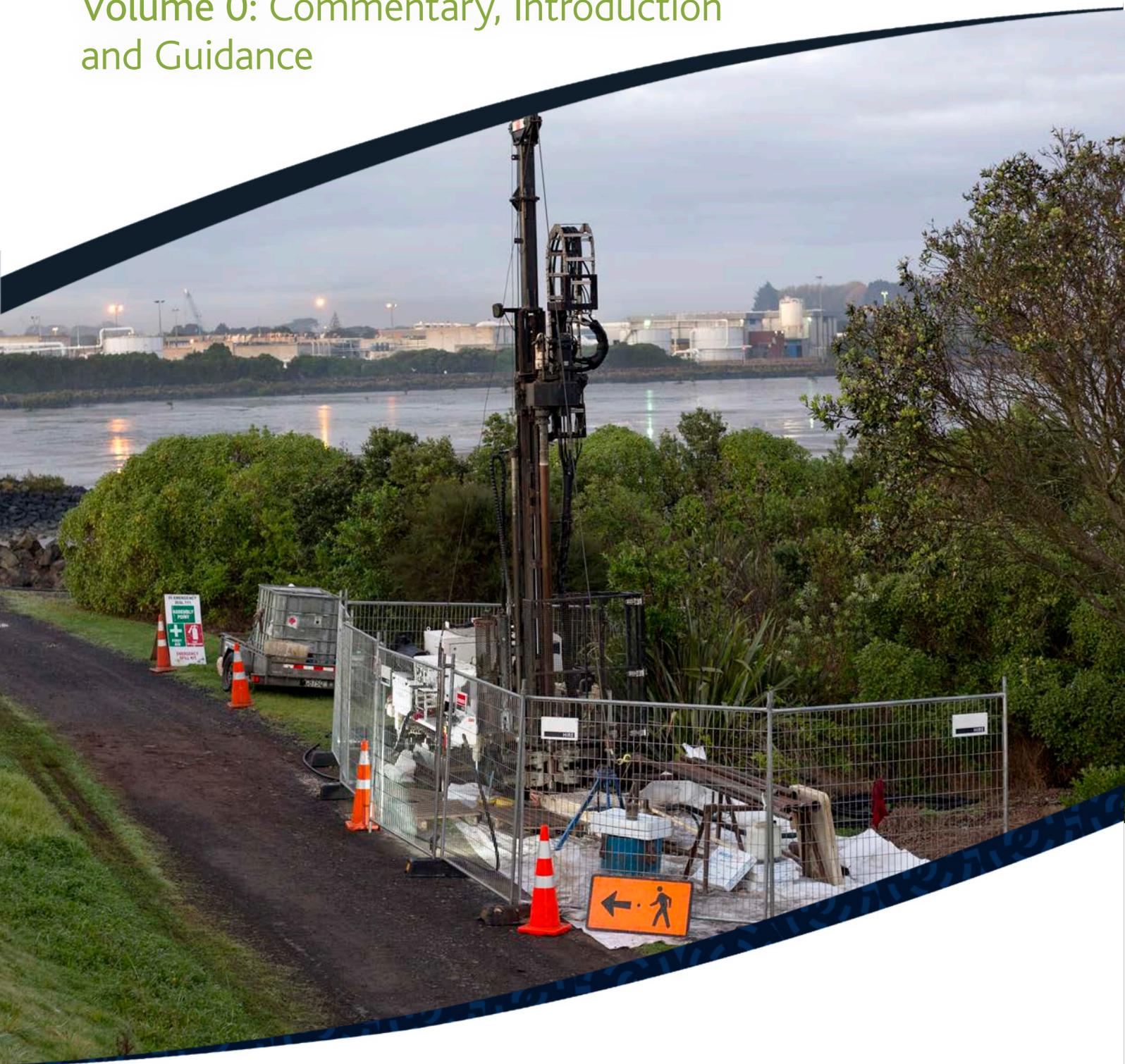


NEW ZEALAND GROUND INVESTIGATION SPECIFICATION

Volume 0: Commentary, Introduction and Guidance



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1 INTRODUCTION



This specification has been written for use in ground investigations undertaken within New Zealand. It is intended for contracts of any size, with an emphasis on encouraging carefully designed, safely executed, consistently high quality and cost effective work.

The specification is independent of the conditions of contract; it is intended to work in conjunction with NZS3910, other general conditions of contract or purchase order that is appropriate for the scale of project.

The full specification comprises a number of inter-related components that, when used together, provide the best opportunity to achieve a quality ground investigation and a simpler, clearer and more consistent tendering process for all parties.

1.1 Volume 0 (this document)

This volume provides general advice regarding the correct application and use of the Specification and the procurement of geotechnical services. It does not form part of the Specification, although the Specification is intended to be read in conjunction with this document.

This document is not a guide to the management or implementation of ground investigations, or the interpretation and development of ground models. For more information on this the reader should consult one of the many text books on the topic. One example is Simons, et al, 2002. The NZGS/MBIE Earthquake Geotechnical Engineering Practice Module 2: 'geotechnical investigation for earthquake engineering' provides an excellent introduction with a New Zealand emphasis.

This volume also provides (as appendices) a set of standard templates and guidance which may be useful in improving the consistency of ground investigation practice but do not form part of the specification. This allows the consultants involved to use their own preferred templates where they already exist or where they are more appropriate for the project and site requirements.

1.2 Volume 1

Master specification

The Specification comprises a series of clauses which are intended as minimum requirements. These minimum requirements have been set for the geotechnical investigation techniques which are most commonly used in New Zealand. It is implicit that only the sections relevant to the specific investigation being undertaken are applied to a particular project.

The Specification is fixed in content and scope; project specific requirements, including identification of which sections of the Specification are relevant to that project, are defined in the Project Specific Requirements. This way the Specification can be scaled to suit a range of project sizes.

Notes for guidance

Associated with the Specification are notes which clarify the intent of the clauses, provide background on why they are worded in a specific manner, or give best-practice advice and/or clarification of general principles where the authors think this is valuable. They do not form part of the Specification or contract.

It should be noted that this document is not intended as a manual for ground investigation. The notes given are for clarity only. There are numerous other references available which provide more detail on the ground investigation process and specific methodologies which should be referred to if additional information is required.

Note

Notes for guidance are presented in blue boxes similar to this example. They do not form part of the Specification or contract.

1.3 Volume 2

Project Specific Requirements

The Project Specific Requirements document is an MS Word format template designed to be completed by the client and geotechnical professional to give details on which aspects of the Specification will apply to the project, and any changes to the standard wording. This template is available from the NZGS website.

1.4 Volume 3

Bill of Quantities

An example of Bill of Quantities is provided, together with a preamble which defines payment terms. The bill of quantities is designed to be compatible with the Specification and allow easy management of a ground investigation by defining consistent payment and measurement methods. It is also the preferred tool to clearly define the scope of work to the consultant or contractor. Some parties may choose to use the specification alone with their own alternative method of measurement. This template is available from the NZGS web site.

2 USING THESE DOCUMENTS

These documents provide a specification for the procurement of the most common aspects of ground investigation services up to factual reporting. Interpretation is a professional service that is beyond the scope of these specifications.

These specifications may be used by clients to engage consultants, contractors or both. They may also be used by consultants to engage contractors on a client's behalf. The way the documents are used will vary slightly depending on each specific project or application. The examples below demonstrate how these documents are expected to be used in typical circumstances where the client engages a consultant and a contractor to undertake the ground investigation.

Details each of the options A through to E are presented in Volume 2.

2.1 Option A: small projects

For the smallest projects (such as small scale residential subdivisions where a desk study suggests good ground conditions with low complexity) it is common for a client to go directly to their preferred consultant for a quote. The consultant (who should be a geotechnical professional) will both scope and price all aspects of the work, including obtaining quotes from any subcontractors required. They may choose to use Volumes 2 and 3, if appropriate.

The contractor will be engaged as a subcontractor to the consultant (for simple investigations the consultant and contractor may be the same organisation).

This approach is not appropriate for tendered projects where price is a scoring attribute for the reasons given in Section 3.

2.2 Options B & C: small to medium projects

For these projects it is expected that the client will issue a tender to one or more consultants to simultaneously scope the investigation and complete Volumes 2 and 3 of this Specification.

The consultant will fill in quantities for all the elements they consider are required, and fill in rates for the elements of work that they will undertake, and leave blank the rates for elements to be undertaken by the contractor. The client will then procure the contractor. The contractor will quote on the remaining items left blank by the consultant. Depending on the preference of the client, the consultant may obtain these quotations on the client's behalf (Option B) or the client may obtain these prices themselves (Option C).

2.3 Options D & E: larger or complex projects

For larger contracts, the client is expected to engage an independent geotechnical professional to prepare tender documents for both the consultant and contractor. The independent geotechnical professional will not be directly involved in the ground investigation, but will:

- assist the client with scoping and procuring to ensure the client's best interests are taken into account
- simultaneously scope the investigation and complete Volumes 2 and 3 of this Specification
- issue tender documents for both the consultant and contractor elements of the work
- assist the client during the tender process to engage using the client's preferred process. The client may choose to keep their geotechnical professional engaged for peer review and advice during the project. It is strongly recommended that alternative tender submissions be allowed during this process so that the consultant and contractor can suggest innovative or alternative methods of ground investigation. The client's geotechnical professional will be invaluable in assessing these alternatives.

In Option D the contractor(s) will be subcontracted to the consultants, while in Option E the contractor(s) will be engaged by the client.

3 BEST PRACTICE IN PROCUREMENT OF GROUND INVESTIGATION SERVICES

'Unfortunately, soils are made by nature and not by man, and the products of nature are always complex.'

Karl von Terzaghi, 1936

3.1 Introduction

Unforeseen ground conditions often have a significant impact on the success of a project. The extent of unforeseen conditions and the resultant capital cost increases are commonly linked to an under-investment in site investigation. International research shows a strong correlation between low spend on ground investigation and high capital cost over-runs (Figure 1). This under-investment occurs for a number of reasons, including:

- Clients are awarding tenders for geotechnical services on lowest price, not best value.
- Site investigation scope is being impacted by inappropriate procurement methods.

Client organisations often report difficulty in procuring geotechnical services. Problems are perceived around large cost variations as the project proceeds, commonly associated with the difficulty of specifying ground investigation requirements upfront.

Figure 1. Impact of ground investigation expenditure on UK highways contract cost over-runs (Mott MacDonald and Soil Mechanics, 1994)



3.2 The site investigation process

'If you do not know what you are looking for in a site investigation, you are not likely to find much of value. What you look for should be suggested by the natural environment, and by the nature of the construction problem to be solved. Thus, a detailed programme of investigation cannot be decided on day one and adhered to, and the engineer who in the long run is responsible for the solution of the construction problem should not expect to order a site investigation and then dismiss the matter from his mind until a report is placed upon his desk.'

Rudolph Glossop, 8th Rankine Lecture

3.2.1 Introduction

Site investigation is the process of acquiring geological, geotechnical, and other relevant information which might affect the construction or performance of a civil engineering or building project. This includes the assessment of the physical characteristics of a site and its surroundings, considering everything from topography, geomorphology and climate to geology and land use (both historical and current).

Within the site investigation process a ground investigation is typically undertaken as a physical investigation of the geological, geotechnical, groundwater and contamination of the site. These documents are specific to the ground investigation element of site investigation.

3.2.2 Purpose of a ground investigation

A ground investigation serves two primary purposes:

- 1 Providing ground model data for analysis and design
- 2 Reducing uncertainty about ground conditions to reduce construction cost variations (ie control of risk).

A ground model will be generated before the ground investigation commences, then tested and iteratively improved during the ground investigation. This model is the tool used to manage and communicate the geotechnical risk and the information for design, and is therefore fundamental to the success of the ground investigation.

The amount, location and method of ground investigation should be selected with these aims in mind. In a tender, point two is much harder to quantify than point one. Each dollar spent on ground investigation reduces the risk of unforeseen conditions, but quantifying the financial benefits at the start of a project can be difficult. As a result, some ground investigations only achieve the first objective (the 'minimum scope'), leaving the client exposed to significant risk over the course of the project. Careful procurement is required to avoid this risk.

3.2.3 Stages in a ground investigation

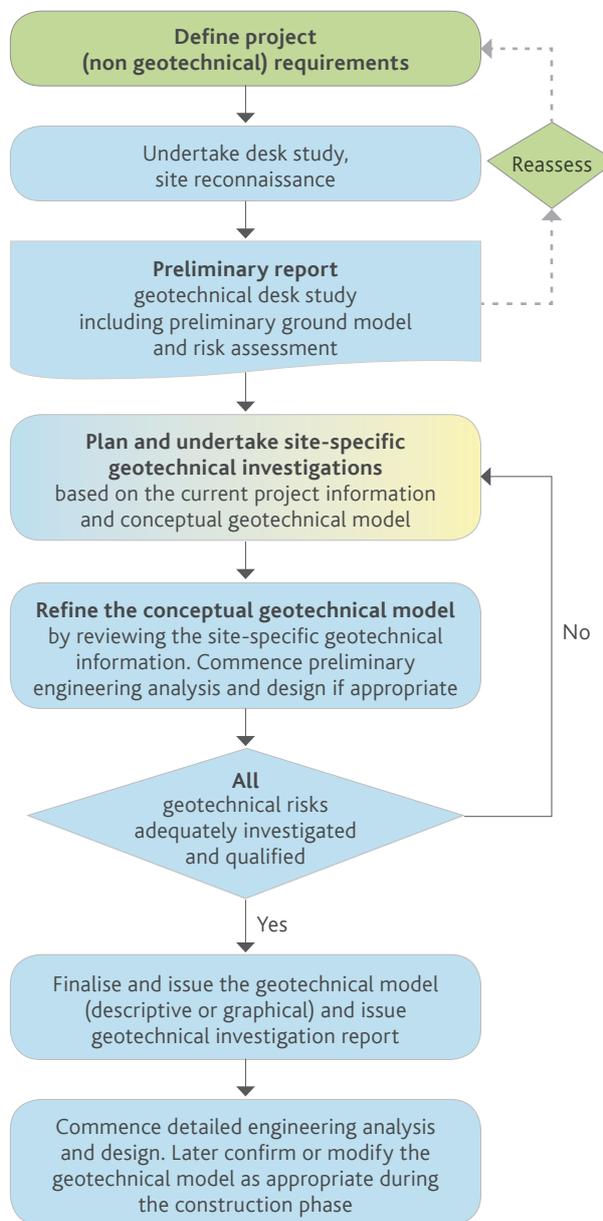
A geotechnical site investigation program for a 'routine' residential or commercial development typically comprises the following three key stages:

- 1 desktop study and site reconnaissance
- 2 ground investigation(s)
- 3 analysis and reporting.

It is common that further rounds of investigation will be required where an investigation finds unexpected ground conditions, or where the project site is large or the project risks are high.

Although commonly viewed from a client's perspective as a single activity, ground investigation and reporting is a multi-phase and multi-organisation activity. Figure 2a illustrates the typical stages of a ground investigation for a small, simple project.

Figure 2a. Typical site investigation stages for a small project



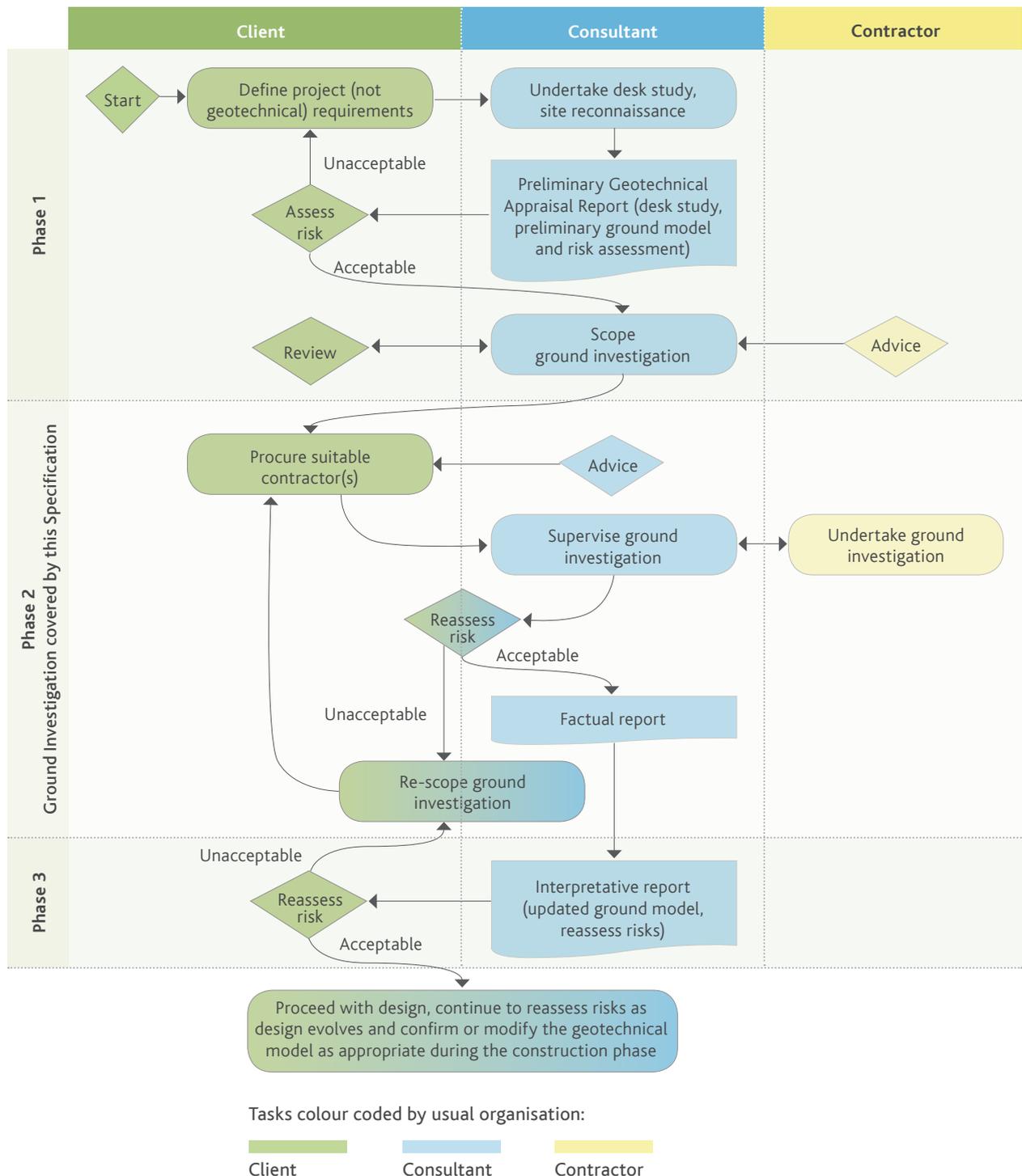
Tasks colour coded by usual organisation:



Figure 2b shows the process for a medium or large project, and clarifies where these specification documents are intended to be used in the process. For large or high risk projects it should be expected to undertake a

round of investigations at each phase of design (eg feasibility, preliminary, and detailed design) and potentially during construction as new risks and uncertainties are identified.

Figure 2b. Typical site investigation phases for a medium or larger project



Ground investigation is a risk assessment and management process and, as such, should be undertaken in an iterative manner. Each investigation will find new, often unexpected information which will change the project's risk profile. After each stage, the ground model is updated, risks are identified and investigated, and the outcome of these assessments determines the next steps. Phases of the ground investigation are repeated, as necessary, until the residual risks are considered acceptable. Additional investigations might be considered during design or construction as new risks are identified.

3.2.4 How much ground investigation is commonly undertaken?

Some examples of actual ground investigation costs from the UK are presented in Table 1, along with information based on surveys asking how much the client believed they spent. All parties spent significantly less on ground investigations than they assumed.

The numbers presented in the table are not appropriate as a guide to the appropriate spend on future projects as they are based on historical spends regardless of outcome. Many of these projects will have gone over budget as a result of unforeseen ground conditions.

3.2.5 How much ground investigation is needed?

The amount of investigation required should be a function of the risks to the project. There are no simple rules of thumb which can be applied across projects, and the involvement of a geotechnical professional at an early stage is recommended to help define the scope.

Research from the United States (U.S. National Committee on Tunnelling Technology 1985) recommended, in light of the amount of claims each project had, that the recommended percentage of investigation should be an average of 3%.

More recent opinion (unsupported by published evidence) suggests that, with the advent of Geotechnical Baseline Reports, a rule of thumb of 1.5% is not unreasonable for tunnelling projects, depending on the variability of the geology along the alignment. It should however be noted that the Geotechnical Baseline Report does not reduce or mitigate geotechnical risk, it simply clarifies how the risk is allocated. By undertaking less investigation the baseline parameters will be set wider. Transferring ownership of risk to a contractor may result in significantly higher tender prices while still leaving open the possibility of large variations or claims.

Table 1. Funding of site investigation as a percentage of total project costs, demonstrating how customers generally significantly over-estimate how much they spend on site investigation (adapted from ICE, *Inadequate Site Investigation*, Table 2, 1991)

CONSUMER	AMOUNT CUSTOMER ...	
	... BELIEVE THEY SPENT ON GROUND INVESTIGATION (% CAPEX)	... ACTUALLY SPENT ON GROUND INVESTIGATION AS CALCULATED BY RESEARCHERS (% CAPEX)
Government authorities	2.20	0.29
Manufacturing/commerce	0.76	0.22
Civil engineering contractors	0.85	0.23
Developers/builders	0.72	0.11
Architects	0.29	0.14
Multidisciplinary consultants	0.92	0.23
Civil engineers	1.94	0.29
Structural engineers	0.23	0.16
Average	0.99	0.21

NZGS and MBIE (2016) have published guidance around the minimum recommended density of ground investigations for residential developments in sites that may be vulnerable to liquefaction. These are reproduced below (Table 3.1 and 2.2) for reference as these are a good starting point. The final number and spacing of intrusive

investigation will depend on many considerations, not least the local geological conditions, and the recommendations in Tables 2.1 and 2.2 should not be used without reading *NZGS/MBIE Module 2: Geotechnical investigations for earthquake engineering*.

Table 2. Recommended minimum deep geotechnical investigation intensity for plan change or subdivision consent applications in sites that may be vulnerable to liquefaction

PROJECT STAGE	RECOMMENDED MINIMUM CUMULATIVE NUMBER OF DEEP INTRUSIVE GEOTECHNICAL SITE INVESTIGATION LOCATIONS		
	SITE PLAN AREA		
	1.0 HECTARE OR MORE	GREATER THAN 2,500 M ² BUT LESS THAN 1.0 HECTARE	LESS THAN 2,500 M ²
Plan change	0.20 per hectare Minimum of 5 total	0.50 per house site Minimum of 3 total	Minimum of 2 total
Subdivision consent	Urban Land 0.50 per lot Rural land Minimum of 1 per house site	Minimum of 1 per house site	Minimum of 1 per house site

Table 3. Recommended minimum density of geotechnical investigation for detailed design/building consent application (recommended minimum number of intrusive investigation locations) in sites that may be vulnerable to liquefaction

INVESTIGATION TYPE	RESIDENTIAL AND COMMERCIAL BUILDINGS UP TO 2 STORIES HIGH AND WITH A GROUND FLOOR AREA	
	LESS THAN 250 M ²	GREATER THAN 250 M ²
Deep investigation	Deep investigation (refer to Section 2.4.4) should be undertaken at no less than 2 locations within or immediately adjacent to the proposed building footprint.	Deep investigations should be undertaken at no less than 3 locations within or immediately adjacent to the proposed building footprint and achieve a minimum density of 1 location/250 m ² of building footprint.
Shallow geotechnical investigation	In addition to deep investigations, shallow geotechnical investigations (refer to Section 2.4.4) should be undertaken at no less than 2 locations within or immediately adjacent to the proposed building footprint.	Shallow geotechnical investigations should be undertaken at no less than 3 locations within or immediately adjacent to the proposed building footprint and achieve a minimum density of 1 location/250 m ² of building footprint.

3.3 Review of current practice

During a tender process it is common practice in New Zealand to:

- 1 Compare tenders by taking into account the total price, as a significant part of the assessment criteria.
- 2 Put out a single tender for the three phases described in Figure 2b.
- 3 Provide a pre-determined scope of investigation for price comparison purposes.

This section provides evidence of some of the risks which are inherent in these approaches.

3.3.1 Why price is a poor indicator – historical evidence

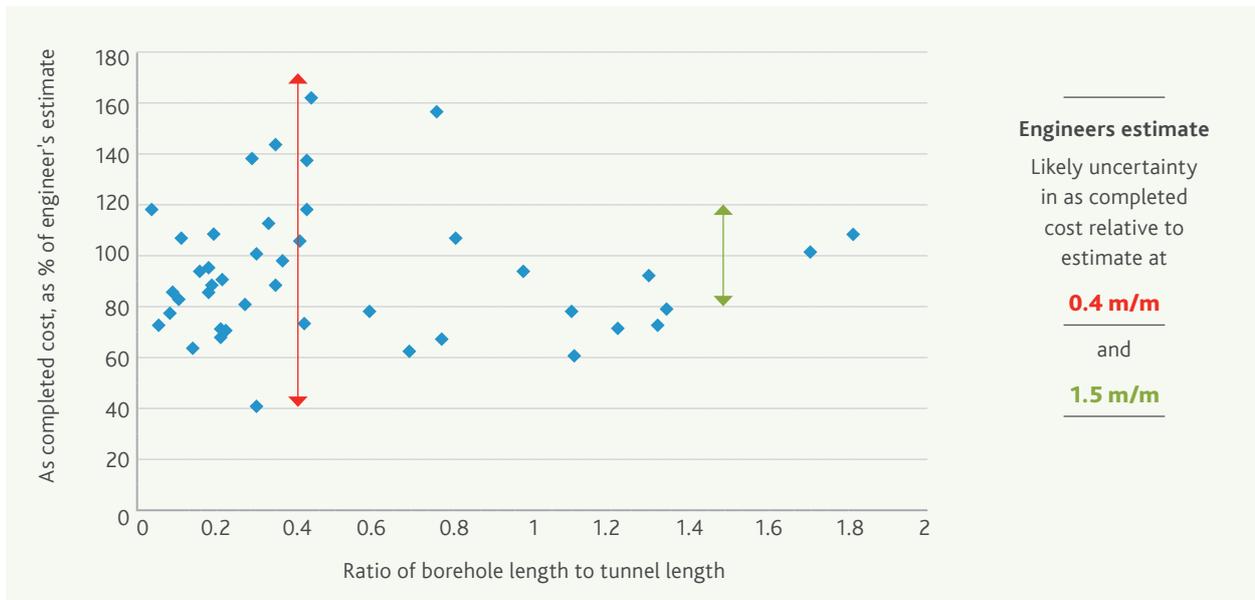
There is a risk that procurement approaches which focus on the cost of the geotechnical investigation will push the scope of investigations down, as part of the competitive tender. Such 'minimum scope' investigations might achieve the first goal of a site investigation (to provide information for design) but are unlikely to meet the second goal (reducing project risk) and are therefore likely to lead to significant increases in construction cost depending on the nature and complexity of the project and ground conditions.

There are useful guidelines available from case studies that show how cost risk varies with ground investigation density. Most of these examples are from tunnelling and highways projects, as these are the most likely to reliably report data for their spending. However, the findings are considered valid for most other projects.

Tyrrell et al., 1983, reported an analysis of ten large construction projects from the UK. They found that 'the final cost was on average 35% greater than the tendered sum, and half of this increase was directly attributable to inadequate planning or interpretation of ground investigation.'

Research from the United States (U.S. National Committee on Tunnelling Technology 1985) on a range of tunnelling projects calculated the linear metres of boreholes drilled per metre of tunnel. This showed that in the 1980s the median metres of borehole per metres of tunnel was 0.4. It recommended, in light of the amount of claims each project had, that this should be increased to 1.5. The data on which their analysis was based is shown in Figure 3.

Figure 3. Tunnel cost variability relative to ground investigation intensity (adapted from U.S. National Committee on Tunnelling Technology 1985)



Another way of comparing case studies is to assess the cost of the investigation as a percentage of the project capital expenditure (CAPEX). The U.S. National Committee on Tunnelling Technology reported in 1985 that cost over-runs are very common for tunnels where the ground investigation cost is less than 1% of the engineer's estimate. This is supported by robust research on roading projects from the UK, which showed that cost over-runs become significantly more common when the ground investigation cost is less than 4% of the construction tender cost (Figure 1).

The evidence demonstrates that expenditure on ground investigation is an investment in risk reduction, with demonstrable benefits in reducing CAPEX cost over-runs.

The cost of increasing a ground investigation from 0.4% to 1.5% of CAPEX has been demonstrated internationally to provide savings in CAPEX cost over-runs, on average an order of magnitude higher than the amount spent on the investigation. While these examples are for transportation and tunnelling projects it is believed the same principles apply to any civil infrastructure or building development project.

Although this section has focussed on the cost savings provided by more comprehensive ground investigation, it should also be considered that the better risk understanding provided by these investigations also applies to project programme and site safety.

3.3.2 Why procuring preliminary studies, ground investigation and interpretation together can fail

There are two specific problems resulting from procuring the physical works of ground investigation and the interpretation in the same contract.

Firstly, site investigation is an iterative process. If a consultant is to reliably price an investigation they first need to undertake a desk study, site reconnaissance, and preliminary ground model and risk assessment to accurately define a ground investigation that will address the critical site risks. It is only on the very smallest projects (such as individual house developments) that this process can be undertaken as part of the tender process. For all other projects there will be many assumptions built in to the tender which will reduce the effectiveness of the investigation in managing the client's risk.

Secondly, as long as price is an element in the tender assessment then there is a direct incentive for the consultant to minimise the scope of the investigation. By reducing the scope to that which is required to provide conservative design parameters only (the 'minimum acceptable') they can submit a lower price and increase their chances of winning. However, such a reduced scope is unlikely to optimally manage the client's risk. The client will get a lower cost investigation but overly conservative design assumptions, a higher overall project cost and greater risk of variations during construction.

3.3.3 Why a pre-determined scope of investigation tender can fail

In order to avoid the problems described in Section 3.3.2 a number of clients prefer to:

- request lump-sum prices for the office-based elements (Phases 1 and 3)
- price Phase 2 by including a detailed schedule of tests. In a typical example, these might include a defined number and depth of boreholes, in-situ and laboratory tests.

Although the aim of this approach, to provide comparable tenders, is laudable, it can fail in practice. Tenderers are aware that they are being engaged as technical experts to re-scope the investigation as they judge necessary and that therefore they can (and should) change the scope to meet the actual project needs. It then becomes a simple process to work out what the 'minimum acceptable' scope for the investigation might be. By under-pricing aspects of the tender that they expect to later remove from the scope they can submit a lower price and increase their chances of winning. The client's desire for a fair tender process has been subverted. In addition, such a reduced scope is unlikely to optimally manage the client's risk and will result in more conservative design assumptions and therefore expensive construction. The client will get a lower cost investigation but a higher overall project cost and greater risk of variations during construction.

This approach also significantly limits the opportunities for innovation by partially locking consultants into a pre-determined scope.

3.3.4 Summary of common procurement approaches

The following procurement approaches have commonly been used in New Zealand:

Table 3. Procurement methods for Ground Investigation used in New Zealand

METHOD	DESCRIPTION	ADVANTAGES	DISADVANTAGES
1 All-inclusive lump sum – consultant specifies ground investigation scope in tender	<ul style="list-style-type: none"> – Consultant is procured to undertake a desk study, ground investigation (including engaging their preferred contractors), interpretation, and geotechnical design as a single lump sum package. It is expected that the consultant will scope the required ground investigation during the tender process. – This approach is commonly used for small and medium sized projects. 	<ul style="list-style-type: none"> – Simple and quick. – Lump sum. – Consultant variations perceived to be contained. 	<ul style="list-style-type: none"> – Consultant incentivised to provide 'minimum' scope that achieves design requirements but without managing client cost and time risks – variations during construction more likely. – Consultant incentivised to make conservative assumptions due to the lack of data, resulting in a more costly design.
2 All-inclusive lump sum – client specifies ground investigation scope in tender	<ul style="list-style-type: none"> – Consultant is procured to undertake a desk study, ground investigation (including engaging their preferred contractors), interpretation, and geotechnical design as a single lump sum package. – As part of the tender the client specifies in detail a conceptual ground investigation. It is expected that the consultant will price the conceptual scope to provide a comparable tender, and amend the scope once their desk study is complete. – This approach is commonly used for small to medium size and complexity projects. 	<ul style="list-style-type: none"> – Simple and quick. – Lump sum. – Consultant variations perceived to be contained. 	<ul style="list-style-type: none"> – Site investigation scope may be established by non-experts and may not be the most appropriate for their design process. This puts more liability back to the client. Client requires some expertise to set scope realistically. – Consultant incentivised to 'game the system' by re-designing the scope to one that achieves design requirements but without managing client risk, then heavily discounting items scheduled by the client which they believe they can eliminate from the scope during design. Supplier tenders may not therefore be comparable and consultant is incentivised during design to select investigation techniques they priced highly instead of the most appropriate technique. – Lump sum price on investigation means that consultant incentivised to provide 'minimum' scope that achieves design requirements but without managing client risk – variations during construction likely. – Consultant incentivised to minimise scope and make conservative assumptions, resulting in a more costly design.

METHOD	DESCRIPTION	ADVANTAGES	DISADVANTAGES
<p>3 All-inclusive lump sum – client’s geotechnical professional specifies ground investigation scope in tender</p>	<ul style="list-style-type: none"> – A geotechnical professional is procured (or in-house capability used) to undertake a desk study and scope a ground investigation. – Consultant is procured to undertake the ground investigation (including engaging their preferred contractors), interpretation, and geotechnical design as a single lump sum package. As part of the tender, the client specifies in detail a conceptual ground investigation. It is expected that the consultant will price the conceptual scope to provide a comparable tender. 	<ul style="list-style-type: none"> – Simple and quick. – Lump sum. – Consultant variations perceived to be contained. 	<ul style="list-style-type: none"> – Unless price is only a small element of the assessment process the consultant is incentivised to ‘game the system’ by re-designing the scope to one that achieves design requirements but without managing client risk, then heavily discounting items scheduled by the client which they believe they can eliminate from the scope during design. Supplier tenders may not therefore be comparable and consultant is incentivised during design to select investigation techniques they priced highly instead of the most appropriate technique.
<p>4 Lump sum, excluding physical ground investigation works</p>	<ul style="list-style-type: none"> – Consultant is procured to undertake a desk study, manage a ground investigation, interpret the results, and complete geotechnical design as a single lump sum package. It is expected that the consultant will scope the required ground investigation during the project and that the client will engage a suitable contractor to undertake the investigation. – This approach is commonly used for medium to large size projects. – The physical works may be set as a provisional sum (often defined during the preliminary design phase). 	<ul style="list-style-type: none"> – Consultant fee variations less likely and contractor fee variations unlikely as working to a well-defined scope. – Separating into two tenders allows separate evaluation of consultant and contractor so the best of each can be selected. – Scope set by the designer during design will be the most appropriate for their design process, reduces client liability and gives opportunity to minimise client’s CAPEX risks without the pressures of low-cost tender pricing. 	<ul style="list-style-type: none"> – No up-front indication of contractor fee. – Unless the field supervision and reporting aspects of the lump sum price are scalable to the size of the final proposed investigation scope, the consultant is incentivised to minimise scope and make conservative assumptions, resulting in a more costly design. – Client may require independent geotechnical advice/peer review to avoid the risk of a consultant ‘over-scoping’ the investigation once competitive pressures are removed.
<p>5 Measure and value</p>	<ul style="list-style-type: none"> – Consultant is procured to undertake a desk study, ground investigation, interpretation, and geotechnical design, charging hourly rates. – This method is suitable where the project scope is poorly defined so that any lump sum approach would be subject to significant variations. 	<ul style="list-style-type: none"> – Scope set by the designer during design will be the most appropriate for their design process, reduces client liability and gives opportunity to minimise client’s CAPEX risks without the pressures of low-cost tender pricing. 	<ul style="list-style-type: none"> – No up-front indication of consultant or contractor fee. – Client may require independent geotechnical advice/peer review to avoid the risk of a consultant ‘over-scoping’ the investigation once competitive pressures removed.

3.3.5 Summary

Each approach has advantages and disadvantages, as summarised quantitatively in the table below (1 is good, 5 is poor):

Table 4. Risk assessment of procurement methods used in New Zealand for ground investigation for medium to large or complex projects

Impact on project risk ▶		Ability to reduce CAPEX risk (variations during construction)	Provides adequate information for design	Risk of variations / cost over-runs to		Simplicity for client	TOTAL RISK
Procurement Method ▼	Weighting ▶			Consultant contract	Contractor fee		
		40%	30%	15%	15%	10%	
5	Measure and value	1	1	4	5	2	2.25
4	Lump sum, excluding physical works	2	1	2	5	3	2.45
3	All-inclusive lump sum – client’s geotechnical professional specifies scope	3	1	2	4	3	2.7
1	All-inclusive lump sum – consultant specified scope	5	2	1	1	1	3
2	All-inclusive lump sum – client specified scope	5	4	2	3	3	4.25

3.4 Recommendations

3.4.1 Simple projects

For very small, low risk projects Method 1 (All-inclusive lump sum) is likely to be an appropriate approach to procure both a consultant and a contractor (as subcontractor to the consultant). It is very simple for the client to manage and provides a relatively high level of cost certainty for the contract fee. However, it is only suited to low risk projects, such as low-rise buildings not founded on weak soils or vulnerable to natural hazards (geotechnical advice and some prior knowledge of ground conditions will be required to assess this). The client will need to take care that the consultant specifies an appropriate scope.

This method is not suited to tendering as it will result in reduced scope tenders. It is also not appropriate for projects where CAPEX variability as a result of ground conditions is likely, or the implications are more significant. For example:

- tunnelling/underground infrastructure projects
- construction on variable or poor ground
- medium or large projects (indications of medium-size projects, include retaining structures greater than 3 m high, earthworks greater than 5 m thick, buildings of four or more storeys, construction durations of three or more months).

3.4.2 Other projects

3.4.2.1 Procurement of a consultant

Method 5 (measure and value) is recommended, except for individual line items within a Bill of Quantities where that specific item is well defined. This method allows the scope to be developed as the investigations progress and gives flexibility to manage the client’s risk.

Where this option is not feasible:

- **Method 3** (lump sum with scope by geotechnical professional) is appropriate for small projects.
- **Method 4** (lump sum excluding physical works) is recommended for larger projects. Although it is sometimes perceived that Method 4 causes difficulty in negotiating competitive prices for the investigation after the design contract is awarded, this can be partially overcome by making the following minor adjustments to the typical lump-sum requirements:
 - a lump sum fee for producing a ground investigation scope, which should provide a detailed justification of the proposed scope for review by the client (or their technical representative/peer reviewer for larger projects)

Table 5. Typical values of provisional sums to set aside for undertaking and reporting on a ground investigation (excluding any design work)

PROJECT TECHNICAL RISK	PROJECT CAPITAL VALUE		
	<\$500,000	\$500,000–\$5M	>\$5M
Simple and low risk	6%	4%	2%
Moderate	8%	5%	3%
Complex or high risk	10%	6%	4%

- a lump-sum or time and expenses fee (depending on how well defined the consultant's role is) for running the tendering process to procure the contractor. This introduces a strong competitive pricing element for the physical works after the investigation has been properly scoped
- a time based rate for office-based management of the investigation and an hourly rate (time and expenses basis) for field staff. This removes the incentive to down-scope the scale of the investigation to win the tender.
- the consultant should make an estimate of the value of the provisional sum to be set aside for:
 - the contractor's fee (this allows the client to check the amount set aside)
 - the consultant's management and field staff (this allows a starting point in negotiations in the case that the actual costs vary).

As a starting point, the Table 5 gives suggested values for the provisional sum to set aside for the contractor's fee and the consultant's management and field staff.

During the project, the consultant should scope the investigation and assist with the procurement of suitable contractors. For high risk or complex projects this scope should be checked to assess how well it manages the client's overall risk (using an independent reviewer if the client lacks in-house expertise).

The client may reserve the option to take the physical investigation out to tender if they suspect the price they are quoted is not good value.

3.4.2.2 Geotechnical team selection criteria and weightings

It is important that the scope of work or services requested in the tender documents contains sufficient detail to support proper evaluation and pricing. The request for proposal must be clear on

what criteria will be used to evaluate the tender. It is recommended that this includes the following non-price criteria:

- relevant expertise and competence (lead consultant and any sub-consultants)
- methodology
- resources (including intellectual property)
- project track record (relevant projects)
- health and safety track record.

Optionally, price may be included as one of the criteria but it is recommended the weighting on the price component be as low as practically possible. Given the evidence in previous sections that cost is a poor indicator of value, this weighting should be less than 20%.

The nature of the work is highly specialised and care is required to ensure that the assessment is technically robust and useful in practice. Selection based primarily on lowest consultant price may compromise the practical usefulness of the work, and result in delays and greater costs during future stages of the development, in particular during construction.

For complex projects it is recommended the tender evaluation panel includes an expert in the geotechnical field to advise on the technical aspects of the submission and review the scope of work proposed by potential providers.

3.4.2.3 Procurement of a contractor

The contractor should normally be engaged using Method 5 (measure and value). Since the contractor is not in control of the scope it is not generally appropriate to use lump sum options except for individual line items within a Bill of Quantities where that specific item is well defined. The capability and skills of the contractor should be assessed separately from the consultant. In general the same non-price criteria will apply.

4 REFERENCES

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Mott MacDonald and Soil Mechanics, 1994. Study of the Efficiency of Site Investigation Practices. Transport Research Laboratory, Workingham, TRRL Project Report 60.

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Tyrrell, A.P., et al., 1983. An investigation of the extra costs arising on highway contracts. Transport and Road Research Laboratory, Crowthorne, SR814.

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APPENDIX A. PERMIT TO DIG – INSTRUCTIONS

A1 Introduction

Some sites and clients require a permit to dig process to be followed prior to breaking any ground. This Permit to Dig methodology sets out one way to manage the risks which are associated with buried services for typical land based geotechnical, contamination and hydrogeological investigations. This methodology may be replaced with a project or organisation specific equivalent with the prior approval of the client and geotechnical professional.

This methodology is not appropriate for:

- Offshore ground investigations (project-specific procedures must be prepared for all such cases).
- Sub-surface land investigations for other purposes (eg geothermal, archaeological).
- Surveys and excavation activities (eg pot-holing) specifically aimed at identifying and mapping existing services.
- Machine boreholes closer than one metre to a known or suspected service, or trial pits with the nearest point within two metres of a service. Such activities should be avoided if at all possible and all other practical options considered to establish an alternative strategy.
- Where underground services are suspected but their locations cannot be confirmed (eg defence bases or industrial sites with limited service location plans) a site specific methodology must be developed and approval obtained from the geotechnical professional, client and service owner.

A suitably experienced representative of the geotechnical professional should be present for the entirety of the service detection works. It is recommended that this person also supervise the subsequent investigation.

The use of this methodology is no guarantee of safety; each party should assess the specific requirements of their project and use an appropriate methodology based on best practice.

A2 Methodology

A2.1 Service location prior to physical ground investigations

1	Look for evidence of unmarked services	Sight and verify all surface indicators of underground services, eg manholes (lift manholes to see pipe direction where safe to do so), valve covers, utility markers, control columns, street lights, traffic lights and reinstated trenches. Do not enter confined spaces unless trained to do so and with appropriate approved controls in place.
2	Mark out planned dig/ investigation locations	Paint marks are normally appropriate. Non-conductive pegs are a useful alternative where paint may wear off. As a minimum all services within 5 m of a proposed investigation location must be marked. Where a professional service locator is being used the site rep shall review the service locator's sketch plans to confirm agreement with their own observations. Linear features identified in the data whilst on site shall be either followed to a node where the identity of the utility can be established or, where this is not practical, labelled as 'unknown utility'.
3	Take photographs of the markings	These photographs will be used if the intrusive ground investigation commences at a later date to confirm that no markings or pegs have been lost with the passage of time.
4	Identify potential conflicts between marked investigation locations and services	If an investigation point needs to be moved it must first be discussed with the project technical lead for the investigation, and the project manager informed. Machine boreholes located within one metre of a service, or trial pits with the nearest point located within two metres of a service, should be avoided whenever possible. In such cases all other options should be considered to confirm that there is no other possible investigation location or safer methodology, and that the investigation location is absolutely essential.
5	Fill out the Permit to Dig Part A	The site rep should complete the Permit to Dig – Part A form during the on-site service location process. This will preferably be the same person who will supervise the intrusive investigation when it takes place.

Typical* risk assessment matrix

*this should be customised to suit local requirements and practice in consultation with the geotechnical professional, client and service owner.

SERVICE	CONSEQUENCE OF STRIKE	SERVICE LOCATION PHYSICALLY PROVEN AND WITHIN 5 m	DISTANCE FROM SUSPECTED SERVICE TO CLOSEST POINT OF THE INVESTIGATION HOLE					
			0 to 1 m	1 to 2 m	2 to 5 m	5 to 15 m	>15 m	
			LIKELIHOOD OF STRIKING OR DISTURBING SERVICE					
			UNLIKELY	HIGHLY LIKELY	LIKELY	POSSIBLE	UNLIKELY	RARE
Domestic storm water pipe	Minor		I	M	L	L	I	I
Domestic water pipe	Minor		I	M	L	L	I	I
Domestic telephone cable	Minor		I	M	L	L	I	I
Domestic sewer pipe	Minor		I	M	L	L	I	I
Telecommunications cable (excluding fibre optic)	Moderate		I	H	M	L	L	I
Storm water main pipe	Moderate		I	H	M	L	L	I
Underground power cable (low voltage)	Major		M	H	H	M	L	I
Sewer main pipe	Major		M	H	H	M	L	I
High pressure water main pipe	Major		M	H	H	M	L	I
Underground gas pipe (domestic supply)	Major		M	H	H	M	L	I
Fibre optic cables	Major		M	NP	H	M	L	I
Hazardous substances transmission (eg fuel, chemicals)	Catastrophic		H	NP	NP	H	M	I
Underground high voltage power cables	Catastrophic		H	NP	NP	H	M	I
Fuel lines	Catastrophic		H	NP	NP	H	M	I
Gas main pipe (all pressures)	Catastrophic		H	NP	NP	H	M	I
Unknown or Suspected	Site-specific safe methodology must be developed and approval obtained from the geotechnical professional, client and service owner.							

- Works that **do not meet ALL** of the criteria listed below will be classified as **M** (or higher if shown as higher in the table above):
 - full copies of underground service plans have been obtained.
 - excavation/drilling works will be in an area with minimal underground services eg rural or suburban areas
 - proposed intrusive works will be outside the service provider's specified minimum clearance distance from an asset.

- Work at service station sites, refineries, heavy industrial areas, electrical substations will not be considered low or insignificant risk.
- Work in urban road and footpath areas will not be considered insignificant risk.
- Avoid, if at all possible, machine boreholes within one metre of a service, or trial pits with the nearest point within two metres of a service.** In such cases all other options should be considered to confirm that there is no other possible investigation location or safer methodology, and that the investigation location is absolutely essential.

Legend

H	M	L	I	NP
High risk	Medium risk	Low risk	Insignificant risk	Not permitted (extremely high risk) without a specific methodology approved by Service owner

Minimum* Required actions

* this should be customised to suit local requirements and practice in consultation with the geotechnical professional, client and service owner.

RATING FROM RISK ASSESSMENT MATRIX	Notes:
NOT PERMITTED (NP)	<ul style="list-style-type: none"> – All of the actions shown in this table are mandatory; it is not acceptable to select one of the mitigations. – All services and borehole locations are to be marked in paint or by other approved means. – NDD means Non-destructive digging and includes vacuum excavation.
HIGH RISK (H)	<ul style="list-style-type: none"> – Not permitted without written approval of a site-specific safe methodology from geotechnical professional, client and service owner before works commence. All other options should be considered. Confirm that there is no other possible investigation location or safer methodology, and that the investigation is absolutely essential. – Confirm that there is no other possible investigation location or safer methodology. – Contact and obtain authorization from service owner. If authorisation not given you must move the investigation to a lower risk (eg Medium) offset. Reconfirm if investigation is relocated. – Insist that service owner mark location on site in presence of site rep. – No mechanical test pitting allowed unless location of service is proven by being exposed. – Engage service locator to locate services using traditional methods (eg radio-detection methods) and more intensive methods (eg NDD or GPR) if location is not physically proven. – Hand-excavate starter pit or NDD to at least the depth of the deepest likely service.
MEDIUM RISK (M)	<ul style="list-style-type: none"> – Contact and obtain authorisation from service owner if they are willing to give this. Reconfirm if investigation is relocated. – Give service owner opportunity to mark location on site. – No mechanical test pitting allowed unless location of service is proven by being exposed. – Engage service locator to locate services using traditional methods (eg radio-detection methods) and more intensive methods (eg NDD or GPR) if location is not physically proven. – For boreholes use a hand auger, NDD or hand-excavate starter pit to at least the depth of the deepest likely service.
LOW RISK (L)	<ul style="list-style-type: none"> – Arrange for service owner to mark location on site if they are willing and able to do so. – Engage service locator to locate services using traditional methods (eg radio-detection methods). – For boreholes use a hand auger, NDD or hand-excavate starter pit to at least the depth of the deepest likely service.
INSIGNIFICANT RISK (I)	<ul style="list-style-type: none"> – Visual check for evidence of services on site. – If deemed appropriate by geotechnical professional, engage service locator to locate services using traditional methods (eg radio-detection methods). – For boreholes, consider using hand auger, NDD or hand-excavate starter pit to at least the depth of the deepest likely service unless confident that no services can be present.

A2.2 Pre-clearance

Where service location is undertaken well in advance of intrusive ground investigations it may be acceptable to hand-excavate the proposed drilling location and backfill as appropriate for the site use (for example, in areas without vehicular access bentonite pellets may be an appropriate backfill). If this approach is used, the following rules shall be applied:

- For locations other than test pits or trenches, a hand-excavated hole shall be completed to at least the depth of the deepest likely service.
- The diameter of the hand-excavation shall be larger than the largest piece of equipment to be used in the ground.
- The excavation shall be backfilled in a way that makes the site safe. The backfill details will depend on the likely site usage.
- If a service is encountered in the excavation the hole shall be backfilled and clearly, permanently marked to avoid confusion for future investigations. Recommended markings include:
 - where the hole is backfilled to the surface with bentonite, mix it with red dye to warn of danger
 - where re-instating a permanent surface such as paving slabs or road surfacing, place hazard warning tape beneath the surface layer.

A2.3 During Intrusive Ground Investigations

1	Check that 'marking out' left by service location team is clearly visible and has not been moved or obscured	Check that markings made during the original investigation have not been lost, by comparing with photos, unless the investigation is commencing immediately after service mark out. Paint marks can easily be washed away, and pegs moved or damaged.
2	Conduct visual checks before commencing and confirm plan and permit conditions are still valid	If in any doubt, get the person who supervised the service location to come to site. If this is not possible, get the services re-marked before commencing work.
3	Fill out Permit to Dig Part B	Check that the minimum required actions in the Permit to Dig are being implemented. If an investigation point needs to be moved, it must be discussed with the project technical lead for the investigation and the project manager informed. The contractor is in control of the site and must make the final decision about locations. ALL site staff have authority to stop any work if they have any concerns.
4	Hand-excavate	For locations other than test pits or trenches, a hand-excavated inspection pit shall be completed to at least the depth of the deepest likely service. The diameter of the pit shall be larger than the largest piece of equipment to be used in the ground. If a service is encountered in the pit, record the service type and location and report to the service owner and local authority. Follow the service owner's instructions for backfilling. If the owner cannot be identified, backfill the excavation in a way that will warn future excavations of the potential hazard.

APPENDIX B. EXAMPLE PERMIT TO DIG TEMPLATE

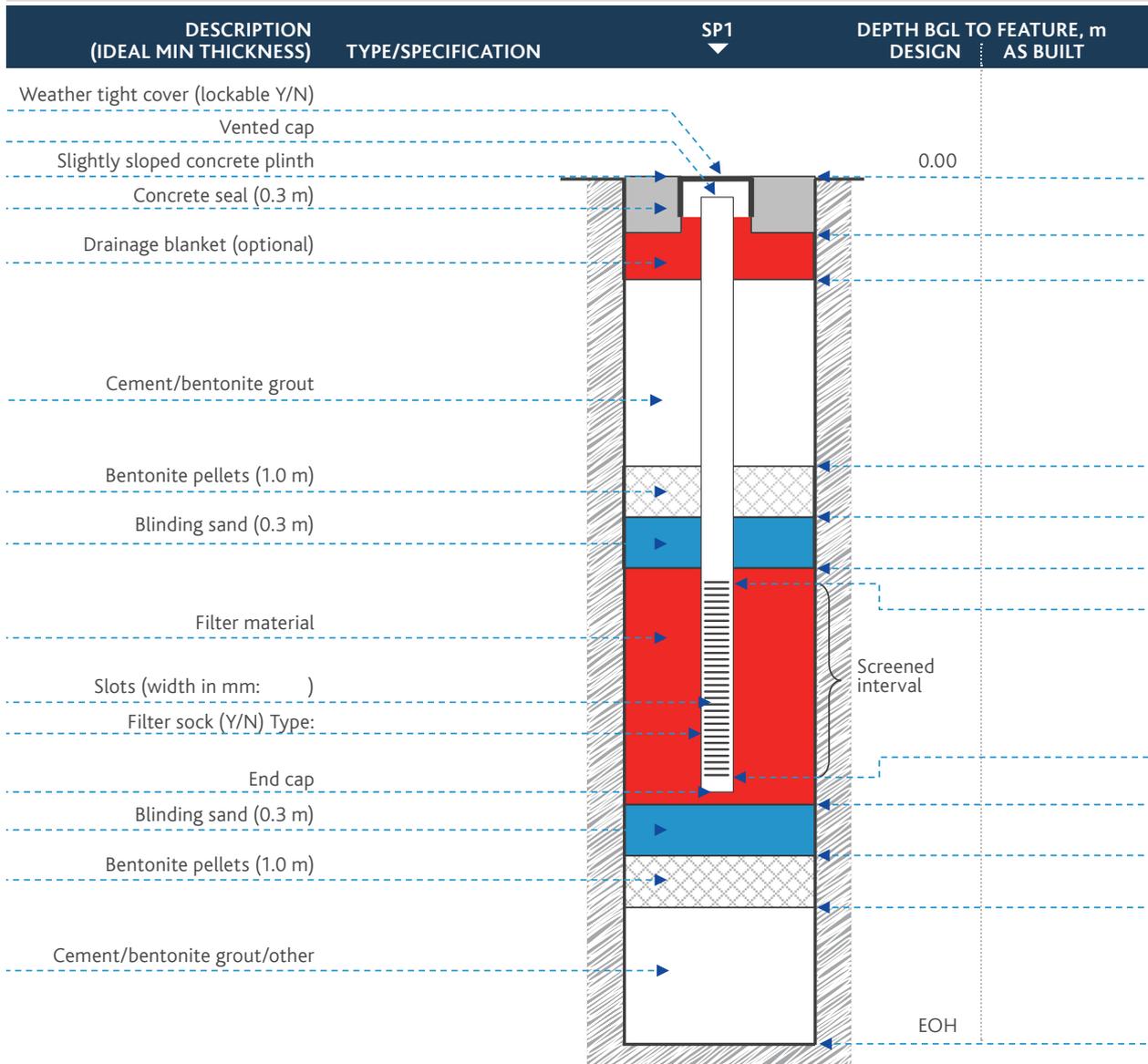
(One per investigation hole/location unless being managed as a single operation and can be shown on a single plan.)
 Print this stand-alone page and keep on site as a record.

A (preparation – complete during service location)	Project No.		Date of issue		Date of expiry				
	Site rep during service location				Signed				
	Exploratory Location ID(s)								
	Site Information Pack contains following plans:		Walkover has identified the following:						
	Y	N	Y	N	Y	N			
	<input type="checkbox"/>	<input type="checkbox"/>	Electricity	<input type="checkbox"/>	<input type="checkbox"/>	Overhead utilities	<input type="checkbox"/>	<input type="checkbox"/>	Paving scars/vegetation changes
	<input type="checkbox"/>	<input type="checkbox"/>	Gas	<input type="checkbox"/>	<input type="checkbox"/>	Lights/warning signs	<input type="checkbox"/>	<input type="checkbox"/>	Gatic covers/concrete pit covers
	<input type="checkbox"/>	<input type="checkbox"/>	Telecommunications	<input type="checkbox"/>	<input type="checkbox"/>	Gas meters/pipes	<input type="checkbox"/>	<input type="checkbox"/>	Underground tanks/fuel systems
	<input type="checkbox"/>	<input type="checkbox"/>	Sewer	<input type="checkbox"/>	<input type="checkbox"/>	Telecoms services/ATMs	<input type="checkbox"/>	<input type="checkbox"/>	Fuel system vents
	<input type="checkbox"/>	<input type="checkbox"/>	Water	<input type="checkbox"/>	<input type="checkbox"/>	Stormwater drains	<input type="checkbox"/>	<input type="checkbox"/>	Sewer inspection pits or outlets
<input type="checkbox"/>	<input type="checkbox"/>	Site owner plans (where available)	<input type="checkbox"/>	<input type="checkbox"/>	Electrical equipment/junction boxes	<input type="checkbox"/>	<input type="checkbox"/>	Other (describe)	
<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	Fire hydrants/water meters				
Sketch plan on reverse of this sheet indicating location of all known services and investigation location (or attach separately). Service locator to check sketch if drawn by site rep and confirm that this matches their understanding of service locations.									
Locator name					Date				
Service/hazard		Dist. (m)	Risk (from matrix)	Accuracy (A/B/C/D) see definition below	Recommended action				
B (before physical works)	<input type="checkbox"/> Confirm that you have required permissions <input type="checkbox"/> Implement all actions required (see table above) <input type="checkbox"/> Confirm that you have all service plans on site and that they are up-to-date <input type="checkbox"/> Ensure that all anticipated services have been marked <input type="checkbox"/> Check for contradictions between service plans and site layout <input type="checkbox"/> Check that the markings for all anticipated services are still present (not obscured or removed) ideally by comparing with photographs taken after services were marked or by comparison with sketch above					Service location accuracy levels: A Verified – exact position confirmed, eg by excavation B Detected – position indicated by remote means C Indicated – evidence on site such as service covers D Desktop – eg service plans			
	Halt work if any concerns and contact service owner/provider and geotechnical professional. Do not sign below or start work until all checks above are complete.								
	Plant operator		Signature			Date			
Site rep		Signature			Date				

APPENDIX C. TYPICAL STANDPIPE INSTALLATION DETAILS

Standpipe installation design and as-built record (single with flush cover)

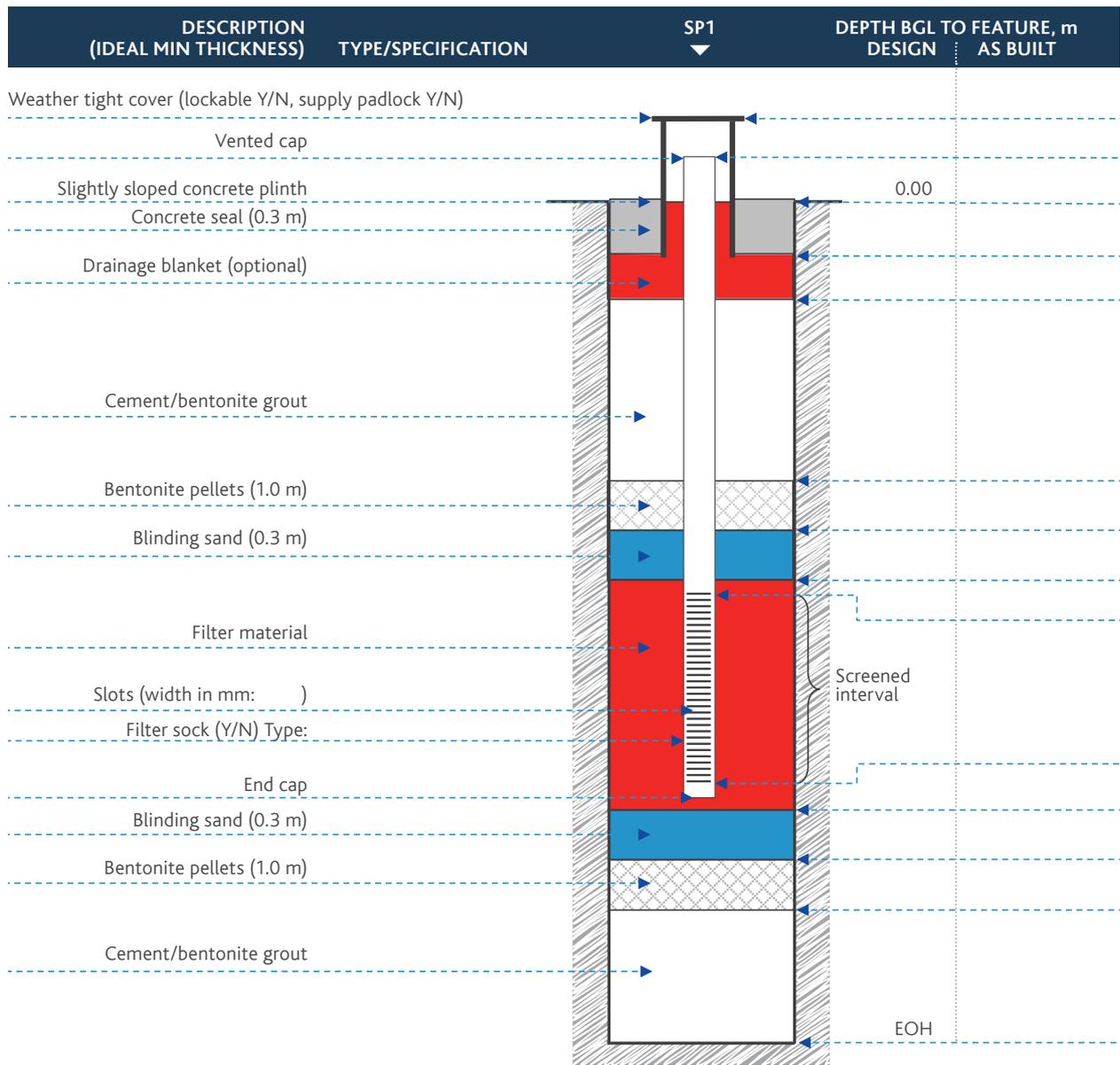
Project number:	Project name:
Location ID:	Date drilled:
Design by:	Date installed:
As-built by:	Coordinates (NZTM):



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				

Standpipe installation design and as-built record (single with raised cover)

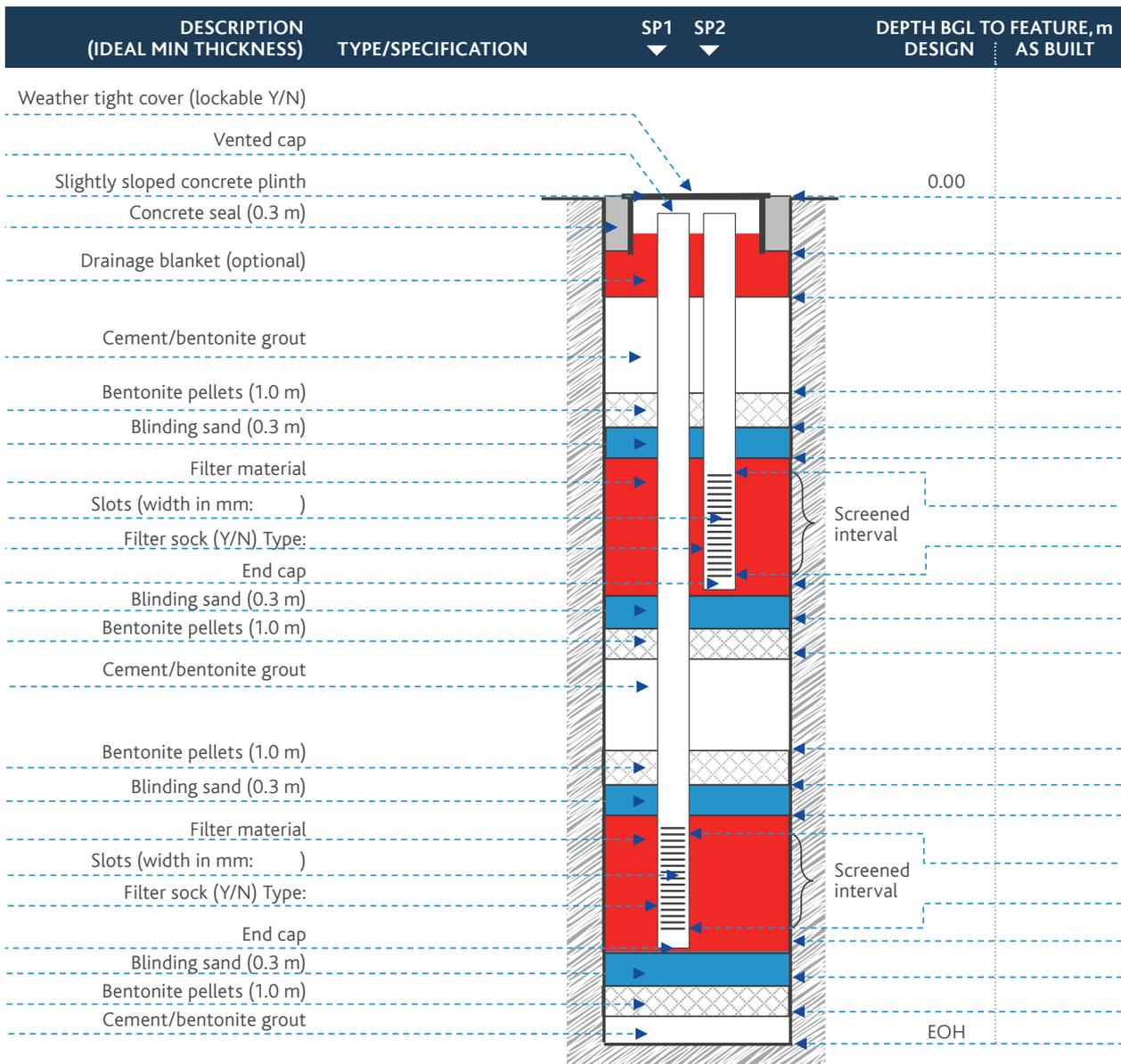
Project number:	Project name:
Location ID:	Date drilled:
Design by:	Date installed:
As-built by:	Coordinates (NZTM):



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				

Standpipe installation design and as-built record (double with flush cover)

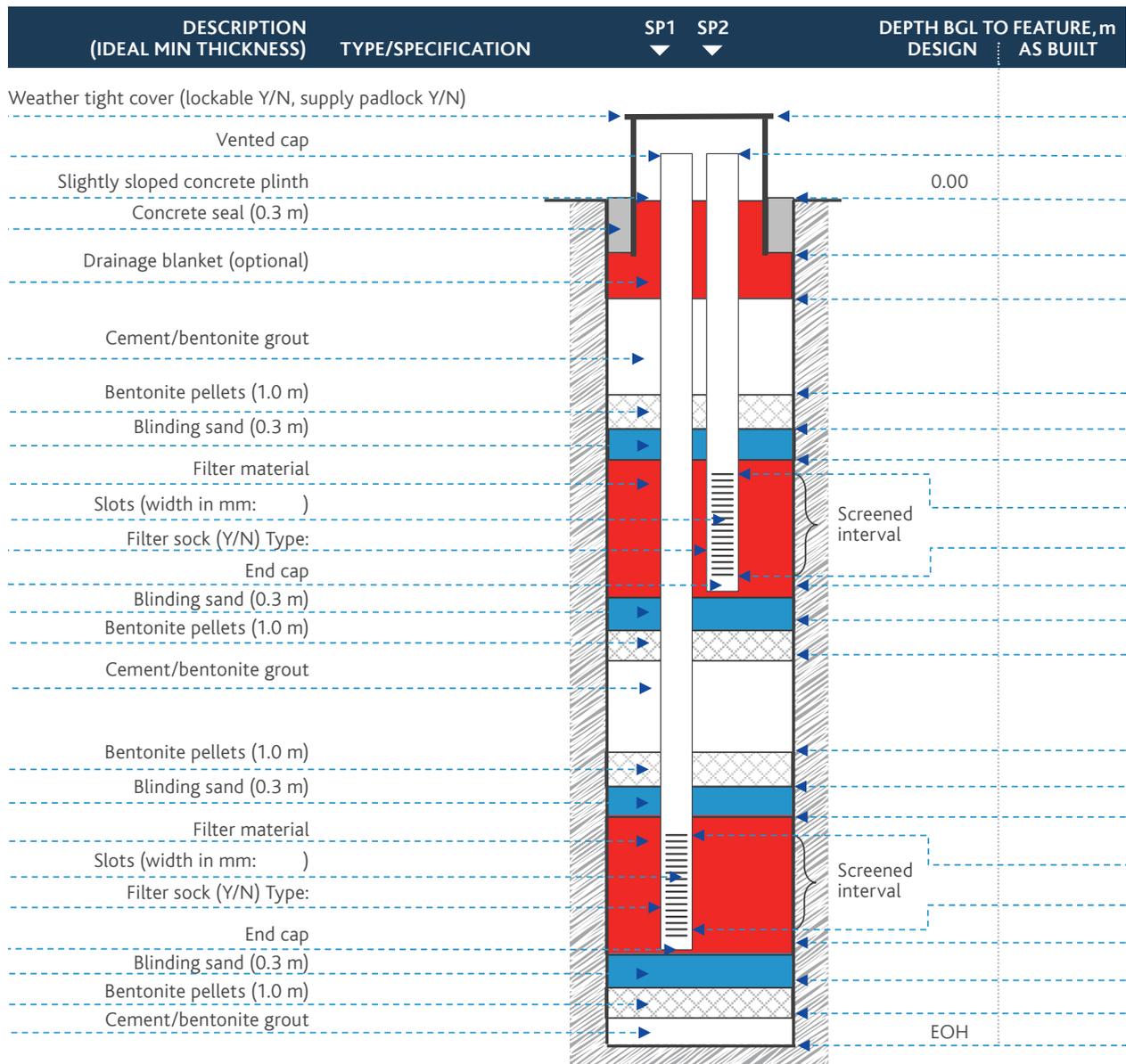
Project number:	Project name:
Location ID:	Date drilled:
Design by:	Date installed:
As-built by:	Coordinates (NZTM):



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				
SP 2				

Standpipe installation design and as-built record (double with raised cover)

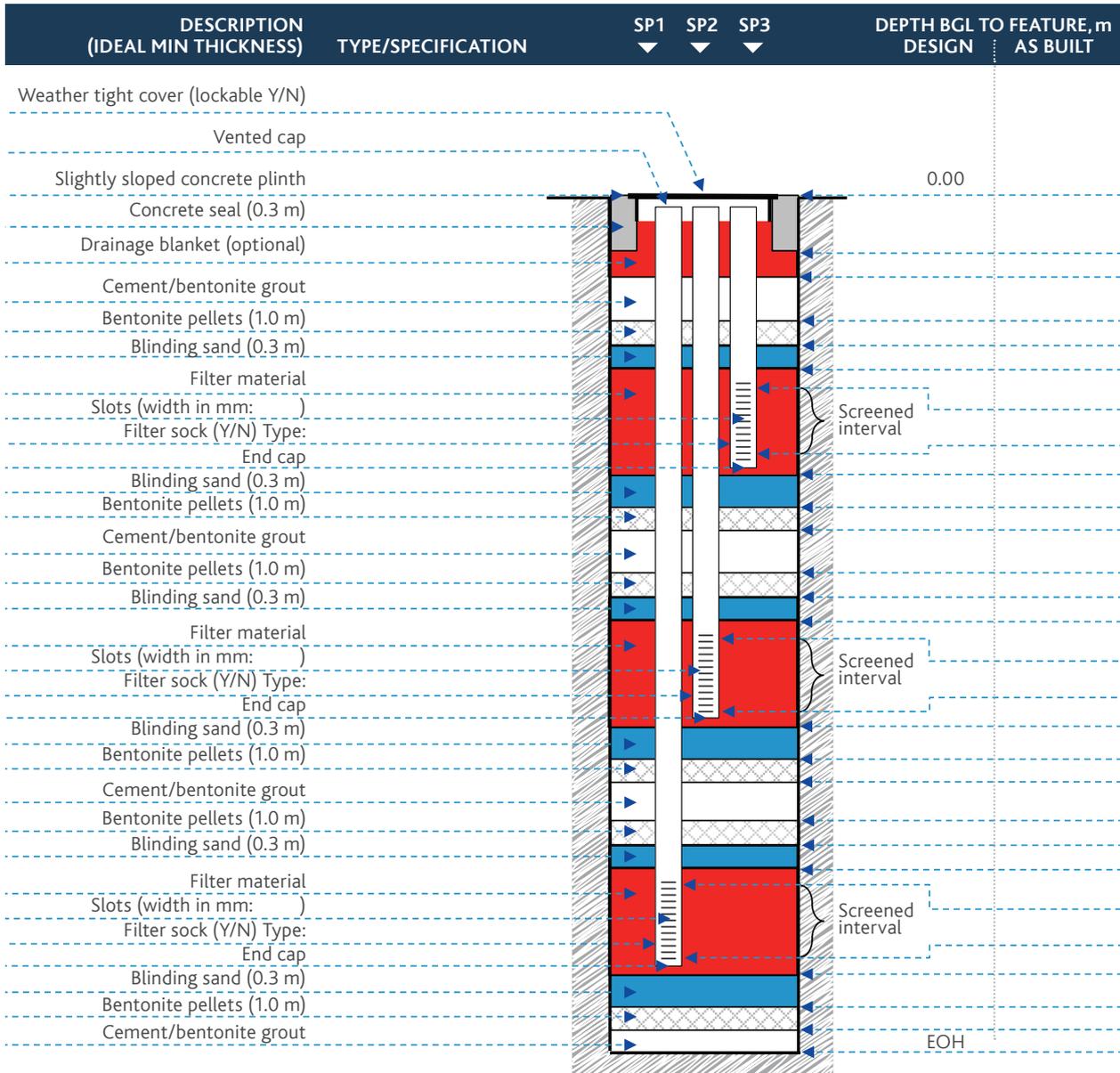
Project number:	Project name:
Location ID:	Date drilled:
Design by:	Date installed:
As-built by:	Coordinates (NZTM):



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				
SP 2				

Standpipe installation design and as-built record (triple with flush cover)

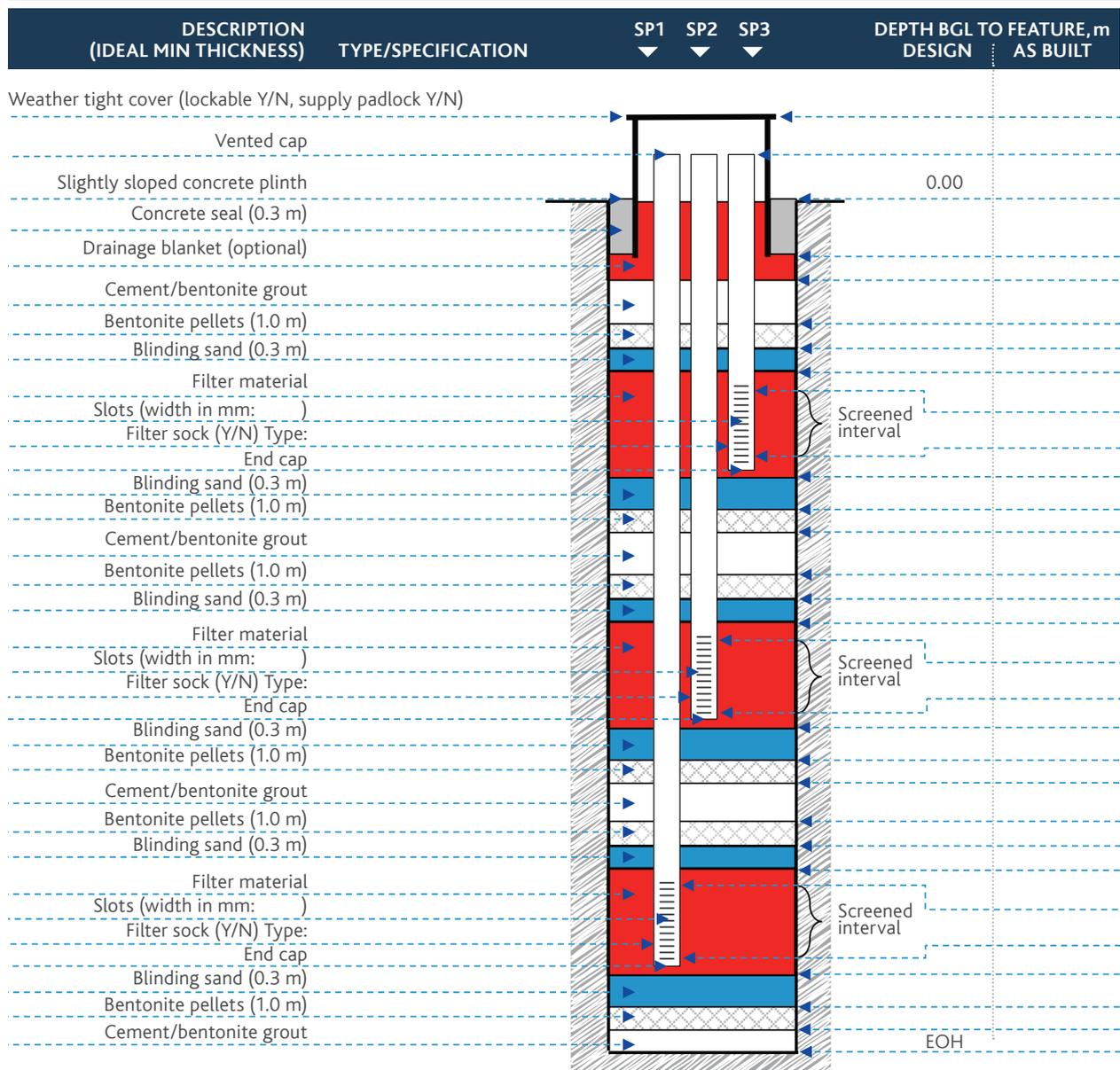
Project number: _____ Project name: _____
 Location ID: _____ Date drilled: _____
 Design by: _____ Date installed: _____
 As-built by: _____ Coordinates (NZTM): _____



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				
SP 2				
SP 3				

Standpipe installation design and as-built record (triple with raised cover)

Project number:	Project name:
Location ID:	Date drilled:
Design by:	Date installed:
As-built by:	Coordinates (NZTM):



STANDPIPE NO.	INTERNAL DIA (MM)	MATERIAL	DEVELOPMENT REQUIREMENTS	AS-BUILT NOTES
SP 1				
SP 2				
SP 3				

APPENDIX D. EXAMPLE CPT LOG SHEET TEMPLATE

CPT Log Sheet	
Site Address	
Project Name	
Contractor Reference	
Suburb/City	
CPT ID No As agreed with geotechnical professional	
Test Date DD/MM/YY	
Easting Coordinate mE (NZTM)	
Northing Coordinate mN (NZTM)	
Elevation 'Not Measured' if not recorded	
CPT Located by 'Survey GPS'/'Hand GPS' or 'Not Located'	
CPT Operator Name of Contractor company and name of equipment operator	
Pre-Drill Metres below ground level	
Assumed GWL	
Max Depth of Test	
Other Testing 'Nil'/'Dissipation' and/or 'Seismic Downhole'	
Comments	
Corrections made to data	

CPT Log Sheet	
CPT Cone Number	
Cone Type eg 'subtraction cone' or 'compression cone'	
Cone Size cm ²	
Cone-Sleeve Offset mm	
Cone-Sleeve Offset included in data supplied 'Applied'/'Not Applied'	
'a' Factor Ratio of cone face to pwp sensor face	
'b' Factor	
Total Zero Shift per channel from last calibration Value and Unit	Channel 1: mV / mA / MPa / Other:
	Channel 2: mV / mA / MPa / Other:
	Channel 3: mV / mA / MPa / Other:
	Channel 4: mV / mA / MPa / Other:
Zero Shift per channel during test Value and Unit	Channel 1: mV / mA / MPa / Other:
	Channel 2: mV / mA / MPa / Other:
	Channel 3: mV / mA / MPa / Other:
	Channel 4: mV / mA / MPa / Other:
Pore Pressure Filter Type and Saturation Method eg disposable PE, glycerine, etc	
Assumed GWL measured by 'Interpretation of pore pressure profile' or 'dipping of hole following rod withdrawal' or 'water on rods' or 'from nearby borehole' or 'other' (provide details)	
Reason for Termination eg 'target depth' or 'inclination' or 'refusal' or 'other' (provide details)	



