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COST-EFFECTIVE MITIGATION STRATEGY DEVELOPMENT FOR FLOOD PRONE BUILDINGS

Development of costing modules for flood mitigation strategies

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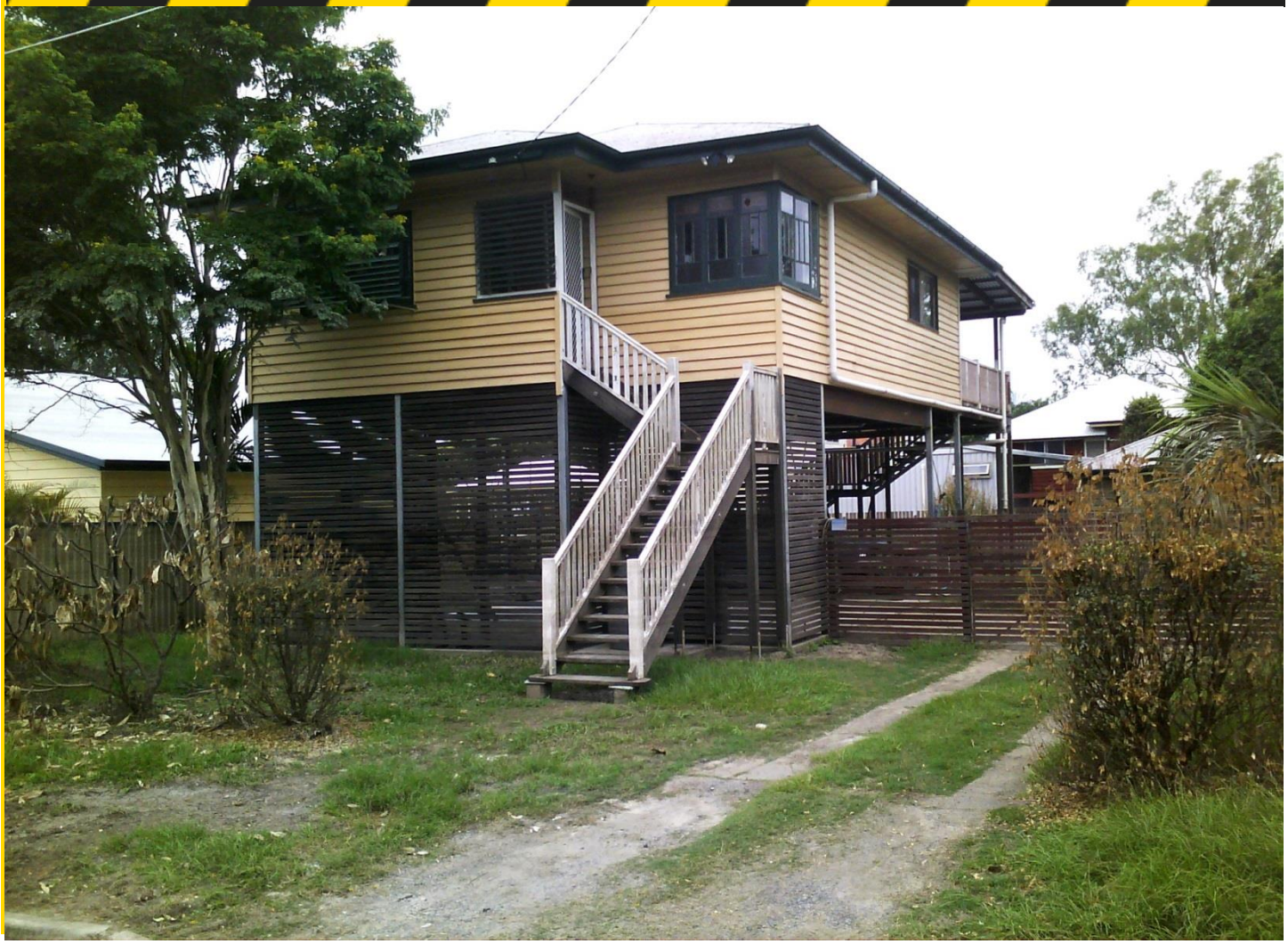

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Cover: Flood mitigation strategy: elevating floor level (Geoscience Australia)

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EXECUTIVE SUMMARY

This report forms part of the output to a research project titled 'Cost effective mitigation strategy development for flood prone buildings' within the Bushfire and Natural Hazards Cooperative Research Centre. The motivation for this project arises from the experience and observations during the recent flooding in Australia in 2011, 2013 and 2015, which caused widespread devastation in Queensland. A fundamental reason for this damage was inappropriate development in floodplains and a legacy of high risk building stock in flood prone areas. The BNHCRC project aims to address this issue and is targeted at assessing mitigation strategies to reduce the vulnerability of existing residential building stock in Australian floodplains.

As a first step to achieving this goal this project has developed a building schema to categorise the Australian residential building stock. The next step was to conduct a literature review of mitigation strategies developed nationally and internationally. The review categorises the strategies into elevation, relocation, dry floodproofing, wet floodproofing and the use of flood barriers. The review helps to evaluate the strategies that suit Australian building types and typical catchment behaviours and, hence, may be adopted in Australia.

Five typical storey types have been selected to evaluate the above mentioned mitigation strategies which represent the most common residential buildings in Australia. The selected storey types are:

- Timber frame (raised floor)
- Cavity masonry - Victorian terrace (raised floor)
- Cavity masonry (raised floor)
- Brick veneer (raised floor)
- Brick veneer (slab-on-grade)

A floodproofing matrix has been developed to assess appropriate strategies for the selected storey types. This report discusses the application of these strategies to the five selected storey types during two construction regimes i.e. existing state before any event and a substantial renovation or reconstruction after an event. Each mitigation strategy has been evaluated and has been costed through engagement of professional quantity surveyor.

In future years (2016-2020) of this project, strength degradation of common building components (materials, structural systems) due to wetting and subsequent drying will be assessed through experimental testing. Vulnerability of selected storey types will also be assessed along with the factors affecting vulnerability. Cost benefit analyses will be conducted to determine optimum retrofit strategies for selected residential building types within a range of catchment behaviours. The result will be an evidence base to inform decision making by government and property owners on the mitigation of flood risk by providing information on the cost effectiveness of different mitigation strategies and an optimal solution for different cases of building and catchment types.

INTRODUCTION

Globally, floods cause tremendous damage with loss of life and property. An analysis of global statistics conducted by Jonkman (2005) showed that floods (including coastal flooding) caused 175,000 fatalities and affected more than 2.2 billion people between 1975 and 2002. In Australia, floods cause more damage on an average annual cost basis than any other natural hazard (HNFMSC, 2006). The fundamental causes of this level of damage and the key factors contributing to flood risk, in general, is the presence of vulnerable buildings constructed within floodplains due to ineffective land use planning.

The Bushfire and Natural Hazards Collaborative Research Centre project entitled 'Cost-effective mitigation strategy development for flood prone buildings' (BNHCRC, 2016) examines the opportunities for reducing the vulnerability of Australian residential buildings to flood. It addresses the need for an evidence base to inform decision making on the mitigation of the flood risk posed by the most vulnerable Australian building types and complements parallel BNHCRC projects for earthquake and severe wind.

The project makes assessments of the reduction in damage loss that will ensue from the implementation of a range of mitigation measures assessed by the project. This report summarises the building schema proposed in this project and presents the development of costing modules to cost the implementation of all appropriate mitigation strategies for the five selected storey types. To facilitate the development of costing modules, a floodproofing matrix has been developed which excludes the mitigation options that are invalid in the Australian context and is based on the characteristics of the selected storey types i.e. building materials and construction type.

Furthermore, a list of typical building materials is compiled to ascertain common storey types which facilitates the selection of the representative storey types for the balance of the research.

PROJECT BACKGROUND

Recent events in Australia (2011and 2013) highlight the vulnerability of housing to flooding which originates from inappropriate development in floodplains (see Figure 1). While there is now a construction standard published by the Australian Building Code Board (ABCB, 2012) for new construction in some flood prone areas, there is a significant proportion of existing building stock that is located in flood prone areas across Australia (HNFMSC, 2006). The Australian Government has developed a National Strategy for Disaster Resilience which defines the roles of government and individuals in improving disaster resilience (NSDR, 2011). The strategy also emphases the responsibility of governments, businesses and households on assessing risk and taking action to reduce the risk by implementing mitigation plans (Productivity Commission, 2014).

An in-depth understanding of the effects of floods is required for the assessment of risk and the development of mitigation strategies, particularly in the context of limited financial resources. In this respect, reliable information about the costs and benefits of mitigation are crucial to inform decision-making and the development of policies, strategies and measures to prevent or reduce the impact of flood.

The objective of this project is to provide an evidence base for two target groups to inform their decision making process around mitigation against flood risk: government and property owners. Federal, State/Territory and local governments have an interest in loss estimates arising from past or future events and require vulnerability information to support several objectives including decision making concerning the allocation of funding and risk management. Property owners are also interested in vulnerability and mitigation assessment to know the potential risk to their properties due to floods and make decisions on undertaking mitigation measures to reduce risk and possibly insurance premiums (Meyer et al. 2012).

The information on vulnerability and the factors/parameters affecting vulnerability is fundamental to evaluating mitigation strategies to reduce future losses. Therefore, this BNHCRC project is systematically developing information about buildings in Australia, their vulnerability and possible mitigation measures associated to different storey types to reduce their vulnerability. The result will be an evidence base to inform decision making by government and property owners on mitigation of flood risk by providing information on the cost effectiveness of different mitigation strategies and an optimal solution for different cases of building and catchment types.

FIGURE 1: EXAMPLES OF BUILDING DAMAGE RECORDED AFTER 2011 SOUTHEAST QUEENSLAND FLOOD

BUILDING CLASSIFICATION SCHEMA

This research requires a building vulnerability classification, or schema which must identify specific classes for which the project will develop mitigation strategies. In this research a literature review has been conducted which reviewed building schemas developed nationally and internationally for a range of uses within different projects. The reviewed schemas are from the USA (FEMA, 2007), Germany (Schwarz and Maiwald, 2008), Philippines (Pacheco et al. 2013), New Zealand (NIWA, 2010), Australia (Wehner et al. 2012) and the UNISDR Global Assessment Report (Maqsood et al. 2014).

Based on the literature review a schema was proposed that represents a fundamental shift from describing the complete building as an entity to one that focuses on sub-components (Maqsood et al. 2015a). The proposed schema divides each building into its major components (i.e. foundation, ground floor, upper floors (if any) and roof) enabling the vulnerability of each of these components to be assessed separately (Figure 2). Each storey type is then classified using the following six attributes.

- Construction period (pre-1960 or post-1960)
- Fit-out quality (standard or low)
- Storey height (3.0m or 2.7m or 2.4m)
- Bottom floor system (slab-on-grade or raised floor)
- Internal wall material (masonry or plasterboard or timber)
- External wall material (brick veneer or weatherboard or masonry)

With the exclusion of combinations that are invalid in an Australian context, the schema defines 60 discrete storey types based on the above listed attributes. Additionally, the schema proposes six roof types based on the material and pitch of the roof.

This approach facilitates the development of vulnerability models for taller buildings, buildings with basements, buildings with mixed usages and/or those with different construction materials used at different floor levels. Therefore, the new approach provides a mechanism to represent building stock in a better way and to improve the quality of flood risk assessment.

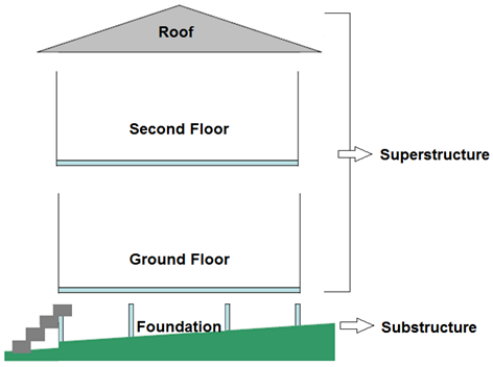


FIGURE 2: BUILDING STRUCTURE DIVIDED INTO MAIN COMPONENTS (MAQSOOD ET AL. 2015A)

SELECTION OF KEY STOREY TYPES

A list of building materials typically used in Australian residential construction has been sourced through literature review (FEMA, 2008; ICA, 2015) and presented in Table 1. FEMA (2008) provides performance of some of these materials when subjected to flooding. This list helped to identity predominant construction materials and storey types in Australia and also informed the development of costing modules.

TABLE 1: BUILDING COMPONENTS AND COMMON CONSTRUCTION MATERIALS (ADAPTED FROM ICA, 2015 AND FEMA, 2008)

Number	Component	Building Material
1	Floor	Concrete Slab on Ground
		Concrete Precast Floor Panels
		Softwood Floorboard & hardwood Joists
		Hardwood Floorboard & hardwood Joists
		Particleboard & hardwood Joists
		Plywood & hardwood Joists
2	Floor insulation	Rockwool
		Glasswool
		Expanded Polystyrene
3	Frame	Concrete
		Steel
		Timber
4	Wall insulation	Rockwool
		Glasswool
		Expanded Polystyrene
5	External walls	Brick
		Concrete Block
		Stone
		Galvanised Steel
		Plywood
		Hardwood Weatherboard
		Softwood Weatherboard
		Fibrecement Weatherboard
6	Internal walls	Brick
		Concrete Block
		Stone
		Plasterboard
		Fibrecement board
7	Ceiling	Plasterboard
		Fibrecement board
8	Roof structure	Timber
		Steel
		Concrete
9	Roof insulation	Rockwool
		Glasswool
		Expanded Polystyrene
		Reflective Foil Sarking
10	Windows	Aluminium Framed
		Softwood Framed
		Hardwood Framed
11	Doors	Softwood
		Hardwood

		Solid Core Veneered
		Hollow Core Veneered
		Steel Clad EPS Core
		Plywood
12	Stairs	Concrete
		Timber
13	Floor finish	Terrazzo Floor Tiles
		Ceramic Glazed Floor Tiles
		Terra Cotta Floor Tiles
		Timber Flooring
		Interlocking Panel Flooring
		Carpet
14	Wall finish	Paint
		Wallpaper
		Timber Panelling
		Tiling
15	Joinery	Laminated Particleboard
		Laminated Softwood

Five typical residential storey types have been selected for the balance of the research which are a subset of the schema proposed earlier in this report. Key characteristics of these storey types are presented in Table 2.

TABLE 2: CHARACTERISTICS OF SELECTED STOREY TYPES

Storey Type	Construction period	Bottom floor system	Fit-out quality	Storey height	Internal wall material	External wall material	Photo
1	Pre-1960	Raised Timber	Low	2.7m	Timber	Weather-board	
2	Pre-1960	Raised Timber	Low	3.0m	Masonry	Cavity masonry	
3	Pre-1960	Raised Timber	Standard	2.4m	Masonry	Cavity masonry	
4	Post-1960	Raised Timber	Standard	2.4m	Plasterboard	Brick veneer	
5	Post-1960	Slab-on-grade	Standard	2.4m	Plasterboard	Brick veneer	

Storey Type 1: Timber Frame (raised floor)

Storey Type 1 is an older (pre 1960) light frame construction made of hardwood timber which is supported on piers made of brick or timber. This type of construction is most common in northern Australia and is supported on both short (low-set) and tall (high-set) piers. The underfloor area is used to cool the building through ventilation, to protect the main structure from termite attack and to reduce flood vulnerability in some localities (for high-set). The typical floor system is made of timber joists and bearers with hardwood strip flooring. Exterior cladding is generally hardwood weatherboards while lining to interior wall is softwood timber boarding. The ceiling consists of timber boarding and/or plasterboard attached to timber battens. More details of the building components are presented in Table 4. Typical building plan and elevations are presented in Appendix A.

The raised floor is critical to avoid damage due to low levels of flooding. However, because of its light weight and no effective connection to foundation, this storey type is most vulnerable to flash flooding and could exhibit velocity related damage. This could result in flotation and displacement of the structure, and in the worst case, total destruction. A recent example of this type of damage was seen in Dungog, NSW, where four houses were washed away (Wehner and Maqsood, 2015). More examples of this type of damage were seen in Grantham, Queensland, during the 2010-11 floods (Wehner et al. 2012).

Storey Type 2: Cavity Masonry - Victorian Terrace (raised floor)

Storey Type 2 is an older (pre 1960) Victorian terrace made of masonry. This type of construction is quite common in older inner city areas of major Australian cites, particularly in Sydney and Melbourne. The typical floor system is made of timber joists and bearers with hardwood floor boards raised to 0.3m above the ground. Exterior walls are made of cavity masonry while interior walls are made of a single leaf of rendered brick. The ceiling is made of plasterboard attached to timber battens. More details of the building components are presented in Table 5. Typical building plan and elevations are presented in Appendix B.

Because of masonry walls this storey type is considered to be less vulnerable to flood damage as much of the damage can be repaired by washing and cleaning.

Storey Type 3: Cavity Masonry (raised floor)

Storey Type 3 represents a pre 1960 cavity masonry construction. This type of construction is quite common in all Australian cites. The substructure consists of reinforced concrete strip footings with chipboard flooring raised to 0.75m off the ground. Exterior walls are made of cavity masonry while interior walls are made of a single leaf of rendered brick. The ceiling is made of plasterboard attached to timber battens. More details of the building components are presented in Table 6. Typical building plan and elevations are presented in Appendix C.

Storey Type 4: Brick Veneer (raised floor)

Storey Type 4 represents relatively newer (post 1960) brick veneer construction. This type of construction is very common in all Australian cites and is comprised of timber frame construction with brick cladding. The substructure consists of reinforced concrete strip footings. The typical floor system is made of timber joists and bearers with chipboard flooring raised to 0.75m off the ground. Exterior cladding is comprised of a single leaf of brick wall attached to the timber frame while lining to the interior face of the timber frame is plasterboard. The ceiling is made of plasterboard attached to timber battens. More details of the building components are presented in Table 7. Typical building plan and elevations are presented in Appendix D.

Storey Type 5: Brick Veneer (slab-on-grade)

Storey Type 5 represents the typical new (post 1960) slab-on-grade residential construction made of brick veneer. This type of construction is the most common new construction type in all Australian cites and is comprised of timber frame construction with brick cladding. The substructure consists of reinforced concrete slab on ground. Floor finishes typically are tiles and carpets. Exterior cladding is made of single leaf of brick wall attached to the timber frame while lining to the interior face of the timber frame is plasterboard. Ceiling is made of plasterboard attached to timber battens. More details of the building components are presented in Table 8. Typical building plan and elevations are presented in Appendix E.

DEVELOPMENT OF COSTING MODULES FOR SELECTED MITIGATION STRATEGIES

A literature review of mitigation strategies developed nationally and internationally has also been conducted within this project (Maqsood et al. 2015b). The review helps to evaluate the strategies that suit Australian building types and typical catchment behaviours for adoption in Australia. Strategies in the international literature have been developed for different types of floods and the selection of a particular strategy depends upon the characteristics of flood hazard and building stock along with any mitigation incentives and associated cost verses benefit.

Further, based on the characteristics of the selected storey types a floodproofing matrix has been developed which excludes the mitigation options noted earlier that are invalid in the Australian context. Costing modules have been developed by quantity surveying specialists to estimate the cost of implementing all appropriate mitigation strategies for these five storey types (see Table 3), which are presently under review.

TABLE 3: COST OF IMPLEMENTING FLOOD MITIGATION STRATEGISES TO EXISTING BUILDINGS FOR SELECTED STOREY TYPES

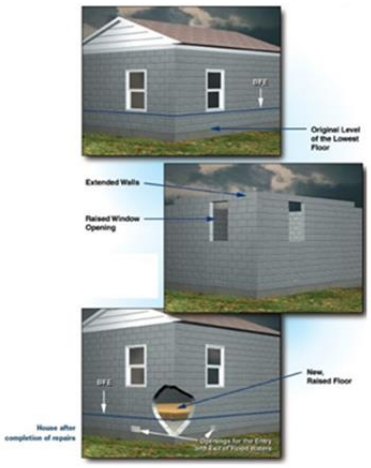
Storey Type	Elevation (Extending the walls)	Elevation (Building a second storey)	Elevation (Raising the whole house)	Relocation	Flood Barriers (Permanent)		Flood Barriers (Temporary)			Dry Flood-proofing	Wet Flood-proofing	
					1.0m high	1.8m high	0.9m high	1.2m high	1.8m high		Existing structure	Substantial Renovation
1	N/A	N/A	$78,200		N/A	N/A	N/A	N/A	N/A	N/A	$11,700	$68,000
2	N/A	$213,500	N/A	N/A	$133,500	$177,600	$62,500	$111,800	$136,300	N/A	$15,400	$56,600
3	$397,700	$429,700	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$17,400	$104,300
4	N/A	$405,200	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$15,500	$140,000
5	N/A	$431,000	N/A	N/A	$154,300	$208,300	$164,600	$144,100	$176,200	$154,320	$17,400	$149,800

A summary of mitigation measures considered for the costing in the context of the five selected storey types is provided below.

Elevation

Elevation of a structure is one of the most common mitigation strategies which aims to raise the lowest habitable floor of a building above the expected level of flooding. This can be achieved, for example, by (i) extending the walls of an existing structure and raising the floor level; (ii) change the ground floor usage and constructing a new floor above the existing one and, (iii) raising the whole structure on new foundations (walls, piers or columns) as shown in Figure 3.

(A) Technique 1: extending the walls of an existing structure and raising the floor level



(B) Technique 2: changing the use of ground floor and constructing a new floor above the existing one

(C) Technique 3: raising the whole structure on new substructure

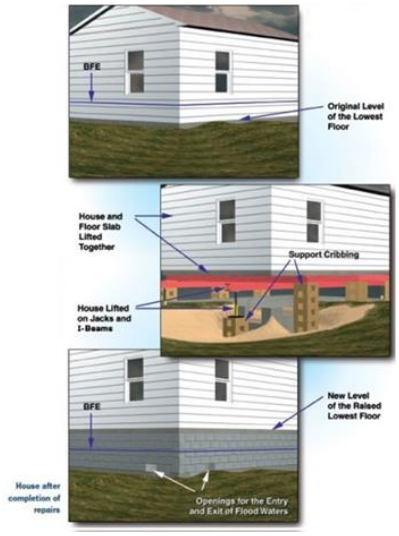


FIGURE 3: TECHNIQUES FOR ELEVATION (FEMA, 2000)

Technique (i) is intended to be applied only to Storey Type 3 which is a cavity masonry construction. The load bearing cavity masonry walls can be extended and the timber floor can be further raised to a level which is expected to be above the target flood level. This technique is not considered suitable for Storey type 1 and 4 as other more suitable options for elevation are available. This technique is also not suitable for Storey type 2 which is normally an attached construction (row housing) and would have practical and aesthetic implications. Furthermore, this technique is considered to be invalid for Storey type 5 which is a slab-on-grade construction due to practical limitations.

Technique (ii) to change the use and construction a second storey is considered to be appropriate for all the selected storey types except the Storey Type 1 for which similar and more cost-effective techniques are available i.e. technique (iii) to elevate the whole structure (USACE, 2000). Technique (iii) is considered more complicated and expensive for Storey Type 2 to 4 because of slab-on-grade construction or walls of masonry (USACE, 1993).

Currently elevation is one of the strategies which result in incentives from the insurance industry in the form of reductions in annual premiums for flood insurance (Bartzis, 2013). An analysis conducted by FEMA (2010) showed that house owners can break even on their investment in adopting this mitigation strategy in a little over five years due to reductions in their flood insurance premiums.

Relocation

Relocation of a building is the most dependable technique in mitigation of flood risk. However, it is generally the most expensive as well (USACE, 1993). Relocation involves moving a structure to a location that is less prone to flooding or exposed to flood-related hazards such as erosion or scouring. Relocation normally involves placing the structure on a wheeled vehicle. The structure is then transported to a new location and set on a new foundation (FEMA, 2012). Relocation is much easier for Storey Type 1 and more complicated for Storey Types 2 to 5 (USACE, 1990).

Dry Floodproofing

In dry floodproofing the portion of a structure that is below the expected flood level is sealed to make it substantially impermeable to floodwaters. Such an outcome is achieved by using sealant systems which include wall coatings, waterproofing compounds, impervious sheeting over doors and windows and a supplementary leaf of masonry (FEMA, 2012). Preventing sewer backflow by using backwater valves is also important in making dry floodproofing effective (Kreibich et al. 2005; FEMA, 2007). Sump pumps are also used to drain out the water which may leak through small openings or due to exterior wall permeability (FEMA, 2013).

Dry floodproofing is generally not recommended for flood depths exceeding one metre based on tests carried out by the US Army Corps of Engineers as the stability of the building becomes an issue over this threshold depth (USACE, 1988; Kreibich et al. 2005). Dry floodproofing is also not recommended for timber frame structures and for structures with raised timber floors. These types of structure can be susceptible to significant lateral and uplift (buoyancy) forces. Therefore, for this project it is considered appropriate only for Storey Type 5 i.e. slab-on-grade brick veneer structures.

Wet Floodproofing

In this measure the building is modified and floodwater is allowed to enter into the building to equalise the hydrostatic pressure on the interior and exterior of the building and thus reduces the chance of building failure (USACE, 1993; FEMA, 2007). As this technique entails all the building components below the flood level being wetted, all construction material and fit-outs should be water-resistant and/or can be easily cleaned following a flood. Wet floodproofing involves raising utilities (heating, ventilation, and air conditioning (HVAC), electrical systems etc.) and important contents above the expected flood level, installing flood openings to equalise the hydrostatic pressure exerted by floodwaters and installing pumps to remove floodwater if the building has a basement (FEMA, 1999).

Wet floodproofing is considered appropriate for each of the five selected storey types. This strategy can be implemented at two different construction regimes i.e. existing state before any event and substantial renovation or reconstruction after an event. Each of the wet floodproofing strategies have been evaluated and costed through engagement of a professional quantity surveying consultant.

Table 4 to Table 8 provide details of the wet floodproofing strategy for different building components for the two construction regimes discussed above.

Flood Barriers

ICPR (2002) states that flood damage can be potentially reduced by 80-100% if water barriers provided are not over-topped. Flood barriers considered here are those built around a single building and are normally placed some distance away (usually 3.0m) from it to avoid any structural modifications to the building. There are two kinds of barriers: permanent and temporary. An example of a permanent barrier is a floodwall which is quite effective because it requires little maintenance and can be easily constructed and inspected. Generally, it is made of reinforced masonry or concrete (rarely glass) and has one or more passageways through it that are closed by gates during a flood and require periodic maintenance. The gates considered here are provided by Flooding Solutions Advisory Group (http://www.floodingsolutions.com.au/).

The options considered here for permanent flood barriers are:

1. 300mm thick and 1500mm high core filled reinforced block walls and 1000mm high self-closing gate
2. 300mm thick and 2300mm high core filled reinforced block walls and 1800mm high self-closing gate

There are also several types of temporary flood barriers available in the market which can be moved, stored and reused. A number of vendors make temporary flood barriers that can be assembled relatively easily, moved into place, anchored and filled with water (if required). Examples of some of the flood barrier options are sandbags, tubes, fences and box wall. Figure 4 presents examples of permanent and temporary flood barriers. The options considered here for temporary flood barriers were provided by Flooding Solutions Advisory Group (http://www.floodingsolutions.com.au/):

1. 900mm high Floodstop barrier system including removable keys
2. 1200mm high Floodplank system including removable posts and planks
3. 1800mm high Floodplank system including removable posts and planks

The cost of flood barriers increases with the increase of the height of barriers. Therefore, these are not considered economically suitable to be used for Storey type 1, 3 and 4 as these storey types have floors at or above 0.7m from the ground level.

(A) Flood wall

(B)Box wall

FIGURE 4 TECHNIQUES EXAMPLES OF PERMANENT AND TEMPORARY FLOOD BARRIERS (BLUEMONT, 2015)

TABLE 4: BUILDING COMPONENTS AND WET FLOODPROOFING MEASURES FOR STOREY TYPE 1

No.	Component	Description	Flood proofing measure: Wet floodproofing (replace original component with)	
			to existing building	during substantial reconstruction
1	Substructure	250mm square reinforced concrete piers embedded 1.0m into ground and bearing on 400x400x200mm concrete pads. External piers painted. Antcaps installed.		
2	Substructure	Timber lattice enclosing underfloor space		
3	External stairs	Painted hardwood entry stairs, 1500mm rise, 1400mm wide o/a complete with painted timber handrail		
4	External stairs	Painted hardwood rear stairs, 1500mm rise, 1200mm wide o/a complete with painted timber handrail		
5	Timber floor structure	125x45 hardwood joists @ 450ctrs on 125x75 hardwood bearers @ 2000 ctrs		
6	Timber flooring	19mm thick T&G hardwood strip flooring		
7	Timber wall framing	90x45 hardwood studs @ 450 ctrs, similar top & btm plates, 2 rows of noggings		
8	Exterior cladding	Hardwood weatherboards, painted		
9	General lining to interior of exterior walls and interior walls	Softwood timber boarding 9mm thick		
10	Lining to bathroom, toilet and laundry walls	Fibre cement sheeting		
11	Lining to kitchen walls	Fibre cement sheeting		
12	Skirting boards	Moulded softwood skirting, paint finish		Aluminium skirting (may require extra packing for attaching the skirting properly due to 30mm gap)
13	Cornices	Preshaped plaster cornice		
14	Ceiling	Softwood timber boarding 9mm thick to lounge, kitchen and bedrooms, 13mm plasterboard to other areas all on timber battens		
15	Timber roof structure	Hardwood cut roof framing		
16	Roofing	Colourbond corrugated iron roofing and flashings screw fixed to timber battens		
17	Wall insulation	Fibreglass batts (thermal to exterior walls, sound to interior walls)		Polystyrene boards/Rigid closed cell board (using nails so that insulation can be removed from inside the house following a flood)
18	Roof insulation	Fibreglass batts		
19	Windows	Timber, single glazed, painted, 50% casement, 50% sash		
20	Window surrounds	Softwood moulded timber		
21	Window sills	Painted softwood moulded sills		
22	External doors	Solid core timber front door with deadlock, ditto to rear door, varnish finish		
23	External door frames	Hardwood timber door frames, varnish finish		Aluminium door frame, paint finish
24	Internal doors	Hollowcore doors, paint finish		
25	Internal door frames	Softwood timber door frames, paint finish		Aluminium door frame, paint finish
26	Eaves lining	Fibre cement sheeting with timber beading at sheet joins		

27	Guttering and downpipes	Painted galvanised rainwater goods		
28	Floor covering (bedrooms)	Carpet with rubber underlay		Polyurethane finished floorboards
29	Floor covering (bathroom, toilet, laundry)	6mm floor tiles on 4.5mm fibre cement sheet.		
30	Floor covering (kitchen)	Linoleum tiles glued to hardboard sheet		Polyurethane finished floorboards
31	Floor covering general	Polyurethane finished floorboards		
32	Wall finishes (general)	Undercoat + 2 top coats paint		
33	Wall finishes (bathroom)	Full height wall tiles adhesive fixed to FC sheet		
34	Wall finishes (toilet)	200mm height skirt tiles, paint above		
35	Wall finishes (laundry)	0.5m2 tile splashback, 200mm height skirt tiles, paint elsewhere		
36	Wall finshes (kitchen)	Tile splashback to all benches, 800 high. Paint elsewhere		
37	Ceiling finishes	Undercoat + 2 top coats paint		
38	Bathroom joinery	Melamine covered mdf vanity, FC sheet skirting around bath.		Melamine covered mdf vanity (wall hung at 0.4m high), FC sheet skirting around bath.
39	Bathroom basin and tapware	Ceramic basin, connecting hydraulics and chrome taps		
40	Bath	Enamelled steel and chrome taps		
41	Bathroom fixtures	Chrome towel rail and soap dish		
42	Shower recess	Frameless glass 0.9m2 shower cubicle and chrome taps		
43	Shower recess hob	Masonry hob finished to accept waterproofing and tiles		
44	Shower water proofing	Paint-on waterproof membrane		
45	Toilet fixtures	Ceramic dual flush toilet and connecting hydraulics, chrome toilet paper holder		
46	Laundry fixtures	Stainless steel tub with chrome taps, chrome taps for washing machine		
47	Laundry joinery	Melamine covered mdf broom cupboard	Melamine covered mdf high level wall mounted cabinets 1.8m long	Melamine covered mdf high level wall mounted cabinets 1.8m long
48	Kitchen joinery	Melamine covered mdf kitchen under bench cupboards, high level cupboards, laminex covered benchtops		Steel shelves, cabinets and benchtop
49	Kitchen fixtures	Stainless steel basin and chrome taps		
50	Kitchen appliances	Gas cooktop, electric underbench oven, dishwasher, electric rangehood	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m height	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m height
51	Mechanical	Bathroom extraction fan		
52	Mechanical	2.5hp A/C system mounted back to back with external unit on ground	2.5hp A/C external unit mounted on brick pier (1.2m high, 0.35m wide and 1.2m long)	2.5hp A/C external unit mounted on brick pier (1.2m high, 0.35m wide and 1.2m long)
53	Mechanical	Check gas supply to kitchen		
54	Electrical - lighting	Central ceiling mounted light fitting (10 No) + ceiling mounted fluorescent fitting to kitchen		
55	Electrical lighting	Wall mounted light switches (11 No)		
56	Electrical exterior lighting	Two No external sensor lights mounted under eaves		
57	Electrical - power	11 No. double GPO	11 No. double GPO at 1.2m above floor level	11 No. double GPO at 1.2m above floor level
58	Electrical - power	Meter box		

59	Electrical - general	Test electrical cabling for faults (item) (assume no rewiring necessary for all depths)		
60	Hydraulic - HWS	Electrical 250l HWS mounted externally on ground	Electrical 250l HWS mounted externally on brick pier (1.2m high, 0.35m wide and 1.2m long)	Electrical 250l HWS mounted externally on brick pier (1.2m high, 0.35m wide and 1.2m long)
61	Hydraulic - water supply piping	Copper 15mm diameter		
62	Hydraulic - sanitary drainage	100mm vitreous clay		
63	Hydraulic - SW drainage	100mm concrete jointed pipe		
64	Window furnishing	Fabric curtains to bedroom & lounge windows. Plastic Venetian blinds to kitchen, laundry, toilet and bathroom windows.		
65	Hydraulic - SW		Installing check valve and gate valve	Installing check valve and gate valve

TABLE 5: BUILDING COMPONENTS AND WET FLOODPROOFING MEASURES FOR STOREY TYPE 2

No.	Component	Description	Flood proofing measure: Wet floodproofing (replace original component with)	
			to existing building	during substantial reconstruction
1	Substructure	Reinforced concrete strip footings (300dp x 600) under all exterior and interior walls. 230 x 230 brick piers on 400 x 400 x 200 concrete pads at 2m ctrs each way between strip footings		
2	Timber floor structure	120x35 hardwood joists @ 450 ctrs on 100x75 hardwod bearers @ 2000 ctrs		
3	Floor sheeting	19mm hardwood floorboards		
4	External walls	Cavity brick including brick chimney	Installing flood vents on exterior walls at 0.2m above floor level (1 brick wide at every 2m)	Installing flood vents on exterior walls at 0.2m above floor level (1 brick wide at every 2m)
5	Exterior finish	Smooth cement render 13mm thick		
6	Exterior finish	Paint		
7	Internal walls	Flush finished single leaf bwk		
8	General lining to interior of exterior walls and interior walls	Smooth cement render 13mm thick		
9	Lining to bathroom and laundry walls	Smooth cement render 13mm thick		
10	Lining to kitchen walls	Smooth cement render 13mm thick		
11	Skirting boards	Moulded softwood skirting, paint finish		Aluminium skirting
12	Cornices	Preshaped plaster cornice		
13	Ceiling	13mm plasterboard on timber battens with decorative plaster ceiling rose in living room		
14	Timber roof structure	Cut hardwood framing		
15	Roofing	Terracotta tiles on timber battens		
16	Roofing	Corrugated galvanised iron on timber battens to shallow slope section of roof		
17	Eaves lining	Fibre-cement sheet on timber sub-framing, paint finish		
18	Roof insulation	Fibreglass batts		
19	Windows	Timber framed, single glazed, sash type, painted		
20	Window surrounds	Moulded softwood, painted		
21	Window sills	Brick set on incline		
22	External doors	Solid core timber front door with deadlock, ditto to laundry door, varnish finish		
23	External door frames	Hardwood timber door frames, varnish finish		Aluminium door frame, paint finish
24	Internal doors	Solid core doors, paint finish		
25	Internal door frames	Moulded softwood door frames, paint finish		Aluminium door frame, paint finish
26	Guttering and downpipes	Colourbond rainwater goods		
27	Floor covering (bedrooms, lounge, dining and family)	Carpet with rubber underlay		
28	Floor covering (bathroom and laundry)	6mm floor tiles on 4.5mm FC sheet		
29	Floor covering (kitchen)	Linoleum tiles glued to hardboard sheet		
30	Wall finishes (general)	Undercoat + 2 top coats paint		
31	Wall finishes (bathroom)	Full height wall tiles adhesive fixed		
32	Wall finishes (laundry)	0.5m2 tile splashback, 200mm height skirt tiles, paint elsewhere		

33	Wall finshes (kitchen)	Tile splashback to all benches, 800 high. Paint elsewhere		
34	Ceiling finishes	Undercoat + 2 top coats paint		
35	Bathroom joinery	Melamine covered mdf vanities, FC sheet skirting around bath.		Melamine covered mdf vanity (wall hung at 0.4m high), FC sheet skirting around bath.
36	Bathroom basins and tapware	Ceramic basin, connecting hydraulics and chrome taps		
37	Bath	Enamelled steel, chrome shower head over and chrome taps		
38	Bathroom fixtures	Chrome towel rail and soap dish, mirror		
39	Toilet fixtures	Ceramic dual flush toilet and connecting hydraulics, chrome toilet paper holder		
40	Laundry fixtures	Stainless steel tub with chrome taps, chrome taps for washing machine		
41	Laundry joinery	Melamine covered mdf broom cupboard	Melamine covered mdf high level wall mounted cabinets 1.8m long	Melamine covered mdf high level wall mounted cabinets 1.8m long
42	Kitchen joinery	Melamine covered mdf kitchen under bench cupboards, high level cupboards, laminex covered benchtops		Steel shelves, cabinets and benchtop
43	Kitchen fixtures	Stainless steel basin and chrome mixer tap		
44	Kitchen appliances	Gas cooktop, electric underbench oven, dishwasher, electric rangehood	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m height	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m height
45	Bedroom joinery	Painted timber framed build-in wardrobe		
46	Mechanical	Bathroom extraction fan		
47	Mechanical	2.5hp A/C system mounted back to back with external unit on ground	2.5hp A/C system with external unit on brick pier (0.95m high from ground , 0.35m wide and 1.2m long)	2.5hp A/C system with external unit on brick pier (0.95m high from ground , 0.35m wide and 1.2m long)
48	Mechanical	Check gas supply to kitchen		
49	Electrical - lighting	Central ceiling mounted light fitting (8 No) + ceiling mounted fluorescent light to kitchen		
50	Electrical lighting	Wall mounted light switches (9 No)		
51	Electrical exterior lighting	Two No external sensor lights mounted under eaves		
52	Electrical - power	10 No. double GPO	10 No. double GPO at 1.2m above floor level	10 No. double GPO at 1.2m above floor level
53	Electrical - power	Meter box	Meter box at 1.8m height, provide brick steps for easy access to meter reading (0.7m wide and 0.25m high)	Meter box at 1.8m height, provide brick steps for easy access to meter reading (0.7m wide and 0.25m high)
54	Electrical - general	Test electrical cabling for faults (item) (assume no rewiring necessary for all depths)		
55	Hydraulic - HWS	Electrical 250l HWS mounted externally on ground	Electrical 250l HWS mounted externally on brick pier 0.95m high from ground	Electrical 250l HWS mounted externally on brick pier 0.95m high from ground
56	Hydraulic - water supply piping	Copper 15mm diameter		
57	Hydraulic - sanitary drainage	100mm UPVC		
58	Hydraulic - SW drainage	100mmUPVC		
59	Window furnishing	Fabric curtains to bedroom, lounge windows. Plastic Venetian blinds to laundry, kitchen and bathroom windows.		
60	Hydraulic - sanitary drainage	Check valve	Installing check valve and gate valve	Installing check valve and gate valve

TABLE 6: BUILDING COMPONENTS AND WET FLOODPROOFING MEASURES FOR STOREY TYPE 3

No.	Component	Description	Flood proofing measure: Wet floodproofing (replace original component with)	
			to existing building	during substantial reconstruction
1	Substructure	Reinforced concrete strip footings (500dp x 300) under all exterior and interior walls and at 6m ctrs each way elsewhere. 230 x 230 brick piers on 400 x 400 x 200 concrete pads at 2m ctrs each way between strip footings		
2	Timber floor structure	120x35MGP10 joists @ 450 ctrs on 2/120x45MGP10 bearers @ 2000 ctrs		
3	Floor sheeting	19mm T&G chipboard		19mm thick T&G hardwood strip flooring
4	External walls	Face cavity brick	Installing flood vents on exterior walls at 0.2m above floor level (1 brick wide at every 2m)	Installing flood vents on exterior walls at 0.2m above floor level (1 brick wide at every 2m)
5	Internal leaf to external walls	Flush finished bwk		
6	Internal walls	Flush finished single leaf bwk		
7	General lining to interior of exterior walls and interior walls	Smooth rendered bwk		
8	Lining to bathroom, toilet, ensuite and laundry walls	Smooth rendered bwk		
9	Lining to kitchen walls	Smooth rendered bwk		
10	Skirting boards	Moulded mdf skirting, paint finish		Aluminium skirting
11	Cornices	Preshaped plaster cornice		
12	Ceiling	13mm plasterboard on timber battens		
13	Timber roof structure	Prefabricated softwood trusses		
14	Roofing	Glazed concrete tiles on timber battens with sarking		
15	Wall insulation	Rigid closed cell board in cavity		
16	Roof insulation	Fibreglass batts		
17	Windows	Aluminium framed, double glazed, mix of sliding and awning types		
18	Window surrounds	Moulded mdf, painted		
19	Window sills	Brick set on incline		
20	External doors	Solid core timber front door with deadlock, ditto to laundryr door, varnish finish		
21	External doors	Sliding aluminium framed double glazed patio door to family room		
22	External door frames	Hardwood timber door frames, varnish finish		Aluminium door frame, paint finish
23	Internal doors	Hollowcore doors, paint finish		
24	Internal door frames	Mdf door frames, paint finish		Aluminium door frame, paint finish
25	Eaves lining	Fibre cement sheeting with timber beading at sheet joins		
26	Guttering and downpipes	Colourbond rainwater goods		
27	Floor covering (bedrooms, lounge, dining and family)	Carpet with rubber underlay		
28	Floor covering (bathroom, toilet, ensuite, laundry)	6mm floor tiles on 4.5mm FC sheet		
29	Floor covering (kitchen)	Linoleum tiles glued to hardboard sheet		
30	Wall finishes (general)	Undercoat + 2 top coats paint		

31	Wall finishes (bathroom and ensuite)	Full height wall tiles adhesive fixed		
32	Wall finishes (toilet)	200mm height skirt tiles, paint above		
33	Wall finishes (laundry)	0.5m2 tile splashback, 200mm height skirt tiles, paint elsewhere		
34	Wall finshes (kitchen)	Tile splashback to all benches, 800 high. Paint elsewhere		
35	Ceiling finishes	Undercoat + 2 top coats paint		
36	Bathroom and ensuite joinery	Melamine covered mdf vanities, FC sheet skirting around bath.		Melamine covered mdf vanity (wall hung at 0.4m high), FC sheet skirting around bath.
37	Bathroom and ensuite basins and tapware	Ceramic basins, connecting hydraulics and chrome taps		
38	Bath	Enamelled steel and chrome taps		
39	Bathroom and ensuite fixtures	Chrome towel rails and soap dishes		
40	Shower recesses	Frameless glass 0.9m2 shower cubicle and chrome taps		
41	Shower recess hobs	Masonry hob finished to accept waterproofing and tiles		
42	Shower water proofing	Paint-on waterproof membrane		
43	Toilet and ensuite fixtures	Ceramic dual flush toilet and connecting hydraulics, chrome toilet paper holder		
44	Laundry fixtures	Stainless steel tub with chrome taps, chrome taps for washing machine		
45	Laundry joinery	Melamine covered mdf broom cupboard	Melamine covered mdf high level wall mounted cabinets 1.8m long	Melamine covered mdf high level wall mounted cabinets 1.8m long
46	Kitchen joinery	Melamine covered mdf kitchen under bench cupboards, high level cupboards, laminex covered benchtops		Steel shelves, cabinets and benchtop
47	Kitchen fixtures	Stainless steel basin and chrome mixer tap		
48	Kitchen appliances	Gas cooktop, electric underbench oven, dishwasher, electric rangehood	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high
49	Mechanical	Bathroom and ensuite extraction fans		
50	Mechanical	2.5hp A/C system mounted back to back with external unit on ground	2.5hp A/C system mounted on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)	2.5hp A/C system mounted on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)
51	Mechanical	Check gas supply to kitchen		
52	Electrical - lighting	Central ceiling mounted light fitting (21 No) + ceiling mounted fluorescent fitting to kitchen		
53	Electrical lighting	Wall mounted light switches (28 No)		
54	Electrical exterior lighting	Two No external sensor lights mounted under eaves		
55	Electrical - power	17 No. double GPO	17 No. double GPO at 1.2m above floor level	17 No. double GPO at 1.2m above floor level
56	Electrical - power	Meter box		
57	Electrical - general	Test electrical cabling for faults (item) (assume no rewiring necessary for all depths)		
58	Hydraulic - HWS	Electrical 250l HWS mounted externally on ground	Electrical 250l HWS mounted externally on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)	Electrical 250l HWS mounted externally on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)
59	Hydraulic - water supply piping	Copper 15mm diameter		

60	Hydraulic - sanitary drainage	100mm UPVC		
61	Hydraulic - SW drainage	100mmUPVC		
62	Window furnishing	Fabric curtains to bedroom, dining, family & lounge windows. Plastic Venetian blinds to laundry, toilet, ensuite and bathroom windows.		
63	Hydraulic - SW drainage	check valve	Installing check valve and gate valve	Installing check valve and gate valve

TABLE 7: BUILDING COMPONENTS AND WET FLOODPROOFING MEASURES FOR STOREY TYPE 4

No.	Component	Description	Flood proofing measure: Wet floodproofing (replace original component with)	
			to existing building	during substantial reconstruction
1	Substructure	Reinforced concrete strip footings (500dp x 300) under all exterior walls and at 6m ctrs each way elsewhere. 230 x 230 brick piers on 400 x 400 x 200 concrete pads at 2m ctrs each way between strip footings		
3	Floor sheeting	19mm T&G chipboard		19mm thick T&G hardwood strip flooring
4	External walls	Face brick veneer		
5	Timber framing to external walls	90 x 45 MGP10 studs @ 450 ctrs with similar top & btm plates, 2 rows of noggings		
6	Timber framing to internal walls	75 x 35 MGP10 studs @ 600 ctrs with similar top and btm plates, 2 rows of noggings		
7	General lining to interior of exterior walls and interior walls	13mm plasterboard		Fibre cement sheeting
8	Lining to bathroom, toilet, ensuite and laundry walls	Fibre cement sheeting		
9	Lining to kitchen walls	Fibre cement sheeting		
10	Skirting boards	Moulded mdf skirting, paint finish		Plastic, paint finish
11	Cornices	Preshaped plaster cornice		
12	Ceiling	13mm plasterboard on timber battens		
13	Timber roof structure	Prefabricated softwood trusses		
14	Roofing	Colourbond corrugated metal roof sheeting screw fixed to timber battens with foil backed insulation blanket		
15	Wall insulation	Fibreglass batts (thermal to exterior walls, sound to interior walls)		Polystyrene boards/Rigid closed cell board
16	Roof insulation	Fibreglass batts		
17	Windows	Aluminium framed, double glazed, mix of sliding and awning types		
18	Window surrounds	Moulded mdf, painted		
19	Window sills	Brick set on incline		
20	External doors	Solid core timber front door with deadlock, ditto to laundryr door, varnish finish		
21	External doors	Sliding aluminium framed double glazed patio door to family room		
22	External door frames	Hardwood timber door frames, varnish finish		Aluminium door frame, paint finish
23	Internal doors	Hollowcore doors, paint finish		
24	Internal door frames	Mdf door frames, paint finish		Aluminium door frame, paint finish
25	Eaves lining	Fibre cement sheeting with timber beading at sheet joins		
26	Guttering and downpipes	Colourbond rainwater goods		
27	Floor covering (bedrooms, lounge, dining and family)	Carpet with rubber underlay		Polyurethane finished floorboards
28	Floor covering (bathroom, toilet, ensuite, laundry)	6mm floor tiles on 4.5mm fibre cement sheet.		
29	Floor covering (kitchen)	Linoleum tiles glued to hardboard sheet		Polyurethane finished floorboards
30	Wall finishes (general)	Undercoat + 2 top coats paint		
31	Wall finishes (bathroom	Full height wall tiles adhesive fixed to FC		

	and ensuite)	sheet		
32	Wall finishes (toilet)	200mm height skirt tiles, paint above		
33	Wall finishes (laundry)	0.5m2 tile splashback, 200mm height skirt tiles, paint elsewhere		
34	Wall finshes (kitchen)	Tile splashback to all benches, 800 high. Paint elsewhere		
35	Ceiling finishes	Undercoat + 2 top coats paint		
36	Bathroom and ensuite joinery	Melamine covered mdf vanities, FC sheet skirting around bath.		Melamine covered mdf vanity (wall hung at 0.4m high), FC sheet skirting around bath.
37	Bathroom and ensuite basins and tapware	Ceramic basins, connecting hydraulics and chrome taps		
38	Bath	Enamelled steel and chrome taps		
39	Bathroom and ensuite fixtures	Chrome towel rails and soap dishes		
40	Shower recesses	Frameless glass 0.9m2 shower cubicle and chrome taps		
41	Shower recess hobs	Masonry hob finished to accept waterproofing and tiles		
42	Shower water proofing	Paint-on waterproof membrane		
43	Toilet and ensuite fixtures	Ceramic dual flush toilet and connecting hydraulics, chrome toilet paper holder		
44	Laundry fixtures	Stainless steel tub with chrome taps, chrome taps for washing machine		
45	Laundry joinery	Melamine covered mdf broom cupboard	Melamine covered mdf high level wall mounted cabinets 1.8m long	Melamine covered mdf high level wall mounted cabinets 1.8m long
46	Kitchen joinery	Melamine covered mdf kitchen under bench cupboards, high level cupboards, laminex covered benchtops		Steel shelves, cabinets and benchtop
47	Kitchen fixtures	Stainless steel basin and chrome mixer tap		
48	Kitchen appliances	Gas cooktop, electric underbench oven, dishwasher, electric rangehood	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high
49	Mechanical	Bathroom and ensuite extraction fans		
50	Mechanical	2.5hp A/C system mounted back to back with external unit on ground	2.5hp A/C system mounted on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)	2.5hp A/C system mounted on brick pier (1.3m high from ground, 0.35m wide and 1.2m long)
51	Mechanical	Check gas supply to kitchen		
52	Electrical - lighting	Central ceiling mounted light fitting (21 No) + ceiling mounted fluorescent fitting to kitchen		
53	Electrical lighting	Wall mounted light switches (28 No)		
54	Electrical exterior lighting	Two No external sensor lights mounted under eaves		
55	Electrical - power	17 No. double GPO	17 No. double GPO at 1.2m above floor level	17 No. double GPO at 1.2m above floor level
56	Electrical - power	Meter box		
57	Electrical - general	Test electrical cabling for faults (item) (assume no rewiring necessary for all depths)		
58	Hydraulic - HWS	Electrical 250l HWS mounted externally on ground	Electrical 250l HWS mounted externally on brick pier (1.2m high, 0.35m wide and 1.2m long)	Electrical 250l HWS mounted externally on brick pier (1.2m high, 0.35m wide and 1.2m long)
59	Hydraulic - water supply piping	Copper 15mm diameter		
60	Hydraulic - sanitary drainage	100mm UPVC		

61	Hydraulic - SW drainage	100mmUPVC		
62	Window furnishing	Fabric curtains to bedroom, dining, family & lounge windows. Plastic Venetian blinds to laundry, toilet, ensuite and bathroom windows.		
63	Hydraulic - SW		Installing check valve and gate valve	Installing check valve and gate valve
64	Hydraulic - vents		Installing flood vents at 0.2m above floor level (2 in each direction = 8 total)	Installing flood vents at 0.2m above floor level (2 in each direction = 8 total)

TABLE 8: BUILDING COMPONENTS AND WET FLOODPROOFING MEASURES FOR STOREY TYPE 5

No.	Component	Description	Flood proofing measure: Wet floodproofing (replace original component with)	
			to existing building	during substantial reconstruction
1	Substructure	Stiffened raft consisting of 100 thick slab on grade on DPM on 20 sand on 100 hardcore. 600 dp x 300 wide rc beams at 4m ctrs each way.		
2	External walls	Face brick veneer		
3	Timber framing to external walls	90 x 45 MGP10 studs @ 450 ctrs with similar top & btm plates, 2 rows of noggings		
4	Timber framing to internal walls	75 x 35 MGP10 studs @ 600 ctrs with similar top and btm plates, 2 rows of noggings		
5	General lining to interior of exterior walls and interior walls	13mm plasterboard		Fibre cement sheeting with a 30mm gap above the bottom wall plate
6	Lining to bathroom, toilet, ensuite and laundry walls	Fibre cement sheeting		
7	Lining to kitchen walls	Fibre cement sheeting		
8	Skirting boards	Moulded mdf skirting, paint finish		Aluminium skirting (may require extra packing for attaching the skirting properly due to 30mm gap)
9	Cornices	Preshaped plaster cornice		
10	Ceiling	13mm plasterboard on timber battens		
11	Timber roof structure	Prefabricated softwood trusses		
12	Roofing	Glazed concrete tiles on timber battens with sarking		
13	Wall insulation	Fibreglass batts (thermal to exterior walls, sound to interior walls)		Polystyrene boards/Rigid closed cell board (using nails so that insulation can be removed from inside the house following a flood)
14	Roof insulation	Fibreglass batts		
15	Windows	Aluminium framed, double glazed, mix of sliding and awning types		
16	Window surrounds	Moulded mdf, painted		Pine timber, painted
17	Window sills	Brick set on incline		
18	External doors	Solid core timber front door with deadlock, ditto to laundryr door, varnish finish		
19	External doors	1 No. Panel-lift garage door, motorised operation		
20	External doors	Sliding aluminium framed double glazed patio door to family room		
21	External door frames	Hardwood timber door frames, varnish finish		Aluminium door frame, paint finish
22	Internal doors	Hollowcore doors, paint finish		
23	Internal door frames	Mdf door frames, paint finish		Aluminium door frame, paint finish
24	Eaves lining	Fibre cement sheeting with timber beading at sheet joins		
25	Guttering and downpipes	Colourbond rainwater goods		
26	Floor covering (garage)	Bare concrete		
27	Floor covering (bedrooms, lounge, dining and family)	Carpet with rubber underlay		6mm floor tiles

28	Floor covering (bathroom, toilet, ensuite, laundry)	6mm floor tiles		
29	Floor covering (kitchen)	Linoleum tiles glued to hardboard sheet		
30	Wall finishes (general)	Undercoat + 2 top coats paint		
31	Wall finishes (bathroom and ensuite)	Full height wall tiles adhesive fixed to FC sheet		
32	Wall finishes (toilet)	200mm height skirt tiles, paint above		
33	Wall finishes (laundry)	0.5m2 tile splashback, 200mm height skirt tiles, paint elsewhere		
34	Wall finshes (kitchen)	Tile splashback to all benches, 800 high. Paint elsewhere		
35	Ceiling finishes	Undercoat + 2 top coats paint		
36	Bathroom and ensuite joinery	Melamine covered mdf vanities, FC sheet skirting around bath.		Melamine covered mdf vanity (wall hung at 0.4m high), FC sheet skirting around bath.
37	Bathroom and ensuite basins and tapware	Ceramic basins, connecting hydraulics and chrome taps		
38	Bath	Enamelled steel and chrome taps		
39	Bathroom and ensuite fixtures	Chrome towel rails and soap dishes		
40	Shower recesses	Frameless glass 0.9m2 shower cubicle and chrome taps		
41	Shower recess hobs	Masonry hob finished to accept waterproofing and tiles		
42	Shower water proofing	Paint-on waterproof membrane		
43	Toilet and ensuite fixtures	Ceramic dual flush toilet and connecting hydraulics, chrome toilet paper holder		
44	Laundry fixtures	Stainless steel tub with chrome taps, chrome taps for washing machine		
45	Laundry joinery	Melamine covered mdf broom cupboard	Melamine covered mdf high level wall hung cabinets 1.8m long	Melamine covered mdf high level wall hung cabinets 1.8m long
46	Kitchen joinery	Melamine covered mdf kitchen under bench cupboards, high level cupboards, laminex covered benchtops		Steel shelves, cabinets and benchtop
47	Kitchen fixtures	Stainless steel basin and chrome mixer tap		
48	Kitchen appliances	Gas cooktop, electric underbench oven, dishwasher, electric rangehood	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high	Gas cooktop, dishwasher, electric rangehood, electric oven at 0.9m high
49	Mechanical	Bathroom and ensuite extraction fans		
50	Mechanical	2.5hp A/C system mounted back to back with external unit on ground	2.5hp A/C system mounted back to back with external unit on brick pier (0.95m high, 0.35m wide and 1.2m long)	2.5hp A/C system mounted back to back with external unit on brick pier (0.95m high, 0.35m wide and 1.2m long)
51	Mechanical	Check gas supply to kitchen		
52	Electrical - lighting	Central ceiling mounted light fitting (25 No) + ceiling mounted fluorescent fitting to kitchen		
53	Electrical lighting	Wall mounted light switches (30 No)		
54	Electrical exterior lighting	Two No external sensor lights mounted under eaves		
55	Electrical - power	19 No. double GPO	19 No. double GPO at 1.2m above floor level	19 No. double GPO at 1.2m above floor level
56	Electrical - power	Meter box	Meter box at 1.8m height, provide brick steps for easy access to meter reading (0.7m wide and 0.25m high)	Meter box at 1.8m height, provide brick steps for easy access to meter reading (0.7m wide and 0.25m high)

57	Electrical - general	Test electrical cabling for faults (item) (assume no rewiring necessary for all depths)		
58	Hydraulic - HWS	Electrical 250l HWS mounted externally on ground	Electrical 250l HWS mounted externally on 0.95m high brick pier	Electrical 250l HWS mounted externally on 0.95m high brick pier
59	Hydraulic - water supply piping	Copper 15mm diameter		
60	Hydraulic - sanitary drainage	100mm UPVC		
61	Hydraulic - SW drainage	100mmUPVC		
62	Window furnishing	Fabric curtains to bedroom, dining, family & lounge windows. Plastic Venetian blinds to laundry, toilet, ensuite and bathroom windows.		
63	Hydraulic - SW		Installing check valve and gate valve	Installing check valve and gate valve

DISCUSSION

The economic losses due to floods have been increasing during recent decades due to vulnerable construction types (such as slab-on-grade houses) in floodplains. The increase in loss highlights the need to improve flood risk management and to reduce future flood losses. These need to be based upon a sound analysis of flood hazard, potential losses and the effectiveness of different mitigation measures (Kreibich and Thieken, 2008).

Flood risk management not only includes the measures taken by government but also includes mitigation measures adopted by private property owners to reduce the potential losses. These measures include elevating structures above the expected flood level, relocating the structure outside the floodplain, dry floodproofing to make the structure water tight, wet floodproofing by using water-resistant materials and installing flood barriers to keep water away from the building. These efforts have a significant potential to reduce flood damage to buildings and contents particularly in low to moderate flood levels. Selection and implementation of any of these strategies would require comprehensive analysis of characteristics of flood, local building standards and a cost benefit analysis to evaluate the optimum strategy.

A conceptual framework for scenario analysis presented by Thieken et al. 2016 will be adapted in this project to evaluate the benefits of implementing the above mentioned mitigation strategies. In this risk framework reference, baseline and alternative future scenarios are distinguished. The reference scenario defines the current flood risk while the baseline scenario defines the changed future flood risk due to external drivers (e.g. change in climate or change in exposed assets). The alternative future scenarios further estimate the effects of different mitigation strategies on the selected baseline scenarios (Thieken et al. 2016).

The result of this BNHCRC flood project will be a clear understanding of the costs and benefits involved in implementing any of these mitigation measures in Australian conditions through a cost benefit analysis.

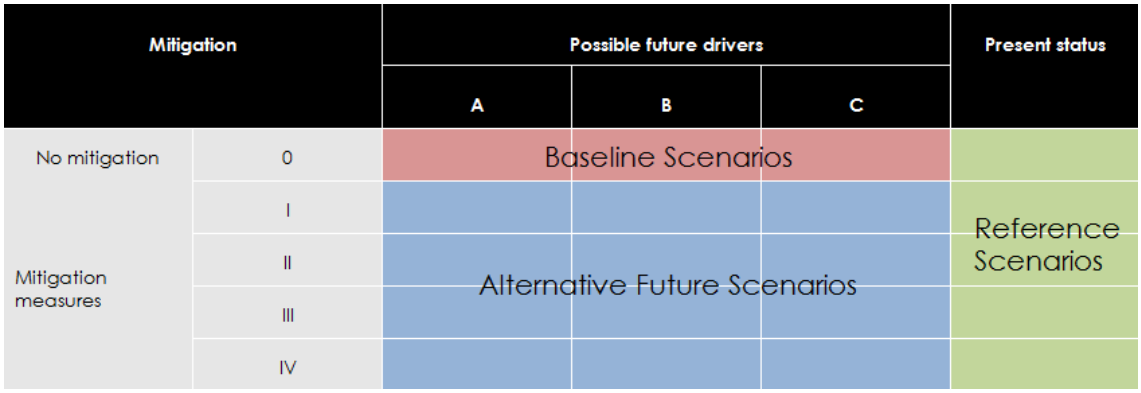


FIGURE 5 CONCEPUAL FRAEWORK FOR SCENARIO ANALYSIS ON CHANGING FLOOD RISK AND MITIGATION STRATGIES (THIEKEN ET AL. 2016)

NEXT STEPS

In the next steps the durability implications of immersion of key structural elements will be examined in conditions of slow water rise to ascertain strength degradation due to wetting and subsequent drying. While the low flood velocity regime considered represents minimal structural loads, the ability of the building elements to resist wind, earthquake and floor live loads after drying will be the focus. Experimental tests will be carried out to ascertain the resilience of preferred material types to flood water exposure.

The vulnerability of selected storey types to a wide range of inundation depths will also be assessed for existing and retrofitted buildings. The outputs of this research will be suitable for use in other CRC research concerning risk assessment and impact forecasting in the immediate aftermath of an actual event.

Furthermore, a comprehensive analysis will be conducted and each mitigation option will be evaluated through cost benefit analyses for use in Australian conditions. The result will be a clear understanding of cost and benefits involved in implementing any of these mitigation measures. This evidence base will facilitate and encourage governments and property owners to make informed and optimal decisions to reduce flood risk.

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APPENDIX A: STOREY TYPE 1 - TIMBER FRAME (RAISED FLOOR)

Typical building drawings

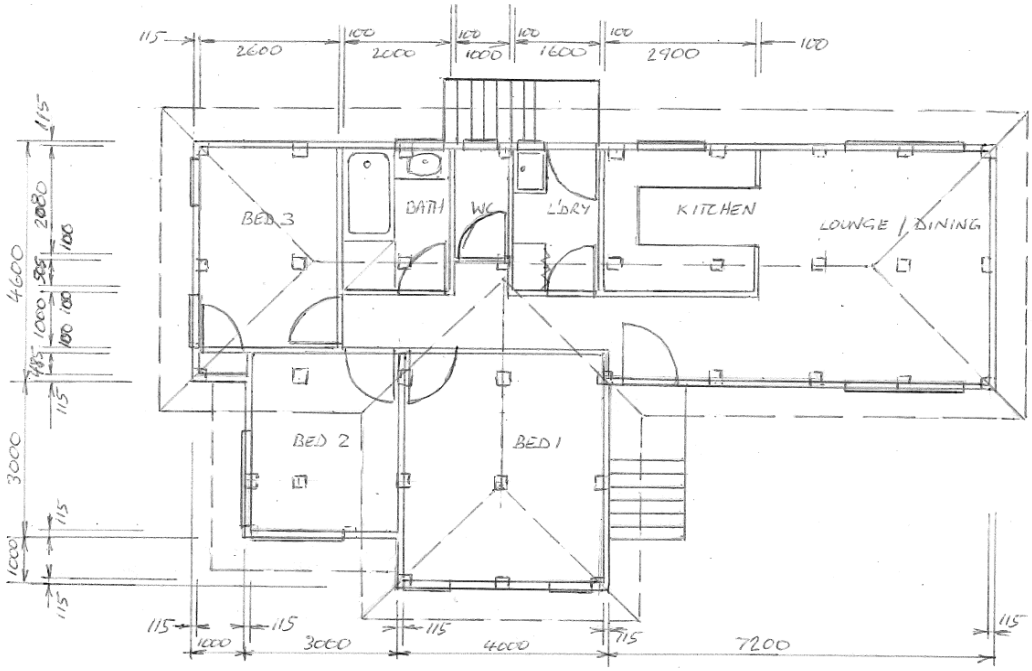

Figure A1: Floor plan

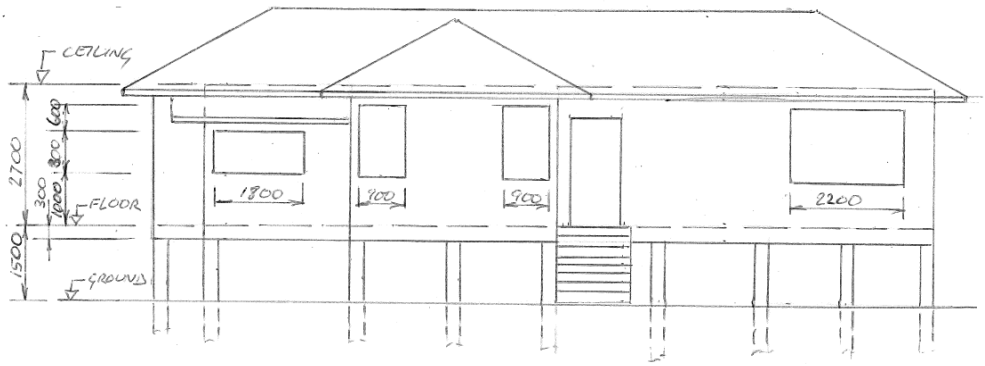

Figure A2: Front elevation

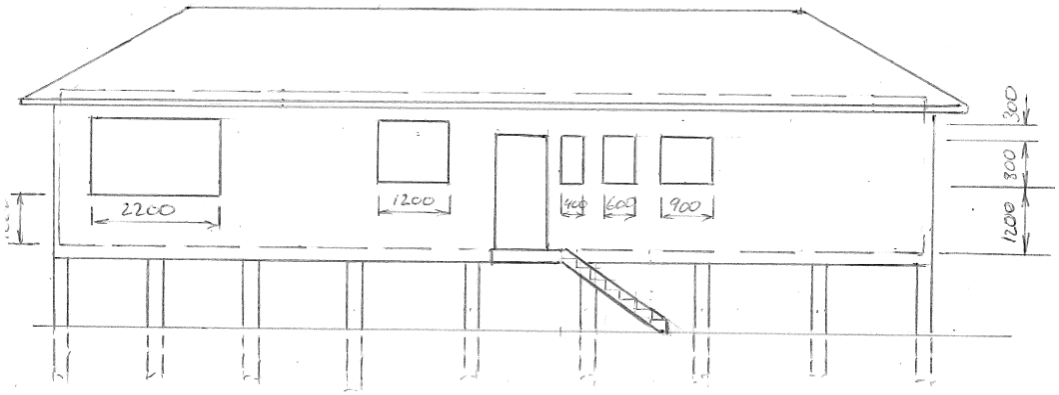

Figure A3: Back elevation

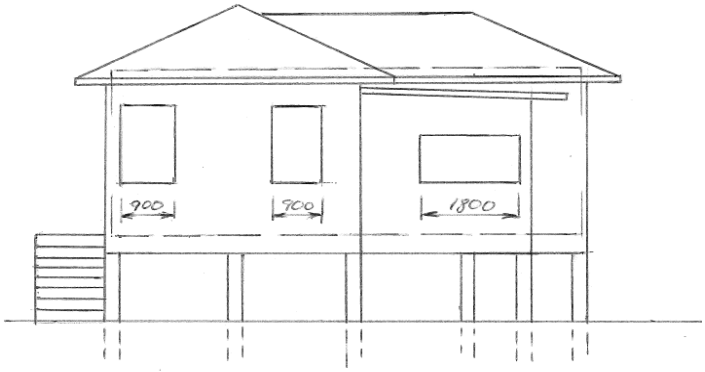

Figure A4: West elevation

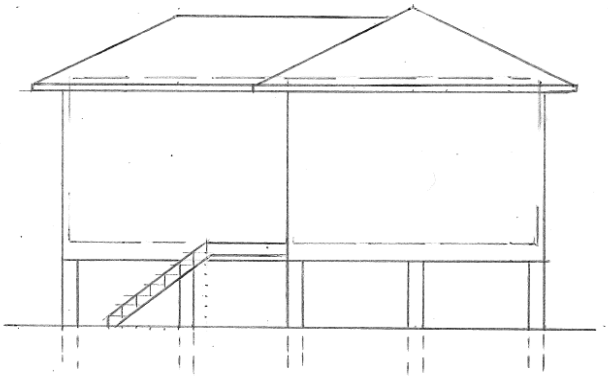

Figure A5: East elevation

APPENDIX B: STOREY TYPE 2 - VICTORIAN TERRACE (RAISED FLOOR)

Typical building drawings

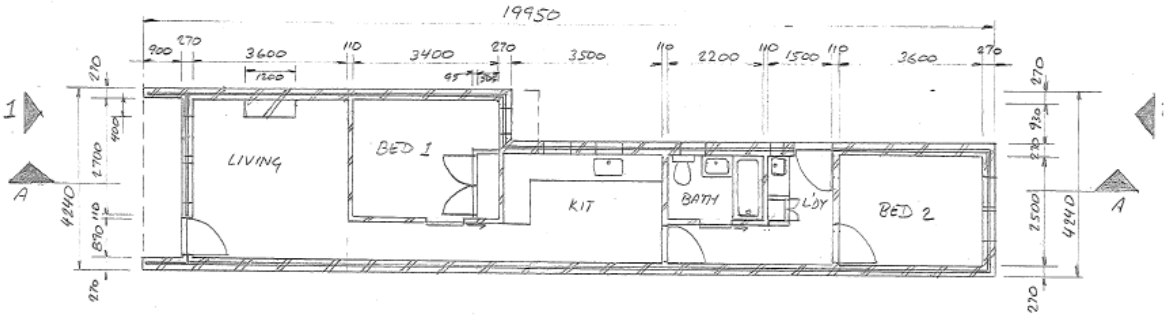

Figure B1: Floor plan

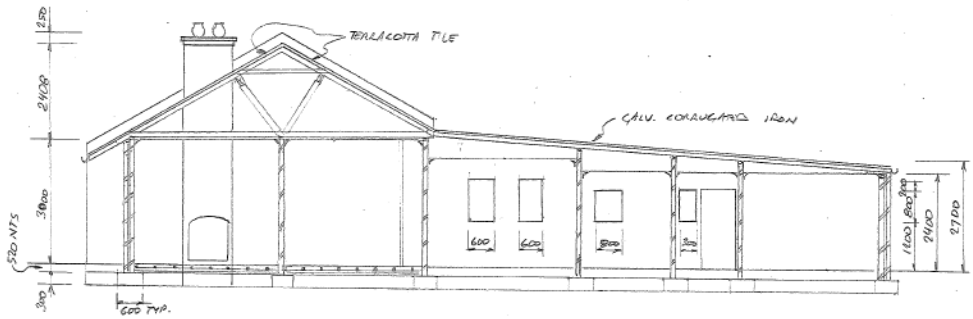

Figure B2: Section A-A

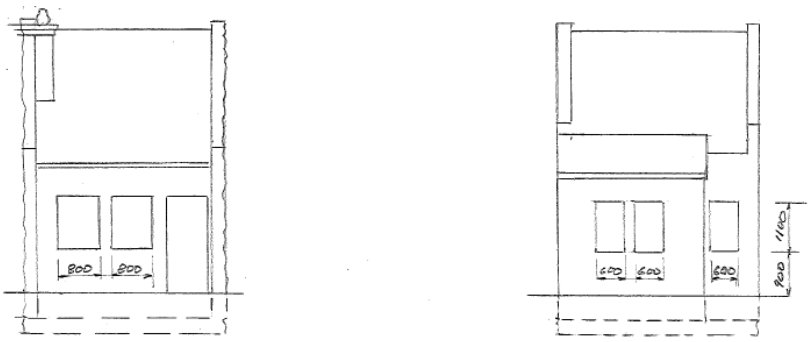

Figure B3: Front (1) and back (2) elevations

APPENDIX C: STOREY TYPE 3 - CAVITY MASONRY (RAISED FLOOR)

Typical building drawings

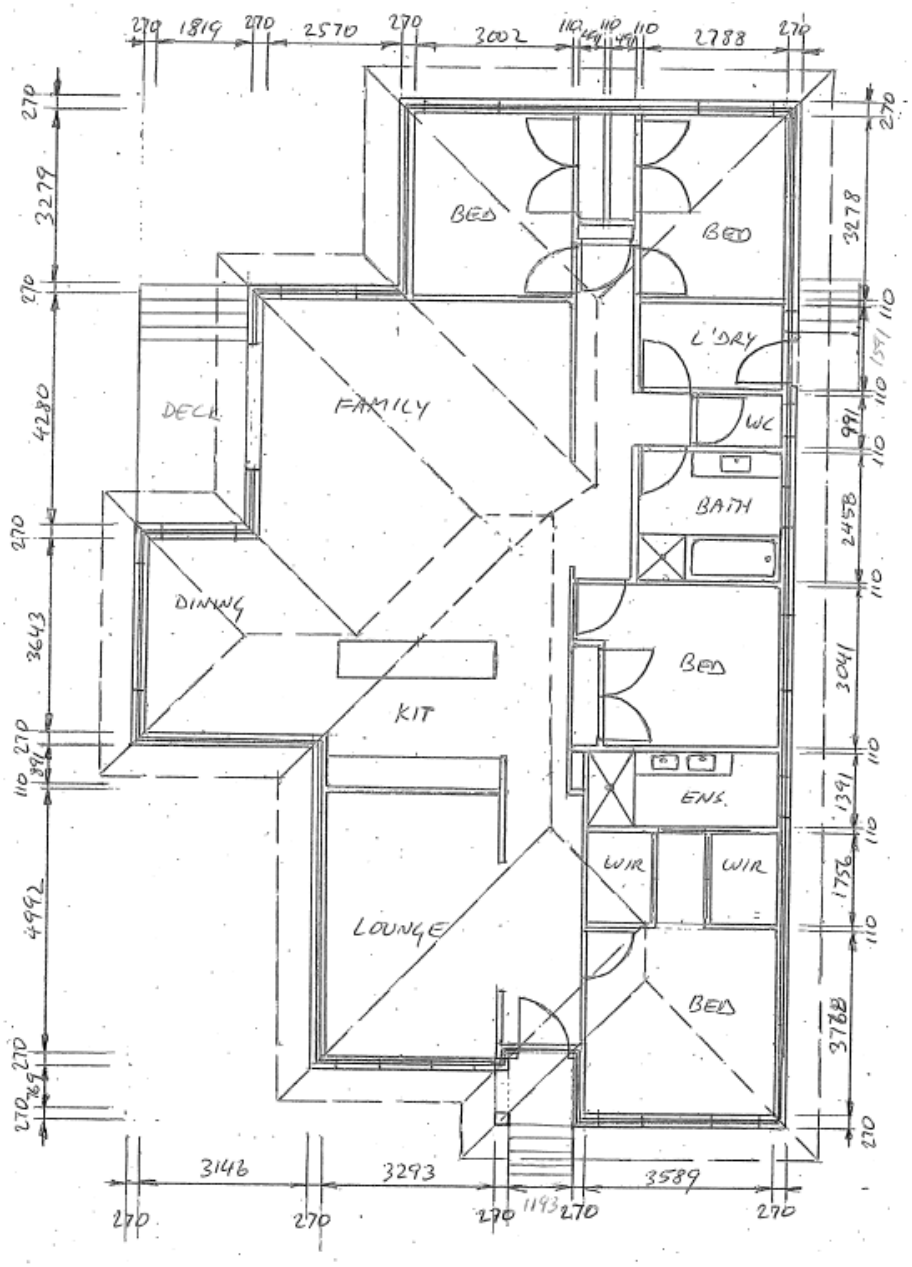

Figure C1: Floor plan

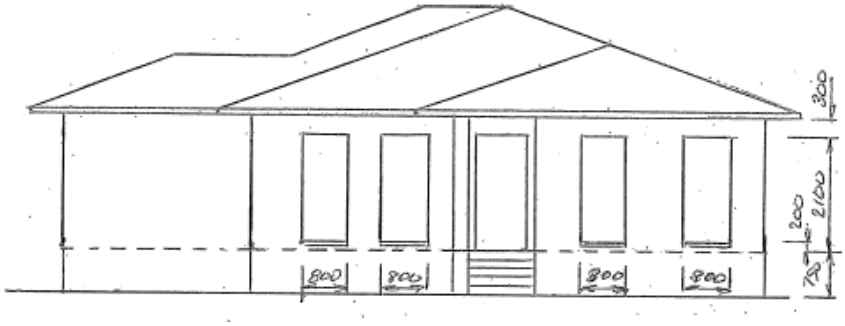

Figure C2: Front elevation

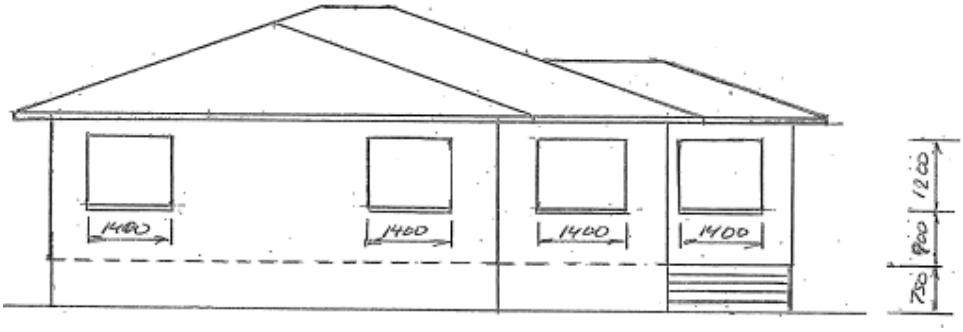

Figure C3: Back elevation

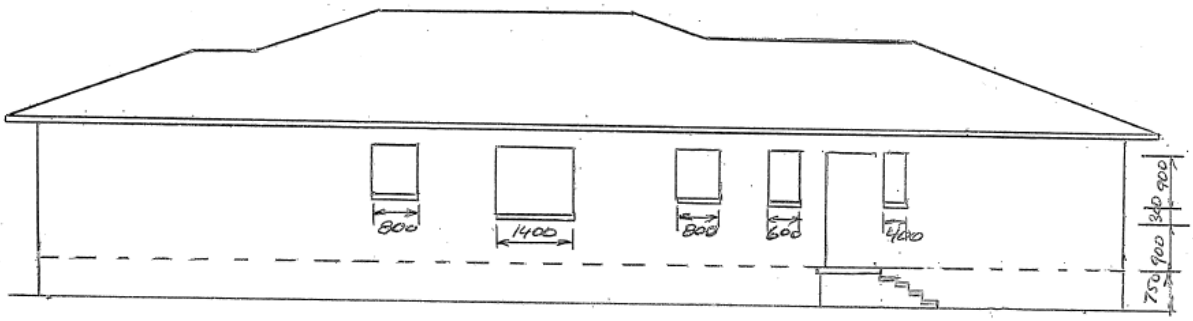

Figure C4: East elevation

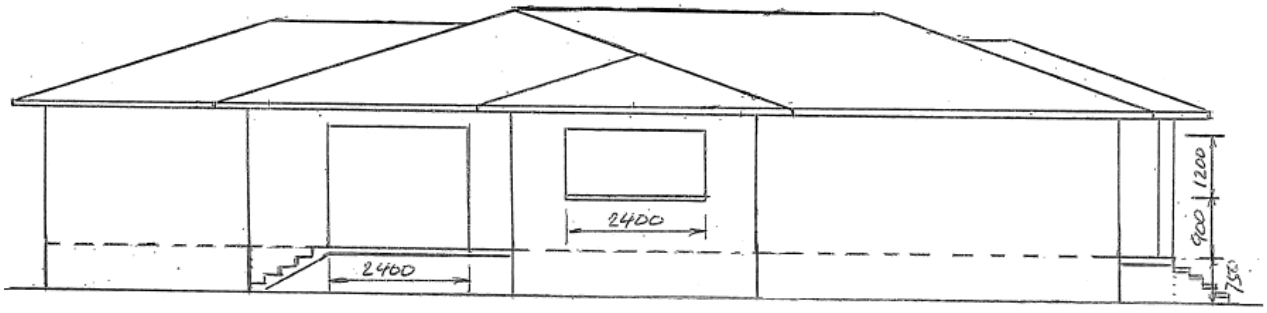

Figure C5: West elevation

APPENDIX D: STOREY TYPE 4 - BRICK MASONRY (RAISED FLOOR)

Typical building drawings

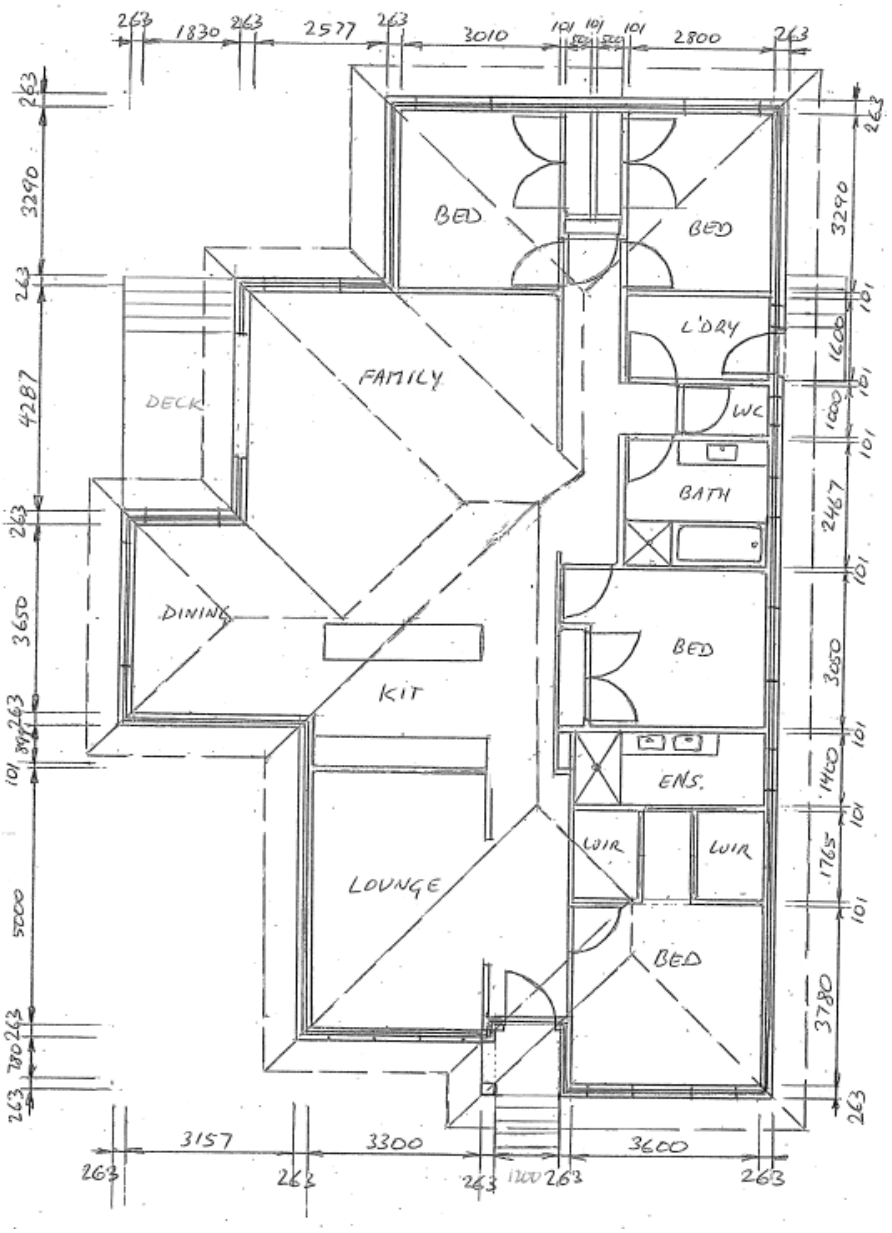

Figure D1: Floor plan

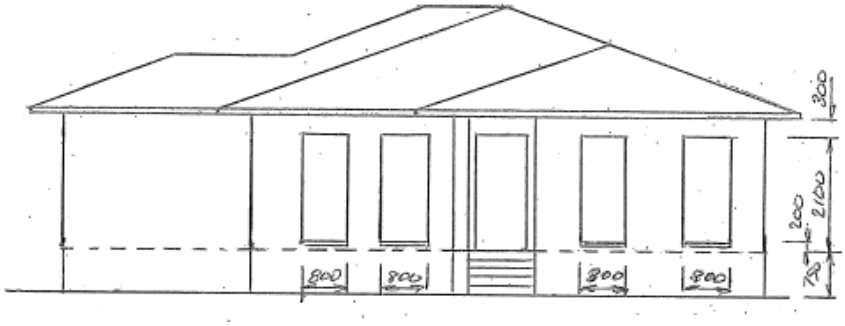

Figure D2: Front elevation

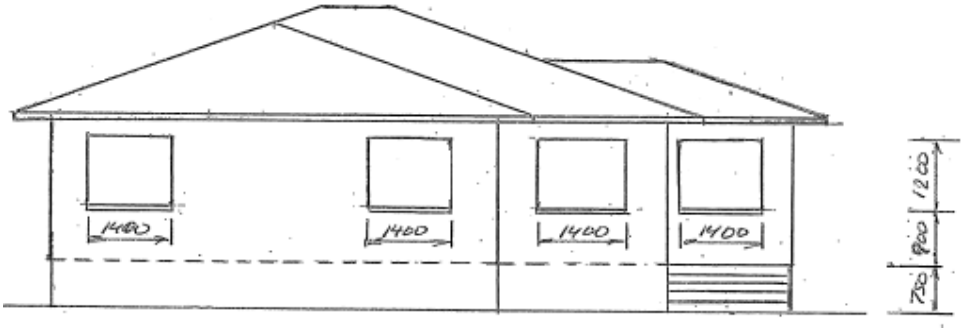

Figure D3: Back elevation

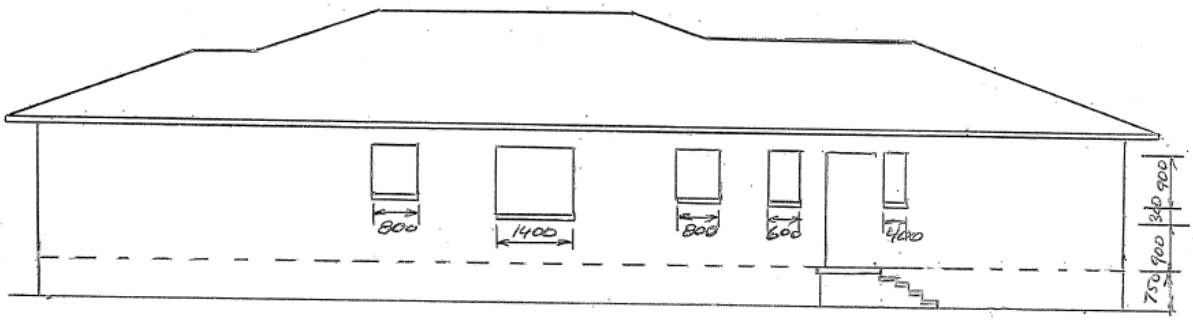

Figure D4: East elevation

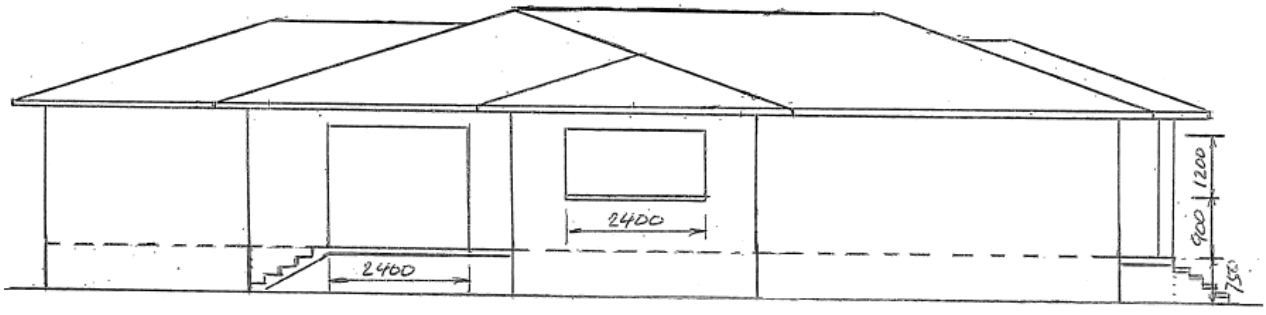

Figure D5: West elevation

APPENDIX E: STOREY TYPE 5 - BRICK MASONRY (SLAB-ON-GRADE)

Typical building drawings

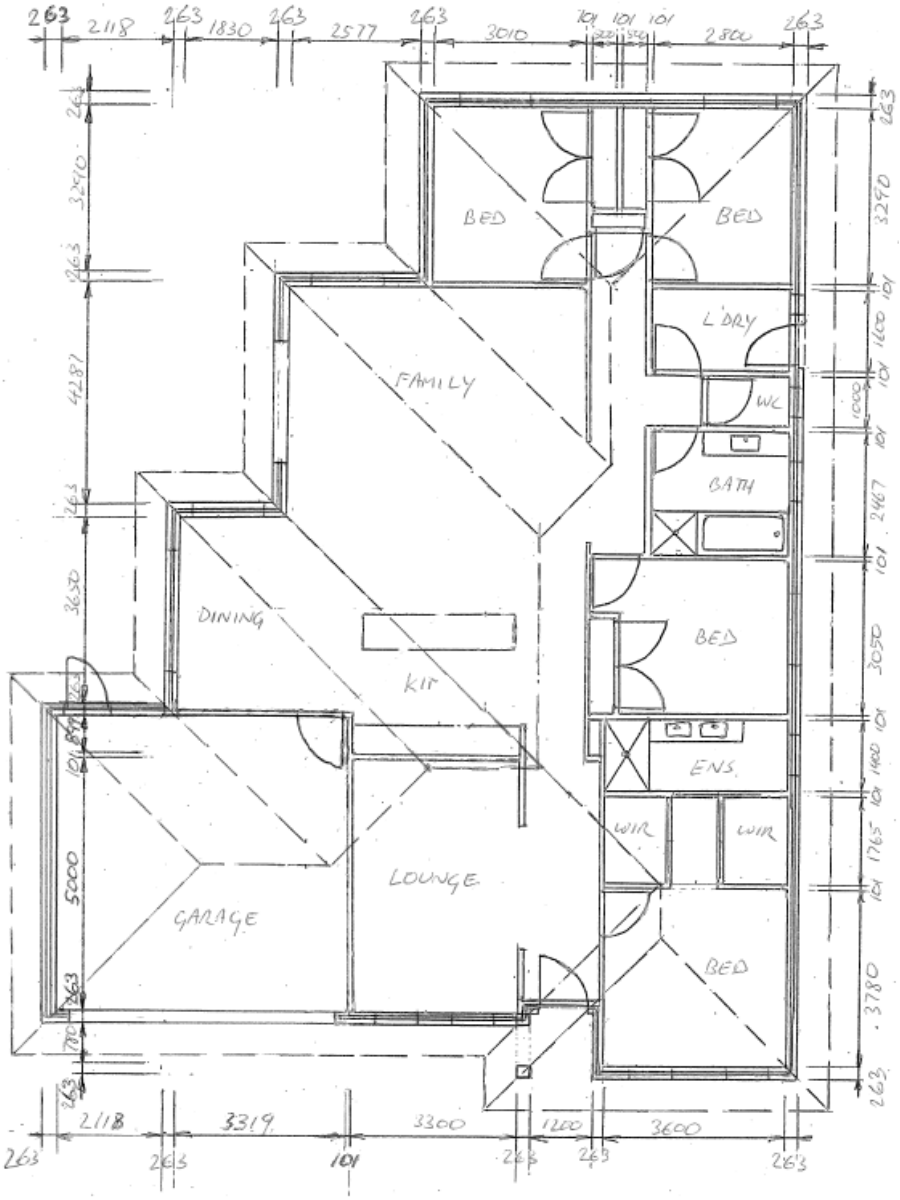

Figure E1: Floor plan

Figure E2: Front elevation

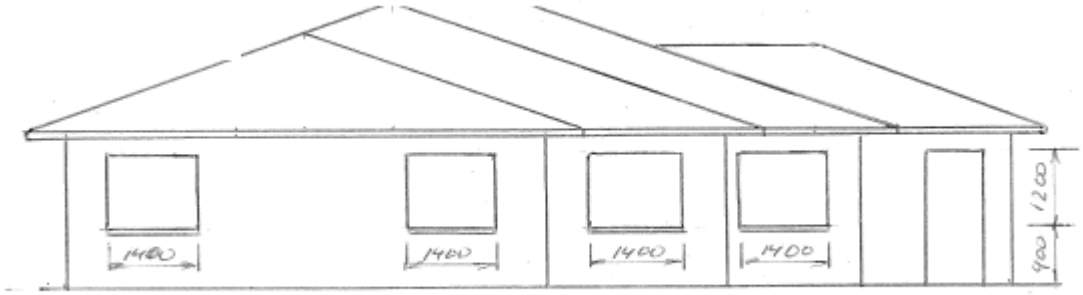

Figure E3: Back elevation

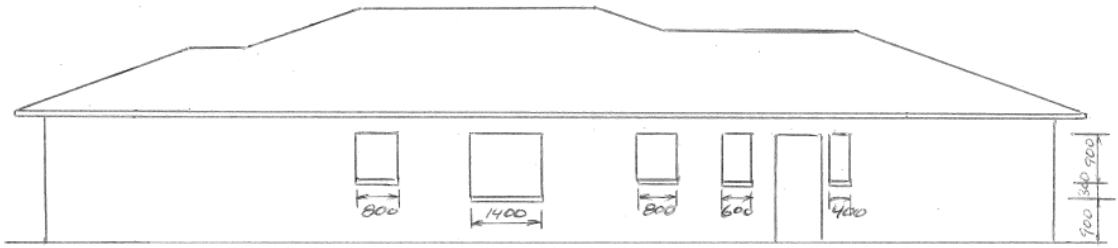

Figure E4: East elevation

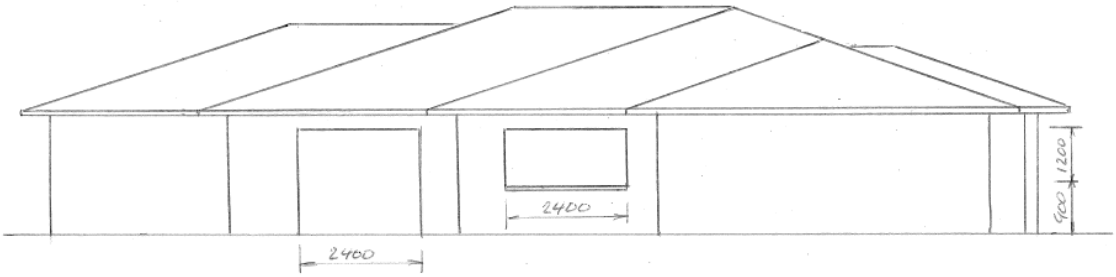

Figure E5: West elevation