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Delivering Watercare's Central Interceptor Project, Auckland New Zealand

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ABSTRACT: This paper explores the successful delivery of tunnelling for the Central Interceptor Project, going back to decisions made since the concept design stage (2009-2011) and more recently through construction, culminating in final tunnelling breakthrough in March 2025. The paper is written from the client's perspective, discussing the key decisions resulting in successful delivery of the project. Topics covered include contract selection and ground risk allocation, along with selection of tunnel alignment and the specification of tunnel boring machine requirements. The paper touches on some of the benefits and disadvantages of Employer's design; approach to sewer gas corrosion and durability; client-side contract delivery and administration using a blended team; and some of the outcomes recognised through collaborative working between all parties to the contract. The importance of a robust approach for budget setting and management is discussed. Perspectives are shared on some of the approaches and initiatives contributing to successful health and safety outcomes.

1 INTRODUCTION

Auckland is New Zealand's largest city, with a population of 1.7M people, located on a narrow isthmus between the Waitemata and Manukau Harbours. Central Auckland is the oldest part of the city and has a mainly combined sewer stormwater system. The area experiences significant rainfall, resulting in regular surcharging and Combined Sewer Overflow (CSO) discharges, via overflow structures located on stream banks and coastlines. In the early 2000s, Watercare recognized the need for a scheme to intercept the CSOs and convey them to the Manukau Wastewater Treatment Plant (WWTP) for treatment.

Following the detailed design phase between 2014-2018 by Watercare's consultants (a Jacobs-led team including AECOM and Delve Underground), the project was put out to international tender for construction. The appointed Contractor was Ghella-Abergeldie Joint Venture (GAJV) and construction commenced in May 2019. TBM mining of the 16.2km of main tunnel was completed in early 2025. The southern system was successfully brought into operation in early 2025.

2 PROJECT OVERVIEW

2.1 *Key requirements*

Following the concept design and consenting phases, the key requirements driving the design of the project included the following:

- Achieve 80% volumetric reduction of CSOs.
- Provide a gravity tunnel system, with a single downstream pumping station.
- Cater for the existing geology, to minimize risk to tunnelling and permanent works.
- Provide a maintenance-free underground tunnel and dropshaft system.

– Provide multiple levels of redundancy for operation of the pumping station.
– Provide a Real-Time Control (RTC) gating system, to protect the pump station from excessive inflows beyond its' pump-out capacity.

2.2 *Scheme details*

While originally designed and tendered as a 13.1km long 4.5m ID segmentally lined tunnel from MPS to Western Springs, the tunnel was subsequently extended to a 16.2km long tunnel with upstream termination in Pt Erin Park. Figures 1a and b indicate the scheme alignment, Figure 2 provides an indicative long section of the main tunnel.

Figure 1a. Scheme southern section (MPS to May Rd).

Figure 1b. Scheme northern section.

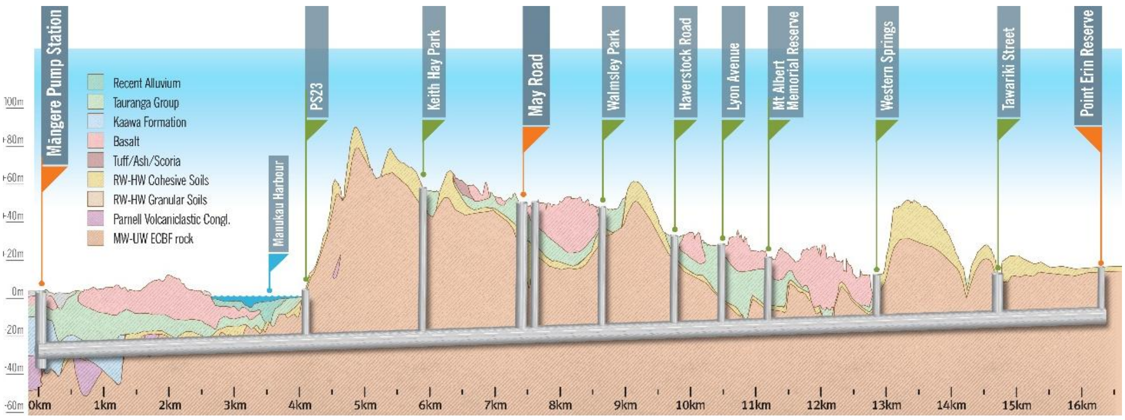

Figure 2. Indicative long section showing geology of the main tunnel alignment (exaggerated vertical scale).

The tunnel carries both dry weather flow (separate sewage) and wet weather flow (CSO), depending on the climactic conditions. The tunnel was constructed with a 1:1000 (V:H) gradient, designed to provide self-cleansing velocities. Upstream grit traps prevent larger material from entering the system. Real-Time Control (RTC) gates manage flow into the tunnel system.

The project included two pipejacked Link Sewers B and C, the purpose being to extend the reach of the scheme out to capture various CSOs that could not be intercepted directly by the main tunnel. At the downstream end, a new 7.2m^3/s max capacity pumping station (the MPS) lifts the wastewater flow from the deep gravity tunnel to the Mangere WWTP for treatment. Air Treatment Facilities (ATFs) are located at both the MPS and May Road.

The project has been future-proofed with connection points for various future upstream projects, to be delivered subsequently to the Central Interceptor. The key project statistics are summarized in Table 1 below:

Table 1. Key project details.

Main Tunnel	-	Earth Pressure Balance (EPB) TBM, precast segmental lining
	-	4.5m Internal Diameter (ID), 16.2km Length, max depth 110m
	-	11 No. shafts (7 No. cascade drops, 2 No. vortex drops, 2 No. other shafts)
Link Sewers B&C	-	EPB MTBM, jacking PE lined reinforced concrete pipe
	-	1.1km of 2.4m ID and 3.2km of 2.1m ID respectively
	-	7 No. cascade dropshafts (6 No. cascade drops, 1 No. access shaft)
MPS	-	7.2 m^3/s max capacity
	-	Peanut shaped (∞) dual diaphragm wall shaft; inlet shaft 12m ID and 33m depth; pump station shaft 26m ID and 38m depth.
	-	Trenched twin rising main, DN1400 PE pipelines, from MPS to WWTP.
Other	-	ATFs (1 x BTF and AC at May Rd; 1 x biotrickling filter at MPS)
	-	10 No. RTC gated inflow locations.

3 SCHEME DEVELOPMENT PHASE RISKS

3.1 *Ground conditions risks*

Central Auckland is underlain by East Coast Bays Formation (ECBF) weak rock, and this material is extensive throughout the project. However, the tunnel horizon was known to encounter dense Kaawa Sands and potentially touch some volcanic deposits within the downstream 3km reach of the tunnel. Previous tunnelling projects have demonstrated the ECBF to be an ideal material for Earth Pressure Balance TBM tunnelling, albeit with occasional problematic lenses of higher strength Parnell Volcaniclastic Conglomerate material.

To inform the design and manage the risk of unexpected ground conditions, several comprehensive geotechnical investigation campaigns were undertaken following the initial tunnel and route selection in 2009. These campaigns were focused on the higher risk materials that couldn't be confidently avoided, particularly aiming to provide confidence on the basal surface of volcanic deposits and characterizing the Kaawa Sands with respect to suitability for EPM TBM tunnelling.

3.2 *Contractual ground risk allocation*

Following the successful use of Geotechnical Baseline Reports (GBRs) for tunnels in Auckland dating back to the mid 2000s, Watercare and its advisors considered it necessary to implement a GBR to provide the clearest possible contractual definitions of ground risk allocation between the Employer and the Contractor. The GBR was contractually dovetailed into the modified FIDIC Red Book contract definition for 'Unforeseeable physical conditions'.

3.3 *Geotechnical Baseline Report - retrospective recommendations*

While the GBR was considered to be a useful and appropriate tool for clarifying ground conditions risk, there are a number of recommendations by Watercare's team for future GBRs and baselines:

1) Baselining groundwater infiltration inflows into shafts will tend to lead to disputes rather than avoid them. All deep shafts on a project such as this require temporary support, often of types such as secant piles, diaphragm walls or caissons, the construction of which all have a significant impact on the quantum of groundwater inflows. Groundwater infiltration into a shaft is not a fundamental property of the ground but is significantly impacted by the temporary works and construction approach. Other commercial approaches to managing the allocation of this risk may be more appropriate.

2) Site contamination was not baselined for the project, but it is recommended that clear baseline statements could and should be made in future for similar projects, depending on the knowledge of contamination and risk appetite of the Employer.
3) While ground conditions were baselined for tunnels and shafts, baselines were not provided for comparatively shallow surface sites, e.g. with permanent works up to 15m depth. This approach is considered pragmatic for the project, given the geographical spread and range of conditions which would have resulted in complex 3D models for comparatively little value.
4) Apart from one claim for Unforeseen physical conditions (UPC) relating to ground conditions for a shaft (i.e. covered under the GBR), the vast majority of UPC claims related to non-baselined items such as contaminated soils, existing assets, and utilities.

3.4 *Key tunnelling risks*

At concept design phase (2009-2011), various tunnelling related risks were identified and considered, with further assessment and mitigation during the detailed design phase (2014-2017). The key tunnelling risks and treatments recognized prior to construction are discussed below:

1) Horizontal alignment challenges
   a. Risk: Auckland has a considerable number of volcanic centres. These volcanoes present difficult ground conditions for EPB TBMs, such as high-strength basalt lava flows and 'necks', and high rockmass permeability.
   b. Treatment: it was elected to adopt a route that avoided volcanic deposits which had been identified during the previous ground investigation campaigns.
2) Vertical alignment and associated ground conditions challenges
   a. Risk: the design of a cost-effective terminal pumping station involves minimizing the pumping head required, and therefore CAPEX and OPEX. Conversely, raising the vertical alignment to the highest level would mean tunnelling through potentially unfavorable ground conditions with associated cost, delay and safety risks. The key sources of risk anticipated with tunnelling in unfavorable ground included:
      i. Abrasion and damage of the cutterhead if volcanic ground was encountered;
      ii. High hydrostatic groundwater pressures (up to 9 bar) could result in excessive groundwater inflows through the EPB screw and loss of plug;
      iii. Hyperbaric cutterhead face interventions, possibly in excess of 3 bar;
      iv. Difficulty with spoil conditioning and maintaining a screw plug when tunnelling in the Kaawa Sands;
   b. Treatment: an optimum vertical alignment was identified which achieved an acceptable trade-off between hydraulic design objectives and tunnelling risk.

3.5 *TBM Tunnelling risk mitigations*

Various tunnelling risk mitigations were included in the TBM specification and via variations:

1) TBM type: the TBM was specified as a new purpose-built EPB TBM, required to be capable of maintaining closed mode pressures for specified reaches of the tunnel in order to manage groundwater inflows and face stability, also minimising surface settlement.
2) TBM specification requirements:
   a. Given the long drive lengths envisaged (e.g. >7.5km) and the risk of encountering high strength (e.g. >200MPa) basalt, the specification included a requirement for "*chromium carbide wear protection plates and hard face welding*".
   b. Design of shield, bearings and seals for a max operating pressure of 9 bar, reflecting anticipated hydrostatic pressures under the deepest sections of the alignment.
   c. A fourth row of wire brush seals was accepted, in lieu of an inflatable safety seal when replacing/maintaining the service wire brush seals.
   d. Provision of dual screw, or substitute, for tunnelling at pressures up to 9 bar: the contractor proposed a positive displacement pump system in lieu of the second screw.
   e. Provision of double guillotine gates on the screw discharge, to manage loss of plug.
   f. Provision of airlock with operating pressure of 5 bar, for hyperbaric interventions.
3) Watercare requested a value-engineering proposal for electric locomotives, which was accepted and instructed into the works, providing benefits of air quality and sustainability.

4) Watercare instructed the Contractor to undertake fire laboratory combustion tests of the embedded PE linings on both the tunnel segments and jacking pipes. The findings indicated that misting systems would be effective at stopping fire spread, further described in reference [1].

3.6 *Pipejacking risk mitigations*

The Employer's pipejacking specifications allowed for either Earth Pressure Balance or slurry micro-tunnel boring machines to be provided. The Contractor elected to provide a refurbished Herrenknecht EPB MTBM capable of jacking pipes at 2.1m ID or 2.4m ID. The same MTBM was employed on both Link Sewers B and C, utilizing up-skinning.

Drive lengths were dictated by the location of the permanent shafts, which had access shaft and dropshaft functions. For the Link Sewer C pipejacking, the maximum drive length at tender was 966m. Post-award the Contractor offered a value-engineering proposal to delete an access-only shaft, resulting in a longest drive length of 1192m. This presented some concerns regarding personnel evacuation times under fire scenarios in the constrained conditions. Ultimately, acceptable mitigations were demonstrated by drills within the pipejack micro-tunnels.

3.7 *Employer design vs Contractor design*

At the outset of the detailed design phase, Watercare determined that it wished to substantially own the design for the scheme, rather than allocate responsibility to the Contractor. Various elements of the scheme, such as the tunnel lining, cascade shafts, and the May Road Air Treatment Facility, were delivered via Contractor's design. The perceived benefits of the Employer's design approach were considered to be:

- Maintaining control where Watercare would be operating assets day to day.
- To obtain mechanical and electrical plant and systems that were compatible with existing Watercare assets and systems, from an operations and maintenance perspective.
- To leverage lessons learned from the design, construction and operation of the 'Project Hobson Scheme' delivered between 2007-2010, considered a smaller scale prototype project.
- To facilitate better understanding of construction cost prior to tendering and budgeting.
- To allow tenderers to bid on the same basis without demanding significant energy and expenditure on tender design, given the extent and complexity of the scheme.

With the benefit of hindsight, the Employer's design approach possibly had some downside with respect to the sizing of the MPS inlet shaft, which adopted a minimum sized approach from a hydraulics, however this presented spatial (safety) and tunnel productivity issues for the Contractor's elected use of the inlet shaft as its tunnelling operation shaft.

4 PROCUREMENT PHASE RISKS

4.1 *Basis of contract, EOI and tendering*

During the detailed design phase, Watercare made the decision to procure the scheme as a single contract based on a FIDIC 1999 Red Book form of contract, modified for local conditions. As discussed in the previous sections, there was split responsibility between Employer and Contractor design elements. The design and specifications for the work were developed accordingly.

In late 2017, Watercare engaged with the international tunnel construction market for expressions of interest for the delivery of the project, ultimately shortlisting four contracting entities including constructors from New Zealand, Australia, France and Italy. The project was tendered in mid-2018, and of the four bidders the GAJV were selected.

At the time of tendering, there was a perceived risk of hyper-inflation occurring in the New Zealand economy. Watercare decided on an approach of risk-sharing, with the Contractor taking the risk of escalation up to a ceiling, beyond which the Employer would take the risk. Due to the pandemic and other Employer's risk events, the escalation ceiling war reached. The approach proved mutually fair and acceptable to both parties.

4.2 *Procurement phase – key materials and supply risks*

Prior to floating tenders, it was recognized by Watercare that the design and specification of the project included two elements which were constrained with respect to the number of suppliers that could meet the requirements. In particular, the following risks and treatments were identified:

1) Prefabricated Glass Reinforced Plastic (GRP) cascade shafts of 3m ID were to be designed by the Contractor for installation in two blind bored shafts (78m and 65m depths respectively). There was a single New Zealand based supplier deemed capable of supply, with perceived risk of pricing and obtaining conforming product. The risk was not resolved prior to floating tenders, but managed in conjunction with the following risk (ARC) post-award.
2) Elements of the works which would be exposed in-service to corrosive H_2SO_4 sewer gas were initially designed as being constructed out of Acid-Resistant Concrete (ARC), described in reference [2]. This included the main tunnel, various cascade dropshafts and the MPS inlet shaft and wet well chambers. Watercare had undertaken extensive pre-tender testing, including *in-situ* performance tests, with potential international suppliers of ARC. While the test results were encouraging, they were ultimately deemed inconclusive and presented significant procurement risk to Watercare if pursued. The following risk treatments were implemented:
   a. *Tunnel lining*: prior to floating tenders, Watercare elected to change the sewer corrosion protection approach from ARC to an embedded mechanically anchored Polyethylene (PE) lining, with additional minimum 50 year-life sacrificial concrete. A tunnel segment is shown in Figure 3, with further details in reference [3]. The concept was similar to the solution adopted on the IDRIS project, see reference [4].
   b. *Cascade Dropshafts*: the requirement for some cascade dropshafts to be constructed from ARC carried over into the contract, while others remained OPC concrete. The Contractor proposed that the GRP cascade shaft concept could be scaled up and applied in lieu of all ARC cascade dropshafts. This proposal was accepted, with GRP cascades being supplied up to 7.5m ID.
   c. *Pumping Station inlet shaft and wet well*: as part of its value engineering proposal, the Contractor successfully proposed that the cast *in-situ* secondary lining of these shafts could be protected by a combination of PE membrane and increased sacrificial ordinary Portland cement concrete, in line with the approach for the tunnel linings. Refer Figure 4 showing the MPS shafts under construction during TBM launching.

Figure 3. Tunnel PE corrosion protection liner segment in precast facility.

Figure 4. MPS shafts during TBM launch, PE corrosion protection lining is green.

4.3 *Budget and contingency management*

One of the critical success factors for Watercare has been appropriate budget management, with timely internal communication of the risks and requirements for additional budget. The development of the project as substantially Employer's design has allowed the costs to be estimated with confidence prior to floating tenders, as compared to many projects which are delivered with a lower level of scope definition. With all four tenders below the budget threshold, Watercare were able to carry an appropriately sized risk contingency to deliver the project. The contingency was utilized for items not foreseen at the time of tender, including:

- Several projects from Watercare's Western Isthmus Water Quality Improvement Programme (WIWQIP), which directly connect into the project, were added-in as variations.
- The Employer accepted some of the Contractor's value-engineering proposals, which ultimately provided benefits to the Employer in improved health and safety outcomes, quality and design life outcomes, lower cost, and schedule certainty.
- The realization of various Employer's risks, such as UPCs, COVID-19 pandemic impacts, global supply chain disruptions due to war, extreme weather and other similar events.

5 CONSTRUCTION DELIVERY PHASE

5.1 *Governance*

Watercare developed the contract documents with the intention of achieving collaborative partnering behaviours to the extent possible within a fixed price lump sum contract. This approach included layers of governance and oversight built into the contract, as summarised below.

1) Project Governance Group (PGG): the PGG included the Engineer and senior members from all parties, including the Employer's designer. The group was set up to provide a governance function for which the main purposes were to:
    a. Pragmatically diffuse potential disputes which would otherwise be difficult for the Engineer and Contractor's Representative to resolve under the contract.
    b. Ensure collaboration between the parties focused on problem solving rather than adopting contractual positions, including initiating various working groups.
    c. Provide alternative points of view and project performance feedback from senior construction industry figures and leaders from the various company organizations.
2) Leadership Steering Group (LSG): the LSG comprised executive leaders of the Contractor participant companies, the Employer and its' designer. The purpose of this group was to regularly review the project health and culture, discuss key issues and risks, and provide direction for resolving sensitive items such as negotiations and settlement of claims.

5.2 Alignment with WorkSafe New Zealand

New Zealand's health and safety regulator is WorkSafe New Zealand (WorkSafe), and the High Hazards Unit is its' relevant division focused on work under the Mining regulations. Watercare engaged regularly with the High Hazards Unit during development of the detailed design, during tender, and alongside GAJV during construction. As at the time of writing, it is considered that proactive communications and transparency exhibited between Watercare, the GAJV and WorkSafe have contributed to good health and safety outcomes for the workers.

5.3 Construction Management

Watercare recognized during the tendering phase that there would be significant benefit to providing an appropriately sized client-side Construction Management (CM) and contract administration team, to ensure that its desired project outcomes were realized. A blended team with a 'one-team' focus were sourced from Watercare and its various consultants, including Jacobs, Rider Levett Bucknall, AECOM, and Delve Underground. The Contractor's staff, the Engineer and the Employer's CM team all adopted collaborative and 'best for project' working approaches from the outset.

In the area of health and safety, all personnel of the Contractor and Employer were chartered with a view to health and safety outcomes being everybody's responsibility, in alignment with the principles of the Health and Safety at Work Act (2015). Watercare collaboratively implemented many initiatives with the GAJV to provide enhanced outcomes. Several examples follow:

1) 'Beacon Site' programme, to award sites a special status when they achieved outstanding H&S standards;

2) Establishing a real-sized pipejacking training facility, to promote working at height and fire simulation scenario training;
3) Providing electric locomotives in the tunnels;
4) Implementing ‘Heartstrong’ programme (worker heart health screening and education).

6 CONCLUSIONS

Successful delivery of the Central Interceptor project has been based on a foundation of ongoing risk assessment and challenge since the initial design stages of the project. As the project has progressed through different stages, various decisions and interventions have been made to manage delivery risk to acceptable levels, as discussed in the paper.

The project is nearly complete and to date has been delivered on time, to budget and has been well received in the media.

Health and safety outcomes to date have been good, with minimal serious harm accidents and no construction-related fatalities.

Good project outcomes do not happen by accident, but rather are the result of hard work and continuous improvement, coupled with a collaborative ‘best for project’ partnership attitude from all parties.

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