Report

FPP Corridor Cost Analysis of Trenching and Ducting Rates in NZ - Final Issue Nov14

Prepared for Commerce Commission (Client)

By Beca Ltd (Beca)
ABN: 77-330-577

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Revision History

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A	Barry Calvert	Partial Report in Draft including key assumptions, methodologies and escalation data	03/10/2014
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Executive Summary

Beca Ltd has been instructed by the Commission to provide technical advisory services on the Final Pricing Principle (FPP) Project, supplying them with a range of 'average' estimating rates generally applied within New Zealand for various trenching technologies and telecommunication ducting sizes, along with an indication of regional variance and likely future pricing trends.

The process involved two streams of work. The first stream required a geology assessment to determine appropriate soil and rock material categories for the corridor cost modelling of urban and rural area terrain and remediation types across New Zealand. The report in Appendix 1 presents the findings of the desk based engineering geology assessment task.

The aim of the study was to provide definition of recommended terrain/remediation categories for use within the TERA cost model, including a table of Landcare classifications to the consultant defined categories, to provide findings supporting the category recommendation – especially relevant trenching and/or civil works factors, and to undertake an assessment of difference between Landcare and QMAP geological classifications

Stream two was primarily a costing exercise to research and ascertain the appropriate trenching technologies for New Zealand soil types, then to cost these trenching activities in the form of an average 'per metre' rate of ducting. The distinctive between rural and urban areas was considered and a premium for urban work was costed into the rates.

The results of this study were tabulated in a format agreed with TERA consultants in France and are attached to this report in Appendix 2.

Beca has not been given the Chorus pricing and is working completely independently from the regulatory framework submission process. The rates we have calculated are based on historical pricing data held within Beca from previous tenders, limited supplier pricing, indicative 'cover all' rates and pricing methodologies received from contractors throughout New Zealand and the estimating experience of Beca's own in-house quantity surveyors.

The methodologies used to build up the rates are the same as those used throughout the industry, and consider market factors such as soil or rock type, site conditions, traffic, localised labour rates, material supply, transport, equipment hire, on and off-site overhead costs and contractor margin.

Verification of the costing data and methodology has been undertaken progressively by senior civil estimators in Auckland & Tauranga.

The Beca group is one of Asia-Pacific's most respected and leading professional services organisations, specialising in the design and management of projects. As a multi-disciplinary organisation, we have the capability to work in a diverse range of sectors. We have more than 3000 employees, and we have operated in more than 70 countries worldwide.

We attached a six page company profile under Appendix 3.

Introduction

Beca's agreement with the Commerce Commission (the Commission) dated 19 September 2014 states that Beca will provide external analysis of corridor costs relating to the FPP price review determinations for the Unbundled Bitstream Access (UBA) and Unbundled Copper Local loop (UCLL) services by answering specific questions asked by the Commission, and by carrying out analysis underlying the questions.

The work was undertaken in two streams. Stream one relates to the geotechnical information required to create the cost model. Stream two is the research, analysis and creation of rating tables.

Beca engineers and quantity surveyors have created cost model datafiles consistent with the datafile format/specification advised by TERA consultants including:

- Mapping table of landcare classifications to the Beca defined categories
- Mapping table of trenching technology options to the terrain/remediation categories
- Table of national average unit costs per metre for trenching and ducting with expected lower and upper ranges defined to reflect estimation uncertainty and regional variance, up to a maximum of 36 ducts per trench, for 50mm and 100mm diameter ducting.
- Regional aerial services pole costs with lower and upper ranges identified to reflect estimation uncertainty and source data variations

In addition to the above Beca have:

- Updated the analysis issued 19 September with additional pricing information obtained from contractors
- Updated the initial "partial" Draft report dated 3 October from the Commissions comments
- Updated the Draft report dated 22 October based on comments received from the Commission on 7 November and 19 November.

It is important to note that Beca has produced this report as an independent consultant without any technical or costing input from the Commission or any other professional firm. All feedback received from the Commission on the various draft issues have been of a general nature, requesting clarification on terminology, methodology or process.

Beca Defined Soil Categories

An engineering geology assessment was required to determine appropriate soil and rock material categories for the corridor cost modelling of urban and rural area terrain and remediation types across New Zealand. The report in Appendix A presents the findings of the desk based engineering geology assessment task.

The aim of the study was to:

- Provide definition of recommended terrain/remediation categories for use within the TERA cost model, including a table of Landcare classifications to the consultant defined categories.
- Provide findings supporting the category recommendation – especially relevant trenching and/or civil works factors
- Undertake an assessment of difference between Landcare and QMAP geological classifications
- Provide recommendation on further work that may be required

We have reviewed the Bell – Ducat (Bell, 2004)[1] system of terrain evaluation method of assessing trenching difficulty for telecommunication services in New Zealand, in terms of its appropriateness for use as a scoping tool.

As discussed in depth within the Appendix 1 document, we consider that it is appropriate to apply the Bell-Ducat soil and rock classification system to the lithologies in the Land Resource Information System GIS datasets. Their definition is summarised in Table 1 below, along with the typical properties of cohesionless, cohesive and organic soils as recognised by Bell

Table 1

Class	Soil and Rock Categories		Soil Engineering Properties		
			Cohesionless	Cohesive	Organic
1	SOFT SOIL	Very easily disaggregated or remoulded soil material	Loose silts, sands or fine gravels	Soft to very soft clay-rich materials	Soft peats/organic rich clays & silts
2	MEDIUM SOIL	"Normal" soil that can be readily excavated	Compact silts, sands or fine-medium gravels	Firm clay-rich soil material/ moist silts	Firm organic-rich clays & silts
3	HARD SOIL	Soil that requires significant excavation pressure	Densely packed or weakly cemented granular soils	Stiff clay-rich soil material/ dry silts	Stiff organic-rich clays & silts
4	SOFT ROCK	Genuine "soft rock" or weathered hard rock			
5	HARD ROCK	High strength rock +/- closely-spaced fractures			

It should be noted that the above soil and rock classifications have only been applied to rural areas. We have established that an assessment of urban areas needs to be undertaken to allow for Bell-Ducat class to be applied to these areas including consideration of incorporation of other geological data sources i.e. GNS published geological maps, and contractor experience.

As this assessment has not yet taken place we are uncomfortable applying a specific soil or rock category to city and major suburban areas. As a result we have created a sixth category "Urban" with the assumption that these areas are predominately either imported or redistributed and compacted fill of the type generally used for development.

We refer the reader to Appendix 1 for the full report

[1] Bell, D.H., 2004: Development of a Trenching Evaluation Method to Assess Trenching Difficulty for Telecommunication Services In New Zealand. Canterprise Limited Report CP/04/04/030 for TelstraClear Limited

Appropriate Trenching Methodologies

In consultation with local contractors the following table of appropriate trenching technologies was developed for use in this model. These are generally accepted trench solutions however the technology may not be appropriate in some situations, for example in loose sand or peat.

Table 2

Soil/Rock Category	Appropriate Trenching Types
Soft Soil (Rural only)	Mole Plough (cable only) Chain Digger Open Trenching Directional Drilling
Medium Soil (Rural only)	Mole Plough (cable only) Chain Digger Open Trenching Directional Drilling
Hard Soil (Rural only)	Open Trenching Directional Drilling
Soft Rock (Rural only)	Open Trenching only
Hard Rock (Rural only)	Rock saw only
Urban	Open Trenching Directional Drilling Thrust boring

Notes on Trenching Types

Mole ploughing, sometimes called cable ploughing is a technology developed for the laying of smaller diameter, semi-flexible cables and pipes into soft and medium soils in rural areas. It is not generally suitable for the installation of ducting larger than 40mm diameter.

When looking at pipe diameters up to 100mm, thrust boring is one of the most expensive of trenching technologies and is usually restricted to short runs of pipe or ducting at relatively shallow depths. This makes it an ideal and cost effective solution in many urban and suburban situations, but not suitable for long rural runs.

Maximum Number of Ducts

We are not aware of any New Zealand standards or codes of practice that govern or restrict the number of ducts that can be placed in to a single open trench. However in terms of practical application we have determined that it is highly unlikely for more than 36 x 100mm diameter ducts to be laid into one open trench – Beca civil engineers have certainly never specified that many without the protection of concrete channels or enclosures.

In theory where 100mm diameter ducts of this number are required in an urban area, a trench 400-500mm wide would need to be 1.8m deep with a minimum of 600 top cover made up of compacted imported structural fill. However it is likely that such a large number of ducts would not be allowable in some circumstances – for example under a roadway, and would require confirmation from a civil engineer before reliance is placed on it.

Regarding the capacity of directional drilling, one of the contractors we spoke to had the equipment to drill up to 500mm diameter holes which would optimistically allow 14 no. 100mm diameter cable ducts to be dragged through. We have taken this as being a maximum, with the 15th duct requiring a second hole to be drilled.

Estimating Basis

The estimation of rates for the cost of trenching and ducting work follows traditional methods and utilises both 'bottom up' and 'top down' approaches. It is assumed that excavation & backfill work must comply with NZ standards, legislation and accepted codes of practice, with all ducting to be installed in accordance with manufacturer's instructions.

For the rates schedule attached in Appendix 2 Beca has researched, verified and built up current market rates and sums based on a traditional procurement route, ie. fully designed and competitively tendering for lump sum tenders from at least three suitable selected tenderers.

Pricing Methodology

The method of calculation was determined by the source of the data. If overall 'indicative' rates were provided by a contractor then the top down approach was utilised. Also known as the 'decomposition' method, this approach is essentially the breaking down of a single, all-encompassing rate to gain insight into its compositional structure. An example of this is the directional drilling rates which were obtained for specific size hole diameters and usually included allowances for labour, plant, material and risk. It should be noted that all of the rates obtained in this manner were deemed to be indicative only and were subject to a number of items such as ground conditions and terms of engagement.

Base elements were identified and split out with 'known' rates allocated, leaving the remaining unallocated rate to be spilt logically between the remaining elements.

Logical allocation of the 'unknown' portion was undertaken by an experienced estimator, using likely labour/material splits, bulk testing and comparisons to similar or complimentary elements.

Rates are considered 'known' when a reliable source is verified, or when the result is determined by the weighted average from tenders or past estimates.

If overall 'indicative' rates are not available, we used the 'bottom up' approach. This method is the piecing together of known rates in a logical "as-built" fashion to give rise to more complex rates, ultimately leading to the overall rate.

An example of this is the open trenching where overall rates would vary depending on width, depth and soil type. These base elements were calculated separately in different tables in order to come up with a single per metre of duct rate for various quantities and for each soil type.

Ducting

New Zealand contractors mainly use two different types of ducting or buried conduit;

uPVC (unplasticised polyvinyl chloride) class SN16 pipe, an extra rigid, high performance pipe required by territorial authorities, supplied in 6.0m lengths and jointed either with glue or rubber rings. Green coloured ducting for communications cable comes in 20mm, 50mm and 100mm diameters.

PE (polyethylene) high quality pipe is approved by all major telco's and is supplied on drums in lengths up to 500 metres. It is jointed with compression fittings or by electrofusion. Green coloured ducting for communications cable comes in 40mm, 50mm, 63mm, 90mm,110mm, 125mm, 140mm and 160mm diameters.

The uPVC pipe is primarily used in open trenching where lengths can be jointed easily in sections, and where the extra rigidity is required below compacted backfill.

The PE pipe is recommended for trenchless technologies where the drums or coils of pipe remain stationary and a continuous length (or multiple lengths) can be pulled through the drilled or thrusted holes.

Ducting which has heavily compacted backfill material above it, such as in the urban environments or under carriageways, needs to be laid into a bedding material to ensure that there are no voids, and allowing the long lengths of pipe to settle evenly.

Statutory Planning and Consenting

Local authority consenting costs do play a part in the overall rate build-up, however it is fairly minimal.

Allowances in the rates for this item were based on historical consenting data, all of which was compiled from projects in the Kapiti and Horowhenua districts. It was judged that due to the 'conceptual' nature of the estimate, the differences in consenting cost between regional consenting authorities would be negligible. It is also worth noting that the area CSA-03 noted in the Regional Variance table was the closest to the national average.

We calculated an average rate of $1.67 per metre of trench via a simple exercise of analysing total cost of consenting divided by overall metres of trench dug or drilled. The average worked out to be $1,000 per 600m of trench.

Traffic Management

Traffic Management is now an essential part of working within the roading corridors and is essentially the cost of protecting the road-side workmen by the use traffic management plans, safety vehicles, signals, cones and "lollypop" signs in order to control and/or re-direct traffic passed or around the work area.

Allowances in the rates for this item were based on actual tender for projects in the Kapiti and Horowhenua districts in 2013. It was judged that due to the 'conceptual' nature of the estimate, the differences in consenting cost between regional consenting authorities would be negligible.

We calculated an average rate of $5.26 per metre of trench via a simple exercise of analysing total cost of traffic management divided by overall metres of trench dug or drilled, then rationalised to reflect the percentage of time spent trenching compared with other activities on site such as installation of manholes and other pipework etc. The average worked out to be $1,000 per 190m of trench.

Contingencies

No allowance was made for contingencies.

Contingencies are a percentage increase in the estimated value of a project, usually applied to the bottom line. It is integral to the estimating total and is a general allowance for the residual cost risk including design development, omissions, construction risk, sundry measured items and assumptions made for construction details not shown. Typically the estimating contingency decreases throughout the design development process.

Beca has developed a protocol around applying contingencies to construction estimates. When forced to consider what stage of the project lifecycle the resulting trenching and ducting rates would fall into we concluded it was probably closest to the Tender or Procurement stage. Following this approach would put the contingency level at approximately +/-5%.

However considering the number of differing sources for pricing data, the range of variance and the level of risk allowance likely to be imbedded within for example the directional drilling rates, we have come to the conclusion that the rates themselves are probably robust enough to warrant the decision to exclude a contingency.

Inflation

We have considered civil and non-residential construction cost escalation for the next 3 years based on Statistics NZ Capital Goods Price Index forecasts. Estimates range from 2.2%, being the average CPGI annual increase to June 2014, up to 3.5% - the average for non-residential buildings. We have based our conclusion on the upward trend in the CGPI generally along with the increase for earthmoving and site works, tempered with the relatively stable prices for electrical works. We therefore forecast the escalation to be at +3.0% per annum.

It is worth noting here the impact that the Christchurch re-build which has had, and continues to have on labour rates in the south and lower north islands. There is a premium being paid in Canterbury for most trades, and the activity there has created a high demand for machinery.

Data from Statistics New Zealand's website in Table 3 and Graph 1 below:

Table 3

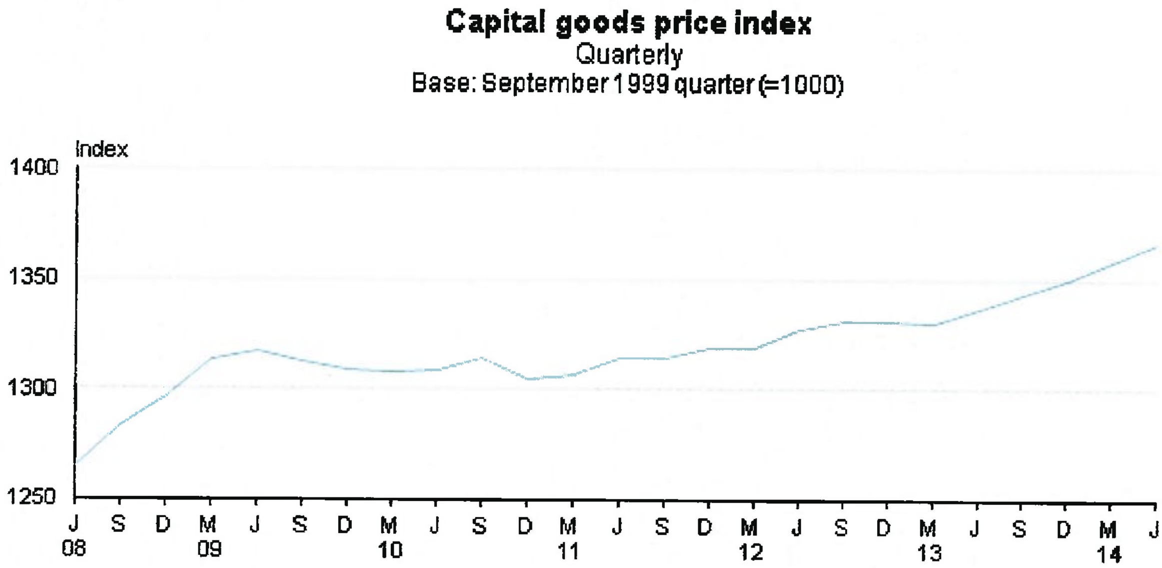
Capital goods price index

Percentage change from same quarter of previous year

Asset type	Series ref: CEPQ	Quarter								
		2012			2013				2014	
		Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun
Civil construction	S2GC	3.1	3.3	2.9	0.1	0.2	-0.1	-0.1	2.1	2.1
Transport ways	S2CA	3.8	4.7	4.3	2.6	2.8	2.3	1.9	2.3	2.2
Pipelines	S2CB	2.0	0.9	0.8	-6.3	-6.4	-6.4	-6.3	1.4	1.7
Electrical works	S2CC	0.9	2.6	2.1	1.3	1.3	-0.1	0.7	0.8	0.4
Earthmoving and site work	S2CD	3.9	2.8	2.6	1.5	1.7	2.0	2.4	3.4	3.2

Graph 1

- The capital goods price index (CGPI) rose 0.7 percent in the June 2014 quarter.
- In the year to the June 2014 quarter, the CGPI increased 2.2 percent.



Source: Statistics New Zealand

Pricing Assumptions

The following pricing assumptions are based either on accepted civil estimating practice, or on conversations held with the Commission leading up the draft report being issued on 19 September 2014.

We assume that:

1. The works are of a large scale and will be procured in sizable portions. However there will be some limitations regarding the size and capability of the localised sub-contractors. Our pricing assumes a mid-size contractors with 20 or less workers
2. The works will be undertaken by either local contractors living in the region, or by external contractors who tendered using competitive local rates
3. Rates to allow for the specific conditions likely to be encountered in each soil type & location
4. There will be a limited number of subcontractors willing to price the work. This particular assumption is based on Beca's experience nationally when dealing with small to mid-size regional contractors.

In relation to assumption 4 above, it should be noted that during our conversations with contractors the issue of working under contract for Chorus was raised as being influential on rates. Being such a large telco they do manage to negotiate lower prices with their subcontractors in return for the promise of regular on-going work. In the opinion of one directional drilling contractor we spoke to the negotiated rates could be as much as 20% lower than their normal tender pricing. We wish to emphasise that this discount has not been taken into account within our pricing.

Regional Variance

Our table for regional variance relied upon a mix of tender information, contractor feedback and anecdotal evidence. Other than the rates received from various contractors around New Zealand, we surveyed our quantity surveyors in Auckland, Tauranga, Wellington and Christchurch.

As expected responses from the various sources were variable and required some rationalising. Results were averaged and used for the Trenching Rates table, with lower and upper ranges entered into the Regional Variance table.

It should be noted that obviously exaggerated rates from a single source were excluded from the datasets in order to arrive at a reasonably reliable upper and lower range.

Pricing Exclusions

Goods and Services Tax (GST)

All rates and calculations exclude an allowance for GST. This is standard practice within the New Zealand construction industry, particularly in the commercial and civil sectors.

Contingencies, Risk & Escalation

No allowance has been made in the rates for estimating contingency, contract or project contingencies, future escalation or any other form of risk allowance for the likes of funding, legal or compliance costs.

Access or Land Purchase Costs

No allowance is made for the cost of accessing or making good to private property, or for the purchase of any land within the corridor.

Fast Tracking

The rates are based on reasonable contract conditions for the likes of material and plant procurement, construction programme and sequence of reinstatement. No allowance is made for acceleration during any stage of the works.

Hazardous Materials

For the purposes of consistency we have not factored in any requirement for testing, over-excavation, containment, removal or disposal of hazardous excavated material.

De Watering

No allowances have been made for de-watering of trenches or for mitigating the effects of a high water table. In our experience only a small percentage of trenches require some form of dewatering so it seemed an unnecessary additional cost to include in national average rates.

Data Sources

General Comments

Our table of rates should not be taken as contractor pricing. In order to get cost data from specialist civil contractors our approach had to be as non-invasive as possible - in other words a minimum time commitment on their part. Contractors are busy people who are not generally open to the idea of giving away commercially sensitive information without the prospect of some return.

We therefore couched our request in terms of being "indicative, cover-all rates" that could be applied to large contracts in various locations. This approach will always result in "average" levels of discount and should be not be considered as their 'best price'.

The following sources of pricing information were used;

Historical Pricing Data

One area of specialty within Beca is civil estimating so it was not difficult to build up specific rates for open trenching and backfilling. The supply and laying of pipework into trenches was also relatively easy.

A limited amount of data existed within Beca for bored pipes and ductwork in the diameter range we wanted. The pricing information we did have was located exclusively within tender submissions received on behalf of clients. However this proved to be of limited value as only one recent thrusting tender contained rates for 63mm and 100mm diameter pipework.

Tender Information

During the course of our business Beca Project and Cost Managers will sometimes coordinate tenders for our clients. This historical pricing information is held in confidence and used as a basis for future estimates.

It should be noted that tenders are usually for well-defined packages of work, with allowance for known conditions and risks, such as local ground conditions and the location of existing services.

Civil pricing is most often presented as separate cost items and sums relating to tasks or packages of work. Combining and/or averaging the cost of individual sums such as those for thrust pits and entry/exit trenches has been necessary in order to build up a single per metre" rate.

Rates for open trenching, directional drilling and thrust boring were identified in four tenders under-taken on behalf of Beca clients in the Wellington region between 2008 and 2014.

Contractors

Not all contractors we contacted were willing to supply us with their rates. A number of the larger firms were tired of consultants ringing them up for pricing information and had stopped responding. One or two others told us that they had recently provided indicative pricing to a consultant during the concept design phase, and had then been called to account when their tendered rates were higher. They did not want to have to justify themselves again in this way.

A third group of contractors were not willing to provide indicative rates at all. They firmly believed that every job had its own challenges and should be priced individually.

In total nine (9) individual civil or trenching contractors were willing to provide indicative pricing information to Beca.

Suppliers

A range of pricing was received for the supply of uPVC rigid ducting from only one wholesaler in the Wellington region. However their supply rates were discounted to reflect the buying power of a large, busy subcontractor.

While retail rates were readily available to us, no other suppliers were willing to provide trade discounted rates.

Verification

Verification of the costing data and methodology has been undertaken progressively utilising our experienced civil estimators in Auckland & Tauranga. Contributing verifiers were Les Lewer, Senior Cost Manager (CM) for open trenching, Steve Davies, Senior CM and Carl Viljoen, Senior Associate CM providing overall comment on rates and methodology, and Mark Wilson, Associate CM assisting with labour rates and regional variance.

Recommendations

During the course of our research one issue kept arising which may be an important factor in the FPP corridor cost analysis. A number of contractors noted that 150 diameter was a more common size for comms ducting. There could be any number of reasons for this however we have identified two key issues which should be noted.

Firstly it is always important to future proof all infrastructure elements. The ability to draw new cable through an existing ducting network will be crucial for future work therefore it makes sense to 'over specify' in order to leave space in every duct run.

Secondly there are efficiencies to be gained by boring larger holes. With the cost of excavating exit/entry trenches for directional drilling and thrust boring, as larger holes are bored the exercise becomes more cost effective. But this applies only up to a certain point where the increased cost of boring along with that of obstacle avoidance begins to diminish the advantage.

Appendix 1

Rock and Soil Classification Method and Data

Report

Commerce Commission New Zealand - Rock and Soil Classification Method

Prepared for Commerce Commission New Zealand (Client)

By Beca Ltd (Beca)

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on behalf of	Beca Ltd		

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Appendices

Appendix A

Appendix B

1 Introduction

Beca has been engaged by Commerce Commission New Zealand (CCNZ) to provide an analysis of corridor costs relating to the final pricing principle (FPP) price review determinations for the Unbundled Bitstream Access (UBA) and Unbundled Copper Local Loop (UCLL) services. Refer to CCNZ Consultancy Agreement for the detailed scope of works.

An engineering geology assessment is required to determine appropriate soil and rock material categories for the corridor cost modelling of urban and rural area terrain and remediation types across New Zealand. This report presents the findings of the desk based engineering geology assessment task.

The aim of the study is to:

- Provide definition of recommended terrain/remediation categories for use within the TERA cost model, including a table of Landcare classifications to the consultant defined categories.
- Provide findings supporting the category recommendation – especially relevant trenching and/or civil works factors.
- Undertake an assessment of difference between Landcare and QMAP geological classifications.
- Provide recommendation on further work that may be required.

2 Assessment

2.1 Key Assumptions

- As requested by CCNZ the source data for the terrain categories is to be obtained from the Landcare Research New Zealand Ltd, Land Resource Information System (LRIS) GIS portal (https://lris.scinfo.org.nz).
- CCNZ has confirmed that a maximum of 10 categories (5 x 2) will be used in the TERA cost model.
- The system of terrain evaluation developed by Bell and Ducat for assessing trenching difficulty for telecommunication services in New Zealand was reviewed and considered.
- Groundwater GIS data or consideration of the effect of groundwater levels have not been considered in determining appropriate terrain categories.

2.2 Source Data

CCNZ requested that the source data for the terrain categories was obtained from the Landcare Research New Zealand Ltd, Land Resource Information System (LRIS) GIS portal (https://lris.scinfo.org.nz). We reviewed the available datasets and determined that the most suitable dataset for categorising the terrains is the 'Lithology' dataset.

The 'Lithology' dataset is understood to be a combination of two layers in the GIS, an older dataset named 'rock' (Lithology, NZRLI Ed1) covering the whole country, and a newer dataset named 'rock2' (Lithology, NZRLI Ed2). The data includes principal surface lithology and the principal underlying lithology for rural areas.

The 'rock' data set is derived from stereo aerial photograph interpretation, field verification and measurement as part of the 1:63,360 scale 1st Edition New Zealand Land Resource Inventory. This includes mapping undertaken between 1973 and 1983.

The 'rock2' data set was developed after 1983 as part of the 1:50 000 scale 2nd Edition New Zealand Land Resource Inventory, including remapping of some areas of 'rock' in selected areas.

The data comprises GIS polygons with attributes for lithology type assigned as strings of abbreviations/letter codes. The letter codes are punctuated and prefixed with symbols to indicate the stratigraphic relationship between the lithology type components that contribute to a particular polygon. The definitions of these codes and their punctuation are explained in a Data Dictionary[1] both for the 'rock' and 'rock2' datasets. Within 'rock2' alone there are 44 rock types and more in the older 'rock' dataset, though these have been correlated with 'rock2', so in essence there are 44 types to consider (refer to table in Appendix A). The 44 types are the starting point classifying in terms of engineering properties for trenching.

The NZLRI datasets do not include the lithologies underlying urban areas. The Geological and Nuclear Sciences (GNS) map series at 1:250,000 (digitised) and 1:50,000 (non-digitised) map series do indicate lithologies underlying urban areas as do older non-digitised published geological maps. However, these maps often do not include shallow or patchy surficial soil layers or weathered rock layers that are considered of greater importance to this study.

2.3 Review of soil and rock classification system by Bell-Ducat

We have reviewed the Bell – Ducat (Bell, 2004)[2] system of terrain evaluation method of assessing trenching difficulty for telecommunication services in New Zealand, in terms of its appropriateness for use as a scoping tool. We have confined our review to geotechnical/engineering geological matters and did not include matters of access or other constraints

The Bell-Ducat method uses the definition of soil and rock from Bell and Pettinga (1983)[3] as a starting point, with three categories: engineering soil, soft rock, and hard rock as defined below:

- Engineering soil = materials formed from the breakdown (weathering) of rock that either accumulates in situ or is transported and redeposited by ice, water or wind AND non-welded products from explosive volcanic activity that are deposited as airfall tephra WHICH readily disaggregate and/ or become remouldable on immersion in water.
- Soft rock = compacted and/ or weakly cemented sediments and some volcanic products that are significantly stronger than engineering soils but may disaggregate, swell or become remouldable upon saturation in water.
- Hard rock = strong cemented or crystalline material that displays volume stability in water and which typically shows mass fracturing at variable spacing.

[1] Newsome, PFJ, Wilde, RH, and Willoughby, EJ, 2008: Land Resource Information System Spatial Data Layers – Data Dictionary. Landcare Research New Zealand Ltd, Private Bag 11052, Palmerston North, New Zealand

[2] Bell, D.H., 2004: Development of a Trenching Evaluation Method to Assess Trenching Difficulty for Telecommunication Services In New Zealand. Canterprise Limited Report CP/04/04/030 for TelstraClear Limited

[3] Bell, DH & Pettinga JR, 1983: Presentation of Geological Data in "Engineering for Dams and Canals", Proc Tech Groups IPENZ vol 9 issue 4(G):14.1-4.35

These categories become five when the soil is further divided into three classes: soft, medium and hard. Their definition is summarised in Table 1 below, along with the typical properties of cohesionless, cohesive and organic soils as recognised by Bell:

Table 1 - Rock and Soil Definition (after Bell, 2004)

Class	Soil and Rock Categories		Soil Engineering Properties		
			Cohesionless	Cohesive	Organic
1	SOFT SOIL	Very easily disaggregated or remoulded soil material	Loose silts, sands or fine gravels	Soft to very soft clay-rich materials	Soft peats/organic rich clays & silts
2	MEDIUM SOIL	"Normal" soil that can be readily excavated	Compact silts, sands or fine-medium gravels	Firm clay-rich soil material/ moist silts	Firm organic-rich clays & silts
3	HARD SOIL	Soil that requires significant excavation pressure	Densely packed or weakly cemented granular soils	Stiff clay-rich soil material/ dry silts	Stiff organic-rich clays & silts
4	SOFT ROCK	Genuine "soft rock" or weathered hard rock			
5	HARD ROCK	High strength rock +/- closely-spaced fractures			

We consider it appropriate to apply the Bell-Ducat soil and rock classification system to the lithologies in the LRIS GIS datasets for the following reasons:

- It is based upon standard, accepted definitions and terms for engineering geological description and classification of rocks and soils (NZ and Internationally).
- Sources of that information include: Bell and Pettinga (1983) and therefore other widely accepted precursors such as the Geological Society of London (1972 and 1977), IAEG (1981), and subsequently NZ Geomechanics Society (1984) and NZ Geotechnical Society (2005) guidelines for rock and soil description and classification for engineering purposes.
- The study included field work/field studies that provide a reliable and independent picture of terrain conditions in an engineering geological context.
- Bell-Ducat system as developed, involved driving a majority of the cabling routes within an ESA and assigning soil and rock classes and constraints.
- Both Bell (engineering geologist) and Ducat (telecommunications and cabling expert) took part together in the field studies.
- It uses a mix of topographic maps, published geological maps and aerial photograph interpretation to establish and extend rock and soils categories verified by the field studies.
- A range of engineering geological terrains were trialled from soft rock (i.e.weak rock) in Auckland and Northland to hill country in the southern Wairarapa to gravel outwash plains in Canterbury to the downlands of South Canterbury.
- The system was trialled in 11 out of 40 ESAs reassessed by Azimuth.
- This provided the basis for the establishment of the Bell/Ducat system of "easy, medium and hard" classes of terrain.

2.4 Application of Bell-Ducat system to LRIS GIS Datasets

The starting point for Beca's analysis was the group of 44 lithologies from the GIS lithology dataset 'rock2' which are summarised in Appendix 1 of the Data Dictionary, and correlated to the older 'rock' codes.

We took the descriptions given for the codes in the Data Dictionary and compared these to the descriptions for the Bell-Ducat classes, and assigned a class from 1 to 5 accordingly (refer Appendix A).

While there are just 44 'rock2' codes, the corresponding 'rock' codes can include multiple codes for a single 'rock2' code, and the same 'rock' code can represent a different 'rock2' code depending on whether it occurs in the North or South Islands. This duplication of codes within the 'rock' dataset meant it was necessary to make some assumptions in order to classify the data. Those assumptions are listed in Appendix A.

To obtain the most up-to-date GIS data coverage for all of NZ the decision was made to adopt the 'rock2' dataset where available, with all other areas retaining the older 'rock' dataset. The attributes of the resulting combined dataset were sorted on source ('rock' or 'rock2') and Island (North and South), making it easy to know when the assumptions relating specifically to the 'rock' dataset were applicable. An Excel spreadsheet with four worksheets resulted, including 'rock' North Island, 'rock' South Island, 'rock2' North Island, and 'rock2' South Island.

A new column was added to each worksheet and the letter codes for soil/ rock type converted to the corresponding Bell-Ducat numbers by way of 'find and replace' in Excel. The result being a reduction of some 3000+ unique letter codes to abouthalf as many Bell-Ducat numerical codes. The reduction does not result in the five Bell-Ducat classes instantly, because typically there are between one and four soil/ rock types assigned to each polygon, their stratigraphic relationships given as overlying/ mixed/ in patches, with the additional modifiers of crushed and deeply weathered.

The final step for reclassification to the Bell-Ducat classes then involved reducing the multiple classes down to just one for each unique code, based on the most likely soil/ rock to occur within the top one metre where trenching was expected to take place. This would ultimately reduce the data to just the 5 Bell-Ducat numbers. Again, assumptions were required to undertake this reduction, and the Data Dictionary gives some guidance in this, as does the Land Use Capability Survey Handbook[4]. Key assumptions/ interpretations we have adopted are:

1. As stated in the Data Dictionary and Land Use Capability Survey Handbook the first number listed in the list of rock type classes is deemed the most dominant (>75% coverage) and we have assumed that this rock type class has a minimum thickness of 1m. For example, scenarios where X/Y or X+Y are given, in both cases we assigned X as the Bell-Ducat number, since X is either overlying Y or is more dominant than Y in that polygon.
2. In cases where the rock type class is denoted as having a significant degree and depth of weathering i.e. written as X' in 'rock' or wX in 'rock2', a lesser Bell-Ducat number has been adopted. For weathered Bell-Ducat class 4 this would be reduced to a 2, i.e. weathered very stiff to weak sedimentary rocks. For weathered Bell-Ducat class 5 this would be reduced to a 4 i.e. weathered metamorphic or moderately strong to extremely strong

[4] Lynn, IH, Manderson, AK, Page, MJ, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, and PJF Newsome, 2009: Land Use Capability Survey Handbook - a New Zealand handbook for the classification of land 3rd ed. Hamilton, AgResearch; Lincoln, Landcare Research: Lower Hutt, GNS Science. 163p.

sedimentary, or weak to extremely strong igneous rocks. This reduction in Bell-Ducat class only applies to the rock classes 4 and 5, the soils 1-3 are assumed to retain their Bell-Ducat class even if weathered.

3. Where there are patches (20-75% coverage) of one class overlying another, i.e. written as (X)/Y in 'rock' or pX/Y in 'rock2', then we have assumed that patches are most representative of the top 1m thickness of material. In these cases the Bell-Ducat number for the patches will be assigned, i.e. X.
4. Polygons which are lakes, quarries, rivers or towns remain as named.

This process outlined above combined with the assumptions we have made can be replicated by CCNZ and interested parties using the original LRIS GIS data. The output of this process is shown on the plans presented in Appendix B.

3 Discussion

The Bell-Ducat system of soil classification has been successfully applied to the LRIS 'Lithology' datasets, providing 5 terrain classes to the rural areas of the north and south island, as presented in Appendix B. However, the following limitations should be considered:

- The LRIS data set is at a resolution that does not consider road cuttings or embankments. As a result it is expected that there are areas where this will result in a different soil class being encountered e.g. engineered fill embankments utilising locally sourced or imported fill materials or road cuttings into the underlying rock materials.
- The LRIS data set does not include 'lithologies' in the urban areas. The surficial deposits in urban areas are typically highly variable, including areas of cut into underlying soils/rock, non-engineered and engineered fill. Assessment of the Bell-Ducat classes for towns will need to be made from other datasets, possibly using other published geological data including GNS published 1:50,000 (non-digitised) or 1:250,000 Q-maps (digitised).
- Existing LRIS GIS layers, including 'slope angle' and 'bare rock' could also be assessed to improve the accuracy of assigned soil classes. As part of our study we considered these layers, including 'bare rock' and 'slope angle greater than 35 degrees over Bell-Ducat class (refer Appendix B). However, a significantly greater amount of time than allowed for in this stage of the project would be required to develop reasonable assumptions and provide improved accuracy.
- Due to the set of assumptions made there is a risk that lithology class may differ to what we have assessed it as. For example: our assumptions regarding thickness and the predominant lithology may be reasonable for the scope of this study and the scale of the GIS data (1:50,000 / 1:63,360 scale). However, locally due to a range of geomorphological factors and processes soil class may be expected to be more variable.
- In line with recommendations provided by Bell (2004), should lithology be a significant factor in a particular ESA, then further desk based study supported by targeted field studies could improve the current model. Such desk based studies could include reviewing other published geological data, topography and aerial photographs.

4 Conclusions

This study has achieved the aim of providing terrain classification system, with no more than 10 classes, to be applied to the Landcare 'lithology' GIS dataset.

The applicability of the Bell-Ducat soil/rock class system has been reviewed with consideration to the engineering geological and geotechnical aspects and we consider this system appropriate to be applied to the 'lithology' dataset.

In the process of applying the Bell-Ducat classes to the 'lithology' dataset a set of assumptions were made based on guidance provided in NZLRIS Data Dictionary and Land Use Capability Survey Handbook, and New Zealand experience. These assumptions may be summarised as follows:

- Overlying (nearest surface) in the 'lithology' dataset assumed to be representative to 1.0m below ground level.
- Most predominant layer 'lithology' dataset assumed to be representative.
- Where 'patchy' material overlying the predominant or nearest surface layer, the 'patchy' layer assumed to be representative.
- Polygons in the GIS that are lakes, quarries, rivers or towns remain as named.

The main limitations on the dataset that we have produced include:

- Insufficient information provided in the NZLRIS database to determine 'lithology' underlying urban areas.
- There may be limited applicability to areas that aren't 'green field' sites.
- Actual trenching may not be in greenfields but along the verge of roads, hence along a cut or incision into the geology and therefore possibly to deeper classes of soil /rock than those shown on the GIS map at any one place.
- This is a high level desk based study utilising GIS data developed from 1:50,000 and 1:63,360 scale studies by NZLRIS, with no field verification to confirm the Bell-Ducat classes that Beca has assigned to the lithologies. It is expected that locally, due to a range of geomorphological factors and processes soil class may be expected to be more variable than provided by our model.

5 Recommendations

It is recommended that:

- Assessment of urban areas be undertaken to allow for Bell-Ducat class to be applied to these areas including consideration of incorporation of other geological data sources i.e. GNS published geological maps, and contractor experience.
- Where telecommunications are to be installed under or immediately adjacent to roads, consideration needs to be given as to how this shall affect our assumed Bell-Ducat class for the 'lithology' data set.
- Discussion with experienced contractors with regard to the Bell-Ducat classes and how the classes relate to different telecommunication installation technologies that could be employed.
- If soil class is considered to have a significant cost impact New Zealand wide or in a particular ESA, then it is recommended that further detailed desk based study and field verification be considered.

6 Applicability

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

Appendix A

Table 2 – Application of Bell-Ducat (B-D) lithology CLASS to NZLRIS lithology rock/rock2

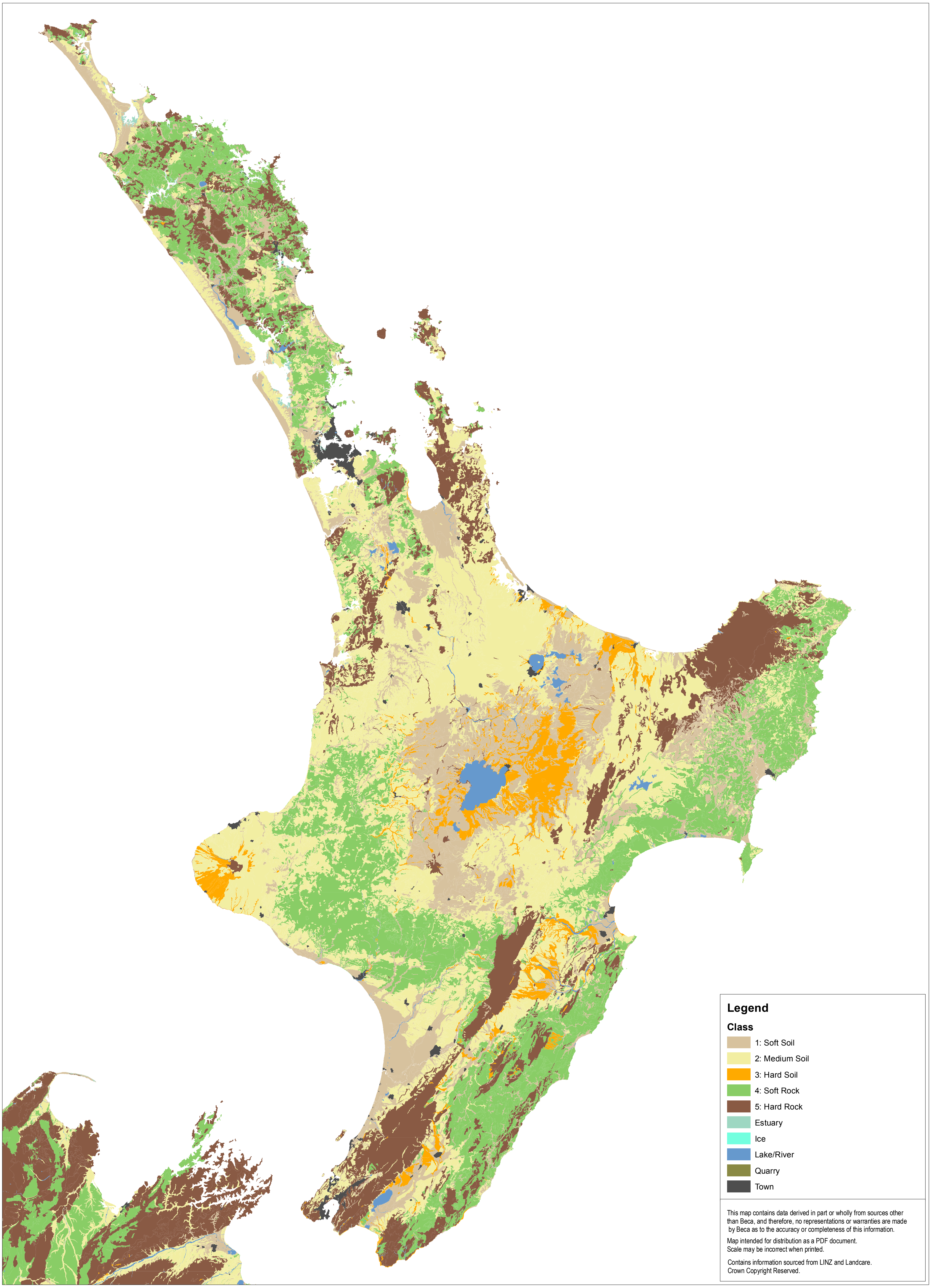
'rock2' code (Ed2)	Interpreted B-D (2004) CLASS	Rock type class	'rock' code (Ed1)				Notes
			North Island (NI)	NI Interpreted B-D (2004) CLASS	South Island (SI)	SI Interpreted B-D (2004) CLASS	
Igneous Rocks: (i) extremely weak to weak							
Ng	1	Ngauruhoe tephra	Ng	1	-	-	
Ta	1	Tarawera tephra	Ta	1	-	-	
Lp	2	Pumiceous lapilli	Lp	2	-	-	
Tp	3	Taupo & Kaharoa breccia & pumiceous alluvium	Tp	3	-	-	
Ft	3	Quaternary breccias older than Taupo breccia	Ft	3	-	-	
Vu	2	Extremely weak altered volcanics	Vu	2	-	-	
Rm	1	Rotomahana mud	Rm	1	-	-	
Sc	2	Scoria	Sc	2	-	-	
Kt	1	Kaharoa & Taupo ashes	Kt	1	-	-	
Mo	2	Ashes older than Taupo ash	Mo	2	-	-	
La	3	Lahar deposits	La	3	-	-	
Igneous Rocks: (ii) weak to extremely strong							
Vo	5	Lavas & welded ignimbrites	ptVo	5	ptVo	5	
Vb	5	Indurated volcanic breccias	ptCg	5	ptTb, ptVo	5	
Gn	5	Plutonics	Gn	5	Gn	5	
Tb	5	Indurated fine-grained pyroclastics	ptCg	5	ptTb	5	
In	5	Ancient volcanics	ptVo	5	In	5	

'rock2' code (Ed2)	Interpreted B-D (2004) CLASS	Rock type class	'rock' code (Ed1)				Notes
			North Island (NI)	NI Interpreted B-D (2004) CLASS	South Island (SI)	SI Interpreted B-D (2004) CLASS	
Um	5	Ultramafics	Um	5	Um	5	
Sedimentary Rocks: (i) very loose to compact (very soft to stiff)							
Pt	1	Peat	Pt	1	Pt	1	
Wb	1	Windblown sand	Wb	1	Wb	1	
Gr	2	Alluvium gravels	ptGr	3	ptAl	2	*ptGR in 'rock' in the North Island also includes coarse slope deposits and weakly consolidated conglomerate, thus CLASS 3 assumed.
?Gl	3	Glacial till	-	-	ptAl	2*	*ptAl in 'rock' in the South Island also includes fine alluvium, coarse slope deposits and alluvial gravel, thus CLASS 2 assumed
Us	2	Unconsolidated sands & gravels	ptUs	2	-	-	
Lo	2	Loess	Lo	2	Lo	2	
Af	1	Fine alluvium	Al	1	ptAl	2*	*ptAl in 'rock' in the South Island also includes coarse slope deposits, glacial till and alluvial gravel, thus CLASS 2 assumed
Cl	3	Coarse slope deposits	ptGr	3	ptAl	2*	*Cl (Coarse slope deposits) where identified in 'rock2' and ptGr are CLASS 3, however where ptAl, then CLASS 2
Uf	1	Unconsolidated clays & silts	ptUs	2*	-	-	*ptUS in 'rock' in the North Island also includes coarse slope deposits and alluvial gravels, thus CLASS 2 assumed
Sedimentary Rocks: (ii) very compact (very stiff) to weak							

'rock2' code (Ed2)	Interpreted B-D (2004) CLASS	Rock type class	'rock' code (Ed1)				Notes
			North Island (NI)	NI Interpreted B-D (2004) CLASS	South Island (SI)	SI Interpreted B-D (2004) CLASS	
Mm	4	Massive mudstone	Mm	4	ptMs	4	
Mf	4	Frittered mudstone or jointed mudstone	ptMj	4	ptMs	4	
Sm	4	Massive mudstone	ptSm	4	Ss	4	
Cw	4	Weakly consolidated conglomerate	ptGr*	3*	Cw	4	*ptGr in 'rock' in the North Island also includes coarse slope deposits and alluvial gravels, thus CLASS 3 assumed
Ac	4	Crushed argillite associate of rocks	ptAc	4	Ar	4	
Mb	4	Bedded mudstone	Mb	4	ptFy, ptMs	4	
Me	4	Bentonitic mudstone	Me	4	ptMs	4	
Sb	4	Bedded sandstone	ptSb	4	ptFy, ptSs	4	
Mx	4	Sheared mixed lithologies	ptMj, ptSb, ptSm, ptAc	4	PtMs	4	
Sedimentary Rocks: (iii) moderately strong to extremely strong							
Ar	5	Argillite	ptAr	5	ptAr	5	
Cg	5	Conglomerate & breccia	ptCg, ptGw	5	Cg	5	
Li	5	Limestone	Li	5	Ls	5	
Si	5	Indurated sandstone	ptSm, ptGw	4* or 5	Hs	5	*ptSm (massive sandstone) in 'rock' in the North Island also includes sheared mixed lithologies and massive sandstone, thus CLASS 4 assumed.

'rock2' code (Ed2)	Interpreted B-D (2004) CLASS	Rock type class	'rock' code (Ed1)				Notes
			North Island (NI)	NI Interpreted B-D (2004) CLASS	South Island (SI)	SI Interpreted B-D (2004) CLASS	
Gw	5	Greywacke association of rocks	PtGw, ptAr	5	ptGw, ptAr	5	
Metamorphic Rocks							
Sx	5	Semi-schist	ptGw	5	St1	5	
Gs	5	Gneiss	-	-	Gs	5	
Sy	5	Schist	-	-	St2	5	
Ma	5	Marble	-	-	Ma	5	

Appendix B



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Map Scale @ A3: 1:2,200,000

0 25 50

Kilometres

Revision	Author	Verified	Approved	Date
1	HEC	AYF	JB	19/09/2014

Title:

North Island rock classification based on NZLRI Rock Dataset

Client: Commerce Commission

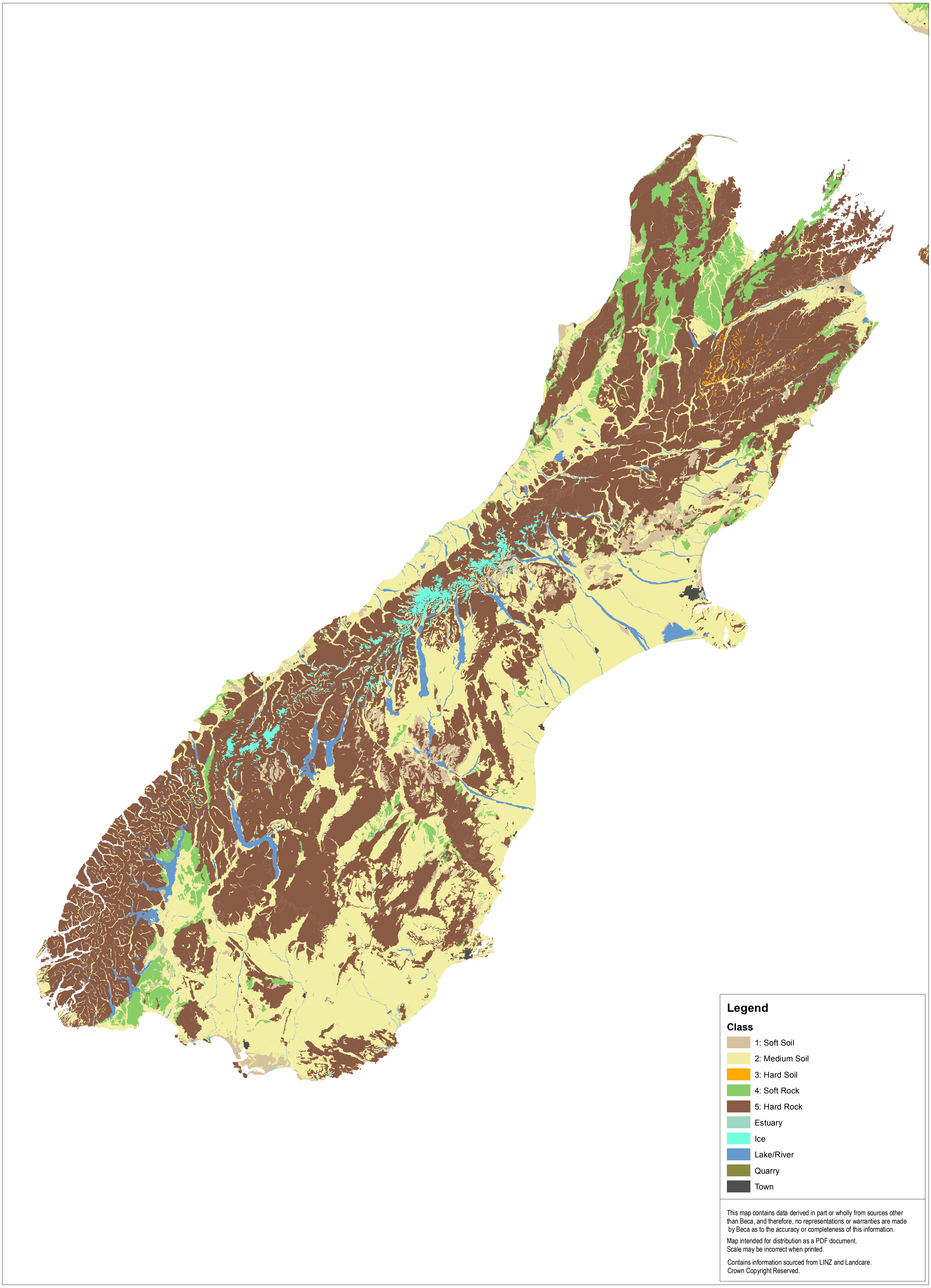
Project: FPP Project Corridor Costs Analysis

N

Beca

Discipline: GIS

Drawing No: GIS-7778015-01



This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.

Map intended for distribution as a PDF document. Scale may be incorrect when printed.

Map Scale @ A3: 1:2,500,000

0 25 50
Kilometres

Revision	Author	Verified	Approved	Date
1	HEC	AYF	JB	19/09/2014

Title:

South Island rock classification based on NZLRI Rock Dataset

Client: Commerce Commission

Project: FPP Project Corridor Costs Analysis

N

Discipline: GIS

Drawing No: GIS-7778015-02

File: P:\777\777-GIS-WLG\7778015\TG\55_Workspaces\01_mxd\GIS-7778015-02_SouthIsland_RockClassification.mxd Author: Date: 30/09/2014

GIS@beca.com

Appendix 2

FPP Corridor Cost Analysis of Trenching Rates in New Zealand

CORRIDOR COST ANALYSIS OF TRENCHING AND DUCTING RATES IN NEW ZEALAND

National averge rates per metre for installed telecommunication duct in New Zealand, revised 26-Sep

Rural Trenching

	In Depths 0.6m to 1.7m	1 duct	2 ducts	3 ducts	4 ducts	5 ducts	6 ducts	7 ducts	8 ducts	9 ducts	10 ducts	11 ducts	12 ducts	13 ducts	14 ducts	15 ducts	16 ducts	17 ducts	18 ducts	19 ducts	20 ducts	21 ducts	22 ducts	23 ducts	24 ducts	25 ducts	26 ducts	27 ducts	28 ducts	29 ducts	30 ducts	31 ducts	32 ducts	33 ducts	34 ducts	35 ducts	36 ducts
Per metre costs in Soil Type 1		NZD excluding GST																																			
	40 - 50mm dia duct																																				
1.1.1	Chain Digger (not in dry sand)	36	58	80	102	124	146	168	190	212	234	256	278	300	322	344	366	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	754	776	798	820
1.1.2	Open trench 400 wide	52	81	111	141	170	200	230	261	291	321	350	380	410	441	471	500	530	560	589	619	651	680	710	740	769	799	830	860	890	919	949	979	1,008	1,040	1,069	1,099
1.1.3	Open trench 600 wide	59	89	118	148	178	207	237	267	296	326	356	385	415	445	479	509	538	568	598	627	657	687	716	746	776	805	840	870	899	929	959	988	1,018	1,048	1,077	1,107
1.1.4	Directional Drilling (not in sand)	51	74	97	120	143	179	202	226	255	278	301	324	358	381	404	427	471	494	517	540	563	600	623	646	669	692	716	754	777	800	846	869	892	915	938	961
	110mm dia duct																																				
1.2.1	Chain Digger (not in dry sand)	44	74	104	134	171	201	231	261	298	328	358	388	425	455	485	514	552	582	611	641	679	708	738	768	806	835	865	895	932	962	992	1,022	1,059	1,089	1,119	1,149
1.2.2	Open trench 400 wide	60	99	137	175	214	256	294	332	371	409	451	489	528	566	604	646	685	723	761	800	857	895	933	972	1,010	1,052	1,090	1,129	1,167	1,205	1,247	1,286	1,324	1,362	1,401	1,439
1.2.3	Open trench 600 wide	68	106	144	183	221	259	298	341	379	418	456	494	533	571	614	652	691	729	767	806	844	887	926	964	1,002	1,041	1,079	1,117	1,175	1,214	1,252	1,290	1,329	1,367	1,406	1,444
1.2.4	Directional Drilling (not in sand)	59	104	141	183	235	267	312	364	409	447	489	540	572	617	677	721	759	801	853	884	930	982	1,026	1,064	1,106	1,158	1,189	1,235	1,294	1,339	1,376	1,418	1,470	1,502	1,547	1,599
Per metre costs in Soil Type 2		NZD excluding GST																																			
	40 - 50mm dia duct																																				
2.1.1	Chain Digger	36	58	80	102	124	146	168	190	212	234	256	278	300	322	344	366	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	754	776	798	820
2.1.2	Open trench 400 wide	45	74	104	134	163	193	223	253	283	313	342	372	402	433	462	492	522	551	581	611	642	671	701	731	760	790	821	850	880	910	939	969	999	1,030	1,059	1,089
2.1.3	Open trench 600 wide	52	81	111	141	170	200	230	259	289	319	348	380	410	439	469	499	528	558	588	617	647	678	708	738	767	797	827	856	886	916	945	975	1,007	1,036	1,066	1,096
2.1.4	Directional Drilling	52	76	99	123	147	183	207	231	261	284	308	332	366	390	413	437	481	505	529	552	576	614	637	661	685	708	732	771	795	819	865	889	913	936	960	983
	110mm dia duct																																				
2.2.1	Chain Digger	44	74	104	134	171	201	231	261	298	328	358	388	425	455	485	514	552	582	611	641	679	708	738	768	806	835	865	895	932	962	992	1,022	1,059	1,089	1,119	1,149
2.2.2	Open trench 400 wide	53	92	130	171	209	247	288	326	365	406	444	482	523	561	600	640	679	717	758	796	835	875	914	952	993	1,031	1,069	1,125	1,163	1,202	1,243	1,281	1,319	1,360	1,398	1,437
2.2.3	Open trench 600 wide	60	99	137	175	214	256	294	332	371	409	451	489	528	566	604	646	685	723	761	800	842	880	918	957	995	1,037	1,075	1,114	1,152	1,190	1,232	1,271	1,309	1,347	1,386	1,428
2.2.4	Directional Drilling	61	106	145	188	241	273	320	373	419	457	500	553	586	632	693	739	777	820	873	906	952	1,005	1,051	1,090	1,133	1,186	1,218	1,265	1,325	1,371	1,410	1,453	1,506	1,538	1,585	1,638
Per metre costs in Soil Type 3		NZD excluding GST																																			
	40 - 50mm dia duct																																				
3.1.1	Open trench 400 wide	45	74	104	134	163	193	223	253	283	313	342	372	402	433	462	492	522	551	581	611	642	671	701	731	760	790	821	850	880	910	939	969	999	1,030	1,059	1,089
3.1.2	Open trench 600 wide	52	81	111	141	170	200	230	259	289	319	348	380	410	439	469	499	528	558	588	617	647	678	708	738	767	797	827	856	886	916	945	975	1,007	1,036	1,066	1,096
3.1.3	Directional Drilling	74	107	141	174	208	260	294	327	370	404	437	471	519	553	587	620	683	717	750	784	817	871	905	938	972	1,005	1,039	1,095	1,128	1,162	1,228	1,262	1,295	1,329	1,362	1,396
	110mm dia duct																																				
3.2.1	Open trench 400 wide	53	92	130	171	209	247	288	326	365	406	444	482	523	561	600	640	679	717	758	796	835	875	914	952	993	1,031	1,069	1,125	1,163	1,202	1,243	1,281	1,319	1,360	1,398	1,437
3.2.2	Open trench 600 wide	60	99	137	175	214	256	294	332	371	409	451	489	528	566	604	646	685	723	761	800	842	880	918	957	995	1,037	1,075	1,114	1,152	1,190	1,232	1,271	1,309	1,347	1,386	1,428
3.2.3	Directional Drilling	80	140	191	247	318	360	421	492	552	602	659	729	772	833	913	973	1,024	1,081	1,151	1,193	1,254	1,325	1,385	1,435	1,492	1,562	1,605	1,666	1,746	1,806	1,857	1,914	1,984	2,026	2,087	2,158
Per metre costs in Soil Type 4		NZD excluding GST																																			
	40 - 50mm dia duct																																				
4.1.1	Open trench 400 wide	66	96	125	155	185	214	244	277	306	336	365	395	425	457	487	517	546	576	605	635	668	697	727	757	786	816	848	878	908	937	967	997	1,026	1,059	1,089	1,118
4.1.2	Open trench 600 wide	84	114	143	173	203	232	262	292	321	351	380	415	444	474	503	533	563	592	622	652	681	715	745	775	804	834	863	893	923	952	982	1,012	1,046	1,075	1,105	1,135
	110mm dia duct																																				
4.2.1	Open trench 400 wide	87	125	163	209	247	286	332	370	408	454	493	531	577	615	653	699	738	776	822	860	898	945	983	1,021	1,067	1,105	1,144	1,205	1,243	1,281	1,327	1,365	1,404	1,450	1,488	1,526
4.2.2	Open trench 600 wide	111	149	187	225	263	314	352	390	428	466	517	555	593	631	669	719	758	796	834	872	922	961	999	1,037	1,075	1,125	1,164	1,202	1,240	1,278	1,328	1,366	1,405	1,443	1,481	1,531
Per metre costs in Soil Type 5		NZD excluding GST																																			
	40 - 50mm dia duct																																				
5.1.1	Rock Saw 600 deep	163	192	222	252	415	444	474	504	666	696	726	755	918	948	978	1,007	1,170	1,200	1,229	1,259	1,422	1,452	1,481	1,511	1,674	1,703	1,733	1,763	1,926	1,955	1,985	2,015	2,177	2,207	2,237	2,266
	110mm dia duct																																				
5.2.1	Rock Saw 600 deep	172	210	382	420	592	630	802	840	1,012	1,050	1,222	1,260	1,432	1,470	1,642	1,680	1,852	1,890	2,062	2,100	2,272	2,310	2,482	2,520	2,692	2,730	2,902	2,940	3,112	3,150	3,322	3,360	3,532	3,570	3,742	3,780

Urban Trenching

	In Depths 0.7m to 1.8m	1 duct	2 ducts	3 ducts	4 ducts	5 ducts	6 ducts	7 ducts	8 ducts	9 ducts	10 ducts	11 ducts	12 ducts	13 ducts	14 ducts	15 ducts	16 ducts	17 ducts	18 ducts	19 ducts	20 ducts	21 ducts	22 ducts	23 ducts	24 ducts	25 ducts	26 ducts	27 ducts	28 ducts	29 ducts	30 ducts	31 ducts	32 ducts	33 ducts	34 ducts	35 ducts	36 ducts
Per metre costs in Soil Type 2/3 or Fill		NZD excluding GST																																			
	40 - 50mm dia duct																																				
6.1.1	Open trench 400 wide	96	128	160	192	224	256	288	322	354	386	418	450	482	516	548	579	611	643	675	707	741	773	805	837	869	901	935	967	999	1,031	1,063	1,094	1,126	1,160	1,192	1,224
6.1.2	Open trench 600 wide	128	160	192	224	256	288	320	352	384	416	448	483	515	547	579	610	642	674	706	738	770	805	837	869	901	933	965	997	1,029	1,061	1,093	1,124	1,159	1,191	1,223	1,255
6.1.3	Directional Drilling	65	95	125	155	184	231	260	290	328	357	387	417	460	490	519	549	605	635	665	694	724	772	801	831	861	891	920	970	999	1,029	1,088	1,118	1,147	1,177	1,207	1,236
6.1.4	Thrust boring	70	140	210	280	350	420	490	560	630	700	770	840	910	980	1,050	1,120	1,190	1,260	1,330	1,400	1,470	1,540	1,610	1,680	1,750	1,820	1,890	1,960	2,030	2,100	2,170	2,240	2,310	2,380	2,450	2,520
	110mm dia duct																																				
6.2.1	Open trench 400 wide	110	152	193	239	280	322	367	409	450	496	537	579	624	666	707	753	794	836	882	923	965	1,010	1,052	1,093	1,154	1,195	1,237	1,282	1,324	1,365	1,411	1,452	1,494	1,539	1,581	1,623
6.2.2	Open trench 600 wide	144	186	227	269	310	358	399	441	482	530	571	613	654	696	743	785	826	868	916	957	999	1,040	1,082	1,129	1,171	1,212	1,254	1,301	1,343	1,384	1,426	1,467	1,515	1,556	1,598	1,640
6.2.3	Directional Drilling	74	130	177	230	295	334	391	456	512	559	612	677	717	774	848	904	951	1,003	1,068	1,108	1,165	1,230	1,286	1,333	1,386	1,451	1,490	1,547	1,621	1,677	1,724	1,777	1,842	1,881	1,938	2,004
6.2.4	Thrust boring	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000	3,100	3,200	3,300	3,400	3,500	3,600

Mole Plough Trenching

	In Depths up to 1.0m	1 cable	2 cable	3 cable	4 cable	5 cable	6 cable
Per metre cost for ploughing only in Soil Types 1/2 - cost of cable not included		NZD excluding GST					
	Cable size up to 30mm dia						
7.1.1	North Island	2	2	3	3	4	4
7.1.2	South Island	5	5	6	6	7	7

Clarifications and Assumptions

All rates are the national average and allow for excavation, duct supply & install, backfill, surface reinstatement, consenting and traffic management
Rates for all open trenches deeper than 1.5m allow for trench shields in all soil types
Rates for rural open trenches deeper than 0.9m allow for trench shields in soil type 1 only
Rates for rural open trenches and chain digging allow for reinstatement of grass only, with no imported and compacted backfill
Rates for urban open trench allow for 'highest cost' reinstatement i.e. compacted, imported backfill with 30mm thick AC14 asphalt
Minimum depth of compacted hard fill under trafficable areas is 600mm
Urban trenching in berms and under carriageways to comply with NZ standard NZS:4404 2010, drawing CM-001
We are not aware of any NZ standards or codes of practice that govern or restrict the number of telecommunication ducts placed in a trench
Rates for ducts in open trenching therefore allow for one (1) trench only with variable depths as required to suit duct numbers
No allowance made for de-watering in any locations
Rates for chain digging are for 100mm wide, 1000mm deep in all cases. Once maximum number of ducts are reached a new trench must be dug.
Rates for rock sawing are for 100mm wide, 600mm deep in all cases. Once maximum number of ducts are reached a new trench must be dug.

Regional Variance

The following regional price variances are calculated from tender information, price enquiries and local estimating rates. The lower and upper range relate to the average nationwide rate shown in the Trenching Table

Priced Regions	% Range	
	Lower	Upper
CSA 10 ~ Northland	-13%	-9%
CSA 07, 08, 09 ~ Auckland	-5%	-3%
CSA 11 ~ Waikato		
CSA 06 ~ Western North Island		
CSA 05 ~ Bay of Plenty	-9%	-5%
CSA 04 ~ Eastern North Island	-10%	-5%
CSA 03 ~ Wellington/Horowhenua	+7%	+9%
CSA 02 ~ Upper South Island	+8%	+12%
Christchurch/Ashburton	+15%	+20%
CSA 01 ~ Lower South Island		

Power Pole Rates

The average new power pole installation rate in New Zealand is approximately $5,000 + GST. The following range takes into account both tender & regional variance.

Supply & install new	Range	
	Lower	Upper
Price per pole	$4,000	$6,000
Cost per kilometre (14 no.)	$56,000	$84,000

Technician Rates

Workman Skill Level	Range	
	Lower	Upper
Certified overhead power linesman	$125.00	$150.00
Telecommunications technician	$55.00	$75.00

Appendix 3

Beca Profile

Since our inception in 1918, the Beca group has become an impressive global organisation, with a strong track record of success and a reputation for quality and innovation. Trust and integrity are cornerstones of our professional practice.

The Beca group is one of Asia-Pacific's most respected and leading professional services organisations, specialising in the design and management of projects. From prestigious landmark developments, to functional and environmentally sustainable projects, Beca's repertoire is broad.

As a multi-disciplinary organisation, we have the capability to work in a diverse range of sectors. We have more than 3000 employees, and we have operated in more than 70 countries worldwide. With such a spread of resource, Beca can tap into a rich pool of specialist knowledge and experience. We work closely with our clients with a view to delivering award-winning solutions as a single collaborative team.

The Beca group is an employee-owned company, focused on providing our clients with independent and impartial advice. We are committed to building strong and lasting relationships by responding to the needs and aspirations of our clients and our communities.

International Operations

Beca operates out of three main hubs within the Oceania and South-East Asia regions:

- **New Zealand** - headquarters of the Beca group, with responsibility for the Pacific: regional offices in Auckland, Tauranga, Hamilton, New Plymouth, Wellington, Christchurch, Dunedin, Palmerston North
- **Australia** - offices in Sydney, Melbourne, Brisbane, Adelaide, Canberra
- **Singapore** – a hub for Asia.

Beca also has associated or affiliated offices in China, Indonesia, Myanmar, Chile, Fiji, Papua New Guinea, and New Caledonia.

Through our regional focus, we have gained valuable experience in the provision of consulting services in developing countries of the Pacific including Samoa, Fiji, Tuvalu, Niue, Cook Islands, Tokelau, Nauru, Marshall Islands, and the Federated States of Micronesia, as well as other developing nations in South East Asia, Asia and Central America.

Beca has a policy of ensuring teams include local professionals and support staff to increase the project's knowledge of the local environment.

Group Capability

- Airport engineering and planning
- Architecture
- Asset performance management
- Automation and control engineering
- Building services engineering
- Chemical engineering
- Civil engineering
- Communications engineering
- Cost management services
- Earthquake engineering
- Electrical engineering
- Environmental management and engineering
- Fire engineering
- Geographic information systems
- Geotechnical services
- Hydraulic engineering
- Illumination engineering
- Land development engineering and surveying
- Mechanical engineering
- Operations research and systems technology
- Petrochemical engineering
- Photogrammetry – aerial mapping
- Planning - urban and resource management
- Port and coastal engineering
- Power systems
- Process control and instrumentation
- Process simulation and modelling
- Project management
- Rail engineering
- Resource management
- Roading
- Soils engineering and geomechanics
- Soils, water and air testing and analysis
- Stormwater management
- Structural engineering
- Systems engineering and technology
- Transportation and traffic engineering
- Valuations
- Water and wastewater engineering

Services

Airport Services – Beca offers tailored planning, design and management services to support core airport activities. Our Airports team provides master planning, strategic planning, runway and pavement design, terminal concept and detailed design, and lighting design for national and international airports. We are conversant with airport procedures and experienced in the detailed planning and liaison with airport management, aviation authorities and airlines.

Architectural Services - Beca's architectural team provides a complete service from brief development, feasibility studies and site master planning, to conceptual and detailed architectural design. We have a solid base of experience in educational, institutional, industrial and infrastructural work and, with access to the engineering expertise within the Beca group, can identify and address critical design issues early in the project cycle.

Buildings – The Beca Buildings team delivers customised building engineering outcomes, integrating structural and building services on a wide variety of international building projects. Our buildings team adds value to our clients and project stakeholders by combining the different skills and technical knowledge of our structural and services engineers into a more integrated and effective “whole building” system. The Beca Buildings team also has established, specialist expertise in the areas of ecologically sustainable design for Green Buildings as well as in fire engineering and protection.

Business Performance - Beca brings together a team of dedicated professionals from across the group, focusing on asset performance, business process improvement, systems engineering, specialist software development and complex simulation modelling. We have intellectual property and experience that can be dedicated to solving highly complex business problems, ranging from organisational restructuring and vendor selection to the optimisation of complex manufacturing processes using dedicated simulation software.

Civil and Transport – Beca’s services in rail, road and transport management include route option identification and analysis, environmental assessments, surveys, materials investigations, design, construction management, cost engineering, safety studies and maintenance planning. We are experienced in the use of the World Bank HDM model and have full capability in RAMM. Our civil team also provides investigation, planning, design and construction management of marine and hydraulic facilities (including marinas, wharves, port structures and coastal protection works).

Cost Management – Beca offers skills, across almost all market sectors, in capital cost estimating, cost planning, estimate overview or verification, value engineering/design optimisation, contracting strategies/methodologies, contract formation and management, preparation of schedules of quantities, procurement plans, procedures and management, cost management, administration, reporting cash flow forecasts and projections.

Food and Beverage – Beca Food and Beverage is currently the largest independent, specialist engineering consultancy to the food and beverage industry in Australasia. We offer an integrated service that spans all stages from raw materials to packaged product, encompassing feasibility studies, preliminary design, detailed design and operation. We have specialists in processing, packaging, refrigeration, energy systems, automation, environmental management, civil and structural, and project management.

Geospatial – Beca's geospatial services include land surveying associated with boundaries, engineering works and construction set-out, Geographic Information Systems (GIS), digital mapping from aerial photos and orthophoto production. We have over 40 technical staff who specialise in data collection (ground survey and photo-grammetric mapping), data management and data analysis of land information using both CAD and GIS tools.

Geotechnical – Beca's geotechnical services include designing and undertaking site investigations, designing foundations and retaining walls, assessing slope stability, geological mapping, pavement design, services to open cast mines, groundwater analysis and hazard studies. Geotest is an IANZ accredited Geotechnical Laboratory, offering independent laboratory and field-testing services to a wide range of clients. Our laboratory is fully equipped for soil, rock, aggregate and concrete testing, providing technical data to assist designers and contractors.

Industrial – This group undertakes Beca's activities in oil and gas processing, mining and metals processing, services to forestry (through Beca AMEC Ltd), and the manufacturing and chemical industries. With access to in-house as well as external industry alliances, Beca can offer engineering, design, asset management and contractual services to smooth the pathway to production. We also have specialists dedicated to plant shutdown, detailed planning, scheduling, procurement and management for a whole range of industries.

Planning – The Beca planning team offers comprehensive advice and a strong track record across the full gamut of planning services from policy and strategic planning, to statutory and development planning, coastal strategies, urban development and renewal, environmental planning, managing community consultation programmes, social planning, and within New Zealand the specialised area of tangata whenua (Maori) planning issues.

Power Systems - The strength and diversity of the power systems team in the generation, transmission and distribution sectors is firmly established and increasingly utilised in projects throughout Australasia and South East Asia. We have capability in the system protection, communications and transmission line design areas, as well as industrial power, instrumentation and controls, and systems integration.

Process and Controls – Beca's process and controls service is founded on technical experience in areas such as control system topology design, SCADA and DCS configuration, RTU configurations and system design, custom software front ends and solutions, electrical and process design, and IT services and network design. We offer a focused solution in bringing together specialist skills in control system design and process design from an integrated design team.

Project Management – Beca provides both management services and project managers to clients, particularly those with multi-disciplinary or management-intensive projects. Other specialised services include quality management, project programming, contract documentation, document control systems and risk management. Our service is based on our knowledge and understanding of project management principles, which we tailor to specific client and project needs.

Structural Engineering - Beca's long history is founded on our skill and experience in the areas of structural and civil engineering, both for commercial as well as industrial projects. Creative, cost-effective structural design is a feature of our projects. Our experience of the technologies in seismic engineering is some of the most advanced in the world, and our engineers are called upon regularly to undertake reconnaissance following major earthquakes both in New Zealand and overseas.

Water and Environment – Beca provides innovative and practical advice for water, stormwater, wastewater and environmental engineering projects. This encompasses water resources, intakes, water treatment plants, pump stations and pipelines, distribution systems, specialised software systems and modelling, short and long-term stormwater management, air and water quality, environmental management plans and systems, compliance auditing and environmental feature designs.

Valuations - Beca's valuation team of property, plant and machinery valuers has diverse skills and experience gained from many industries including government and corporate valuation consultancies, civil and electrical engineering, and defence. Our services include valuations for insurance and financial reporting purposes, asset management, current market valuations and due diligence consultancy.

Collaborative working

Beca has a strong track record in developing long-term relationships with clients in a range of sectors. Having a thorough understanding of a client's capital plans enables us to assist them with strategic capital planning. We recognise 'best value' capital expenditure and optimise operation efficiency with a view to reducing operating costs over the long-term.

By working closely together, Beca can develop site-based delivery programmes for clients working on large projects such as major industrial plants, mines, airports, ports, resorts, hospitals. Clients gain the benefit of drawing on our flexible resources when they need them - often the clients' permanent staff levels required for technical services can be reduced, as Beca can cover peaks in the workload.

Quality Management

Beca is committed to recognising quality standards in all aspects of our operations. In particular, this includes dedication to the experience of our employees and the principles of quality of products and services, the efficiency of work processes and the effectiveness of management systems. An essential element of our policy is a strong focus on and commitment to our clients and their requirements.

Management systems are implemented and subjected to continuous review for consistent quality and ongoing improvement. We seek ongoing certification to the International Quality Standard ISO 9001 to provide confidence in our systems and provide opportunity for added value through external appraisal.

Environmental

Finding the balance between sustainable solutions that work from an environmental, social and cultural standpoint, and meeting statutory obligations within economic restrictions is the primary driver for Beca's work in environmental management. We have staff working on practical ways to manage wide-ranging issues, including industrial hazards and toxic substances, to minimise contamination of the air, soil, water and stormwater. Our team includes auditors registered with the Quality Society of Australasia (RABQSA), including lead auditor level (contaminated sites assessment, compliance, and environmental management).

Health & Safety

Beca has definitive work instructions so Beca staff maintain a safety oriented approach wherever they may be working. This complements our clients' health and safety procedures. A health and safety team is also available to provide support to project staff in all locations around the world.

In response to the requirements of the health and safety legislation in the countries in which we operate, we have developed company-wide policies and procedures relating to our health and safety management. In addition, we have a health and safety policy that provides a statement of our intent and can be supplied on request.

Ownership and Financial Performance

Beca is a company owned by senior employees, who are focused on the growth and success of Beca. The company has achieved steady growth under this shareholding structure. Clearly, the opportunity to participate in the company's financial success with the accompanying sense of ownership engenders a belief in Beca's future, a strong commitment to our clients, and a pride in what we deliver.

Avoiding over-reliance on any single area of business means that Beca has enjoyed longevity and a consistently robust workload, while maintaining steady returns to shareholders, even during periods of economic decline or turbulence in some markets

Group Revenue