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Enquiries to: Philip Bell

TECHNICAL MEMORANDUM

Date	11 June 2026
To:	Brisbane City Council
From	Burchills Engineering Solutions
Project	91 Lytton Road, Balmoral
Subject:	Overland Flow Path Flood Protection Structure

1. BACKGROUND

Burchills Engineering Solutions were engaged by Levande Pty Ltd to prepare a technical memorandum for the application (Council Reference: A006935123) which proposes the establishment of a retirement facility at 91 Lytton Road, Balmoral which is properly described as Lot 39 RP901885.

This tech memo relates specifically to the design of a flood protection structure on the property's western boundary. The structure is required to ensure that mapped overland flow originating from the adjoining lot does not enter or impact upon the function of residential units within the proposed development. The proposed protection structure is required as the ground level residential units of Buildings A and B1 is situated below the finished floor level requirements prescribed by Table 8.2.11.3.L of the Brisbane City Plan's Flood Overlay Code.

This document provides details:

- The minimum finished surface levels required for the proposed flood protection structure; and
- Identifies hydrostatic forces exerted by overland flows the structure must be designed to withstand.

This report relies upon data derived from the approved Flood Impact Assessment prepared by MPN Consulting Pty Ltd dated 26 April 2023 for the site. As the proposed design does not significantly alter the footprint of the previously approved development, it is considered that the MPN and associated modelling remain relevant to the development.

1.1 Flood Protection Structure Design Requirements

Table 8.2.11.3.L of the Brisbane City Plan's Flood Overlay Code prescribes the minimum design floor level for new buildings. For the purposes of this assessment, the top of the flood protection structure (top of structure) will be required to be set at the finished floor level criteria prescribed by Table 8.2.11.3.L for Class A buildings where exposed to overland flow. The prescribed Class A finished floor levels prescribed by Table 8.2.11.3.L is:

- 2% AEP overland flow flood level + 500mm of freeboard.

1.2 Overland Flow Conditions Onsite

The extent, depth, velocity and relative water surface level (height) of overland flows are documented in the approved Flood Impact Assessment prepared by MPN Consulting Pty Ltd dated 26 April 2023 for the site.

Figure 12 of the MPN document plots flood contours for the 2% AEP flood event and is provided below as Figure 1 below.

Figure 1. 2% AEP Overland Flow Flood Surface Levels (Courtesy: MPN)

1.3 Top of Flood Protection Structure Levels

As identified in section 1.1, the finished surface level of the flood protection structure is to be designed to satisfy design requirements prescribed by Table 8.2.11.3.L of the Flood Overlay Code for Category A buildings (2% AEP flood level + 500mm of freeboard). Based upon flood modelling outputs produced by MPN Consulting as part of the approved Flood Impact Assessment, required top of structure levels have been identified.

Figure 2 provides a mark-up detailing the top of structure levels required to satisfy Table 8.2.11.3.L of the Flood Overlay Code. For further details, please refer to the attached design markup.

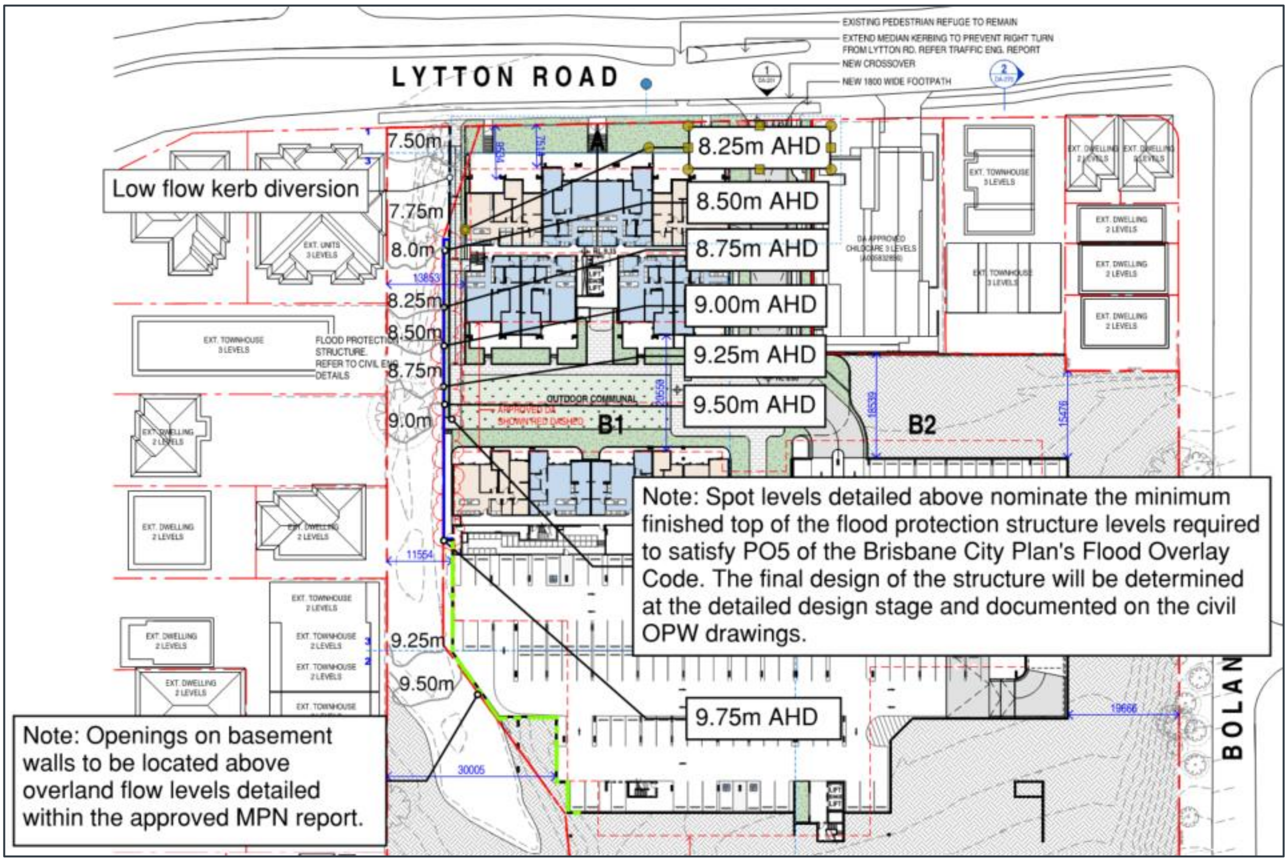


Figure 2. 2% AEP Overland Flow Flood Surface Levels (Courtesy: MPN)

The final design of the flood protection structure will be determined at the detailed design stage and documented on the civil OPW drawings. This will include both elevations and cross sections at relative locations to demonstrate that the overland flow channel cross sectional area is consistent with the existing levels.

In addition to the top of flood protection structure details, the following matters should be considered at the detailed design stage:

- All openings / apertures to basement structures where adjacent to the overland flow path should be located above the 2% AEP water surface level as documented by Figure 12 of the MPN report; and
- A low flow kerb diversion should be provided on the western edge of footpath infrastructure to ensure the nuisance low flows do not impact upon pedestrian access.
- Design the flood protection structure footings to minimise potential of erosion and where required to integrate with the proposed basement walls.

- Final design of the flood protection structure must ensure sufficient area is provided to allow for a free draining outlet to wholly contain piped and overland flows from the landscaped outdoor communal area up to and including major storm events.

1.4 Structural Design Requirements

The structural design of the proposed flood protection structure shall give consideration to the effects of hydrostatic and debris loading. These figures have been extracted from the MPN report.

- Peak velocity in the drainage path (easement) during the 2% AEP event is 2.26m/s.
- Peak D x V in the drainage path (easement) during the 2% AEP of 1.22m2/s

1.4.1 Hydrostatic Design Loading

The proposed flood protection structure will be affected by overland flows during the design flood event (2%AEP flood event). That is there is a 2% chance of flooding in any year. Minimum hydrostatic pressure for the structure equivalent to 1m of water pressure.

1.4.2 Debris Design Loading

Provision for minimum impact from debris loading located at the top of the flood protection structure to be 10kN point load.

1.5 Detailed Design Stage

The flood protection structure will require a certified structural engineer (RPEQ) to complete the final design of the structure to ensure:

- The structure complies with the parameters prescribed in this report; and
- Any additional conditions imposed by the council.

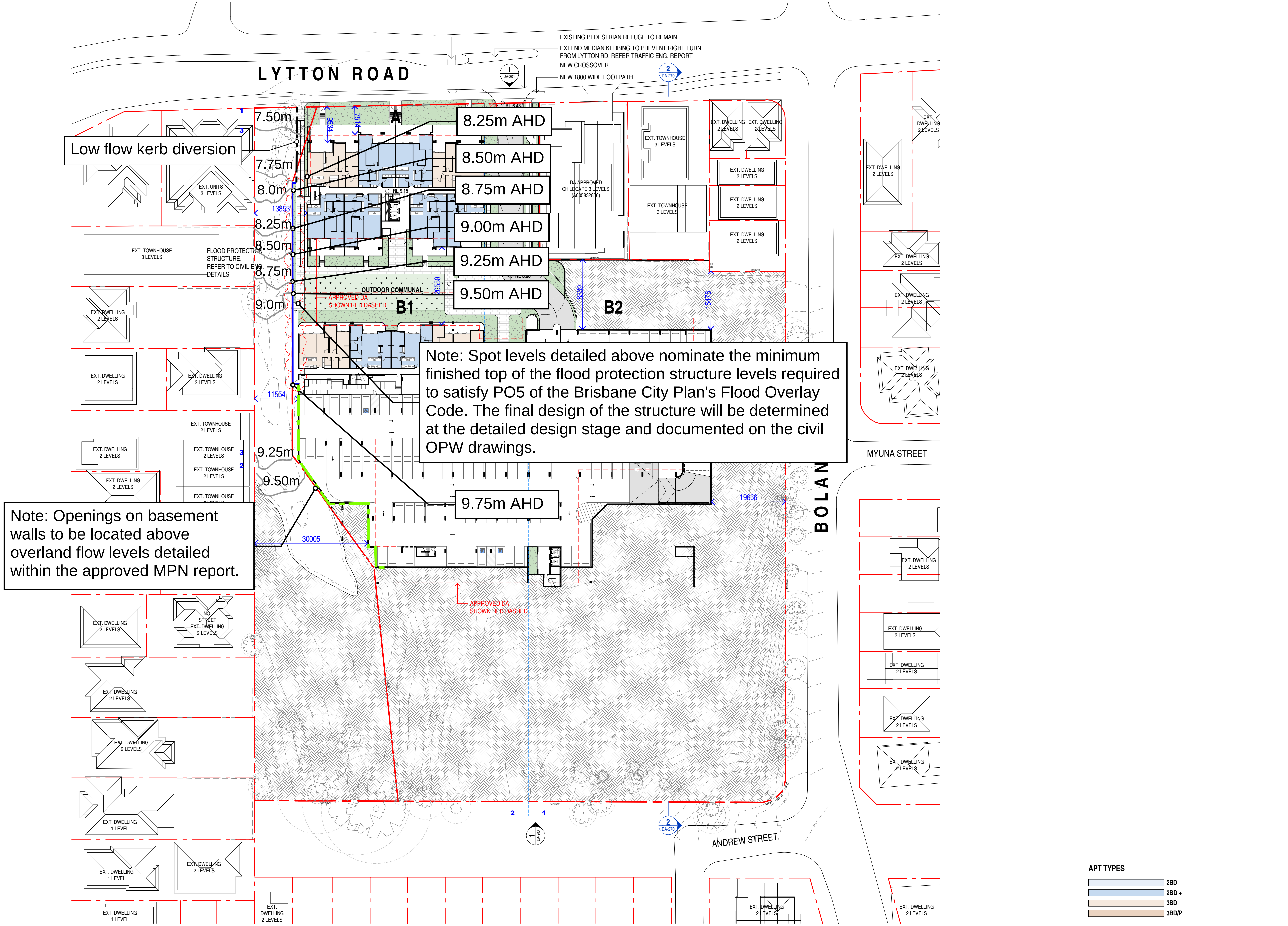
Should you require the provision of any additional information in relation to this matter, please feel free to contact me on (07) 5509 6400 or via email at Philip.bell@burchills.com.au

Yours sincerely,

Philip Bell
Principal Engineer – Civil, Water & Environment
RPEQ 1802

Enc: Flood Impact Assessment prepared by MPN Consulting Pty Ltd dated 26 April 2023
Flood Protection Structure Design Mark-up prepared by Burchills Engineering Solutions

Cc:



WIP

1 LEVEL 01

Plot Date: 10/06/2026 2:41:43 PM

Rev.	Description	Issued	Date
P7	DRAFT DA ISSUE	JDP	05/12/25
1	ISSUE FOR MINOR CHANGE DA	JDP	11/12/25
2	RESPONSE TO COUNCIL RFI	JDP	15/04/26
3	RESPONSE TO COUNCIL RFI	JPD	10/06/26

Client: LEVANDE

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Project No.: 2025073
Project: LEVANDE BULIMBA
Drawing: FLOOR PLAN - LEVEL 1
Drawing Number: DA-101
Revision: 3

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FLOOD IMPACT ASSESSMENT

RESIDENTIAL DEVELOPMENT
91 LYTTON ROAD – BALMORAL

BCC DS
LODGED
17-MAY-2023
APPLICATION REF
A006274495

PLANS AND DOCUMENTS
referred to in the
APPROVAL
Dated: **26/02/2024**

mpn consulting

Prepared By:

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26 April 2023

REVISION STATUS

MPN Reference No:	8715
Client:	Skyhold Project 7 Pty Ltd
Site Address:	91 Lytton Road & 57 Andrew Street, Balmoral
Report Title:	Flood Impact Assessment

DOCUMENT CONTROL

Version	Date	Author	Reviewer	Approved	RPEQ
Issue A	25/11/2022	Martin Roushani-Zarmehri	Peter Derrington	Lachlan Stephenson	16903
Issue B	03/04/2023	MRZ	MRZ	Lachlan Stephenson	16903
Issue C	26/04/2023	MRZ	MRZ	Lachlan Stephenson	16903

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EXECUTIVE SUMMARY

MPN was commissioned by Skyhold Project 7 Pty Ltd to provide hydraulic engineering services in support of a proposed multi-unit residential development at 91 Lytton Road & 57 Andrew Street, Balmoral. The development proposal includes a mix of townhouses, multi-storey residential units, hardstand carparking, landscaping and common area amenities.

Brisbane City Council's Overland Flow Path Flood Overlay Mapping identifies the existing site as being susceptible to flooding from this flood source. A flood study was undertaken with 2D hydraulic modelling outputs to demonstrate no worsening of flood levels or adverse impacts to surrounding roads and adjacent external properties resulting from the proposed development.

The minimum design standard adopted for habitable floor levels was the 2% AEP overland flood level + 500mm freeboard.

Based on flood modelling results for the study, 2% AEP overland flood levels along the western adjacent channel are predicted to range between RL 13.0 mAHD at the south-western regions, to around RL 7.5mAHD at the north-western corner, and down to RL 6.50mAHD within Lytton Road at the northern-eastern regions.

On this basis, the ground level carpark (ie. Basement entry level) is proposed at RL 6.95 mAHD in order to provide flood immunity to this level from storm events up to the 2% AEP. This is deemed achievable due to the steep existing grades within the site. It is also noted there is negligible differences predicted between 1% and 2% AEP peak flood levels generally within the catchment.

The site's runoff is typically captured by onsite stormwater drainage and internal road designs which direct runoff to the existing overland flow channel to the west, or to Lytton Road to the north. The carparks within the site are accessed via Lytton Road and Bolan Street, which are to be designed beneath the proposed residential townhouses and multi-unit dwellings. Overall, the flood risk is quite low to the site, as the carparks are graded up and above Lytton Road, where typical major overland road flooding occurs. The development itself is at potential flood risk from the overland flow path to the west, if in the unlikely event flows were to break out from the existing channel.
A portion of the upstream proposed building is proposed to be suspended over the top of bank of the overland flow path channel, and therefore the minimum undercroft requirements will apply.

Flood impact mapping completed for this flood assessment indicates the proposed development is unlikely to create material impacts to properties located elsewhere within the study catchment, including to peak flood levels within Lytton Road. The existing site is noted to be almost entirely impervious surface via vast concrete hardstand and building areas, and therefore the current scenario is deemed to create minimal infiltration and/or onsite attenuation.

Albeit this, minor impacts of less than 20mm has been illustrated at the site frontage and up to 10mm to the property west of the channel, however these demonstrated impacts are a result of a high-level conceptual design assuming uniform grading to the street and channel. It is anticipated that once a detailed internal road design is provided, the site will provide attenuation of peak flows equal to or better than the existing scenario. Furthermore, this high-level scenario does not take into consideration the effects of the onsite stormwater management strategy such as the internal drainage system, which would have some level of volume storage which would reduce impacts external to the site.

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1 PURPOSE

MPN was commissioned to provide an assessment of the development impacts on local flooding for the proposed residential development at 91 Lytton Road & 57 Andrew Street, Balmoral.

The aim of this assessment is to ensure the proposed development provides an appropriate level of flood immunity, minimises the risk to people and property within the site and limits the development impacts (i.e. the resultant flood behaviour) to acceptable levels, particularly to surrounding, upstream and downstream properties.

2 INTRODUCTION

2.1 Project description

The current proposal involves the construction of a mixed residential development that will comprise of townhouses and multi-unit residential apartment buildings, with a basement carparking area.

Car parking on the site will be provided in a basement (similar to a building undercroft), with street-level vehicle access into the site from Lytton Road and Bolan Street. The vehicle access from Lytton Road will grade upwards into the site, as the existing grades within the site grade towards Lytton Road. The access from Bolan Street is at a level grade into the site towards the basement/undercroft car park area.

There will also be pedestrian access to the west, adjacent to the channel, however this will all be suspended and cantilevered over the channel where required.

The proposed development is depicted on the architectural plans prepared by Fender Katsilitis Architects attached in Appendix 1, with excerpt below.

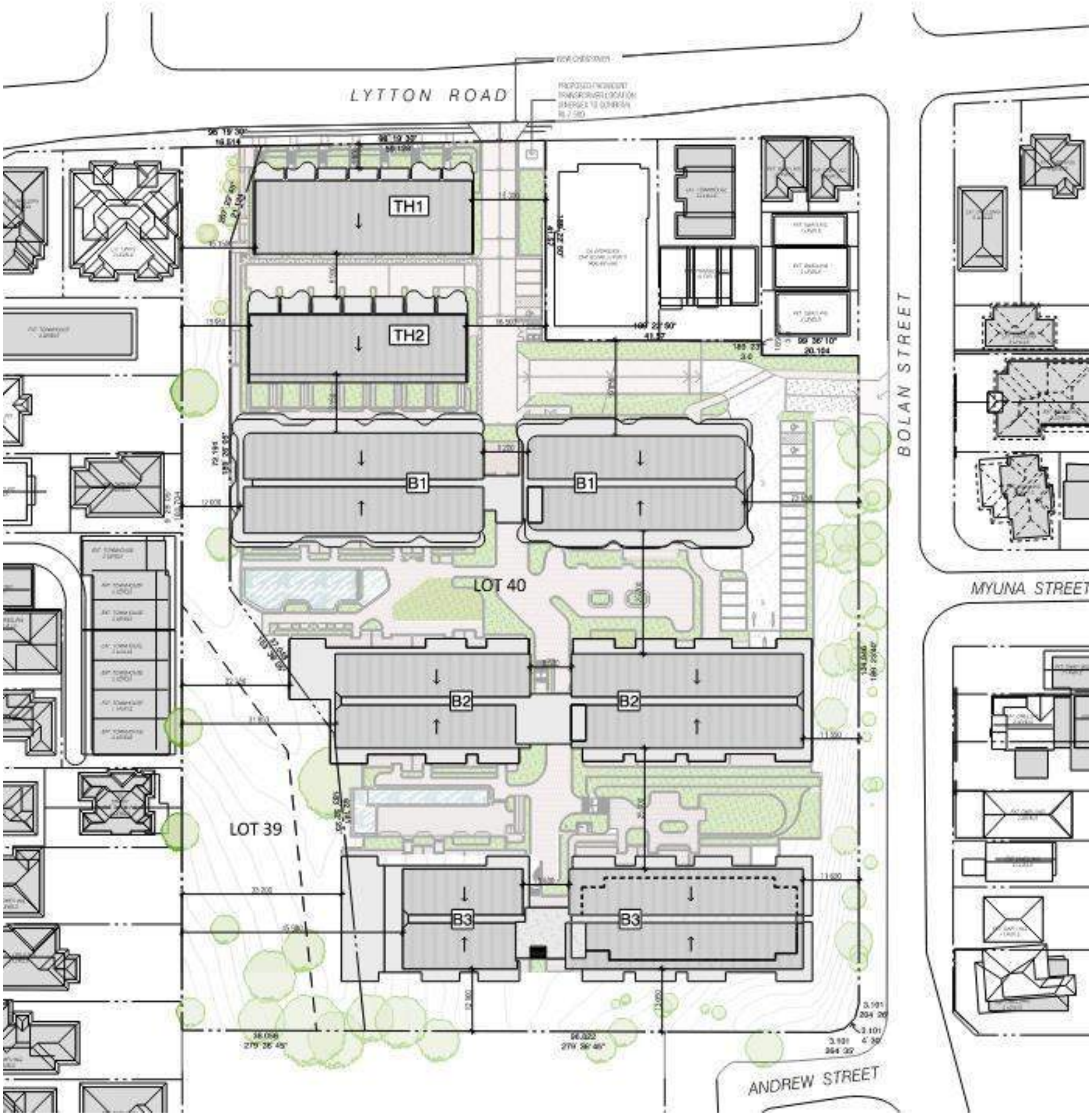

Figure 1 – Proposed Development

2.2 Site Location

The site is located at 91 Lytton Road & 57 Andrew Street, Balmoral and is formally known as Lot 39 & lot 40 on RP901885.

The site is bounded by Lytton Road to the north, Bolan Street to the east, Andrew Street to the south-east (with the remainder of the south being restricted vegetated access), and a deep, highly vegetated channel to the east.

The site location with the BCC Flood Overlay (Overland Flow Path mapping) is provided below in Figure 2 with the Brisbane City Council Floodwise Property Report attached in appendix 2.

Figure 2 – Site Location w/ Overland Flood Overlay (Source: BCC Interactive Mapping)

2.3 Topography and the Existing Site

A copy of the site's survey plan prepared by Lawson Surveys is attached in Appendix 3.

The existing site contains a church with extensive hardstand carparking as illustrated below in Figure 3 (looking south). There are also vegetated areas along the Bolan Street and Andrew Street property boundaries, as well as a highly vegetated channel to the west. The site sits at the top of the bank of the vegetated channel. The site is also surrounded by steep batters along the southern and eastern boundaries, which fall steeply into the site's hardstand region.

The site is adjacent to a set of multi-unit residential properties to the north-east and a recently approved Child Care Centre (93 Lytton Road, BCC Application No: A005832856).

Figure 3 – Existing Site Visit Photo – South Perspective (Source: MPN Site Visit)

2019 LiDAR data was used to develop a Digital Elevation Model (DEM) of the study catchment. The developed DEM and ground elevation contours derived from it are shown on Figure 4.

As this figure shows, the site falls from RL 35.5m AHD near the south-eastern corner down to approximately RL 7.0m AHD along the northern boundary. The average grade between these points is approximately 13.5% which is considered steep.

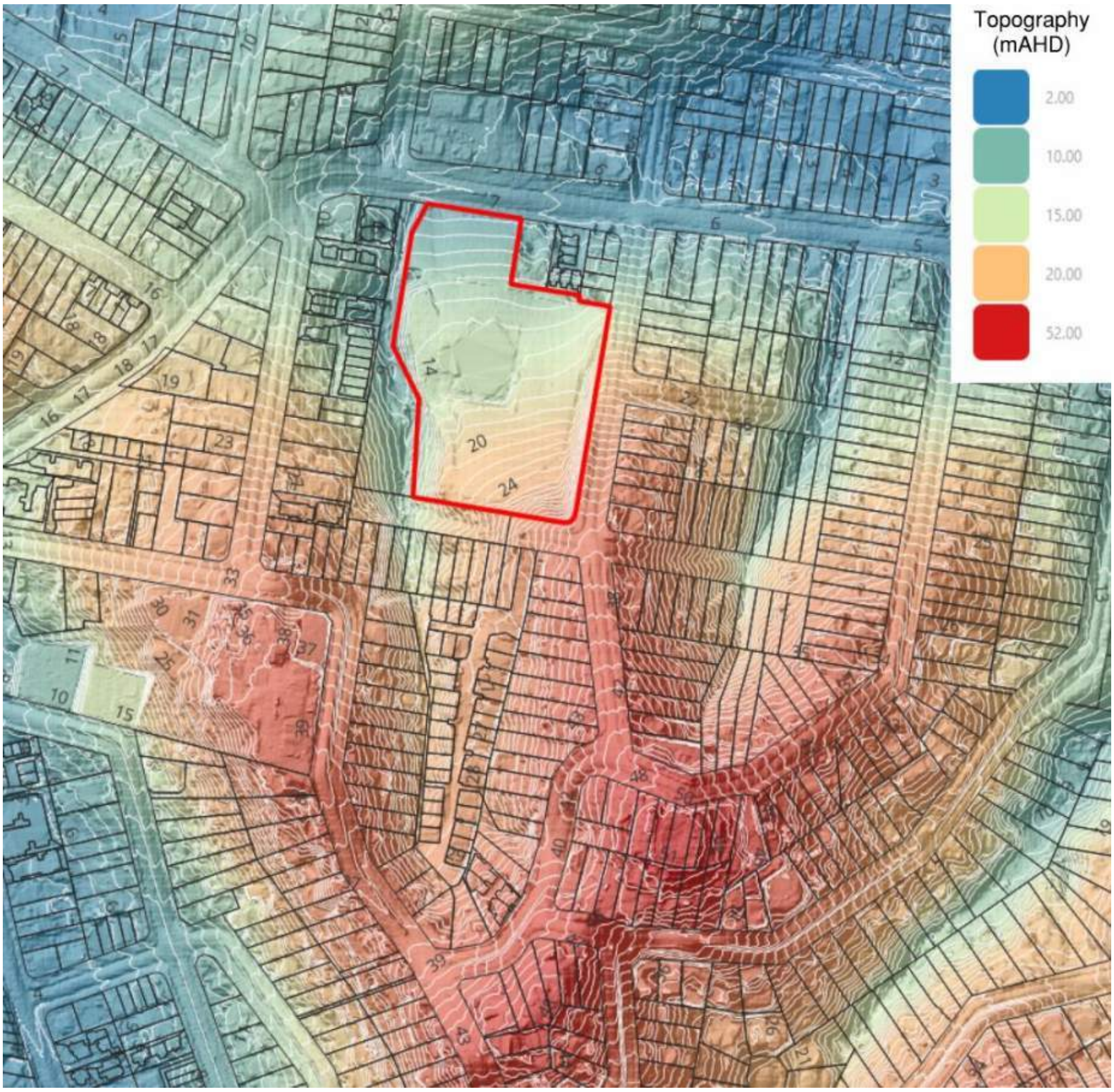

Figure 4 – Site Location w/ Overland Flood Overlay (Source: BCC Interactive Mapping)

As can be seen in the above image, there is a well-defined and deep overland flow path channel along the western site boundary, where it falls towards Lytton Road. There is an existing stormwater culvert (900mm Diameter RCP) at the end of the channel, which connects to BCC's stormwater network within Lytton Road. This pipe has been visually inspected via site visit and an image of this culvert provided below in Figure 5.

Figure 5 – 900mm Diameter RCP – north-west of site (Source: MPN Site Visit)

2.4 Site Data

Site data has been obtained from the following sources of information:

- As Constructed plans – Brisbane City Council (BCC) GIS Open Data;
- Satellite imagery;
- Brisbane City Council – Citywide & Overland Flow Path Mapping – Final Report, prepared by GHD dated April 2017;
    - TUFLOW Flood model data results via Open GIS Data – Central Model Catchment;
- Discussions with relevant authorities;
- DBYD;
- Survey plans – Job Reference: 20054, prepared by Lawson Surveys; and
- Architectural Site Plan prepare by FK Architects

3 LOCAL CATCHMENT MODELLING

3.1 General

To assess the proposed development's impact on flood levels and velocities within the study catchment, a new One-Dimensional (1D) and Two-Dimensional (2D) coupled TUFLOW model was developed. Forcing for the TUFLOW model was derived using 'direct-rainfall-on-grid' (ROG) methodology, which allows for the conversion of rainfall to runoff and subsequent runoff-routing to occur over the catchment without the need for a separate hydrologic model.

The peak flows produced via the ROG methodology has been compared against The Rational Method peak estimation method, to ensure the peak flow rates are within an acceptable range with the TUFLOW hydraulic model outputs.

The following catchment development scenarios have been considered for the flood impact assessment:

- **Pre-Developed Case:** The model developed for this scenario captures existing land uses of the study catchment, based on recent aerial imagery. The model also includes Council's stormwater drainage assets located within road reserves that could be readily sourced from Council's Open Data web-portal and/ or Ebimap service.

- **Conceptual Post-Developed Case:** For this scenario, the pre-development case model has been modified to include a conceptual post-development scenario design, in order to determine conservatively the potential impacts of the proposed development, and also to provide appropriate flood levels to comply with for flood immunity and resilience.

3.2 Hydrology

3.2.1 Overview

A ROG modelling approach was undertaken as noted above, given the topography of the region and the ability to demonstrate concentration of urbanised flows within the area of interest.

Australian Rainfall and Runoff 2019 data and methods have been adopted via TUFLOW's QGIS plugin, to generate all duration and temporal events from 10 min to 60 min durations. Accordingly, 70 storm events were run via a coarse-grid fast model, and post-processed to determine the peak median event to adopt for assessment.

The ROG model peak flow result outputs were compared against the Rational Method peak estimations for the main upstream external catchment. The following sections of this report discuss the development of the TUFLOW model results and the Rational Method comparison results.

3.2.2 Rational Method Comparison

The main sub-catchment adopted for the ROG model comparison has been illustrated below in Figure 6.

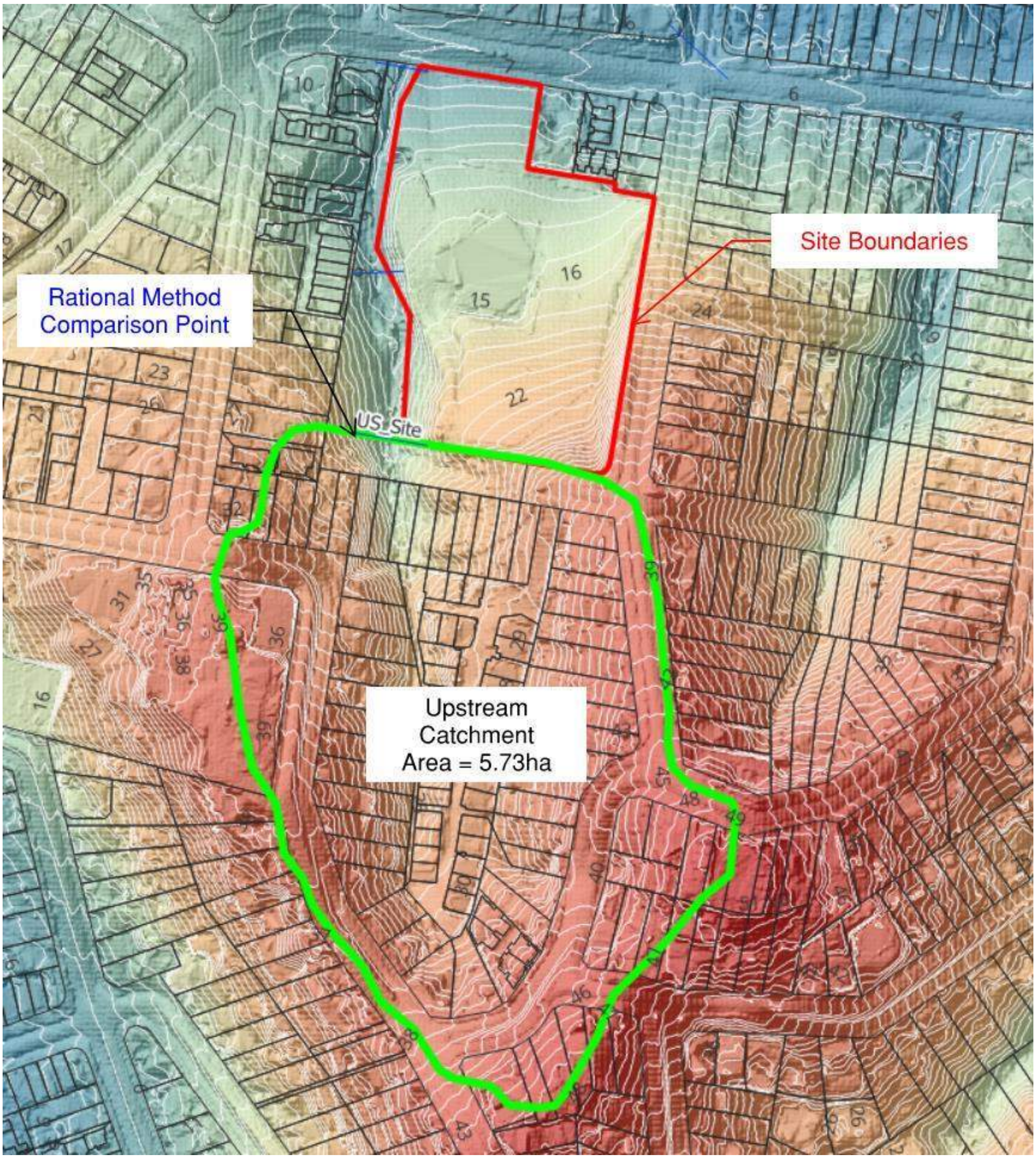

Figure 6 – Rational Method Comparison Location

The peak flow results adopted from the TUFLOW fast-run models critical duration event (and adopted median temporal pattern) and the methodology undertaken, has been discussed in further detail in the sub-sections below. It is noted that catchment delineation has been undertaken within the Rainfall boundary file within the TUFLOW model, which naturally produces surface runoff as the topography dictates within the hydraulic model.

The adopted Rational Method components and values are highlighted in the sub-sections below, with the detailed calculations attached in Appendix 4.

3.2.2.1 Minimum Time of Concentration (Rational Method)
A time of concentration of 10 minutes has been adopted, inclusive of 5 minutes standard inlet time, 1 minute pipe flow and 4 minutes channel flow.

3.2.2.2 Rainfall Data
2016 design-rainfall IFDs for the local catchment were extracted from the Australian Rainfall and Runoff (AR&R) Data Hub web service. The extracted IFDs are shown on Figure 7.

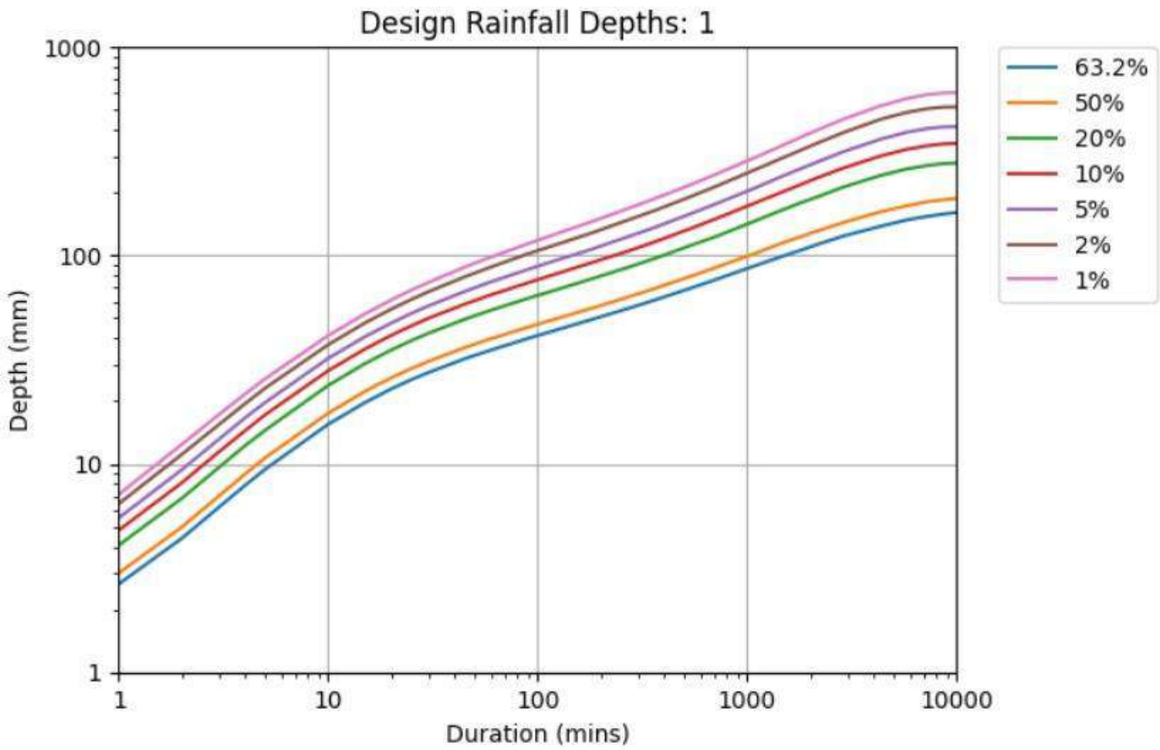

Figure 7 – Rainfall depth (in mm) totals used for design-event analysis

3.2.2.3 Adopted C10 Value
The adopted value has been assessed to provide a balance of urban impervious areas and the vegetated upstream channel regions. Accordingly, a C_{10} value of 0.76 has been adopted for the pre-development scenario value.

3.2.2.4 Pre-Development Case Flow Comparison Summary
As a high-level comparison, the Rational Method estimation technique was utilised to compare the 1% and 2% AEP peak flow rate with the corresponding TUFLOW hydraulic model results, at the upstream site boundary, where incoming upstream external catchment overland flow is deemed to enter the site.

The parameters of the contributing catchment have been provided in Appendix 4, with the peak flow results from the model and estimation from the Rational Method provided below in Table 1.

Overall, it is noted that the peak flow rates extracted from the TUFLOW results compared well to the Rational Method results and therefore is deemed suitable for the flood impact assessment.

Design **AEP** Event (%)	Rational Method Estimation (m^3/s)	TUFLOW Hydraulic Model Results (m^3/s)	Difference (%)
2	3.11	3.14	1
1	3.60	3.63	1

Table 1 – Rational Method vs TUFLOW Results Comparison

The TUFLOW hydraulic model setup which has informed the above results, are discussed in further detail in the sub-sections below.

3.3 Hydraulics – TUFLOW Model Setup

As noted, the developed flood models for the current assessment utilises the 'direct-rainfall-on-grid' (ROG) method to simulate rainfall and runoff on the study catchment. This method ensures every computation grid cell receives an equal amount of total rainfall (in mm), which happens gradually over time and according to a given design temporal pattern. In regards to routing, this happens in the model as it always has; at each timestep, the TUFLOW engine develops a time-varying finite-difference approximation of the fully implicit shallow water wave across the model extent, with elevation and roughness differences between grid cells acting as the primary driver and/ or stresses to propagate the shallow water wave.

The TUFLOW model has been set up to contain the entire contributing overland flooding catchment for the site.

The parameters adopted within the TUFLOW ROG model, have been summarised in the sub-sections below.

3.3.1 Catchment Topography and Stormwater Drainage

3.3.1.1 Pre-Developed Topography

Ground elevations of the existing catchment were developed in the pre-development case model using 2019 LiDAR data. The developed LiDAR DEM in this manner is shown in Figure 4 above.

3.3.1.2 Council Stormwater Drainage Network

Council's existing stormwater drainage assets within the study areas have been adopted, specifically the ones available in GIS format from Council's open data web portal and/ or Ebimap, which have been included in the pre-development case model.

The pre-development hydraulic data adopted within the pre-development model has been illustrated below in Figure 8.

Erroneous/ missing structural details (e.g. invert levels and pipe diameters) in the sourced asset data were redeveloped in the model either on the basis of as-built drawings/ design plans where these were available for assets or by utilising appropriate assumptions. It is noted that some upstream manholes have been converted to pits to replicate collection for upstream connected stormwater pit and pipe systems, thereby allowing an appropriate amount of stormwater to be collected within the model pipe system.

As per the requirement within the Stormwater Drainage Code, BCC's inlet capture charts were used in the pre-developed case model to accurately define the relationship between pit grate size, flow-depth over the grate and stormwater capture (or surcharge), where the hydraulic behaviour all stormwater inlet structures included in the model was modelled.

It is noted that the channel has been inspected via a site visit, and the pipes noted in the GIS data were not found, and therefore removed from the model. Furthermore, the pipe outlet discharge from the onsite building was located, and the downstream headwall and collection point upstream of Lytton Road to the 900mm diameter RCP pipe system was also found. These have been amended within the model to appropriately represent anticipated flow regimes within the site.

It is also noted that pipe systems were deemed partially blocked due to sedimentation and vegetation debris upstream of the pipe system, and therefore a pipe blockage factor of 20% was adopted where this was observed.

Figure 8 – TUFLOW model Setup – MPN Pre-development scenario

3.3.1.3 Post-Developed Scenario

The post-development case model topography has been adjusted to account for an ultimate scenario condition, which discharges captured stormwater via the existing overland flood channel to the west of the site, or to Lytton Road, as per pre-development conditions.

It is noted that this is a conservative approach, given a detailed design scenario would take into consideration a pit and pipe network (ie. Pipe volume storage), and post-development topography design which accounts for ponding and urban storage within the site.

Two columns have also been accounted for, to allow for a connection to the south-western corner of the site via an elevated bridge design.

All existing onsite pipe systems were removed for this scenario, given the conceptual nature of the design at this stage.

The post-development topography model has been illustrated below in Figure 9, for an appreciation of the design.

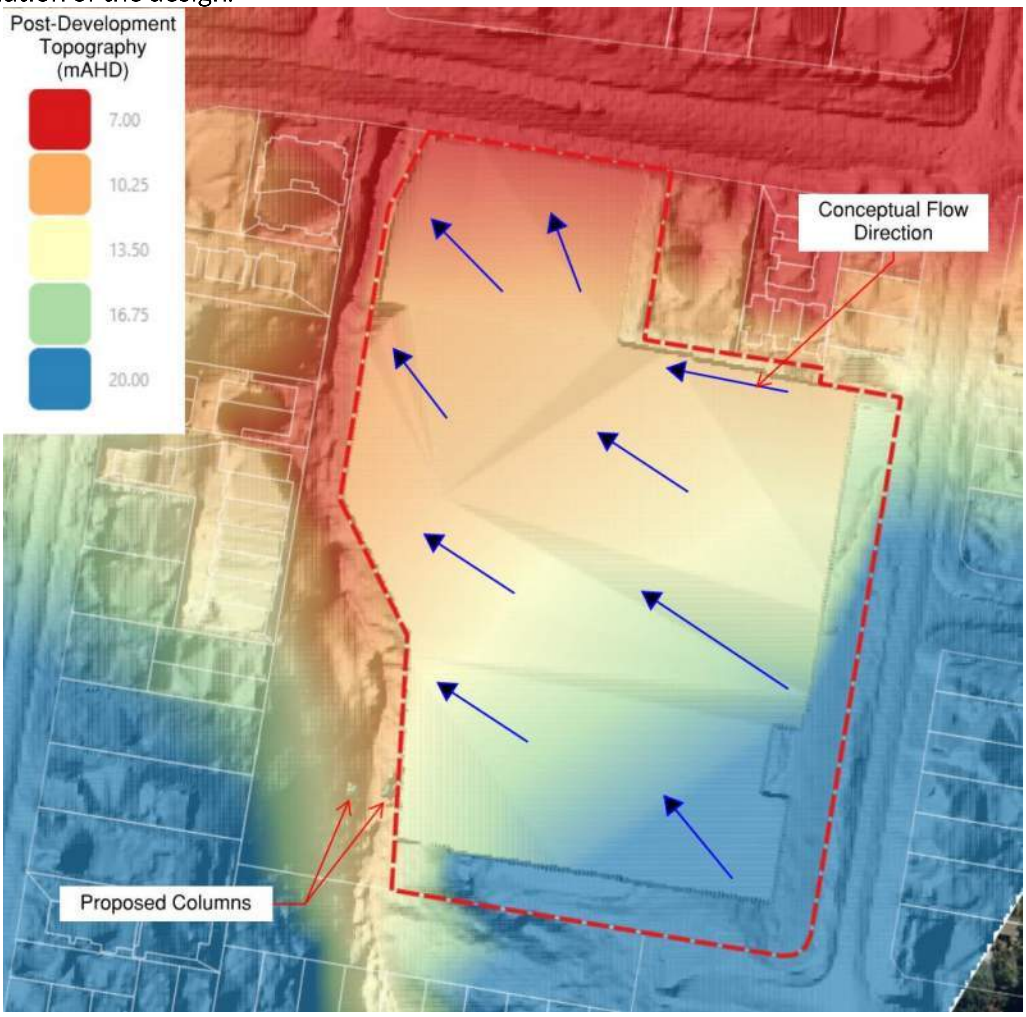

Figure 9 – TUFLOW model DEM – MPN Post-development scenario

3.3.2 Catchment Surface Roughness

Materials on the local catchment that generate distinctive runoff responses (such as buildings, roads, car parks, vegetated and grassed areas) were adopted as per industry standards and generally in accordance with the BCC Flood Planning Scheme Policy. Prior to development in the model, a review of these materials was undertaken using recent aerial imagery for relevancy and adjustments were made where necessary.

The final materials adopted in the pre-development flood mapping is shown below in Figure 10, and the post-development flood mapping in Figure 11.

The corresponding Manning's roughness coefficient (n) values adopted in the models are tabulated in Table 2 below.

Adopted roughness values			
Material ID	**Manning's 'n'**	**IL**	**CL**
Roads/Concrete	0.02	1	0
Urban Areas/Open Grassland	0.06	0	0
Default BCC Value (Urban)	0.10	5	1.7
Riparian Corridor (Vegetated)	0.15	5	0
Dense Vegetated	0.08	5	1.7

Table 2 – Roughness values adopted in the TUFLOW model

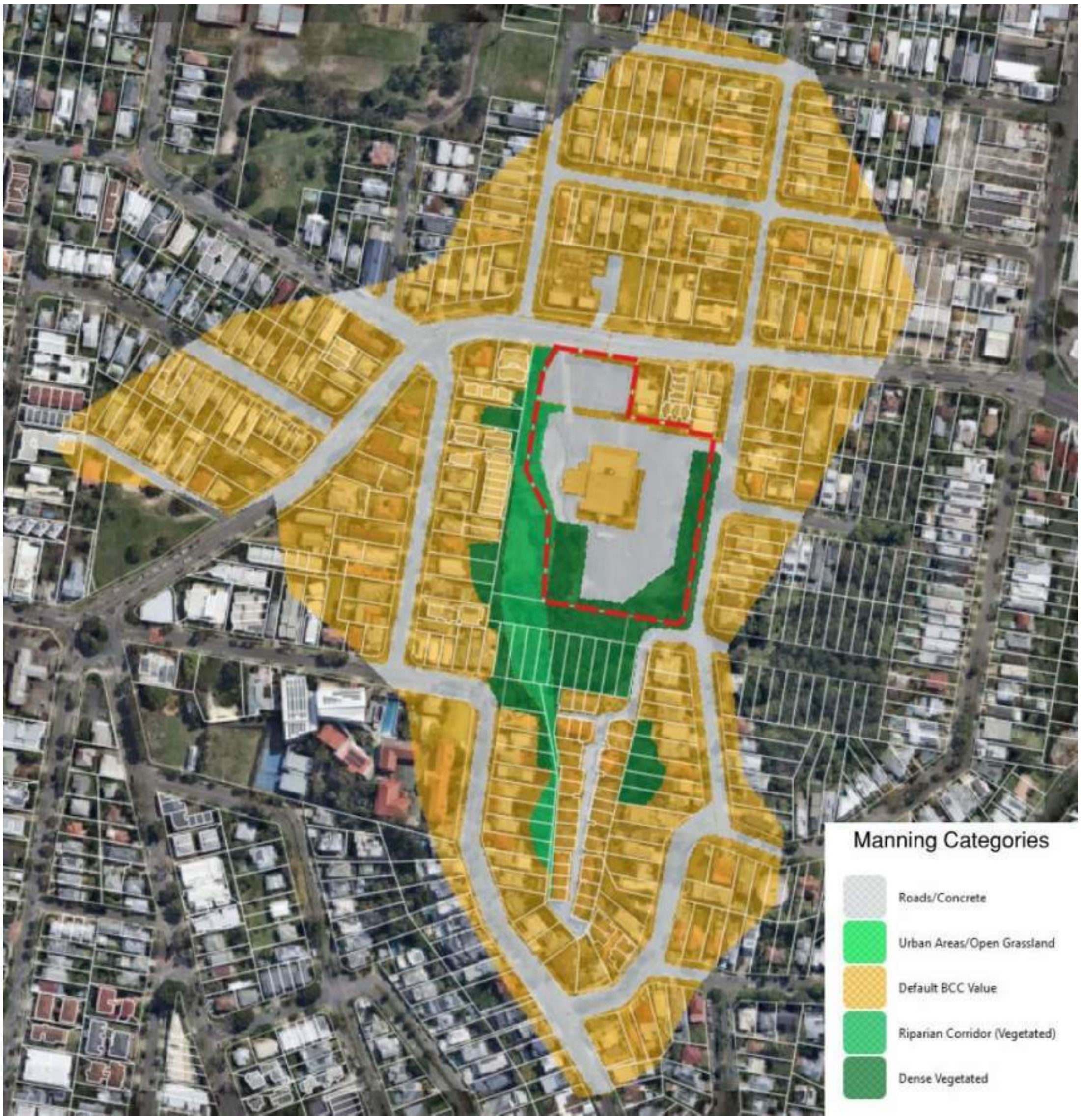

Figure 10 – Pre-Development Manning's n Roughness Mapping

Figure 11 – Post-Development Manning's n Roughness Mapping

3.3.3 Tailwater Boundary Conditions

To ensure the use of appropriate tailwater boundary conditions in the hydraulic model for design event analysis, and given the downstream regions of the site are much lower and therefore little influence on the area of interest, the peak 1% AEP BCC Central overland peak flood level has been adopted as a static tailwater condition for the downstream boundary condition.

To ensure the proposed site can be independently assessed from localised effects at the downstream model boundary, the flood assessment area has been extended sufficiently downstream from the site to include a longer reach of the tributary.

3.3.4 Critical Storm Duration

As noted, a set of ensemble and duration events were run to determine the median temporal patterns and the critical duration/s in the vicinity of the site.

It had been determined that the channel and road adjacent to the site contained multiple critical durations across the 2% and 1% AEP events, and therefore the final detailed runs had adopted the following median temporal pattern storm durations: 10min, 15min, 20min and 25min. Typically, it was found that the upstream side of the channel adjacent to the site was critical for the 10 and 15min durations, whereas Lytton Road's critical durations were in the later duration range.

Albeit this, all durations were run and a peak of peaks result was adopted for both pre and post-development scenarios to determine peak flood characteristics and impacts as a result of the proposed development.

3.4 Hydraulic Model Results

3.4.1 Pre-Developed Scenario

The results obtained for the pre-development case are presented in Appendix 5 for the 2% design flood events.

- 2% AEP Event - Peak Water Surface Levels, Pre-Dev Case
- 2% AEP Event – Peak Flood Depths, Pre-Dev Case
- 2% AEP Event – Peak Flood Velocity, Pre-Dev Case
- 2% AEP Event – Peak Flood Depth-Velocity Product, Pre-Dev Case

The following brief observations are made in relation to existing catchment conditions during the 2% AEP peak flood event:

- The depth of water along Lytton Road reaches a peak of approximately 390mm within the kerb in front of the overland flood channel, however it typically has an average peak of around 300mm at the road frontage. The road frontage also exhibits a peak Depth-Velocity Hazard (DV) of up to 0.6m2/s, as peak velocities can reach up to 2.26m/s. It is noted that albeit these higher flood risks, it is unlikely these access points will be used during the very short high hazard inundation time. Accordingly, signage should be provided to inform occupants of the site.
- The peak flood characteristics within the channel reach up to a peak DV of 1.22m2/s and a peak velocity of 1.32m/s, however this is to be anticipated given the typical channel cross-section and slope of channel. Accordingly, access should be restricted to this channel at all times and appropriate signage to be erected around the channel, given the short warning times for peak flooding.
- The site itself is almost entirely flood free, given the steep topographies through the site, and the existing imperviousness, which rapidly discharge surface water into the channel and road.

3.4.2 Post-Developed Scenario

The flood impact due to the proposed development was assessed for the 2% AEP flood event in accordance with BCC's Flood Overlay Code requirements.

The results obtained for the post-developed case are presented in Appendix 6 and as follows:

- 2% AEP Event - Peak Water Surface Levels, Post-Dev Case
- 2% AEP Event – Peak Flood Depths, Post-Dev Case
- 2% AEP Event – Peak Flood Velocity, Post-Dev Case
- 2% AEP Event – Peak Flood Depth-Velocity Product, Post-Dev Case
- 2% AEP Event – Peak Flood Impacts, Post-Dev vs Pre-Dev Case

It is highlighted these post-development maps contain concept plan layouts, however there are no fundamental changes to the townhouse blocks or access points in the latest detailed Architectural Plans attached in Appendix 1.

With reference to the provided flood impact maps, it can be seen that the proposed development is unlikely to create material impacts to properties located elsewhere within the study catchment. The following brief observations are made in relation to the post-development impacts during the 2% AEP peak flood event:

- A minor impact of up to 19mm is exhibited just upstream of the possible columns, which have been modelled conservatively, however these impacts are contained within the channel, and only extend up less than 10m within the channel, therefore deemed negligible.
- Approximately 60m in length of channel within the downstream region adjacent to the site demonstrates an average impact of 10mm, however these are deemed negligible impacts given the peak flood depths in this region are on average 900mm. Furthermore, this is based off a post-development scenario that discharges all runoff directly into the channel, and does not take into account onsite storage factors or pit and pipe volume storage. Therefore, this impact is deemed negligible.
- Lytton Road is demonstrated to contain a maximum peak level impact of approximately 15mm for a total of 30m of road frontage to the site, however this is based on the conservative modelling approach as noted in the dot point above. Accordingly, these impacts are deemed negligible given the existing flooding conditions at the site frontage during a peak overland flood event (which is a short duration event), and also given the onsite storage ability has not been considered at this conceptual phase. Accordingly, these demonstrated impacts are deemed negligible.

For additional reference, Figure 12 below illustrates the 2% AEP flood levels with peak level contours under post-developed site conditions. Overall it can be seen that the site has low risk to flood inundation given the channel profile adjacent to the site which conveys the catchment's peak overland flow.

However, it is noted that there is a flood risk present to site users at the access points, and therefore flood risk management principles should be considered via deterrent methods such as flood risk signage and fencing off regions susceptible to higher flood risk (ie. Overland flood channel).

The site has also been assessed against the 1% AEP peak flood event, noting that the site will contain appropriate freeboards against this peak event as well.

The image below in Figure 12 is based off the concept plans, however the overall updated detailed layout has been retained as per below, and is fundamentally the same.

Figure 12 – 2% AEP Flood Levels – Post-Development Case w/ Proposed Concept Plan

4 FLOOD PLANNING ASSESSMENT

4.1 BCC Flood Overlay Code

As noted in Figure 2, the site is subject to the BCC overland flood mapping, and therefore triggers an assessment against the Performance Outcomes within the BCC Flood Overlay Code.

Responses to the Flood Overlay Code have been provided in Appendix 7.

4.1.1 Minimum Flood Levels

The peak 2% AEP peak flood levels (peak of peaks) have been adopted to confirm to the architect the peak flood levels at particular chainages across the site.

Given the rapidly varying peak flood levels along the channels chainage as demonstrated in Figure 12, the minimum flood levels are based off a chainage peak level plus freeboard as per the tables below.

Albeit this, the basement carparking entry level and proposed transformer at the site frontage is deemed to contain a static level, given the one entry point into the site. It is noted the basement carparking minimum level is easily achieved, given the entrance ramps up into the basement carpark.

The basement carparking minimum level requirement is RL 7.00mAHD, and the transformer minimum level requirement located at the north-eastern corner of the site is RL 7.10mAHD.

Minimum floor height requirements for proposed buildings were assessed against Council's City Plan 2014 flood immunity standards applicable to the building classification types in the Building Code of Australia (BCA). The following tables in the Flood Overlay Code define the minimum development level for a range of uses.

- Table 8.2.11.3.D Flood planning categories for development types
- Table 8.2.11.3.L Categories of flood planning levels

Given the intended building type within the proposed development (BCA classes 1a & 2), the minimum level of flood immunity shall be in accordance with tables 8.2.11.3.D and 8.2.11.3.L in the Flood Overlay Code. Table 3 below lists the relevant flood planning levels applicable to the proposed site.

BCA Building Class	Flooding Source (as identified from BCC's Flood Overlay mapping)	Minimum Design Standard	
Class 1a + Class 2	Overland Flow Path	Habitable Floor Level	2% AEP flood level + 500mm
		Non-habitable room including patio and courtyard	2% AEP flood level + 300mm
		Parking located in the building undercroft of a multiple dwelling	2% AEP flood level
		Carport, unroofed car park; vehicular manoeuvring area	2% AEP flood level
		Essential electrical services of a Class 2 or Class 3 building only	2% AEP flood level + 500mm
		Basement parking entry	2% AEP flood level + 300mm

Table 3 – Minimum Planning Levels Adopted for the Proposed Development

Additionally, any proposed building which is to be suspended over the existing overland flood channel, requires the following minimum clearance requirement shown below in Table 4.

An extract of the acceptable undercroft conditions, assuming no excavation over the existing channel, has been illustrated below in Figure 13 (derived from Figure I of the BCC Flood Planning Scheme Policy), to provide clarity of design outcomes in accordance with the BCC Flood Overlay Code.

Flooding Source (as identified from BCC's Flood Overlay mapping)	Minimum Clearance Requirement
Overland flow – Low Hydraulic Hazard (DV <0.6 m^2/s and depth <600mm in 2% AEP flood event)	Lowest floor level is to be 1.5m above the highest ground elevation in undercroft area[1], with at least 50% of undercroft area meeting 1.5m height requirement
Overland flow – High Hydraulic Hazard (DV >0.6 m2/s or depth >600mm in 2% AEP flood event)	Lowest floor level is to be 2.5m above the highest ground elevation in undercroft area OR >2m if providing additional excavated area under the undercroft to increase conveyance

Table 4 – BCC Minimum Undercroft Clearances as applicable to the site.

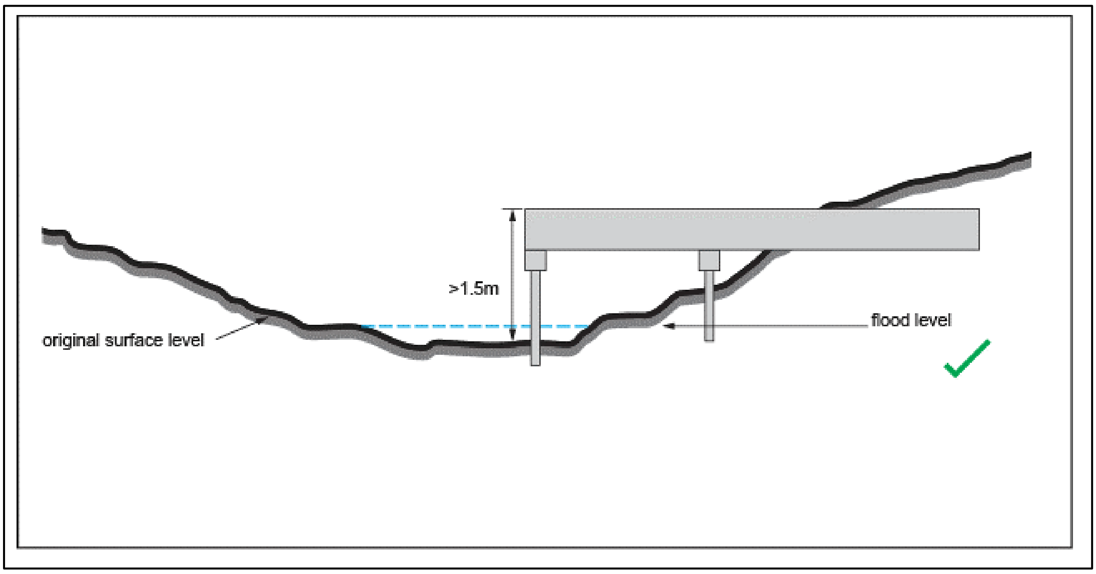

Figure 13 – Undercroft Cross Section – Extract from Figure I of BCC Flood PSP

4.1.2 Flood Risk Assessment

As per the TUFLOW model results, the existing overland flood channel and the Lytton Road entrance have demonstrated peak 2% AEP peak flood Depth-Velocity products greater than $0.4m^2/s$, and peak flood depths that can be deemed as being unsafe. Therefore, the following items are recommended for the development to reduce flood risks to personnel within the site:

- Signage to be provided at the site entrance and throughout the elevated western pedestrian entrance path notifying occupants that road access and pedestrian access may be subject to flooding and therefore caution should be taken when entering or leaving the site during flood events. It is noted the risks of vehicular damage risks are low, given the chance of occurrence is low and also given there is a short peak time of inundation;
- Signage to be provided adjacent to the channel to notify occupants of the site that flooding occurs within the channel, and to restrict access to this region particularly during rain events;
- Fencing around channel perimeter, to restrict unauthorised access to the channel; and
- Providing information to the occupants of the site regarding the potential flood risks present on the perimeters of the site, as a precautionary measure.

5 CONCLUSION

To assess the impact of the proposed development on flooding parameters within the wider catchment, a new One-Dimensional (1D) and Two-Dimensional (2D) coupled TUFLOW model was developed.

In order to provide the necessary flood immunities to the proposed site and to prevent external flood impacts, the following measures are proposed as part of the proposed development:

1. The proposed development will be designed to adopt the minimum flood level requirements for the buildings and access points into the site. The 2% AEP peak overland flooding is typically contained in the channel in the pre and post-development scenarios, and therefore no earthworks are proposed in the channel, to minimise impacts;
2. Access ramp and basement parking within the site will be located higher than the peak 2% AEP overland flood levels at the site frontage, and therefore flood immunity is achieved. Albeit this, there is an existing high flood risk (though low chance of occurrence) present at the site access point to vehicles and pedestrians, and therefore this should be communicated to the occupants of the site (responsibility of the site owners and operators); and
3. Minimising access to the existing overland flood channel, as well as providing appropriate signage at the site access and overland channel perimeter to ensure risks are understood by all stakeholders and occupants of the site.

The results presented in this document show that the proposed development, together with the proposed measures as above, would not create a material worsening on properties located within the local study catchment, and would assist in reducing flood risks to occupants within the site.

6 LIMITATIONS OF REPORT

MPN have prepared this report for the proposed mixed residential development at 91 Lytton Road & 57 Andrew Street, Balmoral in accordance with MPN's proposal to Skyhold Project 7 Pty Ltd. This report is provided for the exclusive use of Skyhold Project 7 Pty Ltd for this specific project and its requirements. It should not be used or relied upon by a third party and MPN accepts no responsibility for the use of this report by any party other than Skyhold Project 7 Pty Ltd.