APPENDIX 11 – ENVIRONMENTAL LETTER FROM HLA

17 November 2005

Mr. Matthew Crozier
Crozier CGS Pty Ltd
PO Box 741
NEWCASTLE NSW 2300

Dear Mr. Crozier,

SEPP 55 Considerations, Development Application No.734/05 (Lot 6, DP 774923, Lot 2, DP 809795 & Lot 4, DP 129431, No.595 Pacific Highway, Crangan Bay

In response to your request, please find the following technical responses, specifically relating to the SEPP 55 – Remediation of Land issues raised by Wyong Shire Council (WSC) for the Development Application No.734/05 (Lot 6, DP 774923, Lot 2, DP 809795 & Lot 4, DP 129431, No.595 Pacific Highway, Crangan Bay.)

Each of WSC's six (6) comments are presented below (and numbered for easy future reference), together with associated responses, as appropriate.

1. *The Preliminary Site Investigation is inadequate for this proposal. HLA's assessment was prepared for cleaning and rehabilitating the site for recreational and ecological use not for a residential subdivision.*

The HLA investigations were specifically developed to address Mine Site Lease conditions and were not for detailed site characterisation and redevelopment planning purposes. This HLA work was entirely appropriate for the mine lease and closure planning purposes. Supplementary investigations, consistent with NSW EPA's 1997 "Consultant Reporting Guidelines for Contaminated Sites", could be performed to specifically assess the suitability of the Site for its intended landuses, and determine if any remedial works may be required.

However, notwithstanding the different objective of the HLA October 2004 reports for LakeCoal Pty Ltd in relation to the Catherine Hill Bay Sites, and using all of the available information, it is possible to conclude that the potential for significant contamination to exist at the site is low and remediation is possible. Furthermore, the nature, extent and scale of remediation are likely to be low, and may be classified as **Category 2 works** under SEPP 55. Therefore, consistent with the (then) DUAP / EPA 1998 Planning Guidelines and SEPP 55, a consent agency may chose to follow the "**suggestions for possible planning responses for DAs**" (see page 25 of Planning Guidelines), being that:

"If investigations find that contamination makes the land unsuitable for the proposed use and requires remediation, this may be enforced by:

- ☑ *if the remediation may be carried out without consent under SEPP 55 (category 2 work):*
  - i. *imposing **conditions** on the development consent for the use, requiring remediation to be carried out and validated either before other work commences or before occupation of the site, or*

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ii. *issuing a **deferred commencement** consent for the use, and requiring remediation to be carried out and validated before other work commence."*

Justification that the remedial works are "Category 2" in nature and extent could be developed from the existing and additional information, as a supplementary report, for WSC's consideration.

2. *The major omission in the report is determining whether coal chitter is or is not a contaminated material under guidelines for residential landuse. The proposal depends on coal chitter being an acceptable material on which to build houses. The study states that the chitter contains hydrocarbons at levels that exceed the assessment criterion. This question is critical to the viability of the proposal.*

Coal chitter is a common by-product material that has been used extensively for filling purposes, especially in Council areas such as Wyong, Lake Macquarie, Port Kembla, Wollongong, Newcastle, Lithgow, Cessnock, Maitland and other areas that are also associated with coal mining and processing activities.

Notwithstanding its extensive beneficial use, some concerns have been raised as to the human, ecological and fire risks that may be associated with this material. Consistent with NSW DEC's guidelines, a preliminary chemical assessment of the material against threshold landuse health investigation levels (HILs) would suggest that further investigation was required, due to presence of elevated levels of Polycyclic Aromatic Hydrocarbons (PAHs) and Total Petroleum Hydrocarbons (TPHs). This further investigation of these indicator chemical groupings would include consideration of the material's actual chemical composition, contaminant mobility and the contaminant toxicology of the variety of hydrocarbons that make up the coal chitter.

It has been our experience that the typical chemical composition of coal chitter is of low human and ecological risk due to the low solubility of the chemicals within the material, and their associated low human and ecological toxicity. We understand that guidelines for the beneficial reuse of this material have been developed by local government and these could be considered to confirm the suitability of the material for beneficial use. This overall assessment could be produced in a scientifically-defensible manner and reported to WSC, to confirm the human health and ecological risks posed by the subject material.

3. *I recommend that because this [coal chitter characterisation and suitability] issue is crucial to approval of the development that the proponents be required to submit an accredited EPA site auditors report and statement supporting residential landuse on coal chitter before further consideration be given to the development proceeding.*

The review and suitability signoff process nominated by WSC, in using an accredited site auditor, is entirely appropriate and consistent with SEPP 55 Guidelines, and with the current NSW Planning Guidelines for the Management of Contaminated Land. Early involvement of these accredited independent Site Auditors is always strongly recommended, to avoid unnecessary re-working of investigations and subsequent remediation, if required.

It is critical to note that Site Auditors are totally independent specialists and some supplementary information may be required by Auditors to satisfy themselves of the specific issues that they are considering.

4. *Another issue with coal chitter is whether it is likely to ignite or in the Catherine Hill Bay location sustain fire started by bushfire from the nearby State Recreation Area. This question is also critical in determining its use under buildings.*

This issue of coal chitter fire risk has been investigated by local government and the risk is considered to be negligible, provided appropriate management techniques are implemented. These measures are simple and easy to implement such that the coal chitter may be beneficially used with no adverse impacts to the environment (including fire risk). The specific process for ensuring this risk management would be included in the Site's RAP, using the available local government coal chitter guidance.

5. *The HLA report identified contaminants, namely asbestos, mineral fibre and lead paints in the buildings and hydrocarbons in dam 7 and around some of the maintenance areas. How does Rosecorp propose to deal with these contaminants?*

A comprehensive **Remedial Action Plan (RAP)**, presented in a manner consistent with the requirements of the EPA's 1997 *Consultant Reporting Guidelines* would describe the methodologies that would be undertaken to address any unacceptable risks identified at the Site, including risks associated with asbestos fibre, mineral fibre, lead (Pb) and hydrocarbons. The submission of such an RAP could be required by WSC as a Condition of Consent in relation to the current DA, as per page 25 of the 1998 DUAP / EPA Planning Guidelines. It is common for RAPs to be provided as part of the information package that is presented to Consent Agencies where remediation is undertaken as Category 2 Works under SEPP 55.

6. *Further, chromium 5 turned up in samples from the vehicle maintenance building. These samples were reanalysed to get improved results. This is not an acceptable approach as the holding time is likely to have affected the results. Re-sampling is required especially considering the change in intended use. These issues are manageable but have not been covered in the report due to the intended landuse being recreational and ecological.*

The WSC letter presents a typographical error and the correct contaminants of concern for discussion here are Chromium (III) and Chromium (VI).

A total of 19 samples (plus further QA samples) were analysed for Total Chromium which is a combination of Chromium in a number of valency states, primarily as Cr (III) and to a much lesser extent as Cr (VI). Total Chromium analysis is a standard analytical technique that is consistent with the 1999 NEPM Guidelines for Laboratory Analysis of environmental samples. The Threshold Levels for Chromium (III) for the most sensitive landuse is 120,000 mg/kg, while Chromium (VI) has a threshold level for most sensitive landuse of 100 mg/kg. Where samples exceed the nominal Chromium (VI) level in total Chromium analyses, it is common for samples to be reanalysed if the samples have not exceeded their nominal laboratory holding times. Where the holding times have been exceeded, the resultant data is considered as indicative rather than absolute. For the subject Site, of the 19 samples analysed, two sample results, for MS10-1 (0.1 – 0.2m below ground surface or bgs) and MS11-1 (0.1 – 0.2 m bgs) reported Total Chromium results of 311 and 412 mg/kg, respectively. While these results are above the threshold level for Chromium VI (of 100 mg/kg for the most sensitive landuse) they are well below the threshold level for Chromium (III) of 120,000 mg/kg.

Considerable experience in the environmental chemistry of Chromium contamination exposed to the natural environment has confirmed that Chromium (VI) has a very short environmental half-life (i.e. the time that is remains in the environment before it decays to its more stable Chromium (III) state) under normal conditions, especially such as occurs close to the soil surface (i.e. less than 0.2m bgs). Therefore, it is most likely that the Total Chromium reported at these locations is in the most commonly occurring Chromium (III) state, rather than in the unstable and higher toxicity Chromium (VI) state. Nonetheless, further investigations of this anomaly are considered to be warranted to confirm these assumptions.

Conclusions

The HLA October 2004 report for the Moonee Colliery was prepared specifically for mine closure purposes and the furthermore, the reports specifically conclusions (Section 9):

> "The need for remediation is determined largely by the proposed future land use and the form that land rehabilitation might take."

Notwithstanding the Report's very specific mine closure plan purpose, the report may be used as a reasonable indicator of the nature and extent of potential contamination as the subject Site and therefore whether remediation may be required. *Based on the available information, remediation would be required to make the site suitable for more sensitive landuse purposes.*

Furthermore, while the extent of the remediation would depend upon the nature of the future landuse, it is possible to conclude from the available data, that the scale of remediation, even for the most sensitive landuse, is likely to be low and as such would constitute *"Category 2 Works"* under SEPP 55. Supplementary investigations would be appropriate to confirm this conclusion.

Due to the nature and extent of impacted materials identified at the Site, a remedial action plan **(RAP)** would be appropriate to address these impacts. This RAP could be provided as part of the SEPP 55 Category 2 works information package provided to WSC as a DA condition of consent and prior to the commencement of any site works.

Due to the nature of the Site and its remediation, it may be appropriate to **appoint an independent government accredited Site Auditor** to review the proposed works and, at the completion of remediation, provide a site audit statement (SAS) and site audit report (SAR), confirming the suitability of the Site for its intended purposes.

I would be pleased to provide further information in support of this review and associated conclusions and recommendations, at your request. Please contact me on 02 4968 0044 or 0413 833811.

Yours faithfully
HLA-Envirosciences Pty Limited

Ross McFarland
Principal

APPENDIX 12 – SEA LEVEL RISES REPORT

ENSR | AECOM

Prepared for:

Rose Group Pty Ltd

51 Riley Street
Woolloomooloo NSW 2011



Catherine Hill Bay Redevelopment - Sea Level Rise and Coastal Inundation Assessment
Montefiore Street
Catherine Hill Bay

Final

ENSR Australia Pty Ltd (ENSR)

3 March 2009

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Distribution

Catherine Hill Bay Redevelopment - Sea Level Rise and Coastal Inundation Assessment
Montefiore Street
Catherine Hill Bay

3 March 2009

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Contents

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Concept Approval – Condition 21 1
1.3 Purpose of this Report 1
2.0 AUSTRALIAN REGIONAL SEA LEVEL RISE PROJECTIONS AND IMPACTS 3
2.1 Climate Change 3
2.2 Global and Regional Sea Level Rise Projections and Impacts 3
3.0 SEA LEVEL RISE AND COASTAL INUNDATION ASSESSMENT 5
3.1 Site Description 5
3.2 Sea Level Rise Predictions 5
3.3 Digital Elevation Model 6
3.3.1 DEM South East Quadrant 7
3.3.2 DEM North East Quadrant 7
3.3.3 DEM North West Quadrant 7
3.3.4 DEM South West Quadrant 7
3.4 Sea Level Rise and Coastal Inundation Assessment 8
3.4.1 North East Quadrant 8
3.4.2 South East Quadrant 8
3.4.3 Stormwater Management 9
4.0 CONCLUSIONS 11
5.0 REFERENCES 13

List of Tables

Table 1: Components of the sea level rise planning benchmarks (DECC, 2009) 5
Table 2: Indicative floor levels for a habitable room (LMCC, 2008) 6

List of Figures

Figure 1: Proposed Subdivision Extent
Figure 2: Digital Elevation Model – South East Quadrant
Figure 3: Digital Elevation Model – North East Quadrant
Figure 4: Digital Elevation Model – North West Quadrant
Figure 5: Digital Elevation Model – South West Quadrant

List of Appendices

Appendix A Bulk Earthworks Plan (Parsons Brinckerhoff, 2007a)
Appendix B Stormwater Management Strategy (Parsons Brinckerhoff, 2007b)

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1.0 Introduction

1.1 Background

ENSR Australia Pty Ltd (ENSR) has been engaged by Rose Group Pty Ltd (Rose Group) to prepare an evaluation of potential effects of sea level rise and coastal inundation on the proposed Moonee Hamlets redevelopment at Catherine Hill Bay.

A Concept Plan was prepared incorporating the proposed development under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Concept Plan comprises proposed development of land at Catherine Hill Bay, known as the Moonee Hamlets redevelopment, incorporating 374 hectares of land on both sides of the Pacific Highway, as well as a site at Gwandalan controlled by Lakeside Living Pty Ltd. The Concept Plan includes dedication of part of the subject 374 hectares at Catherine Hill Bay as public land, subdivision of the Moonee Hamlets site, and subdivision and redevelopment of the site a Gwandalan.

A Concept Approval was issued in respect of the development on 2 September 2008. Two project applications have now also been lodged with the NSW Department of Planning for development included within the Concept Plan:

- Civil and Community Works Package (MP 07_0108); and
- Hamlet 2 residential development (MP 07_0110).

These project applications are currently being considered by the Department of Planning.

1.2 Concept Approval – Condition 21

The Concept Approval specified further assessment requirements for future applications relating to the Concept Plan. Condition C21 states:

> *Future applications are to address impacts of possible sea level rise and coastal inundation on the proposed development and proposed safeguards to mitigate impacts.*

This condition requires project applications lodged in respect of the Concept Plan to address the impacts of possible sea level rise and coastal inundation.

1.3 Purpose of this Report

This report has been prepared to consider impacts of possible sea level rise and coastal inundation on the following components of the proposed development:

- Civil and Community Works Package;
- Hamlets 1 and 2 residential developments.

An assessment of high resolution terrain mapping undertaken by the Department of Planning which has been used to generate a Digital Elevation Model (DEM) of the development footprint has been undertaken to assess the potential for possible sea level rise to affect the project, and potential impacts of sea level rise on the development are considered.

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2.0 Australian Regional Sea Level Rise Projections and Impacts

2.1 Climate Change

Climate change is broadly defined as a climatic response to increased greenhouse gases in the Earth's atmosphere, and is widely accepted by the scientific community as occurring on a global scale. The primary impact of climate change is an increase in atmospheric temperatures, supported by the following observations:

- Increase in the mean global surface air temperature;
- Regional changes in precipitation;
- Atmospheric concentrations of greenhouse gases; and
- Rate of global sea level rise.

A report prepared on behalf of the NSW Government in 2004 by CSIRO and the Bureau of Meteorology found that between 1950 and 2003, temperatures in NSW increased by 0.9 C, while total annual rainfall declined by and average of 14 mm per decade, with the largest declines experienced near the coast (CSIRO, 2007). While implications of climate change are far-reaching, this assessment focuses on the potential impacts of sea level rise on the proposed development.

2.2 Global and Regional Sea Level Rise Projections and Impacts

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007) reports that global average sea level has risen at an average rate of 1.8 mm/yr since 1961, and at 3.1 mm/yr since 1993. Contributions to global rises in sea level rise are attributable to:

- Thermal expansion of the oceans as ocean temperature increases; and
- Glacial melting and melting of the polar ice sheets.

The IPCC Fourth Assessment Report, which provides an integrated assessment of the causes and impacts of climate change based on predicted global greenhouse gas emissions from human activities, updates sea level rise predictions of previous IPCC reports based on a number of greenhouse gas emission scenarios. The IPCC predicts that under the worst case greenhouse gas emissions scenario, global average sea level rise (ignoring ice melt) would be up to 0.59 m by 2099 (relative to 1980-1999 levels). This prediction increases when an allowance for uncertainties associated with ice melt and local variations are added.

Sea level rise is predicted to have major impacts on the coastal zone. The two primary impacts of sea level rise are:

- A permanent increase in sea levels relative to current levels; and
- An increase in coastal hazards such as erosion and flood risks from coastal inundation during major storms.

Other predicted impacts include:

- Loss of coastal wetlands, their ecosystems and protective physical buffering;
- Problems with local drainage adjacent to beaches and in lower estuaries during storm flooding; and
- Erosion of developed sandy coasts.

Climatic changes including increased frequency and intensity of storms, as well as changes to wind, wave setup and tidal conditions along the coast will also influence the impacts of sea level rise on the coast and subsequent inundation of low-lying areas (DECC, 2008; Department of Planning, 2008).

3.0 Sea Level Rise and Coastal Inundation Assessment

3.1 Site Description

The proposed redevelopment is located on a headland between two sandy embayments; Catherine Hill Bay to the north, and Moonee Beach to the south. The extent of the development footprint is shown on **Figure 1**. Catherine Hill Bay is generally oriented to the east south east, while Moonee Beach is oriented to the east, and is bounded to the south by a prominent headland which affords the more northern headland protection from dominant south easterly swells.

The proposed site on the headland was formerly used as a coal mine preparation area which included coal stockpile areas and a coal preparation and handling plant. As a result of mining activities the topography of the site is heavily disturbed, and has an elevation ranging from approximately 10 m to in excess of 50 m at some locations, however is typically between 20 and 40 m.

The eastern perimeter of the site is bounded by the Pacific Ocean, with steep cliffs rising from the ocean to a level of approximately 35 m AHD. This area was the site of the former bin building which was used for storing and distributing the processed coal product to the wharf, which is located at the bottom of the cliff (Parsons Brinckerhoff, 2007).

Montefiore Street is the primary access to the site from the Pacific Highway and follows an east-west oriented ridgeline which roughly dissects the development footprint, with an elevation of approximately 40 m AHD. Drainage and stormwater runoff from the site generally flow away from Montefiore Street to the north and south towards creeks which connect to Catherine Hill Bay beach embayment to the north and Moonee Beach embayment to the south and drain to the Pacific Ocean.

Significant bulk earthworks are proposed in order to render the site suitable for residential development. The bulk earthworks and construction of local roads form part of the initial project application (Civil and Community Works Package (MP 07_0108)) to prepare the site for future use.

3.2 Sea Level Rise Predictions

The DECC has released a Draft Sea Level Rise Policy Statement (DECC, 2009) which acknowledges the medium and long term social, economic and environmental impacts of sea level rise. The draft policy statement adopts the IPCC's predictions for a rise relative to 1990 mean sea levels of up to 0.40 m by 2050 and 0.90 m by 2100. The calculations of current sea level rise predictions provide by DECC (2009) are shown in **Table 1**. A design life of 100 years is considered appropriate for the proposed development, therefore calculations for 2100 are relevant to this assessment.

Table 1: Components of the sea level rise planning benchmarks (DECC, 2009)

Component	2050	2100
Sea level rise	0.30 m	0.59 m
Accelerated ice melt	(included in above value)	0.20 m
Regional sea level rise variation	0.10 m	0.14 m
Rounding*	-	- 0.03 m
Total	**0.40 m**	**0.90 m**

Rounding was adopted as the projections have a degree of uncertainty, and adopting values to the nearest centimetre would imply a high degree of accuracy in the projections.

Lake Macquarie City Council has prepared the *Lake Macquarie Sea Level Rise Preparedness Adaptation Policy* (LMCC, 2008) (the Policy) which provides a framework for responding to hazards associated with sea level rise hazards and risks. LMCC has adopted the NSW DECC (2007) *Floodplain Risk Management Guideline* projected upper sea level rise figure for 2100 of up to 0.91 m as a basis for risk assessment for hazards associated with sea level rise.

While the most recent DECC draft policy statement provides a lower value for sea level rise in NSW, for the purposes of this assessment, adopts a more conservative value of 0.99 m for 2100. Furthermore, the LMCC (2008) Policy provides design levels for habitable rooms in areas affected by flooding, and incorporates sea level rise, the 1% average recurrence interval (ARI) from Lake Macquarie Flood Study (LMCC, 1998), increases in rainfall, and additional freeboard capacity. The calculations are shown in **Table 2**. The minimum indicative floor level is calculated as 2.85 m, which is adopted for the purposes of this assessment.

Table 2: Indicative floor levels for a habitable room (LMCC, 2008)

Requirement	Description	Design Level (m AHD)
1% ARI	The 1% ARI from the Lake Macquarie Flood Study (LMCC, 1998).	1.38 m
Freeboard	Additional margin for uncertainty and local risk recommended by DECC's *NSW Floodplain Management Manual* (DECC, 2005).	0.50 m
Rainfall	Rainfall calculated on upper level of rainfall increase by 2100 of 30% stipulated in DECC's publication *Floodplain Risk Management Guideline Practical Consideration of Climate Change* (DECC, 2007).	0.18 m
Sea Level Rise	Sea level rise upper scenario of 0.91 m adopted from the IPCC (2007) and CSIRO (2007) reports on climate change (incorporating 0.59 m sea level rise + 0.20 m allowance for ice melt uncertainty + 0.12 m for local variations = 0.91 m). LMCC adopts a design level value of 0.99 m.	0.99 m
Discount from climate change uncertainty	Reduction to account for climate change uncertainty already incorporated in freeboard.	- 0.20 m
Total		**2.85 m**

*Source: *Lake Macquarie Sea Level Rise Preparedness Adaptation Policy* (LMCC, 2008)

3.3 Digital Elevation Model

The NSW Department of Planning undertook a project in conjunction with Wyong, Lake Macquarie, Newcastle City, Port Stephens and Gosford council areas, the *High Resolution Terrain Mapping of NSW Central and Hunter Coasts* (DoP, 2008), to identify low-lying areas on the Hunter and Central coasts at risk of sea level rise resulting from climate change. The project used airborne Light Detection and Ranging (LiDAR) laser technology to indentify low-lying areas (defined as less than 10 m above mean sea level) within the study area. One of the primary objectives of the project was to provide a basis for considering the likely impacts of sea level rise and coastal inundation on low lying coastal areas for both existing and future development.

A digital elevation model (DEM) of the proposed redevelopment area and surrounds was generated using data obtained from the DoP (2008) high resolution terrain mapping project to identify the low-lying areas. The development footprint is shown on **Figure 1**. The DEM has been separated into four quadrants, which are shown on **Figures 2** to **5**.

The DEM indicates that elevations across the development footprint typically vary between 20 to 40 m above Australian Height Datum (AHD). The elevations shown on the DEM are indicative of pre-development (2007) ground levels. The 10 m AHD contour line is indicated on each of the quadrants, which indicates the upper limit of low-lying areas considered at risk of sea level rise. A discussion of each of the four quadrants is provided below.

Bulk earthworks are proposed as part of the redevelopment to regrade and level the site. The Bulk Earthworks Plan (2122743A-CIV-0031 RevA) indicating cut and fill activities proposed as part of the Civil and Community Works Package project application is attached as **Appendix A**. A review of this plan indicates that the typical final elevation of the site would be between 20 and 40 m AHD.

3.3.1 DEM South East Quadrant

The South East Quadrant of the DEM is shown on **Figure 2**. The majority of the development footprint within the South East Quadrant has an elevation greater than 10 m AHD, with elevations typically greater than 18 m AHD. The lowest point within the development footprint is indicated on **Figure 2**, with an elevation of 8.5 m. This area is within the Asset Protection Zone (APZ) of the development footprint, therefore no habitable dwellings/structures would be constructed in this area. An APZ of 20 m width has been considered for this assessment, however this is the minimum requirement recommended by the Bushfire Hazard Assessment prepared for the development (Barry Eddie Consulting Pty Ltd) and the actual APZ is likely to be greater. The elevation beyond the APZ is greater than 11 m AHD, therefore the potential for the development to be affected by changes to sea level and inundation levels is considered remote.

3.3.2 DEM North East Quadrant

The North East Quadrant of the DEM is shown on **Figure 3**. The majority of the development footprint within this quadrant is above 10 m AHD. The lowest point is located along the northern most point of the footprint, and represents the cliff line along the rear of the Catherine Hill Bay beach embayment. This area predominately forms parts of the Wallarah House Precinct, which is to be retained in its current form, therefore minimal development would be undertaken in this area. Existing structures within this precinct are located above the 10 m AHD contour. The remainder of this area is generally greater than 22 m AHD. This quadrant is therefore unlikely to be affected by changes to sea level and inundation levels.

3.3.3 DEM North West Quadrant

The North West Quadrant of the DEM is shown on **Figure 4**. The entire development footprint within this quadrant is well above the 10 m AHD contour, with the lowest point along the development footprint boundary being 17.5 m AHD. The remainder of this quadrant is predominantly greater than 25 m AHD and is not likely to be affected by changes to sea level and inundation levels.

3.3.4 DEM South West Quadrant

The South West Quadrant of the DEM is shown on **Figure 5**. The entire development footprint within this quadrant is above 10 m AHD. The lowest elevation along the development footprint boundary is 12 m AHD. The lowest point within the development footprint that is outside the APZ is identified through the DEM as 16.5 m AHD and the remainder of this quadrant is predominantly greater than 26 m AHD. Due to its elevation, development within the development footprint in this quadrant is not likely to be affected by changes to sea level and inundation levels.

3.4 Sea Level Rise and Coastal Inundation Assessment

The DEM indicates that the majority of the proposed development footprint does not contain low lying areas (areas less than 10 m AHD that could be affected by seal level rise). Two areas, one in each in the South East Quadrant (**Figure 2**) and the North East Quadrant (**Figure 3**), were identified as being below 10 m AHD.

The potential for development in the South East and North East Quadrants to be affected by changes in sea level rise and consequent coastal inundation is discussed below.

3.4.1 North East Quadrant

As discussed in **Section 3.3.2** above, the area less than 10 m AHD in the North East Quadrant forms part of the Wallarah House Precinct which is to be retained in its current form. All existing associated structures within this precinct are located above the 10 m AHD contour, and as these areas are not planned to be affected by additional habitable development, land in the North East Quadrant is not likely to be affected by changes to sea level and inundation levels.

3.4.2 South East Quadrant

The DEM for the South East Quadrant (**Figure 2**) identifies a small area within the development footprint that may have the potential to be affected by inundation of the creek line located south of the development footprint which flows to Moonee Beach as a result of sea level rise. The potential impact of inundation on this area as a result of sea level rise is discussed below.

The *NSW Coastline Management Manual* (NSW Government, 1990) identifies two mechanisms for coastal inundation of low lying areas:

- Elevated water levels - increase in Still Water Level (SWL) by storms along the coast by the mechanisms of wind setup, barometric setup and wave setup, resulting in inundation of low lying beach areas and low lying backbeach areas that are hydraulically connected to coastal waters.
- Wave runup and overtopping – wave runup is a mechanism of coastal inundation occurs. Waves can runup and overtop a coastal barrier, such as a dune, seawall or cliff, thereby inundating landward areas protected by the barrier. While the vertical height of wave runup can be very high (up to 7 m), this does not pose a risk to the proposed development as no beachfront development is proposed, and the elevation of development landward of the headland is some 20 to 40 m AHD, and development is set back from the cliff line approximately 30 m.

As mean sea level rises, this creek line will potentially experience a greater increase in the frequency and duration of inundation, particularly where increased average sea levels are coupled with simultaneously occurring high tides, storm surge, and wave setup. These mechanisms could potentially result in temporary inundation of the creek line, and increased flooding risk further upstream.

Assuming a sea level rise of 0.99 m as adopted by DECC and LMCC, a vertical rise in water level along the creek line could be expected to be less than the 0.99 m sea level rise. As discussed in **Section 3.3.1** above, development would not occur within the minimum 20 m APZ extending north from the development footprint boundary. The elevation of land within the development footprint beyond the APZ is greater than 11 m AHD, therefore the potential for a vertical rise in water level along the creek line of up to 0.99 m to affect the development beyond the APZ boundary is considered remote.

Additionally, the bulk earth works to regrade the site proposed as part of the Civil and Community Works Package project application (refer **Appendix A**) propose earth works that will raise the low points along the southern boundary of the development footprint by an additional 2 m, further reducing the likelihood of inundation at these points. The Bulk Earthworks Plan (2122743A-CIV-0031 RevA) indicating cut and fill activities proposed as part of the bulk earthworks prepared by Parson Brinckerhoff for the Civil and Community Works Package project application is attached as **Appendix A**.

Furthermore, primary access to and from the site via Montefiore Street to the Pacific Highway is not likely to be affected by flooding and coastal inundation given that Montefiore Street is located along the east-west ridgeline described in **Section 3.1**.

3.4.3 Stormwater Management

Stormwater runoff from the site has the potential to contribute to water levels in the adjacent watercourses during a storm event and increase the risk of inundation of the development. A review of the Stormwater Management Strategy (SMS) prepared by Parsons Brinckerhoff (2007b) for the proposed development was undertaken in order to consider the impacts of stormwater runoff on water levels in the watercourse to the south of the development footprint. It is noted that the Stormwater Management Strategy only relates to the development footprint south and east of Montefiore Street (refer **Appendix B**).

The SMS specifies the incorporation of structures designed to attenuate developed stormwater flows to current, or below existing (predevelopment) flows. It is assumed that stormwater management on the northern side of Montefiore Street (not covered by the SMS) would be designed in accordance with these principles. Structures utilised across the site would consist of:

- Local swale drainage network;
- Storage reservoirs;
- Rainwater tanks on selected lots within Precinct 1; and
- An existing pond located within the southern natural watercourse.

Runoff originating from roads within the development footprint, vegetated areas and surface hardstand areas of lots will be drained via swales within the road alignments (refer **Appendix B**). Swales will be used to convey peak flows from the system whereby water will infiltrate back into the natural water table, where it will be used by plantings within the swales (Parsons Brinckerhoff, 2007b).

A separate drainage network, also located in the road reserve, will be used to convey up to 1 year average recurrence interval (ARI) flows originating from the roof areas of lots to a series of reservoirs strategically located within the site (refer **Appendix B**). The harvested rainwater will then be reticulated throughout the lots using separate pump systems to pressurise mains for reuse (Parsons Brinckerhoff, 2007b).

Gross pollutant traps will be placed at the inlet of each reservoir to improve the treatment capacity of the reservoirs. The local swale drainage network in each precinct catchment will be required to capture and convey flows up to and including the 5 year ARI storm event, with enough capacity within the road reserve to convey the 100 year ARI storm event (Parsons Brinckerhoff, 2007b).

An existing pond of approximately 1,500m^3 capacity (located to the south of the site) has been modelled as a temporary storage for end of pipe peak flow mitigation for Precincts 4 and 5. Rock lined swales will be provided for road drainage through precinct 1B to attenuate flows from the catchment (Parsons Brinckerhoff, 2007b).

The structures proposed for on site stormwater management in the SMS will act to attenuate stormwater flows from the site to predevelopment levels, and are not likely to contribute significantly to the water level in the watercourse to the south of the development flowing to Moonee Beach.

4.0 Conclusions

An assessment of potential impacts associated with sea level rise and coastal inundation has been undertaken for the proposed development. The assessment has used a predicted sea level rise of 0.99 m, based on IPCC predictions from the 2007 Fourth Assessment Report, and recommended by the NSW Department of Planning as appropriate for the planning of developments with a design life of 100 years, which is considered appropriate for this project. In addition, the DECC and LMCC adopt the same level of 0.99m increase in sea level as the basis for planning of flood inundation risks in flood liable areas.

A review of digital elevation data and generation of a DEM indicates that at the lowest point in the development footprint within the South East Quadrant (DEM South East Quadrant, **Figure 2**), the elevation of the development footprint beyond a 20 m wide APZ is higher than the inundation level comprising the potential sea level rise induced increase in water level rise in the watercourses. In addition, the potential for stormwater runoff from the development footprint to contribute to a change in water levels in the watercourses was considered. Flows and attenuating structures are to be designed to maintain stormwater flows at predevelopment levels, and changes in rainfall intensity are not considered likely to contribute to water level and potential inundation risks within the development footprint.

Based on the assessment undertaken, it is unlikely that sea level rise and associated coastal inundation would have a substantial or adverse affect on the footprint of the proposed development, or access arrangements to and from the site.

This assessment has been based on sea level rise predictions by the IPCC 2007 Fourth Assessment Report and adopted by DoP, as well as DECC and LMCC polices and guidelines current at 2009, however it is recognised that sea level rise predictions may be adjusted over time.

It is recommended that State and Commonwealth Government guidelines and policies adopted in respect of climate change and sea level rise are regularly reviewed as part of an Operational Environmental Management Plan (or similar) for the site. If sea level rise predictions substantially exceed the 0.99 m considered in this assessment, further assessment should be undertaken to quantify potential risks associated with the development.

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Figures

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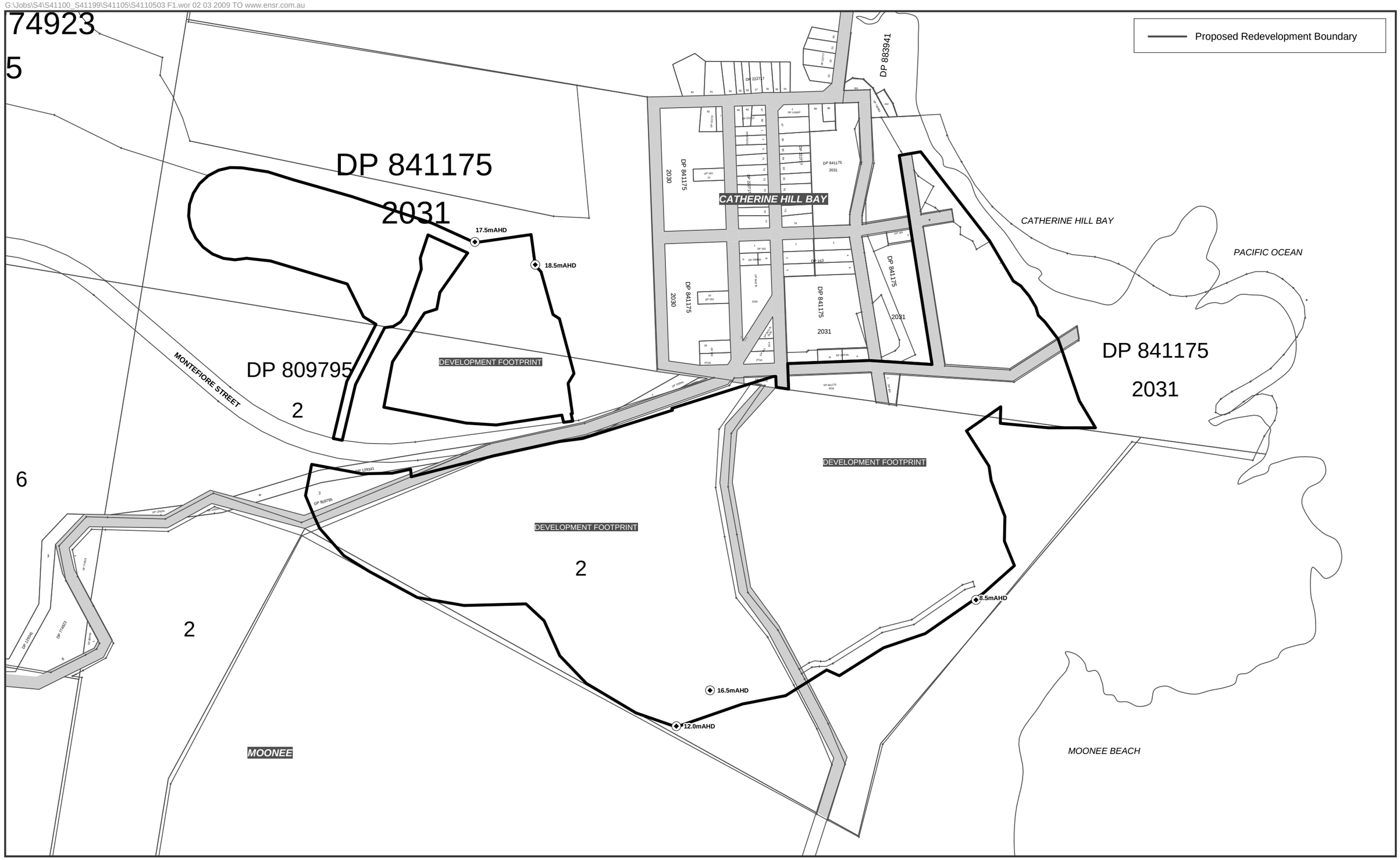

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Figure 1 **Proposed Subdivision Extents**

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Sea Level Rise and Coastal Inundation Assessment

Catherine Hill Bay Redevelopment

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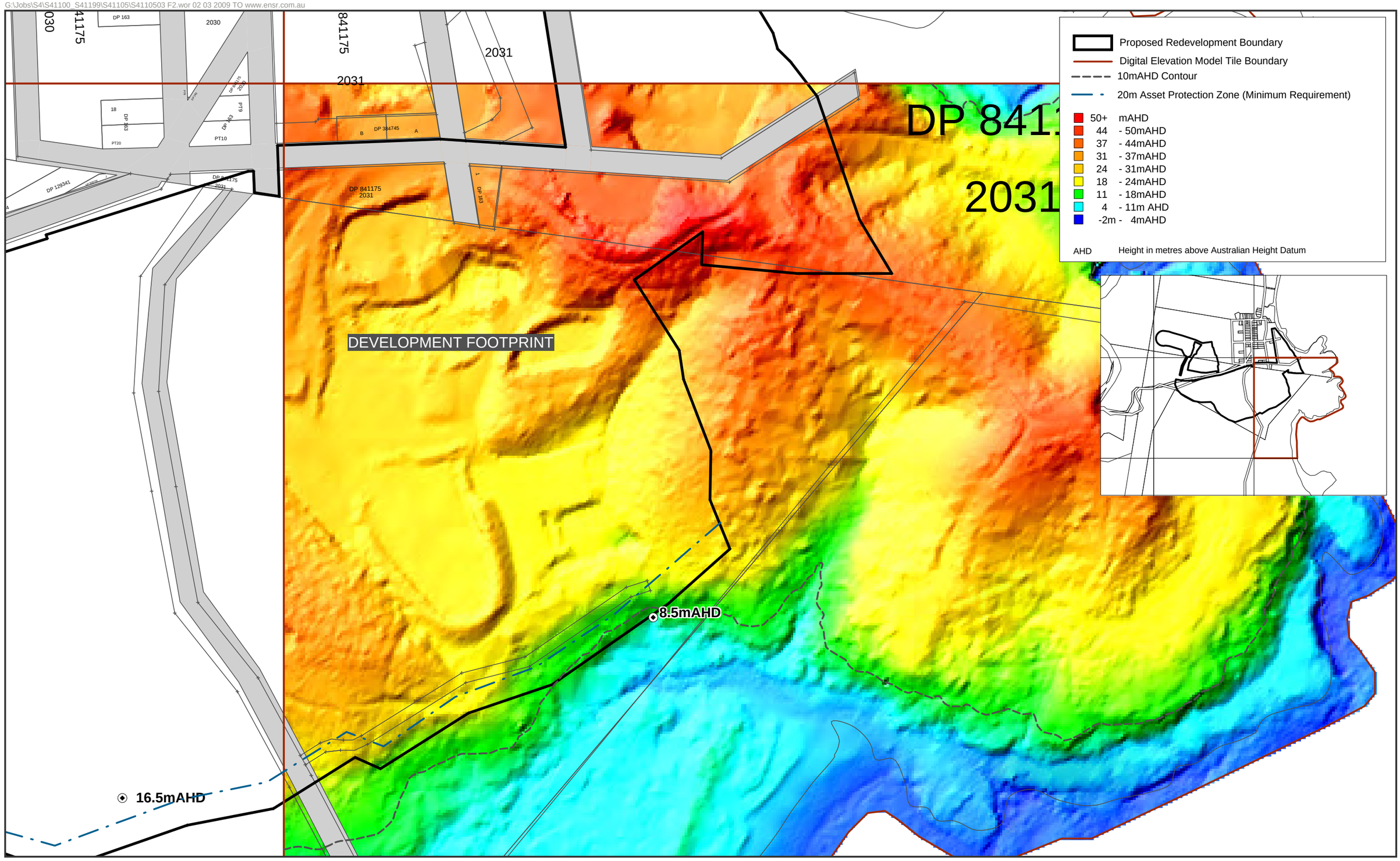

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Figure 2 **Digital Elevation Model - South East Quadrant**

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Catherine Hill Bay Redevelopment

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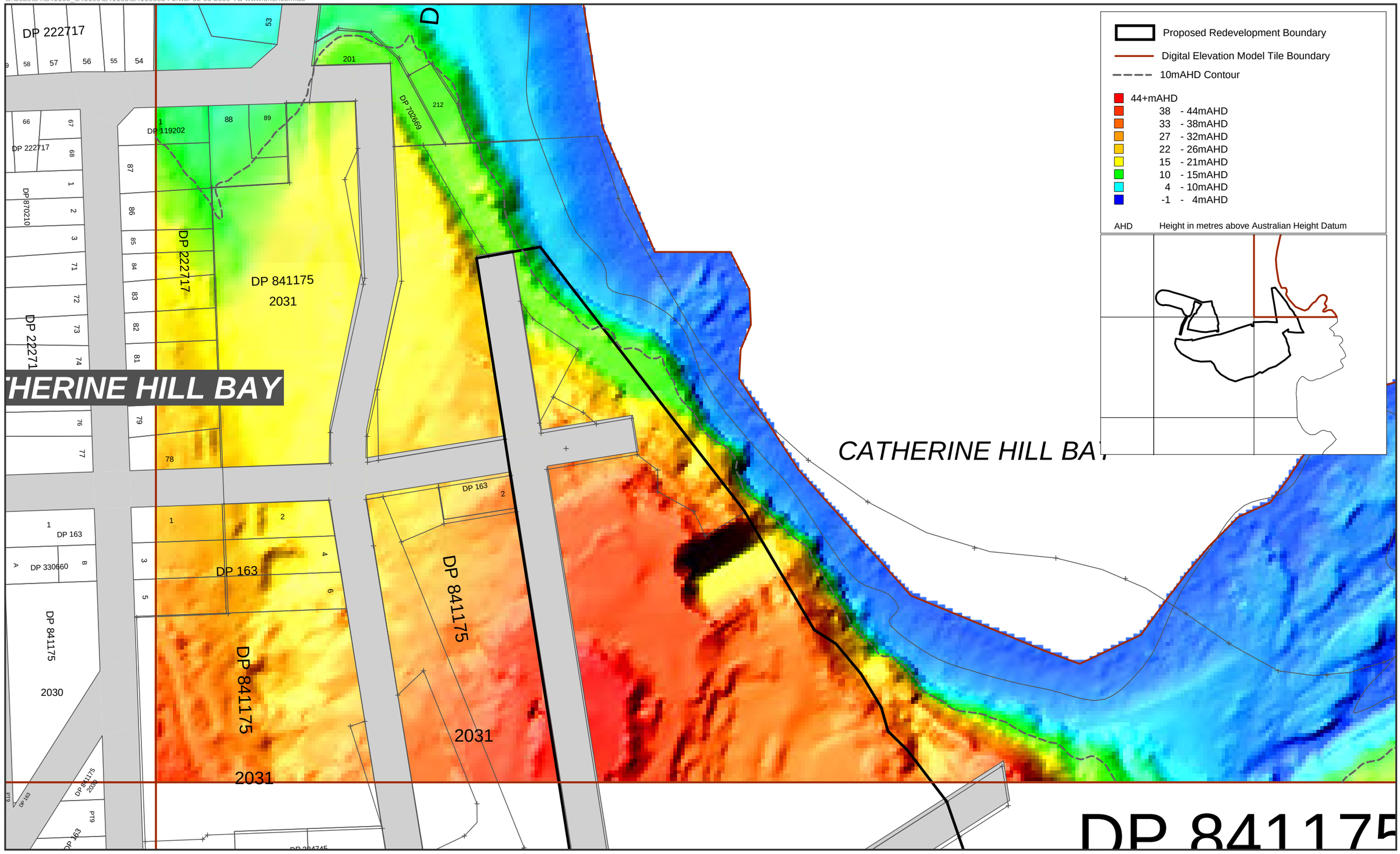

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Figure 3 **Digital Elevation Model - North East Quadrant**

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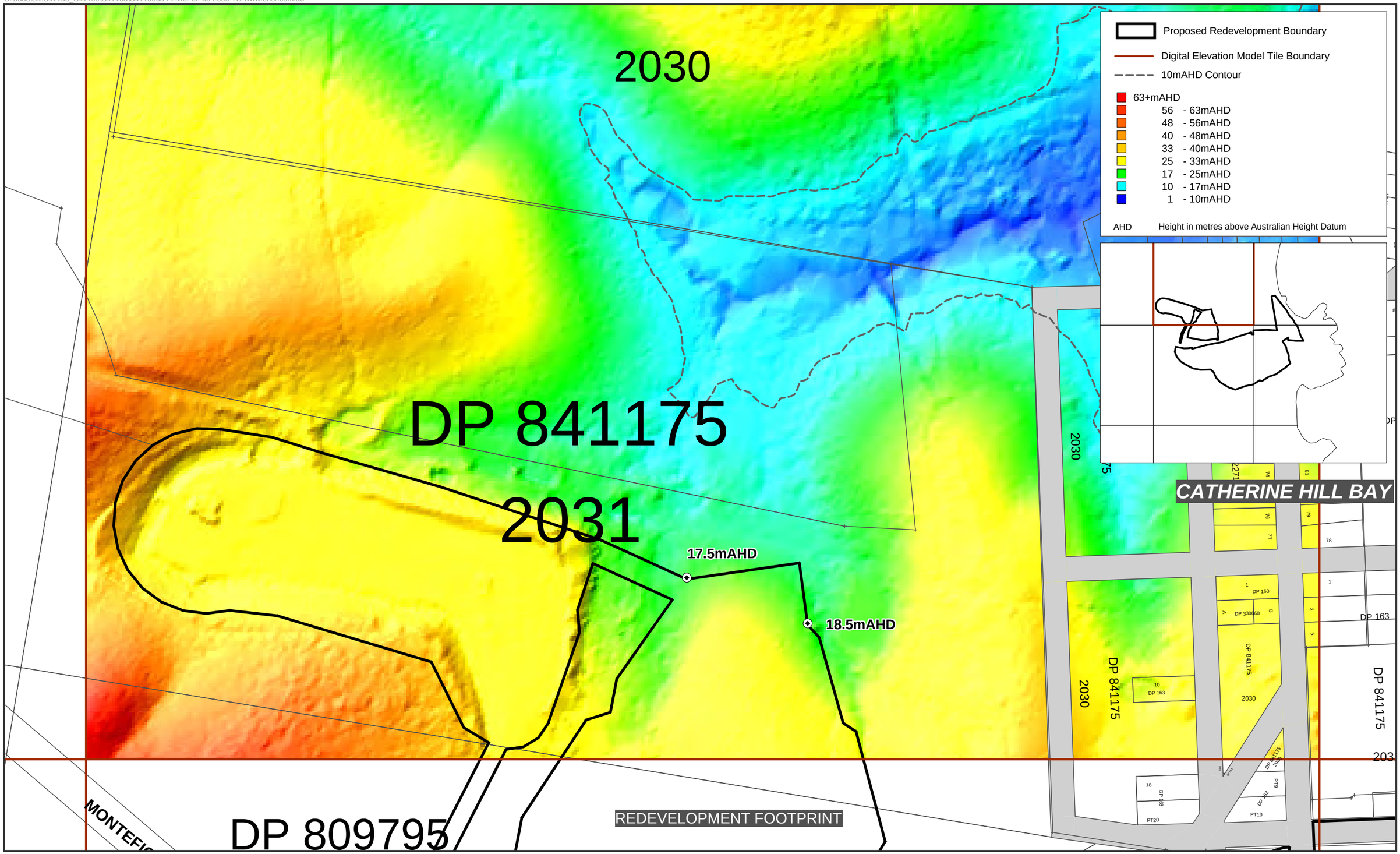

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Figure 4 **Digital Elevation Model - North West Quadrant**

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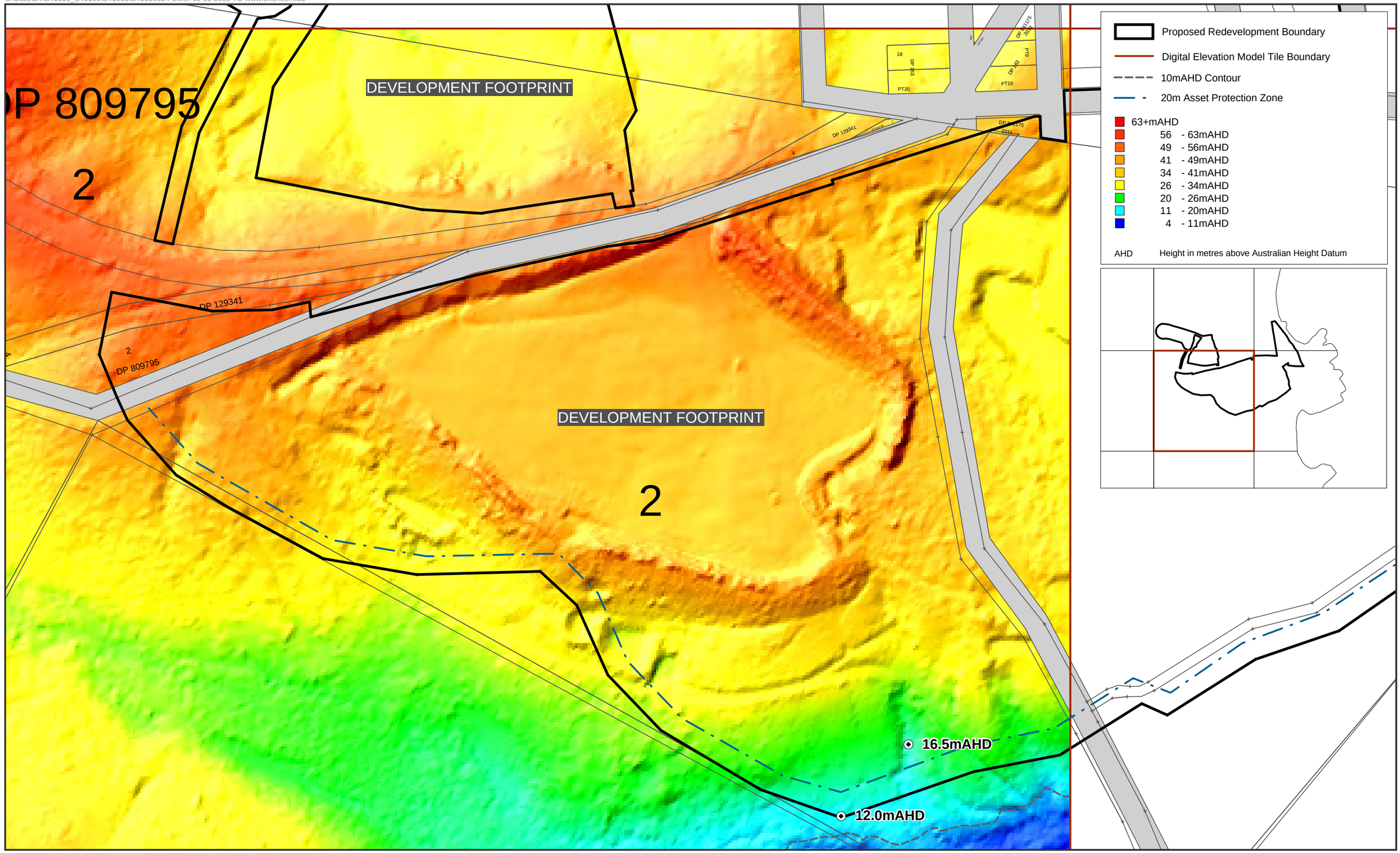

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0 50 100m

Figure 5 **Digital Elevation Model - South West Quadrant**

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Sea Level Rise and Coastal Inundation Assessment

Catherine Hill Bay Redevelopment

Appendix A

Bulk Earthworks Plan (Parsons Brinckerhoff, 2007a)

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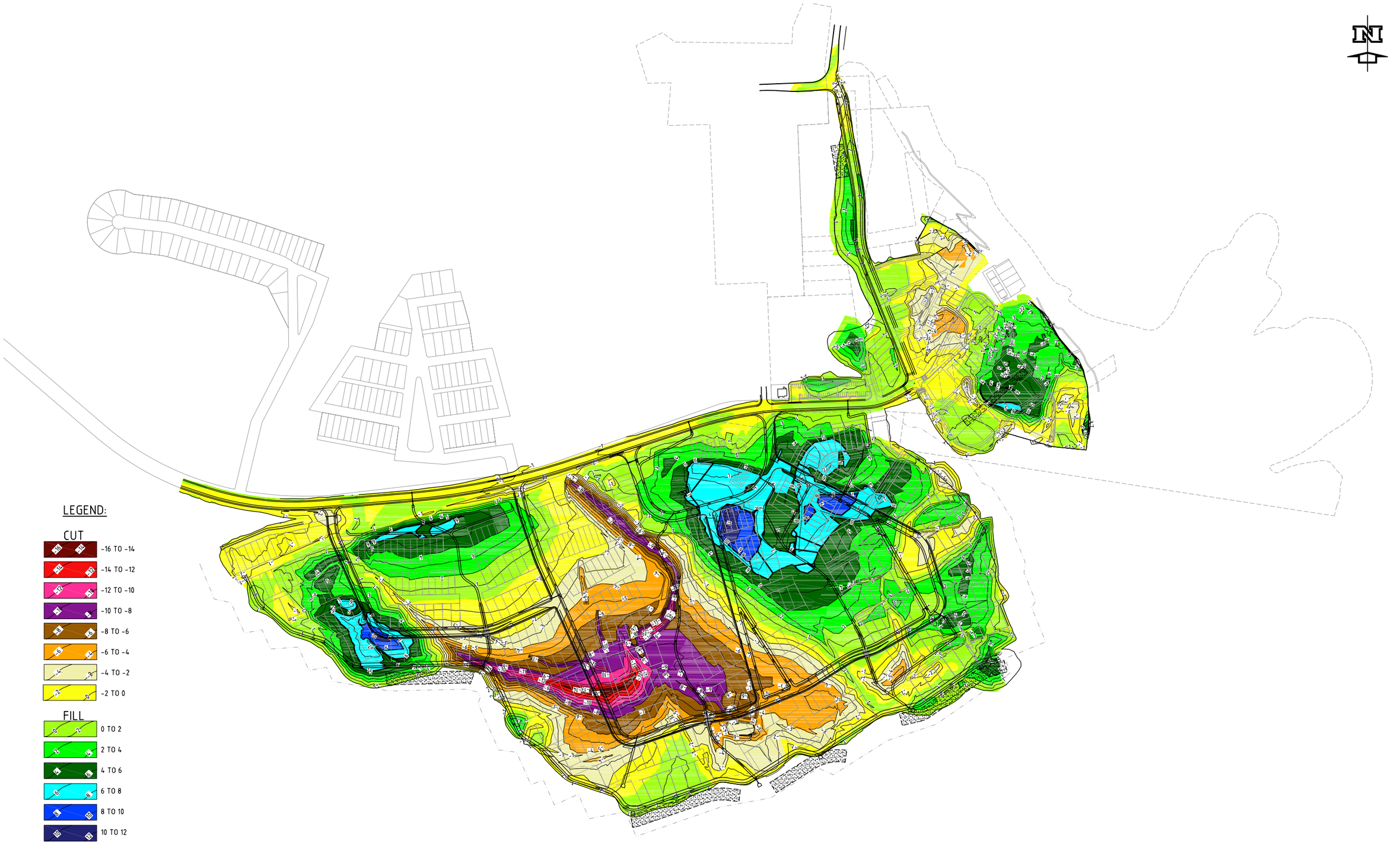

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0 50 100 A1 / A3
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2122743A	CIV	0031	A

100mm AT FULL SIZE

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Appendix B

Stormwater Management Strategy (Parsons Brinckerhoff, 2007b)

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Client: ROSECORP
Project: Stormwater Strategy - Catherine Hill Bay
Location: Catherine Hill Bay
NEW SOUTH WALES

20 0 20 40 60 80 100 Metres

Scale 1 : 2000

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LEGEND

- ROOF WATER PIPE
- ROOF WATER RESERVOIR
- RECYCLED WATER MAIN
- SWALE DRAIN
- (5) CATCHMENT (PRECINCT)

STORMWATER MANAGEMENT PLAN

Figure 3

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Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
Ireland	+353 1631 9356
Italy	+39-02-3180 77 1
Japan	+813-3541 5926
Malaysia	+603-7725-0380
Netherlands	+31 10 2120 744
Philippines	+632 910 6226
Scotland	+44 (0) 1224-624624
Singapore	+65 6295 5752
Thailand	+662 642 6161
Turkey	+90-312-428-3667
United States	+1 978-589-3200
Venezuela	+58-212-762-63 39

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