
**Report on Investigation Plan to Support
Development Application**

Proposed Residential Subdivision

144 Boundary Road, Wallsend NSW

**Prepared for Eden Estates (Newcastle) Pty
Ltd**

Project 91610.09

11 August 2025

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

Signature

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Report on Investigation Plan to Support Development Application Proposed Residential Subdivision 144 Boundary Road, Wallsend NSW

1. Introduction

This report prepared by Douglas Partners Pty Ltd (Douglas) presents an investigation plan to support development application for a proposed residential subdivision at 144 Boundary Road, Wallsend NSW. The investigation plan was undertaken for Eden Estates (Newcastle) Pty Ltd and in accordance with Douglas' proposal 91610.09.P.Rev0 dated 30 May 2025.

It is understood that the proposed development of the site includes the construction of a residential subdivision which will feature between 3,200 to 3,700 dwellings including two neighbourhood / local centres and a road network.

The site is located in the Lake Macquarie and Newcastle mine subsidence district and is in an area known to be underlain by historical mine workings. Based on previous mine subsidence assessments and investigations undertaken by Douglas, the site is underlain by workings in both the Young Wallsend Seam and Borehole Seam.

The aim of the investigation plan was to outline an investigation and assessment plan to allow for effective evaluation of the mine subsidence risks associated with the proposed development. The outlines the investigation requirements to address the identified risks relating to mine workings. The intention of the plan is to minimise the extent of investigation drilling and modelling of the workings required, in order to provide information to the development team for consideration.

2. Scope of Work

The scope and aims of the investigation plan are as follows:

- Review of Douglas available data to develop a geotechnical conceptual site model in relation to areas of potential mine subsidence issues and characteristics. This has been correlated with areas of proposed residential development;
- Develop an investigation plan for that includes:
 - o Relevant / applicable guidelines for mine subsidence;
 - o Assessment of the existing analysis based on latest Subsidence Advisory requirements (Subsidence Advisory, 2023a);
 - o Preliminary mine subsidence conceptual site model;
 - o Proposed investigation approach (i.e. indicative likely bore locations and depths, which would be subject to changes as further data is available);
 - o Proposed analytical analysis of mine workings, and discussion on when such analysis may be required;

- o Drawing showing proposed indicative locations of boreholes;
- o Description of data to be collected and methodology for data collection; and
- o Preliminary indicative timetable for investigations (based on a single stage as timing of each stage is currently unknown).

The methodology or approach to develop the investigation plan for strategic investigation of the site is to address mine subsidence considerations detailed below. The methodology is separated according to the key issues related to mine subsidence which are to be addressed within the investigation plan:

- Areas of Secondary Extraction:
 - o In areas mapped as secondary extraction, confirmation that the workings have collapsed (are down);
 - o Confirm extent of areas of secondary extraction.
- Areas of Primary Extraction:
 - o In areas mapped as primary extraction, provide comments around the geotechnical uncertainty factors and the likelihood that the workings would be deemed acceptable based on the Subsidence Advisory NSW updated criteria;
 - o Should the areas be likely to not satisfy the updated criteria, comments around suitable subsidence parameters for consideration by the structural engineers in relation to the design of the future structures and associated services and subdivision infrastructure;
 - o Possible options for remedial measures to reduce mine subsidence parameters, and possible options for additional mine subsidence modelling which may justify less onerous subsidence parameters.
- Areas of Shallow Workings:
 - o Confirmation of the extent of areas of the site which have cover to the upper coal seam of less than 30 m;
 - o Possible options for remedial measures to reduce the risk of pothole subsidence.
- Mine Entries:
 - o Identification of the exact location of known mine openings (shafts, portals and tunnels);
 - o Comments on possible measures to render these openings safe.

3. Site Description and Proposed Development

The site covers a large area of land extending from Elernmore Vale in the south-east, Fletcher in the north and Edgeworth in the south-west of approximated 592 hectares. The Newcastle Link Road bisects the site area and runs east-west as indicated on Figure 1 below. Majority of the site lies within the local government area of Newcastle City Council and partly southern and western parts of the site is within Lake Macquarie City Council.

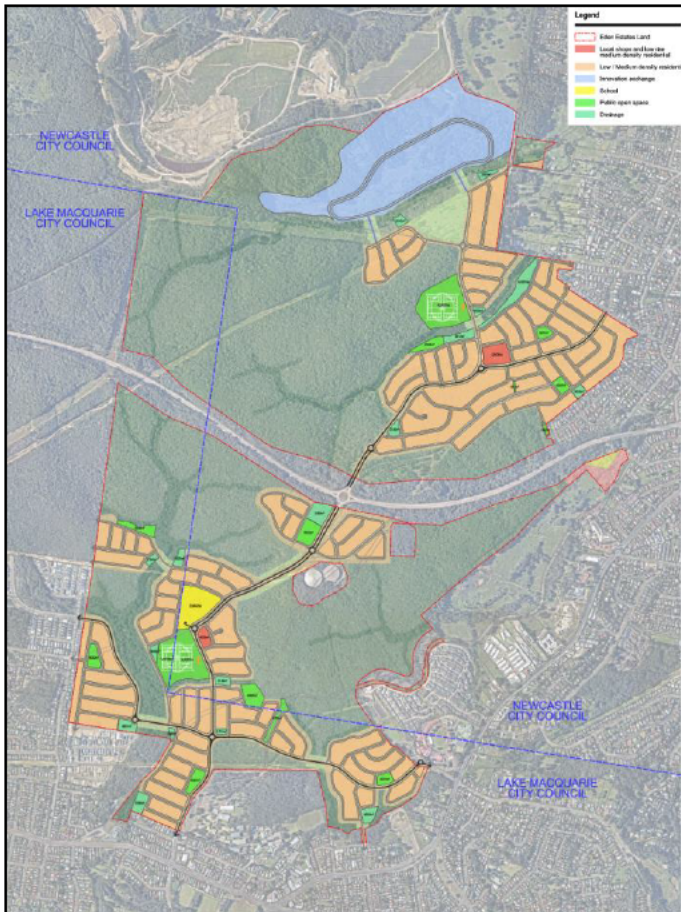


Figure 1: Proposed Layout of the Development (residential areas in yellow and public areas in bright green)

The proposal is to rezone land to accommodate 3,200 to 3,700 homes including two neighbourhood / local centres, land for public recreation and associated road network. Approximately 340 hectares of the site is also proposed to be conserved for environmental conservation. The proposed development areas consist of local shops, low rise medium density residential, innovation exchange, schools, public open space and drainage.

The site is primarily covered with vegetation, although some areas of the site have been previously cleared. The cleared areas are mostly associated with former pit top facilities.

The elevations for the site range from about RL 20 to above RL 90 AHD. The topography is complex and includes three valleys. Two of the valleys fall towards the north-east and one towards the south-west. The areas of higher elevation are typically within the north-west and west of the site but include a spur with an elevation of up to about RL 90 which projects into the site from the west.

The site, layout of the proposed development and labelling of divided areas which are used to reference specific development areas in this report are presented in Drawings 1-1 and 1-2 in Appendix B.

4. Regional Geology

Reference to NSW Seamless Geology mapping indicates that the site is underlain by rocks of the Newcastle Coal Measures Boolaroo, Adamstown and Lambton subgroups (sandstone, siltstone, claystone, coal, tuff) and does not indicate the presence of alluvial sediments. The site stratigraphy is summarised in Table 1, below and shown in Drawings 2-1 and 2-2 of Appendix B.

Table 1: Site Stratigraphy

Group	Subgroup	Formation (Mapping Code)	Description
Newcastle Coal Measures (NCM) (Permian Age)	Boolaroo	Sandstone, conglomerate, siltstone, claystone, coal and tuff	
		Mount Hutton Formation (<i>Pnbm</i>)	Intermixed sandy shales and shaly sandstones
	Adamstown	Tickhole Formation (<i>Pndt</i>)	Conglomerate, sandstone and shale
		Wave Hill Seam	Coal
		Glebe Formation (<i>Pndg</i>)	Conglomerate, sandstone, shale and tuff
		Fern Valley Seam	Coal
		Kotara Formation (<i>Pndo</i>)	Conglomerate, sandstone, shale and tuff
		Victoria Tunnel Seam	Coal
	Lambton	Shepherds Hill Formation (<i>Pnls</i>)	Conglomerate, sandstone, shale and tuff
		Dudley / Young Wallsend Seam	Coal
		Tighes Hill Formation	Siltstone, Sandstone, and Laminite
		Borehole Seam	Coal
		Waratah Sandstone (Base unit of the NCM)	Sandstone

Notes to Table:
 Shaded cells include the coal seams that have been mined below the site.

In addition to the Young Wallsend and Borehole Seams, the upper coal seams are likely only to be present, if at all, in the southernmost part of the site. The stratigraphy in this area is complex given that the Young Wallsend Seam consists of the Nobbys Seam coalescing into the underlying upper split of the Dudley Seam and at times referred to as the Nobbys-Dudley Split. Similarly, the Dudley Seam merges into the Yard Seam and is called the Dudley Yard Seam, as shown in Figure 2 below.

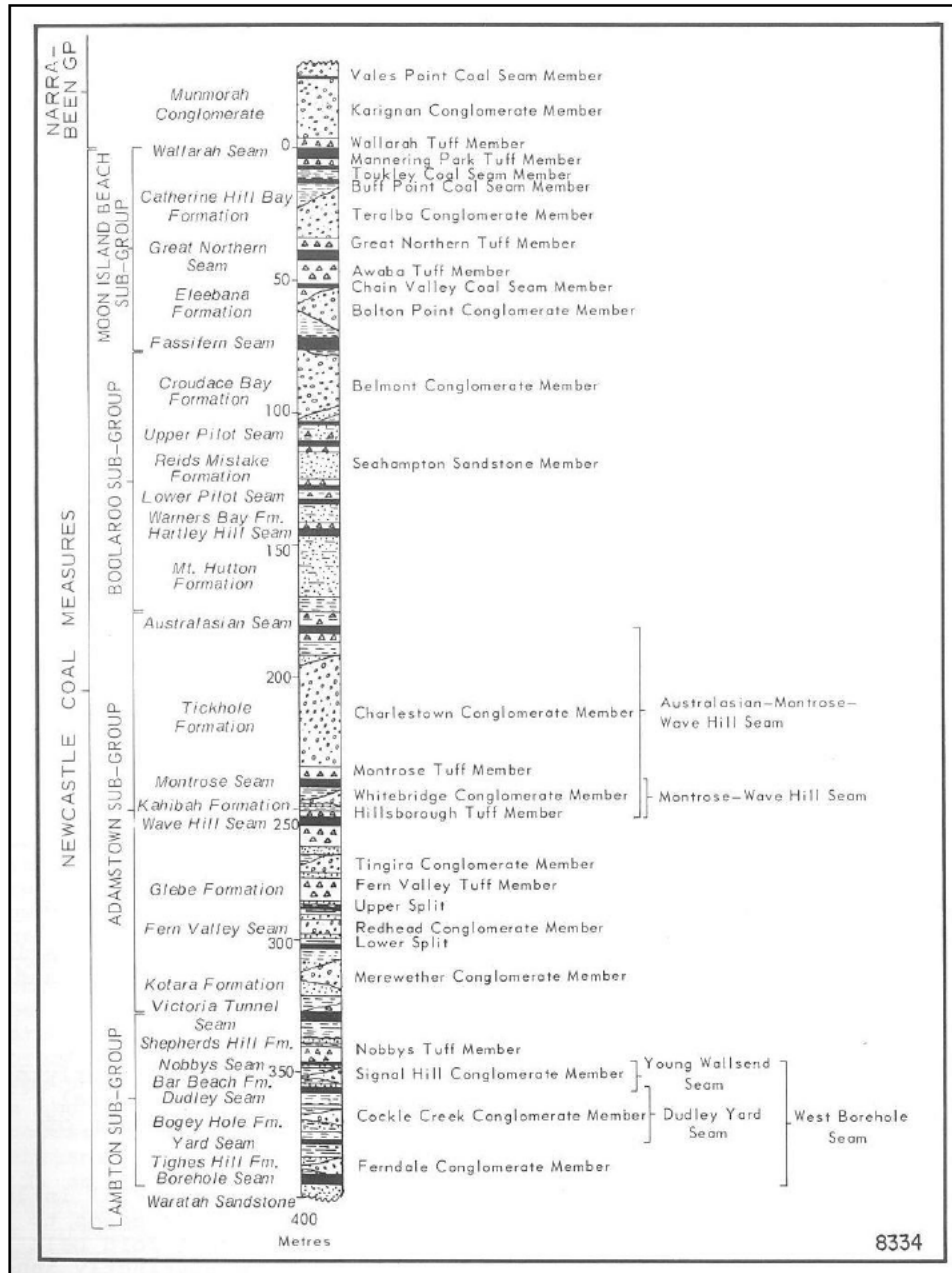


Figure 2: Stratigraphy of the Newcastle Coal Measures, reproduced from (NSW Department of Mines, 1973)

Reference to the Newcastle Coalfields Surface Geology Sheet, published by BHP indicates that the Warners Bay Formation subcrops to the west of the site and locally extends onto the site at the spur discussed above in Section 3. The age of the strata increases to the east and the Waratah Sandstone, which forms the basal member of the Newcastle Coal Measures, subcrops near north-east of the site boundary.

5. Data Review

5.1 Relevant Previous Douglas Investigations

Douglas has undertaken a number of previous investigations within the site for the proposed residential subdivision, as outline below:

- Desktop Geotechnical Assessment of the site (Douglas, 2020);
- Geotechnical Investigation of Filled Areas (Douglas, 2020a);
- Summary of Investigations (Douglas, 2020b) & (Douglas, 2022a);
- Desktop Mine Subsidence Assessment (Douglas, 2021);
- Geotechnical Investigation of Precinct R7 (Douglas, 2022).

Relevant data from the previous investigations have been used in the current assessment and various drawings files from these referenced reports have been utilised to provide information to the development team for consideration, support the development application and the basis in developing the investigation plan.

To date, only limited subsurface investigation has been undertaken across the larger development site (Douglas, 2019) and (Douglas, 2020a), and where undertaken has been limited to shallow depth, and hence a targeted investigation plan within this report has been developed to address the identified mine workings risks and to minimise the extent of investigation drilling and modelling of the site.

5.2 Mining Records / Mine Subsidence Constraints

Douglas has previously completed the process of collating identified historical mining beneath the site, which consists of the applicable record traces (RTs) obtained from Department of Regional NSW, Mining, Exploration and Geoscience (DoR) and geo-referencing them relative to a cadastral plan.

The previous desktop mine subsidence assessment included the digitisation of selected pillars and panels beneath the site based on review of the appropriate record traces together with assessment of the location of drifts, shafts and mine entries which have been used within the current assessment (Douglas, 2021).

The majority of the site has been undermined within the underlying Dudley / Young Wallsend Seam, Borehole Seam or both by several collieries over a period of 40 to 80 years where the types of mining and extent within the site have been identified within the previous study. The site is subjected to various types and extents of mining which can be summarised as follows:

- Areas of primary extraction in bord and pillar workings;

- Areas of secondary extraction in bord and pillar workings;
- Areas of partial extraction in bord and pillar workings;
- Areas of mini longwall panel extraction;
- Areas identified as goaf on RTs;
- Areas identified as open cut workings; and
- Areas of unknown workings described on the RTs as 'old workings in Wallsend Colliery'.

The depth to cover to the mined coal seams was calculated based on digital elevation models retrieved from the NSW Government website and seam elevation contours shown on the RTs. It is noted that some interpolation was undertaken between areas of mining and seam contours shown on the RT and are considered approximate only and therefore require subsurface investigation to confirm.

It was also identified that there is less certainty available for the depth of cover to the Borehole Seam, however based on available information a separation of 20 m was adopted between the Young Wallsend Seam and the Borehole Seam. This is consistent with the interburden thickness between the two seams as encountered in the Empire Shaft.

6. Subsidence Advisory NSW Guidelines / Requirements

6.1 Subsidence Advisory NSW Guidelines

The NSW Government Planning Portal (<https://www.planningportal.nsw.gov.au/>) provides information on mine subsidence districts and also allows identification of the Subsidence Advisory's Surface Development Guidelines for the site.

Reviewing the information from the source above indicated the following:

- The site lies within the proclaimed mine subsidence district of Newcastle and Lake Macquarie; and
- The site where lots are proposed are classified as either Guideline 2 (potential subsidence risk) or 7 (on application) with reference to Subsidence Advisory's Surface Development Guidelines (Subsidence Advisory, 2023a).

Currently development applications for subdivisions and surface development on the site are assessed in accordance with the Coal Mine Subsidence Compensation Act, Subsidence Advisory surface development guidelines, subdivision and merit assessment policies current at the time of application.

It should be recognised that regulatory requirements including those of Subsidence Advisory may change over the period of development for the proposed site and the preliminary investigation plan that has been developed on the guidance / requirements at the time of this report.

6.2 Subsidence Advisory NSW Recommendations

Based on the correspondence from Subsidence Advisory provided by the client (EOTH25-00012), the areas of the site within the Lake Macquarie mine subsidence district are categorised as Surface Guideline 7. Subsidence Advisory recommends that as the subdivision layout is developed, detailed geotechnical studies should be completed to describe the risk in each stage combined with sub-surface investigations undertaken where recommended by the geotechnical practitioner.

The Newcastle Council Advice letter provided by the client mentions that geotechnical assessment report in accordance with Ministerial Direction 4.6 Mine Subsidence and Unstable Land where consultation with Subsidence Advisory is required. Therefore, the same approach recommended by Subsidence Advisory for the Lake Macquarie district has been adopted for areas of the site within the Newcastle mine subsidence district which is applicable for majority of the site.

A summary of Subsidence Advisory recommendations for the key issues related to mine subsidence are:

- Areas of pothole risk and former mine entries such as shafts and drifts must be remediated such that the risk is removed;
- Where trough subsidence risk is identified on land intended for surface development, and the estimated subsidence parameters are greater than those in the Subsidence Advisory Guideline 2 detailed below, remediation measures may be required to reduce the subsidence impact.

With reference to the Surface Guideline 2, the following subsidence induced ground movements are provided by Subsidence Advisory NSW:

Maximum Horizontal Ground Strain:	2 mm/m tensile or compressive
Maximum Tilt:	4 mm/m
Minimum Radius of Curvature:	10 km (hogging or sagging)

Therefore, where trough subsidence is identified in areas where surface developments are proposed they are to be designed to accommodate the subsidence movements estimated. It is likely that the proposed buildings and infrastructure (eg services) require articulation and subsidence impact amelioration details such as slip joints to be included in the design of the superstructure of the proposed buildings to accommodate estimated subsidence parameters. Alternatively, where high subsidence impact parameters which may not be readily catered for in the design may require remedial grouting to reduce the subsidence impact.

7. Assessment of Existing Analysis in Light of Revised Policies

7.1 Passage through Subsidence Advisory's Policies

In the following sections, which informs the likely assessment criteria and required additional investigation and assessment, Douglas has made assumptions in relation to the likely passage through the various Subsidence Advisory NSW policies.

It is recommended that an iterative process of consultation with Subsidence Advisory NSW is undertaken during the ongoing assessment to confirm and adjust the relevant criteria within the policies.

7.2 Geotechnical Risk Factor

The previous analytical analysis and numerical modelling was undertaken with reference to the previous Subsidence Advisory Merit Assessment Policy and requirements at the time (Subsidence Advisory, 2018). The previous desktop mine subsidence assessment categorised the geotechnical uncertainty for the site for each seam resulting in a high uncertainty factor for both the Young Wallsend and Borehole Seam for the site (Douglas, 2021). Previously the 2018 Merit Assessment Policy criteria required a panel factor of safety greater than 2.1 and a pillar width to height ratio greater than 5 which is consistent with the current policy.

With reference to the current Subsidence Advisory Development Application - Merit Assessment Policy (Subsidence Advisory, 2023a), a qualitative assessment has been undertaken to revise the level of geotechnical uncertainty (ie 'geotechnical risk factor') for the site.

The Merit Assessment Policy (Subsidence Advisory, 2023a) categorises the level of geotechnical uncertainty as low, moderate or high based on the level of uncertainty of the following factors.

- Geological Environment (R1);
- Level of Geotechnical Investigation (R2);
- Coal Mine Plans and Records (R3); and
- Method used to assess stability and impact (R4).

With reference to Table C1 and the procedures outlined in the Merit Assessment Policy (Subsidence Advisory, 2023a), the following table summarises the assessment of the site's geotechnical risk factor (GRF). It is understood that the aim of the geotechnical risk factor is to qualify the risk for the site as a whole and therefore considers both the Young Wallsend and Borehole seam in the one geotechnical risk factor. It is noted that proposed areas could be assessed individually in stages as the development progresses which may result in a different geotechnical risk factor and therefore design requirements.

Table 2: Assessment of Geotechnical Risk Factor (GRF)

Model Scenario	Weighting Value (Ri)	Uncertainty Value (Ui)	Comment	Geotechnical Risk Factor	
				Weight x Value (RiUi)	GRF ($\sum RiUi$)
R1 – Geological Environment	3	Moderate (2)	Minor Faults present in both seams	6	= 30 High (GRF $\geq$ 23)
R2 – Level of Geotechnical Investigation	2	High (3)	No site-specific borehole data undertaken to date	6	
R3 – Type of Coal Mine Plans and Records	3	High (5)	Secondary extraction within 50 m	15	
R4 – Method Used to Assess Stability and Impact	3	Low (1)	Pillar stability validated by numerical modelling	3	

With reference to Table 2, a GRF of 30 has been assessed for the site, which results in a high geotechnical risk. It is noted that this would need to be confirmed by Subsidence Advisory NSW. This risk factor was based the previous pillar stability assessment of selected areas for the Young Wallsend and Borehole Seam (total of nine panels) which adopted the estimated full seam thickness in line with the current Subsidence Advisory NSW requirements resulting in an average width to height ratio of greater than 2 and FoS greater than 2.1 for the pillars assessed. Additionally numerical modelling has been undertaken for the site as a whole however it is recommended that analysis is refined and detailed further in Section 8.4.

7.3 Trough Subsidence Risk Requirements

It is understood that the proposed subdivision would be assessed under Subsidence Advisory's Subdivision Assessment Policy (Subsidence Advisory, 2023), where the subdivision size proposed would be classified as large scale (>20 lots) and adopting a high geotechnical risk factor.

The policy requirements for subdivision infrastructure for trough risk (ie kerb and gutter, drainage and services) are to be designed to be "serviceable" and "repairable" under the estimated subsidence ground movements based on an agreed failure criteria. If the design is unable to accommodate the subsidence movements to remain "serviceable", mitigation through grouting of the workings will be required.

Pavements will be required to be either flexible according to Austroads (2024) or bound / rigid pavements will need to be designed to be "repairable" under subsidence movements (Subsidence Advisory, 2023). Douglas' interpretation of the Subdivision Assessment Policy for trough subsidence risk workflow is presented in Figure 3 below.

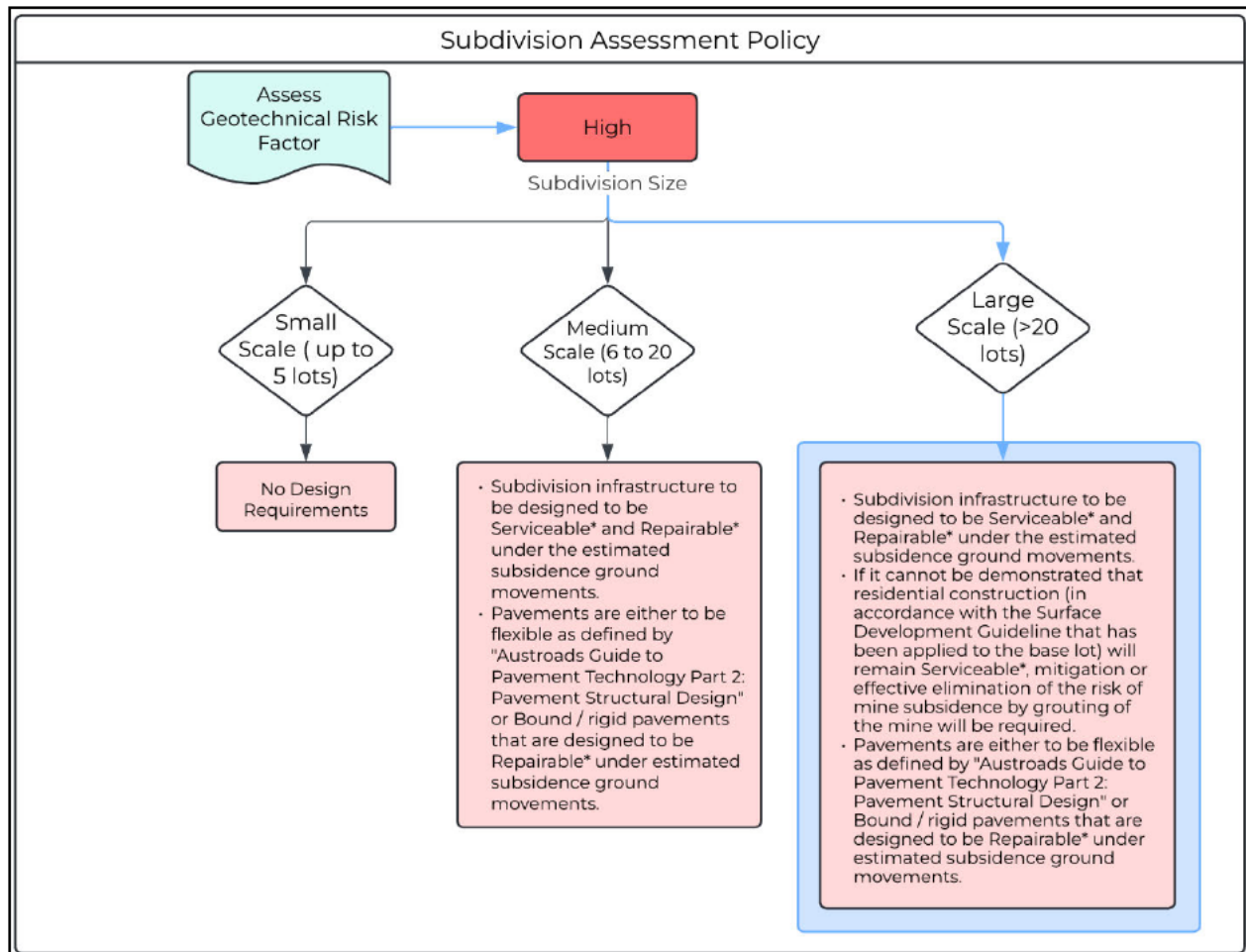


Figure 3: Subdivision Assessment Policy Workflow for Trough Subsidence Risk (Adopted Process in Blue)

It is also understood that future development on the site may require to be assessed under the merit assessment policy whereby a geotechnical risk factor could be assessed for individual proposed areas as the development progresses and based on the Subsidence Advisory building category.

The developments proposed for the site are R2 low density residential, R3 medium density residential and B2 local centres. Low density residential developments are likely to be two storeys, while medium density are likely up to four storeys, and for B2 local centres an assumption of up to four storeys has been adopted.

Based on the above, it is assumed the R2 low density residential structures are likely to be categorised up to the B1 building type and the neighbourhood / local centre structures are likely to be categorised as B3 assuming a conservative importance level of 3 under AS1170 but may be considered to be B2 if a lower importance level applies.

Therefore, in reference to the merit policy alone, provided a high geotechnical risk for the site residential structures will require to be designed to be "safety" (B1) to accommodate the subsidence design parameters consistent with the Surface Guideline 2.

Whereas the neighbourhood / local centre structures will require to be designed for “serviceability” to accommodate the design parameters provided by Subsidence Advisory or a geotechnical practitioner (B3). If the structure is unable to be design to the provided parameters, mitigation or elimination of the risk of mine subsidence by grouting would be required.

Douglas’ interpretation of the Merit Assessment Policy for trough subsidence risk workflow is presented in Figure 4 below.

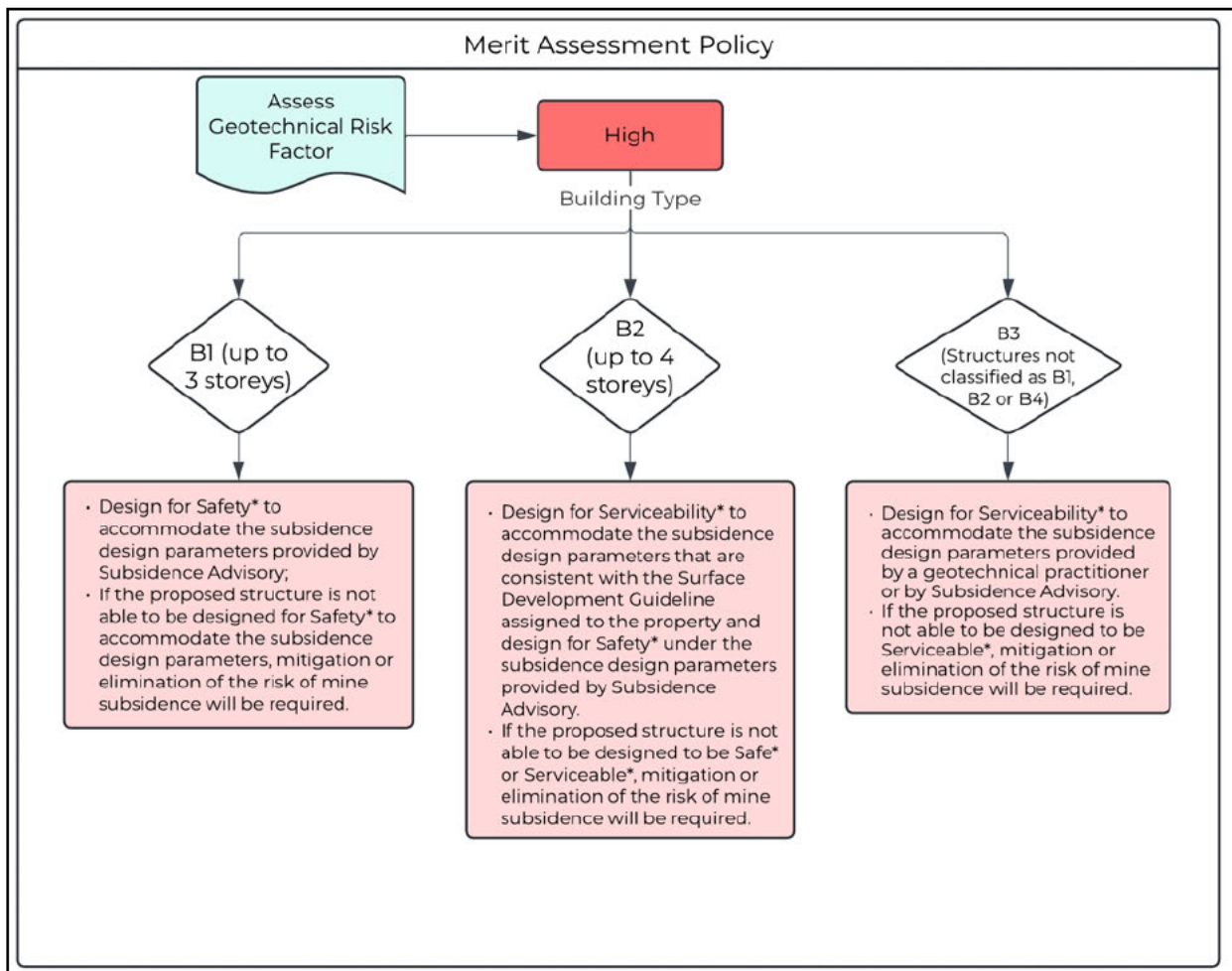


Figure 4: Merit Assessment Policy Workflow for Trough Subsidence Risk

7.4 Pothole/Sinkhole Risk Requirements

The Subsidence Advisory requirements for subdivision infrastructure for pothole/sinkhole risk is effective elimination of the risk of mine subsidence via grouting will be required and development of a grout methodology and verification plan. (Subsidence Advisory, 2023).

Similarly, requirements for development applications for pothole/sinkhole risk is design for “serviceability” to accommodate the maximum design sinkhole consistent with the Surface Development Guideline assigned to the property or provided by Subsidence Advisory. If the proposed development is unable to accommodate this within design to be “serviceable”, then elimination of the risk of mine subsidence by grouting of the mine will be required and development of a grout methodology and verification plan.

7.5 Summary of Subsidence Advisory Policy Requirements

Considering both the subdivision assessment policy (Subsidence Advisory, 2023) and the merit assessment policy (Subsidence Advisory, 2023a) given the site being categorised as a high geotechnical risk factor, the requirement for a minimum pillar is not applicable. It is important to note that the proposed development sub-areas could be assessed as individual sites to refine geotechnical risk factors which may in turn result in different design requirements based on minimum pillar FoS. Therefore, it is recommended that pillar stability analysis is conducted for sub-areas of the proposed development to understand the risk and design requirements of subsequent lots instead of the proposed development area as a whole.

7.6 Pillar Stability Analysis

Reviewing the previous pillar stability assessment with reference to the current requirements of Subsidence Advisory assessment procedure, it follows the requirements for future analysis are as follows:

- The pillar dimensions assume a full seam thickness;
- The average panel pillar FoS; and
- The pillar loading environment should be appropriately assessed.

The pillar stability analysis was previously undertaken on five separate panels in the Young Wallsend Seam and four separate panels in the Borehole Seam and the results indicate the panel factors of safety and width to height ratios are acceptable (average W/H ratios >5 and panel FoS >2.1). The extent and location of the selected panels are presented on Drawing sets 3 and 4 in Appendix B.

Considering the range of building categories and the minimum pillar FoS governing the outcomes as previously discussed in Section 7.1 additional pillar stability analysis should be undertaken for sub-areas of the proposed development in stages.

7.7 Pothole Risk

The previous assessment of pothole risk was primarily based on the depth of over relative to seam thickness, geotechnical data and site subsidence history and was classified into low, medium or high. The current Merit Assessment Policy states that an accepted assessment of sinkhole (pothole) risk can be undertaken by a geotechnical practitioner with experience in shallow mine subsidence (Subsidence Advisory, 2023a). Therefore, it is assumed that the previous assessment given it considers the typical characteristics in the policy is an accepted assessment of pothole risk. The characteristics that were used to classify the risk category is outlined in Table 3 below.

Table 3: Factors Used to Determine the Uncertainty Factor

Pothole / Sinkhole Risk	Factors
Low	Cover depth less than 10 times the seam thickness, with evidence that workings have completely failed and risk is limited to piping of soil into pre-existing tension cracks and consolidation of goaf.
Moderate	- Cover of depth is 5 to 10 times the seam thickness. - No previous history of pothole formation. - Records indicate seam dip less than 10 degrees. - Subsidence Advisory have assessed the risk of pothole formation as being moderate.
High	- No borehole confirmation and cover of depth is less than or equal to 10 times the seam thickness. - Borehole confirmation that cover between 5 to 10 times the seam thickness. - Records indicate seam dip is greater than 10 degrees. - History of pothole formation. - Geotechnical environment allows for accelerating weathering and degradation of both pillars and overburden. - Subsidence Advisory have assessed the risk of pothole formation as being high.

The report states that areas of the site where 30 m or less of cover is present to the Young Wallsend and Borehole Seam, based on review of the RTs with some of these areas underlain by primary workings and hence the risk of pothole subsidence in these areas would be high. Furthermore, there is known pothole formation in the area with similar depths of cover. The areas identified where the depth of cover is less than 30 m is presented on Drawing set 5 in Appendix B.

7.8 Numerical Modelling

An independent numerical modelling assessment was previously undertaken by Ditton Geotechnical Services (Ditton), which has also informed the previous Douglas mine subsidence assessment (Douglas, 2021). The Ditton assessment included the following:

- Estimation of the Factors of Safety (FoS) of assumed standing pillars in first workings and partial second workings areas for RT-scaled and RT - 0.5 m pillar dimensions and probability / likelihood of failure, as a further independent assessment to the Douglas' assessment;
- Prediction of the maximum subsidence effects for the site after all of the first workings and remnant pillars with width to height (w/h) ratio of less than 8 in the Dudley/Young Wallsend Seam and Borehole Seam have 'failed' or crushed;
- Prediction of the worst-case subsidence contours for the site due to instability in either the Dudley/Young Wallsend or Borehole Seams;

- Estimation of worst-case subsidence contours due to instability in both seams using superposition techniques and appropriate interaction factors. The contours were then added to develop the multiple-seam subsidence contours for both seams;
- Refinement of the above by assuming worst-case subsidence applies only for standing pillar panels with a long-term stable FoS and w/h ratio under full tributary area (FTA) or abutment loading conditions (i.e. pillars adjacent to critical length goaf edges) as defined by the Geotechnical Uncertainty Factor in the 2018 SA NSW Subdivision Guidelines;
- Provision of recommendations on potential subsidence hazard zones in regard to further drilling investigations required to ascertain whether a pillar panel is standing or already failed.

With reference to the current Merit Assessment and Subdivision Assessment Policies (Subsidence Advisory, 2023a) (Subsidence Advisory, 2023) subsidence impact parameters should be based on all pillars with an acceptable W/H ratio or a FoS failure criteria defined by Subsidence Advisory or the geotechnical practitioner. The assessment undertaken by Ditton assumed standing pillar panels which meet the following criteria:

- Average pillar FoS > 1.8 (medium uncertainty) or > 2.1 (high uncertainty);
- Average pillar W/H > 3 (medium uncertainty) or > 5 (high uncertainty);

In accordance with the current policy, it provides a different criteria of minimum FoS based on the building type and geotechnical risk factor. Therefore, the predictions of maximum subsidence effects presented in Ditton's report should be revised to align with the current Subsidence Advisory merit policy.

Reviewing the numerical modelling methodology undertaken indicates that Zones 1 and 2 panels where pillar W/H < 8 fail and a residual subsidence of 100 mm was adopted for Zones 3 and 4. This methodology is conservative given the current pillar failure assumption is pillars that have FoS < 2.1 or W/H < 5 fail. The subsidence effect contours adopted the input parameters of the convergence data and subsidence profile at Honeysuckle and it is understood that this would be an acceptable methodology to develop subsidence contour based on historical events without utilising numerical modelling software similar to FLAC3D or Plaxis 3D. The multiple-seam subsidence was increase by 16% for simplicity based on the work of Li et al (2007) and it is recommended that refined numerical modelling is undertaken for the proposed development areas using industry standard numerical software with refined parameters based on available data and recent studies associated with Newcastle.

The parameters presented for the estimations of worst-case subsidence contours have been adopted to inform this assessment when selecting estimates of subsidence parameters for applicable areas. The preliminary indicative parameters have been selected from interpolating the Drawings 15A to 15D in Ditton's report which have been adapted to suite the current proposed development areas presented in Appendix C.

The reported values of tilt, curvature and horizontal strain for each seam are likely to exceed the limits of the Surface Guideline 2 for Zones 1 and 2, however when considering the multi-seam case, these parameters are greater than those provided in Surface Guideline 2. Therefore, residential structures will need to be designed to be "safe" (B1), whereas the neighbourhood / local centre structures will require to be designed for "serviceability" to accommodate the design parameters provided by Subsidence Advisory or a geotechnical practitioner. If the structure is unable to be design to the provided parameters, mitigation or elimination of the risk of mine subsidence by grouting would be required.

8. Proposed Investigation Plan

8.1 Allocation of Investigation Areas

The site has been subject to extensive underground mining where the mapped style of mining consists of primary workings by bord and pillar, secondary extraction of pillars with extensive full extraction, and secondary workings with partial extraction. Given variation of mining methods and presence of multiple seams, the site has been divided into areas provided from the proposed development, together with consideration to the presence of mine workings, depth of workings, presence of deep fill and key issues related to mine subsidence resulting to the type of mining which are applicable to the site:

- Bord and pillar 'primary extraction' – primary trough subsidence;
- Bord and pillar / mini longwall 'secondary extraction' – residual subsidence;
- Shallow Workings – pothole risk; and
- Mine Entries.

The divided areas are presented on Drawing sets 3 and 4 in Appendix B overlayed with the type of mining within the Young Wallsend and Borehole Seam sourced from Douglas' previous desktop mine subsidence assessment (Douglas, 2021). Drawing sets 5 and 6 in Appendix B convey areas of shallow workings (considered pothole risk) and geotechnical constraints which were also used to develop the proposed investigation plan.

Based on Douglas' understanding of the site and the proposed development a summary of the following presented in Table 4:

- Relevant / applicable guidelines for mine subsidence;
- Results of existing analysis;
- Preliminary mine subsidence conceptual site model;
- Proposed investigation approach; and
- Relevant / applicable guidelines for development.

Table 4: Outline Summary of Investigation Plan

Investigation Area / Sub-Areas	Deep Fill Anticipated (m) ⁽¹⁾	Approximate Depth of Workings (m)	Type of Workings - Young Wallsend Seam ⁽²⁾	Type of Workings - Borehole Seam ⁽²⁾	Key Subsidence Risk ⁽³⁾	No. of Known Mine Openings	Geological Mapping	Existing Analysis Parameters (Smax [mm], Tilt[mm/m], Strains[mm/m], Curvature[km ⁻¹])	Relevant Design Guidelines / Remedial Requirements	Proposed Investigation Approach
IE	DEM - 0 to 20 1974 - Yes	YW - 0 to 60 BH < 30	Primary , Open Cut	Goaf , Primary, Secondary	YW – Trough/Pothole BH – Residual/Pothole	5	Shepherds Hill Formation	0.7, 25, 20, 2.5	Design for Estimated Subsidence Parameters, Pothole Remediation, Mine Entry Remediation	Cored Bores, Open Hole Bores, Pothole, Mine Openings
PS1	DEM - 0 to 30 1974 - Yes	YW - 10 to 40 BH <30	Primary	Goaf, Primary, Secondary	YW – Trough/Pothole BH - Residual/Pothole	-	Shepherds Hill Formation	0.7, 22.5, 12.5, 1.25	Design for Estimated Subsidence Parameters, Pothole Remediation	Cored Bores, Pothole
MD	DEM - 0 to 5 Not currently mapped	YW - 25 to 35 BH 35	-	Primary	BH – Trough/Pothole	1	Shepherds Hill Formation	0.5, 12.5, 7.5, 0.375	Design for Estimated Subsidence Parameters, Mine Entry Remediation	Open Hole Bores, Mine Openings
R1	DEM - 0 to 5 1974 - Yes	YW - 5 to 35 BH < 30	-	Goaf, Primary, Secondary	BH - Residual/Pothole	1	Shepherds Hill Formation	0.5, 22.5, 12.5, 1.25	Design for Estimated Subsidence Parameters, Pothole Remediation, Mine Entry Remediation	Open Hole Bores, Pothole, Mine Openings
R2	DEM - 0 to 10 1974 - Yes	YW - 0 to 55 BH < 30	-	Goaf , Primary, Secondary	BH - Residual/Pothole	-	Kotara Formation	0.5, 22.5, 12.5, 0.75	Design for Estimated Subsidence Parameters, Pothole Remediation	Cored Bores, Open Hole Bores, Pothole
R3	DEM - 0 to 10 1974 - Yes	YW - 5 to 35 BH < 30	Primary	Goaf, Partial, Primary, Secondary	BH – Residual/Pothole	2	Shepherds Hill Formation	0.5, 25, 12.5, 1.25	Design for Estimated Subsidence Parameters, Pothole Remediation, Mine Entry Remediation	Cored Bores, Open Hole Bores, Pothole, Mine Openings
R4	DEM - 0 to 15 1974 - Yes	YW - 10 to 65 BH < 30	Primary	Goaf, Partial, Primary, Secondary	YW – Trough/Pothole BH – Residual/Pothole	3	Shepherds Hill Formation	0.7, 52, 20, 2	Design for Estimated Subsidence Parameters, Pothole Remediation, Mine Entry Remediation	Cored Bores, Open Hole Bores, Pothole, Mine Openings
R5	DEM - 0 to 5 1974 - Yes	YW - 10 to 60 BH < 35	Primary	Primary, Secondary	YW – Trough/Pothole BH – Residual/Pothole	1	Shepherds Hill Formation	0.7, 35, 20, 2	Design for Estimated Subsidence Parameters, Pothole Remediation, Mine Entry Remediation	Cored Bores, Pothole, Mine Openings
R6	DEM - 0 to 5 Not currently mapped	YW - 25 to 60 BH < 30	Primary	Goaf , Partial, Primary , Secondary	YW – Trough/Pothole BH - Residual/Trough/Pothole	-	Kotara Formation	0.7, 52, 7.5, 0.75	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R7	DEM - 0 to 10 Not currently mapped	YW - 25 to 75 BH < 35	Primary	Secondary	YW – Trough/Pothole BH – Residual/Pothole	-	Kotara Formation	0.7, 12.5, 3.75, 0.75	Design for Estimated Subsidence Parameters, Pothole Remediation	Cored Bores, Open Hole Bores, Pothole
R8	DEM - 0 to 5 Not currently mapped	YW - 45 to 80 BH >30	Primary	Primary, Secondary	YW - Trough BH - Residual	-	Glebe Formation	1.1, 12.5, 3.75, 0.35	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores

Notes to Table:

YW – Young Wallsend Seam
BH – Borehole Seam,
UK? - Unknown

(1) 1974 - Comparison between the previous fill investigation that deep fill was present

(2) Preliminary assessment of the type of workings beneath the area only and does not include the angle of draw. Where multiple type of workings is identified, the type that covers the largest area is highlighted in **bold**

(3) Key subsidence risk is based on type of workings that covers the largest area in the proposed investigation area. Further assessment would be undertaken on an area-by-area basis to refine key subsidence risks

Investigation Area / Sub-Areas	Deep Fill Anticipated (m) ⁽¹⁾	Approximate Depth of Workings (m)	Type of Workings - Young Wallsend Seam ⁽²⁾	Type of Workings - Borehole Seam ⁽²⁾	Key Subsidence Risk ⁽³⁾	No. of Known Mine Openings	Geological Mapping	Existing Analysis Parameters (Smax [mm], Tilt[mm/m], Strains[mm/m], Curvature[km ⁻¹])	Relevant Design Guidelines / Remedial Requirements	Proposed Investigation Approach
R9	DEM - 0 to 10 Not currently mapped	YW - 65 to 105 BH ~ 50?	Primary, Secondary	Primary	YW - Residual BH - Trough	-	Glebe Formation/ Tickhole Formation	0.5, 10, 3.75, 0.375	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R10	DEM - 0 to 5 Not currently mapped	YW - 45 to 80 BH – UK?	Mini Longwall, Secondary	Primary	YW - Residual BH - Trough	-	Glebe Formation	0.4, 12, 3.75, 0.375	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R11/R12	DEM - 0 to 5 Not currently mapped	YW - 35 to 80 BH – UK?	Mini Longwall , Secondary	Primary	YW - Residual BH - Trough	-	Kotara Formation	0.125, 7.5, 3.75, 0.375	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R13	DEM - 0 to 5 Not currently mapped	YW - 40 to 85 BH – UK?	Mini Longwall , Primary	-	YW - Residual/Trough	-	Mount Hutton Formation/ Kotara Formation	0.125, 12.5, 12.5, 1.25	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R14	DEM - 0 to 5 Not currently mapped	YW - 50 to 85 BH -UK?	Mini Longwall , Primary, Secondary	-	YW - Residual/Trough	-	Tickhole Formation	0.7, 17.5, 7.5, 0.375	Design for Estimated Subsidence Parameters	Cored Bores
R15	DEM - 0 to 5 Not currently mapped	YW - 60 to 110 BH – UK?	Mini Longwall, Primary , Secondary	-	YW - Residual/Trough	-	Tickhole Formation	0.7, 17.5, 7.5, 0.75	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores
R16	DEM - 0 to 5 Not currently mapped	YW - 55 to 75 BH – UK?	Mini Longwall, Primary	-	YW - Residual/Trough	-	Glebe Formation	0.5, 25, 7.5, 0.75	Design for Estimated Subsidence Parameters	Cored Bores, Open Hole Bores

Notes to Table:
YW – Young Wallsend Seam
BH – Borehole Seam,
UK? - Unknown
(4) 1974 - Comparison between the previous fill investigation that deep fill was present
(5) Preliminary assessment of the type of workings beneath the area only and does not include the angle of draw. Where multiple type of workings is identified, the type that covers the largest area is highlighted in **bold**
(6) Key subsidence risk is based on type of workings that covers the largest area in the proposed investigation area. Further assessment would be undertaken on an area-by-area basis to refine key subsidence risks

8.2 Investigation Plan Approach

The methodology or approach to develop the investigation plan of the site to address mine subsidence considerations is briefly outlined below:

- Identify key types of workings governing each divided area of the proposed development for the following:
 - o Type of extraction (primary, secondary, partial extraction);
 - o Single or multi-seam conditions;
 - o Shallow workings (<30 m depth of cover); and
 - o Known mine entries.
- Select key subsidence risk for each seam based on the types of workings beneath the area and the depth of cover of the following:
 - o Pothole Subsidence;
 - o Trough Subsidence;
 - o Residual Subsidence; and
 - o Mine Entries.
- The following recommendations as per Subsidence Advisory and assessment referencing their merit assessment policy, whereby areas of the following mine subsidence risk require:
 - o Areas of potholes risk must be remediated to eliminate the risk of mine subsidence by grouting;
 - o Areas of trough subsidence that have estimated subsidence is greater than those in Subsidence Advisory Guideline 2, remediation measures may be required to reduce the subsidence impact if they are not able to be designed for;
 - o It is considered likely that all mine entries will need to be appropriately sealed/remediated and restrictions for development over mine openings are likely to apply.
- Based on the types of workings and the key subsidence risk beneath the area the following proposed investigation approach has been selected:
 - o **Subsurface Investigation:** Confirm working conditions within the areas of proposed development by drilling bores (cored bores and open hole);
 - o **Pothole Investigation:** In areas that have a depth of cover <30 m, undertake line bores to identify the 30 m depth of cover line (Pothole Mine Subsidence Investigation); and
 - o **Mine Opening Investigation:** Costeans for shafts positioned in such a way to target the historic mine entry by excavating a section perpendicular to the entry where accessible and bores for adits. Bores may also be need in areas of adits/entries.

8.3 Proposed Investigation Approach

8.3.1 Subsurface Investigation

Based on the limited information available to date, the overall site has been assessed as having a “high” uncertainty value. It is recommended that a consultative approach be undertaken with Subsidence Advisory during the assessment of the site to seek concurrence with key assumptions which inform assessment criteria and acceptability criteria.

Given the complexity of the site and various combining risks of trough subsidence, pothole and mine openings, it is recommended subsequent subsurface investigation be undertaken to confirm conditions of the workings and depths of cover to qualify the pothole risk / tough subsidence areas and presence and condition of mine openings identified from the mine subsidence desktop assessment.

Therefore, subsurface investigation primarily by means of drilling of test bores is proposed. The purpose of the bores is to confirm the depth to workings, seam thickness, working seam thickness and condition of the workings, all of which contribute to the geotechnical uncertainty factor, pillar stability analysis and numerical modelling.

The number of bores within each sub-area / investigation area would be dependent on a number of factors, including but not limited to:

- Results of previous/cumulative investigations (to be reassessed on an individual sub-area basis during ongoing investigations);
- Depth of cover; and
- Type of workings.

For preliminary planning purposes Table 5 below provides a summary of the anticipated number of bores within each of the investigation areas but this should be confirmed with Subsidence Advisory NSW prior to each stage and adjusted as required as the investigation progresses. The indicative likely bore locations are presented on Drawing 7 in Appendix B.

Table 5: Summary of Anticipated Mine Subsidence Drilling Bores in Each Investigation Area

Investigation Area / Sub-Areas	Total Development Sub-Area (ha)	Number of Cored Bores	Number of Open Bores	Approximate Depth of Bores (m)	Total Number of Bores
IE	40.31	1	1	70	2
PS1	4.85	1	0	50	1
MD	2.68	1	0	45	1
R1	6.38	1	0	45	1
R2	13.62	2	1	65	3
R3	11.31	1	1	45	2
R4	13.27	3	0	75	3
R5	11.14	1	0	70	1
R6	8.27	1	1	70	2

Investigation Area / Sub-Areas	Total Development Sub-Area (ha)	Number of Cored Bores	Number of Open Bores	Approximate Depth of Bores (m)	Total Number of Bores
R7	10.76	2	0	85	2
R8	11.19	1	1	90	2
R9	16.71	1	1	115	2
R10	7.26	1	1	100	2
R11/R12	29.45	3	1	100	4
R13	13.97	1	1	105	2
R14	17.42	2	0	115	2
R15	15.95	2	1	130	3
R16	12.14	1	1	95	2

The subsurface investigation would include the following:

Preliminaries

- BYDA, and review of buried service plans;
- Prepare in-house fieldwork safety and environmental plan and SWMS.

Drilling

- Fully cored bores would be cored from the top of rock to the base of the Borehole Seam to approximately the depth shown in Table 5 (ie targeting base of Borehole Seam). The bore would be drilled using HQ coring methods to the base of the Borehole Seam;
- Bores using "open hole" methods with possible coring in the roof above the seams to the depth to workings shown in Table 5 (ie targeting base of Borehole Seam);
- All field work would be co-ordinated by a geotechnical engineer. Soil and rock would be logged in accordance with Australian Standards (AS 1726-2017) taking note on the following:
 - o Groundwater level observations;
 - o Drilling water observations including any zones where water is lost during drilling will be noted during the investigation program to assess for any fractures;
 - o Overburden lithology, defects;
 - o Seam thickness through first workings pillars (if encountered);
 - o Evidence of pillar crush (core loss, crush and fracture zones);
 - o Rubble and void height.
- At the completion of logging and sampling, as well as inspection using DP Sonar / CCTV, the bores would then be sealed with permanent PVC casing from ground surface to the top of rock and a PVC bore cap at the surface;
- A portion of the bores would have groundwater monitoring wells installed for determining standing groundwater levels and facilitate ongoing groundwater level monitoring;
- Excess drill fluids will be dispersed within a grass bunded area onsite;

- Drilling cuttings will be collected on site within a grassed bunded area;
- The rock (where cored) will be placed in core boxes and photographed by a geotechnical engineer;
- Point load index tests will be completed on the core during the fieldwork at about 1 m to 3 m intervals within rock near the target seam/s;
- Where coal pillars have been intersected, downhole geophysics will be undertaken which will include deviation, density, natural gamma & neutron tools. Where workings are encountered sonar and/or camera inspections will be undertaken as discussed below;
- Survey of the bores using a differential GPS, with an accuracy typically ± 0.1 m relative to MGA coordinates and a level accuracy typically ± 0.1 m relative to AHD.

Inspection of Workings

After completion of drilling we would inspect the workings, where possible, using both CCTV borehole camera and sonar equipment as outlined below:

- A CCTV camera is used to assess the condition of the borehole and then workings, in particular the presence of any rubble within the workings. Video images are recorded and reviewed by DP engineer;
- A dummy sonar head is lowered down the hole to check for bore / shaft collapse or obstructions etc. prior to deploying the actual sonar head;
- The sonar head and leader rods are lowered into the bore on a cable using either a tripod and winch arrangement at the surface or using the wireline of a drilling rig;
- The sonar head orientation is checked using the integrated compass unit; and
- If a suitable sized void is encountered and the workings are flooded, sonar images are then taken at various depths within the workings.

Sonar images from each bore which encounters voids can then be geo-referenced using GIS software to provide a composite of the images to allow overall interpretation of the layout of the workings. This interpretation would generally be undertaken by a Senior Geotechnical Engineer in the Newcastle office. Sonar is only suitable in the event the workings are flooded.

8.3.2 Pothole Mine Subsidence Investigation

Subsurface investigation would be undertaken in areas of each assessment precinct which has a mapped cover to either seam workings of less than 30 m. The bores would be drilled using air track drilling methods or wash boring methods (depending on volatility of the coal) and would be taken to the base of the seam or 35 m depth, whichever is the lesser. The purpose of the bores is to confirm the depth to workings, condition of the seam (whether goafed or standing), and seam thickness.

The number of bores anticipated within each assessment precinct is outlined in Table 6 based on undertaking a line bore spacing of approximately 10 m perpendicular to depth of cover contours in areas having a cover of less than 30 m with workings to identify the 30 m depth of cover line. This scope should be discussed with Subsidence Advisory NSW prior to each stage for their concurrence. The indicative likely bore locations are presented on Drawing 7 in Appendix B.

Table 6: Summary of Anticipated Pothole Mine Subsidence Bores in Investigation Area

Investigation Area / Sub-Areas	Total Development Sub-Area (ha)	Estimated Area of Precinct with Shallow Cover (ha)	Total Number of Bores within Investigation Area
IE	40.31	15.73	34
PS1	4.85	0.73	7
R1	6.38	1.41	5
R2	13.62	2.68	17
R3	11.31	1.78	10
R4	13.27	3.84	15
R5	11.14	2.98	14
R7	10.76	0.47	10

All field work would be co-ordinated by a geotechnical engineer. Soil and rock would be logged based on chip samples returned to the surface and drilling resistance. Broadly, the following information will be collected:

- Groundwater level observations;
- Depth to workings (if encountered);
- Seam thickness (if encountered);
- Evidence of pillar crush (core loss, crush and fracture zones);
- Rubble and void height;
- At the completion of logging and sampling, as well as inspection using DP Sonar / CCTV (if undertaken), the bores would be reinstated with cuttings;
- Excess fluids (if any) will be dispersed within a grass bunded area onsite;
- Drilling cuttings will be collected on site within a grassed bunded area;
- Survey of the bores using a differential GPS , with an accuracy typically ± 0.1 m relative to MGA coordinates and a level accuracy typically ± 0.1 m relative to AHD.

After completion of drilling we would inspect the workings, where possible, using CCTV borehole camera equipment. Video images are recorded and reviewed by Douglas engineer.

It should be noted that the investigation is not aimed at comprehensively confirming the extent of workings or the extent or areas which have less than 30 m of cover to the workings. However, will provide an indication on the accuracy of the contours developed as part of the previous mine subsidence desktop.

It should be further noted that opportunities may be present during the investigation to allow grouting trials within the drilled bores to enable firmer estimates of grouting costs.

8.3.3 Mine Openings

Assessment of the presence and condition of identified mine openings will be required and consultation with Subsidence Advisory to clarify if known mine opening outside of the proposed development will require assessment and remediation for remote areas. The exact scope of the investigation required cannot be fully determined at this stage, however, it is likely to include the following:

- Liaison with the project surveyor to set out likely mine openings for subsurface investigation;
- Review of the available data on closure of previous mine openings;
- Site walkover and inspection of each known area by a senior geotechnical engineer from Douglas;
- Excavation of a series of test pits at possible mine opening locations to identify the type and condition of backfill material. Costeans for shafts positioned in such a way to target the historic mine entry by excavating a section perpendicular to the entry where accessible;
- Drilling of bores in areas of possible drifts and adits to assess the backfill methods utilised during closure and the condition of such;
- Pegging of the test locations for later survey by the project surveyors;
- Reporting in relation to the above and the implications for development in the area of the mine openings, including the need for remediation or further engineered capping etc.

Table 7 summarises the number of known mine openings which would require geotechnical investigation, assuming that each site is investigated on a standalone basis, and assuming that the site is accessible. The site overall identifies 25 known mine openings where 16 are shafts and 9 are adits, however the known mine openings within the areas of the proposed development are the focus of the table below. The indicative likely investigation locations (shaft and adit locations) are presented on Drawing 7 in Appendix B.

Table 7: Known Mine Openings Anticipated for Subsurface Investigation

Investigation Area / Sub-Areas	Approximate Number of Mine Openings (shafts)	Approximate Number of Mine Openings (adits)	Total Number of Mine Openings
IE	2	3	5
MD	1	-	1
R1	1	-	1
R3	2	-	2
R4	-	3	3
R5	1	-	1

It should be noted owing to the uncertainty in location of the mine openings, they may not be readily identified within the proposed scope of works. Additional investigation, including geophysics may be required in such instances, at additional costs.

It has been assumed that the client would engage surveyors/consultants previously engaged to design caps over the mine who may assist with the preliminary locating and identification of the mine openings prior to subsurface investigation. This may assist in reducing the scope of work needed for this part of the work.

Based on previous experience shafts within the proposed development will require an engineered designed slab to cap the shaft, with the cap slab footings founded in rock. The shaft should be grouted to mitigate the risk of future collapse. The immediate area surrounding the shaft will also require grouting given the likelihood of several mine working tunnels / roadways entering into the shaft.

In addition to the above, reference is made to the Guideline for the Permanent Filling and Capping of Surface Entries to Coal Seams (Mine Safety, 2012) and the following additional considerations are recommended:

- The shaft should be fully supported on weathered rock around the entire perimeter of the cap;
- "All steel reinforcement used in the surface capping structure should have a minimum 100 mm of concrete cover".

8.4 Proposed Analytical Analysis

8.4.1 Targeted Stability Analysis

Following completion of drilling and utilising the information in the supplementary desktop assessment, analytical analysis of the workings will be undertaken with reference to the Subsidence NSW current policy on subdivisions and development applications and will include the following:

- Parametric Analysis – This will include identifying primary input parameters and their expected variability. These parameters include height of workings, depth of workings and width of pillars across the site;
- Re-assessment of the geotechnical uncertainty factor based on the quality of the data from the desktop review and subsurface investigation. This will provide guidance on the target factors of safety required for pillar stability analysis for each sub-area;
- Analytical modelling will be undertaken to assess the factors of safety using the UNSW pillar strength formula of selected pillars and panels beneath the site. A sensitivity analysis will be completed to assess how the variables affect the outcomes of the analysis.

8.4.2 Possible Numerical Modelling

In the event that the following additional desktop assessment, subsurface investigation and stability analysis, satisfactory safety and width to height ratios cannot be achieved or subsidence parameters are unable to be designed for, additional targeted numerical modelling is recommended which would be completed by Douglas. The main objective of the numerical modelling is to provide plans presenting contours of the following subsidence parameters to allow an understanding on potential constraints to surface development and refine the previous preliminary numerical modelling completed on the overall site. This would include modelling using industry standard numerical software with refined parameters based on available data and recent studies associated with Newcastle to provide the following:

- Vertical subsidence (mm);
- Horizontal displacement both tensile and compressive (mm/m);
- Tilt (mm/m); and
- Radius of curvature (km⁻¹).

8.5 Indicative Timetable

A preliminary indicative time period for the proposed investigations based on undertaking the investigations over single stages per investigation areas would be around 3 to 5 months which would vary per investigation area given the variability in conditions, proposed investigation approach and design requirements.

8.6 Reporting Deliverables

At the completion of field work and laboratory testing a report would be provided for each “investigation area” outlining the results of the investigation and commenting on the items outlined each subheading of Section 8.3.

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10. Limitations

Douglas Partners Pty Ltd (Douglas) has prepared this report for this project at 144 Boundary Road, Wallsend NSW in line with Douglas' proposal dated 30 May 2025 and acceptance received from Tim Goldacre of Eden Estates (Newcastle) Pty Ltd dated 1 June 2025. The work was carried out under Douglas' Engagement Terms. This report is provided for the exclusive use of Eden Estates (Newcastle) Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas' field testing has been completed.

Douglas' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by Douglas. This is because this report has been written as advice and opinion rather than instructions for construction.

Appendix A

About This Report

Introduction

These notes have been provided to amplify Douglas' report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

Douglas' reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather

changes. They may not be the same at the time of construction as are indicated in the report; and

- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, Douglas will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, Douglas cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, Douglas will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, Douglas requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. Douglas would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Appendix B

Drawing 1 – Overview of Proposed Development

Drawing 2 – Overview of Geological Mapping

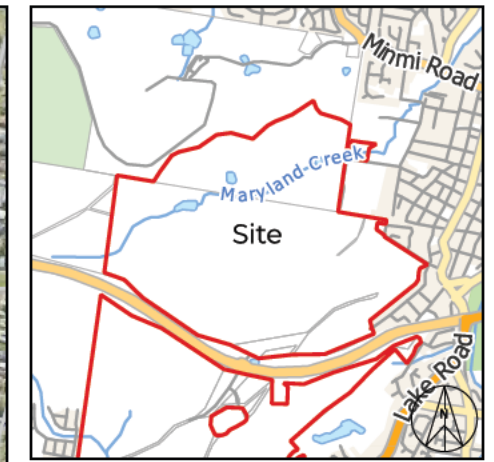
Drawing 3 – Extent and Type of Identified Workings in Young Wallsend Seam

Drawing 4 – Extent and Type of Identified Workings in Borehole Seam

Drawing 5 – Areas Identified with <30 m of Cover to Young Wallsend and Borehole Seam

Drawing 6 – Identified Areas of Geotechnical Constraints

Drawing 7 – Indicative Borehole Locations



SITE LOCATION

LEGEND

- Site Boundary
- Public Open Space
- Innovation Exchange
- Commercial
- R2-Low Density Residential
- Low / Medium Density Residential
- ABSRegionalBoundariesLGA

0 100 200 300 400 500 m



PROJECT:	91610.09
DRAWING NO:	1-1
REVISION:	0

NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Client supplied drawing titled "Development Concept Plan" dated 12.06.2025



CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Overview of Proposed Development**
Proposed Residential Subdivision
New Wallsend Land Parcel



SITE LOCATION

LEGEND

- Site Boundary
- Public Open Space
- Commercial
- R2-Low Density Residential
- Low / Medium Density Residential
- School
- ABSRegionalBoundariesLGA

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Client supplied drawing titled "Development Concept Plan" dated 12.06.2025

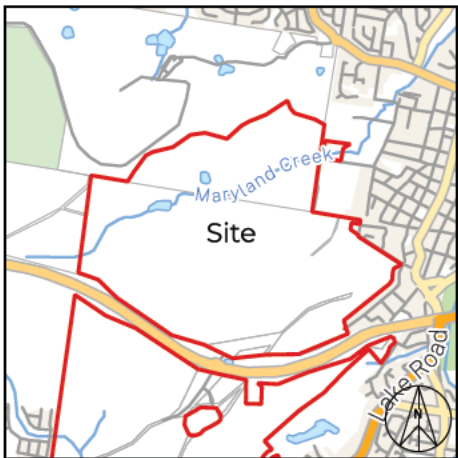
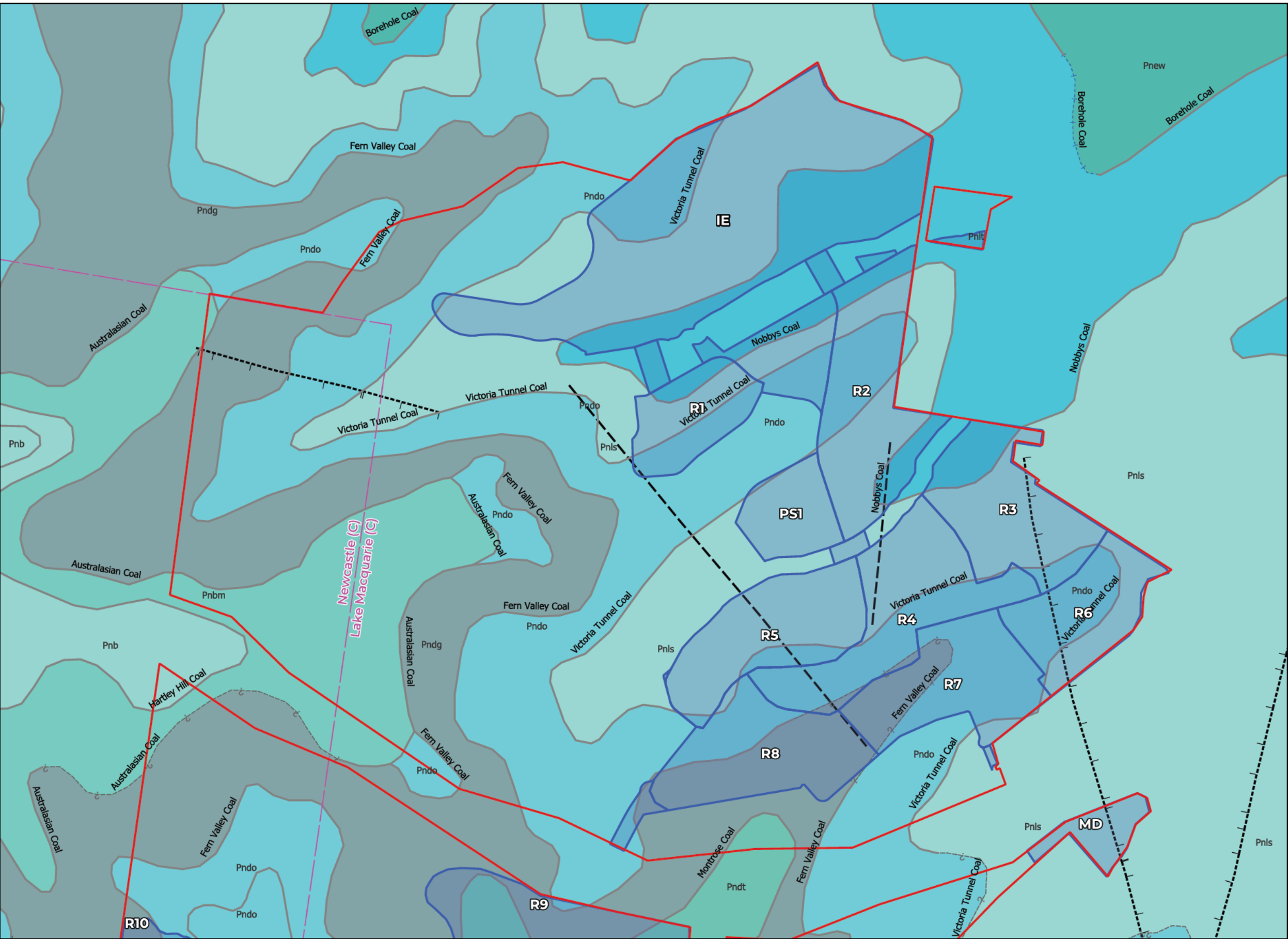


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Overview of Proposed Development
Proposed Residential Subdivision
New Wallsend Land Parcel**



PROJECT:	91610.09
DRAWING NO:	1 - 2
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- ABSRegionalBoundariesLGA
- Fault, position approximate
- Normal fault, concealed
- Boolaroo Subgroup (Pnb)
- Mount Hutton Formation (Pnbm)
- Glebe Formation (Pndg)
- Kotara Formation (Pndo)
- Tickhole Formation (Pndt)
- Waratah Sandstone (Pnew)
- Shepherds Hill Formation (Pnls)
- Tighes Hill Formation (Pnlt)

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from NSW Seamless Geology dataset provided by the Department of Regional NSW, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025



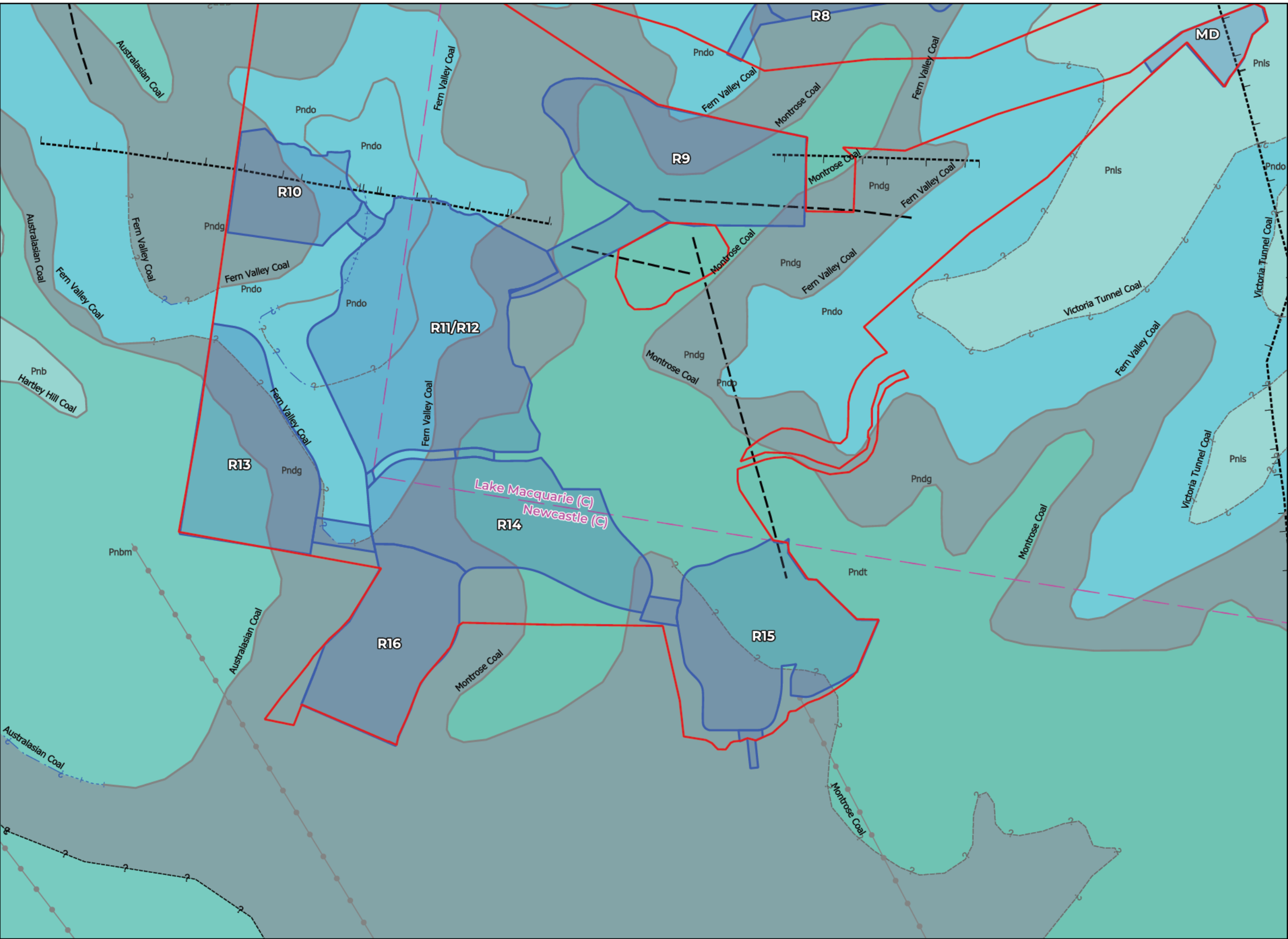
CLIENT: Eden Estates (Newcastle) Pty Ltd
OFFICE: Newcastle
SCALE: 1:10000 @A3

DRAWN BY: CET
DATE: 18.July.2025

TITLE: **Overview of Geological Mapping**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT: 91610.09
DRAWING NO: 2 - 1
REVISION: 0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- ABSRRegionalBoundariesLGA
- Dyke or vein
- Fault, position approximate
- Normal fault, concealed
- Boolaroo Subgroup (Pnb)
- Mount Hutton Formation (Pnbm)
- Glebe Formation (Pndg)
- Kotara Formation (Pndo)
- Tickhole Formation (Pndt)
- Shepherds Hill Formation (Pnls)

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from NSW Seamless Geology dataset provided by the Department of Regional NSW, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

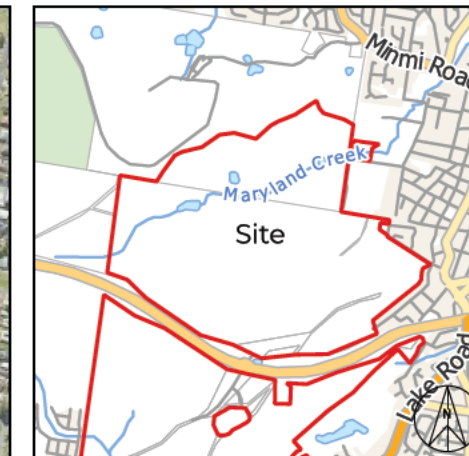
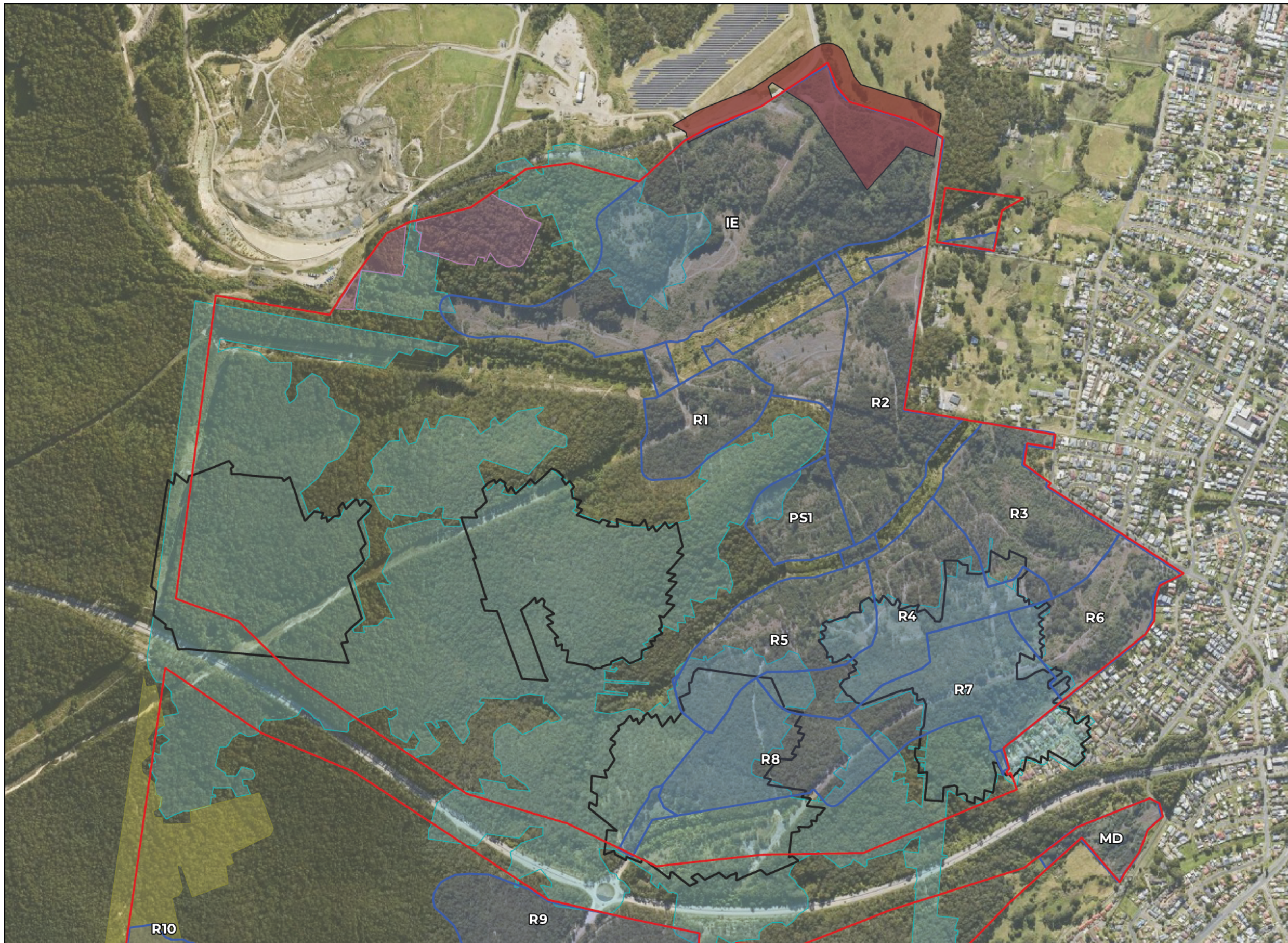


CLIENT: Eden Estates (Newcastle) Pty Ltd
OFFICE: Newcastle DRAWN BY: CET
SCALE: 1:10000 @A3 DATE: 18.July.2025

TITLE: **Overview of Geological Mapping**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT: 91610.09
DRAWING NO: 2 - 2
REVISION: 0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Open Cut Areas
- Partial Extraction
- Secondary Extraction
- Primary Extraction
- Assessment Panel Areas

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

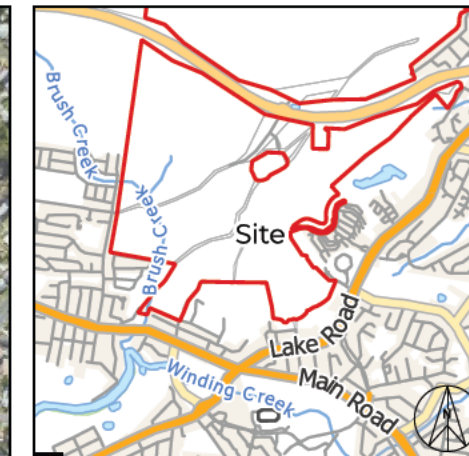


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Extent and Type of Identified Workings in Young Wallsend Seam**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	3 - 1
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Partial Extraction
- Panel Extraction
- Secondary Extraction
- Primary Extraction
- Assessment Panel Areas

0 100 200 300 400 500 m



NOTE:

1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

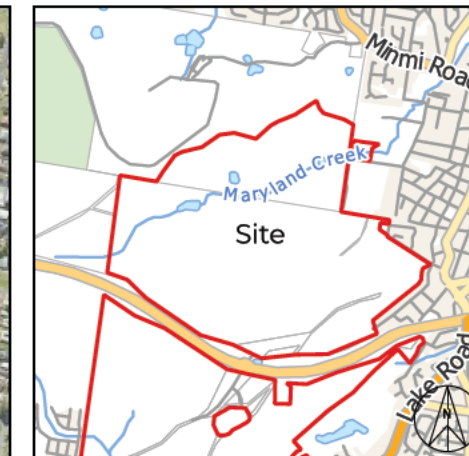
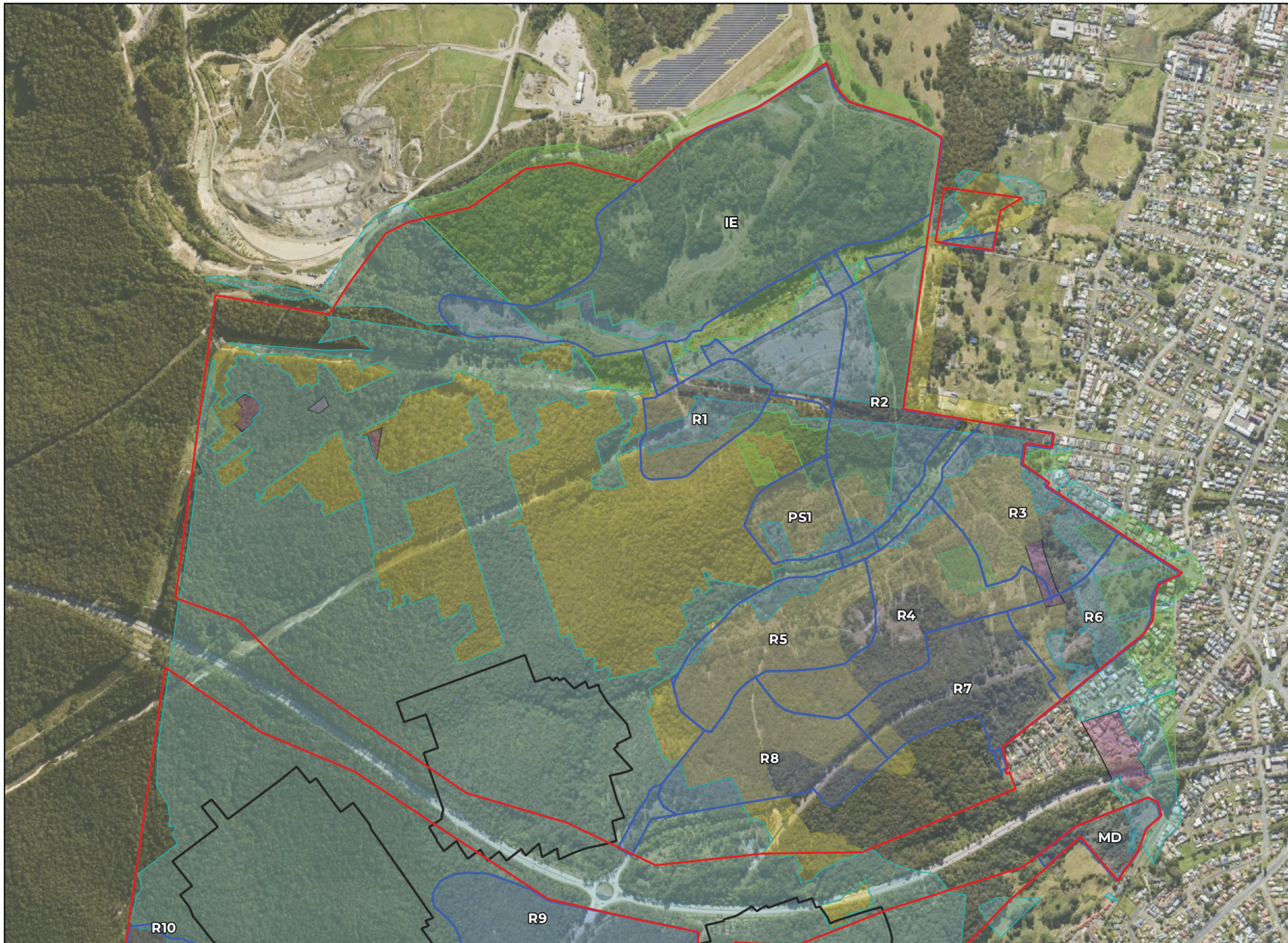


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Extent and Type of Identified Workings in Young Wallsend Seam
Proposed Residential Subdivision
New Wallsend Land Parcel**



PROJECT:	91610.09
DRAWING NO:	3 - 2
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Goaf
- Primary Extraction
- Secondary Extraction
- Partial Extraction
- Assessment Panel Areas

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

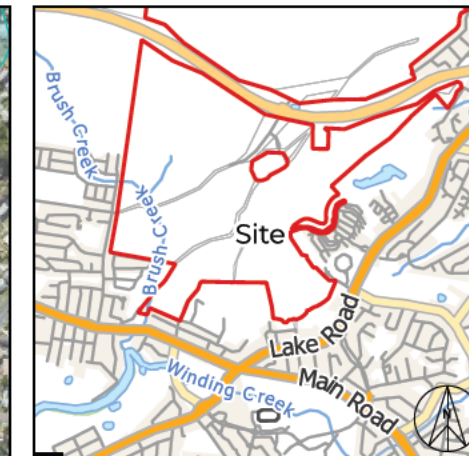


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Extent and Type of Identified Workings in Borehole Seam
Proposed Residential Subdivision
New Wallsend Land Parcel**



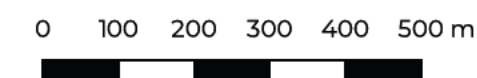
PROJECT:	91610.09
DRAWING NO:	4 - 1
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Primary Extraction
- Secondary Extraction
- Assessment Panel Areas



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

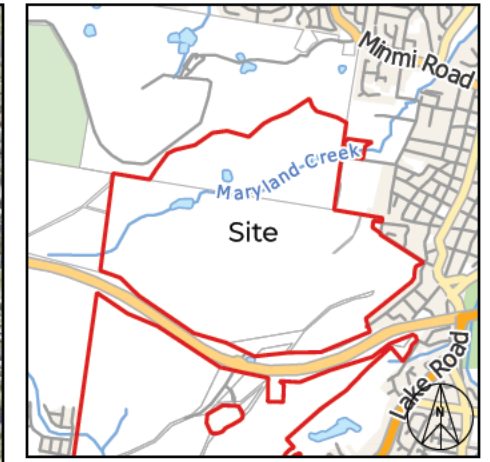
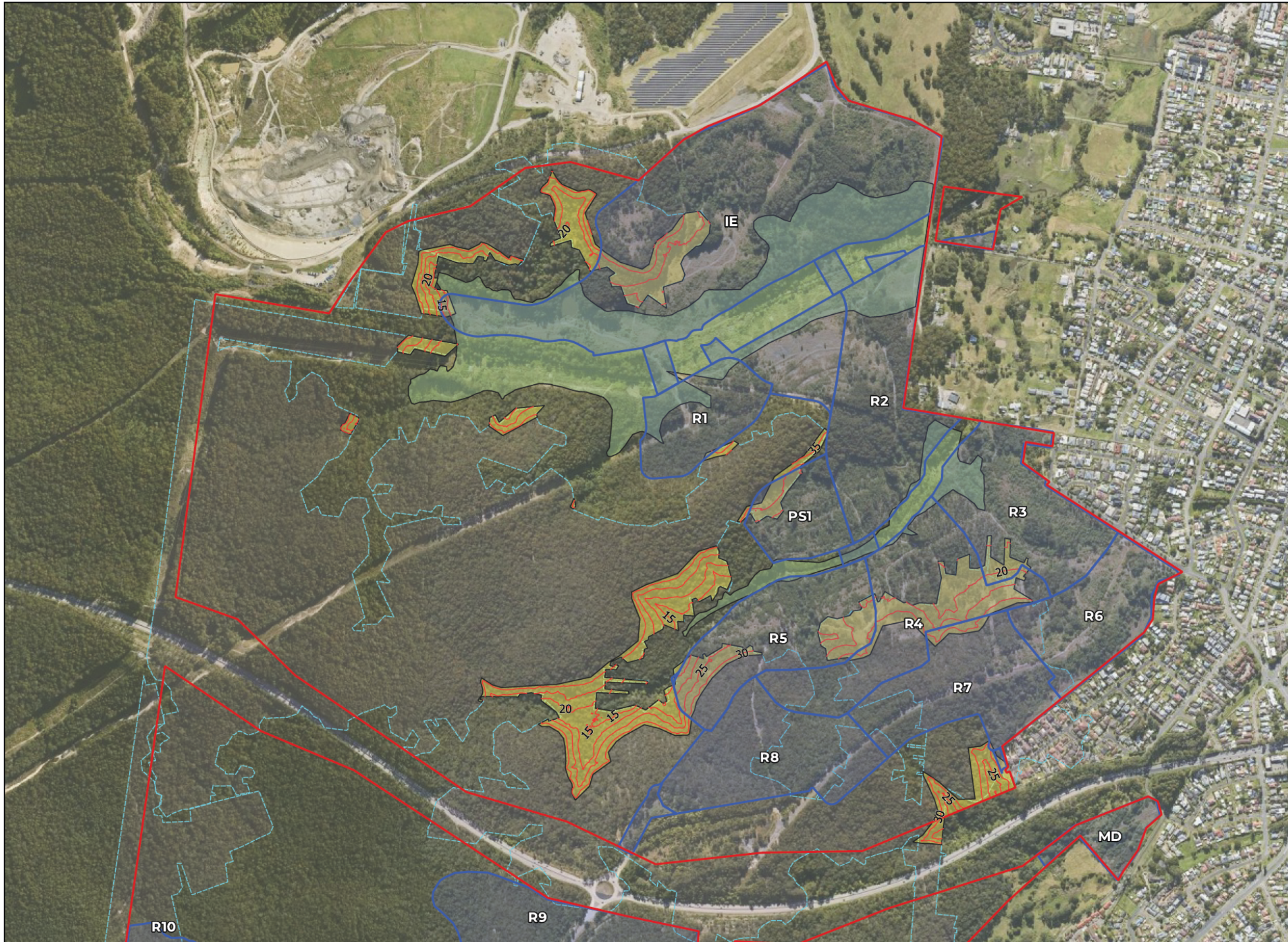


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Extent and Type of Identified Workings in Borehole Seam**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	4 - 2
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Approximate Depth of Cover (DoC) to Young Wallsend Seam
- Areas of DoC<30m to Young Wallsend Seam
- Extent of Workings in Young Wallsend Seam
- Areas of DoC<30m to BH Seam

0 100 200 300 400 500 m



NOTE:

1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

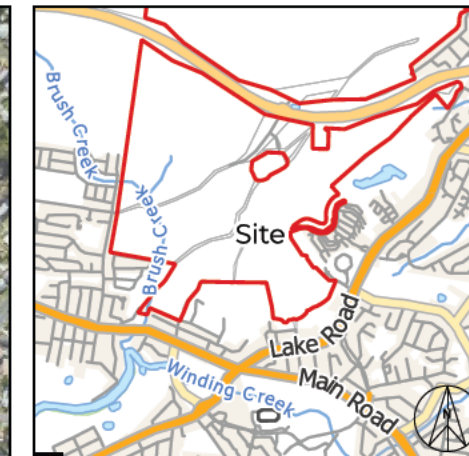


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Areas Identified with <30 m of Cover to Young Wallsend and Borehole Seam**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	5 - 1
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Approximate Depth of Cover (DoC) to Young Wallsend Seam
- Areas of DoC<30m to Young Wallsend Seam
- Extent of Workings in Young Wallsend Seam

0 100 200 300 400 500 m



NOTE:

1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025

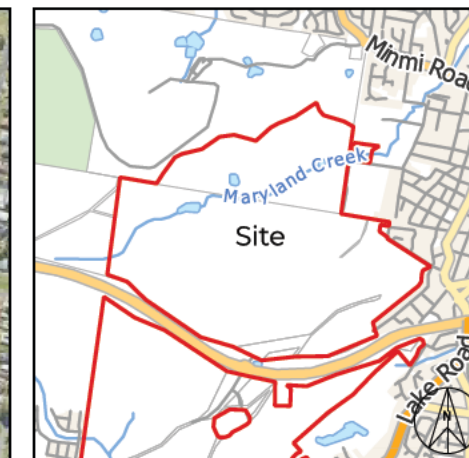
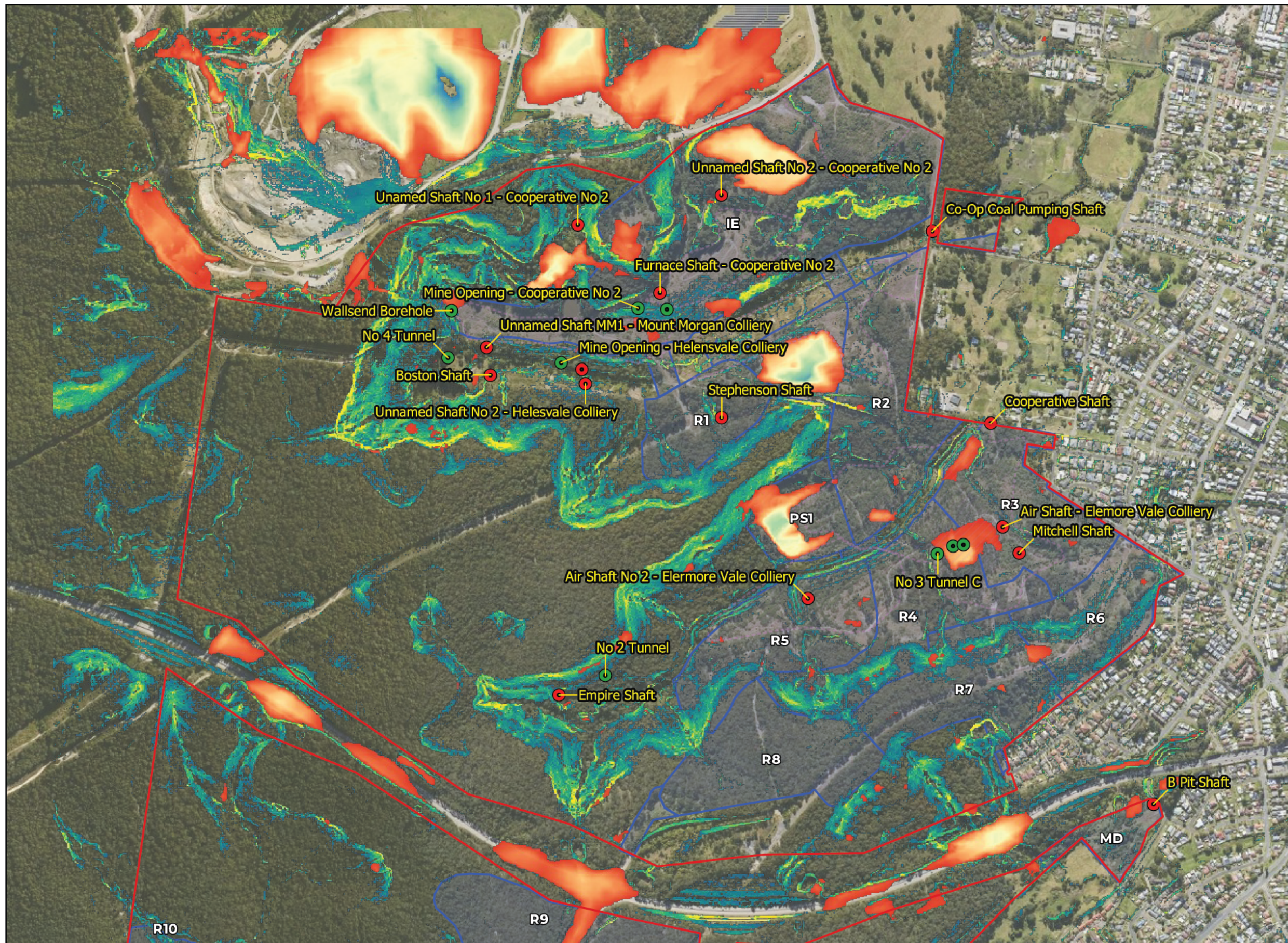


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: **Areas Identified with <30 m of Cover to Young Wallsend and Borehole Seam**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	5 - 2
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Mine Openings (Approximate)
 - Adit
 - Shaft
 - Areas of Deep Fill (present prior to 1974)
- Approx. Depth of Fill Since 1974
 - 35
 - 0
- Areas of Steep Ground
 - 35
 - 5

0 100 200 300 400 500 m



NOTE:

1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025
2. Additional mine openings and shafts may be present on the site and the mapped locations of known mine openings are approximate only

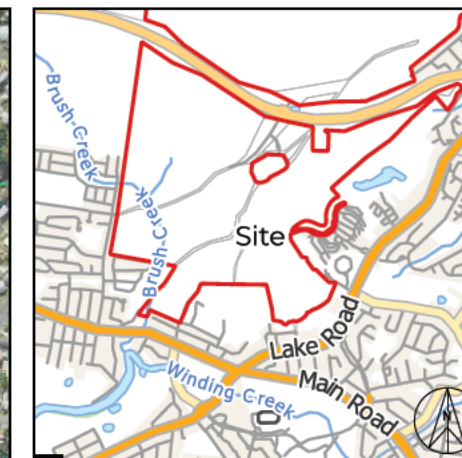
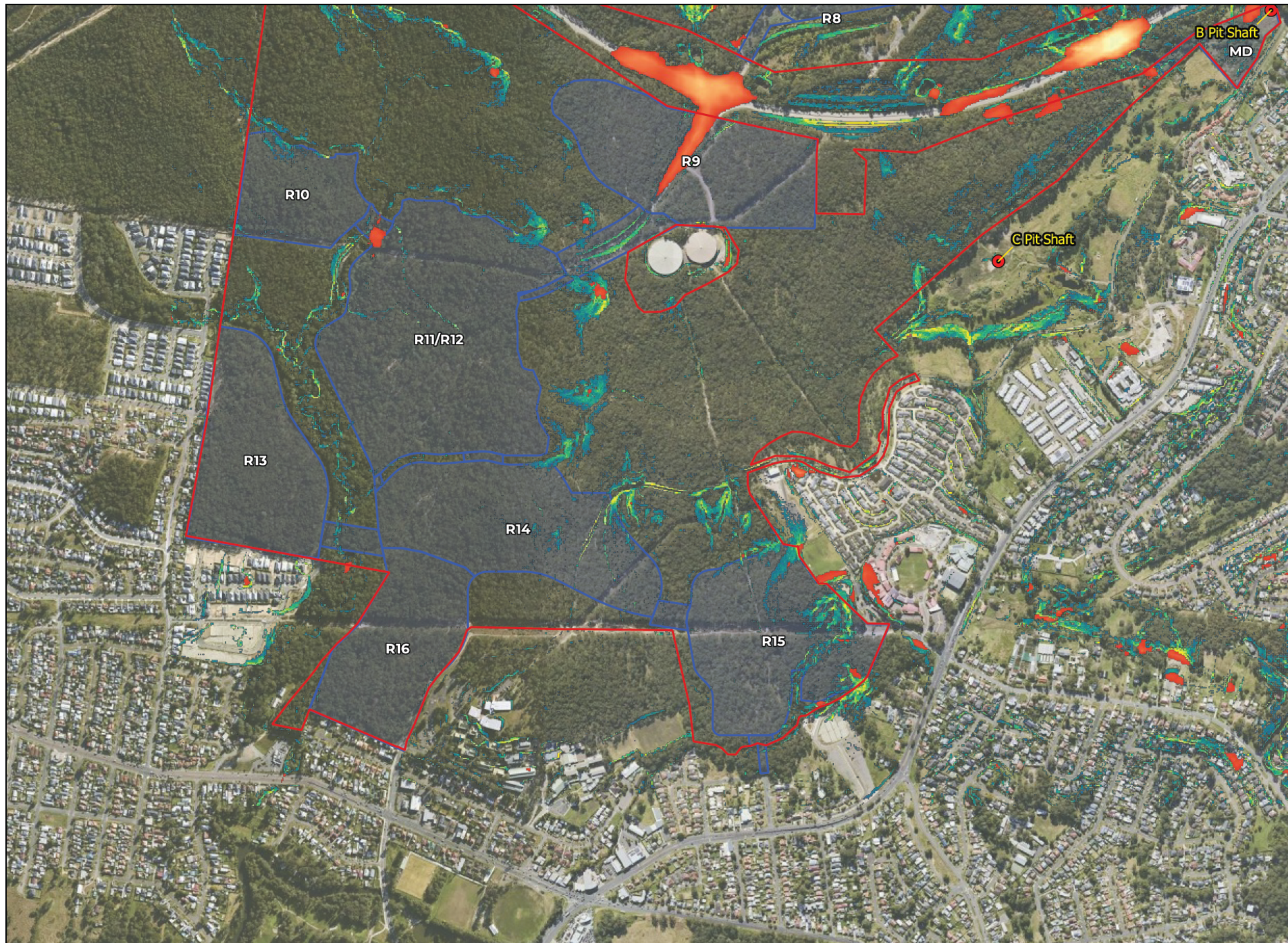


CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 11.July.2025

TITLE: Identified Areas of Geotechnical Constraints
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	6 - 1
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Mine Openings (Approximate)
 - Shaft
 - Approx. Depth of Fill Since 1974
 - 35
 - 0
 - Areas of Steep Ground
 - 35
 - 5

0 100 200 300 400 500 m

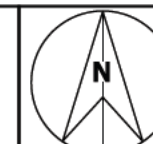
NOTE:

- Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025
- Additional mine openings and shafts may be present on the site and the mapped locations of known mine openings are approximate only

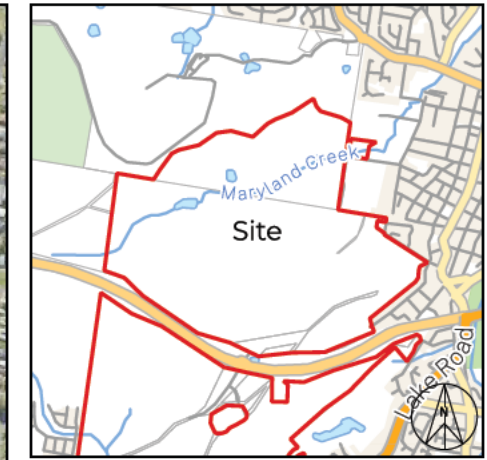


CLIENT: Eden Estates (Newcastle) Pty Ltd
OFFICE: Newcastle DRAWN BY: CET
SCALE: 1:10000 @A3 DATE: 11.July.2025

TITLE: **Identified Areas of Geotechnical Constraints**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT: 91610.09
DRAWING NO: 6 - 2
REVISION: 0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Investigation Approach**
- + Cored
- Open
- Air Track / Wash Bore
- Shaft
- Adit
- Pothole Risk within Development

0 100 200 300 400 500 m



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025
2. Additional mine openings and shafts may be present on the site and the mapped locations of known mine openings are approximate only



CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 18.July.2025

TITLE: Indicative Borehole Locations Proposed Residential Subdivision New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	7 - 1
REVISION:	0



SITE LOCATION

LEGEND

- Site Boundary
- Development Boundary
- Investigation Approach
 - Cored
 - Open



NOTE:
1. Drawing adapted from aerial imagery from MetroMap dated 22.07.2024, Development Boundary adapted from client supplied drawing titled "Development Concept Plan" dated 12.06.2025
2. Additional mine openings and shafts may be present on the site and the mapped locations of known mine openings are approximate only



CLIENT: Eden Estates (Newcastle) Pty Ltd	
OFFICE: Newcastle	DRAWN BY: CET
SCALE: 1:10000 @A3	DATE: 18.July.2025

TITLE: **Indicative Borehole Locations**
Proposed Residential Subdivision
New Wallsend Land Parcel



PROJECT:	91610.09
DRAWING NO:	7 - 2
REVISION:	0