Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

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1 EXECUTIVE SUMMARY

The Minister for Planning's Approval Condition 274 for the Cross City Tunnel (CCT) states that any development in the vicinity of the CCT stack requires an air quality assessment of potential impacts from the stack plume. The Redevelopment of 31 Wheat Road, Sydney is within 50 metres of the CCT stack and therefore triggers the requirement to undertake an air quality assessment.

Pacific Environment have completed a screening level air quality assessment of the CCT ventilation stack.

The assessment concludes that at levels below 60m, there is low risk of the CCT stack plume resulting in concentrations of NO_2 above the air quality goal, at the location of the Redevelopment of 31 Wheat Road. It is understood that air intakes for the building are currently positioned at a low level (approximately 20m) and at this level, impacts from the stack are predicted to be minimal.

At levels above 60m, there appears to be an increased risk of the CCT stack plume resulting in concentrations of NO_2 above the air quality goal. However, it is noted that the screening level assessment uses a synthetic meteorological input file where all winds blow from the stack across the building and other meteorological parameters are varied to test a variety of conditions. While it is not possible, using this approach, to determine the frequency at which this risk of impact might occur, it is not expected that this would occur on a frequent basis (i.e. for many hours of the year).

Nevertheless, based on the screening level assessment, it is recommended that access via balconies, roof terraces and operable windows is restricted above 60m.

The proposed redevelopment is predicted to have minimal impact in terms of plume grounding with a low predicted risk of ground level concentrations reaching levels higher than the air quality goal.

2 BACKGROUND TO THE STUDY

An air quality assessment was undertaken during the Environmental Impact phase of the Cross City Tunnel project and subsequently to determine the potential impact of the ventilation stack on future buildings in the vicinity of the stack. Part of the Minister for Planning's Approval Condition 274 for the project was that for any future building, a protocol would need to be developed to allow an assessment of the impact of both the ventilation stack plume on any proposed building and the potential for the building to affect dispersion of the plume. The Protocol has now been prepared and sets out a methodology for identifying and assessing developments which may be impacted by or impact upon the plume from the CCT ventilation stack in Darling Harbour.

The Redevelopment of 31 Wheat Road, Sydney is within 50 metres of the CCT stack. The preliminary building design is shown in **Appendix A**.

3 APPLICATION OF PROTOCOL

Part 1 of the protocol provides an air quality assessment trigger. It identifies buildings which by virtue of their height and proximity to the CCT stack, have the potential to be adversely affected by the emissions from the stack and/or have the potential to affect the dispersion of the plume.

The proposed building has heights varying from approximately 20m above local ground level at the western end to 90m above local ground level at the eastern end. The building is located within 50m of the CCT stack and therefore triggers the requirement to undertake a quantitative air quality assessment (refer **Table 1**).

Table 1: Table for determining whether a specific air quality assessment is triggered

Distance of proposed building from stack (m)	Height of a proposed building in the potential adverse impact zone of the plume (m)
0 – 50	>25
50 – 100	>30
100 – 150	>40
150 – 200	>50
200 – 250	>60
250 – 300	>70
300 – 400	>90
400 – 500	>100
> 500	no restriction due to CCT stack plume

Part 2 of the Protocol describes the levels of assessment required. The Protocol requires that a Level 1 Assessment is completed in the first instance. A Level 1 Assessment involves air quality dispersion modelling and uses a number of conservative assumptions regarding emissions and meteorology to provide a simple means of assessing projects to determine if a more detailed assessment of potential air quality impacts is required.

If the building is found to be affected by the plume on the basis of the Level 1 Assessment, a more advanced Level 2 Assessment will be required. A Level 2 Assessment uses refined modelling techniques and site-specific input data. The Level 2 Assessment methodologies consist of techniques that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide more specialised emission estimates. As a result they provide a more refined and, at least theoretically, a more accurate estimate of potential impact.

A Level 1 (screening) dispersion modelling assessment was undertaken assuming the Approved Design of the ventilation stack and emission rates based on predicted rather than actual traffic volume through the CCT. Low, medium and high emission scenarios have been determined for the Level 1 modelling purposes. These relate to peak, off-peak and night-time traffic scenarios and corresponding varying tunnel ventilation rates. The emission scenarios are based on modelling undertaken for the CCT stack (Holmes Air Sciences, 2002) and include the assumption that 20% of the oxides of nitrogen (NO_X) are emitted as nitrogen dioxide (NO_2).

The Protocol focuses on NO_2 concentrations only. The assessment of risk is based on a prescribed air quality goal for NO_2 of 150 µg/m³, expressed as a 1-hour maximum. This assumes an existing background of 96 µg/m³ to achieve the NSW Environmental Protection Agency (EPA) impact assessment criteria of 246 µg/m³ for 1-hour average NO_2.

4 DISPERSION MODELLING

Dispersion modelling was completed using the CALPUFF model in screening mode, using a single meteorological input file in lieu of three dimensional gridded meteorological data. A screening meteorological input file was constructed based on a range of potential meteorological conditions that might be experienced at the site. Parameters such as wind speed, stability class and mixing height were varied each hour to account for a range of meteorological conditions, from worst case poor dispersion conditions to favourable dispersion conditions. Wind direction was set so that the plume would travel directly towards the proposed building.

Predictions were made for three CCT operating scenarios, as follows:

- Low Emissions (night time, low traffic, reduced fan speed);
- Medium Emissions (off peak traffic, medium fan speed);
- High Emissions (peak hour, maximum fan speed);

Stack parameters are based on the Approved Design of the ventilation stack and emission rates based on predicted rather than actual traffic volume through the CCT. This provides a worse-case scenario but is required as traffic volume could ultimately reach levels predicted for the Environmental Impact Assessment (EIA) and the subsequent studies.

The modelled parameters are given in **Table 2**. The stack temperature has been set at the ambient level to reflect neutral buoyancy of the plume (i.e. equivalent to the meteorological input file).

Table 2: Stack Parameters

Parameter	Value	
Stack Height (m)	60	
Stack Diameter (m)	5.97	
Stack Temperature (K)	293	
	NO_2 Emission Rate (g/s)	Exit Velocity (m/s)
Low emissions (night time)	0.4	5
Medium emissions (off peak)	1.0	11
High emissions (peak hour)	1.8	21

Model predictions were made at elevated receptors at heights from ground level to 77 m above ground level (the approximate maximum height of the proposed building).

4.1 Building Wake Effects

Wind flow is often disrupted in the immediate vicinity of buildings. Plumes emitted nearby are assumed to be unaffected by building wakes if they reach building height plus 1.5 times the lesser of building height or projected building width. If this is not the case, pollutants can be brought to ground within a highly turbulent, generally recirculating cavity region in the immediate lee of the building and/or be subject to plume downwash and enhanced dispersion in a turbulent region which extends further downwind behind the building (**EPAV, 1999**).

The simulation of building wake effects, modelled using the BPIP-PRIME model (used in the Level 1 assessment) is based on a relatively simple building geometry, as it is not possible to incorporate complex building shapes adequately within the CALPUFF model. The simplified building geometry shown in **Figure 1** was incorporated for Level 1 assessment purposes. The more complex actual building design is shown in **Appendix A**.

BPIP-PRIME uses heights and corner locations of buildings in the vicinity of the plume to simulate the effective height and width of the structures. The downwash algorithm calculates effective building dimensions relative to the plume, resolved down to ten degree intervals. CALPUFF then calculates the impact of these buildings on plume dispersion and consequently on ground level concentrations. Although a simplified building geometry is used, it should provide a reasonable indication of how the building may disrupt wind flow in the immediate vicinity.

Figure 1: Visualisation of the simplified building shape used in the model

5 RESULTS AND CONCLUSIONS

Table 3 shows the potential impact of the CCT stack plume on the proposed building. Contour plots are shown in Appendix B. The following conclusions can be drawn from the results.

At levels below 60m, there appears to be low risk of the CCT stack plume resulting in concentrations of 1-hour NO_2 above the air quality goal, at the location of the proposed building.

At levels above 60m, there appears to be significant risk of impact from the plume on the building, under the low emission scenario. This is shown by the red contour line in Appendix B. The risk at 90m is lower for the high emissions scenarios, due to the improved dispersion achieved with higher operating fan speeds and associated increased exit velocities.

It is noted that the screening level assessment uses a synthetic meteorological input file where all winds blow from the stack across the building and other meteorological parameters are varied to test a variety of conditions. While it is not possible to determine the frequency at which this risk of impact might occur, it is not expected that this would occur on a frequent basis (i.e. for many hours of the year).

Table 3: Predicted Impact of Plume on Proposed Building

Scenario	Receptor Height (AHD)	Predicted 1-Hr NO_2 Concentration – Grid Max	Criteria
Low Emissions	0 m	34	150
	30 m	34	
	60 m	47	
	70 m	**380**	
	80 m	**626**	
	90 m	**803**	
Medium Emissions	0 m	38	
	30 m	38	
	60 m	56	
	70 m	**326**	
	80 m	**567**	
	90 m	**884**	
High Emissions	0 m	22	
	30 m	22	
	60 m	123	
	70 m	**188**	
	80 m	**519**	
	90 m	**783**	

Table 4 demonstrates the potential impact the building may have on the plume, in terms of building wake effects increasing ground level concentrations. The proposed building is predicted to have an impact in terms of plume grounding, with higher predicted ground level concentrations (glcs) predicted when building wake effects are included when compared to the 'no building' scenario. However, there appears to be a low risk of glcs reaching levels higher than the air quality goal.

Table 4: Predicted Impact of Proposed Building on Plume Dispersion

Scenario		Predicted Ground Level 1-Hr NO_2 Concentration (Grid Max)	Criteria
Low Emission	With Building	34	150
	Without Building	9	
Medium Emission	With Building	37	
	Without Building	8	
High Emissions	With Building	22	
	Without Building	8	

It is understood that air intakes for the building are currently positioned at a low level (approximately 20m). At this level, impacts from the stack are predicted to be minimal. It is recommended that access via balconies, roof terraces and operable windows are restricted above 60m.

The model used to assess these impacts is limited in its ability to discern differences in building configurations and in its ability to assess impacts in a complicated, near-field built environment. It is recommended therefore that during the building's detailed design stage, further assessment be undertaken using Computational Fluid Dynamics (CFD) modelling to determine the most appropriate positioning and elevation of HVAC air intakes.

6 REFERENCES

EPAV (1999) Ausplume Gaussian Plume Dispersion Model Technical User Manual. Publication No. 671, ISBN 0 7306 7560 2, Environmental Protection Authority of Victoria, Melbourne.

Holmes Air Sciences (2002) "Proposed alterations to the modified activity as outlined in the supplementary Environmental Impact Statement for the Cross City Tunnel" prepared by Holmes Air Sciences for the RTA NSW, October 2002.

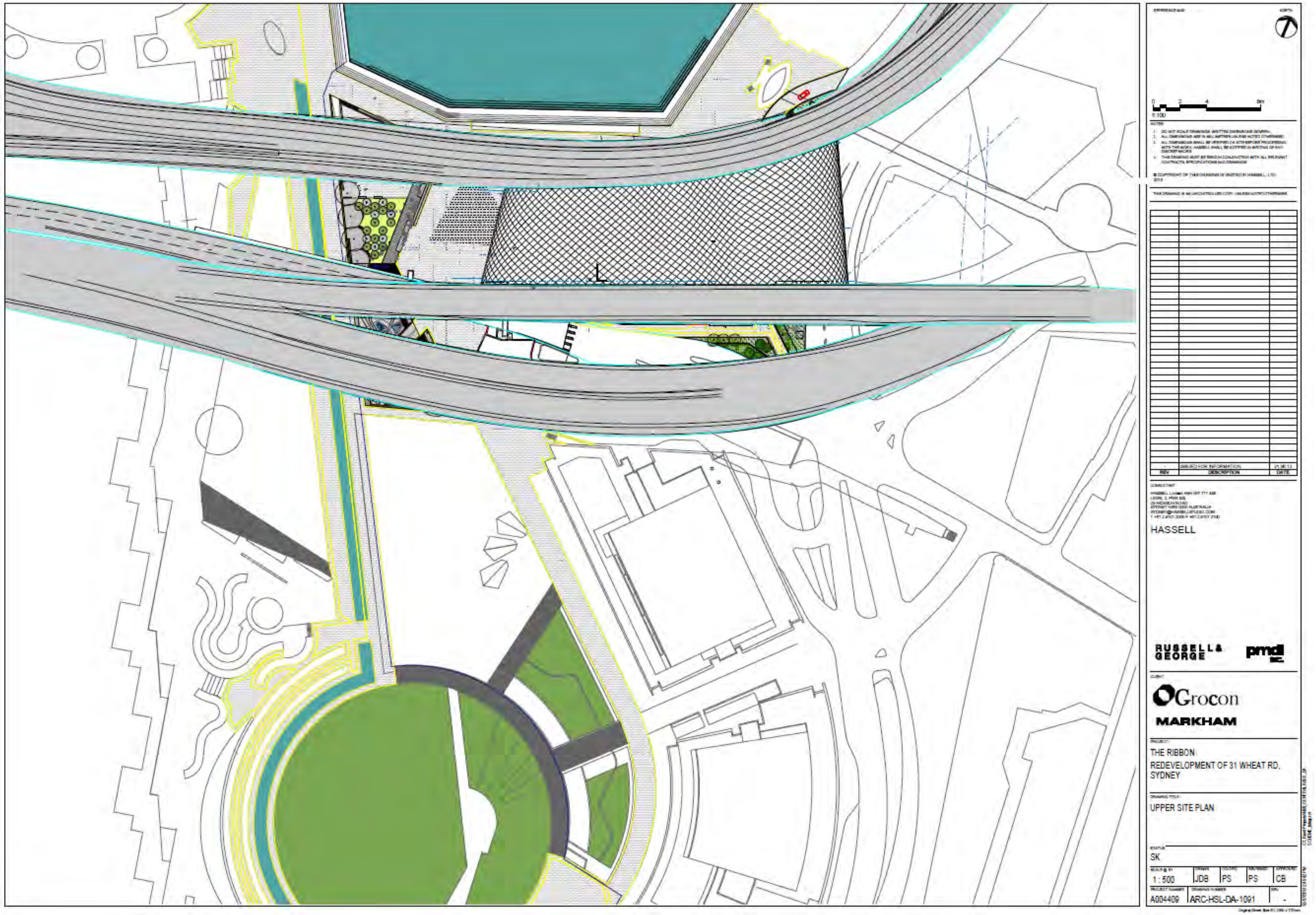
Holmes Air Sciences (2004) "Draft: Cross City Tunnel Buffer Analysis" prepared by Holmes Air Sciences for the RTA NSW, March 2004.

Regards,

RONAN KELLAGHAN – Principal Consultant – Air Quality

Pacific Environment

APPENDIX A. BUILDING DRAWINGS


HASSELL
RUSSELL & GEORGE
pmdl
Grocon
MARKHAM
THE RIBBON
REDEVELOPMENT OF 31 WHEAT RD, SYDNEY
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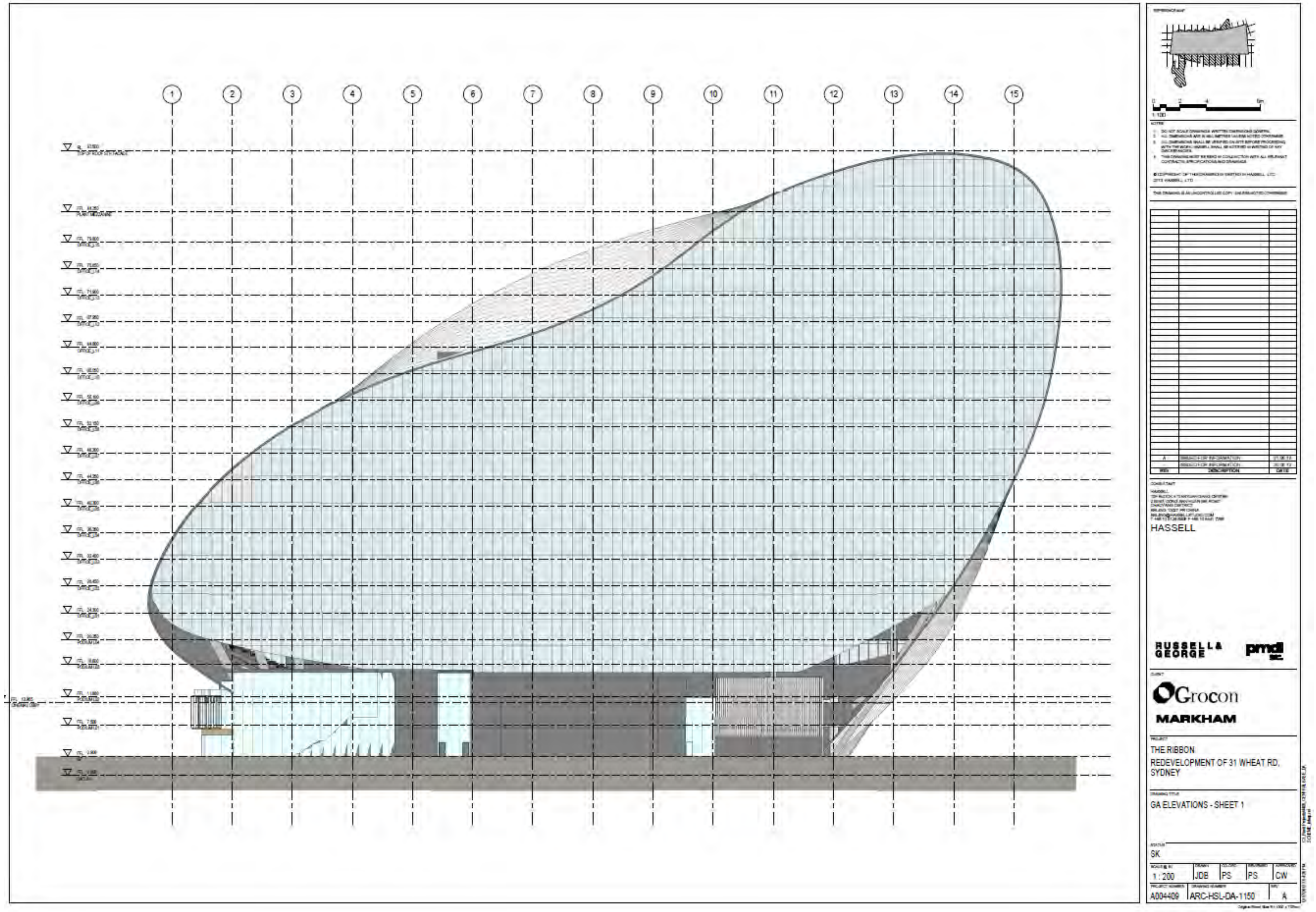
ARC-HSL-DA-1091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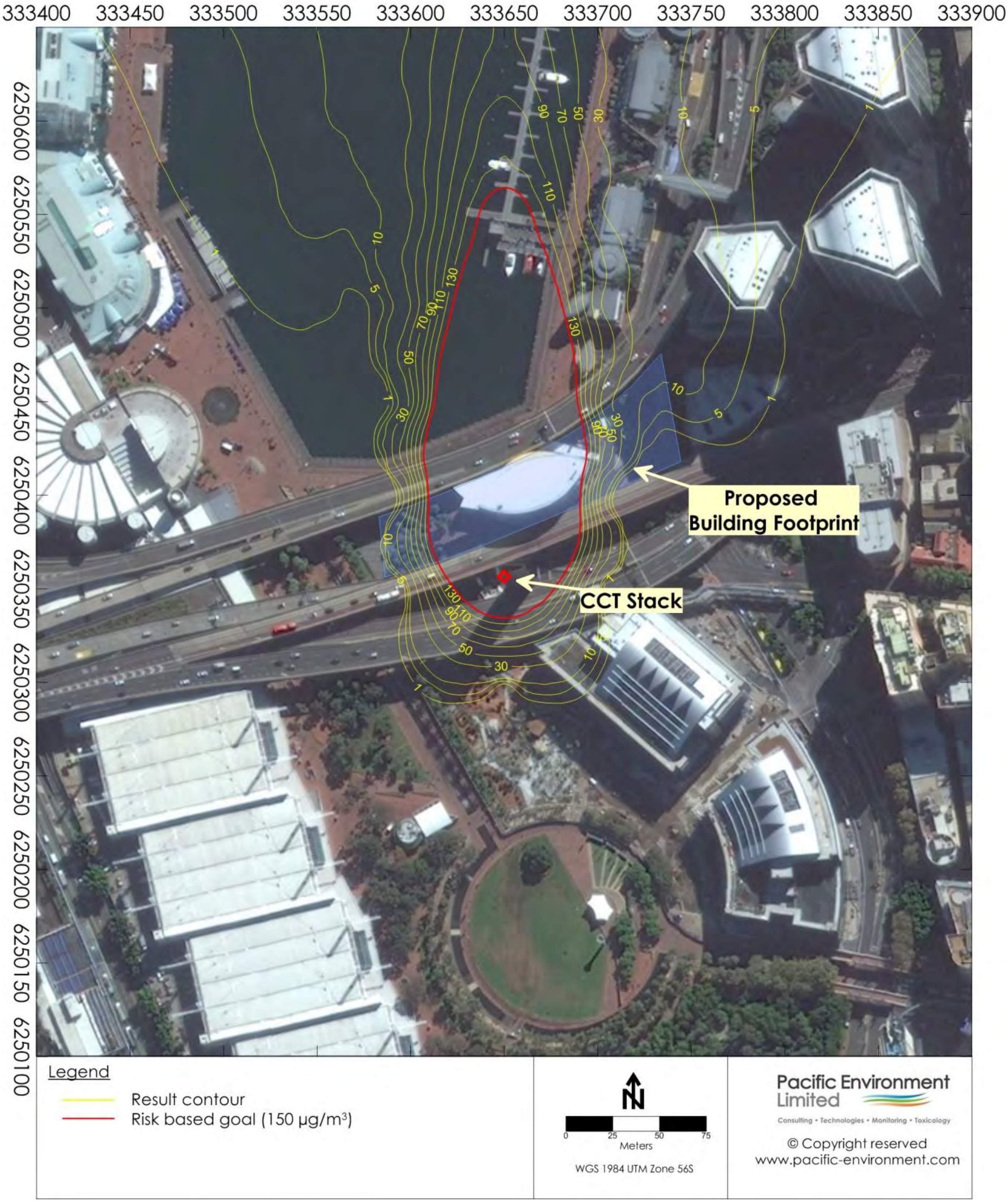
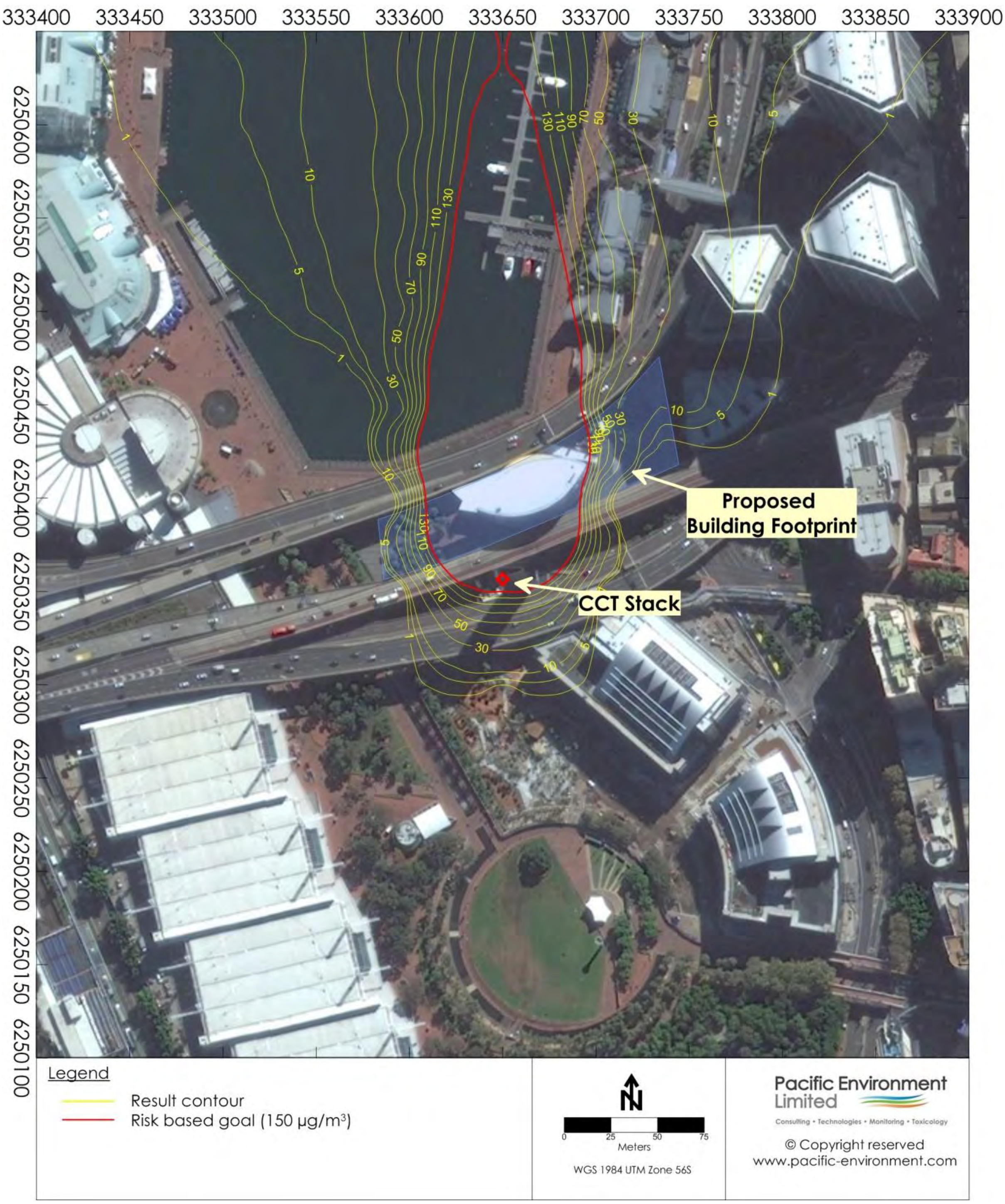
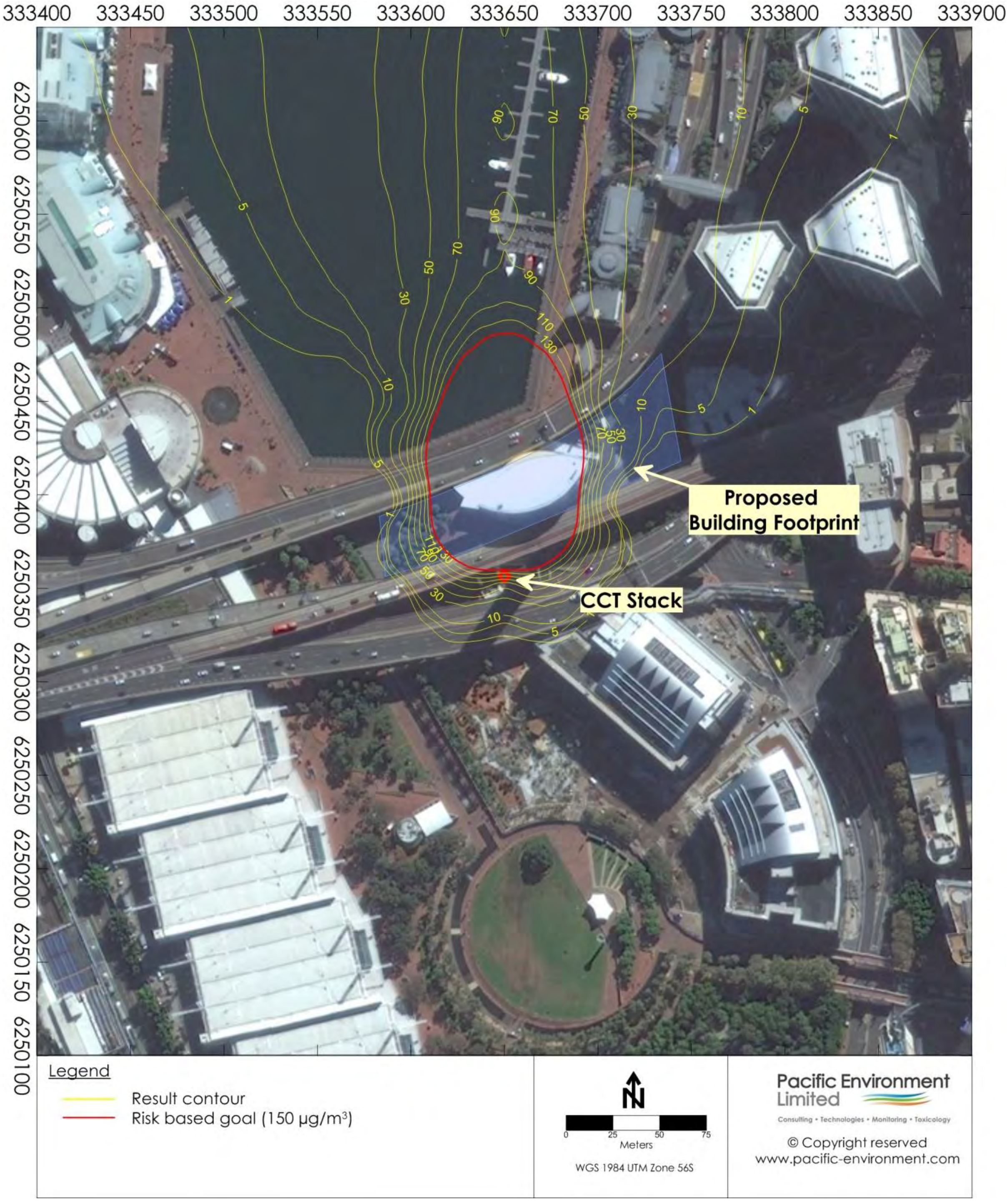
APPENDIX B. MODELLING RESULTS



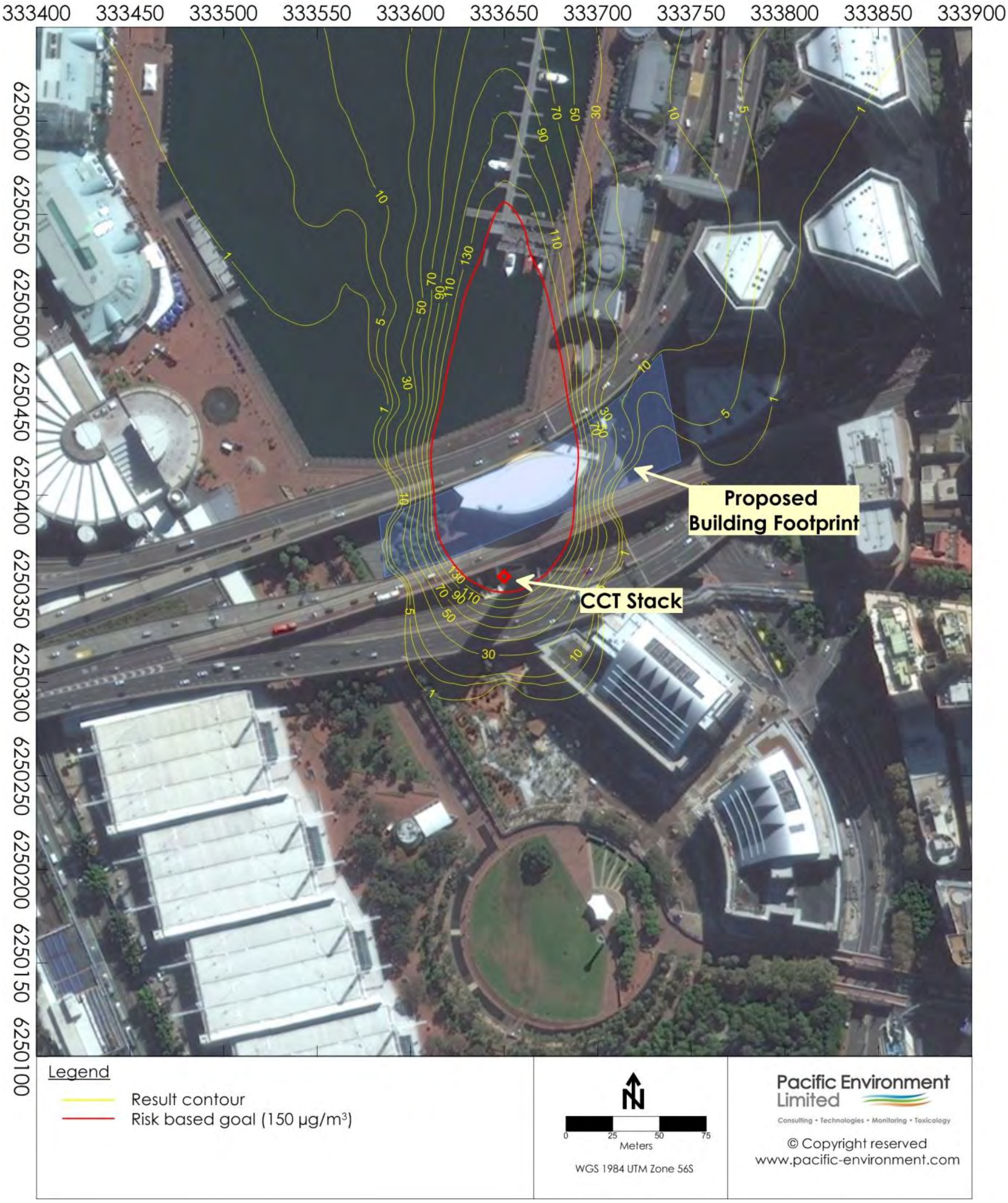
90 m - Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³ - Red Line)



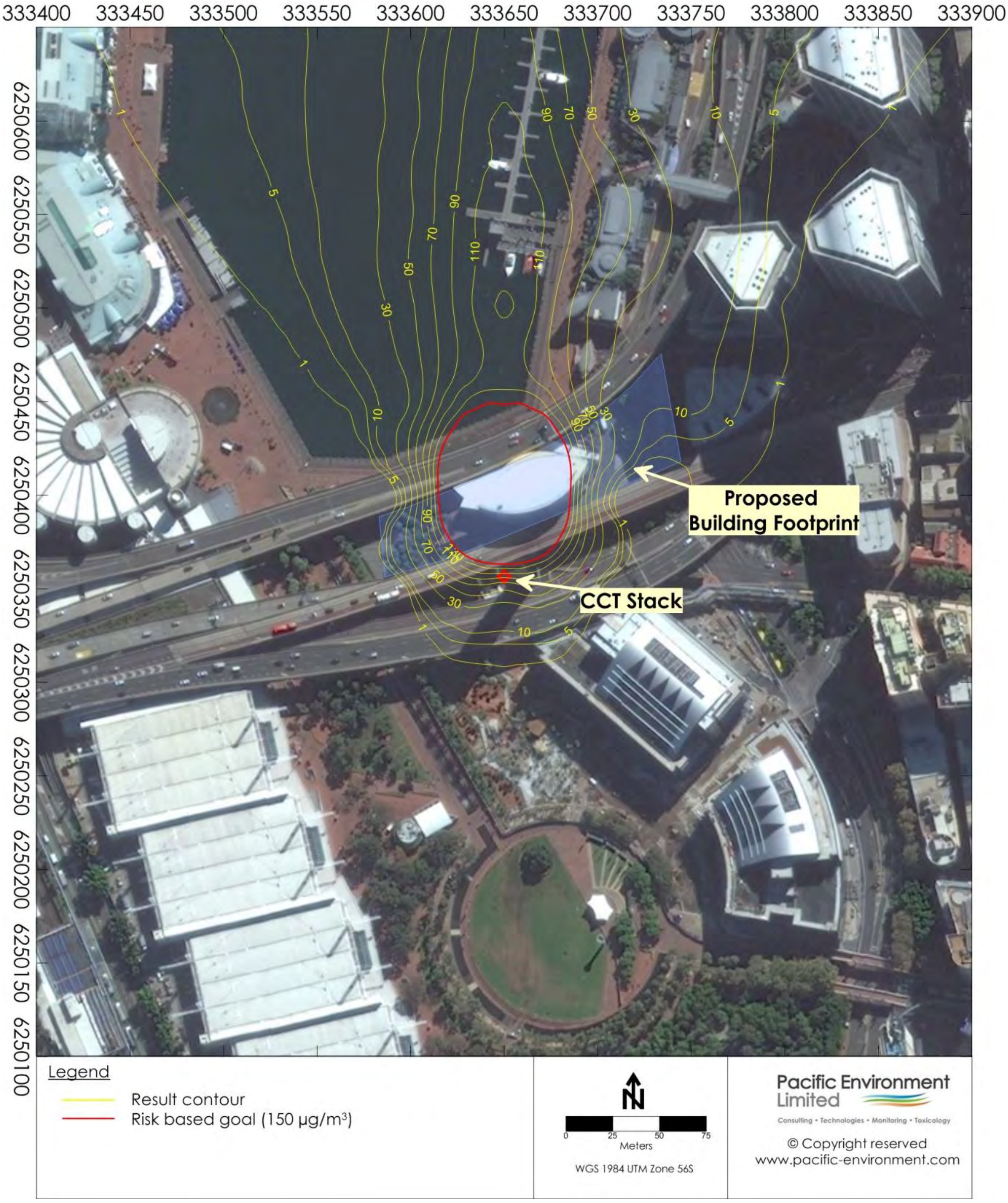
90 m - Medium Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



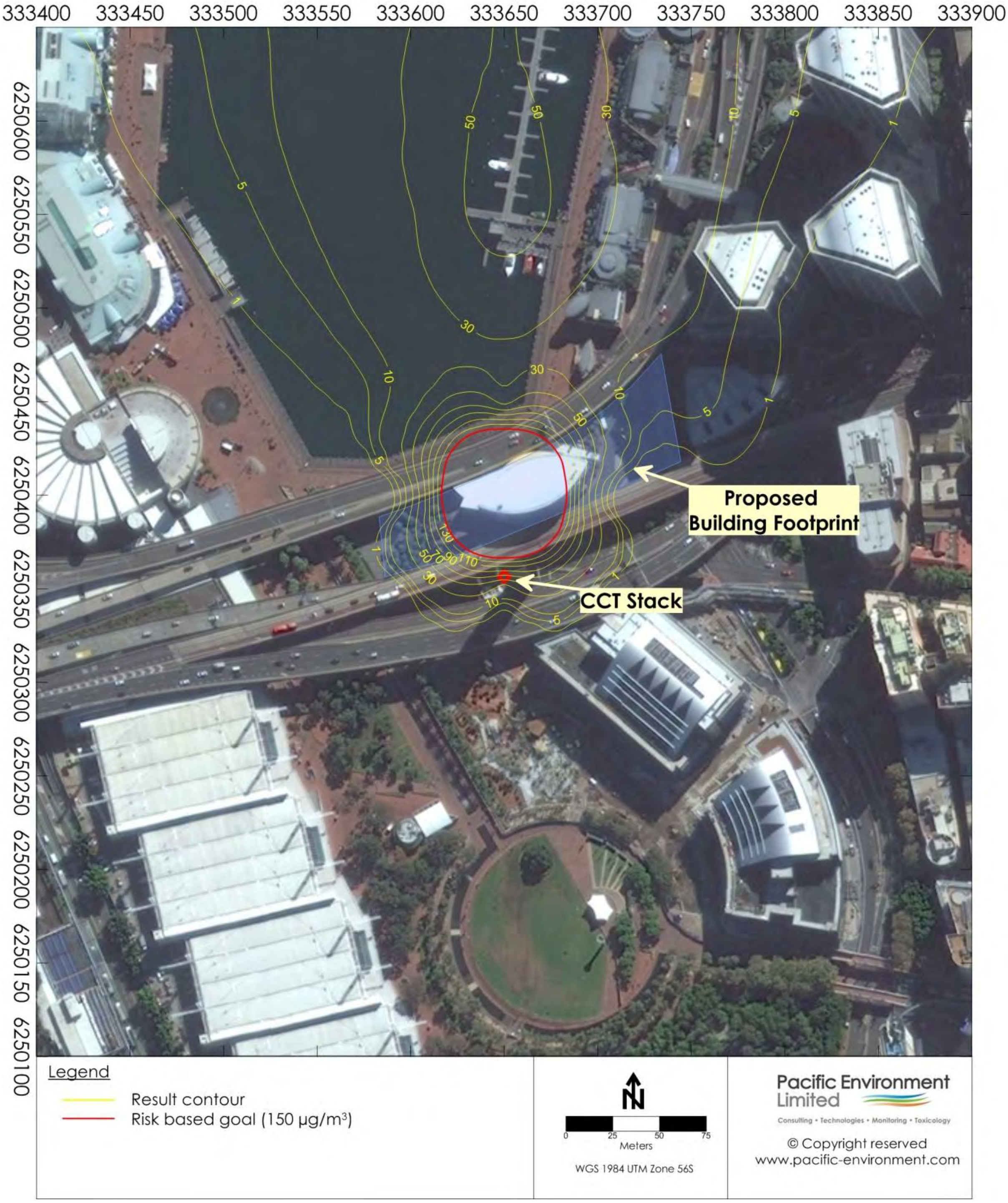
90 m – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



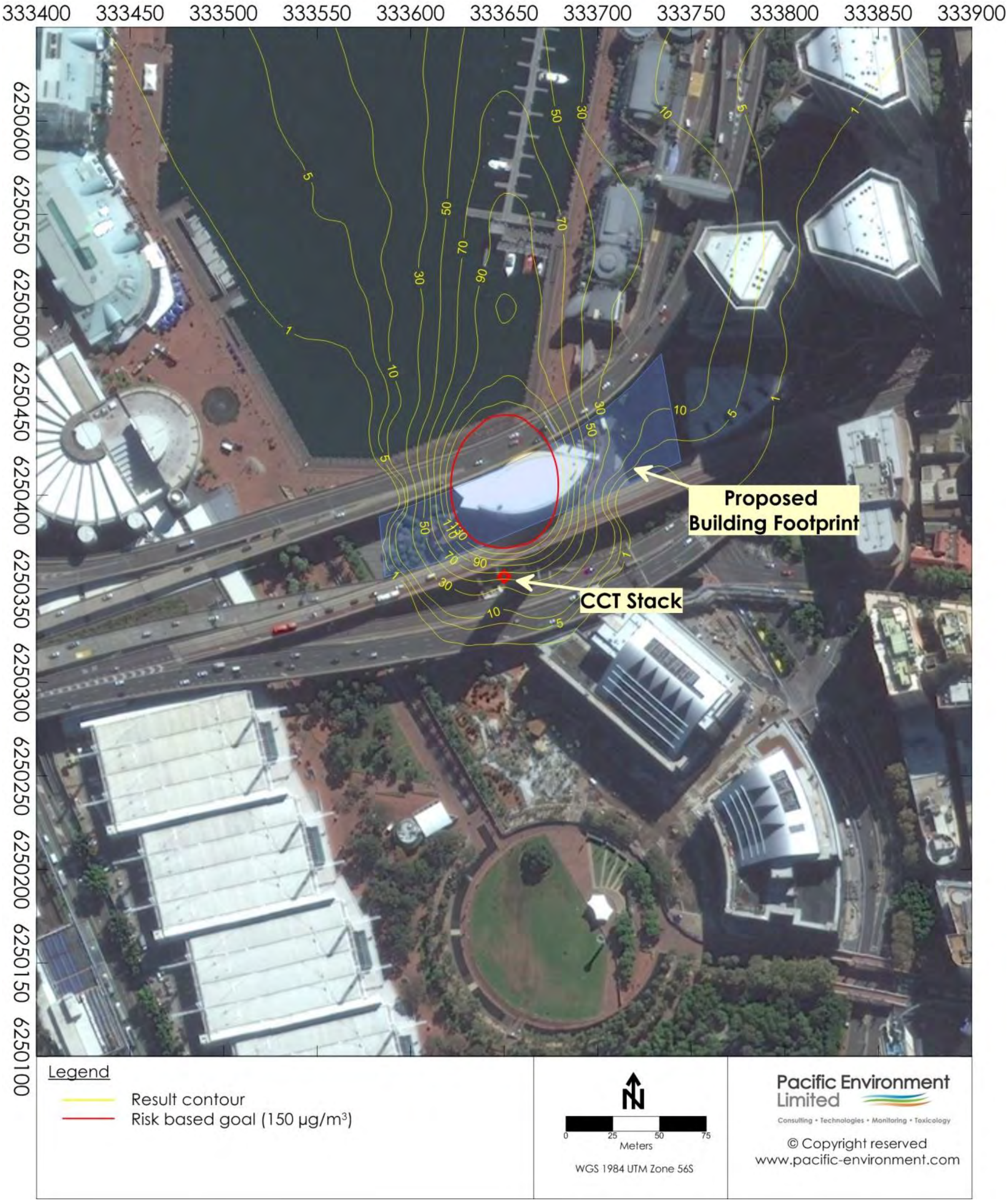
80 m - Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³ - Red Line)



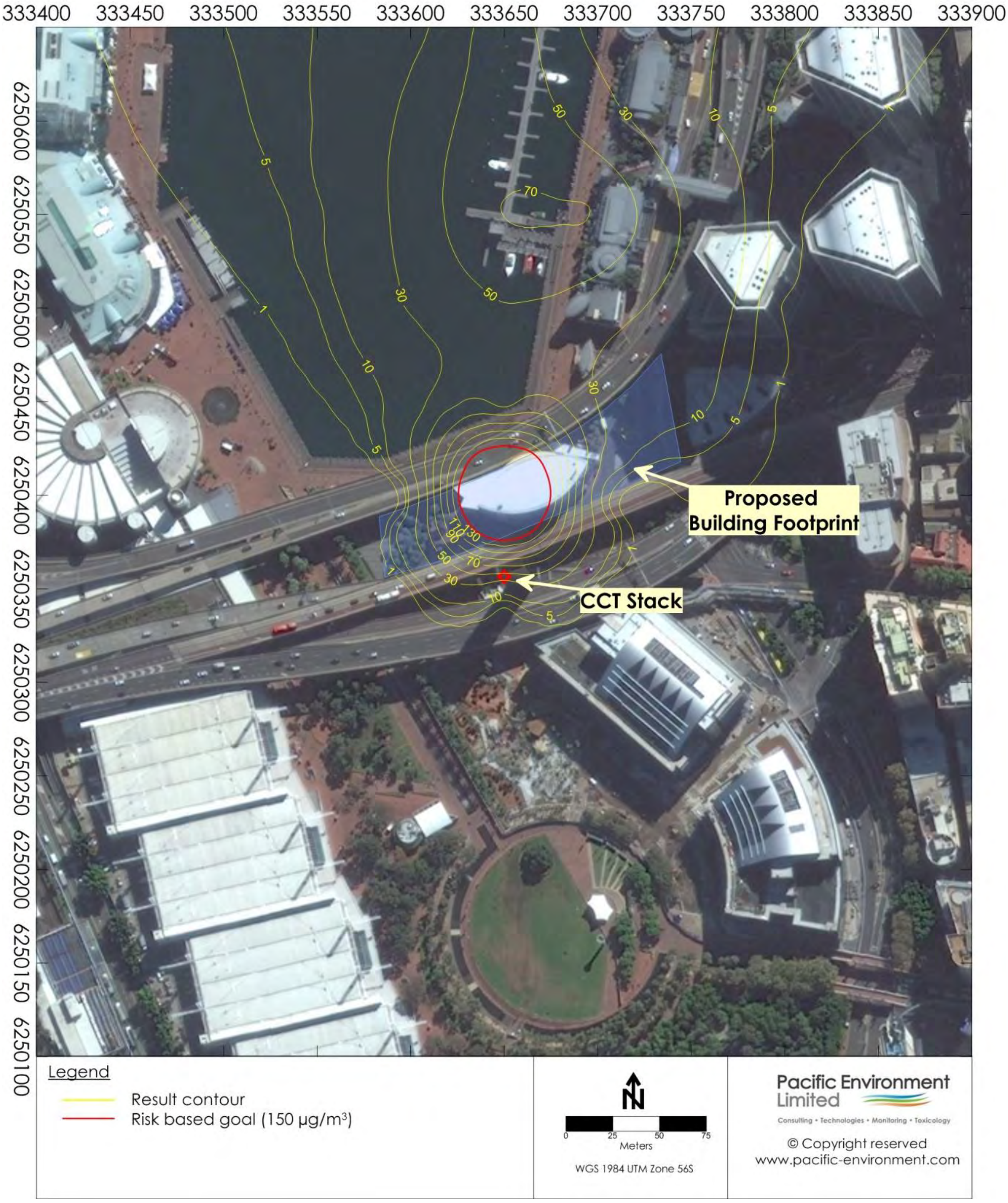
80 m - Medium Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



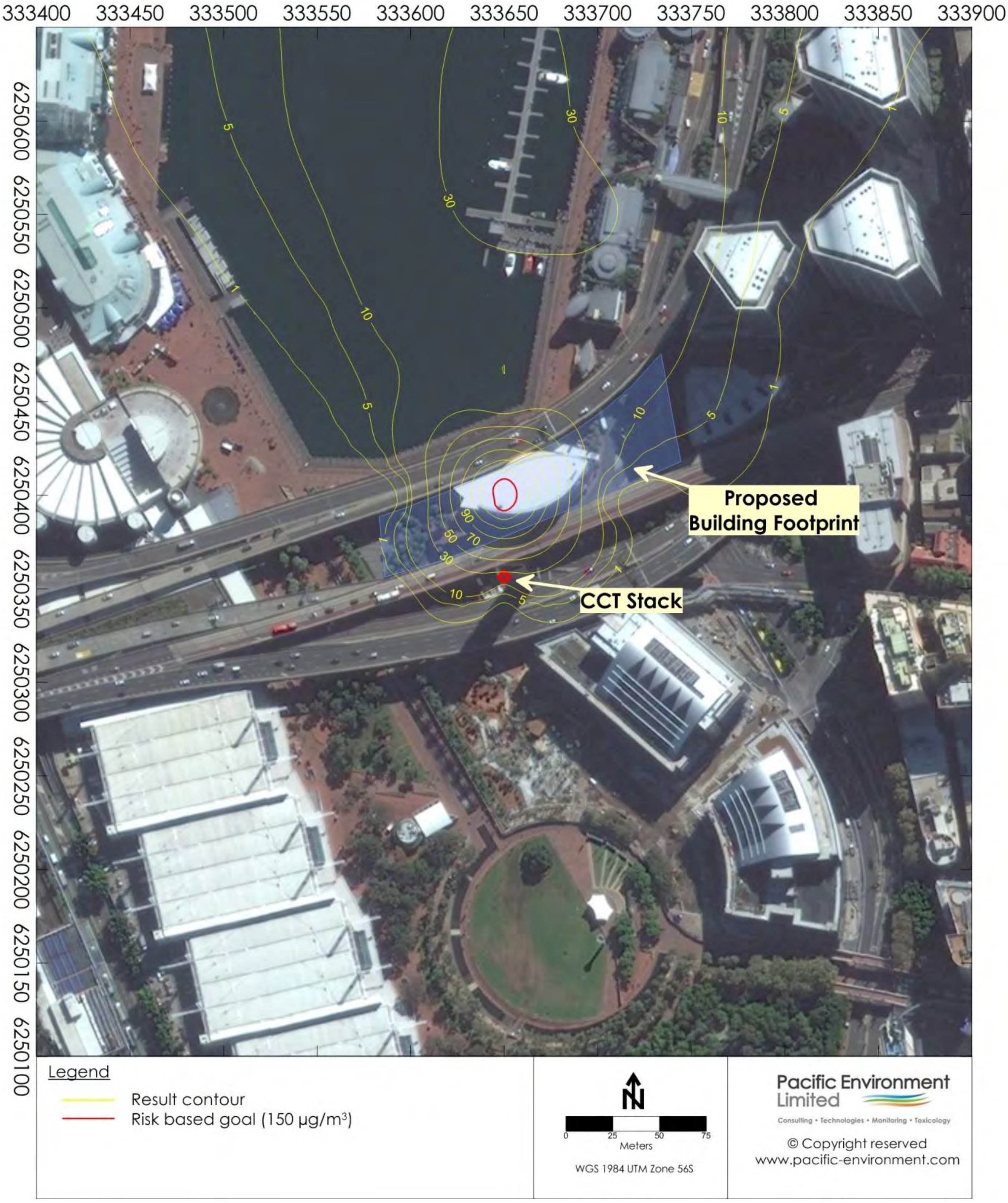
80 m – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 μg/m³)



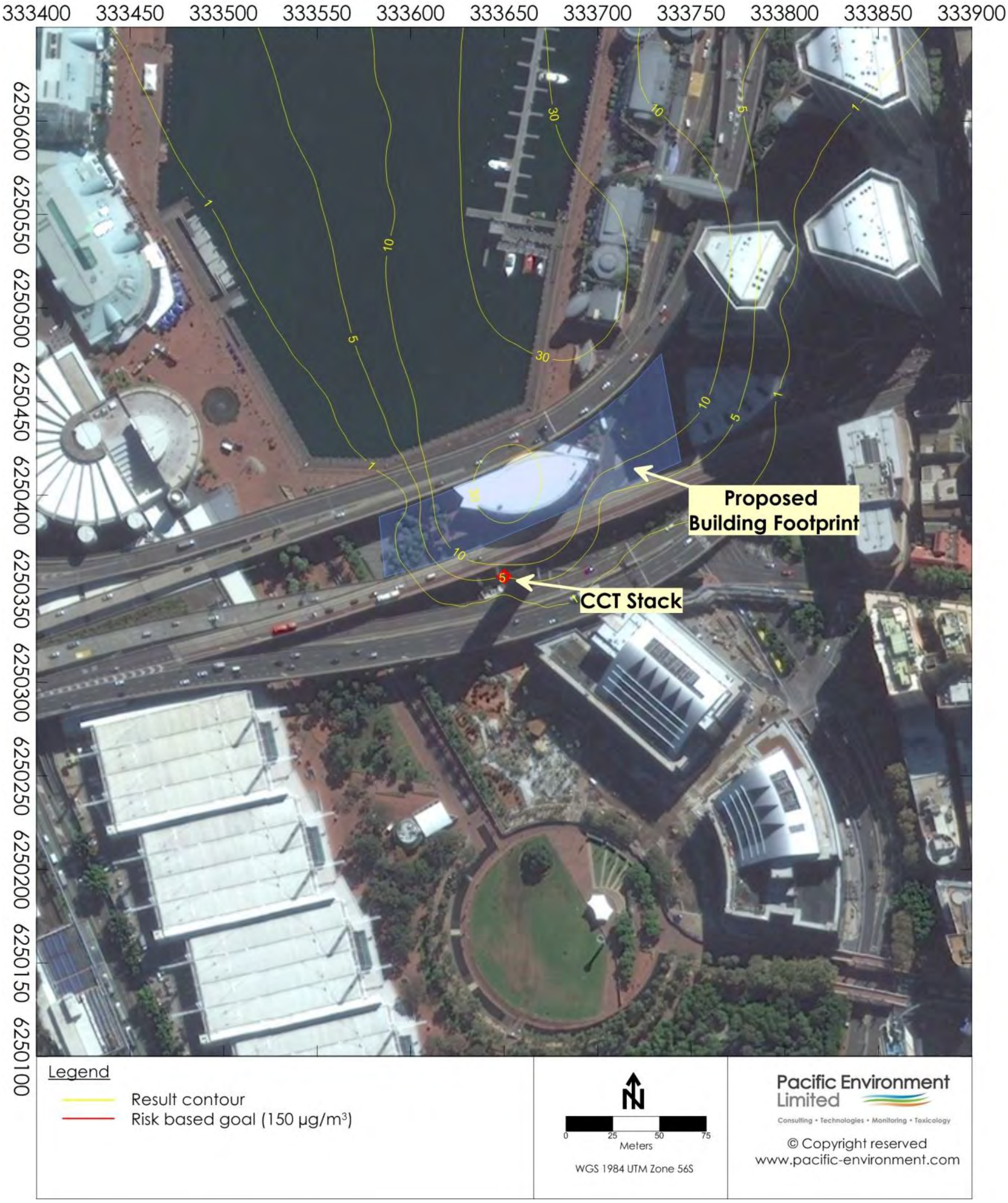
70 m - Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³ - Red Line)



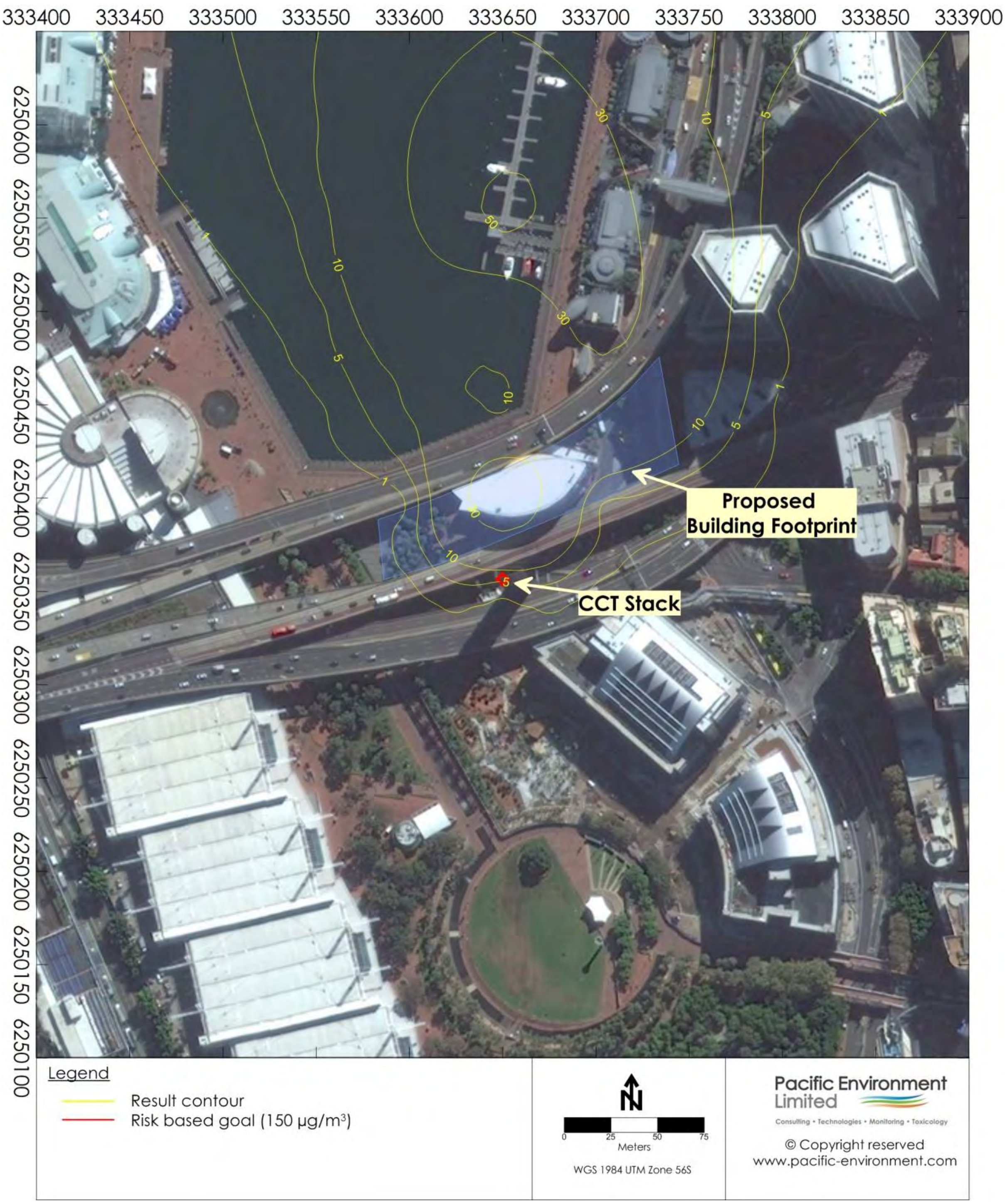
70 m - Medium Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



70 m – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



60 m – Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



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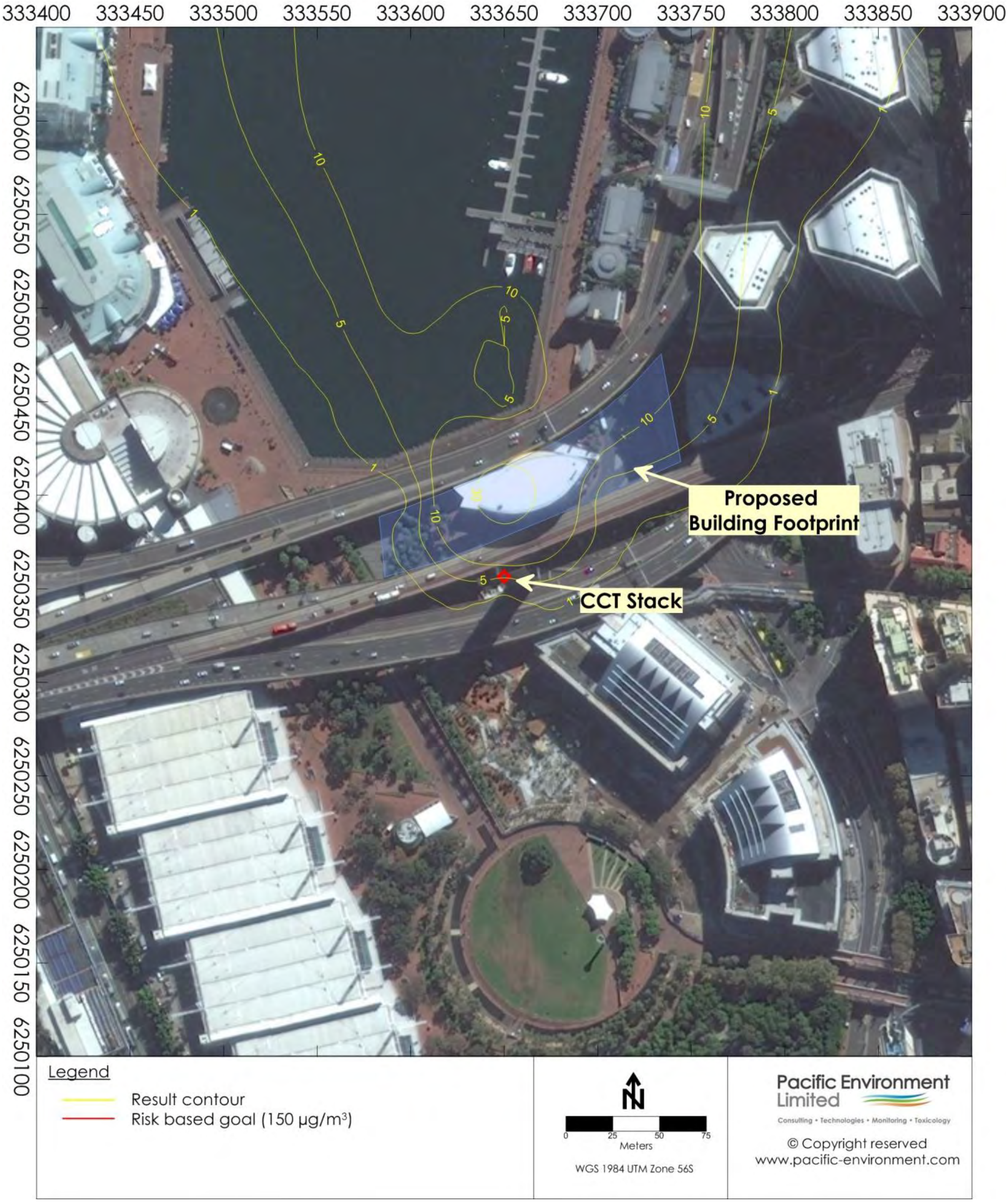
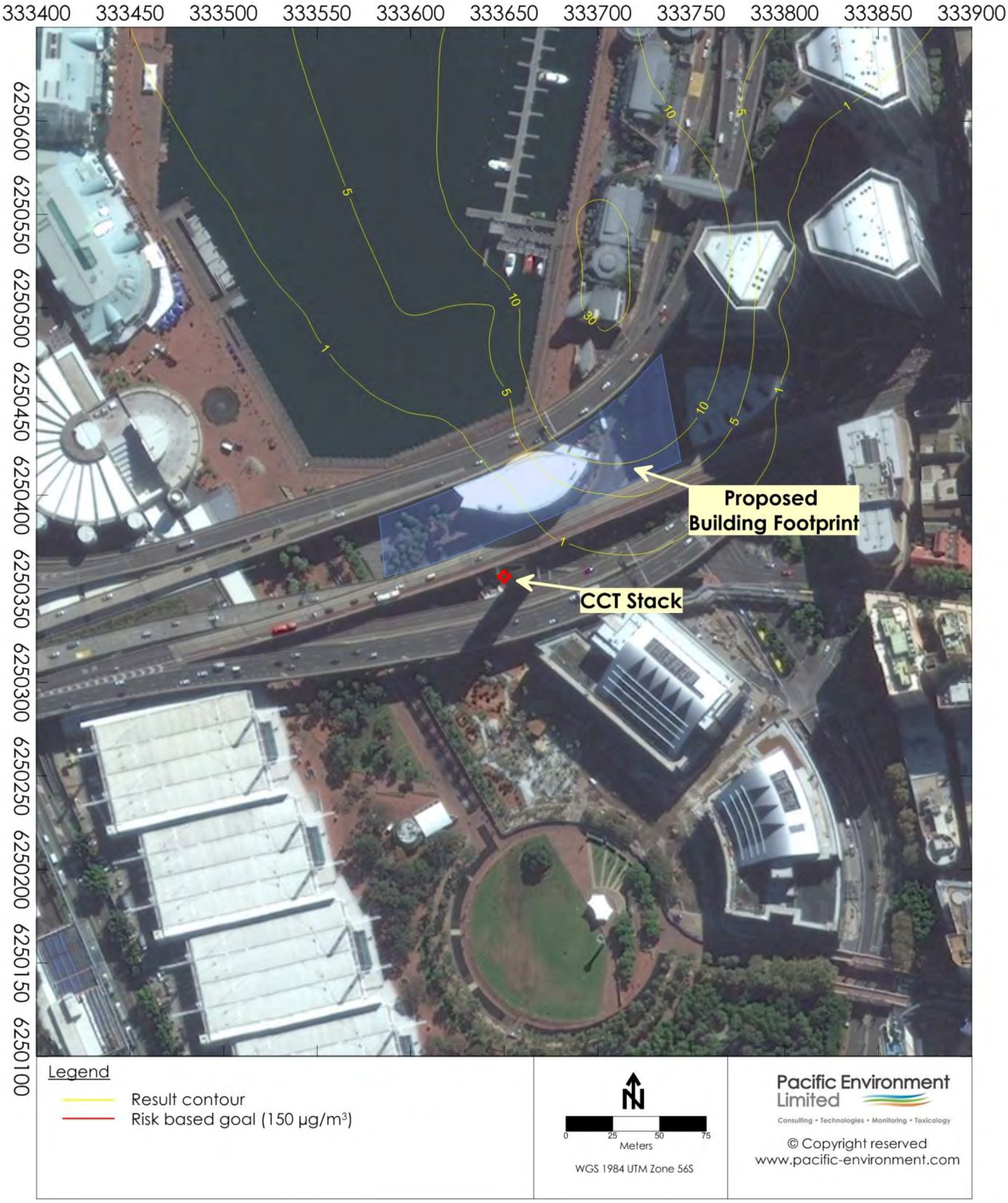


60 m – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



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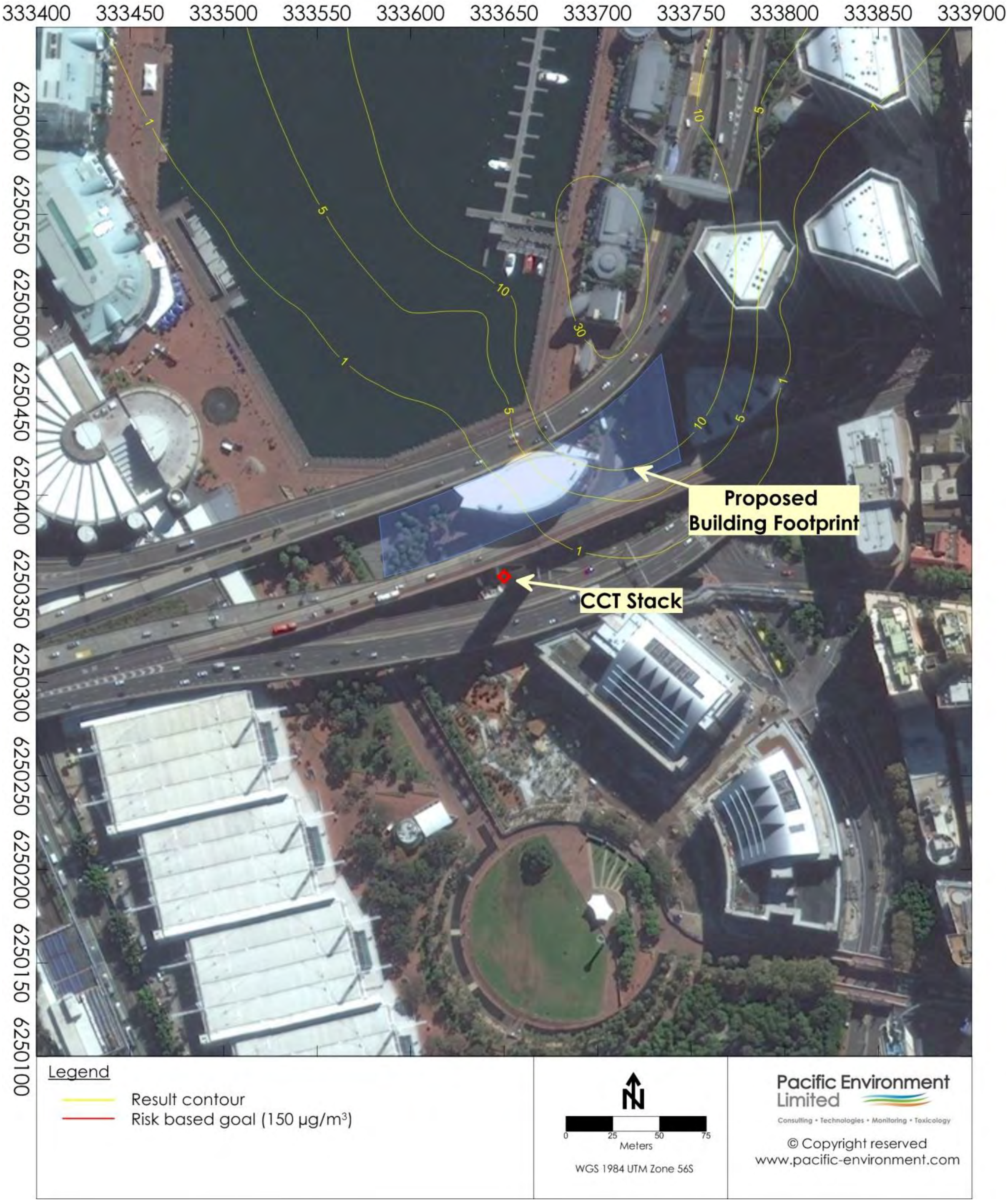
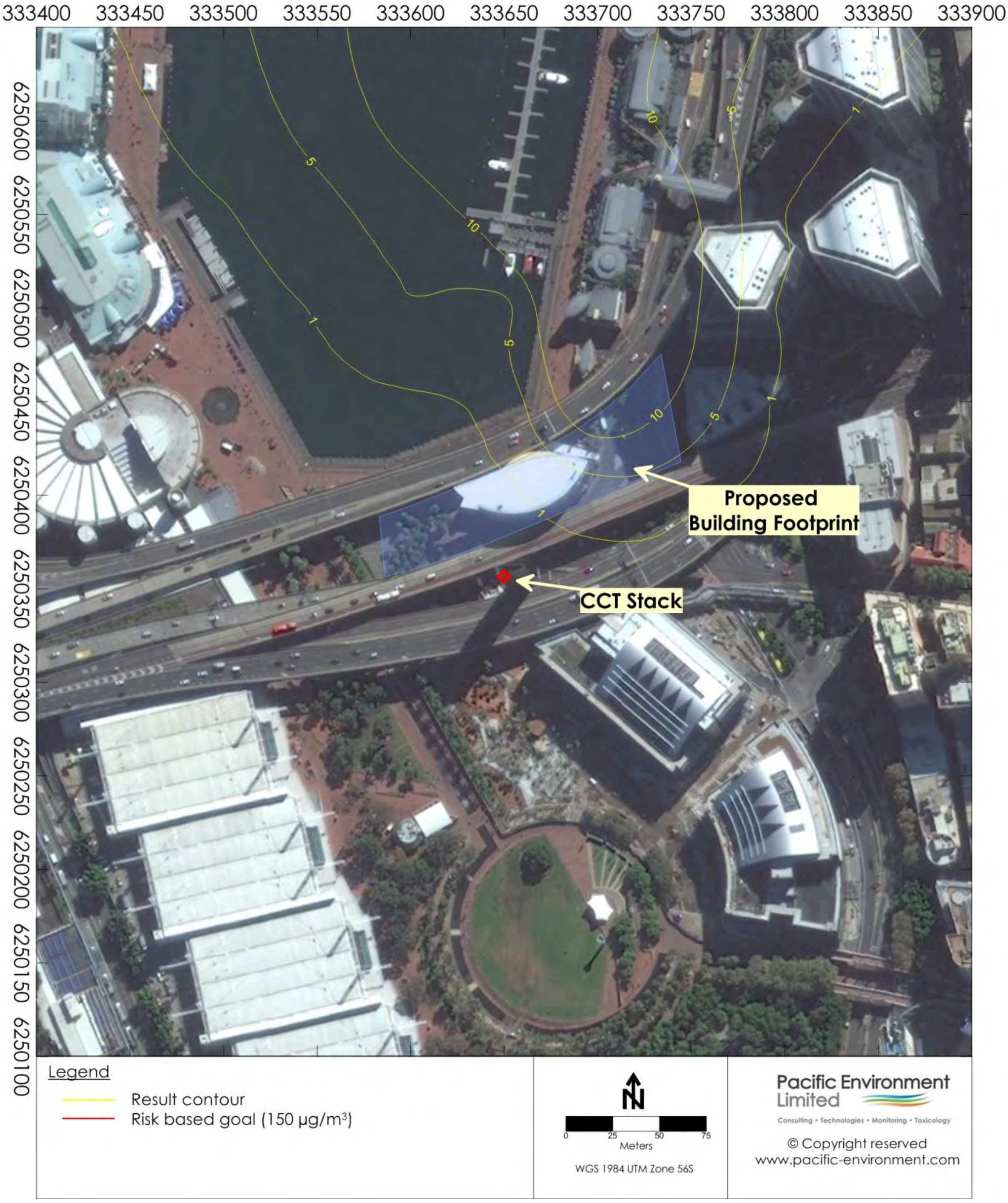
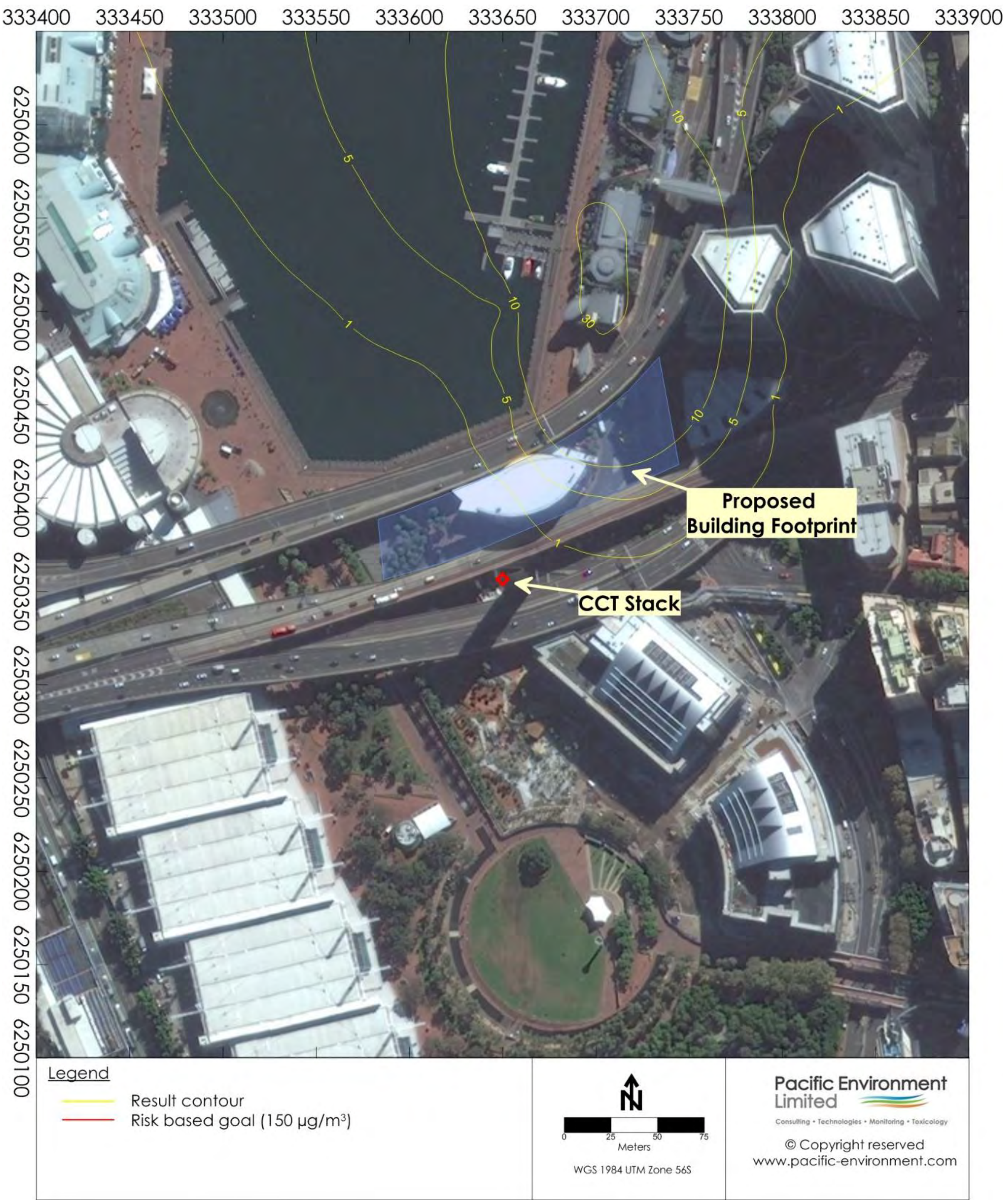


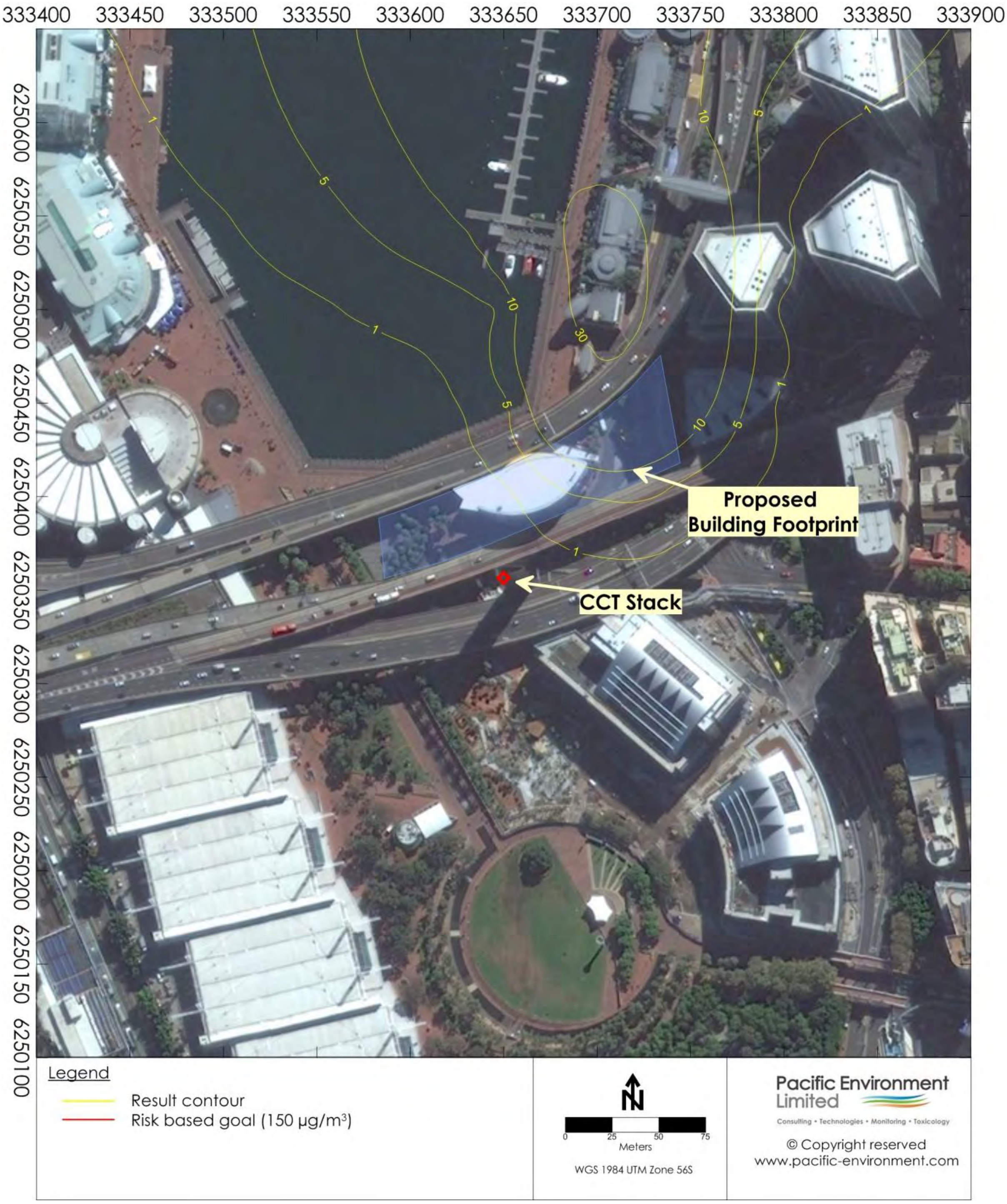
30 m – Medium Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



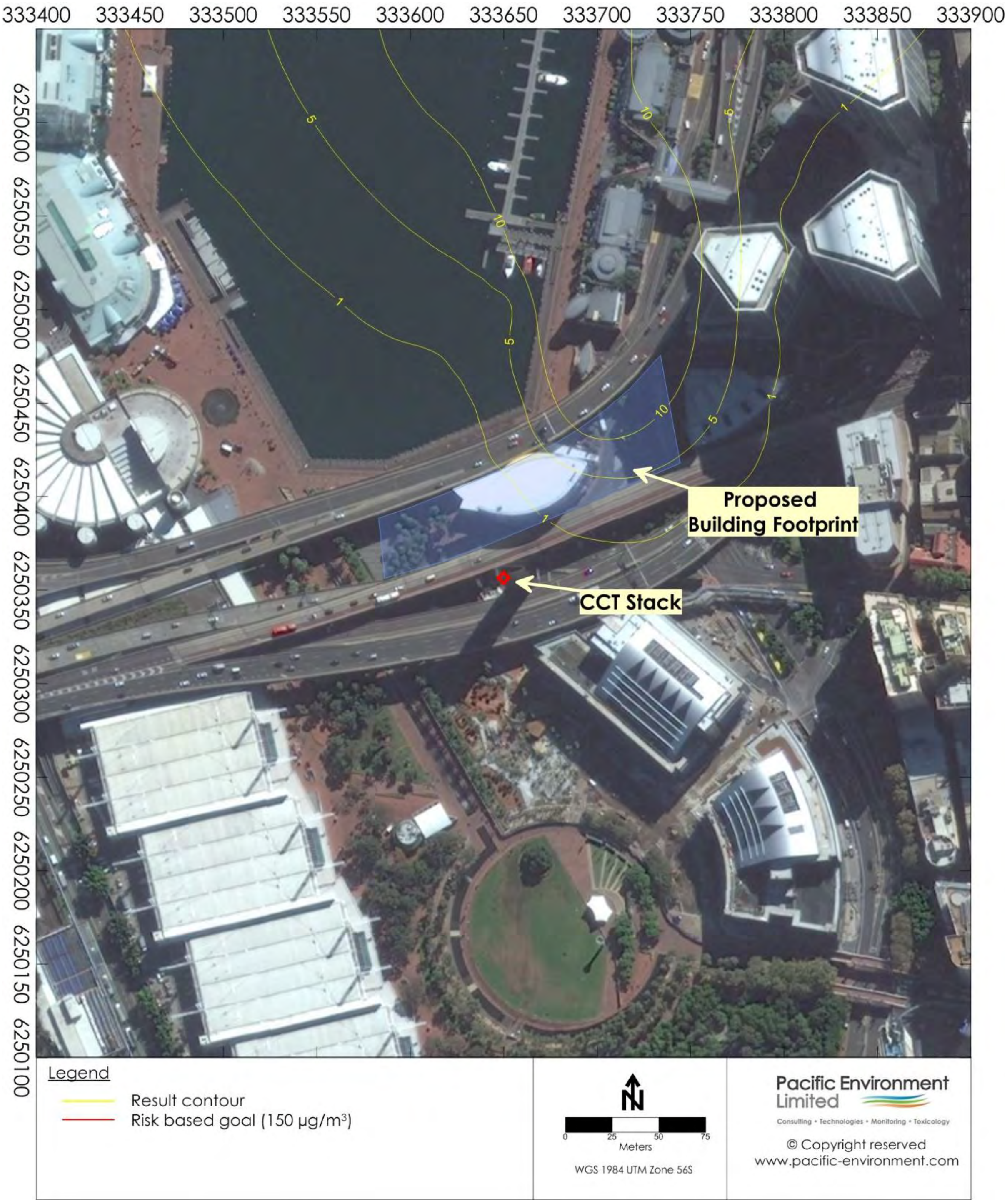
30 m – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



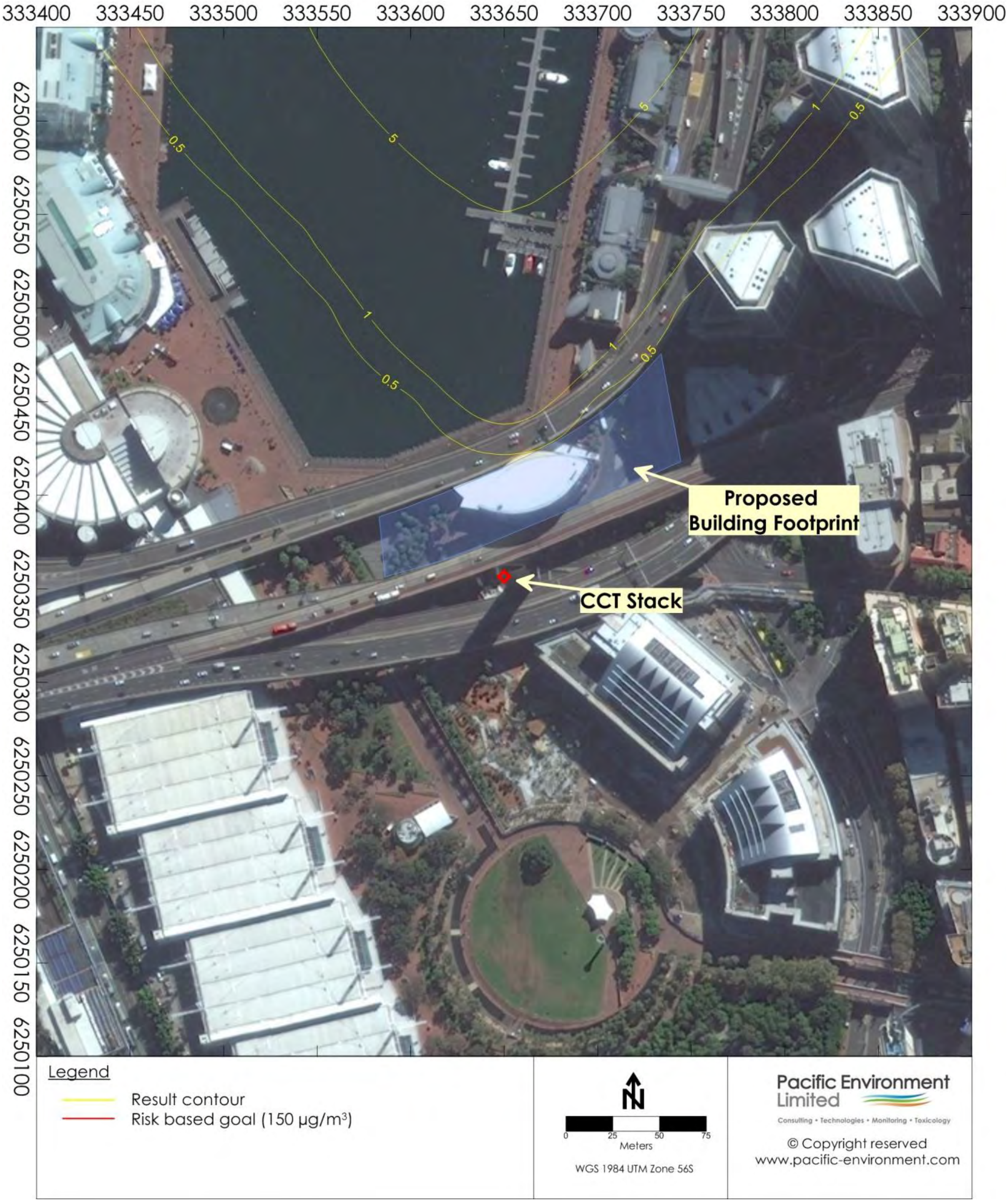
Ground Level – Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



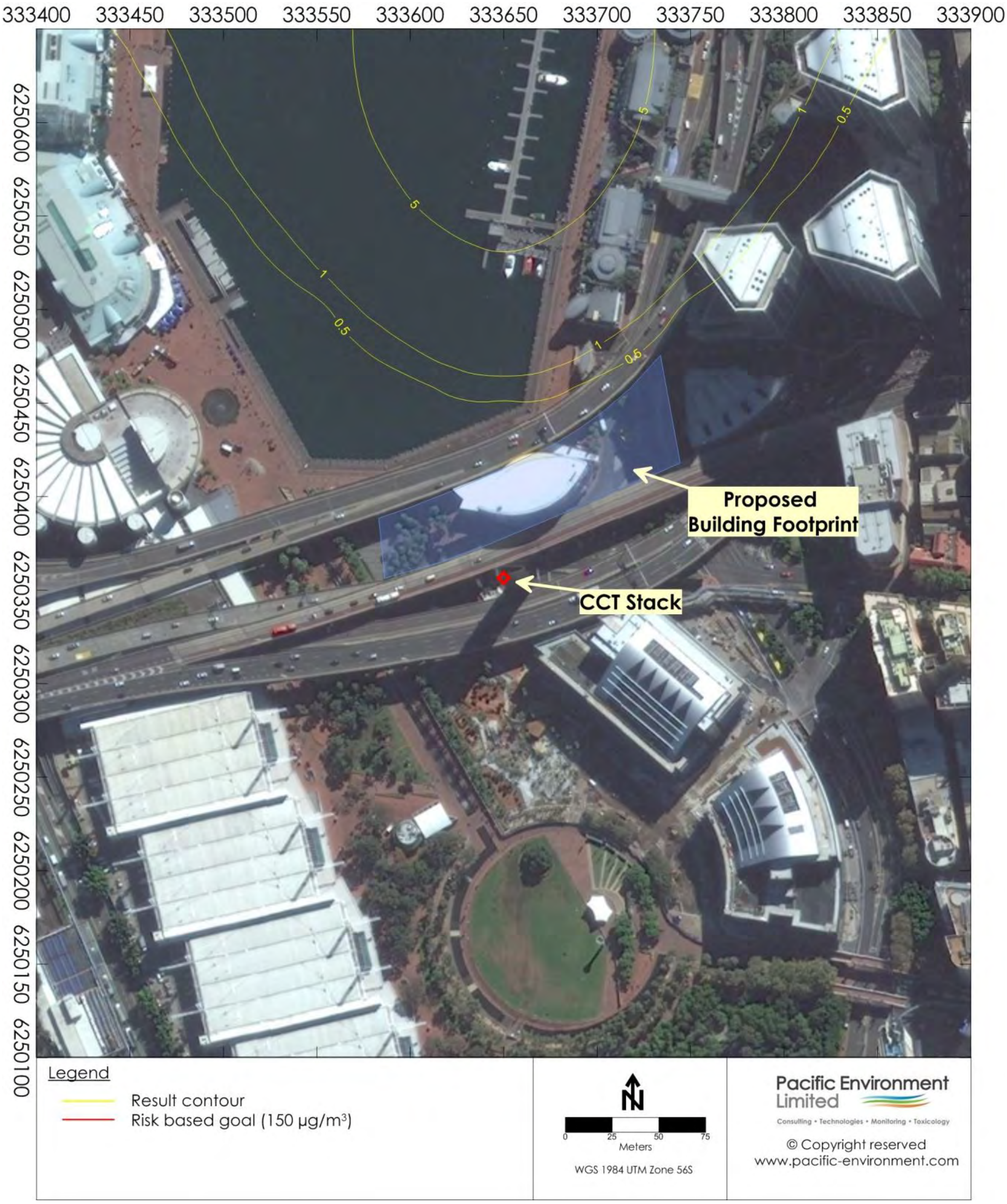
Ground Level – Medium Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



Ground Level – Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)

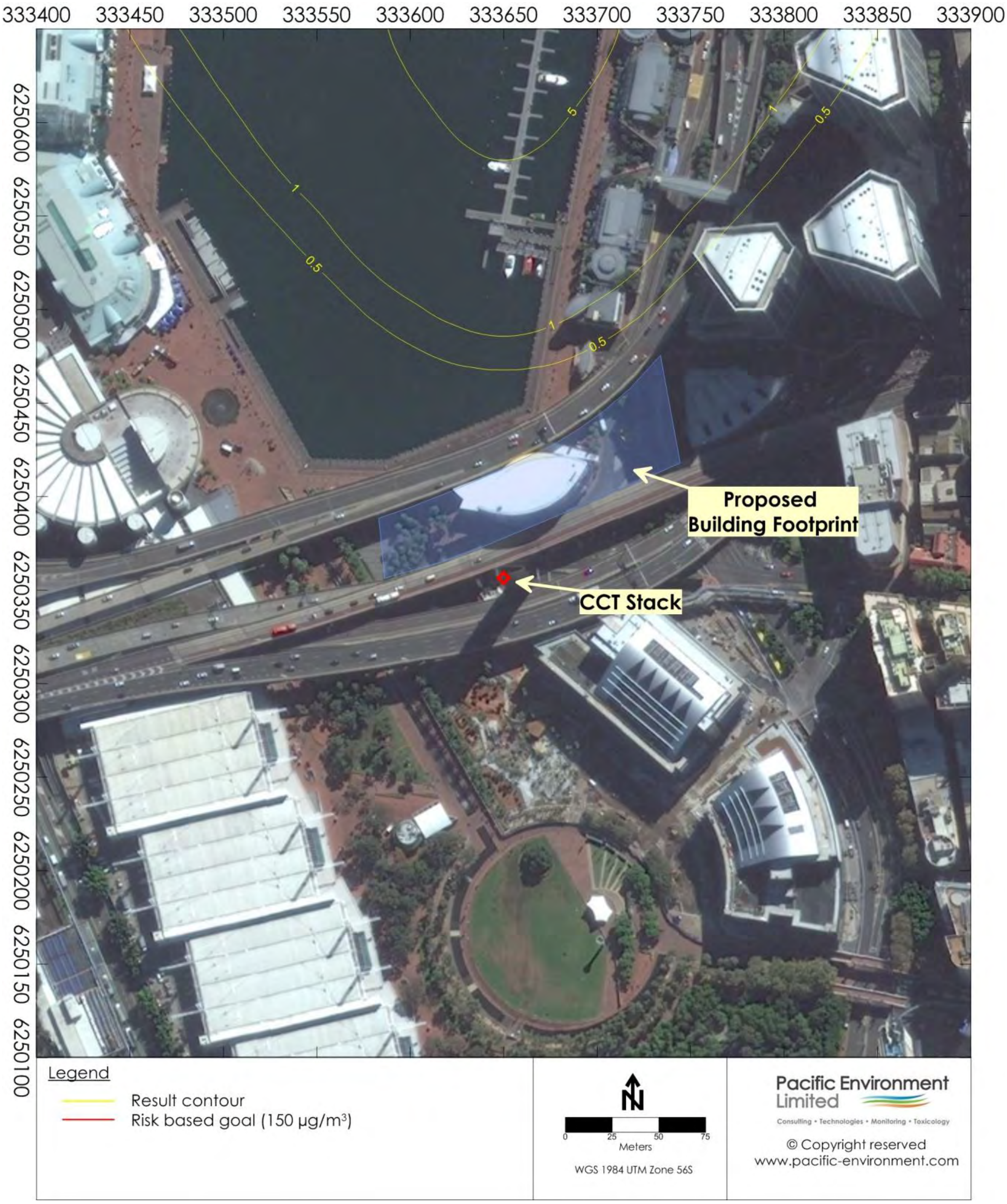


Ground Level – No Building Low Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)



Ground Level – No Building Medium Emissions Scenario – 1-Hour NO_2 Concentration

(Goal – 150 µg/m³)



Ground Level – No Building Peak Emissions Scenario – 1-Hour NO_2 Concentration (Goal – 150 µg/m³)