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Engaging beneath the surface

Tauranga Southern Pipeline - Harbour Crossing

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Abstract
The Tauranga Southern Pipeline Harbour Crossing is one of the largest HDD crossings completed in the region in recent times. It involved the completion of a 1560m long HDD crossing to accommodate a 914mm diameter steel casing. a DN800 HDPE pipe was then installed within the steel casing.

The project required the installation of 1500mm steel casings on each side of the crossing to cross the shore lines and the HDD crossing then intersected into each casing.

The drilling and downhole steering techniques were very complex due to a compound curve profile drilled to minimum bend radii. Reaming passes were up to 1425mm in diameter.

We utilized our Herrenknecht HK400 ton drilling rig, 1000 GPM Brandt mud systems of each side of the crossing and 2 Gardner Denver PZ8 mud pumps.

The project encountered a latent condition during the works that required multiple methodology deviations. The material encountered was assessed to be a 53,000 year Totara tree.

Despite these challenges, the project was able to be successfully delivered without any health, safety of environmental incidents.

This will address the high complexity of the project, the significant engineering phase of the works, the latent condition encountered and resolving the methodology so that the project could be successfully completed.

1.0 Introduction

The Southern Pipeline is a large wastewater pipeline that has been constructed to future-proof the city of Tauranga on the North Island of New Zealand. It gives the city's wastewater network much-needed capacity and will reduce the risk of sewer overflows into natural water ways.

The steady growth of the city of Tauranga has put increasing pressure on their wastewater treatment plants. The Southern Pipeline redirects some of the city's wastewater to a treatment plant which has extra capacity.

Planning for the Southern Pipeline began in 2005. Several different routes were considered.

The primary goal was to divert wastewater from the new southern catchments across to the Te Maunga treatment plant, because the Chapel Street plant would not be able to cope.

Figure 1 – Southern Pipeline Route

The route that offered the best result for the whole city was to bring the Southern Pipeline from Greerton to Memorial Park, then across the harbour to Matapihi. This option solved several wastewater network problems at once. It achieved the primary goal of diverting sewage from the southern catchments to the Te Maunga treatment plant, and it also offered more ability to relieve the overall wastewater burden that the wider city was placing on the Chapel Street treatment plant.

Construction began in 2009 with the pipeline fully operational at the end of 2018. The final cost for the entire project sits at around $99 million.

The harbour crossing connects Memorial Park pump station to the Matapihi section of pipeline that had already been constructed.

The consented route across the Harbour was through a corridor that allowed for both direct or curved routes using trenchless technology. It required the drilling or tunneling to be at least 10m below the bed of the Tauranga Harbour. All construction works had to start and finish on land; thereby avoiding any disruption to the surface of the harbour bed (including shellfish) or tidal waters within the harbour.

The site encompasses two land sections being Memorial Park to the west and Matapihi Peninsula to the east. Memorial Park is relatively flat comprising grassed recreational and sports fields (Jordan Field), around 2m above sea level. There are also a recreation centre, swimming pool, pump station, skate park and rowing club.

Matapihi Peninsula has a relatively flat carpark and grassed reserve area about 1 to 2m above sea level before rising up a 10m high terrace. The pipe is then trenched across land and the road up the hill to connect with the existing pipe.

Figure 2 – Site Locations

The majority of the pipeline is installed beneath the harbour seabed. The seabed is relatively flat (approximately ≤ 0mRL) with some channels (as deep as -5mRL) and is around 1500m wide.

2.0 Tender Process

An initial tender process commenced in September 2015 for the installation of a DN800 HDPE pipeline to cross the pipeline by Trenchless Technology. The pipeline as proposed was to be installed directly into bore crossing the harbour. At this time a bidding team involving Brian Perry Civil (a Fletcher Building Company), Beca and Lucas was formed. We completed the tender process and were deemed the preferred bidder.

Following a further evaluation period Council notified us that no tenders would be accepted. The Council recorded its intention to carry out further geotechnical investigations of the site to provide more comprehensive information to the original tenderers before issuing a new Request for Proposal for the Project to the tenderers who had been evaluated in the first stage.

The new geotechnical investigations were substantial for a HDD project with seven bores completed adjacent to the proposed pipeline route. At the same time the requirements of the Council for the installation changed with the inclusion of a steel casing to carry the HDPE Pipeline.

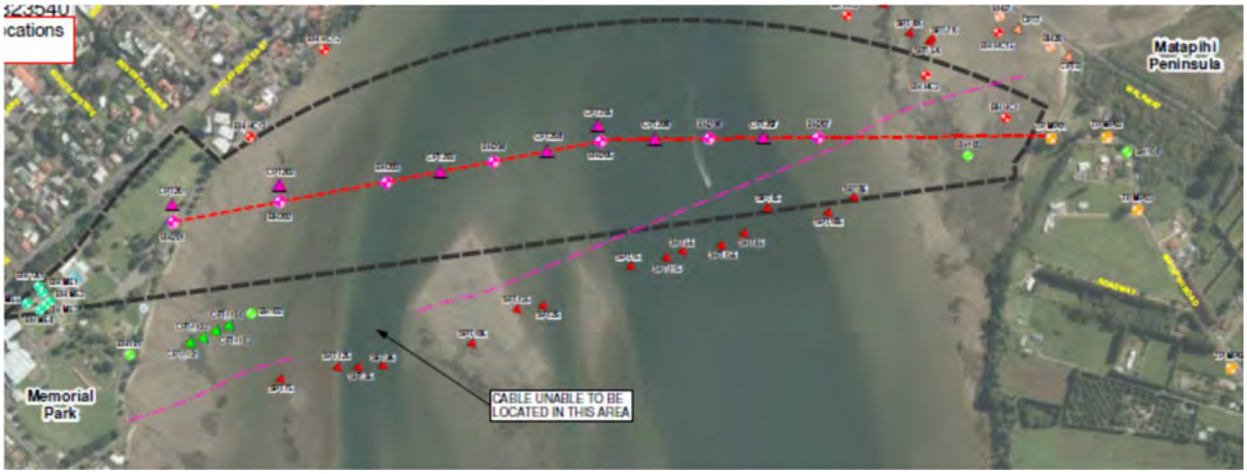


Figure 3 – Additional Geotechnical Investigation

The HDD methodology in the second tender submission was substantially different from the first tender submission as a result of the introduction by the Council of the requirement for a steel casing pipe. Further details of the methodology will be discussed later in this presentation. The first methodology was simpler and required a small diameter hole (44" instead of 54').

Again our proposal was successful and Brian Perry, Beca and Lucas were engaged to complete the installation of the crossing. The final plan was to install significant conductor casing on each side of the harbour so as to maintain a depth of cover at the shoreline. This required significant pits on each side to accommodate equipment. The steel casing pipe at 914mm diameter would be installed as 300m long strings with a DN800 HDPE pipeline of similar length strings to be inserted within the casing.

Figure 4- Final Crossing Concept

3.0 Geological Assessment & HDD Profile

The city of Tauranga is located almost completely within the Tauranga Basin, a Pleistocene to Holocene tectonic sedimentary basin up to 150m thick. The basement of the Tauranga Basin consists of variably welded ignimbrites of Upper Tertiary age.

Deposits infilling this basin are broadly termed Tauranga Group and consist of a basal Pleistocene sequence and an upper Holocene unit. The Pleistocene sequence comprises mainly alluvial deposits interbedded with unwelded ignimbrites and tephras. The Holocene sediments include estuarine, alluvial, beach and dune deposits.

The site is located across a southern branch of the Tauranga Harbour and generally consists of Holocene Estuarine Deposits overlying Pleistocene sediments of the Matua Subgroup. Fill overlies the Holocene Estuarine Deposits on the western side of the harbour (Memorial Park) and undifferentiated volcanic ash overlies the Matua Subgroup on the eastern side (Matapihi Peninsula).

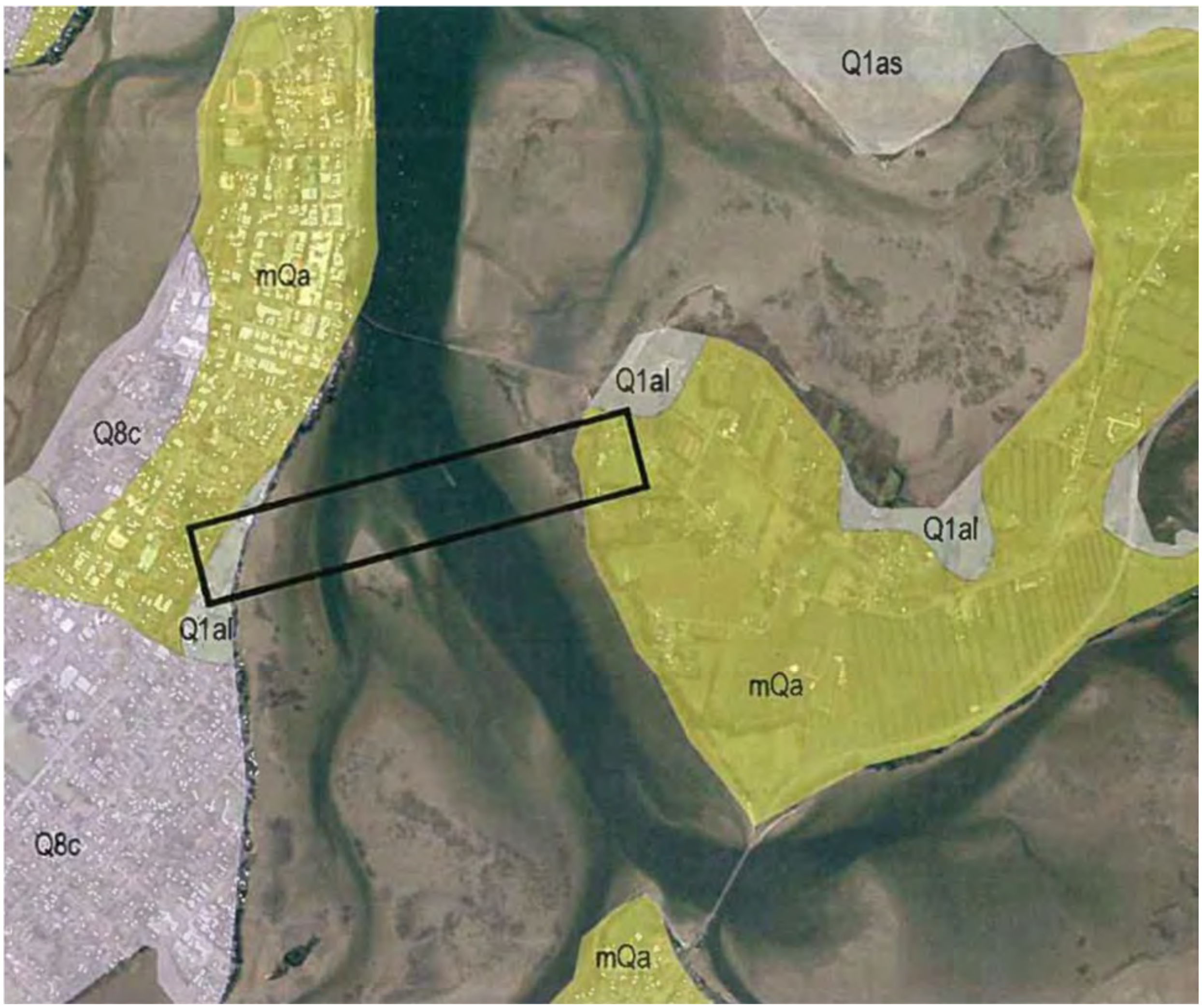


Figure 5 - Geological QMap

3.1 The key units relating to the pipe alignment and design are shown on the following long section in Figure 5.

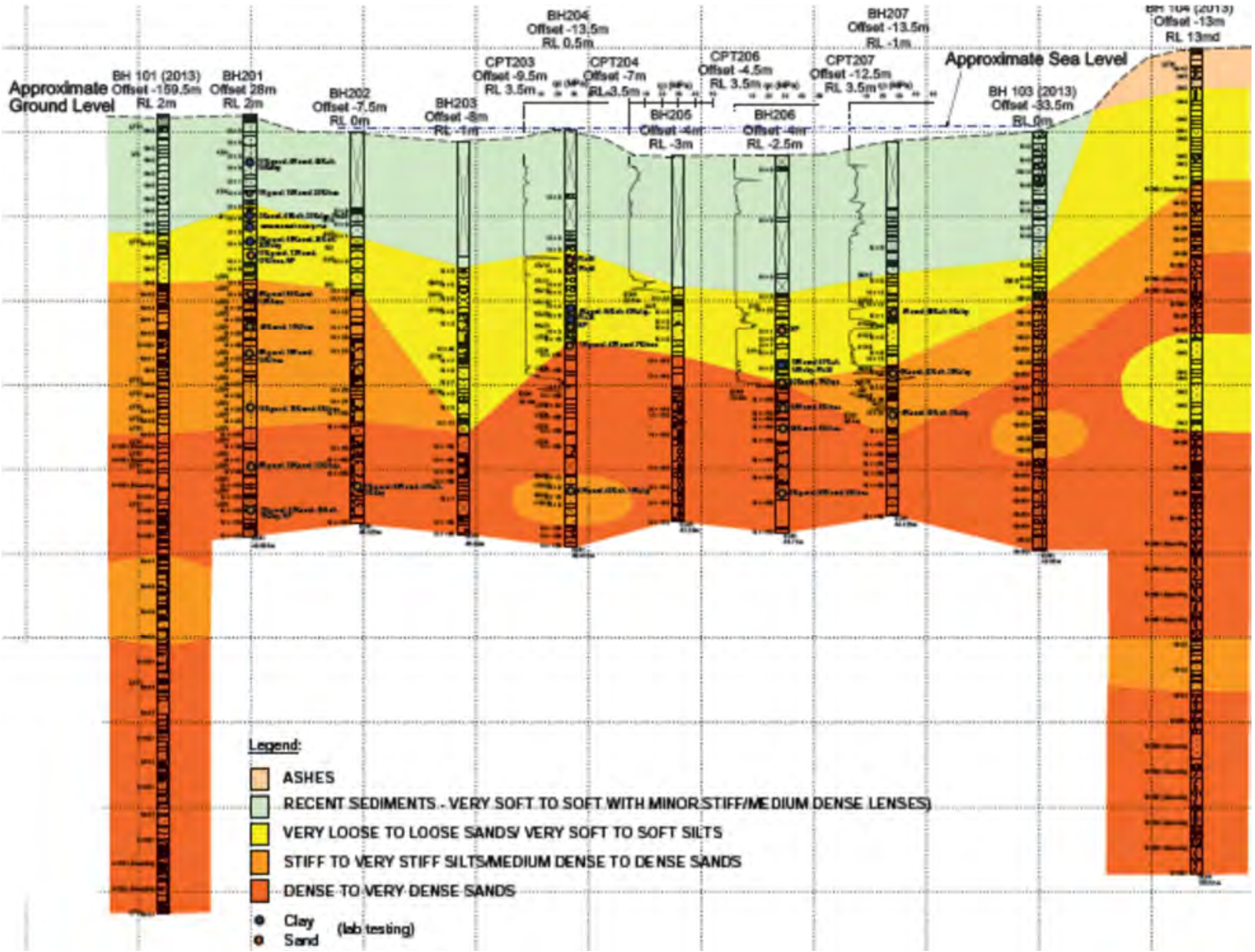


Figure 6 - Geological Long section

a. Unit 2a - Holocene Estuarine Deposits [Green]

The Holocene Estuarine Deposits are the upper unit in the harbour area. Based on the boreholes and cone penetrometer tests (CPTs) the unit consists of very soft high plasticity silt with loose sand (and some shell) deposits. Our planning was to case off as much of this zone as possible with a 60" conductor casing.

b. Matua Subgroup

Underlying the Holocene Estuarine Deposits, Matua Subgroup will be encountered. This geological unit shows significant lithological variability. It comprises mainly plagioclase and pumice rich sands with variable fines content. This unit has been split into three geotechnical sub units based on strength/ density. The pipeline will sit directly within these units.

• Unit 3a [Yellow]– Soft to Firm Silt and Very Loose to Medium Dense Sand: This unit typically comprises moderate to highly plastic silt with some sand lenses. Some of the silts in this layer are sensitive and laboratory testing indicates very high natural water contents and moderately low density which is indicative of pumiceous lenses within this layer. Approximately 200m of pipeline length on each side is located within this unit.

• Unit 3b [Orange]– Stiff to Very Stiff Silt and Medium Dense to Dense Sand: This unit typically comprises sand with gravels and silt/clay. In the lenses with higher fines content these soils are moderate to highly plastic.

• Unit 3c [Bright Orange]– Dense to Very Dense Sand and Very Stiff Silt: This unit has been typically defined as very dense sand with Standard Penetrometer Test (SPT) >50+ blows/300mm. The majority of the pipeline length (over 1000m) is contained within this unit.

3.2 The Plan and Profile of the alignment is shown in Figure 6 below:

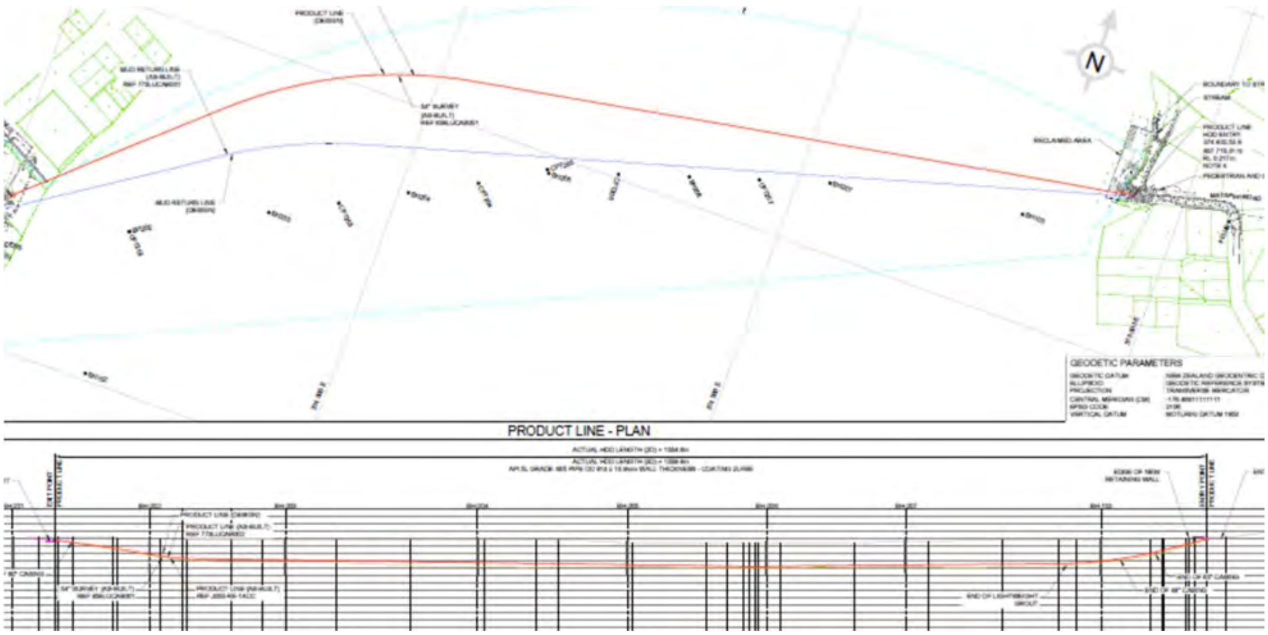


Figure 6 - Plan and profile

There are four distinct sections comprising this crossing - [importantly the constructed pipeline will not allow air to accumulate in the pipeline under normal operation. The drill path will follow constant grades with no intermediate high points. It is proposed that the minimum grade to the east of the low point will be 0.5% and the minimum grade to the west of the low point will be 0.8%]

1. Entry point and surface casing including initial section across the harbour

The entry point section of the drill extends for 200-300 metres. Initially the drill string will exit out through the pre-installed surface casing, and then drill ahead through the near shore environment which includes a tidal flat area. During this phase the pipeline moves from an entry angle of 14deg to close to horizontal.

2. Middle section across the harbour

The middle section across the harbor continues to a low point at approx. 550m and then builds at approx. 0.8% at approx. 1350m whilst also completing a horizontal curve of approx. 1000m radius.

3. Exit point section, up to the position of the exit point casing

For the third section the drill extends for approx. 150m to an exit angle of 7deg.

4. Intersection of the exit point casing

To achieve the accuracy required to enter the exit side casing it was proposed to use a combination of the wire tracking and magnetic ranging from one drill string to another. A small sized rig was to be set up on the exit side casing. A 4-¾" assembly is run down through the casing and out approximately 30 to 40 m from the end of the casing to be ranged against with the main assembly.

4.0 Mobilisation

The key drilling equipment including our Herrenknecht HK400 Drill Rig, Gardner Denver PZ-8 pumps and Brandt drilling fluid processing units were mobilised from Australia.

Figure 7 – HK400 Drill Rig

New 6-5/8" Grade S135 drill pipe was manufactured by DP Master in China and downhole tooling was manufactured in Australia and Indonesia

5.0 Site Layouts

The Rig side was located at Matapihi

Figure 8 – Mataphihi Site Location

A sheet pile pit to a depth of approx. 3m was installed so as to maintain a depth of cover at the shoreline of more 10 metres.

The Pipe side was at Memorial Park. An exit receipt portal was excavated for installation of the exit side casing.

Figure 9 – Memorial Park Site Location

6.0 Surface Casing & Mud Return Line

As is described further in Drilling Operations- Section 7, a mud return was needed for the Product Pipe Drilling Operations. The steel mud return pipeline was drilled from Matapihi to Memorial Park. This pipeline was used to return drilling fluid from the exit pit in Memorial Park to the drill rig site. It also transferred fresh water to the drilling rig. The mud return line remained in place once works had finished.

The drilling was on an alignment different from the sewer pipeline but at a similar elevation so that ground conditions could be evaluated with the product pipeline trajectory in mind. This was drilled in one pass as a pilot hole leaving the drill pipe in place. It took 7 days to completed and provided a good geological profile in preparation for the product pipe works.

The hydro fracture calculations accentuate the low strength of the recent alluvials (the Holocene Estuarine Deposits). The drill path will be cased through this formation for the 36-inch diameter steel enveloper pipe and mud return line steel casing to a vertical depth of -11m. The approximate lengths on each side is 45-65m. Casing were installed at Memorial Park first. The 30” casing for the mud return line was performed initially to gauge noise and vibration levels followed by the 60” pipe. The equipment was then relocated to Matapihi where the 16” and 60” casings were installed.

7.0 Drilling Operations

It is now at this point that this project starts to get quite interesting. Our planned drilling operations were quite simple. ‘6-Passes’ and the pipe is installed is what we had planned.

‘Pass 1’- Pilot Hole was to be drilled at 12-¼” diameter using a jetting assembly, ‘Pass 2’- was to then trip out the survey tool wireline, and at the same time complete a 16” reaming pass by back reaming and a ‘clean tail string added’. ‘Passes 3 & 4’- hole opening reaming passes were planned at 40” and 54” again by back reaming with ‘Pass 5’-a cleaning pass to be completed prior to ‘Pass 6’- pull back.

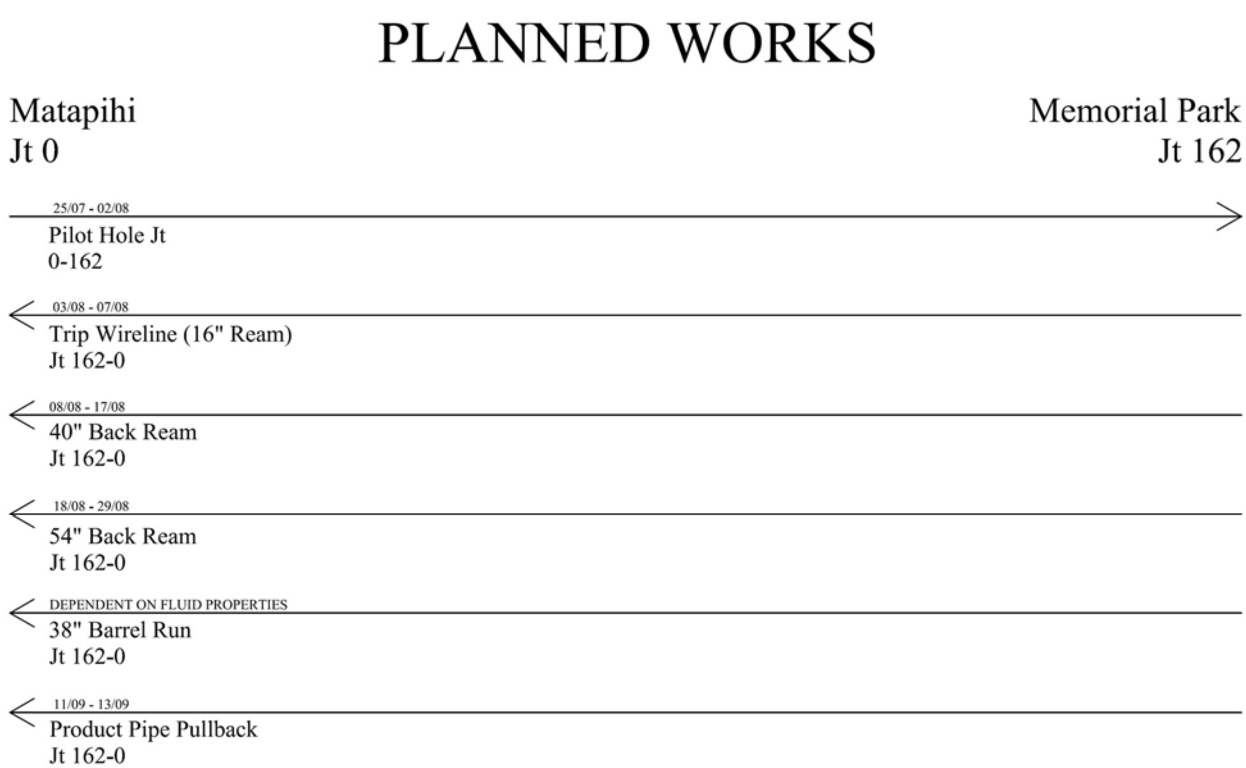


Figure 10 – Planned works

But as often happens in HDD *‘things don’t always go to plan’*.

Work commenced with very good progress with the pilot hole drilling being completed in 10 days with achievement of the planned alignment. The Exit intersect was a little complicated but successfully achieved.

As detailed earlier, a small rig on the exit side with a 4 ¾” assembly was utilised. Once the 4 ¾” assembly was far enough outside of the casing to be magnetically clear, the exit side Paratrack coil was used to determine the position of the exit string. The exit string was then placed 500 mm below the design of the main pilot hole. The pilot hole then drilled ahead using the same exit side coil for positioning, until it was above the exit side string.

Once the position of the pilot hole was determined in relation to the exit side drill string, then the exit side drill string was withdrawn by one drill rod. The pilot hole was drilled ahead by the same distance until it was once again overhead.

Magnetic ranging was repeated and the distance and orientation of the two strings in relation to each other was calculated again. This was repeated until the pilot hole string entered the casing.

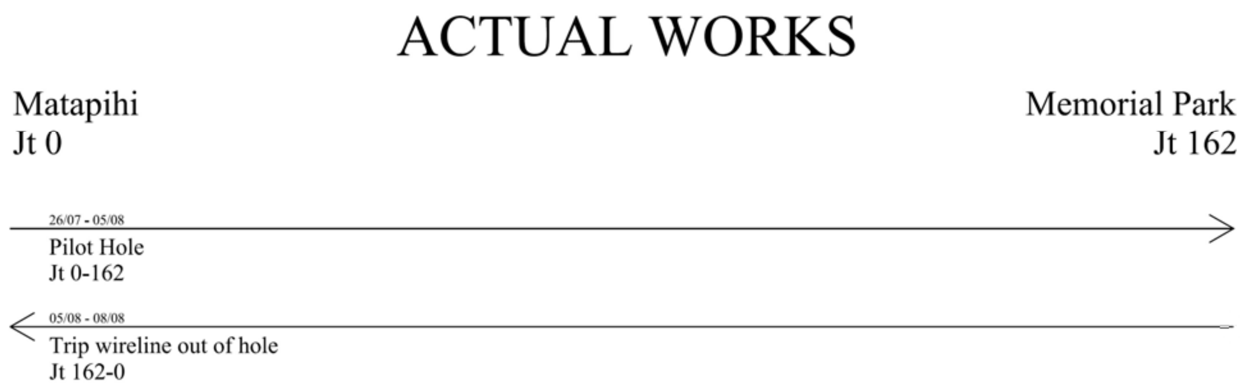


Figure 11 – Actual Works – Pilot Hole & 16” Ream Pass

Things were going well and given we had successfully completed the mud return line, pilot hole and 16” ream, we progressed to the 40” reaming pass.

For the 40” back ream an average penetration rate of ~20 minutes per joint was achieved with just two small peaks also observed. This indicated the 40” fly-cutter was suited to the formation and working consistently to achieve a constant rate of penetration.

At joint 45, having already reamed 117 joints, the 40” reamer became jammed and was unable to regain rotation or movement in either direction. At this location the tooling encountered formation that was materially and substantially different from the previous 500m section reamed within Matua Subgroup 3c.

As is the common case in HDD works, you fear multiple circumstances that may have affected the works, and in this case, we considered a significant tooling failure, substantial hole collapse and finally and anomaly in the geology. Fortunately following a significant effort, we were able to free the reamer, but leaving behind a significant amount of debris that then lead to scoring of the drill pipe within the hole with 2 separate snaps of the pipe and a change in the direction of the methodology. Significantly this included the mobilisation of a second rig so that the passes could be completed by either direction.

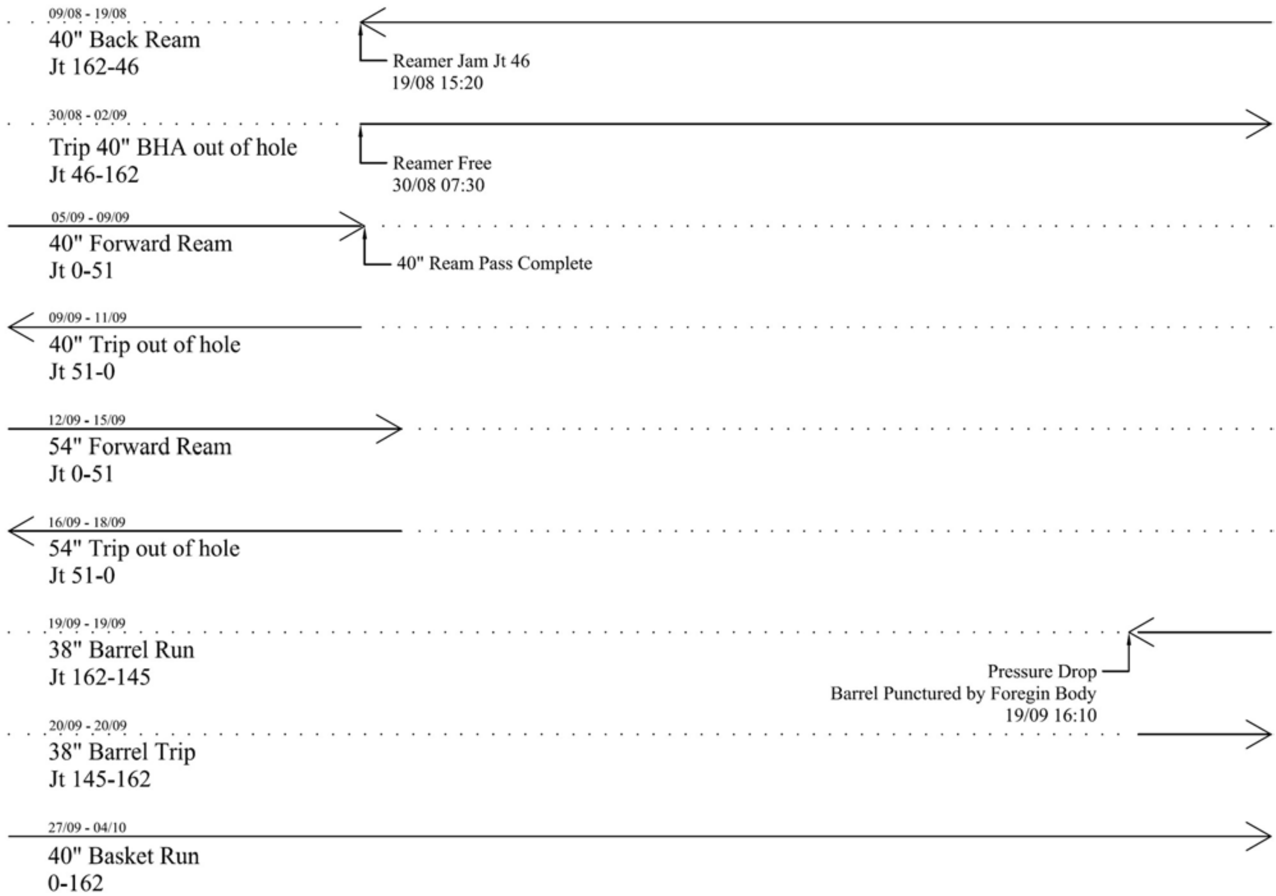


Figure 12 – 40" Ream Pass and Latent Condition Interaction

Despite these challenges and although not very common with latent condition circumstances, we were able to ascertain that the obstruction was timber deposits. Testing of timber recovered from the borehole revealed it to be Totara and approximately 50,000 years old. Several large pieces of timber were retrieved from the hole through junk basket runs and also by floating out of the hole.

Figure 13- Totara

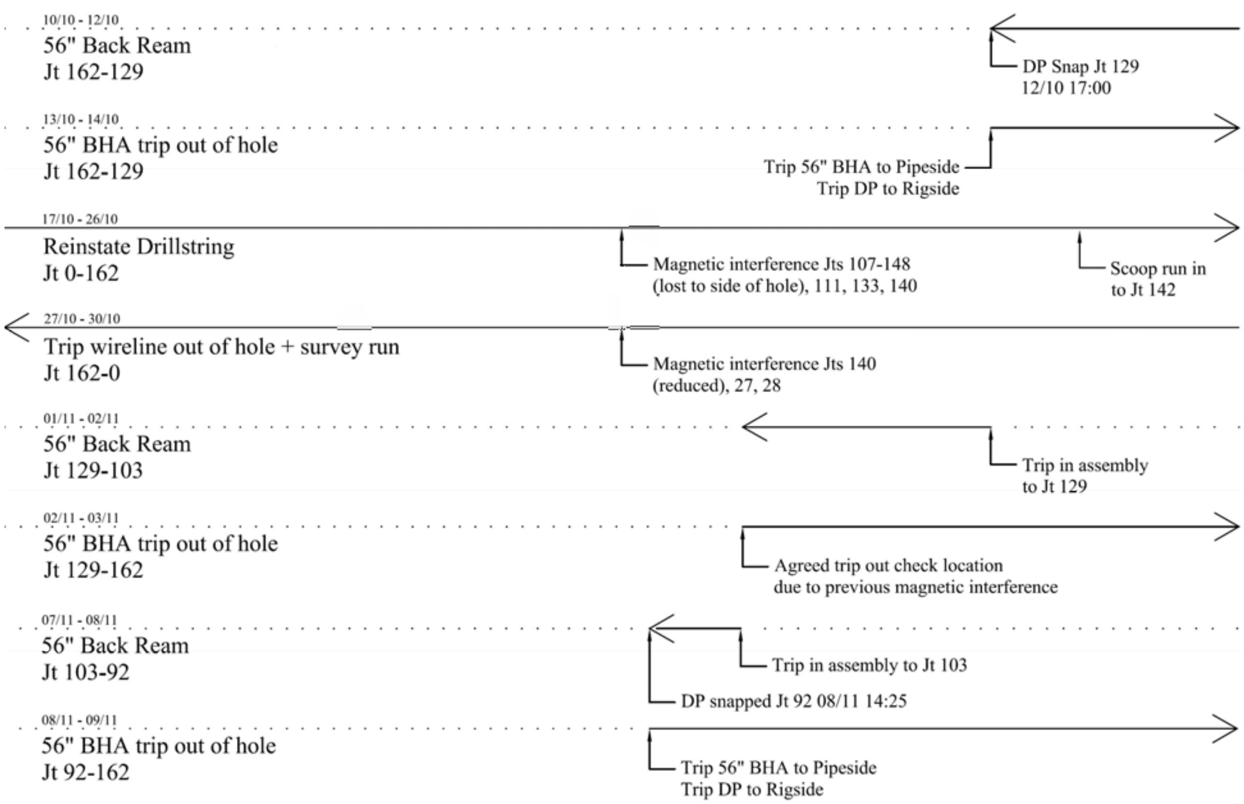
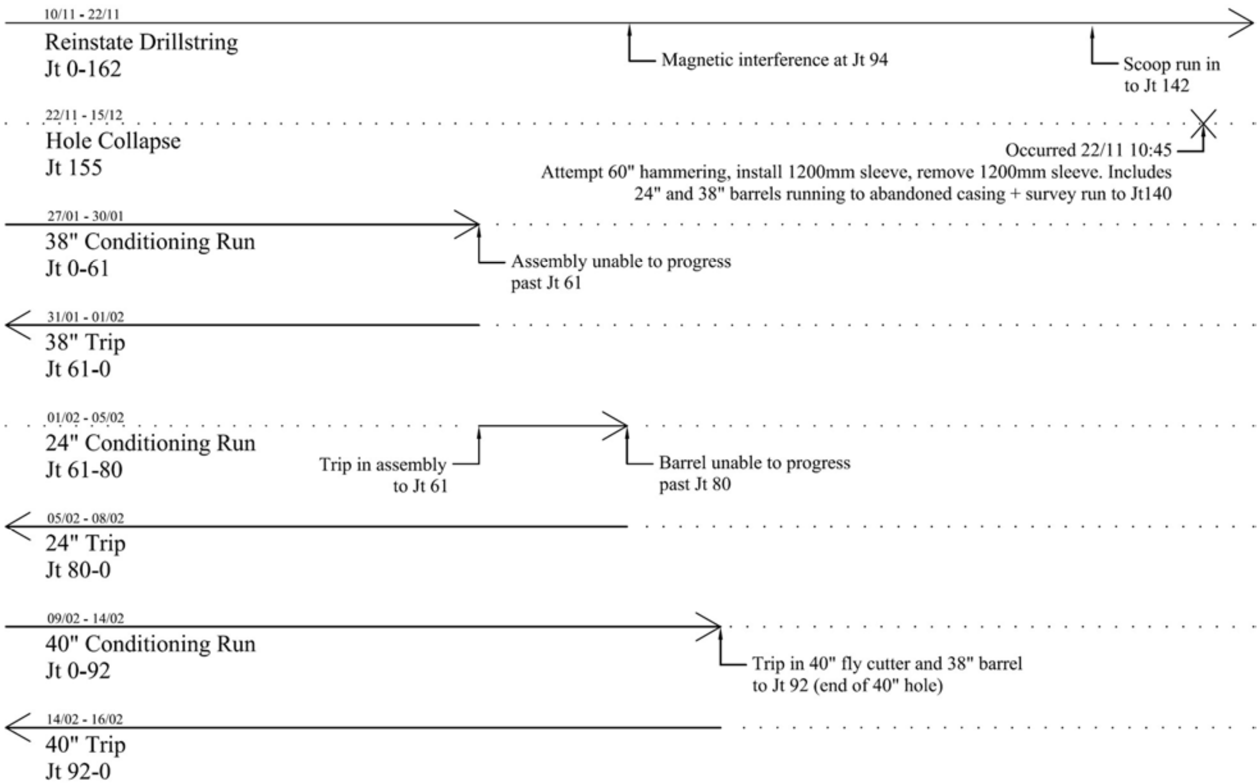


Figure 14- Drill Pipe Snaps

By this stage, drilling in the hole had been underway for approximately 4 months, during this time, we have encounter the latent condition, have incurred two separate drill pipe snaps due to scoring from the reamer debris but have finally been able to complete a 40” clear path within the bore. As happens with HDD, things often go from bad to worse and we then encountered a significant area of hole collapse. Without delving into each of the steps that were taken, another 4 months progressed, and again the hole was able to be restored and finally after 11 months of operation we completed the crossing. Importantly, at all stages, the equipment was fully available for operation, our downhole tooling maintained consistent penetration rates without tool failure and the works were completed without any health and safety incidents.



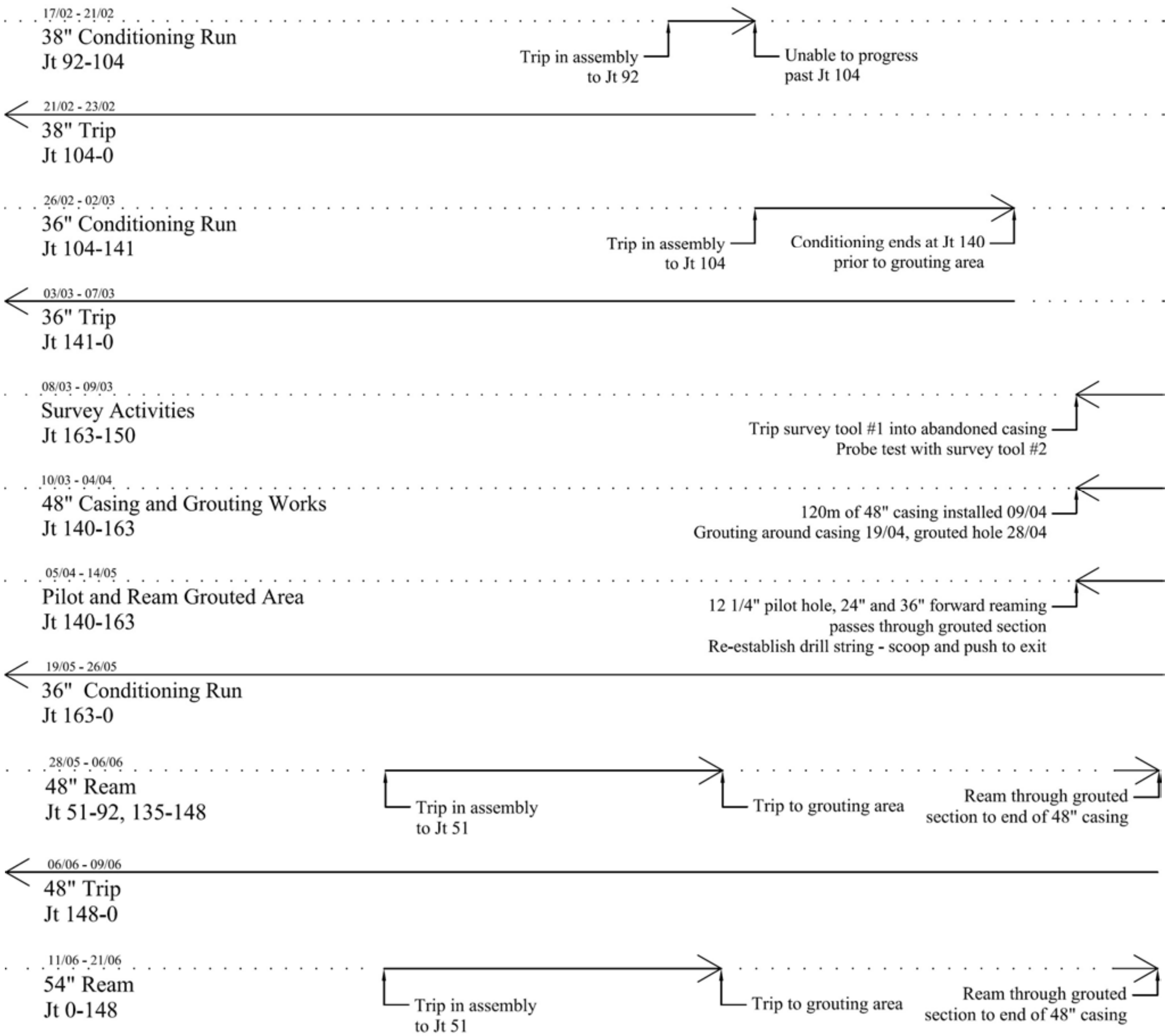


Figure 15 – Drill Path Recovery

Prior to pulling in the product pipe, we completed a full length "dummy run" of a 30m section of the pipeline that was completed without incident. The final pullback was completed over an 8-day period working continuously 24 hours per day. The pipeline was installed in strings of approx. 300m in length. The pipe was pulled with a maximum installation load of 90 tonnes which was 50% of the predicted loads.

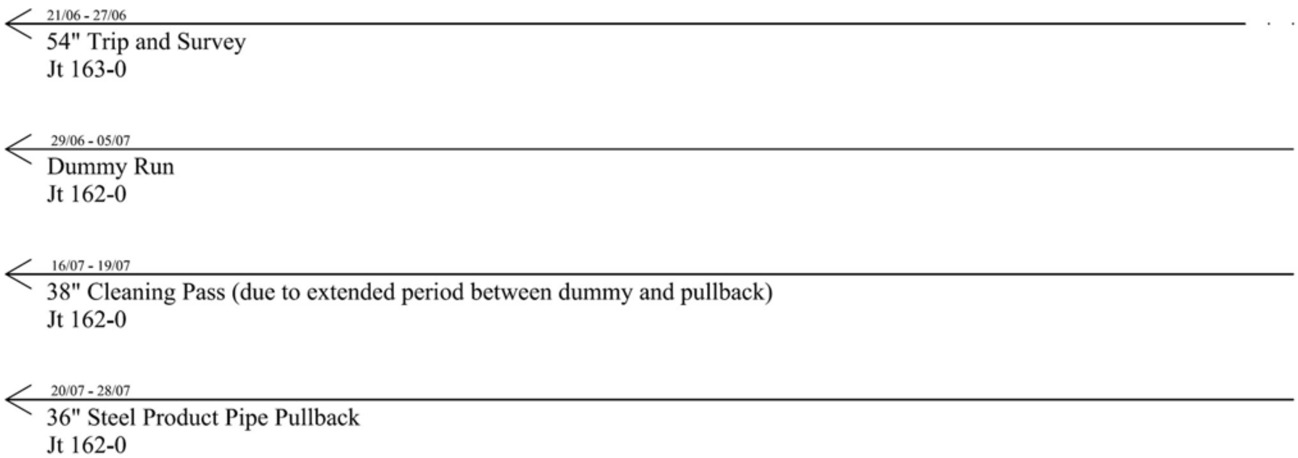


Figure 16 – Pipe Pullback

8.0 Conclusion

As a result of encountering the Physical Obstruction, this was a project that encountered significant additional work that was beyond the scope originally envisaged. We had planned to undertake ‘Six Passes’ to complete the works but ultimately we had to undertake a total of ‘43 Passes’ through the borehole.

In doing this though, it is a project where collaboration of all parties was achieved. Standards were maintained and the outcome was achieved.

As a business we have taken away a significant number of learnings from the project and continue to challenge ourselves “would we have done anything differently??’.

This project was contracted on a lump sum basis- different Contractual Terms may not be achievable, but in hindsight were probably appropriate for these works- especially where the latent condition was encountered.

Many times throughout the works, we considered re-drilling the hole. Again with a different contract mechanism in place this may have occurred. The challenge of a narrow corridor, substantial entry and exit pits and casings, this was not achievable without a complete ‘rethink ‘of the project. Equally, our ability to maintain an open hole for the duration of the works is a testament to the drilling process and drilling fluid programme that was maintained throughout the works.

The Tauranga Southern Pipeline was a successful project despite significant unforeseen challenges and its success should be considered as benchmark for large scale projects in this region.

9.0 References

Beca Limited - Geotechnical Design Report: TC 65/16 for Southern Pipeline Tauranga Harbour Crossing – 1 March 2017

Tauranga City Council – Southern Pipeline Updates – Website Data.