Artifact Jervois Ltd
8A Glenside Crescent
Eden Terrace
Auckland 1011

Attention: Mr Liam Joyce

Dear Sir

GEOTECHNICAL INVESTIGATION
PROPOSED APARTMENT BUILDING
113 JERVOIS ROAD, HERNE BAY

1.0 Introduction

Riley Consultants Ltd (RILEY) has been engaged by Artifact Jervois Ltd (Artifact Jervois) to provide engineering services for a proposed apartment block development at the above site. This report presents the results of field investigations, together with comments and general recommendations regarding the satisfactory development of the site. It is intended that this report will provide consideration of geotechnical effects to support the application for a resource consent to Auckland Council (Council).

2.0 Background

2.1 Project Description

The site (Lot 4 DP 3989) is located on the northern side of Jervois Road. It is bounded by residential properties to the north (4B Hamilton Road), east (139 Jervois Road) and west (111 Jervois Road). Dwellings on the neighbouring properties are located between approximately 1.5m and 6m from the common boundaries with the site. The site generally comprises gentle slopes (approximately 4°) towards the north-west. The southern and central portions of the site are currently occupied by a timber framed residential dwelling, while a detached garage is positioned in the north-eastern corner of the property.

The concept design drawings prepared by Monk Mackenzie Ltd (Dwgs: RC020-RC024, RC031-033, and RC040-041) indicate that it is proposed to remove the existing structures, and replace them with a multi-storey building. The new building will incorporate a split-level basement car park (B1, B2, and B3), with ground floor for retail/residential purposes and five levels of residential units on the upper floors.

Excavations up to approximately 3.5m depth (including excavations to subgrade) below existing ground surface are proposed to form the split-level basement. Excavations in the southern portion of the site are up to approximately 3.5m depth, and are up to approximately 2.0m depth adjacent to the northern boundary. The B1 floor level is proposed to be at RL 40.8m, the B2 floor level at RL 39.6m, and the B3 floor level at RL 38.2m. The proposed basement area covers the full extent of the property (i.e. boundary to boundary), with access to the basement from Jervois Road. A draft plan for the basement levels provided by Monk Mackenzie Ltd is attached (Dwg: RC-040).
2.2 Geotechnical Setting

Published geological information indicates that the site is underlain by weathered soil and weak rock of the East Coast Bays Formation (ECBF). This material is described as alternating layers of muddy sandstone and mudstone with occasional interbedded grit lenses. These materials weather to form residual soils consisting of silt, clay, and sand. The presence of these materials was confirmed on-site by the subsurface investigation.

2.3 Review of Property Files

As part of the geotechnical investigation, we have reviewed the Council property files for the site and 4B Hamilton Road. No existing available geotechnical information was obtained from the property files. It appears that the existing structures on both properties are lightweight timber-framed and founded on shallow-type foundations.

3.0 Site Investigation

3.1 Geotechnical Field Investigation

A limited geotechnical investigation was carried out at the site on 19 May 2017 to assess the subsurface conditions. The field investigation consisted of two hand auger boreholes (HA1 and HA2) drilled to a maximum depth of 5m. HA1 is located in the south-eastern corner of the site, whilst HA2 is positioned in the north-western corner of the property. The test locations are shown on attached RILEY Dwg: 170292-1 (Note: no geotechnical field testing has been carried out within the footprint of the existing dwelling on-site due to access restrictions).

Hand-held shear vane (soil strength) testing was undertaken at 0.5m intervals in the cohesive soils encountered. Scala penetrometer (Scala) testing was carried out at the base of both hand auger boreholes to investigate the depths to hard/dense material.

On completion of drilling, standpipe piezometers (with bentonite and cement installed up to 0.5m depth below ground level) 5m long were installed within both HA1 and HA2 to facilitate groundwater level monitoring.

3.2 Subsurface Conditions

Results of all strength tests, together with detailed descriptions of strata encountered during drilling are shown on the attached borehole logs. A summary of the subsurface conditions encountered in the boreholes is presented below:

- Fill was encountered up to approximately 0.7m below the ground level during the field testing. The fill consisted of silt, with varying amounts of gravel, clay, and organic matter. This fill is inferred to be non-engineered. Shear strengths measured within the fill layer were typically of firm consistency (44kPa to 50kPa).
- Beneath the non-engineered fill, residually to completely weathered ECBF soils comprising silt and clay, with varying amounts of sand were encountered extending to the base of both holes. Shear strengths encountered during the investigation were typically of very stiff (101kPa to 177kPa) consistency. A slightly weaker zone of soil strength, of stiff consistency between 62kPa and 69kPa, was identified at 5m and 3m depths in HA1 and HA2, respectively. These horizons of stiff soils were approximately 0.5m thick.
Scala testing reached effective refusal (more than three consecutive blow counts of ten or above per 50mm of penetration) at approximately 5.8m to 5.9m depths below the ground surface in HA1 and HA2, indicating the presence of hard/dense materials.

Groundwater was encountered at 2.3m depth in the front portion of the property in HA1 and at 1m depth in HA2 located downslope near the rear of the property on completion of drilling. The soils above the water levels were generally noted to be wet.

Monitoring of the investigation piezometers has been undertaken following their installation. A summary of the measured groundwater levels is presented in Table 1.

Table 1: Summary of Measured Groundwater Levels

<table>
<thead>
<tr>
<th>Date of Measurement</th>
<th>HA1 (m)</th>
<th>HA2 (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Level - Depth Below Ground</td>
<td>Groundwater Level (RL m)</td>
<td>Groundwater Level - Depth Below Ground (m)</td>
</tr>
<tr>
<td>19 May 2017</td>
<td>2.3</td>
<td>39.7</td>
</tr>
<tr>
<td>26 May 2017</td>
<td>2.7</td>
<td>39.3</td>
</tr>
<tr>
<td>4 July 2017</td>
<td>2.6</td>
<td>39.4</td>
</tr>
</tbody>
</table>

Note: Reduced levels for HA1 and HA2 are inferred to be at approximately 42m and 40.2m based on topography information provided by Artifact Jervois.

5.0 Geotechnical Considerations

5.1 General

The following geotechnical issues have been considered with this report:

- Groundwater assessment.
- Seismic design parameters.
- Overall ground stability.
- Concept design/recommendations of basement excavations/construction and walls.
- Preliminary foundation recommendations.

5.2 Groundwater Assessment

The proposed floor levels of B1, B2, and B3 are at RL 40.8m, RL 39.6m, and RL 38.2m, respectively. We have assumed the excavated basement subgrade would be up to approximately 0.5m depth below the B2 and B3 finished floor levels (refer to the attached Monk Mackenzie Ltd plan for elevations/layout of the basement). Therefore, the proposed basement excavations would be up to approximately 1.2m below the winter groundwater table, based on the currently limited available groundwater records.

We consider that the summer groundwater levels will almost certainly be greater than 1.2m depth below the existing measured winter levels. Thus, the ‘draw-down’ of groundwater due to basement excavation is likely to be within the range of seasonal groundwater table fluctuation. The potential adverse effects to the neighbouring properties (including Jervois Road) due to basement excavation induced groundwater drawdown are therefore considered negligible.
Note: Groundwater drawdown induced settlement typically occurs most significantly within normally consolidated soils when groundwater has been lowered more than its typical seasonal fluctuation. The decrease of groundwater table below the seasonal fluctuation range would reduce the buoyancy force, and thus, increase the effective stress acting on soil layers beneath the groundwater table. Ground settlement would then occur. The encountered ECBF materials on-site are inferred to be over consolidated soils. This means they are less prone to settlement.

If the proposed basement excavation is to be undertaken during winter months, the base of excavation is likely to be up to 1.2m depth below the winter high groundwater level. As discussed above, this is not considered a critical situation as the potential groundwater ‘draw-down’ would be within the seasonal fluctuation. Therefore, it is unlikely to cause potential adverse effects to the neighbours. Some groundwater seepage inflow should be anticipated during excavation in winter, and pumping of free water would be required. Based on the measured groundwater level, we are of the opinion that a detailed Burland type of assessment is not required.

5.3 Planning Rules

As part of the geotechnical investigation, we have reviewed applicable rules contained within the Auckland Unitary Plan - Operative in part (AUP-Op) as they relate to geotechnical and groundwater aspects of the proposed development. This is shown in Table 2 below.

**Table 2: Auckland Unitary Plan Operative in Part (November 2016), Chapter E – Auckland Wide, Part 7 Taking, using, Damming and Diversion of Water and Drilling**

<table>
<thead>
<tr>
<th>Rule</th>
<th>Activity</th>
<th>Applicability to this Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table E7.4.1 Activity Table.</td>
<td>Take and use of groundwater. (A20) Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed.</td>
<td>Restricted discretionary activity</td>
</tr>
<tr>
<td></td>
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<td>The proposal does not comply with Standard E7.6.1.6.</td>
</tr>
<tr>
<td>Table E7.4.1 Activity Table.</td>
<td>Diversion of groundwater. (A28) The diversion of groundwater caused by any excavation (including trench), or tunnel that does not meet the permitted activity standards or not otherwise listed.</td>
<td>Restricted discretionary activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The proposed excavation will not comply with Standard E7.6.1.10 (5)</td>
</tr>
<tr>
<td>E7.6.1.6</td>
<td>Dewatering or groundwater level control associated with a groundwater diversion permitted under Standard E7.6.1.10, all of the following must be met – Permitted Activities:</td>
<td>Does not comply:</td>
</tr>
<tr>
<td></td>
<td>(1) The water take must not be geothermal water;</td>
<td>(2) and (3) – there will be permanent water take during winter months due to diversion into retaining wall and basement slab drainage.</td>
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<td>(2) the water take must not be for a period of more than ten days where it occurs in peat soils, or 30 days in other types of soil or rock; and</td>
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<td>(3) the water take must only occur during construction.</td>
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<td>Rule</td>
<td>Activity</td>
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| E7.6.1.10.(1) | Diversion of groundwater caused by any excavation (including trench) or tunnel - Permitted Activities. | All of the following activities are exempt from the Standards E7.6.1.10(2) – (6):  
(a) Pipes, cables, or tunnels including associated structures which are drilled or thrust and are less than 1.2m in external diameter;  
(b) pipes including associated structures up to 1.5m in external diameter where a closed faced or earth pressure balanced machine is used;  
(c) piles up to 1.5m in external diameter are exempt from these standards;  
(d) diversions for no longer than ten days; or  
(e) diversions for network utilities and road network linear trenching activities that are progressively opened, closed, and stabilised where the part of the trench that is open at any given time is no longer than ten days. | Does not apply:  
The proposal does not involve any of the activities that are exempt from the Standards E7.6.1.10(2) – (6). |
| E7.6.1.10.(2) | Any excavation that extends below natural groundwater level, must not exceed:  
(a) 1ha in total area; and  
(b) 6m depth below the natural ground level. | Complies:  
Excavations will not exceed 507m² in area and 3.5m (approx.) in depth. |
<p>| E7.6.1.10.(3) | The natural groundwater level must not be reduced by more than 2m on the boundary of the adjoining site. | Complies |</p>
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<th>Rule</th>
<th>Activity</th>
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</table>
| E7.6.1.10.(4) | Any structure, excluding sheet piling that remains in place for no more than 30 days, that physically impedes the flow of groundwater through the site must not:  
(a) Impede the flow of groundwater over a length of more than 20m; and  
(b) extend more than 2m below the natural groundwater level. | Complies:  
The proposed basement will not extend more than 2m below the natural groundwater level. |
| E7.6.1.10.(5) | The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site from the edge of any:  
(a) trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation;  
(b) tunnel or pipe with an external diameter of 0.2m to 1.5m that extends below natural groundwater level must be 2m or greater; or  
(c) a tunnel or pipe with an external diameter of up to 0.2m that extends below natural groundwater level has no separation requirement. | Complies - Summer:  
The basement excavation will be above the summer groundwater table, and will not extend below the natural groundwater levels.  
Does Not Comply – Winter:  
The basement excavation will be deeper than separation to the neighbour’s structure. |
| E7.6.1.10.(6) | The distance from the edge of any excavation that extends below natural groundwater level, must not be less than:  
(a) 50m from the Wetland Management Areas Overlay;  
(b) 10m from a scheduled Historic Heritage Overlay; or  
(c) 10m from a lawful groundwater take. | Complies:  
The excavation edge is in excess of 50m from any wetland management overlays, and is in excess of 10m from any scheduled historic heritage overlays and lawful groundwater take. |
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| E7.8.1.(6)(a) | Matters of Discretion – Diversion of groundwater - Restricted discretionary activity. | (i) N/A  
(ii) N/A  
(iii) N/A  
(iv) there are no known existing lawful groundwater takes and diversions in the vicinity of the site.  
(v) No adverse effects.  
(vi) Potential differential ground settlement on neighbouring sites is considered unlikely as the proposed excavation is above the summer groundwater table, and there will be no adverse effects due to groundwater drawdown.  
(vii) The proposal will not increase the risk of flooding on the site.  
(viii) There are currently no known buildings in proximity to the site with basement excavations. No cumulative effects are anticipated to occur.  
(ix) Sediment laden discharges will be addressed.  
(x) N/A  
(xi) N/A |
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<td>E7.8.1.(6)(c)</td>
<td>Monitoring and reporting requirements incorporating, but not limited to:</td>
<td>Further groundwater monitoring, via existing and future monitoring wells is recommended to</td>
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<td>(i) The measurement and recording of water levels and pressures.</td>
<td>be carried out at this site.</td>
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<td>(ii) The measurement and recording of the settlement of the ground</td>
<td>A groundwater and settlement monitoring layout plan could be provided to Council on</td>
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<td>buildings, structures, and services.</td>
<td>request.</td>
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<td>(iii) The measurement and recording of the movement and any retaining</td>
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<td>walls constructed as part of the excavation or trench.</td>
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<td>(iv) Requiring the repair, as soon as practicable and at the cost of the</td>
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<td>consent holder, of any distress to buildings, structures, or services</td>
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<td>caused by the groundwater diversion.</td>
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<td>request.</td>
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<td>E7.8.1.(6)(d)</td>
<td>The duration of the consent and the timing and nature of reviews of</td>
<td>A 35-year consent duration is sought.</td>
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<td>consent conditions.</td>
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<td>E7.8.1.(6)(e)</td>
<td>The requirement for and conditions of a financial contribution and/or</td>
<td>N/A</td>
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<tr>
<td></td>
<td>bond.</td>
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<td>E7.8.1.(6)(f)</td>
<td>The requirement for a monitoring and contingency plan or contingency</td>
<td>This plan will be developed if required.</td>
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<td>and remedial action plan.</td>
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<tr>
<td>E7.8.2.(10)(a)</td>
<td>Assessment Criteria: Groundwater diversion proposal - Restricted</td>
<td>The proposal will not cause drawdown of groundwater, and will allow for the appropriate</td>
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<td></td>
<td>discretionary activity.</td>
<td>management of groundwater after construction is completed. The proposal will avoid any</td>
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<td>adverse effects on scheduled historic heritage places and people and communities.</td>
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<td>adverse effects on scheduled historic heritage places and people and communities.</td>
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<tr>
<td>E7.8.2.(10)(b)</td>
<td>The groundwater diversion does not cause or exacerbate any flooding</td>
<td>The proposed development will not cause or exacerbate any flooding.</td>
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<td>Rule</td>
<td>Activity</td>
<td>Applicability to this Site</td>
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<td>E7.8.2.(10)(c)</td>
<td>Monitoring has been incorporated where appropriate, including:</td>
<td>Monitoring of groundwater levels will be continued. Refer Section 5.4 in this report.</td>
</tr>
<tr>
<td></td>
<td>(i) Measurement and recording of water levels and pressures.</td>
<td></td>
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<tr>
<td></td>
<td>(ii) Measurement and recording of the movement of ground,</td>
<td></td>
</tr>
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<td></td>
<td>buildings, and other structures.</td>
<td></td>
</tr>
<tr>
<td>E7.8.2.(10)(d)</td>
<td>Mitigation has been incorporated where appropriate including:</td>
<td>The potential adverse effects to the neighbouring properties due to the water take during winter months are considered unlikely. This is because the water take is within the range of seasonal groundwater fluctuation as discussed above.</td>
</tr>
<tr>
<td></td>
<td>(i) Minimising the period where the excavation is open/unsealed.</td>
<td>The following mitigation measures may be implemented in the specific design stage of the retaining walls:</td>
</tr>
<tr>
<td></td>
<td>(ii) Use of low permeability perimeter walls and floors.</td>
<td>• Adopt a 'top-down-construction' methodology.</td>
</tr>
<tr>
<td></td>
<td>(iii) Use of temporary and permanent systems to retain the excavation.</td>
<td>• Minimising the period where the excavation is open/unsealed.</td>
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<tr>
<td></td>
<td>(iv) Re-injection of water to maintain groundwater pressures.</td>
<td>• Use of temporary and permanent systems to retain the excavation.</td>
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<td>• Develop a detailed construction/ excavation methodology at the time of building consent.</td>
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26 July 2017
Riley Consultants Ltd
5.4 Further Groundwater Monitoring

- Our assessment is based on a small monitoring data set over a limited timeframe in winter. We recommend regular monitoring of existing standpipe piezometers around the site prior to construction to assess seasonal range including the summer low groundwater levels.

- We recommend that further monitoring wells be installed, particularly within the existing building footprint (once the existing dwelling is demolished) to provide additional groundwater data and increase the overall understanding of the groundwater profile across the site.

Monitoring monthly may be required for three months following construction to confirm that groundwater has not been significantly altered by the construction of the basement. This should be assessed and confirmed at a later stage.

5.5 Seismic Design

Site investigations show that the site is underlain by cohesive soils and weathered rock of the ECBF. Based on its strength and consistency, and our experience with these materials, the underlying soils are considered extremely unlikely to liquefy in a design level earthquake.

For the design of structural and foundation elements of the proposed building, the site subsoil category should be taken as Class C – Shallow Soil in terms of NZS 1170.5:2004.

5.6 Overall Ground Stability

On-site observations indicate no obvious evidence of past instability, erosion, or creep at the site. In addition, the site is gently sloping and the development will incorporate a retained basement, and hence, global instability affecting the proposed development is considered unlikely.

5.7 Basement Excavation and Wall Construction

The concept drawings provided indicate that the basement will be constructed immediately adjacent to the neighbouring properties and Jervois Road. Excavations in the southern portion of the site are up to approximately 3.5m depth, and are up to approximately 2m depth adjacent to the northern boundary. Concept structural design of the basement is not available at the time of report preparation (i.e. whether the basements will be supported by ‘dry’ or ‘wet’ walls). In order to ensure that the basement excavation/construction will not adversely affect the neighbouring properties and Jervois Road, RILEY recommends the following:

- A top-down construction methodology is typically recommended for the perimeter basement walls to maintain present stability of the neighbouring properties and Jervois Road.

- If ‘wet’ walls are proposed, specifically designed semi-contiguous concrete retaining walls at approximately 2.5D spacing are recommended. Permanent capping beams and temporary propping/soil berms during construction should be considered to minimise wall deflection, hence, settlements on the neighbouring land. Detailed wall modelling (i.e. assessing passive forces on walls using the Wallap software programme), and structural design should be carried out at the building consent stage.

- A detailed/refined construction/excavation methodology should be developed between a selected wall contractor and the engineers at the time of building consent stage.
RILEY has also considered alternative basement construction methodologies consisting of battering and temporary retaining (i.e. timber pole sacrificial walls) as part of our assessment. Given the close proximity between the proposed basement excavation and the boundaries, batter is considered not practical. Sacrificial timber retaining walls are considered feasible; however, the following factors should be taken into account:

1. Propping of the sacrificial timber wall will likely be required given the proposed excavation height. The props could reduce embedment requirement and limit deflection; however, they could restrict access to the site for future construction.
2. Unfavourable forces (due to sacrificial timber wall deflection) could be generated, acting on the top of the permanent basement wall (i.e. basement tilt slabs). These unfavourable forces should be taken into account during design.
3. Further geotechnical inputs will be required to confirm the feasibility of this option.

Note: Sacrificial sheet piling was considered. Installation and removal of the sheet pile wall could be ‘problematic’ due to its vibration and noise. Therefore, this option is not recommended.

5.8 Preliminary Wall Design Inputs

Preliminary wall design parameters are presented below. This will need to be refined during detailed design stage (associated basement wall deflections), with RILEY providing input to the structural engineer.

1. \( \phi' = 25^\circ \) and \( \gamma = 18\text{KN/m}^3 \) for non-engineered fill behind the basement walls.
2. \( \phi' = 28^\circ \) and \( \gamma = 18\text{KN/m}^3 \) for completely weathered ECBF soils.
3. \( \phi' = 40^\circ \) and \( \gamma = 19\text{KN/m}^3 \) for ECBF rock.
4. A permanent surcharge loading (ULS) of 12kPa on the basement walls due to the close proximity of the boundaries. These loads will need to be reviewed and confirmed by the project structural engineer during the detailed design phase.
5. A temporary surcharge loading of 5kPa is considered suitable during construction where there is no traffic load above the walls (i.e. along the northern and eastern boundaries).
6. The neighbouring residential buildings at 4B Hamilton Road, 139 Jervois Road, and 111 Jervois Road appear to be lightweight timber-framed structures supported by shallow foundations. The existing dwelling at 111 Jervois Road is located approximately 1.5m from the proposed eastern boundary retaining wall. Therefore, a stringent preliminary target horizontal deflection of not greater than 8mm is required. A back analysis based on the Burland\(^1\) damage criteria indicates that this configuration of horizontal deflections (i.e. no greater than 8mm at top of walls) over the closest neighbouring structure (at 111 Jervois Road) falls into Category 1, ‘Very Slightly’. We note that the Burland criteria was primarily developed for brittle structures constructed from brick and concrete. Based on our previous experience, Category 1, ‘Very Slight’ is considered appropriate for timber framed structures.

We consider the northern, southern, and western basement retaining walls could accommodate a higher tolerance to deflections due to greater setback to existing structures/infrastructures (i.e. Jervois Road). It is recommended that such higher tolerance to deflections to be assessed and confirmed at the time of detailed design.

Based on findings of our geotechnical investigation, we consider that it is feasible to construct the proposed basement walls while ensuring that the effects on neighbouring site/public roads due to ground deformation comply with the requirements outlined above.

5.9 Foundation Requirements

We consider that the proposed apartment building should be generally supported on specifically designed pile foundations. Piles should found within the ECBF sandstone/siltstone, and founding depth should be confirmed at the time of detailed design. For preliminary pile foundation design calculations, a geotechnical ultimate (failure) end bearing capacity of 4.5MPa is recommended when founding at least four pile diameters into the ECBF rock. We consider that shaft adhesion should be ignored within residual soils at this stage.

The proposed basement excavation should remove all of the non-engineered fill material below the building platform. The B2 and B3 car park floors could be supported on the stiff to very stiff ECBF soils. Drainage is recommended under the floor slabs. For preliminary structural design of shallow foundations founded into stiff (i.e. Su greater than 50kPa) ECBF material, a geotechnical ultimate (failure) bearing capacity of 300kPa is considered available. At the time of subgrade preparation, inspection(s) should be undertaken to confirm the founding conditions.

It is recommended that RILEY reviews the finalised structural and architectural foundation drawings to ensure our recommendations have been adopted.

6.0 Further Geotechnical Inputs

At present, there is limited geotechnical information available from within the site of the proposed development. To complete specific design of the elements noted above in Section 5.0, further investigations are recommended to assess the strength and stiffness of founding materials and the groundwater profile across the site.

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Such further investigation works may involve deep machine boreholes (i.e. into rock) within footprint of the existing dwelling, associated laboratory testing, installation of additional piezometer(s), and further groundwater monitoring to assess seasonal range, including the summer low groundwater levels. We would recommend one to two machine boreholes up to 10m depth be drilled at detailed design stage. This will enable us to confirm depth/quality of the underlying ECBF rock and refine the design parameters for the foundation and retention system.

7.0 Conclusions and Recommendations

We summarise our conclusions and recommendations regarding the proposed development at 113 Jervois Road, Herne Bay as follows:

- The site is underlain by stiff to very stiff residually weathered soil of the ECBF.
- The proposed development will require excavation to up to approximately 3.5m depth below existing ground surface. We consider the proposed basement excavations will be above the assumed summer groundwater table. The potential adverse effects to the neighbouring properties from groundwater drawdown are, therefore, considered unlikely.
- In terms of NZS 1170.5 the site subsoil class is Category C – Shallow Soil.
- The risk of overall ground instability affecting the proposed development is considered low.
- We have reviewed applicable rules contained within the AUP-Op. Our comments are presented in Section 5.3.
- Top-down constructed reinforced concreted walls can provide sufficient stiffness to minimise ground deformation at the excavation boundaries. Specific design of the basement retaining wall will be required at the building consent stage to confirm structural details and the necessary construction sequence. Sacrificial timber retaining walls could be an alternative methodology with careful control to minimise wall deflections. Further geotechnical inputs will be required to confirm the feasibility of the sacrificial wall option.
- A detailed/refined construction/excavation methodology should be developed between a selected wall contractor and the engineers at the time of building consent stage.
- Bored reinforced concrete piles, embedded into the underlying ECBF rock are considered appropriate to support the proposed apartment building. Preliminary geotechnical ultimate bearing capacities and recommendations are outlined in this report. It is recommended that RILEY reviews the finalised structural and architectural foundation drawings to ensure our recommendations have been adopted.
- Further geotechnical investigation and groundwater monitoring are recommended.

8.0 Limitation

This report has been prepared solely for the benefit of Artifact Jervois Ltd as our client with respect to the brief and Auckland Council in processing the consent(s). The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties’ sole risk.
Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to Artifact Jervois Ltd and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

Yours faithfully

RILEY CONSULTANTS LTD

Prepared by: Nicole Li
Geotechnical Engineer, GIPENZ

Reviewed by: Simon Orgias
Engineering Geologist

Approved for issue by: Brett Black
Director, CPEng

Enc: Borehole logs
Plan of basement elevations by Monk Mackenzie Ltd
RILEY Dwgs: 170292-1 to -3
## Soil Types and Symbols

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill</td>
<td></td>
</tr>
<tr>
<td>Topsoil</td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td></td>
</tr>
<tr>
<td>Peat</td>
<td></td>
</tr>
<tr>
<td>Groundwater Level</td>
<td></td>
</tr>
<tr>
<td>Scala Penetrometer</td>
<td>Last 3 Number of Blows per 50mm Increment</td>
</tr>
</tbody>
</table>

## Rock Types and Symbols

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>Basalt</td>
<td></td>
</tr>
<tr>
<td>Silstone</td>
<td></td>
</tr>
<tr>
<td>Tuff</td>
<td></td>
</tr>
<tr>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>Ignimbrite</td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td></td>
</tr>
<tr>
<td>Greywacke</td>
<td></td>
</tr>
</tbody>
</table>

## Soil Strength Classification - Fine Grained Cohesive Soils

<table>
<thead>
<tr>
<th>Term</th>
<th>Field Identification</th>
<th>Undrained Shear Strength (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft (Vs)</td>
<td>Exudes between fingers when squeezed.</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Soft (S)</td>
<td>Easily indented by fingers.</td>
<td>12 - 25</td>
</tr>
<tr>
<td>Firm (F)</td>
<td>Indented only by strong finger pressure.</td>
<td>25 - 50</td>
</tr>
<tr>
<td>Stiff (St)</td>
<td>Indented by thumb pressure.</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Very Stiff (VSt)</td>
<td>Indented by thumbnail.</td>
<td>100 - 200</td>
</tr>
<tr>
<td>Hard (H)</td>
<td>Difficult to indent by thumbnail.</td>
<td>200+</td>
</tr>
</tbody>
</table>

## SPT & Scala Penetrometer Results

<table>
<thead>
<tr>
<th>Term</th>
<th>SPT Value</th>
<th>Scala Penetrometer No. of Blows/300mm</th>
<th>Scala Penetrometer No. of Blows/100mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very dense</td>
<td>&gt;50</td>
<td>17+</td>
<td></td>
</tr>
<tr>
<td>Dense</td>
<td>30 - 50</td>
<td>7 - 17</td>
<td></td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 - 30</td>
<td>3 - 7</td>
<td></td>
</tr>
<tr>
<td>Loose</td>
<td>4 - 10</td>
<td>1 - 3</td>
<td></td>
</tr>
<tr>
<td>Very Loose</td>
<td>0 - 4</td>
<td>0 - 2</td>
<td></td>
</tr>
</tbody>
</table>

## Rock Strength Classification

<table>
<thead>
<tr>
<th>Term</th>
<th>Field Identification</th>
<th>Unconfined Uniaxial Compressive Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Weak</td>
<td>(EW) Indented by thumbnail.</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Very Weak</td>
<td>(VW) Crumbles under firm blows with point of geological hammer. Can be peeled with pocket knife.</td>
<td>1 - 5</td>
</tr>
<tr>
<td>Weak</td>
<td>(W) Difficult to peel with pocket knife.</td>
<td>5 - 20</td>
</tr>
<tr>
<td>Moderately Strong</td>
<td>(MS) Cannot be scrapped or peeled with pocket knife.</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Strong</td>
<td>(S) More than one blow of geological hammer to fracture.</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Very Strong</td>
<td>(VS) Many blows of geological hammer to break.</td>
<td>100 - 250</td>
</tr>
<tr>
<td>Extremely Strong</td>
<td>(ES) Can only be chipped with geological hammer.</td>
<td>250+</td>
</tr>
</tbody>
</table>

## Moisture Condition

- **Dry (O)**: Looks and feels dry; powdery and friable.
- **Moist (M)**: Feels cool; darkened in colour; no free water when remoulded.
- **Wet (W)**: Feels cool; darkened in colour; free water forms on hands.
- **Saturated (S)**: Free water is present on sample.

## Sample Types

- **Undisturbed**
- **Machine Auger Disturbed**
- **Hand Auger Disturbed**
- **Standard Penetration Test (solid cone)**
- **Standard Penetration Test (hollow cone)**

## Drilling Method

- **OB**: Open Barrel
- **TT**: Triple Tube
- **WB**: Wash Bore
- **SH**: Undisturbed Shelby Tube
- **RC**: Rock Core
- **SPT**: Standard Penetration Test

## Field Tests

- **V**: Shear Vane (corrected to BS:1377)
- **R**: Remoulded Strength
- **P**: Pocket Penetrometer
- **CH**: Clegg Hammer

Information based on the NZ Geotechnical Society Inc. Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes.
### Geological Description

<table>
<thead>
<tr>
<th>Elevation (m)</th>
<th>Depth (m)</th>
<th>Geological Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>+42.00</td>
<td></td>
<td>Fill</td>
</tr>
<tr>
<td>+41.35</td>
<td>0.65</td>
<td>SILT, some gravel; dark brown. Stiff, non plastic [FILL]</td>
</tr>
<tr>
<td>+41.10</td>
<td>0.90</td>
<td>0.30 m - 0.40 m 100mm clayey pocket; light orange</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill</td>
</tr>
<tr>
<td>+41.10</td>
<td></td>
<td>SILT, minor clay, minor sand; light brownish orange with light grey and orange pockets. Very stiff, slightly plastic [EAST COAST BAYS FORMATION]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clayey SILT; light orange. Very stiff, moderately to highly plastic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.50 m Grades to mixed light grey and light orange; moderately plastic</td>
</tr>
<tr>
<td></td>
<td>2.00 m</td>
<td>Grades to some clay, trace sand</td>
</tr>
<tr>
<td></td>
<td>2.30 m</td>
<td>Grades to Clayey SILT; light grey with trace light orange staining</td>
</tr>
<tr>
<td></td>
<td>2.50 m</td>
<td>Grades to minor clay; slightly plastic</td>
</tr>
<tr>
<td></td>
<td>2.80 m</td>
<td>Grades to Silty CLAY; light orange; highly plastic</td>
</tr>
<tr>
<td></td>
<td>3.40 m</td>
<td>Grades to SILT, trace clay, trace sand; slightly plastic</td>
</tr>
<tr>
<td></td>
<td>3.60 m</td>
<td>Grades to minor sand</td>
</tr>
<tr>
<td></td>
<td>4.00 m</td>
<td>Grades to some sand</td>
</tr>
<tr>
<td>+37.10</td>
<td>4.90</td>
<td>Sandy SILT; medium grey. Stiff, slightly cohesive</td>
</tr>
<tr>
<td>+37.00</td>
<td>5.00</td>
<td>EOH @ 5.00 m</td>
</tr>
</tbody>
</table>

**Legend**

- M: 50 100 150 200
- W: 3 6 9 12 15

<table>
<thead>
<tr>
<th>Soil Shear Strength (kPa)</th>
<th>Scala Penetrometer (blows / 50 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V=Peak</td>
<td>R=Residual</td>
</tr>
<tr>
<td>UTP=Unable to penetrate</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks**

- Slow Seep (depth 2.3m) |
- Rapid Inflow (depth )
- Hole Terminated Due To: Target Depth

**Groundwater**

- None

**Explanations:**

- Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
- Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense
- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample

**Scale Penetrometer** - blows/50mm

- Schmidt Hammer
- In situ Vane Shear Strength (kPa)
- V=Peak, R=Residual, UTP=Unable to penetrate

**Groundwater**

- Mezometer Installed: Screen 2.5m, GAP7 backfill and filter sock, bentonite gap to 0.5m
- Groundwater level recorded at 2.7m depth on 26 May 2017
- 2.30 m: Water strike - Measured after drilling

**Hand Auger Log**

- Project: 113 Jervois Road
- Client: Artific Jervois Limited
- Hole position: South-eastern corner of site
- Sheet: 1 of 1

**Geological Information**

- Job No.: 170292
- Start Date: 19-05-17
- Finish Date: 19-05-17
- Ground Level (m): 42.00
- Co-Ordinates (): E 397,547.24 N 803,871.75
- Hole Depth: 5.00 m

**Recorded by:** GJ
**Checked by:** SRO
**RILEY Consultants Limited**

4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4579727
Fax: 09 450 5127

**HAND AUGER LOG**

**Project:** 113 Jervois Road  
**Location:** Herne Bay  
**Hole position:** North-western corner of site  
**Job No.:** 170292  
**Start Date:** 19-05-17  
**Finish Date:** 19-05-17  
**Ground Level (m):** 40.20  
**Co-Ordinates ( ):** E 397,576.71 N 803,865.41  
**Hole Depth:** 5.00 m  
**Sheet:** 1 of 1

**Client:** Artifact Jervois Limited  
**Logged by:** AL  
**Checked by:** SRO  

**Geological Description**  
(refer to separate Geotechnical and Geological Information sheet for further information)

- **Elevation (m):**  
  +40.20  
  +39.60  
  +38.90  
  +36.20  
  +35.20  
  +30.00  
  +26.00  
  +22.00  
  +18.00  
  +14.00  
  +10.00  
  +6.00  
  +2.00  
  +0.00

- **Depth (m):**  
  0.00  
  0.60

- **Soil Shear Strength (kPa):**  
  50 100 150 200

- **Scala Penetrometer (blows / 50 mm):**  
  3 6 9 12 15

- **Legend:**
  - FILL  
  - EAST COAST BAYS FORMATION  
  - CLAY  
  - SILT  
  - SANDY SILT  
  - CLAY  
  - UNCLASSIFIED

- **Samples:**
  - U100 Undisturbed Sample  
  - Small Disturbed Sample  
  - Large Disturbed Sample

- **Tests:**
  - Permeability Test  
  - Schmidt Hammer  
  - Thin Wall Vane Shear Strength (kPa)

- **Target Depth:**  
  +40.00  
  +39.60  
  +38.90  
  +36.20  
  +35.20

- **EOH @ 5.00 m**

**Explanations:**
- **Rock Mass Weathering:** unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
- **Relative soil Strength:** very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense
- **Small Disturbed Sample**
- **Large Disturbed Sample**
- **U100 Undisturbed Sample**
- **Groundwater:**
  - Slow Seep (depth 1.0 m)
  - Rapid Inflow (depth )

**Remarks:**
- **GROUNDOVERWATER**
- **HOLE TERMINATED DUE TO:**
  - Target Depth

**Measurment:**
- **Piezometer Installed:** Screen 2-5m, GAP 7 backfill and filter sock, bentonite cap to 0.5m
- **Groundwater level at 1.0m depth after drilling on 19 May 2017**
- **Groundwater level recorded at 1.5m depth on 26 May 2017**

**All dimensions in metres**

**Scale:** 1:34

**Shear Vane No.:** 1743

**Logged by:** AL

**Shear Vane No.:** 1743

**Checked by:** SRO

**Location:** Herne Bay

**Shear Vane No.:** 1743

**Logged by:** AL

**Checked by:** SRO

**Location:** Herne Bay

**Shear Vane No.:** 1743

**Logged by:** AL

**Checked by:** SRO