Inundation Practice Note:

Calculating minimum ground and/or floor levels for subdivision, new buildings and major alterations

March 2019

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Statutory Status: This practice note has been developed in support of the Nelson-Tasman Joint Land Development Manual (2019) and provides an acceptable approach for determining minimum ground and/or floor levels under the Resource Management Act 1991 and the Building Act 2004.

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DEFINITIONS

Annual exceedance probability (AEP)	The Annual Exceedance Probability is the chance or probability of a natural hazard event (such as storm tide) of a particular size or greater occurring or being exceeded annually and is usually expressed as a percentage.
Climate change effects (CCE) factor	A minimum allowance for climate change effects, including sea level rise and more intense rainfall.
E1 E1 AS or VM	The clause of the Building Code relating to "Surface Water" that relates to the protection of Residential and Communal Building from inundation in the 2% AEP event. The Acceptable Solution or Verification Method under the Building Code which provides a pathway to demonstrate compliance with E1.
Freeboard allowance	A freeboard allowance is added to the calculated flood level to result in a minimum ground and/or floor level to account for any uncertainties associated with historical data and hydraulic assessments.
Inundation	Freshwater or seawater entry to land or buildings
Local adjustment (LA) factor	Takes account of local, site or project specific matters e.g. existing hazard mitigation, topographical effects, design life of buildings, etc.
Land Development Manual (LDM)	Joint Nelson City and Tasman District Councils' manual that specifies engineering design and construction standards.
Mean sea level (MSL)	An average level for the surface of the sea from which heights such as elevations may be measured. For the Tasman and Golden Bays this is defined as being 3.195m below Reference Mark N1 (AC4T) as defined by the NZVD2016 Datum.
Mean high water springs 6 (MHWS-6)	Refers to the level equalled or exceeded by the highest 6% of all predicted tides relevant to Tasman and Golden Bays, ranging between 1.86m - 1.93m NZVD2016 (MSL 2020 projection), or between 1.72m - 1.79m NZVD2016 (MSL 2008-17)
New Zealand Vertical Datum (NZVD2016)	New Zealand Vertical Datum 2016 as per standard LINZS25009.
Major alteration	The Building Act 2004 does not provide a definition of 'major alteration' of a building but in determining a threshold Council will consider factors such as (a) intended use and degree of design and construction complexity; (b) size of the alteration; (c) increase in building footprint and percentage of site coverage. Refer to Determination 2017/055 for more information.
Reduced level (RL)	Reduced level in surveying refers to equating elevations of survey points with reference to a common assumed datum. It is a vertical distance between survey point and adopted datum plane (NZVD2016). Thus it is considered as the base elevation which is used as reference determine heights or depths.
Storm surge	Storm surge is the rise in seawater level caused solely by a storm; this can be caused by wind and wave action and low barometric pressure.
Storm tide	Storm tide is the observed seawater level during a storm.
Wave runup	Wave runup is the maximum vertical extent of wave uprush on a beach or structure above the mean level of the sea
Wave setup	Wave setup is the increase in mean water level due to the presence of breaking waves. Also includes the increase in the mean water level against the shore due to wind blowing across a water body.

1 Introduction

1.1 Purpose

This practice note explains the methodology to determine minimum ground and/or floor levels for subdivision, new buildings and major alterations in areas identified as being subject to seawater and/or freshwater inundation within the Nelson and Tasman districts.

The document comprises of two key parts:

- **Section 2**: a 'how to' guide which summarises the processes and information required to determine minimum ground and/or floor levels.
- **Sections 3-7**: supporting information which provides further explanation for the methodology used and other factors which should be considered when determining levels including building servicing, building use and hazard tolerance, and Building Act 2004 s73 hazard notices.

This practice note provides guidance to support Nelson City Council and Tasman District Council's administration of the Building Act 2004 and New Zealand Building Code, the natural hazards provisions in the Councils' resource management plans and the Nelson-Tasman Joint Land Development Manual. It provides a standard approach to be used by Council staff and development industry professionals during building and resource consent processes.

The Councils' resource management plans set out the policy framework to assess development on land subject to inundation hazards and include other plan considerations such as design, neighbourhood amenity, access and servicing. Some areas of Nelson and Tasman districts are not suitable for new development due to inundation hazards. In other locations, raising ground and/or floor levels may provide appropriate mitigation and this practice note documents the process used to determine minimum levels.

1.2 Summary of Seawater Inundation Calculation and Freshwater Inundation Process

Seawater Inundation Calculation

The information contained within this practice note enables the calculation of minimum ground and/or floor levels in coastal locations subject to seawater inundation. Section 2 (Figure 3) outlines the 8 steps required to calculate a minimum ground and/or floor level based on the following information:

- identification of the **development setting** such as greenfield subdivision, intensification, non-habitable assets, etc.
- consideration of what **seawater inundation information** is available from Council.
- a **'storm tide adjustment factor'** that includes storm surge and wave set up for all properties, and wave runup for those properties within 30m of the coast.
- a **'climate change effects factor'** which takes into account effects of sea level rise based on recent Ministry for the Environment (MfE) guidance.
- a **'freeboard'** requirement which also accounts for any uncertainties associated with historical data and the hydraulic assessments. The freeboard will vary depending on the type development and any local adjustment factors.
- **'local adjustment factors'** which may increase or decrease the levels after considering additional factors such as exposure to coastal effects due to particular local topographic features or coastal barriers; risks of inundation from impounded sea water and/or freshwater, or risks from overland flow of seawater.
- consideration of **Building Act 2004 requirements** and s73 hazard notices.

Freshwater Inundation Process
The practice note also outlines the general process to determine minimum ground and/or floor levels in areas subject to freshwater inundation. Locations that are subject to freshwater inundation are not restricted to a specific distance to the coast or a river. There are many factors that contribute to potential risks of freshwater inundation and these need to be considered for any site at any location.

The methodology is broadly similar to the seawater inundation calculation, although the data sources for determination of inundation water levels are variable and include flood records and computer model simulations (which include a tidal boundary condition). Section 2 (Figure 4) outlines the 6 step process which includes:

- consideration of what **freshwater inundation or floodwater flow information** is available from Council. This information should consider any site specific **'local adjustment factors'** such as particular local topographic features or barriers; risks of inundation from impounded freshwater, or risks from overland flow of water.
- the need for a **site specific assessment** in circumstances where Council does not hold sufficient information or where particular local adjustment factors may apply.
- identification of **flood levels for a 2% or 1% annual exceedance probability (AEP) event**, dependant on subdivision or building requirements.
- a **'freeboard'** requirement which also accounts for any uncertainties associated with historical data and the hydraulic assessments. The freeboard will vary depending on the type development and any local adjustment factors.
- consideration of **Building Act 2004 requirements** and s73 hazard notices.

1.3 Combined Seawater and Freshwater Inundation

Some sites in the Nelson and Tasman districts may be subject to both seawater and freshwater inundation. In these locations both the seawater calculation, the freshwater process and a combination of the two should be applied to determine which of the three inundation scenarios poses the greatest exposure to inundation hazard. The highest value of the three levels calculated will determine the minimum ground and/or floor level.

1.4 Inundation hazards and scope of practice note

Development near the coast or a seawater body, such as a harbour or estuary influenced by tides, is potentially subject to coastal hazards. Such hazards include inundation from waves and/or storm surge, impounded seawater, or combinations of wave effects, impounded sea and fresh water flooding. In addition to these, sea level and rainfall intensity are projected to increase as a result of changes to the climate. However, due to a variety of earth processes (e.g. tectonic motion, subsidence and seismic activity), relative sea level change at different locations may differ from the national or regional norm.

Beyond coastal influences, inundation can occur from incident rainfall, capacity exceedance in established watercourses and infrastructure networks, ponding behind embankments and causeways, and secondary flowpaths that only occur during significant rain or blockage of the normal route of stormwater.

This practice note outlines the approach to determine minimum finished ground and/or floor levels for new development and buildings in areas identified as being subject to inundation. It considers different hazard scenarios for either seawater and/or freshwater inundation. It does not cover all other potential sources of inundation such as groundwater, tsunami, and dam break (in certain areas).

There are many variables in relation to the coast and watercourses in terms of topography, land

and beach composition and profiles, as well as building types and designs. Therefore, a site specific assessment of the proposed development taking into account specific hazard influences (by applying local adjustment factors) may still be required. Council can advise further in such situations.

Note that properties indicated as not being subject to inundation under this practice note methodology may still be at risk from inundation hazards in more extreme or unpredictable weather events than allowed for. A pragmatic approach to mitigating hazard exposure in events exceeding the design guidelines is recommended, consistent with acceptable risk.

1.5 Exceptions

Circumstances will arise when the standardised approach as outlined in this practice note may not be preferred. Such scenarios should be treated as exceptions, requiring a site specific assessment which Council will consider on a case-by-case basis.

1.6 Councils' inundation information

Both councils have ongoing programmes of work to model inundation hazards and are obliged to make existing natural hazard information available to the public, under the Local Government Official Information and Meetings Act 1987 and the Building Act 2004. Check with each Council for the most up-to-date information available. Updates to this practice note may be undertaken as inundation information is refined and/or new modelling datasets are developed.

Seawater inundation
Both Councils are using a 'coastal calculator tool' developed by NIWA (updated to include data to April 2018) to determine the seawater inundation hazard potential at various places around the Tasman and Golden Bay coastlines. This calculator assesses wave runup and wave setup elevations and shoreline structure overtopping rates for a variety of datum, beach slope, storm-tide event probability and sea level rise settings. Calculations show that coastal influences on the level setting process progressively increase below the reduced level of 6m (NZVD2016), particularly within 30m of MHWS-6. In addition, freshwater inundation may be a contributing or even dominant threat to a building or development.

A number of seawater inundation hazards reports are available as listed in Appendix 2 References. For further information please contact the relevant Council.

Freshwater inundation
Flood levels vary spatially and temporally and can be determined through hydrological and hydraulic modelling processes which include a number of assumptions and model inputs.

Nelson City Council has undertaken modelling of inundation extents associated with all major rivers and streams in the district. The modelling includes a number of scenarios to the year 2120 for a 1% AEP event and takes into account the effects of climate change on sea level rise and rainfall intensity. The outputs of this modelling can be viewed on Nelson City Council's website.

Tasman District Council has undertaken similar studies in some urban areas, with further modelling and mapping continuing and planned to be undertaken for other urban drainage areas and rivers. Available information includes floodplain modelling data for the coast adjacent to Takaka township, the Mapua-Ruby Bay coastal plain and historic records of flooding in the Waimea, Takaka, Motueka, Aorere delta and a number of minor river systems. This historical data generally maps the extent of particular flood events, from which flood depth can sometimes be inferred using LiDAR contour data, and in some instances flood heights are noted.

Both Councils' inundation modelling work programmes include secondary flowpath modelling. Where this modelling has yet to be undertaken, secondary flow paths will be considered as a 'local adjustment factor' (refer to Section 3.6.3). Council will be able to advise on what information is held to help inform the calculation of minimum ground and/or floor levels in these situations.

1.7 Resource Management Act 1991 and Building Act 2004

The Resource Management Act 1991 and Building Act 2004 are the two key pieces of legislation which empower councils to manage the risk of inundation hazard in relation to new development and land use.

Resource Management Act 1991 (RMA 1991)
Under the RMA 1991, councils are required to recognise and provide for the management of significant risks from natural hazards as a matter of national importance (s6(h)) and to have particular regard to the effects of climate change (s7(i)).

National instruments prepared under the RMA 1991 place requirements on councils. The New Zealand Coastal Policy Statement 2010 (NZCPS) details existing national objectives and policies for coastal natural hazards. Policy 24 requires councils to identify coastal areas that will be potentially affected by coastal hazards over *at least* 100 years. Policy 25 sets the policy framework for planning decisions for land use and development in areas potentially affected by coastal hazards, with an emphasis on avoidance and reduction of risks.
It is anticipated that Government will develop national direction in the form of a National Policy Statement or National Environmental Standards on natural hazards which will provide further guidance to councils and their communities on natural hazards management. This practice note may need updating at that time.

Councils must give effect to the NZCPS and other national direction through their regional policy statement, regional plans and district plans. The operative suites of resource management plans for the two districts set out the management regimes for dealing with risks from natural hazards and include controls on the use of land for the purpose of the avoidance or mitigation of natural hazards.

When considering an application for resource consent, Council must have regard to any actual and potential effects on the environment of allowing the activity, including the effects arising from natural hazards (s104).

Council may refuse or grant a subdivision consent subject to conditions if there is a significant risk from natural hazards (s106). Any assessment of the risk from natural hazards requires a combined assessment of:

(a) the likelihood of natural hazards occurring (whether individually or in combination); and

(b) the material damage to land in respect of which the consent is sought, other land, or structures that would result from natural hazards; and

(c) any likely subsequent use of the land in respect of which the consent is sought that would accelerate, worsen, or result in material damage of the kind referred to in (b) above.

Conditions attached to subdivision consents granted may include the protection of the land and any adjacent land against natural hazards including inundation (s220).

For any new subdivision and development, an applicant will need to demonstrate that newly formed allotments contain adequate space for buildings which are not subject to material damage from inundation in response to a 1% AEP design event (refer to Section 2.3). Furthermore, it will need to be demonstrated that in achieving this there are no adverse effects (raised flood levels, diversion of flood flows and/or secondary flood routes) that occur on adjacent or surrounding property in response to this design flood event. Other resource management plan considerations such as amenity and servicing also need to be incorporated into design and decision making processes.

For other development (on existing titles) subject to the RMA 1991, the practice note process will be the same as for subdivision and development as described above. However, the full application of this process may be modified on a case by case basis where the development is of a limited duration and consequently will not be subject to long term projected climate change effects.

Building Act 2004 (BA 2004) and the New Zealand Building Code (Building Code)

The BA 2004 manages natural hazards in relation to the construction and modification of buildings. Council is required to take into account certain natural hazards, including inundation, when determining whether to grant building consents on land subject to specified natural hazards, with certain exceptions (under s71-74). The emphasis in the management of natural hazards is to encourage people to avoid situations in which they or their property could be at risk. Sections 71-74 of the BA 2004 regarding building on land subject to natural hazards and the application of hazard notices on property titles are discussed in detail under Section 6.

E1 of the Building Code requires buildings and site work to be constructed to protect people and other property from the adverse effects of surface water. Performance E1.3.2 requires that surface water, resulting from an event having a 2% AEP, shall not enter housing, communal residential and communal non-residential buildings.

2 How to Determine Minimum Ground and/or Floor Levels

2.1 Introduction

This section provides a summary guide of how to determine minimum ground and/or floor levels for subdivision, new buildings and major alterations. It applies to areas identified as being subject to seawater and/or freshwater inundation within the districts of Nelson City Council and Tasman District Council. It should be read in conjunction with the supporting information and explanation contained in Sections 3-7.

2.2 Development considerations

If you wish to develop your property, or you are a developer or agent acting on behalf of a landowner, there are a number of preliminary planning and development matters that you should consider as part of any building design. This will depend on the nature and location of the property, the type of development proposed, and any legal and resource management plan requirements.

If the development site is (or may be) located in an area subject to inundation, it is recommended that you consider the potential impacts of the development proposal within and beyond the site. Speak to the relevant Councils' Duty Planner and hazards information staff as they can assist you in making informed decisions about your proposal and the resource consent process.

General matters that you should consider include:

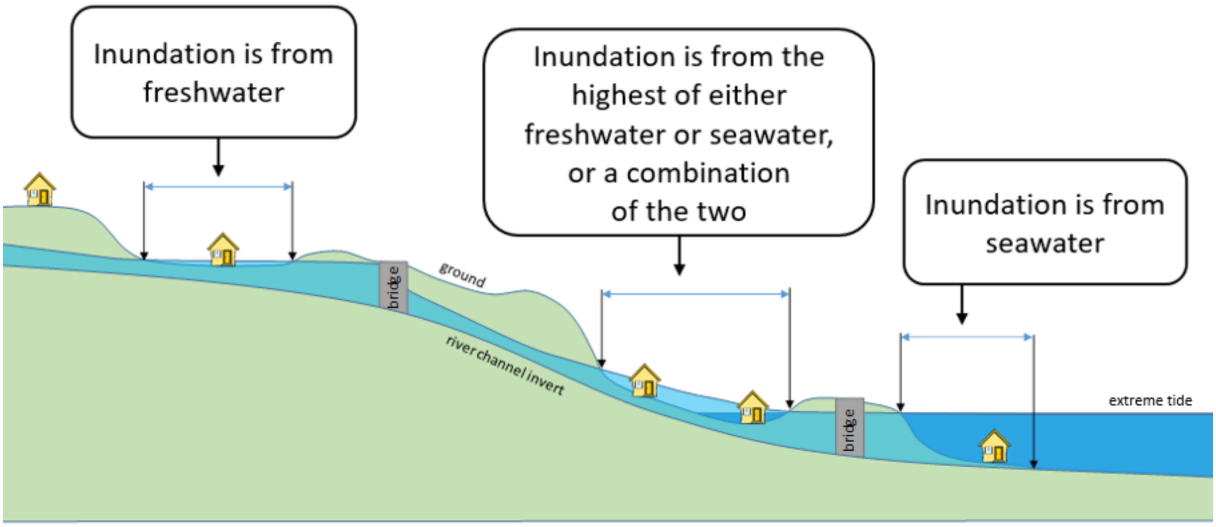
- The choice of foundation design. Raising the ground level to mitigate inundation hazard may not be allowable due to potential adverse effects on your own or neighbouring land from floodwater diversion or floodwater storage removal.
- Preserving future options with respect to adapting to unknown or increasing hazard exposure. For example, a pile foundation design allows for adaption to any increase in erosion or inundation hazards via further house elevation, relocation within the site or removal from the site.
- Functionality of the building and vulnerability of activities proposed within the building.
- Identifying if your site needs to be serviced for on-site stormwater and wastewater disposal over some or all of the lifetime of the building.
- Building access and use, particularly during an inundation event.
- Other resource management plan requirements including design, neighbourhood amenity, and landscape considerations.

It should also be noted that building design and location on site may have implications for obtaining or retaining inundation insurance.

2.3 Identifying locations subject to seawater and/or freshwater inundation hazards

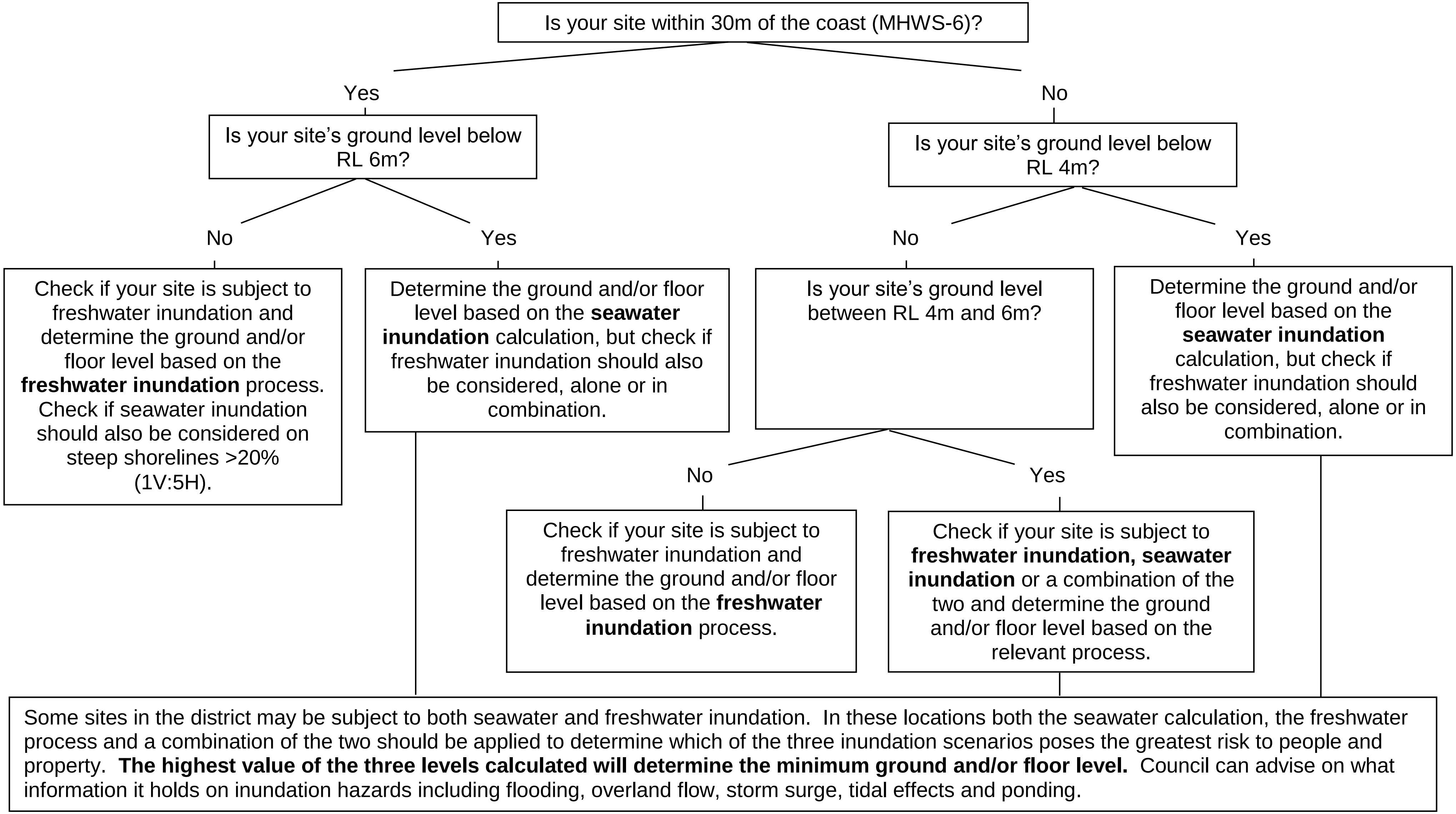
This practice note considers different scenarios from either seawater and/or freshwater inundation as shown in Figure 1.

Figure 1: Locations of where the seawater inundation calculation and/or freshwater inundation process may apply



In coastal locations subject to inundation hazards, both the seawater inundation calculation and the freshwater inundation process relies on 'reduced level' (RL) thresholds as a starting point to determine locations that may be subject to these hazards. A RL is a level measured against a specified datum and NZVD2016 Datum is used in this practice note. Figure 2 provides a flow diagram to help determine which type of inundation hazard may be applicable to a specific site, based on RLs and a 30m distance from MHWS-6.

Figure 2: How to determine if your site is subject to seawater and/or freshwater inundation using RL thresholds



In coastal locations within 30m of MHWS-6, the seawater inundation calculation applies below RL 6m. Ground up to at least this level can be affected by seawater inundation depending on shoreline slope or other factors. These areas may also be affected by the influence of freshwater inundation (for example at river mouth locations) and this hazard also needs to be considered both in isolation and in combination with seawater inundation.

Similarly, in low lying areas more than 30m away from MHWS-6, both seawater and/or freshwater inundation may be present and should be considered. If a site's ground level is between RL 4m and 6m, the risk of freshwater and/or seawater inundation hazard may be present (depending on distance from MHWS-6) in isolation or in combination and the higher value of the three levels calculated will determine the minimum ground and/or floor level.

Above RL 6m, freshwater inundation is likely to predominate but also check for the possibility of seawater inundation adjacent to steep shorelines where the upper beach slope is >20%. For more information or guidance on which inundation hazard may be present on your site, please contact the relevant Council.

2.4 Seawater and freshwater inundation design events

The required "design event" sets the context for the assessment of effects under the resource consent and building consent processes and the calculation of ground levels and floor levels (as shown in Table 1).

Under RMA 1991 processes, the design event is a 1% AEP generally over a 100 year planning horizon. This encompasses projections of a 1% AEP event occurring with at least 100 years of projected climate change normally taken into account. This is driven largely by the NZCPS 2010, which indicates that a planning horizon of *at least* 100 years be considered for coastal development (Policy 24 and elsewhere). Given the close inter-relationship between freshwater and river systems and the open coast, this 100 year planning horizon is also adopted for these systems to ensure consistency in application. A planning horizon of *more than* 100 years is specifically considered for subdivision, greenfield developments and major asset infrastructure developments in coastal locations where a sea level rise component applies. This is consistent with the recent MfE guidance as detailed in Section 3.4.2.

E1 of the Building Code requires the avoidance of water entering residential and communal buildings in a 2% AEP event, over the unlimited life of the structure but no less than 50 years.

In coastal settings subject to both seawater and rainfall runoff (freshwater) inundation hazard, consideration of the combined effects of storm-tide and rainfall runoff events is required. This may be a low probability storm-tide event coupled to a higher probability rainfall event (e.g. 1-2% AEP storm tide and 5% AEP rainfall), or the reverse, to determine the most severe appropriate design case. In some specific instances the use of a different design event may be justified and should be treated as a local adjustment factor. All such cases may be treated as exceptions requiring a site-specific assessment.

2.5 Seawater Inundation Calculation

Figure 3 summarises the 8 steps required to calculate a minimum ground and/or floor level in coastal locations subject to seawater inundation. The calculation is dependent on the 'development setting' and transitional sea level rise allowances taken from the Ministry for the Environment's guidance on 'Coastal Hazards and Climate Change: Guidance for Local Government' (MfE, 2017). An explanation of each of the factors included in the calculation is provided in Sections 3-7 and should be read in conjunction with this summary.

Table 1: Design criteria to determine ground and/or floor levels based on activity and land elevation

Site Location[1]	Joint Probability AEP	Design Event Criteria
Subdivision under RMA 1991		
• <30m and <6m RL	1%	The higher level determined from: a) 1% AEP rainfall/inundation event at or beyond 2120 occurring at the same time as the MHWS-6 tide level elevated by sea level rise*; or b) 1% AEP storm-tide event elevated by sea level rise* occurring with no rainfall; or c) 1% AEP storm-tide event elevated by sea level rise* coincident with a 5% AEP rainfall/inundation event at the year 2120. *Sea level rise in accordance with the development setting in the 2017 MfE guidance.
• >30m and <4.0m RL • >30m and >4m, <6m RL	1%	The higher level determined from: a) to c) above; or d) a 1% AEP rainfall/inundation event at or beyond 2120
• >30m and >6.0m RL	1%	1% AEP rainfall/freshwater inundation event at or beyond 2120.
Development[2] where no subdivision is required under the RMA 1991		
• <30m and <6m RL • >30m and <4.0m RL • >30m and >4m, <6m RL	1%	The higher level determined from a) to d) above
• >30m and >6m RL	1%	1% AEP freshwater inundation event at or beyond 2120
Residential and Communal Buildings[3] on existing title under BA 2004[4]		
<30m and <6m RL	2%	The higher level determined from: e) A RMA process as recorded as a consent notice on the title, or f) 2% AEP rainfall/inundation event occurring at the same time as MHWS-6 by the year 2120; or g) 2% AEP storm-tide event, with sea level and 5% AEP rainfall by the year 2120.
• >30m and <4.0m RL • >30m and >4m, <6m RL	2%	The higher level determined from: e)-g) above
>30m, >6m	2%	2% AEP freshwater inundation event by the year 2120
Other buildings on existing title under BA 2004		
All sites	NA	In the absence of a consent notice on title, no ***requirements*** but encouragement to adopt prudent levels

[1] 30m is in relation to distance inland from MHWS-6.
[2] Comprehensive housing developments or multiple apartments on one title, commercial/industrial developments (e.g. industrial parks with private roads), multiple tenancy buildings.
[3] NZ Building Code E1.3.2 limits the application of the 2% AEP level of protection to housing, communal residential, and communal non-residential buildings.
[4] Properties where land intimately connected to a building that is subject to inundation in a 1% AEP event may require a hazard notice under s73 of the BA 2004. Refer to Section 6 for more information.

Figure 3: Seawater Inundation Calculation

Step 1: Determine your development setting

A	B	C	D
Coastal subdivision[*], greenfield developments and major new infrastructure	Changes in land use and redevelopment (intensification)	Land-use planning controls for existing coastal development and assets planning	Non-habitable short-lived assets with a functional need to be at the coast, and either low-consequences or readily adaptable (including services)

Step 2: Inundation Information

Is there seawater inundation information available for your site? Acceptable information includes Council inundation modeling and mapping, or a site specific assessment required by Council. Check with Council on what information is available or acceptable.

Yes → go to Step 4

No → go to Step 3

Step 3: Identify a Storm Tide Adjustment Factor

Refer to Table 2 for a location specific value.

Step 4: Add a Climate Change Effects Factor relevant to your development setting

Note: If you are using a council approved model or site assessment, the CCE factor (sea level rise) may already be included depending on the model parameters used. If so, go straight to Step 5.

A	B	C	D
1.5m[‡]	Adapt to hazards by using the MfE pathways approach	1.0m	0.65m

Step 5: Add Freeboard

Refer to Table 3 for a development specific minimum requirement (based on NZS4404).

Step 6: Consider Local Adjustment Factors

It may be necessary to increase or decrease the ground and/or floor level if the site or building is:

- at risk from impounded sea water or overland flow of sea water
- seawater backflow via pipes, drains and river systems
- exposed to freshwater flooding hazard associated with tidal influence
- located where a topographical effect could reduce/increase the risk (dune, hill, low point)
- located where a coastal barrier affects the risk of inundation (sea wall, tidal gate, causeway)
- located within a secondary flow path

Check with Council on what inundation hazard information is available.

Step 7: Consider Building Act 2004 Requirements

S71-74 of the Building Act applies if you are proposing to build on land subject to natural hazard(s). The land intimately associated with the building or major alteration must be flood free in a 1% AEP event to avoid a s73 notice. Council can advise on when s71-74 may apply and how this can be factored into determining a minimum ground level to avoid a notice.

Step 8: Minimum Ground and/or Floor Level

The elevation that is determined from the above process is the minimum ground and/or floor level required, relative to RL 0m (NZVD2016).

Note: There may be additional freeboard requirements for new buildings and alterations based on E1 or E2 of the Building Code. Council can advise when this may apply.

Notes:
* “Coastal subdivision” will be deemed as subdivision of land below RL 6m.
ǂ Avoid hazard risk by using sea level rise over more than 100 years and the H+ scenario (which is a sea level rise of 1.5m for the year 2130 and increases to 1.9m out to the year 2150).

2.6 Storm Tide Adjustment Factor

Within the seawater inundation calculation, the Storm Tide Adjustment Factor (Table 2) provides example values for storm-tide (ST) and wave setup (WS) for specific upper beach slopes of a sandy nature. These factors may apply to properties on land adjacent to the open coast, estuaries and low lying land that is more distant from the shoreline. Additionally, wave runup (WR) may be a factor affecting those properties within 30m of the open coast. The values in Table 2 apply to typical beach slopes at a variety of general locations. These values will need to be checked for each site, as the adjacent beach slope may vary from the generalised beach slope listed in the table at that locality. The maximum value (shaded columns) is the factor generally applied in the seawater inundation calculation for the relevant setting. However, some modification of the maximum ST+WS factor may be possible due to the WS component not being fully developed, particularly within larger estuaries.

Table 2: Storm Tide Adjustment Factor

Select a value from the shaded columns relevant to your site’s location.

	Data below assumes SLR = 0.0m and 1% AEP storm-tide event.	**Land adjacent to Estuaries and land >30 from MHWS-6**			**Land adjacent to Open Coast and <30m from MHWS-6**		
Location	Beach Slope Between 2.0m-2.5m (mV:1mH) NZVD2016	**Max. ST & WS**	Storm Tide	Wave Setup	**Max. ST, WR & WS**	Storm Tide	Wave runup (incl. setup)
NELSON							
Oananga Bay	0.16	**3.13**	2.34	0.95	**4.39**	2.34	2.31
Delaware Spit (open coast)	0.08	**2.84**	2.34	0.66	**3.90**	2.34	1.84
Glenhaven to Glenduan	0.20	**3.70**	2.34	1.64	**5.80**	2.34	3.90
Nelson Haven (Tahunanui Beach)	0.06	**2.62**	2.32	0.38	**3.32**	2.32	1.20
TASMAN BAY							
Rabbit Island	0.08	**2.66**	2.29	0.46	**3.39**	2.29	1.28
Ruby Bay-natural	0.16	**2.91**	2.28	0.73	**3.88**	2.28	1.77
Kina Peninsula	0.09	**2.68**	2.27	0.52	**3.46**	2.27	1.41
Motueka Nth	0.12	**2.76**	2.27	0.62	**3.62**	2.27	1.58
Kaiteriteri	0.17	**2.97**	2.27	0.87	**4.10**	2.27	2.11
Marahau Nth	0.16	**2.83**	2.27	0.61	**3.67**	2.27	1.48
Totaranui	0.14	**3.19**	2.27	1.15	**4.74**	2.27	2.85
GOLDEN BAY							
Tata Beach	0.13	**2.73**	2.36	0.66	**3.50**	2.36	1.66
Rototai	0.11	**2.64**	2.35	0.53	**3.28**	2.35	1.36
Paton Rock	0.12	**2.67**	2.36	0.54	**3.31**	2.36	1.37
Parapara	0.11	**2.61**	2.36	0.41	**3.13**	2.36	1.07
Pakawau	0.07	**2.51**	2.36	0.20	**2.83**	2.36	0.60
Puponga	0.12	**2.62**	2.36	0.36	**3.09**	2.36	0.91

(Source: NIWA coastal calculator outputs for Tasman District Council and Nelson City Council.)

Notes:

1. The 'response-variable module' of the coastal calculator was used to calculate Table 2 data. The calculator assumes a number of parameters, including that the beaches are sandy in nature. The above data excludes those parts of shorelines partially or completely affected by rock revetment or other structural interventions, such as at The Haven, Riwaka, Ruby Bay south, Motueka south, mid-Kina Peninsual, mid-Pakawau and much of the Puponga coast.

2. Data is relative to NZVD2016 including -0.17m offset for baseline MSL (2008-2017) projection, being 0.15m above NVD55 0m. NVD55-NZVD2016 differential is assumed as being 0.32m in the coastal calculator.

3. The beach gradients are the average of a number of measurements taken between the 2.0m and 2.5m LiDAR contours (NZVD2016). The data is very sensitive to the beach slope used and for specific design, the upper beach gradient measurement should be checked.

4. The Coastal Calculator uses the Stockdon et al (2006) wave setup and wave runup formula, developed for sandy beaches only. The formula employs a constant beach slope and thus for composite slopes as generally occurs, an upper beach slope is recommended and has been used, as this will conservatively return a higher wave setup and wave runup value. The calculator also assumes that the beach slope used remains constant for whatever sea level rise scenario selected – this may not be the case in reality due to the effect of a number factors such as shoreline erosion, changes to nearshore sediment composition and the like.

2.7 Freeboard

With all hydraulic assessments, whether derived from historical mapped data or computer modelling assessment, there is a degree of uncertainty in the flood level results obtained. In order to account for these uncertainties, as well as for certainties such as maintaining building weather tightness during rainfall, it is usual that a "freeboard" allowance (Table 3) is applied to building platforms and floor levels above the calculated flood level (as illustrated in Figure 5).

Table 3: Minimum Freeboard Requirements

Type of Structure	Freeboard height above design inundation level
Non-habitable residential buildings and detached garages*	0.20m
Commercial and industrial buildings*	0.30m
Habitable dwellings (including attached garages)*	0.50m
Major community facilities related to supply of electricity, telecommunications, water supply or wastewater disposal	0.60m
Bridges and buildings over watercourses (freeboard to the underside of structure)^	0.60m

** Levels as per NZS4404: 2010 Land Development and Subdivision Infrastructure*
^ Levels as per NZTA Bridge Manual, SP/M/022, 3rd edition, May 2016

The minimum freeboard shall be measured from the prescribed water level (e.g. a 1% or 2% AEP event) to either the building platform level, the underside of the floor joists, or underside of the floor slab. Structures need to comply with freeboard requirements of the NZ Building Code and those may be separate from and in addition to the freeboard requirements above. Council can advise on when this may apply.

2.8 Freshwater Inundation Process

The freshwater inundation process uses a methodology broadly similar to the seawater inundation calculation, although the data sources for determination of inundation water levels are variable and include flood records and computer model simulations. Figure 4 summarises the 6 step process to determine minimum ground and/or floor levels in locations subject to freshwater inundation. An explanation of each of the factors included in the calculation is provided in Sections 3-7 and should be read in conjunction with this summary.

Figure 4: Freshwater Inundation Process

Step1: Inundation Information

Is there flooding, secondary flow path or ponding information available for your site to determine water levels? Acceptable information includes Council flood modelling and mapping, or a site specific assessment approved by Council. This information should account for any local adjustment factors such as:

- exposure to freshwater flooding hazard in combination with tidal influence
- topographical effects or changes which could reduce or increase the hazard risk (dune, hill or low point)
- if the site is located within a secondary flow path

Check with Council on what acceptable information is available.

No

Step 2: Site Specific Assessment

A site specific assessment for flooding, overland flow and ponding may be required where there is a lack of information on water levels or if local adjustment factors apply. Council can advise on when it is appropriate to undertake such an assessment.

Yes

Step 3: Identify Inundation Levels on Your Site

Based on a minimum of:

- 1% AEP inundation event for subdivision and new buildings (2120 climate) under the RMA 1991 (taking into account climate change effects such as rainfall intensification)
- 2% AEP inundation event for new buildings and alterations (current climate) under the BA 2004

Step 4: Add Freeboard

Refer to Table 3 for a development specific minimum requirement (based on NZS4404).

Step 5: Consider Building Act 2004 Requirements

S71-74 of the Building Act applies if you are proposing to build on land is likely to be or is presently subject to natural hazard(s). The land intimately associated with the building or major alteration must be flood free in a 1% AEP event to avoid a s73 hazard notice. Council can advise on when s71-74 may apply and steps that can be taken (e.g. minimum ground level) to avoid a notice.

Step 6: Minimum Ground and/or Floor Level

The elevation that is determined from the above process is the minimum ground and/or floor level required, relative to RL 0m (NZVD2016).

Note: There may be additional freeboard requirements for new buildings and alterations based on E1 or E2 of the Building Code. Council can advise when this may apply.

2.9 Combined seawater and freshwater inundation

Some sites in the districts may be subject to both seawater and freshwater inundation. In these locations both the seawater calculation, the freshwater process and a combination of the two should be applied to determine which of the three inundation scenarios poses the greatest hazard to land and buildings. The highest value of the three levels calculated will determine the minimum ground and/or floor level. Refer to Table 1 for design event criteria.

2.10 Determining the minimum ground and/or floor level

Once all the steps in the seawater inundation calculation or freshwater inundation process are completed, an elevation will be determined which is relative to RL 0m (NZVD2016). The additional height of the minimum ground and/or floor level required for hazard mitigation at the site will be the difference between the calculated level and the existing ground level.

This can be demonstrated using the scenario illustrated in Figure 5 for a 1% AEP freshwater inundation event. The existing ground level is RL 33.4m. The calculated minimum ground level required for a non-pile foundation design is RL 34.6m. This is a combination of the inundation level (RL 34.1m) and a freeboard (0.5m).

The floor level of House A will be a minimum of 1.425m above existing ground level (RL 34.825m). This allows for the additional minimum 0.225m floor level clearance above the filled ground level as required under the Building Code. However, for the building pile substructure foundation examples, the floor level of Houses B and C will be up to 1.2m above the existing ground level to provide appropriate mitigation against inundation hazard (RL 34.6m).

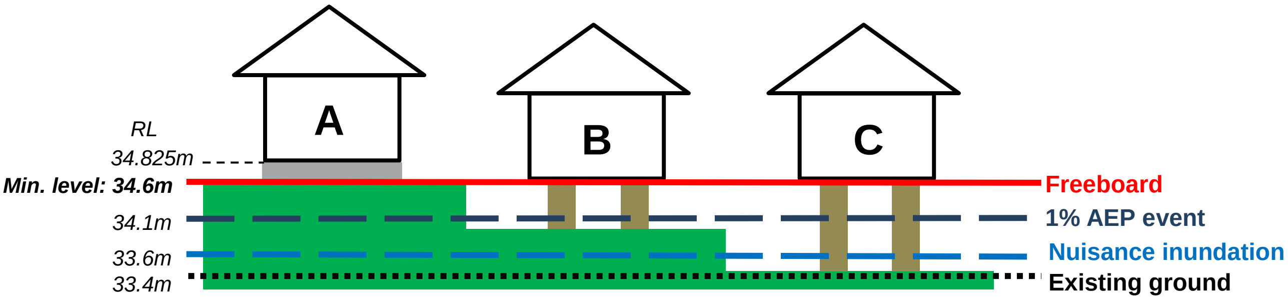
2.11 Options for raising ground and/or floor levels

Various options exist to reduce and mitigate inundation hazard exposure to land and buildings. Generally, both Councils will seek to avoid subdivision and development in areas subject or potentially subject to significant risk from inundation hazard, by promoting development in areas with no or low flood hazard exposure through its resource management plans and resource consent processes.

Both Councils will also seek options to reduce and mitigate the likelihood and magnitude of inundation hazard to land and buildings where these activities do not significantly increase the inundation hazard to other properties. This includes the raising of ground and/or floor levels as well as various design considerations and technological innovations as discussed in further detail in Section 7. Any option will need to comply with relevant legislation and the respective resource management plans. Its feasibility will be assessed on a case by case basis, and should be discussed with Council.

Figure 5 shows examples of options for raising ground and/or floor levels, and suggests activities for which these might be appropriate. In locations where there is or maybe an inundation hazard, any new property titles created through subdivision should provide functional land where a building platform can be established that is free from inundation. The potential of adverse effects on other parties will be an important consideration, especially when considering raising the ground level. In this case, it will need to be demonstrated that there are no adverse effects incurred or exacerbated on adjacent properties, including by raised flood levels, diversion of flood flows and/or secondary flood routes, building design, neighbourhood amenity, access and servicing.

Figure 5: Examples of options for raising ground and/or floor levels



Options	
A	Subdivision or buildings on river floodplains, freshwater ponding areas, and in seawater inundation locations (either by wave run-up or ponding on lower-lying land), where filling for a building platform can be undertaken and there are less than minor adverse effects off-site.
B	Buildings on river floodplains, freshwater ponding areas and in seawater inundation locations, where filling for a building platform can be undertaken to a small degree to reduce nuisance inundation (for example a 20% AEP event) without adverse effects off-site occurring but where filling for a building platform has more than minor adverse effects off-site.
C	Buildings on river floodplains, freshwater ponding areas and in seawater inundation locations, where any filling for a building platform has more than minor adverse effects off-site.

3 Supporting Information for Calculating Levels

3.1 Introduction

This section provides supporting information and explanation on the different factors of the seawater inundation calculation and freshwater inundation process, as outlined in Section 2. Some subsections and information is relevant to both types of inundation hazard, while others may only be relevant to either seawater or freshwater inundation.

3.2 Seawater and freshwater inundation design events

In this practice note, reference is made to rainfall and sea level/storm-tide events. Both have probabilities associated with them that reflect event severity. The lower the probability of an event occurring, the more severe that event.

It is usual that when the effects of severe rainfall are determined through modelling, a nested rainfall pattern is often used which distributes rainfall in time in such a way as to cause the most adverse performance from the system analysed for the given frequency. In simpler terms, when a 1% AEP rainfall event is used for analysis particularly in small catchments, this rainfall intensity will be assumed to be occurring everywhere in the catchment. In reality rainfall distribution does not always occur in this way and appropriate rainfall distributions are likely to be modelled in larger catchments. When a 1% AEP rainfall event occurs at one location, it is seldom occurring at the same intensity everywhere else in the catchment at the same time, although that depends on the size of the catchment under consideration.

When a sea level is applied in any assessment, this level is made up of several factors which include both tidal and weather related influences. The “predicted tide” is independent of prevailing weather, and is based solely on a standard atmospheric pressure condition and factors including the relative positions of the sun and moon. However, factors relating to a weather event includes low barometric pressure, wind speed and duration, fetch (distance over which the wind blows over water) and shoreline conditions, i.e. factors typically associated with storm conditions and local geography and topography.

The MHWS-6 tide is adopted for the tidal baseline condition from which the hydraulic grade line is calculated, for discharges from open channels and pipelines terminating at the coast. This is to ensure that the effect of a 1% AEP rainfall/runoff event on the drainage network is appropriately simulated or designed for the development being considered, without imposing an improbable tidal boundary condition (such as highest astronomical tide) that would unduly influence rainfall runoff at the coast.

Conversely, an extreme storm-tide event is invariably accompanied by some rainfall. A 5% AEP rainfall event has been allowed for as a reasonable but not improbable combination. Lastly, coinciding extreme (e.g. 1% AEP) storm-tides and rainfall can occur at the same time. However such events have a very low joint probability that is certainly less than 1%. In this practice note, it is considered that reasonable joint probability limits have been set to provide a practical and affordable basis for design. These scenarios are summarised in Table 1 (Section 2).

3.3 Identifying locations subject to seawater and/or freshwater inundation hazards based on reduced level thresholds

In coastal locations both the seawater inundation calculation and the freshwater inundation process relies on RL thresholds as a starting point to determine locations that may be subject to these hazards, as shown in Figure 2 (Section 2). Appendix 1 lists previous vertical datums used.

Historically, 0.0m NZVD55 was the same as 0.0m MSL. In NZVD2016, the datum used for the Top of the South Maps and Nelson City Council/Tasman District Council LiDAR contour maps, RL 0.0m is no longer the same as MSL 0.0m. The NVD55 0.0m (MSL1939-1942) is 0.337m lower than NZVD2016 0.0m. Due to 0.15m sea level rise since 1939-1942 MSL assessment, MSL (2008-2017) is 0.187m NZVD2016 and becomes 0.047m NZVD2016 (MSL 2020 projection). Once sea levels have risen 0.337m from NVD55 0.0m, NZVD2016 0.0m will then also become mean sea level. This is projected to occur in the early 2020s.

The land elevation and coastal setback thresholds (the ‘RLs’) have been selected on the basis that they are conservative values that capture land potentially affected by a seawater inundation event occurring over a minimum of the next 100 years. The 30m distance threshold from MHWS-6 also coincides, for the moment, with the minimum permitted activity setback distance for buildings from MHWS-6 in the Tasman Resource Management Plan and other national practices such as the coastal marine area setback in the NES for Plantation Forestry (2018).

3.4 Supporting information to inform the Seawater Inundation Calculation

This section details supporting information and explanation specific to the application of the seawater inundation calculation. Refer to Section 2 for the flow diagram summary (Figure 3) to calculate ground and/or floor levels in locations subject to seawater inundation.

3.4.1 Storm Tide Adjustment Factor

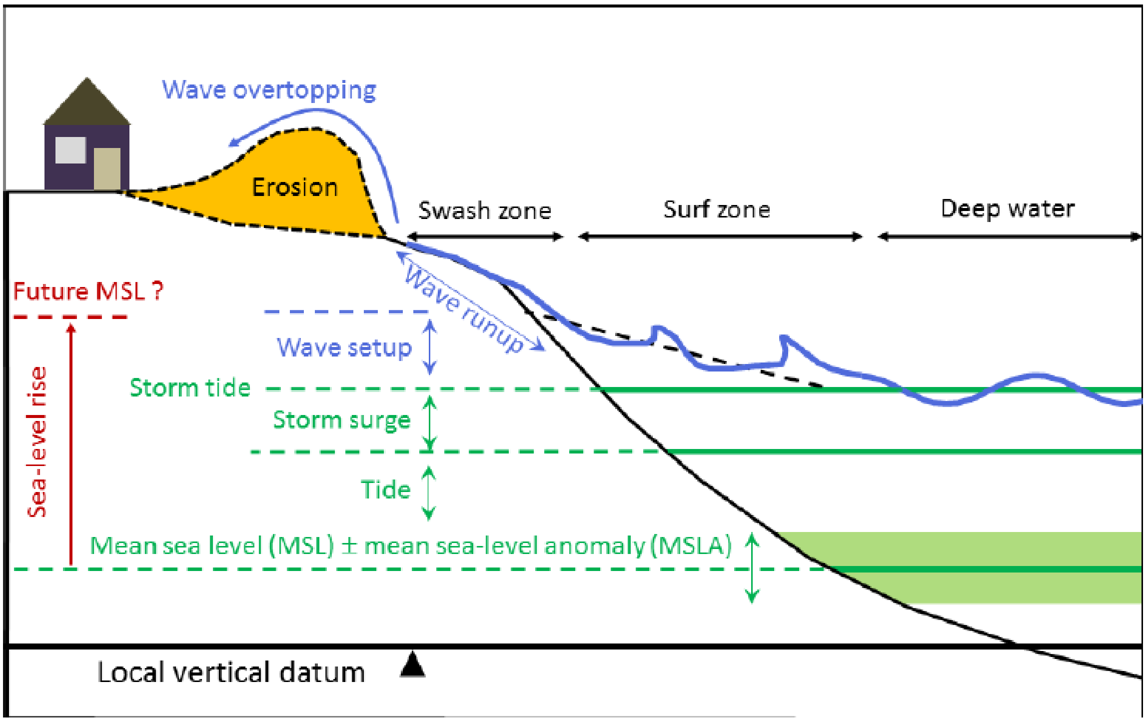
The storm tide adjustment factor considers storm surge and wave set up for all properties, and wave runup for those properties within 30m of the coast as discussed further below.

3.4.1.1 Extreme sea-level elevations from storm-tides and waves

The primary factors affecting seawater inundation hazard are storm surge, wave setup, wave run up and sea level rise. These effects are illustrated in Figure 6 below.

Figure 6: Processes that contribute to seawater inundation and erosion

(Source: MfE (2017))



3.4.1.2 Tasman and Golden Bay coastlines

Extreme tide (storm tide) analysis indicates that Tasman and Golden Bays are tide (as opposed to wave) dominated. Storm-tides having 1% AEP have an elevation varying within a 0.14m range (without wave effects). These elevations change once the effects of waves on a shoreline of a particular gradient and material composition are taken into account.

A NIWA study commissioned by Tasman District Council (NIWA 2014(1)) considered 14 representative “open coastline” locations exposed to extreme sea levels within Tasman district and included consideration of combined tide, storm surge (inverse barometric and wind-induced effects), wave setup and wave runup. The Coastal Calculator has been revised (May 2018). This tool can be used at each of these locations to determine a range of outputs for selected inputs, as previously described.

The study shows that wave setup makes a small contribution to total elevation of the sea at the coastline relative to storm tides, owing to the relatively large tidal range and sheltered wave environment within the bays. However, wave runup makes a significantly larger contribution, being almost four times as large as wave setup. Wave runup is very sensitive to beach slope and is calculated at the MHWS-6 level of the beach profile (NIWA, 2014(1)).

The NIWA assessment does not take into account the effects of potential future erosion when considering the risk of inundation and does not provide maps or assessment on the extent, depth or volume of inundation inland of the shoreline.

An additional wave overtopping module to the NIWA coastal calculator enables assessment of the volume of wave overtopping for a range of sea wall structure configurations.

3.4.1.3 Nelson City coastline

NIWA has undertaken a number of coastal assessment studies for Nelson City Council over recent years, most recently in November 2015 (NIWA 2015 (2)).
Like the Tasman District, the Nelson City coastal environment is variable, and requires region-specific assessment in terms of design storm tides.

The Wood is effectively protected from wave runup by the Boulder Bank and Nelson Haven. The Wood is located close to the sea-level gauge from which storm-tide elevation probabilities were derived, providing a good degree of confidence in assessed storm-tide elevations for that area.

Stoke is located inside the Waimea Inlet and is protected from direct ocean wave effects. The storm-tide elevations were derived on the coast outside the tidal inlet. Tidal and storm-surge waves can amplify (or decay) inside tidal inlets. While NIWA do not have information on tidal shoaling inside Waimea Inlet, they have allowed for an 8cm amplification in storm surges affecting Stoke, based on NIWA studies from Auckland’s Waitemata Harbour. Monaco is also located within the Waimea inlet, but less so than Stoke. Depending on the aspect of the shoreline under consideration and the wind and wave direction, Monaco is likely to be subject to wave runup and wave setup effects somewhere between those experienced at Tahunanui Beach and Stoke.

Glenduan and Tahunanui Beach are both directly exposed to waves from Tasman Bay, thus they require local adjustment factors in the form of wave setup and runup elevations. NIWA’s approach to assessing storm tide and wave set up/run up is outlined in their November 2015 report.

3.4.1.4 Coastal inlets

Natural tidal inlets and estuaries in Tasman and Golden Bays and the Nelson Haven have sufficient tidal flow in and out of their entrances such that they effectively reach equilibrium with the open coast sea level across the high tide cycle. That is, at high tide the sea level within the estuary and on the open coast is effectively the same. However, there will be a difference in elevation mid tide when sea water is flowing either in or out of the estuary.

Because estuaries are relatively sheltered environments and have reduced fetch compared to the open coast, wind-generated waves are smaller and their shorelines are subject to reduced wave runup, wave setup and erosion effects. However, sea level elevation resulting from storm surge and wave set up occurs over a sufficiently long duration for open coast shoreline and estuary water levels to be very similar if not the same. For calculating ground and/or floor levels adjacent to estuary margins, only the storm tide and wave setup factor need be used, Wave runup need not be considered unless the site is exposed to some degree of open-coast wave generation or surge effects, with possibly a small allowance made if the fetch across the estuary becomes significant.

Where a tidal inlet or estuary has been modified (such as the construction of a causeway with a culvert or tide gate that restricts the tidal flow) the sea water level within the truncated estuary embayment will often be lower than for the wider estuary and the open coast. However, such locations are also likely to be influenced by stormwater or stream inflows.

Both of these effects should be assessed and taken into account with an additional 'local adjustment factor'.

3.4.1.5 Storm tide adjustment factor

Values shown for the storm tide adjustment factor (Table 2, Section 2) are calculated for a present-day 1% AEP joint probability storm-tide event, assuming a sandy shoreline and for the prescribed MHWS-6 beach slope. All structurally modified (e.g. rock revetment) and other shoreline types, including rocky shoreline locations, will require site specific assessment. The data in this table is derived from the NIWA coastal calculator for each of the sites in the Nelson and Tasman districts.

3.4.2 Climate change effects factor: sea level rise

Within the seawater inundation calculation, the climate change effects (CCE) factor accounts for projected sea level rise. The CCE factor applies the transitional sea level rise values shown in Figure 3. The CCE factor does not consider increased rainfall or increased frequency of storm events.

Since the early 2000s, MfE has provided local government with guidance on how to adapt to coastal hazards arising from climate change, particularly hazards associated with sea level rise. This guidance has been used by councils to inform land use and infrastructure asset planning in coastal areas. MfE publications in 2008 and 2009 (MfE 2008(1) and MfE 2009) provided baseline sea level rise recommendations for different future timeframes[5], in metres relative to the 1980-1999 average. To date, both Councils have applied these sea level rise recommendations to their flood modelling scenarios and assumptions and the setting of minimum ground and/or floor levels.

MfE's publication 'Coastal Hazards and Climate Change: Guidance for Local Government' (December 2017) has provided a major revision to the previous guidance and includes the findings of the latest Fifth Assessment Report produced by the Intergovernmental Panel on Climate Change (IPCC). The guidance provides an iterative 10 step framework to enable local government to undertake 'long-term adaptive planning' for climate change in coastal communities, recognising that because of the uncertainty about future climate change it is necessary to examine a range of sea level rise scenarios. The guidance advises councils to consider and apply four sea level rise scenarios when developing and testing adaptation plans and policy, and for the design and adaptive development of assets and infrastructure at the coast. Table 4 provides a bracketed sequence of years in the future when specific sea level rise increments could be reached in New Zealand.

While councils across New Zealand work towards the recommended long term adaptive planning pathways approach as detailed in the guidance, MfE has provided minimum transitional sea level allowances to be used in planning processes as shown in Table 5. Sea level rise allowances are provided for four categories of activities or types of development (A – D) and are expressed as either scenarios or a minimum value. These categories are referred to as the 'development setting' within the seawater inundation calculation.

[5] The previous guidance (MfE July 2008(1)) adopted a risk-based approach, advising local government to start assessments of a range of higher sea levels at a base level of 0.5 metres and at least consider 0.8 metres by the 2090s, with an extension beyond 2100 applying a rate of 10 mm/yr.

Table 4: Range of timeframes when specific sea level rise increments would be reached

(source MfE, 2017)

Table 11: Approximate years, from possible earliest to latest, when specific sea-level rise increments (metres above 1986–2005 baseline) could be reached for various projection scenarios of sea-level rise for the wider New Zealand region

SLR (metres)	Year achieved for RCP8.5 H+ (83%ile)	Year achieved for RCP8.5 (median)	Year achieved for RCP4.5 (median)	Year achieved for RCP2.6 (median)
0.3	2045	2050	2060	2070
0.4	2055	2065	2075	2090
0.5	2060	2075	2090	2110
0.6	2070	2085	2110	2130
0.7	2075	2090	2125	2155
0.8	2085	2100	2140	2175
0.9	2090	2110	2155	2200
1.0	2100	2115	2170	>2200
1.2	2110	2130	2200	>2200
1.5	2130	2160	>2200	>2200
1.8	2145	2180	>2200	>2200
1.9	2150	2195	>2200	>2200

The earliest year listed is based on the RCP8.5 (83rd percentile) or H+ projection and the next three columns are based on the New Zealand median scenarios in figure 27, with the latest possible year assumed to be from a scenario following RCP2.6 (median). Note: the year for achieving the sea-level rise is listed to the nearest five-year value.

Table 5: Minimum transitional New Zealand-wide sea level rise allowances to be applied as the climate change effects factor

(source MfE 2017)

Table 12: Minimum transitional New Zealand-wide SLR allowances and scenarios for use in planning instruments where a single value is required at local/district scale while in transition towards adaptive pathways planning using the New Zealand-wide SLR scenarios

Category	Description	Transitional response
A	Coastal subdividion, greenfield developments and major new infrastructure	Avoid hazard risk by using sea-level rise over more than 100 years and the H+ scenario
B	Changes in land use and redevelopment (intensification)	Adapt to hazards by conducting a risk assessment using the range of scenarios and using the pathways approach
C	Land-use planning controls for existing coastal development and assets planning. Use of single values at local/district scale transitional until dynamic adaptive pathways planning is undertaken	1.0 m SLR
D	Non-habitable short-lived assets with a functional need to be at the coast, and either low-consequences or readily adaptable (including services)	0.65 m SLR

For category ‘A’ the guidance advises the use of the H+ scenario which identifies a sea level rise of 1.5m for the year 2130 and increases to 1.9m out to the year 2150 (as shown in Table 4). This is a significant change to the previous nominal 1m sea level rise which was applied. The use of the H+ scenario future-proofs the anticipated longer life of new developments and gives cognisance to the NZCPS requirement to avoid future hazard risk over planning timeframes *beyond* 100 years.

For informing where intensification of existing development is inadvisable (category ‘B’), the guidance does not provide for a transitional value and instead the full MfE adaptive pathways planning approach should be applied. MfE’s guidance outlines the process for the adaptive pathways approach. In such situations, it is recommended to discuss early on the suitability of your proposal with Council.

Transitional sea level rise values for categories ‘C’ (existing development) and ‘D’ (short-lived non-habitable assets) within Table 5 correspond to the equivalent values recommended for sea level rise from the previous MfE guidance (MfE, 2008a).

Until such time that each Council has progressed the adaptive planning pathways approach as detailed in the MfE guidance, the transitional sea level rise values for each of the development settings (as shown in Table 5) will be applied in planning processes.

3.5 Supporting information to inform the Freshwater Inundation Process

This section details information that informs the application of the freshwater inundation process. Refer to Section 2 for the flow diagram summary (Figure 4) of how to calculate ground and/or floor levels in locations subject to freshwater inundation.

3.5.1 Piped networks, waterways and secondary flowpaths

As described in Section 1, both Councils have inundation modelling work programmes in place and this includes modelling of piped stormwater networks, waterways, and secondary flowpaths that may impact on urban areas. Check with each Council on what modelling information is available or being developed.

Modelled results provide an overview of the flood extent and flood depths. This information can be used to determine the base water level for ground and/or floor level calculations.

The Councils have also mapped or are in the process of mapping some secondary flowpaths for some urban areas. In these circumstances, the location and peak volume of the flowpath has been determined by Council and can be used to determine the appropriate siting of development under both building (Building Act s71-74) and resource consent (RMA s106) processes.

In areas that have not yet had flowpaths mapped, the appropriate location, level and freeboard of ground and/or floor levels for new development will need to be determined from first principles and will be considered as a ‘local adjustment factor’ when setting the minimum level.

3.5.2 Climate change effects factor: increase in rainfall intensity

Within the freshwater inundation process, the CCE factor accounts for a projected increase in rainfall intensity. It is anticipated that incidences of extreme weather (rainfall events) and associated freshwater inundation will increase in the future, both in magnitude and frequency. Annual rainfall is predicted to rise over the summer, autumn and winter seasons across the Nelson and Tasman districts with high intensity rainfall occurring more often. The CCE factor for the increase in rainfall intensity (approximately 15% greater than present by

2120) should be applied in determining the 1% AEP inundation event for the year 2120, when considering inundation levels for subdivision and new buildings under RMA 1991 processes.

3.6 Supporting information relevant to both the Seawater Inundation Calculation and the Freshwater Inundation Process

3.6.1 Sloping sites

Ground level at the point of interest (which should be taken as an individual building footprint and some curtilage, even if it is within a subdivision development) may be on a slope. In scenarios where ponding (as opposed to overland flow) is the primary consideration, the ground level is to be taken as the lowest ground level subject to ponding as determined either by topographical survey, LiDAR or other relevant method. In the case where overland flow (e.g. river flood plains) is the primary consideration, the ground level at the upstream edge of the proposed development is the ground level that applies. Where multiple buildings are proposed to be formed, the ground levels at each of these should be considered individually.

3.6.2 Freeboard: allowances for flood level uncertainties

With all hydraulic assessments, whether derived from historical mapped data or computer models, there is a degree of uncertainty in the flood level results obtained. There are several reasons for this including a change in topography or watercourse morphology since a flood event map was drawn or modelling undertaken, changing shoreline conditions altering wave runup or inland flow capability, or model parameters that cannot be defined with precision due to lack of climate data. In order to account for these uncertainties, as well as for certainties such as maintaining building weather tightness during rainfall, it is usual that a “freeboard” allowance is also applied to building platforms and floor levels above the calculated flood level. A freeboard factor also allows for water levels that may occur in an unlikely but possible event such as infrastructure blockage or failure, capacity exceedance, floodwater diversion and waves generated by vehicles.

The freeboard allowance when applied to land is intended to ensure that any new subdivision meets the tests of s106 of the RMA 1991 or, in relation to new buildings and major alterations, to avoid the need for a BA 2004 s73 hazard notice. This circumstance applies where land that a building is intimately connected with is likely to be subject to inundation hazard. Section 71-74 of the BA 2004 applies at the building consent stage, irrespective of what other conditions apply in a previous or accompanying resource consent. Applicants can contact the relevant Council for the latest information prior to making any major decisions, as hazard knowledge and management directives evolve over time (refer to Section 6 for more information on s73 hazard notices).

The freeboard allowances specified in Table 3 (Section 2) are to be added to the assessed flood level, to result in a <u>minimum</u> ground and/or floor level. There may be local adjustment factors that affect the nominal freeboard required. This may be due to the effect of unusual topography, new flood mitigation structures or shoreline changes affecting seawater inundation potential. Such circumstances may result in the freeboard being higher or lower than the initial minimum value. Council can advise in those circumstances.

The freeboard allowances listed in Table 3 are taken from the Subdivision and Development Standard NZS4404:2010 in relation to habitable dwellings, non-habitable residential buildings and detached garages, and commercial and industrial buildings. Buildings will also need to comply with freeboard requirements of the Building Code and those may be separate from and in addition to the freeboard requirements listed. Council can advise when this will apply.

The Building Code's Acceptable Solutions and Verification Methods for Clause E1 Surface Water (AS and VM for NZ Building Code) requires a minimum freeboard *to the floor level* of 0.15m above the highest adjacent ground level (which could be inferred to be the ponding level). However, the conditions where 0.15m can be applied are restrictive (see below) and unlikely to be applicable in most inundation scenarios:
A catchment area of no more than 0.25 hectares, and which is:

- *free from a history of flooding;*
- *not adjacent to a watercourse;*
- *not located in low lying area; and*
- *not located in a secondary flow path.*

Conditions are also restrictive where Verification Method E1/VM1 of the AS and VM for NZ Building Code requires a freeboard of 0.50m. This applies where ponded water (2% AEP event assumed) exceeds 100mm in depth and extends from the building directly to a road or carpark and therefore likely to be subject to waves generated by vehicles. Such waves will not be sustained unless there is at least 100 mm depth of water and an unobstructed path from the point where the wave is generated to the building. In calculating this 0.50m freeboard, 0.15m is attributed to flood level estimation uncertainty and the remaining 0.35m to wave effects including 0.20m wave height and 0.15m wave runup (Determination 1999/005). This provides a sound base reference for inundation mitigation calculations in some circumstances. Verification Method E1/VM1 shall be used where the Council does not have more accurate data available from sophisticated hydrological modelling as part of its flood management plans[6]. For all other cases, E1/VM1 requires a freeboard of 0.15m.

The required freeboard for development and subdivision in coastal and near-coastal locations takes into account inundation elevations determined from seawater inundation modelling incorporating allowances for sea level rise, or in the absence of modelling, other assessments that provide reasonably reliable flood levels in a projected climate change/sea level rise future.

3.6.3 Local adjustment factors

The local adjustment (LA) factor enables the minimum acceptable land or floor level at any particular site to be adjusted up or down. The LA factor takes account of local, site or project specific matters that would be inappropriate to apply generally.

In some cases, such as greenfield subdivision, and where Council does not hold sufficient information, the applicant may be required to provide a more detailed site specific assessment of natural hazards to determine an appropriate LA factor. Site specific LA factors should be discussed with Council to ensure all factors are addressed and appropriate minimum ground and/or floor levels are determined.

This practice note does not define the potential LA factors in great detail. The matters listed below are not exhaustive, and there may be further aspects that should be considered when determining the LA factor (including those listed in Section 4). A specialist engineering assessment may be required to determine relevant details for a particular site.

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[6] Acceptable Solutions and Verification Methods are produced by MBIE as a means of compliance with the Building Code. E1/VM1 provides a method for verifying that a proposed building will meet the requirements of Building Code E1.3.1 and E1.3.2 in the following circumstances: (a) the catchment area does not exceed 100ha; and (b) the surface water results only from rainfall on the catchment and does not include water from other sources such an inundation from rivers, lakes or the sea.

- **Existing hazard mitigation works or infrastructure**

Land and/or floor levels may be increased or reduced where, for example, there are existing inundation (or erosion) hazard mitigation works or infrastructure present that will function effectively for a time into the future, but beyond that time mitigation function cannot be relied on or becomes no longer available. In the case of hazard mitigation works, this may be due to expiry of consents or a change of policy with respect to the presence of those works (e.g. tide banks, revetments). In the infrastructure case, the elevation of road corridors or causeways can act to exclude the tide to some degree, but over time may no longer have sufficient elevation to continue to do so.

- **Freshwater/seawater inundation hazard associated with increasing tidal influence**

Ground and/or floor level increases may also be necessary in an area where stormwater/ freshwater or groundwater inundation hazard to inland areas increases as a result of increasing (or elevated) sea states. This would include, for example, areas reliant on natural drainage to the coast, or areas where stormwater detention is provided. As sea levels rise, more frequent and/or longer periods of stormwater detention may be required before drainage can occur. With increasing sea levels, drainage infrastructure may require modification with flap gate or tide exclusion gates, to prevent backflow into low lying areas. Some areas may require pumping systems to discharge stormwater to the coast or be used to lower groundwater levels, without which flood hazard risk to existing or proposed greenfield or infill development becomes a concern.

In soft shoreline areas, particularly where erosion mitigation structures are not already present or are relatively minimalist in scale, increasing sea levels will very likely exacerbate coastal erosion hazard. Further coastal erosion may reduce or remove the depth and/or height of elevated back-beach barrier systems such as dunes, exposing any lower lying hinterland behind to increased frequency and/or severity of inundation.

- **Groundwater**

There may be sites where groundwater may affect potential inundation levels. These are likely to be very low lying areas adjacent to the coast below RL 2.5m (NZVD2016). As the level of the sea rises, the water table will rise in these areas, which may lead to surface ponding in some places and more extensive inundation after heavy rain. It is not known the potential extent of groundwater inundation in low lying coastal areas and therefore this should be considered as a local adjustment factor where it may apply.

- **Topographical effects**

Topographical effects including exposure to wave runup at open sea beach locations during storm surge events require specific assessment. Reference should be made to the extreme sea level elevations from the relevant NIWA reports and any detailed hazard maps that may be available at the time of development when an appropriate LA factor is determined.

Other topographical features or effects can alter storm-tide shoreline water levels or affect wave runup potential in both a present day and future projected sea level rise climate. These include dynamic coastal features such as sand spits and bar deposits that form and disperse over time, and sea level rise exacerbating or initiating erosion of coastal barrier systems, overtopping of natural and/or constructed barriers to seawater inundation, or exacerbating the frequency and/or magnitude of stormwater impounding.

- **Design life of buildings**

The Building Regulations have a requirement that primary structural building elements, including floors, function for the life of the building (for an indefinite period but not less than 50 years, unless specified). Building determination 95/006 clarified that a building that is *"...not stated to have a limited intended life in terms of section 39,* [...] *its intended life is to be* *taken as indefinite but not less than 50 years".*

However, other than for buildings having a specified short term life, the effects of sea level rise beyond the 50 year timeframe applies, dependant on the nature and duration of building use, as per central government guidance, the NZCPS and decisions from the Environment Court.

Where short-lived buildings or assets are proposed, the minimum floor level required may be reduced below that needed to mitigate long-term, extreme hazard exposure, dependent on the use of the building or asset. For more information refer to Section 5 Building Use and Risk.

4 Building Servicing

The following section outlines servicing matters that will need to be considered as part of any new development proposed and may influence minimum ground and/or floor levels as a local adjustment factor.

4.1 Dwellings and onsite effluent and stormwater disposal

For ground level assessments, the level will need to be sufficient to provide effective functioning of wastewater and stormwater systems, treatment or disposal that takes into account rising ground water and sea levels. Development at a number of coastal communities where wastewater reticulation is unavailable hinges upon the feasibility and ongoing function of onsite effluent and stormwater disposal systems. Council may require site specific assessments where new dwellings cannot be connected to reticulated wastewater or stormwater systems. The viability of residential development will depend on being able to achieve wastewater and stormwater standards.

4.2 Reticulated stormwater servicing

Where subdivided lot(s) are being connected to a reticulated stormwater system the ground level assessment will need to take into account making an effective connection to any proposed network. The key considerations will include pipe size, cover and outlet level. This is to ensure the outlet of the stormwater system will not be subject to tailwater effects during the design rainfall or inundation event that the proposed network has adequate cover over the pipes and there is enough fall in the pipe network to effectively connect and function with the network pipe sizes. Also, the secondary flow from uphill areas, roads etc must not impact the new development.

4.3 Backwater

In some locations, the minimum floor level will need to take into account water level affected, for example, by the tide constraining rainfall runoff from rivers and streams, open channels and pipe networks discharging to the coast. In these circumstances, the tide causes a "backwater effect" that can increase water levels in low lying coastal locations.

Typical locations are where land drainage pathways (either built channels, pipe outfalls or streams and rivers) exit to the coast, estuaries, areas inland of causeways or low lying areas adjacent to the coast. Development areas that rely on stormwater detention areas adjacent to the coast are also potentially prone to backwater effects, as these areas may also have drainage outflows constrained by the level of the tide.

For ground and/or floor level assessments at these locations, the inundation level should be determined either with the assistance of historical data and/or by hydraulic calculations taking into account the local catchment characteristics.

4.4 Settlement due to liquefaction

Tasman District
The generally gravely nature of the underlying geology over much of the near coast land in Tasman and Golden Bay is such that widespread seismic liquefaction (as experienced in Christchurch) is considered unlikely to occur. Whilst “pockets” of liquefaction may occur during a strong seismic event in places that are low lying adjacent to the coast, particularly adjacent to existing or former estuary areas, it is generally considered unnecessary at this time to specifically allow for the effects of liquefaction when setting floor levels and building site ground levels in coastal locations.

There are specific sites where liquefaction may affect ground and potential inundation levels. These include tidally-affected and partially enclosed flood zones such as the estuary between Wharf Road and Old Wharf Road in Motueka. While no investigation as to liquefaction risk and response in strong earthquake conditions have been undertaken in these locations, this should be considered for a local adjustment factor.

Nelson City
Nelson City Council has undertaken a preliminary liquefaction assessment across the district and identified Tahunanui may be subject to liquefaction during an extreme seismic event. Further assessments have identified an area in Tahunanui where the risk of liquefaction hazard should be managed and mitigated at the time of new subdivision and development. More information on Nelson’s liquefaction hazard can be found on the Council’s website. Liquefaction susceptibility should be considered through a local adjustment factor.

5 Building Use and Hazard Tolerance

The following section outlines building use and inundation hazard considerations which may influence minimum ground and/or floor levels as a local adjustment factor.

5.1 Building use and risk

The nature and use of a building, affects the tolerance to inundation hazard. Clause E1.3.2 of the Building Code requires that water from the 2% AEP flood event shall not enter residential and communal buildings. Council can exercise discretion under the Building Code and accept a lower floor level, or may grant a waiver of any minimum floor level requirement, where the risk of damage is low. A range of factors should be considered by Council and developers/owners when considering appropriate floor levels. Considerations include (but are not limited to):

- building functionality
- vehicle access
- disabled access
- building materials
- community significance of use eg ‘lifeline’ facilities, such as communications equipment, hospitals and other essential services
- risk to life from inundation
- value at risk vs cost to protect
- building owner-insurer relationships or requirements
- amenity and historical value

5.2 Further considerations for owners and designers

The Building Code refers to categories of buildings by importance level based on structural failure considerations. The table of categories is comprehensive and in practice is too complex to assist any process for determining building importance relative to inundation risk exposure for the purpose of this practice note. Therefore a simple classification based on the use of the building can be applied[7] as follows:

- **'Occupied' buildings**

Structures in which people live, sleep or work (i.e. habitable and productive buildings) or have important post disaster functions. 'Habitable or productive buildings' are of high social and economic importance. For example, habitable/productive buildings include residential housing and attached garages, sleepouts, shops, offices, and factories, hospitals and care facilities, buildings containing communication equipment.

- **'Non-Productive' buildings**

Flood hazard exposure to non-productive, non-habitable buildings may generally have only a low economic impact, low structural significance or minor effect. As a consequence, they generally do not need serious consideration when making building decisions on hazard-prone land. They may occupy productive hazard prone land, but contribute only in an ancillary way to its productivity and the consequence of flooding hazard to these buildings is generally not significant. Such buildings may include public toilets, garden sheds, car ports, detached garages, domestic sheds and rural sheds.

There may be situations where a new residential house ('occupied building') is built with a raised floor level while a detached garage or ancillary shed does not require the same raised level as it is a 'non-productive building'. However, a risk to occupants arises when homeowners want to convert these detached garages or sheds to habitable buildings (e.g. creation of an additional room, sleepout, airbnb). In these circumstances, the garage or shed becomes an occupied building and the floor level should be raised to ensure people are not at risk from inundation.

Where there are multiple uses proposed for a new building (e.g. garage with a sleepout), Council will consider the function of the building and require floor levels to be raised to ensure the most vulnerable use (where it is an occupied building) is protected from inundation.

6 Imposing Hazard Notices on Property Titles

Under Section 71 of the BA 2004, a property may be deemed to be subject to a natural hazard and some assessment is required to determine if hazard occurrence is considered "likely" during the lifetime of the building. Section 71(3)(d) identifies inundation as a hazard, including flooding, overland flow, tidal effects, and ponding.

The threshold adopted for this is whether the land that the building is intimately connected to is likely to be subject to inundation during a 1% AEP event (as supported by Determination 2008/82). Thus, it may be possible to meet the requirements of the Building Code by having a minimum floor level set above the 2% AEP flood level, but still be subject to a hazard notice on the title because the land on which the building is intimately connected to is subject to inundation.

Under Section 71 a building consent authority must refuse to grant a building consent for construction of a building, or major alterations to a building if (a) the land on which the building work is to be carried out is subject or is likely to be subject to one or more natural

[7] The two proposed building classifications only relate to implementation of this practice note and does not override requirements under the Building Code or compliance with the BA 2004.

hazards; or (b) the building work is likely to accelerate, worsen, or result in a natural hazard on that land or any other property'.

However, where the building consent authority is satisfied that adequate provision has been or will be made to –

a) protect the land, building work, or other property from the natural hazard or hazards; or
b) restore any damage to the land or other property as a result of the building work, then the building consent must be granted under Section 72 of the BA 2004.

Where a building consent has been granted under Section 72, Section 73 requires that a notice advising of the hazard is placed onto the title of the property.

In order to avoid any consent notices under Sections 72 and 73 of the BA 2004, a property owner will generally need to ensure that both the floor level and land intimately associated with the building is above the 1% AEP flood level. Specific discussion with Council is recommended for landowners seeking this outcome.

7 Options for Reducing Inundation Hazard

Various options exist to reduce inundation hazard exposure to land and buildings. Generally, both Councils will seek to avoid subdivision and development in areas subject or potentially subject to the significant risk from inundation hazards, by promoting development in areas with no or low flood hazard exposure through its resource management plans and resource consent processes. Both Councils will also seek options to reduce and mitigate the likelihood and magnitude of inundation hazard to land and buildings where these activities do not significantly increase the inundation hazard to other properties.

This means that Council will seek to avoid development in flood hazard areas wherever possible, or mitigate to the hazard exposure of the development to the greatest extent practicable. The purpose of this is to reduce the hazard risk to people and property and preserve expected or required levels of functionality, while allowing for uncertainties associated with increased rainfall, sea level rise and modelling. Mitigating inundation hazard effects through building design is an option available to applicants through the BA 2004 and RMA 1991.

The feasibility of any option will need to be assessed on a case by case basis and should include an assessment of the potential adverse effects on other parties and whether resource consent will also be required (e.g. for earthworks, alteration of secondary flow paths, exceeding building height standards etc). Where public funding is involved, the life cycle costs of maintaining any option over the lifespan of the development or building also needs consideration.

Any particular option will need to comply with relevant legislation and the policies and rules of the respective Councils' resource management plans, or obtain resource consent or other permits as necessary.

Options for reducing inundation hazards to land where it can be demonstrated that this action will not create an increased hazard or nuisance for any other property include:

- raise ground level
- onsite structural intervention to prevent flood water entry, contain location of, or divert flood waters away from the site including:

    - diversion bunds or walls; and
    - protected preferential drainage flow paths
- offsite structural intervention to reduce site flood hazard exposure by provision of additional works or infrastructure elsewhere including:
    - diversion bunds or walls;
    - protected preferential drainage flow paths; and
    - floodwater detention.

Options for reducing inundation hazards to buildings (in addition to the above):
- alternative building site within a property;
- raising floor height;
- foundation and building design (to allow for future building relocation or raising of the floor height); and
- maintaining required freeboard between ground and/or flooding level and floor levels by avoiding landscaping works or other site developments that may compromise the function of secondary flow paths, flood storage and building freeboard.

Technologies that support these options include:
- Adjustable screw piled houses
- Floating houses as used in New Orleans and Holland
- Flexible, waterproof service connections
- Manual or automatic flood barriers
- Pressure sewer systems with elevated control systems.
- Overhead or off grid power supply

8 Further Information and Guidance

For further information or guidance on how to determine minimum ground and/or floor levels for subdivision, new buildings, and major alterations, please contact the relevant Council as detailed below.

Nelson City Council	**Tasman District Council**
Civic House	Richmond Office
110 Trafalgar Street	189 Queen Street
Nelson	Richmond
Phone: 03 546 0200	Phone: 03 543 8400
Email: enquiry@Nelson City Council.govt.nz	Email: info@tasman.govt.nz

9 Appendices

Appendix 1: **Previous vertical datum**
Appendix 2: **References**

Appendix 1: Superseded vertical datums

Nelson City Council Datum	Nelson City Council Datum (12.07 m below NVD-55)
NVD-55	Nelson Vertical Datum 1955 **Conversions:** NVD-55 = +2.24m CD (source: NIWA, 2015 and LINZ, 2016) NVD-55 = -0.337m NZVD2016 at Nelson Port Sea Level gauge (source: LINZ, 2016) NZVD2016 = +2.577m CD (source: LINZ, 2016)

Appendix 2: References

LINZ, 2016	New Zealand Vertical Datum 2016, Land Information New Zealand, July 2016
MfE July 2008(1)	Coastal Hazard and Climate Change: A Guidance Manual for Local Government in New Zealand, Ministry for the Environment, July 2008:
MfE July 2008(2)	Preparing for Climate Change; A guide for Local Government in New Zealand, Ministry for the Environment, July 2008.
MfE March 2009	Preparing for Coastal Change - A guide for Local Government in New Zealand, Ministry for the Environment, March 2009.
MfE, 2017	Coastal Hazards and Climate Change, Guidance for Local Government, Ministry for the Environment, December 2017
NIWA 2009	Review of Nelson City minimum ground level requirements in relation to coastal inundation and sea-level rise, NIWA, August 2009
NIWA 2012	Combined wave and storm tide hazard for southern Tasman Bay, NIWA, July 2012
NIWA 2013	MHWS-6 Report for Tasman District Council, NIWA 2013
NIWA 2013 (2)	MHWS levels including sea-level rise scenarios, Envirolink Small Advice Grant (1437-NLCC80), NIWA, November 2013.
NIWA 2014(1)	Extreme Sea Level Elevations from Storm Tides and Waves Tasman and Golden Bay Coastlines, NIWA, 2014
NIWA 2014 (2)	Synthesis of information from several NIWA studies on high-tide, storm-tide and wave setup and run up along the Nelson City Coastline, Letter report for NELSON CITY COUNCIL dated 21 July 2014
NIWA 2015	Climate Variability and Change – Tasman District, August 2015, Chappel et al.
NIWA 2015 (2)	Nelson extreme storm tide plus wave setup and runup, NIWA, November 2015