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Memorandum

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Date	2025-07-29	**Pages** (including this page)	18
Subject	Construction Statement Memorandum		

1 Purpose

This memorandum provides the construction statement for the proposed Western Isthmus Water Quality Improvement Programme (WIWQIP) Motions Catchment Improvement Project (the Motions Project). This has been produced following the completion of the Concept Design.

2 Construction Information

The following sections provide details on the proposed construction method of the Motions Collector Sewer. It is broken down to work elements that are repeated along the alignment. The pipeline will be constructed using a series of shafts, from which a micro-tunnelling machine (also known as pipe jacking machine) or tunnel boring machine (TBM) is launched (via thrust shafts) and retrieved (via receiving shafts). As the tunnelling machine advances, pipe sections are installed in the thrust shaft and jacked in behind the machine in the case of pipe jacking, or segmental linings are installed immediately behind the machine in the case of TBM tunnelling.

This memo covers the following construction methods:

- Pipe jacking (pipe internal diameter up to 2.4 m, DN 2400), Figure 1
- Tunnel Boring Machine (TBM) (pipe internal diameter 3.0 m up to 4.5 m, DN 4500), Figure 2

The draft alignments for pipe jacking and TBM options, based on the DN 1800 pipe jacking option in the Concept Design, are presented in Figure 1 and Figure 2 respectively.

For the pipe jacking option, there are two alignment options:

- Option A1: Same alignment as the DN 1800 pipe jacking option.
- Option A2: SH08 location is shifted to the existing Central Interceptor shaft by 5 m to reduce the tunnel length.

Shafts are located along the alignment including the branch lines to facilitate hydraulic connections and in the case of pipe jacking, thrust and receiving shafts. The diameter of each shaft will be determined by the working space required during construction and the functional requirements for the permanent installation.

Figure 1 Overall Plan (up to DN 2400 Pipe Jacking Option)

Figure 2 Overall Plan (DN3000 up to DN 4500 TBM Option)

Interception shafts are required in a number of locations along the alignment to provide connections from the local network to the Main Collector Sewer where they are not required to facilitate a thrust shaft or receiving shaft. The shaft sizes and construction areas provided in this memo are based on past experience of similar projects and best estimates for construction planning purposes. It is noted these are based on a Concept Design and final dimensions will be further developed during the detailed design phase.

2.1 Traffic Management

Shafts are typically located within local roads and parks. During shaft construction, affected roads will be closed to through traffic. Lane closures will remain in place throughout the tunnelling phase to support construction logistics and site operations. These type of construction activities typically generate 2 to 5 additional traffic movements per hour depending on the stage of works. Given the low traffic volumes and availability of alternative routes, significant traffic disruptions are not anticipated. Where residents have no alternative access, temporary driveways will be provided on road berms or alternative arrangements made with the resident. Where necessary, access restrictions during work hours will be coordinated directly with residents to ensure safety and minimise inconvenience.

The main collector sewer alignment is positioned to the south of the Northwestern Cycle Path between shaft SH03 and SH07. Construction areas at the shaft locations along this alignment may require traffic management to facilitate the cycle path users in addition to vehicular traffic. Part of the cycle path falls within the designation for SH16; however, the cycle path is managed by Auckland Transport.

2.2 Construction Staging, Equipment, and Activities

The Main Collector Sewer will be constructed using either the pipe jacking method (up to 2400 mm I.D.) or the TBM Method (3000 to 4500mm I.D.) for the main line of the Motions Collector Sewer. Branch lines connecting to Shaft 02 in Suffolk reserve (1200 mm I.D.) may be undertaken using either directional drilling (machine capable ranging from 32 mm to 1200 mm I.D.) or a pipe jacking method (capable ranging from 250 mm to 3000 mm I.D., the current maximum pipe jacking size achievable in New Zealand).

Pipe jacking method is currently proposed for the branch lines comprising of 600 mm I.D. in Newton Gully, Arch Hill Scenic Reserve, and the upstream branch in Basque Park.

The sequence and staging will be determined by the Contractor however an assumed construction sequence is provided below to assist in the development of high-level programmes to inform consenting and Watercare planning and procurement processes.

Table 1 has summarised the project components with tunnelling method.

There are two alignment options for pipe jacking:

- Option B1: Maintain the alignment stepping at SH04 and SH02 which is a shallower alignment.
- Option B2: Remove the alignment stepping at SH04 and SH02 which is a deeper alignment with a deeper shaft ~ 45 m deep at the upstream end.

Table 2 presents the Engineered Overflow Points (EOP) and reticulation diversions to Motions Collector Sewer. The dimensions are presented in Table 2.

Ventilation stacks have been identified as likely requirements for the ventilation and odour control of the Motions Collector Sewer. Possible locations at Shaft 01 and Shaft 02 have been identified. Each stack has an approximate footprint of 2.0 m x 2.0 m and a height of 4.5 m above ground level. The final locations and dimensions will be confirmed during detailed design.

Table 1 Proposed Construction Method for DN 2400 Pipe Jacking Option and DN 4500 TBM Option.

Components of the Motions Collector Sewer (Refer to **Figure 1** and **Figure 2** for visual layout)	Pipeline Internal Diameter (mm)	Shaft – Temporary Approx. Internal Diameter /Dimension (m)	Shaft Approx. Depth (m)
Main collector sewer			
Main Collector Sewer: Canada/East streets to Suffolk Park Reserve (Shaft 01 to Shaft 02)	2400 (Pipe jacking)	SH01: 6	23 (Option B1) 45 (Option B2)
		SH02: 10	32 (Option B1) 40 (Option B2)
	4500 (TBM)	SH01: 12 SH02: 10	45 39
Main Collector Sewer: Suffolk Park Reserve to Nixon Car Park (Shaft 02 to Shaft 04)	2400 (Pipe jacking)	SH03: 6	17 (Option B1) 25 (Option B2)
		SH04: 9	24 (Option B1) 24 (Option B2)
	4500 (TBM)	SH03: 6 SH04: 9	25 24
Main Collector Sewer: Nixon Car Park to Myrtle/Levonia Streets (Shaft 04 to Shaft 07)	2400 (Pipe jacking)	SH05: 3.5 SH06: 6 SH07: 9	23 22 20
	4500 (TBM)	SH05: 3.5 SH06: 6 SH07: 9	22 22 20
Main Collector Sewer: Myrtle/Levonia Streets to Western Springs Park (Shaft 07 to Shaft 08), plus stub connection to CI	2400 (Pipe jacking)	SH07a: 3.5 SH08: 9	21 25
	4500 (TBM)	SH07a: 3.5 SH08: 14 with temporary backshunt tunnel	23 25
Branch connections			
Branch connection: Newton Gully (Shaft 09, 10 and 11)	600	SH09: 6 x 4 SH10: 6 x 4 SH11: 6	9 6 25
Branch connection: Basque Park (Shaft 12, 12a and 02)	600 1200	SH12: 6 x 4 SH12a: 6	8 17

Components of the Motions Collector Sewer (Refer to **Figure 1** and **Figure 2** for visual layout)	**Pipeline Internal Diameter (mm)**	**Shaft – Temporary Approx. Internal Diameter /Dimension (m)**	**Shaft Approx. Depth (m)**
Branch connection: Arch Hill Scenic Reserve (Shaft 13, 14, 15)	600 1200	SH13: 6 x 4 SH14: 6 SH15: 6 x 4	8 15 6

Table 2 Engineered Overflow Points and reticulation diversions to Motions Collector Sewer

Shaft No.	Locations	Proposed New Connection Internal Diameter (mm)	Approx. Connector Pipe Depth Below Ground (m)
01	Corner of Canada/East Streets	300	2 to 5
02	Suffolk Reserve	300	15
03	Mostyn Street Reserve	300	2
04	Fourth Avenue Car Park (adjacent to Nixon Park)	300	3
05	Branch 7A Catchment	800	5
05	Kingsland Avenue	225 to 450	2
06	Finch Street	375	6
07	Myrtle Street	375	Up to 5
07a	Ivanhoe Road Cul de Sac car park	300	2
08	Western Springs Park	910	Up to 3.5
09	Ophir Street/Edinburgh Street	375	3
10	Gundry Street Cul de Sac	300	2
11	Burgoyne Street	225 to 375	4 to 12
12	Basque Park	600	3
13	Cooper Street Cul de Sac	225	1
14	Arch Hill Reserve	225	1
15	Arch Hill Reserve	300	1
Remarks: Construction can be undertaken using either open trench or trenchless methods, depending on pipe sizing, depth, geology, and Contractor preference. The general construction methodology is detailed in Section 3 of this memorandum.			

Table 3 outlines the typical construction elements, with associated activities and plant required for the Motion project.

Table 3 Typical Construction Staging

	Item	Commentary	Equipment/ vehicles/ materials example
Main Collector Sewer Tunnel and Shaft Construction			
1.1	Mobilisation and establishment	Including establishment of site access/egress, environmental controls, traffic management, potholing of services, services relocation as first shaft location, establishment of site compound at/near first launch site.	▪ Trucks ▪ Fencing ▪ Portacabin ▪ Portaloo ▪ Containers ▪ Generator ▪ Hardfill site area
1.2	Enabling	Enabling works ▪ Service diversions	▪ 6-wheeler truck ▪ Fencing ▪ Excavator ▪ Hydrovac ▪ Concrete saw
1.3	Satellite Site Establishment (if any)	▪ Traffic & Fencing Management ▪ Environmental controls ▪ Hardfill ▪ Plant Delivery	▪ Traffic attenuators ▪ Hiab ▪ Roller ▪ Low loader ▪ Excavator ▪ Spoil truck

	Item	Commentary	Equipment/ vehicles/ materials example
2	Shaft Construction	• Local service relocation as part of enabling works at shaft site. • Piling the shaft • Removal of Spoil • Excavation • De-watering shafts • Concrete construction Possible sequence to reflect pipe jacking tunnelling sequence: Launch Shaft at SH 07 Reception Shaft at SH 08 Reception Shaft at SH 06 Launch Shaft at SH 04 Reception Shaft at SH 03 Launch Shaft at SH 02 Reception Shaft at SH 01	▪ Piling rig for secant shafts or steel casing shafts ▪ Tracked crane ▪ Hiab ▪ Remmie Rack ▪ Excavator ▪ Hydrovac/ sucker truck ▪ Spoil & Concrete trucks ▪ Generator ▪ Concrete Pump ▪ Mobile crane ▪ Compressor & concrete breakers ▪ Muck skips ▪ Dewatering pumps ▪ Rock breaker ▪ Vibratory hammer
3	Prepare shaft sites for tunnelling	Including commissioning of tunnelling machine	▪ Tunnel machine assembly. ▪ Shaft modification for tunnelling works
4	Mainline tunnelling Tunnel Western Springs to Canada/East Streets Tunnelling – Drive 1 Tunnelling – Drive 2 Tunnelling – Drive 3 Tunnelling – Drive 4 Tunnelling – Drive 5 Tunnelling – Drive 6	Tunnelling • Set up tunnelling rig/ equipment • Tunnel boring • Removal of spoil • Pipe installation Possible tunnelling sequence, based on one pipe jacking machine for Main Sewer Collector: Shaft 07 to Shaft 08 Shaft 07 to Shaft 06 Shaft 04 to Shaft 06 Shaft 04 to Shaft 03 Shaft 02 to Shaft 03 Shaft 02 to Shaft 01	▪ Tunnelling machine ▪ Crane tunnel machine delivery ▪ Tunnel machine support system ▪ Cooling and lubrication plant ▪ Mobile crane ▪ Wheeler truck for spoil removal ▪ Electric locomotives ▪ Pipe delivery ▪ Ventilation fan ▪ Generator ▪ Excavators ▪ Forklifts ▪ Mucking system

	Item	Commentary	Equipment/ vehicles/ materials example
5	Construction of/conversion to permanent manholes	Including local connections, EOP connections and reinstatement of shaft site. - Install manholes within shafts - Progress backfilling of shaft around manhole - Removal of sheet piling or casing shaft as required - Break down concrete of secant shaft 1m below ground - Reinstatement of surrounding Roadway	- Spoil & Concrete trucks - Excavator & Breaker - Compactor - Mobile crane - Manholes - Generator
Branch Pipelines 1200mm ID pipe jacking tunnels, 600mm ID micro-tunnelled Pipelines			
6	Launch and Reception Shafts (Pits) Arch Hill Scenic Reserve	Including site establishment for smaller sites and local connections and EOPs Launch/Reception Shaft at SH 14 Reception Shaft at SH 15 Reception Shaft at SH 13	Refer to Item 2
7	Microtunnel – Drive 1 Microtunnel – Drive 2 Microtunnel – Drive 3	Shaft 04 to Shaft 14 Shaft 14 to Shaft 15 Shaft 14 to Shaft 13	Refer to Item 4
8	Launch and Reception Shafts (Pits) Newton Gully and Basque Park Reserve	Reception/Launch Shaft at SH 12a Reception Shaft at SH 12 Reception Shaft at SH 11 Reception Shaft at SH 10 Launch/ Reception Shaft at SH 09	Refer to Item 2
9	Tunnelling – Drive 7 Tunnelling – Drive 8	Shaft 02 to Shaft 12a Shaft 02 to Shaft 11	Refer to Item 4
10	Microtunnel – Drive 4 Microtunnel – Drive 5 Microtunnel – Drive 6	Shaft 12a to Shaft 12 Shaft 11 to Shaft 10 Shaft 09 to Shaft 10	Refer to Item 4
11	Construction of/conversion to permanent manholes	Including location connections, EOP connections and reinstatement of shaft site.	Refer to Item 5
Interception Shafts			

	Item	Commentary	Equipment/ vehicles/ materials example
12	Shaft 07a Shaft 05	Construction of temporary shaft and permanent manhole and connections.	▪ Piling rig ▪ Tracked crane. ▪ Excavator ▪ 6-wheeler truck ▪ Diesel Generator ▪ Rock breaker
Others			
13	Satellite Site Establishment	▪ Traffic & Fencing Management ▪ Environmental controls ▪ Hardfill ▪ Plant Delivery	▪ Traffic attenuators ▪ Hiab ▪ Roller ▪ Low loader ▪ Excavator ▪ Spoil truck
14	Direction Drilling	Directional drill ▪ Excavate drill pits with trench shields ▪ Drill bore ▪ Pull through drainage line	▪ Excavator ▪ HDD drilling rig ▪ PE welding machine ▪ Generator
15	Open Trenching	Open trench construction (limited section as needed) ▪ Temporary excavation support – trench shields ▪ Removal of spoil – to be loaded onto truck and removed from site ▪ Install bedding and then new pipe, manhole backfill ▪ Reinstatement works	▪ Concrete saw ▪ Spoil & Concrete trucks ▪ Excavator ▪ Trench shield ▪ Hydrovac/ sucker truck ▪ Compactor ▪ Roller ▪ Aggregate, pipes, manholes
16	Reinstatement	Road reconstruction ▪ Concrete break out and excavation ▪ Kerbing ▪ Traffic Islands & footpaths ▪ Asphalt ▪ Line marking	▪ Excavator & breaker ▪ Spoil & Concrete trucks ▪ Road Miller ▪ Paving plant ▪ Plate compactor ▪ Vibratory roller
Remarks: 1. Construction activities can occur concurrently, subject to Contractor preference and the construction programme.			

2.3 Excavation Volume

Based on the constructability report (Revision 1) for this Project prepared by McConnell Dowell, the estimated volume of material to be excavated and removed from the site varies significantly depending on the selected pipe size and shaft diameter. For the DN 1800 Concept Design, the total estimated excavated volume is approximately 45,000 m^3 with about 4,500 trucks (6 wheels Truck Loads, 10 m^3 per truck).

In comparison, the DN 2400 pipe jacking option would require the removal of around *69,600 m^3 (Option B1) (about 6,960 trucks) and *72,400 m^3 (Option B2) (about 7,240 trucks) by assuming no increase in shaft size, while the DN 4500 TBM option involves a substantially larger volume, estimated at approximately *175,100 m^3 (about 17,510 trucks) including larger size of launching and retrieving shaft diameters and temporary backshunt tunnel for TBM locomotive logistic. These figures reflect the increased scale and associated excavation requirements of the larger diameter options.

A bulk factor of 1.8 has been applied to the spoil volume estimations. This bulk factor accounts for the swell of excavated material upon removal from in-situ conditions, which is critical for planning material handling, transport logistics, and disposal requirements.

**Note: The spoil volume has not included the manhole of the 'Branch 7a overflow connection' at Fourth/Kingsland Avenues.*

3 Construction Elements

3.1 Construction Working Areas

Construction Working Areas (CWAs) will be established at each shaft location to provide the physical space necessary for safe, efficient, and effective execution of the works. These areas encompass all temporary and permanent facilities required throughout the construction phase. The CWAs will typically include:

- Zones for actual construction activities, such as excavation, foundation works, and structural installation
- Space for temporary works, including scaffolding, formwork, and construction access roads.
- Operational areas for equipment and machinery
- Storage zones for materials, plant, and construction site offices
- Facilities for workers, including amenities and designated safety zones.
- Laydown areas for tunnel lining segments or ring components, particularly where tunnel boring machines (TBMs) are used.
- Dedicated zones for slurry treatment, ventilation plant, spoil (muck) handling and disposal, and other ancillary systems

The indicative extent of the whole project construction footprint is shown in Figure 1 and Figure 2. A conceptual site layout for SH04 is provided in Figure 3. For the launching/ jacking and retrieval shafts, the construction working areas will be significantly larger than for the interception shafts. This additional space is required to accommodate the tunnelling machine setup, launch operations, jacking equipment, and spoil mucking out processes. An indicative site layout for the multi-jacking shaft SH02 is presented in Figure 4. The extent and configuration of each CWA may vary depending on site-specific constraints, access requirements, and the construction methodology adopted at each shaft location.

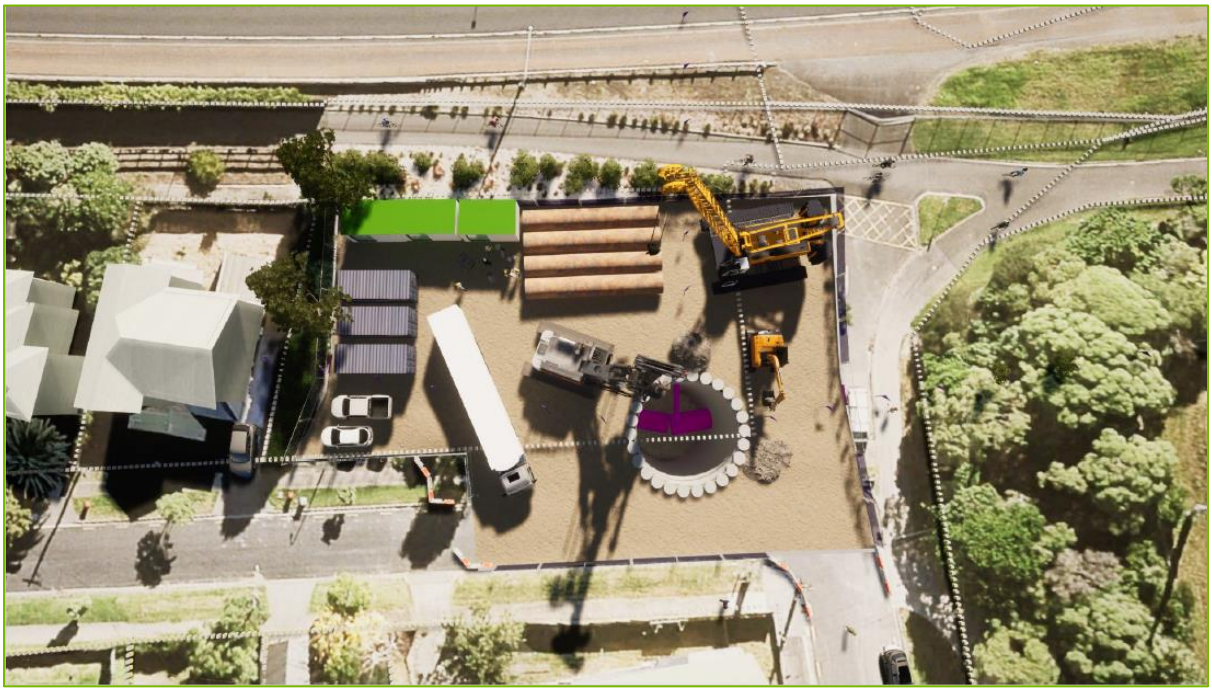

Figure 3 SH04 Conceptual site layout developed with McConnell Dowell for stakeholder purposes (during shaft construction) Note the site boundary would extend to either half or all the Fourth Ave Road Corridor

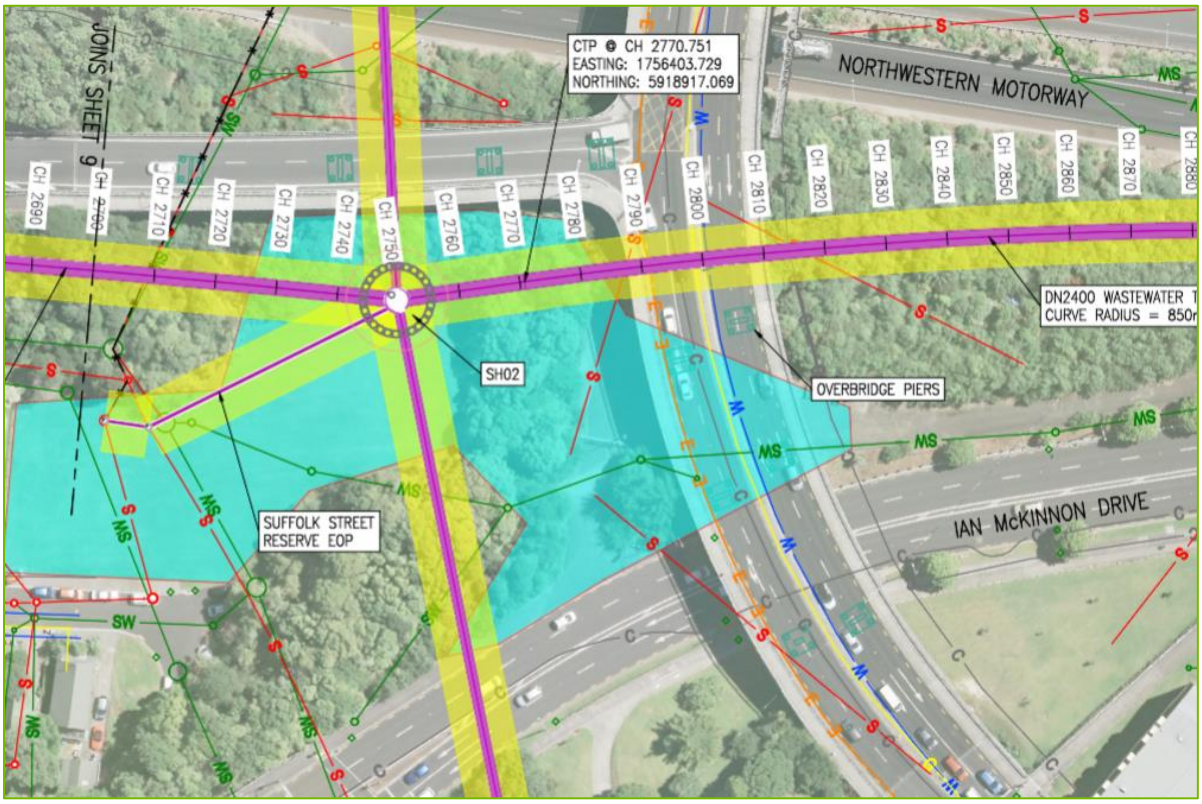

Figure 4 SH02 Indicative Site Layout in Suffolk Reserve

3.2 Tunnelling Supporting Plant

In general, there are two main types of Tunnel Boring Machines (TBMs): Earth Pressure Balance (EPB) and slurry. EPB machines typically require a smaller site construction area, with associated equipment such as a TBM cooling tank, water treatment plant, grout plant, and bentonite or foam injection systems. In contrast, slurry TBMs require slurry separation units, which generally demand a larger construction area compared to EPB systems.

3.3 Enabling work and service investigations

At each shaft location, service investigations will be carried out first, followed by service diversions. These activities will require small construction sites, typically involving hydrovac units, trucks, and excavators to locate and redirect existing services. The service diversions will occupy a smaller footprint than the main shaft construction and are expected to cause minimal disruption to local stakeholders, usually requiring only shoulder and footpath closures. To avoid delays to the main works, these diversions are often scheduled in advance, considering the need to coordinate with multiple service providers and manage potential delays.

3.4 Satellite Construction Sites

At each shaft location, a satellite construction site (CS) may be established where space permits, with its footprint minimised by utilising the central compound for material and plant storage. These satellite sites will be set up progressively as the project advances and will be disestablished as soon as they are no longer required, in order to minimise the number of active CSs at any one time.

There are two locations that have been identified that will allow more room to support the construction sites and enable additional storage space for materials and plant when required. The two locations allowing a larger temporary hubs are:

- Western Springs Park
- Suffolk Reserve

As activities change within each site and different types of plant are introduced or removed, traffic management plans will be revised to minimise disruption. Where feasible and safe, traffic management measures and site fencing will be adjusted or retracted to reopen roads to traffic.
Once work in an area is completed, roads and kerbing will be fully reinstated, and a temporary paving surface will be laid. Upon completion of all works, permanent paving will be reinstated across all construction areas.

3.5 Shaft Earth Retaining Support System and Construction

There are various construction methods available for shaft excavation and the associated support structures. These methods may include drilling and support using secant piles or sheet piles in soft ground conditions, and rock dowels with shotcrete in rock conditions. The chosen construction method may vary for each shaft in the project, depending on the following factors:

- Geological and geotechnical conditions
- Hydrogeological conditions and potential present aquifers
- Site specific constraints
- Availability of the contractor and equipment
- Estimated cost and construction timeframe.

One commonly used earth-retaining system for the deep excavation is the bored pile wall. Bored pile walls generally offer high stiffness and are effective in limiting wall deflection during excavation. They are typically used in excavations deeper than 15 m. A bored pile wall is constructed by installing a row of either contiguous bored piles or secant bored piles along the excavation perimeter.

Contiguous bored piles are installed with intentional gaps, typically ranging from 100 mm to 500 mm, to account for construction tolerances and to avoid overlapping at depth. These gaps can be larger in more competent soils. A grout curtain is often installed to control water seepage through the gaps during excavation. Bored pile walls are usually permanent structures and may include a secondary internal wall, tied back to the pile wall, to improve water tightness and provide a smoother, more aesthetically pleasing finish.

In contrast, secant bored piles (Figure 5) are overlapping concrete piles cast in situ to provide greater continuity between adjacent piles. The piles are typically arranged in an alternating sequence of soft and hard piles. Soft piles are usually constructed with plain concrete, though jet grouting has been used in some cases. The hard piles, which cut into the soft piles during boring, serve as the main structural elements and are properly reinforced. The soft piles support the soil between the hard piles and help to limit groundwater ingress.

Piling for bored pile walls is typically carried out using a bored pile rig and crane. Steel casings and tooling will be stored and reused on site, while reinforcement cages are fabricated offsite and delivered to the site ready for installation. The cages are lifted directly from the truck and placed into the bored hole, followed by concreting.

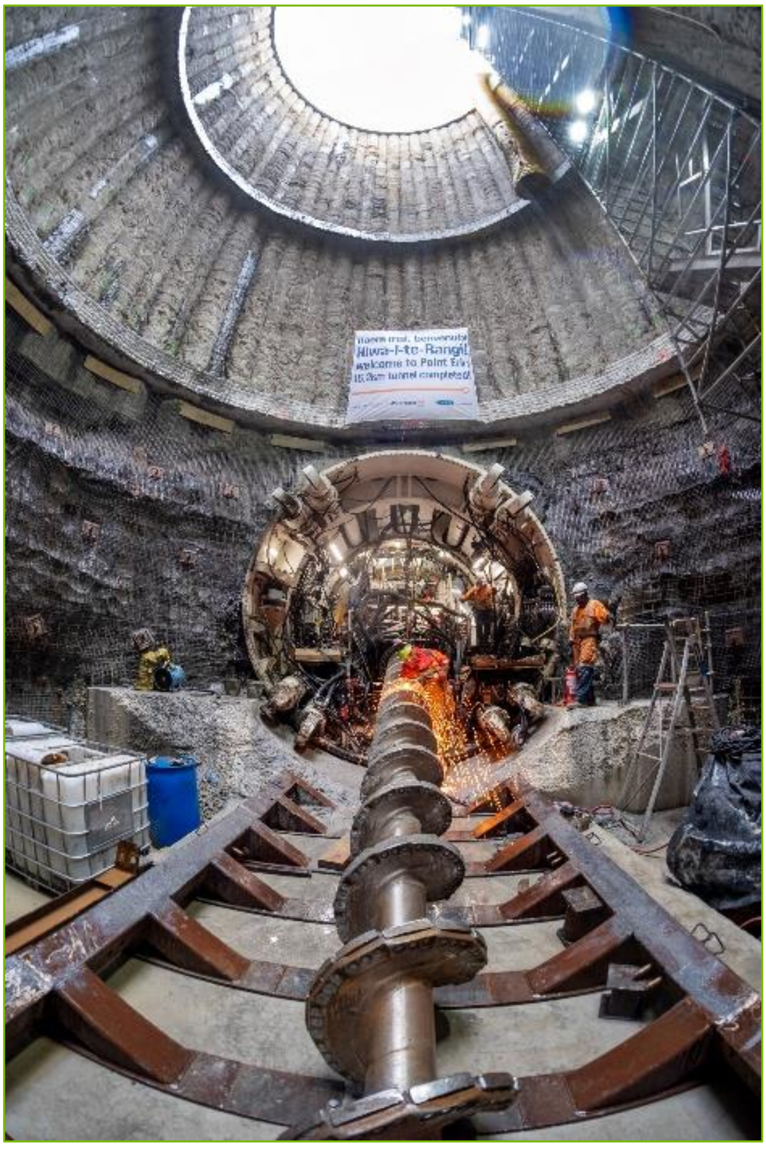

Figure 5 Secant Bored Pile Shaft – Central Interceptor

Another excavation method, used in projects like the Central Interceptor, is caisson excavation.

Segmental caisson excavation (Figure 6) involves assembling pre-cast concrete segments at ground level, which are then pushed into the ground. Excavation is carried out from within the shaft by an excavator, while hydraulic rams apply downward pressure to advance the caisson.

Cast in-situ caisson (Figure 7) involves constructing rings by placing steel reinforcement around the shaft and pouring concrete in-situ to form each section. These sections are then progressively jacked into the ground using hydraulic rams.

Figure 6 Pre-cast Segmental Concrete Caisson Excavation – Central Interceptor

Figure 7 Cast In-situ Caisson Excavation – Central Interceptor

3.6 Tunnelling

Tunnelling will be carried out using either a pipe jacking machine (Figure 8) or a Tunnel Boring Machine (TBM) (Figure 9). The machine will be lowered into a launch shaft and will bore along the tunnel alignment, eventually emerging at the retrieval shaft.

In the case of a pipe jacking machine, also known as a Micro Tunnelling Boring Machine (MTBM), machine hydraulic jacks push prefabricated pipe segments through the ground from a launch shaft toward an interception or reception shaft.

In contrast, a TBM is equipped with its own propulsion system, enabling it to undertake long single-drive lengths with continuous operation and logistical support. As a result, fewer access points are required. However, for the Motions Project, the number of interception shafts is the same for both the pipe jacking and TBM options, to cater to the designed hydraulic connection points to the Main Collector Sewer.

As the pipe jacking machine advances, pipe sections are lowered and jacked in behind the machine. An Earth Pressure Balance (EPB) machine removes spoil into a muck bin, which is then hauled by locomotive back to the shaft. There, the muck bin is lifted out and transferred to a truck for disposal at a spoil stockpile. In the case of a TBM, segmental linings are assembled piece by piece to form a complete circular ring within the tunnel.

Figure 8 Micro-tunnelling (pipe jacking machine) and jacking pipe – Central Interceptor

Figure 9 Tunnel Boring Machine (TBM) and Segmental Tunnel – Central Interceptor

3.7 Manhole Construction

Upon completion of tunnelling through the shaft and removal of the tunnelling machine, the shaft will be decommissioned through the installation of a permanent manhole structure. The annular space between the shaft and the manhole will be backfilled to ensure structural stability and prevent future ground movement.

To facilitate natural groundwater flow and reduce the risk of water accumulation, weep holes or strip drains will be punched into the shaft walls prior to backfilling. These allow for the controlled migration of groundwater into the surrounding soil matrix.

Following the installation of the manhole and backfilling operations, the upper portion of the shaft walls will be broken down to a depth of approximately 1 metre below the finished road surface. The surface will then be reinstated in accordance with Auckland Transport or Landowner requirements, including reconstruction of pavement layers and any associated kerbing, footpaths, or road markings to restore the area to its original condition.

This decommissioning approach ensures both structural integrity and environmental compliance, while minimising long-term maintenance requirements.

3.8 Interception Shaft

Interception shafts will be constructed to connect the local network to the main alignment. This will be at locations where shafts are not required for launch or retrieval of a pipe jacking TBM (e.g. Shafts 05 and 07a). Similarly for the segmentally lined TBM option, the majority of shafts could be reduced in size and similar shaft construction methods adopted, as explained in the following paragraphs.

The site will be re-established for the construction of each shaft. As excavation progresses, temporary support systems, such as steel casings or other suitable methods, may be installed to maintain shaft stability and ensure a safe working environment. These temporary supports will facilitate the construction of a connection to the main pipeline and the installation of manhole structures, which will provide access for future maintenance and inspection of the network.

Upon completion of the manhole construction, the temporary support system will be removed, and the surrounding annular space will be backfilled using suitable materials to ensure ground stability and minimise the risk of settlement. Final surface reinstatement will be carried out in coordination with the overall works program to minimise disruption to the public and adjacent infrastructure.

For larger-diameter pipelines, a correspondingly larger interception shaft may be constructed in advance to facilitate construction sequencing, logistics, and the subsequent installation of the pipeline. The construction method will be confirmed based on the final design and dimensions of the shaft.

3.9 Directional Drilling

Directional drilling will be utilised where feasible to minimise disruption to the surrounding area. A drilling pit and a receiving pit will be excavated and supported using trench shields to ensure safe working conditions. Once the pits are prepared, the directional drilling rig will be mobilised to site.

The drilling process involves creating a pilot bore using a bentonite slurry system to facilitate cutting removal and bore stability. After the pilot bore is completed, a polyethylene (PE) pipe will be pulled back through the bore. The annular space between the PE pipe and the borehole wall will then be pressure-grouted to provide support, prevent ground settlement, and ensure long-term durability.

This trenchless method not only reduces surface disturbance and reinstatement requirements but is also particularly suitable for crossing under existing infrastructure, roads, and environmentally sensitive areas.

3.10 Open Trenching

Open trench drainage will be constructed using traditional methods, incorporating trench shields, or shoring slide rail systems. Typical excavation equipment, including excavators and spoil trucks such as 23-tonne excavator and 6-wheeler spoil trucks, are assumed to be used. The work will be coordinated with local residents to ensure continued access to their properties, using road plates or temporary spot backfilling as needed.

3.11 Reinstatement

Final reinstatement of the carriageway and park will be carried out as work at each shaft is completed. Kerbing and footpaths will be reinstated, and speed humps and traffic islands will be reconstructed. A temporary paving surface will be laid as part of the interim works.

Once all construction activities are complete, permanent resurfacing of all sites will be undertaken—either over one or two nights, or during the day if traffic conditions permit.

Details to be developed at next stage depending on the reinstatement works.