



Nelson Consulting Engineers Ltd

CIVIL · GEOTECHNICAL · STRUCTURAL

8 October 2014

Job No: 13483

Brook Waimarama Sanctuary Trust
C/o Opus International Consultants
Private Bag 36
Nelson Mail Centre
NELSON 7042

Attention: Alastair Wiffen

Dear Alastair,

Re: Geotechnical Assessment for the Proposed Brook Waimarama Sanctuary Predator Fence Alignment, Brook Valley, Nelson

RM085099

1.0 Introduction

Nelson Consulting Engineers Ltd (NCE) was engaged to provide a geotechnical assessment for the proposed Brook Waimarama Sanctuary predator proof fence alignment, located in the Brook Valley, Nelson. As part of our work, we also undertook an assessment for two alternative fence alignments, located at the lower east and lower west sides of the Sanctuary entrance, as shown on the attached *Geotechnical Site Plan*, dated 6 October 2014.

The Nelson City Council (NCC) *Decision on Application for Resource Consent*, RM05099 document, dated 9 October 2009, specifies in *Condition 7* the requirement for a geotechnical assessment of proposed fence, access and quad bike track routes, including any potential impact that the earthworks may have on the Dun Mountain Walkway.

As outlined in the Resource Consent application the site is a former water reserve vested in NCC, and is currently zoned *Rural* and *Conservation* in the Resource Management Plan.

This report is intended to meet the requirements of Condition 7, and provides:

- an assessment of the proposed predator fence alignment and alternate quad bike access tracks,
- the expected general ground conditions,
- a review of stormwater, and
- geotechnical recommendations for development.

2.0 Scope

This geotechnical assessment is based on the following scope of work:

- Review of the Brook Waimarama Sanctuary Trust (Trust) Application for resource consent and assessment of effects on the environment, dated 15 May 2009.

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- Review of the Nelson City Council (NCC) on-line GIS aerial photograph of the site, with cadastral boundaries, recreational tracks, waterways and topographic contours.
- Review our previous Geotechnical assessment titled *Geotechnical Assessment for Education Buildings and Fence Line Brook Campground, Nelson*, dated 5 September 2014.
- Review the geology map *Dun Mountain* (Johnston, 1981), scale 1:50,000.
- Review of the topographic map of the site and vicinity, BQ26 Nelson, scale 1:50,000.
- Review Google Earth aerial photographs of the site and vicinity.
- Review of the available stereo paired aerial photographs of the site and vicinity.
- Consultation with the client, and contractor including a drive to Third House via the Dun Mountain Walkway and a brief walk along a section of track from Third house to Jenkins Hill.
- Engineering geological mapping based on inspections of the Dun Mountain Walkway track formation from the Brook Waimarama Sanctuary Visitor's Centre to Third House. This includes off track inspections of steeper ground to the approximate downslope offset position for the proposed fence line. Our inspections also include the two alternate fence alignments and a walkover of the fence alignment from Third House to Jenkins Hill and the west firebreak route, returning to the Sanctuary Visitor's Centre.
- Preparation of this report.

3.0 Investigations

3.1 Desktop Study

Prior to our on-site investigations we undertook a desktop study that included a review of:

- Brook Waimarama Sanctuary Fence and Contours plan, prepared by Opus, dated 4 September 2014,
- Stereo-paired aerial photographs provided by Aerial Surveys (Nelson), revealed no evidence of deep seated instability or significant shallow instability along the fence alignment or within the sanctuary catchment. The available photographs of the site date from 1972 through to 1999. Our review of more recent satellite images (Google Earth), dated 14 December 2006 and 12 October 2010, reveal the extent of windfall within mature beech forest within the Sanctuary catchment, predominantly on ridge tops and southeast aspect slopes, arising from the July 2008 wind storm event. No evidence of significant shallow instability was observed.
- GIS aerial photographs (Top of the South website) of the site showing topographic contours, some of the existing walking tracks and structures,
- the geology publication and map of the area, *Dun Mountain* (Johnston, 1981) which shows the mapped underlying geology, and the currently mapped position of nearby fault traces, confirms the general geology as described in the report prepared by the Brook Waimarama Sanctuary Trust for the resource consent application.

In addition we undertook a topographic analysis using an AutoCAD Civil3D digital terrain model. The results are shown on the *Topographic Analysis* plan attached to this report. The digital model is based on 5m contour intervals derived from the NCC GIS.

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Based on the analysis, the typical cross sections for the proposed alignment, prepared by Opus, appear to generally fit the majority of the alignment. The main exceptions are within the north alignment on Cummings Spur through to Third House.

3.2 Geology

As previously mentioned, the underlying geology is generally described in previous reports. In addition, the following geological features underlie the proposed fence alignment:

- *Scree Deposits* overlying the *Greville Formation* bedrock of the Maitai Group underlying the areas of the lower east and west boundaries of the sanctuary, and
- the *Appleby Gravel Formation*, a poorly graded alluvium derived from east Nelson bedrock which is geologically very young (Holocene), covers the valley floor in the vicinity of the proposed main entrance to the sanctuary's "predator free environment".

The near parallel section of the Dun Mountain Walkway provides good exposure of the underlying Greville and Waiua Formation bedrock, planes of weakness and thickness of colluvium.

The extensive folding of relatively thin laminated rocks (<100mm) about a NNE to ENE axis, result in variable geological dip, generally northwest or southeast. In association with nearby fault movement there is extensive bedrock fracturing, generally observed as close to moderately wide (60mm to 600mm), with dominant tabular block shape. Both planar and irregular bedrock interfaces with overlying unconsolidated soils was observed, which affects stability of the ground.

Loose and variable thickness of scree on steep slopes was observed along sections of the proposed fence alignment.

The Whangamoa Fault is shown on the geology map to cross the mid-section of the Sanctuary, with an associated fault hazard overlay as shown on Map 55 of the RMP. The construction of the fence alignment across the fault and within the fault hazard overlay is not assessed as a significant geotechnical hazard.

3.3 General Description of the Proposed Predator Fence Alignment

The site and the proposed route of the predator fence are described in the report prepared by the Brook Waimarama Sanctuary Trust for Resource Consent application. In general terms, the fence alignment is within the Brook Stream catchment. The ridgeline sections of the fence alignment contain existing tracks and fire breaks that are generally of a grade, which from a geotechnical perspective, enable the proposed alignment to follow the ridgeline.

The main variation from the ridgeline, and most challenging section of topography crossed by the fence alignment, is the section from Four Corners to Third House. As specified in the conditions for Resource Consent, this section requires a down slope offset of 50m from the Dun Mountain Walkway.

While the historic railway route crosses terrain of similar topography, the design parameters for its alignment differ from the proposed fence alignment, in that it requires a relatively consistent grade to be maintained. To achieve this, some large cut batters and cuts through steep spurs exist. In contrast, the fence alignment formation can vary grade and direction rapidly to follow favourable ground conditions, and in some cases may be reduced in width.

The proposed typical fence track formation prepared by Opus, is indicated on the contract drawings and Resource Consent application, a copy of which is appended to this report (Figure 1).

3.4 Field Investigation

We undertook a preliminary site visit with the client on 19 September 2014, driving the access track from the Brook Valley via Cummings Spur, to Four Corners and through to Third House. This also included an approximate 650m walk of the ridgeline trail to towards Jenkins Hill.

Our main field investigation was undertaken on 23 through 25 September 2014, comprising an inspection of the existing tracks to Four Corners, the offset fence alignment at discrete intervals along the Dun Mountain Walkway to Third House, and a walkover of the remaining fence alignment from Third House to Jenkins Hill and down the west fire break, returning to the sanctuary entrance. This also included the west alternate alignment. Our inspections comprised observations of near surface ground materials, bedrock exposures, geological dip or other potential planes of weakness. In addition we measured ground slopes and noted the locations of main drainages and two sections of historic dry stacked stone wall, as well as the performance of the existing walkway formation.

During our field assessment for a previous alternate fence alignment, we undertook field inspections of the lower west aspect slopes of Cummings Spur. These inspections adequately form the basis our assessment for the current east alternative alignment.

The locations of our mapped features shown on the *Geotechnical Site Plan*, are approximate NZTM coordinates, recorded in the field using GPS.

4.0 Geotechnical Assessment

4.1 Ground Conditions Observed and Specific Recommendations for Development

Based on our assessment no deep seated instability is recorded or known to exist in the vicinity of the proposed fence alignment. The upper catchment area is within mature native vegetation. The only significant damage to this original forest canopy relates to windfall, mainly on ridgelines, as previously mentioned.

In the status quo condition, the slopes within the sanctuary are currently well vegetated and appear to be in relative equilibrium with respect to erosion and overall stability of unconsolidated soil horizons, including scree deposits. In general, shallow instability mainly relates to widespread soil creep on steeper slopes, as well as minor landslips adjacent to cut batters in localised areas overlain by thick colluvium.

While variable geological dip exists, relatively few areas were identified where dip is unfavourable for the proposed fence alignment. The areas where potential instability exists as a result of proposed earthworks, are generally limited to a few locations within the alignment between Four Corners and Third House, as shown on the *Geotechnical Site Plan*. These locations are discussed in more detail in Section 4.1.2.

Generally, the cut batters on the adjacent portion of the Dun Mountain Walkway, provide a good indication of the anticipated batter performance and the anticipated level of instability risk. In this regard, we assess the performance of the walkway to be satisfactorily.

Where the fence alignment is located on ridgelines, minimal earthworks are required to construct the fence. The main instability risks for these areas generally relate to the placement of excess fill, placement of fallen tree root mass, and surface erosion. These sections of the alignment are discussed in more detail in Sections 4.1.3 and 4.1.4.

4.1.1 Sanctuary Entrance East to Four Corners, including the alternative east alignment.

The proposed fence alignment obliquely gains lower Cummins Spur via the Coleman's Link walking track, leading to a skid site straddling the ridge. The ground slopes generally average 36°, waning near the toe of slope, and contain some localised 42° to 44° steep sections. The surface ground conditions reveal generally silty clayey GRAVEL covering the mid to upper slopes rising to Cummins Spur. Many loose angular tabular gravel of size ranging up to approximately 400mm diameter are scattered across the ground surface, and chaotic silt / clay and gravel mixes are exposed in cut batters. The lower slopes are more typical of talus or scree slopes, with the surface covered with loose angular gravel and relatively few fines. To upgrade the walking track for the fence alignment, end-hauling of excess material is likely to be required.

The fence alignment continues from the skid site on an existing 4WD track, initially on slopes east of the spur, then crosses to slopes within the Sanctuary's catchment for the remainder of the proposed fence alignment. It is near the ridge crossing where the alternate east route joins from the Brook Valley floor. The cut batters of the track expose a mix of gravelly silty CLAY colluvium to the full depth of cut, in some instances exceeding 2m high, while other sections expose bedrock. The existing track appears to have performed satisfactory with only minor batter fritter and rilling, which does not appreciably affect the track's function. However, as part of development and track maintenance, a suitable watertable is recommended to mitigate the risk of erosion undermining the integrity of the predator fence. Stormwater energy dissipating structures, such as simple rock weirs, or rock lining for steeper sections not formed in bedrock may also be required.

At a track location approximately 120m below Four Corners, the fence alignment heads "off track" to the downslope area to provide for the separation from the Dun Mountain Walkway. Ground slopes in the vicinity are steep (38° - 40°) and end hauling is likely to be required.

The alternate alignment rises obliquely from the valley floor at a steeper grade than that of Coleman's Link. While this shorter route stays entirely within the Sanctuary catchment, it requires an entirely new track formation on similar topography and ground conditions to those described for Coleman's Link. This new route is likely to create excess cut material that will require end-hauling.

We are not aware of suitable disposal sites in the vicinity for excess ground materials from this section of the alignment.

4.1.2 Four Corners to Third House

As specified in Condition 35 of the Resource Consent Notice of Decision letter, earthworks shall as far as practical maintain a 50m separation below the walkway. In order to achieve this a new formation is required.

This section generally traverses steep (>30°) terrain as shown on the *Topographic Analysis* plan. Significant sections of the alignment crosses moderately steep (<30°) slopes meeting the typical cross section specifications. However, the variable topography also comprises deeply incised gullies and tributaries of Brook Stream, steep spurs, and very steep rock outcrops / bluffs.

The following table summarises the observed sections of the proposed alignment where significant geotechnical risk was observed.

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GPS MARK	GEOTECHNICAL FEATURES
447	Generally loose angular scree on slopes averaging 34°, with 38° to 40° slope and rock outcrops common.
451	Very steep 64°- 65° slopes with unfavourable geology. Risk of possible slab failure. End-hauling required.
452–455	Steep 30°- 34° slopes, thick colluvium overlying unfavourable geology, seepage. Risk of shallow instability.
456	Very steep slopes (45°- 46°) with favourable geology. End hauling required.
460	Very steep (48°- 48°) with unfavourable failure planes. Risk of possible slab failure.
461	Very steep spur face / bluff. End hauling required.
462	Shallow ephemeral drainage. Stormwater and sediment / debris management.
465	Carter's Creek, deeply incised gully, significant flow, steep (33°- 35°) flanking slopes.
467	Deeply incised gully, very steep (40°-45°), loose scree slopes, highly fractured bedrock.
468	Confluence of streams at GPS marks 465 and 467. Bedrock outcrops & bluffs. Re-alignment of proposed alignment to downslope area and more favourable ground.
470	Historic Dun Mountain Walkway dry stacked stone wall. Adequate offset provided.
472	Very steep (±45°) spur with bedrock outcrops. End-hauling or re-alignment to more favourable ground.
474	Very steep slope (44°- 46°), chaotic slope debris overlying unfavourable bedrock slab dipping ESE. Shallow instability risk.
475	Minor ephemeral creek crossing. Stormwater and sediment / debris management.
477	Minor ephemeral creek crossing and historic Dun Mountain Walkway dry stacked stone wall. Adequate offset provided, stormwater and sediment / debris management.
483	Steep ground slopes (±40°). End-hauling.
487	Minor ephemeral creek crossing. Stormwater and sediment / debris management.

We anticipate some of the very steep slopes or bluffs can be avoided with re-alignment of the proposed fence route. While the exact route is unknown, re-alignment may need to be within the 50m setback from the Dun Mountain Walkway. Providing the intent of Condition 35 is met, which is for the fence alignment to have minimal impact on the walkway, we recommend such realignment and / or reduction of the alignment width, to enable appropriate earthworks to be undertaken and mitigate instability risk.

In areas where reduced track formation width may risk compromising security of the predator fence, specifically engineered retaining structures may be required to mitigate instability risk.

The two stream crossings within deeply incised gullies exist at Mark 465 and 467, and are reported to flow throughout the year. The confluence of these two drainages is approximately 120m downslope from the Dun Mountain Walkway, and may provide opportunity for a single fence alignment crossing. However, significant bluffs exist on the true right side of Carter's Creek (Mark 465) near the

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confluence (Mark 468). A more suitable single stream crossing may exist further downslope, but has not been assessed.

Based on our assessment, we anticipate a significant excess of cut ground material and end-haul volumes within this section of fence alignment. We have not identified suitable disposal sites to accommodate such volumes of spoil within the forested area of the sanctuary, and these will need to be determined during construction.

4.1.3 Third House to the Top of the West Firebreak

From the proposed fence offset adjacent to Third House, the alignment slowly gains the catchment's ridgeline crossing slopes of approximately 25°. From this location, the proposed alignment generally remains on the ridge through to the west firebreak descent to the Brook Valley floor. In general, the ridgeline is relatively broad and smoothly rounded, with limited sections of ridgeline rising or falling at ground slopes of 25° to 28°. As previously mentioned, the ridgeline contains significant areas of windfall, comprising of mature tree trunks with large root mass within the proposed alignment.

The exception to otherwise smooth ridgeline topography is a steep section ($\pm 45^\circ$), locally known as the "Ramp" (Mark 497 & 499), which ascends to a high point (786m) shown on the topography map. From the Ramp to Jenkins Hill, the broad ridgeline smoothly undulates with no significant variations in slope. The walking track intersects a 4WD track between the Barnicoat Range and Jenkins Hill, and follows this route to Jenkins Hill and the top of the west firebreak.

The existing walking track has been formed with minimal earthworks and bedrock exposures are common within or next to the track formation. The 4WD track leading to Jenkins Hill has performed satisfactory and provides an example of vegetation clearance and track formation similar to that required for the fence alignment. No evidence of significant instability was observed along this section of the proposed alignment.

The most significant earthworks required is to provide alternate safe quad bike access adjacent to the Ramp. For this reason a two metre wide track formation to by-pass the ramp is proposed, traversing steep to very steep slopes within the Roding catchment. From our observation of competent bedrock exposures in the vicinity and satisfactory performance of the existing walking track ascending the Ramp on the Brook side, the track appears feasible.

We recommend the track be constructed with a single traverse, at an appropriate safe grade for 4WD quad bike operation. Our cursory review of 4WD quad bike turning radius reveals a minimum 3m radius corner would be required to avoid multi-point turn switchbacks. A single traverse minimises cut batter height, fill volumes and the disturbance of vegetation.

4.1.4 Top of West Firebreak to Sanctuary Entrance West and the Alternate West Alignment.

This section of alignment generally follows the existing firebreak, which is located on or slightly east of the ridge centreline through to the Brook Valley floor. Few segments of the firebreak contain appreciable surface erosion. In general no significant earthworks are required, including where the firebreak and fence alignment needs to be re-aligned to meet legal boundary conditions.

The ridgeline is step like in form, with steep sections up to 32° and bedrock is commonly exposed. However, moderately steep slopes of approximately 25° or less are more common. Near the toe of the ridgeline and the top of the proposed west alternate fence alignment, the ground slopes increase (35° - 37°). From this location (Mark 522) to the valley floor (Mark 530), the existing firebreak

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formation is over-grown. Rilling within colluvium exists, and at some locations bedrock is exposed by narrow rills to approximately 0.8m depth.

This steep section of the alignment requires minor earthworks to provide adequate watertable draining away from the fence to avoid undermining the buried fence skirt. We recommend the provision of stormwater management features, such as rock or soil stormwater bunds designed to spread overland stormwater flow and reduce stormwater energy at regular intervals. In addition, sowing the cleared route with grass immediately following construction can mitigate surface erosion. It may be possible to use erosion control blankets at specific locations to further mitigate surface erosion if required.

With minor improvement, the existing track meeting the firebreak at Mark 522, could provide alternate safe quad bike access to the valley floor.

From the toe of the west firebreak, the proposed alignment crosses an open paddock on a gently sloping river terrace, and then enters regenerating native vegetation. Near Mark 533, the river terrace narrows, with scree deposits and cross slopes of 20°. At Mark 534 to Mark 536, cross slopes of 33° is suitable for walking access only, for the final approximate 60m section of alignment. Should more level formation be required for fence construction, end hauling and a suitable disposal site will be required.

From Mark 522, the alternate west alignment follows an existing track to Mark 518. The track cut batters may need to be trimmed to provide adequate clearance for fence posts founded in original ground. The existing batters stand in satisfactory condition. From Mark 518 the proposed alignment requires a new track formation crossing steep (35°-38°) scree slopes to connect with the main walking track at Mark 514. An excess of spoils and end hauling to a suitable disposal site will be required.

4.2 Proposed Fence Track Formation

The proposed track formation design indicated in the Resource Consent documentation is based on ground slopes up to 30° and a cut batter of 0.25 (H):1(V). As indicated on the attached *Figure 2 Track Formations* drawing, at 30° a cut bench of about 3.8m width can be created with a 2.6m high cut batter. Placing additional fill to 1.2m width, can provide an overall track width of 5m. This portion of fill provides access to the downhill side of the fence and is not required to carry temporary or maintenance vehicle loads. The fence posts are to be founded in native ground and not the fill wedge, which may settle or have other localised stability issues. These are general expected to be resolvable with maintenance and as adjacent plant roots take hold. The proposed formation is generally expected to perform satisfactorily and be cost effective for flatter areas and slopes up to 30° and slightly steeper.

As previously mentioned, the proposed track alignment crosses a significant portion of land with slopes of greater than 30°. About 3600 m of new track formation is proposed to cross land with steep slopes between 30° and 45°. Another 300m crosses very steep slopes over 45°. The steepest slopes might be avoided by local shifts in alignment, but in keeping to the proposed sanctuary perimeter as much as possible, some of the steep to very steep slopes will be unavoidable.

The proposed typical track formation would not work efficiently on these steep slopes. At slopes steeper than 35° the fill batter will be difficult to construct. At 45° and steeper the fill batter would be impossible to construct, and a "full bench" formation would need to be considered. In this case a 5m formation would result in cut batters of up to 7m high, with more pronounced stability issues and generate a considerable and costly amount of spoils to be end-hauled. For this reason the Trust

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should consider a narrower formation as suggested in *Figure 2*, which will greatly reduce construction and maintenance costs, enhance stability and lessen the visual impact.

Some of the very steep slopes and bluffs can be avoided by local re-alignment, given enough foresight. In cases it may be more practical to shift the alignment uphill as opposed to downhill. As mentioned in Section 4.1.2, this could result in the desired 50m setback from the Dunn Mountain Walkway being locally breached. However, the re-alignment would still meet the intent of Resource Consent Condition 35.

4.3 Earthworks

Condition 30 of the Resource Consent requires that all earthworks, drainage and retaining walls associated with the track formation be constructed under the supervision of a Chartered Professional Engineer practicing in civil engineering or a contractor recognised by NCC as “experienced in the construction of roads and ancillary structures in forested hill catchments”.

The proposed typical fence track formation cross section is intended to provide somewhat of a cut / fill volume balance to avoid end hauling costs and the need for disposal sites. However, as previously mentioned, significant portions of the track alignment adjacent to the Dun Mountain Walkway will require end hauling and the use of significant disposal sites. Assuming the Trust adopts the suggested narrower formation for steeper slopes, rough order estimates indicate that 15000 to 25000 of spoils may be generated for disposal. As clearing of trees and vegetation may be required, the areas to take this fill will need to be identified and approved by the owner prior to placement. The details of end hauling and the locations of temporary tracks and significant disposal sites will need to be submitted as part of the construction methodology also required by Condition 30 of the Resource Consent. If development of significant disposal sites are considered on moderate to moderately steep slopes (12° to 30°), in gullies or near streams, advice from a Chartered Professional Engineer practising in geotechnical engineering should be sought.

The practical limits for rapid changes in fence alignment to avoid unfavourable ground, may also be dependent on the size and type of end haul equipment used. This needs to be fully considered along with the possible need for passing bays, depending on the distance to disposal sites.

Stripped vegetation associated with track clearing is proposed to be windrowed at the base of the fill batter or placed below full bench formations.

4.4 Sediment Control

Erosion and sediment control measures will generally be comprised of windrows of cut vegetation from track clearance and the natural sediment filtering of the forest duff or grass. Additional measures such as silt fences may be required when works are undertaken near running or ephemeral streams. No captured stormwater should be directed, directly into streams during construction without sediment control.

Condition 31 of the Resource Consent requires that an *Erosion and Sediment Control Plan* be provided by the professional engineer or contractor noted in Condition 30 to the NCC’s Resource Consent Monitoring Officer for review prior to commencing earthworks.

4.5 Stormwater Management

The proposed fence alignment crosses two streams and three significant ephemeral drainages as shown on the *Geotechnical Site Plan*. The design of drainage crossings for the predator fence will be provided by Opus.

The sections existing 4WD track or firebreak to be used for the alignment have generally performed satisfactorily, and few areas of appreciable surface erosion exist. Significant rills within portions of the track on Cummings Spur and the lower west firebreak exists, but does not appreciably affect the track's function.

The construction of the predator fence is unlikely to significantly change the status quo stormwater drainage for these track formations, provided no excess spoils or other significant fill are placed on the firebreak formation. This is with the exception of bunds designed for stormwater control.

For sections of the alignment located on vegetated ridges, stormwater is generally unlikely to be a significant issue, based on the *Typical Cross Section / Ridge Bush* prepared by Opus, which shows the dispersal of captured stormwater to either side of the track to mitigate shallow instability risk.

The risk of stormwater damage to the buried fence skirt, requires special consideration along steeper portions of the track. The alignment's water table should be formed to direct stormwater away from the skirt, and may require management features to reduce stormwater energy where concentrated flows exist, as previously outlined in Section 4.1.1 and 4.1.4.

5.0 Conclusions

Providing the recommendations in this report are followed, the proposed fence alignment is unlikely to appreciably worsen the status quo stability of the Dun Mountain Walkway.

Ongoing inspections and maintenance of the fence alignment at regular intervals, especially with respect to stormwater management, is required to mitigate the risk of shallow instability and surface erosion, which may otherwise damage the track formation and predator fence.

6.0 Recommendations

1. Prior to vegetation clearance and earthworks, the proposed alignment needs to be surveyed by the contractor or the project civil engineer to avoid unnecessary damage to vegetation and land due to forced re-alignments.
2. Refer to Section 4.2 for recommended options to amend the proposed route and avoid adverse ground conditions. Should unexpected adverse ground conditions and instability be encountered during earthworks, the advice from a Chartered Professional Engineer practising in geotechnical engineering should be sought, prior to further earthworks being undertaken in that section of the alignment.
3. Refer to Section 4.3 for recommendations associated with earthworks. Suitable fill disposal sites need to be confirmed with the land owner prior to significant surplus cut ground materials being produced. If development of disposal sites are considered on moderate to moderately steep slopes (12° to 30°), in gullies or near streams, advice from a Chartered Professional Engineer practising in geotechnical engineering should be sought.
4. Refer to Section 4.4 for recommendations associated with erosion and sediment control measures.

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5. Refer to Section 4.5 for recommendations associated with stormwater management.

7.0 Limitation

This report is confidential and has been prepared solely for the benefit of Brook Waimarama Sanctuary Trust and Nelson City Council. No liability is accepted by Nelson Consulting Engineers Ltd or by any principal, director, employee or agent of this firm, in respect of its use by any other person.

This report must be reviewed for its applicability in the event that any substantial modifications are made to the site or adjacent properties, such that site conditions are changed substantially from the conditions at the time of the investigations.

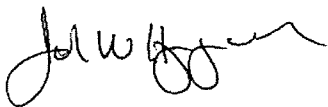
If conditions are observed that are not as indicated in this report, please contact this office immediately. Unusual conditions may include signs of seepage, subsidence, cracking or slumping.

8.0 References

JOHNSTON, M R 1981: *Dun Mountain*, Map Sheet O27AC, Institute of Geological & Nuclear Sciences Limited, Lower Hutt.

Yours faithfully

NELSON CONSULTING ENGINEERS LTD



John Higginbotham, CPEng, MIPENZ (Geotechnical, Structural)

Principal Civil Engineer

Attachments: Geotechnical Site Plan, Topographic Analysis Plan, Figure 1: Typical Cross Section / Side Cast, Figure 2: Track Formation.



- LEGEND**
- LITTLE BOUNDARY
 - PROPOSED FENCE LINE
 - FENCE LINE
 - MAJOR CONTOUR LINE
 - MINOR CONTOUR LINE
 - 4000 GPS BOUNDARY
- GROUND SLOPE COLOUR CODE**
- 0 to 5% SLOPE
 - 5 to 10% SLOPE
 - 10 to 15% SLOPE
 - 15 to 20% SLOPE
 - 20 to 25% SLOPE
 - 25 to 30% SLOPE
 - 30 to 35% SLOPE
 - 35 to 40% SLOPE
 - 40 to 45% SLOPE
 - 45 to 50% SLOPE
 - 50 to 55% SLOPE
 - 55 to 60% SLOPE
 - 60 to 65% SLOPE
 - 65 to 70% SLOPE
 - 70 to 75% SLOPE
 - 75 to 80% SLOPE
 - 80 to 85% SLOPE
 - 85 to 90% SLOPE
 - 90 to 95% SLOPE
 - 95 to 100% SLOPE
- NOTE: MAP REFERENCE**
1. LITTLE BOUNDARY, PROPOSED FENCE LINE, AND MAJOR CONTOUR LINE ARE TO BE APPROXIMATE. THEY ARE NOT TO BE USED FOR ANY OTHER PURPOSE.
 2. PROVIDED BY DOTS, INTERPOLATED.

BROOK WAIMARAMA SANCTUARY TRUST
 BROOK VALLEY, NELSON
 GEOTECHNICAL ASSESSMENT FOR PREDATOR FENCE LINE ROUTE
 TOPOGRAPHIC ANALYSIS

NCE
 Nelson Consulting Engineers Ltd

140 Collingwood Street
 Nelson
 Phone 03 5394145
 Fax 03 5394146
 Email john@nce.co.nz

Task	Start	End	Status
Topographic	14/08/14	14/08/14	Completed
Design	14/08/14	14/08/14	Completed
Construction	14/08/14	14/08/14	Completed
Monitoring	14/08/14	14/08/14	Completed
Maintenance	14/08/14	14/08/14	Completed

13483.0.04
 CONCEPT
 02 of 03
 06 OCT 14

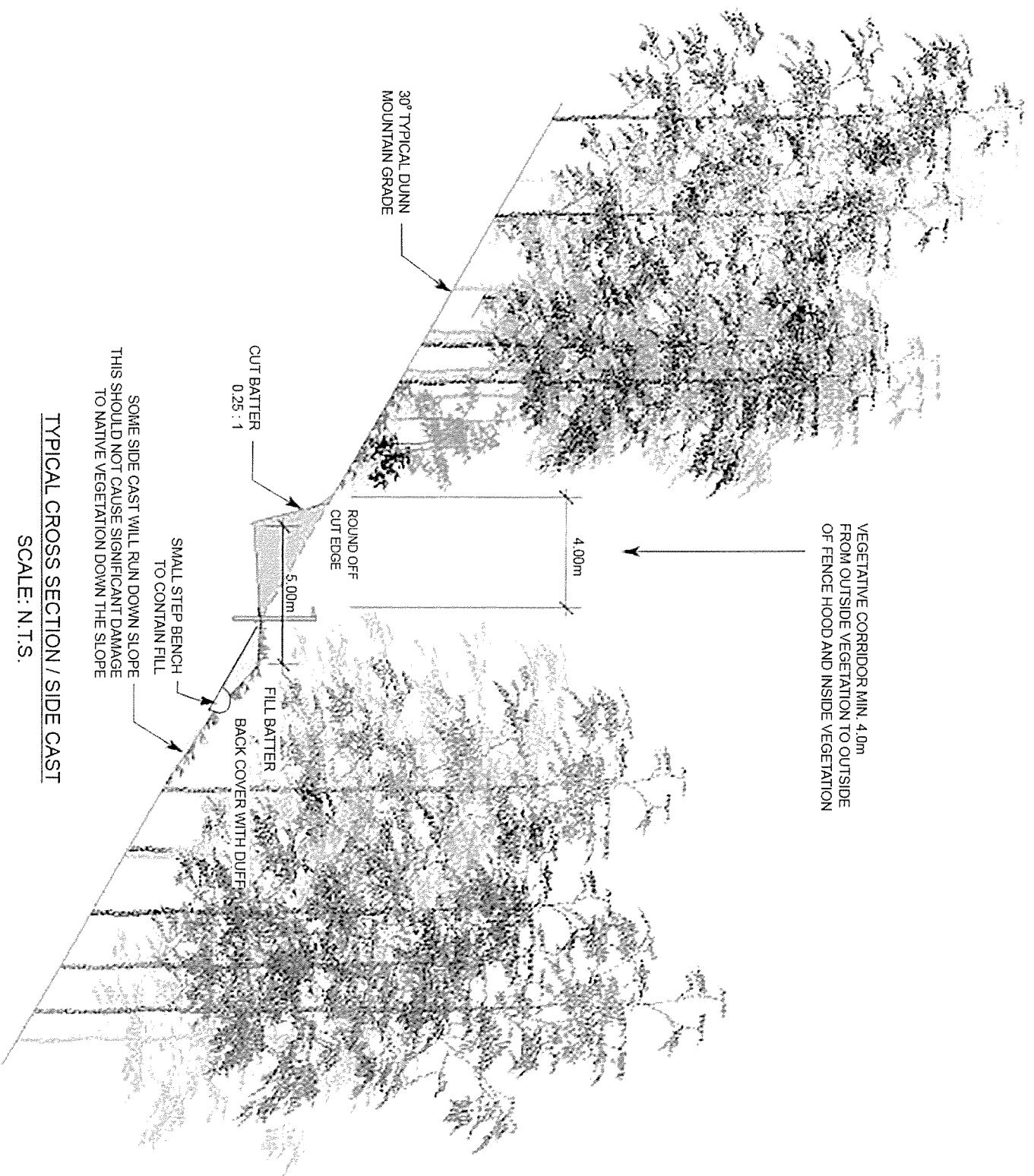
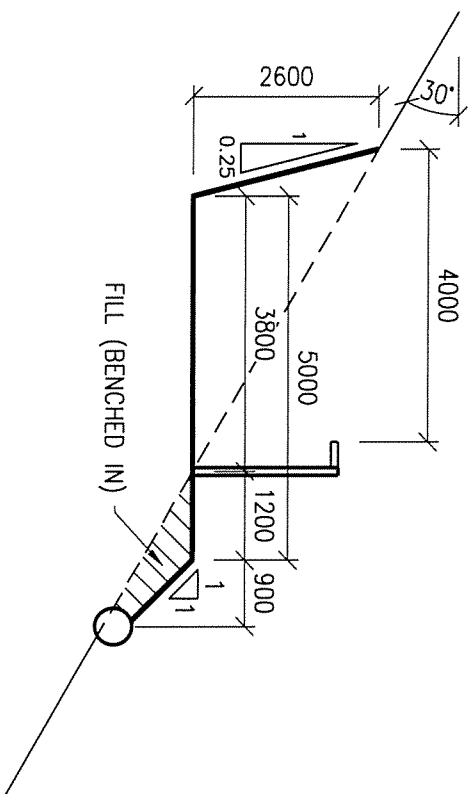
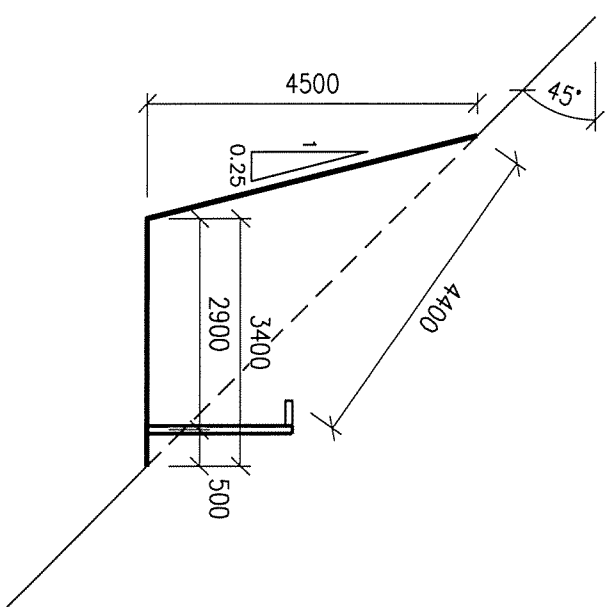


FIGURE 1



30° GROUND SLOPE (PER PROPOSED RESOURCE CONSENT)



45° GROUND SLOPE (SUGGESTED NARROWER FORMATION)

TRACK FORMATIONS

1 : 100

Scale (A4)

13483.0.05 Brook Sanctuary Track Formation CONCEPT 06 Oct 14.dwg

1:100



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GEOTECHNICAL ASSESSMENT
FIGURE 2 - TRACK FORMATIONS

Rev	Comment	Date	Int	Stamp	Job No
1	CONCEPT	06 OCT 14		CONCEPT	13483
2					
3					
4					
5					
6					
7					
8					
9					
10					

Designed by J. GIBBOTHAM Approved by J. GIBBOTHAM

Stamp	Job No
CONCEPT	13483
Date	06 OCT 14
Revision	03 OF 03

