INNOVATING WITH SEGMENTAL CAISSON CONSTRUCTION TO BUILD A NEW PUMP STATION IN WELLINGTON'S CBD

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ABSTRACT

Growth is vital to keeping our cities vibrant and attractive places to live. The limited capacity of the wastewater network in the Wellington CBD has restricted the ability for the city to grow and develop.

This paper outlines the investigations, tender, construction and contract supervision for a new wastewater pump station (PS), and associated pipework undertaken on behalf of Wellington Water Limited (Client) for Wellington City Council (Asset Owner).

This was the first PS to be constructed in the CBD in over 40 years. The CBD setting presented significant challenges in terms of feasible site locations; managing existing services, providing operations and maintenance access, and accommodating third party stakeholders and local business needs.

The paper discusses the difficulties of constructing a combined drywell / wet well water retaining structure, in a difficult location, with critical Health and Safety considerations and why these complexities ultimately, drove the project towards the adopted solution.

The client accepted GHD's proposal to open the tender to alternative construction methodologies that might offer better solutions. The nominated Contractor, Brian Perry Civil (BPC), proposed an innovative proprietary precast caisson segmental system for the PS structure. Caisson construction generally, offers cost effective, efficient and safe method for constructing below ground chambers; the segmental system added speed of construction with significantly improved Health and Safety advantages.

The paper details the close collaboration between GHD and BPC to ensure the precast system met geotechnical, seismic and structural performance requirements and the additional quality assurance (QA) requirements for elements prefabricated overseas.

The paper also describes the challenges that were faced and successfully overcome during construction. Focusing on, first attempt using this construction system for the contractor, managing contaminated ground and associated contaminated groundwater, and managing groundwater drawdown and associated building settlement risks associated with constructing the temporary concrete base plug.

GHD and BPC do not believe that anyone else in New Zealand has inserted internal walls within a pre-cast segmental structure like this, with the intention of using it as a combined operational building and water retaining structure in a seismically challenging environment.

KEYWORDS

population growth, innovation, caisson, segmental, innovation, pump station, risk management, customer / stakeholder management

PRESENTER PROFILE

Callum Allison MEng CEng MICE (GHD) - Water Lead with 17 years consultancy experience in design, supervision and contract administration within the water, environment and energy sectors.

Caroline Anderson BEng (Hons) (BPC) – Contractor Site Engineer with a solid background in civil engineering projects and an eye for detail.

1 INTRODUCTION

1.1 PROJECT DEVELOPMENT

The population of Central Wellington is estimated to grow by approximately 65,000 people over the next 30 years. To accommodate this growth sustainably, Wellington City Council (WCC) have developed the Wellington Urban Growth Plan (WUGP), of which encouraging development in Central Wellington is a key component.

Figure 1: 2018 Developments in catchment

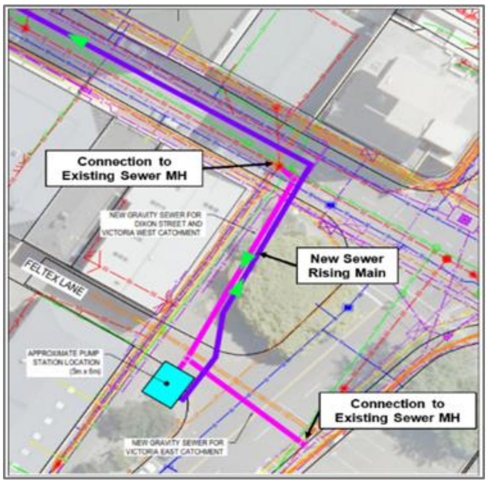
The Victoria Street area in Central Wellington is classified as a WUGP transformational growth area, with potential to form a major population hub with over 7,300 new dwellings. Three residential high-rise developments began construction in 2018, with two more in 2019.

Central Wellington had aging wastewater infrastructure which was significantly undersized for these new residential areas. Early investigations by the client, Wellington Water Limited, (WWL) identified that imminent new high rise residential and commercial developments would increase the risk of wastewater overflows to the harbour. The preferred solution was to construct a new wastewater pump station to accommodate additional flows from new developments, alleviating capacity issues in the downstream network.

1.2 SOLUTION

In March 2017, WWL engaged us to carry out the investigation, design, tender and contract supervision for the new pump station and its associated pipework.

Figure 2: Proposed pump station Location



The first pump station to be constructed in Central Wellington in over 40 years, the central location presented numerous complex challenges, including the management of existing services, operations and maintenance access, and accommodating stakeholder and local business needs.

Constructing a combined drywell/wetwell water retaining structure in a difficult location, with critical health and safety considerations drove the project towards the adopted solution of a new pump station constructed using segmental caisson methodology.

1.3 KEY STAGES AND ADDED VALUE

Together with BPC, we added significant value to the client during three key stages of this project:

- Identification of an innovative construction methodology, assessment of its risk, and working together to develop a viable solution,
- Development of a conforming design solution in collaboration with the preferred tenderer, and
- Providing reliable support and multi-disciplinary services to manage risks during construction. Monthly site meetings ensured the client was fully aware of progress, and were critical to successful project delivery.

1.3.1 ALTERNATIVE TENDER METHODOLOGY

An initial review of the local contractor market indicated that the typical solution would be either a caisson, or a sheet-piled excavation using cast in situ construction. We recognised that more efficient methodologies, such as a proprietary precast concrete segmental structure using a caisson sinking technique, could provide significant cost savings and risk reduction.

Figure 3: Diversion of existing services

Open caisson methodology enables a shaft structure to be sunk in a controlled manner, from the surface, to a predetermined depth (refer to Appendix B). We sought further advice, and confirmed that there were contractors capable of delivering the segmental caisson type of construction method.

WHY THIS METHODOLOGY?

Wedged between businesses and Victoria Street's busy traffic, and with numerous existing services, the proposed site was extremely constrained. Under other underground pump station construction methodologies, a larger site would have been required, either for excavation or to allow the caisson structure to be constructed. This methodology significantly reduced the construction footprint required, reducing the impact on those living and working nearby, and creating fewer delays for road users.

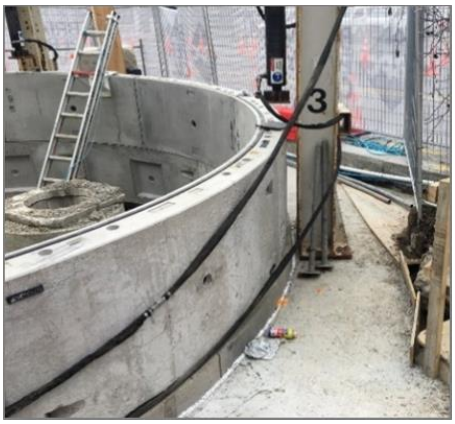


Figure 4: Caisson Rings with hydraulic jacks

The segmental caisson technology retains the surrounding soil, eliminating the need for extensive enabling works, and minimising the impact on the surroundings. It reduces installation time and construction impacts such as noise, vibration and machinery, and reduces risks associated with adjacent buildings and roads. All excavations inside the shaft can be managed by machines, eliminating the need for people to work within deep excavations or confined spaces, reducing health and safety risk. The segmental system also provides the added benefit of not requiring any above ground construction and permits the use of hydraulic jacks rather than relying on the mass of the structure to sink the caisson.

AN INNOVATIVE IDEA

We highlighted the benefits of the innovative segmental caisson method to WWL, and were initially met with uncertainty. We proposed a rectangular caisson as the baseline construction methodology and welcomed alternative tenders for potential methodologies that the client had not used previously. We also included general arrangement drawings for a circular structure.

BPC submitted a tender proposing a proprietary precast caisson segmental system. However, precast segments are not readily available in New Zealand, and BPC proposed to source these from the UK, where this type of methodology is more common.

CONVINCING THE CLIENT

BPC's proposal posed risks, in that they had not used this system before, and the segmental systems used in the UK did not have internal walls. The structure required would have a cast in situ internal wall, to separate the required wetwell and drywell, and needed to accommodate potential displacement from seismic events. We sought assurance from BPC that the system met consenting and quality assurance (QA) requirements for an underground structure in a seismically active area.

Recognising the benefits of this innovative system, and BPC's reliable project delivery history, the client accepted our recommendation to accept BPC's proposal.

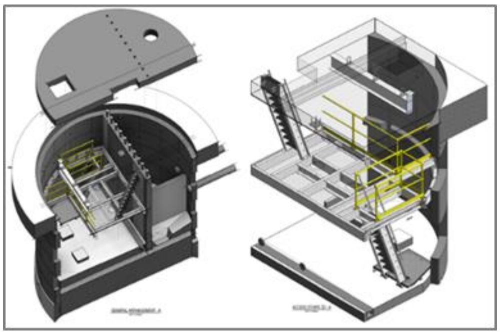
We arranged a meeting to determine all parties' roles and responsibilities (an organisational chart is provided in Appendix A). Throughout the project lifecycle, monthly progress meetings with WWL ensured they were fully involved in the project delivery. Many members of the WWL management team visited the site, providing feedback and comments that were positive, including the below feedback:

"*In all aspects GHD delivered a successful outcome for Wellington City. This is a testament to GHD's technical skills, planning and the collaboration between Client, Designer and Constructor. I look forward to similar future projects."* **Tristan Reynard, Project Director**

1.3.2 COLLABORATION TO DELIVER CONFORMING STRUCTURAL DESIGN

Following contract award, we worked with BPC and Arup, their sub-consultant, to finalise the design. This included assessing ground conditions, seismic modelling and defining structural performance requirements to ensure in-situ walls could be designed to work together with the external structure, and that the whole structure would perform effectively in an earthquake.

Figure 5: 3D Model of pump station



A 3D model was generated to help visualise the pump station layout. This proved to be a vital tool to assist with the fitout of the pipework, fittings and ladder access, required as part of the building consent conditions.

1.3.3 MANAGING RISKS IN CONSTRUCTION STAGE

During construction, we provided site support to BPC and helped to overcome two significant challenges that had the potential to disrupt the programme and create additional costs; overcoming contaminated groundwater discharges and modelling groundwater drawdown to determine potential risk of settlement next to a multistorey masonry building with shallow foundations. These challenges are described further in Section 1.6.

2 COMMUNITY OUTCOMES

2.1 WELLINGTON WATER STATEMENT OF INTENT

WWL's work focuses on three customer outcomes, each of which have four associated goals. Six of these service goals are directly linked to the success of this project. See below:

1. **Safe and healthy water**

Minimise public health risks associated with wastewater and stormwater, by protecting the public from direct exposure to untreated wastewater onto land or beaches.

2. **Respectful of the environment**

Enhance the health of the waterways and the ocean by ensuring that the water quality is not adversely affected by discharges from water, stormwater or wastewater.

Ensure the impact of water services suit natural and built environments, by managing water services to comply with consents and not be intrusive to communities.

3. **Resilient networks support the economy**

Provide customers with access to reliable water and wastewater services.

- Provide water, stormwater and wastewater networks that are resilient to shocks and stresses by working towards agreed levels of service to restore water services to customers.
- Plan to meet future growth and manage demand.

2.2 COLLABORATION ACROSS STAKEHOLDERS

2.2.1 CUSTOMER EXPERIENCE

Figure 6: Retention of popular community area

Customer experience is at the heart of everything WWL delivers. Customer satisfaction was identified as a significant risk in this project, due to the recently completed Victoria Street redevelopment project. Businesses and residents in the area did not want further disruption less than two years after the redevelopment was completed. In addition to the many stakeholders in the area who would be impacted by physical works, our communications and engagement approach also needed to consider those commuting through the area, ensuring their safety and preparedness for changes to the road and footpath layout.

3 COMPLEXITY

The biggest test for this project was finding a system that would provide a water retaining structure, accommodate pump station operations, and had a minimal construction footprint. Alongside BPC, we developed a system that was viable in a challenging and complex urban environment, and would:

- Construct a nine metre diameter (6.5m internal), seven metre deep structure that was 3.5 metres beneath the groundwater table,
- Have a limited site footprint, as the site was only one metre away from a live road and five metres away from inhabited buildings, and needed to accommodate movements of a 24tonne crane,
- Safely maintain pedestrian, vehicle and cycle access at all times,
- Enable works to divert a number of existing utility services (gas, HV power, telecoms, water, stormwater),

Figure 7: Diversion of existing services

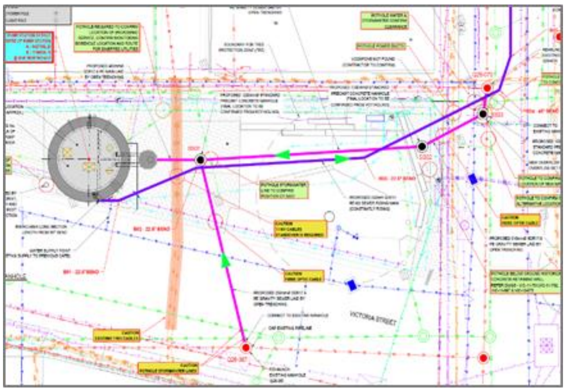
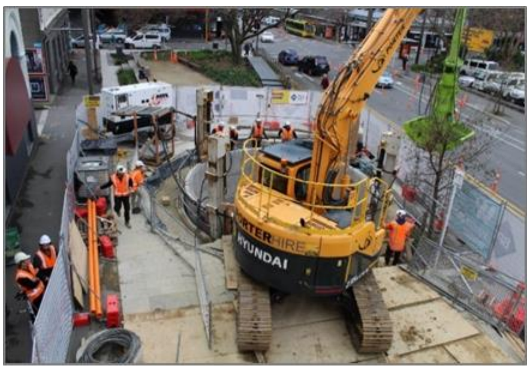


Figure 8: Construction within restricted site compound



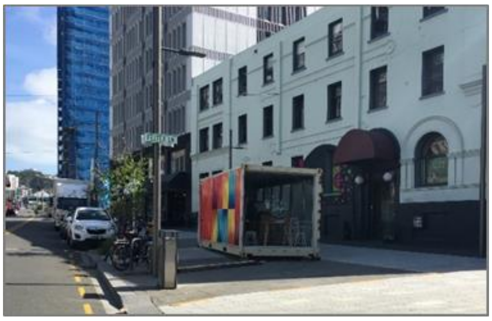
- Retain the existing streetscape layout and protect trees in the area,
- Minimise noise, vibration and disruption to nearby residents and businesses,
- Meet seismic design requirements for a critical water asset,
- Satisfy WCC's Building Consent requirements for an underground structure,

- Meet contaminated land and dewatering resource consent requirements, and
- Work around the limited availability of the precast concrete segments.

The chosen segmental caisson construction methodology was flexible enough to meet the complexities of the site, the stakeholder requirements, and the environmental considerations, while shortening the construction timeframe and providing improvements in health and safety.

UNREINFORCED MASONRY BUILDINGS

Figure 9: Unreinforced masonry buildings on site



In collaboration with BPC, we meet the complexities of the small site by committing to simplifying the construction process. There were unreinforced masonry buildings only five metres away from the construction site, which needed evaluating to ensure they would maintain their structural integrity, as they would be extremely sensitive to damage from settlement and vibration during construction. We addressed any owner and tenant concerns through our communication and engagement strategy, and mitigated these risks through our innovative construction methodology. The caisson construction method in this location ensured that:

- The extent of excavation was reduced, ensuring it was as far away from surrounding buildings as possible,
- The excavation work could proceed beyond the groundwater table without the requirement for dewatering, removing the associated risk from groundwater induced settlement, and
- Mass concrete ring beam meant hydraulic jacks could be used to push against and ease the structure into the ground, eliminating almost all vibration-induced movement.

4 INNOVATION

PRECAST CAISSON SEGMENTS IN SEISMIC CONDITIONS

Confirming that the seismic risk profile was acceptable to WWL and WCC was a milestone in proving that caisson technology was suitable for this project. We worked with BPC and Arup to confirm the structure would meet building consent requirements for performance in a seismic event.

INTEGRATION OF PRECAST AND IN SITU INTERNAL MODULES

Our team demonstrated innovative thinking through the integration of internal walls within the modular caisson walls, to create water-retaining chambers. Standard New Zealand pump station construction has the flexibility to modify the external structural to accommodate adjoining internal walls. Pump stations formed as segmental caisson structures in the UK and Europe are generally wetwell only designs. In New Zealand, for the size of the pumps required, the WWL Regional Standard stipulates that a separate drywell to house pumps and controls is required. We designed an innovative solution which ensured that the internal walls could be integrated with the segmental structure, to perform as an overall system. This was critical to ensuring that the structure would retain water tightness (from external groundwater and internal wastewater) and structural integrity if there was a significant seismic event. We completed this stage in collaboration with BPC, to ensure the proposed solution was constructible.

Integrating the modular caisson and supplementary structure reduced the need for separate wet and drywell structures. This approach allowed the use of proprietary elements in the caisson, which had significant material and programme efficiencies, including reducing construction time by about two months.

REAL-TIME MONITORING OF TRAFFIC FLOWS AND GROUNDWATER LEVELS

We used monitoring software systems for traffic flow and ground water, allowing real-time data to be reviewed daily from the office.

Traffic flow monitoring allowed our design team to assess peak traffic flows around the proposed construction area, and plan ahead with WCC's road authority to ensure that traffic disruption would be minimal. The live information during construction also provided accurate data of delay times through the site, allowing for modifications to the traffic management set up.

Monitoring groundwater levels from a borehole near the site provided accurate updates of potential drawdown of the water table around the shallow foundations of the nearby buildings. This proved invaluable during construction, and is further described in Section 1.6.

WORKING THROUGH THE WATER TABLE.

Early in the design stages, we identified that a large volume of dewatering may be required during construction, as the second floor of the pump station was located below the expected water table. Dewatering presented a significant risk, due to the potential settlement of surrounding unreinforced masonry buildings. Using a precast segmental caisson system reduced the volume of dewatering required, as the caisson rings simultaneously formed the structure, and blocked groundwater from entering the excavation from the sides. The precast system also reduced construction time significantly, which reduced the dewatering volumes. During construction, real-time groundwater monitoring ensured maximum efficiency of the dewatering process.

Innovative construction and monitoring technologies allowed us to reduce the risks associated with working through the water table. In doing so, delays to the project were minimised, and the volume of water discharged to the stormwater and wastewater networks was reduced.

3D MODELLING

3D modelling (revit) is not new technology, but we were innovative in how we applied it to this project.

The revit model was crucial in communicating with WWL, stakeholders, and the public, as it told the story of the construction and shed light on what was happening onsite that they would not otherwise see. Revit was also used extensively to communicate within the design team.

Initially, the revit model was not considered a crucial function, with the design team committing to identifying potential design clashes and joint configurations manually. However, as the design progressed, the benefits provided through the modelling became clear.

To achieve water tightness, it was important that there were no in situ joints clashing with the vertical joint in the caisson segments. Revit modelling was able to verify that this was possible, giving confidence to the design team and set out requirements to the contractor. Revit modelling was also critical in verifying that proprietary corbel (precast concrete support for internal flooring) elements could be used at exactly the right height and location as well as assisting in the pipework and internal steel work fit out.

PROCUREMENT MODEL

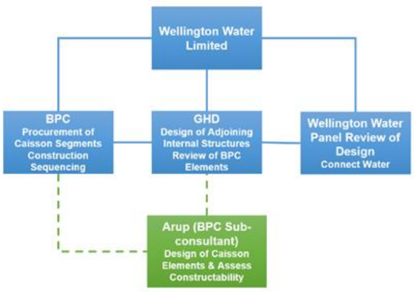
The procurement model followed was not a normal process for WWL and required flexibility and belief from all parties that the risk profile for the innovative segmental system was acceptable in comparison to other methodologies.

5 DEPTH AND EXTENT OF TECHNICAL EXPERTISE

STRUCTURAL

Building consent – QA systems already in place

Figure 10: Design and review process



Early on, we identified that obtaining a building consent for the segmental caisson elements was a risk. The first question in this process was determining whether this was in fact a "building" requiring consent. We worked with WCC to identify a process to meet their consenting needs, and decided that the pump station did require a building consent, as it is a place of work for maintenance personnel. These discussions identified that the consenting authority would also be focusing on requirements for fire and access.

The design and review process captured in the figure above was established to satisfy both WCC's and WWL's risk management requirements.

Seismic and Internals

The pumping station is classed as a critical asset, and therefore was designed to Importance Level 4 (IL4), as determined in AS/NZ1170.0.

Our team displayed their technical experience in their development of a viable design solution. We drew on the experience of our design team to map out a path between contract award and consent lodgement. This programme identified potential risks, and took steps to manage these. Our design team recognised that there were many possible ways to approach this design, and interpret the client's requirements. To manage this risk, design parameters were established early and communicated to both GHD's and BPC's design teams.

We worked with BPC to develop solutions for the integration of the supplementary structure and the external caisson. This included initially identifying the stiffening effect of the internal walls on the caisson structure, and continued with the design of the internal walls, which had to allow for the imposed deflections of the caisson.

Figure 11: Caisson internal walls

We demonstrated our technical expertise in the review of BPC's proposed construction methodology and in the development of the supplementary structural elements. The supplementary structure design was complex, as it was subject to the building type accelerations due to its self-weight and the imposed deformation of the surrounding ground. Finite element modelling was used to determine these effects, and to verify that watertightness could be maintained.

Our team also demonstrated their technical expertise in developing a waterproofing strategy that was compatible with the construction methodology and final construction. Our design identified the different joints required, and their interaction with the various structural elements. Joints between the caisson and internal walls were required to accommodate articulated movement of the caisson while integrating with the caisson elements and the precast wall panels. Stitch joints between the internal walls needed to consider the placement of starter bars and ease of transportation, early age stresses, and construction sequencing. The design delivered a watertight solution that made the construction straightforward.

SEISMIC DESIGN

A primary requirement of this system was that it would be able to function well in a region prone to seismic activity. In the preliminary design stage, we identified that the pump station's location had a peak ground acceleration in the order of 0.81g, and segmental caisson construction is typically used in areas with lower seismicity.

The delineation between the proprietary design and supply of the caisson elements by BPC, and the interactions between this structure and the internal fitout elements, added further complexity. It was crucial that all parties had a clear understanding of their responsibilities, and worked to common parameters as the design progressed to consent.

Common design parameters were established early in the design process and communicated to both GHD's and BPC's design teams. As we reviewed the caisson design for the client, we were able to clearly set out what would be required in the design package for review. This collaboration helped to make the design run smoothly, as everyone worked towards common targets.

Arup provided a design basis and supporting information that showed the caisson could remain intact when subjected to the Ultimate Limit State (ULS) seismic ground accelerations and ground deformations. The maximum deformation at each caisson joint was determined, and assessed against the limits of the waterproofing mechanisms.

It was crucial to demonstrate that the internal walls of the caisson did not compromise the integrity of the caisson, and vice versa. Arup addressed this by illustrating that the restraint created by the internal wall was within the limits of the caisson elements. We were then able to demonstrate that the internal partition walls could accommodate the loading imposed by the surrounding ground deformations.

We addressed this with clear planning and communication of design parameters, establishment of team roles, and open communication throughout the design stage.

CONNECTIONS

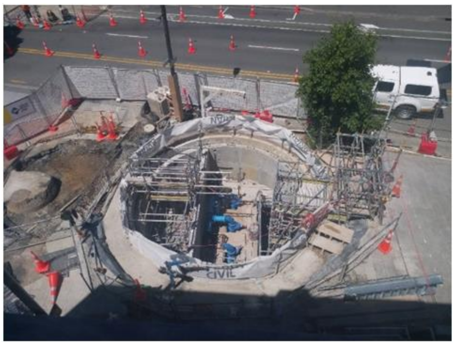


Figure 12: Completed internal walls and pump connections

The caisson construction was able to limit the required footprint of excavation to the shaft only, and we addressed this in the design of the supplementary structures. Connections between precast elements and the caisson were developed in collaboration with BPC, to make the construction as simple as possible. Elements were sized, cut and stitched to fit within the lifting requirements of the 24 tonne excavator that could access the site. Joints were detailed to allow elements to be placed with movement in one direction only, and with sufficient space for steel tying and securing at each stage of construction. The requirements for propping of supplementary elements during construction were identified early in the design and minimised with the introduction of integrated corbel units, allowing working platform construction to be supported by the structure itself prior to being secured.

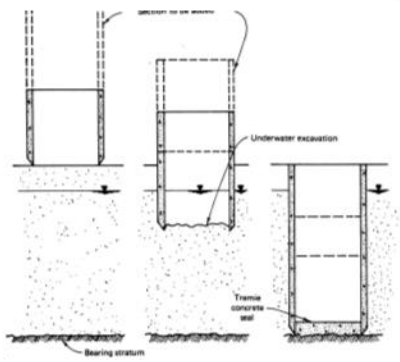
GEOTECHNICAL

Identification of Geotechnical Risks

Conventional construction techniques involve propped sheet piles. This method is industry tested, but has health and safety limitations around personnel entering the excavation, and requires a large construction footprint. It was clear from the concept phase that the segmental caisson construction would present several key advantages:

- Reduced programme,
- Ease of construction,
- Full excavation from surface,
- Ability to cast plug underwater,
- Permanent works doubled as temporary works solution, and
- Cost savings and reduced programme from reduced materials (no sheet piles or backfill around caisson) and time on site (can install internal fit out immediately; removal of temporary works not required).

Figure 13: Sinking of caisson



There were several high-risk aspects of this design that needed mitigation to show stakeholders that this innovative solution was fit for purpose:

- Possible caisson rotation, tilt or misalignment, that could cause interlocking with the surrounding ground,

- Dense gravels at depth that caisson may refuse or be unable to advance, due to collapse and side adhesions. This became an issue at depth, where BPC was unable to advance the caisson without dewatering. The pump rate and volume removed were recorded, and checked against the remote groundwater monitoring, and
- Although not a high construction risk, the installation of a caisson had significant liability implications to stakeholders involving surrounding infrastructure damage resulting from ground settlement induced by groundwater drawdown.

Detailed design and settlement limits

The main geotechnical risks identified were to the surrounding infrastructure and adjacent buildings with shallow foundations, due to settlement induced by groundwater drawdown. We undertook desktop assessments and managed physical ground investigations to determine the design parameters required to work within.

Two boreholes and a Core Penetration Test were undertaken adjacent to the pump station location, with an ultrasonic level logger installed within for continuous groundwater monitoring. The investigations indicated fill overlying a thin silt layer and gravels, with a silt layer at depth. As the footprint of the pump station was adjusted, a wash bore was installed prior to construction, to maintain continuous water monitoring remotely via the eagle.io host website. Placement of the wash bore was dictated by services on site. Groundwater monitoring indicated low level GWT and high level GWT at 4.3m RL and 4. m RL respectively.

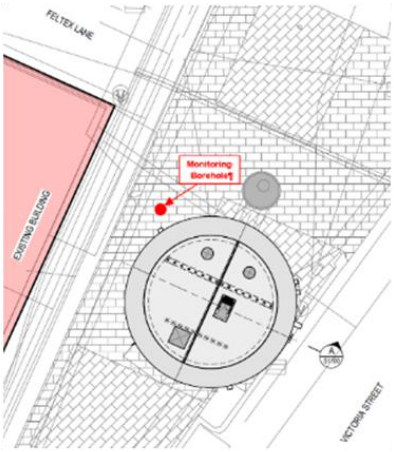


Figure 15: Monitoring borehole location

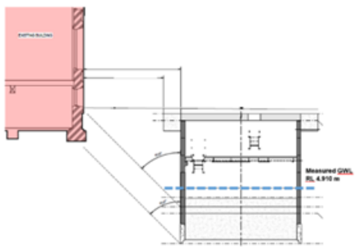


Figure 14: Measured GWL

The resource consent had settlement induced by groundwater drawdown alarm warning levels of 5mm based on foundation depth of 6m bgl (below ground level). Due to the change from a box caisson to a circular segmented caisson, the invert depth increased from 6m bgl to 7.5m bgl. The increased depth of excavation had a corresponding increase in groundwater drawdown along with a larger radius of influence resulting in a larger change in effective stress in the soil. This corresponds to higher predicted settlements (larger than the alarm levels set out in the Resource Consent). Consequently, tighter controls around dewatering were required. The groundwater dewatering was checked using Ciria 113: *Control of groundwater for temporary works*, based on permeability of the gravels and the compressibility of silt below the base of the foundation.

Integrated construction methodology and collaborative workshops with BPC

Seamless interaction between BPC's design team, and our delivery and design teams was vital to the success of this project. An iterative process was required to align ground model and parameters across the two teams. This involved two workshops and the verification of the design parameters, including skin friction, internal friction, side adhesion, caisson mass against uplift and buoyancy, and permeability.

Internal review and external Panel Review.

The WWL consultancy panel review provided peer review feedback around constructability, associated risks, and mitigation measures required. The agreed methodology was to expand the risk register in collaboration with BPC, to include other mitigation measures. If any lateral movement was detected over and above a trigger value, work was to be stopped on the caisson installation and an agreed mitigation measure was to be installed.

The chosen construction methodology allowed the excavation to be manned from the ground surface. This meant the base of the excavation did not need to be fully dewatered to excavate and advance the caisson. Likewise, due to the accommodating nature of the caisson design, allowance could be made for potentially casting the concrete plug underwater, as opposed to fully dewatering the excavation prior to pouring.

Once the foundation depth was reached, real time onsite monitoring allowed for dewatering the caisson while simultaneously pouring the concrete plug in the base, mitigating settlement of the surrounding ground.

Onsite monitoring and design verification – mitigation of high risks

One geotechnical inspection per caisson ring was undertaken every 1m, confirming that the ground conditions were the same as those encountered in the boreholes.

Project review, lessons learnt, and certification.

Lessons learnt through this installation included the specific construction methodology around the use of bentonite slurry, and sealing of the lower caisson cutting shoe to enable recycling and retention of the bentonite slurry.

HYDROGEOLOGICAL SCENARIO TESTING

Figure 16: ground water in caisson

During the construction stage, once the caisson had been successfully lowered to the required formation level, a significant construction challenge had to be overcome. Pouring the mass concrete base plug into the void at the bottom of the structure is a critical stage, as it forms a temporary base which resists potential ground heave / uplift from water pore pressures. The chamber was full of groundwater (approximately 2.4m deep to foundation layer) and the contractor was required to drop this level to approximately 500mm to ensure that when pumping concrete into the excavation they could successfully see the top of the layer and ensure a uniform finish to the top of the plug.

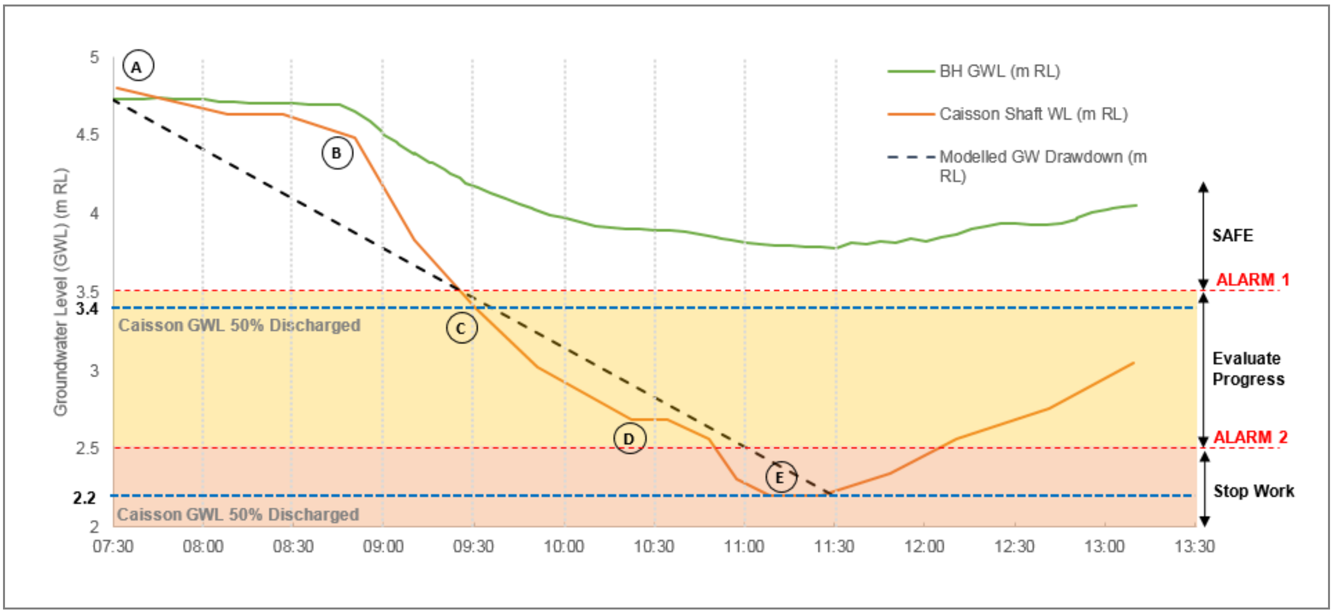
The dewatering resource consent extraction limit was set as 173m^3/day and at a maximum rate of 2/ls. Estimated volume to be extracted was between 75-85m^3. At 2l/s, this would have taken up to 12 hours to remove, making placing concrete in the same day virtually impossible. To assess if the dewatering rate could be increased, we undertook a groundwater assessment using SEEP/W (Geostudio). The alarm levels of 3.5m RL (5mm settlement) and 2.5m RL (10mm settlement), previously set during the excavation stages, were used to assess the potential impact of increased dewatering.

The groundwater assessment model predicted, for a given water level in the caisson, what the corresponding levels in the monitoring borehole and base of building foundations would be. Therefore, monitoring the borehole levels continuously, while pumping out water, gave an estimation of settlement at the building foundations.

We used real time monitoring data from the ultrasonic sensor to inform scenario testing. This provided validation of a suitable pump rate and associated draw down of water level that would not trigger the risk alarms.

BPC had a pump (and standby) that could reach circa 6/ls. We ran a conservative model for 10l/s, which estimated that the first alarm level may be reached in 2.1 hours, and the second within 3 hours. This timeframe was tight, but if successful, would ensure that pumping and concreting could be completed successfully in a normal working day.

We contacted the consenting compliance officer to inform them of the findings, and that we were confident the increased flow rate would not have a detrimental effect on the surrounding buildings. The proposed short time-frame of dewatering also supported our management methodology, and WCC subsequently accepted it. We set up a graph for groundwater monitoring during the pumped dewatering stage to assess the risk as detailed below.



Stage	Total Time	Comment
A	0 mins	- Pump started at 2.0 l/s to monitor initial water level changes
A – B	60 mins	- No significant change, therefore pump increased to max output of 5.7 l/s
B – C	120 mins	- 50% target water level in caisson - BH water sensor level tracking above estimated drawdown profile, no risk of settlement - Tracking line of water levels in BH v. caisson were diverging which increased confidence - Confirmed safe to proceed with 56m^3 concrete delivery to complete base plug installation
D	160 mins	- Pump failure, switched to back up
E	220 mins	- Target water level in caisson reached - BH water sensor level remained above alarm level 1 confirming no risk of settlement

The key information obtained on this day was at 3 stages. When the pumps were increased to 6l/s, the drawdown rate of the BH level was similar to the drawdown rate calculated. By undertaking manual water level measurements within the caisson, when it reached 50% 90 minutes had elapsed, which again matched the predictions. Based on this, and assessing that the BH water level line versus the caisson were diverging, we were confident that there was little risk of groundwater induced settlement at the buildings, and could confirm the concrete order which was provisionally on hold until we were satisfied that the concreting operation could progress.

This was a high-risk stage of the project with potential risk to occupied buildings, as well as potentially large abortive costs if the concreting had to be terminated at any stage. We were delighted at the teamwork and successful outcome of this stage of the project.

6 MATERIALS AND PLANT

To overcome the complexities of the site, careful consideration was put into the selection of plant and equipment. The plant chosen enabled construction to progress efficiently and safely, contributing to the overall success of the project.

6.1 MATERIALS

We sourced the precast caisson segments from FP McCann, in the UK. Preliminary market investigations indicated that precast segments of the required size could not be sourced as standard off-the-shelf products in New Zealand or Australia. The precast segments had many benefits over cast-in-situ segments, including smaller construction footprint, reduced plant and equipment requirements, reduced construction time, and environmental benefits from utilising a mass manufacturing process, while achieving the functionality and durability goals required of the structure.

6.2 PLANT

Figure 17: 4 No. 25tonne hydraulic jacks

Four 25 tonne hydraulic jacks with power pack unit

One of the benefits of the segmental precast system is that hydraulic jacks can assist with sinking the caisson rings, as opposed to the caisson sinking under its own weight. We used hydraulic jacks powered by a heavy-duty hydraulic pump and high-capacity generator to sink the caisson, minimising vibration that could have damaged the surrounding buildings. To get the jacks into position, they were bolted down to holding bolts cast into the concrete collar.

Without use of the hydraulic jacks, the footprint of the caisson may have had to increase to allow the structure to sink under its own weight, and further excavation inside the caisson may have been required. The hydraulic jacks reduced the construction timeframe, while minimising health and safety risks and the risk of damage to surrounding buildings.

24 tonne zero tail swing excavator with 2.4m extension arm and clamshell bucket

Figure 18: 24tonne excavator with clamshell attachment

We chose this excavator as it was compact enough to fit within the constrained site, and powerful enough to lift the precast segments at full extension. This meant that all segment lifting could be done without a crane. The excavator was used in standard configuration to dig the first 3m, before adding a custom-made clamshell bucket fitted to a 2.5m extension arm, allowing excavation to continue to 7.6m below ground level. All lifting and excavation was done from one location, without the need to track the machine around the site, limiting plant movements and reducing health and safety risks.

100 tonne mobile crane

Due to the limited space on site, the maximum size crane that could be used on site was a 100tonne mobile crane. This was a governing factor in how the precast wall panels and the precast roof slab were sized. The crane was fully utilised to lift the largest sections possible, saving construction time and reducing the number of loads to be transported to site. Increased section sizes also reduced the number of joints required, improving construction efficiency, and reducing the likelihood of leaks within the structure.

Figure 19: Mobile crane placing wall panel

Various excavators from 3 to 24 tonne for pipeline construction

A range of excavators were used in the construction of the gravity and rising main connections to the pump station. As a variety of excavator sizes were available, smaller excavators could be used when appropriate, reducing the plant footprint on site.

Horizontal directional drill

Figure 20: 3tonne excavator working in Willis Street

A directional drill was used to drill and pullback 20m of pipeline under the Willis Street intersection. This offered several benefits to the project:

- Quicker installation time, minimising disruption to stakeholders,
- Traffic flow through Willis Street intersection was not affected,
- This intersection is highly congested with existing services. Services were pot holed and located in advance, so that the drillshot could be sent underneath them, minimising the risk of a service strike.

7 ELEGANCE OF THE SOLUTION

Figure 21: Caisson from above

The precast segmental caisson solution we chose had the flexibility to overcome complex site conditions, reduced disruption to local residents and businesses, and minimised disturbance to the streetscape.

This construction methodology is cheaper, faster and safer than traditional methodologies that require many more human interactions with the structure. Less construction equipment was required, as the segments were bulk manufactured, rather than cast on site. This created a smaller site footprint, and reduced health and safety risks to workers and the public. The minimisation of plant and equipment also reduced construction noise, and the impact on local stakeholders.

The caisson rings were not required to sink solely under their own weight. This allowed for use of thinner walled caisson segments, reducing the environmental and the physical footprint of the structure. Thinner walls allowed for the internal pump station space to be maximised, increasing the comfort and accessibility of operators and maintainers. The smaller physical footprint of the structure also reduced the reinstatement requirements to the streetscape, minimising the impact of the project on the urban design improvement works previously undertaken by WCC.

8 ENVIRONMENTAL CONSIDERATIONS

Figure 22: WCC trees adjacent to pump

There are two trees very close to the new structure, one less than 2m from the excavation perimeter. Initially, the future of the tree closest to the site was in doubt, as it was too close for BPC to confirm that they could work around it safely. Understanding however that the tree was important to maintaining the atmosphere of the popular public space nearby, we consulted with WCC Parks and Gardens, and developed a plan to ensure it would not be affected. During enabling works, the design team confirmed the pump station could move 300mm towards the buildings. The tree was then protected with fences, and the works managed around it. This was a great outcome for the project, as the tree remained unharmed.

CONTAMINATED GROUNDWATER

Figure 23: Contaminated groundwater

During construction, contaminated land and groundwater proved much worse than the detailed site investigation had anticipated.

The levels of hazardous substances present in the groundwater meant it was not permitted to be discharged to the sewer network. Instead, this was stored in containers onsite until the contaminants had settled, allowing the middle layers of water to be discharged under a trade waste consent. On site testing of the water in containers showed contaminants had risen to the top of the tanks, so the bottom two-thirds could be discharged to sewers under a trade waste consent. A minimal volume of contaminated water was sent to the landfill, which was a positive environmental outcome.

If a different construction methodology had been chosen, a much greater volume of water may have been removed and there may not have been sufficient space to store it prior to discharge. The flexible caisson methodology minimised the disruption to the construction programme caused by this issue.

NOISE AND VIBRATION

The site was adjacent to workplaces and apartments, meaning many people would have been affected by noise and vibration. This construction methodology has inherently lower noise and vibration, resulting in a better outcome for residents and business owners.

CONSTRUCTION MATERIALS

The shipping of precast units from the other side of the world does raise questions of the nature of the sustainability. However, the effectiveness of a mass manufacture production, together with a smaller footprint, time on site and construction equipment required, results in an overall reduction in environmental impact.

SUSTAINABILITY IN DESIGN

This project is directly associated with triple bottom line issues facing many local authorities in the world. Without this new asset, the potential for population growth in Central Wellington would be restricted by the risk of wastewater overflows. Growth is vital to keeping our cities vibrant and attractive places to live. This pump station enables WCC to access the social and economic benefits of population growth and investment in housing and business developments.

New Zealanders expect their infrastructure to be resilient and future-proof. The Dixon Street pump station is hidden out of sight, but will ease the pressure on the aging pipe network, reduce pump rates, and prevent environmentally undesirable wastewater overflows to the ocean. In the centre of the city, the pump station allows Wellington to continue to grow and prosper for decades to come.

9 EFFICIENT DELIVERY OF PROJECT OBJECTIVES

The project was a resounding success, but it was subject to some significant challenges, including contaminated ground and groundwater, to a much greater degree than could have been reasonably predicted. This resulted in increased costs and minor programme delays, but innovative and proactive thinking ensured issues were successfully overcome and overruns minimised.

This project was ultimately funded by, required by, and will be relied on by Wellington ratepayers for at least the next 100 years. The solution was innovative and smart, ensuring that community's investment was the best value possible.

The desired outcomes for the community as set out in WWL's Statement of Intent were fully delivered, specifically:

9.1.1 SAFE AND HEALTHY WATER

The new pump station reduces the stress on the existing network. This reduces the risk of wastewater overflows to the stormwater network, removing the risk of exposure to public health risks, and ultimately ensures the high quality recreational waters that the population expects.

9.1.2 RESPECTFUL OF THE ENVIRONMENT

URBAN LANDSCAPE AND MAINTAINING VOLUNTEER CORNER GARDEN AREA

There are two significantly important trees to WCC in close proximity to the new structure. We regularly consulted, and planned all works with WCC Parks and Gardens. The first tree was less than 2m away from the excavation perimeter. Initially the future of the tree was in doubt, as it was too close for BPC to confirm that they could work around it safely. During enabling works the design team confirmed the pump station could move 300mm towards the buildings. The tree was then protected with fences and the excavation / installation works were continually managed around the tree. This was a great outcome for the project - the integrity of the tree remained intact.

Figure 24: WCC trees adjacent to pump station

The drip line of the second tree was over the proposed pipeline route. Excavation trial holes were undertaken in advance to confirm the root structure and ensure that the pipeline could pass safely with no damage to the tree.

DEWATERING AND CONTAMINATED LAND CONSENTS

During construction, contaminated land and associated groundwater was much worse than the detailed site investigation had predicted. The levels of hazardous substances present in the groundwater were significantly higher than that permitted to be discharged to the sewerage network.

Figure 25: Storage of contaminated ground water

The contaminated water was stored in containers on site until the contaminants had settled out, allowing the middle layers of water to be discharged under a trade waste consent.

Through utilising innovative construction and monitoring technologies, we reduced the risks associated with working through the water table. In doing so, delays to the project were minimised, and the volume of water discharged to the stormwater and wastewater networks drastically reduced.

NOISE AND VIBRATION

As the site was located adjacent to workplaces and apartments, there were many local stakeholders who would be negatively affected by noise and vibration. This construction methodology has inherently lower noise and vibration than the alternative, resulting in a better outcome for residents and business owners.

CONSTRUCTION MATERIALS

Figure 26: Caisson from above

The effectiveness of mass manufacture, together with a smaller footprint, time on site and construction equipment required, results in an overall reduction in the environmental impact that could have been the case with more traditional construction.

MAINTAINING VOLUNTEER CORNER

New Zealanders expect their infrastructure to be resilient, future proofed and aesthetically pleasing. The pump station is designed around the urban streetscape, hidden out of sight, enabling the public to carry on unhindered.

9.1.3 RESILIENT NETWORKS SUPPORT THE ECONOMY

SEISMIC RESILIENCE DESIGN

Segmental caisson construction is typically used in regions with lower seismicity. One of the primary complexities of the project was to demonstrate that this system could be used in a region of high seismicity. The pumping station is classified as a critical asset and therefore was designed to Importance Level 4 (IL4).

"*Buildings that must be operational immediately after an earthquake or other disastrous event" (*seismicresilience.org – Level of importance classifications)

Ground assessment, seismic modelling and defining the structural performance requirements were undertaken to ensure the in situ walls were designed to work with the external structure, and that the whole structure would perform effectively and remain operational in the event of an earthquake.

GROWTH

Smart cities rely on smart solutions to thrive and grow. This project is directly associated with triple bottom line issues facing many local authorities in the world. As communities grow, the need for reliable infrastructure to keep up with change is vital to the region’s economic success. Without this new asset, the potential for new development in Central Wellington would be restricted. This pump station enables WCC to access the social and economic benefits of population growth, supporting housing and business developments.

COMMUNICATIONS AND STAKEHOLDER ENGAGEMENT

Figure 27: Information Sign in Volunteer Corner

Regardless of the benefits the chosen construction methodology held for the local community, this project required significant attention to customer and stakeholder management, given its central location.

We invested in our local relationships in advance of arriving on site, first getting to know business owners, through meetings and drop-in sessions. Understanding their specific business activities allowed us to tailor our works to, for example, allow for deliveries on certain days and, in one instance, re-install additional sound-proofing insulation that a business had used during previous works in the area.

Throughout the project’s lifecycle, we kept all local businesses and residents informed of progress and prepared them in advance for any particularly noisy or disruptive works. Face-to-face contact was supplemented with regular newsletter updates that were delivered to businesses and posted online on the project’s web page (refer to Appendix D).

The use of real-time traffic monitoring was also part of our commitment to local and commuting stakeholders. This allowed us to track the impact of traffic management controls to ensure any delays were within the approved limits of our Traffic Management Plan, and uphold WWL and WCC’s promise to minimise the project’s impacts.

We also wanted to be sure that the reason for disruption, and the benefits of the project, were recognised by an audience wider than the immediate businesses. To do this, we encouraged media interaction and developed an information board at Volunteer Corner (refer to Appendix C) that told the story of the project, within the context of supporting Wellington’s sustainable growth.

10 CLIENT SATISFACTION

“This was a great example of an innovative approach to working in a challenging urban environment. The available site to build on was constrained and the finished project had to blend into the urban landscaping. GHD did a great job of getting this project moving at short notice through the optioneering phase and onto detailed design then construction. The final methodology used an innovative caisson approach which minimised health & safety risk, contaminated land risk and disruption to neighbouring businesses and will be used by Wellington Water for similar future projects.” **Steve Hutchison, Chief Advisor – Wastewater**

“GHD, successfully managed and adapted to several challenges in the design and delivery of the wastewater pump station, while the eyes of Wellington observed the daily progress. Our key expectations, were all met to our satisfaction, for the project. These included:

- *Seismic risk and resilience was incorporated into the design,*
- *Minimise construction footprint and onsite construction time,*
- *Minimise the impact and disruption to traffic and residents, and*

- *Manage contaminated ground issues .*

In all aspects GHD delivered a successful outcome for Wellington City. This is a testament to GHD's technical skills, planning and the collaboration between Client, Designer and Constructor. I look forward to similar future projects." **Tristan Reynard, Project Director**

11 CONCLUSIONS

With new resilient and future-proof infrastructure, Central Wellington can grow and develop, while the environment is protected from wastewater overflows to the ocean.

The proprietary precast caisson system for use as a pump station structure was a first for WWL and WCC. We are not aware of another similar system, modified with a cast-in-situ internal wall, being used before in New Zealand.

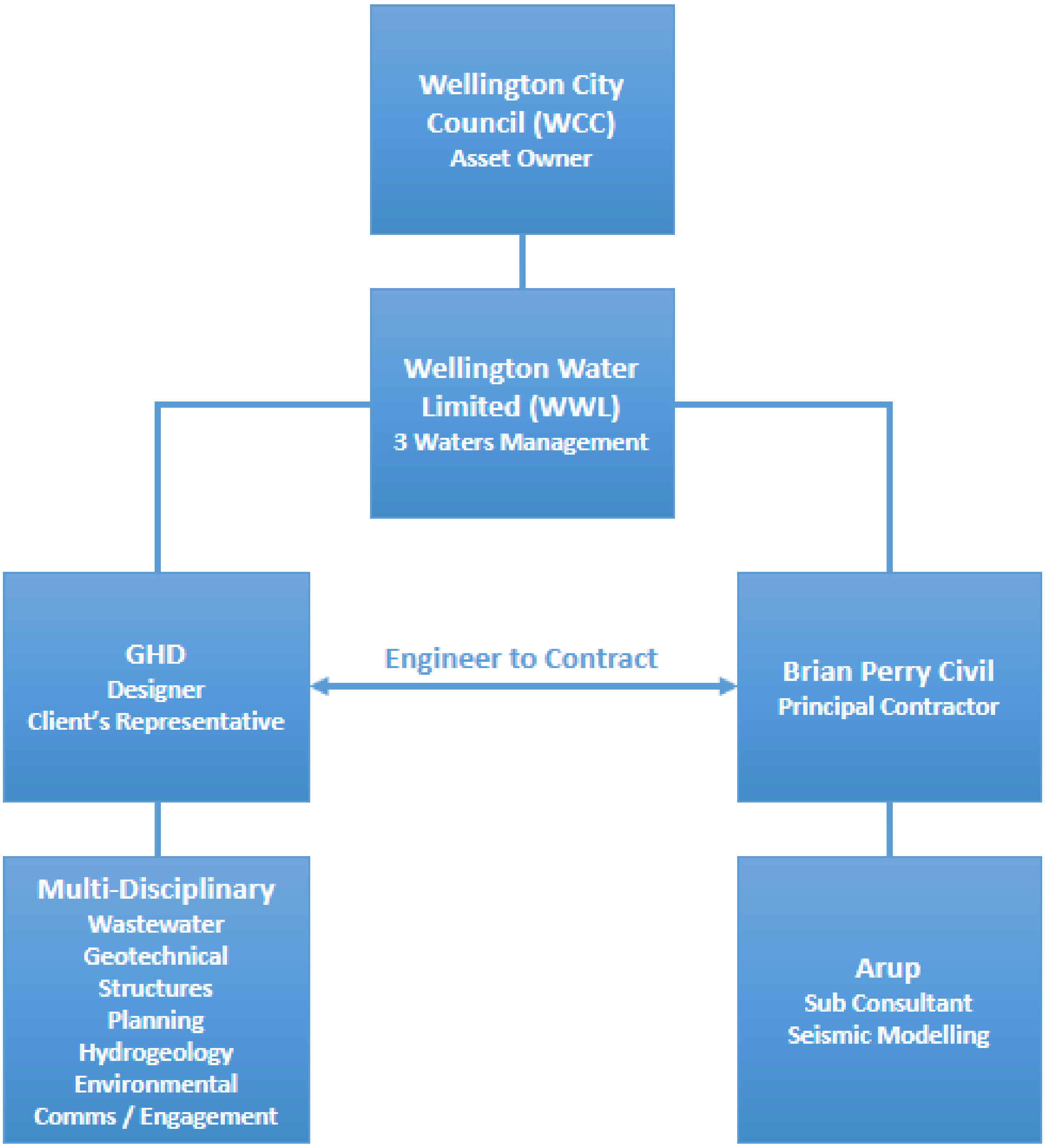
The innovative construction methodology we recommended was flexible enough to overcome the numerous challenges encountered in the complex and congested central location, and was the key component to the successful delivery of this project.

The success achieved in the project is also due to the teamwork and collaboration between the consultant, client and contractor during design and construction. The pump station has achieved everything that we had hoped it would do, despite significant challenges in construction.

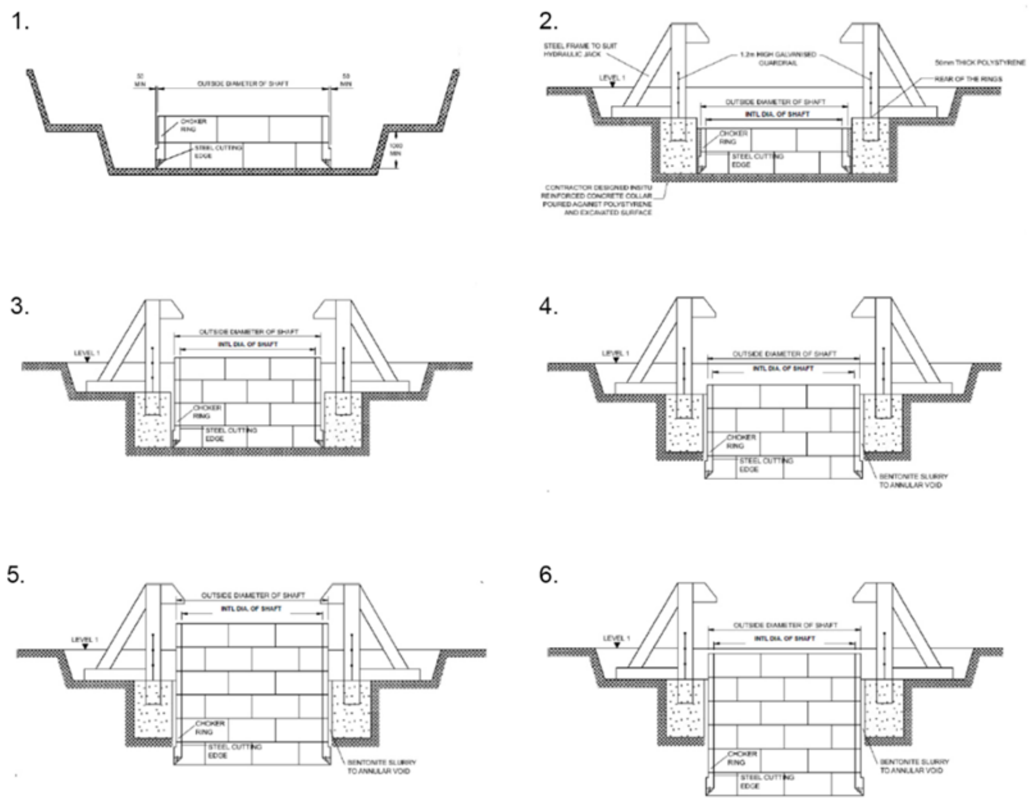
With the increasingly poor condition of nationwide wastewater assets, the benefit of this methodology to New Zealand is clear. We are confident that adoption of this technique will become commonplace, as more clients realise the reduced risks, improved health and safety, costs savings, resiliency and reduced impact to their communities such an approach can offer.

12 APPENDICES

APPENDIX A – ORGANISATIONAL CHART



APPENDIX B – OPEN CAISSON METHODOLOGY



Open Caisson Methodology (FP McCann – Precast Tunnel & Shaft Solutions)

APPENDIX C – PROJECT INFORMATION SIGN

DIXON STREET WASTEWATER UPGRADE

New infrastructure to support our growing city

What's happening here?

We're improving the city's wastewater network by installing a new pump station and upgrading the wastewater pipes.

The new pump station will be located underground close to Volunteer Corner. It will pump wastewater from the local catchment area through upgraded pipes on Dixon Street up to the 'interceptor main' just beyond Willis Street – this is the mains pipe that carries wastewater through to the treatment plant at Moa Point.

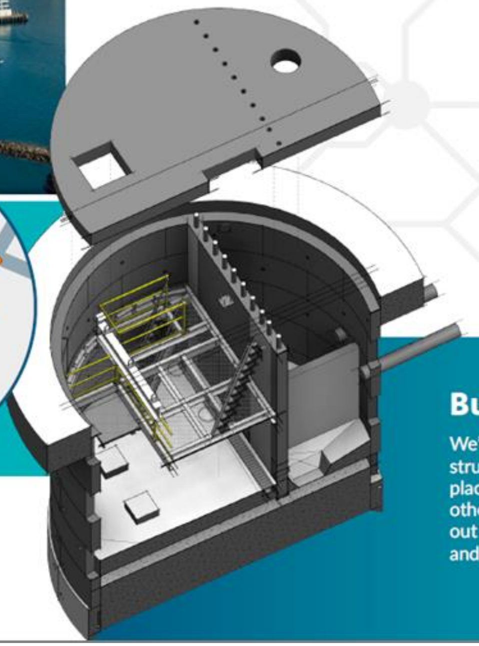
Wellington Water
Our water, our future.

Absolutely Positively Wellington City Council
Me Heke Ki Pōneke

Managing the impacts of construction

Our priority is to deliver this work safely and with the least possible disruption to local businesses, residents, pedestrians and traffic. To achieve this we've chosen to build the new pump station with pre-cast concrete segments – not only because this is quieter and quicker than the conventional approach, but also because we can manage the works within a smaller footprint.

To avoid disruption to CBD commuters, we will keep all lanes on Victoria Street open during the morning and afternoon peaks. Outside of these hours, we will be constantly monitoring the impacts of temporary lane closures so we can tailor these to minimise impacts.



Why is it happening?

This area of the city has been designated as a transformational growth area in Wellington City Council's urban growth plan. More than 7000 new dwellings will likely be built here over the next 25 years. Growth is already happening with new apartment blocks under construction on Victoria Street and Dixon Street. This upgrade will meet demand from these new developments, and provide capacity for future residential and commercial growth.

The upgrade will also add capacity and resilience to the city's wider wastewater network. This will relieve the pressure on other pump stations and reduce the possibility of overflows into the harbour during extended periods of heavy rain.

How long will the works take?

We expect to complete the project by mid-December. The pipes along Dixon Street will be upgraded in stages over this period, with the streetscape and roads fully reinstated once the new underground infrastructure is in place.

Thank you for your patience as we carry out this important upgrade. For more information visit:

www.wellingtonwater.co.nz/work-in-your-area

Wellington Water 04 912 4400

Wellington City Council 04 499 4444

Building the pump station

We're taking an innovative approach to building the 7.5m deep structure that houses the pump station – effectively sinking it in to place by progressively adding pre-cast concrete rings on top of each other. This reduces the amount of excavation work needed to carry out this project, allowing us to work within a more confined area and create less disruption for those around us.

APPENDIX D – STAKEHOLDER NEWSLETTER UPDATES

Wellington Water

May 2018

Dixon Street & Victoria Street Wastewater Upgrades

Wellington Water on behalf of Wellington City Council is preparing to begin work to upgrade the Victoria Street wastewater pump station. We're nearly ready to start, so you'll soon see work beginning.

Why are we doing this work?

Upgrading the Victoria Street pump station allows for us to future-proof the network to meet the future demands of development.

Victoria Street has been classified as a transformational growth area in Wellington City Council's Urban Growth Plan.

This plan estimates over 7300 new dwellings could be established in the central city, and Victoria and Dixon streets have been recognised as having potential as a residential and commercial hub.

What is happening next?

So far, we have identified the site for the new wastewater pumping station: underground, beneath the paved area beside Victoria Street near Feltex Lane.

Now, we are completing design of the pumping station and preparing to start construction on site. As a part of this, we need to carry out some investigative work, including targeted excavation on site. The reason for this work is to accurately determine the location of other underground services, such as telecommunications lines, so that we can avoid these when construction begins.

When construction begins, we will install the underground pumping station using a specialised approach. This involves assembling a circular chamber made of precast concrete segments that will contain the underground pump equipment when finished. This approach is faster, and quieter than traditional underground pump station construction.

When is the work taking place?

Investigative work is taking place on site in May, with construction scheduled to start on the pump station on June 14. Throughout the project, the hours of work will be between 7am and 6pm.

We'll keep you updated as the project progresses, to let you know what to expect.

Keeping in touch:

If you have any questions, please feel free to get in touch with the project team:

Joel Rowan +64 27 231 4318

Planned Construction Areas

Options Assessment Stage	Feltex Lane Option Selected	May 2018 Investigative work taking place on site	June 2018 Construction work begins on site	December 2018 Planned completion and reinstatement

Project Timeline

04 912 4400

Private Bag 39804, Wellington Mail Centre 5405

Level 4, IBM Centre, 25 Victoria Street, Petone 5011

wellingtonwater.co.nz

Our water, our future

Wellington Water

7 September 2018

Dixon Street Wastewater Upgrades

A major construction milestone has marked the halfway point on this vital upgrade project – and we now look forward to completing the job with as little disruption to our neighbours as possible.

Progress update:

The 6.5m diameter and 7.5m deep circular concrete chamber has been successfully lowered into place, meaning we can now get on with building the pump station inside it.

We've also installed the pipework across part of Volunteer Corner and are moving on to the longer stretches of pipe on Dixon Street.

By the end of the year, this infrastructure will be complete, hidden from view beneath a fully restored streetscape, ready to provide the extra wastewater capacity our central city needs to cater for residential and commercial growth.

Minimising disruption in the area:

While major infrastructure upgrades like this are vital, we know that they can create short term inconvenience. We're constantly looking for opportunities to improve our work, and limit disruption to people in the area.

We previously intended to dig an open trench across the Willis and Dixon Street intersection to lay the new pipe, which would have had an impact on traffic flow.

Now we have investigated and confirmed that it will be possible to lay the new pipe by drilling from one side of the intersection to the other, and feeding the pipe through. This will help us keep traffic moving through the intersection in all directions.

Traffic management:

Traffic management will continue on Victoria Street and Dixon Street during the work, including temporary lane closures and parking restrictions. Please take care when driving, walking or cycling through the area, and allow extra time if needed.

These traffic management changes are necessary for the safety of both the public and our people working on site. Thank you for your ongoing patience and understanding.

Work on the pump station chamber

Get in touch:

This work is being managed by our engineering consultants, GHD Ltd. If you have any questions or concerns, please contact Joel Rowan at GHD on **027 231 4318** or **joel.rowan@ghd.com.**

You can also contact our contractors, Brian Perry Civil directly on their on-site phone number: **027 607 2498.**

Work Areas Update:

04 912 4400

Private Bag 39804, Wellington Mail Centre 5405

Level 4, IBM Centre, 25 Victoria Street, Petone 5011

wellingtonwater.co.nz

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Wellington Water

Wellington Water

December 2018

Dixon Street Wastewater Upgrades

We have nearly finished work on this project. We are taking a break over Christmas, before we return in the new year to bring the pump station into service and restore the area to its original condition.

Project Update

We have now finished laying new wastewater pipes on Dixon Street, and have almost completed work to install the new pump station at Victoria Street.

The large roof slabs for the station were craned into place on Friday, November 23 - with a large audience watching on from nearby offices.

We appreciate your continued patience and understanding as we reach the final stages of this project.

What is happening next?

Before Christmas, we will finish work for the year. To free up some footpath space, we will bring in some of our fences and reduce the size of our site. We will leave our site cabins and facilities in place as these will be needed for the final stages of our work.

In the new year, our electricians will connect the pump station to the electricity network, and then we will bring the pump station into service - which will involve a few days of work inside the pump station and nearby manholes.

Restoring the pavement at Volunteer Corner

The last step in this project is to replace the footpath paving in the pump station area and fully restore Volunteer Corner to its original condition.

To reduce disruption over the holiday period, we will wait until February 2019 to do this. We expect it to take up to three weeks to complete.

Once finished, the paved area will look almost identical to the way it looked before our project began and will be reopened for public use.

Traffic and parking

The road layout on Dixon Street and Victoria Street is now back to normal, with road lanes and most parking reopened.

Get in touch:

This work is being managed by our engineering consultants, GHD Ltd.

If you have any questions, please contact Joel Rowan at GHD on **joel.rowan@ghd.com**

Craning the second of two large roof slabs into place.

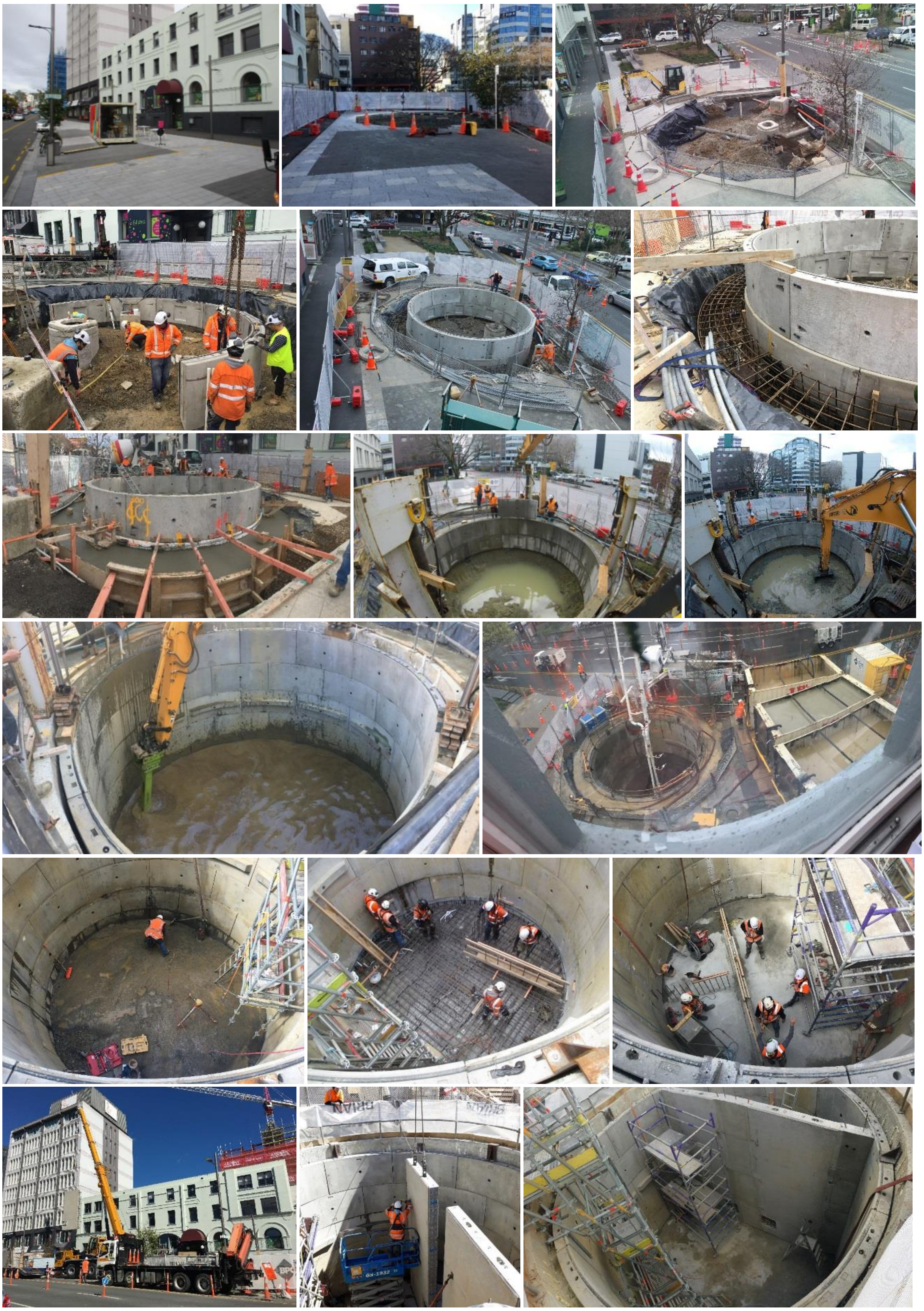
The pump station chamber, now covered.

04 912 4400
Private Bag 39804, Wellington Mail Centre 5405
Level 4, IBM Centre, 25 Victoria Street, Petone 5011
wellingtonwater.co.nz

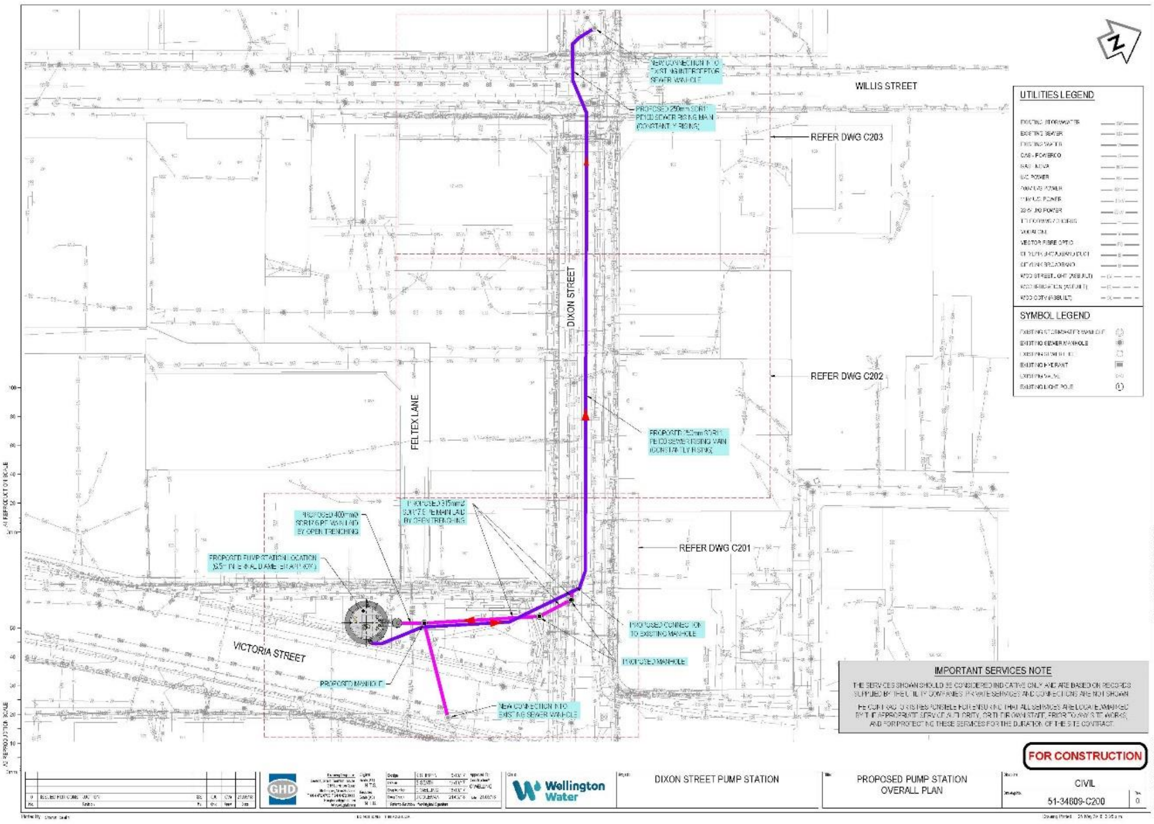
Our water, our future

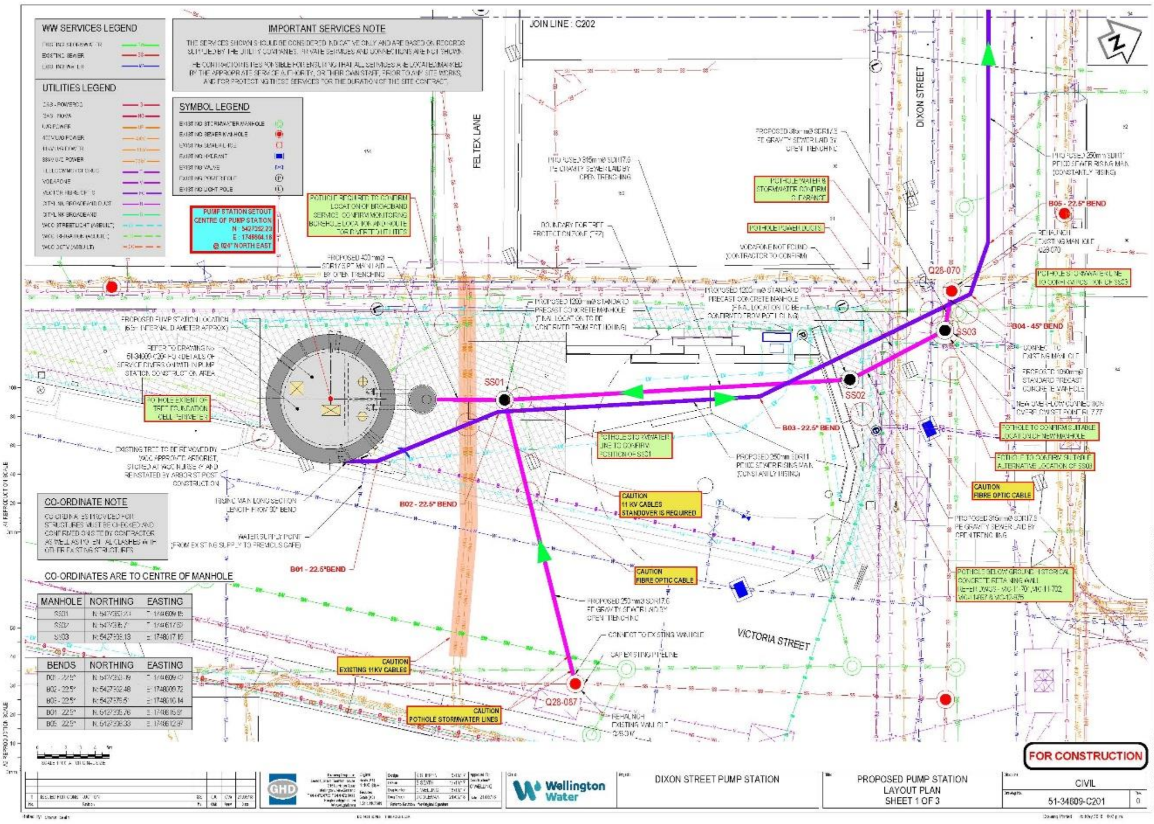
Wellington Water

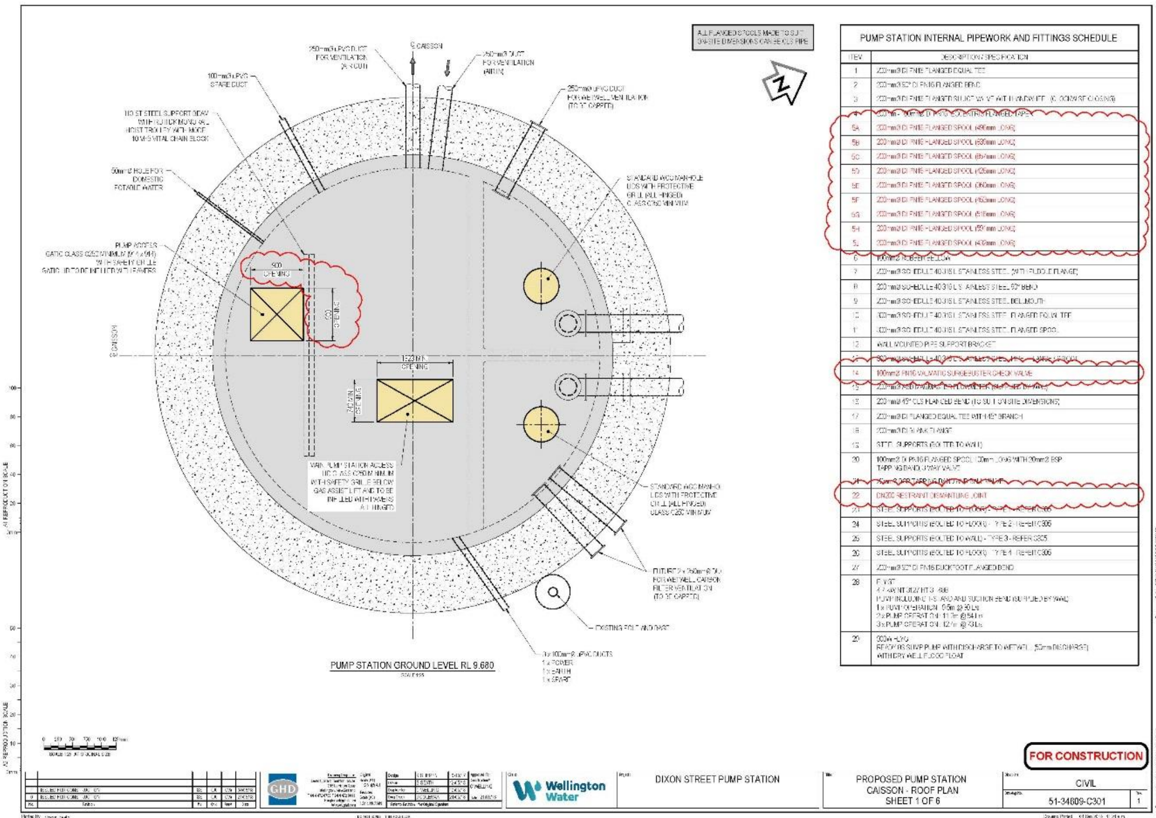
APPENDIX E – CONSTRUCTION TIMELAPSE

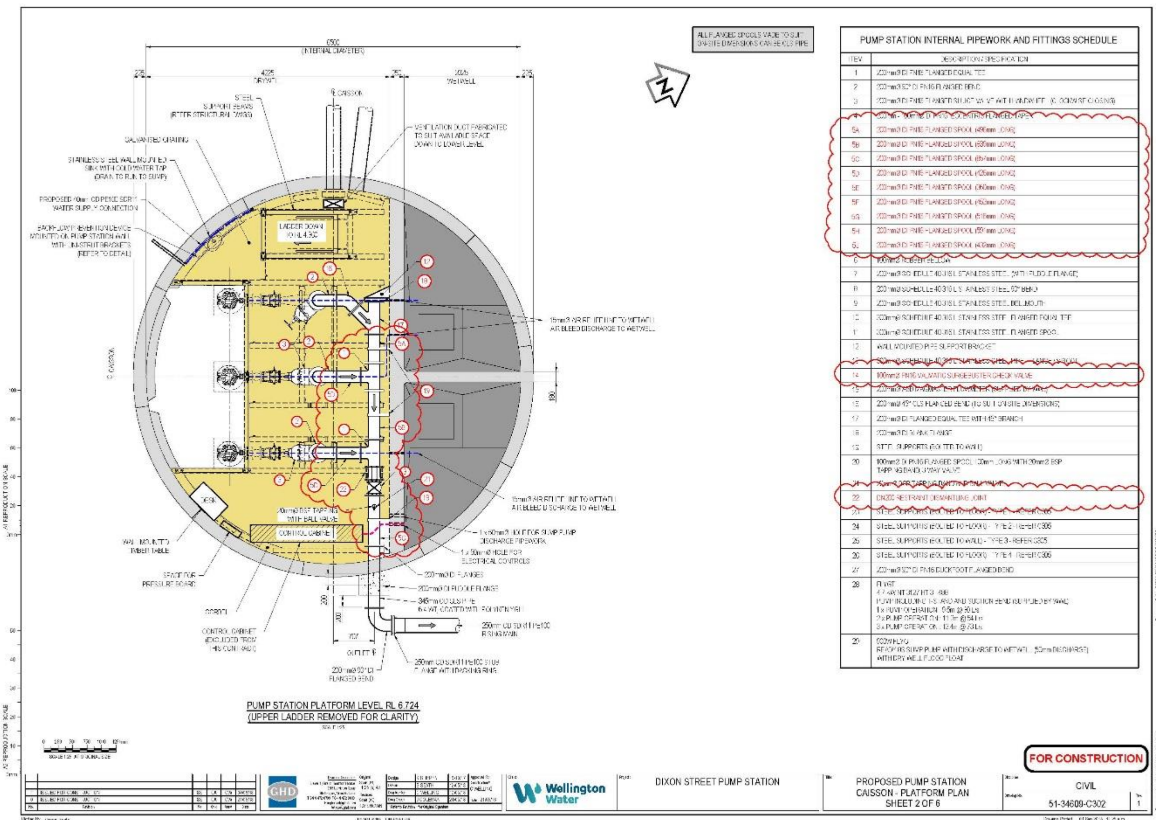


APPENDIX F – CONSTRUCTION DRAWINGS






PUMP STATION INTERNAL PIPEWORK AND FITTINGS SCHEDULE
ITEM
DESCRIPTION / SPECIFICATION
1 200mmØ DI PN16 FLANGED EQUAL TEE
2 200mmØ 90° DI PN16 FLANGED BEND
5A 200mmØ DI PN16 FLANGED SPOOL (490mm LONG)
5B 200mmØ DI PN16 FLANGED SPOOL (630mm LONG)
6 100mmØ RUBBER BELLOW
9 200mmØ SCHEDULE 40 316 L STAINLESS STEEL BELLMOUTH
12 WALL MOUNTED PIPE SUPPORT BRACKET
14 100mmØ PN16 VALMATIC SURGEBUSTER CHECK VALVE
17 200mmØ DI FLANGED EQUAL TEE WITH 45° BRANCH
22 DN200 RESTRAINT DISMANTLING JOINT
25 STEEL SUPPORTS (BOLTED TO WALL) - TYPE 3 - REFER C305
27 200mmØ 90° DI PN16 DUCKFOOT FLANGED BEND
PUMP STATION GROUND LEVEL RL 9.680
FOR CONSTRUCTION
Wellington Water
DIXON STREET PUMP STATION
PROPOSED PUMP STATION
CAISSON - ROOF PLAN
SHEET 1 OF 6
CIVIL
51-34609-C301


PUMP STATION INTERNAL PIPEWORK AND FITTINGS SCHEDULE
ITEM
DESCRIPTION / SPECIFICATION
1 200mmØ DI PN16 FLANGED EQUAL TEE
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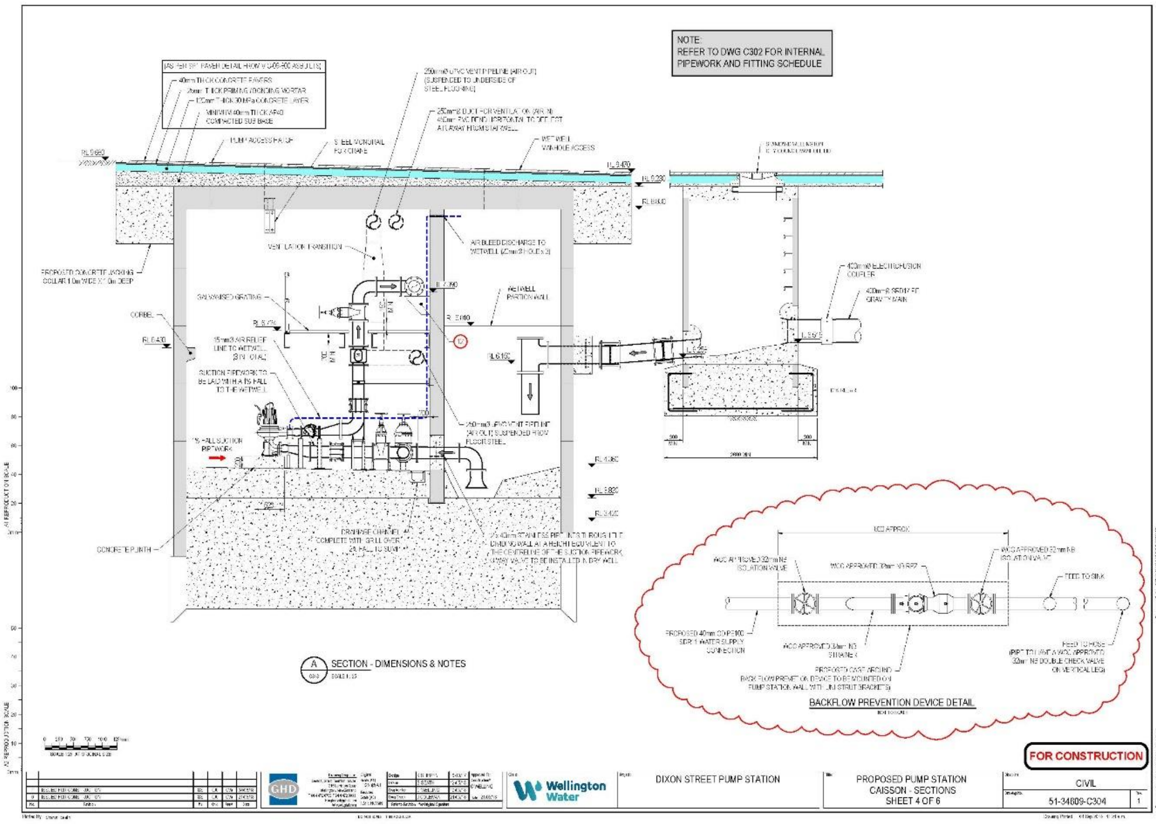
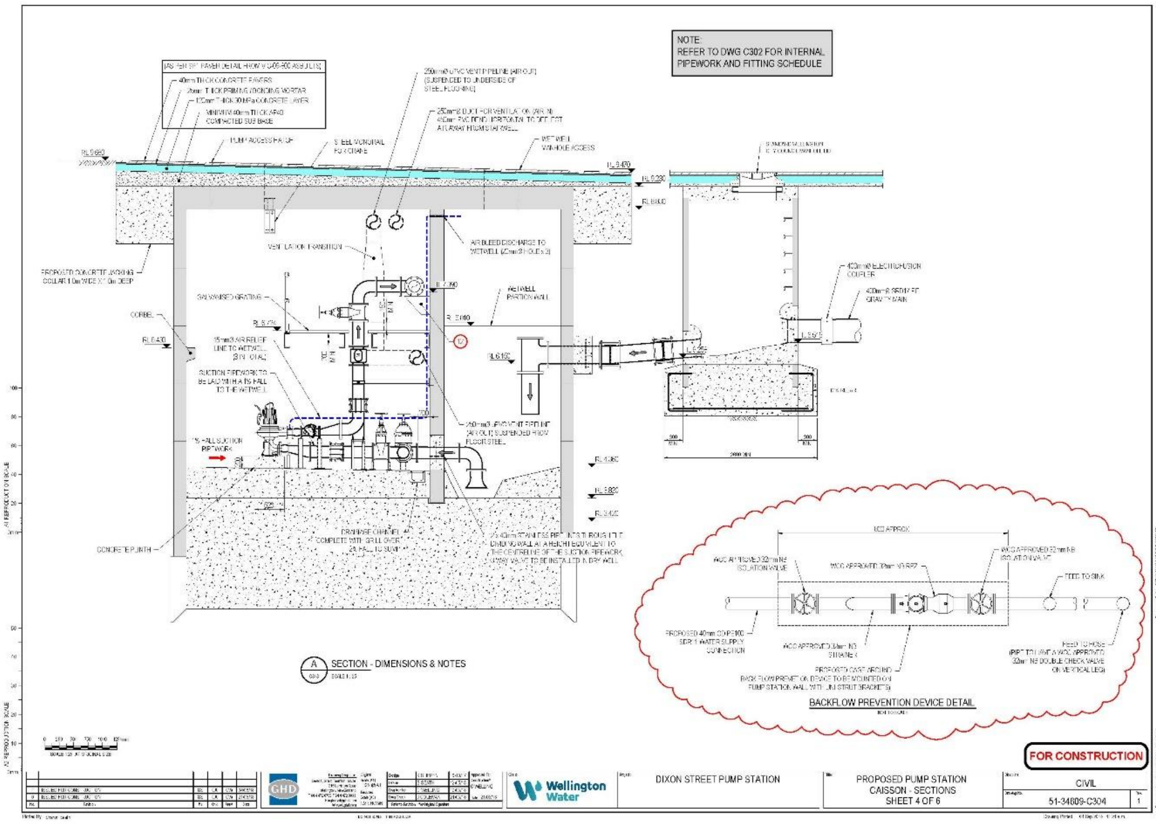
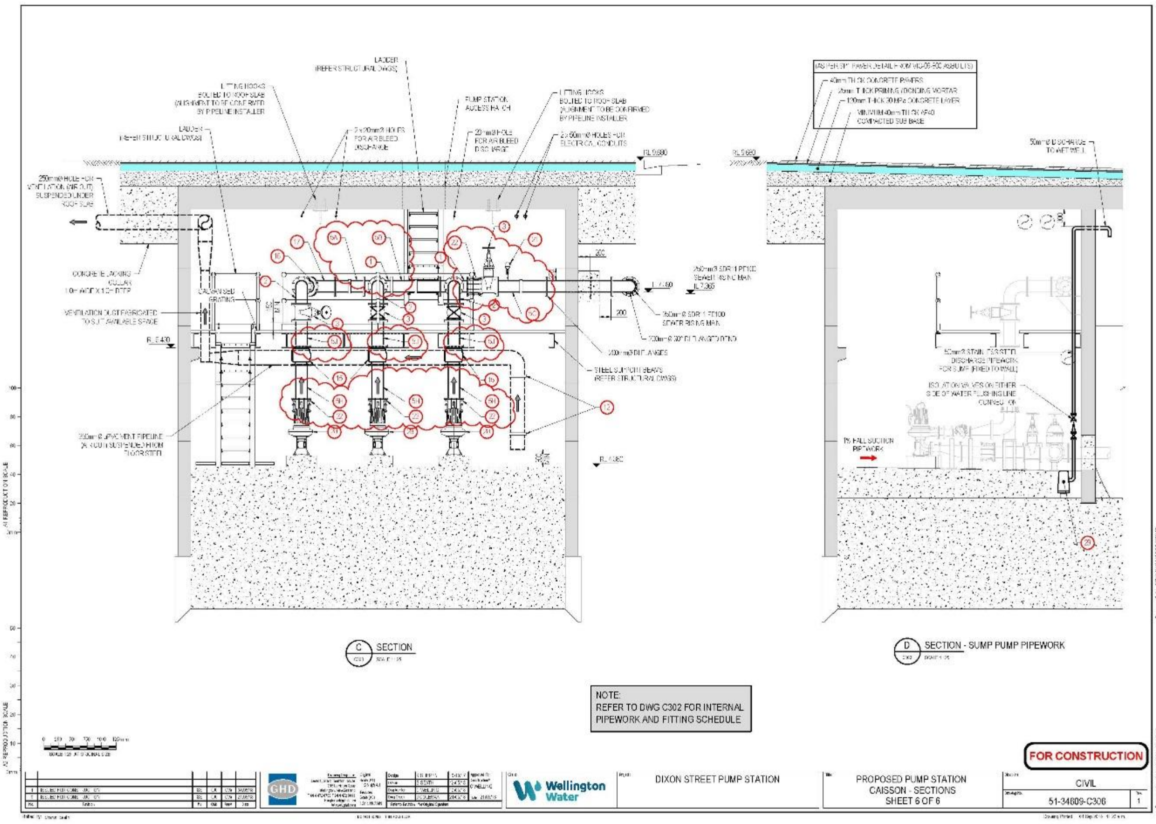
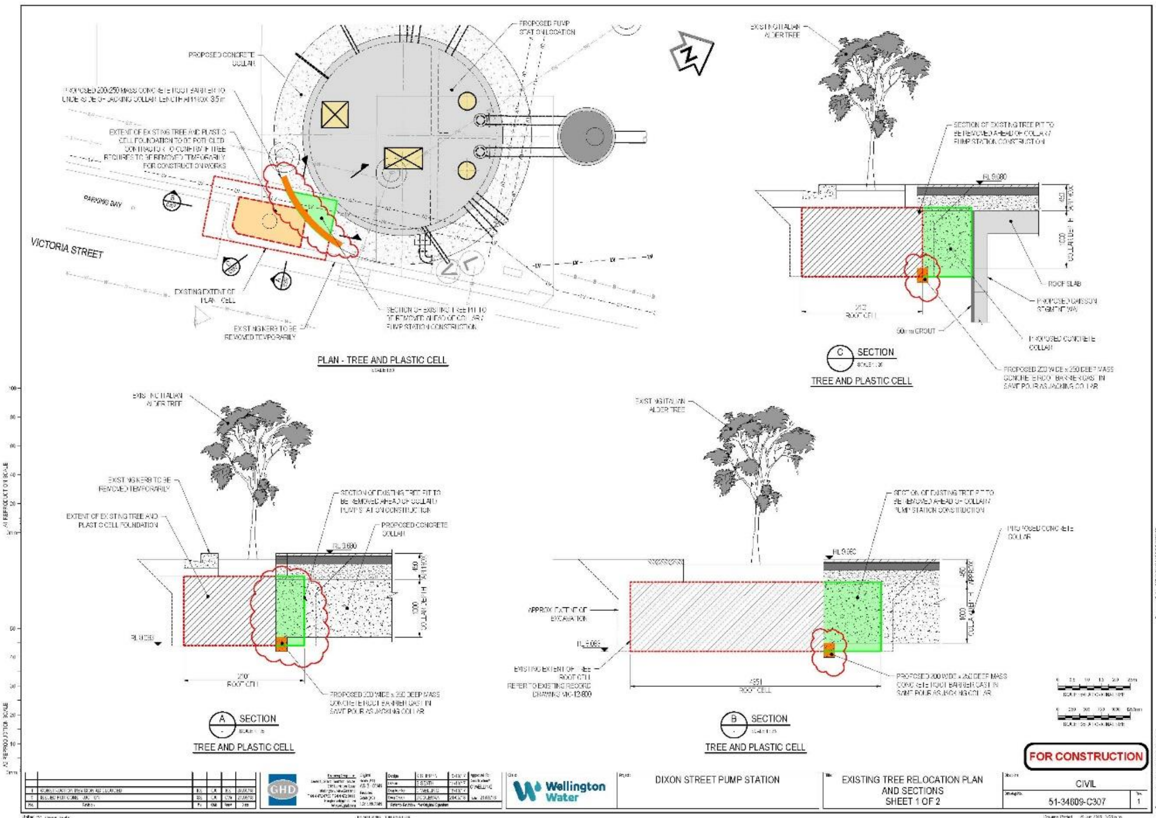
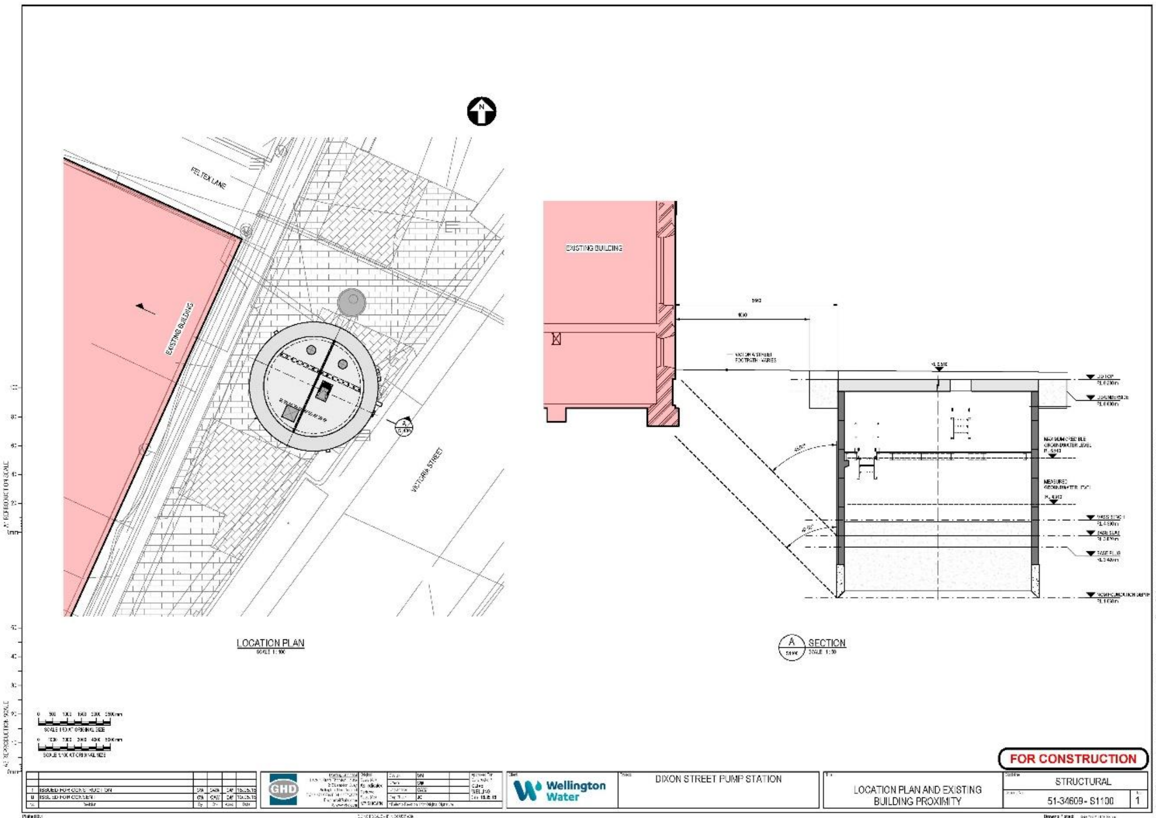
22 DN200 RESTRAINT DISMANTLING JOINT
25 STEEL SUPPORTS (BOLTED TO WALL) - TYPE 3 - REFER C305
27 200mmØ 90° DI PN16 DUCKFOOT FLANGED BEND
GALVANISED GRATING
CONTROL CABINET
PUMP STATION PLATFORM LEVEL RL 6.724
(UPPER LADDER REMOVED FOR CLARITY)
FOR CONSTRUCTION
Wellington Water
DIXON STREET PUMP STATION
PROPOSED PUMP STATION
CAISSON - PLATFORM PLAN
SHEET 2 OF 6
CIVIL
51-34609-C302

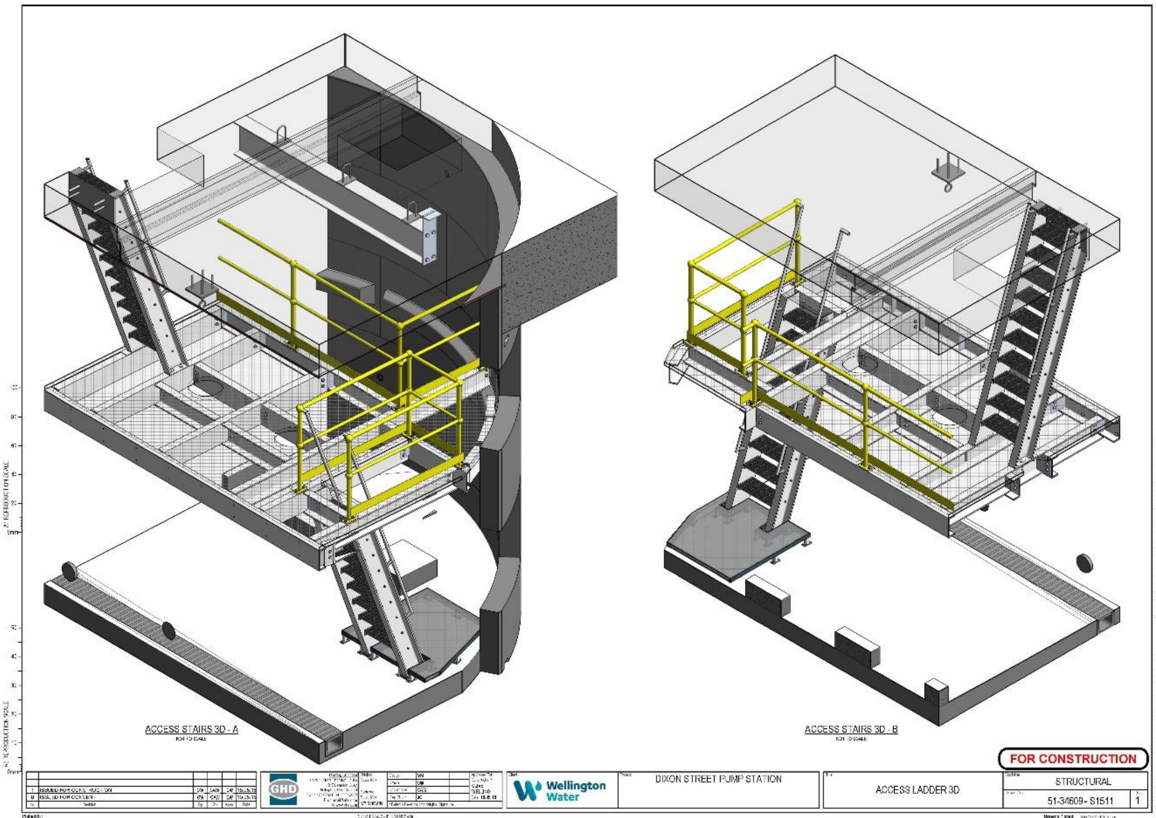

NOTE:
REFER TO DWG C302 FOR INTERNAL PIPEWORK AND FITTING SCHEDULE
A SECTION - DIMENSIONS & NOTES
BACKFLOW PREVENTION DEVICE DETAIL
FOR CONSTRUCTION
Wellington Water
DIXON STREET PUMP STATION
PROPOSED PUMP STATION
CAISSON - SECTIONS
SHEET 4 OF 6
CIVIL
51-34809-C304


NOTE:
REFER TO DWG C302 FOR INTERNAL PIPEWORK AND FITTING SCHEDULE
A SECTION - DIMENSIONS & NOTES
BACKFLOW PREVENTION DEVICE DETAIL
FOR CONSTRUCTION
Wellington Water
DIXON STREET PUMP STATION
PROPOSED PUMP STATION
CAISSON - SECTIONS
SHEET 4 OF 6
CIVIL
51-34809-C304


C SECTION
D SECTION - SUMP PUMP PIPEWORK
NOTE:
REFER TO DWG C302 FOR INTERNAL PIPEWORK AND FITTING SCHEDULE
FOR CONSTRUCTION
GHD
Wellington Water
DIXON STREET PUMP STATION
PROPOSED PUMP STATION
CAISSON - SECTIONS
SHEET 6 OF 6
CIVIL
51-34809-C306


VICTORIA STREET
PLAN - TREE AND PLASTIC CELL
C SECTION
TREE AND PLASTIC CELL
A SECTION
TREE AND PLASTIC CELL
B SECTION
TREE AND PLASTIC CELL
FOR CONSTRUCTION
GHD
Wellington Water
DIXON STREET PUMP STATION
EXISTING TREE RELOCATION PLAN
AND SECTIONS
SHEET 1 OF 2
CIVIL
51-34809-C307


FELTEX LANE
EXISTING BUILDING
VICTORIA STREET
EXISTING BUILDING
LOCATION PLAN
SECTION
FOR CONSTRUCTION
GHD
Wellington Water
DIXON STREET PUMP STATION
LOCATION PLAN AND EXISTING BUILDING PROXIMITY
STRUCTURAL
51-34609 - S1100
1


ACCESS STAIRS 3D - A
ACCESS STAIRS 3D - B
FOR CONSTRUCTION
GHD
Wellington Water
DIXON STREET PUMP STATION
ACCESS LADDER 3D
STRUCTURAL
51-34609 - S1511
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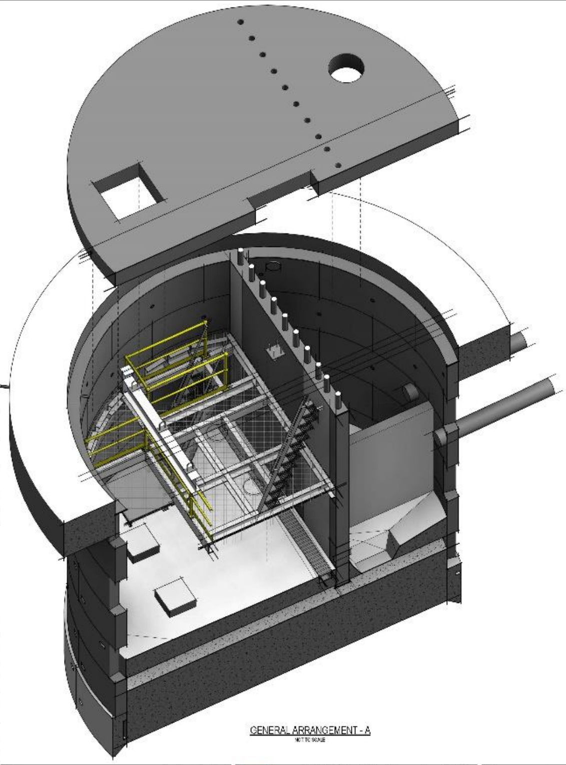
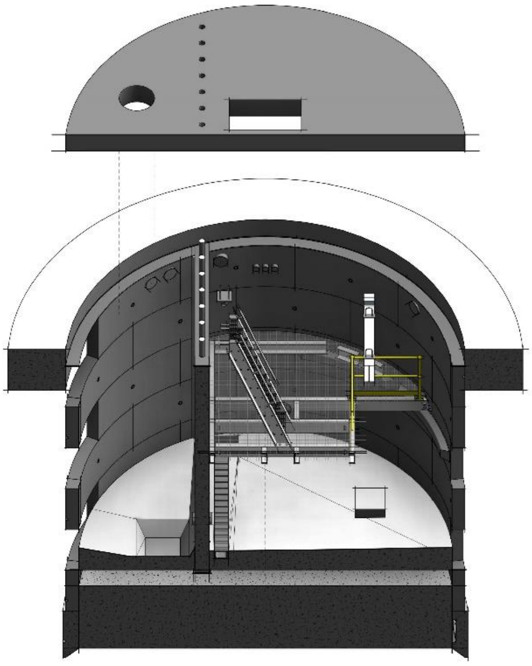


GENERAL ARRANGEMENT - A

NOT TO SCALE



GENERAL ARRANGEMENT - B

NOT TO SCALE

FOR CONSTRUCTION

No	Revision
1	ISSUED FOR CONSTRUCTION
0	ISSUED FOR CONSENT

GHD

Wellington Water

DIXON STREET PUMP STATION

STRUCTURAL 3D

STRUCTURAL

51-34609 - S1600

1