Designation Notice of Requirement

Geotechnical and Coastal Assessments

PREPARED FOR NELSON AIRPORT LIMITED | September 2022

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Revision Schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1	24.09.21	Draft report for client comment	Roy Ching Ryan Abrey	Andy Mott Andrew Craig		
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3	19.08.22	Revised Report for RESA's and sea level rise	Roy Ching Ryan Abrey	Andy Mott Andrew Craig	Andy Mott	Alison Knowles
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6	08.03.23	MCA Addendum added as Appendix B	Andy Mott	James Newton	James Newton	Alison Knowles

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Executive Summary

This report presents the results of a high-level desktop assessment to determine the key geotechnical constraints and baseline coastal processes that would impact the construction of a runway extension to allow a take-off length of 1510m at Nelson Airport. The primary purpose of this assessment is to accompany Nelson Airport Limited's (NAL) Notice of Requirement for designation(s) in relation to Nelson City Council's comprehensive review of its operative Unitary Plan. This assessment was executed by evaluating publicly available, NAL supplied, and Stantec geotechnical and coastal information.

This assessment has examined the two runway extension options supplied by NAL. The northern extension option would construct the runway into the adjacent golf course land; the southern extension option would bridge across Jenkins Stream to NAL land on the Monaco peninsula and extend into the Waimea Inlet on reclaimed land.

As indicated in the assessment, the northern extension option into Nelson Golf Course has fewer geotechnical and coastal constraints compared to the southern runway extension option.

From a geotechnical perspective, the ground conditions to the north of the runway are more favourable compared to the south, with reduced risk of settlement, less ground improvements required, reduced design and construction complexity and overall reduced cost. The northern extension option has no impacts on coastal processes as it would be set back from predicted coastal erosion shoreline. Regarding urban flood risk, only minor works for the diversion or canalization of Maire Stream would be required.

The southern option would require the construction of a bridge over Jenkins Stream and a rock revetment perimeter with a reclaimed land platform into Waimea Inlet. This option would add significant cost and complexity in terms of the design and construction in an ecologically sensitive environment. Ground conditions in the stream and estuary are likely to be poor and require costly remedial works. From a coastal perspective, there may be some minor effects to adjacent shorelines in the Waimea Inlet through tidal erosion and wave reflection, especially under future sea-level rise scenarios. In terms of urban flood risk, the design of the canalization of Jenkins Stream would need to consider upstream flooding. There could be an opportunity to protect the inner city from coastal flooding by incorporating gates into the bridge.

This Executive Summary should be read in conjunction with the main body of the assessment for the reader to fully understand the basis for the information presented in this assessment.

Subsequent to issuing of this report a Multi Criteria Analysis (MCA) of the two runway extension options has been undertaken and added as an appendix addendum. Further details are provided in Section 7 of the report.

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Abbreviations

Enter Abbreviation	Enter Full Name
AEP	Annual Exceedance Probability
m BGL	Metres below ground level
IL	Importance Level
NAL	Nelson Airport Limited
NOR	Notice of Requirement
RESA	Runway End Safety Area
SLR	Sea Level Rise
SLS	Serviceability Limit State
ULS	Ultimate Limit State

1. Introduction

Stantec New Zealand (Stantec) has been commissioned by Nelson Airport Limited (NAL) in September 2021 to provide a preliminary geotechnical, geohazard and coastal assessment of effects of a runway extension for a Nelson Airport Notice of Requirement (NoR) proposal. After the initial analysis, Stantec communicated its high level options findings to Nelson Airport limited in November 2021, and subsequently prepared this report to accompany the Notice of Requirement documentation to be submitted to Nelson City Council.

The site location map showing the study area, Figure 1 and 2 below, show the two runway options. This is also included as Appendix A to this report. Runway infrastructure in Figure 1 showing the southern extension option has been estimated by Stantec based on discussions with NAL, while Figure 2 has been provided by NAL.

This preliminary assessment has been carried out to document likely differences in geotechnical and coastal engineering constraints that may be encountered under each option. The assessment scope is outlined further in Section 1.1.

Figure 1: Southern runway extension and designation area

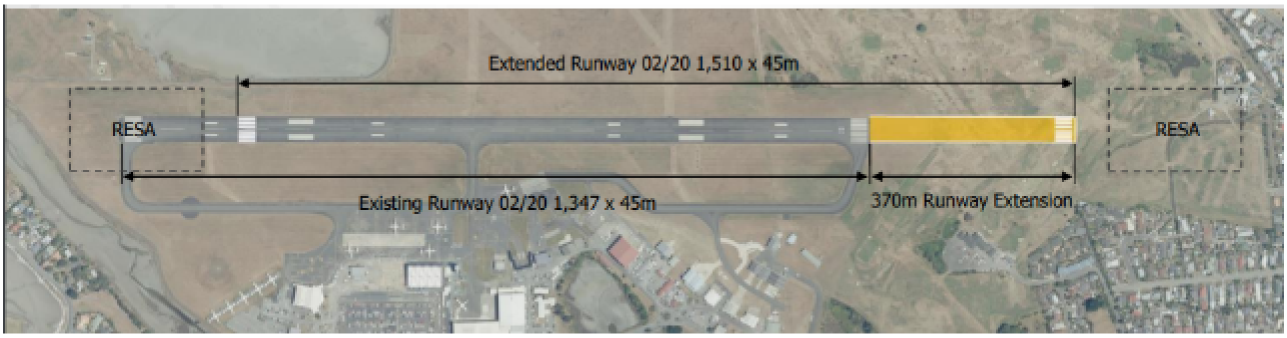

Figure 2: Northern runway extension and designation area (NAL, 2022).

1.1 Scope of Works

The scope of this report is to carry out a desk study and prepare a geotechnical and coastal assessment which will indicate the possible geotechnical and coastal engineering constraints that may influence the constructability and/or effects of the two runway extension options. The following tasks were undertaken:

- Desktop review of publicly available geotechnical and coastal information, client provided information and previous Stantec projects.
- Identify from the information obtained from the desk study, the geotechnical and coastal hazards for the runway extension options.
- Advise NAL on the impact that the geotechnical and coastal hazards may have on the proposed runway extension options.

At the completion of a consideration of the alternative sites, routes and methods by Nelson Airport Limited and its advisers, Stantec has also been tasked with providing recommendations based on the effects management hierarchy to avoid, minimise, remedy or mitigate adverse effects of the preferred option. Those matters will be contained in a separate report.

2. Geotechnical Assessment

2.1 Regional Geology

The published geology for the site (Figure 3) is taken from the Nelson Urban Geology map, 1:25,000 Scale (Johnston 1979). The site encompasses three geological units, described in Table 1. Recent geological maps such as the GNS Geology of the Nelson area (Rattenbury, Cooper and Johnston 1998) and Revised Geological Map of the Nelson-Richmond Urban Area (Johnston, Ghisetti and Wopereis 2021) show similar geological units and are mapped at much smaller scales.

Table 1: Mapped Urban Geological Units Intersecting Current NAL Site and Runway Extension Options (Johnston 1979).

Unit Code (Johnston 1979)	Unit Code (GNS 1998)	Unit Name	Lithology	Age
xd	Qan	Reclaimed Land	Reclaimed land – hard and domestic fill.	Recent
qt	Q1d	Tahunanui Sand	Sand forming beach ridges and dunes, local estuarine and swamp deposits.	Quaternary
qt/qr	Q1b	Tahunanui Sand overlying Rabbit Island Gravel	Sand with pebbles, cobbles, and boulders. GNS QMAP description: Beach deposits consisting of gravel with sand and mud, and boulder banks.	Quaternary

Figure 3: Mapped geology of the Nelson Airport site and greater Tahunanui area (Johnston 1979)

2.1.1 Natural Hazards

The following Nelson City Council and Nelson Tasman Civil Defence hazard maps were reviewed in the geotechnical assessment:

- Fault hazard Map: site is not listed on Fault Hazard Corridor
- Liquefaction Map: see section 2.1.4
- Slope instability: not applicable to either southern or northern runway extension.

2.1.2 Active Faults

The Geological and Nuclear Science (GNS) active faults database shows three active faults mapped within 15km of the NAL site. Details of the faults are found in Table 2.

Table 2: GNS Active f\Faults Near the NAL Site

Fault Name	Distance to Site (km)	Fault Sense	Recurrence Interval	Last Event	Slip Rate	Single Event Displacement
Bishopdale Fault	2.7	Dextral	Unknown	Unknown	Low	Unknown
Waimea Fault	4.2	Reverse	IV (>5,000 to <= 10,000 years)	Holocene	Low	Minor
Eighty-Eight Fault	4.5	Reverse	III (>3,500 to <= 5,000 years)	Unknown	Low	Unknown

2.1.3 Tahunanui Fault

The Tahunanui Fault is a recently added NE-SW striking reverse fault that is concealed beneath the Quaternary Tahunanui sediments. The fault shows no recent activity and has been inferred from the superposition of the older Magazine Point Formation (ja) above the Moutere Gravels (tm) (Johnston, Ghisetti and Wopereis 2021).

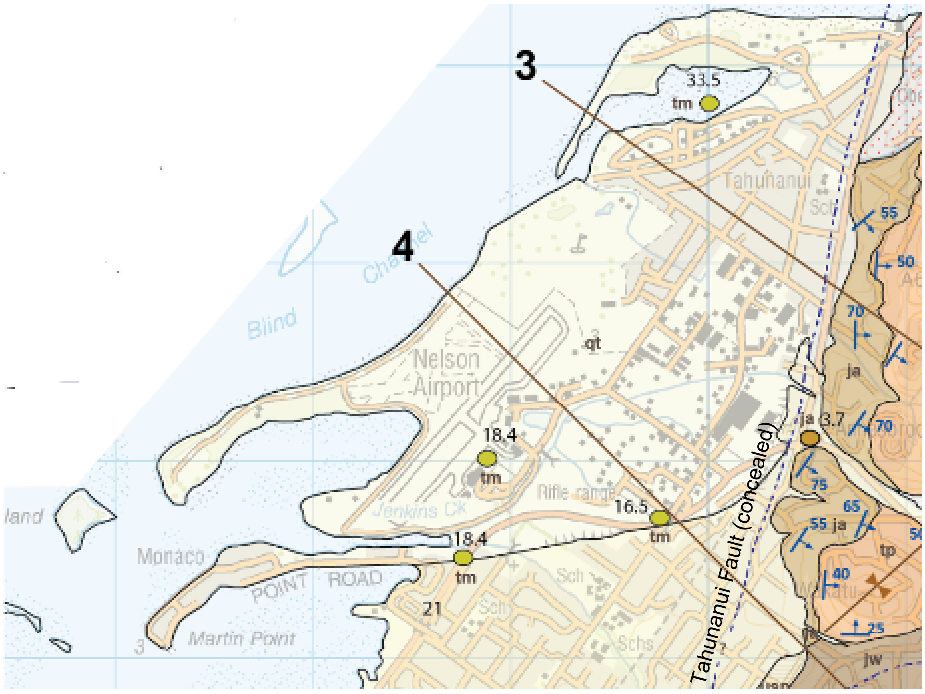

Figure 4: The concealed Tahunanui Fault trace (Johnston, Ghisetti and Wopereis 2021)

2.1.4 Liquefaction

Liquefaction occurs when loose sandy or silty soils below the groundwater table lose their strength and stiffness in response to an applied cyclic force, such as during an earthquake. The Tonkin and Taylor 2013 report has identified several effects from liquefaction for the whole Tahunanui Liquefaction Risk study area, which are listed in the bullet points below. Figure 5 shows the NAL site and the extent of the Tahunanui Liquefaction Risk study area. Nelson City Council has identified this area as being the liquefaction risk overlay in the Council hazard maps. Note that liquefaction can occur outside of the study area.

Figure 5: Extent of the Tonkin and Taylor 2013 Liquefaction study area (yellow) and the NAL site (red).

The Tonkin and Taylor 2013 Tahunanui area liquefaction assessment has been determined using limit state design loads, based on Site Subsoil Class and building Importance Levels from the relevant standard, NZS1170.5 Structural Design Actions. Note that the Tonkin and Taylor 2013 report has used an importance level 2 (IL2) in their calculation for peak ground accelerations and the airport runway is likely to be a higher importance level meaning the reported liquefaction effects are likely to be conservative compared to IL3 and IL4 earthquake loads. This report has classified liquefication effects based on the SLS and ULS loading requirements.

- Serviceability Limit State (SLS): This represents a level of stress or strain within the building below which there is a high expectation the building can continue to be used as originally intended without repair. Consequently, the limiting level of stress or strain defined for this limit state is low.
- Ultimate Limit State (ULS): Design for the ULS represents a defined process that is aimed at ensuring the probability of collapse of a building (and therefore the risk to human life) is at an acceptable level. The ULS process is therefore primarily associated with consideration of large (severe), relatively rare events.

A summary of the potential effects on the structures associated with a runway extension are shown in Table 3 below.

Table 3: Summary of Potential Consequences from Liquefaction at the NAL Site Under SLS and ULS Conditions (modified from T&T 2013 and CGW 2016)

Effects	Consequences	
	Serviceability Limit State (SLS) conditions	Ultimate Limit State (ULS) conditions
Sand Boils	Localised	Widespread
Buoyancy and uplift of buried pipes and manholes	Unlikely	Likely where pipes or manholes are below the groundwater level.
Bearing failure of shallow foundations and associated subsidence	Localised	Widespread
Free-field settlement of ground surface	Minor	Widespread and significant (up to 290mm)
Lateral spreading	Minor	Significant, can occur up to 300m from free faces

2.2 Ground Conditions

2.2.1 General

The following ground investigation data has been collated to determine the anticipated ground conditions underlying the runway extension areas. The following data sources have been used in this assessment:

- Published geological maps
- New Zealand Geotechnical Database (NZGD)
- Previous Stantec Investigations
- Client supplied data: CGW Preliminary Geotechnical Investigation & Pile Design Report (2016)
- Other publicly available geotechnical reports for the Tahunanui area, notably:
  - Tonkin and Taylor 2013 and 2014 Tahunanui Liquefaction Assessments
  - An Assessment of Areas of Lower Risk of Potential Settlement due to Seismic-induced Ground Shaking, Tahunanui, Nelson City (Johnston 2017)

Within 500m of the northern and southern extension options there are a total of 19 machine drilled boreholes and 30 Cone Penetration Tests (CPT) that have been used in this geotechnical assessment.

Figure 6: Publicly available and client provided geotechnical information reviewed in the geotechnical assessment.

2.2.2 Topography and Landforms

The current airport site is flat to gently sloping, with the elevations ranging from 3.5m at the northernmost point of the runway to 2.5m at the southernmost point of the runway. The ground surface generally slopes towards the estuary west of the runway. The natural ground surface has been significantly altered by earthworks and reclamation. The original ground surface would be comparable to the current dune fields found at the Nelson Golf Course. The beach ridges have continuously been eroded from the migration of the Blind Channel, particularly since the 1870’s when the channel moved to its current position.

The northern option extent of the runway would extend into the sand dunes of Nelson Golf Course. The dune fields vary in elevation from 1-9m above mean sea level. These irregular shaped dunes overlie relic north-west trending beach ridges formed from the northern migration of the Tahunanui shoreline from Monaco to the current shoreline position, since the end of the last glaciation circa 7000 years before present (Johnston 2017).

The southern runway option would extend into the estuarine area of Jenkins Stream, through the Point Road on the Monaco peninsula and into the Waimea Inlet. The Jenkins Stream and Waimea Inlet estuarine environments are locally tidal and/or swampy and are at depths up to 0.3m below MSL.

2.2.3 Subsurface Geology

A summary of the currently available geotechnical data:

- The mapped geology, Figure 3, shows the northern option and the land-based part of the southern option to be located on Tahunanui Sand (qt).
- The southern option extends into the Jenkins Stream estuarine area.
- The current runway is located on Tahunanui Sand (qt) and reclamation fill (xd) around the terminal and across to Aerodrome Point. The qt geological unit typically comprises marine deposits including loose sandy and silty sediments. Some localised gravels may be present. The reclamation fill is likely to be dominantly or entirely Tahunanui Sand material (Johnston 2017).
- There are localised fan gravels deposited at the mouth of Jenkins Stream, derived from the abandoned sea cliff.
- The site is underlain by the Moutere Gravels (tm) at depths of 18.4m at the current terminal location (Johnston, Ghisetti and Wopereis 2021)

Assessment of available land-based information indicates the northern and southern options are likely to have similar ground conditions and engineering properties. However, the southern option crosses tidal mud flats and although there is no information regarding these deposits in this report, experience of working in similar environments indicates soft to very soft cohesive soils are likely to be present.

2.2.4 Groundwater

Groundwater levels have been recorded at numerous locations near the NAL site. The Tahunanui Liquefaction report encountered groundwater between depths of 0.7m bgl and 2.3m bgl (T&T 2013). The CGW Terminal preliminary report 2017 recorded groundwater between 1.44m bgl. and 1.50m bgl. Groundwater levels throughout the site and Tahunanui area are generally level and tidally influenced, typically follow the topography of the land and fall to the north-west (Johnston 2017).

2.3 Historic Imagery

A review of oblique and historic imagery available from the Nelson Museum archive and Retrolens has shown the evolution of land use throughout the establishment of the Nelson township. Figure 7 shows the extent of the estuary that was reclaimed prior to the opening of Nelson Airport in 1937. Figure 8 shows the Nelson Airport development, similar in extent compared to its present-day extent, except for the northern section.

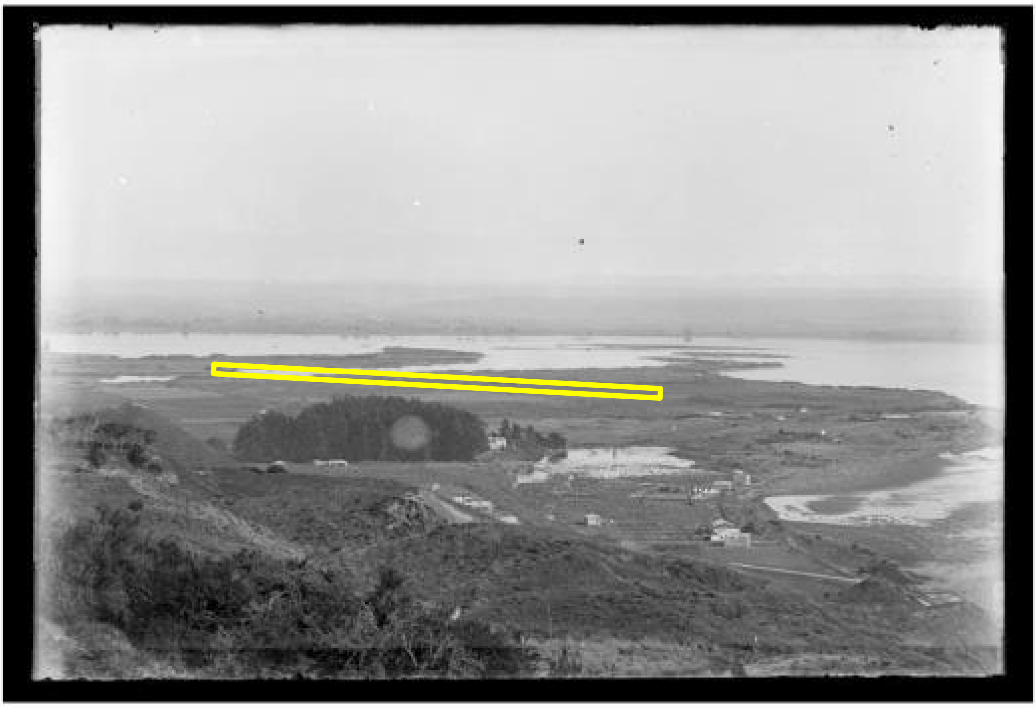

Figure 7: Oblique view of Tahunanui looking from the Tahunanui hillside. Approximate runway location shown in yellow. Photo taken between 1902 and 1908. (Tahunanui from hillside. Nelson Provincial Museum, Kerr Collection: 317300).

Figure 8: Aerial photograph of Nelson Airport from 1948 (Retrolens).

3. Geotechnical Comparison of the Runway Extension Options

A high-level qualitative assessment comparing the two runway extension options has been undertaken in Table 4 with additional comment provided in sections 3.1.1 to 3.1.8.

Table 4: Qualitative Runway Extension Option Assessment

Assessment Factor	Extension Option		Relevant Section Heading
	Southern Extension	Northern Extension	
Ground conditions	Poor	Average	3.1.1
Settlement	High	Low to moderate	3.1.2
Liquefaction and seismicity	Significant	Significant	3.1.3
Ground improvement	High	Low to moderate	3.1.4
Level of investigation and design	High	Low to moderate	3.1.5
Construction complexity	High	Low to medium	3.1.6
Other natural hazards	Low to moderate	Low	3.1.7
HAIL sites	None identified	Small area in far northern extent	3.1.8

3.1 Ground conditions

The southern option is likely to have poorer ground conditions relative to the northern option due to the likely presence of soft estuarine soils in Jenkins Stream and the Waimea Inlet. The thickness of these estuarine soils is unknown due to there being no geotechnical information. These soils are likely to be problematic for investigation, design and construction of a southern runway extension are likely torequire complex and costly geotechnical solutions. Elsewhere the northern and southern option appear to have similar ground conditions and engineering properties. Groundwater is shallow and is tidally influenced near the shoreline.

3.2 Settlement

Soft estuarine soils along the southern option are likely to be susceptible to settlement requiring significant ground improvement and earthworks. The northern option will require significantly less engineering to manage the effects of settlement.

3.3 Liquefaction and seismicity

Nelson airport is in an area of high seismicity although there are no known active faults crossing either of the options. The northern extension option extends into the Tahunanui Liquefaction Study area (Tonkin and Taylor 2013), the effects of which have been quantified in their report. The southern extension extends out of the study area however the extent and severity of liquefaction is likely to be of a similar nature. This can only be confirmed with geotechnical site investigations. The northern extension is likely to experience the liquefaction-based effects listed in section 2.1.4.

Lateral spreading potential is likely to be more significant for the southern option due to the proximity of free faces (ie slopes).

3.4 Ground improvement

Based on available ground investigation information, published geology and previous experience working with similar soils and environments, ground improvement is likely to be required for both the northern and southern extension options. However, the level of ground improvement for the southern option is likely to be significantly more extensive due to the presence of estuarine deposits. The level of ground improvements for development will largely be dependent on the importance level assigned through design.

3.5 Level of investigation and design

The southern option is significantly more complex and would require a higher level of investigation and design than the northern option due to the estuary and Jenkins Stream.

3.6 Construction complexity

The southern extension would include a high level of construction complexity due to working in a tidal estuarine environment with likely soft soils prone to settlement and likely requiring significant ground improvement. Jenkins Stream would require culverting under the runway extension or diverting to the south into Waimea inlet. Furthermore, Point Road (between Jenkins Stream and Waimea Inlet) would require diverting around, or tunneled under, the end of the proposed runway infrastructure. These options would be both costly and time consuming to construct. The northern extent would not have similar restrictions.

3.7 Other natural hazards

Both options are located within the Civil Defence Tsunami Evacuation Zones and although the southern option is currently shown to be at a higher tsunami risk compared with the norther option due to ground level. Following construction and raising ground level for a southern option the tsunami risk is likely to be similar for both options. The slope instability hazard is not applicable to either northern or southern extension option.

3.8 HAIL sites

The northern extent extends into two HAIL sites: 10894 and 10087. The extent of the possible contamination at these sites is unknown and would require further investigation. Figures 9 and 10 show the extent of the HAIL sites around Tahunanui and the proposed northern extension.

Figure 9: Locations of HAIL sites on the Nelson City Council HAIL database (Nelson City Council 2021).

Figure 10: Nelson HAIL sites and extent of the northern runway extension option.

4. Coastal Assessment

4.1 Background

Of the two options considered for the extension of the Nelson Airport runway, the southern extension extends into the Waimea Inlet which is the largest semi-enclosed estuary in the South Island. The inlet is fed by the Waimea River, along with many smaller streams and stormwater outlets while being predominantly tidal with the large open channel out into the Tasman Bay. The extension would also cross over Jenkins Creek, which would need to be culverted under the extension or possibly diverted south under Point Road through a shorter culvert or bridge.

The northern extension into the golf course is well set back from the shoreline and does not encroach directly on any coastal or intertidal areas.

Figure 11: Area Overview.

4.2 Coastal Processes

The coastal form in the vicinity of Nelson Airport is strongly influenced by its position on the eastern side of the throat section of Waimea Inlet. The astronomical tidal range is just over 4m, which is relatively large by NZ standards. The tide is therefore capable of moving fine sediment to form or change sandbanks outside and within Waimea Inlet. The prevailing directions for stronger winds are from the north or south-west, discussed below. Due to the mountain ranges around Tasman Bay and inland, the prevailing wind strengths at Nelson Airport are much weaker than more exposed locations such as the Cook Strait or Wellington Airport.

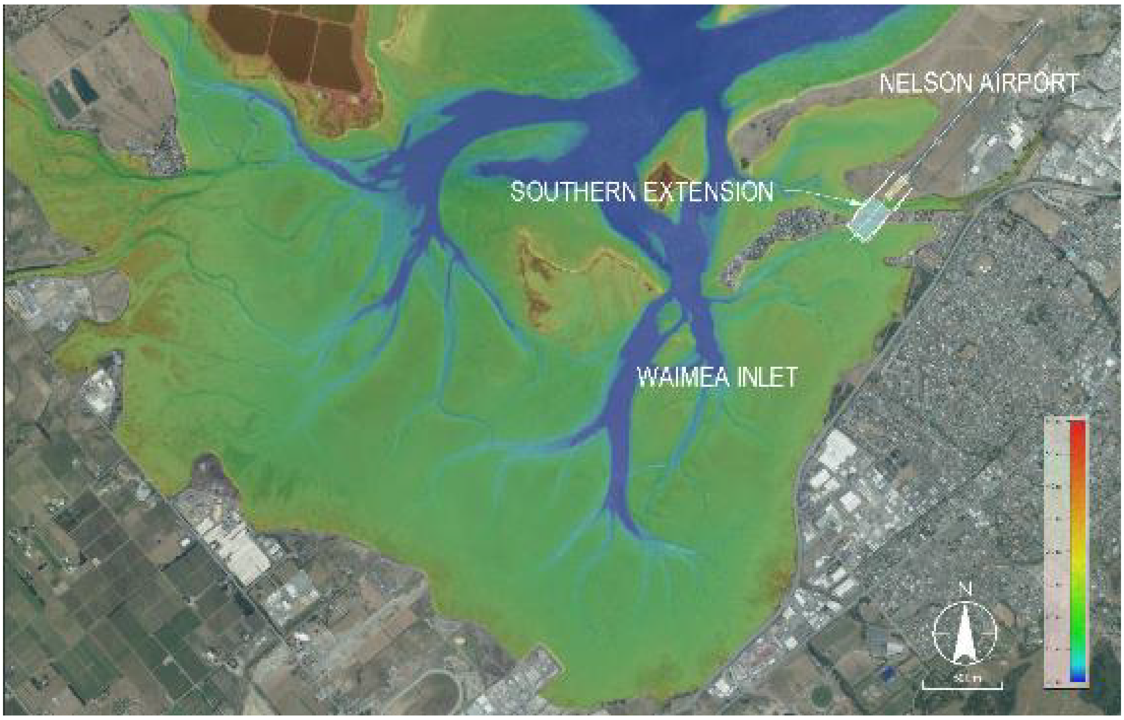

Figure 12: Waimea Inlet Bathy with average (LINZ, 2015).

The northern shoreline of the Waimea Inlet is highly modified with rock seawall already running adjacent to Point Road at the proposed location of the southern extension. This length of rock seawall is considered a low stressor to the overall Waimea Estuary, (Wriggle Coastal Management Limited, 2012). It should also be noted that Point Road is currently the only access way to the residential area of Monaco and alternate access would need to be provided should the proposed southern runway extension fall along the existing roadway. There is a service road for the airport lights, next to point road, which could prove a temporary access solution during construction. Another diversion would be required should Jenkins Creek be diverted under the road prior to construction of the runway, see Figure 21, however the old riverbed could allow for space to construct the future access tunnel.

Figure 13: Northern shoreline of Waimea Inlet along Point Road (Google, 2021).

There is a relatively deep tidal channel in front of Point Road, as seen in Figure 14, which also takes stormwater from a small culvert near the beach. This channel would naturally be redirected around the south-western end of the reclamation and the modified currents would possibly need to be assessed for increased erosion further along Point Road. The wave armoring system selected for the reclamation structure may benefit from a permeable surface structure and/or a shallow slope to minimise refraction of wind-driven waves.

Figure 14: Bathy in bay adjacent to Port Road (LINZ, 2015).

Swell and more local wind generated waves from the north can both arrive with some energy at Tahunanui Beach north of the airport, giving this area a higher erosion potential and more dynamic nature. However, this northerly wave energy is rapidly dissipated through the sandbanks and narrower throat of the inlet, with minimal penetration of long period waves into the inlet.

Table 5: Astronomical Tide Levels at Port Nelson (Tonkin + Taylor, 2020).

Heading	CD (m)	NZVD 2016 (m)
Highest Astronomical Tide (HAT)	**4.76**	**2.1**
Mean High Water Springs (MHWS)	**4.32**	**1.75**
6% Mean High Water Springs (MHWS-6)	**4.29**	**1.72**
Mean High Water Neaps (MHWN)	**3.29**	**0.72**
Mean Sea Level (MSL)	**2.34**	**-0.23**
Mean Low Water Neaps (MHWN)	**1.39**	**-1.18**
Mean Low Water Springs (MHWS)	**0.44**	**-2.13**
Lowest Astronomical Tide	**0.07**	**-2.5**

Currents within the Tasman Bay are driven by high tidal flows with similar tidal elevations experienced as Golden Bay where currents have measured at 0.15 - 0.30cm/sec (Harris 1990), these stronger currents may not penetrate into the estuary which would be flushed predominately by the tidal ebb and flow. Currents have been measured in the main channel off Bell Island with speeds of 90cm/sec during peak spring tides. This can further increase with river flood flows to a current speed approaching 150cm/sec under La Niña conditions (MetOcean Solutions Ltd, 2017).

Wind generated waves in south-westerly winds are limited by the fetch and relatively shallow depths over the sandbanks toward the Monaco peninsula. The fetch length from the southern Waimea bank to the southern extension location is somewhat approximately 3km which could theoretically generate a significant wave height (H_s) of 1.5m along with a wave set-up of 0.25m, however the shallow depth may limit this to a H_s of 1.1m (Tonkin + Taylor, 2020).

The sediment regime on Tahunanui Beach and in Waimea Inlet are noted to consist of firm sand and soft mud, (Wriggle Coastal Management Limited, 2012). Nearby cores taken on the intertidal flats between Headingly Lane and Saxton Island found the top 100mm having a D_{50} of 76 µm and D_{90} of 187 µm with the entire core consisting predominantly of fine sand (D < 250 µm) with a large portion being made up of silt (D < 63 µm), (Wriggle Coastal Management Ltd, 2011). In the intertidal areas of the inlet, some patches of mixed grade gravel are present, due to wind waves stirring up the finer material which can then be transported in suspension to deeper water where it may settle or be washed out to sea depending on tidal currents.

The northern extension is well set back from the anticipated erosion zone which in the worst case is shown as the green line in left of Figure 15 and corresponds to the 2130 RCP 8.5 H+ condition. The southern runway extension would need to consider any anticipated erosion as it is crossing over the shoreline and extending out into the estuary.

The modifications to the shoreline profile would also need to be analyzed to ensure that erosion is not enhanced at a nearby location due to wave reflection or focusing.

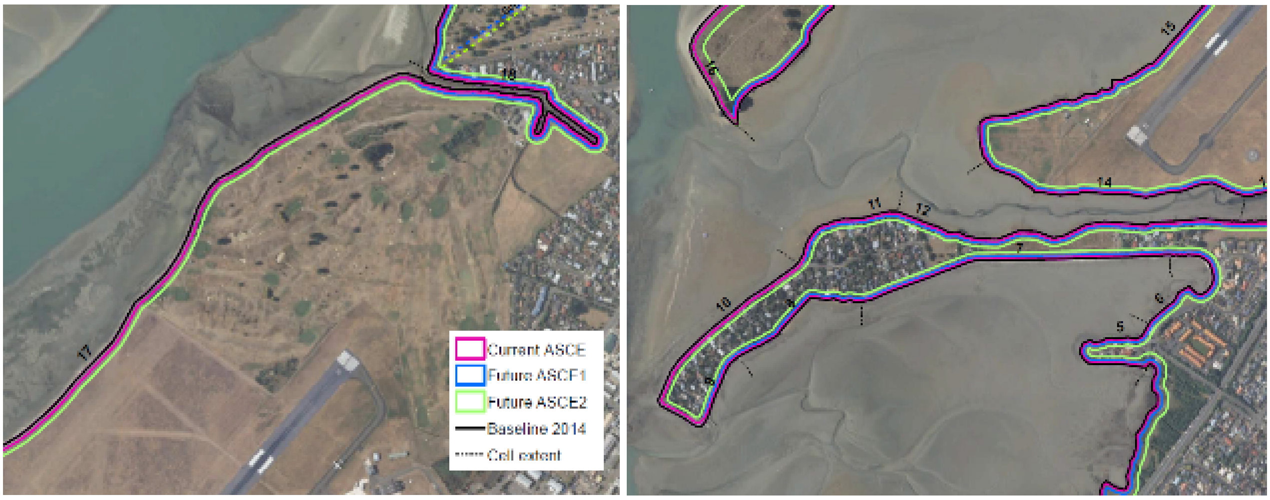

Figure 15: Coastal Erosion surrounding the Airport area (Tonkin & Taylor, 2020).

Sea level rise due to climate change over the next 30 years to 2050 is expected to be between 0.1m to 0.4m (depending on RCP/SSP scenario) relative to 2020 levels, (MfE, 2017). However, the guidance recommends for short-lived non-habitable assets a minimum of 0.65 m sea-level rise is allowed for, and for new major infrastructure the 100-year extreme scenario (RCP 8.5 H+, blue line in Figure 16) should be considered at least in terms of hazard or resilience. The NZ Searise Project has released a map illustrating the combined effect of SLR and Vertical Land Movement (VLM) which has increased the anticipated increase in water level approximately a further 100mm (see Figure 16) however this is anticipated to still be below the 0.5m considered by the Council’s Coastal Inundation Maps (Figure 18). For comparing the runway extension designation options (northern and southern), the comparison will focus on the period to 2050. One effect of SLR would be the deeper waters within the Waimea Inlet allowing for more fully fetch limited waves to develop within the bay increasing erosion.

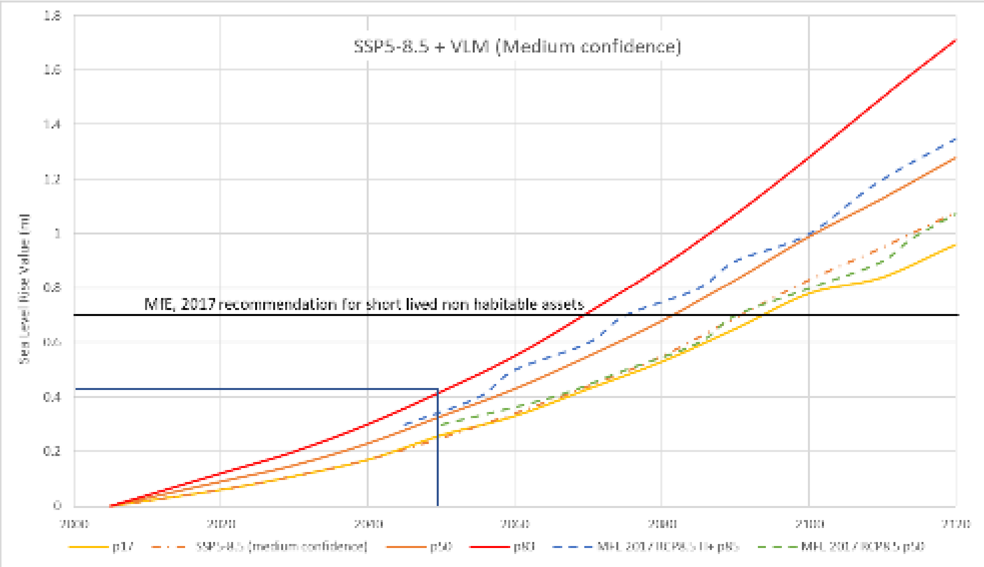

Figure 16: NZ Searise Project Revised SLR

The coastal inundation maps provided on the Councils website, show that for present day conditions, there is inundation up Jenkins River during a 6% MHWS tide which extends onto the airport land with the 1% AEP (annual exceedance probability) storm-tide, see Figure 18 below. With sea level rise this inundation extends further back into the city centre along with the airport land flooding on a regular basis with the 6% MHWS tide, as seen in Figure 18. There is a potential opportunity to include some coastal flooding protection by incorporating gates into the culvert over the Jenkins Creek which can be closed during storm surge events and hold back the sea. This potential opportunity would need to be considered in the context of Nelson City Council long term strategy, as it is beyond the scope of this desktop assessment.

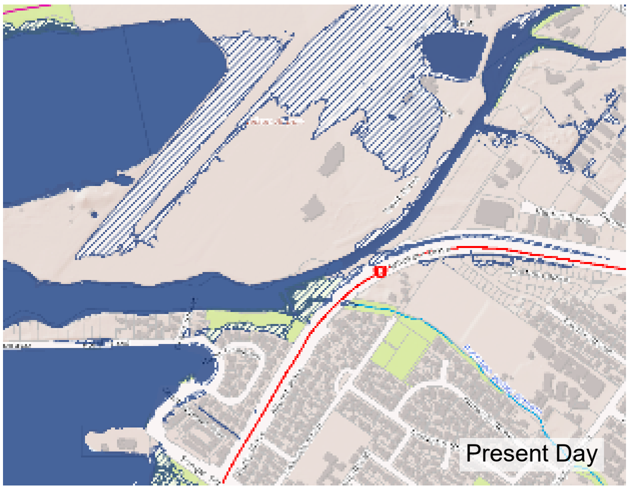

Figure 17: Coastal Inundation Maps at MHWS-6 with 1% AEP Storm Tide (Nelson District Council, 2021).

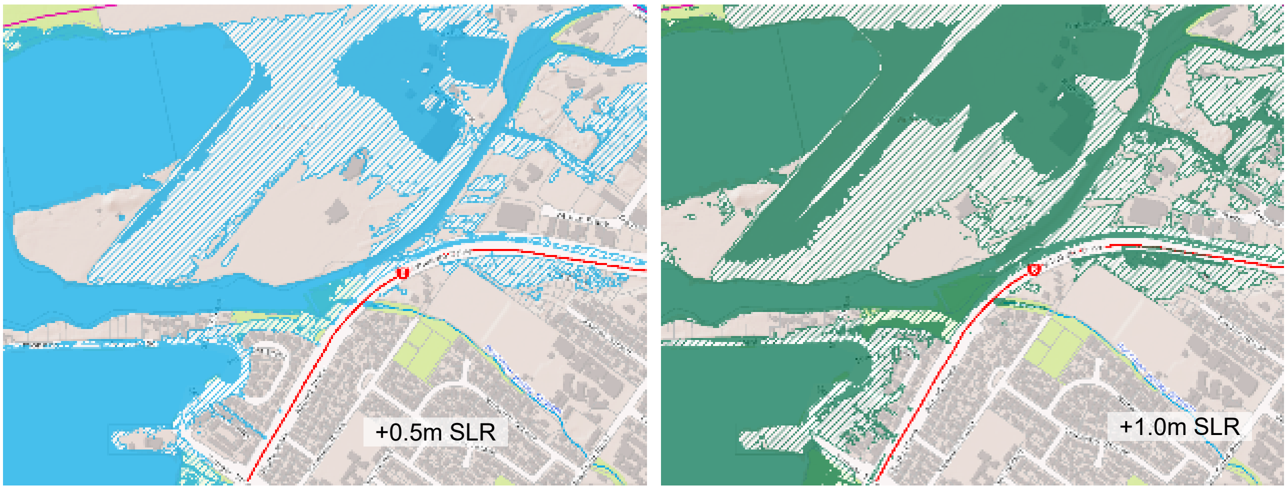

Figure 18: Coastal Inundation Maps at MHWS-6 with 1% AEP Storm Tide and SLR (Nelson District Council, 2021).

4.3 Hydrological Context

Jenkins Creek and Poorman Valley Stream discharge into Waimea Inlet just north of Monaco peninsula, (relevant to southern extension option only). The catchment size (Figure 19), land use and sediment loads, proximity of urban areas means the creek is likely to be very sensitive to any tide locking or reduction in peak conveyance capacity during floods.

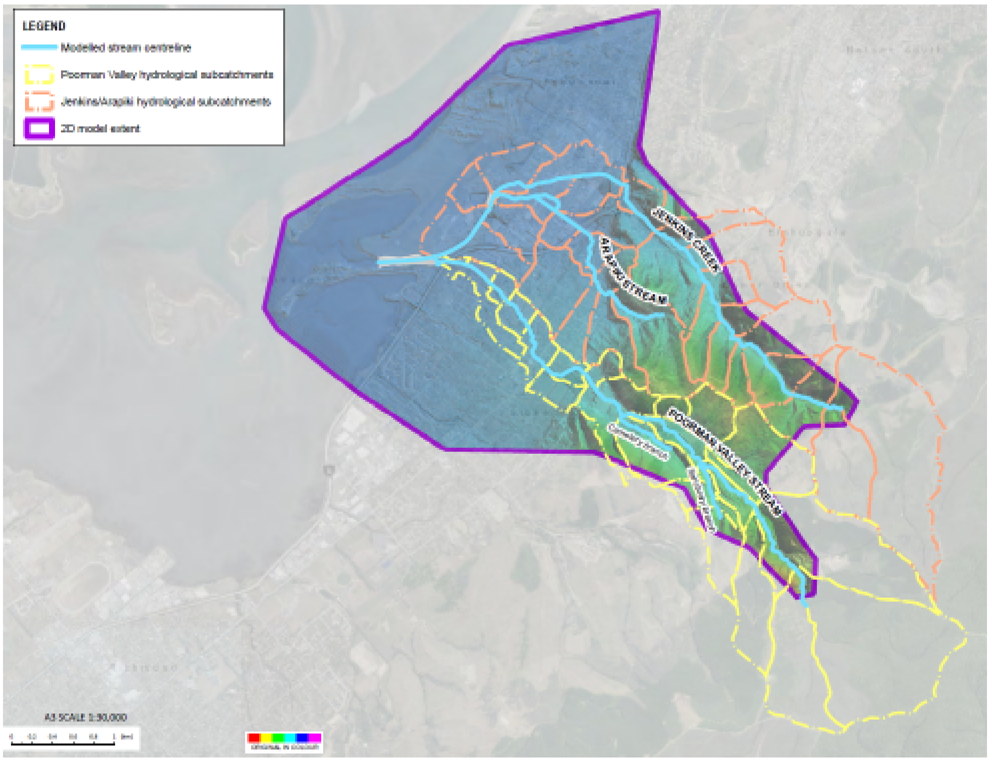

Figure 19: Jenkins/Arapiki/Poorman Valley Flood Model Extents (Tonkin & Taylor, 2021).

There is currently some flooding under the present day 1% AEP event, as seen in Figure 20 below, which increases to the airport area when climate change is accounted for. This could be exacerbated should the channel at the end of the runway be constrained by the extension.

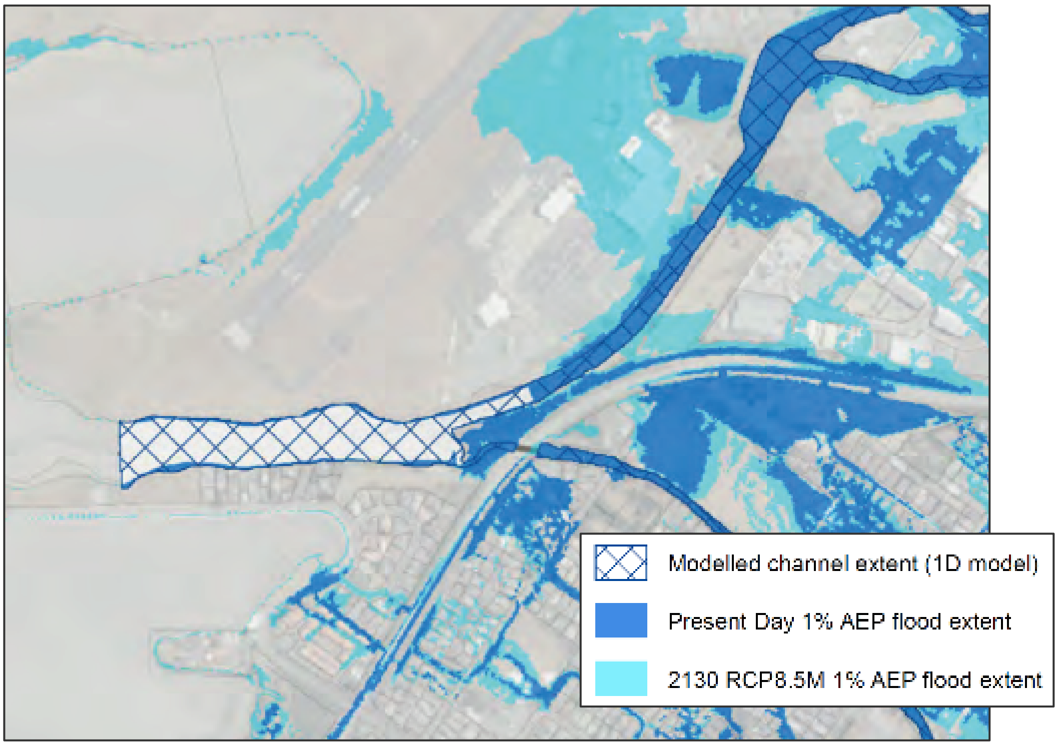

Figure 20: Jenkins/Arapiki Flood Map (Tonkin & Taylor, 2021).

As noted above, there is a potential opportunity to divert the Jenkins Creek under Point Road that could be considered. This may allow for easier construction of the runway without requiring a long substantial tunnel. This would have a minor influence on the bathymetry in this corner of the Waimea Inlet and this would need to be checked as noted in the previous section.

Figure 21: Jenkins Creek potential diversion.

5. Coastal Comparison of Runway Extension Options

Table 6 below, provides a summary of the coastal challenges and opportunities for the northern and southern extension options.

Table 6: Option Comparison Summary

Aspect	Northern Extension	Southern Extension
Option description	Extending the runway northwards into adjacent golf course land.	Extending runway southwards over Jenkins Creek and Monaco Peninsula with a ±3.6Ha reclamation into the Waimea Inlet.
Technical challenges and risks.	Would require the canalization or diversion of the Maire Stream and Maire Stream Tributary drainage ditch.	Ground investigations to inform design will be complex to complete in the estuary areas with significant cost. Ground conditions are prone to liquefaction and would require large scale remedial measures. Remedial measures are likely to have significant cost if designed to IL3 or IL4 requirements. Constructability of the proposed runway embankment will be complex and require the excavation of estuary material, disposal of spoil material and importation of fill. The runway would block access to the Monaco Peninsula and hence a tunnel would be required. The Jenkins Creek would need to be culverted, either under the runway or under Point Road. A reclaimed section would need to be constructed into the Waimea Estuary.
Effect on coastal processes.	None to note, the runway is well set back from the predicted shoreline erosion and does not encroach into existing coastline.	There is likely less than minor effects on the coastal processes as the area is already highly modified and artificially protected with rock revetments, however the effect on adjacent shorelines would need to be assessed, especially with future SLR scenarios which may allow for larger wind waves to develop within the estuary.
Effect on urban flood risk (hydrological)	None to note due to proximity to potential outlet locations (Jenkins Creek and/or the small creek between the golf course and Parkers Road. Treatment of runoff from paved areas to be considered prior to discharge.	The canalization of Jenkins Creek would be needed to avoid or minimise constriction or increase in flooding upstream. Possible wider opportunity to reduce coastal flooding by including flood gates into the design.
Consenting challenges and risks	Less complex from an RMA perspective.	More complex from an RMA perspective. Even though the impacts are expected to be minor or possibly less than minor, there are more residents on Monaco Peninsula impacted by the construction and long-term access changes, river diversion and/or culverting, plus minor changes to bathymetry in the Waimea Inlet.

6. Recommendations/Conclusions

Considering the aspects discussed above it is evident that of the two runway extension options, the extension to the North is preferable over the southern option extending into the Waimea Inlet. This is due to the following:

- The technical challenges to construct the southern runway extension into the Waimea Inlet are more complex than the northern extension option. The southern option would have significant construction and operational effects, require significantly more earthworks and time to construct than a northern option.
- Even though the Maire Stream will be required to run through a culvert, this is of a magnitude smaller than that required to run Jenkins Creek under the runway or to divert it elsewhere.
- The northern extension option has no effect on coastal processes and minimal effect on urban flood risk.
- The northern extension option will be much less complex to gain consent under RMA.

7. Multi Criteria Analysis (Addendum)

Following completion of this report Stantec undertook a high-level engineering economic assessment of the two runway extension options and a Multi Criteria Analysis (MCA). The MCA is presented in this report as Appendix B.

8. References

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9. Limitations

This report has been prepared for Nelson Airport Limited in accordance with the generally accepted practices and standards in use at the time it was prepared. Stantec accepts no liability to any third party who relies on this report. The information contained in this report is accurate to the best of our knowledge at the time of issue. Stantec has made no independent verification of this information beyond the agreed scope set out in the report.

The interpretations as to the likely subsurface conditions contained in this report are based on the information obtained from desk study. Stantec accepts no liability for any unknown or adverse ground conditions that would have been identified had ground investigations, sampling, and testing been undertaken.

Actual ground conditions encountered may vary from the predicted subsurface conditions. For example, subsurface groundwater conditions often change seasonally and over time. No warranty is expressed or implied that the actual conditions encountered will conform to the conditions described herein.

Where conditions encountered at the site differ from those inferred in this report Stantec should be notified of such changes and should be given an opportunity to review the report recommendations made in this report in light of any further information.

Appendices

We design with community in mind

Appendix A Site Location Plan

Southern runway extension and designation area with current planning zones

Northern runway extension and designation area with current planning zones

Appendix B Multi Criteria Analysis

Attachment B –MCA

Options Assessment Scoring

For the purposes of inputting into the overall Multi-Analysis Criteria (MCA), a rating has been applied to each criterion using a scoring system of +3 (significant positive effect) to 0 (neutral / change) to -3 (significant adverse effect) (refer to **Table 1** below).

Table 1

Effects / Outcome criteria	Scoring
Significant adverse effect / substantial negative effect on the project outcome	-3
Moderate / Major adverse effect	-2
Minor adverse effect	-1
Neutral / no change	0
Minor positive effect	1
Moderate / Major positive effect	2
Significant positive effect / achievement of project outcome.	3

Geohazard Criteria	Option A – Northern Extension Option		Option B – Southern Extension Option	
Ground Conditions	1	Soils likely to largely consist of well draining dune sands.	-2	The southern option is likely to have poorer ground conditions relative to the northern option due to the likely presence of soft estuarine soils in Jenkins Creek and the Waimea Inlet. The thickness of these estuarine soils is unknown due to there being no ground investigation information. These soils are likely to be challenging for investigation, design and construction of a southern runway extension, as well as being likely to require complex and costly geotechnical solutions.
Settlement	1	Settlement effects are anticipated to be low to moderate for the northern option.	-3	Soft estuarine soils along the southern option will be susceptible to settlement requiring significant ground improvement and earthworks.
Liquefaction and seismicity.	-2	Nelson airport is in an area of high seismicity although there are no known active faults under the site. The northern extension option extends into the Tahunanui Liquefaction Study area (Tonkin and Taylor 2013), the effects of which have been quantified in their report	-2	Nelson airport is in an area of high seismicity although there are no known active faults under the site. The southern extension extends out of the study area however the extent and severity of liquefaction is likely to be of a similar nature.

Ground Improvement	0	Limited ground improvement may be required if soils are loose or soft.	-3	The level of ground improvement for the southern option is likely to be significantly more extensive due to the presence of estuarine deposits.
Level of Investigation and Design	1	Likely straightforward investigation and design	-3	The southern option is significantly more complex and would require a higher level of investigation and design than the northern option due to Waimea inlet and Jenkins Creek. These impacts will then require extensive consenting and environmental studies especially in relation to modifications to Jenkins Stream (for example in relation to flood capacity and potential impacts on the Waimea inlet.)
Construction complexity.	0	Some earthworks cut and fill required including diversion of a drainage channel around the outside of the northern RESA.	-3	The southern extension would include a high level of construction complexity due to working in a tidal estuarine environment with likely soft soils prone to settlement requiring significant ground improvement. Jenkins Creek is assumed to be diverted through Point Road into Waimea inlet (adjacent to the southern RESA) which would require significant earthworks, possibly ground improvement, and a bridge under Point Road. This option would be both costly and time consuming to construct especially as marine construction requires specialised equipment.
Other Natural Hazards	-1	The northern option is within the Civil Defence Tsunami Evacuation Zone	-2	Although both options are located within the Civil Defence Tsunami Evacuation Zones, slope instability and lateral spreading risk exists for the southern option realigned Jenkins Inlet and RESA.
HAIL Sites	-1	Small area to the far northern extent. The northern extent extends into two HAIL sites: 10894 and 10087	0	None identified.

Geocoastal Processes Criteria	Option A – Northern Extension Option		Option B – Southern Extension Option	
Effects on Coastal Processes	0	Runway well setback from predicted shoreline erosion.	-1	Area already highly modified and contains revetments.
Effects on Urban Flood Risk	0	None to note. Stormwater treatment of runoff.	-2	Canalization of Jenkins Creek will require extensive bridging or diversion in order to minimise flooding upstream.

In summary, the Geotechnical and Geohazard Options assessment identifies that the northern extension option is the more feasible and preferable in terms of the matters identified. This includes the substantial technical challenges present in constructing the southern runway extension into the Jenkins Creek and Waimea inlet, including the extent of investigative works and associated construction and operational effects associated with the southern extension option.

While the Maire Stream (northern option) will be required to be diverted, this is of a magnitude smaller than that required to divert Jenkins Creek elsewhere as would be associated with the southern option.

The northern option also has no effect on coastal processes and minimal effect on urban flood risk.

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