Horizontal Evacuation Pilot Study

Parramatta CBD

SJB Architects

Project
Horizontal Evacuation Pilot Study

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Introduction

- Parramatta is Sydney's second CBD and is expected to grow significantly in the coming years.

- Parramatta CBD lies within the Parramatta River floodplain, and is subject to flash flooding that can potentially have less than 1 hour warning to evacuate.

- NSW SES has developed a classification of communities to determing priority areas for evacuation, including:
  - **Low flood island (high risk)**
  - **High flood island**

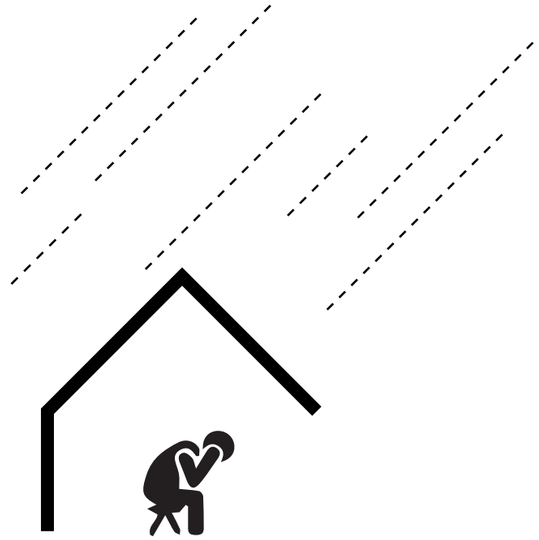
- Safest option for emergency situation was determined to be **Shelter in Place** (not evacuate).

- Saftey concerns for occupants sheltering in some buildings due to:
  - **injury;**
  - **fire;**
  - **duration of flood event; and**
  - **occupants entering hazardous floodwaters.**

- Risk to buildings and occupants is lowered by through connecting buildings via passageways **elevated above the PMF.**

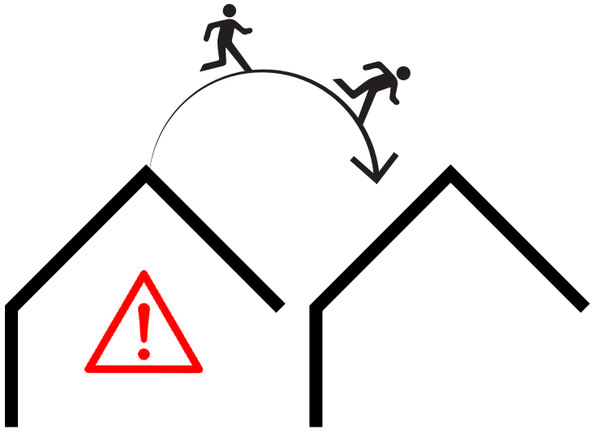
- SJB to investigate potential issues with three methods of connecting passageways above the PMF.

Emergency response



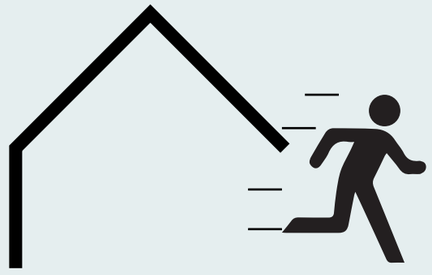
01. Shelter in Place

Occupants are encouraged to stay within the building for as long as possible, unless there is a hazard present such as a fire, or if an occupant requires medical assistance.



02. Evacuate to Adjacent Building to Shelter in Place

Occupants are encouraged to evacuate to the nearest adjacent building that provides a safe space to Shelter in Place.

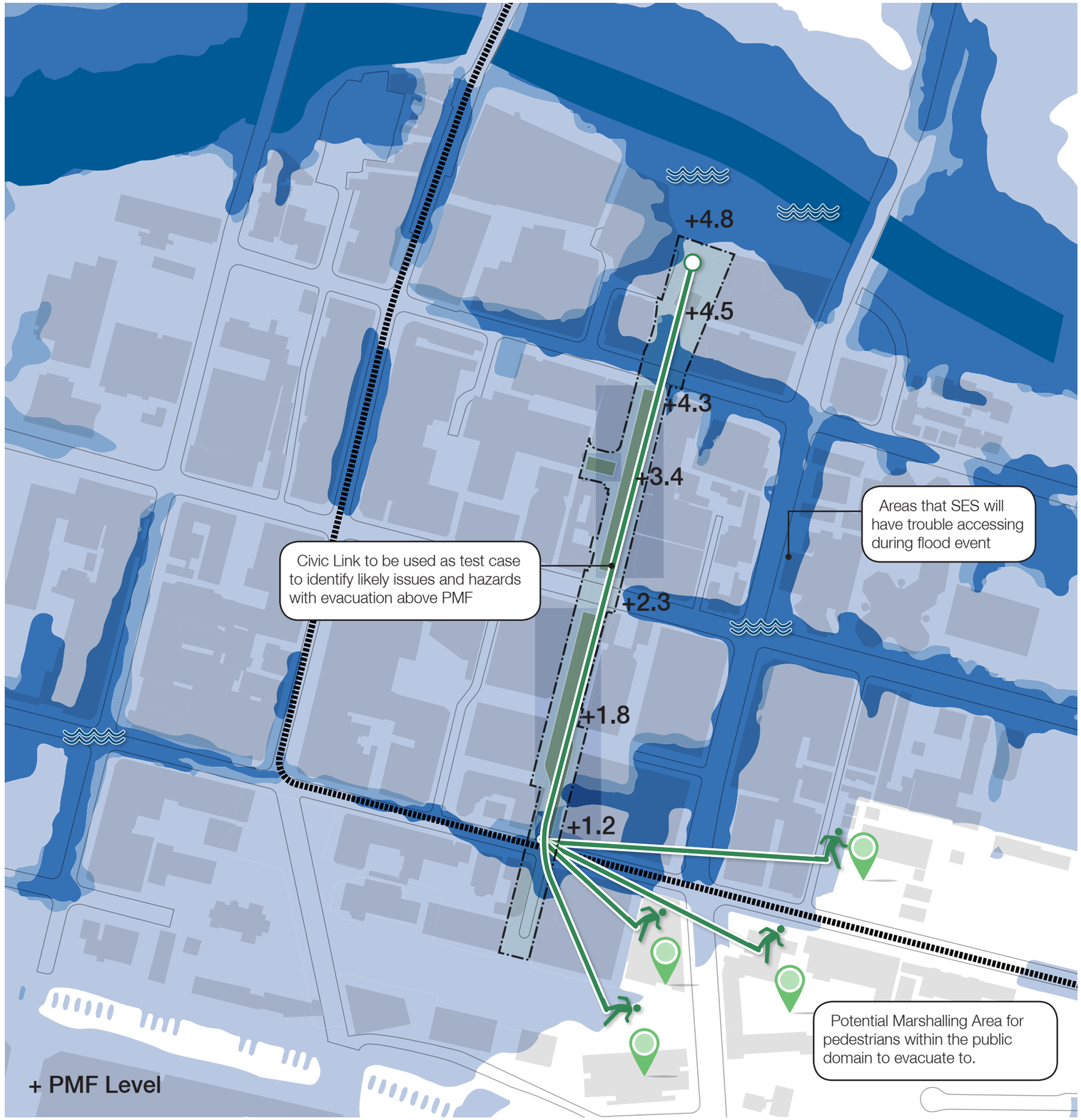


03. Evacuate to Marshalling area

If all adjacent buildings are considered unsafe to Shelter in Place, only then are occupants encouraged to evacuate via the proposed method to a public marshalling area that is located above the PMF.

The Situation

- CoP has identified a rough outline of marshalling areas and evacuation routes for a flood event, however this is largely for **pedestrians within the public domain**.
- Ideally occupants already within buildings will **shelter in place** within the building for the duration of the flood event, which is likely to be a **matter of hours**.
- Using the Civic Link project to test the issues associated with evacuation above the PMF, this report identifies potential issues, conflicts, and saftey concerns with three methods of evacuation:
  - **Above Awning**
  - **Above Podium**
  - **Indoors**
- The areas identified as dark blue are the 1 in 100 year flood levels, and are considered **inaccessesible by SES during a flood event.**
- The area shown in light blue indicates the PMF which varies throughout the CBD as being below and above the height of an awning.



Baseline Review

The *Best Practice Urban Design In Flood Prone Areas Urban Design Strategy Report* was prepared by Architectus for Parramatta City Council and completed in December 2016.

The report considers the particular opportunities and challenges for Parramatta, as a flood prone area that is currently undergoing intensive urban development.

These concerns have generally been addressed according to the particular characteristics of key areas of interest within the Parramatta region. These are identified as the Parramatta CBD, River Foreshore and Clay Cliff Creek, Urban Renewal Areas - Rosehill and Camellia, North Parramatta and Granville.

A series of integrated built form and public domain design strategies have been developed to address the particular flood conditions, in alignment with the requirements of the NSW State Government Flood Prone Land Policy and other relevant legislation, policy and guidelines.

The study addresses the specific issues identified for Parramatta within the following categories:

- Activation
- Density
- Awareness
- High hydraulic hazard
- Car parking

The report recommends an integrated approach to managing Parramatta's urban form and public realm that responds to these five categories, while still ensuring an attractive and accessible urban environment.

Final design recommendations for best practice approaches are supported by relevant case studies and design testing, in addition to consideration of policy context and site conditions,

The following pages provide a summary of key aspects of the report (text extracted from the body of the report).

Objectives

The following objectives are outlines in the introduction section of the report:

- To create active and vibrant streets and public spaces within flood prone areas of Parramatta.
- To minimise flood damage and risks, to increase resilience and to ensure safety within both the public domain and adjacent building spaces.
- To identify lessons learned, their relevance to Parramatta and implication for the existing NSW policy context.
- To address a range of flood conditions and scales relevant to Parramatta from the scale of the city to the riverfront to buildings and their public domain interface.
- To test case study findings against sample building designs (ground level and basement) to demonstrate compliance with standards, building systems design requirements, viability and good urban design outcomes.
- To complement the CBD Planning Framework flood study work being undertaken by Council.
- To provide recommendations for policy that could inform an alternative approach to current practice in NSW and that can be reviewed by Office of Environment and Heritage (OEH) and the State Emergency Services (SES).
- To use diagrams, precedents and technical references to clearly explain analysis and recommendations

Considerations for Flood Management Design

The Human Scale:

A series of height thresholds are proposed to define urban design solutions that vary according to flooding impact, in relation to the human scale. These heights are defined as:
- Seating Height - 450mm and under
- Railing Height - 900mm and under
- Eye Level - 1500mm and under
- Ceiling Height - 1500mm and above

Built Form:

Four main aspects of the management of flood risk in development have been identified as causes of undesirable built form outcomes:

1. Minimum floor level requirements and the Flood Planning Level (FPL)
By constructing minimum floor levels to the current FPL there is often significant grade changes between ground floors and adjacent street levels requiring careful design to ensure activation and aesthetics.

2. Basement entry level requirements
The current basement entry minimum level requirement for FPL cannot feasibly be achieved in developments where the FPL is up to 3 metres higher than adjacent street levels.

3. Flood emergency response requirements
The rapid rate of rise for Parramatta River and its tributaries limits the feasibility of flood emergency response provisions for developments, in particular evacuation.

4. Maintaining flood conveyance and storage
One currently adopted approach to maintaining flood conveyance through sites is to utilise screened undercroft areas below ground floors. This presents difficulties for the streetscape and building design.

Assessment Criteria

An assessment criteria has been established to measure the effectiveness of proposed design strategies and solutions from both an urban design and flood risk management perspective. This criteria is categorised as the following:

Urban Design Criteria:

- Context
- Activation
- Connectivity
- Aesthetics

Flood Management, Feasibility and Risk Criteria Flood Management:

- Flood Risk to Life and Evacuation
- Feasibility

Flood Context - Parramatta

An investigation of the existing flood conditions for Parramatta has been included in the preliminary stages of the report. The flood characteristics particular to the Parramatta region are described on page 12:

'The spectrum of flooding in Parramatta ranges from shallow, fast moving water occurring as a result of frequently occurring heavy storms through to large, slow-subsiding inundations of depths over 3m that occur much more rarely. Flood events affect streets, shops, homes, offices and public space; each has its own specific design requirements and patterns of use.'

The constraints for flood emergency reponse as a result of these conditions are elaborated on further in Section 3.0 'Flood Context' (p.28):

'...Parramatta River and its tributaries is classed as a flash flooding environment as the time to flooding is less than 6 hours, at some locations on tributaries this can reduce to less than 30 minutes. This means that flood emergency response is difficult for the area as there will be very limited time available for emergency services such as the SES to evacuate occupants of the floodplain in the event of flooding.'

The specific flood characteristics for the Parramatta CBD area are identified as the following (p. 21):

- A number of Parramatta River foreshore sites are affected by 100yr ARI high hazard from river flooding.
- Other parts of the CBD are affected in the 100yr ARI by low hazard overland flow flooding which mostly align with the road reserve.
- The majority of the CBD is affected by high hazard flooding (up to 4 metres depth, assumed low velocities) from Parramatta River in the PMF event.
- There is significant overland flow and consequent flooding across much of the CBD reaching higher levels than river flooding.

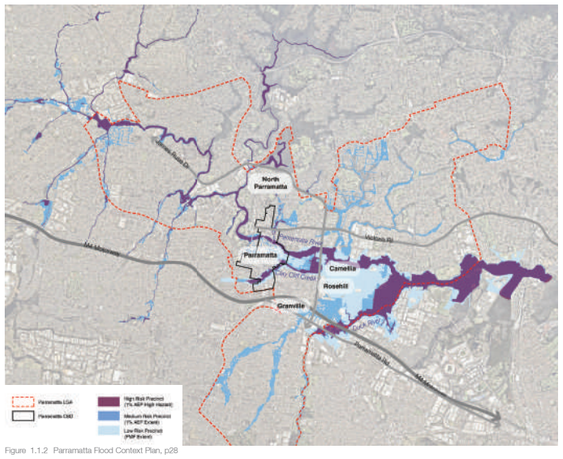


Figure 1.1.2 Parramatta Flood Context Plan, p28

Note: Parramatta LGA boundary is prior to amalgamation on 12 May 2016

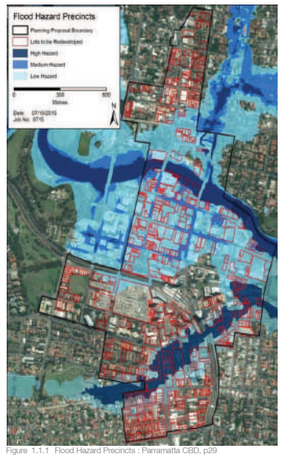


Figure 1.1.1 Flood Hazard Precincts : Parramatta CBD, p29

Flood Response - Case Studies

A series of case studies are presented in the Architectus report to investigate potential design approaches and solutions for the flood prone area of Parramatta. The overarching strategy and key design elements are identified for each case study through an analysis of local and international examples of where it has been implemented.

The following case study categories are included in the report:

1. Placing over the water
Involves the integration of elevated built form elements with the urban environment.

2. Impermanence, Movement and Managed Inundation
Involves the use of public domain elements that can be easily transported or safely submerged during a flood event.

3. Temporary Resistance
Involves the temporary activation of barriers and built form elements during a flood event.

4. Integrated Resistance
Provides permanent flood protection and resilience through the use of flood-resistant built form elements, construction materials and design approaches.

5. Step within the Site
Addresses the management of level changes within a building and across the site.

6. Step within Streets
Addresses strategies for the design and retrofitting of the streetscape to manage floodwaters.

Design Testing

A series of design testing options were developed to provide alternative built form solutions that address the specific flood conditions and urban environments within the Parramatta Context. This included the testing of design strategies for residential, retail and commercial built form typologies as well as elements within the public realm.

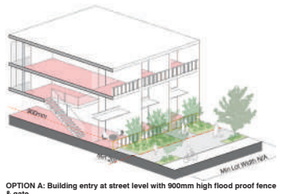
The design testing was informed by the case study research and guided by the following key principles:

1. Human Scale Steps
Aims to minimise the height transition from the public domain to the ground floor of a building. This includes the testing of tiered building setbacks, inclusion of human scaled design elements and defining of a desirable maximum height change within a step.

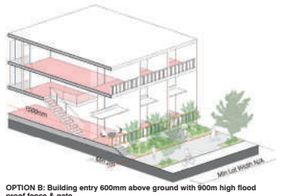
2. Active Spaces - Not Just Transition
Focuses on the activation of transitional spaces through good design integration and connectivity. This includes the integration of amenity within a transition zone, definition of the optimal width that permits an active transition space and the use of upper level promenades to connect buildings.

3. A Two Tier City
Addresses approaches to design for creating safe refuge facilities in the event of the PMF worst case scenario. This involves the provision of active, connected spaces at ground and first floor level.

Figure 1.1.3 Diagrams illustrating Design Guiding Principles, p80



OPTION A: Building entry at street level with 900mm high flood proof fence & gate.



OPTION B: Building entry 600mm above ground with 900m high flood proof fence & gate.

Figure 1.1.4 Residential Built Form Testing, p82

OPTION A: Building entry at street level with internal steps and ramps

OPTION B: Building entry at street level with internal steps and retractable stair / integrated lift system.

OPTION C: Temporary resistance barrier at the property boundary

Figure 1.1.5 Retail & Commercial Testing, p83

Recommendations - Parramatta CBD

The following design recommendations are provided for the Parramatta CBD precinct, in line with the three Design Guiding Principles:

- Step within the Site and connected promenades that allow pedestrian circulation during flood events. Supporting the installation of new and retrofitted green roofs should be considered.
- Streets and adjacent parklets could be upgraded to include new WSUD plantings at footpaths and medians
- More extensive on-street contouring and conversion of parking spaces to landscaped pedestrian zones should be considered where appropriate.
- Implementation of new bicycle path infrastructure should consider additional accommodation of flood water channelling.
- In areas of fine grain retail such as Church Street, utilise temporary resistance strategies to retain the integration between shop fronts, the footpath and outdoor dining areas.
- Managed inundation for a portion of the tenancy adjacent the footpath could also be consider to reduce the impact of steps and ramps on the public domain and building frontage.

Recommendations - Overall

The Best Practice Study provides a set of recommendations that are informed by flood management and response policy, context analysis, case study research and design testing undertaken within the report.

These recommendations are presented under the following categories:

1. Design Approach:

Specific design objectives and principles are provided to address the different characteristics and requirements of the following elements within the urban fabric:
- Interconnected Public Realm
- Precincts and Renewal Areas
- Infill Sites
- Building Typologies (Commercial CBD; Mixed Use; Fine Grain Retail; Adaptive Re-use; Residential Apartments)
- The Details (Emergency Egress; Basement Design; Vehicle Entries and Pedestrian Access; Building Services; High Hydraulic Hazard; Flood Conveyancing; Stairs, Walkways and Ramps; Walls and Materials).

2. Guiding Principles

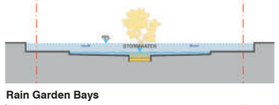
Recommendations that enable the optimum implementation of the three guiding principles (See 'Design Testing') have been derived from the testing of design options.

3. Site Planning and Design Process

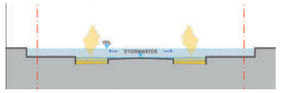
A series of steps are outlined to be undertaken as part of the planning and design process for future development of flood affected sites.

Bicycle Paths

Rain Garden Median



Rain Garden Bays



Park Median

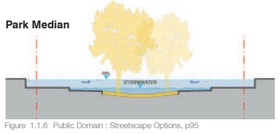
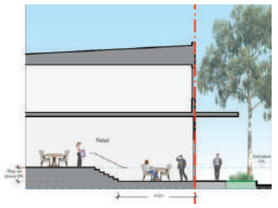


Figure 1.1.6 Public Domain : Streetscape Options, p95



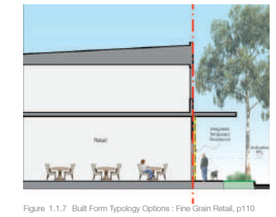
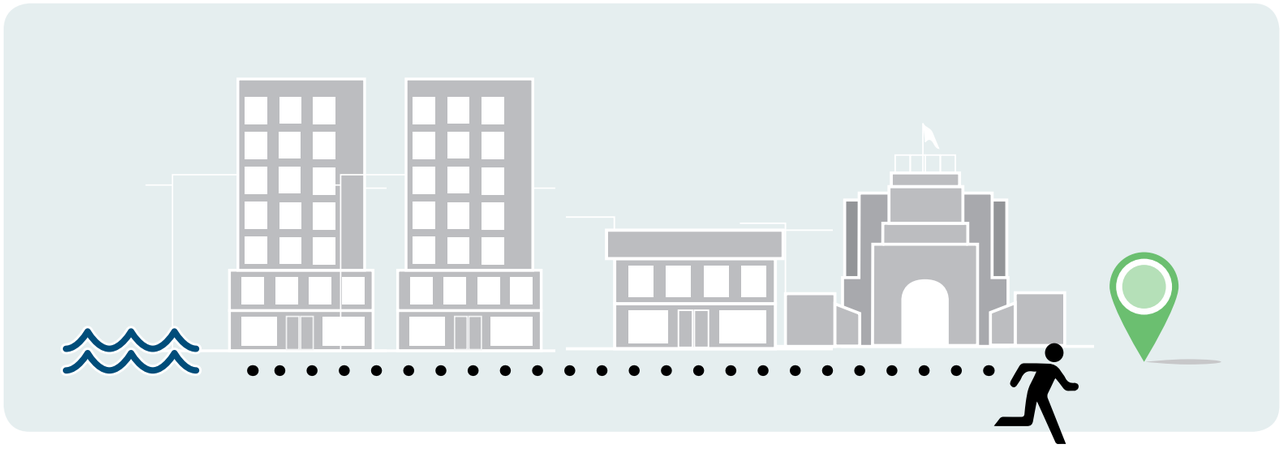


Figure 1.1.7 Built Form Typology Options : Fine Grain Retail, p110

Approach methodolody

01 Urban Conditions - Challenges and Opportunites



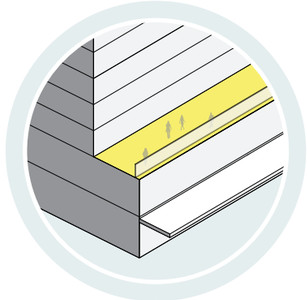
Can be achieved

Difficult to achieve - requires further consultation

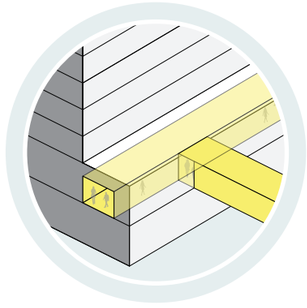
Cannot be achieved

02 Strategies

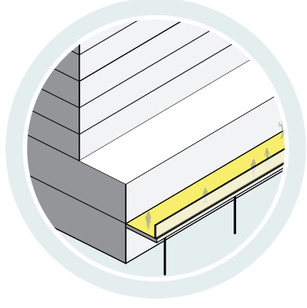
Above Podium



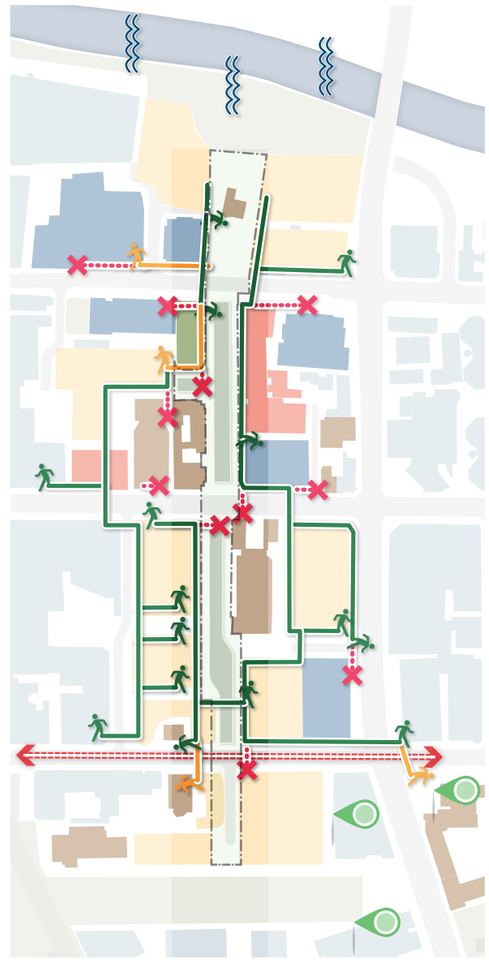
Indoors



Above Awning

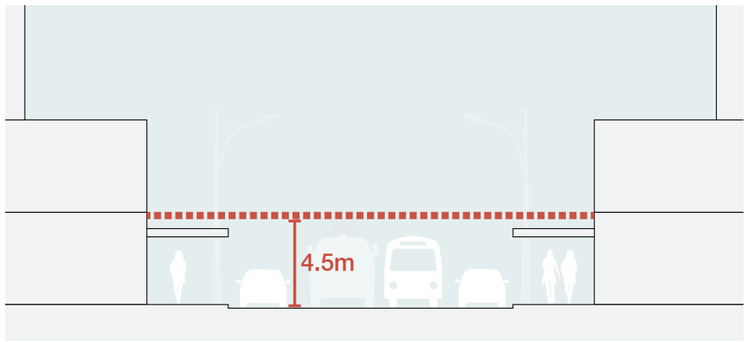


03 Testing on Civic Link



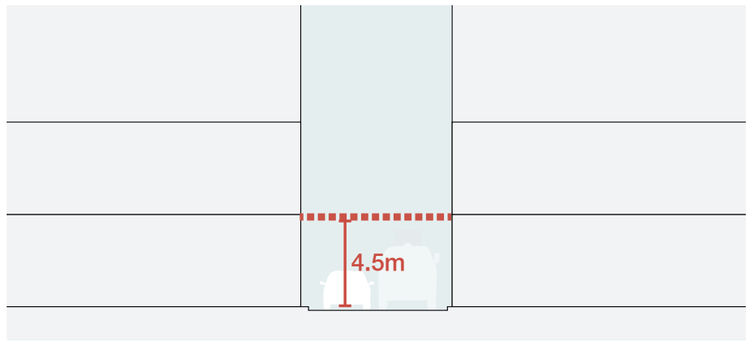
Evacuation Strategies

Urban Conditions



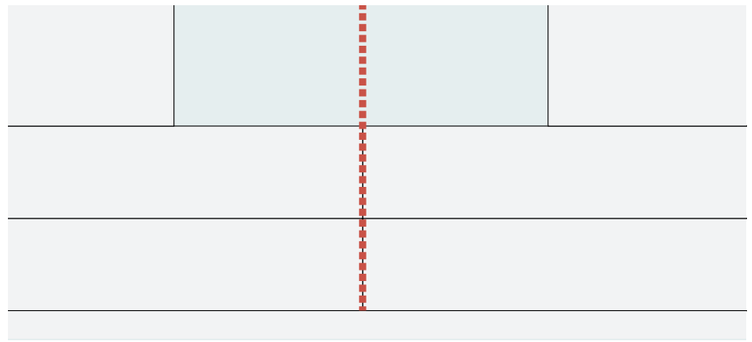
Over the Road

- Maintaining clearance height for service vehicles
- Spans of walkways will be longer and will need structural support within the public domain
- BCA/AS compliance issues
- Feasibility and cost issues



Over Lane

- Spans of walkways will be shorter and may not require structure within the public domain
- Maintaining clearance height for service vehicles
- BCA/AS compliance issues
- Feasibility and cost issues

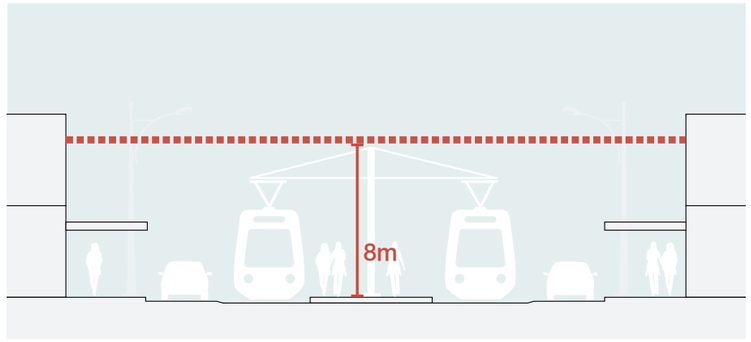


Over Boundary

- Dependant on adjacent buildings have podiums and internal floor levels at similar heights
- BCA/AS compliance issues
- Feasibility and cost issues

Over Public Space

- Visual structure in the space would detract from amenity and character of the public space
- Overhead structure may impede on solar access for open space.
- Requires clearance height for emergency and services vehicles.
- Structure to achieve span of walkways



Over Parramatta Light Rail

- 8m clearance height for light rail vehicles and infrastructure.
- Safety issues regarding interference with power lines and infrastructure.
- Spans of walkways

Evacuation Strategies

Building Conditions

New Building - New Building

- Access paths can be integrated in new building design
- Opportunity to create continuous street wall heights

New Building - ‘Unlikely to Change’

- Spans of walkways will be shorter and may not require structure within the public domain
- Maintaining clearance height for service vehicles
- BCA/AS compliance issues
- Feasibility and cost issues

‘Unlikely to Change’ - ‘Unlikely to Change’

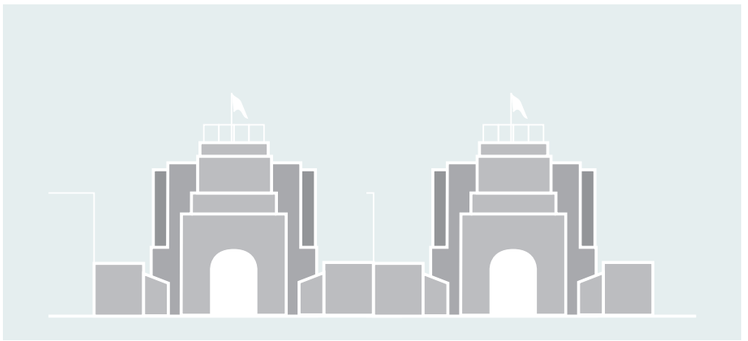
- Dependant on adjacent buildings have podiums and internal floor levels at similar heights
- BCA/AS compliance issues
- Feasibility and cost issues

Heritage - New Building

- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)

Heritage - ‘Unlikely to Change’

- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)



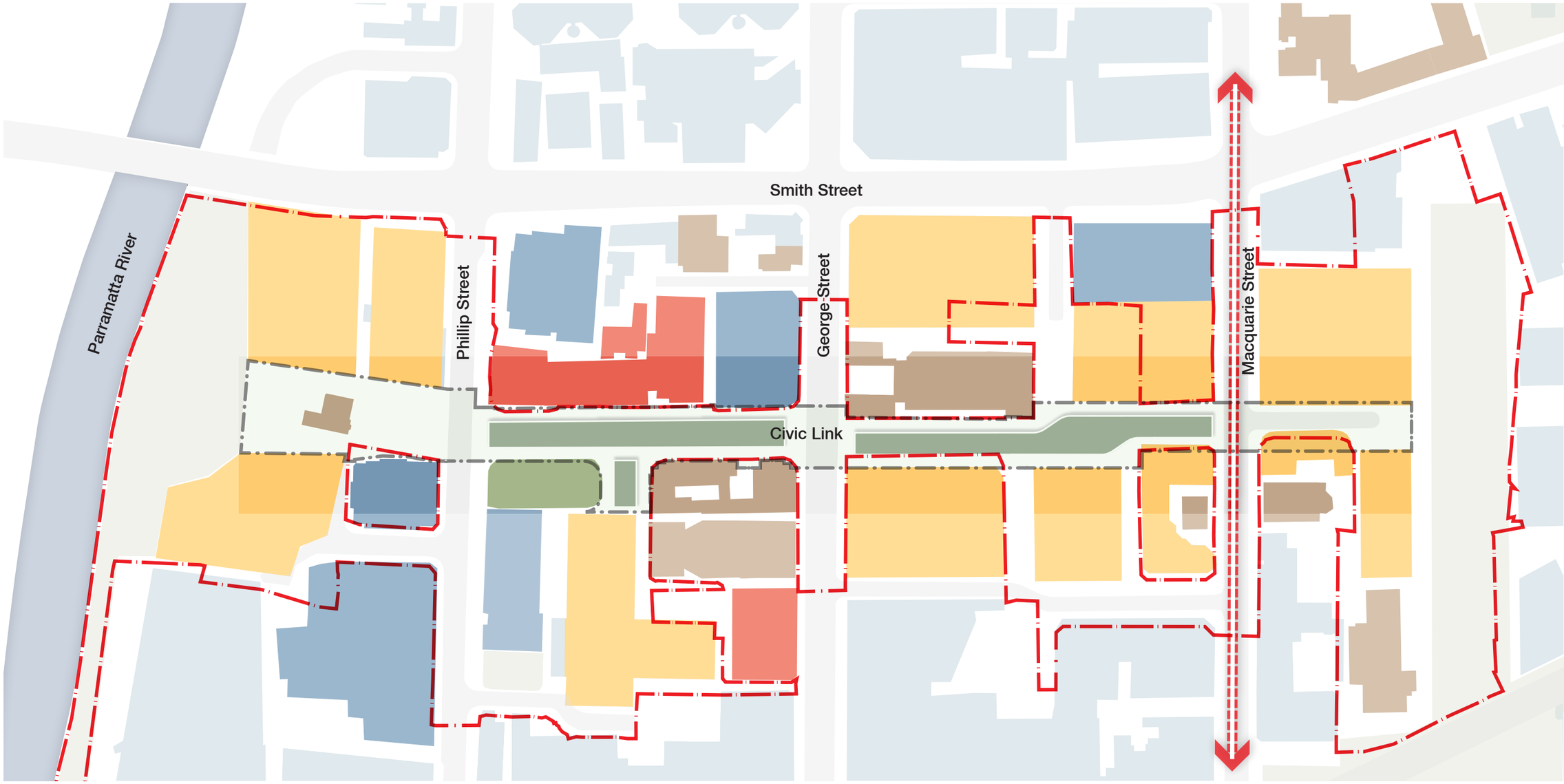
Heritage - Heritage

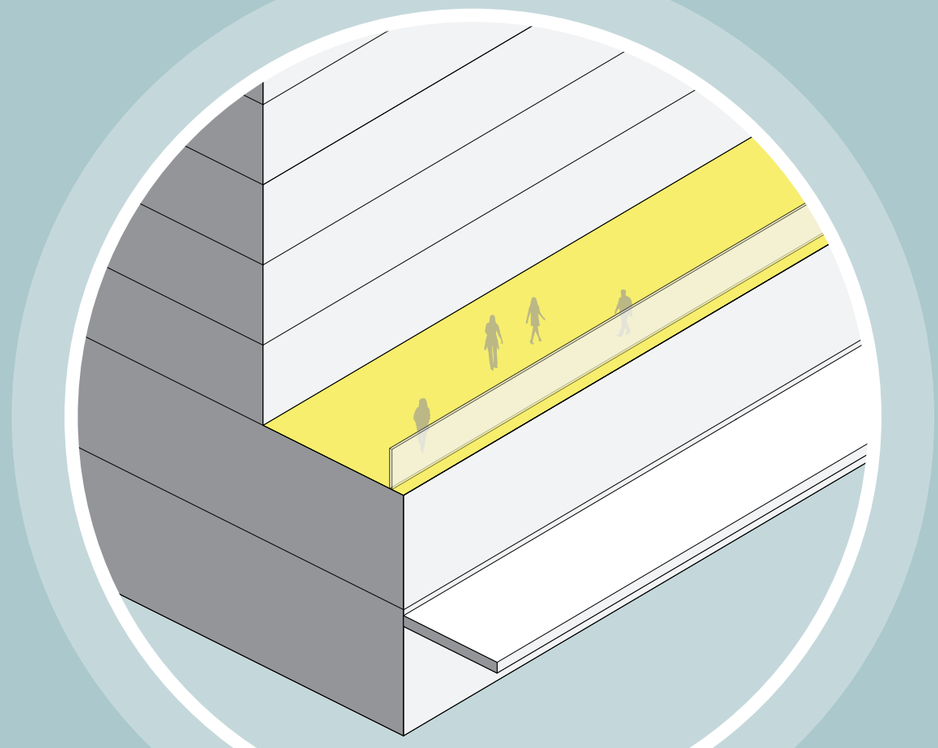
- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)

The Civic Link

Building Conditions

- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change

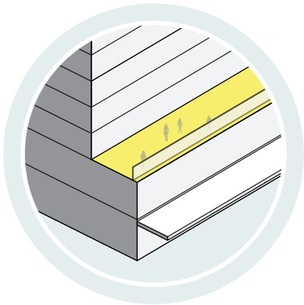




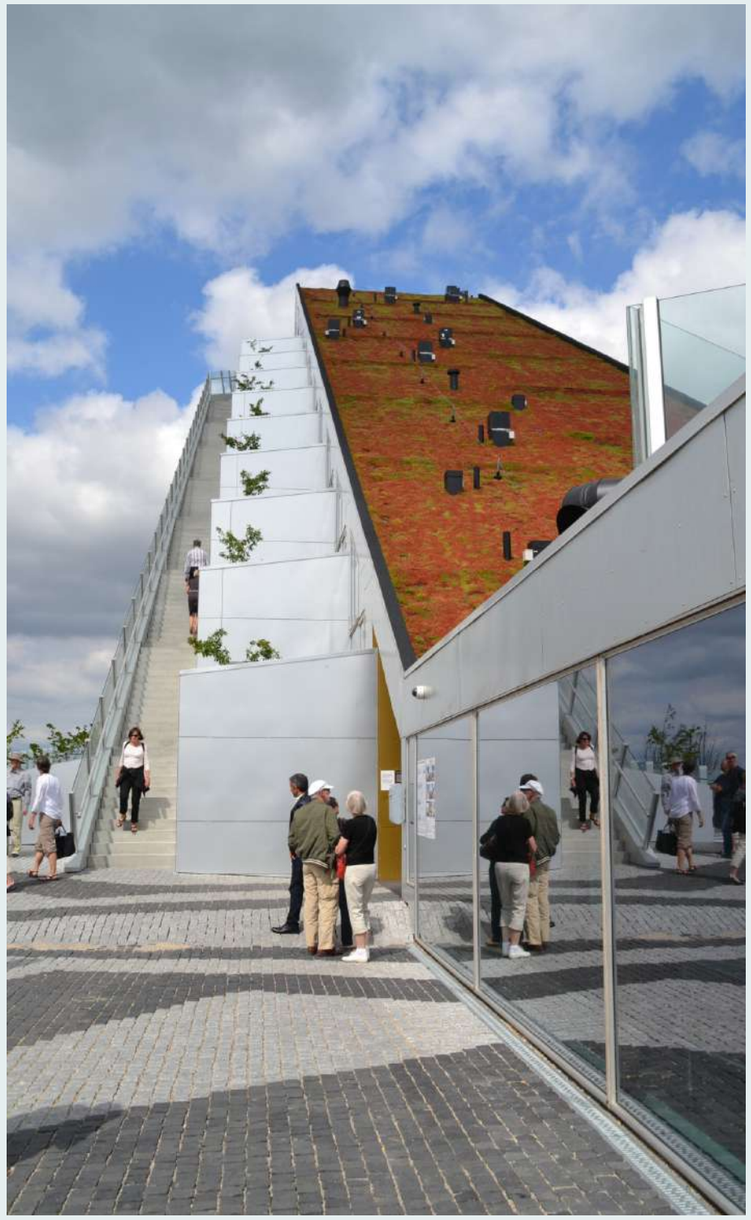
Top of Podium

Evacuation Strategy

Top of Podium

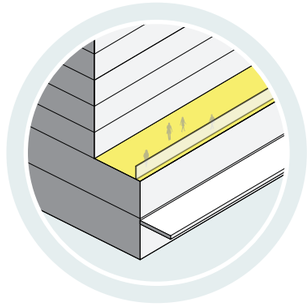


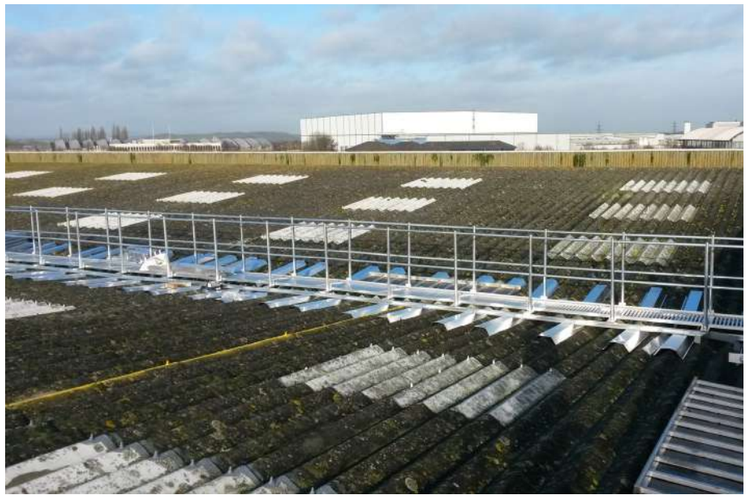
This evacuation method utilises setbacks above the street wall, roofs of existing small scale buildings, and podiums of new larger developments as an evacuation route to safety.
This strategy assumes that most of these spaces are typically not occupied for everyday uses, and can be made to allow for evacuation to other rooftops.
Proposed solutions as a part of this strategy are intended for the purposes of a flood event only and would not provide access at other times.



Case Study

Top of Podium





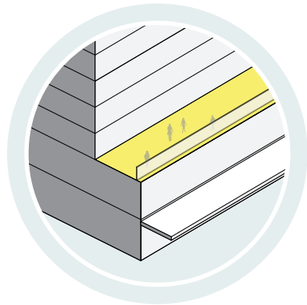
Strategy Evaluation

Top of Podium

✓ Can be achieved

– Difficult to achieve - requires further consultation

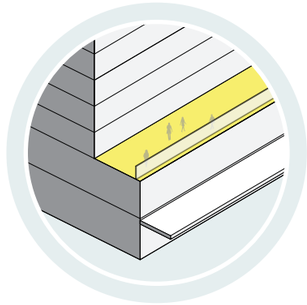
✗ Cannot be achieved



Conditions / Interface	1. New Building - New Building	2. New Building - Existing Building 'Unlikely to Change'	3. Existing Building - Existing Building	4. Heritage - New Building	5. Heritage - Existing Building 'Unlikely to Change'	6. Heritage - Heritage
A. Over Road	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Bridges and walkways over the road will may impact the integrity of the heritage item
B. Over Lane	✓ · New sky bridge / temporary structure can be integrated as part of design	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.
C. Over Boundary	✓ · New sky bridge/ temporary structure can be integrated as part of design	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but adjaceny of buildings can help conceal built external walkways
D. Over Public Space	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item
E. Over Light Rail LIne	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Required clearances for bridges and walkways over the PLR may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item

Civic Link Testing

Top of Podium



- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change

No streetwall or podium

No streetwall or podium to heritage item

Approximate Public Marshalling Area

Smith Street

Parramatta River

Phillip Street

George Street

Macquarie Street

Civic Link

No streetwall or podium

Link between heritage buildings and unlikely to change is problematic

No streetwall or podium

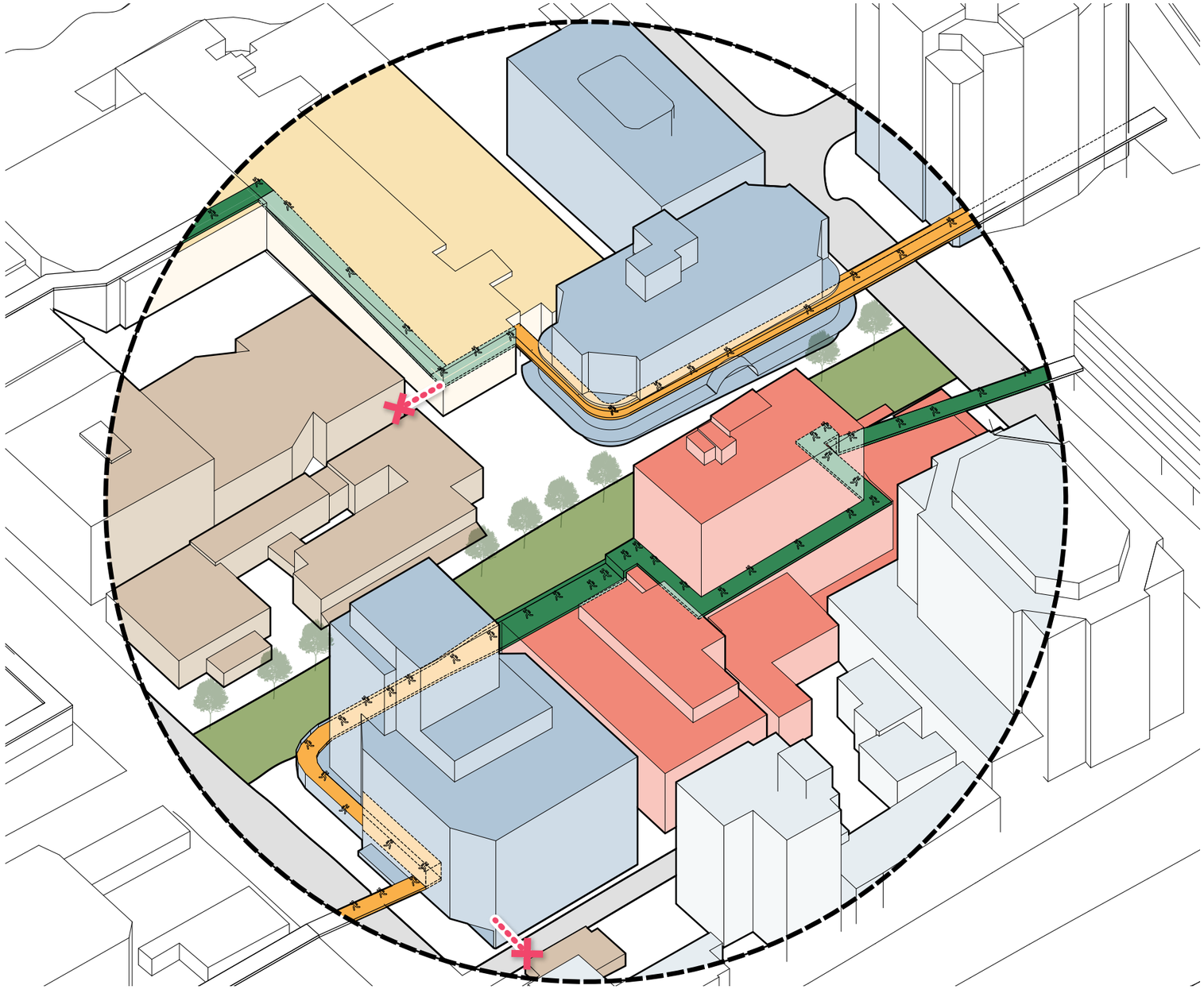
Evacuation path can be integrated into podium parking

Link above Civic Link is discouraged due to impacts upon amenity and character

Discussion

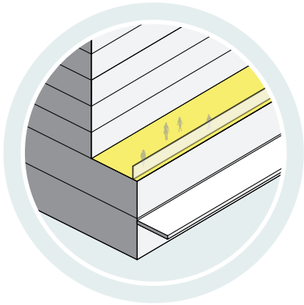
Top of Podium

- Possible to create a route well above the PMF.
- Most adjacent buildings can be connected either via the podium or podium to a rooftop via a staircase.
- Will require coordination between city blocks as to crossing point over a road or lane, should that be required.
- Lifting the path of travel will remove a number of hazards including floating or submerged and moving objects crashing into awnings.
- Hazards may include slips and falls as well as security of buildings.
- Hazard during a thunderstorm with lightning.



Evacuation Strategies

Top of Podium



Challenges

Feasibility
The cost of retrofitting walkways between the tops of podiums or buildings is relatively minor, and could be required as standard for all new buildings.

Heritage value
Due to the height of existing heritage items, this solution may require a walkway that sits above the roof of the building, which would dramatically impact the heritage item. Due to the difficulties involved with evacuating occupants to the rooftop of a heritage item such as new access ways, increased structure required and likely pitched rooves, it is unlikely that this option would an appropriate solution for heritage items, and thus the heritage items would remain a “low flood island” risk.

Visual impact
When retrofitting an existing building, lightweight materials such as aluminium and expanded steel may be utilised to connect to other buildings, or to provide one safe path of access across a rooftop or podium that may otherwise be inaccessible.

Adjacent levels
The various developments occurring around the CBD will provide a range of challenges when connecting between them. Connecting over the top of buildings that vary in height should be able to me managed as lightweight stairs are able to be provided and retrofitted into the system.

Safety
Appropriate safety measures should be able to be employed via handrails and signage. This solution will provide numerous situations for hazards including:
- slipping and falling from walkway
- moving off walkway and onto areas of buildings that are not usually accessible to the public
- hazard of being exposed to downpours of rain.

Additional safety measures to ensure that an evacuation route does not enable people to break into, or inappropriately access, areas of a building that are privately owned.

Wayfinding
Appropriate signage within the building is to be provided to inform occupants that the most appropriate strategy is to Shelter in Place, however if this is no longer safe, to evacuate to the podium or rooftop. Clear descriptions and wayfinding would need to be provided to ensure that evacuees are travelling towards a marshalling area or collection point, or more appropriately into the adjacent building to Shelter in Place. If evacuees are simply moving to an adjacent building, a plan for alerting SES as to the whereabouts of these occupants is crucial.

Structural integrity
Adequate structure will need to be provided if retrofitting existing buildings, and to ensure that these areas are trafficable and safe.

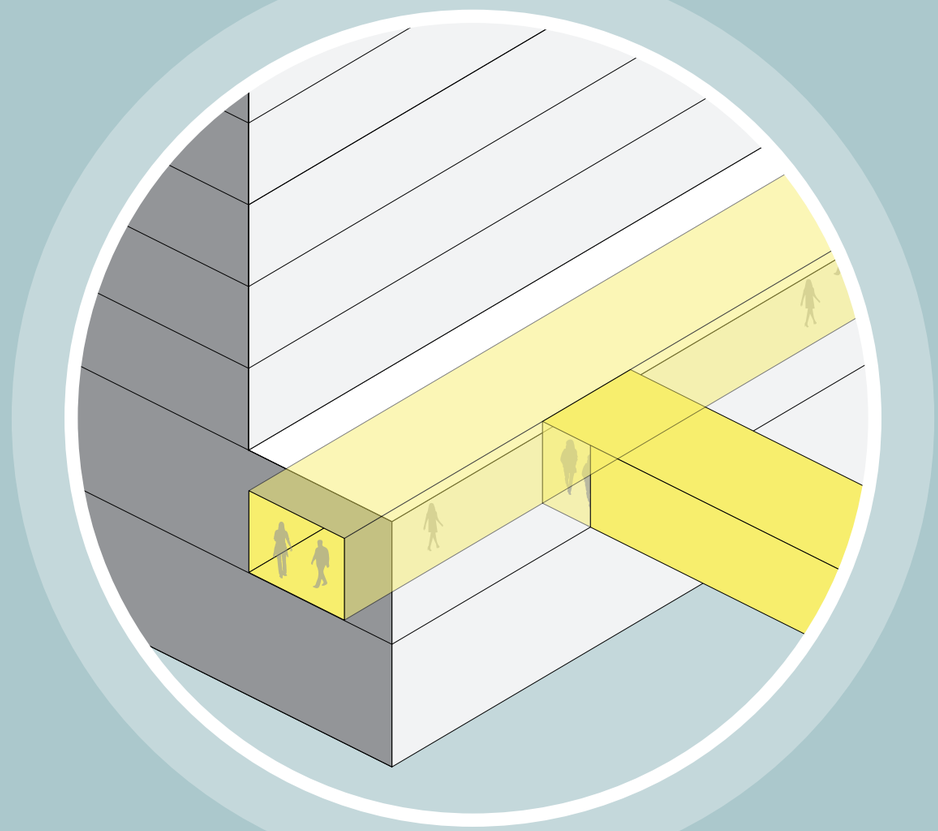
Continuous Path of Travel
This strategy is likely to be able to create a continuous path, however not one that is level. The continuous path will be formed of stairs, ramps and walkways, and can easily connect over the top of roads and public spaces if needed.
If the mechanisms are not permanently set up on the buildings, the way in which these are set up in an emergency event will need to be coordinated by both the CoP and building occupants.
However if evacuees are simply moving from one building to an adjacent building bridges to connect across roads and public spaces will not be required in most cases.

Opportunities

Feasibility
The cost of providing expanded metal walkways to existing buildings is minor, and can be incorporated throughout the city in a reasonably short period of time.

Implementation
If providing lightweight walkways to the buildings around the city, this could be funded by Council and other public sources, and implemented in a reasonable short period of time.

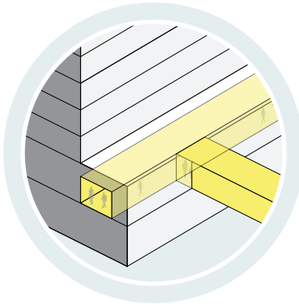
Design
New buildings would be able to incorporate a more permanent option within their design, as well as being better able to nagivate security concerns from the design phase.



Indoor Strategies

Evacuation Strategy

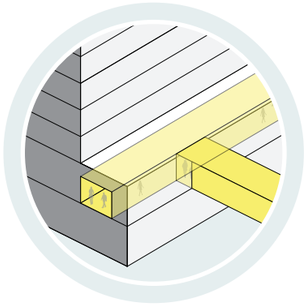
Indoor Evacuation

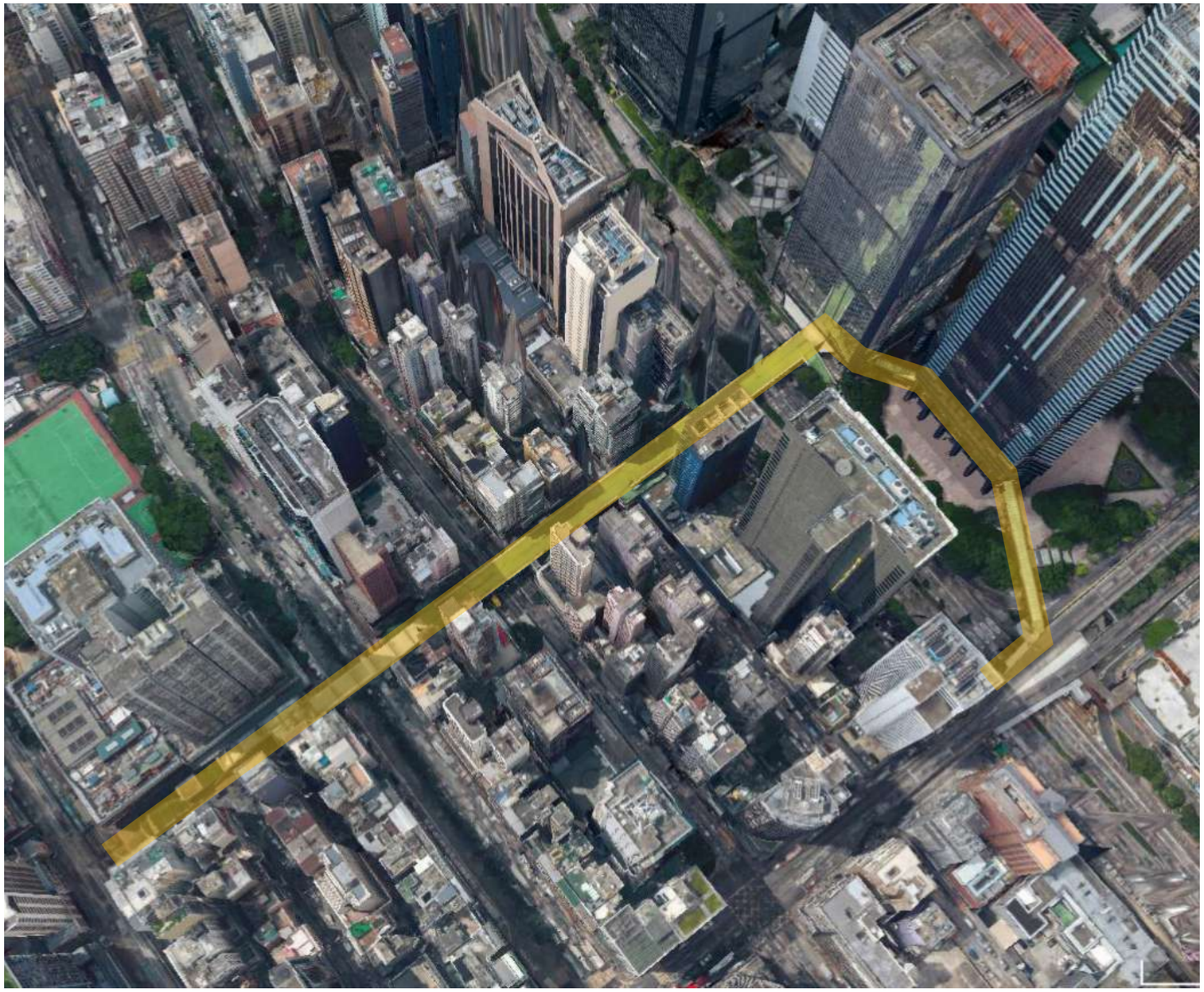


Indoor evacuation relies on the creation of a two tier city, connecting the upper levels of the city with public walkways providing a secondary address to buildings. This strategy assumes that the proposed connection will be internal publicly accessable privately owned space that is accessible 24hours a day. These spaces can be both passive and active, fronted by levels of double height retail spaces, commercial offices suites or planting.

Case Study

Indoor Evacuation





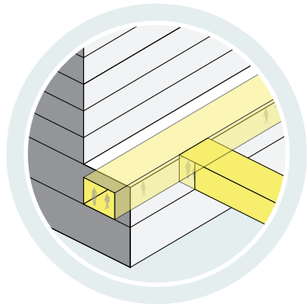
Strategy Evaluation

Indoor Evacuation

✓ Can be achieved

– Difficult to achieve - requires further consultation

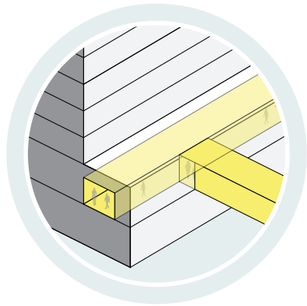
✗ Cannot be achieved



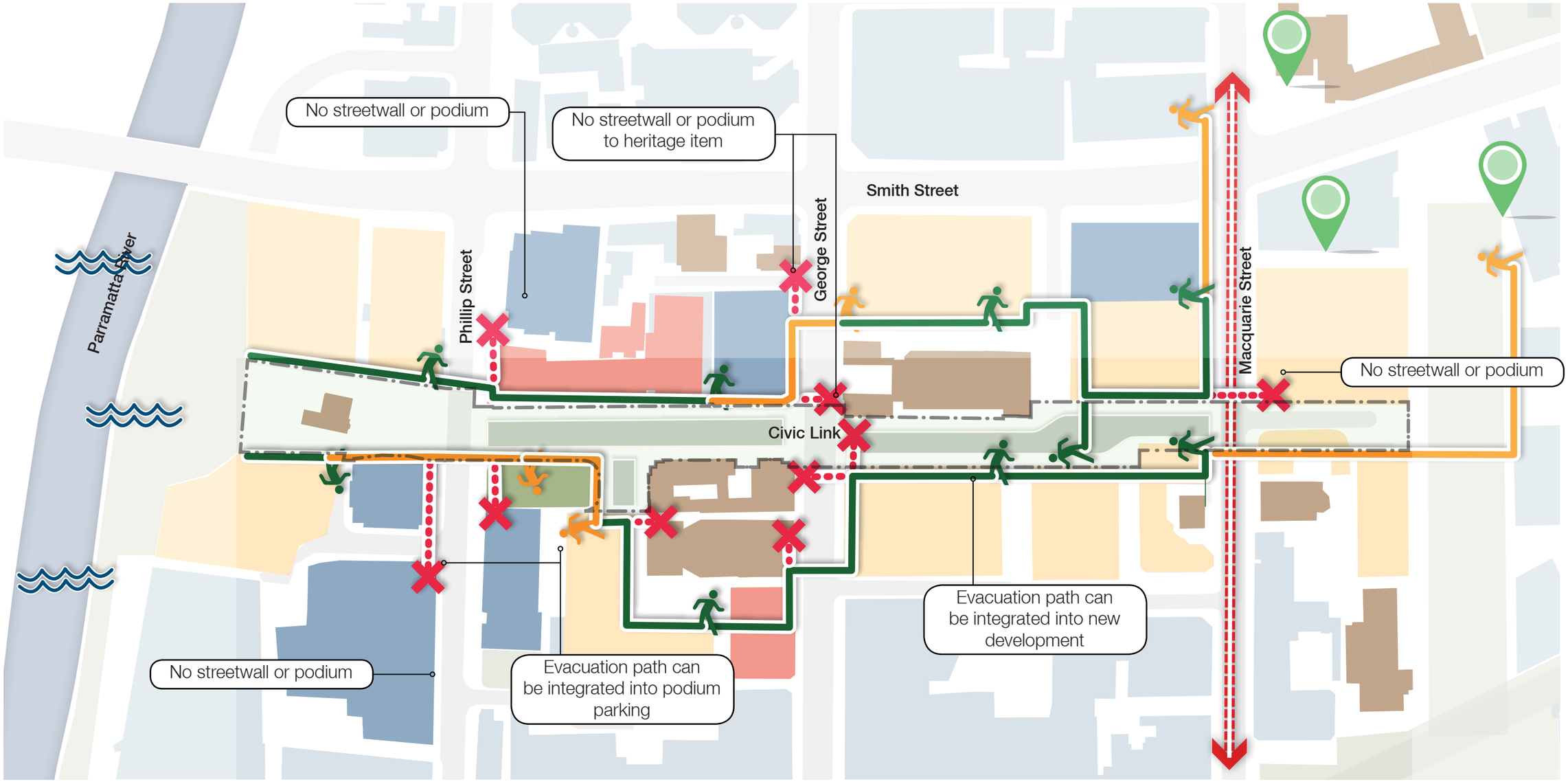
Conditions / Interface	1. New Building - New Building	2. New Building - Existing Building 'Unlikely to Change'	3. Existing Building - Existing Building	4. Heritage - New Building	5. Heritage - Existing Building 'Unlikely to Change'	6. Heritage - Heritage
A. Over Road	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
B. Over Lane	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
C. Over Boundary	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
D. Over Public Space	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
E. Over Light Rail LIne	– · New sky bridge/ internal walkways can be integrated as part of design. Height clearance	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items

Civic Link Testing

Indoor Evacuation



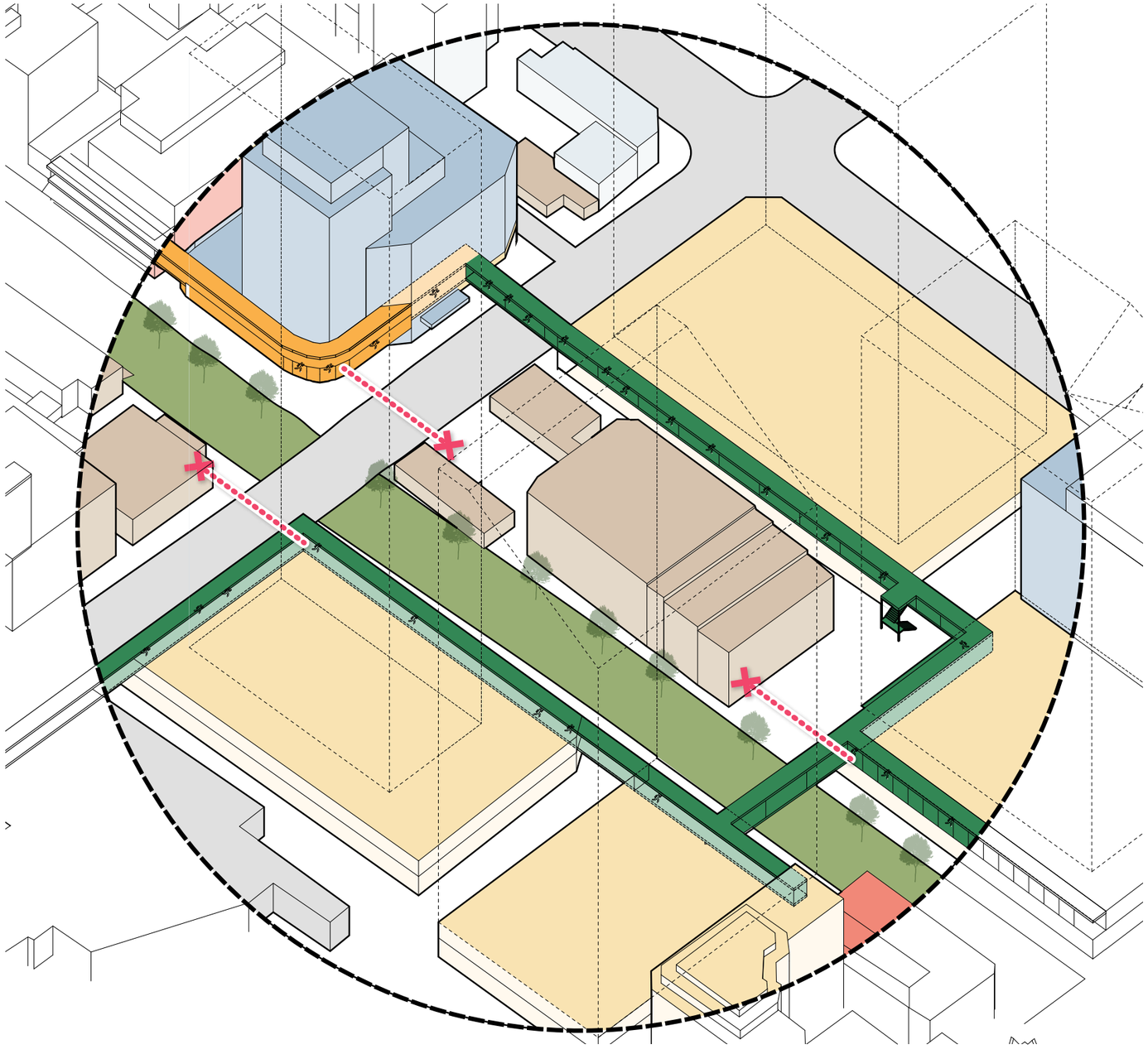
- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change



Discussion

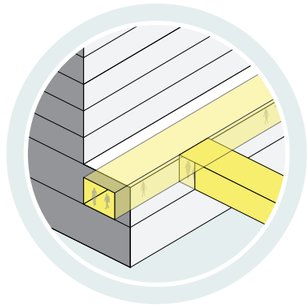
Indoor Evacuation

- Possible to create a route above the PMF, however this will take many years to implement.
- Most adjacent buildings can be internally connected.
- This strategy is costly and will require extensive coordination between land owners. It is unclear who would cover what costs.
- Will require coordination between city blocks as to crossing point over a road or lane, should that be required.
- This option provides a safe path of travel.
- Potential to connect the city and create new two-tiered city.



Strategy Evaluation

Indoor Evacuation



Challenges

Feasibility

This evacuation option is likely to be more expensive due to the cost of integration into the existing fabric of the building. Walkways spanning between buildings also need to be structurally sound, and create a complete seal to the building where they enter.

Heritage value

Creating a walkway that connects into a heritage building would significantly damage or compromise the integrity of the item.

Adjacent levels

Due to the rapid development underway in the CBD, it is likely that there will be existing and new buildings constantly changing. New buildings now have to address flood levels through elevated floor levels, whilst many existing buildings will have floor levels that do not align. Hence the connection of various floors between buildings will pose a challenge to creating a path of access, and an appropriate architectural solution.

Integrity

This is a more complicated approach as the walkways connecting between buildings have not been accounted for in the original design of a building (in the case of retrofitting). This requires additional cost to ensure the structural integrity of the walkway, as well as the cost to the architectural integrity of the building.

Safety

The risk to evacuees moving between buildings is greatly reduced in this option, as the path of travel is sheltered from the weather, and is less likely to create a slip hazard, or allow access to aeas that occupants should not travel to.
In the case that occupants are evacuating because of a fire in a building, this option will not be safe, as appropriate fire measures would need to be in place to separate the buildings. As such, in the case of a fire, these internal walkways would either need to be treated in the same manner as a fire escape, or alternatively, provide separation between the buildings and create an inaccessible area. In the later case, the walkway can no longer serve it's purpose for evacuation. In the first case, the walkway takes up valuable space within a building envelope that is only used in the case of an emergency.

Implementation

This strategy would have a lengthier time frame than the other two strategies, and would require extensive negotiations between land owners, Council, and other government organisations. A holistic strategy could take years to deliver, and in the meantime a more appropriate strategy may need to be implemented to reduce the levels of risk within the CBD. This would suggest that a more appropriate response may be to address the immediate needs of the CBD. Existing uses will also need to be renegotiated to allow public access to parts of the building as a permanent solution.

Continuous Path of Travel

This strategy is unlikely to be able to provide a continuous path of travel due to the private nature of many of the buildings in the CBD. Connecting to different levels between the buildings will cause the main problem for connectivity, as well as some building operators not wishing to create an internal and permanent connection.
As this strategy assumes that there is a new 24 hour public space running above the city, there will be no issues with the need to instigate the emergency response such as connecting bridges over roads. The walkways are permanent and already in place.

Opportunities

Visual impact

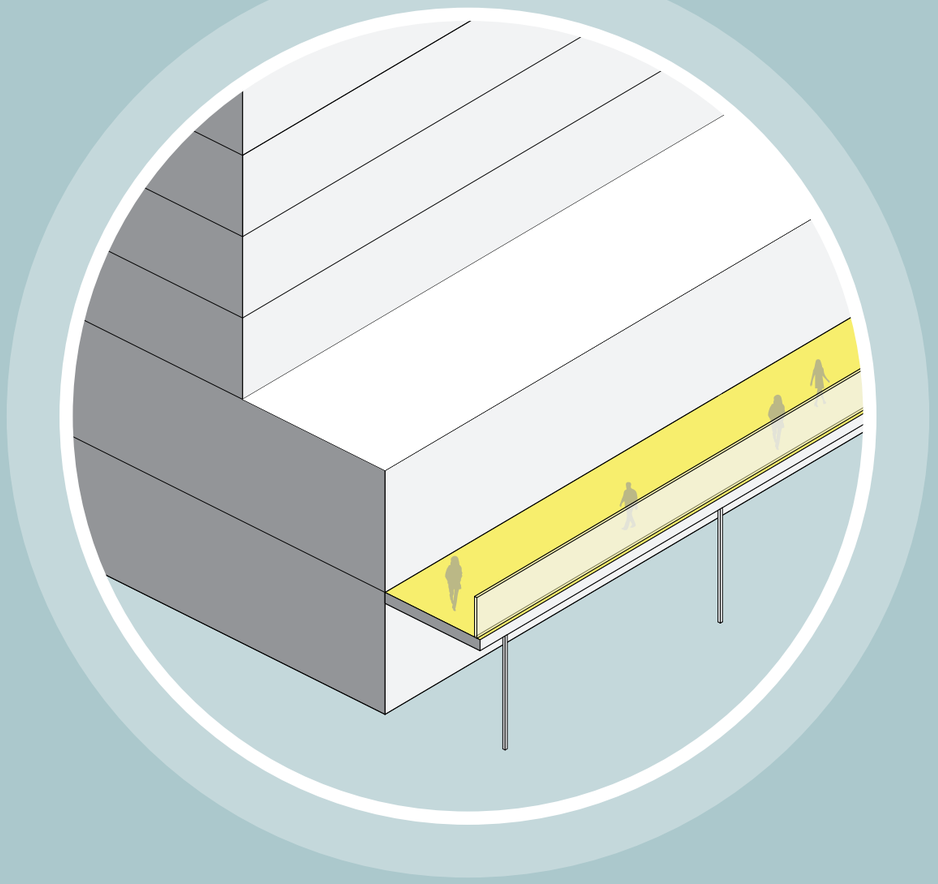
The impact upon the city of this strategy will only be seen between buildings, and could potentially be dealt with in an attractive manner.

Wayfinding

A wayfinding strategy within internal paths of travel would be easier to manage and implement, as the walkways can be clearly signed within the buildings.

Design

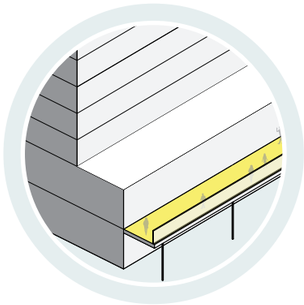
A number of cities around the world have indoor pathways that connect large sections of the city, whether through raised walkways or underground arcades. These can be designed to become the 'second tier' of the city, and provide retail or public amenity to these walkways.



Above Awnings

Evacuation Strategy

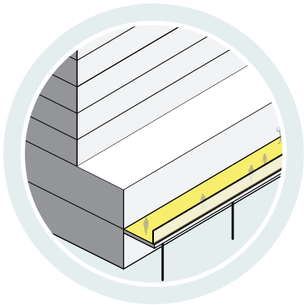
Evacuation via Awnings and external walkways

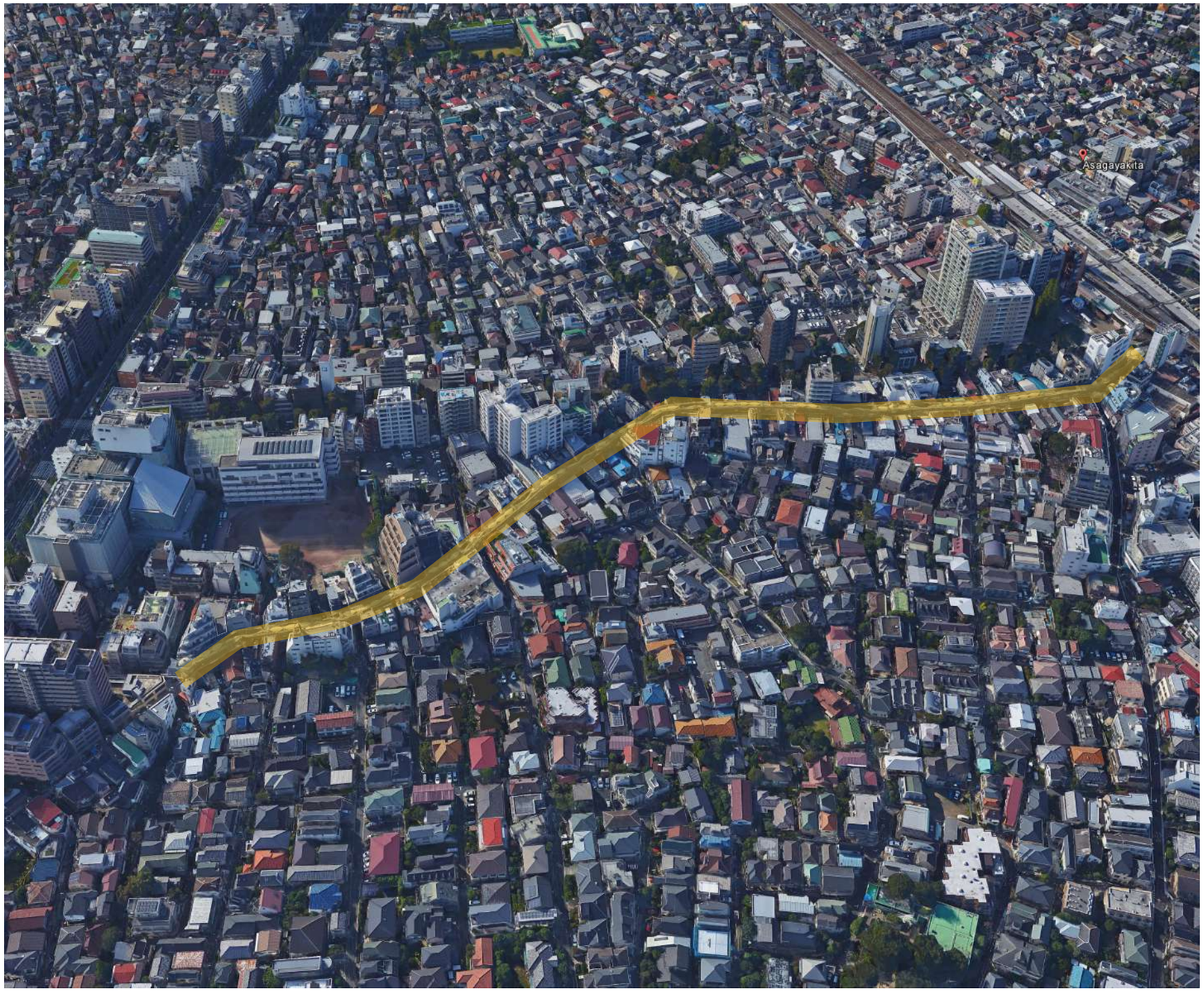


This strategy relies on the construction of trafficable awnings to prove access to refuge in the event of a flood within the CBD. Awnings typically only extend to the front of the building and do not cross streets and lanes, and would require a bridge to cross should evacuees need to move to a public marshalling area.
A continuous awning can be delivered by individual developments or as a single public domain element delivered by the Civic Link.

Case Study

Evacuation via Awnings and external walkways





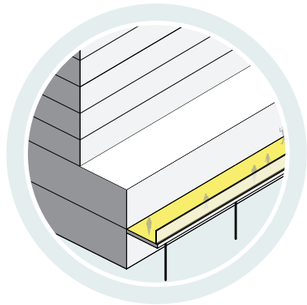
Strategy Evaluation

Evacuation via Awnings and external walkways

✓ Can be achieved

– Difficult to achieve - requires further consultation

✗ Cannot be achieved



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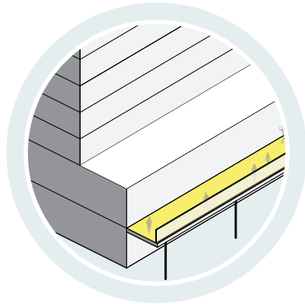
A. Over Road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require independant structure to cross the roads	– · will require independant structure to cross the road	– · will require independant structure to cross the road
B. Over Lane	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road
C. Over Boundary	✓ · Awnings can be made to align with adjoing properties	✓ · Awnings can be made to align with adjoing properties	✓ · Awnings can be made to align with adjoing properties	– · May have significant impact the integrity and structural of heritage item	– · May have significant impact the integrity and structural of heritage item	– · May have significant impact the integrity and structural of heritage item
D. Over Public Space	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road
E. Over Light Rail LIne	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective

Civic Link Testing

Evacuation via Awnings and external walkways



- Heritage Item
- Unlikely to Change
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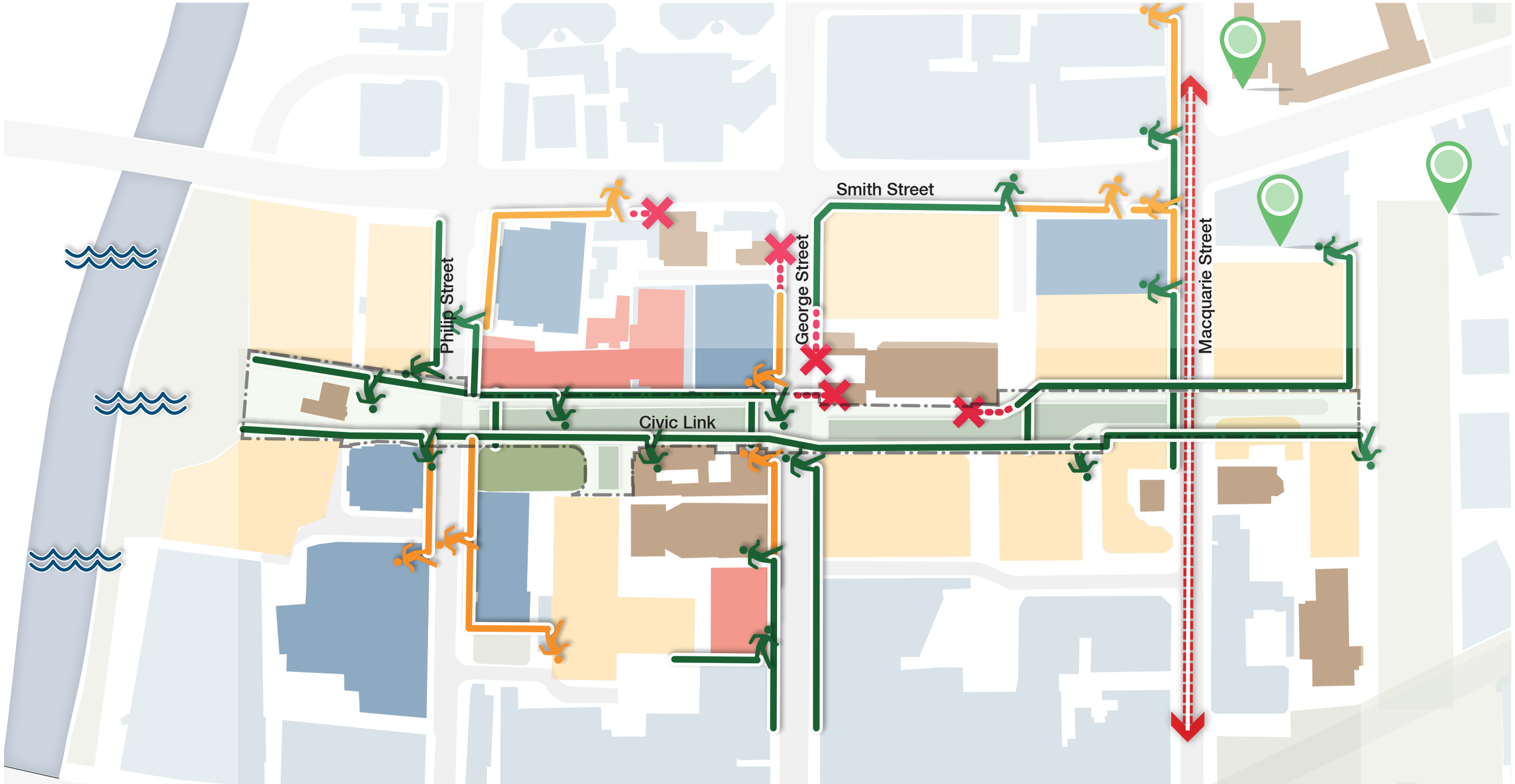


Discussion

Evacuation via Awnings and external walkways

- Possible to create a route, however this is not always above the PMF and hence does not lower the risk of developments.

- Does not create a safe path of travel, with submerged objects moving underwater and crashing into awnings.

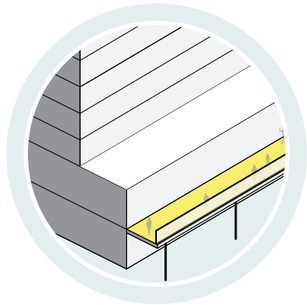
- Most adjacent buildings can be connected.

- This strategy is costly due to most awnings needing to be replaced to carry the load of people walking during an emergency.

- Will require coordination between city blocks as to crossing point over a road or lane, should that be required. This would create a permanent fixture in the public domain which is unlikely to be desireable as an urban design feature.

Strategy Evaluation

Evacuation via Awnings and external walkways



Challenges

Feasibility

There may be challenges in getting a unified roll out of this strategy through the city. Owners of buildings with recently completed awnings will not wish to replace the awnings with new, more structurally sound awnings. Whilst more feasible than the Indoor strategy, it will still be more expensive than the Above Podium option.

Heritage value

Heritage items that have flat and trafficable awnings would need to replace them to ensure their structural integrity. However a number of items have bull-nose awnings which would not be trafficable. Replacing these with a different style would damage the integrity of the item.
In the case where an item has no awning, the addition of an awning would again damage the integrity of the item.

Adjacent levels

The creation of a continuous and level awning throughout the city is a fairly straightforward task, however the PMF level throughout the CBD varies significantly.
It is crucial to an effective evacuation strategy that the evacuation route is above the PMF. As such, this strategy will not be applicable through some areas of the CBD, where the PMF is above typical awning height.

Wayfinding

Wayfinding would be challenging due to the discontinuous path of travel, and having to place signage on the exterior of buildings.

Integrity

To appropriately provide a safe and effective route of travel, the awnings must be structurally sound and able to carry a heavy temporary load. This will require additional cost to a typical awning, and dependant on the size of the building and the number of occupants, may even require structural posts to the street frontage. Awnings of this style can be troublesome due to RMS requirements, and may not be approrpiate within the city.

Safety

Travelling along an awning provides the greatest number of risks to an evacuee including exposure to heavy rain and potential storm conditions. A number of floating objects are also likely to threaten evacuees, such as cars that are floating at or just below awning height.
Safety railing is recommended to be provided to avoid slips and falls, which could pose an unpleasant addition to the built form.
Powerlines from the streets or Parramatta Light Rail may potentially be active and fall, creating additional hazards.

Implementation

This strategy would be reasonably straightforward to implement throughout the city in terms of providing a continous awning and requiring additional safety measures for them, however creating a continuous path of travel around the city would be challenging, and would require a combination of strategies.

Continuous Path of Travel

It will not be possible to have a continuous path of travel through the city, as some awnings are under the PMF height.
When the path of travel comes to a road, lane or public open space, a bridge would be required to connect to the other side. As such, in any application of travel on the awning, a combination of strategies will be required.
If the mechanisms are not permanently set up on awnings, the way in which these are set up in an emergency event will need to be coordinated by both the CoP and building occupants. Allowing time for bridges to be set up throughout the city is something that is unlikely to have time in an emergency event, however simply moving from one building to the adjacent building should not require a bridge in most cases.

Opportunities

Visual impact

This strategy will have minimal visual impact, provided that any additional safety measures are able to be hidden when not in use (i.e. hand rails to prevent slipping and falling).

Design

A continous awning of this nature could be designe and delivered as part of the Civic Link project.

Discussion & Recommendations

Heritage Items

- Evacuating heritage items will always be an issue. Retrofitting any of the three solutions to a heritage item is likely to severely compromise the integrity of the item. As such, any heritage item within the 1 in 100 year flood level will remain a “low flood island” (high risk), and should have a specific evacuation strategy. Occupants of heritage items should evacuate the city in the same way as a pedestrian in the public domain.

Strategies

Indoor

- The indoor evacuation scheme could potentially provide a good outcome for the city, and architecturally could be made to become an asset to the city. However, this strategy is likely to take upwards of 10 years to deliver a city-wide scheme, and will not help the evacuation of the city in a flood event before its implementation.

Above Awning

- The above awning strategy poses a significant cost to the city, without a truly safe evacuation route, or a route that is continuous through the city.

Above Podium

- The above podium provides the most immediate strategy that can be implemented city-wide by the CoP, and has the opportunity to develop into a more permanent and designed solution over time. This solution not only immediately lowers the societal risk within the city, but can also provide safe access to evacuees through the city.
- The nature of the temporary walkway response above podiums will also convey a sense of caution within an emergency event, and minimise the amount of travel that an evacuee will be comfortable to take. This will encourage occupants to remain within a building unless it is necessary that they evacuate.

Recommendations - Above Podium/Elevated Walkways

- It is recommended that Council continue to work with the SES to educate occupants as to a building or **city block emergency management plan** as follows:
    - The emergency response to a flood event for an occupant is to **Shelter in Place** as the first and most preferable response.
    - In the case that occupants must evacuate their building, they are advised to move to the **adjacent building to Shelter in Place**.
    - In the extreme event of all buildings in a city block being unsafe to Shelter in Place, evacuees are permitted to **move between city blocks via the walkways across the podiums or rooftops**. This would require coordination between city blocks to establish the most appropriate crossing point between buildings across a road or laneway.
    - **Clear signage and wayfinding** will be required to ensure that the most efficient route is travelled by evacuees, and that evacuees are made aware that Sheltering in Place is the safest option.
    - **Communication devices** should be made available and clearly marked within all buildings to contact the SES and alert them of the number of people Sheltering within a building.
    - **Flotation Devices and Personal Flotation Devices** may be considered as part of an emergency response, to be made available to evacuees on the way out of a building in the case of evacuation.
    - Given that the natural response of occupants within an emergency may be to evacuate via the fire stairs, it is important that the **fire stairs are clearly signed** to indicate that exiting at the ground or first floor may be hazardous due to flood waters outside the building. The evacuation route for buildings during a flood event will be different to the evacuation route during a fire event. This is important to educate occupants about in the same way a fire drill is conducted, a **flood drill** should also be conducted, and coordinated between city blocks.
- A **city-wide emergency communication system** should also be implemented by Council to inform occupants within the city about the flood event, and provide regular updates.

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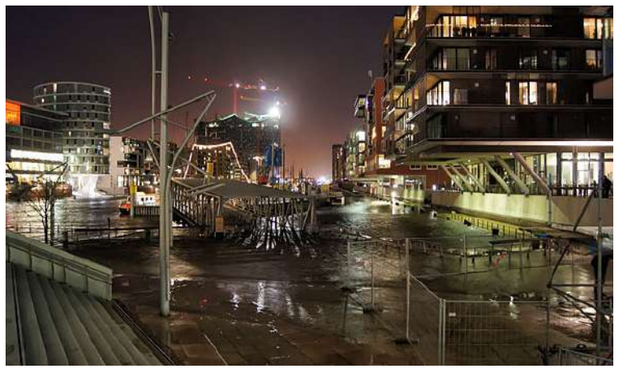
1.1 HafenCity, Hamburg

Key principles

- Hafen uses a high dike which provides a continuous protection along a distance of 100km to protect lower lying areas against flooding.
- Retains access to the water whilst guaranteeing protection from floods
- The first floor of every building on the promenade is dedicated to retail outlets, and exhibition spaces, that are sealed off in times of flooding.
- Buildings behind the promenade are built on “warts” (elevated mounds) 8-9 meters above mean sea level. The streets are also on this higher level and not effected by the neighborhood’s annual flood.

Risks and Challenges

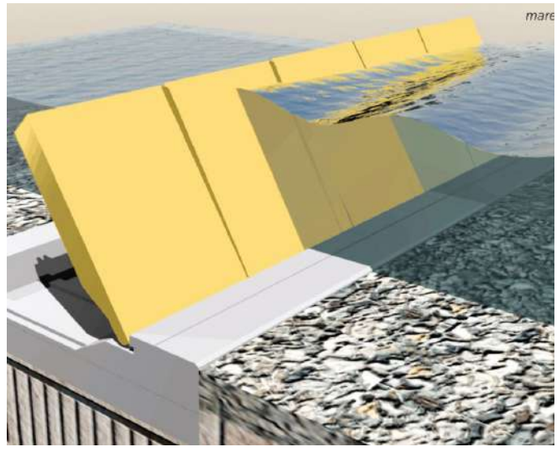
- Three eastern neighbourhoods are more isolated and less integrated in the the city
- Large amounts of built landscape in comparison to green space, in particular in the western part of the district which is due to the fact that the surface of HafenCity is the result of the artificial soil during the construction of the port, it is evident in the lack of trees and other natural elements.
- Dikes are very expensive device for flood management and prevention however warts and sealed off first floor are a relatively inexpensive solution
- Elevated mounds and sealed off first floors would be difficult to implement in existing buildings

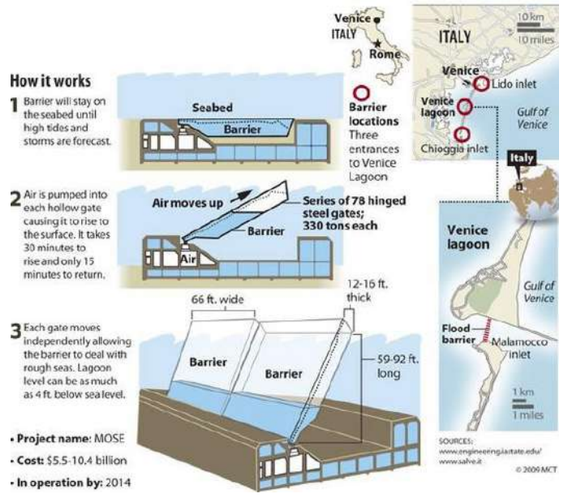


1.2 Piazza San Marco, Venice

Key Principles
- The city installs a network of walkways along the main pedestrian paths, generally at 120cm above the standard sea level
- Water transport becomes available all across all weather routes
- Flood information is provided in real time and usually lasts for 2.5 hours
- Currently underway is a new flood management system called MOSE (MOdulo Sperimentale Elettromeccanico, Experimental Electromechanical Module) a project intended to protect the city of Venice, Italy, and the Venetian Lagoon from flooding. The project is an integrated system consisting of rows of mobile gates installed at the Lido, Malamocco and Chioggia inlets that are able to temporarily isolate the Venetian Lagoon from the Adriatic Sea during high tides. Together with other measures such as coastal reinforcement, the raising of quaysides, and the paving and improvement of the lagoon, MOSE is designed to protect Venice and the lagoon from tides of up to 3 metres (9.8 ft).

Risks and challenges
- Storage of temporary devices
- Tidal appropriate
- Preparation time

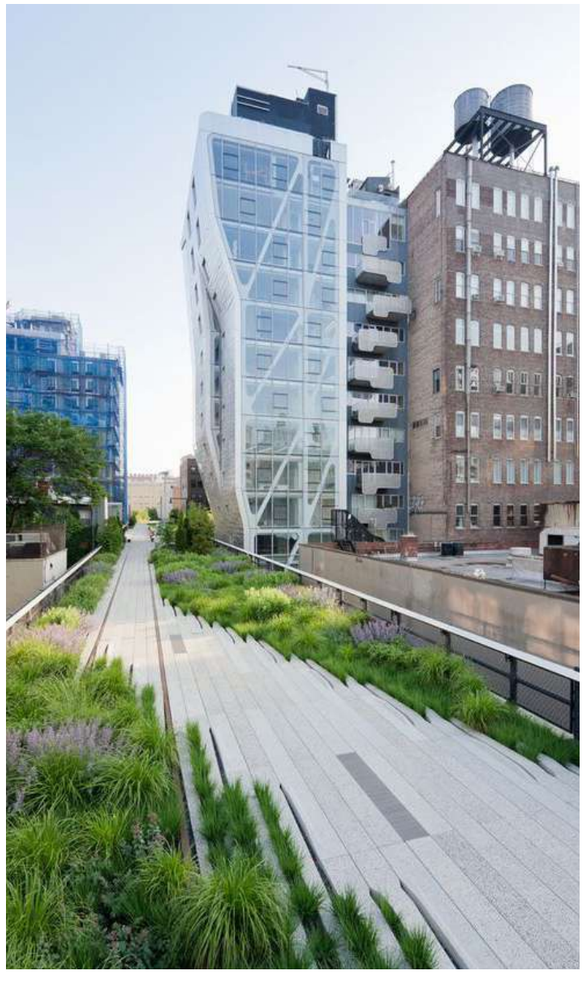




1.3 Evacuation to Permanent Devices in the Public Domain

Delivery challenges:

- Expensive to build into the public domain
- Durable materials would be required to ensure longevity and high use
- Coordination with building owners to decide how these devices are connected to buildings and manage different building levels
- Access from the street to these devices required
- Retrofitting existing public domain would be difficult and require it to be accessible, withstand vandalism and quickly implemented
- Barrier is created between the streets and public domain and therefore a strong connection would need to be created to ensure no dead space
- Capacity of the space needs to be aligned with future growth of the CBD and needs to be structurally sound to hold a large volume of people.
- Impact on the amenity of the public domain need to be considered.



1.4 Evacuation to Temporary Devices in the Public Domain

Delivery challenges:

- Storage requirements for temporary devices would need to be retrofitted into the public domain and/or existing buildings
- Possible vandalism to devices kept in the public domain
- Maintenance to ensure devices are safe and in working condition
- Volume and size of the devices would have to be appropriately designed for to ensure they cater for the estimated number of people that would need it and the amount of water preventing
- Structurally sound to hold people using it
- Time required to setup devices which might always be possible
- Durability of materials to endure weathering, volume of people and possible vandalism
- Would require a coordinated emergency flood management plan