Sunshine Coast COUNCIL

Guideline for improving flood resilience for new development

A selection of case studies

www.sunshinecoast.qld.gov.au
mail@sunshinecoast.qld.gov.au
T 07 5475 7272 **F** 07 5475 7277
Locked Bag 72 Sunshine Coast Mail Centre Qld 4560

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This is a technical guidelinethat uses generally accepted industry standard definitions for stormwater and flooding terminology.

This document includes contributions from the following organisations:

HydraLogic
WATER INTELLIGENCE

Blackburne Jackson Design
Architecture | Landscape | Interiors

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Contents

Executive Summary

This flood resilience implementation guideline has been prepared to assist council officers and potential developers with gaining an understanding of possible design options that respond to inundation scenarios. This guideline has been prepared in response to recent flood events and to support the Sunshine Coast Planning Scheme 2014 that regulates new development.

This document is intended to demonstrate that the requirements of the Sunshine Coast Planning Scheme 2014 are practical for new development and acceptable outcomes are possible. This guideline focuses on four nominated development case study sites which include a dual occupancy (duplex) development, a multi-unit residential development, a mixed use (high rise) development and a commercial development. The nominated case study sites are actual sites which have been the subject of a development application and assessment process in the past. The specific location of each case study site is not revealed within the guideline however, the response options prepared as part of this guideline have benefitted from having actual development sites with genuine site constraints and risks of inundation.

This guideline presents a collection of design responses for the nominated development sites. The response options are offered as a reference guide for possible measures which increase the resilience of the occupants and the buildings to consequences of inundation from flooding or stormwater.

This document is not presented as a prescriptive guide for any situation, instead relying on industry to innovate and find equally effective solutions for the given circumstances of individual sites. Furthermore, the response options presented are not intended to be exclusive for each style of development. Designers are encouraged to mix and match possible responses to suit each development case and site conditions.

The design response options presented in this guideline are not to be considered as a ‘deemed to comply’ solution for any new development. For each new development a risk assessment will need to be undertaken and the proposal will be considered on its own merits. However, guidance may be taken from this document on the features identified and responses offered which may be relevant for consideration in the design phase of the new development.

The response options for each case study site are discussed and presented using graphic visualisations, annotated with key design features and supplemented with less formal commentary gathered throughout the process of preparing the guideline.

Responding to the anticipated risks of climate change is not the focus of this guideline. The requirement for flood resilience in design is a concept that will benefit future communities and development. It is seen as a planning tool that has the potential to minimise the consequences of flood inundation above the Defined Flood Event. This is important for the Sunshine Coast because it will give communities the opportunity to be better prepared for flood events with implications for affordable insurance.

Guideline Synopsis

HydraLogic in collaboration with Blackburne Jackson Design, Climate Planning and DLA Piper (the Project Team) were engaged by the Sunshine Coast Council to prepare a flood resilience implementation guideline for a selection of case study development sites located within areas anticipated to be affected by a range of possible future inundation scenarios.

The nominated case study sites are actual sites which have been the subject of a past development application and assessment process. The specific location of each case study site is not revealed within the guidelines. However, the response options prepared as part of this guideline have benefitted from having actual development sites with genuine site constraints and risk of inundation. The development scenarios presented in this guideline for each of the case study sites do not reflect the actual developments proposed within the development applications that identified these sites.

The guideline has been prepared to assist Council officers and potential developers with gaining an understanding of possible design options that respond to inundation scenarios. This guideline has been prepared to support the Sunshine Coast Planning Scheme 2014 that regulates new development.

The planning scheme intent is to avoid flood inundation of floor levels for events less than or equal to the defined flood event. Floods greater than the defined flood event remain possible whilst being less likely. The risk of flooding above the defined flood event is a residual flood risk. These guidelines address the residual flood risk by offering urban design solutions which seek to further minimise the consequences of flooding should an event larger than the defined flood event occur.

The response options presented in the guideline have not been prepared as an instruction of what to do but more as an example of what could be done for sites with similar characteristics. Some of the design response options, whilst generally practicable, will introduce other challenges to be addressed within an urban environment. Where possible, some of these challenges have been identified and are presented as annotations alongside the more formal outline of the features presented in each plan.

Each of the design response options have attempted to address and/or capture key concerns expressed by council stakeholders during the consultative process that was undertaken throughout the preparation of the guideline.

The guideline focusses on response options for each case study site related to inundation from flooding and stormwater. In some cases the design options presented may also contribute to addressing other parameters associated with extreme weather, such as peak wind speeds and extreme temperatures however these factors have not been specifically or intentionally addressed in this scope.

The Structure of the Guideline

The guideline documents a brief summary of the parameters pertaining to flood inundation and the potential implications for the case study sites. The key considerations and inundation characteristics for the case study sites are also discussed.

With consideration of the adopted inundation characteristics for the case study sites, the guideline then presents an outline of the design philosophy that has been applied to derive the response options presented.

Finally, the response options for each case study site are discussed and presented using graphic visualisations annotated with key design features and supplemented with less formal commentary gathered throughout the process of preparing the guideline.

This guideline has been prepared to support the Sunshine Coast Planning Scheme 2014 that regulates new development.

The Need for Flood Resilience on the Sunshine Coast

Recent flood events in Queensland over the last few years have demonstrated the need for flood resilience in building design and new developments on the Sunshine Coast. Flood resilience will provide the Sunshine Coast with the opportunity to better plan for a stronger, more flood responsive community, economy and environment. The cost to the region's economy, environment and communities are unsustainable if floods of these magnitudes are to occur on a more frequent basis in the future.

The need for flood resilience on the Sunshine Coast can best be described through an understanding of the recent Queensland state-wide flooding events of December 2010/January 2011 and January 2013 and the locally significant floods which occurred on the Sunshine Coast in early 2012, affecting the popular and highly populated suburbs of Mooloolaba, Maroochydore, Alexandra Headlands, Buddina and Warana.

The Queensland Government responded to the scale of the December 2010/January 2011 flooding events by establishing the Queensland Flood Commission of Inquiry (QFCoI) on the 17 January 2011. The QFCoI released two reports, an interim report and a final report. The interim report was published on 1 August 2011 and included some 165 recommendations on the subjects of flood preparedness and dam operation. The final report from the QFCoI, published on 16 March 2012 included an additional 177 recommendations across a range of topics including land use planning, building controls, emergency management, mining and insurance. The Sunshine Coast Council is directly responsible for complying with a number of these recommendations particularly in the areas of land use planning, building controls and emergency management.

On the 19 January 2011, the formation of the Queensland Reconstruction Authority (QRA) was announced, with the Authority formally established on 21 February 2011. The Authority was established by the Queensland Government to decide priority for rebuilding works of affected communities with a focus on delivering value for money and effective governance, to ensure public money was/is being spent where it is needed most (QRA, 11-12 annual report). Key outputs from the QRA relevant to the Sunshine Coast Council included the 2011-2012 release of a two-part guideline Planning for Stronger, More Resilient Floodplains.

State Planning Policy (July 2014) is a key component of Queensland's land use planning system. The State Planning Policy (SPP) defines the Queensland government's policies about matters of state interest in land use planning and development. Local government must consider and integrate these interests when assessing development applications and preparing a new planning scheme. The SPP addresses natural hazards including flooding and coastal hazards. The recent flooding events have also impacted on insurers and the affordability of insurance to property owners, with some property owners either no longer able to obtain insurance or insurance is at an unreasonable cost.

The Sunshine Coast Council understands that it also has a role to play in ensuring flood resilience within its region minimising the effects of flooding on its communities, economy and environment and one avenue to achieve this is by providing guidance on appropriate planning, development and building frameworks.

The 2010/11 and 2013 Queensland Floods

The recent December 2010/January 2011 floods saw more than 78% of the state flood affected and declared a disaster zone. This equated to some 2.5 million people being affected while some 29,000 homes and businesses which suffered some form of inundation. Thirty-three people died in the floods and three remain missing. The cost of flooding was estimated to be in excess of $5 billion by the Queensland Reconstruction Authority (QFCoI, p32, final report).

The Sunshine Coast experienced two significant flood events in 2012 both of which demonstrated a clear need for a flood resilient Sunshine Coast. The first flood event occurred on the 24th February 2012, affecting the towns[1] of Cooroy, Cooran, Pomona and Tewantin, where rainfalls of up to 182 mm in 1 hour were recorded. Houses and businesses were damaged from flash flooding, roads were closed, the bridge at Six Mile Creek Cooroy was destroyed and the small town of Cooran was isolated for days. The swift water rescue teams from Queensland Fire and Rescue Service carried out a number of rescues, the main rail line was washed out and cars were swept away.

On the 22nd March 2012, gauges along the coast between Maroochydore and Warana recorded in excess of 200 mm in 6 hours, including 351 mm at Parrearra Weir. Across the five worst affected suburbs of Mooloolaba, Maroochydore, Alexandra Headland, Buddina and Warana, some 320 properties (homes and businesses) reported inundation. The swift water rescue teams from Queensland Fire and Rescue Service assisted in the evacuation of a Mooloolaba child care centre and office workers at Maroochydore, while some residents also required evacuation in Buddina and Warana. With many roads inundated by the time peak hour traffic occurred, many drivers had no option but to abandon their cars on roads, footpaths and centre median strips. Many basement car parks also flooded. The flood event which occurred on the Thursday afternoon also coincided with participants arriving for the start of the annual Mooloolaba Triathlon Festival on the following day. Council and affected businesses worked non-stop on Friday to ensure the popular Mooloolaba strip was ready for business on the following Saturday and Sunday, giving business the opportunity to maximise their commercial opportunities over the busy weekend. The financial benefit of the Mooloolaba Triathlon Festival to the Sunshine Coast is estimated to be some $25 million of which $15 million is injected directly into the community through accommodation, food and retail (Sunshine Coast Daily, 26 March 2012).

In January 2013, Tropical Cyclone Oswald crossed the western coast of Cape York and tracked down the Queensland coast as a low pressure system over the following seven days, before crossing south into New South Wales and affecting 54 local government regions in its path. The ex-Tropical Cyclone Oswald had a devastating effect on the City of Bundaberg with more than 2,000 residents evacuated in the region of which 1,000 were by emergency airlift. Over 4,000 properties were damaged across the state with more than 2,000 deemed uninhabitable. Across the state there was significant damage to crops and livestock production with coal mines, refineries and ports disrupted by the rain, flooding and rail closures. Six people died as a consequence of the weather event. Fifty-nine per cent of marine turtle nests at Mon Repos nesting area and an estimated 46,000 eggs were lost. At 30 January 2013, the Insurance Council of Australia reported insurance losses of $187 million and this was expected to quickly increase (QRA, p4-5, QLD 2013 Flood Recovery Plan). Initial costs of the floods were estimated to be at $2.4 billion by the Premier Campbell Newman (Sunshine Coast Daily, 12 February 2013).

Given that future climate projections indicate that floods of these magnitudes or greater are likely to occur more frequently in the future, council needs to provide the region with the opportunity to be more flood resilient, planning for a stronger more responsive community, economy and environment. The three flood examples above clearly demonstrate that the Sunshine Coast cannot afford the loss of life, social consequences or costs to the community by not being prepared for such flood events.

[1] These towns were part of Sunshine Coast Council at the time. They are now part of Noosa Shire Council.

The Queensland Floods Commission of Inquiry

The Queensland Government responded to the scale of the December 2010/January 2011 flooding events by establishing the Queensland Flood Commission of Inquiry (QFCoI) on the 17 January 2011. The terms of reference for the Commission were extensive and included a review of:

(a) the preparation and planning by federal, state and local governments; emergency services and the community for the 2010/2011 floods in Queensland

(b) the performance of private insurers in meeting their claims responsibilities

(c) all aspects of the response to the 2010/2011 flood events, particularly measures taken to inform the community and measures to protect life and private and public property, including:

- immediate management, response and recovery
- resourcing, overall coordination and deployment of personnel and equipment
- adequacy of equipment and communications systems
- the adequacy of the community's response

(d) the measures to manage the supply of essential services such as power, water and communications during the 2010/2011 flood events

(e) adequacy of forecasts and early warning systems particularly as they related to the flooding events in Toowoomba, and the Lockyer and Brisbane Valleys

(f) implementation of the systems operation plans for dams across the state and in particular the Wivenhoe and Somerset release strategy and an assessment of compliance with, and the suitability of the operational procedures relating to flood mitigation and dam safety

(g) all aspects of land use planning through local and regional planning systems to minimise infrastructure and property impacts from floods

(h) in undertaking its inquiries, the Commission was required to:

- take into account the regional and geographic differences across affected communities
- seek public submissions and hold public hearings in affected communities

The Commission released its interim report on 1 August 2011, with 165 recommendations on matters associated with flood preparedness and dam operation. The publication of the interim report was intended to enable early recommendations to be implemented before the 2012 wet season.

The final report from the QFCoI, published on 16 March 2012, provided an additional 177 recommendations across a range of topics including land use planning, building controls, emergency management, mining and insurance (QRA, 2011-12 annual report,p8). The Sunshine Coast Council is directly responsible for complying with 44 of these recommendations particularly in the areas of land use planning, building controls and emergency management.

One key recommendation of particular note to council is that floods larger than 1% AEP can happen and consequently should be planned for to build flood resilience into the region.

The Queensland Reconstruction Authority

In response to the disaster events of 2010-2011, the Queensland Government formally established the Queensland Reconstruction Authority (The Authority) on 21 February 2011, under the Queensland Reconstruction Act 2011.

The Authority was established to decide priority for rebuilding works of affected communities with a focus on delivering value for money and effective governance, to ensure public money was/is being spent where it is needed most. The Authority is taking the lead on five recommendations from the QFCoI that fall within the categories of flood studies for urban areas, model flood planning controls and publication of flood information. The Authority is providing support for 30 other recommendations being led by other agencies (QRA, 2011-12 annual report).

A key output from the QRA relevant to the Sunshine Coast Council included the 2011-2012 release of a two-part guideline Planning for Stronger, More Resilient Floodplains. Part 1 provided interim measures to support floodplain management in development assessment processes which were generally used by low growth councils (ie not the Sunshine Coast Council). Part 2 included guidance on undertaking flood investigations, land use strategies for development in existing infill and broad hectare areas and example Queensland Planning Provision-compliant planning scheme provisions developed from the land use strategies (QRA, Part 2, p3).

For the Sunshine Coast Council, Part 2 of Planning for Stronger, More Resilient Floodplains was of particular importance. This document provided methods for considering a broad range of floods during the flood modelling, flood management, land use planning and development assessment process. This document highlighted that flood risk is the product of flood likelihood and flood consequence, and therefore flood risk can be managed by controlling flood consequence (damaged) through better planning.

Risk = Likelihood x Consequences

The State Planning Policy

The State Planning Policy (July 2014) is a key component of Queensland's land use planning system. The State Planning Policy (SPP) defines the Queensland government's policies about matters of state interest in land use planning and development. Local government must consider and integrate these interests when assessing development applications and when making or amending a planning scheme.

The SPP includes the theme 'natural hazards, risk and resilence' as a state intetest. The policy states, *"The risks associated with natural hazards are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards."* The SPP details how planning schemes are to appropriately integrate this state interest for all natural hazards (eg flood, bushfire, landslide and coastal hazards including erosion prone areas).

It is also highlighted in the SPP that, *"Land use planning provisions are one component of an integrated disaster management strategy. Land use planning provisions are required to work in conjunction with other risk management measures including building controls, mitigation infrastructure, early warning systems, community awareness and disaster management."*

The Sunshine Coast Planning Scheme 2014 was prepared in accordance with the previous State Planning Policy (December 2013) and appropriately reflects the natural hazard aspects of the SPP.

The Impacts on Flood Insurers and Insurance Premiums

The recent flood events have also impacted on insurers and the affordability of insurance to property owners, with some property owners no longer able to obtain insurance or insurance at a reasonable cost. Furthermore, Flood Insurers are also required to prove their viability to their creditors indicating the risks and potential costs they are insuring. Through better flood modelling, flood management, land use planning and development assessment process, the insurance industry has the potential to benefit from lower risks and this has a flow-on effect to insurance premium accessibility and affordability.

The Role of Sunshine Coast Council to Ensure a Flood Resilient Community

The risk of flooding from flash floods, riverine floods and storm tides exists within many Sunshine Coast communities. Adopting appropriate responses to protect people and property, preserve local lifestyles, provide confidence to investors and provide flood resilience over the long term are key Council priorities.

There is an expectation that governments at all levels will act to protect the community from disaster and that appropriate information will be supplied to the community in order that the nature and extent of risk is known and appropriate action taken to ameliorate it.

Local governments have a range of responsibilities with respect to flood risk management and emergency response, including:

- preparation of flood risk studies including accurate mapping of design floods
- preparation and implementation of flood mitigation strategies
- incorporating land use planning controls in relation to flooding into Council's planning scheme in accordance with the *Sustainable Planning Act 2009* and the State Planning Policy (for example flood hazard overlay maps, a flood hazard overlay code and and a planning scheme policy)
- assessing development proposals to determine their suitability in respect to appropriate levels of flood immunity
- coordination of disaster management in the local area
- retaining an emergency and disaster response capability
- preparation of a disaster management plan for its area and reviewing the plan's effectiveness at least once a year under the Disaster Management Act 2003
- informing the community of flood risk by way of regional flood mapping to facilitate emergency preparedness
- provision of locally specific information to the community including property owners and business owners, about flood risks and other flood information held by council.

The Sunshine Coast Council has developed this guideline in response to the:

- Queensland flood events of December 2010/January 2011 and January 2013 and the Sunshine Coast flood events of early 2012
- recommendations of the QFCoI
- guidance provided by the QRA through the publication of the guidelines Planning for Stronger, More Resilient Floodplains
- feedback from council's draft Sunshine Coast Planning Scheme (2012) community consultation process
- need from insurers for council to provide flood resilience guidance
- feedback from the Insurance Council of Australia that South-East Queensland Councils should be ensuring that new communities are built to better standards

This guideline has been prepared to support the Sunshine Coast Planning Scheme 2014 that regulates new development. The planning scheme requires new development to address flooding issues and includes flood hazard overlay maps, the Flood hazard overlay code and the Planning Scheme Policy for the flood hazard overlay code.

Council understands that existing flood risks are expected to occur in the future with greater frequency given future climate predictions. Flood resilience is about managing consequences and council has developed this guideline to provide coarse guidance on how flood resilience may be achieved in the planning and building design of future developments.

Projected Inundation for the Case Study Sites

Detailed flood mapping was undertaken for each of the nominated case study sites to determine the extent of inundation under future climate conditions (ie the year 2100, which is the planning period for climate change in the Sunshine Coast Planning Scheme 2014). A projected mean sea level rise of 0.8m by 2100 was adopted (in accordance with the definintion of a coastal hazard area in the State Development Assessment Provisions (SDAP).

This value was added to existing estimates of design inundation levels for storm tides and tailwater boundary conditions for riverine flooding. Freshwater riverine flooding also included increased factors for rainfall intensity associated with severe weather events.

For each of the case study sites the anticipated design inundation levels (to 2100 climate conditions) were projected onto a digital elevation model of the surrounding ground surface area derived from Aerial Laser Scanning (ALS). From these projections detailed depths of inundation for a range of inundation scenarios were extracted from key points of each study area to determine depth of inundation over roads accessing each site and depth of inundation over the existing site. The inundation scenarios chosen to inform the design response options were:

Highest Astronomical Tide, 2100 (HAT_{2100}) – This value generally represents the anticipated highest seasonal tide on an annual basis, and hence is anticipated to occur at least once each year. However, numerous other peak tide levels throughout a year would still occur up to this value and hence similar inundation characteristics could be expected on a monthly or weekly basis by 2100. This inundation scenario represented the most frequent potential inundation to influence the case study areas. An assessment of the impact and response to this level and frequency of inundation will generally determine the ongoing functionality of a location in 2100. Inundation from the HAT_{2100} will be predominately salt water and hence may adversely affect vegetation, soils and metallic fixtures.

10% AEP riverine inundation ($Q10_{2100}$) – This value represented the estimated inundation level from a moderate freshwater riverine flood. This event is referred to as having a 10% annual exceedance probability (AEP_{2100}) and hence is expected to have a 1 in 10 chance of occurring in any given year. This event represents a relatively high probability of occurrence and hence responses to this level of inundation should demonstrate a high level of resilience enabling quick recovery and the resumption of normal lifestyles.

1% AEP riverine inundation ($Q100_{2100}$) – This value represented the estimated inundation level from a major to extreme freshwater riverine flood. This event is referred to as having a 1% AEP_{2100} and hence, is expected to have a 1 in 100 chance of occurring in any given year. This event represents a relatively low probability of occurrence and hence responses to this level of inundation should demonstrate a commensurate level of resilience.

1% AEP storm tide inundation (StormTide 100_{2100}) - This value represented the estimated inundation level from a storm tide and also possesses a 1% AEP_{2100}. There is currently insufficient evidence to relate the coincidence of a storm tide with a freshwater riverine flood of the same probability and hence these events are considered independently. For the coastal locations of the case study sites the anticipated inundation level for storm tides will generally be the dominate inundation level.

Probable Maximum Flood (PMF) – This value represents the estimated inundation from a theoretical event which has been derived from optimum atmospheric conditions delivering maximum possible rainfall intensities over critical durations to maximise flooding conditions. For this guideline, the PMF is presented as the anticipated worst case freshwater flooding scenario. Current building design and regulatory standards do not require a measurable response to events in excess of the 1% AEP however, consideration and minimisation of the possible consequences of such events represents responsible planning and design for affected locations.

Whilst minor variations in the inundation depths were evident between each site location there were obvious similarities in characteristics of each inundation scenario. Under HAT_{2100} conditions all sites exhibited road access inundation (generally > 500mm) and site inundation to a slightly lesser extent. Similar conditions existed for $Q10_{2100}$. For the 1% AEP_{2100} storm tide and riverine inundation events significant inundation persisted for all road access (>1.3m) with marginally lower levels (approximately 1.2m) across the sites. Under these conditions minimum habitable design floor levels should be 500mm above this and hence (on average) approximately 1.7m above the existing surface levels. The PMF levels presented an average depth of inundation across all the sites of approximately 2.0m.

Adopted Inundation Characteristics for the Case Study Sites

To demonstrate a variety of possible response options for the different development types associated with each case study site a consistent set of inundation characteristics (depths) were adopted to test and derive designs.

The specifics of the adopted levels (or depths) which have informed the response options in this guideline are not critical to demonstrating the general design principles. The purpose of the guideline is to encourage discussion and consideration of a variety of possible response options that could be applied to other sites which exhibit similar (but not necessarily the same) inundation characteristics.

The adopted inundation characteristics are illustrated on **Figure 1.**

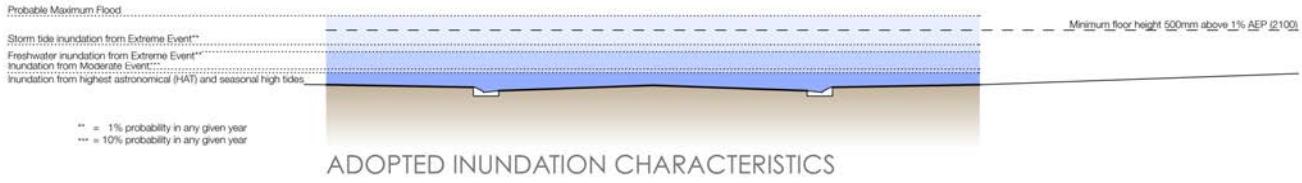


Figure 1 Adopted inundation characteristics

The Design Response Philosophy

A design response philosophy was adopted by the project team to guide and inform the development of possible response options. The design response philosophy reflects a hierarchy of needs which each response sought to address with respect to inundation from flooding and stormwater. Each element of the hierarchy is discussed in the following sections.

Public Safety

Public safety is paramount to flood risk management and was considered as the highest design priority when preparing the response options. The response to public safety focussed upon separating people from the inundation and considered factors such as connectivity between the buildings and the surrounding land, possible isolation for extended periods, evacuation needs and maintaining the function of critical on-site services.

Protection of Hazardous Substances

The mobilisation of dangerous or harmful substances by runoff or flood waters poses a risk to the environment and to the community. Potential pollutants include (but are not limited to) substances such as fuels, oils, solvents, fertilisers, herbicides, sewage and pool chemicals. Many of these are found in typical urban environments. Items such as potential debris from vegetation, building materials or stored equipment were also considered when preparing the response options.

Protection of Assets

Prudent design and placement of buildings and other assets on the site will reduce possible economic loss caused by flood damage or loss of productivity and function. The primary focus of this element of the hierarchy was on the protection of vehicles and other significant personal and commercial items from inundation.

Preservation of Conveyance

Areas of high flood conveyance are important elements of a floodplain where inference and disturbance should be avoided. Interference or encroachment into areas of high flood conveyance may exacerbate flood levels locally or on neighbouring properties. Infrastructure and landscaping exposed to areas of high flood conveyance will also be subject to higher destructive forces and will require either higher design specifications and/or incur greater maintenance and more frequent replacement costs. However, not all parts of the floodplain are actively engaged in conveying flood waters. Areas of high flood conveyance are typically characterised by a combination of flood depth and flow velocity.

Preservation of Storage

Areas of flood storage are important components of a floodplain. Flood storage areas generally have much lower velocities than areas of high conveyance. The presence of flood storage slows the conveyance of flood waters, whilst storage areas fill. Consequently, if flood storage is removed or substantially reduced the volume of the water previously contained within the storage will either be forced downstream adding to the flood wave and peak flood levels, or present an impediment to flood flows and cause higher flood levels in the remaining flood storage area and possibly upstream.

When considering the loss of flood storage on individual lots due to filling or barrier walls the Planning Scheme may require consideration of how the loss of flood storage may directly, indirectly or cumulatively alter the flooding characteristics external to the development site. Cumulative impacts may arise when potential flood storage losses are applied across significant numbers of lots in the broader flood plain. This is further complicated by low density residential zoning where the total amount of associated land is significantly larger than higher density residential, commercial and industrial zones, implying greater potential for impact associated with cumulative loss of flood storage. There is also greater uncertainty associated with the timing of re-development of low density residential properties.

Case Study Sites

Four development types were considered for possible response options to the inundation characteristics described above. Each site and general design considerations that were applied in response to the design philosophy are discussed in the following sections. Features of a response option are generally not repeated throughout all options however combinations of features (via mixing and matching) is expected and encouraged where ever appropriate.

Case Study 1 - Dual Occupancy (Duplex) Site

The dual occupancy (duplex) case study site is characterised by needing to specifically cater for residential living in an urban neighbourhood environment. Four response options are presented in **Figure 2** to **Figure 7.** The following sections discuss these options in general terms with more specific details displayed on the relevant figures.

Elevating the Building (No Site Filling)

In this response option, the principle building is raised to ensure that the minimum habitable floor level is at or above the defined flood event[2] plus the freeboard[3] as required by the planning scheme. This style of response may be used to preserve a flow conveyance across the site and/or to reduce the loss of floodplain storage. For assessable development this option avoids potentially complicated assessments which may be required to evaluate affects of filling.

This design option inherits a vertical separation of the building's living areas to the site ground level which may not be a desirable feature for elderly residents. Visual connections are maintained from the residence to the street and neighbouring properties. Refer to **Figure 2.**

The response includes reference to appropriate material selection for elevations up to the probable maximum flood which may be subject to inundation.

This response also includes a low impermeable perimeter wall to provide immunity to more frequent inundation events. The inclusion of such a wall would negate the flow conveyance and flood storage benefits of the elevated building.

Filling the Site – Mounding and Split Level

In this option, the site area is filled and graded to allow slab on ground construction. The site filling includes fill levels to achieve the minimum habitable floor level and an additional stepped floor profile to elevate a portion of the floor area to be above the PMF. This elevated internal floor area would allow for the temporary relocation of flood sensitive items (electronic equipment, furniture etc) to be above any anticipated flood level. Refer to **Figure 3**.

Internal utilities such as power outlets, communications and sewer fixtures are also shown to be positioned above the PMF.

An emergency evacuation exit is also noted. This evacuation point may service evacuation by air (winch to helicopter) or boat depending upon the circumstances. Some consideration may need to be given to the rooftop design in this area so as not to compromise the safety of the evacuees. This option also includes a full height boundary fence. As per the previous response option the lower portion of this wall is intended to provide some degree of flood immunity to the site, which in this case is also achieved via the filling. In addition to the impermeable lower portion of the wall the panels of the upper/infill sections may act as barriers protecting the site from large floating debris entering and retaining loose items within the site that may have mobilised by flood waters. The permeable fence panels will also enable breezes and ventilation of the site at street level and casual surveillance from yard to street. Refer to **Figure 4**.

[2] Defined flood event (DFE) generally refers to the 1% AEP Flood Event with a planning horizon to the year 2100. The Defined flood event is defined in Schedule 1 Definitions of the Sunshine Coast Planning Scheme 2014.

[3] The Flood hazard overlay code of the Sunshine Coast Planning Scheme 2014, generally requires that the minimum floor level is at least 500mm above the defined flood event (DFE) and the defined storm tide event (DSTE). The critieria for self assessable development differentiates habitable floor levels in the determination of minimum floor level. The critieria for assessable development does not differentiate.

Providing an Upper Level Retreat

The upper level retreat option is shown as an obvious measure of ensuring a flood free refuge and storage area. Market drivers for duplex developments may not favour the additional storey if targeting elderly residents who may desire single level living. Refer to **Figure 5**.

This option also includes a low level boundary wall backfilled by site fill. This wall would allow less frequent inundation events to enter the site and offer the greatest level of connectivity to the street and neighbourhood.

Onsite Car Parking

Enclosed garages are requried to have the same minimum floor levels as for habitable areas. Garages constructed to be water tight with an approved self sealing flood gate may be permitted to have floor levels lower than habitable areas provided that they are sealed to a level equal or greater than the minimum floor level.

Unenclosed car ports may also be permitted to have floor levels lower than habitable areas provided minimum flood immunities and maximum flood depths are achieved[4].

Sealing the Site with a Perimeter Wall

In this response option, a full height (maximum of 1.8m for properties on a major road or else maximum of 1.2m) impermeable boundary wall is used to seal the site from external inundation. In this instance the site could be filled or retained at natural ground level depending upon the design interactions with the building structure. The decision between filling the site and elevating the building on stumps would not need to be made for reasons directly related to flooding. Due to the sealed site, this option includes a site based sump and pump to collect and remove internal drainage. This would need to be positioned at the lowest point in the yard and surfaces graded to direct flows to this point. During periods of localised rainfall (without external flood conditions) free flowing site drainage through the boundary wall may be considered, provided the interallotment drainage requiremnts of QUDM are addressed and backflow prevention can be included or engaged when necessary. Refer to **Figure 6**.

This option also demonstrates the storage of the vehicle above the defined flood level[5]. The driveway gradient and elevation would be similar for all the duplex options however, in the case of the sealed site and additional wall isolating the driveway - where inundation would penetrate up to the external flood level. In this instance, pedestrian access which preserves the integrity of the sealed site is also demonstrated as a possible stairway to an elevated landing which may then lead to the building floor level. Evacuation from the site by boat would be expected to be made possible via the driveway. Refer to **Figure 7**.

Inter-allotment communications and street level observations are likely to be limited for the boundary wall option however this feature may also suit locations near busy roads or high trafficked public areas.

[4] As per QUDM

[5] The Flood hazard overlay code of the Sunshine Coast Planning Scheme 2014, contains requirements for the flood immunity of car parking and manoeuvring areas.

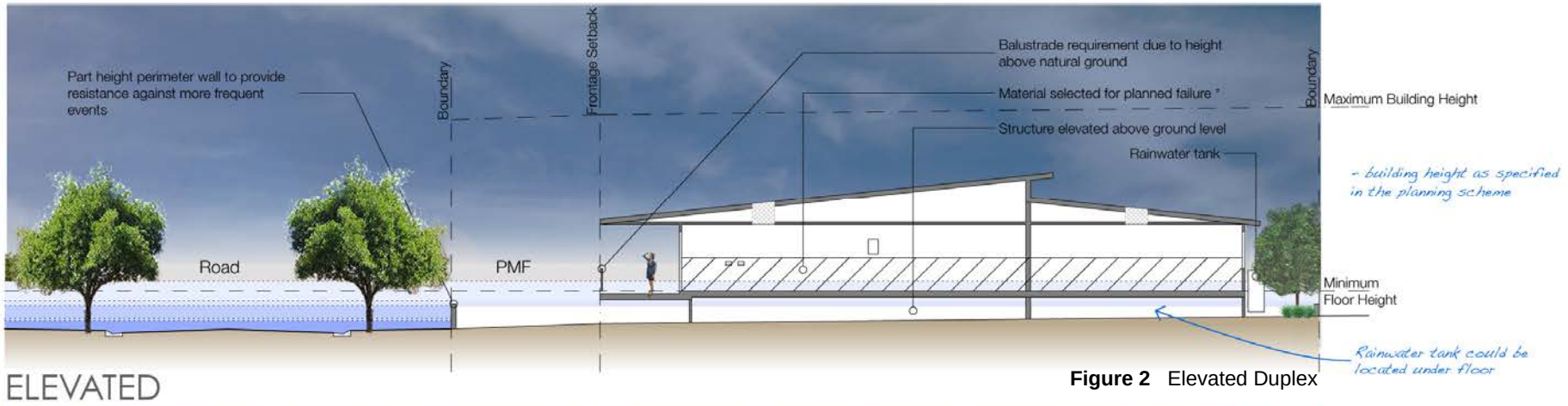


Figure 2 Elevated Duplex

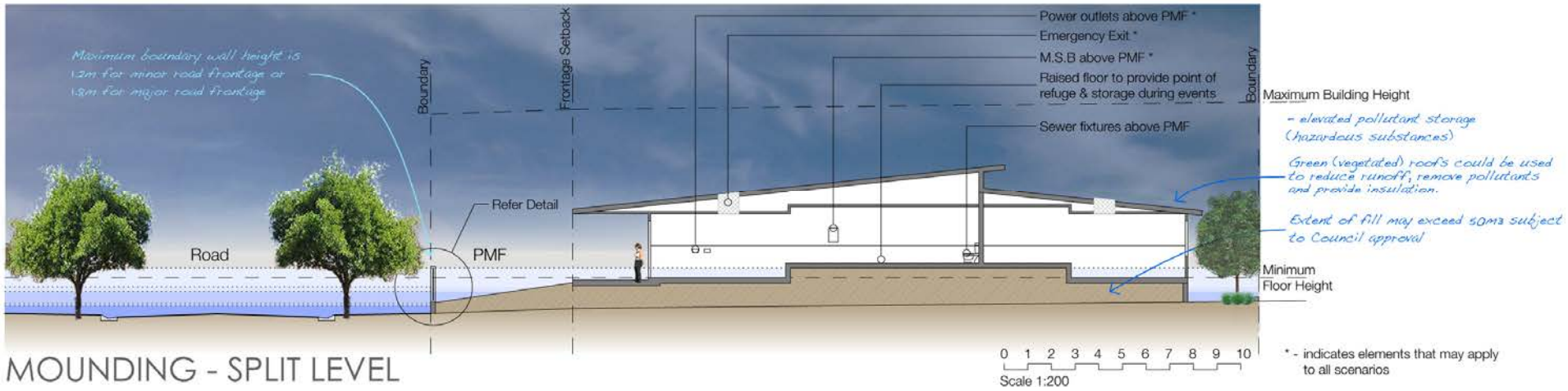


Figure 3 Duplex - Mounding with Split Level

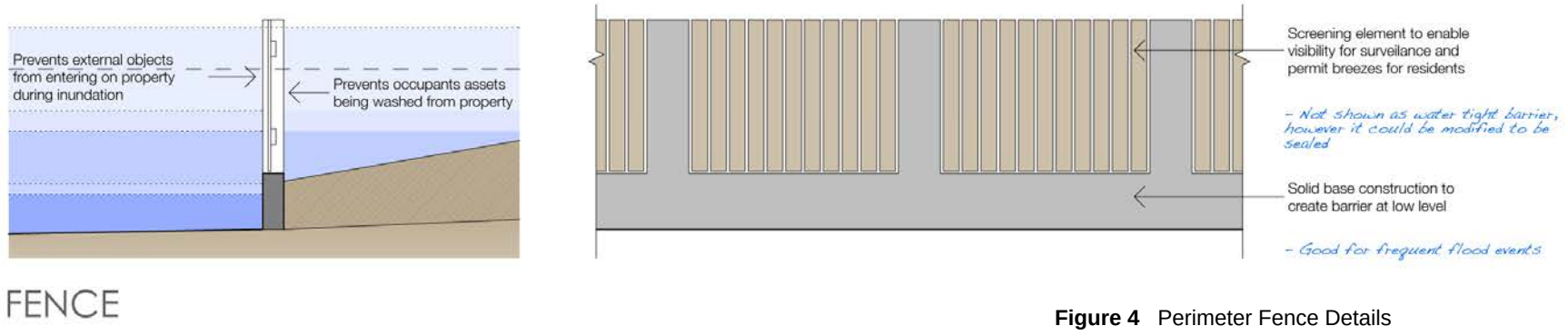


Figure 4 Perimeter Fence Details

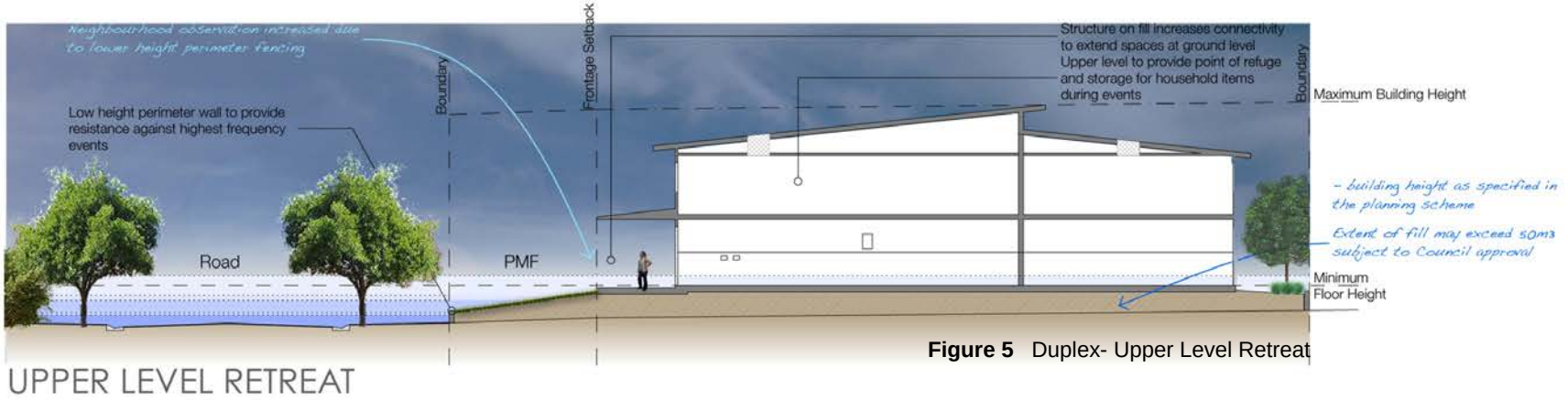


Figure 5 Duplex- Upper Level Retreat

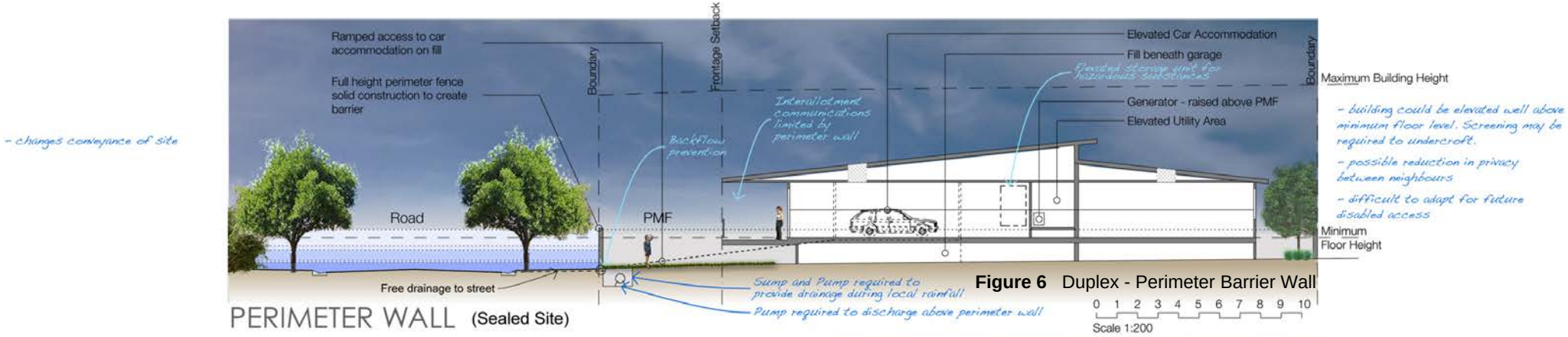


Figure 6 Duplex - Perimeter Barrier Wall

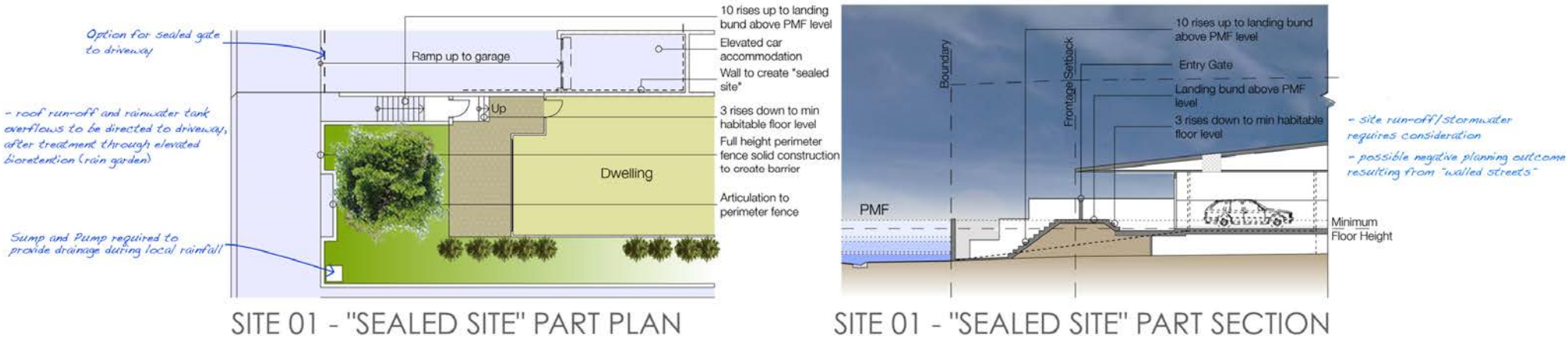


Figure 7 Duplex - Sealed Site Sections

Case Study 2 - Multi-Unit Residential Development

The multi-unit residential development site is characterised as a relatively small unit development located on a narrow parcel of land extending back from the road frontage. Floors for the units are assumed to commence from the first level (above ground) with car parking for residents and visitors provided on ground level. Specific considerations demonstrated via this development option include equitable access for disabled persons and access to the units via a common ground floor lobby. Basement car parking could be incorporated however; this option is covered by other development styles presented in this guideline.

Two design response options are presented in **Figure 8** to **Figure 11**. The following sections discuss these options in general terms with more specific details displayed on the relevant figures.

Sealed Site

The sealed site response includes an impermeable boundary perimeter wall which may require the inclusion of solid (impermeable) gates across the driveway to complete the seal in extreme events. This option includes elevation of the ground floor including the entrance lobby to levels at or above the defined flood level. In this instance the boundary wall (and gate seal) is assumed to provide internal flood immunity up to the PMF level. Refer to **Figure 10**.

The entrance lobby is accessed via disabled compliant pathway from the footpath frontage or from the visitor and resident car parking area. Removable barriers may be required to temporarily seal the site during times of inundation but provide direct access to refuse collection areas and the site frontage entrance.

A common elevated evacuation area is indicated as well as elevated main switch room and critical storage facilities. Evacuation from ground level during times of flood may require consideration of how evacuees are to scale the perimeter wall or gate.

Stepped Site

The stepped site option addresses some of the problems which may arise through sealing the site with a boundary wall. In this option, the ground floor elevation of the residents' car parking is at or above the defined flood level and hence for flood events which may exceed the defined flood level these areas will be inundated. Refer to **Figure 11**. This option also includes a spilt level lobby, allowing access directly from the ground level (during periods of no inundation) and also access to an intermediate lobby area from the visitor car parking level which is elevated above the frequent flood event levels.

Figure 8 Multi-Unit - Sealed site plan

Figure 9 Multi-Unit- Stepped

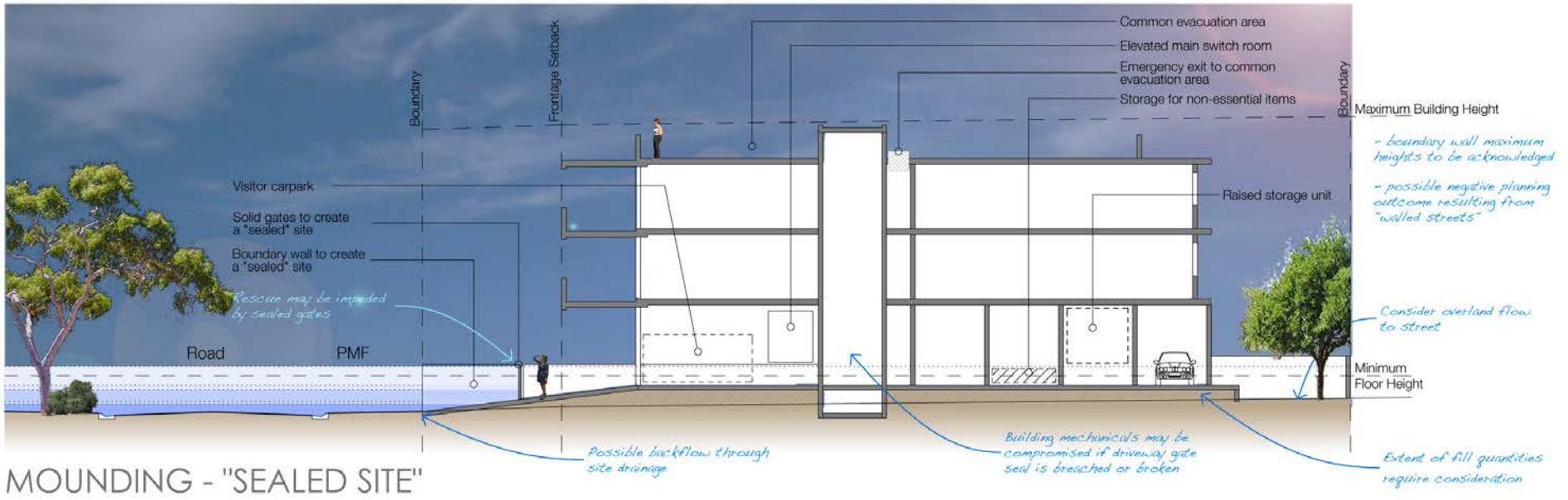


Figure 10 Multi-Unit - Sealed site section

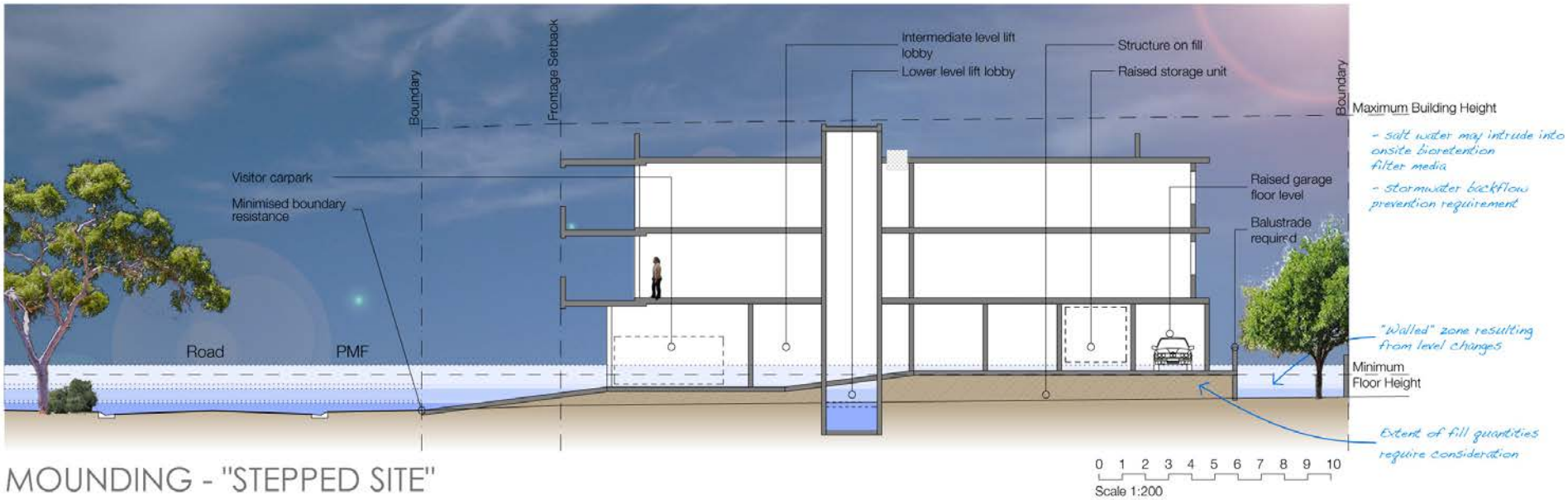


Figure 11 Multi-Unit - Stepped site section

Case Study 3 - Mixed Use (High Rise) Development

The mixed use (high rise) site is characterised by:

- its active commercial/retail frontage;
- requirements to cater for on-site parking for tenants, shoppers and visitors; and
- requirements to maintain connections with the footpath and street. Refer to **Figure 12**.

Principal access to the ground floor from street level is provided by a feature stairway. Equitable disabled access to the active frontage from the street level footpath is presented as ramp requiring (in this instance) approximately 24m to achieve the desired elevation at the appropriate gradient. Refer to **Figure 13**. Temporary (removable) barriers may be required for each of these access points for flood events greater than the defined flood level. Elevation differences between the street level footpath and the ground floor active frontage may introduce a disconnection with traditional street level movements and grade discontinuities along the footpath if not undertaken within an integrated development or streetscape.

Design options presented for this site include a crested driveway entrance to the basement car park. The elevation of the driveway crest is shown to be at the define flood level for the site. An approved flood gate may also be considered to increase the flood immunity of the basement to levels up to the PMF or to reduce driveway gradients for constrained sites.

Fire stairs from the basement will need to incorporate an intermediate landing to prevent flood water from entering the basement via the stairwell. Ventilation shafts to and from the basement car park will also need to be vented above the PMF levels. Refer to **Figure 14**.

Current design standards for pad mounted transformers require them to be accessed from street level and hence this utility may be inundated during frequent inundations events under 2100 conditions.

Achieving minimum floor levels for the ground floor may require the roof of the basement to extend above the ground level of the site. Where the height of this extension is more than one metre above ground level that basement is no longer considered a basement. This may limit the potential developable yield of the site if it is constrained by the number of permissible storeys. Refer to **Figure 15**.

The response options also present an option to reduce the ground floor level to be below the 2100 minimum defined flood event floor level[6] by achieving the 2100 defined flood level via a low (impermeable) barrier wall beneath the shop front windows in lieu of floor to ceiling glass panels. This consideration would allow the site to address current climate conditions (and for perhaps the next 30 to 50 years) with an overall lower ground floor level, reducing the length of ramp access and increasing the street level connectivity. Future adaptation of the ground level floor area to more flood resilient uses could be considered at a (much) later date. In anticipation of this future adaption the response options include the floor to ceiling height of the first floor to be suitable for (future) commercial or retail activity. In addition to this, the response options include an awning structure over the ground floor frontage which could be utilised as an extended first floor patio or a future elevated walkway linking adjacent buildings within the precinct and providing flood free pedestrian mobility. Refer to **Figure 16**.

[6] Refer to Case Study 4 – Commerical Development regarding sealing the active frontage commercial floor from flooding to the level of the PMF

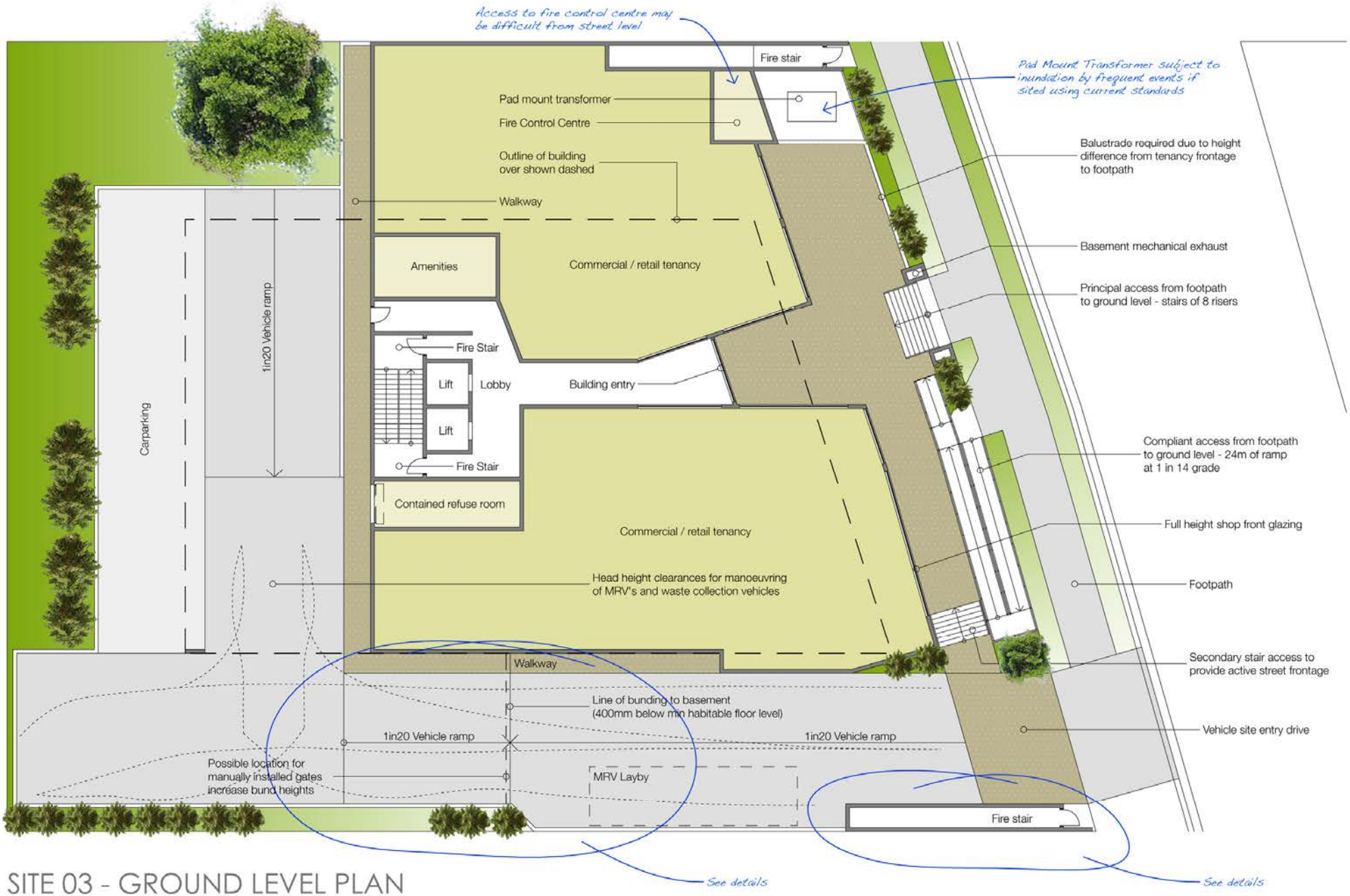


Figure 12 Mixed Use (High rise) - Plan

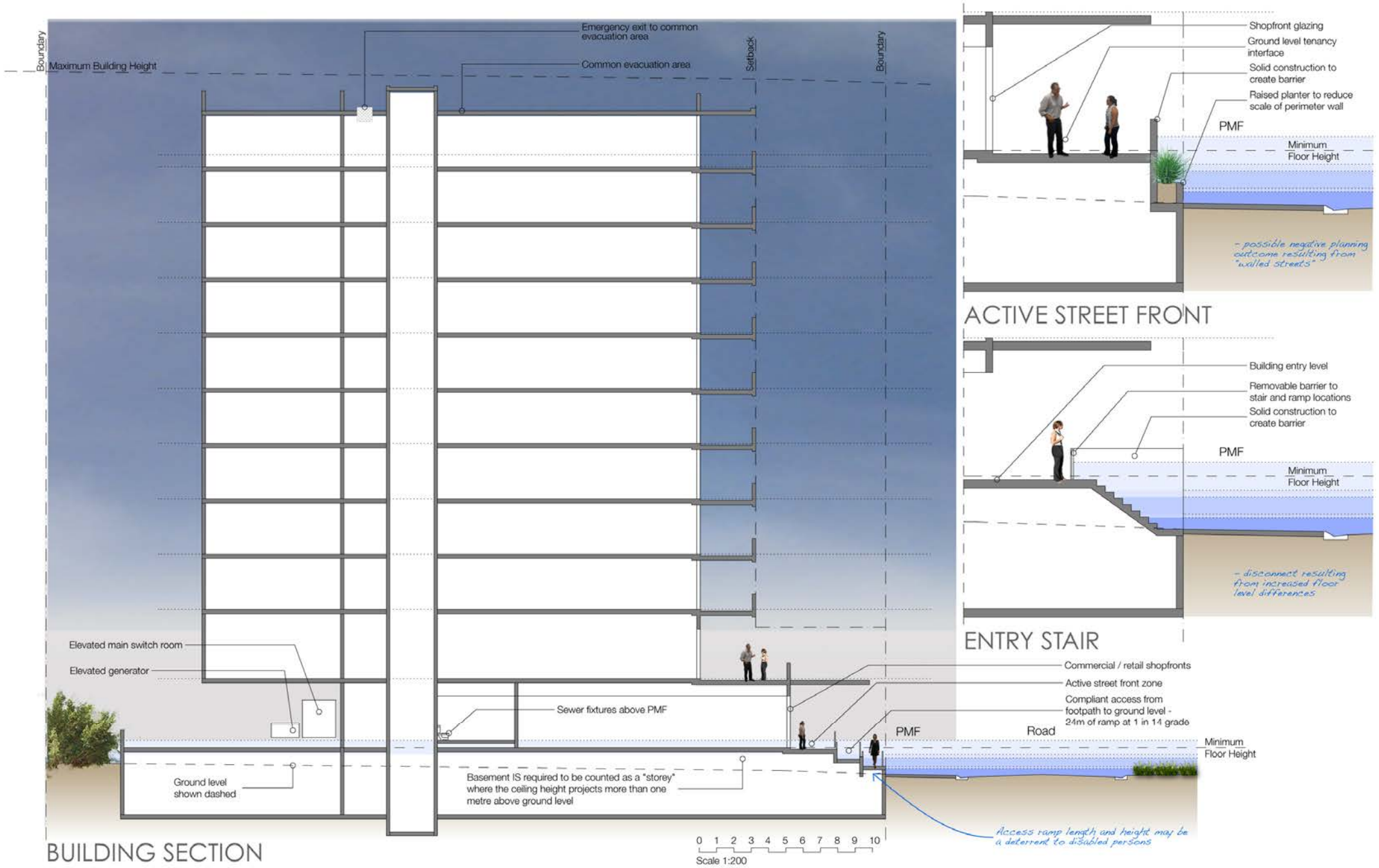
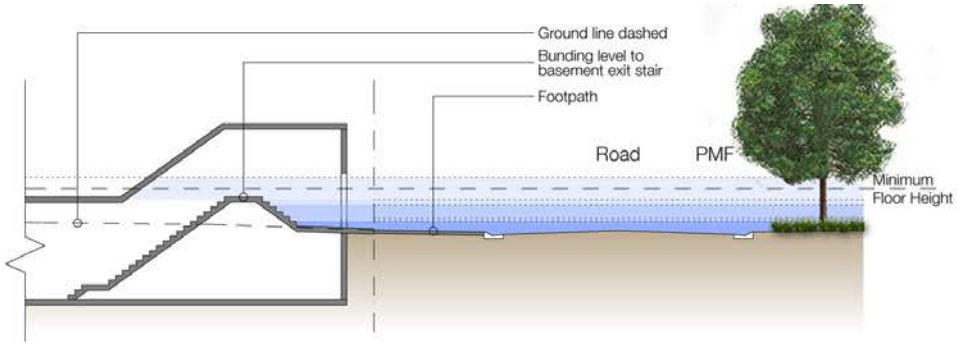
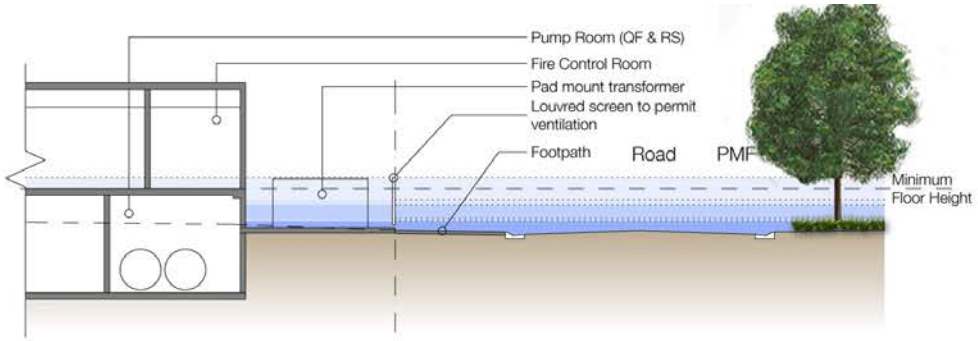


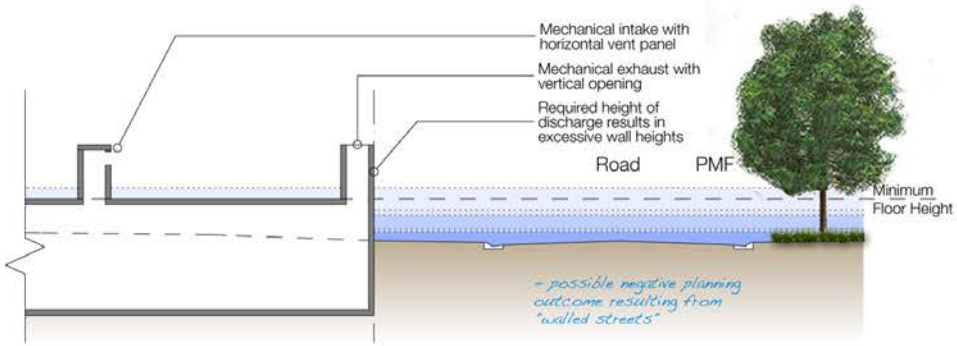
Figure 13 Mixed Use (High-rise) - Building sections



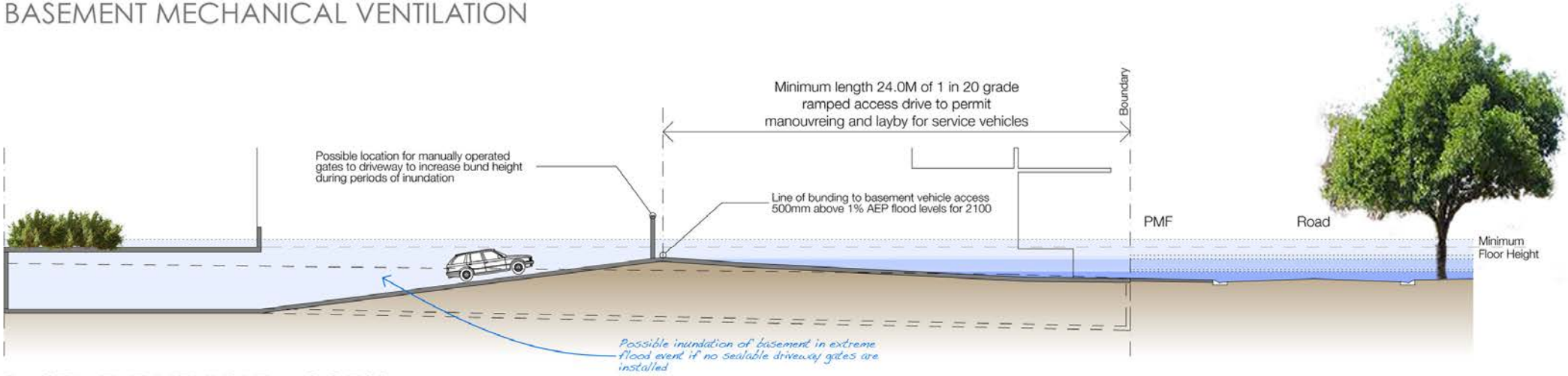
BASEMENT EXIT STAIR



BUILDING SERVICES



BASEMENT MECHANICAL VENTILATION



BASEMENT VEHICLE ACCESS

Figure 14 Mixed Use (High-rise) - Sections

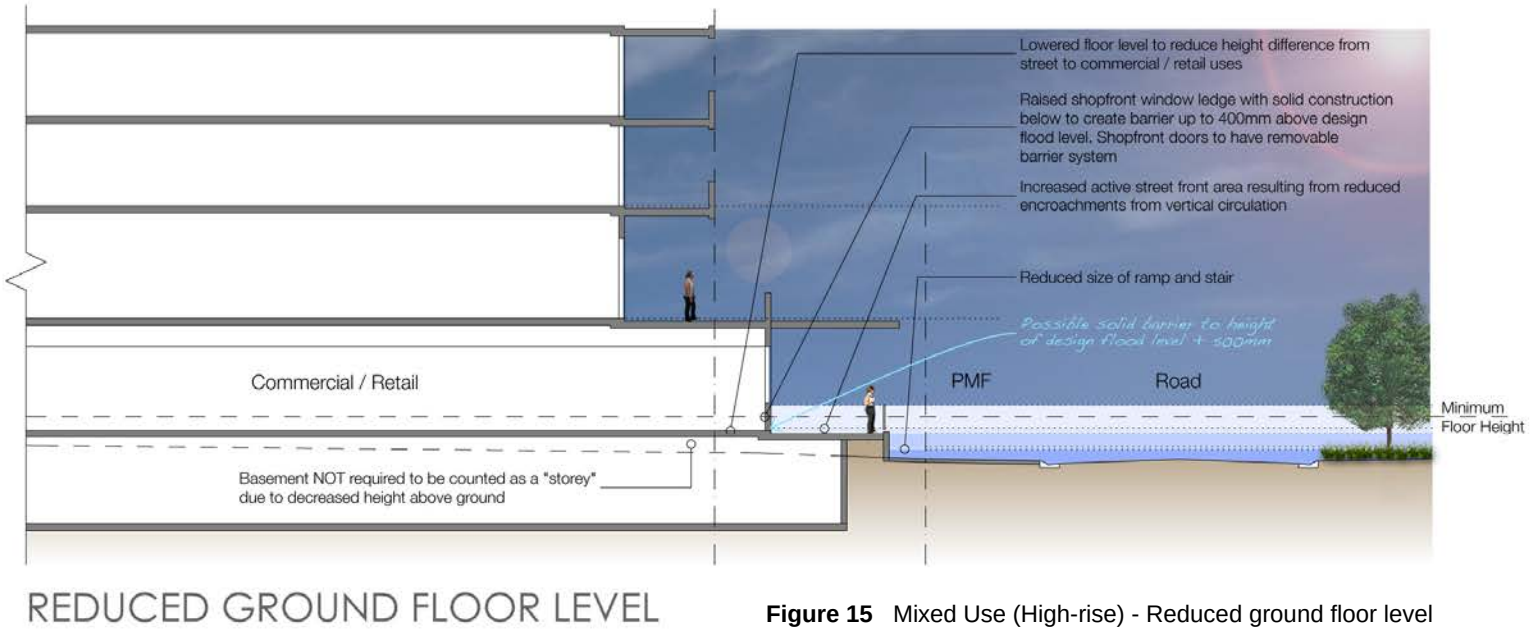


Figure 15 Mixed Use (High-rise) - Reduced ground floor level

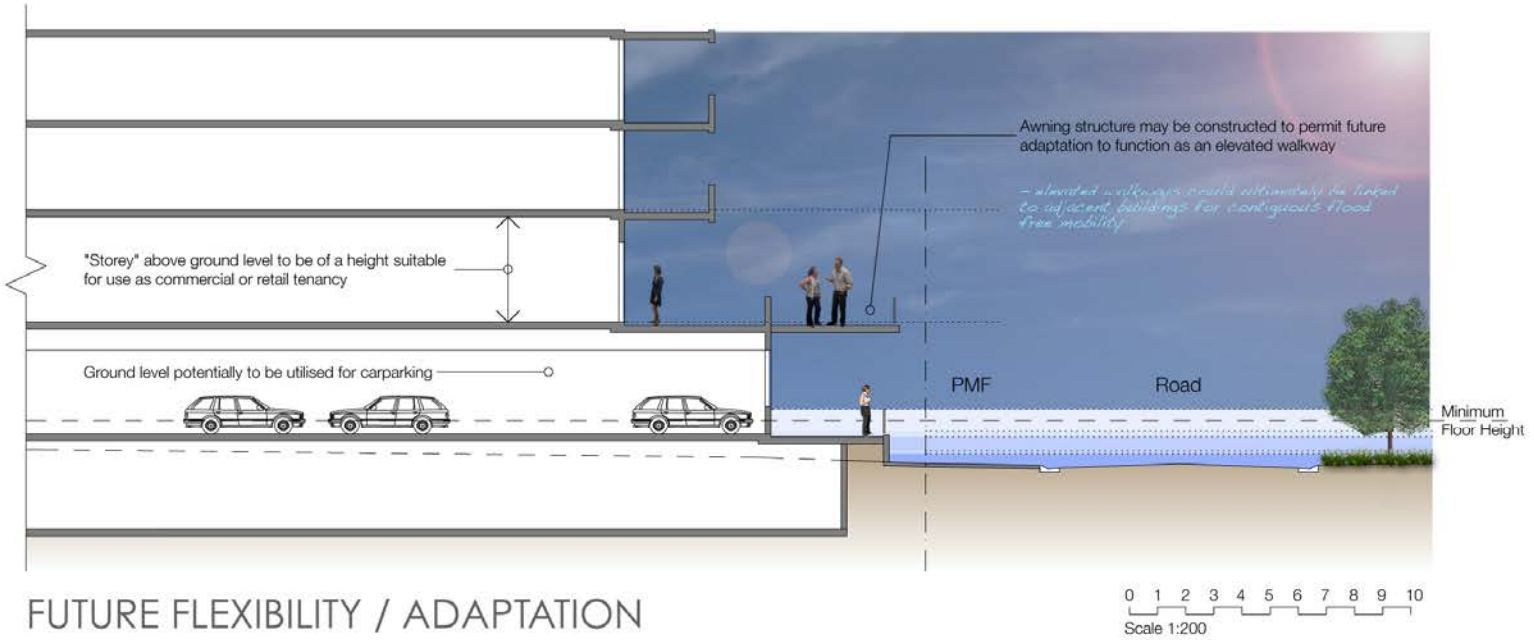


Figure 16 Mixed Use (High-rise) - Future flexibility/adaptation

Case Study 4 – Commercial Development

Many of the physical design constraints and possible responses presented for the multi-use high rise development site, apply similarly, to the commercial development site. As a point of difference to the multi-use high rise site, the response options presented for the commercial site include ground level car parking and variations in the options to maintain connectivity with the street level footpath. As per the multi-use high rise site, the commercial site also includes active retail/commercial tenancies on the ground level. Refer to **Figure 17** to **Figure 22**.

One of the response options presented to address the potential disconnection between the street level footpath and active commercial/retail frontage is to seal the commercial floor from flooding to the level of the PMF. This option allows the floor level of the commercial area to adopt alternate minimum floor level requirements dependant upon the nature of flooding and the type of sealed solution. This option would often reduce the elevation difference between the level of the road and the active frontage. Refer to **Figure 21** and **Figure 22**.

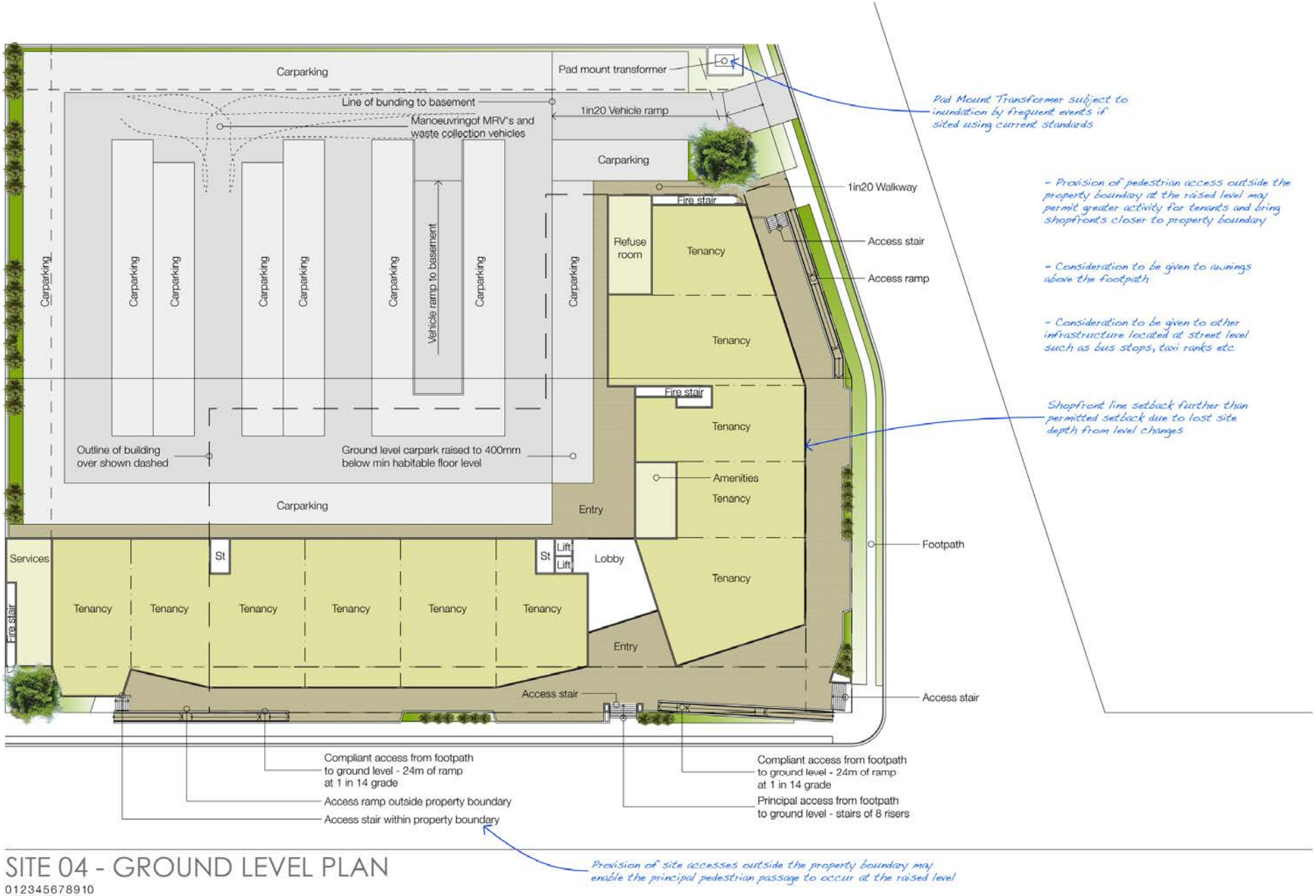


Figure 17 Commercial - Ground level plan

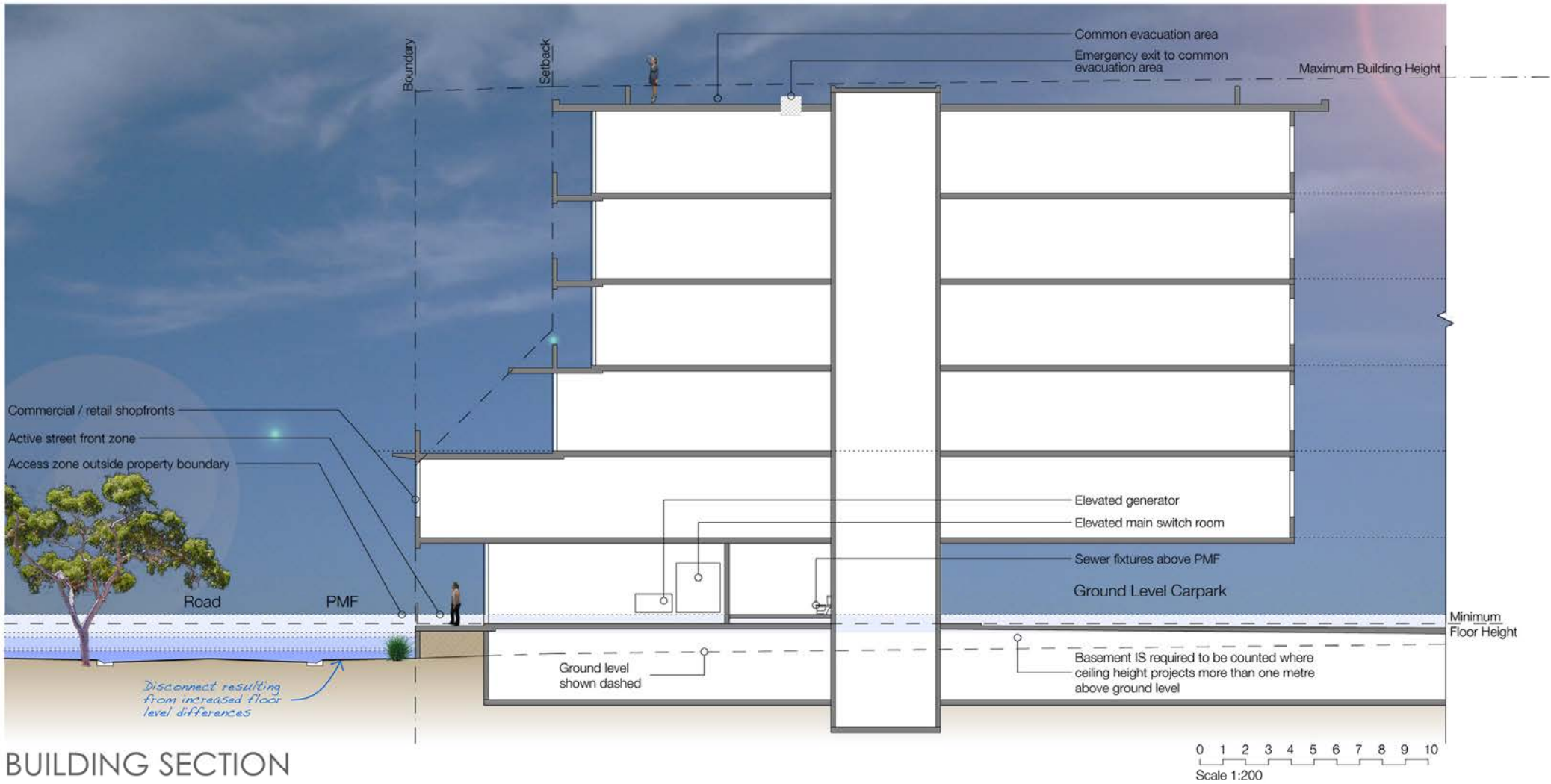


Figure 18 Commercial - Building section

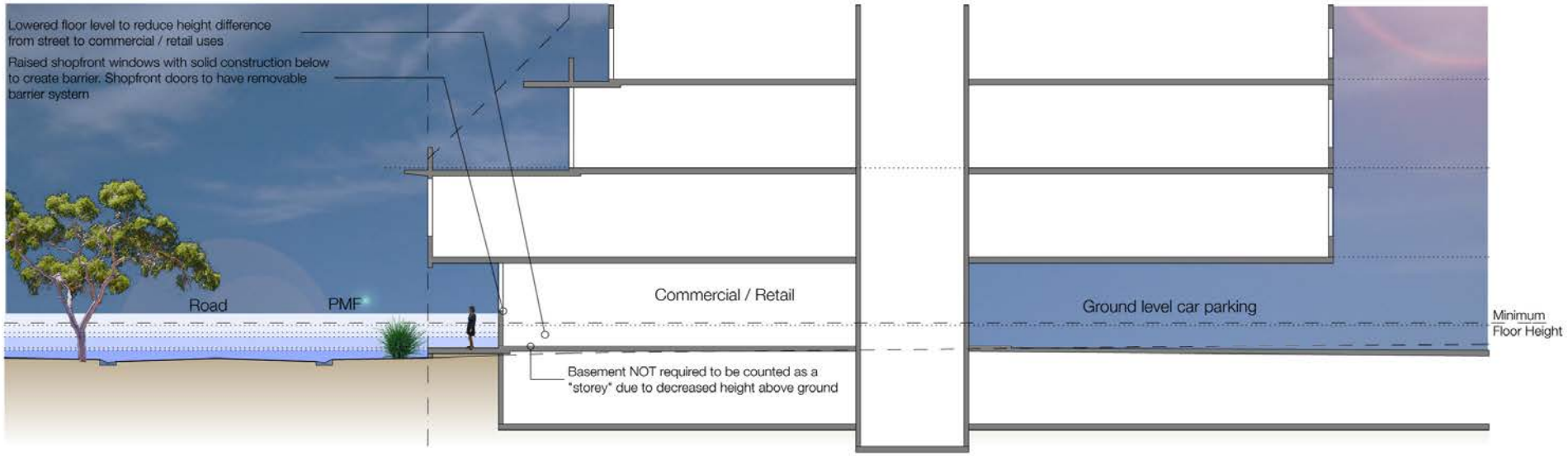


Figure 19 Commercial - Reduced ground floor level

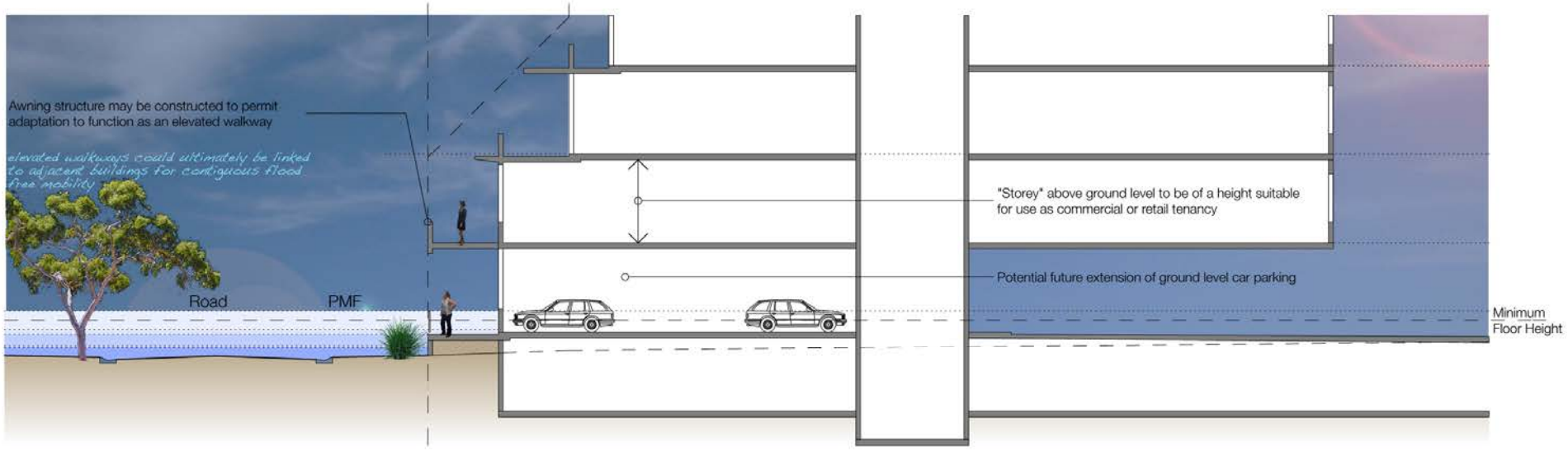
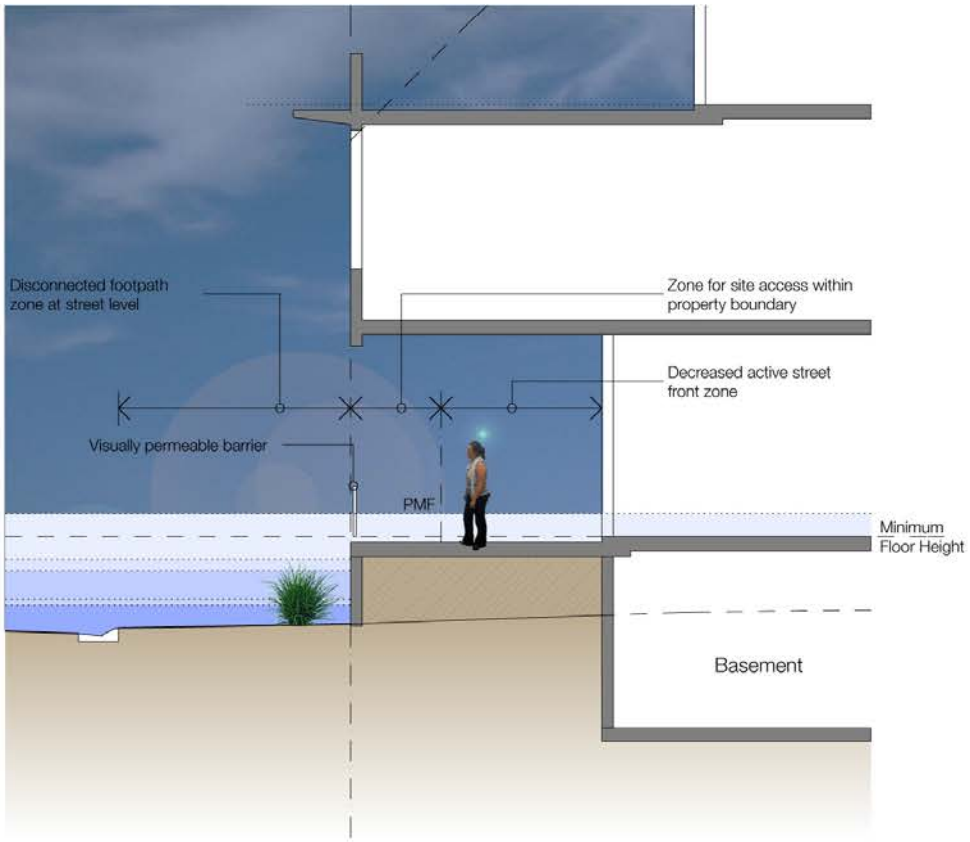


Figure 20 Commercial - Future flexibility/adaptation



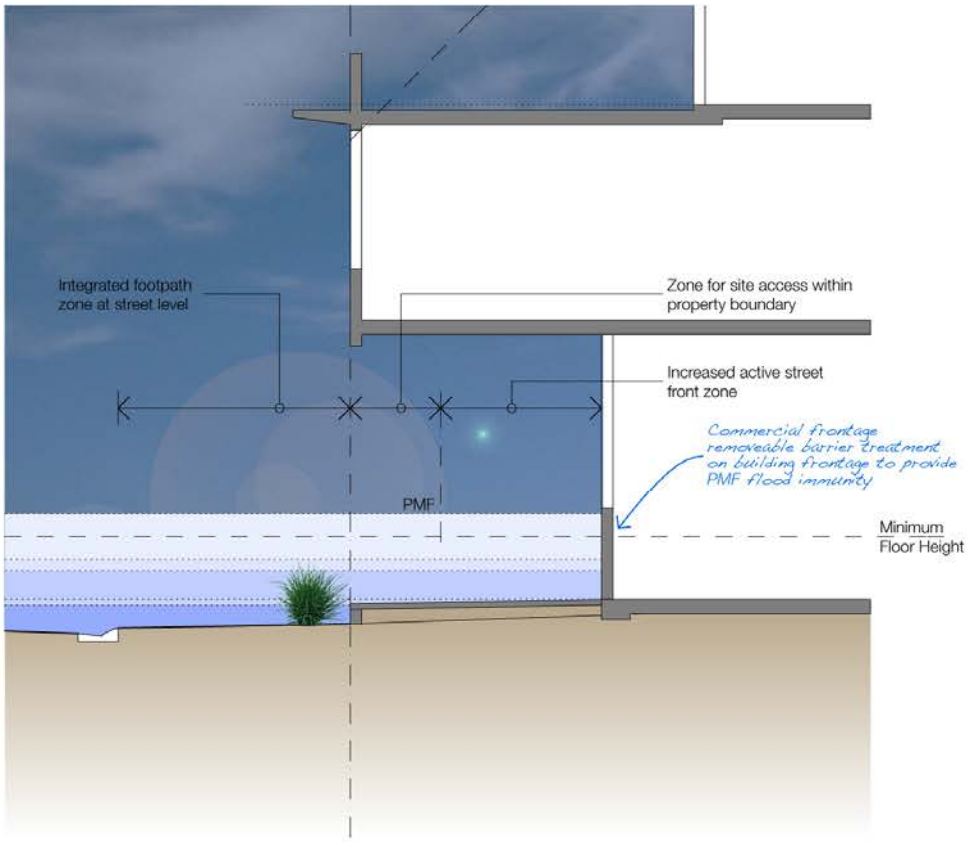


Figure 21 Commercial - Active street front option 01

Figure 22 Commercial - Active street front option 02

The Way Forward

To effectively facilitate the application of any of these possible response options it is important for developers to assess and understand their flood-related risks. Flood risk management planning may provide further clarity to planners, developers and assessment officers as to where certain risks may exist and what level of response should be expected within these areas. In addition to adoption of on-site responses broader urban adaptation strategies will need to be prepared to merge private sites with the public space in ways that complement the location's risk response objectives.

This guideline presents a collection of design responses for the nominated development categories of dual occupancies, multi-units, mixed use (high rise) and commercial. In addition to these development styles further guidance may be developed to cover other development styles and public infrastructure. Over time a catalogue of possible response options may be prepared for all facets of infrastructure and development in areas of risk.

The response options are offered as a reference guide for possible measures which increase the resilience of the future occupants and the future buildings they will inhabit to potential inundation from flooding or stormwater.

The response options presented are not intended to be exclusive for each style of development. Designers are encouraged to mix and match possible responses to suit each development case.

The design response options presented in this guideline are not to be considered as a 'deemed to comply' outcome for any new development.

For each new development a flood risk assessment (for the proposal and the site conditions) will need to be undertaken. Guidance may be taken from this document on the some of the features identified and responses offered which may be relevant for consideration when designing a new development. The proposed development will be assessed against the requirements of the Sunsine Coast Planning Scheme 2014.

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COUNCIL

www.sunshinecoast.qld.gov.au
mail@sunshinecoast.qld.gov.au
T 07 5475 7272 F 07 5475 7277
Locked Bag 72 Sunshine Coast Mail Centre Qld 4560

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