@regional.nsw.gov.au.

Yours sincerely

Scott Anson
Manager Industry Advisory & Mining Concierge
Industry Development
Department of Regional NSW – Mining, Exploration & Geoscience
2 November 2021

for
Anthony Keon
Executive Director Strategy, Performance & Industry Development
Department of Regional NSW – Mining, Exploration & Geoscience

DOC SF21/137908
MAAG0012517

Gabrielle Allan
Principal Planning Officer
Planning and Assessment Group
Department of Planning, Industry and Environment

Via: Major Project Portal / Email

Dear Ms Allan,

Re. Russell Vale Underground Expansion - Stage 1 Extraction Plan

I refer to your request of 18 October 2021 for advice regarding Russell Vale Underground Expansion - Stage 1 Extraction Plan. The Resources Regulator has reviewed the request.

Assessment
Based on the review of the draft conditions, the Resources Regulator advises that the holder of relevant mining leases is required to ensure that the rehabilitation commitments outlined in any approved Extraction Plan are included in the Mining Operations Plan / Rehabilitation Management Plan regulated by the Resources Regulator pursuant to the conditions of the mining leases under the Mining Act 1992. The holder of the mining leases must ensure the Mining Operations Plan / Rehabilitation Management Plan for the area covered by this Russell Vale Colliery Revised Underground Expansion Project - Extraction Plan Stage 1 is updated where necessary.

Due to the required Performance Measures, i.e. "*Always safe and serviceable*", for the Key Public Infrastructure as set out in Condition C7 of the Development Consent (MP09_0013, dated 8 December 2020), we suggest that the Approving Authority obtains the infrastructure operators' written endorsement of the proponent's proposed Built Features Management Plan prior to the determination of approval of the above-mentioned Extraction Plan.

Note – The above-mentioned Built Features Management Plan is part of Russell Vale Colliery's Extraction Plan (RVE EC PLN 010, Version: 02, Effective: 8 October 2021).

The endorsement by the operators of the Key Public Infrastructure as set out in Condition C7 of the Development Consent (MP09_0013, dated 8 December 2020) is to ensure:

- Completion of consultation between the proponent and the infrastructure operators in relation to all the actions raised and/or questions/requests asked by the infrastructure operators;
- Accuracy of the proponent's understanding of the Key Public Infrastructure at the subject site (e.g. the proponent's statement in the Extraction Plan that the 132kV transmission line at the subject site is managed/operated by TransGrid is incorrect); and

- Risk assessments and the subsequent development of management and contingency plans is undertaken in consultation with the infrastructure operators. The infrastructure operators' expertise and resources form a fundamental part of the risk management system. It follows that the endorsement by the infrastructure operators of the Built Features Management Plan is fundamentally important to ensure the proponent's compliance with the requirements under the Development Consent (MP09_0013, dated 8 December 2020).

Note that the infrastructure operators' endorsement (or agreement) has been suggested in Appendix D (i.e. Subsidence Assessment) of the proponent's Extraction Plan (RVE EC PLN 010, Version: 02, Effective: 8 October 2021) as follows:

These management plans and risk control measures need to be developed in consultation and with the agreement of the asset owners and relevant stakeholders through risk assessments.

Limitations
The Extraction Plan is assessed and determined by DPIE under the conditions of the development consent. The Resources Regulator provides advice to DPIE to assist in the determination.

Regulatory requirements if approved
The authorisation holder is required to ensure that the rehabilitation commitments outlined in any approved Extraction Plan are included in the Mining Operations Plan / Rehabilitation Management Plan regulated by the Resources Regulator under the conditions of the mining lease and the *Mining Act 1992*. The authorisation holder must ensure the Mining Operations Plan / Rehabilitation Management Plan for the area covered by this Extraction Plan is updated where necessary.

The Resources Regulator may undertake assessments of the mine operators' proposed mining activities under the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and Regulation as well as other WHS regulatory obligations.

Subsidence associated with the proposed Extraction Plan will be regulated by under relevant provisions of WHS laws in particular Clause 33 and Clause 67 of the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* relating to High Risk Activities and Subsidence.

Background
The NSW Resources Regulator is responsible for compliance and enforcement of the Extraction Plan is so far as it relates to requirements under the Mining Act 1992 and Work Health and Safety legislation. This role principally relates to rehabilitation, workplace safety and public safety.

The Mining Act Inspectorate within the Resources Regulator undertake risk-based compliance and enforcement activities in relation to obligations under the *Mining Act 1992*. This includes undertaking assessment and compliance activities in relation to mine rehabilitation activities and determination of security deposits.

The Mine Safety Inspectorate within the Resources Regulator is responsible for ensuring the mine operators' compliance with the Work Health and Safety (WHS) legislation, in particular the effective management of risks associated with the principal hazards as specified in the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*.

Contact
Should you require any further information or clarification, please contact the Office of the Executive Director (ED.ResourcesRegulator@planning.nsw.gov.au)

Yours sincerely,

Garvin Burns
Executive Director
NSW Resources Regulator

8 November 2021

PO Box 398, Parramatta NSW 2124
Level 14, 169 Macquarie Street
Parramatta NSW 2150
www.waternsw.com.au
ABN 21 147 934 787

5 November 2021

Contact: Ravi Sundaram
Telephone: 0428226152
Our ref: *D2021/116712*

Jessie Evans, Director Resource Assessments, DPIE
Email: Jessie Evans@DPIE.nsw.gov.au

Dear Jessie

Russell Vale Colliery Underground Expansion Project - Stage 1 – PC07-08 and 21 -25 Extraction Plan

WaterNSW appreciates the opportunity to review the above application located within the Metropolitan Special Area and the Upper Nepean Catchment (specifically within the upper catchment of the Cataract Reservoir).

WaterNSW has an important statutory role "*to protect and enhance the quality and quantity of water in declared catchment areas*". It also has a set of 'Mining Principles' which underpin WaterNSW decision making in relation to managing mining impacts in the declared Sydney catchment area and on catchment infrastructure.

WCL has consulted with WaterNSW in preparing several key management plans required under the approval including Water Management Plan, Land Management Plan, Swamp Monitoring Program, and the Public Safety Management Plan. The EP has addressed feedback provided by WaterNSW to these plans.

The EP includes the revised and updated subsidence assessment including risk of "pillar run" in multi-seam mining areas. The EP predicts that vertical subsidence is expected to be less than 100mm and generally imperceptible over most of the EP Areas. As a result, the EP expects the impacts, and consequences to natural, surface, and sub-surface features to be negligible and imperceptible in the undeveloped bushland setting over most of the EP subject areas.

WaterNSW notes that the EP has comprehensively addressed the pillar stability and pillar failure issues through changes to mine design including:

- Increased pillar dimensions in PC07 and PC08 area from 19.5m by 24.5m (as originally identified in the Response to Second PAC Review and Revised Project Assessment (Umwelt 2019) to 22.5m by 24.5m to below the Balgownie Seam longwall goafs
- Pillar generally square in shape in PC21 and PC22-25 area with minimum coal pillar dimensions of 24.5m by 24.5m
- Longer rectangular barrier type pillars incorporated into the three headings entries to the PC22-25 sub-panels, and
- Three barrier pillars (coal) separate the PC22-PC25 sub-panels.

The EP reports that risk analysis undertaken (SCT, 2020a) quantifies the risk of such a pillar failure occurring as less than 1 in 100,000 (0.001 % over the life of the project and therefore less than 0.01 % per year). The likelihood of initiating event occurring is remote.

WaterNSW considers that:
- The mining method and mine design adopted by WCL would result in negligible impacts on water resources, biodiversity, and catchment environmental values.
- WCL have addressed the potential risk of 'pillar run' for proposed extraction in a multi-seam area where overlying seams have been extracted previously.
- The proposed monitoring and management measures are appropriate for the planned mining method and subsidence predictions.

- The underground mine water balance monitoring system is expected to be effective as a guide to any unexpected inflows and inrush events from previously mined overlying seams and from Cataract Reservoir.
- The Trigger Action Response Plans (TARPs) for water and swamp monitoring including stream and swamp triggers developed based on baseline monitoring of performance indicators and anticipated subsidence effects are reasonable and appropriate.

WaterNSW does not have any concerns to the approval of the EP and extraction as it has taken into consideration WaterNSW's Mining Principles, poses low risk to overlying catchment values and water resources, and is likely to meet the performance measures set in the development consent.

Please contact Dr. Ravi Sundaram if you would like to discuss any of theabove matters further.

Yours sincerely

Daryl Gilchrist
Manager, Catchment Protection

<u>Attachment B – Request for clarifications - Russell Vale UEP Stage 1 Extraction Plan</u>

General Comments

- Please provide a consolidated summary of the status of baseline monitoring relevant to this EP.
- Please provide a summary of how BCD/EES comments on the Upland Swamp Monitoring Plan (dated 11 May 2021) were addressed in the updated plan, including justification if comments have not been addressed.

TARP Comments – General

- Where TARPS have multiple performance indicators, it is sometimes unclear whether these performance indicators are related or independent of each other. A review of the TARP performance indicators is requested to clarify whether 'and' or 'or' should be added between multiple performance indicators. E.g. for the Heritage TARP, it's unclear whether both a change in condition and exceedance of vertical subsidence trigger is required to trigger a level 2 or level 3 event, or whether triggering one of these two indicators is sufficient to activate the TARP.

Surface Water TARP – Swamps

- Water level is noted as a performance indicator for swamps CCus3, CCus4c and CRus1c in order to determine if mining operations are impacting surface water quality of swamp outflows, however no monitoring parameter relevant to water level is provided.
- The level 2 performance indicator for swamps (*Subsidence impacts: Potential change in steady water levels (i.e., significant increase / decrease*)) does not define the magnitude of change required to trigger this performance indicator, or how this would be monitored.
- The level 3 performance indicator for swamps (*Subsidence impacts: Swamp has dried (loss of water))* is not well defined, does not reflect the highly variable nature of water flow in swamps and does not provide for long term changes in water level that could result in an exceedance of the performance measure for swamps. There is also no indication of how this would be monitored.

Groundwater TARP – Swamp Water Level

- It is noted that the performance indicator in the Groundwater - Swamp Water Level TARP refers to a 'water level trigger' which is cross-referenced to a footnote providing the values for the water level trigger. Please consider a clearer method of presenting the trigger levels in the body of the TARP.
- Further to the point above, it is noted that the cross-reference to water level trigger values is not carried across to the Master TARP, with no values provided in the footnotes of the TARP.

Subsidence TARP

- Why is the upper limit of vertical subsidence considered by the General Subsidence TARP less than 300mm? Similarly, why is the Cataract Creek Valley Closure TARP limited to less than 300mm? What actions / responses will occur if subsidence or closure exceeds 300mm?
- The subsidence section of the Master TARP states that the relevant 'Aspect' being monitored for Valley Closure across Cataract Creek is vertical subsidence rather than closure. The Department assumes this reference to vertical subsidence is made in error and should be corrected.

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19th November 2021

Jessie Evans
Director - Resource Assessments
Department of Planning, Industry and Environment
4 Parramatta Square, 12 Darcy Street
Parramatta, NSW, 2150

Re: Russell Vale Underground Expansion (MP09_0013) - Stage 1 Extraction Plan - Request for additional information

Dear Jessie,

I refer to the Department of Planning, Industry and Environment (DPIE) correspondence dated 8 November 2021, in which further information is requested to effectively address additional matters raised by agencies in regard to the Extraction Plan for Stage 1 as submitted to DPIE on 8 October 2021.

Wollongong Coal Pty Ltd (WCL) has considered and responded to each of the additional matters raised by the agencies in the correspondence provided from NSW EPA, Heritage NSW, NSW Resource Regulator (see Appendix A – Agency Response) and would welcome the opportunity to discuss with the Department and or specific agencies if required.

WCL also have submitted a revised Extraction Plan which includes a revised Extraction Plan and updated sub plans.

Attachment A – Includes correspondence NSW EPA. Heritage Council, Heritage NSW – Aboriginal Cultural Heritage Regulation, Department of Regional NSW – Mining, Exploration & Geoscience (MEG, NSW DPIE (Resources Regulator), WaterNSW

Attachment B – DPIE RFI

Attachment C – BCS / ESS Response

Should you have any questions or queries in relation to the content of this letter please do not hesitate to contact me on 0404 972 746.

Yours sincerely

19/11/2021.

Richard Sheehan
Wollongong Coal Group Environment Manager
E: Richard.sheehan@wcl.net.au

Ph: 0412 766 849

Enc
Appendix A – Correspondence from stakeholders on EP

Appendix B – DPIE RFI regarding EP

Appendix C – BCD/EES correspondence regarding EP

Appendix A

DPIE NSW - WCL Response to DPIE Additional Information Request

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Table A.1 **DPIE RFI Response**

Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
1	NSW EPA	The plan has divided the installation of surface infrastructure into two stages. Stage 1 includes construction of new noise walls, noise bunds and a new primary sizer. Board and pillar mining will be undertaken and the coal will be loaded onto trucks from the ROM stockpile using front-end loaders. The coal will be transported to PKCT for export. The plan states that Stage 1 includes an "evaluation of the feasibility of a coal processing plant (CPP) to be installed as part of the new Stage 2 surface infrastructure". The EPA understands that the Revised Preferred Project Report and evaluation of environmental impacts during the planning approval included a new coal processing plant.	If the plant is built as part of the project, the EPA recommends that expert confirmation be provided by Wollongong Coal that noise and dust impacts will be no more than those predicted in the environmental assessment and approved in the Consent	The CPP continues to progress through a process to evaluate the feasibility of a coal processing plant. WCL notes the EPA recommendation and should the CPP feasibility study confirm the plant installation as required will carry out a review with suitably qualified and experienced expert consultants to ensure expert confirmation that noise and dust impacts will be no more than those predicted in the revised preferred project report (RPPR) and approved in the UEP project.
2	Heritage NSW – Heritage Council	The following report was considered: Russell Vale Colliery Revised Underground Expansion Project – Extraction Plan Stage One – PC07, PC08 & PC21 to PC25, prepared by Wollongong Coal, dated 8 October 2021. This Extraction Plan includes the updated Heritage Management Plan: Russell Vale Colliery, Russell Vale East – Revised Underground Expansion Project, Cultural and Historical Heritage Management Plan, prepared by Wollongong Coal, dated 30/9/2021. The following comments are provided to address the applicant's response to the heritage issues raised:	It is noted that the previously recommended actions in case of vibration and subsidence within Cataract Dam SHR curtilage included stopping activity in surrounding area, followed by urgent rehabilitation of the area and submission of a report to HNSW outlining the actions taken. Table 23 of the TARP (Trigger Action Response Plan) within Appendix A of the HHMP includes actions for three subsidence prediction levels. • The previously recommended actions have not been included into the TARP. It is requested that the	The feedback provided by NSW Heritage Office has been incorporated into a revised Heritage Management Plan as detailed: • Section 8.2 of the HHMP has been updated to describe the monitoring program, • Table 23 of the TARP (Trigger Action Response Plan) within Appendix A of the HHMP has been revised to include monitoring and remediation actions particularly at Level 2 (100-300mm recorded subsidence) and 3 (greater than 300mm recorded subsidence), where changes in site conditions are observable.

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
		• Section 8.2 of the HHMP states that vertical subsidence impacts are predicted to be less than 100mm and the Performance Measure for vertical subsidence has been set at 300mm under the development consent; and that this level of subsidence impact would be restricted to the edge of the FSL area immediately adjacent to the Extraction Plan area and will have no observable impacts on the Reservoir and would not have any effect on the heritage values of the Cataract Dam.	monitoring and remediation actions be incorporated into the HHMP, particularly at Level 2 (100-300mm recorded subsidence) and 3 (greater than 300mm recorded subsidence), where changes in site conditions are observable. • It is noted that section 10.4.3 of the HHMP includes actions to be taken in instances of discovery of 'relics', as per the provisions of s.146 of the Heritage Act 1977. This is supported	Noted. No action required
3	Heritage NSW – Aboriginal Cultural Heritage Regulation	Heritage NSW has reviewed the Wollongong Coal submitted Extraction Plan (EP) for stage 1 bord and pillar mining (sub panels PC07, PC08, and PC21-25) in accordance with condition C10 of the project approval for the Revised Underground Expansion Project.	Heritage NSW has no additional recommendations or comment on the submitted extraction plan.	Noted. No action required
4	Department of Regional NSW – Mining, Exploration & Geoscience (MEG)	I refer to your correspondence dated 18 October 2021 inviting the Department of Regional NSW – Mining, Exploration & Geoscience (MEG) to provide comments on the Russell Vale U/G Expansion – Stage 1 – Revised Extraction Plan variation (the Project), submitted by Wollongong Coal Limited (the Proponent). MEG has reviewed the information supplied and raises no issues regarding the Russell Vale U/G Expansion – Stage 1 – Revised Extraction Plan variation.	MEG considers the extraction plan to adequately recover coal resources and provide an appropriate return to the NSW Government. For further advice concerning this matter, please contact Industry Advisory & Mining Concierge on 02 4063 6534 or mining.concierge@regional.nsw.gov.au.	Noted. No action required
5	NSW DPIE (Resources Regulator)	I refer to your request of 18 October 2021 for advice regarding Russell Vale Underground Expansion - Stage 1 Extraction Plan.	Based on the review of the draft conditions, the Resources Regulator advises that the holder of relevant mining leases is required to ensure that the	A review of the Russell Vale Colliery Revised Underground Expansion Project – Extraction Plan Stage 1 will be carried out post approval to ensure all rehabilitation commitments are included in the Mining

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
		The Resources Regulator has reviewed the request. **Assessment.**	rehabilitation commitments outlined in any approved Extraction Plan are included in the Mining Operations Plan /Rehabilitation Management Plan regulated by the Resources Regulator pursuant to the conditions of the mining leases under the Mining Act 1992. The holder of the mining leases must ensure the Mining Operations Plan / Rehabilitation Management Plan for the area covered by this Russell Vale Colliery Revised Underground Expansion Project – Extraction Plan Stage 1 is updated where necessary.	Operations Plan, with the plan updated where necessary.
			Due to the required Performance Measures, i.e., "Always safe and serviceable", for the Key Public Infrastructure as set out in Condition C7 of the Development Consent (MP09_0013, dated 8 December 2020), we suggest that the Approving Authority obtains the infrastructure operators' written endorsement of the proponent's proposed Built Features Management Plan prior to the determination of approval of the above-mentioned Extraction Plan. *Note – The above-mentioned Built Features Management Plan is part of Russell Vale Colliery's Extraction Plan (RVE EC PLN 010, Version: 02, Effective: 8 October 2021).* The endorsement by the operators of the Key Public Infrastructure as set out in	Wollongong Coal has undertaken a comprehensive and detailed consultation program with the key public infrastructure owners being Transport for NSW (TfNSW), TransGrid, and Endeavour Energy wherever possible inclusive of the NSW Resource Regulator. The records of this consultation are detailed in the Extraction Plan Built Features Management Plan (BFMP). Feedback from this consultation process has been included in the BFMP with reference to where the details have been addressed in the document.

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
			Condition C7 of the Development Consent (MP09_0013, dated 8 December 2020) is to ensure:	
			• Completion of consultation between the proponent and the infrastructure operators in relation to all the actions raised and/or questions/requests asked by the infrastructure operators;	Noted. Detailed and specific consultation has been carried out with all infrastructure operators. Feedback has been detailed within the BFMP inclusive of reference points. In addition the draft management plan has been wherever possible provided to the infrastructure operators for feedback.
			• Accuracy of the proponent's understanding of the Key Public Infrastructure at the subject site (e.g., the proponent's statement in the Extraction Plan that the 132kV transmission line at the subject site is managed/operated by TransGrid is incorrect); and	Noted and addressed.
			• Risk assessments and the subsequent development of management and contingency plans is undertaken in consultation with the infrastructure operators. The infrastructure operators' expertise and resources form a fundamental part of the risk management system. It follows that the endorsement by the infrastructure operators of the Built Features Management Plan is fundamentally important to ensure the proponent's compliance with the requirements under the Development Consent (MP09_0013, dated 8 December 2020).	Where identified as being required during the course of or in response to the detailed consultation risk assessments have been carried out with the key infrastructure operators. Such records have been included in and appended to the BFMP.
			Note that the infrastructure operators' endorsement (or agreement) has been	

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
			suggested in Appendix D (i.e., Subsidence Assessment) of the proponent's Extraction Plan (RVE EC PLN 010, Version: 02, Effective: 8 October 2021) as follows: *"These management plans and risk control measures need to be developed in consultation and with the agreement of the asset owners and relevant stakeholders through risk assessments."*	
			Limitations The Extraction Plan is assessed and determined by DPIE under the conditions of the development consent. The Resources Regulator provides advice to DPIE to assist in the determination.	Noted. No further action required
			Regulatory requirements if approved The authorisation holder is required to ensure that the rehabilitation commitments outlined in any approved Extraction Plan are included in the Mining Operations Plan / Rehabilitation Management Plan regulated by the Resources Regulator under the conditions of the mining lease and the Mining Act 1992. The authorisation holder must ensure the Mining Operations Plan / Rehabilitation Management Plan for the area covered by this Extraction Plan is updated where necessary. The Resources Regulator may undertake assessments of the mine operators' proposed mining activities under the	Noted. No further action required

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
			Work Health and Safety (Mines and Petroleum Sites) Act 2013 and Regulation as well as other WHS regulatory obligations. Subsidence associated with the proposed Extraction Plan will be regulated by under relevant provisions of WHS laws in particular Clause 33 and Clause 67 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 relating to High Risk Activities and Subsidence.	
		WCL has consulted with WaterNSW in preparing several key management plans required under the approval including Water Management Plan, Land Management Plan, Swamp Monitoring Program, and the Public Safety Management Plan. The EP has addressed feedback provided by WaterNSW to these plans. The EP includes the revised and updated subsidence assessment including risk of "pillar run" in multi-seam mining areas. The EP predicts that vertical subsidence is expected to be less than 100mm and generally imperceptible over most of the EP Areas. As a result, the EP expects the impacts, and consequences to natural, surface, and sub-surface features to be negligible and imperceptible in the undeveloped bushland setting over most of the EP subject areas. WaterNSW notes that the EP has comprehensively addressed the pillar stability and pillar failure issues through changes to mine design including:	WaterNSW does not have any concerns to the approval of the EP and extraction as it has taken into consideration WaterNSW's Mining Principles, poses low risk to overlying catchment values and water resources, and is likely to meet the performance measures set in the development consent.	Noted. No further action required

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
		• Increased pillar dimensions in PC07 and PC08 area from 19.5m by 24.5m (as originally identified in the Response to Second PAC Review and Revised Project Assessment (Umwelt 2019) to 22.5m by 24.5m to below the Balgownie Seam longwall goafs • Pillar generally square in shape in PC21 and PC22-25 area with minimum coal pillar dimensions of 24.5m by 24.5m • Longer rectangular barrier type pillars incorporated into the three headings entries to the PC22-25 subpanels, and • Three barrier pillars (coal) separate the PC22-PC25 sub-panels. The EP reports that risk analysis undertaken (SCT, 2020a) quantifies the risk of such a pillar failure occurring as less than 1 in 100,000 (0.001 % over the life of the project and therefore less than 0.01 % per year). The likelihood of initiating event occurring is remote. WaterNSW considers that: • The mining method and mine design adopted by WCL would result in negligible impacts on water resources, biodiversity, and catchment environmental values. • WCL have addressed the potential risk of 'pillar run' for proposed extraction in a multi-seam area where overlying seams have been extracted previously.		

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Item	Agency	Feedback provided	Request for information	WCL Response to Additional Information Request
		• The proposed monitoring and management measures are appropriate for the planned mining method and subsidence predictions. • The underground mine water balance monitoring system is expected to be effective as a guide to any unexpected inflows and inrush events from previously mined overlying seams and from Cataract Reservoir. • The Trigger Action Response Plans (TARPs) for water and swamp monitoring including stream and swamp triggers developed based on baseline monitoring of performance indicators and anticipated subsidence effects are reasonable and appropriate.		

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Appendix B

DPIE NSW – RFI Attachment B Request for clarifications

Table B.2 **DPIE RFI Attachment B Response**

Comment Source	Comment	Russell Vale Response
General Comments	Please provide a consolidated summary of the status of baseline monitoring relevant to this EP	Consolidated summary of baseline monitoring completed and attached as Appendix B - Attachment 1. Baseline data is included in the respective sub plans. Actions undertaken by WCL and subconsultants, post submission of the EP, as well as baseline monitoring required to be undertaken prior to second workings, is also outlined in Attachment 1.
	Please provide a summary of how BCD/EES comments on the Upland Swamp Monitoring Plan (dated 11 May 2021) were addressed in the updated plan, including justification if comments have not been addressed.	A summary of the response has been included in Appendix J of EP. The response was not included as an attachment to the USMP in the submitted EP, this was as an administrative oversight. The response is also included as Appendix B - Attachment 2 and has been be added to the sub plan.
TARP Comments – General	Where TARPS have multiple performance indicators, it is sometimes unclear whether these performance indicators are related or independent of each other. A review of the TARP performance indicators is requested to clarify whether 'and' or 'or' should be added between multiple performance indicators. E.g. for the Heritage TARP, it's unclear whether both a change in condition and exceedance of vertical subsidence trigger is required to trigger a level 2 or level 3 event, or whether triggering one of these two indicators is sufficient to activate the TARP.	The logic for any triggers with multiple performance indicators has been included in the Master TARP (Appendix A to the EP) and in the subplans of the EP.
Surface Water TARP - Swamps	Water level is noted as a performance indicator for swamps CCus3, CCus4c and CRus1c in order to determine if mining operations are impacting surface water quality of swamp outflows, however no monitoring parameter relevant to water level is provided.	There are a range of parameters other than water level which provide appropriate TARPs for the management of swamps, and as such the utilisation of a water level trigger has been removed from the TARP. As per Section 7.3.1.1.1 of the Water Management Plan, surface water level is too variable to allow for the development of water level based triggers. This has been previously discussed with BCD (24th May 2021 meeting between BCD, Wollongong Coal, Umwelt and Biosis– see Appendix B - Attachment 3 Page 1). The relatively shallow nature of the swamps was discussed (<2 m in depth). The swamps are also ephemeral and the swamps are dry up to 40% of the time under normal conditions (see attached Briefing note: 4 June 2021 (Attachment 3) which was submitted to DPIE on 09 June 2021 (this was as an attachment on the correspondence outlined in Appendix B - Attachment 4)).

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	The level 2 performance indicator for swamps (Subsidence impacts: Potential change in steady water levels (i.e., significant increase / decrease)) does not define the magnitude of change required to trigger this performance indicator, or how this would be monitored.	As per surface water TARP response above.
	The level 3 performance indicator for swamps (Subsidence impacts: Swamp has dried (loss of water)) is not well defined, does not reflect the highly variable nature of water flow in swamps and does not provide for long term changes in water level that could result in an exceedance of the performance measure for swamps. There is also no indication of how this would be monitored.	As per surface water TARP response above.
Groundwater TARP – Swamp Water Level	It is noted that the performance indicator in the Groundwater - Swamp Water Level TARP refers to a 'water level trigger' which is cross-referenced to a footnote providing the values for the water level trigger. Please consider a clearer method of presenting the trigger levels in the body of the TARP.	Trigger levels for Groundwater TARP – Swamp Water Level, Level 2 and Level 3 have been revised to include the information which was referenced in the footnotes to the table within the TARP, please note there has been no change to the TARP values. Six groundwater monitoring sites have been included in the TARP across the Stage 1 EP Area for Level 2 and 3 triggers. The sites and corresponding groundwater trigger levels within the EP Area as per the Ground Water TARP are presented below. Level 2: One monthly water level reading above the water level trigger of: PCc10A: 0.56 mbgl; or PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded during a period with rainfall above 20 mm/month Level 3: Two consecutive monthly water level readings above the water level trigger of: PCc10A: 0.56 mbgl; or

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		PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded during a period with rainfall above 20 mm/month
	Further to the point above, it is noted that the cross-reference to water level trigger values is not carried across to the Master TARP, with no values provided in the footnotes of the TARP.	Master TARP Trigger levels have been revised to reflect the Level 2 and 3 trigger levels listed as per above.
Subsidence TARP	Why is the upper limit of vertical subsidence considered by the General Subsidence TARP less than 300mm? Similarly, why is the Cataract Creek Valley Closure TARP limited to less than 300mm? What actions / responses will occur if subsidence or closure exceeds 300mm?	Subsidence TARPs have been updated to change the upper limit of the Level 2 Subsidence TARP to 300 mm and Level 3 to be greater than 300 mm. This change will be carried through to each of the relevant subplans.
	The subsidence section of the Master TARP states that the relevant 'Aspect' being monitored for Valley Closure across Cataract Creek is vertical subsidence rather than closure. The Department assumes this reference to vertical subsidence is made in error and should be corrected.	Vertical subsidence is utilised as the measure to monitor for valley closure. TARPS in Appendix A have been updated to reflect revisions to TARPS made within the respective sub plans.

App B Attachment 1 – Baseline monitoring summary

App B Attachment 2 – Biosis responses (21 September 2021) to BCD Comments from 11 May 2021

App B Attachment 3 – Briefing note to BCD re: Swamp Offset Policy

App B Attachment 4 – Email BCD to WCL re clarification of USMP Comments

Appendix B Attachment 1

Mgt plan	EP Appendix	Plan baseline section reference	Monitoring type	Commentary on status of baseline monitoring (as per respective sub plan), as at submission of EP	Actions completed by WCL/sub-consultant following EP Submission	Baseline monitoring associated with Stage 1a and 1b.
Built Features	E	3 Appendix C	LiDAR GNSS Attended ground-based survey	**Monitoring Undertaken** **As per Section 3:** For some (built) features surveys date back to 2012. These surveys provide context on the baseline condition of built features. They provide a record of the historic subsidence experienced at these features and inform the baseline condition for those aspects/features. The baseline monitoring program includes the following: • Lidar • GNSS continuous subsidence monitoring • Attended ground-based survey. **Appendix C of BFMP :** LiDAR was flown on 31 August 2021 over 'Area of Interest', prior to commencement of mining operations to capture baseline spatial information In addition, a baseline survey of Cataract Creek closure measurements were undertaken and included in Appendix C. Baseline survey measurements for CC1, CC2, CC3 and CC4 are included to 30 June 2021. Monitoring data for GNSS units #1, #2, #3, #5, #6, #7, #8, #9, #11, #12, #13, #14, #15 has also been included in Appendix C to 5 October 2021. (GNSS units #10, #16 and #17 noted in Appendix C as yet to be installed).	An email from Richard Sheehan (WCL) to Gabrielle Allan (DPIE) on 1 November 2021 showed updated GNSS unit measurements for Cataract Creek. The email included updated data to 28 October 2021 in addition to those as mentioned in the main EP. Units #16 and #17 have also now been installed, and additional data was presented in the email from 13 October to 28 October 2021 Unit #10 scheduled to be installed in November 2021.	<u>GNSS Units:</u> #1, #2, #3, #5, #6, #7, #8, #9, #10, #11, #12, #13, #14, #15, #16, #17 <u>RMS Survey Point</u> Mount Ousley Road - Carriageway general - Carriageway Cataract Creek - Mount Ousley Road Ridge (P46) - Slopes - Picton Road Interchange Bridge and Steel Arch and Culvert over Cataract River - Cataract Creek Culverts <u>Creek Closure Points</u> #1, #2, #3, #4 <u>Tower Locations</u> *330 kV -* TWR-T54, TWR-T55, TWR-T56, TWR-T57, TWR-T58 *132kV -* TWR-E63, TWR-E64, TWR-E65, TWR-E66, TWR-E67, TWR-E68, TWR-E69
Public Safety Management Plan	F	3	As per BFMP	As per BFMP	As per BFMP	See Built Features and Land Management
Water Management Plan	G	3	Surface monitoring network, and groundwater monitoring network, including - Piezometer - Soil moisture probe	**As per section 3.1:** An extensive surface and groundwater monitoring network is currently in place at WCL. Surface and groundwater monitoring sites are monitored every 2 – 6 months. **As per section 3.2.3:** Analyses of the baseline water quality monitoring data for pH, EC, TSS, and TDS at each monitoring location along watercourses, tributaries and upland swamps is presented in Appendix F (of the WMP). The analysis included the identification of the exceedance limits for selected parameter and percentiles, suitable for the specification of trigger values.	No further monitoring undertaken since submission of the EP. WCL to continue to monitor baseline data at the current frequency up to initiation of mining	See matrix following this table.

Mgt plan	EP Appendix	Plan baseline section reference	Monitoring type	Commentary on status of baseline monitoring (as per respective sub plan), as at submission of EP	Actions completed by WCL/sub-consultant following EP Submission	Baseline monitoring associated with Stage 1a and 1b.
			- Vibrating wire piezometer	**As per section 3.2.4:** A comprehensive visual and photographic survey of Cataract Creek was conducted between monitoring sites CC5 and CC7 in April 2012. Visual inspection of these sites is to be undertaken prior to, during, and following mining activities (Appendix D of the WMP). Monitoring will commence at least two months prior to mining within the vicinity of each monitoring location, to allow for the current channel conditions and potential mine related impacts to be identified. **As per section 3.3:** Regarding Cataract Reservoir; stream flow, height and water quality monitoring installations were installed by WCL on 12 April 2012. **As per Table 6 Section 3.1** Regarding Cataract Reservoir; stream height and water quality at monitoring stations have been monitored on a two-monthly basis since 2012 at CR1, CR2 and CR3. **As per Tables 8 to 11, Section 3.2** Regarding Cataract Reservoir; insufficient samples have been recorded at CR4 due to its position in the high water zone and CR4 has not been included in Table 12 (of the WMP) as a monitoring location.		
Groundwater management plan	F	5	As per WMP	As per WMP	As per WMP	
Biodiversity Management Plan	I	3	Ecological monitoring, including: - Aquatic and terrestrial monitoring - Plant community monitoring - Threatened and endangered species surveys	**As per section 3.1:** Aquatic ecological monitoring has been undertaken by Biosis within the UEP area between 2012 to 2020, however, there have been various iterations of monitoring locations due to modifications in the suitability of control sites. The aquatic ecological monitoring sites in Table 6 (of the Biodiversity MP) have been the subject of monitoring since 2015. The most recent aquatic ecological monitoring report has been prepared by Biosis (2020). Monitoring will continue in 2021. **As per section 3.2:** The plant community types (PCT's) within the UEP area, with the exception of Coastal upland swamps (Figure 4 of the Biodiversity MP), were mapped using desktop mapping (DPIE 2010). **As per section 3.3:** Annual reports have been provided to Wollongong Coal since the ecological monitoring program commenced in 2011.	Nil	<u>Aquatic Impact Monitoring</u> RVE-AQ3, RVE-AQ6 <u>Flora Impact Monitoring Site</u> 3 × CCUS5 Transects & Photopoints 3 × CCUS10 Transect & Photopoint 3 × CCUS4 Transects & Photopoints 3 × CRUS1 Transect & Photopoint 3 x CCUS2 Transects & Photopoints 3 x CRUS3 Transects & Photopoints 3 x CCUS1 Transects & Photopoints <u>Threatened Fish Monitoring Reach</u> 3 x Threatened Fish Monitoring Reaches (WGE-AQ4/AQ5-FISH; WGE-AQ2DS-FISH; WGE-AQ6DS-FISH) <u>Threatened Frog Impact Monitoring Transects</u>

Mgt plan	EP Appendix	Plan baseline section reference	Monitoring type	Commentary on status of baseline monitoring (as per respective sub plan), as at submission of EP	Actions completed by WCL/sub-consultant following EP Submission	Baseline monitoring associated with Stage 1a and 1b.
				As per section 3.4: A desktop assessment confirmed that one EEC, Coastal upland swamps in the Sydney Basin Bioregion (Endangered, BC Act and EPBC Act), was previously mapped within the study area as part of the Southeast NSW Native Vegetation Classification and Mapping project SCIVI VIS ID 2230 (DPIE 2010). Historical records also exist within the locality for 21 threatened flora and fauna species listed under the EPBC Act and BC Act (Figure 6 of the Biodiversity MP). These records are outlined in Appendix B – FLORA AND FAUNA (of the Biodiversity MP), along with those species and communities identified by the Protected Matters Search Tool and BioNet that are considered likely to occur in the study area due to the presence of potential habitat. Not all of the threatened species and communities that have the potential to occur within the study area are considered to be susceptible to the subsidence related impacts. As there are no direct impacts associated with the UEP program (i.e. no threatened species habitat will be directly removed), this impact assessment focuses on the species and communities, and their habitats, which have potential to occur in the study area, and are considered susceptible to the indirect impacts resulting from subsidence (See Appendix B – FLORA AND FAUNA and Table 7, both of the BioMP). As a result some species have been excluded from requiring further assessment, being species reliant on terrestrial environments that are at negligible risk of impact. The Russell Vale Colliery – Underground Expansion Project: Preferred Project Report - Biodiversity (Biosis 2014a) report identified one EEC, two flora species and nine fauna species (five terrestrial and four aquatic) listed under the EPBC Act and/or BC Act, that have the potential to occur or are known to occur in the study area (Figure 6 of the BioMP), and are considered susceptible to subsidence impacts. An assessment of the likelihood of occurrence of these species, based on additional monitoring data collected since 2014, and the risk of impact from the approved UEP is provided in Table 9 (of the BioMP).		4 x *Mixophyes balbus* transects 2 x *Litoria littlejohni* & *Heleioporus australiacus* transects
Heritage Management Plan	L	5 Appendix D	Visual inspection and identification	**As per Section 5:** An updated baseline assessment of Aboriginal heritage sites previously identified in the vicinity of the first workings mine panels was undertaken. This section outlines the results of the updated baseline assessment, the process of survey and site identification, and updated impact assessment for Aboriginal heritage sites included in the Consent. **As per Section 5.1:** There are 18 Aboriginal heritage sites recorded as part of the Project approval (Appendix 6 of Development Consent) as outlined in Table 9 (of the HMP). The location of these sites is shown in Figure 8 (of the HMP). Details for Aboriginal heritage sites within the Project Area for this HMP are provided below as summarised from the site cards and the updated baseline recording can be found in APPENDIX D (of the HMP). Refer to sections 5.1.1 to 5.1.1.8 for detailed descriptions of specific heritage sites.	Nil	<u>Within Stage 1 EP Area:</u> 52-2-4171, 52-2-4170, 52-3-0325, 52-3-0323 <u>Within 350 m of Stage 1 first workings</u> 52-3-0311, 52-3-0313

Mgt plan	EP Appendix	Plan baseline section reference	Monitoring type	Commentary on status of baseline monitoring (as per respective sub plan), as at submission of EP	Actions completed by WCL/sub-consultant following EP Submission	Baseline monitoring associated with Stage 1a and 1b.
				As per Section 5.2: An updated AHIMS search was conducted on 22 January 2021 (Client Service ID: 563187), which identified an additional six Aboriginal sites. These sites are listed below in Table 10 (of the HMP) and shown in Figure 8 (of the HMP). Two additional sites (52-2-4171, 52-2-4170) were identified within the six that are relevant to Stage 1.		
Land Management Plan	K	3	Visual inspections LiDAR	**As per Section 3:** Previous longwall mining extraction within the Bulli and Balgownie seams has resulted in various subsidence impacts within the EP Area. These impacts occur mostly as rock falls and surface cracking on hard rock surfaces (SCT, 2019). Changes in the character of stream channels such as cracking, iron staining, and sediment infilling in areas where the stream bed has been subsided have also occurred due to previous mining. **As per Section 3.1 (Rock falls):** The subsidence assessment completed for the UEP (SCT, 2019) notes that previous inspections of cliff formations have identified several rock falls consistent with previous mining activity within the Bulli and Balgownie seams. Note there are no identified cliffs (defined as greater than 10 m in height) within the EP Area. **As per Section 3.2 (Surface Cracking):** The previous subsidence assessment (SCT, 2019) noted that surface cracking has previously been documented on subsidence plans prepared during and after mining of the Balgownie Seam longwall panels. Most of the cracks can be found within proximity to the start of the previously mined Longwall 3 on a topographic ridge. Similar cracks are likely to have occurred at other locations but most of these would be in bushland locations where they would be difficult to detect. Inspections conducted in association with previous cracking identified on Mount Ousley Road show that there are a series of tension cracks and minor sinkholes evident along the northern side of the ridgeline between Cataract River and Cataract Creek. These cracks are locally aligned with the direction of one of the principal joint directions in the Hawkesbury Sandstone.	No further visual inspections or LiDAR undertaken since submission of the EP.	No specific monitoring sites. Visual inspection across Stage 1 EP Area.
Upland Swamp Monitoring Program	J	3	Mapping and characterisation Ecological surveys Surface and groundwater monitoring	**As per section 3:** Detailed mapping and characterisation of Coastal Upland Swamps in the Sydney Basin Bioregion EEC (listed under the EPBC Act and BC Act) was undertaken by Biosis (2012) throughout the study area. A total of 39 upland headwater swamps (approximately 49 hectares in total) were recorded in the study area. All 39 swamps are considered to meet the requirements for listing under the EPBC Act and BC Act. Refer to Biosis (2014b) for comprehensive details on the regional and local distribution of Coastal Upland Swamps, historic impacts of mining on Coastal Upland Swamps, including impacts to hydrogeological features.	Nil	<u>Swamp Monitoring Sites:</u> See matrix following this table.

Mgt plan	EP Appendix	Plan baseline section reference	Monitoring type	Commentary on status of baseline monitoring (as per respective sub plan), as at submission of EP	Actions completed by WCL/sub-consultant following EP Submission	Baseline monitoring associated with Stage 1a and 1b.
				As per section 3.1: Monitoring of soil moisture within swamps is currently conducted at Coastal Upland Swamps BCUS4, CCUS10, CCUS12, CCUS4, CCUS5 and CRUS1. Water level monitoring is also conducted along with soil moisture monitoring at swamps BCUS4, CCUS10, CCUS12, CCUS4, CCUS5 and CRUS1. **As per section 3.1.1:** Water level trends for site monitoring piezometers show a good correlation to rainfall trends, with water levels in the swamps rising to at or near surface generally in response to rainfall (i.e. over 100 mm/month). Across the RVE swamp monitoring network the available manual dipped water levels indicate unsaturated conditions approximately 47% of the time. For periods when the swamps are saturated, the median (50th percentile) of readings indicates water present around 0.57 m below surface. **As per Section 3.1.2:** Water quality monitoring of the shallow swamp piezometers has occurred since March 2012. A summary of the swamp water quality data is presented in Table 7 and timeseries pH and EC trends shown in Figure 8 and Figure 9 respectively. The swamp water quality is generally acidic to neutral (pH 3.3 – 8.5) and fresh (EC 23 – 420 µS/cm). **As per Section 3.2:** Upland swamp ecological monitoring has been undertaken in the RVE domain since autumn 2011. **As per Section 3.2.1:** Monitoring is undertaken according to a modified Before-After Control-Impact (BACI) design where data is collected before (baseline) and after impact at control and impact sites. **As per Section 3.2.1.4:** Annual reports have been provided to Wollongong Coal since the ecological monitoring program has commenced. The most recent annual report covered the 2019 year of monitoring (Biosis 2020). This report evaluated the first year of the recommencement of the ecological monitoring in RVE in the context of the previous years of data, and in response to the TARP trigger levels previously developed for longwall extraction.		

GREEN highlight denotes sites monitored as per EP

Area	Site	Type	Sampling parameters	Pre Mining Sampling Interval	During Mining Sampling Interval	Post M iningSampling Interval
Russel Vale East Swamp Piezos and Soil Moisture* Exisiting sites	SP1	Swamp piezo	**Field Analysis** EC, pH, DO, ORP, temp and turbidity **Discrete analysis** Field analysis + Laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO3, CaCO3, NO3, Total N, Total P, Total alkalinity + Filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba. **Full analysis** Field analysis + Discrete analysis + Additional dissolved metals B, Cd, Co, Hg, Se and Ag	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual
	SP2	Swamp piezo				
	PCc2*	Swamp piezo + Soil Moisture				
	PCc3	Swamp piezo				
	PCc4A	Swamp piezo				
	PCc4B*	Swamp piezo + Soil Moisture				
	PCc4C*	Swamp piezo + Soil Moisture				
	PCc4D*	Swamp piezo + Soil Moisture				
	PCc5A*	Swamp piezo + Soil Moisture				
	PCc5B*	Swamp piezo + Soil Moisture				
	PCc5C	Swamp piezo				
	PCc5D*	Swamp piezo + Soil Moisture				
	PCc6	Swamp piezo				
	PCr1A*	Swamp piezo + Soil Moisture				
	PCr1B*	Swamp piezo + Soil Moisture				
	PCr1C*	Swamp piezo + Soil Moisture				
	PCR1D	Swamp piezo				
	PB4A*	Swamp piezo + Soil Moisture				
	PB4B*	Swamp piezo + Soil Moisture				
	PB4C	Swamp piezo				
	PB4D*	Swamp piezo + Soil Moisture				
	PCc10A*	Swamp piezo + Soil Moisture				
	PCc10B*	Swamp piezo + Soil Moisture				
	PCc12A*	Swamp piezo + Soil Moisture				
	PCc12B*	Swamp piezo + Soil Moisture				
	SP1 C	Swamp drainage line				
	SP2 C	Swamp drainage line				
	Cc4c	Swamp drainage line				
	Cr1c	Swamp drainage line				

Additional UEP sites	PCC1A*	Swamp piezo + Soil Moisture				
	PCC1B	Soil moisture				
	PCC1C*	Swamp piezo + Soil Moisture				
	PCC20*	Swamp piezo + Soil Moisture				
	PCC21	Soil moisture				
	PCC6B*	Swamp piezo + Soil Moisture				
	PCC14A*	Swamp piezo + Soil Moisture				
	PCr6	Soil moisture				
	PCc14B	Soil moisture				
	PCr2	Soil moisture				
	PB11	Soil moisture				
	PCc11	Soil moisture				
	PCr3	Soil moisture				
Cataract River (Surface Water)	CR1	Creek	**Field Analysis** EC, pH, DO, ORP, temp and turbidity **Discrete analysis** Field analysis + Laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO3, CaCO3, NO3, Total N, Total P, Total alkalinity + Filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba. **Full analysis** Field analysis + Discrete analysis + Additional dissolved metals Al, B, Cd, Co, Hg, Se and Ag + NO2, TKN	Field analysis: Monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: Monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: 6 monthly Full analysis: Annual
	CR2	Creek				
	CR3	Creek				
Cataract Creek (Surface Water)	CC1	Creek	**Field Analysis** EC, pH, DO, ORP, temp and turbidity **Discrete analysis** Field analysis + Laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO3, CaCO3, NO3, Total N, Total P, Total alkalinity + Filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba.	Field analysis: Monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: Monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: 6 monthly Full analysis: Annual
	CC2	Creek				
	CC3	Creek				
	CC4	Creek				
	CC5	Creek				
	CC6	Creek				
	CC7	Creek				
	CC8	Creek				

	CC9	Creek	**Full analysis** Field analysis + Discrete analysis + Additional dissolved metals Al, B, Cd, Co, Hg, Se and Ag + NO2, TKN			
	CD1	Dam				
	CT1	Tributary				
Cataract Creek Weirs	CT1A	Tributary	**Field Analysis** EC, pH, DO, ORP, temp and turbidity **Discrete analysis** Field analysis + Laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO3, CaCO3, NO3, Total N, Total P, Total alkalinity + Filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba. **Full analysis** Field analysis + Discrete analysis + Additional dissolved metals Al, B, Cd, Co, Hg, Se and Ag + NO2, TKN	Field analysis: 2 monthly Discrete analysis: 2 monthly	Field analysis: 2 monthly Discrete analysis: 2 monthly	Field analysis: 2 monthly Discrete analysis: 2 monthly
	CT2	Tributary				
	CT3	Tributary				
	CT3A	Tributary				
	CC3	Creek				
	CC4	Creek				
	CT4A	Tributary				
	CT4B	Tributary				
RV East Open Stand Pipe Piezos Existing sites	NRE 1A	Shallow ground water	**Field Analysis** EC, pH, DO, ORP, temp and turbidity **Discrete analysis** Field analysis + Laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO3, CaCO3, NO3, Total N, Total P, Total alkalinity + Filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba. **Full analysis** Field analysis + Discrete analysis + Additional dissolved metals B, Cd, Co, Hg, Se and Ag	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: Quarterly Full analysis: Annual
	NRE 1C	Shallow ground water				
	NRE 1D	Shallow ground water				
	NRE 1 GW01A	Shallow ground water				
	RV18	Shallow ground water				
	RV19	Shallow ground water				
	RV21	Shallow ground water				
	RV22A	Shallow ground water				
	RV23A	Shallow ground water				
Additional UEP sites	RV39	Shallow ground water		Field analysis: 2 monthly Discrete analysis: 2 monthly Full analysis: Annual	Field analysis: Monthly in areas actively undermined Discrete analysis: 2 monthly Full analysis: Annual	Field analysis: 2 monthly Discrete analysis: 2 monthly Full analysis: Annual
	RV41	Shallow ground water				
	RV42	Shallow ground water				
	RV40	Shallow ground water				
	RV45	Shallow ground water				
	RV44	Shallow ground water				
	RV43A	Shallow ground water				

	RV46	Shallow ground water				
	RV47	Shallow ground water				
RV East Vibrating Wire Piezos Existing sites	NRE 1B (3913)	Ground water, Vibrating wire piezo (4)	Water head pressure	2 monthly download	Monthly download in areas actively undermined	2 monthly download
	NRE 1D (939)	Ground water, Vibrating wire piezo (4)				
	NRE1 GWO1 (2501)	Ground water, Vibrating wire piezo (8)				
	NRE1 A (SWM3 (909))	Ground water, Vibrating wire piezo (4)				
	RV16 (3460)	Ground water, Vibrating wire piezo				
	RV17 (3667)	Ground water, Vibrating wire piezo				
	RV20 (3953)	Ground water, Vibrating wire piezo (5)				
	RV22 (3891)	Ground water, Vibrating wire piezo (8)				
	RV29 (8007)	Ground water, Vibrating wire piezo				
	RV24 (7793	Ground water, Vibrating wire piezo				
	RV25 (7772)	Ground water, Vibrating wire piezo				
	RV27	Ground water, Vibrating wire piezo				
	RV35	Ground water, Vibrating wire piezo				
	RV36	Ground water, Vibrating wire piezo				
	RV23 (3923)	Ground water, Vibrating wire piezo (8)				
Additional UEP sites	RV43	Ground water, Vibrating wire piezo				
	RV48	Ground water, Vibrating wire piezo				

Appendix B – Attachment 2

BCD comments 11/05/2021 Biosis response 21/09/2021

Section	Comments	How addressed
3.1	Page 17: Please fix error in text reference to Table 3 and check the table is complete and contains all water monitoring locations and details.	Fixed
3.22	This section is poorly written and difficult to follow. Some graphs or tables of results or summary findings could be provided.	3.22 deleted and report from biometrician is included as an appendix.
	Page 24: Please add in text reference to TARP level definitions at each mention and provide better explanation of the TARP trigger levels in this section.	To avoid confusion between old TARPs and new TARPs, the old tarps are specified in the biometricians report. New TARPs and levels are specified in 7.3 and Appendix D.
4.1	Page 25 "Aspects of the proposed monitoring program will not be directly linked to TARPs but will instead be undertaken to inform investigations into the cause of potential impacts should the identified TARP triggers be exceeded." This statement is unclear. Please explain what you are monitoring and what TARPS you are proposing to use as triggers. If you are not using the previously defined TARPS, please provide a clear explanation of what has changed and why in this section of the report. Linking monitoring to TARPs is important for transferability of results between prior studies and ongoing monitoring results. The relationship between TARPs and what is being proposed to be monitored in the monitoring plan is unclear and needs to be better defined and justified throughout.	This seems to be poor wording that has been amended. The TARPs are specifically what is being tested during the data analysis.
	Page 25: Please fix reference errors	Fixed

Section	Comments	How addressed
	Page 25: “It is to be noted that there are currently no groundwater monitoring sites at swamps CCUS1, CCUS14, CCUS20, CCUS21, CRUS2 and CRUS6. Additional monitoring sites for these locations have been proposed and will be installed at least 2 months prior to each swamp being mined under.” This project identified that there was likely to be negligible environmental consequences for upland swamps as a result of predictions of negligible total subsidence. As a result, DPIE concurs that application of the “Upland Swamp Offset Policy” is highly unlikely to be triggered. However, swamps CCUS1, CCUS20, CCUS21 have been identified as most likely to be affected by subsidence as a result of undermining. Therefore, collecting adequate baseline data for these swamps should be a priority of the monitoring program. The installation of groundwater monitoring piezometers 2 months prior to commencement is insufficient to provide adequate data to describe baseline groundwater regime in these swamps. The “Upland Swamps Offset Policy” requires a minimum of two years baseline data on which to assess compliance with negligible impacts on groundwater level and swamp water balance. This also contradicts minimum monitoring periods stated in the following sections of the report. Please clarify minimum pre-mining monitoring periods.	This has been resolved during project approval with monitoring being required 12 months prior to the commencement of workings. This has been reflected throughout the plan.
4.1	Page 26: Please include minimum monitoring periods for pre-impact, during mining and post mining monitoring in this section and ensure it matches the information provided in Table 7 and references the “Upland Swamps Offset Policy”. As currently written, it is difficult to determine the total monitoring periods suggested for the study.	We have included confirmation of the pre-mining requirements now that they have been received. This has been provided in the instrument of approval and has been included to specify 12 months prior to mining and post mining monitoring requirements.
	Page 26: “In this regard, swamps which are yet to be directly undermined can be used as reference swamps for the swamps which are mined under. Additionally, swamps which have been mined under but which show no adverse effects from this mining can be used as part of the reference site network where there is confidence that potential impacts are unlikely to occur post mining.” Reference sites should be independent from impacted sites and assigned to control treatments prior to commencement of study period in order to comply with BACI monitoring standards. Please outline the methods and statistical analysis you will undertake to assess the suitability of "less impacted sites" to be considered as a reference sites. Include details on the minimum time frame for monitoring of prior impacted sites to be considered reference condition and the specific criteria assessed.	The proposal here is to use nearby swamps as additional controls, up until the point that mining occurs within 350 metres of the boundary. As these swamps are closer together the power of analysis is increased (removing variation) and the number of control swamps is higher (greater df). The only shortfall of this method is that the power of analysis decreases as less “control” swamps are available over time. The purpose of the proposed is to improve statistical analysis at any point, given the limited availability of true control sites.

Section	Comments	How addressed
	Page 27: Swamp specific water balances should be developed for swamps to be directly undermined in order to comply with the consent conditions and requirement for negligible environmental consequences. Please see previous comments regarding requirements for baseline data in individual swamps.	Swamp specific water balances can be developed based on the data collected if these are considered to be of benefit to the investigation of potential causes of any observed changes in swamp groundwater regimes. However it was determined that soil moisture and shallow piezos will provide a more accurate account of the likely effects to the swamps caused by subsidence.
	Page 32: replace "prior" with period	Fixed
4.21	Page 35 Table 9: Swamps to be used as control sites need to be subject to the same baseline monitoring prior to mining as impacted sites. Baseline data needs to be collected and directly comparable between control and impact categories. Will these additional control sites have the same baseline monitoring durations and ecological monitoring as the impacted sites?	All control sites are monitored for swamp extent, TSR and species composition the same as a CAT 1 swamp.
	Page 35: "Control sites will not have been mined beneath during the monitoring period being investigated." Will swamps that have been mined beneath or in close proximity to undermining outside of the monitoring period be excluded as control sites? Please provide additional details on the requirements and criteria for additional sites to be considered control swamps.	Addressed for p.26 comment. There is limited availability of suitable control sites, we have proposed 8 and how the data is analysed is in 6.4. To be used as a control the swamp, first it must meet the descriptors for an upland swamp and second be outside of the area of influence of the proposed activity.
4.4	Page 39: The definitions of treatments provided here are unclear. Please use the same terminology as Table 5 which refers to 'Control' and 'impact' swamps. Pre-mining and Post-mining monitoring should occur at both control and impacted sites. Pre-mining impact sites and pre-mining control sites data should not be pooled.	Please see above comments.
	Page 40: Please give more details on the methods and analysis that will be performed to determine suitability of control sites for inclusion in the study, including the minimum number of control sites needed for the study. What constitutes ecological similarity? You should define the parameters used to determine this prior to analysis.	Please see above comments.
4.42	Page 41: A measure of relative abundance of each species would enable more analysis options and diversity could also be calculated which would address the consent condition for negligible consequences for biodiversity - the current monitoring plan is not measuring diversity in swamps.	Total species richness as proposed in the monitoring is a measure of species diversity.

Section	Comments	How addressed
	Page 41: When describing the statistical analysis performed you refer to 'mining status' as a predictor rather than the previously defined 'control/impact' treatment and this is confusing. It would be clearer if you used the same terminology to refer to treatment groups (Control versus impact) in your study design throughout the document.	Control vs impact is a simplification of the methods proposed. We use before, after, control, impact and year. This allows for drivers of change to be identified through the use of generalised linear mixed models. We have a variety of scenarios tested and the resultant tests of those models give us the AIC, which provides the model of best fit. Please see report from biometrician for further information.
5	Page 56: "Significant statistical difference between control and impact sites or between before and after mining at the control sites (one year duration – first year after mining commences)." This should read: significant statistical difference between control and impact sites or between before and after mining at the impact sites No change in control sites is expected. A change in impact sites indicates greater than negligible impact has occurred.	Typo has been fixed.
	Page 56: Swamp water quality (two consecutive readings above the trigger, or below for pH) The relevance of these trigger values needs to be justified especially with the inclusion of new control sites in the study design. Data should be provided to validate these. Will these values be revised after the inclusion of new control sites in the study?	Detail is provided in the Water management plan.
	Ideally the 20th and 80th percentile values of baseline water quality in control swamps should be used as a trigger – you should identify which TARP this relates to. Page 56-58 & Appendix D Triggers for Performance measures and TARPS: The description of triggers for performance measures here does not match the triggers described in following section, and their relationship to the TARPS in Appendix D is confusing. Please revise these sections and state clearly which triggers will be used in the proposed monitoring plan – are you using all of the TARPS in Appendix D as triggers for further monitoring or just those mentioned in the triggers for performance measures section? A Table in the body of the report would help. If you are proposing different triggers for the revised monitoring plan then consider including a section in the report where you explain this. The reference to triggers and TARPs in sections 3 & 4 of the report should likewise be clarified and consistent throughout.	TARPs sections have undergone multiple revisions and have been finalised. The plan now reflects these changes.

Richard Sheehan

From:	Chris Page <Chris.Page@environment.nsw.gov.au> on behalf of Chris Page
Sent:	Thursday, 1 July 2021 10:52 AM
To:	Richard Sheehan
Cc:	Vanessa Allen
Subject:	RE: Russell Vale UEP BMP comments

Hi Richard,

Apologies for any confusion.

We have no further comments on the upland swamp monitoring program and management plan.
Thank you for forwarding the information to us.

Regards

Chris Page
Senior Team Leader, Planning (Illawarra)
South East Branch

Biodiversity and Conservation Division | Department of Planning, Industry and Environment
T 02 4224 4180 | **E** chris.page@environment.nsw.gov.au
Level 3, 84 Crown Street, Wollongong NSW 2500
www.dpie.nsw.gov.au

Please note I do not work Fridays

Our Vision: Together, we create thriving environments, communities and economies.

The Department of Planning, Industry and Environment acknowledges that it stands on Aboriginal land. We acknowledge the traditional custodians of the land and we show our respect for elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

From: Richard Sheehan <richard.sheehan@wcl.net.au>
Sent: Monday, 28 June 2021 5:38 PM
To: Chris Page <Chris.Page@environment.nsw.gov.au>
Cc: Vanessa Allen <Vanessa.Allen@environment.nsw.gov.au>
Subject: Re: Russell Vale UEP BMP comments

Thankyou Chris

Further to the meeting we had with Calvin in regard to the comments on the draft plan and the presentation outlining our approach amd how we sought to address the points raised did you have anything further to add in regard to the upland swamp monitoring program and management plan?

Regards

Richard Sheehan
Wollongong Coal Environment and Approvals Manager

On 28 Jun 2021, at 3:42 pm, Chris Page <Chris.Page@environment.nsw.gov.au> wrote:

Hi Richard,

Please be advised that we have no further comment to make on the above BMP.

Regards

Chris Page
Senior Team Leader, Planning (Illawarra)
South East Branch

Biodiversity and Conservation Division | Department of Planning, Industry and Environment
T 02 4224 4180 | **E** chris.page@environment.nsw.gov.au
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From: Richard Sheehan <richard.sheehan@wcl.net.au>
Sent: Thursday, 24 June 2021 11:20 PM
To: Chris Page <Chris.Page@environment.nsw.gov.au>
Cc: Vanessa Allen <Vanessa.Allen@environment.nsw.gov.au>
Subject: Re: Russell Vale UEP BMP comments

Good evening Chris

Further to this correspondence as below with regard to the Wollongong coal Russell vale underground expansion project swamp monitoring plan are you able to advise if the department has any further comment as we would like to close off this matter as having been resolved.

Regards

Richard Sheehan
Wollongong Coal Environment and Approvals Manager

On 9 Jun 2021, at 4:43 pm, Richard Sheehan <richard.sheehan@wcl.net.au> wrote:

Good afternoon Vanessa,

Thank you for the detailed feedback on the Wollongong Coal UEP BMP.

Further to your comments on the Wollongong Coal UEP USMP and the meeting that we had between WCL and BCD in relation to this feedback provided on this Management Plan (as attached for ease of reference) we have attached a copy of the presentation and a briefing note on the applicability of “Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence” to UEP projects bord and pillar mining program as approved under MP09_0013 for the departments review and further consideration.

Should you have any further feedback on the USMP in consideration of this briefing note in the next week please advise and we can organise a time to discuss.

Regards

Richard Sheehan
Group Environmental & Approvals Manager

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Appendix C

BCS/EES Correspondence regarding EP

WOLLONGONG COAL

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Table C.3 **BCS/EES Response**

Aspect of BCD response	WCL Response
1. Comment on the BMP regarding Giant Burrow Frog	The Giant Burrowing Frog has been identified within a 245 metre section of a tributary of Cataract River below swamp CRUS2 during previous ecological monitoring in the Russell Vale East area. The species was detected consistently as tadpoles and is to be used as an indicator of breeding activity. The irregular records of adults and metamorphs does not provide any meaningful data and will not be part of any future monitoring, beyond incidental records. Habitat for the Giant Burrowing Frog within the study area consists of small sections of upper tributaries. Detailed surveys undertaken have indicated that other than the tributary of Cataract River below CRUS2, other tributaries are unlikely to support these species, particularly given the survey effort undertaken. While potential impacts to this species are considered to be negligible, a one year survey program will be undertaken covering both pre-mining and mining, with sampling undertaken during and after breeding (spring to autumn). Monitoring will focus on tadpole (or adults/egg masses) presence. Should the species be found to be present a review would be undertaken to determine the requirements for ongoing monitoring. Ongoing monitoring of potential impacts to habitat for this species will only occur in the event that subsidence monitoring indicates that there has been an impact to the identified habitat for this species or impacts to swamp water quality are detected. The Biodiversity Management Plan has been updated to include this monitoring.
2. Clear documentation of the Methods and statistical analyses to assess "less impacted sites" as reference sites.	Information regarding the methods and statistical analysis is included in two documents which are included as attachments to this letter. The attachments referenced in this email include: **Appendix B Attachment 3:** Briefing Note to BCD regarding Applicability of "Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland Swamps impacted by longwall mining subsidence" to bord and pillar mining approved under MP09_0013". **Appendix B Attachment 2:** Biosis response to BCD comments on draft plan 11/05/2021. It is noted that these two attachments were not included in the consultation appendix of the Upland Swamp Monitoring Plan (USMP) as included in the Extraction Plan submitted to DPIE on 8 October 2021. These attachments were omitted from the Appendix of the USMP due to an administrative error. **Attachment 1** – Notes the following in relation to this aspect. "*The proposal here is to use nearby swamps as additional controls, up until the point that mining occurs within 350 metres of the boundary. As these swamps are closer together the power of analysis is increased (removing variation) and the number of control swamps is higher (greater df). The only shortfall of this method is that the power of analysis decreases as less "control" swamps are available over time. The purpose of the proposed is to improve statistical analysis at any point, given the limited availability of true control sites".*

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		The Coastal Upland Swamp Ecological Monitoring approach is detailed in Section 3.2.1, 6.4.1 and 6.4.2 of the USMP. This includes detail regarding the utilisation of both impact monitoring and control sites.
	3. Minimum monitoring periods for pre-impact, during mining and post mining be provided in accordance with the policy. 12 month monitoring appears to have been proposed.	In a presentation to BCD (May 2021), Umwelt and WCL indicated that the application of the swamp offset policy is not relevant for proposed board and pillar mining as the policy was developed for longwall mining, even when considering the cumulative impact of past mining. "Primary monitoring" has limited application as being definitive of impacts from proposed mining. Secondary monitoring of vegetation is extensive with two years of baseline data available at 12 swamps over the proposed mining area in addition to reference swamps (refer to **Attachment 2**). Biosis / WCL have confirmed, refer to **Attachment 1**, and also as included in Section 6.1 of the USMP that the following monitoring will occur: • Minimum 12 months of baseline monitoring prior to mining occurring within 350 m of Coastal Upland Swamps • Monitoring during mining. • A minimum of 12 months of monitoring post-mining to confirm negligible environmental consequence as a result of mining. It is also noted that it is proposed to utilise nearby swamps as additional control sites, refer to item 4. Section 6 of the USMP details the proposed Coastal Upland Swamp Monitoring Program.
	4. Monitoring program should clearly define an appropriate monitoring design that identifies impact and control (reference) sites/swamps	**Attachment 1** – Notes the following in relation to this aspect. "*The proposal here is to use nearby swamps as additional controls, up until the point that mining occurs within 350 metres of the boundary. As these swamps are closer together the power of analysis is increased (removing variation) and the number of control swamps is higher (greater df). The only shortfall of this method is that the power of analysis decreases as less "control" swamps are available over time. The purpose of the proposed is to improve statistical analysis at any point, given the limited availability of true control sites".* The Coastal Upland Swamp Ecological Monitoring approach is detailed in Section 3.2.1, 6.4.1 and 6.4.2 of the USMP. This includes detail regarding the utilisation of both impact monitoring and control sites.
	5. Capture adequate baseline data prior to undermining.	Refer to Item 3.
	6. Rigorous QA/QC program to accompany the Environmental monitoring program	An overview of the QA / QC process applied to Swamp and Biodiversity Monitoring data includes: • Flora transects and photo points are marked with gps coordinates in the field and are re-visited during each survey. • Transect start points, transect end points and photo points are all marked with a star picket and flagging tape, ensuring exact points can be revisited on each repeat survey. • 30 quadrats measuring 0.5 m x 0.5 m are surveyed along each 15 m transect, such that they are precisely side by side.

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	• Field survey are undertaken by Botanists experienced with the identification of upland swamp vegetation. • Proforma field data sheets are used to record the field data. • Quality assurance is undertaken on each field datasheet prior to entry into the flora monitoring dataset. • Quality assurance is then again completed on the entry of this data into the dataset. • This dataset is validated prior to analysis by a specialist statistician. • The suitability of control sites selected for analysis are compared to using exploratory data analysis to confirm that the data were statistically suitable and available for the same period of time as impact sites.
7. The Subsequent reporting and analysis of data should conform to a statistically rigorous BACI design.	Section 3.2.1 of the USMP details the current swamp monitoring program. Section 3.2.1.2 provides detail on the BACI monitoring with Section 3.2.1.3 on the analysis undertaken. Appendix B of the USMP also details the statistical analysis which is applied to the data which is monitored. A summary of the monitoring undertaken is included in Section 6.9 of the USMP. Further discussion of this is also included in Section 4.1 of **Attachment 1** which states: "The proposal here is to use nearby swamps as additional controls, up until the point that mining occurs within 350 metres of the boundary. As these swamps are closer together the power of analysis is increased (removing variation) and the number of control swamps is higher (greater df). The only shortfall of this method is that the power of analysis decreases as less "control" swamps are available over time. The purpose of the proposed is to improve statistical analysis at any point, given the limited availability of true control sites.
8. Provide data in Excel File format including: • Swamp water level and soil moisture data • Vegetation quadrat and fauna count data • Raw groundwater data.	WCL have included the following data as an attachment: • swamp water level and soil moisture data from soil moisture probes back to 2019. • Raw groundwater data from the installed groundwater wells - GW1, NRE A, NRE B, NRE D, RV16, RV17, RV20, RV22, RV23, RV24, RV25, RV29 • Ecological monitoring data

APPENDIX C: RISK ASSESSMENT

RISK ASSESSMENT
SIGN OFF/APPROVAL SHEET

OPERATION: Russell Vale Colliery	**RA Document Control Number:**
Risk Assessment Title: Extraction Plan PC07, PC08 and PC21 to PC25.	
AUTHOR/OWNER: WCL **Name:** Richard Sheehan	**Title:** Group Environmental and Approvals Manager

Table of Contents

PC07, PC08 and PC21 to PC25 Extraction Plan Risk Assessment

1. EXECUTIVE SUMMARY OF ACTIONS

The below includes a summary of the additional improvement action required to be completed during the development of the Extraction Plan and associated sub-plans.

No.	Item No.	Risk Rating	Improvements/Actions (12 month)	Who	When	Action status
1	37	**Low 1**	Two previously recorded sites 52-3-0323 and 52-3-0325 could not be located during a field survey undertaken. Further site survey to locate the sites to be undertaken.	Richard Sheehan	During development of heritage management plan – May 2021	Completed during revision of heritage management plan, September 2021

2. INTRODUCTION

A risk assessment was conducted which analysed the hazards relating to the mining of PC07, PC08 and PC21 to PC25 and assessed risk of manifestation of those hazards.

This risk assessment is required to support the Extraction Plan for mining PC07, PC08 and PC21 to PC25 and to satisfy condition C10 of the Development Consent (MP09_0013).

This risk assessment will identify the potential for any required actions and mitigation measures if any of the controls are inadequately applied.

2.1 Key controls

The following existing controls are in place to ensure that the management of any potential impacts from mining is effective:

- Proposed non-caving mining method is not expected to result in perceptible surface subsidence.
- Non-caving mining method is adaptable if required.
- TARPs established for each management plan and contingency plans implemented for any exceedances.
- Risk analysis undertaken by (SCT, 2020a) quantifies the risk of such a pillar failure occurring as less than 1 in 100,000 (0.001 % over the life of the project and therefore less than 0.01 % per year). The likelihood of initiating event occurring is considered to be remote.

2.2 Assumptions

The following assumptions were made during the risk assessment:

- Subsidence assumed to be 30-100 mm.
- Health and safety management related to the underground mining operations are excluded from this risk assessment.
- Additional vertical subsidence (up to 500mm) is possible but unlikely in one small isolated area over the Bulli Seam Goaf Area #Area 11 where the full collapse of all pillars cannot be confirmed. This area is located over panels PC23, 24 and 25. There are no swamps located over this area. Subsidence associated with the failure of any remnant standing pillars in these areas are cumulative impacts from previous mining impacts, which are likely to occur irrespective of the approved mining within the UEP area. Cumulative existing subsidence predictions used in the risk assessment have assumed these areas have fully collapsed. Groundwater modelling has also assumed these areas have fully collapsed.
- Risk analysis undertaken by (SCT, 2020) quantifies the risk of such a pillar failure occurring as less than 1 in 100,000 (0.001 % over the life of the project and therefore less than 0.01 % per year). The likelihood of initiating event occurring is considered to be remote.

3. CONTEXT STRTEGY, CORPORTATE AND RISK MANAGEMENT

The process followed in this review was based on the Wollongong Coal Risk Management Procedure. This procedure is consistent with the requirements of the NSW Trades and Investment Mine Safety MDG1010 Guidelines for Risk Management and Risk Assessment and as well as the Australian/NZ Standard for Risk Management AS/NZ/ISO:31000:2009.

The results from the risk assessment will be used to ensure all controls including practices and procedures, are adequate for the identified risks. Additionally, it defines the controls and conditions necessary to ensure the safe handling application and management of the materials, process at any 'generic' location.

4. OBJECTIVES AND SCOPE

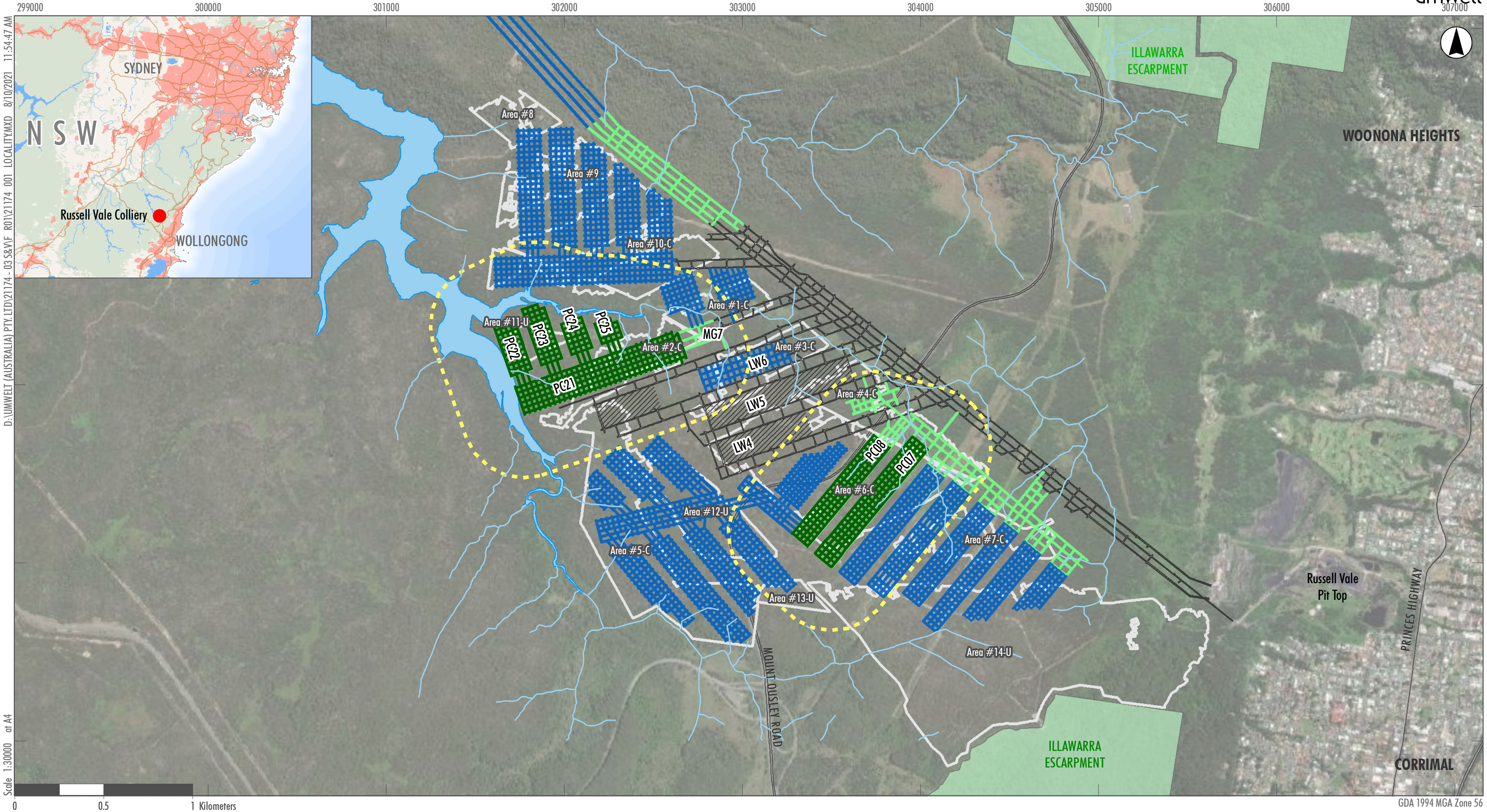
The objectives of the risk assessment process were as follows:

- Demonstration that critical risks have been identified and risk reduction strategies and systems have been adopted which will manage those.
- Verification that the risk reduction strategies will be effective in managing those risks to a level acceptable to WCL Wongawilli/Russell Vale Colliery.

The risk assessment scope was restricted to WCL Russell Vale Colliery Extraction Plan Area, specifically for the environmental management of subsidence and public safety management relating to the EP Area (mining of PC07, PC08 and PC21 to PC25).

EP Assessment Area defined based on distance equal to 1x overburden depth and consideration of coal barriers remaining in Bulli seam workings. This was considered conservative for impact assessment purposes.

The assessment team was assembled at WCL Russell Vale Colliery and undertook the assessment on 10 March 2021. The scope of the EP Area is shown on **Figure 1** below.



umwelt

Legend

- EP1 Areas PC07-08 and PC21-25
- EP1 Layout PC07-08 and PC21-25
- Proposed EP Wongawilli Seam Workings (Year 2 Onwards)
- Proposed Wongawilli Seam First Workings
- Existing Wongawilli Seam Workings
- Bulli Seam Goaf Areas -
  - C - Confirmed as collapsed/subsided
  - U - Unconfirmed as collapsed/subsided
- Drainage Line
- Road
- State Conservation Area

FIGURE 1

Russell Vale Colliery Locality Plan

Image Source: ESRI (2021) Data source: DFSI (2020)

4.11 The Work of the Risk Assessment Team

A key factor in the effectiveness of an exercise is the availability of relevant information and expertise. This is addressed mainly through the group workshop. Group workshops recruit the knowledge and experience of a group of people who are familiar with a particular work situation.

The role of team members is to provide their expertise, experience and technical knowledge, and to respect that provided by others. Outcomes are critically dependent on the team as a whole providing a balanced view at a level of expertise appropriate to the nature of the subject under Assessment. The experience and expertise of the team, together with the quality of facilitation, are crucial factors in the quality of the results derived.

4.12 Assessment Team

Facilitator: Luke Bettridge

Name	Role	Experience relevant to this risk assessment
Warwick Lidbury	CEO WCL	CEO WCL GM Caledon Resource Mine Manager North Goongella, Crinom, Cook, Russell Vale, Clarence, Kestral Extension Site Senior Executive Cook Registered Survey SEE Queensland First Class Cert of Competency Bachelor of Science (Safety) Newcastle Uni Mines Rescue
Devendra Vyas	Tech Service Manager	30+ years in mining in various roles. Associated with Russel Vale and Wollongong Coal approvals throughout the process. Mine planning, scheduling, financial evaluation, HSC etc.
Richard Sheehan	Group Environmental and Approvals Manager	Richard has over 15 years industry experience, with skills and experience in the complimentary fields of environmental impact assessment, environmental management.
Robert Faddy-Vrouwe	Environmental Coordinator	5 years mining industry experience Degree Environmental Chemistry (Hon)
Sasa Cugalj	Environmental Monitoring Coordinator	4.5 Years Environmental/Mining Experience. BSC Physical Geography/Human Geography
Luke Bettridge (Umwelt)	Manager Operational Environmental Support NSW / principal Consultant	Luke has extensive experience in environmental assessment and management, particularly in the mining and extractive industry sector. Luke has a Bachelor of Environmental Science with a major in Environmental Management and has accredited qualifications regarding risk management. Luke has 17 years experience and has spent approximately 8 years in on site coal mining environmental management roles.

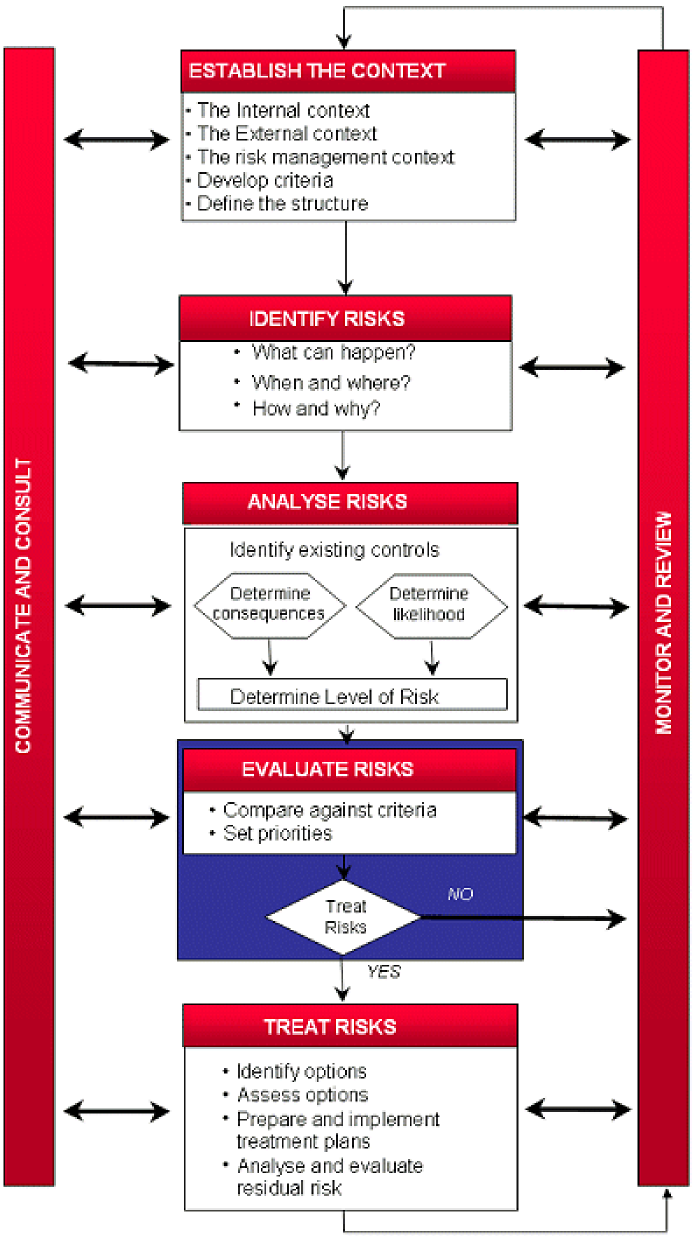
THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Name	Role	Experience relevant to this risk assessment
David Holmes (Umwelt)	Principal Environmental Consultant	David is a Principal Environmental Consultant with particular expertise in environmental impact assessment (EIA), environmental policy and environmental and natural resource regulatory systems. David has also peer reviewed a number of technical assessments for the Russell Vale UEP Project.
Michelle Grierson (Umwelt)	Senior Environmental Scientist	An experienced Environmental Specialist with a demonstrated history of working in the mining & metals industry for over 10 years. Highly skilled in maintaining environmental compliance, managing and monitoring environmental issues.
Claire Stephenson (Umwelt)	Leader, Hydrogeology Services	Claire has over 13 years' experience in groundwater consulting across Australia, with prior experience working in agriculture and forestry. Claire has extensive experience managing complex groundwater projects to meet Local Government, State and Commonwealth regulatory requirements.
Rebecca Dwyer (Biosis)	Team Leader - Ecology (NSW)	Rebecca has 14 years on-ground experience in ecology and has been involved in a large number of ecological studies of varying scales throughout Australia.
Stephen Wilson (SCT)	Consultant / Mine Planner	Steve has over 40 years experience at various underground mine sites, mainly in the NSW Southern Coalfield. Steve has been involved in broad range of consulting tasks including mining approval applications, pillar and mining layout design, as well as projects associated with monitoring ground movements and ground water behaviour.
Adam Wyatt (Engeny)	Principal Engineer - Water Resources	Adam has 10 years experience modelling and assessing natural and man-made systems, incorporating disciplines of hydrology, hydraulics, terrain modelling and infrastructure design for projects ranging in scale from flood plains to residential subdivisions.
Luke Stone (Biosis)	Consultant Aquatic Ecologist	Luke's broad range of experience includes AusRivAs field survey methodology and model analysis, fish community surveys including electrofishing techniques, aquatic habitat surveys, water quality sampling, waterway classification and geomorphic river assessment. Luke has considerable experience managing and improving long term ecological monitoring programs.
Samantha Keats (Biosis)	Team Leader - Heritage (NSW)	Samantha has worked as an Archaeologist in the Wollongong region for over 4 years and has extensive experience in working with Aboriginal Representative Bodies and mining and exploration companies.

5. METHODOLOGY

The assessment was conducted in line with the requirements of the Australian Standard for Risk Management (AS/NZS ISO 31000:2009) and MDG 1010 Minerals industry safety & health risk management guideline (January 2011) while utilising the colliery's methodology in the identification, assessment and effective control of each of the recognised hazards and, included rating of likelihood and consequence of occurrence based on a combination of aspects including health and safety.

The resulting documented assessment of hazards, their rating, proposed controls and residual assessment were then included in this document. An action plan with specific responsibilities was then developed to ensure implementation of the identified controls.



6. ASSUMPTIONS AND REFERENCES

Compliance with the requirements of the:

- Development Consent (MP09_0013).
- Work Health and Safety Act 2011,
- Work Health and Safety Regulation 2011,
- Work Health and Safety (Mines & Petroleum Sites) Act 2013,
- Work Health and Safety (Mines & Petroleum Sites) Regulation 2014,
- MDG 1010 Minerals industry safety & health risk management guideline (January 2011),
- MDG 1014 Guide to reviewing a risk assessment of mine equipment & operations (July 1997),
- Safe Work Australia Code of Practice - How to Manage Work Health & Safety Risks,
- WCL Mine Safety Management System,
- WCL SHECQ Management System.

7. DEFINITIONS

7.1 Hazard

The term "hazard" is defined as "a source of potential harm". The minerals industry has many large and sometimes complex hazards. Using this definition, electricity, large mobile equipment, ground and objects at height all have a potential for harm. This guideline, in conjunction with the NMIHSRAG, suggests that good risk management involves the identification and understanding of hazards, the establishment of potential unwanted events related to those hazards and, subsequently, the analysis of risk related to the unwanted event. Using this approach risk is a measure of concern; used to increase awareness, set priority or determine acceptability of an unwanted event risk.

Environment note: The term 'hazard' is essentially equivalent to 'environmental aspect'.

Establishing the context within the risk management process involves the overall direction setting and rationale for the entire process. AS/NZS ISO 31000:2009 includes consideration of external and internal factors in establishing context as well as the resultant goals, objectives and strategies including definition of risk acceptability criteria.

7.2 Incident (or ongoing condition)

An incident (or ongoing condition) is any occurrence that has the potential to result in adverse consequences to people, the environment, property/plant, or a combination of these.

7.3 Consequence

Consequences can result from the development of an incident over time (immediately after or over an extended period). The concept of consequence includes, within its scope, the potential adverse impacts/effects on people, the environment, plant or property, or a combination of these. By definition, consequence must be expressed as a quantitative between 1 and 5.

7.4 Impact/Effect

Impacts are specific adverse effects resulting from an incident and may be related to people, the environment, plant or property, or a combination of these.

7.5 Probability

Probability is an expression of the chance of a particular outcome. By definition, probability must be expressed as an alphabetical reference between A and E. Within this guideline the term probability is the qualitative description of likelihood and/or frequency in relation to the chance that something will occur & will be referenced as such in this risk assessment.

7.6 Frequency

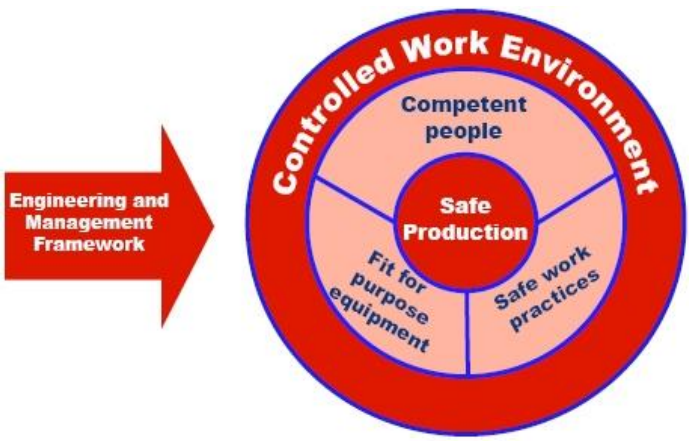
Frequency is defined as the number of times something (e.g.an activity, the hazard or incident) may occur within a specified timeframe, such as daily, weekly or annually. Within this guideline the frequency term is used in quantitative risk assessments.

7.7 Risk

Risk is defined as the likelihood of an impact on people, the environment, property, or a combination of these.

7.8 "Nertney Wheel"

The "Nertney Wheel" (Bullock, 1979), illustrated below, offers a model of an ideal work process for achieving safe production - the intended outcome of most site decisions. The wheel identifies four components of a safe and productive work process, competent people, safe work practices, fit for purpose equipment and a controlled environment.



Process Model or the Nertney Wheel

The term competent people is intended to not only refer to competency related to training and skills but also appropriate motivation and "fitness for duty".

7.9 The basic risk management process

The first step in understanding risk management involves becoming comfortable with the terminology and the intention of risk management. Obviously correct use of the word "risk", considering its definition, is important to successful risk management. Risk is defined as "effect of uncertainty on objectives" (AS/NZS ISO 31000:2009). This definition has evolved over the last 10 years, improving its clarity. AS/NZS ISO 31000:2009 also notes that "Risk is often characterized by reference to potential events and consequences or a combination of these". For the purposes of this guideline, the identification of an unwanted event will be separated from the term "risk". The term "risk" will be used to describe MDG 1010 – Risk Management Guideline Page 14 of 117 only the measure of event consequences and likelihood. Note that a risk is usually thought of in terms of negative impact but similar approaches can be used to identify positive events or opportunities. It is important to note that there is no "zero risk". A source may suggest that risks must be eliminated but unless the hazard is totally removed and no related hazard put in its place, elimination cannot be achieved. Risk is managed to a level of acceptability or practicality.

Risk analysis is defined as a "process to comprehend the nature of risk and to determine the level of risk" (AS/NZS ISO 31000:2009). In other words, this is the step where likelihood and consequence are somehow estimated. Risk analysis is usually done considering the impact of existing controls though there are circumstances where estimating inherent risk, or risk without controls, is desirable.

AS/NZS ISO 31000:2009 defines risk assessment as the "overall process of risk identification, risk analysis and risk evaluation" as outlined above. In practice, most risk assessment involves the application of a variety of informal and formal, qualitative and quantitative methods to assist with the management of risk.

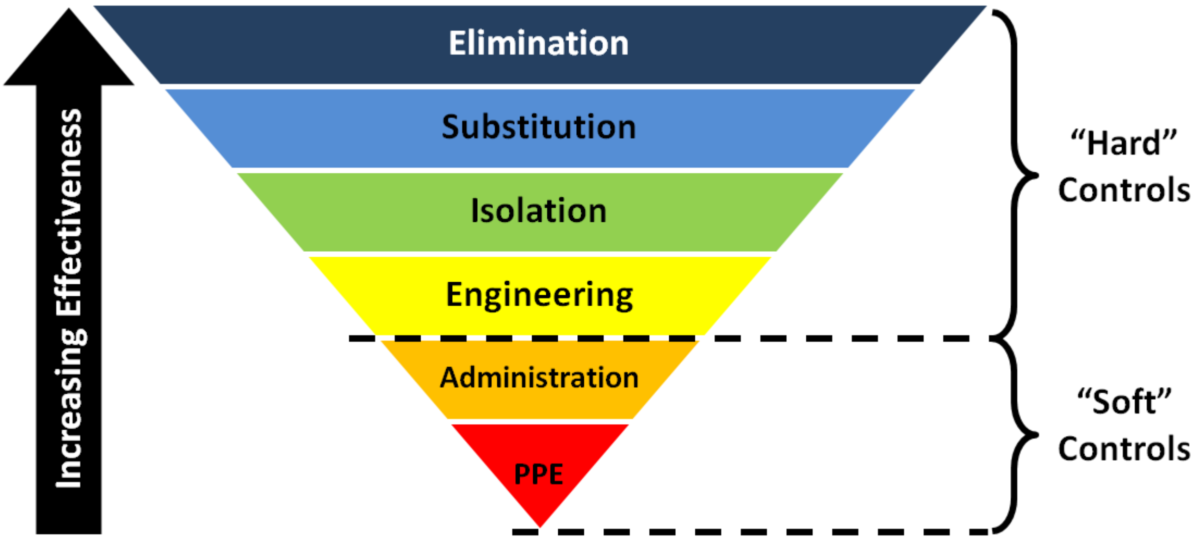
7.10 Common Mining Energies

Biological	bacteria, viruses, contagious diseases, natural poisons, etc.
Chemical	coal, gases, fuels, lubes, degreasers, solvents, paints, etc.
Electrical	high voltage, low voltage, batteries, etc.
Gravitational (objects)	falling coal, rock, tools, components, structures, etc.
Gravitational (people)	falling from or into equipment, structures, ladders, sumps, etc.
Machine (Fixed)	powered by electrical, hydraulic, pneumatic, combustion, etc.
Machine (Mobile)	haulage trucks, LHDs, service vehicles, gen sets, tools, etc.
Magnetic	handling metal objects in strong magnetic fields
Noise	from machines and other sources
Object	pressurised systems, cylinders, springs, chains, flying bits, etc.
People	slip, trip, lift strain, push/pull sprain, repetitive /postural strain
Thermal	conducted (contact), convected (airstreams), radiation
Vibration	from vehicles, equipment, tools, etc.
Other	friction, wind, animal, bio-chemical.

7.11 Hierarchy of Controls

In occupational health and safety risk management there is a hierarchy of controls referred to as the Safety Precedence Sequence for Barriers/Controls. This lists the types of control and their effectiveness in descending order.

The most effective controls are those that eliminate the hazard. If a hazard cannot be eliminated it should be minimised to an acceptable level. This may be achieved through a system of engineering controls, often referred to as 'hard' barriers down to administrative controls usually referred to as 'soft' barriers. Hard barriers actually prevent or minimise the risk of contact with the hazard whereas soft barriers may rely on policies and procedures and their enforcement, training, skills and experience, work organisation and the wearing of personal protective equipment (PPE). These controls are primarily based on controlling human behaviour and are subject to human error. Therefore they may be less effective in preventing exposure to hazards. Nevertheless, there is a place for both hard and soft barriers in any risk management plan.



The effectiveness and place of each control on the 'hierarchy' is considered at all times when identifying and suggesting controls for hazards. Existing controls are considered and where necessary, additional controls are recommended

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7.12 Risk acceptability

Risk acceptability and risk management is one of the most challenging concepts in risk management concerns the establishment of risk acceptability. There is no zero risk if a hazard is truly or potentially present. Risk must be managed to a level that is as low as reasonably practicable (ALARP).

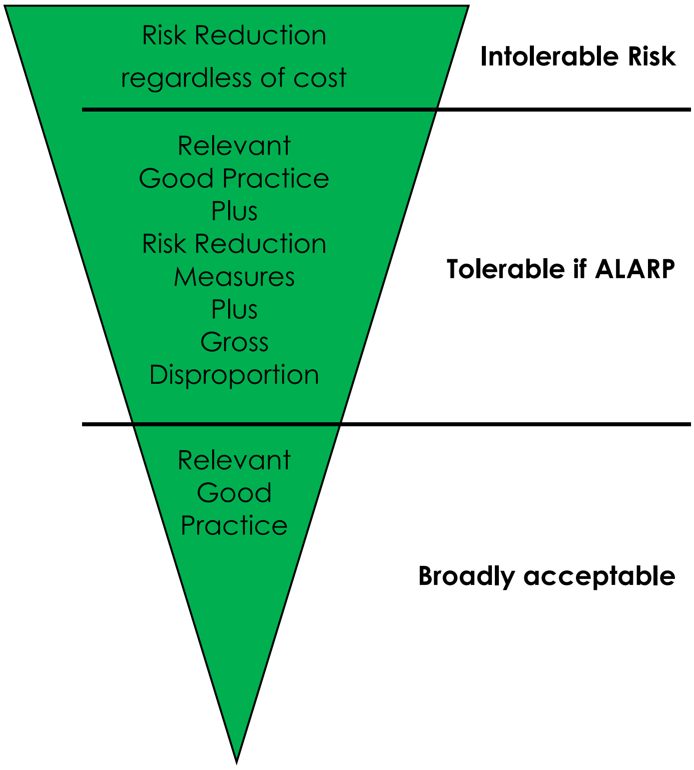

Diagram – Risk Acceptability

8. RISK METHODOLOGY

Wollongong Coal Ltd Risk Methodology - (as reference).

Consequence Severity

	Consequence Definitions (Where a scenario has more than one 'Loss Type', choose the one with the maximum credible rating)				
Loss Type (Additional 'Loss Types' may exist for an event; identify and rate accordingly)	**1** **Insignificant**	**2** **Minor**	**3** **Moderate**	**4** **High**	**5** **Major**
Harm to People Safety & Health (S/H)	First aid case/exposure to minor health risk	Medical treatment case / Exposure to major health risk	Lost time injury/reversible impact on health	Loss of quality of life/ Irreversible impact on health	Single or multiple fatalities/Impact on health ultimately fatal
Environmental Impact (EI)	Negligible impacts such as small spill or leak immediately contained or recovered. One adverse local public complaint	Minor environmental harm such as large release of contaminant to land that is contained and readily recoverable using pumps or mobile plant. Recovery and clean up costs less than $5,000. Minor complaint from local resident/s likely easily rectified	Moderate, environmental harm e.g. release of contaminant into storm drain or soil causing deep or moderate contamination. Possible cumulative impact event such as nutrient/sediment runoff. Recovery/clean up and or legal costs up to $50,000. Numerous public complaints from community moderately difficulty address	Significant off-site release of contaminant to land/water/air. Difficult to recover and major environmental harm or potential harm expected e.g. fish kill, human health with recovery/clean up/ legal costs up to $250,000. Numerous ongoing public complaints/government lobbying difficult and costly to address	Uncontrolled release of toxic contaminant to land/water/air off-site with significant and long-term environmental harm. Clean up costs over $250,000. Widespread and serious public outcry/ government lobbying difficult and costly to address
Business Interruption/ Damage and Other Losses (BI/MD)	No disruption to operation/ < $150k (effect NPBT)	Brief disruption to operation / $150k to $750k	Partial shutdown / $750k to $3m	Partial loss of operation / $3m to $5m	Substantial or total loss of operation / > $5m

	Consequence Definitions (Where a scenario has more than one 'Loss Type', choose the one with the maximum credible rating)				
Loss Type (Additional 'Loss Types' may exist for an event; identify and rate accordingly)	**1 Insignificant**	**2 Minor**	**3 Moderate**	**4 High**	**5 Major**
Legal and Regulatory (L&R)	Low level legal issue	Minor legal issue; non-compliance and breaches of the law	Serious breach of law; investigation/report to authority, prosecution and/or moderate penalty possible	Major breach of the law; considerable prosecution and penalties	Very considerable penalties and prosecutions. Multiple law suits and jail terms
Impact on Reputation/ Social/Community (R/S/C)	Slight impact - public awareness may exist but no public concern	Limited impact - local public concern	Considerable impact - regional public concern	State impact - state public concern	National impact - national public concern

8.1 Probability Chart

The probability that the consequence will occur or re occur.

Level	Descriptor	Description
A	Almost Certain	Expected to occur in most circumstances multiple/12 months (> 80% probability)
B	Likely	Will probably occur in most circumstances once/12 months (61-80% probability)
C	Possible	Might occur within 1-2 year time period once/12 months – 2 years (41-60% probability)
D	Unlikely	Could occur during specified time period once/12 months – 5 years (21-40% probability)
E	Rare	May only occur in exceptional circumstances once > 5 years (20% probability)

8.2 Risk Matrix

	CONSEQUENCE				
PROBABILITY	Insignificant 1	Minor 2	Moderate 3	High 4	Major 5
A Almost Certain	M11	S16	S20	E23	E25
B Likely	M7	M12	S17	E21	E24
C Possible	L4	M8	S13	S18	E22
D Unlikely	L2	L5	M9	S14	S19
E Rare	L1	L3	M6	M10	S15

Risk Ranking Legend

8.3 Safety Standard to be Achieved

Selection of controls to reduce risks are made with due regard to their reliability. That is, installing engineering modifications is a superior control to operator training, education or warning signs. Removing the hazard altogether is the most effective control of all.

In every case the effectiveness of the controls in place was considered and assessed by the team for adequacy. In this manner the Risk Control Effectiveness (RCE) was assessed by the team using the risk rank and potential consequences of each hazard to ensure that the controls bring the risk to an acceptable level as low as reasonably practicable (ALARP).

Risk Rating	Risk Level	Guidelines for Risk Rating Matrix
E21 to E25	(E) – Extreme	Eliminate, avoid, implement specific action plans/procedures to manage and monitor – elevate to Senior Management Team for consideration prior to activity – must include improvements to decrease level of risk
S13 to S20	(S) – Significant	Proactively manage with systems and approval of same by Senior Management Team – must include improvements to decrease level of risk
M6 to M12	(M) – Medium	Actively manage
L1 to L5	(L) - Low	Monitor and manage as appropriate

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8.31 Table 1: Risk Assessment

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
1	Approvals	Administrative - Non-compliance with reporting, licencing or related timeline, failure to follow due diligence	Extraction Plan area monitoring and management measures fail leading to non-compliance with approval conditions.	Extraction Plan and key component management plans. Monitoring plans	C - Possible	1 - Insignificant	**Low 4**	No further controls required	C -Possible	1 - Insignificant	**Low 4**	No further actions	Not applicable
2	Natural Features	Mining induced subsidence	Visual amenity impact of subsidence	Land Management Plan Rehabilitation Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
3	Natural Features	Mining induced subsidence	Subsidence of cliff lines	No cliff lines in Extraction Plan area that align to MSEC definition of Cliffs. Land Management Plan Rehabilitation Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
4	Natural Features	Mining induced subsidence	Subsidence of steep slopes	Proposed non-caving mining method is not expected to result in perceptible surface subsidence. Land Management Plan Rehabilitation Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
5	Natural Features	Mining induced subsidence	Subsidence of rock face features	Proposed mining is not expected to result in perceptible surface subsidence. Land Management Plan Rehabilitation Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
6	Natural Features	Mining induced subsidence	Subsidence adversely impacts the Illawarra Escarpment	EP area located over 1km from Escarpment Proposed mining is not expected to result in perceptible surface subsidence or impacts.	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
7	Public Safety	Mining induced subsidence	Unauthorised access into subsidence zone leads to injury to persons	EP area is wholly within the Sydney Drinking Water Catchment Area which does not allow general public access. Public Safety Management Plan Landowner Signage noting restricted access PPE requirements for staff/authorised persons	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
8	Public Safety	Mining induced subsidence	Damage to Mount Ousley Road causing road accidents	Public roads are not expected to be significantly impacted by mining. Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program Current risk control measures e.g. closure slot.	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable
9	Public Safety	Mining induced subsidence	Damage to Electrical transmission lines leading to loss of power to key service users or bushfire	Public Safety Management Plan Built Features Management Plan Subsidence Assessment Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
10	Public Safety	Mining induced subsidence	Subsidence causes damage to fencing allowing livestock or wildlife to readily access roadways, causing injury to people	*Not located in EP Area - not assessed further.*			**#N/A**				**#N/A**		
11	Groundwater	Mining induced subsidence	Groundwater inflows exceed Water Access License Capacity (615ML)	Groundwater Management Plan Groundwater monitoring program Subsidence Monitoring Program Site Water Balance Monitoring quality of water pumped from the mining areas Correlation of rainfall records with mining area seepage records/model estimates Management and monitoring of adit outflows Predicted to be very unlikely to exceed 543ML per year Non-caving Mining Method	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
12	Groundwater	Mining induced subsidence	Groundwater drawdown in Hawkesbury sandstone extent greater than predicted - loss of water to swamps	Groundwater Management Plan Groundwater monitoring program Subsidence Monitoring Program Site Water Balance Monitoring quality of water pumped from the mining areas Correlation of rainfall records with mining area seepage records/model estimates Management and monitoring of adit outflows Triggers for vertical groundwater head and site monitoring bores Ongoing monitoring of BWP's and open standpipes Regional proposed network for longterm monitoring of depressurisation Model updates based on 3 years of data Non-caving Mining Method	D -Unlikely	2 - Minor	**Low 5**	Proposed new monitoring bores Conceptual Swamp Water Balance (measure within the TARPs)	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable
13	Groundwater	Mining induced subsidence	Groundwater depressuration beyond predictions within the Permian Coal Measures and Narrabeen Group	Groundwater Management Plan Groundwater monitoring program Subsidence Monitoring Program Site Water Balance Monitoring quality of water pumped from the mining areas Correlation of rainfall records with mining area seepage records/model estimates Management and monitoring of adit outflows Triggers for vertical groundwater head and site monitoring bores Ongoing monitoring of BWP's and open standpipes Regional proposed network for longterm monitoring of depressurisation Model updates based on 3 years of data Non-caving Mining Method	D -Unlikely	1 - Insignificant	**Low 2**	Ongoing monitoring in accordance with GWMP	D -Unlikely	1 - Insignificant	**Low 2**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
14	Groundwater	Mining induced subsidence	Groundwater depressuration beyond predictions within the Hawkesbury Measures	Groundwater Management Plan Groundwater monitoring program Subsidence Monitoring Program Site Water Balance Monitoring quality of water pumped from the mining areas Correlation of rainfall records with mining area seepage records/model estimates Management and monitoring of adit outflows Triggers for vertical groundwater head and site monitoring bores Ongoing monitoring of BWP's and open standpipes Regional proposed network for longterm monitoring of depressurisation Model updates based on 3 years of data Non-caving Mining Method	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable
15	Groundwater	Mining induced subsidence	Groundwater baseflow losses beyond predictions	Reduction in baseflow for Cataract River, Cataract Creek and Bellambi Creek combined is predicted to be very small. Groundwater Management Plan Groundwater monitoring program Subsidence monitoring program Surface water monitoring program	D -Unlikely	1 - Insignificant	**Low 2**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
16	Groundwater	Mining induced subsidence	Subsurface cracking leads to groundwater quality changes beyond predictions	Due to the very low level of predicted subsidence, and by association, the minimal overburden fracturing that could develop as a result of the proposed bord and pillar workings, no observable pH or iron hydroxide changes are anticipated in the shallow strata during active mining. Groundwater Management Plan Groundwater monitoring program Monitoring quality of water pumped from the mining areas (including field analysis, discrete and full suite) Management and monitoring of adit outflows	E - Rare	2 - Minor	**Low 3**	No further controls required	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
17	Groundwater	Mining induced subsidence	Underground mine rejects cause groundwater quality changes to the Permian Coal Measures	Groundwater Management Plan Ongoing representative monitoring of reject material will be undertaken prior to disposal and on a 6-monthly ongoing basis during active operations, if underground storage of tailings is undertaken. No wet washing to be undertaken on site. Waste Management Plan Adit Management Plan	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
18	Surface Water	Mining induced subsidence	Surface cracking of first order watercourses requiring remediation	Surface Water Management Plan Rehabilitation Management Plan Existing monitoring and flow monitoring	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable
19	Surface Water	Mining induced subsidence	Surface cracking of second order watercourses requiring remediation	Surface Water Management Plan Rehabilitation Management Plan Existing monitoring and flow monitoring	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
20	Surface Water	Mining induced subsidence	Increased sedimentation/erosion of creeks	Surface Water Management Plan Rehabilitation Management Plan Existing monitoring and flow monitoring Aquatic monitoring within BMP	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable
21	Surface Water	Mining induced subsidence	Interconnective cracking of watercourses into lower strata causing loss of water resources from creeks	Surface Water Management Plan Rehabilitation Management Plan Existing monitoring and flow monitoring	E - Rare	3 - Moderate	**Medium 6**	No further controls required	E - Rare	3 - Moderate	**Medium 6**	No further actions	Not applicable
22	Surface Water	Mining induced subsidence	Loss of water storage within Cataract Dam	Water Management Plan Surface Water Management Plan Rehabilitation Management Plan Dam Safety NSW Approval/Notification Mining method - no undermining of Dam	E - Rare	2 - Minor	**Low 3**	No further controls required	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
23	Surface Water	Mining induced subsidence	Increased flooding or inundation of land	Water Management Plan Surface Water Management Plan	C - Possible	1 - Insignificant	**Low 4**	No further controls required	C -Possible	1 - Insignificant	**Low 4**	No further actions	Not applicable
24	Surface Water	Mining induced subsidence	Groundwater impacts - Surface water quality changes/interactions/seepage.	Water monitoring program, TARPs, Mitigation measures where practical	D -Unlikely	2 - Minor	**Low 5**	No further controls required	B - Likely	1 - Insignificant	**Medium 7**	No further actions	Not applicable
25	Swamps	Mining induced subsidence	Subsidence impacts the water holding capacity within the swamps	Low potential for vertical subsidence Swamp water monitoring program Swamp water level and soil moisture monitoring network Swamp subsidence monitoring program Ecological monitoring program Surface water monitoring program Biodiversity Management Plan Water level monitoring Non-Caving mining method can be adapted if required	E - Rare	4 - High	**Medium 10**	Offsets in the event of impacts	E - Rare	4 - High	**Medium 10**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
26	Swamps	Mining induced subsidence	Change to the composition or distribution of flora and fauna species (Giant Dragonfly) within Swamp CCUS5	Proposed mining is not expected to result in perceptible surface subsidence. Upland Swamp Monitoring Plan Biodiversity Management Plan Terrestrial Biodiversity Monitoring Program Baseline monitoring Swamp florisitic monitoring and Giant Dragonfly targeted surveys Monitoring of the soil moisture Water level monitoring	E - Rare	3 - Moderate	**Medium 6**	Offsets in the event of impacts	E - Rare	3 - Moderate	**Medium 6**	No further actions	Not applicable
27	Swamps	Mining induced subsidence	Change to the composition or distribution of flora and fauna species (Giant Dragonfly) within Swamp CCUS20	Proposed mining is not expected to result in perceptible surface subsidence. Pre-data to be gathered for 1 year with monitoring. Field monitoring. Ongoing monitoring to be implemented if required based on pre-data.	E - Rare	2 - Minor	**Low 3**	Offsets in the event of impacts	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
28	Swamps	Mining induced subsidence	Change to the composition or distribution of flora and fauna species (Giant Dragonfly) within Swamp CCUS1	Low potential for vertical subsidence Proposed mining is not expected to result in perceptible surface subsidence. Upland Swamp Monitoring Plan Biodiversity Management Plan Terrestrial Biodiversity Monitoring Program Baseline monitoring Swamp florisitic monitoring and Giant Dragonfly targeted surveys Monitoring of the soil moisture Water level monitoring	E - Rare	3 - Moderate	**Medium 6**	Offsets in the event of impacts	E - Rare	3 - Moderate	**Medium 6**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
29	Flora and Fauna	Mining induced subsidence	Changes in flow or natural drainage behaviour of pools leads to negative impact to fauna habitat	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan UEP Aquatic Ecological Monitoring Program Rehabilitation Management Plan	E - Rare	2 - Minor	**Low 3**	No further controls required	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
30	Flora and Fauna	Mining induced subsidence	Changes in flow or natural drainage behaviour of pools leads to negative impact to fauna habitat	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan UEP Aquatic Ecological Monitoring Program Rehabilitation Management Plan	D -Unlikely	3 - Moderate	**Medium 9**	No further controls required	D -Unlikely	3 - Moderate	**Medium 9**	No further actions	Not applicable
31	Flora and Fauna	Mining induced subsidence	Water quality data within upper or lower limits of baseline monitoring, OR, Change in Taxa Score; OR, Change in AUSRIVAS Band.	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan UEP Aquatic Ecological Monitoring Program AUSRIVAS monitoring surveys of impact monitoring sites and necessary control sites.	E - Rare	2 - Minor	**Low 3**	No further controls required	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
32	Flora and Fauna	Mining induced subsidence	Water quality data exceeding upper or lower limits of baseline monitoring, OR, Change in Taxa Score; OR, Change in AUSRIVAS Band.	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan UEP Aquatic Ecological Monitoring Program AUSRIVAS monitoring surveys of impact monitoring sites and necessary control sites.	E - Rare	2 - Minor	**Low 3**	No further controls required	E - Rare	2 - Minor	**Low 3**	No further actions	Not applicable
33	Flora and Fauna	Mining induced subsidence	Change to the composition or distribution of flora (*Pultenea aristata, Crypstylus huntariana*) or Fauna species (Cave dwelling bats, Broad-headed snakes)	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan Terrestrial Biodiversity Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
34	Flora and Fauna	Mining induced subsidence	Change to the composition or distribution of Giant Burrowing Frog and Little Johns Tree Frog	Not within EP Area (potential habitat within EP Area) Water management plan Biodiversity management plan	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
35	Flora and Fauna	Mining induced subsidence	Changes in water quality or flows impact fish species such as Macquarie Perch etc.	Proposed mining is not expected to result in perceptible surface subsidence. Biodiversity Management Plan Aquatic Biodiversity Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
36	Heritage	Mining induced subsidence	Change in historic heritage site condition is observed, and the heritage values of a site are impacted.	Not located in EP Area - not assessed further.			**#N/A**				**#N/A**		
37	Heritage	Mining induced subsidence	Impact on previously identified heritage sites from subsidence	Proposed mining is not expected to result in perceptible surface subsidence. Heritage Management Plan Two previously recorded sites 52-3-0323 and 52-3-0325 could not be located during inspection. Monitoring to re-find locations to occur.	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	Richard Sheehan Two previously recorded sites 52-3-0323 and 52-3-0325 could not be located during a field survey inspection. Further site survey to locate the sites to be undertaken.	During development of Heritage Managemen t Plan
38	Built Features	Mining induced subsidence	Damage to walking/access tracks	Rehabilitation Management Plan Built Features Management Plan Subsidence Monitoring Program Restricted access to land which forms the EP Area	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
39	Built Features	Mining induced subsidence	Damage to fences causing unauthorised access to Catchment Land	Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable

Step	Aspect	Failure mechanism	Identified hazards	Existing risk reductions	Prob.	Cons.	Risk Rating	Proposed strategies/ Additional Controls	Prob.	Cons.	Residual Risk Rating	Action/ Responsibility	Timing
40	Built Features	Mining induced subsidence	Damage to fire trails impeding access/use	Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
41	Built Features	Mining induced subsidence	Damage to electrical transmission lines	Non located directly above mining Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program Monitoring of the 330kV, 132kV and 33kV transmission lines	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
42	Built Features	Mining induced subsidence	Damage to Telecommunication lines/Telstra assets	Not located in EP Area - not assessed further.			**#N/A**				**#N/A**		
43	Built Features	Mining induced subsidence	Damage to the integrity of Cataract Dam Wall	Remote from EP area Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
44	Built Features	Mining induced subsidence	Interaction with adjacent non Russell Vale workings (Corrimal etc.)	Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program Groundwater Management Plan	E - Rare	1 - Insignificant	**Low 1**	No further controls required	E - Rare	1 - Insignificant	**Low 1**	No further actions	Not applicable
45	Built Features	Mining induced subsidence	Damage to Mount Ousley Road (pavement, culverts, cuttings and embankments)	Public roads are not expected to be significantly impacted by mining. Built Features Management Plan Public Safety Management Plan Subsidence Monitoring Program Current risk control measures e.g. closure slot.	D -Unlikely	2 - Minor	**Low 5**	No further controls required	D -Unlikely	2 - Minor	**Low 5**	No further actions	Not applicable

9. ACTION PLAN

Issue Hazard/Risk	Action	Safety/ Production/ Compliance	Responsibility	Department/ Area	Due Date	Action status
Impact on previously identified heritage sites from subsidence	Two previously recorded sites 52-3-0323 and 52-3-0325 could not be located during a field survey undertaken. Further site survey to locate the sites to be undertaken.	Compliance	Richard Sheehan	Environment	During development of Heritage Management Plan - May 2021	Completed during revision of heritage management plan, September 2021

10. RISK REDUCTION VERIFICATION DETAILS

To be completed prior to activity taking place.

Process Step	Risk Reduction Measure	Responsible Person	Date Completed

11. REFERENCES

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

12. CONTROL AND REVISION HISTORY

PROPERTY	VALUE
Approved by	Mining Engineering Manager
Document Owner	Warwick Lidbury
Effective Date	Draft

Revisions

VERSION	DATE REVIEWED	REVIEW TEAM (CONSULTATION)	NATURE OF THE AMENDMENT
1	08/10/2021	WCL	Draft risk assessment
2			
3			

APPENDIX D: SUBSIDENCE ASSESSMENT

Strata Control Technology

WOLLONGONG COAL LTD

Russell Vale Colliery: Subsidence Assessment for PC07-08 and PC21-25 Extraction Plan

WCRV5285

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Title

Russell Vale Colliery: Subsidence Assessment for PC07-08 and PC21-25 Extraction Plan

Report No

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Prepared By

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Date

23 June 2021

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SUMMARY

Wollongong Coal Limited (WCL) owns the Russell Vale Colliery located approximately 9km north-northwest of Wollongong in the Southern Coalfield of New South Wales. WCL is preparing an Extraction Plan for bord and pillar mining in the Wongawilli Seam as required by development consent MP09_0013 for the Russell Vale Revised Preferred Underground Expansion Project. WCL commissioned SCT Operations Pty Ltd to forecast the likely subsidence effects, assess impacts from the planned mining, and prepare a subsidence assessment report to support the Extraction Plan application, specifically Condition C10(e) and part of Condition C10(f) of MP09_0013. This report presents the results of our assessment for the planned PC07-08 and PC21-25 bord and pillar panels and first workings required to access/service these panels and sub-panels.

Our assessment indicates vertical subsidence associated with the planned bord and pillar mining geometry is expected to be less than 100mm and generally imperceptible. Vertical subsidence of greater than 500mm is considered possible, but most unlikely, in isolated areas above Bulli Seam goaf areas not yet confirmed as collapsed and subsided. The potential for this additional subsidence exists irrespective of planned mining. These estimates are consistent with previous assessments (SCT 2019) and peer reviews (Hebblewhite 2020).

Impacts and consequences to natural, surface, and sub-surface features are expected to be negligible and imperceptible in the undeveloped bushland setting over most of the subject areas considered in this Extraction Plan subsidence assessment.

Impacts to Mount Ousley Road are expected to be minor and manageable with appropriate management plans and risk control measures in place following consultation and agreement with the asset owner. No perceptible subsidence effects or impacts are expected at the electricity transmission lines which are located well outside the area of mining planned and assessed in this report. Additional risk to public safety is expected to be negligible.

Notwithstanding the input of other specialists, impacts and consequences are expected to be compliant with the subsidence impact performance measures in the MP09_0013 conditions of consent.

Potential impacts from subsidence movements are not expected to constitute a principal hazard as defined by the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* with the required management plans and other risk control measures to manage risks to the health and safety of workers and other persons from subsidence.

A subsidence monitoring program as required by MP09_0013, relevant guidelines and legislated standards and management measures that are appropriate for the planned mining method and subsidence expectations is recommended.

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1. INTRODUCTION

Wollongong Coal Limited (WCL) owns the Russell Vale Colliery (RVC) located approximately 9km north-northwest of Wollongong in the Southern Coalfield of NSW. In accordance with development consent for the Russell Vale Revised Preferred Underground Expansion Project (RPUEP) MP09_0013, WCL is preparing an Extraction Plan (EP) for bord and pillar mining of the Wongawilli Seam in the multi-seam Russell Vale East (RVE) area of RVC. WCL commissioned SCT Operations Pty Ltd (SCT) to forecast the likely subsidence effects and assess impacts from the planned mining and prepare a subsidence assessment report to support the EP application. This report has been prepared to meet the requirements of Condition C10(e) and part of Condition C10(f) of MP09_0013 and provides revised predictions of potential subsidence effects and subsidence impacts for the planned PC07-08 and PC21-25 bord and pillar panels and first workings required to access/service these panels and sub-panels.

The report is structured to provide:

- Conclusions and recommendations including:
  - a review of subsidence forecasts since consent for RPUEP
  - assessment of expected compliance with subsidence impact performance measures in the MP09_0013 consent conditions
  - a review of performance indicators
  - recommendations for subsidence monitoring and subsidence management.
- A brief overview of the site, including a general description of significant surface features within the EP assessment areas (EP Areas) including those identified during the risk assessment undertaken for this EP application.
- Estimates of the subsidence effects expected within the EP Areas as a result of the planned mining including a review of previous subsidence experience at RVE.
- A description of the subsidence impacts expected to the various surface and sub-surface features and surface infrastructure located across the EP Areas resulting from the forecast subsidence movements for the planned mining.

Figure 1 shows a site plan of the existing and planned mining in the Wongawilli Seam and the EP Areas superimposed onto a 1:25,000 topographic map of the area. Secondary extraction areas of the overlying Balgownie and Bulli Seams are also shown. The subsidence assessment presented in this document is based on this plan. Variations to this plan would require reassessment of the subsidence potential.

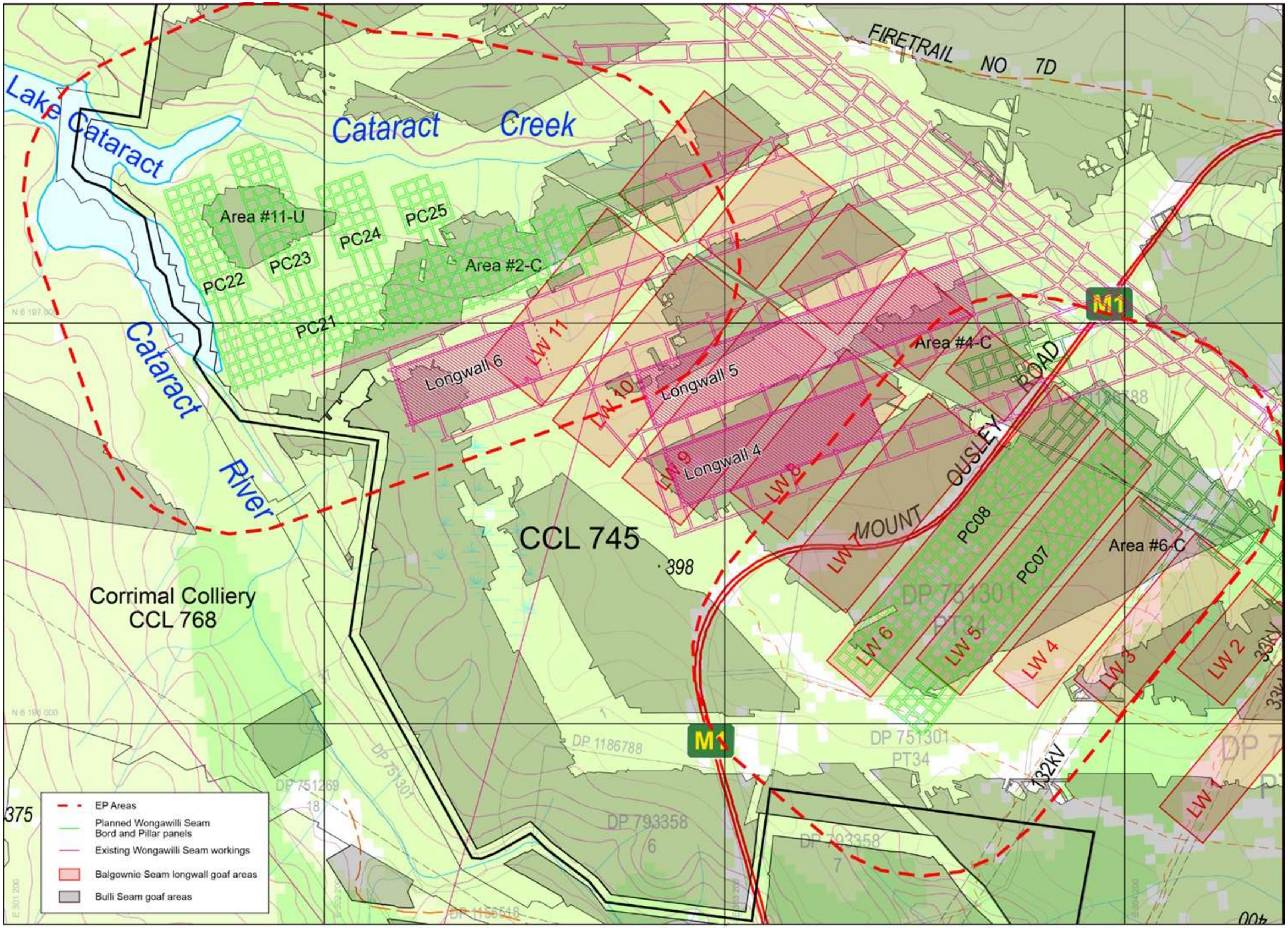


Figure 1: Site plan superimposed on 1:25,000 topographic map.

WCL is also planning to extract the remaining 25m of the approved panel length in Longwall 6 to recover the longwall face equipment. It is assumed that this mining will be undertaken in accordance with the previously approved EP for this panel. This matter is outside the scope of this report and as such, not discussed further.

This subsidence assessment includes considerations of a risk assessment conducted on 10 March 2021 for the planned mining, the "Guideline for Applications for Subsidence Management Approvals" and "Guidelines for the Preparation of Extraction Plans".

The subsidence effects and impacts to surface features are assessed as required for an EP, but also in the context of the requirements under the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* to manage risks to health and safety associated with subsidence. The information presented is intended to assist in:

- Determination of whether subsidence is or is not a principal hazard.
- Informing risk assessments and the development of control measures to manage or control risks to health and safety.
- Managing risks to health and safety associated with mining induced seismic activity.
- Improving co-operation and co-ordination of action, with respect to subsidence, between the mine operator and relevant persons conducting any business or undertaking that is, or is likely to be, affected by subsidence.
- Detailing the site characteristics, including relevant mining geometries, geological, hydrogeological or geotechnical conditions and potential impacts on relevant surface and sub-surface features to develop control measures to manage the risks from subsidence.
- Providing information about the land above or in the vicinity of the proposed mining that may be affected by subsidence.
- Managing the risks to the health and safety of workers and other persons from subsidence.

SCT has conducted research and investigations for the preparation of this EP additional since the RPUEP development consent was approved. This research has focused on the reliability of the Bulli Seam mine plan records and status of the goaf areas not yet confirmed as collapsed and includes additional information. The details of this research are presented in Appendix 3. The research and review of available data confirms the interpretation and assumptions made by SCT in previous assessments.

2. CONCLUSIONS AND RECOMMENDATIONS

Estimates of subsidence effects, primarily vertical subsidence, for the planned bord and pillar mining in this EP are consistent with previous assessments (SCT 2019) and peer reviews (Hebblewhite 2020).

Vertical subsidence is expected to be less than 100mm and generally imperceptible within the EP Areas. The IAPUM (2020) suggests allowance for subsidence of up to 300mm to cover possible reactivation of goafs in both the Bulli and Balgownie Seams. Vertical subsidence of greater than 500mm is considered possible, but most unlikely. If such subsidence were to occur, it would be expected in small, isolated areas within and near the edges of Bulli Seam goaf areas where remnant pillars not already collapsed may become unstable. This potential for additional subsidence greater than 100mm exists irrespective of planned bord and pillar mining in the Wongawilli Seam.

Subsidence impacts and environmental consequences from the planned bord and pillar mining are consistent with the subsidence impact performance measures in the MP09_0013 conditions of consent. The impacts and environmental consequences are expected to be negligible in the undeveloped bushland setting that exists over most of the EP Areas.

Impacts from planned bord and pillar mining to natural, surface, and sub-surface features are expected to be negligible. Impacts to the two upland swamps (CCUS1and CCUS5) above the planned mining are expected to be negligible.

Impacts to built features and infrastructure are expected to be minor and manageable with appropriate management plans and risk control measures in place. These management plans and risk control measures need to be developed in consultation and with the agreement of the asset owners and relevant stakeholders through risk assessments. Impacts to Mount Ousley Road are expected to be minor and manageable, consistent with previous experience. No perceptible subsidence effects or impacts are expected at the electricity transmission towers. These structures are located on the far side of substantial main heading pillars remote from proposed mining.

Additional risk to public safety is expected to be negligible.

Potential impacts from subsidence movements are not expected to constitute a principal hazard as defined by the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* with the required management plans and other risk control measures to manage risks to the health and safety of workers and other persons from subsidence.

2.1 Review of Subsidence Forecast Since Consent for RPUEP

The EP process provides an opportunity to update subsidence forecasts and assessment of impacts based on additional information and understanding gained since consent was granted. The subsidence forecasts and assessment of impacts for the EP Areas assessed in this report has not changed from those provided to the IPC for final determination of the RPUEP. Subsidence effects forecasts are consistent with previous assessments (SCT 2019) and other peer or expert reviews.

Impacts are expected to be negligible or minor and manageable consistent with the previous assessment for the planned bord and pillar mining geometry.

2.2 Subsidence Impact Performance Measures

Our assessment indicates that impacts from the planned bord and pillar mining, with the required management plans and associated risk control measures in place, are expected to be compliant with the subsidence impact performance measures detailed in Table 6 and Table 7 of MP09_0013.

Table 6 requires negligible or no impacts, consequences, and other changes to natural and heritage features. Table 7 requires infrastructure and built features to remain safe and serviceable and if damaged, repaired or compensated for with negligible additional risk to public safety. Appendix 2 summarises the subsidence impact performance measures of the development consent conditions for MP09_0013.

The performance measure for mine workings to remain long-term stable and 'non-subsiding' is taken to apply to the planned first and second workings as the performance measure for vertical subsidence is a limit of not more than 300mm for all areas of the site affected by the development.

2.3 Performance Indicators

Conditions of MP09_0013 require detailed performance indicators for each of the subsidence impacts performance measures in Tables 6 and 7 to be included in relevant management plans. Most of the categories of subsidence impacts performance measures that require performance indicators are outside SCT's areas of expertise and so need to be set by other specialists given the forecast subsidence.

Performance indicators for subsidence effects can be set. We recommend performances indicators for multi-seam mining are set at greater than 20% above forecast values. With this margin, it is envisaged that natural variability will not trigger unnecessary reporting procedures for events of no practical consequence. For a non-caving mining method where the forecast vertical subsidence levels are low and an upper limit of 300mm has been set by experts in this field (IAPUM 2020) as a performance measure for swamps, values of 100mm and 250mm are considered appropriate to activate trigger action response plans (TARP) for the planned mining geometry in this EP. Similarly, 100mm additional closure from all mining in the Wongawilli Seam, including from Longwalls 4-6, is considered appropriate as a lower valley closure trigger with an upper level of 150mm following confirmation of the current measurement of valley closure from the final survey for Longwall 6.

2.4 Recommendations

We recommend subsidence monitoring for the planned bord and pillar mining shown in Figure 1 includes:

- A shift from previous conventional monitoring of subsidence lines to selected, continuous, high accuracy (GNSS) ground-based point measurements supported by broader scale, remote monitoring such as LiDAR.

- Retention of the existing conventional surveying techniques for the monitoring of Mount Ousley Road and closure across Cataract Creek.
- Monitoring of the electricity transmission lines.
- Underground geotechnical mapping as an indicator for the status of the overlying Bulli Seam goaf areas and the potential for additional subsidence.

Full details of recommendations for a subsidence monitoring program are presented in Section 6.

The management plans required by an EP under Condition C10 of MP09_0013 are expected to be suitable to manage the potential risks and impacts from subsidence effects expected for the planned bord and pillar mining shown in Figure 1.

Further recommendations for subsidence monitoring, the application of performance indicators, and for risk control measures to mitigate or remediate potential subsidence impacts are made throughout this report. These are presented in the context of each relevant management plan.

3. SITE DESCRIPTION

This section presents a description of the surface features within the EP Areas for PC07-08 and PC21-25 as well as other items of relevance to this subsidence assessment.

3.1 Site Overview

The surface within the EP Areas for PC07-08 and PC21-25 is located below the ridgeline between Cataract River and Cataract Creek valleys within the catchment for the Cataract Reservoir. The surface is mainly undeveloped bushland. Natural features include a section of the Cataract Reservoir within the Full Supply Level (FSL), watercourses including Cataract River, Cataract Creek and tributaries, upland swamps and sandstone outcrop formations. Major built features include the Mount Ousley Road (M1 Princes Motorway) and high voltage electricity transmission lines to the east of Mount Ousley Road.

The mine workings of RVC (previously known as South Bulli and NRE No1 Colliery) in the Bulli, Balgownie and Wongawilli Seams and sections of Bulli Seam workings at the adjacent Corrimal Colliery exist within the EP Areas. The Bulli Seam workings of South Bulli and Corrimal Collieries are separated by a 40m wide barrier of coal along the boundary of the mining leases.

Figure 2 shows the existing and planned workings in the Wongawilli Seam superimposed onto an aerial photograph with vegetation, watercourses, and land ownership details.

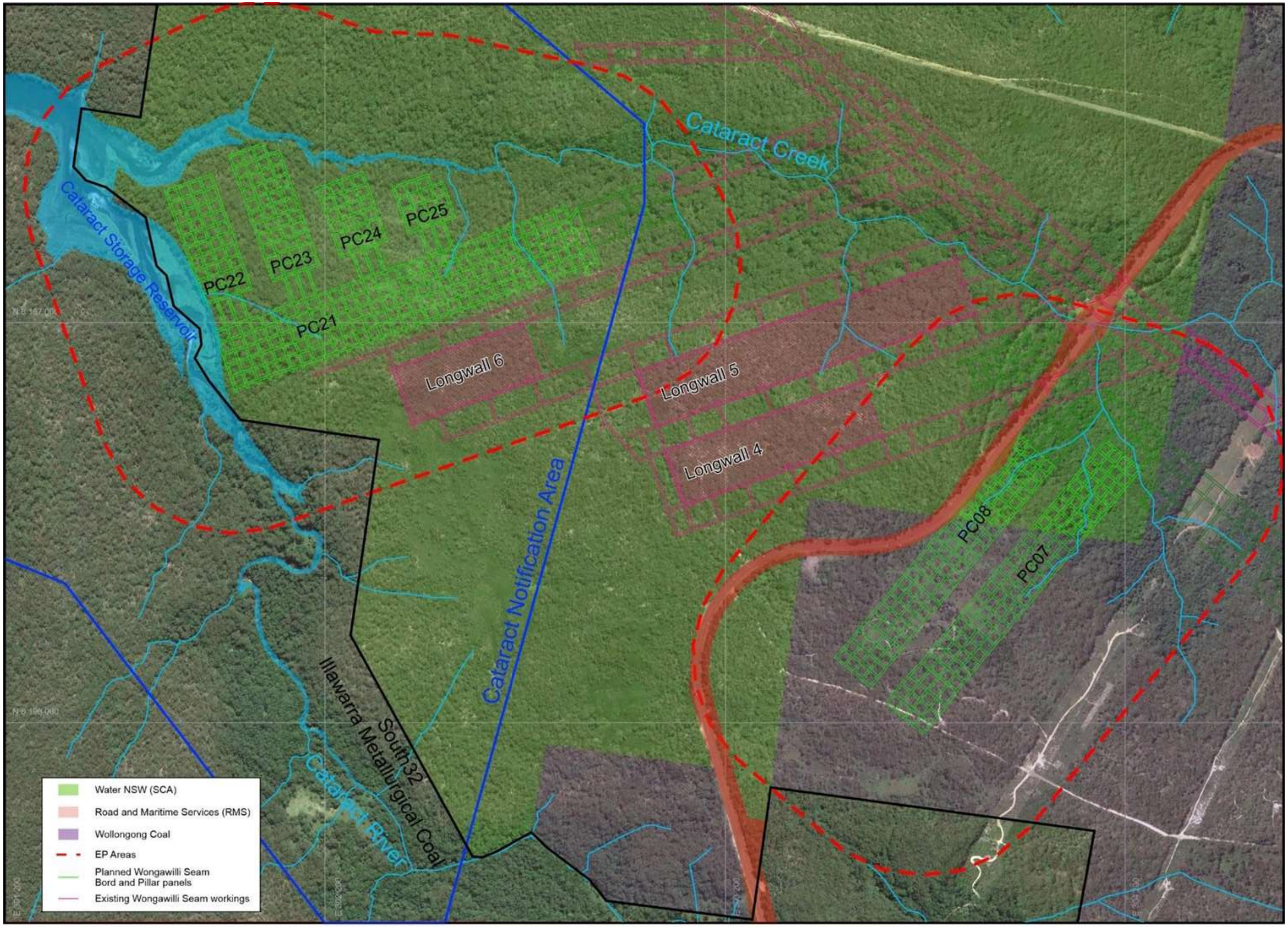


Figure 2: Site plan showing land ownership.

3.2 Extraction Plan Assessment Areas

The EP Areas for PC07-08 and PC21-25 shown in Figure 1 are considered conservative zones where all impacts from the planned mining would be expected to occur and are focus of the assessment of potential subsidence impacts.

The EP Areas are determined based on a distance of 350m, which is equal to or greater than the overburden depth to the Wongawilli Seam (equivalent to a 45° angle of draw), around the planned bord and pillar workings rather than the 35° angle of draw traditionally used for subsidence management plan application areas. The size of the EP Areas also includes consideration of coal barriers remaining in the Bulli Seam workings and incorporates the first workings required to access/service these panels and sub-panels. In this situation, EP Areas of this size are considered a conservative option for the identification of surface features and assessment of impacts to these features. Any subsidence related movements beyond the boundary of the EP Areas are expected to be imperceptible and generally insignificant for all practical purposes.

3.3 Approvals Context

The planned mining within the EP Areas for PC07-08 and PC21-25 is wholly within Consolidated Coal Lease 745 (CCL745).

WCL was granted development consent MP09_0013 under of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Russell Vale Revised Preferred Underground Expansion Project (RPUEP) by the Independent Planning Commission (IPC) of NSW in December 2020. Condition C10, Part 3 of MP09_0013, requires WCL to prepare an EP for all second workings to the satisfaction of the Secretary of the Department of Planning, Industry and Environment (DPIE).

Second workings are defined as the workings in the bord and pillar panels. These workings are intended to be a non-caving and non-subsiding mining method. The conventional industry definition for second workings involves secondary extraction of first workings or other areas of the coal seam where caving of the immediate seam roof and overburden strata, with the potential for subsidence of the surface, may be intentional.

As part of the EP requirements, the EP must:

- "Provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed mining covered by the EP, incorporating any relevant information obtained since obtaining the development consent."

- Describe the performance indicators that would be implemented to ensure compliance with the subsidence impact performance measures and manage or remediate any impacts and/or environmental consequences to meet the rehabilitation objectives of MP09_0013.

This report specifically addresses Section C10(e) and part of Section C10(f).

In addition to a subsidence monitoring program, MP09_0013 requires specific subsidence management plans and monitoring programs for Built Features, Water, Biodiversity, Swamps, Land, Heritage, Public Safety, as well as Trigger Action Response Plans and a Contingency Plan. These provide for the management of potential subsidence impacts and/or environmental consequences caused by the planned mining.

3.4 Land Ownership and Land Use

Figure 2 shows details of the land ownership within the EP Areas.

The surface within the EP Areas for PC07-08 and PC21-25 is owned by WCL, Water NSW (previously Sydney Catchment Authority) and Roads and Maritime Services (RMS). An adjacent area above the eastern area of Corrimal Colliery is owned by South32 - Illawarra Metallurgical Coal.

The EP Areas are wholly within the Metropolitan Special Area for the Sydney water catchment. This catchment area is a restricted area with no access for the general public and limited access for other persons.

3.5 Mining Geometry

This section provides details of the previous multi-seam mining in the Bulli, Balgownie and Wongawilli Seams at RVE relative to the planned mining of the Wongawilli Seam in the EP Areas for PC07-08 and PC21-25.

3.5.1 Previous Mining

Coal has previously been mined in three seams within the EP Areas, the Bulli Seam, the Balgownie Seam and the Wongawilli Seam.

The Bulli Seam was mined extensively at RVE from the late 1800's until circa 1950. This seam is also referred to in historical records as the Top, Upper or No1 Seam. The Bulli Seam thickness and mining height is approximately 2.2m.

The early mining layouts of the Bulli Seam were irregular compared to later mining methods. The layouts include the full evolution of hand-working bord and pillar methods from the early 'Welsh bords' technique that resulted in very wide roadways and very narrow pillars in "worked out" areas through to complete pillar extraction by hand. Hand-working techniques were superseded with the introduction of mechanised mining from the 1950's. There are areas of completed pillar extraction and large areas of standing coal pillars remaining as first workings. Some of these areas are under and around the FSL of the Cataract Reservoir. Reliable (accurate and complete) mine plan records (mine working plans and the record tracing copy) are available for areas of interest to this EP recognising that more detail is shown after 1931 when legislated standards required plans to be certified as accurate by a surveyor. Further detail of Bulli Seam workings is presented in Appendix 3.

The Balgownie Seam is approximately 10m below the Bulli Seam. The seam thickness is 1.2-1.3m but anecdotal and survey plan evidence indicates the actual mining height in later panels and on the longwall faces was increased to 1.5m by including some floor material. Most of the Balgownie Seam workings in RVE were mined with continuous miners and longwall methods from 1968 to 1982. Eleven longwall panels of various lengths and widths were extracted from 1970 to 1982.

The floor of the Wongawilli Seam is approximately 25m below the Balgownie Seam. The seam is approximately 10m thick but only the bottom 2-3m is economic due to coal quality. Three short longwall panels, 150m in width, were extracted between 2012 and 2015.

3.5.2 Planned Mining

Figure 3 shows the planned mining layout and contours of overburden depth to the mining horizon in the Wongawilli Seam assessed in this report.

The mining plan layout for this EP integrates with the existing Wongawilli Seam workings and consists of bord and pillar (non-conforming) workings in:

- two panels (PC07 and PC08) to the east of Mount Ousley Road
- one panel (PC21) and 4 sub-panels (PC22, PC23, PC24 and PC25) to the west of Mount Ousley Road adjacent to the Cataract Storage Reservoir
- and the first workings (conforming pillars) required for access and services, including ventilation, to the bord and pillar panels.

Conforming pillars are prescribed by *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* as having a minimum dimension of greater than one tenth of the thickness of cover (to the surface). These first workings pillars are designed to remain stable and ‘non-subsiding’ as required by MP09_0013 with large width to height ratios and factors of safety greater than 2.11 where a factor of safety of 2.11 implies a probability of instability of 1 in 1,000,000.

The layout avoids mining below the abutment load bearing (and subsidence controlling) Balgownie Seam chain pillars between longwall goafs. Limiting bord and pillar panels to five headings with barrier pillars between each panel and increasing pillar dimension near the major geological structures in the EP Areas (i.e. Dyke D8 and extension of Corrimal Fault at Wongawilli Seam horizon) is recommended. The risks to Cataract Reservoir from longwall mining through Corrimal Fault and Dyke D8 at RVE are assessed in SCT (2015).

PC07 and PC08 bord and pillar panels are positioned below Bulli Seam goaf Areas #4 and #6 and the goaf of Longwall 5 and Longwall 6 in the Balgownie Seam. These goaf areas are confirmed as collapsed (see Appendix 3). The Bulli Seam goaf areas are identified in SCT (2020a) using an identification number (ID#). PC07 and PC08 are separated by a barrier pillar of 54m (coal) in width positioned below the Balgownie Seam chain pillars.

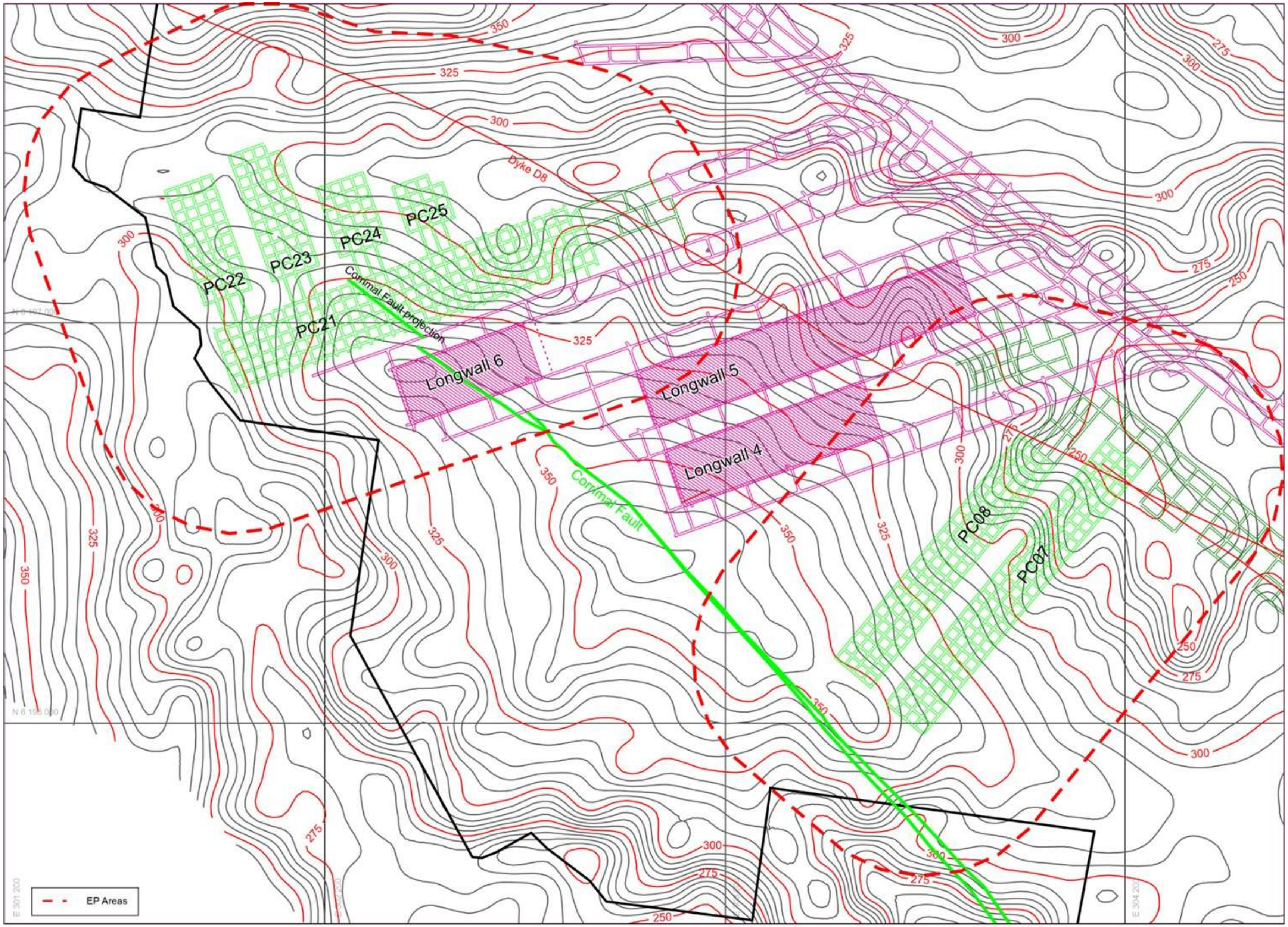


Figure 3: Contours of overburden depth to Wongawilli Seam mining horizon.

Pillar dimensions in PC07 and PC08 have been increased since approval for MP09_0013 was granted. The pillars are increased in size to accommodate full tributary load below the Balgownie Seam longwall goafs consistent with IAPUM (2020) assessment and IESC (2021) comments.

The coal dimensions increased from 19.5m to 22.5m for width and 19.5m to 24.5m for length to increase pillar strength and still maintain an offset from being directly below the Balgownie Seam chain pillar edges. These changes to the layout in PC07 and PC08 are for the pillars at an overburden depth of up to 330m.

In PC21 and PC22-25, the pillars are generally square in shape with minimum coal pillar dimensions of 24.5m. Longer rectangular barrier type pillars are incorporated into the three headings entries to the PC22-25 sub-panels. Three barrier pillars of 54m (coal) width separate the PC22-PC25 sub-panels.

The overburden depth ranges from approximately 250m to 350m for the PC07 and PC08 bord and pillar panels and first workings. The overburden depth ranges from approximately 280m to 340m for the PC21 and PC22-25 bord and pillar panels and first workings. The planned mining height is 2.4m for the non-conforming bord and pillar workings and 3.0m for the conforming first workings. These planned working sections of the Wongawilli Seam are at the base of the seam. All roadways are assumed to be at the maximum prescribed width of 5.5m.

As shown in Figure 1, most of PC21 and all of PC22-25 bord and pillar panels are located in areas where there is previous extraction in one seam only, mainly the Bulli Seam. Only a small area of PC21 is below Balgownie Seam Longwall 11 and in this area, the Bulli Seam has only been mined as first workings. Area #11 is the Bulli Seam goaf area located over PC22-24 and is yet to be confirmed as having subsided. Area #2 is located over the eastern area of PC21 and is confirmed as having subsided. Details of the pillar extraction areas on the mine working plans and copies of the recording tracings indicate the dates of mining in these two areas are similar. Dates of mining were 1942-1945 in Area #11 and 1943-1949 in Area #2.

3.6 Surface Features and Surface Infrastructure

Figure 4 shows the locations of surface features identified within the EP Areas for PC07-08 and PC21-25 during a risk assessment conducted on 10 March 2021. These features are described in this section.

The risk assessment team included environmental and subsidence specialists, and management personnel from WCL. The risks associated with subsidence impacts to the features identified within the EP Areas were considered in the context of the subsidence management requirements under the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*.

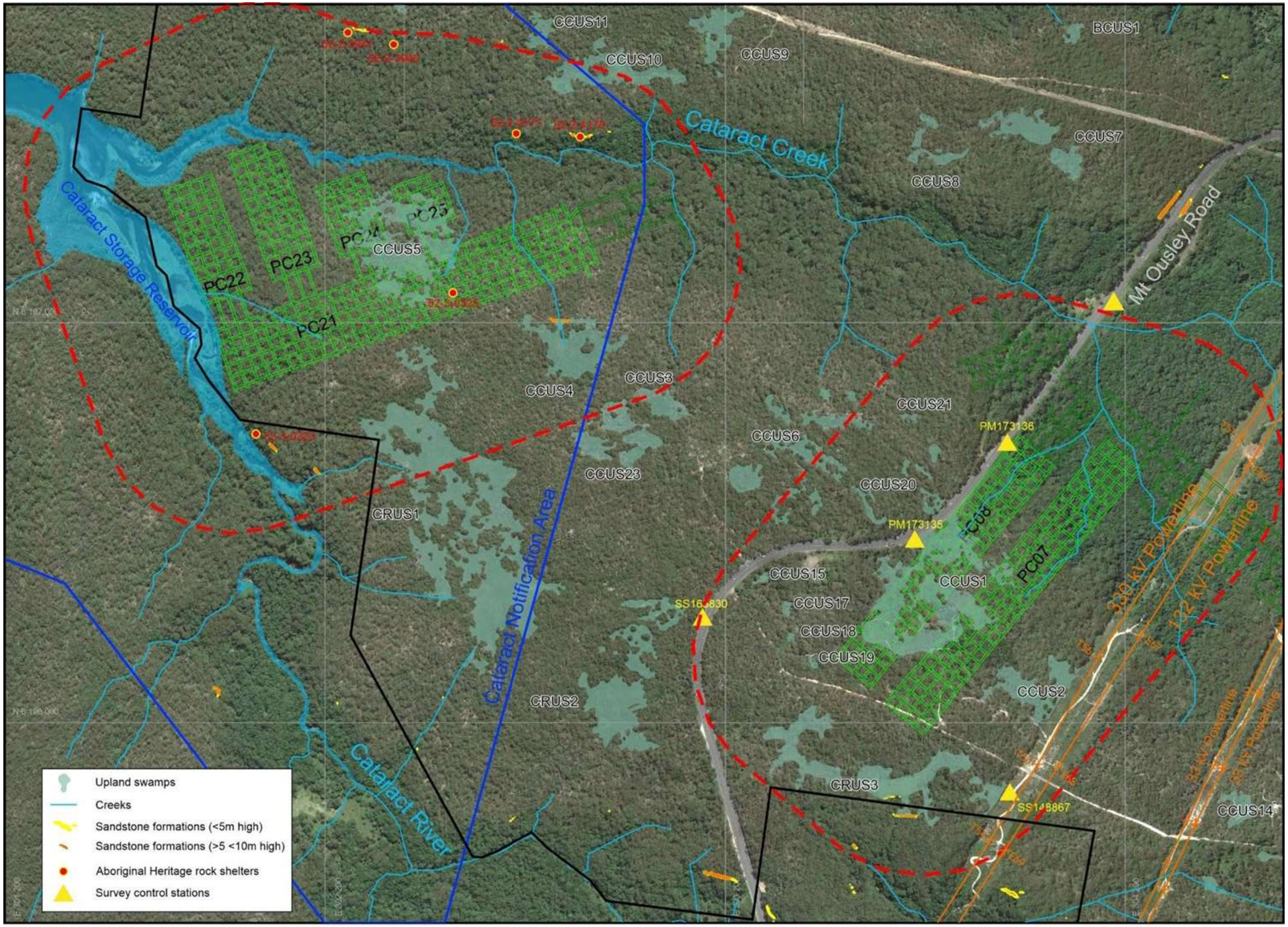


Figure 4: Surface features.

The NSW Department of Mineral Resources "Guideline for Applications for Subsidence Management Approvals" provides a comprehensive list of surface and sub-surface features to be considered in a subsidence assessment. With no such equivalent list included in the draft (Version 5 - unpublished) Department of Planning & Environment, NSW Trade & Investment – Division of Resources and Energy – "Guidelines for the Preparations of Extraction Plans" for EP applications, the SMP list has been used as a guide instead. A complete list of these items is provided in Appendix 1.

3.6.1 Natural Features

The major natural features within EP Areas for PC07-08 and PC21-25 are the Cataract River and Cataract Creek valleys and ridgeline between these features. The surface terrain is mainly undeveloped bushland.

First, second, third and fourth order streams, mainly in the Cataract Creek valley, cross the EP Areas but only first and second order tributaries of Cataract Creek and a first order tributary of Cataract River are located above the planned bord and pillar panels.

There are 16 upland swamps located partially or wholly within the EP Areas, but only two, CCUS1 and CCUS5, are above the planned bord and pillar panels. Swamp CCUS1 is above the planned PC07 and PC08 bord and pillar panels. Swamp CCUS5 is above the planned PC21, PC24 and PC 25 bord and pillar panel and sub-panels.

There are multiple sandstone formations located within the EP Areas, but none are greater than 5m high directly above the planned mining. There are no sandstone formations located within the EP Areas that would be described as cliffs by contemporary mining approval definitions.

3.6.2 Man-Made or Built Features

The major built features or infrastructure within the EP Areas for PC07-08 and PC21-25 are the Cataract Reservoir, the Mount Ousley Road and the 330kV and 132kV electricity transmission lines in the east. Other features include Aboriginal heritage sites, unsealed access tracks/fire roads, and survey control marks. No European or historical heritage features have been identified.

The planned mining for PC21 and PC22 bord and pillar panels is marginally below the FSL of the Cataract Reservoir at RL289.9m AHD in Cataract River and Cataract Creek.

All the planned mining in PC21 and PC22-25 bord and pillar panels and sub-panels is within the Notification Area around the Cataract Storage Reservoir administered by Dams Safety NSW (previously NSW Dams Safety Committee).

The section of Mount Ousley Road between Cataract Creek and the crest of the ridge to the south crosses the EP Area for PC07-08. The PC08 bord and pillar panel is immediately adjacent to the section of Mount Ousley Road that is above the chain pillar between Longwalls 6 and 7 in the Balgownie Seam.

A 330kV and a 132kV electricity transmission line are on the eastern edge of EP Area for PC07-08 but are not above the bord and pillar panels. The pylon structures that support the conductors of these powerlines are also not above any of the planned first workings in the EP Area for PC07-08.

Appendix 6 of MP09_0013 shows two Aboriginal heritage rock shelter sites located (52-3-0323 and 52-3-0325) within EP Area for PC21-25. The positions shown on this plan are inconsistent with previously assessments and recent ground-truthing field work confirms this plan is incorrect. Figure 4 shows the locations of six rock shelter sites (52-3-0323, 52-3-0325, 52-2-4170, 52-24171, 52-2-3940 and 52-2-3941) within the EP Area for PC21-25. Only one site (52-3-0325) located above Bulli Seam goaf Area #2 (confirmed as collapsed) is over the planned bord and pillar panels. No aboriginal heritage sites are located above the EP area for PC07-08.

Unsealed access road/four-wheel drive tracks cross the EP Area for PC07-08 on land owned by WCL and Water NSW. These tracks provide access to and along the high voltage powerline easements and to the telecommunications installation at Brokers Nose. These are not recognised fire roads.

Four permanent survey control marks have been identified within the EP Area for PC07-08. Three marks are along the edge of the Mount Ousley Road easement and one mark is on the southern edge of this EP Area in the 330kV and 132kV powerline easement.

Historical heritage features at the Russell Vale pit-top area and the Cataract dam wall are more than 1.5km and 9Km respectively from the planned bord and pillar panels and not expected to be impacted by the planned mining.

4. FORECAST SUBSIDENCE BEHAVIOUR

In this section, the subsidence movements expected above the planned PC07-08 and PC21-25 bord and pillar panels and within the EP Areas are estimated from experience of subsidence behaviour at RVC and elsewhere in the Southern Coalfield and NSW more generally.

4.1 Review of Previous Subsidence at RVE

This review is presented in the context of the advancements in understanding of the mechanics of multi-seam subsidence behaviour made since the last forecast for longwall mining at RVE was prepared in 2014. Back analysis of measured vertical subsidence profiles from mining in the Balgownie and Wongawilli Seams indicates behaviour consistent with this latest multi-seam understanding.

4.1.1 Vertical Subsidence

The only known records of subsidence effects associated with mining of the Bulli Seam are comments on historical plans regarding individual subsidence impacts. However, it is possible to estimate subsidence given the geometry of the panels mined and estimating the likely secondary extraction percentages.

The vertical subsidence for the Bulli Seam mining in RVE is estimated based on subsidence monitoring results and subsidence profiles from mining in the Bulli Seam further to the west above the T and W (200 and 300 Series) longwall panels at South Bulli Colliery and subsequent pillar extraction operations. Maximum vertical subsidence of up to 1.0m is estimated.

Monitoring of the subsidence from the Balgownie Seam longwalls was comprehensive for the period of mining. Each of the 11 longwalls mined between 1970 and 1982 had a longitudinal line along the whole length of the panel and three cross panel lines were also installed perpendicular across Longwalls 1-11.

The incremental vertical subsidence was monitored at regular intervals during panel retreat above the initial panels and less frequently during mining of the last few panels. Ground strains were only measured during the last panel; Longwall 11. The last subsidence surveys for the Balgownie Seam longwalls were completed in 1983.

Longwall 7 mined directly below Mount Ousley Road in 1976-77 where maximum subsidence of approximately 1.0m was measured. Sections of Mount Ousley Road were realigned coincidental with the period of active longwall mining. Subsidence impacts were managed as part of the realignment construction activities.

Observations from the database of subsidence monitoring for the Balgownie Seam longwalls indicate:

- The chain pillars and other areas of coal not mined by the longwall are evident in the subsidence profile.
- Incremental subsidence of approximately 75% (generally 65-85%) of mining height is evident in areas where secondary extraction in both the Bulli and Balgownie Seams has been undertaken.
- Subsidence occurred primarily within the footprint of the Balgownie Seam longwall panels.
- Goaf edge subsidence is greater and extends further where there is overlying Bulli Seam goaf.
- Incremental subsidence of greater than 90% of the Balgownie Seam mining height is evident where latent subsidence is recovered. Latent subsidence in this context is the subsidence associated with Bulli Seam mining that did not occur during mining of the Bulli Seam because of proximity to the edge of the panel. Maximum incremental subsidence of 1.42m was measured above Longwall 10 where latent subsidence from Bulli Seam pillars is likely to have been recovered. This subsidence represents 95% of the nominal 1.5m mining height.

Monitoring of subsidence from longwall mining in the Wongawilli Seam indicated maximum incremental vertical subsidence of 1.8m occurred over Longwalls 4 and 5 after Longwall 5 was mined. Incremental vertical subsidence over the short section of Longwall 6 mined to date is estimated at 0.72m. These values are consistent with and less than the forecast for these longwalls provided the subsidence assessment for the Preferred Project Report (PPR) longwall layout at RVE (SCT 2014).

Cumulative vertical subsidence can be estimated in the form of subsidence contours for mining in each seam. Figure 5 shows the estimated contours of cumulative subsidence for all three seams relative to swamps and the planned mining geometry.

Although mining has been conducted in three seams at RVE, there are only a few places where secondary extraction has occurred at the same location in all three seams. Total cumulative subsidence is not necessarily the addition of all the increments. The maximum cumulative vertical subsidence for all three seams is approximately 3.7m above Longwall 4 in the Wongawilli Seam at a location below parts of Swamp CCUS6.

Mills and Wilson (2017) present measurements and observations of the incremental and cumulative subsidence effects from longwall mining in two seams in a regular, parallel, offset geometry at a site in NSW. More recent monitoring to 2020 at this site confirms these earlier observations and interpretation and includes additional learnings for multi-seam subsidence from longwall mining in three seams.

4.1.2 Tilt and Strain

Detailed measurements of tilt and strain effects on the ground surface from mining subsidence are not available for the Bulli Seam mining and most of the Balgownie Seam longwalls. Incremental strains were measured for the mining of Longwall 11 in the Balgownie Seam. Incremental tilts and strains were measured for the mining completed in Longwalls 4-6 in the Wongawilli Seam.

Maximum strains over Longwall 11 were measured at the northern end of the panel were there has been pillar extraction in the Bulli Seam. Strains ranged from 3-4mm/m along the panel to peaks of 13-14mm/m in compression across the topographic low point of Cataract Creek and 8-9mm/m in tension on the slope beyond after vertical subsidence of 1.3-1.4m.

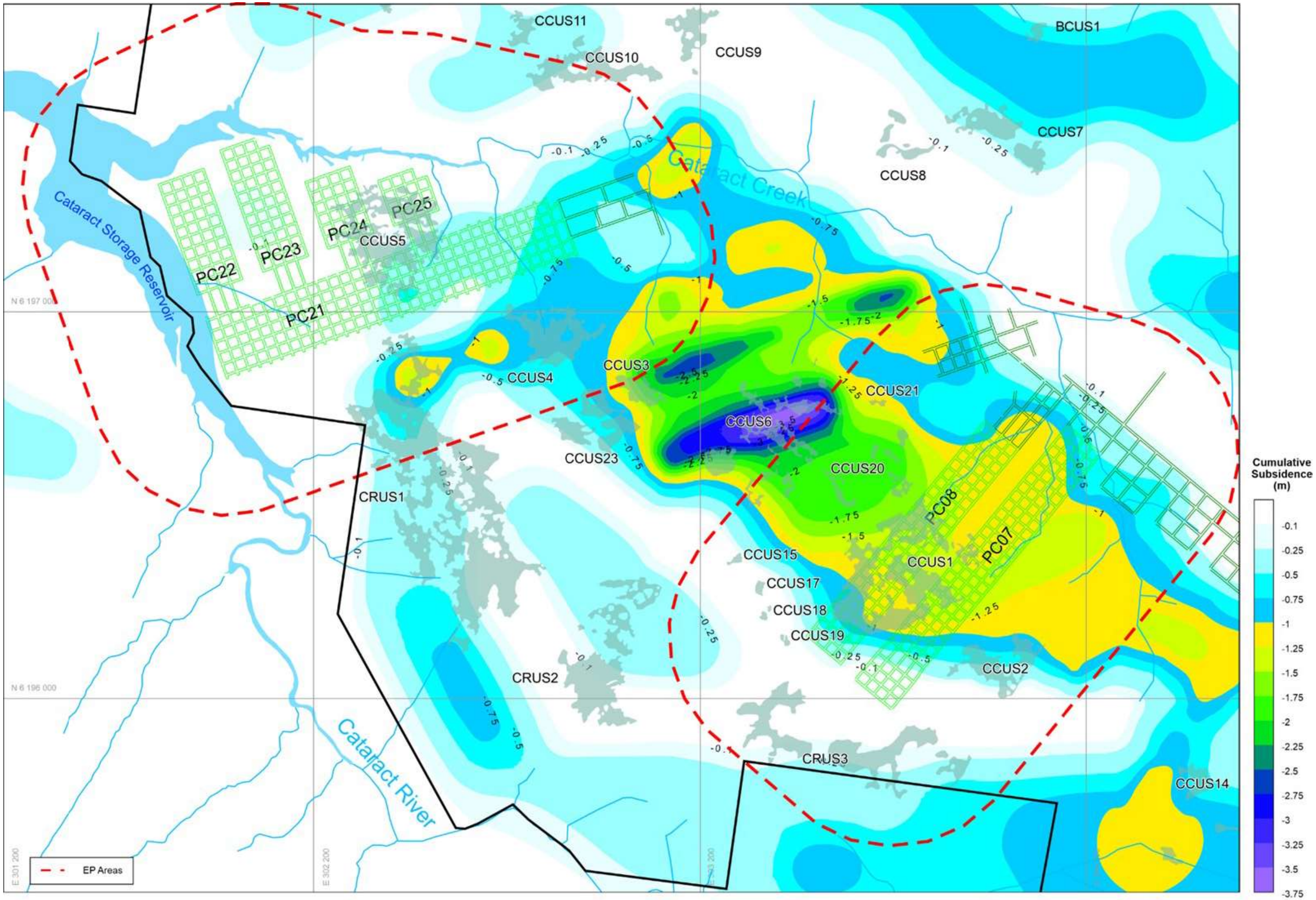


Figure 5: Estimate of existing cumulative subsidence relative to swamps.

The monitoring of incremental subsidence movements from the mining of Longwalls 4, 5 and 6 in the Wongawilli Seam indicates:

- Maximum tilt of 30mm/m in the RVE area was measured on the southern cross-panel line over Longwall 4 after mining Longwall 5. This maximum tilt was measured near the edge of Longwall 9 in the Balgownie Seam superimposed onto a goaf edge in the Bulli Seam. Maximum tilts measured elsewhere along Longwalls 4 and 5 were in the range of 10-25mm/m.

- Maximum tensile strain in the range 3-6mm/m.

- Maximum compressive strain of 12mm/m at the pillar and D8 Dyke over Longwall 5. Maximum compressive strains elsewhere along Longwalls 4 and 5 were in the range of 3-6mm/m.

Cumulative tilts and strains are not able to be derived, due to the limits of the database. However, Mills and Wilson (2017) present results that show that in areas remote from stacked goaf edges, the levels of permanent tilt and strain in multi-seam mining are similar or less than for single seam mining despite the greater vertical subsidence.

Cumulative values for tilt and strain are not necessarily the addition of the increments from each seam due to the general softening, or reduction in shear stiffness, of the overburden with each episode of subsidence. Transient and permanent levels of tilt and stain are much higher when a stacked goaf edge is formed and especially when the edge is undercut. At RVE, there are no stacked goaf edges of any significant length due to the irregular mining layouts in the three seams.

These observations suggest that tensile ground strains from previous mining are likely to be less than about 60% of values estimated and forecast in SCT (2014) for longwall mining of the PPR layout in RVE. This reduction is significant when considering cumulative effects including those from the planned bord and pillar mining.

4.2 Forecast of Subsidence Effects

In this section, the maximum subsidence effects for the primary subsidence parameters are estimated for the planned geometry shown in Figure 1.

4.2.1 Vertical Subsidence

Figure 6 shows contours for the estimated vertical subsidence expected at the completion of the planned bord and pillar panels in the EP Areas. Vertical subsidence from the mining of the planned bord and pillar panels is expected to be less than 100mm and generally less than 30mm within the EP Areas. These levels of subsidence are expected to be imperceptible for all practical purposes.

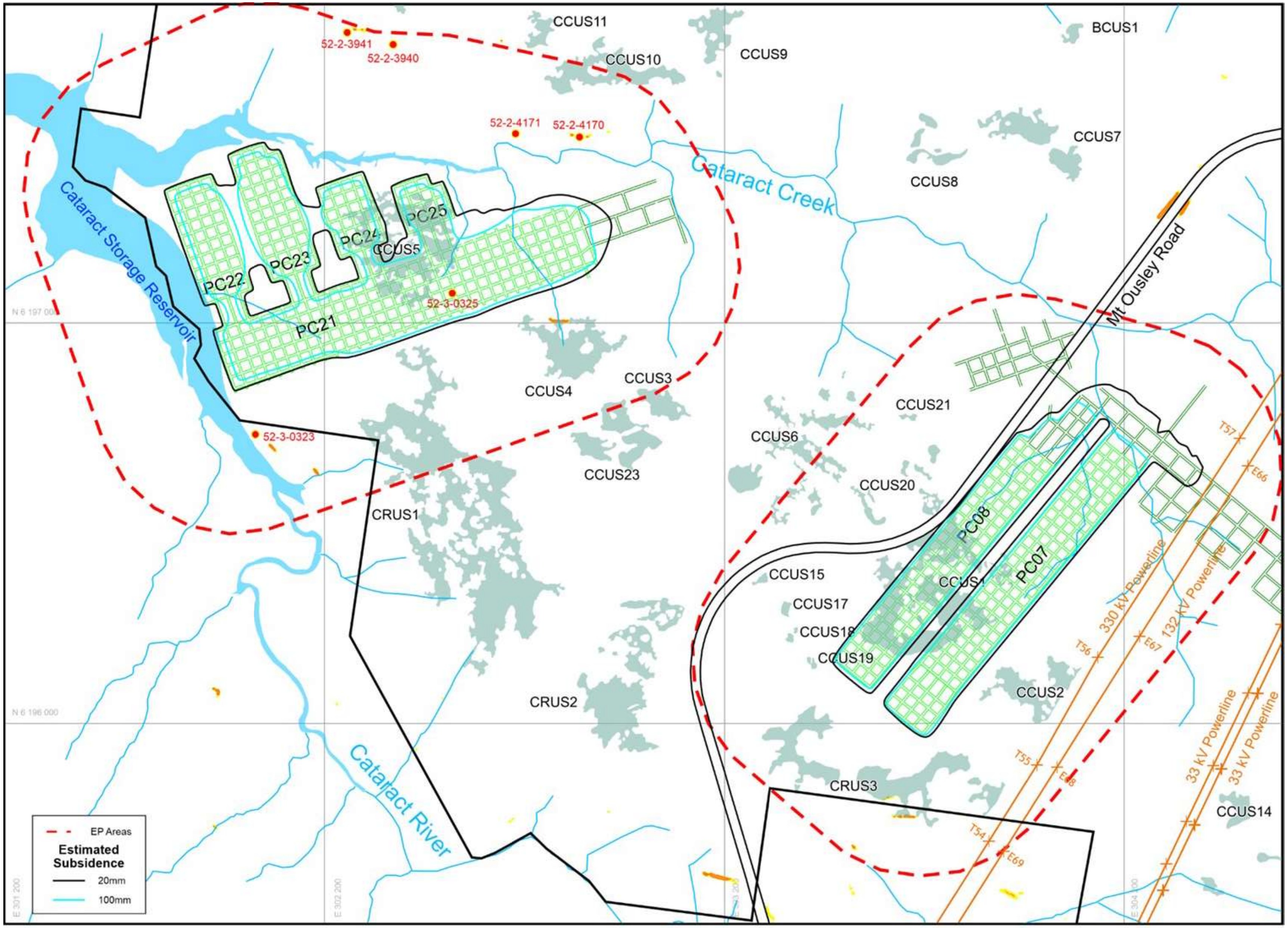


Figure 6: Estimated subsidence contours and surface features.

Vertical subsidence of greater than 500mm is considered possible, but most unlikely. If such subsidence were to occur, it would be expected in small, isolated areas at RVE near edges or below Bulli Seam goaf areas where any remnant pillars not already collapsed are destabilised. The IAPUM (2020) identify the potential for subsidence up to 300mm in some areas. The potential for this greater vertical subsidence exists because of subsidence associated with previous mining. This potential exists irrespective of planned mining, but additional subsidence of this magnitude would be considered a significant departure from the low levels of subsidence expected. Any such subsidence would be identified from LiDAR monitoring and investigated to better inform subsequent mining layouts.

A previously identified and inspected area of Welsh bords in the Bulli Seam adjacent to the main headings is outside the EP Area for PC07-08 and not expected to be affected by the planned mining. Although considered to be marginally stable based on pillar stability calculations, the pillars have been standing for 120 years. The expected 300mm subsidence associated with failure of these pillars would occur in a small area that would not affect surface infrastructure.

4.2.2 Tilt and Strain

The approach to estimate incremental tilt and strain levels outlined in Holla and Barclay (2000) for single seam mining in the Southern Coalfield indicates that for 100mm of vertical subsidence at 280m depth the following maximum values can be estimated:

- Tilt of less than 2.0mm/m.
- Tensile strain of approximately 0.5mm/m.
- Compressive strain of approximately 1.0mm/m.

Mills and Wilson (2017) found that in areas of multi-seam mining remote from stacked edges, incremental tilt and strain are not necessarily increased by greater vertical subsidence, so the Holla and Barclay (2000) approach is likely to give a conservative estimate of the strains and tilts.

Changes to the surface from these low-level values of tilt and strain are expected to be generally imperceptible.

Any changes in the small areas where additional subsidence does develop are also expected to be generally imperceptible and less than the tilt and strain levels already experienced at the site over a wide area.

4.2.3 Horizontal Movements

Systematic horizontal ground movements from vertical subsidence are expected to be generally imperceptible. However, ongoing low-level horizontal movements of the southern slope down to Cataract Creek are expected to continue irrespective of the planned mining.

These movements are a legacy of the previous mining at the site, including early Bulli Seam mining, the Balgownie Seam longwalls and the mining of Longwalls 4 and 5 in the Wongawilli Seam more recently.

These horizontal movements are expected to continue to cause horizontal strains that increase cracking at the top of the ridge line, cause minor cracks in the slope and cause minor compression at the Cataract Creek crossing point.

4.2.4 Unconventional Subsidence Effects

No significant unconventional subsidence movements are expected from the planned mining. Valley closure movements are expected but far-field movements from stress relief in the overburden strata are not envisaged.

Ongoing low-level valley closure movements are expected irrespective of the planned mining.

The current incremental closure at Cataract Creek from the Wongawilli Seam mining is approximately 60mm. This incremental closure is expected to remain well below the 150mm threshold set for the previously approved longwall mining in the Wongawilli Seam.

Any far-field horizontal movements from stress relief in the overburden strata are expected to have already occurred from the previous secondary extraction mining in the Bulli and Balgownie Seams and to a lesser extent, in the Wongawilli Seam. The planned mining in the Wongawilli Seam involves a non-caving method so additional far-field horizontal movements are not expected.

4.2.5 Risk of Pillar Instability

In this section, the existing coal pillars at RVE and pillars to be formed by the planned mining in this EP are assessed for stability and convergence at seam level that may result in subsidence at the surface.

The basis of the assessment is the University of NSW pillar design formulae (UNSW 1999) and consideration of width to height ratios, roof and floor properties, potential loading scenarios in the multi-seam environment and factors of safety. The Australian and South African failed pillars database developed by UNSW does not contain any cases where the factor of safety is greater than 1.5 for a width to height ratio of 5. Both these parameters are less than for the planned pillars in this EP.

The UNSW approach recognises that:

- Stable bord and pillar workings result in minimal surface subsidence.
- The design of stable pillars requires consideration of the strength of the 'pillar system' and the load that will be acting on the pillar system.

Generally, with the pillar system parameters remaining constant, vertical subsidence decreases as the width to height ratios of pillars increases. For pillars with width to height ratios of greater than about 8 in strong roof and floor strata, the load bearing capacity of the pillars can increase beyond the nominal strength, so the pillars become 'stronger' by a process referred to as 'strain hardening'. Some small convergence or deformation of the pillar occurs during this process.

The IAPUM (2020) advises the maximum probability of instability of 1 in 1,000,000 for all mine workings minimises (almost eliminates) the likelihood of pillar instability developing. A probability of failure of 1 in 1,000,000 equates to a factor of safety of 2.11.

Figure 7 shows the details of the existing Bulli and Balgownie Seam workings and the existing and planned mining in the Wongawilli Seam relative to the EP Areas.

4.2.5.1 Wongawilli Seam Pillars

The planned Wongawilli Seam pillars are assessed as long-term stable.

It is recognised that pillar width to height ratio and pillar strength are sensitive to the mining height of the surrounding roadways. Where the width to height ratio is small, pillar strength and factors of safety reduce significantly with only small increases in mining height. The coal pillars in the PC07-08 bord and pillar panels are planned to have a minimum width of 22.5m and be 24.5m long. SCT understands that the mining height is planned to be 2.4m and maximum roadway width is 5.5m. These pillars have a width to height ratio of greater than 9. Pillar stability is assessed on this basis.

Strong roof and floor conditions typical of the Wongawilli Seam are expected. Assuming full tributary overburden load, these pillars have a factor of safety of greater than 2.11 at depths up to 330m. There is no experience in Australia or South Africa of pillars in this geometry failing when the factor of safety is 2.11.

Assuming full tributary load for workings below Longwall 5 and 6 in the Balgownie Seam is considered conservative based on the observations of load on the adjacent Balgownie Seam chain pillars inferred from subsidence profiles, observed mining conditions below these pillars and the experience of drilling a borehole referred to as RV16 from surface to the Wongawilli Seam for groundwater monitoring.

RV16 shown on Figure 7, was drilled down through the collapsed Bulli Seam goaf, through the Balgownie Seam chain pillar between Longwall 5 and 6 and down the Wongawilli Seam floor at approximately 320m depth. Fragments of timber were encountered at the Bulli Seam mining horizon indicating the presence of previous mining activity, but the Bulli Seam mining horizon was observed to be completely compressed. This borehole was not cased through the strata above the chain pillar but was observed to support more than 300m of water head indicating the Bulli Seam mining horizon was tightly compressed.

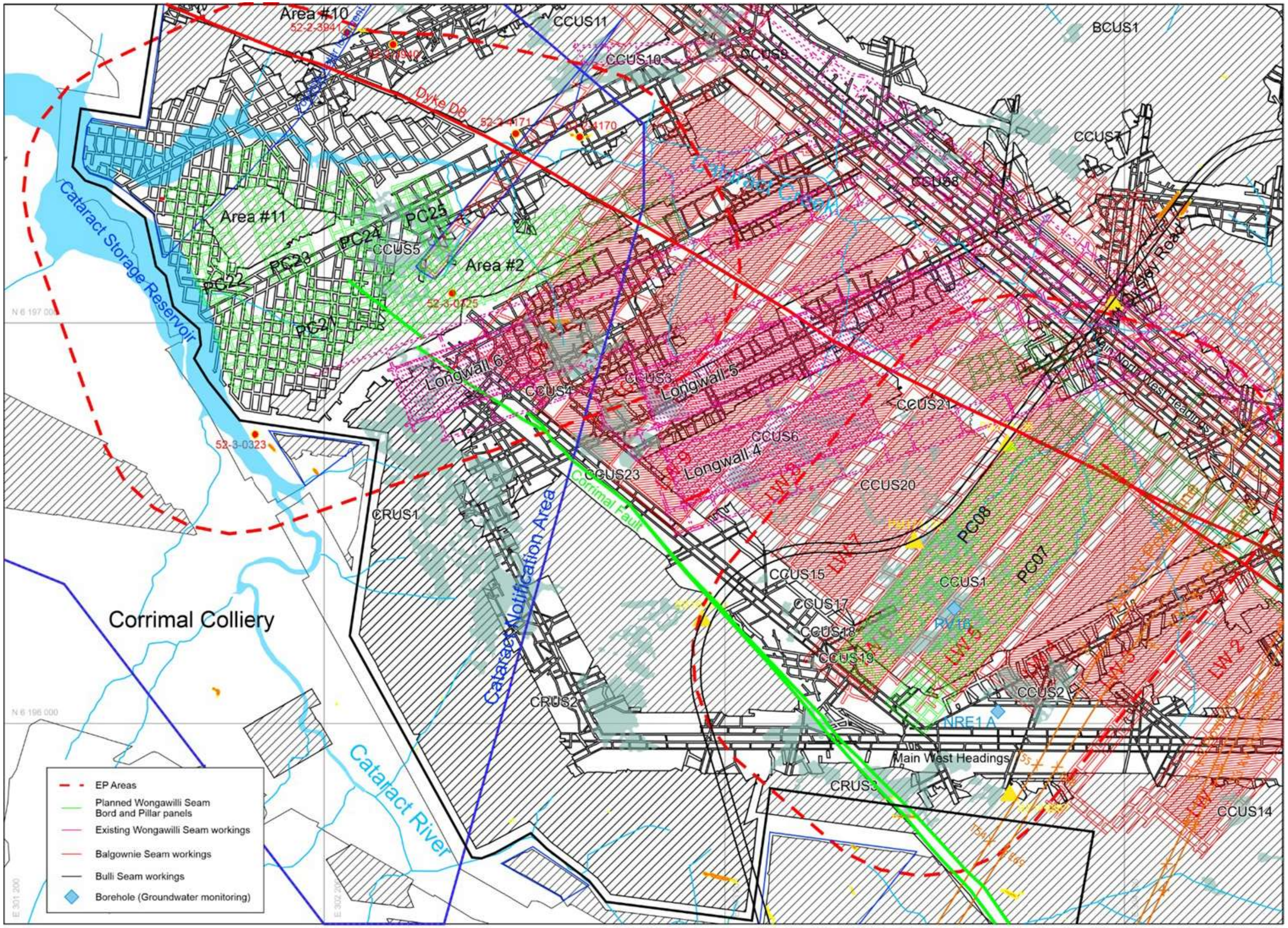


Figure 7: Workings in Bulli and Balgownie Seams with existing and planned workings in Wongawilli Seam.

The coal pillars in the PC21 and PC21-25 bord and pillar panels are planned to be a minimum size of 24.5m wide and 24.5m long. SCT understands that the mining height is to be 2.4m and maximum roadway width 5.5m. The minimum sized pillars have a width to height ratio of greater than 10. Pillar stability is assessed on this basis.

Strong roof and floor conditions typical of the Wongawilli Seam are expected. Assuming full tributary overburden load, these pillars have a factor of safety of greater than 2.11 for the maximum 335m depth above these panels.

The potential for perceptible subsidence should pillars become overloaded and deform over time is significantly reduced by limiting the panels to five headings and incorporating a barrier greater than 50m wide between panels. This strategy isolates individual panel width to approximately 125m at depths of 280-340m.

4.2.5.2 Balgownie Seam Pillars

The existing Balgownie Seam pillars are assessed as long-term stable after consideration of the status and the potential for interactions from the planned Wongawilli Seam mining.

The existing Balgownie Seam coal pillars above or adjacent to the planned bord and pillar panel within the EP Areas range in width from a minimum of 25m to 40m or larger. These pillars have width to height ratios of greater than 16 to greater than 26 for a mining height of 1.5m and greater than 19 to greater than 30 for a seam thickness of 1.3m.

4.2.5.3 Bulli Seam Pillars

The potential for any remnant pillars in the Bulli Seam goaf areas to become destabilised and result in additional subsidence has been identified and considered in the forecast of subsidence effects.

Most of the planned bord and pillar panels in the PC07-08 EP Area are below Bulli Seam goaf areas and Balgownie Seam longwall panels. Detailed mine workings plan and record tracings are available for the two Bulli Seam goaf areas referred to as Area#4 and Area#6. Subsidence profiles from longwall mining in the Balgownie Seam, inspections of the Balgownie Seam goaf edge at the Bulli Seam horizon and experience from mining the Wongawilli Seam below these areas confirm that Bulli Seam pillars above Balgownie Seam longwall goafs are collapsed as would be expected with full extraction less than 10m below the Bulli Seam horizon.

The planned PC21 and PC22-25 bord and pillar panels are located below two areas of Bulli Seam goaf and some first workings. The edges and some of the goaf area above PC21 (identified as Area #2 in SCT 2020a) have already been confirmed as collapsed from the Balgownie Seam subsidence profiles and from experience of difficult mining conditions in the Wongawilli Seam below the edge of this goaf area. A second area of Bulli Seam goaf above the planned PC22-25 bord and pillar sub-panels (identified as Area #11 in SCT 2020a) is not confirmed as collapsed and subsided because there has not been any Balgownie or Wongawilli Seam mining at this location.

In Area #2, secondary extraction of the pillars that form this goaf area was undertaken between 1943 and 1949 according to the original mine working plan and record tracing copy. There are some small pillars shown as not mined. These remnant pillars are unlikely to be standing as they are generally less than 10m wide and 15m long surrounded by secondary extraction at a depth of 285m. These pillars have lower width to height ratios and are expected to have collapsed at the time of secondary extraction in the Bulli Seam because of the high abutment loads generated by the secondary extraction process.

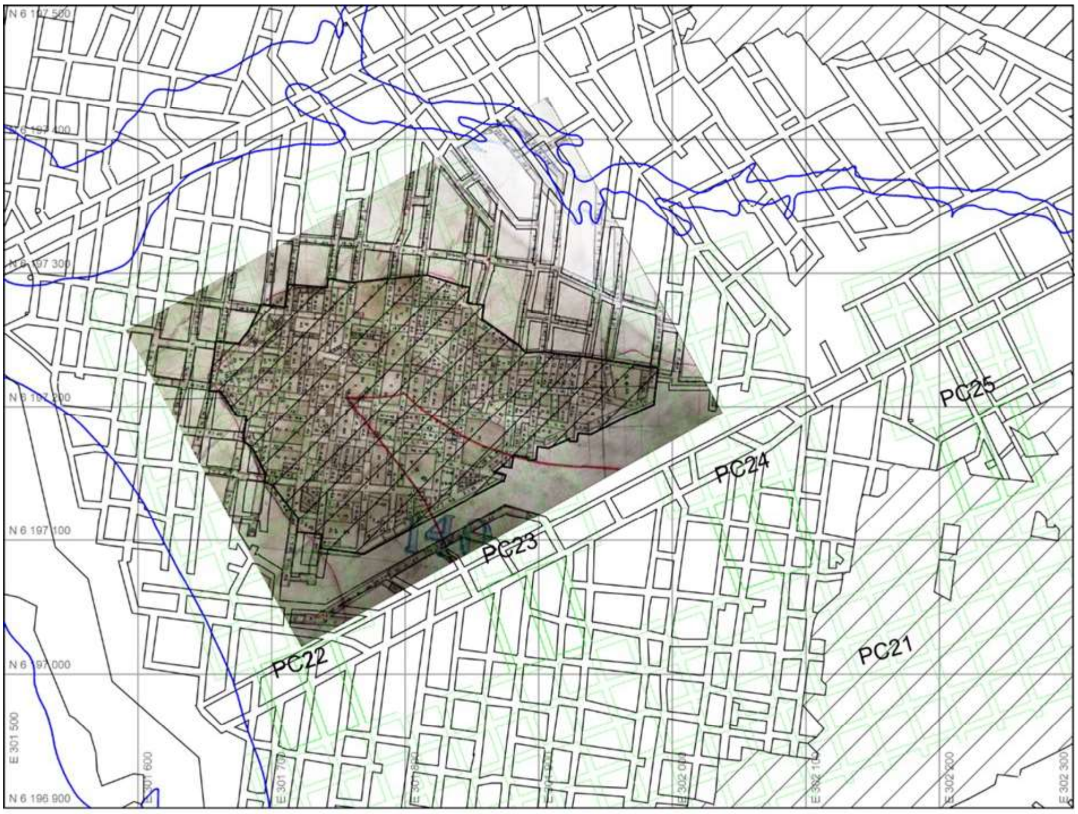
In Area #11, the original mine working plan and record tracing copy indicate the secondary extraction of the first workings pillars was undertaken from 1942 to 1945. Care was taken to show the extraction of pillars and sections of pillars to the limit for secondary extraction around the FSL of Cataract Reservoir allowed at that time. Only two small remnant pillars are shown as not mined, but these are likely to have collapsed at the time of secondary extraction because they are less than 8m wide and 10m long and surrounded by secondary extraction at a depth of 280m. Figure 8 shows sections of the mine working plan and the record tracing copy for Area # 11 demonstrating the reliability of the Bulli Seam records. These are two hand-drawn plans drafted at different times, updated at different intervals, and using different depictions for secondary extraction. Similar records are available for Area #2.

The potential for additional subsidence above these two Bulli Seam goaf areas cannot be eliminated, but this potential exists irrespective of the planned mining and the planned mining is not expected to cause a significant change at the Bulli Seam mining horizon. In the unlikely event that remnant pillars are still standing and were to collapse at the time of mining the Wongawilli Seam below, additional subsidence is expected to be less than 300mm over an area with a radius of approximately 50m.

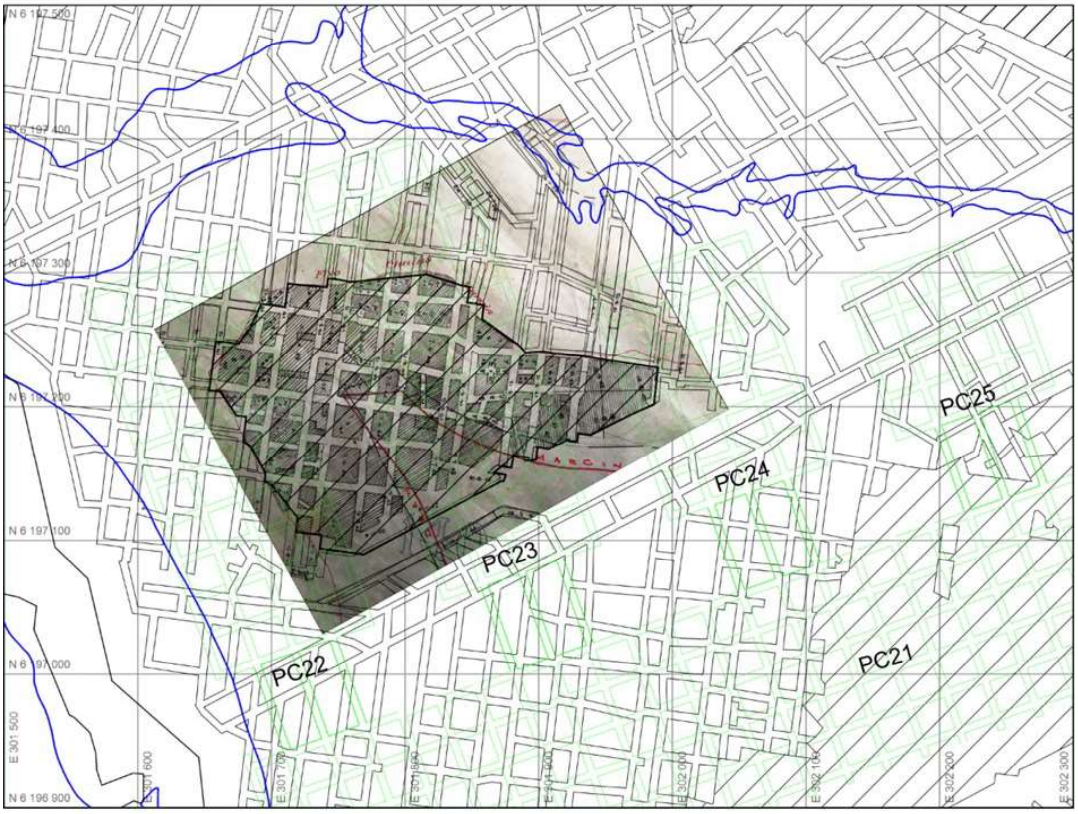
The Bulli Seam first workings layout in the vicinity of planned bord and pillar panels in the PC21-25 EP Area consists of two heading panels and sub-panels. The pillars in the first workings are expected to remain long-term stable because of their large width to height ratios and high factors of safety against instability.

The two parallel headings are separated by long, narrow pillars ranging in width from 12m to 17m. The pillars are typically rectangular in shape with the length being more than 1.5-2.0 times greater than width. Flanking the narrow two heading panels and sub-panels are wider pillars, typically 20m to 30m wide. There is one section of main headings with 10m wide pillars flanked by pillars 40m to 50m wide. Some irregular shaped pillars, including triangular pillars, were formed where the sub-panels intersect the main headings. The width to height ratios for the standing pillars in the PC21-25 EP Area range from generally greater than 5 to greater than 13 and are typically around 9.

Where there are more cut-throughs and smaller pillars, the pillars typically range in width from 17m to 20m and are marginally longer than wide. The depth at this location is approximately 280m. Assuming these pillars are square in shape, are 2.2m high and surrounded by 6m wide roadways, the factor of safety ranges from 1.67 to 2.22 for strong roof and floor conditions typical for the Bulli Seam.



a) Mine working plan of Bulli Seam goaf Area #11.



b) Record tracing of Bulli Seam goaf Area #11.

Figure 8: Example of Bulli Seam mine plan records.

There are some areas where there are narrow (12m) pillars. The 12m wide pillars are generally about 24m long and flanked on both sides by pillars at least 24m wide. Assuming the unlikely scenario that the 12m pillars cannot carry any load, the tributary load of the overburden above these narrow pillars would then be required to be carried by the larger flanking pillars to maintain equilibrium. In this scenario the factor of safety for the 24m square pillars is estimated as greater than 2.8. A greater stability is derived for the 10m wide pillars flanked by pillars at least 40m in width.

Some of the Bulli and Balgownie Seam workings located above the planned bord and pillar panels in the PC21-25 EP Area are likely to be flooded. Assessment of pillar stability for the geometry in both seams indicates that the pillars are expected to remain stable without any reduction in load due the minimal buoyancy effects of the water. That is, if the water is removed to render the inrush hazard harmless, overall stability of pillars in the overlying seams is unlikely to be affected.

4.3 Reliability and Accuracy of Subsidence Forecasts

Maximum vertical subsidence in a single seam mining environment is naturally variable by about 15% for any given panel geometry and overburden depth. In a multi-seam situation, the variability is somewhat greater particularly given the sensitivity of subsidence to the interaction between mining geometries in each seam. For multi-seam mining, performance indicators of 20% greater than maximum forecast values are recommended to provide an alert that subsidence is not tracking as expected while avoiding unnecessary triggering of insignificant events associated with natural variation.

Guidelines for Subsidence Management Approvals recommend assessing impacts at 1, 1.5, 2 or 2.5 times the maximum values forecast for subsidence parameters or 5 times where subsidence is forecast at less than 150mm.

The limited extraction and limited width of individual panels relative to overburden depth makes it difficult for instability in the Wongawilli Seam to cause greater than 100mm of surface subsidence. Maximum convergence at seam level would be 440mm before the roadways became filled (assuming no bulking). The limited panel width and significant depth means that maximum subsidence at the surface would be less than 100mm if the Wongawilli Seam pillars were to totally collapse.

Instability of the overlying Bulli Seam would be possible in those areas where no subsidence has occurred previously. There is potential for up to 1m of subsidence from instability in the overlying Bulli Seam, this potential exists irrespective of any further mining activity. The surface terrain in the general vicinity has historically experienced subsidence of this magnitude and greater following mining in the overlying Bulli and Balgownie Seams. In a bushland environment, such levels of subsidence are barely perceptible.

The main surface features likely to be impacted are upland swamps. The probability of such an event causing loss of a swamp is assessed as "very rare" using the National Emergency Risk Assessment Guidelines (SCT 2020a) and "extremely rare" once Bulli Seam pillars are confirmed as having previously collapsed during the period of active mining. SCT understands that the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) considers these risks to be tolerable.

4.4 Comparisons with Previous Subsidence Forecasts and Consent Subsidence Performance Measures

Condition C10, Part 3 of MP09_0013, requires WCL to prepare an EP for all second workings. The EP must:

- "Provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed mining covered by the EP, incorporating any relevant information obtained since obtaining the consent."

- "Describe in detail the performance indicators that would be implemented to ensure compliance with the performances measures in Tables 5 and 6 (sic) and manage or remediate and impacts and/or environmental consequences to meet the rehabilitation objectives in Table 4 (sic)."

We note that Tables 4, 5 and 6 referred to above have been renumbered in the document as Tables 5, 6 and 7.

This section provides details of:

- The scope of the subsidence assessment for this EP.

- Changes to the subsidence effects forecast since the subsidence assessment (SCT 2019) for the RPUEP was prepared.

- Recommendations for performance indicators for subsidence effects consistent with the subsidence performance measures of the consent.

4.4.1 Basis for EP Subsidence Assessment

The mining plan layout and mining sequence for this EP has been revised from that approved by development consent MP09_0013. This subsidence assessment is for the mining layout shown in Figure 1 and described in detail in Section 3.5.2.

A conservative approach to subsidence forecasts has been adopted for the purpose of impact assessment and compliance thresholds.

4.4.2 Changes to Subsidence Parameters Since RPUEP Subsidence Assessment

The subsidence assessment for the RPUEP was presented in SCT (2019). This assessment was peer reviewed (Hebblewhite 2019a and 2019b). Since then, further information on potential subsidence impacts was sought by the IPC, NSW Department of Planning Industry and Environment (DPIE) and the Australian Government Department of Agricultural, Water and the Environment. Advice was also sought from the IESC and the IAPUM to inform the NSW and Federal Government approval processes for the proposed mining.

The IESC (2019) advice to DPIE concluded further assessment was required to quantify the potential risk to coastal upland swamps from pillar failure. SCT (2020a) responded to this risk assessment requirement. IAPUM (2020) responded to a request for advice from the IPC on the risk assessment for upland swamps and the forecast of subsidence effects more generally with reference to estimated subsidence effects at upland swamps presented in SCT (2014) for the longwall mining proposed at that time.

IAPUM (2020) suggests an upper limit of 300mm for vertical subsidence as a threshold for significant impact to swamps as compared to the more conservative 100mm subsidence used by SCT (2020a) for the quantitative risk assessment. The IPC has included 300mm as a subsidence performance measure in the consent conditions for MP09_0013.

SCT's assessment of the likely maximum subsidence of less than 100mm has not changed, but the maximum subsidence considered tolerable by upland swamps has increased from 100mm to 300mm on the advice of the IAPUM.

4.4.3 Recommendation for Performance Indicators

Most of the categories of subsidence impacts performance measures that require performance indicators are outside the SCT's area of expertise and need to be determined by other specialists.

SCT typically recommends performance indicators for subsidence effects that are generally 20% above the maximum values forecast so that natural variability does not trigger unnecessary reporting procedures for events of no practical consequence. For the non-caving mining method planned where the forecast vertical subsidence levels are low and the upper limit of 300mm has been set as a performance measure, values of 100mm and 250mm are considered appropriate to activate trigger action response plans (TARPs) for the planned mining geometry in this EP.

Similarly, 100mm additional closure from all mining in the Wongawilli Seam, including from Longwalls 4-6, is considered appropriate as a lower valley closure trigger with an upper level of 150mm consistent with the EPBC 21014/7259 approval conditions for the first 400m of Longwall 6. These trigger levels need to be confirmed based on the measurement of valley closure from the final survey for Longwall 6.

5. SUBSIDENCE IMPACT ASSESSMENT

In this section, the potential subsidence impacts are assessed for the various surface features located within the EP Areas for PC07-08 and PC21-25.

5.1 Natural Features

Natural features considered in this section comprise upland swamps, watercourses, sandstone formations and steep slopes, surface landform and groundwater more generally. Figure 4 shows the locations of these surface features.

5.1.1 Upland Swamps

Upland swamps CRUS1, CRUS3, CCUS1, CCUS2, CCUS3, CCUS4, CCUS5, CCUS6, CCUS10, CCUS15, CCUS17, CCUS18, CCUS19, CCUS20, CCUS21 and CCUS23 are located partially or wholly within the EP Areas, but only CCUS1 and CCUS5 are above the planned bord and pillar panels. No significant impacts are expected to any of these features from the planned mining based on specialist advice from the IAPUM. Consequences are expected to negligible in the context of previous impacts.

Sections of the planned PC07 and PC08 bord and pillar panels are below CCUS1 Swamp. Maximum incremental vertical subsidence from the mining in these panels is expected to be much less than 100mm. Tensile strain of 0.5mm/m and tilt of less than 2mm/m is expected from 100mm of vertical subsidence. No significant impacts are expected to CCUS1 Swamp based on specialist advice provided by IAPUM (2020). Parts of CCUS1 Swamp are estimated to have already experienced up to 0.7m vertical subsidence from the mining in the Bulli Seam and 0.8m of subsidence was measured during the mining of the Balgownie Seam longwalls. The total 1.5m subsidence is less than the 2m used in SCT (2014) to estimate maximum strain and tilt values associated with previous mining. For reference, parts of the nearby CCUS6 Swamp are estimated to have experienced up to 3.7m of vertical subsidence from the previous mining in all three seams.

The experience presented in Holla and Barclay (2000) indicates maximum tensile strain of 7.9mm/m and tilt of 26.3mm/m would be expected for 1.5m of subsidence. The actual levels of tilt and strain for most areas of the swamps are likely to be much less than the maximum predictions with the maxima only occurring in small areas where sections of the swamp coincide with the fringes of the subsided areas.

PC21 and PC24-25 bord and pillar panels and sub panels are located below part of CCUS5 Swamp. Parts of this swamp are also located over areas of existing first workings and part of Bulli Seam goaf Area #2. The potential for additional subsidence above some of Area #2 cannot be completely eliminated, but this potential exists irrespective of the planned mining. In the unlikely event that remnant pillars are still standing and were to collapse, additional subsidence is expected to be less than 300mm over an area with a radius of approximately 50m. Parts of CCUS5 Swamp that are confirmed as fully subsided are likely to have already experienced vertical subsidence from the mining in the Bulli Seam of up to 0.6m with associated maximum tensile strain of 3.3mm/m and maximum tilt of up to 11mm/m.

Maximum incremental subsidence from planned mining of PC21 and PC24-25 bord and pillar panels is expected to be less than 100mm. Maximum tensile strains of approximately 0.5mm/m and tilt of less than 2mm/m are expected. Any changes to the surface from the levels of tilt expected are unlikely result in flow patterns that would significantly increase erosion within a swamp. No significant impacts are expected to CCUS5 Swamp based on specialist advice provided by IAPUM (2020

5.1.2 Watercourses

First, second, third and fourth order streams cross the EP Areas but only first and second order tributaries of Cataract Creek and a first order tributary of Cataract River are located above the planned bord and pillar panels. No significant additional subsidence impacts are expected to these watercourses. Impacts and consequences are expected to be negligible in the context of previous impacts.

First and second order tributaries of Cataract Creek, remote from the main channel, traverse the surface above PC07 and PC08. Incremental vertical subsidence of up to 100mm with low-levels of tilt and strain is expected along these tributaries from the planned bord and pillar mining. No significant additional impacts are expected.

Two first order tributaries of Cataract Creek cross over PC21 and a first order tributary of Cataract River crosses above PC21 and PC22. The two first order creeks above PC21 flow from swamps CCUS4 and CCUS5 down the steeper terrain to Cataract Creek. The first order creek above PC21 and PC22 flows into Cataract River. There are no creeks above Bulli Seam goaf Area #11.

The two first order creeks that cross PC21 are likely to have been previously subsided by approximately 0.2m and up to 0.8m from secondary extraction in the Bulli and Balgownie Seams, respectively. Maximum incremental subsidence from the mining in this panel is expected to be less than 100mm with low levels of tilt and strain. No significant additional impacts are expected.

The first order tributary of Cataract River is above first workings in the Bulli Seam and unlikely to have experienced any substantial vertical subsidence in the past. Incremental vertical subsidence of up to 100mm with low-levels of tilt and strain is expected from the mining of PC21 and PC22.

No significant impacts are expected to watercourses from any additional cracking or erosion from the low levels of subsidence effects forecast.

5.1.3 Sandstone Formations

There are no definitions for cliffs and steep slopes included in the consent conditions of MP09_0013. For the purposes of this assessment cliffs are defined as sandstone formations or rock faces greater than 10m high, consistent with contemporary definitions and steep slopes are defined as extended slopes, that are not sandstone formations, with an average slope of greater than 1 in 1.

There are several sandstone formations within the EP Areas. These are all less than 10m high. There are no sandstone formations greater than 5m in height above the planned bord and pillar panels. There are no areas above the planned bord and pillar panels considered to be steep slopes.

No significant, additional impacts to sandstone outcrop formations (including Aboriginal heritage rock shelter sites) or instability of steeper ground is expected from the low level subsidence effects forecast. Impacts and consequences are expected to be negligible in the context of previous impacts.

Subsidence warning signs, restricting access where possible, and regular inspections before and after active mining in Land and Heritage Management Plans are considered appropriate measures to monitor and limit exposure to potential subsidence impacts.

The nearest cliff to the EP Areas is Brokers Nose on the Illawarra Escarpment, more than 1.3km from PC07. No impacts from the planned mining are expected at Brokers Nose. The Illawarra Escarpment and Brokers Nose are protected from any pillar run potential by the barriers of solid coal remaining in the Bulli Seam on either side of the Main West Headings and the unworked panel to the east of Longwall 1 in the Balgownie Seam and the larger coal pillars of the main headings in all three seams. The coal barrier pillars adjacent to the Main West and Main Northwest Headings are those used as the eastern boundary for the additional subsidence management area in the subsidence management plan approval for the Wongawilli Seam Longwalls 4 and 5.

The battered road cuttings for Mount Ousley Road located on the northern side of the Cataract Creek are outside the EP Areas and more than 500m from PC07. No perceptible impacts to these features are expected from the planned mining.

5.1.4 Surface Landform

Ongoing low-level horizontal movements of the slope on the south side of Cataract Creek, a legacy of the previous mining on site, are expected to continue irrespective of the planned mining. This movement is likely to result in small increases in tensile cracking along the topographic high point, the crest/ridgeline between the Cataract River and Cataract Creek valleys, minor cracks on the slope and valley compression closure across Cataract Creek.

Inspection of the main channel of Cataract Creek indicates that there is almost no physical disturbance to the rock strata in the bed of the creek despite previous mining activity in three seams. Geological mapping indicates that this section of the creek flows across outcrops of the Bald Hill Claystone and Bulgo Sandstone immediately below it. These strata units appear more tolerant of valley closure movement than Hawkesbury Sandstone.

This level of impact to the creek may change in the future regardless of any further mining. The basal shear plane is at limiting equilibrium (on the verge of moving) as a legacy of previous longwall mining. Only very small changes, such as changes in pore pressure caused by high intensity rainfall events, are required to cause further movement.

The main impacts from this ongoing movement are closure of the pavement, compression of the culverts at Cataract Creek and stretching at the top of the ridge to the south. These impacts and management measures are discussed in Section 5.3.

5.1.5 Groundwater

The planned first workings and bord and pillar mining in the Wongawilli Seam below existing Bulli and Balgownie Seam workings are not expected to significantly alter the current groundwater regime. The overburden strata is already depressurised to various heights from the previous secondary extraction mining. Groundwater levels are expected to respond more to weather patterns than to the planned mining. Any additional impacts to groundwater are expected to be negligible and limited to only in the immediately vicinity of the Wongawilli Seam.

5.2 Heritage Sites

In this section, the potential subsidence impacts to Aboriginal heritage features located within the EP Areas are assessed. There are no historical heritage items in or within the vicinity of the EP Areas.

Figure 4 shows the locations of six rock shelter sites (52-3-0323, 52-3-0325, 52-2-4170, 52-24171, 52-2-3940 and 52-2-3941) within the EP Area for PC21-25. No aboriginal heritage sites are located above the EP Area for PC07-08.

Of the six sites, only 52-3-0325 is located over the planned bord and pillar panels. This rock shelter with art and deposit is located above PC21 and has already been mined under by the workings in the Bulli Seam but not the Balgownie Seam. Site 52-3-0325 is positioned above the already confirmed as collapsed Bulli Seam goaf Area #2 where approximately 0.3m of subsidence is estimated to be occurred.

In this location, the site is expected to experience less than 100mm of vertical subsidence and corresponding level of compressive strain from the mining in PC21. No significant impacts to this detached boulder type feature are expected at this location. Any impacts and consequences are expected to be negligible in the context of previous impacts.

Site 52-3-0323 is located above a solid coal barrier pillar in the Bulli Seam workings of Corrimal Colliery. The barrier pillar is approximately 120m wide below the FSL of the Cataract Reservoir. Previous subsidence at this site is estimated at less than 0.1m. This location is more than 100m from PC21. No perceptible subsidence effects or impacts are expected at this location from the planned mining in the EP Area for PC21-25.

Sites 52-2-4170 and 52-2-4171 are located on the northern side of Cataract Creek above first workings in the Bulli and Balgownie Seams. Previous subsidence at these sites is estimated at less than 0.1m. These locations are more than 150m from PC21 on the northern side of Dyke D8. No perceptible subsidence effects or impacts are expected at these locations from the planned mining in the EP Area for PC21-25.

Sites 52-2-3940 and 52-2-3941 are located further north on the edge of the EP Area beyond the extent of the Balgownie Seam workings. Site 52-2-3940 is located above Bulli Seam first workings where previous subsidence is estimated at about 0.1m. Site 52-2-3941 is located above the edge of Bulli Seam goaf Area#10 where previous subsidence is estimated at approximately 0.2m. Both these sites are more than 300m from PC24 on the northern side of Dyke D8. No perceptible subsidence effects or impacts are expected at these locations from the planned mining in the EP Area for PC21-25.

Subsidence warning signs, restricting access where possible, and inspections before and after active mining as detailed in the Heritage Management Plan (HMP) are considered appropriate measures to monitor and limit exposure to potential mining related hazards during the planned mining in the EP Area for PC2125.

5.3 Built Features and Infrastructure

Built features are shown in Figure 4. Public utilities identified within the EP Areas or in positions with potential to be affected include: Mount Ousley Road, the Cataract Storage Reservoir and overhead electricity transmission lines. Minor infrastructure is limited to unsealed access road/four-wheel drive tracks and survey control stations. There are no public amenities, farmland and facilities, industrial, commercial and business establishments, residential establishments, or items of architectural significance.

5.3.1 Mount Ousley Road

Mount Ousley Road (or M1 Princes Motorway) traverses the EP Area for PC07 and PC08 from the Cataract Creek crossing in the north to the ridgeline between Cataract River and Cataract Creek in the south. The planned PC07 and PC08 bord and pillar panels are immediately adjacent to a section of the road easement that was realigned soon after being impacted by subsidence from Longwall 7 in the Balgownie Seam. As well as the developments for PC07 and PC08, two underground access roadways are planned to pass below Mount Ousley Road remote from PC07 and PC08.

Vertical subsidence of approximately 30mm is expected from the planned mining. This level of subsidence is expected to be generally imperceptible and of a similar magnitude to the subsidence experienced on the road alignment during the nearby mining of Wongawilli Seam longwall panels. The difference between the planned mining and the earlier longwall mining is that there will no longer be any large-scale subsidence below the adjacent terrain. Horizontal movements associated with the planned mining will therefore be much less than the small ongoing movements associated with longwall mining. The magnitude and rate of these movements has not been measured since longwall mining ceased but will be determined when the first surveys are conducted as required within the existing Built Features Management Plan (BFMP) for the Mount Ousley Road.

Impacts to the road pavement, culverts and cuttings/embankments are expected to be minor and manageable within the existing risk control measures and the subsidence management plans currently in place. Subsidence monitoring required within the Built Features Management Plan (BFMP) required by the EP for the Mount Ousley Road in consultation with NSW Roads and Maritime Services (RMS) is expected to be appropriate to manage subsidence impacts to Mount Ousley Road. It is envisaged the BFMP would be developed through consultation and agreement with the asset owner to the required standards and the process would include a risk assessment conducted to relevant standards,

Impacts to the pavement surface include tension cracks at the crest/ridgeline and on the slope down to Cataract Creek and a compression hump at the Cataract Creek crossing. The potential for this closure to impact the safety of road users was previously identified and actioned by the installation of a slot across the pavement surface to mitigate the hazard of closure from horizontal movements.

Impacts to the culverts for the creek from ongoing closure movements are expected to be minor, manageable, and repairable if required. Impacts to embankments from small differential movements are expected to generally be insignificant but repairable if required. No perceptible impacts to cuttings are expected as these features are remote from the planned mining.

5.3.2 Electricity Transmission Lines

There are four overhead electricity transmission lines to the east of Mount Ousley Road. These comprise a 330kV and 132kV powerline in the same easement and two 33kV powerlines further to the east. The 330kV and 132kV powerlines owned by TransGrid and Endeavour Energy, respectively are located at the east of the PC07-08 EP Area. These powerlines are more than 150m to the east of the planned PC07 and 08 bord and pillar panels. The pylon structures that support the conductors of these powerlines are also not above any of the planned first workings in the EP Area for PC07-08.

No perceptible subsidence effects or impacts from the planned mining are expected at the towers, however, consultation with the asset owners and monitoring of the structures during the period of active mining in the PC07-08 EP Area consistent with the BFMP is recommended. It is envisaged the BFMP would be developed through consultation and agreement with the asset owners to the required standards and the process would include a risk assessment conducted to relevant standards.

Research from aerial photography indicates the 330kV and 132kV powerlines were constructed between 1951 and 1961, after the Bulli Seam extraction but before Longwall 3 in the Balgownie Seam was mined in 1972.

Towers T54 and E69 were constructed above a Bulli Seam goaf area mined circa 1914. Towers T55 and E68 are located above the Bulli Seam solid coal barrier on the southern side of the Main West Headings. Towers T56 and E67 are above Longwall 3 in the Balgownie Seam. Towers T57 and E66 are located above the main heading pillars of the Bulli Seam (Main Northwest Headings) and Balgownie Seam and above solid coal adjacent to the main headings in the Wongawilli Seam. The coal barrier pillars adjacent to the Main West and Main Northwest Headings are those used as the eastern boundary for the additional subsidence management area in the subsidence management plan approval for the Wongawilli Seam Longwalls 4 and 5.

The two towers above Longwall 3, Towers T56 and E67, have experienced significant subsidence movements since their construction. Maximum subsidence of 1.3m was measured above the centre of Longwall 3. The towers are located near the panel edges. T56 is estimated to have experienced 0.6-0.8m of vertical subsidence and E67 is estimated to have experienced 1.0m of vertical subsidence. We understand neither tower was replaced following these subsidence movements suggesting that the four legs of each tower are located within the same block of sandstone strata. Cracks are reported to have occurred nearby supporting this hypothesis. Any further subsidence would be expected to localise on the existing fractures (cracks) formed during mining of the Balgownie Seam. The tower legs are all anchored to the same block of sandstone so that the structural integrity of the tower is protected. Nevertheless, Towers T56 and E67 are expected to require a structural engineering review as part of a risk assessment prior to any future mining.

Towers T54, T55, T57, E66, E68 and E69 are not expected to have previously experienced significant subsidence movements by virtue of their position, timing of construction and the protection provided by the remaining coal barriers, but are expected to be included in the risk assessment before any future mining.

5.3.3 Cataract Storage Reservoir

All planned mining in the PC21 and PC22-25 EP Area is within the Notification Area for Cataract Storage Reservoir. The planned mining layout includes mining up to directly below the FSL of the reservoir. The revised mining plan for the EP is expected to require consent from Dams Safety NSW (DSNSW) and the approval of the Chief Inspector of Coal Mines.

The expected subsidence effects and impacts from the planned mining within the Notification Area are expected to be tolerable to Dams Safety NSW. Any changes to water quantity flowing into the mine are expected to be negligible and no additional conductive cracking is expected. No changes to water quality are expected.

A detailed risk and engineering assessment consistent with DSNSW guidelines is expected to be required before any further mining within the Notification Area is conducted. The mining consent/approval is expected to require a detailed underground mine water balance measurement system to be implemented and maintained. The underground mine water balance monitoring system is expected to be effective as a guide to any unexpected inflows from the reservoir. The underground mine water balance reviewed in SCT (2021) indicates that there is no significant flow from the reservoir into the mine workings.

5.3.4 Access Road/Four-Wheel Drive Tracks

Several unsealed access road/four-wheel drive tracks cross the edge of the PC07-08 EP Area. These access roads are on land owned by WCL and Water NSW and entry to these roads is controlled by locked gates. These tracks provide access from the crest/ridgeline on Mount Ousley Road, to and along the high voltage powerline easements, and to the telecommunications installation at Brokers Nose. These are not recognised fire roads but may be used for bushfire control purposes.

No additional subsidence effects or impacts are expected to be perceptible from the planned mining. Regular inspections during active mining, and timely remediation are considered appropriate management measures in the unlikely event of any impacts or changes to the surface being observed. Including these measures in the Land and Public Safety Management Plan is recommended.

5.3.5 Survey Control Stations

There are four survey control stations within the EP Area for PC07-08. Permanent marks PM173136, PM173135 and state survey mark SS165830 are positioned along the Mount Ousley Road easement from north the south. State survey mark SS14867 is positioned in the south of the EP Area some 200m to the east of PC07.

State survey marks are designed to be stable reference points. Ground movements caused by mining subsidence have potential to move the position of these marks. Reference to a mark displaced by mining subsidence could, in certain circumstances, have significant consequences. All four marks are likely to have been disturbed by the previous and ongoing subsidence movements at RVE. Although the subsidence movements at these marks from planned mining are expected to be of low magnitudes, subsidence impacts nevertheless need to be managed.

A BFMP that includes a process to manage impacts to survey marks is recommended. A practical way to manage subsidence impacts from mining on survey control stations is to notify the asset owner to temporarily decommission marks that may be affected. Once the subsidence effects have taken place and the position of marks known to have stabilised, the horizontal and vertical position of the marks are re-established, and they are returned to service with revised coordinates and height.

5.4 Public Safety

The only potential risk to public safety associated with the planned mining is expected to be from impacts to Mount Ousley Road and the electricity transmission lines.

Any potential impacts to Mount Ousley Road and risks to public safety are expected to be manageable within a BFMP developed in consultation with RMS. A BFMP like that used successfully to manage impacts for the previous longwall mining in the Wongawilli Seam is expected to be suitable.

Planned mining is not expected to cause perceptible subsidence effects or impacts to the powerlines, so no additional risk to public safety is expected. However, including monitoring of the powerlines during the period of active mining in a BFMP is considered an appropriate risk control measure for this infrastructure.

A Public Safety Management Plan (PSMP) that includes reference to the risk control measures for public safety in the BFMP and Land and Heritage Management Plan is recommended.

6. SUBSIDENCE MONITORING

Subsidence monitoring is recommended to manage operational, personal, and public safety risks and to address the specific requirements of MP09_0013 conditions including those detailed in the subsidence monitoring program.

The aim of this monitoring is to:

- Provide data to assist with the management of the risks associated with subsidence.
- Confirm the status of Bulli Seam goaf areas.
- Validate subsidence forecasts.
- Provide a basis to analyse the relationship between the forecast and actual subsidence effects and impacts including any environmental consequences.
- Ensure compliance with subsidence performance measures.
- Inform adaptive management process for compliance with performance measures.
- Collect sufficient baseline data for future mining applications.
- Enhance general understanding of subsidence behaviour at RVE.

An overview of the recommended monitoring approach to satisfy these aims is presented here. The full details are provided in a revised subsidence monitoring program required by Condition C10 (g) (i) of MP09_0013, relevant guidelines and legislated standards.

Conventional subsidence monitoring is not suitable to confirm the low levels of subsidence expected in the bushland environment at RVE. The requirement to minimise disturbance to the bushland conflicts with the need to develop a well-controlled survey network for subsidence monitoring in the steep terrain above the site.

A continuous, high-accuracy ground-based array of monitoring points combined with a broad-area remote monitoring system is considered the best option. The high-accuracy ground-based points are planned to be located at suitable locations above planned mining and on adjacent high-value infrastructure to confirm the low-level ground movements expected. Broad-area remote monitoring is planned across the entire area to check for unexpected movements, particularly any that may be associated with instability of remnant pillars in Bulli Seam goaf areas.

A commercially available GNSS (GPS) system can be installed at single points over the mining panels and in or on specific natural or built features. The location in three dimensions of these points can be continuously monitored and made available on the internet in real time to interested parties. To be effective, the units require clear access to the sky for GNSS signals, mobile phone coverage, and solar power. The GNSS units can continuously record position in three dimensions to better than ±10mm accuracy. The units can be programmed to provide a record of positioning data to track trends and trigger levels can be set to alert of any exceedances.

Installing these units at suitable locations above the initial panels, adjacent to the Mount Ousley Road and on adjacent electricity pylons is recommended. The number and spacing of GNSS units and the frequency of LiDAR surveys needs to be confirmed in consultation with the supplier of the units and the infrastructure owners.

Broad-area monitoring could be undertaken using airborne LiDAR (Light Detection and Ranging) or dInSAR (satellite based differential synthetic aperture radar).

LIDAR is expected to produce surveys with a tolerance of ±150mm, potentially resulting in up to 300mm difference between two surveys. Pre-mining surveys exist already and could be re-flown at regular intervals during mining to confirm there have been no subsidence events associated with instability of the Bulli Seam workings.

Satellite monitoring using dInSAR is expected to be accurate to a few centimetres on hard surfaces, but experience indicates it tends to be affected by ground cover vegetation. The dInSAR monitoring could provide deformation updates (changes to the surface topography) annually for instance or more regularly if required.

Continuation of the existing systems of closure monitoring across Cataract Creek including closure slot monitoring on the Mount Ousley Road pavement, culvert surveys and survey closure monitoring at four cross-sections is recommended. Monitoring of the Picton Road interchange bridge is not considered necessary, and this monitoring could be discontinued in consultation with RMS. Periodic ground surveys and inspections of the relative positions of individual legs of powerline towers is recommended with a program developed in consultation with the asset owners.

The proposed GNSS and remote sensing techniques like LiDAR surveys are expected to be able to identify the subsidence effects in all areas above and adjacent to the proposed Wongawilli Seam first workings, including Bulli Seam goaf areas yet to be confirmed as collapsed.

Underground geotechnical mapping of changes to the observed vertical and horizontal stress conditions, around the edges of the areas shown as goaf on the original Bulli Seam mine working plans and record tracing copies, is expected to be a strong indicator of the status of Bulli Seam goafs. There are currently seven Bulli Seam goaf areas that are likely to have collapsed but there is no direct evidence to confirm this collapse. Underground observations of roadway condition in the Wongawilli Seam are considered a reliable technique to confirm these areas have collapsed. Once all seven areas are confirmed as collapsed, the scale of the broad-area monitoring could be reduced.

The proposed mining method is flexible compared to longwall mining and easily adaptable to unexpected or unfavourable mining conditions. Adaptive management practices including TARPs would allow for immediate changes to the mining layout in response to changes in mining conditions, risk profiles and potential impacts.

In addition to incident reporting (e.g. a TARP exceedance), the 'Guidelines for the Preparation of Extraction Plans' requires subsidence impact reporting on a bi-monthly (every two months), six-monthly and annual basis. Subsidence effects monitoring results are required in the annual report.

The subsidence monitoring program is expected to include, amongst other things, provisions to ensure the mine operator manages risks to health and safety associated with subsidence as required by Clause 67 of *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.*

Clause 67 (2), requires:

b) monitoring of subsidence to be conducted, including monitoring of its effects on relevant surface and subsurface features

c) any investigation of subsidence and any interpretation of subsidence information is carried out only by a competent person.

On this basis, it is suggested that subsidence effects and impacts are reviewed and validated for compliance with forecast by a competent person and reported at the end of a panel (or significant milestone in mining of the underground layout) and/or annually as a minimum.

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APPENDIX 1 – THE EP/SMP APPLICATION GUIDELINES LIST OF SURFACE FEATURES TO BE CONSIDERED IN A SUBSIDENCE ASSESSMENT

Table A1: The EP/SMP Application Guidelines List of Surface Features to be Considered in a Subsidence Assessment

Natural Features	Within EP Area	Relevant Section
1) Catchment areas and declared Special Areas;	**Y**	*3.1, 3.4*
2) Rivers and creeks;	**Y**	*3.6.1, 5.1.2*
3) Aquifers, known groundwater resources;	**Y**	*3.6.1, 5.1.5*
4) Springs;	**N**	
5) Sea/lake;	**N**	
6) Shorelines;	**N**	
7) Natural dams;	**N**	
8) Cliffs / pagodas;	**Y**	*3.6.1, 5.1.3*
9) Steep slopes;	**Y**	*3.6.1, 5.1.3*
10) Escarpments;	**N**	
11) Land prone to flooding or inundation;	**N**	
12) Swamps, wetlands, water related ecosystems;	**Y**	*3.6.1, 5.1.1*
13) Threatened and protected species;	**Y**	
14) National parks;	**N**	
15) State conservation areas;	**N**	
16) State forests particularly areas zoned FMZ 1, 2 and 3;	**N**	
17) Natural vegetation;	**Y**	*3.1, 3.6.1*
18) Areas of significant geological interest, and	**N**	
19) Any other feature.	**N**	
Public Utilities		
1) Railways;	**N**	
2) Roads (all types);	**Y**	*3.6.2, 5.3.1*
3) Bridges;	**N**	
4) Tunnels;	**N**	
5) Culverts;	**Y**	*5.1.4, 5.3.1*
6) Water/gas/sewerage pipelines;	**N**	
7) Liquid fuel pipelines;	**N**	
8) Electricity transmission lines (overhead/underground) and associated plants;	**Y**	*3.6.2, 5.3.2*
9) Telecommunication lines (overhead/underground) and associated plants;	**N**	
10) Water tanks, water and sewage treatment works;	**N**	
11) Dams, reservoirs and associated works;	**Y**	*3.6.2, 5.3.3*
12) Air strips,	**N**	
13) Any other infrastructure items.	**N**	
Public Amenities		
1) Hospitals	**N**	
2) Places of worship	**N**	
3) Schools	**N**	
4) Shopping centres	**N**	
5) Community centres	**N**	
6) Office buildings	**N**	
7) Swimming pools	**N**	

Public Amenities	**Within EP Area**	**Relevant Section**
8) Bowling greens	**N**	
9) Ovals and cricket grounds	**N**	
10) Racecourses	**N**	
11) Golf courses	**N**	
12) Tennis courts	**N**	
13) Any other amenities considered significant	**N**	
Farm Land and Facilities		
1) Agricultural utilisation or agricultural suitability of farmland;	**N**	
2) Farm buildings / sheds;	**N**	
3) Gas and / or fuel storages;	**N**	
4) Poultry sheds;	**N**	
5) Glass houses;	**N**	
6) Hydroponic systems;	**N**	
7) Irrigation systems;	**N**	
8) Fences;	**N**	
9) Farm dams;	**N**	
10) Wells, bores, and	**N**	
11) Any other feature.	**N**	
Industrial, Commercial and Business Establishments		
1) Factories;	**N**	
2) Workshops;	**N**	
3) Business or commercial establishments;	**N**	
4) Gas and / or fuel storages and associated plants;	**N**	
5) Waste storages and associated plants;	**N**	
6) Buildings, equipment and operations that are sensitive to surface movements;	**N**	
7) Surface mining (open cut) voids and rehabilitated areas;	**N**	
8) Mine infrastructure including tailings dams and emplacement areas, and	**N**	
9) Any other feature considered significant.	**N**	
Areas of Archaeological and/or Heritage Significance	**Y**	
Items of Architectural Significance	**N**	
Permanent Survey Control Marks	**Y**	*3.6.2, 5.3.5*
Residential Establishments	**N**	
1) Houses;	**N**	
2) Flats / Units;	**N**	
3) Caravan parks;	**N**	
4) Retirement/aged care villages;	**N**	
5) Associated structures such as workshops, garages, on-site waste water systems, water or gas tanks, swimming pools and tennis courts, and	**N**	
6) Any other feature considered significant.	**N**	

APPENDIX 2 – SUBSIDENCE IMPACT PERFORMANCE MEASURES

Feature	Performance Measures
Watercourses	
Watercourses, including Cataract River, Cataract Creek and associated	• Negligible subsidence impacts or environmental consequences including o Negligible diversion of flows or changes in the natural drainage behaviour of pools. o Negligible increase in waters cloudiness. o Negligible increase in bank erosion and o Negligible increase in sediment load
Water Supply	
Cataract Reservoir	• Negligible leakage from reservoir • Negligible reduction in water quality of reservoir • No connective cracking between the reservoir surface and the underground workings
Land	
Cliffs, steep slopes and rock face features	• Negligible environmental consequences (including subsidence induced rockfalls, displacement or dislodgement of boulders or slabs or fracturing)
Swamps	
Upland swamps identified in the figure in Appendix 5	• Negligible environmental consequences including negligible change to the structural integrity of the bedrock base or any controlling rockbar of swamp.
Biodiversity	
Threatened species, threatened populations, or endangered ecological communities	• Negligible environmental consequences
Heritage Sites	
Aboriginal heritage sites identified in the figure in Appendix 6	• Negligible subsidence impacts and environmental consequences • Negligible loss of heritage value
Historic heritage sites identified in the figure in Appendix 7	• Negligible subsidence impacts and environmental consequences • Negligible loss of heritage value
Other Aboriginal and historic heritage sites	• Negligible subsidence impacts and environmental consequences • Negligible loss of heritage value

Feature	Performance Measures
Mine workings	
First workings and Second workings	• To remain long-term stable and non-subsiding
Key Public Infrastructure	
M1 Princes Motorway (formally known as Mount Ousley), electricity transmission lines and towers (330kV, 132kV, 2x33kV) and telecommunications line	• Always safe and serviceable • Damage that does not affect safely or serviceability must be fully repairable and must be fully repaired.
Other Infrastructure	
Access roads, fire trails and other public infrastructure and built features	• Always safe. • Serviceability should be maintained wherever practicable. • Loss of serviceability must be fully compensated. • Damage must be fully repairable and must be fully repaired or else replaced or fully compensated.
Public Safety	
Public Safety	• Negligible additional risk
Vertical Subsidence	
All areas of the site affected by the development	• Vertical subsidence limit of not more than 300mm

APPENDIX 3 – RELIABILITY OF MINE PLAN RECORDS FOR RUSSELL VALE EAST

The planned mining at Russell Vale East (RVE) is in an area where previous mining has occurred in two overlying seams. Staunton (1998) stressed in the formal investigation report into the accident that occurred at Gretley Colliery how additional care is required to understand the potential for seam interaction effects when mining in the vicinity of previous workings. He found it is incumbent on the mine manager and mine surveyor to undertake research into the adequacy of the plans of previous mining to enable identified hazards to be managed safely. These findings have subsequently been translated in the legal requirements detailed in the WHS (Mines and Petroleum Sites) Regulations 2014.

This appendix presents our research into the reliability of Bulli Seam mine plan records. This research is undertaken from the perspective of residual risk for greater than predicted subsidence from unstable pillars remaining as undocumented remnant pillars in areas depicted as goaf or as marginally stable pillars identified on the mine working plan. The research is for the greater RVE area but with more focus on the areas associated with the EP for PC07-08 and PC21-25 including areas where the Balgownie Seam longwalls were extracted. The research does not include consideration of inrush from overlying seams, which SCT understands will be addressed separately by Wollongong Coal and is outside the scope of the work described in this document.

SCT has expertise in geotechnical and multi-seam subsidence engineering as well as over 40 years' experience in mine surveying and drafting. These skills have been applied directly and indirectly to researching the reliability of the mine plan records for RVE. We believe the findings of the research to be true and accurate, but we note that this research does not obviate the responsibilities of the mine manager and mine surveyor under the WHS (Mines and Petroleum Sites) Regulation 2014. An independent review of the data by the mine manager and mine surveyor is recommended.

This document details the research conducted and the basis for the conclusions reached. The research includes:

- Examination of detailed mine plans held by:
    - Wollongong Coal
    - Department of Mineral Resources
    - University of Wollongong Library - Archives
    - Wollongong City Library – Local Studies
    - Other historical groups

- Consideration of subsidence measurements conducted during mining of the Balgownie Seam longwall panels with insight provided by multi-seam mining at Ashton Underground Mine.

- Drilling of multiple holes, from underground and the surface, to confirm the location and status of overlying workings.

- Visual inspections of underground workings in the two overlying seams.

- Observation of seam interaction effects associated with mining in the Wongawilli Seam.

- Consideration of pillar sizes required to maintain stability under the overburden loads, goaf edge loading and chain pillar loading from overlying seams and the potential for these to contribute to a pillar run.

The integrity of the mine plans is improved because the three seams of mining are all within the same colliery and the mine records for the areas of interest are complete throughout the period of mining.

The research has been conducted for the RVE area in its entirety. The eastern area of interest to the current EP is located almost entirely below Balgownie Seam goaf where subsidence records are available and sensitive infrastructure to the east is protected from multi-seam interaction by solid coal pillars associated with main heading developments. The western area of interest to the current EP is located remote from sensitive surface infrastructure. The interaction issues associated with the broader area of the RVE will be addressed in subsequent EP's with the benefit of subsidence information gathered by the planned mining in the current EP areas. The sequence of mining the western area first is expected to provide further confirmation of ground behaviour.

A3.1 Introduction

There have been many references during the UEP environmental impact assessment process to the reliability of the historical mine plan data for RVE and the risk resulting from any uncertainty and assumptions based on poorly defined or unknown information. Reliability, in this situation, refers to accuracy, completeness and the somewhat subjective, percentage of extraction of the coal seam depicted by the drafting standards of the plans.

SCT has expertise in geotechnical and multi-seam subsidence engineering as well as experience in mine surveying and drafting and have been indirectly or directly involved in research into the reliability of the mine plan records at RVE since 2010. The initial investigations were into the origin and transformation process for the creation of the digital (electronic) plans for the Bulli and Balgownie Seam used in the management of daily operations, for mine planning and subsidence prediction and assessment purposes. The results of these initial investigations were presented to Dams Safety NSW (previously Dams Safety Committee - DSC) and Roads and Maritime Services (RMS - previously Roads and Traffic Authority - RTA) prior to the commencement of longwall mining in the Wongawilli Seam adjacent to Mount Ousley Road and the Cataract Storage Reservoir.

Our research indicates that the Balgownie Seam records are of a high quality and reliability having been drafted or converted to the standards of the 1976 survey and drafting instructions for coal mine surveyors. These records provide relevant information regarding mining heights and implications for the inferred status of the overlying Bulli Seam workings from interpretations of the subsidence monitoring conducted for the Balgownie Seam longwalls.

Our research is based on review of the mine workings plans (original and redrafted versions) held by WCL, the recording tracing hand drawn copies of the plans (from circa 1948), a plan from 1903 and annual production plans for the years 1911, 1912, 1913, 1916, 1917 held in the University of Wollongong library archives and the recently discovered (May 2021) mine working plan held by the AusIMM – Illawarra Branch – Mineral Heritage sub-committee. This mine working plan, in combination with the others held by WCL, provides the details, missing on some later mine working plans and the record tracings, for mining within all the Bulli Seam areas shown as goaf above or in the vicinity of the planned bord and pillar mining in the Wongawilli Seam at RVE.

Observations from subsidence monitoring, borehole drilling and other investigations are included.

This appendix is structured to include relevant points in background information on:

- The evolution of mining layouts in NSW.
- The history of surveying for and drafting of mine plans.
- The correlation of Bulli Seam records with Balgownie Seam records.
- A review of the Balgownie Seam vertical subsidence measurements in the context of latest understanding of the mechanics of multi-seam subsidence.
- Details of other investigations into or observations of the status of the Bulli Seam workings.

The appendix provides a review of the mine plans for accuracy, completeness and percentage extraction or likelihood of remnant pillars in goaf areas that may affect subsidence outcomes.

A3.2 Conclusions

Our research indicates that the detail of the historical Bulli Seam and Balgownie Seam mining is now available for all areas of interest to the currently planned Wongawilli Seam mining in RVE. The complete details for the goaf areas recorded at the time of mining can be pieced together by combining all information shown on the from the mine workings and record tracings. The interpretation and assumptions made by SCT in previous assessments of pillar stability at RVE are consistent with this detail.

Our review of the available evidence indicates the Bulli Seam records are accurate, complete and the only remaining uncertainty is in the percentage extraction as shown by the drafting standards. This uncertainty is common for all historical mine plans and reflects the ‘artistic licence’ of the surveyors and draftsmen of the day. This artistic licence is still common practice in pillar extraction mining using continuous miners including the depiction of stook ‘X’ in Wongawilli system mining.

It is not considered practical to drill boreholes across the entire area of Bulli Seam goafs to confirm the status of each of these areas. This view is also recognised by the IAPUM (2020). Other methods are likely to be more effective. Geotechnical mapping of mining conditions in the Wongawilli Seam is expected to provide clear evidence of the presence of goaf edges in the Balgownie and Bulli Seams and any load bearing remnant pillars remaining in the Bulli Seam goaf areas.

The subsidence monitoring data from the Balgownie Seam longwall mining indicates consistent incremental vertical subsidence. The variation in subsidence is less than 200mm and within the variability expected for multi-seam mining. Natural variability, latent subsidence and changing incremental subsidence as a percentage of seam mining height with each successive seam mined are recognised to contribute to variability. There are no significant variations in magnitude or irregularities in subsidence profiles that would indicate collapse or progressive failure (pillar run) of standing pillars over a substantial area.

Substantially higher than predicted subsidence from the mining of Longwalls 4 and 5 in the Wongawilli Seam is consistent with under-prediction of subsidence for these panels. Consistent with the IAPUM (2020) advise our research indicates the issue stems from under-prediction of subsidence levels rather than excessive subsidence for the multi-seam mining geometry in Longwalls 4 and 5. Almost all the Bulli Seam areas above Longwalls 4 and 5 had been previously undermined by Longwalls 8-10 in the Balgownie Seam. There is no potential for standing pillars and open voids to remain in the Bulli Seam above Longwalls 8-10 in the Balgownie Seam prior to the mining Longwalls 4 and 5 in the Wongawilli Seam.

A3.3 Mining Layouts and Method

Coal mining in NSW has been undertaken for approximately 220 years in the Newcastle area and for around 170 years in the Southern Coalfield with mining at RVE for more than 130 years.

The evolution of coal mining layouts for the bord and pillar method in NSW was by a process of trial and error with local ‘rules of thumb’ dictating the width of first workings pillars, bord (roadway) width and at different times, mining or pillar heights. Some of these dimensions were prescribed for the first time or varied by legislation in response to significant accidents or incidents (both in Australia and worldwide) including recognition of the influence of increasing depth of mining on pillar stability. Local anecdotal evidence indicates pillar crush or creeps did occur. It appears minor events may have been a regular occurrence and as such are not well documented.

The first workings of the early Bulli Seam mining in RVE (and at the adjacent Old Bulli and Corrimal mines) using hand working methods were developed to maximise coal recovery percentages. These workings date from circa 1860 and 1870. The method has been referred to as “Welsh Boards” and consisted of long narrow driveages (bords) that were progressively widened out leaving narrow pillars of coal between adjacent bords. The bords were widened to about 8 yards (7.3m) with pillars as small as 4 yards (3.7m) wide between the bords. The smallest pillars had width to height ratios of less than 2. There are large areas of these bords and pillars in the earliest workings of South Bulli (including Bellambi), Old Bulli and Corrimal mines.

Some of the narrow pillars have then been removed by a secondary extraction process and are shaded or cross-hatched and labelled as “pillars extracted”, “coal extracted” or “pillared”. Other areas are shown as remaining with notations of “bords worked” or “worked ground”, “old workings and falls” and “fallen bords”. Presumably, the latter comments refer to the areas becoming unstable and inaccessible for secondary extraction, effectively sterilising the coal remaining in the narrow pillars.

Following a significant pillar failure accident in the 1880’s (in the Newcastle coalfield) and subsequent government inquiry and royal commission into mining conducted in the 1890’s, it was recommended that bord and pillar mining systems be adjusted to increase pillar widths to 8-16 yards. The methods and systems of working were still not extensively prescribed, and it is likely these would have overseen by government mines inspectors allowing some tolerance on local ‘rules of thumb’.

As the mining advanced, the mining layouts reflect a change to larger first pillars and the option of a more systematic or controlled secondary extraction process.

The first mention of losses, or sterilizing, of coal from methods or systems of working is in a 1941 amendment to the 1912 Coal Mines Regulation Act (CMRA). This is likely a reference to the impacts from unstable mining geometries and potential pillar failure or pillar run or pillar creep events.

The CMRA 1912 was amended in 1964 after the 1960 mining disaster at Coalbrook Colliery in South Africa involving the collapse of substantial areas of pillars. These amendments to the CMRA 1912 included maximum roadway widths being restricted to 6 yards and minimum pillars widths were prescribed as 8-26 yards, based on depth, with widths of 12-18 yards more typical for the depths at RVE. Mining heights were also restricted to 14 feet without the consent of the Minister. These dimensions were converted to metres in a 1974 amendment to the CMRA 1912 and this prescription for pillar widths and percentage extraction at various depths remained in place until the 1984 Regulations were introduced to support the CMRA 1982. It is noted that the 1982-84 legislation removed the prescription controlling mining heights.

Large areas of small pillars in the early Bulli Seam workings at RVE have either been removed by the secondary extraction of coal between roadways (bords), are expected to have deformed (collapsed) by abutment loading or been destabilised (collapsed and subsided) by secondary extraction in the Balgownie Seam below. Any small pillars with low w/h ratios around the perimeter of areas shown on plans as extracted (or “worked out”) are likely to have collapsed at or around the time of secondary extraction of the Bulli Seam, or if in the vicinity of the Balgownie Seam panels then, during the time the secondary extraction in the Balgownie Seam was undertaken.

A3.4 History of Surveying for and Drafting of Mine Plans in NSW

An appreciation of the reasons mine plans were prepared and the standards for reporting are helpful in the interpretation of the mine working plans and record tracings and other information recorded on mine plans.

The information on early mine working plans were recorded for two main reasons: first, to provide operational (production) needs of the mine and second to comply with NSW legislation. This legislation was aimed at both workplace health and safety and public safety.

Extensive historical research and re-education of the coal mining industry on the accuracy and reliability of mine plans was undertaken in 1998 to comply with the recommendations from the Gretley Disaster Inquiry (DMR1998). The following passage summarises the key points considered appropriate to this assessment.

- The first coal mining by European settlers in NSW is believed to have started in the late 1790's. In the Illawarra district, the first legal mining started in the 1840's.

- The first legislated requirement to accurately record mine workings on a plan was in 1902.

- The requirement to preserve mining plans was first introduced in 1931 when the plan of abandonment at the cessation of mining at a site was to be sent to the Mines Department for future reference.

- Plans were not required to be certified as accurate by a surveyor until 1931.

- The requirement for certificates of competency for mining surveyors was not introduced until 10 years later in 1941.

- Amendments to the 1912 NSW Coal Mines Regulation Act (CMRA) enforcing the Record Tracing concept (a second accurate copy of mine working plan information) were gazetted in 1947.

- While the requirement to keep plans and copies in safe keeping was then in place, the actual standards for surveys and the drafting methods for depiction of the workings and associated information, was still missing. This meant that many adjacent mines had different coordinate systems and height datums as well as different ways of showing the same type of mining method.

- Previous amendments to the 1912 CMRA had provided for 'the general rate and direction of dip of the strata', but the requirement to record detailed information for reduced levels of the seam floor and geological features in the workings were not introduced into legislation until during the 1950's with further amendments in the early 1970's.

- The first attempt to set uniform standards for surveying and drafting practices was in 1968, but it was not until 1976 that the comprehensive Surveying and Drafting Instructions for Coal Mine Surveyors were published.

- These instructions and the introduction of the Integrated Survey Grid (ISG) for NSW brought into place standard practices for systems including coordinate grids, height datums, scales of plans, the plan area and orientation (with no overlap) and as well as the requirement for a separate plan (or series of plan sheets) for each seam worked.

This summarises the evolution of hand-drawn plans. All of the earliest plans at mines were drafted by hand. Sometimes these were on large scroll type natural drafting medium (linen or cloth) or 'film' type medium suitable for tracing. There were many plans kept for operational and statutory requirements, that were invariably drawn by different individuals, at various scales and were not necessarily traced from previous plans.

- Since the surveying and drafting instructions and ISG were implemented, opportunities for further inconsistencies to develop have arisen through the advent of Computer Aided Drafting (CAD) and conversion to digital records, as well as the transformation from state to national (and international) coordinate systems for mapping.

- The current surveying and drafting standards for the digital Mine Survey Plan (no longer mine working plan and record tracing) in NSW are now contained within the Surveying and Drafting Direction for Mining Surveyors 2020.

This summary of the development of mine plans and record keeping indicates that there are likely to be differences across the database of information in the type of information presented, the level of detail, the completeness, and the accuracy of that information. Prior to 1977 there is a standard, prior to 1948 a different standard with a significant change in 1931. As a warning, users should be more suspicious of plans of mine workings abandoned prior to 1947 that have been stamped "Record Tracing" by the Department of Mines. These plans may not have been compiled to the standard expected of a record tracing.

From 1931, with the legal requirement to certify as accurate the quarterly (3 monthly) working places surveys, regular datelines for all mined areas appear on the plans for the first time. Prior to 1931, there are some workings dated but because it was not a legislated requirement, there is often inconsistency in the frequency of date notations. A change in the detail recorded in response to the 1931 legislative change is clearly apparent in the later mine working plans for South Bulli and the adjacent mines.

It has also been recognised through experience, that different surveyors (and mining companies) have different interpretations of legal requirements. The compliance with standards may have been enforced through auditing by the local mines inspectorate. This auditing may have been infrequent. Poor compliance often resulted in opportunities to collect data being lost due to mining progress making worked–out areas inaccessible. The nature of some mining methods precludes the possibility of retrofitting newer legislated standards for recording information in previously mined areas.

There are two key points in the evolution of mine plan standards relevant to this research. The first point is the extension of the plan area as the early mining areas expanded and the overlap for each plan area as additional mine working plans were created. The second point is the introduction of record tracings.

A3.4.1 Plan Area Overlap

The overlap issue stems from extending the mine plan areas as the mine expands in a sometimes irregular manner and a new plan is created to cover the new mining area. The new mining area may have changed from the previous intentions in size or direction based on more working places for greater production, unexpected geological features, change to leases or other factors. These plans could be physically large (commonly up to 1.8m wide and 5m long) with a large scale of 1:1584 (1 inch equals 2 chains) to capture more detail clearly. In this instance, it was typical for the new plan created not to show all the detail in the overlap section of the plans as all plans were drafted by hand. It was common practice to outline an area of secondary extraction with a polygon and a notation of “pillars extracted” or “goaf” (or similar) to reduce the amount of work in creating the new plan. Afterall, the detail was already recorded on the older plan.

However, some of the mine plan detail for the earlier mining could be lost as the older plans physically deteriorate, are misplaced, or destroyed.

A3.4.2 Record Tracings

The introduction of record tracings, circa 1948, as an accurate copy of the mine working plan information for safe keeping, resulted in the mine working plan information, including some areas where there as a lack of information, being duplicated. The record tracings do not necessarily include all information from all the mine working plans produced over the life of the mine.

The creation of record tracings appears to have been a massive undertaking at some larger mines at that time. This is seen in the standard of plans deemed to be record tracings. Some are clearly new plans drafted to satisfy the legislated requirements while others appear to be plans already in existence at the mine that have been designated as a ‘record tracing’.

The original record tracings for RVE are new plans created to satisfy the legislation. However, these record tracings, as a copy of the mine working plans, include some of the polygons of ‘goaf’ areas without all the detail for workings prior to 1931.

The manual redrafting of the Bulli and Balgownie Seam workings at RVE to the standard of the 1976 Surveying and Drafting Instructions including ISG coordinates and reduced levels on AHD 1971 datum, are the basis of the digital CAD files currently in use. The mine working plans and record tracings, in ISG format, appear to be scaled and orientated tracings of some original mine working plans and the original record tracings. These ISG plan area sheets have been converted to the MGA94 coordinate system and stitched together to provide the current digital plan drawings. The lack of detail in some of the ‘goaf’ polygons for areas mined prior to 1931 remains but the missing detail is available in the format of the original mine working plans including the mine working plan uncovered in May 2021.

A3.5 Correlation of Bulli Seam and Balgownie Seam Records

Research into the history of the Balgownie Seam mining at South Bulli Colliery has been undertaken to investigate any previous interactions or commonality that may have relied on the accuracy of the position of the Bulli Seam workings. Mining systems such as ventilation, coal transport and labour and materials transport are shown to have been linked between the seams via several drifts and staple shafts near the outcrop in the eastern section of the mine. Further historical research has also revealed that the hazard of inrush from the overlying Bulli Seam workings, appears to have been dependant on the correlation of the workings in both seams. This inrush hazard was effectively managed by the sequencing of the mining operations in conjunction with a series on inter-seam boreholes to drain the ponded water and allow the mine atmosphere to be tested. Most of these boreholes were drilled from first workings roadways to first workings roadways in the overlying seam.

It is noted that the information uncovered, and the resulting interpretations are consistent with the previous assumptions and conclusions reached from assessments for both mine water balance and pillar run (creep) potential during the UEP - PPR subsidence and groundwater studies conducted by SCT. The following section outlines the background and a summary of the water management measures successfully employed for the retreating longwall faces of the Balgownie Seam mining.

The initial area of the Balgownie Seam selected for longwall mining in the late 1960's was directly below an extensive goaf area in the Bulli Seam with bord and pillar workings dating from around 1910 to the 1930's that was suspected to be partially flooded due to the evidence of underground water flows that were able to be observed and the extent of the workings and dip of the seam depicted on the mine plans of the area.

The shape and volume of this water lodgement was controlled by an unmined barrier of coal known as the 'No7 left' or 'No7 SW" (southwest)' pillar off the Main North-West Headings, with the overflow from No7 left district being handled by the mine dewatering system. Sufficient survey information was available to permit the floor contours within the goaf area to be plotted with reasonable accuracy. Due to the safety concerns and the legislated requirements at that time, it was intended to dewater the Bulli Seam workings at a rate that would keep the vertical boundary of the water level at least 200m from the longwall faces. An early attempt to lower the water levels in the Bulli Seam via pumping infrastructure installed and advanced as required at this horizon was quickly abandoned due to the difficulties of reconstituting and maintaining access to the previously worked-out areas. Instead, inter-seam boreholes were drilled from the Balgownie Seam development panels. As a result of the large volumes of accumulated water (and recharge rate) against to No7 left barrier and the required timeframes, the development workings were sequenced to provide progressively lower access points to the inferred ponded water lodgements while maintaining safety for the development units and continuity of longwall operations.

From close inspection of the mining dates, it appears that in some instances the development panel faces were stopped for up to 12 months at a time while the drilling and draining rendered the overlying inrush hazard harmless. In some cases, it seems that this process was then repeated after only a short distance of panel advance due to the geometry of the Bulli Seam layouts compared to the Balgownie Seam longwall panel alignments, seam gradients and the potential risks. The mine working plans and the record tracings for the Balgownie Seam detail a total of seven boreholes sites with eight boreholes (one site with two parallel boreholes). Records from other sources indicate that eight borehole sites where established (including three sites with two parallel boreholes each) with one borehole attempt unable to successfully hit the intended target. The reason provided for this failure seems feasible. It is not suggested that it was due to the accuracy of the Bulli Seam mine plans.

The possibility has been considered that other boreholes failed to hit the target may not be documented on plans. However, the success of this dewatering program is in part due to the availability of accurate plans of the Bulli Seam workings, significantly the position of the first workings roadways developed prior to 1931. These 75mm diameter boreholes were drilled over a period of almost five years from 1973 to 1978 in an area covering Longwalls 6 to 11 of the Balgownie Seam and were estimated to have drained 890ML from the Bulli Seam workings. Although the interburden thickness between the Bulli and Balgownie Seams is only about10m, the drilling distances were up to 115m in length because of the targeted inclination and direction of the boreholes. Given the borehole steering and surveying technology of that time it is likely that it would have been difficult to achieve the planned outcomes to an accuracy of a few metres necessary to intersect roadways in the overlying seam.

WCL have also drilled inter-seam boreholes between 2009 and 2015 for inrush prevention purposes. These boreholes were drilled from the Wongawilli Seam to both the Balgownie and Bulli Seam during the development and secondary extraction of Longwalls 4, 5 and 6. The boreholes drained overlying water lodgements, that have accumulated after longwall mining in the Balgownie Seam, and in Bulli Seam areas outside the Balgownie Seam longwall footprint. This drilling program for hazard reduction further confirmed the accuracy of the Balgownie and Bulli Seam mine plans to within a few metres and their relativity to the Wongawilli Seam workings.

A3.6 Subsidence Monitoring for the Balgownie Seam Longwalls

In this section, insights into the status of the Bulli Seam goaf areas provided by the subsidence monitoring for the Balgownie Seam mining are discussed.

The incremental vertical subsidence measured for the mining of the Balgownie Seam longwalls is reviewed in the context of the advancements in understanding of the mechanics of multi-seam subsidence behaviour made since 2014.

Monitoring of subsidence from the Balgownie Seam longwalls was comprehensive for the period of mining. Each of the 11 longwalls mined between 1970 and 1982 had a longitudinal line along the whole length of the panel and three perpendicular cross-panel lines were also installed across Longwalls 1-11.

The incremental vertical subsidence was monitored at regular intervals during panel retreat above the initial panels and less frequently during mining of the last few panels. Ground strains were only measured during the last panel; Longwall 11. The last subsidence surveys for the Balgownie Seam longwalls were completed in 1983.

Maximum vertical subsidence in a single seam mining environment is naturally variable by about 15% for any given panel geometry and overburden depth. In a multi-seam situation, this variability is typically greater due to the sensitivity of subsidence to the interaction between mining geometries in each seam.

A3.6.1 Multi-Seam Subsidence at Ashton Underground

Mills and Wilson (2017) present measurements and observations of the incremental and cumulative subsidence effects from longwall mining in two seams in a regular, parallel, offset geometry at the Ashton Underground mine in the Hunter Valley of NSW. More recent monitoring of additional panels in the second seam up to 2020 at this site confirms the earlier observations and interpretation for two seams and includes additional learnings for multi-seam subsidence from longwall mining in three seams.

The key points from the Ashton observations applicable to this assessment of the Balgownie Seam monitoring are summarised here.

The Ashton site is unique when compared to other multi-seam sites for several reasons including:

- Longwall panels are all mined in a regular, parallel, offset layout with substantial remaining chain pillars. In the multi-seam area mined to date, all longwalls are of the same width and all chain pillars are of similar width.

- Gradually increasing overburden thickness toward the west, so that the overburden depth increases with each subsequent panel. Initial panel geometry in the upper seam is supercritical transitioning to near-critical width to the west.

- Longwall panels with different starting and finishing positions and goaf edge geometries enable a range of mining scenarios to be studied.

- Modern, reliable mine plan records.

- No areas of irregular pillar extraction (bord and pillar mining)

- No potential for small remnant pillars (or 'stooks') to fail and contribute to risk of pillar run or pillar creep.

For the longwalls mined to date in the upper two seams:

- All longwall voids are 216m wide and all inter-panel chain pillars are 24m wide.
- Mining heights for each seam are similar at 2.5m ±0.3m.
- Interburden thickness is 35-40m.
- Panels are offset by 60m.

The monitoring data allows the mechanics that drive the magnitude and the distribution of subsidence movements in the multi-seam environment at the site to be determined. Effects such as:

- difference in behaviour between overburden strata that is undisturbed by previous mining and strata that has already been subsided (disturbed or modified)
- recovery of latent subsidence from the overlying seam
- the effects of stacked goaf edges
- the effect of mining direction on subsidence above stacked goaf edges.

Analysis and interpretations of the Ashton data, where the mining layouts are regular and mechanics of subsidence behaviour are easily identified, indicates:

- Subsidence from multi-seam mining is more complex than for single seam mining, but the mechanics of overburden behaviour in response to mining are consistent. The incremental vertical subsidence profiles, with prominent latent subsidence areas, are regular and repeatable and as such, predictable once the various interactions and geometry effects are recognised and considered.
- Some conventional single seam concepts such as angle of draw and subcritical-supercritical width are less meaningful for multi-seam mining due to the subsequent behaviour of the disturbed (or modified) ground beyond the first episode of subsidence.

Although not directly applicable at RVE, due to the irregular mining geometries (including an absence of stacked goaf edges) and reduced interburden thickness, the key points of relevance to the Balgownie Seam monitoring data for vertical subsidence parameters from the two seams of mining at Ashton are:

- In general background areas (away from overlying pillar edges), incremental subsidence is approximately 75% (72-83%) of the seam mining height. This percentage reduced with subsequent panels where depth increased, and a more critical width behaviour was observed.
- Where latent (extra) subsidence is recovered from near the edges of the overlying pillars where the supporting effect to the overburden from the pillars is lost, incremental subsidence of approximately 90% (up to 92%) of the seam mining height was measured. This percentage was also observed to reduce in subsequence panels. Although the magnitude of latent subsidence is not a function of the lower seam mining height. In the case of Ashton, this additional, 15% was about 300mm for a 2.5m mining height in the overlying seam.
- This greater incremental subsidence, as a percentage of mining height, is due to the softening of the overburden strata or a reduction in shear stiffness with each episode of subsidence which reduces the bridging or spanning and overhang ability of the overburden and results in wider and steeper subsidence troughs.

It should be noted:

- Depending on the overlying geometry and where any latent subsidence is released, the latent subsidence component may not necessarily increase the maximum value in the subsidence profile.

- Where longwall extraction in the second seam starts below a goaf, subsidence at this goaf edge is greater and the angle of draw increases. Minor subsidence is seen to extend out the next load bearing pillar in some cases. The angle of draw around the outermost panel edge remains largely unchanged.

A3.6.2 Multi-Seam Subsidence from the Balgownie Seam

Figure A3.1 shows the Balgownie and Bulli Seam workings with the 11 longitudinal and 3 cross-panel subsidence monitoring lines and measured vertical subsidence profiles.

This section details our review of the Balgownie Seam subsidence data. Previous reports by others have stated the incremental vertical subsidence was equivalent to or greater than mining height (Kapp 1982, Holla and Barclay 2000 and MSEC 2007). Our research does not indicate this.

The Balgownie Seam longwalls are of two different widths with either two-heading or three-heading gateroad panels. The seam thickness is approximately 1.3m.

The voids for Longwalls 1-6 are approximately 143m wide with tailgate chain pillars widths in two heading or three heading layouts of approximately 17m or 26m.

Anecdotal evidence (personnel communication with operators) indicates the mining height was equal to seam thickness for Longwalls 1-6 and was increased to greater than seam thickness in Longwalls 7-11 after new longwall face equipment was purchased. One of the 'run-of-face' longwall supports used in these later panels is on display in a park on the Princes Highway at Russell Vale.

Voids for Longwalls 7-11 are approximately 189m wide and chain pillars are approximately 40m wide. These panels are in two sections as they step around a dyke structure referred to as Dyke D8 leaving a section of coal on either side of the dyke. The ISG mine plan records indicate mining heights in gateroads were greater than seam thickness. The detailed roof and floor RL information for the gateroads shows heights of 1.5-2.0m. Anecdotal evidence indicates mining height on the longwall face was at least 1.5m, achieved by mining the carbonaceous shale below the seam floor.

For Longwalls 1-6, individual panels are subcritical in a single seam context. The average overburden depth ranges 250-280m. The panel width to depth ratio is 0.51-0.58. In a single seam context, maximum subsidence of 30-40% of the mining height or up to approximately 0.5m would be expected over these early longwalls. However, in the multi-seam environment up to 75% of the mining height or approximately 1.0m would be expected with any latent subsidence being additional. These estimates exclude natural variation for single and multi-seam subsidence.

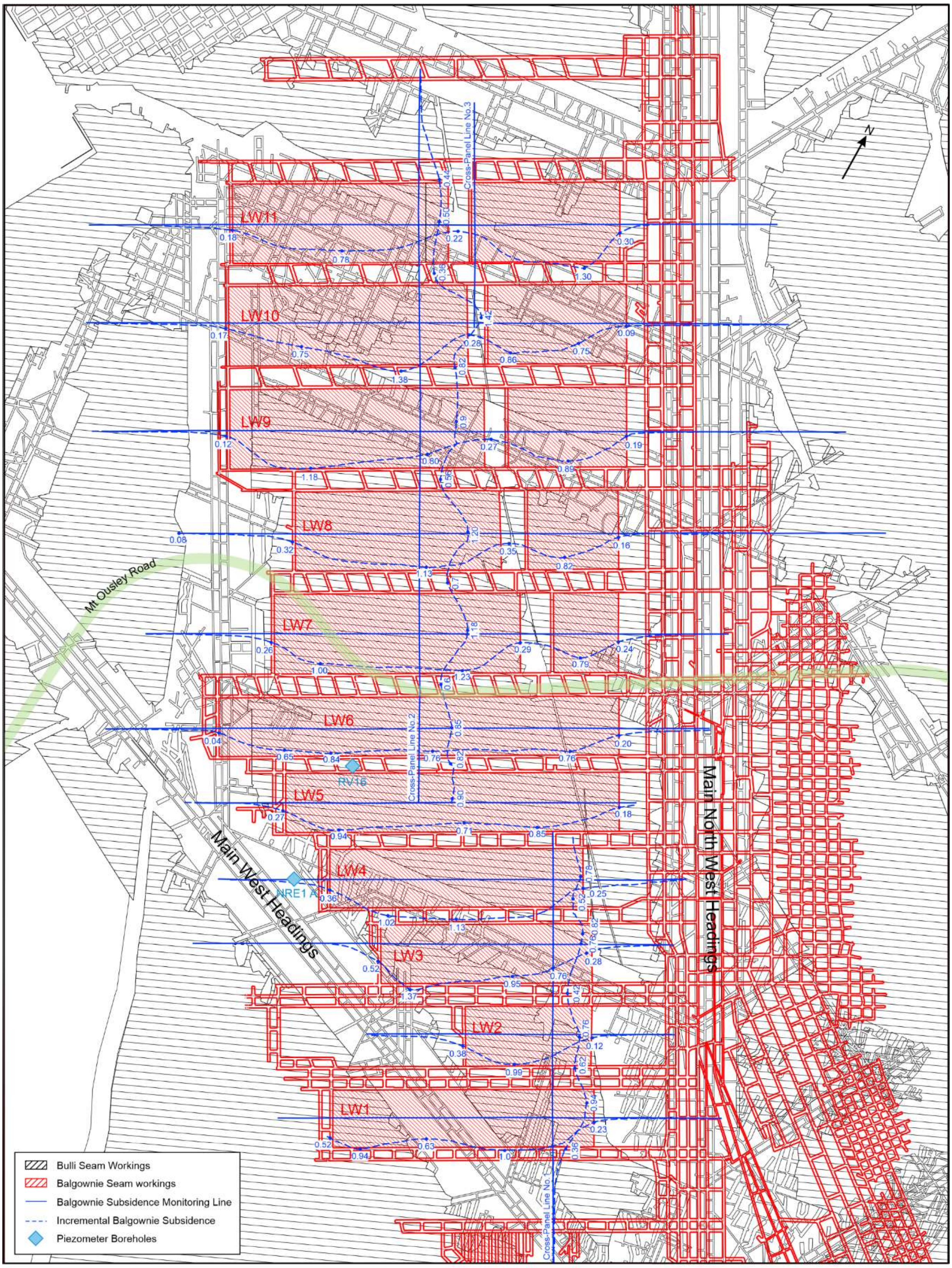

Figure A3.1: Incremental Subsidence measured for Balgownie Seam Longwalls.

For the wider Longwalls 7-11, the mining geometry is also subcritical in single seam terms. The average overburden depth ranges 275-280m. The panel width to depth ratio is 0.67-0.69. In a single seam context, maximum subsidence of about 45% of the mining height or approximately 0.7m would be expected over these later longwalls. However, in the multi-seam environment up to around 75% of the mining height or up to 1.2m could be expected excluding any latent subsidence. These estimates exclude natural variation.

Table 1 shows details of the actual incremental subsidence measured on the longitudinal monitoring lines above Longwalls 1-6 and Longwalls 7-11. The maximum subsidence shown was measured between 6 months and 9 years after individual panels were mined.

Table1: Balgownie Seam Incremental Vertical Subsidence on Longitudinal Lines

Longwall	Goaf Edge at panel start	Maximum	Estimated Latent	Minimum over large Bulli pillars	Goaf Edge at panel finish
LW1	0.52 (below goaf)	1.00	-	0.63	0.23 (near Bulli goaf edge)
LW2	0.38 (below goaf)	0.99	-	-	0.12 (near dyke)
LW3	0.5.2 (below goaf)	1.30 (includes latent)	0.3	0.76	0.28 (below goaf)
LW4	0.36 (below Bulli pillars)	1.13 (includes latent)	0.1		0.25 (below goaf)
LW5	0.27 (near goaf edge)	0.94	-	-	0.18 (below goaf)
LW6	0.04 (below Bulli pillars/solid)	0.84	-	-	0.20 (below goaf)
LW7	0.26 (near goaf edge)	1.23	-	-	0.24 (below goaf)
LW8	0.32 (below goaf)	1.13	-	-	0.16 (below Bulli pillars)
LW9	0.12 (below Bulli pillars/solid)	1.18	-	0.80	0.19 (below goaf)
LW10	0.17 (below Bulli pillars/solid)	1.38	0.25	0.75	0.09 (below Bulli pillars/solid)
LW11	0.18 (below Bulli pillars/solid).	1.30	-	0.78	0.30 (below goaf)

The data from the long-panel lines indicates consistent vertical subsidence behaviour. The variation in subsidence for similar geometry and locations is less than 200mm. This range is within expectation for multi-seam mining including considerations for natural variability, latent subsidence and incremental subsidence as a percentage of second seam mining height. Significantly, there are no variations in magnitude or irregularities in subsidence profiles that would be consistent with collapse of standing pillars over a substantial area or any form of 'pillar run' (widespread destabilisation of pillars).

Tables 2 and 3 show details of the actual incremental subsidence measured on the cross- panel monitoring lines No1 and No2 above Longwalls 1-4 and Longwalls 5-11, respectively.

Table 2: Balgownie Seam Incremental Vertical Subsidence Cross-Panel 1

Subsidence (m)							
Goaf Edge	LW1	Chain pillars (3 hdgs)	LW2	Chain pillars (3 hdgs)	LW3	Chain pillar (2 hdgs)	LW4
0.36 (below Bulli pillars)	0.94 (below Bulli pillars)	0.62 (below Bulli pillars)	0.76 (below Bulli solid/pillars)	0.42 (below Bulli solid/pillars)	0.82 (below Bulli solid/pillars) Includes 0.1 latent	0.52 (below goaf)	0.78

Table 3: Incremental Vertical Subsidence (m) on Cross-Panel Line No2

Subsidence (m)											
LW5	Chain pillar	LW6	Chain pillar (wider)	LW7 (wider)	Chain pillar (wider)	LW8 (wider)	Chain pillar (wider)	LW9 (wider)	Chain pillar (wider)	LW10 (wider)	Chain pillar (wider)
0.90 (below goaf	0.82 (below goaf	0.85 (below goaf)	0.6 (below goaf)	1.18 (below goaf)	0.70 (below goaf)	1.20 (below goaf)	0.56 (below goaf)	0.90 (below Bulli pillars)	0.82 (near Bulli pillars) includes 0.1 latent	1.42 (near Bulli pillars) includes 0.3 latent	0.36

The vertical subsidence is consistent with expectations for the Balgownie Seam geometry and confirms the status of the overlying Bulli Seam workings.

Comparing the subsidence measured on the long and cross lines and considering the line position relative to panel edges, the values on cross-panel lines agrees with the long-panel data to within 100mm.

The subsidence monitoring data from the long-panel and cross-panel lines indicates that, in the vicinity of the monitoring lines:

- Areas above and immediately adjacent to the Balgownie Seam longwalls are collapsed and fully subsided.

- Areas of Bulli Seam shown as goaf were collapsed prior to mining of the Balgownie Seam longwalls. These areas include remnant pillars in the Bulli Seam identified on mine plans.

- In isolated areas, smaller pillars located above the panel edge are observed to soften the subsidence profile. Their status prior to mining the Balgownie Seam longwalls cannot be determined so it is possible that pillar instability was caused by the Balgownie Seam longwalls, but the effect is limited in magnitude and extent.

A3.7 Other Investigations and Observations

Other investigations that indicate the status of the Bulli Seam workings include the drilling of surface to seam boreholes, underground inspections of accessible Bulli Seam workings identified on the mine plans with potential to be marginally stable if not already collapsed and subsided, and observations of elevated vertical stress conditions in the Wongawilli Seam below the edges of overlying goaf areas.

A3.7.1 Boreholes

A surface to seam borehole referred to as RV16, was drilled in 2014 to investigate the status of the Bulli Seam goaf area as part of groundwater monitoring. This borehole was positioned to drill through the Bulli Seam horizon, through the Balgownie Seam chain pillar between Longwalls 5 and 6 and down to the floor of the Wongawilli Seam. Some wood fragments, but no coal, were recovered in core from the depth where the Bulli Seam was expected. This uncased borehole was able to maintain a 300m head of water during drilling and piezometer installation but the piezometric profile indicates a downward hydraulic gradient toward the mine.

The observations in this borehole confirm the Bulli Seam is extracted and the roof strata has collapsed at this location.

The collapsed status of the Bulli Seam at the location of RV16 is consistent with the mining detailed in the recently discovered mine working plan and in the annual production plans from 1913, 1916 and 1917. These plans indicate the Bulli Seam was extracted at this location within the larger area that is now depicted as 'goaf' on other mine workings plans and record tracings. Extraction of the Bulli Seam and collapse of the strata above the Bulli Seam is also consistent with the subsidence profiles from the Balgownie Seam mining along the cross-panel monitoring line that traverses the longwalls panels adjacent to this location.

Figure A3.2 shows the extent of mining in the Bulli Seam in the vicinity of location of RV16 from the 1916 yearly plan and the mine working plan for this area. A later mine working plan which also includes this area shows that additional pillar extraction to the west was undertaken in 1944.

a) Position of Borehole RV16 relative to Bulli Seam workings on plan from 1916.

b) Position of Borehole RV16 relative to Bulli Seam workings on mine working plan to 1932.

Figure A3.2: Position of Borehole RV16 relative to Bulli Seam records.

Borehole NRE1A provides confirmation of the existence of the Bulli Seam barrier pillar adjacent to the Main West Headings. NRE1A is a groundwater monitoring borehole, drilled in 2009. The hole is positioned above the Bulli Seam coal barrier and outside the Balgownie Seam mining footprint. The hydrostatic piezometric pressure profile at this location indicates there has not been any drawdown at this location consistent with the strata above the barrier pillar being intact and likely compressed by abutment loading from the surrounding goaf areas.

A3.7.2 Inspections

An underground inspection of two areas of Bulli Seam workings identified from mine plans as potentially unstable and were still accessible was conducted by SCT in June 2013.

An area of Welsh bords adjacent to the Main North West Headings (main headings) to the east of Mount Ousley Road have been described as marginally stable, a pocket of standing pillars with potential to become unstable and collapse with some subsidence is possible, and an area where additional subsidence is considered possible due to pillar instability.

Research indicates the roadways (bords) in this area were mined from1899-1901. These roadways were driven adjacent to an area with a similar layout where the bords were mined and the pillars extracted during the 1890's. The earlier workings were developed, and the pillars extracted, up to a dyke. Subsequent longwalls in the Balgownie Seam (Longwalls 1 and 2) mined below the earlier area of pillar extraction and stopped short of the dyke.

The remaining Welsh bords are separated from the Bulli Seam pillar extraction area and Longwalls 1 and 2 by a barrier of solid coal on one side and the barrier of coal adjacent to the main headings on the other side.

Although inspected and considered "marginally stable" at the time, assessment of this remaining section of Welsh bords indicates that the smallest pillar shown on mine plans has a width to height ratio of five, a factor of safety of 1.4 and a probability of instability of 2 in 100.

The smaller pillars are adjacent to larger pillars and together with the surrounding barrier coal may explain why these pillars are still standing some 120 years after being formed. Nevertheless, these pillars are not considered long-term stable and an estimate of the potential subsidence should these pillars collapse or be destabilised into the future indicates maximum vertical subsidence is expected to be less than 0.3-0.5m due to the width of this area of standing pillars and the depth below the surface. Any additional subsidence would be over a small, isolated area where there are no surface features sensitive to subsidence movements.

A second area of pillars identified on the Bulli Seam mine plans directly to the west of Mt Ousley Road were also inspected. Although shown as unmined, these pillars were undermined by Longwall 7B in the Balgownie Seam. This area is described as an area where pillar instability was evident directly above the edge of the Balgownie Seam longwall goaf.

Observations from the inspection were consistent with expectation and indicate the Bulli Seam horizon was completely collapsed and subsided forming part of goaf from the floor of the Balgownie Seam horizon approximately 10m below. A similar situation is expected in all areas of the Bulli Seam undermined by the Balgownie Seam longwalls.

A3.7.3 Underground Mapping and Stress Observations

There are many places in the Wongawilli Seam at RVE where the overlying goafs have elevated the vertical and horizontal stresses resulting in difficult mining conditions. The change in stress results from loads generated around the abutments of secondary extraction areas or from remnant pillars within secondary extraction areas. These areas of increased stress are associated with both Bulli and Balgownie Seam goafs with the Balgownie generally dominating the Bulli Seam due to the proximity to the Wongawilli Seam mining horizon. However, there are clear examples of difficult conditions adjacent to the Bulli Seam goaf edges, including the in main headings, Maingate 6 Panel transport road and Tailgate 9 Panel where the continuous miner was buried.

Elevated stress levels are expected to provide a strong indication of the status of the overlying Bulli Seam goaf areas. There are currently seven Bulli Seam goaf areas that are likely to have collapsed but there is no direct evidence from subsidence monitoring or observations from mining below to confirm this collapse. Underground observations of roadway conditions in the Wongawilli Seam are considered a reliable technique to confirm these areas have collapsed and subsided.

A3.8 Predicted and Actual Subsidence for Wongawilli Seam Longwalls

The original subsidence predictions for the Wongawilli Seam longwalls in RVE for the UEP were undertaken by Seedsman Geotechnics Pty Ltd (SG). These predictions and updates were subsequently used for modification to the Preliminary Works Project (PWP) approval to allow secondary extraction of Longwalls 4 and 5 and in applications for a Subsidence Management Plan (SMP) for these two panels.

An initial report (SG 2011) discusses the potential for reduced bridging capacity of the overburden after multi-seam mining but predicts a low-level of vertical subsidence of 0.2m over the majority of Longwall 4 and up to 1.2m over Longwall 5. It is noted that the lengths of Longwalls 4 and 5 were shortened several times after SG (2011).

The predictions for vertical subsidence were revised (SG 2012a) after the first subsidence survey for Longwall 4 during the extraction of this panel. Maximum vertical subsidence of 1.2m was predicted for both Longwalls 4 and 5 based on what was measured above Longwall 4 at that time of the first survey and the assumption that there is a reduction in spanning capacity of the overburden strata due to previous subsidence associated with the overlying Bulli and Balgownie goaf areas.

The prediction for vertical subsidence in the SMP for Longwall 5 (SG 2012b) was revised again to 1.4m after mining of Longwall 4 was complete and subsidence for this first Wongawilli Seam panel was measured.

The actual incremental subsidence measured over Longwall 4 after mining in this panel was 1.4m. This incremental subsidence increased to 1.8m after the mining of Longwall 5 with compression of the inter-panel chain pillar and strata above and below the pillar. Maximum incremental subsidence measured over Longwall 5 at the completion of this panel was also 1.8m.

SCT were engaged in 2013, during the mining of Longwall 5, to provide predictions of subsidence effects and assessment of impacts for the longwall mining proposed at RVE in a revised longwall layout referred to as the UEP-Preferred Project Report (PPR). An initial report was prepared in 2013 which included predictions for Longwalls 1-7 and Longwalls 9-11. The length, widths and orientations of longwalls were changed, and the Longwall 8 panel was removed in the PPR layout.

SCT (2013) presents vertical subsidence predictions for Longwalls 4 and 5 of 2.1m and 1.9m, respectively, based on the method for predicting multi-seam subsidence from longwall mining suggested in Li et al (2007 and 2010). The Li et al method considers the mechanics of the modified overburden similar to the subsequent experience from Ashton Underground Mine.

The adoption of the Li et al method, which is based on the combined extraction height in each seam, provided a conservative estimate of the actual maximum incremental subsidence for Longwalls 4 and 5 in the Wongawilli Seam. The actual incremental subsidence of 1.8m represents about 60% of the mining height which is not excessive for multi-seam mining and consistent with the irregular geometry relative to the overlying Balgownie Seam chain pillars, dyke pillar, and areas of larger Bulli Seam pillars. The areas of maximum subsidence appear to be associated with latent subsidence near the overlying Balgownie Seam longwall edges.

The IAPUM (2020) advise states "*concerns regarding elevated levels of vertical subsidence arise out of subsidence predictions that did not properly account for increased subsidence in a multiseam mining situation; that is, subsidence had been under-predicted rather than excessive for a multiseam situation. This deficiency appears to have been overcome by appointing SCT to undertake subsidence predictions*".

The IAPUM (2020) reference relates to SG (2011) where SG had chosen not to comply with the direction of the Sydney Catchment Authority (now Water NSW) to use the Li et al method at that time.

APPENDIX E: BUILT FEATURES MANAGEMENT PLAN

RUSSELL VALE COLLIERY

REVISED UNDERGROUND EXPANSION PROJECT

Extraction Plan PC07-08 and PC21-25
BUILT FEATURES MANAGEMENT PLAN

RVC EC PLN 002

Revisions

Property	Value
Approved by	Group Environment Manager
Document Owner	Group Environment Coordinator
Effective Date	

Revision history

Version	Date reviewed	Review team (consultation)	Nature of the amendment
Draft 1	28/06/2021	Ken Mills (SCT) Stephen Wilson (SCT) Umwelt	Initial Draft for consultation with the Resource Regulator, TfNSW Endeavour Energy & TransGrid.
Draft 2	17/09/2021	Robert Faddy-Vrouwe (WCL) Devendra Vyas (WCL	Updated following consultation with TransGrid and Endeavor Energy
Draft 3	06/10/2021	Richard Sheehan (WCL) Devendra Vyas (WCL)	Final draft post receipt of consultation outcomes from Surveyor General, TransGrid, and completion of the TfNSW risk assessment.,

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1 INTRODUCTION

1.1 Overview

This Built Features Management Plan (this Plan) has been prepared in support of an Extraction Plan (EP), as required by ***Condition 10 (g)(ii)/Schedule 2*** of the Project Approval MP09_0013 (the consent). In accordance with ***Condition C10(a)*** of the Development Consent, this Built Features Management Plan (BFMP) has been prepared by WCL with the assistance of Dr Ken Mills and Stephen Wilson from SCT Operation Pty Ltd (SCT).

This BFMP is intended to manage the potential subsidence impacts of the underground workings proposed in the current EP (PC07, PC08, PC21-PC25) on built features to meet the requirements detailed in the Condition C10 (g)(ii) of the consent. The management of subsidence impacts from further proposed mining will be addressed in subsequent EPs.

This BFMP is also intended to follow the guidelines outlined in DPE (c2012) (excluding the elements associated with formal risk assessments).

1.2 Project Background

Wollongong Coal Limited (WCL) operates the Russell Vale Colliery (formerly the NRE No.1 Colliery) located in the Southern Coalfield of New South Wales (NSW). The mine is located at Russell Vale, approximately 8 km north of Wollongong and 70 km south of Sydney, within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW.

Russell Vale Colliery operates under the current project approval Development Consent MP09_0013 (the approval) granted by the NSW Independent Planning Commission (IPC) on 8 December 2020. The approval, known as the Underground Expansion Project (UEP), is based on the Revised Preferred Project Report and Response to Second PAC Review by Umwelt dated July 2019. Under the approval WCL may:

- Extract 1.2 Mt of Run of Mine (ROM) coal per annum, with a maximum of 1 Mt of ROM coal being processed from site in a calendar year; and
- Undertake mining operations for a period of 5 years from the date of commencement of mining operations.

The approved workings are contained within Consolidated Coal Lease 745 (CCL 745) and Mining Lease 1575 (ML 1575). In accordance with Condition C10(g)(ii), Part C of the Development Consent, this Built Features Management Plan (BFMP) has been prepared as a component of the Russel Vale Colliery Extraction Plan (RVC EP) to manage the potential impacts to built features located in proximity to the proposed bord and pillar workings defined as being 'second workings' under MP09_0013. The BFMP covers the area relating to Pillars PC7, PC8 and PC 21 to PC25. PC7, PC8 and PC 21 to PC25 are situated to the west (PC21 to PC25), and south-east (PC7 and PC8) of the previously mined Longwall 6 (refer to Figure 1 and Figure 2).

Section 2 of the main extraction plan, 'Project Description', provides a full summary of the project, including details on the:

- mine planning and design;
- mining methodologies;
- phasing of the surface infrastructure relating to the project over 2 stages, which are both wholly covered under the extraction plan;

- staging of secondary workings
  - stage 1(a) – PC21 to PC25
  - stage 1(b) – PC7 and PC08.

The secondary workings for the remaining panels approved under Development Consent MP_09_0013 will be mined in a staged approach and will therefore be subject to future Extraction Plans (EP).

1.3 Purpose and Scope

This BFMP has been developed to meet the requirements of, and in compliance with, ***Schedule 2 Condition 10 (g)(ii)*** of the consent, as well as the other relevant conditions and requirements outlined in Section 2 below. This plan details how WCL will manage potential subsidence risks and impacts to the built features within the current EP second workings area. This BFMP applies to the EP study area outlined in Figure 1 and incorporates the features above panels PC07, PC08 and PC 21 to PC25.

The built features that are addressed in this plan include the key public infrastructure as listed in Table and key infrastructure owners considered in this document include:

Table 1 – Key public infrastructure and owners

Key/ other public Infrastructure	Key public Infrastructure owner
M1 Princess Motorway (Mount Ousley Road and associated built features (e.g., culverts, embankments)	Transport for NSW (TfNSW) – Roads and Maritime Services (RMS)
Electricity transmission lines and towers (including angle towers)	TransGrid – 330 and 132KV Endeavour Energy – 2 * 33KV
Access roads and fire trails	WatrerNSW
Permanent survey marks	NSW Survey General

The EP Assessment Areas (study area or EP area) is based on a distance of 350m, which is equal to the overburden depth (equivalent to an angle of draw of 45°). A description of the key infrastructure features and an assessment of the subsidence they are likely to experience are included in the EP Subsidence Assessment (SCT 2021).

The location of this infrastructure relative to the planned mining and historic workings within the current EP study area is shown in Figure 1. There are no built features within the EParea of panels PC21-PC25, all the built features discussed in this plan are associated with panels PC07 & PC08.

The Cataract Reservoir dam wall (and associated infrastructure) and Telstra infrastructure are not within the current EP study area and are not expected to be affected by subsidence movements. As such these features have not been considered further within this plan.

This BFMP is also intended to follow the DPE *Guidelines for the Preparation of Extraction Plans* (c2012) (excluding the elements associated with formal risk assessments).

The management of subsidence impacts from further proposed mining will be addressed in subsequent EPs.

Figure 1 - Mine Plan & Study Area

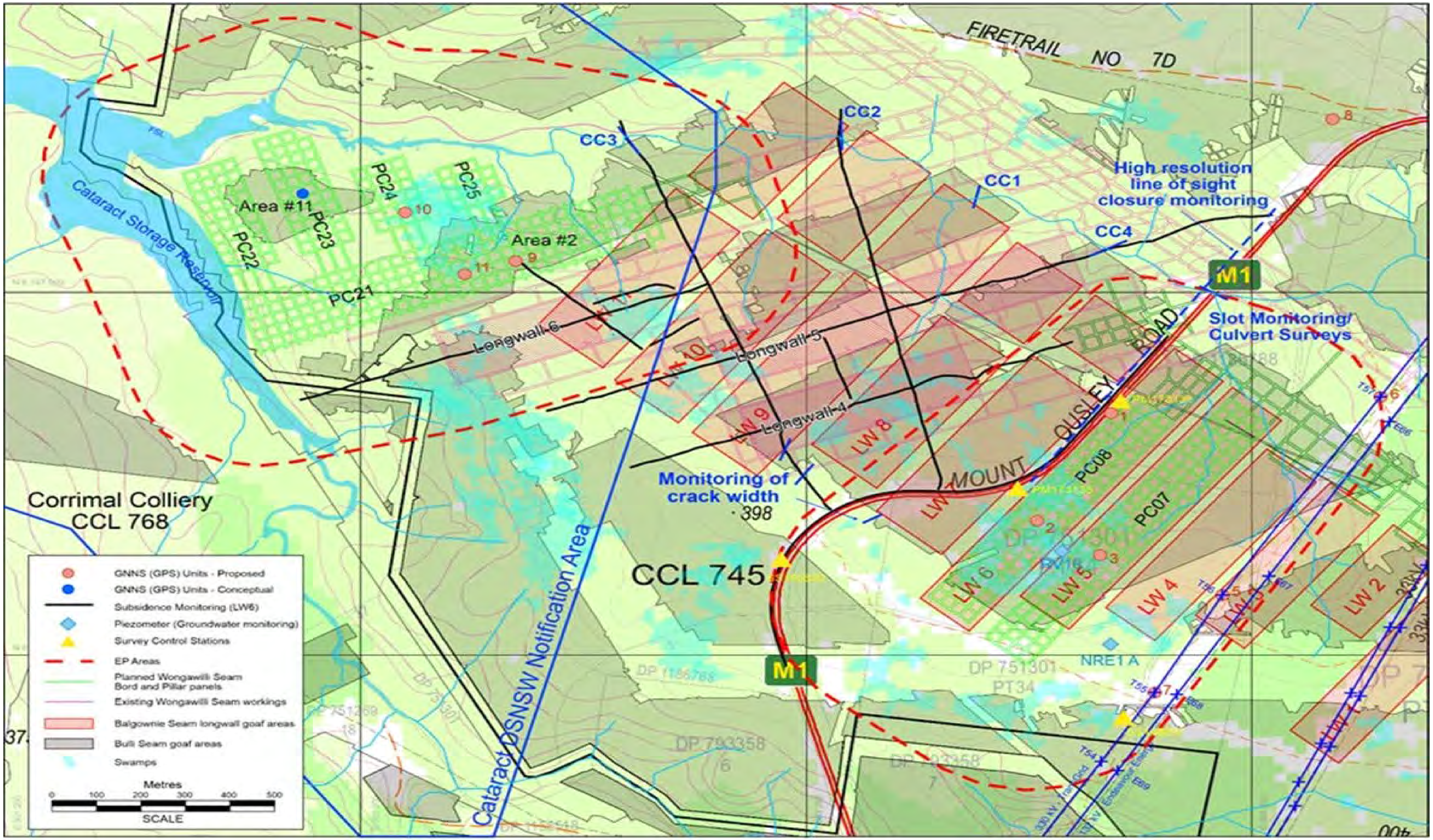

Figure 1: Site plan of Russell Vale Colliery superimposed onto a 1:25,000 topographic map.

1.4 Mine Design and Mining Method

Full details on the EP Area mine design and mining method are outlined within the Main Extraction Plan. This BFMP covers the mining plan layout found in Figure 1 and includes:

- Stage 1(a) - one panel (PC21) and 4 sub-panels (PC22, PC23, PC24 and PC25) to the west of Mount Ousley Road adjacent to the Cataract Storage Reservoir; and
- Stage 1(b) - two panels (PC07 and PC08) to the east of Mount Ousley Road

1.5 Report Structure

The remainder of this Plan is structured as follows:

Section 2: Outlines the statutory requirements applicable to the Plan.

Section 3: Outlines the built features baseline data

Section 4: Details the predicted subsidence and baseline conditions within the EP Area.

Section 5: Describes the performance measures and indicators that will be used to assess the Project.

Section 6: Describes the monitoring program.

Section 7: Describes the management, remediation and mitigation measures that will be implemented to reduce potential impacts. This section also details the Contingency Plan to manage any unpredicted impacts and their consequences.

Section 8: Describes the required reporting and communication processes for management of incidents, complaints and non-conformances.

Section 9: Describes the reporting processes for monitoring

Section 10: Outlines the plan administration requirements.

Section 11: Describes how the Plan will be implemented, managed, reviewed and updated.

Section 12: describes the process of audit and review.

Appendix A: Details the TARP's for the Built Features above the second workings

Appendix B: Details the records of the Consultation undertaken during the development of this plan

Appendix C: Details the baseline surveys as detailed in Section 3 of this plan including the LIDAR report and GNSS results.

2 STATUTORY REQUIREMENTS

2.1 Development Consent Conditions

Condition C10(g)(ii)/Schedule 2 of the State Development Consent (MP09_0013) outlines the requirement to prepare a BFMP for the EP Area for all second workings. Table 2 below summarises the Development Consent conditions and BFMP requirements.

In accordance with ***Condition C10(c)*** WCL will ensure implementation of this Management Plan as approved by the Secretary.

Table 2 - Development Consent (MP 09_0013) Conditions for BFMP

Condition	Condition Requirement	Section Addressed
C10. (g) (ii)	Built Features Management Plan which has been prepared in consultation with RR, to manage the potential subsidence impacts of the proposed underground workings on built features, and	Section 2.4.2
	which has been prepared in consultation with the owner/s of potentially affected feature/s;	Section 2.4.2
	addresses in appropriate detail all items of key public infrastructure (with particular consideration of transmission lines and towers (including angle towers), other public infrastructure and all classes of other built features;	Section 1.3 Table 7
	recommends appropriate pre-mining mitigation measures to reduce subsidence impacts;	Section 3 Section 7
	recommends appropriate remedial measures and includes commitments to mitigate, repair, replace or compensate predicted impacts on potentially affected built features in a timely manner, and	Section 7.6 Section8
	in the case of all key public infrastructure, and other public infrastructure except roads, trails, and associated structures, reports external auditing for compliance with ISO 31000 (or alternative standard agreed with the infrastructure owner), and provides for annual auditing of compliance and effectiveness during extraction which may impact the infrastructure.	Section 12.11, 2.2

2.2 Management Plan Requirements

Condition F5 of the Consent MP09_0013 requires that management plans under this consent to be prepared in accordance with the relevant guidelines as detailed. Table 3 details where each component of the Condition F5 is addressed within this BFMP.

Table 3 - Management Plan Requirements

Condition	Condition Requirement	Section Addressed
F5.	Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:	Section 2.2
F5 (a)	a summary of relevant background or baseline data;	Section 3

Condition	Condition Requirement	Section Addressed
F5. (b)	details of: (i) the relevant statutory requirements (including any relevant consent, licence or lease conditions); (ii) any relevant limits or performance measures and criteria; and (iii) the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 2
F5. (c)	any relevant commitments or recommendations identified in the document/s listed in condition A2;	NA
F5. (d)	a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Section 5
F5. (e)	a program to monitor and report on the: *(i)* impacts and environmental performance of the development; and *(ii)* effectiveness of the management measures set out pursuant to condition F5(c)	Section 6 Appendix A - TARPs
F5. (f)	a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 7.6 Section8
F5. (g)	a program to investigate and implement ways to improve the environmental performance of the development over time;	Section 6 Section 12
F5. (h)	a protocol for managing and reporting any: *(i)* incident, non-compliance or exceedance of any impact assessment criterion or performance criterion; *(ii)* complaint; or *(iii)* failure to comply with other statutory requirements;	Main Extraction Plan Document Section 8 and 9. APPENDIX A - Built Features Trigger Action Response Plan (TARP)
F5. (i)	public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	Main Extraction Plan Document and Section 13
F5. (i)	a protocol for periodic review of the plan.	Section 12

2.3 Leases, Licences and Permits

In addition to the Development Consent, second extraction undertaken will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending issue:

In addition to the requirements of the Project Approval, all activities at or in association with the WCL RVC will be undertaken in accordance with the licences, permits and leases which have been issued or are pending as outlined in Table 4.

Table 4 Licences, Permits and Leases

LICENCE/APPROVAL	ISSUE DATE	EXPIRY DATE
Consolidated Coal Lease 745 (CCL 745)	27/12/1990	30/12/2023
Mining Lease 1575 (ML 1575).	22/03/2012	22/03/2029
Mining Purposes Lease (ML 271)	09/05/1991	09/05/2033

2.4 Consultation

2.4.1 Consultation During the Environmental Assessment Process

Extensive community and government consultation has been carried out prior to and during the preparation of the original environmental assessment, the Revised Preferred Project Report, the Submissions Report and other project-related assessment documentation. The primary objective of consultation was to keep the community, government agencies and other stakeholders informed and involved during project development process.

Community engagement was carried out in two phases and is summarised in Section 4.1.2 and Section 4.1.3 of the Revised Preferred Project Report.

A complete summary of previous and ongoing government agency and stakeholder consultation is provided in Table 4.5 of the Revised Preferred Project Report. Consulted parties included:

- the Department of Planning, Industry and Environment (DPIE);
- NSW Environment Protection Authority (EPA);
- Wollongong City Council (WCC); and
- WaterNSW.

2.4.2 Consultation During the Preparation of the Management Plan

This Plan has been prepared in consultation with the following state agencies and relevant stakeholders and owners of potentially affected features in accordance with Schedule 2 Condition C10(g)(ii):

- NSW Resource Regulator (RR)
- Transport for NSW (TfNSW) – RMS Division
- TransGrid
- Endeavour Energy
- NSW Spatial Services/ Surveyor General
- Water NSW

Details of the consultation with the above stakeholders is provided in Table 5 below.

Table 5 - Consultation undertaken as part of the preparation of this Management Plan

Stakeholder	Consultation Feedback	Relevant section where feedback is addressed in this Plan
NSW RR	During consultation with key infrastructure agencies as (TfNSW, Endeavour Energy, and TransGrid) the RR advised they expected compliance with the specific consent conditions. No specific feedback on this management plan or response has been provided during the preparation of this management plan as their specific role in this process is that of an independent observer.	No feedback
DPIE (Planning)	Letter to the department advising on the proposed team for the development of the Extraction Plan including its sub-plans.	See DPIE response to this letter in Appendix A of the Extraction Plan.
TfNSW	Initial correspondence regarding the project identified the need for a preliminary risk assessment. The preliminary risk assessment meeting held on 5 August 2021 resulted in the need for a further detailed risk assessment including the formation of the technical committee. The detailed Risk assessment workshop for Wollongong Coal proposed mining in Mt Ousley was held Friday 17 September 2021. The outcome of this detailed risk assessment is pending at this time.	Specific feedback on the monitoring from the risk assessment has been taken and included in Section 5 and 6. Appendix A contains a copy of the TfNSW Risk Assessment
TransGrid	A draft copy of the BFMP was provided to TransGrid for review prior to the consultation meeting on the 24 August 2021. Post draft management plan consultation TransGrid (reference number 2021-331) provided a response to WCL as detailed below on Monday 20 September 2021 regarding the draft plan. Note: No comments or changes were made to the draft plan as included in the feedback Section 5: a. Subsidence prediction due to PC07 & PC08 to be reviewed based on the subsidence records for PC21- 25. b. Any changes to the predicted subsidence and impact to TransGrid asset to be notified. Section 7.12: a. What is the tolerance of GNSS system re: vertical, tilt and tower leg separation measurements? b. How tilt of the towers will be monitored? c. How frequently GNSS data will be downloaded and monitored during and after mining?	Section 5, Table 7 Appendix A, and Table 12 Table 6 and Table 9 Table 8 Section 6.2

Stakeholder	Consultation Feedback	Relevant section where feedback is addressed in this Plan
	d. Prism to be installed on each legs of affected towers and frequency of survey to be specified. Section 8.2 Trigger Action Response Plan: a. Performance measure TARP is expected to be something similar to attached for 330kV Transmission Line. Specific subsidence values to be included for level 1, 2 3 in TARP, attached Typical TARP has subsidence figures to be used. b. All affected towers are noted in TARP. Section 8.4 Contingency Plan: • No contingency plan is outline in DRAFT BFMP. Please add the detail of contingency plan in the event of emergency due to large unexpected subsidence near TransGrid asset.	Section 5, TARP as per Table 13 Table 9, TARP as per Table 13. See Extraction Plan - Contingency Plan as per C10(ix)
Endeavour Energy	A consultation meeting was held with Endeavour Energy on 21 July 2021 to discuss the UEP EP. The proposed monitoring program was outlined. A draft copy of the BFMP was provided to Endeavour Energy for review 19/07/2021. Noted as at 06/10/21 that as feedback from Endeavour Energy was outstanding at the time of submission a conservative approach was taken noting the 33kV line and Infrastructure is located further East of the TransGrid HV infrastructure as shown in Figure 4. The baseline (Section 3), monitoring (Section 6) and TARP's (TARP as per Table 13) as determined during the consultation process with TransGrid has been applied to the Endeavour Energy assets.	The baseline (Section 3), monitoring (Section 6) and TARP's (TARP as per Table 13) as determined during the consultation process with TransGrid has been applied to the Endeavour Energy assets.
Water NSW	Consultation with Water NSW undertaken during the Technical Working Group (TWG) meeting on the 20 August 2021. Water NSW advised that they do not have any infrastructure within the extraction area. As such they have requested that WCL provide a copy of the final extraction plan (including this built features management plan) once approved by the secretary of the DPIE.	Once approved by the Secretary this plan will be provided to WNSW for their records.
NSW Surveyor General – Spatial Services	NSW spatial services were contacted 17 September 2021 with a request to disturb the state and permanent survey marks. An approval was received 20 September 2021 detailing the process to undertake for monitoring and reporting. See Appendix B for the records of this consultation.	Section 6.4

3 BASELINE DATA

Subsidence surveys of built features within the Russell Vale East Area have been conducted for historic mining in previous Longwall projects for LW's 4, 5 & 6. For some features these surveys date back to 2012 and provide context on the baseline condition of these features. These surveys provide a record of the historic subsidence experienced at these features and inform the baseline condition for those aspects/features.

The baseline monitoring program includes the following:

- Lidar
- GNSS continuous subsidence monitor
- Attended ground-based survey.

Pre mining baselines will be established for all of the sites and features listed in Table 6 prior to second workings under the EP with existing historic and baseline data for built features as presented in Appendix C.

Table 6 - Subsidence Monitoring Baselines

Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
Natural and Built Features							
GNSS #1	Mt Ousley Road	General subsidence - Mt Ousley Road & valley closure	3D, +/- 5mm	303687	6196669	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #2	Mt Ousley Road & Upland Swamp CCUS1	General subsidence - Mt Ousley Road & at Swamp CCUS1 (including Bulli & Balgownie goaf)	3D, +/- 5mm	303520	6196372	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #3	General subsidence at Upland Swamp CCUS1	General subsidence & at Swamp CCUS1 (including Bulli & Balgownie goaf)	3D, +/- 5mm	303662	6196277	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #5	Transgrid **330kV Powerline tower T57, 33KV Tower E66, &** Endeavour Energy powerline	General subsidence & at powerlines (Including Balgownie goaf)	3D, +/- 5mm	303937	6196166	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #6	Transgrid **330kV Powerline tower T57, 33KV Tower E66**, & Endeavour Energy powerline	General subsidence & at powerlines	3D, +/- 5mm	304292	6196714	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #7	Transgrid **330kV Powerline tower T55, 33KV Tower E68**, & Endeavour Energy powerline	General subsidence & at powerlines	3D, +/- 5mm	303796	6195900	15 July 2021	Established prior to second workings in panels PC07 & PC08
GNSS #8	Mt Ousley Road	General subsidence & valley closure	3D, +/- 5mm	304184	6197480	15 July 2021	Established prior to second workings in panels PC07 & PC08

Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
GNSS #9	General monitoring to inform expected subsidence at PC07 & PC08	General subsidence (including Bulli goaf #2) above PC21	3D, +/- 5mm	302349	6197089	15 July 2021	Established prior to second workings in panels PC21 – PC25
GNSS #10	General monitoring to inform expected subsidence at PC07 & PC08	General subsidence (including Bulli goaf #11) above PC23	3D, +/- 5mm	301879	6197250	TBA	Established prior to second workings in panels PC21 – PC25
GNSS #11	General monitoring to inform expected subsidence at PC07 & PC08	At Swamp CCUS5 (Bulli goaf #2) above PC21	3D, +/- 5mm	302235	6197053	15 July 2021	Established prior to second workings in panels PC21 – PC25
GNSS #12	General monitoring to inform expected subsidence at PC07 & PC08	At Swamp CRUS1 (including the edge of Bulli & Wongawilli goaf) South of PC21	3D, +/- 5mm	302217	6196907	TBA	Established prior to second workings in panels PC21 – PC25
GNSS #13	General monitoring to inform expected subsidence at PC07 & PC08	At Swamp CCUS4 (including Balgownie goaf) South of PC21	3D, +/- 5mm	302542	6196985	TBA	Established prior to second workings in panels PC21 – PC25
GNSS #14	Mt Ousley Road	At Swamp CCUS19 (Bulli pillars) West of PC08	3D, +/- 5mm	303209	6196193	TBA	Established prior to second workings in panels PC07 & PC08
GNSS #15	Transgrid **330kV Powerline tower T57** & **33KV Tower E66,** Endeavour Energy powerline	At Swamp CCUS3 (Bulli pillars)	3D, +/- 5mm	303537	6196027	TBA	Established prior to second workings in panels PC07 & PC08
GNSS 16	RMS Infrastructure	General subsidence between second workings panels and RMS infrastructure at Picton Road interchange.	3D, +/- 5mm	303095	6195591	TBA	Established prior to second workings in panels PC07 & PC08
GNSS #17	Transgrid **330kV Powerline Tower T54 &33KV Tower E69**, Endeavour Energy powerline	General subsidence & at powerlines	3D, +/- 5mm	303695	61957623	TBA	Established prior to second workings in panels PC07 & PC08

Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
LIDAR	Russell Vale East Coverage - including Mt Ousley Road, Picton Road interchange, Illawarra Escarpment and Powerlines	General subsidence - all surface features	3D +/- 100mm	NA	NA	31 August 2021	Survey prior to second workings
Hi res survey measurement	Cataract Creek CC1, CC2, CC3 and CC4	Valley closure (upsidence) at CC1-CC4	1D ±/ - 3mm	NA	NA	Installed – 28/02/2013 Resurveyed – 3/08/21	Completed resurvey prior to second workings
Infrastructure - RMS							
Mt Ousley Rd Carriageway General	Mt Ousley Road – carriageway Genera	General Pavement Condition	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08	Undertake a baseline condition survey of the carriageway before mining. Reinstate or assess alternatives to the P-Line survey on southbound carriageway. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.
Mt Ousley Rd Carriageway Cataract Creek	Mt Ousley Road – Carriageway / Cataract Creek	General Pavement Condition – Cataract Creek	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08	Check condition of crack meters and replace if necessary. Check the physical condition of the slot. Mill or mill and re-sheet the slot if required. Note schedule any works

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Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
							with other road closures / road works if possible.
Mt Ousley Rd Ridge (P46)	Carriageway / Tension Zone @ ridge (P46)	Carriageway - Tension Zone	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08	Survey monitoring of installed pins (to be identified) Inspect prior to mining of PC07-08 and establish baseline.
Mt Ousley Rd Slopes	ARL2 – 955771/ 95770/ 13482 ARL3 – 10839/ 13483/ 13484/ 13485	Carriageway – slopes monitoring	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08	No baseline identified as required, as cuttings more likely to be stretched than compressed
Mt Ousley Rd – Picton Rd interchange bridge Steel Arch and Culvert over cataract river	Picton Rd interchange bridge (B7926) Steel Arch over Rocky Creek (B7932) Culvert over Cataract River (B814)	Picton Rd interchange bridge, Steel arch, Cataract River Culvert	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08, Prior to secondary workings PC 21-25.	Monitoring pins (prisms at the bridge) noted as being installed prior to longwall mining, required to be inspected, replaced (If required) in consult with RMS prior to baseline survey. Install additional GNSS unit (WCL ref # GNSS 16) at location beyond the ridge to inform movements at the bridge to act as an early warning system. Visual Inspection of Steel Arch over Rocky Creek (B7932), and Culvert over Cataract River (B814)

Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
Mt Ousley Rd – Cataract Creek Culverts	Mt Ousley Road – Cataract Creek Culverts	Monitor culvert condition and joints	1D ±/ - 3mm	NA	NA	Prior to secondary workings PC07 PC08	Monitor GNSS and undertake subsequent survey of Cataract Creek culverts if trigger levels reached. Use precondition assessments of the culverts from longwall mining as baseline.
Mount Ousley Road **Mono Pole Structure**	Mono Pole Structures – E.g., signs	Not required – RA identified no change to existing risk	NR	-	-	NR	NR
Mount Ousley Road **VMS**	None in the area	Not required – no assets identified in the EP area.	NR	-	-	NR	NR
Infrastructure – TransGrid and Endeavour Energy							
Survey of ground and footing monitoring marks	Transgrid 330kV and 132kV powerlines Endeavour Energy 33kV lines	Documentation of pre- mining conditions.	TBD	see tower number	see tower number	TBA	Establish prisms and carry out baseline prior to second workings
Survey of tower legs	Transgrid 330kV and 132kV powerlines	Documentation of pre- mining conditions.	TBD	see tower number	see tower number	TBA	Establish prior to second workings
Leg diff measurements	Transgrid 330kV and 132kV powerlines	Power supply integrity	1D ±/ - 2mm	NA	NA	TBA	Establish prisms on each of the legs of the four identified effected towers prior to second workings

Monitoring Site	Built Feature/ Aspect	Purpose	Data & Accuracy	Location		Date Installed/ Survey Conducted	Baseline
				Easting	Northing		
Survey of poles for 33KV lines	Endeavour Energy 33kV lines	Documentation of pre- mining conditions.	TBD	TBD	TBD	TBA	Establish prior to second workings
Visual inspections of two 33kV lines	Endeavour Energy 33kV lines	Inspection of visual condition of powerlines, poles, surface cracking and photographic records	NA	NA	NA	TBA	Re-establish prior to second workings

Note: Sites that are To Be Advised (TBA) will be installed or surveyed prior to second workings being conducted in the associated panels.

4 PREDICTED IMPACTS

The main hazards to the built features were identified in the EP risk assessment as being public safety associated with impacts to Mount Ousley Road and the Electricity Transmission Lines. These hazards are expected to be minor and manageable with the appropriate risk control measures in place for the planned mining of Panels PC07 - PC08 and PC21-PC25.

Second workings in Stage 1(a) includes PC21-25 which does not have any overlying built features (i.e., Mt Ousley Road, TransGrid and Endeavour Energy powerlines, and survey marks). The subsidence monitoring for second workings above these panels will prove the mining method and subsidence predictions and form the basis for second workings in PC07 - PC08 as part of Stage 1(b).

Figure 2 -Site Plan and Working overlay showing previous workings and Bulli Goaf

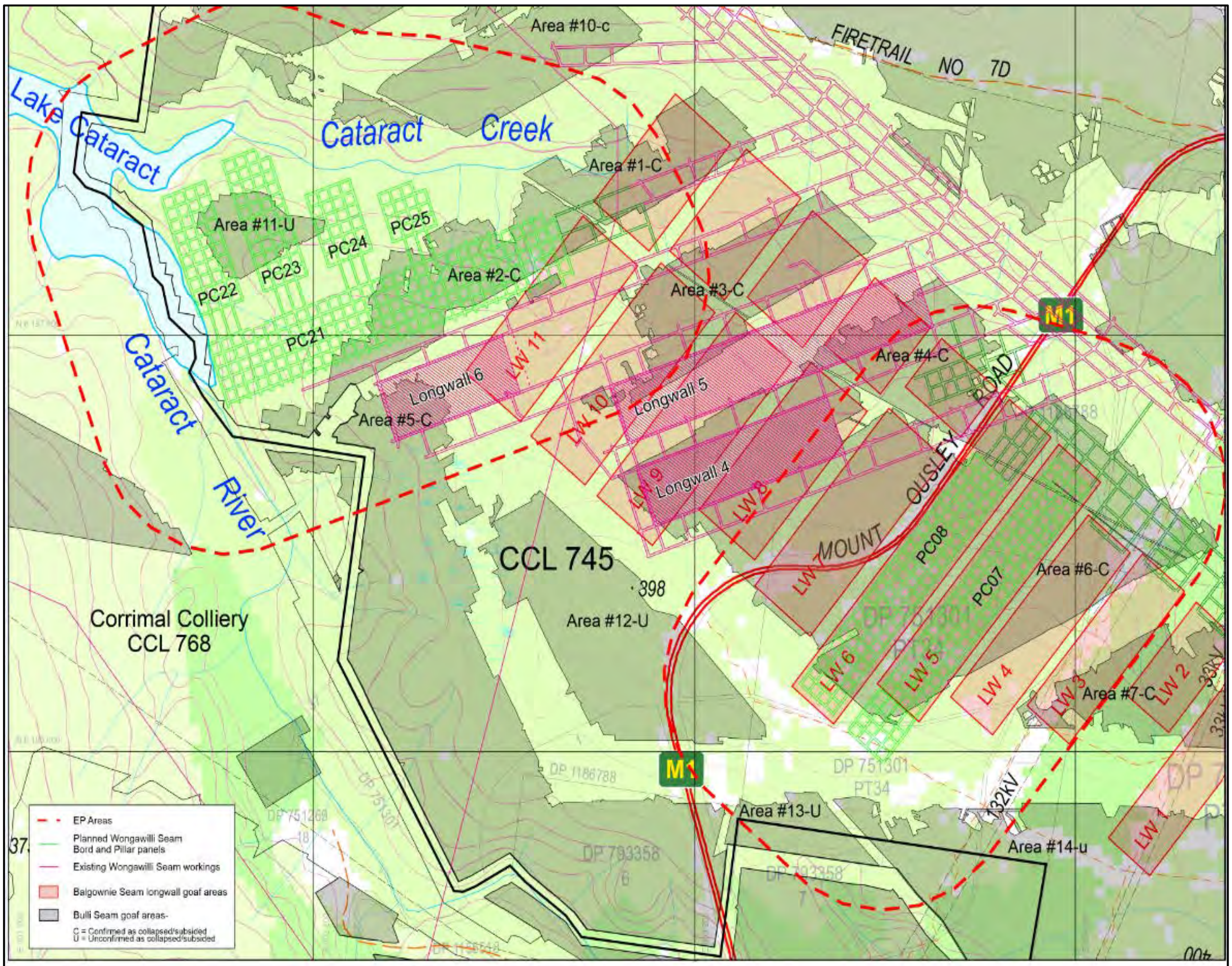

Figure 1: Site plan superimposed on 1:25,000 topographic map.

Low-level subsidence below the straight section of Mount Ousley Road to the south of the Cataract Creek crossing are expected, but the magnitude of this movement is expected to be less than a few tens of millimetres and much less than the movements that were observed during the period of mining Longwalls 4 and 5. Impacts are expected to be barely perceptible. Near real-time monitoring of the closure across Cataract Creek is planned to manage these movements.

The four electricity transmission lines (330kV, 132kV, 2 * 33kV) located between Mount Ousley Road and the Illawarra Escarpment are located above and to the east of main heading pillars in the Bulli Seam. These towers are greater than 200m from the mining proposed in this EP. There is no potential for subsidence movements from either the mains headings or the planned mining of Panels PC07, PC08 and PC21-PC25 to impact the structural integrity or operation of the towers. Nevertheless, near real¬ time three-dimensional monitoring of the towers is planned as detailed in section 3 and 6.

Small vertical movements associated with low level subsidence may affect some permanent survey marks. The process of disturbance for the survey marks is detailed in section 6.4.

There is no potential for subsidence movements from either the mains headings or the planned mining of Panels PC07, PC08 and PC21-PC25 to impact on the Telstra infrastructure located adjacent to Brokers Nose because this infrastructure is located on the opposite side of main heading pillars in the Bulli Seam to the areas of proposed mining in the Wongawilli Seam. As a result Telstra infrastructure is not considered further in this plan.

Potential subsidence hazards associated with mining the remainder of the approved panels is planned to be addressed in future EPs and is not considered in this BFMP.

5 PERFORMANCE MEASURES AND OBJECTIVES

The proposed workings are not considered to have any potential to perceptibly impact on built features. Wollongong Coal's primary objective is to prevent subsidence impacts through ensuring the long-term stability of the workings during and post extraction in accordance with the bord and pillar mine design.

The subsidence impact performance measures are specified in Table 7 and Condition C7 of the Development Consent (MP 09_0013) which are of relevance to this BFMP are outlined in Table 7.

Table 7 - Subsidence Impact Performance Measures

Feature - Built	Performance Measure
Key Public Infrastructure M1 Princes Motorway (formally known as Mount Ousley Road), electricity transmission lines and towers (330kV, 132kV, 2x33kV) and telecommunication lines	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable and must be fully repaired.
Other Infrastructure Access roads, fire trails and other public infrastructure and built features	Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable and must be fully repaired or else replaced or fully compensated.

The performance indicators in Table 8 below are designed to ensure that the above performance measures are conformed with during second workings under the extraction plan.

Table 8 - Subsidence Impact Performance Indicators

Feature - Built	Performance Indicator	Monitoring
<u>Key Public Infrastructure:</u> M1 Princes Motorway (formally known as Mount Ousley Road)	Vertical subsidence at GNSS units 1, 2 or 3 ≤100mm	GNSS Units
	Pavement Movement: - Pavement step height ≤50 mm; - Pavement compressive strains (Cataract Creek) ≤1.0mm/m over a 40m bay length; - Pavement compressive strains (Bend) ≤1.0mm/m over a 40m bay length.	Pavement Surveys
	Culverts: - Negligible visible distortion or damage to culverts	Culvert Surveys

Feature - Built	Performance Indicator	Monitoring
	- Movement in pavement associated with culvert distortion within performance criteria for pavement above. - Minimal formation of voids due to culvert distortion - Ground closure ≤50mm - Convergence ≤50mm Cuttings/Embankments - Negligible observed changes in cuttings - Strains ≤0.5mm/m in pavement at Cataract Creek Picton Interchange Bridge - Subsidence < 50m	Embankment Surveys M1 South GNSS Unit 16
<u>Key Public Infrastructure:</u> *TransGrid HV line Transmission towers*	• No observable surface deformations • <5 mm leg vertical differential; • <20 mm vertical subsidence; • Tilt <1mm/m.	GNSS Units – Subsidence below 20mm, with quarterly reporting. Subsidence prediction due to PC07 & PC08 to be reviewed based on the subsidence records for PC21. Quarterly attended prism surveys of the HV Towers during secondary extraction for panels PC07 - PC08
<u>Key Public Infrastructure:</u> *Endeavour Energy transmission lines*	• No observable surface deformations • <5 mm leg vertical differential; • <50 mm vertical subsidence; • Tilt <1mm/m.	GNSS Units – Subsidence below 50mm with quarterly reporting Subsidence prediction due to PC07 & PC08 to be reviewed based on the subsidence records for PC21 Quarterly attended surveys of the HV Towers during secondary extraction for panels PC07 - PC08
<u>Other Infrastructure:</u> Access roads and fire trails	Cracking ≤10mm and no noticeable instability or traffic (foot/vehicular) impedance	Visual Inspection
<u>Other Infrastructure:</u> Permanent survey marks	General movement of survey markers	Monitored via NRTK survey every 6 months during secondary workings. The monitoring will continue until the mine workings has been

Feature - Built	Performance Indicator	Monitoring
		completed and the subsidence has ceased. Completion of secondary workings via completion of a NSW Spatial Services End *of Project Applicant Compliance Statement*.

6 MONITORING PROGRAM

This section presents monitoring, triggers and responses that will be undertaken to manage potential impacts on built features.

6.1 TfNSW – M1 Princess Highway/ Mt Ousley Rd

TfNSW undertook a preliminary risk assessment, the outcome of which indicated that there are risks to TfNSW that exceed the preliminary acceptability limits (See Appendix B). This risk assessment aims to resolve these matters.

Arup has assessed the risks through a workshop with relevant stakeholders to determine impacts of the mining activities on the road infrastructure, functionality and road safety, and identify appropriate risk mitigation measures.

Since the expected subsidence is less than 100mm which is likely to have no perceptible impacts to TfNSW assets (refer to Section 4), the focus of this risk assessment addresses the contingency case if subsidence of greater than 100mm results.

The two stages of mining being stage 1(a) for PC21-25 and stage 1b for PC07-08 were considered separately due to their proximity to TfNSW assets and the corresponding risk.

6.1.1 PC21-25

For PC21-25, the only assets within five times the depth of cover, is a section of the Mt Ousley Road carriageway and small culverts. The worst-case subsidence is not considered to present a credible risk to these assets (i.e. the level of possible impacts is insignificant).

6.1.2 PC07-08

A total of 24 risks were identified for PC07-08 considering a scenario of worst-case subsidence.13 events were not considered to present a credible risk (i.e. the level of possible impacts is insignificant). The residual risk profile has no extreme or high risks.

For PC07-08, the assets considered in the risk assessment include:

- Carriageway.
- Bridges/ structures (B7926 (Picton Road Bridge), B7932 (Steel Arch Culvert) and B814 (Cataract River Culvert)
- Culverts.
- Cuttings.
- Embankments. (Slopes > 5m high and those slopes closer to TfNSW infrastructure than a distance equal to twice slope height).
- Mono pole structures, e.g. road signs, noise walls, barriers.
- Variable Message Sign (VMS).

The key hazards during secondary workings are expected to be closure at the existing road crossing across Cataract Creek. This closure will be monitored by:

- Near real-time monitoring of GNSS stations located on either side of Cataract Creek.
- Closure measurements across Cataract Creek at four locations, referred to as CCC1-CCC4.

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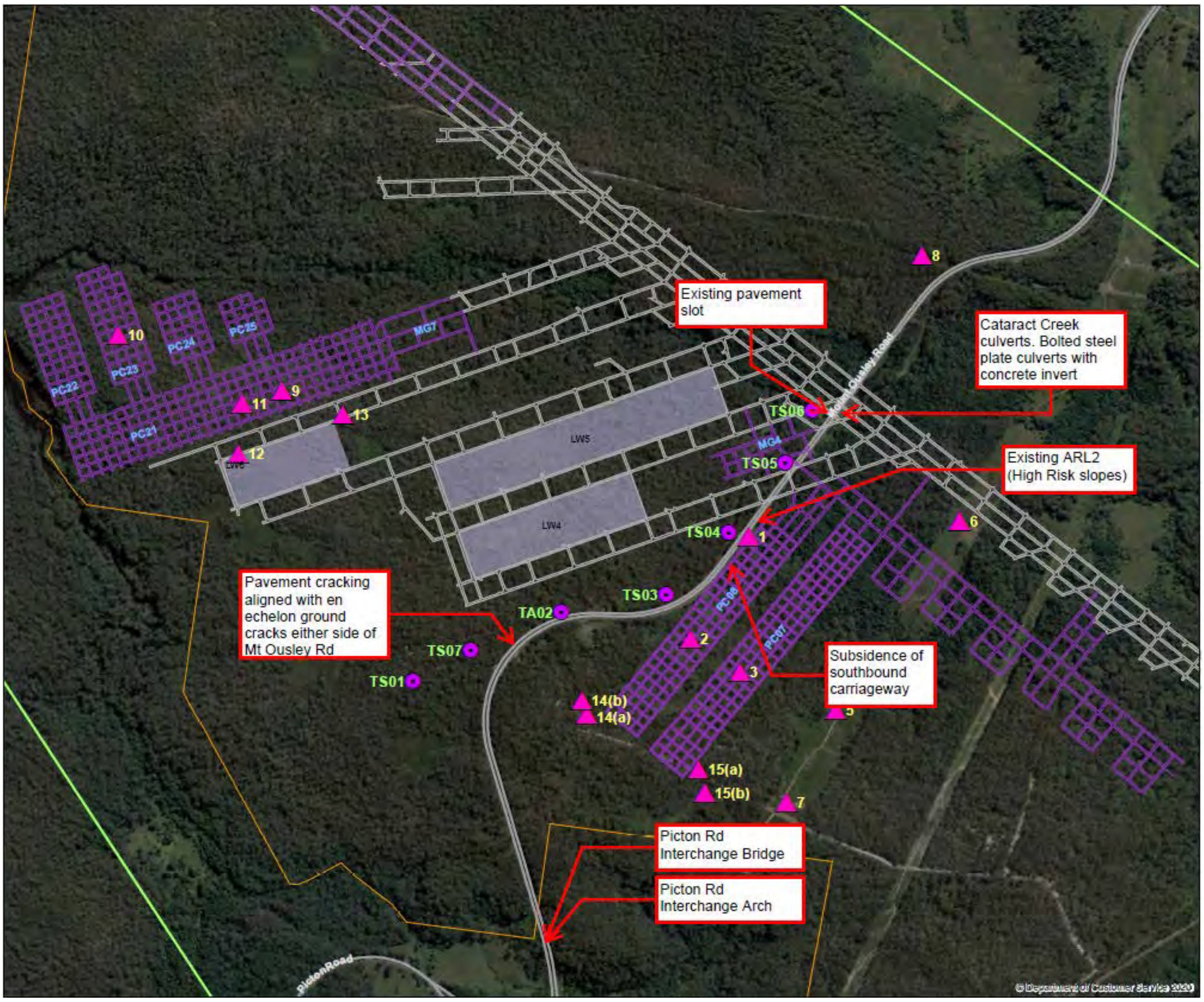
- Continuous monitoring of pavement closure across the slot at the crossing point on the low point of Mount Ousley Road where it crosses Cataract Creek.
- Periodic inspections of the geometry of the Cataract Creek culvert (if movements are detected).
- Periodic surveys of the cracks at the ridge top to the south of Cataract Creek.
- High resolution surveying of opening and closure slot on Mount Ousley Road.

An initial survey would be carried out prior to mining to confirm a new baseline for the proposed mining and monitoring frequencies as detailed in Table 6.

Any significant movement as determined by the performance criteria in Table 8 and the specific TARP in Table 14 would be regarded as a trigger for further investigations including visual inspection and survey of differential leg movements & position compared to baseline to review compliance with the performance criteria in Table 8.

A trigger of 50mm of closure on any of the monitoring systems would be regarded as significant. This level of closure would trigger a technical committee meeting and further investigations to determine the nature of any impacts.

Figure 3 – Key TfNSW Assets in UEP Area



6.2 TransGrid 330 and 132kV HV Electricity Transmission Lines and Towers

The key hazard for the two (330 and 132kV) high voltage (HV) transmission lines and towers is recognised to be differential movements of the legs of the electricity transmission towers.

An initial survey would be made prior to mining to confirm a new baseline for future mining and monitoring frequencies for the survey points on the towers are detailed in Table 5.

Monitoring to be undertaken during secondary extraction of panels PC 07 and PC 08 as detailed in Table 8 includes:

- Quarterly surveyed measurements to determine tilt of the towers or differential movement of individual legs via a prism to be installed on each of the legs of affected towers.
- Absolute vertical subsidence movement of the tower measured by near real-time GNSS monitoring (tolerance level of +/- 5mm in 3D).
- Quarterly Lidar (+/-100mm)

Any significant movement as determined by the performance criteria in Table 7 and the specific TARP in Table 12 would be regarded as a trigger for further investigations including visual inspection and survey of differential leg movements & position compared to baseline to review compliance with the performance criteria in Table 7.

6.3 Endeavour Energy 33KV Electricity Transmission Lines and Pylons

SCT (2021) note that the two 33KV transmission towers appear from the detailed review of historic workings and subsidence monitoring plans to have been in place when the Balgownie Seam longwall panels were mined resulting in vertical subsidence of up to 1.3m.

The key hazard for the 33KV lines and pylons is recognised to be vertical subsidence movement of the pylons. An initial baseline survey would be undertaken prior to mining to confirm a new baseline for future mining as detailed in Table 6 and monitoring frequencies for the survey points on the pylons are detailed in Table 9

Monitoring to be undertaken during secondary extraction of panels PC 07 and PC 08 as per Table 9 includes:

- Quarterly surveyed measurements to determine vertical movement via a prism to be installed on each pylon
- Absolute vertical subsidence movement of the pylon measured by near real-time GNSS monitoring (tolerance level of +/- 5mm in 3D).
- Quarterly Lidar (+/-100mm)

Any significant movement as determined by the performance criteria in Table 8 and the specific TARP in Table 12 would be regarded as a trigger for further investigations including visual inspection and survey of differential leg movements & position compared to baseline to review compliance with the performance criteria in Table 8.

6.4 Permanent Survey Control Stations

The permanent survey control stations within the EP Area for PC07-08, Permanent marks (PM 173135, PM 173136) and state survey mark (SS165830), are positioned along the Mt Ousley road easement from north to south. State Survey mark SS 14867 is located approximately 200m to the East of PC07.

As state survey marks are designed to be stable reference points there is the potential for their position to move as a result of subsidence. The strategy to manage subsidence impacts is to notify the asset owner via an NSW Spatial services Survey mark removal application. .

The movement of the affected permanent survey marks is monitored by NRTK survey every six months during secondary workings. This monitoring will continue until the mine workings has been completed and the subsidence, if any, has ceased.

At the completion of secondary workings WCL will complete a NSW Spatial Services *End of Project Applicant Compliance Statement* for submission to NSW Spatial Services.

6.5 Access Roads and Fire Trails

Fire trails within the Metropolitan Special Area and overlying the mining area have a low to negligible potential to be impacted by subsidence due to the mining method adopted.

A list of Water NSW roads and fire trails which may be utilised by WCL are listed in Schedule 4 of the WCL WNSW special areas access consent (F2020/3092) and in any specific activity approvals issued by WaterNSW under Part 5 of the EP&A Act.

Periodic visual inspections would be expected to be sufficient to identify any impacts.

In the most unlikely event that subsidence impacts do become apparent on any of the listed fire trails or access roads as listed in the WNSW special areas access consent (F2020/3092) minor remedial work may be required. Details on such minor remedial repairs as required to be undertaken by WCL in consultation with WNSW as soon as possible to maintain them in a working safe and serviceable condition for the listed fire trails and access roads are detailed in the WCL EP Land Management Plan (RVC EC PLN 035).

Table 9 - Subsidence Effects Monitoring Program – Built Features

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
Built Features							
Edge of Mt Ousley Road	GNSS #1	General subsidence & valley closure Mt Ousley Pavement	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC08 (Bulli & Balgownie goaf)	GNSS #2	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, DPIE, RR
PC07 (Bulli & Balgownie goaf)	GNSS #3	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings,	WCL	**During Mining** GNSS readings prior to second workings,	Website (20 days after period) and email to DAWE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				During mining • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining		During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	
330kV/ !32 KV Powerline and tower T56 / E69 Endeavour Energy 33KV powerline and pylons (Balgownie goaf)	GNSS #5	General subsidence & at powerlines	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV/ !32 KV Powerline tower T57 / E66 Endeavour Energy 33KV powerline and pylons (pillars)	GNSS #6	General subsidence & at powerlines	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining**	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining**	Website (20 days after period) and email to TG, EE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				• Quarterly for 12 months after cessation of mining		Quarterly for 12 months after cessation of mining	
330kV/ !32 KV Powerline tower T55 / E 68 tower (solid coal) Endeavour Energy 33KV powerline and pylons	GNSS #7	General subsidence & at powerlines	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to TG, EE, DPIE, RR
WCL easement (Bulli goaf)	GNSS #8	General subsidence & valley closure	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC21 (Bulli goaf #2)	GNSS #9	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining**	WCL	**During Mining** GNSS readings prior to second workings,	Website (20 days after period) and email to DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				• During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining		During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	
PC23 (Bulli goaf #11)	GNSS #10	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DPIE, RR
PC21 (Bulli goaf #2)	GNSS #11	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining**	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining**	Website (20 days after period) and email to DAWE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				• Quarterly for 12 months after cessation of mining		Quarterly for 12 months after cessation of mining	
South of PC21 (edge Bulli & Wongawilli goaf)	GNSS #12	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (Balgownie goaf)	GNSS #13	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, DPIE, RR
West of PC08 (Bulli pillars)	GNSS #14	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings,	WCL	**During Mining** GNSS readings prior to second workings,	Website (20 days after period) and email to DAWE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				During mining • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining		During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	
South of PC07 (Bulli pillars)	GNSS #15	General subsidence	3D +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, DPIE, RR
RMS Infrastructure- Picton Rd Bridge	GNSS #16	General subsidence between second workings panels and RMS infrastructure at Picton Road interchange.	3D, +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining**	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining**	Website (20 days after period) and email to DAWE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				• Quarterly for 12 months after cessation of mining		Quarterly for 12 months after cessation of mining	
Transgrid **330kV Powerline tower T54** & **33KV Tower E69,** Endeavour Energy 33KV powerline and pylons	GNSS #17	General subsidence & at powerlines	GNSS - 3D, +/- 5mm	**Prior to second workings** • Monthly GNSS readings prior to second workings, **During mining** • During mining GNSS data recorded on a real time basis, reviewed on a monthly basis or as per TARP trigger. **Post Mining** • Quarterly for 12 months after cessation of mining	WCL	**During Mining** GNSS readings prior to second workings, During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. **Post Mining** Quarterly for 12 months after cessation of mining	Website (20 days after period) and email to DAWE, DPIE, RR
Infrastructure – RMS							
Mt Ousley Rd Carriageway General	GNSS 1, 8, 16 CT1- CT4 P-Line survey twice weekly drive-through inspections	General Pavement Condition	GNSS - 3D, +/- 5mm	**During Mining (GNSS)** • Subsidence monitoring by real time GNSS units as per specific GNNS detail (GNSS, 1, 8, 16) **During Mining CT1- CT4** • Yearly survey of CT1- CT4 creek closure **P-line southbound survey** • P-Line survey on southbound carriageway - reinstate or assess alternative before commencement of second workings. • Within three months of completion of second workings panel.	WCL WCL WCL	**GNSS** • GNSS readings prior to second workings, • During mining over active mining area GNSS data reviewed weekly, Monthly in all other areas, or as required by TARP trigger. **CT1- CT4** • Yearly CT1-CT4. **P-line southbound survey** • Within three months of completion of second workings panel.	Website (20 days after period) and email to DAWE, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
				Drive through inspection • TfNSW undertake twice weekly drive-through inspections (done at traffic speed) during mining.	TfNSW	**Drive through inspection** • Report on new defects, and repair as necessary.	
Carriageway– Cataract Creek (100m in length)	GNSS, 1, GNSS 8	Condition Carriageway– Cataract Creek	GNSS - 3D, +/- 5mm	• Subsidence monitoring by real time GNSS units as per specific GNNS detail (GNSS, 1, 8, 16) • Undertake subsequent survey of culverts if GNSS TARP reached.	WCL	• GNSS readings prior to second workings, • During mining over active mining area GNSS data reviewed weekly • Monthly in all other areas, or as required by TARP trigger. • Post Mining - Quarterly for 12 months after cessation of mining-	Website (20 days after period) and email to DAWE, DPIE, RR
Carriageway- Mt Ousley Road – tension zone at ridge (P46)	Attended survey	Pavement condition from tension	Survey - 1D, ±3mm	• Within three months after each panel • Annual • By TARP trigger	WCL	• Within three months of each panel • Annual • As required by TARP	Website (20 days after survey) and email to RMS, DPIE, RR
Bridges Picton Rd interchange - B7926 Steel Arch over Rocky Creek Culvert – B7932 Culvert over Cataract River – B814	GNSS #16 Attended survey	General subsidence between second workings panels and RMS infrastructure at Picton Road interchange, and other bridges.	GNSS - 3D, +/- 5mm Survey - 1D, ±/ - 3mm	• Quarterly GNSS readings prior to second workings for PC 07 and PC08, • During mining over active mining area GNSS data recorded on a real time basis, reviewed weekly and monthly in all other areas, or as required by TARP trigger. • Quarterly for 12 months after cessation of mining	WCL	• Within three months of each panel • Annual • As required by TARP	Website (20 days after survey) and email to RMS, DPIE, RR

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
Culverts Cataract Creek Culverts Multiple Culverts	Attended survey	Determine changes from baseline	GNSS - 3D, +/- 5mm Survey - 1D, ±/ - 3mm	• Quarterly GNSS readings prior to second workings for PC 07 and PC08, • During mining over active mining area GNSS data recorded on a real time basis, reviewed weekly and monthly in all other areas, or as required by TARP trigger. • Quarterly for 12 months after cessation of mining • TARP attended survey	WCL	• Within three months of each panel • Annual • As required by TARP	Website (20 days after survey) and email to RMS, DPIE, RR
Slopes ARL2 – 955771/ 95770/ 13482 ARL3 – 10839/ 13483/ 13484/ 13485	Attended survey	Determine changes from baseline	Survey - 1D, ±/ - 3mm	• GNSS monitoring to provide early warning. • TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	WCL	• GNSS readings prior to second workings, • During mining over active mining area GNSS data reviewed weekly	Website (20 days after survey) and email to RMS, DPIE, RR
Mono pole structures, e.g. road signs, noise walls, barriers.	N/A	Not required No assets in UEP Area	--	-	WCL -	-	--
Variable Message Sign (VMS).	-N/A	Not required No assets in UEP Area	-	-	WCL	-	--
TransGrid and Endeavor Energy infrastructure							

Location	Monitoring Site	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Resp.	Reporting Frequency	Reporting Timing & Distribution
330kV and 132kV powerline and Towers	GNSS 5 – 7, GNSS 17 Tower survey points	• General Subsidence • Leg diff measurements • Tilt	1D ±2mm	After each panel or annual or by TARP trigger	WCL	Within 3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
33 KV Power lines and pylons	GNSS 5 – 7, GNSS 17	Power pylons • General Subsidence • Tilt	1D ±2mm	After each panel or annual or by TARP trigger	WCL	Within 3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
Visual inspections and photos	TransGrid and Endeavour Energy Infrastructure	Inspect for visual damage	n/a	After each panel or annual or by TARP trigger	WCL	Within 3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR

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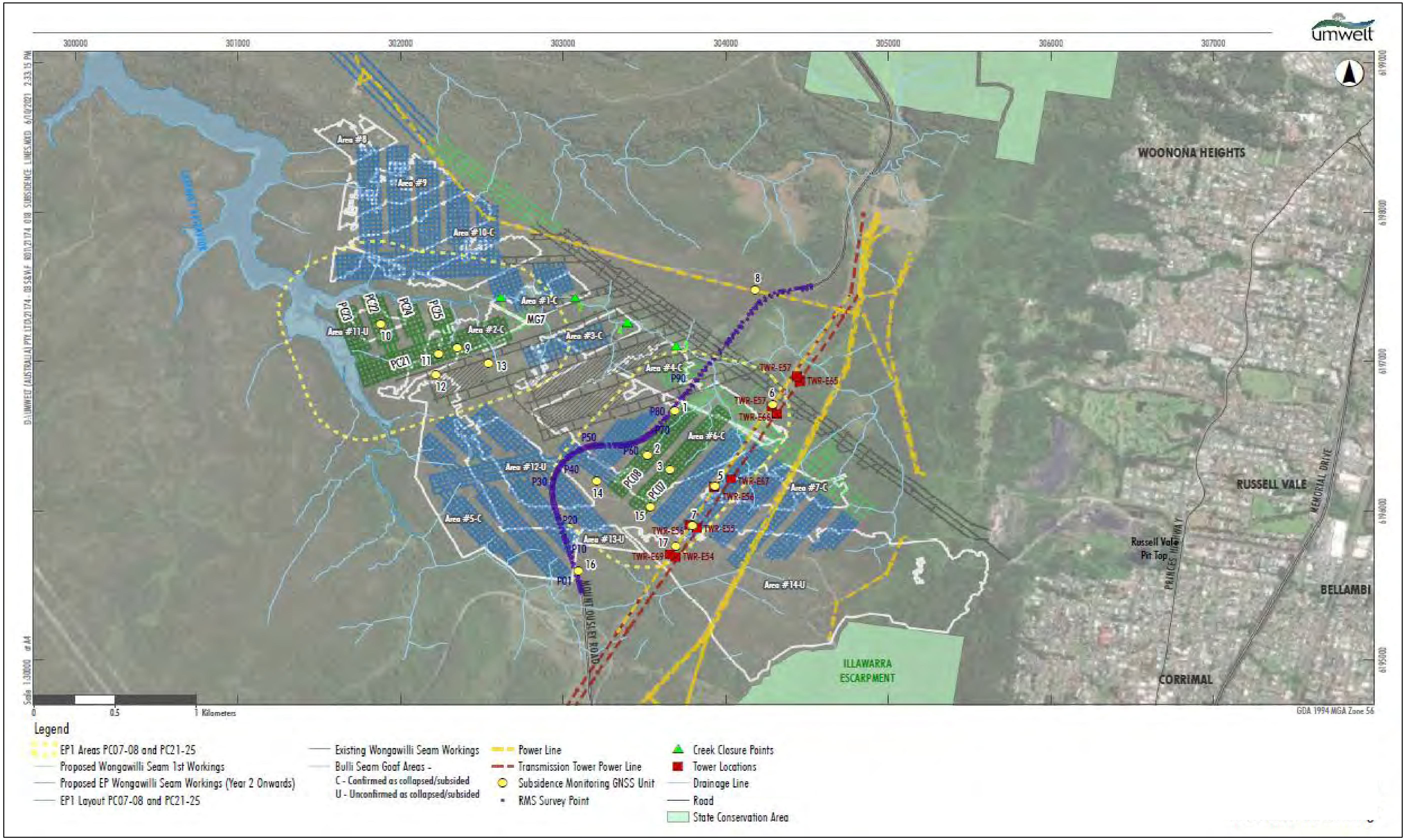
Figure 4 - Built Features Monitoring Locations



7 MITIGATION AND MANAGEMENT MEASURES

7.1 General

The three main controls for subsidence hazards are:

1. the nature of the proposed bord and pillar mining system causing low levels of disturbance and low levels of subsidence
2. the staged sequence of planned mining initially to the west of the Mount Ousley Road and subsequently below previously extracted Balgownie Seam longwall panels separated from key infrastructure by coal barriers known to be stable – with subsequent mining of other panels planned as to be covered by a separate EP.
3. a review of mine plans and previous subsidence monitoring associated with mining longwall panels in the Balgownie and Wongawilli Seams.

Additional controls are based on high precision, near real-time GNSS monitoring of key locations. Further controls may be developed in consultation with infrastructure owners following risk assessment and associated discussions.

7.1.1 Mining Technique

The bord and pillar mining system is designed to be long-term stable and cause only very low levels of ground disturbance and surface subsidence. The stability of this pillar system has been confirmed by peer review (Hebblewhite 2020). Near real-time subsidence GNSS monitoring will be used to confirm the low levels of subsidence expected.

7.1.2 Mine Planning and staging

A staged sequence of mining is planned with Stage 1(a) and Stage 1(b) as outlined in **Section 1.2** above. The first stage (Stage 1(a)) of second workings (PC21-PC25) are planned to the west of Mount Ousley Road in an area that is remote from subsidence sensitive infrastructure and separated from them by previous longwall mining in the Wongawilli Seam.

Surface subsidence will be monitored directly above these panels using a combination of near real-time GNSS monitoring and LIDAR to confirm the low levels of subsidence expected. The second stage (stage 1(b)) of second workings (PC07 and PC08) is planned directly below two previously mined Balgownie Seam longwall panels. PC08 is adjacent to the Mount Ousley Road but not directly under it. Electricity transmission pylons are located a minimum of 200m from the eastern edge of PC07, some 265m above the Bulli Seam mining horizon and 295m above the Wongawilli Seam mining horizon.

7.1.3 Review of mine plans and previous subsidence

Panels PC07 and PC08 are located directly below previously extracted longwall panels in the Balgownie Seam and areas in the Bulli Seam indicated as being fully extracted. The vertical interburden thickness between the Bulli Seam and the Balgownie Seam is in the range 5-10m. There is no potential for there to be marginally stable pillars left in the Bulli Seam above these panels after the Bulli Seam has been subjected to incremental longwall extraction 5-10m below.

Further evidence to support subsidence monitoring observations of the Bulli Seam being fully collapsed in this area is provided by RV16 which was drilled through the Balgownie Seam chain pillar between PC07 and PC08 down to the Wongawilli Seam mining horizon. This borehole encountered some wood chips at the Bulli Seam mining horizon but no significant thickness of coal. The borehole held water to the surface during installation of piezometers in the hole. These observations confirm the full collapse of the Bulli Seam goaf in this location and supports the conclusion that the goaf is fully collapsed, and consolidated, in this area.

A review of the subsidence monitoring from the period of longwall mining in the Balgownie Seam indicates that the subsidence observed is consistent with the Bulli Seam having fully subsided. This information indicates that there is no potential for further collapse of pillars in the Bulli Seam above or close to PC07 and PC08. Further detail supporting this conclusion is provided in the EP Subsidence Assessment Report (SCT 2021).

7.2 TfNSW Mitigation Measures

The risk mitigations measures resulting from the TfNSW risk assessment are summarised below and in detail in Table 5 Baseline Surveys and Table 8 Monitoring program:

- Undertake a baseline condition survey of the carriageway before mining.
- Reinstate or assess alternatives to the P-Line survey on southbound carriageway.
- Check condition of crack meters and replace if necessary.
- Check the physical condition of the slot.
- Mill or mill and resheet the slot if required. Note schedule any works with other road closures / road works if possible.
- Assess during mining, the nature of any movements (perform crack sealing if required).
- Assess post mining, if crack sealing is sufficient or if further treatment is required.
- Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline.
- Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system.
- Monitor GNSS and undertake subsequent survey of Cataract Creek culverts if trigger levels reached.
- Use precondition assessments of the culverts from longwall mining as baseline.
- Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining.
- Groom slopes prior to mining.
- Use GNSS monitoring to provide early warning of impacts to the slopes.
- TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.
- Develop TARP with trigger points for various actions.

The risks and mitigation measures identified in this risk assessment are addressed and managed in this Built Features Management Plan by inclusion in the baseline (Section 3), monitoring (Section 6) and TARP's (Appendix A).

7.3 RVC Environmental Management System

RVC operate under the RVC Environmental Management Strategy (EMS) (RVC EC STD 001) which provides a framework to ensure activities at WCL are undertaken in an environmentally responsible manner and in general accordance with the following:

- Russell Vale Revised Preferred Underground Expansion Project development consent MP09_0013.
- ISO14001 Environmental Management Standard; and
- Legislative and other requirements.

While the EMS includes general requirements for the reporting and management of incidents, the EP provides specific requirements in relation to the management of subsidence related impacts associated with the mining covered by the EP and the EP requirements (including the requirements set out in this management plan) prevail to the extent of any inconsistency between documents. Figure 6 outlines the WCL environmental Management Process.

7.4 Trigger Action Response Plan

The Trigger Action Response Plan (TARP), as presented in Appendix A, has been designed specifically for this BFMP to illustrate how the various predicted subsidence impacts, monitoring components, performance measures, and responsibilities are structured to achieve compliance with the relevant statutory requirements, and the framework for management and contingency actions.

The TARP system provides a simple, transparent, and useable record of the monitoring of environmental performance and the implementation of management and/or contingency measures.

The TARP is designed with consideration of baseline conditions and predicted indirect impacts and comprises the following:

- Trigger levels from monitoring to assess performance; and
- Triggers that flag implementation of contingency measures.

Table 10 below outlines the trigger level definitions to be applied to the TARPs established under this EP.

Table 10 - Extraction Plan Trigger Levels

TRIGGER LEVEL	DESCRIPTION
Level 1	Monitoring indicates performance criteria are satisfied. Operations continue as normal.
Level 2	Minor or persistent changes in monitoring results indicate potential alteration of the environment (could be natural or mining related) or impacts outside of predictions. Internal investigation of potential causes required to determine if there is potential to cause material harm due to mining operations. Exceedances of subsidence triggers may result in implementation of adaptive management measures.
Level 3	Significant change in monitoring results indicates a likely alteration of the environment (could be natural or mining related) or impacts outside of predictions.

TRIGGER LEVEL	DESCRIPTION
	Investigation into potential causes required to determine if material harm has been caused due to mining operations. External notification of *potential* incident required for Performance Measures TARPs. Exceedances of subsidence triggers likely to result in implementation of adaptive management measures.

The TARP's as referred to in Appendix A have been developed to address the specific built features for the key public infrastructure:

- Mt Ousley Road and the Mt Ousley Rd/ Picton Rd Interchange
- TransGrid 330 and 132KV power lines and transmission towers
- Endeavour Energy 33KV power lines and transmissions pylons
- Surveyor General permanent survey markers.,

The TARP process has been developed in consultation with the above stakeholders. Specifically, the TransGrid TARP's have been adopted for the Endeavour Energy 33KV power lines and transmissions pylons as they are located further away from the secondary workings panels.

Figure 5 below provides a flow chart covering the Performance Measure TARP Process.

Figure 5 - Performance TARP Process

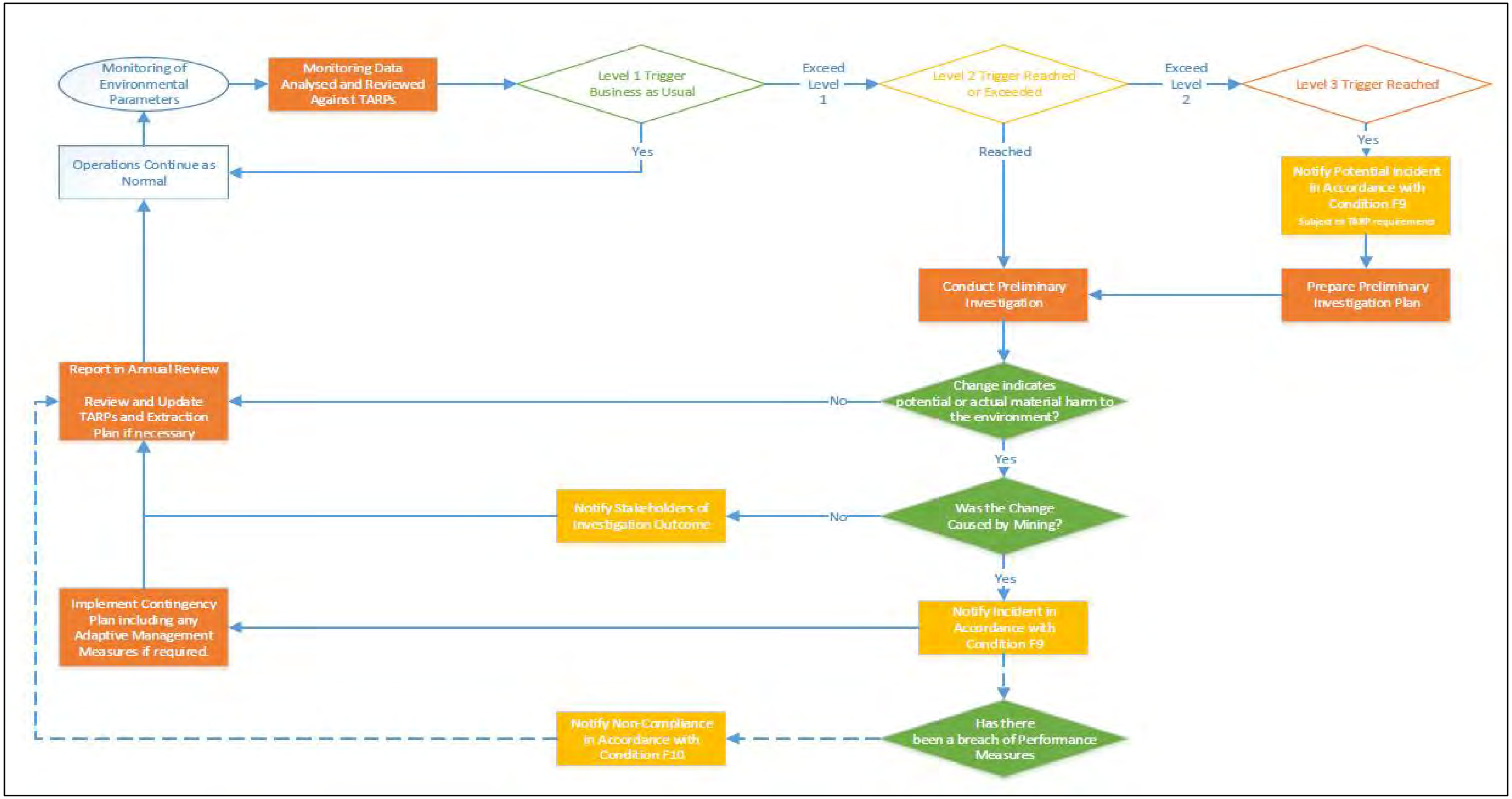
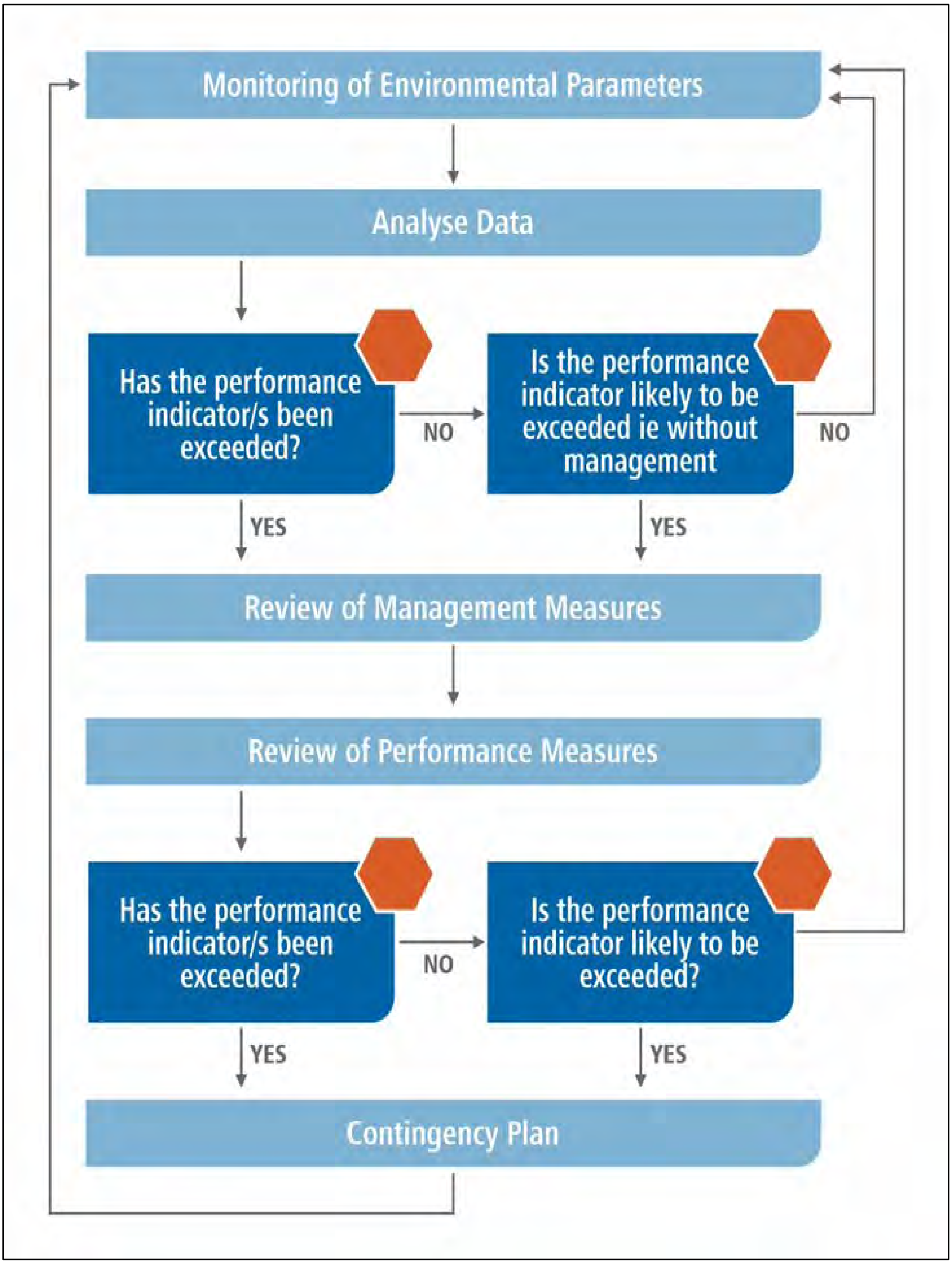


Figure 6 - Environmental Management Process



7.4.1 Adaptive Management

Due to the nature of the proposed bord and pillar mining, adaptive management measures and TARPs are designed to identify circumstances where observed impacts differ from those predicted. Departures from these predictions may indicate the potential for exceedances of performance criteria.

Where investigations triggered by the Performance Measure TARPS indicate that the changed conditions of sites have been, or are likely to have been, caused by mining operations, the response to these impacts include adaptive management measures to ensure further impacts to the site will not occur or be mitigated or that impacts to future sites do not occur in the future.

Due to the nature of the proposed mining and low likelihood of underground mining resulting in any impacts to the site provided subsidence impacts remain within predictions, these adaptive management measures that will be implemented, will be considered in the investigation process. Adaptive management measures to be implemented in the event of a clear linkage between the mining authorised under the development consent and any impacts to the bult features described in this plan, will include a review of the design and layout of future mining within areas that may potentially impact on such items to avoid a recurrence of any such impacts. These adaptive management measures include:

- stop mining and investigate causes of the exceeding of subsidence predictions.
- undertake a review of the panel design parameters in consultation with the resource regulator.

The Contingency Planning process set out in Section 7.5 also covers this process.

The TARPS in APPENDIX A contain adaptive management measures for subsidence which inform decisions regarding underground mining operations, should higher than predicted vertical subsidence effects be observed. The purpose of this adaptive management measures are to implement additional measures where necessary to:

- enable potential impacts associated with higher than predicted subsidence impacts to be monitored; and/or
- the implementation of changes in mining operations to prevent performance criteria from being exceeded.

WCL will assess and manage development-related risks to ensure that there are no exceedances of the criteria and/or performance measures in this consent in accordance with Condition F4 of Schedule 2. Any exceedance of the Subsidence criteria and/or performance measures constitutes a breach of this consent and may be subject to penalty or offence provisions under the EP&A Act or EP&A Regulation, notwithstanding offsetting actions taken. Where any exceedance of these criteria and/or performance measures has occurred, WCL will at the earliest opportunity:

- take all reasonable and feasible steps to ensure the exceedance ceases and does not re-occur;
- consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action;
- within 14 days of the exceedance occurring, submit a report to the Secretary describing these remediation options and any preferred remediation measures or other course of action; and

- implement remediation measures as directed by the Planning Secretary,

to the satisfaction of the Secretary.

7.5 Contingency Plan

Condition F5(f) requires WCL to establish a contingency plan to manage any unpredicted impacts and their consequences, and to ensure that ongoing impacts reduce to levels below relevant performance measures or criteria as quickly as possible.

The following section details the process that WCL will implement to ensure compliance with Condition F5(f).

In the event that observed parameters or impacts exceed, or are considered likely to exceed, the performance measures detailed in Section 5 of this Plan, WCL will implement the following Contingency Plan:

- The observation will be reported to WCL's Group Environmental Manager as soon as possible, or within 24 hours;
- The observation will be recorded;
- WCL will report any exceedance of the performance measure to the DPIE and the relevant built features stakeholder/s as soon as practicable after WCL becomes aware of the exceedance;
- WCL will assess the exceedances referred to in the TARPs of this document and where appropriate, implement safety measures in accordance with the appropriate Management Plans;
- The Group Environmental Manager will investigate any potential contributing factors and identify an appropriate action plan to manage the identified impact(s), in consultation with specialists and/or relevant agencies if necessary;
- WCL will identify any appropriate action plan to manage the identified impact(s), in consultation with other specialists and/or key stakeholders;
- WCL will submit the proposed course of action to DPIE for approval;
- WCL will implement the approved course of action to the satisfaction of the DPIE;
- WCL will continue to monitor performance with the new action plan in place and, if successful will formalise these actions as part of the Management Plan.

Contingency measures will be developed in consideration of the specific circumstances of the issue and the assessment of consequences in consultation with the key infrastructure stakeholders to identify and implement appropriate remedial measures which includes commitments to mitigate, repair, replace or compensate predicted impacts on potentially affected built features in a timely manner.

8 COMMUNICATIONS PROTOCOL

Specific Built Features agency reporting with regard to the monitoring program and in the case of exceedance of performance measures is detailed for the asset as below.

8.1 TransGrid 330 and 132 kV Transmissions Lines and Towers

In the instance that there are any changes to the predicted subsidence as recorded via the GNSS meters and or subsequent impact to TransGrid assets as recorded via the quarterly surveys during secondary workings on the panels PC 07 PC08 TransGrid is to be notified.

The Notification would be via the TransGrid emergency line 1800 027 253, quoting the following project details

- TransGrid Reference Number: 2021-331
- Location: Russell Vale Colliery
- TransGrid: Transmission Line 11 Dapto 330kV – Sydney South 330kV

8.2 Endeavour 33 kV Transmissions Lines and Pylons

In the instance that there are any changes to the predicted subsidence as recorded via the GNSS meters and or subsequent impact to Endeavour Energy assets as recorded via the quarterly surveys during secondary workings on the panels PC07 and PC08 Endeavour Energy is to be notified.

The Notification would be via the Endeavour Energy emergency line 131 003, quoting the following project details:

- Location: Russell Vale Colliery,
- Locality of power lines and pylons – Cataract.
- Endeavour Energy: Transmission Line (details TBA)

8.3 Surveyor General - Permanent Survey Marks

In the instance that a variation was required to the information regarding the impacts described in the Surveyor General application to disturb or remove permanent survey marks WCL notes the following requirements in accordance with the Surveying and Spatial Information Regulation 2017:

- If a minor variation to this approval is required, then notification of that variation needs to be sent to the Office of the Surveyor-General by commenting on SO-559 in the DCS Spatial Services Customer Hub.
- If there are any major variations to the subject proposal, this consent is nullified and a new Survey Mark Removal application must be lodged for assessment by the Surveyor-General.
- Where possible, provide at least 30 business days notification before the proposed removal or replacement of survey marks (Permanent Survey Marks or Cadastral Reference Marks) thereby extending the timeframe of 14 days minimum under Clause 90 of the Surveying and Spatial Information Regulation 2017.

8.4 TfNSW - Mt Ousley Road

In the instance that there are any changes to the predicted subsidence as recorded via the GNSS meters and or subsequent impact to RMS assets as recorded via the quarterly surveys during secondary workings RMS is to be notified.

The Notification would be via the Traffic Management Centre (TMC). The TMC responds in accordance with RMS incident response protocols. RMS Works Supervisor inspects site and acts in accordance with these protocols and if the incident is confirmed, informs the Asset Manager who will request a TC meeting to determine appropriate action as per the process outlined below.

- WCL will set up teleconferencing facilities with phone in numbers and call cards.
- Ensure the Flow Chart is referenced to ensure notification occurs appropriately.
- First response to any trigger is a site inspection.
- Green – normal operation of RMS infrastructure – infrastructure managed in accordance with normal asset management procedures.
- Amber and red triggers relate to behaviour of RMS infrastructure that could lead to risks to infrastructure, safety or network availability. Technical specialists may determine other triggers from monitoring information and alert TC members and Works Supervisor–see also response flow chart.
- Grey triggers relate to the performance of the monitoring system. The behaviour of the RMS's infrastructure is not directly at risk as a result of a grey trigger, but the ability to assess its current and likely future behaviour is. WCL Control Room is not informed of grey triggers. Grey are triggers reported in the relevant monitoring report.
- Due to interactions between monitoring elements and ultimate need to protect the assets, this TARP is based on infrastructure elements to be protected.
- 'After mining', 'end of mining' and similar terms mean after completion of the longwalls covered by this BFMP.
- Cross lines and longitudinal lines are not trigger devices but are monitoring devices to assist the Technical Committee in reaching decisions in conjunction with other monitoring devices.
- Survey is the main monitoring/control system. It is carried out approximately monthly. Amber trigger response times are geared to this frequency. Red triggers need urgent response in all cases.
- Slot closure is the total slot closure due to mining impacts and is net of any pre-mining movement, temperature, creep and other effects.
- TC meeting can be a teleconference call – all TC members to be supplied with business card providing call in details.
- Duty cards to be supplied to all organisations undertaking monitoring in terms of the monitoring plan.

8.5 WaterNSW Fire Trails and Access Roads

In the instance that there are any changes to the predicted subsidence as recorded via the GNSS meters and or subsequent impact to WaterNSW fire trails and access roads the communication protocols described in the WCL WaterNSW special area access agreement would be applied with notification to the WaterNSW mining manager.

Table 11 - Technical Committee Contact List

Organisation	Position	Name		Notification required for		
		Name	Contact details	Amber	Red	Grey
TfNSW (RMS)	Technical Committee Chair	Martin Upitis Talis	0416 275 739	Y	Y	N
TfNSW (RMS)	Pavement Maintenance Planner	Cyril Gunaratne	0429 667 012	Y	Y	N
AECOM	Senior Geotechnical Engineer	Henk Buys	0448 997 500	Y	Y	N
TfNSW (RMS)	Pavement Manager	Dave Mullens	02 6492 9540	Y (Pavement only)	Y (Pavement only)	N
TfNSW (RMS)	Bridge Engineer	Dony Castro	0403 098 092	Y (Bridge Only)	Y (Bridge Only)	N
WCL	Group Environment Manager	Richard Sheehan	0449 665 084	Y	Y	N
WCL	Environment Monitoring Manager	Sasa Cugalj	0439 709 513	Y	Y	N
SCT	Principal Geotechnical Engineer	Dr K.W. (Ken) Mills	0417 674 436	Y	Y	N
AECOM	Technical Director	Henk Buys	0448 997 500	Y	Y	N

9 INCIDENTS, COMPLAINTS AND NON-CONFORMANCES

9.1 Incidents

The Development Consent (MP09_0013) defines:

- An 'incident' to be *"an occurrence or a set of circumstances that causes or threatens to cause material harm and which may or not be or cause a non-compliance".* Examples may include a breach of specific development consent criteria or performance measure.
- Exceedance or non-compliance as "an occurrence, set of circumstances or development that is a breach of this consent".

In both circumstances, an Incident or Non-Compliance must be attributable to the development approved under the development consent.

Incidents and associated reporting requirements will be managed through established procedures set out in Section 4.2 of the EP. All incident notification related to built features will be sent to DPI, the Resources Regulator and relevant infrastructure owner/operator.

9.2 Complaints Handling

Complaints will be managed through established WCL procedures and as required by **Schedule 2 Condition 17** (x) of the Development Consent, by where a copy of a complaints register (updated on a Monthly basis) will be kept on the WCL website.

A summary of complaints will be available to regulatory authorities on request and provided in the Annual Environmental Management Reports (AEMRs).

10 REPORTING

The Reporting Framework set out in Section 5.2 of the EP will apply to the implementation of this plan in association with the specific triggers for regular and or incident/ TARP related reporting as detailed sections 5, 6, 7 of this plan.'

This reporting framework as detailed in Table 9 includes regular reporting as the following frequencies:

- Incident reporting;
- Weekly
- Monthly
- Quarterly monitoring data reporting;
- Impact reporting (in the event of an observed impact associated with the development covered by the EP); and
- Annual Review reporting requirements.

11 PLAN ADMINISTRATION

11.1 Roles and Responsibilities

Environment and community management is regarded as part of the responsibilities of all Colliery personnel. The roles and function of the main personnel responsible for the implementation of environmental and community management including the plans, procedures and action plans contained in this BFMP are outlined in WCL's Management Operating System.

11.2 Resources Required

In accordance with the WCL SYS POL 003 Environmental Policy, Management shall ensure that the appropriate resources are made available to achieve the implementation of this Plan.

It is the role of the Group Environment Manager to ensure that these requirements are communicated to WCL Management.

11.3 Training

Staff training will consist of three levels of applicable to different types of staff:

- Level 1 – High level training on environmental legislative requirements (management staff);
- Level 2 – Operational level training (project managers, supervisors, surface personnel, control room operators); and
- Level 3 – Basic awareness of environmental management (underground staff, all personnel).

Targeted environmental awareness training will be provided to individuals or groups of workers with a specific authority or responsibility for operational environmental management, or those undertaking an activity with a high risk of potential environmental impacts. Training will be provided as deemed necessary to contractors to provide them with the knowledge, skills and awareness to minimise environmental impacts and conditions of consent relevant to their activities in accordance with Condition A28. At a minimum this will include:

- contractors whose activities are not directly supervised by Colliery personnel; and
- contractors whose activities are ongoing and have the potential to result in an environmental incident (e.g. truck drivers, stockpile contractors).

The EM or delegate and Mine Training Manager will review the training program and monitor its implementation.

11.4 Inductions

All personnel, including contractors, sub-contractors and staff, are required to attend a compulsory site induction that includes an environmental component prior to commencement on site. The Environment Manager or delegate, will conduct the environmental component of the site induction.

The environmental component will include an overview of:

- Relevant details of this Management Plan, including purpose and objectives;
- Key environmental issues;
- Conditions of environmental licences, permits and approvals;

- Mitigation measures for environmental issues; and
- Incident response and reporting requirements.

A record of all environmental training and inductions will be maintained and kept on site. The Environmental Manager may authorise amendments to the induction where required to address project modifications, legislative changes or amendments to this Management Plan or related documentation.

The Environment Manager or authorized delegate will review and endorse the induction program and monitor its implementation.

12 AUDIT AND REVIEW

12.1 Annual Review

In accordance with **Condition F11** of the PA, an Annual Review of the environmental performance of the UEP is prepared.

The Annual Review will act to investigate and implement ways to improve the environmental performance of the development over time by

- Describe the development (including any rehabilitation) that was carried out in the previous calendar year and the development that is proposed to be carried out over the current financial/calendar year;
- Including a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against the:
    - relevant statutory requirements, limits or performance measures/criteria,
    - requirements of any plan or program required under this consent;
    - monitoring results of previous year/s; and
    - relevant predictions in the document/s listed in condition A2(c).
    - Identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance.
- identify any non-compliance or incident which occurred in the previous calendar year, and describe what actions were (or are being) taken to rectify the non-compliance and avoid reoccurrence.
- evaluate and report on:
    - the effectiveness of the noise and air quality management systems; and
    - compliance with the performance measures, criteria and operating conditions of this consent.
- Identify any trends in the monitoring data over the life of the Project.
- Identify any discrepancies between the predicted and actual impacts of the UEP and analyse the potential cause of any significant discrepancies.
- Describe what identified measures will be implemented over the next calendar year to improve the environmental performance of the development

Copies of the annual review will be submitted to WCC, WSC and made available to the CCC and any interested person upon request and will be made public via listing on the website.

12.2 Auditing

In accordance with Condition F13, an Independent Environmental Audit will be undertaken by a suitably qualified auditor and include experts in any field specified by the Secretary. The timeframe and scope of the audit are defined in Section 5.2 of the EMS.

12.3 Plan revision

In accordance with Condition F7, this HMP will be reviewed within three months of:

- the submission of an incident report under **Condition F9**;
- the submission of an annual review under **Condition F11**;
- the submission of an independent environmental audit under **Condition F13**; or

- the approval of any modification of the conditions of the development consent (unless the conditions require otherwise).
- the identification of any Aboriginal or historical unexpected finds.
- In accordance with the prescribed staging, i.e. prior to Stage 2 Extraction Plans.
- following the locations of Aboriginal sites that were unable to be located during the baseline recording survey.

The suitability of existing strategies, plans and programs required under the development consent will be reviewed by WCL.

In accordance with Condition F8, if necessary, to either improve the environmental performance of the project, cater for a modification or comply with a direction, the strategies, plans and programs required under the Development Consent will be revised, to the satisfaction of the Planning Secretary.

Where revisions are required to ensure the required updates are included as required, the revised document incorporating the relevant updates as above will be submitted to the Planning Secretary for approval within 6 weeks of the review.

Revisions to any documents listed within this Plan will not necessarily constitute a revision of this document.

13 RECORDS AND DOCUMENT CONTROL

13.1 Document control

Any revisions undertaken will be the responsibility of WCL and any notifications will be sent accordingly to Heritage NSW, WCC, WSC, the registered aboriginal groups, and DPIE.

During the next major update of the plan as would likely be associated with subsequent extraction plans, further consultation with the identified stakeholders will be sought and the plan will be amended accordingly.

WCL will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on WCL's computer system, website, and hard copy at the Russell Vale Colliery, 7 Princes Highway, Corrimal NSW 2518.

13.2 Record Keeping and Control

Environmental records are to be managed in accordance with the WCL SYS PRO 001 Document and Data Control procedure.

All records of the EMS will be stored so that they are readily retrievable and suitably protected from deterioration or loss. Archiving will be managed in accordance with the WCL SYS PRO 001 Document and Data Control procedure.

A master copy of each EMS document including all appendices and supporting information is to be held in the office of the E&C Department.

13.3 Information Access

Before the commencement of construction until the completion of all rehabilitation required under this consent WCL will ensure the information and documents as stipulated in **Condition F17** and the EMS, are made publicly available on its website as they are obtained, approved or as otherwise stipulated within the conditions of this consent.

This information must be kept up to date to the satisfaction of the planning secretary.

13.4 Public sources of Information

To assist the public and other stakeholders understand the impacts from the development, including monitoring results, newsletters and updates, and in accordance with Condition F5 (i), WCL will:

- publish information on the company website;
- notify the local community through the Russell Vale CCC;
- contact individuals by direct notification (email subject to registration of interest) where relevant.

Information required to be published in accordance with **Condition F17**, such as CCC minutes, current statutory approvals and complaints register will also be included on the company website.

This information will be updated as required.

14 REFERENCES

DPE c2012 "Guidelines for the Preparation of Extraction Plans" Undated and unpublished draft guidelines prepared by the then Department of Planning and Environment and NSW Trade & Investment – Division of Resources and Energy circa 2012.

B.K. Hebblewhite Consulting 2020 "Peer Review – Russell Vale Colliery Assessment of Risk of Pillar Failure" Letter Report No. 2003/03.1(final) to Ron Bush dated 7 April 2020.

SCT 2020 "IESC 2019-108: Quantitative Assessment of Risk of Pillar Failure in Russell Vale East Area" SCT Report WCRV5111 Rev4 for Wollongong Coal dated 12 June 2020.

SCT 2021 "Russell Vale Colliery: Subsidence Assessment for PC07-08 and PC21-25 Extraction Plan" SCT Report WCRV5285 for Wollongong Coal.

TfNSW 2021 "Major Projects MP09_0013-PA-2 – Proponent Request for Advice- Russell Vale Underground Expansion (CEMP)" Letter from Transport for NSW to Richard Sheehan dated 10 February 2021.

15 GLOSSARY OF TERMS AND ABBREVIATIONS

Abbreviations	
BCD	Biodiversity Conservation Department – now incorporated into Environment, Energy and Science Group,
BFMP	Built Features Management Plan
CCC	Community consultative committee
DPIE	Department of Planning, Industry and Environment
EP	Extraction Plan
kV	Kilovolt
LGA	Local Government Area
MSB	Mine Subsidence Board
IPC	Independent Planning Commission
RMS	Roads and Maritime Services (formerly the Roads and Traffic Authority)
ROM	Run of Mine
RPPR	Revised Preferred Project Report
RR	Resource Regulator
RVC	Russell Vale Colliery
TfNSW	Transport for NSW (incorporates RMS)
TARP	Trigger Action Response Plan
UEP	Underground Expansion Project
USWMP	UEP EP Upland Swamp Monitoring Program
WNSW	Water NSW
WCL	Wollongong Coal Limited

Terms	Definition
Baseline data	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g., species occurrence or noise levels) prior to commencement of a specific activity.
Bord and pillar	Mining method comprising of a series of self-supporting roadways (or bords) within the coal seam leaving a grid of pillars of unmined coal which are designed to be stable in the long term.
Development Consent	Russell Vale Revised Underground Expansion Project MP09-0013
First Workings	Involves the development headings or roadways which will provide access to the coal resource. They are developed using continuous miners with integrated roof and

Terms	Definition
	rib bolting rigs. First workings leave the coal pillars intact, and the overlying strata fully supported
Incident	An occurrence or set of circumstances that cause or threaten to cause material harm and which may or may not be or cause a non-compliance
Land	Has the same meaning as the definition of the term in section 1.4 the EP&A Act, except for where the term is used in the noise and air quality conditions in PART B of this consent where it is defined to mean a whole of a lot, or contiguous lots owned by the same landowner, in a current plan registered at the Land Titles Office at the date of the development consent.
Longwall	A secondary extraction method of mining coal that continuously removes the coal from the working face onto a series of conveyors that transfer the coal to the surface. As the coal is cut away (a 'shear'), both the longwall machine (known as a 'shearer') and the hydraulic roof supports advance forward ready for the next shear.
Material Harm	Is harm to the environment that: • Involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial, or • Results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (such loss includes the reasonable cost and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment) This definition excludes "harm" that is authorised under either this consent or any other statutory consent.
Mine operations	The carrying out of mining, including the extraction, processing, stockpiling and transportation of coal on the site and the associated removal, storage and/or emplacement of vegetation, topsoil, overburden and reject material.
Minor	Not very large, immaterial.
Negligible	Small and unimportant, such as not to be worth considering
Non-compliance	An occurrence, set of circumstances or development that is a breach of the development consent.
Pillar Extraction	A continuous miner system of mining whereby coal pillars are systematically extracted.
Pillar Run	A large scale progressive collapse of coal pillars in a short period of time.

Terms	Definition
Public Infrastructure	Linear and related infrastructure and the like that provides services to the general public such as roads, railways, water supply infrastructure, drainage, sewerage, gas supply, electricity, telephone, telecommunications, etc.
Privately-owned Land	Land that is not owned by a public agency or a mining, petroleum or extractive industry company (or its subsidiary or related party).
Public infrastructure	Linear and related infrastructure and the like that provides services to the general public, such as roads, railways, water supply, drainage, sewage, gas supply, electricity, telephone, telecommunications etc.
Rehabilitation	The restoration of a landscape and especially the vegetation following its disturbance.
Second Workings	Extraction of coal from bord and pillar workings
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Subsidence	The totality of subsidence effects, subsidence impacts and environmental consequences of subsidence impacts
Subsidence effects	Deformation of the ground mass due to mining, including all mining-induced ground movements, such a vertical and horizontal displacement, tilt, strain and curvature.
Subsidence impacts	Physical changes to the ground and its surface caused by subsidence effects, including tensile and shear cracking of the rock mass, localised buckling of strata caused by valley closure and upsidence and surface depressions or troughs.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Upsidence	Relative upward movement, or uplift, created by the horizontal compression and buckling behaviour of the rock strata in the vicinity of a valley floor
Valley closure	A phenomenon whereby one or both sides of a valley move horizontally towards the valley centreline, due to changed stress conditions beneath the valley and its confining land masses

APPENDIX A - Built Features Trigger Action Response Plan (TARP's)

Table 12 – TransGrid TARP

Aspect	Monitoring			Trigger			
	Sites	Parameters	Frequency	Level	Action/Reporting	Timing	Responsibility
Transmission Line 11 Dapto to Sydney South and Towers	• 330KV Single Circuit – Suspension Towers: 54, 55, 56, & 57 • 132 kV Single Circuit - Tower No. E66 to E69	• Observable surface deformations - ***LIDAR*** • Separation between tower legs – prism/ point Survey • Vertical subsidence - GNSS • Tilt - – prism/ point Survey	Prior to second workings • conduct baseline survey Prism/ point - Survey • GNSS continuous reading prior to second workings During second workings within 350m of sites • Prism/ point - Survey After each panel or annual or by TARP trigger • LIDAR - Quarterly • GNSS - continuous During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. Post mining - 12 months after completion of each panel.	Observations within prediction and Approved Impact.			
				• No observable surface deformations • <5 mm leg vertical differential; • <20 mm vertical subsidence; • Tilt <1mm/m.	• Data and report to: - TransGrid - Principal Subsidence Engineer RR;-	•Within 1 week following collection & processing of data, document report quarterly during secondary extraction.	• Russell Vale Colliery (Environmental Manager) •Survey Manager
				Observations within approved impact but exceed or potential exceed predictions.			
				• Observable surface deformations and / or • Separation between tower legs (10 to 20 mm) • vertical subsidence >20 mm •Tilt >1mm/m	• Notify the following key stakeholders within 24hours of becoming aware of the trigger: - TransGrid - Principal Subsidence Engineer – DRE. • Continue consultation with TransGrid	• Notify the Key Stakeholders, as appropriate, within 24hrs of becoming aware of the trigger:	• Russell Vale Colliery (Environmental Manager) •Survey Manager
				Observations exceed approved impact.			
				• Observable surface deformations and/ or • Separation between tower legs (>20mm) •Subsidence greater than predicted maximum (Upper 95% CL – identified as 100mm)	• Notify the following Key Stakeholders, as appropriate: - TransGrid - Principal Subsidence Engineer – DRE. Cease underground mining immediately and review mining options. Undertake additional 3D survey and check against pre-mining data and review against predictions; TransGrid and RVC to undertake visual inspections accordingly; RVC to review mining options and Extraction Plan • Liaise with asset owner TransGrid regarding any action/s required. •Review mining options.	• Notify the following Key Stakeholders, as appropriate, immediately following awareness of trigger being met:	• Russell Vale Colliery (Environmental Manager) •Survey Manager

Table 13 – Endeavour Energy TARP

Aspect	Monitoring			Trigger			
	Sites	Parameters	Frequency	Level	Action/Reporting	Timing	Responsibility
Transmission Line 33KV transmission line and pylons	• 33 kV pylons	• Observable surface deformations - ***LIDAR*** • Vertical subsidence - GNSS • Tilt – prism/ point Survey	Prior to second workings • conduct baseline survey Prism/ point - Survey • GNSS continuous reading prior to second workings During second workings within 350m of sites • Prism/ point - Survey After each panel or annual or by TARP trigger • LIDAR - Quarterly • GNSS - continuous During mining over active mining area GNSS data reviewed weekly Monthly in all other areas, or as required by TARP trigger. Post mining - 12 months after completion of each panel.•	Observations within prediction and Approved Impact.			
				• No observable surface deformations • <50 mm vertical subsidence; • Tilt <1mm/m.	• Data and report to: - Endeavour Energy - Principal Subsidence Engineer RR;	• Within 1 week following collection & processing of data, document and report quaterly during secondary extraction.	• Russell Vale Colliery (Environmental Manager) •Survey Manager
				Observations within approved impact but exceed or potential exceed predictions.			
				• Observable surface deformations and / or • vertical subsidence (50 – 100 mm) •Tilt >1mm/m	• Notify the following key stakeholders within 24hours of becoming aware of the trigger: - Endeavour Energy - Principal Subsidence Engineer – DRE. • Continue consultation with Endeavour Energy	• Notify the Key Stakeholders, as appropriate, within 24hrs of becoming aware of the trigger:	• Russell Vale Colliery (Environmental Manager) •Survey Manager
				Observations exceed approved impact.			
				• Observable surface deformations and/ or •Subsidence greater than 100mm (> 100 mm)	Notify the following Key Stakeholders, as appropriate: • Endeavour Energy • Principal Subsidence Engineer – DRE. Cease underground mining immediately and review mining options. Undertake additional 3D survey and check against pre-mining data and review against predictions; Endeavour Energy and RVC to undertake visual inspections accordingly; RVC to review mining options and Extraction Plan • Liaise with Endeavour Energy regarding any action/s required. • Review mining options.	• Notify the following Key Stakeholders, as appropriate, immediately following awareness of trigger being met:	• Russell Vale Colliery (Environmental Manager) •Survey Manager

Table 14 – Transport for NSW (RMS) TARP-

Aspect	Monitoring			Trigger			
	Sites	Parameters	Frequency	Level	Action/Reporting	Timing	Responsibility
M1/ Mt Ousley Rd Carriageway General Carriageway– Cataract Creek (100m) Carriageway- Mt Ousley Road – tension zone at ridge (P46) **Bridges** Picton Rd interchange - B7926 Steel Arch over Rocky Creek Culvert – B7932 Culvert over Cataract River – B814 **Culverts** Cataract Creek Culverts Multiple Culverts **Slopes** ARL2 – 955771/ 95770/ 13482 ARL3 – 10839/ 13483/ 13484/ 13485	GNSS 1, 8, 16 CT1- CT4 P-Line survey RMS twice weekly drive-through inspections	• Subsidence monitoring by real time GNSS units as per specific GNNS detail (GNSS, 1, 8, 16) • Yearly survey of CT1-CT4 creek closure • P-Line survey on southbound carriageway - reinstate or assess alternative. • RMS undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	GNSS • GNSS readings prior to second workings, • GNSS data reviewed During mining over active mining area weekly • Monthly in all other areas, or as required by TARP trigger. Survey • Yearly CT1-CT4 survey • P-line Baseline Survey • Within three months of completion of second workings panel. • Post Mining - Quarterly for 12 months after cessation of mining-.	**Minor**			
				• GNSS Subsidence <100mm • Valley Closure not greater than 100mm • Attended survey Pot bearings - longitudinal +- 10 mm from baseline,	Continue to monitor as per monitoring plan	Ongoing	WCL
				Moderate			
				• GNSS Subsidence 100mm – 280mm • Valley Closure 100-150mm • Attended survey Pot bearings - longitudinal +- 20 mm from baseline,	• Continue to monitor as per monitoring plan • Review underground mining • Commence investigation into potential exceedance • Attended survey to be undertaken • RMS-TC to meet to review monitoring data to decide on and to direct proactive action • WCL and RMS to undertake visual inspections;	• Inform the Technical Committee within 7 days • Investigation commences immediately • Notify DPIE of potential exceedance	WCL RMS Technical Committee
				Severe			
				• GNSS Subsidence >280mm • Valley Closure greater than 150mm • Attended survey - Pot bearings - longitudinal >+- 25 mm	• Stop mining and review mining options. • Commence investigation into potential exceedance • Attended survey to be undertaken • RMS-TC to meet to review monitoring data to decide on and to direct proactive action • WCL and RMS to undertake visual inspections;	• Inform the Technical Committee within 24 hours • Investigation commence immediately • Notify DPIE within 48 hours • Immediately Notify RR with written confirmation within 48hours	WCL RMS Technical Committee

APPENDIX B – Consultation

- TfNSW (RMS) – Risk Assessment presentation
- TGrid- Letter response to draft BFMP submission including TARP
- Endeavour – Presentation and correspondence
- Surveyor general correspondence and approval
- Risk assessment report

Subsidence Monitoring Plan for Wollongong Coal Russell Vale East PC07-08 and PC21-25 Extraction Plan: TfNSW Consultation

Ken Mills 24/8/2021

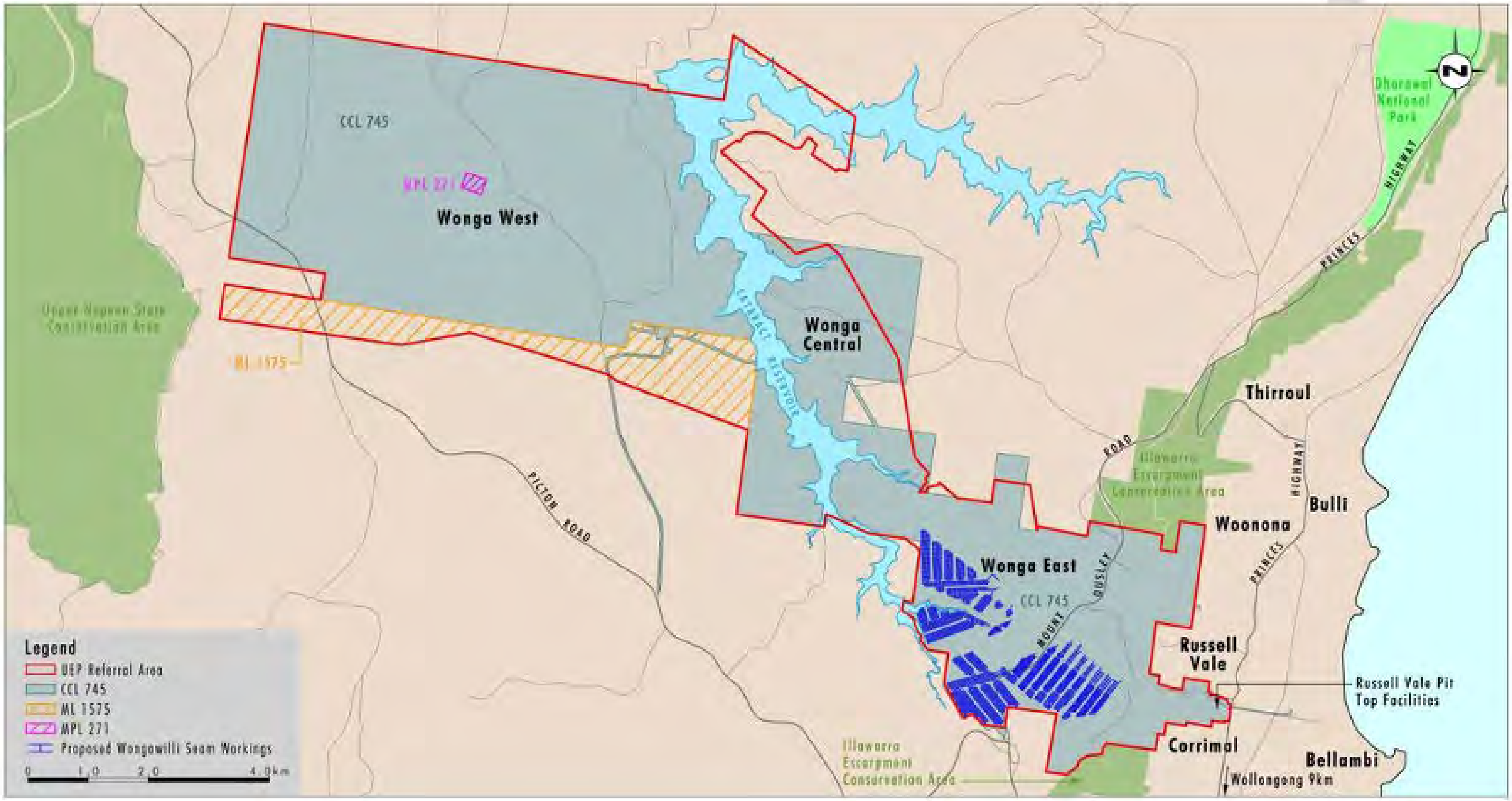
Geotechnical consulting, research and
instrumentation for mining and civil industries.

SCT

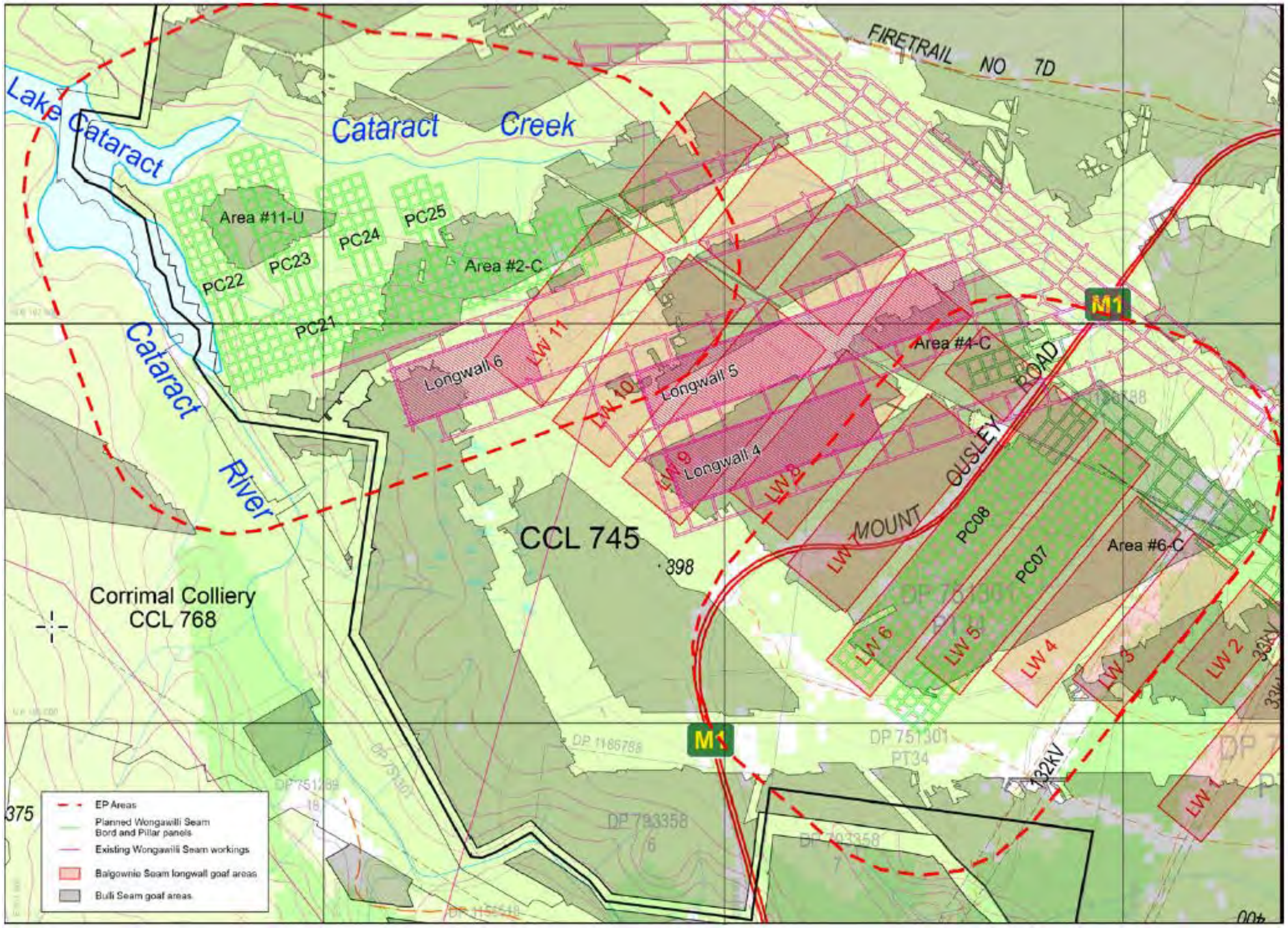
Overview of Presentation

- Site description
  - Mining context
  - Surface features
  - Etraction Plan staging
- Expected subsidence to be monitored
  - From proposed first and "second" (bord and pillar) workings mining <100mm
  - Legacy of historical Bulli Seam mining (very, very, unlikely, possibly >500mm over small areas)
  - Ongoing effects from recent longwall mining (horizontal closure <20mm)
- Strategies
  - Staging the mining program and extraction plan
  - Subsidence monitoring of proposed mining via GNSS units: accurate (<20mm), three dimensional, continuous, accessible to all interested parties at locations of interest in near-real-time
  - Flexible mining method easily adaptable to unexpected or unfavourable mining conditions
  - Monitoring of legacy mining in Bulli Seam
    - LiDAR for overall coverage and confirmation no significant subsidence across the site (±200mm)
    - Underground monitoring of roadway conditions approaching Bulli Seam goafs
  - Monitoring of TfNSW infrastructure including from recent longwall mining in Wongawilli Seam
    - Re-establishment of and continued monitoring of valley closure monitoring (±5mm)
    - Slot monitoring
    - GNSS closure monitoring

Russell Vale Project Area



Site Description



Mining Context:

Three seams of mining with complete mining records now available

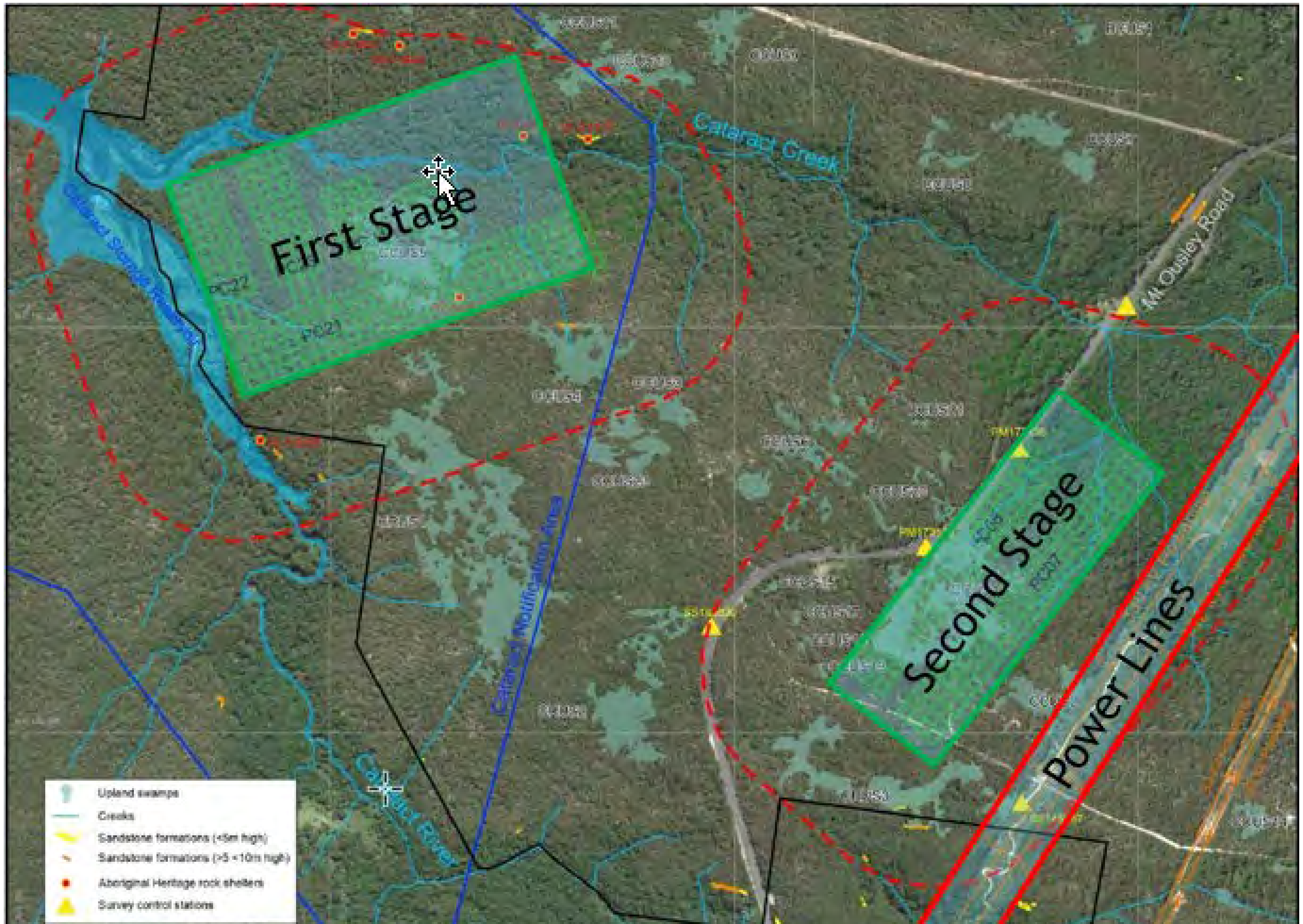
Subsidence monitoring available for Balgownie and Wongawilli

Previous subsidence to 3.7m

Expect <100mm over panels shown in green

No large scale subsidence below adjacent terrain

Location of RMS Assets and Proposed Mining



TfNSW Surface Features:

Mt Ousley Road (TfNSW)

Other Surface Features:

Cataract Reservoir (DSNSW)

Upland Swamps (WaterNSW)

Permanent Survey Marks (Lands)

Heritage sites

Minor access tracks

Subsidence and Surface Features

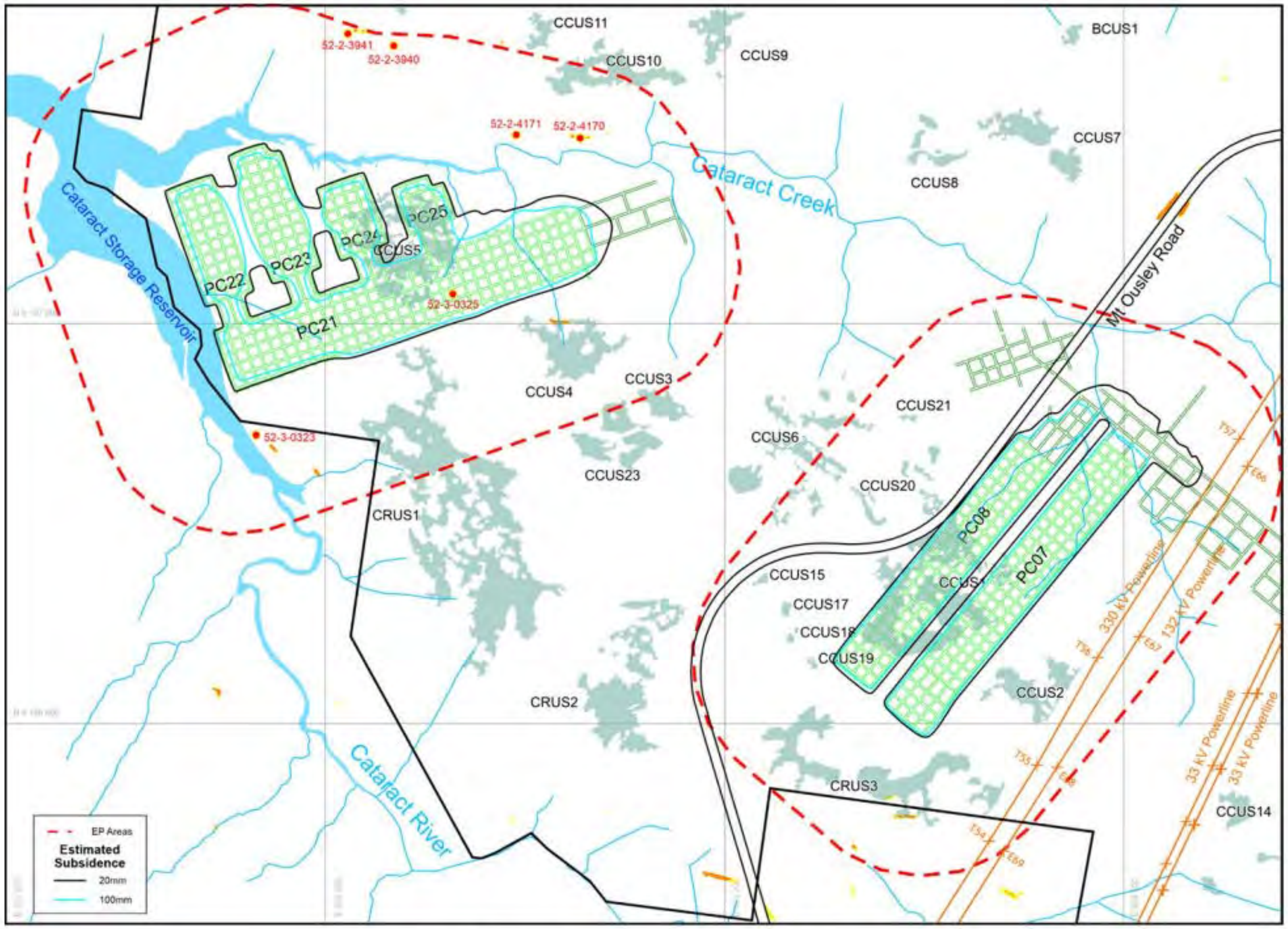
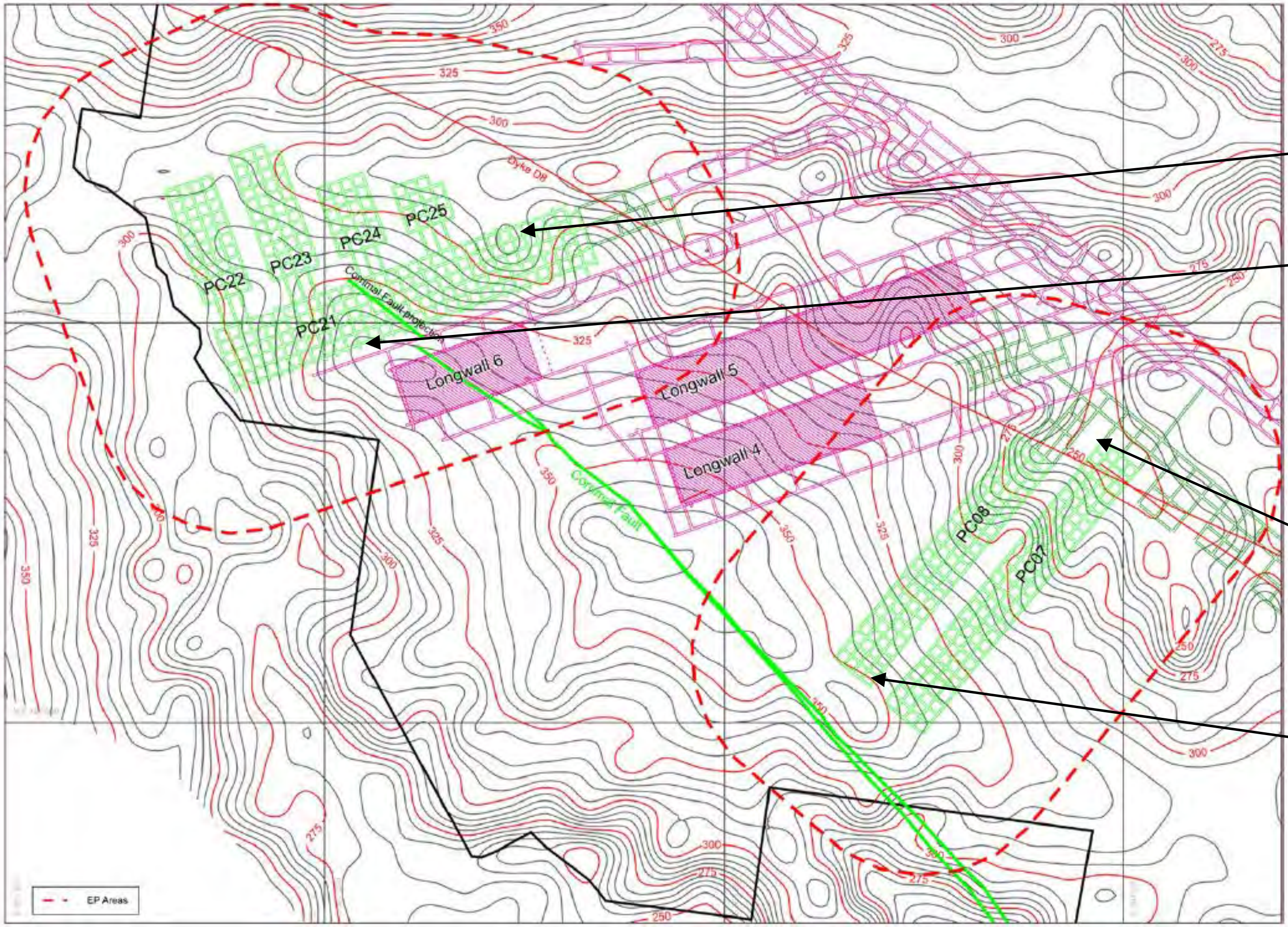


Figure 6: Estimated subsidence contours and surface features.

Overburden depth



Minimum 285m

Maximum 340m

Minimum 250m

Maximum 350m

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Extraction Plan Staging

- Extraction plan has been developed for Year 1 mining
  - Stage 1 extraction Plan to be comprised of
    - Stage 1(a) mining on western side of Mount Ousley Road where there is no infrastructure on panels PC 21-25
    - Stage 1(b) mining on the eastern side of Mount Ousley Road

Expected Subsidence from Proposed Mining

First workings: approximately 25% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- ~~No movements expected at the Power Pylons~~
- Movements at the surface barely perceptible
- Large, long-term stable pillars
- No potential for significant interaction with overlying Bulli Seam

"Second" (bord and pillar) workings: approximately 33% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- ~~No movements expected at the Power Pylons~~
- Movements at the surface barely perceptible.
- Large, long-term stable pillars
- No potential for significant interaction with overlying Bulli Seam

SCT

Existing Hazards from Legacy Mining: Bulli, Balgownie & Wongawilli Seam Mining

Any subsidence risk is an existing risk irrespective of further mining

Bulli Seam goaf areas

- No further subsidence expected in vicinity of pylons from planned mining
- Mine plans confirm all areas indicated as goaf are extracted and collapsed
- Borehole RV16 through Bulli Seam goaf confirms collapse
- Roadway conditions in Wongawilli Seam confirms collapse
- Surface cracking confirms collapse
- Subsidence records from Balgownie Seam reinterpreted based on multi-seam subsidence experience at Ashton Underground Mine and confirm collapse
- All 7 of 7 goaf areas able to be confirmed as collapsed are collapsed
- Other 7 goaf areas expected to be collapsed but cannot be confirmed
- Borehole NRE1 over main heading pillars confirms stable pillars

Balgownie Seam Goaf Areas

- No further subsidence expected in vicinity of pylons
- Complete subsidence records confirming full subsidence
- Plans from time of mining show pylons subsidence but isolated between surface cracks

Legacy of recent longwall mining

-Possible ongoing closure movements at Cataract Creek (<20mm)

-No evidence of further road cracks

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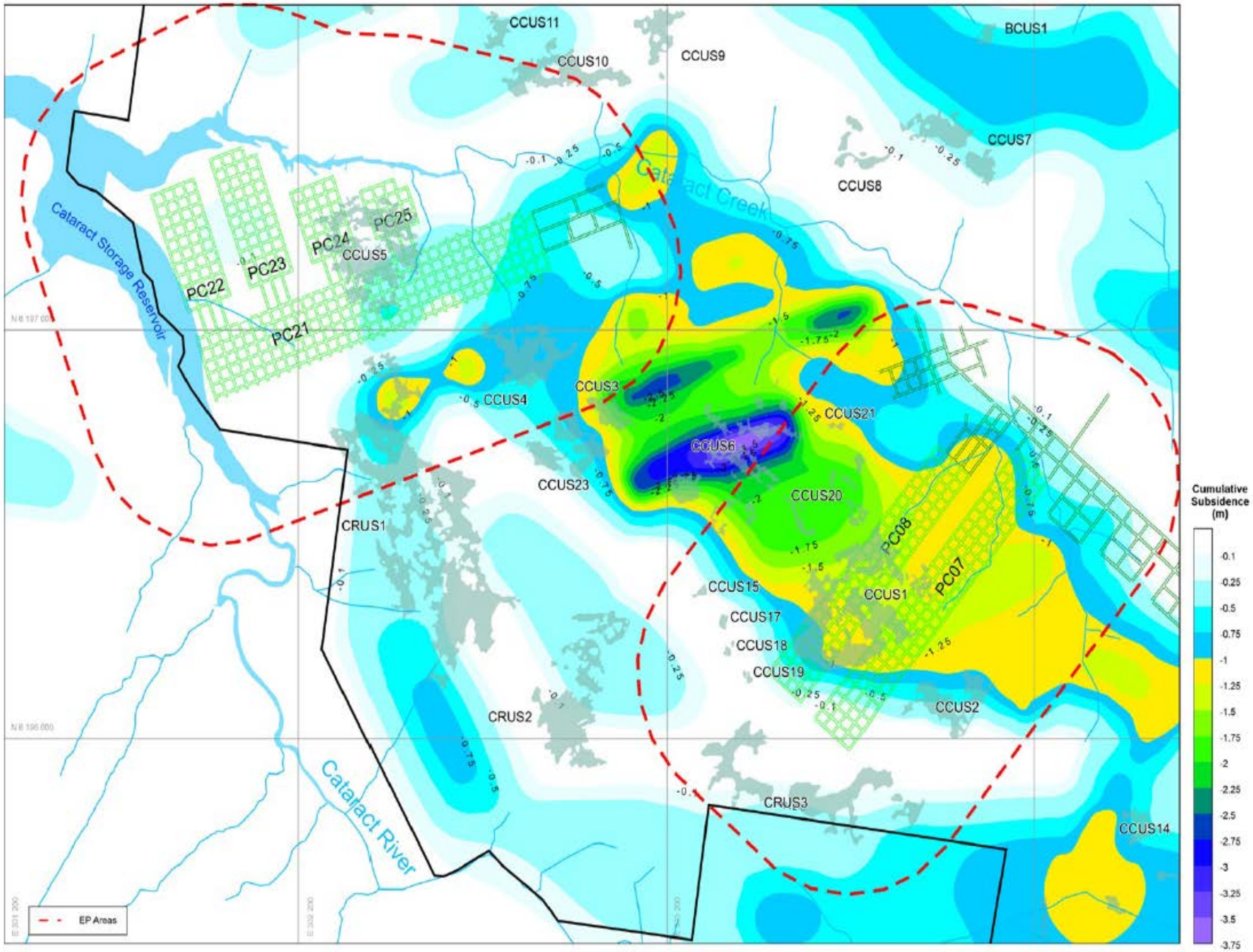
Legacy Subsidence:
Bulli, Balgownie & Wongawilli Seam Mining



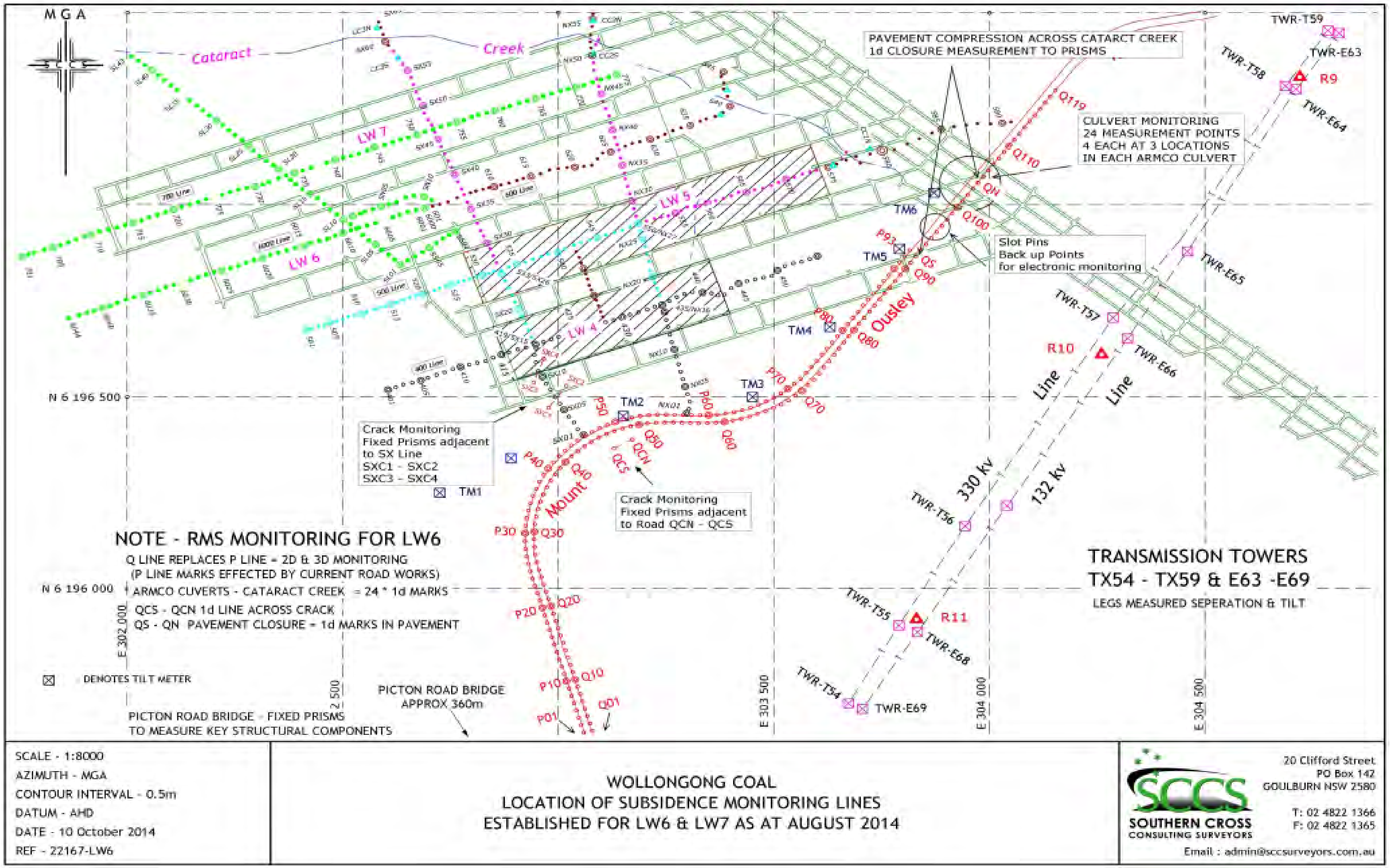
Bulli Seam Up to 1m

Balgownie Seam
up to 1.4m more

Wongawilli Seam
up to 1.8m more

But only a few small areas where all three seams have secondary extraction at the same location

Proposed Monitoring – TfNSW Assets



Performance Criteria

Feature	Performance Measures
Mine workings	
First workings and Second workings	• To remain long-term stable and non-subsiding
Key Public Infrastructure	
M1 Princes Motorway (formally known as Mount Ousley), electricity transmission lines and towers (330kV, 132kV, 2x33kV) and telecommunications line	• Always safe and serviceable • Damage that does not affect safely or serviceability must be fully repairable and must be fully repaired.
Other Infrastructure	
Access roads, fire trails and other public infrastructure and built features	• Always safe. • Serviceability should be maintained wherever practicable. • Loss of serviceability must be fully compensated. • Damage must be fully repairable and must be fully repaired or else replaced or fully compensated.
Public Safety	
Public Safety	• Negligible additional risk
Vertical Subsidence	
All areas of the site affected by the development	• Vertical subsidence limit of not more than 300mm

Mount Ousley Road (or M1 Princes Motorway) traverses the EP Area for PC07 and PC08 from the Cataract Creek crossing in the north to the ridgeline between Cataract River and Cataract Creek in the south. The planned PC07 and PC08 bord and pillar panels are immediately adjacent to a section of the road easement that was realigned soon after being impacted by subsidence from Longwall 7 in the Balgownie Seam. As well as the developments for PC07 and PC08, two underground access roadways are planned to pass below Mount Ousley Road remote from PC07 and PC08.

Vertical subsidence of approximately 30mm is expected from the planned mining. This level of subsidence is expected to be generally imperceptible and of a similar magnitude to the subsidence experienced on the road alignment during the nearby mining of Wongawilli Seam longwall panels. The difference between the planned mining and the earlier longwall mining is that there will no longer be any large-scale subsidence below the adjacent terrain. Horizontal movements associated with the planned mining will therefore be much less than the small ongoing movements associated with longwall mining. The magnitude and rate of these movements has not been measured since longwall mining ceased but will be determined when the first surveys are conducted as required within the existing Built Features Management Plan (BFMP) for the Mount Ousley Road.

Impacts to the road pavement, culverts and cuttings/embankments are expected to be minor and manageable within the existing risk control measures and the subsidence management plans currently in place. Subsidence monitoring required within the Built Features Management Plan (BFMP) required by the EP for the Mount Ousley Road in consultation with NSW Roads and Maritime Services (RMS) is expected to be appropriate to manage subsidence impacts to Mount Ousley Road. It is envisaged the BFMP would be developed through consultation and agreement with the asset owner to the required standards and the process would include a risk assessment conducted to relevant standards,

Impacts to the pavement surface include tension cracks at the crest/ridgeline and on the slope down to Cataract Creek and a compression hump at the Cataract Creek crossing. The potential for this closure to impact the safety of road users was previously identified and actioned by the installation of a slot across the pavement surface to mitigate the hazard of closure from horizontal movements.

Impacts to the culverts for the creek from ongoing closure movements are expected to be minor, manageable, and repairable if required. Impacts to embankments from small differential movements are expected to generally be insignificant but repairable if required. No perceptible impacts to cuttings are expected as these features are remote from the planned mining.

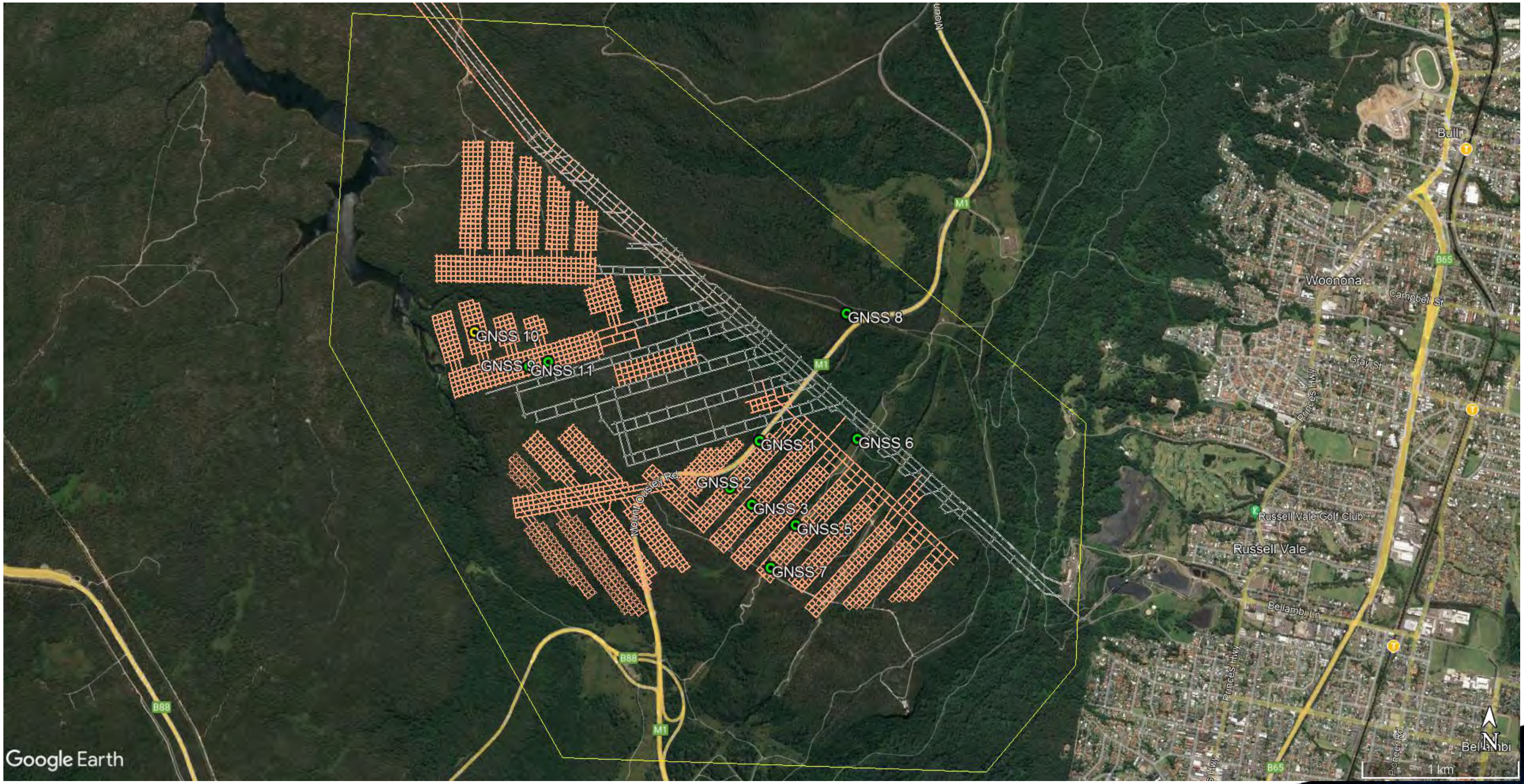
Proposed Monitoring

- Key hazard expected to be closure at the road crossing across Cataract Creek. This closure will be monitored by:
  - Real-time location or asset specific monitoring via of GNSS stations on either side of Cataract Creek.
  - Broad area monitoring via LIDAR
  - Continuous monitoring, downloaded as required of closure across the slot at the crossing point.
  - Periodic inspections of the geometry of the Cataract Creek/ M1 Highway culvert.
  - Periodic surveys of the cracks at the ridge top to the south of Cataract Creek.

  Note: An initial survey would be made prior to secondary extraction for panels PC 21-25 to confirm new base line for future mining.

  - TfNSW monitoring as per the existing BFMP for previous mining including weekly inspections of the road surface to ensure identification of any minor deformation of the road surface during undermining.

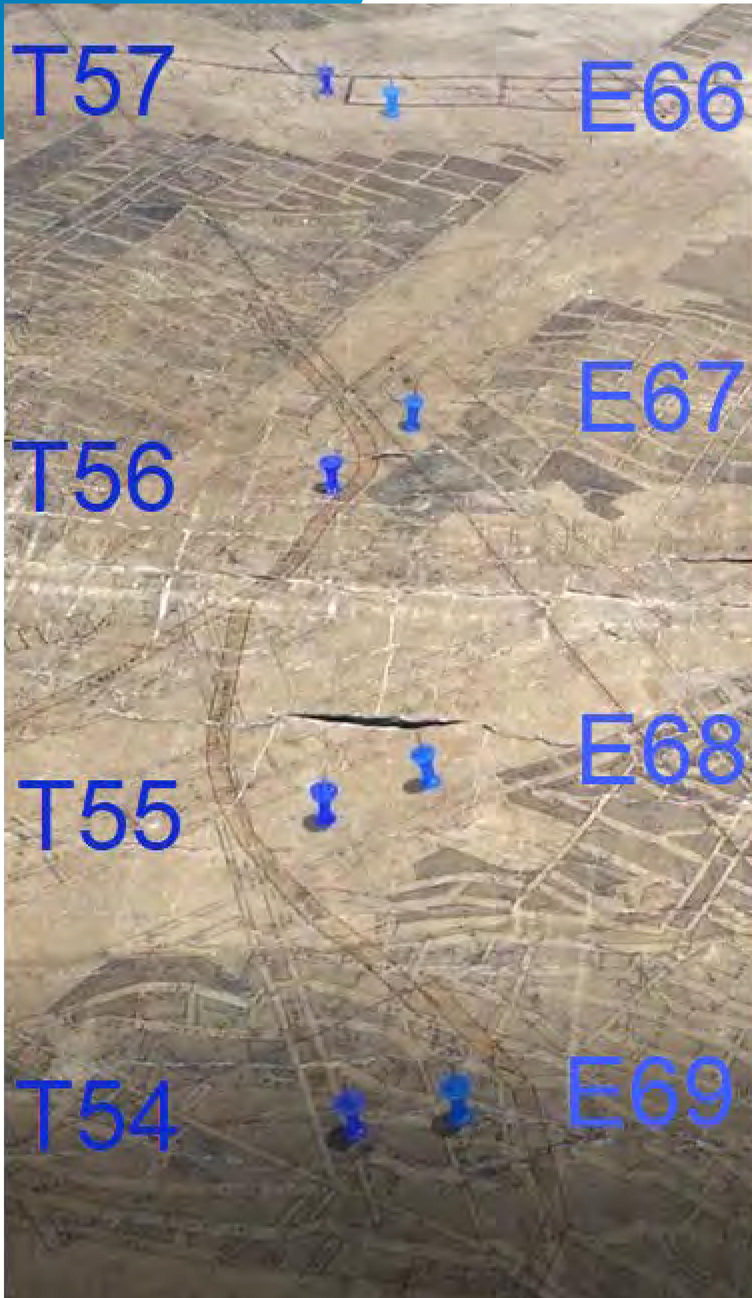
Proposed Baseline Monitoring – GNSS & LIDAR



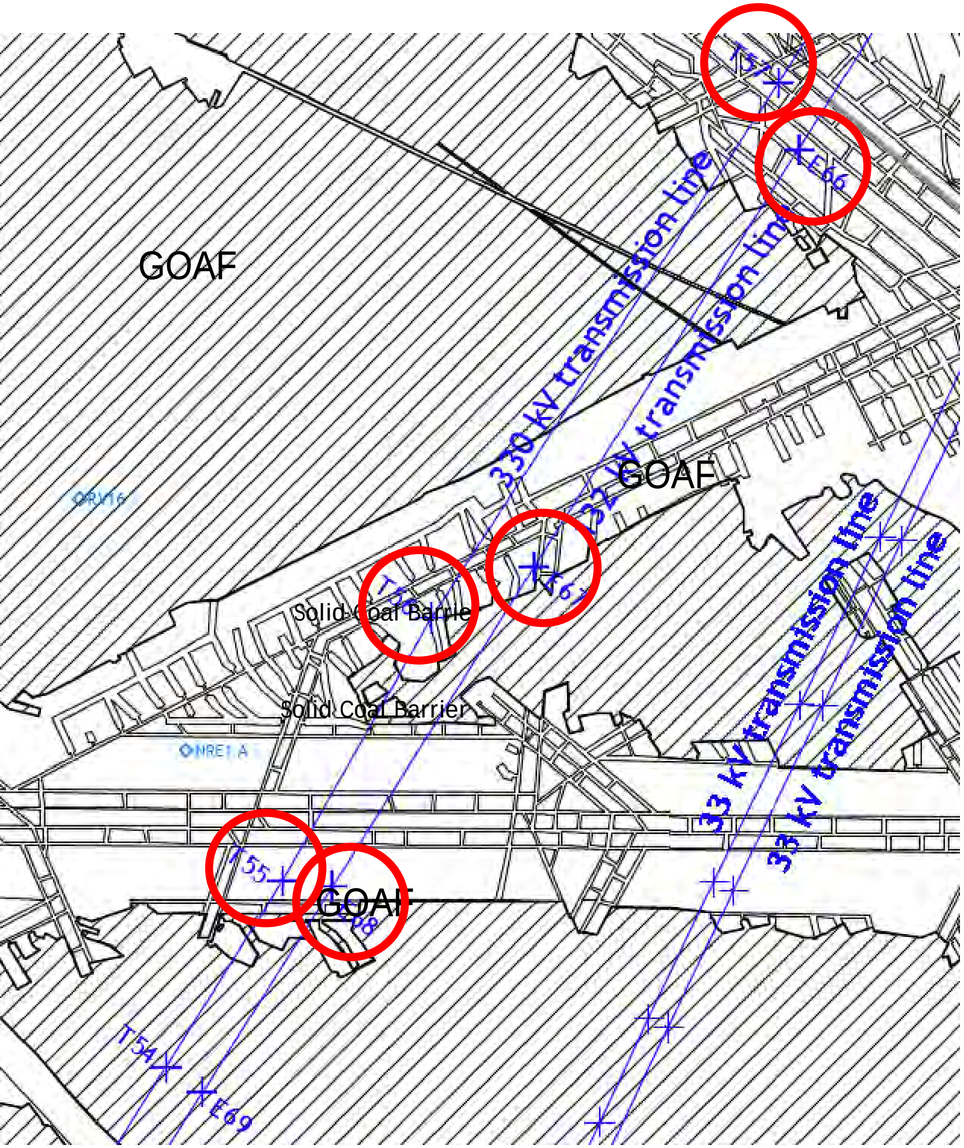
Legacy Subsidence: Bulli Seam Mine Working Plan

The very small risk of further subsidence from legacy mining is an existing risk.

Proposed mining does not substantially change this existing risk.

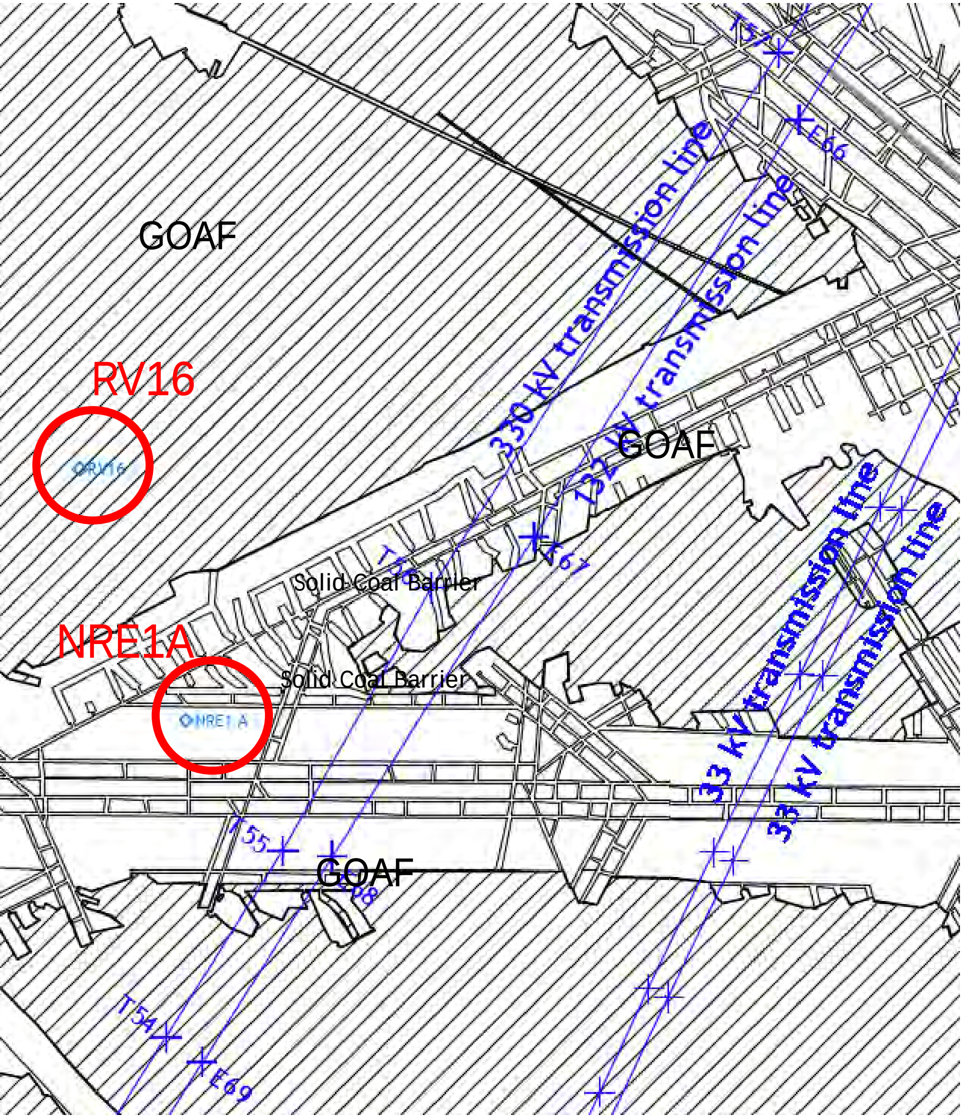


Bulli Seam Workings relative to Power Transmission Lines



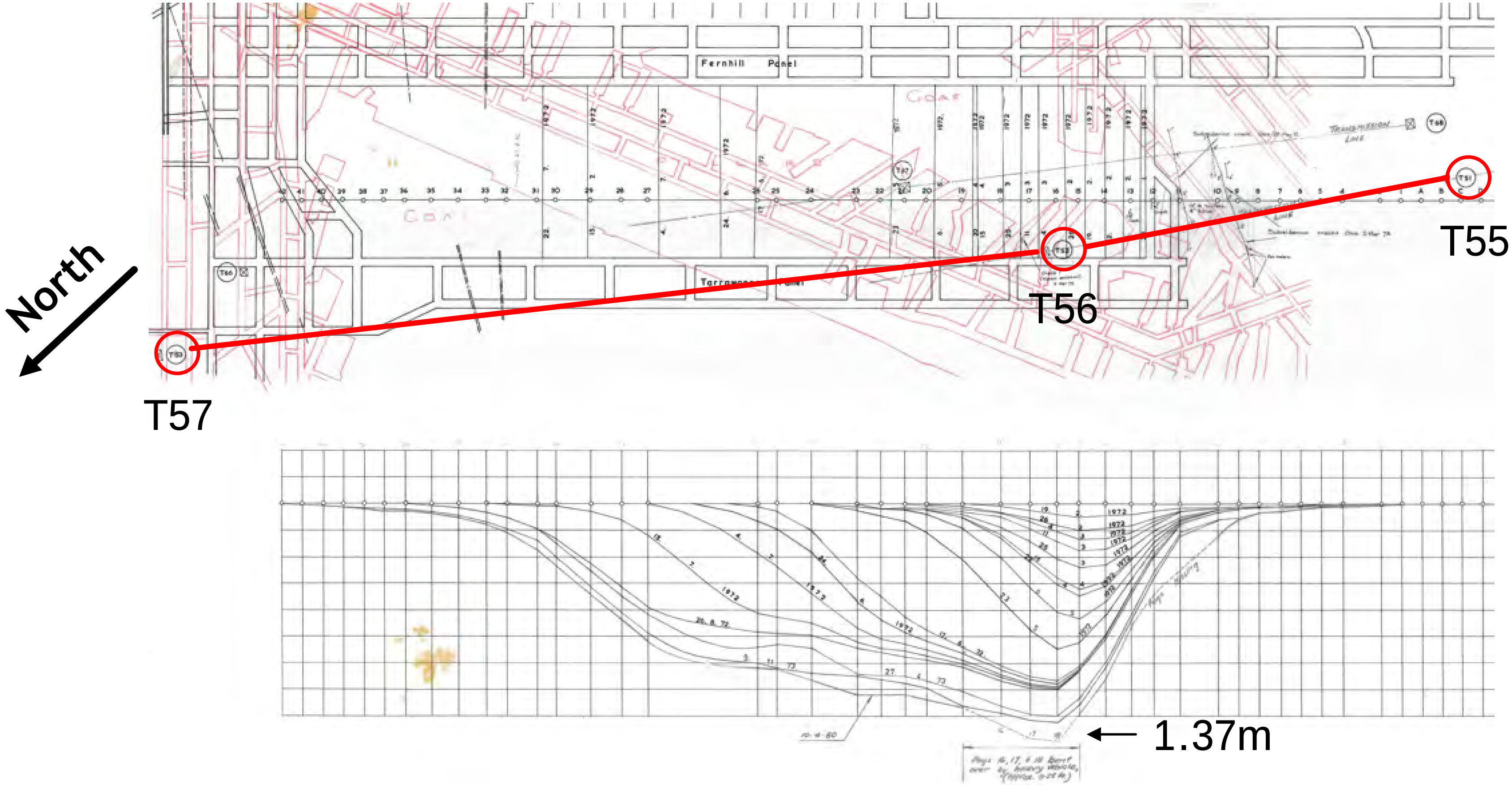
- T57 and E66 over Bulli Seam main heading pillars:
  - Long-term stable
  - No potential for subsidence
- T56 and E67 over edge of Bulli Seam main heading pillars in area fully subsided by Balgownie Seam longwalls:
  - Long-term stable after previous subsidence of 1.37m
  - Isolated by cracks from previous subsidence
  - No potential for subsidence impacts
- T55 and E68 over Bulli Seam main headings
  - Long-term stable
  - No potential for subsidence

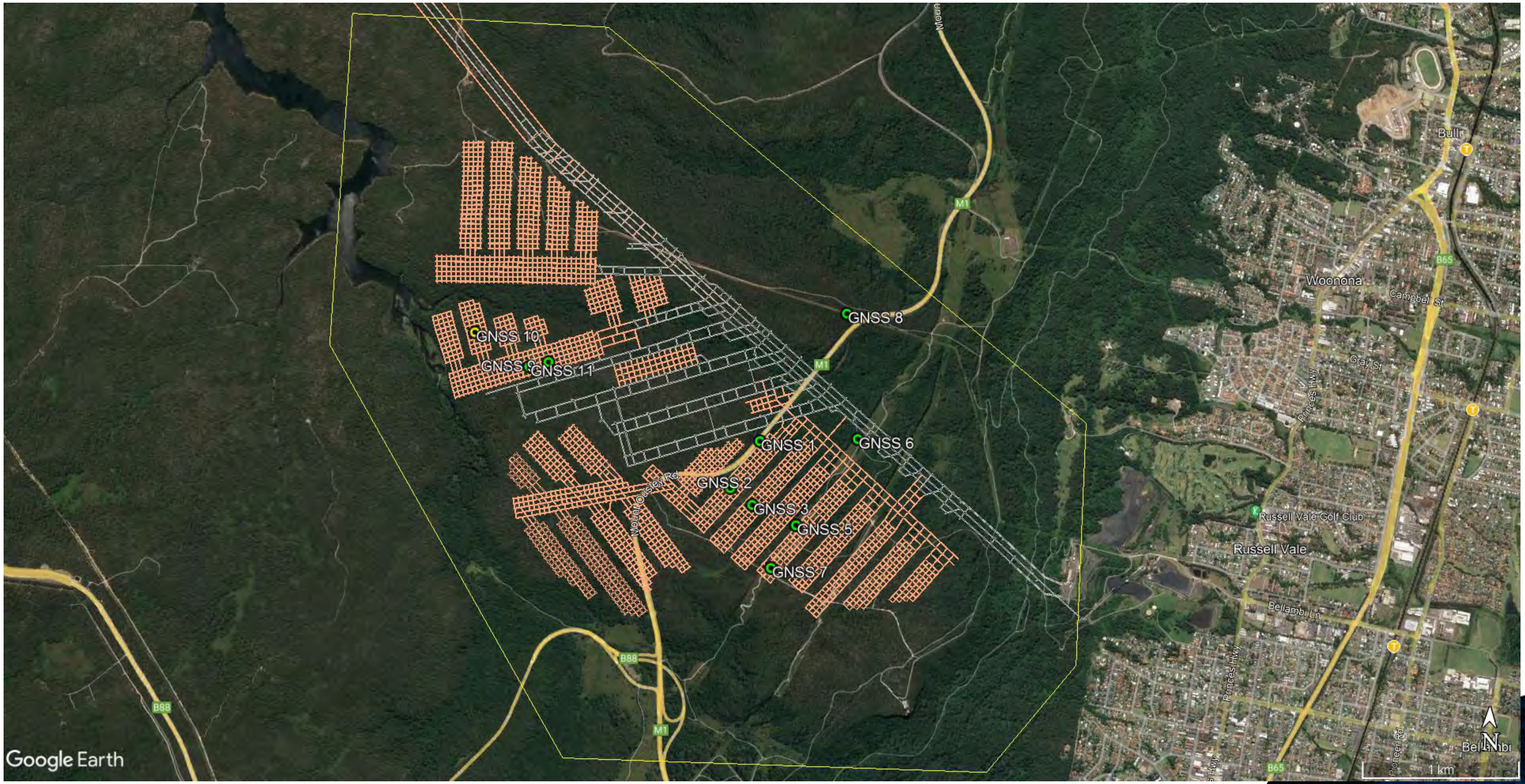
Bulli Seam Workings relative to Power Transmission Lines



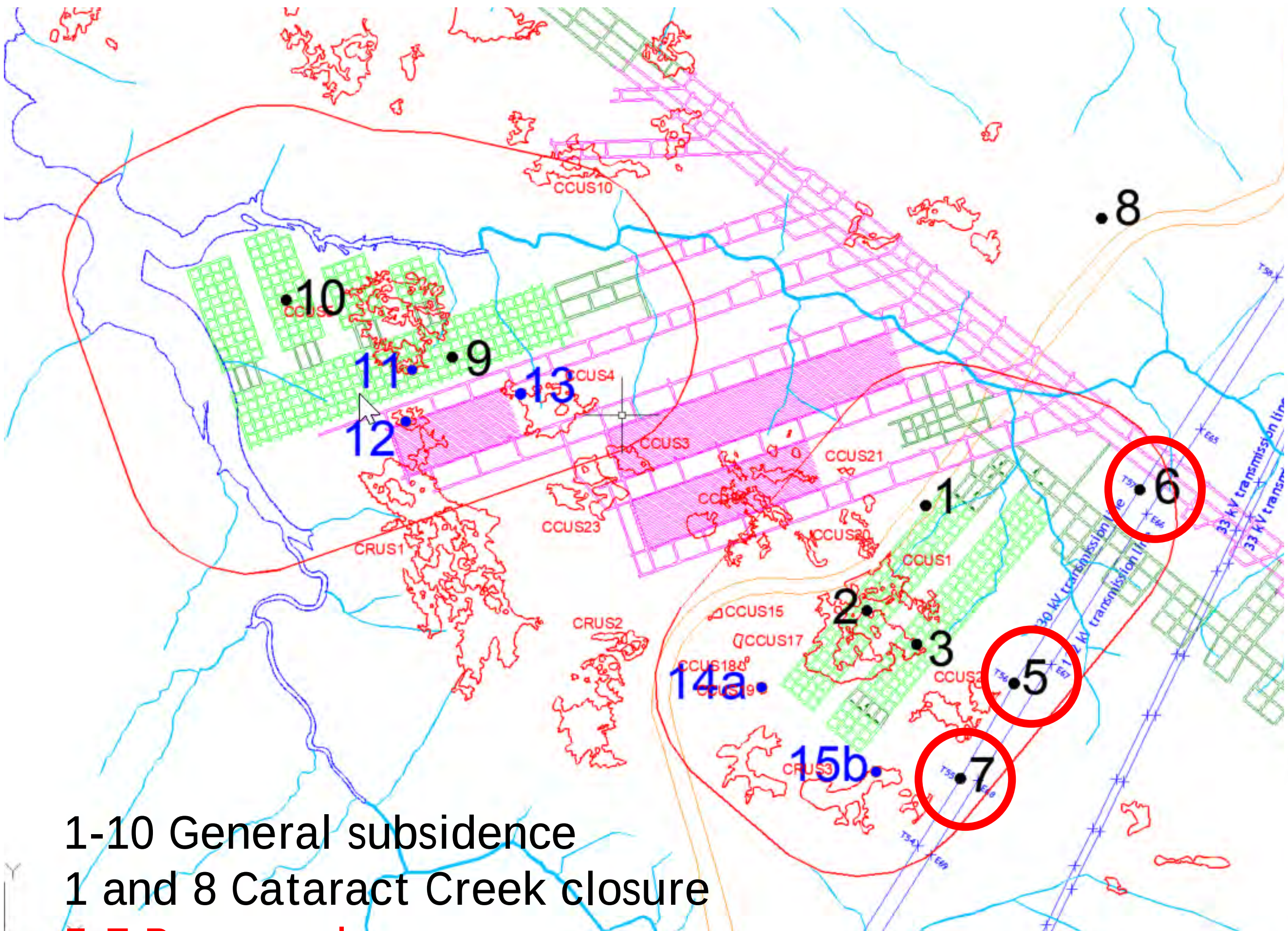
- Borehole RV16 confirms Bulli Seam fully extracted and goaf collapsed at this location
- Borehole NRE1A confirms Bulli Seam solid coal barrier pillar intact at this location
- Comparison of Mine Working Plan with ACAD plan indicates accuracy of workings of a few metres which is insignificant compared to the 250-350m overburden depth

Balgownie Seam Subsidence




GNSS 8
GNSS 10
GNSS 9
GNSS 11
GNSS 1
GNSS 6
GNSS 2
GNSS 3
GNSS 5
GNSS 7
Woonona
Bulli
Russell Vale Golf Club
Russell Vale
Bellambi
1 km
Google Earth

Subsidence Monitoring: GNSS Units



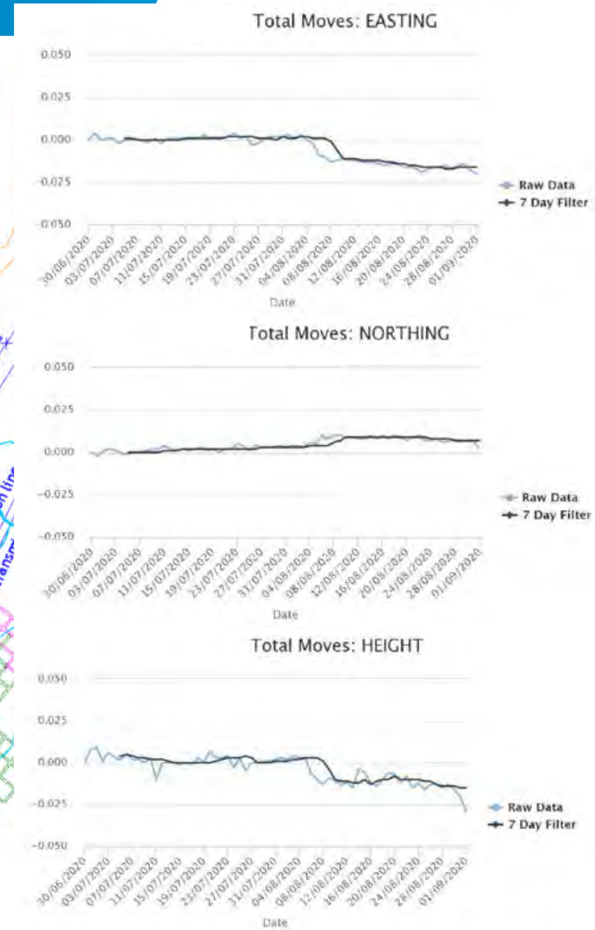
1-10 General subsidence

1 and 8 Cataract Creek closure

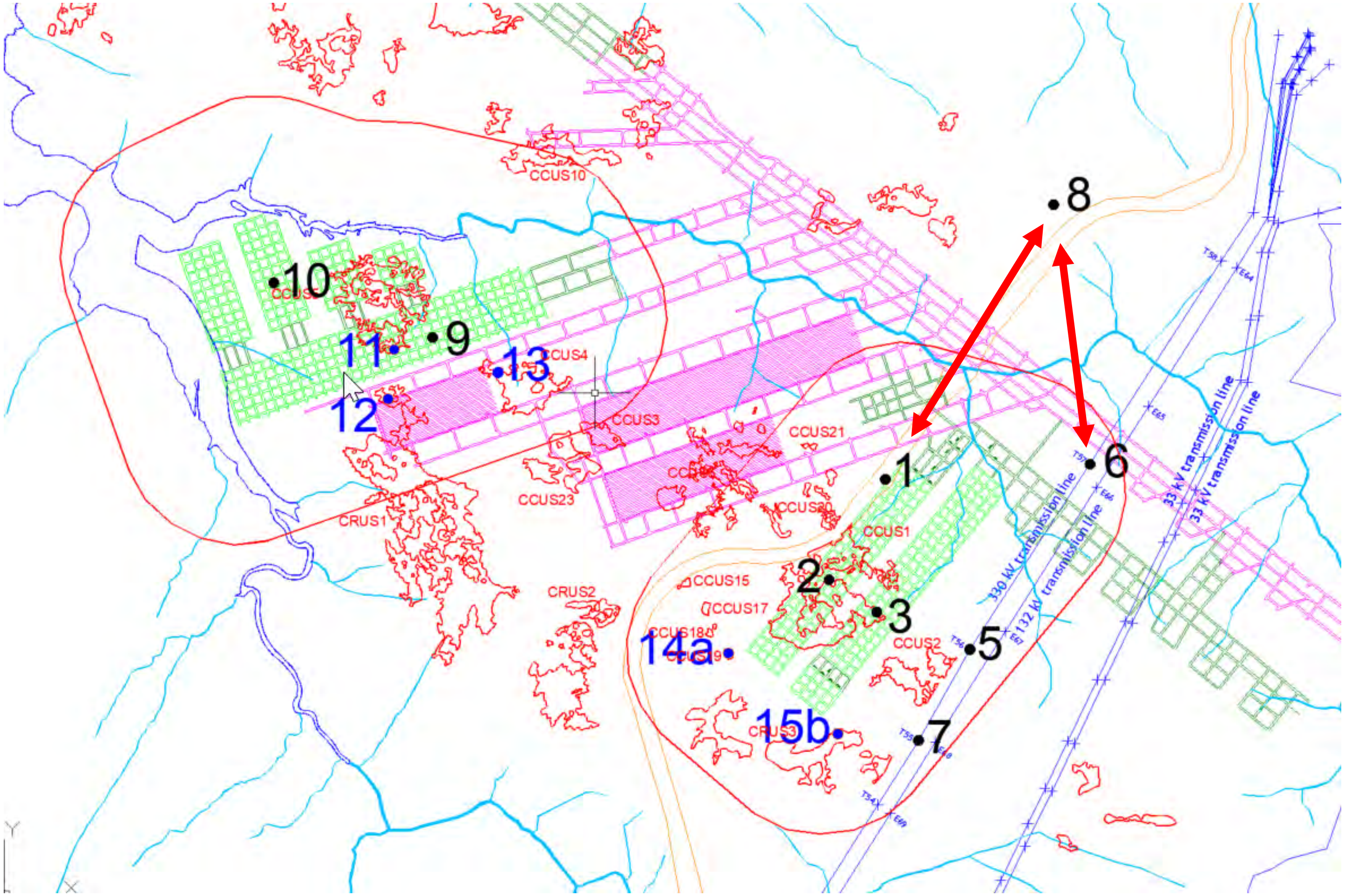
5-7 Power pylons

11-15 Swamp Specific

Example Data



Subsidence Monitoring: GNSS Units

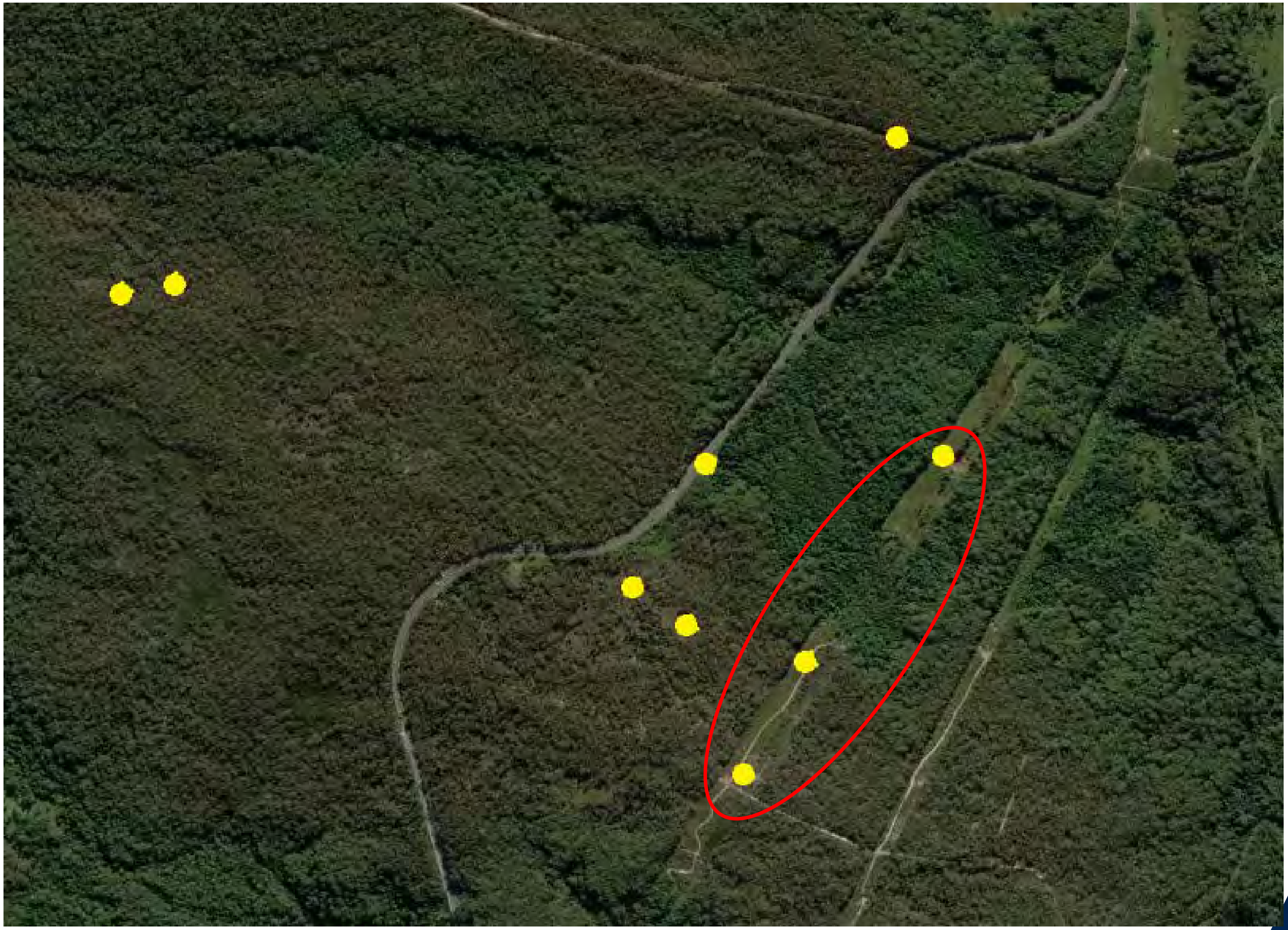


Infrastructure Monitoring

Mt Ousley Road closure across Cataract Creek

NB Recent research indicates these towers were in place when Balgownie Seam caused 1.3m of subsidence. Cracks nearby indicate towers are founded in one unit of solid rock.

Subsidence Monitoring: GNSS Units

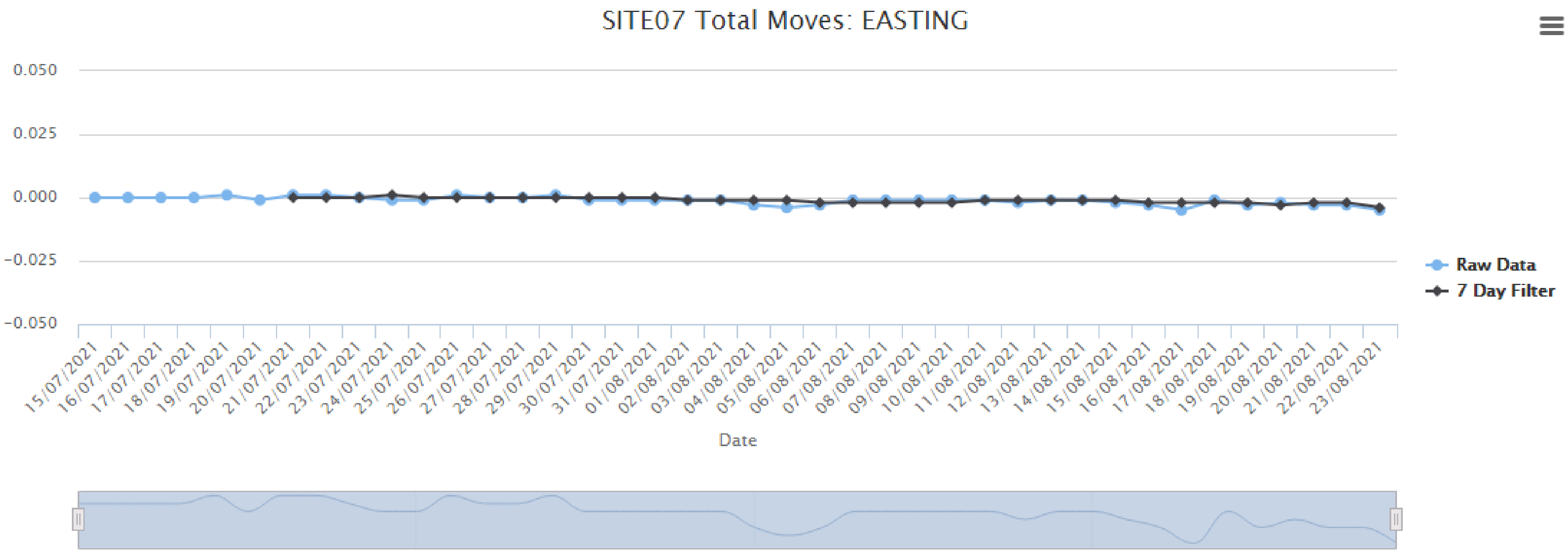


WCL GNSS Portal

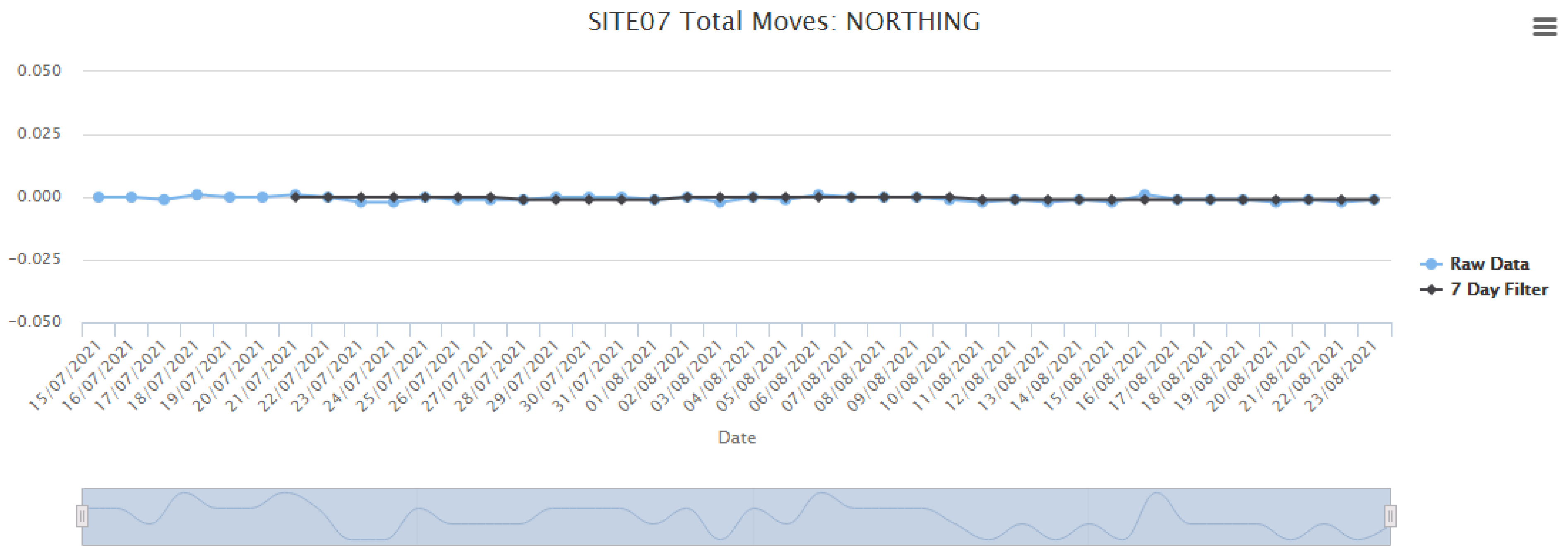
Transgrid 330kV power transmission lines

GNSS Units installed and providing near real time data

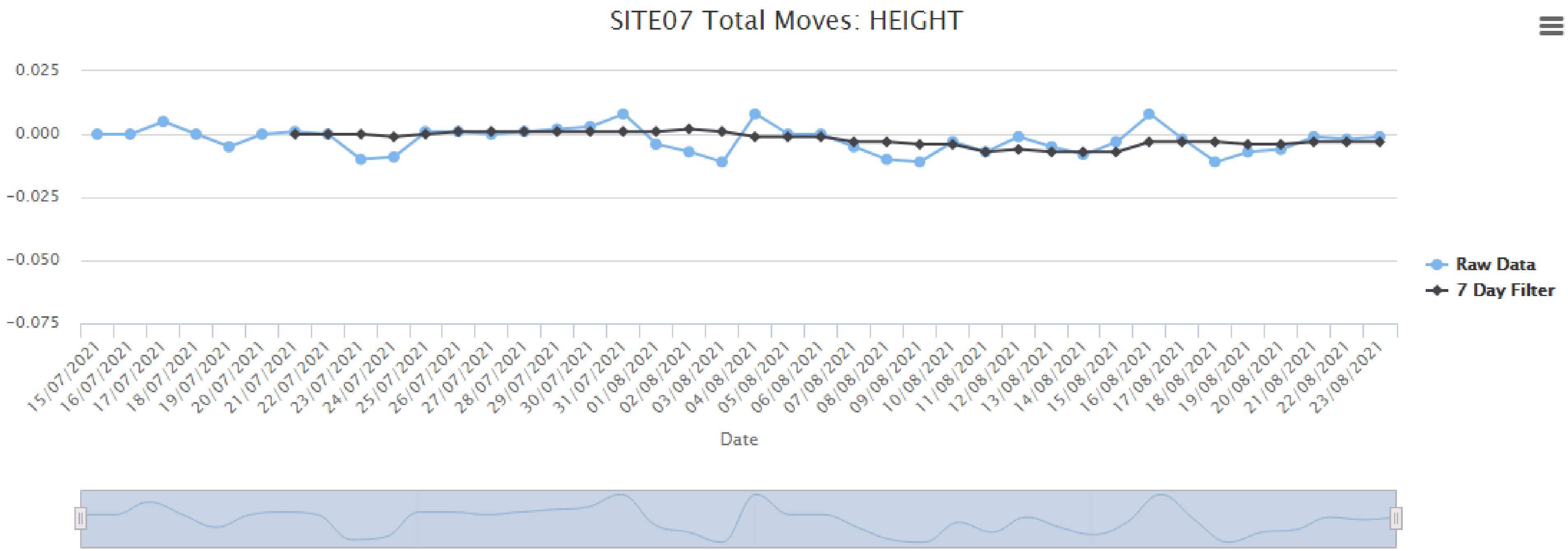
Subsidence Monitoring: GNSS Units



Subsidence Monitoring: GNSS Units



Subsidence Monitoring: GNSS Units



Subsidence Monitoring: GNSS Units

Site 2

Site 7

Subsidence Monitoring: GNSS Units

Site 8

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Natural and Built Features						
Edge of Mt Ousley Road	GNSS #1	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC08 (Bulli & Balgownie goaf)	GNSS #2	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
PC07 (Bulli & Balgownie goaf)	GNSS #3	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
330kV Powerline T56 tower (Balgownie goaf)	GNSS #5	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T57 tower (pillars)	GNSS #6	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T55 tower (solid coal)	GNSS #7	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
WCL easement (Bulli goaf)	GNSS #8	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC21 (Bulli goaf #2)	GNSS #9	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC23 (Bulli goaf #11)	GNSS #10	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC21 (Bulli goaf #2)	GNSS #11	At Swamp CCUS5	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (edge Bulli & Wongawilli goaf)	GNSS #12	At Swamp CRUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (Balgownie goaf)	GNSS #13	At Swamp CCUS4	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
West of PC08 (Bulli pillars)	GNSS #14a	At Swamp CCUS19	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC07 (Bulli pillars)	GNSS #15b	At Swamp CCUS3	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
Russell Vale East Area-	LIDAR	General subsidence - all surface features	3D ±200mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DAWE, RMS, TG, EE, DPIE, RR
Cataract Creek at CC1, CC2, CC3 and CC4	Hi res survey	Valley closure (upsidence) at CC1-CC4	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DPIE, RR

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration		Reporting Frequency	Reporting Timing & Distribution
Infrastructure							
Mt Ousley Road - Pavement	Crackmeter monitoring at Slot	Pavement condition from compression	1D ±1mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Pavement	Hi res survey across extension zone at ridge	Pavement condition from tension	1D ±3mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Culverts	Direct measurements of Cataract Creek culverts	Drainage and pavement conditions	1D ±1mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Visual inspections and photos						3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
330kV and 132kV powerlines	3D Position of Towers	Power supply integrity	3D ±20-25mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
330kV and 132kV powerlines	Leg diff measurements	Power supply integrity	1D ±2mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
Visual inspections including 33kV lines				After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR

Notes – * excludes reporting of incident or non-compliance.

Reporting includes an evaluation of the risk of the 100mm subsidence limit at swamps (EPBC 2020/8702) being reached or exceeded.

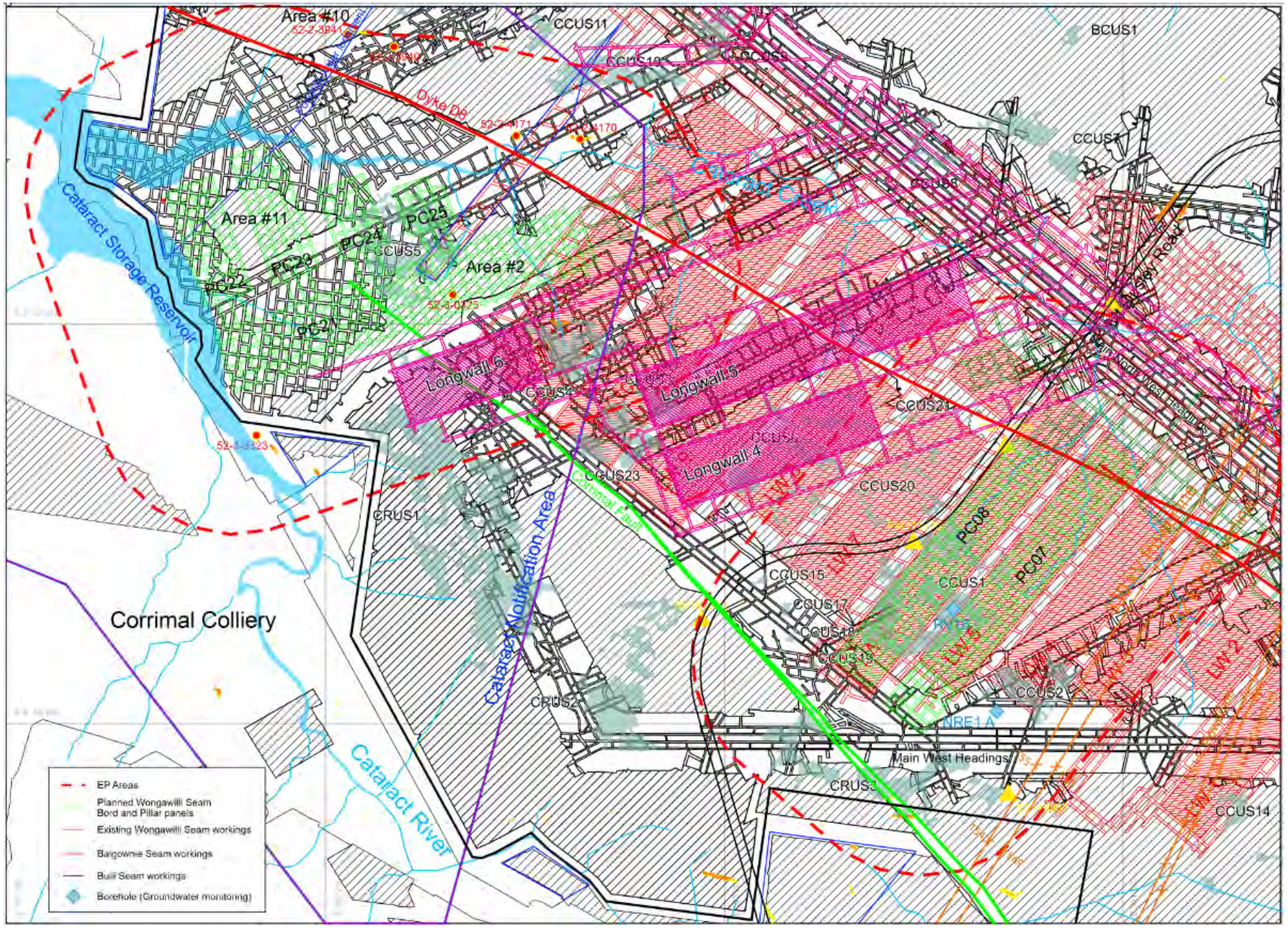
Each control survey and subsidiary survey must be planned, surveyed and analysed to ensure they satisfy the conditions to achieve a standard of accuracy as prescribed in ICSM (2007) SP1 (version 1.7) to achieve Class "D" or better (S&DD 2020)

Baseline surveys for GNNS units and LIDAR undertaken prior to the commencement of mining.

Baseline survey (for end of longwall mining) of Mt Ousley Road, Cataract Creek and powerlines undertaken prior to the commencement of mining.

Cessation of mining is taken as completion of mining in adjacent panel.

Subsidence Monitoring: LiDAR

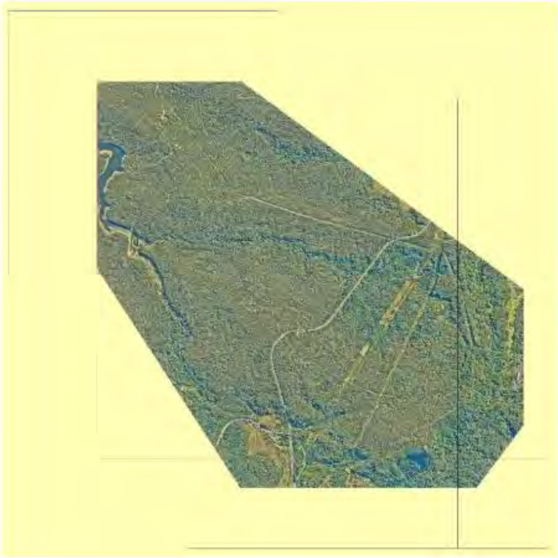


Not expecting to see any significant change in LiDAR

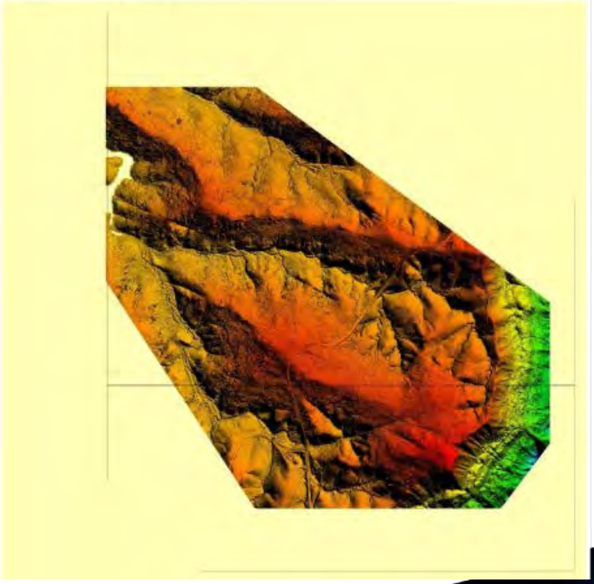
Baseline - LIDAR Survey Results

LIDAR Baseline survey complete

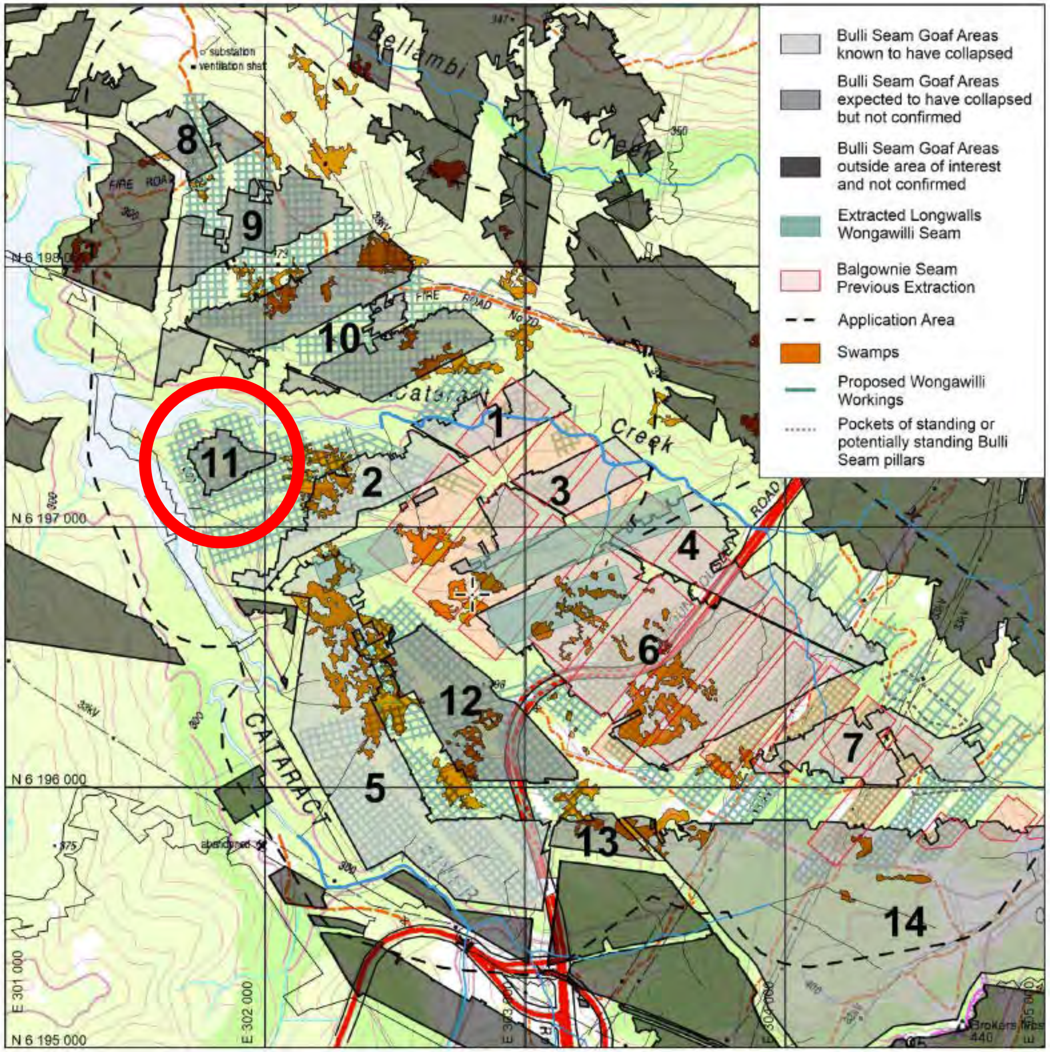
Orthoimage of the site.



Bare earth Digital Terrian Model (DTM).



Legacy Subsidence Areas: Unconfirmed Bulli Seam Goaf

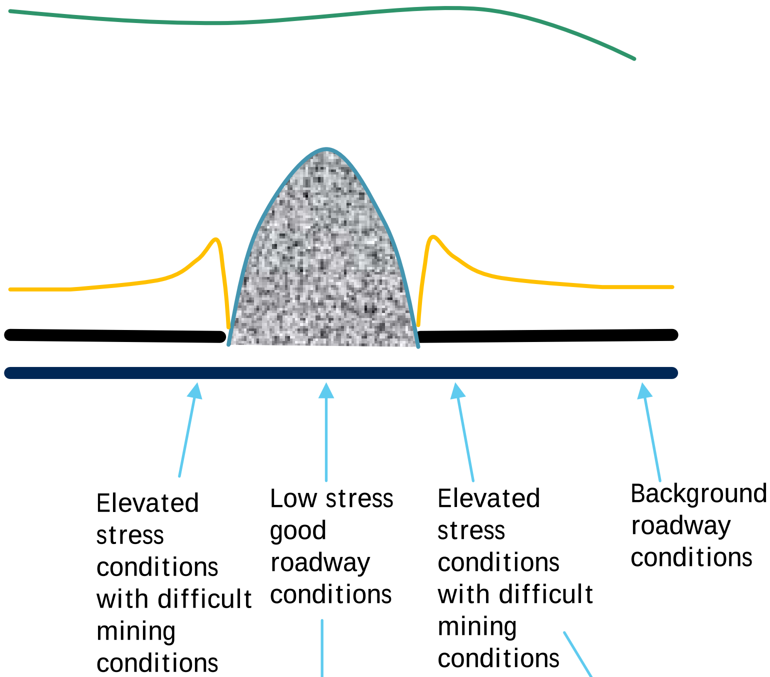


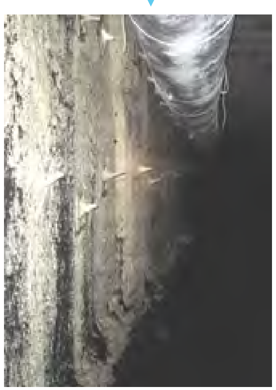
Reproduced from SCT5111 Rev4 (2020)

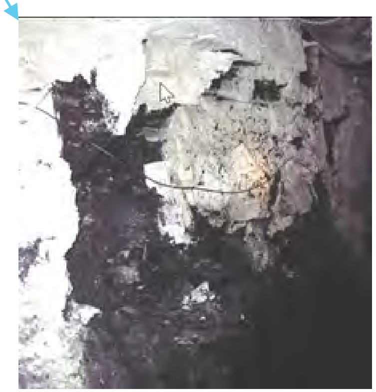
Only one area of Bulli Seam goaf (#11) that is not independently confirmed as having collapsed

Area #11 is remote from RMS infrastructure and swamps, and outside of the zone of influence

Underground roadway condition monitoring

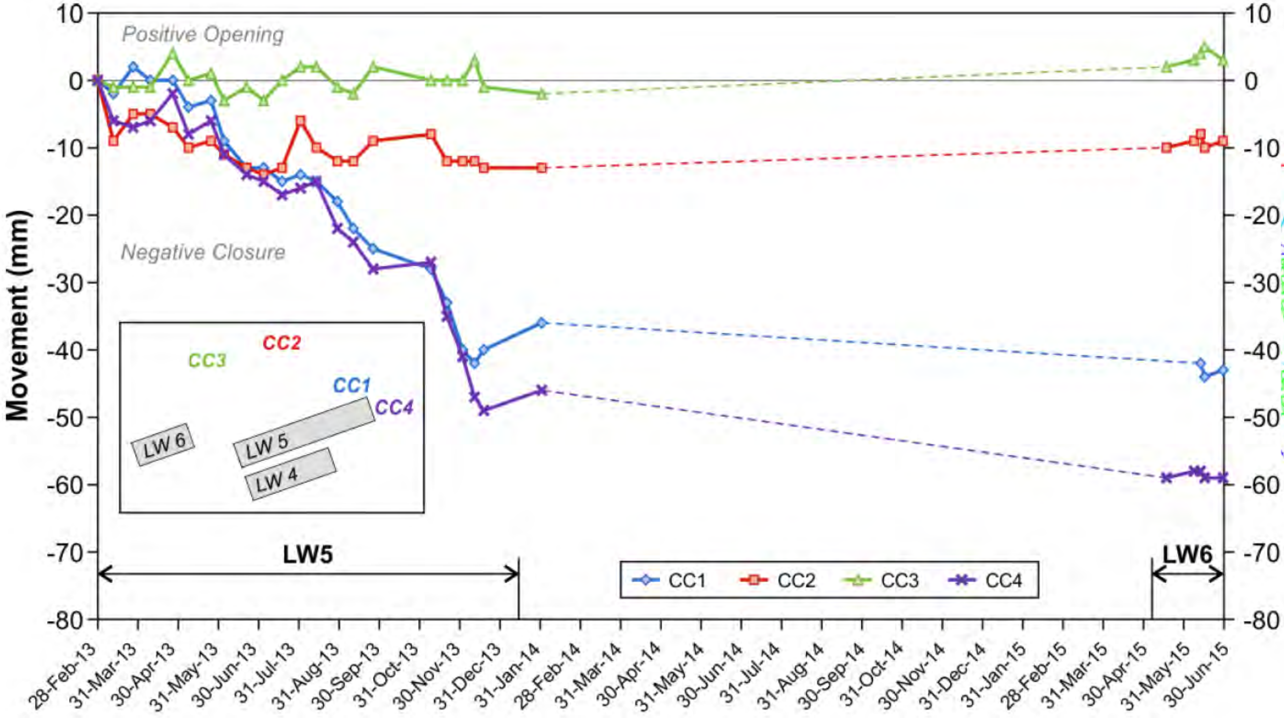


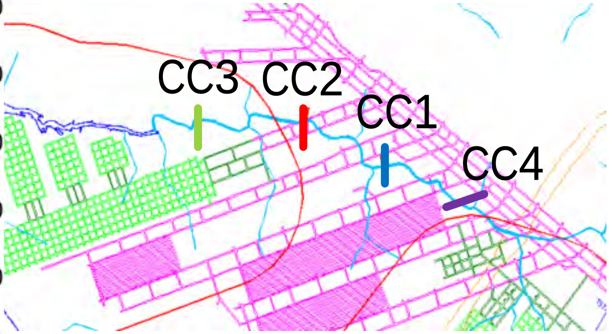


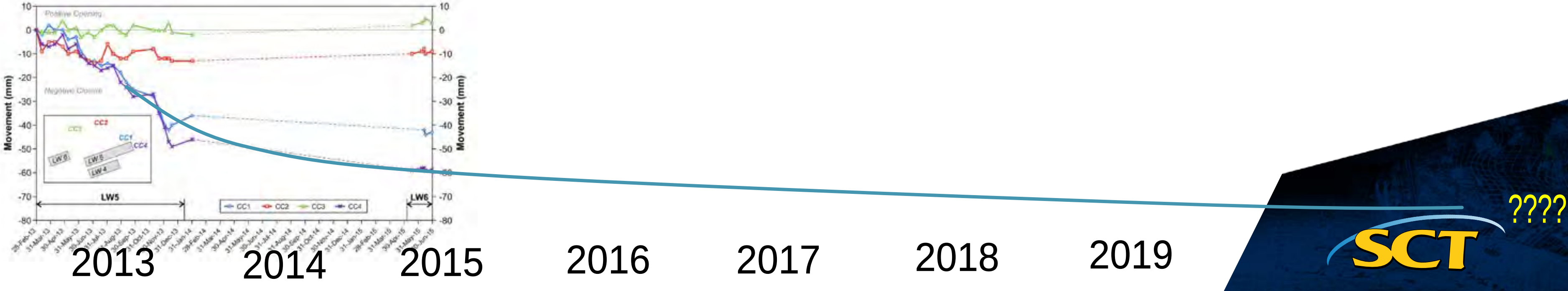


The difference between elevated stress conditions and background roadway conditions is clearly apparent and confirms that a goaf has formed i.e. extracted pillars are not still standing.

Valley Closure Measurements







Additional Research

Additional research into the reliability of the Bulli Seam mine plan records since Development Consent approved included in the Subsidence Assessment to be included in Extraction Plan

29 June 2021 - Ken Mills and Steve Wilson

Reliability of Bulli Seam Mine Plans

Purpose:

To identify areas of potentially marginally stable pillars to assist quantify the residual risk for greater than predicted subsidence

To assist Mine Manager and Mine Surveyor in their considerations for PHMP for subsidence

Tasks:

Examination of detailed mine plan records (mine or colliery working plans, record tracings and other subsidiary plans such as for production, ventilation) and other records held by:

- Wollongong Coal
- Department of Mineral Resources
- University of Wollongong Library Archives
- Wollongong City Library – Local studies
- AusIMM – Illawarra Branch – Mineral Heritage sub-committee (significant additional data)

Detailed review of Balgownie Seam longwall subsidence data in the context of advancement in understanding multi-seam subsidence (Mills and Wilson 2017)

Reliability of Bulli Seam Mine Plans

Other information considered:

- Drilling of boreholes from underground and from the surface to confirm the location and status of Bulli Seam workings
- Visual inspections of underground workings in the two overlying seams
- Observations of seam interaction effects associated with mining in the Wongawilli Seam
- Consideration of pillar sizes required to maintain stability under the goaf edge loading and chain pillar loading from seams below and potential to contribute to a pillar run

Reliability of Bulli Seam Mine Plans

Conclusions:

- Complete mining details of the Bulli Seam workings are available (following discovery of "missing link" that provides complete detail of goaf areas recorded at the time of mining).

- The interpretations and assumptions made in previous assessments of Bulli Seam goaf stability are consistent with detailed mine records

- Subsidence monitoring from the Balgownie Seam longwall panels indicates:
    - Consistent vertical subsidence with a variation of less than 200mm (typical range for multi-seam subsidence)
    - No significant irregularities in the subsidence profile that would indicate collapse or progressive failure (pillar run) of standing pillars over a substantial area
    - Some softening of goaf edges consistent with overlying workings

- Substantially higher than predicted subsidence from mining Longwalls 4 and 5 in the Wongawilli Seam is consistent with under-prediction of subsidence for these panels

From:	Easements&Development
To:	rfaddy@wcl.net.au
Cc:	devendra.vyas@jindalsteel.com
Subject:	FW: Russell Vale Extraction plan Consultation
Date:	Monday, 20 September 2021 8:34:12 AM
Attachments:	RVC BFMP Draft V1 - 28.6.2021.docx TARP(typical) RVE.pdf

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Good Morning,

TransGrid Reference Number: 2021-331

Location: Russell Vale Colliery

Proposal: Extraction Plan for review

TransGrid: Transmission Line 11 Dapto 330kV – Sydney South 330kV

Please see TransGrid response: Questions & Comments:

Regards
Michael

Michael Platt
Development Assessment and Control Officer/Network Planning and Operations
TransGrid | 200 Old Wallgrove Road, Wallgrove, NSW, 2766
T: (02) 9620 0161 **M:** 0427 529 997
E: Michael.Platt@transgrid.com.au **W:** www.transgrid.com.au

---

From: Sanu Maharjan <Sanu.Maharjan@transgrid.com.au>
Sent: Friday, 17 September 2021 4:10 PM
To: Easements&Development <Easements&Development@transgrid.com.au>
Subject: RE: Russell Vale Extraction plan Consultation

Hi Michael,
Below are some questions and comments on DRAF BFMP supplied by Russel Vale Colliery.

Section 5:

a. Subsidence prediction due to PC07 & PC08 to be reviewed based on the subsidence records for PC21- 25.
b. Any changes to the predicted subsidence and impact to TransGrid asset to be notified.

Section 7.12:

a. What is the tolerance of GNSS system re: vertical, tilt and tower leg separation measurements?
b. How tilt of the towers will be monitored?
c. How frequently GNSS data will be downloaded and monitored during and after mining?
d. Prism to be installed on each legs of affected towers and frequency of survey to be specified.

Section 8.2 Trigger Action Response Plan:

a. Performance measure TARP is expected to be something similar to attached for 330kV

Transmission Line. Specific subsidence values to be included for level 1, 2 3 in TARP, attached Typical TARP has subsidence figures to be used.

b. All affected towers are noted in TARP

Section 8.4 Contingency Plan:

a. No contingency plan is outline in DRAFT BFMP. Please add the detail of contingency plan in the event of emergency due to large unexpected subsidence near TransGrid asset.

Regards
Sanu

Sanu Maharjan
Senior Structural Engineer/Tl&Cd | Works Delivery
____
Transgrid | 180 Thomas Street, Sydney, NSW, 2000
T: (02) 9284 3446 **M:** 0408 574 445
E: Sanu.Maharjan@transgrid.com.au **W:** www.transgrid.com.au

TYPICAL TARP

Transmission Line 11 Dapto to Sydney South - 330kV Single Circuit –Suspension Tower 54 , 55, 56 & 57			
Management Period	**Monitoring**	**Trigger**	**Response**
Baseline studies prior to mining. Located within ED	• Survey of ground and footing monitoring marks • Survey of tower legs Earth Peaks Monitoring	• Documentation of pre- mining conditions.	• Russell Vale Colliery (RVC) document and Report to: o TransGrid;
During minin	**Level 1 – LOW**	**Operations with prediction and approved impact**	
	• Survey of ground and footing monitoring marks • Survey of tower legs • Earth Peaks Monitoring	• No observable surface deformations • <4 mm separation between tower legs • Vertical subsidence < 20mm • Tilt < 1mm/m	• RVC to provide subsidence monitoring to: o TransGrid o Principal Subsidence Engineer - DRE
	Level 2 – ADVISORY	**Operations within approved impact but exceed or potentially exceed predictions**	
	• Survey of ground and footing monitoring marks • Survey of tower legs Earth Peaks Monitoring	• Observable surface deformations; and / or • Separation between tower legs (4 to 8 mm); • Vertical subsidence > 20mm • Tilt >1mm/m	• Notify the following Key Stakeholders, as appropriate, within 24hrs of becoming aware of the trigger/s: o TransGrid o Principal Subsidence Engineer - DRE • Continue consultation with TransGrid.
	Level 3 – HIGH	**Operations exceed approved impact**	
	• Survey of ground and footing monitoring marks • Survey of tower legs on • Earth Peaks Monitoring	• Observable surface or tower deformations; and / or • Separation between tower legs (>8mm); • Subsidence greater than predicted maximum (Upper 95% CL).	• Notify Key Stakeholders, as appropriate, immediately following awareness of the trigger/s to o TransGrid; o Principal Subsidence Engineer – DRE • Cease unground mining immediately • Undertake additional 3D survey and check against pre-mining data and review against predictions; • TransGrid and RVC to undertake visual inspections accordingly; • RVC to review mining options and Extraction Plan

TYPICAL TARP

Post mining	• Survey of monitoring lines/points • Survey of tower legs • Earth Peaks Monitoring	• Check against subsidence predictions and baseline survey	• RVC to provide subsidence monitoring to: o TransGrid o Principal Subsidence Engineer - DRE

Subsidence Monitoring Plan for Wollongong Coal Russell Vale East PC07-08 and PC21-25 Extraction Plan: Endeavour Energy Consultation

Ken Mills 21/7/2021

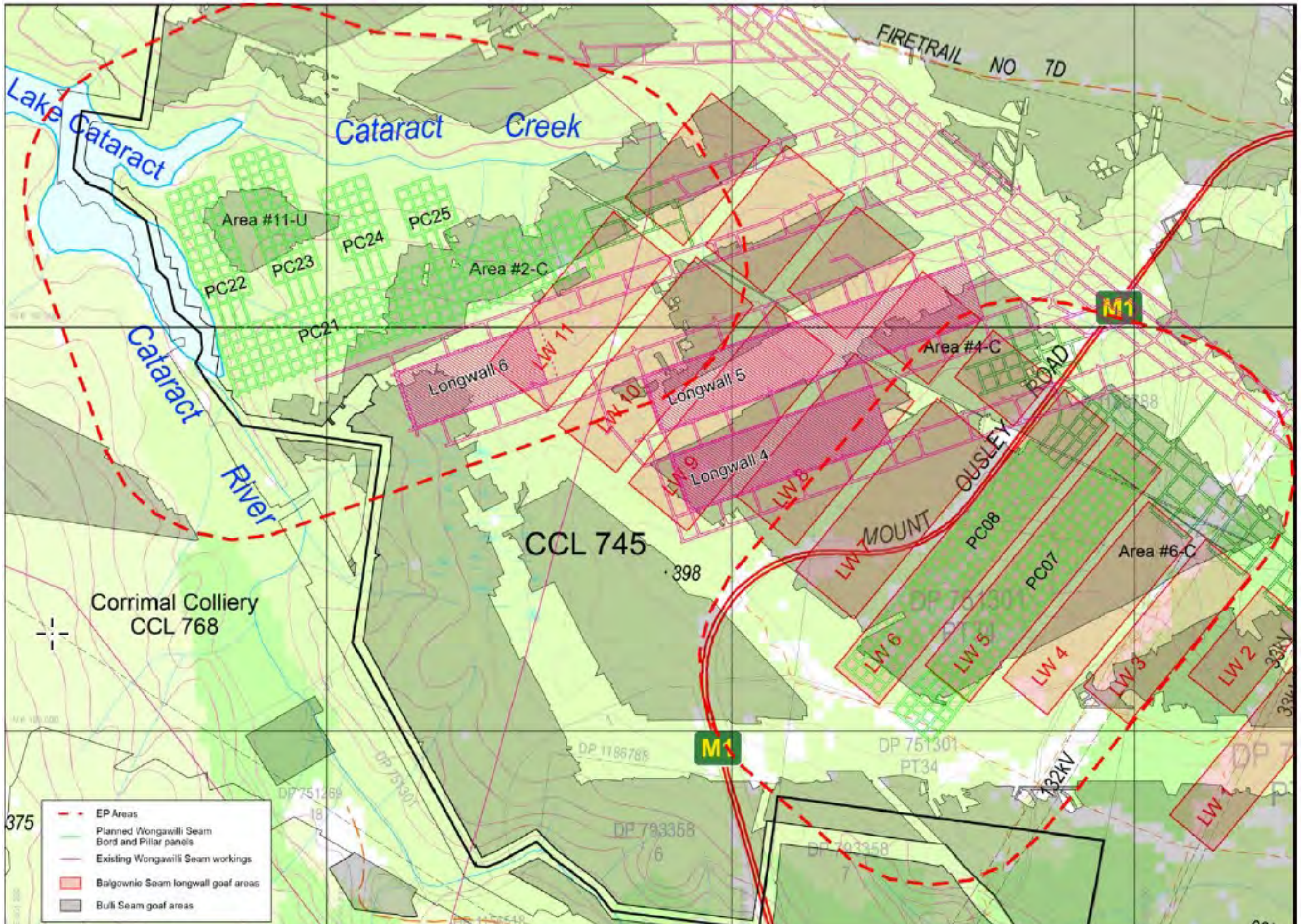
Updated Ken Mills & Stephen Wilson 6/8/2021

Geotechnical consulting, research and instrumentation for mining and civil industries.

Overview of Presentation

- Site description
  - Mining context
  - Surface features
- Expected subsidence to be monitored
  - From proposed first and "second" (bord and pillar) workings mining <100mm
  - Legacy of historical Bulli Seam mining (very, very, unlikely, possibly >500mm over small areas)
  - Ongoing effects from recent longwall mining (horizontal closure <20mm)
- Strategies
  - Start mining on western side of Mount Ousley Road where there is no infrastructure
  - Subsidence monitoring of current mining GNSS units: accurate (<20mm), three dimensional, continuous, accessible to all interested parties at locations of interest in near-real-time
  - Monitoring of legacy mining in Bulli Seam
    - LiDAR for overall coverage and confirmation no significant subsidence across the site (±200mm)
    - Underground monitoring of roadway conditions approaching Bulli Seam goafs
  - Monitoring of Transgrid Power Pylons
    - GNSS monitoring to confirm no movement
    - Detailed surveying of pylon base
    - Other monitoring as decided through consultation process

Site Description



Mining Context:

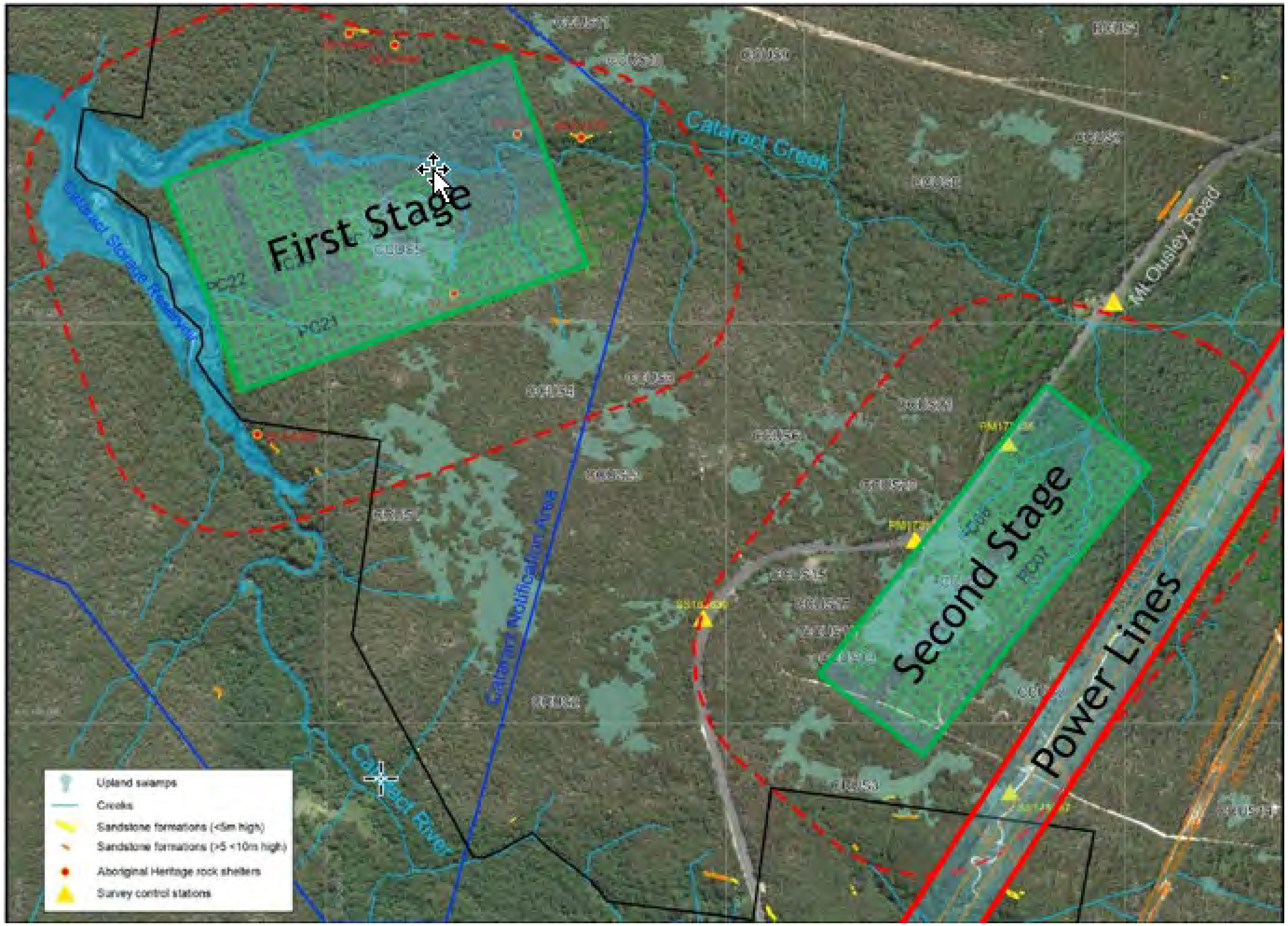
Three seams of mining with complete mining records now available

Subsidence monitoring available for Balgownie and Wongawilli

Previous subsidence to 3.7m

Expect <100mm over panels shown in green

Location of Power Lines and Proposed Mining



Power Transmission Lines:

330kV Powerlines (Transgrid)

132kV Powerline (Endeavour)

Other Surface Features:

Mt Ousley Road (TfNSW)

Cataract Reservoir (DSNSW)

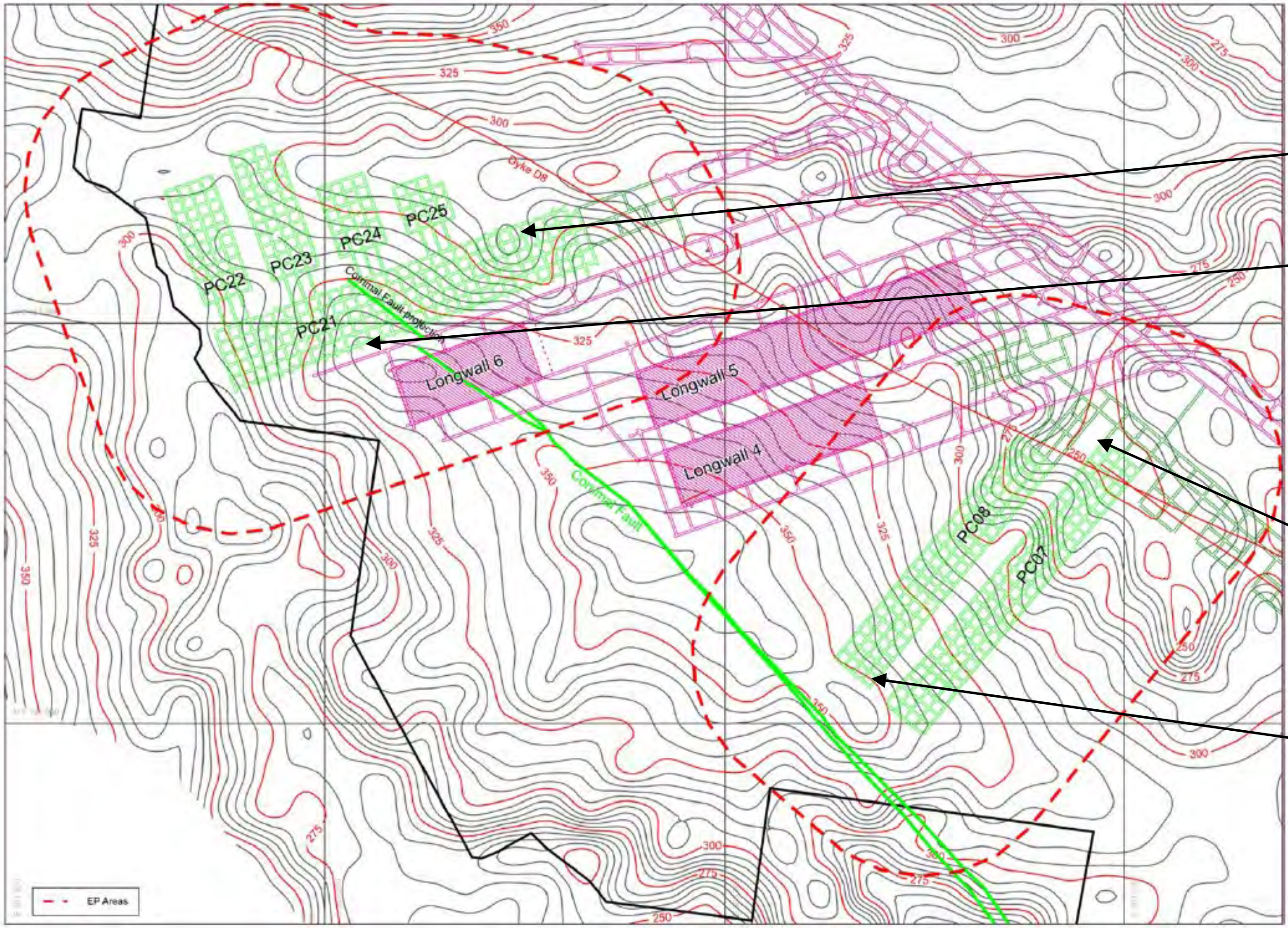
Upland Swamps (WaterNSW)

Permanent Survey Marks (Lands)

Heritage sites

Minor access tracks

Overburden depth



Minimum 285m

Maximum 340m

Minimum 250m

Maximum 350m

SCT

Expected Subsidence from Proposed Mining

First workings: approximately 25% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- No movements expected at the Power Pylons
- Movements at the surface barely perceptible
- Large, long-term stable pillars
- No potential for significant interaction with overlying Bulli Seam

"Second" (bord and pillar) workings: approximately 33% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- No movements expected at the Power Pylons
- Movements at the surface barely perceptible.
- Large, long-term stable pillars
- No potential for significant interaction with overlying Bulli Seam

Legacy Subsidence: Bulli, Balgownie & Wongawilli Seam Mining

Bulli Seam goaf areas (no further subsidence expected in vicinity of pylons)

- Mine plans confirm all areas indicated as goaf are extracted and collapsed
- Borehole RV16 through Bulli Seam goaf confirms collapse
- Roadway conditions in Wongawilli Seam confirms collapse
- Surface cracking confirms collapse
- Subsidence records from Balgownie Seam reinterpreted based on multi-seam subsidence experience at Ashton Underground Mine and confirm collapse
- All 7 of 7 goaf areas able to be confirmed as collapsed are collapsed
- Other 7 goaf areas expected to be collapsed but cannot be confirmed
- Borehole NRE1 over main heading pillars confirms stable pillars

Balgownie Seam Goaf Areas (no further subsidence expected in vicinity of pylons)

- Complete subsidence records confirming full subsidence
- Plans from time of mining show pylons subsidence but isolated between surface cracks

Legacy of recent longwall mining

- Possible ongoing closure movements at Cataract Creek (<20mm)
- No evidence of further road cracks
- Quantify these movements before commencement of planned mining

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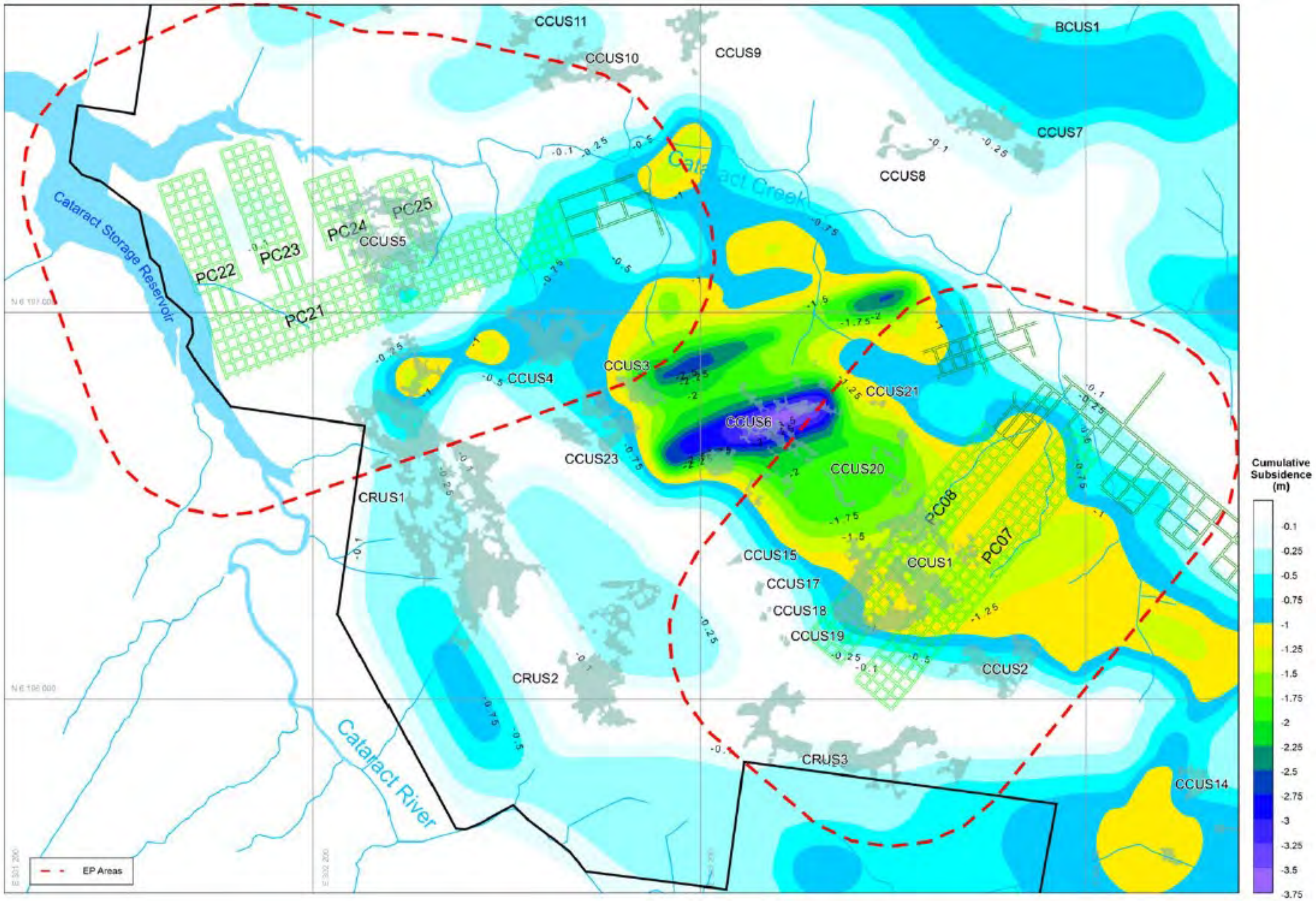
Legacy Subsidence:
Bulli, Balgownie & Wongawilli Seam Mining



Bulli Seam Up to 1m

Balgownie Seam
up to 1.4m more

Wongawilli Seam
up to 1.8m more

But only a few small areas where all three seams have secondary extraction at the same location

Legacy Subsidence:
Bulli Seam Mine Working Plan

The risk of further subsidence from legacy mining is an existing risk.

Proposed mining does not substantially change this existing risk.

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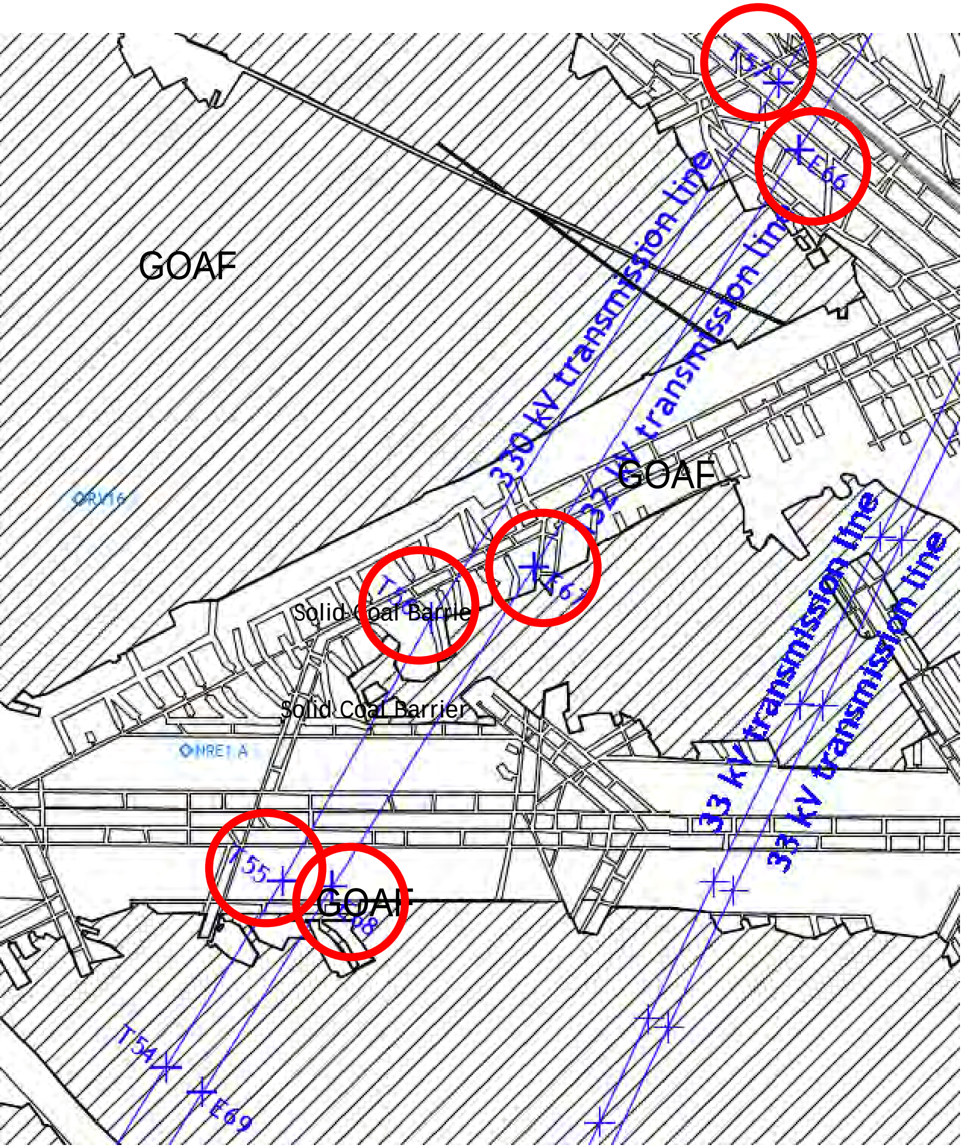
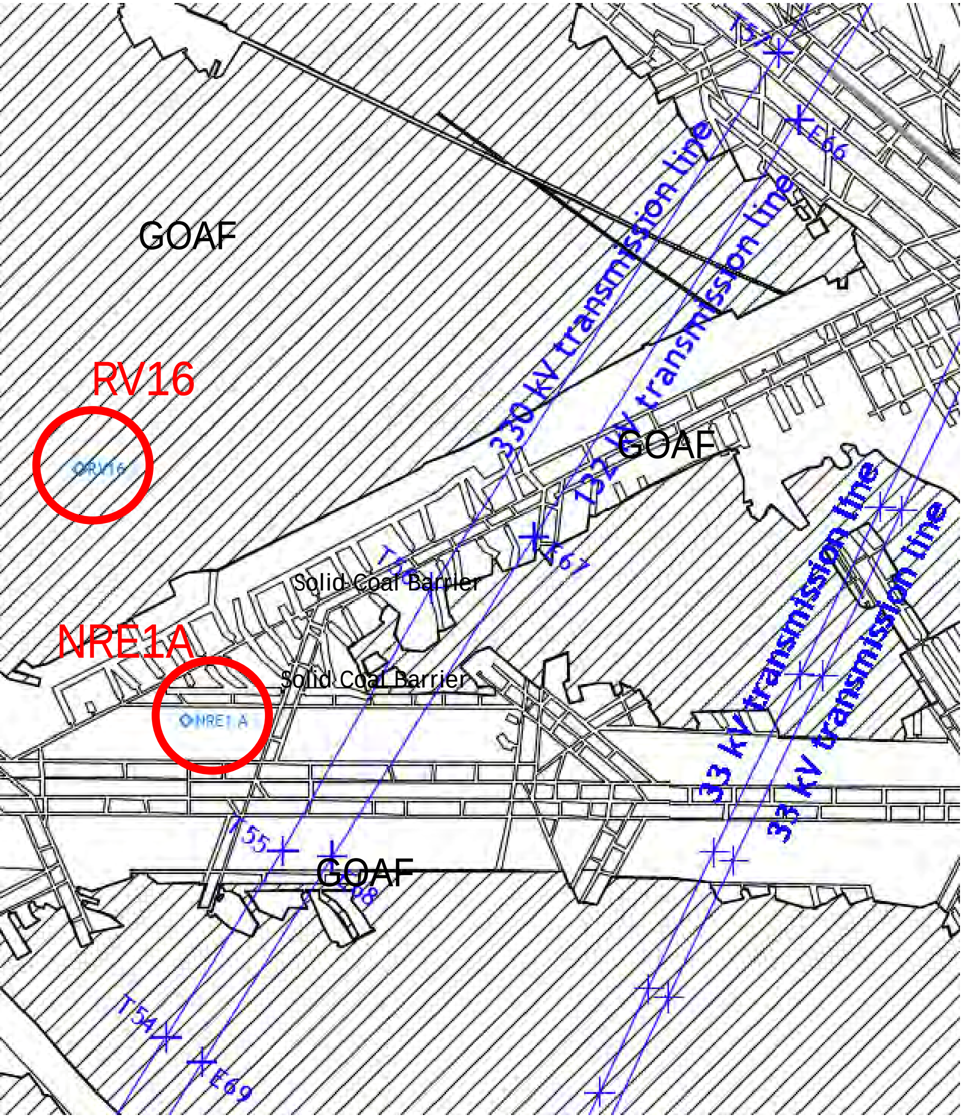
Bulli Seam Workings relative to Power Transmission Lines



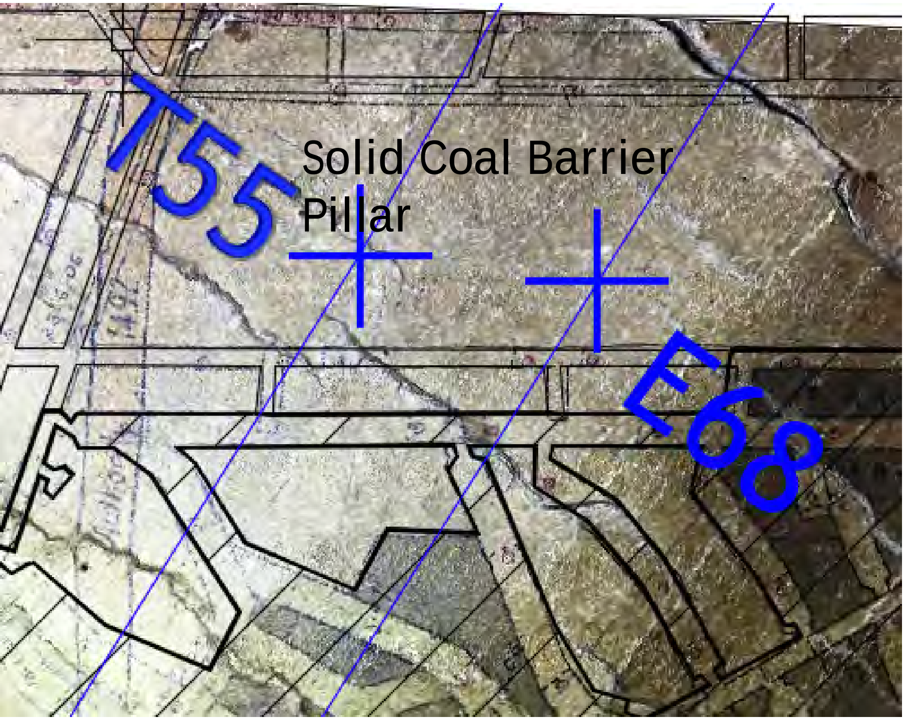
- T57 and E66 over Bulli Seam main heading pillars:
  - Long-term stable
  - No potential for subsidence
- T56 and E67 over edge of Bulli Seam main heading pillars in area fully subsided by Balgownie Seam longwalls:
  - Long-term stable after previous subsidence of 1.37m
  - Isolated by cracks from previous subsidence
  - No potential for subsidence impacts
- T55 and E68 over Bulli Seam main headings
  - Long-term stable
  - No potential for subsidence

Bulli Seam Workings relative to Power Transmission Lines



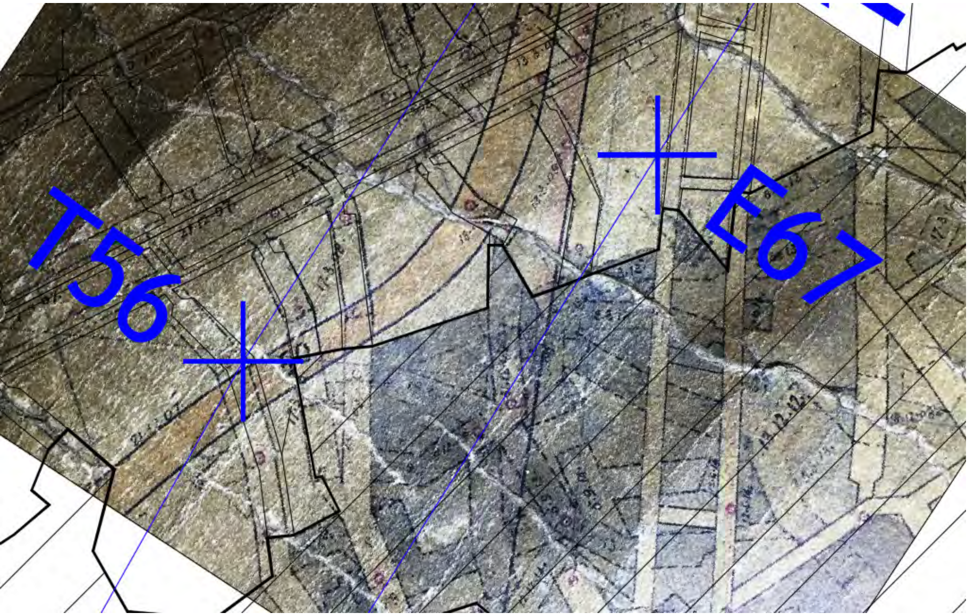
- Borehole RV16 confirms Bulli Seam fully extracted and goaf collapsed at this location
- Borehole NRE1A confirms Bulli Seam solid coal barrier pillar intact at this location
- Comparison of Mine Working Plan with ACAD plan indicates accuracy of workings of a few metres which is insignificant compared to the 250-350m overburden depth

Details of Bulli Seam Workings below Towers T55 and E68



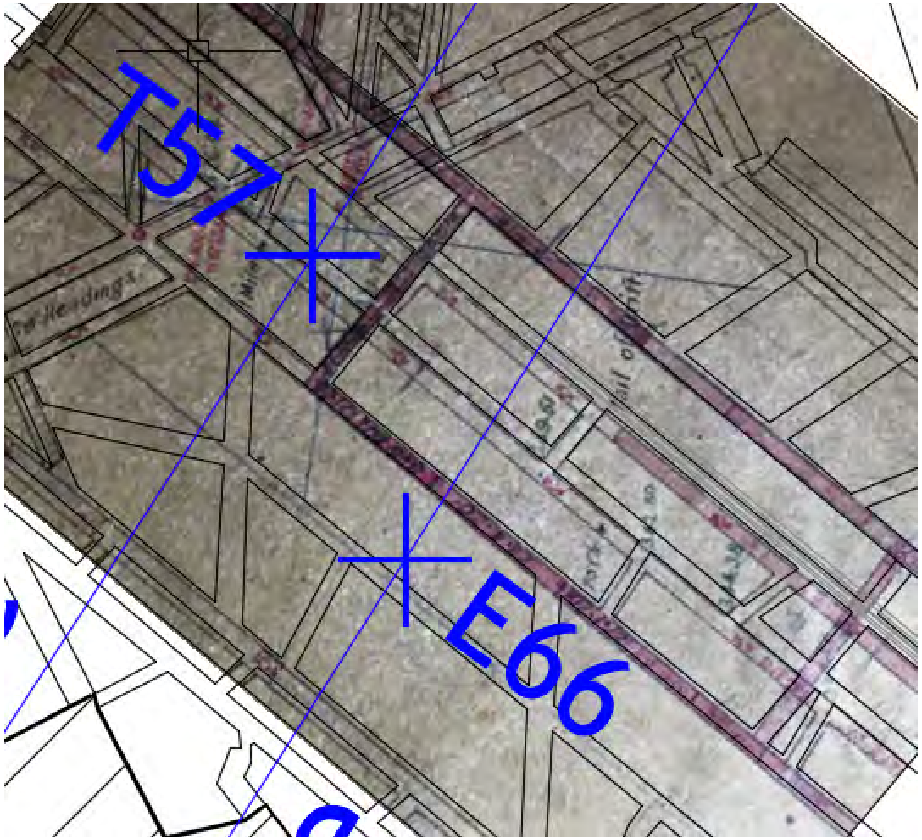
- T55 and E68 above solid coal barrier pillar
- Detailed plan of workings showing survey stations (red circles) and reduced level information
- Adjacent goaf areas extracted circa 1904

Details of Bulli Seam Workings below Towers T56 and E67



- T56 and E67 near the edge of a Bulli Seam goaf area – subsequently mined under by Longwall 3 in Balgownie seam in 1972
- Detailed plan of workings showing survey stations (red circles)
- Roadways formed circa 1907
- Pillars extracted circa 1912

Details of Bulli Seam Workings below Towers T57 and E66



- T57 and E66 above main headings coal pillars in Bulli Seam (and Balgownie Seam and coal barrier in Wongawilli Seam)
- Detailed plan of workings showing survey stations (red circles) coordinate values and reduced level heights
- The presence of documented survey points is indicative of a methodical survey process.

Power Transmission Lines Predate Balgownie Seam Mining

1951

1961

Aerial photographic evidence that powerlines were constructed approximately 10 years before Towers T56 and E67 were undermined in 1972 by Longwall 3 in the Balgownie Seam

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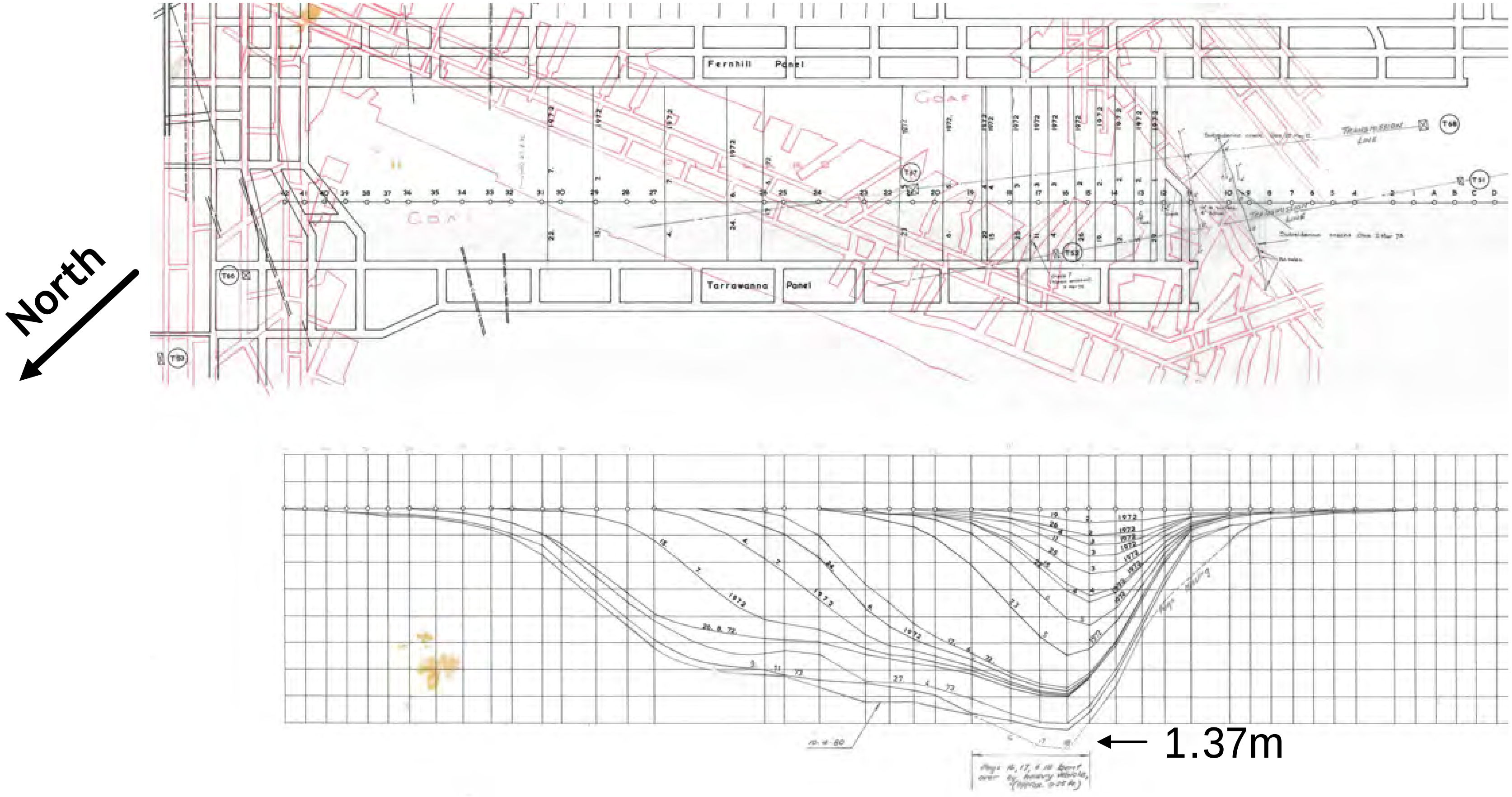
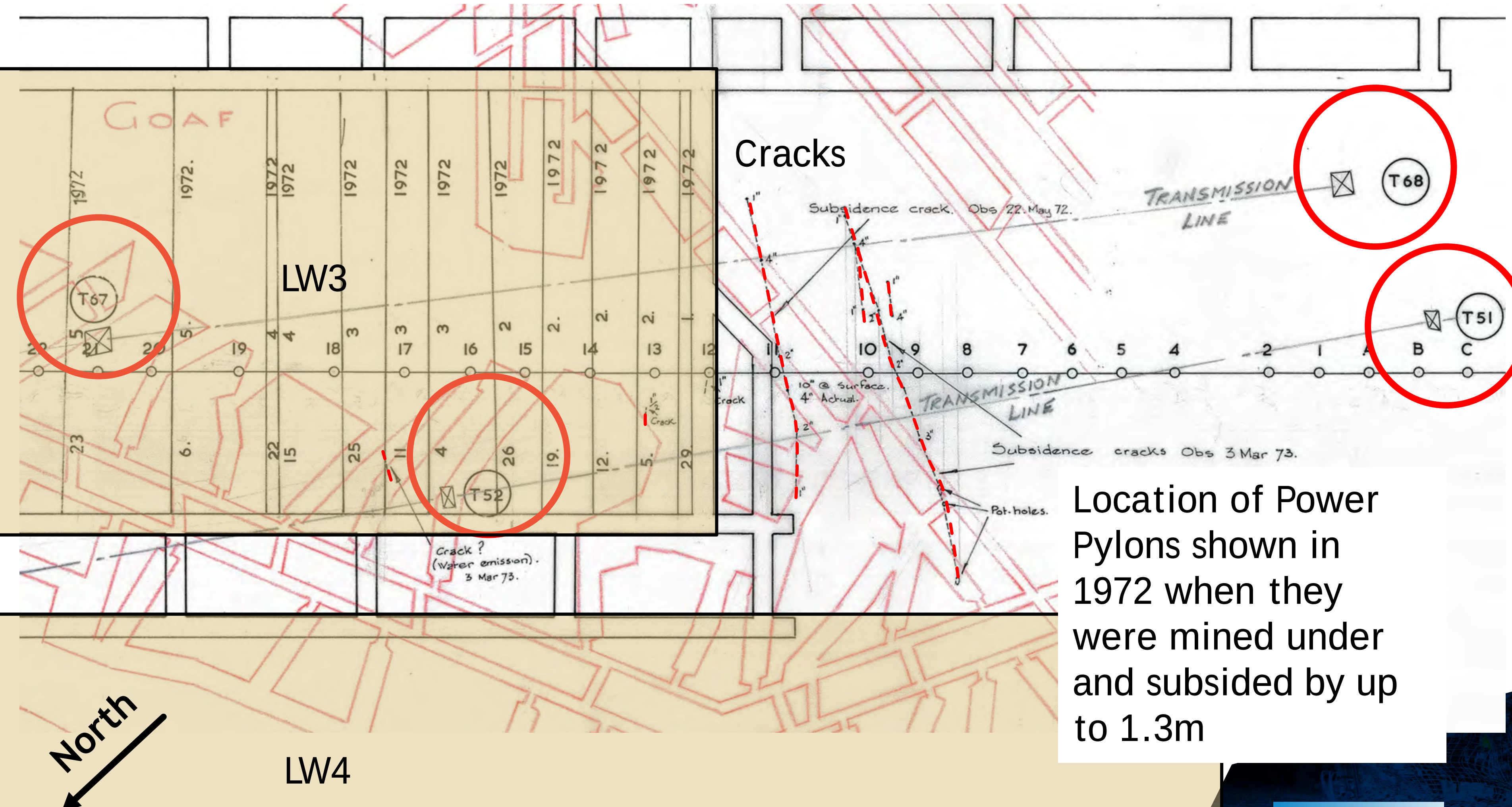
Balgownie Seam Subsidence

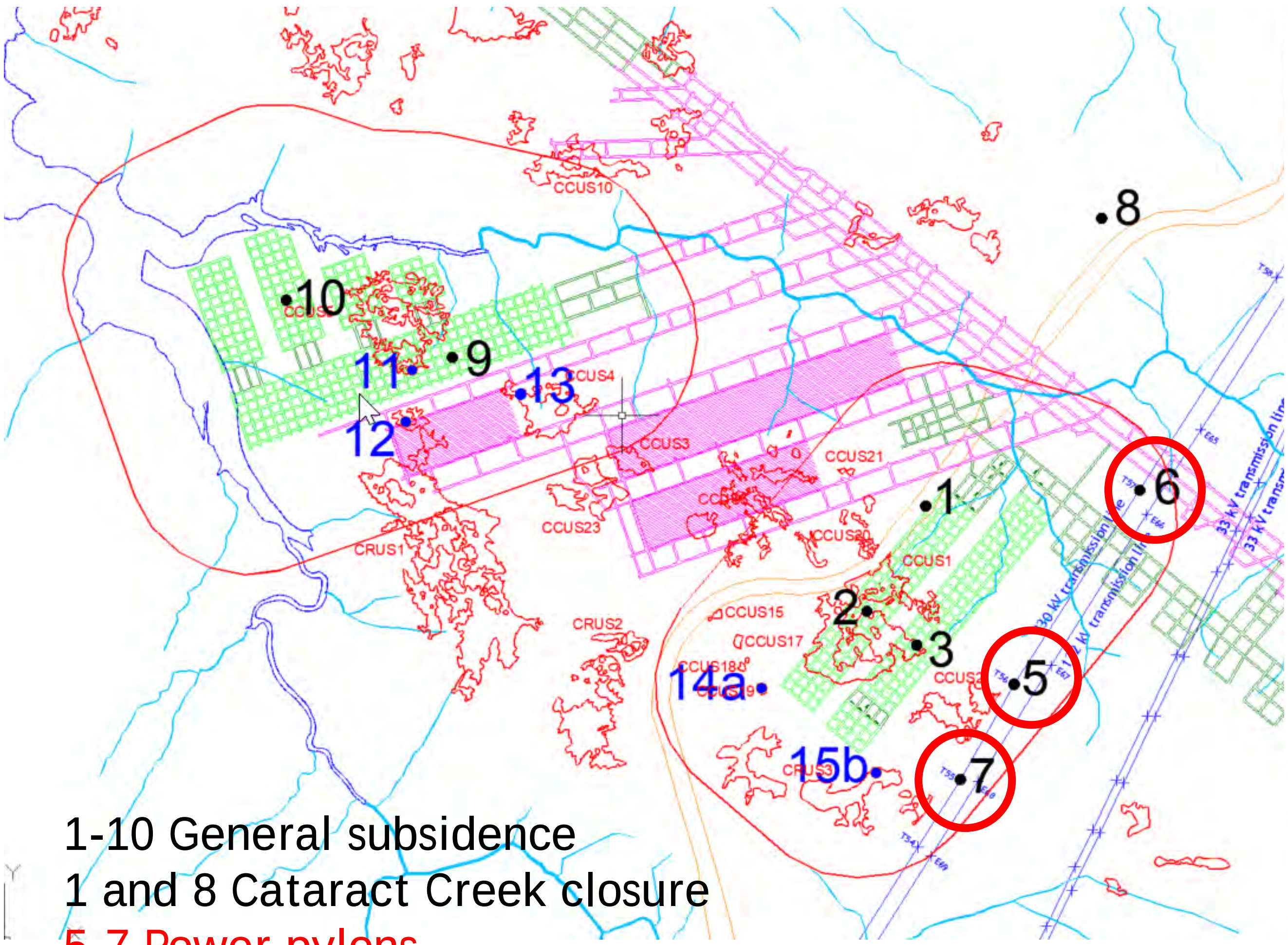


Power Transmission Lines 1972 Balgownie Seam Mining and Cracks



Location of Power Pylons shown in 1972 when they were mined under and subsided by up to 1.3m

Subsidence Monitoring: GNSS Units



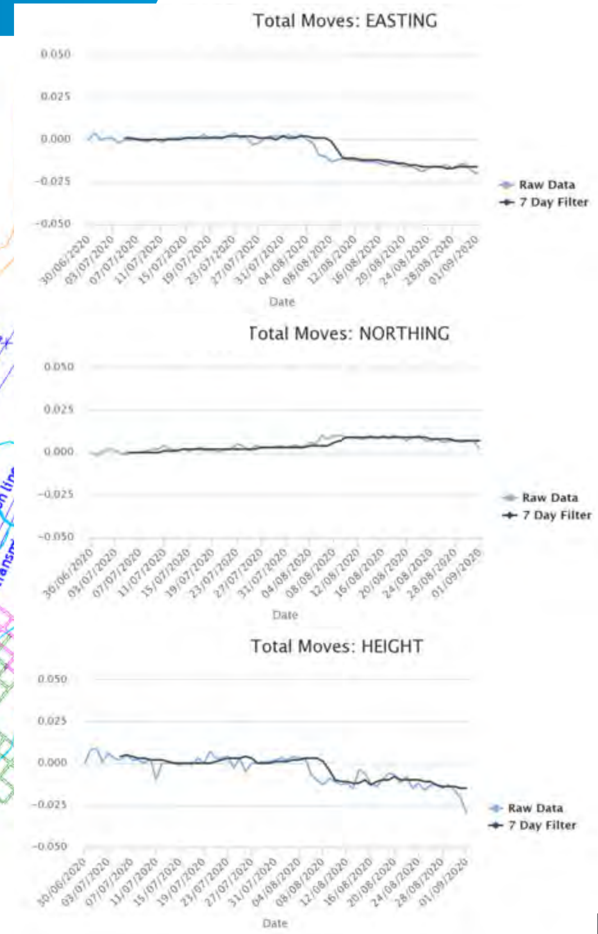
1-10 General subsidence

1 and 8 Cataract Creek closure

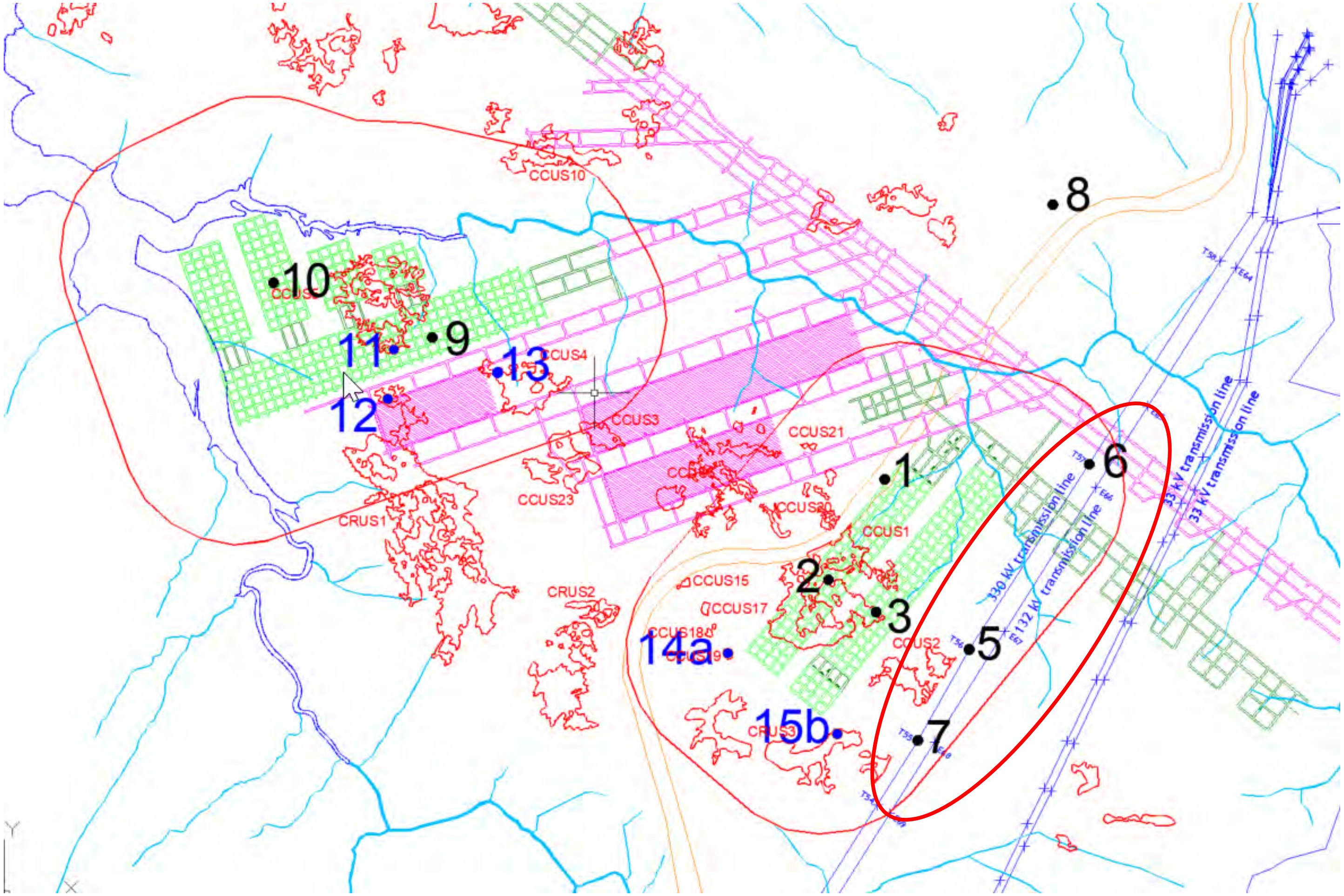
5-7 Power pylons

11-15 Swamp Specific

Example Data



Subsidence Monitoring: GNSS Units



Infrastructure Monitoring

Transgrid 330kV power transmission lines

NB Recent research indicates these towers were in place when Balgownie Seam caused 1.3m of subsidence. Cracks nearby indicate towers are founded in one unit of solid rock.

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Natural and Built Features						
Edge of Mt Ousley Road	GNSS #1	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC08 (Bulli & Balgownie goaf)	GNSS #2	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
PC07 (Bulli & Balgownie goaf)	GNSS #3	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
330kV Powerline T56 tower (Balgownie goaf)	GNSS #5	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T57 tower (pillars)	GNSS #6	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T55 tower (solid coal)	GNSS #7	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
WCL easement (Bulli goaf)	GNSS #8	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC21 (Bulli goaf #2)	GNSS #9	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC23 (Bulli goaf #11)	GNSS #10	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC21 (Bulli goaf #2)	GNSS #11	At Swamp CCUS5	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (edge Bulli & Wongawilli goaf)	GNSS #12	At Swamp CRUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (Balgownie goaf)	GNSS #13	At Swamp CCUS4	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
West of PC08 (Bulli pillars)	GNSS #14a	At Swamp CCUS19	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC07 (Bulli pillars)	GNSS #15b	At Swamp CCUS3	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
Russell Vale East Area-	LIDAR	General subsidence - all surface features	3D ±200mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DAWE, RMS, TG, EE, DPIE, RR
Cataract Creek at CC1, CC2, CC3 and CC4	Hi res survey	Valley closure (upsidence) at CC1-CC4	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DPIE, RR

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration		Reporting Frequency	Reporting Timing & Distribution
Infrastructure							
Mt Ousley Road - Pavement	Crackmeter monitoring at Slot	Pavement condition from compression	1D ±1mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Pavement	Hi res survey across extension zone at ridge	Pavement condition from tension	1D ±3mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Culverts	Direct measurements of Cataract Creek culverts	Drainage and pavement conditions	1D ±1mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Visual inspections and photos						3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
330kV and 132kV powerlines	3D Position of Towers	Power supply integrity	3D ±20-25mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
330kV and 132kV powerlines	Leg diff measurements	Power supply integrity	1D ±2mm	After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
Visual inspections including 33kV lines				After each panel or annual or by TARP		3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR

Notes – * excludes reporting of incident or non-compliance.

Reporting includes an evaluation of the risk of the 100mm subsidence limit at swamps (EPBC 2020/8702) being reached or exceeded.

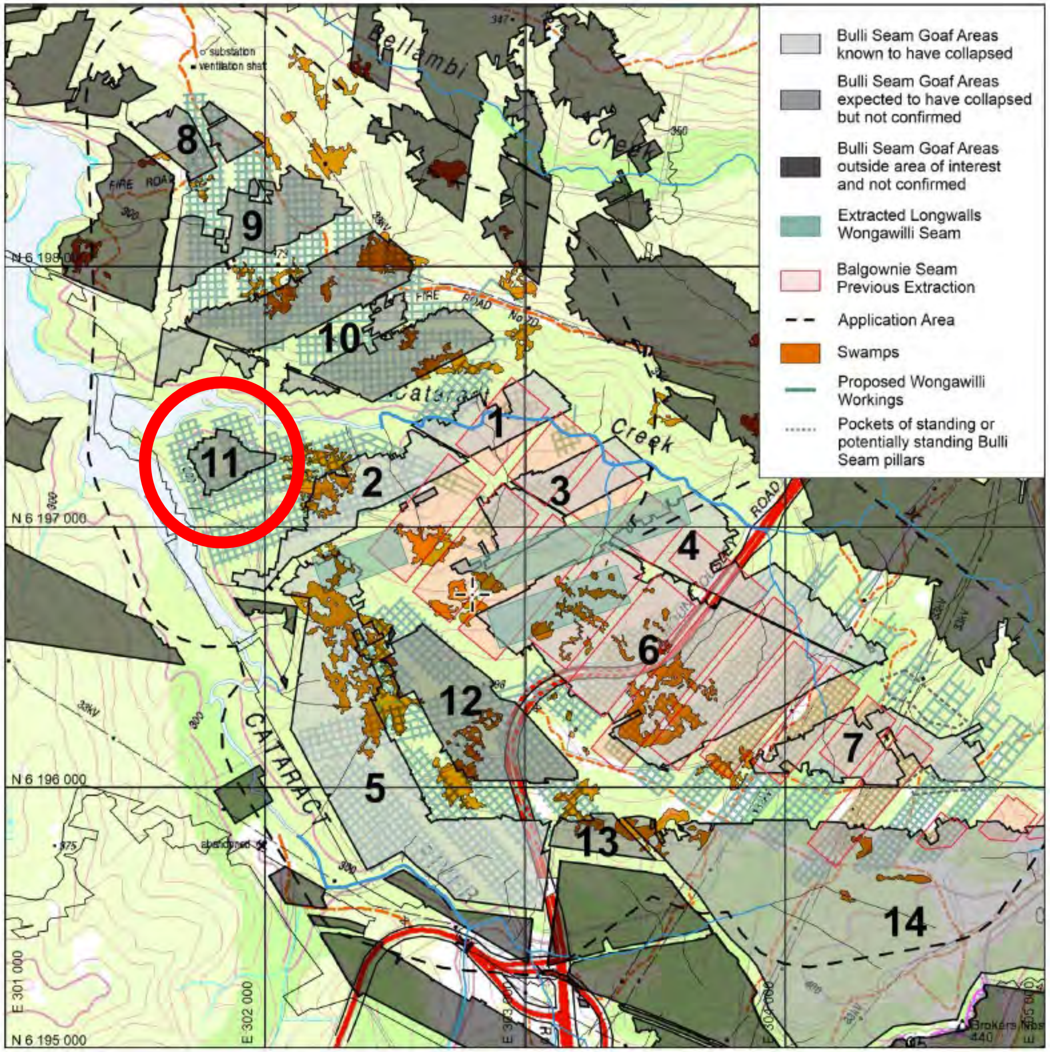
Each control survey and subsidiary survey must be planned, surveyed and analysed to ensure they satisfy the conditions to achieve a standard of accuracy as prescribed in ICSM (2007) SP1 (version 1.7) to achieve Class "D" or better (S&DD 2020)

Baseline surveys for GNNS units and LIDAR undertaken prior to the commencement of mining.

Baseline survey (for end of longwall mining) of Mt Ousley Road, Cataract Creek and powerlines undertaken prior to the commencement of mining.

Cessation of mining is taken as completion of mining in adjacent panel.

Legacy Subsidence Areas: Unconfirmed Bulli Seam Goaf

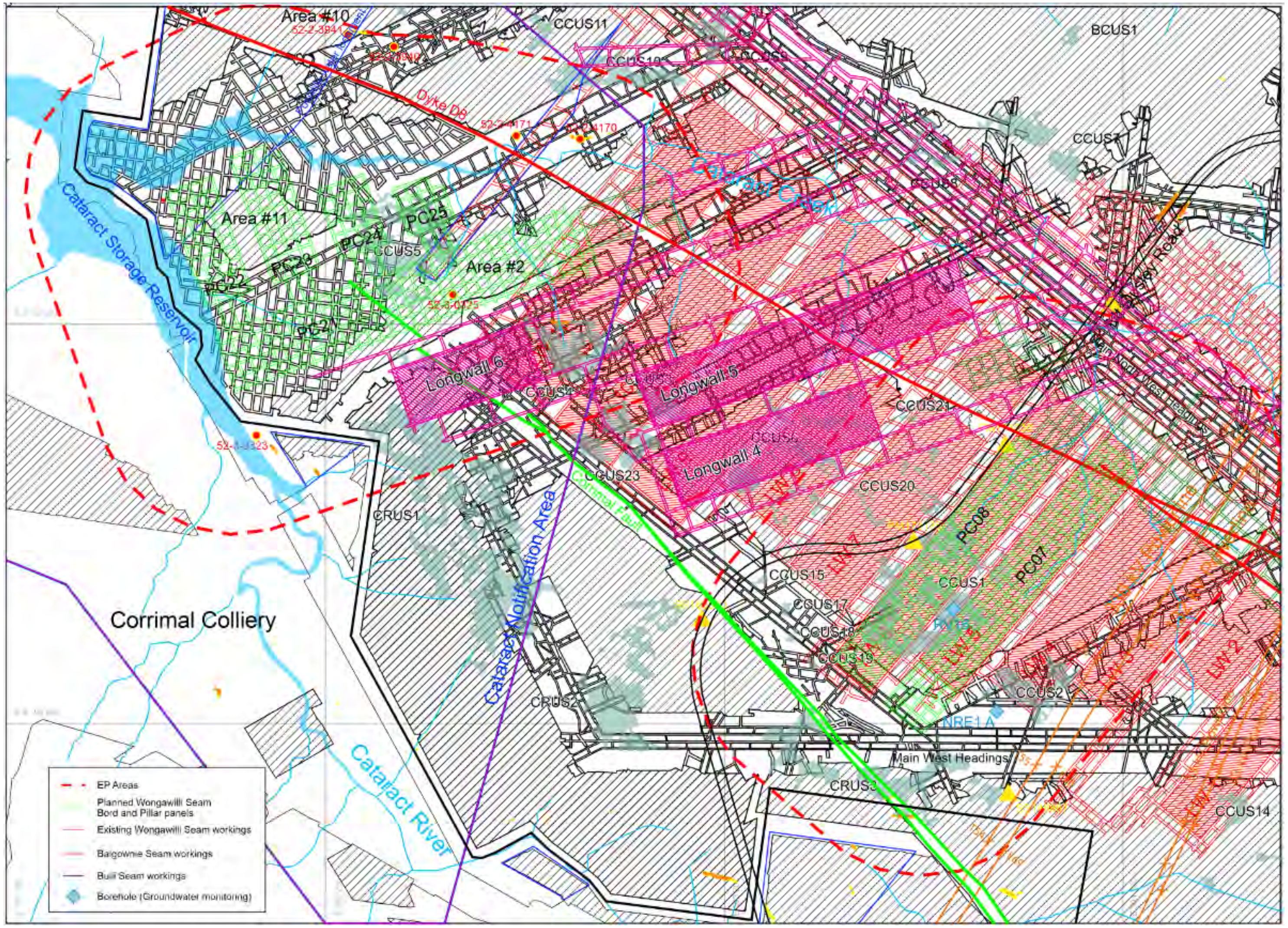


Reproduced from SCT5111 Rev4 (2020)

Only one area of Bulli Seam goaf (#11) that is not independently confirmed as having collapsed

Area #11 is remote from infrastructure and swamps

Subsidence Monitoring: LiDAR



Not expecting to see any significant change in LiDAR

Additional Research

Additional research into the reliability of the Bulli Seam mine plan records since Development Consent approved included in the Subsidence Assessment for Extraction Plan

29 June 2021 - Ken Mills and Steve Wilson

Reliability of Bulli Seam Mine Plans

Purpose:

To identify areas of potentially marginally stable pillars to assist quantify the residual risk for greater than predicted subsidence

To assist Mine Manager and Mine Surveyor in their considerations for PHMP for subsidence

Tasks:

Examination of detailed mine plan records (mine or colliery working plans, record tracings and other subsidiary plans such as for production, ventilation) and other records held by:

- Wollongong Coal
- Department of Mineral Resources
- University of Wollongong Library Archives
- Wollongong City Library – Local studies
- AusIMM – Illawarra Branch – Mineral Heritage sub-committee (significant additional data)

Detailed review of Balgownie Seam longwall subsidence data in the context of advancement in understanding multi-seam subsidence (Mills and Wilson 2017)

Reliability of Bulli Seam Mine Plans

Other information considered:

- Drilling of boreholes from underground and from the surface to confirm the location and status of Bulli Seam workings
- Visual inspections of underground workings in the two overlying seams
- Observations of seam interaction effects associated with mining in the Wongawilli Seam
- Consideration of pillar sizes required to maintain stability under the goaf edge loading and chain pillar loading from seams below and potential to contribute to a pillar run

Reliability of Bulli Seam Mine Plans

Conclusions:

- Complete mining details of the Bulli Seam workings are available (following discovery of “missing link” that provides complete detail of goaf areas recorded at the time of mining).

- The interpretations and assumptions made in previous assessments of Bulli Seam goaf stability are consistent with detailed mine records

- Subsidence monitoring from the Balgownie Seam longwall panels indicates:
  - Consistent vertical subsidence with a variation of less than 200mm (typical range for multi-seam subsidence)
  - No significant irregularities in the subsidence profile that would indicate collapse or progressive failure (pillar run) of standing pillars over a substantial area
  - Some softening of goaf edges consistent with overlying workings

- Substantially higher than predicted subsidence from mining Longwalls 4 and 5 in the Wongawilli Seam is consistent with under-prediction of subsidence for these panels

BUILT FEATURES MP - CONSULTATION MEETING MINUTES

MEETING	Wollongong Coal Limited (WCL) – Endeavour Energy (EE) – Built Features Management Plan Consultation		
DATE	21 July 2021	Time	11.00 am -12.24 pm
LOCATION	Zoom Meeting		
CHAIR	Warwick Lidbury		
INVITED ATTENDEES	WCL (Proponent)	Warwick Lidbury (WL) – *CEO* Brenton Vermeulen (BV) – *GM Operations* Devendra Vyas (DV) – *Manager Technical Services* Robert Faddy-Vrouwe (RFV) – *Environmental Co-ordinator* Suzanne Naumovski (SN) – *Executive Assistant*	
	EE (Stakeholder)	Vaib Bohra (VB) – *Manager, Transmission - South* Chris Kindinger (CK) – *Transmission Asset Engineer - South* John Pang (JP) - *Operations* Rodney Quick (RQ) – *Operations Manager, Transmission Mains - South*	
	SCT (Technical Specialist Consultant)	Ken Mills (KM)	
	Resources Regulator (Subsidence Expert)	Gang Li (GL)	
APOLOGIES	Jason Causer - EE; Bradley Ham – EE; Barry Ward – EE. Richard Sheehan – *Group Environment and Approvals Manager – WCL.*		

ITEM	Meeting Actions
Introductions ***Brief introduction by meeting participants.*** As part of DPIE's (NSW Department of Planning, Industry & Environment) consent conditions for the Russell Vale Colliery (RVC) Underground Expansion Plan (UEP), WCL is required to consult with all stakeholders in relation to its CMP (Construction Management Plan).	
Overview of RVC UEP Mining ***Brief overview of the RVC UEP and mining methodology by WL.*** WCL ceased longwall mining at its operations in 2015. All future mining will use the bord and pillar method.	
Subsidence Assessment and Relationship to Stakeholders Built Features ***Overview of the Extraction Area in relation to built features and assessment of subsidence impacts.*** Presentation by KM – *Subsidence Monitoring Plan for Wollongong Coal Russell Vale East PC07-08 and PC21-25 Extraction Plan: Endeavour Energy Consultation*. GL noted his concern over comments that RVC UEP has no subsidence and is not directly undermining EE assets. The concern relates to possibly misleading infrastructure operators. The mining proposal involves undermining two layers of previously mined workings. There is high level uncertainly when undermining old workings where subsidence could occur. KM: Confirmed legacy of historical mining in Bulli Seam where there is possibility of subsidence. With reference to the 1951 and 1961 aerial photographs, which indicate that the Transgrid and/or Endeavour Energy powerlines were in place at that time, KM would like some feedback from EE as to whether it is aware of any replacement of the powerline pylons since that time and whether any remediation work has since been undertaken. This is in order to determine whether the towers have already been subsided.	
Proposed Monitoring Program and Mitigation plan ***Outline of the monitoring network and program to quantify impacts of mining and subsidence management strategy.*** Continued via KM's presentation.	

ITEM	Meeting Actions
GPS solar-powered system in use for monitoring in various locations. It is continually updated and reported electronically. Plan to install GPS units on the power pylons, pending further discussion. RQ: Will need to look at past activity to know what has occurred to those towers as no current employees would have knowledge of what has occurred in the past. RQ: Requests simplified information that shows an overlay of where the EE towers are in relation to the old and proposed mining areas. In addition to EE's records, RQ will talk to some of his long-term field staff to gather any knowledge they may have. WL: Does EE have a contingency should a powerline fail. RQ: EE has a dual feeder/circuit on the 132 run from Dapto TG to Bellambi TS and believes there is little contingency should one of those towers be lost. JP: Pre-drilling of rock base for quick installation of poles at difficult and vulnerable sites has been suggested by others in the past. Discussion between KM and JP regarding the use of LIDAR. GL: There is a standard procedure used for monitoring of transmission towers affected by subsidence but does not see it in the mine's proposed monitoring. (WCL to seek Transgrid's advice as to how its monitoring was conducted in the past.) KM: Happy to be guided by the DPIE regarding its required standard for monitoring. WL requested EE to put this in its response and WCL will adjust its monitoring to suit EE's requirements. GL: Referred to the comment he made when RVC met with Transport NSW regarding consultation on Mt Ousley Road. It is important that it is communicated that proposed mining by RVC undermines two layers of overlying workings, especially Bulli pier workings mined over 100 years ago. It is not known how accurate the records are but can say there are high levels of uncertainty in relation to the nature, distribution, magnitude, and timing of subsidence. That is the reason why there is a condition in the DC requiring, as part of the EP, to develop a contingency plan. WL: WCL has a contingency plan developed as part of the EP. KM: In relation to making the line stable for any perceived ground movements, questioned the timeframe/lead time to make changes and whether they would	

ITEM	Meeting Actions
be pre-emptive. JP: It is not done pre-emptively. The only lead-time concern is in relation to rocky sites/difficult sites. WL: Reiterated that RVC is not a longwall mine and does not use similar methods to mines in the west or other mines in the Illawarra; it is a place-change with conforming pillars that will withstand and not collapse. RVC is confident that it will not affect the powerlines or the towers. JP: If subsidence occurs, how quickly would that start and finish? WL: When we commence the panels and go past the GNSS units we will have an indication to confirm what we're predicting. KM: There are two elements: ground movement associated with Wongawilli Seam mining (small level of ground movement). The issue is, does that small level of ground movement cause a change on the surface because of a sense of destabilisation of the Bulli Seam goaf and the Bulli Seam mining that has occurred above that area? We should make a simple plan that we should talk specifics around each tower and understand the specific controls and issues. The concern is around the Bulli Seam destabilisation that could cause additional subsidence on the surface. The magnitude of that additional subsidence is likely to be relatively small, hard to see if it is going to be as much as a metre, much more in the 200-300 mm range, based on the geometries that we understand and have seen to date. It is also unlikely, given the history that such a level of movement would cause the towers to be impacted. There is a thread through that, but it is still possible, but it is becoming a more remote or distant thing. So, it is really the juxtaposition of the significance of the structures and the fact that there is no back-up plan, and we cannot have a situation where the power lines go down. The consequence side is high, and the probability is very low. If it were to occur, what could we do in advance to close that out as an issue? What is involved in putting towers in place that are tolerant? What is the time and the cost, etc? RQ: Quickest way to do that in identified higher risk areas is to pre-bore holes and have the ability to stand poles quickly. Would involve design and engineering considerations. Would require information (from WCL) identifying the unknowns on each tower and may be able to provide clarity. KM: Will put together a simplified plan that shows each structure, the ground movement that has already occurred and the potential for subsequent ground movement. RFV: Timing of subsidence – lead-time on subsidence movements?	

ITEM	Meeting Actions
KM: Subsidence associated with Wongawilli Seam will occur gradually and in proportion to mining and is of a low level. Should Bulli Seam instability occur, it would be sudden because it is an instability of smaller pillars. In that case, the lead time would be short, which is a worst-case scenario. Theoretically, it is not possible to have small pillars that can collapse right next to an existing goaf that would become overloaded by first workings. JP: Suggested WCL make a worst-case prediction to better guide EE on the contingency planning. CK: Requested simplified data on the maps and designs and the monitoring process to allow EE to consider. GL: Previously advised WCL that proposed monitoring is inadequate in terms of contingency planning, particularly in detecting early warnings, so that risk controls can be implemented in time. Now it looks significantly inadequate so suggests that RVC looks into it. Pay attention to how to detect early warnings; where, when, how, what parameters, to inform the contingency plan.	
Stakeholder Feedback and outcome of consultation ***Discussion of any questions or comments from stakeholder and feedback based on presentation.*** VB: Suggested we move forward on the suggestion that WCL provides EE with information to review, provide a response and follow-up with another meeting. Site visit to be arranged.	
Any other business	

Tabled Documents:

SCT – (PowerPoint presentation) - Subsidence Monitoring Plan for Wollongong Coal Russell Vale East PC07-08 and PC21-25 Extraction Plan: Endeavour Energy Consultation.

SCT (WCRV5285) – RVC Subsidence Assessment Report for PC07-08 and PC21-25 (Rev3 Dated 23/06/2021)

WCL – RVC UEP Subsidence Monitoring Program, GNSS Monitoring (Plan dated 30/6/2021)

WCL – RVC UEP Built Features Management Plan (Initial Draft for Consultation dated 28/06/2021)

Richard Sheehan
Wollongong Coal
PO Box 281
Fairy Meadow NSW 2519
Email: richard.sheehan@wcl.net.au

Survey Mark Removal (SMR) Application: Granted (conditional)

Dear Richard,

Re: Underground Coal mining

Your Reference: TBC SMR Application reference: SO-559

Locality: Cataract, 2560 LGA: Wollongong

Please quote the SMR Application reference SO-559 in any correspondence.

Your request to disturb the Survey Marks detailed in your application has been considered and granted with the following conditions:

1. This consent must be read in conjunction with the documents listed below (available for download at DCS Spatial Services Customer Hub):
   - Appendix A - 1 WCRV5285 Goaf Areas.tif
2. The movement of affected Permanent Survey Marks is monitored by NRTK survey every 6 months and the results are submitted to the Office of the Surveyor-General by the Project Data Submission in the DCS Spatial Services Customer Hub.
3. The monitoring will continue until the mine workings has been completed and the subsidence has ceased.
4. Upon the completion of the project, an End of Project Applicant Compliance Statement and all required deliverables are submitted to the Office of the Surveyor-General by the Project Data Submission in the DCS Spatial Services Customer Hub.
   The template for an End of Project Applicant Compliance Statement can be found in the POSI Resource Pack under *Surveyor-General's Direction No.11*.

Please note:

- During the interim period of mark destruction to the re-establishment of new survey marks and/or lodgement of Plan of Survey Information Only, your contact details will be provided to any persons from the public enquiring about the loss of survey infrastructure. If contacted by any such person then the applicant must supply any relevant information that may assist in their inquiry (such as survey data that may assist in defining GDA, AHD or the cadastre).

- If a minor variation to this approval is required, then notification of that variation needs to be sent to the Office of the Surveyor-General by commenting on SO-559 in the DCS Spatial Services Customer Hub.
- If there are any major variations to the subject proposal, this consent is nullified and a new Survey Mark Removal application must be lodged for assessment by the Surveyor-General.
- SCIMS survey mark data can be obtained free of charge from the SIX Maps - SCIMS Online facility within the DCS Spatial Services Portal by logging in or registering a new "SIX" user account.
- Where possible, provide at least 30 business days notification before the proposed removal or replacement of survey marks (Permanent Survey Marks or Cadastral Reference Marks) thereby extending the timeframe of 14 days minimum under Clause 90 of the *Surveying and Spatial Information Regulation 2017*.
- For all future requests to remove a survey mark, please make a Survey Mark Removal application by logging in or registering a new customer account on the DCS Spatial Services Customer Hub.

If you have any concerns regarding this matter, please add a comment to request SO-559 through the DCS Spatial Services Customer Hub.

Yours sincerely,

Janez Rom

For Narelle Underwood
Surveyor-General of NSW

20 September 2021

APPENDIX C – Baseline Surveys

LIDAR Baseline Survey Report for the Russell Vale East EP Area

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

WOLLONGONG COAL LIMITED

PRJ39682 RUSSELL VALE COLLIERY JUNE 2021 BASELINE AERIAL SURVEY

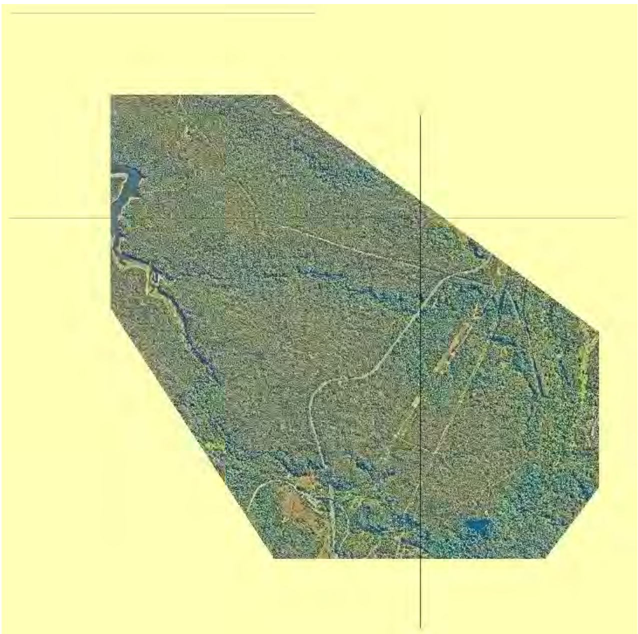
VOLUME: PRJ39682_01

PROJECT SUMMARY

The Russel Vale Colliery Baseline Project is an Airborne LiDAR Survey that was carried out on the 31 August 2021 over a 15.755 km^2 site northwest of Wollongong in NSW.

The purpose of this project is to supply Wollongong Coal with baseline spatial information datasets ahead of commencement of operations for underground mining at Russell Vale Colliery, near Wollongong, New South Wales.

The LiDAR capture over the project Area of Interest (AOI) was planned to achieve a minimum point density of 4 point per square metre +/- 10cm vertical accuracy at 68% confidence of the absolute ground height in clear areas over the site and simultaneous orthoimage with 10 cm GSD. The LiDAR point cloud data is to be classified to ICSM level 2, and RGB orthoimage will be included in the final delivery.



DATA SUMMARY

This volume includes the following data in MGA56 (GDA94) and AHD (Via Ausgoid09):

- 28 tiles at 1km² of ICSM L2 Classified Point Cloud data in LAS v1.2 format
- 28 tiles at 1km² of 0.5m cell size DTM in XYZ ASCII format (Ground)
- 28 tiles at 1km² of 0.5m cell size DSM in XYZ ASCII format (unclassified "Non-ground")
- 1 x 10cm GSD RGB Orthophoto Mosaic in ECW format
- 28 tiles at 1km² of 10cm RGB orthophoto in TIFF format.
- 1 X 1km² Tile layout in Shapefile format
- 1 flight trajectory in Shapefile format
- 1 Area of interest polygon in Shapefile format
- File listing in .txt format
- Readme (PRJ39682_01.pdf) file: This document in PDF format

This volume also includes the above data in MGA56 (GDA2020) and AHD (Via Ausgeoid 2020)

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CONTENTS

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1. DATA INFORMATION

Data supply:	AAM AWS S3 (Links via e-mail)
Number of files:	3 zipped data files and this README.PDF
Data formatted on:	7.09.2021
README Document:	This file

Previous Project Deliveries	Date	Data Title	Contents

File Details this Delivery	Contents
WCL_e300000n6197000_2021Aug31_gda94-mga56.las	classified LAS 1.2
WCL_e300000n6197000_2021Aug31_gda2020-mga56.xyz	ASCII XYZ
WCL_e300000n6197000_10cm_2021Aug31_gda2020-mga56.ecw	Tiled 10cm Orthoimage
WCL_e300000n6197000_10cm_2021Aug31_gda94-mga56.tif	Tiled 10cm Orthoimage
WCL_10cm_2021Aug31_gda94-mga56.ecw	Transparent Mosaic
WCL_10cm_2021Aug31_gda2020-mga56.ecw	Transparent Mosaic
PRJ39682_01_File_Listing.txt	Listing of files delivered in this volume

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2. METADATA

Source Data	Source	Description	Ref No	Date
LiDAR	AAM	Optech Orion H300 - 325	FL015699	31.08.21
Imagery	AAM	Phase One P1-174	FL015699	31.08.21
Trajectory	AAM	RTX	FL015699	31.08.21
Survey control	AAM	RTK	PRJ39682	31.08.21
Test points	AAM	RTK	PRJ39682	07.07.21
Imagery control	AAM	RTK	PRJ39682	07.07.21

LiDAR Characteristics	Description
Format	LAS 1.2, XYZ
Emitted Density	4 ppm^2
Tile size	1000m x 1000m
ICSM Classification	Level 2. Ground surface improvement

Reference: https://www.icsm.gov.au/

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Number	Point Class	Description	ICSM	CI %
1	Default	Unclassified	1	95
2	Ground	Bare ground	2	98

Ortho Characteristics	Description
Format	TIF / ECW
Ground Sample Distance	10cm
Tile size	1000m x 1000m
Sample Type	8-bit Integer
Image Bands	RGB
Orientation/AT	Block Adjustment.

Reference Systems	Horizontal	Vertical
Datum	GDA94 / GDA2020	AHD
Projection	MGA Zone 56	N/A
Geoid Model	N/A	Ausgeoid09 / Ausgeoid2020

Note: On 11-10-2017, Australia formally changed its official reference datum from GDA94 to GDA20, and its map grid from MGA94 to MGA2020. MGA2020 coordinates are approximately 1.7m different from MGA94.

GDA

This data is GDA94-compliant

GDA2020

and GDA2020-compliant

GDA94/2020 compliant spatial data is information which has been measured with direct reference to the GDA94 or 2020 datum

Notes On Expected Accuracy

- Values shown represent standard error (68% confidence level or 1 sigma), in metres
- “Derived points” are those interpolated from a terrain model.
- “Measured points” are those observed directly.
- Accuracy estimates for terrain modeling by Lidar or photogrammetry refer to the terrain definition on clear ground.
- LASER strikes have been classified into “ground” and “unclassified (non-ground)”, based upon algorithms tailored for major terrain/vegetation combinations existing in the project area. The definition of the ground may be less accurate in isolated pockets of dissimilar terrain/vegetation combinations.

Limitations of Data

- Data supplied extends beyond the limits of control; such data is of unknown accuracy.
- Features depicted are as shown on the legend.
- Features obscured by foliage or shadow may not appear.
- The definition of the ground under trees or shadow may be less accurate.
- Underground services have not been mapped.

Data Validation – LiDAR Data

- Ground data in this volume has been compared to 262 test points obtained by field survey and assumed to be error-free. The test points were distributed in 3 groups across the mapping area and located on clear ground. Comparison of the test points with elevations interpolated from measured data resulted in:

  Shift(s) applied: -0.146m (whole project extent)

  Summary of statistics

Pre-Shift:		Post-Shift:	
Average dz	+0.146	Average dz	-0.000
Minimum dz	+0.101	Minimum dz	-0.045
Maximum dz	+0.191	Maximum dz	+0.045
Average magnitude	0.146	Average magnitude	0.018
Root mean square	0.147	Root mean square	0.022
Std deviation	0.022	Std deviation	0.022

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Data Validation – Orthophoto Image

- This data has not been field tested for accuracy. Comparison of the orthophoto with control points which were also used in the photo orientation process resulted in a horizontal standard error (RMS) of 0.103 m. Full proof of accuracy achieved requires comparison to independent test points.

Measured Control Point List:						
Point ID	**Type**	**Easting**	**Northing**	**Height**	**dX**	**dY**
Point_01	XYOnly	302868.089	6195310.957	306.136	-0.028	0.193
Point_02	XYOnly	301735.705	6198878.299	317.135	0.113	0.199
Point_03	XYOnly	304757.367	6197969.401	336.524	-0.182	0.130
Point_04	XYOnly	305722.291	6195953.668	137.640	0.026	-0.009
Point_05	XYOnly	303058.107	6196388.465	386.871	-0.078	0.130

Data Validation – Field Survey Data

- This data has not been tested for accuracy by an independent, more accurate method. Data was compiled in a process that regularly yields the accuracy estimates reported above

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3. CONDITIONS OF SUPPLY

The data in this volume has been commissioned by **WOLLONGONG COAL LIMITED**.

The data in this volume is provided by AAM Pty Limited (AAM) to **WOLLONGONG COAL LIMITED** under **AAM Terms of Engagement (MQM020)**, which require **WOLLONGONG COAL LIMITED** to assume beneficial ownership following full payment for the related services, subject to the following conditions:

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Suite 3, Level 23
6-10 O'Connell Street,
SYDNEY NSW 2000
AUSTRALIA
Telephone: +61 2 8879 1600
Facsimile: +61 2 8879 1633
info@aamgroup.com
www.aamgroup.com

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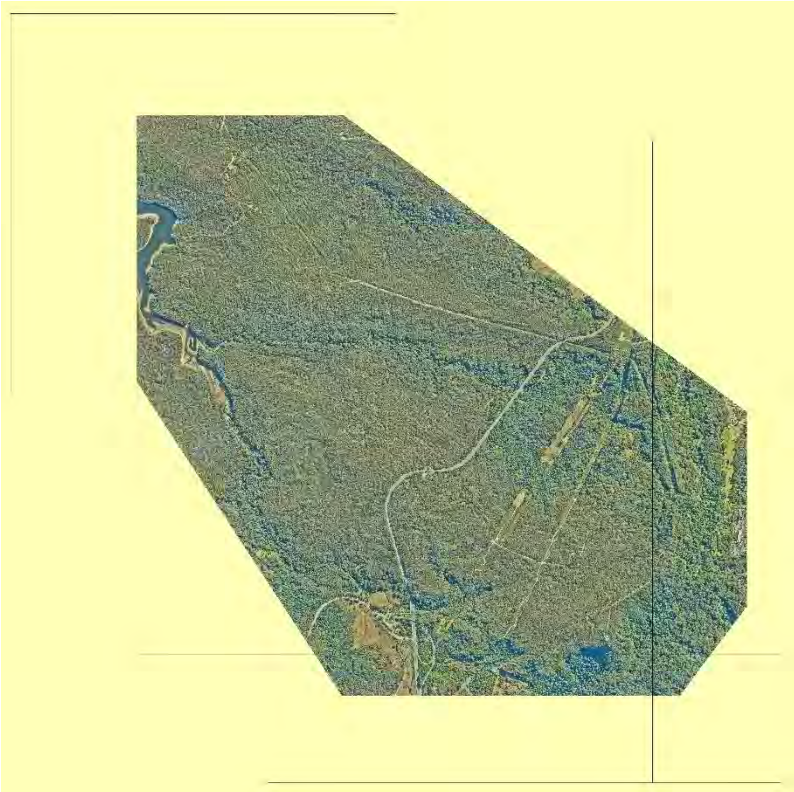
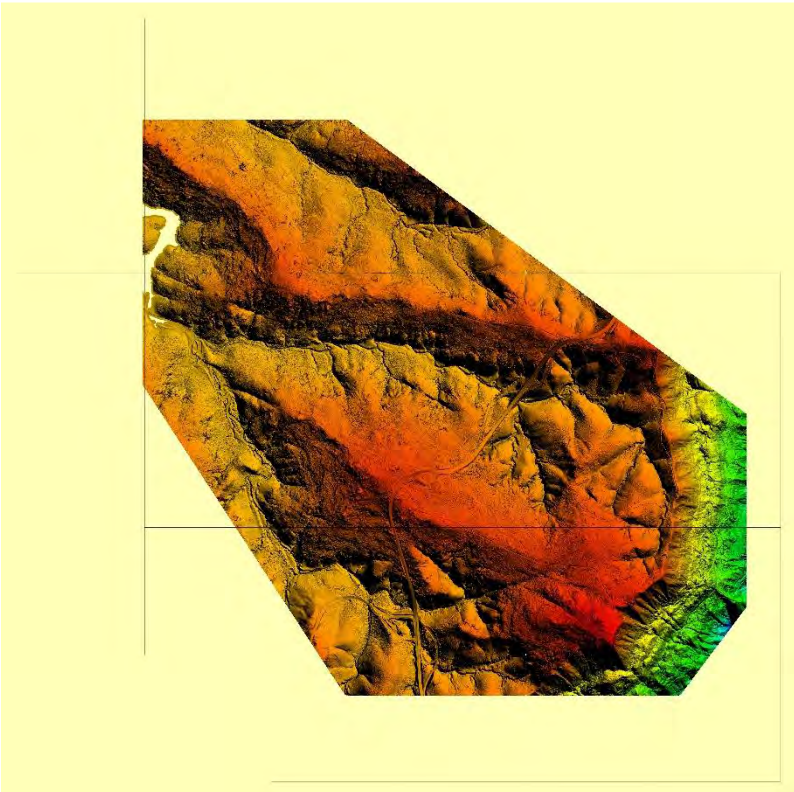
4. VALIDATION

Orthoimage of the site.



Bare earth Digital Terrian Model (DTM).



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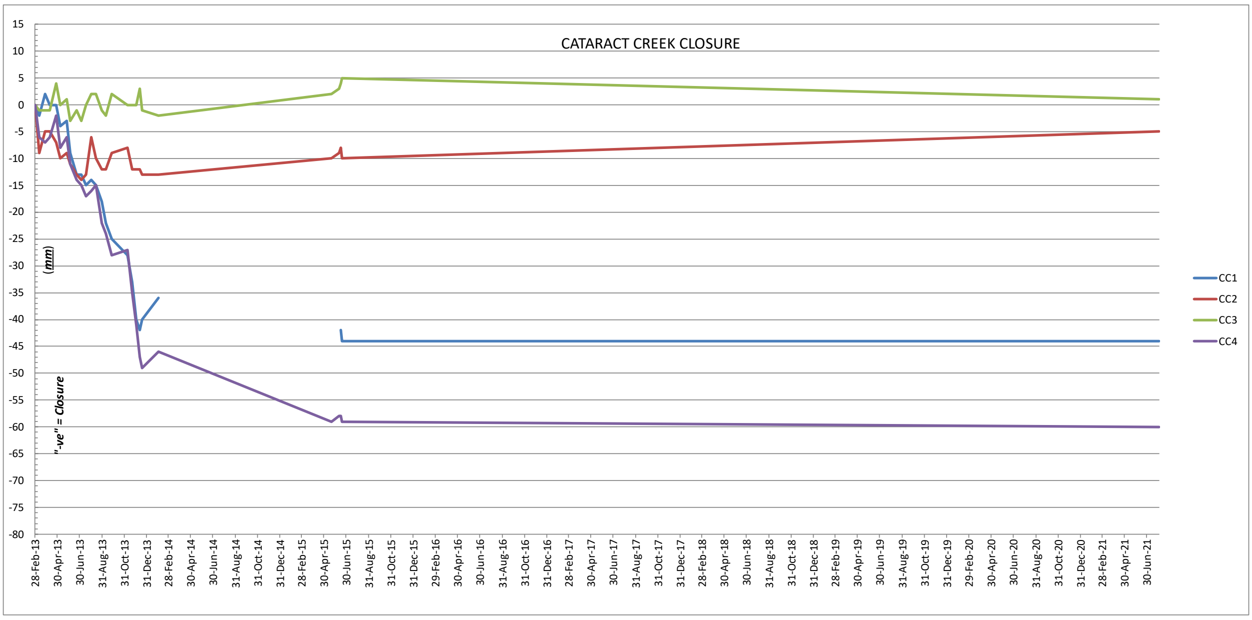
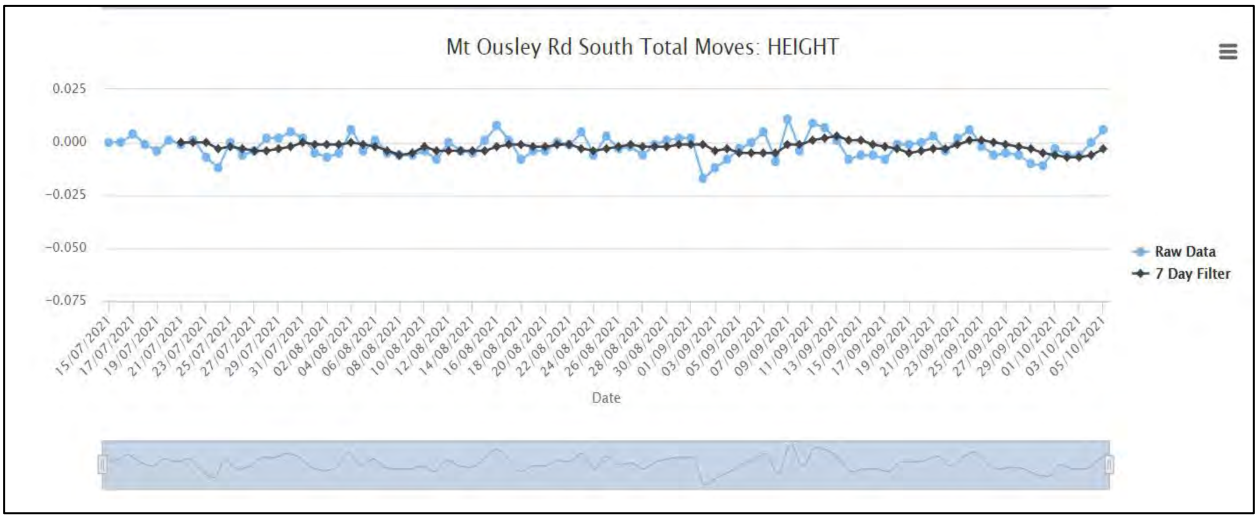
Cataract Creek at CC1, CC2, CC3 and CC4 - Survey measurement.

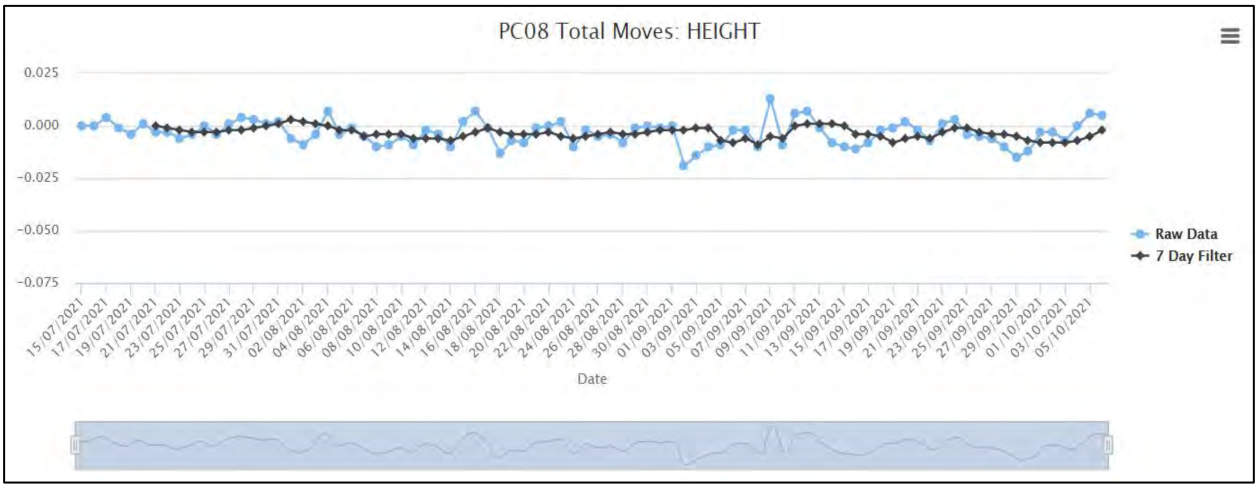


GNNS sites

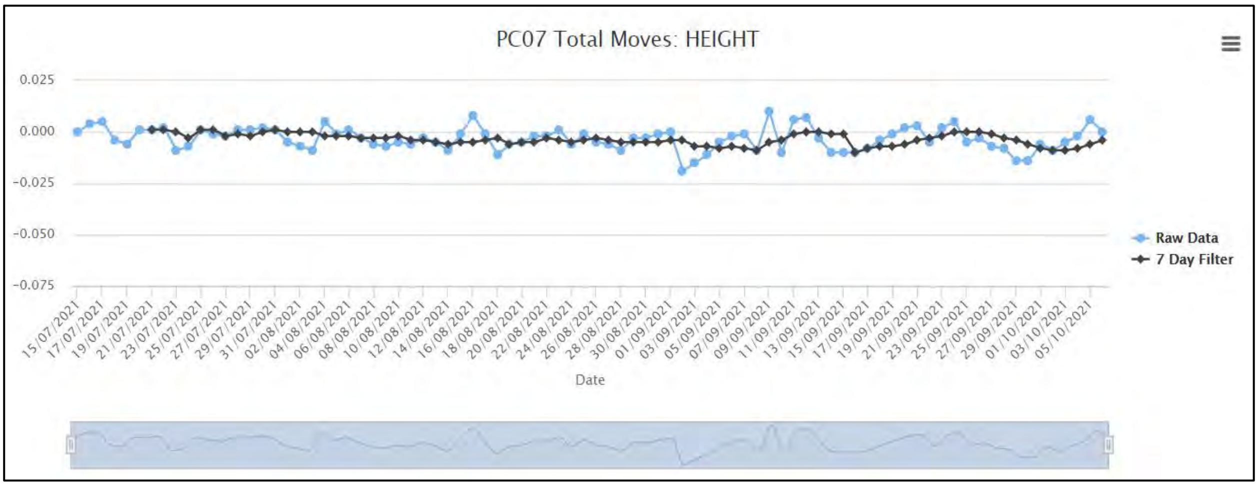
GNSS #1- Mt Ousley Road South



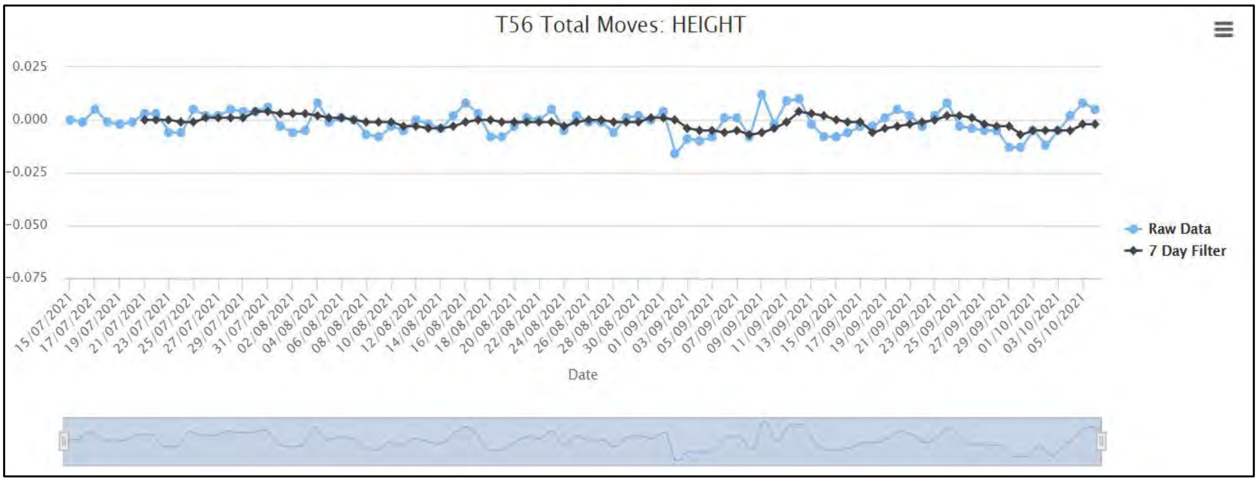
GNSS #2 - PC08 (Bulli & Balgownie goaf)



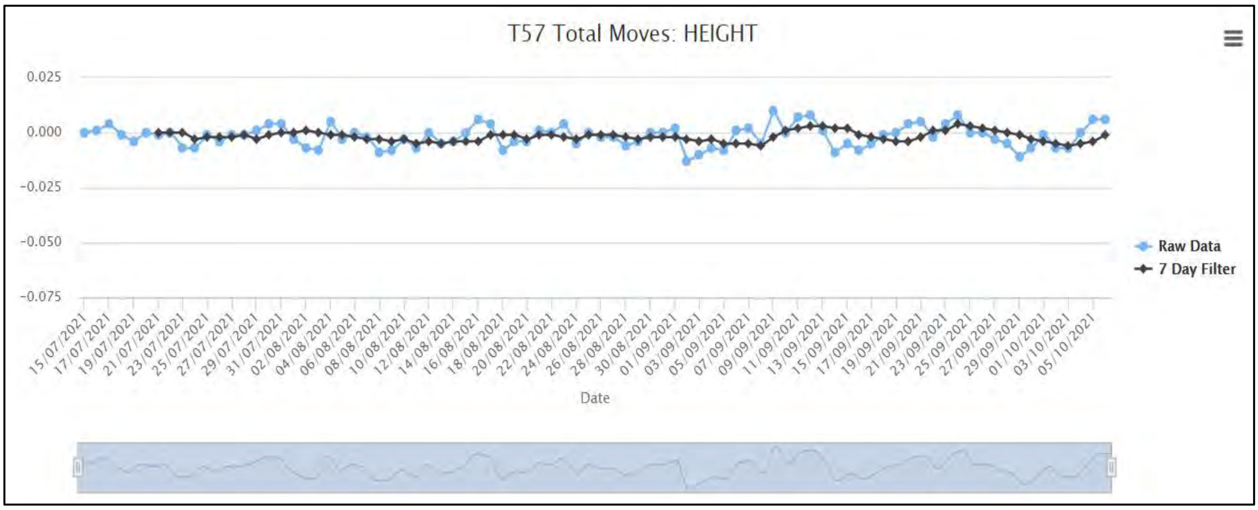
GNSS #3 - PC07 (Bulli & Balgownie goaf)



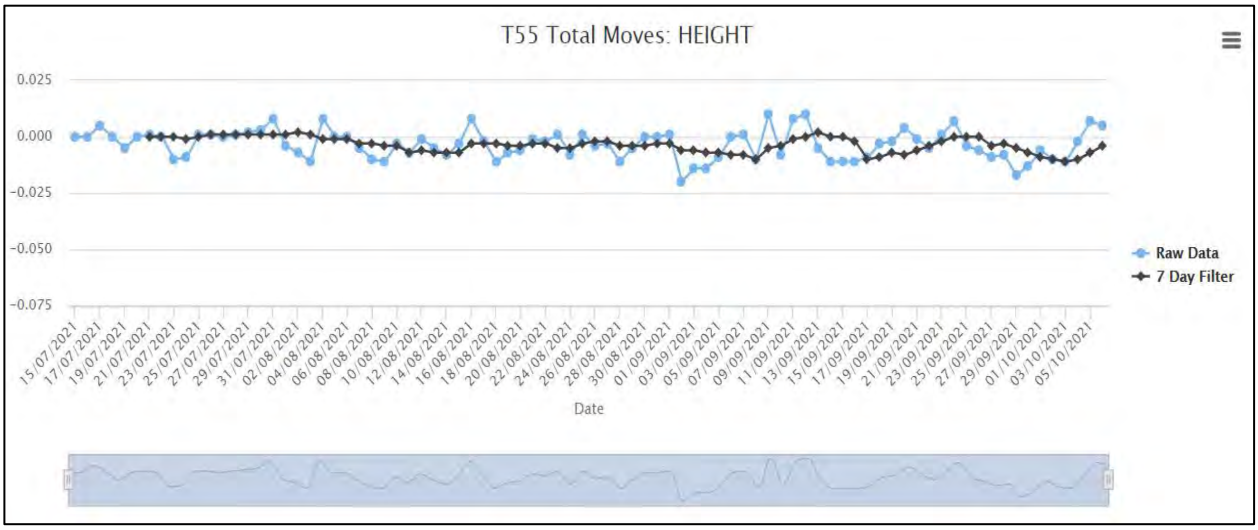
GNSS #5 - 330kV/ 132 KV Powerline tower T56 / E69 (Balgownie goaf), Endeavour Energy powerline



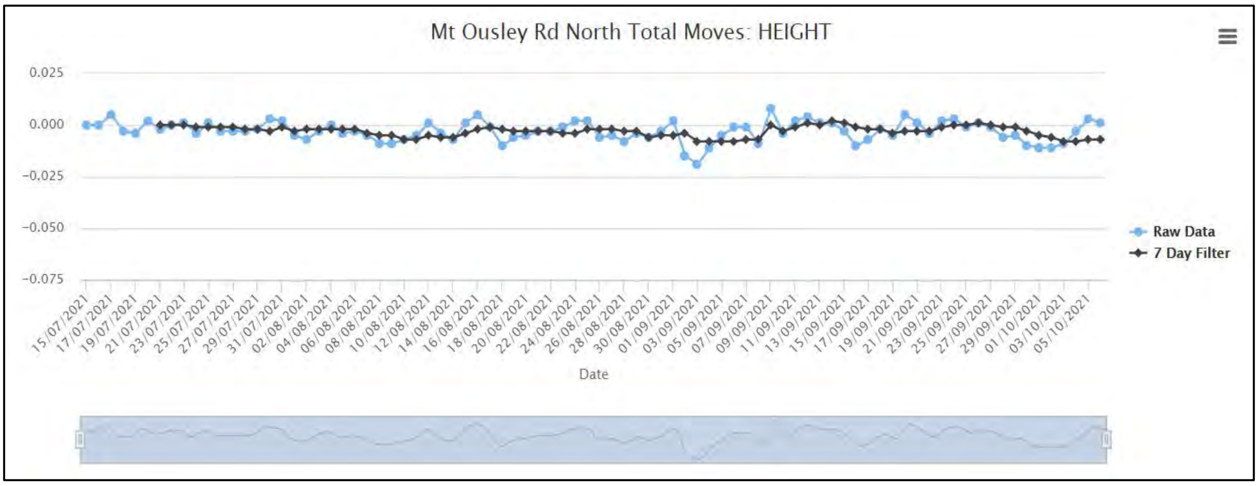
GNSS #6 - 330kV/ 132 KV Powerline tower T57 / E66 (pillars), Endeavour Energy powerline.



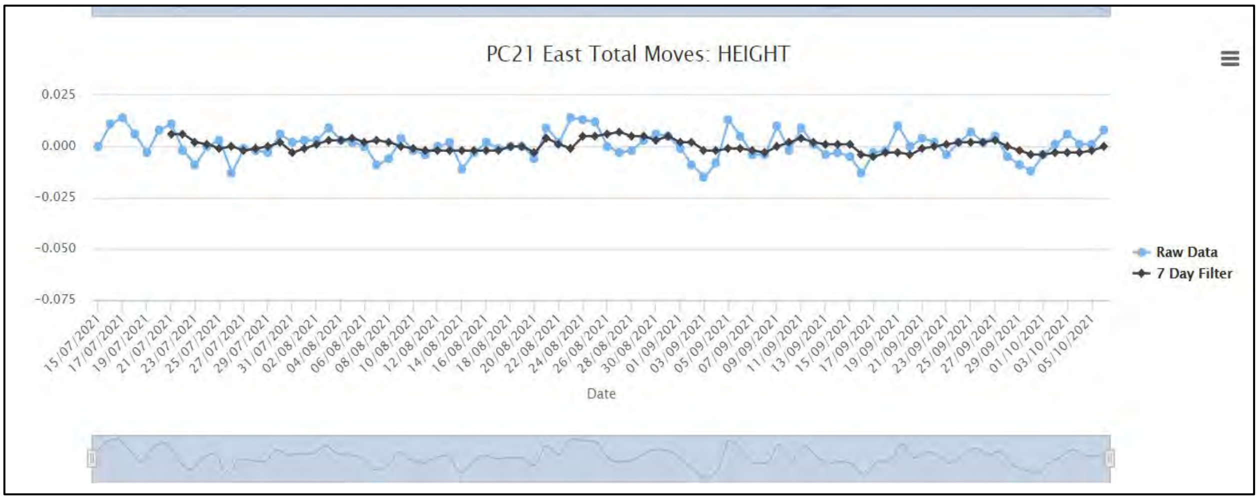
GNSS #7 - 330kV/ !32 kV Powerline tower T55 / E 68 tower (solid coal), Endeavour Energy powerline.



GNSS #8 – Mt Ousley Rd north (Bulli goaf)



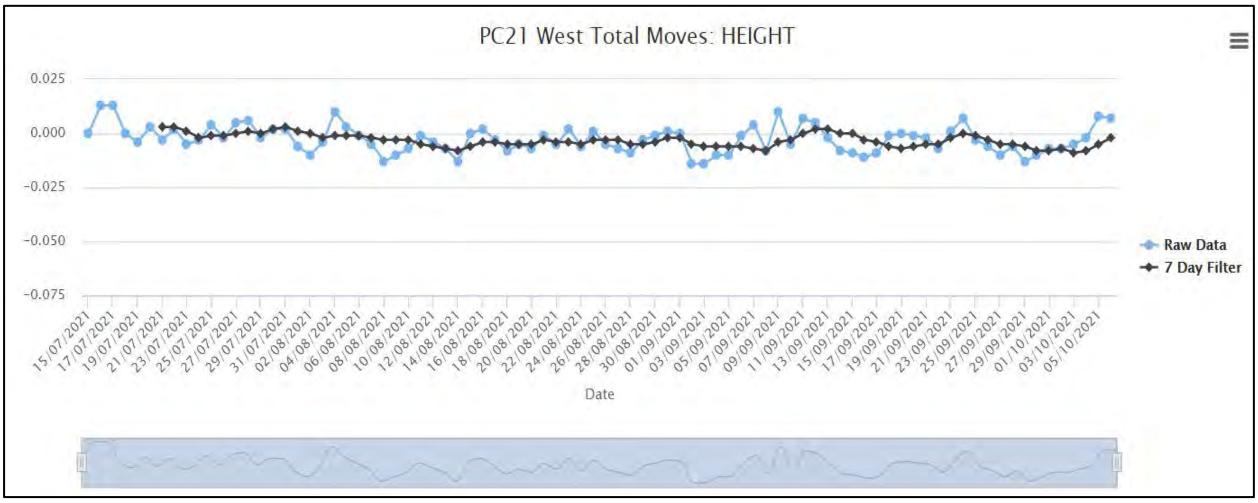
GNSS #9 - PC21 (Bulli goaf #2)



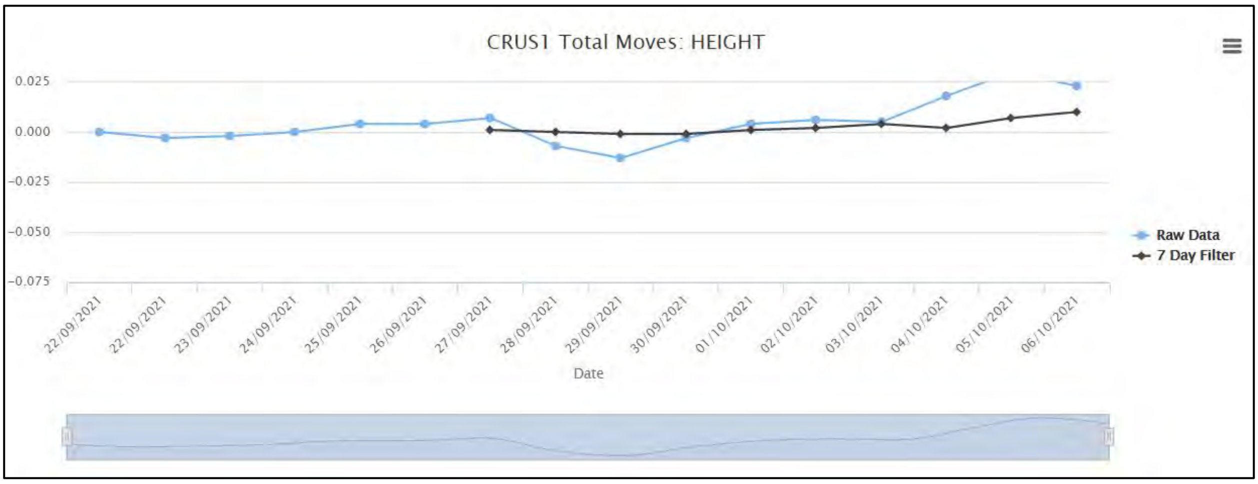
GNSS #10 - PC23 (Bulli goaf #11)

Not available – to be installed.

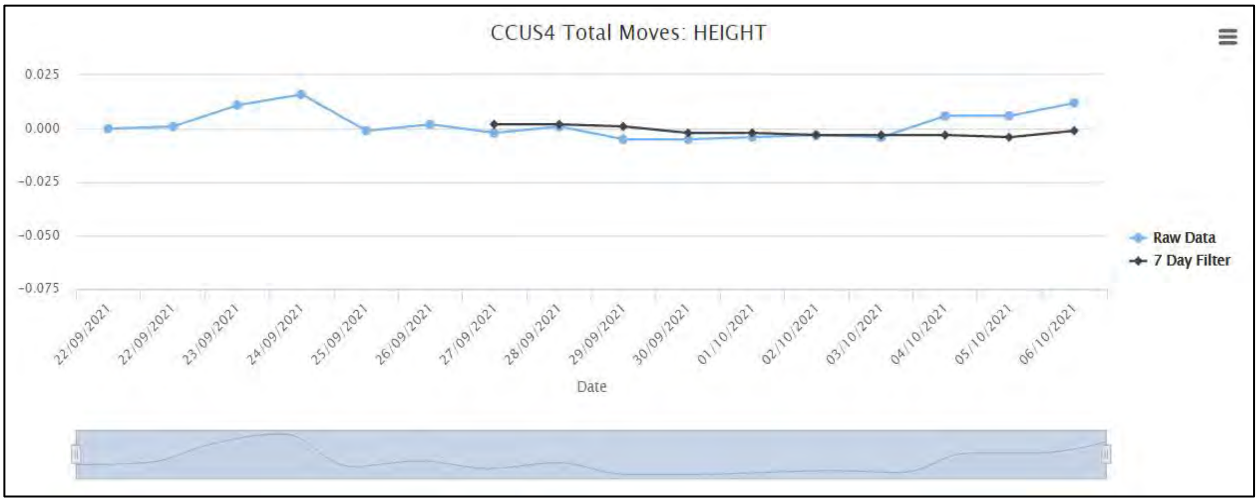
GNSS #11 - PC21 (Bulli goaf #2)



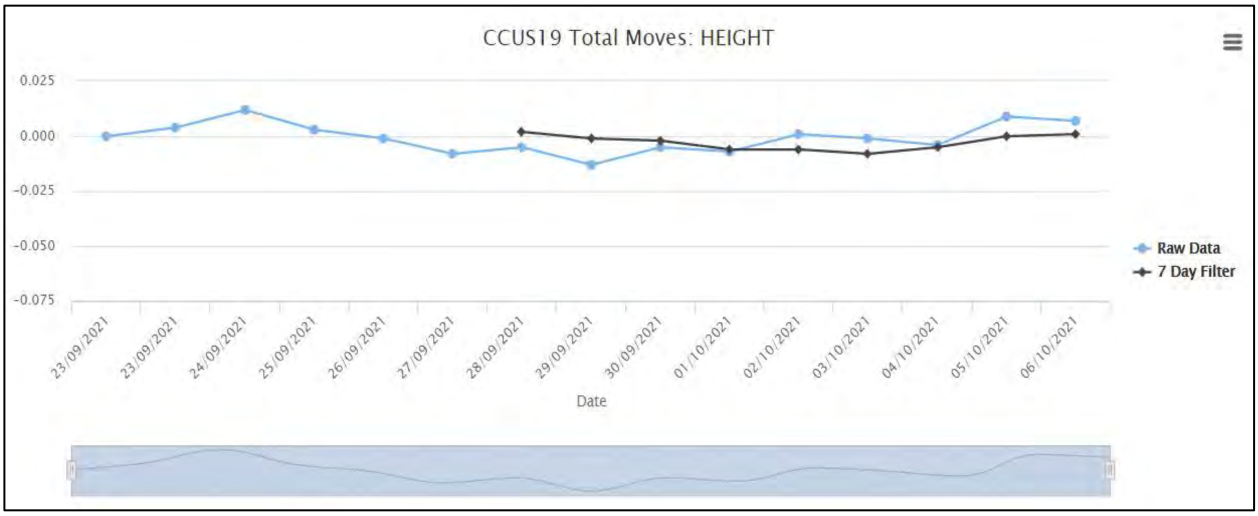
GNSS #12 - South of PC21 (edge Bulli & Wongawilli goaf)



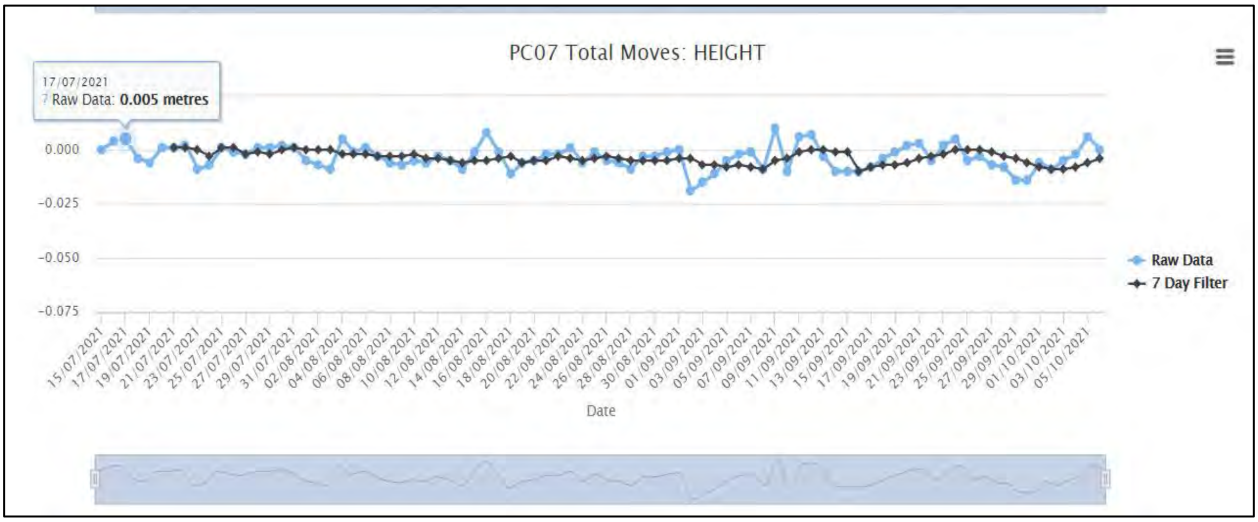
GNSS #13 - South of PC21 (Balgownie goaf)



GNSS #14 - West of PC08 (Bulli pillars)



GNSS #15 - South of PC07 (Bulli pillars)



GNSS #16 - TransGrid 330kV/ 132kV Powerline Tower T54 & E69, Endeavour Energy powerline

Not yet available. To be installed.

GNSS #17 - RMS Infrastructure

Not yet available. To be installed.

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

APPENDIX D - RMS RISK REGISTER

Transport for NSW

Risk Assessment for Panels PC07-08 and PC21-25 Mt Ousley Road

Risk Assessment Report

REP-283741-001

Issue 1 | 8 October 2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 283741-00

Arup Australia Pty Ltd ABN 76 625 912 665

Arup Pty Ltd
Sky Park
One Melbourne Quarter
699 Collins Street
Docklands Vic 3008
Australia
www.arup.com

ARUP

Document verification

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283741-00</td></tr>
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<tr><td></td><td>Prepared by</td><td>Checked by</td><td>Approved by</td></tr>
<tr><td>Name</td><td>Jenny Li</td><td>Nigel Cann</td><td>Nigel Cann</td></tr>
<tr><td>Signature</td><td></td><td></td><td></td></tr>
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<tr><td></td><td>Prepared by</td><td>Checked by</td><td>Approved by</td></tr>
<tr><td>Name</td><td>Jenny Li</td><td>Jenny Li</td><td>Nigel Cann</td></tr>
<tr><td>Signature</td><td>Jenny Li</td><td>Jenny Li</td><td>N K Cann.</td></tr>
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Contents

Appendices

Executive Summary

A risk assessment has been completed to assess the risks to Transport for NSW (TfNSW) assets from the proposed mining of panels PC07-08 and PC21-25 by Wollongong Coal Limited (WCL).

Previous assessments were completed on the impacts due to the extraction of longwalls LW4-5 (2011), and longwalls LW6-7 (2014). A history of the impacts of subsidence has been gained, along with knowledge about the performance of mitigation control measures applied, and the reliability of the monitoring systems utilised.

The subsidence limits provided in this report relate to subsidence over proposed bord and pillar panels and previously mined areas. TfNSW infrastructure is generally located away from these areas and subsidence impacts are generally expected to be of a similar order to impacts from the earlier WCL longwall mining panels.

The expected subsidence from the proposed mining of PC07-08 and PC21-25 is less than 100mm and is very unlikely to lead to perceptible impacts to TfNSW infrastructure. For comparison, the subsidence from previous longwall mining was approximately 1800mm. The focus of this risk assessment addresses the contingency case if subsidence of greater than 100mm results. Given approximately 1800mm of subsidence was experienced during previous longwall extraction, the worst case subsidence from PC07-08 and PC21-25 is estimated to be 500mm, and this value is used in this contingency case for the risk assessment.

Arup has assessed the risks through a workshop with relevant stakeholders to determine impacts of the mining activities on the road infrastructure, functionality and road safety, and identify appropriate risk mitigation measures. The risks and risk mitigation measures are recorded in a Risk Register. The TfNSW risk criteria has been used to assess the risks.

For PC21-25, the only assets within five times the depth of cover, is a section of the Mt Ousley Road carriageway and small culverts. The worst case subsidence of 500mm is not considered to present a credible risk to these assets (i.e. the level of possible impacts is insignificant).

A total of 24 risks have been identified for PC07-08 for the worst case subsidence of 500mm. 13 events were not considered to present a credible risk (i.e. the level of possible impacts is insignificant). All risks have been reduced to medium or low with the implementation of risk mitigation measures.

The risks and mitigation measures identified in this risk assessment will be addressed and managed in the Built Features Management Plan following consultation with TfNSW.

1 Introduction

Arup has been engaged by the Transport for NSW (TfNSW) to undertake an assessment of the risks to TfNSW infrastructure associated with the extraction of panels PC07-08 and PC21-25 by Wollongong Coal Limited (WCL). The proposed mining activities are in the vicinity of Mount Ousley Road.

Previous assessments were completed on the impacts due to the extraction of longwalls LW4-5 (2011), and longwalls LW6-7 (2014). A history of the impacts of subsidence has been gained, along with knowledge about the performance of mitigation control measures applied, and the reliability of the monitoring systems utilised.

The subsidence limits provided in this report relate to subsidence over proposed bord and pillar panels and previously mined areas. TfNSW infrastructure is generally located away from these areas and subsidence impacts are generally expected to be of a similar order to impacts from the earlier WCL longwall mining panels.

As with the previous assessments, the concerns of TfNSW are the potential impacts from the mining activities on its surface assets with a specific emphasis on how the mining might result in loss of functionality of the assets with regards to the users (motorists and public), possible life safety issues, and damage to infrastructure and cost of reinstatement.

2 Description of Mining Activities

WCL operates the Russell Vale Colliery in the Southern Coalfield of NSW. WCL is proposing to extract coal from panels PC07-08 and PC21-25 using bord and pillar mining techniques (refer to Figure 1).

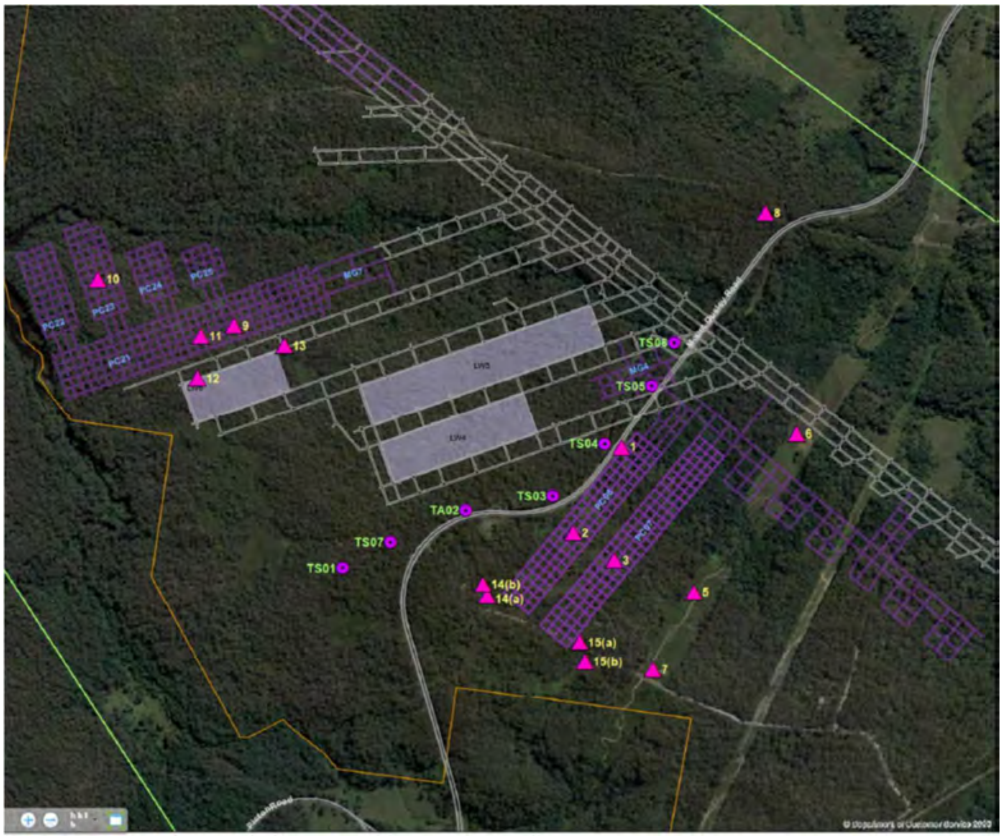


Figure 1: Site Layout

The proposed extraction plan is as follows:

- Stage 1(a): Mining of panels PC21-25, on the western side of Mount Ousley Road.
- Stage 1(b): Mining of panels PC07-08, on the eastern side of Mount Ousley Road.

Strata Control Technologies (SCT) has undertaken an assessment of the subsidence and geological impacts from the previous mining activities and predictions for the mining of PC07-08 and PC21-25. Refer to Appendix A for more details on the mining activities.

3 TfNSW Assets

As with the previous risk assessments, TfNSW assets within five times the depth of cover, are considered. For PC21-25, this includes a section of the carriageway.

For PC07-08, the assets considered in the risk assessment include:

- Carriageway.
- Bridges.
- Culverts.
- Cuttings.
- Embankments.
- Mono pole structures, e.g. road signs, noise walls, barriers.
- Variable Message Sign (VMS).

Figure 2 shows the key assets for consideration in the risk assessment.

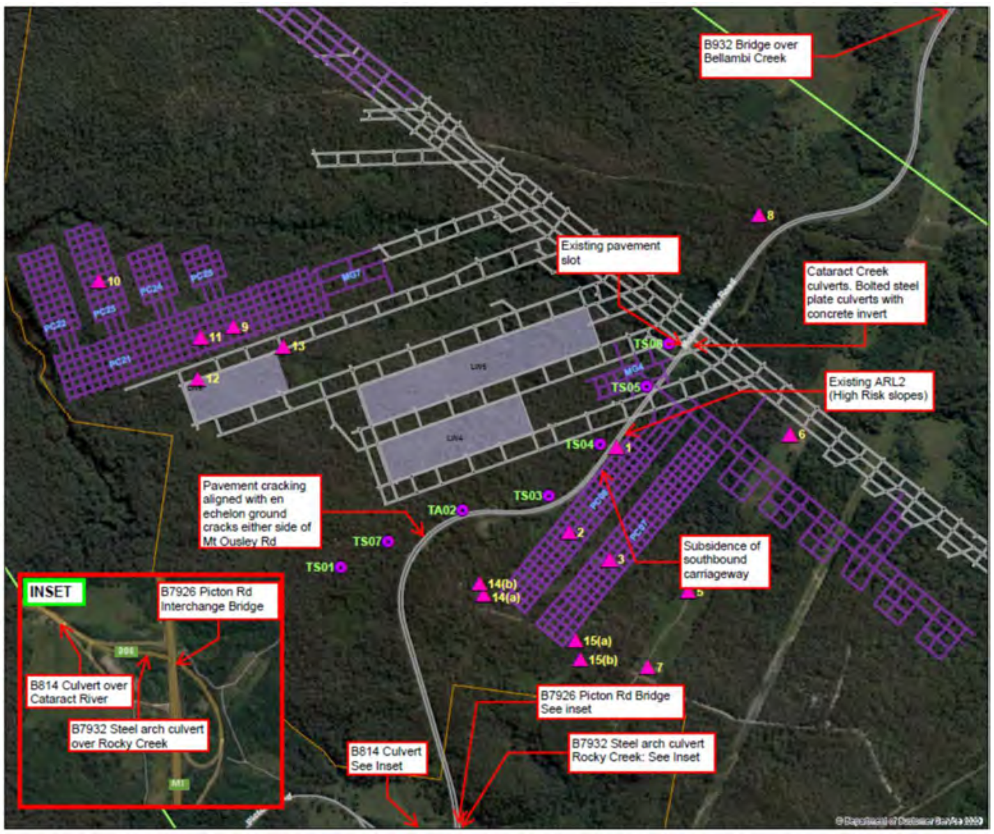


Figure 2: Key TfNSW Assets

4 Predicted Impacts

SCT has undertaken an assessment of the subsidence and geological impacts from the previous mining activities and predictions for the mining of PC07-08 and PC21-25 (refer to Appendix A).

The expected subsidence and impacts from the mining activities is summarised in Table 1.

Table 1: Expected Subsidence

First workings (approximately 25% extraction over area of panel)	Second (bord and pillar) workings (approximately 33% extraction over area of panel)
Expected subsidence less than 100mm directly over the panels	Expected subsidence less than 100mm directly over the panels
Movements at the surface barely perceptible	Movements at the surface barely perceptible
Large, long-term stable pillars	Large, long-term stable pillars
No potential for significant interaction with overlying Bulli Seam	No potential for significant interaction with overlying Bulli Seam
No perceptible movements on Mount Ousley Road	Movements on Mount Ousley Road less than 20mm

For comparison, the subsidence from previous longwall mining was approximately 1800mm. As a result, the expected subsidence from the proposed mining of PC07-08 and PC21-25 of less than 100mm is very unlikely to lead to perceptible impacts.

This area has also been subject to mining in the past. Any subsidence risk from legacy mining exists irrespective of further mining. The Bulli and Balgownie Seams, which are above the Wongawilli Seam, were previously mined several decades ago. The most recent longwall mining has resulted in possible ongoing closure movements at Cataract Creek (< 20mm).

5 Management Strategy

To manage the potential of legacy mining impacts (which exist irrespective of the proposed mining) and impacts due to the proposed mining, the following monitoring measures are proposed:

- Broad area LIDAR.
- Underground observations of roadway conditions.
- Valley closure monitoring.
- Subsidence monitoring by GNSS units.

In addition, to manage the potential of experiencing greater than 100mm of subsidence, contingency measures are made, including:

- Mining in Stage 1(a) to occur first as PC21-25 are remote from TfNSW assets.
- Mining in Stage 1(b) (PC07-08) will only occur if subsidence of less than 100mm is confirmed in PC21.
- Using a flexible mining system that can be modified to reduce subsidence.
- Undertaking the Technical Committee process (including this risk assessment).

A number of controls measures and monitoring systems were identified and employed in controlling the risks posed by previous longwall mining. These were considered to have operated effectively and reliably, and the observed impacts from the previous longwall mining have been used to inform this risk assessment.

Of note is a slot that was installed on the Mount Ousley Road embankment above Cataract Creek (after LW4 and before LW5) as part of the Management Plan for LW4-5. The slot experienced approximately 11mm of closure during the mining of LW5 and resulted in a bump in the slot surface that required milling to reinstate rideability. However no significant compression has been experienced in the pavement in the vicinity of Cataract Creek due to the existence of the slot. The slot can accommodate compressive forces generated by up to 40m of pavement length on either side of the slot. The workshop group discussed that the slot has been performing as expected and that it is in the appropriate position.

6 Risk Assessment Process

TfNSW has undertaken a preliminary risk assessment, which indicated that there are risks to TfNSW that exceed the preliminary acceptability limits (refer to Appendix B). This risk assessment aims to resolve these matters.

Arup has assessed the risks through a workshop with relevant stakeholders to determine impacts of the mining activities on the road infrastructure, functionality and road safety, and identify appropriate risk mitigation measures.

Risks and risk mitigation measures have been recorded in a Risk Register, based on the same format as with previous risk assessments. The risk assessment will form part of the Built Features Management Plan.

The process adopted by Arup follows closely the principles set out in ISO31000:2018 – Risk Management, and also the various standards of TfNSW, specifically those relating to the assessment of subsidence risks posed by mining.

Since the expected subsidence is less than 100mm which is likely to have no perceptible impacts to TfNSW assets (refer to Section 5), the focus of this risk assessment addresses the contingency case if subsidence of greater than 100mm results. Given approximately 1800mm of subsidence was experience during previous longwall extraction, the worst case subsidence from PC07-08 and PC21-25 is estimated to be 500mm, and this value is used in this contingency case for the risk assessment.

The two stages of mining are considered separately due to their proximity to TfNSW assets.

6.1 Risk Rating

The rating of risks involves two criteria: the likelihood of the adverse event occurring and the severity of its consequences. The combination of the likelihood and the severity gives the risk. Arup has used TfNSW risk criteria, as presented in Appendix C.

The risk rating is performed twice. The initial risk rating is without any risk mitigation measures, and the residual risk rating is after the implementation of the risk mitigation measures.

7 Risk Workshop

The risk workshop was held in a virtual Teams meeting on 17 September 2021. The purpose of this workshop was to assess the risks posed to the assets of the TfNSW from the proposed mining activities of PC07-08 and PC21-25.

The workshop discussions were recorded using Google Jamboard, a digital collaborative tool. An output of the Jamboard, including the workshop agenda and attendance, is provided in Appendix D.

8 Risk Register

The discussions from the workshop have been recorded in the Risk Register, which is provided in Appendix E, and attached separately as an excel file.

The two stages of mining are considered separately due to their proximity to TfNSW assets. The risk register is split into a section for PC21-25, and a section for PC07-08.

The format Risk Register follows the previous risk assessments, and the contents of the previous assessments are included as a separate tab in the excel file.

9 Findings

9.1 PC21-25

For PC21-25, the only assets within five times the depth of cover, is a section of the Mt Ousley Road carriageway and small culverts. The worst case subsidence of 500mm is not considered to present a credible risk to these assets (i.e. the level of possible impacts is insignificant).

9.2 PC07-08

A total of 24 risks have been identified for PC07-08 for the worst case subsidence of 500mm. 13 events were not considered to present a credible risk (i.e. the level of possible impacts is insignificant).

The risk profile, before and after the application of additional mitigation and control measures, is shown in Table 2 below. The residual risk profile has no extreme or high risks.

Table 2: Base and Residual Risk Profiles for PC07-08

Risk Level	BASE RISK LEVELS				RESIDUAL RISK LEVELS			
	Infra.	Funct.	Safety	Total	Infra.	Funct.	Safety	Total
E	0	0	0	0	0	0	0	0
H	3	3	0	6	0	0	0	0
M	6	5	1	12	4	4	0	8
L	2	2	1	5	7	6	2	15

10 Risk Mitigation Measures

The risk mitigations measures are summarised below (for more detail, refer to the Risk Register in Appendix E):

- Undertake a baseline condition survey of the carriageway, bridge B7932 (steel arch culvert over Rocky Creek), and bridge B814 (culvert over Cataract River) before mining.
- Reinstate or assess alternatives to the P-Line survey on southbound carriageway.
- Check condition of crack meters and replace if necessary.
- Check the physical condition of the slot.
- Mill or mill and resheet the slot if required. Note schedule any works with other road closures / road works if possible.
- Assess during mining, the nature of any movements (perform crack sealing if required).
- Assess post mining, if crack sealing is sufficient or if further treatment is required.
- Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline.
- Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system.
- Monitor GNSS and undertake subsequent survey of Cataract Creek culverts if trigger levels reached.
- Use precondition assessments of the culverts from longwall mining as baseline.
- Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining.

- Groom slopes prior to mining.
- Use GNSS monitoring to provide early warning of impacts to the slopes.
- TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.
- Develop TARP with trigger points for various actions.

The risks and mitigation measures identified in this risk assessment will be addressed and managed in consultation with TfNSW in the Built Features Management Plan.

11 Conclusions

A risk assessment has been completed to assess the risks to TfNSW assets from the proposed mining of PC07-08 and PC21-25. A number of risk mitigation measures have been identified. All risks are reduced to medium or low. The risks and mitigation measures identified in this risk assessment will be addressed and managed in consultation with TfNSW in the Built Features Management Plan.

Appendix A

Overview of Subsidence for TfNSW Risk Assessment

Subsidence Overview for TfNSW Risk Assessment: Wollongong Coal Russell Vale East PC21-25 and PC07&08

Ken Mills 17/9/2021

Geotechnical consulting, research and instrumentation for mining and civil industries.

SCT

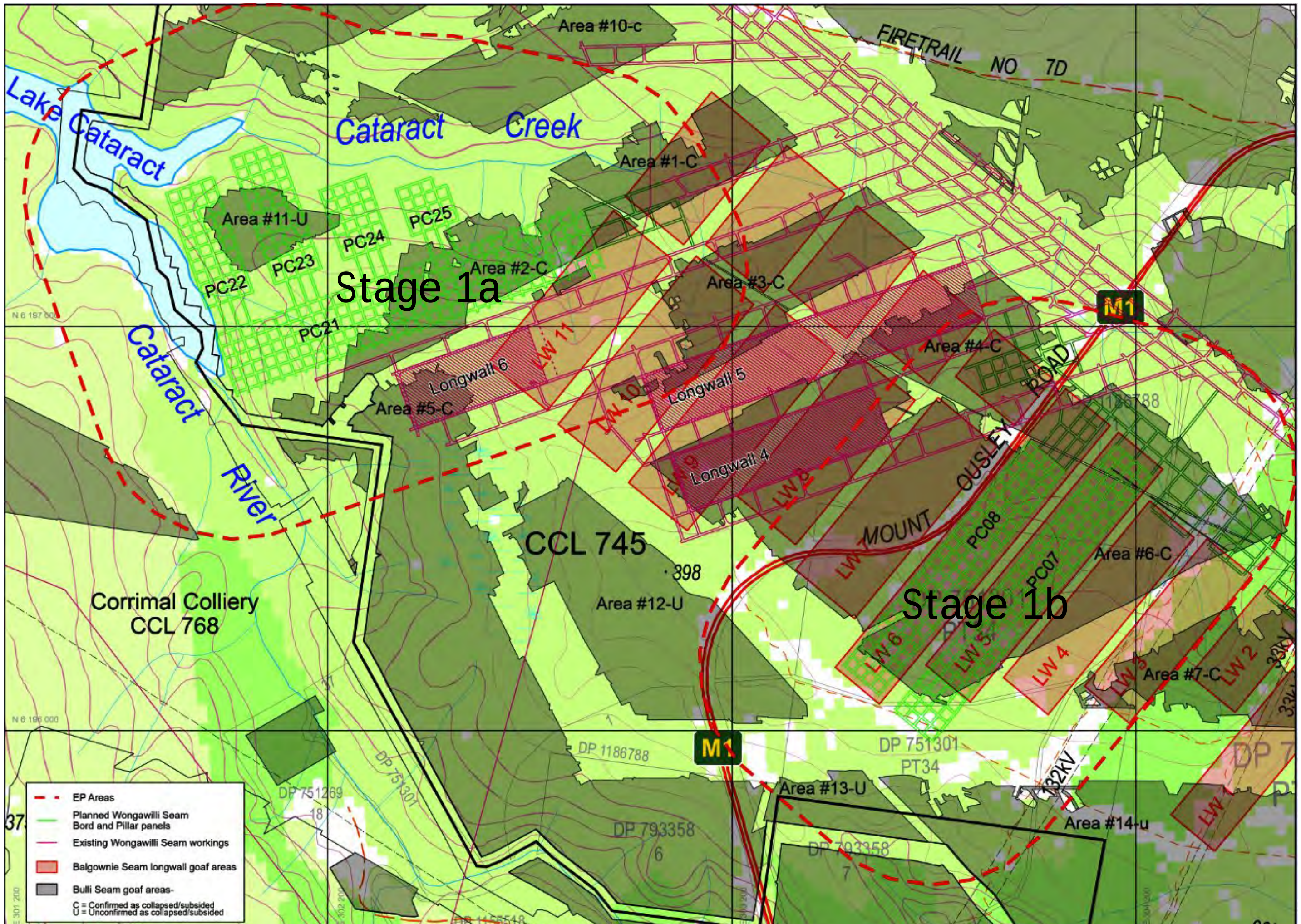
Overview of Presentation

- Key Message
- Site description
  - Mining context
  - Surface features
- Expected subsidence to be monitored
  - From proposed first and “second” (bord and pillar) workings mining <100mm
  - Existing risk of historical legacy mining in Bulli Seam (very, very, unlikely, but possibly >500mm over small areas)
  - Ongoing effects from recent longwall mining (horizontal closure <20mm)
- Strategies
  - Staging of the mining program and extraction plan to confirm subsidence is less than 100mm
  - Contingency is based on flexible mining method easily adaptable to unexpected or unfavourable mining conditions
  - Subsidence monitoring of proposed mining via GNSS units: accurate (<20mm), three dimensional, continuous, accessible to all interested parties at locations of interest in near-real-time
  - Monitoring of TfNSW infrastructure including from recent longwall mining in Wongawilli Seam
    - Re-establishment of and continued monitoring of valley closure monitoring (±5mm)
    - Slot and GNSS closure monitoring
  - Monitoring of legacy mining in Bulli Seam
    - LiDAR for overall coverage and confirmation no significant subsidence across the site (±200mm)
    - Underground monitoring of roadway conditions approaching Bulli Seam goafs

Key Messages

- Expecting subsidence less than 100mm (i.e. much less than longwall subs 1800mm)
  - No perceptible impacts
- Managing contingency of potential for greater than 100mm by staging extraction
  - Stage 1(a) – Remote from infrastructure (PC21-25 and further west)
  - Stage 1(b) – Offset from infrastructure (PC07 & PC08)
  - Flexible mining system that can be modified to reduce subsidence
  - Mining in Stage 1(b) (PC07 & PC08) will only commence once subsidence confirmed as less than 100mm in PC21
  - Technical Committee Process involving TfNSW, RR and Assessment
- Some very low potential for legacy mining impacts that exists irrespective of proposed mining
  - Managed by
    - Broad area LIDAR
    - Underground observation of roadway conditions
    - Valley closure monitoring

Site Description



Mining Context:

Three seams of mining with complete mining records now available

Subsidence monitoring available for Balgownie and Wongawilli

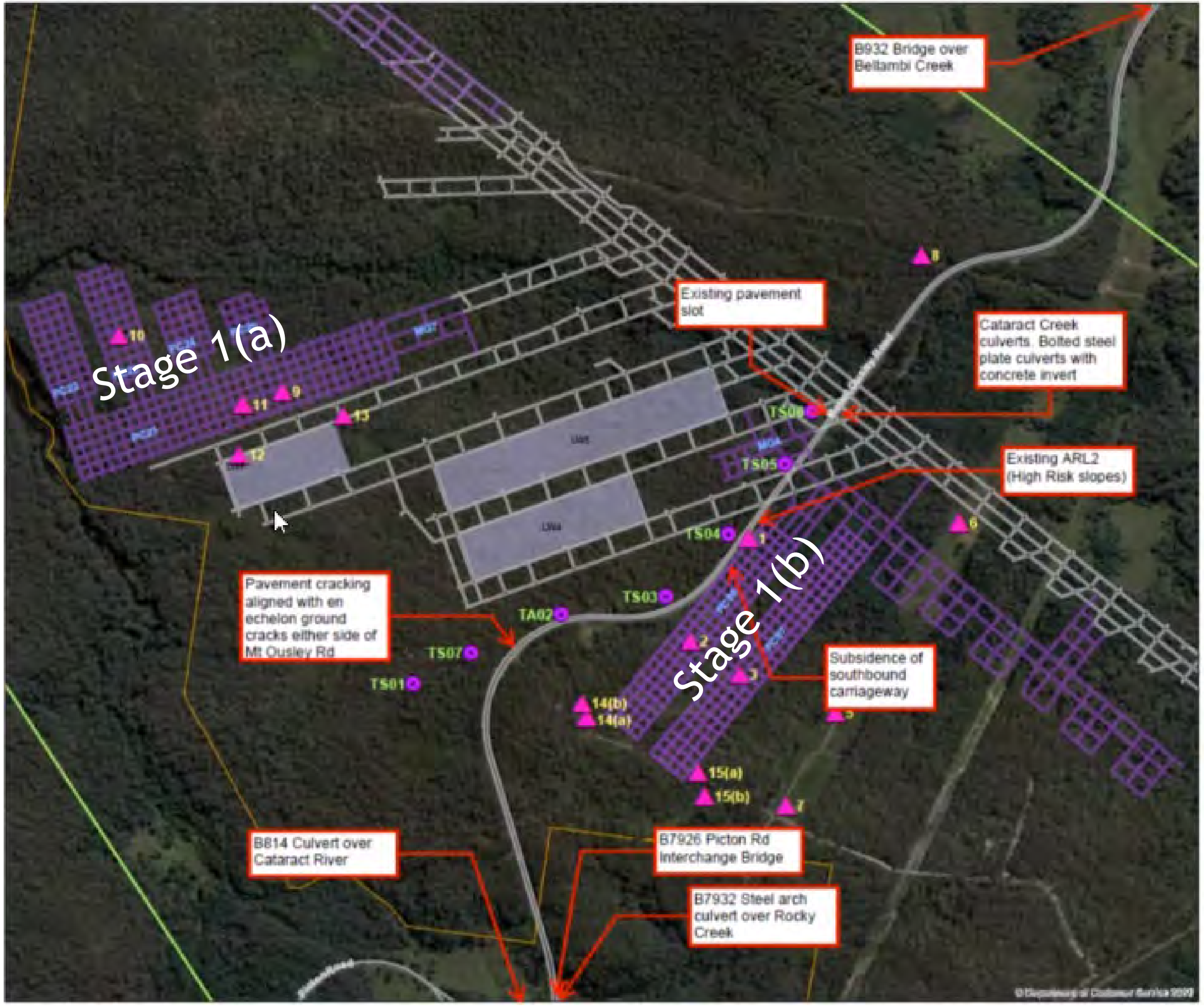
Previous subsidence to 3.7m

Expect <100mm over panels shown in green

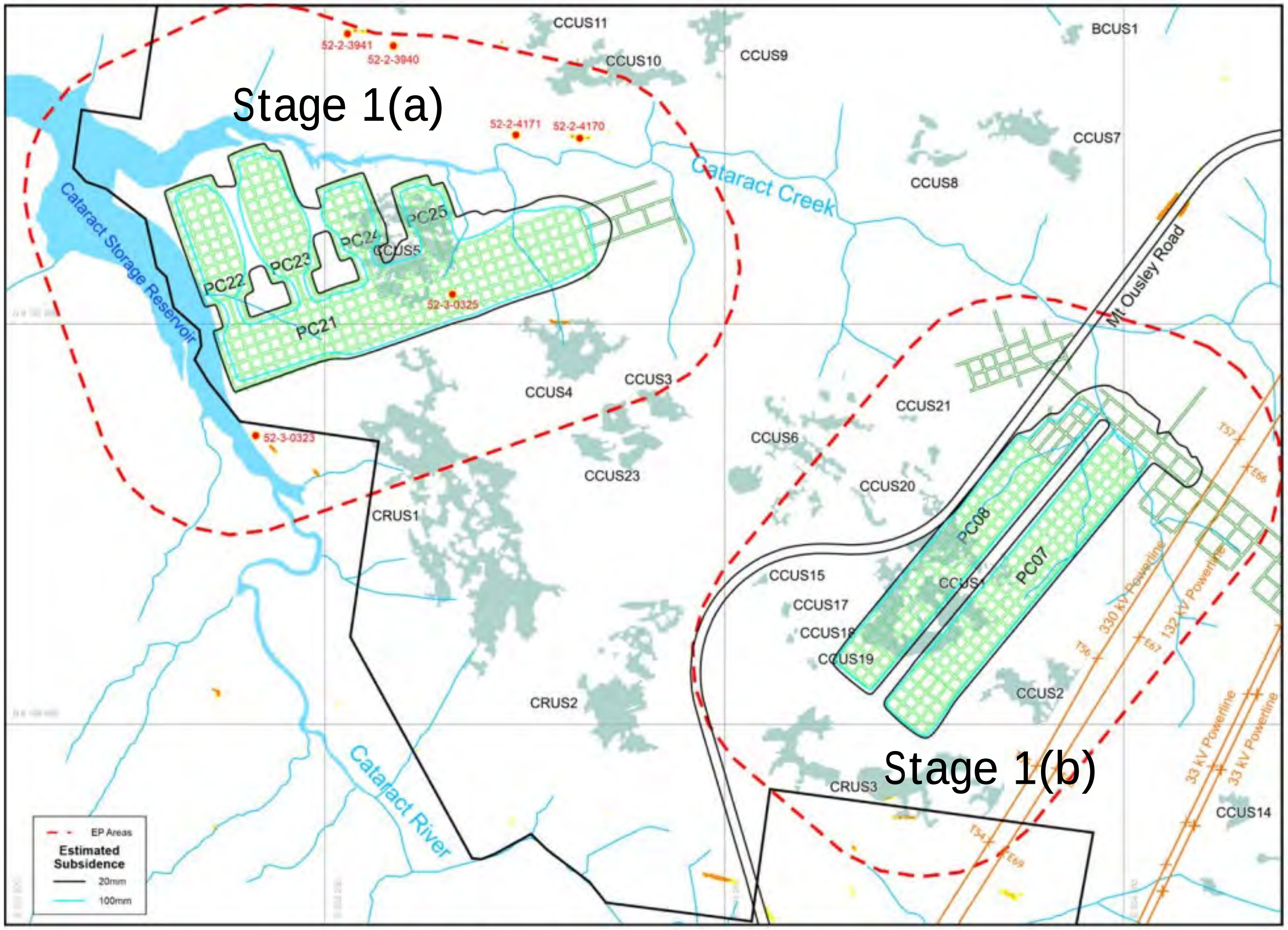
No large scale subsidence below adjacent terrain

Site Description

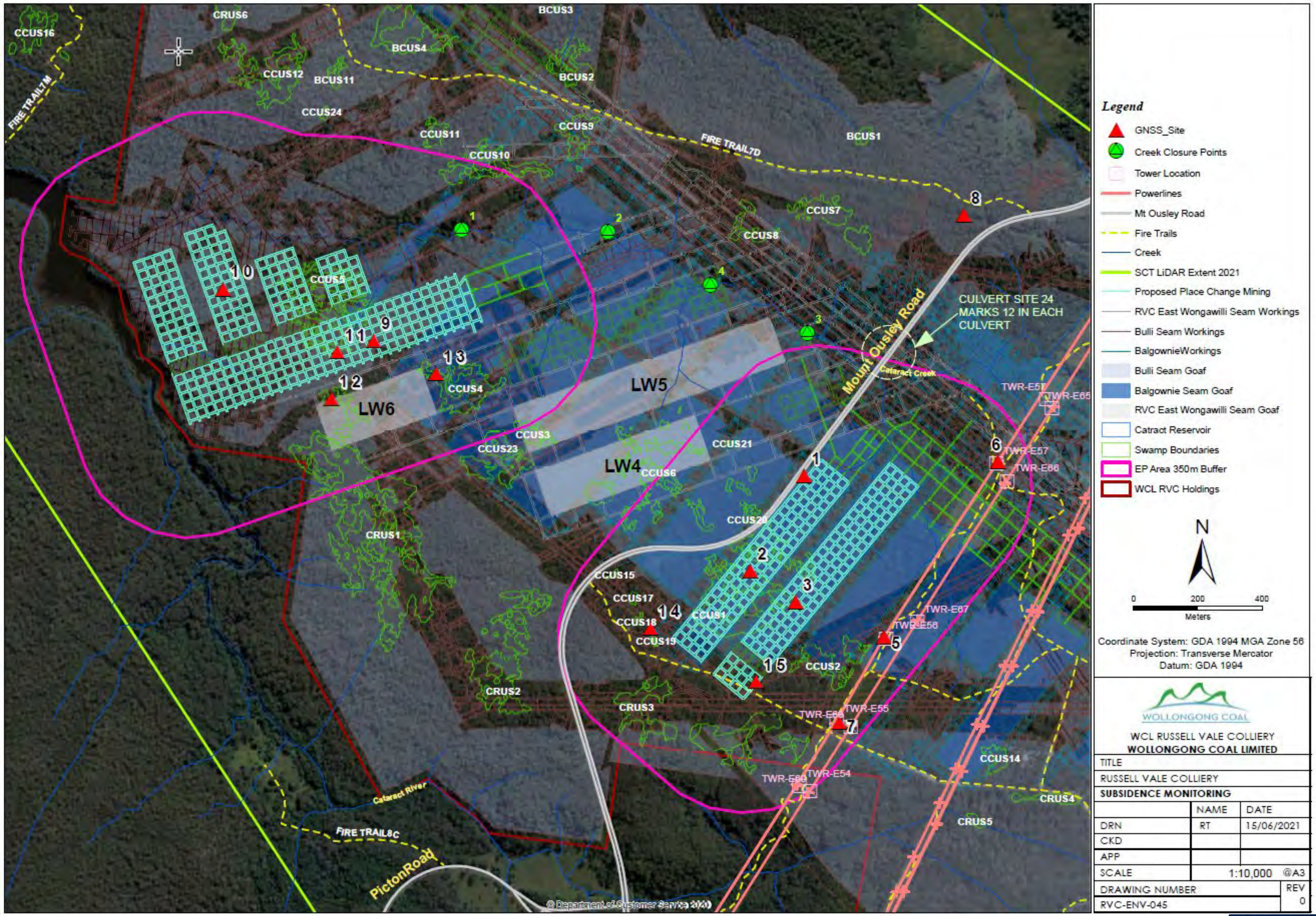
TfNSW Assets



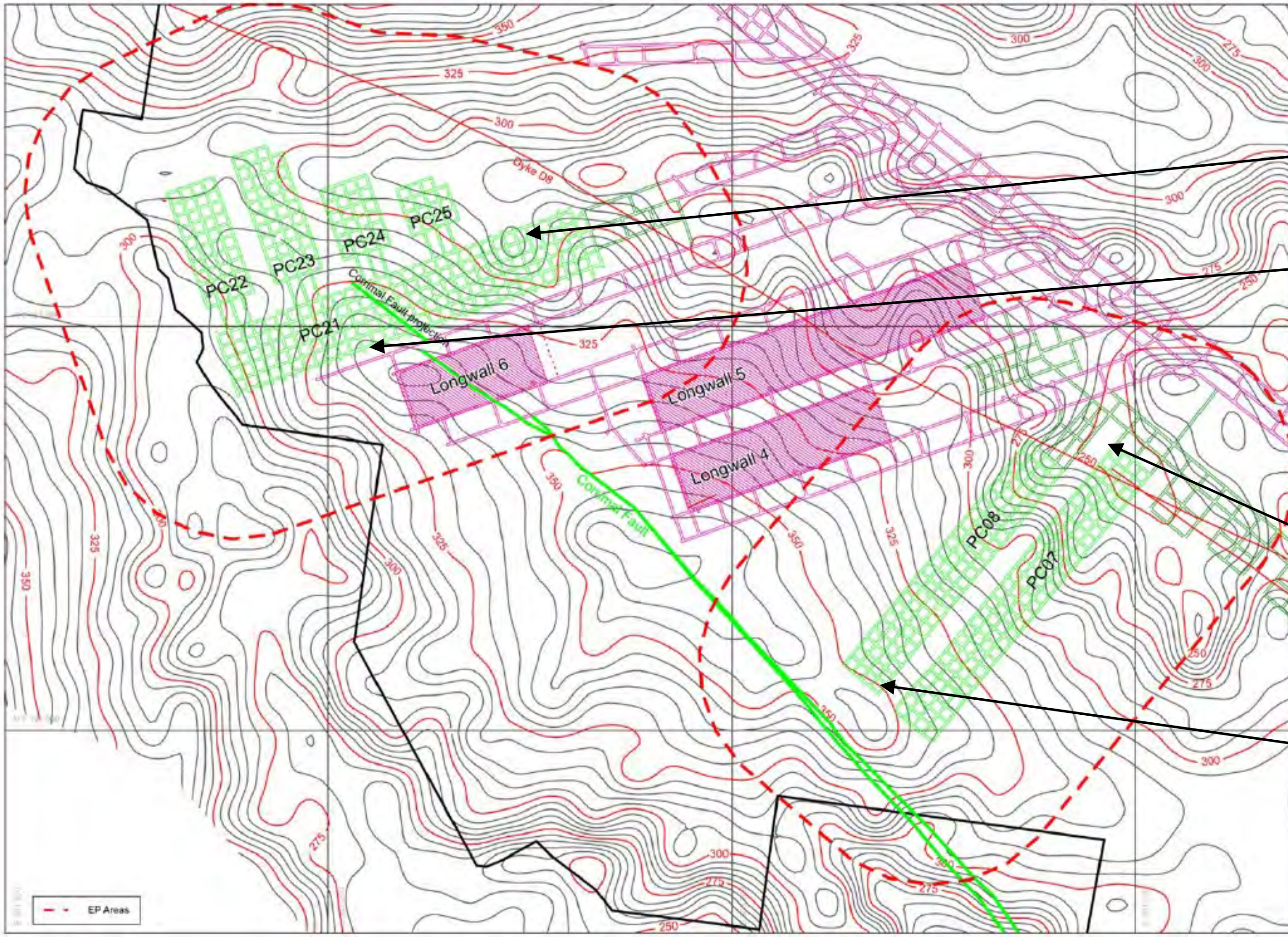
Subsidence and Surface Features



Subsidence and Surface Features



Overburden depth



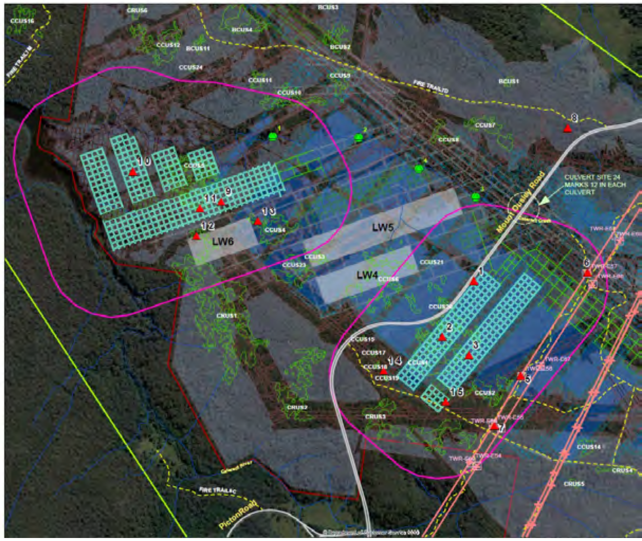
Minimum 285m

Maximum 340m

Minimum 250m

Maximum 350m

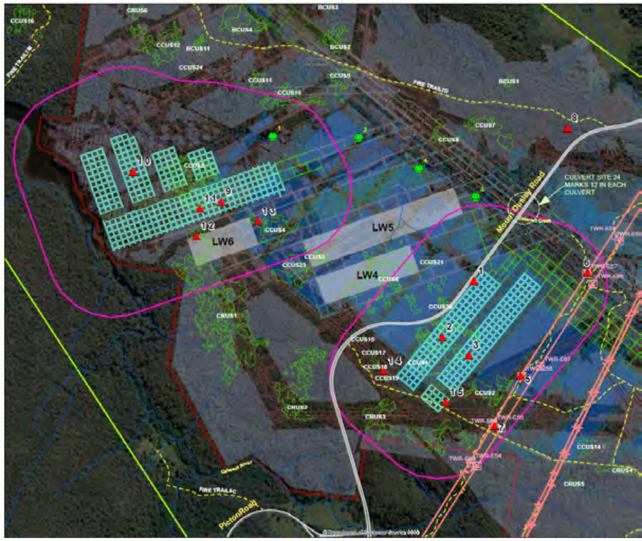
Extraction Plan Staging and Contingency Plan



- Extraction plan has been developed for Year 1 mining
  - Stage 1 extraction Plan to be comprised of
    - Stage 1(a) mining on western side of Mount Ousley Road where there is no infrastructure on panels PC 21-25
    - Stage 1(b) mining on the eastern side of Mount Ousley Road

- Contingency Plan (Consent Condition)
  - If subsidence over Stage 1(a) is greater than 100mm then Stage 1(b) will not commence until the mining system has been refined in areas remote from surface infrastructure to maintain subsidence less than 100mm.
  - To be developed through TfNSW risk assessment process to meet all TfNSW requirements to maintain Mount Ousley Road as safe, serviceable and repairable throughout the period of mining.

Expected Subsidence from Proposed Mining



- First workings: approximately 25% extraction over area of panel
  - Expected subsidence less than 100mm directly over the panels
  - Movements at the surface barely perceptible
  - Large, long-term stable pillars
  - No potential for significant interaction with overlying Bulli Seam
  - No perceptible movements on Mount Ousley Road

- “Second” (bord and pillar) workings: approximately 33% extraction over area of panel
  - Expected subsidence less than 100mm directly over the panels
  - Movements at the surface barely perceptible.
  - Large, long-term stable pillars.
  - No potential for significant interaction with overlying Bulli Seam.
  - Movements on Mount Ousley Road less than 20mm.

Existing Hazards from Legacy Mining: Bulli, Balgownie & Wongawilli Seam Mining

Any subsidence risk from legacy mining exists irrespective of further mining

Bulli Seam goaf areas (14 in total)

- No further subsidence expected in vicinity of planned mining
- Mine plans confirm all areas indicated as goaf are extracted and collapsed
- All 7 of 7 goaf areas able to be independently confirmed as collapsed are collapsed
- Other 7 goaf areas are expected to be collapsed but have not yet been confirmed so
- Borehole NRE1 over main heading pillars confirms stable pillars
- Borehole RV16 through Bulli Seam goaf confirms collapse
- Roadway conditions in Wongawilli Seam confirms collapse
- Previous surface cracking on Mount Ousley Road confirms collapse

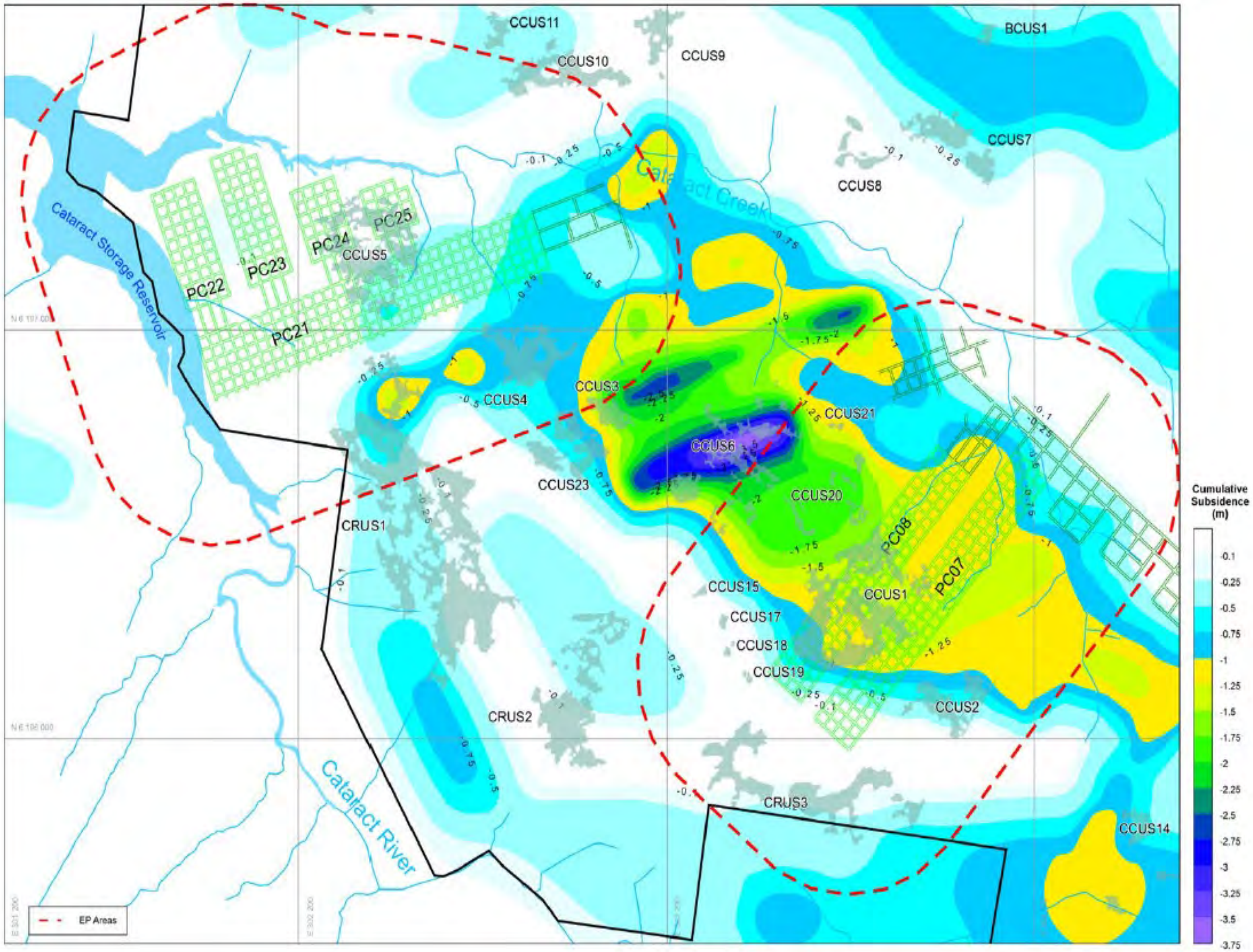
Balgownie Seam Goaf Areas

- No further subsidence expected
- Complete subsidence records confirming full subsidence

Legacy of recent longwall mining

-Possible ongoing closure movements at Cataract Creek (<20mm)
-No evidence of further road cracks

Legacy Subsidence:
Bulli, Balgownie & Wongawilli Seam Mining



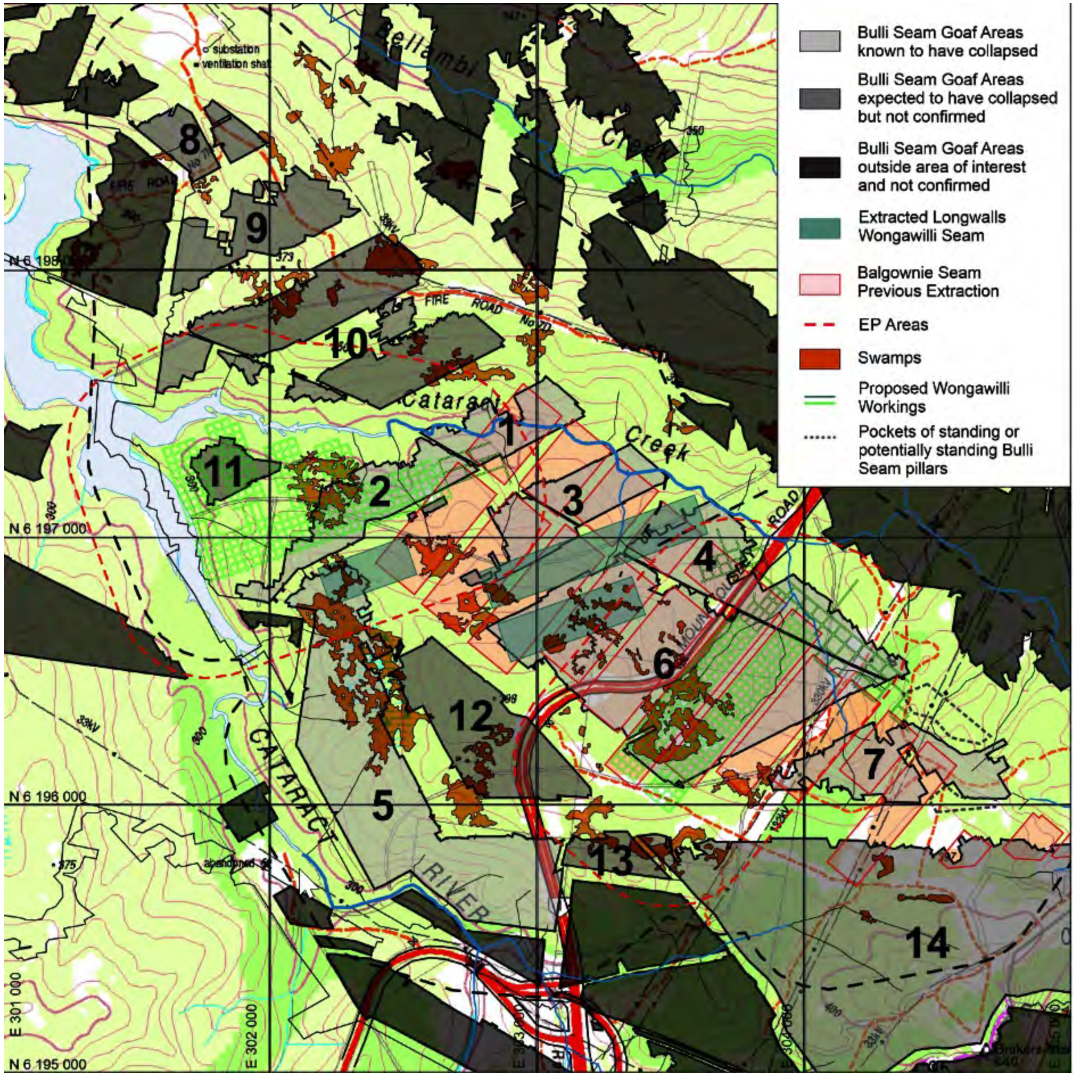
Bulli Seam Up to 1m

Balgownie Seam
up to 1.4m more

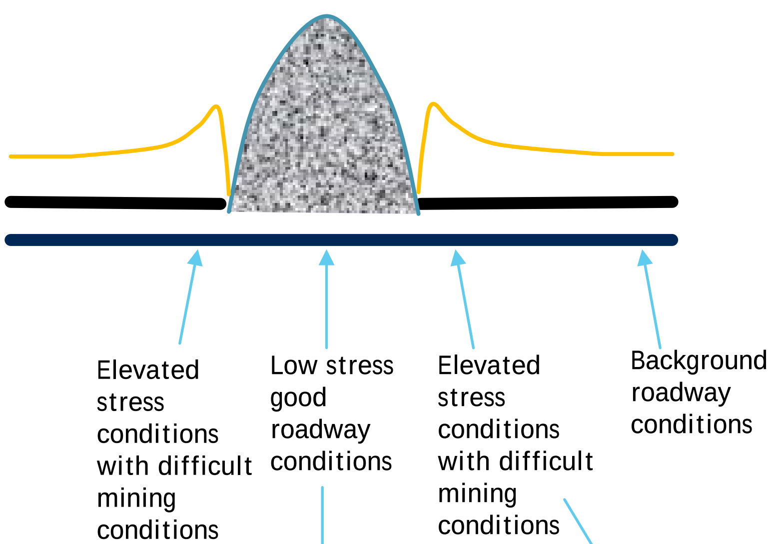
Wongawilli Seam
up to 1.8m more

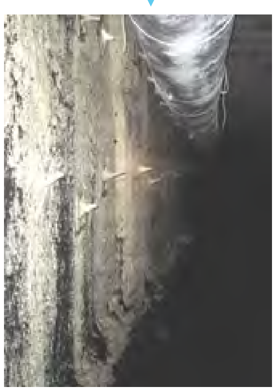
But only a few small areas where all three seams have secondary extraction at the same location

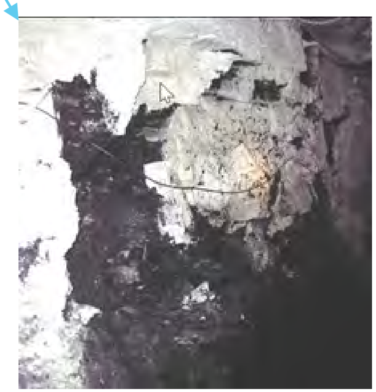
Legacy Subsidence: Bulli, Balgownie & Wongawilli Seam Mining



Underground roadway condition monitoring

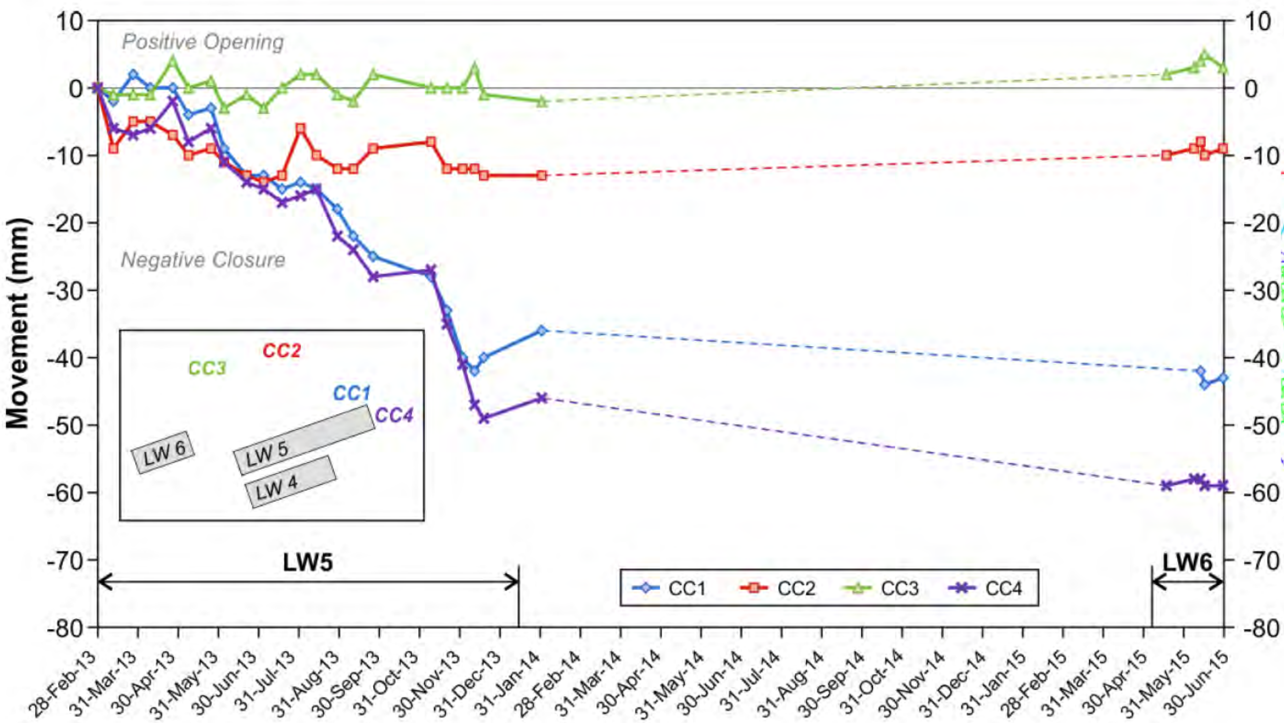


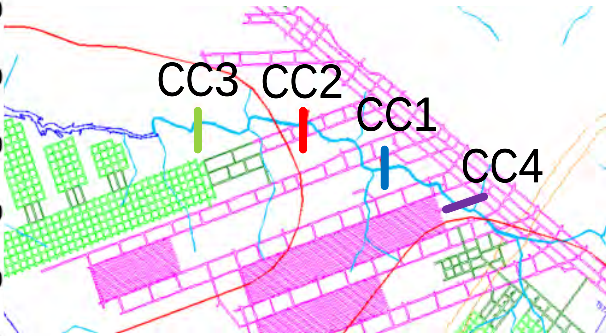


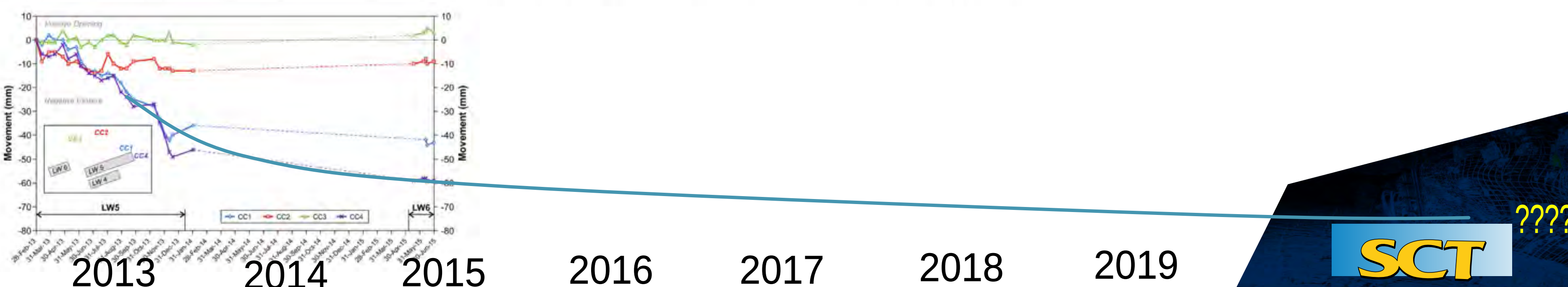


The difference between elevated stress conditions and background roadway conditions is clearly apparent and confirms that a goaf has formed i.e. extracted pillars are not still standing.

Valley Closure Measurements
Legacy of Longwall Mining





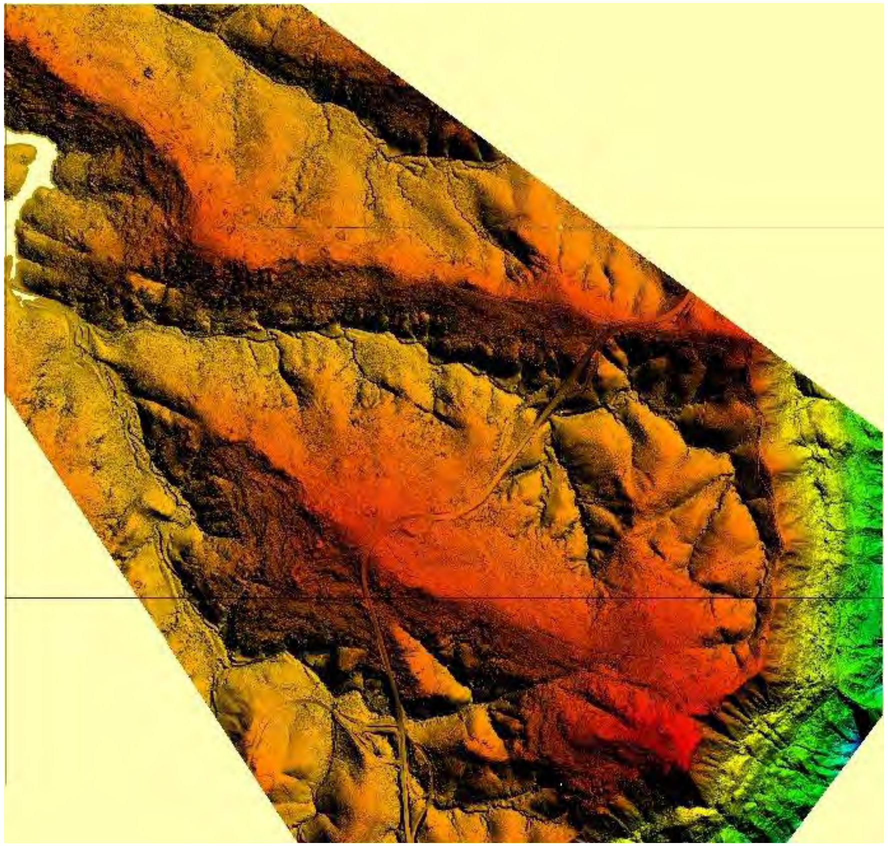


Performance Criteria

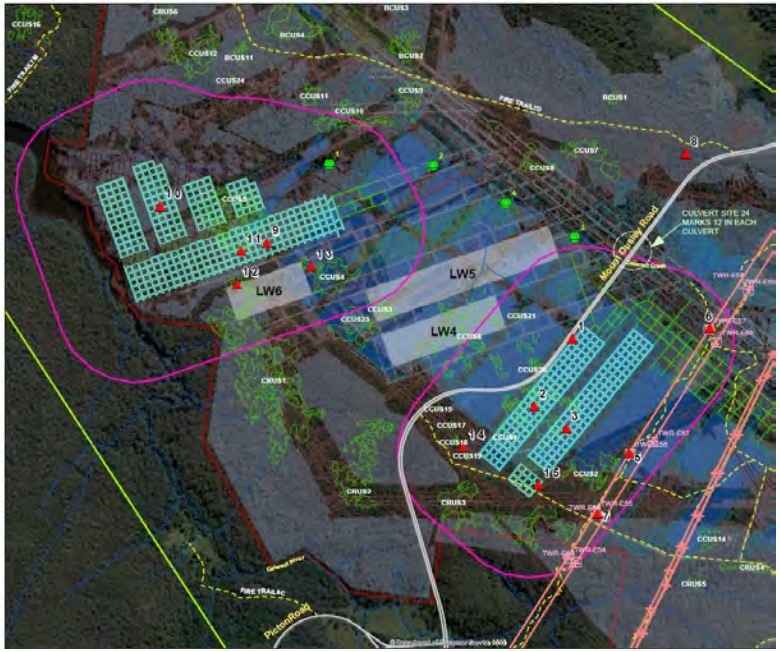
Feature	Performance Measures
Mine workings	
First workings and Second workings	• To remain long-term stable and non-subsiding
Key Public Infrastructure	
M1 Princes Motorway (formally known as Mount Ousley), electricity transmission lines and towers (330kV, 132kV, 2x33kV) and telecommunications line	• Always safe and serviceable • Damage that does not affect safely or serviceability must be fully repairable and must be fully repaired.
Other Infrastructure	
Access roads, fire trails and other public infrastructure and built features	• Always safe. • Serviceability should be maintained wherever practicable. • Loss of serviceability must be fully compensated. • Damage must be fully repairable and must be fully repaired or else replaced or fully compensated.
Public Safety	
Public Safety	• Negligible additional risk
Vertical Subsidence	
All areas of the site affected by the development	• Vertical subsidence limit of not more than 300mm

Proposed Monitoring – TfNSW Assets

LIDAR Survey 31/8/21



GNSS Units



Closure Monitoring at Cataract Creek
Slot Monitoring
Culvert Inspection / Surveys
Crack Opening at crest
Other as determined
in this RA

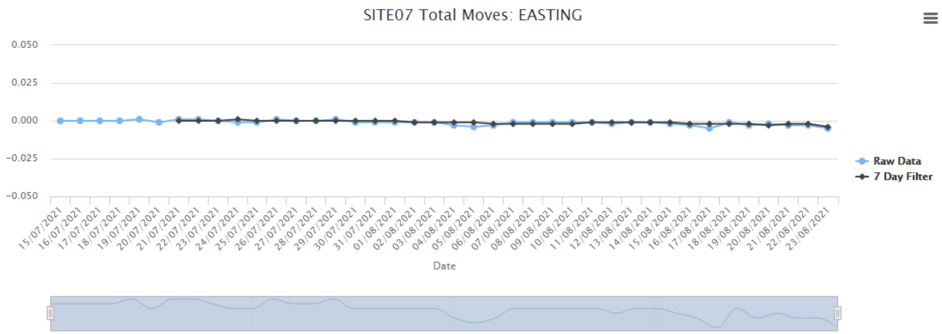
Proposed Monitoring

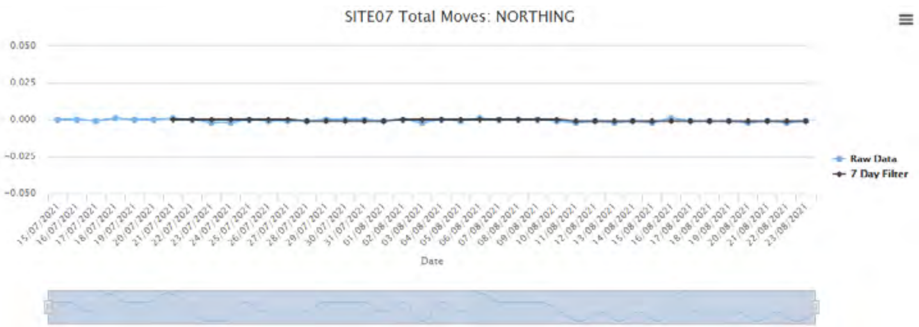
- Valley closure movements expected to be main effect.
- This closure will be monitored by:
  - Near real-time continuous monitoring using GNSS stations on either side of Cataract Creek.
  - Continuous monitoring, downloaded as required of closure across the slot at the crossing point.
  - Periodic inspections of the geometry of the Cataract Creek/ M1 Highway culvert.
  - Periodic surveys of the cracks at the ridge top to the south of Cataract Creek.

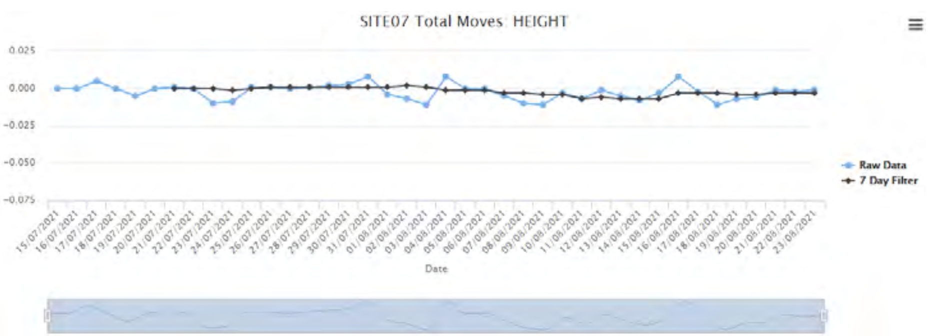
  Note: An initial survey would be made prior to secondary extraction for panels PC 21-25 to confirm new base line for future mining.

  - TfNSW monitoring as per the existing BFMP for previous mining including weekly inspections of the road surface to ensure identification of any surface cracks.

Subsidence Monitoring: GNSS Units





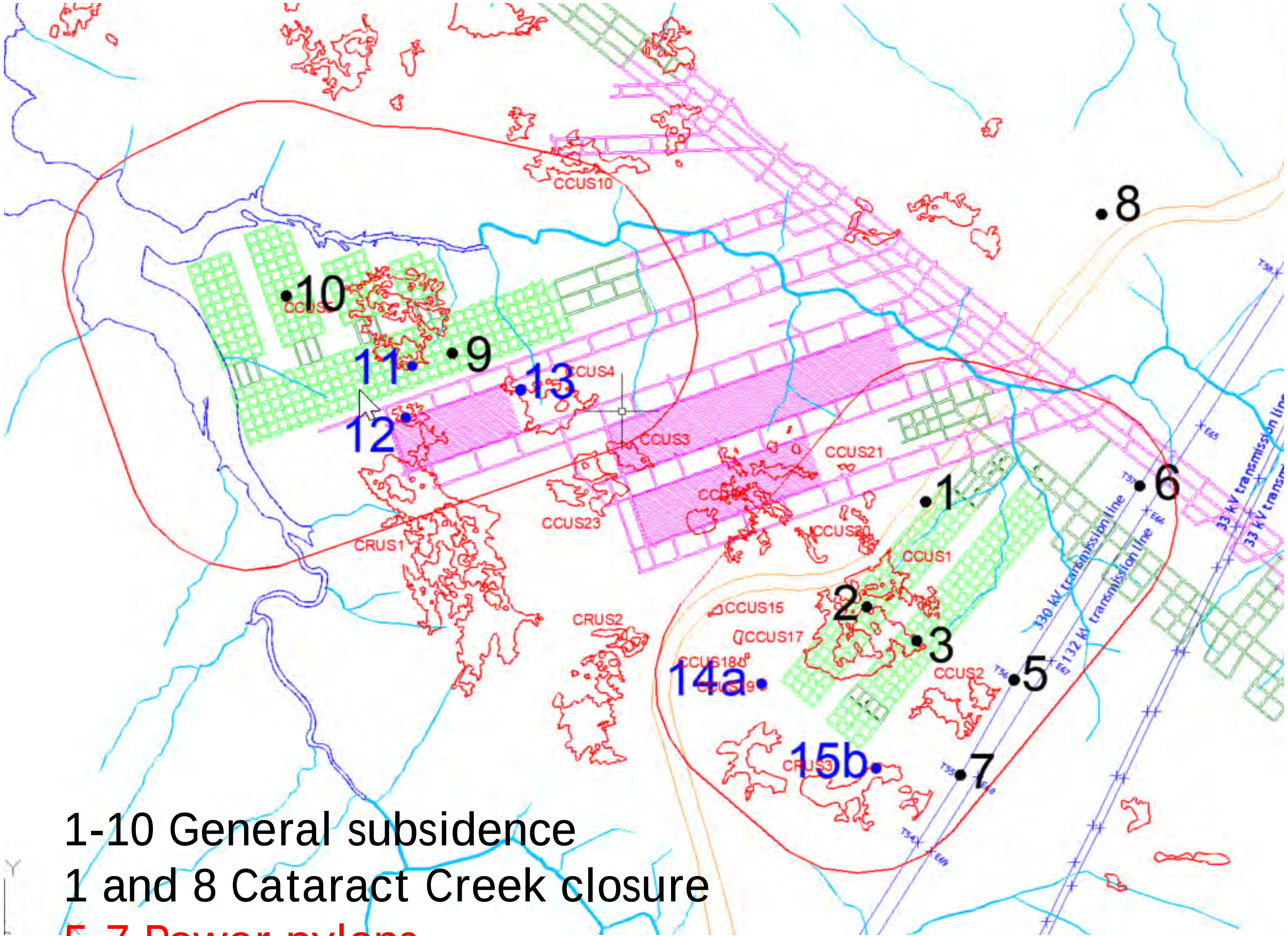


Site 7

Experience at another site running since 2018

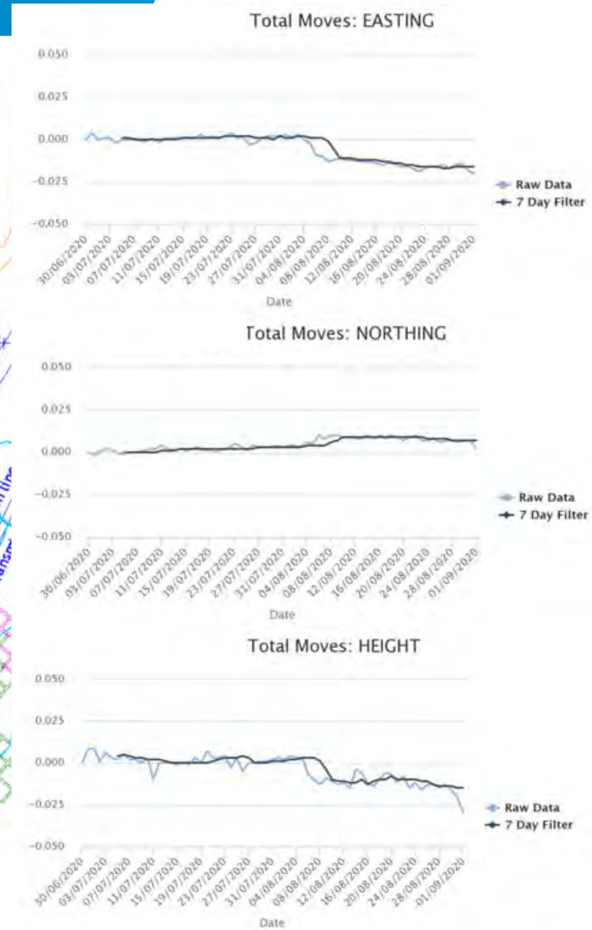
Daily Std Deviation Easting 3mm
Daily Std Deviation Northing 3mm
Daily Std Deviation Height 7mm

Subsidence Monitoring: GNSS Units



1-10 General subsidence
1 and 8 Cataract Creek closure
5-7 Power pylons
11-15 Swamp Specific

Example Data



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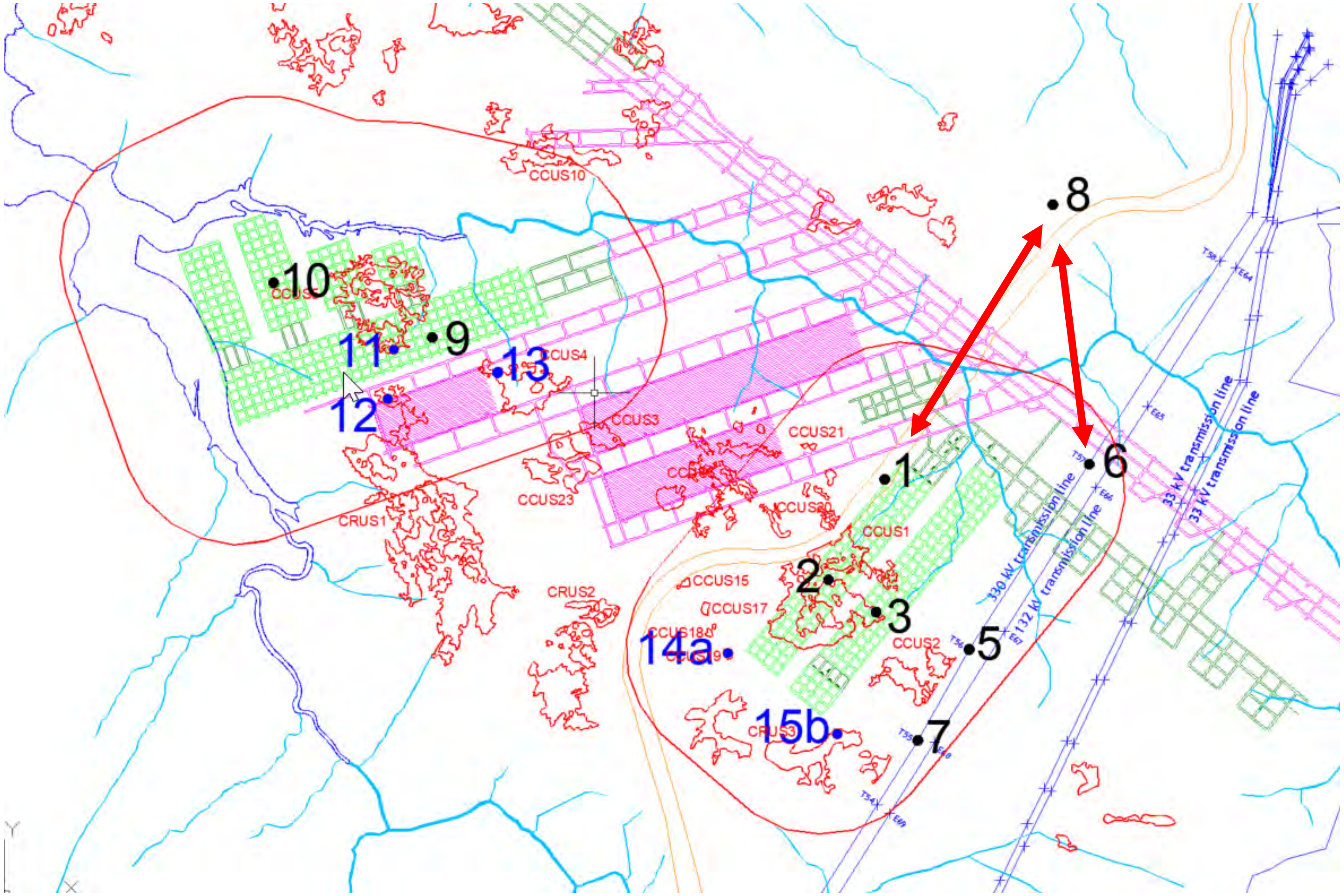
Subsidence Monitoring: GNSS Units



Infrastructure Monitoring

Mt Ousley Road closure across Cataract Creek

NB Recent research indicates these towers were in place when Balgownie Seam caused 1.3m of subsidence. Cracks nearby indicate towers are founded in one unit of solid rock.

Subsidence Monitoring: GNSS Units

WCL GNSS Portal

GNSS Units installed and providing near real time data

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Natural and Built Features						
Edge of Mt Ousley Road	GNSS #1	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC08 (Bulli & Balgownie goaf)	GNSS #2	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
PC07 (Bulli & Balgownie goaf)	GNSS #3	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
330kV Powerline T56 tower (Balgownie goaf)	GNSS #5	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T57 tower (pillars)	GNSS #6	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T55 tower (solid coal)	GNSS #7	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
WCL easement (Bulli goaf)	GNSS #8	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC21 (Bulli goaf #2)	GNSS #9	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC23 (Bulli goaf #11)	GNSS #10	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC21 (Bulli goaf #2)	GNSS #11	At Swamp CCUS5	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (edge Bulli & Wongawilli goaf)	GNSS #12	At Swamp CRUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (Balgownie goaf)	GNSS #13	At Swamp CCUS4	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
West of PC08 (Bulli pillars)	GNSS #14a	At Swamp CCUS19	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC07 (Bulli pillars)	GNSS #15b	At Swamp CCUS3	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
Russell Vale East Area-	LIDAR	General subsidence - all surface features	3D ±200mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DAWE, RMS, TG, EE, DPIE, RR
Cataract Creek at CC1, CC2, CC3 and CC4	Hi res survey	Valley closure (upsidence) at CC1-CC4	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DPIE, RR

Subsidence and Surface Features

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Infrastructure						
Mt Ousley Road - Pavement	Crackmeter monitoring at Slot	Pavement condition from compression	1D ±1mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Pavement	Hi res survey across extension zone at ridge	Pavement condition from tension	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Culverts	Direct measurements of Cataract Creek culverts	Drainage and pavement conditions	1D ±1mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Visual inspections and photos					3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
330kV and 132kV powerlines	3D Position of Towers	Power supply integrity	3D ±20-25mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
330kV and 132kV powerlines	Leg diff measurements	Power supply integrity	1D ±2mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
Visual inspections including 33kV lines				After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR

Notes – * excludes reporting of incident or non-compliance.

Reporting includes an evaluation of the risk of the 100mm subsidence limit at swamps (EPBC 2020/8702) being reached or exceeded.

Each control survey and subsidiary survey must be planned, surveyed and analysed to ensure they satisfy the conditions to achieve a standard of accuracy as prescribed in ICSM (2007) SP1 (version 1.7) to achieve Class “D” or better (S&DD 2020)

Baseline surveys for GNNS units and LIDAR undertaken prior to the commencement of mining.

Baseline survey (for end of longwall mining) of Mt Ousley Road, Cataract Creek and powerlines undertaken prior to the commencement of mining.

Cessation of mining is taken as completion of mining in adjacent panel.

Key Messages

- Expecting subsidence less than 100mm (i.e. much less than longwall subs 1800mm)
  - No perceptible impacts

- Managing contingency of potential for greater than 100mm by staging extraction
  - Stage 1(a) – Remote from infrastructure (PC21-25 and further west)
  - Stage 1(b) – Offset from infrastructure (PC07 & PC08)
  - Flexible mining system that can be modified to reduce subsidence
  - Mining in Stage 1(b) (PC07 & PC08) will only commence once subsidence confirmed as less than 100mm in PC21
  - Technical Committee Process involving TfNSW, RR and Assessment

- Some very low potential for legacy mining impacts that exists irrespective of proposed mining
  - Managed by
    - Broad area LIDAR
    - Underground observation of roadway conditions
    - Valley closure monitoring

Appendix B

Preliminary Risk Assessment

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Mining Risk Assessment

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Technical Procedure

Scope

Scope

- All mining proposals, open cut or underground, under or adjacent to TfNSW infrastructure
- The process must be used:
  - To ascertain if there are TfNSW assets at risk
  - To assess the level of risk

General Description

- Allows TfNSW to provide preliminary response to the Proponent
- No arbitrary decisions to be made on likely impact on TfNSW assets.
- Response can be one of the following:
  - TfNSW does not object to mining (subject to conditions)
  - Further analyses required to address risks
  - TfNSW objects to mining (unacceptable risks)
- TfNSW only states only that it has no objections (or has objections) to a mining proposal
- TfNSW does not accept a mining proposal

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General Description

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- Procedure can be used for first workings (mine development roads, access shafts or tunnels)
- For these structures, decommissioning plans need to be reviewed to assess long-term impacts on TfNSW infrastructure
- Coal seam gas extraction not considered, but the broad principles contained in the Procedure can be used for guidance for evaluation
- TfNSW and Proponent should develop open relationship for this process

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General Description

Risks Assessed

- Infrastructure
  - Considers damage to pavements bridges, slopes, culverts
- Functionality
  - Loss of amenity and economic loss – does not consider loss of functionality imposed as a preventative measure
- Safety
  - Considers likely accidents, but without mitigation measures.

Methodology Overview

- Three phase process with escalation to subsequent stage only if requirements are not met
- First two phases completed by the regional office – allows improved communication between TfNSW and proponent – benefits both parties
- Third phase is likely to require external specialist advice

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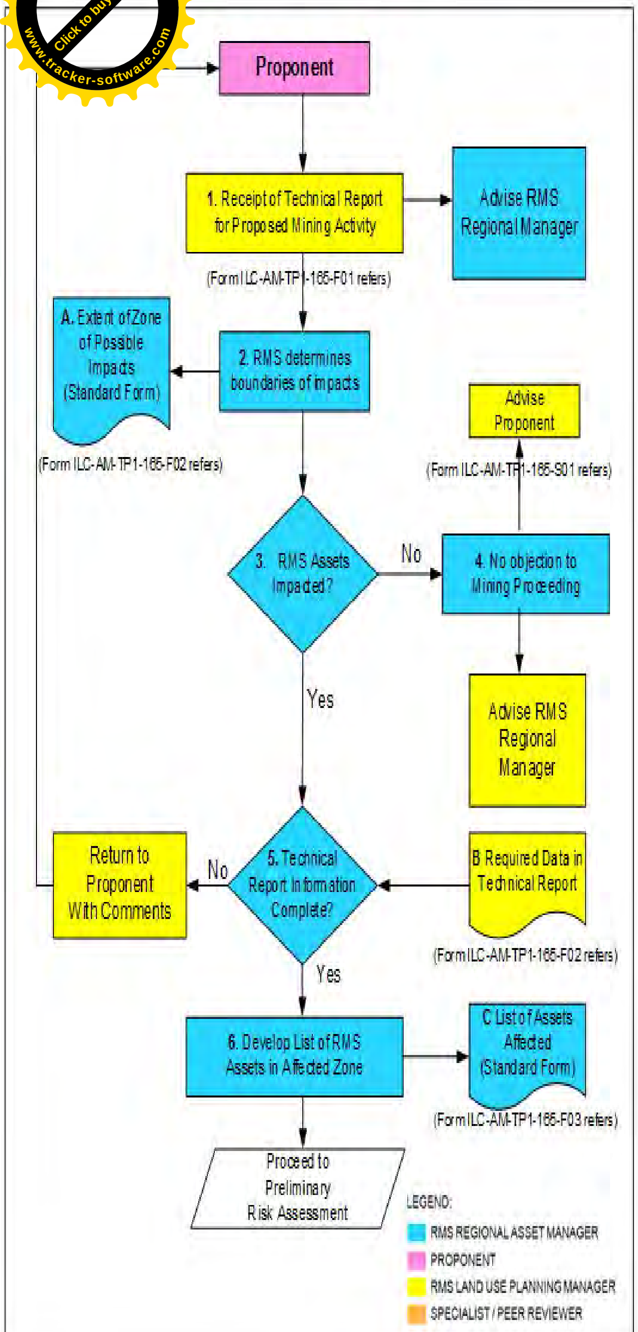
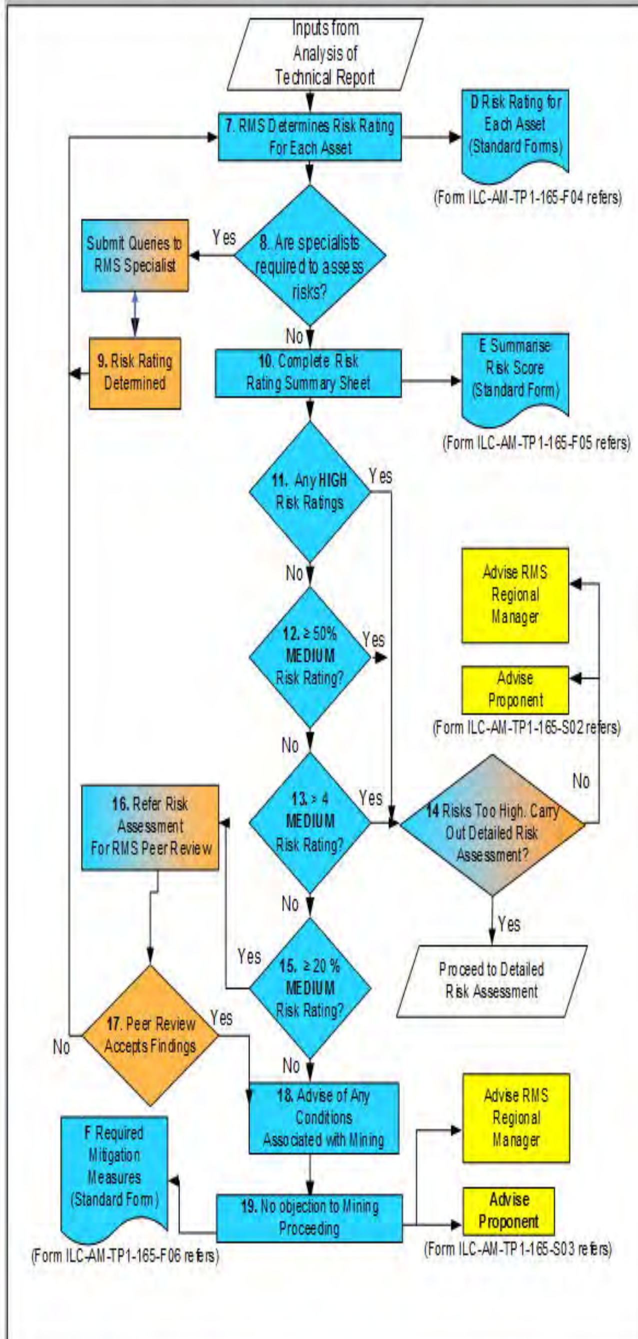
The ss for the receipt and analysis of technical report



The process for the preliminary risk assessment



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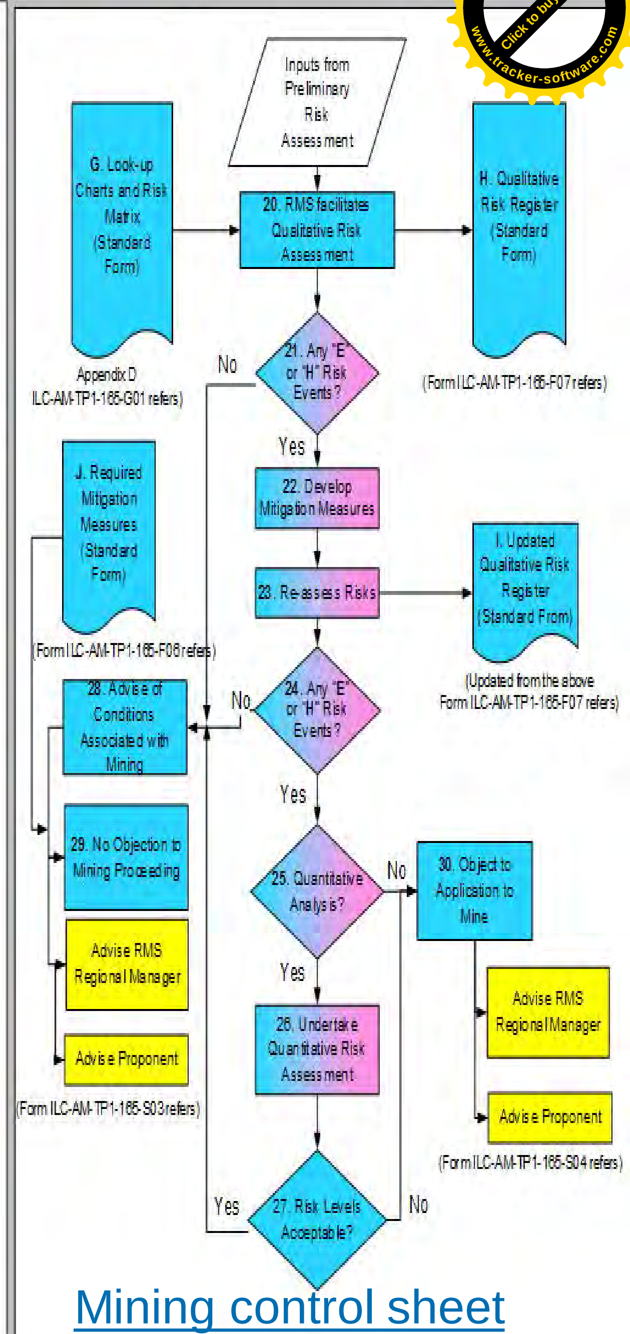

Mining control sheet

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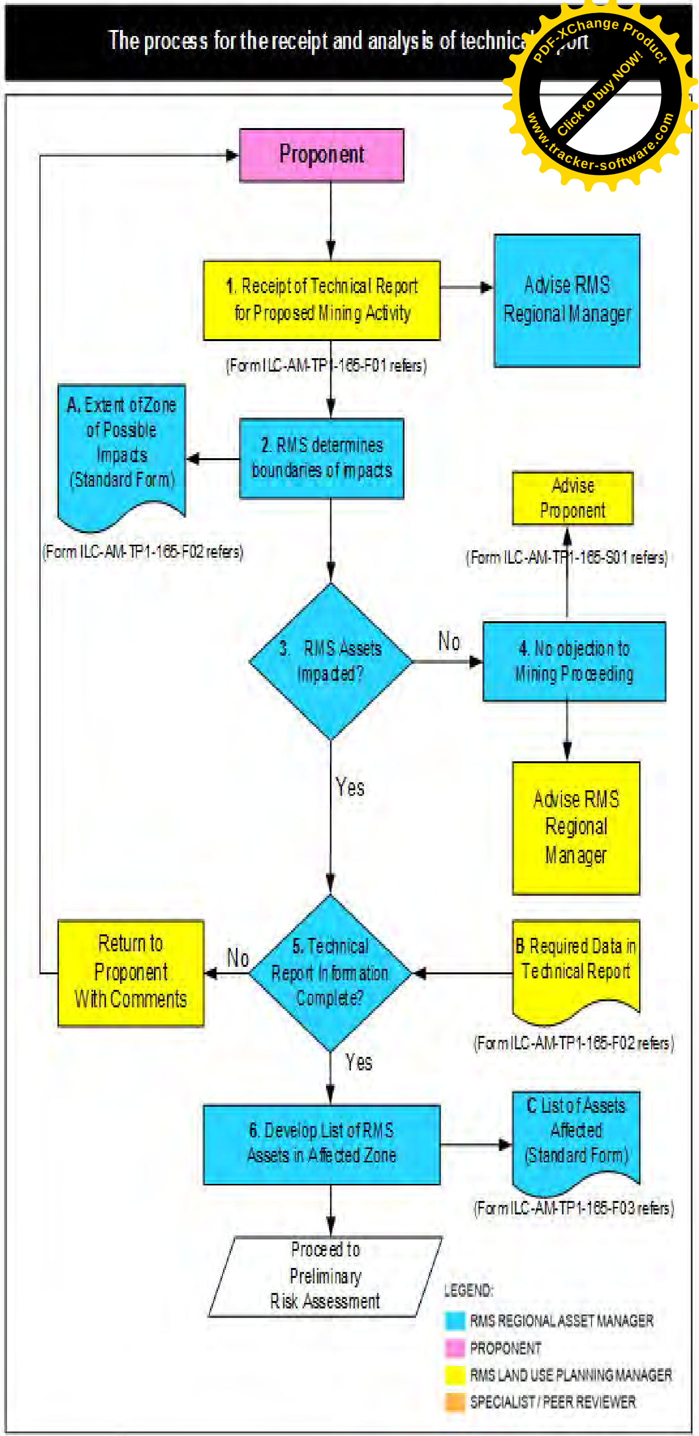
Receipt and Analysis of Technical Report

1. Applications normally received by Regional Land Use Planning Manager
2. Based on information in the Technical Report, Corridor Manager to determine TfNSW assets impacted
3. If, no assets are impacted, TfNSW has no objection to mining proceeding
4. If assets are impacted carry on to next phase of Procedure (Preliminary Risk Assessment)



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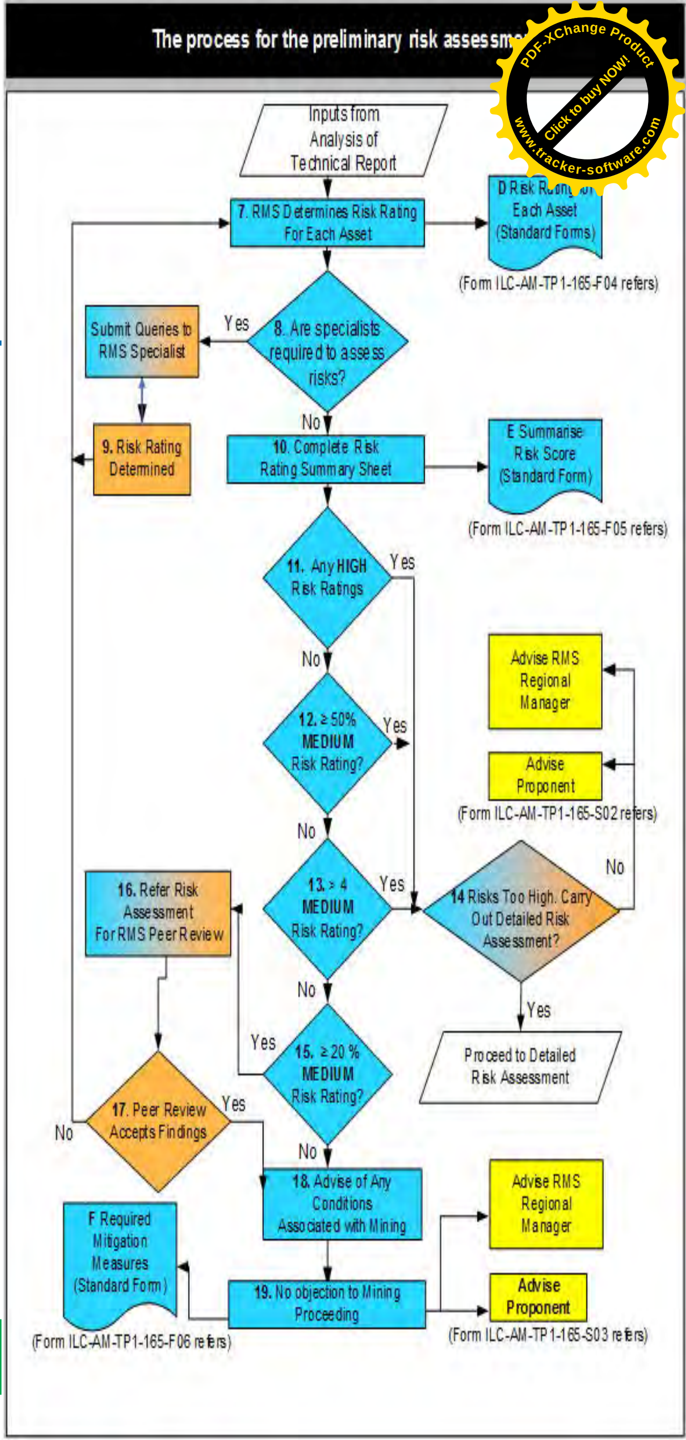
Preliminary risk assessment

- Aimed at providing quick assessment of mining risks
- Risk assessment normally be carried out by TfNSW Regional Technical Personnel
- Risk assessment is qualitative and rapid with look up charts to determine level of risk exposure or Risk Ratings
- Risk exposure includes infrastructure, functionality and safety.
- If risks are acceptable there would be no objection to mining, but certain conditions such as monitoring or pre-emptive actions may be imposed.
- If risks are unacceptable carry on to next phase of Procedure (Detailed Risk Assessment).



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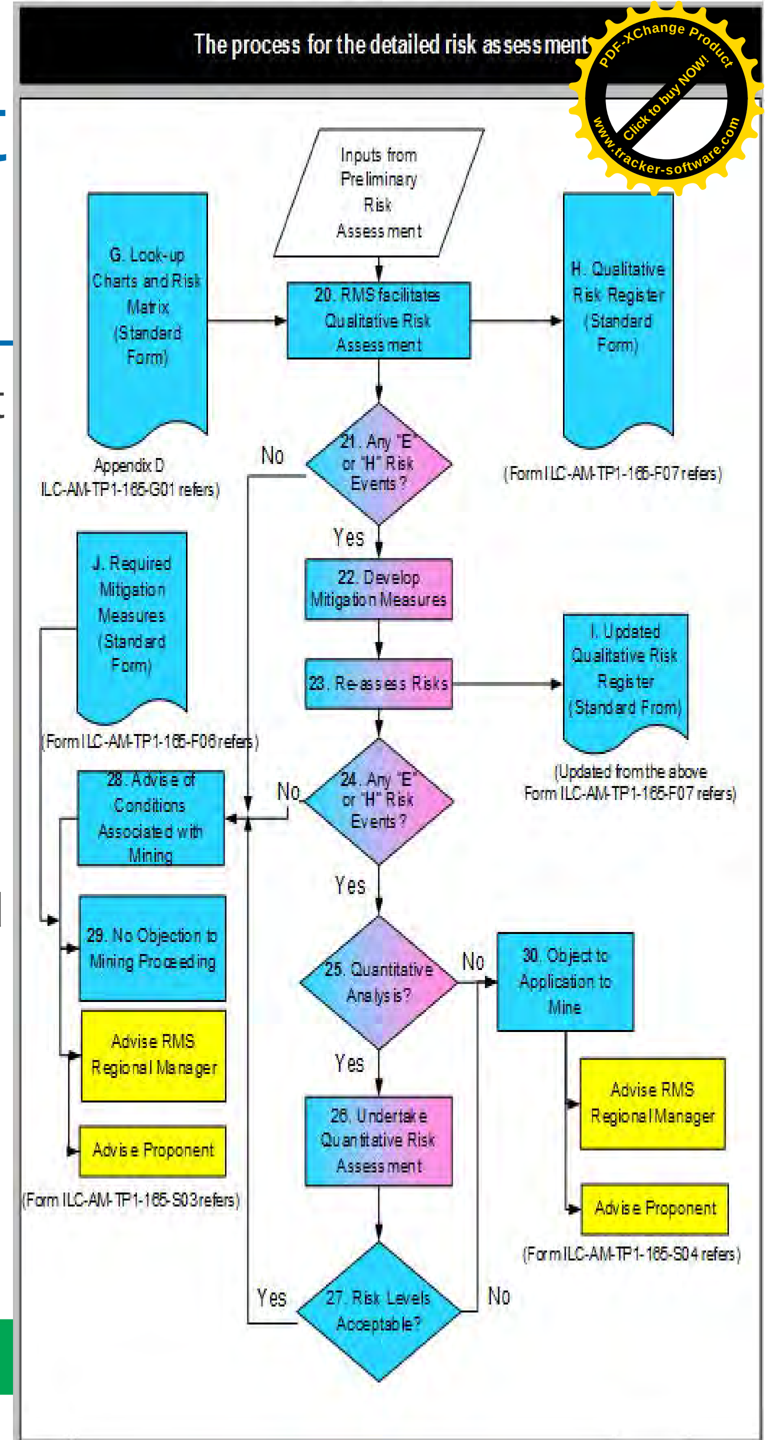
Detailed risk assessment

- Undertaken when Preliminary Risk Assessment identifies risks as unacceptable to TfNSW.
- Detailed Risk Assessment follows more traditional process
- The first stage is a qualitative risk assessment as in AS/NZS 4360 – 2004: Risk Management.
- Where qualitative risk assessment identifies risks that are unacceptable, a quantitative risk assessment on specific assets may be required
- If risks are acceptable, TfNSW would have no objection to mining, but certain conditions such as monitoring or pre-emptive actions may be imposed.
- If risks are unacceptable TfNSW will object to mining proposal



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Detailed methodology

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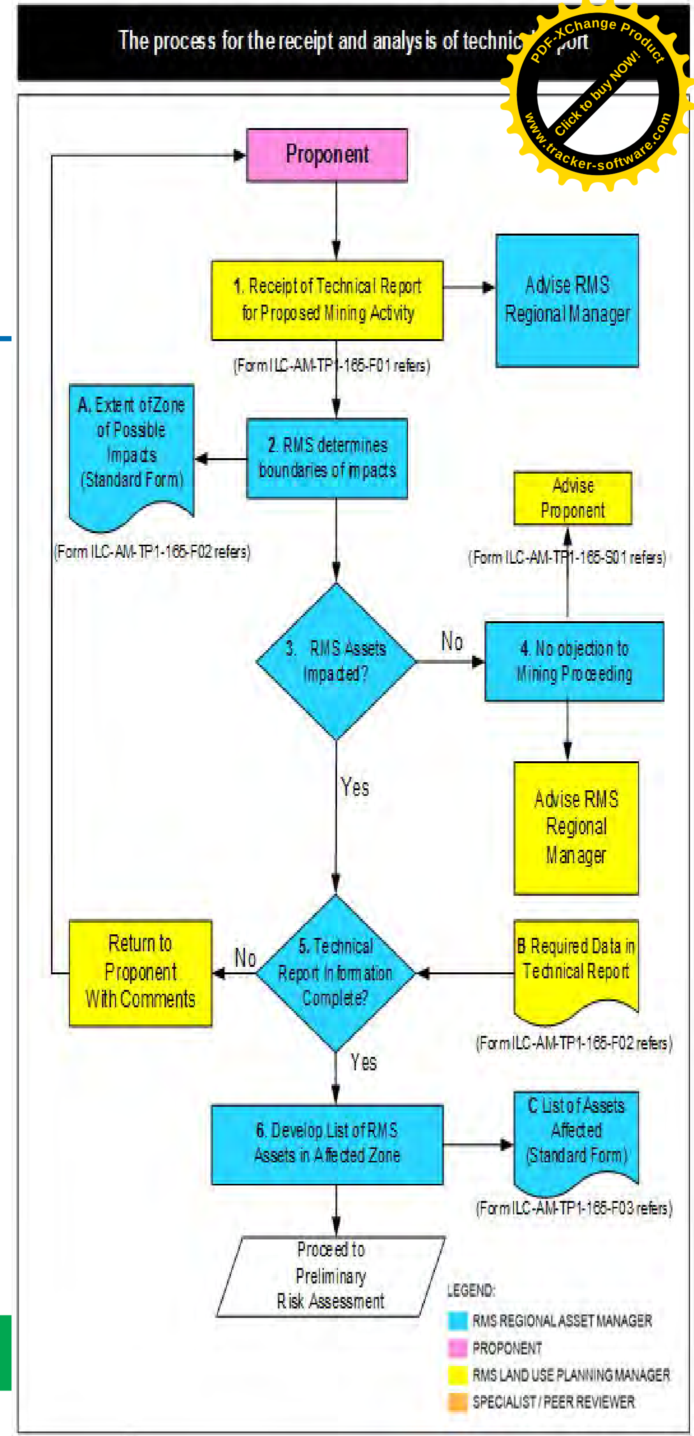
Receipt and Analysis of Technical Report

1. Receive the proposal to mine (Technical Report) from mining company (Proponent)
2. Assess extent of the possible impacts
3. Assess if assets are impacted
4. No? – No objection
5. Yes? – Check Technical Report contains sufficient information to complete risk assessment
6. Develop list of TfNSW assets for risk assessment

[Assess extent and assets](#)

- Proceed to Preliminary Risk Assessment

[Record subsidence data](#)



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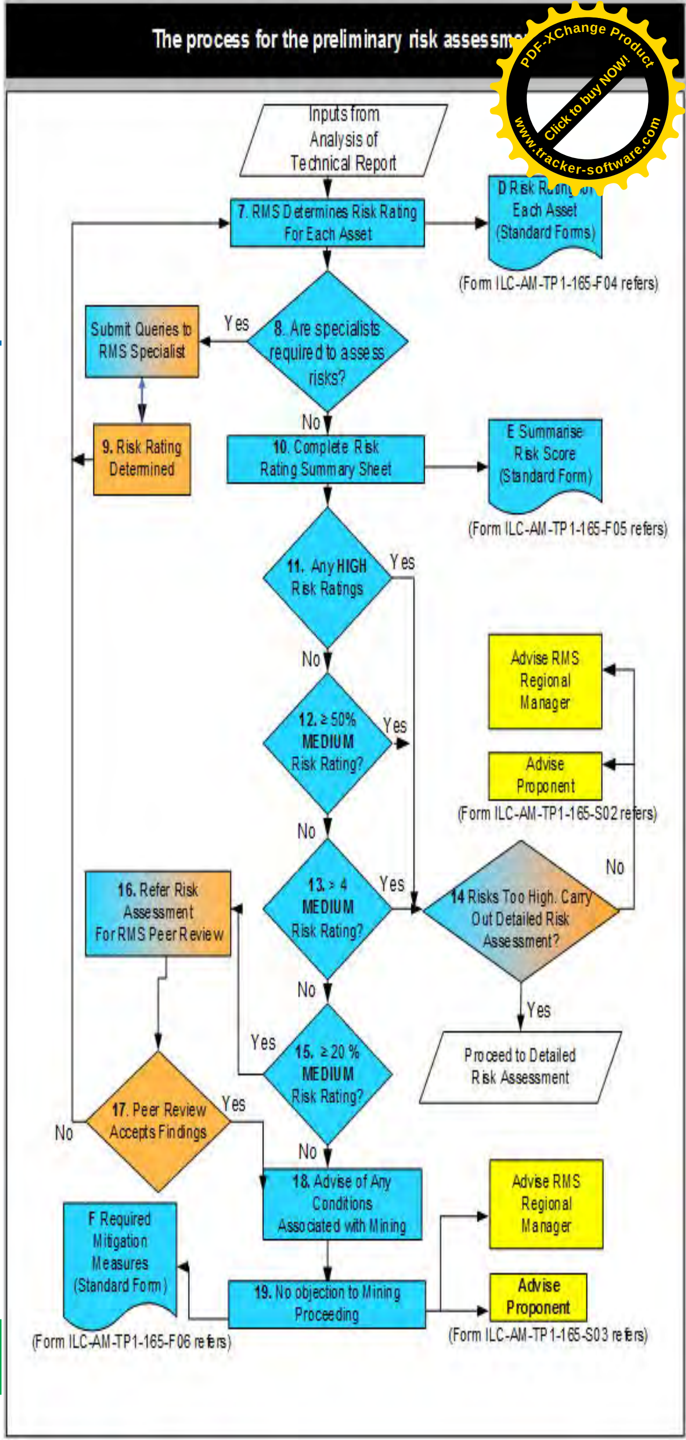
Preliminary risk assessment

- Use look up charts to determine level of risk exposure or Risk Ratings
- Risk assessment is qualitative
- Aimed at providing quick assessment of mining risks
- Risk Ratings refer to extent to which assets could be damaged by mining and the consequences
- Consequences include losses to infrastructure, functionality and safety.



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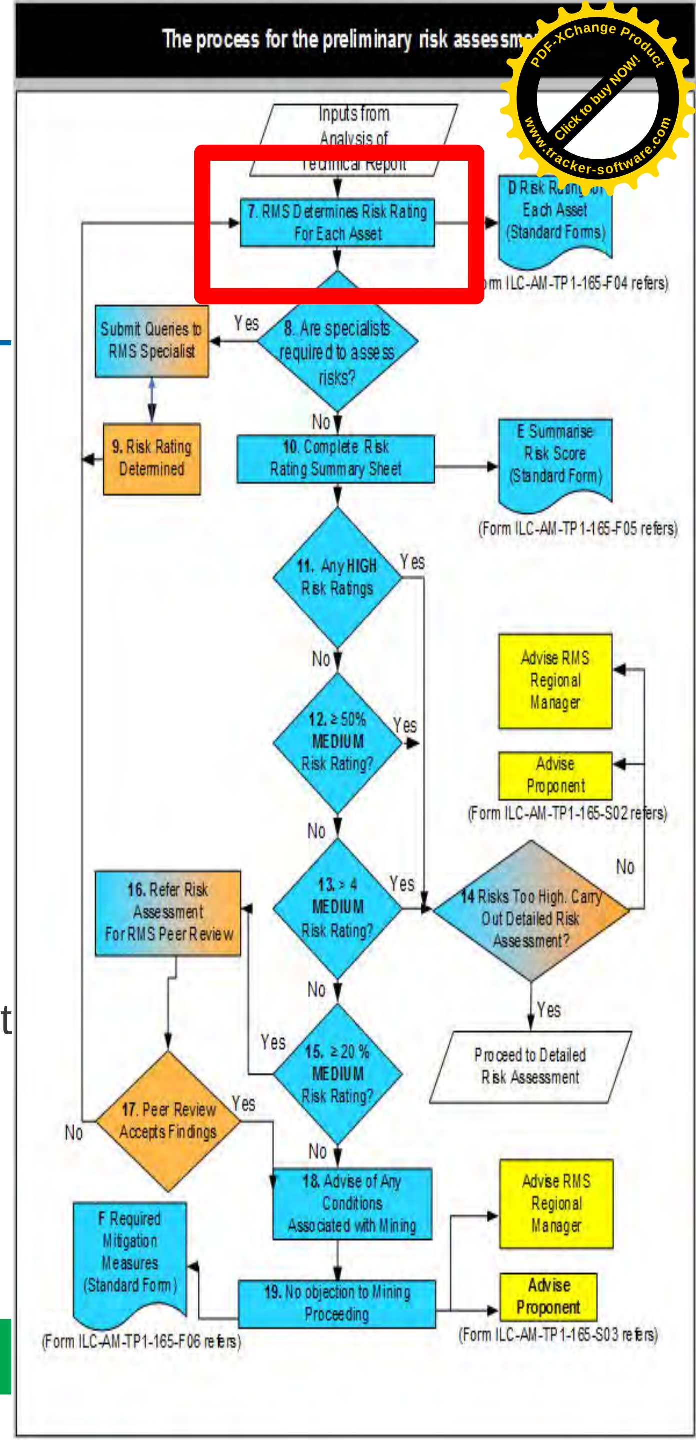
Determine Risk Values for Each Asset (Step 7)

- Risk Rating determined for each asset on the asset list using the lookup chart relevant to that asset.
- Risk Rating value predetermined for each asset based resilience inherent in the asset.
- Risk values will fall into one of four categories:
  - HIGH – asset potentially at risk from mining
  - MEDIUM – asset may be at risk from mining
  - LOW – asset is unlikely to be at risk from mining
  - REFER – risk to asset to be assessed by a Specialist



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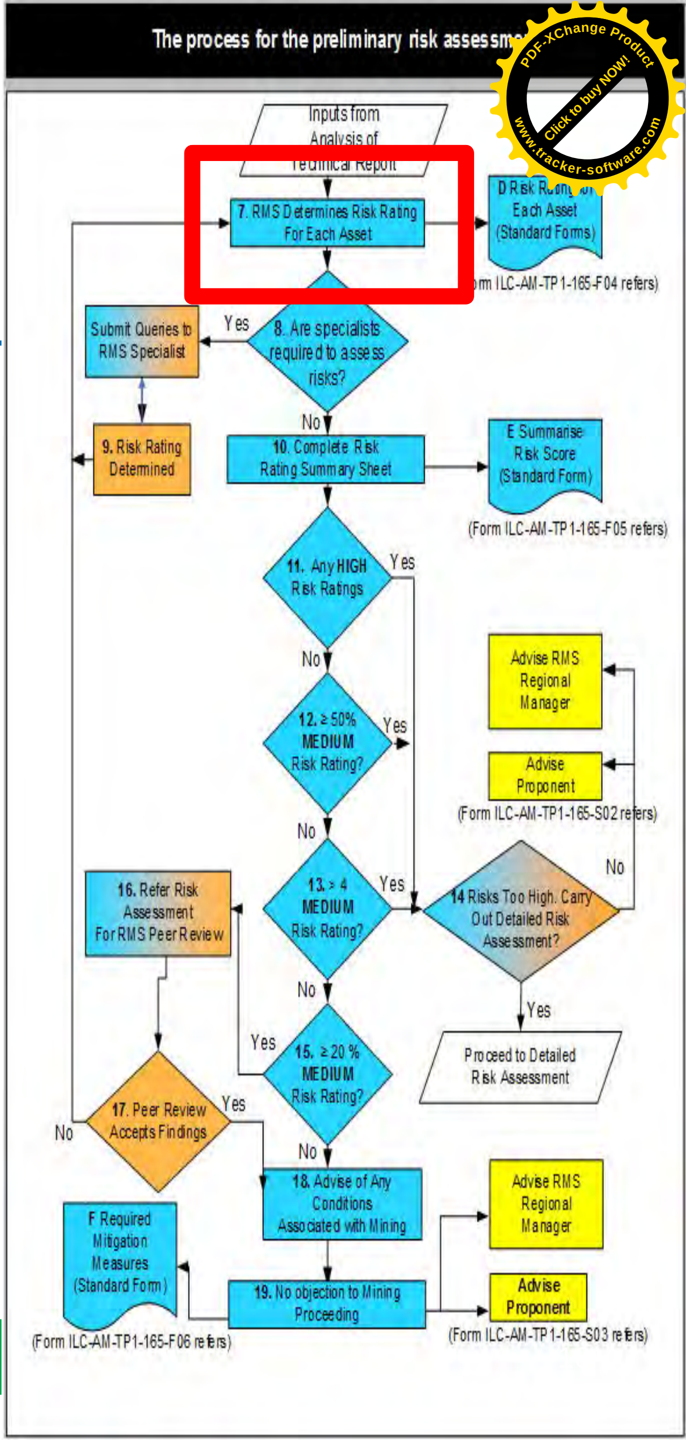
Determine Risk Values for Each Asset (Step 7)

- Ratings to be entered on Risk Rating forms in Appendix A
- Asset types rated:
  - Bridges (3.2.2.1)
  - Pavements (3.2.2.2)
  - Pavement Geometry (3.2.2.3)
  - Slopes (3.2.2.4)
  - Tunnels (3.2.2.5)
  - Culverts (3.2.2.6)
  - Miscellaneous structures (3.2.2.7)



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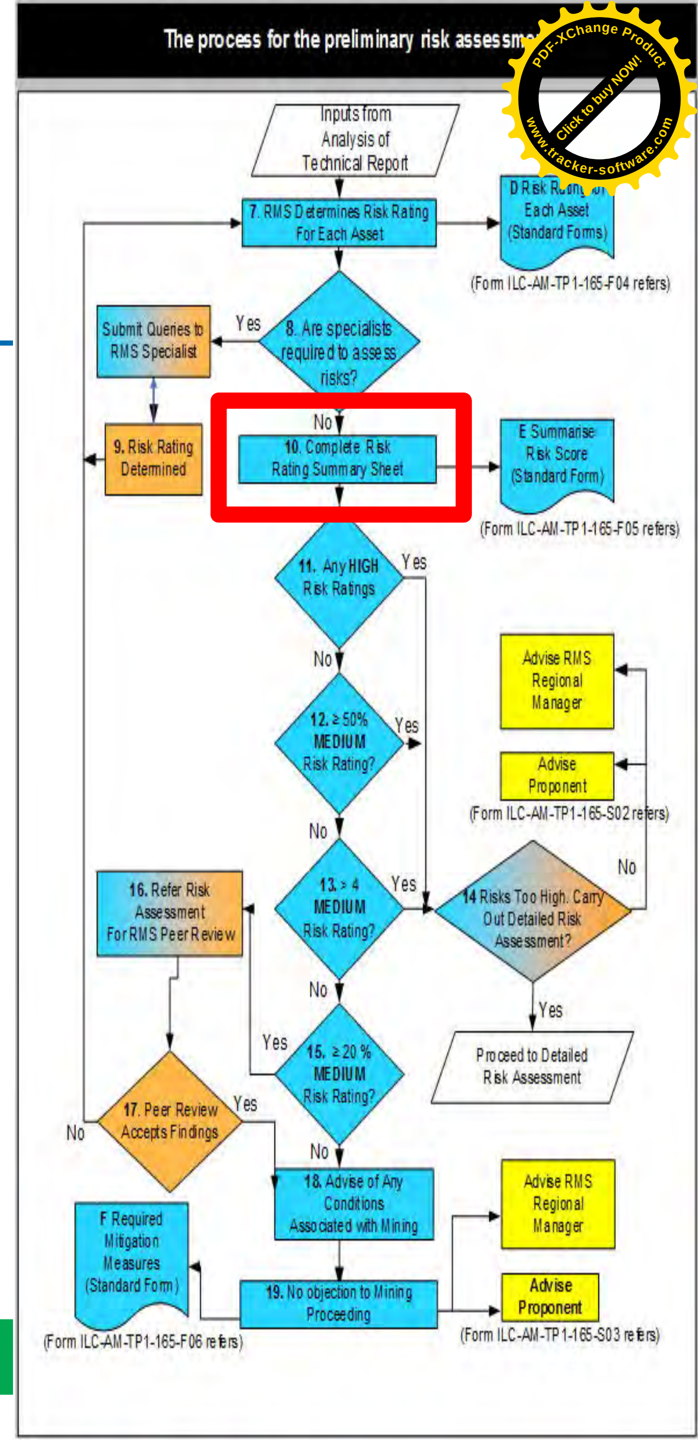
Summarise Risk Ratings (Step 10)

- Risk Ratings summarised using the form in Here
- Risk ratings summed to provide an assessment of total risk the mining activity poses to TfNSW's assets.



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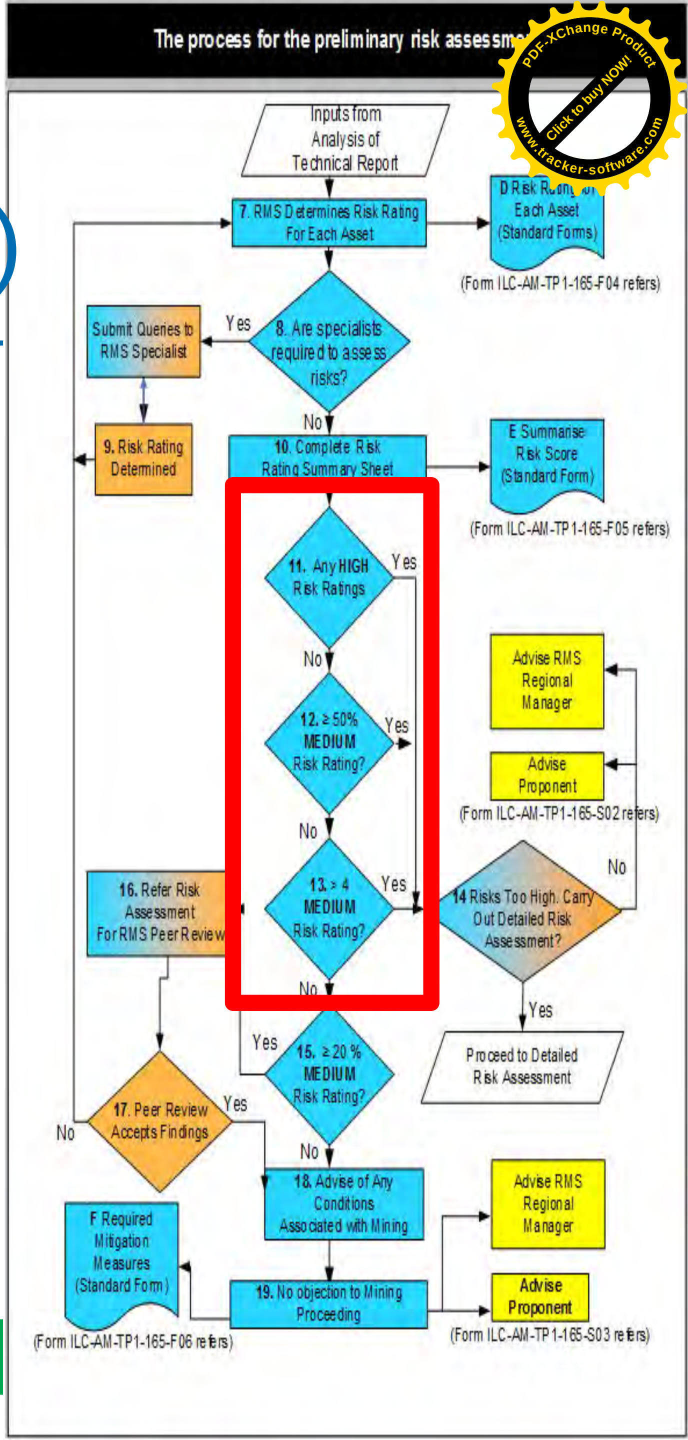
High and Medium Risk Exposure (Steps 11, 12, 13)

- Are There Any HIGH Risks? (Step 11)
- Do MEDIUM Risks Equal 50% or More? (Step 12)
- Are There more than 4 MEDIUM Risks? (Step 13)
  - If ‘Yes’ to any of the above, the level of risk to TfNSW, exceeds the Preliminary Risk Assessment acceptability limits
  - In this case, a Detailed Risk Assessment must be undertaken (Step 14)
  - Else Proceed to Step 15



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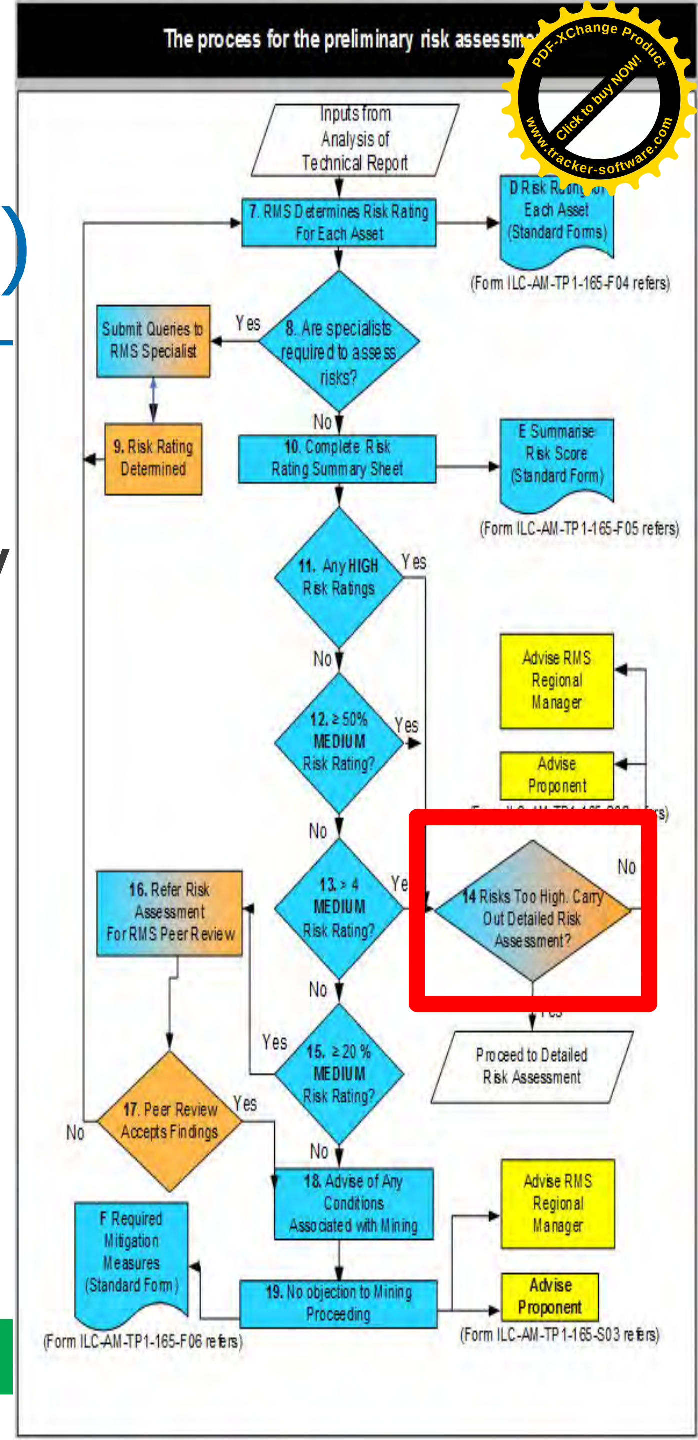
Risks Exceed Preliminary Acceptability Limits (Step 14)

- **TfNSW have carried out an initial risk assessment which indicates that there are risks to TfNSW that exceed the preliminary acceptability limits**
- **These risks will need to be resolved through a Detailed Risk Assessment**



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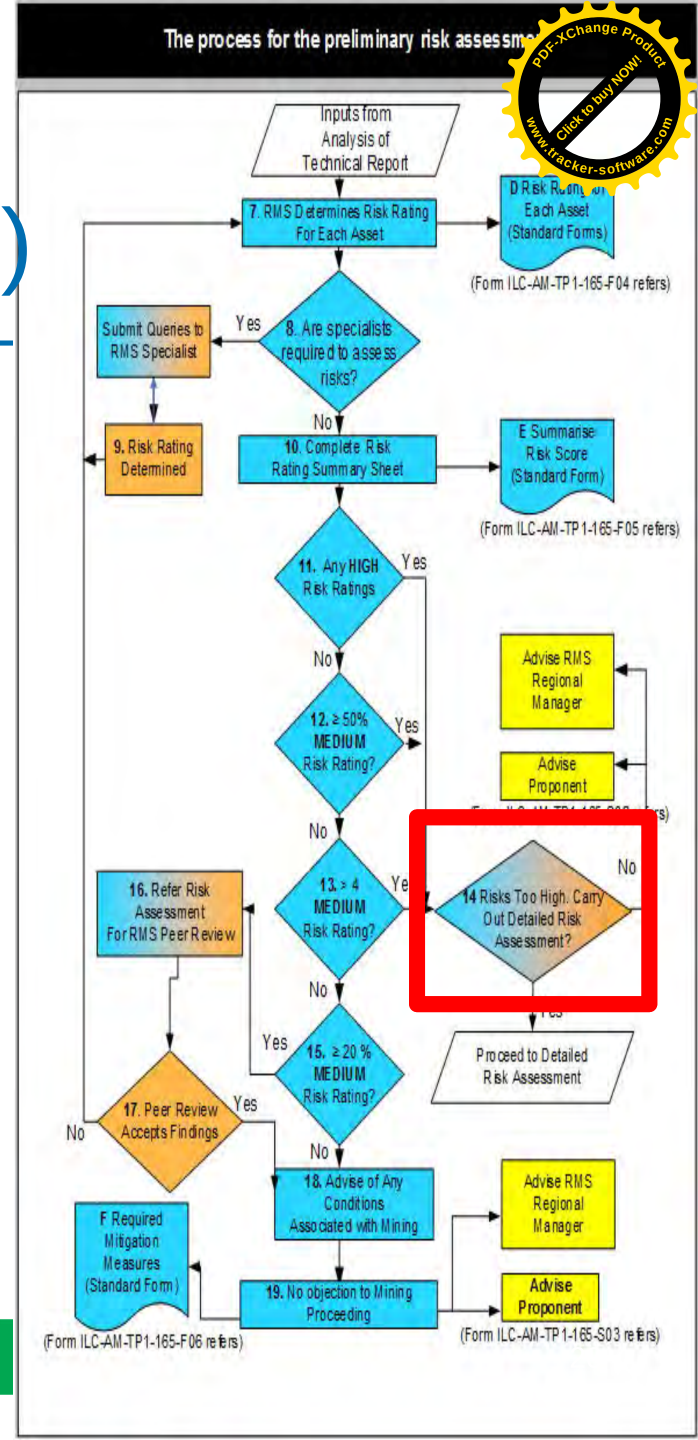
Risks Exceed Preliminary Acceptability Limits (Step 14)

- Detailed Risk Assessment to be managed by person nominated by the Asset Manager
- Nominated person to
  - appoint a facilitator to carry out the detailed risk assessment
  - provide all documentation to the facilitator
  - brief the facilitator prior to the risk assessment
  - arrange a venue
  - distribute the risk assessment outcomes to the participants
- The facilitator may be internal or external to TfNSW
- GM Asset Maintenance Planning to be advised of need to proceed to the Detailed Risk Assessment
- Regional Asset Manager to stay involved nominate point of contact between TfNSW and Proponent



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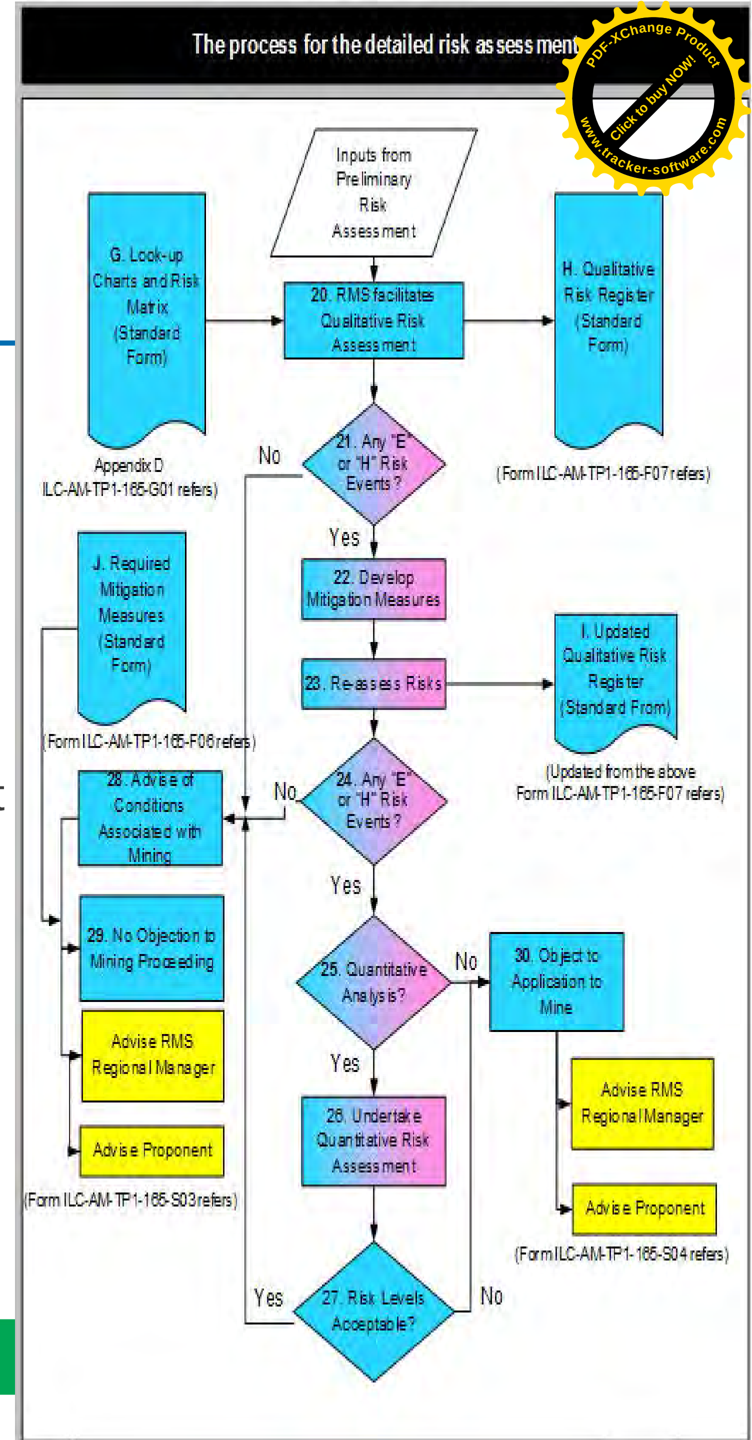
Detailed risk assessment

- Only undertaken when Preliminary Risk Assessment identifies risks exceed the Preliminary Acceptability limits of TfNSW.
- Detailed Risk Assessment follows more traditional process
- The first stage is a qualitative risk assessment as set out in AS/NZS 4360 – 2004: Risk Management.
- Where qualitative risk assessment identifies risks that are unacceptable, a quantitative risk assessment on specific assets may be required
- Qualitative risk assessment generally undertaken in workshop
- Mitigation measures identified in the risk workshop to be listed as a condition of TfNSW not having any objections to the mining and included in management plan



Management Plan

- A detailed management plan will be required prior to proceeding with mining.
- The management plan is a statutory requirement.
- The approving authority may vary this and the form of the plan will depend on the requirements of the approval authority.
- The management plan is to be drawn up by the proponent in consultation with TfNSW.
- It is to include all the requirements of the approval authority and all the risks identified in the Risk Assessment.
- Management of these risks to be clearly described in the Management Plan.
- A Trigger Action Response Plan to be included in the Management Plan where appropriate.

Thank you

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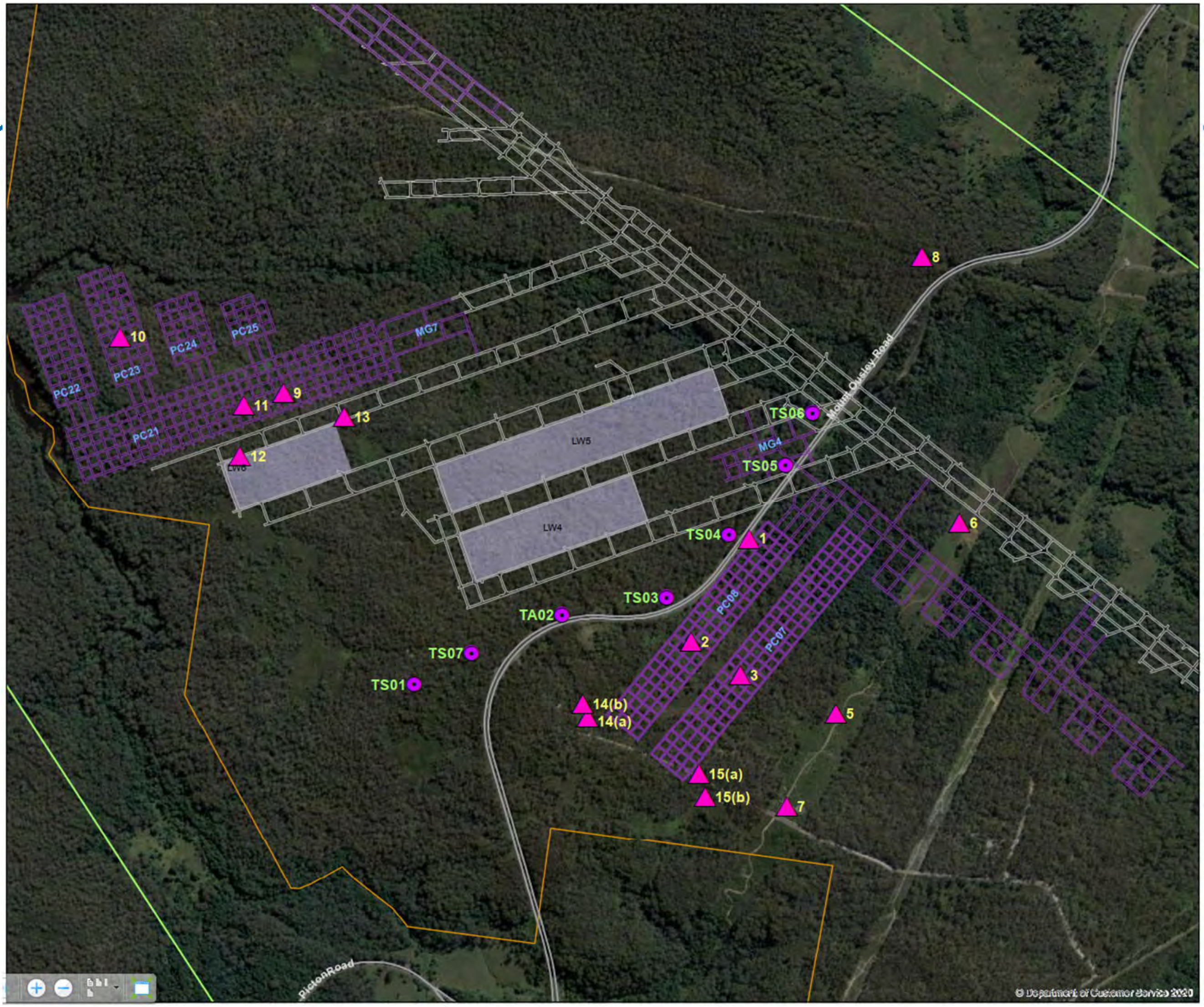
LINKED SLIDES

Mine Layout



PC22
PC23
PC24
PC25
PC21
MG7
10
11
9
13
12
LW5
LW4
TS06
MG4
TS05
TS04
1
8
6
TS03
TA02
TS07
TS01
PC08
PC07
2
3
5
14(b)
14(a)
15(a)
15(b)
7
Mount Ousley Road
Picton Road

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Culverts

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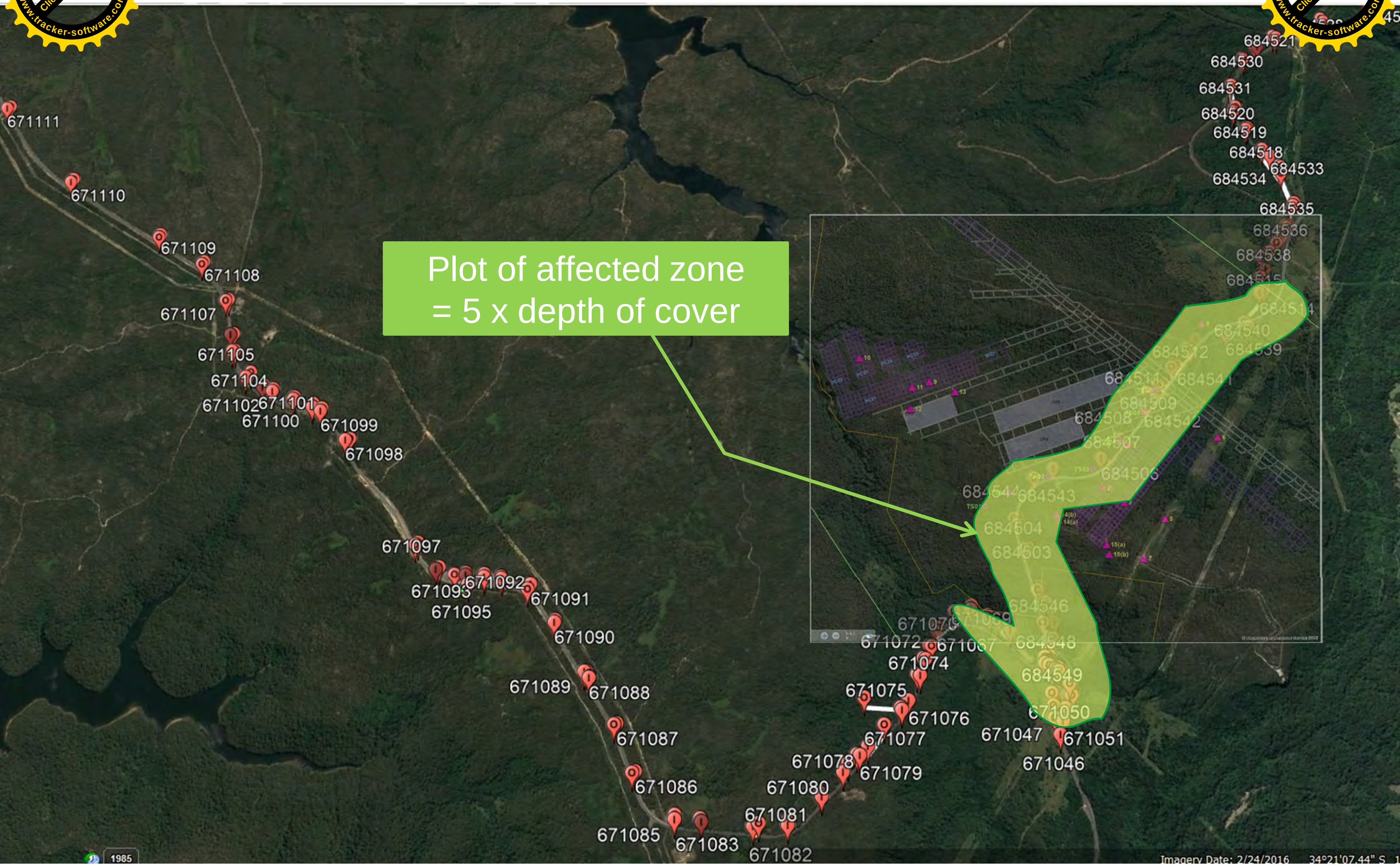

Slopes

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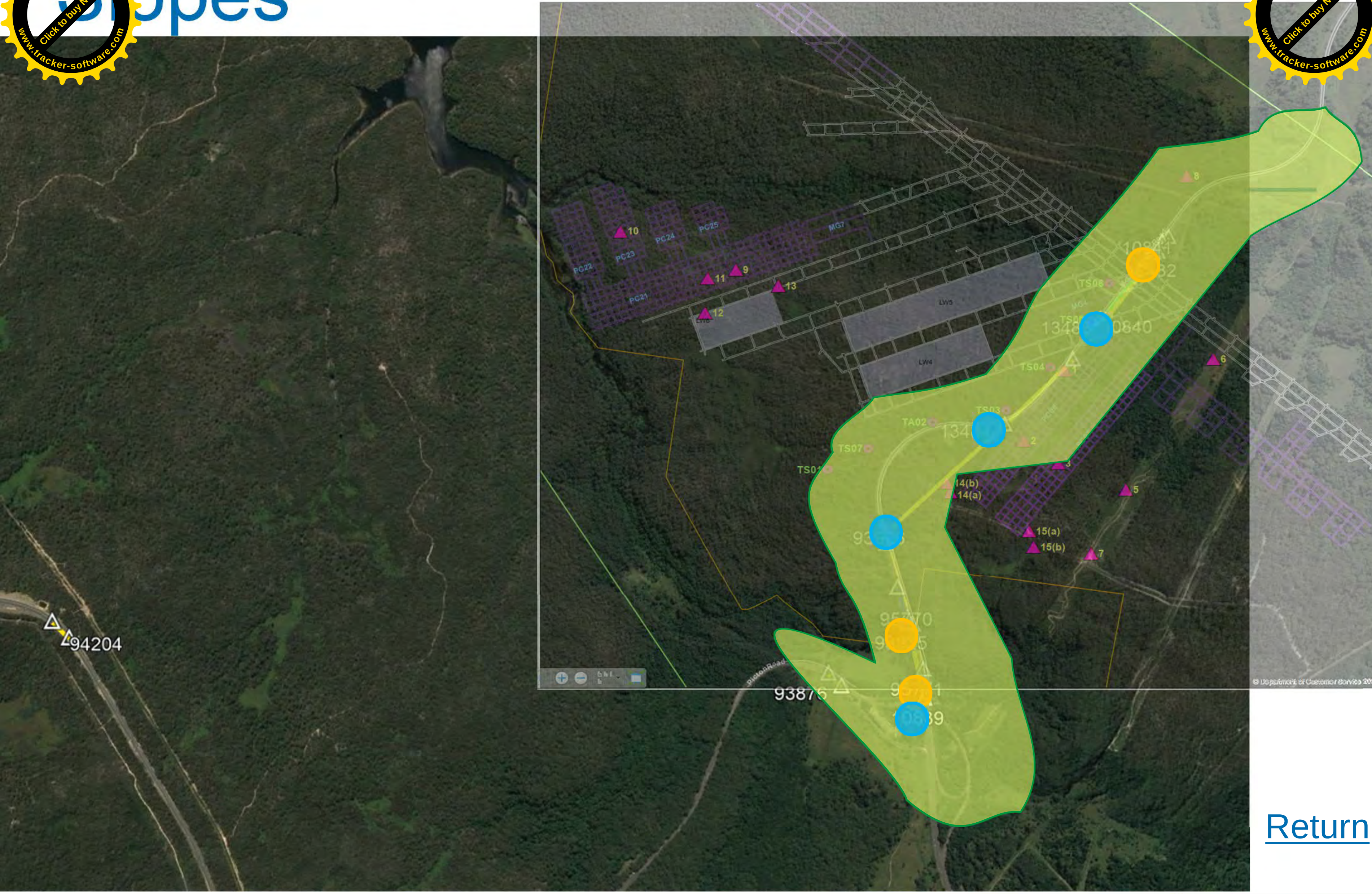

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Subsidence Information

Figure 6 shows contours for the estimated vertical subsidence expected at the completion of the planned bord and pillar panels in the EP Areas. Vertical subsidence from the mining of the planned bord and pillar panels is expected to be less than 100mm and generally less than 30mm within the EP Areas.

- Tilt of less than 2.0mm/m.
- Tensile strain of approximately 0.5mm/m.
- Compressive strain of approximately 1.0mm/m.

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Preliminary Risk Assessment Bridges

- Risk Rating for bridges from Table 2
- Or determined by a Specialist)
- For movement to have an adverse impact on a bridge it must be differential
- All horizontal movements to be referred to bridge specialist – get regional bridge engineer involved early

Table 2: Risk Ratings for Bridges

BRIDGES			
Type	**Construction Material**	**Differential**	
		Vert	**Horiz**
Structurally continuous (Picton Rd Interchange)	Concrete	**H**	**R**
	Steel	**M**	**R(M)**
Structurally simply supported (North)	Concrete	**L**	**R**
	Steel	**L**	**R(L)**
Frame bridges	Concrete	**H**	**R**
Cable stayed bridges	Either / All	**M**	**R**
Arch (Picton Rd Interchange)	Masonry	**H**	**R**
	Concrete	**H**	**R(H)**
	Steel	**M**	**R**
Timber	Timber	**L**	**R**
Bridge sized culverts	All / Any	**H**	**R**

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Preliminary Risk Assessment Pavements

- For carriageways, Risk Ratings are assessed separately for:
  - Infrastructure Damage
  - Functionality
  - Safety

Preliminary Risk Assessment Pavements

Infrastructure Damage

- To determine the risk value:
  - Determine the pavement type
  - Determine the strain
  - Determine the risk value from Table 3

Table 3: Risk Rating – Pavement Infrastructure

RISK RATING FOR INFRASTRUCTURE DAMAGE TO PAVEMENT				
Pavement Type	**Strain**			
	≤ 0.3%	**> 0.3% to ≤ 0.5%**	**> 0.5 to ≤ 5%**	**> 5%**
	Risk Ratings			
Full depth asphalt	L	L	M	H
Flexible - No bound layer	L	L	M	H
Bound Pavement	L	M	H	H

Preliminary Risk Assessment Pavements

Functionality

- To determine the risk value:
  - Determine the traffic volume
  - Determine the carriageway classification
  - Determine the risk value from Table 4

Table 4: Risk Rating – Pavement Functionality

RISK RATING FOR PAVEMENT FUNCTIONALITY			
Total Traffic Volume (AADT)	**Carriageway Classification**		
	Auslink	**Freight Route**	**Other**
	Risk Ratings		
< 1,000	L	L	L
≥ 1,000 to < 10,000	M	M	L
≥ 10,000 to < 20,000	H	H	M
≥ 20,000	H	H	H

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Preliminary Risk Assessment Pavements

Safety

Table 5: Safety risks – Pavement damage

SAFETY RISK RATINGS – PAVEMENT DAMAGE			
Pavement Type	**Speed (km/h)**		
	≤ 60	**> 60 to ≤ 80**	**> 80**
	Risk Ratings		
Full depth asphalt	**L**	**L**	**M**
Flexible - No bound layer	**L**	**M**	**M**
Plain Concrete	**M**	**M**	**H**
Continuously Reinforced Concrete Pavement (CRCP)	**M**	**M**	**H**
Asphalt over LMC (Lean Mix)	**M**	**H**	**H**
Bound Layer	**M**	**H**	**H**

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Preliminary Risk Assessment Pavement geometry

- Changes in pavement geometry caused by tilt may increase risks to road users
- More likely to occur if the pavement is directly over, or close to, mining
- Only required for roads is located within the General Application Area

Table 6: Change in Pavement Geometry Risk Ratings

CHANGE IN PAVEMENT GEOMETRY (TILT) RISK RATINGS		
Asset Type	**Tilt**	**Risk Rating**
Pavements where tilt is predicted to occur	**≤ 0.5%**	**L**
	>0.5% and ≤2%	**M**
	> 2.0%	**H**

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Preliminary Risk Assessment Slopes

- Geotechnical and slope risks presented in Table 6
- Risks also to be considered for slopes proposed by the proponent for:
  - Slopes > 5m high
  - The slopes closer to TfNSW infrastructure than a distance equal to twice slope height.
- Details of these slopes to be provided by proponent

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Table 7: Geotechnical and Similar Risk Ratings

GEOTECHNICAL AND SLOPE RISK RATINGS	
Asset Type	**Risk Rating**
Slope – ARL 1	**H**
Slope – ARL 2 95771/95770/13482	**3 X H**
Slope – ARL 3 10839/13483/13484/13485	**4 X R(M)**
Slope – ARL 4	**2 X L**
Slope – ARL 5	**4 X L**
Soil slope with batter steeper than 2(H):1(V) and height > 5m	**R**
Slopes treated with geotechnical measures	**R**
Flexible retaining structures ≤ 5m high,	**L**
Non flexible retaining structure, Flexible retaining structures > 5m high	**R**
Rock slope height > 3 metres	**R**
Geologically complex features	**R**

Preliminary Risk Assessment Tunnels

Table 8: Risk Ratings for Tunnels

TUNNEL RISK RATINGS	
Tunnel Description	**Risk Rating**
All tunnels – regardless of length, width or type of construction	**H**

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Preliminary Risk Assessment Culverts

Table 9: Culvert Risk Ratings

CULVERT RISK RATINGS	
Asset Type	**Risk Rating**
Culvert ARL1	**R**
Culvert ARL2	**R**
Culvert ARL3	**M**
Culvert ARL4	**L**
Multiple culverts	**44 X L**
Culverts > 1200 mm diameter	**6 X R(M)**
All butt jointed pipes and masonry culverts	**R**

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Preliminary Risk Assessment Miscellaneous structures

Table 10: Miscellaneous structure Risk Ratings

MISCELLANEOUS STRUCTURE RISK RATINGS		
Asset Type	**Parameter**	**Risk Rating**
Mono pole structures (road signs) noise walls, barriers etc	**< 2.0% tilt**	**L**
	≥ 2.0% tilt	**R**
VMS gantry portal structures, rest area structures, detention basins	**<1% strain**	**L**
	≥1% strain	**R**

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Holding Company					
Mining Company					
Mine Name / Ref.					
Technical Report Ref.		Date Received			
TfNSW Office		Regional Asset Manager		File No.	

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RISK RATING ANALYSIS and ASSESSMENT

RISK RATING	COMPUTATION	ROW ID	NUMBER
HIGH	Total number of assets that have a HIGH Risk Rating	1	6
MEDIUM	Total number of assets that have a MEDIUM Risk Rating	2	11
LOW	Total number of assets that have a LOW Risk Rating	3	55

TOTAL	Total number of ALL assets with Risk Rating	4 = (1+2+3)	72

ASSESSMENT	COMPUTATION	ROW ID	RESULT
MEDIUM	Calculate number of assets with a MEDIUM Risk Rating as a percentage of the TOTAL number of assets with a Risk Rating	5 = (2 / 4 x 100)	15%

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Risk Rating Analysis and Assessment

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RISK RATING ANALYSIS and ASSESSMENT (Continued)

ACCEPTABILITY	CRITERIA	YES / NO
HIGH > 0	Are there any assets with a HIGH Risk Rating? (Row 1)	Yes
MEDIUM ≥ 50%	Are there 50% or more of the assets with a MEDIUM Risk Rating? (Row 4)	No
MEDIUM > 4	Are there 4 or more assets with a MEDIUM Risk Rating? (Row 2)	Yes

TOLERABILITY	CRITERIA	YES / NO
MEDIUM ≥ 20%	Are there 20% or more of the assets with a MEDIUM Risk Rating? (Row 4)	No

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Possible Mitigation Measures

- Establish a Technical Committee to investigate and manage all mining risks to TfNSW infrastructure, functionality and road user safety
- Regular ground surveys
- Installation of monitoring equipment on critical assets e.g. bridges
- Installation of fibre optic strain monitoring system along sections of critical roads at highest risk
- Regular physical inspections of assets – includes pavements, culverts, bridges etc
- Establishment of rapid response (on call) teams, with equipment and materials, to react to changes in road profiles (including steps, humps, cracks etc)
- Installation of VMS along critical sections of roads
- Cut engineered slots in bound pavements prior to the commencement of mining
- Full briefing of all emergency services of potential risks, including regular updates

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Transport for NSW

Risk Assessment for Panels PC07-08 and PC21-25 Mt Ousley Road

Risk Assessment Report

REP-283741-001

Issue 1 | 8 October 2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 283741-00

Arup Australia Pty Ltd ABN 76 625 912 665

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Document verification

ARUP

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Document title	Risk Assessment Report	**File reference**	
Document ref	REP-283741-001		

Revision	**Date**	**Filename**			
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		Name	Jenny Li	Nigel Cann	Nigel Cann
		Signature			
Issue 1	08 Oct 2021	Filename			
		Description	Issue incorporating comments from DC and HB.		
			Prepared by	Checked by	Approved by
		Name	Jenny Li	Jenny Li	Nigel Cann
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
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		Name			
		Signature			

Issue Document verification with document ✓

Contents

Executive Summary

A risk assessment has been completed to assess the risks to Transport for NSW (TfNSW) assets from the proposed mining of panels PC07-08 and PC21-25 by Wollongong Coal Limited (WCL).

Previous assessments were completed on the impacts due to the extraction of longwalls LW4-5 (2011), and longwalls LW6-7 (2014). A history of the impacts of subsidence has been gained, along with knowledge about the performance of mitigation control measures applied, and the reliability of the monitoring systems utilised.

The subsidence limits provided in this report relate to subsidence over proposed bord and pillar panels and previously mined areas. TfNSW infrastructure is generally located away from these areas and subsidence impacts are generally expected to be of a similar order to impacts from the earlier WCL longwall mining panels.

The expected subsidence from the proposed mining of PC07-08 and PC21-25 is less than 100mm and is very unlikely to lead to perceptible impacts to TfNSW infrastructure. For comparison, the subsidence from previous longwall mining was approximately 1800mm. The focus of this risk assessment addresses the contingency case if subsidence of greater than 100mm results. Given approximately 1800mm of subsidence was experienced during previous longwall extraction, the worst case subsidence from PC07-08 and PC21-25 is estimated to be 500mm, and this value is used in this contingency case for the risk assessment.

Arup has assessed the risks through a workshop with relevant stakeholders to determine impacts of the mining activities on the road infrastructure, functionality and road safety, and identify appropriate risk mitigation measures. The risks and risk mitigation measures are recorded in a Risk Register. The TfNSW risk criteria has been used to assess the risks.

For PC21-25, the only assets within five times the depth of cover, is a section of the Mt Ousley Road carriageway and small culverts. The worst case subsidence of 500mm is not considered to present a credible risk to these assets (i.e. the level of possible impacts is insignificant).

A total of 24 risks have been identified for PC07-08 for the worst case subsidence of 500mm. 13 events were not considered to present a credible risk (i.e. the level of possible impacts is insignificant). All risks have been reduced to medium or low with the implementation of risk mitigation measures.

The risks and mitigation measures identified in this risk assessment will be addressed and managed in the Built Features Management Plan following consultation with TfNSW.

1 Introduction

Arup has been engaged by the Transport for NSW (TfNSW) to undertake an assessment of the risks to TfNSW infrastructure associated with the extraction of panels PC07-08 and PC21-25 by Wollongong Coal Limited (WCL). The proposed mining activities are in the vicinity of Mount Ousley Road.

Previous assessments were completed on the impacts due to the extraction of longwalls LW4-5 (2011), and longwalls LW6-7 (2014). A history of the impacts of subsidence has been gained, along with knowledge about the performance of mitigation control measures applied, and the reliability of the monitoring systems utilised.

The subsidence limits provided in this report relate to subsidence over proposed bord and pillar panels and previously mined areas. TfNSW infrastructure is generally located away from these areas and subsidence impacts are generally expected to be of a similar order to impacts from the earlier WCL longwall mining panels.

As with the previous assessments, the concerns of TfNSW are the potential impacts from the mining activities on its surface assets with a specific emphasis on how the mining might result in loss of functionality of the assets with regards to the users (motorists and public), possible life safety issues, and damage to infrastructure and cost of reinstatement.

2 Description of Mining Activities

WCL operates the Russell Vale Colliery in the Southern Coalfield of NSW. WCL is proposing to extract coal from panels PC07-08 and PC21-25 using bord and pillar mining techniques (refer to Figure 1).

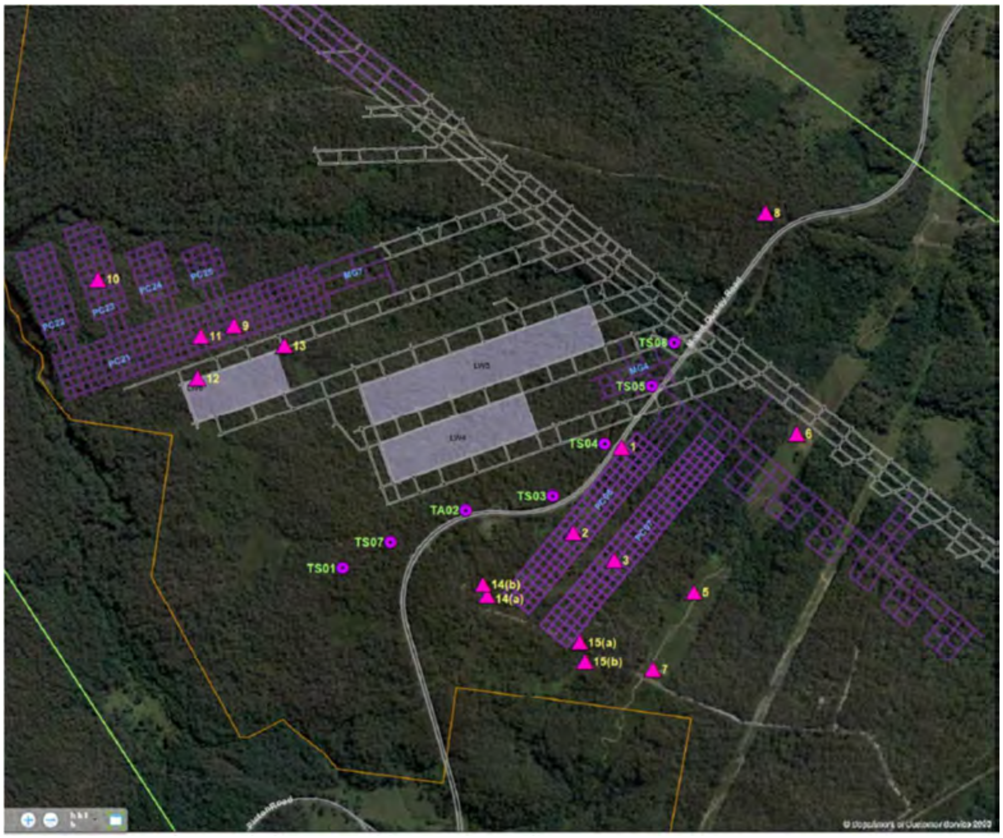


Figure 1: Site Layout

The proposed extraction plan is as follows:

- Stage 1(a): Mining of panels PC21-25, on the western side of Mount Ousley Road.
- Stage 1(b): Mining of panels PC07-08, on the eastern side of Mount Ousley Road.

Strata Control Technologies (SCT) has undertaken an assessment of the subsidence and geological impacts from the previous mining activities and predictions for the mining of PC07-08 and PC21-25. Refer to Appendix A for more details on the mining activities.

3 TfNSW Assets

As with the previous risk assessments, TfNSW assets within five times the depth of cover, are considered. For PC21-25, this includes a section of the carriageway.

For PC07-08, the assets considered in the risk assessment include:

- Carriageway.
- Bridges.
- Culverts.
- Cuttings.
- Embankments.
- Mono pole structures, e.g. road signs, noise walls, barriers.
- Variable Message Sign (VMS).

Figure 2 shows the key assets for consideration in the risk assessment.

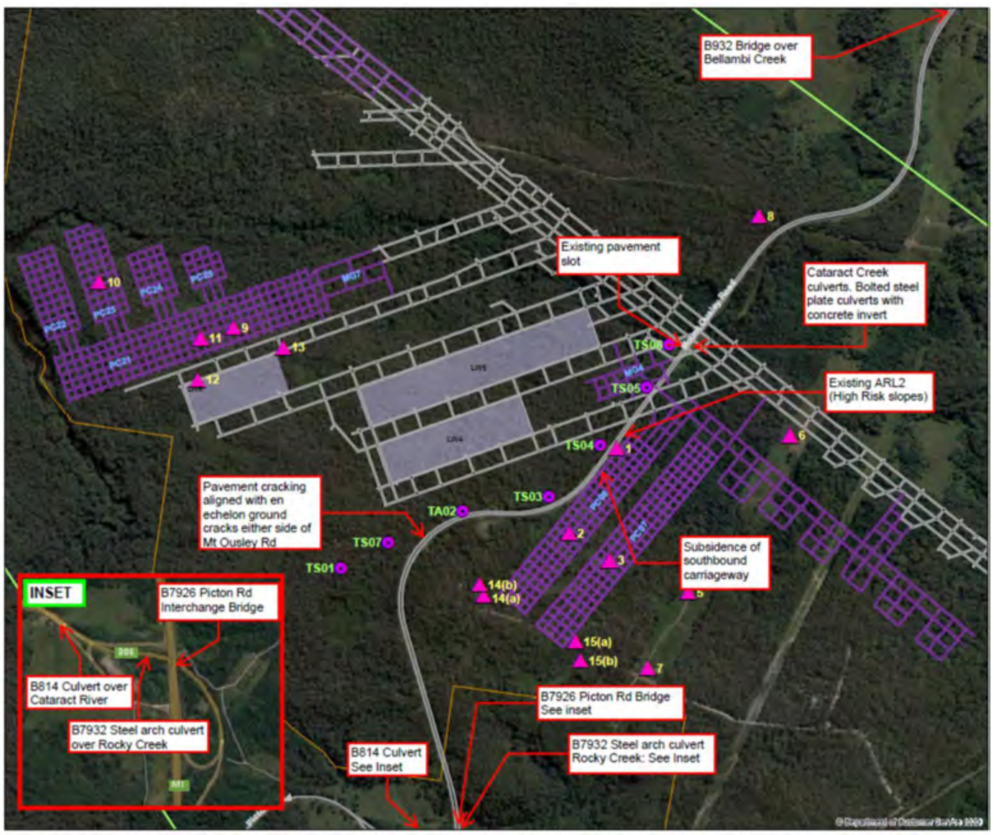


Figure 2: Key TfNSW Assets

4 Predicted Impacts

SCT has undertaken an assessment of the subsidence and geological impacts from the previous mining activities and predictions for the mining of PC07-08 and PC21-25 (refer to Appendix A).

The expected subsidence and impacts from the mining activities is summarised in Table 1.

Table 1: Expected Subsidence

First workings (approximately 25% extraction over area of panel)	Second (bord and pillar) workings (approximately 33% extraction over area of panel)
Expected subsidence less than 100mm directly over the panels	Expected subsidence less than 100mm directly over the panels
Movements at the surface barely perceptible	Movements at the surface barely perceptible
Large, long-term stable pillars	Large, long-term stable pillars
No potential for significant interaction with overlying Bulli Seam	No potential for significant interaction with overlying Bulli Seam
No perceptible movements on Mount Ousley Road	Movements on Mount Ousley Road less than 20mm

For comparison, the subsidence from previous longwall mining was approximately 1800mm. As a result, the expected subsidence from the proposed mining of PC07-08 and PC21-25 of less than 100mm is very unlikely to lead to perceptible impacts.

This area has also been subject to mining in the past. Any subsidence risk from legacy mining exists irrespective of further mining. The Bulli and Balgownie Seams, which are above the Wongawilli Seam, were previously mined several decades ago. The most recent longwall mining has resulted in possible ongoing closure movements at Cataract Creek (< 20mm).

5 Management Strategy

To manage the potential of legacy mining impacts (which exist irrespective of the proposed mining) and impacts due to the proposed mining, the following monitoring measures are proposed:

- Broad area LIDAR.
- Underground observations of roadway conditions.
- Valley closure monitoring.
- Subsidence monitoring by GNSS units.

In addition, to manage the potential of experiencing greater than 100mm of subsidence, contingency measures are made, including:

- Mining in Stage 1(a) to occur first as PC21-25 are remote from TfNSW assets.
- Mining in Stage 1(b) (PC07-08) will only occur if subsidence of less than 100mm is confirmed in PC21.
- Using a flexible mining system that can be modified to reduce subsidence.
- Undertaking the Technical Committee process (including this risk assessment).

A number of controls measures and monitoring systems were identified and employed in controlling the risks posed by previous longwall mining. These were considered to have operated effectively and reliably, and the observed impacts from the previous longwall mining have been used to inform this risk assessment.

Of note is a slot that was installed on the Mount Ousley Road embankment above Cataract Creek (after LW4 and before LW5) as part of the Management Plan for LW4-5. The slot experienced approximately 11mm of closure during the mining of LW5 and resulted in a bump in the slot surface that required milling to reinstate rideability. However no significant compression has been experienced in the pavement in the vicinity of Cataract Creek due to the existence of the slot. The slot can accommodate compressive forces generated by up to 40m of pavement length on either side of the slot. The workshop group discussed that the slot has been performing as expected and that it is in the appropriate position.

6 Risk Assessment Process

TfNSW has undertaken a preliminary risk assessment, which indicated that there are risks to TfNSW that exceed the preliminary acceptability limits (refer to Appendix B). This risk assessment aims to resolve these matters.

Arup has assessed the risks through a workshop with relevant stakeholders to determine impacts of the mining activities on the road infrastructure, functionality and road safety, and identify appropriate risk mitigation measures.

Risks and risk mitigation measures have been recorded in a Risk Register, based on the same format as with previous risk assessments. The risk assessment will form part of the Built Features Management Plan.

The process adopted by Arup follows closely the principles set out in ISO31000:2018 – Risk Management, and also the various standards of TfNSW, specifically those relating to the assessment of subsidence risks posed by mining.

Since the expected subsidence is less than 100mm which is likely to have no perceptible impacts to TfNSW assets (refer to Section 5), the focus of this risk assessment addresses the contingency case if subsidence of greater than 100mm results. Given approximately 1800mm of subsidence was experience during previous longwall extraction, the worst case subsidence from PC07-08 and PC21-25 is estimated to be 500mm, and this value is used in this contingency case for the risk assessment.

The two stages of mining are considered separately due to their proximity to TfNSW assets.

6.1 Risk Rating

The rating of risks involves two criteria: the likelihood of the adverse event occurring and the severity of its consequences. The combination of the likelihood and the severity gives the risk. Arup has used TfNSW risk criteria, as presented in Appendix C.

The risk rating is performed twice. The initial risk rating is without any risk mitigation measures, and the residual risk rating is after the implementation of the risk mitigation measures.

7 Risk Workshop

The risk workshop was held in a virtual Teams meeting on 17 September 2021. The purpose of this workshop was to assess the risks posed to the assets of the TfNSW from the proposed mining activities of PC07-08 and PC21-25.

The workshop discussions were recorded using Google Jamboard, a digital collaborative tool. An output of the Jamboard, including the workshop agenda and attendance, is provided in Appendix D.

8 Risk Register

The discussions from the workshop have been recorded in the Risk Register, which is provided in Appendix E, and attached separately as an excel file.

The two stages of mining are considered separately due to their proximity to TfNSW assets. The risk register is split into a section for PC21-25, and a section for PC07-08.

The format Risk Register follows the previous risk assessments, and the contents of the previous assessments are included as a separate tab in the excel file.

9 Findings

9.1 PC21-25

For PC21-25, the only assets within five times the depth of cover, is a section of the Mt Ousley Road carriageway and small culverts. The worst case subsidence of 500mm is not considered to present a credible risk to these assets (i.e. the level of possible impacts is insignificant).

9.2 PC07-08

A total of 24 risks have been identified for PC07-08 for the worst case subsidence of 500mm. 13 events were not considered to present a credible risk (i.e. the level of possible impacts is insignificant).

The risk profile, before and after the application of additional mitigation and control measures, is shown in Table 2 below. The residual risk profile has no extreme or high risks.

Table 2: Base and Residual Risk Profiles for PC07-08

Risk Level	BASE RISK LEVELS				RESIDUAL RISK LEVELS			
	Infra.	Funct.	Safety	Total	Infra.	Funct.	Safety	Total
E	0	0	0	0	0	0	0	0
H	3	3	0	6	0	0	0	0
M	6	5	1	12	4	4	0	8
L	2	2	1	5	7	6	2	15

10 Risk Mitigation Measures

The risk mitigations measures are summarised below (for more detail, refer to the Risk Register in Appendix E):

- Undertake a baseline condition survey of the carriageway, bridge B7932 (steel arch culvert over Rocky Creek), and bridge B814 (culvert over Cataract River) before mining.
- Reinstate or assess alternatives to the P-Line survey on southbound carriageway.
- Check condition of crack meters and replace if necessary.
- Check the physical condition of the slot.
- Mill or mill and resheet the slot if required. Note schedule any works with other road closures / road works if possible.
- Assess during mining, the nature of any movements (perform crack sealing if required).
- Assess post mining, if crack sealing is sufficient or if further treatment is required.
- Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline.
- Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system.
- Monitor GNSS and undertake subsequent survey of Cataract Creek culverts if trigger levels reached.
- Use precondition assessments of the culverts from longwall mining as baseline.
- Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining.

- Groom slopes prior to mining.
- Use GNSS monitoring to provide early warning of impacts to the slopes.
- TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.
- Develop TARP with trigger points for various actions.

The risks and mitigation measures identified in this risk assessment will be addressed and managed in consultation with TfNSW in the Built Features Management Plan.

11 Conclusions

A risk assessment has been completed to assess the risks to TfNSW assets from the proposed mining of PC07-08 and PC21-25. A number of risk mitigation measures have been identified. All risks are reduced to medium or low. The risks and mitigation measures identified in this risk assessment will be addressed and managed in consultation with TfNSW in the Built Features Management Plan.

Appendix A

Overview of Subsidence for TfNSW Risk Assessment

Subsidence Overview for TfNSW Risk Assessment: Wollongong Coal Russell Vale East PC21-25 and PC07&08

Ken Mills 17/9/2021

Geotechnical consulting, research and instrumentation for mining and civil industries.

SCT

Overview of Presentation

- Key Message
- Site description
  - Mining context
  - Surface features
- Expected subsidence to be monitored
  - From proposed first and "second" (bord and pillar) workings mining <100mm
  - Existing risk of historical legacy mining in Bulli Seam (very, very, unlikely, but possibly >500mm over small areas)
  - Ongoing effects from recent longwall mining (horizontal closure <20mm)
- Strategies
  - Staging of the mining program and extraction plan to confirm subsidence is less than 100mm
  - Contingency is based on flexible mining method easily adaptable to unexpected or unfavourable mining conditions
  - Subsidence monitoring of proposed mining via GNSS units: accurate (<20mm), three dimensional, continuous, accessible to all interested parties at locations of interest in near-real-time
  - Monitoring of TfNSW infrastructure including from recent longwall mining in Wongawilli Seam
    - Re-establishment of and continued monitoring of valley closure monitoring (±5mm)
    - Slot and GNSS closure monitoring
  - Monitoring of legacy mining in Bulli Seam
    - LiDAR for overall coverage and confirmation no significant subsidence across the site (±200mm)
    - Underground monitoring of roadway conditions approaching Bulli Seam goafs

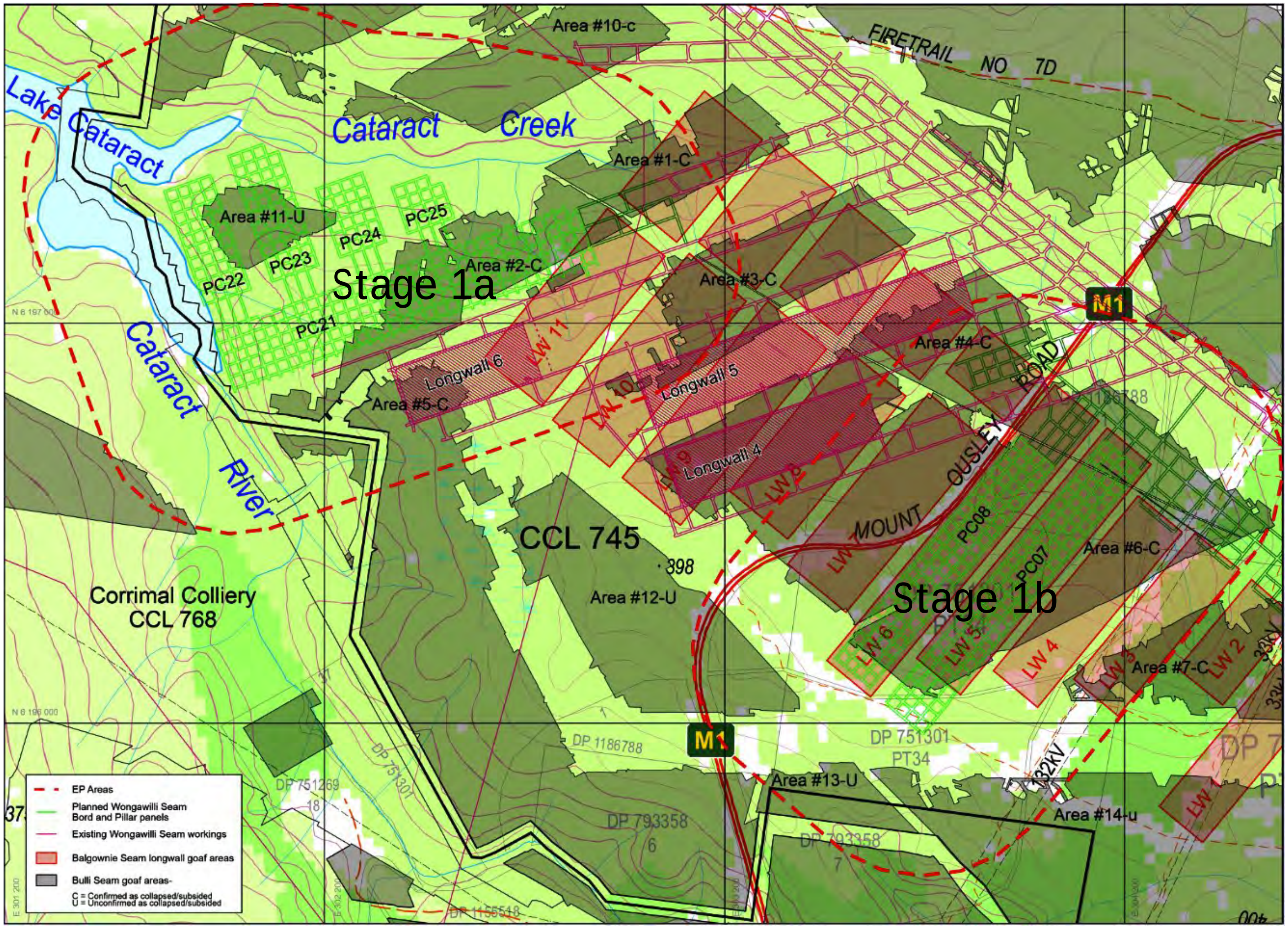
Key Messages

- Expecting subsidence less than 100mm (i.e. much less than longwall subs 1800mm)
  - No perceptible impacts

- Managing contingency of potential for greater than 100mm by staging extraction
  - Stage 1(a) – Remote from infrastructure (PC21-25 and further west)
  - Stage 1(b) – Offset from infrastructure (PC07 & PC08)
  - Flexible mining system that can be modified to reduce subsidence
  - Mining in Stage 1(b) (PC07 & PC08) will only commence once subsidence confirmed as less than 100mm in PC21
  - Technical Committee Process involving TfNSW, RR and Assessment

- Some very low potential for legacy mining impacts that exists irrespective of proposed mining
  - Managed by
    - Broad area LIDAR
    - Underground observation of roadway conditions
    - Valley closure monitoring

Site Description



Mining Context:

Three seams of mining with complete mining records now available

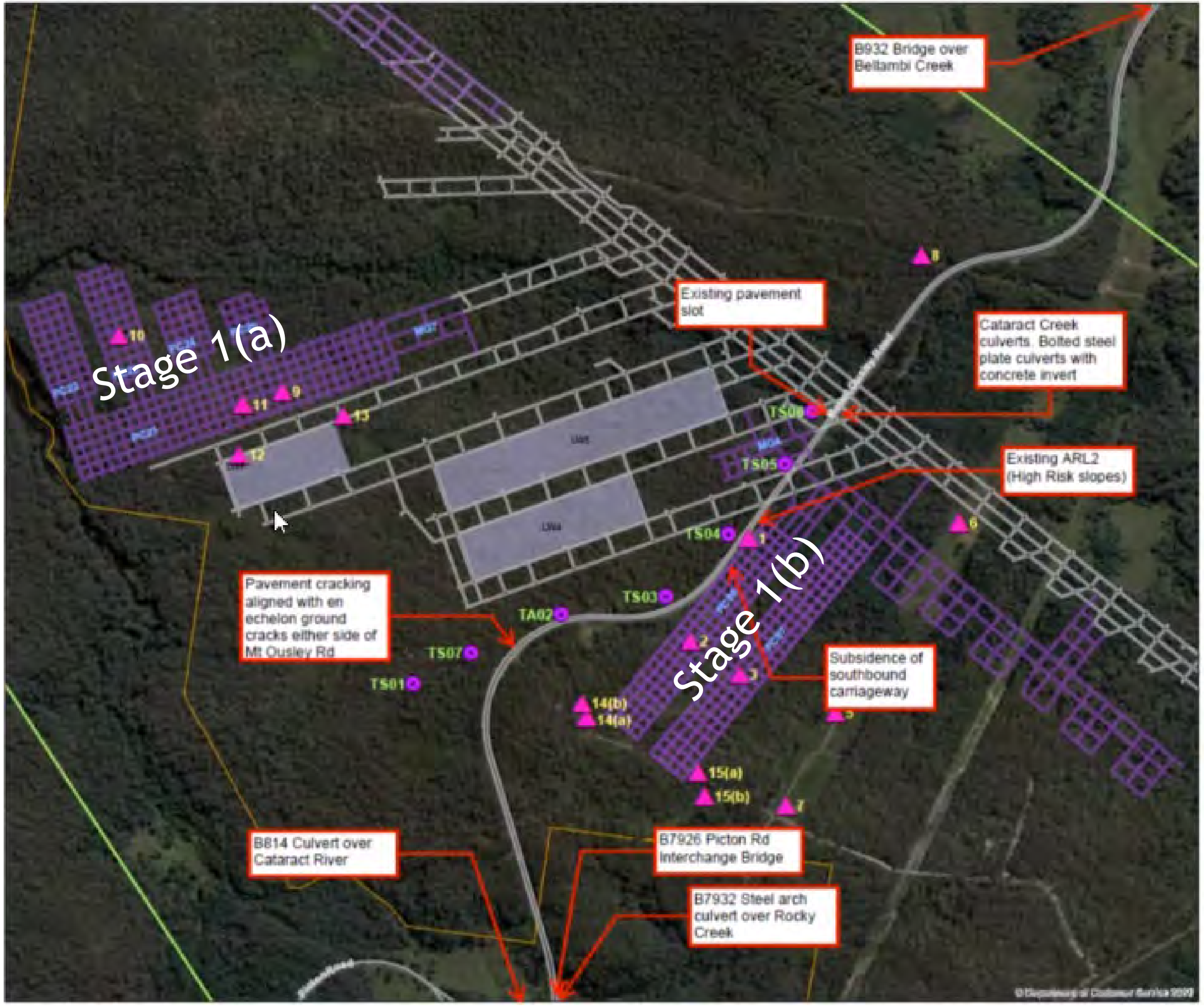
Subsidence monitoring available for Balgownie and Wongawilli

Previous subsidence to 3.7m

Expect <100mm over panels shown in green

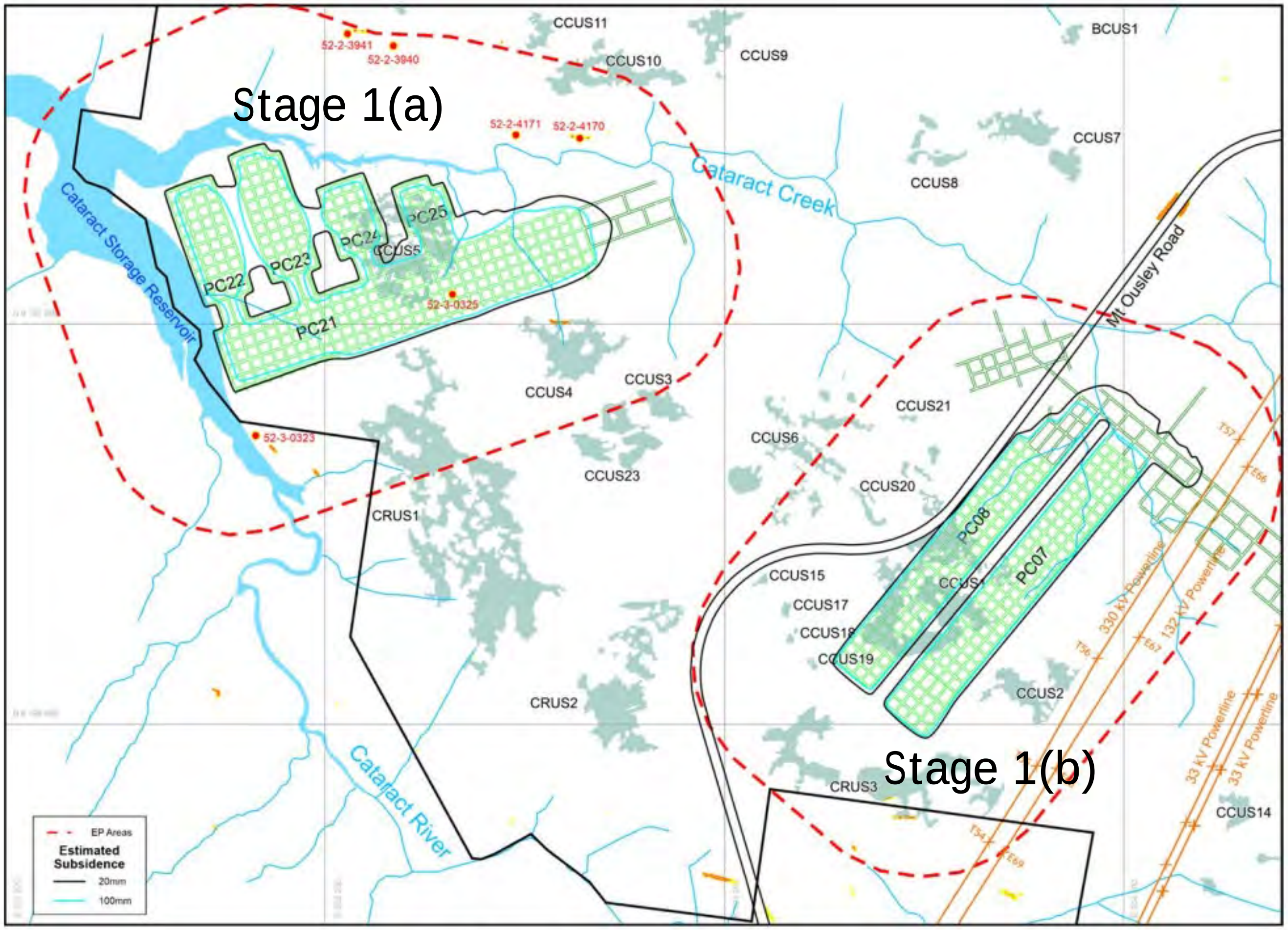
No large scale subsidence below adjacent terrain

Site Description

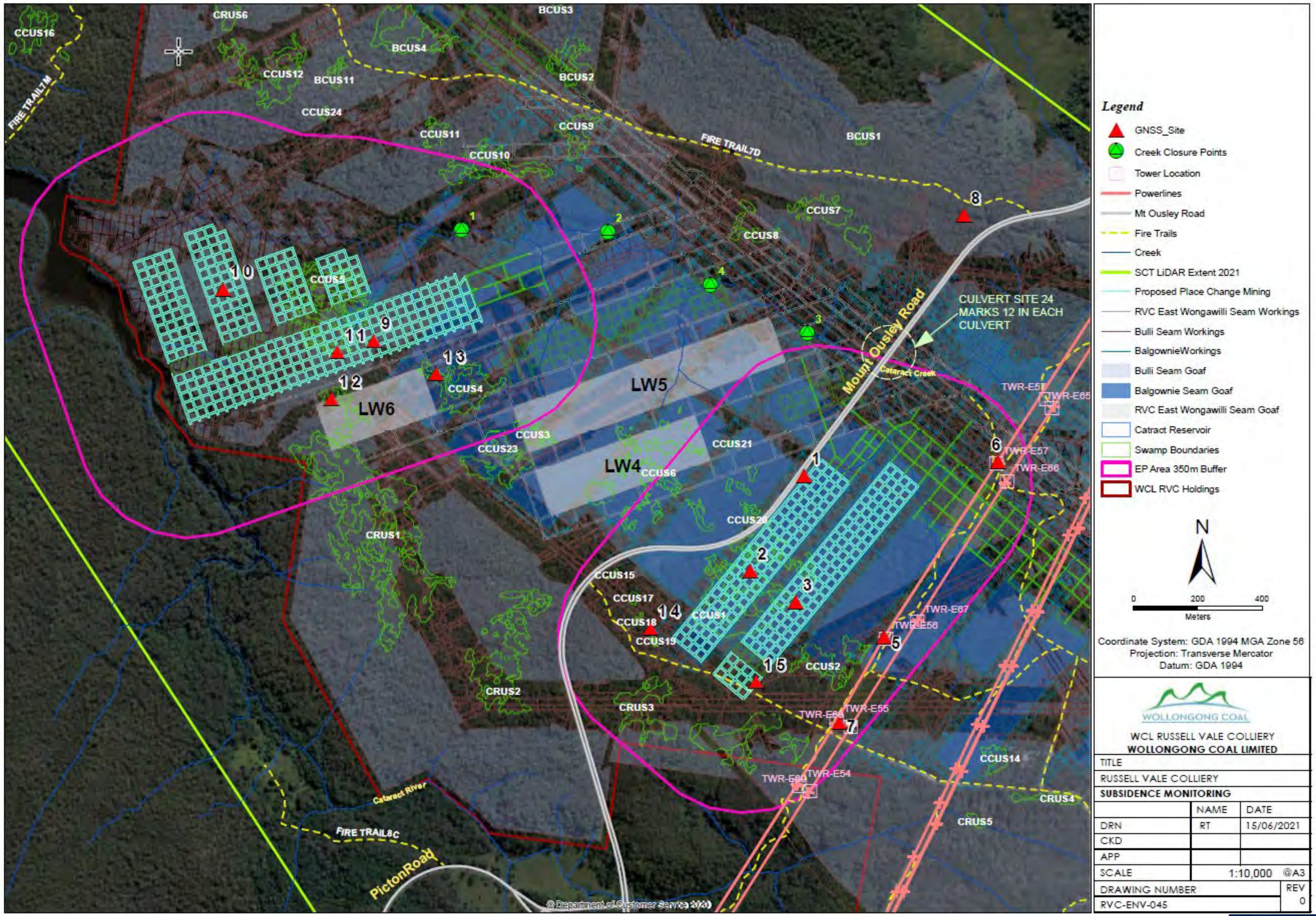


TfNSW Assets

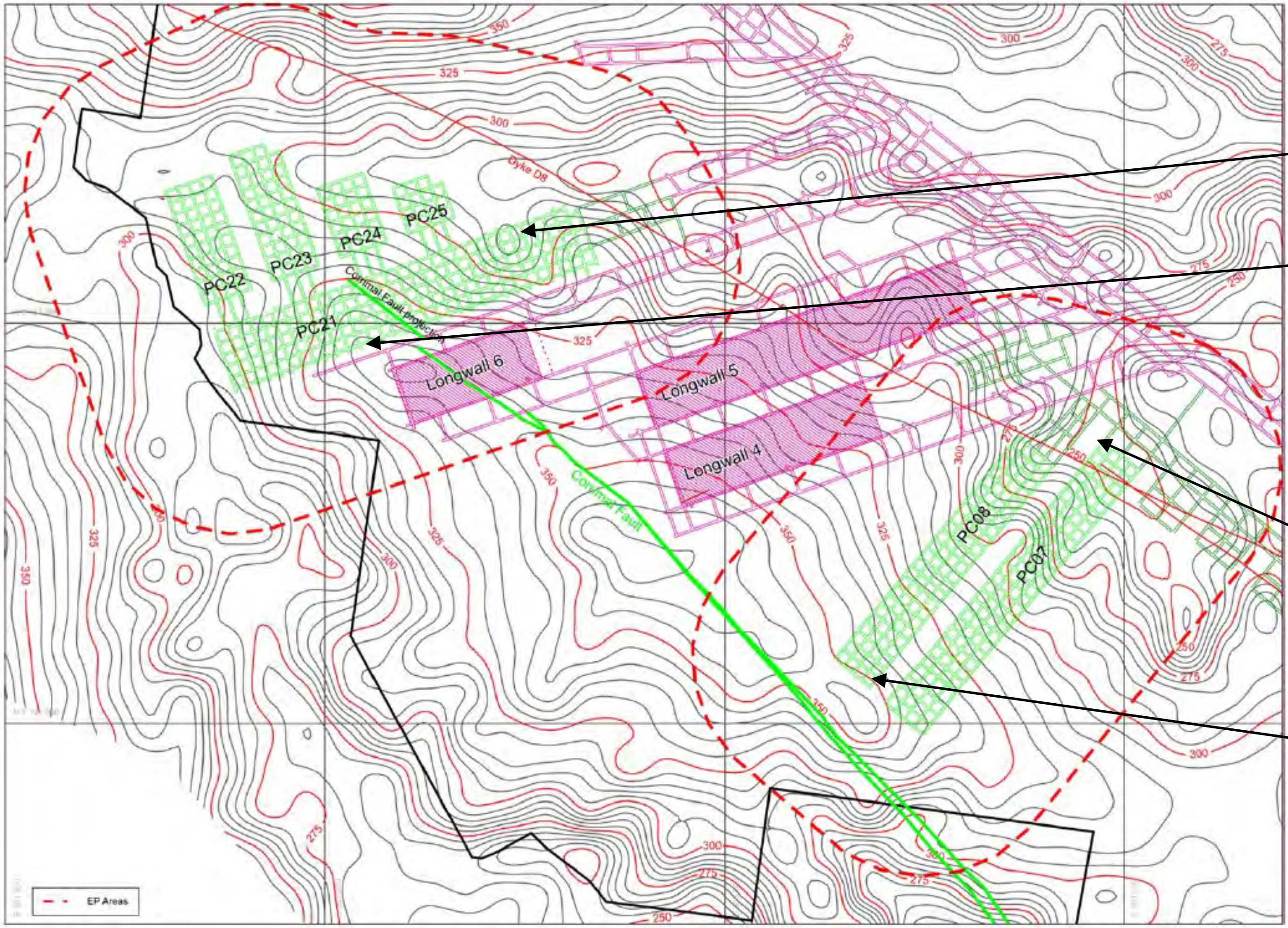
Subsidence and Surface Features



Subsidence and Surface Features



Overburden depth



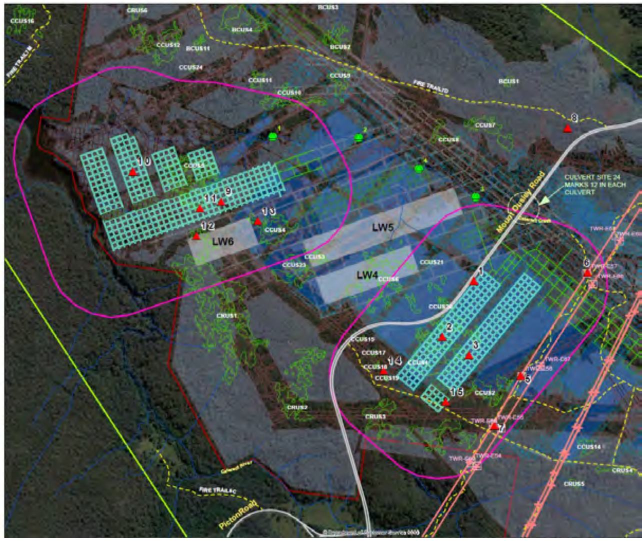
Minimum 285m

Maximum 340m

Minimum 250m

Maximum 350m

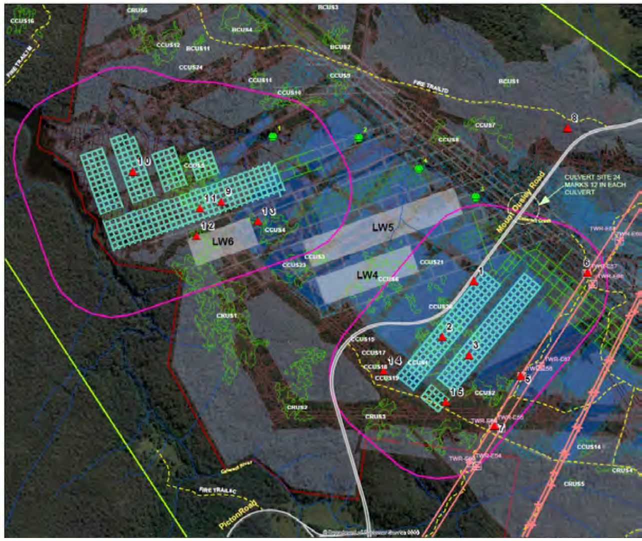
Extraction Plan Staging and Contingency Plan



- Extraction plan has been developed for Year 1 mining
  - Stage 1 extraction Plan to be comprised of
    - Stage 1(a) mining on western side of Mount Ousley Road where there is no infrastructure on panels PC 21-25
    - Stage 1(b) mining on the eastern side of Mount Ousley Road

- Contingency Plan (Consent Condition)
  - If subsidence over Stage 1(a) is greater than 100mm then Stage 1(b) will not commence until the mining system has been refined in areas remote from surface infrastructure to maintain subsidence less than 100mm.
  - To be developed through TfNSW risk assessment process to meet all TfNSW requirements to maintain Mount Ousley Road as safe, serviceable and repairable throughout the period of mining.

Expected Subsidence from Proposed Mining



First workings: approximately 25% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- Movements at the surface barely perceptible
- Large, long-term stable pillars
- No potential for significant interaction with overlying Bulli Seam
- No perceptible movements on Mount Ousley Road

“Second” (bord and pillar) workings: approximately 33% extraction over area of panel

- Expected subsidence less than 100mm directly over the panels
- Movements at the surface barely perceptible.
- Large, long-term stable pillars.
- No potential for significant interaction with overlying Bulli Seam.
- Movements on Mount Ousley Road less than 20mm.

Existing Hazards from Legacy Mining: Bulli, Balgownie & Wongawilli Seam Mining

Any subsidence risk from legacy mining exists irrespective of further mining

Bulli Seam goaf areas (14 in total)

- No further subsidence expected in vicinity of planned mining
- Mine plans confirm all areas indicated as goaf are extracted and collapsed
- All 7 of 7 goaf areas able to be independently confirmed as collapsed are collapsed
- Other 7 goaf areas are expected to be collapsed but have not yet been confirmed so
- Borehole NRE1 over main heading pillars confirms stable pillars
- Borehole RV16 through Bulli Seam goaf confirms collapse
- Roadway conditions in Wongawilli Seam confirms collapse
- Previous surface cracking on Mount Ousley Road confirms collapse

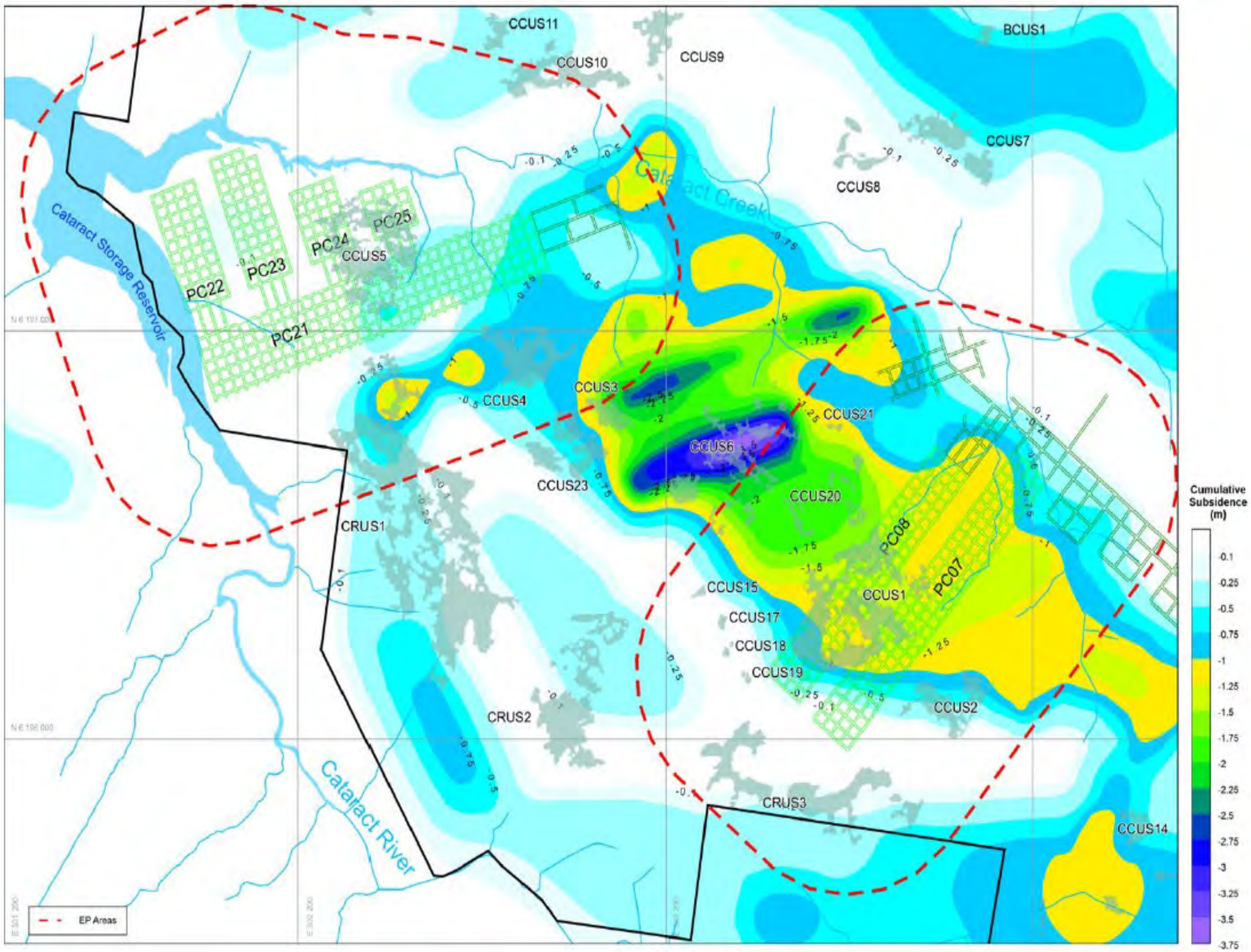
Balgownie Seam Goaf Areas

- No further subsidence expected
- Complete subsidence records confirming full subsidence

Legacy of recent longwall mining

- Possible ongoing closure movements at Cataract Creek (<20mm)
- No evidence of further road cracks

Legacy Subsidence:
Bulli, Balgownie & Wongawilli Seam Mining



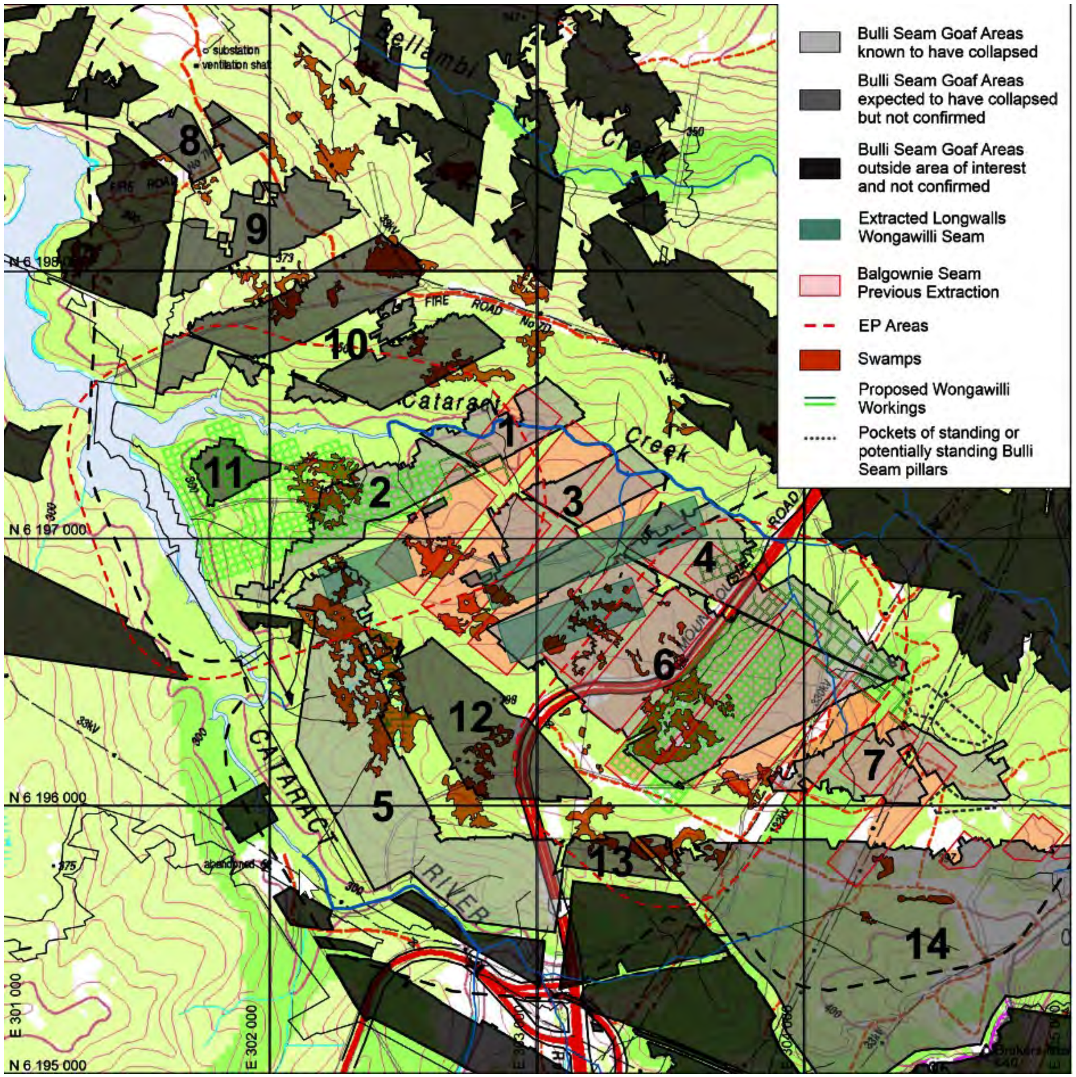
Bulli Seam Up to 1m

Balgownie Seam
up to 1.4m more

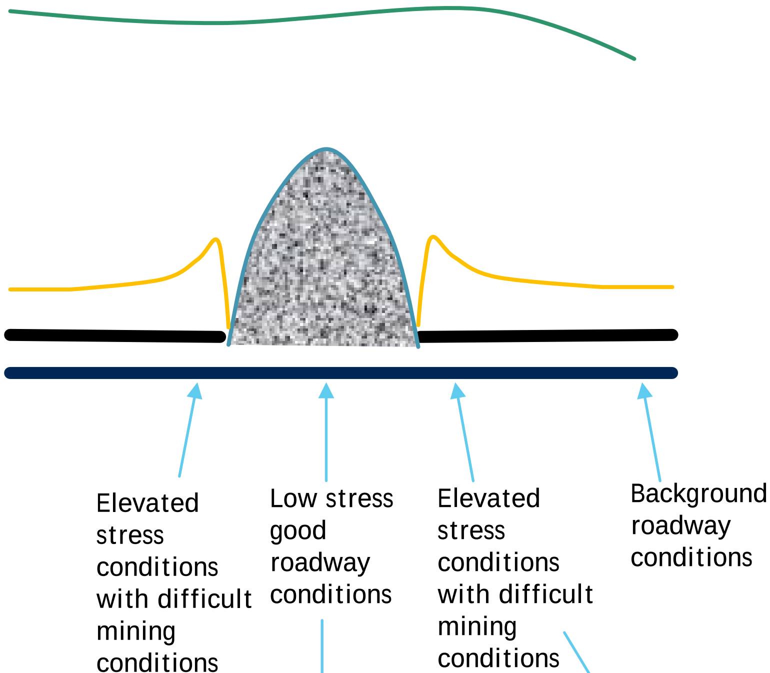
Wongawilli Seam
up to 1.8m more

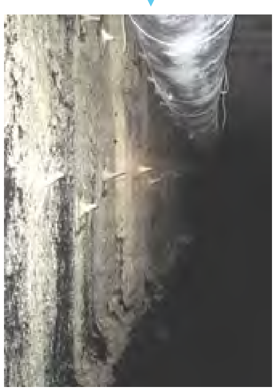
But only a few small areas where all three seams have secondary extraction at the same location

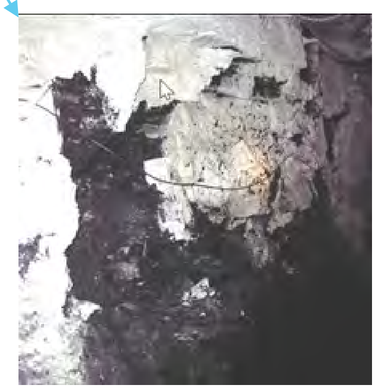
Legacy Subsidence:
Bulli, Balgownie & Wongawilli Seam Mining



Underground roadway condition monitoring

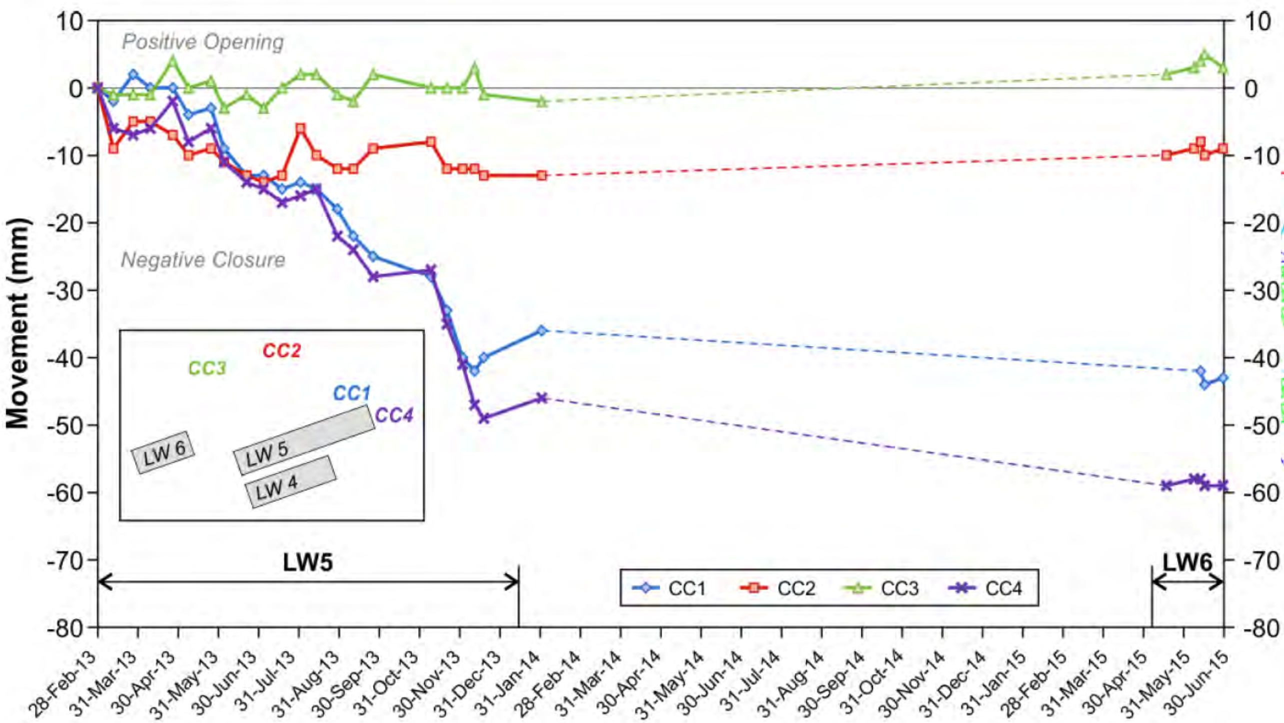


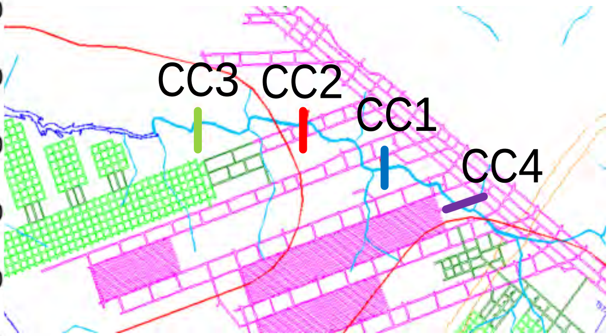


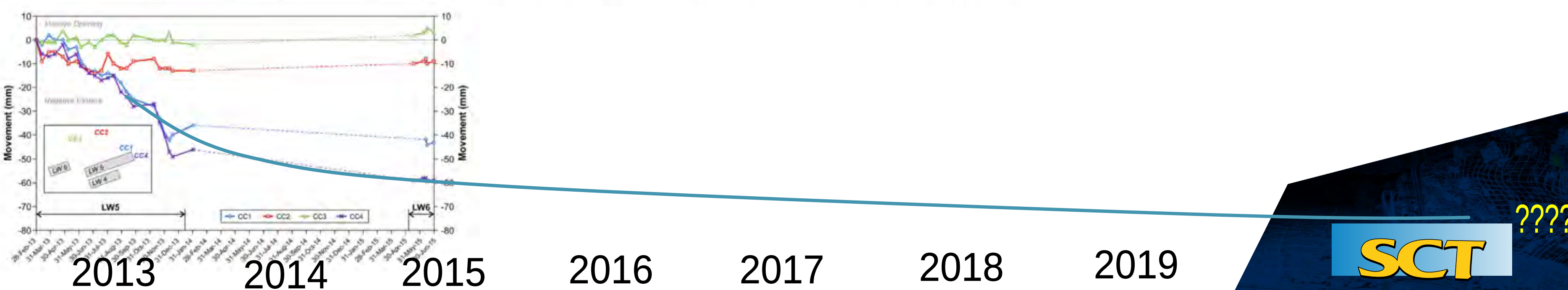


The difference between elevated stress conditions and background roadway conditions is clearly apparent and confirms that a goaf has formed i.e. extracted pillars are not still standing.

Valley Closure Measurements
Legacy of Longwall Mining







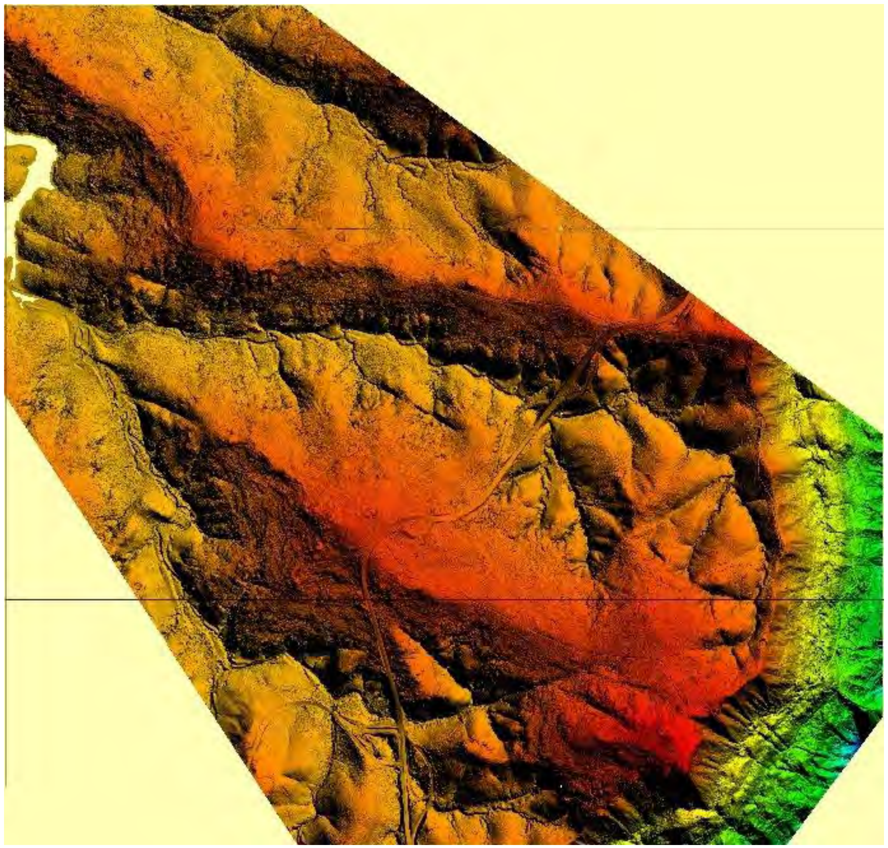
SCT

Performance Criteria

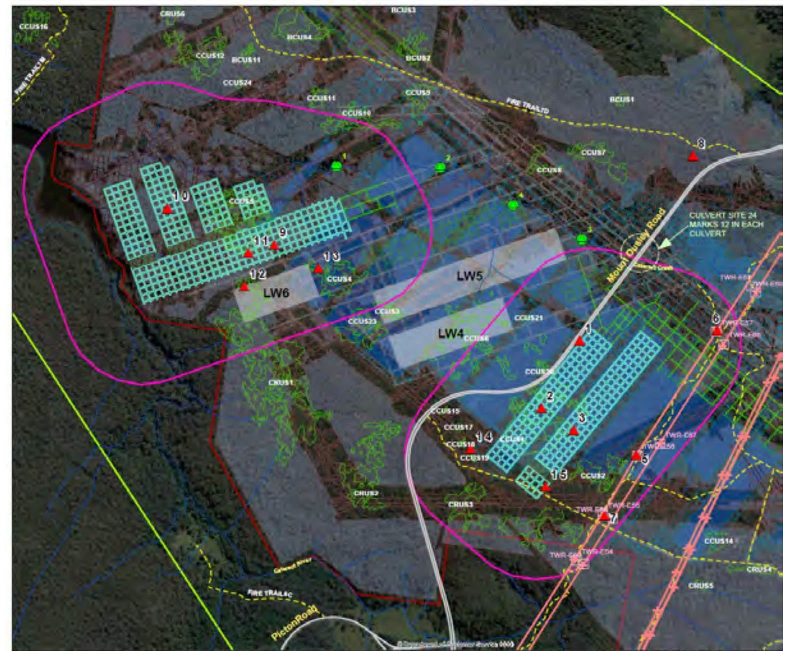
Feature	Performance Measures
Mine workings	
First workings and Second workings	• To remain long-term stable and non-subsiding
Key Public Infrastructure	
M1 Princes Motorway (formally known as Mount Ousley), electricity transmission lines and towers (330kV, 132kV, 2x33kV) and telecommunications line	• Always safe and serviceable • Damage that does not affect safely or serviceability must be fully repairable and must be fully repaired.
Other Infrastructure	
Access roads, fire trails and other public infrastructure and built features	• Always safe. • Serviceability should be maintained wherever practicable. • Loss of serviceability must be fully compensated. • Damage must be fully repairable and must be fully repaired or else replaced or fully compensated.
Public Safety	
Public Safety	• Negligible additional risk
Vertical Subsidence	
All areas of the site affected by the development	• Vertical subsidence limit of not more than 300mm

Proposed Monitoring – TfNSW Assets

LIDAR Survey 31/8/21



GNSS Units



Closure Monitoring at Cataract Creek
Slot Monitoring
Culvert Inspection / Surveys
Crack Opening at crest
Other as determined
in this RA

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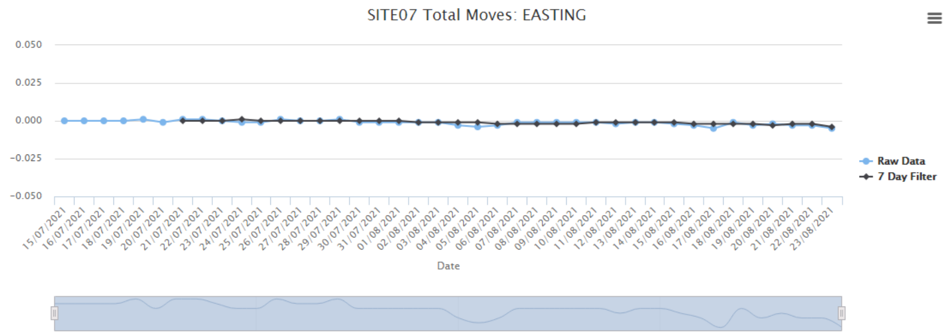
Proposed Monitoring

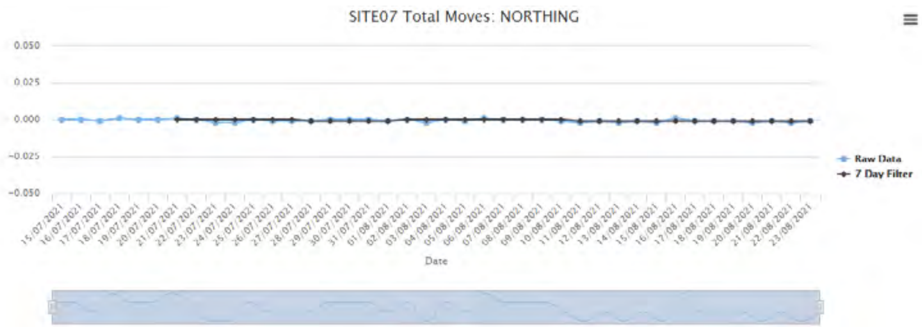
- Valley closure movements expected to be main effect.
- This closure will be monitored by:
    - Near real-time continuous monitoring using GNSS stations on either side of Cataract Creek.
    - Continuous monitoring, downloaded as required of closure across the slot at the crossing point.
    - Periodic inspections of the geometry of the Cataract Creek/ M1 Highway culvert.
    - Periodic surveys of the cracks at the ridge top to the south of Cataract Creek.

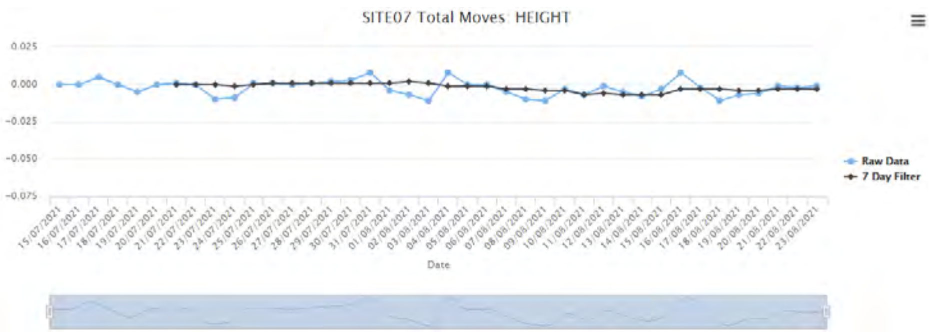
  Note: An initial survey would be made prior to secondary extraction for panels PC 21-25 to confirm new base line for future mining.

    - TfNSW monitoring as per the existing BFMP for previous mining including weekly inspections of the road surface to ensure identification of any surface cracks.

Subsidence Monitoring: GNSS Units





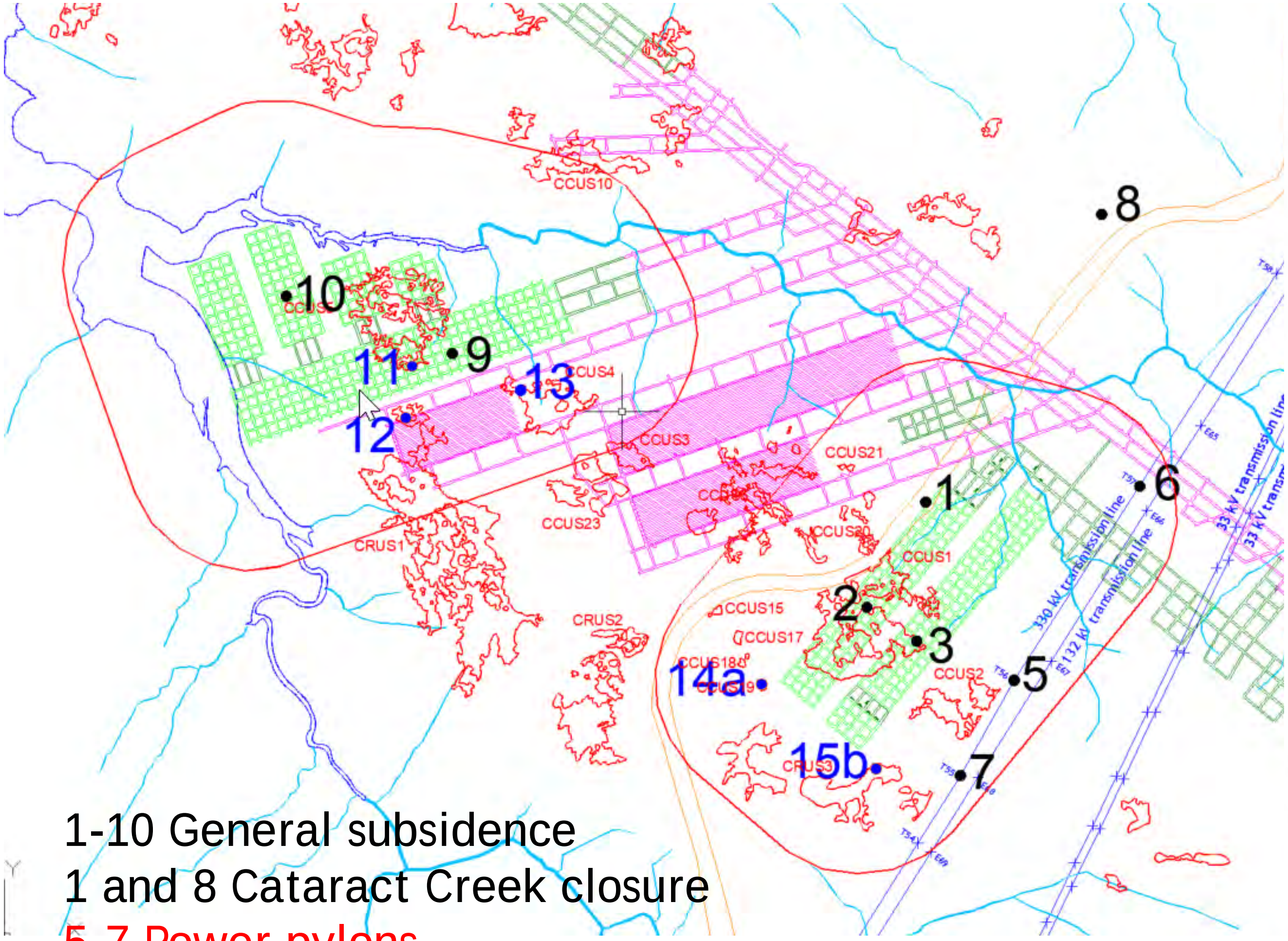


Site 7

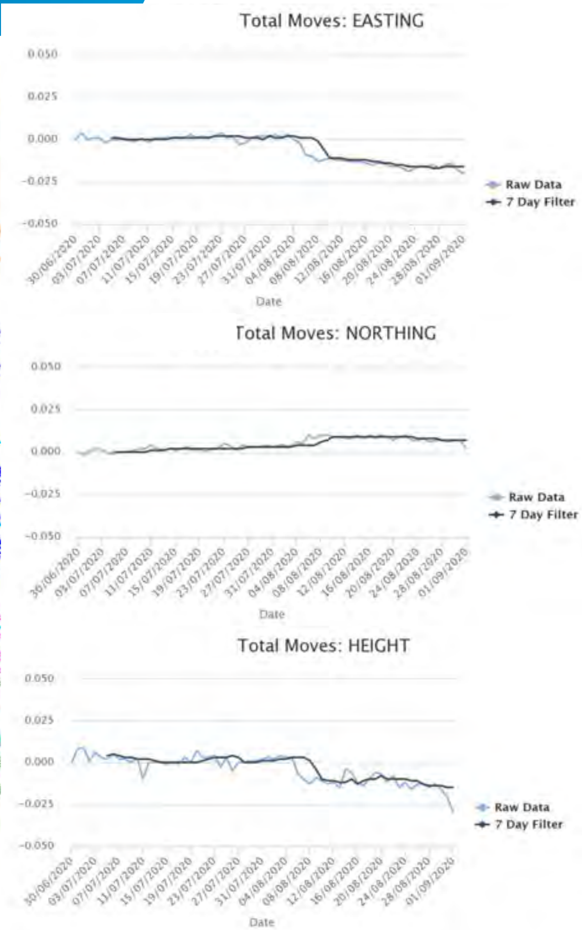
Experience at another site running since 2018

Daily Std Deviation Easting 3mm
Daily Std Deviation Northing 3mm
Daily Std Deviation Height 7mm

Subsidence Monitoring: GNSS Units

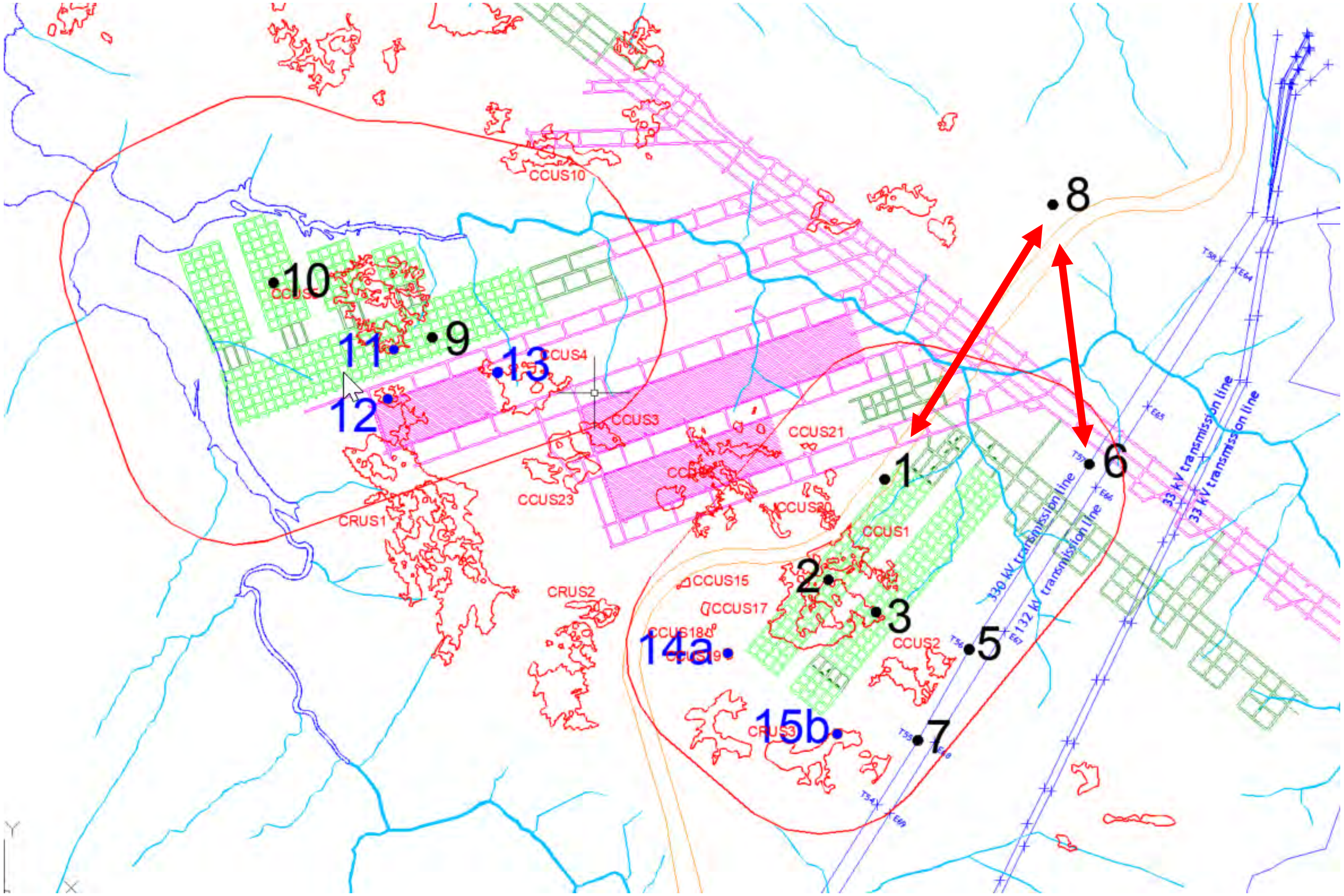


Example Data



1-10 General subsidence
1 and 8 Cataract Creek closure
5-7 Power pylons
11-15 Swamp Specific

Subsidence Monitoring: GNSS Units



Infrastructure Monitoring

Mt Ousley Road closure across Cataract Creek

NB Recent research indicates these towers were in place when Balgownie Seam caused 1.3m of subsidence. Cracks nearby indicate towers are founded in one unit of solid rock.

Subsidence Monitoring: GNSS Units

WCL GNSS Portal

GNSS Units installed and providing near real time data

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Natural and Built Features						
Edge of Mt Ousley Road	GNSS #1	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC08 (Bulli & Balgownie goaf)	GNSS #2	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
PC07 (Bulli & Balgownie goaf)	GNSS #3	General subsidence & at Swamp CCUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
330kV Powerline T56 tower (Balgownie goaf)	GNSS #5	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T57 tower (pillars)	GNSS #6	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
330kV Powerline T55 tower (solid coal)	GNSS #7	General subsidence & at powerlines	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to TG, EE, DPIE, RR
WCL easement (Bulli goaf)	GNSS #8	General subsidence & valley closure	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, RMS, DPIE, RR
PC21 (Bulli goaf #2)	GNSS #9	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC23 (Bulli goaf #11)	GNSS #10	General subsidence	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DPIE, RR
PC21 (Bulli goaf #2)	GNSS #11	At Swamp CCUS5	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (edge Bulli & Wongawilli goaf)	GNSS #12	At Swamp CRUS1	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC21 (Balgownie goaf)	GNSS #13	At Swamp CCUS4	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
West of PC08 (Bulli pillars)	GNSS #14a	At Swamp CCUS19	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
South of PC07 (Bulli pillars)	GNSS #15b	At Swamp CCUS3	3D <20mm	Daily (weekly) until 12 months after cessation of mining	3-monthly or TARP	Website (20 days after period) and email to DAWE, DPIE, RR
Russell Vale East Area-	LIDAR	General subsidence - all surface features	3D ±200mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DAWE, RMS, TG, EE, DPIE, RR
Cataract Creek at CC1, CC2, CC3 and CC4	Hi res survey	Valley closure (upsidence) at CC1-CC4	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to DPIE, RR

Subsidence and Surface Features

Location	Type	Purpose	Data & Accuracy	Monitoring Frequency & Duration	Reporting Frequency	Reporting Timing & Distribution
Infrastructure						
Mt Ousley Road - Pavement	Crackmeter monitoring at Slot	Pavement condition from compression	1D ±1mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Pavement	Hi res survey across extension zone at ridge	Pavement condition from tension	1D ±3mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Mt Ousley Road - Culverts	Direct measurements of Cataract Creek culverts	Drainage and pavement conditions	1D ±1mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
Visual inspections and photos					3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to RMS, DPIE, RR
330kV and 132kV powerlines	3D Position of Towers	Power supply integrity	3D ±20-25mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
330kV and 132kV powerlines	Leg diff measurements	Power supply integrity	1D ±2mm	After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR
Visual inspections including 33kV lines				After each panel or annual or by TARP	3 months after each panel or annual or TARP survey*	Website (20 days after survey) and email to TG, EE, DPIE, RR

Notes – * excludes reporting of incident or non-compliance.

Reporting includes an evaluation of the risk of the 100mm subsidence limit at swamps (EPBC 2020/8702) being reached or exceeded.

Each control survey and subsidiary survey must be planned, surveyed and analysed to ensure they satisfy the conditions to achieve a standard of accuracy as prescribed in ICSM (2007) SP1 (version 1.7) to achieve Class “D” or better (S&DD 2020)

Baseline surveys for GNNS units and LIDAR undertaken prior to the commencement of mining.

Baseline survey (for end of longwall mining) of Mt Ousley Road, Cataract Creek and powerlines undertaken prior to the commencement of mining.

Cessation of mining is taken as completion of mining in adjacent panel.

Key Messages

- Expecting subsidence less than 100mm (i.e. much less than longwall subs 1800mm)
  - No perceptible impacts
- Managing contingency of potential for greater than 100mm by staging extraction
  - Stage 1(a) – Remote from infrastructure (PC21-25 and further west)
  - Stage 1(b) – Offset from infrastructure (PC07 & PC08)
  - Flexible mining system that can be modified to reduce subsidence
  - Mining in Stage 1(b) (PC07 & PC08) will only commence once subsidence confirmed as less than 100mm in PC21
  - Technical Committee Process involving TfNSW, RR and Assessment
- Some very low potential for legacy mining impacts that exists irrespective of proposed mining
  - Managed by
    - Broad area LIDAR
    - Underground observation of roadway conditions
    - Valley closure monitoring

Appendix B

Preliminary Risk Assessment

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Roads & Maritime

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Mining Risk Assessment

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Technical Procedure

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Scope

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Scope

- All mining proposals, open cut or underground, under or adjacent to TfNSW infrastructure
- The process must be used:
  - To ascertain if there are TfNSW assets at risk
  - To assess the level of risk

General Description

- Allows TfNSW to provide preliminary response to the Proponent
- No arbitrary decisions to be made on likely impact on TfNSW assets.
- Response can be one of the following:
  - TfNSW does not object to mining (subject to conditions)
  - Further analyses required to address risks
  - TfNSW objects to mining (unacceptable risks)
- TfNSW only states only that it has no objections (or has objections) to a mining proposal
- TfNSW does not accept a mining proposal

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General Description

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- Procedure can be used for first workings (mine development roads, access shafts or tunnels)
- For these structures, decommissioning plans need to be reviewed to assess long-term impacts on TfNSW infrastructure
- Coal seam gas extraction not considered, but the broad principles contained in the Procedure can be used for guidance for evaluation
- TfNSW and Proponent should develop open relationship for this process

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General Description

Risks Assessed

- Infrastructure
  - Considers damage to pavements bridges, slopes, culverts
- Functionality
  - Loss of amenity and economic loss – does not consider loss of functionality imposed as a preventative measure
- Safety
  - Considers likely accidents, but without mitigation measures.

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Methodology Overview

- Three phase process with escalation to subsequent stage only if requirements are not met
- First two phases completed by the regional office – allows improved communication between TfNSW and proponent – benefits both parties
- Third phase is likely to require external specialist advice

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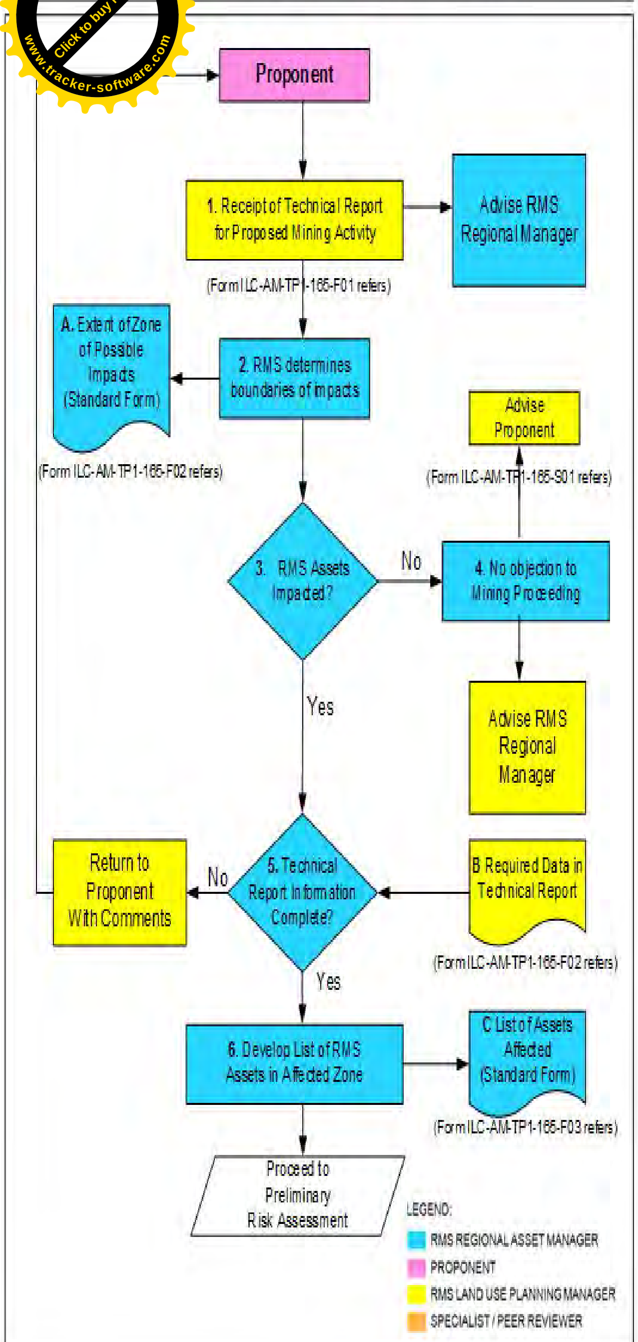
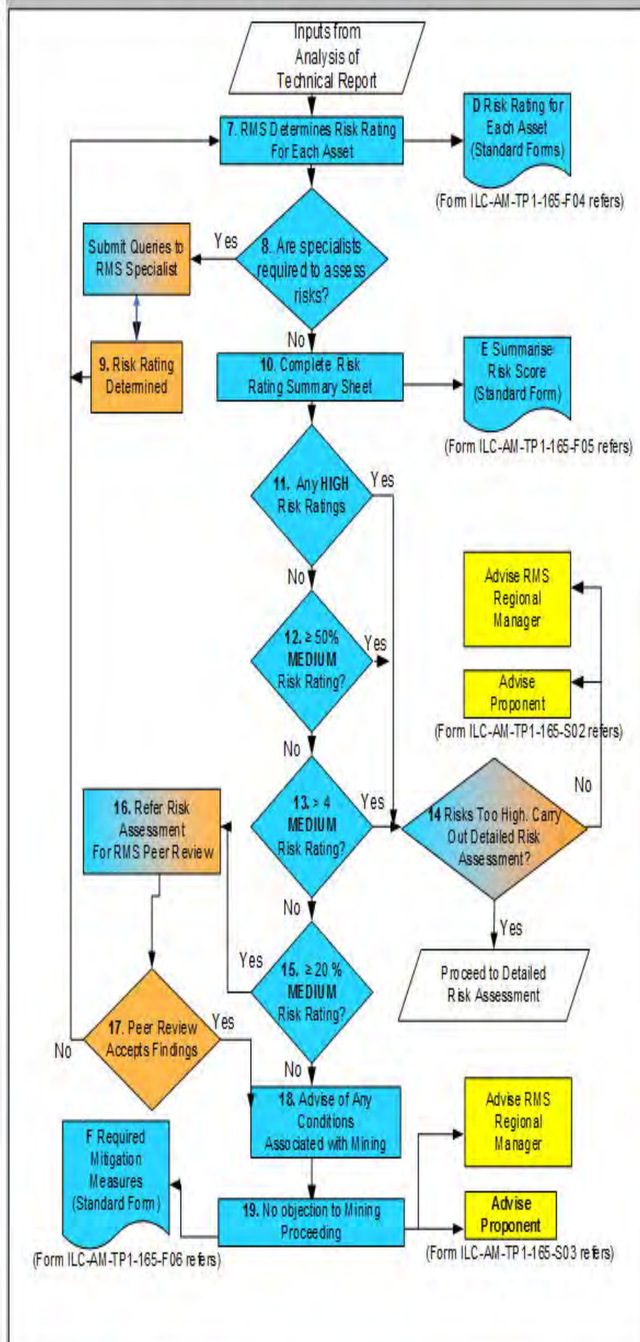
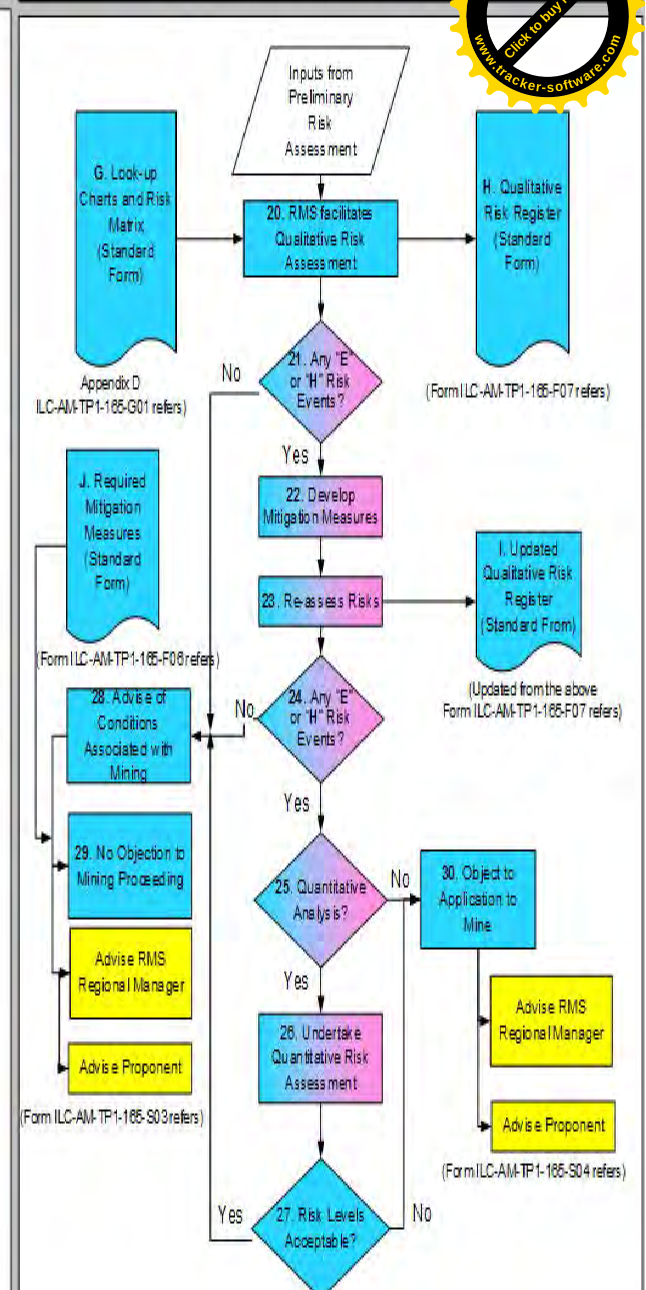
The [illegible]ss for the receipt and analysis of technical report



The process for the preliminary risk assessment



The process for the detailed risk assessm[illegible]



Mining control sheet

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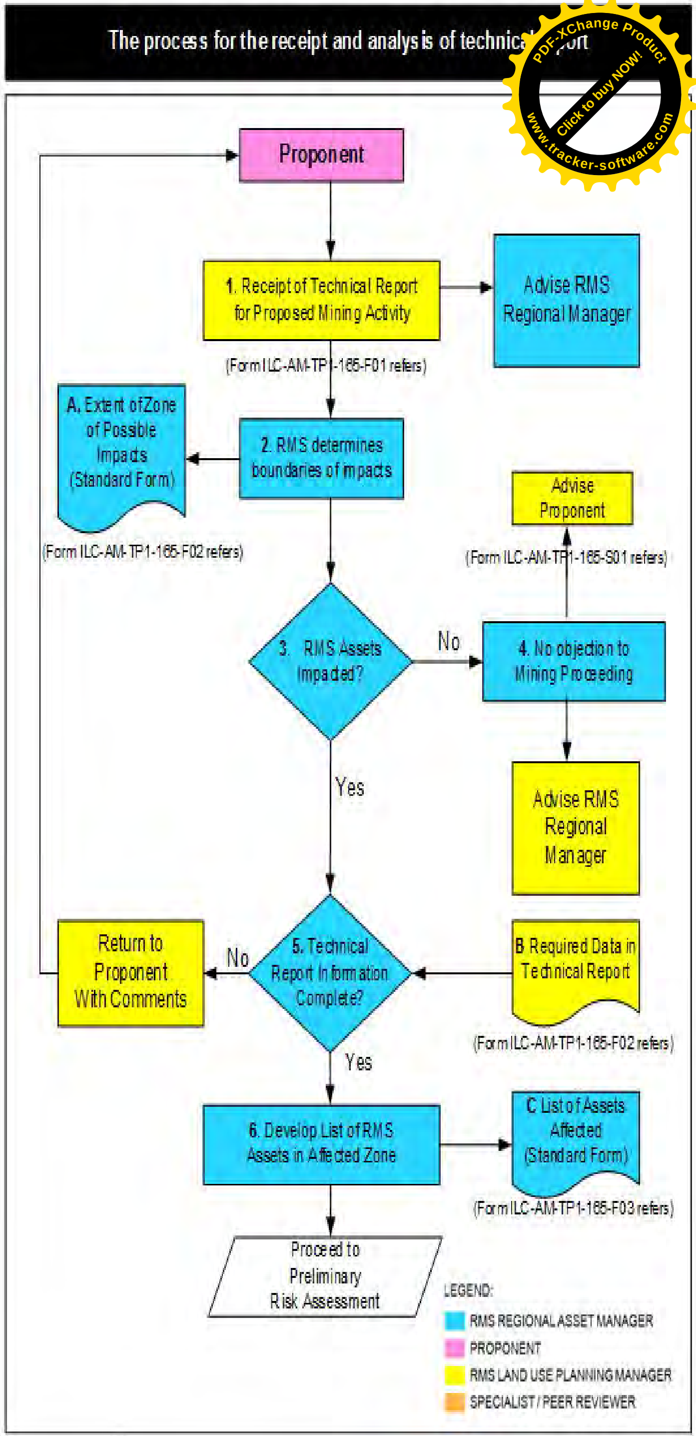
Receipt and Analysis of Technical Report

1. Applications normally received by Regional Land Use Planning Manager
2. Based on information in the Technical Report, Corridor Manager to determine TfNSW assets impacted
3. If, no assets are impacted, TfNSW has no objection to mining proceeding
4. If assets are impacted carry on to next phase of Procedure (Preliminary Risk Assessment)



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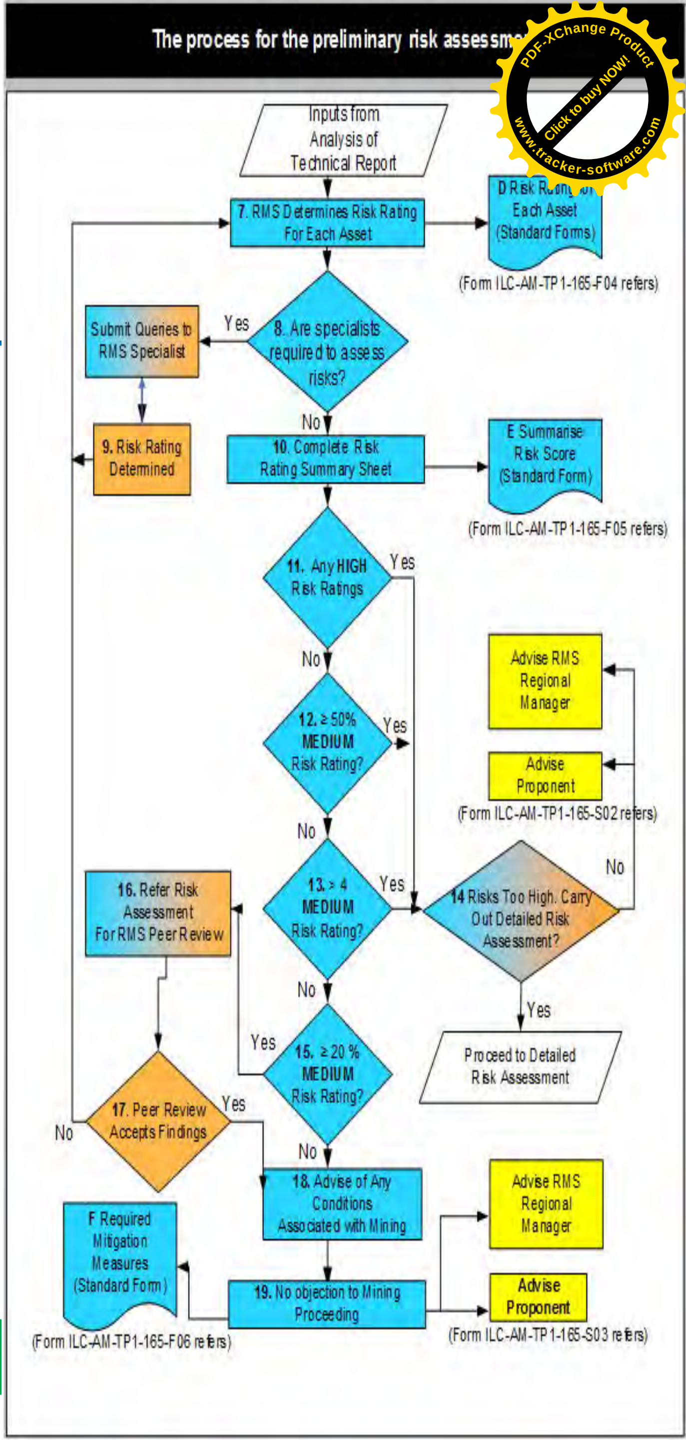
Preliminary risk assessment

- Aimed at providing quick assessment of mining risks
- Risk assessment normally be carried out by TfNSW Regional Technical Personnel
- Risk assessment is qualitative and rapid with look up charts to determine level of risk exposure or Risk Ratings
- Risk exposure includes infrastructure, functionality and safety.
- If risks are acceptable there would be no objection to mining, but certain conditions such as monitoring or pre-emptive actions may be imposed.
- If risks are unacceptable carry on to next phase of Procedure (Detailed Risk Assessment).



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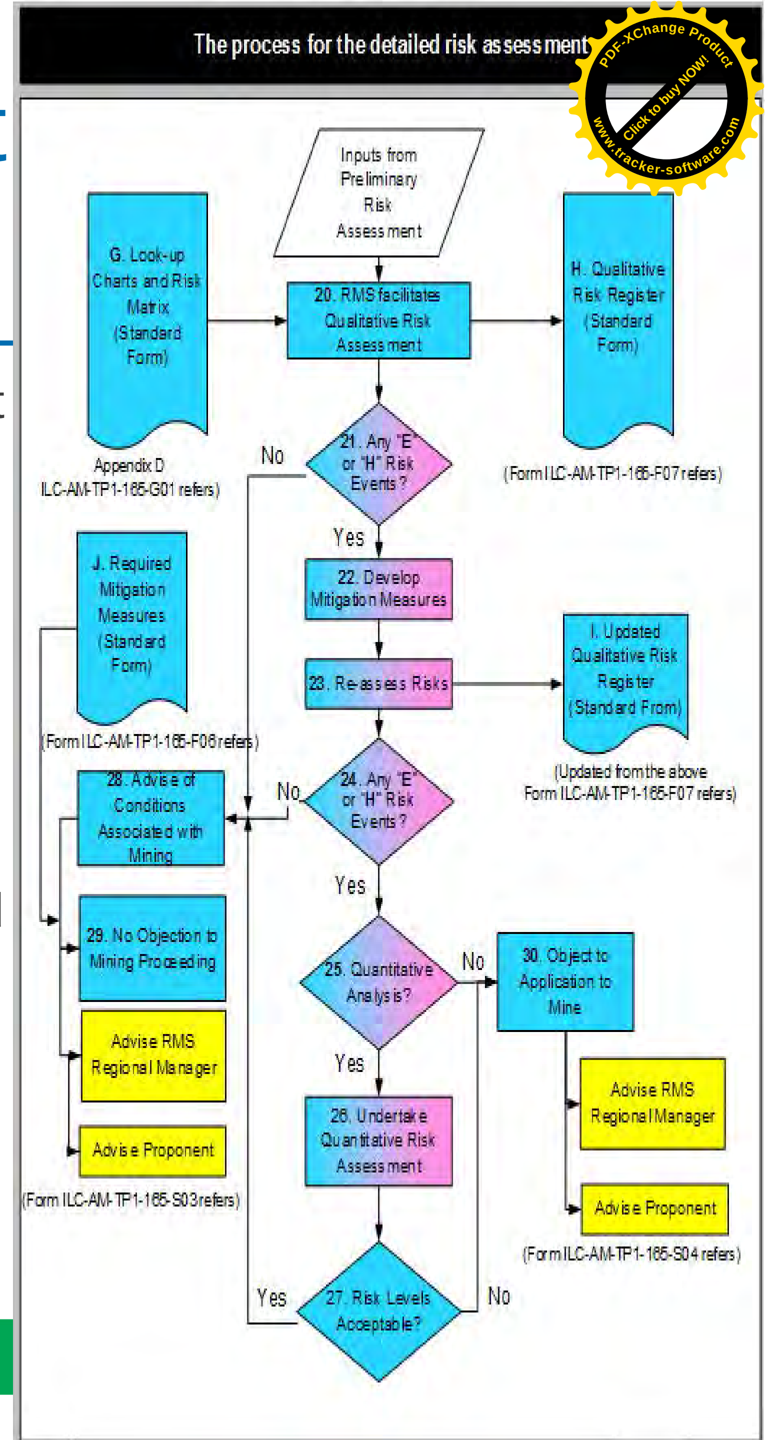
Detailed risk assessment

- Undertaken when Preliminary Risk Assessment identifies risks as unacceptable to TfNSW.
- Detailed Risk Assessment follows more traditional process
- The first stage is a qualitative risk assessment as in AS/NZS 4360 – 2004: Risk Management.
- Where qualitative risk assessment identifies risks that are unacceptable, a quantitative risk assessment on specific assets may be required
- If risks are acceptable, TfNSW would have no objection to mining, but certain conditions such as monitoring or pre-emptive actions may be imposed.
- If risks are unacceptable TfNSW will object to mining proposal



Detailed methodology

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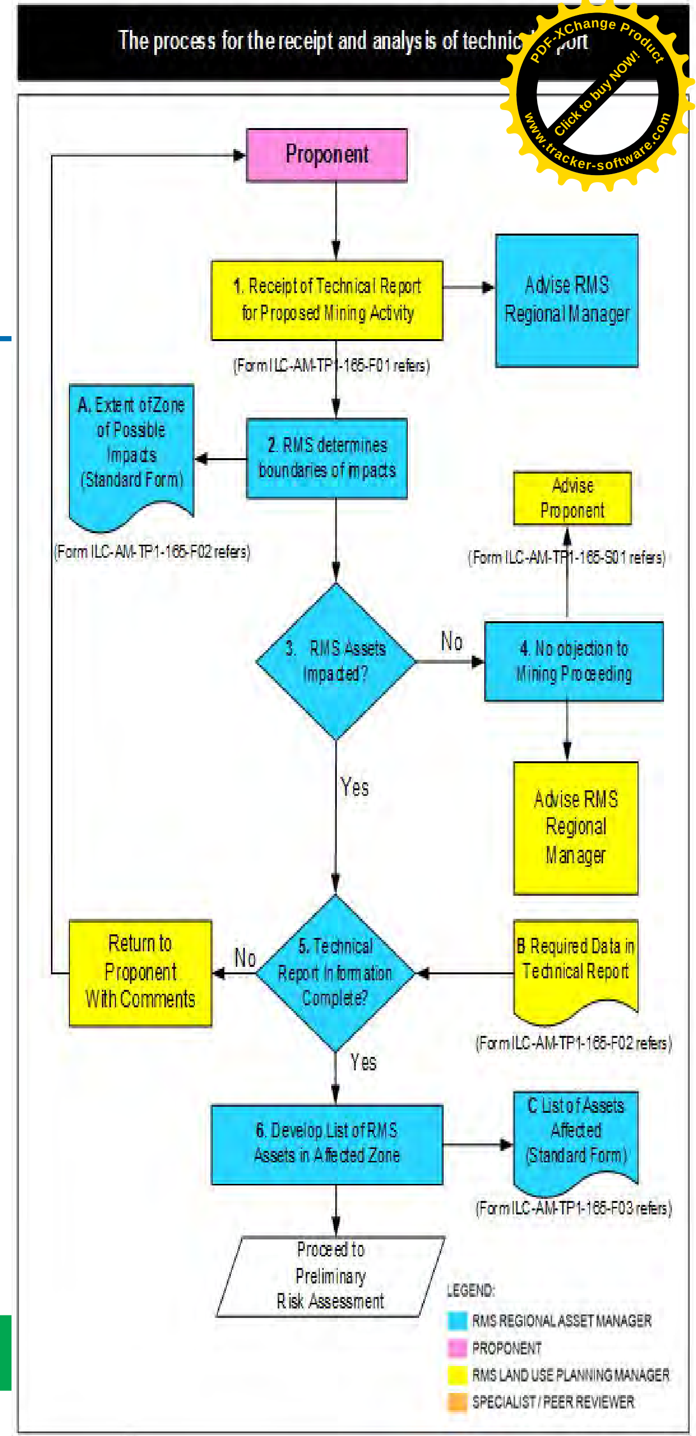
Receipt and Analysis of Technical Report

1. Receive the proposal to mine (Technical Report) from mining company (Proponent)
2. Assess extent of the possible impacts
3. Assess if assets are impacted
4. No? – No objection
5. Yes? – Check Technical Report contains sufficient information to complete risk assessment
6. Develop list of TfNSW assets for risk assessment

[Assess extent and assets]

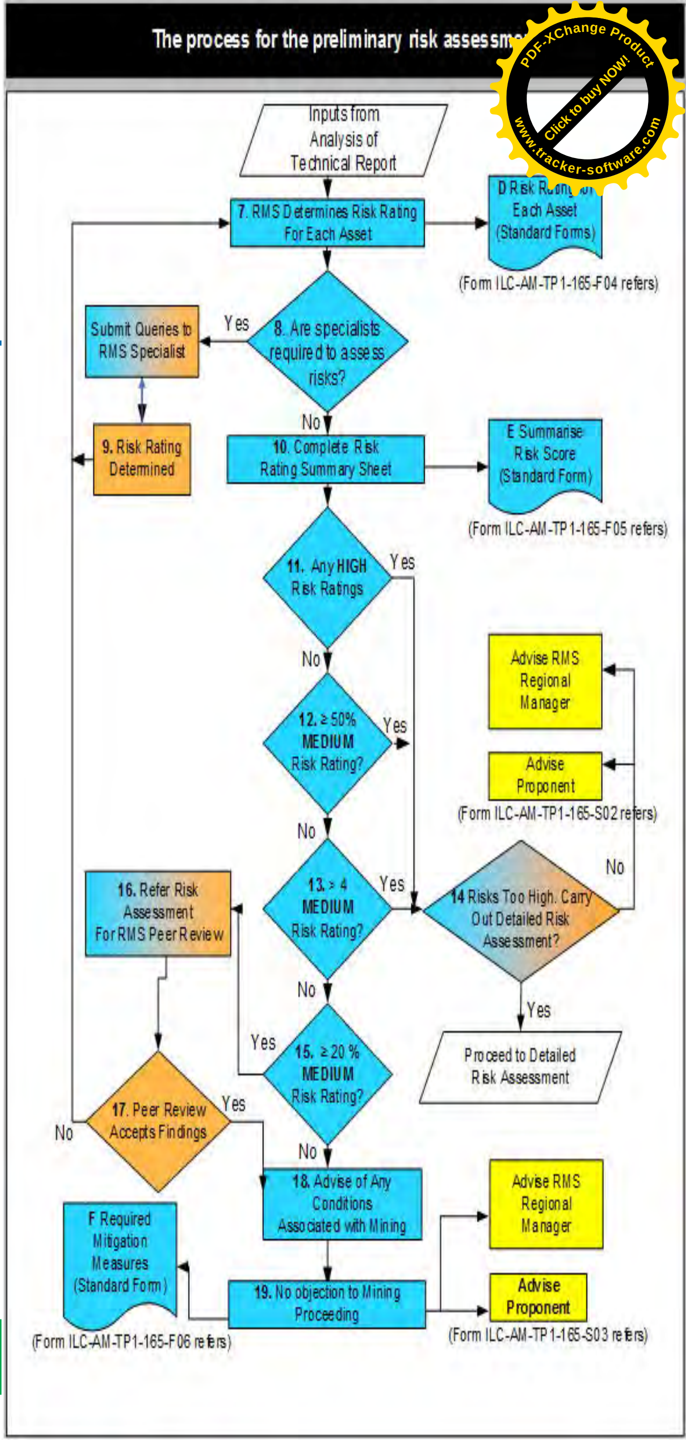
- Proceed to Preliminary Risk Assessment

[Record subsidence data]



Preliminary risk assessment

- Use look up charts to determine level of risk exposure or Risk Ratings
- Risk assessment is qualitative
- Aimed at providing quick assessment of mining risks
- Risk Ratings refer to extent to which assets could be damaged by mining and the consequences
- Consequences include losses to infrastructure, functionality and safety.



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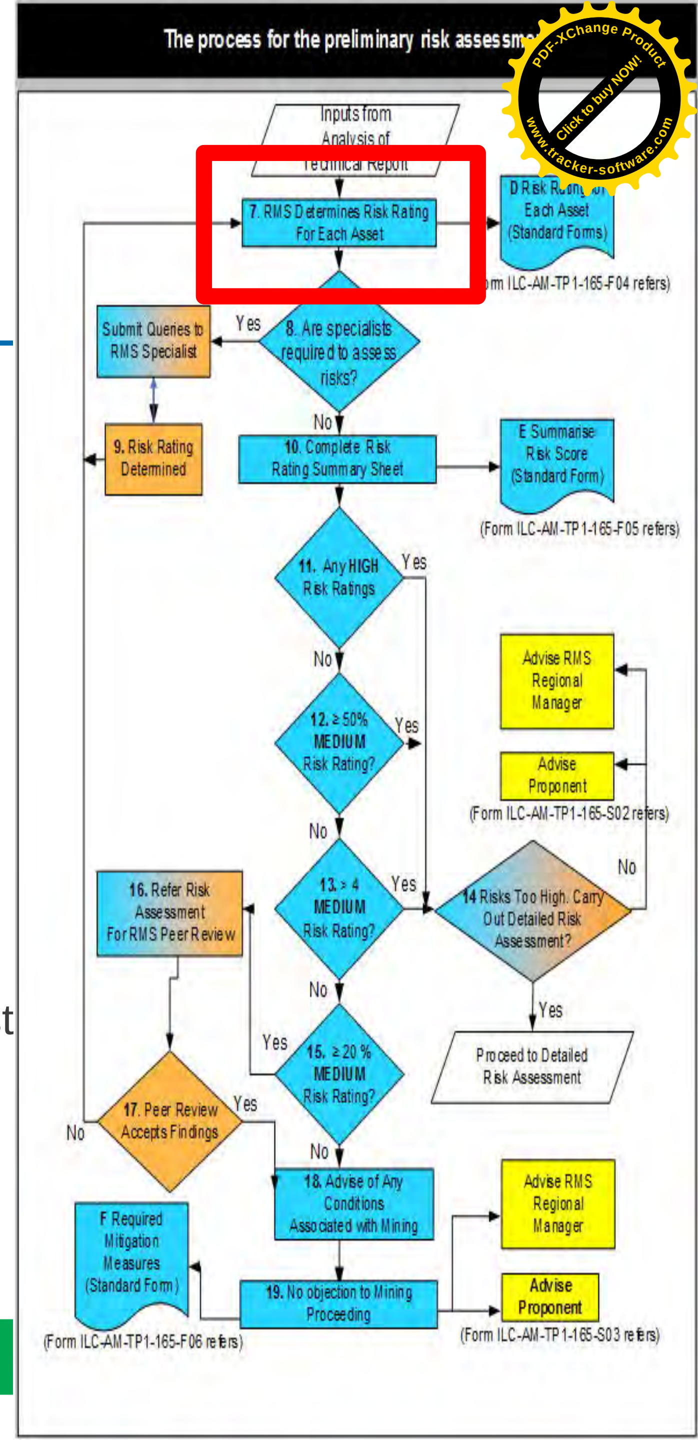
Determine Risk Values for Each Asset (Step 7)

- Risk Rating determined for each asset on the asset list using the lookup chart relevant to that asset.
- Risk Rating value predetermined for each asset based resilience inherent in the asset.
- Risk values will fall into one of four categories:
  - HIGH – asset potentially at risk from mining
  - MEDIUM – asset may be at risk from mining
  - LOW – asset is unlikely to be at risk from mining
  - REFER – risk to asset to be assessed by a Specialist



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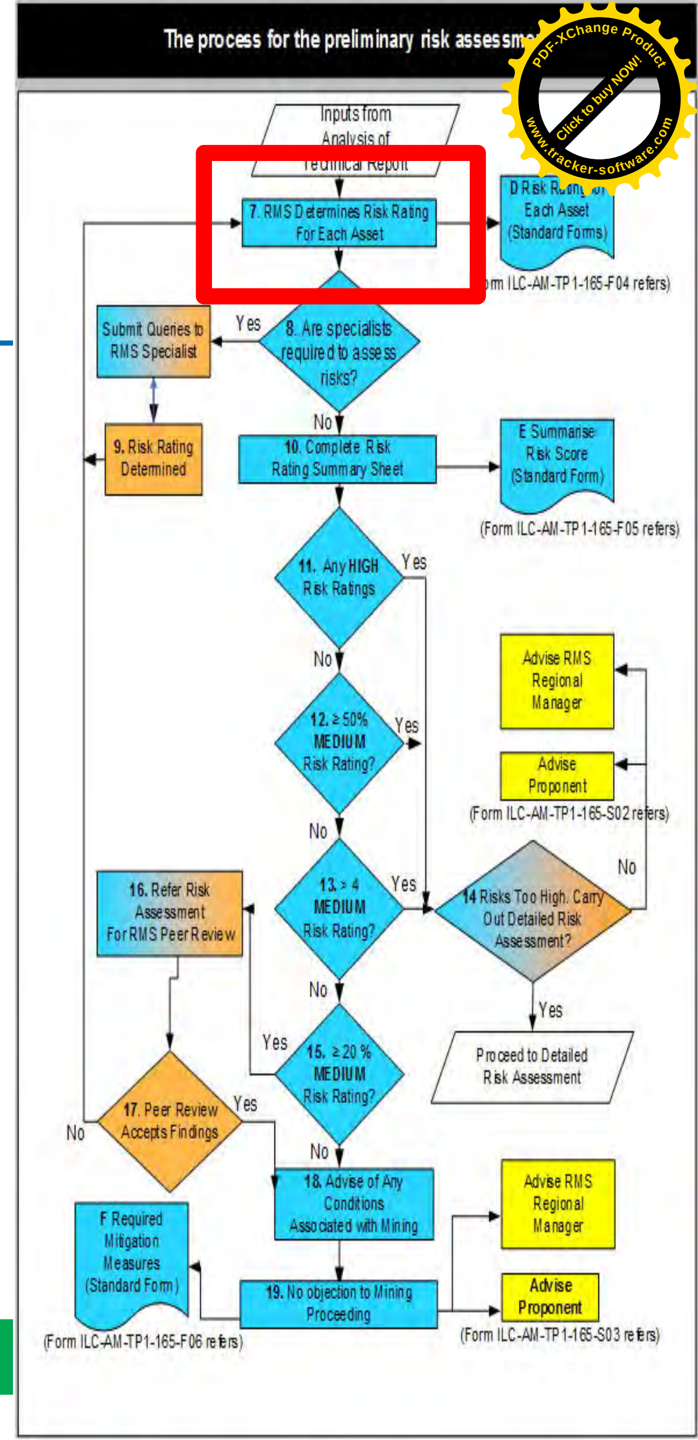
Determine Risk Values for Each Asset (Step 7)

- Ratings to be entered on Risk Rating forms in Appendix A
- Asset types rated:
  - Bridges (3.2.2.1)
  - Pavements (3.2.2.2)
  - Pavement Geometry (3.2.2.3)
  - Slopes (3.2.2.4)
  - Tunnels (3.2.2.5)
  - Culverts (3.2.2.6)
  - Miscellaneous structures (3.2.2.7)



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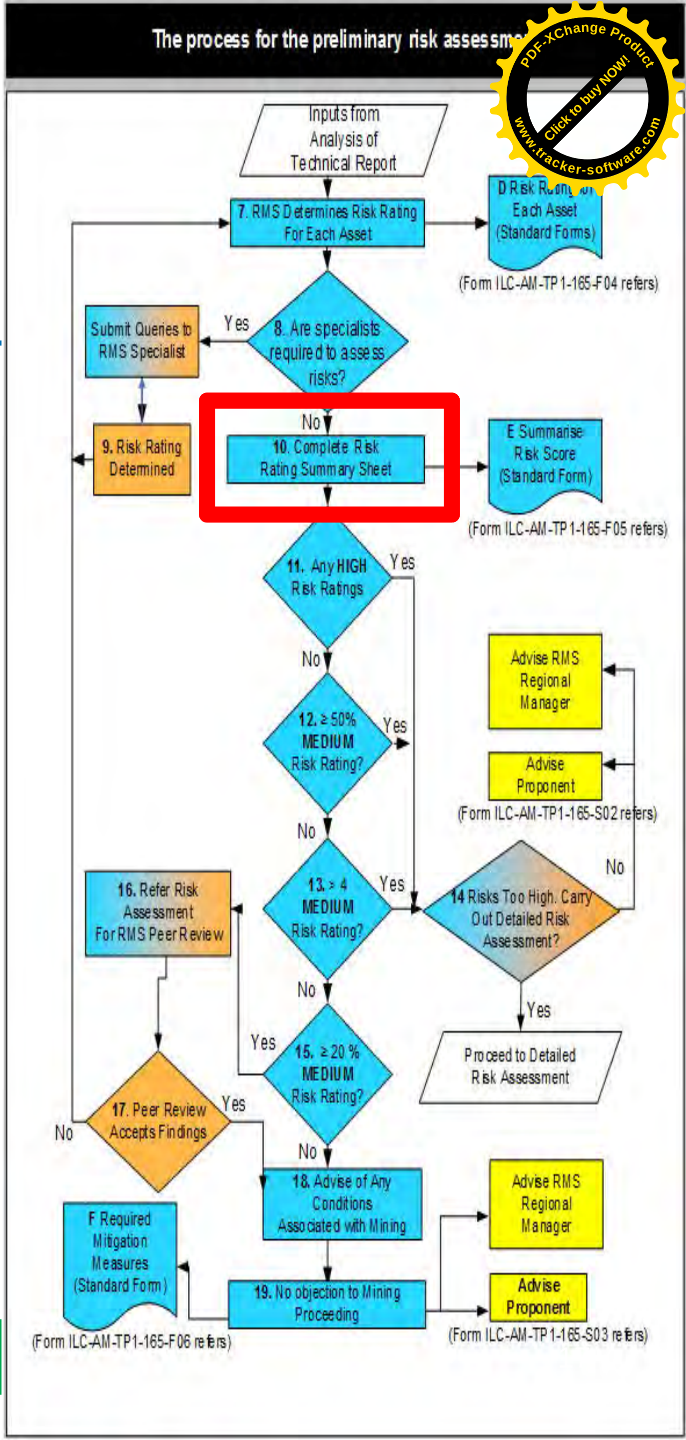
Summarise Risk Ratings (Step 10)

- Risk Ratings summarised using the form in [Here]
- Risk ratings summed to provide an assessment of total risk the mining activity poses to TfNSW's assets.



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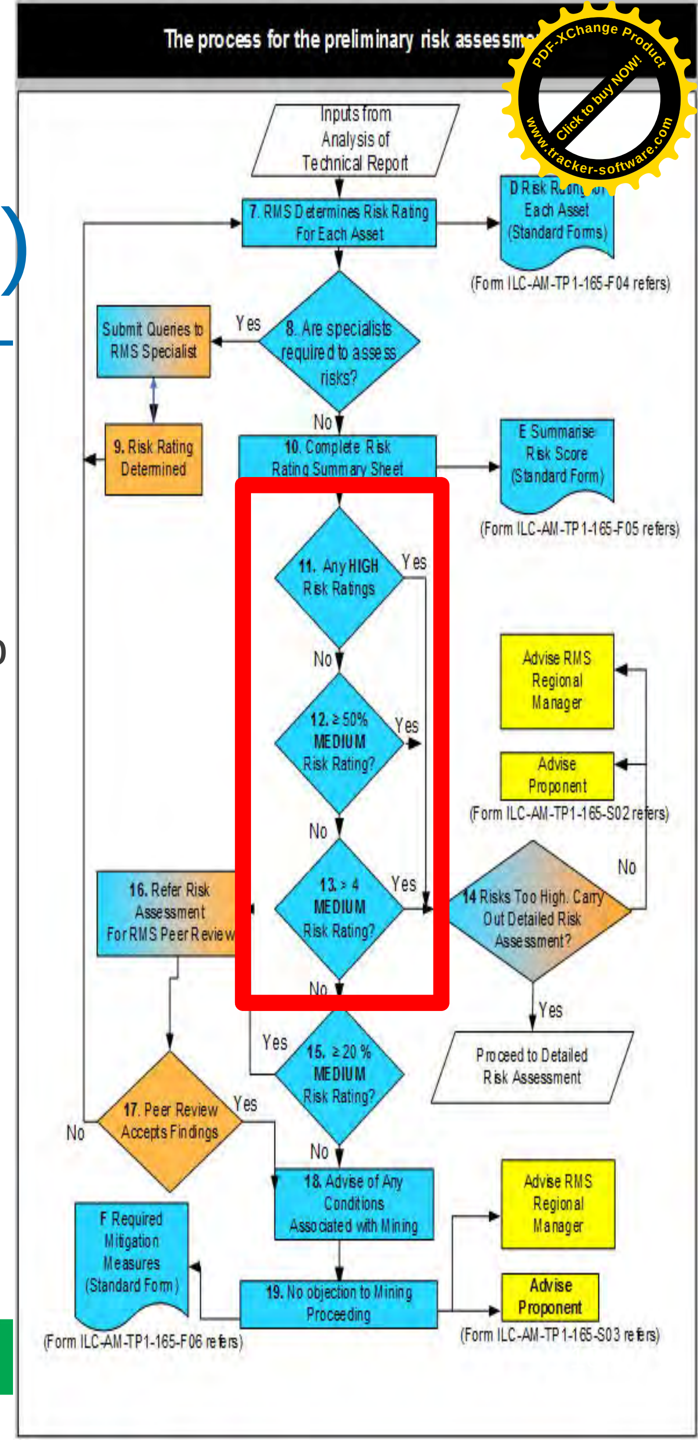
High and Medium Risk Exposure (Steps 11, 12, 13)

- Are There Any HIGH Risks? (Step 11)
- Do MEDIUM Risks Equal 50% or More? (Step 12)
- Are There more than 4 MEDIUM Risks? (Step 13)
    - If ‘Yes’ to any of the above, the level of risk to TfNSW, exceeds the Preliminary Risk Assessment acceptability limits
    - In this case, a Detailed Risk Assessment must be undertaken (Step 14)
    - Else Proceed to Step 15



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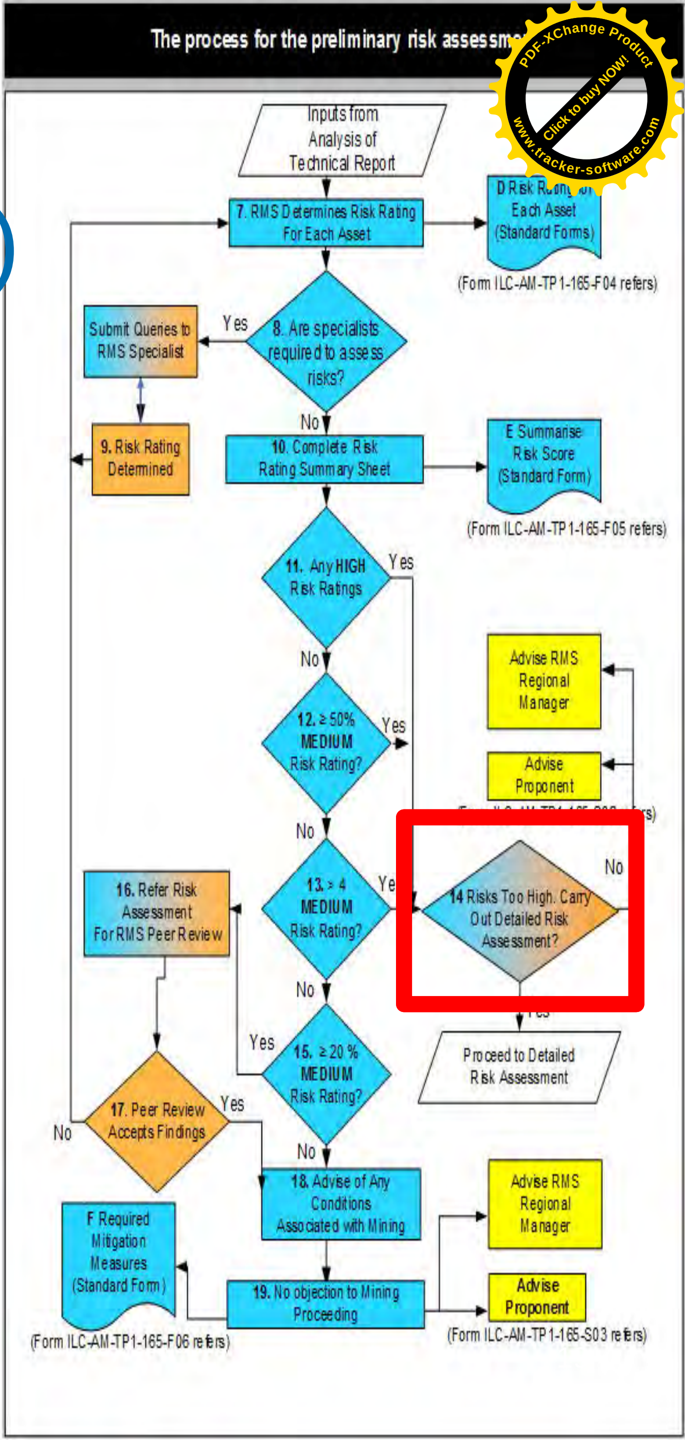
Risks Exceed Preliminary Acceptability Limits (Step 14)

- **TfNSW have carried out an initial risk assessment which indicates that there are risks to TfNSW that exceed the preliminary acceptability limits**
- **These risks will need to be resolved through a Detailed Risk Assessment**



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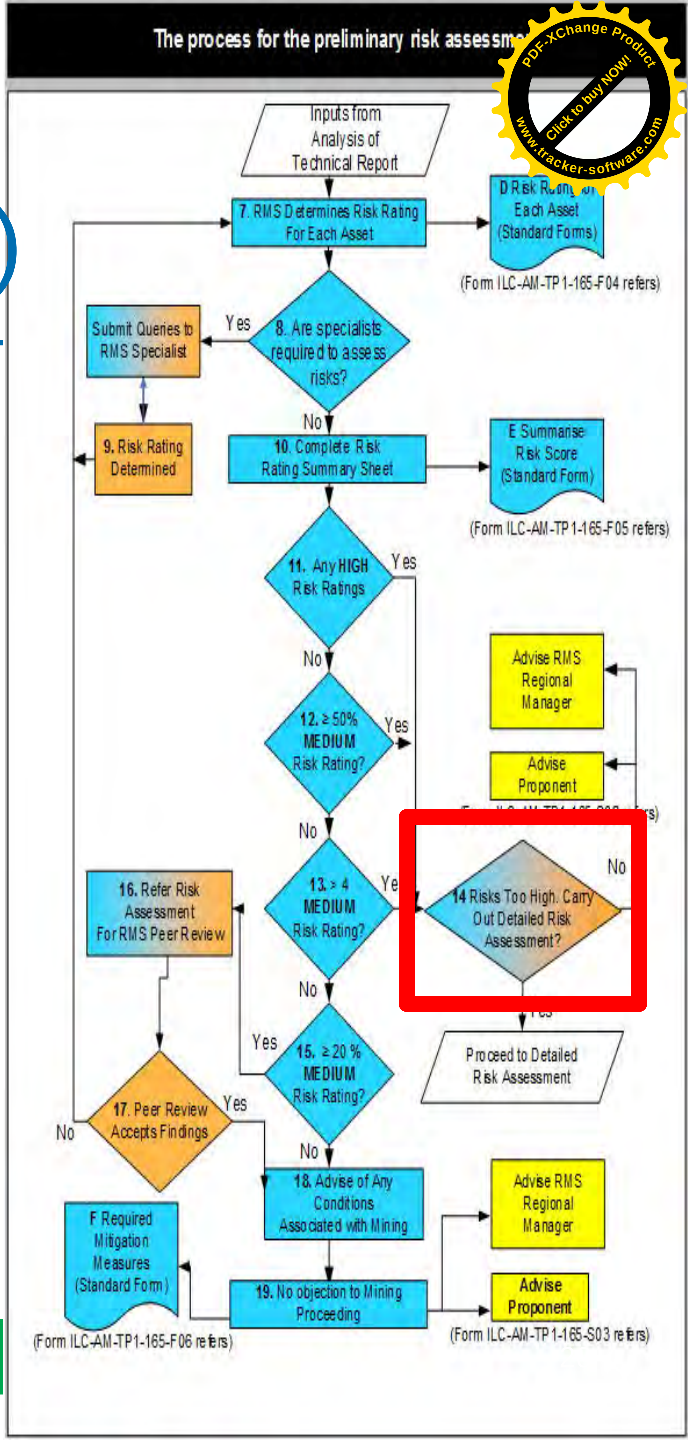
Risks Exceed Preliminary Acceptability Limits (Step 14)

- Detailed Risk Assessment to be managed by person nominated by the Asset Manager
- Nominated person to
  - appoint a facilitator to carry out the detailed risk assessment
  - provide all documentation to the facilitator
  - brief the facilitator prior to the risk assessment
  - arrange a venue
  - distribute the risk assessment outcomes to the participants
- The facilitator may be internal or external to TfNSW
- GM Asset Maintenance Planning to be advised of need to proceed to the Detailed Risk Assessment
- Regional Asset Manager to stay involved nominate point of contact between TfNSW and Proponent



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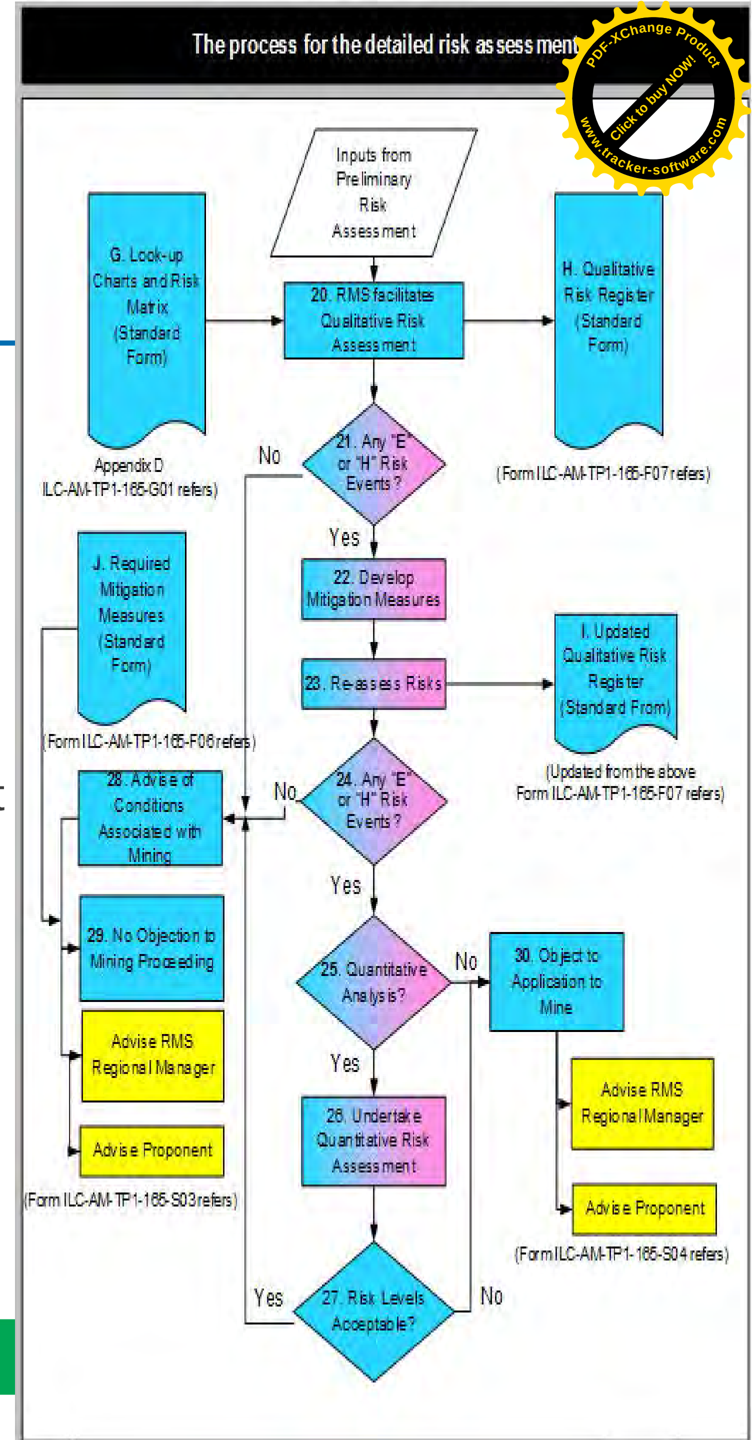
Detailed risk assessment

- Only undertaken when Preliminary Risk Assessment identifies risks exceed the Preliminary Acceptability limits of TfNSW.
- Detailed Risk Assessment follows more traditional process
- The first stage is a qualitative risk assessment as set out in AS/NZS 4360 – 2004: Risk Management.
- Where qualitative risk assessment identifies risks that are unacceptable, a quantitative risk assessment on specific assets may be required
- Qualitative risk assessment generally undertaken in workshop
- Mitigation measures identified in the risk workshop to be listed as a condition of TfNSW not having any objections to the mining and included in management plan



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Management Plan

- A detailed management plan will be required prior to proceeding with mining.
- The management plan is a statutory requirement.
- The approving authority may vary this and the form of the plan will depend on the requirements of the approval authority.
- The management plan is to be drawn up by the proponent in consultation with TfNSW.
- It is to include all the requirements of the approval authority and all the risks identified in the Risk Assessment.
- Management of these risks to be clearly described in the Management Plan.
- A Trigger Action Response Plan to be included in the Management Plan where appropriate.

Roads & Maritime

Thank you

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LINKED SLIDES

Roads & Maritime

every journey matters

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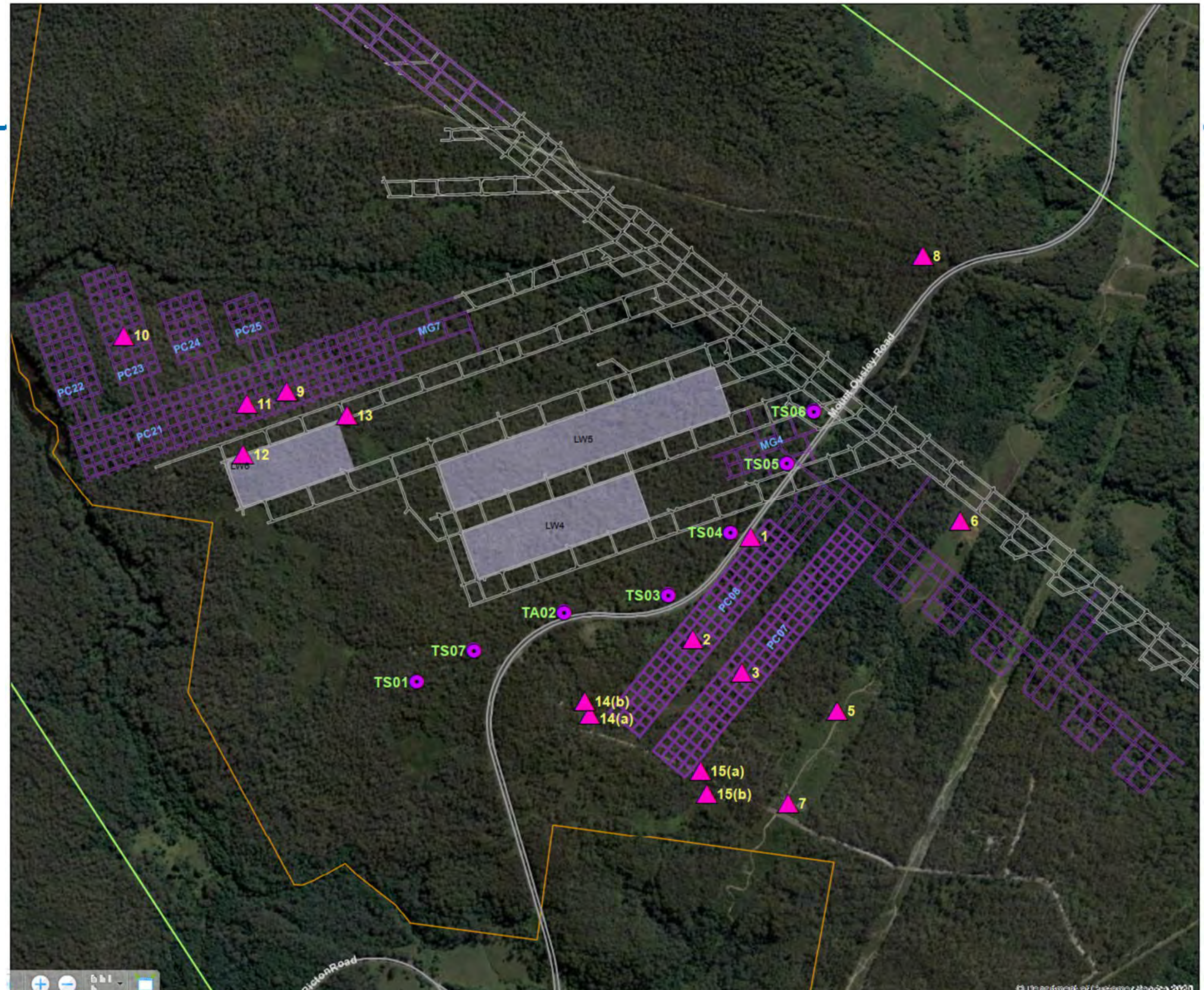
Mine Layout



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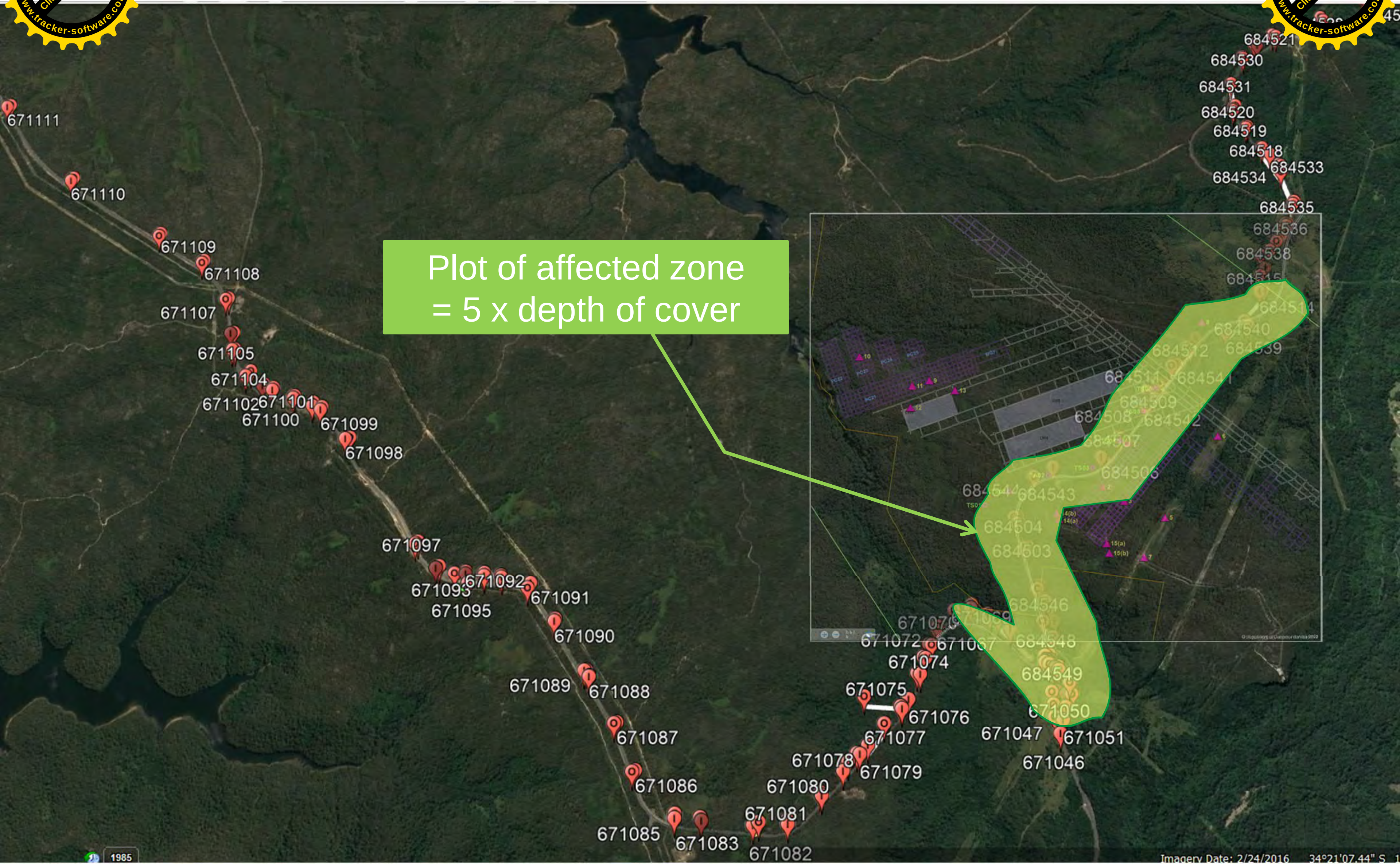
Culverts



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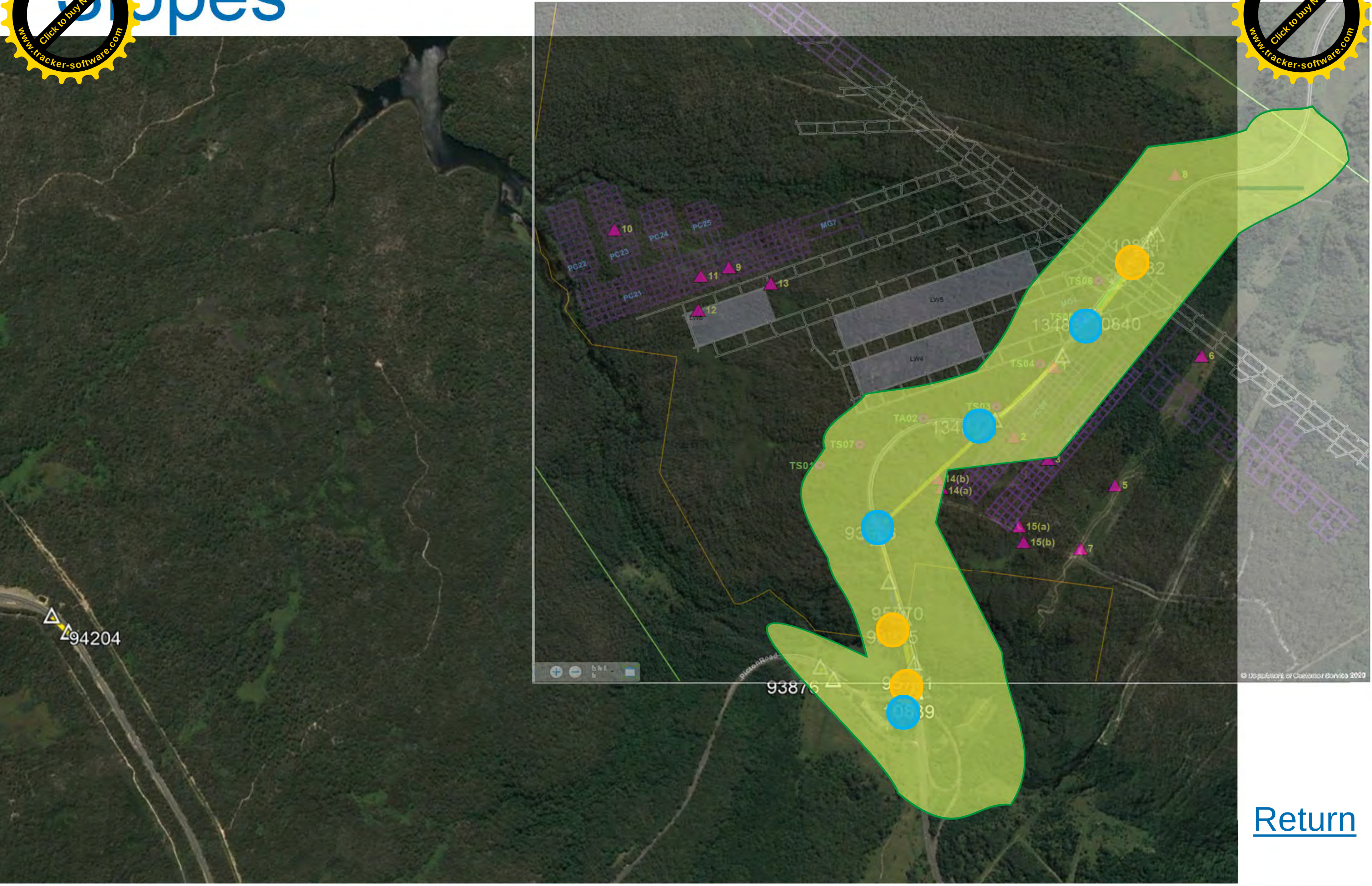
Slopes



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Subsidence Information

Figure 6 shows contours for the estimated vertical subsidence expected at the completion of the planned bord and pillar panels in the EP Areas. Vertical subsidence from the mining of the planned bord and pillar panels is expected to be less than 100mm and generally less than 30mm within the EP Areas.

- Tilt of less than 2.0mm/m.
- Tensile strain of approximately 0.5mm/m.
- Compressive strain of approximately 1.0mm/m.

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Preliminary Risk Assessment Bridges

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- Risk Rating for bridges from Table 2
- Or determined by a Specialist)
- For movement to have an adverse impact on a bridge it must be differential
- All horizontal movements to be referred to bridge specialist – get regional bridge engineer involved early

Table 2: Risk Ratings for Bridges

BRIDGES			
Type	**Construction Material**	**Differential**	
		Vert	**Horiz**
Structurally continuous (Picton Rd Interchange)	Concrete	**H**	**R**
	Steel	**M**	**R(M)**
Structurally simply supported (North)	Concrete	**L**	**R**
	Steel	**L**	**R(L)**
Frame bridges	Concrete	**H**	**R**
Cable stayed bridges	Either / All	**M**	**R**
Arch (Picton Rd Interchange)	Masonry	**H**	**R**
	Concrete	**H**	**R(H)**
	Steel	**M**	**R**
Timber	Timber	**L**	**R**
Bridge sized culverts	All / Any	**H**	**R**

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Preliminary Risk Assessment Pavements

- For carriageways, Risk Ratings are assessed separately for:
  - Infrastructure Damage
  - Functionality
  - Safety

Preliminary Risk Assessment Pavements

Infrastructure Damage

- To determine the risk value:
  - Determine the pavement type
  - Determine the strain
  - Determine the risk value from Table 3

Table 3: Risk Rating – Pavement Infrastructure

RISK RATING FOR INFRASTRUCTURE DAMAGE TO PAVEMENT				
Pavement Type	**Strain**			
	≤ 0.3%	**> 0.3% to ≤ 0.5%**	**> 0.5 to ≤ 5%**	**> 5%**
	Risk Ratings			
Full depth asphalt	L	L	M	H
Flexible - No bound layer	L	L	M	H
Bound Pavement	L	M	H	H

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Preliminary Risk Assessment Pavements

Functionality

- To determine the risk value:
  - Determine the traffic volume
  - Determine the carriageway classification
  - Determine the risk value from Table 4

Table 4: Risk Rating – Pavement Functionality

RISK RATING FOR PAVEMENT FUNCTIONALITY			
Total Traffic Volume (AADT)	**Carriageway Classification**		
	Auslink	**Freight Route**	**Other**
	Risk Ratings		
< 1,000	L	L	L
≥ 1,000 to < 10,000	M	M	L
≥ 10,000 to < 20,000	H	H	M
≥ 20,000	H	H	H

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Preliminary Risk Assessment Pavements

Safety

Table 5: Safety risks – Pavement damage

SAFETY RISK RATINGS – PAVEMENT DAMAGE			
Pavement Type	**Speed (km/h)**		
	≤ 60	**> 60 to ≤ 80**	**> 80**
	Risk Ratings		
Full depth asphalt	**L**	**L**	**M**
Flexible - No bound layer	**L**	**M**	**M**
Plain Concrete	**M**	**M**	**H**
Continuously Reinforced Concrete Pavement (CRCP)	**M**	**M**	**H**
Asphalt over LMC (Lean Mix)	**M**	**H**	**H**
Bound Layer	**M**	**H**	**H**

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Preliminary Risk Assessment Pavement geometry

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- Changes in pavement geometry caused by tilt may increase risks to road users
- More likely to occur if the pavement is directly over, or close to, mining
- Only required for roads is located within the General Application Area

Table 6: Change in Pavement Geometry Risk Ratings

CHANGE IN PAVEMENT GEOMETRY (TILT) RISK RATINGS		
Asset Type	**Tilt**	**Risk Rating**
Pavements where tilt is predicted to occur	**≤ 0.5%**	**L**
	>0.5% and ≤2%	**M**
	> 2.0%	**H**

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Preliminary Risk Assessment Slopes

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- Geotechnical and slope risks presented in Table 6
- Risks also to be considered for slopes proposed by the proponent for:
    - Slopes > 5m high
    - The slopes closer to TfNSW infrastructure than a distance equal to twice slope height.
- Details of these slopes to be provided by proponent

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Table 7: Geotechnical and Similar Risk Ratings

GEOTECHNICAL AND SLOPE RISK RATINGS	
Asset Type	**Risk Rating**
Slope – ARL 1	**H**
Slope – ARL 2 95771/95770/13482	**3 X H**
Slope – ARL 3 10839/13483/13484/13485	**4 X R(M)**
Slope – ARL 4	**2 X L**
Slope – ARL 5	**4 X L**
Soil slope with batter steeper than 2(H):1(V) and height > 5m	**R**
Slopes treated with geotechnical measures	**R**
Flexible retaining structures ≤ 5m high,	**L**
Non flexible retaining structure, Flexible retaining structures > 5m high	**R**
Rock slope height > 3 metres	**R**
Geologically complex features	**R**

Preliminary Risk Assessment Tunnels

Table 8: Risk Ratings for Tunnels

TUNNEL RISK RATINGS	
Tunnel Description	**Risk Rating**
All tunnels – regardless of length, width or type of construction	**H**

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Preliminary Risk Assessment Culverts

Table 9: Culvert Risk Ratings

CULVERT RISK RATINGS	
Asset Type	**Risk Rating**
Culvert ARL1	**R**
Culvert ARL2	**R**
Culvert ARL3	**M**
Culvert ARL4	**L**
Multiple culverts	**44 X L**
Culverts > 1200 mm diameter	**6 X R(M)**
All butt jointed pipes and masonry culverts	**R**

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Preliminary Risk Assessment Miscellaneous structures

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Table 10: Miscellaneous structure Risk Ratings

MISCELLANEOUS STRUCTURE RISK RATINGS		
Asset Type	**Parameter**	**Risk Rating**
Mono pole structures (road signs) noise walls, barriers etc	**< 2.0% tilt**	**L**
	≥ 2.0% tilt	**R**
VMS gantry portal structures, rest area structures, detention basins	**<1% strain**	**L**
	≥1% strain	**R**

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Holding Company					
Mining Company					
Mine Name / Ref.					
Technical Report Ref.		Date Received			
TfNSW Office		Regional Asset Manager		File No.	

RISK RATING ANALYSIS and ASSESSMENT

RISK RATING	COMPUTATION	ROW ID	NUMBER
HIGH	Total number of assets that have a HIGH Risk Rating	1	6
MEDIUM	Total number of assets that have a MEDIUM Risk Rating	2	11
LOW	Total number of assets that have a LOW Risk Rating	3	55

TOTAL	Total number of ALL assets with Risk Rating	4 = (1+2+3)	72

ASSESSMENT	COMPUTATION	ROW ID	RESULT
MEDIUM	Calculate number of assets with a MEDIUM Risk Rating as a percentage of the TOTAL number of assets with a Risk Rating	5 = (2 / 4 x 100)	15%

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Risk Rating Analysis and Assessment

RISK RATING ANALYSIS and ASSESSMENT (Continued)

ACCEPTABILITY	CRITERIA	YES / NO
HIGH > 0	Are there any assets with a HIGH Risk Rating? (Row 1)	Yes
MEDIUM ≥ 50%	Are there 50% or more of the assets with a MEDIUM Risk Rating? (Row 4)	No
MEDIUM > 4	Are there 4 or more assets with a MEDIUM Risk Rating? (Row 2)	Yes

TOLERABILITY	CRITERIA	YES / NO
MEDIUM ≥ 20%	Are there 20% or more of the assets with a MEDIUM Risk Rating? (Row 4)	No

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Possible Mitigation Measures

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- Establish a Technical Committee to investigate and manage all mining risks to TfNSW infrastructure, functionality and road user safety
- Regular ground surveys
- Installation of monitoring equipment on critical assets e.g. bridges
- Installation of fibre optic strain monitoring system along sections of critical roads at highest risk
- Regular physical inspections of assets – includes pavements, culverts, bridges etc
- Establishment of rapid response (on call) teams, with equipment and materials, to react to changes in road profiles (including steps, humps, cracks etc)
- Installation of VMS along critical sections of roads
- Cut engineered slots in bound pavements prior to the commencement of mining
- Full briefing of all emergency services of potential risks, including regular updates

Appendix C

Risk Criteria

FREQUENCY

Level	Descriptor	Alt. Description	Description	Chance %	Frequency
O	Absolutely Certain	Definite	This event will occur - known to occur now *- Will occur several (many) times each year and many times (constantly) during this project*	99.99	Several times each year
A	Almost Certain	Frequent	This event is expected to occur in most circumstances *- Expected to occur more than once during the duration of this project*	95	1 / year
B	Likely	Probable	This event will probably occur in most circumstances *- Expected to occur once during the duration of the project*	10	at least 1 / 10 years
C	Possible	Occasional	This event might (should) occur at some time *- Not likely to occur in life of project, but it is possible.*	1	at least 1 / 100 years
D	Unlikely	Remote	This event could occur at some time *- Unlikely (very) to occur in life of project*	0.1	at least 1 / 1,000 years
E	Rare	Very Unlikely	This event may occur in exceptional circumstances *- Examples of this have occurred historically, but it is not anticipated for this project*	0.01	at least 1 / 10,000 years
F	Hypothetical	Barely credible	Theoretically possible but never occurred to date (anywhere in the world) *- Often applied to natural events*	1.00E-03	at least 1 / 100,000 years

CONSEQUENCES

Level	Descriptor	Infrastructure			Amenity			Safety / Societal Cost
		Pavement	Bridges	Cost	Access	Speed	Political	
1	Insignificant	Minor damage	Minor repairable damage	< $50 k	Some loss in condition	No traffic effect	No political impact	No injuries or health effects
2	Minor	Noticeable damage	Damage that will deteriorate if not repaired quickly	< $100 k	One lane closed for < half day. One planned lane closure < 1 day	Speed reduction for < 1 month - 80 kph	Minimal political impact brief press coverage)	First aid treatment or minor damage to vehicles
3	Moderate	Significant damage	Significant damage	< $1 Mk	One lane closed for < 1 day	Speed reduction for > 1 month - 80 kph or < 1 day - 40 kph	Political impact (press coverage)	Medical treatment required
4	Major	Extensive damage	Major damage - restricted speed	< $10 M	One lane closed for > 1 day	Speed reduction for < 1 month - 40 kph	Significant political impact (extensive negative press coverage)	Extensive injuries or one or two permanent disabilities
5	Catastrophic	Loss of use of carriageway	Extensive damage. One carriageway closed until repaired	< $50 M	One carriageway closed for > 1 day or both cways for < 2 day	Speed reduction for > 1 month - 40 kph	Major political impact (Commission of Enquiry)	Single fatality or severe permanent disabilities to several people
6	Untenable		Total failure of bridge or closed until repaired	> $50 M	Both carriageways closed for > 2 day	Speed restrictions for > 12 months - 40 kph		Multiple fatalities

RISK MATRIX

LIKELIHOOD		CONSEQUENCES Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	Unthinkable 6
Multiple	O	H	E	E	E	E	E
Almost Certain	A	H	H	E	E	E	E
Likely	B	M	H	H	E	E	E
Possible	C	L	M	H	E	E	E
Unlikely	D	L	L	M	H	E	E
Rare	E	L	L	M	H	H	E
Hypothetical	F	L	L	L	M	H	H

Low	Low risk; managed by routine procedures.
Moderate	Moderate risk; requires above normal attention.
High	High risk; ALARP must be applied.
Extreme	Extreme risk; not acceptable and must be reduced.

Appendix D

Workshop Jamboard

Wollongong Coal - PC07-08 and PC21-25
Risk Assessment Workshop

17 September 2021

Agenda

Session 1: 11am - 1pm

11:00am - 11:15am	Introductions and housekeeping
11:15am - 11:25am	Workshop process
11:25am - 11:45am	Proposed mining activity
11:55am - 12:05pm	Existing mitigation measures
12:05pm - 1:00pm	Risk assessment

- Existing mitigation measures
- Risk rating
- Determine assets that require additional treatment / mitigation measures
- Identify additional mitigation measures and re-assess risks

Break: 1pm - 2pm

Session 2: 2pm - 4pm

2:00pm - 3:45pm	Risk assessment - continued
3:45pm - 4:00pm	Next steps and close-out

Attendance

Please use a sticky note (4th icon on the left) to write:
Your name - Role - Organisation

Jenny Li - Facilitator - Arup

Dr Ken Mills SCT Operations Pty Ltd 40+ years experience

Cyril Gunaratne, TfNSW, Pavement Maintenance planner

Richard Sheehan - WCL Environment Manager

Warwick Lidbury - WCL CEO

Robert Faddy Vrouwe WCL Environmental Coordinator

Dave Mullens TfNSW, Sen. Manager Pavement Planing

Dony Castro Bridge Maintenance Planner TfNSW

Henk buys - Geotechnical Engineer - AECOM

Martin Upitis Talis Consultants Chair Tech Committee

Devendra Vaas - WCL Technical Services Manager

Workshop Process

- Risk Assessment for LW4-5 & LW6 undertaken in 2014
- Preliminary Risk Assessment undertaken
- TfNSW assets affected
- Existing mitigation measures
- Risk rating
- Additional mitigation measures
- Residual risk rating

Risks Assessed

1. Infrastructure

Considers damage to pavements bridges, slopes, culverts

2. Functionality

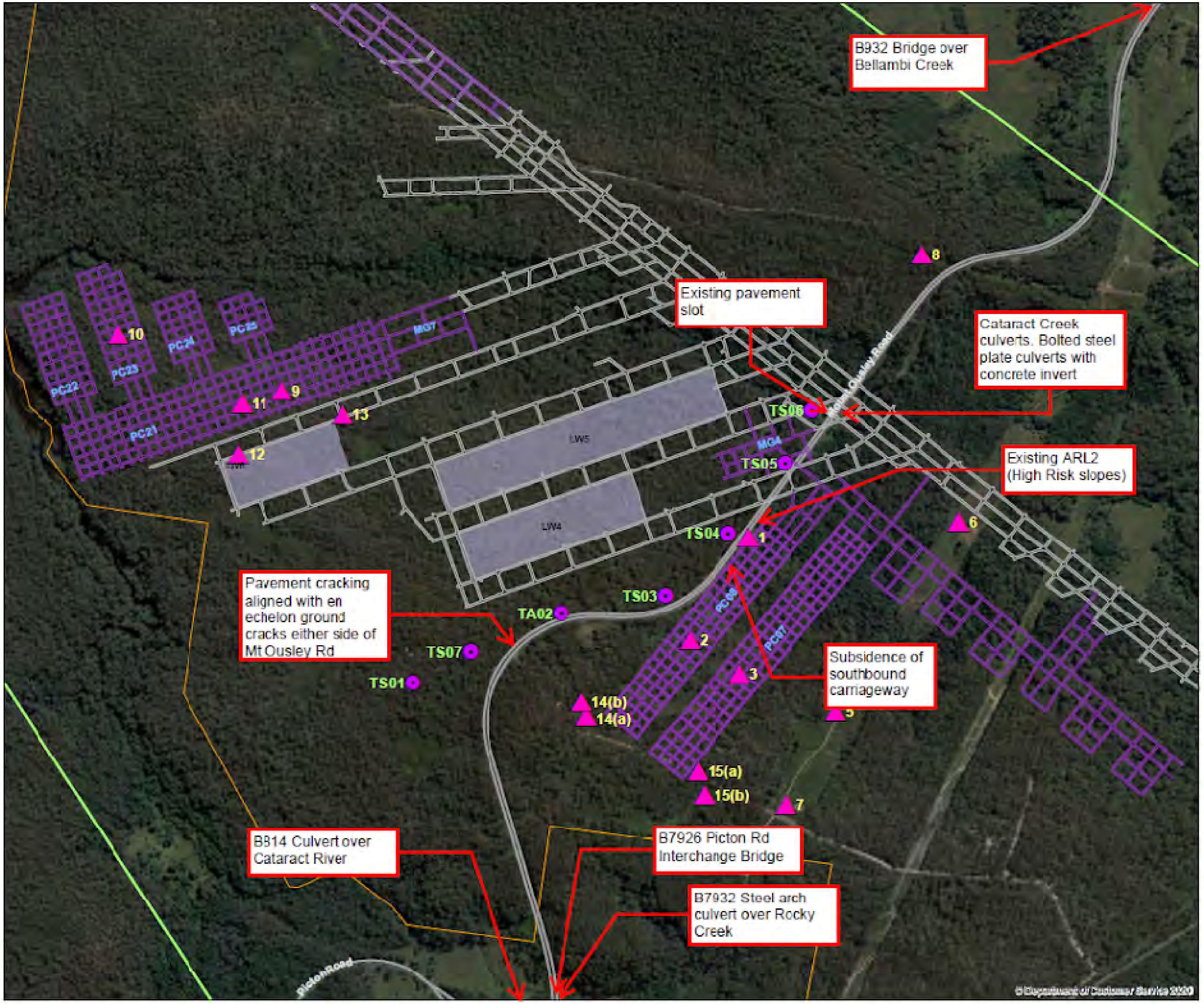
Loss of amenity and economic loss. Does not consider loss of functionality imposed as a preventative measure

3. Safety

Considers likely accidents, but without mitigation measures.

TfNSW Assets

1. Bridges
   - Picton Rd Interchange Bridge
   - Picton Rd Interchange Arch
   - North Bridge
2. Carriageways
   - General
   - Cataract Creek
   - RIdge
3. Slopes
4. Culverts
5. Miscellaneous Structures



Risk Rating

FREQUENCY

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B	**Likely**	Probable	This event will probably occur in most circumstances *- Expected to occur once during the duration of the project*	10	at least 1 / 10 years
C	**Possible**	Occasional	This event might (should) occur at some time *- Not likely to occur in life of project, but it is possible*	1	at least 1 / 100 years
D	**Unlikely**	Remote	This event could occur at some time *- Unlikely (very) to occur in life of project*	0.1	at least 1 / 1,000 years
E	**Rare**	Very Unlikely	This event may occur in exceptional circumstances *Examples of this have occurred historically but it is not anticipated for this project*	0.01	at least 1 / 10,000 years
F	**Hypothetical**	Barely credible	Theoretically possible but never occurred to date (anywhere in the world) *- Often applied to natural events*	1.00E-03	every Million years

CONSEQUENCES

Level	Descriptor	Infrastructure			Amenity			Safety / Societal Cost
		Pavement	Bridges	Cost	Access	Speed	Political	
1	**Insignificant**	Minor damage	Minor repairable damage	< $50 k	Some loss in condition	No traffic effect	No political impact	No injuries or health effects
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6	**Untenable**		Total failure of bridge or closed until repaired	> $50 M	Both carriageways closed for > 2 day	Speed restrictions for > 12 months 40 kph		Multiple fatalities

RISK MATRIX

LIKELIHOOD		CONSEQUENCES 1 (Insignificant)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Catastrophic)	6 (Unthinkable)
Multiple	O	H	E	E	E	E	E
Almost Certain	A	H	H	E	E	E	E
Likely	B	M	H	H	E	E	E
Possible	C	L	M	H	E	E	E
Unlikely	D	L	L	M	H	E	E
Rare	E	L	L	M	H	H	E
Hypothetical	F	L	L	L	M	H	H

Low	Low risk; managed by routine procedures.
Moderate	Moderate risk; requires above normal attention.
High	High risk; ALARP must be applied.
Extreme	Extreme risk; not acceptable and must be reduced.

Possible Mitigation Measures

Ref: Preliminary Risk Assessment

1. Establish a Technical Committee to investigate and manage all mining risks to TfNSW infrastructure, functionality and road user safety
2. Regular ground surveys
3. Installation of monitoring equipment on critical assets e.g. bridges
4. Installation of fibre optic strain monitoring system along sections of critical roads at highest risk
5. Regular physical inspections of assets – includes pavements, culverts, bridges, etc
6. Establishment of rapid response (on call) teams, with equipment and materials, to react to changes in road profiles (including steps, humps, cracks etc)
7. Installation of VMS along critical sections of roads
8. Cut engineered slots in bound pavements prior to the commencement of mining
9. Full briefing of all emergency services of potential risks, including regular updates

1. Bridges

Failure Type / Risk Event

Mitigation Measures

Monitoring pins installed prior to LW mining - to be inspected

Additional GNSS unit beyond ridge to inform movements at the bridge.

Baseline surveys for bridges

Picton Rd Interchange Bridge - B7926 (structurally continuous / steel)

Barrier stops vertical subsidence. Ridge stops horizontal subsidence

- Differential vertical movements: M
- Differential horizontal movements: M

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Steel arch culvert over Rocky Creek - B7932

Initial Risk Rating
- Infrastructure: E3
- Functionality: E3
- Safety:

Residual Risk Rating
- Infrastructure: F2
- Functionality: F2
- Safety:

Culvert over Cataract River - B814

Initial Risk Rating
- Infrastructure: E3
- Functionality: E3
- Safety:

Residual Risk Rating
- Infrastructure: F2
- Functionality: F2
- Safety:

North Bridge - Bridge over Bellambi creek (structurally simply supported / steel)

Outside of area of interest

				LW4&5																			
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
13	Bridge	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses exceeding code requirements - potentially leading to damage to bridge	F	5	11	F	5	11				Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse - 5 mm. Strains in region of up to 0.1 mm/metre are expected. Note that mining is away from bridge	Bridge to be fully surveyed prior to mining including measurement of available movements at bearings. TARP to be developed with trigger points for various actions. Develop survey plan of critical points for regular monitoring during mining	F	5	11	F	5	11				Note that as mining away from bridge any noticeable impacts unlikely to be resolved by ceasing mining (unless very early and large movements detected). Provided all reasonable actions are taken to prevent bridge damage / collapse prior and during to mining this risk event can be reasonably be considered to be managed in accordance with ALARP

2. Culverts

Failure Type / Risk Event

Mitigation Measures

Invert concreted culverts prior to LW mining.

Monitoring pins installed - to be relocated

Cataract Creek Culverts

- Bolted steel plate culverts with concrete invert
- Rating: M
- >1200mm

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Fun						
				F	C	R	F	C	R	F	C	R			F	C	R	F						
19	Cataract Creek (includes culvert)	Culvert cracking / movement	Crushing (buckling) of side walls resulting in deformation requiring remedial actions										3.4 m diameter corrugated steel culvert.	Baseline condition survey before mining										
20			Crushing (buckling) of side walls leading to total failure	D	4	H	D	5	E				Retreating towards culvert provides better window of opportunity for early warning LW4 will provide data for possible impacts from LW5.	Base line condition. Monitoring - ongoing survey. Concrete floor Check (engineer) strength of deformed culvert. Check required hydraulic capacity (consider lining and grouting annulus after deformation). TARP to be developed.										
21			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert)	C	3	H							Potential for 100 mm vertical movement (movement could be sudden) Cost to make repairs to culvert (grouting etc)											
22			Loss of crossfall leads to ponding on road surface										Existing cross fall > 3% - would reduce to approx 2%	Impacted areas with reduced pavement crossfalls will be monitored for performance before any remedial works. RMS will be paid for the cost of reshaping the pavement										Typical pavement crossfalls for asphaltic pavements should be within 2.5% 3.0%.

Multiple Culverts

- Rating: L (x44)
- Vary in size from 300mm to 750mm in diameter

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Smaller culverts in PC21-25 5x cover zone.

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
5	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking)	C	3	M							Culverts vary in size from 300 mm to 750 mm in diameter. Requirement to undertake pre-mining condition survey of culverts - confirm actions with MSB Ponding not an issue based on cross falls.	Condition survey before and after mining (consider impacts from LW4&5) RMS will be financially compensated for any repairs	C	1	L							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS.
6		Loose culvert cracking (compression buckling)	Ponding (on carriageway)																					

3. Carriageways - General

Failure Type / Risk Event

Mitigation Measures

P-Line survey on southbound carriageway - reinstate or assess alternative

Twice weekly drive-through inspections (done at traffic speed) - road maintenance. Report on new defects. Will not be able to notice subtle changes.

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Infrastructure Damage

- Bound pavement
- Strain <= 0.3%
- Rating: L

Functionality

- Total traffic volume (AADT)
- Auslink
- Rating: H

Safety - Pavement Damage

- Bound layer
- Speed > 60km/h to <= 80km/h
- Rating: H

Change in Pavement Geometry (Tilt)

- Pavements where tilt is predicted to occur
- Tilt <= 0.5%
- Rating: L

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
1		Compression buckling	Rapid pavement failure leading to hump or step > 50mm										Rapid implies very fast matter of minutes to few hours. Not credible to get compression failure											
2		Stepping (Shearing)	Rapid pavement failure leading to hump or step > 50mm										Not credible to get compression failure.											
3	Carriageway excluding Cataract Creek	Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (LW6)	C	2	M	C	2	M				Any cracking would be visible - probably <5 mm in width. Not deemed to be a safety issue as crack propagation would be gradual and would be repaired before it caused accident	TARP to be developed to respond to cracks. RMS will be paid for the cost of all repairs. Baseline condition survey before mining	C	1	L	C	2	M				
4		Various	Reduced life of pavement	D	4	H							Requirement to undertake pre-mining condition survey of road - confirm actions with MSB		D	2	L							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS

3. Carriageways - Cataract Creek (approx. 100m in length)

Failure Type / Risk Event

Closure of slot - forming a bump (10mm to 20mm of closure). Drive-through inspections. Mill / mill or resheet. Schedule with other road closures / road works.

Initial Risk Rating
- Infrastructure: D3
- Functionality: D3
- Safety:

Residual Risk Rating
- Infrastructure:E3
- Functionality: E3
- Safety:

Mitigation Measures

Existing pavement slot

Check condition of crackmeters - replace if necessary

Physical condition of slot to be checked

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
14	Cataract Creek (includes all pavement in this area - approx 100 m in length)	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	E	E	5	H	Compressive strains estimated to be in region of 0.5 mm / metre. Closure estimated to be 50 mm (assume 100 mm as worst case). Valley 100 metres long. Mining towards Cataract Creek. Assumes bound pavement layer.	Longitudinal road survey (ongoing at regular intervals) with TARP. Slotting: Pavement preslotting to be installed before commencement of LW5. Additional slotting if deemed necessary based on TC review of monitoring data										
15		Shearing (Shearing)	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	[illegible]	F	5	H												
16		Various	Reduced life of pavement	C	3	H								Condition survey of roads pavement before and after mining (consider impacts from LW4&5 and LW 3)	C	2	M							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS

3. Carriageways - Tension Zone at Ridge (P46)

Mitigation Measures

Crack repaired.

Monitoring pins installed - to be identified.

Failure Type / Risk Event

Pavement cracking aligned with en echelon ground cracks either side of Mt Ousley Rd

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

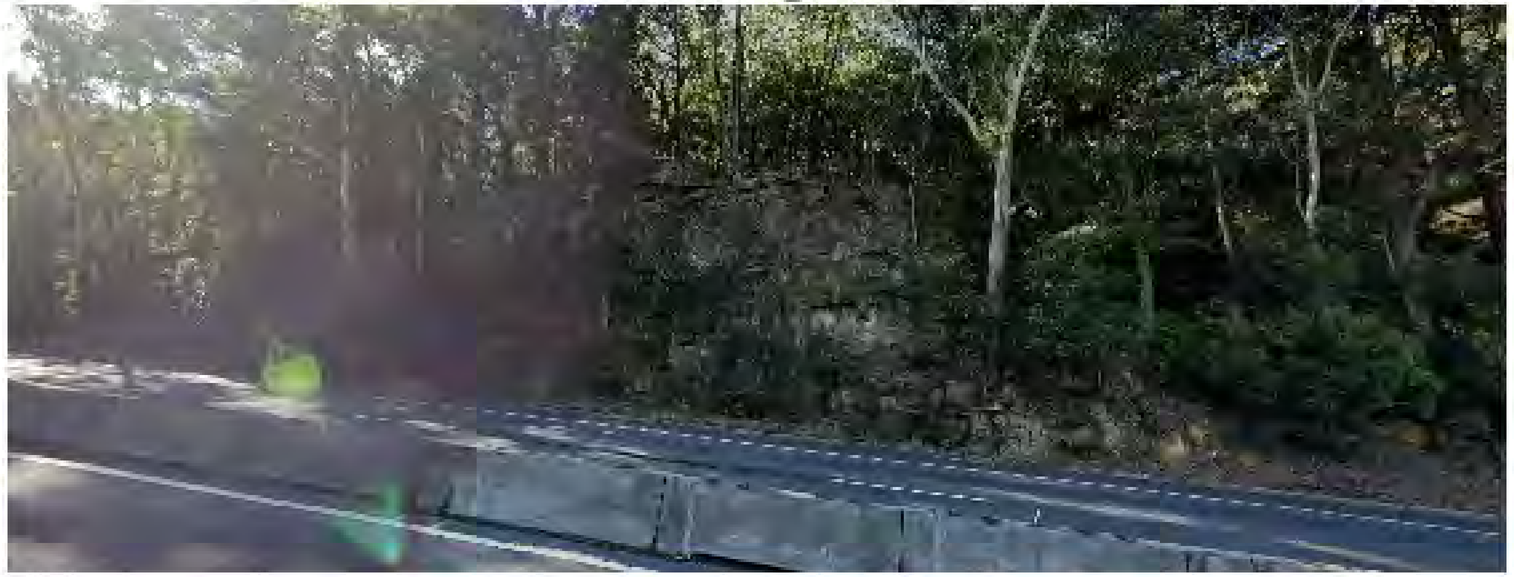
Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

				LW4&5																					
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
23	Pavement at the Tension Zone at Ridge (P46)	Cracking	Crack due to tensile movement - Tension Zone at Ridge (P46)																					

4. Slopes

Failure Type / Risk Event

Mitigation Measures



ARL2 - 95771 / 95770 / 13482

- Rating: H (x3)

ARL 3 - 10839 / 13483 / 13484 / 13485

- Rating: M (x4)

Cuttings more likely to be stretched than compressed.

Adjacent PC08

Initial Risk Rating
- Infrastructure: E3
- Functionality: E4
- Safety: E3

Residual Risk Rating - unchanged from existing
- Infrastructure:
- Functionality:
- Safety:

Beyond ridge, near Picton Rd interchange

Initial Risk Rating
- Infrastructure: F3
- Functionality: F4
- Safety: F3

Residual Risk Rating - unchanged from existing
- Infrastructure:
- Functionality:
- Safety:

														LW4&5										
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
8	Cuttings	Excessive ground movement	Slumping, cracks, water in, falling material	D	2	L	D	2	L	E	5	H	Currently ARL (Assessed Risk Level - RMS term) along this section of road is mainly 3 with one area of 2. ARL 2 is a HIGH risk. Will undertake a total inspection of the cuttings to re assess the ARL's with a view to any changes that might occur due to mining.	Undertake reassessment prior to mining followed by adequate remedial actions to reduce risks to ALARP (As Low As Reasonably Practicable) RMS to be compensated for any expenses caused by mining or responding to needs prior to mining commencing.	D	1	L	D	2	L	E	5	H	Note that the risk level with regard to public safety has not been reduced. The chance of an event is not credibly less than RARE and should the event occur the consequences do not change. Provided all reasonable actions are taken to stabilise and make safe the slopes prior to mining and regular inspections are undertaken during mining this risk event can be reasonably be considered to be managed in accordance with ALARP.
9	Embankments	Excessive ground movement	Cracks, water, instability	E	4	M	E	4	M				North of Picton Rd Interchange - ARL 3. Slope is at limit of stability. Damage to edge of road. Failure is expected to be slow - allows intervention before significant impact. Nearest longwall is approx. 700 m away.	Normal maintenance inspections supplemented by data from other surveys to trigger actions in regard to the embankment.	E	4	M	E	4	M				

ARL 4

- Rating: L (x2)

ARL 5

- Rating: L (x4)

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Water ingress - not an issue as water level is not high.

5. Miscellaneous Structures

Failure Type / Risk Event

Mitigation Measures

Mono Pole Structures

- Road signs, noise walls, barriers, etc.
- < 2.0% tilt
- Rating: L

No change to existing risk.

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Barriers - if pinned to the ground, then would move with crack. Low risk. Based on experience, no impacts on barriers.

Other Structures

- VMS gantry portal structures, rest area structures, detention basins
- < 1% strain
- Rating: L

None in area.

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				I	C	R	I	C	R	I	C	R			I	C	R	I	C	R	I	C	R	
10	Furniture	Excessive ground movement											Guard rails, median barriers & signs No credible consequence											
12	VMS	Excessive ground movement	Damage to buried cables										None present											

6. Other Assets

Failure Type / Risk Event

Mitigation Measures

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Parking Lot

Next Steps

- Draft risk register and report will be sent for review within 2 weeks.
- 1 week review period.
- Final risk register and report.

Appendix E

Risk Register

Transport for NSW

RISK ASSESSMENT - SUBSIDENCE IMPACTS ON TfNSW ASSETS

RISK REGISTER ISSUE REV A 8/10/2021

ARUP

ID	ASSET	FAILURE TYPE	EVENT	PC21-25																							
				Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
1	Carriageway excluding Cataract Creek section	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm. Rapid implies very fast - matter of minutes to few hours.										Not considered a credible risk from subsidence of 500mm.											
2		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not considered a credible risk from subsidence of 500mm.											
3		Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (P46).										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).											
4		Various	Reduced life of pavement.										Not considered a credible risk from subsidence of 500mm.											
5	Carriageway - Cataract Creek (section approximately 100m in length)	Compression buckling	Due to the presence of the slot, compression buckling leading to bump forming at the slot (closure of the slot) - 10mm from 20mm of closure.										Not in 5x depth of cover.											
6		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not in 5x depth of cover.											
7		Treatment and response of pavement from mining activities	Reduced life of pavement.										Not in 5x depth of cover.											
8		Cracking	Crack due to tensile movement.										Not in 5x depth of cover.											
9		Upsidence (impact on pavement)											Risk etc included in events above.											

ID	PC07-08																							
	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
	F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
1										Not considered a credible risk from subsidence of 500mm.											
2										Not considered a credible risk from subsidence of 500mm.											
3										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).	Undertake baseline condition survey before mining.										
4	E	2	L	E	2	L				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
5	D	3	M	D	3	M					P-Line survey on southbound carriageway - reinstate or assess alternative. Check condition of crack meters and replace if necessary. Check the physical condition of the slot. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Mill or mill and resheet if required. Note schedule any works with other road closures / road works if possible. Develop TARP with trigger points for various actions.	E	3	M	E	3	M				
6										Not considered a credible risk due to slot.											
7	B	2	H	B	2	H				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	D	2	L	D	2	L				
8										Not considered a credible risk.											
9										Not considered a credible risk.											

				PC21-25																					PC07-08																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R		F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
10	Pavement at the Tension Zone at Ridge (P46)	Cracking	Pavement cracking aligned with en echelon ground cracks either side of Mt Ousley Rd.										Not in 5x depth of cover.												C	2	M	C	2	M				Crack of same order of less experience from previous mining activities. Monitoring pins installed - locations to be identified.	Assess during mining the nature of the movement (perform crack sealing if required). Assess post mining if crack sealing is sufficient or if further treatment is required. Develop TARP with trigger points for various actions.	C	2	M	C	2	M				
11	Bridge - Picton Rd interchange bridge (B7926)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.												E	4	H	E	4	H				Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse +- 5 mm. 500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	3	L	F	3	L				
12	Bridge - steel arch culvert over Rocky Creek (B7932)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.												E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
13	Culvert over Cataract River (B814)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.												E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
14	Cataract Creek Culverts	Culvert cracking / movement	Deformation of the side walls resulting in a shear failure and requiring remedial actions.										Not in 5x depth of cover.	Baseline condition survey before mining											E	4	H	E	2	L				Expect 3-4mm of closure (from 500mm of subsidence). Inverts of plate steel culverts were concrete encased prior to longwall mining. Existing slot will prevent step forming or failure of pavement.	Monitor GNSS and undertake subsequent survey of culverts if trigger levels reached. Develop TARP with trigger points for various actions.	F	4	M	F	2	L				
15			Crushing (buckling) of side walls leading to total failure / deformation requiring remedial actions.										Not in 5x depth of cover.																					Not considered a credible risk due to upper limit of 20mm of closure.											
16			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert).										Not in 5x depth of cover.																					Not considered a credible risk due to volume of flow in the culvert.											
17			Loss of crossfall leads to ponding on road surface.										Not in 5x depth of cover.																					Not considered a credible risk due to high fill.											
18	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking).										Small culverts in the 5x depth of cover. Any impacts would be insignificant.												D	3	M							Culverts vary in size from 300 mm to 750 mm in diameter. Minimal impacts to culverts observed from longwall mining.	Use precondition assessments from longwall mining as baseline.	D	3	M							
19		Lose culvert grading (compression buckling)	Ponding (on carriageway).										Not considered a credible risk.																					Not considered a credible risk.											

ID	ASSET	FAILURE TYPE	EVENT	PC21-25 Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT	PC07-08 Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R		F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
20	Cuttings adjacent PC08	Excessive ground movement (compression movements)	Slumping, cracks, water in, falling material.										Not in 5x depth of cover.												E	3	M	E	4	H	E	3	M	13483 and 13484 are adjacent PC08. Both are ARL3 - medium risk. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
21	Cuttings near Picton Rd interchange	Excessive ground movement (compression movements)	Slumping, cracks, water ingress, falling material.										Not in 5x depth of cover.												F	3	L	F	4	M	F	3	L	95771, 95770 (both ARL2 - high risk) and 10839, 13485 (both ARL3 - medium risk) are located beyond the ridge line close to the Picton Rd interchange. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure ARL does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
22	Embankments	Excessive ground movement	Cracks, instability.										Not in 5x depth of cover.																					Embankments are ductile structures. Any impacts would be insignificant.											
23	Mono pole structures, e.g. road signs, noise walls, barriers	Excessive ground movement	Damage.										Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.																					Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.											
24	VMS	Excessive ground movement	Damage.										Not in 5x depth of cover.																					Not in 5x depth of cover.											

NOTE:
All mitigation measures, regardless of the cell in which they are recorded, are deemed to apply to all risk events. Furthermore, control and mitigation measures listed in the report are also deemed to apply to all risk events in the risk register.

Appendix C

Risk Criteria

FREQUENCY

Level	Descriptor	Alt. Description	Description	Chance %	Frequency
O	**Absolutely Certain**	Definite	This event will occur - known to occur now *- Will occur several (many) times each year and many times (constantly) during this project*	99.99	Several times each year
A	**Almost Certain**	Frequent	This event is expected to occur in most circumstances *- Expected to occur more than once during the duration of this project*	95	1 / year
B	**Likely**	Probable	This event will probably occur in most circumstances *- Expected to occur once during the duration of the project*	10	at least 1 / 10 years
C	**Possible**	Occasional	This event might (should) occur at some time *- Not likely to occur in life of project, but it is possible.*	1	at least 1 / 100 years
D	**Unlikely**	Remote	This event could occur at some time *- Unlikely (very) to occur in life of project*	0.1	at least 1 / 1,000 years
E	**Rare**	Very Unlikely	This event may occur in exceptional circumstances *- Examples of this have occurred historically, but it is not anticipated for this project*	0.01	at least 1 / 10,000 years
F	**Hypothetical**	Barely credible	Theoretically possible but never occurred to date (anywhere in the world) *- Often applied to natural events*	1.00E-03	at least 1 / 100,000 years

CONSEQUENCES

Level	Descriptor	Infrastructure			Amenity			Safety / Societal Cost
		Pavement	Bridges	Cost	Access	Speed	Political	
1	**Insignificant**	Minor damage	Minor repairable damage	< $50 k	Some loss in condition	No traffic effect	No political impact	No injuries or health effects
2	**Minor**	Noticeable damage	Damage that will deteriorate if not repaired quickly	< $100 k	One lane closed for < half day. One planned lane closure < 1 day	Speed reduction for < 1 month - 80 kph	Minimal political impact brief press coverage)	First aid treatment or minor damage to vehicles
3	**Moderate**	Significant damage	Significant damage	< $1 Mk	One lane closed for < 1 day	Speed reduction for > 1 month - 80 kph or < 1 day - 40 kph	Political impact (press coverage)	Medical treatment required
4	**Major**	Extensive damage	Major damage - restricted speed	< $10 M	One lane closed for > 1 day	Speed reduction for < 1 month - 40 kph	Significant political impact (extensive negative press coverage)	Extensive injuries or one or two permanent disabilities
5	**Catastrophic**	Loss of use of carriageway	Extensive damage. One carriageway closed until repaired	< $50 M	One carriageway closed for > 1 day or both cways for < 2 day	Speed reduction for > 1 month - 40 kph	Major political impact (Commission of Enquiry)	Single fatality or severe permanent disabilities to several people
6	**Untenable**		Total failure of bridge or closed until repaired	> $50 M	Both carriageways closed for > 2 day	Speed restrictions for > 12 months - 40 kph		Multiple fatalities

RISK MATRIX

LIKELIHOOD		CONSEQUENCES					
		Insignificant	Minor	Moderate	Major	Catastrophic	Unthinkable
		1	2	3	4	5	6
Multiple	O	H	E	E	E	E	E
Almost Certain	A	H	H	E	E	E	E
Likely	B	M	H	H	E	E	E
Possible	C	L	M	H	E	E	E
Unlikely	D	L	L	M	H	E	E
Rare	E	L	L	M	H	H	E
Hypothetical	F	L	L	L	M	H	H

Low	Low risk; managed by routine procedures.
Moderate	Moderate risk; requires above normal attention.
High	High risk; ALARP must be applied.
Extreme	Extreme risk; not acceptable and must be reduced.

Appendix D

Workshop Jamboard

Wollongong Coal - PC07-08 and PC21-25
Risk Assessment Workshop

17 September 2021

Agenda

Session 1: 11am - 1pm

11:00am - 11:15am	Introductions and housekeeping
11:15am - 11:25am	Workshop process
11:25am - 11:45am	Proposed mining activity
11:55am - 12:05pm	Existing mitigation measures
12:05pm - 1:00pm	Risk assessment - Existing mitigation measures - Risk rating - Determine assets that require additional treatment / mitigation measures - Identify additional mitigation measures and re-assess risks

Break: 1pm - 2pm

Session 2: 2pm - 4pm

2:00pm - 3:45pm	Risk assessment - continued
3:45pm - 4:00pm	Next steps and close-out

Attendance

Please use a sticky note (4th icon on the left) to write:
Your name - Role - Organisation

Jenny Li - Facilitator - Arup

Dr Ken Mills SCT Operations Pty Ltd 40+ years experience

Cyril Gunaratne, TfNSW, Pavement Maintenance planner

Richard Sheehan - WCL Environment Manager

Warwick Lidbury - WCL CEO

Robert Faddy Vrouwe WCL Environmental Coordinator

Dave Mullens TfNSW, Sen. Manager Pavement Planing

Dony Castro Bridge Maintenance Planner TfNSW

Henk buys - Geotechnical Engineer - AECOM

Martin Upitis Talis Consultants Chair Tech Committee

Devendra Vaas - WCL Technical Services Manager

Workshop Process

- Risk Assessment for LW4-5 & LW6 undertaken in 2014
- Preliminary Risk Assessment undertaken
- TfNSW assets affected
- Existing mitigation measures
- Risk rating
- Additional mitigation measures
- Residual risk rating

Risks Assessed

1. Infrastructure

Considers damage to pavements bridges, slopes, culverts

2. Functionality

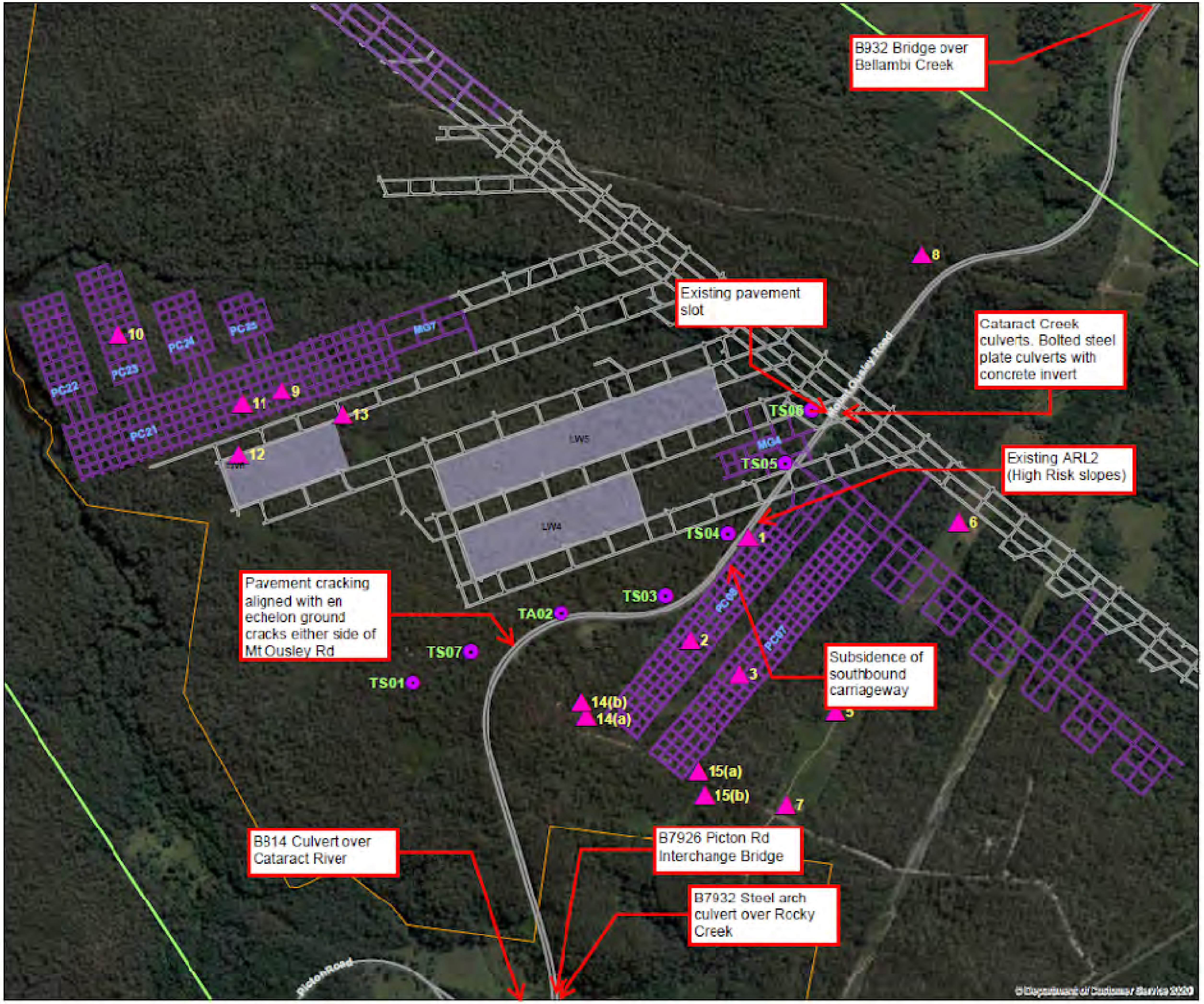
Loss of amenity and economic loss. Does not consider loss of functionality imposed as a preventative measure

3. Safety

Considers likely accidents, but without mitigation measures.

TfNSW Assets

1. Bridges
    - Picton Rd Interchange Bridge
    - Picton Rd Interchange Arch
    - North Bridge
2. Carriageways
    - General
    - Cataract Creek
    - RIdge
3. Slopes
4. Culverts
5. Miscellaneous Structures



Risk Rating

FREQUENCY

Level	Descriptor	Alt. Description	Description	Chance %	Frequency
O	**Absolutely Certain**	Definite	This event will occur - known to occur now *- Will occur several (many) times each year and many times (constantly) during this project*	99.99	Several times each year
A	**Almost Certain**	Frequent	This event is expected to occur in most circumstances *- Expected to occur more than once during the duration of this project*	95	1 / year
B	**Likely**	Probable	This event will probably occur in most circumstances *- Expected to occur once during the duration of the project*	10	at least 1 / 10 years
C	**Possible**	Occasional	This event might (should) occur at some time *- Not likely to occur in life of project, but it is possible*	1	at least 1 / 100 years
D	**Unlikely**	Remote	This event could occur at some time *- Unlikely (very) to occur in life of project*	0.1	at least 1 / 1,000 years
E	**Rare**	Very Unlikely	This event may occur in exceptional circumstances *Examples of this have occurred historically but it is not anticipated for this project*	0.01	at least 1 / 10,000 years
F	**Hypothetical**	Barely credible	Theoretically possible but never occurred to date (anywhere in the world) *- Often applied to natural events*	1.00E-03	every Million years

CONSEQUENCES

Level	Descriptor	Infrastructure			Amenity			Safety / Societal Cost
		Pavement	Bridges	Cost	Access	Speed	Political	
1	**Insignificant**	Minor damage	Minor repairable damage	< $50 k	Some loss in condition	No traffic effect	No political impact	No injuries or health effects
2	**Minor**	Noticeable damage	Damage that will deteriorate if not repaired quickly	< $100 k	One lane closed for < half day. One planned lane closure < 1 day	Speed reduction for < 1 month 80 kph	Minimal political impact (brief press coverage)	First aid treatment or minor damage to vehicles
3	**Moderate**	Significant damage	Significant damage	< $1 Mk	One lane closed for < 1 day	Speed reduction for > 1 month 80 kph or < 1 day - 40 kph	Political impact (press coverage)	Medical treatment required
4	**Major**	Extensive damage	Major damage - restricted speed	< $10 M	One lane closed for > 1 day	Speed reduction for < 1 month - 40 kph	Significant political impact (extensive negative press coverage)	Extensive injuries or one or two permanent disabilities
5	**Catastrophic**	Loss of use of carriageway	Extensive damage. One carriageway closed until repaired	< $50 M	One carriageway closed for > 1 day or both ways for < 2 day	Speed reduction for > 1 month 40 kph	Major political impact (Commission of Enquiry)	Single fatality or severe permanent disabilities to several people
6	**Untenable**		Total failure of bridge or closed until repaired	> $50 M	Both carriageways closed for > 2 day	Speed restrictions for > 12 months 40 kph		Multiple fatalities

RISK MATRIX

LIKELIHOOD		CONSEQUENCES 1 (Insignificant)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Catastrophic)	6 (Unthinkable)
Multiple	O	H	E	E	E	E	E
Almost Certain	A	H	H	E	E	E	E
Likely	B	M	H	H	E	E	E
Possible	C	L	M	H	E	E	E
Unlikely	D	L	L	M	H	E	E
Rare	E	L	L	M	H	H	E
Hypothetical	F	L	L	L	M	H	H

Low	Low risk; managed by routine procedures.
Moderate	Moderate risk; requires above normal attention.
High	High risk; ALARP must be applied.
Extreme	Extreme risk; not acceptable and must be reduced.

Possible Mitigation Measures

Ref: Preliminary Risk Assessment

1. Establish a Technical Committee to investigate and manage all mining risks to TfNSW infrastructure, functionality and road user safety
2. Regular ground surveys
3. Installation of monitoring equipment on critical assets e.g. bridges
4. Installation of fibre optic strain monitoring system along sections of critical roads at highest risk
5. Regular physical inspections of assets – includes pavements, culverts, bridges, etc
6. Establishment of rapid response (on call) teams, with equipment and materials, to react to changes in road profiles (including steps, humps, cracks etc)
7. Installation of VMS along critical sections of roads
8. Cut engineered slots in bound pavements prior to the commencement of mining
9. Full briefing of all emergency services of potential risks, including regular updates

1. Bridges

Failure Type / Risk Event

Mitigation Measures

Monitoring pins installed prior to LW mining - to be inspected

Additional GNSS unit beyond ridge to inform movements at the bridge.

Baseline surveys for bridges

Picton Rd Interchange Bridge - B7926 (structurally continuous / steel)

Barrier stops vertical subsidence. Ridge stops horizontal subsidence

- Differential vertical movements: M
- Differential horizontal movements: M

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Steel arch culvert over Rocky Creek - B7932

Initial Risk Rating
- Infrastructure: E3
- Functionality: E3
- Safety:

Residual Risk Rating
- Infrastructure: F2
- Functionality: F2
- Safety:

Culvert over Cataract River - B814

Initial Risk Rating
- Infrastructure: E3
- Functionality: E3
- Safety:

Residual Risk Rating
- Infrastructure: F2
- Functionality: F2
- Safety:

North Bridge - Bridge over Bellambi creek (structurally simply supported / steel)
Outside of area of interest

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
13	Bridge	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses exceeding code requirements - potentially leading to damage to bridge	F	5	H	F	5	H				Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse - 5 mm. Strains in region of up to 0.1 mm / metre are expected. Note that mining is away from bridge	Bridge to be fully surveyed prior to mining including measurement of available movements at bearings. TARP to be developed with trigger points for various actions. Develop survey plan of critical points for regular monitoring during mining	F	5	H	F	5	H				Note that as mining away from bridge any noticeable impacts unlikely to be resolved by ceasing mining (unless very early and large movements detected). Provided all reasonable actions are taken to prevent bridge damage / collapse prior and during to mining this risk event can be reasonably be considered to be managed in accordance with ALARP

2. Culverts

Failure Type / Risk Event

Mitigation Measures

Cataract Creek Culverts

- Bolted steel plate culverts with concrete invert
- Rating: M
- >1200mm

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Invert concreted culverts prior to LW mining.

Monitoring pins installed - to be relocated

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Fun						
				F	C	R	F	C	R	F	C	R			F	C	R	F						
19			Crushing (buckling) of side walls resulting in deformation requiring remedial actions										3.4 m diameter corrugated steel culvert.	Baseline condition survey before mining										
20	Cataract Creek (includes culvert)	Culvert cracking / movement	Crushing (buckling) of side walls leading to total failure	D	4	H	D	5	E				Retreating towards culvert provides better window of opportunity for early warning LW4 will provide data for possible impacts from LW5.	Base line condition. Monitoring - ongoing survey. Concrete floor Check (engineer) strength of deformed culvert. Check required hydraulic capacity (consider lining and grouting annulus after deformation). TARP to be developed.										
21			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert)	C	3	H							Potential for 100 mm vertical movement (movement could be sudden) Cost to make repairs to culvert (grouting etc)											
22			Loss of crossfall leads to ponding on road surface										Existing cross fall > 3% - would reduce to approx 2%	Impacted areas with reduced pavement crossfalls will be monitored for performance before any remedial works. RMS will be paid for the cost of reshaping the pavement										Typical pavement crossfalls for asphaltic pavements should be within 2.5% 3.0%.

Multiple Culverts

- Rating: L (x44)
- Vary in size from 300mm to 750mm in diameter

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Smaller culverts in PC21-25 5x cover zone.

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
5	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking)	C	3	M							Culverts vary in size from 300 mm to 750 mm in diameter. Requirement to undertake pre-mining condition survey of culverts - confirm actions with MSB Ponding not an issue based on cross falls.	Condition survey before and after mining (consider impacts from LW4&5) RMS will be financially compensated for any repairs	C	1	L							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS.
6		Loss culvert grading (compression buckling)	Ponding (on carriageway)																					

3. Carriageways - General

Failure Type / Risk Event

Mitigation Measures

P-Line survey on southbound carriageway - reinstate or assess alternative

Twice weekly drive-through inspections (done at traffic speed) - road maintenance. Report on new defects. Will not be able to notice subtle changes.

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Infrastructure Damage

- Bound pavement
- Strain <= 0.3%
- Rating: L

Functionality

- Total traffic volume (AADT)
- Auslink
- Rating: H

Safety - Pavement Damage

- Bound layer
- Speed > 60km/h to <= 80km/h
- Rating: H

Change in Pavement Geometry (Tilt)

- Pavements where tilt is predicted to occur
- Tilt <= 0.5%
- Rating: L

				LW4&5																		
				Infra			Function			Safety					Infra			Function			Safety		
ID	ASSET	FAILURE TYPE	EVENT	F	C	R	F	C	R	F	C	R	COMMENT	ADDITIONAL MITIGATION	F	C	R	F	C	R	F	C	R	COMMENT
1	Carriage way excluding Cataract Creek	Compression buckling	Rapid pavement failure leading to hump or step > 50mm										Rapid implies very fast matter of minutes to few hours. Not credible to get compression failure											
2		Stepping (Shearing)	Rapid pavement failure leading to hump or step > 50mm										Not credible to get compression failure.											
3		Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (P46)	C	2	M	C	2	M				Any cracking would be visible - probably <5 mm in width. Not deemed to be a safety issue as crack propagation would be gradual and would be repaired before it caused accident.	TARP to be developed to respond to cracks. RMS will be paid for the cost of all repairs. Baseline condition survey before mining	C	1	L	C	2	M				
4		Various	Reduced life of pavement	D	4	H							Requirement to undertake pre-mining condition survey of road - confirm actions with MSB		D	2	L							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS

3. Carriageways - Cataract Creek (approx. 100m in length)

Failure Type / Risk Event

Closure of slot - forming a bump (10mm to 20mm of closure). Drive-through inspections. Mill / mill or resheet. Schedule with other road closures / road works.

Initial Risk Rating
- Infrastructure: D3
- Functionality: D3
- Safety:

Residual Risk Rating
- Infrastructure:E3
- Functionality: E3
- Safety:

Mitigation Measures

Existing pavement slot

Check condition of crackmeters - replace if necessary

Physical condition of slot to be checked

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
14	Cataract Creek (includes all pavement in this area - approx 100 m in length)	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	E	E	5	H	Compressive strains estimated to be in region of 0.5 mm / metre. Closure estimated to be 50 mm (assume 100 mm as worst case) Valley 100 metres long. Mining towards Cataract Creek. Assumes bound pavement layer.	Longitudinal road survey (ongoing at regular intervals) with TARP. Slotting - Pavement preslotting to be installed before commencement of LW5. Additional slotting if deemed necessary based on TC review of monitoring data										
15		Shearing (Shearing)	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	L	F	5	H												
16		Various	Reduced life of pavement	C	3	H								Condition survey of roads pavement before and after mining (consider impacts from LW4&5 and LW3)	C	2	M							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS

3. Carriageways - Tension Zone at Ridge (P46)

Mitigation Measures

Crack repaired.

Monitoring pins installed - to be identified.

Failure Type / Risk Event

Pavement cracking aligned with en echelon ground cracks either side of Mt Ousley Rd

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

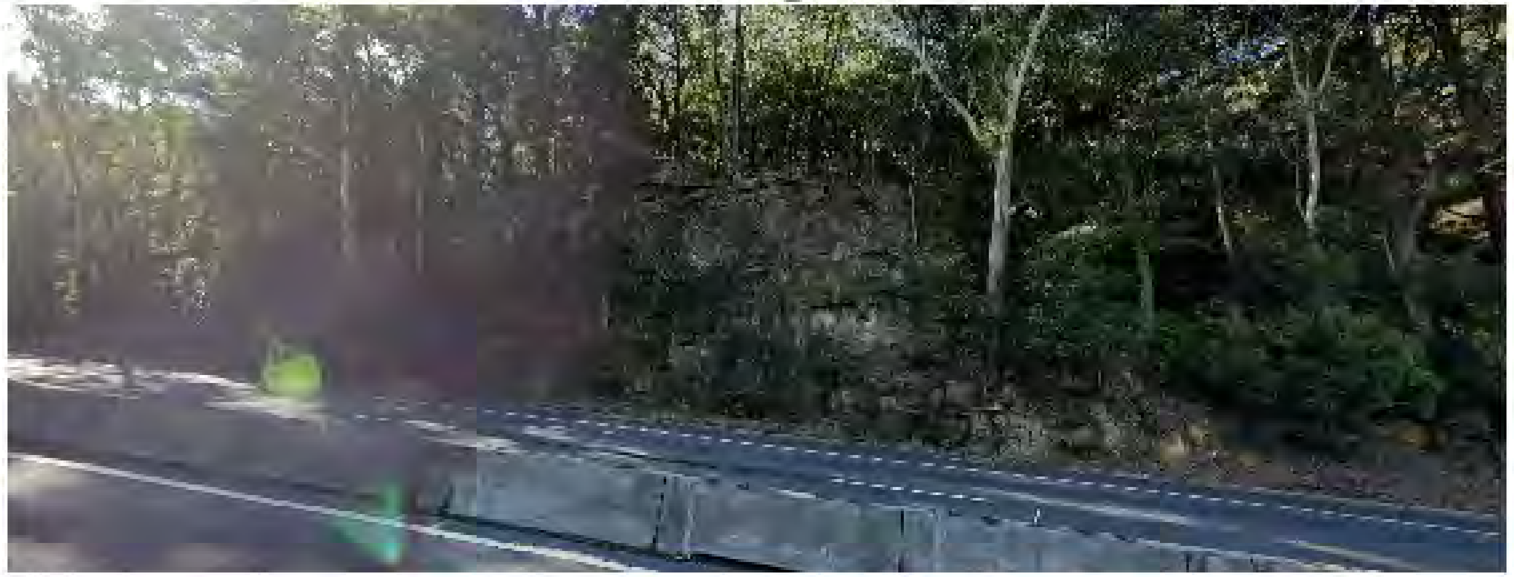
Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

				LW4&5																					
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
23	Pavement at the Tension Zone at Ridge (P46)	Cracking	Crack due to tensile movement - Tension Zone at Ridge (P46)																					

4. Slopes

Failure Type / Risk Event

Mitigation Measures



ARL2 - 95771 / 95770 / 13482
- Rating: H (x3)

ARL 3 - 10839 / 13483 / 13484 / 13485
- Rating: M (x4)

Cuttings more likely to be stretched than compressed.

Adjacent PC08

Initial Risk Rating
- Infrastructure: E3
- Functionality: E4
- Safety: E3

Residual Risk Rating - unchanged from existing
- Infrastructure:
- Functionality:
- Safety:

Beyond ridge, near Picton Rd interchange

Initial Risk Rating
- Infrastructure: F3
- Functionality: F4
- Safety: F3

Residual Risk Rating - unchanged from existing
- Infrastructure:
- Functionality:
- Safety:

ARL 4
- Rating: L (x2)

ARL 5
- Rating: L (x4)

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Water ingress - not an issue as water level is not high.

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
8	Cuttings	Excessive ground movement	Slumping, cracks, water in, falling material	D	2	L	D	2	L	E	5	H	Currently ARL (Assessed Risk Level - RMS term) along this section of road is mainly 3 with one area of 2. ARL 2 is a HIGH risk. Will undertake a total inspection of the cuttings to re assess the ARL's with a view to any changes that might occur due to mining.	Undertake reassessment prior to mining followed by adequate remedial actions to reduce risk to ALARP (As Low As Reasonably Practicable). RMS to be compensated for any expenses caused by mining or responding to needs prior to mining commencing.	D	1	L	D	2	L	E	5	H	Note that the risk level with regard to public safety has not been reduced. The chance of an event is not credibly less than RARE and should the event occur the consequences do not change. Provided all reasonable actions are taken to stabilise and make safe the slopes prior to mining and regular inspections are undertaken during mining this risk event can be reasonably be considered to be managed in accordance with ALARP.
9	Embank ments	Excessive ground movement	Cracks, water, instability	F	4	M	F	4	M				North of Picton Rd Interchange - ARL 3. Slope is at limit of stability. Damage to edge of road. Failure is expected to be slow - allows intervention before significant impact. Nearest longwall is approx. 700 m away.	Normal maintenance inspections supplemented by data from other surveys to trigger actions in regard to the embankment.	F	4	M	F	4	M				

5. Miscellaneous Structures

Failure Type / Risk Event

Mitigation Measures

Mono Pole Structures

- Road signs, noise walls, barriers, etc.
- < 2.0% tilt
- Rating: L

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

No change to existing risk.

Barriers - if pinned to the ground, then would move with crack. Low risk. Based on experience, no impacts on barriers.

Other Structures

- VMS gantry portal structures, rest area structures, detention basins
- < 1% strain
- Rating: L

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

None in area.

				LW4&5																				
ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				I	C	R	I	C	R	I	C	R			I	C	R	I	C	R	I	C	R	
10	Furniture	Excessive ground movement											Guard rails, median barriers & signs No credible consequence											
12	VMS	Excessive ground movement	Damage to buried cables										None present											

6. Other Assets

Failure Type / Risk Event

Mitigation Measures

Initial Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Residual Risk Rating
- Infrastructure:
- Functionality:
- Safety:

Parking Lot

Next Steps

- Draft risk register and report will be sent for review within 2 weeks.
- 1 week review period.
- Final risk register and report.

Transport for NSW

RISK ASSESSMENT - SUBSIDENCE IMPACTS ON TfNSW ASSETS

RISK REGISTER ISSUE REV A 8/10/2021

ID	ASSET	FAILURE TYPE	EVENT	PC21-25																				
				Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
1	Carriageway excluding Cataract Creek section	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm. Rapid implies very fast - matter of minutes to few hours.										Not considered a credible risk from subsidence of 500mm.											
2		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not considered a credible risk from subsidence of 500mm.											
3		Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (P46).										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).											
4		Various	Reduced life of pavement.										Not considered a credible risk from subsidence of 500mm.											
5	Carriageway - Cataract Creek (section approximately 100m in length)	Compression buckling	Due to the presence of the slot, compression buckling leading to bump forming at the slot (closure of the slot) 10mm from 20mm of closure.										Not in 5x depth of cover.											
6		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not in 5x depth of cover.											
7		Treatment and response of pavement from mining activities	Reduced life of pavement.										Not in 5x depth of cover.											
8		Cracking	Crack due to tensile movement.										Not in 5x depth of cover.											
9		Upsidence (impact on pavement)											Risk etc included in events above.											

ID	PC07-08																				
	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
	F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
1										Not considered a credible risk from subsidence of 500mm.											
2										Not considered a credible risk from subsidence of 500mm.											
3										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).	Undertake baseline condition survey before mining.										
4	E	2	L	E	2	L				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
5	D	3	M	D	3	M					P-Line survey on southbound carriageway - reinstate or assess alternative. Check condition of crack meters and replace if necessary. Check the physical condition of the slot. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Mill or mill and resheet if required. Note schedule any works with other road closures / road works if possible. Develop TARP with trigger points for various actions.	E	3	M	E	3	M				
6										Not considered a credible risk due to slot.											
7	B	2	H	B	2	H				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	D	2	L	D	2	L				
8										Not considered a credible risk.											
9										Not considered a credible risk.											

ID	ASSET	FAILURE TYPE	EVENT	PC21-25																				
				Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
10	Pavement at the Tension Zone at Ridge (P46)	Cracking	Pavement cracking aligned with en echelon ground cracks either side of Mt Ousley Rd.										Not in 5x depth of cover.											
11	Bridge - Picton Rd interchange bridge (B7926)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
12	Bridge - steel arch culvert over Rocky Creek (B7932)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
13	Culvert over Cataract River (B814)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
14			Deformation of the side walls resulting in a shear failure and requiring remedial actions.										Not in 5x depth of cover.	Baseline condition survey before mining										
15	Cataract Creek Culverts	Culvert cracking / movement	Crushing (buckling) of side walls leading to total failure / deformation requiring remedial actions.										Not in 5x depth of cover.											
16			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert).										Not in 5x depth of cover.											
17			Loss of crossfall leads to ponding on road surface.										Not in 5x depth of cover.											
18	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking).										Small culverts in the 5x depth of cover. Any impacts would be insignificant.											
19		Lose culvert grading (compression buckling)	Ponding (on carriageway).										Not considered a credible risk.											

ID	PC07-08																				
	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
	F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
10	C	2	M	C	2	M				Crack of same order of less experience from previous mining activities. Monitoring pins installed - locations to be identified.	Assess during mining the nature of the movement (perform crack sealing if required). Assess post mining if crack sealing is sufficient or if further treatment is required. Develop TARP with trigger points for various actions.	C	2	M	C	2	M				
11	E	4	H	E	4	H				Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse +- 5 mm. 500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	3	L	F	3	L				
12	E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
13	E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
14	E	4	H	E	2	L				Expect 3-4mm of closure (from 500mm of subsidence). Inverts of plate steel culverts were concrete encased prior to longwall mining. Existing slot will prevent step forming or failure of pavement.	Monitor GNSS and undertake subsequent survey of culverts if trigger levels reached. Develop TARP with trigger points for various actions.	F	4	M	F	2	L				
15										Not considered a credible risk due to upper limit of 20mm of closure.											
16										Not considered a credible risk due to volume of flow in the culvert.											
17										Not considered a credible risk due to high fill.											
18	D	3	M							Culverts vary in size from 300 mm to 750 mm in diameter. Minimal impacts to culverts observed from longwall mining.	Use precondition assessments from longwall mining as baseline.	D	3	M							
19										Not considered a credible risk.											

ID	ASSET	FAILURE TYPE	EVENT	PC21-25 Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT	ADDITIONAL MITIGATION	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT
20	Cuttings adjacent PC08	Excessive ground movement (compression movements)	Slumping, cracks, water in, falling material.										Not in 5x depth of cover.											
21	Cuttings near Picton Rd interchange	Excessive ground movement (compression movements)	Slumping, cracks, water ingress, falling material.										Not in 5x depth of cover.											
22	Embankments	Excessive ground movement	Cracks, instability.										Not in 5x depth of cover.											
23	Mono pole structures, e.g. road signs, noise walls, barriers	Excessive ground movement	Damage.										Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.											
24	VMS	Excessive ground movement	Damage.										Not in 5x depth of cover.											

ID	ASSET	PC07-08 Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT	ADDITIONAL MITIGATION	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT
20	Cuttings adjacent PC08	E	3	M	E	4	H	E	3	M	13483 and 13484 are adjacent PC08. Both are ARL3 - medium risk. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
21	Cuttings near Picton Rd interchange	F	3	L	F	4	M	F	3	L	95771, 95770 (both ARL2 - high risk) and 10839, 13485 (both ARL3 - medium risk) are located beyond the ridge line close to the Picton Rd interchange. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure ARL does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
22	Embankments										Embankments are ductile structures. Any impacts would be insignificant.											
23	Mono pole structures, e.g. road signs, noise walls, barriers										Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.											
24	VMS										Not in 5x depth of cover.											

NOTE:
All mitigation measures, regardless of the cell in which they are recorded, are deemed to apply to all risk events. Furthermore, control and mitigation measures listed in the report are also deemed to apply to all risk events in the risk register.

ROADS & MARITIME SERVICES

RISK ASSESSMENT - SUBSIDENCE IMPACTS ON RMS ASSETS

RISK REGISTER - 10 July 2014 | ISSUE | REV D

ID	ASSET	FAILURE TYPE	EVENT	LW4&5 Infra (F C R)	LW4&5 Function (F C R)	LW4&5 Safety (F C R)	COMMENT	ADDITIONAL MITIGATION	Infra (F C R)	Function (F C R)	Safety (F C R)	COMMENT	LW6&7 EVENT	Infra (F C R)	Function (F C R)	Safety (F C R)	COMMENT	ADDITIONAL MITIGATION	Infra (F C R)	Function (F C R)	Safety (F C R)	COMMENT
1	Carriage way excluding Cataract Creek	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm				Rapid implies very fast - matter of minutes to few hours. Not credible to get compression failure.										No compression zone except Cataract Creek - No risk.					
2		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm				Not credible to get compression failure.										No compression zone except Cataract Creek - No risk.					
3		Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (P46)	C 2 M	C 2 M		Any cracking would be visible - probably <5 mm in width. Not deemed to be a safety issue as crack propagation would be gradual and would be repaired before it caused accident	TARP to be developed to respond to cracks. RMS will be paid for the cost of all repairs Baseline condition survey before mining	C 1 L	C 2 M				C 1 L			Likely will get a small movement (<5mm). Minor impact. Not a safety issue.		C 1 L			
4		Various	Reduced life of pavement	D 4 H			Requirement to undertake pre-mining condition survey of road - confirm actions with MSB		D 2 L			Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS.					No predicted risk outside Ridge and Cataract Creek areas.					
5	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking)	C 3 M			Culverts vary in size from 300 mm to 750 mm in diameter. Requirement to undertake pre-mining condition survey of culverts - confirm actions with MSB	Condition survey before and after mining (consider impacts from LW4&5). RMS will be financially compensated for any repairs	C 1 L			Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS.		D 1 L			Post condition survey for LW 4&5 needs to be completed by RMS. Take action if any issues highlighted. This will be the baseline condition report for LW6&7. RMS to be reimbursed for any repairs.		D 1 L			
6		Lose culvert grading (compression buckling)	Ponding (on carriageway)				Ponding not an issue based on cross falls.															
7	Kerb	Kerb/gutter cracking / buckling	Kerb cracking / buckling requiring repair	C 1 L			Credible loads are tension.		C 1 L					E 1 L			Not predicted to be an issue but will be monitored via weekly drive through and monthly visual site inspections.		E 1 L			
8	Cuttings	Excessive ground movement	Slumping, cracks, water in, falling material	D 2 L	D 2 L	E 5 H	Currently ARL (Assessed Risk Level - RMS term) along this section of road is mainly 3 with one area of 2. ARL 2 is a HIGH risk. Will undertake a total inspection of the cuttings to re-assess the ARL's with a view to any changes that might occur due to mining.	Undertake reassessment prior to mining followed by adequate remedial actions to reduce risks to ALARP (As Low As Reasonably Practicable). RMS to be compensated for any expenses caused by mining or responding to needs prior to mining commencing.	D 1 L	D 2 L	E 5 H	Note that the risk level with regard to public safety has not been reduced. The chance of an event is not credibly less than RARE and should the event occur the consequences do not change. Provided all reasonable actions are taken to stabilise and make safe the slopes prior to mining and regular inspections are undertaken during mining this risk event can be reasonably be considered to be managed in accordance with ALARP.		E 1 L	E 2 L	E 5 H	Currently ARL (Assessed Risk Level - RMS term) along this section of road is mainly 3 with one area of 2. ARL 2 is a HIGH risk. LW4&5 has created no impacts. None expected with LW6&7. As all reasonable actions have been undertaken to stabilise and make safe the slopes prior to mining and regular inspections are undertaken during mining this risk event can be reasonably be considered to be managed in accordance with the ALARP principle.		E 1 L	E 2 L	E 5 H	
9	Embank ments	Excessive ground movement	Cracks, water, instability	F 4 M	F 4 M		North of Picton Rd Interchange - ARL 3. Slope is at limit of stability. Damage to edge of road. Failure is expected to be slow - allows intervention before significant impact. Nearest longwall is approx 700 m away	Normal maintenance inspections supplemented by data from other surveys to trigger actions in regard to this embankment	F 4 M	F 4 M				F 4 M	F 4 M		There is not expected to be a change due to LW6&7. Review in relation to LW1-3.		F 4 M	F 4 M		
10	Furniture	Excessive ground movement					Guard rails, median barriers & signs. No credible consequence															
12	VMS	Excessive ground movement	Damage to buried cables				None present															
13	Bridge	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge	E 5 H	E 5 H		Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse +- 5 mm Strains in region of up to 0.1 mm / metre are expected. Note that mining is away from bridge	Bridge to be fully surveyed prior to mining including measurement of available movements at bearings. TARP to be developed with trigger points for various actions. Develop survey plan of critical points for regular monitoring during mining	F 5 H	F 5 H		Note that as mining away from bridge any noticeable impacts unlikely to be resolved by ceasing mining (unless very early and large movements detected). Provided all reasonable actions are taken to prevent bridge damage / collapse prior and during to mining this risk event can be reasonably be considered to be managed in accordance with ALARP.		F 5 H	F 5 H		For LW6&7 it is not forseen that there can be an impact. Needs to be revisited for LW1-3. Monitoring of bridge to be consistent with Monitoring Plan and any action required managed by TARP. If point-to-point survey after LW6 shows no movement, then none required for LW7.		F 5 H	F 5 H		

14	Cataract Creek (includes all pavement in this area - approx 100 m in length)	Compression buckling	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	E	E	5	H	Compressive strains estimated to be in region of 0.5 mm / metre. Closure estimated to be 50 mm (assume 100 mm as worst case). Valley 100 metres long. Mining towards Cataract Creek. Assumes bound pavement layer.	Longitudinal road survey (ongoing at regular intervals) with TARP. Slotting - Pavement preslotting to be installed before commencement of LW5. Additional slotting if deemed necessary based on TC review of monitoring data																E	2	L				Slot installed prior to LW5. Creek closure about 40mm from LW4&5, slot closure about 20mm to end of LW5. Approximately half slot closure prior to mining, half due to mining LW5. Closure resulted in the need to remill the slot surface. Pre-mining slot closure was due mainly to downhill creep and temperature effects. Similar scenario is expected for LW6&7, but with the increased distance from the road, mining is predicted to have less of an impact on slot closure. Frequency relates to getting a sudden 50mm step					E	2	L				
15		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm	C	3	H	C	4	E	E	5	H																		E	2	L				Slot installed prior to LW5. Creek closure about 40mm from LW4&5, slot closure about 20mm to end of LW5. Approximately half slot closure prior to mining, half due to mining LW5. Closure resulted in the need to remill the slot surface. Pre-mining slot closure was due mainly to downhill creep and temperature effects. Similar scenario is expected for LW6&7, but with the increased distance from the road, mining is predicted to have less of an impact on slot closure. Frequency relates to getting a sudden 50mm step					E	2	L				
16		Various	Reduced life of pavement	C	3	H								Condition survey of road / pavement before and after mining (consider impacts from LW4&5 and LW 3).	C	2	M							Risk event virtually eliminated provided RMS are able to be reasonably compensated - residual risk is that smaller dollar amount that resides with the RMS		C	2	M							From LW4&5 experience, remilling of the slot surface is likely to be required, but there is essentially no funtionality or safety risk due to slow change in ride quality and managed intervention.	Condition survey of road / pavement before and after mining.	C	2	M							
17		Cracking	Crack due to tensile movement	C	2	M	C	2	M				Any cracking would be visible - probably <5 mm in width Not deemed to be a safety issue as crack propagation would be gradual and would be repaired before it caused accident	TARP to be developed to respond to cracks. RMS will be paid for the cost of all repairs	C	1	L	C	2	M									E	1	L				No Tension at Cataract Creek. Predicted impact is valley closure with no tensile cracking.					E	1	L				
18		Upsidence (impact on pavement)											Risk etc included in events above.																																		
19	Cataract Creek (includes culvert)	Culvert cracking / movement	Crushing (buckling) of side walls resulting in deformation requiring remedial actions										3.4 m diameter corrugated steel culvert	Baseline condition survey before mining												D	2	L							Monitoring of diagonal measurements indicated no impact on culvert from LW4&5. For LW6 monitoring will focus on horizontal and vertical measurements of the culvert for better sensitivity. Note that for a flexible steel culvert, crushing is the likely failure mode.		D	2	L							
20			Crushing (buckling) of side walls leading to total failure	D	4	H	D	5	E				Retreating towards culvert provides better window of opportunity for early warning. LW4 will provide data for possible impacts from LW5.	Base line condition. Monitoring - ongoing survey. Concrete floor. Check (engineer) strength of deformed culvert . Check required hydraulic capacity (consider lining and grouting annulus after deformation). TARP to be developed.												F	3	L	F	4	M				Monitoring of diagonal measurements indicated no impact on culvert from LW4&5. For LW6 monitoring will focus on horizontal and vertical measurements of the culvert for better sensitivity. Note that for a flexible steel culvert, crushing is the likely failure mode.		F	3	L	F	4	M				
21			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert)	C	3	H							Potential for 100 mm vertical movement (movement could be sudden) Cost to make repairs to culvert (grouting etc)																							Not a realistic Risk For LW6&7. Reconsider for LW 1,2&3.											
22			Loss of crossfall leads to ponding on road surface										Existing cross fall >3% - would reduce to approx 2%	Impacted areas with reduced pavement crossfalls will be monitored for performance before any remedial works. RMS will be paid for the cost of reshaping the pavement										Typical pavement crossfalls for asphaltic pavements should be within 2.5%-3.0%.											Not a realistic Risk For LW6&7. Reconsider for LW 1,2&3.											
23	Pavement at the Tension Zone at Ridge (P46)	Cracking	Crack due to tensile movement - Tension Zone at Ridge (P46)																							B	2	H				C	2	M	Trenches to be dug in shoulder to investigatecracking in underlying rock to confirm cracks existed before road construction. Possible some crack opening from LW4&5 leading to local settlement and creating a step. Balgownie LWs north of road may also have contributed to initial movement. Likely to see block movement with LW6 towards Cataract Creek. Consequences expected to be minor (<5mm - increase from 10 to 15mm).	Existing crack and step will require treatment (correction layer) to maintain safety/rideability. Monitor crack width (RMS weekly drive through and C Dove monthly site inpection) and respond with temporary treatment as required.	B	1	M							With mitigation no safety consequence.

NOTE:
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FREQUENCY

Level	Descriptor	Alt. Description	Description	Chance %	Frequency
O	**Absolutely Certain**	Definite	This event will occur - known to occur now *- Will occur several (many) times each year and many times (constantly) during this project*	99.99	Several times each year
A	**Almost Certain**	Frequent	This event is expected to occur in most circumstances *- Expected to occur more than once during the duration of this project*	95	1 / year
B	**Likely**	Probable	This event will probably occur in most circumstances *- Expected to occur once during the duration of the project*	10	at least 1 / 10 years
C	**Possible**	Occasional	This event might (should) occur at some time *- Not likely to occur in life of project, but it is possible.*	1	at least 1 / 100 years
D	**Unlikely**	Remote	This event could occur at some time *- Unlikely (very) to occur in life of project*	0.1	at least 1 / 1,000 years
E	**Rare**	Very Unlikely	This event may occur in exceptional circumstances *- Examples of this have occurred historically, but it is not anticipated for this project*	0.01	at least 1 / 10,000 years
F	**Hypothetical**	Barely credible	Theoretically possible but never occurred to date (anywhere in the world) *- Often applied to natural events*	1.00E-03	at least 1 / 100,000 years

CONSEQUENCES

Level	Descriptor	Infrastructure			Amenity		
		Pavement etc	Bridges	Cost	Access	Speed	Political
1	**Insignificant**	Minor damage	Minor repairable damage	< $50 k	Some loss in condition	No traffic effect	No political impact
2	**Minor**	Noticeable damage	Damage that will deteriorate if not repaired quickly	< $100 k	One lane closed for < half day. One planned lane closure < 1 day	Speed reduction for < 1 month - 80 kph	Minimal political impact brief press coverage)
3	**Moderate**	Significant damage	Significant damage	< $1 Mk	One lane closed for < 1 day	Speed reduction for > 1 month - 80 kph or < 1 day - 40 kph	Political impact (press coverage)
4	**Major**	Extensive damage	Major damage - restricted speed	< $10 M	One lane closed for > 1 day	Speed reduction for < 1 month - 40 kph	Significant political impact (extensive negative press coverage)
5	**Catastrophic**	Loss of use of carriageway	Extensive damage. One carriageway closed until repaired	< $50 M	One carriageway closed for > 1 day or both cways for < 2 day	Speed reduction for > 1 month - 40 kph	Major political impact (Commission of Enquiry)
6	**Untenable**		Total failure of bridge or closed until repaired	> $50 M	Both carriageways closed for > 2 day	Speed restrictions for > 12 months - 40 kph	

Safety / Societal Cost
No injuries or health effects
First aid treatment or minor damage to vehicles
Medical treatment required
Extensive injuries or one or two permanent disabilities
Single fatality or severe permanent disabilities to several people
Multiple fatalities

RISK MATRIX

LIKELIHOOD		CONSEQUENCES: Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	Unthinkable 6
Multiple	O	H	E	E	E	E	E
Almost Certain	A	H	H	E	E	E	E
Likely	B	M	H	H	E	E	E
Possible	C	L	M	H	E	E	E
Unlikely	D	L	L	M	H	E	E
Rare	E	L	L	M	H	H	E
Hypothetical	F	L	L	L	M	H	H

Low	Low risk; managed by routine procedures.
Moderate	Moderate risk; requires above normal attention.
High	High risk; ALARP must be applied.
Extreme	Extreme risk; not acceptable and must be reduced.

Appendix E

Risk Register

PC21-25

ID	ASSET	FAILURE TYPE	EVENT	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT	ADDITIONAL MITIGATION	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT
1		Compression buckling	Rapid pavement failure, leading to hump or step > 50mm. Rapid implies very fast - matter of minutes to few hours.										Not considered a credible risk from subsidence of 500mm.											
2		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not considered a credible risk from subsidence of 500mm.											
3	Carriageway excluding Cataract Creek section	Cracking	Crack due to tensile movement - excluding Tension Zone at Ridge (P46).										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).											
4		Various	Reduced life of pavement.										Not considered a credible risk from subsidence of 500mm.											
5	Carriageway - Cataract Creek (section approximately 100m in length)	Compression buckling	Due to the presence of the slot, compression buckling leading to bump forming at the slot (closure of the slot) - 10mm from 20mm of closure.										Not in 5x depth of cover.											
6		Stepping (Shearing)	Rapid pavement failure, leading to hump or step > 50mm.										Not in 5x depth of cover.											
7		Treatment and response of pavement from mining activities	Reduced life of pavement.										Not in 5x depth of cover.											
8		Cracking	Crack due to tensile movement.										Not in 5x depth of cover.											
9		Upsidence (impact on pavement)											Risk etc included in events above.											

PC07-08

ID	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT	ADDITIONAL MITIGATION	Infra F	Infra C	Infra R	Function F	Function C	Function R	Safety F	Safety C	Safety R	COMMENT
1										Not considered a credible risk from subsidence of 500mm.											
2										Not considered a credible risk from subsidence of 500mm.											
3										Not considered a credible risk from subsidence of 500mm. Any impacts would be insignificant (e.g. requiring crack sealing only).	Undertake baseline condition survey before mining.										
4	E	2	L	E	2	L				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
5	D	3	M	D	3	M					P-Line survey on southbound carriageway - reinstate or assess alternative. Check condition of crack meters and replace if necessary. Check the physical condition of the slot. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Mill or mill and resheet if required. Note schedule any works with other road closures / road works if possible. Develop TARP with trigger points for various actions.	E	3	M	E	3	M				
6										Not considered a credible risk due to slot.											
7	B	2	H	B	2	H				Any mining activities is likely to reduce the life of the pavement. Any impacts would be minor.	P-Line survey on southbound carriageway - reinstate or assess alternative. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary. Develop TARP with trigger points for various actions.	D	2	L	D	2	L				
8										Not considered a credible risk.											
9										Not considered a credible risk.											

PC21-25

ID	ASSET	FAILURE TYPE	EVENT	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
				F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
10	Pavement at the Tension Zone at Ridge (P46)	Cracking	Pavement cracking aligned with en echelon ground cracks either side of Mt Ousley Rd.										Not in 5x depth of cover.											
11	Bridge - Picton Rd interchange bridge (B7926)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
12	Bridge - steel arch culvert over Rocky Creek (B7932)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
13	Culvert over Cataract River (B814)	Destructive movements on bridges	Differential horizontal movements over a period of time causing excessive stresses - exceeding code requirements - potentially leading to damage to bridge.										Not in 5x depth of cover.											
14			Deformation of the side walls resulting in a shear failure and requiring remedial actions.										Not in 5x depth of cover.	Baseline condition survey before mining										
15	Cataract Creek Culverts	Culvert cracking / movement	Crushing (buckling) of side walls leading to total failure / deformation requiring remedial actions.										Not in 5x depth of cover.											
16			Ponding in creek, loss of hydraulic flow, potential damage due to bypassing and erosion etc (differential upsidence across length of culvert).										Not in 5x depth of cover.											
17			Loss of crossfall leads to ponding on road surface.										Not in 5x depth of cover.											
18	Culvert	Culvert cracking / movement	Culvert joints open, culvert damage (minor cracking).										Small culverts in the 5x depth of cover. Any impacts would be insignificant.											
19		Lose culvert grading (compression buckling)	Ponding (on carriageway).										Not considered a credible risk.											

PC07-08

ID	Infra			Function			Safety			COMMENT	ADDITIONAL MITIGATION	Infra			Function			Safety			COMMENT
	F	C	R	F	C	R	F	C	R			F	C	R	F	C	R	F	C	R	
10	C	2	M	C	2	M				Crack of same order of less experience from previous mining activities. Monitoring pins installed - locations to be identified.	Assess during mining the nature of the movement (perform crack sealing if required). Assess post mining if crack sealing is sufficient or if further treatment is required. Develop TARP with trigger points for various actions.	C	2	M	C	2	M				
11	E	4	H	E	4	H				Pot bearings - longitudinal +- 25 mm (ranges between 30 and 10), transverse +- 5 mm. 500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Monitoring pins (prisms at the bridge) were installed prior to longwall mining. Inspect prior to mining of PC07-08 and establish baseline. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	3	L	F	3	L				
12	E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
13	E	3	M	E	3	M				500mm of subsidence leads to very low levels of movements at the bridge. Differential movements are expected to be even less.	Undertake baseline condition survey before mining. Install additional GNSS unit beyond the ridge to inform movements at the bridge to act as an early warning system. Develop TARP with trigger points for various actions.	F	2	L	F	2	L				
14	E	4	H	E	2	L				Expect 3-4mm of closure (from 500mm of subsidence). Inverts of plate steel culverts were concrete encased prior to longwall mining. Existing slot will prevent step forming or failure of pavement.	Monitor GNSS and undertake subsequent survey of culverts if trigger levels reached. Develop TARP with trigger points for various actions.	F	4	M	F	2	L				
15										Not considered a credible risk due to upper limit of 20mm of closure.											
16										Not considered a credible risk due to volume of flow in the culvert.											
17										Not considered a credible risk due to high fill.											
18	D	3	M							Culverts vary in size from 300 mm to 750 mm in diameter. Minimal impacts to culverts observed from longwall mining.	Use precondition assessments from longwall mining as baseline.	D	3	M							
19										Not considered a credible risk.											

ID	ASSET	FAILURE TYPE	EVENT	PC21-25 Infra F	C	R	Function F	C	R	Safety F	C	R	COMMENT	ADDITIONAL MITIGATION	Infra F	C	R	Function F	C	R	Safety F	C	R	COMMENT
20	Cuttings adjacent PC08	Excessive ground movement (compression movements)	Slumping, cracks, water in, falling material.										Not in 5x depth of cover.											
21	Cuttings near Picton Rd interchange	Excessive ground movement (compression movements)	Slumping, cracks, water ingress, falling material.										Not in 5x depth of cover.											
22	Embankments	Excessive ground movement	Cracks, instability.										Not in 5x depth of cover.											
23	Mono pole structures, e.g. road signs, noise walls, barriers	Excessive ground movement	Damage.										Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.											
24	VMS	Excessive ground movement	Damage.										Not in 5x depth of cover.											

ID	ASSET	PC07-08 Infra F	C	R	Function F	C	R	Safety F	C	R	COMMENT	ADDITIONAL MITIGATION	Infra F	C	R	Function F	C	R	Safety F	C	R	COMMENT
20	Cuttings adjacent PC08	E	3	M	E	4	H	E	3	M	13483 and 13484 are adjacent PC08. Both are ARL3 - medium risk. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure the ARL of slopes does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
21	Cuttings near Picton Rd interchange	F	3	L	F	4	M	F	3	L	95771, 95770 (both ARL2 - high risk) and 10839, 13485 (both ARL3 - medium risk) are located beyond the ridge line close to the Picton Rd interchange. Note ARL - Assessed Risk Level - TfNSW term. Cuttings more likely to be stretched than compressed.	Undertake risk assessment to ensure ARL does not change as a result of mining. Groom slopes prior to mining. Use GNSS monitoring to provide early warning. TfNSW undertake twice weekly drive-through inspections (done at traffic speed), report on new defects, and repair as necessary.	F	3	L	F	4	M	F	3	L	
22	Embankments										Embankments are ductile structures. Any impacts would be insignificant.											
23	Mono pole structures, e.g. road signs, noise walls, barriers										Not considered a credible risk. Barriers: If pinned to the ground, would move with cracks. Based on previous experience, no impacts to barriers.											
24	VMS										Not in 5x depth of cover.											

NOTE:
All mitigation measures, regardless of the cell in which they are recorded, are deemed to apply to all risk events. Furthermore, control and mitigation measures listed in the report are also deemed to apply to all risk events in the risk register.